ANDRITZ Hydro

DRS

Library of Protective Functions

Protection

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CAUTION

Installing, commissioning and operating of this product may be performed only by thorough trained and

specialized personnel (*).

We explicitly will not take any responsibility for any damage on our products caused by improper installation, configuration and handling. Internal modifications must solely be carried out by specialised personnel authorised by

ANDRITZ HYDRO GmbH

During commissioning the operating instructions and also the applicable Local Safety Standards have strictly to be observed.

(*) **Definition:** specialised personnel are persons who

- are familiar with installing, mounting, commissioning and operating of the device and the system in which the device is to be installed;
- are instructed in maintenance and use of safety equipment according to standard rules and regulations of safety technology;
- passed an extensive First Aid training.

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1. General

1.1. Contents of This Document

The document contains the description of the characteristic features and parameter settings of all the available protective functions of the “Digital Relay System" from now on referred to as DRS. The feasible operating characteristics, setting ranges, input matrices, connections- and logic diagrams as well as the necessary completing information is outlined for each protective function. For User information during relay configuration an extensive Help Feature is included into the DRS operating system.

1.2. General Terms Definition

In the function descriptions following general denominations are used:

Function Denomination:

Specifies the application possibilities of the protective function.

Function Name:

Denomination of the protective function which is also shown in the device configuration window display.

Function Abbreviation:

Designation of the protective function as shortened text displayed on the hand terminal.

Function Type:

Name of the protective function as Model Type for exact Version Definition.

Analogue Inputs:

The analogue input signals (current, voltage) into the protective function.

Digital Inputs:

Digital input signals into the protective function.

Slow Analogue Inputs:

Analogue signal input (DC-input) for special applications, i.e. temperature, DC current, DC voltage, etc.

Test Input:

Digital input enabling operation of the respective protective function, respectively function Stage.

Blocking Input:

Digital input enabling blocking of the respective protective function, respectively function Stage.

Outputs:

Initiation: Initiating signal of the protective function or stage

Trip: Trip signal of the protective function or stage

All outputs can be configured to set the LED indications.

Setting Parameters:

All relevant protection setting values for correct operation are displayed for the various functions.

Reset Ratio:

Ratio between the reset- and operating value.

Operating Time:

Time delay between the fault initiation and the trip output of the protective function, i.e. start of the initiating signal for time delayed functions or the trip signal for instantaneous functions.

Time Delay:

Time lag between the initiation- and the trip signal for time delayed functions.

Internal Measured Values:

Derived from the external CT/VT signals the function internal measured values relevant for the operation of a protective function.

Function characteristic, i.e. specific digital outputs, digital inputs, etc. which are generally not displayed for all functions are outlined and described in the respective detailed description.

1.3. Measuring Method

All protective DRS functions which are applying the power system frequency signals to evaluate the parameters are using the Fourier-Transformation.

Thereby the CT/VT signals after potential isolation and filtering are sampled 12 times each cycle and subsequently processed according to the formulas of the mentioned algorithm as per Fig. 1-1. The results of the computations are then at disposal for further processing of the signal vector value, i.e. amplitude and phase angle, for the basic harmonic.

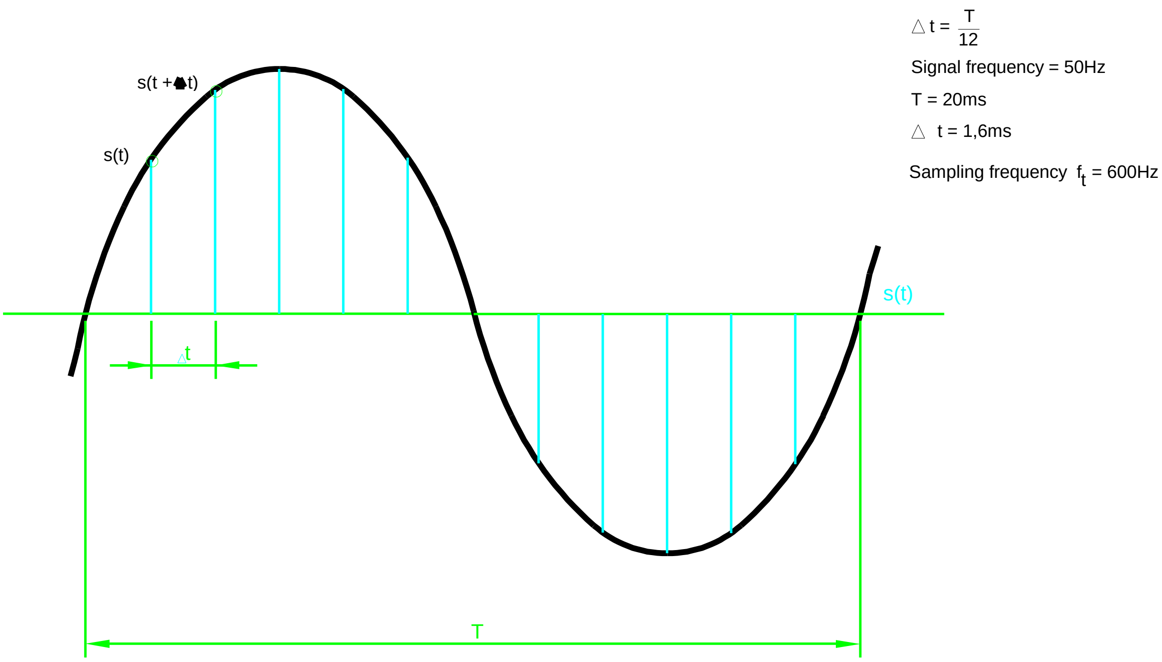

Fig. 1-1

Due to physical- and measuring principle reasons the above outlined method is not applicable for all functions. For power measuring functions, i.e. overload, power direction, etc. a more complex digital signal computation is applied which is described in detail in the specific chapters.

1.4. General Influencing Quantities and Tolerances:

Power supply voltage: Range 80 - 120 % V_N: < 0,5%
Temperature: Range -5 - +45°C: ≤ 0,5%/10K
Frequency: Range 10 Hz - f_{max}: ≤ 1%

Typical time delay accuracy: ≤ 10 ms

Further information to the measuring accuracy is outlined in the specific function descriptions.

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2. MB... LOGIC FUNCTIONS

2.1. OVERVIEW

List of the available MB . . . LOGIC FUNCTIONS

Abbreviations:

C2	... DRS-COMPACT2
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function Number (VE-internal number of the protective function)
TYPE	... Function Type (short denomination of the protective function)
ANSI	... ANSI Device Number (international protective function number)

PROTECTIVE FUNCTIONS: MB . . .	FNNR	TYPE	ANSI	Application
Signal function 1: 1 Signal function, time delay range: 0 - 180 sec.	1099	MB111	94	C2,M,L
Signal function 4: 4 Signal functions, time delay range: 0 - 2 sec.	1096	MB141	94	C2,M,L
Signal function 4: 4 Signal functions, time delay range: 0 - 180 sec.	1098	MB142	94	C2,M,L
Trip circuit supervision	1078	MB211	94	C2
Out of step counter	1036	MB311	94	C2,M,L
Logic function 2	1094	MB442	94	C2,M
Logic function 2	2028	MB442	94	L

2.2. TECHNICAL DATA

2.2.1. Signal Functions

PROTECTIVE FUNCTION: MB111	FNNR	TYPE	ANSI	Application
Signal function 1: 1 signal function, time delay range: 0 - 180 sec.	1099	MB111	94	C2,M,L

Input signal processing of an external digital input for annunciation-, alarm- and trip with an adjustable time delay.

<u>MB111</u>
<u>Technical Data</u>

Inputs

Binary:	Binary input (digital signal)
	Blocking input

Outputs

Binary:	Initiation
	Trip

Parameter Settings

Time delay range:	0 ... 180 s in steps of 0,05 s
Active slope:	rising/falling

Response Time

Operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

PROTECTIVE FUNCTION: MB141	FNNR	TYPE	ANSI	Application
Signal function 4: 4 signal functions, time delay range: 0 - 2 sec.	1096	MB141	94	C2,M,L

Input signal processing of 4 external digital inputs for annunciation-, alarm- and trip with an independent adjustable time delay for each stage.

MB141
Technical Data

Inputs

Binary:	Binary input (digital signal) stage 1
	Binary input (digital signal) stage 2
	Binary input (digital signal) stage 3
	Binary input (digital signal) stage 4
	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Blocking input stage 4

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2
	Initiation stage 3
	Trip stage 3
	Initiation stage 4
	Trip stage 4

Parameter Settings

Time delay range stage 1:	0 ... 2 s in 0,01 s steps
Active slope stage 1:	rising/falling
Time delay range stage 2:	0 ... 2 s in 0,01 s steps
Active slope stage 2:	rising/falling
Time delay range stage 3:	0 ... 2 s in 0,01 s steps
Active slope stage 3:	rising/falling
Time delay range stage 4:	0 ... 2 s in 0,01 s steps
Active slope stage 4:	rising/falling

Response Time

Operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

PROTECTIVE FUNCTION: MB142	FNNR	TYPE	ANSI	Application
Signal function 4: 4 signal functions, time delay range: 0 - 180 sec.	1098	MB142	94	C2,M,L

Input signal processing of 4 external digital inputs for annunciation-, alarm- and trip with an independent adjustable time delay for each stage.

MB142
Technical Data

Inputs

Binary:	Binary input (digital signal) stage 1
	Binary input (digital signal) stage 2
	Binary input (digital signal) stage 3
	Binary input (digital signal) stage 4
	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Blocking input stage 4

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2
	Initiation stage 3
	Trip stage 3
	Initiation stage 4
	Trip stage 4

Parameter Settings

Time delay range stage 1:	0 ... 180 s in 0,05 s steps
Active slope stage 1:	rising/falling
Time delay range stage 2:	0 ... 180 s in 0,05 s steps
Active slope stage 2:	rising/falling
Time delay range stage 3:	0 ... 180 s in 0,05 s steps
Active slope stage 3:	rising/falling
Time delay range stage 4:	0 ... 180 s in 0,05 s steps
Active slope stage 4:	rising/falling

Response Time

Operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

2.2.2. Trip Circuit Supervision

PROTECTIVE FUNCTION: MB211	FNNR	TYPE	ANSI	Application
CB trip circuit supervision	1078	MB211	94	C2

Trip circuit supervision of the CB TRIP circuit and the CB auxiliary circuit (2 digital inputs) with a setting selection for the internal logic evaluation.

MB211
Technical Data

Inputs

Binary:	TRIP circuit (trip circuit supervision)
	Auxiliary circuit (trip circuit supervision)
	Blocking input

Outputs

Binary:	Trip circuit faulty

Parameter Settings

Time delay range:	0 ... 30 s in steps of 0,05 s
TRIP circuit healthy (normal operation):	0/1
Auxiliary circuit healthy (normal operation):	0/1
Logic connection (result=1 ... →alarm):	EXOR/ NOT EXOR/ OR/ NOR/ AND/ NAND

Response Time

Minimum operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

2.2.3. Out of Step Counter

PROTECTIVE FUNCTION: MB311	FNNR	TYPE	ANSI	Application
Pole slipping evaluation	1036	MB311	94	C2,M,L

Out of step conditions are recognised by the number of pole slips within a set measuring time period.
Note: The pole slip pulses are provided by another protective function, e.g. field failure protection.

MB311
Technical Data

Inputs

Binary:	Auxiliary input system 1
	Auxiliary input system 2
	Auxiliary input system 3
	Blocking input
	Test input

Outputs

Binary:	Trip

Parameter Settings

Pole slipping number:	1 ... 25
Measuring time:	0 ... 180 s in 5 s steps

Window Display for Internal Relay Computation Values

Pole slip pulses:	Number of pole slips within the configured actual measuring time frame

Response Time

Minimum operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

2.2.4. Logic Function 2

PROTECTIVE FUNCTION: MB442	FNNR	TYPE	ANSI	Application
Logic function 2	1094	MB442	94	C2,M
Logik function 2	2028	MB442	94	L

Logic connections of digital signals with inverted output and with configurable time delay.

<u>MB442</u>
<u>Technical Data</u>

Inputs

Binary:	*Selection of:* IN01 ... IN32 inv. IN01 ... inv. IN32 OUT01 ... OUT32 inv. OUT01 ... inv. OUT32

Outputs

Binary:	Logic function

Parameter Settings

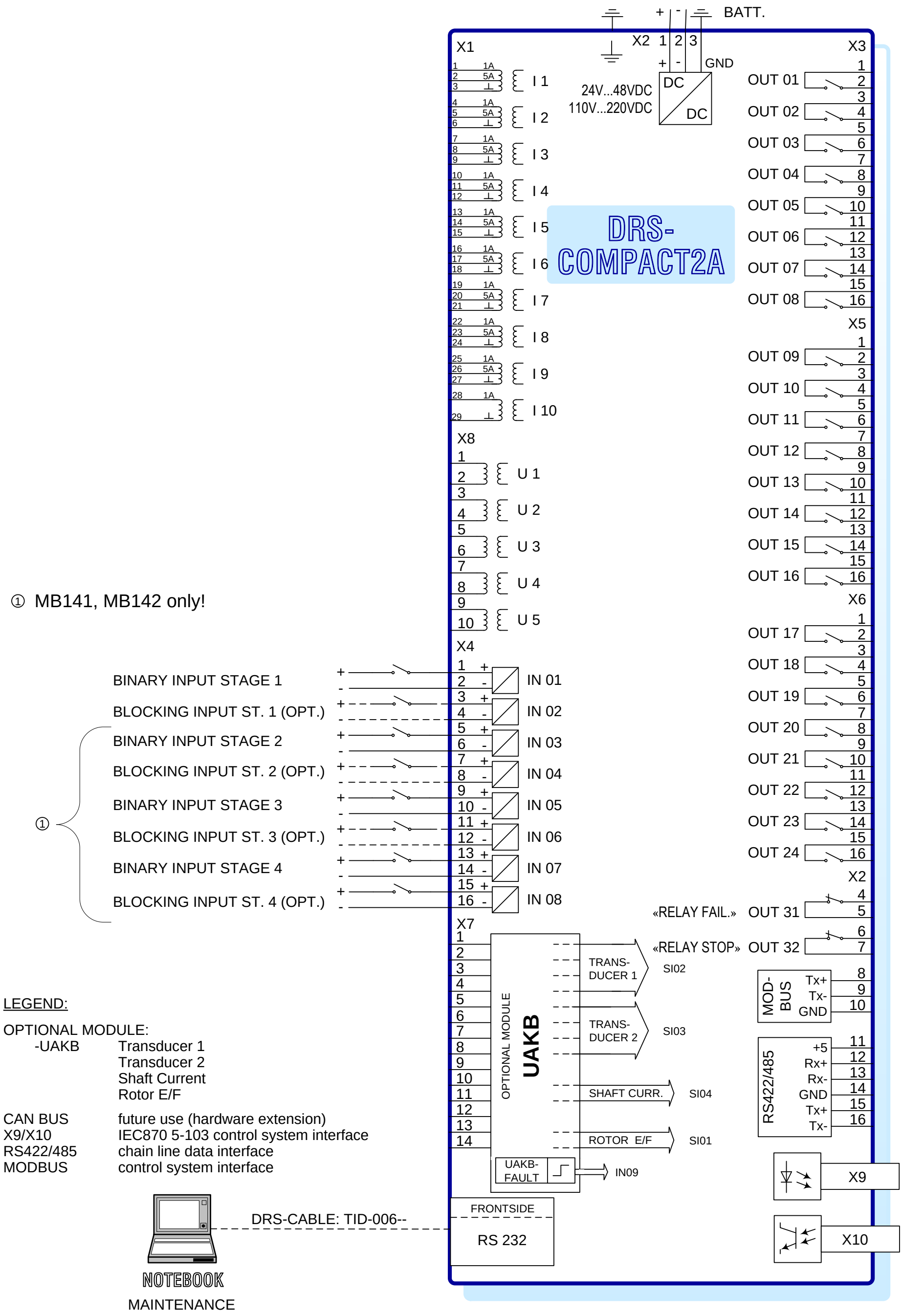
Adjustable time delay:	0 ... 999 s in 0,01 s steps
Logic output:	normal/ inverted

Response Time

minimum operating time:	≥ 7 ms (50 Hz), respectively 6 ms /60 Hz), respectively 20 ms (16 2/3 Hz)

2.3. CONNECTION DIAGRAMS

2.3.1. MB111 /MB141/ MB142



MB111 SIGNAL FUNCTION 1 WIRING DIAGRAM
MB141 SIGNAL FUNCTION 4 WIRING DIAGRAM
MB142 SIGNAL FUNCTION 4 WIRING DIAGRAM

Fig. 1 MB111 MB141 MB142 Signal Function Wiring Diagram

2.3.2. MB211

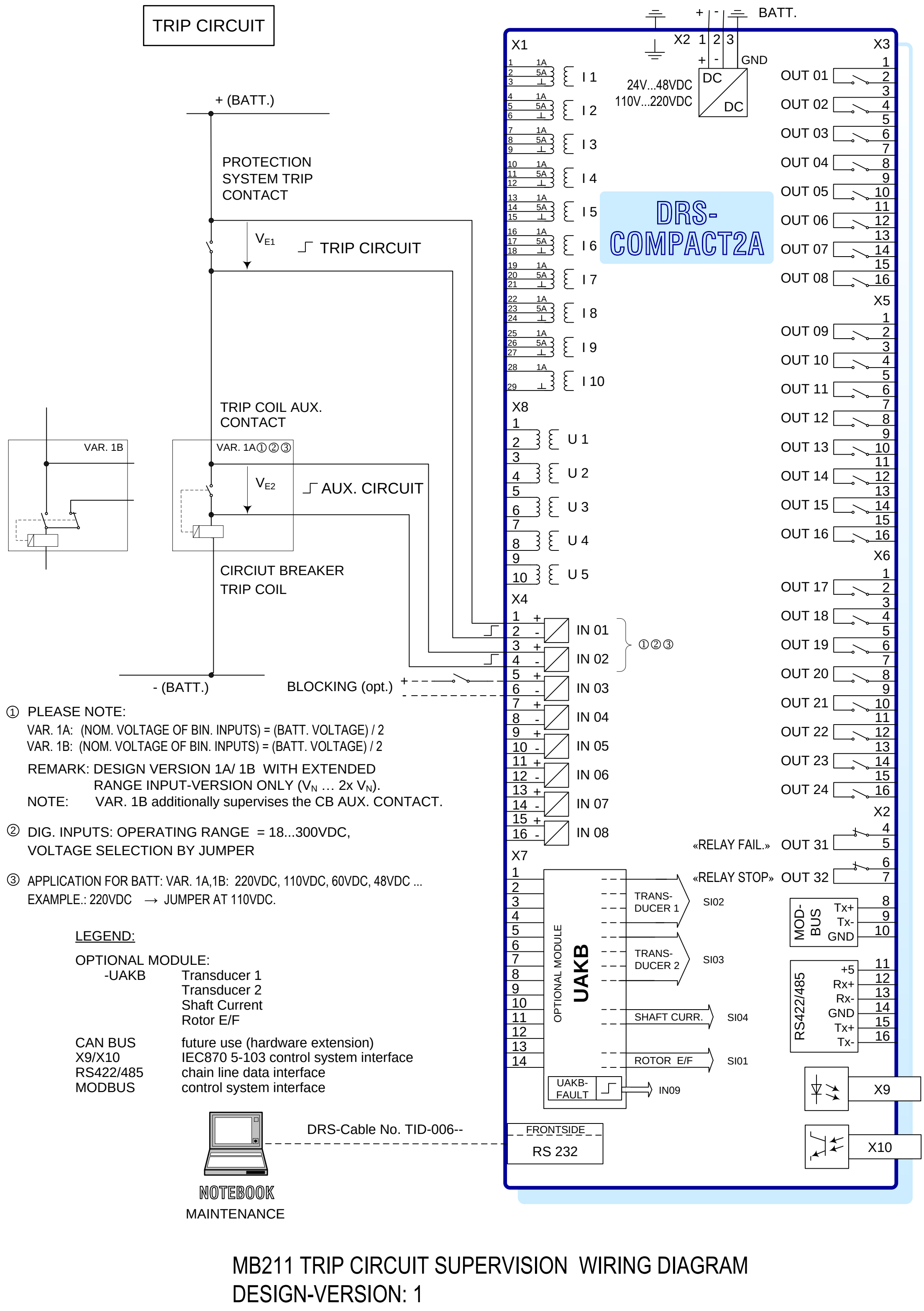
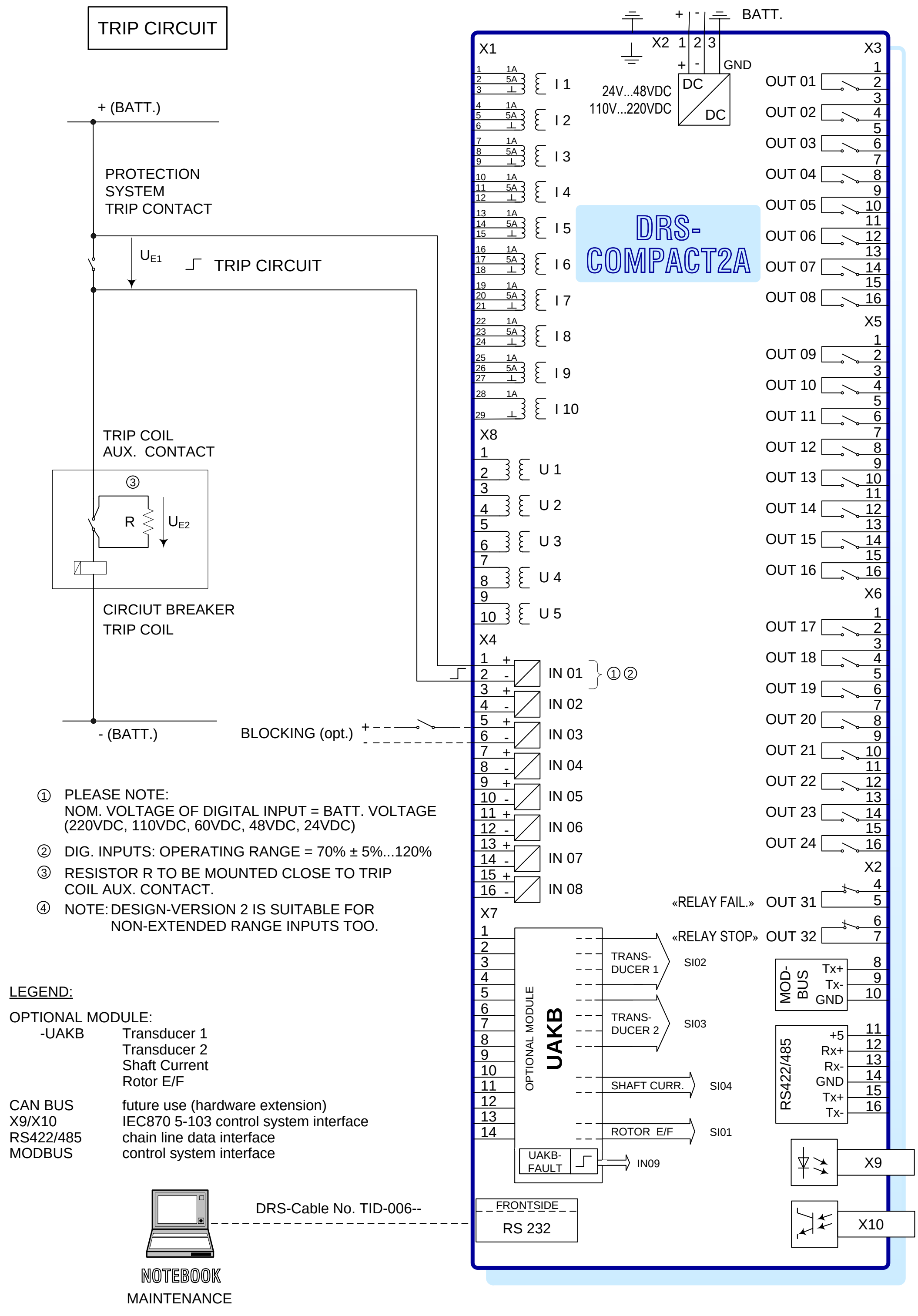


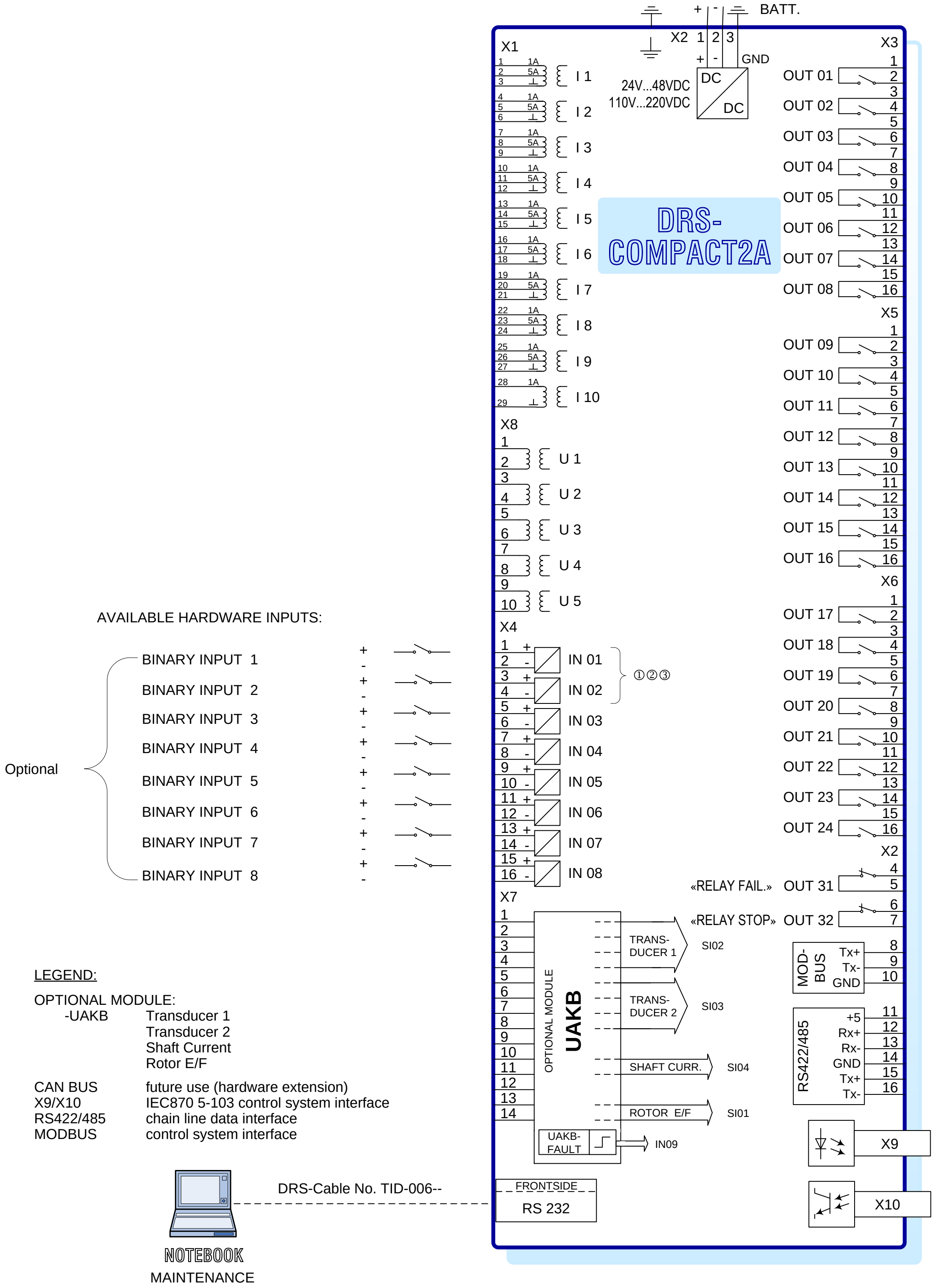
Fig. 2 MB211 Trip Circuit Supervision Wiring Diagram



MB211 TRIP CIRCUIT SUPERVISION WIRING DIAGRAM
DESIGN-VERSION: 2

Fig. 3 MB211 Trip Circuit Supervision Wiring Diagram

2.3.3. MB442



MB442 LOGIC FUNCTION 2 WIRING DIAGRAM

Fig. 4 MB442 Logic Function 2 Wiring Diagram

2.4. LOGIC DIAGRAMS

2.4.1. MB111/ MB141/ MB142

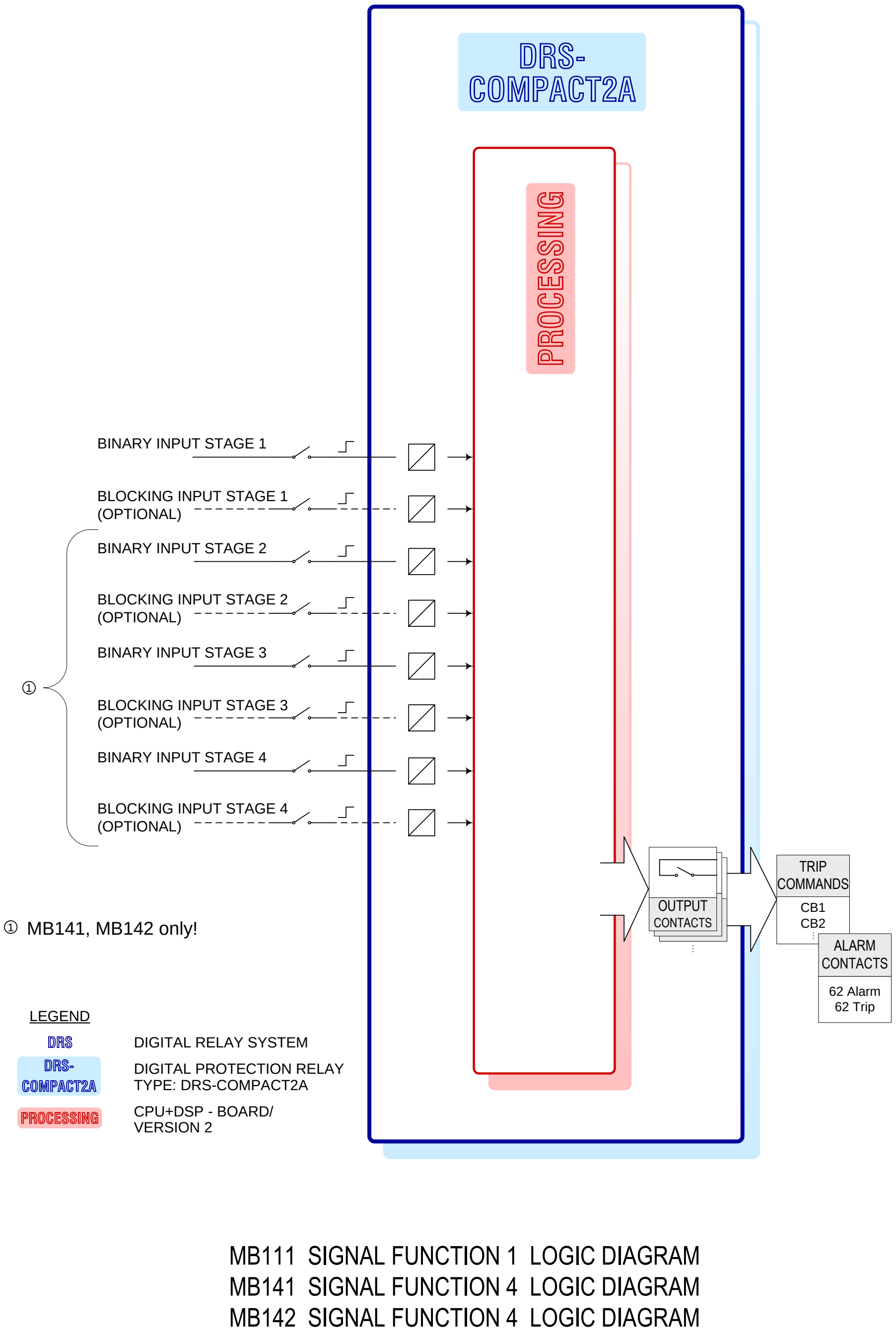
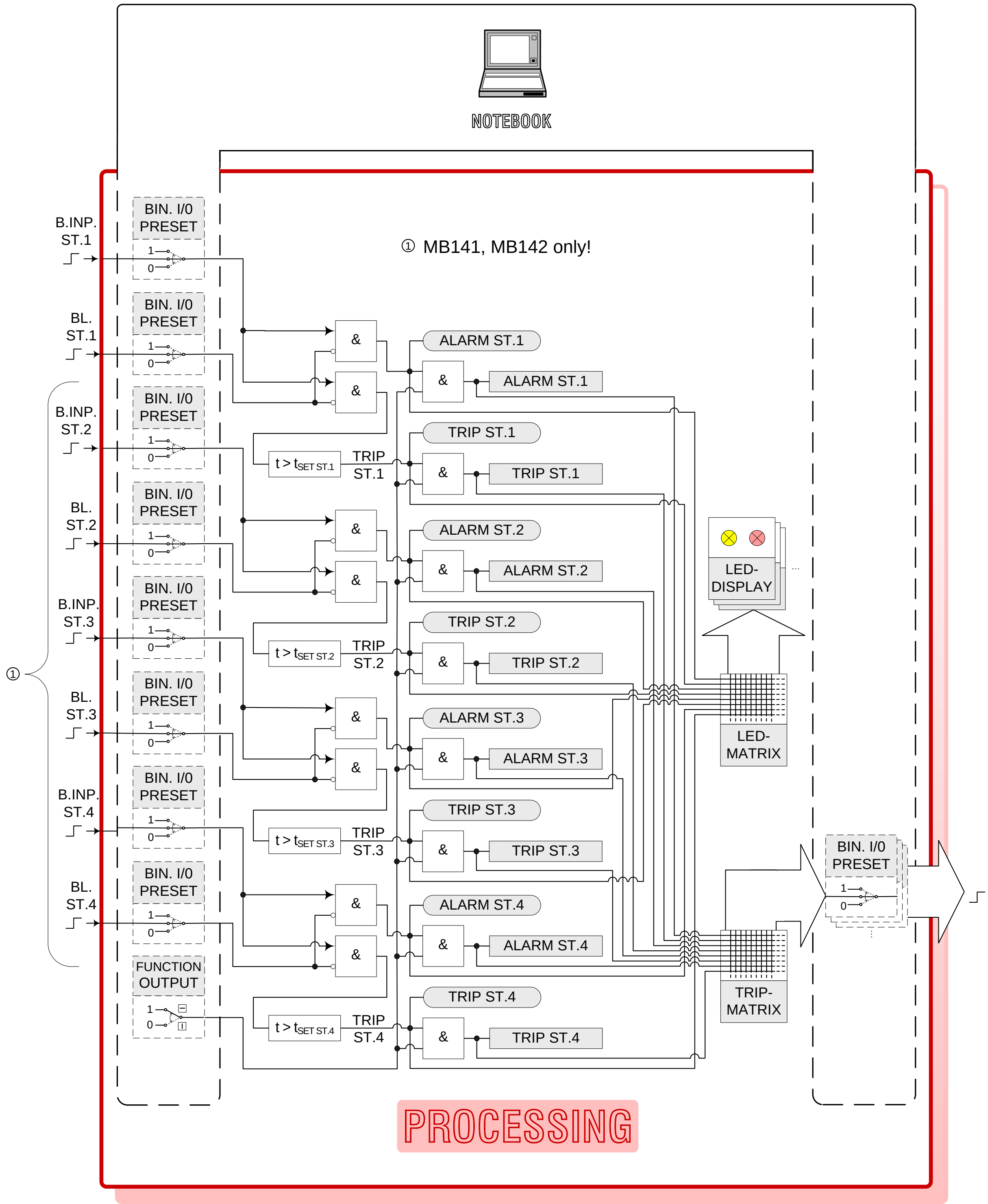


Fig. 5 MB111 MB141 MB142 Signal Function Logic Diagram

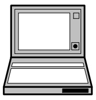


MB111 SIGNAL FUNCTION 1 LOGIC DIAGRAM / PROCESSING
MB141 SIGNAL FUNCTION 4 LOGIC DIAGRAM / PROCESSING
MB142 SIGNAL FUNCTION 4 LOGIC DIAGRAM / PROCESSING

Fig. 6 MB111 MB141 MB142 Signal Function Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MB111, MB141, MB142



Online simulation via notebook

BIN. I/0 PRESET (1 / 0) — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT (1 / 0) — Online-simulation of the FUNCTION OUTPUTS of the protective function MB111, MB141, MB142
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

ALARM ST.1 (rounded box) — „ALARM STAGE1"-signal going to LED-MATRIX

ALARM ST.1 (rectangular box) — „ALARM STAGE1"-signal going to TRIP-MATRIX

> — Type of function: over-detection (actual value > set value)

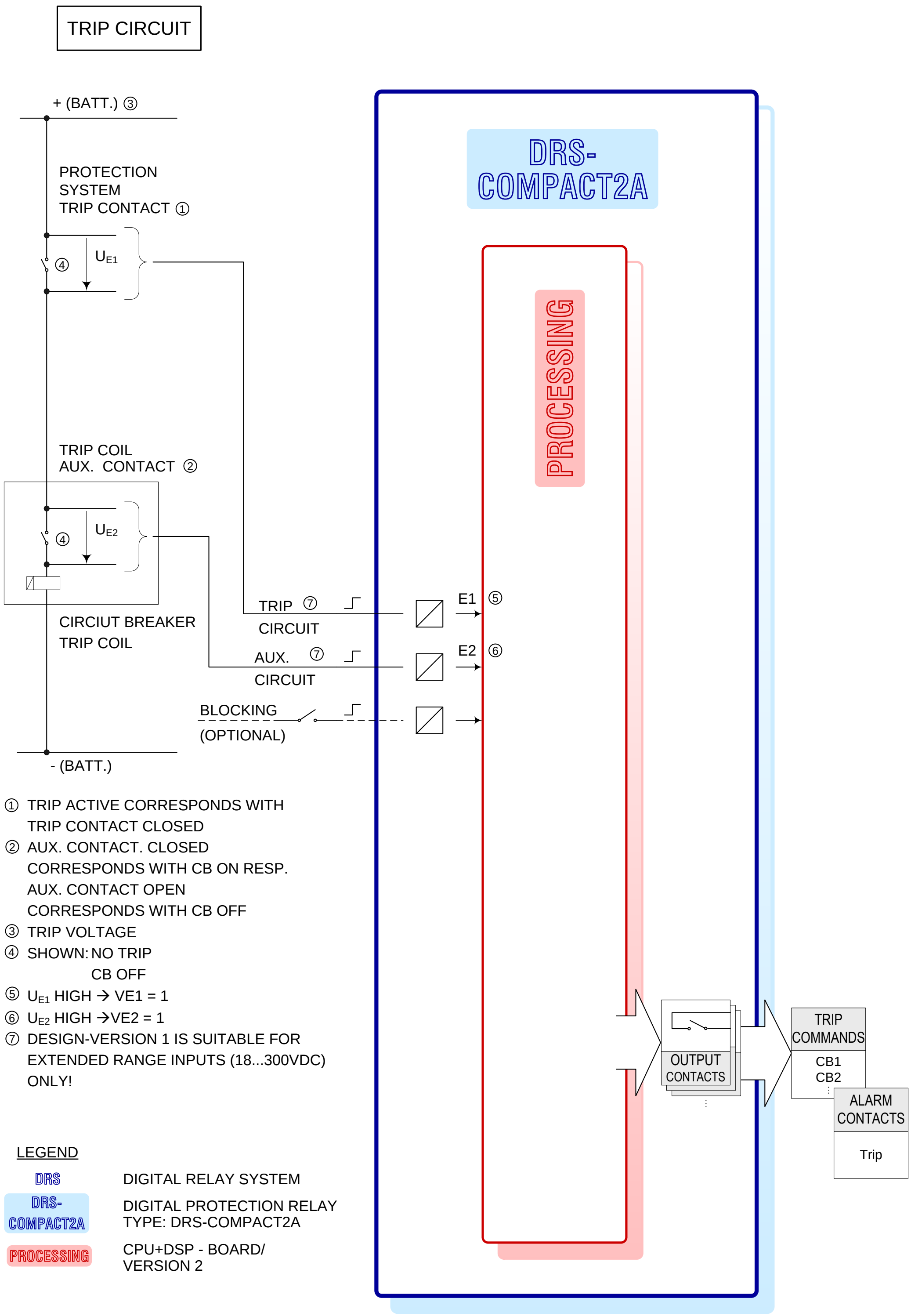
< — Type of function: under-detection (actual value < set value)

Set Value (BINARY INPUT):
- „Active Edge" = RISING ®
- „Active Edge" = TRAILING ®

MB111 SIGNAL FUNCTION 1 LOGIC DIAGRAM PROCESSING / LEGEND
MB141 SIGNAL FUNCTION 4 LOGIC DIAGRAM PROCESSING / LEGEND
MB142 SIGNAL FUNCTION 4 LOGIC DIAGRAM PROCESSING / LEGEND

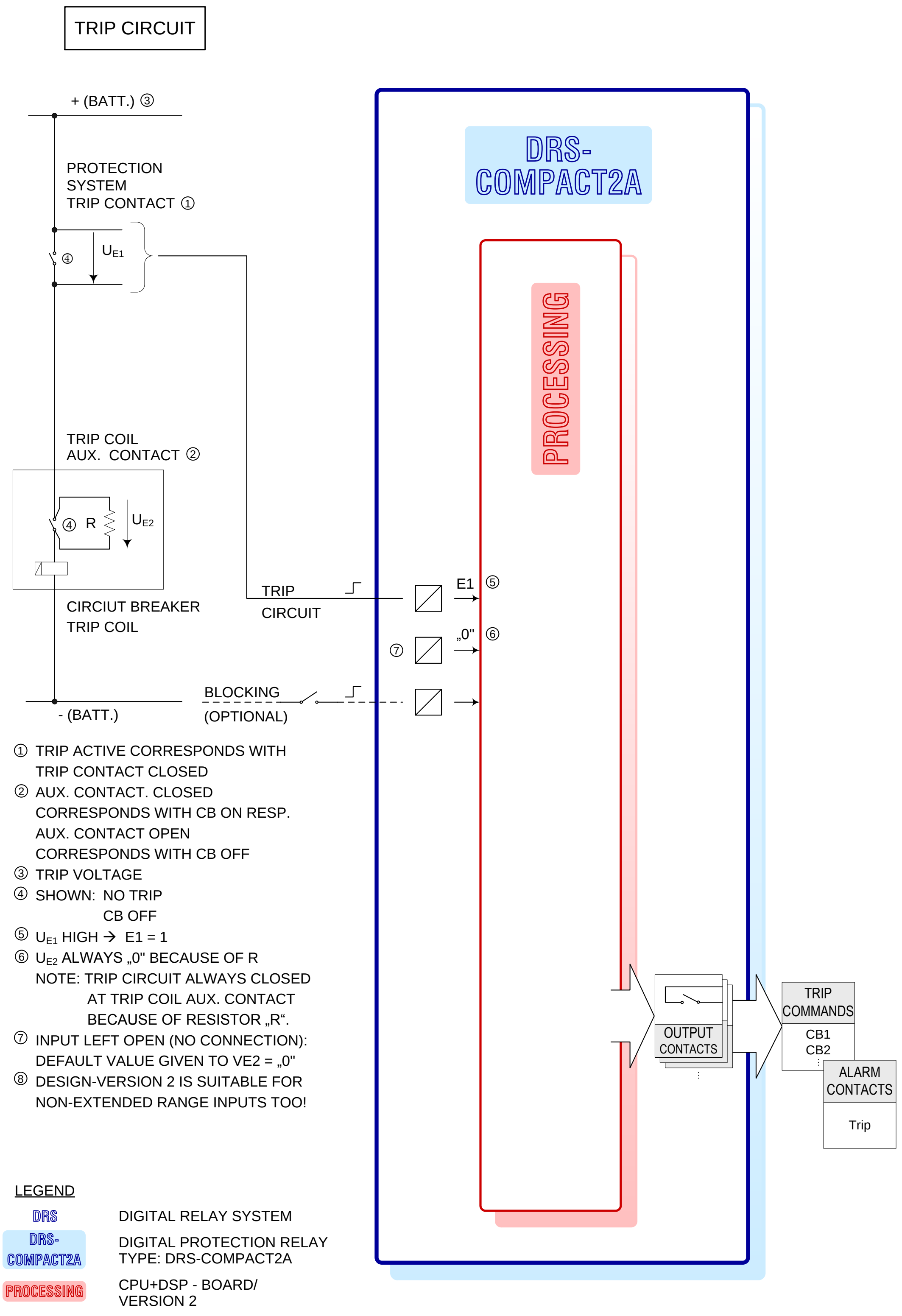
Fig. 7 MB111 MB141 MB142 Signal Function Logic Diagram Processing / Legend

2.4.2. MB211



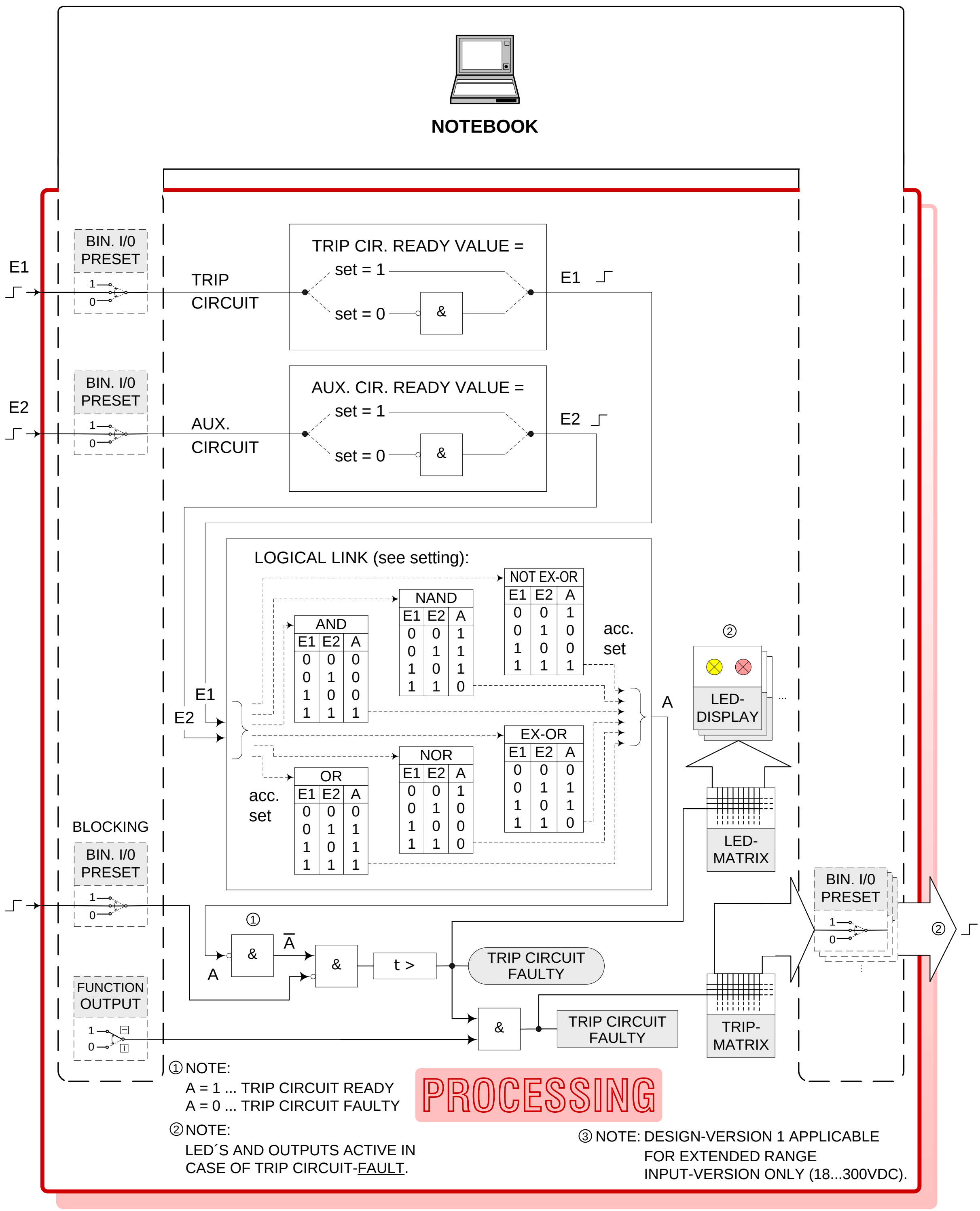
MB211 TRIP CIRCUIT SUPERVISION LOGIC DIAGRAM
DESIGN-VERSION: 1

Fig. 8 MB211 Trip Circuit Supervision Logic Diagram Desisgn Version: 1



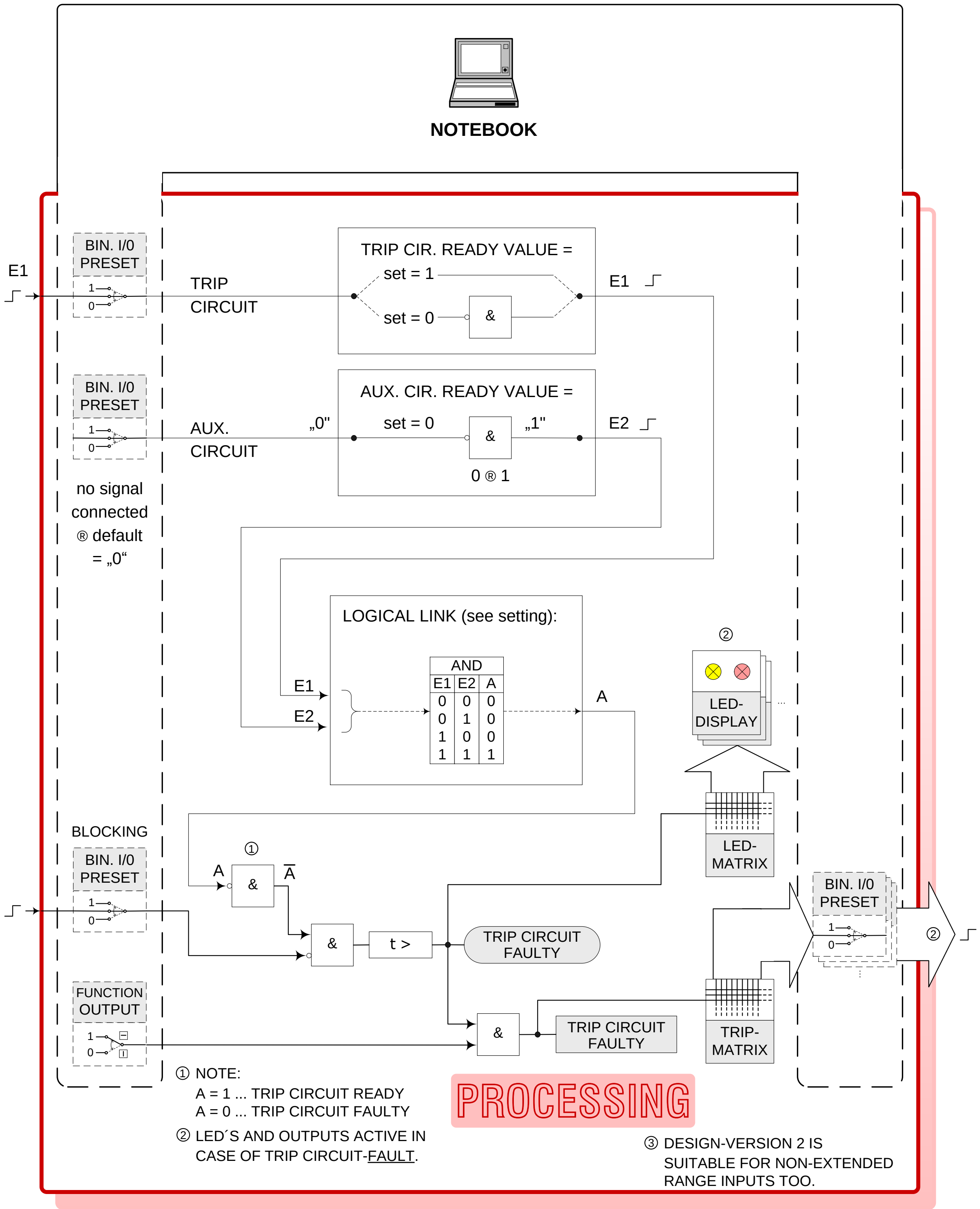
MB211 TRIP CIRCUIT SUPERVISION LOGIC DIAGRAM
DESIGN-VERSION: 2

Fig. 9 MB211 Trip Circuit Supervision Logic Diagram Design Version: 2



MB211 TRIP CIRCUIT SUPERVISION LOGIC DIAGRAM/ PROCESSING
DESIGN-VERSION: 1

Fig. 10 MB211 Trip Circuit Supervision Logic Diagram / Processing Design Version: 1

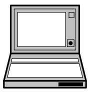


TRIP CIRCUIT SUPERVISION LOGIC DIAGRAM/ PROCESSING
DESIGN-VERSION: 2

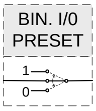
Fig. 11 MB211 Trip Circuit Supervision Logic Diagram / Processing Design Version: 2

LEGEND PROCESSING

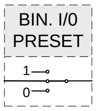
FIRMWARE-MODULE: MB211



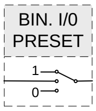
Online simulation via notebook



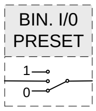
Online-simulation of DIG. IN-/OUTPUTS via notebook:



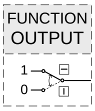
regular function



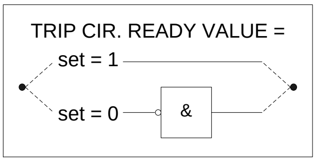
always „1"



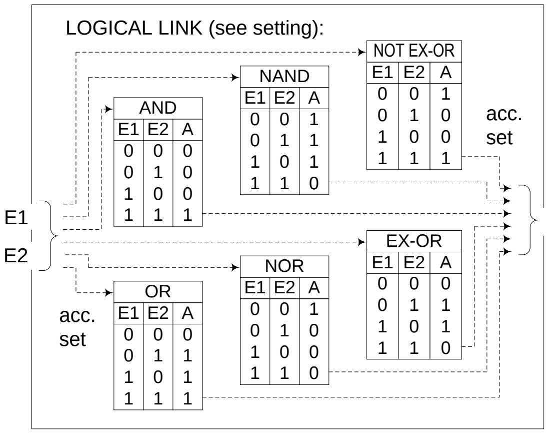
always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MB211
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



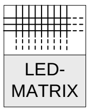
Please choose which INPUT VALUE corresponds with a healthy TRIP CIRCUIT (see: SETTINGS).



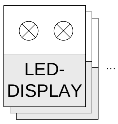
Please choose the LOGICAL LINK of the INPUT SIGNALS E1 and E2 in order to get the correct OUTPUT SIGNAL A (see: SETTINGS).

LOGICAL LINK:
Specifies the condition of E1, E2 in order to get a TRIP CIRCUIT READY decision (A = 1).

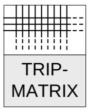
Note: applies for EXTENDED RANGE INPUTS only!



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

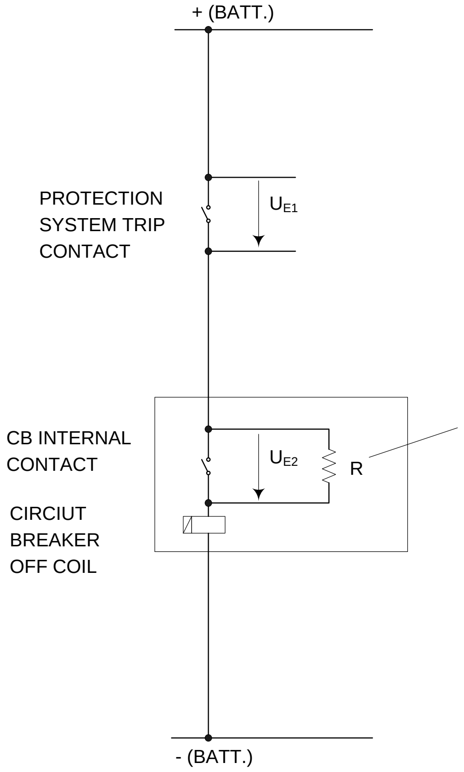
Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

MB211 TRIP CIRCUIT SUPERVISION LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 12 MB211 Trip Circuit Supervision Logic Diagram Processing / Legend

EXAMPLE: TRIP CIRCUIT SUPERVISION DESIGN VERSION 2
EXAMPLE WITHOUT AUX. CIRCUIT



SIMPLIFIED DESIGN:

USE AUX. RESISTOR INSTEAD OF AUX. CIRCUIT IN ORDER TO CLOSE THE TRIP CIRCUIT SUPERVISION-SCHEME.

<u>NOTE:</u> DESIGN OF RESISTOR:

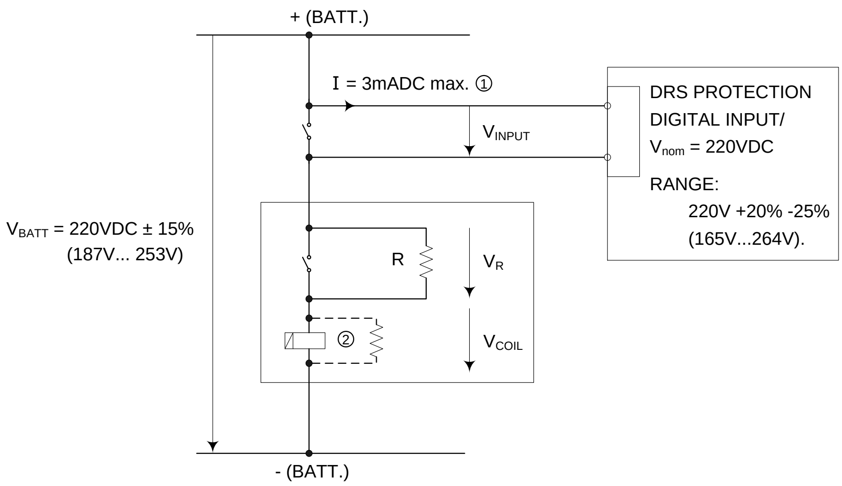
a) MUST NOT AFFECT THE OFF-COIL → (R ↗)
b) SHOULD PROVIDE ENOUGH CURRENT TO THE SUPERVISION CIRCUIT (R ↘)
→ CURRENT SHOULD BE APPROX. 3 mA DC (MIN.).
c) DRS-Digital Input Voltage Range: 70% ± 5% … 120%.
d) BATTERIE VOLTAGE RANGE: V_{nom} ± 15% (ALLOWED).

DESIGN EXAMPLE: SEE PAGE 2/2 !

MB211 TRIP CIRCUIT SUPERVISION DESIGN EXAMPLE / NOT USING AUX. CIRCUIT
DESIGN VERSION: 2 page 1/2

Fig. 13 MB211 Trip Cicuit Supervision Design Example / Not Using Aux. Ciruit Design Version : 2

DESIGN EXAMPLE:



EXAMPLE (given for $V_{BATT\ nom}$ = 220VDC):

PRECONDITION: INPUT VOLTAGE JUMPER IS SET TO: 220VDC

$V_{BATT} = V_{INPUT} + V_R + V_{COIL}$ = 187V (= min. allowed battery volt.)

$V_{INPUT\ min}$ = (220V - 25%) = 165 VDC → (min. allowed input volt.)
($V_R + V_{COIL}$) max = 187V - 165V = 22V
I = 3mADC = const. (controlled by DRS Digital Input/ control range = V_{nom} +20% -25% at input terminals)
($V_R + V_{COIL}$) / 3mA = $R_R + R_{COIL}$

to be calculated (R_R) — given (R_{COIL})

Assume: V_{COIL} = 0 → R_R = 22V / 3mA → R_R = 7333W
Max. heat dissipation of R_R in case the TRIP-contact is closed:
$V_{BATT} = V_{BATT\ max}$ = 264V. → $P_R = V^2 / R = 264^2$ / 7333W = 9,5W.

① Input current is controlled by DRS Digital Input.
Input voltage range: V_{nom} (of dig. input) +20% -25%.

② In case the relay does not drop off because of the 3mADC-test-current a loading resistor should be added in parallel to the coil in order to lessen the voltage drop at the coil.

MB211 TRIP CIRCUIT SUPERVISION DESIGN EXAMPLE/ NOT USING AUX. CIRCUIT
DESIGN VERSION: 2 page 2/2

Fig. 14 MB211 Trip Circuit Supervision Design Example / Not Using Aux Circuit Design Version: 2

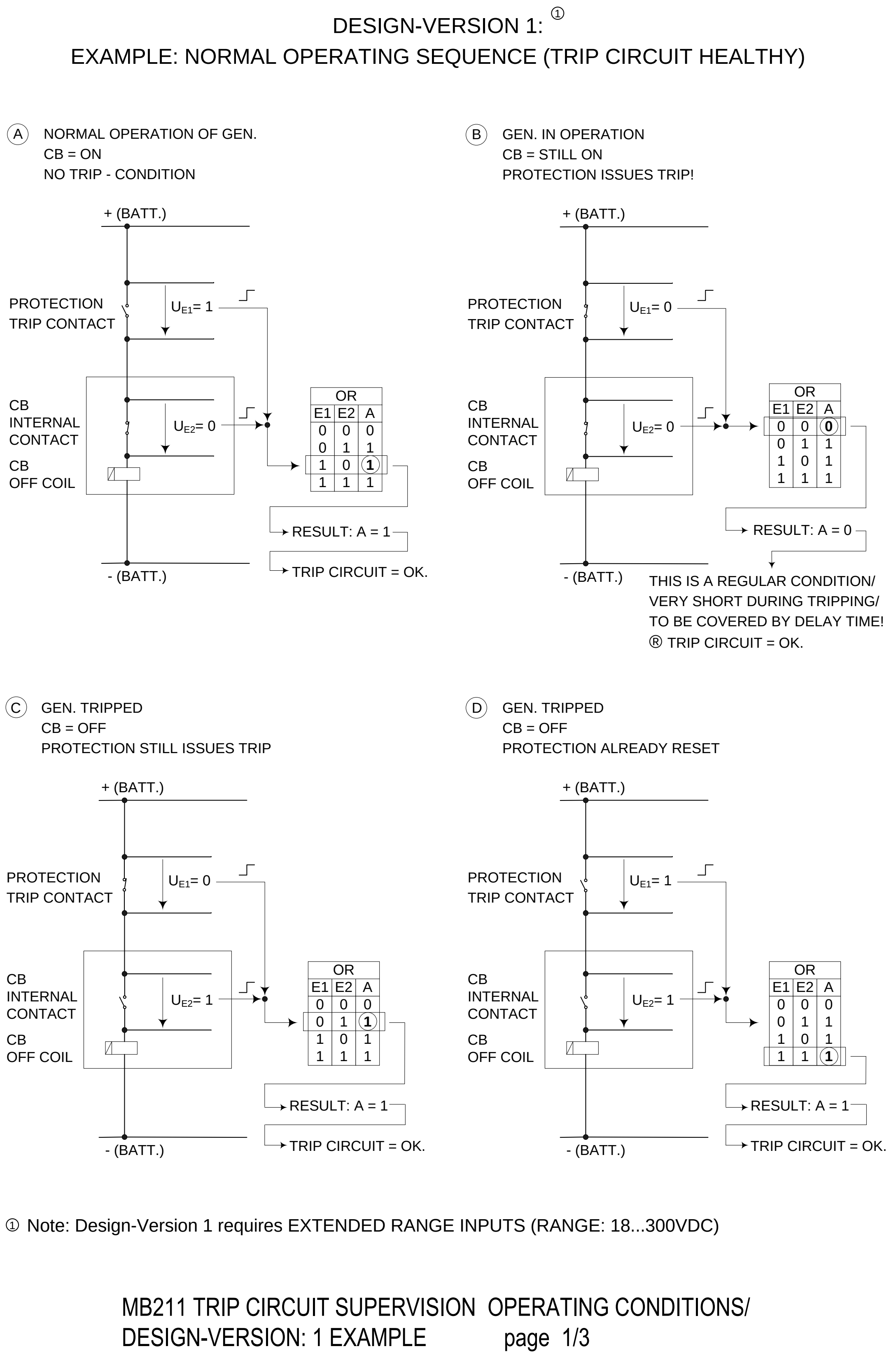
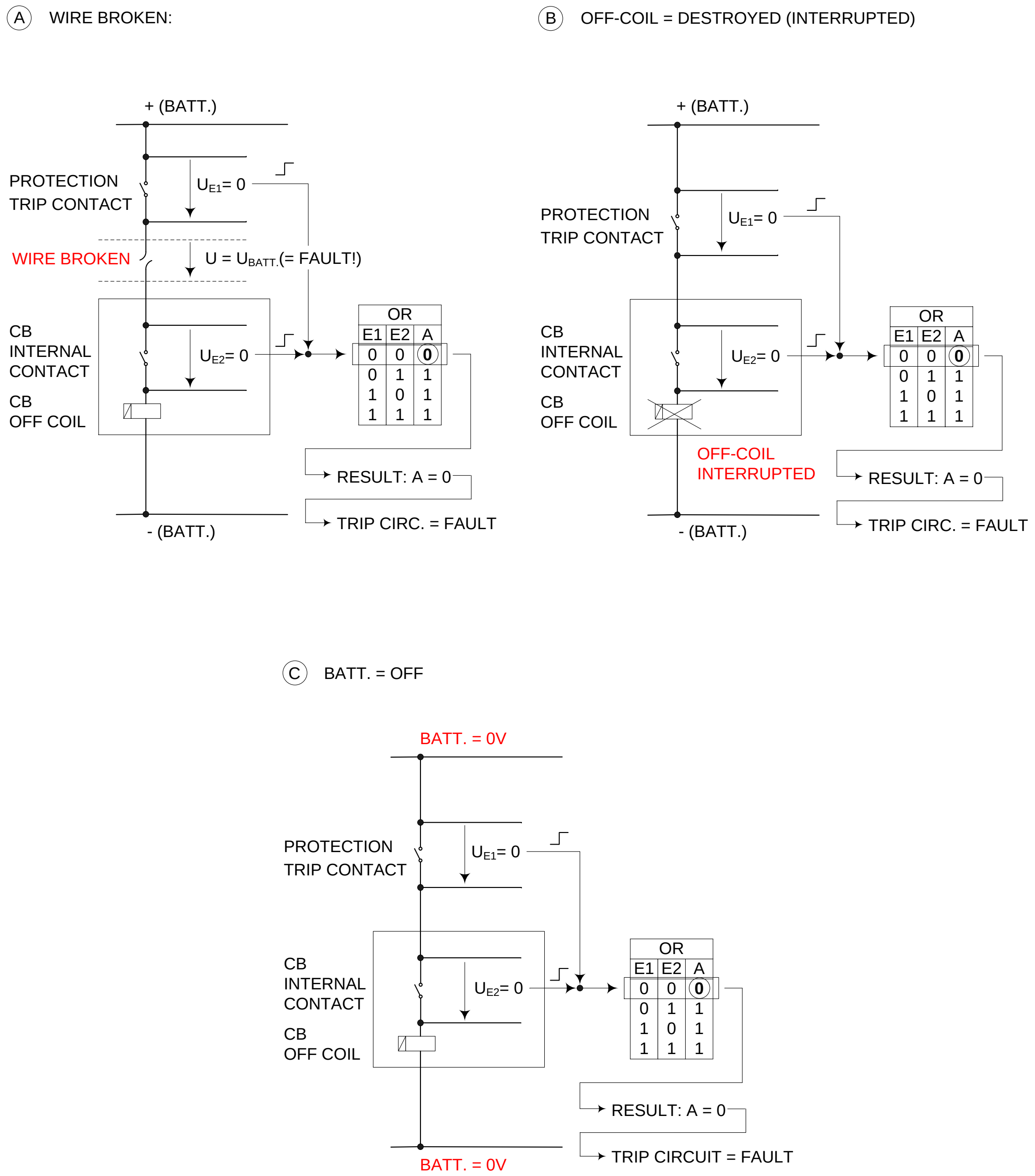


Fig. 15 MB211 Trip Circuit Supervision Operating Conditions Design Version: 1 Example

DESIGN-VERSION 1: ①
EXAMPLE: TRIP CIRCUIT FAULTY



① Note: Design-Version 1 requires EXTENDED RANGE INPUTS (RANGE: 18...300VDC)

MB211 TRIP CIRCUIT SUPERVISION OPERATING CONDITIONS/
DESIGN-VERSION: 1 EXAMPLE page 2/3

Fig. 16 MB211 Trip Circuit Supervision Operating Conditions Design Version: 1 Example

DESIGN-VERSION 1:
EXAMPLE: HOW TO CHOOSE THE INPUT VOLTAGE FOR DESIGN VERSION 1
INPUTS (see Fig. 2-2)

THE DRS-COMPACT2A HAS 4 NOM. INPUT VOLTAGE RANGES WICH CAN BE CHOOSEN BY JUMPERS FOR EVERY INPUT SEPARATLY

FOR DESIGN VERSION 1 THE JUMPERS FOR THE TWO REFERING INPUTS SHOULD BE SET TO:

VAR. 1A:

BATT. VOLTAGE	SET JUMPER TO:	
220 VDC	110 VDC	(77V...300 VDC)
110 VDC	60 VDC	(42V...300 VDC)
60 VDC	24 VDC	(17V...300 VDC)
48 VDC	24 VDC	(17V...300 VDC)

VAR. 1B:

BATT. VOLTAGE	SET JUMPER TO:
220 VDC	220 VDC
110 VDC	110 VDC
60 VDC	60 VDC
48 VDC	48 VDC
24 VDC	24 VDC

MB211 TRIP CIRCUIT SUPERVISION DESIGN-VERSION: 1A, 1B /
DIG INPUT-VOLT. JUMPERS page 3/3

Fig. 17 MB211 Trip Circuit Supervision Design-Version: 1A, 1B / Dig Input-Volt. Jumpers Design Version: 1A, 1B

2.4.3. MB442

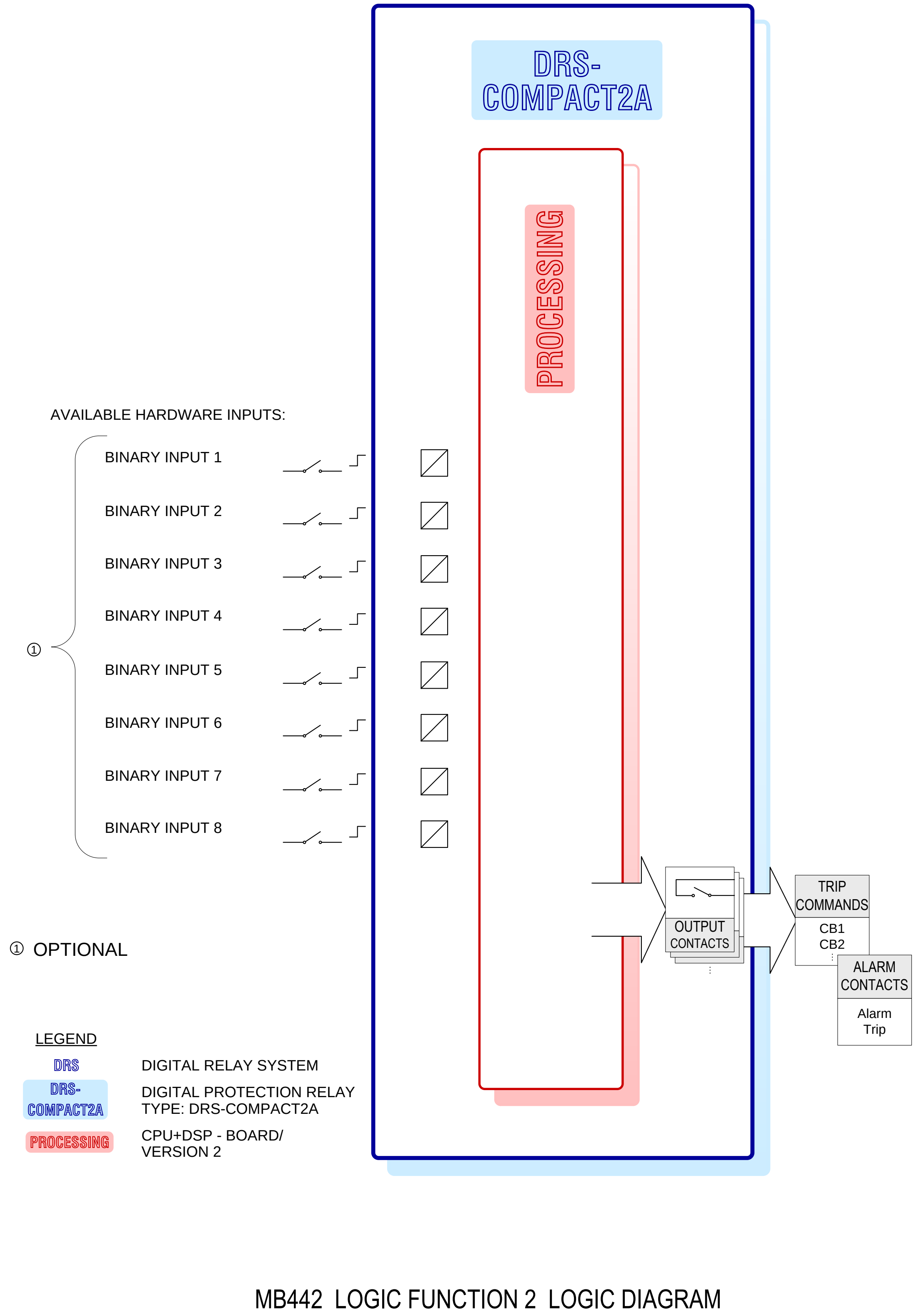
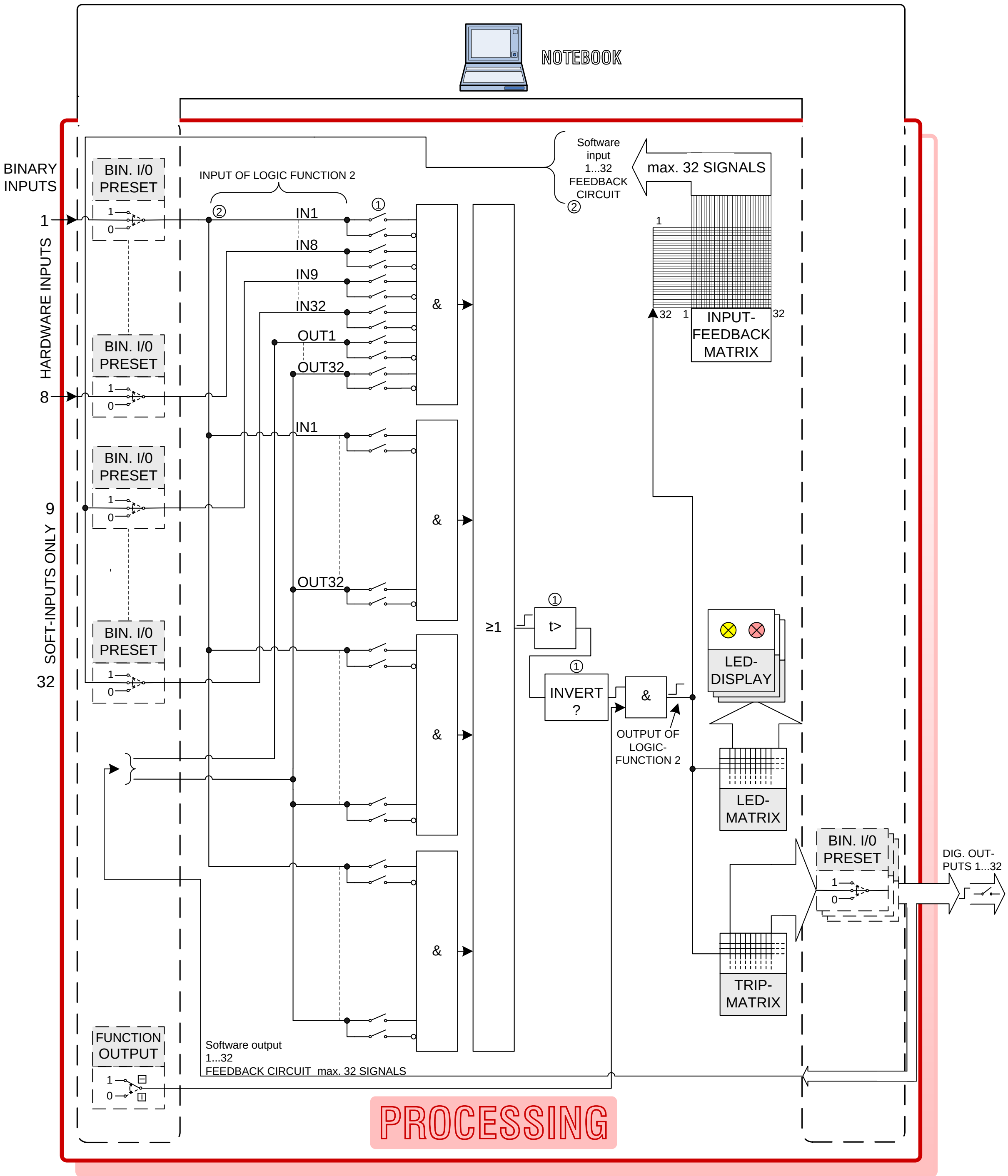


Fig. 18 MB442 Logic Function 2 Logic Diagram



① SETTING VIA SOFTWARE / SEE DRS WIN „LOGIC FUNCTION 2" RELAY PARAMETERS
NOTE: DELAYTIME APPLICABLE FOR („0" → „1") ⎍ ONLY.

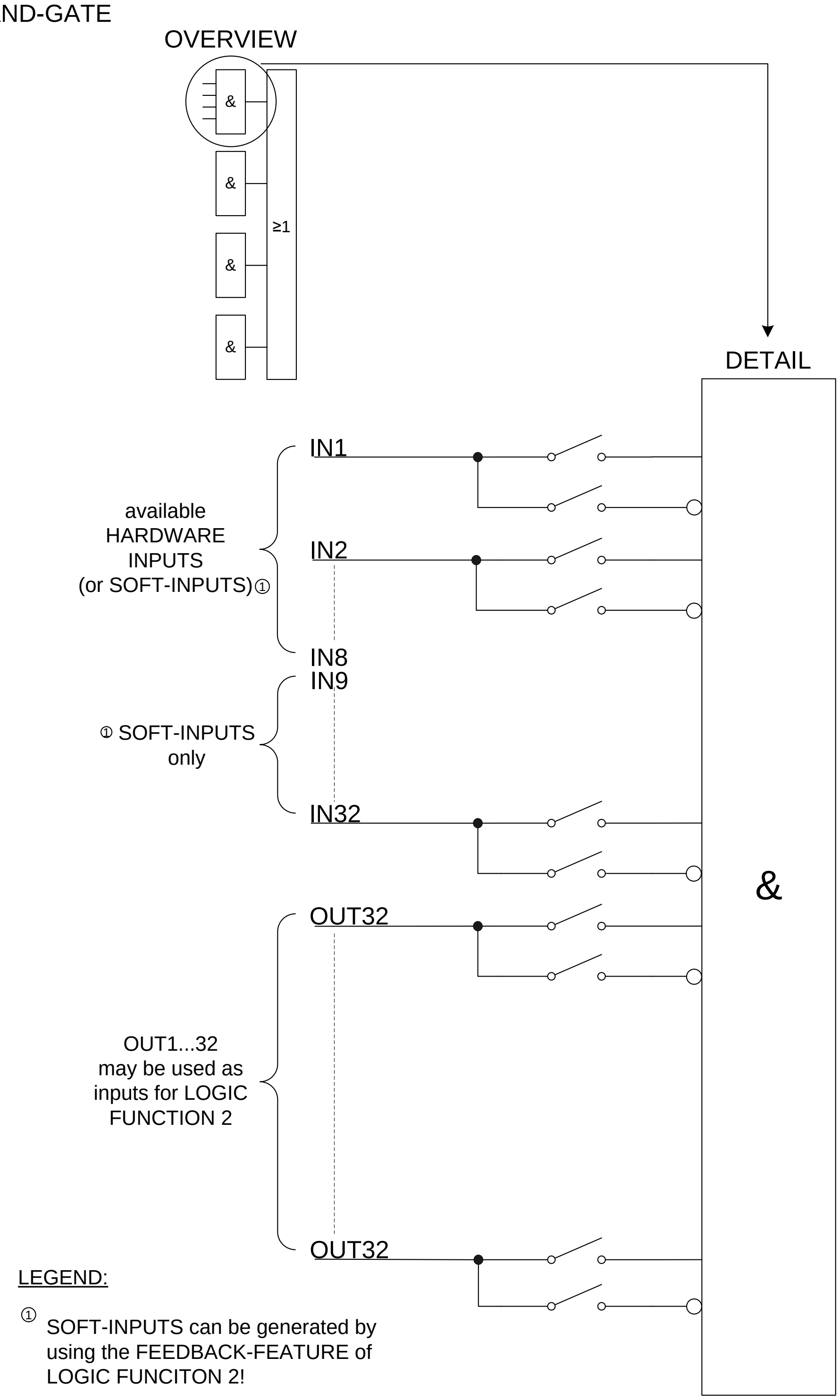
② INPUTS: HARDWARE INPUTS OR SOFTWARE INPUTS (VIA FEADBACK CIRCUIT)
NOTE: FEEDBACK CIRCUITS IF USED OVERWRITES THE HARDWARE - INPUTS! VALID FOR „0" AND „1"
PRIORITY FOR STATUS OF INPUTS: 1. SIMULATION VIA NOTEBOOK (BINARY I/O PRESET)
2. FEEDBACK CIRCUIT
3. HARDWARE INPUT
RECOMMENDED: IN ORDER TO FIND OUT THE VALID STATUS OF AN INPUT → CHECK „BINARY I/O - TABLE" (USING NOTBOOCK);
CAUTION: THE INDICATION MAY BE TOO SLOW IN CASE OF A FAST FLIP - FLOP - ACTION!

MB442 LOGIC FUNCTION 2 LOGIC DIAGRAM PROCESSING

Fig. 19 MB442 Logic Function 2 Logic Diagram Processing

DETAIL:

AND-GATE



MB442 LOGIC FUNCTION 2 LOGIC DIAGRAM / PROCESSING DETAIL

Fig. 20 MB442 Logic Function 2 Logic Diagram / Processing Detail

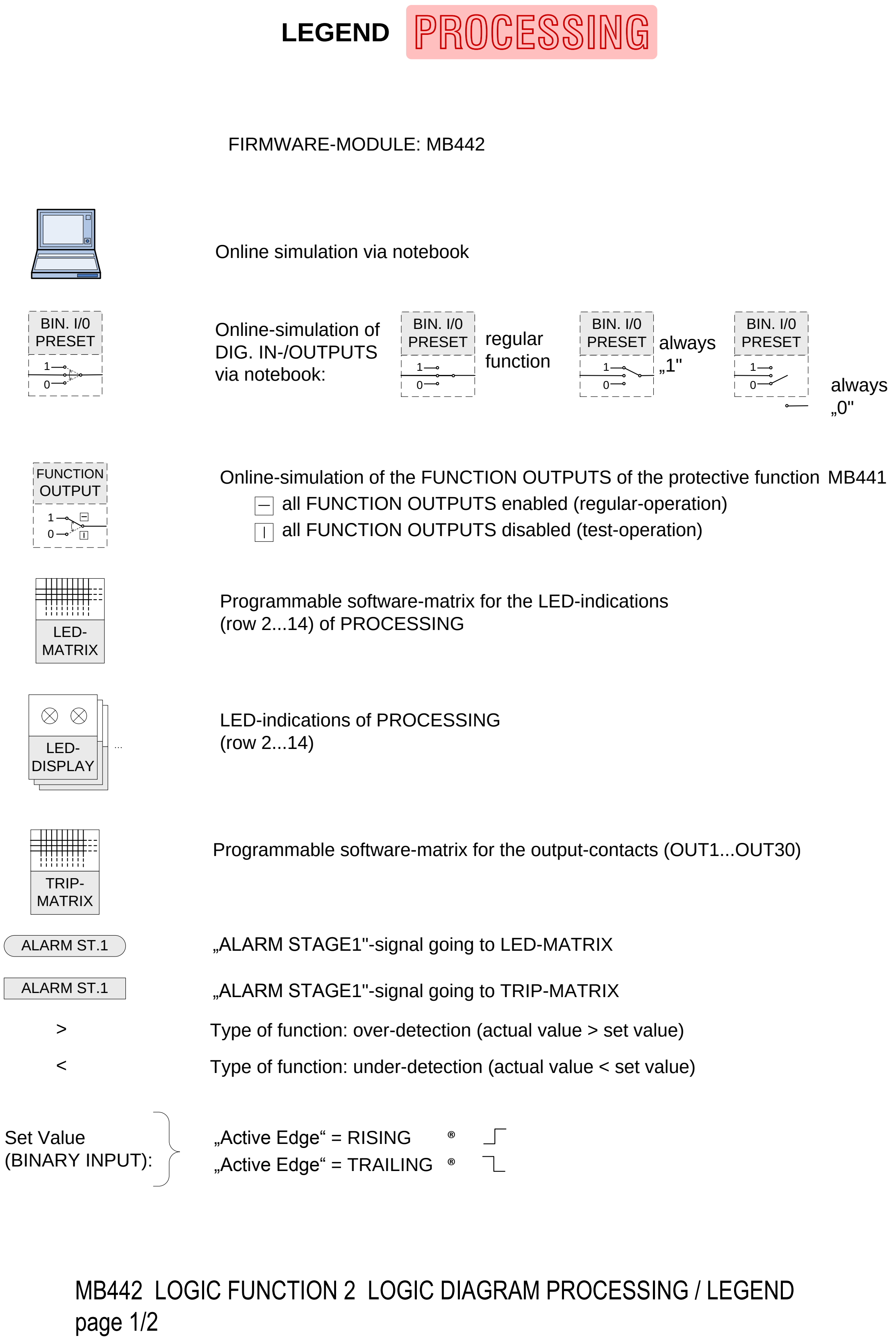
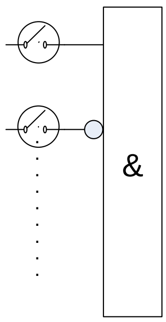


Fig. 21 MB442 Logic Function 2 Logic Diagram Processing / Legend

LEGEND PROCESSING



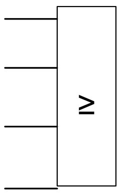
„AND“ - GATE:
„AND“ - Connection of all activated digital signals:

(IN)

resp. (inv IN)

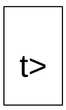
resp (OUT) (feedback circuit)

resp. (inv OUT) (feedback circuit)

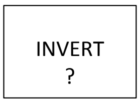


„OR“ - GATE:

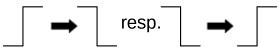
„OR“ - CONNECTION of the output signals of the 4 „AND“ gates



Time delay for „0" → „1" (_┌) only!



If „SET VALUE = INVERT“ is chosen:

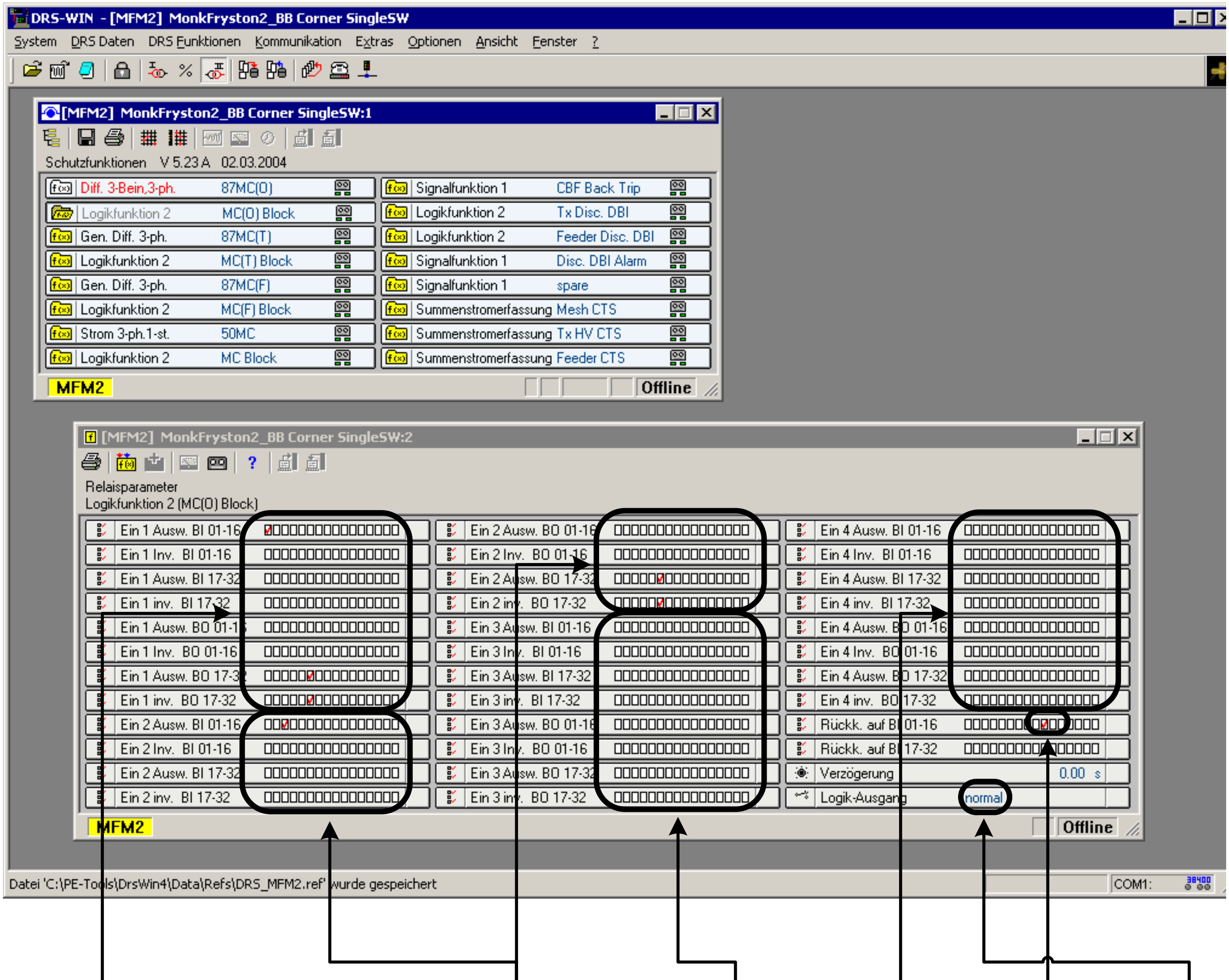


FEEDBACK CIRCUITS for IN and OUT

Please note: actual status of signals can be checked by using the notebook „Binary I/O preset“ feature

MB442 LOGIC FUNCTION 2 LOGIC DIAGRAM PROCESSING / LEGEND
page 2/2

Fig. 22 MB442 Logic Function 2 Logic Diagram Processing / Legend

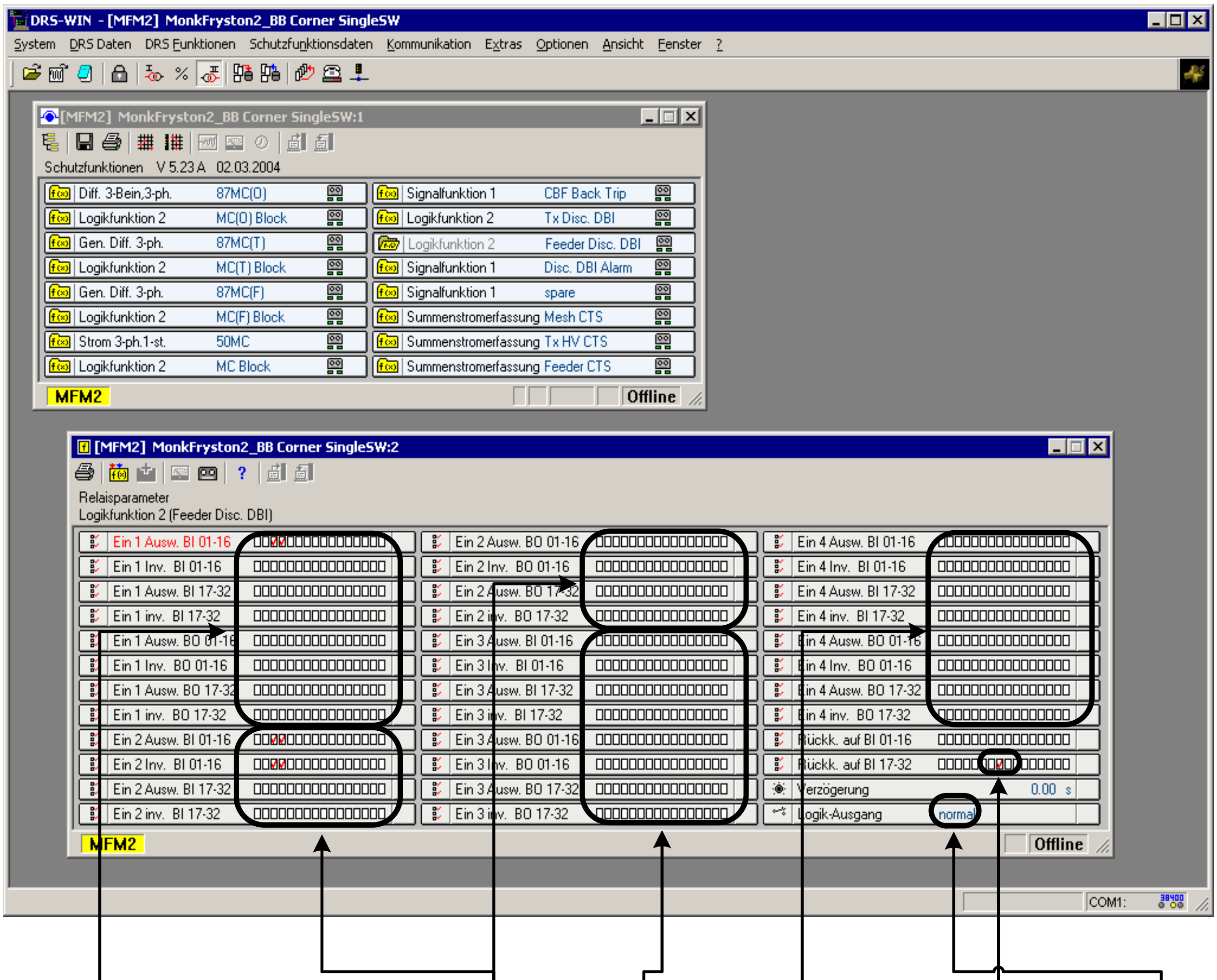


LOGIC: FUNCTION OUPUT =
(IN1 & invOUT22).OR.(IN2 & invOUT22).OR.(not used).OR.(not used)

Note 1: The FUNCTION OUTPUT-signal is feed back to IN10. The FUNCTION OUTPUT is not inverted („normal

MB442 LOGIC FUNCTION 2 EXAMPLE 1

Fig. 23 MB442 Logic Function 2 Example 1



<u>LOGIC:</u> FUNCTION OUPUT =
(IN3 & IN4).OR.(invIN3 & invIN4).OR.(not used).OR.(not used)

Note 1: The FUNCTION OUTPUT-signal is feed back to IN24. The FUNCTION OUTPUT is not inverted („normal“)

Note 2: These Settings are used for supervision of the aux. contacts of a CB (DBI...Don’t Believe It)
IN3 = CB open - contact
IN4 = CB closed - contact
In case of both contacts are „1“ or boths contacts are „0“ → DBI...don’t believe the contacts!

MB442 LOGIC FUNCTION 2 EXAMPLE 2

Fig. 24 NB442 Logic Function 2 Example 2

2.5. FUNCTION

2.5.1. MB111/ MB141/ MB142

Signal functions are provided to evaluate binary signals from the protected plant for alarm and/or trip conditions in the DRS, as for example the initiation of an internal transformer fault, e.g. Buchholz, oil- or winding over temperature, pressure relieve valve, cooler failure, etc.

The binary input signal is supervised according to the selected active signal slope (positive slope = transition from logic 0 to logic 1, inverted slope = transition from logic 1 to logic 0) during each sample and after a contact bounce delay of 4 samples the output initiation is started. When the initiating condition is maintained during the whole set time delay a corresponding trip signal will be produced.

Signal function 1 and signal function 4 differ only in the number of input signals to be processed. Signal function 4 is especially used when several signals from a specific plant part are to be evaluated, e.g. transformer mechanical protection which may be combined into a protective group.

2.5.2. MB211

The digital trip circuit supervision function MB211 has a similar operating characteristic as the analogue hardware solution.

The function is provided with two digital inputs:
- Trip circuit healthy
- Auxiliary circuit healthy

The digital “Trip Circuit Healthy” corresponding parameter settings are configured whether during normal system conditions the state of the trip circuit is sent to the digital input of the PROCESSING as either “0” or “1”. The same applies for the auxiliary circuit healthy conditions.

In our example we assume that:
Both Healthy settings are logic “1“.
A logic “AND“ configuration therefore means that both digital inputs (trip circuit healthy + auxiliary circuit healthy) have to be “1“ to affirm that the trip circuit is recognised to be in order.
If not, an alarm annunciation “Trip Circuit Failure“ is being initiated.

In a normal state, i.e. trip circuit healthy, no output will be set from the DRS protection system and no LED indication is shown. This corresponds to our User Operating Philosophy that no yellow or red LED indication is present when everything is in order.
The time delay is provided in order to not initiate a false alarm during CB operation but to produce an alarm output for a real trip circuit fault.

<u>Examples</u> for the setting value "logical connection" under the presupposition that the Healthy configuration is set to "1":

„EX-OR“:
One of the two inputs has to be "1" and the other one must be "0" for a trip circuit OK.

„OR“:
One or both inputs have to be "1" for a trip circuit OK.

„NOR“:
Both inputs must be "0" for a trip circuit OK.

„AND“:
Both inputs must be "1" for a trip circuit OK.

„NAND“:
At least one of the two inputs have to be "0" for a trip circuit OK.

<u>Important Note:</u>
The only possibility to use the whole range of the possible logical configuration is as follows:

Battery: 220 VDC
Inputs: 110 VDC (set jumper to 110VDC).
Note: The 110VDC rated inputs can also be used permanently with 220 VDC.

2.5.3. MB442

Logic Scheme:
This logic function consists of 4 AND Gates which are conveyed to a common OR Gate. In the Setting Value Window of the DRSWIN these 4 AND Gates are clearly visible and there are 4 large blocks of input parameters, i.e. 1 to 4 for these 4 AND Gates. For following OR Connection after the AND Gate no setting values are required and simply the output signals of the 4 AND Gates are assigned to the respective outputs.

This way, each of the 4 function inputs of the OR Gate represents thereby an AND Connection of all these inputs or outputs assigned by the Selection Mask as per setting value window. Please note that the polarity for each selected input or output (AND Gates) can be inverted. Therefore when an inverted input or output is to be used also the Inverting Mask has to be marked and as an important NOTE: For an inverted input 2 confirmation selection marks are required, i.e. in the Selection Mask as well as in the Inverting Mask.
It is not sufficient just to mark the Inverting Mask!

The inputs of the logic functions by themselves are either "Real" inputs, e.g. IN03 or "Real" outputs, e.g. OUT01, or "simulated" (via notebook) inputs or outputs, or "feed-back" signals (output is routed back to an input via set value of the protective function – see Fig. 19), which then can be suitably connected into the logic function.
To further describe the logic functions outputs:
The output of a logic function 2 can be configured and routed to a virtual input as well as to a real input or inputs or to a virtual output as well as real output or outputs. This way it is possible to transfer the state of the logic function 2 to an input of the DRS COMPACT2 software programme. This is necessary because, for example, the blocking inputs for protective functions only accept binary inputs (BI).

Time Module:
The result of the OR logic is time delayed according to the setting value and this delay is only active during a transition from 0 →1 on the input of the time delay module (please also refer to the corresponding logic diagram) and afterwards when thus set either directly or inverted activating the function output. Please note that this time delay is **not** operative in case of a change from 1 →0 at the input of the time module and the input to the time delay module has always to be observed according to the logic diagram. Should the time delay module be activated during an inverted slope condition then the desired result may be implemented by an additional, double inversion, i.e. before and after the delay module.
Example: By a suitable selection of the parameter setting value “Inversion” by the input signals as well as by the output signals of the logic function 2 it is possible to obtain configurable operating and/or reset time delays

Output:
The output of the logic function which is a single digital signal without initiation annunciation but a trip can be allocated to the respective LED- and trip matrix and can be assigned to the general distribution to the LED- and trip matrices. In addition these signals can be assigned to the back-coupling mask and returned to the binary inputs.

2.6. COMMISSIONING

Note: During all Commissioning Activities the Relevant Safety Precautions Have to Be Strictly Observed!

2.6.1. MB111/ MB141/ MB142/ MB211/ MB311/ MB442

Connections:

The external connections to the binary input signals are realised via adapted coupling modules according to plant requirements and then transferred to the Central Control Unit VE.
The coupling modules may either be relay modules or opto-isolator modules. The selectable input voltage can have a rating between 24VDC to 220VDC **whereby the 220VDC opto- isolator inputs can be energised continuously with up to 300VDC.**

- Pre-Commissioning:

The DRS WIN User program enables the operation (simulation) of all digital inputs and outputs (please also refer to: “System “/” Binary In- and Output Selection) which can be carried out either ONLINE or OFFLINE and have preference over the real plant signals.
Thus it is possible to test all the complete logic functions OFFLINE.

- Commissioning Tests:

These tests can basically be limited to only verify the correct external input- and output signals for the protection relay since the internal functions were already confirmed during the pre-commissioning tests.

- Input signals of the protective function:
  The initiated external plant inputs are displayed in the Window "System"/ "Binary In/Output Selection".

- Output signals of the protective function:
  By operating (simulating) the outputs in the Window "System"/ "Binary In/Output Selection" to verify the external circuitry, e.g. CB trip circuit, etc.

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3. MC... CIRCUIT BREAKER FAILURE PROTECTION

3.1. OVERVIEW

List of the available MC . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTION: MC 316	FNNR	TYPE	ANSI	Application
CB Failure Protection *Note: Available from PROCESSING Firmware Version 5.24 on*	1115	MC316	40	C2,M

3.2. TECHNICAL DATA

PROTECTIVE FUNCTION: MC316	FNNR	TYPE	ANSI	Application
CB Failure Protection *Note: Available from PROCESSING Firmware Version 5.24 on*	1115	MC316	40	C2,M

2- stage CBF protection with "LOW GAS PRESSURE" logic and time monitoring of the "CB Failure Start" (CBFS) signal.
TRIP output extension is provided as a standard.

MC316
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	CB closed position (from CB auxiliary contacts)
	CBF start (CB failure start)
	LOW GAS PRESSURE (CB not ready)
	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	CB failure stage 1 trip
	CB failure stage 2 trip
	CB failure stage 3 trip

Setting Parameters

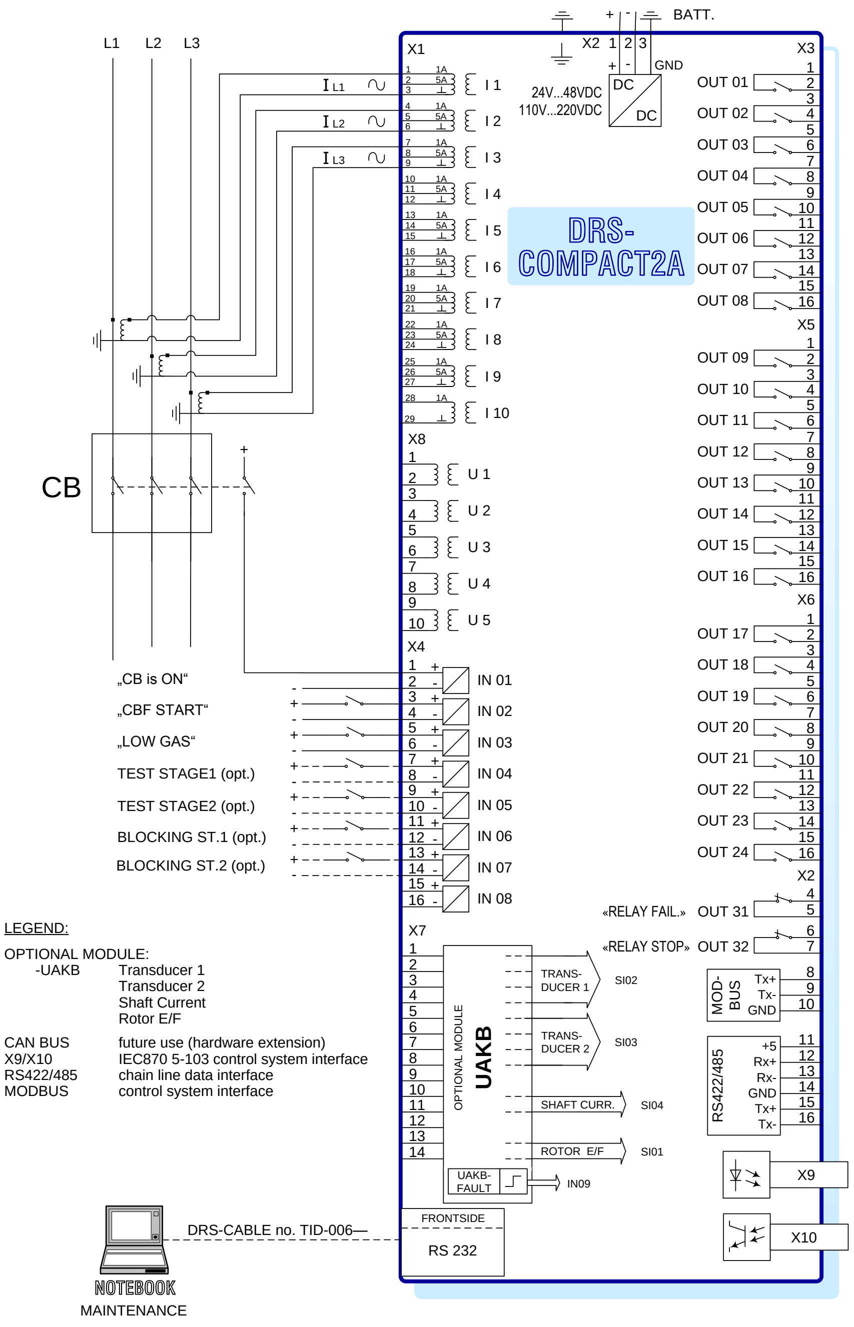
Current interlock CBF	0,1 ... 2 A in 0,05 A steps
CBF feeder TRIP time delay	0,01 ... 0,99 s in 0,01 s steps
CBF bus section TRIP time delay	0,01 ... 0,99 s in 0,01 s steps
Maximum CBF STARTING time	1 ... 180 s in 1 s steps

Measuring

Reset Ratio:	0,97
Operating Time:	≥ 2 Periods
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

3.3. CONNECTION DIAGRAMS

3.3.1. MC316



MC316 CBF (CIRCUIT BREAKER FAILURE) LOGIC DIAGRAM

Fig. 25 MC316 CBF (Circuit Breaker Failure) Logic Diagram

3.4. LOGIC DIAGRAM

3.4.1. MC316

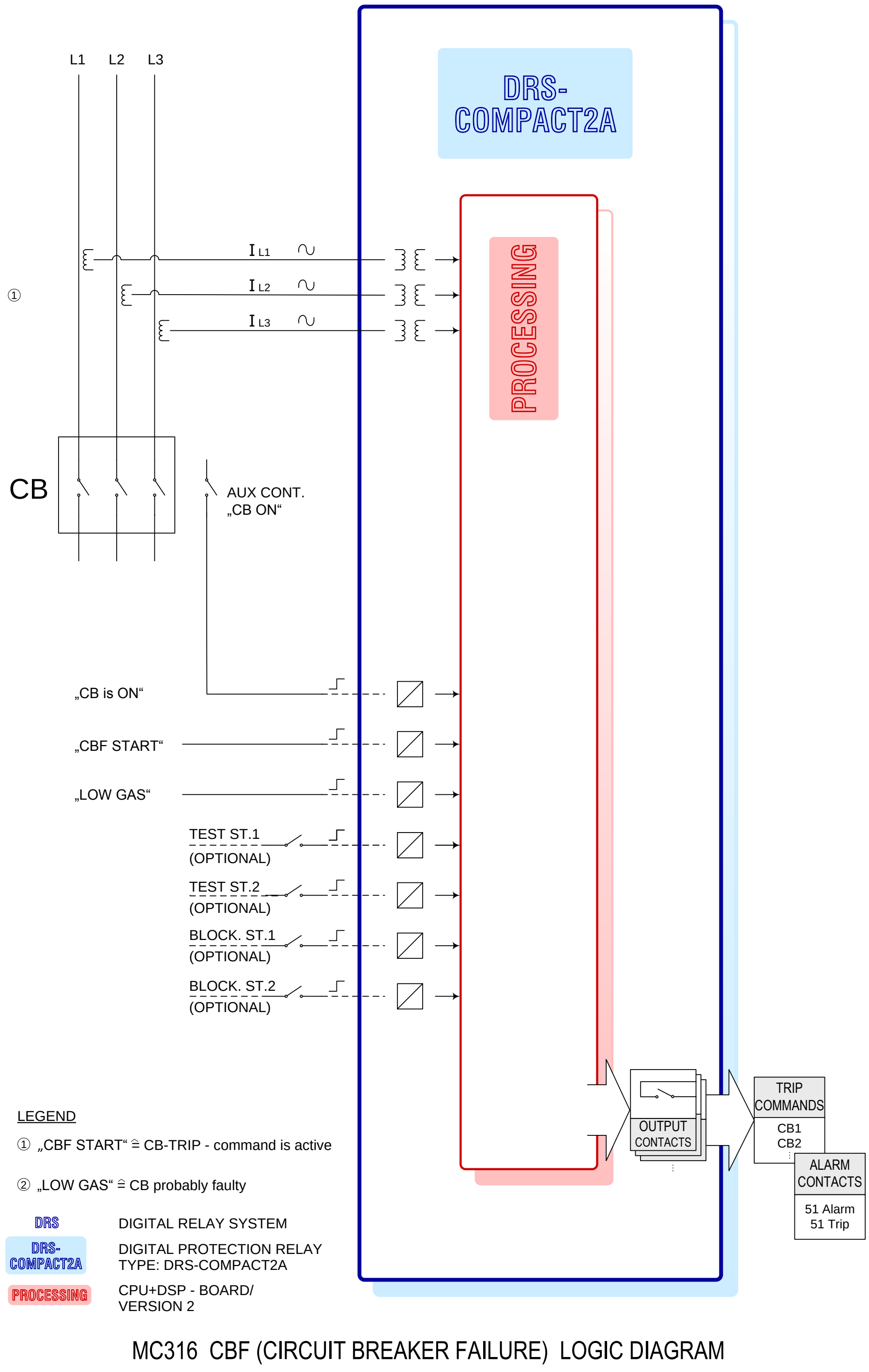
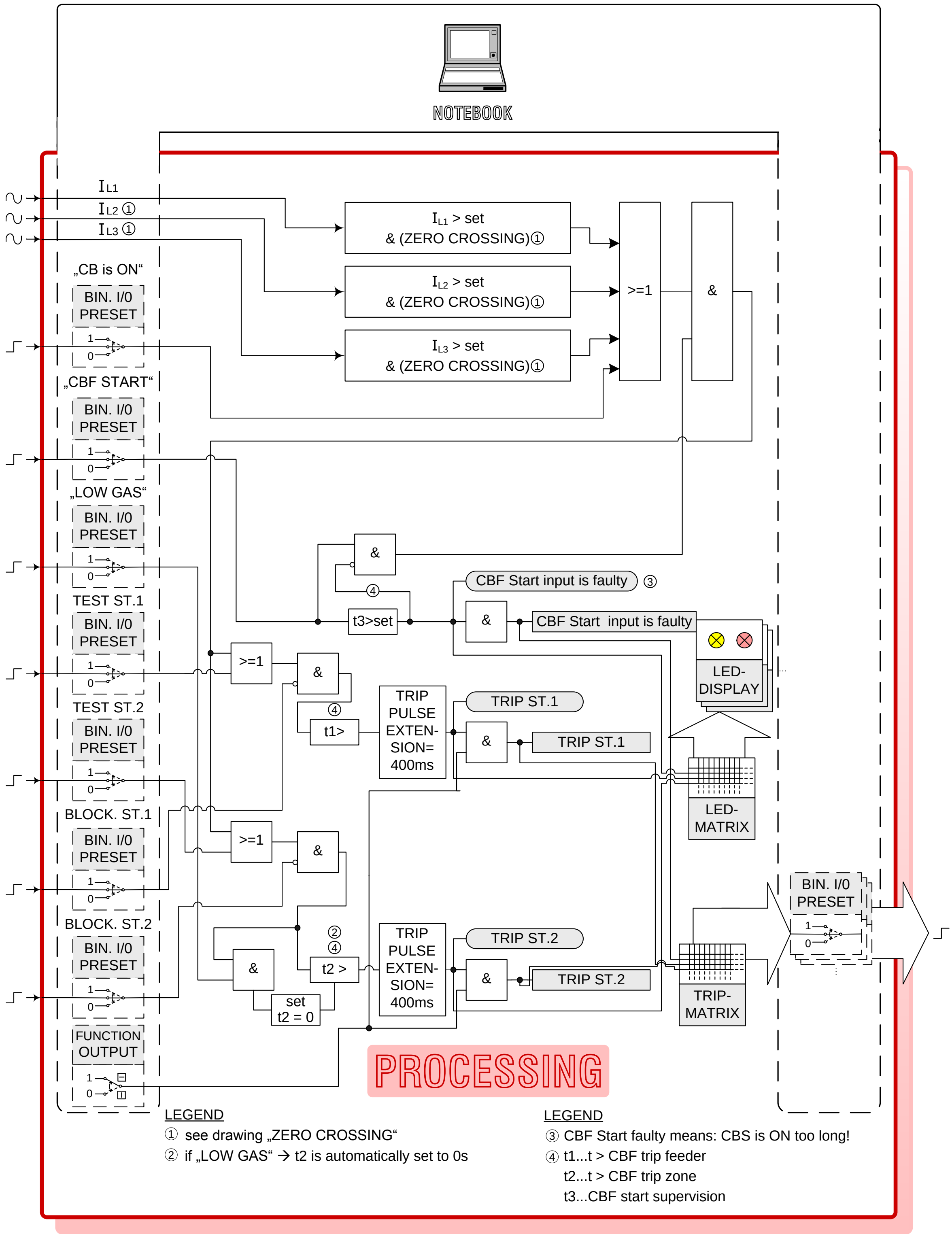


Fig. 26 MC316 CBF (Circuit Breaker Failure) Logic Diagram



MC316 CBF (CIRCUIT BREAKER FAILURE) LOGIC DIAGRAM PROCESSING

Fig. 27 MC316 CBF (Circuit Breaker Failure) Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MC316

Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET 1 0

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET 1 0 regular function; BIN. I/0 PRESET 1 0 always „1"; BIN. I/0 PRESET 1 0 always „0"

FUNCTION OUTPUT 1 0

Online-simulation of the FUNCTION OUTPUTS of the protective function MC316

- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

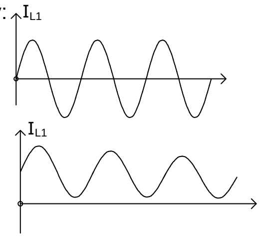
I_{L1} > set & (ZERO CROSSING)

2 conditions must be fulfilled:

a) I_{1L} > set value

b) the actual values of I_{1L} have to cross the ZERO-line periodically:

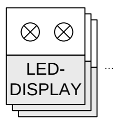
not valid:



CBF Start input is faulty

Usually the „CBF START“ (dig. input) should be ON for short time only (less than t3). If t3 is exceeded → ALARM!
Check input „CBF START“ (≙ TRIP-command)

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Symbol	Meaning
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MC316 CBF (CIRCUIT BREAKER FAILURE)
LOGIC DIAGRAM PROCESSING / LEGEND

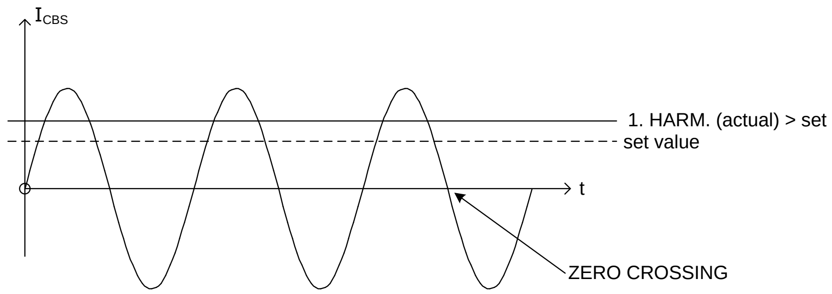
Fig. 28 MC316 CBF (Circuit Breaker Failure) Logic Diagram Processing / Legend

EXPLANANTION OF CONDITION
„ZERO CROSSING“

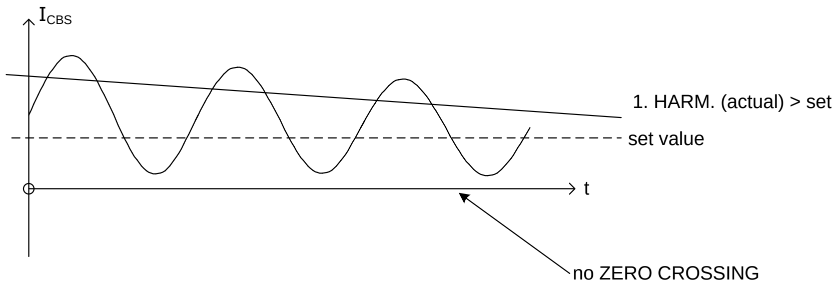
MEANING OF:

I_{L1} > set
& (ZERO CROSSING)

Condition fullfilled („ZERO CROSSING“)



Condition not fullfilled (no „ZERO CROSSING“)



MC316 CBF (CIRCUIT BREAKER FAIL) „ZERO CROSSING“

Fig. 29 MC316 CBF (Ciruit Breaker Fail) ,,Zero Crossing“

3.5. FUNCTION

3.5.1. MC316

Digital Inputs:
CB closed position (condition: CB is closed)
CBF start (condition: CB failure start = trip command is initiated)
LOW GAS PRESSURE (CB is possibly not ready / can possibly not be tripped)
2x BLK
2x TST

Analogue Inputs:
Current Phase L1
Current Phase L2
Current Phase L3

Digital Outputs:
Stage 1: After expiry of time delay t1.
Stage 2: After expiry of time delay t2.

Note: In case of LOW GAS PRESSURE then the time delay t2 is automatically set to 0 sec. and stage 2 is operating first.

Stage 3: After expiry of time delay t3.

Logic for Stage 1 / Stage2:
CBF start & CB closed position .... time delays t1 and t2 are beginning to start.
Or:
CBF start & one of the three phase currents are exceeding the set value ....
time delays t1 and t2 are beginning to start.

Features:
1.
When set to "LOW GAS PRESSURE" (binary input), then the program will automatically set the delay t2 to 0 sec., i.e. the stage 2 trip is initiated immediately because of a possible CB not ready condition and the higher level trip command is given first.
2.
When the time delay t3 has expired it means that the CBF start signal is initiated for an excessive time which can indicate that either the stage 1 and stage 2 tripping were not successful or that the CBF start signals are faulty or not being previously reset.
3.
After CB trip there may be some current oscillations which however have no zero crossings even though the 1st harmonic is still above the configured setting value and in this case the CB failure protective function will be blocked, i.e. no trip output.
4.
TRIP signal extension:
The tripping commands from stage 1 and stage 2 are being extended by 400 ms (in addition but not overall) in order to prevent fleeting trip signals to the CB trip coil.
Stage 3 is not provided with a trip time extension but only will initiate an alarm annunciation meaning a fault condition of the CBF function for internal or external causes.
5.
"CB is ON" – signal may be used optionally (instead or additionally to the Overcurrent Measuring System); this measure would act as a mechanical CB Failure Detection.

3.6. COMMISSIONING

Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

3.6.1. MC316

-Pre-Commissioning

With a relay test set the test current is injected and the binary inputs set with the aid of a terminal or notebook “Binary In/Output Pre-Selection” are displayed and controlled on-screen.
Note: in order to activate the protective function during test operation additionally the
"CBF Start" – input has to be set (for example by simulation via notebook).
Note: If real trip outputs to the external plant have to be prevented this can be achieved by opening the disconnecting terminals or by temporary re-programming and/or blocking of the function outputs (please refer to the "Function Outputs ..." in the logic diagram).

-Commissioning Tests

During the commissioning tests by use of the “Actual Measured Values" window the correct measurement of the input currents is verified, and the binary inputs are checked by operation of the external auxiliary contacts of the protected plant.

The trip circuits have to be checked via the "Binary In/Outputs Selection" by actual tripping of the corresponding plant equipment when set to "1" of the relevant switchgear parts thereby saving the result of the tests into the event recording feature.

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4. MD... GENERATOR DIFFERENTIAL

4.1. OVERVIEW

List of the Available MD . . . Generator Differential Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MD . . .	**FNNR**	**TYPE**	**ANSI**	**Application**
Generator differential protection 2-phase, with Standard-BIAS characteristic.	1018	MD222	87G	C2,M,L
Generator differential protection 2-phase. Characteristic with reduced inference of restraint current.	1114	MD223	87G	C2,M
Generator differential protection 2-phase, with Standard-BIAS characteristic, with CT Saturation Detection, High Set O/C (ΔI >>) and Quick Trip – feature.	1146	MD228	87G	C2,M
Generator differential protection 2-phase. Characteristic with reduced inference of restraint current. Includes CT Saturation Detection, High Set O/C (ΔI >>) and Quick Trip – feature.	1148	MD229	87G	C2,M
Generator differential protection 3-phase, with Standard-BIAS characteristic.	1014	MD322	87G	C2,M,L
Generator differential protection 3-phase. Characteristic with reduced inference of restraint current.	1113	MD323	87G	C2,M
Generator differential protection 3-phase, with Standard-BIAS characteristic, with CT Saturation Detection, High Set O/C (ΔI >>) and Quick Trip – feature.	1145	MD328	87G	C2,M
Generator differential protection 3-phase. Characteristic with reduced inference of restraint current. Includes CT Saturation Detection, High Set O/C (ΔI >>) and Quick Trip – feature.	1147	MD329	87G	C2,M

Comparison

	Number of Phases	Standard BIAS	Reduced BIAS	CT Saturation Detection	High Set O/C (ΔI >>)
MD222	2	+			
MD223	2		+		
MD228	2	+		+	+
MD229	2		+	+	+
MD322	3	+			
MD323	3		+		
MD328	3	+		+	+
MD329	3		+	+	+

4.2. TECHNICAL DATA

4.2.1. Generator Differential 2-phase 2-winding

<table>
<tr><th>PROTECTIVE FUNCTIONS: MD . . .</th><th>FNNR</th><th>TYPE</th><th>ANSI</th><th>Application</th></tr>
<tr><td>Generator differential protection 2-phase
<u>Formula for Restraint Current:</u>
Restraint Current =
(|FFT 1H of $I_{SYSTEM1\ L1\ resp.\ L3}$|
+ |FFT 1H of $I_{SYSTEM2\ L1\ resp.\ L3}$|) / 1.
<u>BIAS-Characteristic:</u>
Restraint Current = 0 ... 1: Bias = const.
Restraint Current = 1 ... 3: Bias = 30%
Restraint Current > 3: Bias = Set value</td><td>1018</td><td>MD222</td><td>87G</td><td>C2,M,L</td></tr>
</table>

2- phase generator differential protection with through fault stabilising (bias).
Standard BIAS-characteristic.

<table>
<tr><th>PROTECTIVE FUNCTIONS: MD . . .</th><th>FNNR</th><th>TYPE</th><th>ANSI</th><th>Application</th></tr>
<tr><td>Generator differential protection 2-phase
<u>Formula for Restraint Current:</u>
Restraint Current =
(|FFT 1H of $I_{SYSTEM1\ L1\ resp.\ L3}$|
+ |FFT 1H of $I_{SYSTEM2\ L1\ resp.\ L3}$|) / 1.
<u>BIAS-Characteristic:</u>
Restraint Current = 0 ... 2: BIAS = const.
Restraint Current = 2 ... 6: Bias = 30%
Restraint Current > 6: Bias = Set value</td><td>1114</td><td>MD223</td><td>87G</td><td>C2,M,L</td></tr>
</table>

2- phase generator differential protection with through fault stabilising (bias).
Characteristic with reduced inference of restraint current.

<table>
<tr><th>PROTECTIVE FUNCTIONS: MD . . .</th><th>FNNR</th><th>TYPE</th><th>ANSI</th><th>Application</th></tr>
<tr><td>Generator differential protection 2-phase
<u>Formula for Restraint Current:</u>
Restraint Current =
(|FFT 1H of $I_{SYSTEM1\ L1\ resp.\ L3}$|
+ |FFT 1H of $I_{SYSTEM2\ L1\ resp.\ L3}$|) / 1.
<u>BIAS-Characteristic:</u>
Restraint Current = 0 ... 1: Bias = const.
Restraint Current = 1 ... 3: Bias = 30%
Restraint Current > 3: Bias = Set value</td><td>1146</td><td>MD228</td><td>87G</td><td>C2,M</td></tr>
</table>

2- phase generator differential protection with through fault stabilising (bias).
Standard BIAS-characteristic.
With CT Saturation Detection. High Set O/C Quick-Release (DiffStrom >>) and Quick Trip-feature.

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Generator differential protection 2-phase Formula for Restraint Current: Restraint Current = (|FFT 1H of ISYSTEM1 L1 resp. L3| + |FFT 1H of ISYSTEM2 L1 resp. L3|) / 1. BIAS-Characteristic: Restraint Current = 0 ... 2: Bias = const. Restraint Current = 2 ... 6: Bias = 30% Restraint Current > 6: Bias = Set value	1148	MD229	87G	C2,M

2- phase generator differential protection with through fault stabilising (bias).
Characteristic with reduced inference of restraint current.
With CT Saturation Detection. High Set O/C Quick-Release (DiffStrom >>) and Quick Trip-feature.

MD222/ MD223/ MD228/ MD229
Technical Data:

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L3
	Current system 2 phase L1
	Current system 2 phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip
	Available for MD228/ MD229 only: CT Saturation

Setting Parameters

Operating value:	0,05 ... 2.5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
High Set O/C:	Available for MD228/ MD229 only: 2 … 15 x In in 0,5A steps
Saturation Detection (CT):	Available for MD228/ MD229 only: 0 … 240 periods. Explanation: BIAS-characteristic change to 65% will be activ for selected number of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	in A
Differential current phase L3:	in A
Bias current phase L1:	in A
Bias current phase L3:	in A

Measuring

Reset ratio:	Set value Differential Current: 0,875 Set value High Set O/C: 0,75
Operating time:	<30ms at 50 Hz (including output relays) <90ms at 16.66 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

4.2.2. Generator Differential 3-phase 2-winding

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Generator differential protection 3-phase Formula for Restraint Current: Restraint Current = (|FFT 1H of ISYSTEM1 L1 resp. L2 resp. L3| + |(FFT 1H of ISYSTEM2 L1 resp. L2 resp. L3| + |(FFT 1H of ISYSTEM3 L1 resp. L2 resp. L3|) / 1. BIAS-Characteristic: Restraint Current = 0 ... 1: Bias = const. Restraint Current = 1 ... 3: Bias = 30% Restraint Current > 3: Bias = Set value	1014	MD322	87G	C2,M,L

3- phase generator differential protection with through fault stabilising (bias).
Standard BIAS-characteristic.

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Generator differential protection 3-phase Formula for Restraint Current: Restraint Current = (|FFT 1H of ISYSTEM1 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM2 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM3 L1 resp. L2 resp. L3|) / 1. BIAS-Characteristic: Restraint Current = 0 ... 2: Bias = const. Restraint Current = 2 ... 6: Bias = 30% Restraint Current > 6: Bias = Set value	1113	MD323	87G	C2,M,L

3- phase generator differential protection with through fault stabilising (bias).
Characteristic with reduced inference of restraint current.

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Generator differential protection 3-phase Formula for Restraint Current: Restraint Current = (|FFT 1H of ISYSTEM1 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM2 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM3 L1 resp. L2 resp. L3|) / 1. BIAS-Characteristic: Restraint Current = 0 ... 1: Bias = const. Restraint Current = 1 ... 3: Bias = 30% Restraint Current > 3: Bias = Set value	1145	MD328	87G	C2,M

3- phase generator differential protection with through fault stabilising (bias).
Standard BIAS-characteristic.
With CT Saturation Detection. High Set O/C Quick-Release (DiffStrom >>) and Quick Trip-feature.

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Generator differential protection 3-phase Formula for Restraint Current: Restraint Current = (|FFT 1H of ISYSTEM1 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM2 L1 resp. L2 resp. L3| + |FFT 1H of ISYSTEM3 L1 resp. L2 resp. L3|) / 1. BIAS-Characteristic: Restraint Current = 0 ... 2: BIAS = const. Restraint Current = 2 ... 6: Bias = 30% Restraint Current > 6: Bias = Set value	1147	MD329	87G	C2,M

3- phase generator differential protection with through fault stabilising (bias).
Characteristic with reduced inference of restraint current.
With CT Saturation Detection. High Set O/C Quick-Release (DiffStrom >>) and Quick Trip-feature.

MD322/ MD323/ MD328/ MD329
Technical Data

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 1 phase L3
	Current system 2 phase L1
	Current system 2 phase L2
	Current system 2 phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip
	Available for MD328/ MD329 only: CT Saturation

Setting Parameters

Operating value:	0,05 ... 2.5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
High Set O/C:	Available for MD328/ MD329 only: 2 … 15 x In in 0,5A steps
Saturation Detection (CT):	Available for MD328/ MD329 only: 0 … 240 periods. Explanation: BIAS-characteristic change to 65% will be activ for selected number of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	in A
Differential current phase L2:	in A
Differential current phase L3:	in A
Bias current phase L1:	in A
Bias current phase L2:	in A
Bias current phase L3:	in A

Measuring

Reset ratio:	Set value Differential Current: 0,875 Set value High Set O/C: 0,75
Operating time:	≥ 30 ms at 50 Hz (including output relays) ≥ 26 ms at 60 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

4.3. CONNECTION DIAGRAMS

4.3.1. MD222

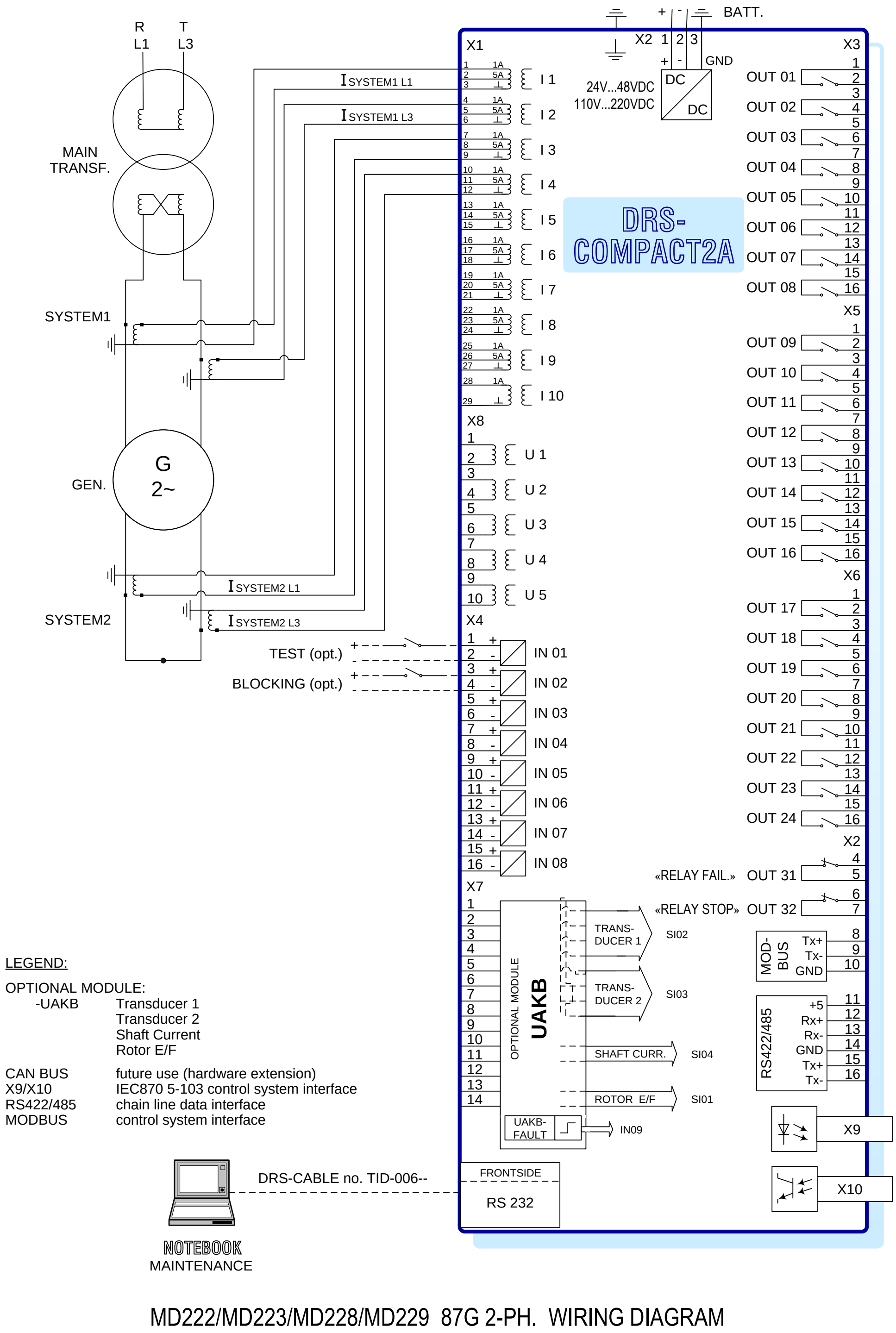


Fig. 30 MD222/MD223/MD228/MD229 87G 2-PH. Wiring Diagram

4.3.2. MD322/ MD323

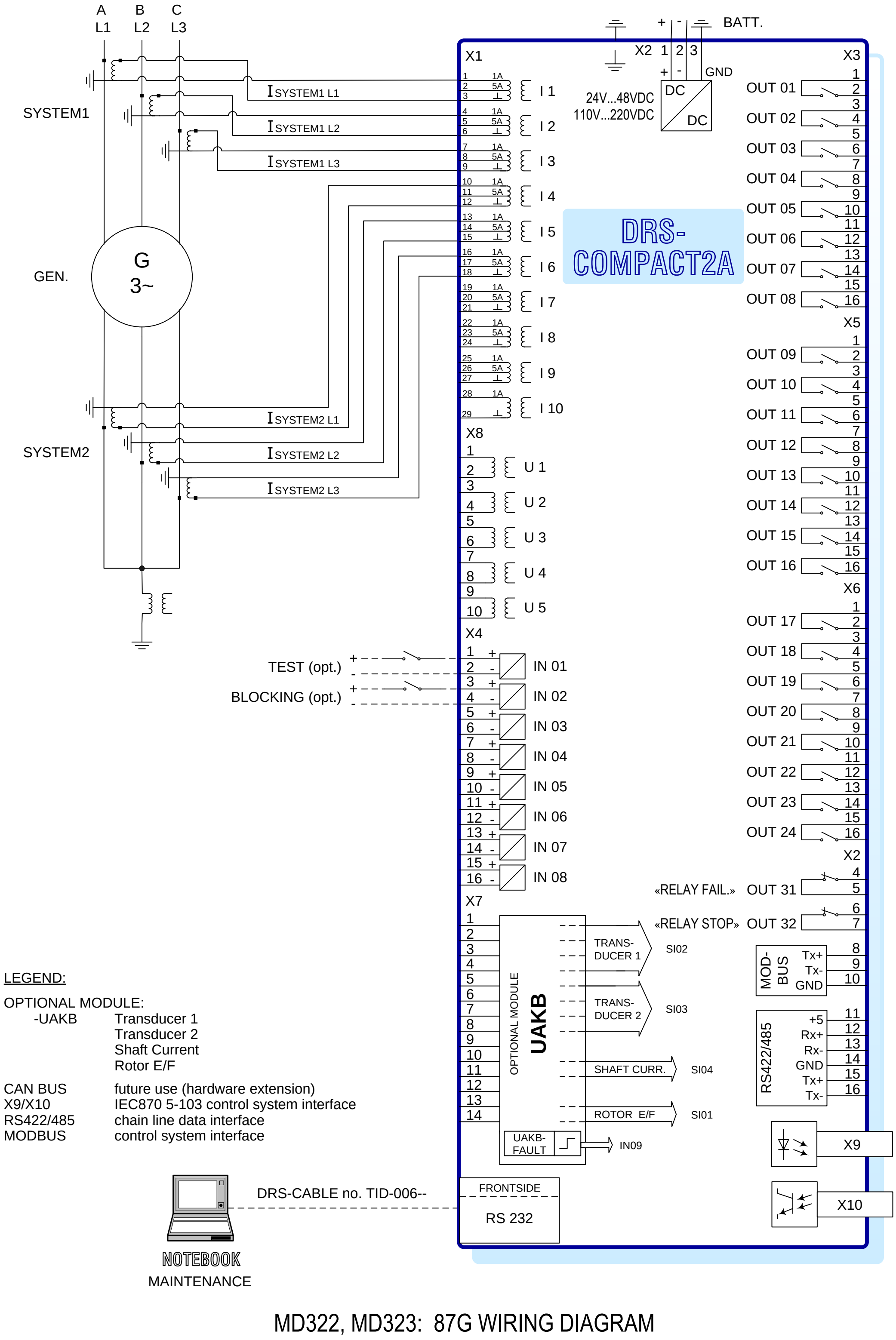


Fig. 31 MD322, MD323: 87G Wiring Diagram

4.4. LOGIC DIAGRAMS

4.4.1. MD222

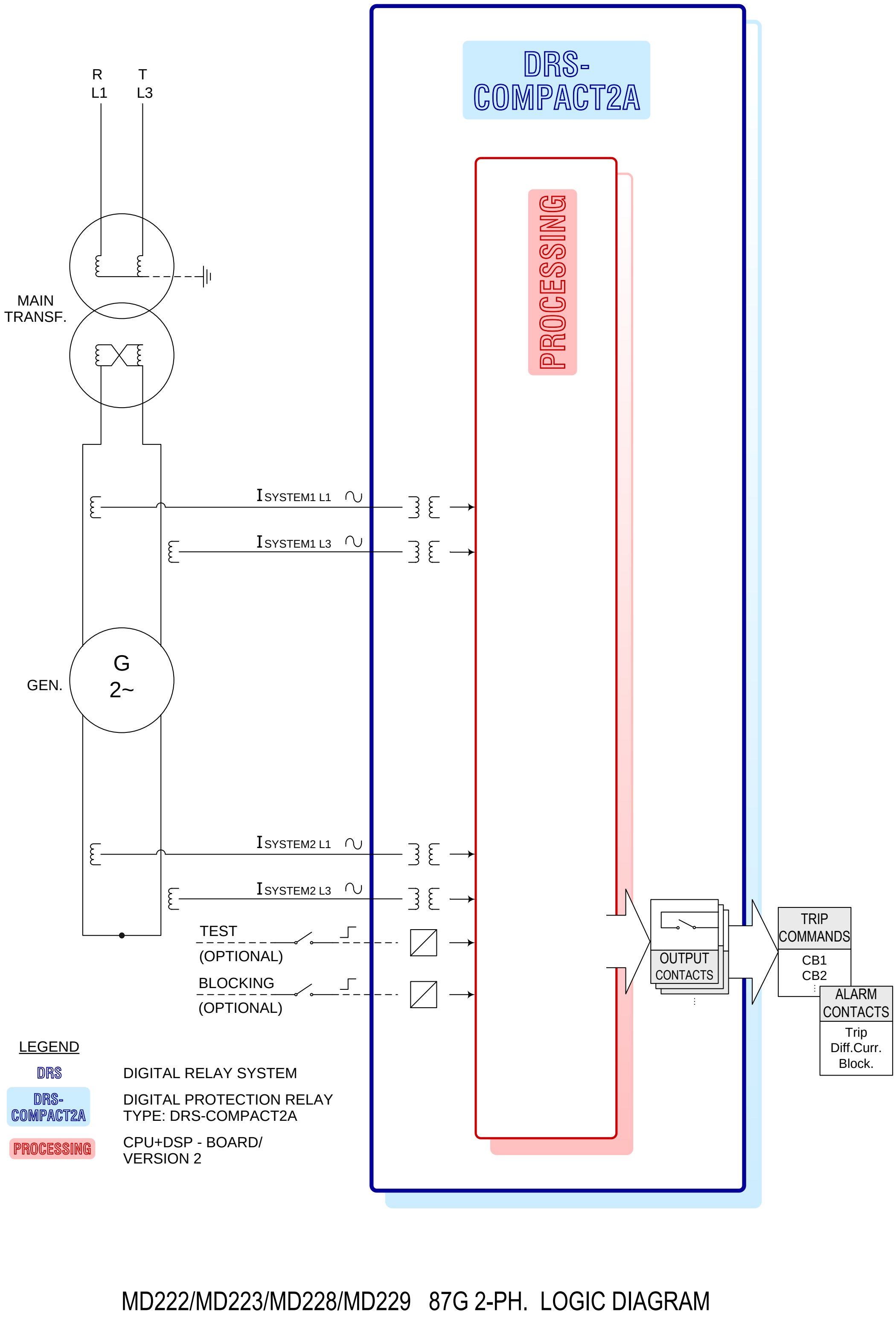
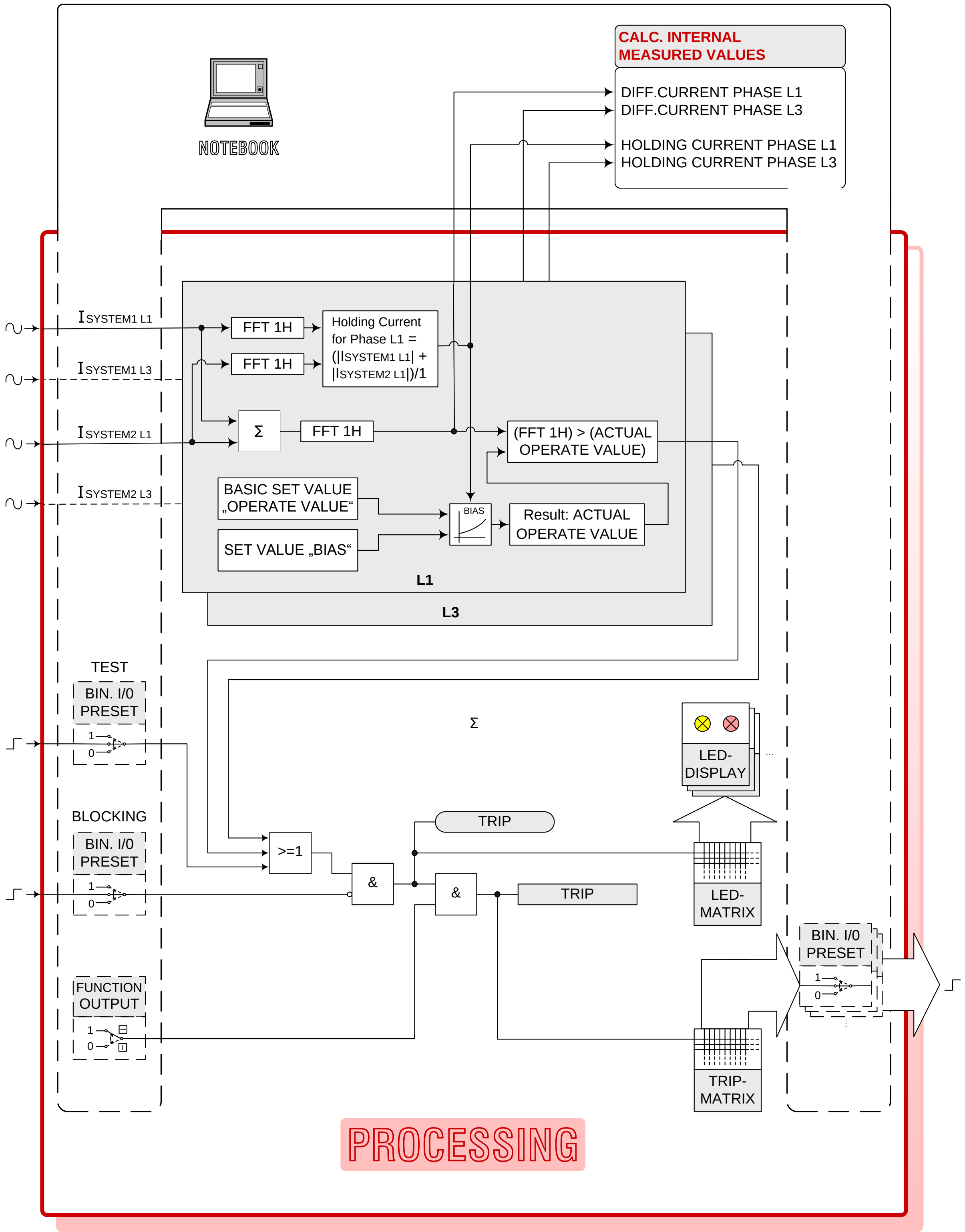


Fig. 32 MD222/MD223/MD228/MD229 87G 2-PH. Logic Diagram



MD222/MD223/MD228/MD229 87G 2-PH. LOGIC DIAGRAM PROCESSING

Fig. 33 MD222/MD223/MD228/MD229 87G 2-PH. Logic Diagram Processing

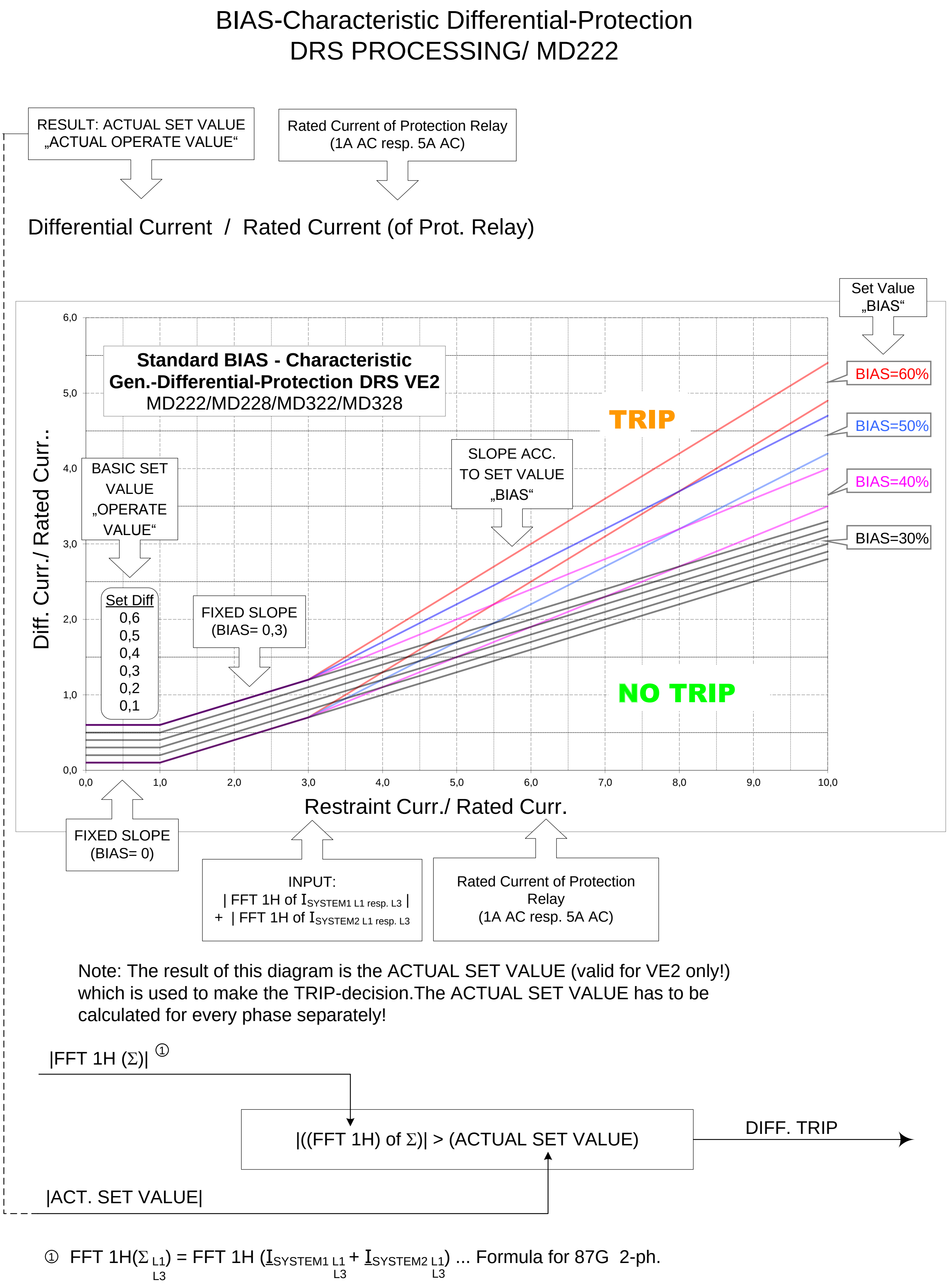
LEGEND PROCESSING

FIRMWARE MODULE: MD222

Symbol	Description
CALC. INTERNAL MEASURED VALUES	Online simulation via notebook — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET	Online-simulation of DIG. IN-/OUTPUTS via notebook: regular function; always „1"; always „0"
FUNCTION OUTPUT	Online-simulation of the FUNCTION OUTPUTS of the protective function MD222 ⊟ all FUNCTION OUTPUTS enabled (regular-operation) ◫ all FUNCTION OUTPUTS disabled (test-operation)
Σ	Calculation of differential current by adding up the (proper signed) currents
FFT 1H	Fast Fourier Transformation: 1. Harmonic
BIAS	Calculation of „ACTUAL OPERATE VALUE“ by using the BIAS CHARACTERISTIC DIAGRAM. Input: Set Values „Operate Value“, „Bias“ Restraint current: $I_{RESTRAINT} = \lvert I_{SYSTEM1}\rvert + \lvert I_{SYSTEM2}\rvert$ Output: „ACTUAL OPERATE VALUE“
(FFT 1H) > (ACTUAL OPERATE VALUE)	The 1. Harmonic of the actual measured differential current is compared with the „actual operate value“ derived from the BIAS-diagram.
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
LED-DISPLAY	LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
TRIP	FUNCTION OUTPUT: Trip (no blocking active)

MD222MD223/MD228/MD229 87G 2-PH. LOGIC DIAGRAM
PROCESSING / LEGEND

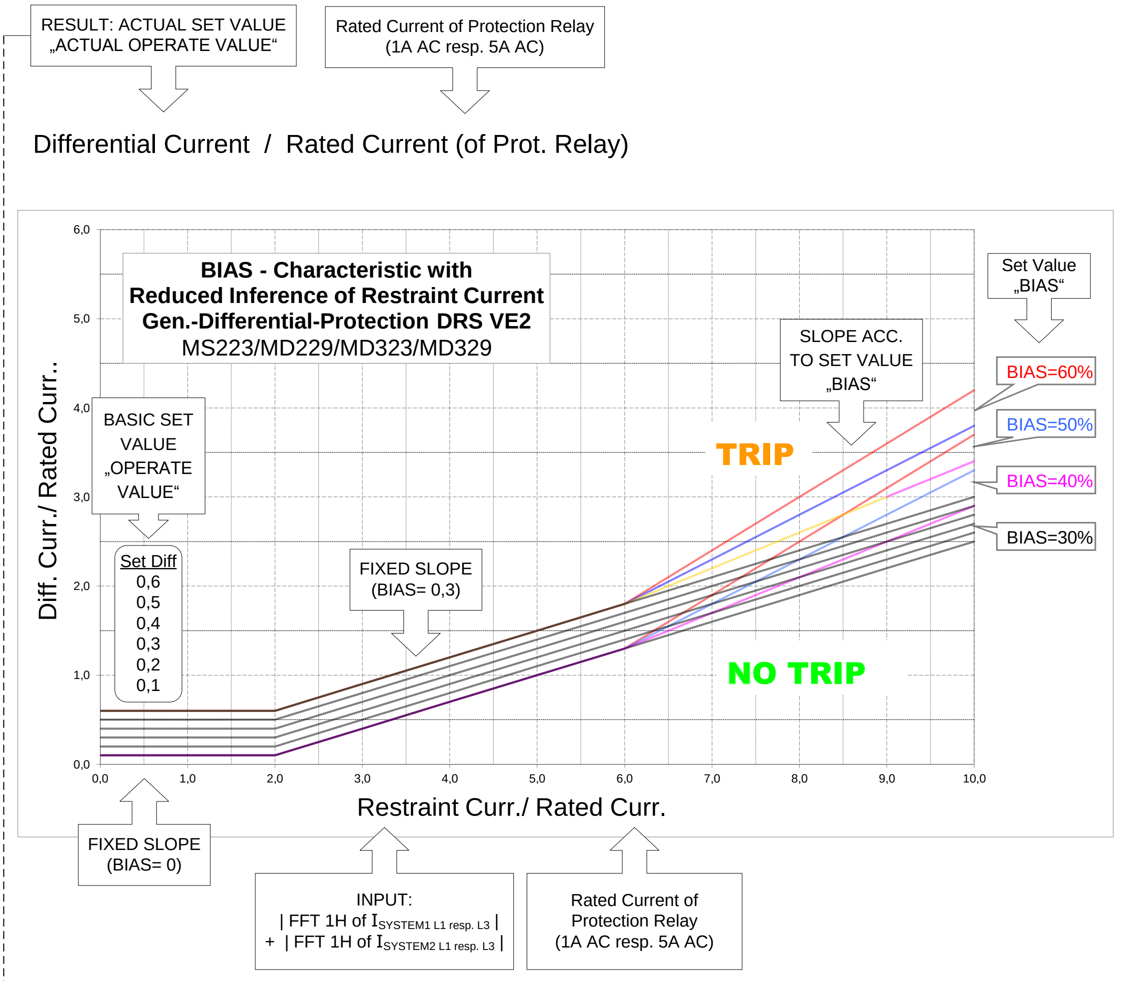
Fig. 34 MD222/MD223/MD228/MD229 87G 2-PH. Logic Diagram Processing / Legend



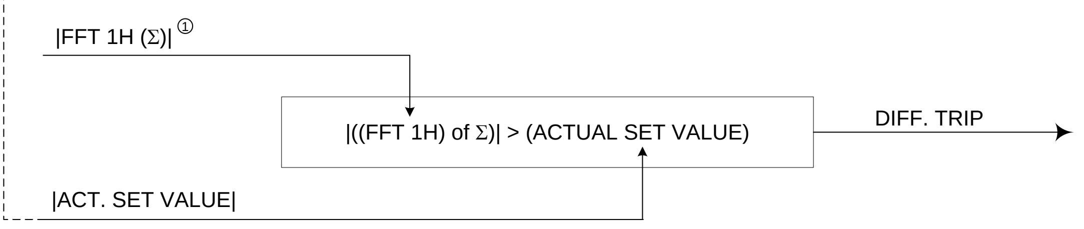
MD222/MD228 87G 2-PH. STANDARD BIAS CHARACTERISTIC

Fig. 35 MD222/MD228 87G 2-PH. Standard Bias Characteristic

BIAS-Characteristic Differential-Protection
DRS PROCESSING



Note: The result of this diagram is the ACTUAL SET VALUE (valid for VE2 only!) which is used to make the TRIP-decision.The ACTUAL SET VALUE has to be calculated for every phase separately!



① FFT 1H($\Sigma_{L1 \ldots L3}$) = FFT 1H ($I_{SYSTEM1\ L1 \ldots L3}$ + $I_{SYSTEM2\ L1 \ldots L3}$)

MD223/MD228 87G 2-PH. BIAS CHAR. WITH REDUCED INFERENCE OF RESTRAINT CURR.

Fig. 36 MD223/MD228 87G 2PH. Bias Char. With Reduced Inference of Restraint Curr.

4.4.2. MD322/ MD323

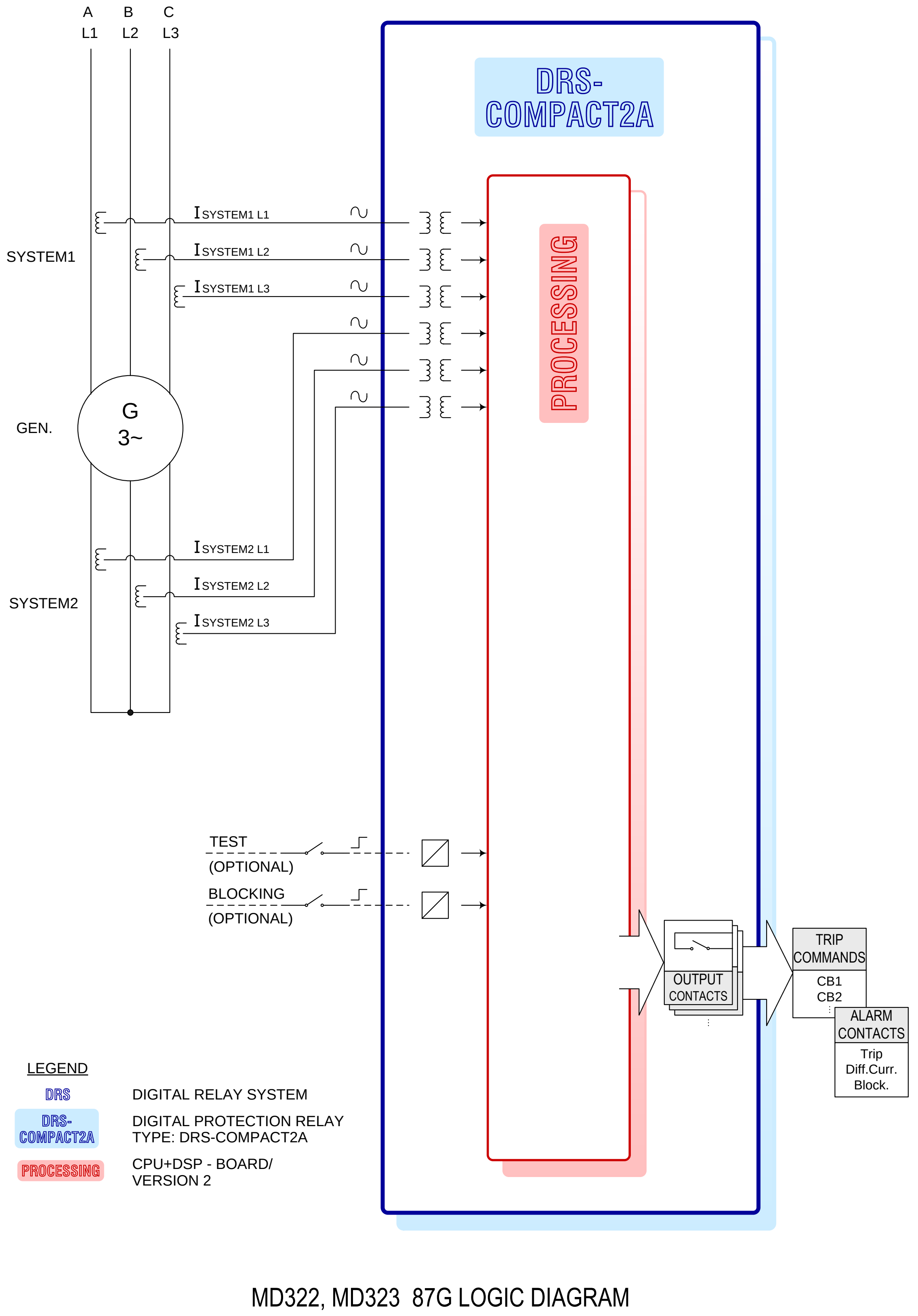
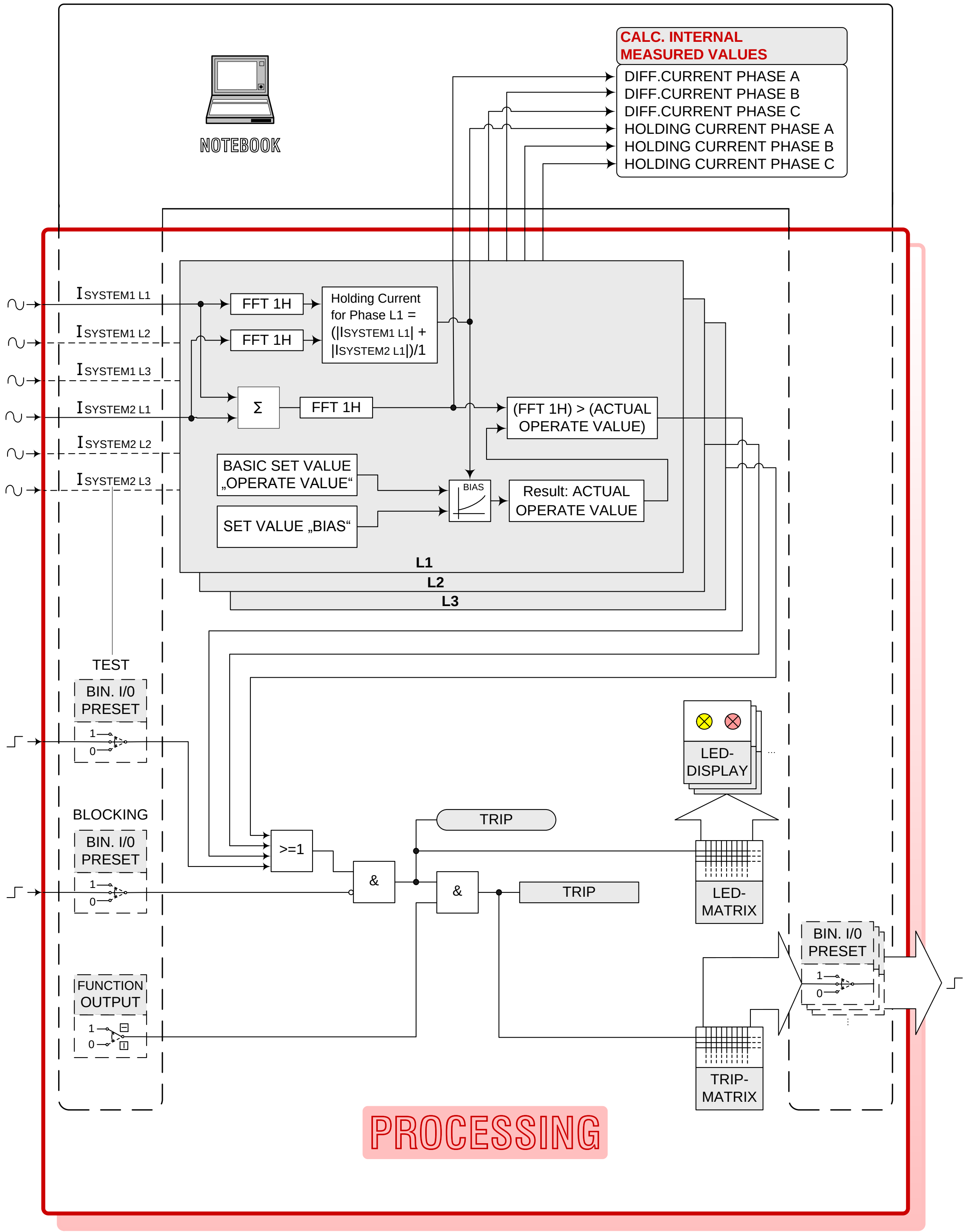


Fig. 37 MD322, MD323 87G Logic Diagram

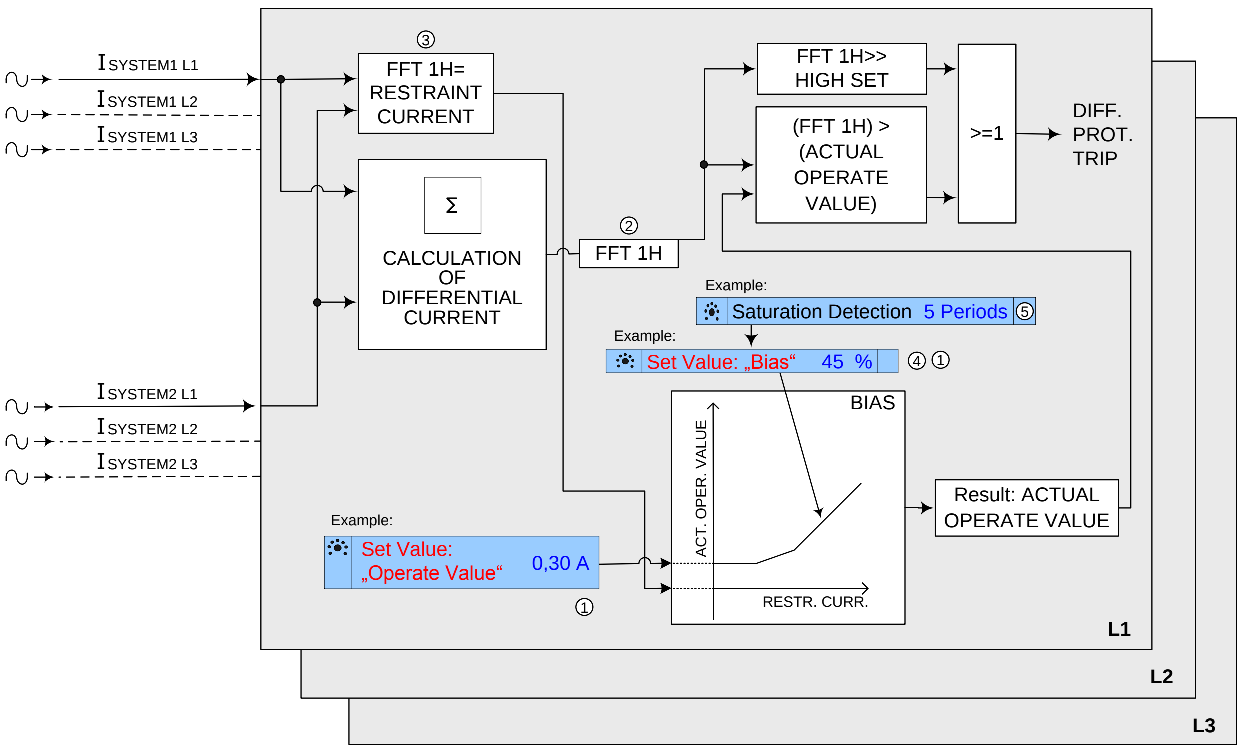


MD322, MD323: 87G LOGIC DIAGRAM PROCESSING

Fig. 38 MD322, MD323: 87G Logic Diagram Processing

DETAIL TO: MD322/MD323/MD328/MD329

BASIC CALCULATION LOGIC CIRCUIT (FIRMWARE)
FOR SYSTEM1



LEGEND

① RELAY PARAMETERS (SET VALUE)
② FFT 1H...FOURIER TRANSFORM./ 1st HARM.
③ RESTRAINT CURRENT...USED FOR BIAS CALC.
④ ANGLE OF SLOPE OF BIAS CHARACTERISTIC
⑤ „CT SATURATION DETECTION AVAILABE AT
MD228/MD229 ONLY.

MD322/MD323/MD328/MD329: 87T LOGIC DIAGRAM
PROCESSING / DETAIL

Fig. 39 MD322/MD323/MD328/MD329: 87T Logic Diagram Processing / Detail

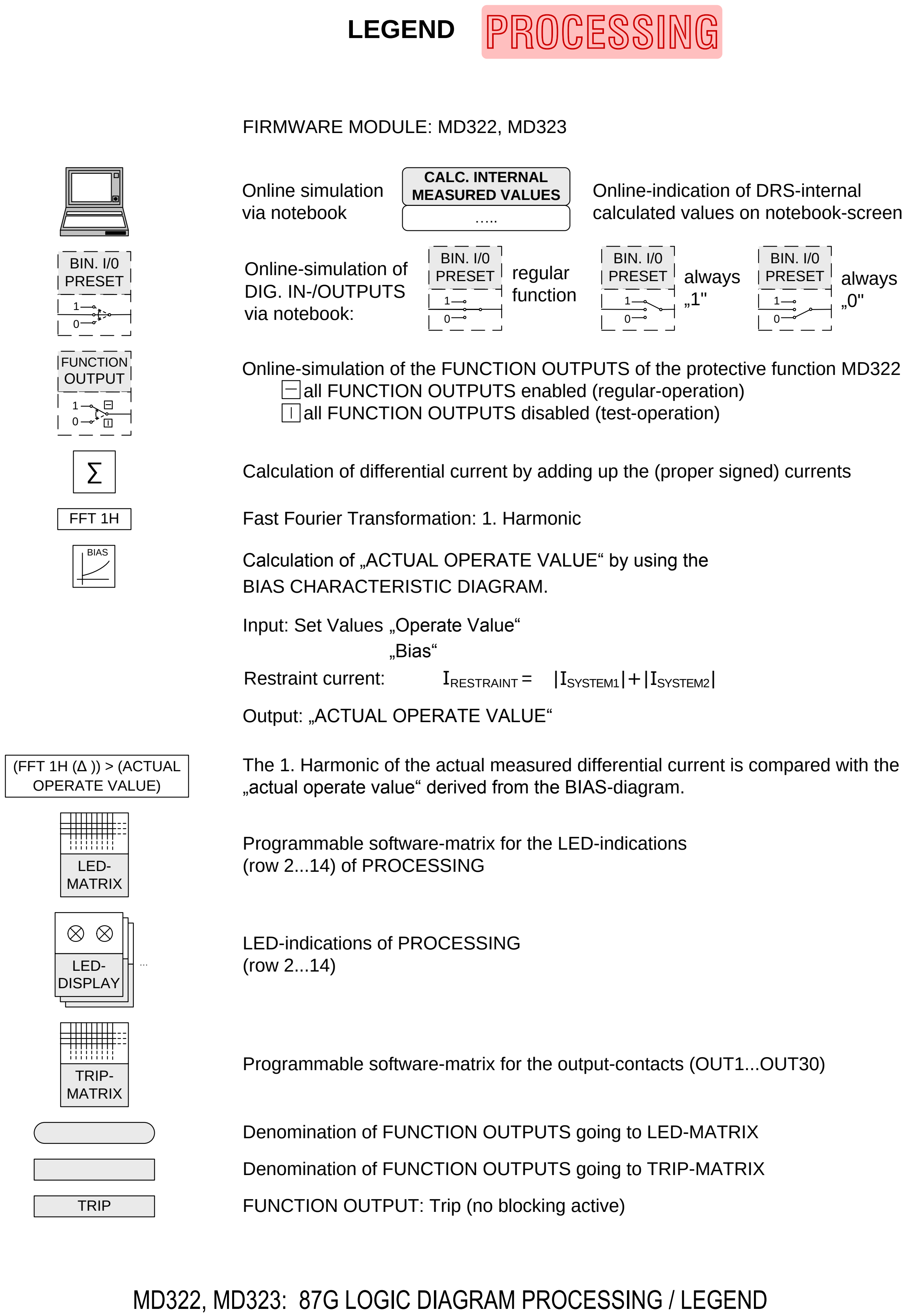
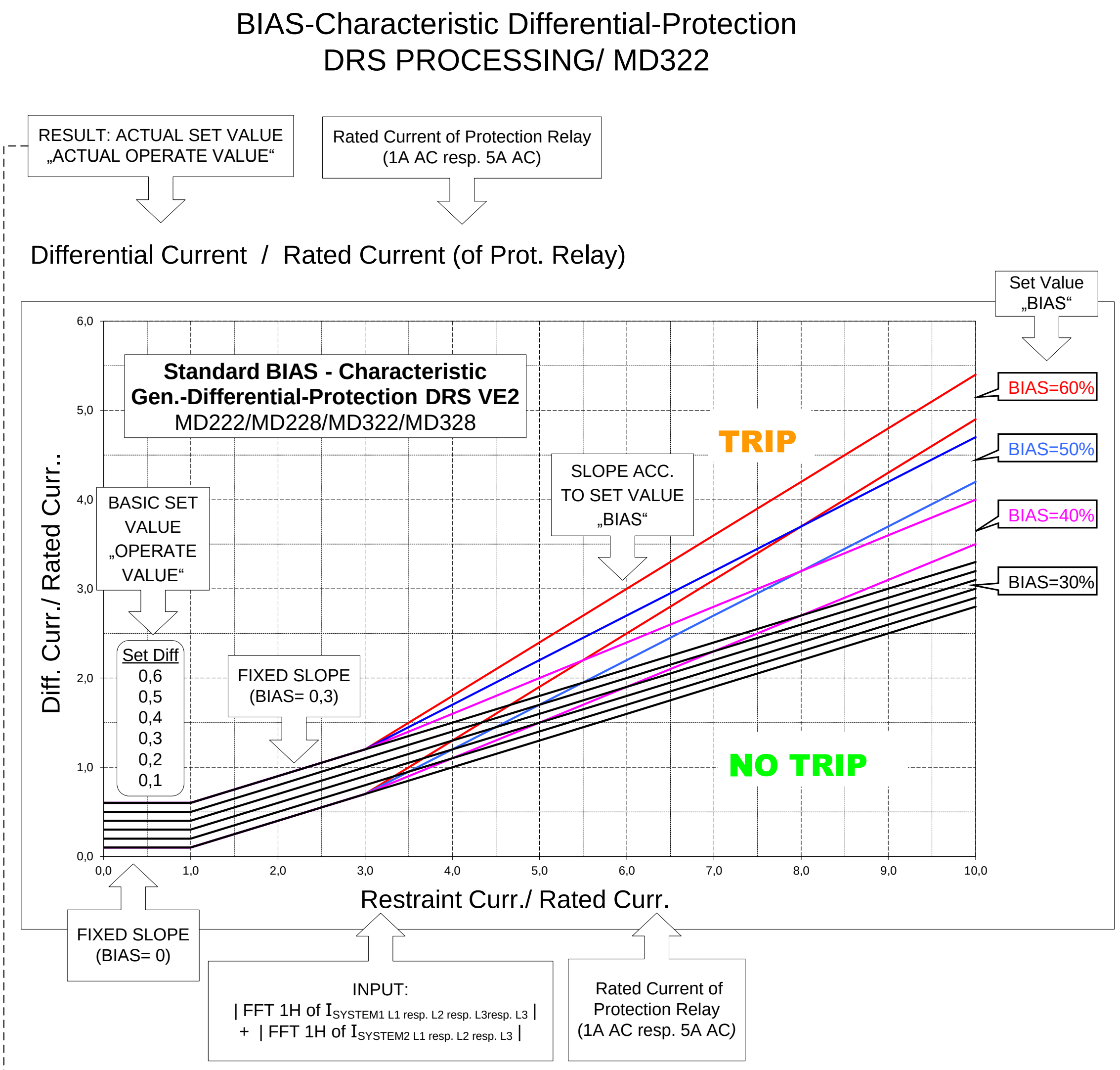
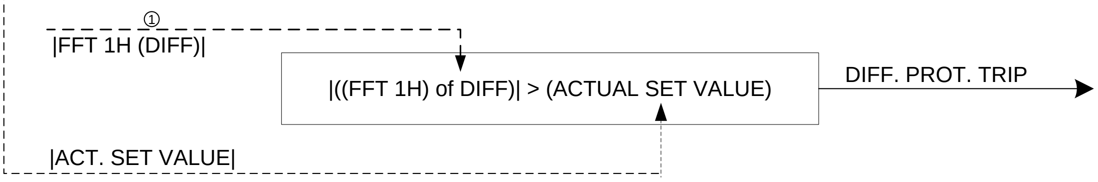


Fig. 40 MD322, MD323: 87G Logic Diagram Processing / Legend



Note: The result of this diagram is the ACTUAL SET VALUE (valid for VE2 only!) which is used to make the TRIP-decision.The ACTUAL SET VALUE has to be calculated for every phase separately!



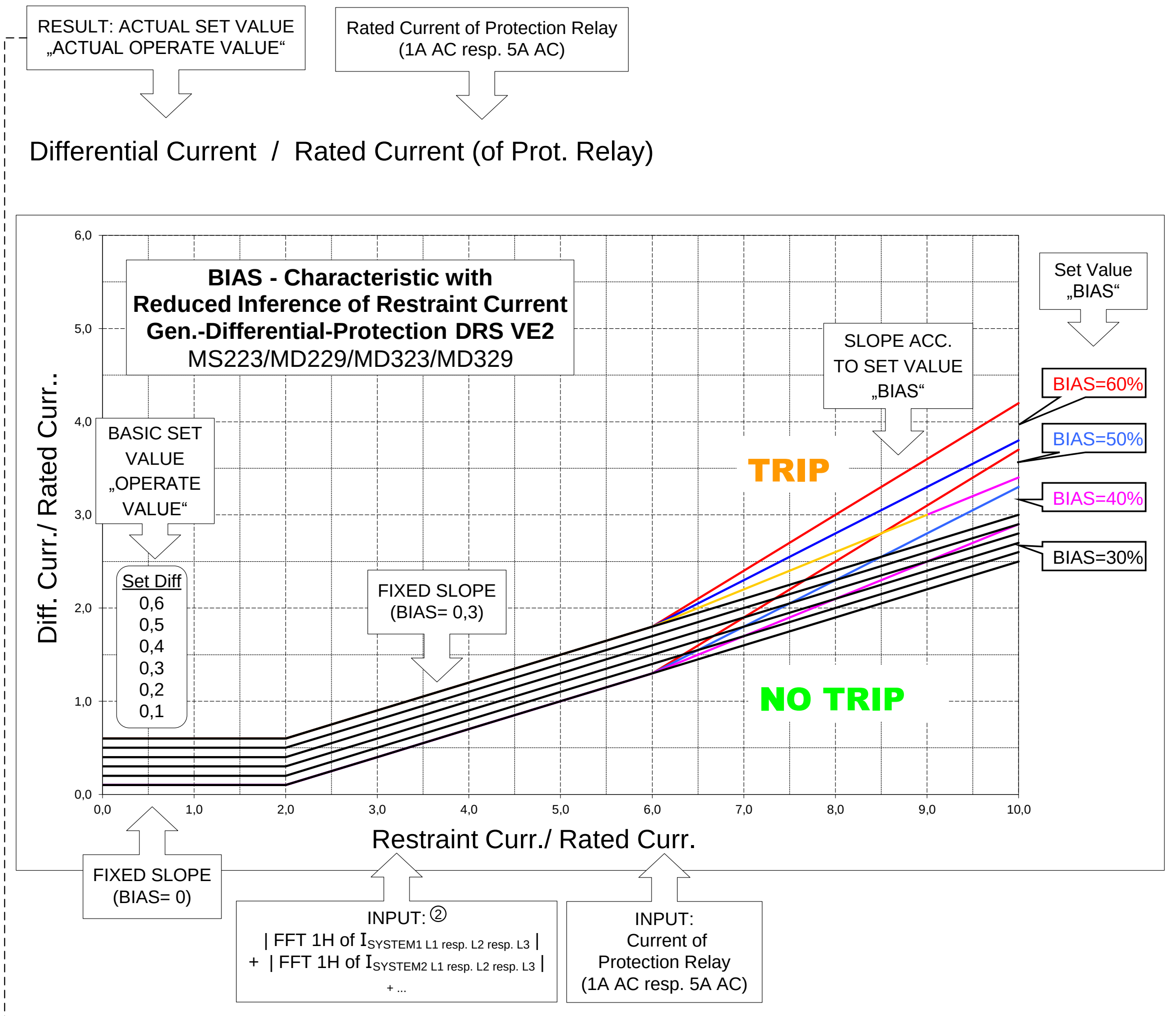
① FFT 1H(DIFF $_{L1, L2, L3}$) = FFT 1H ($\underline{I}_{SYSTEM\ L1, L2, L3}$ + $\underline{I}_{SYSTEM2\ L1, L2, L3}$) … DIFF. CURRENT

② RESTRAINT CURRENT = |(CURRENT OF SYSTEM1 H1)| + |(CURRENT OF SYSTEM2 H1)|

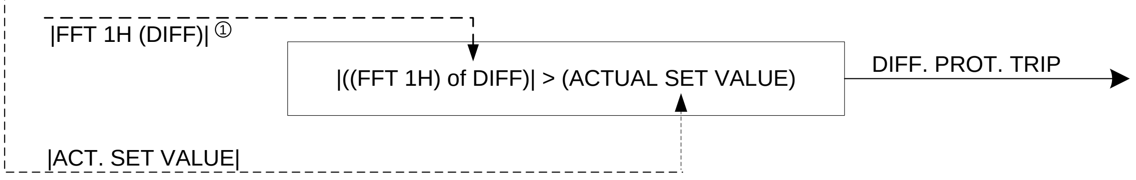
MD322 87G STANDARD BIAS CHARACTERISTIC

Fig. 41 MD322 87G Standard BIAS Characteristic

BIAS-Characteristic Differential-Protection
DRS PROCESSING/ MD323



Note: The result of this diagram is the ACTUAL SET VALUE (valid for VE2 only!) which is used to make the TRIP-decision.The ACTUAL SET VALUE has to be calculated for every phase separately!

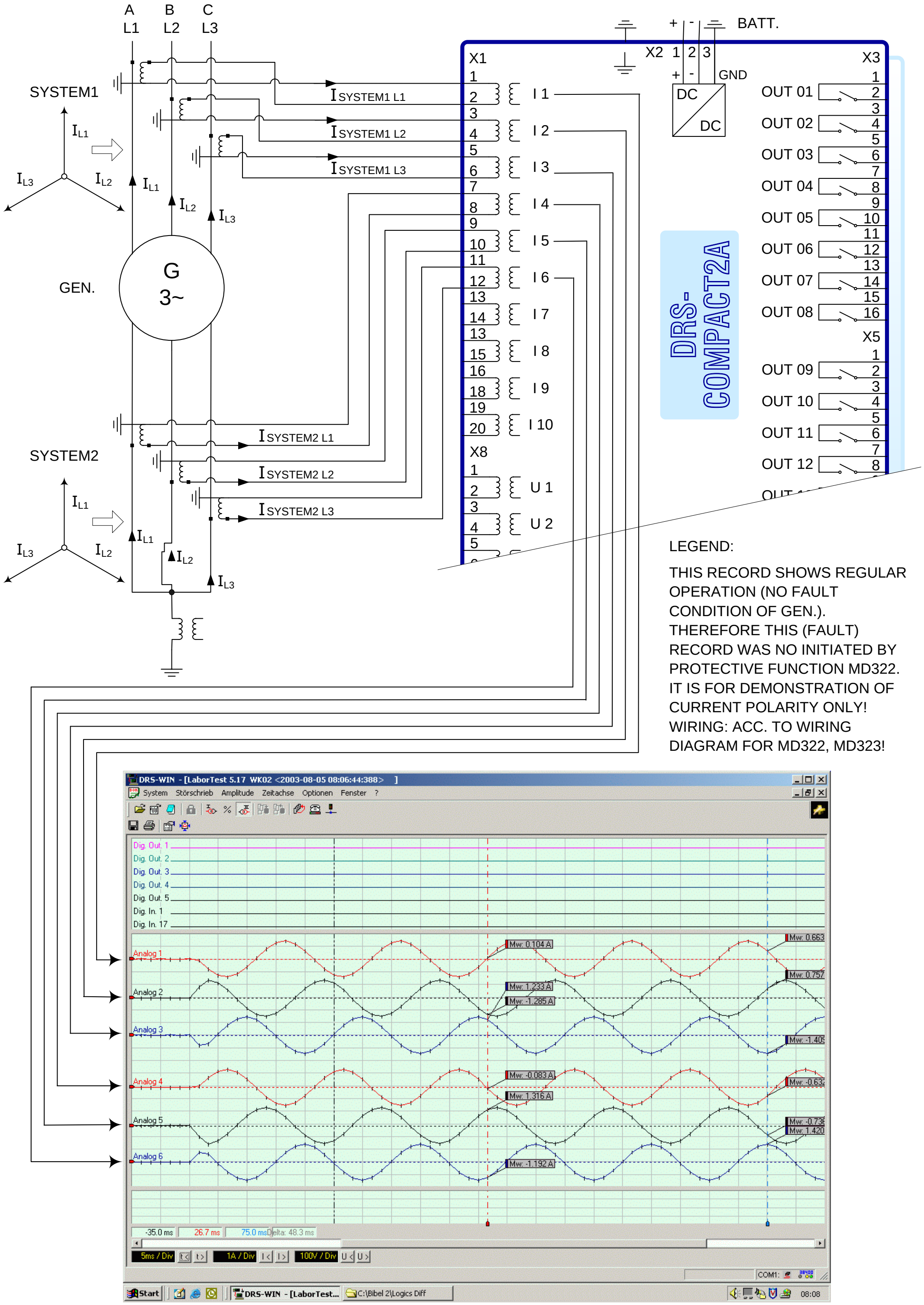


① FFT 1H(DIFF $_{L1/L2/L3}$) = FFT 1H ($I_{SYSTEM1\ L1/L2/L3}$ + $I_{SYSTEM2\ L1/L2/L3}$) … DIFF. CURRENT

② RESTRAINT CURRENT = |(CURRENT OF SYSTEM1 H1)| + |(CURRENT OF SYSTEM2 H1)|

MD323 87G BIAS CHAR. WITH REDUCED INFERENCE OF RESTRAINT CURR.

Fig. 42 MD323 87G BIAS Char. with Reduced Inference of Restraint Curr.



MD322, MD323 87G CURRENT POLARITY VERIFICATION SHOWN:
REGULAR OPERATION OF GENERATOR + REGULAR WIRING OF C.T.´s.

Fig. 43 MD322, MD323 87G Current Polarity Verification Shown: Regular Operation of Generator + Regular Wiring of C.T's

4.5. FUNCTION

Differential protective functions are provided as a selective unit protection system against winding short circuits. The measuring principle is based on the current vector differential computation within the protected zone of the relevant sets of CT's.

Measuring Principle:
All analogue signals of the function are sampled 12 times per cycle. By means of the Fourier-Analysis (DSP) the corresponding vectors (value and phase) for 1^{st} harmonic (nominal frequency) are computed and transferred to the CPU.

The CPU evaluates for each sample instant the differential signals for each phase and checks whether the actual setting value has been exceeded (please also refer to the BIAS characteristic graph). If during 11 consecutive samples (0.9 cycles) the values are above the setting a trip signal will be initiated.
By this the trip operating time consists of following single time values:
a)
Fourier-Coefficient of the differential signal reaches and exceeds the actual setting value:
Duration: 1 ... 12 ms, depending on the size of the differential signal, respectively the ratio to the setting value.
b)
Safety time: 11 consecutive samples = 0.9 cycles.
c)
Output relay: Approximately 5 ms
d)
The sum of times is typically smaller than 30 ms.

Bias Current / Stabilising:
The bias currents are phase-wise computed from the 1^{st} harmonic currents of systems 1 and 2 of the differential protection.

The trip conditions per phase are indicated in detail in the respective logic diagrams.

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

Please mind: Two Bias characteristics are available:
Fig. 4-1: Generator Differential-Protection:
Standard BIAS–Characteristic: MD222, MD228, MD322, MD328
Fig. 4-2: Generator-Differential-Protection:
Characteristic with reduced influence of restraint current (GE-type):
MD223, MD229, MD323, MD329

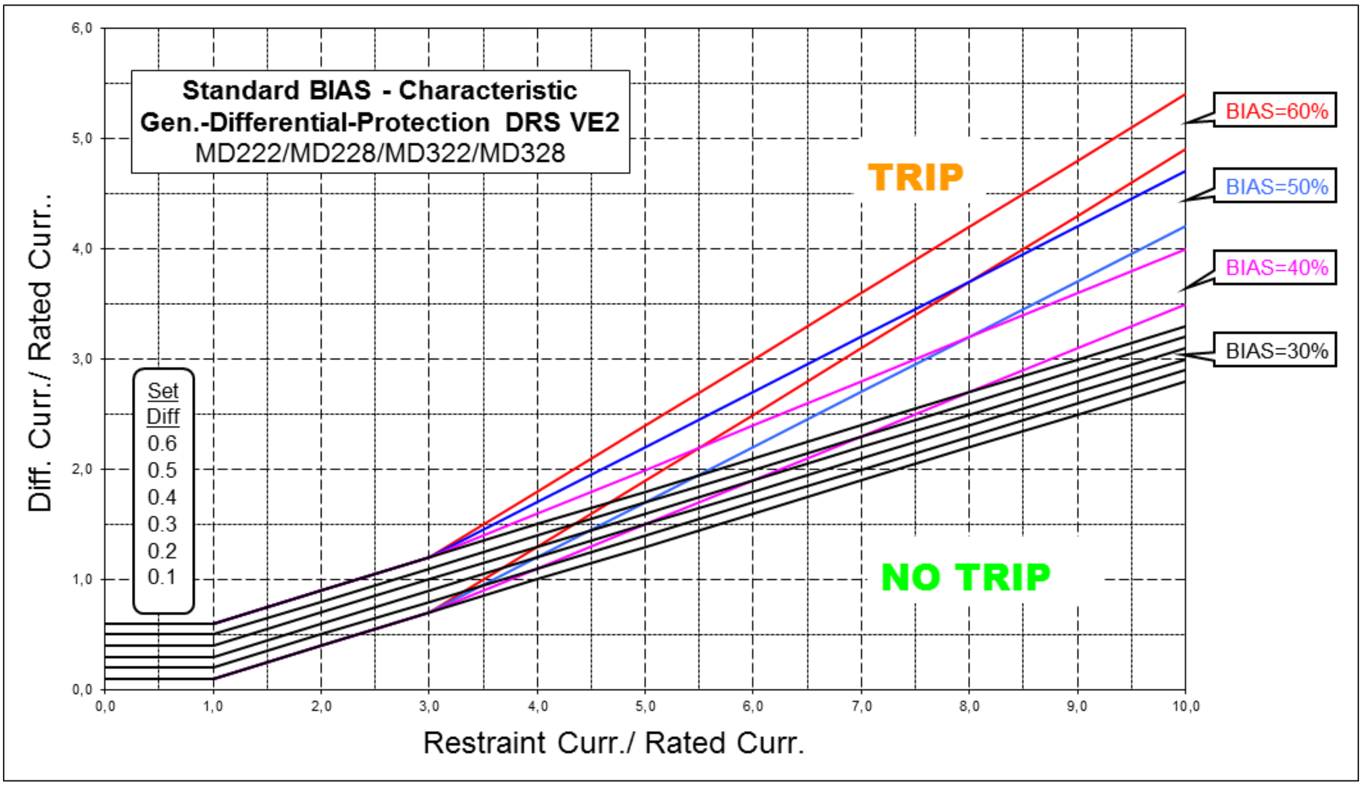


Fig. 4-1
Standard BIAS–Characteristic

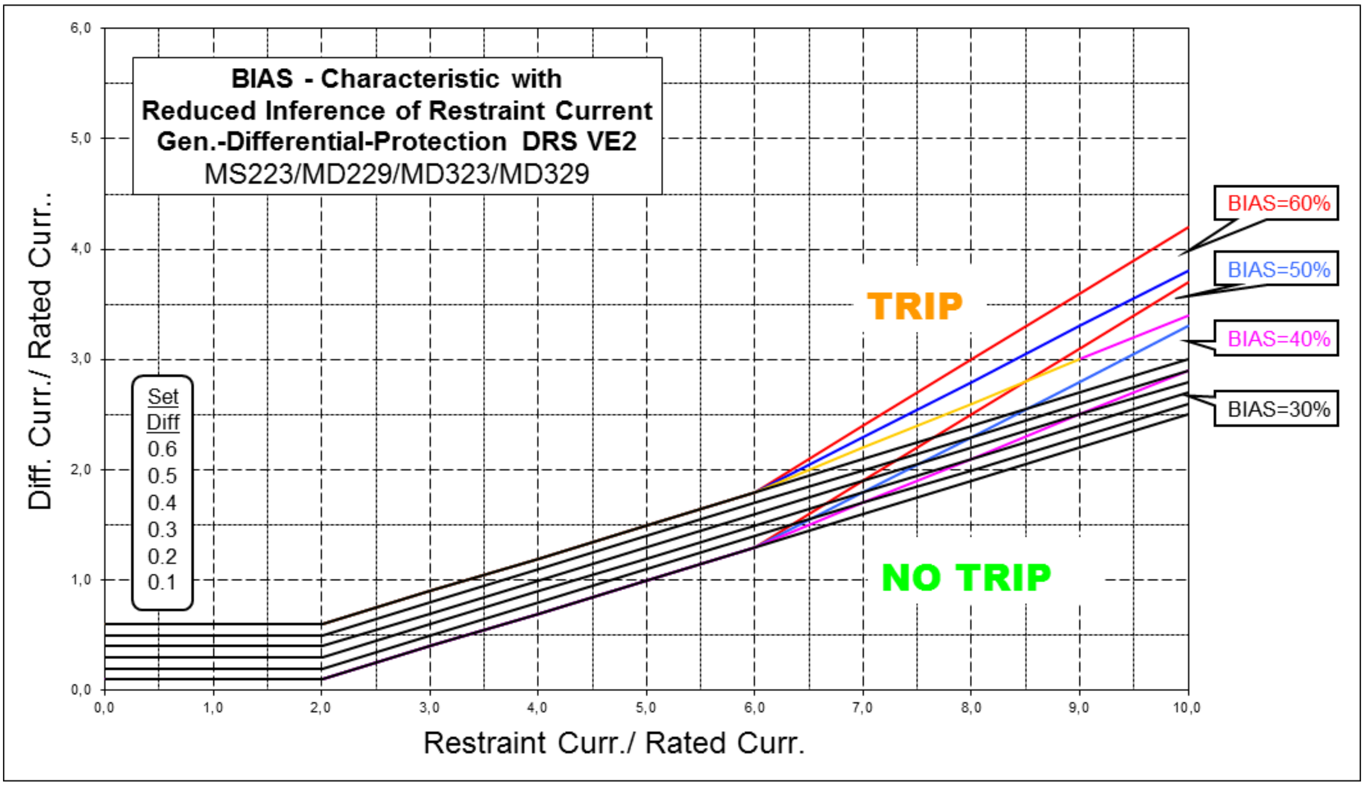


Fig. 4-2
Characteristic with reduced influence of restraint current

4.5.1. CT – Saturation Detection

For explanation please refer to Transformer Differential Protection System.

4.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry and the operating value and the bias slope set according to requirements.

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

The function checks are preferably performed with the primary protected plant being out of service.
To check the function with a relay test set, e. g. the CT inputs for system 1 phase L1 the test current is injected and raised up to the operation of the relay thereby observing the operating value with respect to the operating characteristic.

The injected test current is now reduced and the reset value of the function recorded.

Please note that the external injected current values can be displayed and compared with the internal measured values, i.e. phase – and differential currents, in the User operating program display Window.

The same is to be carried out for the other two phases of system 1 and the measured values recorded.

To check the through fault stability of phase 1 system 1 short out relay terminals 2 and 8 and inject at least the rated current between terminals 1 and 7 (please also refer to the relevant connection diagram) and the protective function must neither be operating nor showing a differential current in the internal measured values display of more than 5% I_n.

The same test should be carried out on the second phase whereby the analogous terminal numbers shown on the connection diagram are applicable.

The trip- and alarm signals and the LED indications should be confirmed according to the relay configuration and the connection diagrams.

Measuring with twice the differential current setting injection and the resulting operating time of the protective function should to be carried out for each phase either via a timer or the "Recorded Curves" in the User program to record the measured values.

A test of the configured function blocking input should be done in conjunction with a continuously initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal can be verified without any external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to the plant requirements.

After the tests any temporary setting changes should be restored to the original parameter settings.

Commissioning Tests:

During commissioning the function of the protection scheme is tested during normal service conditions.
If possible following tests under operating conditions are recommended:

- Short Circuit Test for an Internal Fault

Install a short circuit with a suitable cross section between all phases inside the protected zone.
Block protection trips.
Connect measuring instruments into the CT circuits and/or display the actual measured values window in the User program.
Start up the generator to rated speed and manually raise excitation to produce operation of the differential protection. Record the operating values.
Restore the protection trips.
Shut down the generator if possible via a protection trip and remove the short circuit.

- Short Circuit Test for a Through Fault

Install a short circuit with a suitable cross section between all phases outside the protected zone so that the two sets of CT's can be provided with the test current flow.
Block protection trips.
Start up the generator to rated speed and manually raise excitation up to nominal current. Thereby the differential protection has to be stable. Select the display of the actual measured values window in the User program and record these values.
Restore the protection trips.
Shut down the generator if possible via a protection trip and remove the short circuit.

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5. MD... TRANSFORMATOR DIFFERENTIAL

5.1. OVERVIEW

List of the Available MD . . . Transformer Differential Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MD . . .	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective blocking. With Standard-BIAS characteristic.	1033	MD221	87T	C2,M,L
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/phase overlapping blocking. With Standard-BIAS characteristic.	1119	MD224	87T	C2,M
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current.	1124	MD225	87T	C2,M,L
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic.	1133	MD226	87T	C2,M
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current.	1138	MD227	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective blocking. With Standard-BIAS characteristic.	1034	MD231	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking. With Standard-BIAS characteristic.	1120	MD234	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current.	1125	MD235	87T	C2,M

Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic.	1134	MD236	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current.	1139	MD237	87T	C2,M
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective blocking. With Standard-BIAS characteristic.	1001	MD321	87T	C2,M,L
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking. With Standard-BIAS characteristic.	1116	MD324	87T	C2,M,L
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current.	1121	MD325	87T	C2,M,L
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic.	1130	MD326	87T	C2,M
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current.	1135	MD327	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective blocking. With Standard-BIAS characteristic.	1002	MD331	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking. With Standard-BIAS characteristic.	1117	MD334	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current.	1122	MD335	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic.	1131	MD336	87T	C2,M
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current.	1136	MD337	87T	C2,M
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective blocking. With Standard-BIAS characteristic.	1003	MD341	87T	M
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking. With Standard-BIAS characteristic.	1118	MD344	87T	M
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current.	1123	MD345	87T	M

Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic.	1132	MD346	87T	M
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current.	1137	MD347	87T	M

Comparison

	Number of Phases	Number of Windings	Phase Overlapping Blocking	Standard BIAS	Reduced BIAS	CT Saturation Detection
MD221	2	2		+		
MD224	2	2	+	+		
MD225	2	2	+		+	
MD226	2	2	+	+		+
MD227	2	2	+		+	+
MD231	2	3		+		
MD234	2	3	+	+		
MD235	2	3	+		+	
MD236	2	3	+	+		+
MD237	2	3	+		+	+
MD321	3	2		+		
MD324	3	2	+	+		
MD325	3	2	+		+	
MD326	3	2	+	+		+
MD327	3	2	+		+	+
MD331	3	3		+		
MD334	3	3	+	+		
MD335	3	3	+		+	
MD336	3	3	+	+		+
MD337	3	3	+		+	+
MD341	3	4		+		
MD344	3	4	+	+		
MD345	3	4	+		+	
MD346	3	4	+	+		+
MD347	3	4	+		+	+

5.2. TECHNICAL DATA

5.2.1. Transformer Differential Protection 2-phase 2-winding

PROTECTIVE FUNCTION: MD221	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective blocking; with Standard-BIAS characteristic. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of phase overlapping* blocking *is required ... please refer to MD224!*	1033	MD221	87T	C2,M,L
PROTECTIVE FUNCTION: MD224	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking; with Standard-BIAS characteristic. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of no phase overlapping* blocking *is required ... please refer to MD221!*	1119	MD224	87T	C2,M
PROTECTIVE FUNCTION: MD225	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1124	MD225	87T	C2,M,L
PROTECTIVE FUNCTION: MD226	**FNNR**	**TYPE**	**ANSI**	**Application**

Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. With Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value.	1133	MD226	87T	C2,M
PROTECTIVE FUNCTION: MD227	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1138	MD227	87T	C2,M

Application:
Suitable for 2-phase, two winding transformers or two winding generator-transformer units with stabilising for through faults and energising blocking feature.
MD 226/ MD227 additionally include CT Saturation Detection and Quick-Trip Module.

MD221/ MD224/ MD225 MD226/ MD227
TECHNICAL DATA:

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 2 phase L1
	Current system 2 phase L2
Binary:	Blocking input
	Test input
	Auxiliary input system 1 (neutral isolator open/closed)
	Auxiliary input system 2 (neutral isolator open/closed)

Outputs

Binary:	Trip
	Differential current
	Interlock 2.H./5.H.
	CT Saturation (MD226/ MD227 only)

Setting Parameters

Operating value:	0,1 ... 2.5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
Vector group 1–2:	None/0/6
Zero sequence filter 1:	On/Off/External
Zero sequence filter 2:	On/Off/External
2nd harmonic:	10 ... 50 % in 1 % steps
5th harmonic:	5 ... 20 % in 1 % steps
High set differential stage:	2 ... 15 xIn in 0,5 xIn steps
CT ratio compensation 2–1:	0 ... 2,5 in 0,01 steps
Higher harmonics blocking (2.H., 5.H.):	MD224, MD225, MD226, MD227: Phase selective/ phase overlapping. Note: MD221 ... only phase selective.
Saturation Detection (CT):	Available for MD226/ MD227 only: 0 … 240 periods. Explanation: in case of CT saturation there will be an automatic BIAS-characteristic change to 65% activ for selected numbers of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	In Amps
Differential current phase L2:	In Amps
Bias current phase L1:	In Amps
Bias current phase L2:	In Amps

Measuring

Reset ratio:	Differential Current: 0,875 High Set O/C (DiffCurr >>): 0,75
Operating time:	≥ 75 ms at 16.66 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

Properties

CT saturation detection:	MD226, MD227
Standard BIAS–Characteristic:	MD221, MD224, MD226: Characteristic graph: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. Bias current equation: Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1.
Characteristic with reduced inference of restraint current:	MD225, MD227: Characteristic graph: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value. Bias current equation: Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)|) / 1.

5.2.2. Transformer Differential Protection 2-phase 3-winding

PROTECTIVE FUNCTION: MD231	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective blocking; with Standard-BIAS characteristic. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of phase overlapping* blocking *is required ... please refer to MD234!*	1034	MD231	87T	C2,M
PROTECTIVE FUNCTION: MD234	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking. with Standard-BIAS characteristic. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of no phase overlapping* blocking *is required ... please refer to MD231!*	1120	MD234	87T	C2,M
PROTECTIVE FUNCTION: MD235	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1. <u>BIAS characteristic:</u> Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1125	MD235	87T	C2,M

PROTECTIVE FUNCTION: MD236	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature; with Standard-BIAS characteristic. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value.	1134	MD236	87T	C2,M
PROTECTIVE FUNCTION: MD237	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current. <u>Equation for the bias current (restraint current):</u> Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1139	MD237	87T	C2,M

Application:
Suitable for 2-phase, three winding transformers or three winding generator-transformer units with stabilising for through faults and energising blocking feature.
MD 236/ MD237 additionally include CT Saturation Detection and Quick-Trip Feature.

MD231/ MD234/ MD235/ MD236/ MD237
TECHNICAL DATA:

Inputs

Analog:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 2 phase L1
	Current system 2 phase L2
	Current system 3 phase L1
	Current system 3 phase L2
Binary:	Blocking input
	Test input
	Auxiliary input system 1 (neutral isolator open/closed)
	Auxiliary input system 2 (neutral isolator open/closed)
	Auxiliary input system 3 (neutral isolator open/closed)

Outputs

Binary:	Trip
	Differential current
	Interlock 2.H./5.H.
	CT Saturation (MD236/ MD237 only)

Setting Parameters

Operating value:	0,1 ... 2.5 xIn in 0,01 xIn steps
Bias slope:	30 ... 60 % in 5 % steps
Vector group 1–2:	None/0/6
Vector group 1–3:	None/0/6
Zero sequence filter 1:	On/Off/External
Zero sequence filter 2:	On/Off/External
Zero sequence filter 3:	On/Off/External
2nd harmonic:	10 ... 50 % in 1 % steps
5th harmonic:	5 ... 20 % in 1 % steps
High set differential stage:	2 ... 15 xIn in 0,5 xIn steps
CT ratio compensation 2–1:	0 ... 2,50 in 0,01 steps
Higher harmonics blocking (2.H., 5.H.):	MD234, MD235: Phase selective/phase overlapping. Note: MD231 ... only phase selective.
Saturation Detection (CT):	Available for MD236/ MD237 only: 0 … 240 periods. Explanation: in case of CT saturation there will be an automatic BIAS-characteristic change to 65% activ for selected numbers of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window for calculated internal measured values

Differential current phase L1:	In Amps
Differential current phase L2:	In Amps
Bias current phase L1:	In Amps
Bias current phase L2:	In Amps

Measuring

Reset ratio:	Differential Current: 0,875 High Set O/C (DiffCurr >>): 0,75
Operating time:	≥ 75 ms at 16.66 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

Properties

CT saturation detection:	MD236, MD237
Standard BIAS–Characteristic:	MD231, MD234, MD236: Characteristic graph: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1.
Characteristic with reduced inference of restraint current:	MD235, MD237: Characteristic graph: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L3)|) / 1.

5.2.3. Transformer Differential Protection 3-phase 2-winding

PROTECTIVE FUNCTION: MD 321	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective blocking; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of phase overlapping* blocking *is required ... please refer to MD324!*	1001	MD321	87T	C2,M
PROTECTIVE FUNCTION: MD 324	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of no phase overlapping* blocking *is required ... please refer to MD321!*	1116	MD324	87T	C2,M
PROTECTIVE FUNCTION: MD 325	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking; Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1121	MD325	87T	C2,M
PROTECTIVE FUNCTION: MD 326	**FNNR**	**TYPE**	**ANSI**	**Application**

Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value.	1130	MD326	87T	C2,M
PROTECTIVE FUNCTION: MD 327	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 3-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1135	MD327	87T	C2,M

Application:
Suitable for 3-phase, two winding transformers or two winding generator-transformer units with stabilising for through faults and energising blocking feature.
MD 326/ MD327 additionally include CT Saturation Detection and Quick-Trip Module.

MD321/ MD324/ MD325/ MD326/ MD327
TECHNICAL DATA:

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 1 phase L3
	Current system 2 phase L1
	Current system 2 phase L2
	Current system 2 phase L3
Binary:	Blocking input
	Test input
	Auxiliary input system 1 (neutral isolator open/closed)
	Auxiliary input system 2 (neutral isolator open/closed)

Outputs

Binary:	Trip
	Differential current
	Interlock 2.H./5.H.
	CT Saturation (MD326/ MD327 only)

Setting Parameters

Operating value:	0,1 ... 2.5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
Vector group 1–2:	None/0/1/5/6/7/11
Zero sequence filter 1:	On/Off/External
Zero sequence filter 2:	On/Off/External
2nd harmonic:	10 ... 50 % in 1 % steps
5th harmonic:	5 ... 20 % in 1 % steps
High set differential stage:	2 ... 15 xIn in 0,5 xIn steps
CT ratio compensation 2–1:	0 ... 2,50 in 0,01 steps
Higher harmonics blocking:	MD324, MD325: Phase selective/phase overlapping. Note: MD321 ... only phase selective.
Saturation Detection (CT):	Available for MD326/ MD327 only: 0 … 240 periods. Explanation: in case of CT saturation there will be an automatic BIAS-characteristic change to 65% activ for selected numbers of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	In Amps
Differential current phase L2:	In Amps
Differential current phase L3:	In Amps
Bias current phase L1:	In Amps
Bias current phase L2:	In Amps
Bias current phase L3:	In Amps

Measuring

Reset ratio:	Differential Current: 0,875 High Set O/C (DiffCurr >>): 0,75
Operating time:	≥ 30 ms at 50 Hz (including output relays) ≥ 26 ms at 60 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

Properties

CT saturation detection:	MD326, MD327
Standard BIAS–Characteristic:	MD321, MD324, MD326: Characteristic graph: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1.
Characteristic with reduced inference of restraint current:	MD325, MD327: Characteristic graph: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)|) / 1.

5.2.4. Transformer Differential Protection 3-phase 3-winding

PROTECTIVE FUNCTION: MD 331	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective blocking; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of phase overlapping* blocking *is required ... please refer to MD334!*	1002	MD331	87T	C2,M
PROTECTIVE FUNCTION: MD 334	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking; with CT saturation detection; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of no phase overlapping* blocking *is required ... please refer to MD331!*	1117	MD334	87T	C2,M

PROTECTIVE FUNCTION: MD 335	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking; Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1122	MD335	87T	C2,M
PROTECTIVE FUNCTION: MD 336	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, 3-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value.	1131	MD336	87T	C2,M
PROTECTIVE FUNCTION: MD337	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 3-winding, -phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1136	MD337	87T	C2,M

Application:
Suitable for 3-phase, three winding transformers or three winding generator-transformer units with stabilising for through faults and energising blocking feature.
MD336/ MD337 additionally include CT Saturation Detection and Quick-Trip Feature.

MD331/ MD334/ MD335/ MD336/ MD337
TECHNICAL DATA:

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 1 phase L3
	Current system 2 phase L1
	Current system 2 phase L2
	Current system 2 phase L3
	Current system 3 phase L1
	Current system 3 phase L2
	Current system 3 phase L3
Binary:	Blocking input
	Test input
	Auxiliary input system 1 (neutral isolator open/closed)
	Auxiliary input system 2 (neutral isolator open/closed)
	Auxiliary input system 3 (neutral isolator open/closed)

Outputs

Binary:	Trip
	Differential current
	Interlock 2.H./5.H.
	CT Saturation (MD336/ MD337 only)

Setting Parameters

Operating value:	0,1 ... 2.5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
Vector group 1–2:	None/0/1/5/6/7/11
Vector group 1–3:	None/0/1/5/6/7/11
Zero sequence filter 1:	On/Off/External
Zero sequence filter 2:	On/Off/External
Zero sequence filter 3:	On/Off/External
2nd harmonic:	10 ... 50 % in 1 % steps
5th harmonic:	5 ... 20 % in 1 % steps
High set differential stage:	2 ... 15 xIn in 0,5 xIn steps
CT ratio compensation 2–1:	0 ... 2,50 in 0,01 steps
Higher harmonics blocking:	MD334, MD335: Phase selective/phase overlapping. Note: MD331 ... only phase selective.
Saturation Detection (CT):	Available for MD336/ MD337 only: 0 … 240 periods. Explanation: in case of CT saturation there will be an automatic BIAS-characteristic change to 65% activ for selected numbers of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	In Amps
Differential current phase L2:	In Amps
Differential current phase L3:	In Amps
Bias current phase L1:	In Amps
Bias current phase L2:	In Amps
Bias current phase L3:	In Amps

Measuring

Reset ratio:	Differential Current: 0,875 High Set O/C (DiffCurr >>): 0,75
Operating time:	≥ 30 ms at 50 Hz (including output relays) ≥ 26 ms at 60 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

Properties

CT saturation detection:	MD335, MD337
Standard BIAS–Characteristic:	MD331, MD334, MD336: Characteristic graph: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1.
Characteristic with reduced inference of restraint current:	MD335, MD337: Characteristic graph: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value. (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)|) / 1.

5.2.5. Transformer Differential Protection 3-phase 4-winding

PROTECTIVE FUNCTION: MD341	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective blocking; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of phase overlapping* blocking *is required ... please refer to MD344!*	1003	MD341	87T	M

PROTECTIVE FUNCTION: MD344	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. *Note: In case of no phase overlapping* blocking *is required ... please refer to MD341!*	1118	MD344	87T	M
PROTECTIVE FUNCTION: MD345	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 4-winding, 3-phase, with phase selective/ phase overlapping blocking. Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1123	MD345	87T	M

PROTECTIVE FUNCTION: MD 346	FNNR	TYPE	ANSI	Application
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature; with Standard-BIAS characteristic. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value.	1132	MD346	87T	C2,M
PROTECTIVE FUNCTION: MD 347	**FNNR**	**TYPE**	**ANSI**	**Application**
Transformer/Generator-Transformer differential protection 2-winding, 2-phase, with phase selective/ phase overlapping blocking, with CT Saturation Detection and Quick Trip – feature. Characteristic with reduced inference of restraint current. Equation for the bias current (restraint current): Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1. BIAS characteristic: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value.	1137	MD347	87T	C2,M

Application:
Suitable for 3-phase, four winding transformers or four winding generator-transformer units with stabilising for through faults and energising blocking feature.
MD 346/ MD347 additionally include CT Saturation Detection and Quick-Trip Module

MD341/ MD344/ MD345/ MD346/ MD347
TECHNICAL DATA:

Inputs

Analogue:	Current system 1 phase L1
	Current system 1 phase L2
	Current system 1 phase L3
	Current system 2 phase L1
	Current system 2 phase L2
	Current system 2 phase L3
	Current system 3 phase L1
	Current system 3 phase L2
	Current system 3 phase L3
	Current system 4 phase L1
	Current system 4 phase L2
	Current system 4 phase L3
Binary:	Blocking input
	Test input
	Auxiliary input system 1 (neutral isolator open/closed)
	Auxiliary input system 2 (neutral isolator open/closed)
	Auxiliary input system 3 (neutral isolator open/closed)
	Auxiliary input system 4 (neutral isolator open/closed)

Outputs

Binary:	Trip
	Differential current
	Blocking

Setting Parameters

Operating value:	0,1 ... 2,5 x In in 0,01 x In steps
Bias slope:	30 ... 60 % in 5 % steps
Vector group 1–2:	None/0/1/5/6/7/11
Vector group 1–3:	None/0/1/5/6/7/11
Vector group 1–4:	None/0/1/5/6/7/11
Zero sequence filter 1:	On/Off/External
Zero sequence filter 2:	On/Off/External
Zero sequence filter 3:	On/Off/External
Zero sequence filter 4:	On/Off/External
2nd harmonic:	10 ... 50 % in 1 % steps
5th harmonic:	5 ... 20 % in 1 % steps
High set differential stage:	2 ... 15 xIn in 0,5 xIn steps
CT ratio compensation 2–1:	0 ... 2,50 in 0,01 steps
Higher harmonics blocking:	MD344, MD345: Phase selective/phase overlapping. Note: MD341 ... only phase selective.

Saturation Detection (CT):	Available for MD346/ MD347 only: 0 … 240 periods. Explanation: in case of CT saturation there will be an automatic BIAS-characteristic change to 65% activ for selected numbers of periods (= max. limit). Note: Saturation Detection = OFF, if Set value = 0 periods.

Window Display for Relay Internal Determined and Computed Values

Differential current phase L1:	In Amps
Differential current phase L2:	In Amps
Differential current phase L3:	In Amps
Bias current phase L1:	In Amps
Bias current phase L2:	In Amps
Bias current phase L3:	In Amps

Measuring

Reset ratio:	Set value Differential Current: 0,875 Set value High Set O/C: 0,75
Operating time:	≥ 30 ms at 50 Hz (including output relays) ≥ 26 ms at 60 Hz (including output relays)
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

Properties

CT saturation detection:	MD346, MD347
Standard BIAS–Characteristic:	MD341, MD344, MD346: Characteristic graph: Bias current = 0 ... 1: Bias = constant Bias current = 1 ... 3: Bias = 30% Bias current > 3: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1.
Characteristic with reduced inference of restraint current:	MD345, MD347: Characteristic graph: Bias current = 0 ... 2: Bias = constant Bias current = 2 ... 6: Bias = 30% Bias current > 6: Bias = Setting value. Bias current = (|FFT 1H of (ISYSTEM1 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM2 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM3 L1 resp. L2 resp. L3)| + |FFT 1H of (ISYSTEM4 L1 resp. L2 resp. L3)|) / 1.

5.3. CONNECTION DIAGRAM

5.3.1. MD221

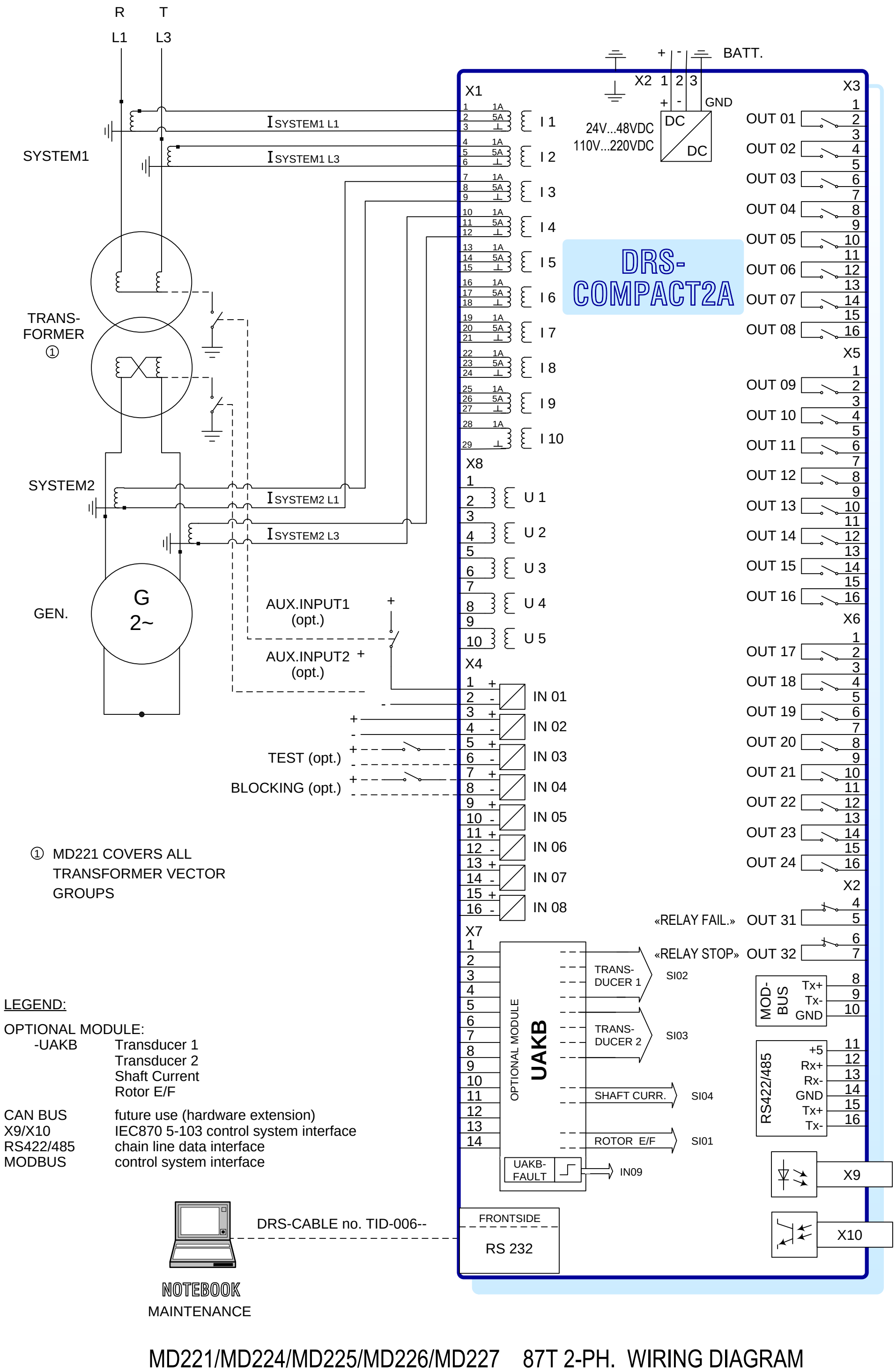
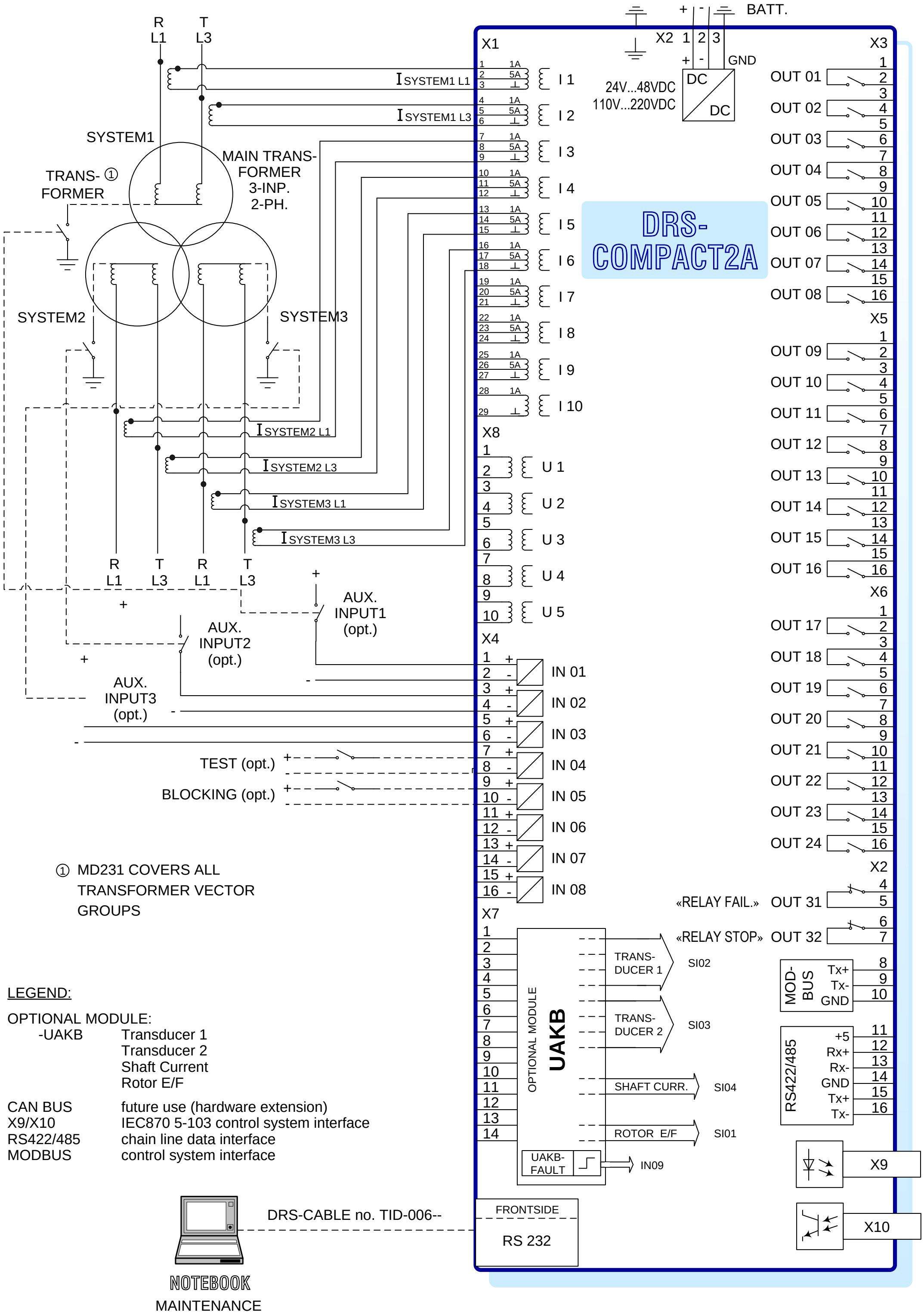


Fig. 44 MD221/MD224/MD225/MD226/MD227 87T 2-PH. Wiring Diagram

5.3.2. MD231



LEGEND:

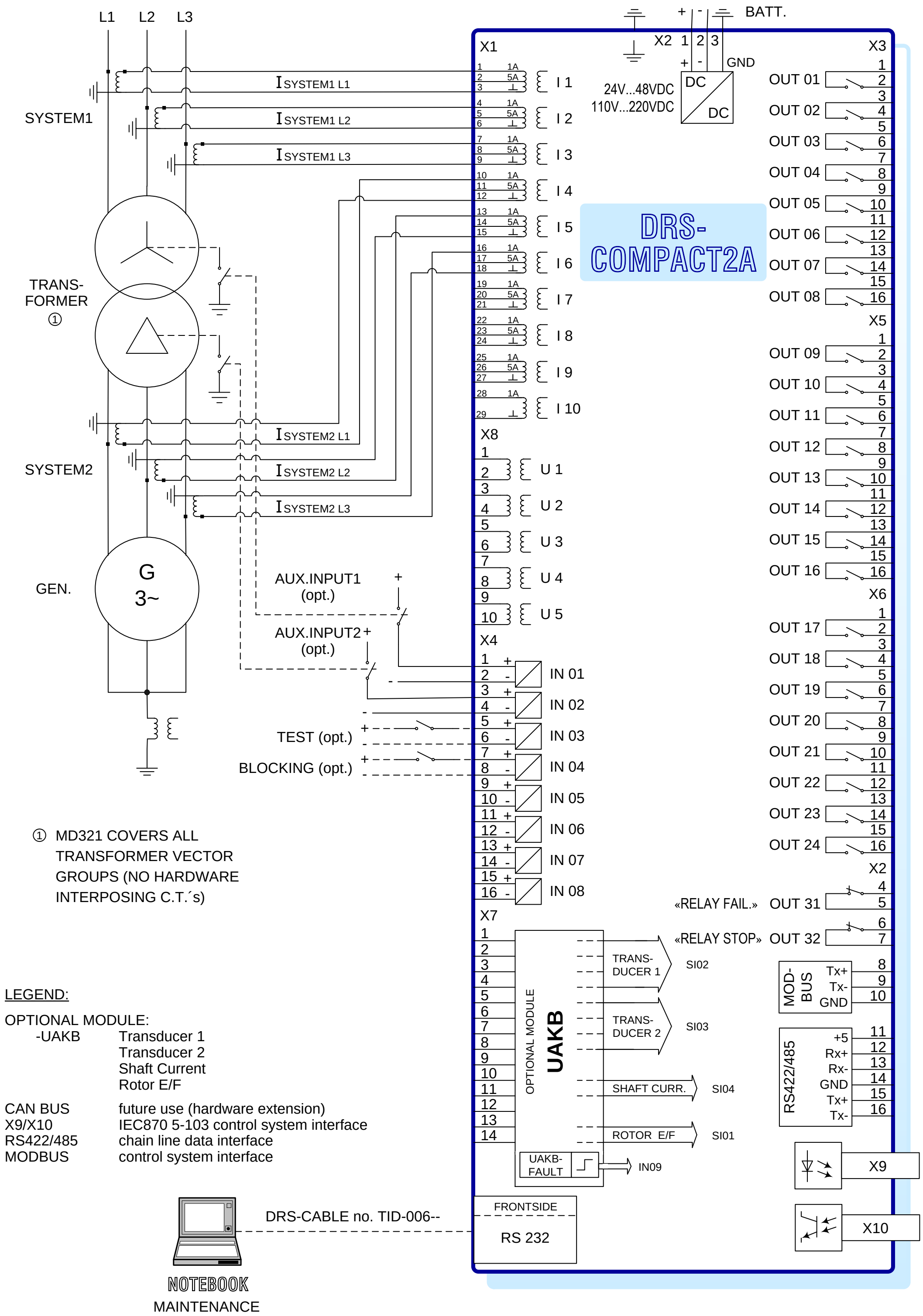
OPTIONAL MODULE:

-UAKB	Transducer 1	
	Transducer 2	
	Shaft Current	
	Rotor E/F	
CAN BUS	future use (hardware extension)	
X9/X10	IEC870 5-103 control system interface	
RS422/485	chain line data interface	
MODBUS	control system interface	

MD231 87T 3-INP., 2-PH. WIRING DIAGRAM

Fig. 45 MD231 87T3-INP., 2-PH. Wiring Diagram

5.3.3. MD321



MD321/MD324/MD325/MD326/MD327 87T WIRING DIAGRAM

Fig. 46 MD321/MD324/MD325/MD326/MD327 87T Wiring Diagram

5.3.4. MD331, MD334

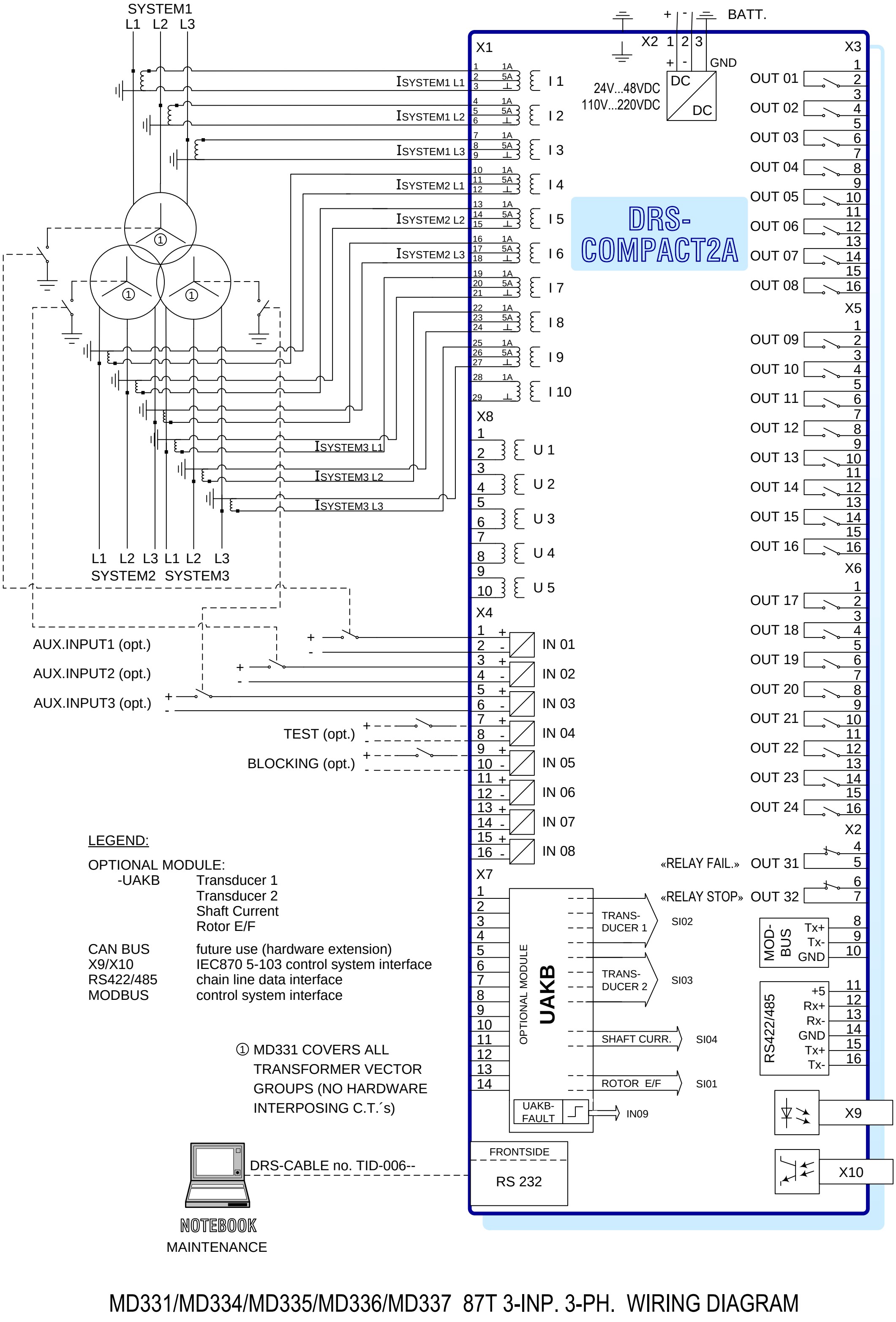


Fig. 47 MD331/MD334/MD335/MD336/MD337 87T 3-INP. 3-PH. Wiring Diagram

5.4. LOGIC DIAGRAMS

5.4.1. MD221

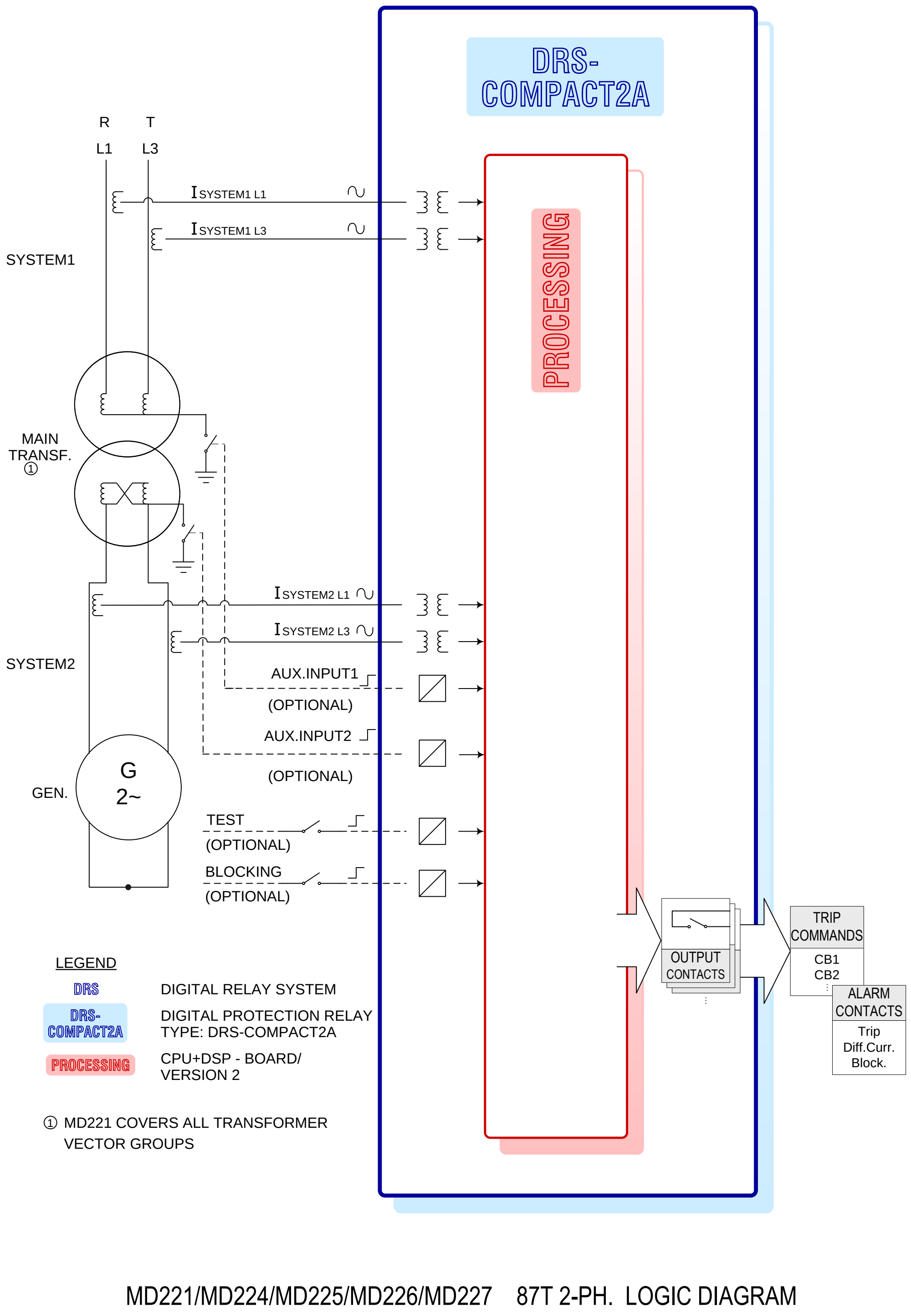
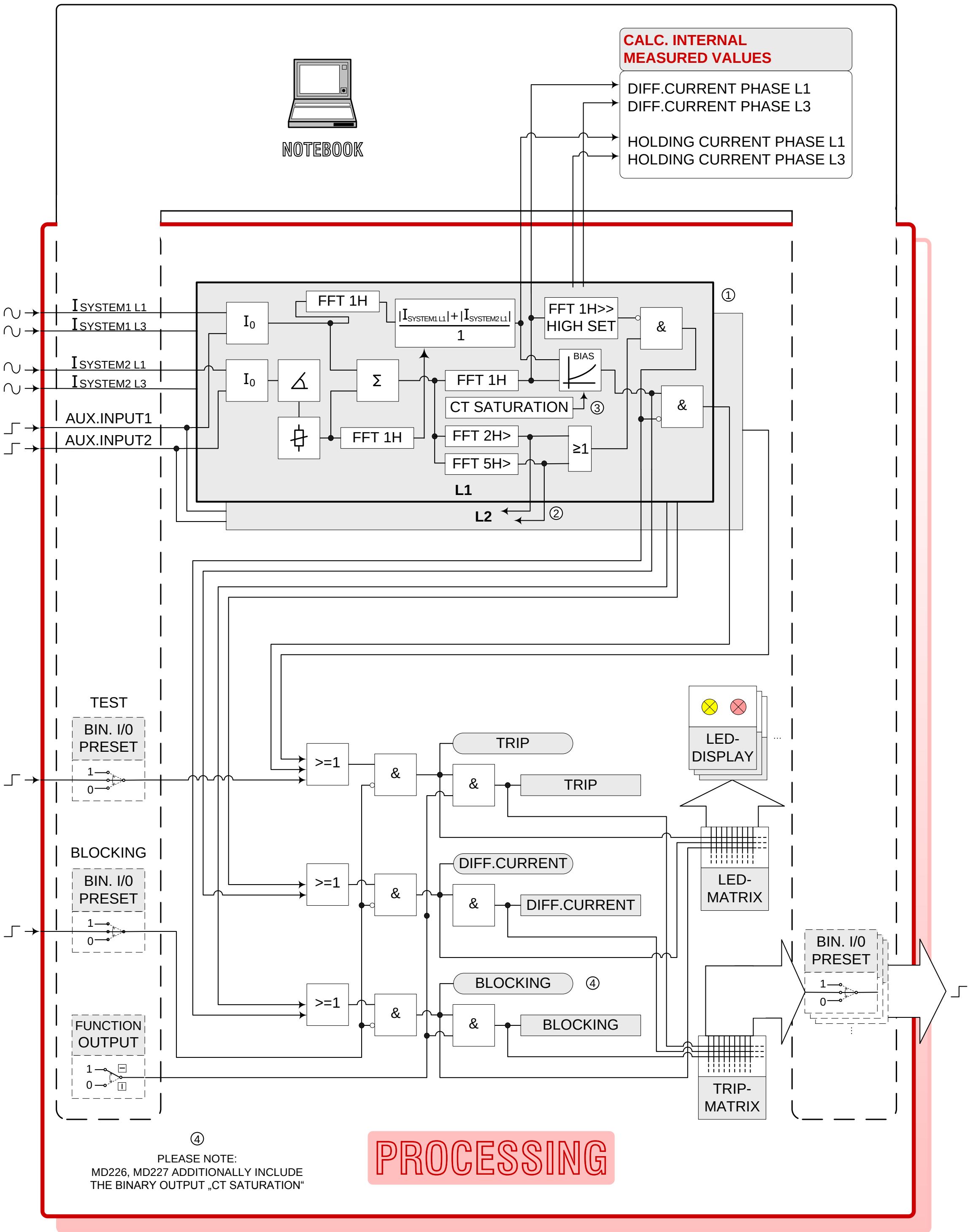


Fig. 48 MD221/MD224/MD225/MD226/MD227 87T 2-PH. Logic Diagram



① FOR DETAILD BASIC CALCULATION LOGIC CIRCUIT: see „MD321 87T LOGIC DIAGRAMM PROCESSING / DETAIL“

② „PHASE OVERLAPPING RESTRAINT“ AT MD224, MD225, MD226, MD227 ONLY.

③ „CT SATURATION“ AT MD226, MD227 ONLY.

MD221/MD224/MD225/MD226/MD227 87T 2-PH. LOGIC DIAGRAM PROCESSING

Fig. 49 MD211/MD224/MD225/MD226/MD227 87T 2-PH. Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE MODULE: MD221

Symbol	Description
	Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET (1 / 0)	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"
FUNCTION OUTPUT (1 / 0)	Online-simulation of the FUNCTION OUTPUTS of the protective function MD221 — all FUNCTION OUTPUTS enabled (regular-operation) I all FUNCTION OUTPUTS disabled (test-operation)
I_0	Zero-sequence current filtering (software-filtering); enabled via settings
∡	Transformer vector group adjustment by software; see settings Note: no hardware-interposing c.t.´s necessary
	Compensator-factor for c.t.-secondary currents; see settings
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING — LED-DISPLAY: LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
Σ	Calculation of differential current by adding up the (proper signed) currents
FFT 1H	Fast Fourier Transformation: 1. Harmonic
FFT 2H>	FFT: 2. H. > set; see setting for „2.H.filter“ for transformer energizing
FFT 5H>	FFT: 5. H. > set; see setting for „5.H.filter“ for transf. saturation by over-voltage
$\frac{\lvert I_{SYSTEM1\,L1}\rvert + \lvert I_{SYSTEM2\,L1}\rvert}{1}$	Restraint current: $I_{RESTRAINT} = \frac{\lvert I_{SYSTEM1}\rvert + \lvert I_{SYSTEM2}\rvert}{1}$
BIAS	BIAS characteristic (differential current <-> restraint current)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
DIFF.CURRENT	FUNCTION OUTPUT: Differential current > set
BLOCKING	FUNCTION OUTPUT: Blocking of tripping by 2. or 5. Harmonic filter or by ext. applied blocking signal
TRIP	FUNCTION OUTPUT: Trip (no blocking active)
FFT 1H>> HIGH SET	The high-set feature deactivates the higher harmonics (2.H.,5.H.) blocking of tripping (tripping is enabled)
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MD221/MD224/MD225/MD226/MD227 87T 2-PH. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 50 MD221/MD224/MD225/MD226/MD227 87T 2-PH. Logic Diagram Processing / Legend

5.4.2. MD321

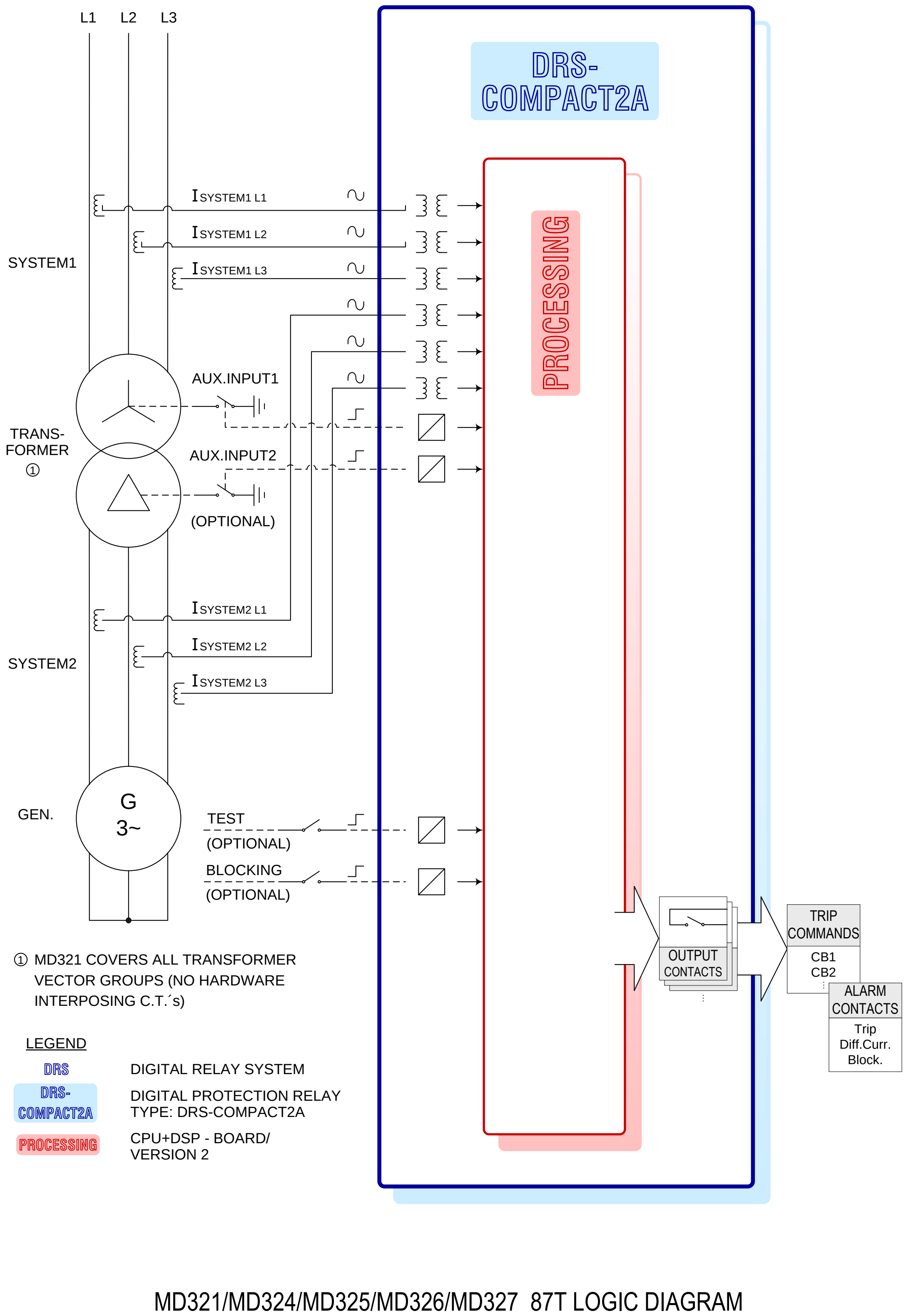
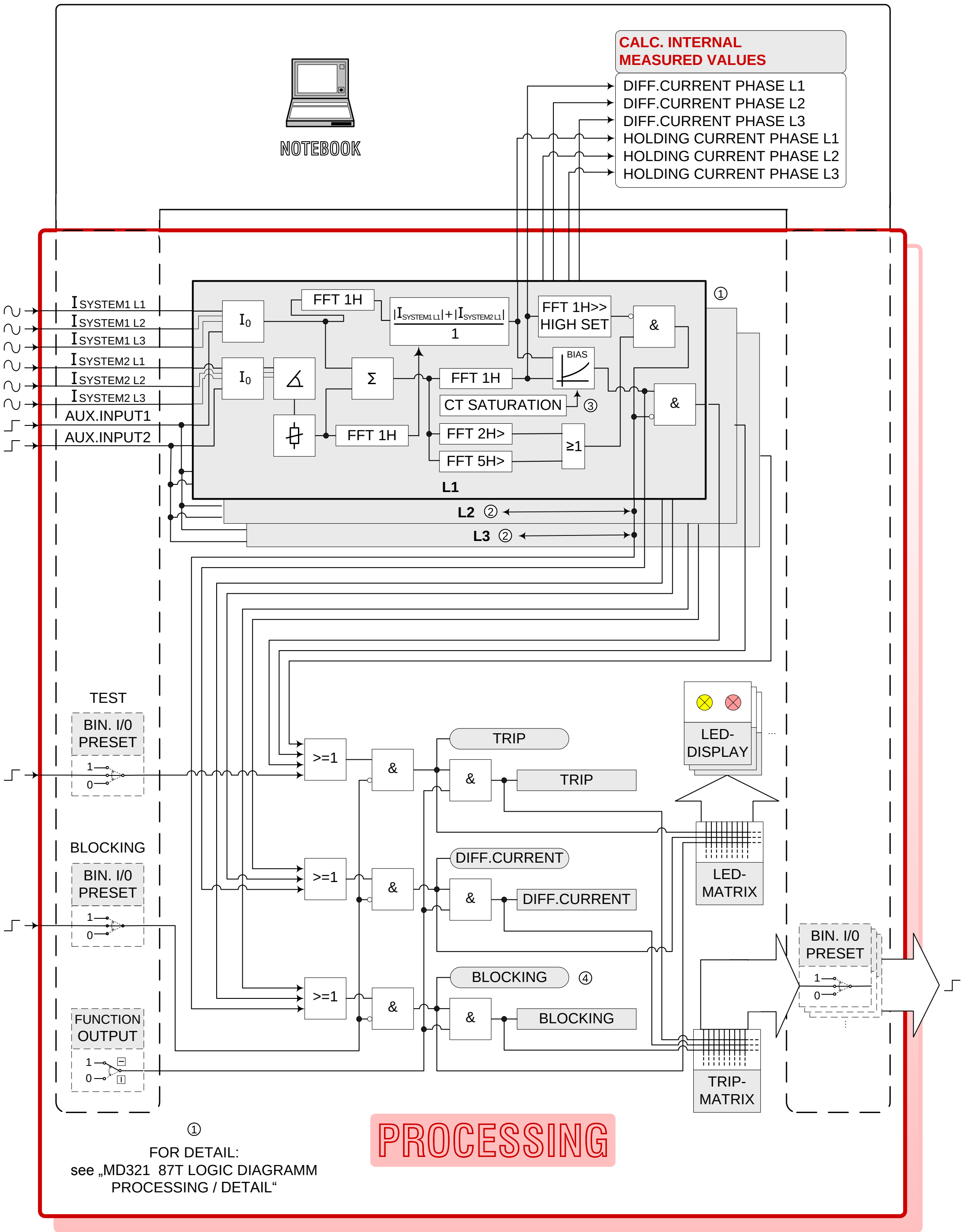


Fig. 51 MD321/MD324/MD325/MD326/MD327 87T Logic Diagram



① FOR DETAILD BASIC CALCULATION LOGIC CIRCUIT: see „MD321 87T LOGIC DIAGRAMM PROCESSING / DETAIL“

② „PHASE OVERLAPPING RESTRAINT“ AT MD324, MD325, MD326, MD327 ONLY.

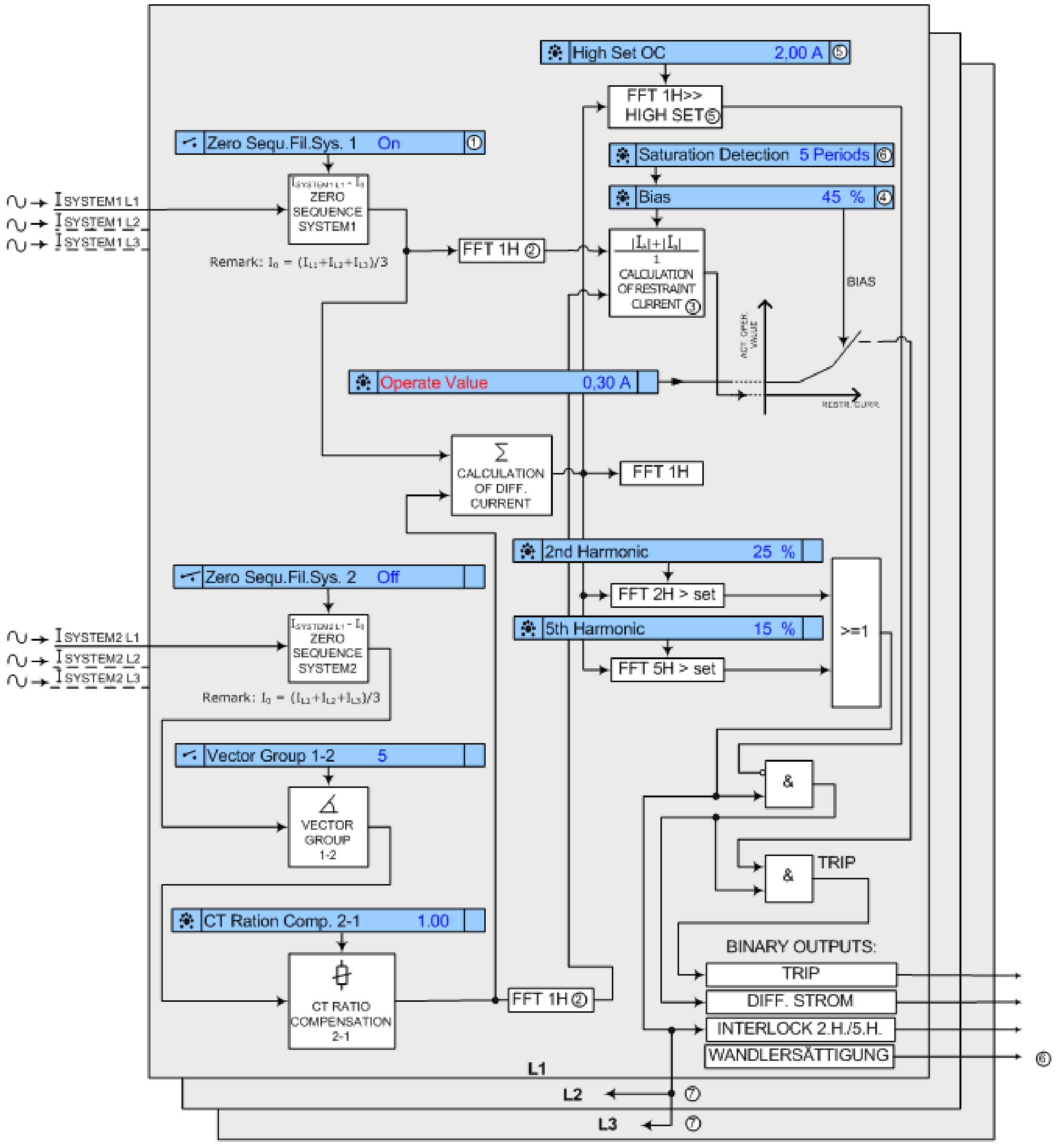
③ „CT SATURATION“ AT MD326, MD327 ONLY.

MD321/MD324/MD325/MD326/MD327 87T LOGIC DIAGRAM PROCESSING

Fig. 52 MD321/MD324/MD325/MD326/MD327 87T Logic Diagram Processing

DETAIL TO: MD321

BASIC CALCULATION LOGIC CIRCUIT (FIRMWARE)
WITH SET VALUES/ FOR SYSTEM1



LEGEND

① RELAY PARAMETERS (SET VALUES)
② FFT 1H...FOURIER TRANSFORM./ 1st HARM.
③ RESTRAINT CURRENT...USED FOR BIAS CALC.
|IA|...HV-SIDE OF TRANSF.
|IB|...LV-SIDE OF TRANSF. (COMPENSATED)
④ BIAS CHARACTERISTIC
⑤ BLOCKING BY 2nd HARM. OR 5th HARM. IS CANCELLED IN CASE: ΔI > HIGH SET.
⑥ „SATURATION DETECTION" AVAILABE AT MD326, MD327 ONLY.
⑦ PHASE OVERLAPPING BLOCKING AT MD324/MD325/MD326/MD327 AVAILABLE ONLY.

MD321/MD324/MD325/MD326/MD327 87T LOGIC
DIAGRAM PROCESSING / DETAIL

Fig. 53 MD321/MD324/MD325/MD326/MD327 87T Logic Diagram Processing / Detail

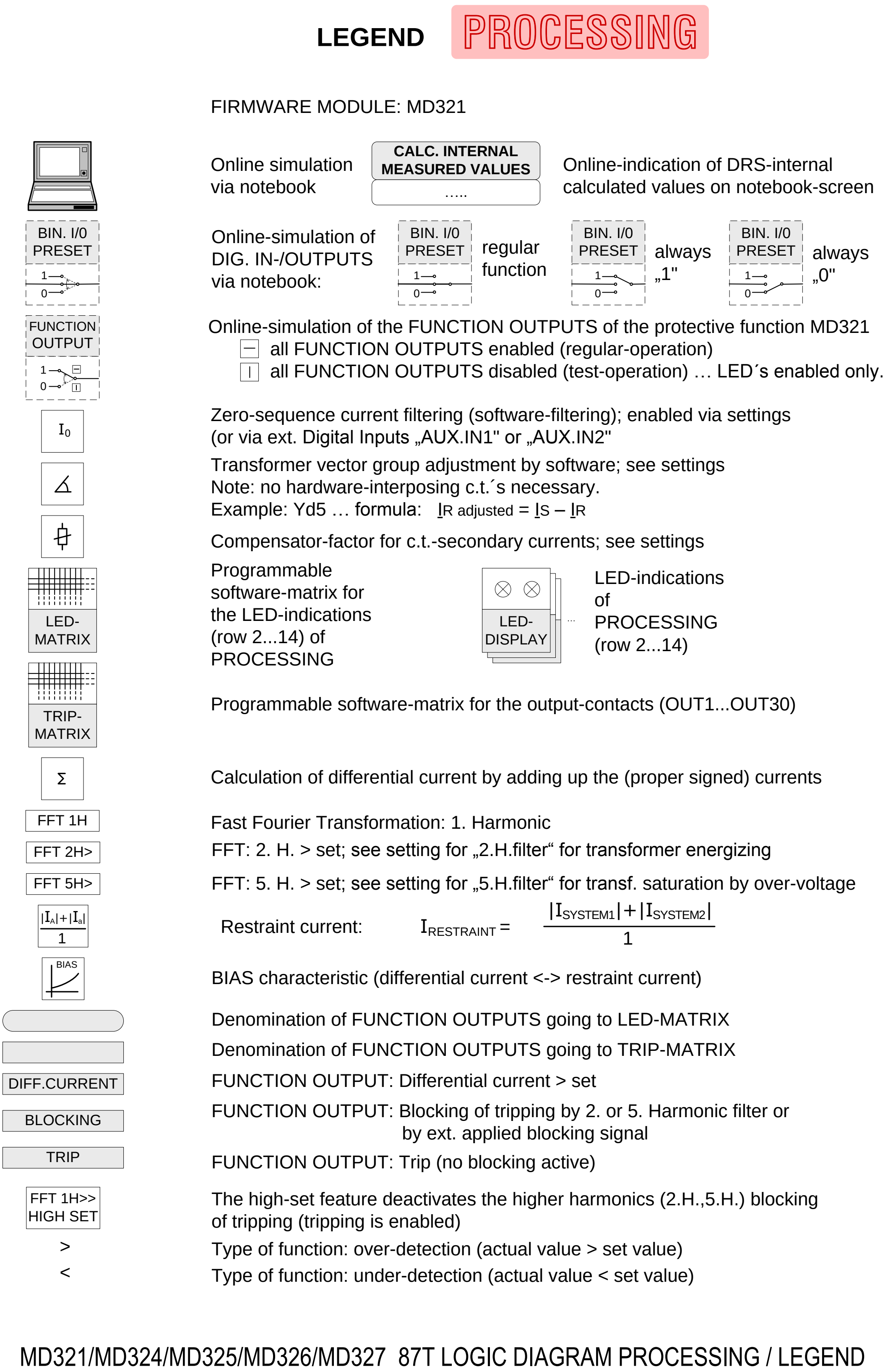
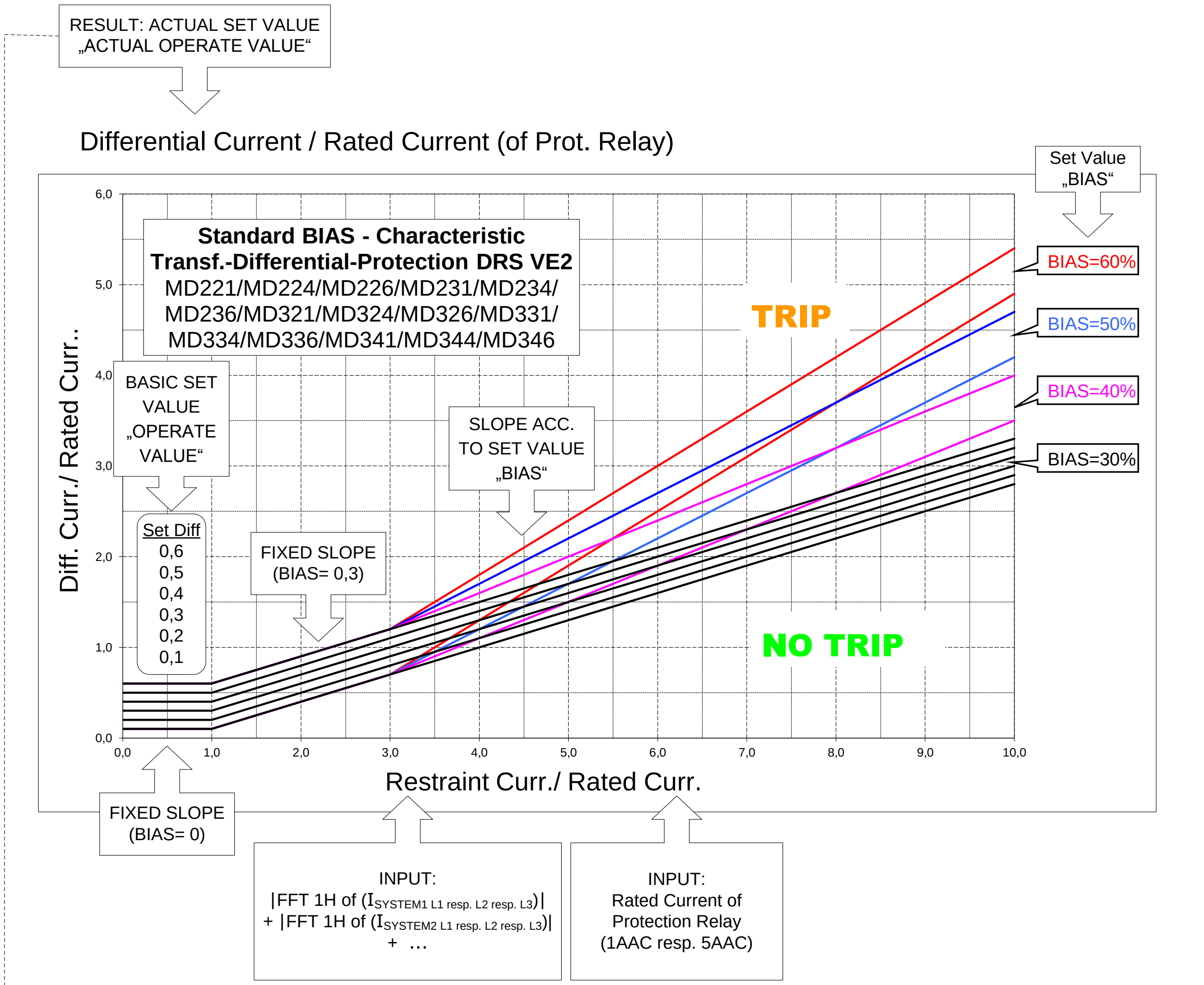
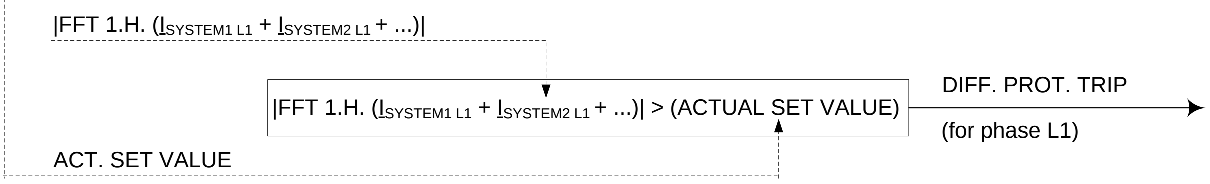


Fig. 54 MD321/MD324/MD325/MD326/MD327 87T Logic Diagram Processing / Legend

BIAS-Characteristic Differential-Protection
DRS PROCESSING / MD321



Note: The result of this diagram is the ACTUAL SET VALUE (valid for VE2 only!) which is used to make the TRIP-decision.The ACTUAL SET VALUE has to be calculated for every phase separately!



MD321 87T STANDARD BIAS CHARACTERISTIC

Fig. 55 MD321 87T Standard Bias Characteristic

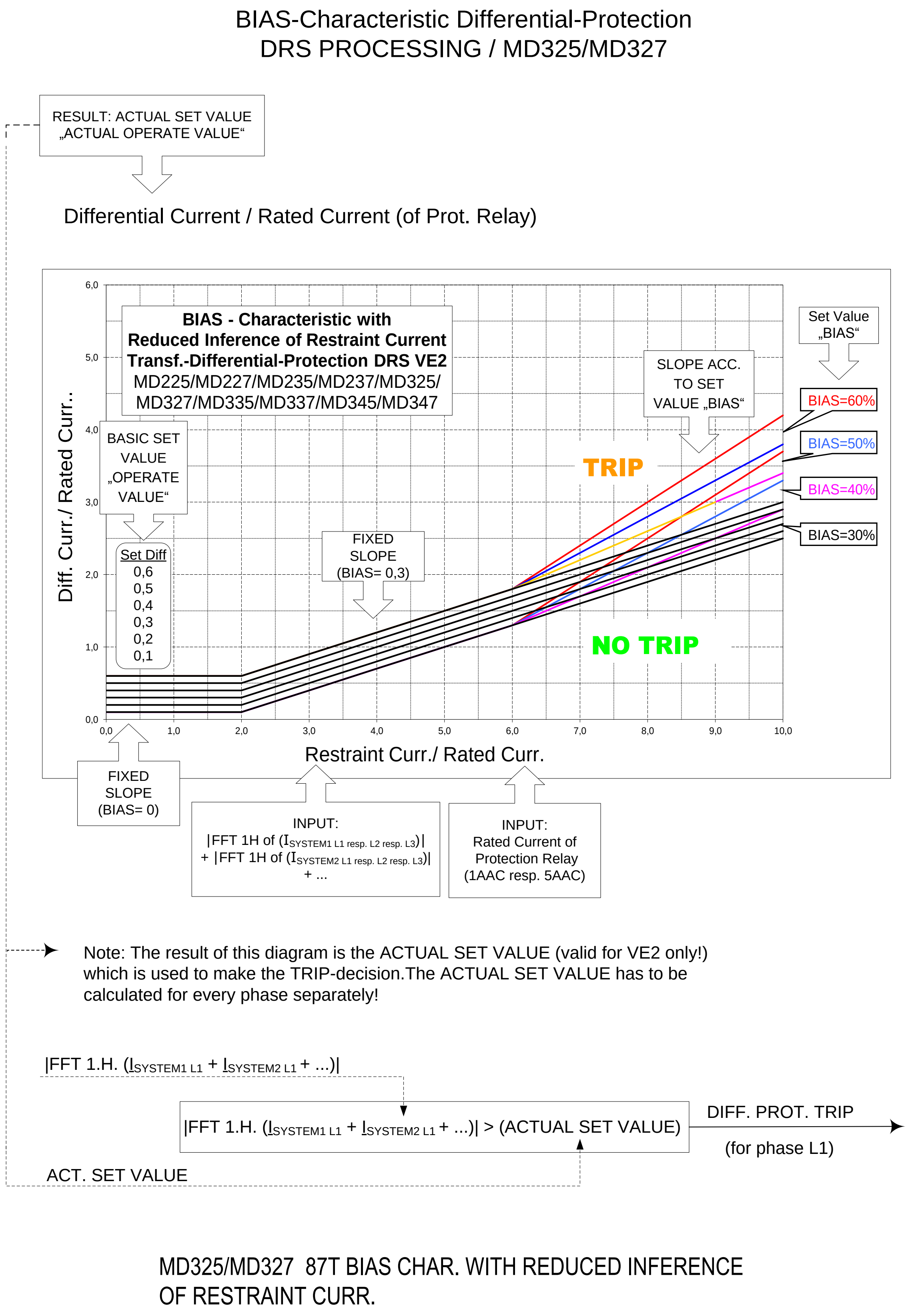
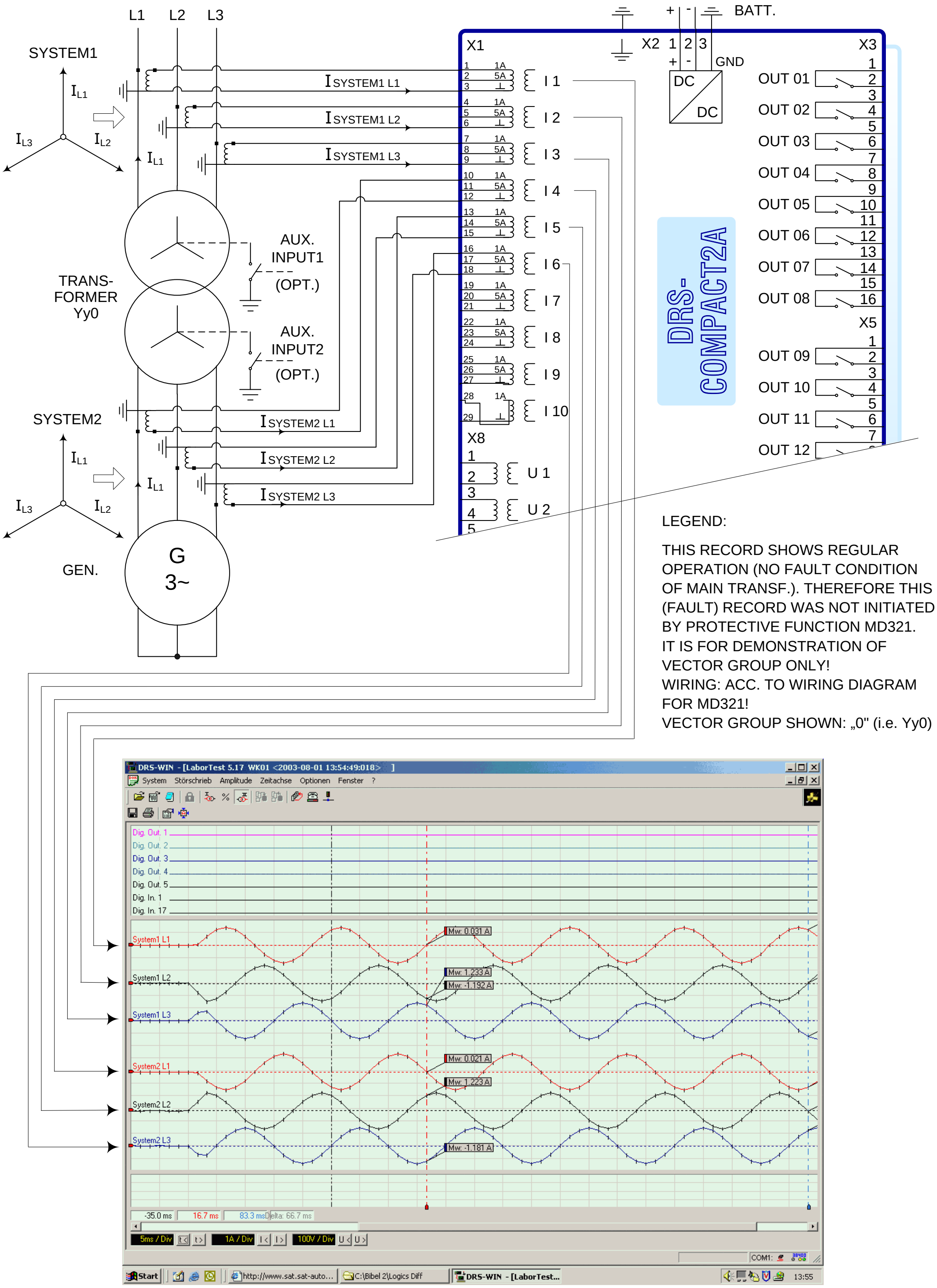
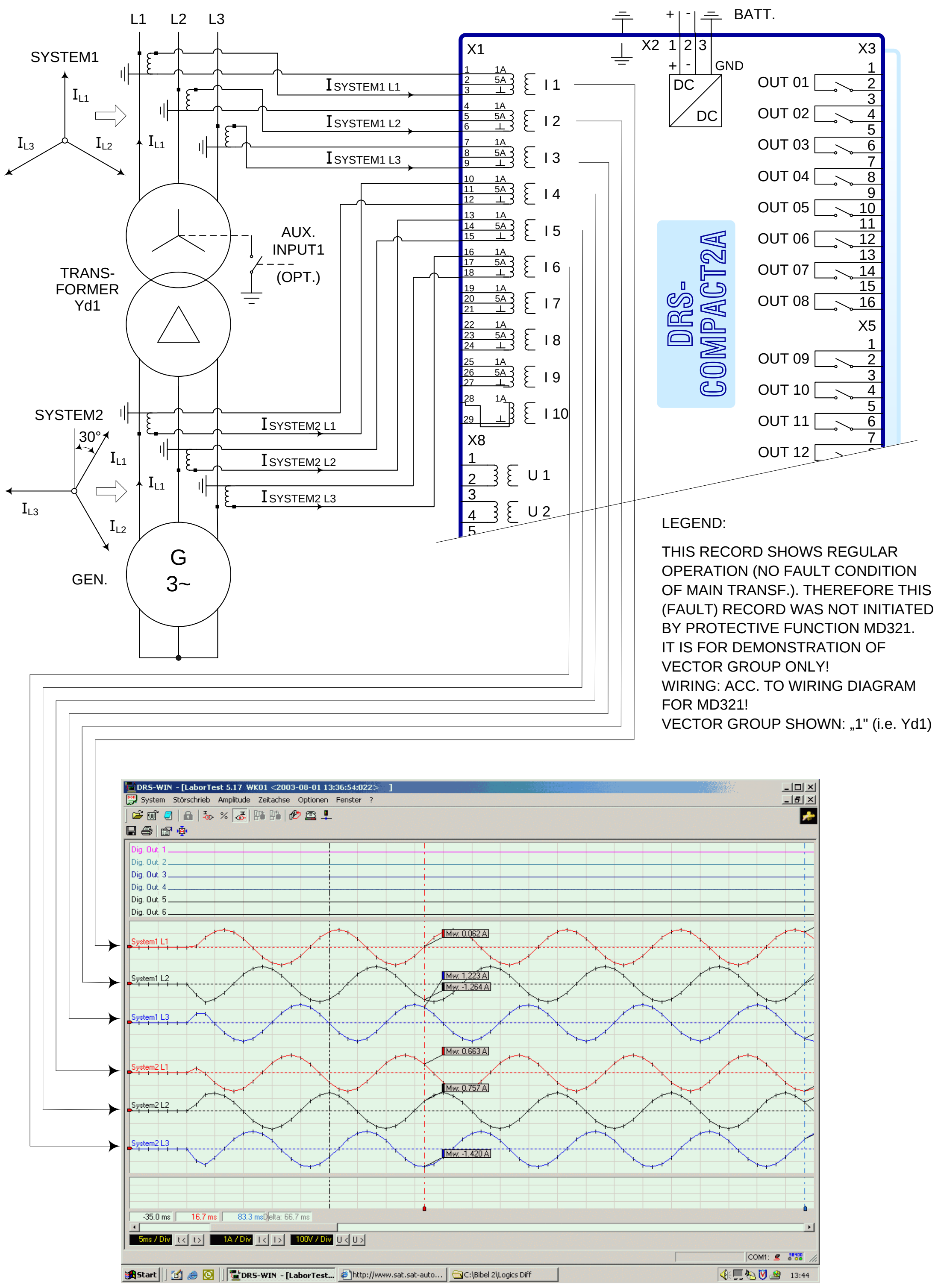


Fig. 56 MD325/MD327 87T Bias Char. With Reduced inference of Restraint Curr.



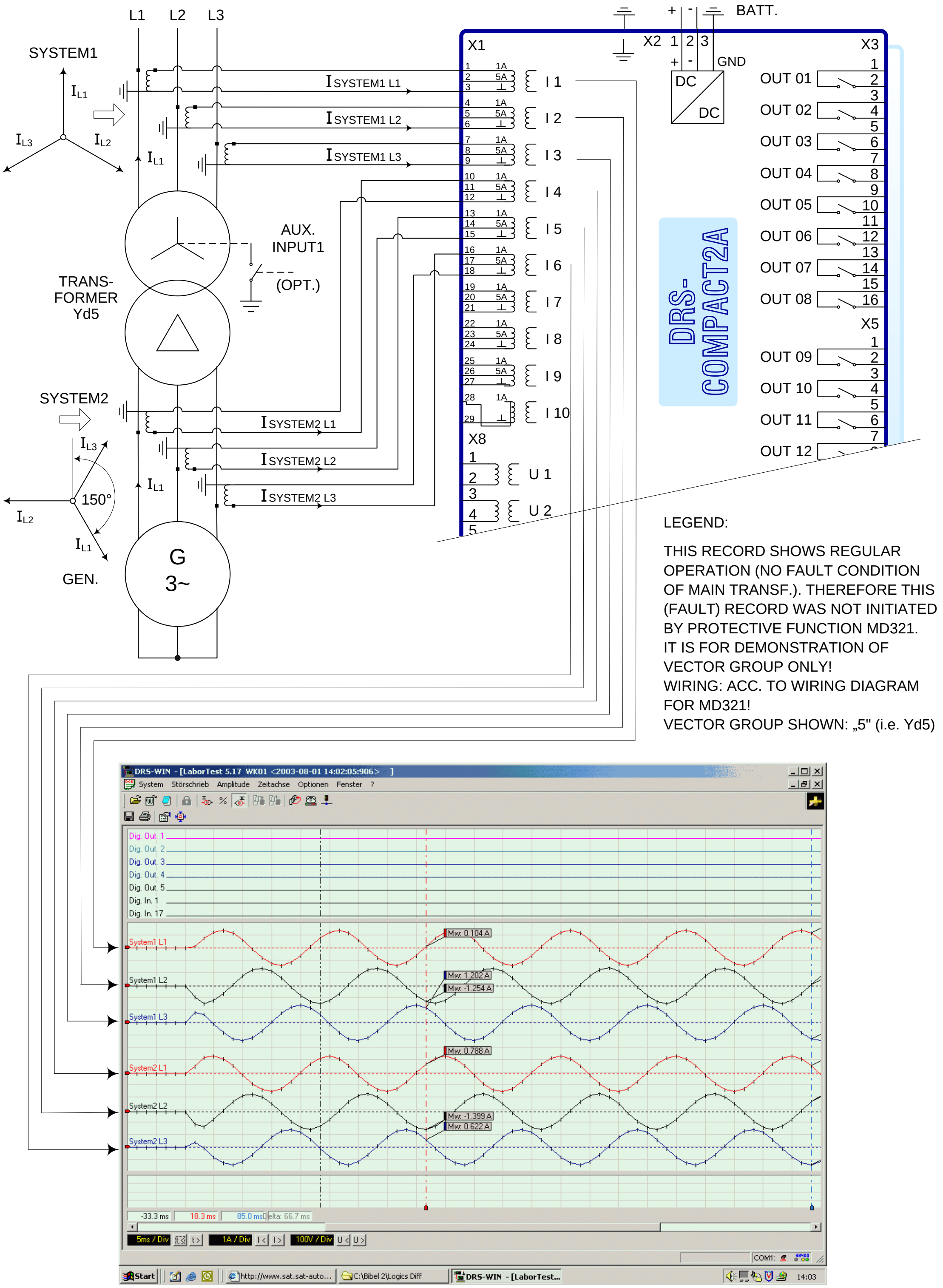
MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „0".

Fig. 57 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,0‘‘.



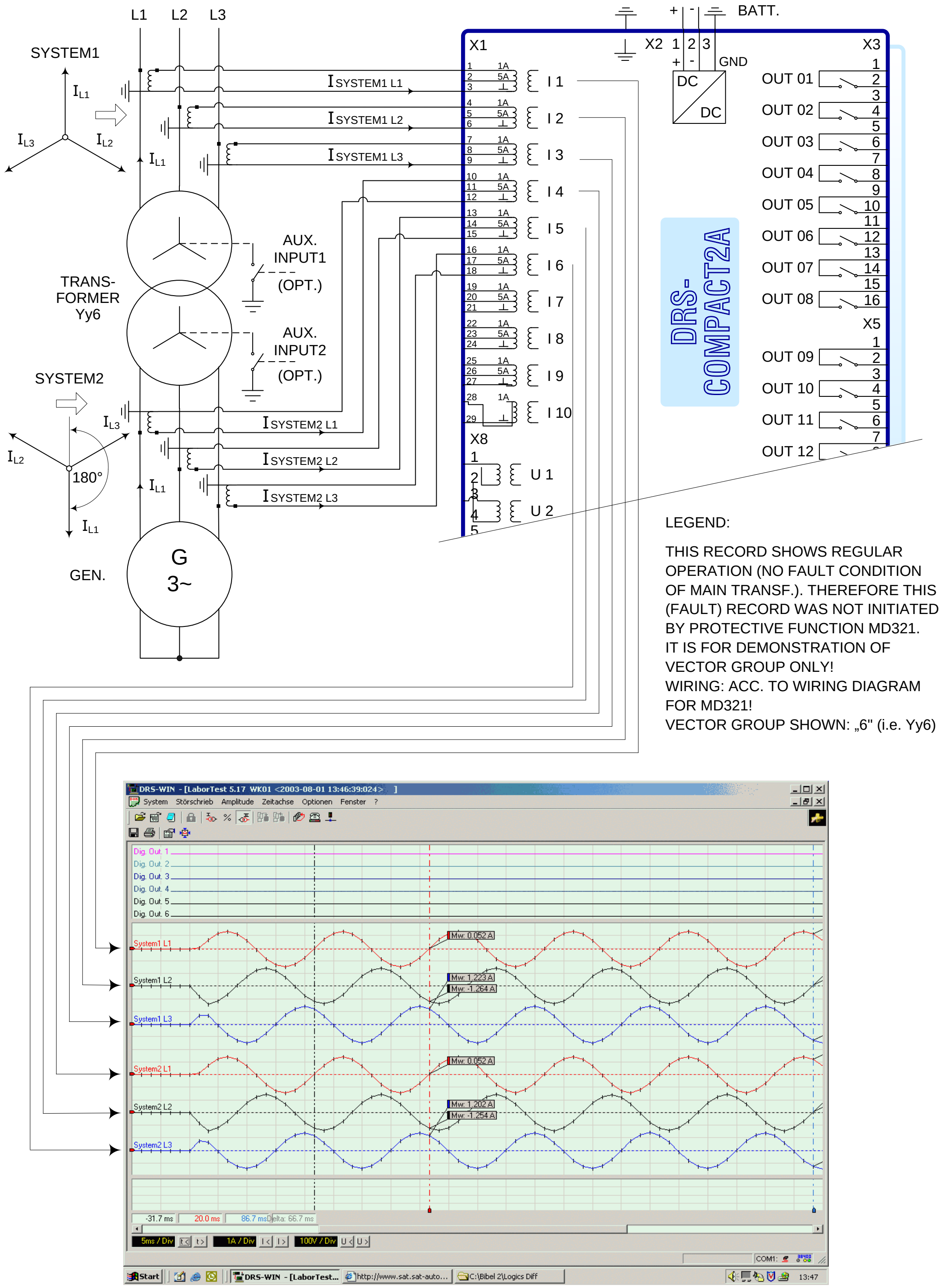
MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „1".

Fig. 58 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,1”



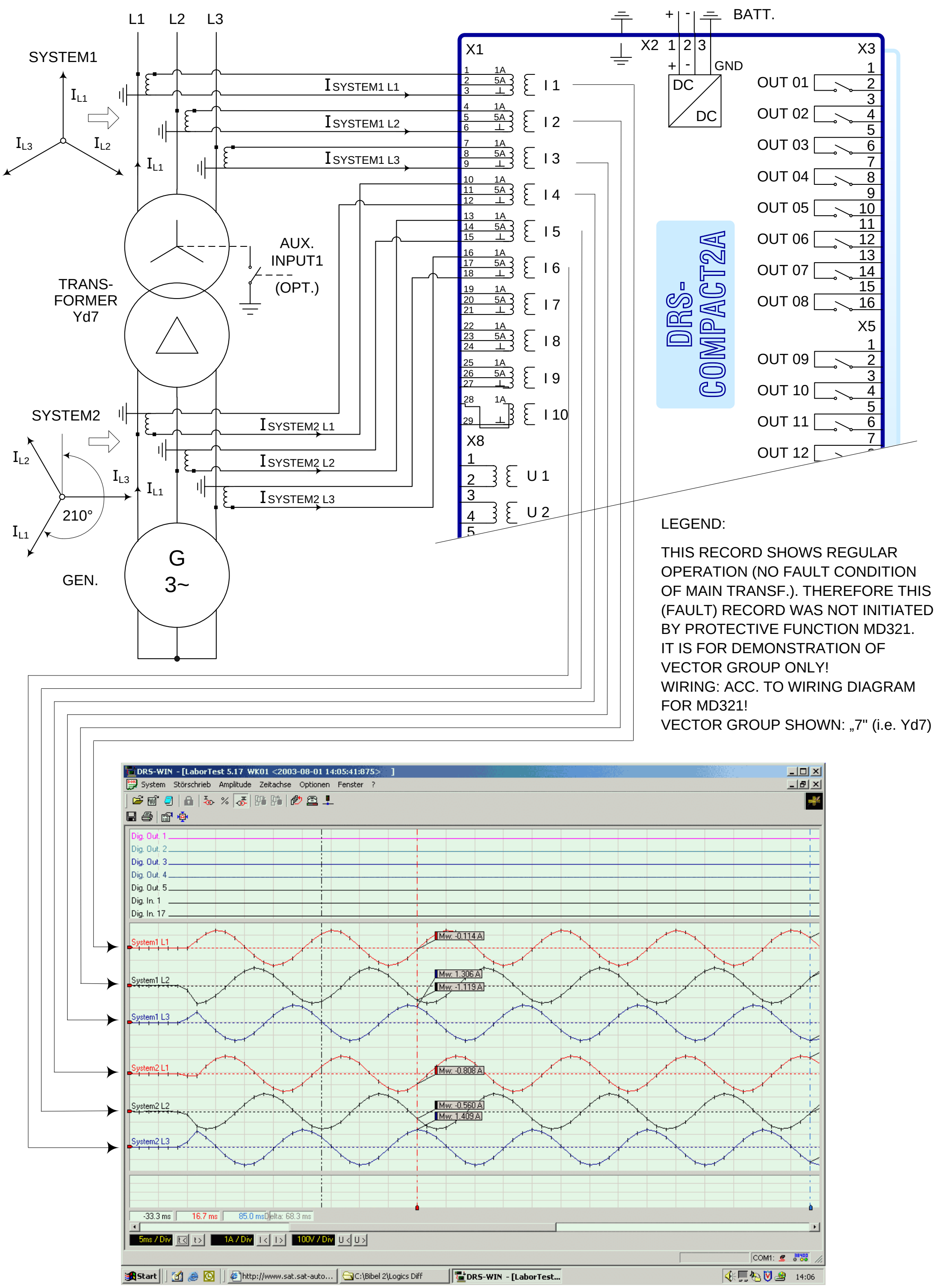
MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „5".

Fig. 59 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,5“.



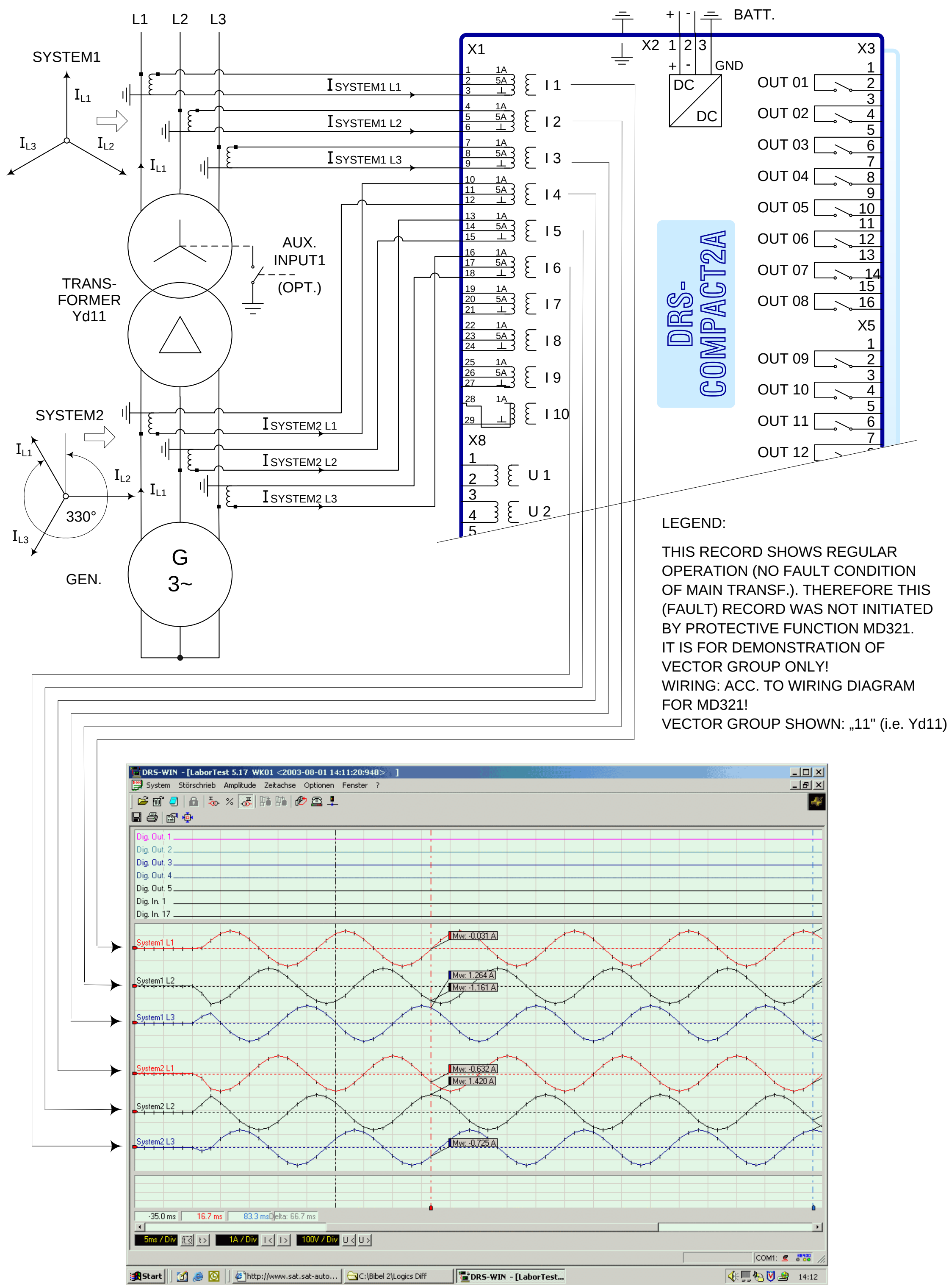
MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „6".

Fig. 60 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,6“.



MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „7".

Fig. 61 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,7‘‘.



LEGEND:

THIS RECORD SHOWS REGULAR OPERATION (NO FAULT CONDITION OF MAIN TRANSF.). THEREFORE THIS (FAULT) RECORD WAS NOT INITIATED BY PROTECTIVE FUNCTION MD321.
IT IS FOR DEMONSTRATION OF VECTOR GROUP ONLY!
WIRING: ACC. TO WIRING DIAGRAM FOR MD321!
VECTOR GROUP SHOWN: „11" (i.e. Yd11)

MD321 VECTOR GROUP VERIFICATION EXAMPLE:
VECTOR GROUP OF MAIN TRANSFORMER = „11".

Fig. 62 MD321 Vector Group Verification Example: Vector Group Of Main Transformer = ,,11“.

5.5. FUNCTION

Differential protective functions are provided as a selective unit protection system against winding short circuits and depending on system grounding also against earth faults. The measuring principle is based on the current vector differential computation within the protected zone of the relevant sets of CT's.

Measuring Principle:
All analogue signals of the function are sampled 12 times per cycle. By means of the Fourier-Analysis (DSP) the corresponding vectors (value and phase) for 1^{st} , 2^{nd} and 5^{th} harmonic are computed and transferred to the CPU

The CPU evaluates for each sample instant the differential signals for each phase and checks whether the actual setting value has been exceeded (please also refer to the BIAS characteristic graph). If during 11 consecutive samples (0.9 cycles) the values are above the setting a trip signal will be initiated.
By this the trip operating time consists of following single time values:
a)
Fourier-Coefficient of the differential signal reaches and exceeds the actual setting value:
Duration: 1 ... 12 Samples (= 1.66 … 20ms, in case of a 50 Hz-system), depending on the size of the differential signal, respectively the ratio to the setting value.
b)
Safety time: 11 consecutive samples = 0.9 cycles.
Note: During the safety time the CPU is checking for any blocking conditions which can be in detail as follows:
- 2^{nd} harmonic is exceeding the setting value (transformer inrush current)
- 5^{th} harmonic is exceeding the setting value (transformer overfluxing due to overvoltage)
- Blocking input of the function is set, e.g. via an external auxiliary contact or a logic function
- C.T. – saturation detection: will result in an change of the BIAS-characteristik (see MD326, MD327)
c)
Output relay: approximately 5 ms
d)
The sum of times is typically smaller than 30 ms.
e)
Accelerated-Tripping-Feature: Decision is done by evaluation of higher harmonics resp. signal quality; waiting time is set to zero if specific preconditions are fulfilled.

Tripping Logic:
The trip conditions per phase are indicated in detail in the respective logic diagrams.
The vector group compensation is digitally computed according to the vector group setting ensuring that the currents of all transformer windings are correctly in phase for the subsequent evaluation.
Any zero sequence currents of the protected plant are compensated either by the zero sequence current compensation setting "ON" or via the "EXTERNAL" input signal in accordance to the neutral isolator position.
The transformer ratio and the CT ratios are considered by the "CT ratio compensation system 2-1".
The current vectors are now phase-wise added to the differential current and the basic harmonic, the 2^{nd} harmonic and the 5^{th} harmonic quantities are phase-wise computed.
If during 11 consecutive samples (0.9 cycles) the values are above the setting a "Trip" and "Differential current" signal will be initiated.

Bias Current / Stabilising:
The bias currents are phase-wise computed from the 1^{st} harmonic currents of all windings of the transformer differential protection and the tripping conditions for each phase are illustrated in the following graph.

Special case:
Functions MD**6 and MD**7 -additionally include a C.T. – saturation detection feature. If a C.T.-saturation is detected then the BIAS-characteristic automatically will be switched to a 65% - gradient.
Precondition: C.T. – Saturation Detection must be active (set value "Saturation Protection" > 0).

Please Note:

Fig. 5-1: Transformer-Differential-Protection:
Standard BIAS-Characteristic for the functions:
MD221, MD224, MD226, MD231, MD234, MD236, MD321, MD324, MD326, MD331, MD334, MD336, MD341, MD344, MD346

Fig. 5-2: Transformer-Differential-Protection:
Characteristic with reduced influence of restraint current for the functions:
MD225, MD227, MD235, MD237, MD325, MD327, MD335, MD337, MD345, MD347

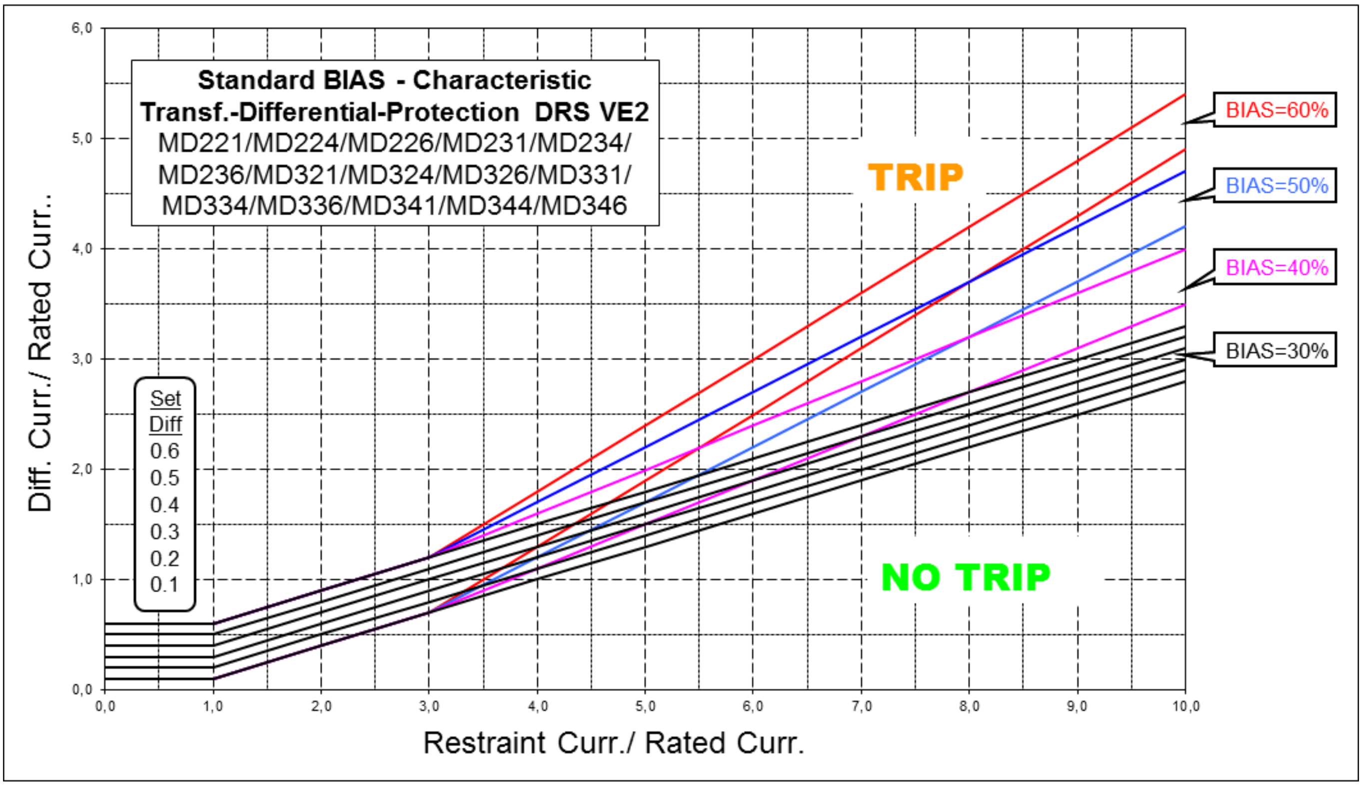


Fig. 5-1: Standard BIAS–Characteristic

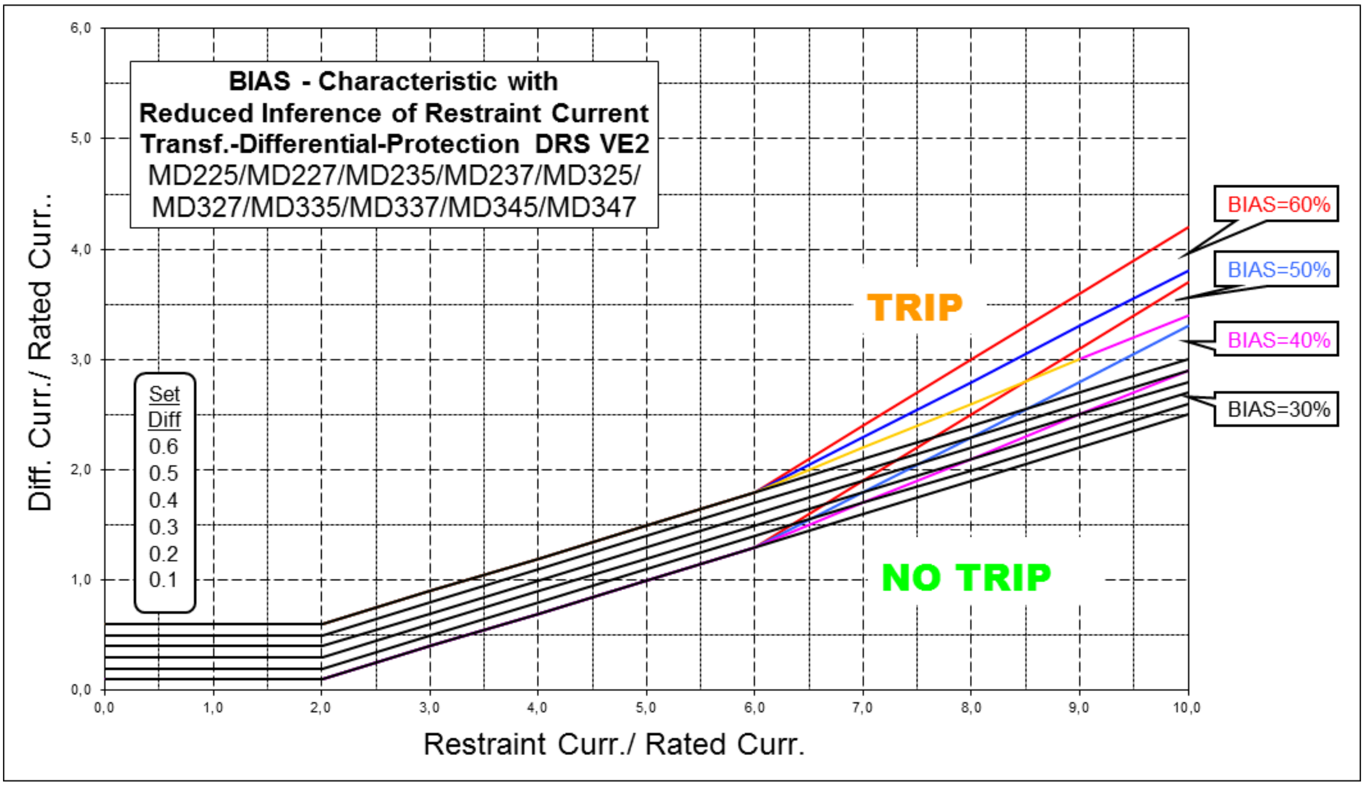


Fig. 5-2: Characteristic with reduced influence of restraint current

Higher harmonics blocking
The Trip of a phase is blocked when the relation between the 2nd and the basic harmonic or the 5th harmonic and the basic harmonic parameter setting value is exceeded. This way a false trip during transformer energizing (2nd harmonic) resp. transformer overexcitation (5th harmonic) is prevented.

Please Note:
For the functions MD221, MD231, MD321, MD331, MD31 the higher harmonics blocking is phase selective, i.e. each phase is considered independently from the others; for the functions MD224, MD225, MD234, MD235, MD324, MD325, MD334, MD335, MD344, MD345 the higher harmonics blocking is either phase selective or phase overlapping according to the respective parameter setting.
The phase overlapping mode means that when the higher harmonics content has been exceeded in one phase also the other two phases are blocked automatically.

High set differential stage (in reference to the higher harmonics blocking and – if applicable – with reference to C.T. saturation detection)
Currents containing higher harmonics can also develop during system faults. Therefore when the differential current "high set differential stage" parameter is exceeding the set value blocking of the trip is being phase-wise and independent of the higher harmonics content resp. – if applicable – the status of the C.T.-saturation detection circuit, de-blocked and tripping initiated. The function output “Blocking" signals the condition of the trip blocking.

CT saturation detection
The transformer differential protective functions MD**6 and MD**7 include an automatic CT saturation detection (phase selective BIAS-change in case of CT saturation due to a high through fault current with DC offset).
The C.T.-saturation detection feature is based on sample values which are evaluated by a special logic. It takes approx. 2 ms to detect an outzone fault with C.T.-saturation.
In this case the BIAS-characteristic is changed automatically to a 65% gradient course which originates from the center of the coordinate system.

Preconditions:
- Set value "Saturation Detection" > 0 (note: "0" means that the feature is switched off)
- Fault is of "outzone" – type

All Differential Protective Functions with CT-saturation detection have an additional digital output: "CT saturation", in order to differentiate between "Interlock 2.H./5.H." and "CT Saturation".

Digital Outputs of Functions MD**6 and MD**7
- Trip (CB trip)
- Diff. Current (differential current is above set value)
- Interlock 2.H./5.H. (2.Harm. above set value, or 5.Harm. above set value)
- CT Saturation (CT saturation was detected during "outzone" fault)

Please note:
The digital output "CT saturation" informs that a CT – saturation during an "outzone" – fault has been detected. As a consequence the BIAS-characteristic will automatically change to a slope of 65%.
There will no direct (digital) blocking of tripping (as it is the case for example with "Interlock 2.H./5.H".

A trip of the Differential Protective Function even in case of CT-saturation could be possible in the following cases:
- Set value "CT Saturation" is zero (= "CT Saturation"- feature is switched off).
- Differential Current exceeds the set value "High Set OC".
- Fault is of "inzone" – type (saturation detection must not respond in case of "inzone")
- "Outzone"-fault with excessive CT saturation (CT saturates immediately). In this case the detection logic could be not working properly (not enough samples), or the 65%-BIAS characteristic is not sufficient anymore for preventing a maltrip. Please mind: It is not possible resp. it does not make sense to detect a CT saturation which is approx. 0% or 100%.

Trip reset

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

5.5.1. Detailed Description of CT Saturation Detection Feature

5.5.1.1. Transformer Differential Protective Functions with CT – Saturation Detection

MD226
MD227
MD236
MD237
MD326
MD327
MD336
MD337
MD346
MD347

5.5.1.2. CT Saturation Detection Principles

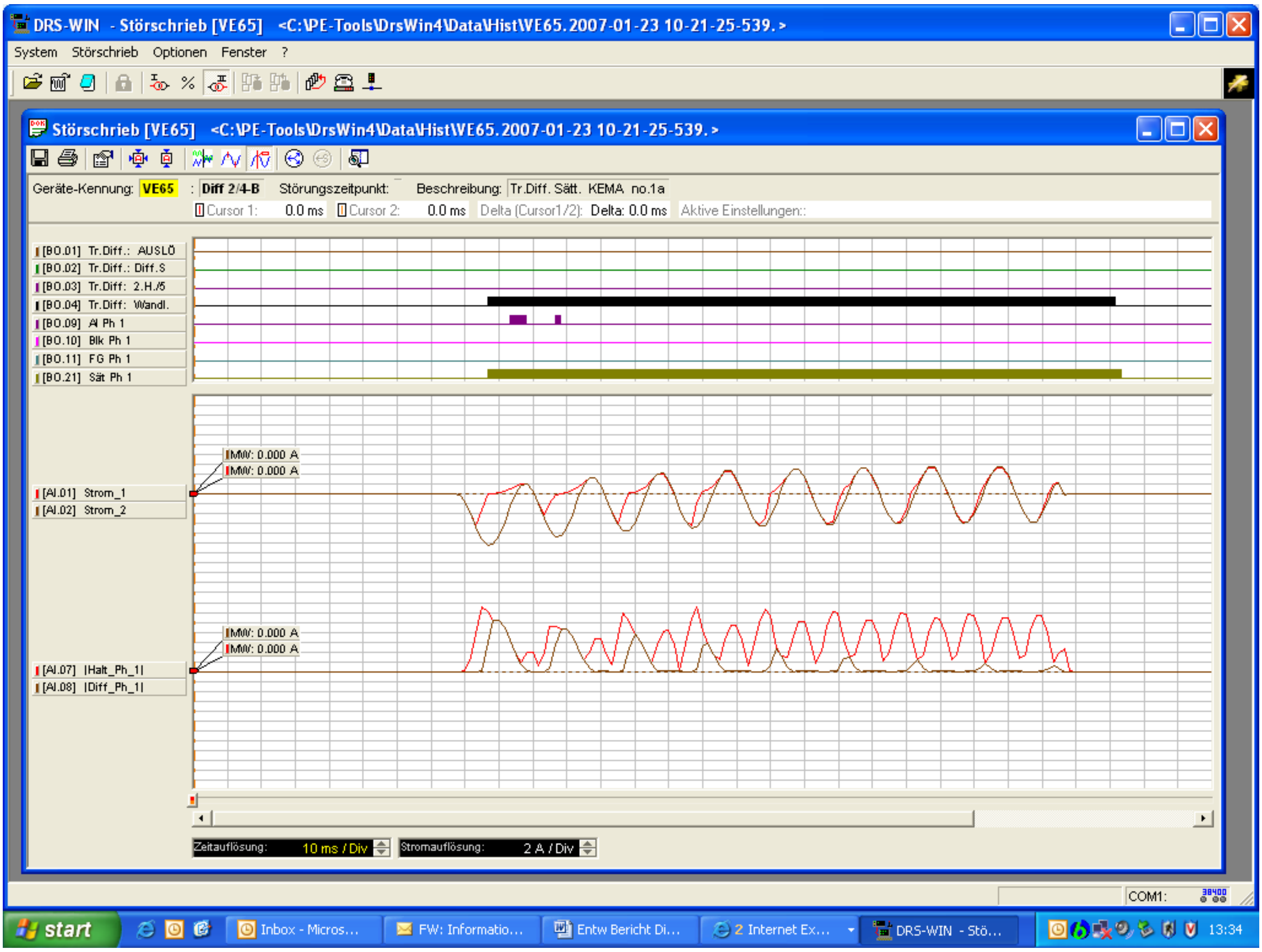
Logic

The differential and the restraint currents are analyzed by a special logic circuit, sample by sample, separately for every phase. CT – Saturation will be detected within approx. 2 ms.
If a CT – Saturation is detected the BIAS-Characteristic is changed to 65 %.
Note: The Differential Protective - function will not be blocked absolutely (for safety reason).
The logic circuits respond to CT-Saturation in case of outzone faults only.

5.5.1.3. Explanation of CT – Saturation Detection

5.5.1.3.1. Precondition: Outzone Fault.

Please see Disturbance Record below:
Note: This Record was saved by a MD326 Transformer Differential Protection.



Analysis of Record:

a)

The record shows an Outzone Fault.

The first two recorded curves show the phase currents of phase L1.
Current of phase L1 HV-side (red line: CT-saturation
Current of phase L1 LV- side (black line): no CT-saturation.

b)

Recorded curves no.3 and 4 (actually these lines are calculated by the DRWIN Operating Program):
These curves show the Differential Current and the Restraint Current (which is used for the BIAS-characteristic).
Black line: Differential current (absolute value of vector difference of the phase currents)
Red line: Restraint current (sum of absolute values of the phase currents)

Please note:
Curve no. 3 and 4 are shown as absolute values in this diagram (rectified values).

c)

The CT saturation detection logic analyzes the curves no. 3 and 4.
The result is a digital CT-saturation bit (please compare Digital Output track no. 4/ counting from top of the Record/ " = black line"). The activation of the CT-saturation bit changes the BIAS-characteristic to 65 %. Please note: The CT saturation detection feature just changes the BIAS characteristic, there is no digital blocking applied to the differential protection function (as it would be the case for example with the Inrush Detection – feature).

d)

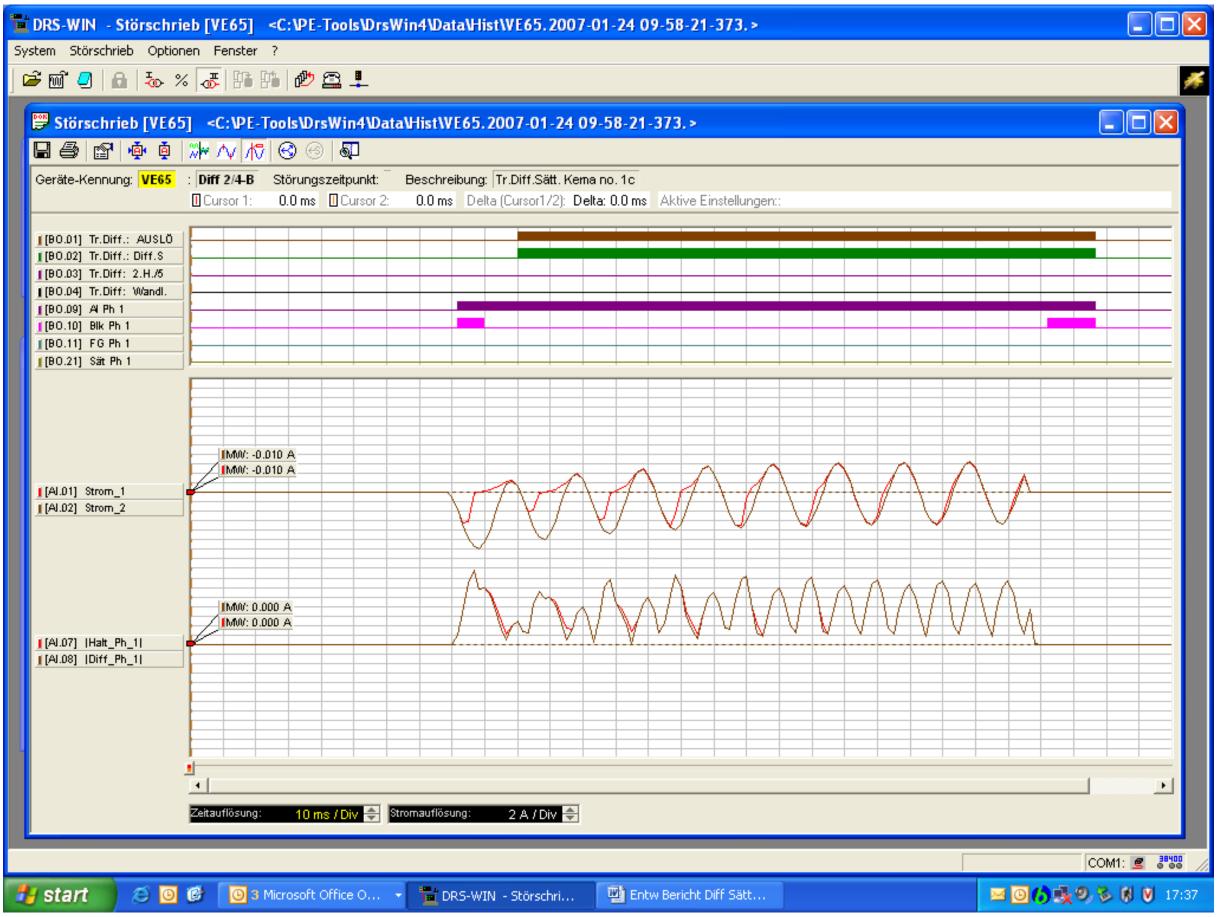
Please note that the CT-saturation detection circuit is very fast. It takes approx. 2 ms to detect a CT-saturation. The saturation bit ends approx 1,1 periods after the last detected CT-saturation in order to avoid malfunction resulting from (for example) unsymmetrical DC-components.

e)

Conclusion:
CT-saturation is detected very fast and reliably.

5.5.1.3.2. Precondition: Inzone Fault

For comparison we also include a Recorded Curve showing an Inzone Fault with CT-saturation.



Result:
As you can see the Protective Functions trips immediately because we have an Inzone Fault.
See digital tracks no. 1 and 2.
Note: The CT – saturation is the same as we had in the former case.

Result:
Reliable and fast tripping in case of inzone fault even in case of heavy CT – saturation.
OK.

5.6. COMMISSIONING

Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry and the operating value and the bias slope set according to requirements.

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

The vector group parameters have to be set according to the transformer vector group and also it has to be considered that system 1 is the reference system.

The zero sequence current filter for system 1, system 2, system 3 and system 4 are to be set to “ON” or “OFF” or for "EXTERNAL" input. Using the external input contact the correct function via the "Binary In/Output pre-selection" has to be verified.

The parameters for the inrush blocking (2nd harmonic, 5th harmonic, high set differential stage) are either set to the existing values to the proposed default values of the User program.

The CT ratio compensation "System 2-1" is set according to following formula.

CT ratio compensation $A = \frac{I_{w2}}{I_{w1} \times R_{T1,2}}$

I_{W1}................. CT primary ratio system 1
I_{W2}................. CT primary ratio system 2
$R_{T1,2}$............. Transformer ratio system 1/system 2

Analogous when applicable "CT ratio compensation system 3-1" and the "CT ratio compensation system 4-1" are being calculated accordingly.

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

The function checks are preferably performed with the primary protected plant being out of service.
To check the function with a relay test set, e. g. the CT inputs for system 1 phase L1 the test current is injected and raised up to the operation of the relay thereby observing the operating value with respect to the operating characteristic.

Please note that with the zero sequence current filter activated a single phase injected test current is evaluated only by 2/3rd of its actual value. The operating value should be recorded into the commissioning test sheets.

The injected test current is now reduced and the reset value of the function recorded.

Please note that the external injected current values can be displayed and compared with the internal measured values, i.e. phase – and differential currents, in the User operating program display Window

The same is to be carried out for the other two phases of system 1 and the measured values recorded.

Now the test current injection should be carried out on phase L1 in system 2.

Please note that for an uneven vector group value (delta connection of system 2) injected current is evaluated by "$A/\sqrt{3}$" and by even vector group (star connection) evaluated by factor "A".

Check the operating- and reset values as with system 1 for all 3 phases and record the result in the test sheets.

The same tests as per system 2 should also be performed for system 3 and system 4 if applicable.

The trip- and alarm signals and the LED indications should be confirmed according to the relay configuration and the connection diagrams.

Measuring with twice the differential current setting injection in system 1 and the resulting operating time of the protective function should to be carried out for each phase either via a timer or the "Recorded Curves" in the User program to record the measured values.

A test of the configured function blocking input should be done in conjunction with a continuously initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal can be verified without any external initiation.

A phase-wise check of the inrush blocking should be carried out by single phase injection of a one-way rectified DC current signal on system 1 regarding blocking and the high set differential stage operation according to the set parameters.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to the plant requirements.

After the tests any temporary setting changes should be restored to the original parameter settings.

<u>Commissioning Tests</u>:

During commissioning the function of the protection scheme is tested during normal service conditions.
If possible following tests under operating conditions are recommended:

- Short Circuit Test for an Internal Fault

Install a short circuit with a suitable cross section between all phases inside the protected zone.
Block protection trips.
Note: Due to safety reasons it is recommended to take precautions against excitation system faults (regulator failure, wrong connections, etc.) and the inadvertent opening of the short circuit.
Suitable safety precautions are, for example, the activation of an overcurrent- and overvoltage function.
Preferably the tests are carried out with reduced settings and only after life trip checks,
e. g. excitation contactor trip, etc.!
Connect measuring instruments into the CT circuits and/or display the actual measured values window in the User program.

Start up the generator to rated speed and manually raise excitation to produce operation of the differential protection. Record the operating values.
Restore the protection trips.
Shut down the generator if possible via a protection trip and remove the short circuit.

- Short Circuit Test for a Through Fault

Install a short circuit with a suitable cross section between all phases outside the protected zone so that the two sets of CT's can be provided with the test current flow (system 1 and system 2) and raise the excitation to produce up to nominal current thereby the differential protection has to be stable (differential current ≤ 5% I_n). Select the display of the actual measured values window in the User program (Notebook) and record these values. The same procedures should be adopted for the other windings of the generator-transformer/transformer unit.
Shut down the generator if possible via a protection trip and remove the short circuit.

- Transformer Energising Tests

All protective systems have to be restored to the original service values. When the transformer is energised for the first time the configured LED indications should be observed. The differential protection must not operate during energising otherwise the it has to be investigated whether the 2nd and 5th harmonic settings are adequate or a real fault is existing by referring to the "Recorded Curves" of the User program. In case of on-load tap changer transformer types these tests should be repeated for different tap positions and possible other parameter settings of the inrush restraint settings.

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6. ME...   OUT OF STEP PROTECTION

6.1. OVERVIEW

List of the Available ME . . . Out of Step Protective Functions

Abbreviations:

C2	... DRS-COMPACT2
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTION: ME 311/ ME312	FNNR	TYPE	ANSI	Application
"Out of Step" for Three Phase Systems Generator, MHO	1073	ME311	78G	C2
"Out of Step" for Three Phase Systems Motor, MHO	1128	ME312	78M	C2

6.2. TECHNICAL DATA

6.2.1. Out of Step Protection With Circular MHO Characteristic for 3-Pase Systems

PROTECTIVE FUNCTION: ME 311/ ME312	FNNR	TYPE	ANSI	Application
"Out of Step" for Three Phase Systems Generator, MHO	1073	ME311	78G	C2
"Out of Step" for Three Phase Systems Motor, MHO	1128	ME312	78M	C2

The "Out of Step" protective functions ME311 (Out of Step Relay for Generators) and ME312 (Out of Step Relay for Motors) are 3-phase / 1-stage "Out of Step Feature" relay functions with configurable blocking settings during unsymmetrical load currents and decrease of the minimum set values of the positive sequence generator current and voltage. They are based on the computation of the time sequence and the complex evaluation of the MHO characteristic settings based on the time event whereby the evaluation is according to the rate of change of the impedance vector of the positive sequence current.

ME311/ ME312
Technical Data

Inputs

Analog:	Current phase L1
	Current phase L2
	Current phase L3
	Phase to phase voltage L1-L2
	Phase to phase voltage L2-L3
	Phase to phase voltage L3-L1
Binary:	Blocking input
	Test input

Outputs

Binary:	Instantaneous alarm
	Time delayed trip
	Alarm: Negative phase sequence current blocking

Setting Parameters

Base point (R1):	-100 ... 100 Ohm in 0,1 Ohm steps
Offset (R1 – R2):	10 ... 250 Ohm in 0,1 Ohm steps
Blinder slope:	20 ... 90 Grad in 0,1 Grad steps
Circle diameter:	10 ... 500 Ohm in 0,1 Ohm steps
Circle centre:	-250 ... 250 Ohm in 0,1 Ohm steps
Slip pulse number:	1 ... 20
Time window t1:	0,01 ... 1.00 s in 0,01 s steps
Slip cycle T1:	0,10 ... 20,00 s in 0,01 s steps
Time window t2:	0,01 ... 1.00 s in 0,01 s steps
Slip cycle T2:	0,10 ... 20,00 s in 0,01 s steps
Activation time T3:	1,0 ... 60,0 s in 0,1 s steps
Negative phase sequence:	10 ... 20 % s in 0,5 % steps
Current interlock:	0,00 ... 4,00 xIn in 0,05 xIn steps
Trip:	Instantaneous / delayed
Current direction:	Direction 1 / Direction 2
Phase rotation:	Clock wise / counter clock wise

Window Display for Relay Internal Determined and Computed Values

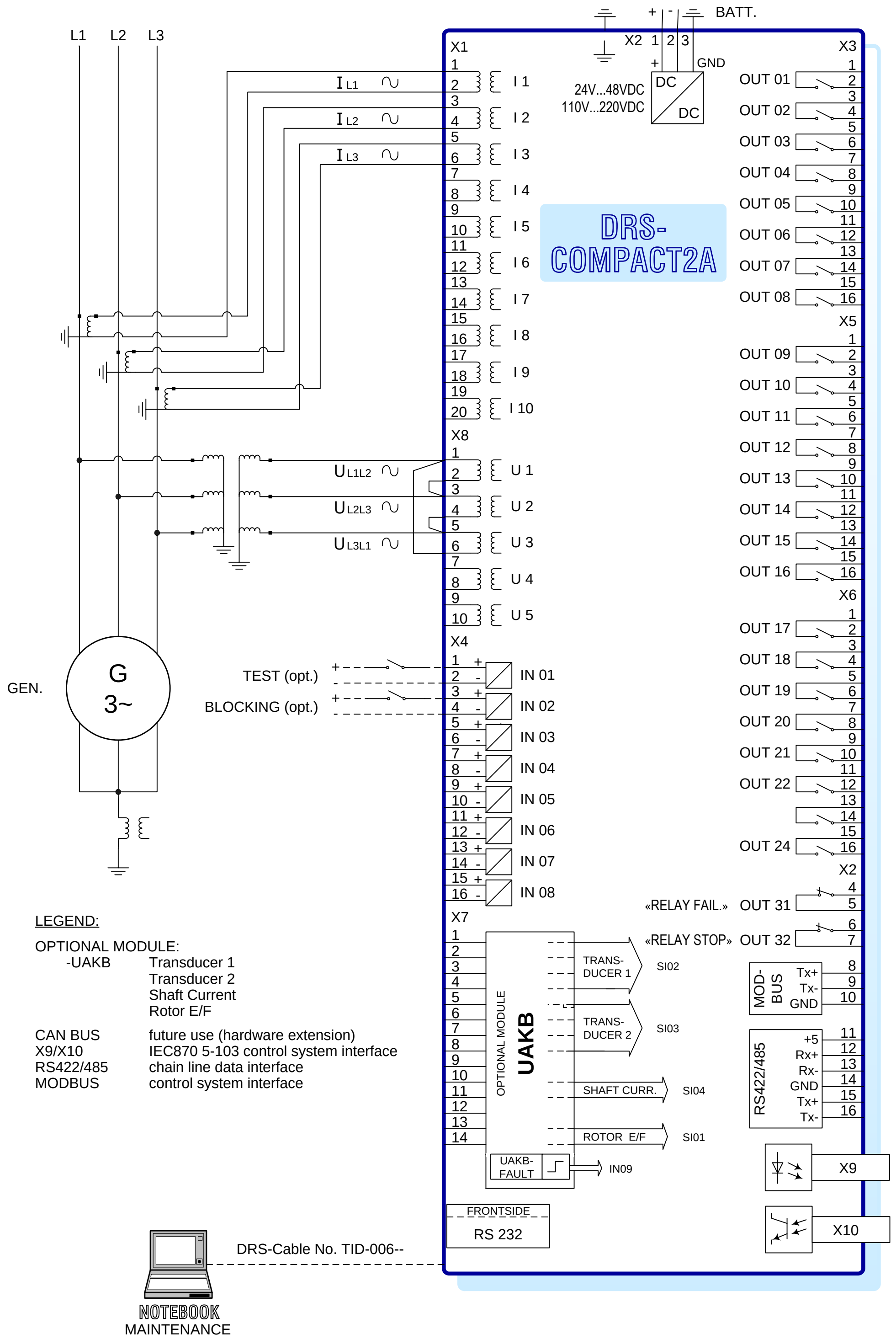
Slip pulse	[number of current slip]
System impedance	In [Ohm] (absolute value of the impedance vector), whereby 1 p.u. = 57.7 Ohm = phase voltage / phase current (in relation to the relay nominal values (100V/1A respectively 100V/5A).
Impedance angle	in [degrees] (angle of the impedance vector)
Time running	[Yes / No]; the time starts when crossing R1 and ends either with a trip or a function reset when one of the necessary conditions are no longer fulfilled
Positive sequence current	in [A]
Positive sequence voltage	in [V]
Negative phase sequence current	In [%], in relation to the relay nominal values (1A respectively 5A).

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

6.3. CONNECTION DIAGRAM

6.3.1. ME311

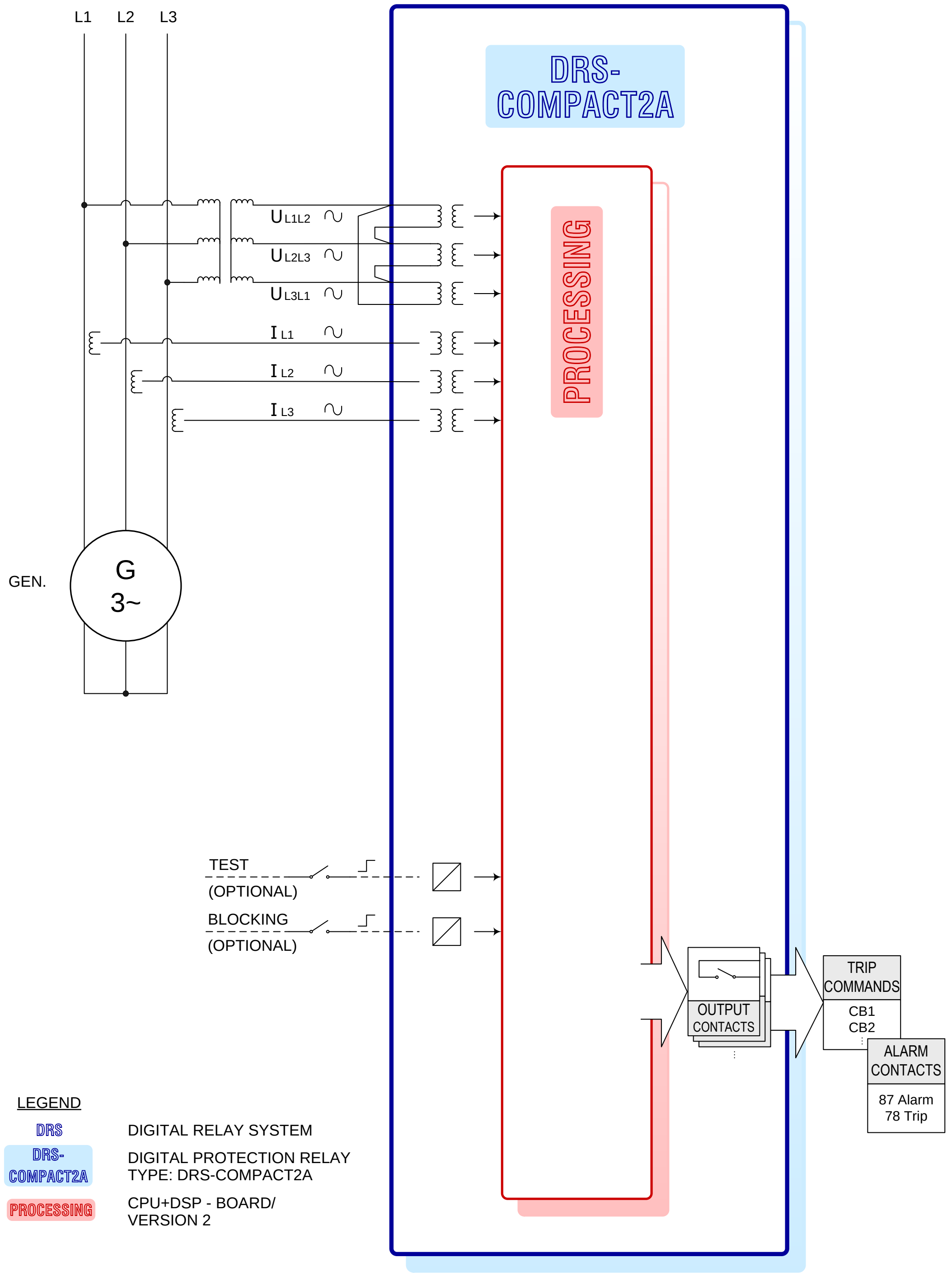


ME311 78MHO WIRING DIAGRAM

Fig. 63 ME311 78MHO Wiring Diagram

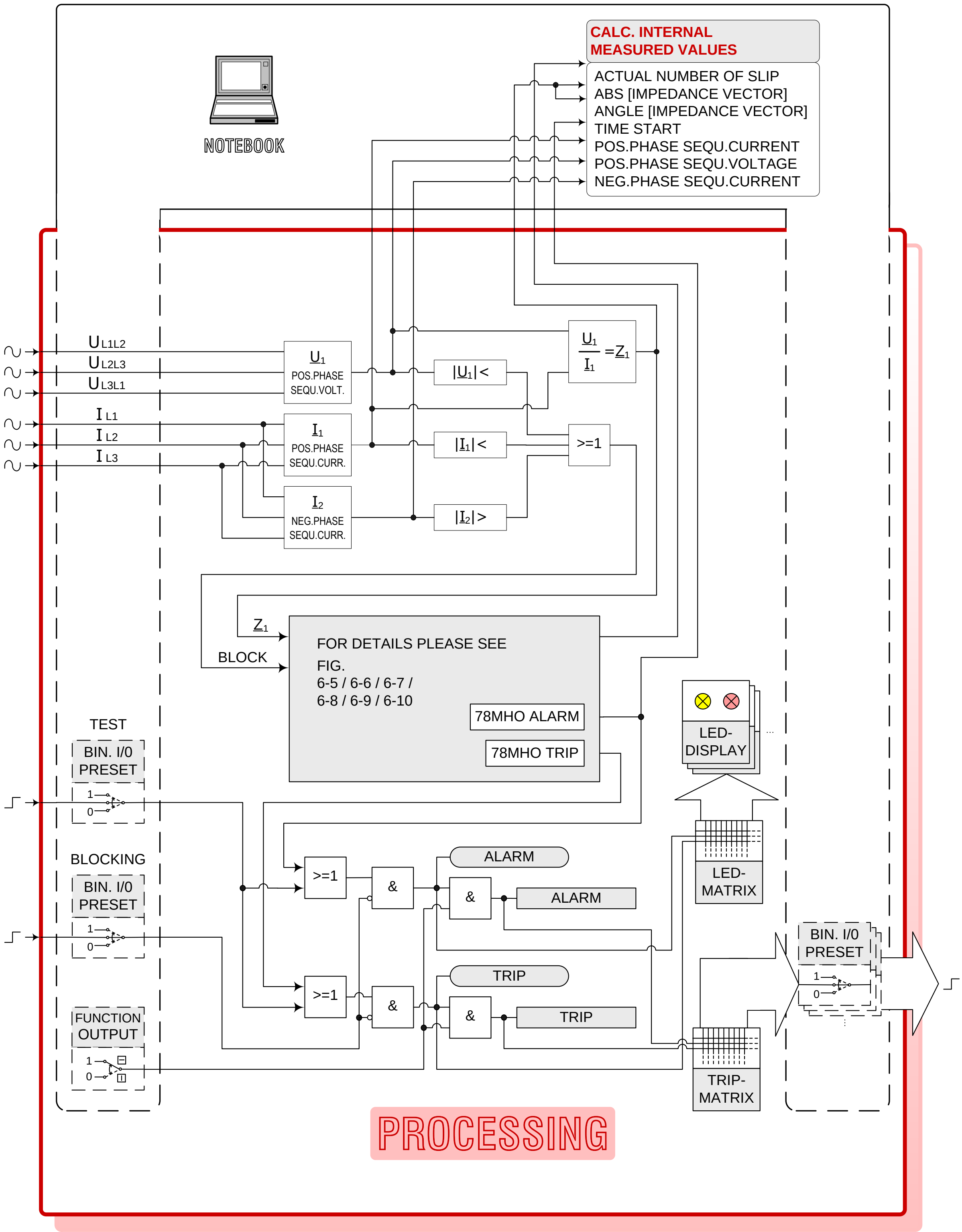
6.4. LOGIC DIAGRAMS

6.4.1. ME311



ME311 78MHO LOGIC DIAGRAM

Fig. 64 ME311 78MHO Logic Diagram



ME311 78MHO LOGIC DIAGRAM / PROCESSING

Fig. 65 ME311 78MHO Logic Diagram / Processing

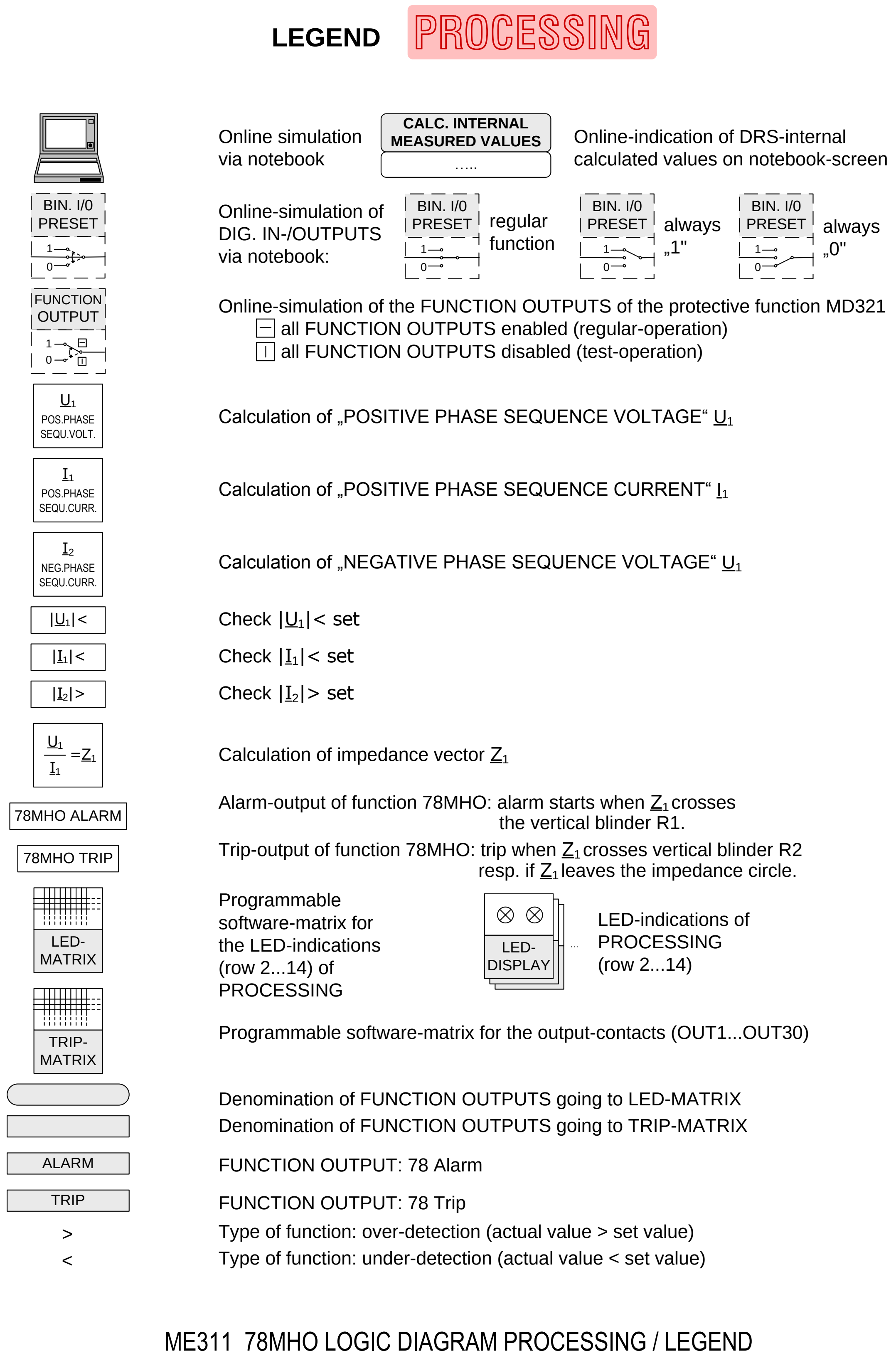
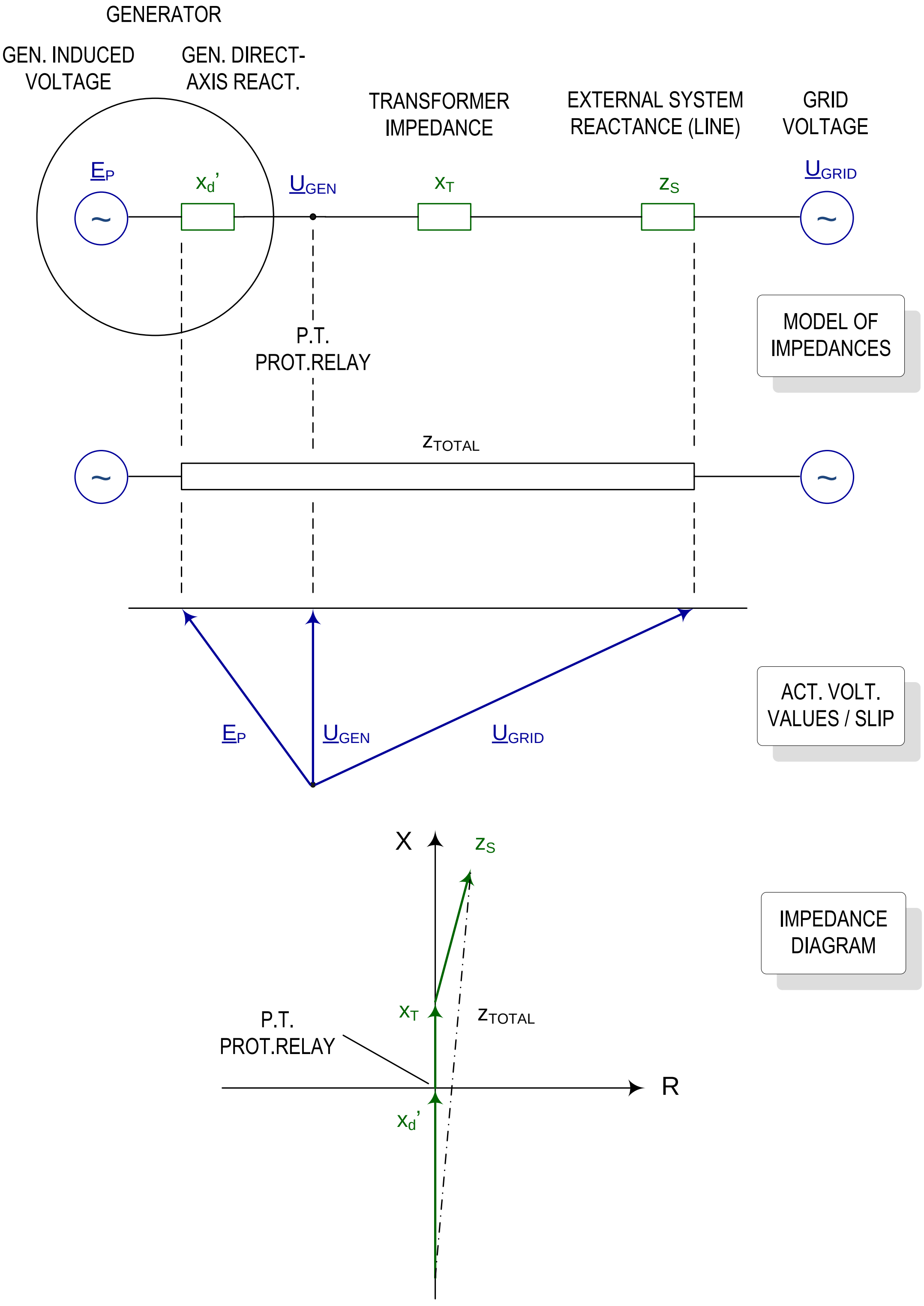
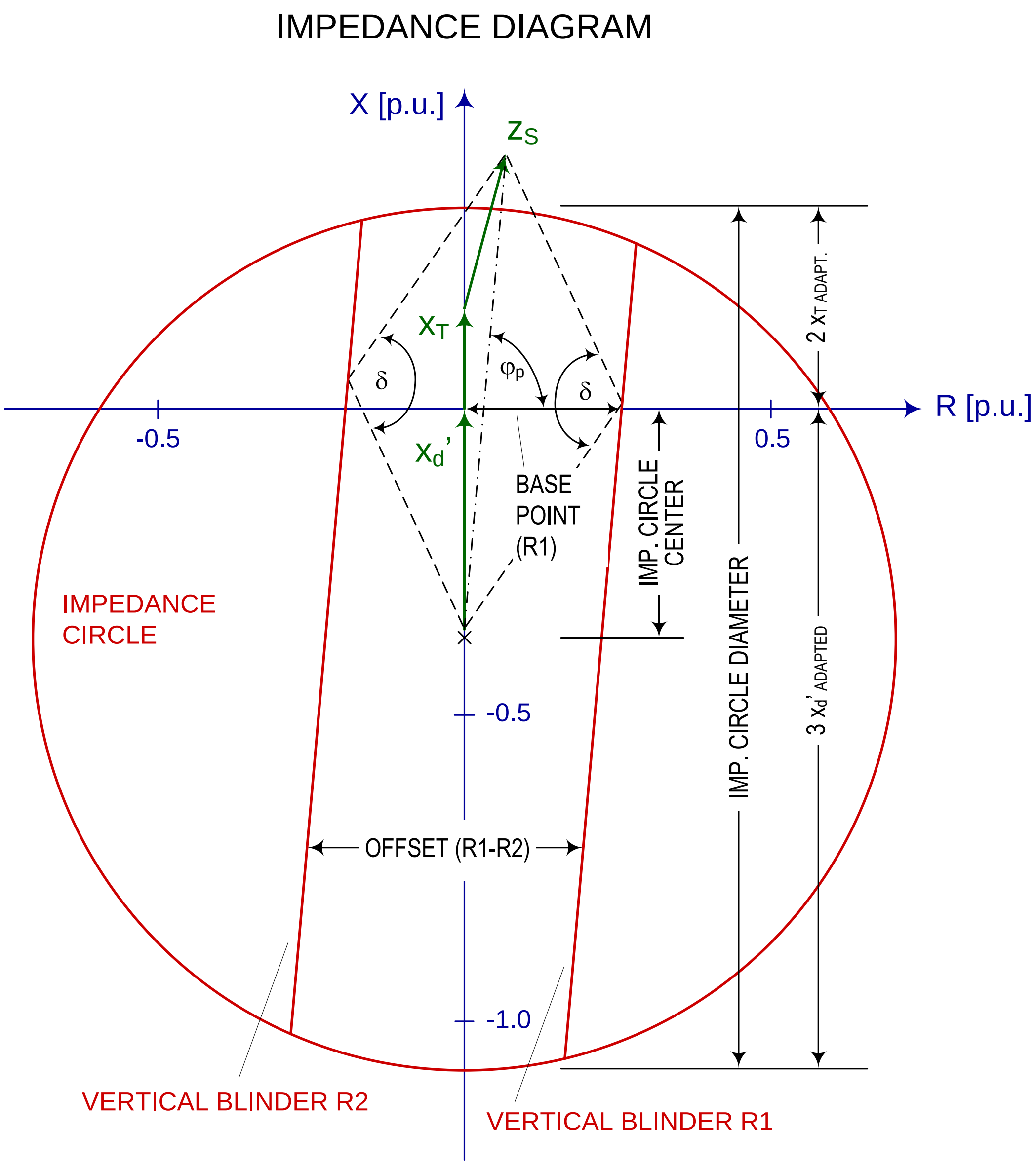


Fig. 66 ME311 78MHO Logic Diagram Processing / Legend



ME311 78MHO THEORIE OF „OUT OF STEP“-FUNCTION

Fig. 67 ME311 78MHO Theorie Of ,,Out Of Step''- Function



<u>LEGEND</u>

x_d'	adapted transient generator reactance
x_T	adapted transformer reactance
z_S	adapted external system impedance (line)
δ	rotor angle (between $\underline{E}_p$ and $\underline{U}_{line}$): 120°/240°
φ_p	phase angle (between $\underline{E}_p$-$\underline{U}_{line}$ and $\underline{I}_{generator}$)
R1	distance between coordinate zero-point and blinder R1
R1-R2	distance between blinder R1 and blinder R2
[p.u.]	refered to RELAY NOM. VALUES/
	all imp. set values to be adapted to RELAY NOM. VALUES

ME311 78MHO CALCULATION OF SET VALUES

Fig. 68 ME311 78MHO Calculation Of Set Values

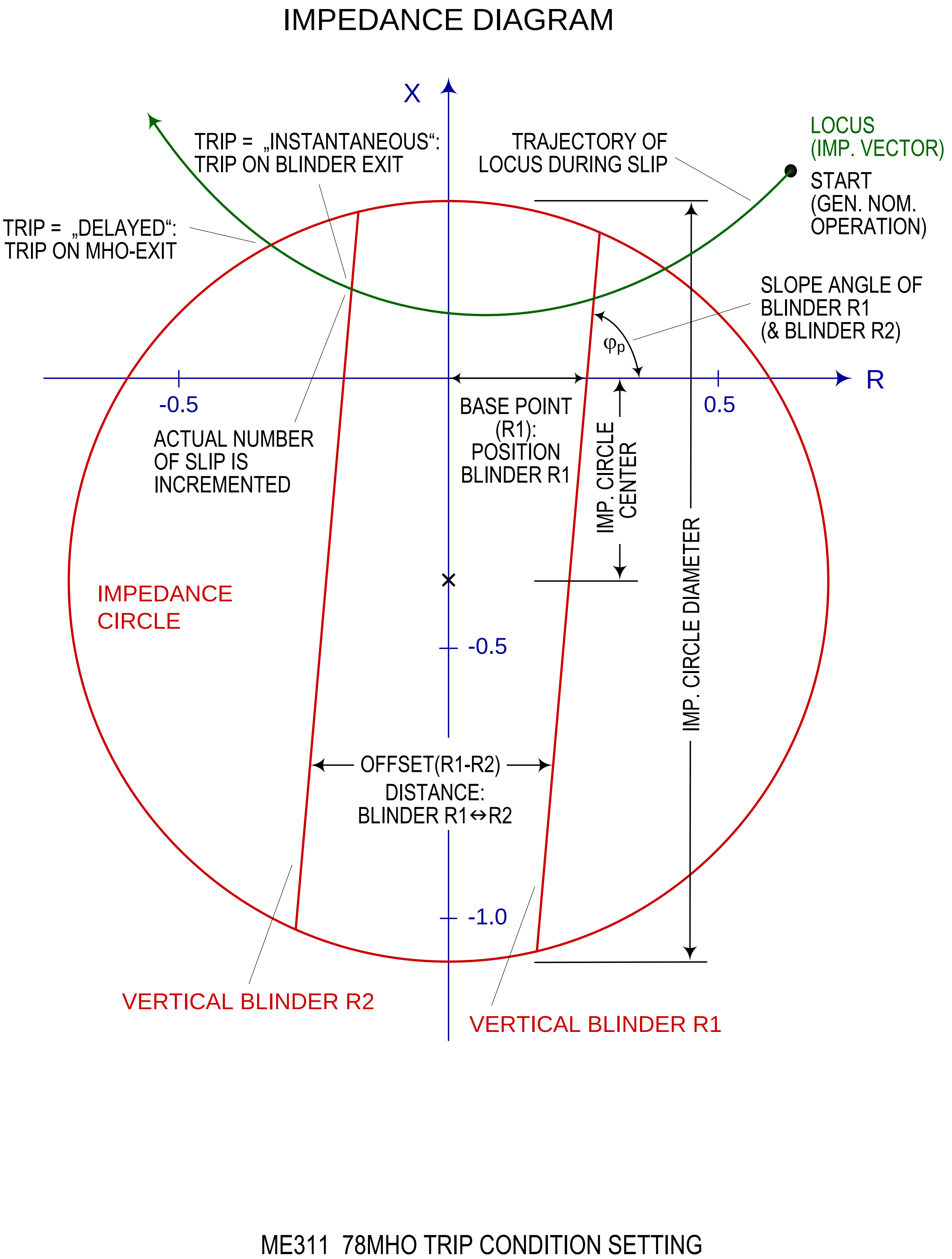
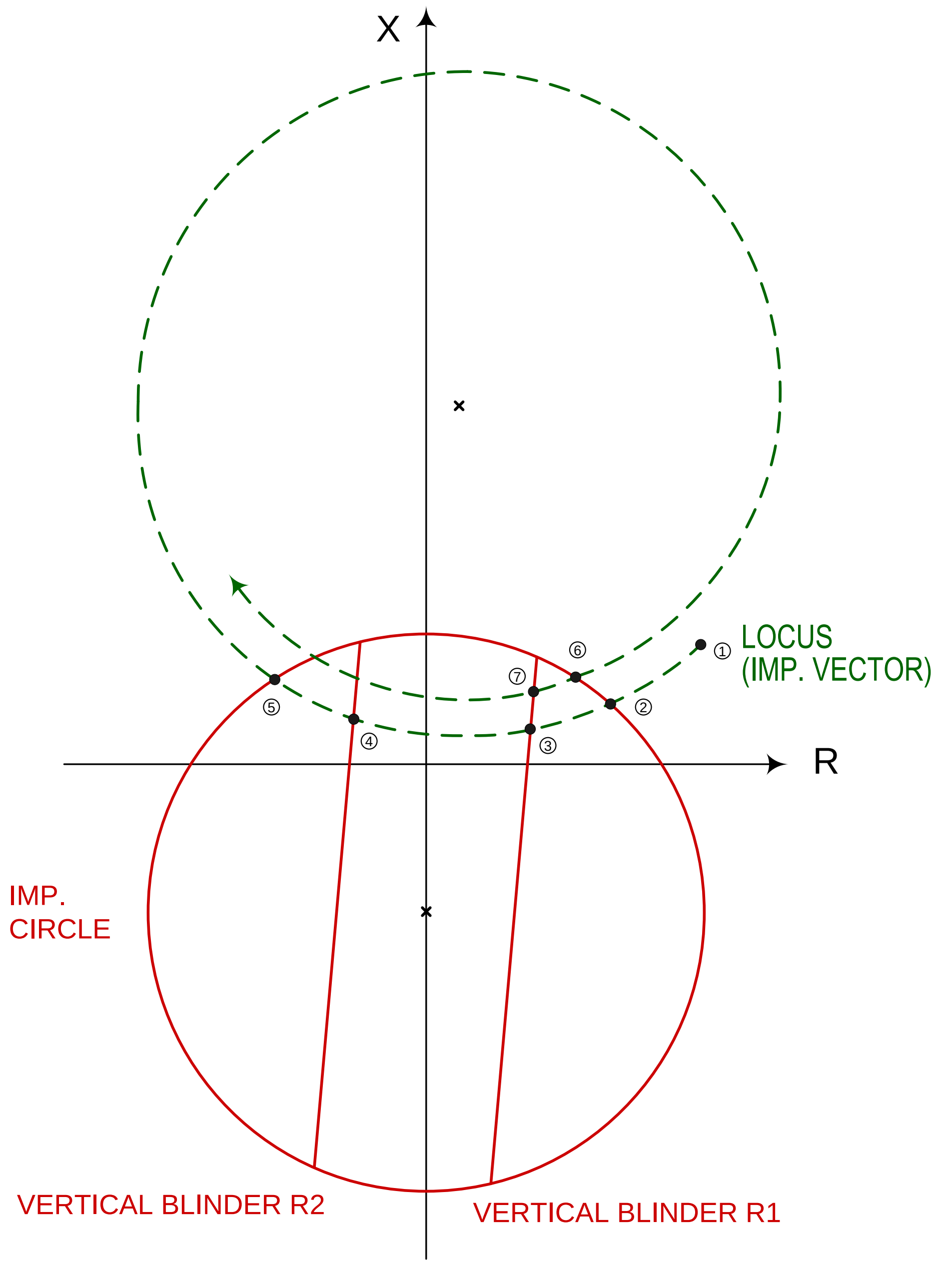


Fig. 69 ME311 78MHO Trip Condition Setting



① LOCUS AT NOM. OPERATION OF GENERATOR
② LOCUS ENTERS IMPEDANCE CIRCLE
③ LOCUS CROSSES BLINDER R1 (1. SLIP STARTS)
④ LOCUS CROSSES BLINDER R2 („INSTANTANEOUS TRIP“)
⑤ LOCUS LEAVES IMPEDANCE CIRCLE (DELAYED TRIP“)
⑥ LOCUS ENTERS IMPEDANCE CIRCLE
⑦ LOCUS CROSSES BLINDER R1 (1. SLIP ENDS; 2. SLIP STARTS)

ME311 78MHO DEFINITION OF SEQUENCE

Fig. 70 ME311 78MHO Definition Of Sequence

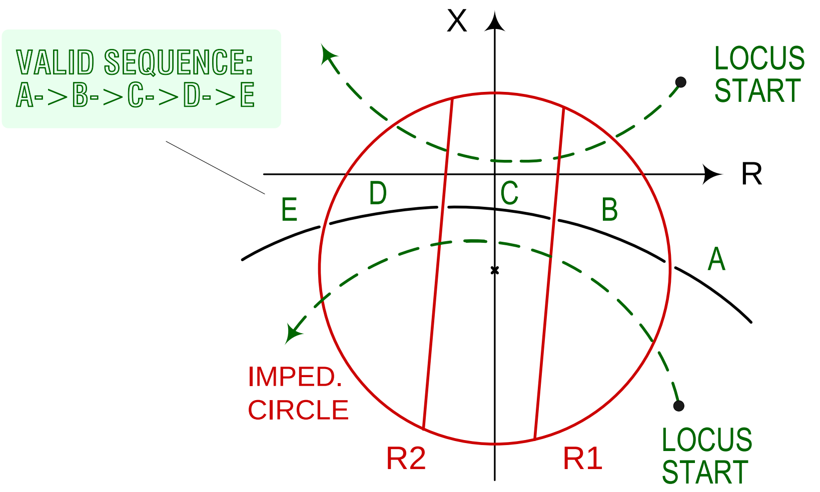


FIG. 6-9 ME311 78MHO TRIP CONDITION FULFILLED

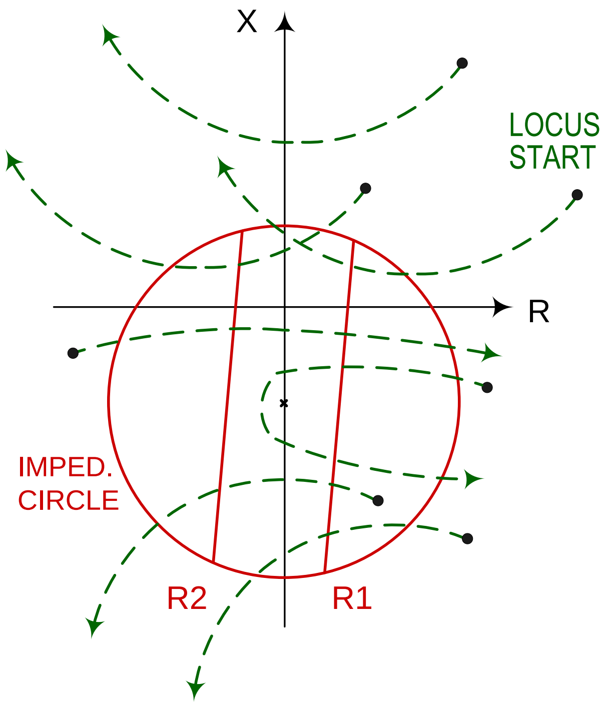


FIG. 6-10 ME311 78MHO NO RELEASE OF TRIP COMMAND

Fig. 71 ME311 78MHO Trip Conditions

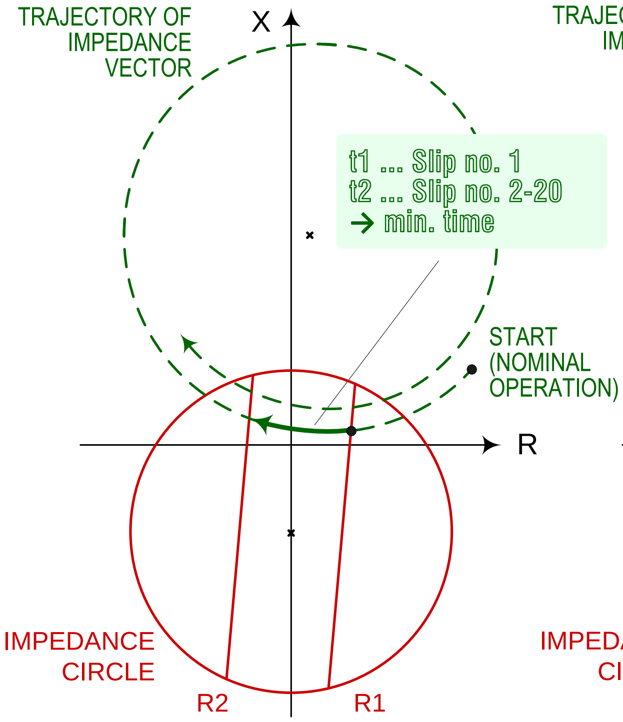


Fig. 6-9 ME311 78MHO TIME SLOT t1 t2

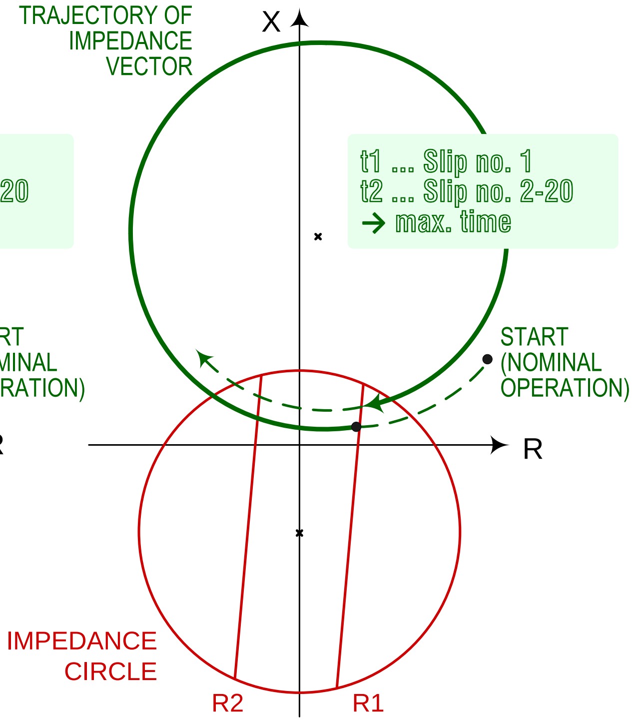


Fig. 6-10 ME311 78MHO SLIP CYCLE T1 T2

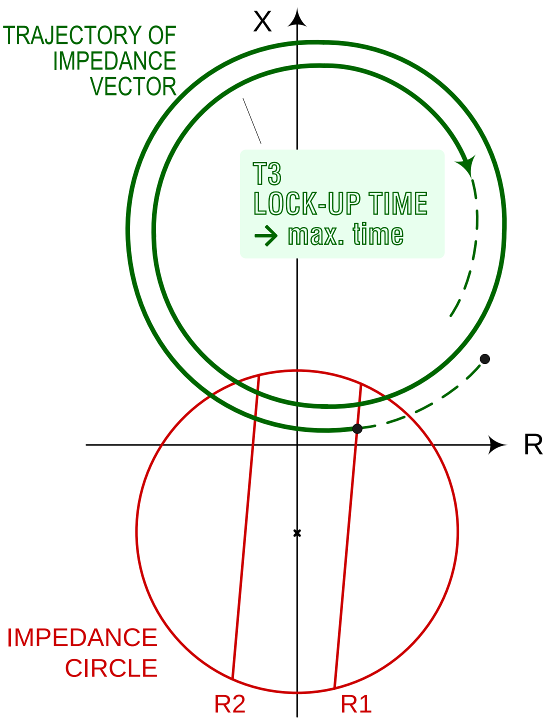


Fig.6-11 ME311 78MHO LOCK-UP TIME T3

Fig. 6-9/10/11: ME311 78MHO DEFINITION OF TIME SETTINGS

Fig. 72 ME311 78MHO Definition Of Time Settings

6.5. FUNCTION

6.5.1. ME311/ ME312

The out of step protective functions ME311 and ME312 (Out of Step Relay) are 3-phase/1-stage "Out of Step" relays with blocking features during unsymmetrical load currents and configurable minimum values of the generator current and generator voltage. The measuring is based on the computation of the trajectory change of the complex impedance vector (MHO) whereby its determination is derived from the positive sequence quantities.

Depending on the external power system parameters and the connected generators dynamic incidences, e.g. switching operations, load changes, short circuits, auto reclosing, etc. may cause oscillating system conditions which can endanger system stability. These consisting load oscillations are endangering power system stability and especially critical are real power swings which may lead to pole slipping of the generators. Since during pole slipping generally the machine current is a multiple of the rated current and in addition the direction of the load current can change from forward to reverse power it may lead to very high mechanical stresses on the generators.

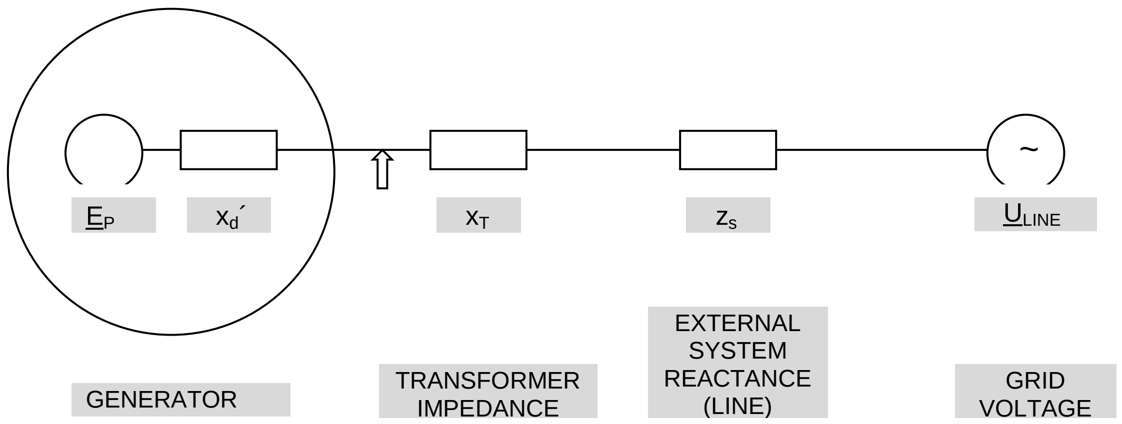
The ME311 relay resp. the ME312 was designed to fulfil the practical requirements of system operation and the parameter setting possibilities will comply even for the highest demands. The application is especially recommended for complex tasks and should several function stages be required, i.e. more than one operating characteristic respectively power swing polygons, several software function stages (ME311 resp. ME312) can easily be configured and combined.

Particularly to following characteristics is being referred to (please also see “Setting Parameters”):

- Trip:	Enables a smooth tripping of the circuit breaker at already reduced current values in case the trip output parameter is configured to time delayed. After the function internal recognition of a pole slip condition during crossing of R2 either an instantaneous or a time delayed trip can be initiated when leaving the impedance circle.
- Slip pulse number:	1 ... 20 configurable pole slips; The initiation for the 1st pole slip during crossing of R1 and the trip output is set at the last pole slip when crossing R2 respectively leaving the leaving the impedance circle.
- Time window t1, t2:	The minimum time for crossing the load blinder range between R1 and R2 which can be individually configured for the 1st slip (generally with a longer delay) and the subsequent slips (usually with shorter time delays); after expiry of this time the function is reset, i.e. no trip and started again.
- Slip cycles T1, T2:	The maximum time for the whole slip cycle (from R1 to R2)which can be individually configured for the 1st slip (generally with a longer delay) and the subsequent slips (usually with shorter time delays); after expiry of this time the function is reset, i.e. no trip and started again.
- Activation time T3:	Total time of all pole slip incidents and after expiry of this time the function will be reset, i.e. no trip and is starting again.
- Neg. ph. sequence load:	The maximum permissible unbalanced load (current) because the out of step disturbance is considered in principle as a symmetrical occurrence.
- Current interlock:	The minimum positive sequence current value for trip enabling of the function since the out of step disturbance is considered in principle as a symmetrical occurrence thereby preventing false trips during external short circuits, etc.
- Current direction:	Enables in a comfortable way to adjust the CT secondary current direction via the software without having to change the external wiring.
- Rotating field direction:	Enables in a comfortable way to adjust the phase rotation via the software without having to change the external wiring.

- Blocking input: Provides blocking of the protective function via an external input contact or the User program with a notebook.
- Test input: Enables testing of the function during maintenance but preferably via notebook operation.

Explanation of the protective function according to the logic diagram (please also refer to Fig. "*ME311 78 MHO LOGIC DIAGRAM/ PROCESSING*"):
The generator phase currents as well as the phase to phase voltages are evaluated for all phases since the function is designed for 3-phase systems. Consequently for the current and voltage values the positive sequence components are computed ($\underline{I}_1$, $\underline{V}_1$) and in addition also the negative phase sequence current value ($\underline{I}_2$) is considered which at last is applied for the blocking feature.
The result: Positive sequence phase currents and positive sequence phase to phase voltages are computing the positive sequence impedance ($\underline{Z}_1$).
It should explicitly be noted that the relay function ME311 resp. ME312 is based onto a three phase measuring and not onto a customary single phase measurement especially applied in the American Region.
The latter simplification may lead to false functioning and/or trips according to the type of fault and the involved phases and is only permissible by strict adherence to symmetrical phenomena.
A further increased functional safety of the ME311 resp. ME312 results in a standard and a much differentiated parameter setting possibility of this function which will fulfil even the highest demands.
The computed positive sequence impedance ($\underline{Z}_1$) is the complex impedance vector (locus) which progression is evaluated to recognise a pole slip condition of the generator. The rate of change of the impedance vector is shown in a simplified model of the impedance locus which is illustrated in the following graph showing the distribution of the impedances with respect to the generator, generator-transformer and the external power system:



$\underline{E}_P$	...	Rotor EMF
x_d'	...	Transient Generator Direct-Axis Reactance
⇧	...	Protection Relay (location of VT)

Impedances of The Generator The Generator-Transformer And The Power System

The generator impedance Z consists essentially of the transient direct axis reactance X_d', the transformer impedance of the reactance X_T and the power system impedance Z_S. In case of the system impedance may vary the smallest value should be selected.
The corresponding impedance vector diagram is shown in Fig.: *ME311 78 MHO Theory of the "Out of Step" Function.*

The protection relay is positioned at the generator leads, i.e. respectively at the there located CT's and VT's. For this reason the co-ordinate zero point is placed at this position. The reverse reach of the relay is measuring into the generator and the forward reach includes the generator-transformer respectively the power system. For the various applications different positions for the power swing locus are requiring discriminative setting configurations which can easily accommodated by the DRS protection system. In this case simply two ME311 software relays are to be configured whereby each of them can be set completely independent from the other one (ME311 functions with regard to the trip outputs are using the same internal trip channels).
For stability considerations of a generator connected to the power system and therefore also
for pole slipping conditions the so-called rotor angle ϑ is decisive. Traditionally it is distinguished between the inner rotor angle ϑ_i, the outer rotor angle ϑ_a and the sum of the rotor angle ϑ.
The relation is show in Fig.: *"ME211 78 MHO Computation of the Setting Values".*
The angle between the generator leads voltage (V_{Gen}) and the inner generator EMF (E_p) is the inner rotor angle ϑ_i.
The angle between the system voltage V_{Net} (this is the theoretical voltage source of the "rigid" power system) and the inner generator EMF (E_p) is the rotor angle sum ϑ,
which is primarily interesting for stability considerations. From the impedance vector diagram (please also refer to Fig.: *ME311 78 MHO Theory of the "Out of Step" Function*) one can easily recognise that this angle (together with the difference of the voltage absolute values of both voltage sources and the impedances between them) determines the compensating current between the inner generator voltage and the system voltage. During normal operation of the generator and with a stable power system this angle will be determined from the system load conditions (real- and reactive power output of the generator and external power consumption)
and therefore is to a large extent constant. However, during pole slipping of the generator this angle is changing continuously and is approaching all values between 0° and 360°. This will result in an oscillation of the generator current vector which thereby is passing through all 4 power quadrants whereby the beat frequency is in accordance to the rate of change of the rotor angle.
In principle we have two voltage sources which are connected via the sum of impedances whereby the voltage vector of the rigid power system remains constant and the voltage vector of the inner generator EMF is rotating through 360°.
What is happening now with the impedance vector in respect to the time event is shown in Fig.
"ME311 78 MHO Trip Conditions".

<u>Compare: 78G .... 78M:</u>
<u>What is the difference between 78G and 78M?</u>

The following discussion references a Generator/ Motor – Unit of a Pumping Power Station whose turbine by means of change of phase rotation (phase rotation is changed from "right" to "left" by exchanging two phases) also can be used for pumping operation. In this case we need two "Out of Step" – functions (78G, 78M) in order to protect the unit in both operating conditions.

a)
The impedances are the same for generator/ motor.
As a result the impedance diagramm will also be the same.
Therefore the settings refering to impedances (blinders, impedance circle, ...) will be the same.
Note: The starting point for the impedance locus will be for generator operation at the right side of the diagramm, for motor operation at the left side of the diagramm.

b)
In principle also the set value for the "Current Direction" and the sequence of phases should be thesame for generator/ motor – operation.
Please note: this statement is valid only if the direction of rotation of the machine is the same for generator- and motor operation. This is not the case in TBI. As already mentioned in TBI the sequence of phases is changed by special circuitbreakers in case of motoroperation
Therefore in TBI the set value for the "Sequence of Phases" has to be changed for motoroperation (from "right" to" left"). Note: the Analog-Input-Matrix for the 78M function is the same as for 78G (because the sequence change is already covered by the set value "Sequence of Phases").
The set value for "Current direction" will be the same (but of course when changing from generator to motor operation the actual current direction will change, but not the set value for current direction/ acc. to the design of the 78M-protective function).

c)
In principle during generator operation the impedance locus during slipping is moving from blinder 1 to blinder 2, but during motor operation the locus is moving from blinder 2 to blinder 1.
Explanation (in principle):
In generator mode during slipping the generator speeds up, however in motor mode the motor during slipping slows down. As a result the locus moves clockwise in generator mode and counterclockwise in motor mode. This is already taken into consideration by the two versions of 78 (78G, 78M).
In principle there has just to be used the proper version (78G or 78M), the settings should be same.
In TBI the direction of rotation of the machine is changed by phase reversal switch. Therefore in TBI the setting for sequence of phases ("Phase Rotation") has to be changed too. All other settings will stay.

<u>Conclusion with reference the practical Set-Value-Calculation –Example (see below):</u>

The settings for 78G and 78M will be in principle the same. In TBI the sequence of phases will be changed by the phase reversal switch therefore we will have to consider two exceptions:
a.)
In our practical Set-Value-Calculation - Example the sequence of phases will be changed. Therefore the set value "Phase Rotation" also has to be changed:
78G: set value "Phase Rotation" = Right
78M: set value "Phase Rotation" = Left
b.)
Analog-Input Matrix for voltage and current signals:
78G: current/ phase/ L1, L2, L3
voltage/ phase-phase/ L1-L2, L2-L3, L3-L1
78M: current/ phase/ L1, L2, L3
voltage/ L1-L2, L2-L3, L3-L1
Note: the analog input matrix will not be changed in TBI because the sequence of phases during G/M - mode is already taken into consideration by the set value "Phase Rotation".

c.)
Input Matrix for Digital Inputs:
78G: "Blk. 78G-B" ... 78G will be blocked when Phase reversal switch in motor position
78M: "Blk. 78M-B" ... 78M will be blocked when Phase reversal switch in generator position

Practical Set-Value-Calculation –Example

The "Out of Step" – function is one the most complex protective function, causing a challenge for the design-engineer to calculate proper set values. For this reason in the following there is included a practical example how to calculate the settings.
The example refers to the Pumping Power Station TBI (Tong Bai) which utilizes a pumping turbine, that means that the turbine also can used for pumping operation (by changing the sequence of phases).
In order to cover both modes of operation there have been implemented two "Out of Step" – protective functions (78G, 78M).

Nachfolgend ein Auszug aus der diesbezüglichen "Setting Calculation":

>>*Start*<<

Data of Generator/Motor:

Rated power:	Generator mode:	334 MVA
	Motor mode:	336 MW
Rated phase-phase voltage:	18kV ± 5 %	
Rated phase current:	Generator mode:	10713A ± 5 %
	Motor mode:	10777A ± 5 %
Rated phase current:	Generator mode:	10713A ± 5 %
	Motor mode:	10777A ± 5 %
C.T. sec. current:	Generator/ Motor mode:	
	C.T. 16000A/1A:	0,67A
Rated power factor:	Generator mode:	0,9
	Motor mode:	0,975
Rated frequency:	Nominal operation:	50 Hz
	Startup:	0 ... 51 Hz
Direct axis reactance:	1,14 p.u. unsaturated	
	0,917 p.u. saturated	
Transient direct axis reactance: 0,297	p.u. unsaturated	
	0,273 p.u. saturated	
Subtransient direct axis reactance:	0,22 p.u. unsaturated	
	0,192 p.u. saturated	
Quadr. axis reactance: 0,757	p.u. unsaturated	
Subtrans. quadr. axis reactance:	0,175 p.u. unsaturated	
	0,153 p.u. saturated	

Data of Main Transformer:

Power:	360MVA	
Impedance:	14 %	
Phase-phase voltage:	520kV ± 8 x 1,25 %/18V	
Vecor group:	Yd11	
Phase current:	399,7A AC/ 11547A AC	
C.T. sec. current:	Main Transformer HV-side:	
	C.T. 1250A/1A:	0,32A
	C.T. 2000A/1A:	0,2A
	Main Transformer LV-side:	
	C.T. 16000A/1A:	0,72A

Data of 525kV-System:

Phase-phase voltage: 525kV

Short circuit power:	1000MVA		
Impedance [p.u.]:	Big Mode:	X0:	0,16
		X1=X2: 0,07	
	Small Mode:	X0:	0,30
		X1=X2: 0,13	

Calculation of set values:

The generator current is

$$I_{gp} = \frac{S_g}{V_{gp} \times \sqrt{3}} = \frac{334000kVA}{18kV \times \sqrt{3}} = 10713A$$

For this purpose a current transformer with a CT ratio of 16000A/1 A is selected and so the generator CT secondary current is calculated

$$I_{gs} = \frac{I_{gp}}{CTratio} = \frac{10713\text{A}}{16000A} \times 1A = 0.67A$$

Data for the current and voltage transformer (valid for all conversions):

$$CT_{\text{Relay}} = \frac{16000A}{1A}, \qquad \text{VT}_{\text{Relay}} = \frac{18000\text{V}}{100\text{V}}$$

1.
With the given data, the conversion factors from [p.u] values to protection relay inputs (including compensation factor for different p.u. references and c.t. ratings), and the absolute impedance values are calculated:

a) for generator:

$$F_{Gen} = \frac{{V_{Gen}}^2}{S_{Gen}} \cdot \frac{CT_{\text{Relay}}}{PT_{\text{Relay}}} = \frac{(18000V)^2}{334000000VA} \cdot \frac{16000A \cdot 100V}{1A \cdot 18000V} = 86{,}23\Omega$$

The secondary transient reactance (at relay inputs) of the generator is:

$$X_d{}'_{\text{sec}} = x_d{}' \cdot F = 0.297 \cdot 86.23\Omega = 25{,}61\Omega$$

c) for transformer:

$$F_{Transf} = \frac{{U_{Transf}}^2}{S_{Transf}} \cdot \frac{CT_{\text{Relay}}}{PT_{\text{Relay}}} = \frac{(18000V)^2}{360000000VA} \cdot \frac{16000A \cdot 100V}{1A \cdot 18000V} = 80\Omega$$

The transformer secondary reactance (at relay inputs) is:

$$X_{T,\sec} = \frac{u_K}{100} \cdot F = \frac{14}{100} \cdot 80\Omega = 11{,}2\Omega$$

d) for 525kV-System:

given:
Positive Sequence Impedance (z1):
$z_S = 0.07 \cdot e^{j75°}$ [p.u.] = 0.018+j 0.067 [p.u.]

given:
S´´ (short circuit power of grid) = 1000 MVA

given:
Voltage = 525 kV (phase – phase voltage)

Calculation (525kV-System):

First we have to calculate the impedance in absolute values of the grid (at 525 kV – side):

$$Z_{system\ at525kVside_{(absolute\_value)}} = z_S \cdot \frac{U_{Grid}^{\ 2}}{S_{Grid}} = 0{,}07.e^{j75°} \frac{(525000V)^2}{1000000000VA} = 19{,}29\Omega.e^{j75°}$$

Second we have to transform this impedance from the Main Transformer HV-side to the Main Transformer LV-side:

$$Z_{system\ at18kVside} = \left(\frac{U_{MainTransformerLV-side}}{U_{MainTransformerHV-side}}\right)^2 .Z_{system\ at525kVside_{(absolute\_value)}} = \left(\frac{18000V}{520000V}\right)^2 \cdot 19{,}29\Omega.e^{j75°} = 0{,}023\Omega.e^{j75°}$$

Third we finally have to transform the impedance to the c.t. resp. p.t. secondary values (relay input values):

$$Z_{systematrelayinputside} = \frac{CT_{\mathrm{Relay}}}{PT_{\mathrm{Relay}}} .Z_{system\ at18kVside} = \frac{16000A \cdot 100V}{1A \cdot 18000V} .0{,}023\Omega.e^{j75°} = 2{,}044\Omega.e^{j75°} = (0{,}529 + j1{,}974)\Omega$$

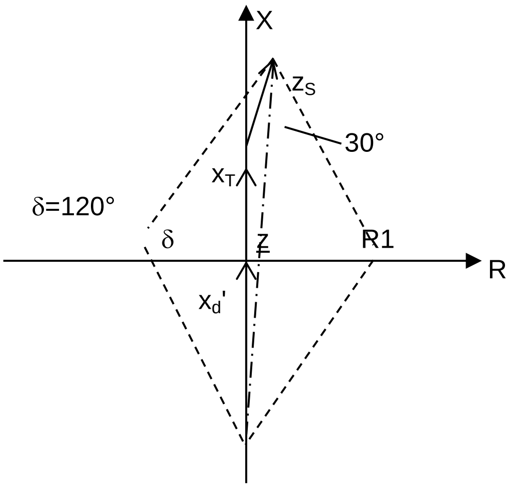
2.
The total impedance is calculated (absolute values as seen at the sec. side of p.t. and c.t.):

$$Z = jX_d^{\ '} + jX_T + \underline{Z}_S = j25{,}61 + j11{,}2 + 0{,}529 + j1{,}974 = (0.529 + j38{,}78)\Omega = 38{,}78 \cdot e^{j89°})\Omega$$

The base point R1 is (formula according to the picture below):

$$R1 = \frac{X_d'}{\tan(\arg(\underline{Z}))} + \frac{\frac{|\underline{Z}|}{2}\cdot\tan(30°)}{\sin(\arg(\underline{Z}))} = \frac{25{,}61}{\tan(89°)} + \frac{\frac{38{,}78}{2}\cdot\tan(30°)}{\sin(89°)} = 11{,}63\Omega$$

Note: diagram is not to scale.



The offset is (R1-R2):

$$'R1 - R2' = 2\cdot\frac{\frac{|\underline{Z}|}{2}\cdot\tan(30°)}{\sin(\arg(\underline{Z}))} = 2\cdot\frac{\frac{38{,}78}{2}\cdot\tan(30°)}{\sin(89°)} = 22{,}39\Omega$$

The slope is equal to angle of the system impedance:

$$slope = \arg(\underline{z}) = 89°$$

The impedance circle diameter is calculated:

$$imp.circle\ diam. = 3\cdot X_d' + 2\cdot X_T = 3\cdot 25{,}61 + 2\cdot 11{,}2 = 99{,}23\Omega$$

Therefore the impedance circle centre is:

$$imp.circle\ cent. = -\left(\frac{imp.circle\ diam.}{2} - 2\cdot X_T\right) = -\left(\frac{99{,}23}{2} - 2\cdot 11{,}2\right) = -27{,}21\Omega$$

The slip pulse number has to be chosen according to the allowed number the generator is getting out of step, for example

Slip pulse numbers=2

Time Slot t1 (minimum time for the first slip between crossing of the impedance vector the right-hand and the left-hand boundary lines.) is selected to be:

t1=0,1s

note: if the timeslot for the locus to pass from Blinder1 to Blinder2 (120° rotor angle to 300° rotor angle) is below t1 then the event is not considered to be a valid slip (acc. to 78).

Slip Cycle T1 (Maximum time for the first slip-cycle):

T1=3s

note: if the timeslot for the locus to pass from Blinder1 to Blinder1 (whole circle) is above T1 then the event is not considered to be a valid slip (acc. to 78).

Time Slot t2 and Slip Cycle T2:

t2=0,1s, T2=2s (usually the following slips need less time in relation to the first one)

Lock up Time T3 (Maximum time for the total sequence starting with the first slip):

T3=5s

The maximum permissible negative phase sequence is selected to be:

Neg. Phase Sequ.=10%

Current Interlock:

$$Current\ Interlock = 1.2 \cdot I_N \approx 1.2 \cdot 1A \approx 0.8A$$

This is the minimum value of the positive sequence current to enable the function. Bear in mind, that the customer wish has to be considered. On the one hand, the function shoud trip at slip cycles with high current, on the other hand there should be trips for all slip cycles. For the second case the Current Interlock has to be selected to be 0 A.

Trip:

Trip=delayed ⇒ The relay trips, when the impedance vector leaves the impedance circle. This helps to spare the circuit breaker.

Current Direction:

Direction 1/Direction 2

The impedance phasor will be displayed in the window for the internal measuring values. For normal conditions the phasor should be in the right area of the impedance diagram with angles of about 0 degree. If there is an angle of about 180° degree, the setting of the parameter is wrong and has to be changed.

The setting for direction will be same for 78G and 78M.

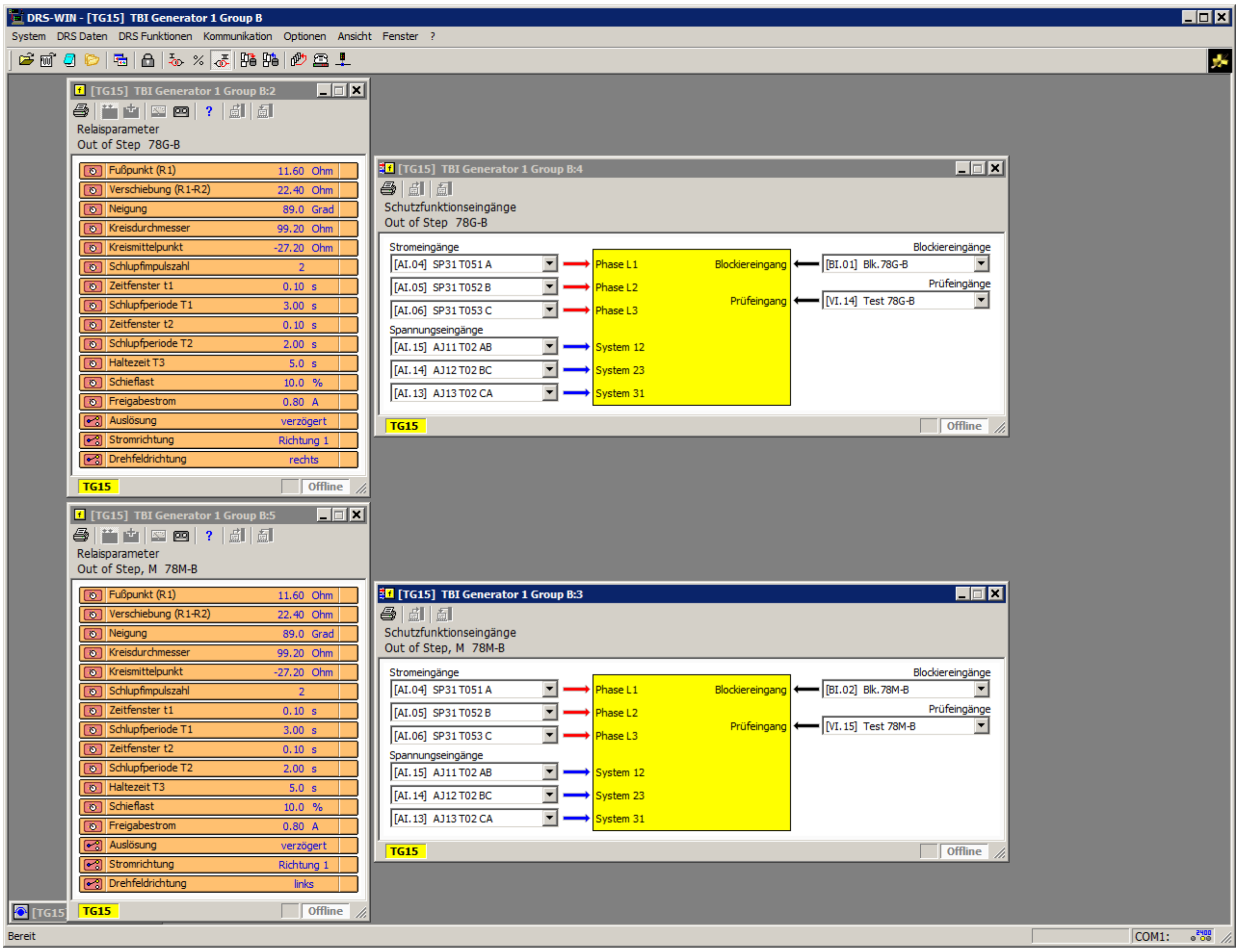
Phase Rotation:

Right/ Left:

Generator operation: Right
Motor operation: Left.

This setting can be checked by the value of the negative phase sequence. In normal condition the negative phase sequence is about 0%. For a value of 100% the setting has to be changed.

The picture below shows the DRSWIN – Protective Function Relay Parameters – windows for 78G and 78M of TBI Pumping Power Station:



6.6. COMMISSIONING

Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

6.6.1. ME311 Protective Function

Pre-Commissioning:

The function ME311 can generally only be verified during the pre-commissioning tests due to reasons of the extensive complexibility thereby requiring a three phase test equipment which can also carry out dynamic simulations with a corresponding long time preparation for these tests.

Therefore two variants of tests to simplify the function tests and to verify the correct operation are recommended which do not require too much effort.

A. Simplified Function Test / Method No 1

The impedance vector is shifted within the impedance circle from left to right (R axis = Re (Z);
X axis = Im (Z)) at the R axis from the right outside the impedance circle (please also refer to the setting parameters) and shifted to the left by continuously reducing the voltage up to a negative value.
Should the relay test set not be able to produce negative voltage values (the angle changes from 0° to 180°) the voltage polarity has to be changed manually and its amplitude raised again.

However for this simplified test method some setting parameters have to be changed temporarily:

Circle centre:	Preferably 0 Ohm; It has to be ensured that the locus is having a transition according to the specified sequence (see logic diagrams).
Slip pulse number:	1
Time window t1:	0.01 s; Since this is a minimum value for the test the smallest possible setting is selected to prevent a function reset because of minimum time duration.
Time window t2:	Can be left to the original setting because of slip pulse number = 1.
Slip cycle T1:	20 s; Since this is a maximum value for the test the largest possible setting is selected to prevent a function reset because of maximum time exceeded.
Slip cycle T2:	Can be left to the original setting because of slip pulse number = 1.
Activation time T3:	60 s; Since this is a maximum value for the test the largest possible setting is selected to prevent a function reset because of maximum time exceeded (in principle also 20 s would be sufficient since T1 has then already expired).
Current interlock:	0 A
Current direction:	According to the injected test current
Phase rotation:	According to the injected test current

By a 1 xIn rated protection relay, for example following current- and voltage values are injected:

Voltage:	3 x 100 V (phase to phase voltage)
Current:	3 x 1 xIn (phase currents) Note: Since the impedance vector has to be moved along the R axis the angle between the phase voltage (not the phase to phase voltage) and the phase current has either to be 0° or 180°.

Monitoring of the tests with the Actual Measured Values Window:

Window Display for Relay Internal Determined and Computed Values

Slip pulse	[Number of the current pole slip]
System impedance	In [Ohm]; the absolute value of the impedance vectors, whereby 1 p.u. = 57.7 Ohm = phase voltage / phase current with respect to the relay nominal values (100V/1A respectively 100V/5A).
Impedance vector angle	In [Degrees] (angle of the impedance vector)
Time running	[Yes / No]; the timing starts when crossing R1 and ends with a trip or a reset when one of the necessary conditions are no longer fulfilled (function reset)
Positive sequence current	In [A]
Positive sequence voltage	In [V]
Negative phase sequence	In [%], in relation to the relay nominal values (100V/1A respectively 100V/5A).

Slip pulse: Shows only 1 slip since after the 1st pole slip already a trip is being initiated (according to set value).

Slip impedance: When injecting 3 x 100 V phase to phase voltage and 3 x 1 xIn phase current the absolute value of the impedance vector is 57.7 Ohm (impedance = phase voltage / phase current).
Note: For the computation of the complex impedance vector the positive sequence values of the 1st harmonic of current and voltage are applicable, i.e. the relay evaluates all three phases.

Impedance angle: Shows at the beginning of a pole slip 0° and then 180°.

Time running: Changes after crossing the blinder R1 from right from to left from "Yes" to "No".

Positive sequence current: Should be a constant display of 1 A (by correct phase rotation according to the "phase rotation" setting value).

Positive sequence voltage: Should be a constant display of 100 V of the phase to phase voltages (by correct phase rotation according to the "phase rotation" setting value).

Unbalanced load: Should be a constant display of 0 % (since the injected current system is symmetrical)

Alarm / Trip:

The instantaneous operation is initiated at the 1st slip during crossing of R1 and the trip is carried out with the last pole slip (in this case it is 1st slip) when crossing R2 ("instantaneous trip") respectively when leaving the impedance circle ("delayed trip")...
Note: Please also refer to the setting parameter "Trip: Instantaneous / Delayed".

.

B. Simplified Function Test / Method No 2

The impedance vector is shifted continuously within the impedance plane (R axis = Re (Z); X axis = Im (Z)) whereby during a 360° revolution first the two load blinders are crossed in the specified direction within the impedance circle and then outside the impedance circle is returning to its point of origin. This way the specified operating sequence of the ME3111 function has been fulfilled.

With modern relay test sets it is easy to shift the impedance vector whereby it is recommended to keep the voltage vector angle constant and rotate the current vector.

It is of advantage to illustrate the movement of the impedance vectors on a hand-sketch. This way the progression of the vector absolute value can easily estimated during the tests. It is noted that the test can only be carried out correctly when the impedance circle centre is not located at the mid-point of the coordinate system of the impedance plane but off-set either in the positive- or negative direction (if necessary a temporary shift has to be configured). Also it has to be made certain that the impedance vector is located outside of the impedance circle prior to the test and then shifted within the impedance circle by choosing the required phase rotation. The return trajectory of the impedance vector should however be outside the impedance circle.

For this simplified test method some setting parameters have to be changed temporarily:

Circle centre:	Has not to be 0 Ohm; The circle must be shifted either in the positive- or negative direction and it has to be established that the locus is following the required trajectory (please refer to the logic diagrams).
Slip pulse number:	About 1...3; When a higher number is selected an excessive operating time may occur during the test (please also refer to the "Activation Time T3" setting value).
Time window t1:	0.01 s; Since this is a minimum value for the test the smallest possible setting is selected to prevent a function reset because of minimum time duration.
Time window t2:	0.01 s; Since this is a minimum value for the test the smallest possible setting is selected to prevent a function reset because of minimum time duration.
Slip cycle T1:	20 s; Since this is a maximum value for the test the largest possible setting is selected to prevent a function reset because of maximum time exceeded.
Slip cycle T2:	20 s; Since this is a maximum value for the test the largest possible setting is selected to prevent a function reset because of maximum time exceeded.
Activation time T3:	60 s; Since this is a maximum value for the test the largest possible setting is selected to prevent a function reset because of maximum time exceeded.
Current interlock:	0 A
Current direction:	According to the injected test current
Phase rotation:	According to the injected test current (generally: clock-wise)

By a 1 xIn rated protection relay, for example following current- and voltage values are injected:

Voltage:	3 x 100 V (phase to phase voltage)
Current:	3 x 1 xIn (phase currents)

Note: The current amplitude has to be chosen such that at the start of the test the impedance vector is rotating outside the actual impedance circle, e.g. at the right side of the impedance circle and is subsequently entering the impedance circle by crossing both load blinder slopes and leaving on its return path the impedance plane.

The phase rotation of the impedance vector, either clock-wise or anticlock-wise, depends on the location of the impedance circle, i.e.
whether positioned above or below the R axis.
Please note in this context the interrelations in the respective logic diagrams.
The rotation of the impedance vector is performed by rotating the current vector
Note: The phase rotation of the impedance vector is always in opposite direction to the rotation of the current vector.

Monitoring of the tests with the Actual Measured Values Window:

Window Display for Relay Internal Determined and Computed Values

Slip pulse	[Number of the current pole slip]
System impedance	In [Ohm]; the absolute value of the impedance vectors, whereby 1 p.u. = 57.7 Ohm = phase voltage / phase current with respect to the relay nominal values (100V/1A respectively 100V/5A).
Impedance vector angle	In [Degrees] (angle of the impedance vector)
Time running	[Yes / No]; the timing starts when crossing R1 and ends with a trip or a reset when one of the necessary conditions are no longer fulfilled (function reset)
Positive sequence current	In [A]
Positive sequence voltage	In [V]
Negative phase sequence	In [%], in relation to the relay nominal values (100V/1A respectively 100V/5A).

Slip pulses: Shows the number of pole slips; this counter is activated during each crossing of the blinder R1 from right to left.

Slip impedance: When injecting 3 x 100 V phase to phase voltage and 3 x 1 xIn phase current the absolute value of the impedance vector is 57.7 Ohm (impedance = phase voltage / phase current).
Note: For the computation of the complex impedance vector the positive sequence values of the 1st harmonic of current and voltage are applicable, i.e. the relay evaluates all three phases.

Impedance angle: Shows at the beginning of a pole slip 0° and is then rotating during the slip (rotation of the impedance vector) continuously through 360°.

Time running: Changes after crossing the blinder R1 from right from to left from "Yes" to "No".

Positive sequence current: Should be a constant display of 1 A (by correct phase rotation according to the "phase rotation" setting value).

Positive sequence voltage: Should be a constant display of 100 V of the phase to phase voltages (by correct phase rotation according to the "phase rotation" setting value).

Unbalanced load: Should be a constant display of 0 % (since the injected current system is symmetrical).

<u>Alarm / Trip:</u>

The instantaneous operation is initiated at the 1st slip during crossing of R1 and the trip is carried out with the last pole slip (in this case it is 1st slip) when crossing R2 ("instantaneous trip") respectively when leaving the impedance circle ("delayed trip")...
Note: Please also refer to the setting parameter "Trip: Instantaneous / Delayed".

IMPORTANT:
After completion of the pre-commissioning tests all setting parameters have to be restored to the original service operating values.

Commissioning Tests

A real pole slip during commissioning is for various reasons mostly not possible (system stability, etc.).

Therefore it is recommended that during normal service operation of the generator the "**window display for the actual relay-internal computed values"** should be taken to analyse the actual computed values and to verify their plausibility, especially:

-System impedance
-Impedance vector angle
-Positive sequence current
-Positive sequence voltage
-Negative sequence current

Further also the digital inputs

-Blocking input
-Test input

And the digital outputs

-Alarm
-Trip
-Annunciation: Negative phase sequence interlock

Should be checked via the menu item: "System"/"Binary In/Output Selection".

6.7. CALCULATION EXAMPE FOR SETTING PARAMETERS

Recommend Procedures To Calculate The Setting Parameters
For The "Out of Step" Protective Function ME311

Generator-, Transformer- and Power System Data (according to the data sheets of the Manufacturer):
Note: All particulars in reverence to the generator nominal values (=100%).

$x_d´$ = 33 % ... Transient generator direct axis reactance
X_T = 15 % ... Transformer reactance
z_S = 24 % ... external power line impedance (grid system)

Determination of the protection relay internal range for the rotor angle – Alarm:
ϑ = 120° ... 240° [degrees electrical]
Note: Rotor angle ... the angle between vectors $\underline{E}_P$ and $\underline{V}_{Line}$
$\underline{E}_P$ ... the induced stator voltage of the synchronous generator (EMF)
$\underline{V}_{Line}$ ... power system voltage

Adaptation of the impedance values respectively the setting parameters:
Note: This adaptation is necessary when: 1 p.u. protection relay $\neq$ 1 p.u. generator.

a)
The nominal values for the protection relay:

1 p.u. relay: 1A; 100V (fixed) or
5A; 100V (fixed)

b)
In our example we assume that the rated values of the generator do not correspond with the nominal rating of the protection relay:

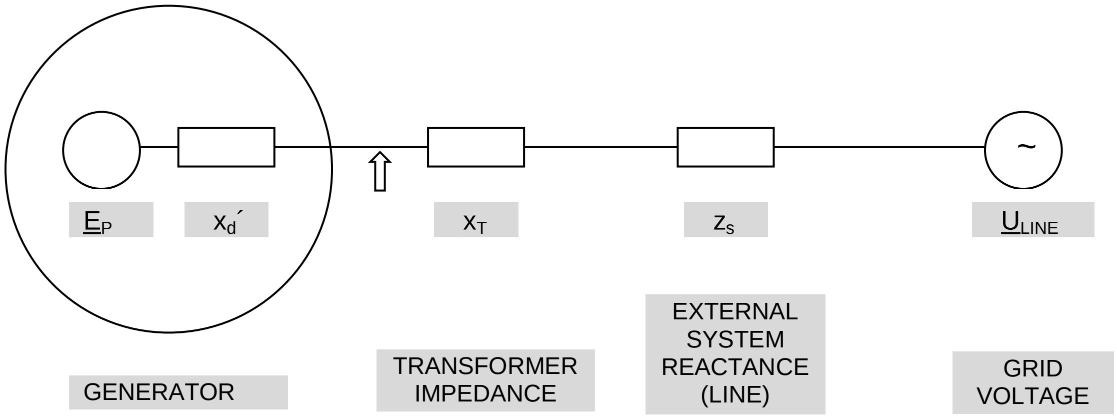
1 p.u. generator: Arbitrary assumption: 0.8A; 115V.

c)
Result:
An adaptation is necessary.

Adaptation factor = A = ($V_{generator\ nominal}/V_{relay\ nominal}$) x ($I_{relay\ nominal}/I_{generator\ nominal}$) =
= (115V/ 100V) x (1A/0,95A) = 1.09

d)
With this adaption factor A are now corrected in order to obtain the "adapted impedance values" respectively the final setting parameters for the ME311 function:

$x_d´_{\ set}$ = 33 % x 1.09 = 36 %
$X_{T\ set}$ = 15 % x 1.09 = 16.4 %
$z_{S\ set}$ = 24 % x 1.09 = 26.2 %



$\underline{E}_P$	...	Rotor EMF
x_d'	...	Transient Generator Direct-Axis Reactance
⇧	...	Protection Relay (location of VT)

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7. ME... UNDER EXCITATION PROTECTION

7.1. OVERVIEW

List of the Available ME . . . Protective Function Types

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: ME . . .	**FNNR**	**TYPE**	**ANSI**	**Application**
Under excitation for single phase systems, rotor angle, excitation current AC	1041	ME121	40	C2,M
Under excitation for single phase systems, rotor angle, excitation current DC	1043	ME122	40	C2,M
Under excitation for three phase systems, rotor angle, excitation current AC	1027	ME321	40	C2,M
Under excitation for three phase systems, rotor angle, excitation current DC	1042	ME322	40	C2,M
Under excitation for three phase systems, MHO characteristic, excitation current AC	1070	ME323	40	C2,M
Under excitation for three phase systems, MHO characteristic, excitation current DC	1071	ME324	40	C2,M

7.2. TECHNICAL DATA

7.2.1. Under Excitation for Single Phase Systems (Excitation Current Measuring AC)

PROTECTIVE FUNCTION: ME121	FNNR	TYPE	ANSI	Application
Under excitation for single phase systems, rotor angle, excitation current AC	1041	ME121	40	C2,M

2- stage under excitation protection for single phase systems with rotor angle measuring and consideration of the rotor current (AC).

ME121
Technical Data

Inputs

Analogue:	Generator current phase L1
	Rotor current (AC)
	Generator voltage L1-L2
Binary:	Blocking input stage 1 (ϑ>)
	Blocking input stage 2 (ϑ> & $I_{Excitation}$<)
	Test input stage 1 (ϑ>)
	Test input stage 2 (ϑ> & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (ϑ>)
	Trip stage 1 (ϑ>)
	Instantaneous operation stage 2 (ϑ> & $I_{Excitation}$ <)
	Trip stage 2 (ϑ> & $I_{Excitation}$ <)

Setting Parameters

Quadrilateral reactance:	0.5 ... 5.0 p.u. in 0.01 p.u. steps
Power system reactance:	0.0 ... 0.2 p.u. in 0.01 p.u. steps
Voltage direction:	Direction 1 / Direction 2
Operating value stage 1:	30° ... 150°electrical in 1° steps
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	0.1 ... 0.5 xIn in 0.01 xIn steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps

Window Display for Relay Internal
Determined and Computed Values

Rotor angle:	In electrical degrees

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
Rotor angle:	≤ 2% electrical of rotor angle

7.2.2. Under Excitation for Single Phase Systems (Excitation Current Measuring DC)

PROTECTIVE FUNCTION: ME122	FNNR	TYPE	ANSI	Application
Under excitation for single phase systems, rotor angle, excitation current DC	1043	ME122	40	C2,M

2-stage under excitation protection for single phase systems with rotor angle measuring and consideration of the rotor current (DC).

ME122
Technical Data

Inputs

Analogue:	Generator current phase L1
	Generator voltage L1-L2
	Rotor current (DC Input)
Binary:	Blocking input stage 1 (ϑ>)
	Blocking input stage 2 (ϑ> & $I_{Excitation}$ <)
	Test input stage 1 (ϑ>)
	Test input stage 2 (ϑ> & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (ϑ>)
	Trip stage 1 (ϑ>)
	Instantaneous operation stage 2 (ϑ> & $I_{Excitation}$ <)
	Trip stage 2 (ϑ> & $I_{Excitation}$ <)

Setting Parameters

Quadrilateral reactance:	0.5 ... 5.0 pu in 0.01 pu steps
Power system reactance:	0.0 ... 0.2 pu in 0.01 pu steps
Voltage direction:	Direction 1 / Direction 2
Operating value stage 1:	30° ... 150°electrical in 1° steps
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	10 ... 220 xIn DC in 1 xIn DC steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps
Rotor current configuration:	1.5 ... 96 ADC/V in 0.1 ADC/V steps
Rotor current offset:	0.000 ... 4.995 V in 0.005 V steps

Window Display for Relay Internal Determined and Computed Values

Rotor angle:	In electrical degrees

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
Rotor angle:	≤ 2% electrical of rotor angle

7.2.3. Under Excitation for Three Phase Systems (Excitation Current Measuring AC)

PROTECTIVE FUNCTION: ME 321	FNNR	TYPE	ANSI	Application
Under excitation for three phase systems, rotor angle, excitation current AC	1027	ME321	40	C2,M

2- stage under excitation protection for three phase systems with rotor angle measuring and consideration of the rotor current (AC).

ME321
Technical Data

Inputs

Analogue:	Generator current phase L1
	Rotor current (AC)
	Generator voltage phase L2-L3
Binary:	Blocking input stage 1 (ϑ>)
	Blocking input stage 2 (ϑ> & $I_{Excitation}$ <)
	Test input stage 1 (ϑ>)
	Test input stage 2 (ϑ> & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (ϑ>)
	Trip stage 1 (ϑ>)
	Instantaneous operation stage 2 (ϑ> & $I_{Excitation}$ <)
	Trip stage 2 (ϑ> & $I_{Excitation}$ <)

Setting Parameters

Quadrilateral reactance:	0.5 ... 5.0 p.u in 0.01 p.u. steps
Power system reactance:	0.0 ... 0.2 p.u. in 0.01 p.u. steps
Voltage direction:	Direction 1 / Direction 2
Operating value stage 1:	30° ... 150° in 1° steps
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	0.1 ... 0.5 xIn in 0.01 xIn steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Rotor angle:	In electrical degrees

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
Rotor angle:	≤ 2% electrical of rotor angle

7.2.4. Under Excitation for Three Phase Systems (Excitation Current Measuring DC)

PROTECTIVE FUNCTION: ME 322	FNNR	TYPE	ANSI	Application
Under excitation for three phase systems, rotor angle, excitation current DC	1042	ME322	40	C2,M

2- stage under excitation protection for three phase systems with rotor angle measuring and consideration of the rotor current (DC).

ME322
Technical Data

Inputs

Analogue:	Generator current phase L1
	Generator voltage phase L2-L3
	Rotor current (DC)
Binary:	Blocking input stage 1 (ϑ>)
	Blocking input stage 2 (ϑ> & $I_{Excitation}$ <)
	Test input stage 1 (ϑ>)
	Test input stage 2 (ϑ> & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (ϑ>)
	Trip stage 1 (ϑ>)
	Instantaneous operation stage 2 (ϑ> & $I_{Excitation}$ <)
	Trip stage 2 (ϑ> & $I_{Excitation}$ <)

Setting Parameters

Quadrilateral reactance:	0.5 ... 5.0 p.u. in 0.01 p.u. steps
Power system reactance:	0.0 ... 0.2 p.u. in 0.01 p.u. steps
Voltage direction:	Direction 1 / Direction 2
Operating value stage 1:	30° ... 150° in 1° steps
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	10 ... 220 xIn DC in 1 xIn DC steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps
Rotor current configuration:	1.5 ... 96 ADC/V in 0.1 ADC/V steps
Rotor current offset:	0.000 ... 4.995 V in 0.005 V steps

Window Display for Relay Internal
Determined and Computed Values

Rotor angle:	In electrical degrees

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
Rotor angle:	≤ 2% electrical of rotor angle

7.2.5. Under Excitation for Three Phase Systems (Excitation Current Measuring AC)

PROTECTIVE FUNCTION: ME 323	FNNR	TYPE	ANSI	Application
Under excitation for three phase systems, MHO characteristic, excitation current AC	1070	ME323	40	C2,M

2-stage MHO under excitation protection with consideration of the rotor current. Instantaneous operation stage 1 when the locus is entering the reactance circle. Instantaneous operation stage 2 when the locus is entering the reactance circle and simultaneous decrease of the minimum permissible rotor current (measurement of the rotor current: AC).

ME323
Technical Data

Inputs

Analogue:	Generator current phase L1
	Rotor current (AC)
	Generator voltage phase L2-L3
Binary:	Blocking input stage 1 (impedance circle)
	Blocking input stage 2 (impedance circle & $I_{Excitation}$ <)
	Test input stage 1 (impedance circle)
	Test input stage 2 (impedance circle & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (impedance circle)
	Trip stage 1 (impedance circle)
	Instantaneous operation stage 2 (impedance circle & $I_{Excitation}$ <)
	Trip stage 2 (impedance circle & $I_{Excitation}$ <)

Setting Parameters

Centre point (reactance circle):	0.5 ... 5.0 p.u. in 0.05 p.u. steps
Diameter (reactance circle):	0.1 ... 3.0 p.u. in 0.05 p.u. steps
Voltage direction:	Direction 1 / Direction 2
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	0.10 ... 0.50 xIn AC in 0.01 xIn AC steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps

Window Display for Relay Internal
Determined and Computed Values

IZI (absolute value of the impedance vector):	in Ohm

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
	≤ 6% of impedance setting value

7.2.6. Under Excitation for Three Phase Systems (Excitation Current Measuring DC)

PROTECTIVE FUNCTION: ME 324	FNNR	TYPE	ANSI	Application
Under excitation for three phase systems, MHO characteristic, excitation current DC	1071	ME324	40	C2,M

3-stage MHO underexcitation protection with consideration of the rotor current.
Instantaneous operation stage 1 when the locus is entering the reactance circle..
Instantaneous operation stage 2 when the locus is entering the reactance circle.
and simultaneous decrease of the minimum permissible rotor current (measurement of the rotor current: DC).

ME324
Technical Data

Inputs

Analogue:	Generator current phase L1
	Generator voltage phase L2-L3
	Rotor current (DC)
Binary:	Blocking input stage 1 (impedance circle)
	Blocking input stage 2 (impedance circle & $I_{Excitation}$ <)
	Test input stage 1 (impedance circle)
	Test input stage 2 (impedance circle & $I_{Excitation}$ <)

Outputs

Binary:	Instantaneous operation stage 1 (impedance circle)
	Trip stage 1 (impedance circle)
	Instantaneous operation stage 2 (impedance circle & $I_{Excitation}$ <)
	Trip stage 2 (impedance circle & $I_{Excitation}$ <)

Setting Parameters

Centre point (reactance circle):	0.5 ... 5.0 p.u. in 0.05 p.u. steps
Diameter (reactance circle):	0.1 ... 3.0 p.u. in 0.05 p.u. steps
Voltage direction:	Direction 1 / Direction 2
Tripping time stage 1:	0 ... 30 sec in 0.05 steps
Operating value stage 2:	10 ... 220 xIn DC in 0.01 xIn DC steps
Tripping time stage 2:	0 ... 3.0 sec in 0.05 sec steps
Rotor current configuration:	1.5 ... 45 ADC/V in 0.1 ADC/V steps
Rotor current offset:	0.000 ... 4.995 V in 0.005 V steps

Window Display for Relay Internal
Determined and Computed Values

IZI (absolute value of the impedance vector):	in Ohm

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
	≤ 6% of impedance setting value

7.3. CONNECTION DIAGRAMS

7.3.1. ME121

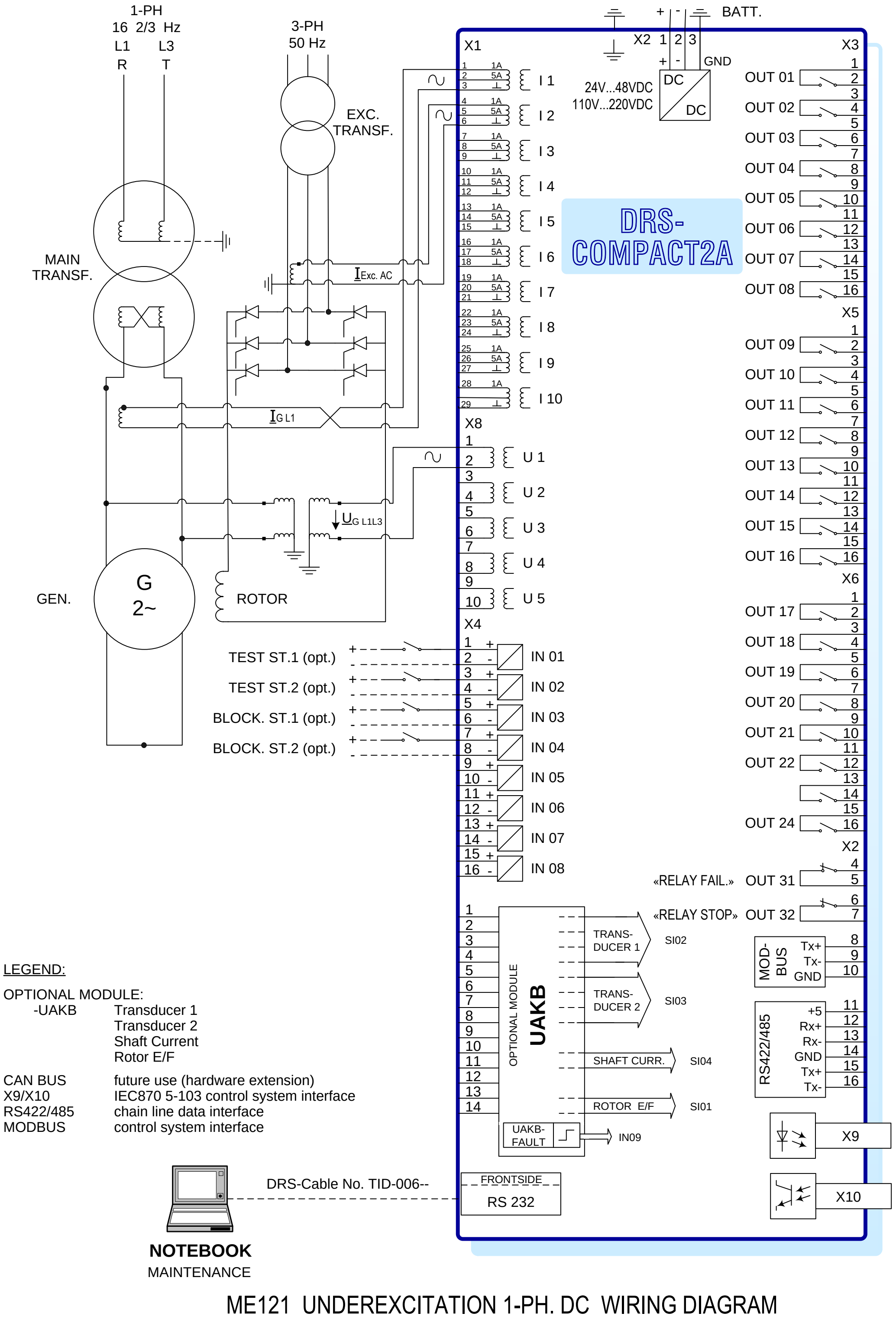


Fig. 73 ME121 Underexcitation 1-PH. DC Wiring Diagram

7.3.2. ME122

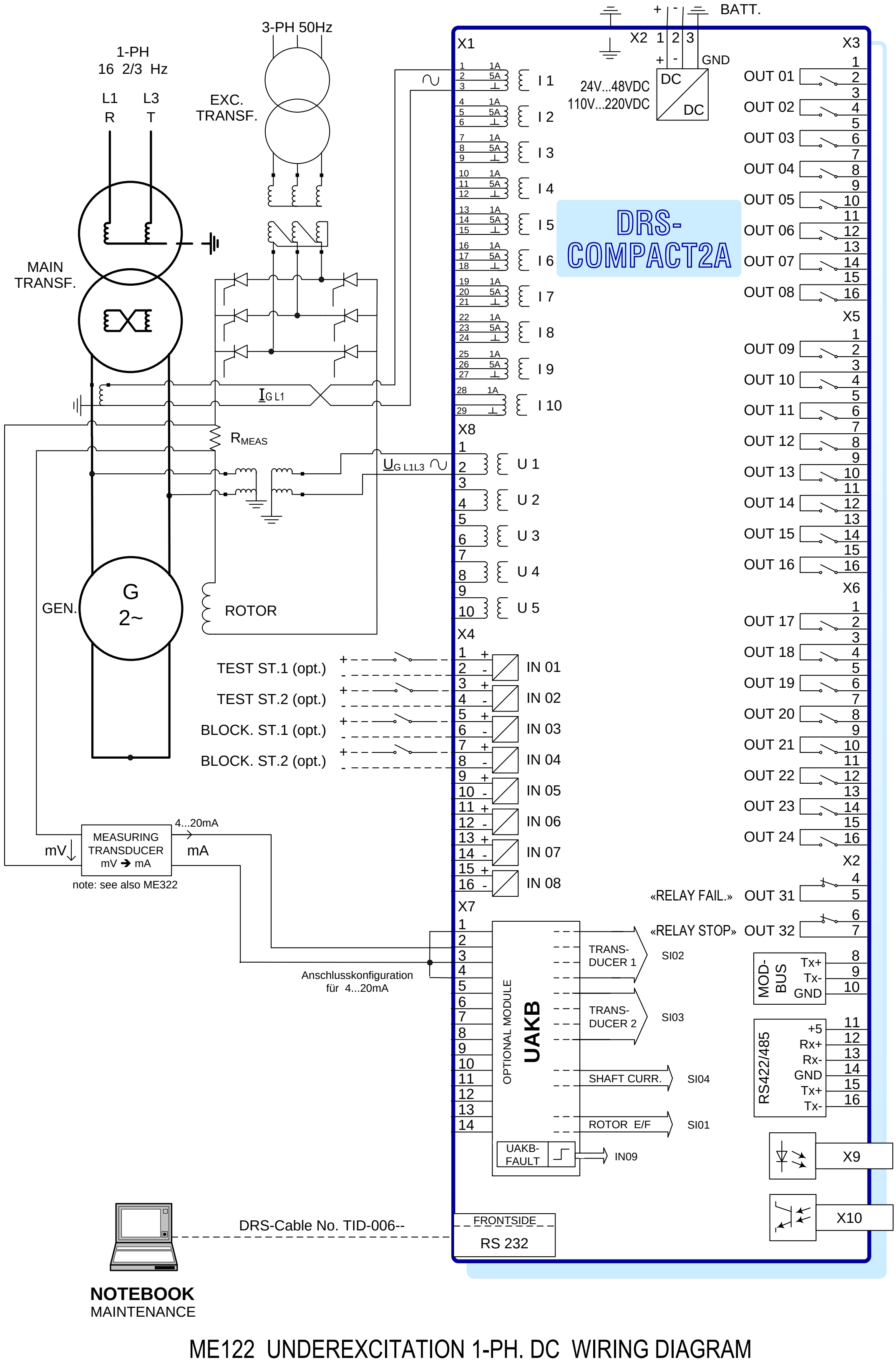


Fig. 74 ME122 Underexcitation 1-PH. DC Wiring Diagram

7.3.3. ME321

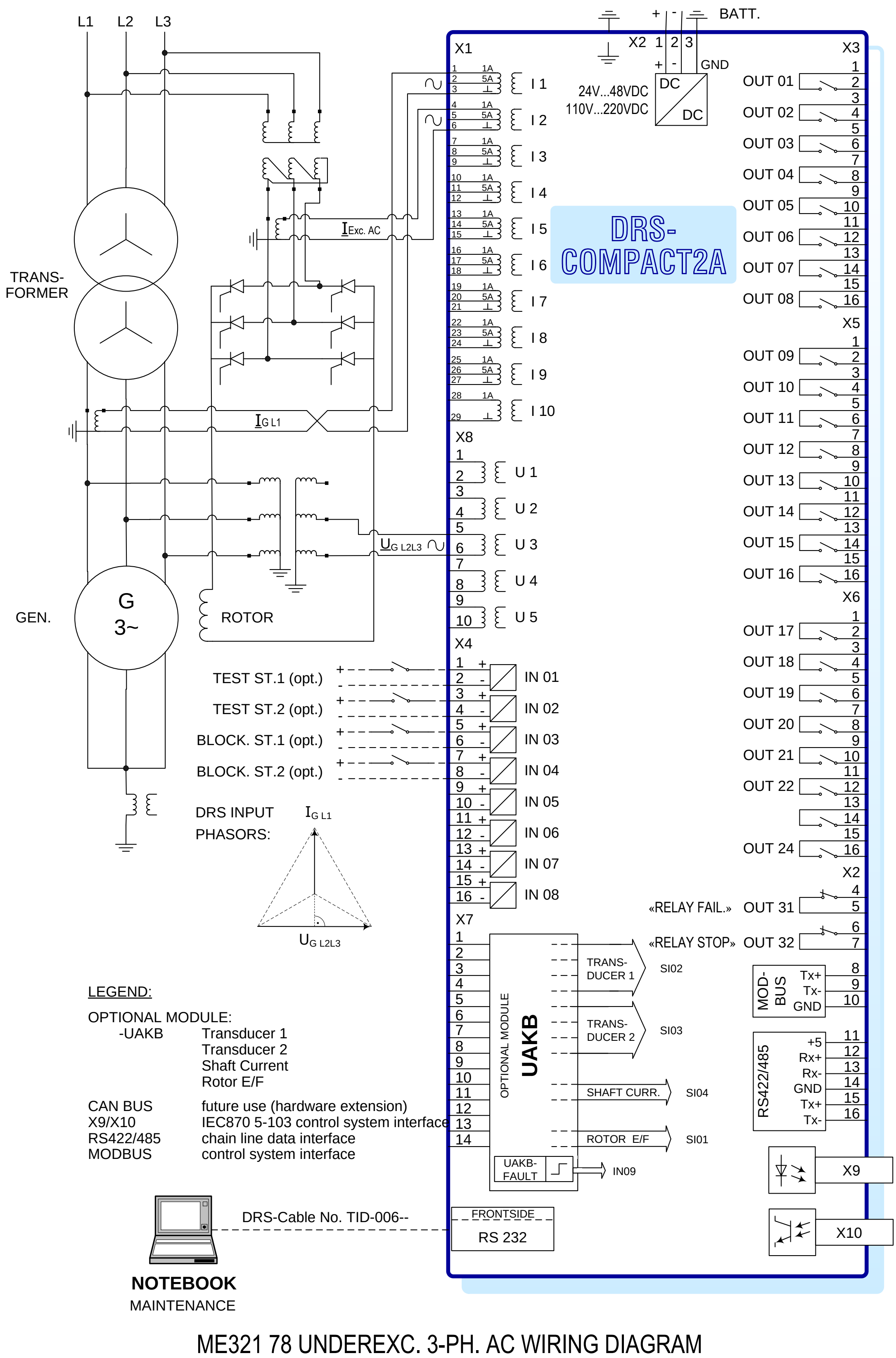


Fig. 75 ME321 78 Underexc. 3-PH. AC Wiring Diagram

7.3.4. ME322

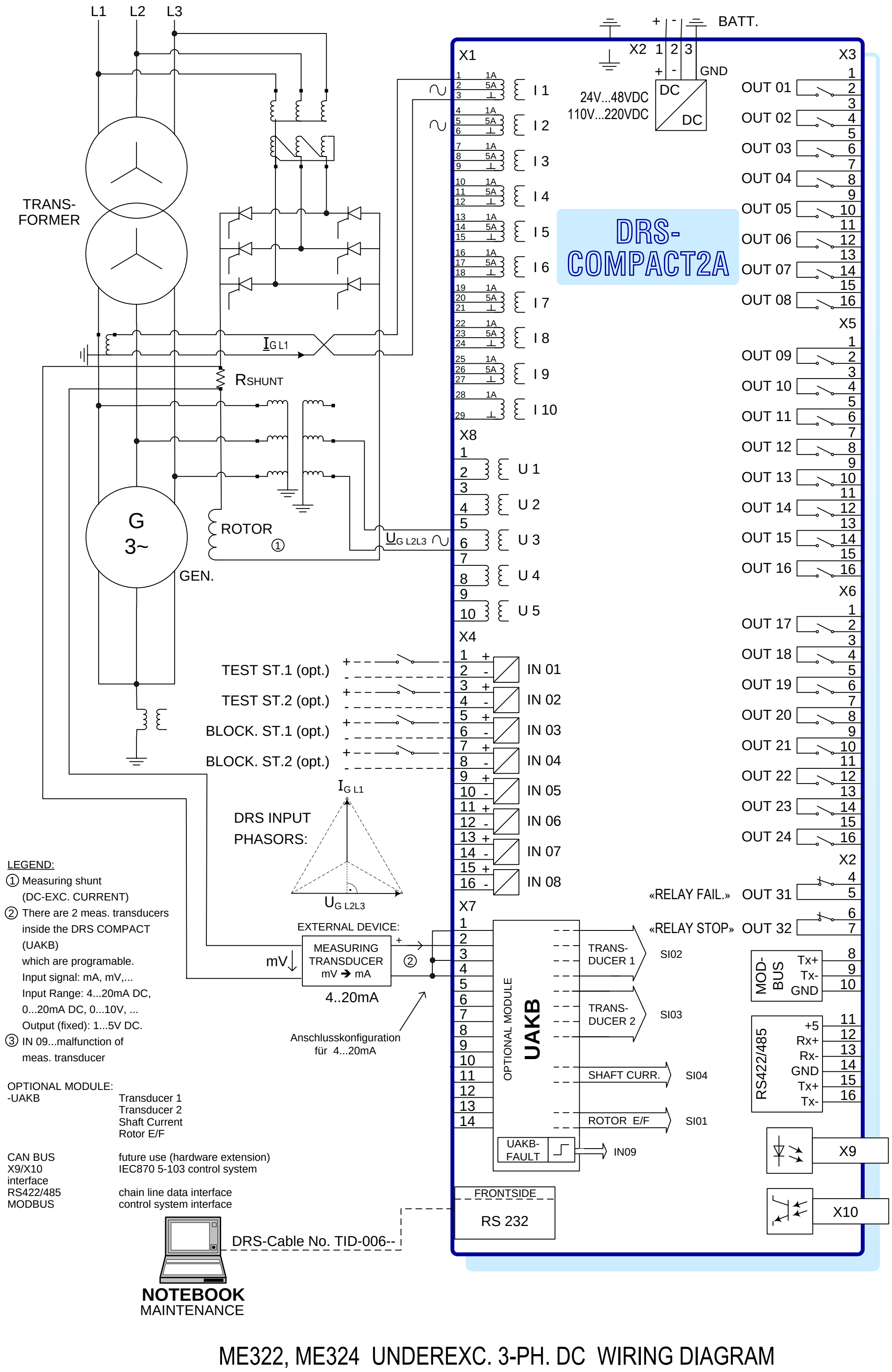


Fig. 76 ME322, ME324 Underexc. 3-PH. DC Wiring Diagram

7.3.5. ME323

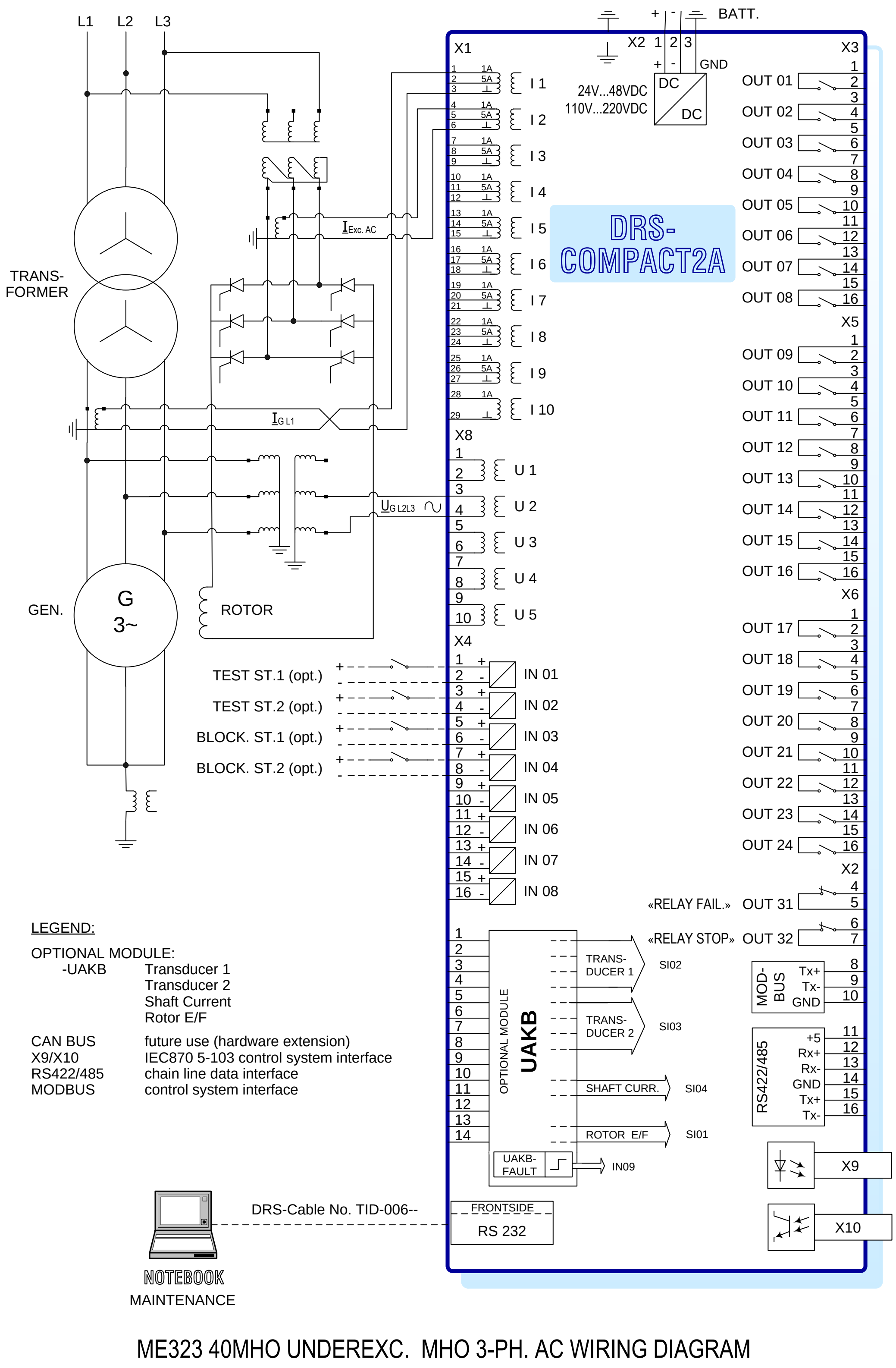
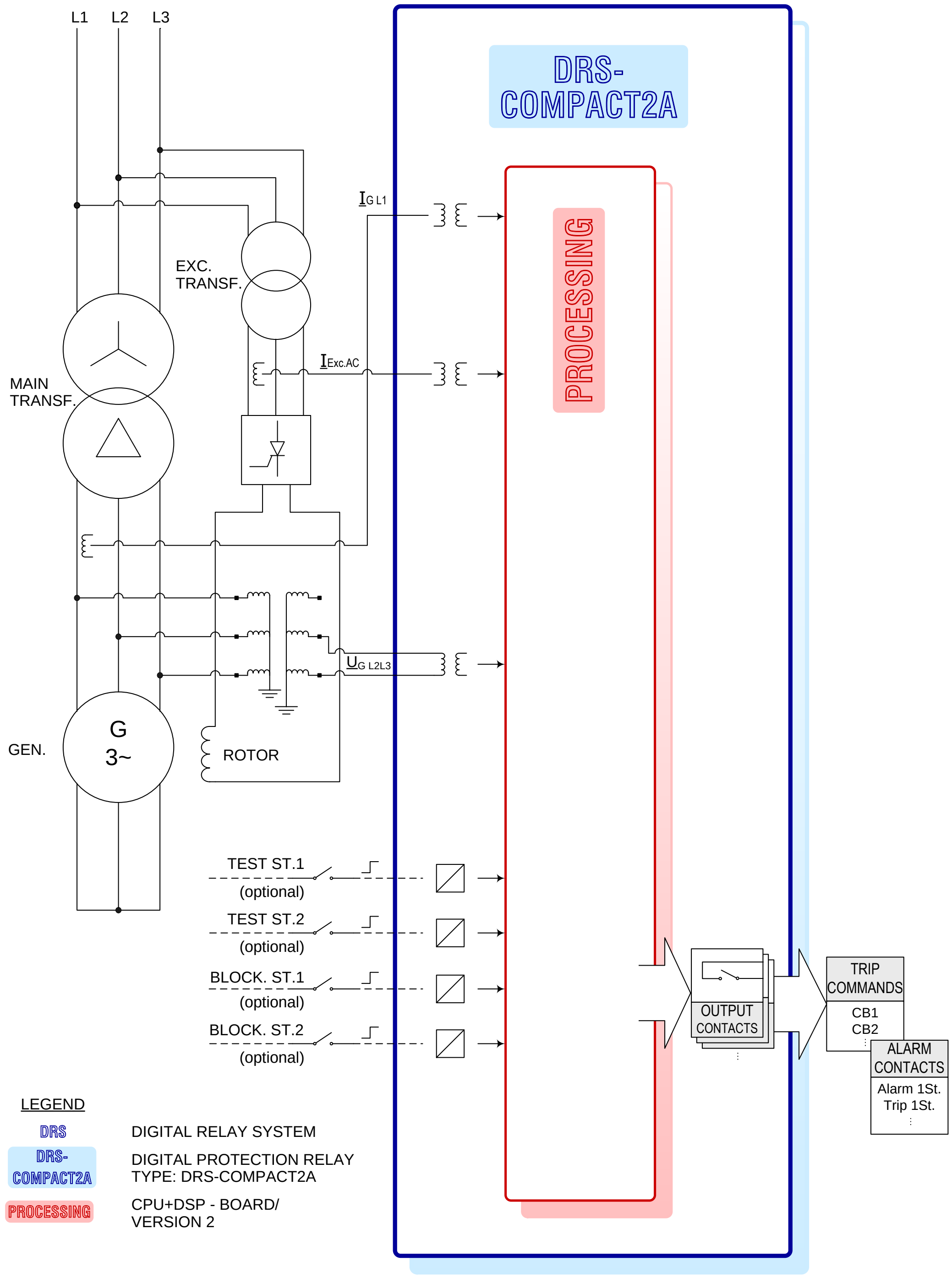


Fig. 77 ME323 40MHO Underexc. MHO 3-PH. AC Wiring Diagram

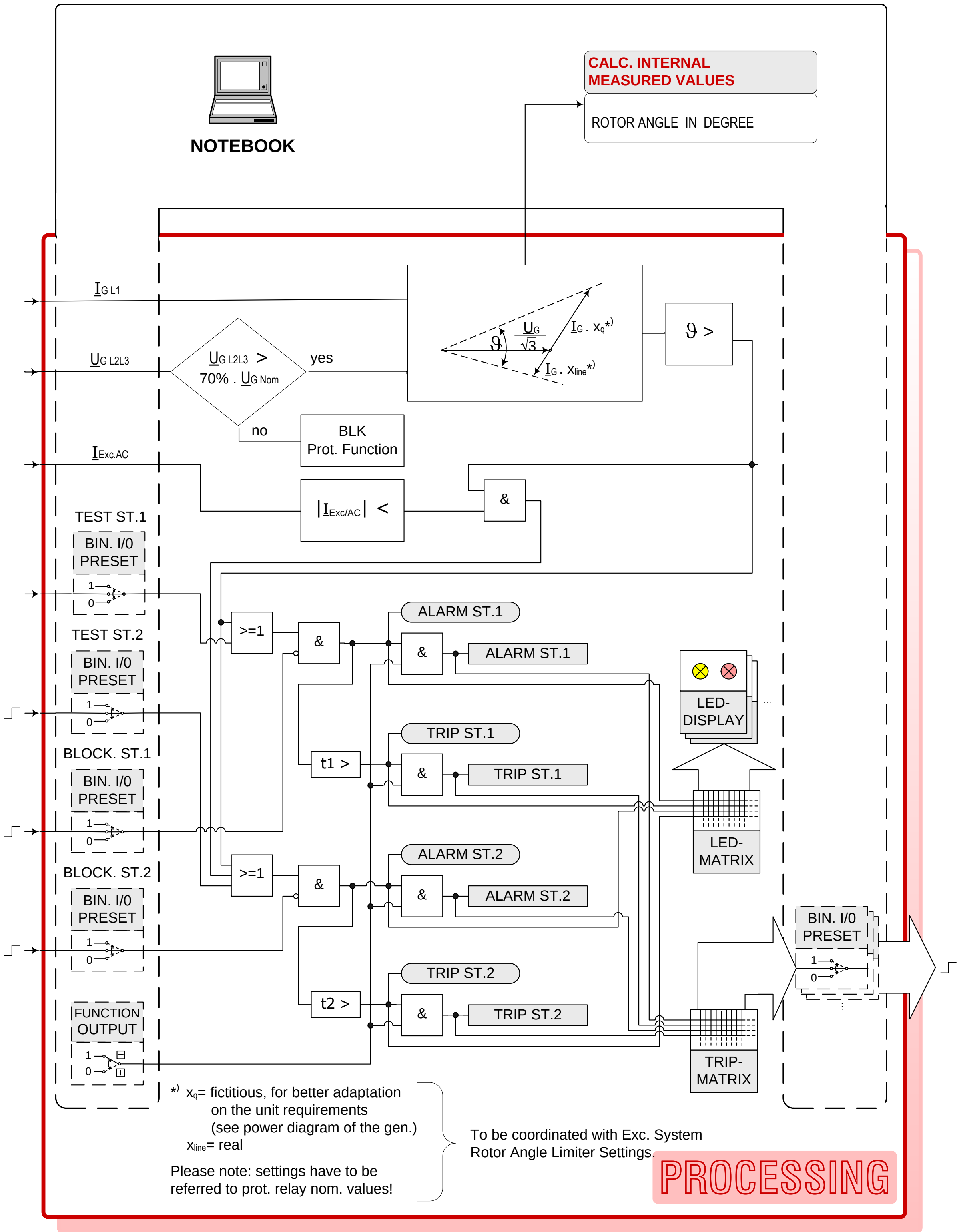
7.4. LOGIC DIAGRAMS

7.4.1. ME321



ME321 78 UNDEREXC. 3-PH. AC LOGIC DIAGRAM

Fig. 78 ME321 78 Underexc. 3-PH. AC Logic Diagram



ME321 78 UNDEREXC. 3-PH. AC LOGIC DIAGRAM / PROCESSING

Fig. 79 ME321 78 Underexc. 3-PH.AC Logic Diagram / Processing

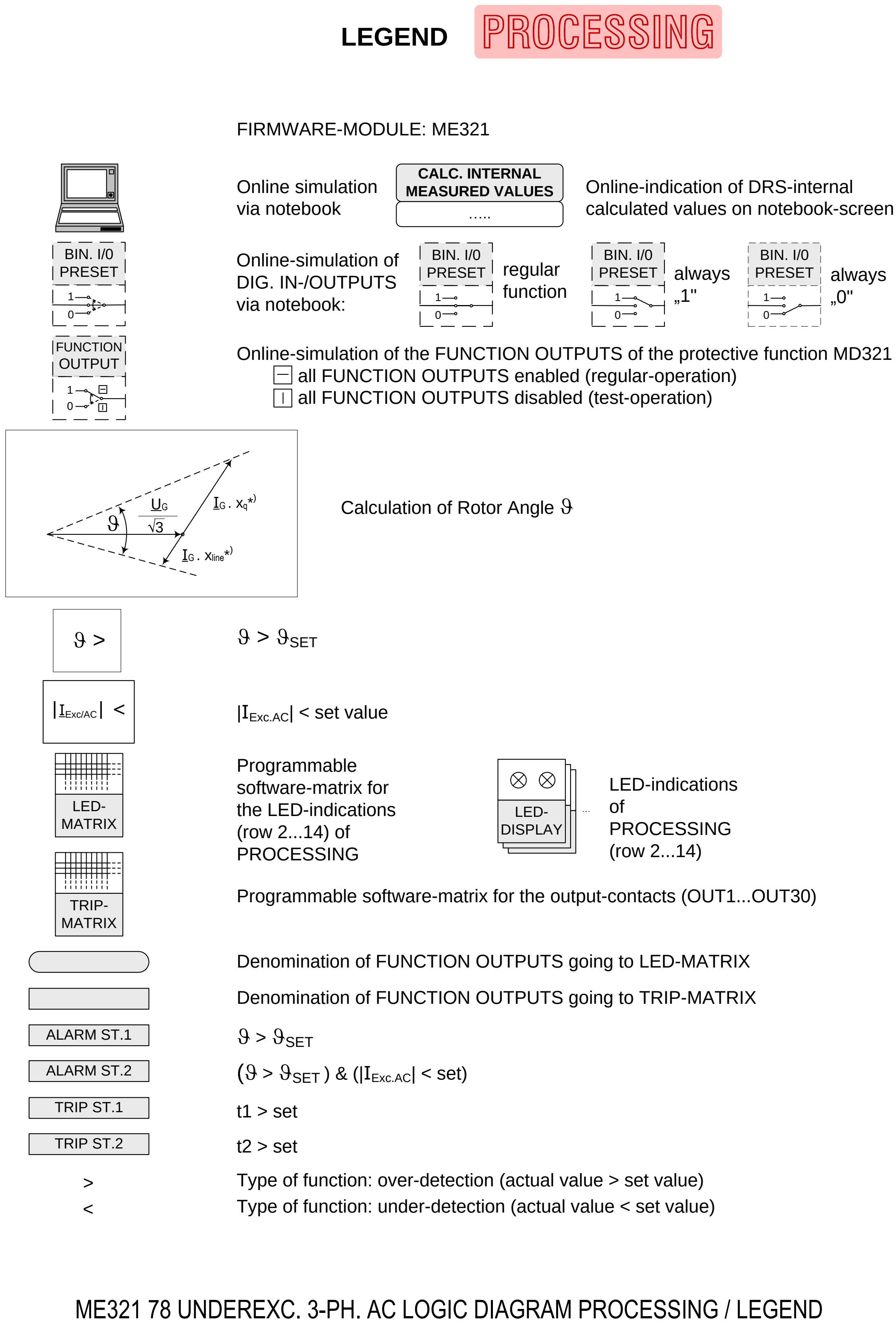
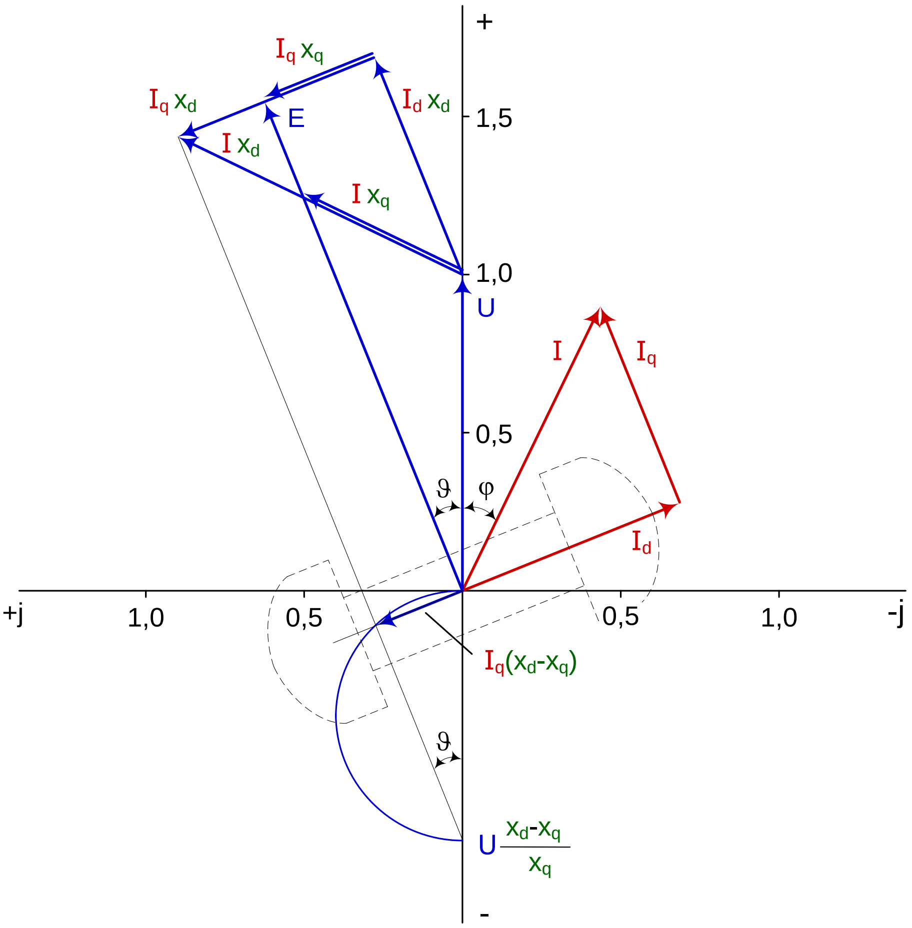


Fig. 80 ME321 78 Underexc. 3-PH. AC Logic Diagram Processing / Legend

VOLTAGE DIAGRAM
OF A SALIENT POLE MACHINE
(SYNCHRONOUS GENERATOR):

DEF. OF ROTOR ANGLE (THEORY)



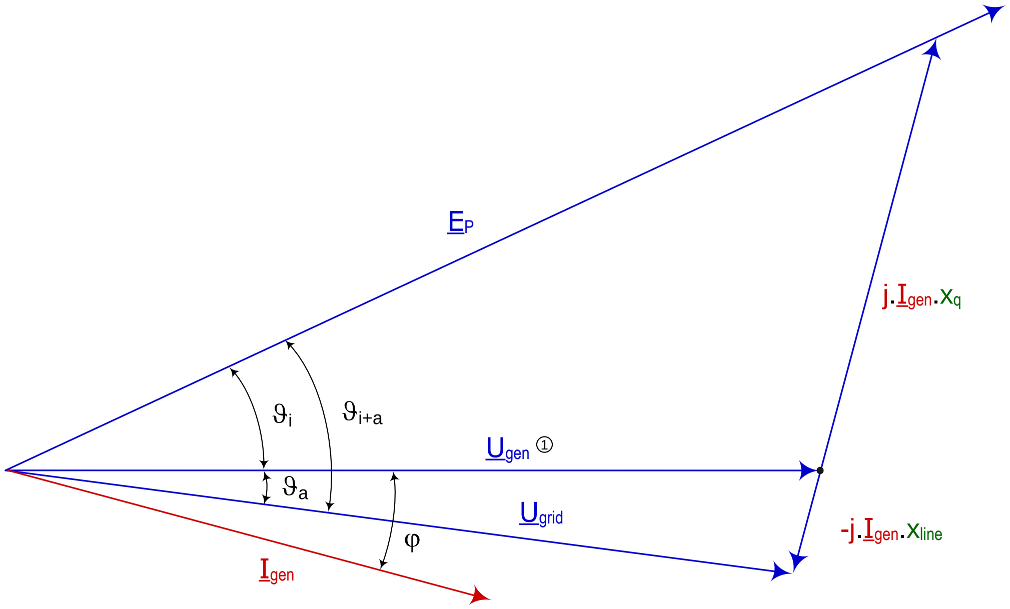
LEGEND

U	generator voltage
I	generator current
E	magnet wheel voltage (corresponds with sum of magnetic flux Φ_e)
x_d	direct-axis syncronous reactance
x_q	quadrature-axis syncronous reactance
ϑ	inner rotor angle
φ	phase angle

ME321 78 UNDEREXC. 3-PH. AC THEOR. DEFINITION OF ROTOR ANGLE

Fig. 81 ME321 78 Underexc. 3-PH. AC Theor. Definition Of Rotor Angle

CALCULATION OF ROTOR ANGLE
OF SYNCHRONOUS GENERATOR/
SET VALUE FOR ME321



LEGEND

$\underline{U}_{gen}$ generator voltage (for example: U_{L1}) ①

$\underline{I}_{gen}$ generator current (for example: I_{L1})

$\underline{E}_{P}$ magnet wheel voltage (corresponds with sum of magnetic flux Q_e)

ϑ_i inner rotor angle
(between gen. internal volt. and terminal volt.) = load angle of the machine

ϑ_a outer rotor angle

ϑ_{i+a} sum of rotor angle
(between gen. internal voltage and grid voltage)

φ phase angle

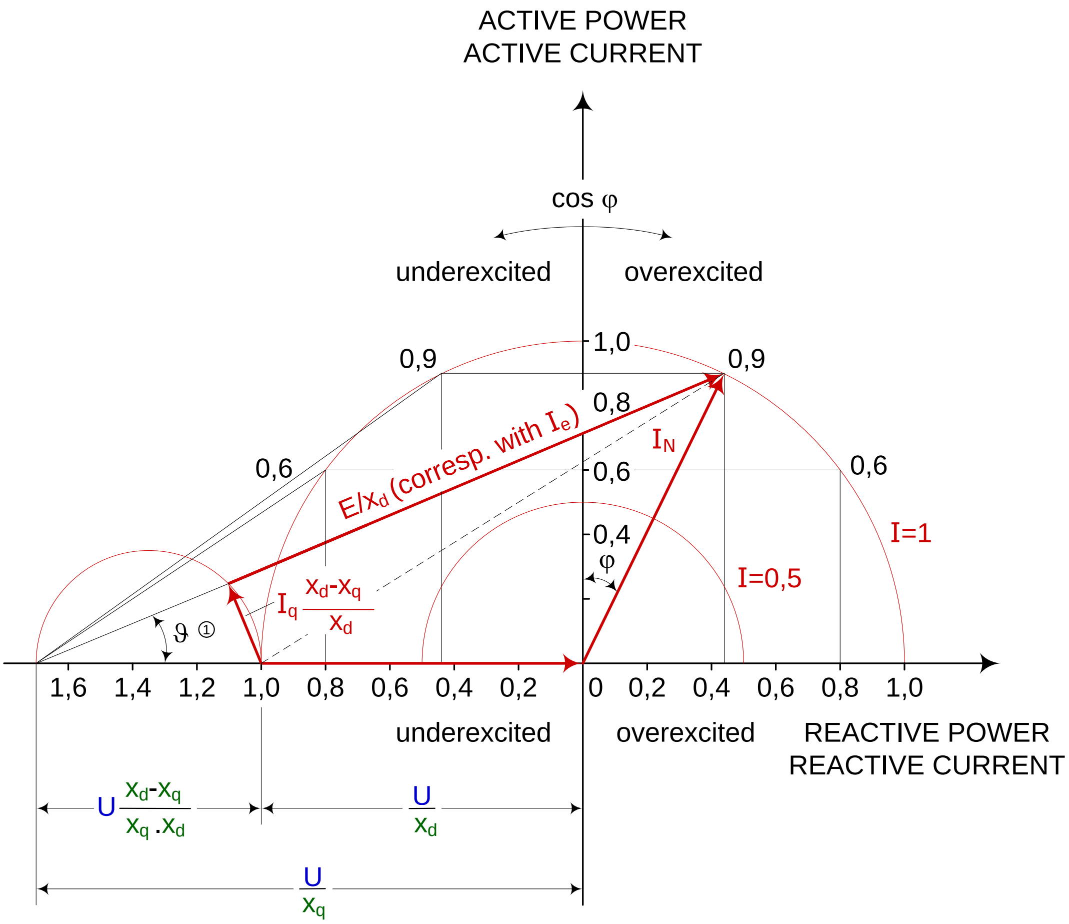
① Note: DIAGRAM USES U_{L1}
DRS INPUT USES U_{L2L3} IN ORDER TO ACHIEVE MULTIPL. BY (j)

ME321 78 UNDEREXC. 3-PH. AC CALCULATION OF ROTOR ANGLE

Fig. 82 ME321 78 Underexc. 3-Ph. AC Calculation Of Rotor Angle

POWER DIAGRAM
OF SALIENT POLE MACHINE
(SYNCHRONOUS GENERATOR):

CALCULATION OF ROTOR ANGLE (EXAMPLE)

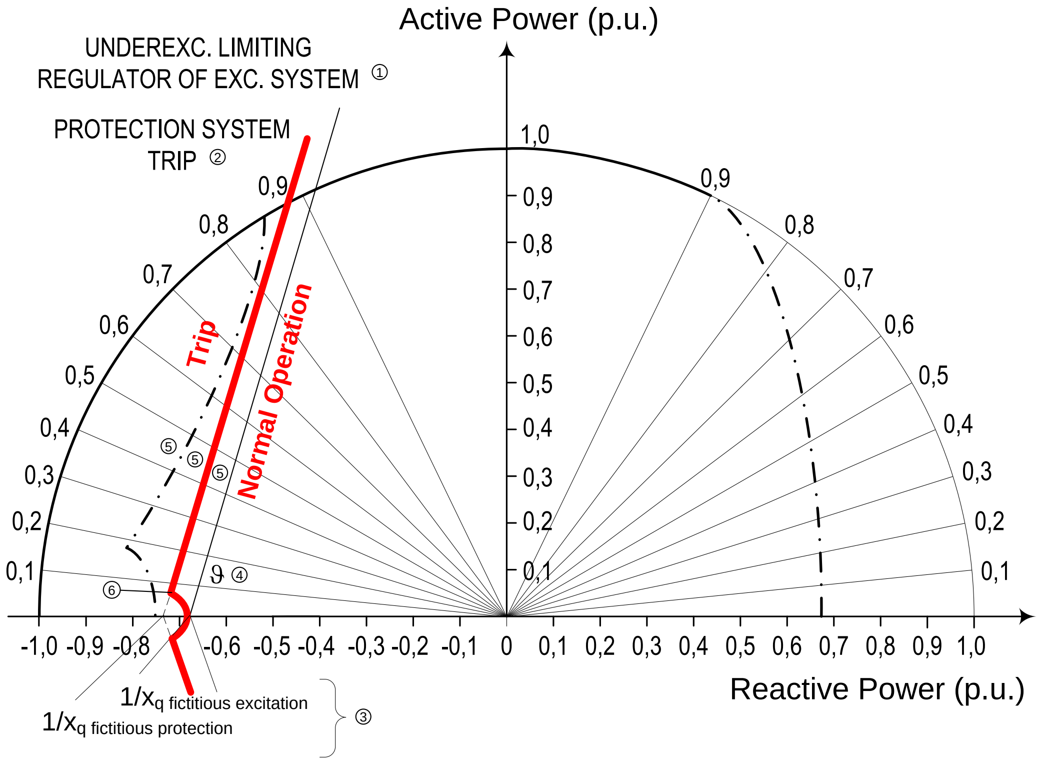


① ϑ ... ROTOR ANGLE
(BETWEEN GEN. INTERNAL VOLT. AND TERMINAL VOLT.) = LOAD ANGLE.

ME321 78 UNDEREXC. 3-PH. AC
EXAMPLE: CALC. OF ROTOR ANGLE USING THE GEN. POWER DIAGRAM

Fig. 83 ME321 78 Underexc. 3-PH.AC Example: Calc. Of Rotor Angle Using The Gen. Power Diagram

POWER DIAGRAM
OF A SALIENT POLE MACHINE
(SYNCHRONOUS GENERATOR)



— · — · — specification of gen. operating range by generator manufacturer (allowed operating range)

<u>Sample in practice:</u>

① Set Value „Excitation“: given by setting of Underexcitation Limiting Regulator of the excitation

② Set Value „Protection“: Tripping by protection system

③ $1/x_{q\ fictitious}$ ... Fictitious x_q for the optimum adaptation of the set points on the unit requirements

④ ϑ … Fictitious inner rotor angle

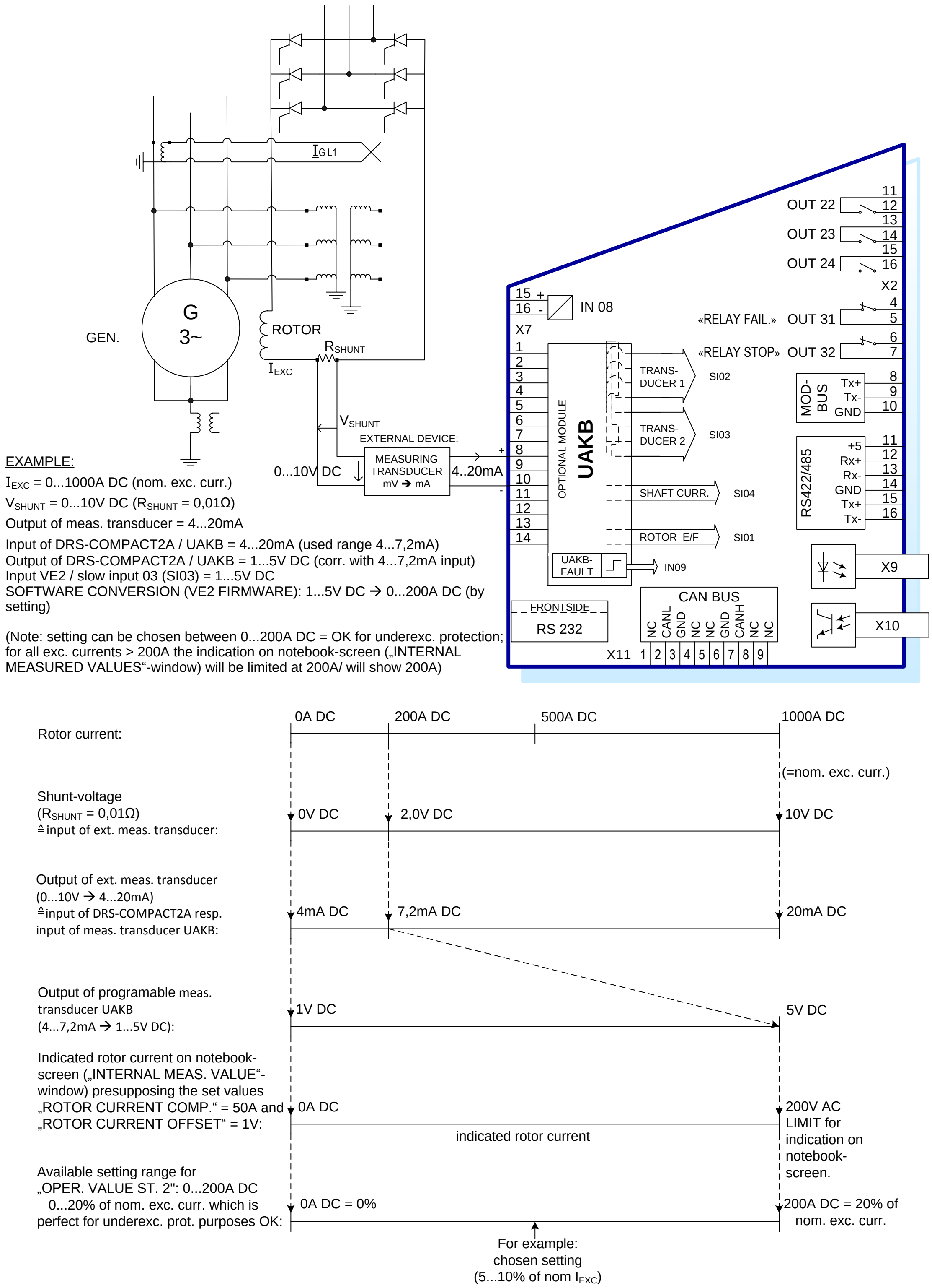
⑤ Note: These limits apply only if the real x_N is assumed to be zero (incl. Main Tr.!).

⑥ Note: Radius of circle = 0,1 p.u. / x_q
TRIP of first stage if: $|\underline{U}_G/x_q - \underline{I}_G| < (0{,}1 \text{ p.u.} / x_q)$
[$\underline{U}_G$, $\underline{I}_G$ …in p. u., related to relay nominal current]

ME321 78 UNDEREXC. 3-PH. AC
EXAMPLE: CALC. OF ROTOR ANGLE SET VALUES
USING GEN. POWER DIAGRAM

Fig. 84 ME321 78 Underexc. 3-PH. AC Example: Calc. Of Rotor Angle Set Values Using Gen. Power Diagram

7.4.2. ME322

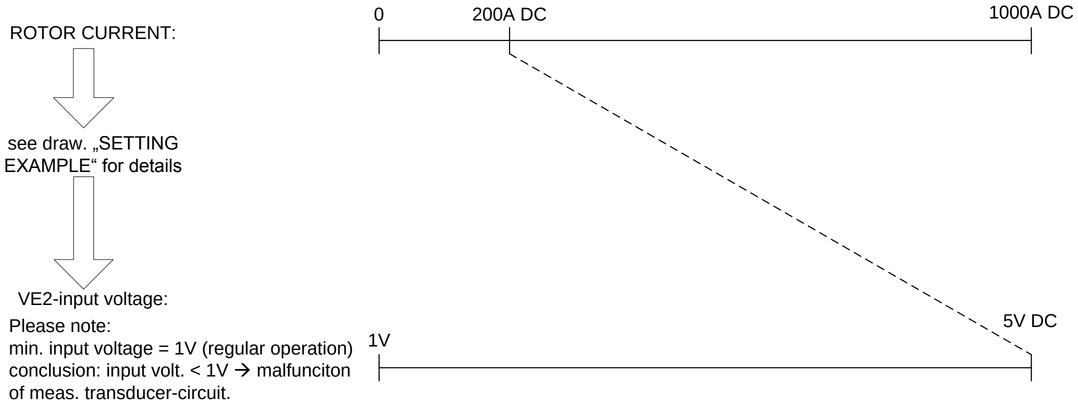


ME322 UNDEREXC. 3-PH. DC SETTING EXAMLPE FOR SLOW INPUT SI03

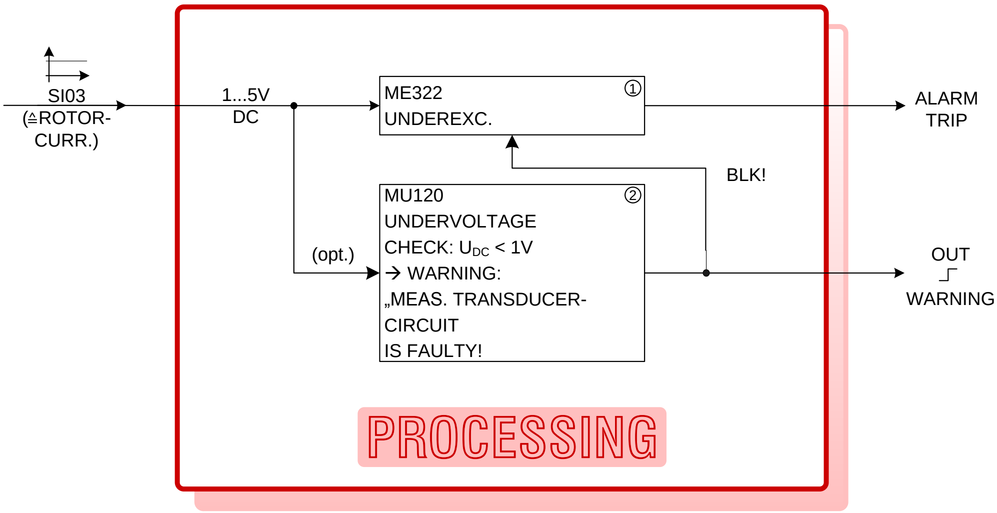
Fig. 85 ME322 Underexc. 3-PH. DC Setting Example For Slow Input SI03

ME322/ OPTION:

SUPERVISION OF MEAS. TRANSDUCER-CIRCUIT OF ROTORCURRENT



LOGIC DIAGRAM / PROCESSING:



LEGEND:
① Software-relay „UNDEREXC. 3-PH. DC“
input signal must be 1...5V DC (regular operation)
② Software-relay „UNDERVOLT.. DC“
input voltage must be 1...5V DC (regular operation)
practical setting (example): 0,5V/ undervoltage → WARNING

ME322 UNDEREXC. 3-PH. DC SUPERVISION OF MEASURING TRANSDUCER FOR ROTORCURR.

Fig. 86 ME322 Underexc. 3-PH. DC Supervision Of Measuring Transducer For Rotorcurr.

7.4.3. ME323

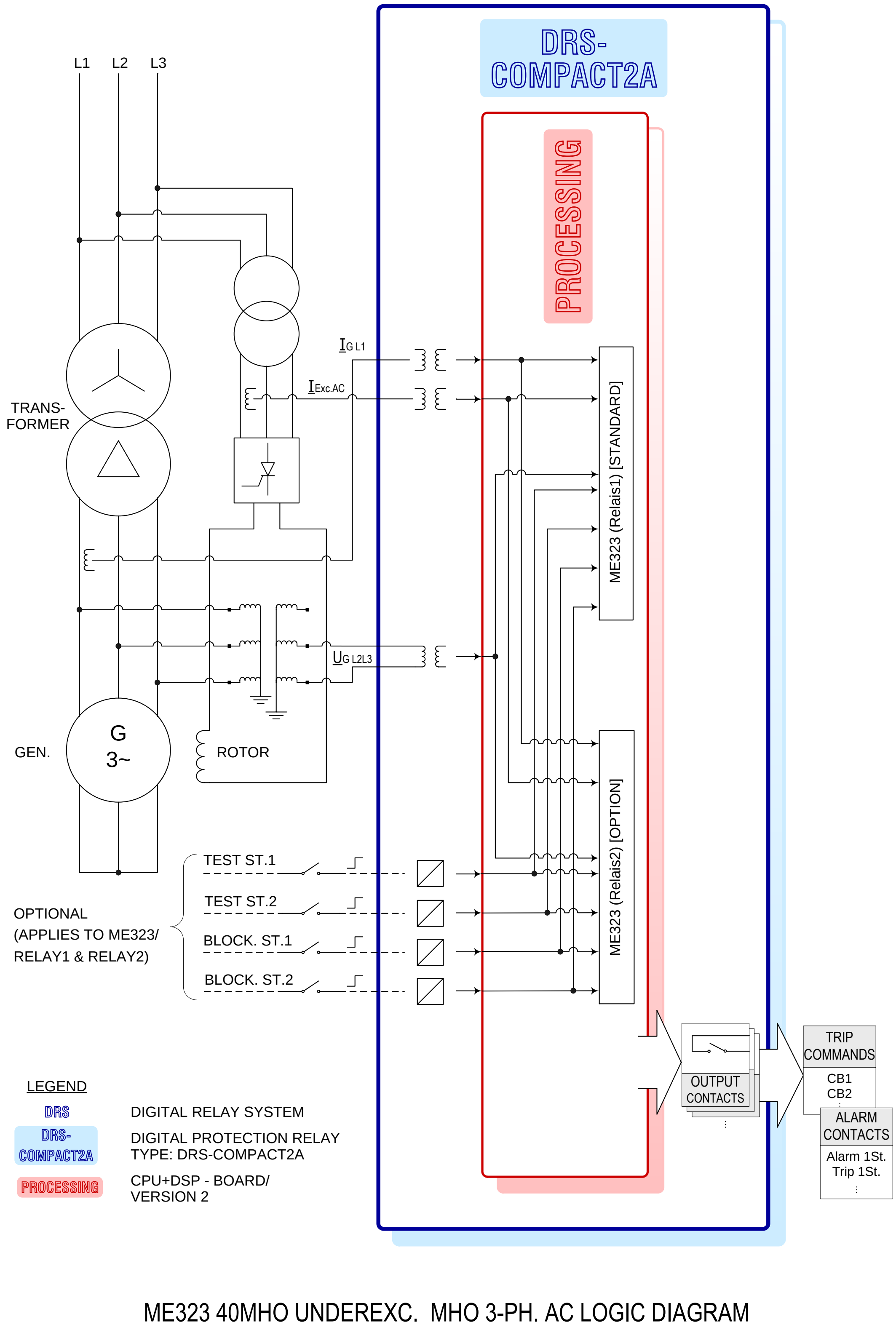
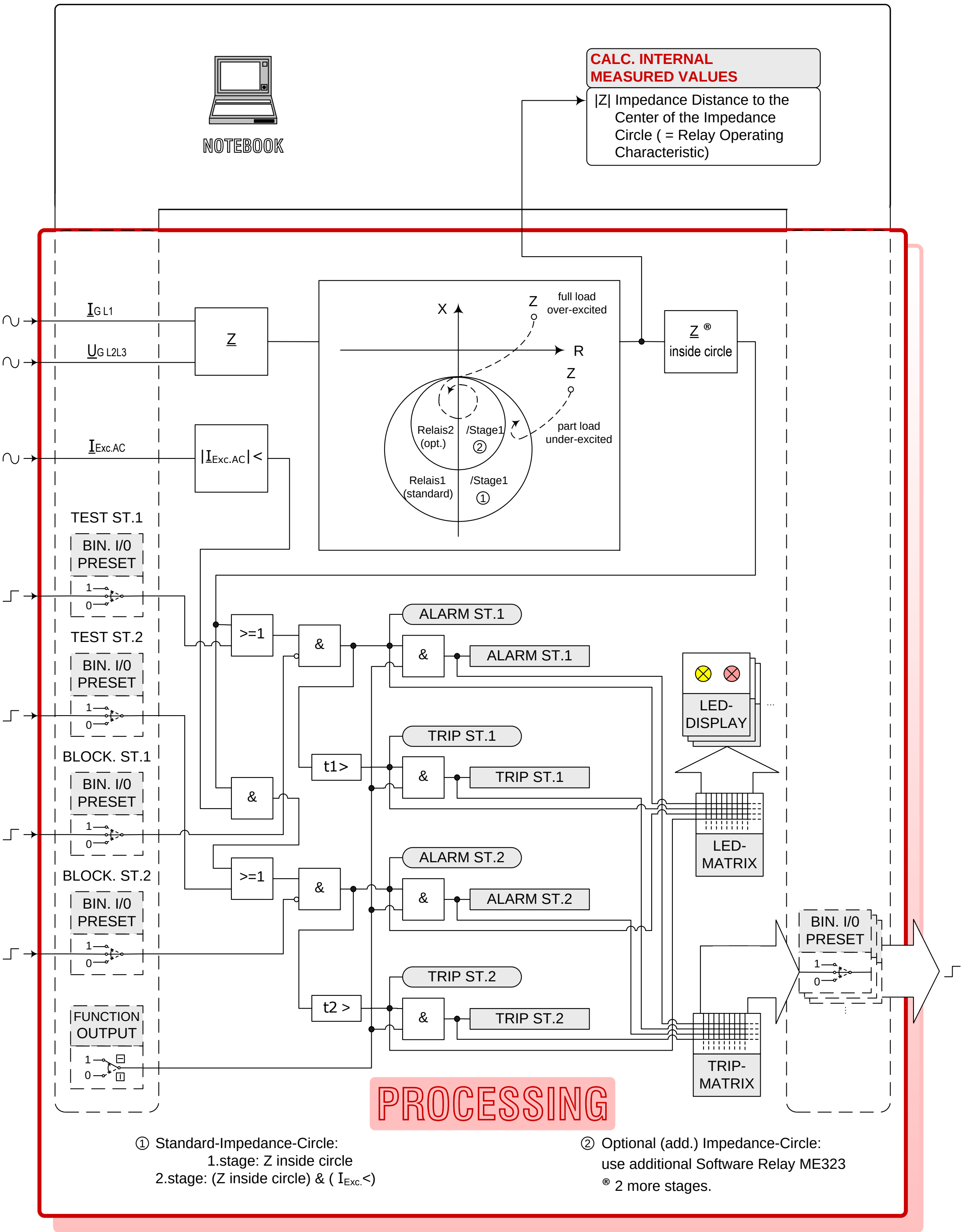


Fig. 87 ME323 40MHO Underexc. MHO 3-PH. AC Logic Diagram



ME323 40MHO UNDEREXC. MHO 3-PH. AC LOGIC DIAGRAM PROCESSING

Fig. 88 ME323 40MHO Underexc. MHO 3-PH. AC Logic Diagram Processing

7.4.4. ME324

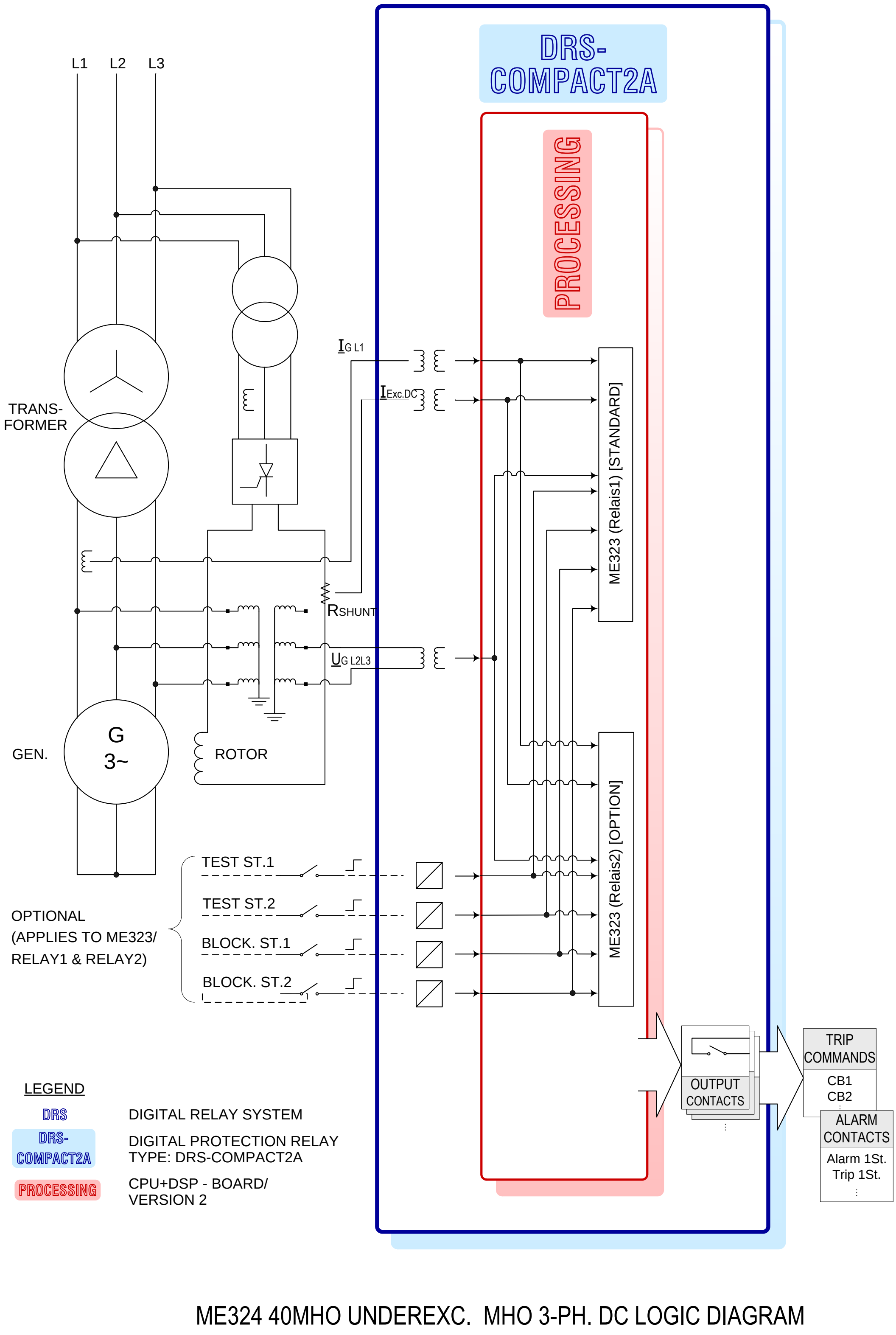


Fig. 89 ME324 40MHO Underexc. MHO 3-PH. DC Logic Diagram

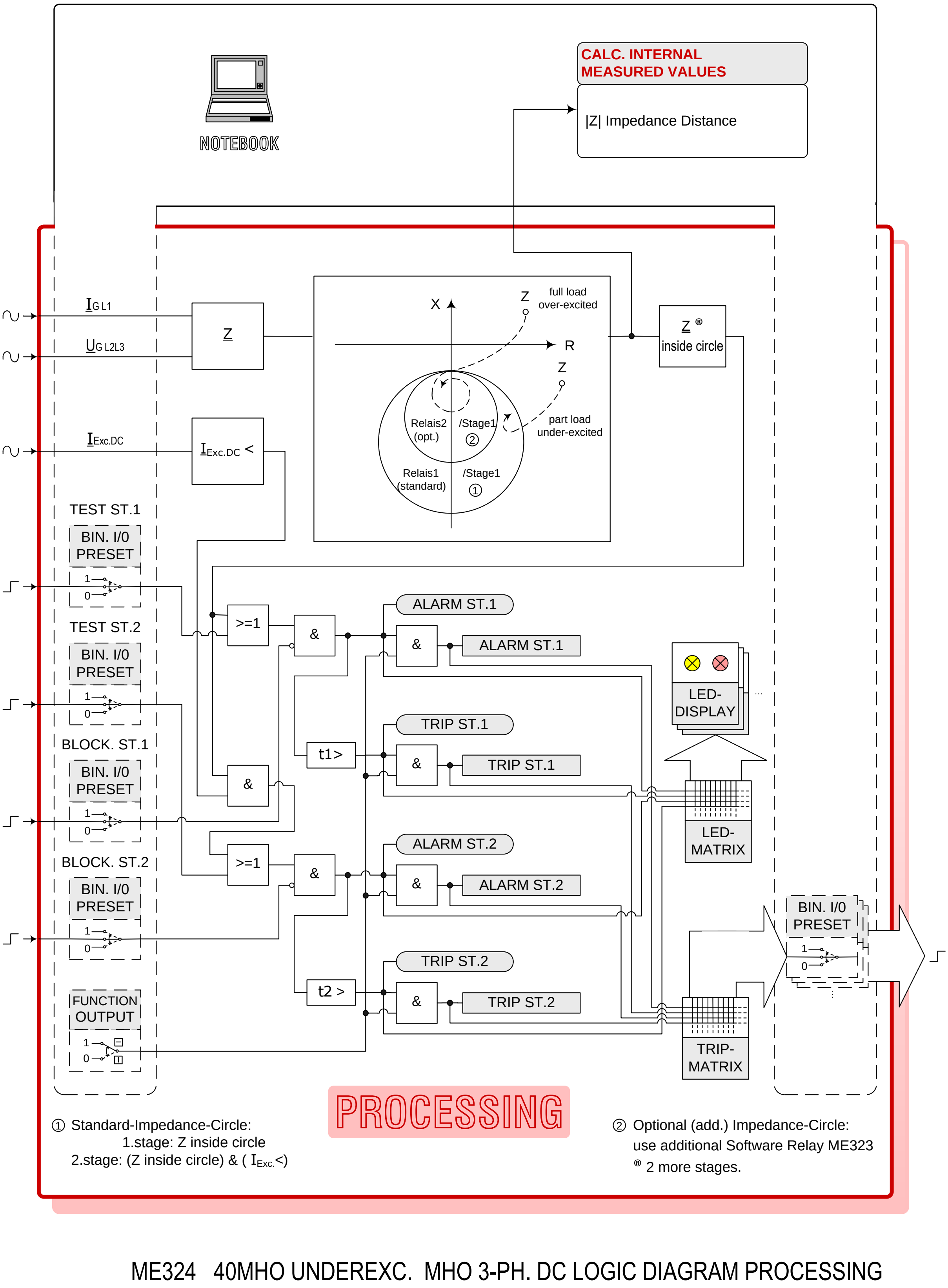


Fig. 90 ME324 40MHO Underexc. MHO3-PH. DC Logic Diagram Processing

LEGEND PROCESSING

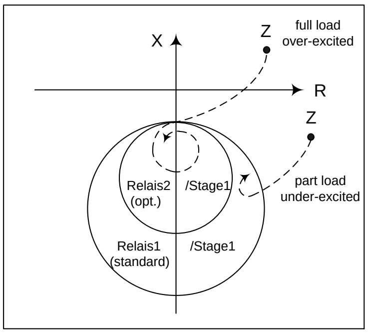
FIRMWARE MODULE: ME323, ME324

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function ME323
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

Z — calculation of phasor Z — Z inside circle — under-excitation detected (ALARM starts)



check: Z inside circle = under-excitation (loss of field)

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING — LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

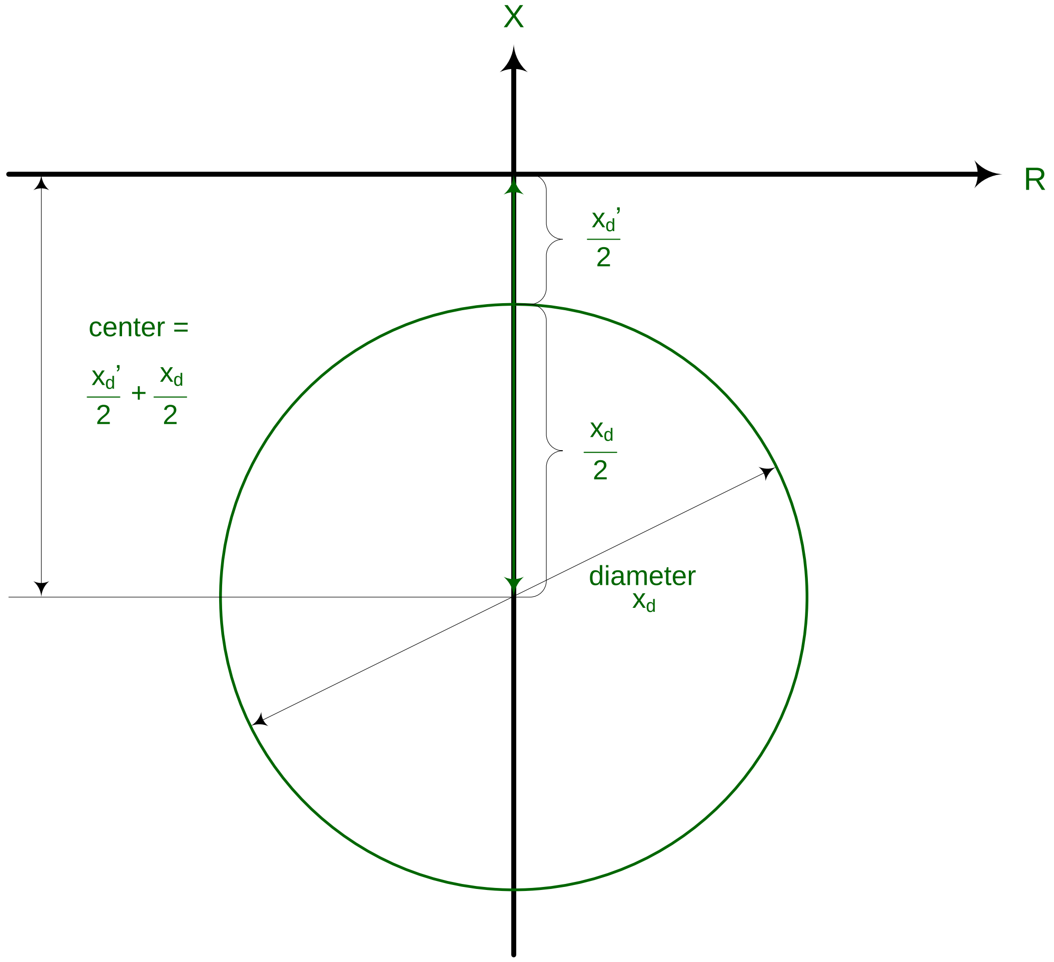
TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM ST.1	FUNCTION OUTPUT: Stage1 ALARM
ALARM ST.2	FUNCTION OUTPUT: Stage2 ALARM
TRIP ST.1	FUNCTION OUTPUT: Stage1 TRIP
TRIP ST.2	FUNCTION OUTPUT: Stage2 TRIP
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

ME323, ME324 40MHO UNDEREXC. MHO 3-PH. AC, DC LOGIC DIAGRAM
PROCESSING / LEGEND

Fig. 91 ME323, ME324 40MHO Underexc. MHO 3-PH. AC, DC Logic Diagram Processing / Legend

STANDARD APPLICATION USING
1 SOFTWARE RELAY ME323



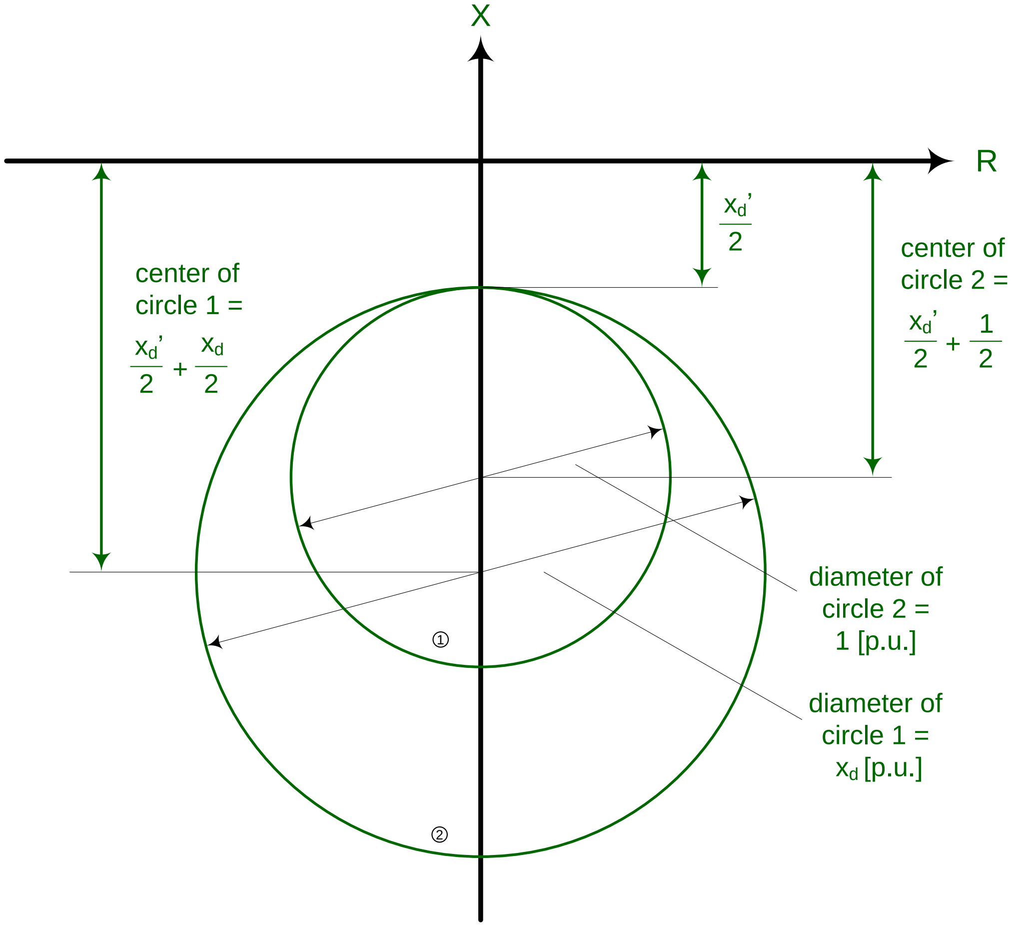
SOFTWARE RELAY ME323:

diameter = x_d [p.u.]	range: 0,1...3,0 p.u.
center $= \frac{x_d}{2} + \frac{x_d'}{2}$ [p.u.]	range: 0,5...5,0 p.u.
t_{stage1} = 0s	range: 0...30s

ME323, ME324 40MHO UNDEREXC. MHO 3-PH. AC/DC
CALCULATION OF SET VALUES
APPLICATION EXAMPLE 1

Fig. 92 ME323,ME324 40MHO Underexc. MHO 3-PH. AC / DC Calculation Of Set Values Application Example 1

NON-STANDARD APPLICATION USING
2 SOFTWARE RELAYS ME323



① 1^{st} SOFTWARE RELAY ME323:

diameter of circle 1 = X_d [p.u.]

centre of circle 1 = $\frac{X_d'}{2}$ [p.u.] + $\frac{X_d}{2}$

t_{stage1} = 0,5s
(of ME323/ relay no.1)

② 2^{nd} SOFTWARE RELAY ME323:

diameter of circle 2 = 1 [p.u.]

centre of circle 2 = $\frac{X_d'}{2}$ [p.u.] + $\frac{1}{2}$

t_{stage1} = 0s
(of ME323/ relay no.2)

ME323, ME324 40MHO UNDEREXC. MHO 3-PH. AC/DC
CALCULATION OF SET VALUES
APPLICATION EXAMPLE 2

Fig. 93 ME323, ME324 40MHO Underexc. MHO 3-PH. AC / DC Calculation Of Set Values Application Example 2

7.5. FUNCTION

The under excitation function provides protection against disturbance in the excitation system of synchronous machines thereby preventing possible mechanical damages due to load oscillations in the power system by initiating a short time trip signal to the respective circuit breaker.

7.5.1. ME121/ ME122/ ME321/ ME322 Functions

As a trip criterion the rotor angle ϑ and the excitation current I_e of the protected synchronous generator are evaluated whereby following logic functions are applicable:

Rotor angle $\vartheta > \vartheta_{Limit}$ (rotor angle conditions are exceeded) initiates an alarm and a long time delayed trip

Rotor angle $\vartheta > \vartheta_{Limit}$ and excitation current $I_e < I_{e,Limit}$ (rotor angle exceeded and low excitation current) initiates an alarm and a short time delayed trip.

The rotor angle ϑ_i of the generator is computed from the generator current I_{gen} and the generator voltage V_{gen} according to the simplified vector diagram.

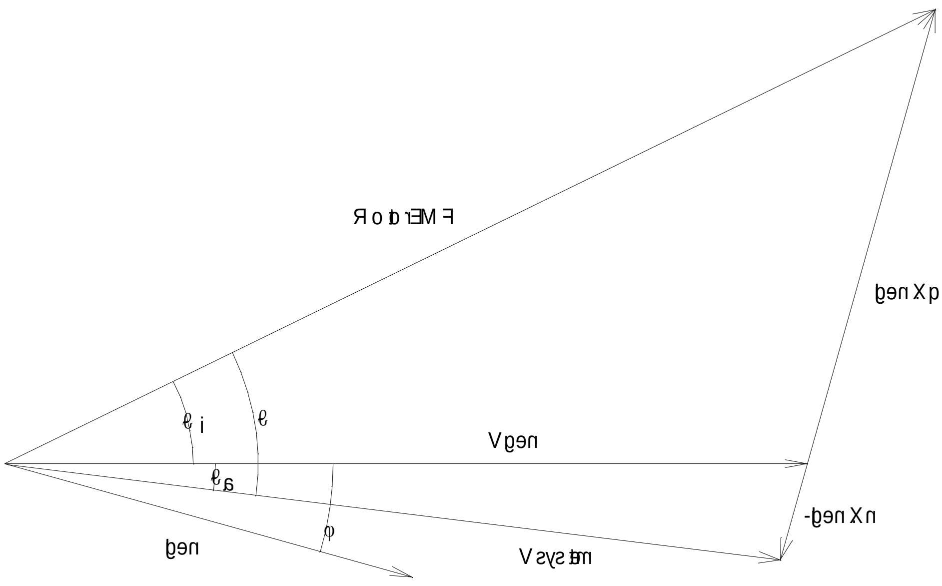


Fig. 7-1

The practical definitive stability condition of the generator with the overall static rotor angle ϑ between the rotor voltage E_p and the rigid power system voltage V_{net} is computed as the sum of the inner rotor angle ϑ_i and the outer rotor angle ϑ_a.

As shown on the above graph the outer rotor angle is derived from the power system reactance X_n, i.e. the reactance between generator leads and the rigid power system.
This reactance is evaluated according to the power system values whereby for short transmission lines the short circuit reactance of the generator-transformer is applicable.

In the arithmetical process of evaluating the different function variants for three phase systems the secondary CT/VT signals are sampled 12 times each cycle, e.g. phase current L1 and the phase to phase voltage V L2-L3. With the aid of the parameters X_q und X_n the vector E_p and V_{net} is computed with the Fourier Transformation according to value and phase angle position and thereby the rotor angle ϑ is determined.

Also the value of the generator voltage is evaluated and in case of being smaller than 70 V secondary the protective function will be blocked.

For models in single phases systems according to the above vector diagram the phase displacement of the current I_{gen} and the reactance X_q, respectively X_n by displacing the phase voltage by 90° (corresponds to a displacement of 3 sample intervals) are considered and in the same way the rotor angle is being evaluated.

After each sample interval of the computed rotor angle there is a comparison with the configured trigger value and when being exceeded 24 times in a consecutive sequence the instantaneous initiation is carried out for stage 1 and the time delay for stage 1 is initiated. In case of the trigger value being exceeded during the whole delay range a tripping signal will be given.
Depending on the selected function variant the excitation current is either measured by a CT signal or evaluated from a rotor current shunt via a measuring transducer and as a DC voltage transferred to a “slow analogue input” of the protective system.
In the first case the excitation current value is determined with the Fourier Transformation and in the second one the excitation current is evaluated in a DC voltage stage.
Again, the computation is carried out for each sample interval, i.e. 12 times each cycle and the calculated rotor current value compared with the configured setting parameter. Should during 24 consecutive cycles this value be exceeded and also the rotor angle trigger level is above its setting, i.e. stage 1 initiated, then the starting signal for stage 2 is set and the time delay stage 2 triggered. In case of the stage 2 setting value remains above the trigger value during the whole time delay of stage 2 a trip signal is initiated. Of course the starting- and trip stages are only set when not being suppressed by the aforementioned 70V undervoltage interlock or a blocking signal. Also when applying a test signal at the corresponding function input a test algorithm is started independent from the measured values which eventually is producing a function trip.

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

7.5.2. ME323 / ME324 Functions

The MHO functions ME323 and ME324 are computing the complex impedance vector on the basis of the generator current and of phase L1 and the phase to phase voltage L2-L3.
Tripping conditions are derived when the impedance vector is entering the impedance circle defined by the setting parameters (1. stage) whereas the 2. stage is in addition also considering the excitation undercurrent value. The excitation current measuring is performed on the AC side for function ME323 and on the Dc side for function ME324.

Details:

Display Window:

"Impedance Distance" (refer to internal display window) means:
Distance of the Impedance Point to the Centre of the Impedance Circle. (Distance between Locus and Centre of Impedance Circle).
That means this value has to be compared with the radius of the circle.

The ”Circle Reactance” is the "Impedance Distance" to the centre of the reactance circle (actually the “Impedance Circle” and not the border of the circle.
The display range is up to 10.5 p.u., i.e. above this value a “>Display Range” is indicated.

The display “Circle Reactance” is in principle a radius whereas the corresponding parameter setting “Diameter” is actually the diameter. So the two values cannot be compared directly.

Note to the Setting Parameters:

Offset = $x_d´$ /2 (direct axis reactance in p.u. divided by 2);
CAUTION: For GE relays the offset means the distance to the outer limit of the reactance circle whereas for the DRS System the distance to the circle centre is applicable.

Recommended Settings:

These recommendations are based on the GE Study GER-3183.

A. Single Stage Solution (With 1 Impedance Circle):

Ensures a certain trip for excitation faults at all power system load conditions but tends to false tripping in case of stable rotor oscillations.
Therefore loss of synchronism is not definitely recognised under all possible load conditions.

Recommended Settings:

Offset = $x´_d$/2 (transient direct axis reactance in p.u. divided by 2);
CAUTION: For GE relays the offset means the distance to the outer limit of the reactance circle whereas for the DRS System the distance to the circle centre is applicable.
DRS setting value "Centre" thus: Setting Centre = $x´_d/2 + x_d/2$ ...[p.u.]

Circle diameter = x_d (direct axis reactance in p.u.),
Note: the "Protective Function Measured Values" – window (see DRSWIN) shows the distance between the impedance locus (actual) and the center of the

reactance circle; this value therefore should not be compared with the set value "Diameter" but rather with the radius of the reactance circle.

t = 0 sec.

B. Enhanced Solution (With 2 Impedance Circles):

In this case two impedance circles are applied, i.e. in case of the DRS Protection System two software functions are used and each being configured with one impedance circle.
The first stage circle corresponds exactly to the “Single Solution” as per Item A., however with a time delay of t = 0.5 sec.
The second circle having a diameter of 1p.u. and a time delay of t = 0 sec. represents the operating characteristic of stage 2.

The advantage of this solution in comparison with the Single Solution according to A.:
No possible false trips during stable rotor angle oscillations or in case of oscillations limited by the excitation regulator.
To achieve this feature the trip criteria for the larger impedance circle are time delayed, say, 0.5 … 0.6 sec., and in case higher delays are selected the generator mechanical withstand capabilities have to be considered.
The smaller operating circle with a diameter of 1p.u. has always a zero time delay.

DRS Parameters:

Circle for 1. Stage (Large Circle):
Setting value centre point = $x'_d/2 + x_d/2$ ...[p.u.]
Setting value circle diameter = x_d ...[p.u.]
Setting value time delay = 0.5 sec.

Circle for 2. Stage (Small Circle):
Setting value centre point = $x'_d/2 + 1/2$ ...[p.u.]
Setting value circle diameter = 1 ...[p.u.]
Setting value time delay = 0 sec.

C. Comparison with Conventional Rotor Angle Evaluation (Setting = Rotor Angle):

In principle both methods (rotor angle und MHO) are based exactly on the same physical criterions, i.e. the impedance circle can be converted into the loading characteristic of the machine (mirror image of the unit impedance circle). It has to be considered that with our standard rotor angle protective functions x_q (and not x_d) is applied. However, on the other hand, that is completely irrelevant since for practical reasons a fictive most suitable x_q setting is chosen anyhow.

7.6. COMMISSIONING

Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

7.6.1. ME121/ ME122/ ME321/ ME322 Protective Functions

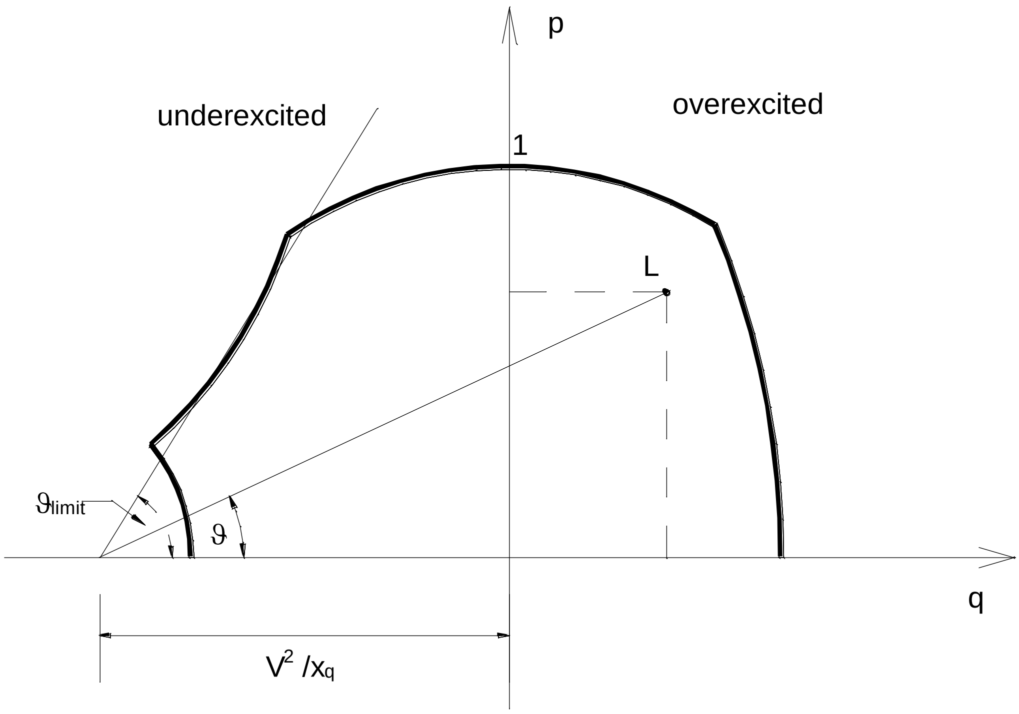
Pre-Commissioning:

At first the correct external wiring connections have to be checked.

The input matrix is to be configured according to the external connections.

The parameters x_q and x_n as well as the operating values and time delays of stage 1 and 2 have to be set to the computed values.

The generator loading diagram has to be considered to determine the reactance setting values as outlined in the diagram below.



Thereby: p........ relative real power in p.u. (also outlined below)
q........ relative reactive in p.u.(also outlined below)

As shown on the above load diagram the power rating of the machine depends onto the
- -Maximum excitation current
- -Maximum stator current, respectively the maximum turbine rating

-Practical stability vector and
-Minimum excitation current

To obtain the reactance setting value x_q a straight line as close as possible to the loading diagram is drawn and the crossing with the represents the $1/x_q$ value.
Please note that this “fictive” reactance x_q is generally not identical to the “real” reactance x_q of the specified x_q by the generator manufacturer, the latter being not suitable for practical protection applications since it does not represent the optimum configuration of the required protective function range.

To adapt the computed reactance value to the relevant CT and VT ratios a configuration factor “F” is determined according to following formula:

$$FF = \frac{U_n}{U_{W,p}} \cdot \frac{U_{W,s}}{100} \cdot \frac{I_{W,p}}{I_n}$$

With	V_n	Generator nominal voltage (V)
	VT_p	VT rated primary voltage (V)
	VT_s	VT rated secondary voltage (V)
	I_n	Generator nominal current (A)
	I_p	CT primary rated current (A)

Thus the reactance setting $X_{q,n}$ is calculated as follows:

$$x_{q,n} = x_q . F$$

The power system reactance X_n is adapted with the same factor.
Also the configuration of the rotor angle ϑ has to be verified according to the above load diagram whereby it has to be realised that the rotor angle measurement in the above diagram is displayed for the inner rotor angle only and considering the usual system reactance an increase of the angle by about 5° has to be taken into account.
When setting the rotor angle also the characteristic of the excitation limiter settings are having an influence and therefore the configured values have to be selected accordingly to provide an an ample safety margin.
The operating value for the excitation undercurrent interlock either for AC- or DC evaluation should be selected to approximately 10% of the nominal off-load excitation current.

Finally, the DRS System outputs for the LED matrix and the tripping matrix are to be set according to plant requirements.

Protective function tests are preferably performed with the plant out of service and, e.g. with the relay test set a test current is injected into phase L1 and the nominal secondary test voltage applied to phase L2-L3 whereby the phase angle between voltage and current has to be known and/or adjustable. The value of the rotor angle is to be verified by selecting the software option “actual measured values” in the relay window.

Between the injected test signals current I and voltage V and the displayed rotor angle ϑ there is a relation as per the formula below:

$$\vartheta\vartheta = \arctan\left|\frac{p}{\frac{u^2}{x_q}+q}\right| + \arctan\left|\frac{p}{\frac{u^2}{x_n}-q}\right|$$

Following definitions are applicable:

$p = \frac{U.I.\cos\varphi}{U_n.I_n}$ ....relative real power in P.U.

$p = \frac{U.I.\sin\varphi}{U_n.I_n}$ .... relative reactive power in P.U.

$u = \frac{U}{U_n}$ .... relative generator voltage in P.U.

x_q .... set quadrilateral reactance in P.U.

x_n ....set power system reactance in P.U.

I_n, U_n ....relay rated current respectively voltage (1 or 5A, 100 V)

The display should be checked according to the calculation of the above formulas and by changing the phase angle and /or current the function is tested up to the operating value. Record these values into the commissioning sheets.

Inject a current signal above the configured trigger value for the excitation current according to the selected excitation current measurement (AC or DC). By reducing the excitation current with stage 1 initiated the operating value of stage 2 is determined. To determine the reset value the excitation current is slowly increased until stage 2 is reset.
Record the operating- and reset values of stage 2 into the commissioning test sheet.

Please note that depending on the excitation current evaluation method the optional excitation current “actual measured values” may be displayed in the relay- or PROCESSING window.

Also the other external measured values, i.e. CT currents and VT voltages, can be displayed in the User program.

Check the trip- and alarm signals and the LED indications according to the configuration and the circuit diagrams.

The time delay of the protective function should be verified with 1.5 times the operating value and recorded into the commissioning sheets.

For each stage the configured blocking inputs should be checked by applying the corresponding external signal whereby the trip outputs have to reset.

The configured function test for each stage can be checked for each stage by setting the test signal input and the respective function stage has to operate without any external CT/VT inputs.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters setting must be configured to the original plant parameter settings.

Primary Commissioning Tests:

During the primary tests the function of the protective system is checked during normal operating conditions. As far as the power system stability permits following load tests are recommended:

- On-Load Tests:

Block protection trips of the under-excitation protection.
Connect external measuring instruments, e.g. wattmeter to the CT and VT circuits if required.
Load internal measured values of the User program.
Start up the generator and synchronise to the power system and load the generator up to the maximum stable real- and inductive power capability.
Via the option "actual measured values" the measured angle is compared with the calculated one as per above formula and double checked with the readings of the external wattmeter.
By controlling the reactive power into the capacitive range the indicated rotor angle has to increase otherwise the function polarity “voltage direction” has to be changed.
Now the setting X_n is set to zero and at 4 loading conditions being preferably in the capacitive region the rotor angle display is compared with the computed values and the angle determined in the generator loading diagram.
For each test rotor angle, real power, reactive power and the generator voltage should be recorded into the commissioning test sheets.
A plausibility check of the rotor current displayed in the DRS System is to be checked with the excitation system instrument indications.
After re-configuration of the X_n value o the original setting the dynamic interaction of the under-excitation protection and the excitation rotor angle limiter controls have to be to be tested by a swift manual shift into the not permissible negative reactance region whereby no protection initiation has to occur.
Check the possible function blocks from the external plant and re-configure the protection trips.
If feasible shut down the generator via a protection trip.
Remove any external measuring instruments and restore all test parameters to their required original settings.

8. MF... OVER/UNDERFREQUENCY / FREQUENY GRADIENT / VECTOR SHIFT

8.1. OVERVIEW

List of the Available MF . . . – Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function Number (VE-internal number of the protective function)
TYPE ... Function Type (short denomination of the protective function)
ANSI ... ANSI Device Number (international protective function number)

PROTECTIVE FUNCTIONS: MF . . .	**FNNR**	**TYPE**	**ANSI**	**Application**
Frequency protection, 1-stage	1022	MF111	81	C2,M,L
Frequency protection, 2- stage	1023	MF121	81	C2,M,L
Frequency protection, 4- stage	1024	MF141	81	C2,M,L
Frequency gradient	1075	MF112	81	C2,M
Voltage Vector Surge	2036	MF311		C2,M,L

8.2. TECHNICAL DATA

8.2.1. MF111

PROTECTIVE FUNCTION: MF111	FNNR	TYPE	ANSI	Application
Frequency protection, 1-stage	1022	MF111	81	C2,M,L

1-stage frequency function selectable for over- or underfrequency detection.

MF111
Technical Data

Inputs

Analogue:	- *Note: There is no definite allocation of the analogue input required.* *ATTENTION: The respective synchronising channel is applied automatically (V respectively I channel).* *Pleas note: It has to be ensured that the synchronising channels regarding the requirements of the frequency protection are selected correctly.*
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Parameter Settings

Minimum voltage:	60 ... 100 V in 1 V – steps
Maximum voltage:	100 ... 140 V in 1 V – steps
Operating value:	10 ... 65 Hz in 0.01 Hz - steps
Type:	Over/under detection
Operating time:	0 ... 30 seconds in 0.05 sec - steps

Window Display for Relay Internal Determined and Computed Values

Frequency:	in Hz

Measuring

Reset ratio:	0,1% of Set Value
Operating time:	20 ms ... 85 ms (depending on the rate of frequency change). *Condition: SYNC – channel must be active for approximately 1 sec.*
Accuracy:	Typical 0.01 Hz

8.2.2. MF121

PROTECTIVE FUNCTION: MF121	FNNR	TYPE	ANSI	Application
Frequency protection, 2-stage	1023	MF121	81	C2,M,L

2-stage frequency function selectable for over- or underfrequency detection per stage.

<u>MF121</u>
<u>Technical Data</u>

Inputs

Analogue:	- *Note: There is no definite allocation of the analogue input required.* *ATTENTION: The respective synchronising channel is applied automatically (V respectively I channel).* *Pleas note: It has to be ensured that the synchronising channels regarding the requirements of the frequency protection are selected correctly.*
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Parameter Settings

Minimum voltage:	60 ... 100 V in 1 V – steps
Maximum voltage:	100 ... 140 V in 1 V – steps
Operating value step 1:	10 ... 65 Hz in 0.01 Hz - steps
Type Step 1:	Over/under detection
Operating time Step 1:	0 ... 30 seconds in 0.05 sec - steps
Operating value Step 2:	10 ... 65 Hz in 0.01 Hz - steps
Type Step 2:	Over/under detection
Operating time Step 2:	0 ... 30 seconds in 0.05 sec - steps

Window Display for Relay Internal Determined and Computed Values

Frequency:	in Hz

Measuring

Reset ratio:	0,1% of Set Value
Operating time:	20 ms ... 85 ms (depending on the rate of frequency change). *Condition: SYNC – channel must be active for approximately 1 sec.*
Accuracy:	Typical 0.01 Hz

8.2.3. MF141

PROTECTIVE FUNCTION: MF141	FNNR	TYPE	ANSI	Application
Frequency protection, 4-stage	1024	MF141	81	C2,M,L

4-stage frequency function selectable for over- or underfrequency detection per stage.

MF141
Technical Data

Inputs

Analogue:	- *Note: There is no definite allocation of the analogue input required.* *ATTENTION: The respective synchronising channel is applied automatically (V respectively I channel).* *Pleas note: It has to be ensured that the synchronising channels regarding the requirements of the frequency protection are selected correctly.*
Binary:	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Blocking input stage 4
	Test input stage 1
	Test input stage 2
	Test input stage 3
	Test input stage 4

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2
	Alarm stage 3
	Trip stage 3
	Alarm stage 4
	Trip stage 4

Parameter Settings

Minimum voltage:	60 ... 100 V in 1 V – steps
Maximum voltage:	100 ... 140 V in 1 V – steps
Operating value stage 1:	10 ... 65 Hz in 0.01 Hz - steps
Type stage 1:	Over/under detection
Operating time stage 1:	0 ... 30 seconds in 0.05 sec - steps
Operating value stage 2:	10 ... 65 Hz in 0.01 Hz - steps
Type stage 2:	Over/under detection
Operating time stage 2:	0 ... 30 seconds in 0.05 sec - steps
Operating value stage 3:	10 ... 65 Hz in 0.01 Hz - steps
Type stage 3:	Over/under detection
Operating time stage 3:	0 ... 30 seconds in 0.05 sec - steps
Operating value stage 4:	10 ... 65 Hz in 0.01 Hz - steps
Type stage 4:	Over/under detection
Operating time stage 4:	0 ... 30 seconds in 0.05 sec - steps

Window Display for Relay Internal Determined and Computed Values

Frequency:	in Hz

Measuring

Reset ratio:	0,1% of Set Value
Operating time:	20 ms ... 85 ms (depending on the rate of frequency change). *Condition: SYNC – channel must be active for approximately 1 sec.*
Accuracy:	Typical 0.01 Hz

8.2.4. MF112

PROTECTIVE FUNCTION: MF112	FNNR	TYPE	ANSI	Application
Frequency gradient	1075	MF112	81	C2,M

1-stage frequency gradient function for negative or positive gradients.

MF112
Technical Data

Inputs

Analogue:	- *Note: There is no definite allocation of the analogue input required.* *ATTENTION: The respective synchronising channel is applied automatically (V respectively I channel).* *Please note: It has to be ensured that the synchronising channels regarding the requirements of the frequency protection are selected correctly.*
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip

Parameter Settings

Minimum voltage:	60 ... 100 V in 1 V – steps
Maximum voltage:	100 ... 140 V in 1 V – steps
Operating value:	0.1 ... 15 Hz/s in 0.1 Hz/s – Schritten *Note:* *Recommended range for 50 Hz – systems: 0.1 ... 11 Hz/s;* *Recommended range for 60 Hz – systems: 0.1 ... 13 Hz/s.*
Operating time:	0 ... 30 seconds in 0.05 sec - steps
Evaluation time constant:	1 ... 15 cycles in 0.5 cycle - steps

Window Display for Relay Internal Determined and Computed Values

Frequency gradient:	in Hz/s

Measuring

Reset ratio:	< 0,1 Hz/s
Operating time:	Depending on the setting parameter "evaluation time constant"
Accuracy:	Typical 0.1 Hz/s (depending on the setting parameter " evaluation time constant ")

8.2.5. MF311

PROTECTIVE FUNCTION: MF311	FNNR	TYPE	ANSI	Application
Voltage Vector Surge available for: a) DRS LIGHT see: Digital Sudden Load Loss Relay Type DRS-LP824 DRS_KER3.VE b) DRS MODULAR/ DRS COMPACT2A	2036	MF311		L M, C2

3-phase, 1-stage voltage vector shift function with common instantaneous - and time delayed trip outputs.

MF311
Technical Data

Inputs

Analogue:	V1
	V2
	V3
Binary:	Blocking input
	Test input

Outputs

Binary:	Vector shift trip

Parameter Settings

Vector shift:	2 ... 30° phase angle shift in 1° - steps
Trip delay:	1 ... 3 cycles in steps of 1 period
Blocking U<:	10 ... 120 V in 0.5 V - steps
Mode:	1-phase 3-phase

Window Display for Relay Internal Determined and Computed Values

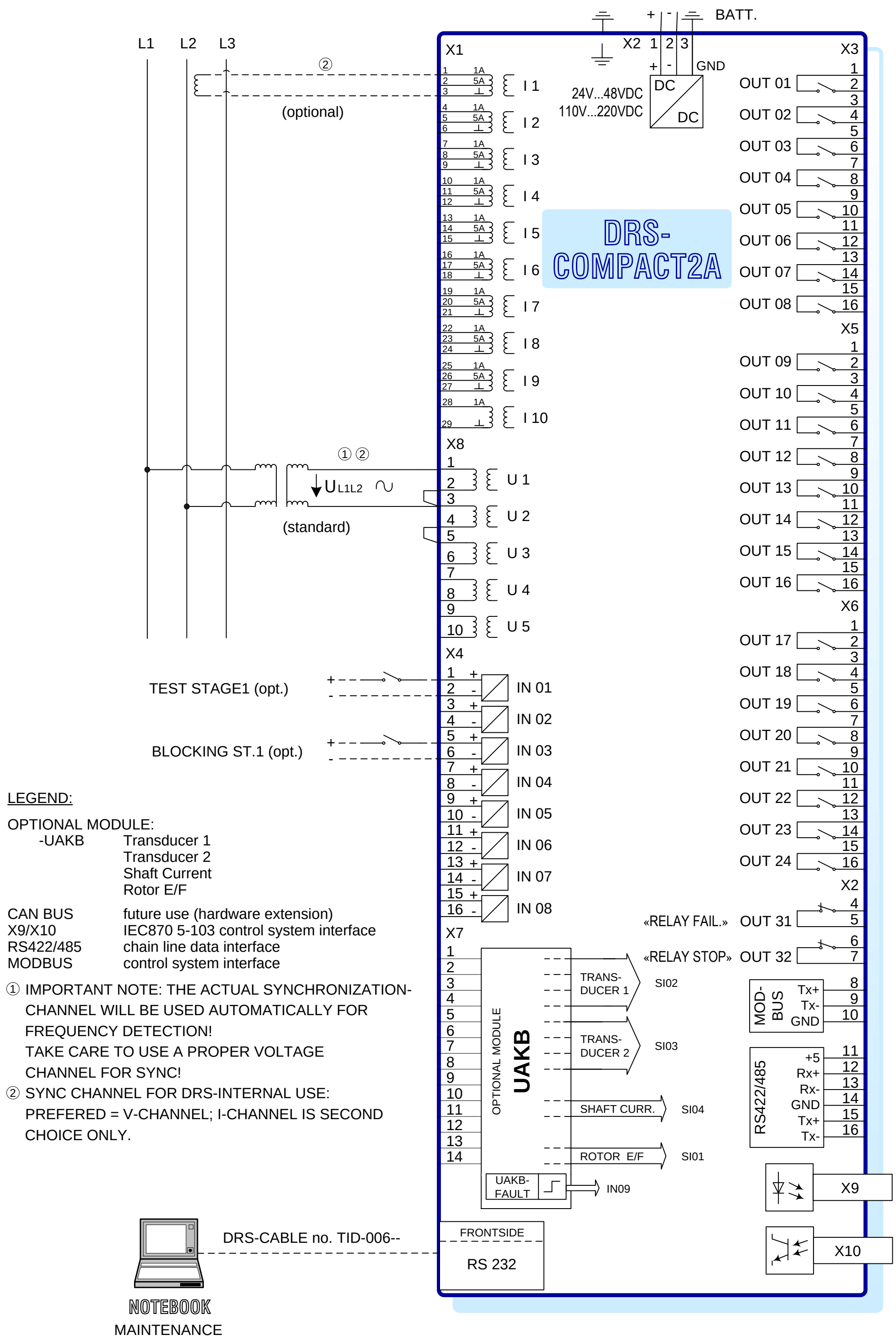
Vector shift:	Vector change V1 [in ° el.] : The last peak value is stored for 10 sec.
	Vector change V2 [in ° el.] .] : The last peak value is stored for 10 sec.
	Vector change V3 [in ° el.] .] : The last peak value is stored for 10 sec.

Measuring

Operating time:	Setting (in cycles) + 1 sample Setting (in cycles) + 12 samples Note: Operating time can vary up to a maximum of 11 samples according to value of the phase shift.
Accuracy:	Typical 1° el.

8.3. CONNECTION DIAGRAMS

8.3.1. MF111/ MF112/ MF121/ MF141



MF112 FREQUENCY GRADIENT WIRING DIAGRAM

Fig. 94 MF112 Frequency Gradient Wiring Diagram

8.3.2. MF311

For a detailed description of the Protective Function Module "MF311" please see the DRS LIGHT Device Description "Digital Unit Decoupling Relay/ Type DRS-LP824"
→ File: "DRS-LP824_Unit_Decoupling_e.pdf".

8.4. LOGIC DIAGRAMS

8.4.1. MF112

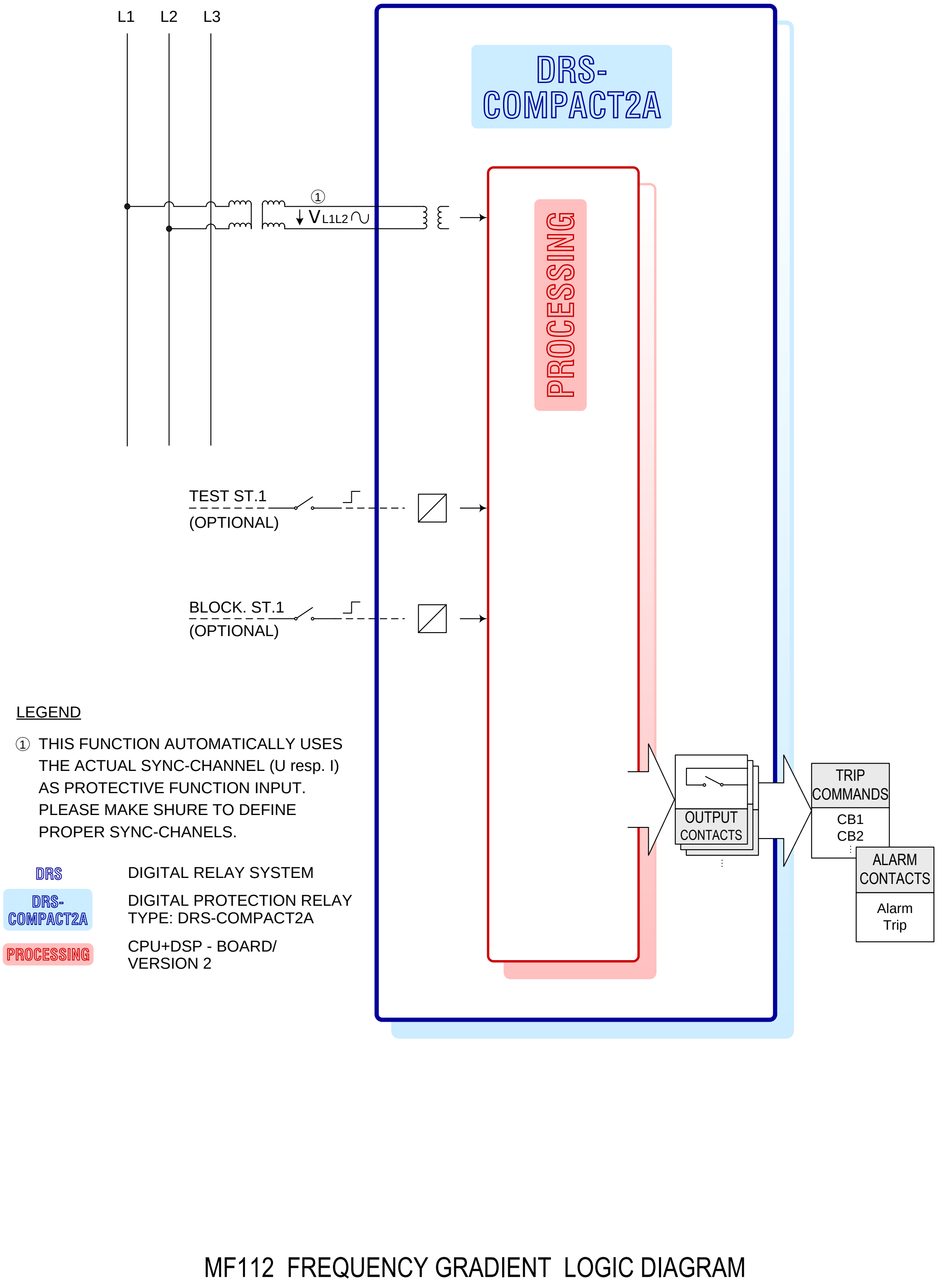


Fig. 95 MF112 Frequency Gradient Logic Diagram

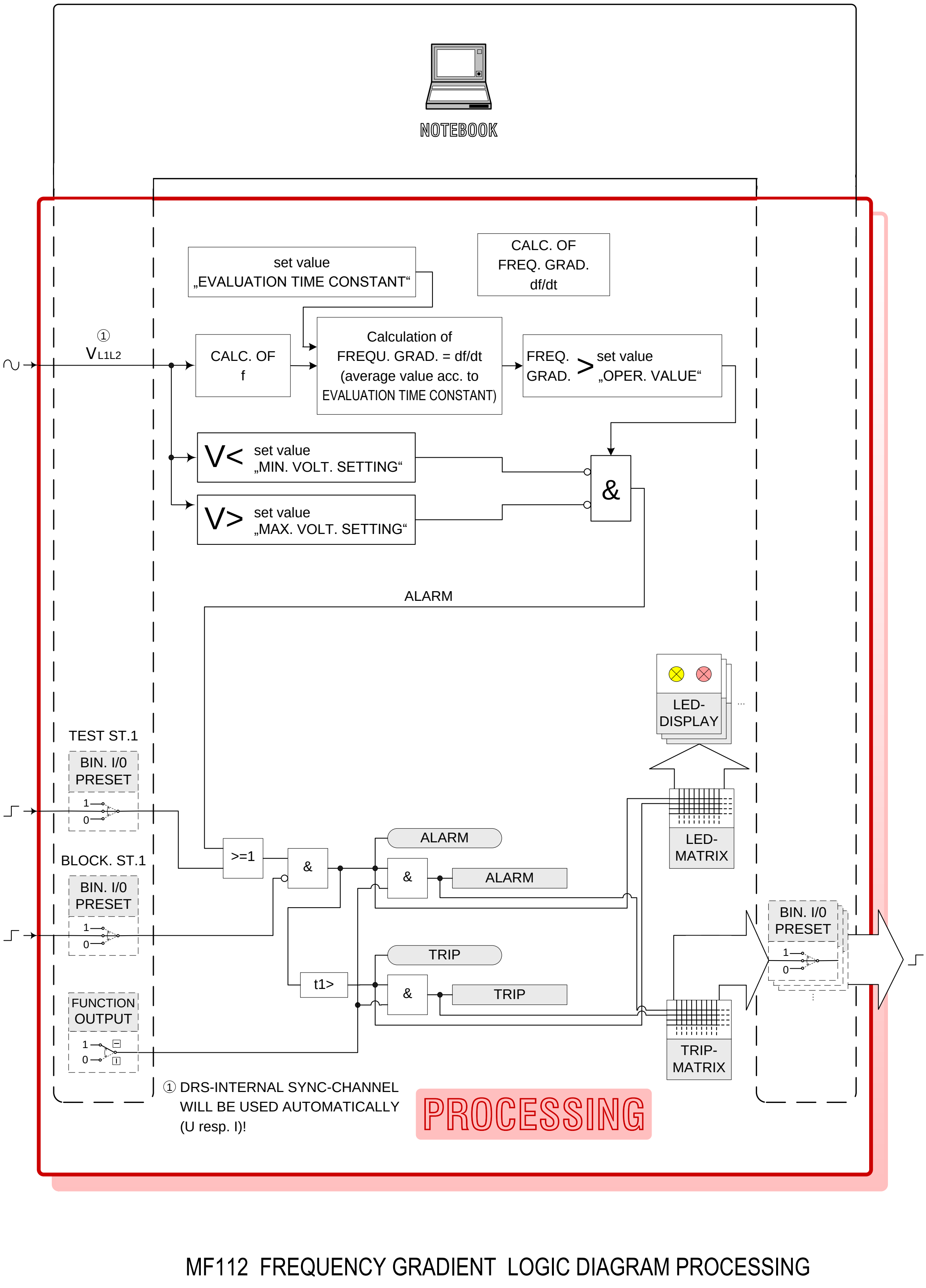


Fig. 96 MF112 Frequency Gradient Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MF112

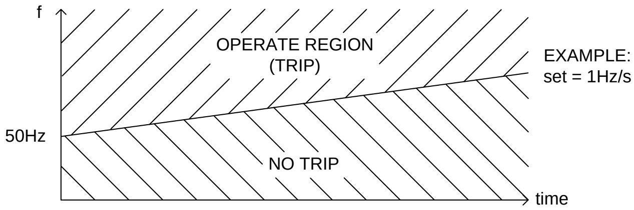
Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ….. — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

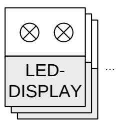
FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MF112
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊡ all FUNCTION OUTPUTS disabled (test-operation)

CALC. OF FREQ. GRAD. df/dt — FREQ. GRADIENT [Hz/s]
Note: max. allowed frequency change
11Hz/s (50Hz Systems) resp.
13Hz/s (60Hz Systems) →
valid for frequencies close to nom. frequency.
Accuracy: approx. 0,1Hz/s
(dependig on set value
„AVERAGE TIME CONST.“ → choose as long
as possible in order to get best accuracy!)

FREQ. GRAD. > set value „OPER. VALUE“



LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MF112 FREQUENCY GRADIENT LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 97 MF112 Frequency Gradient Logic Diagram Processing / Legend

8.5. FUNCTION

8.5.1. MF111/ MF121/ MF141

Electric plant and machinery are generally designed for only a small operating range regarding the rated frequency. Therefore, any inadmissible deviations from the nominal frequency have to be monitored and subsequently corrected by suitable corresponding control- and switching operations to ensure frequency stabilisation into the nominal range and/or initiating plant shut down of the endangered equipment

The measuring principle of the frequency protection is based upon an evaluation of the rate of change of the phase angle $\Delta\varphi$ for the voltage vector by comparing the actual synchronising frequency f_O, i.e. 1/12 of the with the configured nominal frequency of the protection system.

Hence, according to the relation

$$\Delta\varphi = 2\pi\Delta f.\Delta t$$

Δf is computed to the known sample interval Δt and the actual measured frequency calculated as follows.

$$f_1 = f_0 + \Delta f$$

For the practical execution of the above described method the connected measured voltage is sampled 12 times each cycle. To suppress the influence of higher harmonics due to superimposed power system control signals the measured values are directed to a digital filter (Thompson low-pass of the 5^{th} order, limiting factor of 1.2 times nominal frequency). Subsequently via the Fourier Transformation the amplitude and the voltage vector phase position is determined and the frequency computed according to the above formula whereby for each sample interval a new a new frequency value is available. The final frequency is computed from a mean value for a period of 3 cycles (= 36 single values) and when the measured signal is between the parameter settings “minimum amplitude” and “maximum amplitude” the initiating conditions for a function stage are fulfilled and will be set provided that no blocking signal is present. When the initiation continues during the whole time delay the corresponding trip output delivered.
Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

8.5.2. MF311

Application:
The vector shift function is provided as an on-line protection for generators with a relative small power rating in case of system disturbances, e.g. emanating from a system auto reclosing or external short circuits. During a system disturbance an instant unloading of a generator (equivalent to a full load rejection) may occur causing a sudden phase change of the generator voltage vector. On the other hand the synchronising torque is lost at the position of the network short circuit and the recurring system voltage after fault clearing can be asynchronous to the generator voltage whereby the vector shift function is inhibiting a re-synchronising of the generator to the power system under such conditions.
Please note that the vector shift function is preferably applied for smaller generator ratings and is basically evaluating the vector shift of the generator voltage due to de-loading of the machine during system disturbances.
Under special network conditions, i.e. long grading times in conjunction with low rotor inertia a significant speed increase corresponding to a phase shift may occur during certain types of system faults. Such a continuous voltage vector angle change should not primarily be the trip criteria for the vector shift function even though depending on the selected settings a vector angle shift is indicated. In the extreme case with a relative fast speed increase even possible false tripping can take place during a load rejection. As a general rule only the original phase shift happening directly after an auto reclose sequence or a system fault should be taken for the evaluation. Please note that for large generators, e.g. turbine generator in a nuclear power plant the influence of a speed rise to the phase angle must be considered all the time. For this purpose the ELIN out of step protection relay type MSTAB was developed which covers each and every power system operating condition.

Significance of the Parameter Settings:

a)
Vector shift setting:
Phase angle change, respectively a vector shift of the generator voltage leading to a trip.
Note: It is a direct instantaneous trip without any time delay, i.e. a very fast function.

Please note:
During a real phase shift the function always is measuring the same value for a phase angle change (also refer to the display window of the DRS internal computed values) independent whether 1 or 3 cycles are configured.
For a definite frequency threshold response, whereby the phase angle is changing continuously, there are differences since for higher function settings a comparison with more recent cycle events is carried out and thereby increasing the actual computed phase angle.

b)
Time delay setting:
This setting defines the duration where the configured vector shift has to be above the set value to initiate a trip sequence (result of the Fourier Analyses).

Please note:

The real operating time is resulting from following considerations:
After a phase shift (depending on how much the vector shift setting has been crossed by the actual vector shift) it takes about 1 ... 12 samples before the Fourier Analyses feature will detect a transgression of the parameter setting, i.e. Fourier is slowly integrating the phase angle according to it's algorithm. Only from then on the vector shift time delay is initiated.
With a setting = 1 from this moment on the phase angle configuration has to be exceeded during 12 consecutive samples to initiate a trip output. As indicated the vector shift function is extremely fast compared with other protective functions and therefore only a trip signal is generated without any prior initiation.

In praxis this will result in following tripping times:
Setting = 1 cycle:
Internal trip delay = 13 ... 24 samples, typical 20 samples (... corresponding to 33 ms at 50 Hz)
Setting = 2 cycles:
Internal trip delay = 25 ... 36 samples, typical 32 samples (...corresponding to 53 ms at 50 Hz)
EW = 3 Per.:
Internal trip delay = 37 ... 48 samples, typical 44 samples (...corresponding to 73 ms at 50 Hz)

The external tripping time (relay output) is approximately 5 ms longer.

c)
"Blocking V<" Setting:
Generally the function is blocked for very low voltage signals to prevent false tripping when the excitation is switched off, etc.
A second application may arise that during a rapid increase or decrease of the generator voltage the Fourier Analyses will compute a phase shift which cannot be neglected and may lead to false tripping during start-up or shut-down of the generator unit. For this case the "V<" would have to be set relatively high. Also it has to be considered that during external system disturbances the generator voltage should not decrease to this setting value to ensure correct function operation under all conditions.
Note:
When the actual voltage is smaller than the value “V min Sync“ selected in the page0 the function is blocked due to the absence of the Sync-Bit.
Note:
During a real phase shift of the generator voltage the Fourier evaluation will temporarily compute a frequency- and amplitude deviation for a maximum of 1 cycle even though the amplitude and frequency remain constant. This would result in a possible false trip but is being eliminated via suitable firmware measures.
Note:
Either phase to phase or phase to neutral voltages can be applied to the relay function which has to be considered when configuring the V< setting.

d)
"Mode" setting:

"Mode" = 1-phase:
At least one of the three voltage inputs has to show a phase shift larger than the setting value (1 out of 3).
One, two or three input voltages can be applied to the vector shift function. But please note that also in the single phase mode all 3 voltages are measured but it is sufficient when only one voltage will show a vector shift.
The "1-phase" mode is under normal operating conditions with symmetrical voltages sufficient.

"Mode" = 3-phase:
All three input voltages have to show a vector shift above the setting value (3 out of 3) and therefore all 3 voltages have to be connected to the relay.
This mode is recommended to prevent false tripping due to external disturbances, e.g. negative phase sequence quantities, etc.

Internal Measured Values Window "Phase Shift"

The window display will always indicate the maximum value encountered during the last 10 seconds.

Due to the relative fast tripping time (30 ... 70 ms at 50 Hz) no other useful display would be suitable.
Therefore during declining signal conditions the display will still remain for 10 seconds whereas for rising values the indication is changing continuously.
In case of no valid computations, e.g. blocking input, etc. the window will show "0.0 degree".
This display has precedence against the 10 s stored value, i.e. the measured value immediately changes to the "0.0 degree".

Blocking input

During trips of the generator CB by other protective functions a rapid speed increase of the generator in case of a full load rejection can take place and depending on the configuration of the vector shift function a subsequent false trip may occur resulting in a possibly confusing entry into the system event records.
It is therefore recommended that already during the design stage a “CB Open“ blocking input should be included.
With the generator CB in the open position there is no vector shift due to the absence of a load current. However, during speed increase there may be a phase angle shift of the generator voltage.

Function Input Matrix

It is recommended to use all 3 voltage inputs and for safety reasons during the primary commissioning tests the “Mode” parameter setting can be configured to "1-phase" for the time being.
Should this setting proves to be too sensitive (many negative phase sequence system event, etc.) the configuration "3-phase" has to be selected. This setting minimises the probability of a false trip due to unbalanced load conditions during certain power system faults. This configuration will also block the protective function in case of a phase voltage loss.

"V<" Setting

This parameter setting should be selected low enough so that the value is not reached during external system faults whereby a vector shift may occur and unintentional blocking of the function is initiated. It should be noted that a setting value below the minimum voltage configured for the Sync. Channel in Page0 has no meaning since the missing Sync-Bit is preventing a trip of the vector shift function anyhow.

Also the setting should be high enough that it is not exceeded during low excitation conditions of the generator during turbine start-up.

"Vector Shift" Setting

This setting configuration depends on the phase angle displacement of the generator voltage encountered during an auto reclosing condition or system fault whereby the HV circuit breaker is tripped.

High rated power systems:	Setting = approximately 6°.
Low rated power systems:	Setting = approximately10 ... 12°.

During the on-load checks it has to be tested that when connecting or disconnecting larger consumer circuits the vector shift function settings will not produce any false trips.
Therefore a vector shift condition should preferably be detected only above a power change of about 20%. Consequently it is advised that the power regulation of a network node should be configured to a minimum real power flow of approximately 20 %.
The same applies fort he speed control (real power) and the excitation control (reactive power).

Trip Matrix

Only parallel operation: Trip of the generator CB
System parallel- and island operation: Trip of the HV CB

8.5.3. MF112

Frequency Gradient:

Represents the frequency rate of change per time interval in Hz/s.

It has to be noted that the maximum frequency gradient evaluation for the PROCESSING is not a constant Hz/s value but a percentage value with respect to the frequency.
Evaluated is a maximum number of 22% of frequency changes per second, i.e. for example by 50Hz a change of 11Hz/s.

The DRS system configuration window for the frequency gradient displays a maximum range of 0 ... 15 Hz/s and the practical available setting range is, as outlined above, 22% maximum of the frequency change within a second and therefore as follows:
0 … 11 Hz/s for 50 Hz systems
0 … 13 Hz/s for 60 Hz systems

As indicated the recordable frequency change in absolute values is higher for increasing frequencies and lower for falling ones. This fact should be considered when determining the the parameter settings especially when very high values of the gradient and larger time delays are required and preferred.

Accuracy:

Approximately 0.1 Hz/s depending on the evaluation time which should be chosen as long as possible.

Tripping Direction:

The relay function is operating in either direction for frequency decrease or increase and therefore it has to be realised that also during a fast recovery to the nominal frequency a trip sequence may be initiated.

8.6. COMMISSIONING

Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

8.6.1. MF111/ MF121/ MF141

Pre-Commissioning:

First of all the correct external wiring connections have to be verified.

The input matrix is to be configured according to the external connections whereby due to the particularity of the frequency protection the measuring channel cannot be allocated freely but is set during the design stage to a fixed synchronising channel.

For the operating value and the time delay the necessary required parameters have to be set and by defining the permissible “minimum and maximum amplitude” the RMS effective measuring range is determined. According to the desired functionality an over- or under function evaluation is being selected.

The function outputs are to be configured in the LED- and trip matrix according to requirements.

Function tests are preferably performed with the plant out of service and to verify the correct operation a relay test set with a variable voltage amplitude of, say 0 -150 volts and an adjustable frequency range is to be connected to the respective input channels.
The signal amplitude is raised to nominal voltage and by de-activating any blocking inputs the frequency is slowly adjusted to cause operation of the tested stage according to the set direction.

Record the operating and reset values into the commissioning sheets by changing the frequency accordingly.
Again alter the frequency until the function operates and then reduce the amplitude of the frequency generator until the protective function resets. Enter the amplitude value into the commissioning sheets. Now the amplitude should be raised again until the undervoltage interlock resets and the test result recorded in the commissioning sheets.
During these tests the function indications, alarms and trip signals are to be observed as well as the frequency values displayed on the menu item “Actual Measured Values”.
To verify the time delay the operating frequency setting should be shifted by 0.1 Hz and with a suitable timer the trip delay measured and recorded in the test sheets.

The other frequency stages are checked the same way as outlined above.
Check the trip- and alarm signals as well as the LED indications according to the configured parameter settings and the circuit diagrams.

The function blocking feature has to be tested for each stage during an active trip signal output whereby the function stage has to reset when applying the blocking input.

Subsequently check the configured test feature for each stage and the respective protective function stage has to operate without any external VT signal.

Please note that during this test procedure other protective functions may operate without any counter measures taken and should be blocked by applying the respective User application of the DRS System.

After the tests any possible necessary parameter setting changes have to be restored to the original service value.

Primary Commissioning Tests:

During the primary checks the function of the protection system is tested in a normal unit off-load operating condition. As far as service operation permits following tests should be carried out:

- Speed Regulation:

Disable external trips of the frequency protection.
Disable any external blocking inputs.
Run up the generator to rated speed and raise excitation to nominal voltage.
Insert a multimeter into the VT circuits to measure the frequency.
Regulate generator speed into desired direction until operation of the respective frequency stage and record the values.
Test all other stages as indicated above.
Restore the external trip outputs of the frequency protection.
If system conditions permit shut down the generator via a frequency protection trip.

8.6.2. MF112

Frequency Gradient:

During secondary pre-commissioning it has to be noted:

a)
The voltage injection with a test set, e.g. Omicron, has to be applied to the Sync-channel of the DRS Protective System (Sync-channel: Internal DRS synchronising reference channel for the Fourier Analysis).

b)
The frequency change has to be continuously adjusted during the whole time delay and not in sudden steps.
Note: Sudden frequency changes are practically not possible due to the generator inertia and will only conditionally be accepted by the firmware of the protection system. Further it should be realised that in case of a unique instantaneous frequency change the time delay will not expire causing only an alarm initiation.

c)
The maximum rate of frequency shift must not be exceeded, i.e. a maximum of 22% frequency change per second.

d)
The pre-configured and permissible frequency range for the generator and the DRS System must not be exited during the whole time delay setting.

e)
The function caculates for every "EVALUATION TIME CONSTANT" (= period of time acc. to the set value "Evaluation Time Constant") the average FREQUENCY GRADIENT. In order to get a trip command the average frequency gradients have to be above the set value "Operating Value" during the whole "Operating Time" (= set value).

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9. MI... CURRENT IDMT / VOLTAGE RESTRAINT OVERCURRENT / MOTOR OSCILLATION

9.1. OVERVIEW

List of the available MI . . . CURRENT IDMT/ VOLTAGE RESTRAINT OVERCURRENT / MOTOR OSCILLATION - Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MI . . .	FNNR	TYPE	ANSI	Application
IDMT current, 1-phase, 2-stage INVERSE DEFINITE MINIMUM TIME	1038	MI125	50/51	C2,M,L
IDMT current, 3-phase, 2-stage, INVERSE DEFINITE MINIMUM TIME, Separate trip outputs. *Note: MI327 is the preferred function with common outputs different to MI325.* ***Please Note:** The logic of the IDMT characteristic MI325 slightly differs from the MI327 having separate- and common outputs respectively.* *MI325: The 3 phases are treated completely separate with regard of the settings, blocking inputs and trip outputs just like 3 single phase functions.* *MI327: The initiation of the 2nd stage for a phase is blocking the internal trip of the 1st stage for the same phase. However an external trip command can still be generated by the 1st stage when another phase is operating (common trip signal for all 3 phases).*	1037	MI325	50/51	C2,M,L

IDMT current, 3-phase, 2-stage, INVERSE DEFINITE MINIMUM TIME, Common outputs. *Note: MI327 is the preferred function with common outputs different to MI325.* *Note:* There was an error regarding the previous denomination in the PROCESSING file: MI326 but from version 5.17 the nomenclature is in the PROCESSING file: MI327. ***<u>Also:</u>*** *<u>Observe notes for MI325!</u>*	1085	MI327	50/51	C2,M,L
Voltage Restraint Overcurrent	1081	MI318	50/51	C2,M
Motor oscillation protection is available on the PROCESSING from Firmware version 5.24 onwards.	1045	MI119		C2,M

9.2. TECHNICAL DATA

9.2.1. Overcurrent IDMT 1-phasig 2-stufig

PROTECTIVE FUNCTION: MI125	FNNR	TYPE	ANSI	Application
IDMT current, 1 phase, 2 stage INVERSE DEFINITE MINIMUM TIME	1038	MI125	50/51	C2,M,L

1 phase, 2 stage Inverse Definite Minimum Time current function.

MI125
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1:	0.050 ... 1.000 s in 0.005 s steps
Characteristic:	extremely/very/normal/long IDMT
Operating value stage 2:	1 ... 31 xIn in 1 xIn steps
Definite time delay stage 2:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

9.2.2. Overcurrent IDMT 3 Phase, 2 Stage

PROTECTIVE FUNCTION: MI325	FNNR	TYPE	ANSI	Application
IDMT Current, 3 phase, 2 stage, INVERSE DEFINITE MINIMUM TIME, Separate outputs. *Note: MI327 is the preferred function with common outputs different to MI325.).* ***Please Note:*** *The logic of the IDMT characteristic MI325 slightly differs from the MI327 having separate- and common outputs respectively.* *MI325: The 3 phases are treated completely separate with regard of the settings, blocking inputs and trip outputs just like 3 single phase functions.* *MI327: The initiation of the 2nd stage for a phase is blocking the internal trip of the 1st stage for the same phase. However an external trip command can still be generated by the 1st stage when another phase is operating (common trip signal for all 3 phases).*	1037	MI325	50/51	C2,M,L

3-phase 2 stage Inverse Definite Minimum Time current function.

<u>MI325</u>
<u>Technical Data</u>

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage1 L1
	Trip stage1 L1
	Initiation stage1 L2
	Trip stage1 L2
	Initiation stage1 L3
	Trip stage1 L3
	Initiation stage2 L1
	Trip stage2 L1
	Initiation stage2 L2
	Trip stage2 L2
	Initiation stage2 L3
	Trip stage2 L3

Setting Parameters

Operating value stage 1/ phase 1:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 1:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 1:	extremely/very/normal/long IDMT
Operating value stage 1/ phase 2:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 2:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 2:	extremely/very/normal/long IDMT
Operating value stage 1/ phase 3:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 3:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 3:	extremely/very/normal/long IDMT
Operating value stage 2/ phase 1:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2/ phase 2:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 2:	0 ... 30 s in 0.05 s steps
Operating value stage 2/ phase 3:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 3:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI327	**FNNR**	**TYPE**	**ANSI**	**Application**
IDMT current, 3-phase, 2-stage, INVERSE DEFINITE MINIMUM TIME, Common outputs. *Note: MI327 is the preferred function with common outputs different to MI325.* *Note:* There was an error regarding the previous denomination in the PROCESSING file: MI326 but from version 5.17 on the nomenclature is in the PROCESSING file: MI327. ***Also:*** *Observe notes for MI325!*	1085	MI327	50/51	C2,M,L

3-phase, 2-stage inverse Definite Minimum Time current function with common outputs.

MI327
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage1
	Trip stage1
	Initiation stage2
	Trip stage2

Setting Parameters

Operating value stage 1/ phase 1:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 1:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 1:	extremely/very/normal/long IDMT
Operating value stage 1/ phase 2:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 2:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 2:	extremely/very/normal/long IDMT
Operating value stage 1/ phase 3:	0.05 ... 2 xIn in 0.01 xIn steps
Time multiplier stage 1/ phase 3:	0.050 ... 4.000 s in 0.025 s steps
Characteristic/ phase 3:	extremely/very/normal/long IDMT
Operating value stage 2/ phase 1:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2/ phase 2:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 2:	0 ... 30 s in 0.05 s steps
Operating value stage 2/ phase 3:	1 ... 50 xIn in 0,1 xIn steps
Definite time delay stage 2/ phase 3:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

9.2.3. Voltage Restraint Overcurrent

PROTECTIVE FUNCTION: MI318	FNNR	TYPE	ANSI	Application
Voltage Restraint Overcurrent	1081	MI318	50/51	C2,M

This is a 3 phase Voltage Restraint Overcurrent protection with an independent time delayed operating characteristic. In case of a phase to phase voltage drop for the allocated phase current evaluation the operating current will be proportionally reduced according to the function restraint characteristic

.

MI318
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage L1-L2
	Voltage L2-L3
	Voltage L3-L1
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	1 ... 5 xIn in 0.05 xIn steps
Nominal voltage:	70 ... 140 V in 1 V steps
Time delay:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

9.2.4. Motor Oscillation Protection

PROTECTIVE FUNCTION: MI119	FNNR	TYPE	ANSI	Application
Motor oscillation protection For PROCESSING from firmware version 5.24 onwards.	1045	MI119		C2,M

This function protects traction converter units used in railway systems supply against not permissible power oscillations which cannot be detected by the overcurrent protection.

MI119
Technical Data

Inputs

Analogue:	Motor current
	DC input: "Fou Evaluation" (from the control system)
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip
	Measuring alarm ("Fou Evaluation ")

Setting Parameters

Oscillations/min:	1 ... 10 Pend./min in 1 Pend./min steps
Oscillation current amplitude:	0.1 ... 1 xIn in 0.05 xIn steps
Current gradient:	0.05 ... 0.40 xIn in 0.05 xIn steps
Gradient Fou:	0.1 ... 2 %/s in 0.05 %/s steps
Measuring accuracy:	0.1 ... 5 %/V in 0.02 %/s steps
Voltage at 0 %::	0.2 ... 4.8 V in 0.005 V steps

Window Display for Relay Internal Determined and Computed Values

Oscillations	Number of oscillations within the last 60 s time window
Minimum current	in [A] Current minimum of the actual oscillation movement
Maximum current	in [A] Current maximum of the actual oscillation movement
Current gradient	in [A/s] Rate of change for the motor RMS current value
Fou gradient	in [%/s] Rate of speed change from the set frequency value of the control system
Fou	in [%] Set frequency of the control system

Measuring

Reset ratio:	not applicable since only trip output
Operating time:	≥ 2 cycles?
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

9.3. CIRCUIT DIAGRAMS

9.3.1. MI325/ MI327/ MI125

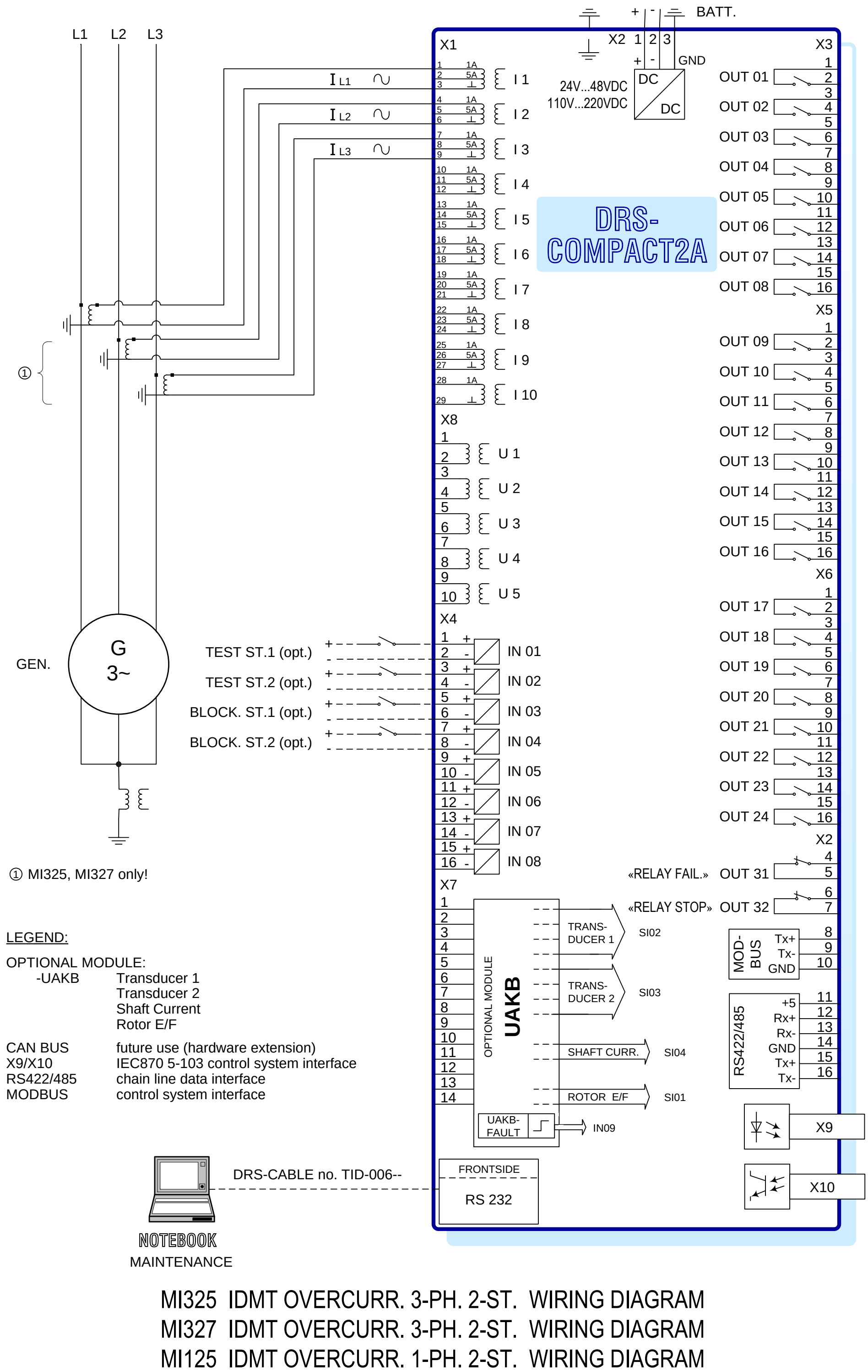


Fig. 98 MI325 MI327 MI125 IDMT Overcurr. Wiring Diagram

9.3.2. MI318

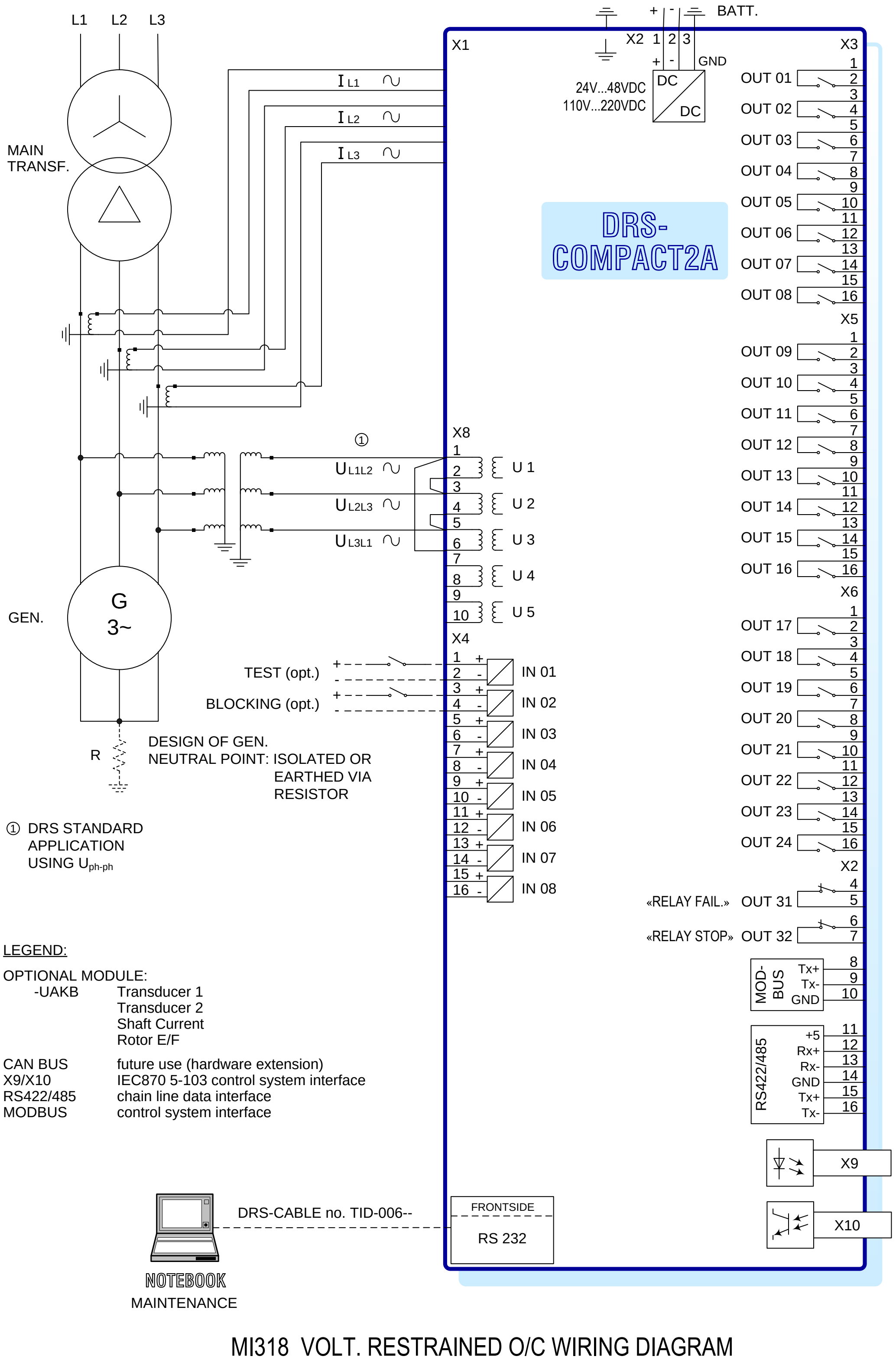
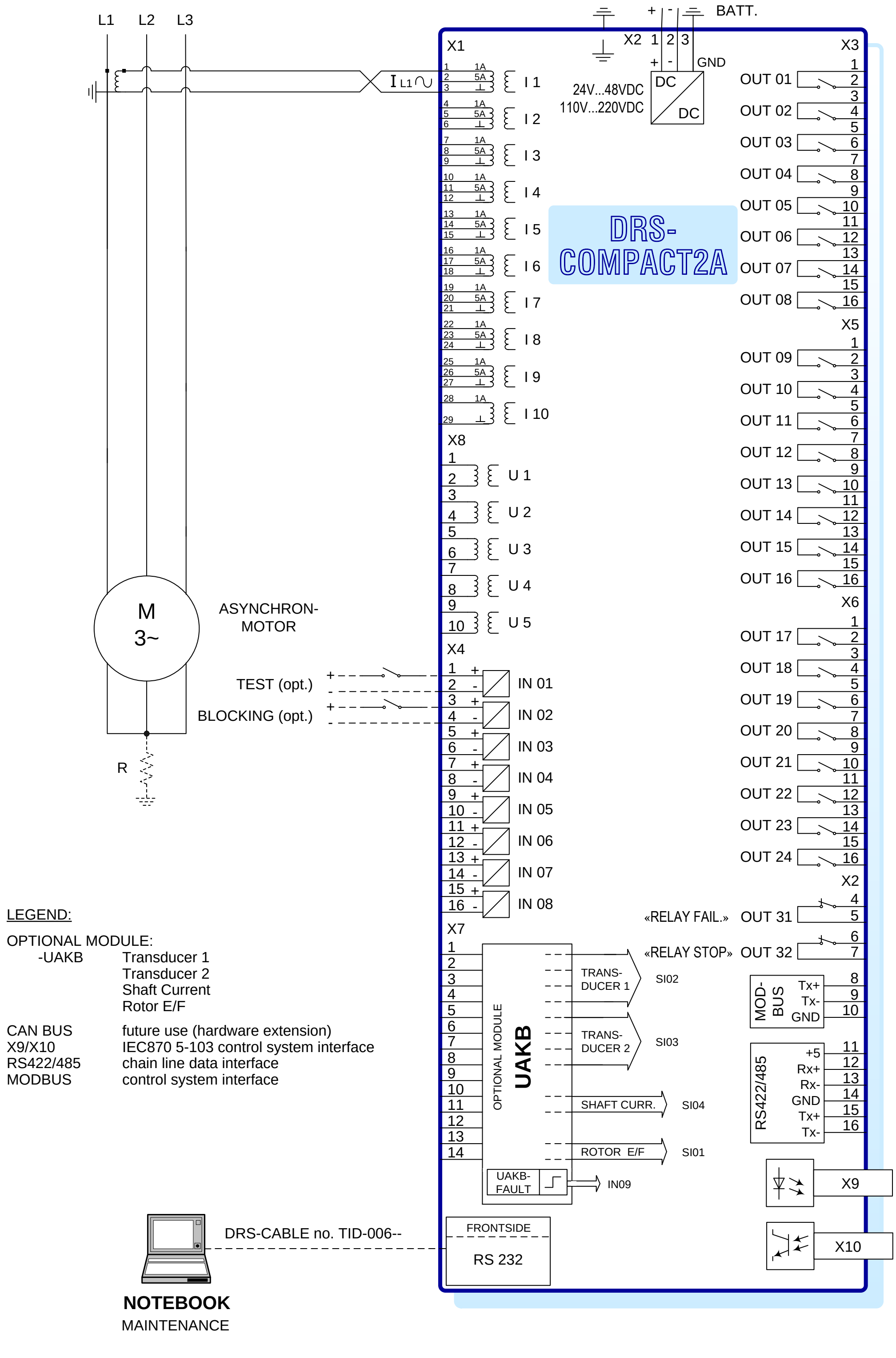


Fig. 99 MI318 Volt. Restrained O/C Wiring Diagram

9.3.3. MI119



MI119 MOTOR OSCILLATION WIRING DIAGRAM

Fig. 100 MI119 Motor Oscillation Wiring Diagram

9.4. LOGIC DIAGRAMS

9.4.1. MI325/ MI327/ MI125

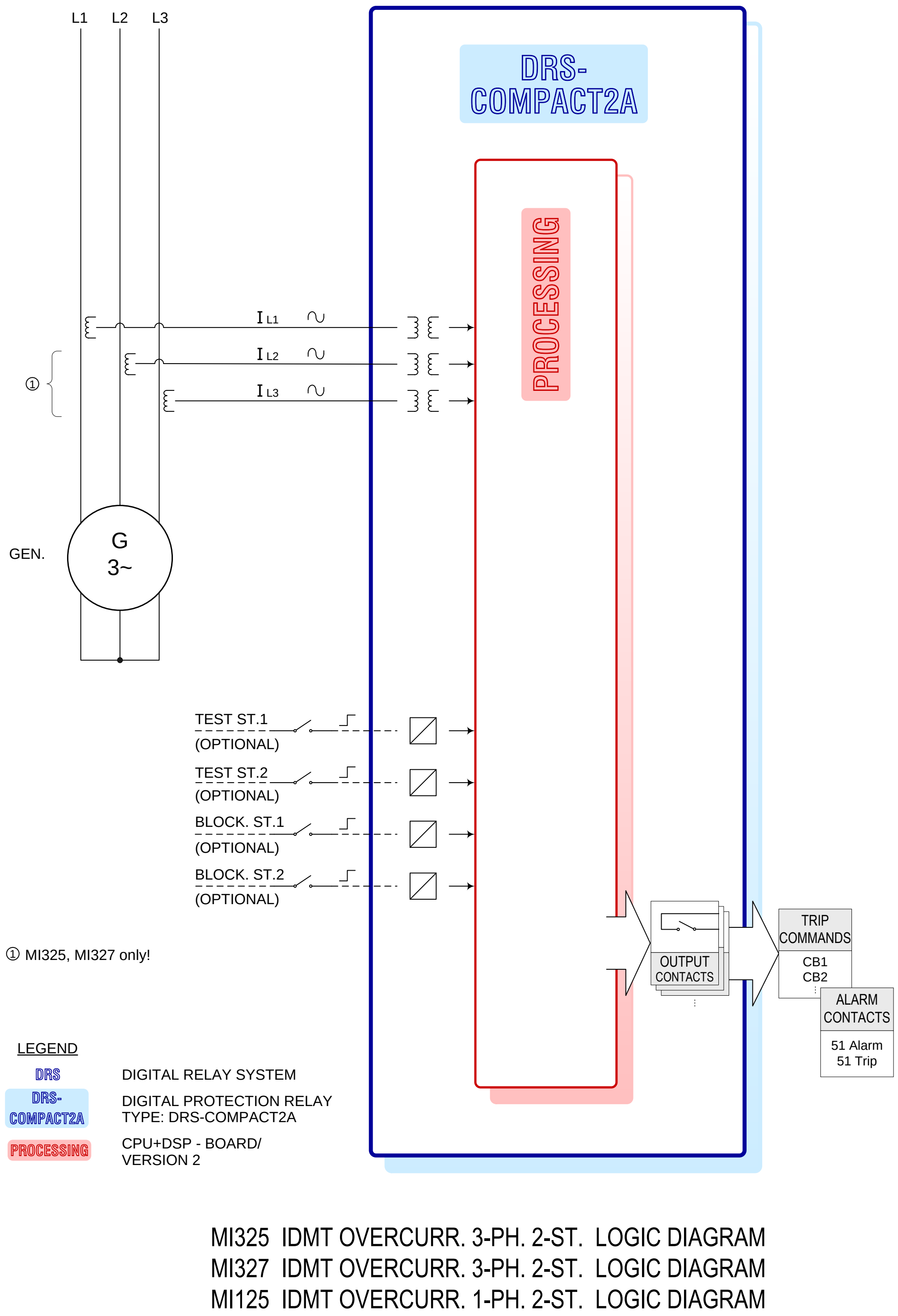
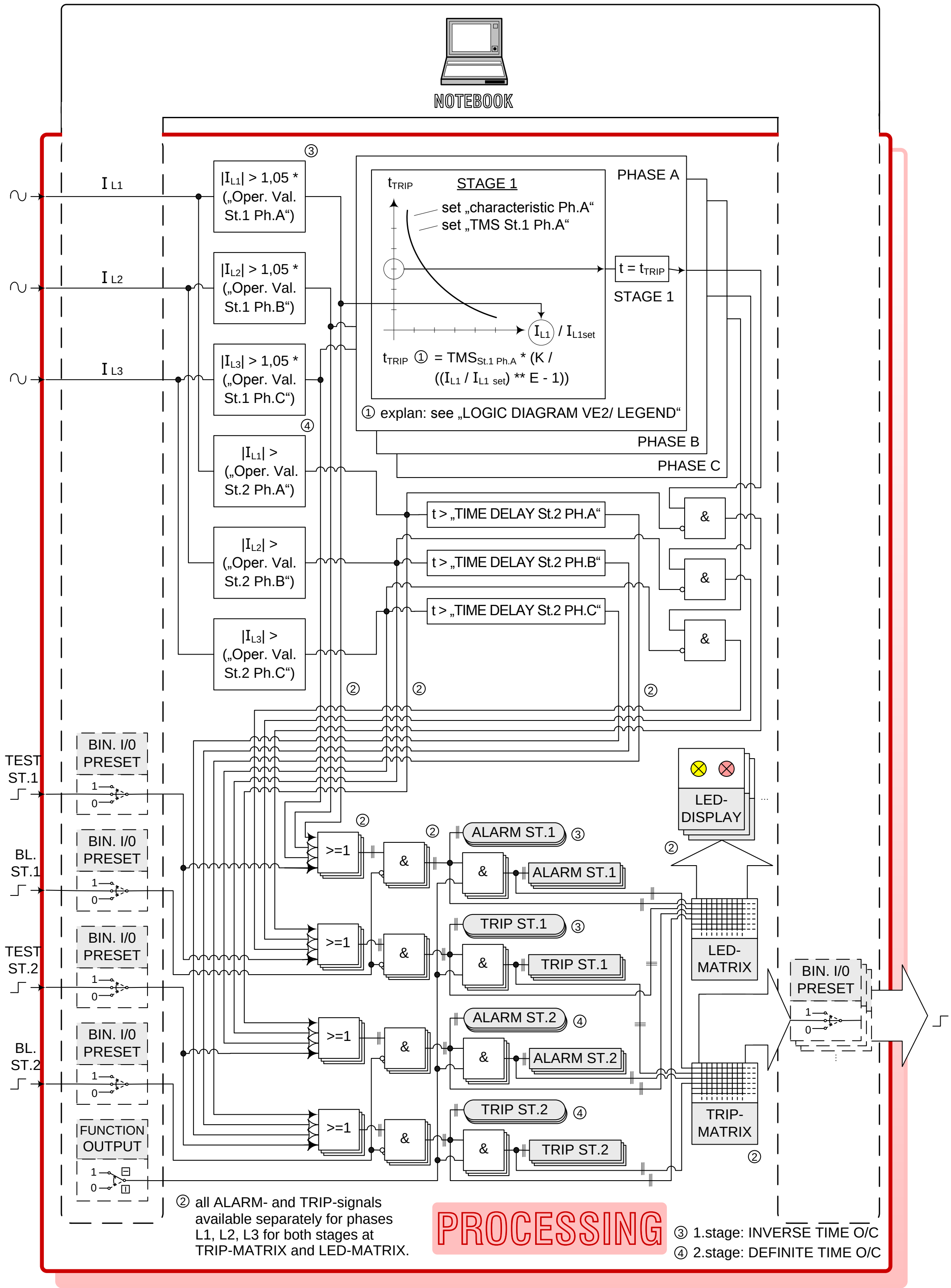
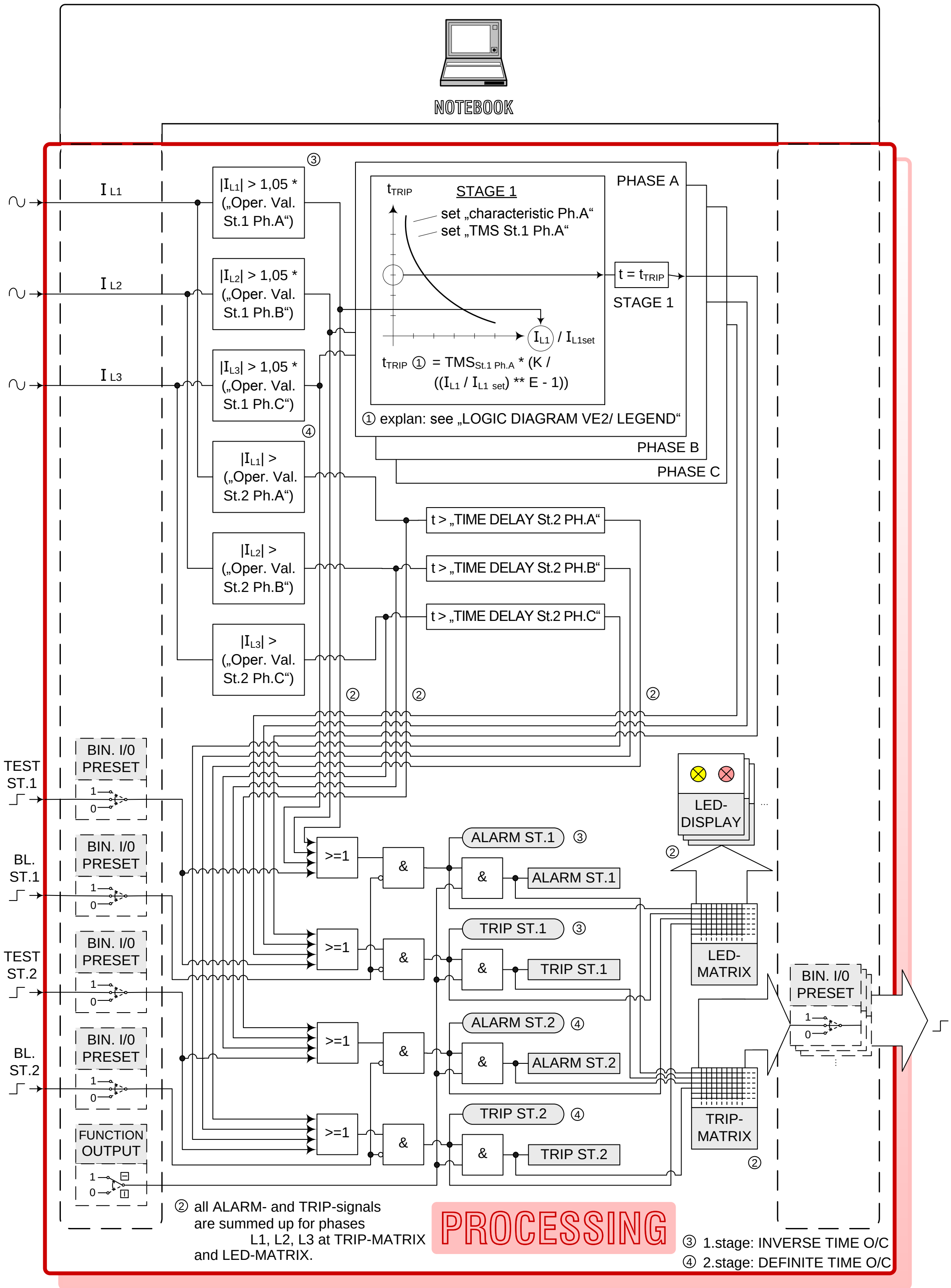


Fig. 101 MI325 MI327 MI125 IDMT Overcurr. Logic Diagram



IDMT OVERCURR. 3-PH. 2-ST. WITH PHASE-SEPARATED OUTPUTS
LOGIC DIAGRAM / PROCESSING

Fig. 102 IDMT Overcurr. 3-PH.2-ST. With Phase-Separated Outputs Logic Diagram / Processing



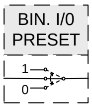
MI327 IDMT OVERCURR. 3-PH. 2-ST. WITH PHASE COMMON – OUTPUTS FOR ALL PHASES LOGIC DIAGRAM / PROCESSING

Fig. 103 MI327 IDMT Overcurr. 3-PH. 2-ST. With Phase Common – Outputs For All Phases Logic Diagram / Processing

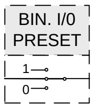
LEGEND PROCESSING

FIRMWARE-MODULE: MI325, MI327, MI125

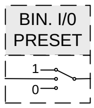
Online simulation via notebook



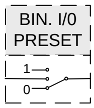
Online-simulation of DIG. IN-/OUTPUTS via notebook:



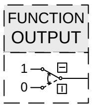
regular function



always „1"



always „0"

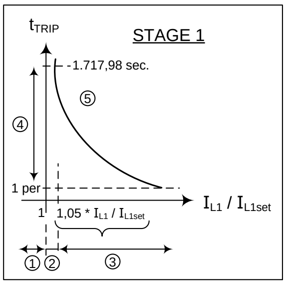


Online-simulation of the FUNCTION OUTPUTS of the protective function MI325, MI327, MI125
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊡ all FUNCTION OUTPUTS disabled (test-operation)

$|I_{L1}| > 1{,}05$ * („Oper. Val. St.1 Ph.A")

Measuring range of 1.stage starts at $|I_{L1}| = 1{,}05 * |I_{set}|$.

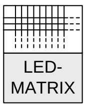
Note: $|I_{L1}| <= 1{,}0$ ® reset alarm (reset „energy capacity memory variable" to 0).
$1{,}0 < |I_{L1}| < 1{,}05$ ® keep old (= freeze „energy capacity" memory variable)



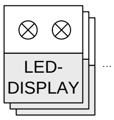
① $|I_{L1}| <= 1{,}05 * |I_{set}|$ → alarm is resetted
② $1{,}0 < |I_{L1}| < 1{,}05$ → keep old
③ $|I_{L1}| > 1{,}05$ → pick-up = alarm
④ t_{TRIP}-range: (1per.) ... (1.717,98 sec.)
⑤ Inverse Time Overcurrent Curve Characteristics (IEC)
FORMULA (IEC255-4, BS142)
t_{TRIP} = TMS * (K / ((I / I_{set}) ** E-1))
® NOTE: STAGE 2 ALARM BLOCKS
STAGE 1 TRIP! (IDMT-CHARACT.)

IEC Curves CHARACTERISTIC	K	E
Extremly Inverse	80	2
Very Inverse	13,5	1
Normal Inverse	0,14	0,02
Long Inverse	120	1

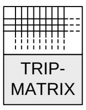
where:
- t_{TRIP} … trip time
- TMS … time multiplier setting (st.1)
- I … input current
- I_{set} … pickups current setpoint
- K, E … constants (see left!)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: 51 Alarm

TRIP — FUNCTION OUTPUT: 51 Trip

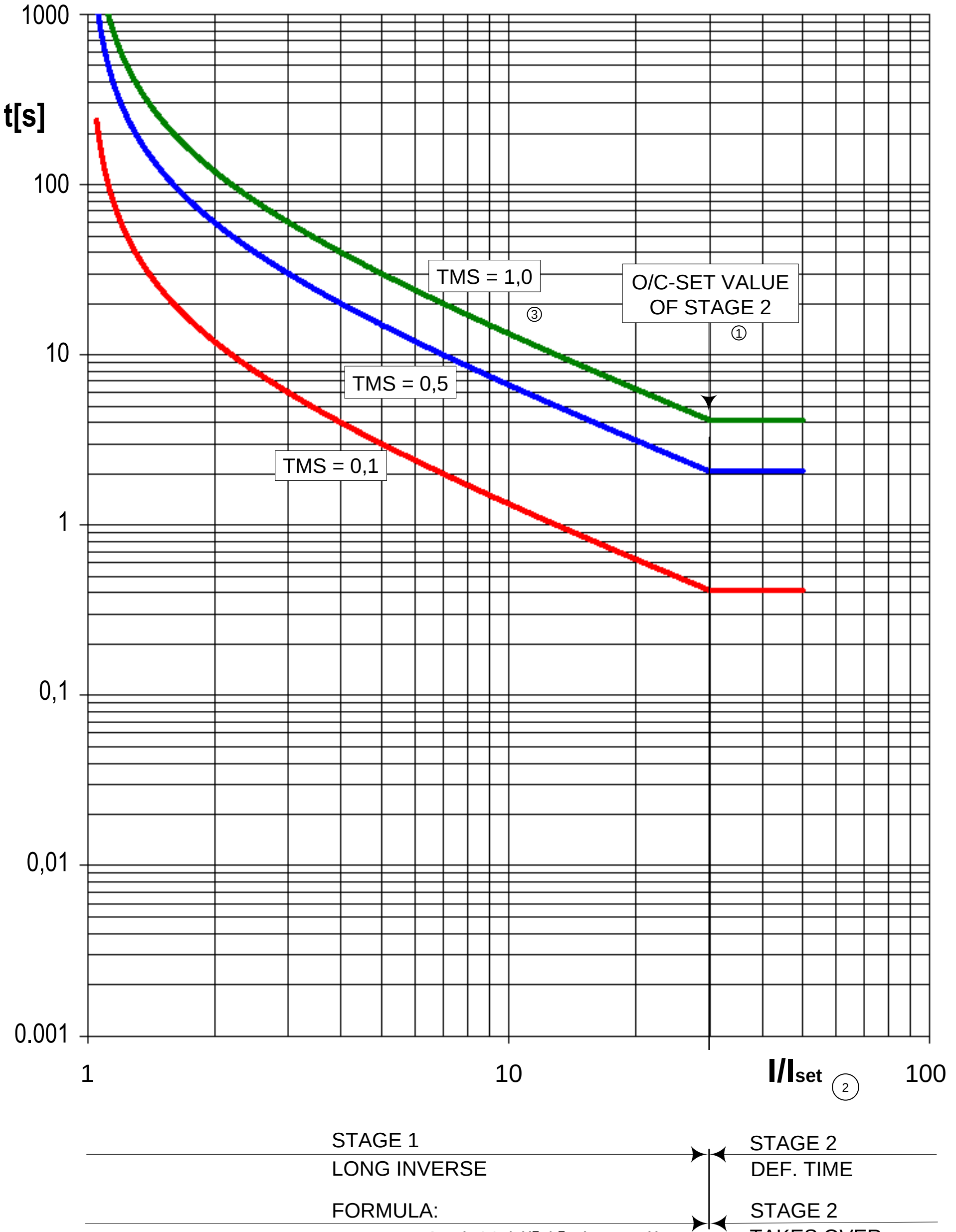
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MI325 IDMT OVERCURR. 3-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MI327 IDMT OVERCURR. 3-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MI125 IDMT OVERCURR. 1-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 104 MI325 MI327 MI125 IDMT Overcurr. Logic Diagram Processing / Legend

LONG INVERSE O/C
IEC CURVES



$t_{TRIP.} = TMS * (120 / ((I / I_{set}) ** 1-1))$

① ALARM OF STAGE 2 BLOCKS TRIP OF STAGE 1

② SCALE OF AXIS VALID FOR STAGE 1 ONLY!

③ TMS … TIME MULIPLIER SETTING

MI325 IDMT OVERCURR. 3-PH. 2-ST. IEC/ LONG INVERSE-CHARACTERISTIC
MI327 IDMT OVERCURR. 3-PH. 2-ST. IEC/ LONG INVERSE-CHARACTERISTIC
MI125 IDMT OVERCURR. 1-PH. 2-ST. IEC/ LONG INVERSE-CHARACTERISTIC

Fig. 105 MI325 MI327 MI125 IDMT Overcurr. IEC/ Long Inverse-Characteristic

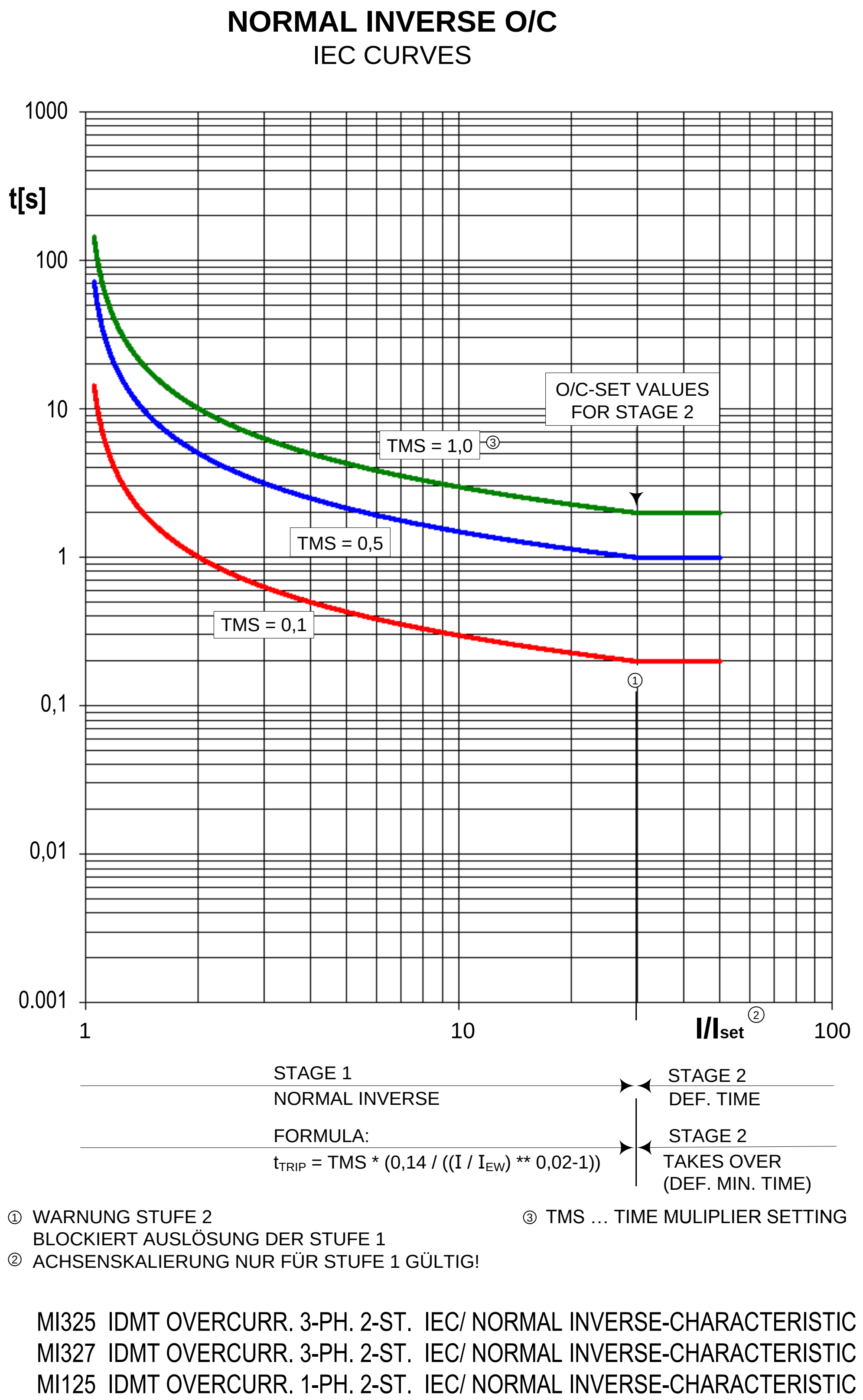
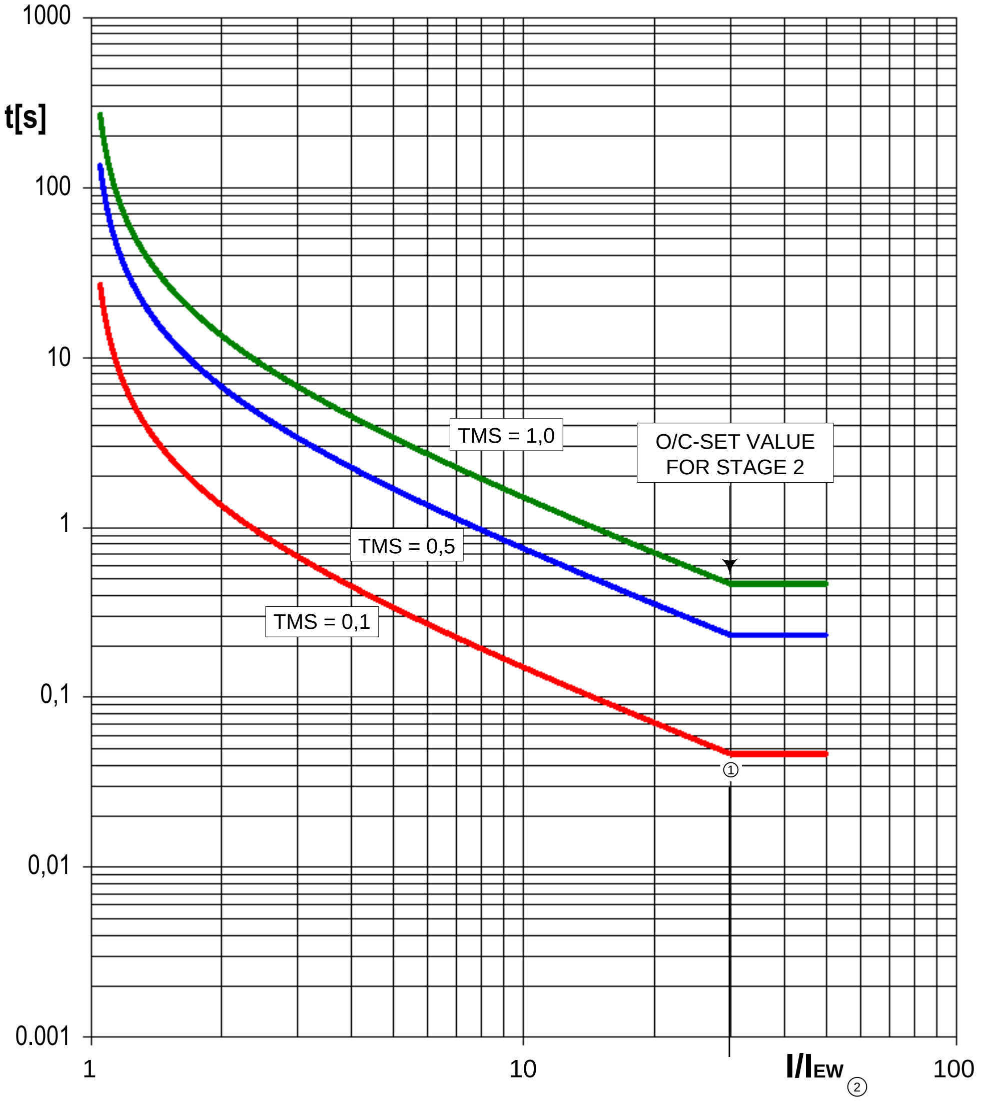


Fig. 106 MI325 MI327 MI125 IDMT Overcurr. IEC/ Normal Inverse-Characteristic

VERY INVERSE O/C
IEC CURVES



STAGE 1
VERY INVERSE

STAGE 2
DEF. TIME

FORMULA:
t_{TRIP} = TMS * (13,5 / ((I / I_{EW}) ** 1-1))

STAGE 2
TAKES OVER
(DEF. MIN. TIME)

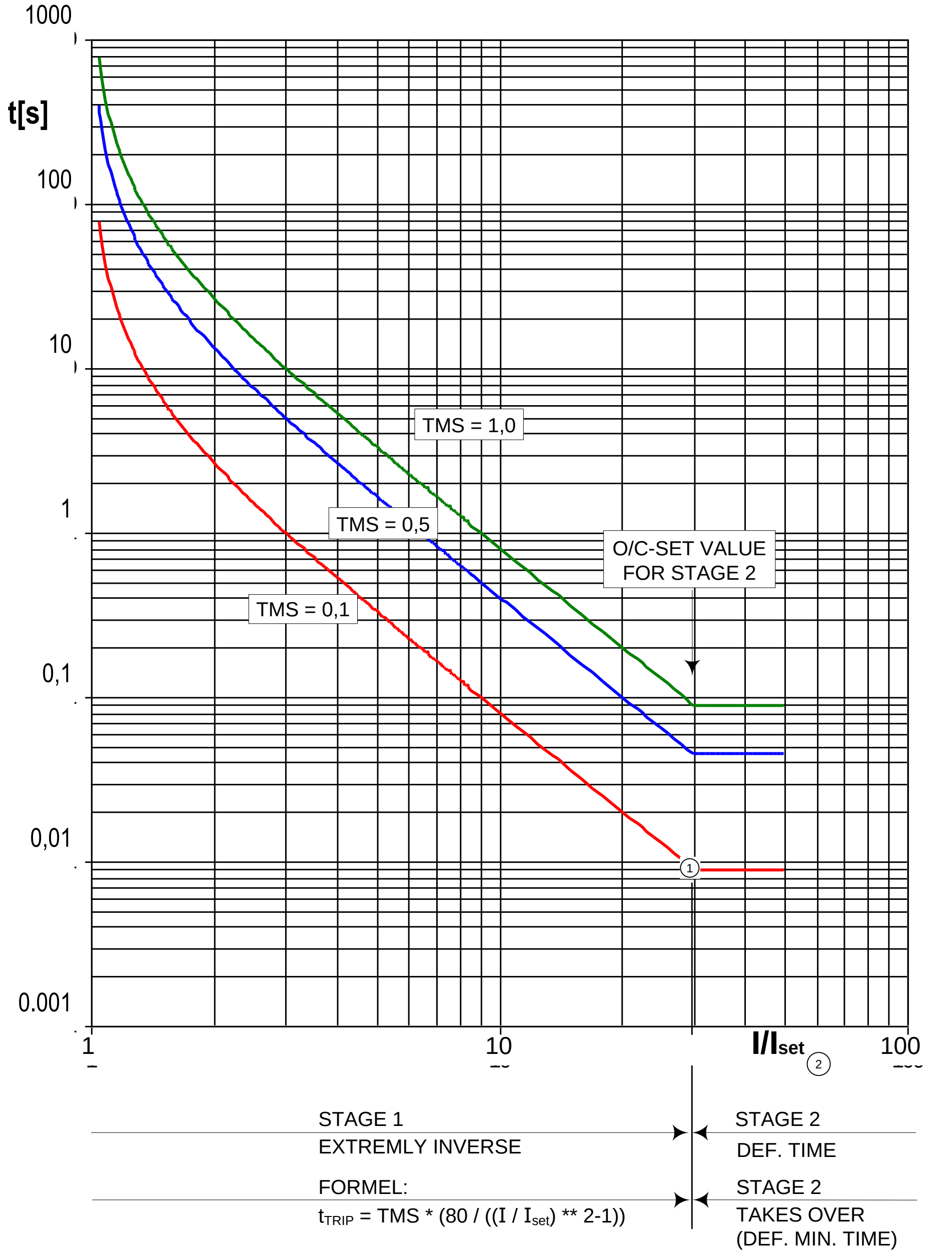
① ALARM OF STAGE 2
BLOCKS TRIP OF STAGE 1

② SCALE OF AXIS VALID FOR STAGE ! ONLY!
③ TMS … TIME MULIPLIER SETTING

MI325 IDMT OVERCURR. 3-PH. 2-ST. IEC/ VERY INVERSE-CHARACTERISTIC
MI327 IDMT OVERCURR. 3-PH. 2-ST. IEC/ VERY INVERSE-CHARACTERISTIC
MI125 IDMT OVERCURR. 1-PH. 2-ST. IEC/ VERY INVERSE-CHARACTERISTIC

Fig. 107 MI325 MI327 MI125 IDMT Overcurr. IEC / Very Inverse-Characteristic

EXTREMLY INVERSE O/C
IEC CURVES



① ALARM OF STAGE 2 BLOCKS TRIP OF STAGE 1

② SCALE OF AXIS VALID FOR STAGE 1 ONLY!

③ TMS … TIME MULIPLIER SETTING

MI325 IDMT STROM 3-PH. 2-ST. IEC/ EXTREMLY INVERSE-CHARACTERISTIC
MI327 IDMT STROM 3-PH. 2-ST. IEC/ EXTREMLY INVERSE-CHARACTERISTIC
MI125 IDMT STROM 1-PH. 2-ST. IEC/ EXTREMLY INVERSE-CHARACTERISTIC

Fig. 108 MI325 MI327 MI125 IDMT Strom IEC/ Extremly Inverse-Characteristic

9.4.2. MI318

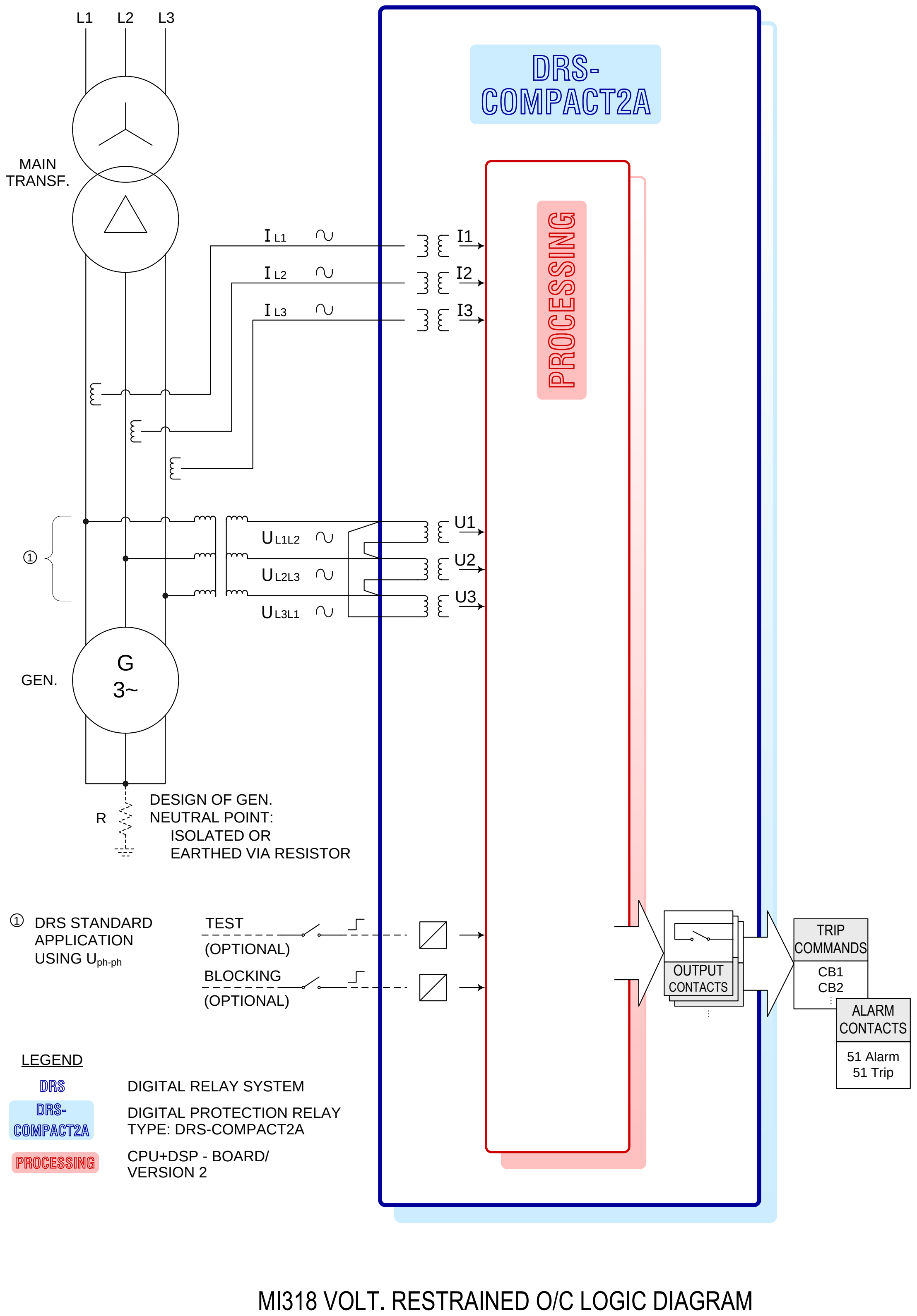
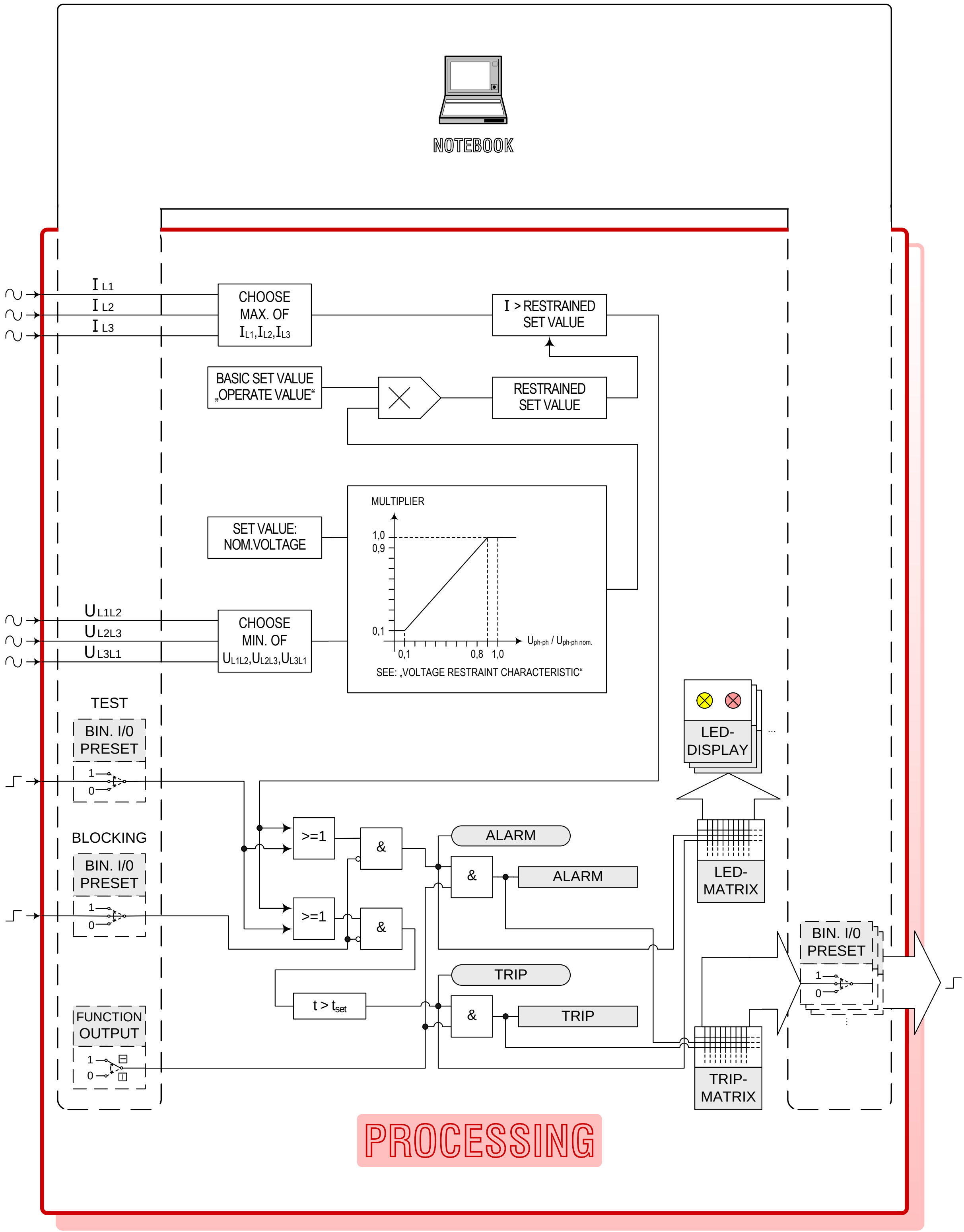


Fig. 109 MI318 Volt. Restrained O/C Logic Diagram



MI318 VOLT. RESTRAINED O/C LOGIC DIAGRAM PROCESSING

Fig. 110 MI318 Volt. Restrained O/C Logic Diagram Processing

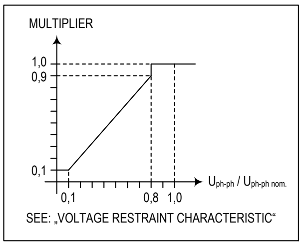
LEGEND PROCESSING

FIRMWARE-MODULE: MI318

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MI318
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



VOLTAGE RESTRAINED-CHARACTERISTIC.

$U_{ph\text{-}ph}$ actual (measured) phase-phase voltage.
$U_{ph\text{-}ph\ nom}$ nominal phase-phase voltage of generator (=SET VALUE: „NOMINAL VOLTAGE“).
MULTIPLIER used to calculate the „RESTRAINED SET VALUE“ according to formula:

„RESTRAINED SET VALUE“ = „OPERATE VALUE“ x „MULTIPLIER“

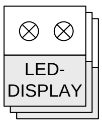
BASIC SET VALUE „OPERATE VALUE“ — Set value (see „Relay parameters“): „System nom. voltage“.

(X) — Multiplication

CHOOSE MAX. OF I_{L1},I_{L2},I_{L3} — The maximum current signal is chosen only and used for further computation.

CHOOSE MIN. OF U_{L1},U_{L2},U_{L3} — The minimum voltage signal is chosen only and used for further computation.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX
Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: 78 Alarm

TRIP — FUNCTION OUTPUT: 78 Trip

> Type of function: over-detection (actual value > set value)
< Type of function: under-detection (actual value < set value)

MI318 VOLT. RESTRAINED O/C LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 111 MI318 Volt. Restrained O/C Logic Diagram Processing / Legend

VOLTAGE RESTRAINED CHARACTERISTIC

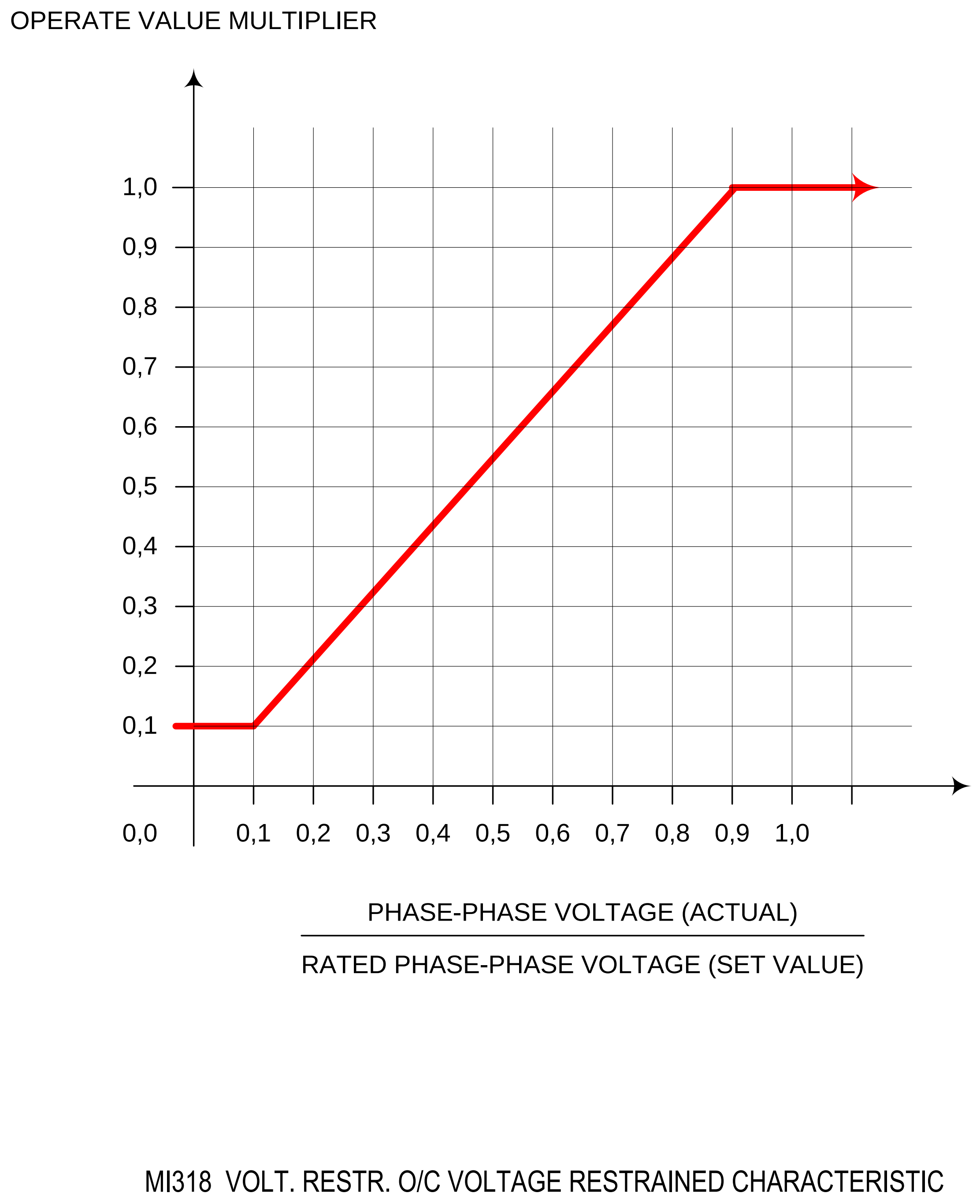


Fig. 112 MI318 Volt. Restr. O/C Voltage Restrained Characteristic

9.4.3. MI119

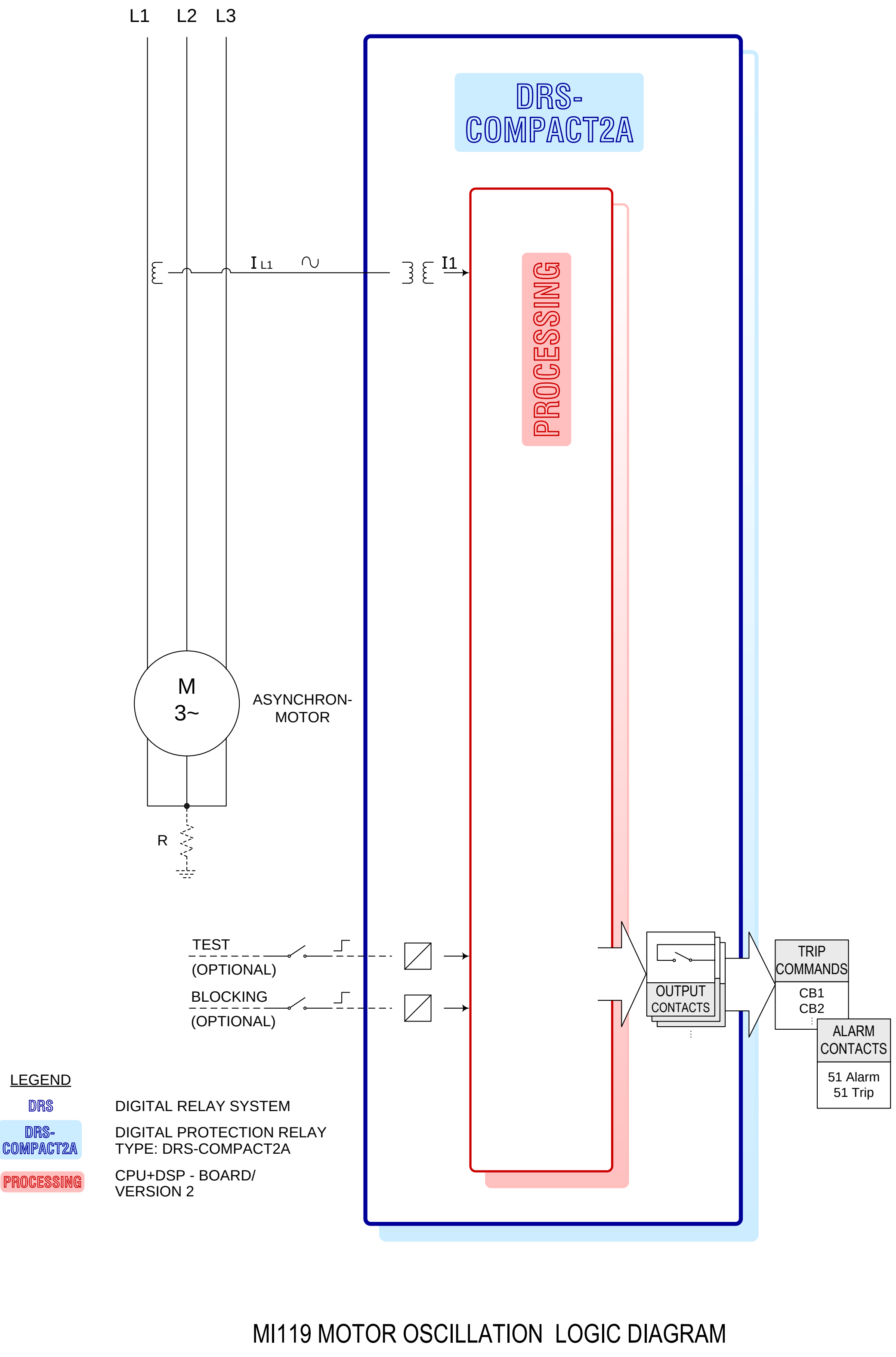
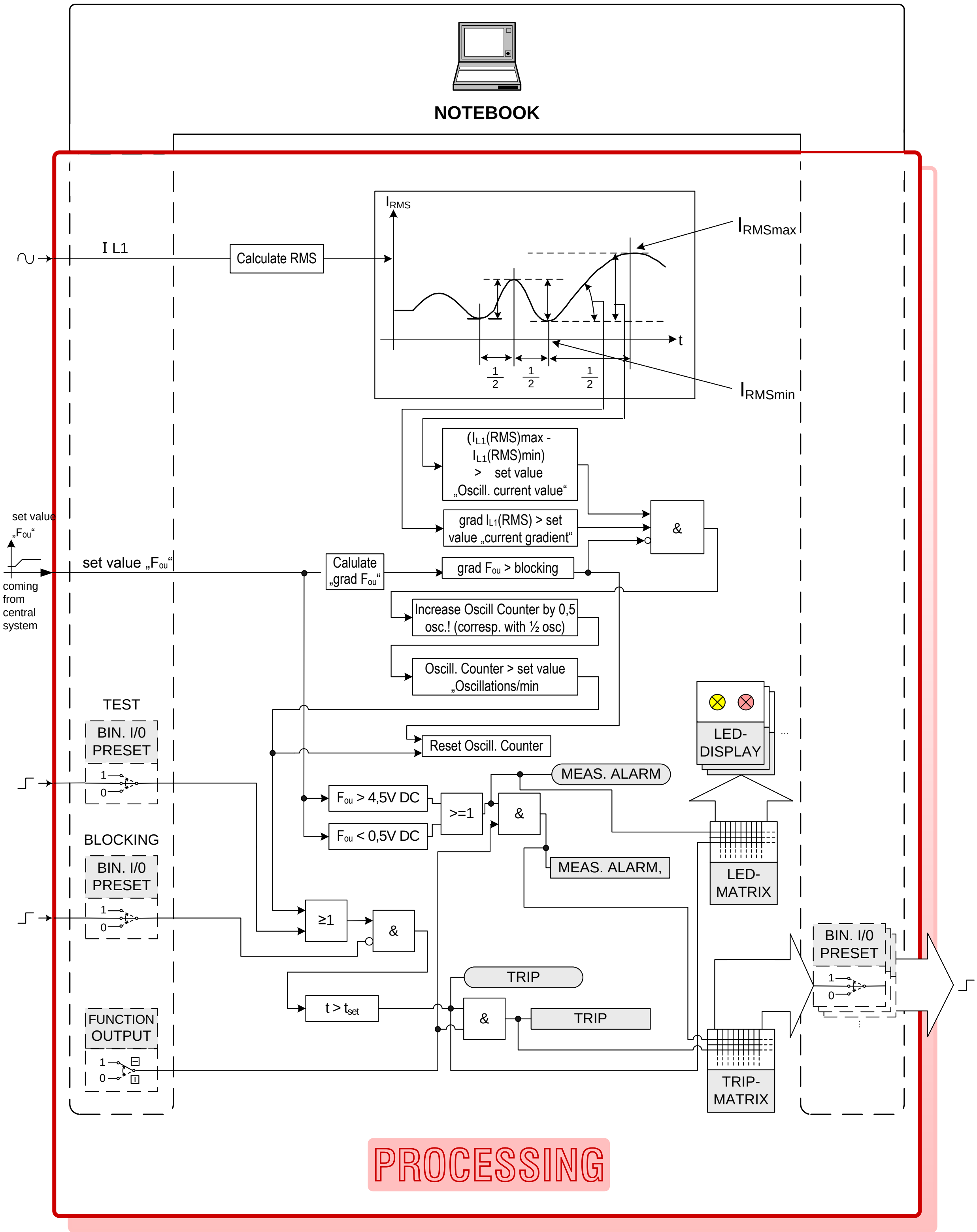


Fig. 113 MI119 Motor Oscillation Logic Diagram



MI119 MOTOR OSCILLATION LOGIC DIAGRAM PROCESSING

Fig. 114 MI119 Motor Oscillation Logic Diagram Processing

LEGEND PROCESSING

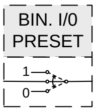
FIRMWARE-MODULE: MI119

Online simulation via notebook

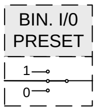
CALC. INTERNAL MEASURED VALUES

.....

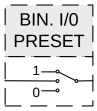
Online-indication of DRS-internal calculated values on notebook-screen



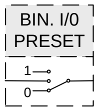
Online-simulation of DIG. IN-/OUTPUTS via notebook:



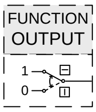
regular function



always „1"

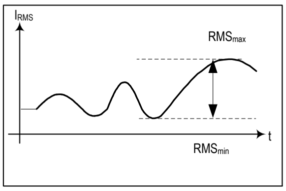


always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MI119

- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



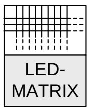
RMS value of I_{L1}.
Osc. counter is increased by 0,5 if ($RMS_{max} – RMS_{min}$) > set.
Check is done every ½ oscillation.
Details: see drawing „Oscillation detection“.

grad I_{L1}(RMS) > set value „current gradient“

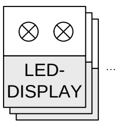
In order to get a valid oscillation (counter increases by 0,5) the gradient must be > set.
Details: see drawing „Oscillation defection“.

grad f_{ou} > blocking

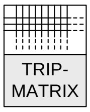
Oscillattions may be caused by changing the Motor - Speed – setting (by operators). In this case the Osc. Counter is resetted and additional blocked for 10sec.



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: 78 Alarm

TRIP — FUNCTION OUTPUT: 78 Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MI119 MOTOR OSCILLATION LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 115 MI119 Motor Oscillation Logic Diagram Processing / Legend

Explanation: Gradient F_{ou}

1. „Gradient F_{ou}“ is used for blocking („Grad. F_{ou}“ > set).
   If exeeded: a) Block of TRIP
   b) Reset Oscill. Counter to 0 for 10 sec.
   Note: „Gradient F_{ou}“ – Blocking is retriggerable.

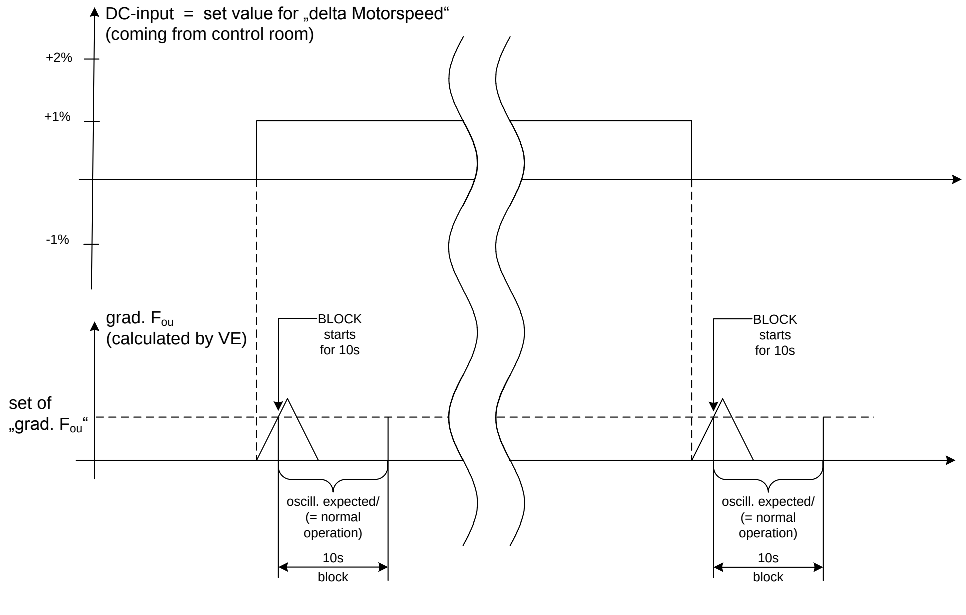
2. Gradient F_{ou} is calculated by the PROCESSING using the DC – input (slow Input / see Input Matrix of the „Prot. Function“) and the set values „Meas Sens.“ and „Volt. at 0%“.
   Result of calculation: „Gradient F_{ou}“

3. Meaning of „Gradient F_{ou}“:
   A changing of the set value for Motor – Speed (by Operators) results in changes of the Motor – Speed probably accompanied by oscillations until the new speed is settled.
   These oscillations depend on the change rate of the speed setting (speed setting = DC-Input) resp. the „Gradient F_{ou}“ (= calculated by PROCESSING using the DC input).
   Oscillations are more probable with high gradients of f_{ou}.. These oscillations are considered to be normal operation conditions, therefore the tripping is blocked for 10s and the Osc Counter is resetted to 0 osc.

4. Meas. Sens. [%/s]:
   defines how to calculate
   the difference of the motor - speed - set value using the Slow Input /DC – input) – signal.
   Note: this input signal is just a speed – difference, not a speed gradient! The gradient is calculated by the PROCESSING.

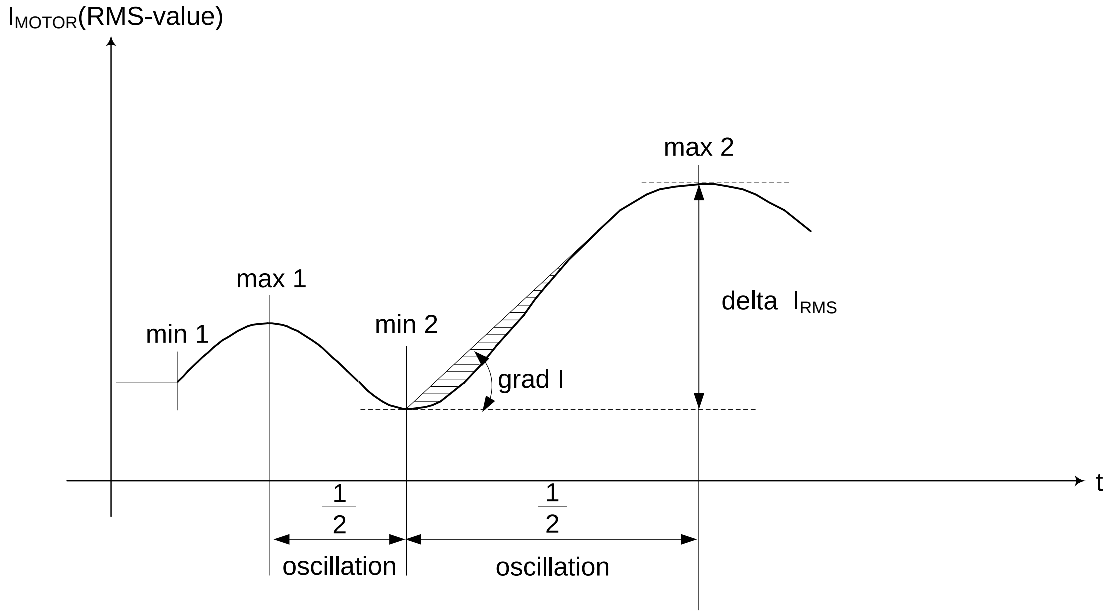
5. „Volt. at 0%“: level of the DC – input signal at nom speed setting (supplied by plant operators).
   Note: corresponds with nom. speed of motor.

6.) „Grad. F_{ou}“:
   time constant for calculation of $F_{ou:}$
   Approx. 1sec.



MI119 MOTOR OSCILLATON
EXPLANATION of „grad f_{ou}“ - BLOCKING

Fig. 116 MI119 Motor Oscillation Explanation of ,,grad f_{ou} - Blocking



delta I_{RMS}…	$=I_{RMS\ max} - I_{RMS\ min}$ ...must exceed set value “Osc Curr. Value“.
grad I …	[A_{RMS}/sec] during ½ oscillation the change rate (increase or decrease) of the RMS value of the motorcurrent must exceed the set value „Curr. Grad.“
Oscil. Counter:	every ½ oscillation the above conditions are checked. If fullfilled (and no blocking) then the Oscill. Counter is increased by 0,5 oscillations. Note: Oscillations which are older than 1min. are taken out from the Counter. Counter is resetted by a) TRIP b) BLOCK

MI119 MOTOR OSCILLATION
OSCILLATON COUNTER DEFINITION

Fig. 117 MI119 Motor Oscillation Oscillation Counter Definition

Setting Example MI119

Denomination of Set Value	**Setting**	**Remark**
Oscillations / min	8	
Osc. Curr. Value	0,3A = 30% In	c.t. nom. current = 1A
Curr. Grad	0,12A = 12% In	c.t. nom. current = 1A
Gradient Fou	0,7%/s	nom speed of motor = 100%
Meas. Sens.	1,5%/V	Input (delta--speed): 0,5V…-2,5% speed 2,16V…nom.speed 4,5V…+3,5% speed INPORTANT NOTE: Input < 0,5VDC or input > 4,5VDC results in "Meas Alarm" !
Volt. at 0%	2,15V	

MI119 MOTOR OSCILLATION SETTING EXAMPLE

Fig. 118 MI119 Motor Oscillation Setting Example

9.5. FUNCTION

9.5.1. MI125/ MI325/ MI327

IDMT Overcurrent Protection:

MI125 ... 1 phase, 2 stages
MI325 ... 3 phase, 2 stage, separate outputs
MI327 ... 3 phase, 2 stage, common outputs

Applicable for all IDMT overcurrent functions the operating characteristic is:

1st stage: IDMT ... Inverse Definite Minimum Time
2ndstage: Definite Time

Function (from 5.17 onwards):

As soon as stage 2 is initiated the 1st stage trip is being blocked, although internally the function is still measuring but is blocked. Thus the operating characteristic will be according to a "Definite Minimum Time" setting whereby high fault currents will not have any influence on the definite time delayed trip in order to obtain proper protection co-ordination.
Note: The blocking logic, i.e. stage 2 initiation is preventing operation of the 1st stage is also applicable for the test inputs in case of secondary injection tests.

MI325:
The function performs as 3 single phase relays their settings being completely independent from each other.

MI327:
Initiation of stage 2 in one phase is blocking the trip of stage1 in the same phase via function internal measures. However, since the external alarm and trip outputs are common an overcurrent condition in another phase which is not being blocked may still lead to a tripping of stage 1.

9.5.2. MI318

Voltage Restraint O/C

This is a 3 phase Voltage Restraint Overcurrent protection with an independent time delayed operating characteristic. In case of a phase to phase voltage drop for the allocated phase current evaluation the operating current will be proportionally reduced according to the function characteristic.

Explanation regarding basic function: Please also refer to VC O/C (MQ312).

Characteristic:

A generator usually has an operating range of V_n+/-10% and therefore also I_n+/-10%.
For a V_n-10% condition I_n+10% is generally valid since P=constant and the slope of the voltage characteristic up to 90% of nominal voltage and 100 % current, please also refer to the LOGIC DIAGRAMS. Within the range of V_n+/-10% the operating value is not being altered.
The start of the slope increase is set to 10% voltage and 10% current.

9.5.3. MI119

Availability of the Function:
VE1
PROCESSING from version 5.24 on

Function:
The relay function evaluates one of the three phase currents

Application:
This function protects traction converter units used in railway systems supply against not permissible power oscillations which cannot be detected by the overcurrent protection.

Function:
This function evaluates the RMS value of the phase current whereby one phase is used as a reference for the asynchronous motor (50 Hz/ 3 phase). When the oscillating amplitude exceeds the configured value a trip output signal is generated as outlined below.

Details of Setting Values:

Oscillations per minute:
The number of full oscillations can be recognised for a + or – sequence and the definition of an oscillating condition is described below.

Oscillation Amplitude:
The setting value is the difference of the RMS current during an oscillation process and strictly speaking not the amplitude but he difference between the maximum and the minimum current values is considered.
Only when during a half oscillation the setting value is exceeded the oscillation counter will be increased by a factor of 0.5.
Example: Rated current = 1 A RMS,
Oscillation of the motor current between 0.5 A RMS and 0.8 A RMS:
Therefore the oscillation amplitude should be adjusted to 0.3 A.
Setting example: 33 % of the nominal motor current.

Current Gradient:
Speed rate of change of the motor current RMS value.
Only when this current gradient is exceeded during a power swing it will be evaluated as an oscillation.
Note: The PROCESSING Program computes the slope of the slope between the starting point and the specific oscillation current, i.e. the maximum and the minimum of the oscillating motor RMS current value.
Setting Example: 12% of the rated motor current per second.

Gradient Fou:
The rate of speed change for the frequency target by the station control system.
This can accept either positive or negative values but only the absolute value is considered.
Note: The control system is determining a frequency change but not a change of the angular velocity.
The gradient is computed by the PROCESSING program on the basis of the required frequency change and the slow input SI01 measures the frequency setting change initiated by the control system which is a frequency control and not a speed control command.
For the protective function only the frequency rate of change is considered and when the value is exceeded then the counter is reset to zero and remains the same for 10 seconds.
It is assumed that short time oscillations are a normal operating condition during large changes of the frequency control value and must not be considered as an oscillation configured in the DRS Protection System.

The "gradient Fou" is also be retriggered and the time constant for the computation of the “Degree Fou“ is actually about 1 second but may be set higher due to some time constants of the motor which can be between 5 ... 10 s.

Setting Example: 0.7 %/s.

Measuring Sensitivity:
This does not concern the Fou gradient but only the input matrix / SI01:
Target change for the frequency.
The units are in %/V (and not %/s / V).
Setting example (also see below): 1.5 %/V.

Voltage at 0%:
As outlined above.
Setting example:
0.5V corresponds to -2.5 %
4.5V corresponds to +3.5%
Therefore the zero point lies at a voltage of: 2.16V.
The measuring sensitivity fort his example will result in: 1.5 %/V

Explanation of Inputs:

Motor Current:
One selectable phase of the motor current
(asynchronous motor 3-phase, 50 Hz).

DC Input: "Fou Target" coming from the control system:
Speed rate of change for the frequency target by the control station.

Explanation of Outputs:

Trip:
Motor oscillation has been recognised.

Measuring Fault:
Refers to the DC input: "Fou Target" coming from the control system.
This DC signal (SI) should always be between 0.5V DC and 4.5 V DC even during standstill of the motor otherwise an alarm annunciation ”Measuring Fault” will be given.
Recommendation: Supervision of the measuring transducer loop, etc. (transducer failure, wire break, …) with the aid of the DRS-WIN measured values window display.

Features of the Protective Function:

The PROCESSING program is counting all oscillations from 0 % of the motor nominal current onwards, i.e. the minimum value.

The oscillation counter is evaluating in 0.5 steps (half oscillations). For each half oscillation following criteria have to be fulfilled:
Oscillation current amplitude >
Current gradient >
Gradient Fou <.

For each half oscillation the 1st minute window is starting to run separately. After expiry of this period the corresponding half oscillation is deducted from the counter values and if no other subsequent oscillations are taking place it can be observed that the counter will slowly tend to zero (except there was a trip … then the counter is immediately reset).
The oscillation counter is only adding when during an oscillation the RMS current differential value is exceeding the set oscillation current amplitude whereby the reference point will be the last measured current minimum or current maximum. The oscillation or half oscillation can either start from the + or - direction.

Applying the blocking- ort he test input will reset the oscillation counter to 0.

9.6. COMMISSIONING

!!! Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!!!

9.6.1. MI325/ MI327/ MI125

Please refer to document "MI Current DT".

9.6.2. MI318

Please refer to document "MI Current DT".
It should be noted that the actual current setting during the primary short circuit tests have to be lowered to about 10% according to the "Voltage Restraint Characteristic".

9.6.3. MI119

-Secondary Tests:

With a suitable test set inject a variable single phase current according to the characteristic (please also refer to Item "Function MI119"):

Inputs

Analogue:	Motor current
	DC input: "Fou Target" (from control system)
Binary:	Blocking input
	Test input

Note:
By simultaneous varying of the DC input "Fou Target " a reset of the oscillation counter is achieved. After resetting the counter to "0" the relay function will remain blocked for 10 s,
i.e. the counter will remain at zero during the next 10 seconds.

Note:
When on the "Fou Target" DC input there is no signal present the function will produce a "Measuring Fault" alarm:
This DC signal (SI) should always be between 0.5V DC and 4.5 V DC even during standstill of the motor otherwise an alarm annunciation ”Measuring Fault” will be given.

Check of the displayed function computed values:

Window Display for Relay Internal Determined and Computed Values

Oscillations	Number of oscillations within the last 60 seconds
Minimum current	in [A] Current minimum of the actual oscillation
Maximum current	in [A] Current maximum of the actual oscillation
Current gradient	in [A/s] Rate of speed change of the motor RMS current value

Take a plausibility check of the displayed values.

<u>On-load Commissioning Tests:</u>

Check the input values via the “Measured Values“ window of the DRS System.

10. MI... OVER/UNDERCURRENT PROTECTION DEFINITE TIME (DT)

10.1. OVERVIEW

List of the Available MI . . . – Over/Undercurrent DT Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MI . . .	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 1 phase, 1 stage, 0.1-5A	1005	MI111	50/51	C2,M,L
Over/undercurrent protection 1 phase, 1 stage, 1-15A	1047	MI112	50/51	C2,M,L
Over/undercurrent protection 1 phase, 2 stage, 0.1-5A/ 0.1-30A	1007	MI121	50/51	C2,M,L
Over/undercurrent protection 1 phase, 2 stage, 1- 15A/ 1-50A	1049	MI122	50/51	C2,M,L
Over/undercurrent protection 3 phase, 1 stage, 0.1-5A/ 10s, separate outputs. *Note: Preferred type see MI313 (common outputs).*	1004	MI311	50/51	C2,M
Over/undercurrent protection 3 phase, 1 stage, 1-15A/ 10s, separate outputs. *Note: Preferred type see MI314 (common outputs).*	1046	MI312	50/51	C2,M
Over/undercurrent protection 3 phase, 1 stage, 0.1-5A/ 10s, common outputs. *Note: MI313 is preferred to MI311 (common outputs).*	1055	MI313	50/51	C2,M,L
Over/undercurrent protection 3 phase, 1 stage, 1-15A/ 10s, common outputs. *Note: MI314 is preferred to MI312 (common outputs).*	1056	MI314	50/51	C2,M,L
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 0.1-5A/10s // 0.1-30A /10s, separate outputs. *Note: Preferred type see MI323 (common outputs).*	1006	MI321	50/51	C2,M
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 1-15A/10s // 1-50A /10s, separate outputs. *Note: Preferred type see MI324 (common outputs).*	1048	MI322	50/51	C2,M

Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 0.1-5A/10s // 0.1-30A /10s, common outputs. *Note: MI323 is preferred to MI321 (common outputs).*	1052	MI323	50/51	C2,M,L
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 1-15A/10s // 1-50A /10s, common outputs. *Note: MI324 is preferred to MI322 (common outputs).*	1054	MI324	50/51	C2,M,L; VE1,PROCESSING
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, extended time delay. 0.1-5A/180s // 0.1-30A /10s, common outputs.	1061	MI326	50/51	C2,M,L
Fast overcurrent "Quick Current I>>>" ; is preferably used as transformer tank protection for the German Railway System (DB). Caution: This is an oversampling function! Caution: This function must only be conditionally used with other functions and has not to be combined with frequency functions due to a possible frequency jitter! Generally valid: Do not combine with functions using higher harmonics. Due to the sampling jitters, which are created in conjunction with the oversampling mode, a resulting tolerance range of the Fourier evaluation will occur. Should a combination with such functions be absolutely necessary then in each particular case the correct response of all functions involved has to be thoroughly tested during which the "Quick Current I>>>" function is to be always active.	1091	MI113	50	C2,M
Current, DC, 2 stage	1050	MI120	50/51	C2,M
Directional overcurrent protection DT characteristic, 1 phase, 3 stage for single phase systems, respectively two phase traction generators, 0.1-5A/10s // 0.1-5A/10s // 0.1-5A/10s	1039	MI132	50/51	C2,M,L
Directional overcurrent protection DT characteristic, 1 phase, 3 stage, extended time delay, 0.1-5A/180s // 0.1-5A/10s // 0.1-5A/10s	1060	MI133	50/51	C2,M,L
Directional overcurrent protection DT characteristic, 3 phase, 3 stage, 0.1-5A/10s // 0.1-5A/10s // 0.1-5A/10s.	1031	MI332	50/51	C2,M,L

10.2. TECHNICAL DATA

10.2.1. Over/Undercurrent DT 1 Phase, 1 Stage

PROTECTIVE FUNCTION: MI111	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 1 phase, 1 stage, 0.1-5A	1005	MI111	50/51	C2,M,L

1 phase, 1 stage definite time current function (DT) selectable for over- or under detection.

MI111
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI112	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 1 phase, 1 stage, 1-15A	1047	MI112	50/51	C2,M,L

1 phase, 1 stage definite time current function (DT) selectable for over- or under detection.

MI112
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	1 ... 15 xIn in 0.05 xIn steps
Operating time:	0 ... 30 seconds in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.2. Over/Undercurrent DT 1 Phase, 2 Stage

PROTECTIVE FUNCTION: MI121	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 1 phase, 2 stage, 0.1-5A/ 0.1-30A	1007	MI121	50/51	C2,M,L

1 phase, 2 stage definite time current function (DT) selectable for over- or under detection.

MI121
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	0.1 ... 30 xIn in 0.05 xIn steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI122		FNNR	TYPE	ANSI	Application
Over/undercurrent protection 1 phase, 2 stage, 15A/ 1-50A	1-	1049	MI122	50/51	C2,M,L

1 phase, 2 stage definite time current function (DT) selectable for over- or under detection.

MI122
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.1 ... 15 xIn in 0.05 xIn steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	0.1 ... 50 xIn in 0.1 xIn steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.3. Over/Undercurrent DT 3 Phase, 1 Stage

PROTECTIVE FUNCTION: MI311	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 3 phase, 1 stage, 0.1-5A/ 10s, separate Outputs *Note: Preferred type see MI313 (common Outputs).*	1004	MI311	50/51	C2,M

3 phase, 1 stage definite time current function (DT) selectable for over- or under detection, separate outputs.

<u>MI311</u>
<u>Technical Data</u>

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation phase L1
	Trip phase L1
	Initiation phase L2
	Trip phase L2
	Initiation phase L3
	Trip phase L3

Setting Parameters

Operating value:	1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI312	**FNNR**	**TYPE**	**ANSI**	**Application**
Over/undercurrent protection 3 phase, 1 stage, 1-15A/ 10s, separate Outputs *Note: Preferred type see MI314 (common Outputs).*	1046	MI312	50/51	C2,M

3 phase, 1 stage definite time current function (DT) selectable for over- or under detection.

MI312
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	1 ... 15 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI313	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 3 phase, 1 stage, 0.1-5A/ 10s, common outputs. *Note: MI313 is preferred to MI311 (common outputs).*	1055	MI313	50/51	C2,M,L

3 phase, 1 stage definite time current function (DT) selectable for over- or under detection, common outputs.

MI313

Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI314	FNNR	TYPE	ANSI	Application
Over/undercurrent protection 3 phase, 1 stage, 1-15A/ 10s, common outputs. *Note: MI314 is preferred to MI312 (common outputs).*	1056	MI314	50/51	C2,M,L

3 phase, 1 stage definite time current function (DT) selectable for over- or under detection, common outputs.

MI134
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	1 ... 15 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.4. Over/Undercurrent DT 3 phase, 2 stage

PROTECTIVE FUNCTION: MI321	FNNR	TYPE	ANSI	Application
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 0.1-5A/10s // 0.1-30A /10s, separate outputs. *Note: Preferred type see MI323 (common outputs).*	1006	MI321	50/51	C2,M

3 phase, 2 stage definite time current function (DT) selectable for over- or under detection, separate outputs.

<u>MI321</u>
<u>Technical Data</u>

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	1 ... 5 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2:	1 ... 30 xIn in 0.05 xIn steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI322	FNNR	TYPE	ANSI	Application
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 1-15A/10s // 1-50A /10s, separate outputs. *Note: Preferred type see MI324 (common outputs).*	1048	MI322	50/51	C2,M

3 phase, 2 stage definite time current function (DT) selectable for over- or under detection, separate outputs.

MI322
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1 L1
	Trip stage1 L1
	Initiation stage 1 L2
	Trip stage 1 L2
	Initiation stage 1 L3
	Trip stage 1 L3
	Initiation stage 2 L1
	Trip stage 2 L1
	Initiation stage 2 L2
	Trip stage 2 L2
	Initiation stage 2 L3
	Trip stage 2 L3

Setting Parameters

Operating value:	1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Operating value:	1 ... 30 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI323	FNNR	TYPE	ANSI	Application
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 0.1-5A/10s // 0.1-30A /10s, common outputs *Note: MI323 is preferred to MI321 (common outputs).*	1052	MI323	50/51	C2,M,L

3 phase, 2 stage definite time current function (DT) selectable for over- or under detection, common outputs.

MI323
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage1
	Trip stage1
	Initiation stage2
	Trip stage2

Setting Parameters

Operating value:	1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Operating value:	1 ... 30 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI326	FNNR	TYPE	ANSI	Application
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, extended timing range, 0.1-5A/180s // 0.1-30A /10s, common outputs.	1061	MI326	50/51	C2,M,L

3 phase, 2 stage definite time current function (DT) selectable for over- or under detection, common outputs with an extended time delay for stage 1.

MI326
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage1
	Trip stage1
	Initiation stage2
	Trip stage2

Setting Parameters

Operating value:	1 ... 5 xIn in 0.01 xIn steps
Operating time:	0 ... 180 s in 1 s steps
Operating value:	1 ... 30 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI324	FNNR	TYPE	ANSI	Application
Over/undercurrent protection, DT characteristic, 3 phase, 2 stage, 1-15A/10s // 1-50A /10s, common outputs. *Note: MI324 is preferred to MI322 (common outputs).*	1054	MI324	50/51	C2,M,L

3 phase, 2 stage definite time current function (DT) selectable for over- or under detection, common outputs.

MI324
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage1
	Trip stage1
	Initiation stage2
	Trip stage2

Setting Parameters

Operating value:	1 ... 15 xIn in 0.05 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Operating value:	1 ... 50 xIn in 0.1 xIn steps
Operating time:	0 ... 30 s in 0.05 s steps
Type:	Over-/under detection

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.5. Fast Overcurrent Function, 1 phase, 1 stage

PROTECTIVE FUNCTION:	FNNR	TYPE	ANSI	Application
Fast overcurrent "Quick Current I>>>"; is preferably used as transformer tank protection for the German Railway System (DB). Caution: This is an oversampling function! Caution: This function must only be conditionally used with other functions and has not to be combined with frequency functions due to possible frequency jitter! Generally valid: Do not combine with functions using higher harmonics. Due to the sampling jitters which are created in conjunction with the oversampling mode it will result into a tolerance range of the Fourier evaluation. Should a combination with such functions be absolutely necessary then in each particular case the correct response of all functions involved has to be thoroughly tested whereby " Quick Current I>>>" is always active.	1091	MI113	50	C2,M

1 phase, 1 stage fast overcurrent definite time delay function (DT) with instantaneous actual value computation.

MI113
Technical Data

Inputs

Analogue:	Current
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip

Setting Parameters

Operating value:	0.1 ... 15 xIn in 0.01 xIn steps
Reset delay:	0.1 ... 0.5 s in 0.01 s steps

Measuring

Reset ratio:	Not applicable since no time delay
Operating time:	≥ 10 ms including relay outputs
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.6. Over/Undercurrent DC Input, 2 stage

PROTECTIVE FUNCTION: MI120	FNNR	TYPE	ANSI	Application
Current, DC, 2 stage	1050	MI120	50/51	C2,M

2 stage definite time DC current function (DT) selectable for over- or under detection.

MI120
Technical Data

Inputs

Analogue:	DC input for current [0 ... 5 V]
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.1 ... 50 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	0.1 ... 50 xIn in 0.01 xIn steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over-/under detection
Measuring accuracy:	0.10 ... 10 A/V in 0.01 A/V steps
Voltage at 0 Amps:	0 ... 4.995 V in 0.005 V steps

Window Display for Relay Internal Determined and Computed Values

DC mean value:	in [A]
DC instantaneous value:	in [A]

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.2.7. Directional Overcurrent DT 1 Phase, 3 Stage

PROTECTIVE FUNCTION: MI132	FNNR	TYPE	ANSI	Application
Directional overcurrent protection DT characteristic, 1 phase, 3 stage, for single phase systems, respectively two phase traction generators, 0.1-5A/10s // 0.1-5A/10s // 0.1-5A/10s	1039	MI132	50/51	C2,M,L

1 phase, 3 stage directional overcurrent function (DT).

MI132
Technical Data

Inputs

Analogue:	Current
	Voltage (in phase with current)
Binary:	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Test input stage 1
	Test input stage 2
	Test input stage 3

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2
	Initiation stage 3
	Trip stage 3

Setting Parameters

Operating value stage 1:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 3:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 3:	0 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal
Determined and Computed Values

Angle:	In [Degrees]

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI133	FNNR	TYPE	ANSI	Application
Directional overcurrent protection DT characteristic, 1 phase, 3 stage, extended time delay range, for single phase systems, respectively two phase traction generators. 0.1-5A/180s // 0.1-5A/10s // 0.1-5A/10s	1060	MI133	50/51	C2,M,L

1 phase, 3 stage directional overcurrent function (DT) with extended time delay for stage 1.
For single phase systems, respectively double phase systems, i.e. railway traction application.

MI133
Technical Data

Inputs

Analogue:	Current
	Voltage (in phase with current)
Binary:	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Test input stage 1
	Test input stage 2
	Test input stage 3

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Initiation stage 2
	Trip stage 3
	Initiation stage 3

Setting Parameters

Operating value stage 1:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 180 s in 0.05 s steps
Operating value stage 2:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps
Operating value stage 3:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 3:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal Determined and Computed Values

Angle:	In [Degrees]

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

PROTECTIVE FUNCTION: MI332	FNNR	TYPE	ANSI	Application
Directional overcurrent protection DT characteristic, 3 phase, 3 stage, 0.1-5A/10s // 0.1-5A/10s // 0.1-5A/10s.	1031	MI332	50/51	C2,M,L

3 phase, 3 stage directional overcurrent function DT.

MI332
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage system 1-2
	Voltage system 2-3
	Voltage system 3-1
Binary:	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 3
	Test input stage 1
	Test input stage 2
	Test input stage 3

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2
	Initiation stage 3
	Trip stage 3

Setting Parameters

Operating value stage 1:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps
Operating value stage 3:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time stage 3:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

10.3. CONNECTION DIAGRAMS

10.3.1. MI111/ MI112/ MI121/ MI122/ MI311/ MI312/ MI313/ MI314 MI321/ MI322/ MI323/ MI324/ MI326

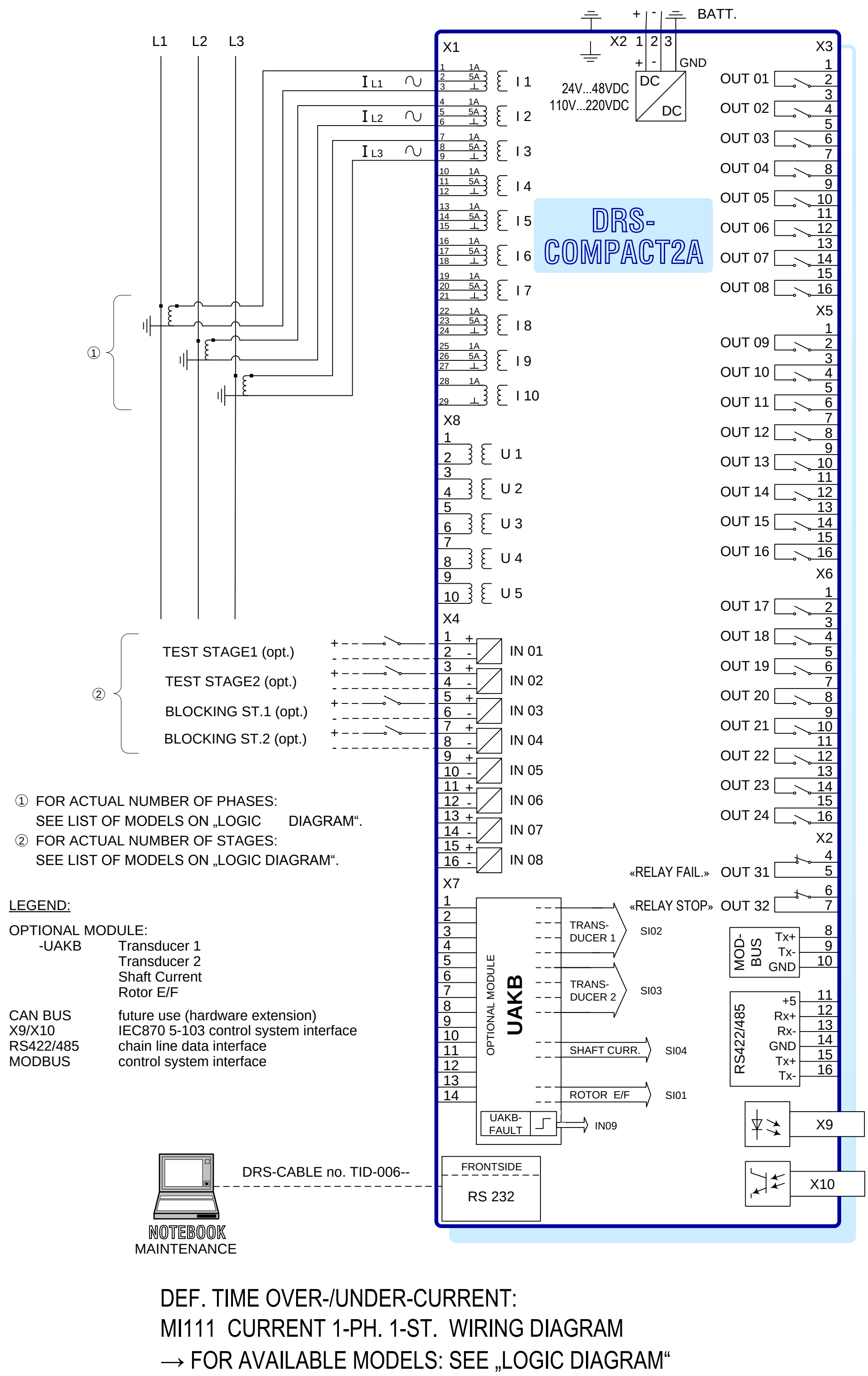


Fig. 119 Def. Time Over- / Under-Current: MI111 Current 1-PH. 1.ST. Wiring Diagram

10.3.2. MI120

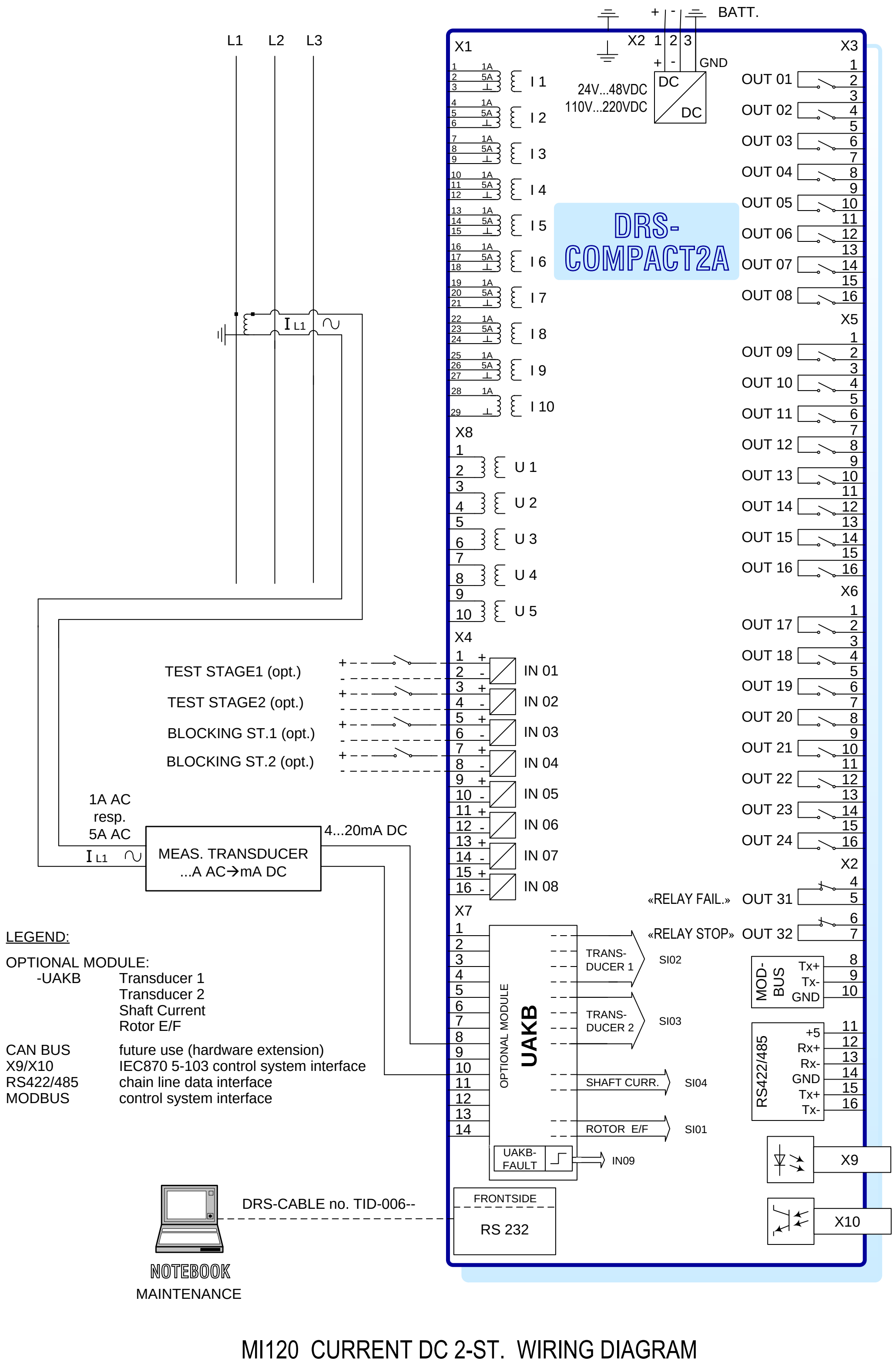
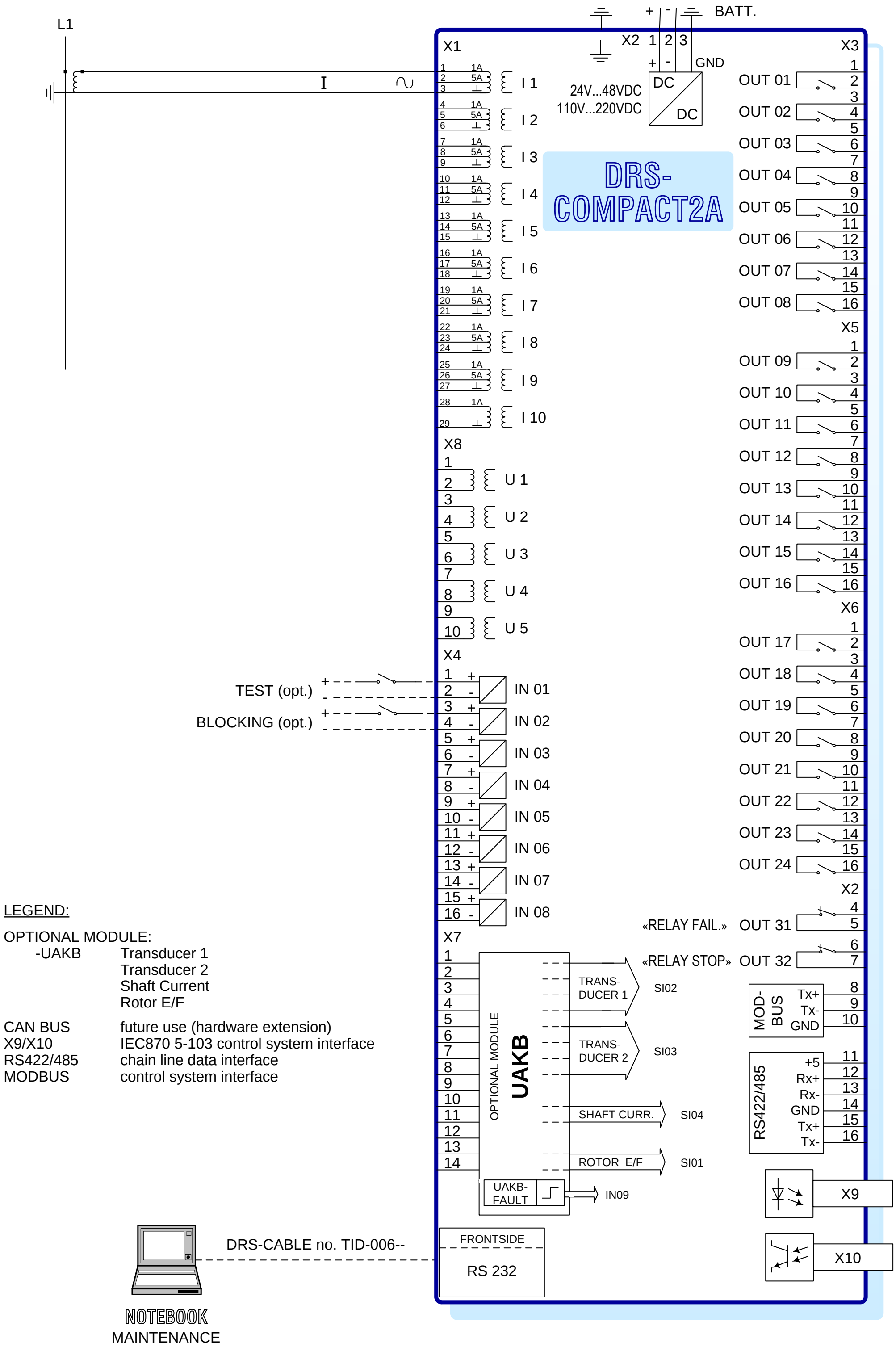


Fig. 120 MI120 Current DC 2-ST. Wiring Diagram

10.3.3. MI113



MI113 „CURRENT I>>>“ (QUICK CURRENT) WIRING DIAGRAM

Fig. 121 MI113 ,,Current I>>>“ (Quick Current) Wiring Diagram

10.3.4. MI132

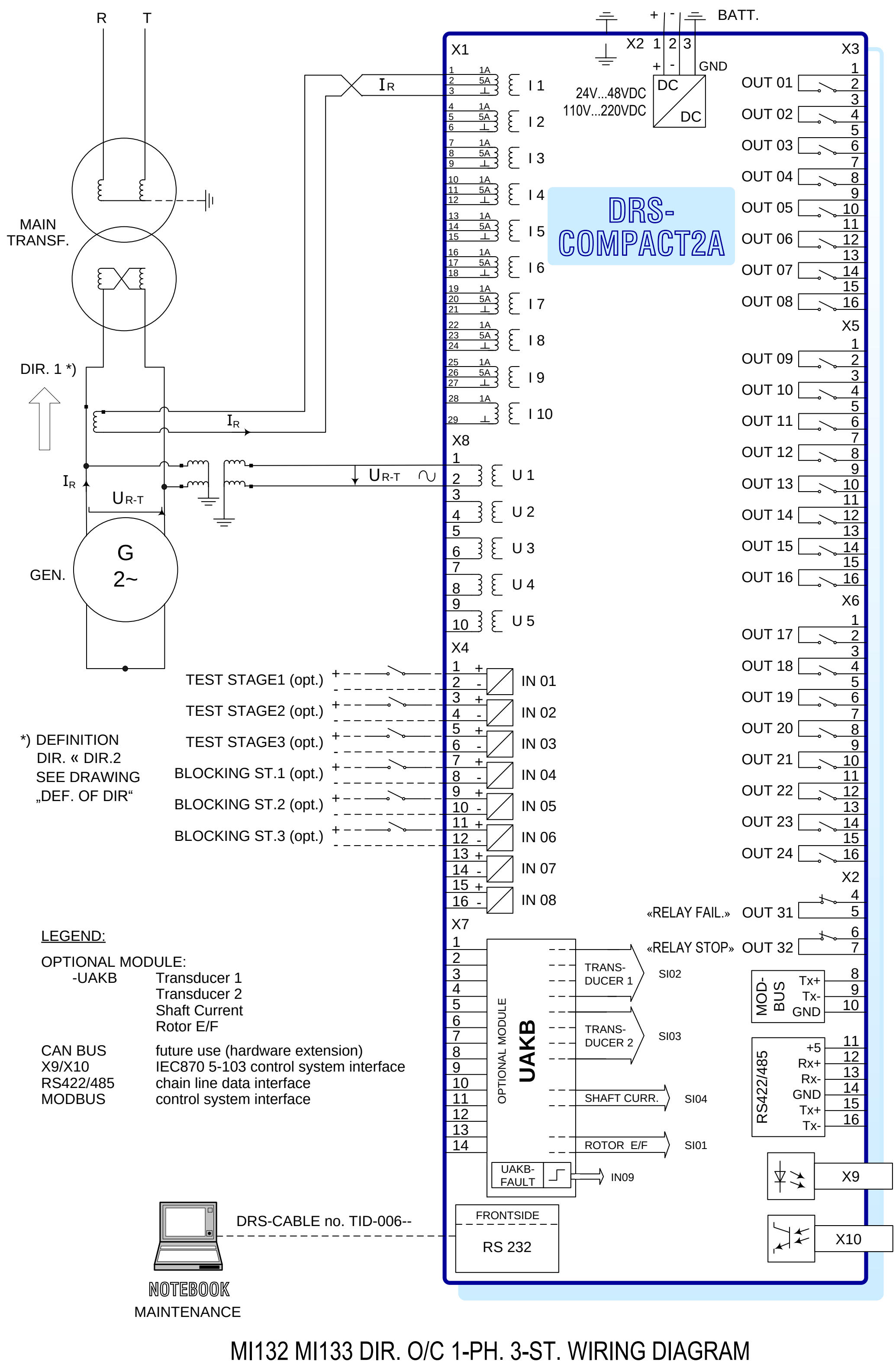
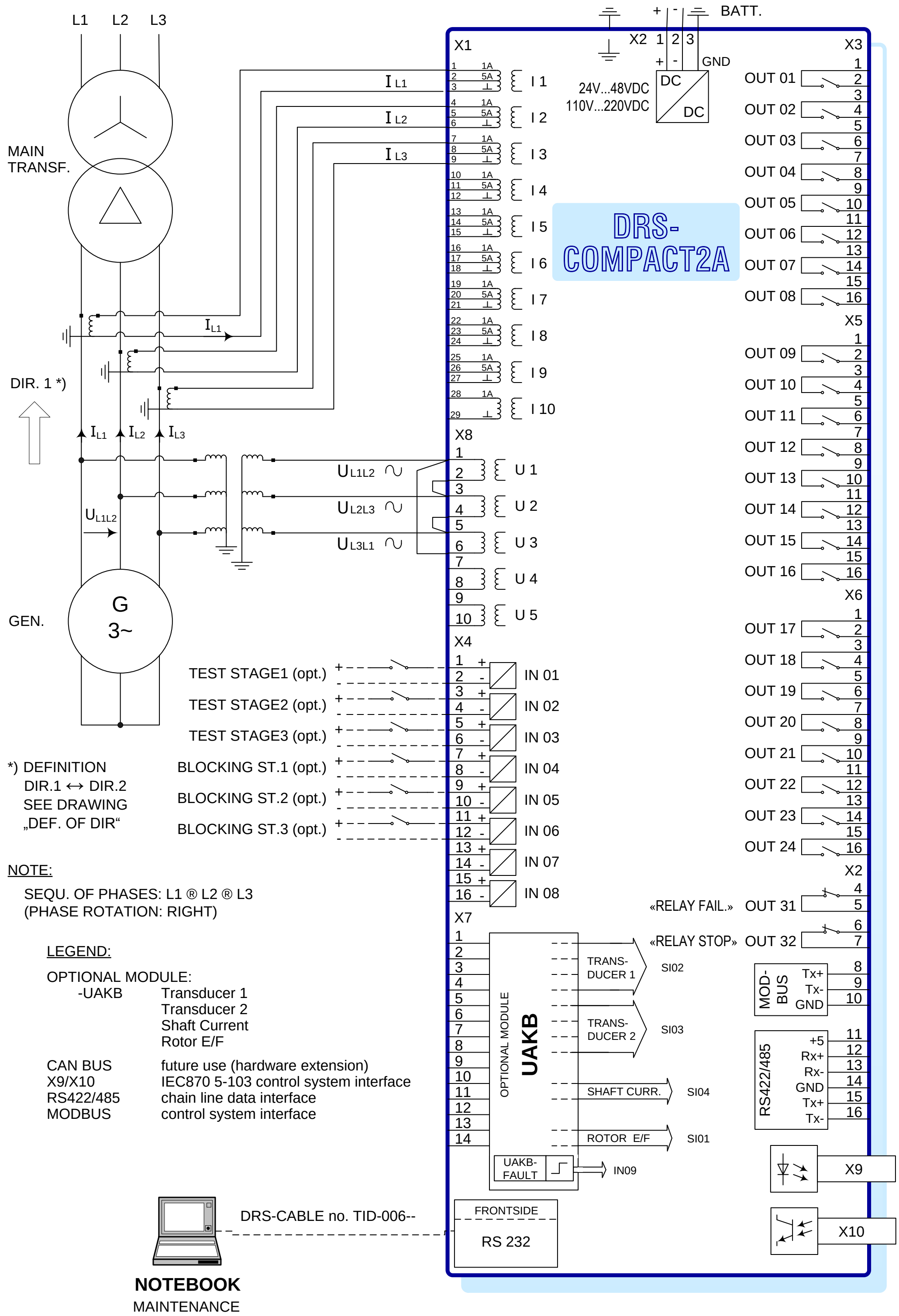


Fig. 122 MI132 MI133 Dir. O/C 1-PH. 3-ST. Wiring Diagram

10.3.5. MI332

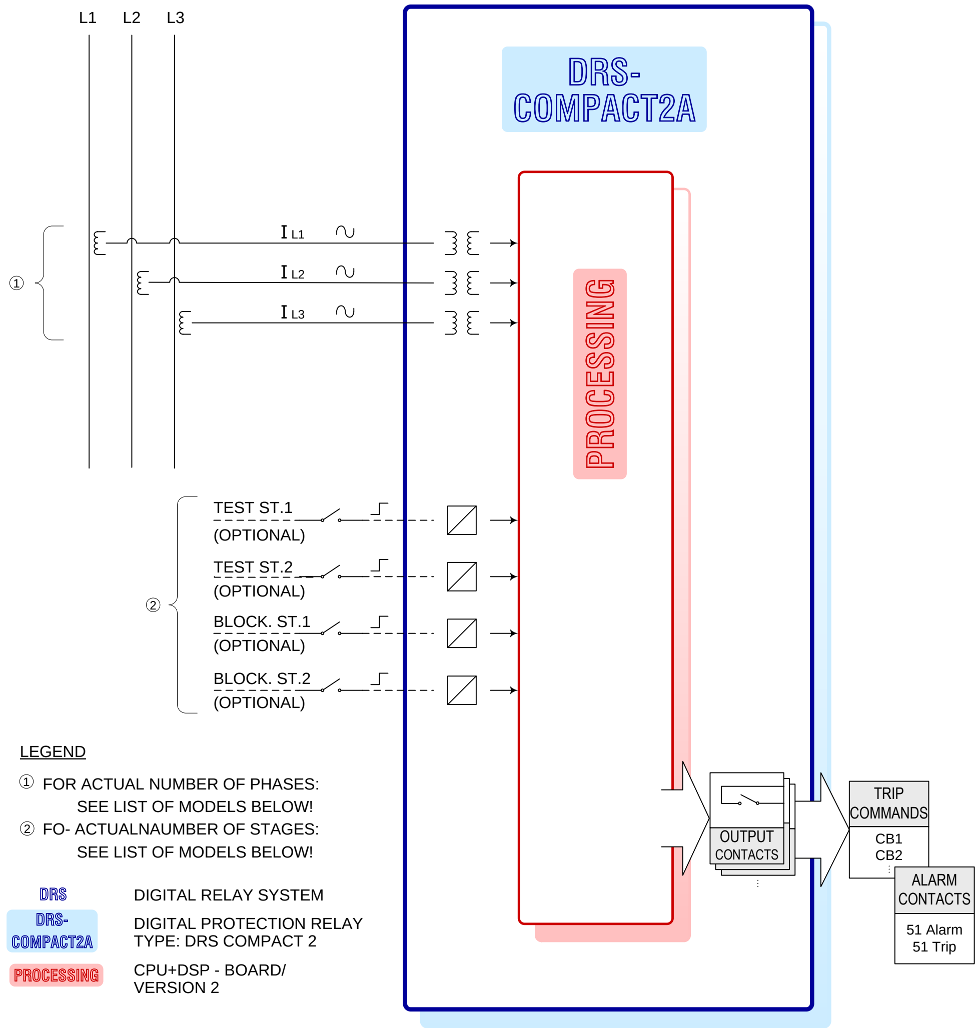


MI332 DIR. O/C 3-PH. 3-ST. WIRING DIAGRAM

Fig. 123 MI332 Dir. O/C 3-PH. 3-St. Wiring Diagram

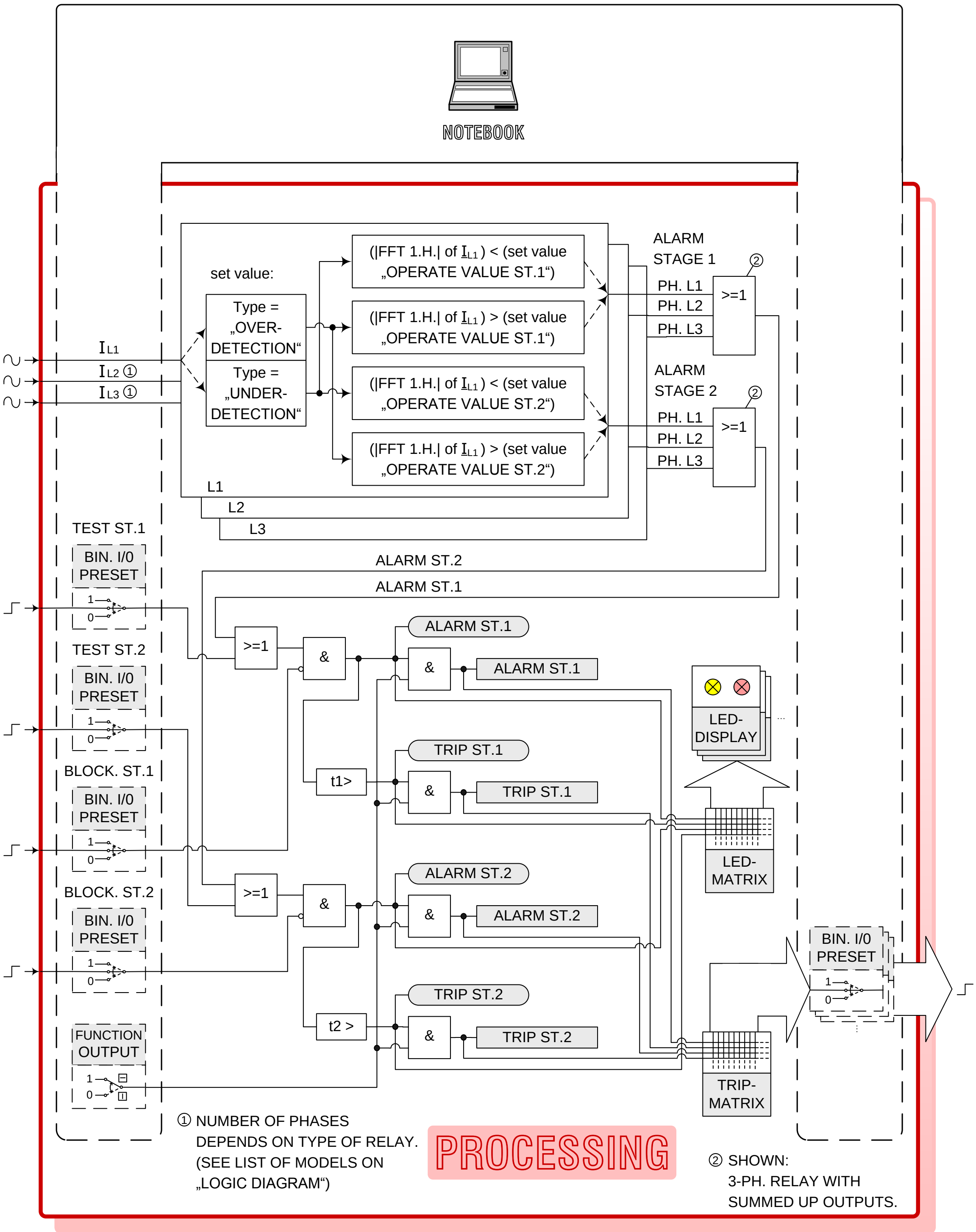
10.4. LOGIC DIAGRAMS

10.4.1. MI111/ MI112/ MI121/ MI122/ MI311/ MI312/ MI313/ MI314 MI321/ MI322/ MI323/ MI324/ MI326



DEF. TIME OVER-/UNDER-CURRENT:
MI111 CURRENT 1-PH. 1-ST. LOGIC DIAGRAM
MI121 CURRENT 1-PH. 2-ST. LOGIC DIAGRAM
MI311 CURRENT 3-PH. 1-ST. LOGIC DIAGRAM
MI313 CURRENT 3-PH. 1-ST. LOGIC DIAGRAM
MI314 CURRENT 3-PH. 1-ST. LOGIC DIAGRAM
MI315 CURRENT 3-PH. 1-ST. LOGIC DIAGRAM
MI321 CURRENT 3-PH. 2-ST. LOGIC DIAGRAM
MI322 CURRENT 3-PH. 2-ST. LOGIC DIAGRAM
MI323 CURRENT 3-PH. 2-ST. LOGIC DIAGRAM
MI324 CURRENT 3-PH. 2-ST. LOGIC DIAGRAM
MI326 CURRENT 3-PH. 2-ST. LOGIC DIAGRAM

Fig. 124 MI111 MI121 MI311 MI313 MI314 MI315 MI321 MI322 MI323 MI324 MI326 Logic Diagram



DEF. TIME OVER-/UNDER-CURRENT:
MI111 CURRENT 1-PH. 1-ST. LOGIC DIAGRAM / PROCESSING
→ FOR AVAILABLE MODELS: SEE „LOGIC DIAGRAM“

Fig. 125 Def. Time Over-/Under-Current: MI111 Current 1-PH. 1-ST. Logic Diagram / Processing → For Available Models: See ,,Logic Diagram’’

LEGEND PROCESSING

FIRMWARE-MODULE: MI111...MI326

	Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET (1, 0)	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET — regular function; BIN. I/0 PRESET — always „1"; BIN. I/0 PRESET — always „0"
FUNCTION OUTPUT (1, 0)	Online-simulation of the FUNCTION OUTPUTS of the protective function MI111 ... MI326 ⊟ all FUNCTION OUTPUTS enabled (regular-operation) ⎕ all FUNCTION OUTPUTS disabled (test-operation)
Type = „OVER-DETECTION“ / Type = „UNDER-DETECTION“	OVER- or UNDERCURRENT - relay function to be choosen via set value.
(|FFT 1.H.| of $\underline{I}_{L1}$) > (set value „OPERATE VALUE ST.1“)	The measured current signal $\underline{I}_{L1}$ is analyzed by use of FAST FOURIER TRANSFORMATION (FFT). The relay function uses the 1.Harmonic of $\underline{I}_{L1}$ only.
MI326	MODEL-NUMBERS (FIRMWARE-FUNCTIONS) EXAMPLE: consecutive number number of stages number of phases type of function (e.g. I … current) microprocessor - based hardware
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING — LED-DISPLAY — LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

DEF. TIME OVER-/UNDER-CURRENT:
MI111 CURRENT 1-PH. 1-ST. LOGIC DIAGRAM LEGEND / PROCESSING
→ FOR AVAILABLE MODELS: SEE „LOGIC DIAGRAM“

Fig. 126 Def. Time Over-/Under-Current: MI111 Current 1-PH. 1ST. Logic Diagram Legend / Processing → For Available Models: See ,,Logic Diagram''

10.4.2. MI113

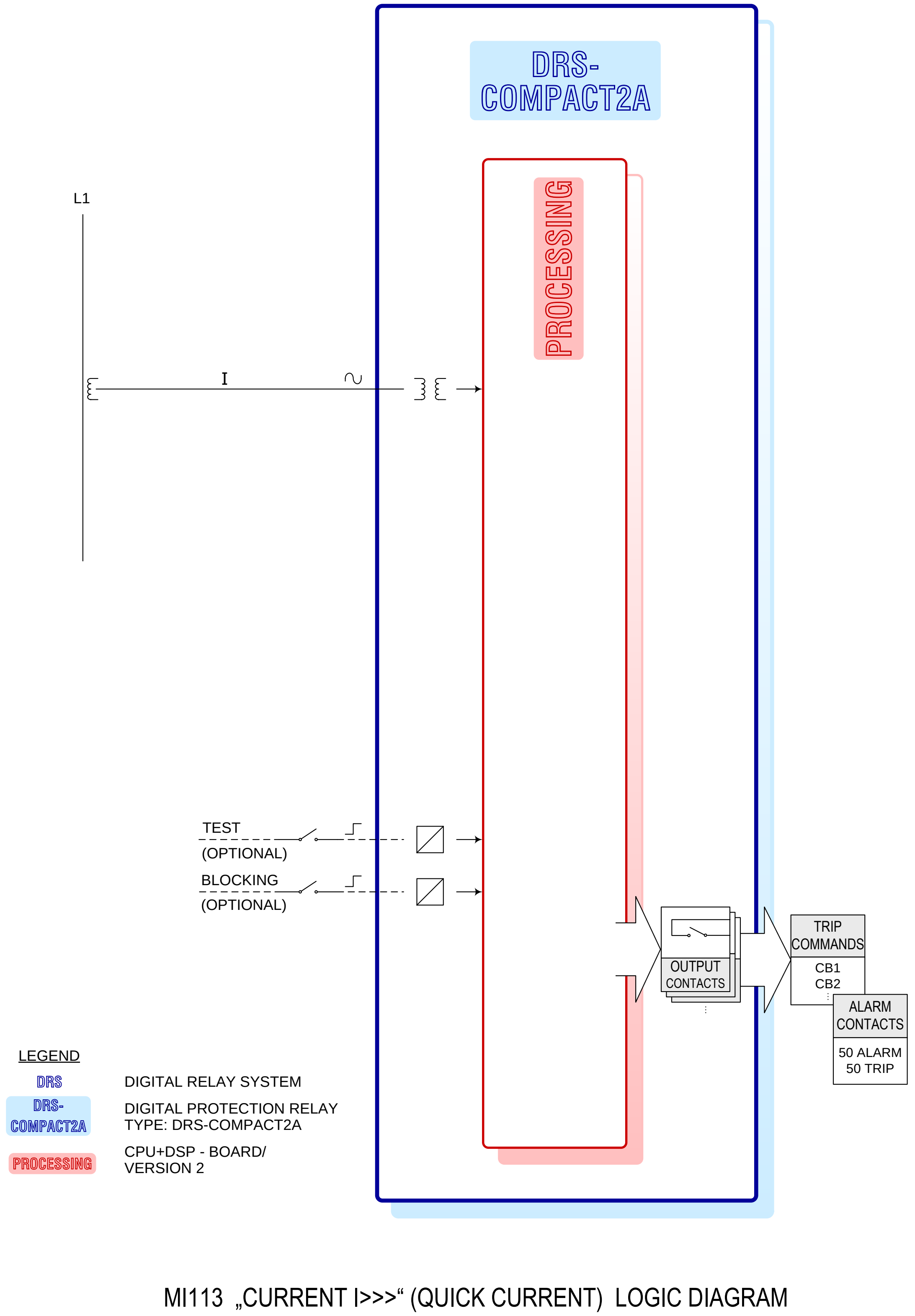


Fig. 127 MI113 ,,Current I>>>“ (Quick Current) Logic Diagram

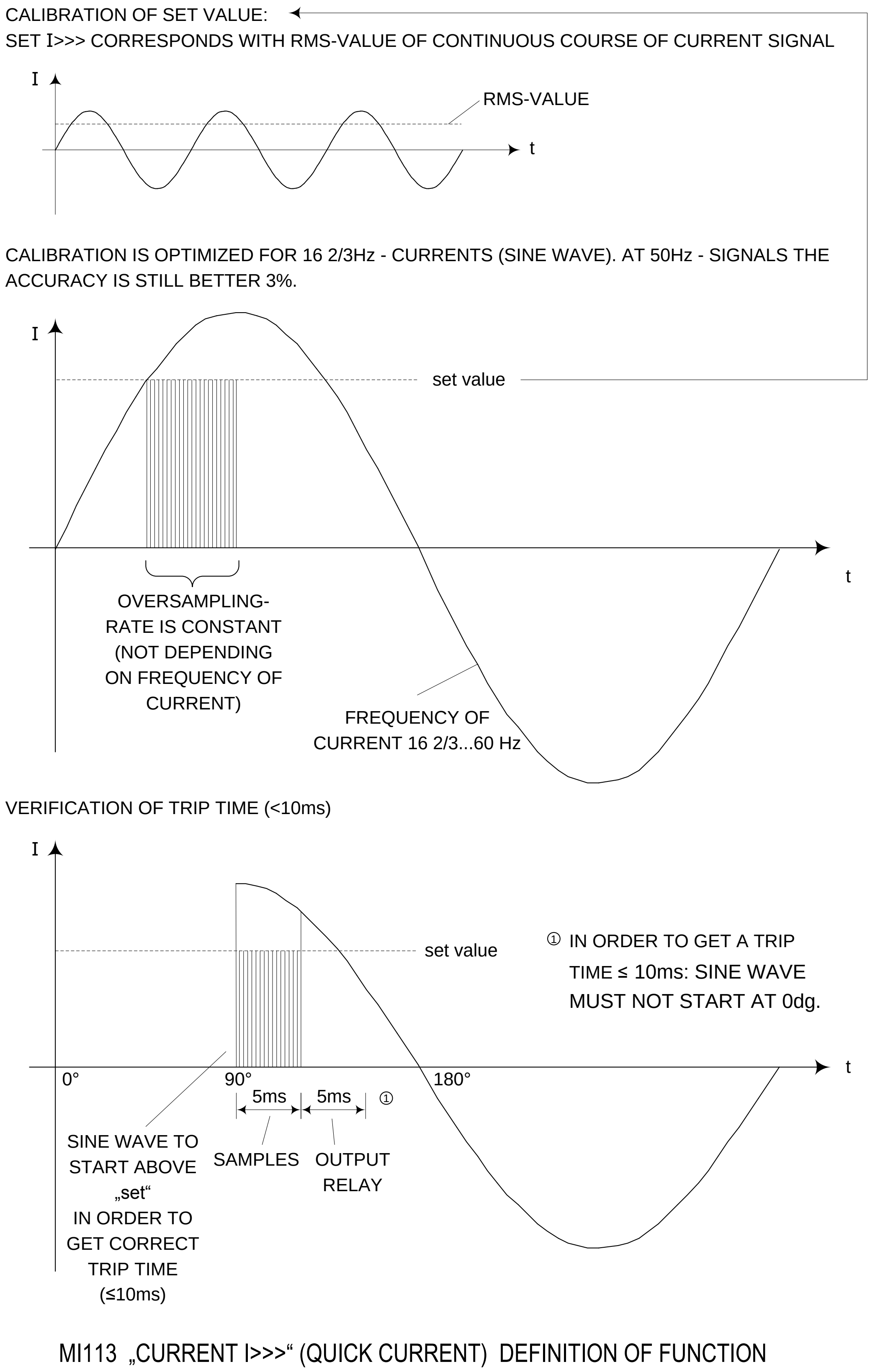
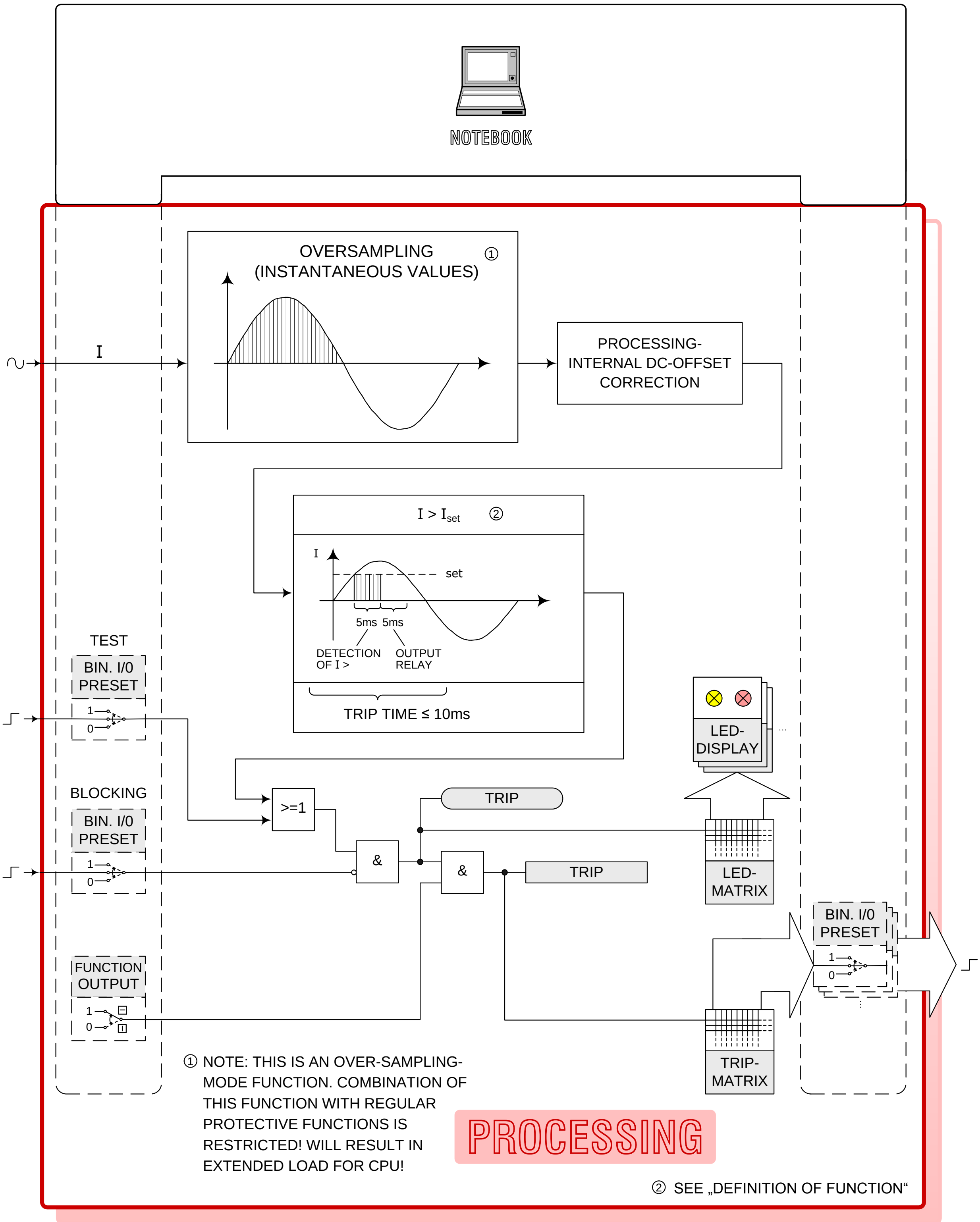


Fig. 128 MI113 ,,Current I>>>‘‘ (Quick Current) Definition Of Function



MI113 „CURRENT I>>>“ (QUICK CURRENT) LOGIC DIAGRAM PROCESSING

Fig. 129 MI113 ,,Current I>>>‘‘ (Quick Current) Logic Diagram Processing

LEGEND PROCESSING

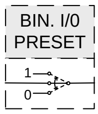
FIRMWARE MODULE: MI113

Online simulation via notebook

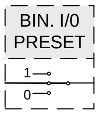
CALC. INTERNAL MEASURED VALUES

.....

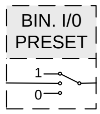
Online-indication of DRS-internal calculated values on notebook-screen



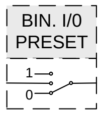
Online-simulation of DIG. IN-/OUTPUTS via notebook:



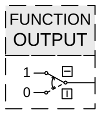
regular function



always „1"

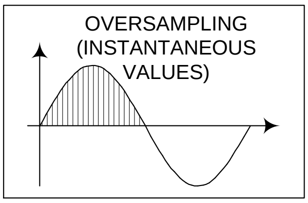


always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MI113

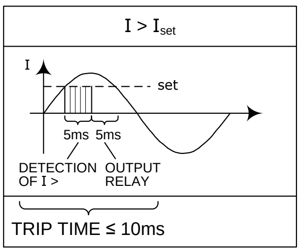
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎅ all FUNCTION OUTPUTS disabled (test-operation)



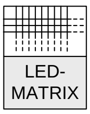
MI113 USES AN OVERSAMPLING MODE IN ORDER TO QUICKEN TRIPPING.

PROCESSING-INTERNAL DC-OFFSET CORRECTION

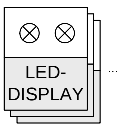
BECAUSE OF (TRIP-TIME) ≤ (1/2-PERIOD) A DC-OFFSET WOULD AFFECT THE TRIGGERING AND HAS TO BE FILTERED OUT BY FIRMWARE.



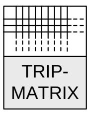
FOR DEFINITION OF FUNCTION MI113 PLEASE SEE PAGE „DEFINITION OF FUNCTION“.



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

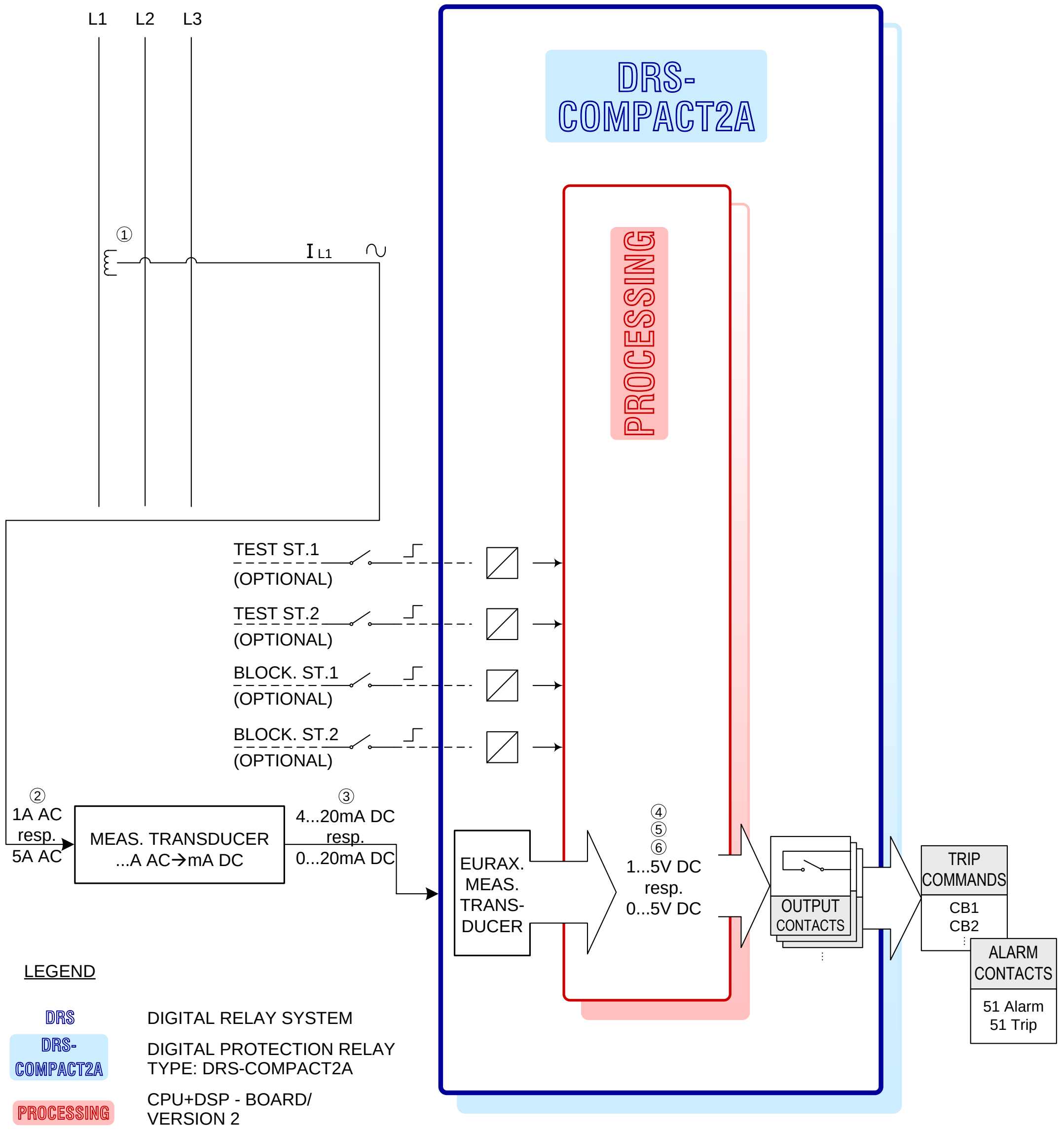
Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

TRIP — FUNCTION OUTPUT: Trip (no blocking active)

MI113 „CURRENT I>>>“ (QUICK CURRENT) LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 130 MI113 ,,Current I>>>“ (Quick Current) Logic Diagram Processing / Legend

10.4.3. MI120



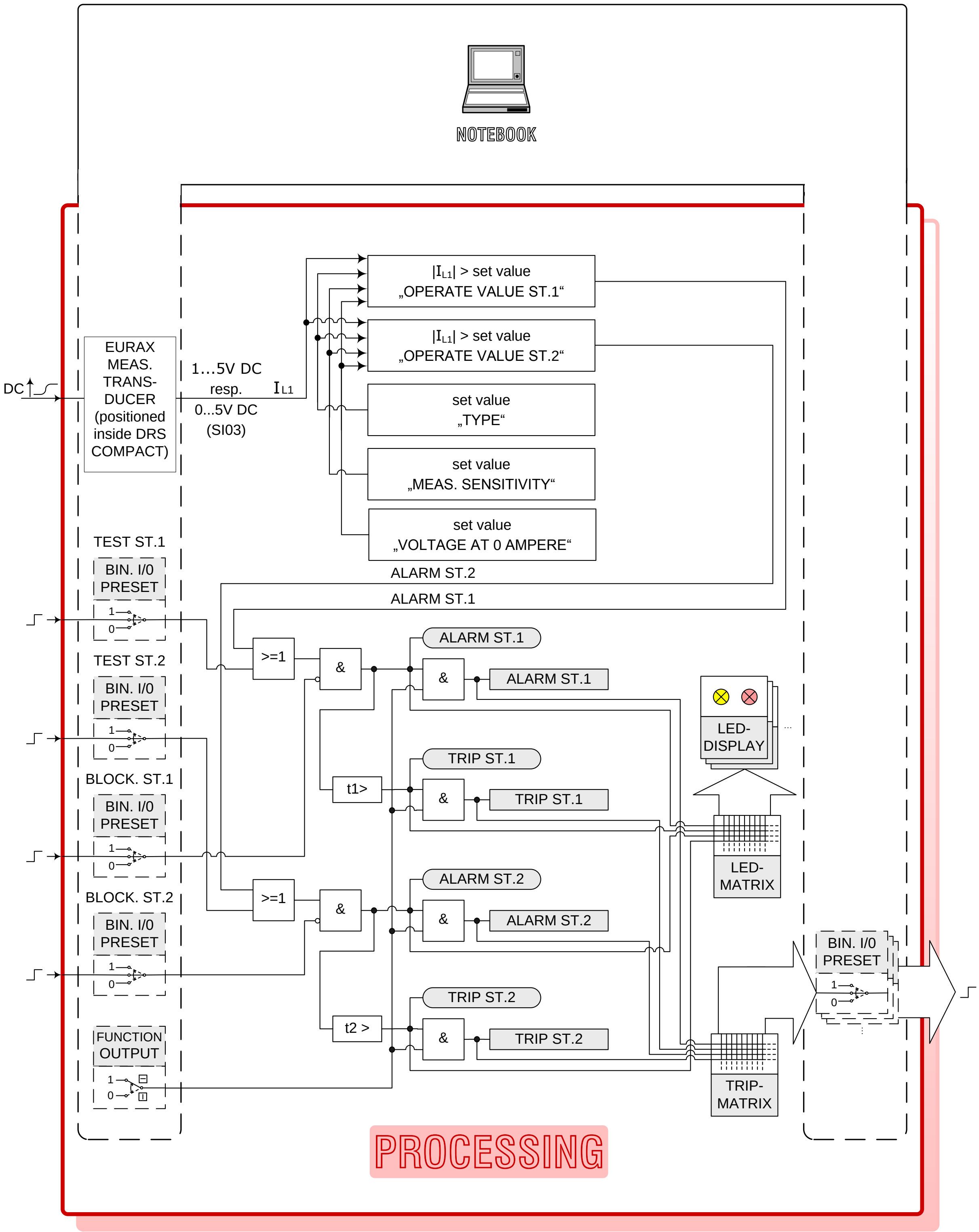
①②③④⑤ SETTING RANGES:

	① C.T. nom	② required primary current range 0...0,4A AC	③ EURAX Input	④ EURAX Output	⑤ set value „Meas. Sensitivity“	⑥ set value „Voltage at 0 Ampere“
EXAMPLE: 1:	C.T. = 1A nom	0...0,4A AC	4...20mAC	1...5V DC	0,1A/V	1V
2:	C.T. = 1A nom	0...40A AC	4...20mAC	1...5V DC	10A/V	1V
3:	C.T. = 1A nom	0...50A AC	0...20mAC	0...5V DC ⑦	10A/V	0V
4:	C.T. = 5A nom	0...200A AC	4...20mAAC	1...5V DC	50A/V	1V

⑦ No LIFE ZERO (no supervision of meas. transducer circuit possible)

MI120 CURRENT DC 2-ST. LOGIC DIAGRAMM

Fig. 131 MI120 Curent DC 2-ST. Logic Diagram

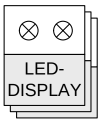


MI120 CURRENT DC 2-ST. LOGIC DIAGRAM PROCESSING

Fig. 132 MI120 Current DC 2-ST. Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MI120

	Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ….. — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET (1, 0)	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"
FUNCTION OUTPUT (1, 0)	Online-simulation of the FUNCTION OUTPUTS of the protective function MI120 — all FUNCTION OUTPUTS enabled (regular-operation) | all FUNCTION OUTPUTS disabled (test-operation)
$\lvert I_{L1} \rvert$ > set value „OPERATE VALUE ST.1“	CHECK: Actual value > set value. NOTE: Actual value is taken from SI03 (Slow Input 03) which is dedicated for DC-input signales.
set value „TYPE“	Over- or undervoltage according to setting.
set value „MEAS. SENSITIVITY“	Conversion between output signal of EURAX-measuring transducer (1...5V DC ≙ input of software relay) and c.t. -secondary current.
set value „VOLTAGE AT 0 AMPERE“	Zero-point calibration of EURAX-measuring transducer (see also above).
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
 LED-DISPLAY	LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MI120 CURRENT DC 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 133 MI120 Current DC 2-ST. Logic Diagram Processing / Legend

MI120/ OPTION
SUPERVISION OF MEAS. TRANSDUCER-CIRCUIT
FOR MI120

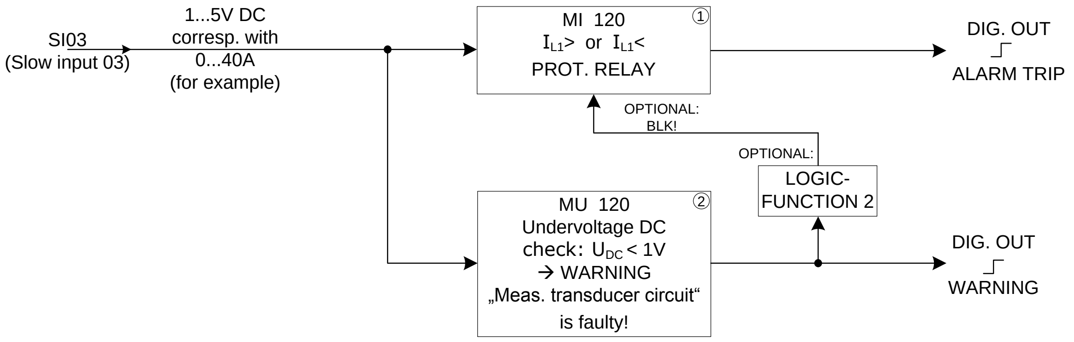
Applicable only if chosen: 4...20mA (≙ 1...5V DC)

[NOTE: 0...20mA => no supervision possible!]

Supervision principle:

Min. input voltage = 1V DC (regular operation).
If <1V DC => malfunction of meas. transducer circuit.

LOGIC DIAGRAM PROCESSING:



LEGEND:

① Software relay „Over-/Undervoltage DC“
Input signal must be „1...5V DC (regular operation)

② „Software relay „Undervoltage DC“ is used for supervision of meas. transducer.
Practical setting (example):
0,5V/ Underdetection => Warning

MI120 CURRENT DC 2-ST. SUPERVISION OF
MEAS. TRANSDUCER FOR PHASE-CURRENT

Fig. 134 MI120 Current DC 2-ST. Supervision Of Meas. Transducer For Phase-Current

10.4.4. MI132

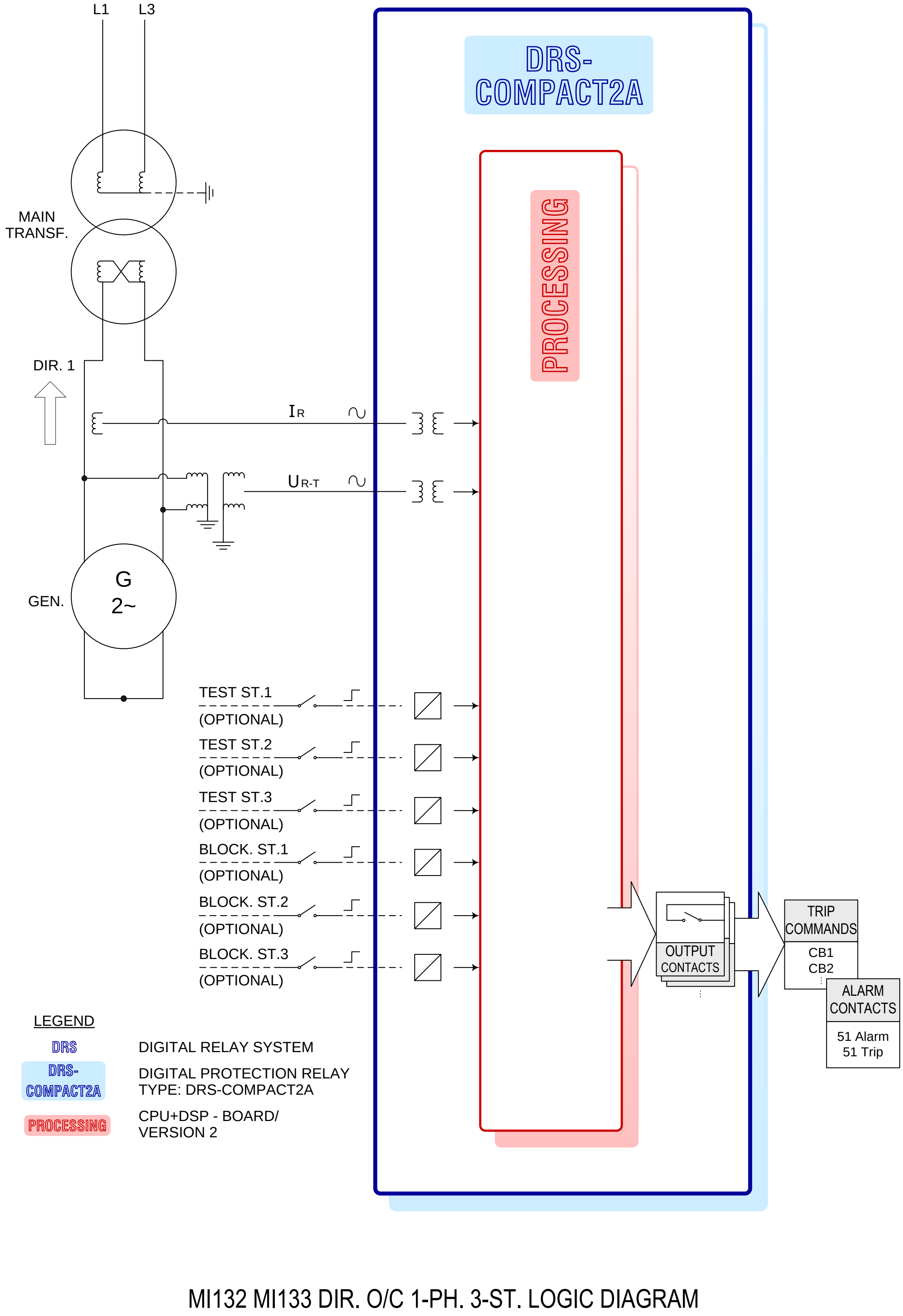
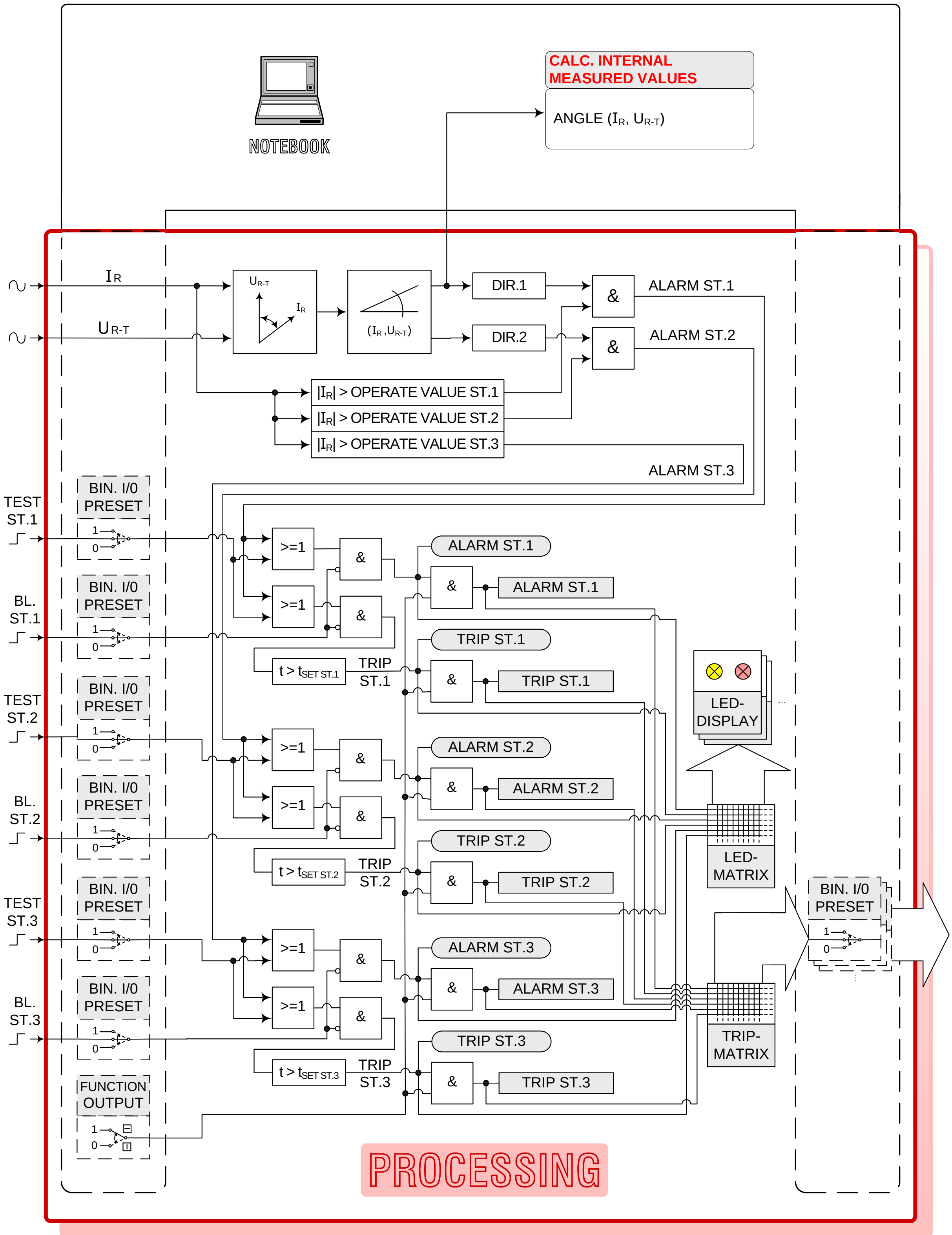


Fig. 135 MI132 MI133 Dir. O/C 1-PH. 3-ST. Logic Diagram

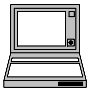


MI132 MI133 DIR. O/C 1-PH. 3-ST. LOGIC DIAGRAM PROCESSING

Fig. 136 MI132 MI133 Dir. O/C 1-PH. 3-ST. Logic Diagram Processing

LEGEND PROCESSING

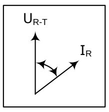
FIRMWARE-MODULE: MI132 MI133



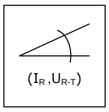
Online simulation via notebook

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MD321
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



Calculation of angle between I_R and U_{R-T}



Angle between I_R and U_{R-T}
This angle ∡ corresponds with the PHASE ANGLE j (I_R ,U_R): ∡= j
Please note: this is a 1-phase system (railway power station) !
The angle ∡ is indicated in the „Internal Measured Value"-window on the notebook-screen.

DIR.1 — ∡ = -100°...+10° corresponds with j = -100°...+10°

DIR.2 — ∡ = +80°...+190° corresponds with j = +80°...+190°

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

ALARM ST.1 — „ALARM ST.1"-Signal going to LED-MATRIX

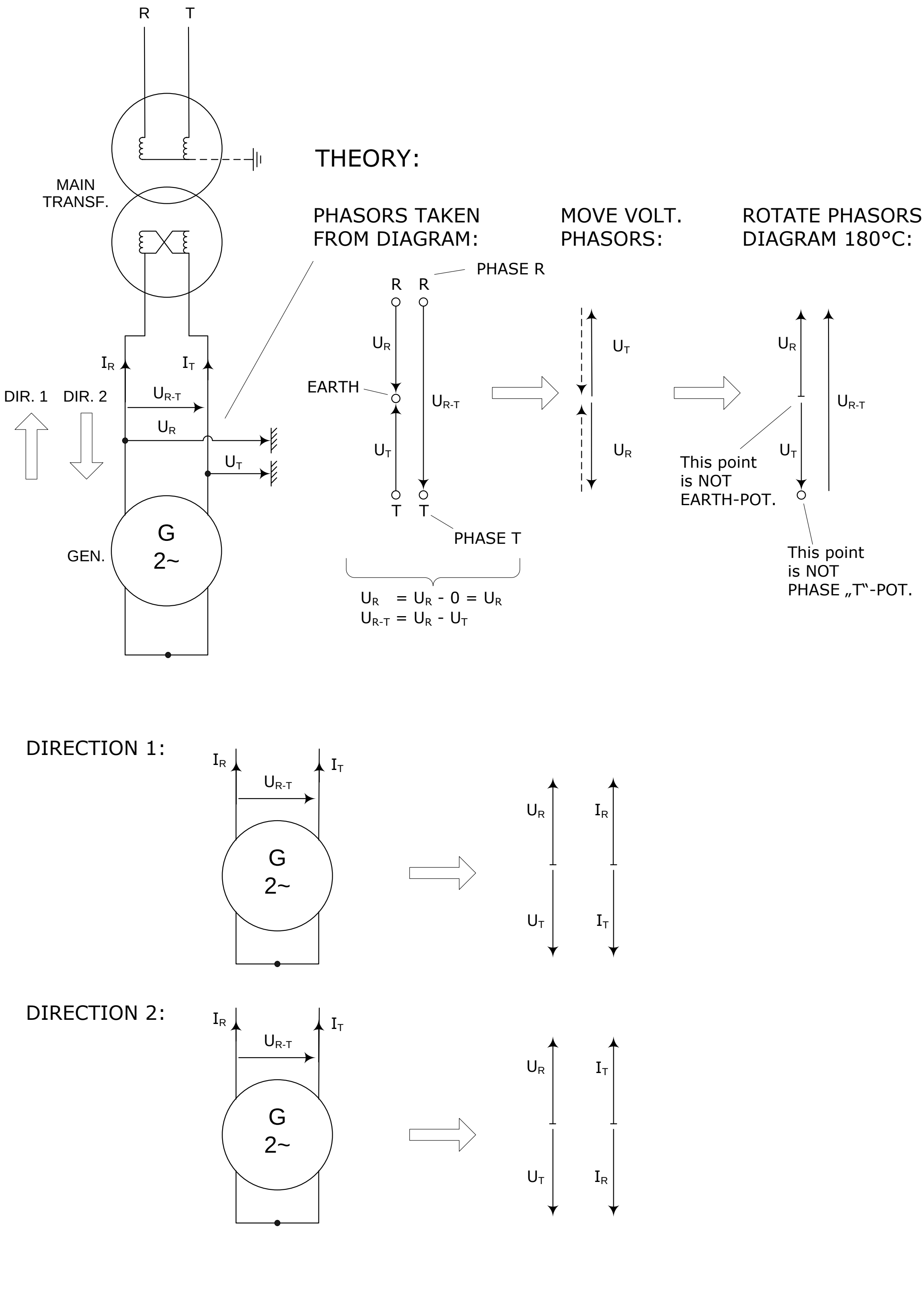
ALARM ST.1 — „ALARM ST.1"-Signal going to TRIP-MATRIX

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MI132 MI133 DIR. O/C 1-PH. 3-ST. LOGIC DIAGRAM PROCESSING / LEGEND

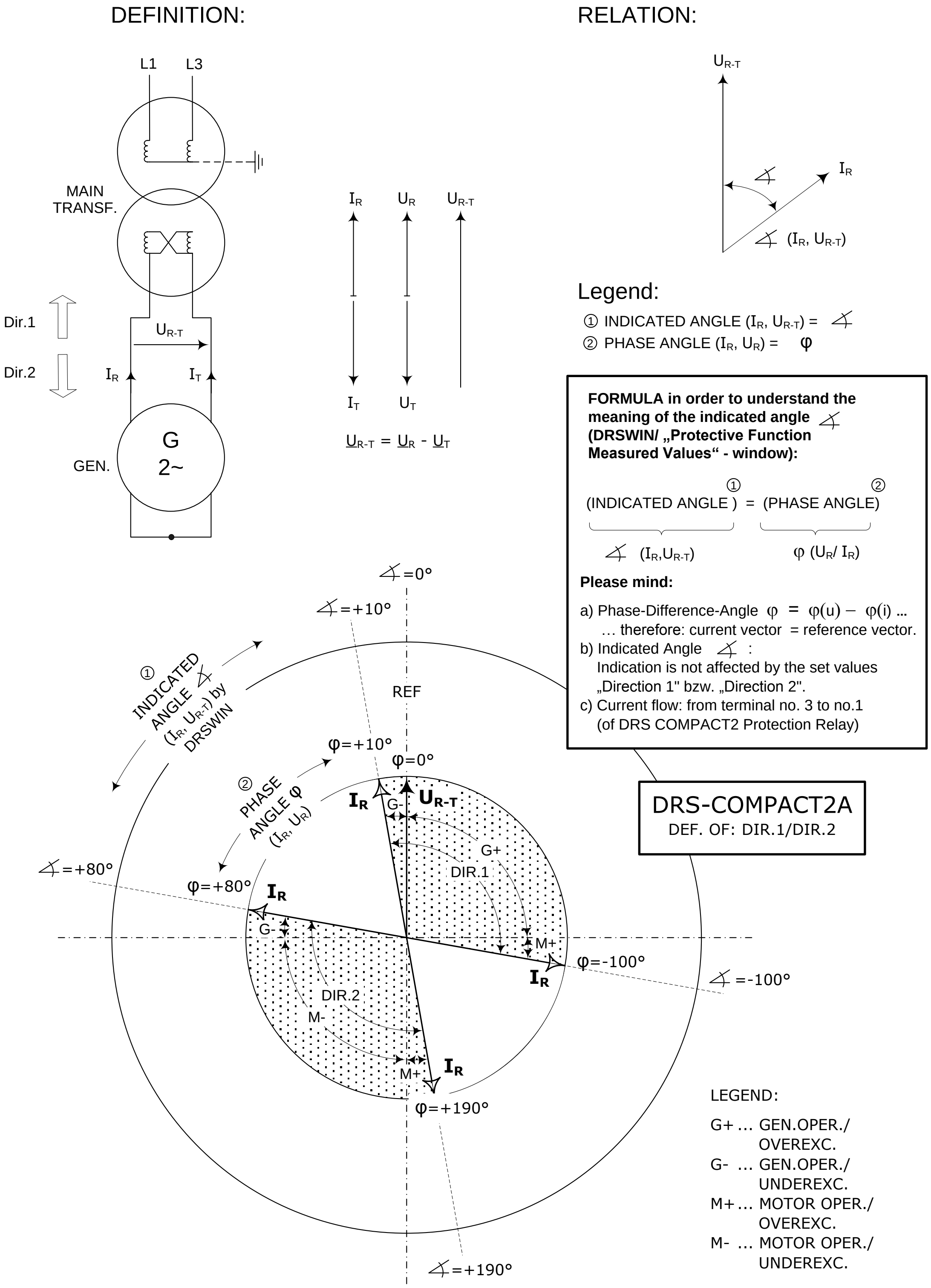
Fig. 137 MI132 MI133 Dir. O/C 1-PH. 3-ST. Logic Diagram Processing / Legend



MI132 MI133 DIR. O/C 1-PH. 3-ST. DEFINITION OF DIRECTIONS

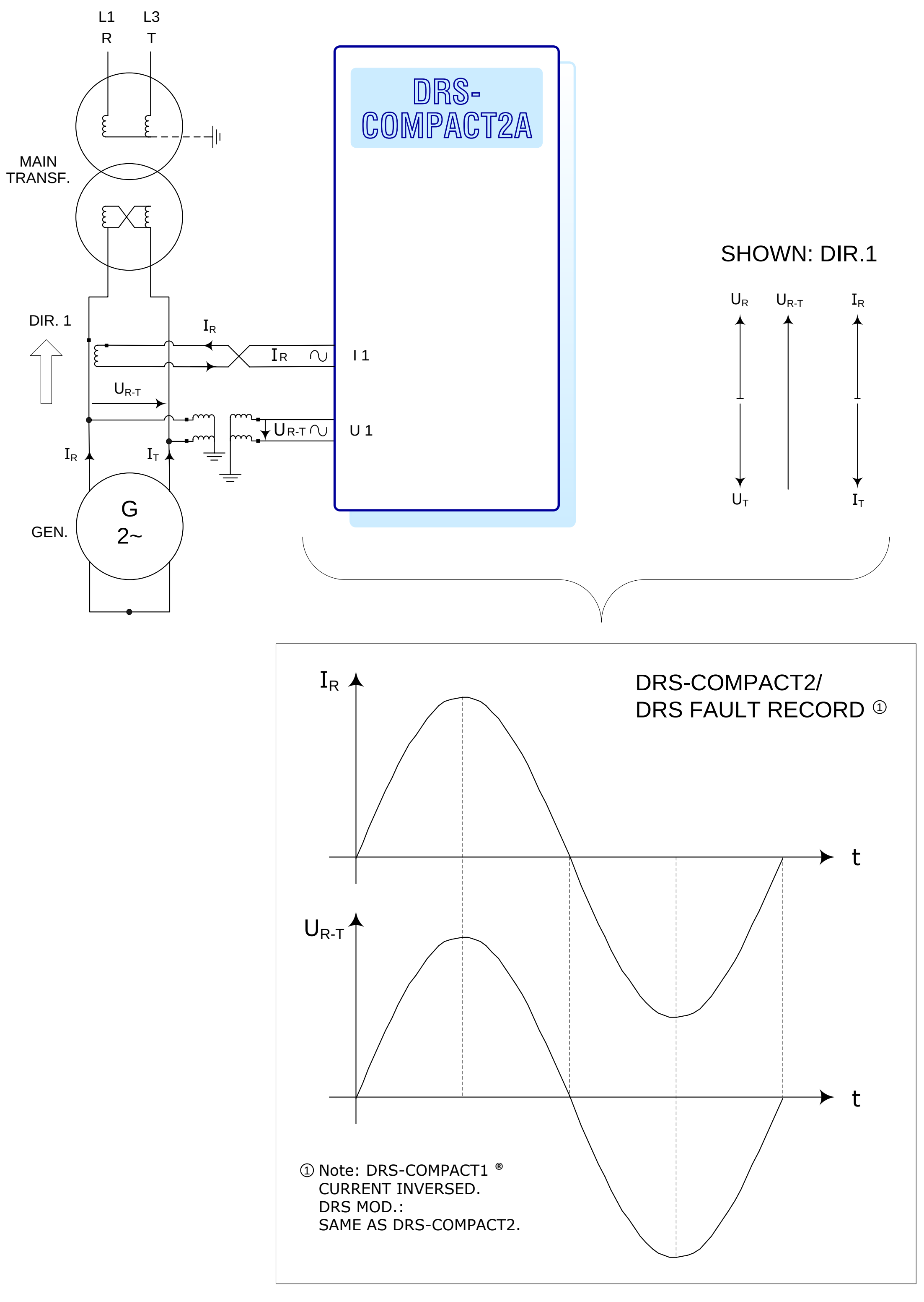
Fig. 138 MI132 MI133 Dir. O/C 1-PH. 3-ST. Definition Of Directions

VECTOR GRAPHICS



MI132 MI133 DIR. O/C 1-PH. 3-ST. DEF. OF RANGES OF DIR.1/ DIR.2

Fig. 139 MI132 MI133 DIR. O/C 1-PH. 3-ST. DEF. Of Ranges Of DIR. 1 / DIR.2



MI132 MI133 DIR. O/C 1-PH. 3-ST. DRS FAULT RECORD / DEF. OF SIGN

Fig. 140 MI132 MI133 Dir. 0/C 1-PH. 3-ST. DRS Fault Record / Def. Of Sign

10.4.5. MI332

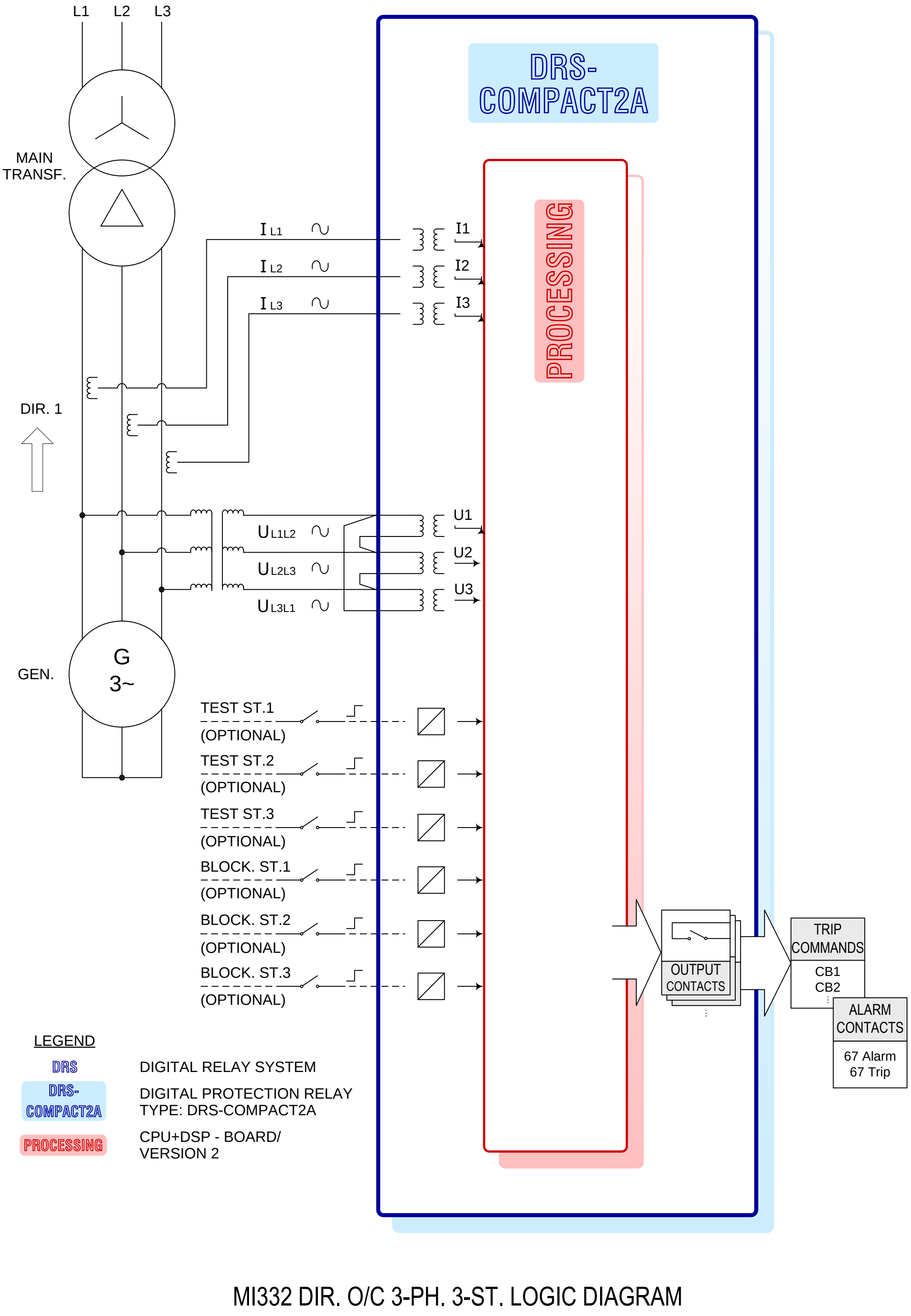
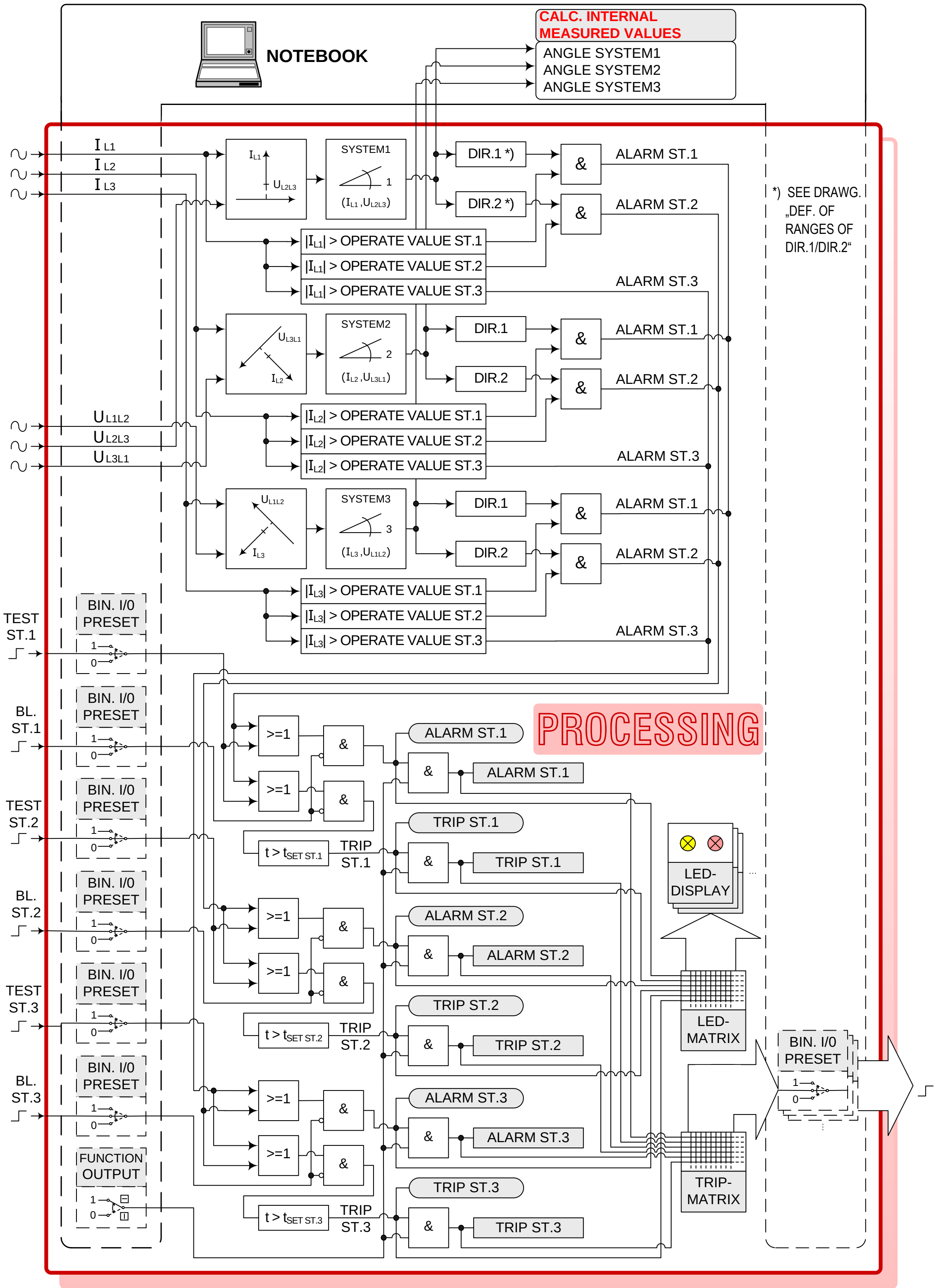


Fig. 141 MI332 Dir. O/C 3-PH. 3-ST. Logic Diagram

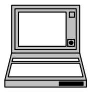


MI332 DIR. O/C 3-PH. 3-ST. LOGIC DIAGRAM PROCESSING

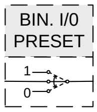
Fig. 142 MI332 Dir. O/C 3-PH. 3-ST. Logic Diagram Processing

LEGEND PROCESSING

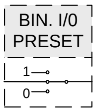
FIRMWARE-MODULE: MI332



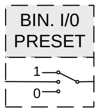
Online simulation
via notebook



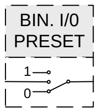
Online-simulation of DIG. IN-/OUTPUTS via notebook:



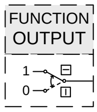
regular function



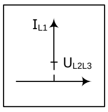
always „1"



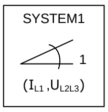
always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MI332
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎕ all FUNCTION OUTPUTS disabled (test-operation)



Calculation of angle of SYSTEM1 uses I_{L1} and U_{L2L3}



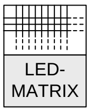
Angle between I_{L1} and U_{L2L3}
This angle $\measuredangle_1$ corresponds with (PHASE ANGLE $\varphi + 90°$)① : $\measuredangle_1 = \varphi + 90°$
The angles $\measuredangle_1$, $\measuredangle_2$, $\measuredangle_3$ are indicated in the „Internal Measured Value"-window on the notebook-screen.

DIR.1

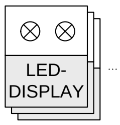
SYSTEM1: $\measuredangle_1$=
SYSTEM2: $\measuredangle_2$=
SYSTEM3: $\measuredangle_3$=
} ① -10°...+100° } corresponds with φ_1 = φ_2 = φ_3 = } ① -100°...+10°

DIR.2

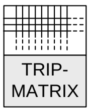
SYSTEM1: $\measuredangle_1$=
SYSTEM2: $\measuredangle_2$=
SYSTEM3: $\measuredangle_3$=
} ① +170°...+280° (-80°) } corresponds with φ_1 = φ_2 = φ_3 = } ① +80°...+190°



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

(ALARM ST.1) „ALARM STAGE1"-signal going to LED-MATRIX

[ALARM ST.1] „ALARM STAGE1"-signal going to TRIP-MATRIX

> Type of function: over-detection (actual value > set value)

< Type of function: under-detection (actual value < set value)

① Assuming a symmetrical power system (for explanation only)

MI332 DIR. O/C 3-PH. 3-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 143 MI332 Dir. O/C 3-PH. 3-ST. Logic Diagram Processing / Legend

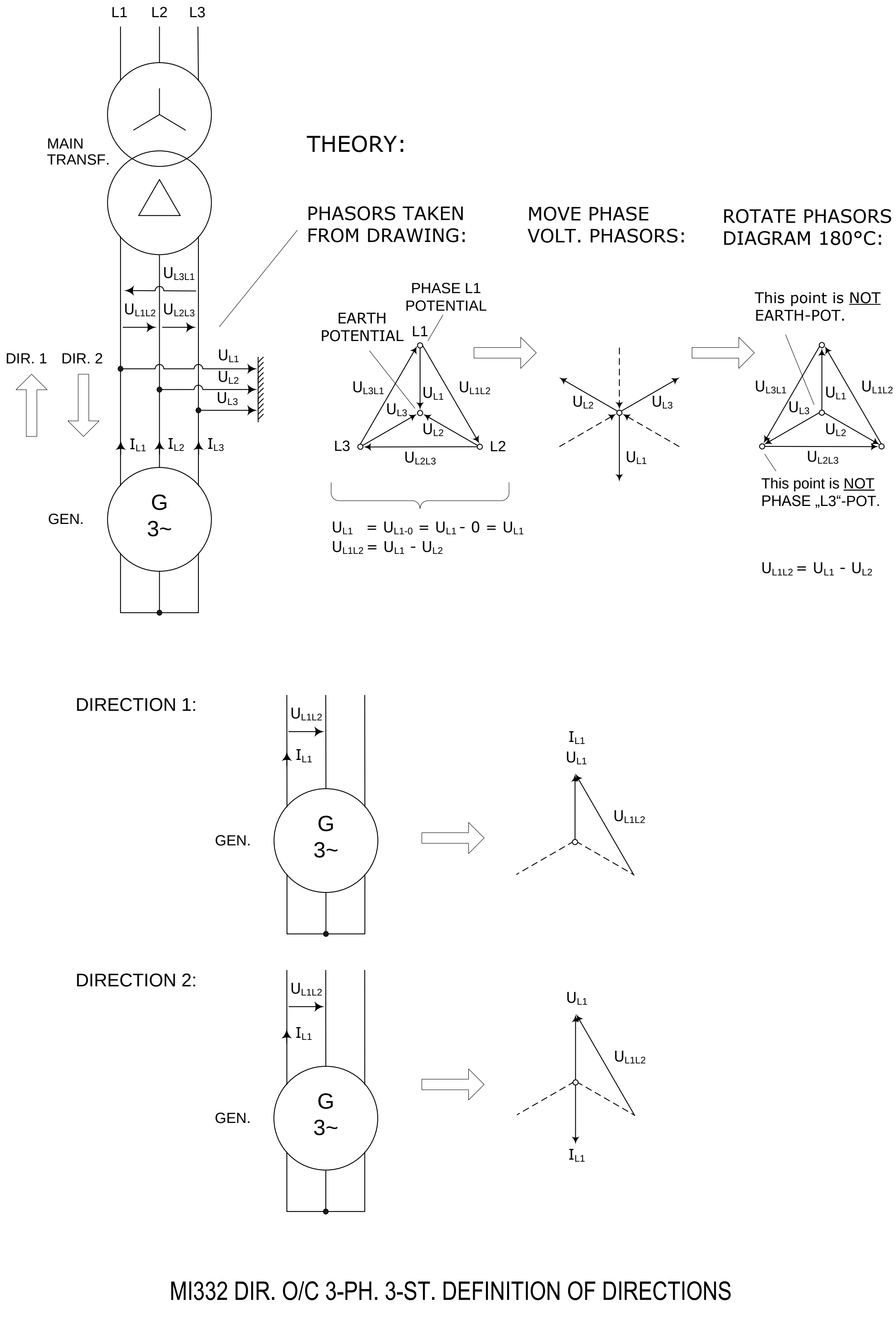
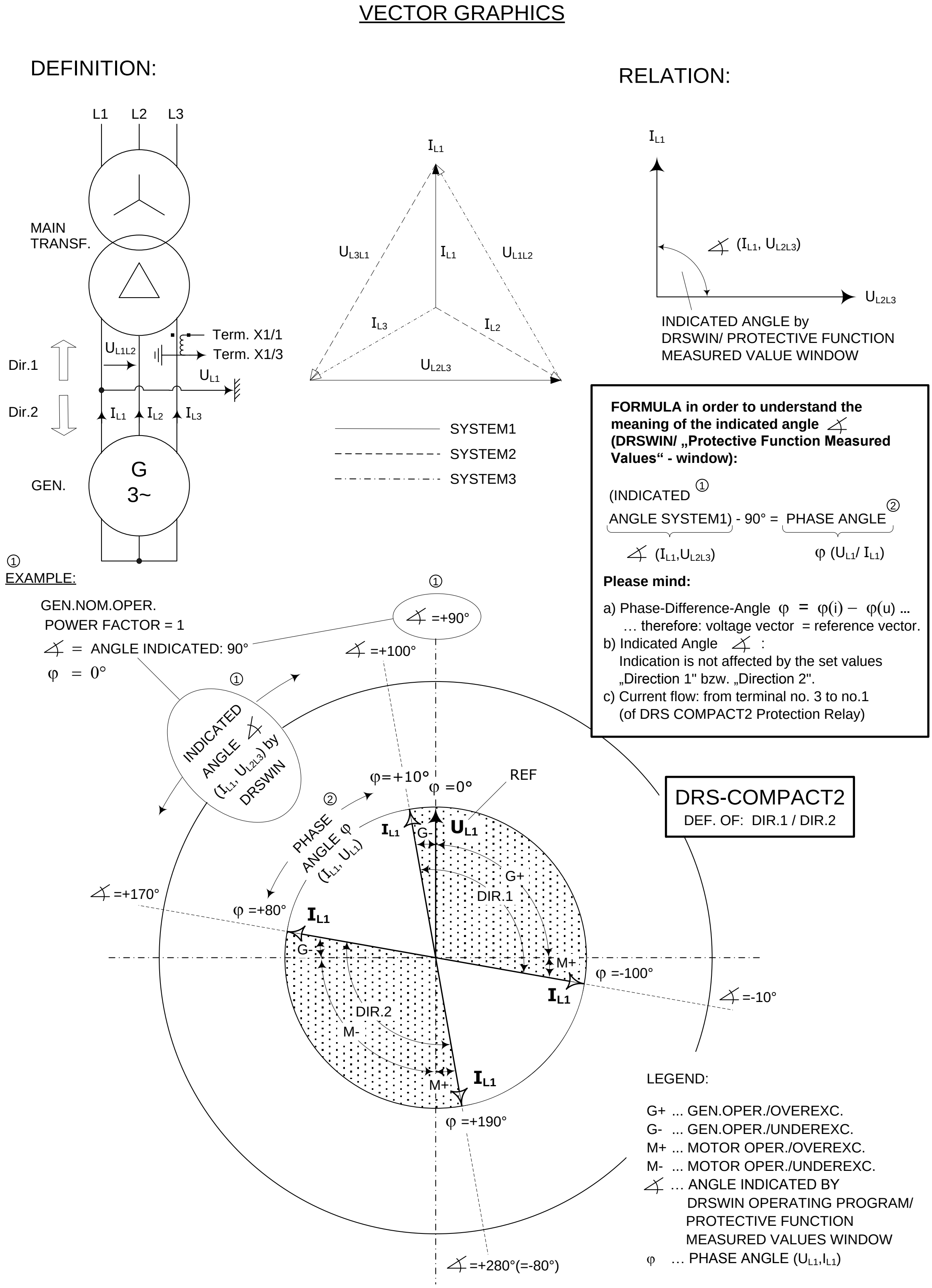
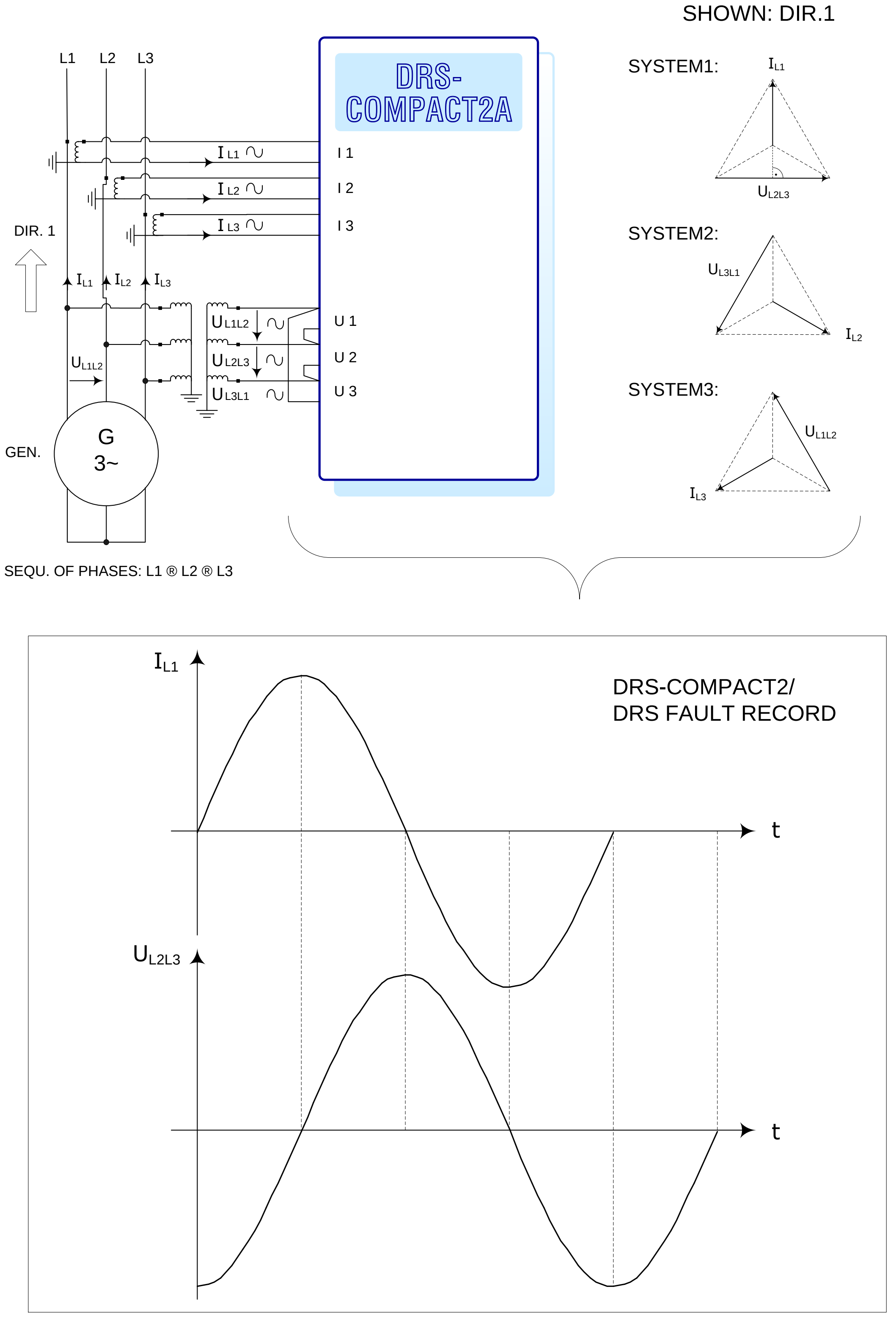


Fig. 144 MI332 Dir. O/C 3-PH. 3-ST. Definition Of Directions



MI332 DIR. O/C 3-PH. 3-ST. DEF. OF RANGES OF DIR.1 / DIR.2

Fig. 145 MI332 Dir. O/C 3-PH. 3-ST. Def. Of Ranges Of Dir. 1 / Dir. 2



MI332 DIR. O/C 3-PH. 3-ST. DRS FAULT RECORD / DEF. OF SIGN

Fig. 146 MI332 Dir. O/C 3-PH. 3-ST. DRS Fault Record / Def. Of Sign

10.5. FUNCTION

10.5.1. MI111/ MI112/ MI121/ MI122/ MI311/ MI312/ MI313/ MI314 MI321/ MI322/ MI323/ MI324/ MI326/ MI132/ MI133/ MI332

Over- and undercurrent DT protection is applied where a defined time delayed disconnection of the protected plant is required when the setting limits are exceeded or reaching below the limit.
Besides the simple current applications the use, for example, as generator winding short circuit protection of generators is also the scope of this function.
All analogue signals of the function are sampled 12 times each cycle. Out of this the amplitude of the fundamental harmonic for each phase is determined according to the standard algorithm (Fourier Transformation).
At each sample interval the computed amplitude value is checked regarding the initiation conditions, i.e. the set operating value being either in the over- or under detection mode.
If the initiating conditions are fulfilled during 24 consecutive intervals (2 cycles) the function is started and the time delay initiated. After expiry of the configured time delay a trip signal will be produced whereby the delay is according to the DT characteristic independent of the input signal amplitude.
Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

10.5.2. MI113

The fast overcurrent function MI113 without any adjustable time delay has a tripping time of a typical 10 ms including the output relays whereby about 5 ms are required for the input signal evaluation and the remaining 5 ms represent the operating time of the output relays.
This trip time is independent from the current frequency and the PROCESSING Basis Sample Rate because for the function an own oversampling algorithm is applicable.
Caution: This function must only be conditionally used with other functions and has not to be combined with frequency functions due to possible frequency jitter!
Generally valid: Do not combine with functions using higher harmonics. Due to the sampling jitters which are created in conjunction with the oversampling mode it will result into a tolerance range of the Fourier evaluation. Should a combination with such functions be absolutely necessary then in each particular case the correct response of all functions involved has to be thoroughly tested whereby “MI113” is always active.
Further, it has to be realised that this function is using up to 40% of the processor resources due to the oversampling mode.

The preferred applications are traditionally the 16 2/3 Hz traction systems where the operating times for “normal” overcurrent functions are relatively large (typical 2 cycles).

Also for 50 Hz systems the function MI113 is operating within half a cycle which is why the usual Fourier Algorithm cannot be applied. Therefore MI113 is using a special oversampling algorithm. The measured values processing is based on the instantaneous values which requires a very extensive interference signal eliminating routine since the filter effect of the Fourier Analyses is not available for this function.

When checking the tripping time during secondary injection tests it has to be noted that the current sinus wave should be starting by 90° otherwise it will take another few milliseconds until the setting value is approached (Note: instantaneous values are considered!).
The current setting (see "Operating Value") is regarded as an RMS value, respectively is calibrated as an RMS value. The instantaneous measured values are function-internally converted into RMS values and then compared with the setting configuration.
This conversion is exactly correct by 16 2/3 Hz at 50 % the deviation is about 3 %. During tests correlation can easily be verified with the aid of the DRSWIN measured values window (Note: this window shows in principle the 1st harmonic of the Fourier analyses converted to the RMS value).
Summary: Even though this function is evaluating the instantaneous values the setting is still be given as a RMS value.

"Reset Delay" setting:
During zero crossings of the current sinus wave the instantaneous values are tending to zero whereby especially for 16 2/3 Hz systems a chatter of the trip output may occur but the parameter ”reset delay” will overcome this time margin.

Offset compensation:
Due to internal device tolerances an additional offset for the measured current input signal can be possible. Since contrary to the Fourier algorithm the extreme short operating time is incorporated into the computation result it is necessary to perform a compensation for this. The latter is done automatically and on a digital basis.
The offset compensation will remain the same when sending new setting data to the DRS. However in case of auxiliary supply interruptions for the DRS-COMPACT it is necessary to adjust the offset again which will only take about 1 ... 5 s after which the function MI113 is in full service conditions.
Result: By the offset compensation it is ensured that even for small settings an over-reaction of the function will not happen.

10.6. COMMISSIONING

10.6.1. All above mentioned functions

!!! Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!!!

Pre-Commissioning:

At first the correct external wiring connections have to be verified.

The input matrix is to be configured according to the external connections.

The parameter settings fort he operating value and time delay have to be configured to the determined values (→ Time Grading).

The relay outputs are to be configured in the LED matrix and the trip matrix according to requirements.

Function tests by secondary injection are preferably performed with the primary plant out of service.
With a test set inject a current into the CT input of, e.g. phase L1 and slowly regulate the current until the function operates.

Note the operating value in the commissioning test sheets.

Adjust the test current into the opposite direction until the function resets and enter the value into the commissioning test sheets.

Please also compare the external input quantities with the internal measured values on the window display of the DRS User program.

Apply the same procedures for the other phases and/or stages and record the test results into the commissioning test sheets.

Observe the trip and alarm signals, respectively the LED indications according to the parameter settings and the circuit diagrams.

Check the operating time at 1.5 times the setting for each phase and stage with a suitable timer and enter the results into the test sheets.

Check the configured function blocks for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test feature for each stage by initiating the test signal and the protective function, respectively the stage has to operate without any external current input.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters must be re-configured to the original plant parameter settings.

Primary Commissioning Tests:

During primary tests the function of the protection system is verified during the plant in service and following check should be carried out when operating conditions permit:

- Short Circuit Test:

Apply a short circuit of adequate rating located at a position where primary current can flow through the respective CT set.
Disable protection trips.
Insert measuring instruments into the CT/VT and/or open the internal measured values window in the DRS User program.
Run up the generator to rated speed and manually raise excitation until operation of the function, if necessary with reduced setting.
Record operating values.
For multi-stage protective functions also test each stage the same way.
Restore protection trips.
If possible shut down the generator via a live protective function trip and remove the short circuit.

11. ML... OVERLOAD

11.1. OVERVIEW

List of the available ML . . . Overload Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: ML . . .	FNNR	TYPE	ANSI	Application
Overload, 1 phase, thermal replica, inverse time	1013	ML121	49	C2,M,L
Overload, 3 phase, thermal replica, inverse time	1012	ML321	49	C2,M,L

11.2. TECHNICAL DATA

11.2.1. Overload 1 Phase

PROTECTIVE FUNCTION: ML121	FNNR	TYPE	ANSI	Application
Overload, 1 phase, thermal replica, inverse time	1013	ML121	49	C2,M,L

1 phase overload function with an I² t characteristic with consideration of the cooling medium temperature provided with an alarm- and trip stage. Depending on the selected operating performance of the overload protection (relative- or absolute value measuring) the adjustable temperature settings in the DRS menu for the function are either configured as percentage
values of the temperature limit in % or as absolute temperature values in degrees.

ML121
Technical Data

Inputs

Analogue:	Current of protected object
	DC input "cooling media temperature"
Binary:	Blocking input
	Test input
	Heating/cooling (0/1)

Outputs

Binary:	Alarm
	Trip
	Measuring fault

Setting Parameters

CT ratio compensation: *Formula:* *Generator nominal current = CT ratio compensation x relay nominal current*	0.4 ... 2 in 0.01 steps
Pre-loading: *Note: Pre-loading with reference to the over temperature limit*	0 ... 100 % in 5 % steps
Heating time constant:	1 ... 100 min in 0.5 minute steps
Cooling time constant:	1 ... 100 min in 0.5 minute steps
Temperature limit:	10 ... 100 degrees, respectively % in 1 degree, respectively % steps
Temperature alarm:	25 ... 150 degrees, respectively % in 1 degree, respectively % steps
Temperature trip:	25 ... 150 degrees, respectively % in 1 degree, respectively % steps
Cooling medium temperature:	Pre-set/measuring

Temperature pre-set: *Note :If applicable…* *… if parameter "Cooling medium temperature" is set to "measuring".*	-30 ... +50 degrees in 1 degree steps
Measuring sensitivity: *Note :If applicable*	10 ... 500 mV/degree in 1mV/degree steps
Gradient: *Note :If applicable*	positive/negative
Voltage at 0 degrees: *Note :If applicable*	0.700 ... 4.800 V in 0.005 V steps

Window Display for Relay Internal Determined and Computed Values

Heating:	In degrees *(absolute temperature)*

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

11.2.2. Overload 3 phase

PROTECTIVE FUNCTION: ML321	FNNR	TYPE	ANSI	Application
Overload, 3 phase, thermal replica, inverse time	1012	ML321	49	C2,M,L

3 phase overload function with an I^2 t characteristic with consideration of the cooling medium temperature provided with an alarm- and trip stage. Depending on the selected operating performance of the overload protection (relative- or absolute value measuring) the adjustable temperature settings in the DRS menu for the function are either configured as percentage
values of the temperature limit in % or as absolute temperature values in degrees.

Ml321
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	DC input "cooling media temperature"
Binary:	Blocking input
	Test input
	Heating/cooling (0/1)

Outputs

Binary:	Alarm
	Trip
	Measuring fault

Setting Parameters

CT ratio compensation: *Formula:* *Generator nominal current = CT ratio compensation x relay nominal current*	0.4 ... 2 in 0.01 steps
Pre-loading: *Note: Pre-loading with reference to the over temperature limit*	0 ... 100 % in 5 % steps
Heating time constant:	1 ... 100 min in 0.5 minute steps
Cooling time constant:	1 ... 100 min in 0.5 minute steps
Temperature limit:	10 ... 100 degrees, respectively % in 1 degree, respectively % steps
Temperature alarm:	25 ... 150 degrees, respectively % in 1 degree, respectively % steps
Temperature trip:	25 ... 150 degrees, respectively % in 1 degree, respectively % steps
Cooling medium temperature:	Pre-set/measuring
Temperature pre-set: *Note :If applicable*	-30 ... +50 degrees in 1 degree steps
Temperature pre-set: *Note :If applicable*	10 ... 500 mV/degrees in 1mV/degree steps

Gradient: *Note :If applicable*	positive/negative
Voltage at 0 degrees: *Note :If applicable*	0.700 ... 4.800 V in 0.005 V steps

Window Display for Relay Internal Determined and Computed Values

Heating:	In degrees *(absolute temperature)* *Note:* *Always the largest phase current is displayed.*

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

11.3. CONNECTION DIAGRAMS

11.3.1. ML121/ ML321

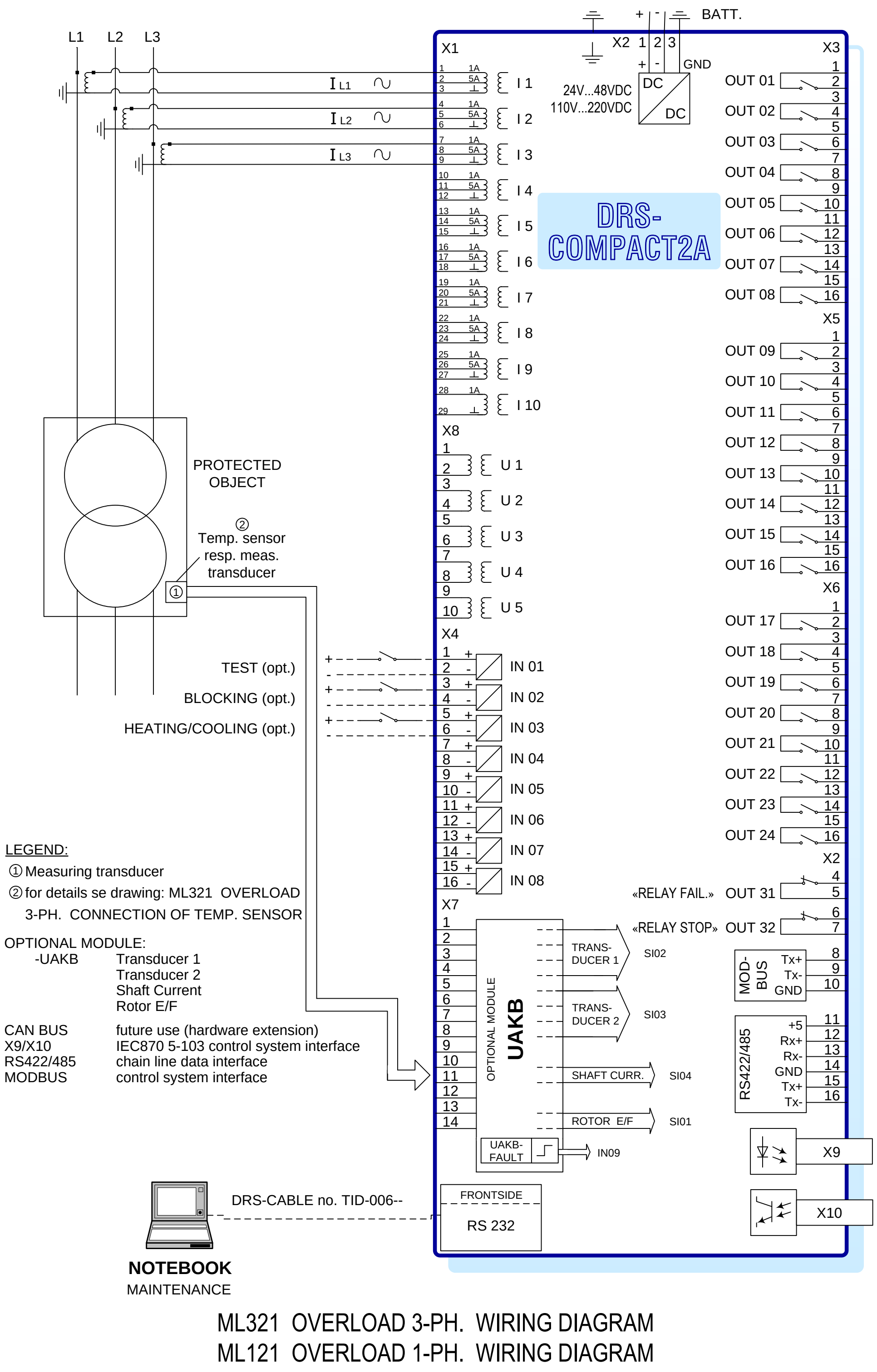


Fig. 147 ML321 Overload 3-PH. / ML121 Overload 1-PH. Wiring Diagram

11.4. LOGIC DIAGRAMS

11.4.1. ML121/ ML321

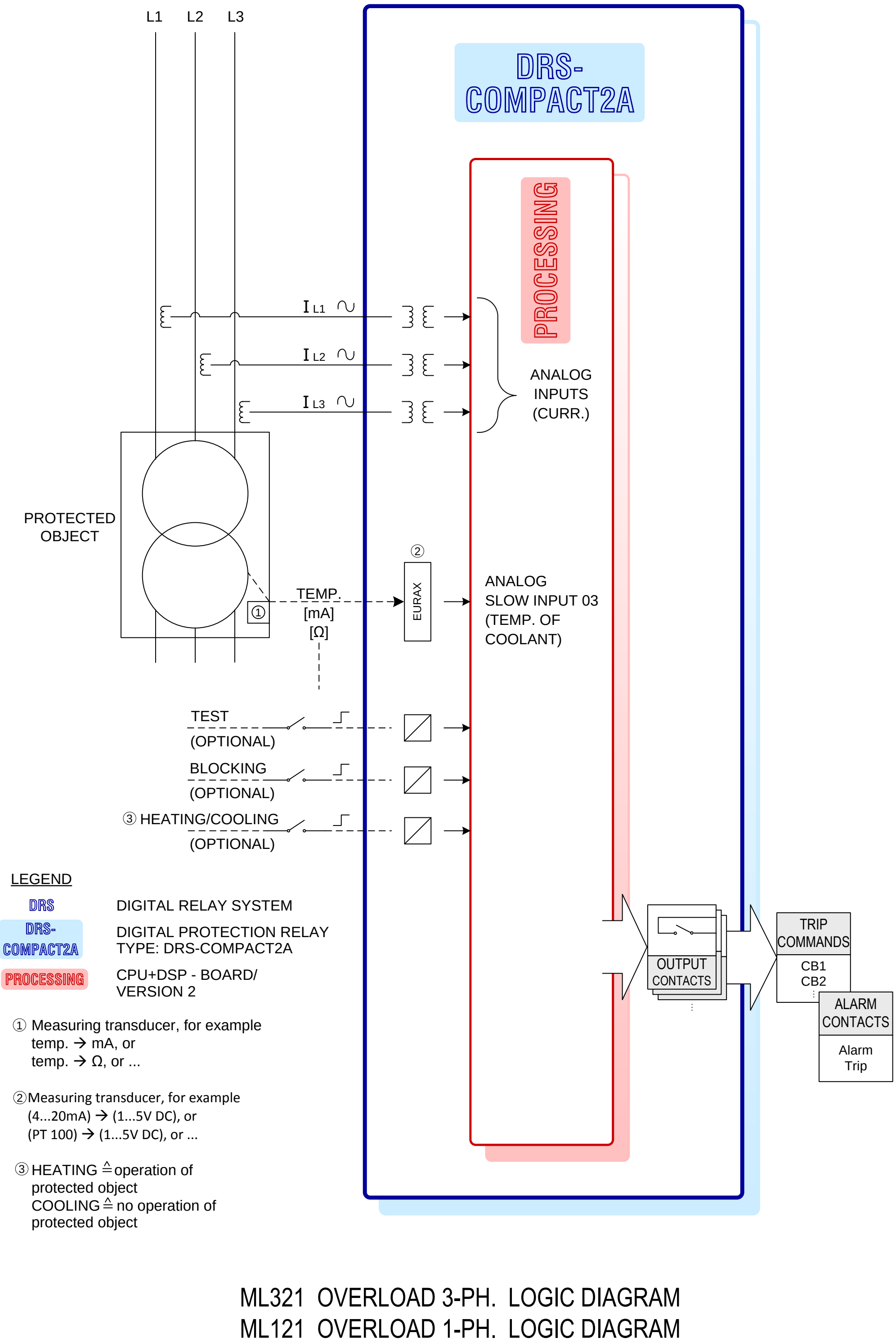
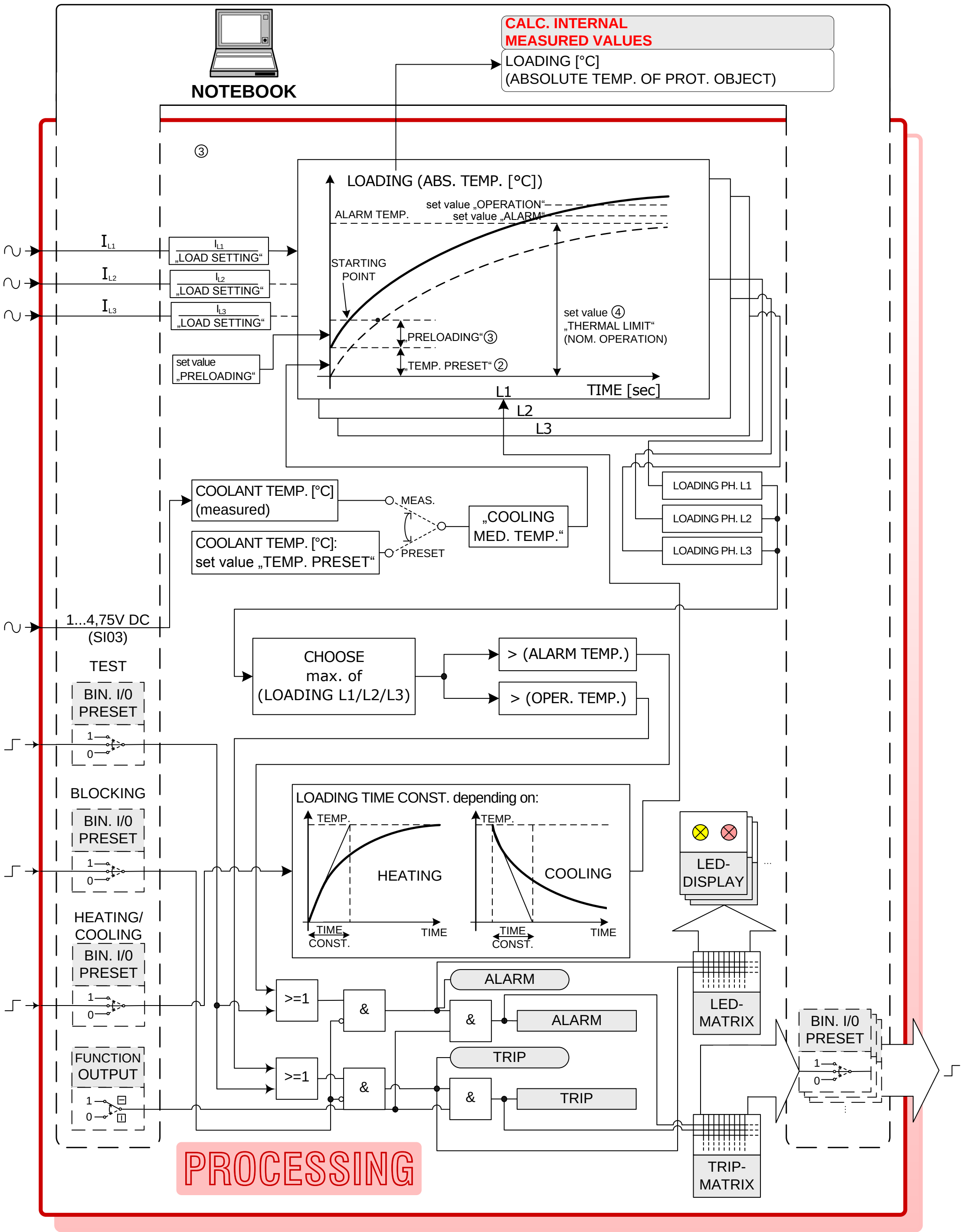


Fig. 148 ML321 Overload 3-PH / ML121 Overload 1-PH.. Logic Diagram



LEGEND:
① (TRANSF. NOM. CURRENT) = (LOAD SETTING) x (RELAY NOM. CURRENT)
② This „PRESET“ value to be used if no measuring input or if „TEMP. SENSING CIRCUIT“ is faulty (input signals (>4,75V DC) or (<1V DC))
③ „PRELOADING“-set value is given as [%] of „THERMAL LIMIT“-set value.
④ „THERMAL LIMIT“-set value is an overtemperature [°C]
⑤ „COOLING MED. TEMP.“-set value is an absolute temp. value [°C] (see also „MEAS. TRANSDUCER“)

ML321 OVERLOAD 3-PH. LOGIC DIAGRAM / PROCESSING
ML121 OVERLOAD 1-PH. LOGIC DIAGRAM / PROCESSING

Fig. 149 ML321 Overload 3-PH. / ML121 Overload 1-PH. Logic Diagram / Processing

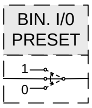
LEGEND PROCESSING

FIRMWARE-MODULE: ML321, ML121

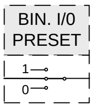
Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

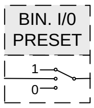
Online-indication of DRS-internal calculated values on notebook-screen



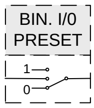
Online-simulation of DIG. IN-/OUTPUTS via notebook:



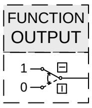
regular function



always „1"



always „0"

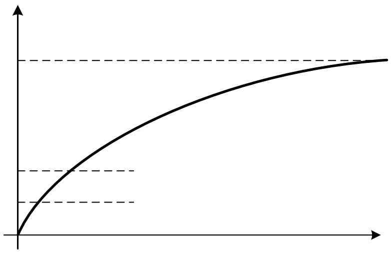


Online-simulation of the FUNCTION OUTPUTS of the protective function ML321 ML121

- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

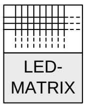
I_{L1}
„LOAD SETTING“

Ratio compensation for c.t.
LOAD SETTING...set value
I_{L1}...gen. current (c.t. secondary)
FORMULA: $I_{Transf.\ nom.}$ = „LOAD SETTING“ x $I_{Relay\ nom.}$
EXAMPLE: assume: $I_{Transf.\ nom.} < I_{Relay\ nom.}$ → set value „LOAD SETTING“ < 1.

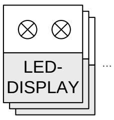


„LOADING“-characteristic depends on:
set value: „TIME CONSTANT“ (Heating/ Cooling)
set value: „THERMAL LIMIT“ (overtemperature)
set value: „PRELOADING“ (% of „THERMAL LIMIT“)
measuring value: „COOLING MED. TEMP.“ (temp. of coolant)

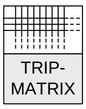
Please see details:
drawing ML321 ML121 OVERLOAD DEFINITION OF SET VALUES



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

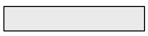


LED-indications of PROCESSING-board (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX



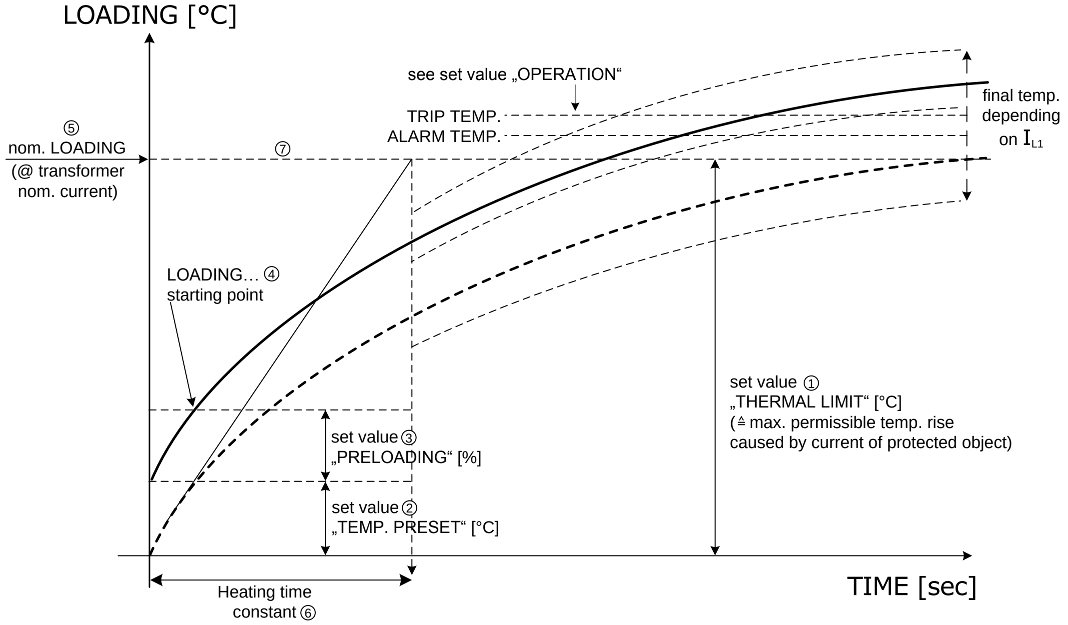
Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

ML321 OVERLOAD 3-PH. LOGIC DIAGRAM PROCESSING / LEGEND
ML121 OVERLOAD 1-PH. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 150 ML321 Overload 3-PH. / ML121 Overload 1-PH. Logic Diagram Processing / Legend

ML321 ML121 DEFINITION OF SET VALUES



① „THERMAL LIMT“ [°C]...temp. difference between (LOADING = 0) and (LOADING = nom.)
LOADING = 0... PRELOADING = 0; TEMP. PRESET = 0; I_{L1} = 0 for infinte time.
LOADING = nom. ... $I_{L1} = I_{L1\ nom}$ (nom. current of protected object) for infinite time.

② „TEMP. PRESET“ [°C]... influence of temp. of coolant of protected object.
Note: There are 2 possibilities to take into consideration the coolant temperature:

a) Measuring of coolant temperature by using a measuring transducer/ via SI03 (Slow Input 03). Set value „COOLING MED. TEMP.“ must be set to „MEASURED“. Please pay attention to the belonging set values: „MEAS. SENSIVITIY“; „GRADIENT“; VOLTAGE AT 0 DEG.“
In case of malfunction of the meas. transducer the algorithm of ML321/ ML121 will automatically change over to (b)... see below! Therefore the set value „TEMP. PRESET“ also must be filled in correctly (default).
b) Fixed preset of coolant temp (no actual measuring). Set value „COOLING MED. TEMP.“ must be set to „PRESET“. Please pay attention to the belonging set value: „TEMP. PRESET“. The set values „MEAS. SENSITIVITY“, „GRADIENT“, „VOLTAGE AT 0DEG.“ will not be used.

③ „PRELOADING“... applies if the protection is reset or if the aux. supply was interupted. In this case the LOADING is resetted too. For safety reason the set value „PRELOADING“ was added in order to cope with an already loaded („hot“) protected object. Should be set according to the LOADING of an average (typical) operation condition. „PRELOADING“ will lose its influence after approx. 3 time constants.

④ >>starting point<<… after reset or power up of the prot. relay the „INTERNAL MEAS. VALUE“-window will show the calculated LOADING-value which depends on the actual coolant temp. resp. „TEMP. PRESET“-set value and on the „PRELOADING“-set value.

⑤ „LOAD SETTING“... ratio comp. for c.t. FORMULA: $I_{Transf.\ nom.}$ = „LOAD SETTING“ x $I_{Relay\ nom.}$

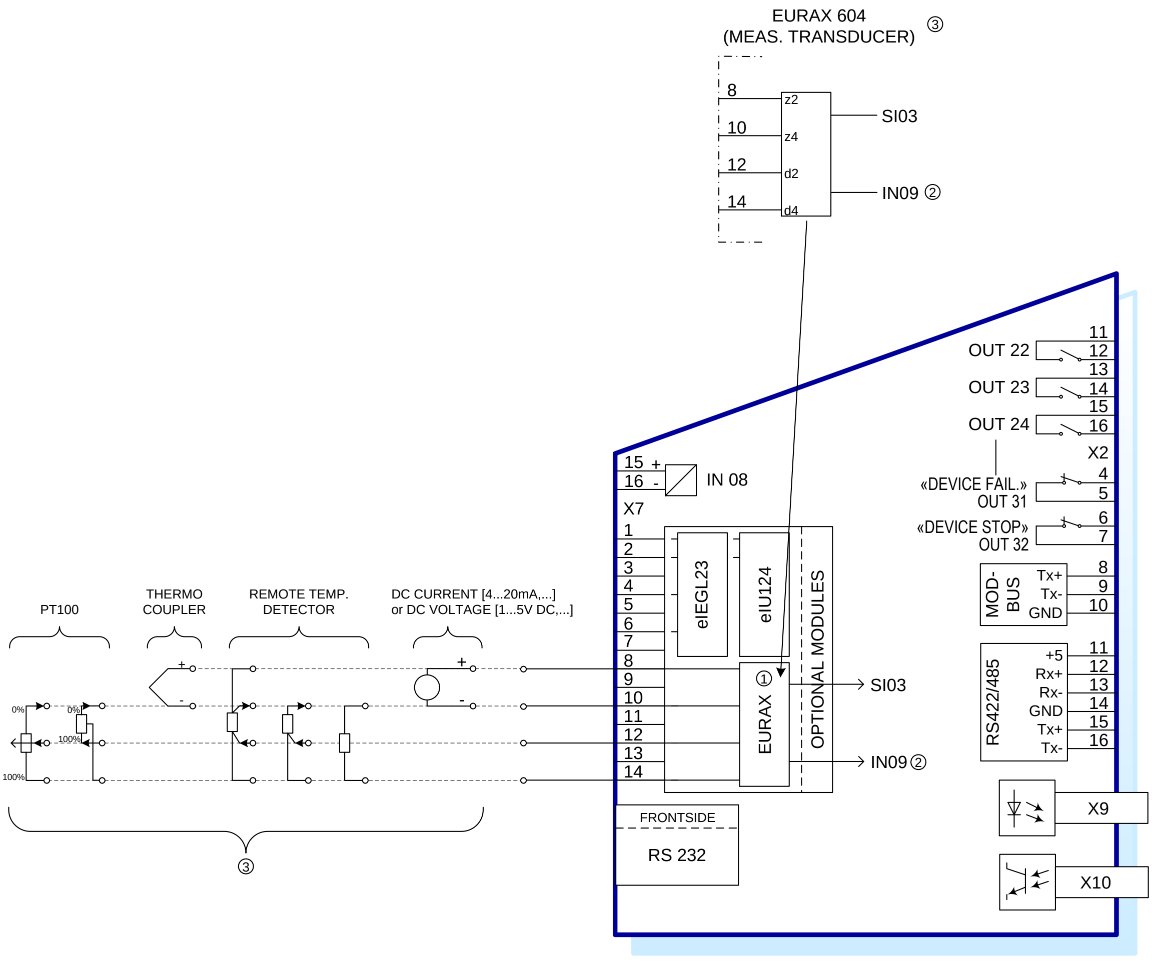
⑥ „HEATING TIME CONSTANT“... thermal time constant (during operation of protected object)
„COOLING TIME CONSTANT“... thermal time constant (protected object is switched OFF)
Note: in order to use the „COOLING TIME CONSTANT“-feature the dig input „HEATING/ COOLING“ must be wired!

⑦ „ALARM TEMP.“/ „OPER. TEMP“... Alarm/ Trip. These set values correlate with the indicated temp. value on the notebook screen (see „INTERNAL MEAS. VALUE“-window).

ML321 ML121 OVERLOAD DEFINITION OF SET VALUES

Fig. 151 ML321 ML121 Overload Definition Of Set Values

ML321/ OPTIONAL MODULES
CONNECTION OF TEMP. SENSOR
APPLICABLE FOR „DRS-COMPACT2" ONLY!



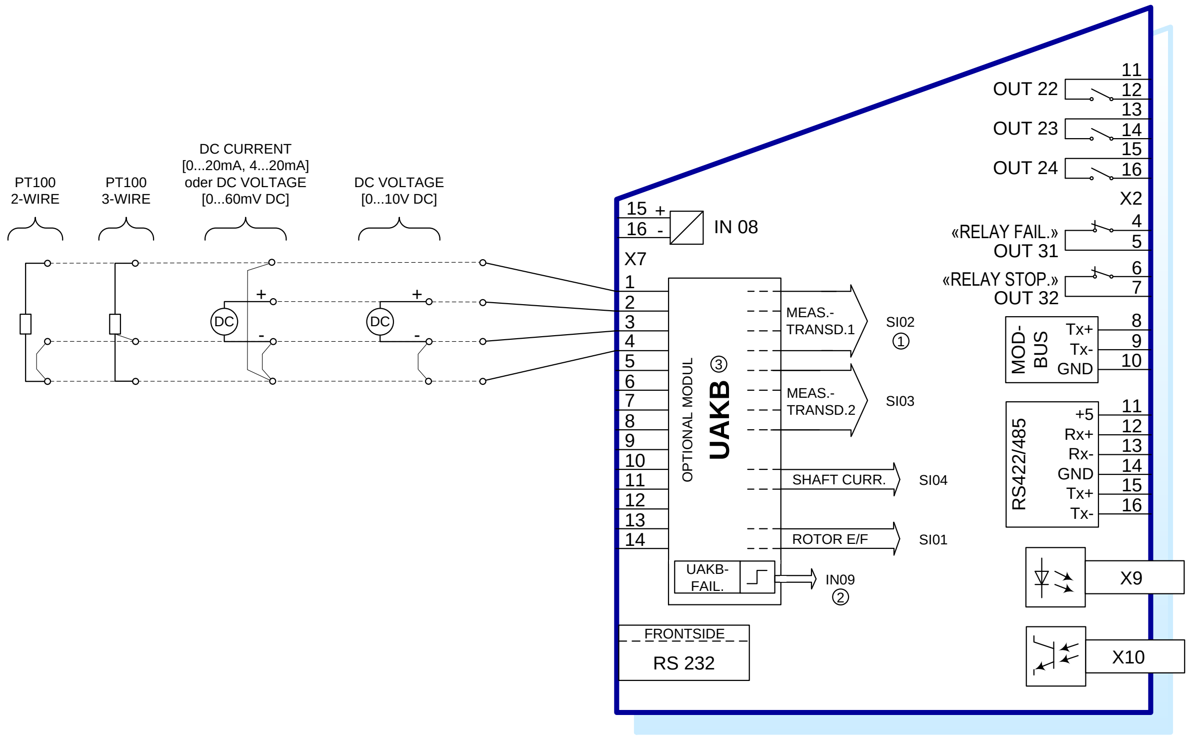
LEGEND:

① Meas. transducer type EURAX 604; used to connect the temp. signal to the PROT. RELAY CPU (=PROCESSING) via SI03 (Slow Input 03)
② IN09: Temp. sensing circuit is faulty.
Note 1: IN9 is an internal input only, not wired to external terminals.
Note 2: not used for ML321 usually. ML321 has an integrated software supervision (see trip matrix inputs!) for detection of temp. sensing circuit faults (broken wire, shortcircuit, supply fail,...)
③ Meas. transducer type EURAX 604 is programable. Type of input signal can be chosen. Output signal = 1...5V DC.

ML321 ML121 OVERLOAD 3-PH. CONNECTION OF TEMP. SENSOR

Fig. 152 ML321 ML121 Overload 3-PH. Connection Of Temp. Sensor (Eurax)

ML321/ OPTIONAL MODULES
CONNECTION OF TEMP. SENSOR
FOR DRS-COMPACT2A



LEGEND:

① The DRS COMPACT- internal module type UAKB contains two identical measuring transducers (Measuring Transducer 1 and Measuring Transducer 2). In our example we will use Measuring Transducer no. 1.

② IN09: Temp. sensing circuit is faulty.
Note 1: IN9 is an internal input only, not wired to external terminals of DRS COMPACT.
Note 2: not used for ML321 usually. ML321 has an integrated software supervision (see trip matrix inputs!) for detection of temp. sensing circuit faults (broken wire, shortcircuit, supply fail,...)

③ Meas. transducer type UAKB is programable. Type of input signal can be chosen. Output signal = 1...5V DC.

ML321 ML121 OVERLOAD 3-PH. CONNECTION OF TEMP. SENSOR

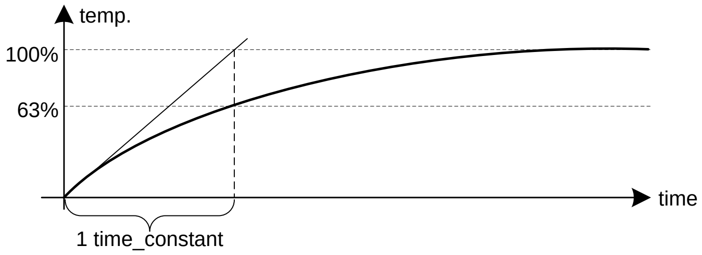
Fig. 153 ML321 ML121 Overload 3-PH. Connection Of Temp. Sensor (UAKB)

ML321 ML121 SETTING EXAMPLE (RELAY NOM. CURR.: 1A)

1. „LOAD SETTING“
   Assume: nom. operation = 0,83A (ct. sec.) → set = 0,83

2. „PRELOADING“
   Assume: average LOAD of prot. object = 30% of nom. LOADING → set = 30%

3. „HEATING TIME CONST.“
   Definition: after 1 time constant, the temperature will reach (1 – 1/e) = 63% of final temp.



4. „COOLING TIME CONST.“
   Depends on cooling conditions when protected object not in operation. If unequal to (3.)
   then it is also necessary to wire the digital input „HEATING/COOLING“.

5. „THERMAL LIMIT“
   Amount of temp. rise based on nom. current assuming no „PRELOADING“ and assuming
   „COOLING MED. TEMP.“ = 0

6. „ALARM TEMP.“
   Corresponds with the indicated temp. on notebook screen (LOADING) → please open
   the „INTERNAL MEAS. VALUE“- window (DRSWIN). Example: set = 105deg. (nom = 100deg.)

7. „OPER. TEMP.“ (TRIP TEMPERATURE)
   Corresponds with the indicated temp. on notebook screen (LOADING) → please open
   the „INTERNAL MEAS. VALUE“- window (DRSWIN). Example: set = 115deg.

8. „COOLING MED. TEMP“
   If not measured → set = preset
   If measured → set = measured

9. „TEMP. PRESET“
   Applies only if the cooling temp is not measured (or if malfunction of meas. transducer).
   Corresponds with temp. of coolant (during normal operation). Example: set = 40deg.

10. „MEAS. SENSITIVITY“ / „GRADIENT“ / „VOLT AT 0DEG.“
    Applies only if coolant temp. is measured (via meas. transducer).
    Example: coolant temperature range = -40deg. ... +110deg. ≙
    1V DC...4,75V DC (output of meas. transducer) → SLOW INPUT SI03 of VE2
    „MEAS. SENSITIVITY“ → set = 25mV/deg.
    „GRADIENT“ → set = positive
    „VOLTAGE AT 0 DEG.“ → set = 2V

Conversion:
1deg. ≙ 25mV.

ML321 ML121 SETTING EXAMPLE

Fig. 154 ML321 ML121 Setting Example

11.5. FUNCTION

Overload

Overload functions are applied to monitor the protected object against not permissible over heating in case of sustained overload conditions whereby the temperature rise is an exact thermal image of the protected plant and when exceeding the configured value an alarm- and trip output will be initiated.

By a simplified model the heating of load current flow through a winding is according to following relation:

$$\vartheta(t) = \vartheta_{Limit} \left(\frac{I}{I_0} \right)^2 \left(1 - e^{-\frac{t}{\tau_E}} \right) \qquad (1)$$

Thereby is

$\vartheta(t)$.... Temperature of the winding after time t when loaded
τ_E....... Thermal heating time constant of the winding
I........ Current flow through the winding
I_0........ Nominal current of the winding
ϑ_{Limit} Maximum over-temperature of the winding which is reached during service with nominal current after about 4 time constants

When also considering the temperature of the cooling medium T_{CM} then following relation for the absolute temperature T(t) at time t after commencing load current is according to following formula:

$$T(t) = T_{CM} + \vartheta_{Limit} \left(\frac{I}{I_0} \right)^2 \left(1 - e^{-\frac{t}{\tau_E}} \right) \qquad (2)$$

By similar considerations the cooling of the winding at zero current this formula applies

$$\vartheta(t) = \vartheta_0 . e^{-\frac{t}{\tau_A}} \qquad (3)$$

$\vartheta(t)$.... Temperature of the winding after time t with zero load current ϑ_0
...... Temperature of the winding when switching to zero current
τ_A....... Thermal cooling time constant of the winding

With consideration of the cooling medium temperature T_{CM} for the absolute temperature T(t) at time t after switching off there is following relation:

$$T(t) = T_{KM} + \vartheta_0 . e^{-\frac{t}{\tau_A}} \qquad (4)$$

The heating- and cooling time constants can vary for several reasons, e.g. no cooling water circulation, no ventilation, etc.

For the application of the thermal overload protection there are basically 2 different operating modes possible. On one hand the usual evaluation know for many protection relays which are matching the relative heating of the protected object is applicable (relative measuring) and on the other hand with the additional inputs of measuring elements or the known cooling medium temperature an absolute measurement of the heating conditions of the monitored machinery is obtained by the DRS function.

Relative Measuring:

This method relies on the fact that after approximately 3 to 4 time constants the limit of the permissible temperature has been reached and a stationary heating of the machine is established when operating with nominal current.
Different cooling conditions are not considered in this mode and therefore formulas (1) and (3) apply. All function settings are this way to be considered as a relative configuration regarding the permissible temperature limit selectable between 1% and 100%.

Absolute Measuring:

For practical considerations the cooling of the machine has a definite influence on the heating process. Therefore, e.g. in case of transformer windings, the absolute temperature evaluation via suitable transducers or additional thermal image load current heating (oil pocket) is obtained by adding these quantities to the load current temperature rise.
Thus the temperature computed by the I^2 t values plus the added cooling medium temperature is representing the absolute temperature of the winding according to formulas (2) and (4). For this method the function setting is to be entered in degrees.

To evaluate the load current heating the function current signals are sampled 12 times each cycle. By squaring and averaging the RMS value of the signal is determined and aligned with the CT ratio compensation I_0/I_n (I_0 = secondary rated current, I_n = function nominal current).

With a simple differential equation the derived temperature rise $\Delta\vartheta$ after each time interval Δt on the basis of the measured current as well as from the previous temperature value samples is illustrated in the formula below and calculated as follows.

$$\Delta\vartheta = \frac{1}{\tau_E}\left[\vartheta_{Limit}\left(\frac{I_a}{I_0}\right)^2 - \vartheta_a\right]\Delta t \qquad (5)$$

I_a....... Current within the sample interval
I_0....... Continuous rated load current
ϑ_a...... Temperature of the previous sample interval

When the computed temperature is exceeding the trigger value of the temperature alarm setting an appropriate annunciation is initiated and by a further temperature increase eventually a trip output is given when the tripping temperature is reached. The tripping time t_a during stationary operating conditions, i.e. no current change during the measuring time, with the set temperature trip value T_{Tr} is according to following formula:

$$t_a = \tau_E . \ln \frac{1}{\left[1 - \frac{T_{Tr} - T_{KM}}{\vartheta_{Grenz}} . \left(\frac{I_0}{I}\right)^2\right]} \qquad (6)$$

I Load current of the protected object
I_o Nominal current of the protected object

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

11.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Overload

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix, LED matrix and the trip matrix have to be configured according to the external circuitry and the plant requirements. Also the function parameters have to be set according to the data of the protected object.

The compensation of the relay rated current to the nominal current of the protected object is carried out via the parameter setting “CT ratio compensation” as per the formula below:

$$\text{Compensation} = \frac{I_e}{I_n}$$

I_e Nominal current of protected object
I_n Nominal current of protective function

With the parameter "Pre-set" the thermal replica of the protected object can be provided with an initial loading value which is accepted after each system start, i.e. each system reset after parameter setting changes, loss of DC auxiliary supply, etc.
The heating- and cooling time constants are separately configurable and will be activated according to the operating mode via suitable external input contacts.
The parameter "Temperature Limit“ is during heating approached after a few time constants.
The method for considering the cooling medium temperature can be selected via the menu item “Cooling Medium Temperature“. When “Measuring“ is chosen the cooling medium temperature can be included with Pt 100 elements via measuring transducers.
In case of “Pre-set” is selected the temperature configured with the parameter setting “Temperature Pre-set“ is used for the assessment of the cooling medium temperature.

By a wire break or short on the cable connection to the Pt 100 element a measuring fault alarm is initiated and the overload protection is continuing the computations with the parameter “Pre-set” configured temperature value until the fault is rectified.

The characteristic of the measuring transducer is configured via 3 additional parameter:
With the "Measuring Sensitivity" menu the slope of the transducer characteristic is determined by the mV/degree setting.
The gradient of the characteristic, either rising or falling, is set in the "Gradient" menu.
The transducer voltage output value at 0°C is configured with the parameter "Voltage at 0 Degrees".

Secondary injection tests for overload functions are generally very time consuming due to the slow response times of the protection. When injecting higher current values to speed up the test procedure care should be taken as not to overload the current input CT’s which have a maximum continuous rating of 4 x I_n.

The function tests are preferably carried out with the primary plant out of service.
With a relay test set inject the test current into the first phase input, e.g. with 3 times the setting value I_e and verify the current indication via the menu option "System, Analogue Values".

Switch off the test current and check whether the „Pre-loading“ is at 0 and the parameter "Cooling Medium Temperature is the target value 0 and send the parameter set of the overload protection to the DRS. Inject the previously adjusted test current again and record the operating time.

The operating time is calculated according to formula (6) by applying following values:

$T_{Tr} = \vartheta_{Limit}$..........	i.e. operating temperature equals the heating temperature limit
$T_{CM} = 0$...................	i.e. cooling medium temperature with pre-set value 0
$I/I_0 = 3$......................	i.e. test current equals 3 times the current setting

$$t_a = \tau_E.\ln\frac{1}{1-\frac{1}{9}} = \tau_E.\ln\frac{9}{8} = \tau_E.0{,}118$$

Verify the temperature rise via the menu item "Actual Measured Values" in the display window of the protective function and record the operating time as well as the injected current value into the commissioning test sheets.

Switch off the test current and observe the decrease of the temperature indication.
The temperature value after 1 time constant is derived according to formula (4)

$$T(\tau_A) = \vartheta_0 \times e^{-1} = \vartheta_0 \times 0.368$$

i.e. that after 1 time constant when switching off the injected current the temperature display must only be approximately 37% of the value at the instant of operation. Enter the temperature value into the commissioning test sheets.

The same procedure should be applied for the other phases and the measured results noted in the sheets.

After secondary injection tests all modified test parameters should be re-configured to the required original service settings.

In case of an external cooling medium temperature evaluation a variable resistor decade can be inserted into this circuit instead of the temperature element. Carry out the wire resistance- and the amplification matching according to the measuring transducer specification by checking the resistance value in relation with the temperature in the "Actual Measured Values" window.

Check the alarm- and trip signals and the LED indications according to the parameter settings and the circuit diagrams.

A test of the configured function blocking input for each stage should be done in conjunction with a continuous initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal for each stage can be verified without any external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to system requirements.

On-Load Commissioning Tests:

During the on-load checks the correct response of the protective function is verified under regular operating conditions. Practically special operating tests during commissioning of a thermal function are hardly possible due to the large operating times. It is therefore advised that during the heat run of the generator or transformer following observations should be performed:

Insert measuring instruments into the CT circuits and verify the external measured values with the indication in the User program.
Compare the values of the external meters with the internal DRS indication display.
Check the window display of the internal temperature measurement especially in the stable range regarding the margin to the operating value.

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12. MN... NEGATIVE PHASE SEQUENCE

12.1. OVERVIEW

List of the available MN . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A	
M	... DRS-MODULAR	
L	... DRS-LIGHT	
FNNR	... Function number (VE-internal number of the protective function)	
TYPE	... Function type (short name of the protective function)	
ANSI	... ANSI device number (international protective function number)	

PROTECTIVE FUNCTIONS: MN . . .	FNNR	TYPE	ANSI	Application
Negative phase sequence protection DT characteristic, 1 stage, 2-50%, 0-30s suitable for three phase systems without neutral (2 current inputs)	1015	MN211	46	C2,M,L
Negative phase sequence protection DT characteristic, 1 stage, 2-50%, 0-30s suitable for three phase systems with neutral (3 current inputs)	1086	MN311	46	C2,M,L
Negative phase sequence protection DT characteristic, 2 stage, 2-50%, 0-30s suitable for three phase systems without neutral (2 current inputs)	1016	MN221	46	C2,M,L
Negative phase sequence protection DT characteristic, 2 stage, 2-50%, 0-30s suitable for three phase systems with neutral (3 current inputs)	1087	MN321	46	C2,M,L
Negative phase sequence protection inverse time characteristic (thermal) suitable for three phase systems without neutral (2 current inputs) and separate setting parameters for alarm- and trip temperature	1017	MN222	46	C2,M
Negative phase sequence protection inverse time characteristic (thermal) suitable for three phase systems with neutral (3 current inputs) and separate setting parameters for alarm- and trip temperature	1088	MN322	46	C2,M

12.2. TECHNICAL DATA

12.2.1. Negative Phase Sequence 1 Stage DT/ Without Neutral

PROTECTIVE FUNCTION: MN211	FNNR	TYPE	ANSI	Application
Negative phase sequence protection DT characteristic, 1 stage, 2-50%, 0-30s suitable for three phase systems without neutral (2 current inputs)	1015	MN211	46	C2,M,L

2 phase, 1 stage definite time (DT) negative phase sequence function.

MN211
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip

Setting Parameters

Operating value:	2 ... 50 % in 0.5 % steps
Operating time:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal Determined and Computed Values

Negative phase sequence:	in % relating to the function nominal current

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.2.2. Negative Phase Sequence 1 Stage DT / With Neutral

PROTECTIVE FUNCTION: MN321	FNNR	TYPE	ANSI	Application
Negative phase sequence protection DT characteristic, 1 stage, 2-50%, 0-30s suitable for three phase systems with neutral (3 current inputs)	1086	MN311	46	C2,M,L

3 phase, 1 stage definite time (DT) negative phase sequence function.

MN311
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Alarm

Setting Parameters

Operating value stage 1:	2 ... 50 % in 0.5 % steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal
Determined and Computed Values

Negative phase sequence:	in % relating to the function nominal current

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.2.3. Negative Phase Sequence 2 Stage DT / Without Neutral

PROTECTIVE FUNCTION: MN221	FNNR	TYPE	ANSI	Application
Negative phase sequence protection DT characteristic, 2 stage, 2-50%, 0-30s suitable for three phase systems without neutral (2 current inputs)	1016	MN221	46	C2,M,L

2 phase, 2 stage definite time (DT) negative phase sequence function.

MN221
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Alarm stage 1
	Trip stage 1
	Alarm stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	2 ... 50 % in 0.5 % steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2:	2 ... 50 % in 0.5 % steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal
Determined and Computed Values

Negative phase sequence:	in % relating to the function nominal current

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.2.4. Negative Pase Sequence 2 Stage DT / With Neutral

PROTECTIVE FUNCTION: MN321	FNNR	TYPE	ANSI	Application
Negative phase sequence protection DT characteristic, 2 stage, 2-50%, 0-30s suitable for three phase systems with neutral (3 current inputs)	1087	MN321	46	C2,M,L

3 phase, 2 stage definite time (DT) negative phase sequence function.

MN321
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Alarm stage 1
	Trip stage 1
	Alarm stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	2 ... 50 % in 0.5 % steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2:	2 ... 50 % in 0.5 % steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal
Determined and Computed Values

Negative phase sequence:	in % of the function nominal current

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.2.5. Negative Phase Sequence Inverse Time (Thermal) / Without Neutral

PROTECTIVE FUNCTION: MN222	FNNR	TYPE	ANSI	Application
Negative phase sequence protection inverse time characteristic (thermal) suitable for three phase systems without neutral (2 current inputs) and separate setting parameters for alarm- and trip temperature	1017	MN222	46	C2,M

2 phase negative phase sequence function with thermal overload characteristic and alarm- and trip stage.

MN222
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip

Setting Parameters

CT ratio compensation: *Formula:* *Generator rated current = CT ratio compensation x function nominal current*	0.4 ... 2 xIn in 0.01 xIn steps
Continuous NPS load: *Note: The generator rated current (=100%) related to the maximum permissible negative phase sequence current (=continuous NPS) determines the setting value*	2 ... 25 % in 0.5 % steps
Time constant:	1 ... 50 minutes in 1 minute steps
Alarm output: *Note: 100 % of the configured continuous permissible NPS*	5 ... 100 % in 1 % steps
Trip output: *Note: 100 % of the configured continuous permissible NPS*	5 ... 100 % in 1 % steps

Window Display for Relay Internal Determined and Computed Values

Negative phase sequence:	In % of the function nominal current *Note: Although a compensation factor is given (see setting values) this negative phase sequence display is referring to the relay nominal values.*
Loading:	In % of the continuous permissible NPS generator withstand. *Note: The displayed "Loading" is considering the CT ratio compensation factor.* *Formula: Generator rated current = compensation x relay nominal current.* *Example:* *Thus, when the ratio compensating factor is decreased then the "Loading" indication value will rise faster.*

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.2.6. Negative Phase Sequence Inverse Time (Thermal) / With Neutral

PROTECTIVE FUNCTION: MN322	FNNR	TYPE	ANSI	Application
Negative phase sequence protection inverse time characteristic (thermal) suitable for three phase systems with neutral (3 current inputs) and separate setting parameters for alarm- and trip temperature	1088	MN322	46	C2,M

3 phase negative phase sequence function with thermal overload characteristic and alarm- and trip stage.

MN322
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip

Setting Parameters

CT ratio compensation: *Formula:* *Generator rated current = CT ratio compensation x function nominal current*	0.4 ... 2 xIn in 0.01 xIn steps
Continuous NPS load: *Note: The generator rated current (=100%) related to the maximum permissible negative phase sequence current (=continuous NPS) determines the setting value*	2 ... 25 % in 0.5 % steps
Time constant:	1 ... 50 minutes in 1 minute steps
Alarm output: *Note: 100 % of the configured continuous permissible NPS*	5 ... 100 % in 1 % steps
Trip output: *Note: 100 % of the configured continuous permissible NPS*	5 ... 100 % in 1 % steps

Window Display for Relay Internal Determined and Computed Values

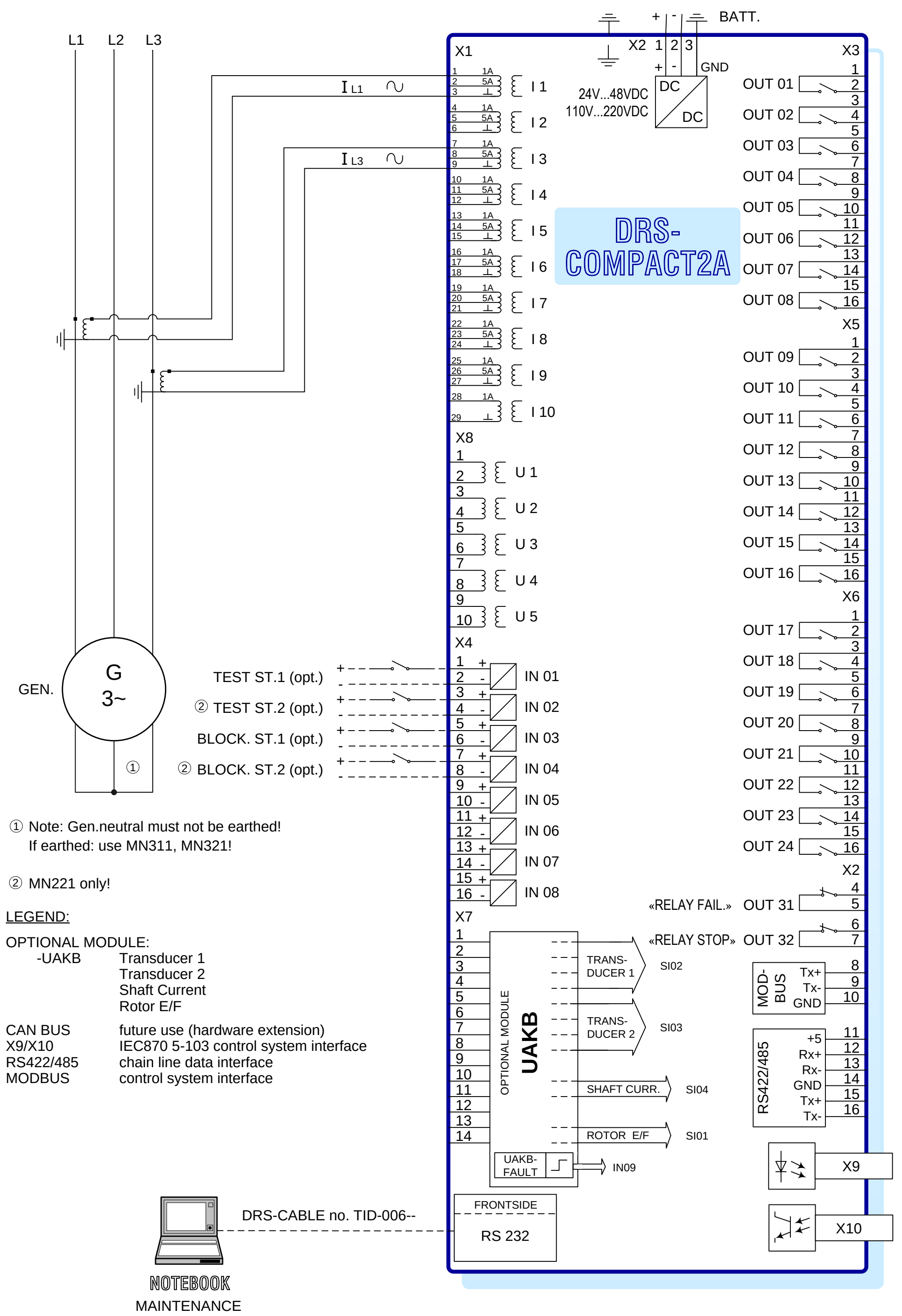
Negative phase sequence:	In % of the function nominal current *Note: Although a compensation factor is given (see setting values) this negative phase sequence display is referring to the relay nominal values.*
Loading:	In % of the continuous permissible NPS generator withstand. *Note: The displayed "Loading" is considering the CT ratio compensation factor.* *Formula: Generator rated current = compensation x relay nominal current.* *Example:* *Thus, when the ratio compensating factor is decreased then the "Loading" indication value will rise faster.*

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

12.3. CONNECTION DIAGRAMS

12.3.1. MN211/ MN221



MN211 NEG. PHASE SEQU. CURR. 1-ST. WIRING DIAGRAM
MN221 NEG. PHASE SEQU. CURR. 2-ST. WIRING DIAGRAM

Fig. 155 MN211 Neg. Phase Sequ. Curr. 1-St. / MN221 Neg. Phase Sequ. Curr. 2-St. Wiring Diagram

12.3.2. MN311/ MN321

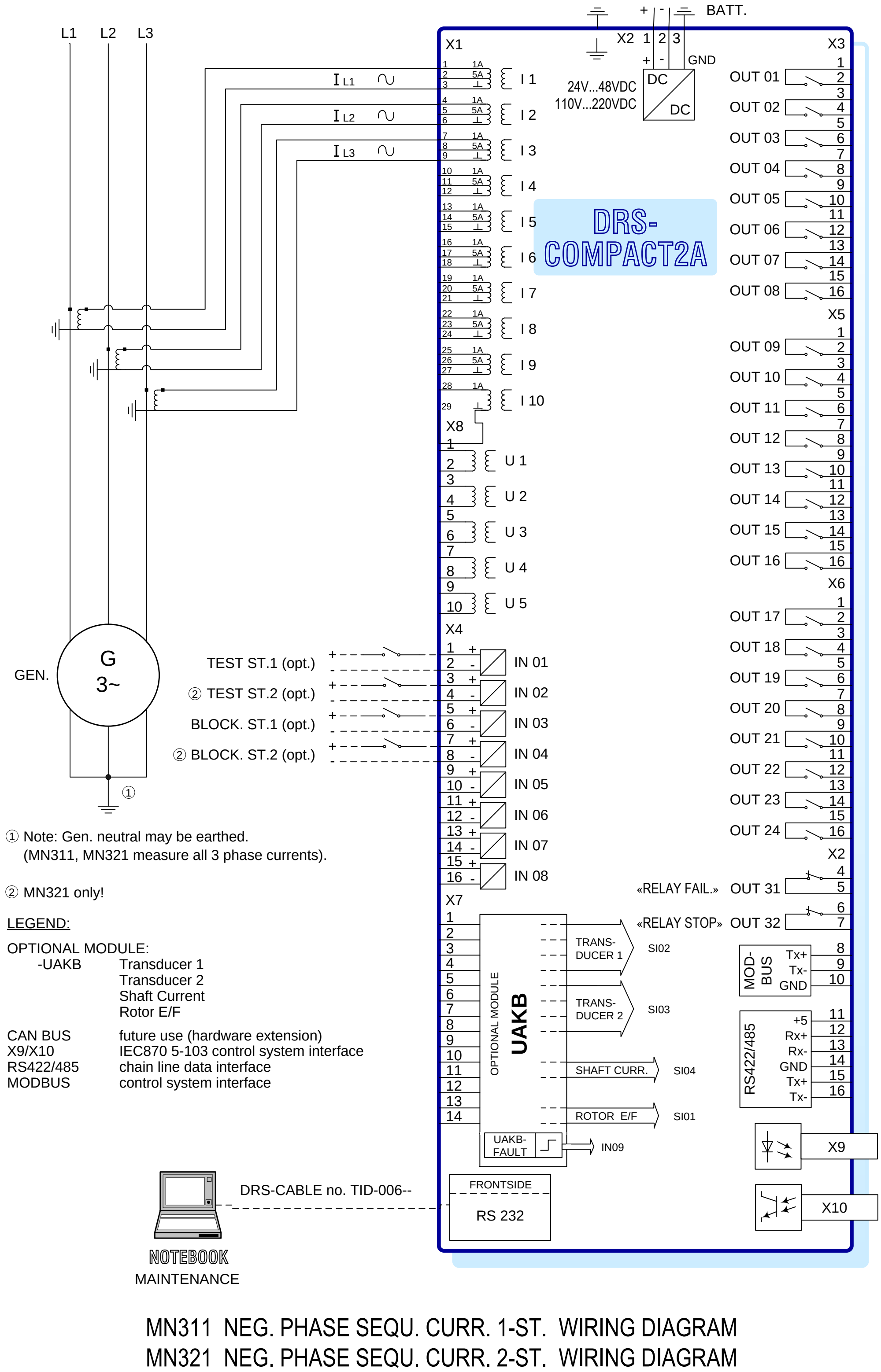
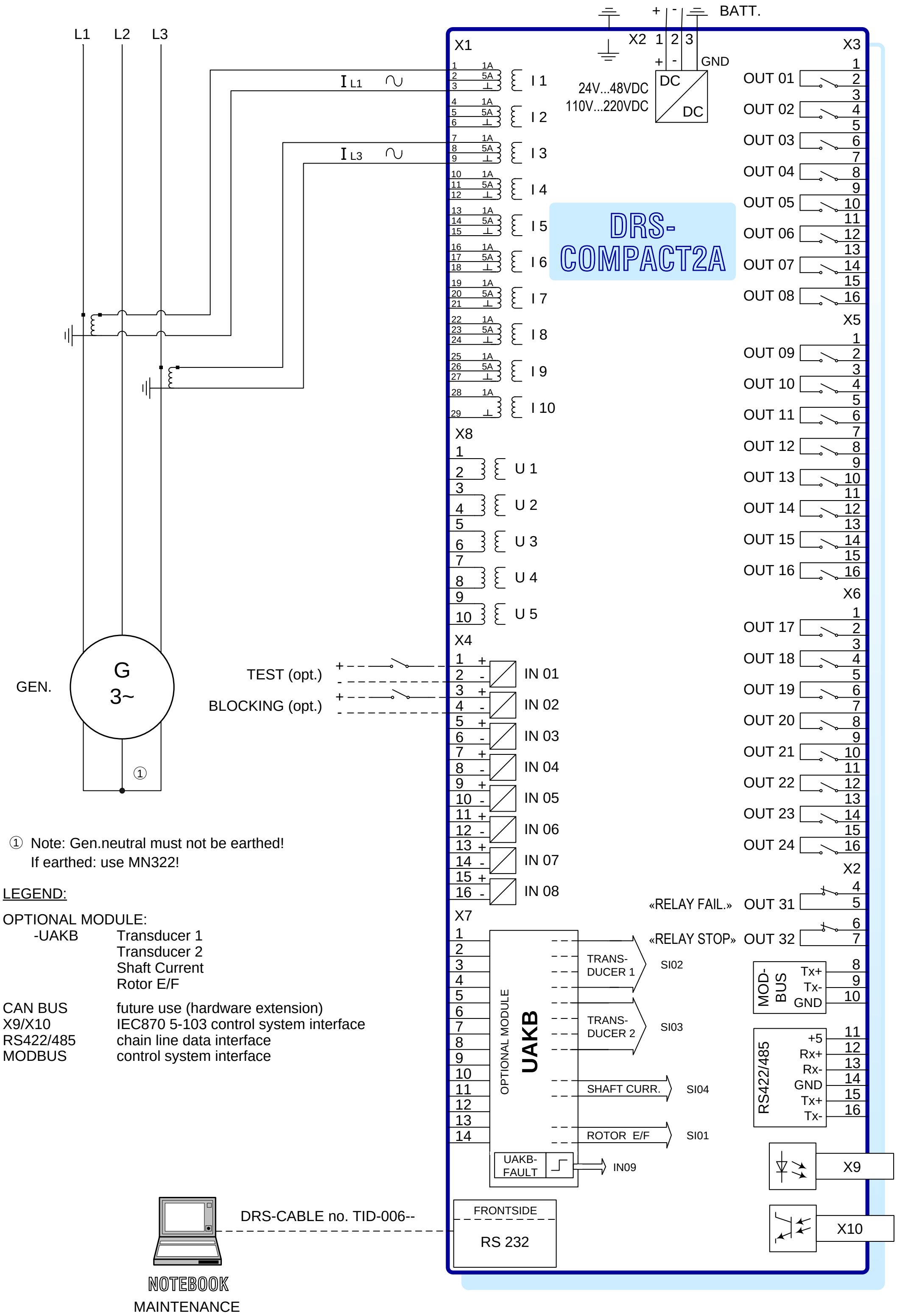


Fig. 156 MN311 Neg. Phase Sequ. Curr. 1-St. Wiring Diagram / MN321 Neg. Phase Sequ. Curr. 2-St. Wiring Diagram

12.3.3. MN222



① Note: Gen.neutral must not be earthed!
If earthed: use MN322!

LEGEND:

OPTIONAL MODULE:

-UAKB		Transducer 1 Transducer 2 Shaft Current Rotor E/F
CAN BUS		future use (hardware extension)
X9/X10		IEC870 5-103 control system interface
RS422/485		chain line data interface
MODBUS		control system interface

MN222 INV. TIME NEG. PHASE SEQU. CURR. WIRING DIAGRAM

Fig. 157 MN222 INV. Time Neg. Phase Sequ. Curr. Wiring Diagram

12.3.4. MN322

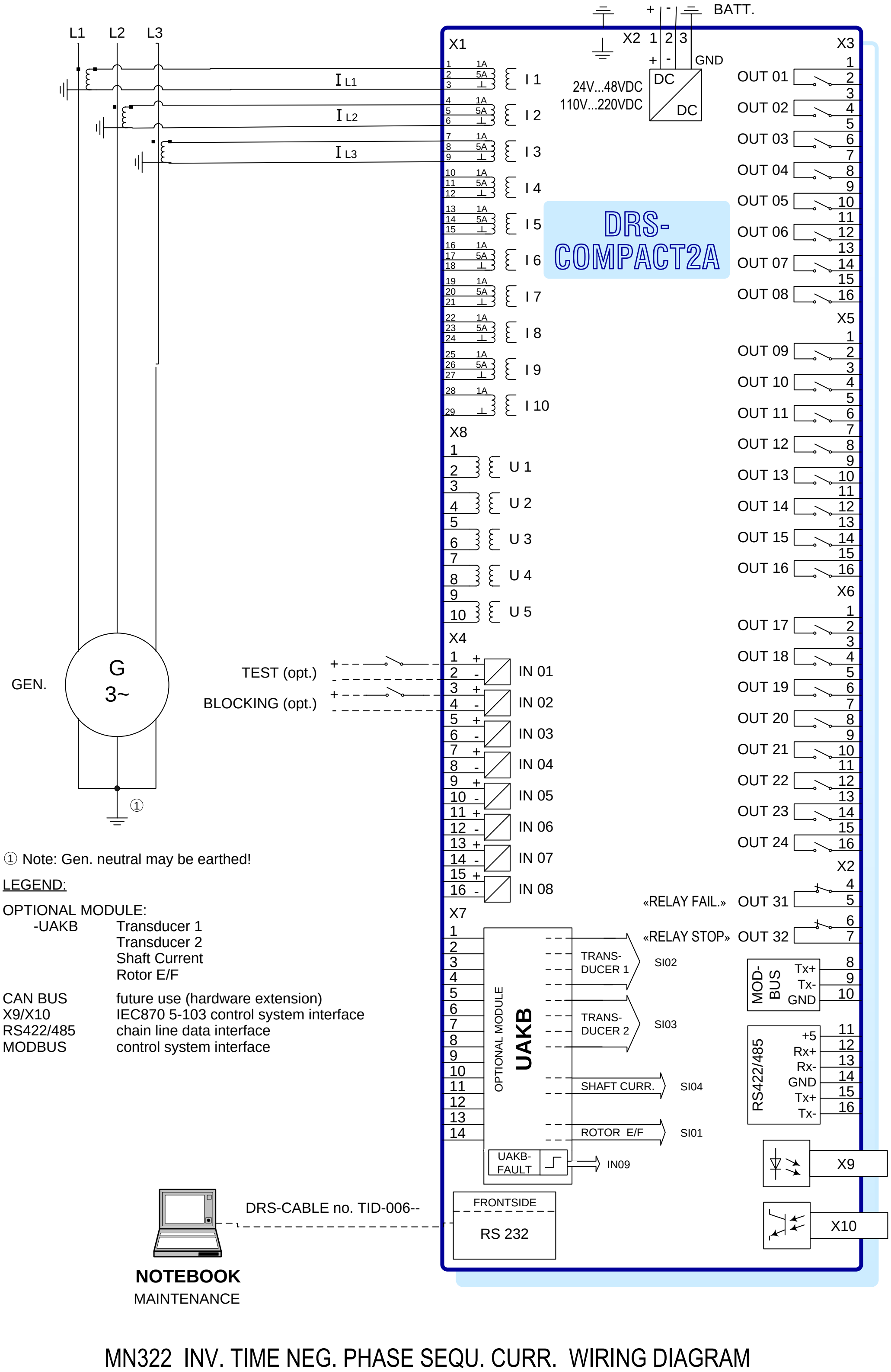
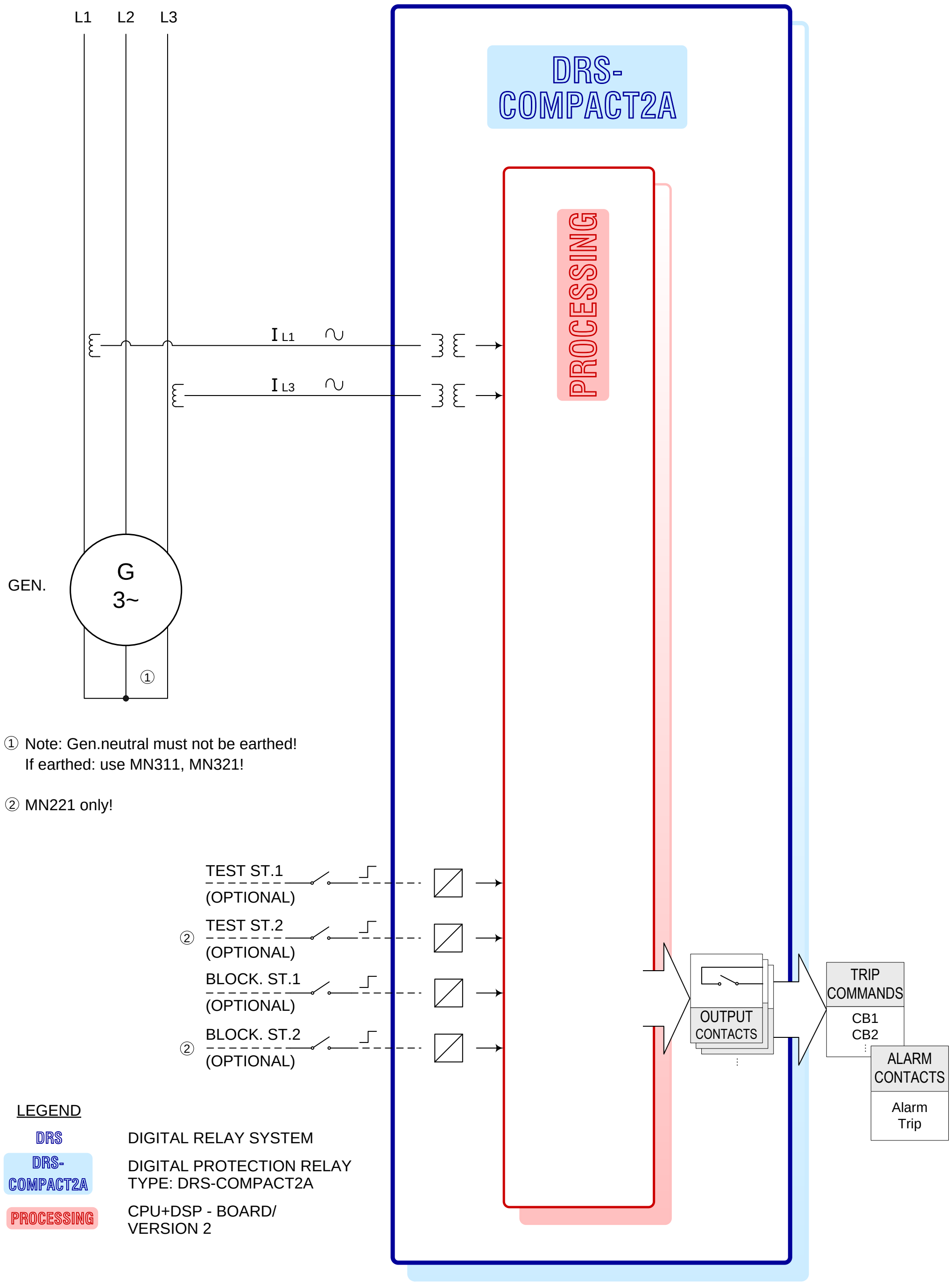


Fig. 158 MN322 Inv. Time Neg. Phase Sequ. Curr. Wiring Diagram

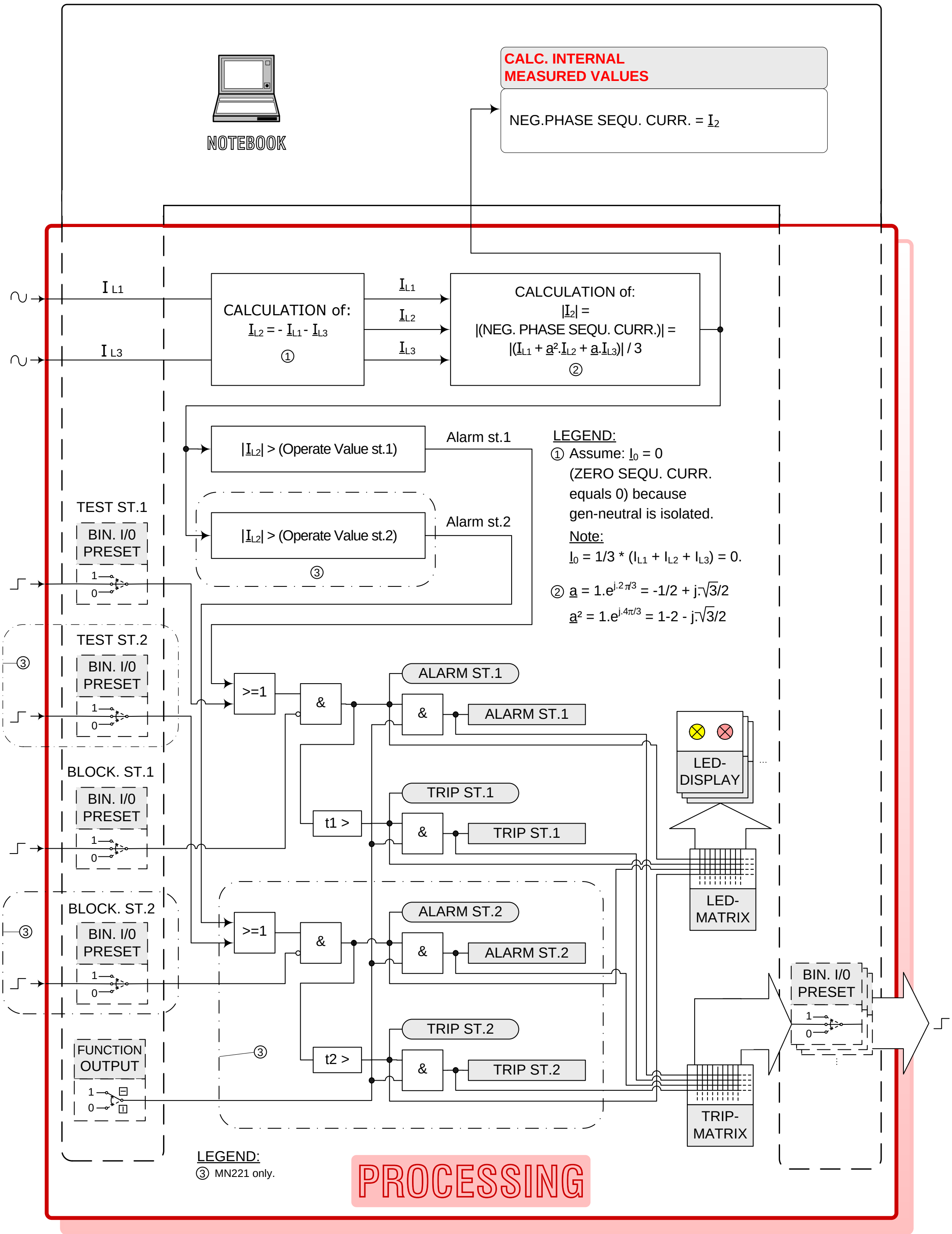
12.4. LOGIC DIAGRAMS

12.4.1. MN211/ MN221



MN211 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM
MN221 NEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM

Fig. 159 MN211 Neg. Phase Sequ. Curr. 1-St. Logic Diagram / MN221 Neg. Phase Sequ. Curr. 2-St. Logic Diagram

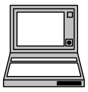


MN211 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM / PROCESSING
MN221 INEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM / PROCESSING

Fig. 160 MN211 Neg. Phase Sequ. Curr. 1-St. Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MN211, MN221



Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MN211, MN221
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ◫ all FUNCTION OUTPUTS disabled (test-operation)

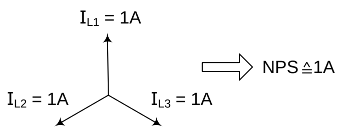
CALCULATION of: $\underline{I}_{L2} = -\underline{I}_{L1} - \underline{I}_{L3}$ ①

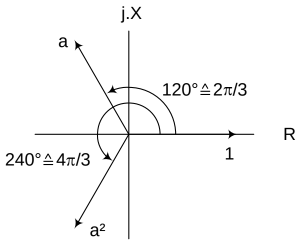
The generator neutral point is not earthed.
Therefore I_0 (ZERO SEQU. SYSTEM CURR.) = 0 (assume: no E/F of gen.).
$\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3} = 3 * \underline{I}_0 \rightarrow \underline{I}_{L2} = -\underline{I}_{L1} - \underline{I}_{L2}$

CALCULATION of: $|\underline{I}_2|$ = |(NEG. PHASE SEQU. CURR.)| = $|(\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3})| / 3$

NPS-CURR: I_2.
$\underline{I}_2 = |\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3}| / 3$
where: $\underline{a} = 1.e^{j.2\pi/3} = -1/2 + j.\sqrt{3}/2$
$\underline{a}^2 = 1.e^{j.4\pi/3} = 1/2 - j.\sqrt{3}/2$

Note: Calibration: 100% NPS ≙1A





LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

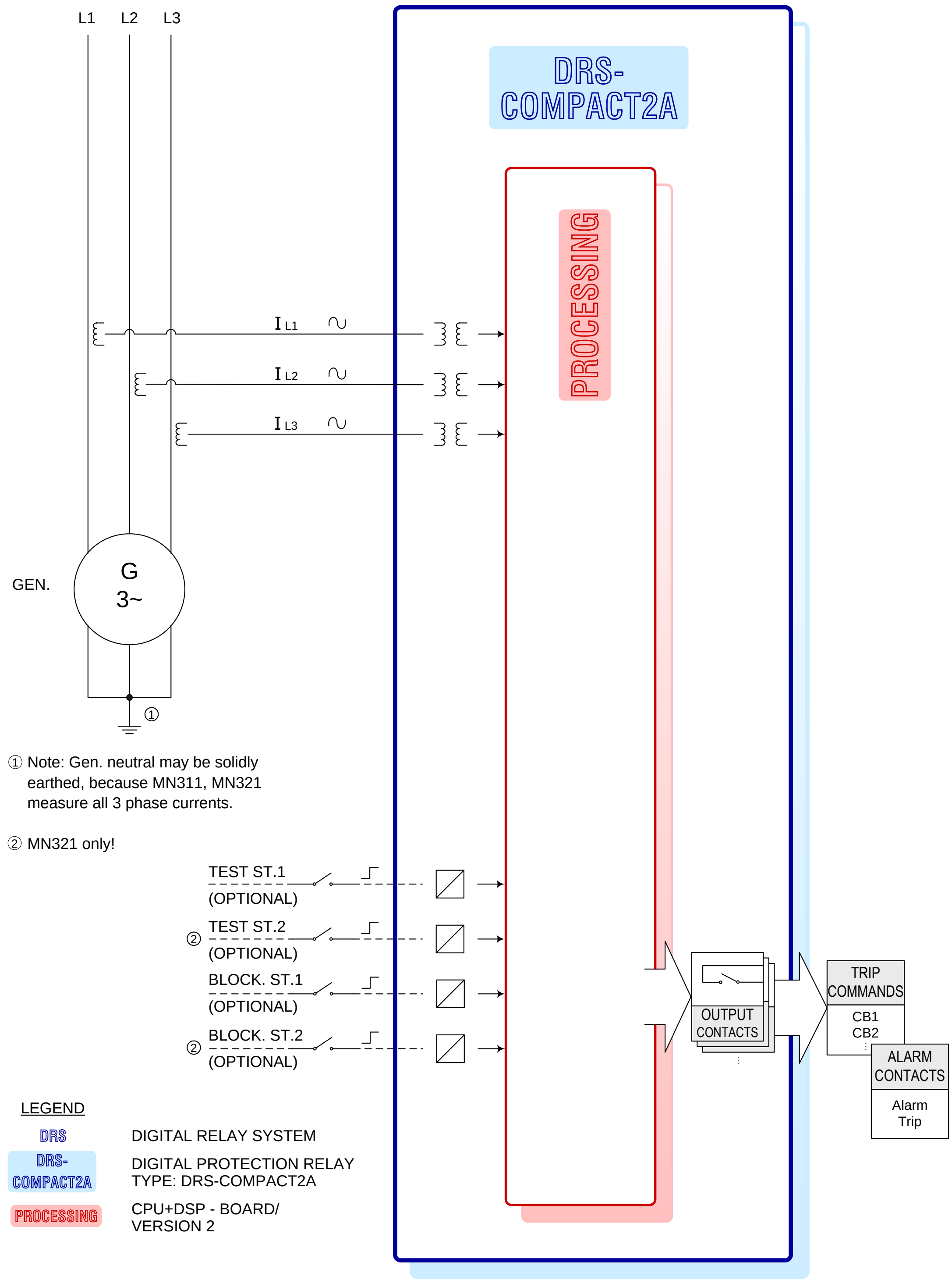
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MN211 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MN221 NEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 161 MN211 Neg. Phase Sequ. Curr. 1-St. / MN221 Neg. Phase Sequ. Curr. 2-St. Logic Diagram Processing / Legend

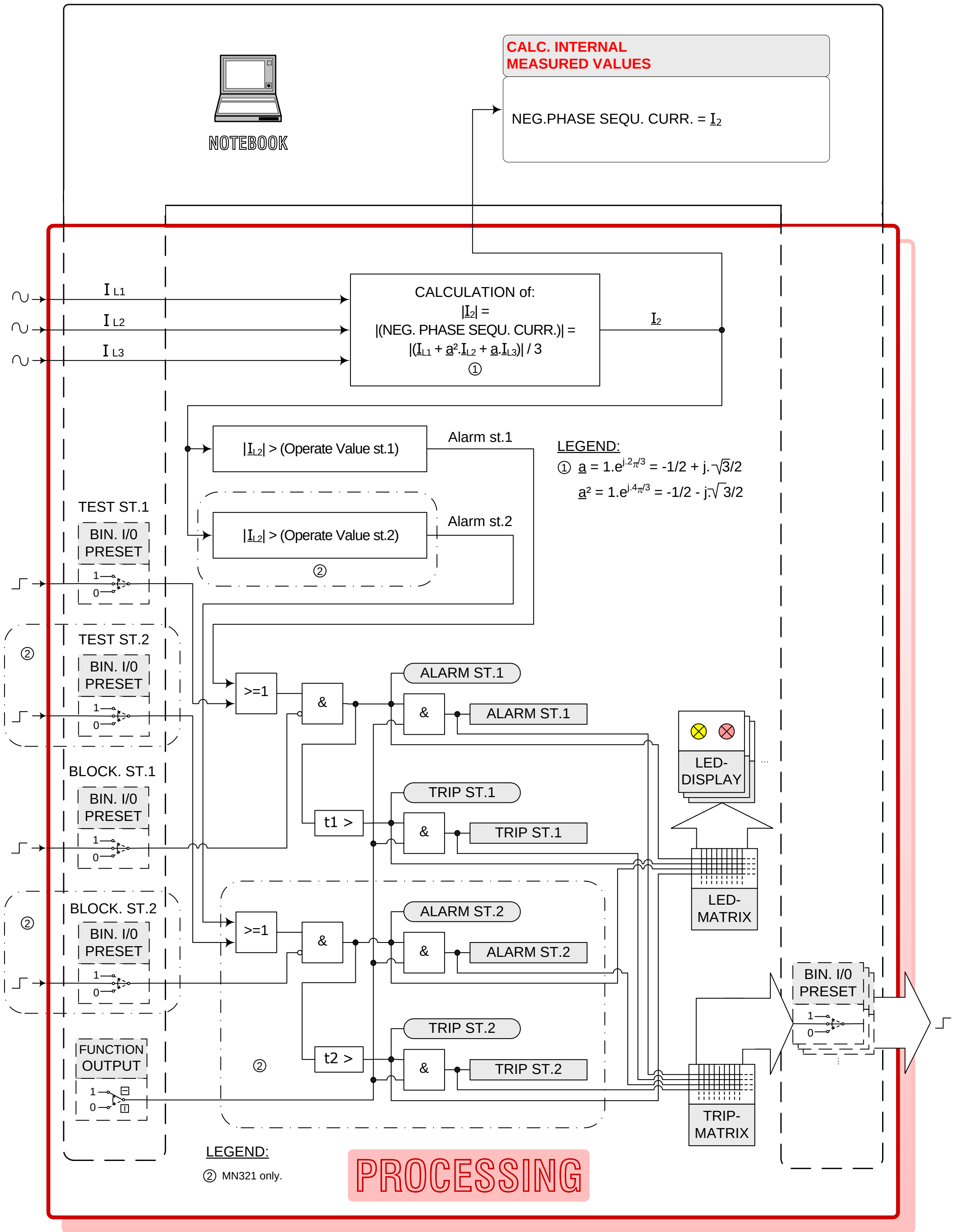
12.4.2. MN311/ MN321



MN311 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM

MN321 NEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM

Fig. 162 MN311 Neg. Phase Sequ. Curr. 1-St. / MN321 Neg. Phase Sequ. Curr. 2-St. Logic Diagram



MN311 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM / PROCESSING
MN321 NEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM / PROCESSING

Fig. 163 MN311 Neg. Phase Sequ. Curr. 1-St. / MN321 Neg. Phase Sequ. Curr. 2-St. Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MN311, MN321

Online simulation via notebook — **CALC. INTERNAL MEASURED VALUES** ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET (1, 0)

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT (1, 0)

Online-simulation of the FUNCTION OUTPUTS of the protective function MN311, MN321
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION of:
$|\underline{I}_2|$ =
|(NEG. PHASE SEQU. CURR.)| =
$|(\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3})| / 3$

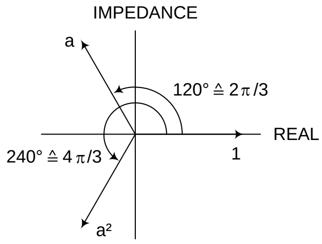
NPS-CURR: I_2.

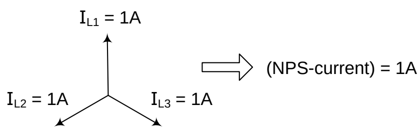
$\underline{I}_2 = (\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3}) / 3$

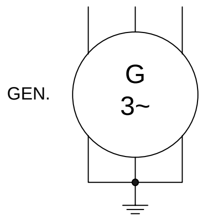
where: $\underline{a} = 1.e^{j.2\pi/3} = -1/2 + j.\sqrt{3}/2$

$\underline{a}^2 = 1.e^{j.4\pi/3} = 1/2 - j.\sqrt{3}/2$

Note: Calibration: 100% NPS confirms 1A

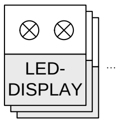






Generator-neutral may be earthed. All 3 phase currents are measured.
$I_0 \neq 0$ is allowed.
Note: If gen. neutral is isolated ® MN211, MN221 may be used as well.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MN311 NEG. PHASE SEQU. CURR. 1-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MN321 NEG. PHASE SEQU. CURR. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 164 MN311 Neg. Phase Sequ. Curr. 1-St. / MN321 Neg. Phase Sequ. Curr. 2-St. Logic Diagram Processing / Legend

12.4.3. MN222

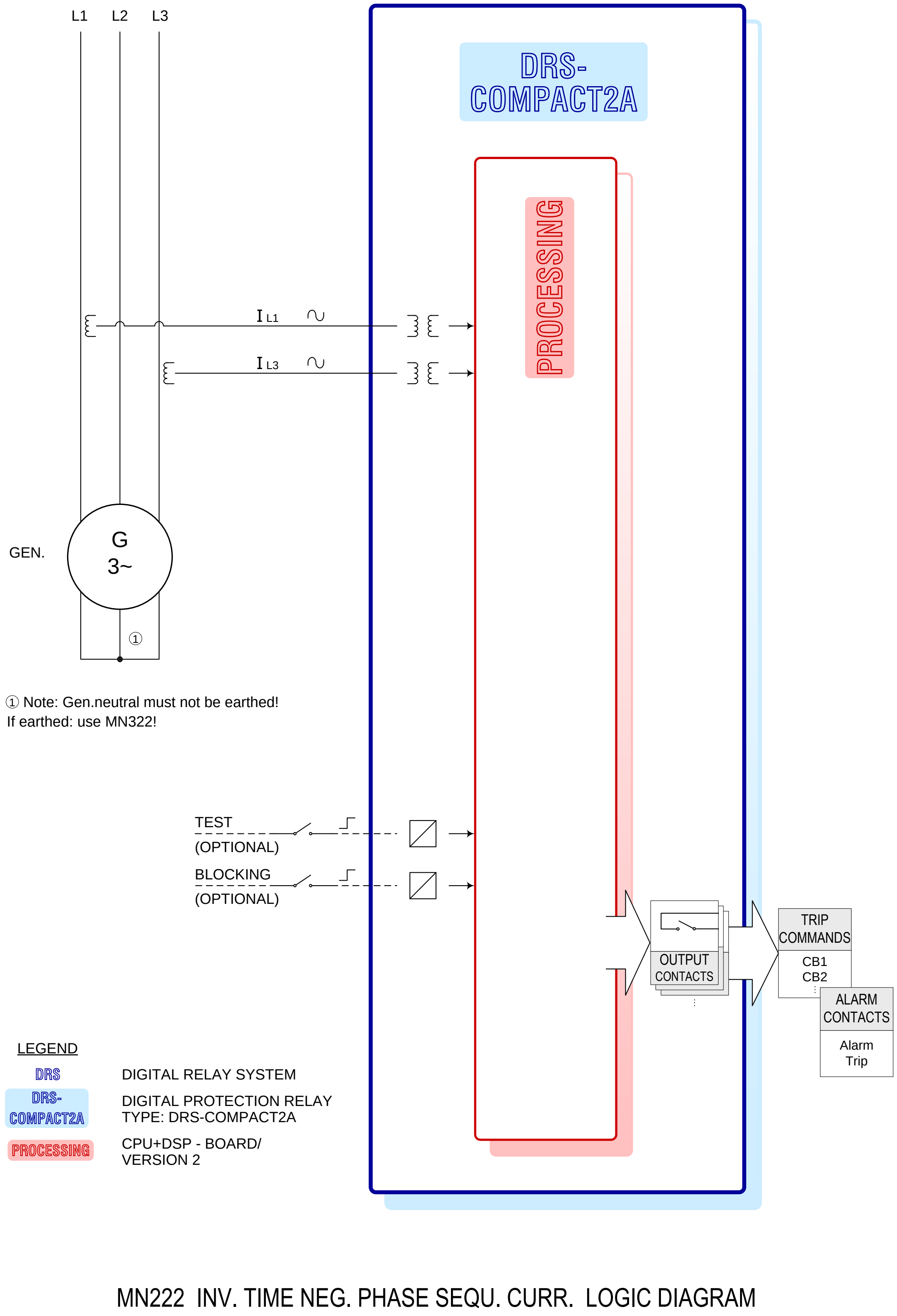
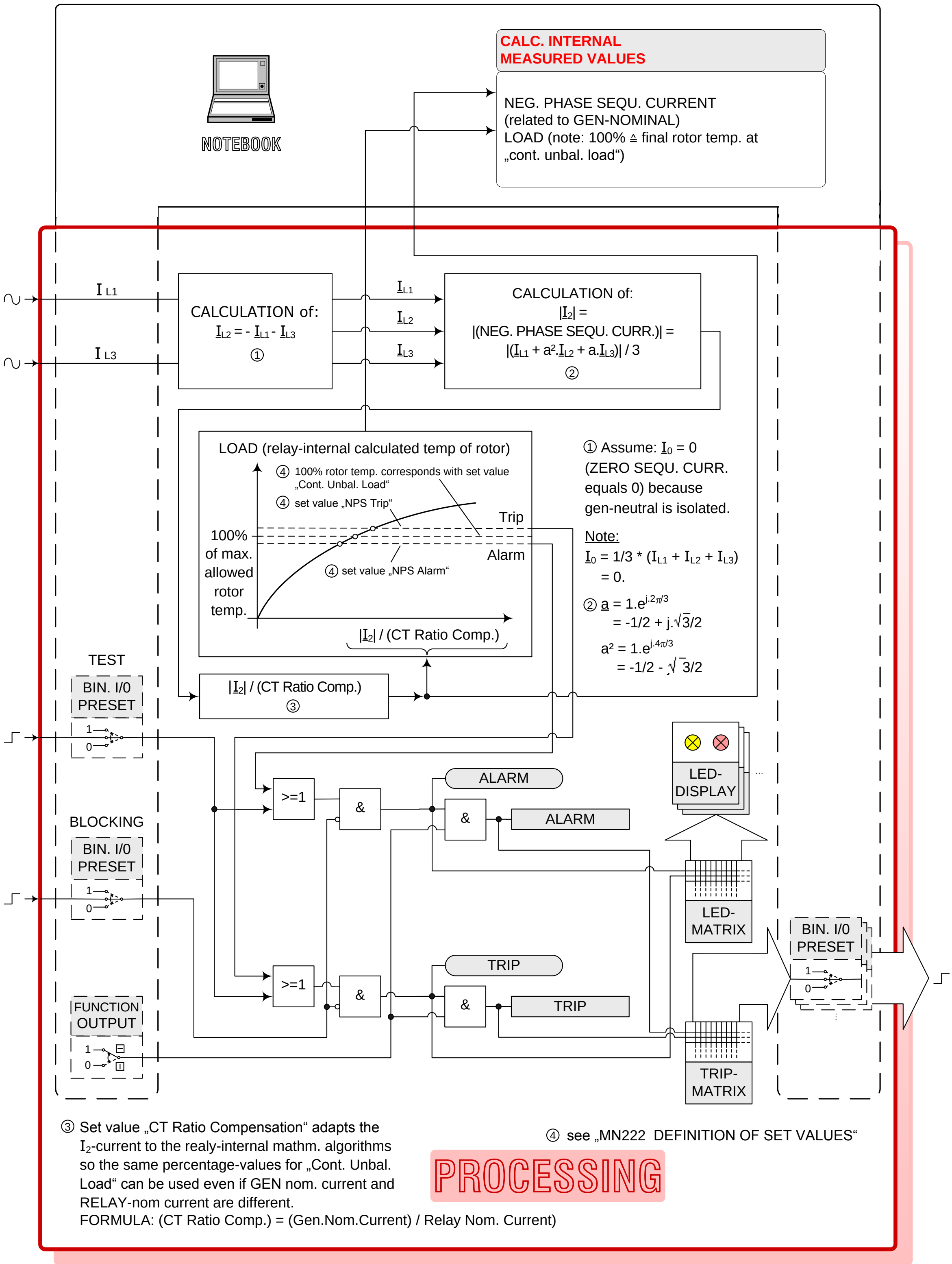


Fig. 165 MN222 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram



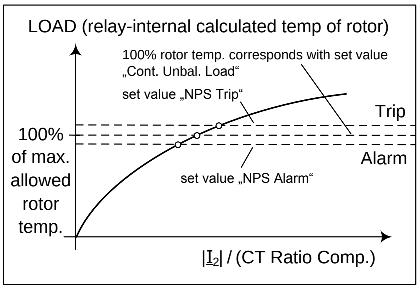
MN222 INV. TIME NEG. PHASE SEQU. CURR. LOGIC DIAGRAM / PROCESSING

Fig. 166 MN222 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MN222

Symbol	Explanation
(notebook)	Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ….. — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"
FUNCTION OUTPUT	Online-simulation of the FUNCTION OUTPUTS of the protective function MN222 – all FUNCTION OUTPUTS enabled (regular-operation) | all FUNCTION OUTPUTS disabled (test-operation)
$\lvert I_{L2}\rvert$ / (CT Ratio Comp)	Explanation: see LOGIC DIAGRAMM/ PROCESSING note ④



I_2-current results in a temperature rise of the gen. rotor
→ = LOAD.

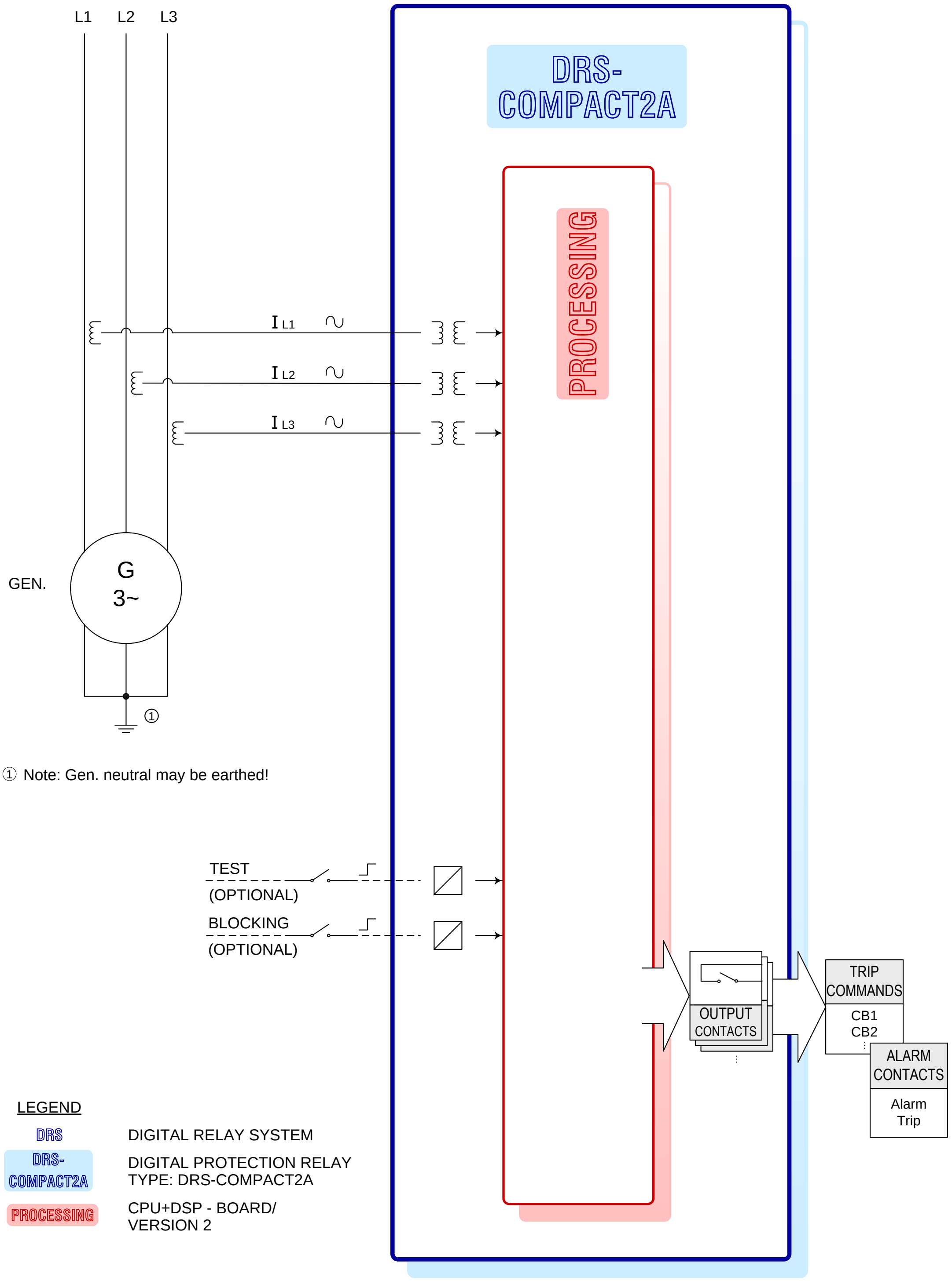
See also: „MN222 DEFINITION OF SET VALUES“

Symbol	Explanation
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
LED-DISPLAY	LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MN222 INV. TIME NEG. PHASE SEQU. CURR. LOGIC DIAGRAM PROCESSING/ LEGEND

Fig. 167 MN222 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram Processing / Legend

12.4.4. MN322



MN322 INV. TIME NEG. PHASE SEQU. CURR. LOGIC DIAGRAM

Fig. 168 MN322 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram

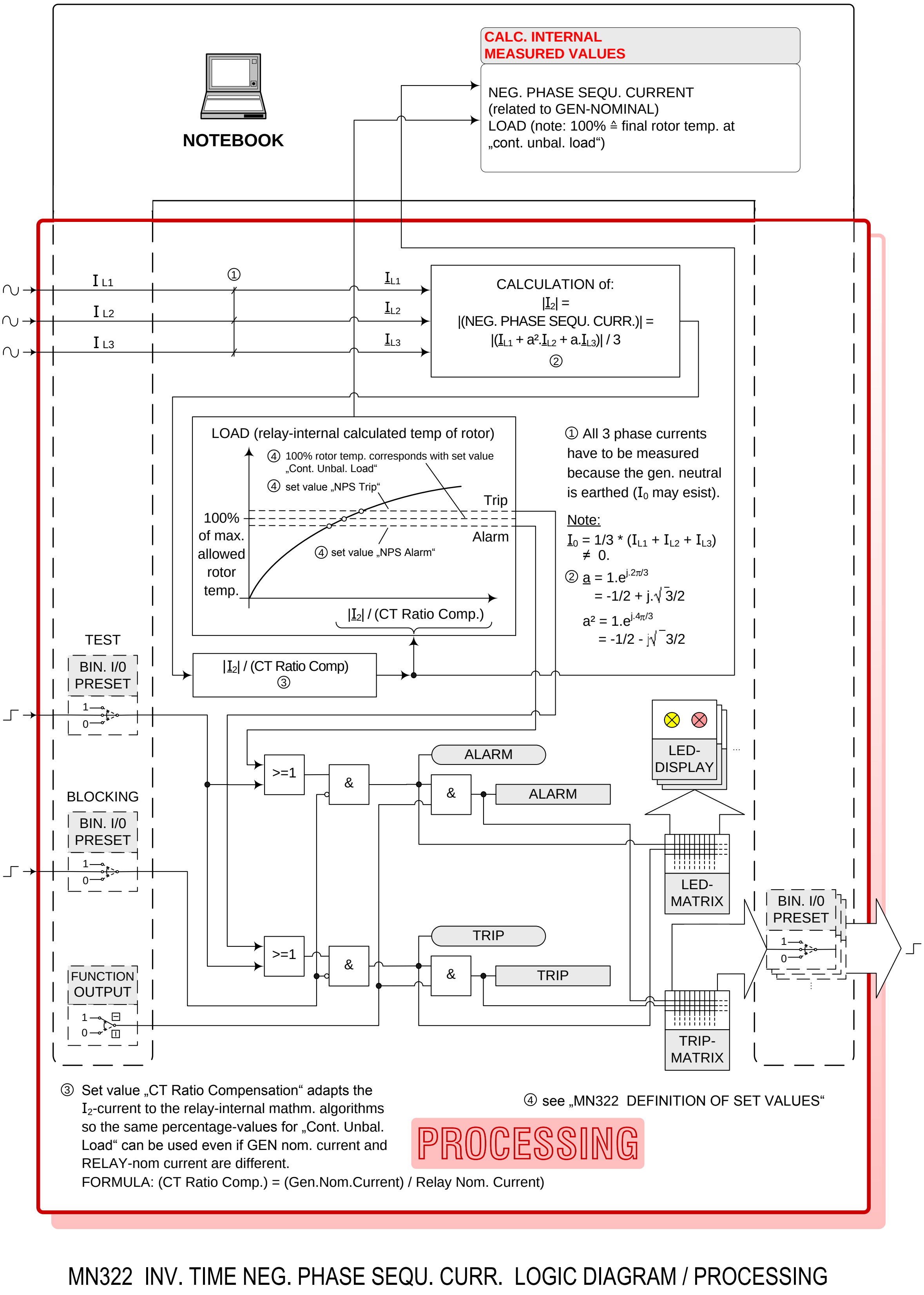


Fig. 169 MN322 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MN322

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

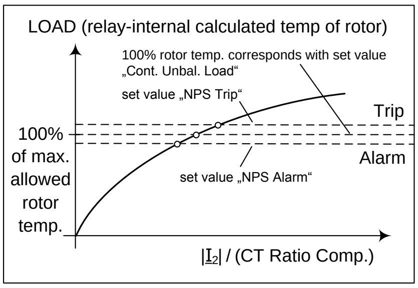
BIN. I/0 PRESET 1 0

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT 1 0

Online-simulation of the FUNCTION OUTPUTS of the protective function MN322
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎅ all FUNCTION OUTPUTS disabled (test-operation)

|I_{L2}| / (CT Ratio Comp) — Explanation: see LOGIC DIAGRAMM/ PROCESSING note



I_2-current results in a temperature rise of the gen. rotor
→ = LOAD.

See also: „MN322 DEFINITION OF SET VALUES“

CAUTION:
LOAD will be set to ZERO if :
1. BLOCK OF FUNCTION
2. SEND PARAMETERS

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING-board (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

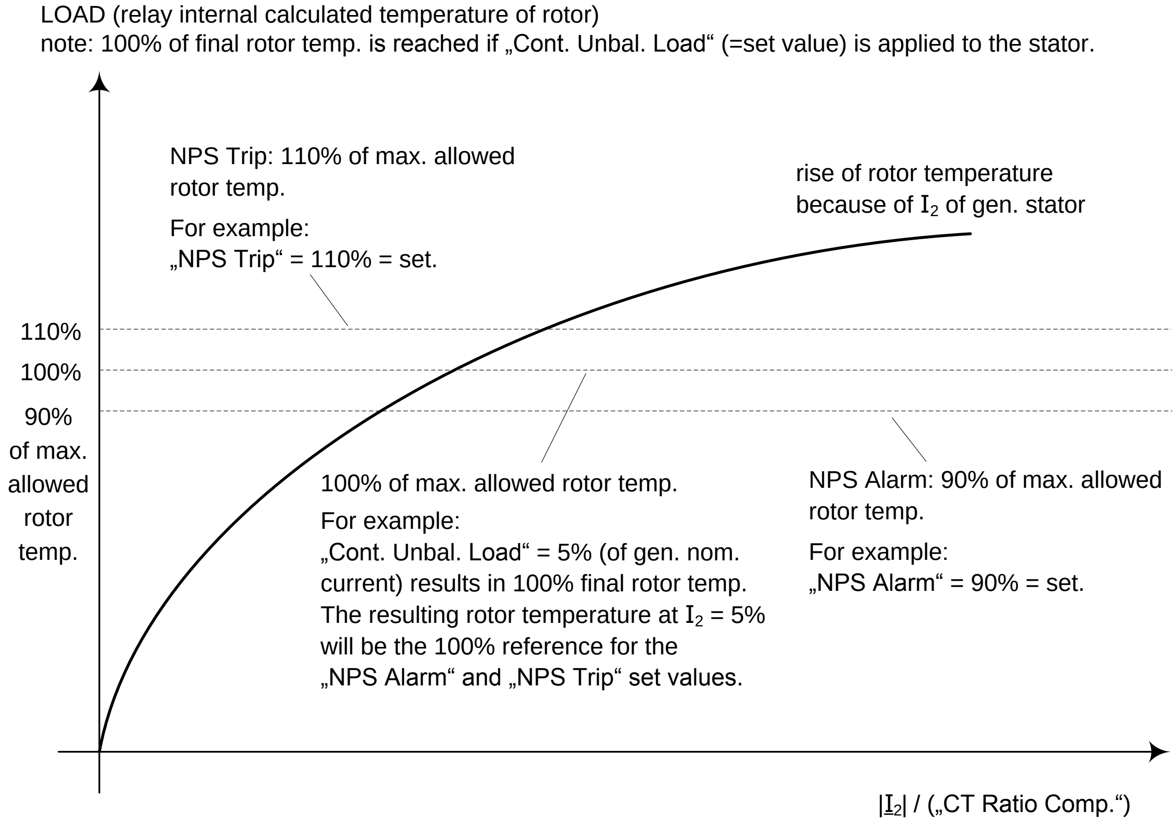
TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MN322 INV. TIME NEG. PHASE SEQU. CURR. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 170 MN322 Inv. Time Neg. Phase Sequ. Curr. Logic Diagram Processing / Legend



EXAMPLE:

Gen. nom. current: 2500A
C.T. nom current: 3000/1A
CT Ratio Comp.: 2500/3000 = 0,8
Max. allowed cont. I_2-current for the gen.: 5% (related to gen. nom. (I_1-) current)

® Settings (example only):

CT Ratio Comp. = 0,8
Cont. Unbal. Load = 5% (≙ 100% final temp. reference)
Time Constant ® acc. to rotor temp. characteristic.
NPS-Alarm: 90% (referred to 100% temp. reference)
NPS-Trip: 110% (referred to 100% temp. reference)

MN322 INV. TIME NEG. PHASE SEQU. CURR. DEFINITION OF SET VALUES

Fig. 171 MN322 Inv. Time Neg. Phase Sequ. Curr. Definition Of Set Values

12.5. FUNCTION

12.5.1. DT Charakteristik: N211/ MN221/ MN311/ MN321

External single pole short circuits in solidly- or low impedance earthed power systems as well as two phase short circuits, transmission line conductor break and faults on circuit breaker poles are causing very high unsymmetrical loading of the generators.
Every unsymmetrical rotating field for high impedance grounded systems can be divided into a positive- and a negative phase sequence current component whereby the negative phase sequence system will induce a rotor current with twice the nominal frequency leading to a non-permissible overheating of the damper winding.
The negative phase sequence protection is evaluating this dangerous situation and is initiating a generator shut down in case of the NPS component is exceeding the permissible value.

To determine the negative phase sequence component the NPS of the generator current is computed. According to the method of the symmetrical components the NPS system is:

$$I_2 = \frac{1}{3}\left(I_{L1} + a^2 I_{L2} + a I_{L3}\right) \qquad \text{and} \quad a = -\frac{1}{2} + j\frac{\sqrt{3}}{2}$$

I_{L1}, I_{L2}, I_{L3}............ Phase currents
I_2............................ Negative phase sequence current

For isolated- and high impedance grounded generator neutrals following formula applies

$$I_{L1} + I_{L2} + I_{L3} = 0$$

and subsequently for the negative phase sequence system.

$$I_2 = \frac{j}{\sqrt{3}}\left(bI_{L1} + I_{L3}\right) \qquad \text{with} \qquad b = \frac{1}{2} - j\frac{\sqrt{3}}{2}$$

For the rotor heating the NPS system value is the major component of the temperature rise.

$$\left|I_2\right| = \frac{1}{\sqrt{3}}\left|bI_{L1} + I_{L3}\right|$$

The factor “b” represents a phase shift of the unit vector by -60° electrical.

Measuring Principle:
All analogue signals of the function are sampled 12 times each cycle. By means of the Fourier Analysis (DSP) the corresponding vectors (value and phase) for the 1^{st} harmonic is computed and transferred to the CPU.

For each sample interval and phase the CPU is evaluating the negative phase sequence component and also for each sample interval the amplitude value regarding the initiating conditions, .i.e. 24 consecutive samples (=2 cycles) above the setting value, is checked and if exceeded the initiation is started and after the set time delay a trip signal is given.
The alarm and any possible trip outputs will reset when during 25 consecutive sample intervals (2 cycles) the initiating conditions are no longer fulfilled (trip output extension).
Note: 37 consecutive samples at DRS-LIGTH and DRS-COMPACT1/VE1.

12.5.2. Inverse Time Characteristic: MN222/ MN322

External single pole short circuits in solidly- or low impedance earthed power systems as well as two phase short circuits, transmission line conductor break and faults on circuit breaker poles are causing very high unsymmetrical loading of the generators.
Every unsymmetrical rotating field for high impedance grounded systems can be divided into a positive- and a negative phase sequence current component whereby the negative phase sequence system will induce a rotor current with twice the nominal frequency leading to a non-permissible overheating of the damper winding.
The negative phase sequence protection is evaluating this dangerous situation and is initiating a generator shut down in case of the NPS component is exceeding the permissible value.

To determine the negative phase sequence component the NPS of the generator current is computed. According to the method of the symmetrical components the NPS system is:

$$\mathbf{I}_2 = \frac{1}{3}\left(\mathbf{I}_{L1} + a^2\mathbf{I}_{L2} + a\mathbf{I}_{L3}\right) \quad \text{with} \quad a = -\frac{1}{2} + j\frac{\sqrt{3}}{2}$$

I_{L1}, I_{L2}, I_{L3}............ Phase currents
I_2............................ Negative phase sequence current

For isolated- and high impedance grounded generator neutrals following formula applies

$$\mathbf{I}_{L1} + \mathbf{I}_{L2} + \mathbf{I}_{L3} = 0$$

And subsequently for the negative phase sequence system

$$\mathbf{I}_2 = \frac{j}{\sqrt{3}}\left(b\mathbf{I}_{L1} + \mathbf{I}_{L3}\right) \quad \text{with} \quad b = \frac{1}{2} - j\frac{\sqrt{3}}{2}$$

For the rotor heating the NPS system value is the major component of the temperature rise.

$$\left|\mathbf{I}_2\right| = \frac{1}{\sqrt{3}}\left|b\mathbf{I}_{L1} + \mathbf{I}_{L3}\right| \qquad (1)$$

The factor “b” represents a phase shift of the unit vector by -60° electrical.

The temperature rise of the rotor, respectively the damper winding itself according to a simplified model is illustrated in the following formula:

$$\vartheta(t) = \vartheta_{Limit}\left(\frac{I_2}{I_{2,0}}\right)^2\left(1 - e^{-\frac{t}{\tau}}\right) \qquad (2)$$

Thereby is

$\vartheta(t)$.... Temperature of the winding at time t after NPS current begin
τ....... Thermal heating time constant of the winding
I_2 .... Negative phase sequence current flow through the winding
$I_{2,0}$ .... Permissible continuous NPS current of the winding
ϑ_{Limit} Maximum temperature rise of the winding with the permissible NPS current which is reached during operation after approximately 4 time constants

Measuring Principle:
All analogue signals of the function are sampled 12 times each cycle. By means of the Fourier Analysis (DSP) the corresponding vectors (value and phase) for the 1st harmonic is computed
and transferred to the CPU.
For each sample interval and phase the CPU is evaluating the negative phase sequence component.

With a simple differential equation the derived temperature rise $\Delta\vartheta$ after each time interval Δt
on the basis of the measured NPS current as well as from the previous temperature value samples is illustrated in the formula below and calculated as follows

$$\Delta\vartheta = \frac{1}{\tau}\left[\vartheta_{Limit}\left(\frac{I_{2,a}}{I_{2,0}}\right)^2 - \vartheta_a\right]\Delta t$$

$I_{2,a}$..... Negative phase sequence current of the sample interval
$I_{2,0}$..... Configured permissible continuous NPS current
ϑ_a...... Temperature of the previous sample interval

After each sample interval the temperature value regarding the initiating conditions, i.e. a value above the operating setting is monitored and when exceeded a 1st stage alarm or a 2nd stage trip output is given.
The alarm and any possible trip outputs will reset when during 25 consecutive sample intervals (2 cycles) the initiating conditions are no longer fulfilled (trip output extension).
Note: 37 consecutive samples at DRS-LIGTH and DRS-COMPACT1/VE1.

12.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

12.6.1. DT Characteristic: N211/ MN221/ MN311/ MN321

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix, LED matrix and the trip matrix have to be configured according to the external circuitry and the plant requirements. Also the function parameters have to be set according to the data of the protected object. For this the generator rating for the negative phase sequence current withstand capability which is obtained from the data sheets of the machine is to be configured in % of the generator nominal current as follows:

$$I_{2,Rel} / \% = I_{2,Gen} / \%. \frac{I_{NG}}{I_{NW}}$$

$I_{2,Rel}/\%$......... Function setting in %

$I_{2,Gen}/\%$....... Generator NPS current in %

I_{NG}................ Generator nominal current

I_{NCT}.............. Primary current rating of the connected CT

The function tests are preferably carried out with the primary plant out of service.

With a relay test set inject the test current into the first phase input and raise the current to produce operation of the function.

Please note that the injected current I_e is shown in the DRS function menu "Actual Measured Values" and the displayed NPS current value I_S is according to the formula below.

$$I_s = \frac{1}{\sqrt{3}} . I_e$$

Record the operating value into the commissioning test sheets.

Reduce the test current until the function resets and note the value into the commissioning test sheets.

The external injected values can be displayed in the User program window.

The same procedure should be applied for the other phases and the measured results noted in the sheets.

Check the alarm- and trip signals and the LED indications according to the parameter settings and the circuit diagrams.

With 1.5 times the setting value check the function operating time for each phase and stage by using a timer and record the values in the commissioning sheets.

A test of the configured function blocking input for each stage should be done in conjunction with a continuous initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal for each stage can be verified without any external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to the plant requirements.

Primary Commissioning Tests:

During the primary tests the function of the protection system is checked under regular service and as far as power system operation permits following tests are recommended:

Short Circuit Test:

Apply a two-pole short circuit of adequate rating located at a position where primary current can flow through the respective CT set.
Disable protection trips.
Insert measuring instruments into the CT circuits and/or open the internal measured values window in the DRS User program.
Run up the generator to rated speed and manually raise excitation until operation of the function, if necessary with reduced setting.
Record operating values.
For multi-stage protective functions also test each stage the same way.
Restore protection trips.
If possible and when power system conditions permit shut down the generator via a live protective function trip and remove the short circuit.

12.6.2. Inverse Time Characteristic: MN222/ MN322

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix, LED matrix and the trip matrix have to be configured according to the external circuitry and the plant requirements. The function parameters are to be set according to the required machine data. At first the “CT Ratio Compensation” has to be determined:

$$\text{Compensation} = \frac{I_G}{I_R}$$

I_G Rated generator current

I_R Nominal current of the protective function

The values for the continuous NPS load and the time constants are to be taken from the machine data sheet specifications. For the alarm- and trip load the required values are configured in % of the temperature limit ϑ_{Limit}.

The function tests are preferably carried out with the primary plant out of service.

With a relay test set inject the test current into the first phase input and raise the current to produce operation of the function.

Please note that the injected current I_e is shown in the DRS function menu "Actual Measured Values" and the displayed NPS current value I_s is according to the formula below.

$$I_s = \frac{1}{\sqrt{3}} . I_e$$

Switch off the test current and operate the RESET key to restore the NPS thermal loading of the negative phase sequence protective function.

CAUTION: The RESET key may only be operated during the secondary injection tests and not during the primary checks since the protective function will have an interrupt which can cause an inadvertent protection trip!

Switch on the pre-adjusted test current again and measure the tripping time delay.

The operating time t_a is calculated according to the formula

$$t_a = \tau . \ln \frac{1}{\left[1 - \left(\frac{I_{2,0}}{I_2}\right)^2\right]} \qquad (6)$$

I_2 Injected negative phase sequence current

$I_{2.o}$ Continuous permissible NPS loading

By injecting following values:

$I_2/I_{2,0} = 3$ ....i.e. the test current is 3 times the nominal current

$$t_a = \tau \times \ln \frac{1}{1-\frac{1}{9}} = \tau \times \ln \frac{9}{8} = \tau \times 0.118$$

Check the load increase via the menu option "Actual Measured Values" in the display window of the DRS function and record the operating time as well as the injected current into the commissioning test sheets.

The same procedure should be applied for the other phases and the measured results noted in the sheets.

Check the alarm- and trip signals and the LED indications according to the parameter settings and the circuit diagrams.

A test of the configured function blocking input for each stage should be done in conjunction with a continuous initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal for each stage can be verified without any external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to system requirements.

Primary Commissioning Tests:

During the primary tests the function of the protection system is checked under regular service and as far as power system operation permits following tests are recommended:

Short Circuit Test:

Apply a two-pole short circuit of adequate rating located at a position where primary current can flow through the respective CT set.
Disable protection trips.
Insert measuring instruments into the CT circuits and/or open the internal measured values window in the DRS User program.
Run up the generator to rated speed and manually raise excitation to verify the NPS current temperature rise according to the configured characteristic.
Record the test results.
Restore protection trips.
If possible and when power system conditions permit shut down the generator via a live protective function trip and remove the short circuit.

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13. MP... POWER

13.1. OVERVIEW

List of the Available MP . . . - Power Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MP . . .	FNNR	TYPE	ANSI	Application
Power, over/under detect., directional, 1 phase, 1 stage	1067	MP111	32	C2,M,L
Real power directional protection, 3 phase, 1 stage	1019	MP311	32	C2,M,L
Real power directional protection, 3 phase, 2 stage	1020	MP321	32	C2,M,L
Reverse power protection, 1 phase, 1 stage	1129	MP112	32	C2,M
Reverse power protection, 3 phase, 1 stage	1021	MP312	32	C2,M,L
Power measuring, 1 phase	1083	MP101	32	C2,M,L
Power measuring, 3 phase	1082	MP301	32	C2,M,L

13.2. TECHNICAL DATA

13.2.1. Active Power Protection 1 Phase, 1 Stage

PROTECTIVE FUNCTION: MP111	FNNR	TYPE	ANSI	Application
Power, over/under detect., directional, 1 phase, 1 stage	1067	MP111	32	C2,M,L

1 phase, 1 stage DT delayed power function selectable for over- or under detection.

MP111
Technical Data

Inputs

Analogue:	Current
	Voltage
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 150 % in 1 % steps
Operating time:	0 ... 600 s in 0.1 s steps
Power direction:	Direction 1/Direction 2
Type:	Over/under detection
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal
Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% of current

13.2.2. Active Power Protection 3 Phase, 1 Stage

PROTECTIVE FUNCTION: MP311	FNNR	TYPE	ANSI	Application
Real power directional protection, 3 phase, 1 stage	1019	MP311	32	C2,M,L

3 phase, 1 stage DT delayed power function selectable for over- or under detection.

MP311
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltages input system 12
	Voltages input system 23
	Voltages input system 31
Binary:	Blocking input
	Blocking input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 150 % in 1 % steps
Operating time:	0 ... 600 s in 0.1 s steps
Power direction:	Direction 1/Direction 2
Type:	Over/under detection
Phase rotation:	Right/Left
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal
Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current

13.2.3. Active Power Protection 3 Phase, 2 Stage

PROTECTIVE FUNCTION: MP321	FNNR	TYPE	ANSI	Application
Real power directional protection, 3 phase, 2 stage	1020	MP321	32	C2,M,L

3 phase, 2 stage DT delayed power function selectable for over- or under detection per stage.

MP321
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltages input system 12
	Voltages input system 23
	Voltages input system 31
Binary:	Blocking input stage 1
	Blocking input stage 1
	Blocking input stage 2
	Blocking input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Power direction:	Direction 1/Direction 2
Operating value stage 1:	2 ... 150 % in 1 % steps
Operating time stage 1:	0 ... 600 s in 0.1 s steps
Type stage 1:	Unter-Erfassung/Über-Erfassung
Operating value stage 2:	2 ... 150 % in 1 % steps
Operating time stage 2:	0 ... 600 s in 0.1 s steps
Type stage 2:	Unter-Erfassung/Über-Erfassung
Phase rotation:	Right/Left
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current

13.2.4. Reverse Power Protection 1 Phase, 1 Stage

PROTECTIVE FUNCTION: MP112	FNNR	TYPE	ANSI	Application
Reverse power protection, 1 phase, 1 stage	1129	MP112	32	C2,M

1 phase, 1 stage DT delayed power function for reverse power detection.

MP112
Technical Data:

Inputs

Analogue:	Current
	Voltage
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	-5,0 ... –0.2 % in 0.1 % steps
Operating time:	0 ... 180 s in 0.1 s steps
Power direction:	Direction 1/Direction 2
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current

13.2.5. Reverse Power Protection 3 Phase, 1 Stage

PROTECTIVE FUNCTION: MP312	FNNR	TYPE	ANSI	Application
Reverse power protection, 3 phase, 1 stage	1021	MP312	32	C2,M,L

3 phase, 1 stage DT delayed power function for reverse power detection.

MP312
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltages input system 12
	Voltages input system 23
	Voltages input system 31
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	-5,0 ... –0.2 % in 0.1 % steps
Operating time:	0 ... 180 s in 0.1 s steps
Power direction:	Direction 1/Direction 2
Type:	Unter-Erfassung/Über-Erfassung
Phase rotation:	Right/Left
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal
Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current

13.2.6. Power Measuring 1 Phase

PROTECTIVE FUNCTION: MP101	FNNR	TYPE	ANSI	Application
Power measuring, 1 phase	1083	MP101		C2,M,L

1 phase power measuring function for railway traction without outputs.

MP101
Technical Data:

Inputs

Analogue:	Current
	Voltage

Outputs

Analogue:	Power (analogue output of internal measured value)

Setting Parameters

Power direction:	Direction 1/Direction 2
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Accuracy:	≤ 3% of setting value or ≤ 2% of current

13.2.7. Power Measuring 3 Phase

PROTECTIVE FUNCTION: MP301	FNNR	TYPE	ANSI	Application
Power measuring, 3 phase	1082	MP301		C2,M,L

3 phase power measuring function without outputs.

MP301
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltages input system 12
	Voltages input system 23
	Voltages input system 31

Outputs

Analogue:	Power (analogue output of internal measured value)

Setting Parameters

Power direction:	Direction 1/Direction 2
Phase rotation:	Right/Left
CT error compensation :	-10 ... +10 deg. in 0.1 deg. steps

Window Display for Relay Internal Determined and Computed Values

Apparent power:	In VA
Real power:	In W
Reactive power:	In VAr
cos phi:	-

Measuring

Accuracy:	≤ 3% of setting value or ≤ 2% of current

13.3. CONNECTION DIAGRAMS

13.3.1. MP312

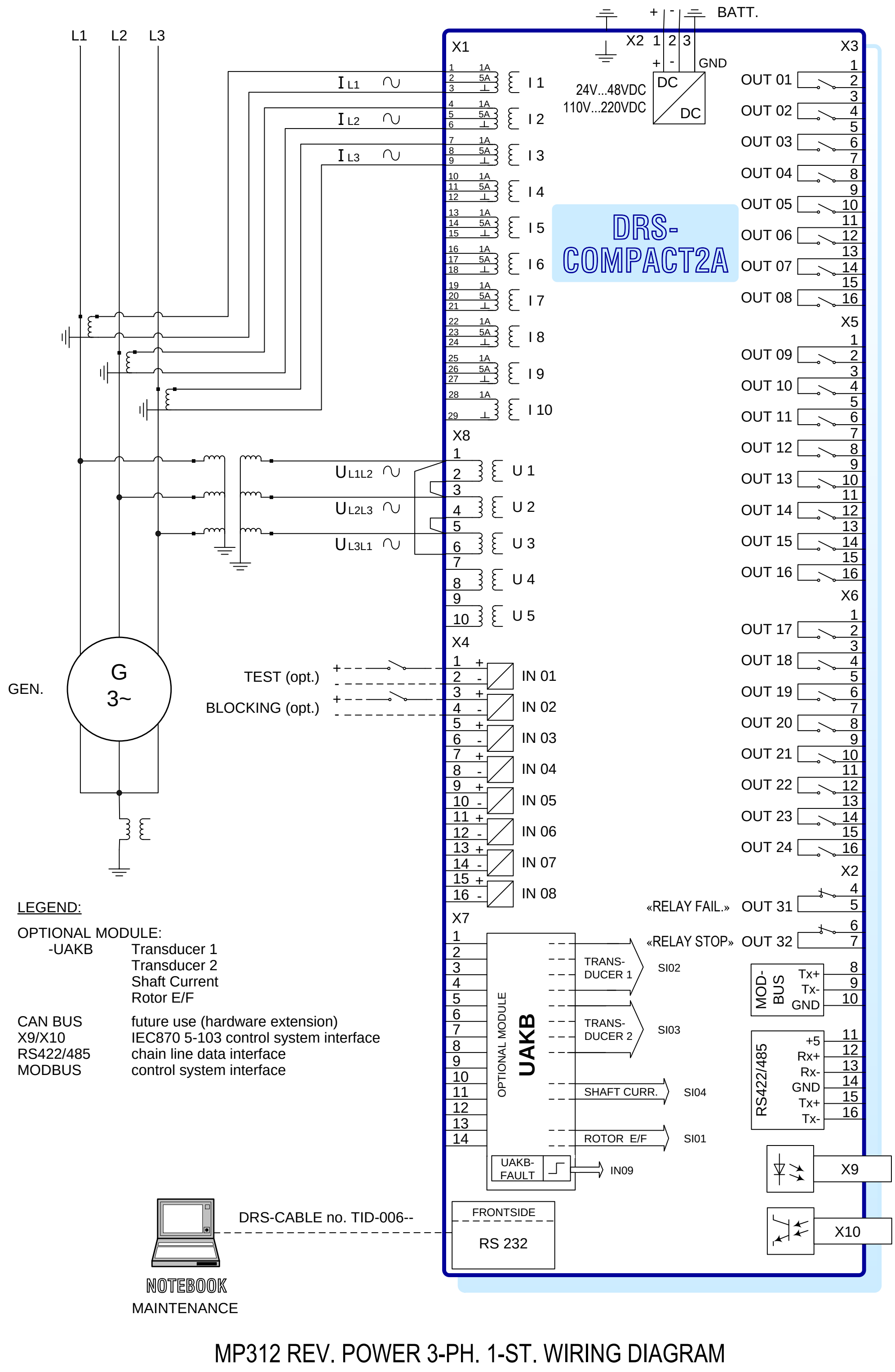
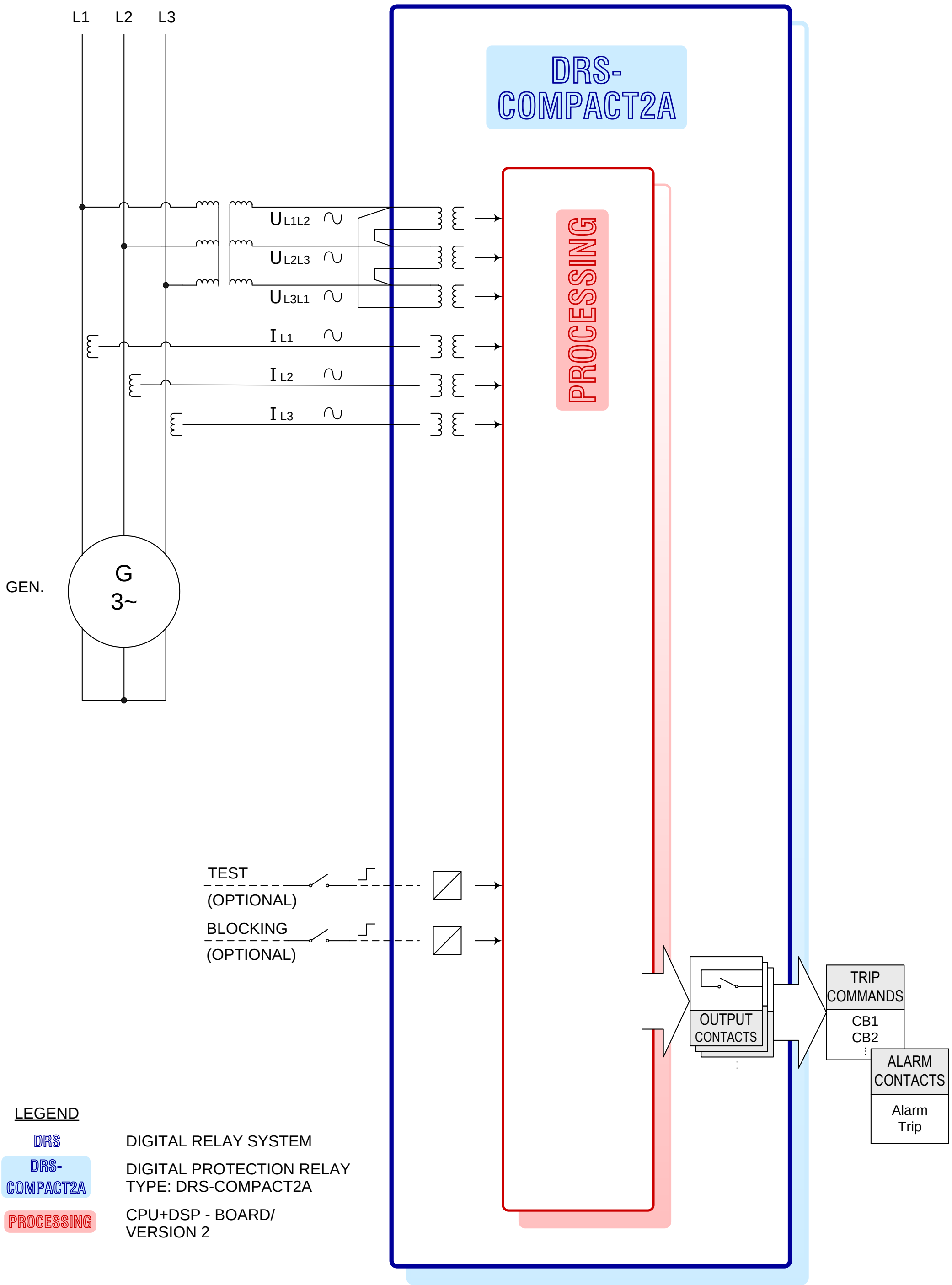


Fig. 172 MP312 Rev. Power 3-PH. 1-St. Wiring Diagram

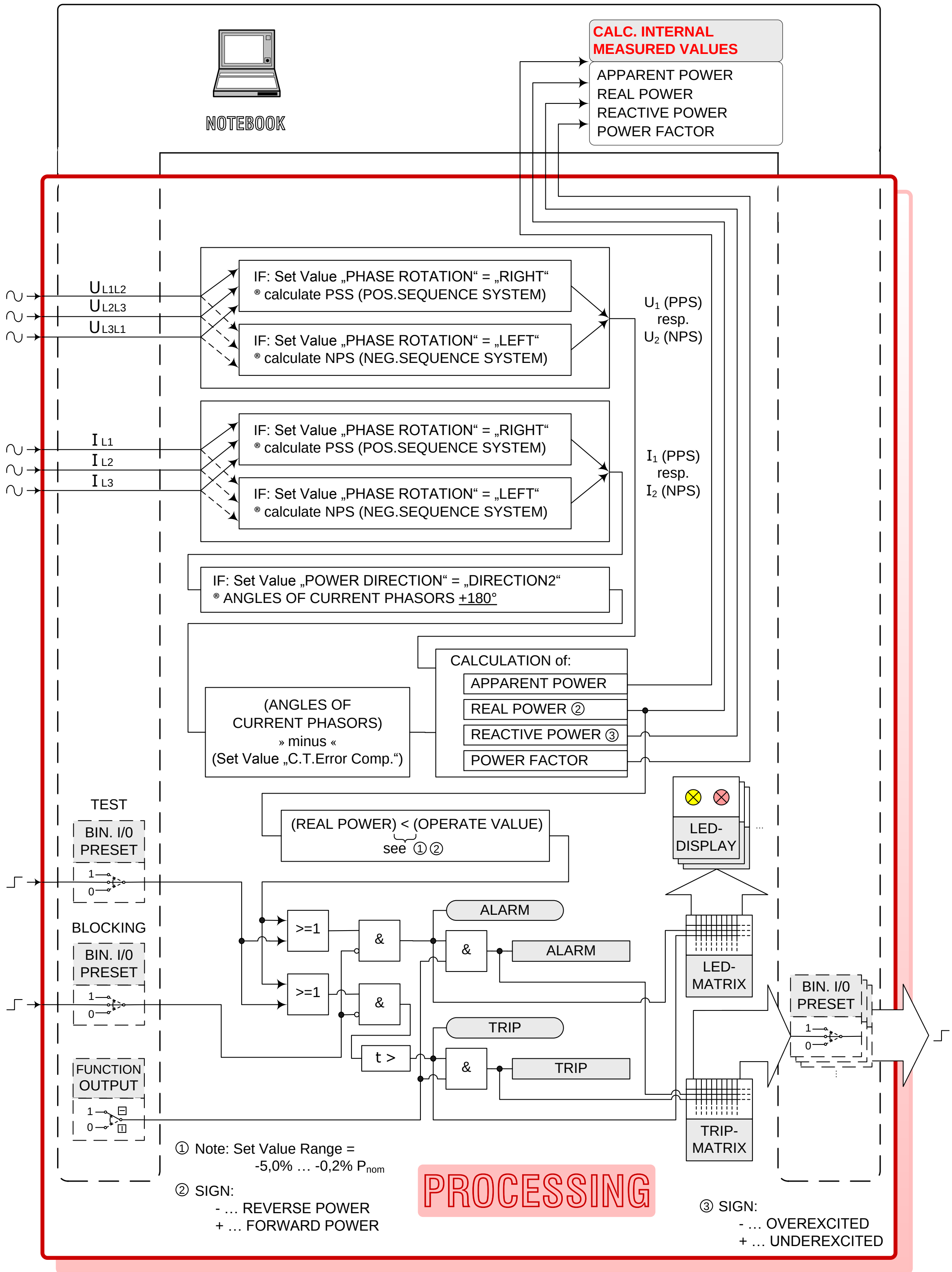
13.4. LOGIC DIAGRAMS

13.4.1. MP312



MP312 REV. POWER 3-PH. 1-ST. LOGIC DIAGRAM

Fig. 173 MP312 Rev. Power 3-PH. 1-St. Logic Diagram

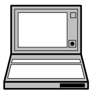


MP312 REV. POWER 3-PH. 1-ST. LOGIC DIAGRAM / PROCESSING

Fig. 174 MP312 Rev. Power 3-PH. 1-St. Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MP312



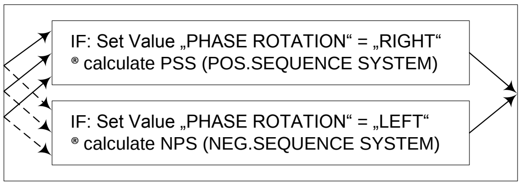
Online simulation via notebook | **NOTEBOOK DISPLAY** ..... | Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT

Online-simulation of the FUNCTION OUTPUTS of the protective function MD321
- — all FUNCTION OUTPUTS enabled (regular-operation)
- | all FUNCTION OUTPUTS disabled (test-operation)



The „Rev. Power“-protection MP312 utilizes the „POSITIVE SEQUENCE SYSTEM“ (condition: „PHASE ROTATION“ = right). If „PHASE ROTATION“ = left ® NEG. PHASE SYSTEM has to be calculated in order to get a correct result.

IF: Set Value „POWER DIRECTION“ = „DIRECTION2“
® ANGLES OF CURRENT PHASORS +180°

During normal operation forward power of generator the NOTEBOOK DISPLAY-window should show a positive ACTIVE POWER-value. If not: please change set value „POWER DIRECTION“ from „Direction 1“ to „Direction 2“. Note: This feature spares you to change the wiring of the C.T.

(ANGLES OF CURRENT PHASORS) » minus « (Set Value „C.T.Error Comp.“)

This feature cmpensates for C.T.-errors.

How to choose the set value:

a) Generator synchronized to grid

b) Close turbine (max. reverse power) and adjust excitation in such way that REACTIVE POWER becomes zero.
Read the indicated value on the notebook screen „REAL POWER“ (it shows a neg. value).

c) Increase the REACTIVE POWER by increasing the excitation. Change the set value „C.T.Error Comp.“ until you get the same indication for „REAL POWER“ as noticed at (b).

(REAL POWER) < (OPERATE VALUE)

Please note:

Sign of REAL POWER:
- \+ … forward power
- \- … reverse power

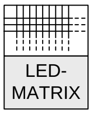
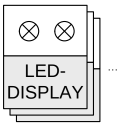
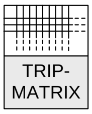
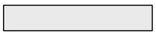
… ./.

MP312 REV. POWER 3-PH. 1-ST. LOGIC DIAGRAM PROCESSING / LEGEND page 1/2

Fig. 175 MP312 Rev. Power 3-PH. 1-St. Logic Diagram Processing / Legend page1/2

… ./. (cont.)

LEGEND PROCESSING

CALCULATION of: APPARENT POWER / REAL POWER / REACTIVE POWER / POWER FACTOR	Please note: If you choose to see these DRS internal calculated values as „Secondary Values“ (=standard) then the %-numbers are referred to relay nom.values.
 LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
 LED-DISPLAY	LED-indications of PROCESSING (row 2...14)
 TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: 78 Alarm
TRIP	FUNCTION OUTPUT: 78 Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MP312 REV. POWER 3-PH. 1-ST. LOGIC DIAGRAM PROCESSING / LEGEND page 2/2

Fig. 176 MP312 Rev. Power 3-PH. 1-St. Logic Diagram Processing / Legend page 2/2

13.5. FUNCTION

Directional- and Reverse Power

Directional power functions can be integrated into a protective scheme for various application possibilities according to plant requirements.
As a maximum power protection to evaluate over power conditions by increasing water head and/or non-permissible opening of the turbine regulator in generator mode.
As pump power monitoring in conjunction with a frequency function in pump storage systems.
As reverse power protection for water power machines with a higher operating value or as very sensitive adjustable functions in case of steam turbine sets.
As minimum power protection in pump storage systems to guard against non-permissible closure of the guide vanes by the governor control to prevent turbulences with subsequent dangerous overheating in the spiral casing.
With the method of the symmetrical components it can be derived that the power computation of a three phase system can be reduced to the evaluation of the positive sequence power only.
The algorithm of the directional power- and reverse power function therefore determines from the 12 samples each cycle the positive phase sequence component of the current I_1, respectively the voltage V_1 according to the formulas

$$I_1 = I_{L1} + a^2 I_{L2} + a I_{L3}$$

$$V_1 = V_{L1L2} + a^2 V_{L2L3} + a V_{L3L1}$$

Measuring Principle:

All analogue signals of the function are sampled 12 times each cycle and from this with the Fourier Analyses (DSP) the corresponding vectors, i.e. value and phase angle, for the 1st harmonic are computed and transferred to the CPU.

At each sample interval the CPU determines the values for apparent power, real power, reactive power and cosφ thereby checking whether the computed real power value is approaching the setting either in the under- or over detecting mode according to configuration.
When the operating conditions are fulfilled during 24 consecutive samples (= 2 cycles) the initiating signal for the directional power function is given and the time delay started.
The special sensitive function applicable for steam turbine sets requires a longer averaging of the measured value until the initiation is started due to the very low setting configuration.
After expiry of the set time delay the trip signal output is activated whereby the DT characteristic is operating independent from the signal value.
Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

13.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Real- and Reverse Power

Pre-Commissioning:

At first the correct external connections have to be verified.

Also the function parameters have to be set according to the data of the protected object whereby it should be considered that for the operating value P_E a calibration has to be carried out according to the formula below.

$$P_E(\%) = \frac{P_B}{P_N}$$

Thereby is

P_B	Primary power operating value in kW
P_N	Primary function power rating in kW

According to the function requirements an over- or under evaluation is to be selected.

The input matrix, LED matrix and the trip matrix have to be configured according to the external circuitry and the plant requirements.

Function tests are preferably performed with the primary plant out of service.

In case of a 3 phase relay test set is available the external test connections have to be made according to the configured input matrix of the protective scheme.
Inject three phase symmetrical current and voltage and regulate the test voltage up to nominal rating.
The measured power by the function can be displayed via the option "Actual Measured Values" and compared with the injected power values.
A wrong power direction can either be corrected by changing the polarity of the external CT connections or by setting the function parameter "Current Direction" in the opposite way.
An incorrect phase rotation can either be rectified by crossing the external VT connections or by modifying the "Phase Rotation" parameter.

The power value is now adjusted in the operating direction by changing the test current or the phase angle accordingly whereby any possible external blocking inputs should be disabled.
Enter the results into the commissioning test sheets.

The "Actual Measured Values" display of the real power $P_m(\%)$ is related to the injected current I and voltage V according to following formula:

$$P_m(\%) = \sqrt{3}\frac{V \times I}{V_N \times I_N}\cos\varphi$$

I_N Function rated current
V_N Function rated voltage

Alter the injected value to the function reset direction and record the reset value in the test sheets.

To check the function with a single phase test set inject the current into, say phase L1 and the voltage into system 1 and adjust the values in the operating direction accordingly whereby any possible external blocking inputs should be disabled.
The relation between the injected quantities V and I and the displayed real power value P_m(%) is as follows:

$$P_m(\%) = \frac{V \times I}{6 \times V_N \times I_N} \cos\varphi$$

I_N Function rated current
V_N Function rated voltage

Note the operating value in the commissioning sheets.

Change the injected value to the function reset direction and record the reset value in the test sheets.

Please consider that all external measured values can internally be displayed in the User program.

Carry out the same checks for the other phases and stages and record the values obtained in the test sheets.

Check the trip and alarm signals, respectively the LED indications according to the parameter settings and the circuit diagrams.

Check the operating time at 1.1 times the setting for each phase and stage with a suitable timer and enter the results into the test sheets ein.

Check the configured function blocks for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test feature for each stage by initiating the test signal and the protective function, respectively the stage has to operate without any external current input.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters must be re-configured to the original plant parameter settings.

Primary Commissioning Tests:

During primary tests the function of the protection system is verified during the plant in service and following check should be carried out when operating conditions permit:

- On-Load Checks:

Block protection trips of the directional power function.
Insert measuring instruments, e.g. a Wattmeter, into the CT/VT circuits and/or display the internal measured values in the User program.
Start up the generator, synchronise to the power system and load the unit.
Via the menu option "Actual Measured Values" compare the power readings with the measurements of the Wattmeter or Control Room instrument.
Configure the function with the parameter "Current Direction" or "Phase Rotation" to the actual external connections.
If necessary re-adjust the measured value via the “CT Error Compensation” parameter.
Raise or lower the generator power output in the operating direction.
Possibly reduce the operating value for these tests and disable any external blocking inputs.
Record the operating values into the test sheets.
For multistage functions proceed in a similar way with the other stages.
Restore the original parameter settings and re-activate the trip outputs of the power function.
If system conditions permit shut down the unit via a protection trip.

14. MP... SUDDEN LOAD LOSS

14.1. OVERVIEW

List of the Available MP . . . – Sudden Load Loss Protective Function

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MP . . .	FNNR	TYPE	ANSI	Application
Sudden load loss interlock	1084	MP319	32	C2,M,L

14.2. TECHNICAL DATA

14.2.1. Sudden Load Loss Function

PROTECTIVE FUNCTION: MP319	FNNR	TYPE	ANSI	Application
Sudden load loss interlock	1084	MP319	32	C2,M,L

3 phase, 1 stage sudden load loss function with blocking provisions during unsymmetrical load currents.

MP319
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip
	NPS load interlock

Setting Parameters

Monitoring time:	0.02 ... 10.00 s in 0.02 s steps
Impedance circle R1:	5 ... 99 Ohm in 0.1 Ohm steps
Impedance ring R1-R2:	1 ... 99 Ohm in 0.1 Ohm steps
NPS load:	10 ... 20 % in 0.5 % steps
Blocking time:	0.1 ... 30 s in 0.1 s steps
Phase rotation:	Right / Left

Window Display for Relay Internal Determined and Computed Values

System impedance:	In Ohm
NPS load:	In %
Delay time in progress:	Yes / No

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current

14.3. CONNECTION DIAGRAMS

14.3.1. MP319

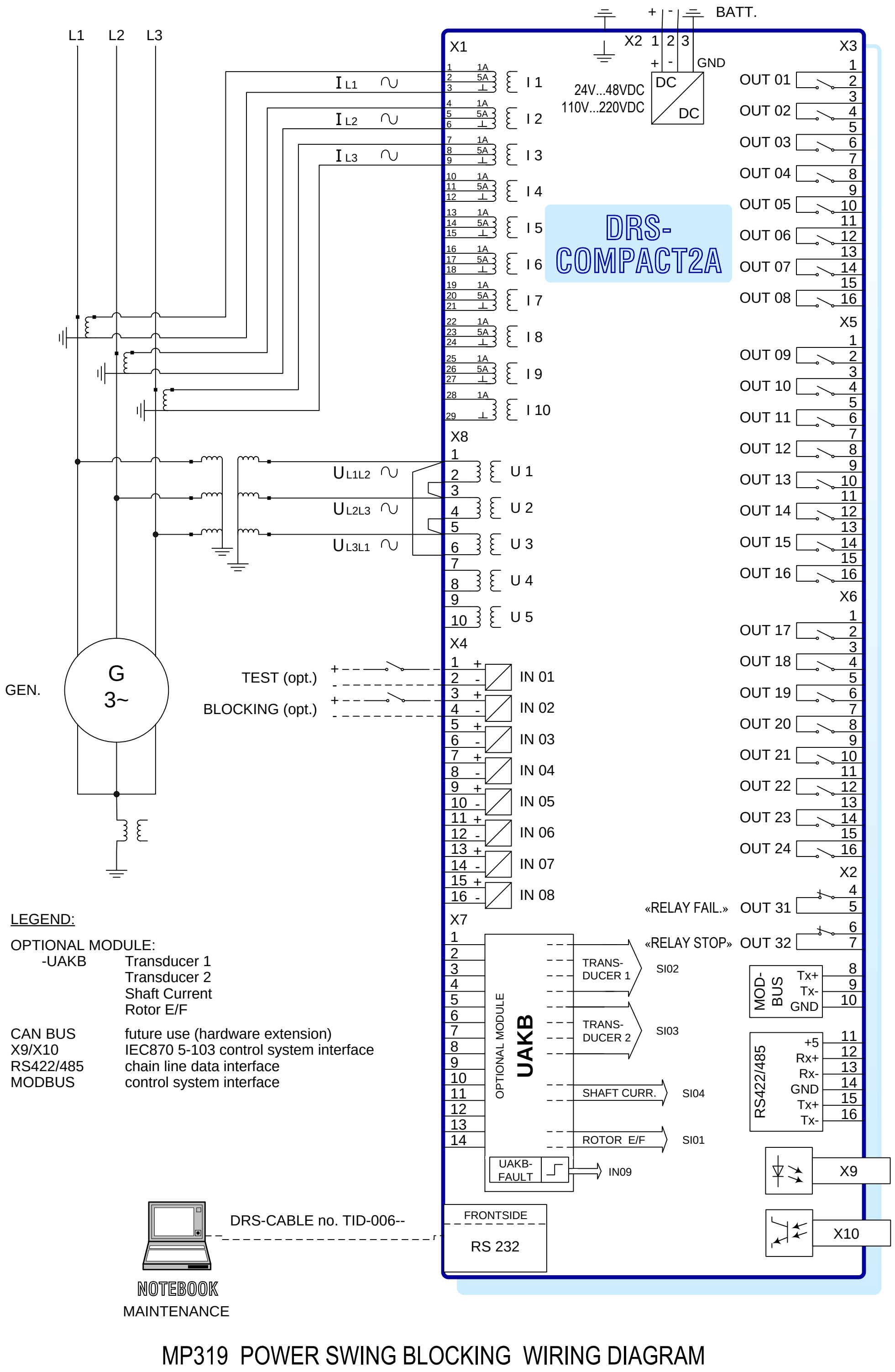


Fig. 177 MP319 Power Swing Blocking Wiring Diagram

14.4. LOGIC DIAGRAMS

14.4.1. MP319

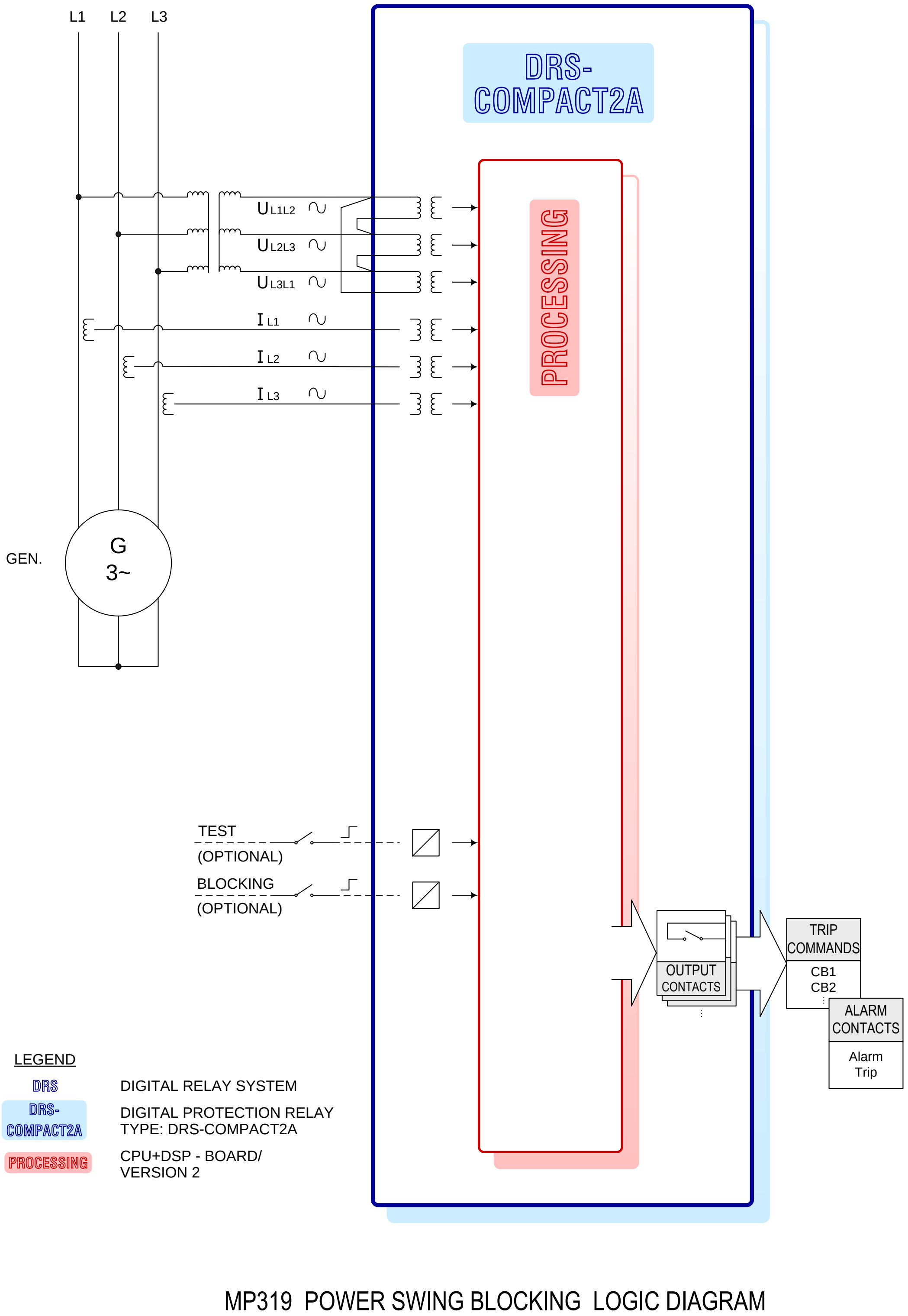
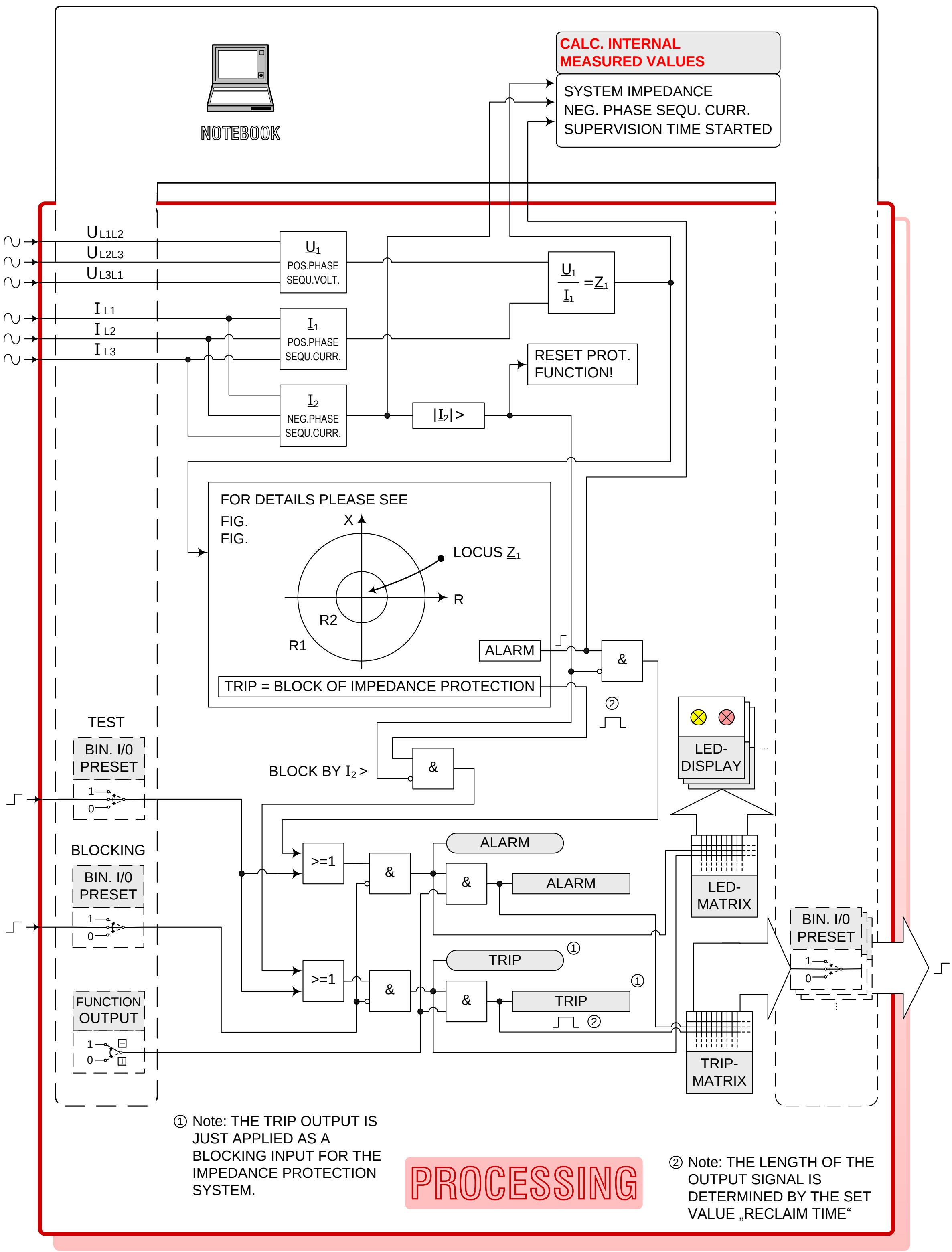


Fig. 178 MP319 Power Swing Blocking Logic Diagram



MP319 POWER SWING BLOCKING LOGIC DIAGRAM / PROCESSING

Fig. 179 MP319 Power Swing Blocking Logic Diagam /Processing

LEGEND PROCESSING

SOFTWARE-MODULE: MP319

Online simulation via notebook | CALC. INTERNAL MEASURED VALUES ….. | Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET (1, 0)

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET – regular function; BIN. I/0 PRESET – always „1"; BIN. I/0 PRESET – always „0"

FUNCTION OUTPUT (1, 0)

Online-simulation of the FUNCTION OUTPUTS of the protective function MD321
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

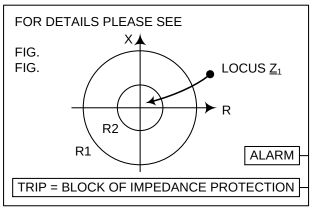
$\underline{I}_1$ POS.PHASE SEQU.CURR. — Calculation of „POSITIVE PHASE SEQUENCE CURRENT“ $\underline{I}_1 = (\underline{I}_{L1} + a.\underline{I}_{L2} + a^2.\underline{I}_{L3}) / 3$

$\underline{I}_2$ NEG.PHASE SEQU.CURR. — Calculation of „NEGATIVE PHASE SEQUENCE CURRENT“ $\underline{I}_2 = (\underline{I}_{L1} + a^2.\underline{I}_{L2} + a.\underline{I}_{L3}) / 3$

$\underline{U}_1$ POS.PHASE SEQU.VOLT. — Calculation of „POSITIVE PHASE SEQUENCE VOLTAGE“ $\underline{U}_1 = (\underline{U}_{L1L2} + a.\underline{U}_{L2L3} + a^2.\underline{U}_{L3L1}) / 3$

$|\underline{I}_2|>$ — Check $|\underline{I}_2|>$ set

$\frac{\underline{U}_1}{\underline{I}_1} = \underline{Z}_1$ — Calculation of impedance vector $\underline{Z}_1$



Check sequence and timing of LOCUS-trajectory.
Make trip decision.
For details please see:

Fig. …
Fig. …

RESET PROT. FUNCTION! — Protective Function MP319 is resetted if [NPS-current > set] is detected because the „Power Swing“-procedure is agreed to be a symmetrical phenomenon.

78MHO ALARM — Alarm-output of function 78MHO: alarm starts when $\underline{Z}_1$ crosses the vertical blinder R1.

78MHO TRIP — Trip-output of function 78MHO: trip when $\underline{Z}_1$ crosses vertical blinder R2 resp. when $\underline{Z}_1$ enters the inner circle.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

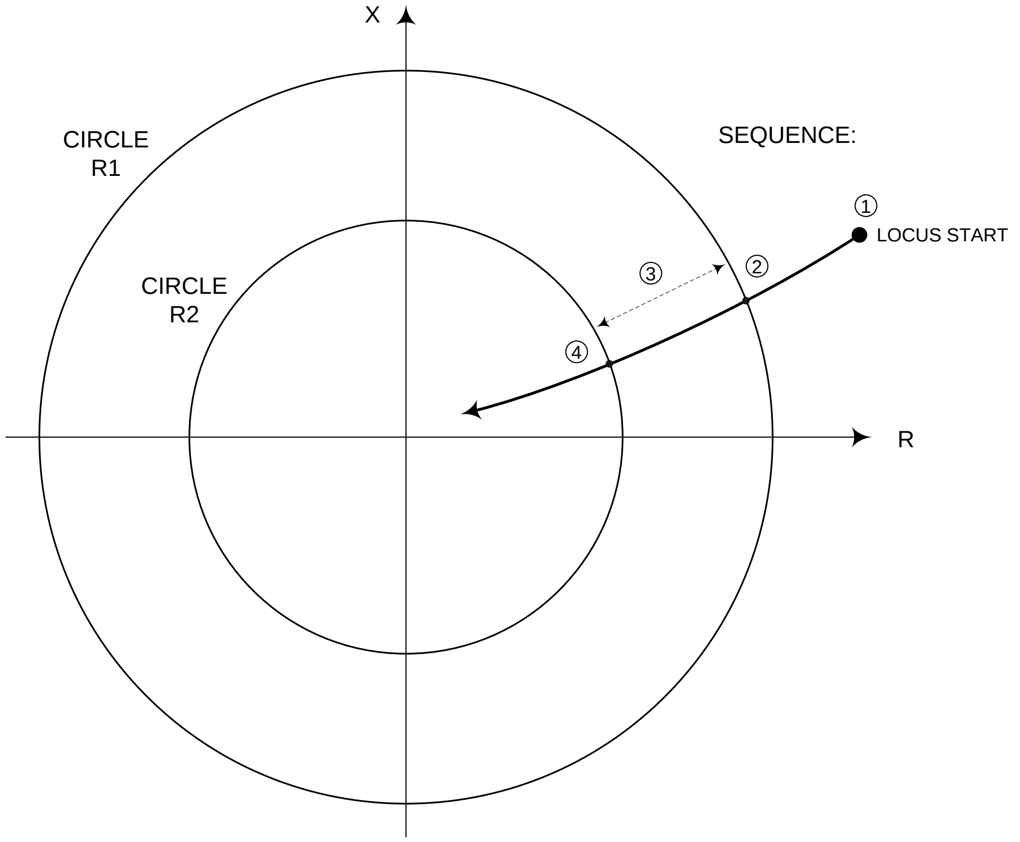
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MP319 POWER SWING BLOCKING LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 180 MP319 Power Swing Blocking Logic Diagram Processing / Legend

IMPEDANCE DIAGRAM:



LEGEND:

① LOCUS AT NORMAL OPERATION OF GENERATOR

② LOCUS ENTERS CIRCLE R1 → ALARM

③ SUPERVISION TIME (MIN. TIME): Requires the impedance phasor (LOCUS) to pass through the circular ring (R1-R2) longer than this time, thus the function is activated and the output of the protective function may be set (if no other blocking active).

④ LOCUS ENTERS CIRCLE R2 → TRIP (if no blocking is active).

MP319 POWER SWING BLOCKING DEFINITION OF SEQUENCE

Fig. 181 MP319 Power Swing Blocking Definition of Sequence

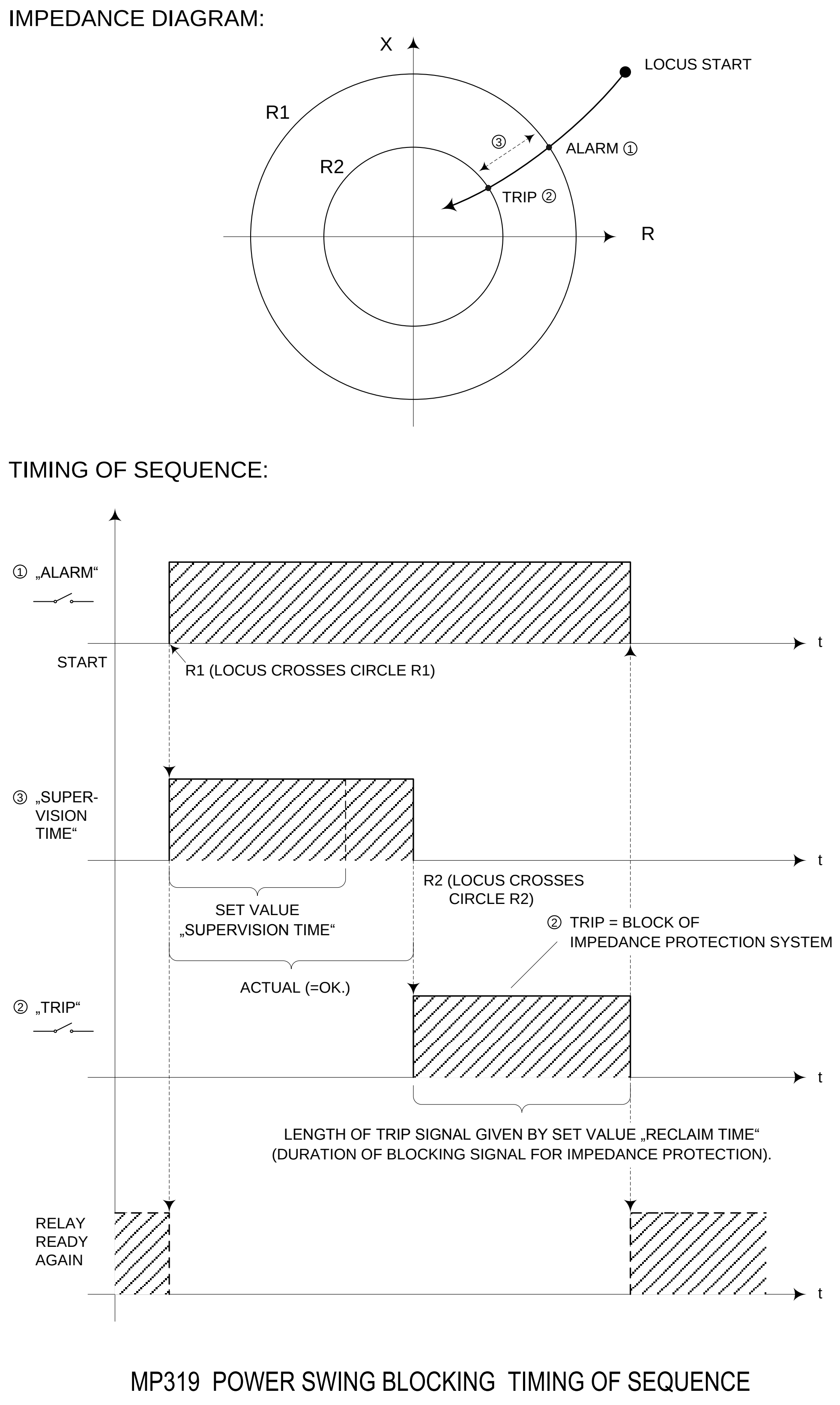


Fig. 182 MP319 Power Swing Blocking Timing of Sequence

14.5. FUNCTION

Power Swing Blocking Function MP319:

The purpose of the sudden load loss interlock function MP319 is the blocking of distance protection relays in case of system load oscillations.
The logic diagram, Item 1.4, shows the basic operation of the MP319 function.
On the impedance plane two circular characteristics with the centre point at the coordinate origin are defined via the parameter settings of the User program with a radius R1 and R2 whereby R1 is the outer circle.
During a load oscillation the impedance locus is entering the circular characteristic R1 from the outside and may reach circle R2 within a preset minimum time interval (please refer to setting values) after which the MP319 will initiate a blocking command to the distance protection.

Pre-condition No. 1 is however that the impedance locus requires a certain minimum time to pass through the R1-R2 defined impedance ring. A sudden change of the impedance locus outside R2 and entering R1 is not considered as a power oscillation but rather refers to an external system short circuit, etc.
In this case the function must not block the distance protection under any circumstances. The setting value “Monitoring Time“ is determining the minimum time for crossing the impedance ring R1-R2. If this time is exceeded a function reset will take place.

Pre-condition No. 2 is that the setting value for the maximum permissible NPS load has not been reached (please refer to “Negative Phase Sequence Load” configuration).
A real power oscillation can basically be considered a symmetrical occurrence without any excessive NPS components.
NPS function calibration for setting value and display window:
Single phase injection of 1 A with the other two phases at zero:
Display shows: 0.33 A which exactly corresponds to the NPS current component.
Three phase injection of a symmetric 3 phase system (3 x 1 A) with an anti-clockwise phase rotation will result in a display: 1 A.

The window display shows the "NPS Load" in %, the power oscillation starting "Delay Time in Progress" Yes / No and also the system impedance which is displayed in Ohm whereby following calibration is applicable:

<u>Injection:</u>

Current =	Phase current = 1 A (Note: 3 phase current has to be symmetrical, otherwise block by NPS
Voltage =	Phase to phase voltage = 100 V
Display =	Computed impedance = phase voltage / phase current = 57.7V/1A = 57.7 Ohm For 5 A rating a nominal impedance value of 57.7 Ohm/5 = 11.5 Ohm is indicated
Note:	The same calibration also applies for the setting value

Setting Values:

Setting Parameters

Monitoring time:	0.02 ... 10.00 s in 0.02 s steps
Impedance circle R1:	5 ... 99 Ohm in 0.1 Ohm steps
Impedance ring R1-R2:	1 ... 99 Ohm in 0.1 Ohm steps
NPS load:	10 ... 20 % in 0.5 % steps
Blocking time:	0.1 ... 30 s in 0.1 s steps
Phase rotation:	Right / Left

Monitoring time:
For the impedance locus when crossing the R1-R2 ring from the outside to the inside this time duration has to be at least required to initiate the function otherwise when the passed time is too short the function will reset.

Impedance circle R1:
Outer characteristic of both circles defining the impedance ring.

Impedance ring R1-R2:
Distance between R1 and R2, i.e. difference between radius R1 and radius R2.
Caution: Not to be considered as radius R2!

NPS Load:
The value corresponds to the NPS current system. When exchanging two of the three phases the negative phase sequence load will be 100 %.
The MP319 function is blocked during NPS load conditions, respectively then the distance protection will not be blocked.

Blocking time:
This setting specifies the trip output duration of the MP319, i.e. the blocking command for the distance protection relay.

Operating sequence:
When the impedance locus enters circle R1 the MP319 function is initiated and by crossing circle R2 the trip, i.e. blocking command is given whereby the time duration is defined by the “Blocking Time“ parameter configuration.

Phase rotation:
The phase rotation encountered during normal operating conditions in relation to the current input matrix of the MP319 function.

14.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

With a relay test set inject following 3 phase symmetrical quantities:
- Phase currents
- Phase to Phase voltages

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Blocking input
	Test input

Shifting the impedance vector by slowly increasing the test current and keeping the test voltage constant function initiation and trip is to be confirmed.
The impedance locus has to cross the setting characteristic from outside to the inside whereby it has to be considered that for crossing R1-R2 a minimum time is required (Monitoring Time) to produce an output otherwise when crossing too fast the function will reset.

Note:
By single phase current injection the NPS interlock will respond thereby causing either function block or function reset.
Note:
The phase rotation has to be considered and if necessary the corresponsing parameter setting modified according to requirements.

Outputs

Binary:	Initiation
	Trip
	NPS load interlock

The correct function operation can be verified with the aid of the window display of the internal measured values:

Window Display for Relay Internal Determined and Computed Values

System impedance:	In Ohm
NPS load:	In %
Delay time in progress:	Yes / No

If required a temporary change of the setting parameters should be done to carry out the tests and to verify the various operating sequences more comfortably:

Setting Parameters

Monitoring time:	0.02 ... 10.00 s in 0.02 s steps
Impedance circle R1:	5 ... 99 Ohm in 0.1 Ohm steps
Impedance ring R1-R2:	1 ... 99 Ohm in 0.1 Ohm steps
NPS load:	10 ... 20 % in 0.5 % steps
Blocking time:	0.1 ... 30 s in 0.1 s steps
Phase rotation:	Right / Left

Primary Commissioning Tests:

Check the analogue inputs with the "Internal Measured Values" of the User program. The phase rotation can be confirmed by activation of the icon “Read Fault Record“ in the PROCESSING window.

Note: For this menu item it should be considered that curve sections are read which have to be combined to obtain the whole characteristic. Therefore by this way of curve issue there will be periodic discrepancy portions which do however not represent the real signal trace.
An on-load function operation can be performed by temporary setting change and by shifting the reactive load current with the excitation system accordingly.

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15. MQ ... INADVERTENT ENERGISING/VOLTAGE CONTROLLED OVERCURRENT

15.1. OVERVIEW

List of the Available MQ . . . – Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MQ . . .	FNNR	TYPE	ANSI	Application
Inadvertent energising	1076	MQ311	27/50	C2,M,L
Voltage controlled overcurrent	1080	MQ312	27/51	C2,M,L

15.2. TECHNICAL DATA

15.2.1. Inadvertent Energising

PROTECTIVE FUNCTION: MQ311	FNNR	TYPE	ANSI	Application
Inadvertent energising protection	1076	MQ311	27/50	C2,M,L

3 phase, 1 stage inadvertent energising current function with voltage interlock.

MQ311
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage system 1-2
	Voltage system 2-3
	Voltage system 3-1
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip

Setting Parameters

Operating value I:	0.1 ... 5 xIn in 0.05 xIn steps
Operating value U:	10 ... 120 V in 0.5 V steps
Operating time delay:	0.1 ... 1 s in 0.05 s steps
Reset time delay:	0.5 ... 10 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

15.2.2. Voltage Controlled Overcurrent

PROTECTIVE FUNCTION: MQ312	FNNR	TYPE	ANSI	Application
Voltage controlled overcurrent	1080	MQ312	27/51	C2,M,L

3 phase DT characteristic voltage controlled overcurrent function.

MQ312
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage system 1-2
	Voltage system 2-3
	Voltage system 3-1
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

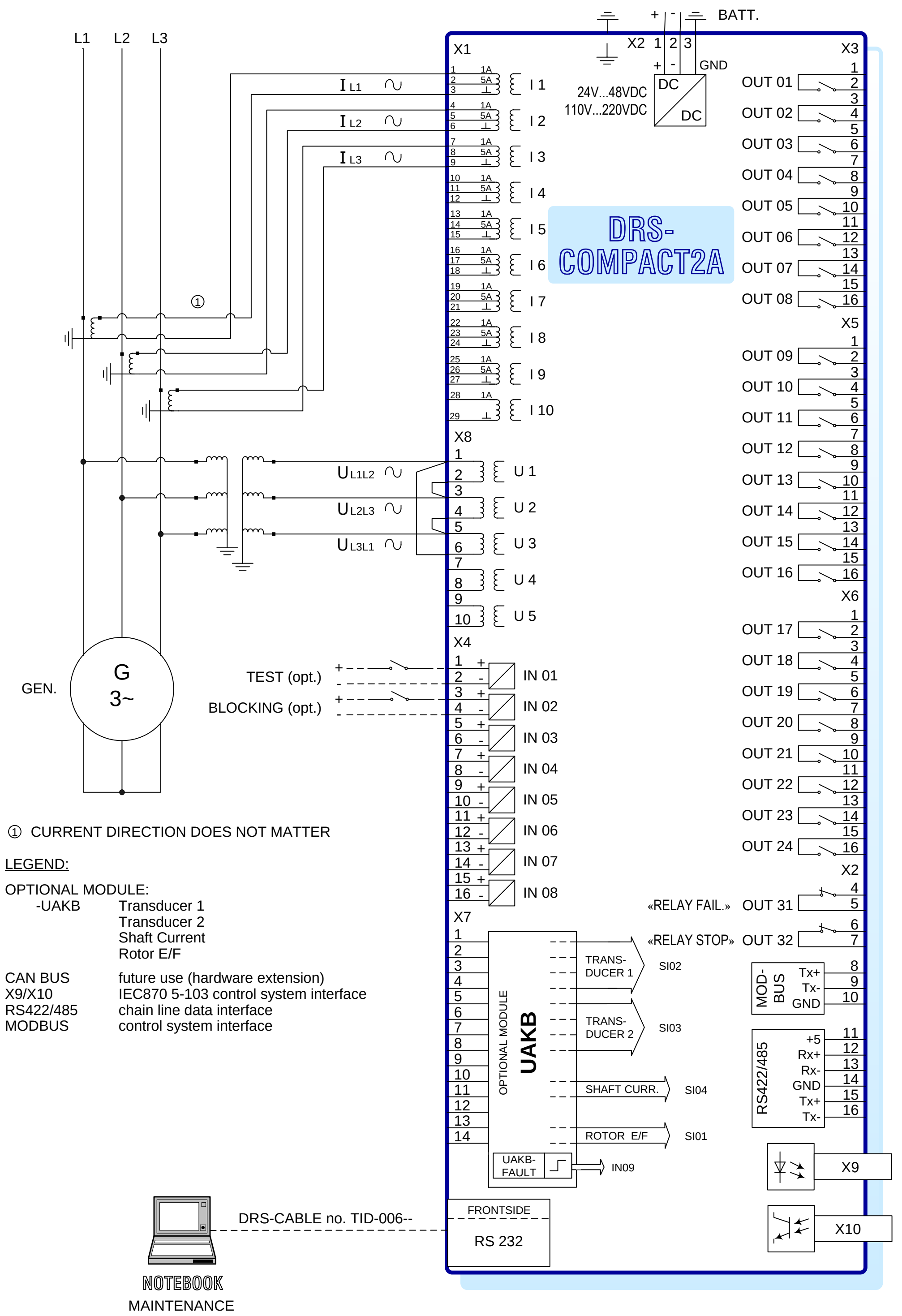
Operating value I:	0.1 ... 5 xIn in 0.05 xIn steps
Voltage interlock:	20 ... 120 V in 1 V steps
K factor:	0.1 ... 1 in 0.01 steps
Time delay:	0 ... 30 s in 0.05 s steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

15.3. CONNECTION DIAGRAMS

15.3.1. MQ311



MQ311 INADVERTENT ENERGIZING WIRING DIAGRAM

Fig. 183 MQ 311 Inadvertent Energizing Wiring Diagram

15.3.2. MQ312

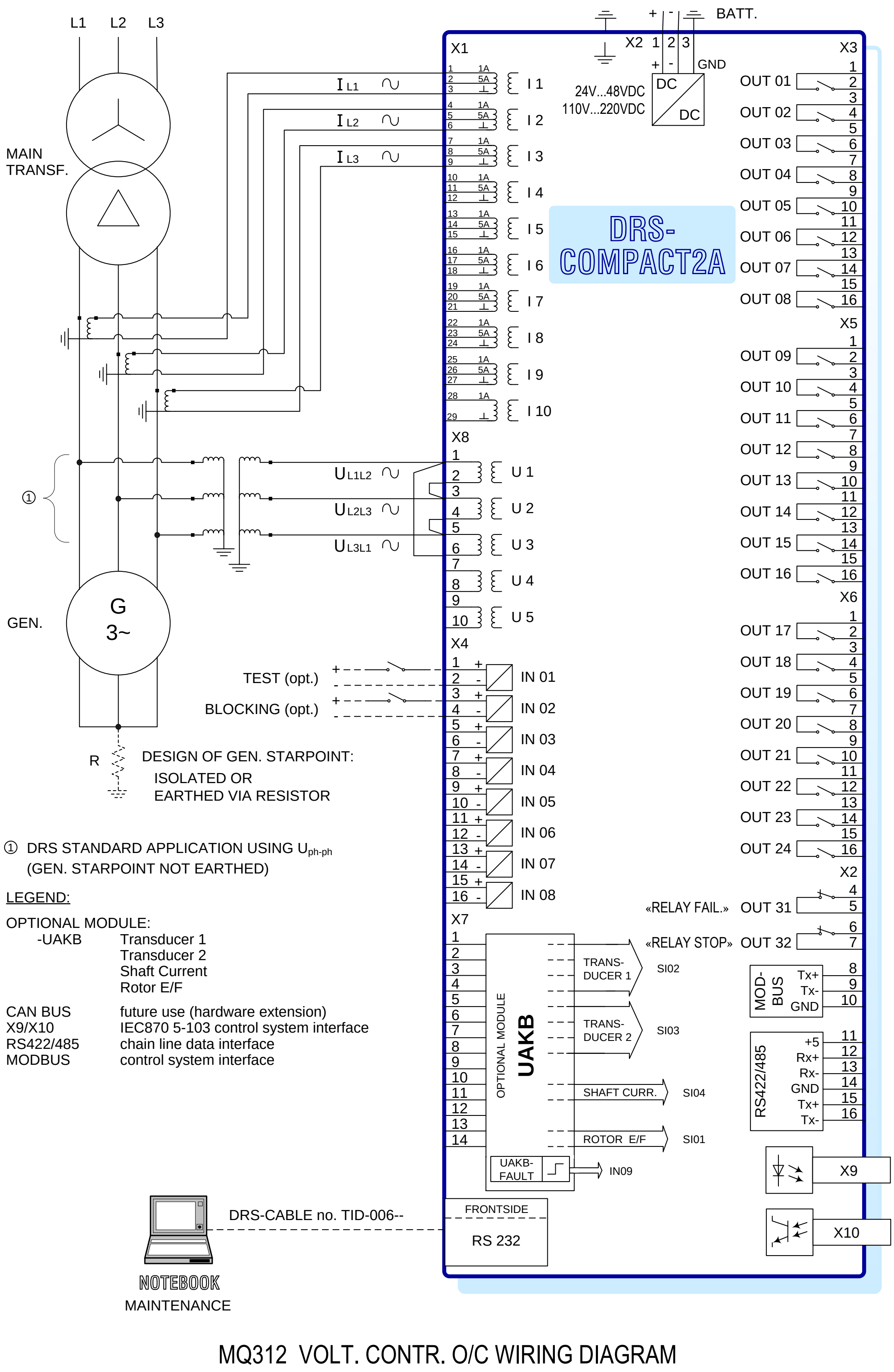


Fig. 184 MQ312 Volt Contr. O/C Wiring Diagram

15.4. LOGIC DIAGRAMS

15.4.1. MQ311

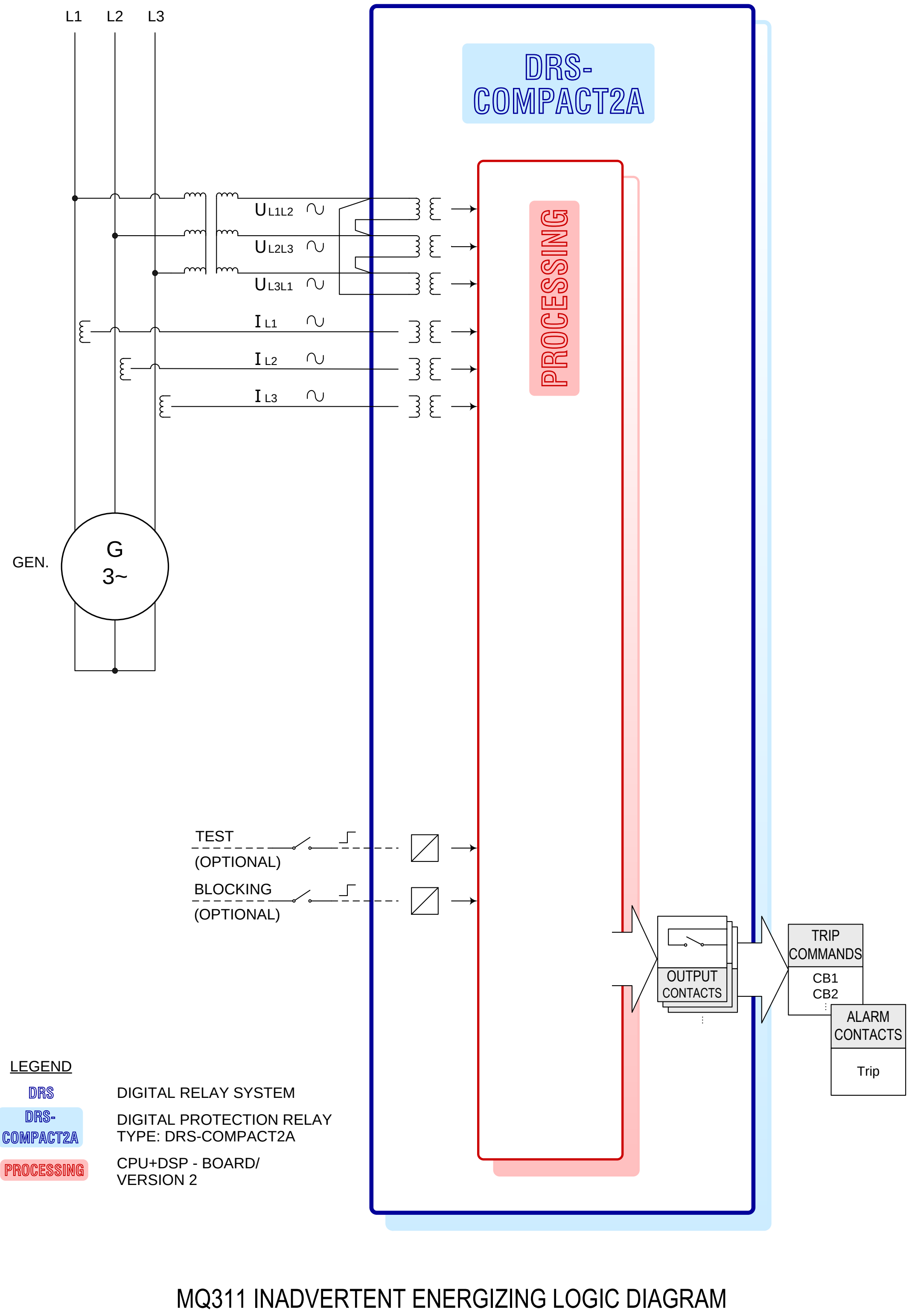
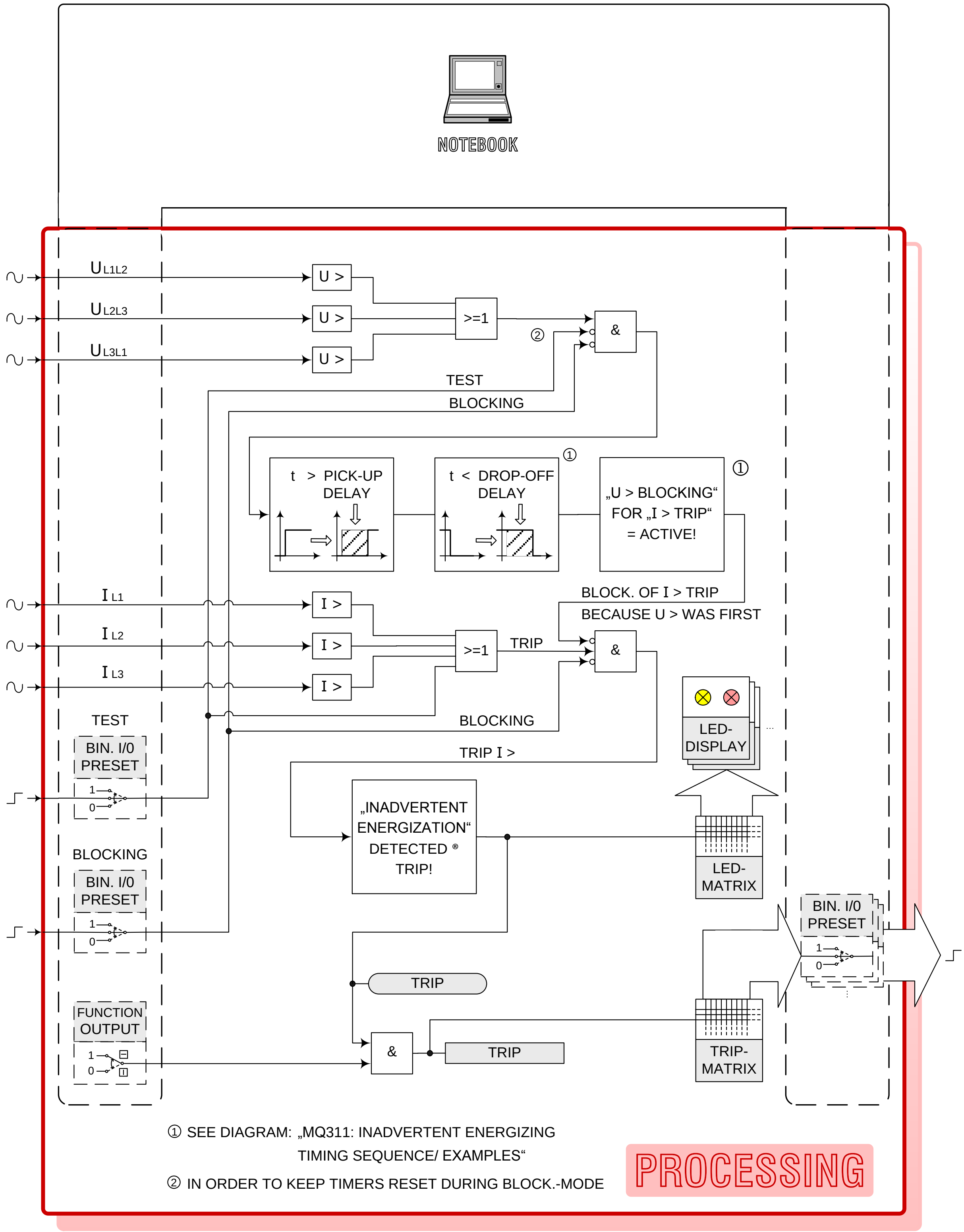


Fig. 185 MQ311 Inadvertent Energizing Logic Diagram



MQ311 INADVERTENT ENERGIZING LOGIC DIAGRAM / PROCESSING

Fig. 186 MQ311 Inadvertent Energizing Logic Diagram / Processing

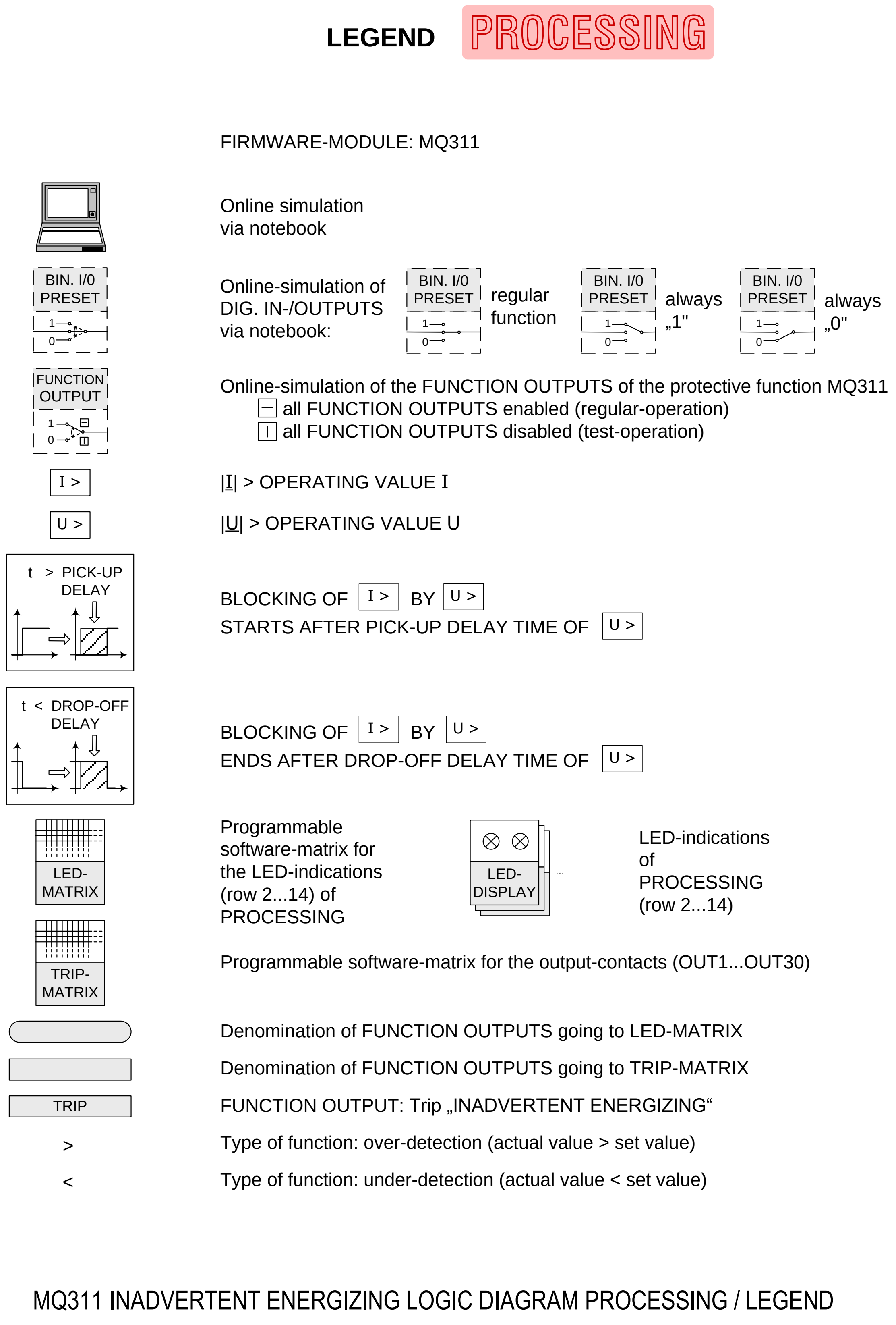
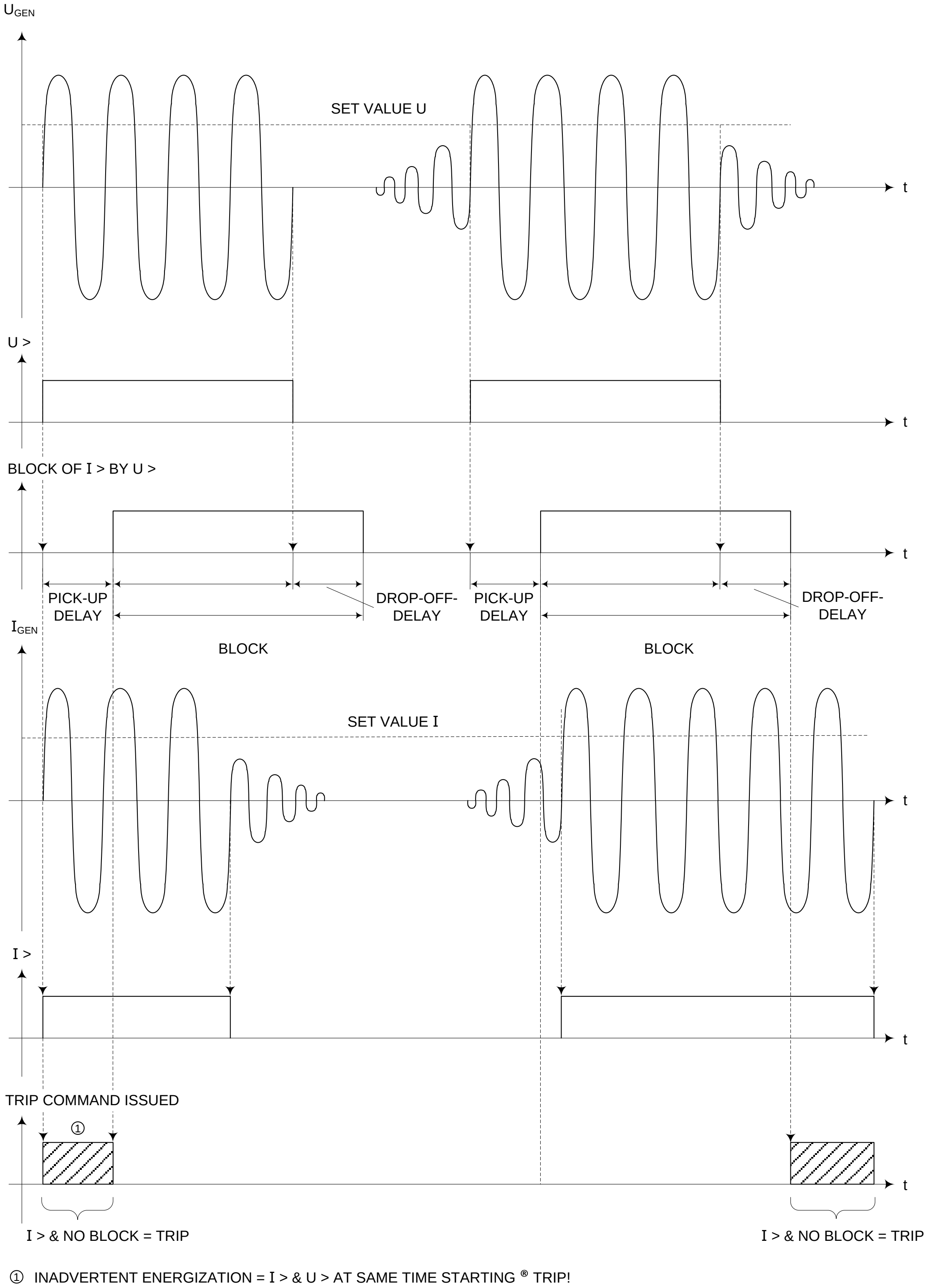


Fig. 187 MQ311 Inadvertent Energizing Logic Diagram Processing / Legend



MQ311 INADVERTENT ENERGIZING TIMING SEQUENCE / EXAMPLES

Fig. 188 MQ311 Inadvertent Energizing Timing Sequence / Examples

15.4.2. MQ312

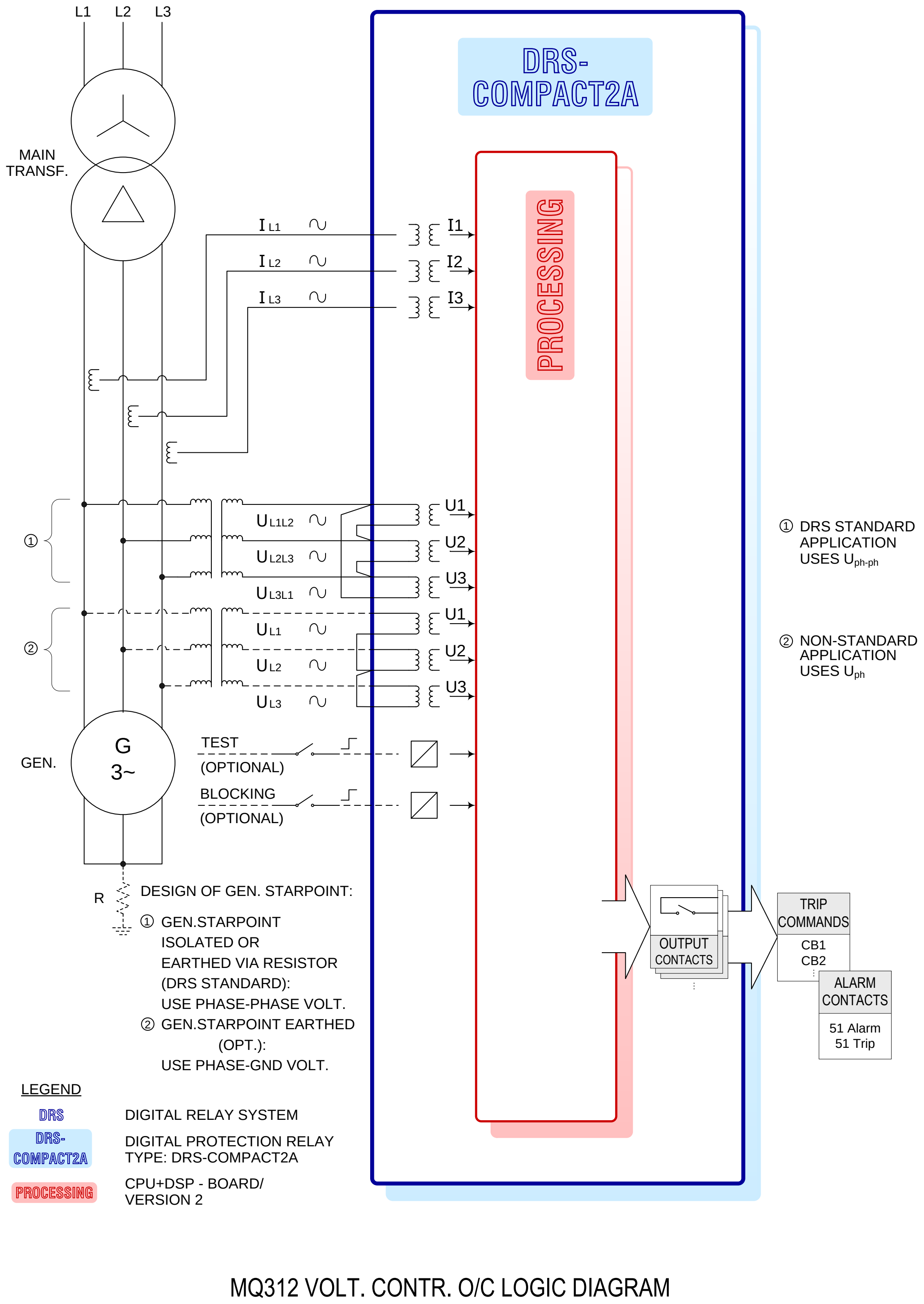
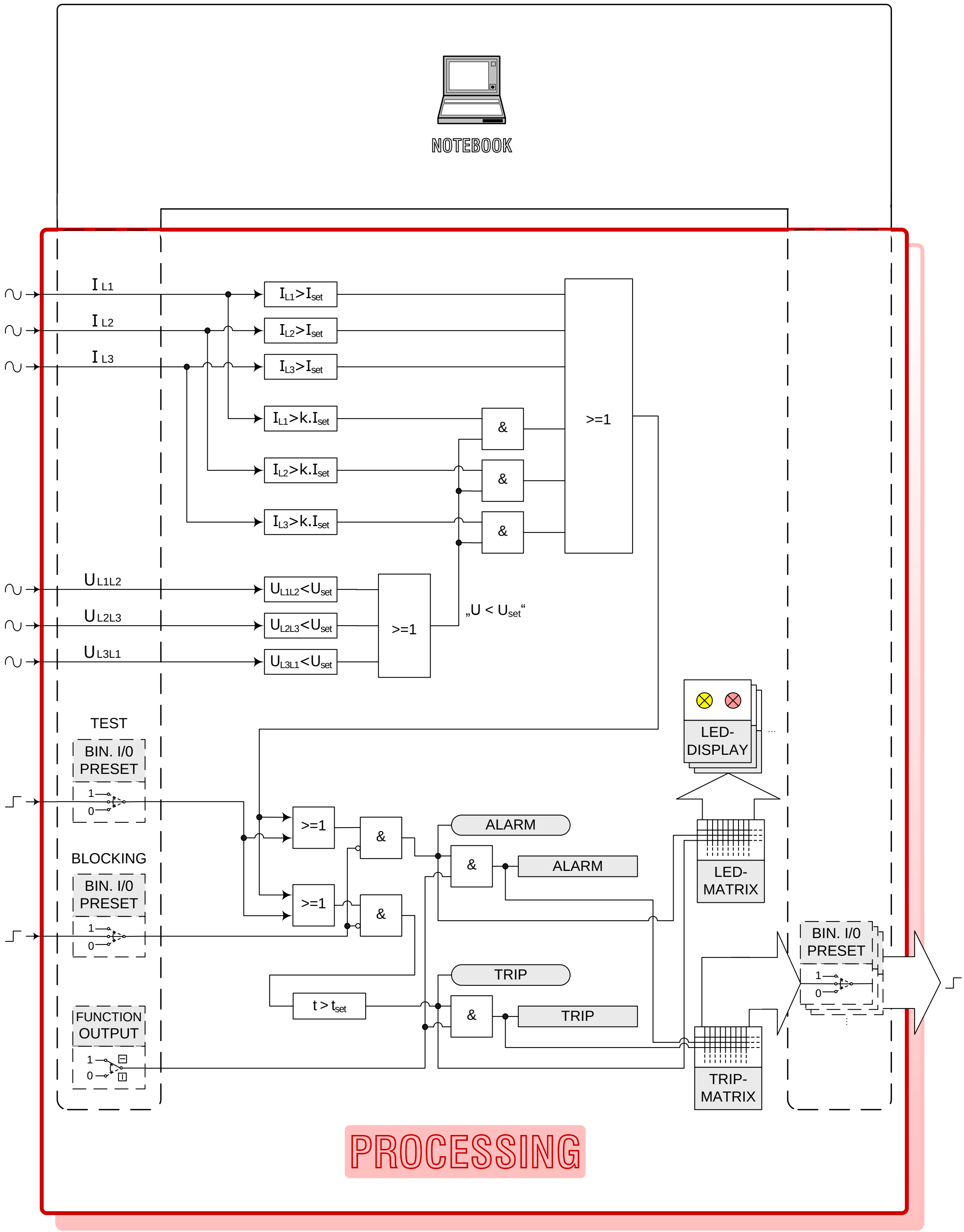


Fig. 189 MQ312 Volt. Contr. O/C Logic Diagram



MQ312 VOLT. CONTR. O/C LOGIC DIAGRAM PROCESSING

Fig. 190 MQ312 Volt. Contr. O/C Logic Diagram Processing

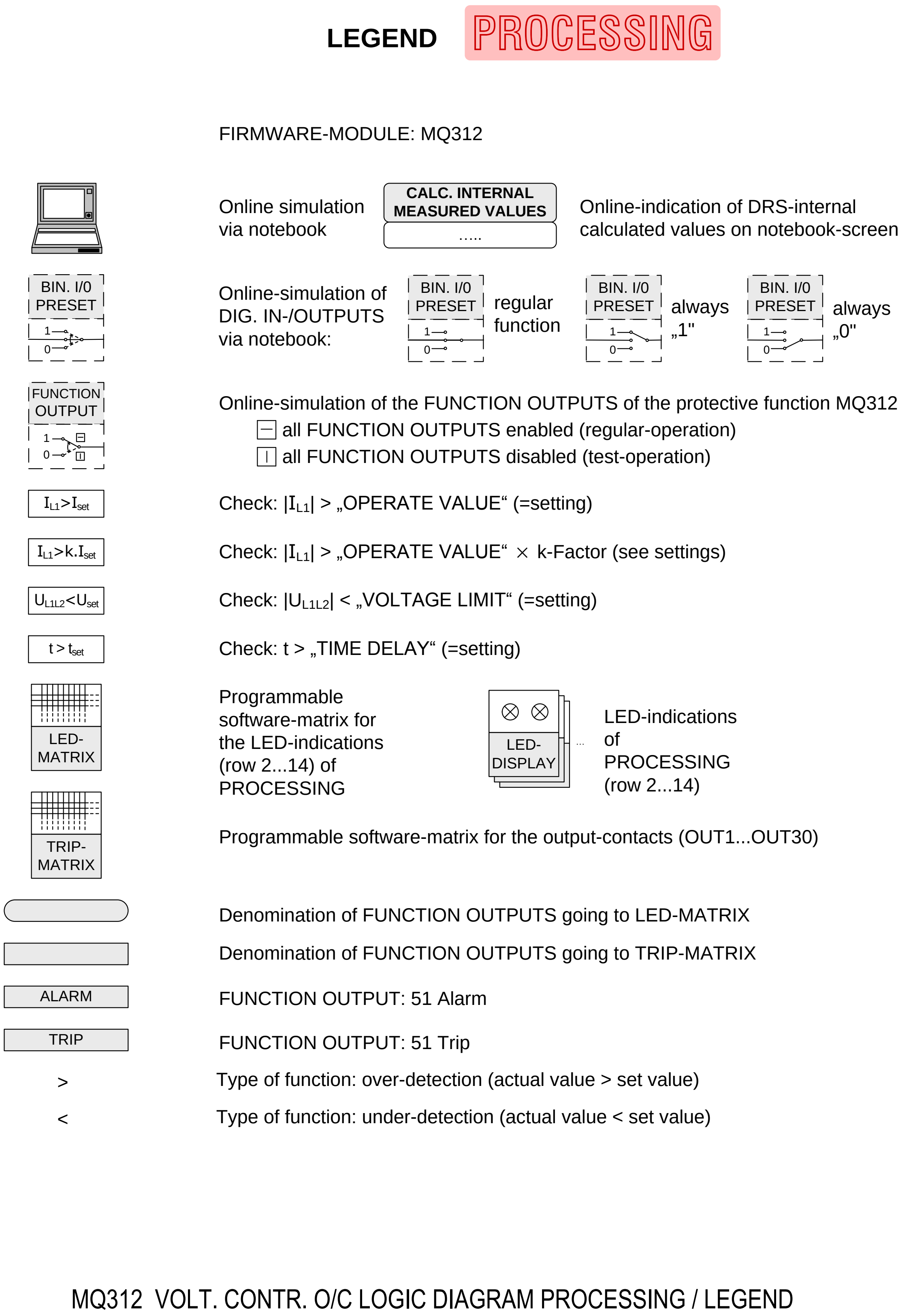


Fig. 191 MQ312 Volt. Contr. O/C Logic Diagram Processing / Legend

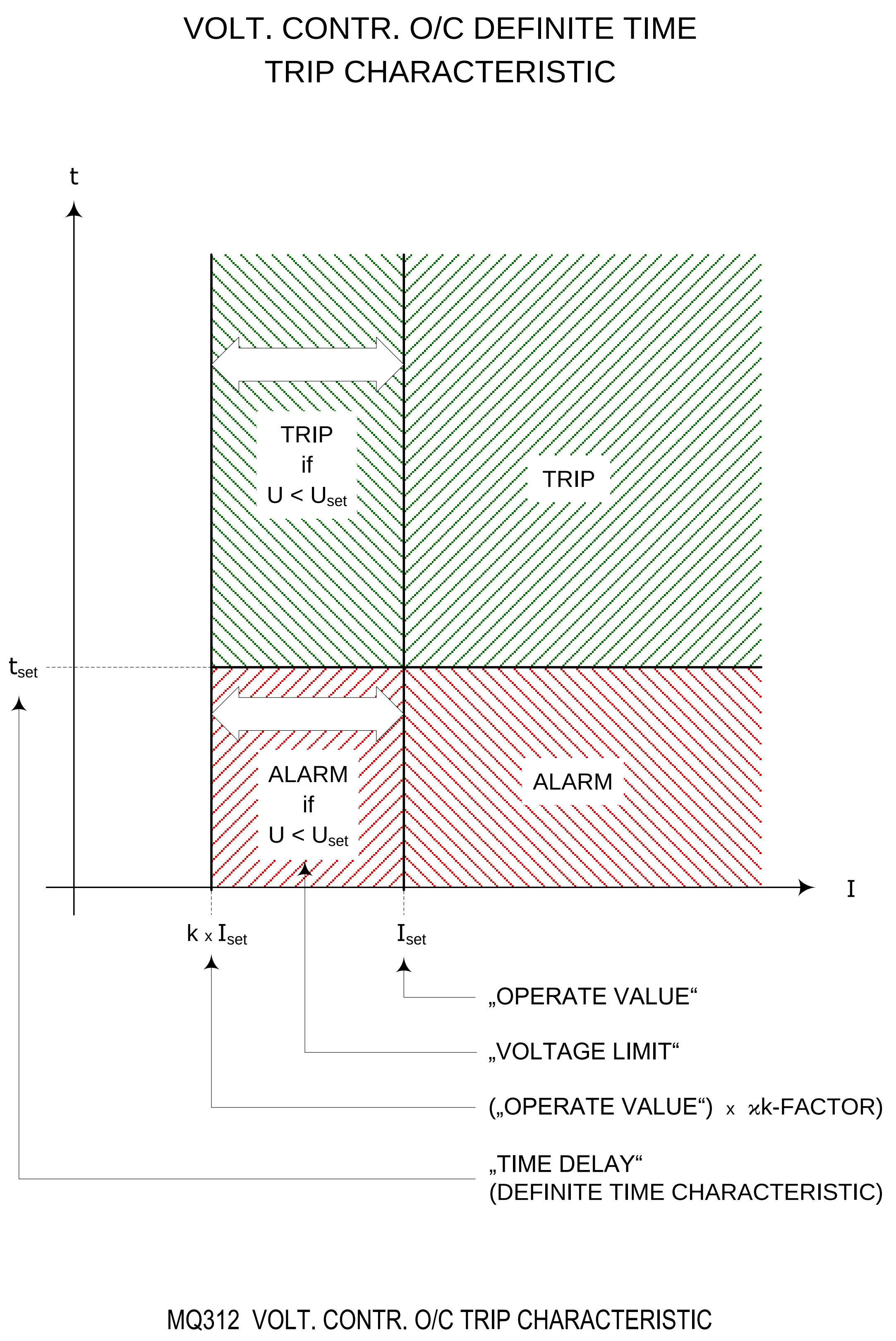


Fig. 192 MQ312 Volt. Contr. O/C Trip Characteristic

15.5. FUNCTION

15.5.1. MQ311

The inadvertent energising function MQ311 is a 3 phase, 1 stage current protection provided with a voltage interlock.

Principle:

Accidental energising of the generator unit at standstill, i.e. the power system voltage is suddenly applied under short circuit conditions and limited only by the generator-transformer impedances thereby causing an instantaneous high short circuit current inrush is detected by this protective function.
The function is monitoring the system conditions during synchronising and on-load operation and in case of an non-permissible V/I relation a protection trip is immediately initiated.
The inadvertent energising protection is basically an overcurrent function which is time delayed blocked at rising voltages and time delayed de-blocked during falling system voltages (please also refer to the LOGIC DIAGRAMS).
Therefore the function is only active for a short time during generator excitation start-up and is subsequently blocked (time delayed) until the unit is taken out of service.

Algorithm:

Please see figures above:
When one of the three input voltages is exceeding the setting “Operating Value V“ the current function will remain active within the configured time delay “Delay on Pick-up”.
Subsequently the current function is blocked and can also be defined as „BLOCK ON – Delay“.

As soon as the three input voltages are falling below the set value the internal function block is de-activated and can therefore be denominated as a “BLOCK OFF – Delay“.

In case of no function block and one of the three currents is larger than the "Operating Value I" an instantaneous trip signal is immediately given.

Recommendation for Protection Design (Please Note!):

Without special measures there is a chance for a maltrip in case of a temporary grid – fault.

Lets consider an example:
a) Grid voltage decreases below set value because of grid fault, current stays above setting
b) "Drop-off" delay will start.
c) During "Drop-off"-delay the grid-fault is cleared and the voltage comes up again, current still above setting.
d) "Pick-up" – Delay starts immediately, causing the function to activate! Maltrip!
Please note the rule: "Safety first" … therefore the "Drop-off" – blocking state is overruled by the "Pick-up"-delay state immediately.
Function trips because current above setting and no blocking during "Pick-Up"!

Solution:
a) Digital Input "CB is on" blocks the protective function (blocking must be delayed).

This solution is highly recommended. Most reliable solution, will work in all cases of grid faults.

b) Setting change. This solution is suitable only if the versions of grid faults resp. the voltage and current – values are exactly predictable.

15.5.2. MQ312

The voltage controlled overcurrent function MQ312 is a 3 phase overcurrent protection with a voltage controlled definite time delayed (DT) operating characteristic.

Principle:

Change of the time-current characteristic at a definite set voltage value and it should be noted that the function is operating differently to the “Voltage Restraint O/C (MI318)“ which is altering the operating characteristic continuously with respect to the voltage.

When one of the three input voltages drops below the “Voltage Limit“ setting the internal operating value is changing from
"Operating Value"
to
"Operating Value x K Factor"

Input Values fort he voltage controlled overcurrent function:

a) Generators with solidly earthed neutrals are using the phase to neutral voltages whereby the recommended setting “Voltage Limit” is approximately 60% nominal covering phase to phase and phase to earth faults.

b) For impedance earthed or ungrounded generator neutrals the recommended phase to phase voltage “Voltage Limit” setting is approximately 30 % of the nominal voltage rating whereby the function is operating only in case of phase to phase faults.

Definition of this Function for the DRS System:

The operating characteristic change does not depend on a current/time curve but is fixed to a definite time delayed overcurrent performance which is reducing the current setting should the system voltage decrease below a defined level.

The application of this DRS System function is in general for generator units having a neutral impedance grounding, i.e. neutral distribution transformer earthing, a neutral earthing resistor, or for ungrounded systems. This means that the parameter setting “Voltage Limit“ is using the phase to phase voltage values thereby operating for phase to phase short circuit faults. The recommended setting for the voltage limit is about 30% nominal and for the K factor configuration approximately 0.4

Characteristic:

The function is representing a relation between the phase currents and the phase to phase voltages. The internal characteristic change from the current setting I to K x I is common for all three phases in case of one of the three phase to phase voltages falls below the configured “Voltage Limit” value meaning that in each chase the smallest phase to phase voltage and the highest phase current are considered.

15.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

15.6.1. MQ311

3 phase, 1 stage inadvertent energising current function with provided with a voltage interlock.

<u>Pre-Commissioning</u>:

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage system 1-2
	Voltage system 2-3
	Voltage system 3-1
Binary:	Blocking input
	Test input

With a relay test set inject a single phase or a three phase test current above the setting parameter "Operating Value I" until the function operates.

With a relay test set inject a single phase or a three phase test current above the setting parameter "Operating Value I" and at the same time a three phase test voltage below the setting parameter “Operating Value V” until the function operates.

With a relay test set inject a single phase or a three phase test voltage above the setting parameter “Operating Value V” and after the “Delay on Pick-up” time apply one ore more phase currents above the configured "Operating Value I" setting. The relay function is blocked and cannot operate.
Note: The current function time delayed blocked after raising the generator voltage during start-up and time delayed re-activated after de-excitation of the generator.

The tests can therefore be finalised by two ways:
a)
Currents and voltages are switched off simultaneously ... no trip.
b)
The voltage is switched off and only after expiry of the “Delay on Drop-off“ setting the test current is switched off ... trip.
Note: During generator standstill where the voltage is zero the function is always active!

Note:

Setting Parameters

Operating value I:	0.1 ... 5 xIn in 0.05 xIn steps
Operating value V:	10 ... 120 V in 0.5 V steps
Delay on pick-up:	0.1 ... 1 s in 0.05 s steps
Delay on drop-off:	0.5 ... 10 s in 0.05 s steps

Primary Commissioning Tests:

During short circuit tests this instantaneous function can be verified just like a “normal“ over-current protection, i.e. with a short circuit by zero system voltage the function is active.

During the voltage- and on-load tests the required correct function de-activation (blocking) can also be observed.

15.6.2. MQ312

3 phase voltage controlled overcurrent protection with a DT characteristic.

<u>Primary Commissioning Tests</u>:

During short circuit tests this function can be verified just like a “normal“ over-current protection. Please also refer to Section "MI… Current DT".

It should be considered that during short circuit tests the actual current setting will be reduced by the “K Factor x Operating Value” according to voltage controlled overcurrent characteristic.

Setting Parameters

Operating value I:	0.1 ... 5 xIn in 0.05 xIn steps
Voltage interlock:	20 ... 120 V in 1 V steps
K factor:	0.1 ... 1 in 0.01 steps
Time delay:	0 ... 30 s in 0.05 s steps

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16. MR... ROTOR EARTH FAULT / ROTOR INSULATION

16.1. OVERVIEW

List of the Available MR . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MR . . .	**FNNR**	**TYPE**	**ANSI**	**Application**
Rotor earth fault protection (eIEGL)	1030	MR111	40	C2,M
Rotor earth fault protection	1062	MR112	40	C2,M
Rotor insulation protection (high resistance) (MIEGL) Note: The new version of the rotor insulation protection has to be used for all new schemes!	1040	MR121	40	C2,M
Rotor insulation (UAKB) 1. Stage: 1 … 100 kOhm / 0 … 840 s 2. Stage: 1 … 20 kOhm / 0 … 99 s Remark: Hardware auxiliary module "UAKB" is necessary.	1092	MR131	40	C2A, M

16.2. TECHNICAL DATA

16.2.1. Rotor Earth Fault

PROTECTIVE FUNCTION: MR111	FNNR	TYPE	ANSI	Application
Rotor earth fault protection (eIEGL)	1030	MR111	40	C2,M

1 stage rotor earth fault function.

Caution: The maximum permissible capacitance to ground which is galvanic connected to the rotor measuring circuit has to be ≤ 2 μF.

MR111
Technical Data

Inputs

Analogue:	DC input rotor-ground resistance
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	500 ... 5000 Ohm in 10 Ohm steps
Operating time:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal Determined and Computed Values

Insulation level:	In Ohm

Measuring

Reset ratio:	0.97
Operating time:	3 cycles typical
Accuracy:	+/- 70 Ohm within the range 2 ... 2.5 kOhm +/- 200 Ohm within the range 1 ... 3 kOhm +/- 1 kOhm within the range 0.6 ... 4 kOhm

PROTECTIVE FUNCTION: MR112	**FNNR**	**TYPE**	**ANSI**	**Application**
Rotor earth fault protection	1062	MR112	40	C2,M

1 stage rotor earth fault function with external attenuator box.

Caution: The maximum permissible capacitance to ground which is galvanic connected to the rotor measuring circuit has to be ≤ 2 μF.

MR112
Technical Data

Inputs

Analogue:	DC input rotor-ground resistance
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	500 ... 5000 Ohm in 10 Ohm steps
Operating time:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal Determined and Computed Values

Insulation level:	In Ohm

Measuring

Reset ratio:	0.97
Operating time:	3 cycles typical
Accuracy:	+/- 70 Ohm within the range 2 ... 2.5 kOhm +/- 200 Ohm within the range 1 ... 3 kOhm +/- 1 kOhm within the range 0.6 ... 4 kOhm

16.2.2. Rotor Insulation

PROTECTIVE FUNCTION: MR121	FNNR	TYPE	ANSI	Application
Rotor insulation protection (high resistance) (MIEGL) Note: The new version of the rotor insulation protection has to be used for all new schemes!	1040	MR121	40	C2,M

2 stage high resistance rotor earth fault function (rotor insulation).

Caution: The maximum permissible capacitance to ground which is galvanic connected to the rotor measuring circuit has to be ≤ 2 μF.

MR121
Technical Data

Inputs

Analogue:	DC input "Rotor Insulation"
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Initiation stage 2
	Trip stage 1
	Trip stage 2

Setting Parameters

Operating value stage 1:	20 ... 100 kOhm in 1 kOhm steps
Operating time stage 1:	0 ... 30 s in 0.05 s steps
Operating value stage 2:	4 ... 25 kOhm in 1 kOhm steps
Operating time stage 2:	0 ... 30 s in 0.05 s steps

Window Display for Relay Internal Determined and Computed Values

Insulation level:	In kOhm

Measuring

Reset ratio:	0.97
Operating time:	typical 0.5 ... 3 min.
Accuracy:	Typical better than 3 % (referred to the range limit value)

PROTECTIVE FUNCTION: MR131	FNNR	TYPE	ANSI	Application
Rotor insulation (UAKB) 1. Stage: 1 … 100 kOhm / 0 … 840 s 2. Stage: 1 … 20 kOhm / 0 … 99 s Remark: Hardware auxiliary module "UAKB" is necessary.	1092	MR131	40	C2A, M

2-stage high impedance rotor earth fault (rotor insulation).

Caution: maximum allowed capacity of measuring unit, which is connected galvanically with the plant part: ≤ 10 µF.
Remark: Hardware auxiliary module "UAKB" is necessary

<u>Remark:</u>
Detailled description of auxiliary module "UAKB": see
"Description of axiliary module UAKB
Universal Ankoppel Baustein CIC-012-A" …
… <u>Important:</u> This description also contains information about various variants of rotor earth fault protection with UAKB (depending on mode of excitation system, etc.) and about further functions of UAKB – module (measuring transducer, shaft current, etc.).

MR131
Technical Data

Inputs

Analogue:	DC-input "UAKB"-output signal (corresponds to rotor - earth resistor)
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Initiation stage 2
	Trip stage 1
	Trip stage 2

Setting Parameters

Operating value stage 1:	1 ... 100 kOhm in 1 kOhm - steps
Operating time stage 1:	0 ... 840 s in 0,5 s - steps
Operating value stage 2:	1 ... 20 kOhm in 1 kOhm - steps
Operating time stage 2:	0 ... 99 s in 0,5 s - steps

Window Display for Relay Internal Determined and Computed Values

Insulation level:	In kOhm

Measuring

Reset ratio:	0.97
Operating time:	typ. 300 ms ... 2 s, depending on rotor-earth capacity.
Accuracy:	typ. better than 3 % (related to range end value)

16.3. CONNECTION DIAGRAMS

16.3.1. MR111 (0 ... 150 VAC)

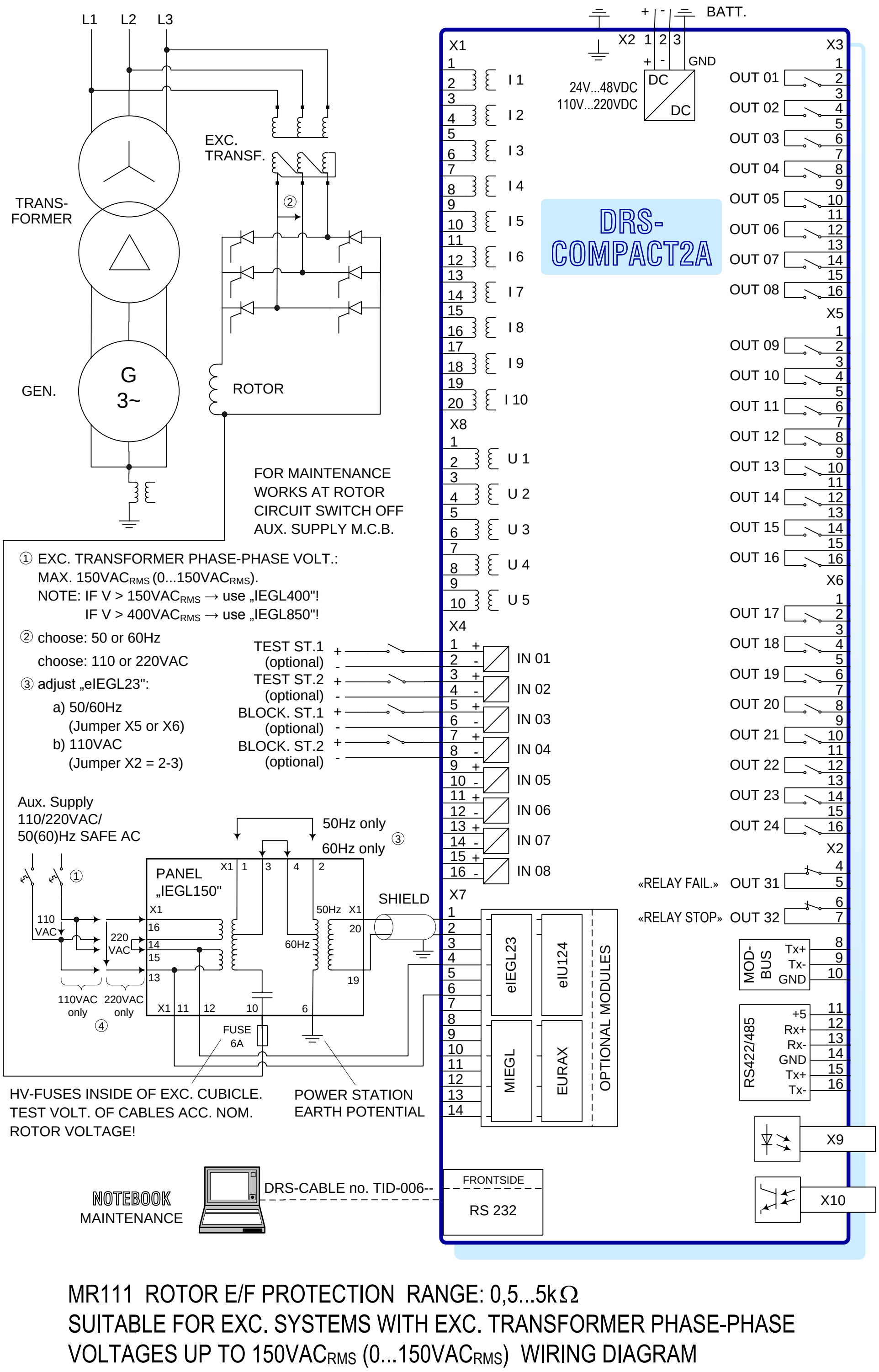
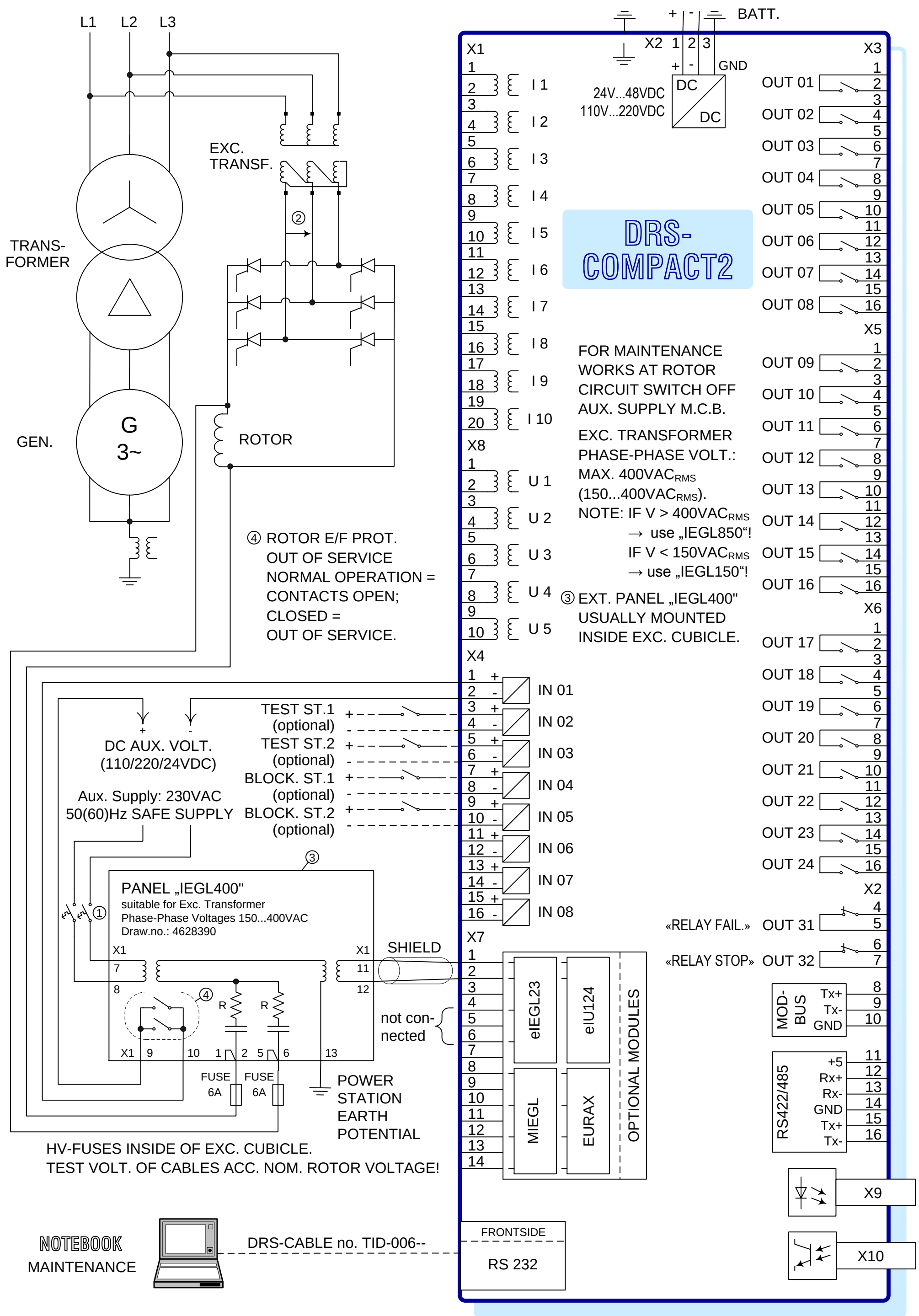


Fig. 193 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase-Phase Voltage Up To $150VAC_{RMS}$ ($0….150VAC_{RMS}$) Wiring Diagram

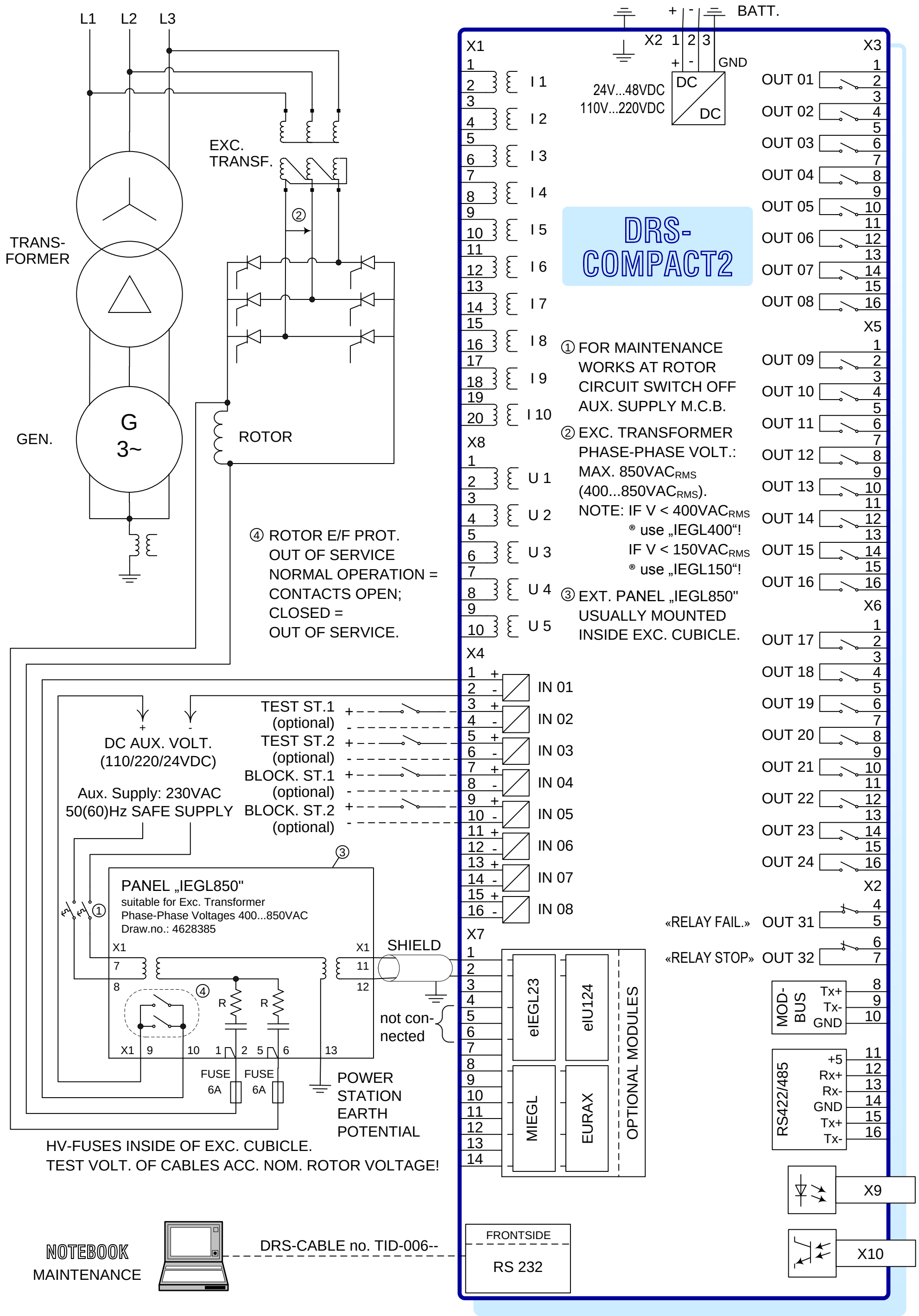
16.3.2. MR111 (150 ... 400 VAC)



MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLTAGES UP TO 400VAC$_{RMS}$ (150...400VAC$_{RMS}$) WIRING DIAGRAM

Fig. 194 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc Systems With Exc. Transformer Phase-Phase Voltages Up To 400VAC$_{RMS}$ (150…400VAC$_{RMS}$) Wiring Diagram

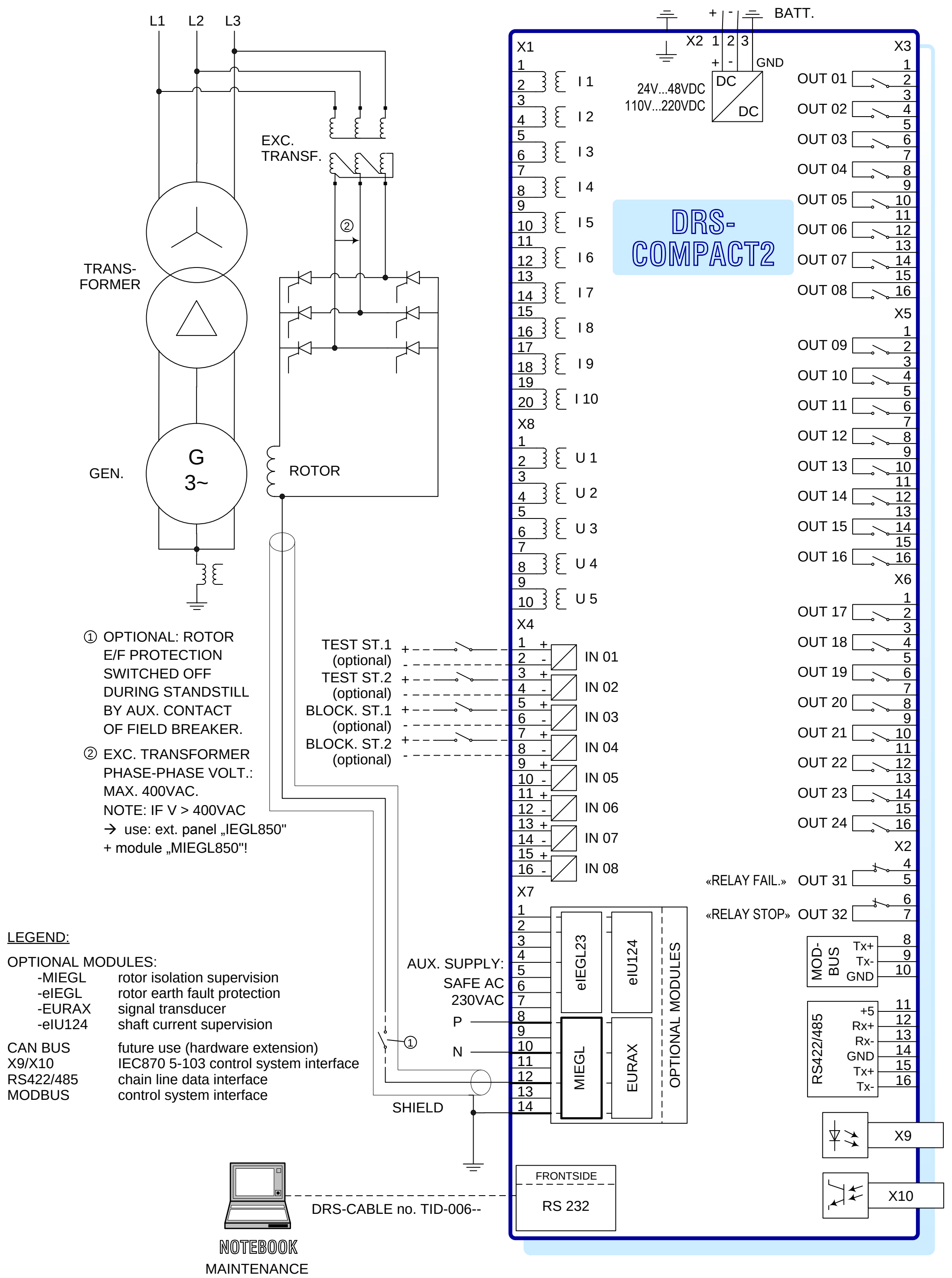
16.3.3. MR111 (400 ... 850 VAC)



MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE VOLTAGES UP TO 850VAC$_{RMS}$ (400...850VAC$_{RMS}$) WIRING DIAGRAM

Fig. 195 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 850VAC$_{RMS}$ (400…850VAC$_{RMS}$) Wiring Diagram

16.3.4. MR121 (0 ... 400 VAC)



MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER
PHASE-PHASE VOLTAGES UP TO 400VAC WIRING DIAGRAM

Fig. 196 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems with Exc. Transformer Phase-Phase Voltages Up To 400VAC Wiring Diagram

16.3.5. MR121 (400 ... 850 VAC)

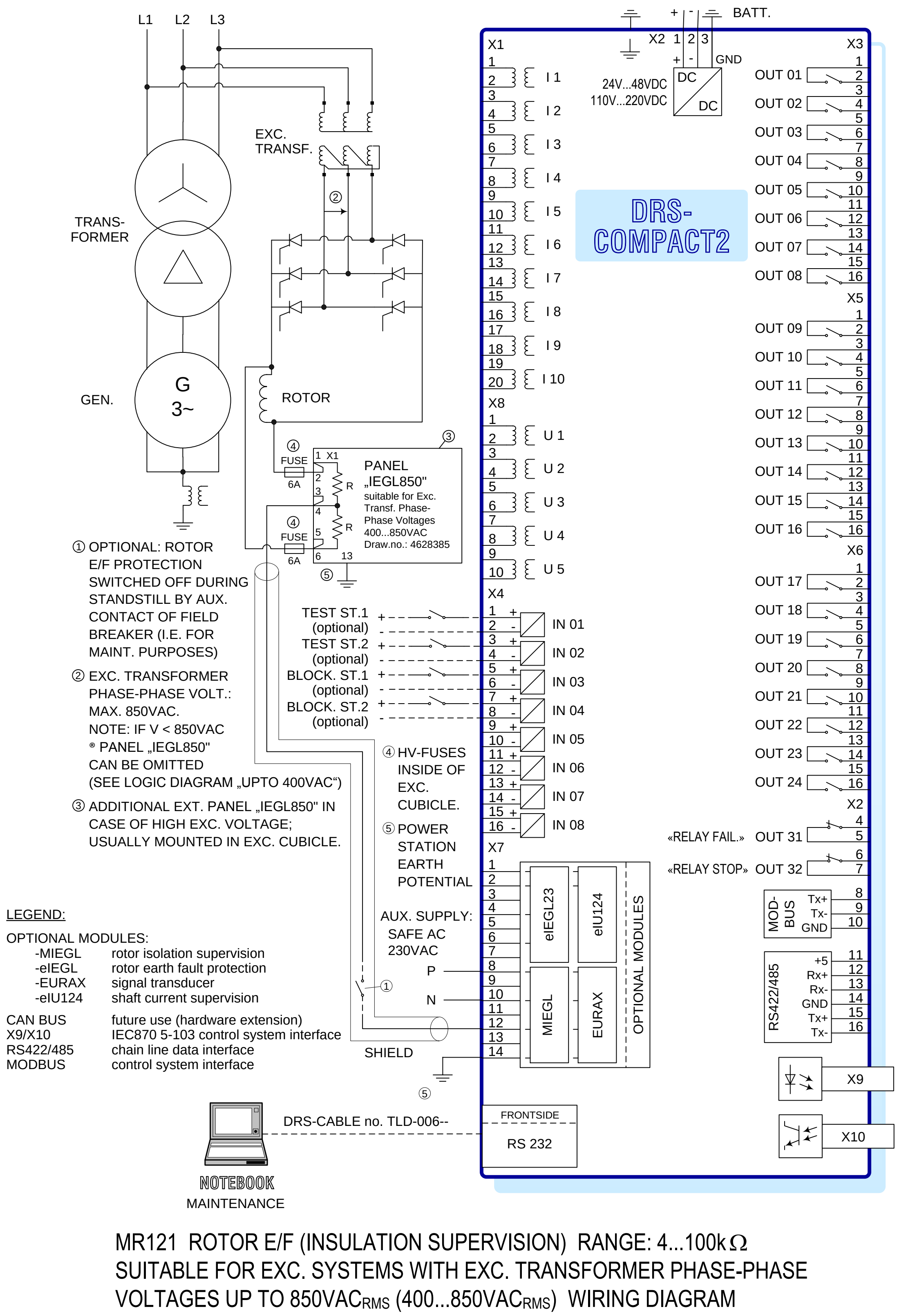
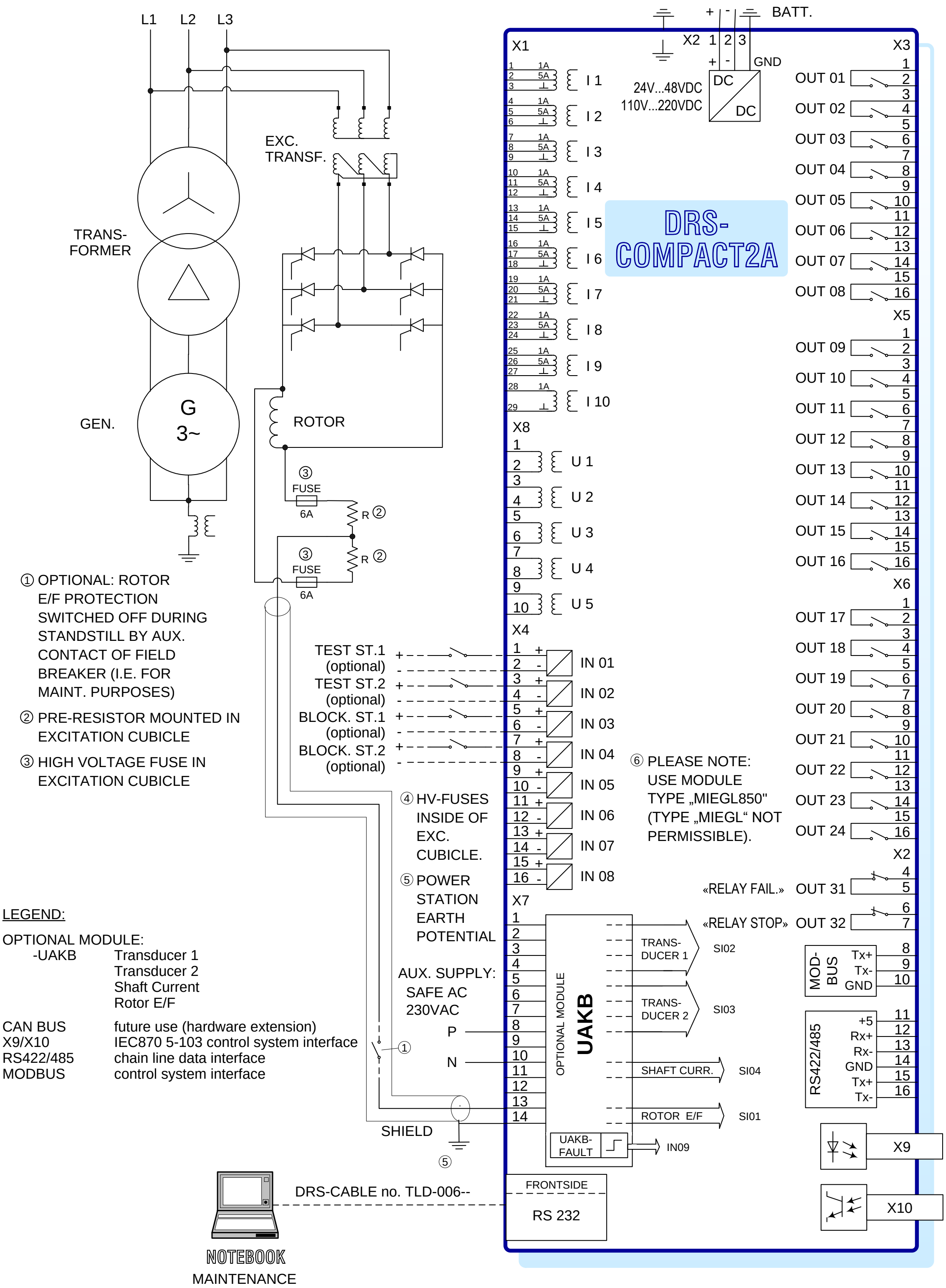


Fig. 197 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase-Phase Voltages Up To 850VAC_{RMS} (400…850VAC_{RMS}) Wiring Diagram

16.3.6. MR131 (UAKB)



MR131 ROTOR E/F (INSULATION SUPERVISION) UAKB
WIRING DIAGRAM

Fig. 198 MR131 Rotor E/F (Insulation Supervision) UAKB Wiring Diagram

16.4. LOGIC DIAGRAMS

16.4.1. MR111 (0 ... 150 VAC)

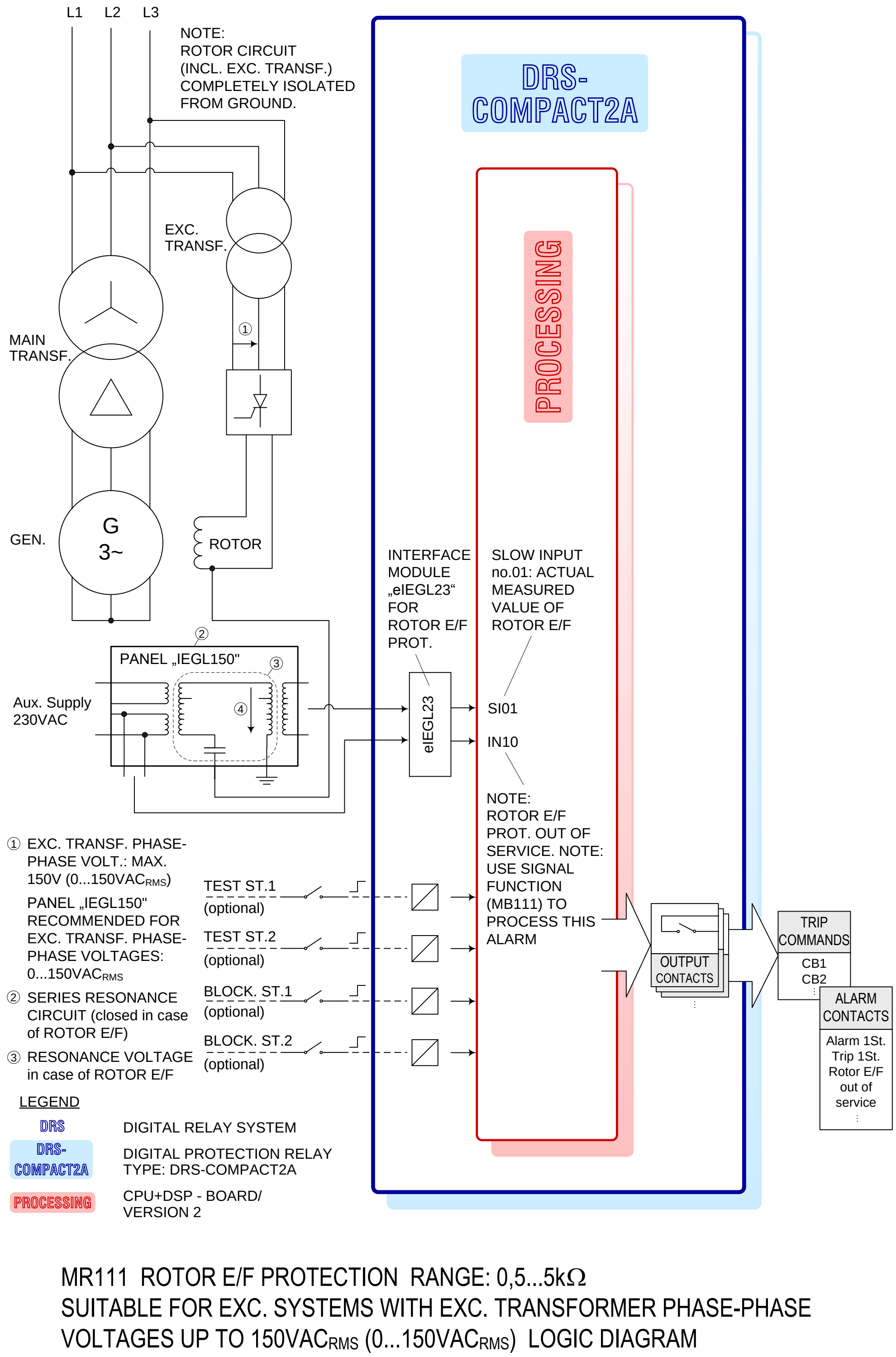
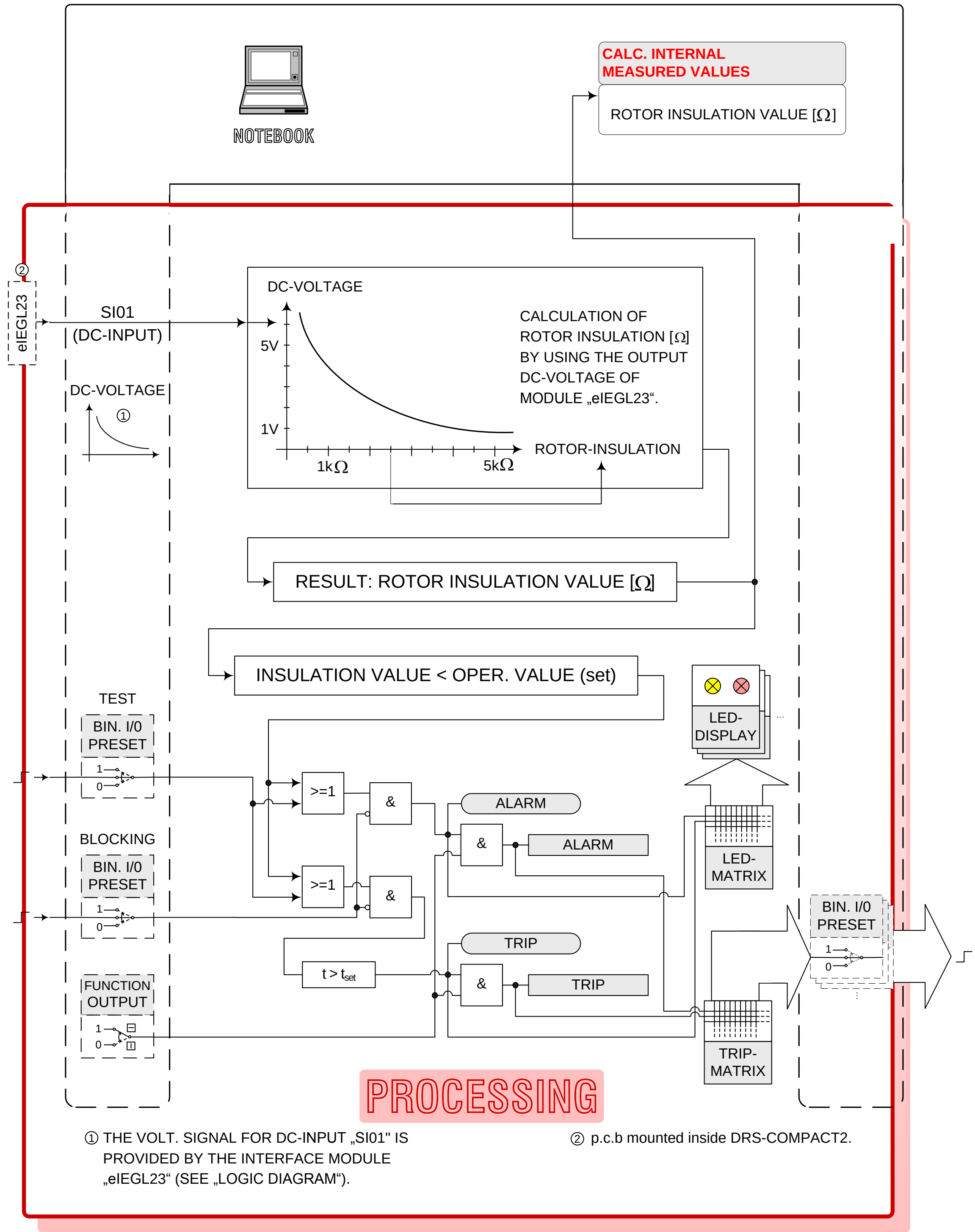


Fig. 199 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 150VAC$_{RMS}$ (0…150VAC$_{RMS}$) Logic Diagram

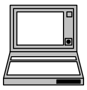


MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLTAGES UP TO 150VAC$_{RMS}$ (0...150VAC$_{RMS}$) LOGIC DIAGRAM / PROCESSING

Fig. 200 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 150VAC$_{RMS}$ (0…150VAC$_{RMS}$) Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MR111



CALC. INTERNAL MEASURED VALUES
.....

Online simulation via notebook

Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET

Online-simulation of DIG. IN-/OUTPUTS via notebook:

BIN. I/0 PRESET – regular function

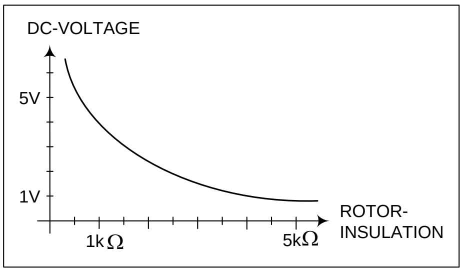
BIN. I/0 PRESET – always „1"

BIN. I/0 PRESET – always „0"

FUNCTION OUTPUT

Online-simulation of the FUNCTION OUTPUTS of the protective function MR111

- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



THE OUTPUT DC-VOLTAGE OF THE INTERFACE-MODULE „eIEGL23“ IS CONVERTED INTO A ROTOR-INSULATION VALUE [Ω].

RANGE: 500...5000Ω

eIEGL23

ROTOR E/F PROTECTION MODULE „eIEGL23“ IS POSITIONED INSIDE DRS-COMPACT2. IT IS DESIGNED FOR APPLICATION WITH THE EXTERNAL PANEL(S) „IEGL850“, „IEGL400“, „IEGL150“.

LED-MATRIX

Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY

LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX

Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLT. UP TO 150VAC$_{RMS}$ (0...150VAC$_{RMS}$) LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 201 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Volt. Up To 150VAC$_{RMS}$ (0…150VAC$_{RMS}$) Logic Diagram Processing / Legend

16.4.2. MR111 (150 ... 400 VAC)

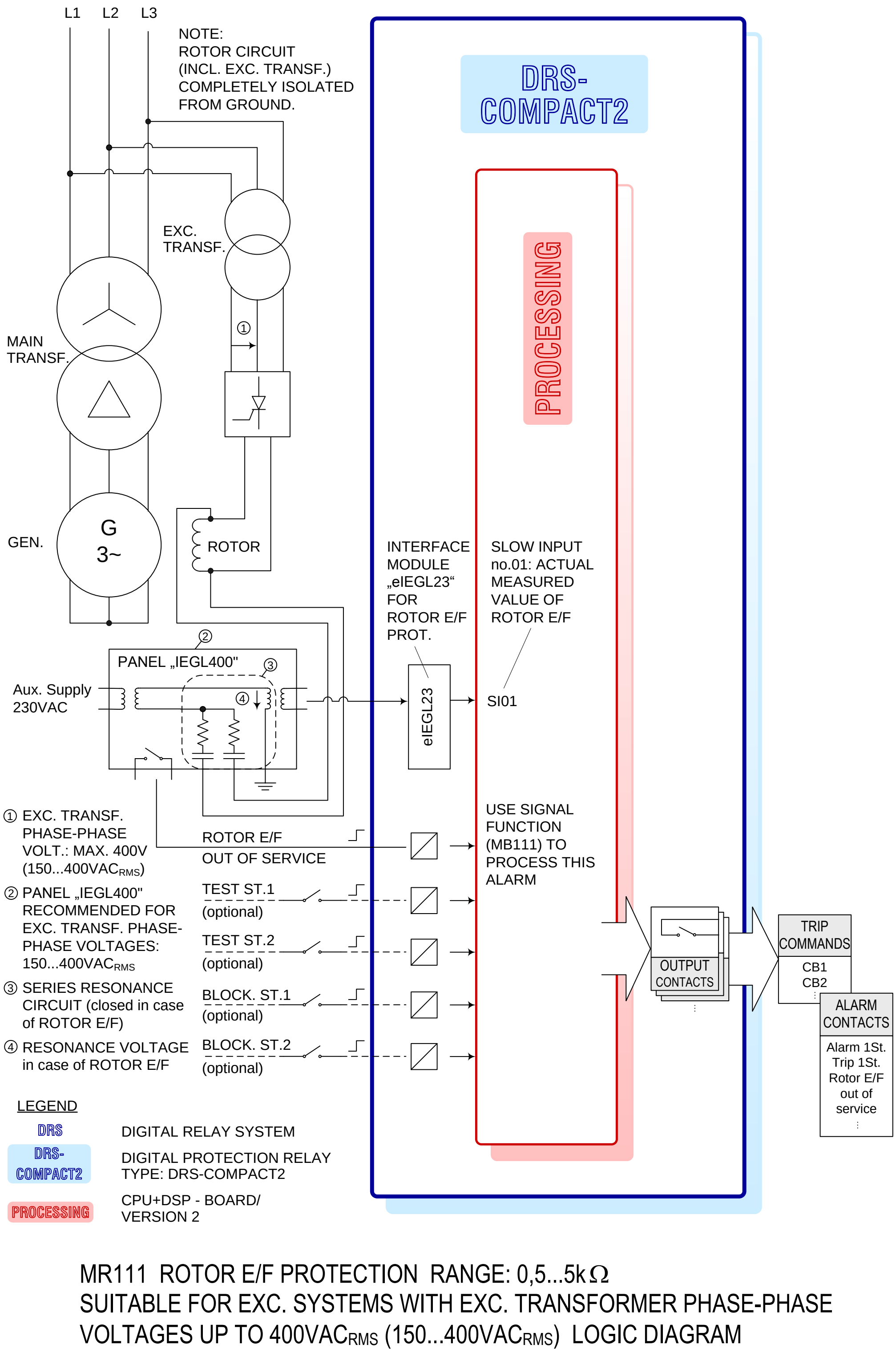
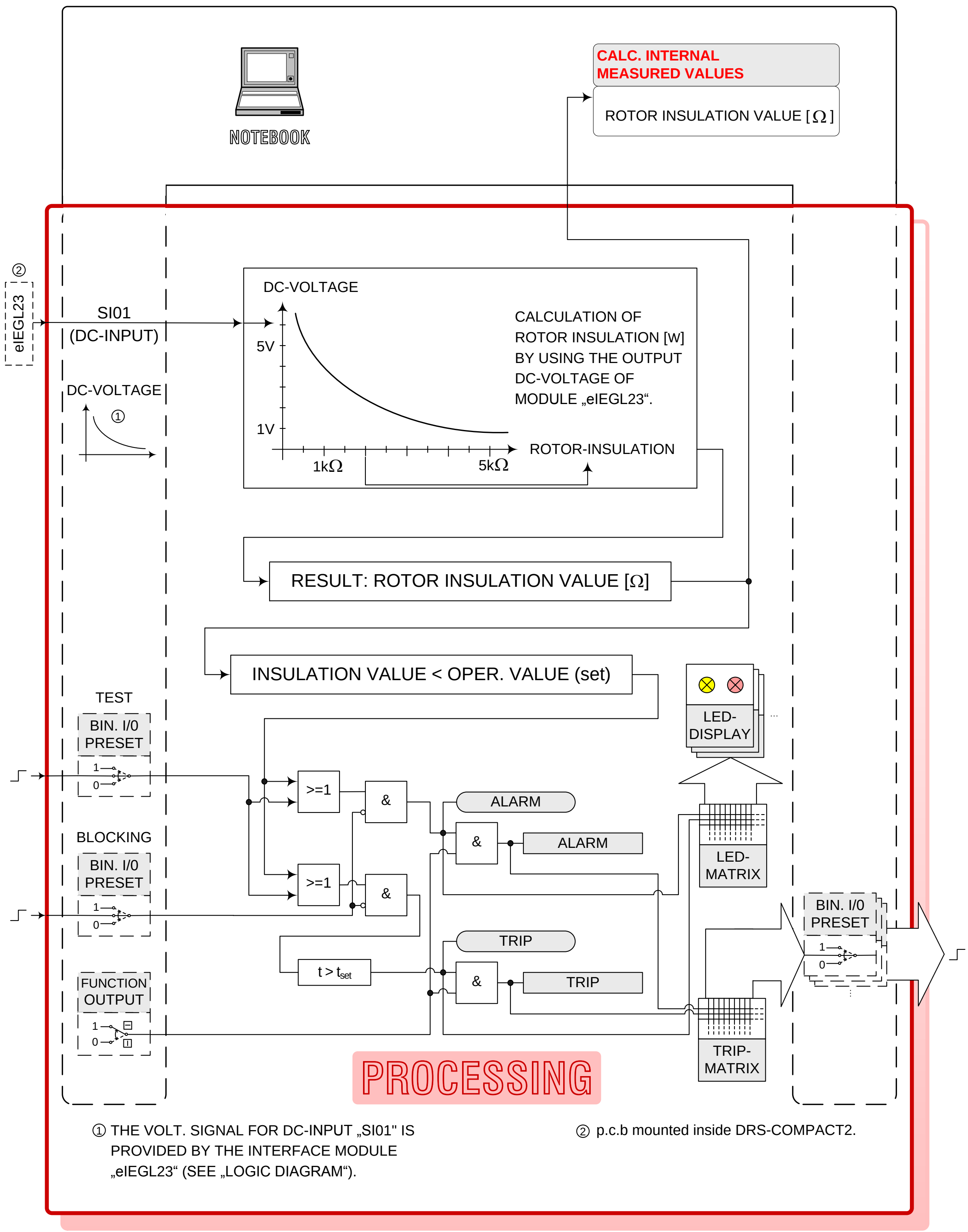


Fig. 202 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 400VAC$_{RMS}$ (150…400VAC$_{RMS}$) Logic Diagram



MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE VOLTAGES UP TO 400VAC$_{RMS}$ (150...400VAC$_{RMS}$) LOGIC DIAGRAM / PROCESSING

Fig. 203 MR111 Rotor E/F Protection Range: 0,5…5kΩk Suitable for Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 400VAC$_{RMS}$ (150…400VAC$_{RMS}$) Logic Diagram / Processing

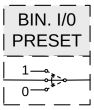
LEGEND PROCESSING

FIRMWARE-MODULE: MR111

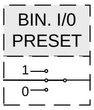
Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

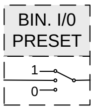
Online-indication of DRS-internal calculated values on notebook-screen



Online-simulation of DIG. IN-/OUTPUTS via notebook:

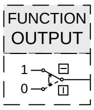


regular function

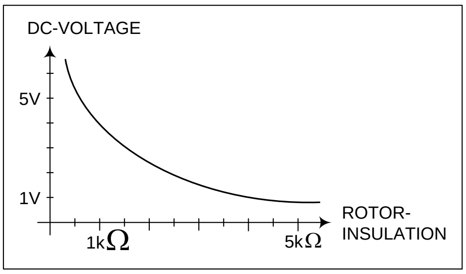


always „1"

always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MR111
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊞ all FUNCTION OUTPUTS disabled (test-operation)

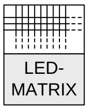


THE OUTPUT DC-VOLTAGE OF THE INTERFACE-MODULE „eIEGL23“ IS CONVERTED INTO A ROTOR-INSULATION VALUE [Ω].

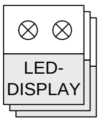
RANGE: 500...5000 Ω

eIEGL23

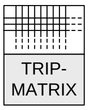
ROTOR E/F PROTECTION MODULE „eIEGL23“ IS POSITIONED INSIDE DRS COMPACT2. IT IS DESIGNED FOR APPLICATION WITH THE EXTERNAL PANEL(S) „IEGL850“, „IEGL400“, „IEGL150“.



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM ST.1	FUNCTION OUTPUT: Alarm
TRIP ST.1	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE VOLT. UP TO 400VAC$_{RMS}$ (150...400VAC$_{RMS}$) LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 204 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems with Exc. Transformer Phase – Phase Volt. Up To 400VAC$_{RMS}$ (150…400VAC$_{RMS}$) Logic Diagram Processing / Legend

16.4.3. MR111 (400 ... 850 VAC)

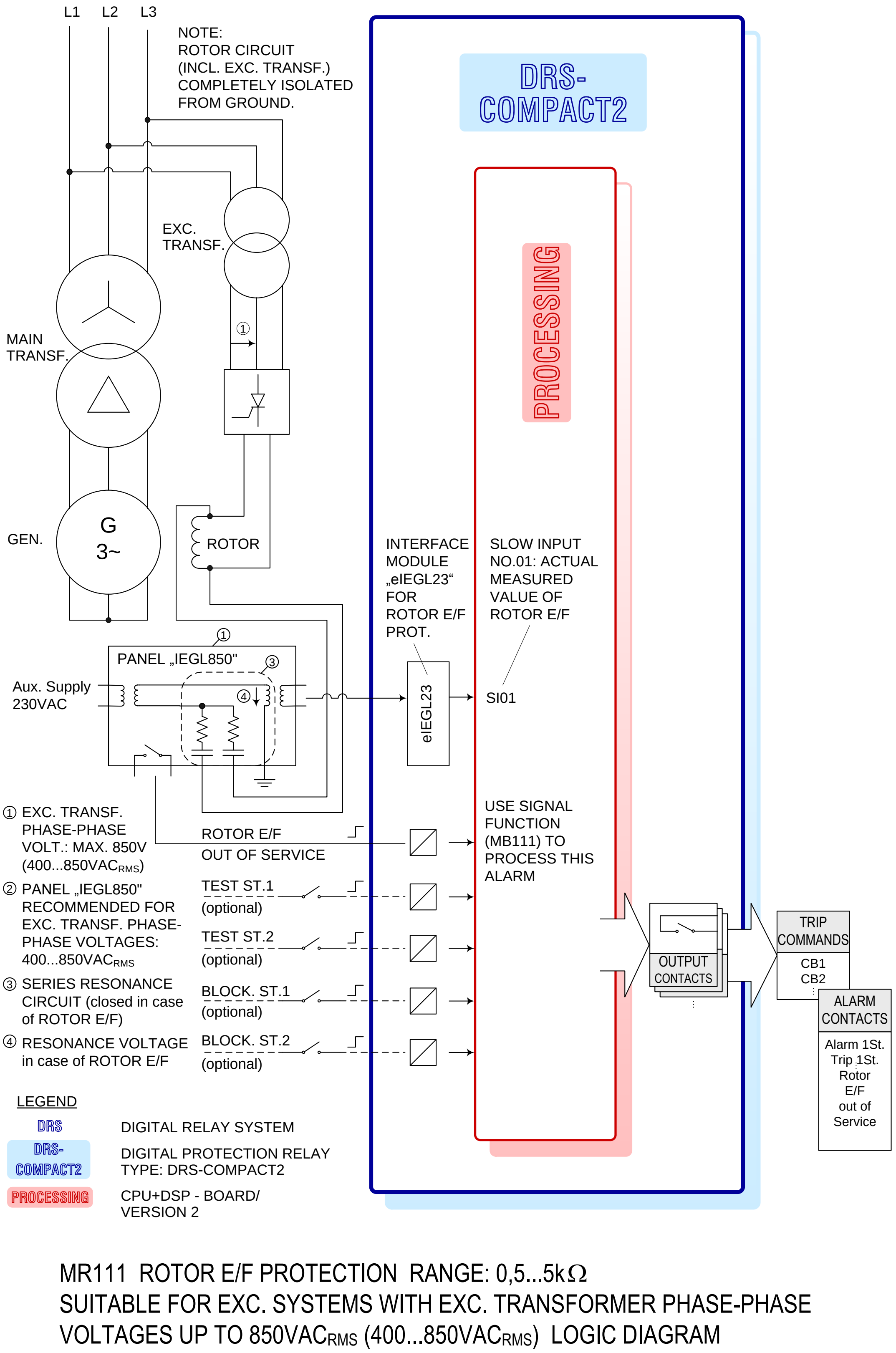
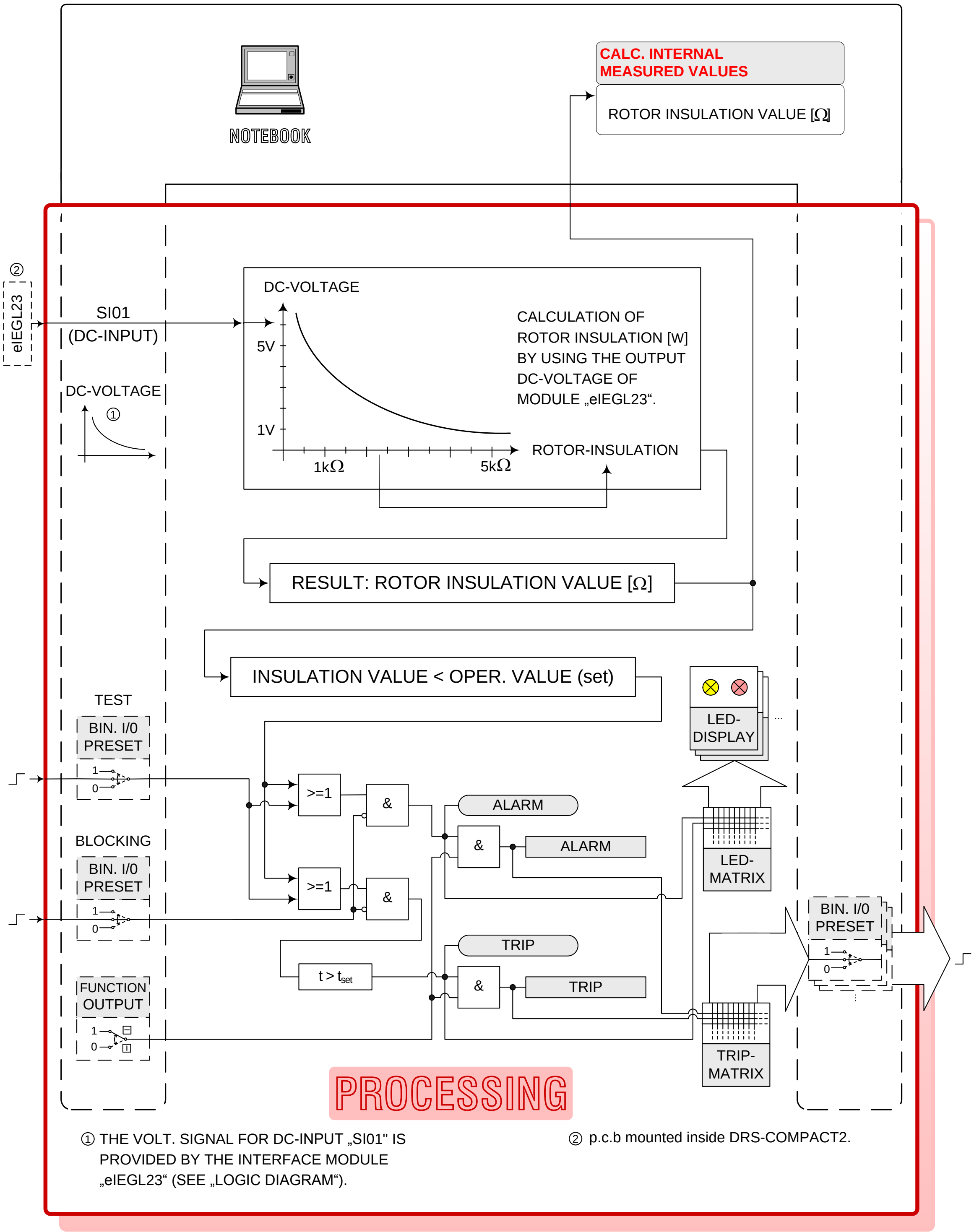


Fig. 205 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 850VAC$_{RMS}$ (400…850VAC$_{RMS}$) Logic Diagram



MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLTAGES UP TO 850VAC$_{RMS}$ (400...850VAC$_{RMS}$) LOGIC DIAGRAM / PROCESSING

Fig. 206 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 850VAC$_{RMS}$ (400…850VAC$_{RMS}$) Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MR111

CALC. INTERNAL MEASURED VALUES .....

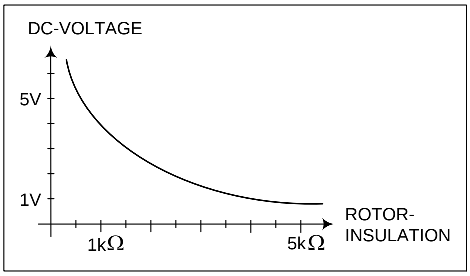
Online simulation via notebook — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT

Online-simulation of the FUNCTION OUTPUTS of the protective function MR111
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



THE OUTPUT DC-VOLTAGE OF THE INTERFACE-MODULE „eIEGL23“ IS CONVERTED INTO A ROTOR-INSULATION VALUE [Ω].

RANGE: 500...5000 Ω

eIEGL23

ROTOR E/F PROTECTION MODULE „eIEGL23“ IS POSITIONED INSIDE DRS COMPACT2. IT IS DESIGNED FOR APPLICATION WITH THE EXTERNAL PANEL(S) „IEGL850“, „IEGL400“, „IEGL150“.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

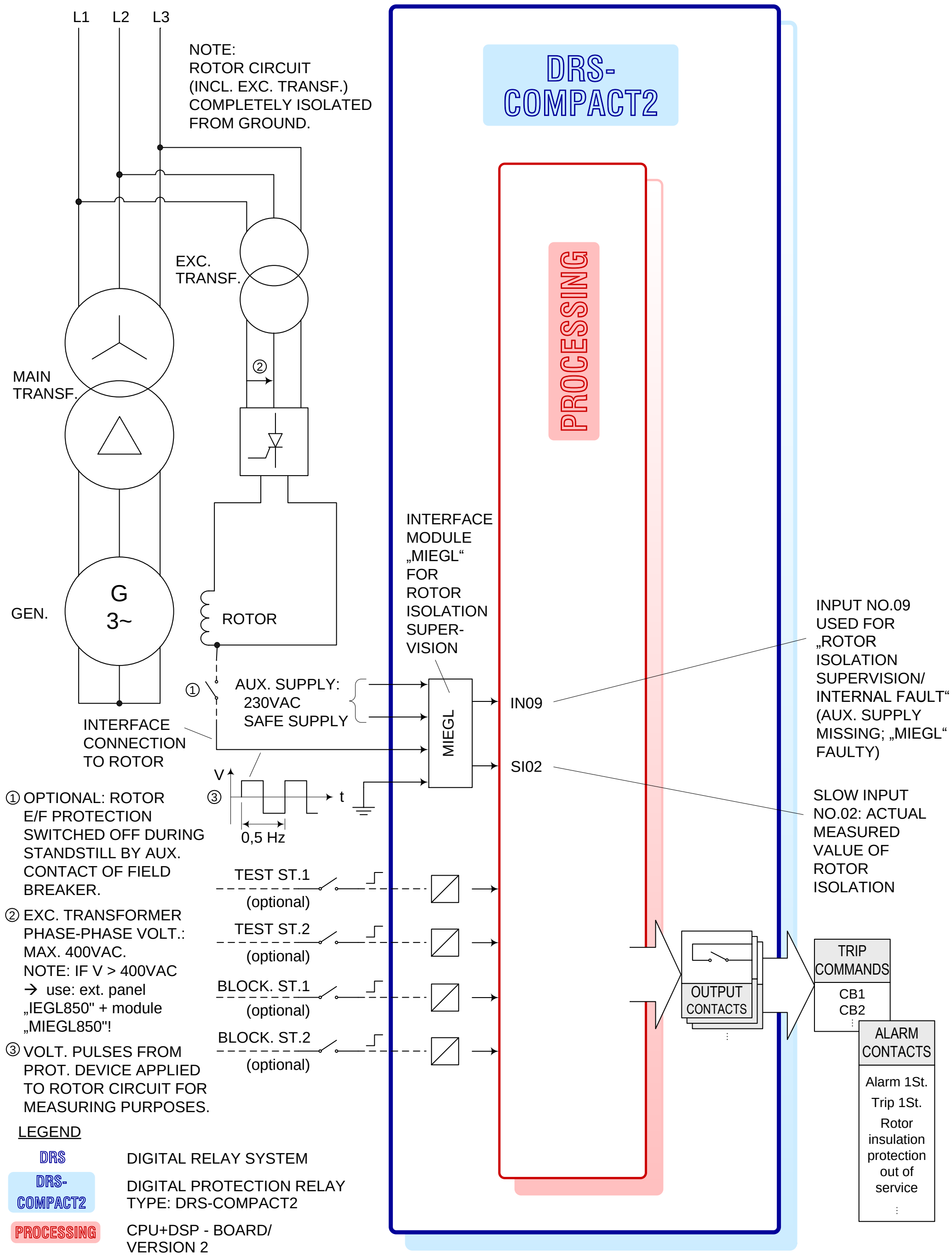
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MR111 ROTOR E/F PROTECTION RANGE: 0,5...5kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLT. UP TO 850VAC$_{RMS}$ (400...850VAC$_{RMS}$) LOGIC DIAGRAM PROCESSING / LEGEND

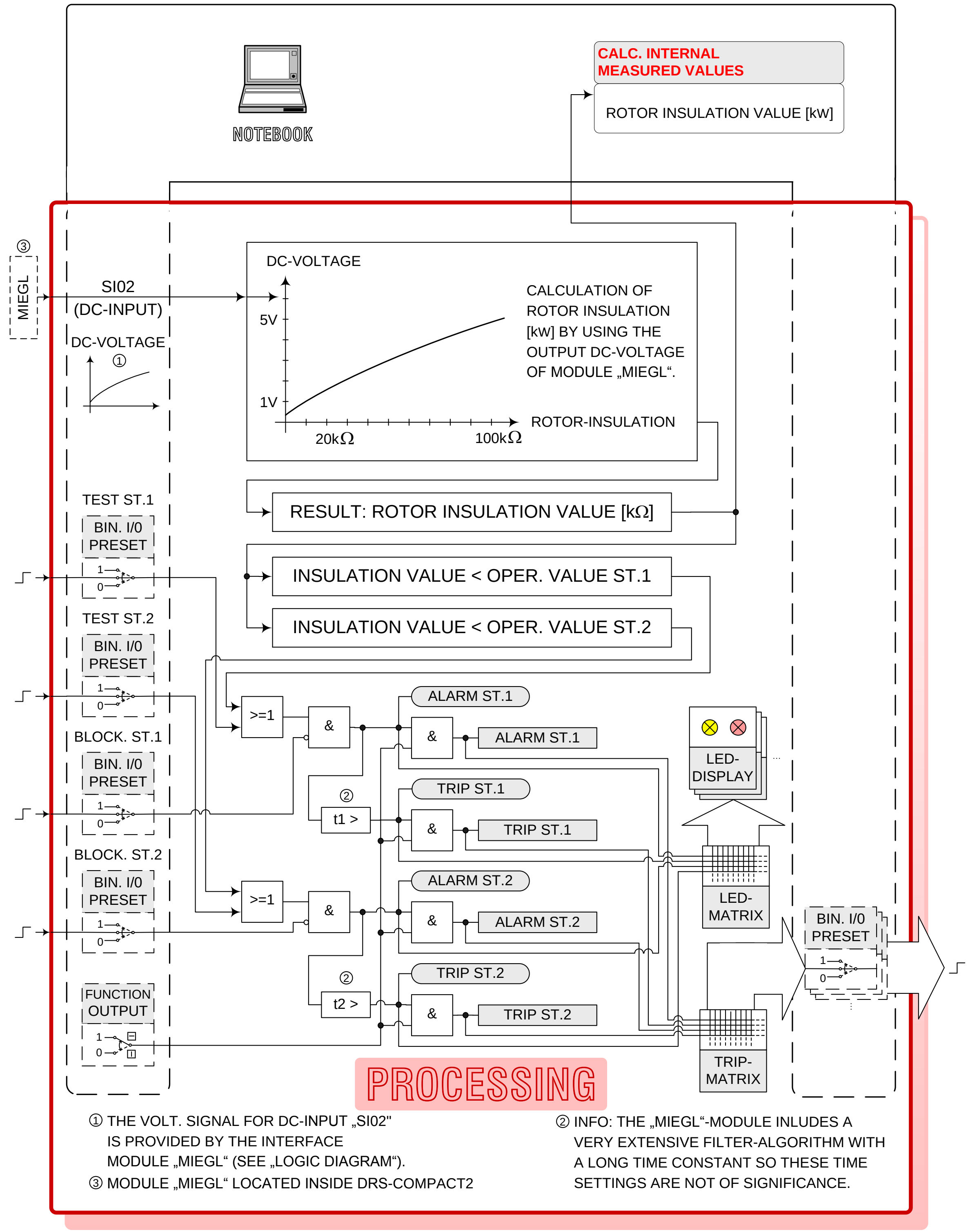
Fig. 207 MR111 Rotor E/F Protection Range: 0,5…5kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Volt. Up To 850VACRMS (400…850VACRMS) Logic Diagram Processing / Legend

16.4.4. MR121 (0 ... 400 VAC)



MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kW
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER
PHASE-PHASE VOLTAGES UP TO 400VAC LOGIC DIAGRAM

Fig. 208 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kW Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 400VAC Logic Diagram



MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER
PHASE-PHASE VOLTAGES UP TO 400VAC LOGIC DIAGRAM / PROCESSING

Fig. 209 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 400VAC Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MR121

Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET 1 0

Online-simulation of DIG. IN-/OUTPUTS via notebook:

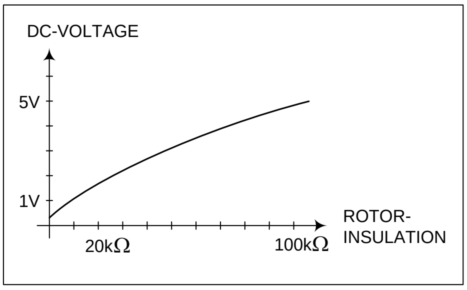
BIN. I/0 PRESET 1 0 regular function

BIN. I/0 PRESET 1 0 always „1"

BIN. I/0 PRESET 1 0 always „0"

FUNCTION OUTPUT 1 0

Online-simulation of the FUNCTION OUTPUTS of the protective function MR121
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



THE OUTPUT DX-VOLTAGE OF THE INTERFACE-MODULE „MIEGL“ IS CONVERTED INTO A ROTOR-INSULATION VALUE [kΩ].

RANGE OF STAGE 1: 4...20kΩ
RANGE OF STAGE 2: 20...100kΩ

MIEGL

ROTOR E/F MODULE „MIEGL“ IS POSITIONED INSIDE DRS COMPACT2. IT IS CONNECTED DIRECTLY TO THE ROTOR (NO ADDITIONAL EXTERNAL PANEL REQUIRED).

LED-MATRIX

Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY

LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX

Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM ST.1 — FUNCTION OUTPUT: Alarm

TRIP ST.1 — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER
PHASE-PHASE VOLTAGES UP TO 400VAC LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 210 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 400VAC Logic Diagram Processing / Legend

16.4.5. MR121 (400 ... 850 VAC)

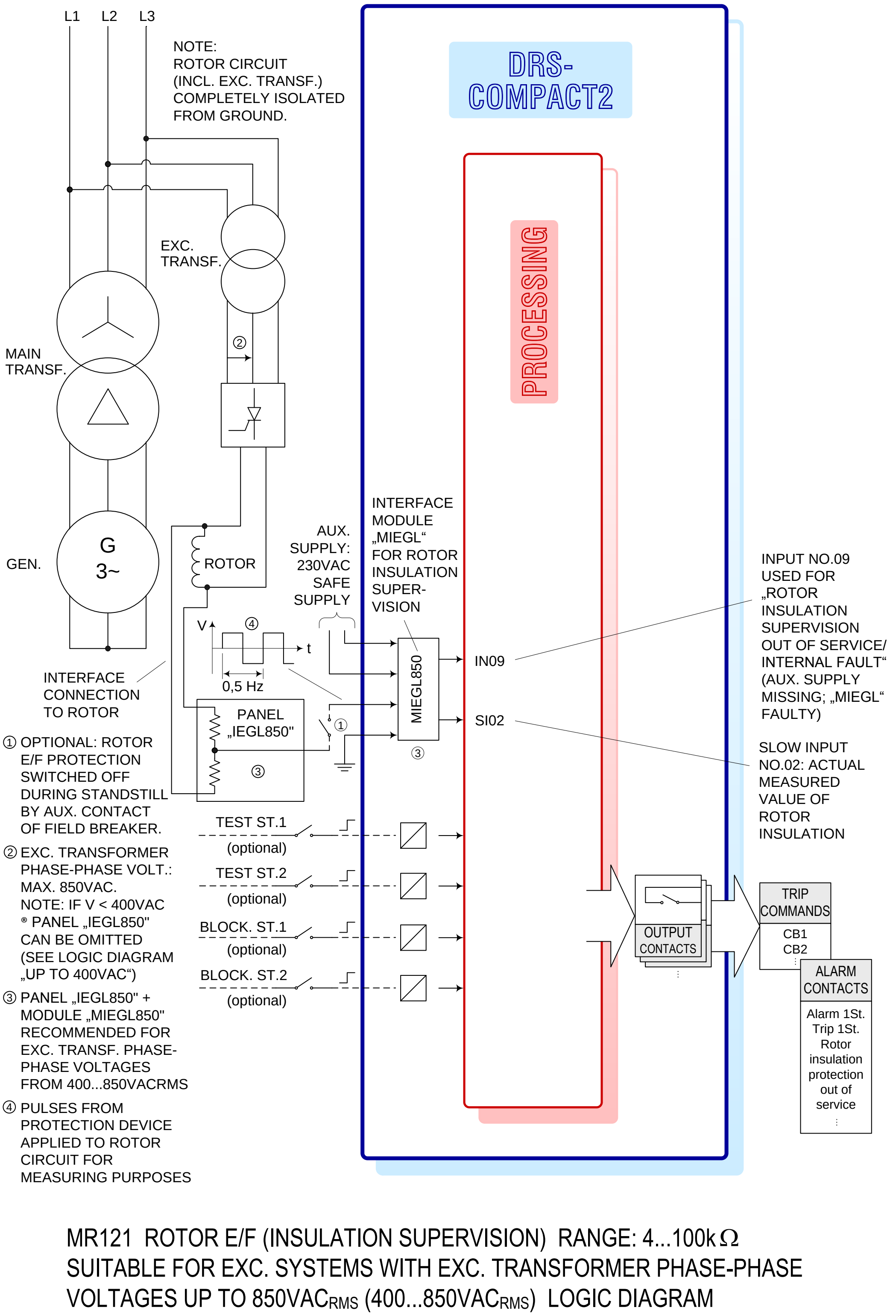
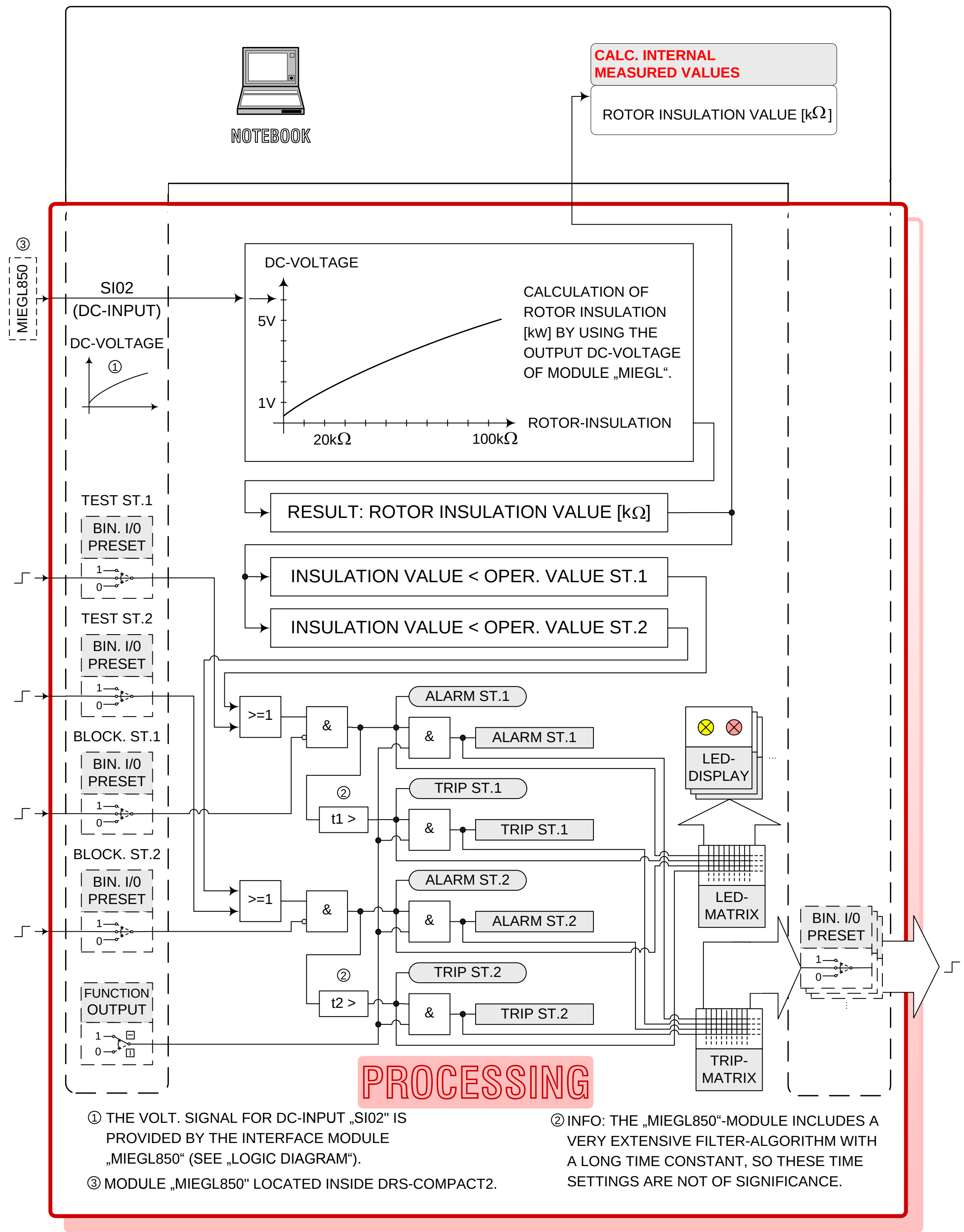


Fig. 211 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 850VAC_{RMS} (400…850VAC_{RMS}) Logic Diagram



MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLTAGES UP TO 850VAC$_{RMS}$ (400...850VAC$_{RMS}$) LOGIC DIAGRAM / PROCESSING

Fig. 212 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Voltages Up To 850VAC$_{RMS}$ (400…850VAC$_{RMS}$) Logic Diagram / Processing

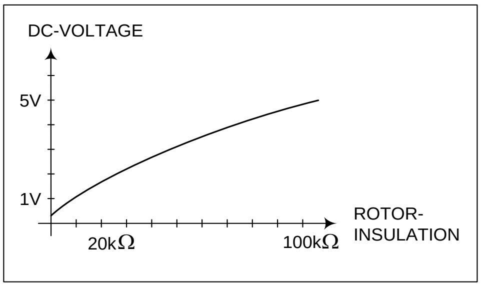
LEGEND PROCESSING

FIRMWARE-MODULE: MR121

CALC. INTERNAL MEASURED VALUES ….. — Online simulation via notebook — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: regular function; always „1"; always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MR121
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊞ all FUNCTION OUTPUTS disabled (test-operation)



THE OUTPUT DC-VOLTAGE OF THE INTERFACE-MODULE „MIEGL850“ IS CONVERTED INTO A ROTOR-INSULATION VALUE [kΩ].

RANGE OF STAGE 1: 4...20kΩ
RANGE OF STAGE 2: 20...100kΩ

MIEGL850 — ROTOR E/F MODULE „MIEGL850“ IS POSITIONED INSIDE DRS COMPACT 2. IT IS DESIGNED FOR APPLICATION WITH THE EXTERNAL PANEL „IEGL850“.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM ST.1 — FUNCTION OUTPUT: Alarm

TRIP ST.1 — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)
< — Type of function: under-detection (actual value < set value)

MR121 ROTOR E/F (INSULATION SUPERVISION) RANGE: 4...100kΩ
SUITABLE FOR EXC. SYSTEMS WITH EXC. TRANSFORMER PHASE-PHASE
VOLT. UP TO 850VAC$_{RMS}$ (400...850VAC$_{RMS}$) LOGIC DIAGRAM PROCESSING/ LEGEND

Fig. 213 MR121 Rotor E/F (Insulation Supervision) Range: 4…100kΩ Suitable For Exc. Systems With Exc. Transformer Phase – Phase Volt. Up To 850VACRMS (400…850VACRMS) Logic Diagram Processing / Legend

16.4.6. MR131 (UAKB)

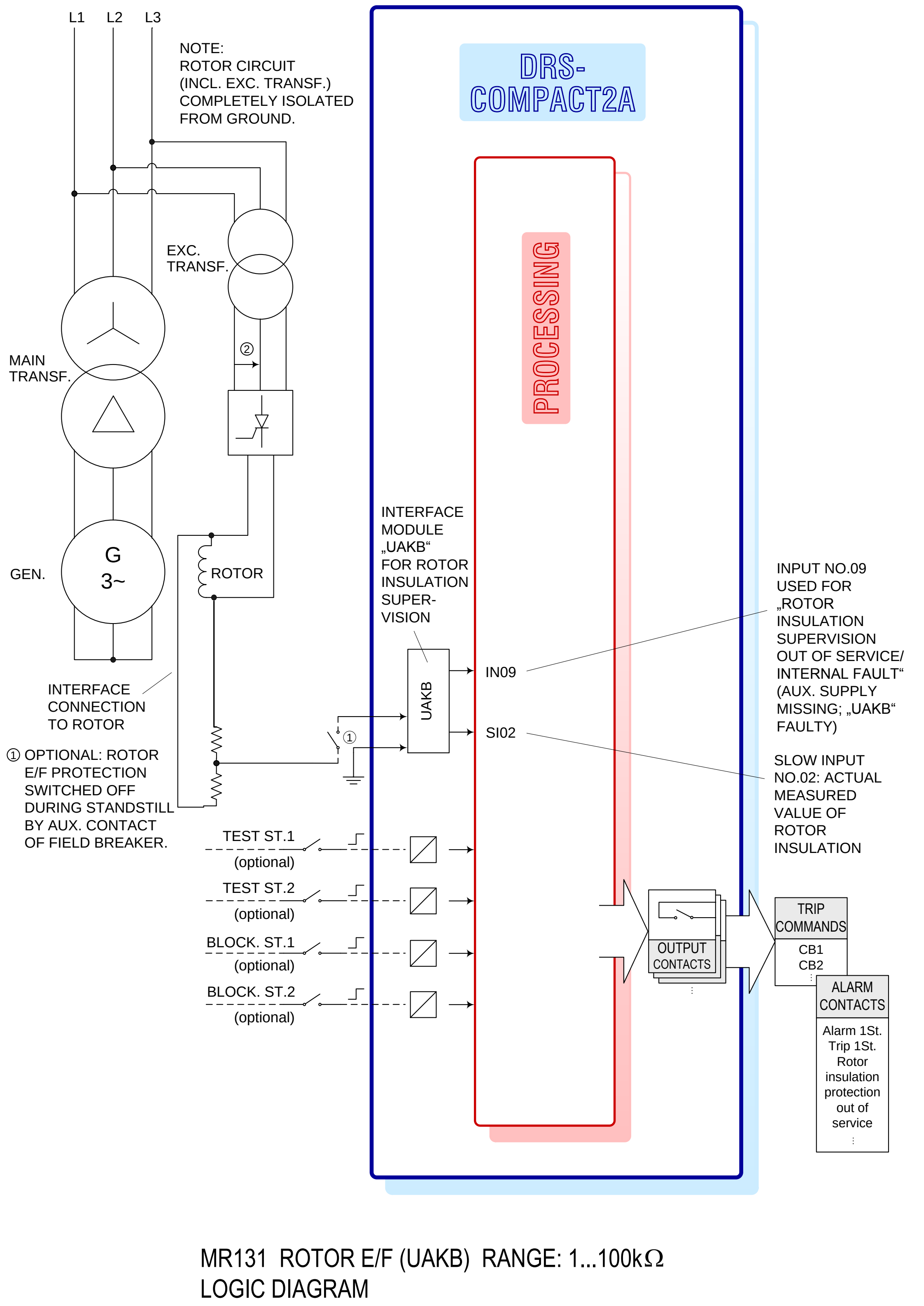
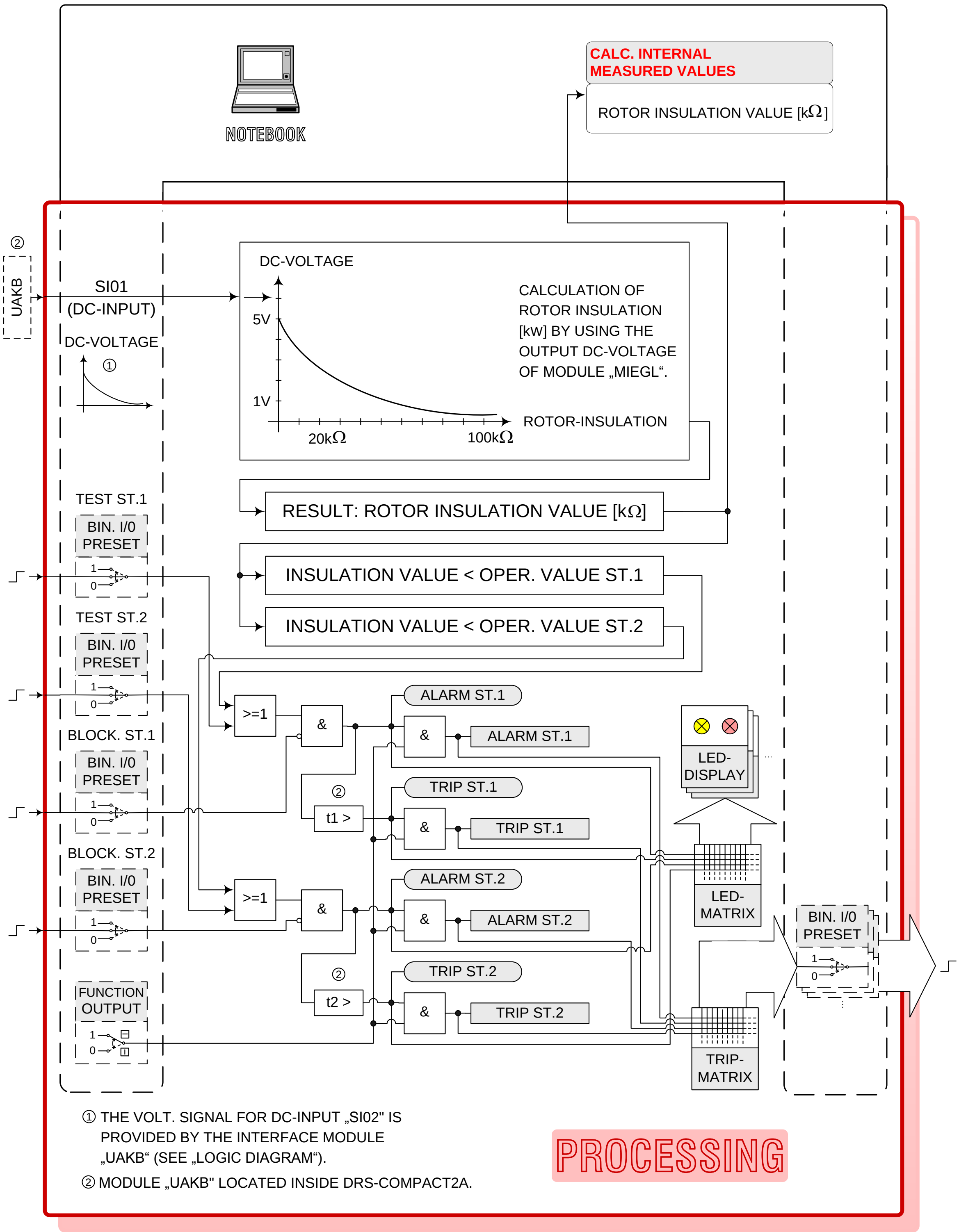
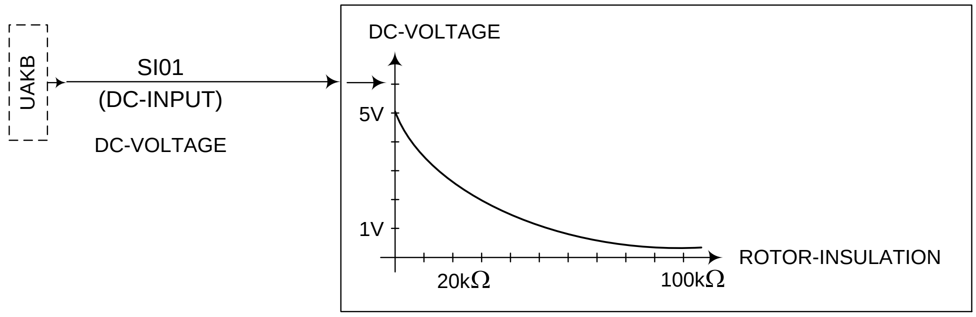


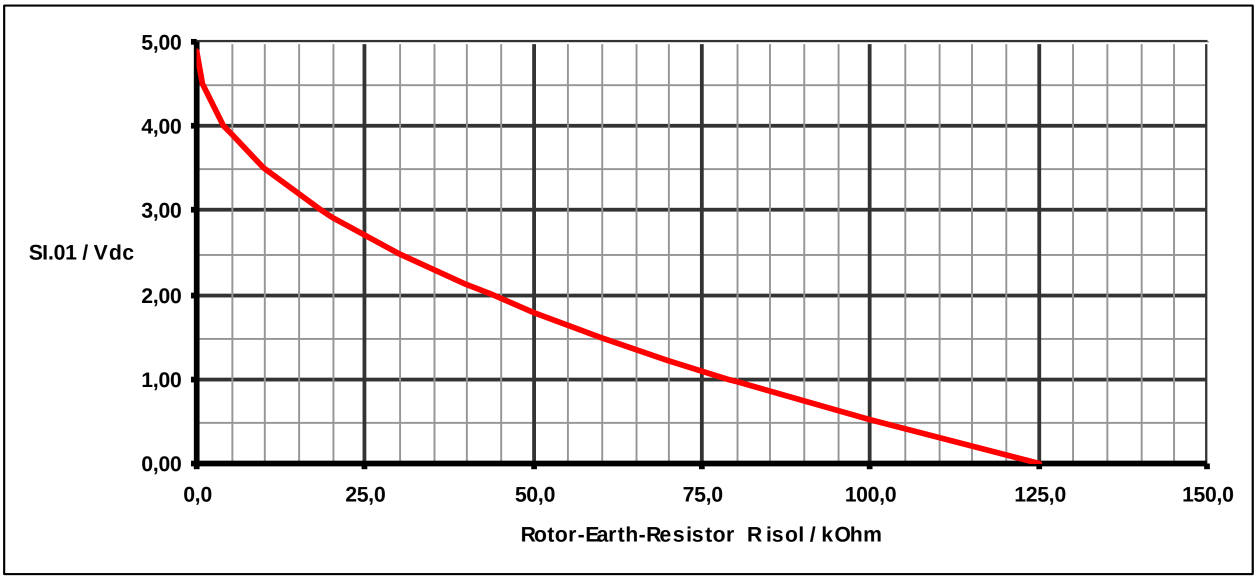
Fig. 214 MR131 Rotor E/F (UAKB) Range: 1…100kΩ Logic Diagram



MR131 ROTOR E/F (UAKB) RANGE: 1...100kΩ
LOGIC DIAGRAM / PROCESSING

Fig. 215 MR131 Rotor E/F (UAKB) Range: 1…100kΩ Logic Diagram / Processing





LEGEND:
SI01 ... DRS-COMPACT2A slow DC-input 01

MR131 ROTOR E/F (UAKB) RANGE: 1...100k Ω
CHARACTERISTIC DIAGRAM

Fig. 216 MR131 Rotor E/F (UAKB) Range: 1…100kΩ Characteristic Diagram

LEGEND PROCESSING

FIRMWARE-MODULE: MR131

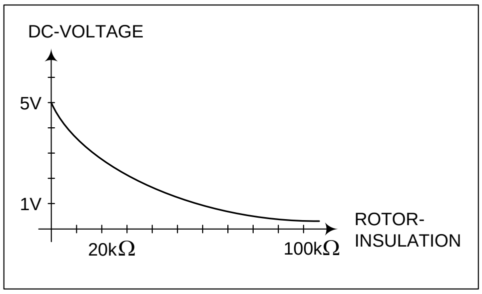
Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT

Online-simulation of the FUNCTION OUTPUTS of the protective function MR121
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)



THE OUTPUT DC-VOLTAGE OF THE INTERFACE-MODULE „UAKB" IS CONVERTED INTO A ROTOR-INSULATION VALUE [kΩ].

RANGE OF STAGE 1: 1 … 100kΩ / 0 … 840 s
RANGE OF STAGE 2: 1 … 20kΩ / 0 … 99 s

UAKB — ROTOR E/F MODULE „UAKB" IS POSITIONED INSIDE DRS-COMPACT2A.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM ST.1 — FUNCTION OUTPUT: Alarm

TRIP ST.1 — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MR131 ROTOR E/F (UAKB) RANGE: 1...100kΩ
LOGIC DIAGRAM PROCESSING/ LEGEND

Fig. 217 MR131 Rotor E/F (UAKB) Range: 1…100kΩ Logic Diagram Processing / Legend

16.5. FUNCTION

16.5.1. MR111/ MR121 / MR131

Rotor earth fault protective functions, respectively rotor insulation protective functions are applied to monitor the insulation level to ground of the excitation circuit for synchronous machines.
A deterioration of the insulation level can thereby be recognised in time to take preventive measures against low resistance single- or double earth faults.
The connection is carried out onto the DC circuit of the rotor whereby not only the rotor is supervised but also all auxiliary circuits with a direct galvanic connection to this system.

MR111/ Rotor Earth Fault Protection:

For measuring the insulation conditions with the input module type eIEGL21 a nominal frequency signal of approximately 30V AC is superimposed onto the rotor circuit which is produced via an auxiliary voltage supply input.
The module output signal represents an indirect proportional DC signal which is converted via a slow analogue input to be evaluated by the DRS Central Control Unit VE.

The DC voltage corresponding to the insulation level is sampled 12 times per cycle and compared with the trigger value parameter. When the measured resistance is smaller than the set trigger value during 25 consecutive samples the function is alarm initiated and the trip delay time started.
When the fault persists during the whole time delay a trip output signal will be given.

MR121/ Rotor Insulation Protection:

With an auxiliary power supply the input module MIEGL produces a pulsed rectangular signal of approximately 30 V amplitude with a selectable frequency (depending on the rotor capacitance) of 0.1 to 0.5 Hz which is connected to the rotor circuit via an external attenuation unit.
In a measuring circuit the pulsed signal echo of the connected excitation system, i.e. rotor, cables, excitation, excitation transformer, etc. is evaluated after a certain measuring time. Depending on the pulse frequency this may take up to a few minutes and is made available as a DC output signal of the module which is proportional to the insulation resistance and transferred via a slow analogue input to the DRS Central Control Unit PROCESSING for further execution.

The DC voltage corresponding to the insulation level is sampled 12 times per cycle and compared with the trigger value parameter. When the measured resistance is smaller than the set trigger value during 25 consecutive samples the function is alarm initiated and the trip delay time started.
When the fault persists during the whole time delay a trip output signal will be given.

The correct performance of the input module MIEGL is monitored in the module itself which is provided with service indication and alarm contacts.

Both functions have test- and blocking inputs which by appropriate configuration and installed hardware (input modules) enable protective function testing and function blocking.

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

MR131 / Rotor Insulation Protection (UAKB):
Refer to: "Description of Module UAKB CIC-012-A" Dwg. No.: CIC-012-A.XX/90

16.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

16.6.1. MR111/ MR121 / MR131

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry.

Also the function parameters have to be set according to the data of the rotor system.

The function outputs for the LED matrix and the trip matrix have to be configured according to requirements.

Function tests are preferably performed with the primary plant out of service.

The pre-commissioning test procedures for the rotor earth fault protection and the rotor insulation protection differ considerably due to the different measuring methods.

MR111/ Rotor Earth Fault Protection:

Insert a resistance decade between a rotor connection, e.g. the slip ring, and the generator shaft.
Reduce the resistance value until the rotor earth fault protection operates.
Record the operating value in the commissioning sheets.
Increase the resistance value until the rotor earth fault protection resets.
Record the reset value in the commissioning sheets.
During all tests check the insulation resistance level via the DRS option "Actual Measured Values" in the window display.

The input matrix, LED matrix and the trip matrix have to be confirmed according to the external circuitry and the circuit diagrams.

With half the resistance parameter setting measure the operating time of the protective function with a timer and record the value into the test sheets.

Check the configured function block for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test input for each stage by initiating the test signal and the protective function, respectively the stage has to operate without external test resistance.

MR121/ Rotor Insulation Protection:

At first for the actual plant configuration the correct pulse frequency has to be adjusted in the MIEGL input module (please also refer to Dwg. No 4-664.523 , MIEGL commissioning).

Insert a resistance decade between a rotor connection, e.g. the slip ring, and the generator shaft and reduce the setting value to about 10% of the operating value for stage 1 of the rotor insulation protection.
By monitoring the window display of the measured insulation level by selecting the option "Actual Measured Values" which are approaching asymptotically the final value showing approximately the value of the test resistor adjustment the correct response of the function is verified.
Record the operating value display of stage 1 insulation level in the test sheets.

Increase the decade resistor value up to a reset of the stage 1 function and record the displayed result in the test sheets.

Proceed in a similar way for stage 2.

The input matrix, LED matrix and the trip matrix have to be confirmed according to the external circuitry and the circuit diagrams.

Should in addition to the measuring mode delay another time delay be configured for each stage they are to be checked by the aforementioned procedures, e.g. via a test input and the operating times recorded into the test sheets.

Check the configured function block for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test input for each stage by initiating the test signal and the protective function, respectively the stage has to operate without external test resistance.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After commissioning all modified test parameters must be re-configured to the original plant parameter settings.

<u>MR111/ MR121/ Primary Commissioning Tests:</u>

During the primary tests the correct response of the protective function is verified during system operating conditions and as far as possible following checks should be carried out:

- Open Circuit Voltage Tests:

Block the function trips of the rotor earth fault or rotor insulation protection.
Start up generator to rated speed and excite to nominal voltage.
Apply the same procedures as during the pre-commissioning tests to check the operating value of the function.
Enter the values into the commissioning sheets.
Verify the possible configured external function block from the plant.
Re-activate the protection trips of the rotor earth fault function, respectively the rotor insulation function.
If system conditions permit shut down the generator by a protection trip.
Remove all external test devices and restore the applicable parameter settings.

<u>MR131 / Rotor Insulation Protection (UAKB):</u>
Refer to: "Description of Module UAKB CIC-012-A" Dwg. No.: CIC-012-A.XX/90.

17. MS... STATOR EARTH FAULT

17.1. OVERVIEW

List of the Available MS . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MS . . .	**FNNR**	**TYPE**	**ANSI**	**Application**
Directional stator earth fault protection	1028	MS111	64G	C2,M,L
Stator earth fault protection for 20 Hz injection method; 2-stage; for use with UAKB.	1149	MS121	64G	C2,M
Stator earth fault protection with 20 Hz injection method; 1-stage. Note: Not to be used in conjunction with oversampling functions, e.g.,.Quick Current..	1044	MS211	64G	C2,M,L
Stabilised stator earth fault protection	1032	MS212	64G	C2,M,L
Stator earth fault protection 3rd harmonic with 1 E/F - Voltage Input and 3 Generator Terminal Voltage Inputs Note: Not to be used in conjunction with oversampling functions, e.g.,.Quick Current.	1144	MS113	64G	C2,M
Stator earth fault protection 3rd harmonic with 2 E/F - Voltage Inputs Note: Not to be used in conjunction with oversampling functions, e.g.,.Quick Current.	1068	MS213	64G	C2,M,L

17.2. TECHNICAL DATA

PROTECTIVE FUNCTION: MS111	FNNR	TYPE	ANSI	Application
Directional stator earth fault protection	1028	MS111	64G	C2,M,L

1 stage directional stator earth fault function.

MS111
Technical Data

Inputs

Analogue:	Current
	Voltage
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 40 V in 1 V steps
Operating time:	0 ... 30 Seconds in 0.05 sec steps
Slope:	0/30/60/90 degrees
Operating direction:	Direction 1/Direction 2 Please mind: When changing from VE1 to VE2 then this parameter changes from "Direction1/Direction2" to "Direction2/Direction1" !

Window Display for Relay Internal Determined and Computed Values

Angle Io-Vo:	In degrees electrical

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
	≤ 2% electrical at angle

PROTECTIVE FUNCTION: MS121	FNNR	TYPE	ANSI	Application
Stator earth fault protection for 20 Hz injection method; for use with UAKB.	1149	MS121	64G	C2,M

Stator earth fault function for 20 Hz system; to be combined with UAKB.
MS121 uses SI.01 (0 … 5 VDC).

MS121
Technical Data

Inputs

Analog DC [SI.01]:	Rotor-Earthfaultvoltage (supplied by UAKB)
Binary:	Blocking input St.1
	Test input St.1
	Blocking input St.2
	Test input St.2

Outputs

Binary:	Alarm St.1
	Trip St.1
	Alarm St.2
	Trip St.2

Setting Parameters

Operating value St.1:	0.5 … 10.0 kOhm in 0,1 kOhm steps
Operating time St.1:	0 ... 840 sec in 0.5 sec steps
Operating value St.2:	0.5 … 10.0 kOhm in 0,1 kOhm steps
Operating timeSt.2:	0 ... 99 sec in 0.5 sec steps

Window Display for Relay Internal Determined and Computed Values

Ground Resistance:	in kOhm

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
	≤ 2% of impedance value

PROTECTIVE FUNCTION: MS211	FNNR	TYPE	ANSI	Application
Stator earth fault protection with 20 Hz injection method Note: Not to be used in conjunction with oversampling functions, e.g. Quick Current,... Note: PROCESSING internal sampling frequency . 20 Hz !	1044	MS211	64G	C2,M,L

Stator earth fault function with 20 Hz signal injection (20 Hz impedance evaluation).

MS211
Technical Data

Inputs

Analogue:	Current 20 Hz
	Voltage 20 Hz
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip
	Measuring alarm

Setting Parameters

Operating value:	4 ... 100 Ohm in 1 Ohm steps
Operating time:	0 ... 30 Seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

System impedance:	in Ohm
Measured voltage:	in V
Measured current:	in A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n
	≤ 2% of impedance value

PROTECTIVE FUNCTION: MS212	FNNR	TYPE	ANSI	Application
Stabilised stator earth fault protection	1032	MS212	64G	C2,M,L

Stator earth fault function with stabilising against overvoltage- and overfrequency conditions.

MS212
Technical Data

Inputs

Analogue:	Stabilising voltage
	Measured voltage
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	10 ... 25 V in 1 V steps
Operating time:	0 ... 30 s in 0.05 s steps
Generator nominal voltage:	70 ... 140 V in 1 V steps
Nominal frequency:	16,7 ... 60 Hz in 0.1 Hz steps
Stabilising:	0 ... 140 % in 1 % steps

Window Display for Relay Internal Determined and Computed Values

Operating value	In V
Stator voltage	In V
Frequency	In Hz

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% U_n

PROTECTIVE FUNCTION: MS113	FNNR	TYPE	ANSI	Application
"SEF 3rd Harmonic 3-ph" Stator earth fault protection 3rd harmonic with 1 E/F - Voltage Input and 3 Generator Terminal Voltage Inputs Note: Not to be used in conjunction with oversampling functions, e.g. Quick Current,... Note: internal sampling frequency = generator nominal frequency	1144	MS113	64G	C2,M

1-stage stator earth fault function with evaluation of the 3rd harmonic component;
with 1 E/F - Voltage Input (Zero Sequence Voltage of Generator Neutral or Generator Busbar) and 3 Generator Terminal Voltage Inputs

Explication of Set Values:

Operating Value:	3. Harmonic relay starting value. The actual 3rd Harmonic voltage value can be calculated by using the Generator Neutral Voltage or the Generator Busbar Open Delta voltage.
Operating Time:	Trip Time Delay of relay.
Type:	Relay starting, when the measured value is lower resp. higher than the pick up value
Positive Phase Sequence Voltage:	Minimum positive phase sequence voltage for release of function in case of underdetection
PPS Voltage Blocking:	Selection, whether the generator PPS voltage disables the operation of the function in underdetection mode or not. Select 'Off' if the function should not be blocked.
Phase Rotation:	Selection of phase rotation.

MS113
Technical Data

Inputs

Analogue:	Voltage L1-L2
	Voltage L2-L3
	Voltage L3-L1
	Voltage E/F (3rd Harmonic) Note: Voltage generator busbar (Open Delta Voltage) or: Voltage generator neutral
Binary:	Blocking input
	Test input stage

Outputs

Binary:	Alarm
	Trip

Setting Parameters

Operating value:	0.5 ... 50 V in 0.1 V - steps
Operating time:	0 ... 60 s in 0.05 s - steps
Type:	Underdetection/ Overdetection
Positive Phase Sequence Voltage:	50 … 90 V in 0,5 V - steps
PPS Voltage Blocking:	Off/ On
Phase Rotation:	Right/ Left

Window Display for Relay Internal Determined and Computed Values

3rd Harmonic Voltage: Note: with reference to Input No. 4 "Voltage E/F"	in V
Positive Phase Sequence Voltage: Note: PPS Voltage is calculated with reference to Inputs No. 1 … 3 "Voltage L1-L2/L2-L3/L3-L1"	in V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or

PROTECTIVE FUNCTION: MS213	FNNR	TYPE	ANSI	Application
Stator earth fault protection 3rd harmonic with 2 E/F - Voltage Inputs Note: Not to be used in conjunction with oversampling functions, e.g. Quick Current,... Note: internal sampling frequency = generator nominal frequency	1068	MS213	64G	C2,M,L

1 stage stator earth fault function with evaluation of the 3rd harmonic component.
with 2 Voltage Inputs (Zero Sequence Voltages of Generator Neutral and Generator Terminals)

MS213
Technical Data

Inputs

Analogue:	Voltage generator busbar
	Voltage generator neutral
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	0.2 ... 5,0 V in 0.1 V steps
Operating time:	0.1 ... 30 s in 0.05 s steps
Balance:	0.20 ... 5.00 in 0.05 steps

Window Display for Relay Internal Determined and Computed Values

Voltage generator leads:	in V
Voltage generator neutral:	in V
Trigger voltage:	in V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or

17.3. CONNECTION DIAGRAMS

17.3.1. MS111

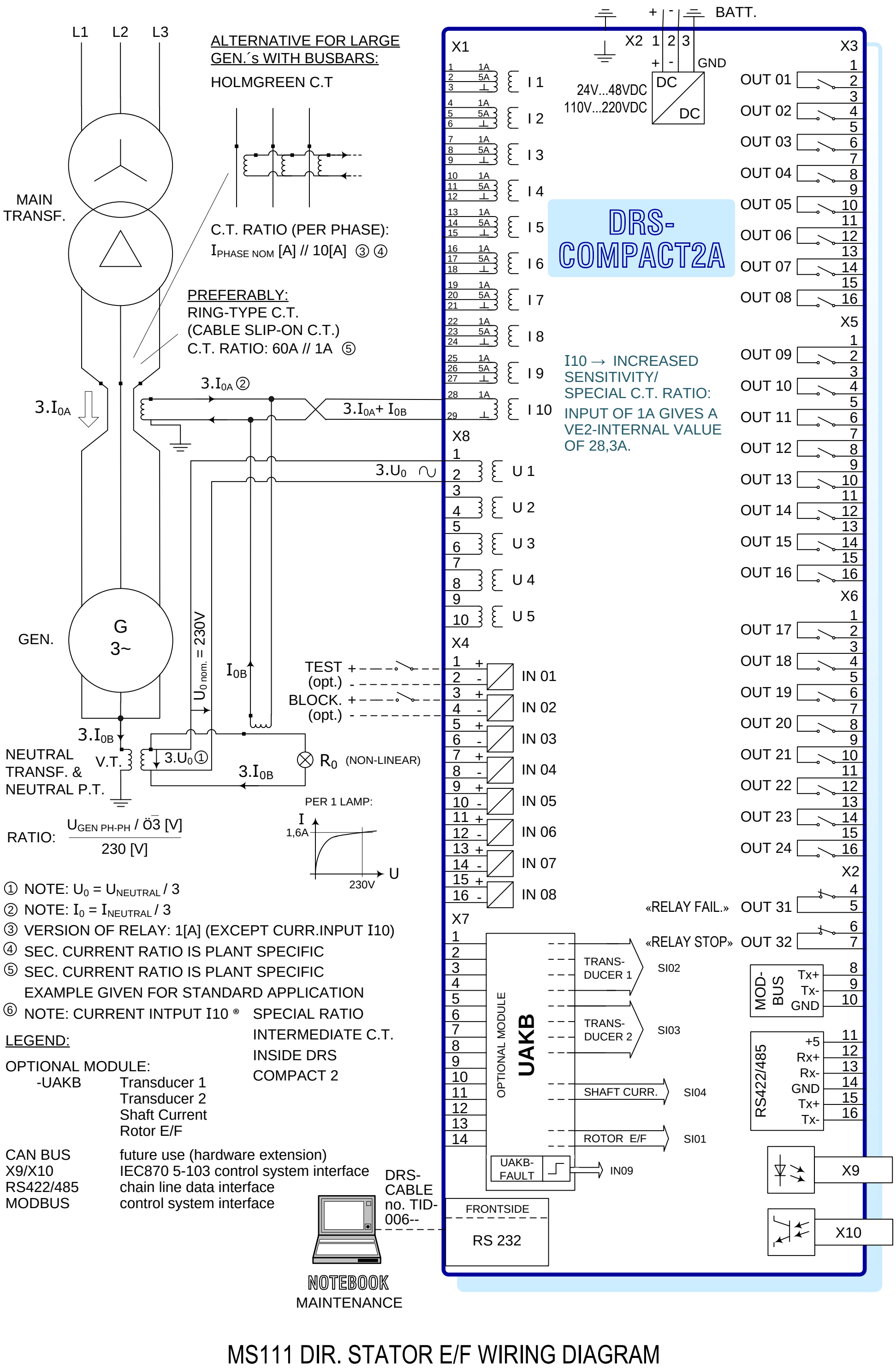


Fig. 218 MS111 Dir. Stator E/F Wiring Diagram

17.3.2. MS211

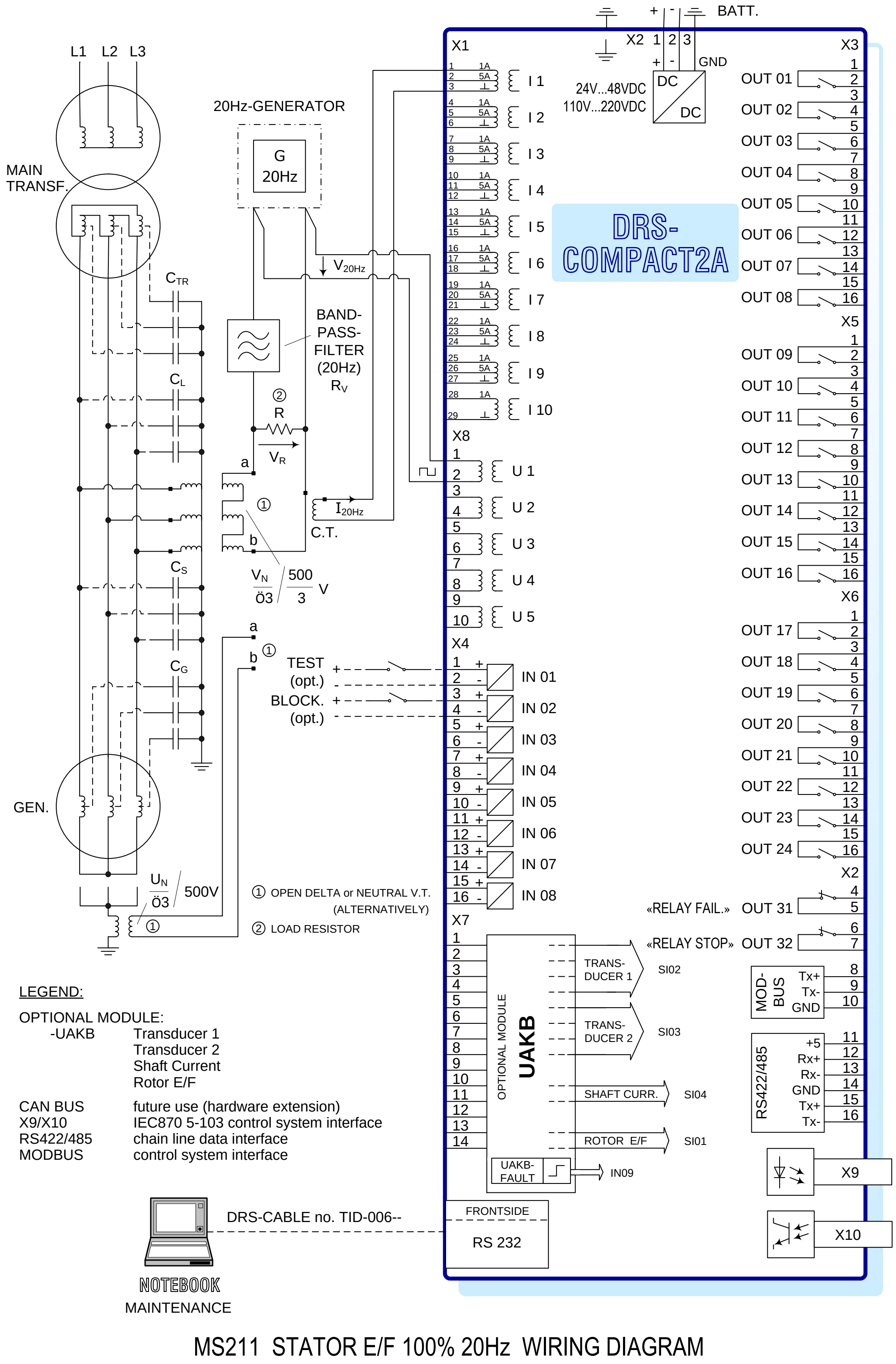
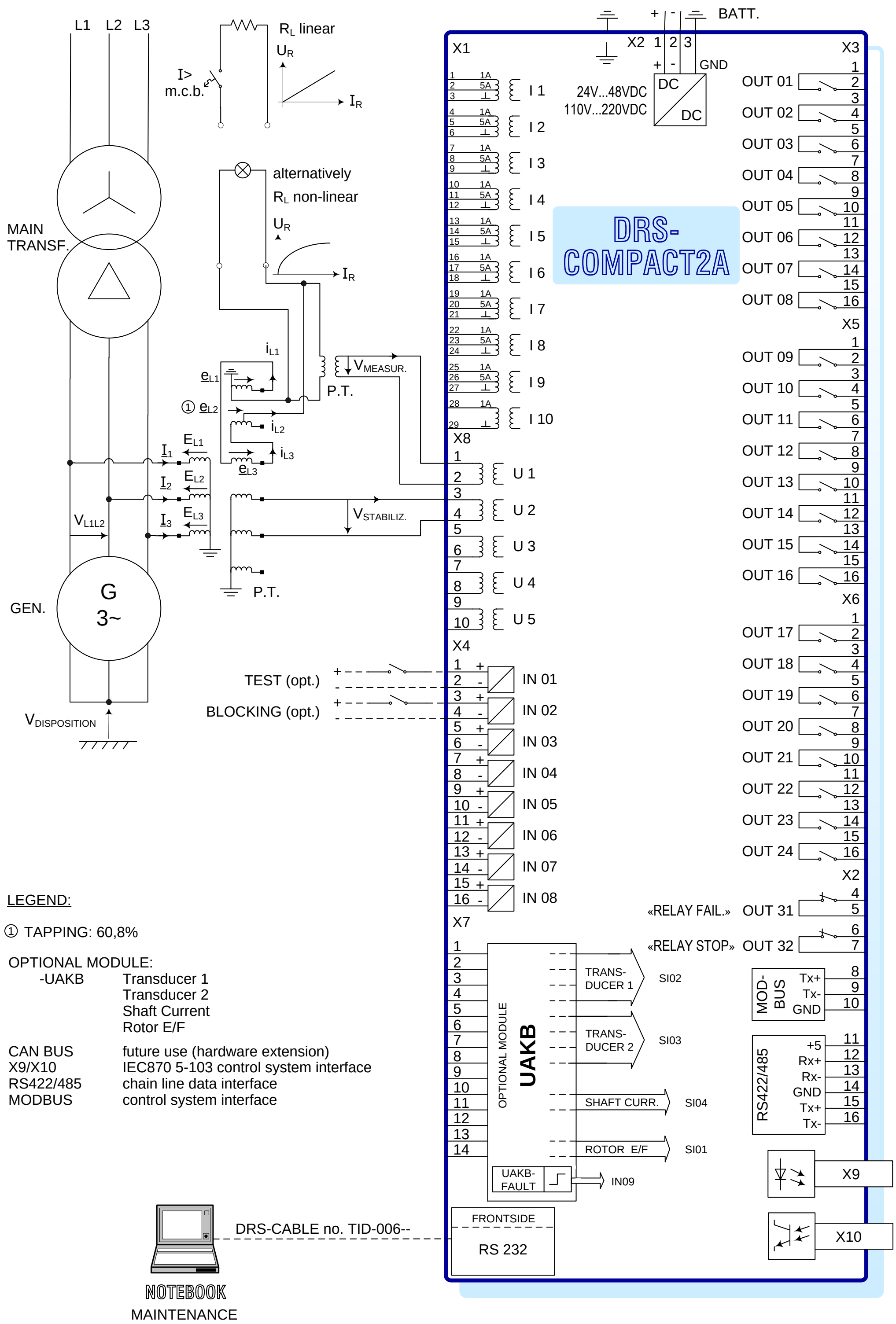


Fig. 219 MS211 Stator E/F 100% 20Hz Wiring Diagram

17.3.3. MS212



MS212 BIASED STATOR E/F 100% WIRING DIAGRAM

Fig. 220 MS212 Biased Stator E/F 100% Wiring Diagram

17.3.4. MS213

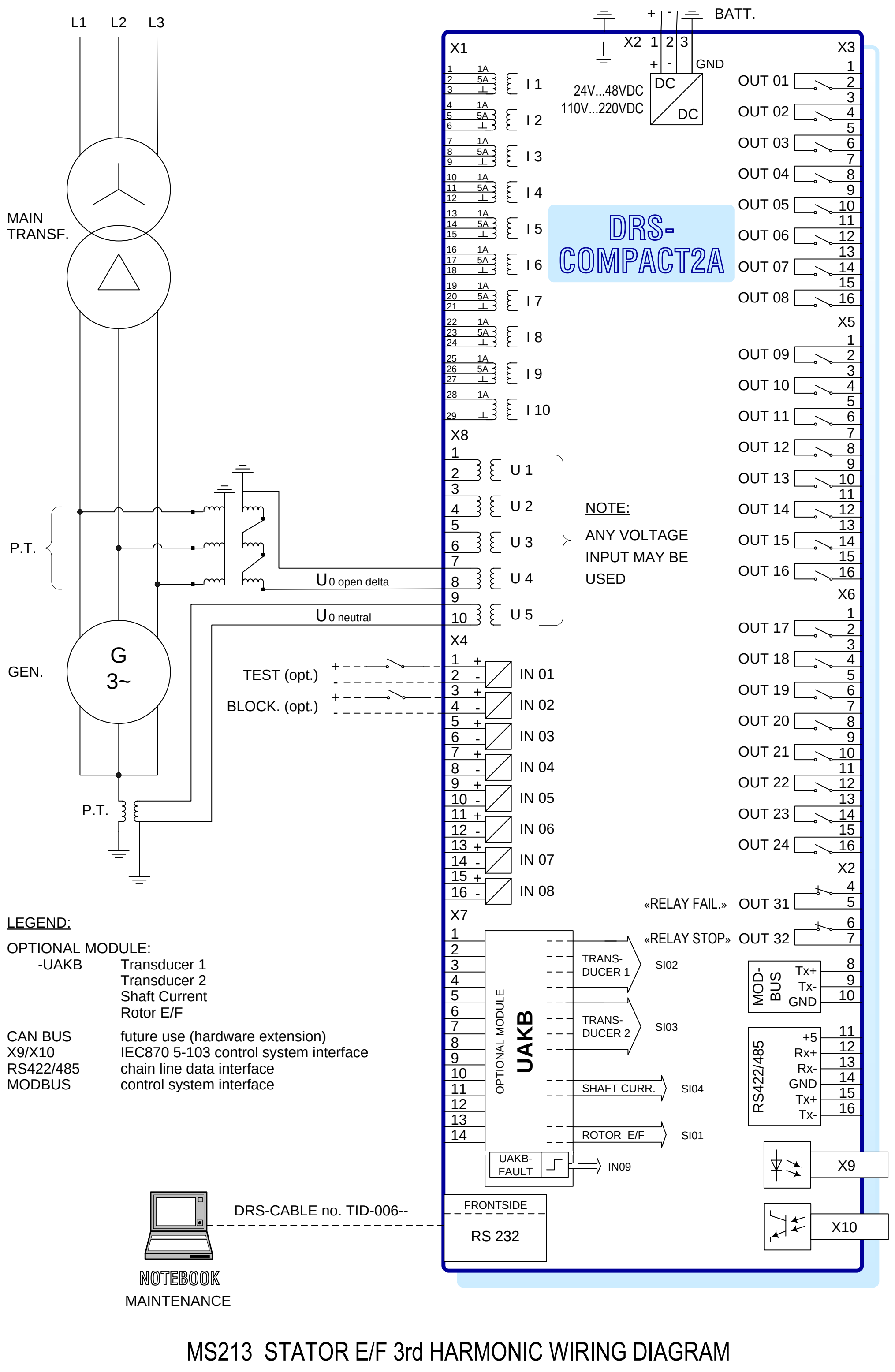


Fig. 221 MS213 Stator E/F 3rd Harmonic Wiring Diagram

17.4. LOGIC DIAGRAMS

17.4.1. MS111

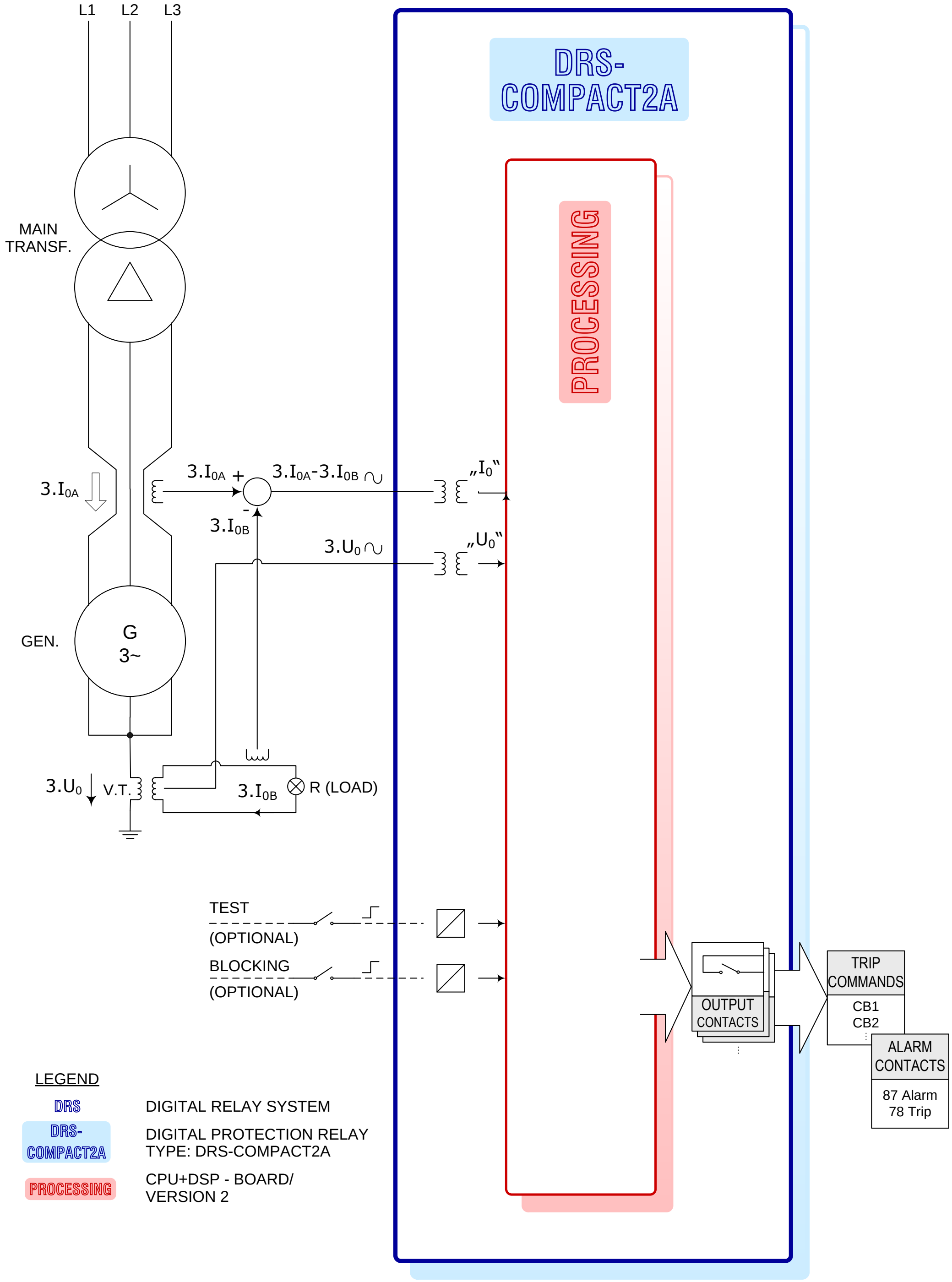
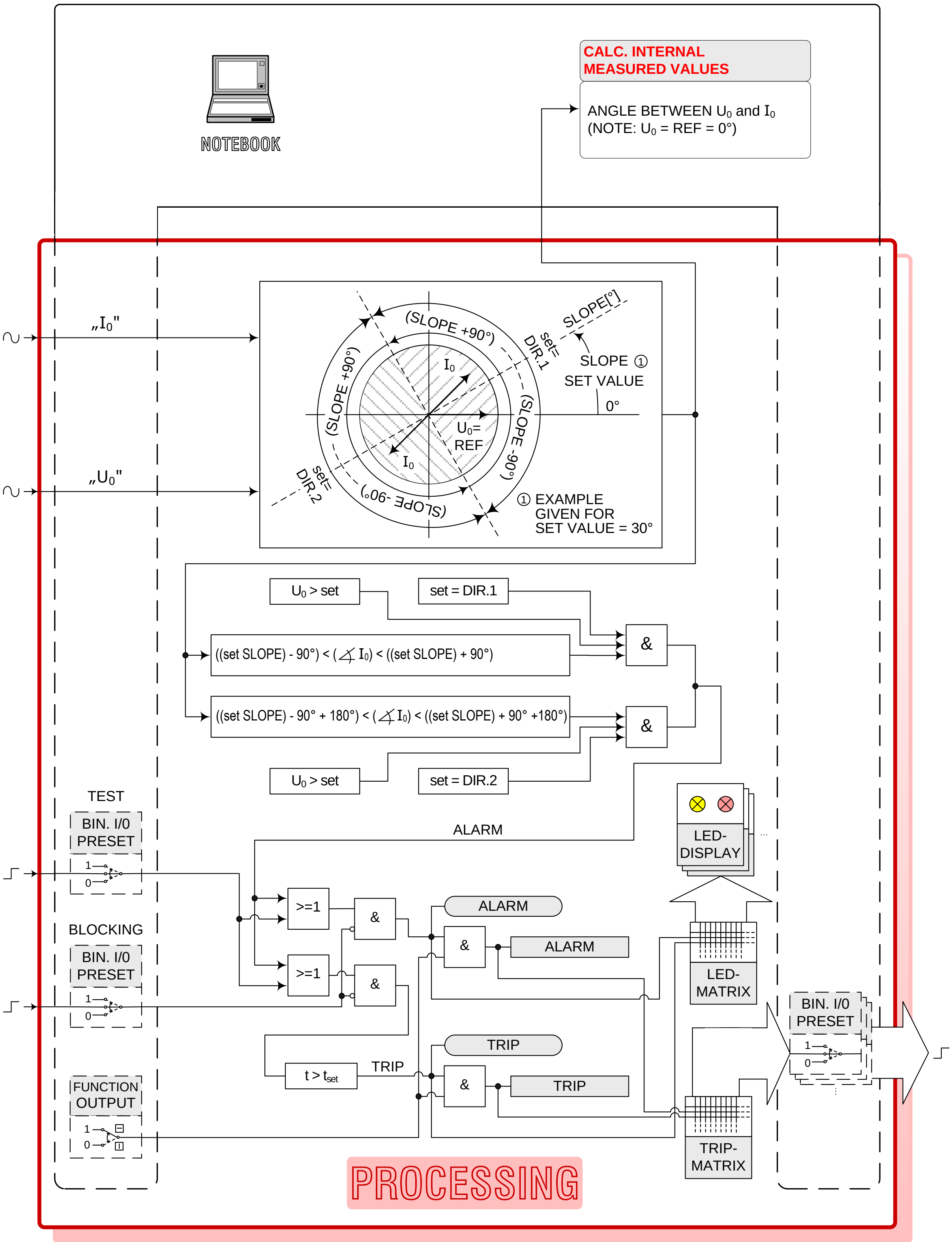


Fig. 17-5: MS111 DIR. STATOR E/F LOGIC DIAGRAM

Fig. 222 MS111 Dir. Stator E/F Logic Diagram



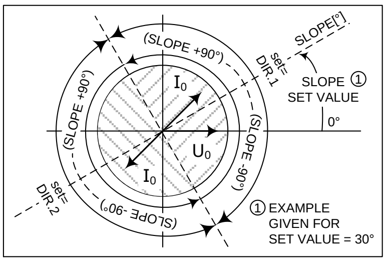
MS111 DIR. STATOR E/F LOGIC DIAGRAM PROCESSING

Fig. 223 MS111 Dir. Stator E/F Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE MODULE: MS111

Symbol	Description
(notebook)	Online simulation via notebook. CALC. INTERNAL MEASURED VALUES ..... Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"
FUNCTION OUTPUT	Online-simulation of the FUNCTION OUTPUTS of the protective function MD321 ⊟ all FUNCTION OUTPUTS enabled (regular-operation) ⊞ all FUNCTION OUTPUTS disabled (test-operation)



Calculation of angel between I_0 and „SLOPE" (reference for angel: $U_0 = 0°$). Result: DIR.1 or DIR.2

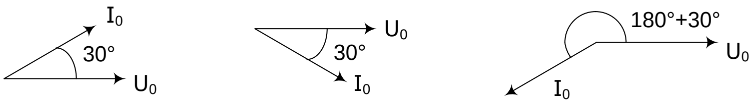
DIR.1 Angle between I_0 and „SLOPE" is in the range from („SLOPE" -90°) ----- („SLOPE" +90°). NOTE: Reference for the angle is „SLOPE"(corresp.with 0°).

DIR.2 Angle between I_0 and „SLOPE" is in the range from ((„SLOPE" +180°) -90°) ----- ((„SLOPE" +180°) +90°). NOTE: Reference for the angle is „SLOPE"(corresp.with 0°).

SLOPE Set-value (0°...30°...60°...90°). „SLOPE" corresponds with the (expected) angle of I_0 (with reference to U_0). NOTE: If „SLOPE" requires a setting of (180°...210°...240° ...270°) please use alternative DIR-setting(= DIR.2).

NOTEBOOK DISPLAY

ANGLE BETWEEN U_0 and I_0 (NOTE: U_0 = REF = 0°)



DISPLAY SHOWS +30° DISPLAY SHOWS -30° DISPLAY SHOWS +210°

Symbol	Description
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING. LED-DISPLAY: LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: 78 Alarm
TRIP	FUNCTION OUTPUT: 78 Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MS111 DIR. STATOR E/F LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 224 MS111 Dir. Stator E/F Logic Diagram Processing / Legend

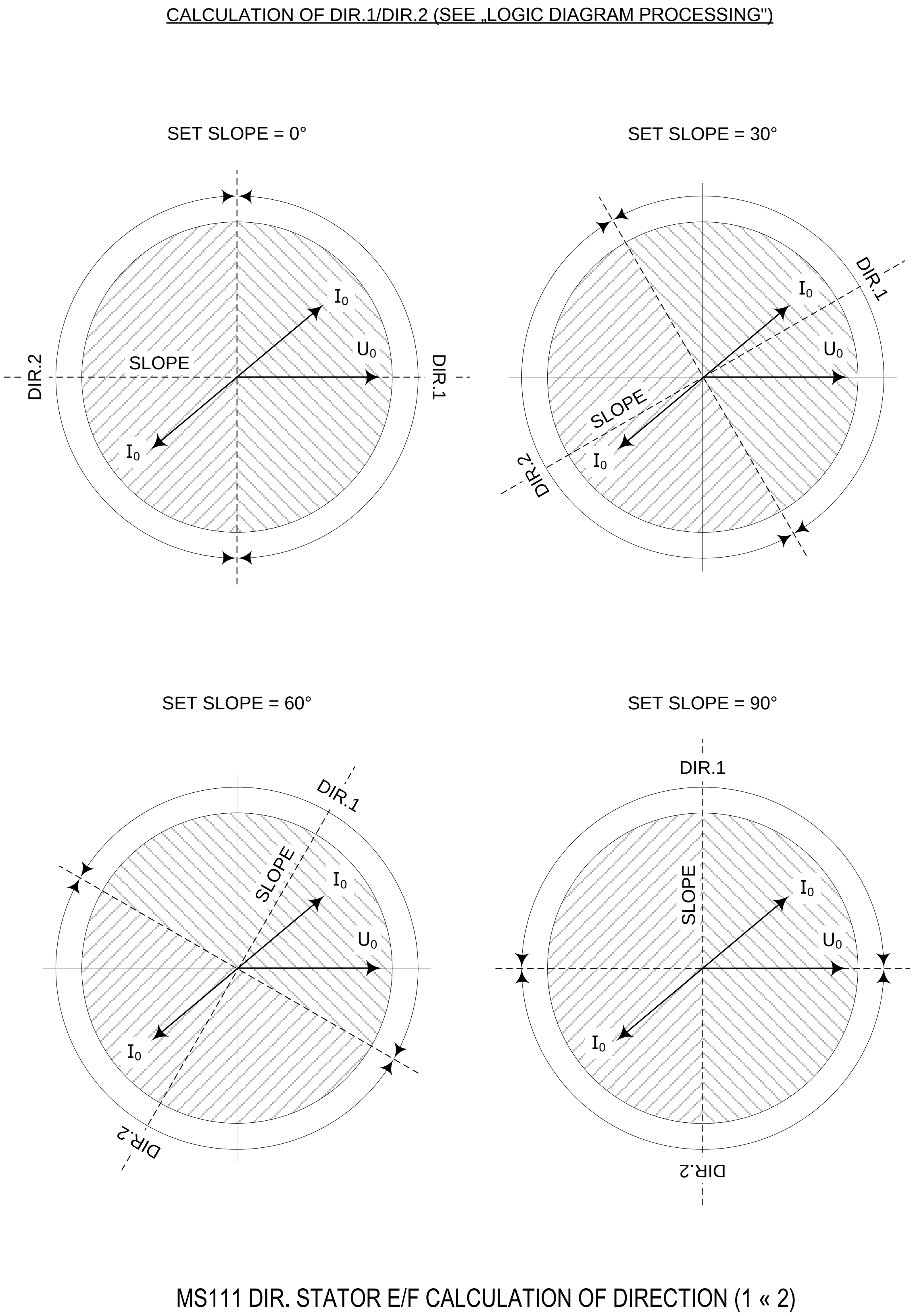


Fig. 225 MS111 Dir. Stator E/F Calculation Of Direction (1 ↔ 2)

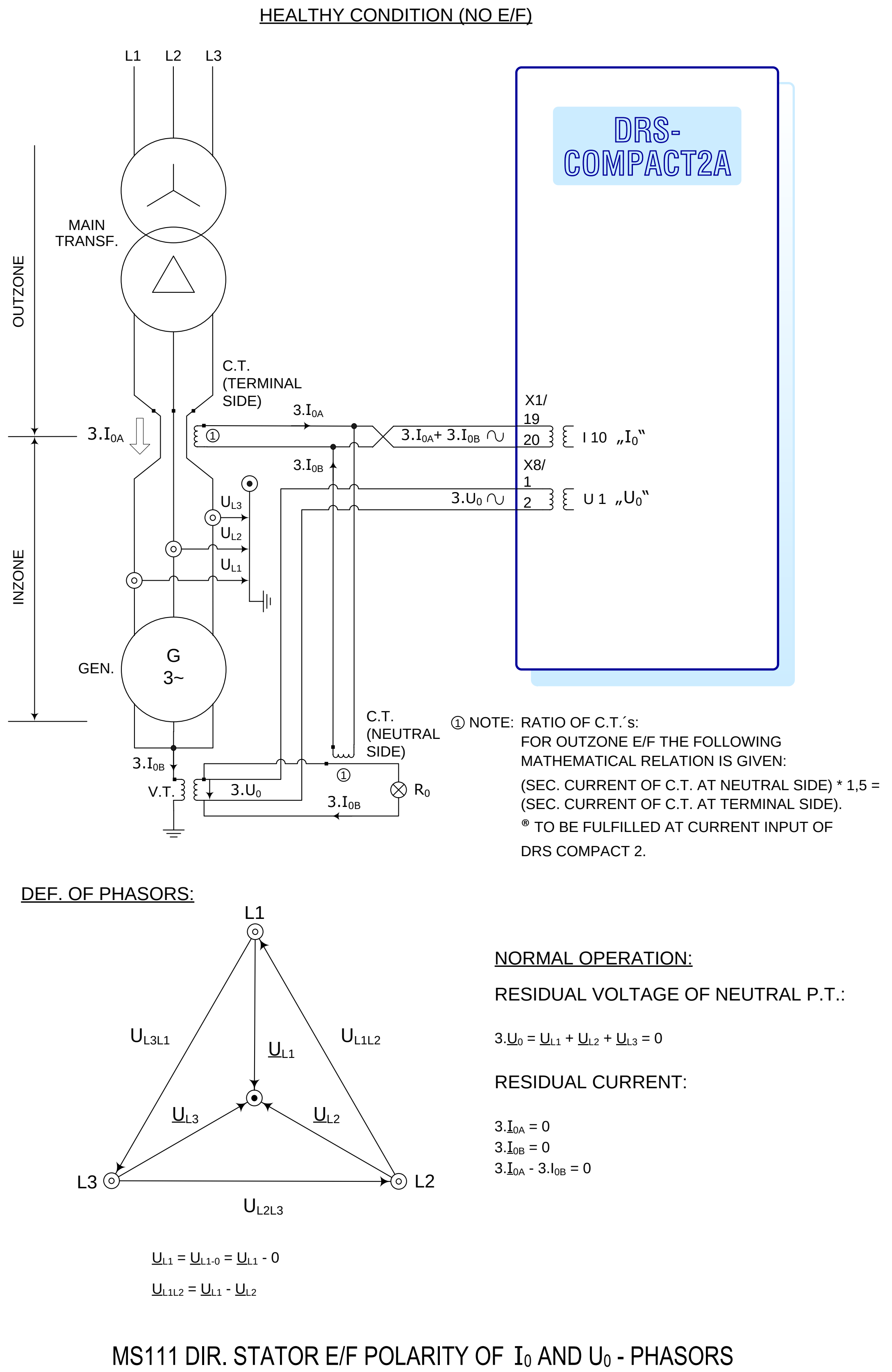
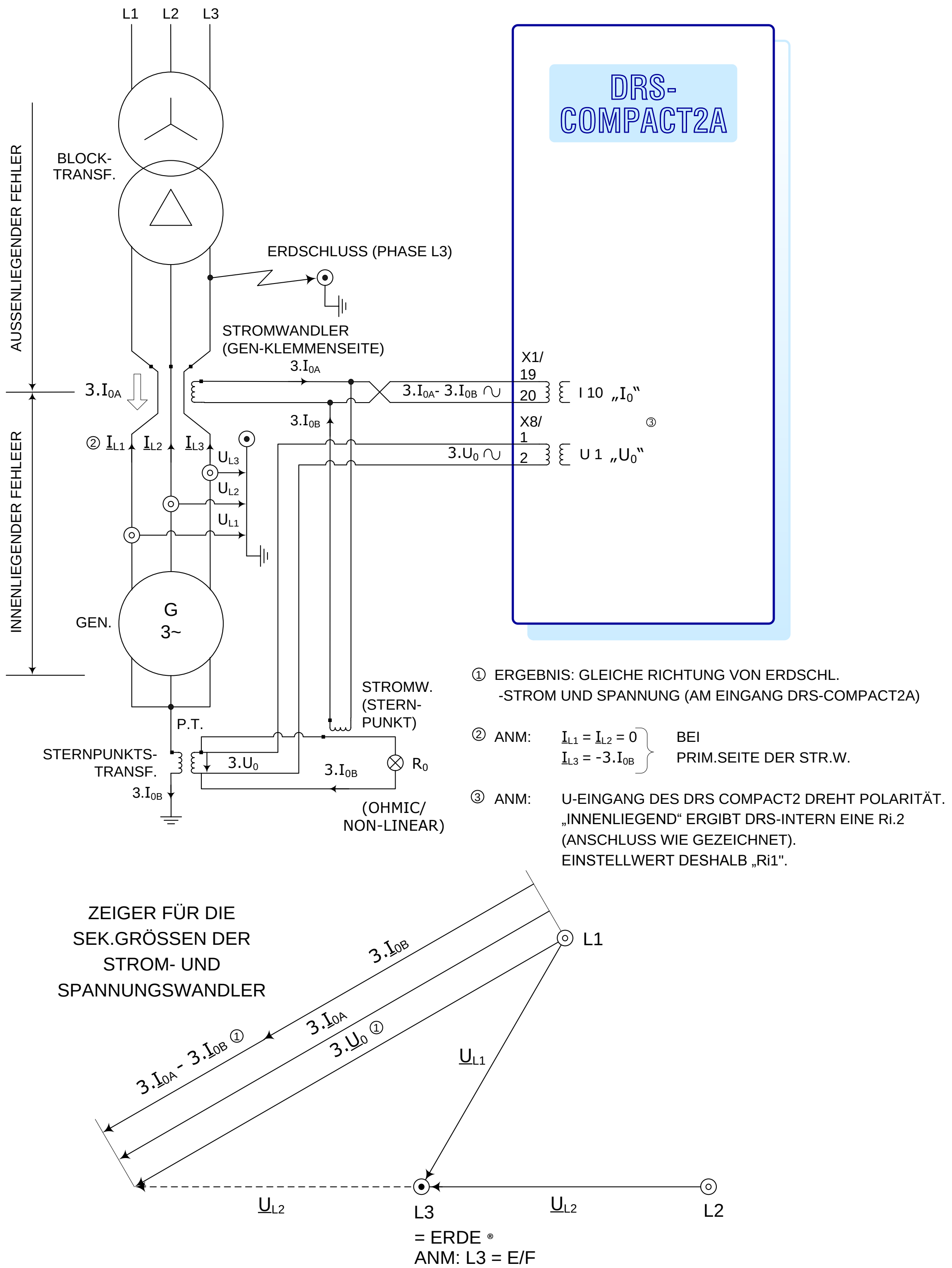


Fig. 226 MS111 Dir. Stator E/F Polarity of I_0 and U_0 - Phasors

AUSSENLIEGENDER FEHLER (AUSLÖSEBEDINGUNG NICHT ERFÜLLT)



MS111 ERSCHLUSSRICHTUNG POLARIÄT DER I_0 UND U_0 - ZEIGER/
AUSSENLIEGENDER FEHLER

Fig. 227 MS111 Dir. Stator E/F Polarity of I_0 and U_0 – Phasors / Outzone E/F

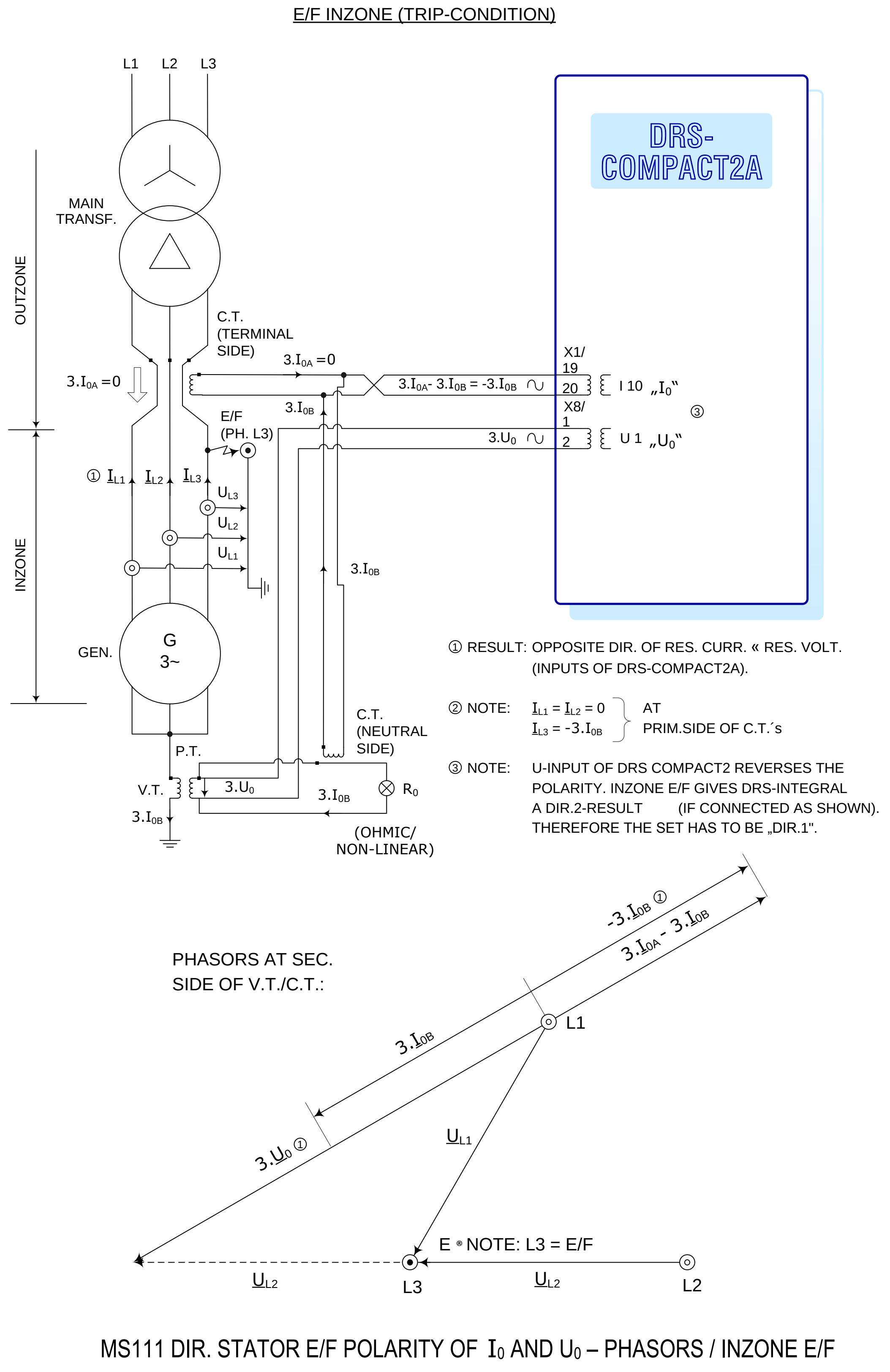
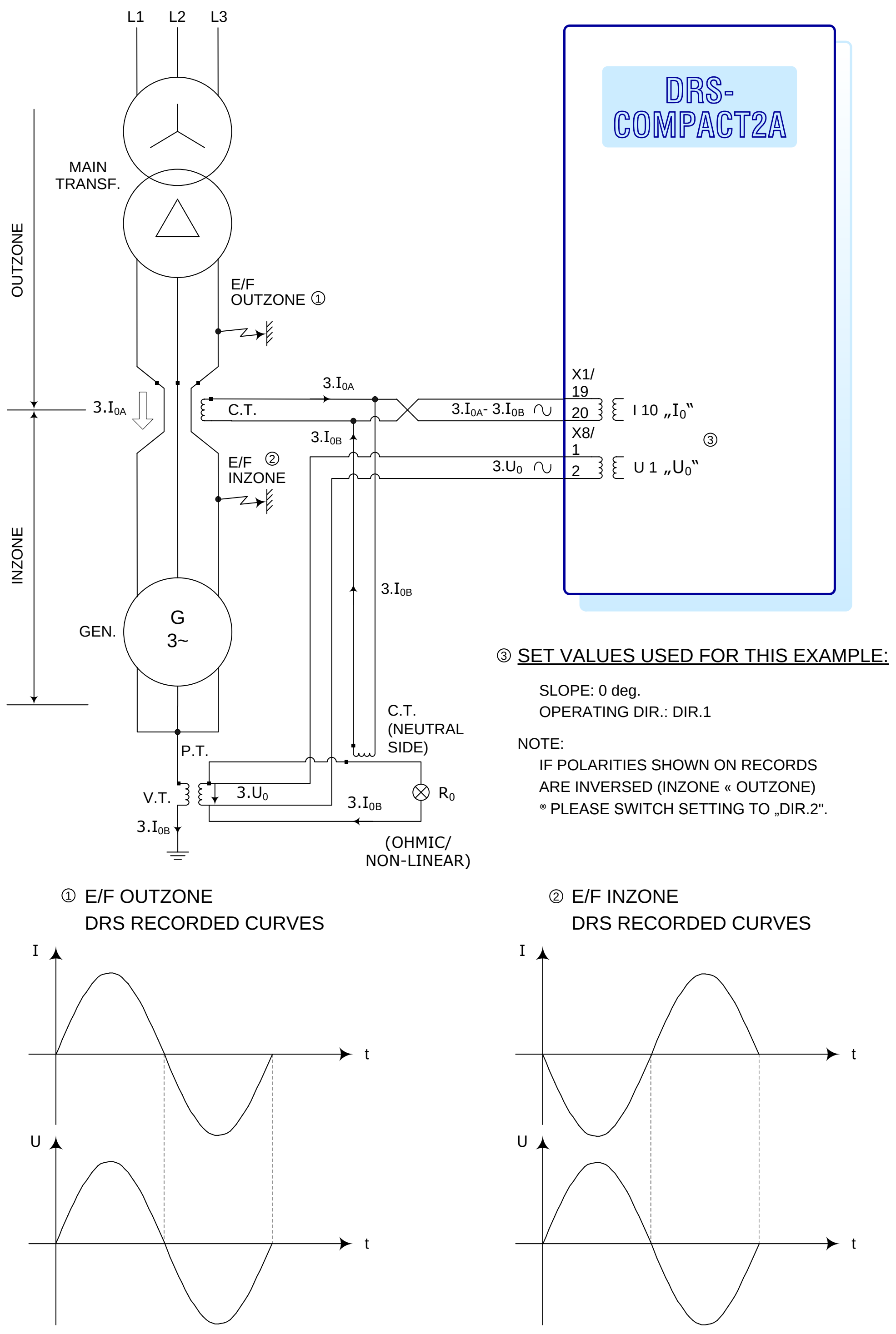


Fig. 228 MS111 Dir. Stator E/F Polarity of I_0 and U_0 – Phasors / Inzone E/F

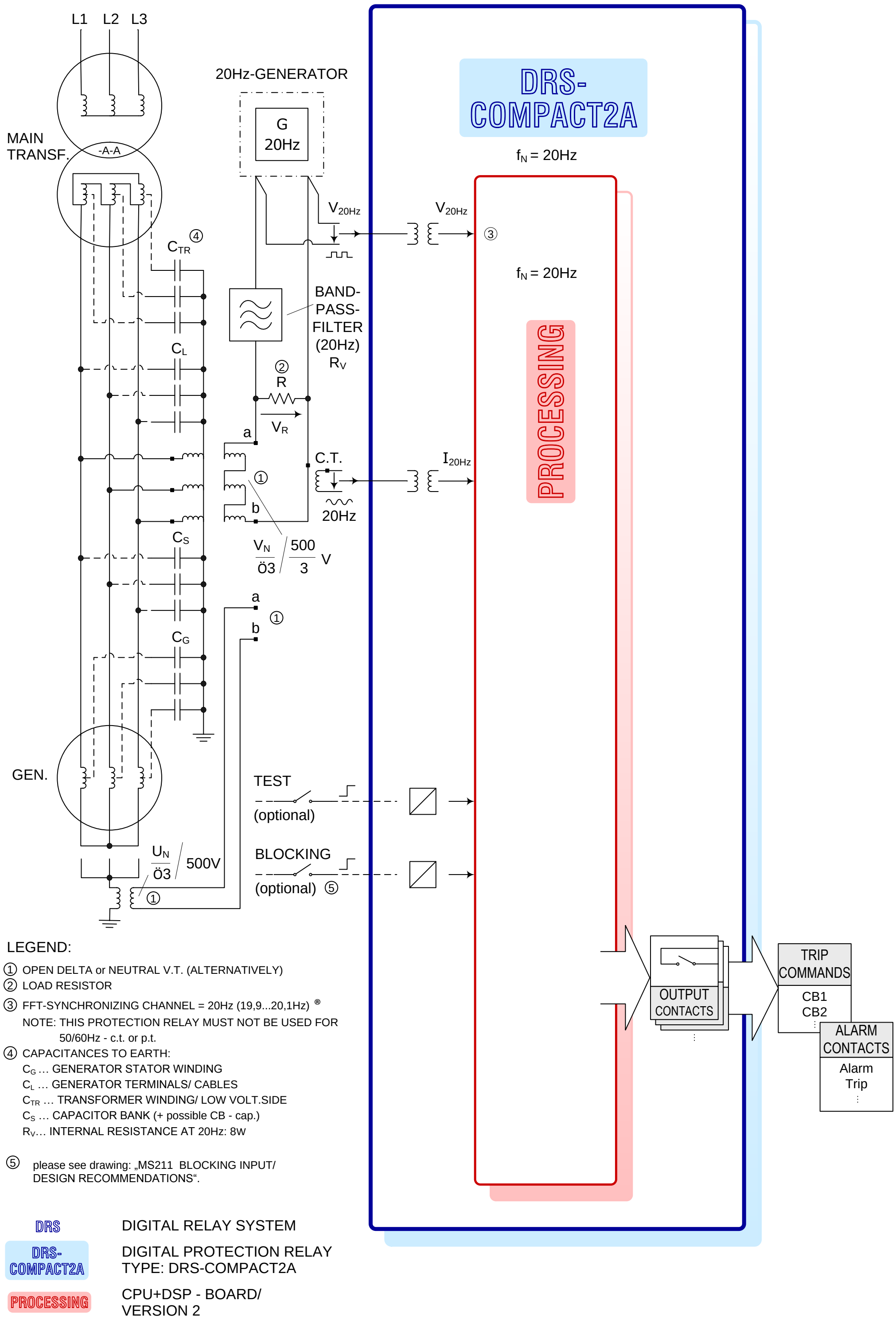
VERIFICATION OF DIRECTION OF U_0 AND I_0 (SEE „LOGIC DIAGRAM PROCESSING")



MS111 DIR. STATOR E/F POLARITY OF I_0 AND U_0 – PHASORS / VERIFICATION

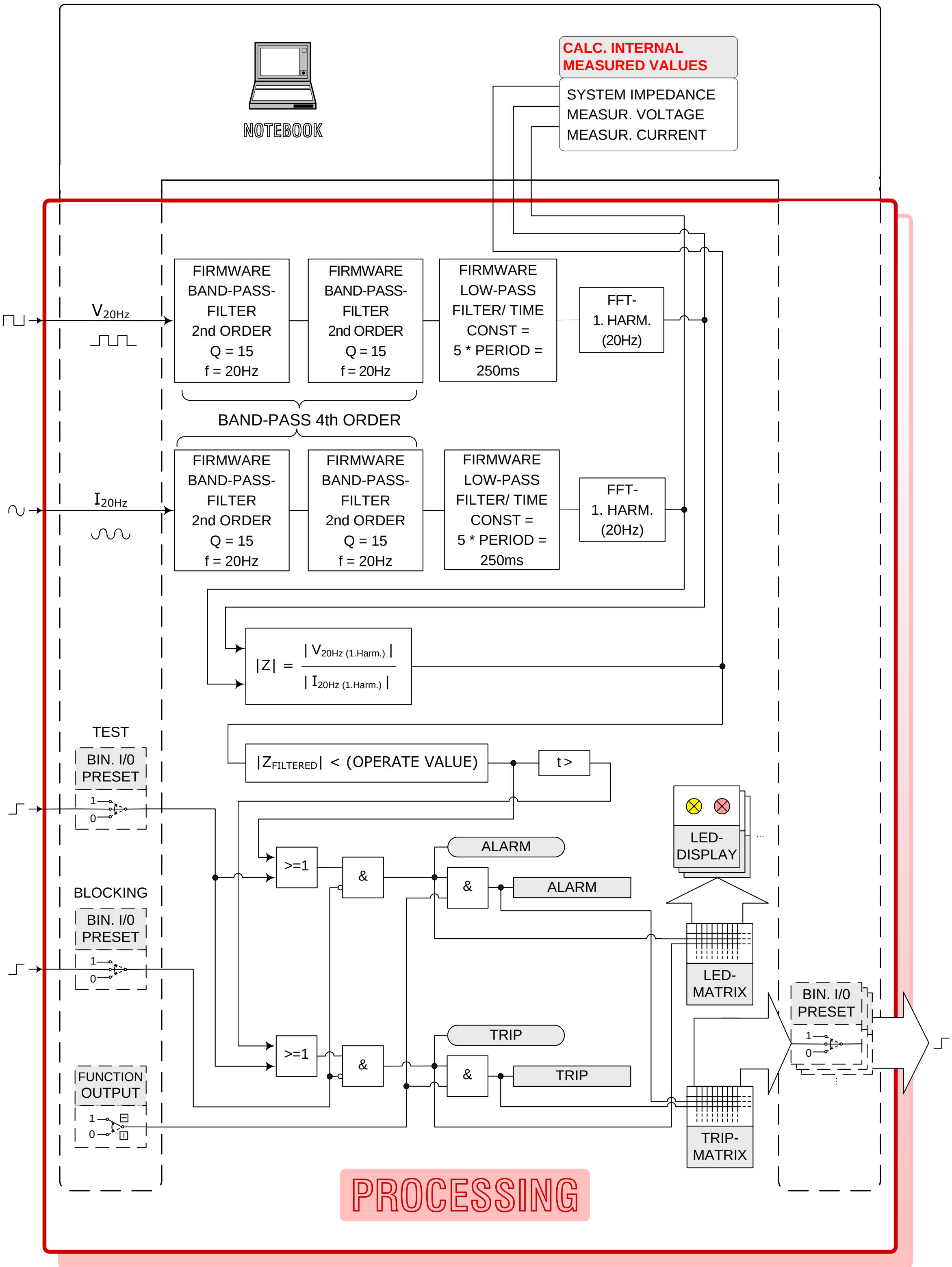
Fig. 229 MS111 Dir. Stator E/F Polarity of I_0 and U_0 – Phasors / Verification

17.4.2. MS211



MS211 STATOR E/F 100% 20Hz LOGIC DIAGRAM
page 1/3: OVERVIEW

Fig. 230 MS211 Stator E/F 100% 20Hz Logic Diagram page 1/3: Overview



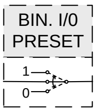
MS211 STATOR E/F 100% 20Hz LOGIC DIAGRAM / PROCESSING

Fig. 231 MS211 Stator E/F 100% 20Hz Logic Diagram / Processing

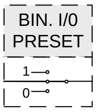
LEGEND PROCESSING

FIRMWARE-MODULE: MS211

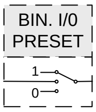
Online simulation via notebook



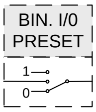
Online-simulation of DIG. IN-/OUTPUTS via notebook:



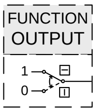
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MS211
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALC. INTERNAL MEASURED VALUES
SYSTEM IMPEDANCE MEASUR. VOLTAGE MEASUR. CURRENT

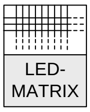
SYSTEM IMPEDANCE:
|Z| is calculated by using the 1.Harm. of the 20Hz-voltage and the 1.Harm. of the 20Hz-current.

MEAS. VOLTAGE resp. CURRENT:
1.Harm. of 20Hz-volt. resp. current
(result of FFT (FAST FOURIER TRANSFORM)).

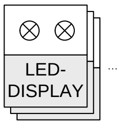
BAND-PASS-FILTER 2nd ORDER Q = 15 f = 20Hz

The 20Hz-volt. and current signals are filtered in order to eliminate the 50/60Hz-component.

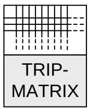
LOW-PASS FILTER/ TIME CONST = 5 * PERIOD = 250ms



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MS211 STATOR E/F 100% 20Hz LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 232 MS211 Stator E/F 100% 20Hz Logic Diagram Processing / Legend

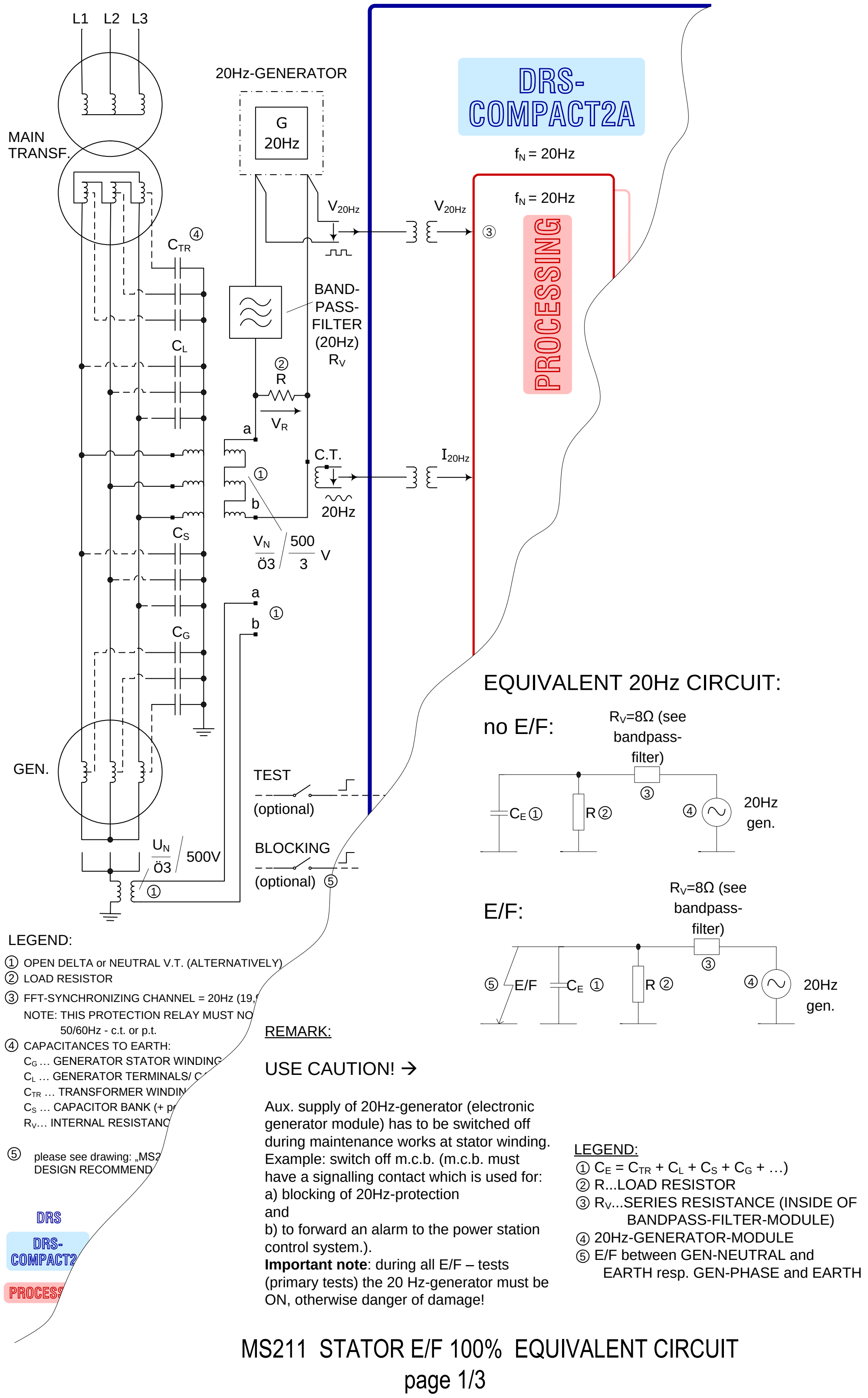


Fig. 233 MS211 Stator E/F 100% Equivalent Circuit page 1/3

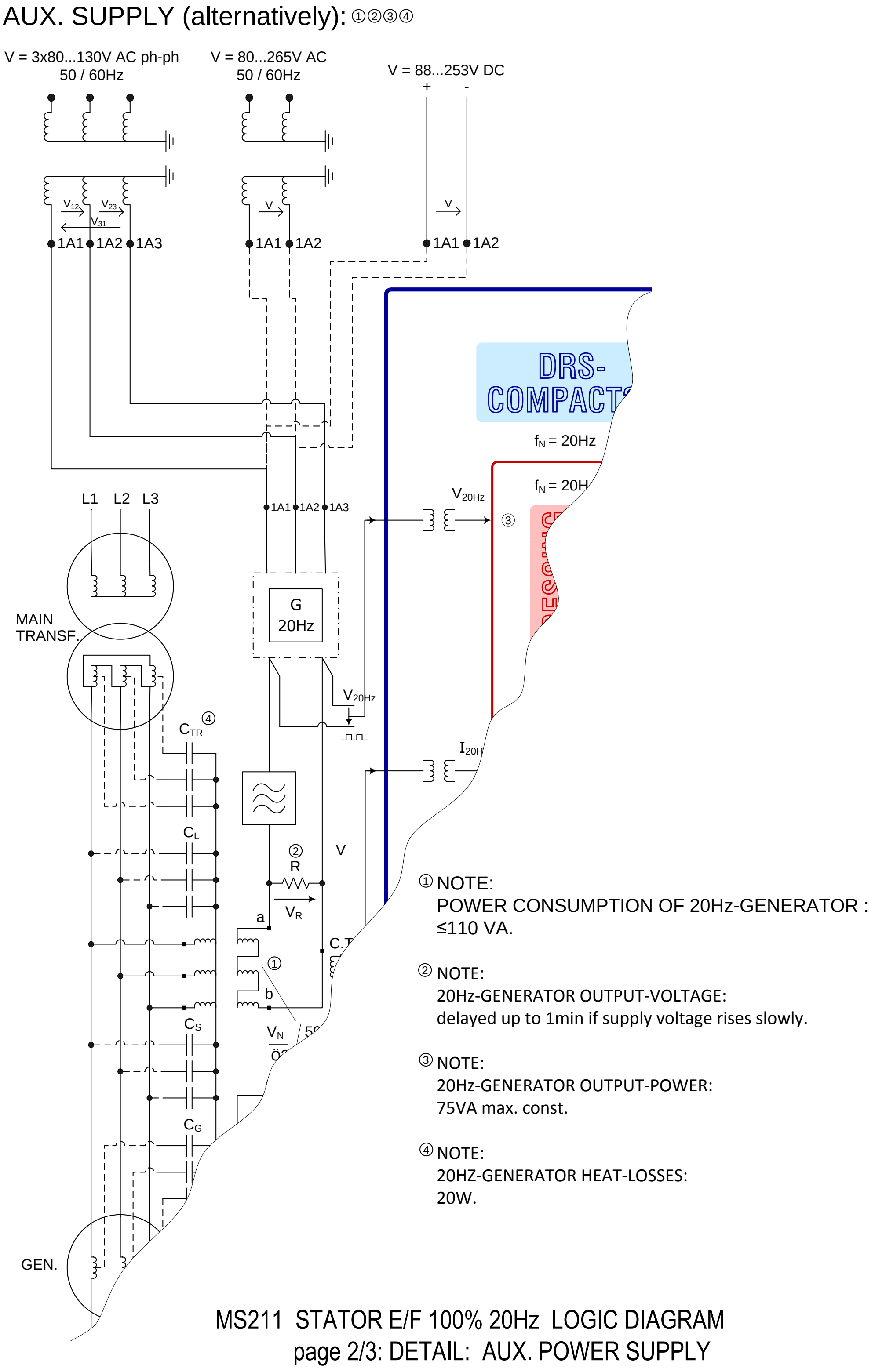
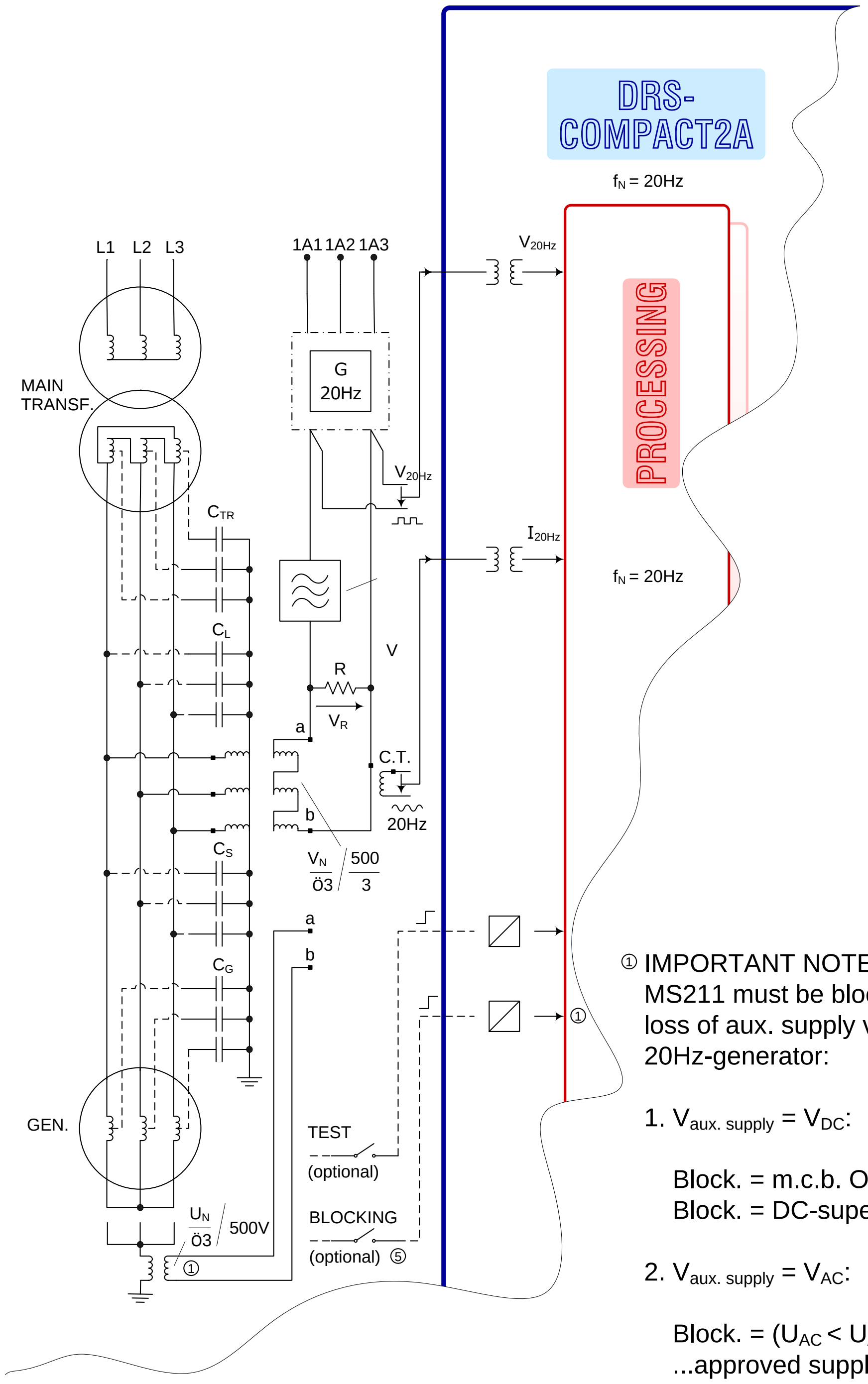


Fig. 234 MS211 Stator E/F 100% 20Hz Logic Diagram page 2/3: Detail: Aux. Power Supply



① IMPORTANT NOTE:
MS211 must be blocked in case of loss of aux. supply voltage of 20Hz-generator:

1. $V_{aux.\ supply} = V_{DC}$:

   Block. = m.c.b. OFF
   Block. = DC-supervision relay OFF

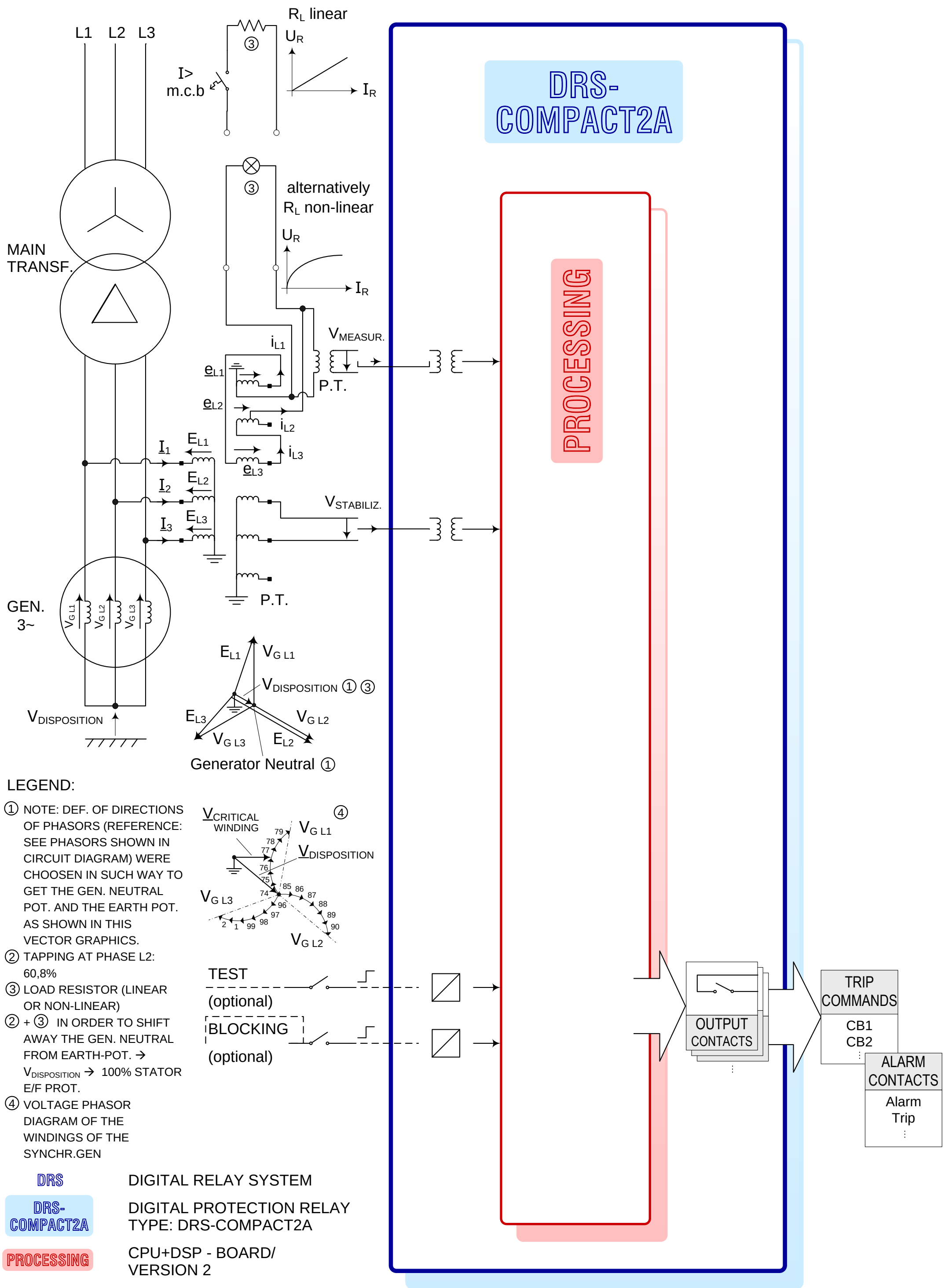
2. $V_{aux.\ supply} = V_{AC}$:

   Block. = ($U_{AC} < U_{AC\ min}$)…
   ...approved supply voltage range →
   → please see page 2/3!
   If supplied by generator-voltage →
   → deexcitation = blocking of E/F-prot.

MS211 STATOR E/F 100% 20Hz LOGIC DIAGRAM
page 3/3: DETAIL: BLOCKING INPUT

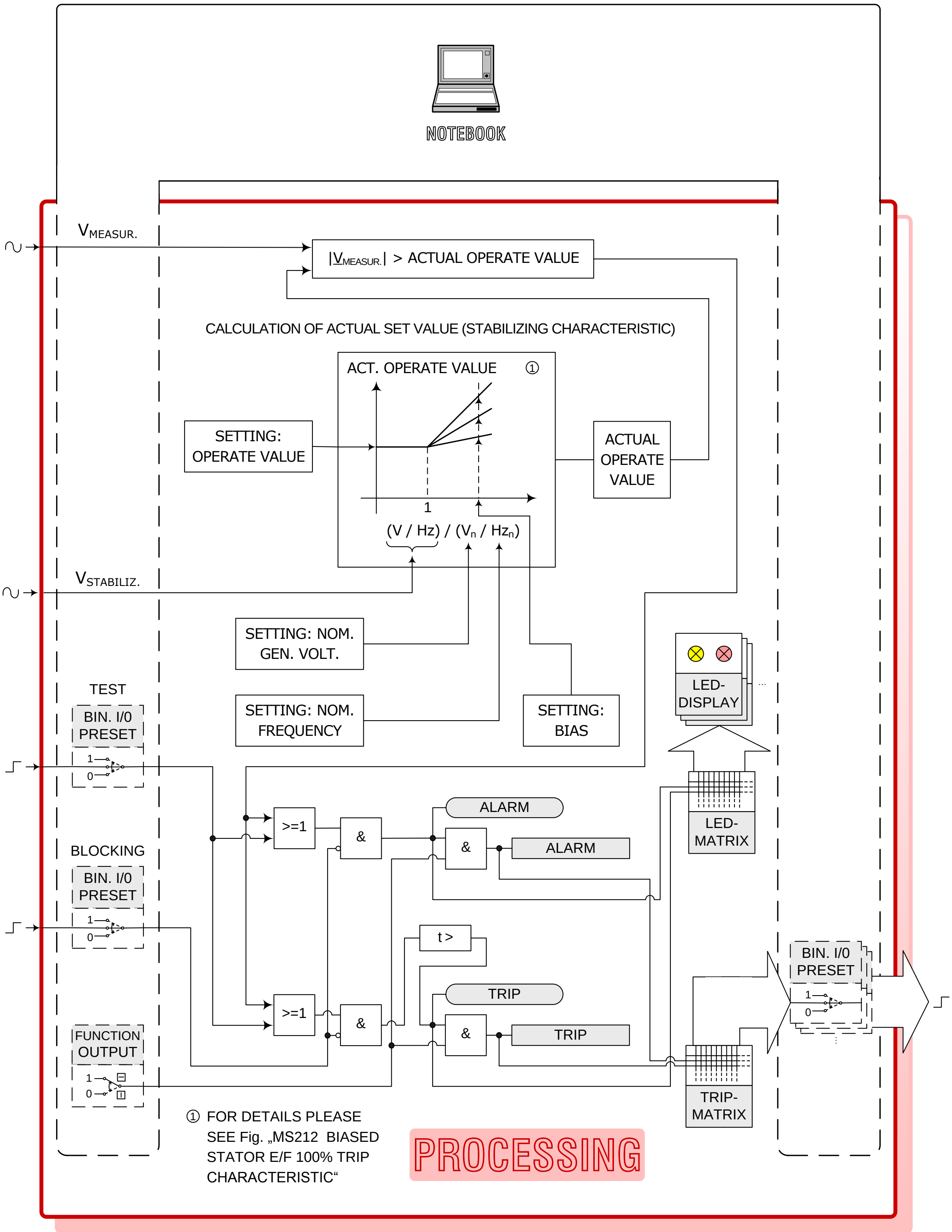
Fig. 235 MS211 Stator E/F 100% 20Hz Logic Diagram page 3/3: Detail: Blocking Input

17.4.3. MS212



MS212 BIASED STATOR E/F 100% LOGIC DIAGRAM

Fig. 236 MS212 Biased Stator E/F 100% Logic Diagram



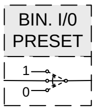
MS212 BIASED STATOR E/F 100% LOGIC DIAGRAM / PROCESSING

Fig. 237 MS212 Biased Stator E/F 100% Logic Diagram / Processing

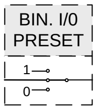
LEGEND PROCESSING

FIRMWARE-MODULE: MS212

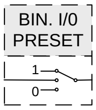
Online simulation
via notebook



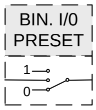
Online-simulation of DIG. IN-/OUTPUTS via notebook:



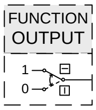
regular function



always „1"



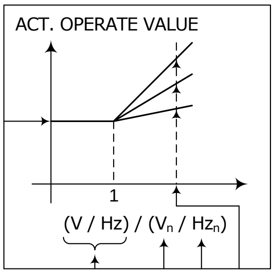
always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MS212
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

|$V_{MEASUR.}$| > ACTUAL OPERATE VALUE

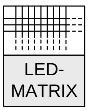
|$V_{MEASUR.}$| is compared with the calculated „Actual Operate Value“.



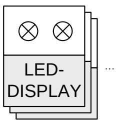
Calculation of the „Actual Operate Value“. This calculation is based on:

a) set value: „Operate Value“
b) set value: „Nom. Gen. Volt.“
c) set value: „Nom. Frequency“
d) set value: „Bias“
e) measured value: „$V_{STABILIZ.}$“ (voltage and frequency)

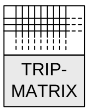
Characteristic/Diagram:
see Fig. „MS212 BIASED STATOR E/F 100% TRIP CHARACTERISTIC“



Programmable software-matrix for the LED-indications
(row 2...14) of PROCESSING



LED-indications of
PROCESSING-board
(row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

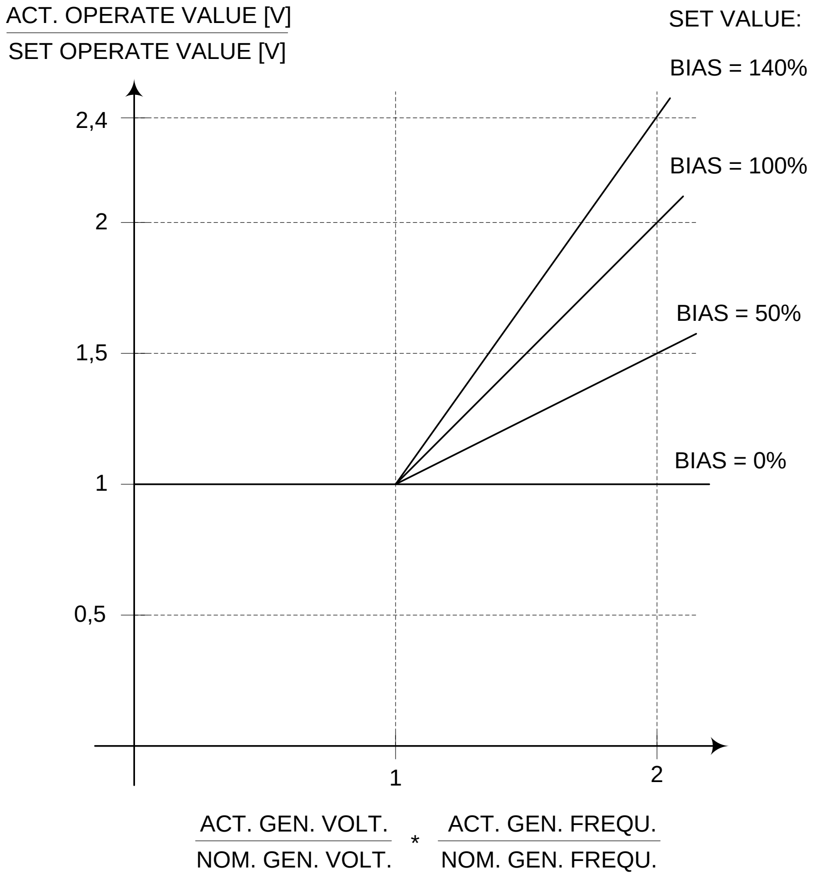
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MS212 BIASED STATOR E/F 100% LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 238 MS212 Biased Stator E/F 100% Logic Diagram Processing / Legend

TRIP CHARACTERISTIC
[PROCESSING (VE2) ONLY]



FORMULA: ①

(ACT. OPER. VALUE) = (SET OPER. VALUE) * [1 + (BIAS) * ($U_G/U_{G\ nom}$ * $f_G/f_{G\ nom}$ - 1)]

① CONDITION:

IF [$U_G < U_{G\ nom}$] ® use $U_G = U_{G\ nom}$!

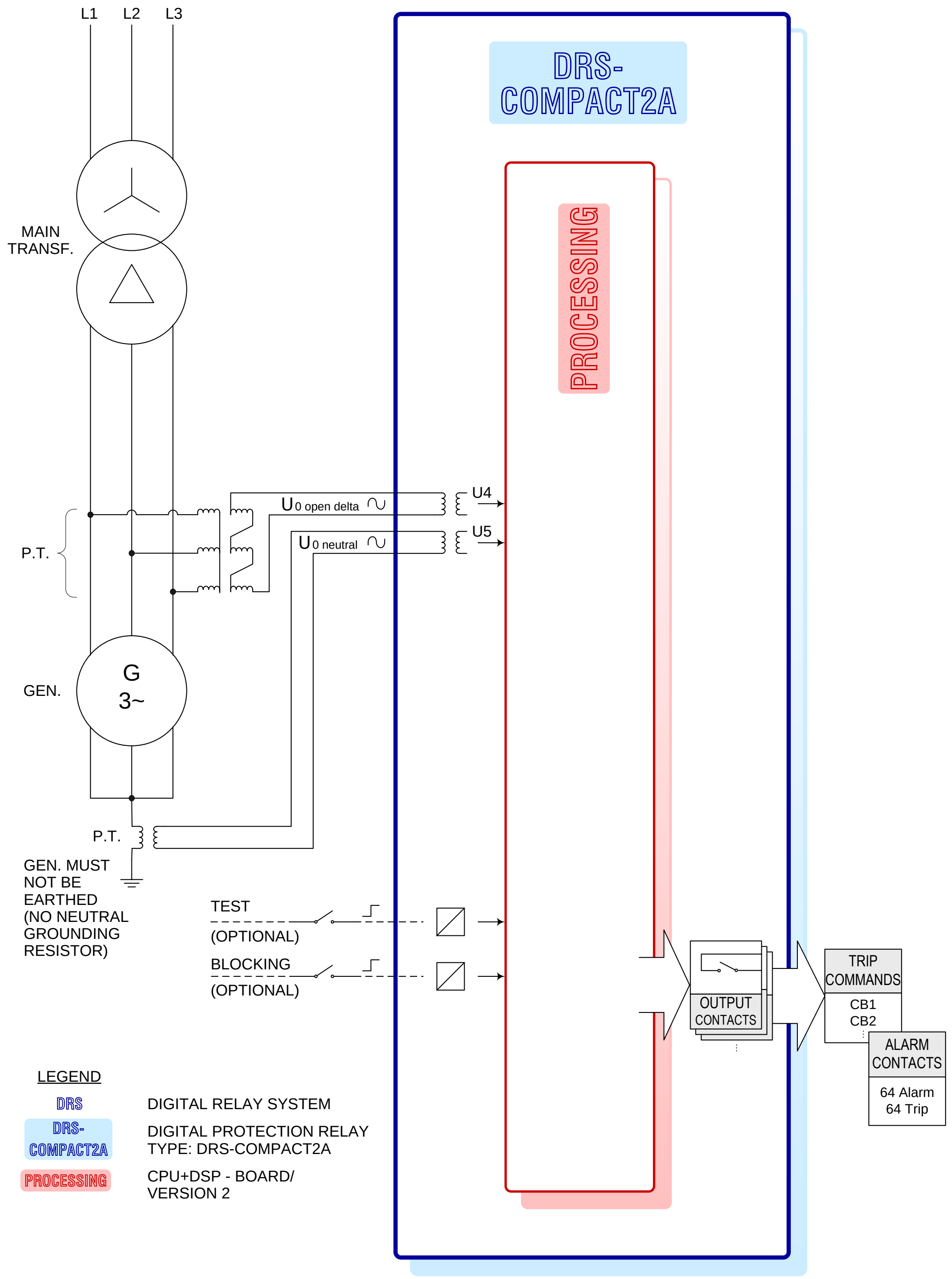
IF [$f_G < f_{G\ nom}$] ® use $f_G = f_{G\ nom}$!

NOTE: THIS FORMULA IS VALID FOR VE2 ONLY! (DOES NOT APPLY FOR VE1).

MS212 BIASED STATOR E/F TRIP CHARACTERISTIC [PROCESSING (VE2) ONLY]

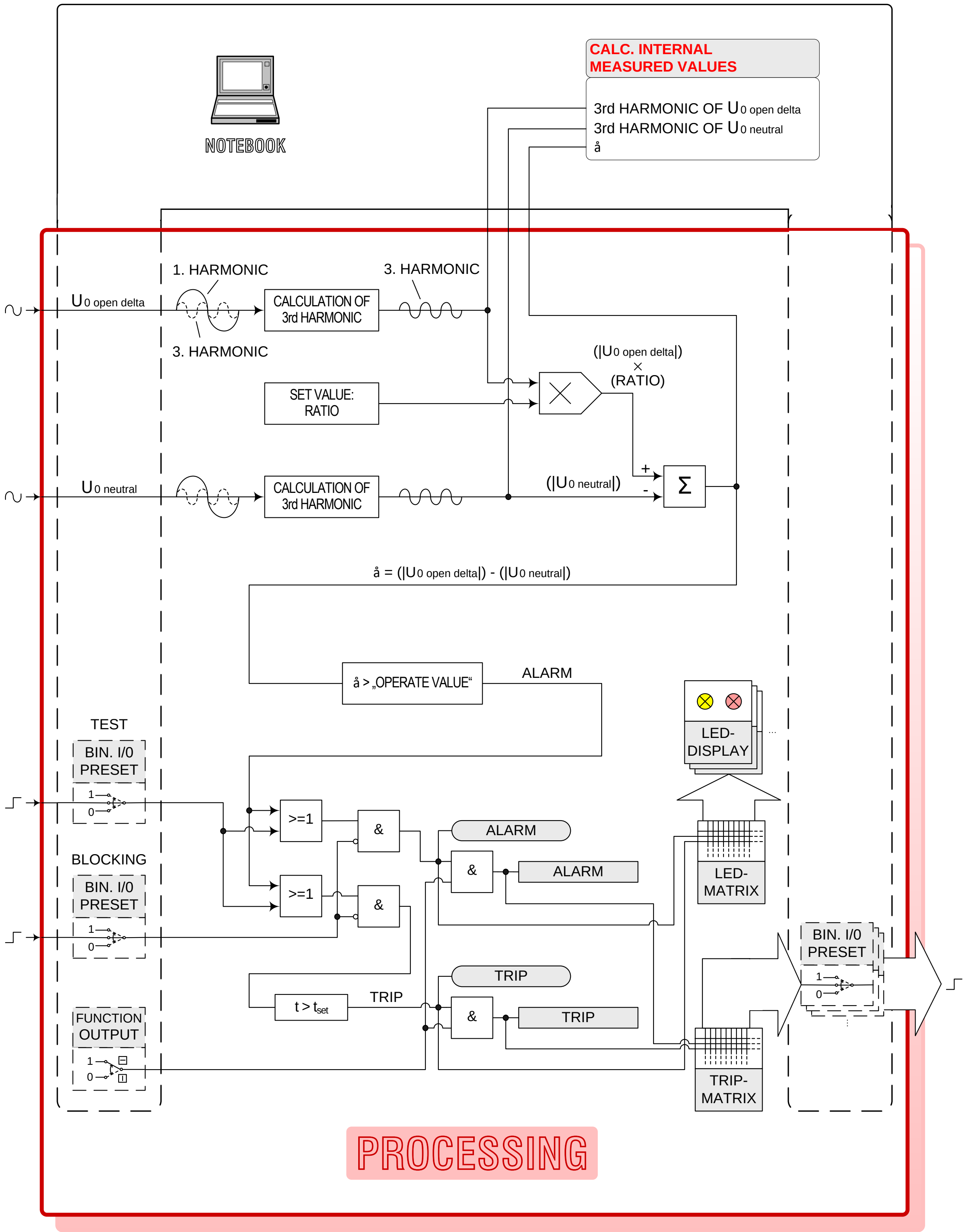
Fig. 239 MS212 Biased Stator E/F Trip Characteristic [Processing (VE2) Only]

17.4.4. MS213



MS213 STATOR E/F 3rd HARMONIC LOGIC DIAGRAM

Fig. 240 MS213 Stator E/F 3rd Harmonic Logic Diagram

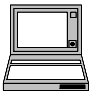


MS213 STATOR E/F 3rd HARMONIC LOGIC DIAGRAM PROCESSING

Fig. 241 MS213 Stator E/F 3rd Harmonic Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MS213



Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MS213
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION OF 3rd HARMONIC — CALC. OF 3rd HARMONIC-CONTENT BY FFT (FAST FOURIER TRANSFORM)

SET VALUE: RATIO — WEIGHING FACTOR FOR ® $U_{0\ open\ delta}$

Σ — Sum

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING — LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: 78 Alarm

TRIP — FUNCTION OUTPUT: 78 Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MS213 STATOR E/F 3rd HARMONIC LOGIC DIAGRAM PROCESSING/ LEGEND

Fig. 242 MS213 Stator E/F 3rd Harmonic Logic Diagram Processing / Legend

17.5. FUNCTION

17.5.1. MS111

The directional stator earth fault protection is detecting earth faults in the stator winding of 3 phase rotating machines and the associated galvanic connected plant. The selective earth fault protection range is approximately 10% from the generator neutral up to the generator leads where the cable slip-on CT's are positioned.

The directional stator earth fault protection is using the zero sequence voltage- and the zero sequence current components for earth fault detection. The zero sequence voltage value serves as an initiation quantity whereas the phase displacement between the zero sequence current and the zero sequence voltage determines whether there is an out of zone- or an in-zone fault.

In case of an earth a neutral displacement voltage is produced in the secondary open delta VT circuit with a value depending on the location of the fault in the generator winding. The configured trigger level of the zero sequence voltage determines the protective range of the stator earth fault function. The zero sequence voltage is also producing a fault current via the earth fault path from all other external plant connections whereby the current value depends on the respective zero sequence impedance of the equipment. The phase displacement of the zero sequence current for the protected generator is measured by the cable slip-on CT's.

From above it can now be deduced that the earth fault is an in-zone fault when voltage and current are in phase. Since the zero sequence current has not only a resistive component a permissible range of ± 60° (= Direction 1) is applicable. However, other locations of the CT/VT installation are sometimes necessary which will result in a different phase angle displacement between voltage and current, i.e. a phase angle >60° (= Direction 2) is selected.

The protection algorithm for the function samples the parameter signals 12 times each cycle. For each sample interval the value and phase angle of the signals is computed according to standard procedures.
The voltage signal is compared with the configured operating value of the function. At the same time the phase angle Direction 1 or Direction 2 is computed and compared with the configured tripping direction. When both criteria are fulfilled during 24 consecutive sample intervals the function is initiated and the trip time delay started. In case the initiating conditions remain during the whole time delay a trip output signal is produced.
Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

Note:
The external equipment such as distribution transformers and loading resistor shown in the circuit diagrams are individually designed for each plant according to the calculations outlined in publication MA 553-7/87e.

17.5.2. MS211

See Technical Description " DRS-C2A-UAKB_V1_3_Beschreibung_D.pdf".

17.5.3. MS211

a)
Alarm "Measuring Fault" when V < 10V.

b)
Initiation delay: 380 ms (due to filtering).

c)
Initiation delay on pick-up: 700 ms.

d)
Time delay of “Measuring Fault” alarm: 640 ms.

e)
Drop-off delay “Measuring Fault” alarm: 440 ms.

f)
The Central Processing Unit PROCESSING has to be configured to a nominal frequency of approximately 19.9 … 20.1 Hz.
Note:
Do not use a wider range! With a Fluke multimeter the frequency of the 20 Hz generator has to be measured and a narrow as possible range adjusted!
The frequency configuration in Page0 must not be set to 50 Hz.

g)
Must not be applied together with oversampling functions!

17.5.4. MS212

The stator earth fault protection enables detection of earth faults in the stator winding of rotating machines and the galvanic connected plant portions which are part of the generator-transformer LV system.
The protection is based on a method which produces an approximate 15% primary voltage displacement of the phase to neutral voltage and does not require any special auxiliary equipment but solely passive plant components. This small displacement voltage of the generator neutral does practically not impose an additional burden to the winding insulation.
The earth fault protection covers 100% of the machine winding including the neutral and in case of an earth fault only a small additional primary current is circulating through the fault path, i.e. generally smaller than 5 A.

Due to the unsymmetrical connection of the distribution transformers also the generator neutral is displaced with respect to ground potential thereby ensuring that also earth faults at the neutral are definitely detected.
For the design and required ratings of the distribution transformers and the secondary loading impedance there are versions with loading resistors and high interruption capacity miniature CB’s available. For details please refer to Publication MA 553-7/87e.

The generator neutral displacement voltage under normal operating conditions is essentially depending on the generator system capacitance to ground and during overspeed- and/or overvoltage conditions during a full load rejection or regulator failure may increase up to the set operating value.
This is particularly the case when a relative small operating value has been selected ensuring decisive operation at a generator voltage even at approximately 50% to cover the required 100% protection of the winding.
In order to keep a sufficient safety margin and to prevent mal-operation the operating value V_a of the function is temporarily increased by a configurable stabilising factor k from the initial V_e value according to following formula:

<u>Formula for PROCESSING (VE1):</u>

$$U_a^{\,2} = U_e^{\,2}\left(1 + k\left(\frac{\left(\frac{U_g}{U_{gn}}\right)^2 + 1}{2} \cdot \frac{f}{f_n} - 1\right)\right) \qquad \text{for } V_g \geq V_{gn} \quad \text{and} \quad \text{for } f_g \geq f_{gn}$$

$$U_a = U_e \qquad \text{for } V_g < V_{gn}$$

$$U_a = U_e \qquad \text{for } f_g < f_{gn}$$

k .... Stabilising factor
V_g ..... Generator voltage
V_{gn} ... Generator nominal voltage
f .... Generator frequency
f_n ...... Generator nominal frequency

<u>Formula for PROCESSING (VE2):</u>

$$U_a = U_e \,.\, [1 + k\,((U_G/U_{GN})\,.\,(f/f_N) – 1)]$$

whereby:
V_a … Modified tripping value (according to stabilising characteristic)
V_e … Configured tripping value
k … Stabilising parameter (as per above formula).

Caution:
In case of $V_G<V_{GN}$ then insert V_{GN} into the formula
In case of $f<f_N$ then insert f_N into the formula

Note for PROCESSING (VE2):
With the PROCESSING (VE2) a linear formula for stabilising is applicable.
The stabilising feature is only active when $V_G > V_{G\,nominal}$ and when f > (as VE1).

The function algorithm is sampling the configured signals 12 per cycle and subsequently computes the basic component of the displacement voltage as well as the frequency and the basic component of the stabilising voltage, i.e. the generator voltage.

Then for each sample interval the operating value is computed according to the above formula and compared with the measured value of the neutral displacement voltage. Should during 24 consecutive sample intervals the measured value is exceeding the operating value the function initiation and the corresponding time delay are started.

When the initiation remains during the whole configured time delay then after delay expiry the trip output will be set.

The function performance can be blocked or tested via the corresponding input signal "Blocking Input" or "Test input".

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

17.5.5. MS113/ MS213

Note:

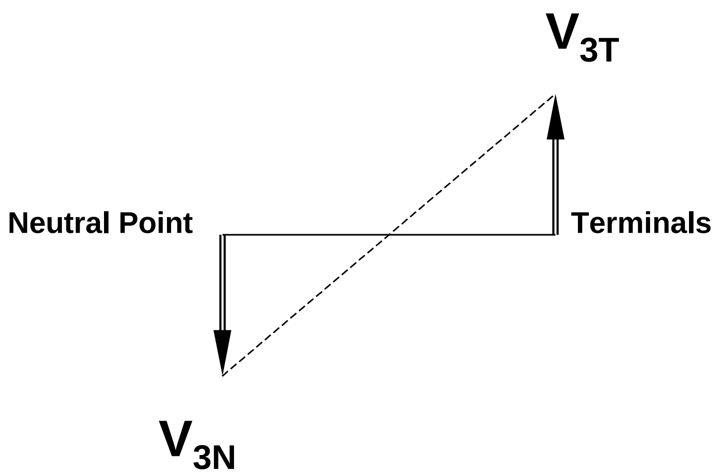
MS213: V_{Leads} and $V_{Neutral}$ must have opposite polarity to enable V=0.
MS113: uses one voltage only (polarity does not matter).

Frequency range (generator overspeed):
a) Approximately +/- 10% in case of no synchronising channel is detected.
b) With active synchronising channel also a range f = 90 … 160 % is possible.

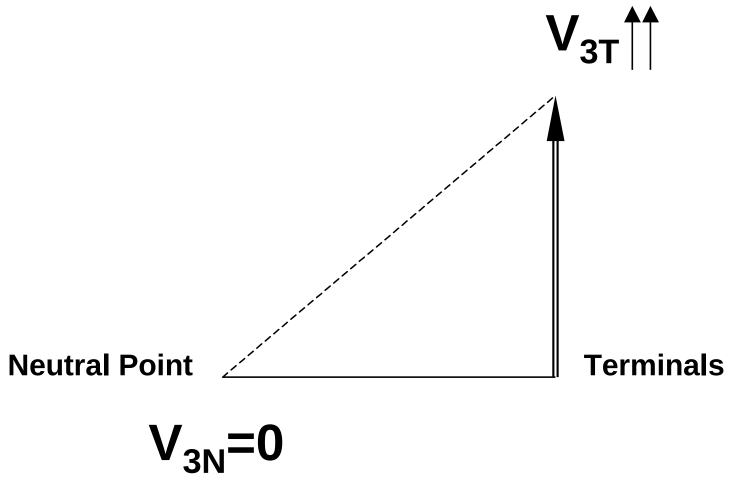
Do not combine with oversampling functions!

General Description of the Function

For a generator under healthy operating conditions we assume for simplification an even distribution of the 3rd harmonic distribution from the neutral to the generator leads (terminals).



In case of an earth fault the 3rd harmonic component in the neutral is shorted whereby the value at the generator leads is increased by the same prior value:



The above described distribution of the 3rd harmonic over neutral and terminal side is taken for the evaluation of earth faults close to the generator neutral.
MS213 and MS113 are using different algorithms: MS213 compares the 3rd Harmonic Zero Sequence E/F Voltages, whereas MS113 evaluates just one of the voltages (for example because there is just one earthfault-voltage available).

a)
MS213:
For the operation of the function we use the following formula:

$$\textbf{Operation Value } V_{Op} = (\textbf{Ratio x } V_{3T}) - V_{3N}$$

This means that the value of the 3rd harmonic at the generator neutral is taken as a reference and the change of the 3rd harmonic component at the generator leads is applied for a ratio balance configuration of the protective function.
The function settings, i.e. operation value and ratio have to be confirmed during the generator primary test procedures.

b
MS113:
MS113 somehow is a simplified version compared with MS213. It has to be choosen if only one of the voltages (V_{3T} or V_{3N}) is available:
V_{3T} … Open Delta Voltage Transformer at Generator Terminals
V_{3N} … Single Phase Voltage Transformer between Generator Neutral and Earth Potential.
Note: please ensure that the VT grounding(s) use(s) proper generator earth potential in order to avoid false readings due to earth potential shifts (valid for both versions!).

MS113 does not compare the 3rd Harmonic components, it just uses and evaluates the change of one of the voltages (Neutral or Terminal-side, whatever there is available). Depending on the voltage choosen, the value can go up or down in case of generator neutral E/F (see Set Value "Type").
As a consequence – in order to avoid a maltrip in case of "Underdetection" - we also have to consider the value of the Positive Phase Sequence Voltage (generator terminals), that means that we need minimum PPS voltage to release the operation of the function. Please see the corresponding set values: "Type", "Pos.Ph.Seq. Voltage" and "PPS Volt. Blocking".
Note: in case of "Overdetection" no blocking is required.

17.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

17.6.1. MS111

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry.

Also the function parameters have to be set according to the data of the stator system.

The function outputs for the LED matrix and the trip matrix have to be configured according to requirements.

Function tests are preferably performed with the primary plant out of service.

Insert an ammeter into the current circuit, a voltmeter onto the voltage input and a phase angle meter into the test circuit and with a relay test set inject the appropriate quantities.

Compare the meter indication with the external measured value display of the VE.

Based on the system calculations inject the minimum operating earth fault current by also applying a voltage and adjust the phase angle to the operating range. Increase the voltage until the function operates and record this value into the test sheets.
Reduce the test voltage until the function resets and record the value in the commissioning sheets.
Compare the operating value with the set protective range and then increase the earth fault current up to 1.5 times the minimum setting and also raise the displacement voltage to about 1.5 times the pick-up level.
Alter the phase angle between voltage and current in the + and – direction until the function resets either way and record these operating values into the commissioning sheets.

Check the alarm- and trip signals and the LED indication according to the configured settings and the circuit diagrams.

At 1.5 times the initiation value verify the function time delay with a suitable timer and enter the results into the commissioning test sheets.

Check the configured function blocks for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test feature for each stage by initiating the test signal and the protective function, respectively the stage has to operate without any external input quantities.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters must be re-configured to the original plant parameter settings.

Primary Commissioning Tests:

During primary tests the function of the protection system is verified during the plant in service and following check should be carried out when operating conditions permit:

- In-Zone Earth Fault Test:

Block trips of the stator earth fault protection.
Connect a cable with suitable cross section, e.g. a safety earth, between a generator phase and ground inside the protected zone.
Insert measuring instruments to evaluate the earth fault current, the neutral displacement voltage and the generator voltage.
Run up the generator to rated speed and manually raise excitation to produce operation of the protective function.
Compare the instrument readings with the “Actual Measured Value” window display in the DRS User program and note the results in the commissioning test sheets.
Confirm the protection range by substituting the values into following formula:

$$S(\%) = 1 - \frac{U_{AG}}{U_{NG}}.100$$

S	Protection range in %
V_{AG}	Generator voltage initiating value
V_{NG}	Generator nominal voltage

Check any possible configured external function blocking inputs from the plant.
Restore the trip outputs of the stator earth fault protection.
If possible shut down the generator via a live protective function trip and remove the ground test connection.
Re-configure any possible parameter changes to the original values.

- Out Of Zone Earth Fault Test:

Block trips of the stator earth fault protection.
Connect a cable with suitable cross section, e.g. a safety earth, between a generator phase and ground outside the protected zone..
Run up the generator to rated speed and manually raise excitation only so far as to prove restraint of the protective function with due consideration of the short time rating of the earthing equipment.
Record the voltage and current values in the commissioning sheets.
Shut down the generator and remove the ground test connection.

17.6.2. MS211

Important note:

The 20Hz – generator should be switched ON whenever the unit is in operation. Otherwise the electronic components of the 20 Hz – generator could be damaged in case of E/F – tests by the arising E/F – voltages.
On the other hand the 20 Hz – generator may cause dangerous voltages (20 Hz) at the primary side of the generator neutral transformer; therefore the 20 Hz – generator should be switched OFF whenever there is installation work etc. in progress.

Initial Tests:

First make sure that all components are connected properly.

Set the parameters of the input matrix in keeping with the external connection.

Set the parameters for the preliminary operating value and time delay to the chosen values.

Set the parameters of the relay outputs in the LED matrix and in the tripping matrix, as applicable.

When testing the function, the plant equipment should preferably be out of service.

Turn on the 20 Hz displacement system after successfully testing its wiring. Connect the voltage transformer input to a suitable auxiliary supply for the 20 Hz generator.

Connect an ammeter to the current transformer circuit, as well as a voltmeter to the output of the 20 Hz generator. Compare the readings of the measuring instruments to the readings of the internal measured values of the protective function. Enter these values, as well as the value "system impedance" (also displayed there) into the test sheets as "without earth fault, unexcited".

Now fit an earth fault at any desired point and re-measure current, voltage and system impedance (at measuring instruments and internal measured values). Enter the values into the test sheets as "with earth fault, unexcited".

Select a definite operating value, which should amount to between 25 % and a maximum of 50 % of the system impedance in its status without earth fault.

Check the tripping and alarm signals, as well as the LED displays, for their set parameters and compliance with circuit diagrams.

Supply half the impedance setting in order to measure the tripping time of the protective function, using a timer, and enter the measured values into the test sheets.

Check relay blocking, by applying the blocking signal to the operated relay. The relay must then reset.

Check relay test input by applying the test signal. This must operate the protective function, or phase, even in fault-free conditions.

Please bear in mind that other protective functions may also be operating when performing the described tests, unless counter-measures are taken. Block the other functions in keeping with the relevant operating procedures, in order to avoid this effect.
After testing, restore any possible changes in parameter settings to their nominal settings.

Start-up Tests:

The start-up test checks the function of the protective system during normal operation. If plant conditions permit, we recommend to carry out the following tests:

If the 20 Hz displacement system has an external supply source, carry out the following test:

- Open Circuit Tests:

Block tripping of stator earth fault protection system.
With the generator running at rated speed repeat the tests, as described above, at
50 % nominal generatorvoltage and enter the measured results into the test sheets as "operation without earth fault" or "operation with earth fault". If necessary, adjust the setting of the operating value according to the test results, bearing in mind the limits given above.
Check any relay blocking inputs.
Re-activate tripping of stator ground fault protection system.
Return generator to standstill, if possible by tripping the protective system.
Remove earth fault and restore all parameters to their nominal values.

If the 20 Hz displacement system is supplied by a voltage transformer, carry out the following test:

- Open Circuit Tests:

Block tripping of the stator earth fault protection system.
With the generator running at rated speed measure system impedance at nominal voltage in earth-fault-free condition, and enter the values into the test sheets.
Apply an earth fault at the generator neutral, measure system impedance at nominal voltage during earth-fault conditions and enter the values into the test sheets.
Adjust operating values according to measured values, if applicable.
Remove earth fault.
Excite generator, without earth fault, to approximately 130 % of nominal voltage. The ground protection must not be operated.
Enter the value for system impedance into the test sheets.

Carry out the below test, which should consider the insulation level of the transformer neutral point, in order to test the stability for earth faults on the transformer high voltage side:

- Open Circuit Test:

Fit an earth fault to the high voltage side of the main transformer.
Start-up the generator and excite up to the permissible voltage level for the transformer neutral.

Measure system impedance via operating program and extrapolate this value for 130 % generator voltage (inversely proportional).
Check whether the extrapolated value provides sufficient safety margin and adjust the operating parameter, if necessary.
Return generator to standstill, if possible by tripping the protective function.
Remove earth fault and restore parameters to nominal values, if applicable.

17.6.3. MS212

Pre-Commissioning:

At first check the external cable connections and the primary bus connections of the distribution transformers as well as the other external auxiliary devices.

The input matrix is to be configured according to the external wiring.

The parameters for the operating values and the time delay are to be set to the designed values.

The function outputs for the LED matrix and the trip matrix have to be configured according to requirements.

Function tests are preferably performed with the primary plant out of service.

Insert voltmeters on the neutral displacement input and the generator voltage input (= stabilising voltage) and with a suitable relay test set carry out following secondary injection test.

Raise the neutral displacement voltage value and keep the stabilising voltage at zero until the protective function operates.
Record the operating value with the remark "No stabilising Voltage" in the test sheets by also comparing the instrument readings with the “external Measured Values” display of the VE.
Reduce the test voltage until the function resets and record the value.
Repeat the above tests with following stabilising voltage values:

- 120 % nominal voltage at rated frequency
- Nominal voltage at 130 % of rated frequency

Compare the test results with above formula and record the measured values in the test sheets.

Check the alarm- and trip signals and also the LED indications according to configuration and circuit diagrams.

At 1.5 times the trigger value measure the operating time with a suitable timer (for example: use DRSWIN-operating program) and record the result into the commissioning test sheets.

Check the configured function blocks for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test feature for each stage by initiating the test signal and the protective function, respectively the stage has to operate without any external input quantities.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters must be re-configured to the original plant parameter settings.

<u>Primary Commissioning Tests</u>:

During primary tests the function of the protection system is verified during the plant in service and following check should be carried out when operating conditions permit:

- In-Zone Earth Fault Test:

Block trips of the stator earth fault protection.
Connect a cable with suitable cross section, e.g. a safety earth, between a generator phase and ground inside the protected zone.
Insert measuring instruments to evaluate the neutral displacement voltage and the generator voltage.
Run up the generator to rated speed and manually raise excitation to produce operation of the protective function.
Compare the instrument readings with the "Actual Measured Value" window display in the DRS User program and note the results in the commissioning test sheets.
Repeat above tests by alternatively grounding the other two phases and the generator neutral and record the values into the commissioning sheets.
Restore the trip outputs of the stator earth fault protection.
If possible shut down the generator via a live protective function trip and remove the ground test connection.
Re-configure any possible parameter changes to the original values.

- Out Of Zone Earth Fault Test:

Block trips of the stator earth fault protection.
Apply a phase to ground connection of suitable cross section to the generator-transformer HV side.
Start up generator to rated speed and manually excite with due consideration of the insulation level of the HV transformer neutral well below the maximum withstand insulation capability.
The protective function has to remain stable and the instruments readings should be compared with the DRS Measured Values and entered into the commissioning sheets.
Extrapolate the measured values of the neutral displacement voltage to 120 % of the nominal system voltage and ensure that the safety margin to the operating value is ≥ 2.
Shut down the generator and re-locate the earth fault connection in turn to the other phases and repeat the tests the same way as outlined above.
With open circuit excite the generator to rated voltage and record the off-load readings "Normal Operation" in the commissioning sheets.

17.6.4. MS113/ MS213

Pre-conditions:
It should be ensured that the function input voltages are to be measured as exact as possible and it is not advisable to connect the VT neutral measuring instruments to the station earth system since there may be a potential difference which can cause a considerable deviation from the real values.

Primary Test With the Generator

The production tolerances and therefore the magnetic characteristics for a generator, especially with regard to the 3^{rd} harmonic, are always slightly different for each unit.
For this reason the following tests have to be carried out with each generator.

Earth Fault at the Generator Neutal
With a direct connection between the generator neutral and the station earth resulting in a trip.

Normal Service Operation
To verify the correct function under stable unit operating conditions.

MS213: The amplitudes of the 3rd harmonics between the generator neutral and the generator leads are usually changing with the unit power loading.
MS113: The amplitude of the 3rd harmonic at generator neutral or at the generator leads is usually changing with the unit power loading.

To determine a stable operating value for all loading conditions against mal-operation and definite operation it may sometimes be required to carry out a certain recommended test procedure outlined in the tables below.

Proposed Commissiong Sheet Layout

1. Test (Open Circuit)	With Earth Fault In Generator Neutral	Without Earth Fault/ Normal Operation
Generator current [A]		
Generator voltage [kV]		
Generator active power (MW)		
Generator reactive power (MVAr)		
3rd harmonic [V] measured at the open delta VT at the generator leads via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic [V] measured at the at the generator neutral transformer via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic sum [V] (DRS internal computed value/ shown in the DRS functions display window (note: MS213 only)		
"Bias" setting value (temporary test setting) (note: MS213 only)		
"Operating Value" setting (temporary test setting)		
Pos. Phase Sequ. Voltage (note: MS113 only)		
RelayTripped [Yes/No]		

2. Test (50% Nominal Power)	With Earth Fault In Generator Neutral	Without Earth Fault/ Normal Operation
Generator current [A]		
Generator voltage [kV]		
Generator active power (MW)		
Generator reactive power (MVAr)		
3rd harmonic [V] measured at the open delta VT at the generator leads via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic [V] measured at the at the generator neutral transformer via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic sum [V] (DRS internal computed value/ shown in the DRS functions display window (note: MS213 only)		
"Bias" setting value (temporary test setting) (note: MS213 only)		
"Operating Value" setting (temporary test setting)		
Pos. Phase Sequ. Voltage (note: MS113 only)		
RelayTripped [Yes/No]		

3. Test (100% Nominal Power)	With Earth Fault In Generator Neutral	Without Earth Fault/ Normal Operation
Generator current [A]		
Generator voltage [kV]		
Generator active power (MW)		
Generator reactive power (MVAr)		
3rd harmonic [V] measured at the open delta VT at the generator leads via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic [V] measured at the at the generator neutral transformer via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic sum [V] (DRS internal computed value/ shown in the DRS functions display window (note: MS213 only)		
"Bias" setting value (temporary test setting) (note: MS213 only)		
"Operating Value" setting (temporary test setting)		
Pos. Phase Sequ. Voltage (note: MS113 only)		
RelayTripped [Yes/No]		

4. Test (Max. Overexcitation)	With Earth Fault In Generator Neutral	Without Earth Fault/ Normal Operation
Generator current [A]		
Generator voltage [kV]		
Generator active power (MW)		
Generator reactive power (MVAr)		
3rd harmonic [V] measured at the open delta VT at the generator leads via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic [V] measured at the at the generator neutral transformer via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic sum [V] (DRS internal computed value/ shown in the DRS functions display window (note: MS213 only)		
"Bias" setting value (temporary test setting) (note: MS213 only)		
"Operating Value" setting (temporary test setting)		
Pos. Phase Sequ. Voltage (note: MS113 only)		
RelayTripped [Yes/No]		

5. Test (Max. Underexcitation)	With Earth Fault In Generator Neutral	Without Earth Fault/ Normal Operation
Generator current [A]		
Generator voltage [kV]		
Generator active power (MW)		
Generator reactive power (MVAr)		
3rd harmonic [V] measured at the open delta VT at the generator leads via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic [V] measured at the at the generator neutral transformer via the DRS functions display window (note: MS213. MS113 only if this voltage has been choosen)		
3rd harmonic sum [V] (DRS internal computed value/ shown in the DRS functions display window (note: MS213 only)		
"Bias" setting value (temporary test setting) (note: MS213 only)		
"Operating Value" setting (temporary test setting)		
Pos. Phase Sequ. Voltage (note: MS113 only)		
RelayTripped [Yes/No]		

Table Evaluation:

It is recommended to draw a diagram where the number of tests are entered in the X-axis.
In the Y-axis the sum of the 3rd harmonic is entered for each test.
Subsequently all earth fault test values are combined to form a graph and the same way all open circuit- and/or on-load test values.
Result: 2 graphs which are representing all permissible generator operating conditions with or without an earth fault.
Between the two graphs a straight line, with Y = constant, is positioned which should have a sufficient safety margin from the curves. Finally this obtained Y-value is used as the function operating value setting.

Should it not be possible to find a line which is not crossing one of the curves then a solution by altering the “Bias Setting“ value could be obtained (MS213).
If still not successful the plausibility of the curves should be investigated. Especially the VT grounding should be checked to ensure that there are no false readings due to earth potential shifts.

In some particular cases it may happen that the generator characteristic is almost symmetrical which then will produce almost no or a too small 3rd harmonic component.
Note:
The generator characteristic symmetry greatly depends on the manufacturing tolerances and therefore it is required to determine protection settings for each generator by separate tests.

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18. MT... VOLTAGE TRANSFORMER SUPERVISION

18.1. OVERVIEW

List of the Available MT . . . – VT Supervision Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MT . . .	FNNR	TYPE	ANSI	Application
VT supervision 2 phase Vector sum of the 2 phase voltage inputs Only applicable for phase to neutral voltages Note: No outputs to trip matrix but common alarm annunciation is provided	1103	MT212	-	C2,M,L
VT Broken Conductor 3-phase Phase-phase voltages are applied to the protection relay (3 wires). "Broken conductor" is detected by comparing the changes of the NPS-voltage and the NPS-current. The protective function will detect: a) shortcircuited VT- winding (one of the phase-voltages is zero) b) VT broken wire (one of the three wires between VT and DRS is interrupted)	1142	MT300		C2,M
VT supervision 3 phase, Y-connection	1101	MT312	-	C2,M,L
Common VT supervision 3 phase. Y-connection Evaluates the voltage sum similar to the VT supervision 3 phase Y-connection, however with standard protective function outputs	1107	MT315	-	C2,M,L
VT supervision 3 phase, D-connection Evaluates the NPS voltage component	1104	MT313	-	C2,M,L
Inverse time VT supervision 3 phase, D-connection Evaluates the NPS voltage component similar to the VT supervision 3 phase D-connection, however with standard protective function outputs	1108	MT317	-	C2,M,L

18.2. TECHNICAL DATA

18.2.1. VT Supervision 2 Phase

PROTECTIVE FUNCTION: MT212	FNNR	TYPE	ANSI	Application
VT supervision 2 phase Vector sum of the 2 phase voltage inputs Only applicable for phase to neutral voltages Note: No outputs to trip matrix but common alarm annunciation is provided	1103	MT212	-	C2,M,L

Supervision of a 2 pole VT set on symmetry (voltage sum computation).

MT212
Technical Data

Inputs

Analogue:	Voltage system L1 (phase to neutral)
	Voltage system L3 (phase to neutral)

Outputs

Red alarm LED 1st row:	DRS fault Note: VT fault

Setting Parameters

Operating value:	5 ... 50 V in 1 V steps
Operating time:	1 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Voltage sum (2 x Vo): Note: "Voltage Sum" refers to the selection of either phase to phase or phase to neutral voltages	In V

Measuring

Reset ratio:	0.97
Operating time:	$\geq$ 2 Cycles
Accuracy:	$\leq$ 3% of setting value or $\leq$ 2% I_n

18.2.2. VT Broken Conductor 3 Phase

VT Broken Conductor 3-phase Phase-phase voltages are applied to the protection relay (3 wires). "Broken conductor" is detected by comparing the changes of the NPS-voltage and the NPS-current. The protective function will detect: a) shortcircuited VT- winding (one of the phase-voltages is zero) b) VT broken wire (one or more of the three wires between VT and DRS are interrupted)	1142	MT300		C2,M

Broken conductor supervision for 3-phase CT circuits (phase-phase connection) to detect single-, two and three-phase interruptions with indication of the faulty phases.

Explication of set values:

U2/U1: Minimum ratio of NPS to PPS in voltage (phase-phase voltage) to start the function in case of single phase interruption

I2/I1: Minimum ratio of NPS to PPS in current to inhibit the function in case of single phase interruption

"Current Change": Minmum change in PPS of current to inhibit the function in case of multiphase interruption

"Blocking Delay": Additional time lag of the functions blocking signal

"Phase Rotation": Selection of phase rotation

"Transf. Supervision": To be selected 'Yes', if the VT broken conductor detection should indicate a CT/VT error with the general device supervision contacts

<u>MT300</u>
<u>Technical Data</u>

Inputs

Analogue:	Voltage system L1-L2 (phase to phase voltage)
	Voltage system L2-L3 (phase to phase voltage)
	Voltage system L3-L1 (phase to phase voltage)
	Current L1 (phase L1)
	Current L2 (phase L2)
	Current L3 (phase L3)

Outputs

Binary:	Trip
Red alarm LED 1st row:	DRS fault Note: subcategory "CT/VT error" Note: "DRS fault" will be issued if set value "Transformer Supervision" is choosen "Yes"

Setting Parameters

U2/U1: Note: U2 … Neg. Phase Sequ. System of 1.Harm. of Phase-Phase-Voltages Note U … Pos. Phase Sequ. System of 1. Harm. of Phase Phase Voltages	0,05 … 0,90 p.U. in 0,01 p.U. - steps
I2/I1: Note: I2 … Neg. Phase Sequ. System of 1.Harm. of Phase Currents Note: I1 … Pos. Phase Sequ. System of 1.Harm. of Phase Currents	0,05 … 0,60 p.U. in 0,01 p.U. - steps
Current Change:	0,10 … 1,00 p.U. in 0,05 p.U. - steps
Blocking Delay:	0,00 … 20,0 s in 0,1 s - steps
Phase Rotation:	Right/ Left
Transformer Supervision:	No/ Yes

Window Display for Relay Internal Determined and Computed Values

U2/U: Note: U2 … Neg. Phase Sequ. System of 1.Harm. of Phase-Phase-Voltages U … Pos. Sequ. Phase System of 1. Harm. of Phase Phase Voltages	in p.U.
I2/I1: Note: I2 … Neg. PhaseSequ. System of 1.Harm. of Phase Currents Note: I … Pos. Phase Sequ. System of 1.Harm. of Phase Currents	in p.U.

Measuring

Reset ratio:	Hysterese 2 … 5 %.
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n resp. U_n

18.2.3. VT Supervision 3 Phase, Y - Connection

PROTECTIVE FUNCTION: MT312	FNNR	TYPE	ANSI	Application
VT supervision 3 phase, Y-connection	1101	MT312	-	C2,M,L

Supervision of a 3 pole VT set with Y-connection for symmetry.
Computation of the voltage sum, i.e. 3 x phase to neutral voltage.
Applicable for phase to neutral voltages only.

MT312
Technical Data

Inputs

Analogue:	Voltage phase L1
	Voltage phase L2
	Voltage phase L3

Outputs

Red alarm LED 1st row:	DRS fault Note: VT fault

Setting Parameters

Operating value:	5 ... 50 V in 1 V steps
Operating time:	1 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal
Determined and Computed Values

Voltage sum (3 x Vo): Note: Voltage sum of phase to neural voltages	In V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

18.2.4. VT Supervision 3 Phase, Y - Connection, With Optional VT Fault LED Indication

PROTECTIVE FUNCTION: MT315	FNNR	TYPE	ANSI	Application
Common VT supervision 3 phase. Y-connection Evaluates the voltage sum similar to the VT supervision 3 phase Y-connection, however with standard protective function outputs	1107	MT315	-	C2,M,L

VT supervision function evaluating the voltage sum of a 3 phase Y-connected VT set.
Computation of the voltage sum (3 x zero sequence voltage).
Applicable for phase to neutral voltages only.
Optional VT fault supervision LED indication.

MT315
Technical Data

Inputs

Analogue:	Voltage phase L1
	Voltage phase L2
	Voltage phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip
Red fault LED, 1st row:	DRS fault (optional / see setting parameters "Fault Evaluation"). Note: VT fault.

Setting Parameters

Operating value:	5 ... 90 V in 1 V steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Fault evaluation:	Yes / No

Window Display for Relay Internal Determined and Computed Values

Voltage sum (3 x Vo): Note: Voltage sum of phase to neutral voltages	In V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% V_n

18.2.5. VT Supervision 3 Phase, D - Connection

PROTECTIVE FUNCTION: MT313	FNNR	TYPE	ANSI	Application
VT supervision 3 phase, D-connection Evaluates the NPS voltage component	1104	MT313	-	C2,M,L

VT supervision function 3 phase, D-connected VT set for symmetry.
Computation of the NPS voltage component.
Suitable for phase to phase voltages.

MT313
Technical Data

Inputs

Analogue:	Phase to phase voltage L1-L2
	Phase to phase voltage L2-L3
	Phase to phase voltage L3-L1

Outputs

Red fault LED, 1st row:	DRS fault Note: VT fault

Setting Parameters

Operating value:	5 ... 50 V in 1 V steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Phase rotation:	Right / Left

Window Display for Relay Internal
Determined and Computed Values

NPS system of the phase to phase voltages:	In V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% V_n

18.2.6. Inverse Time VT Supervision 3 Phase, D – Connection, With Optional VT Fault LED Indication

PROTECTIVE FUNCTION: MT317	FNNR	TYPE	ANSI	Application
Inverse time VT supervision 3 phase, D-connection Evaluates the NPS voltage component similar to the VT supervision 3 phase D-connection, however with standard protective function outputs	1108	MT317	-	C2,M,L

Supervision of a 3 pole VT set with D-connection for symmetry.
Computation of the NPS voltage values.
Applicable for monitoring phase to phase voltages.

MT317
Technical Data

Inputs

Analogue:	Phase to phase voltage L1-L2
	Phase to phase voltage L2-L3
	Phase to phase voltage L3-L1
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip
Red fault LED, 1st row:	DRS fault (optional / see setting parameters "Fault Evaluation"). Note: VT fault.

Setting Parameters

Operating value:	5 ... 50 V in 1 V steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Fault evaluation:	Yes / No
Phase rotation:	Right / Left

Window Display for Relay Internal Determined and Computed Values

NPS system of the phase to phase voltages:	In V

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 Cycles
Accuracy:	≤ 3% of setting value or ≤ 2% V_n

18.3. CONNECTION DIAGRAMS

18.3.1. MT212

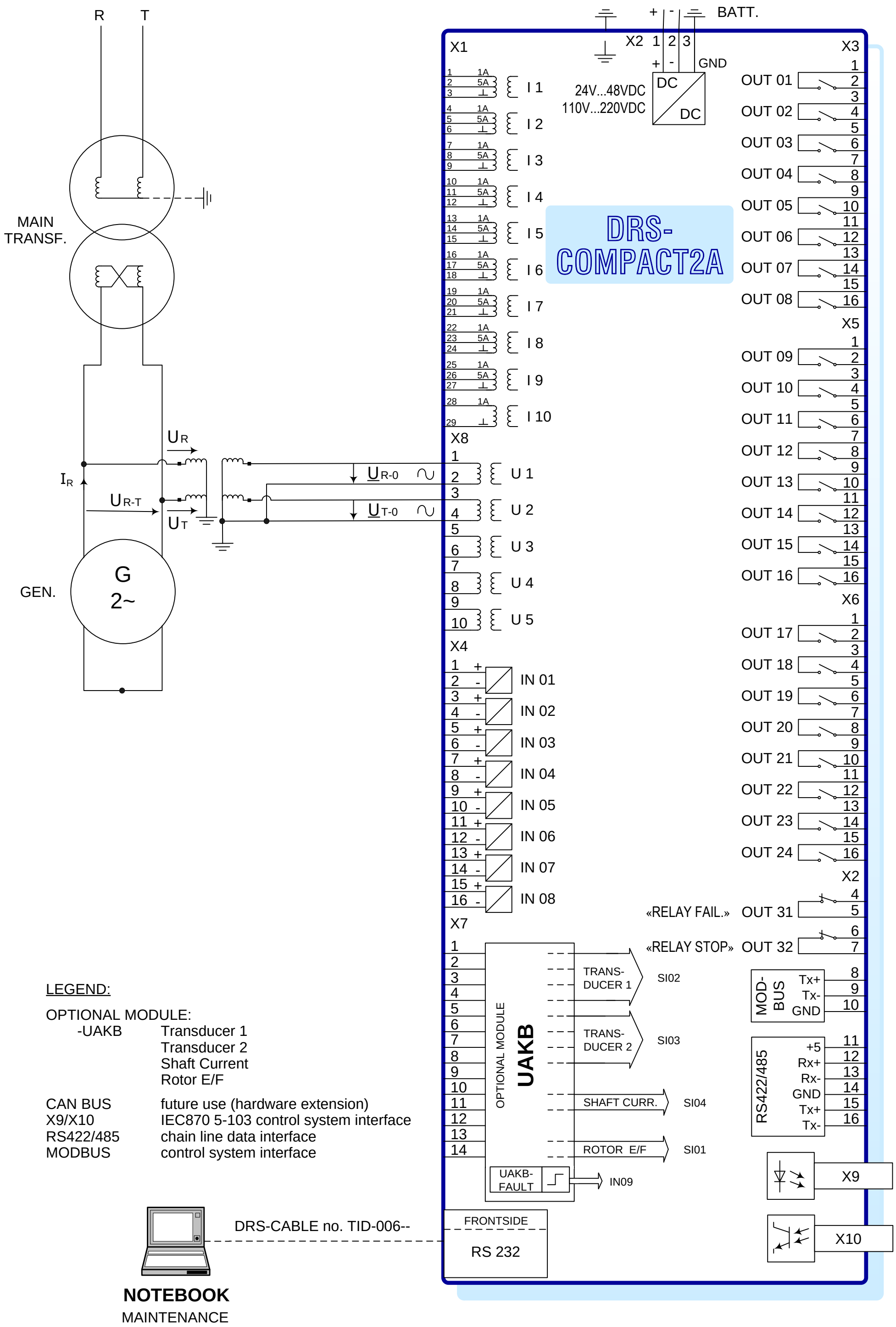


Fig. 243 MT212 V.T. Monitoring 2.PH: Wiring Diagram

18.3.2. MT312/ MT315

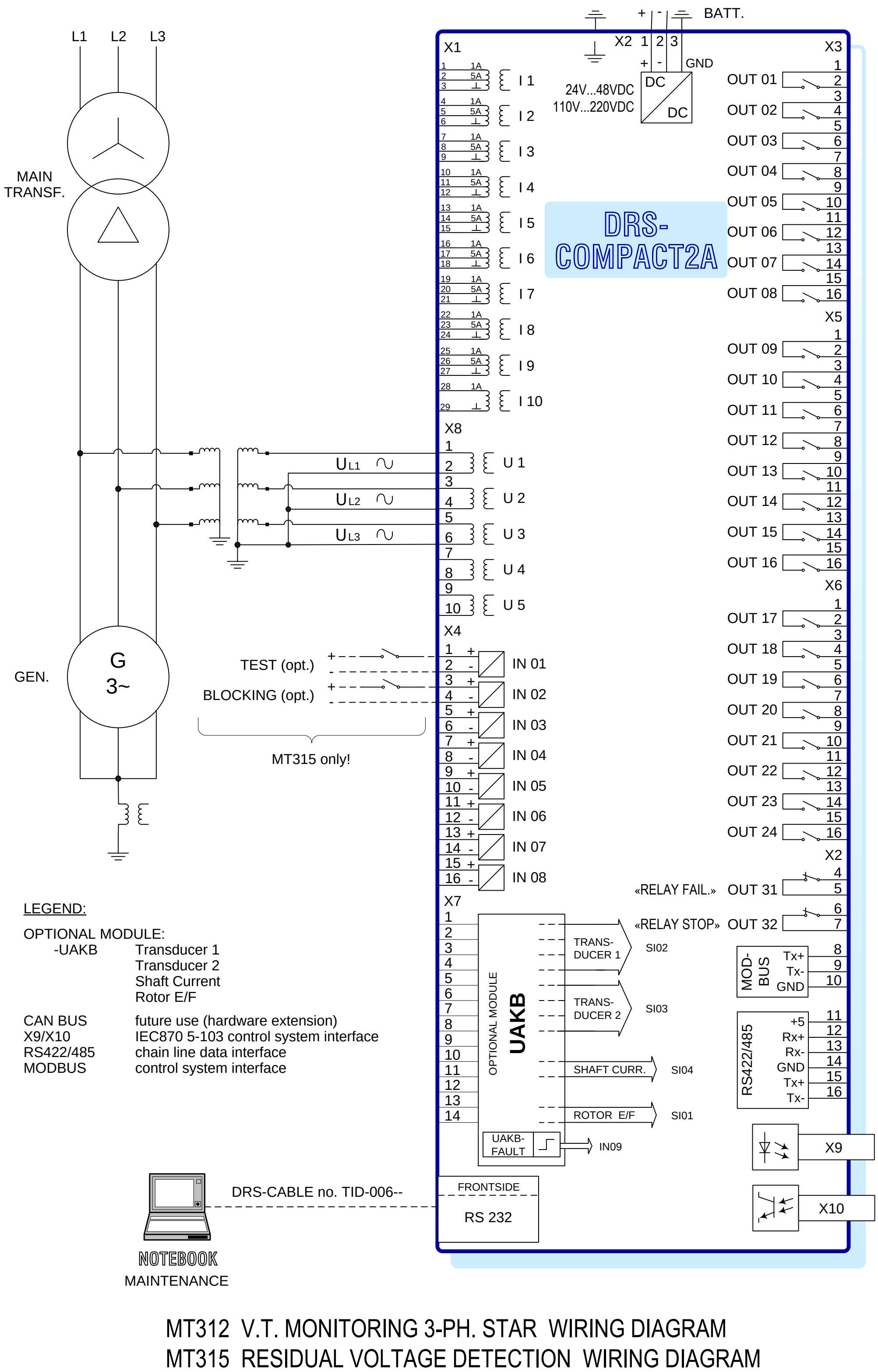


Fig. 244 MT312 V. T. Monitoring 3-PH. Star Wiring Diagram MT315 Residual Voltage Detection Wiring Diagram

18.3.3. MT313/ MT317

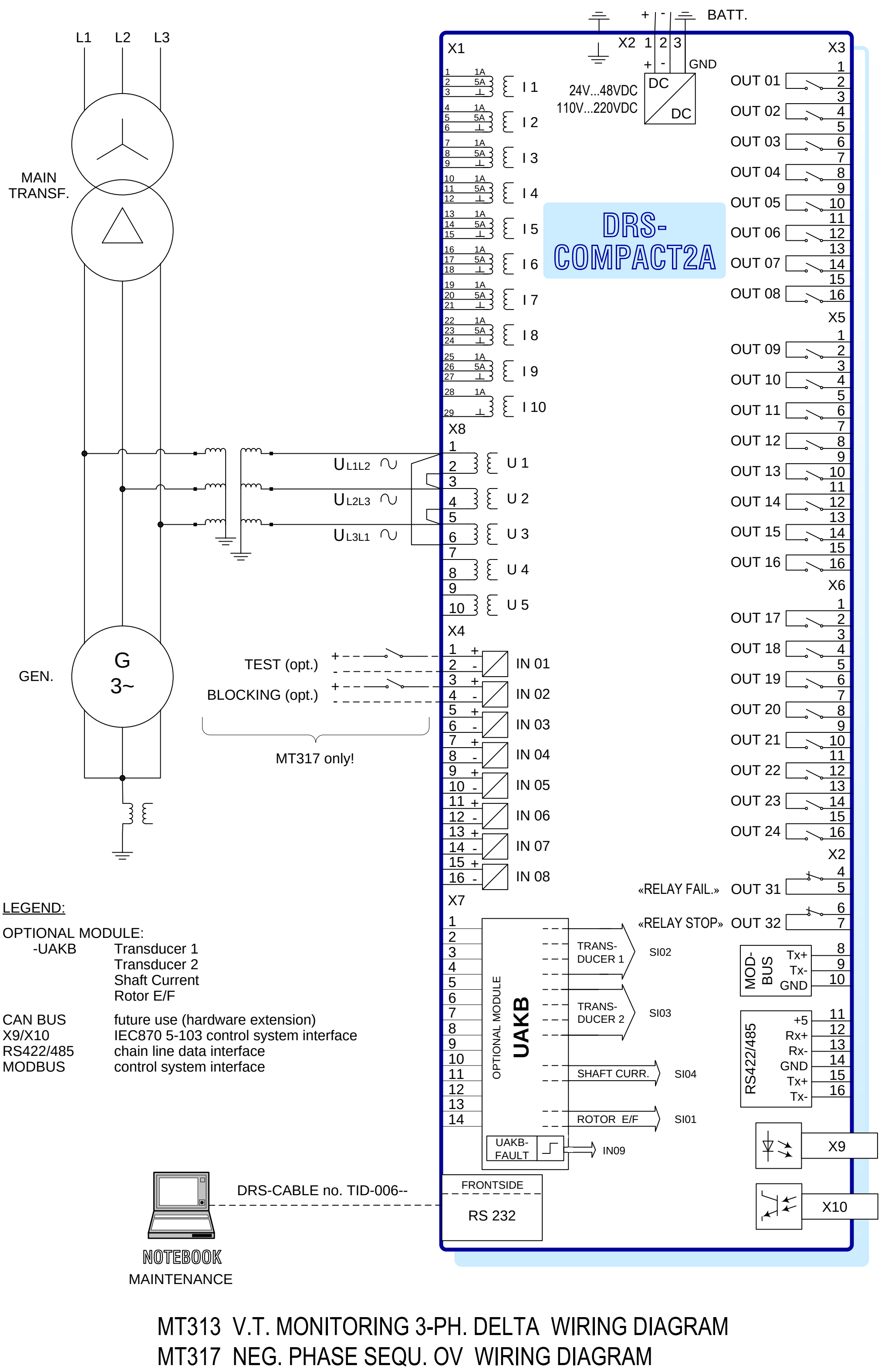
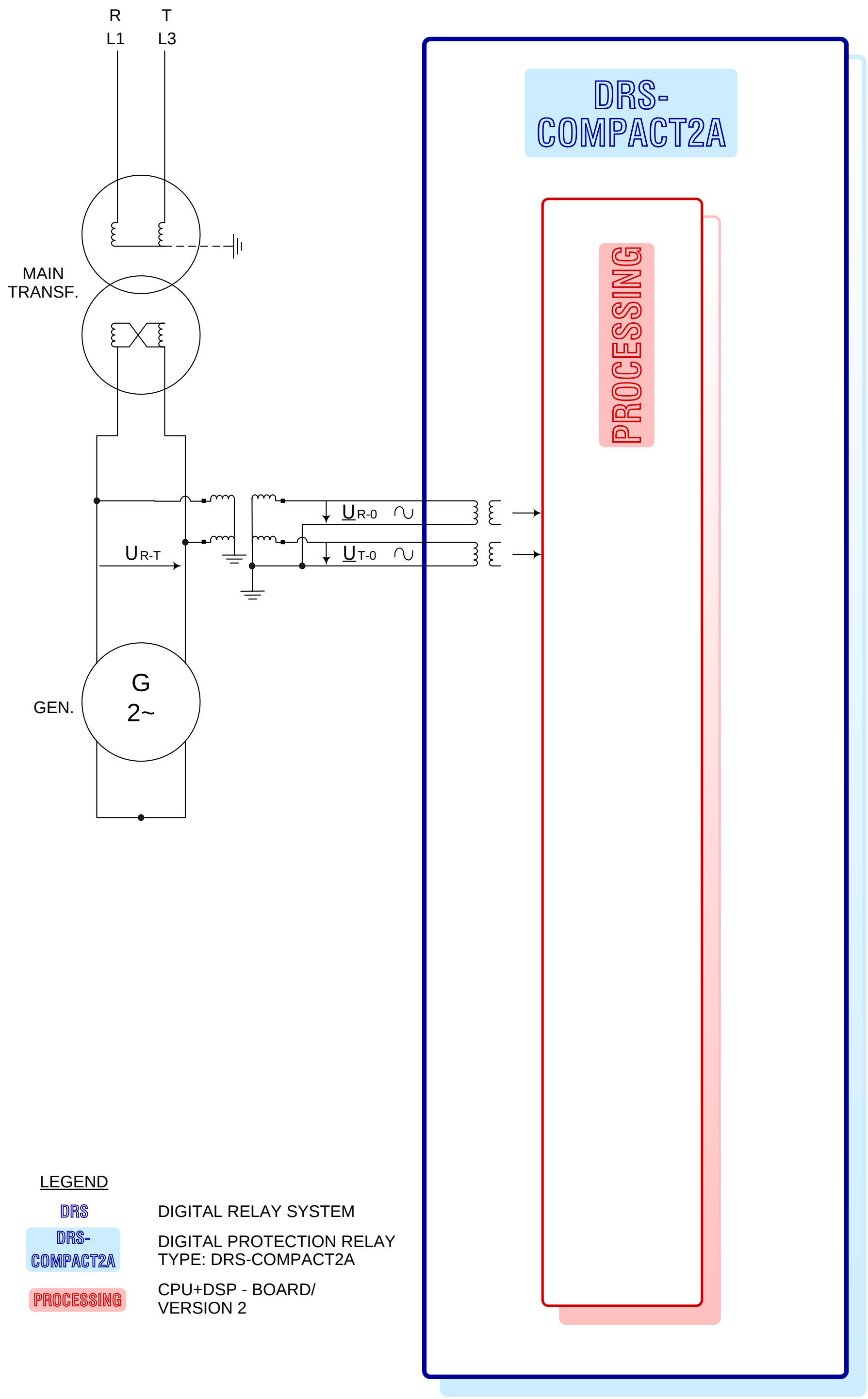


Fig. 245 MT313 V.T. Monitoring 3-PH. Delta Wiring Diagram MT317 Neg. Phase Sequ. OV Wiring Diagram

18.4. LOGIC DIAGRAMS

18.4.1. MT212



MT212 V.T. MONITORING 2.PH. LOGIC DIAGRAM

Fig. 246 MT212 V.T. Monitoring 2.PH. Logic Diagram

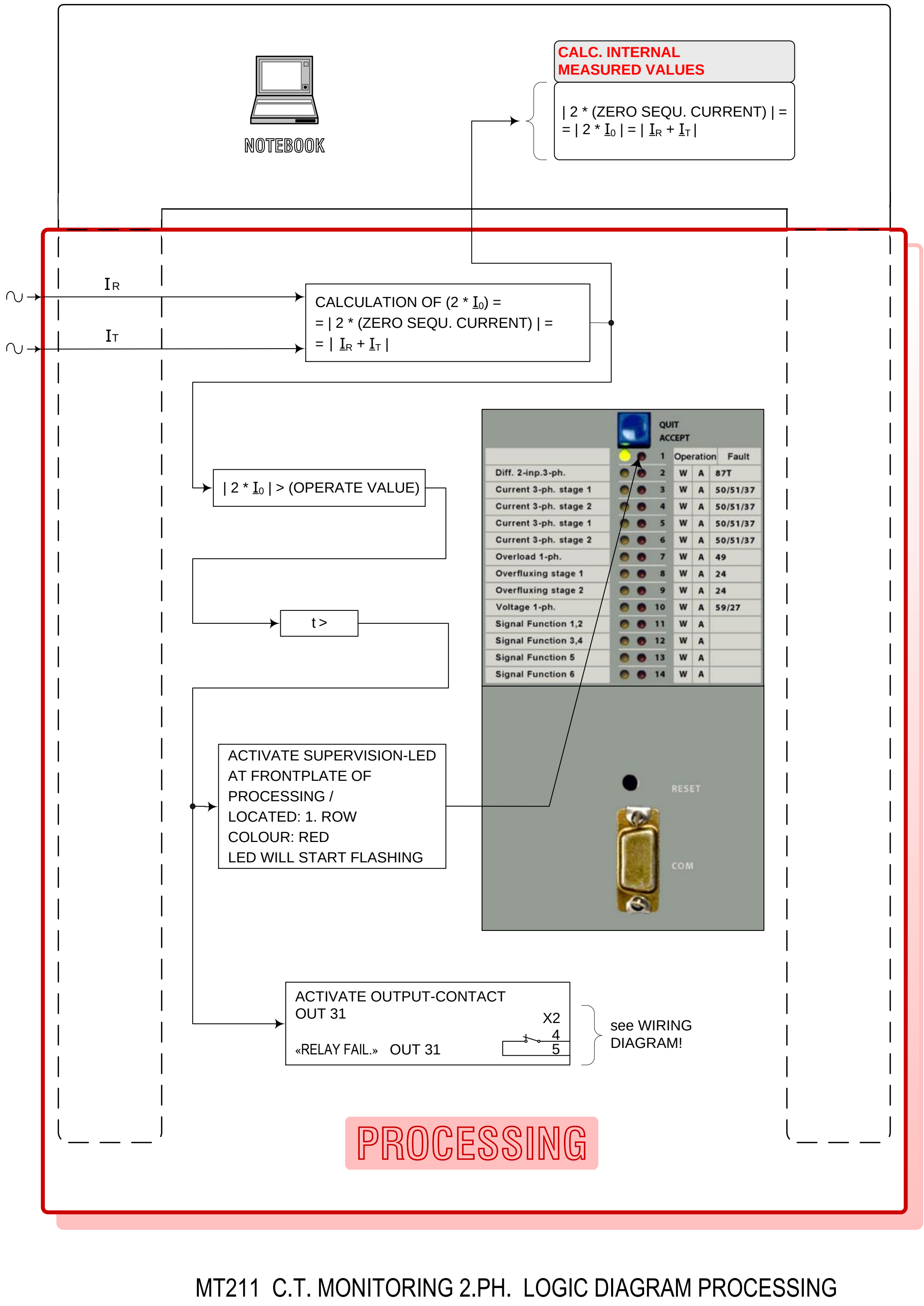
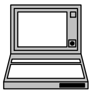


Fig. 247 MT211 C.T. Monitoring 2.PH. Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MT211



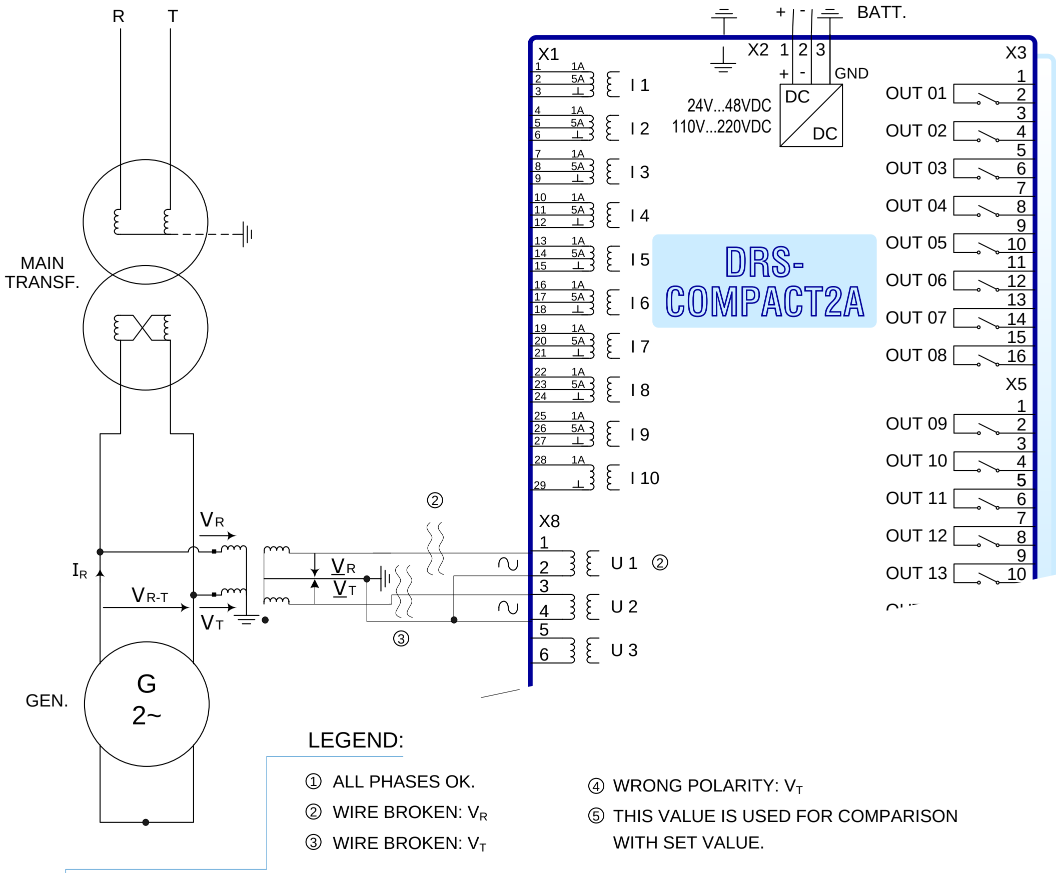
Online simulation
via notebook

CALCULATION OF (2 * $\underline{U}_0$) = = 2 * (ZERO SEQU. VOLTAGE) = = $\underline{U}_R$ + $\underline{U}_T$	Geometric sum of the phase-voltage phasors: $\underline{U}_R + \underline{U}_T = 2 * \underline{U}_0$.
ACTIVATE SUPERVISION-LED AT FRONTPLATE OF PROCESSING/ LOCATED: 1. ROW COLOUR: RED	The red LED in the first row at the frontplate of the PROCESSING-module will start to flash in case of C.T.-fault.
ACTIVATE OUTPUT-CONTACT OUT 31 X2 4 «RELAY FAIL.» OUT 31 5	OUT31: «RELAY FAIL.». NOTE: This «RELAY FAIL.» -signal is the sum of many possible single signals. In case of „C.T.-fault“ it is not a fault of the PROTECTION RELAY itself, usually the fault will be outside of the DRS-COMPACT. Please connect the notebook to find out what there is the exact reason for the alarm „RELAY FAIL“!

>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MT212 V.T. MONITORING 2.PH. LOGIC DIAGRAM PROCESSING / LEGEND

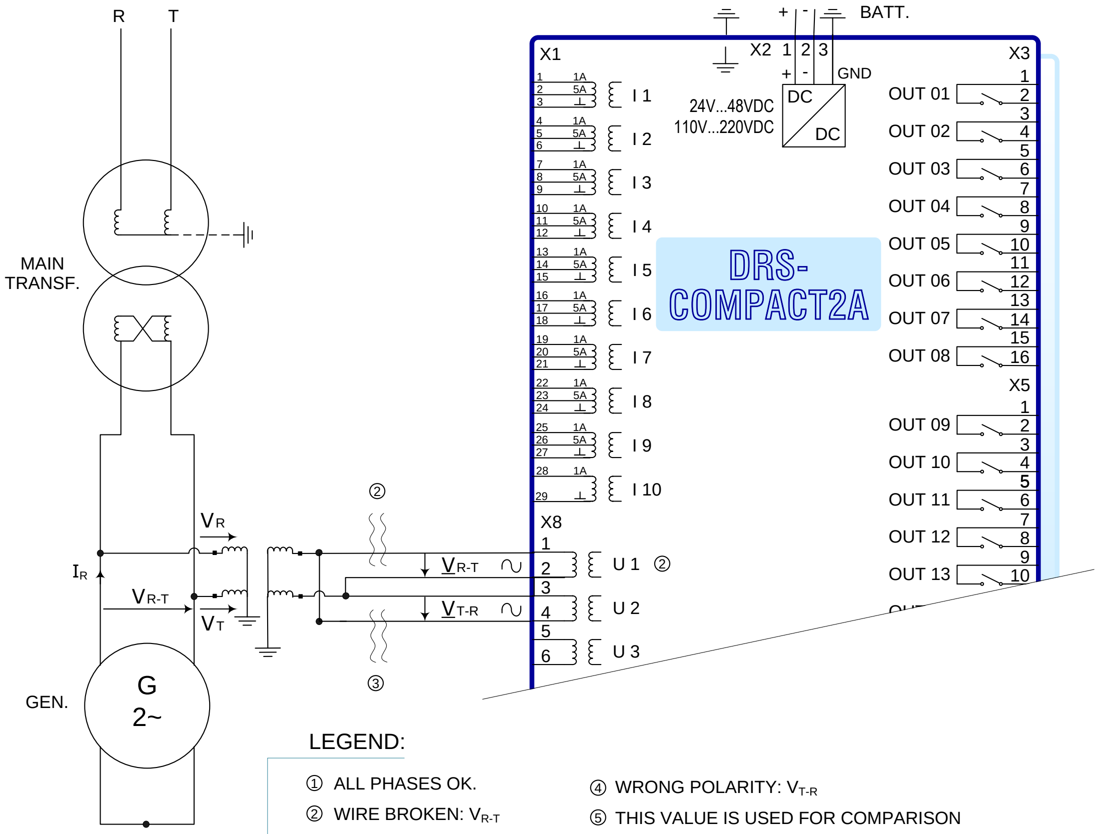
Fig. 248 MT212 V.T. Monitoring 2.PH. Logic Diagram Processing / Legend



	VOLTAGES	PHASE-PHASE			
	V_R	V_T	PHASOR DIAGRAM	$\underline{V}_0 = (\underline{V}_R + \underline{V}_T) / 2$	NOTEBOOK DISPLAY: ⑤ $\lvert 2 * \underline{V}_0 \rvert$ = 2 * |ZERO.SEQU.VOLT.|
① EXAMPLE no. 1	50V	50V	V_R ↓ ↑ V_T	0V	0V
② EXAMPLE no. 2	0V	50V	V_R=0 ↑ V_T	25V	50V
③ EXAMPLE no. 3	50V	0V	↓ V_R V_T=0	25V	50V
④ EXAMPLE no. 4	50V	50V	V_R ↓↓ V_T	50V	100V

MT212 V.T. MONITORING 2.PH. EXAMPLE 1 = USING PHASE-GROUND VOLTAGES

Fig. 249 MT212 V.T. Monitoring 2.PH. Example 1= Using Phase – Ground Voltages



LEGEND:

① ALL PHASES OK.

② WIRE BROKEN: V_{R-T}

③ WIRE BROKEN: V_{T-R}

④ WRONG POLARITY: V_{T-R}

⑤ THIS VALUE IS USED FOR COMPARISON WITH SET VALUE.

	VOLTAGES	PHASE-PHASE			
	V_{R-T}	V_{T-R}	PHASOR DIAGRAM	$\underline{V}_0 = (\underline{V}_{R-T} + \underline{V}_{T-R}) / 2$	NOTEBOOK DISPLAY: ⑤ $\lvert 2 * \underline{V}_0 \rvert = 2 *$ |ZERO.SEQU.VOLT.|
① EXAMPLE no. 1	100V	100V	V_{R-T} ↑↓ V_{T-R}	0V	0V
② EXAMPLE no. 2	0V	100V	$V_{R-T} = 0$ ↓ V_{T-R}	50V	100V
③ EXAMPLE no. 3	100V	0V	V_{R-T} ↑ $V_{T-R} = 0$	50V	100V
④ EXAMPLE no. 4	100V	100V	V_{R-T} ↑↑ V_{T-R}	100V	200V

MT212 V.T. MONITORING 2.PH. EXAMPLE 2 = USING PHASE-PHASE VOLTAGES

Fig. 250 MT212 V.T. Monitoring 2.PH. Example 2= Using Phase – Phase Voltages

18.4.2. MT312/ MT315

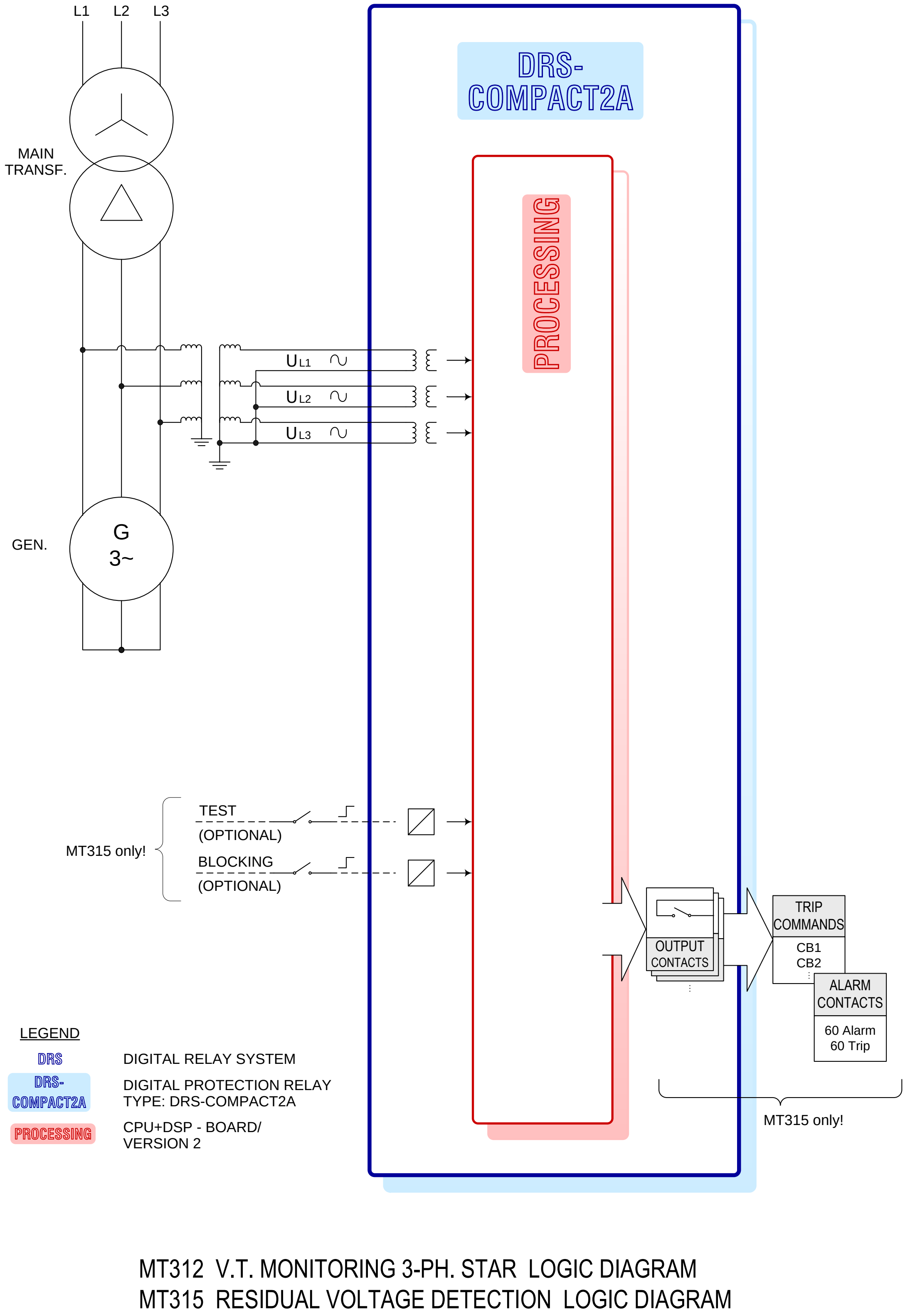
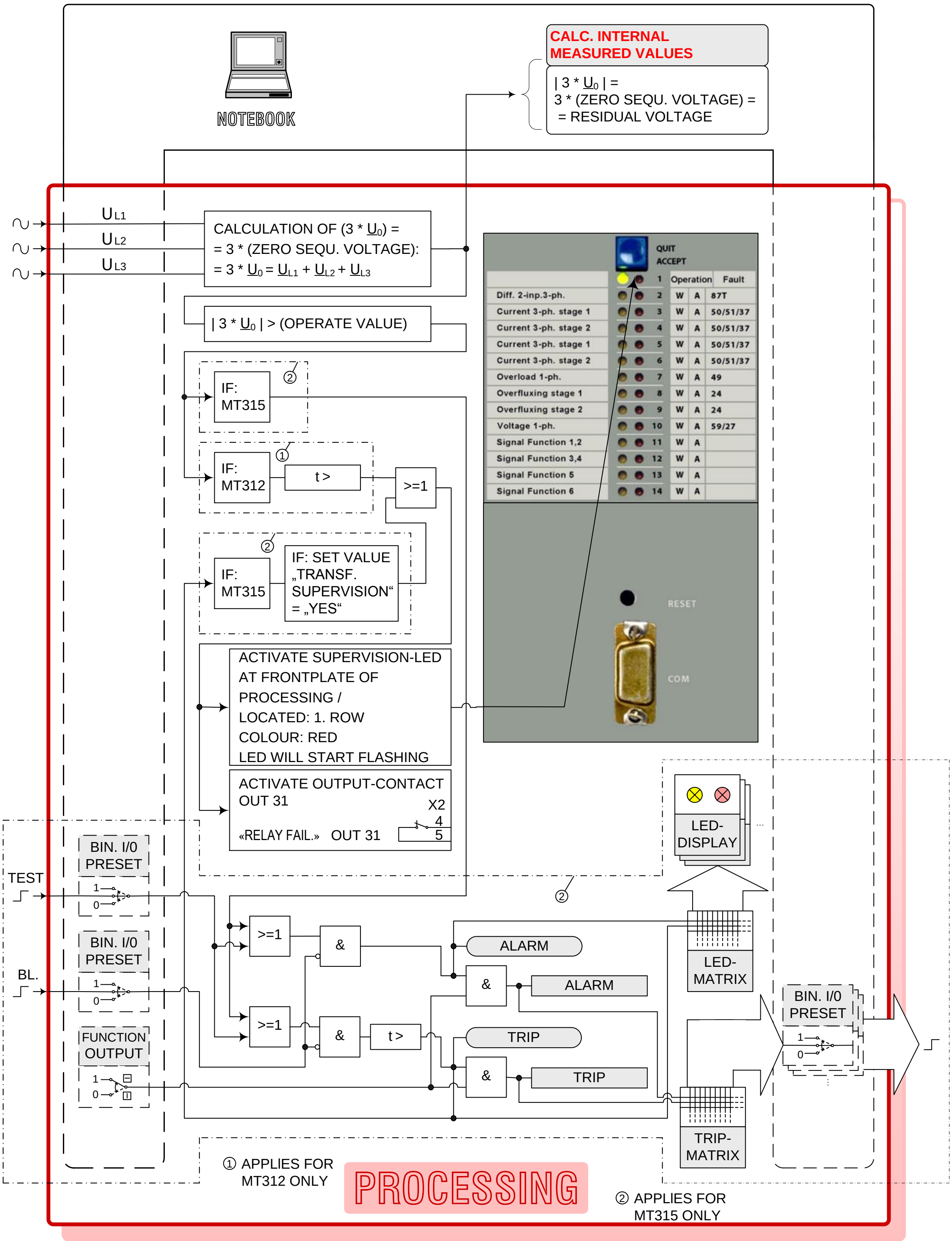


Fig. 251 MT312 V.T.Monitoring 3-PH. Star Logic Diagram MT315 Residual Voltage Detection Logic Diagram



MT312 V.T. MONITORING 3-PH. STAR LOGIC DIAGRAM PROCESSING

MT315 RESIDUAL VOLTAGE DETECTION LOGIC DIAGRAM PROCESSING

Fig. 252 MT312 V.T. Monitoring 3-PH. Star Logic Diagram Processing MT315 Residual Voltage Detection Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MT312, MT315

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MT312, MT315
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION OF (3 * $\underline{U}_0$) = = 3 * (ZERO SEQU. VOLTAGE): = 3 * $\underline{U}_0 = \underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}$

Geometric voltage sum of all 3 phase-voltage phasors.
Note: $\underline{U}_0 = (\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}) / 3$
$3 * \underline{U}_0 = (\underline{U}_{L1} + \underline{U}_{L2} + \underline{U}_{L3}) = \underline{U}_{neutral}$

IF: MT312

MT312: a) supervision LED at frontplate of PROCESSING (1. ROW / red LED) will flash
b) «RELAY FAIL.» OUTPUT-contact OUT1
c) no TRIP-MATRIX, no LED-MATRIX

IF: MT315

MT315: a) this function acts like a standard DRS-protective function: LED-MATRIX, TRIP-MATRIX, TEST-INPUT, BLOCKING-INPUT, FUNCTION OUTPUT.
b) trigger conditions: same as MT312
c) OPTIONALLY (see set value „TRANSF. SUPERVISION"): supervision LED (same as MT312)
«RELAY FAIL.» OUT31 (same as MT312)

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING — LED-DISPLAY — LED-indications of PROCESSING-board (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

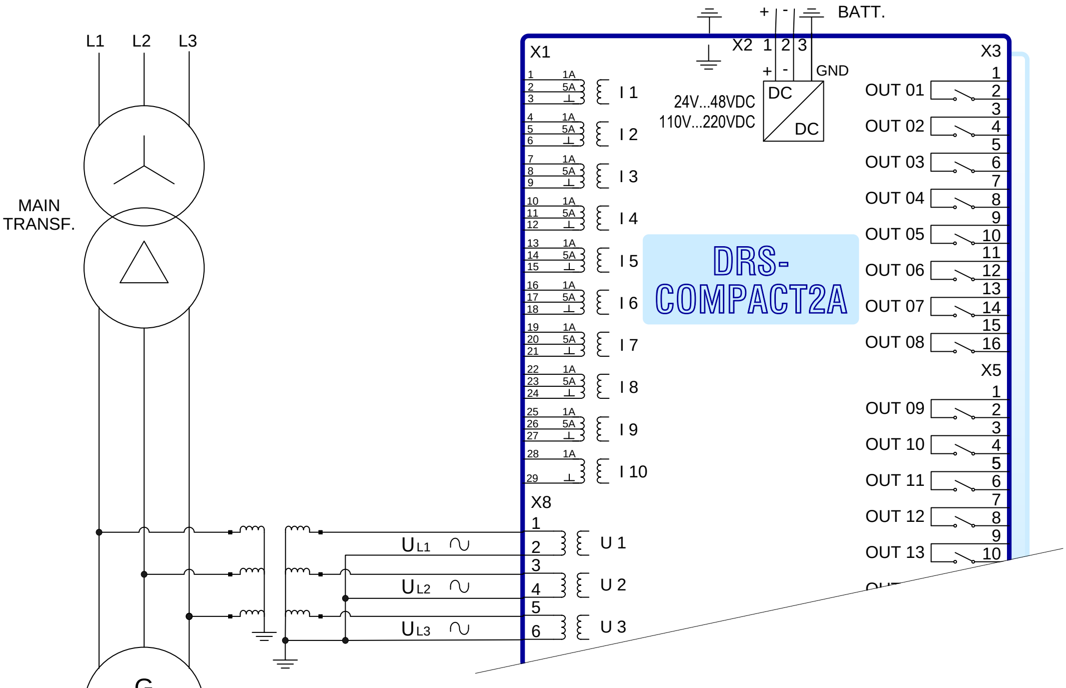
TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MT312 V.T. MONITORING 3-PH. STAR LOGIC DIAGRAM PROCESSING / LEGEND
MT315 RESIDUAL VOLTAGE DETECTION LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 253 MT312 V.T. Monitoring 3-PH. Star Logic Diagram Processing / Legend MT315 Residual Voltage Detection Logic Diagram Processing / Legend



LEGEND:

① STATUS OK.
② 1 WIRE BROKEN
③ 1 PHASE MISSING
} DISPLAY SHOWS: 3 * U_0 = 57,7V.

③ 2 WIRES BROKEN ® 2 PHASES MISSING
④ WRONG SEQUENCE OF PHASES
⑤ THIS VALUE IS USED FOR COMPARISON WITH SET VALUE.

	VOLTAGES PHASE-GROUND					
	U_{L1-0}	U_{L2-0}	U_{L3-0}	PHASOR DIAGRAM	$\lvert \underline{U}_{L1-0} + \underline{U}_{L2-0} + \underline{U}_{L3-0} \rvert / 3 = \lvert \underline{U}_0 \rvert$	NOTEBOOK ⑤ DISPLAY: 3 * U_0
① EXAMPLE no. 1	57,7V	57,7V	57,7V	U_{L1-0}, U_{L3-0}, U_{L2-0}	0V	0V
② EXAMPLE no. 2	57,7V	57,7V	0V	U_{L1-0}, U_{L2-0}	57,7V / 3	57,7V
③ EXAMPLE no. 3	57,7V	0V	0V	U_{L1-0}	57,7V / 3	57,7V
④ EXAMPLE no. 4	57,7V	57,7V	57,7V	U_{L1-0}, U_{L3-0}, U_{L2-0}	173,2V / 3	173,2V

MT312 V.T. MONITORING 3-PH. STAR
MT315 RESIDUAL VOLTAGE DETECTION
} EXAMPLE

Fig. 254 MT312 V.T. Monitoring 3-PH. Star MT315 Residual Voltage Detection } Example

18.4.3. MT313/ MT317

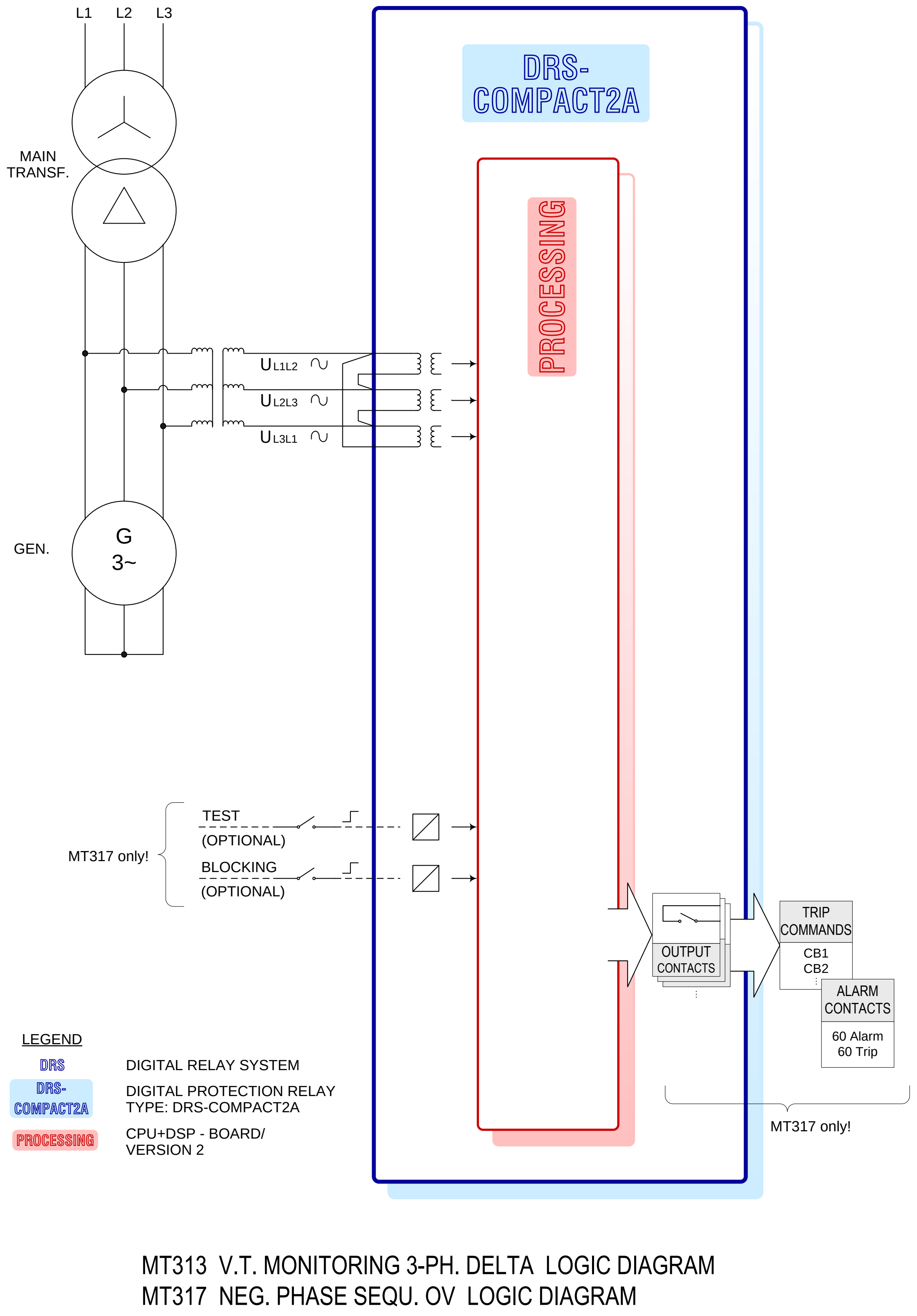
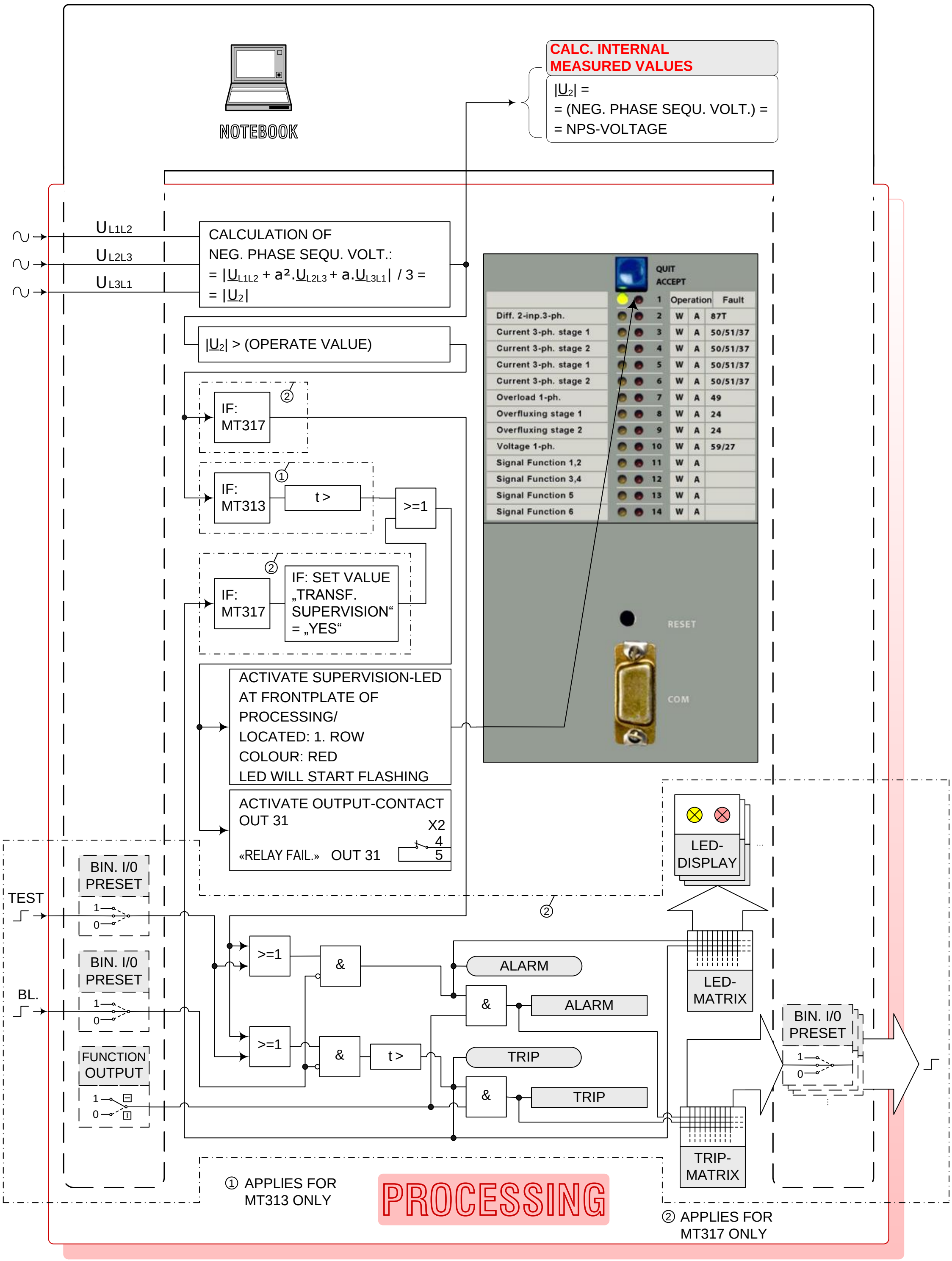


Fig. 255 MT313 V.T.Monitoring 3-PH.Delta Logic Diagram MT317 Neg. Phase Sequ. OV Logic Diagram



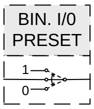
MT313 V.T. MONITORING 3-PH. DELTA LOGIC DIAGRAM PROCESSING
MT317 NEG. PHASE SEQU. OV LOGIC DIAGRAM PROCESSING

Fig. 256 MT313 V. T. Monitoring 3-PH. Delta Logic Diagram Processing MT317 Neg. Phase Sequ. OV Logic Diagram Processing

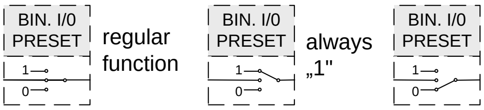
LEGEND PROCESSING

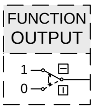
FIRMWARE-MODULE: MT313, MT317

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen



Online-simulation of DIG. IN-/OUTPUTS via notebook:





Online-simulation of the FUNCTION OUTPUTS of the protective function MT313, MT317
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION OF NEG. PHASE SEQU. VOLT.: $= |\underline{U}_{L1L2} + a^2.\underline{U}_{L2L3} + a.\underline{U}_{L3L1}| / 3 = = |\underline{U}_2|$

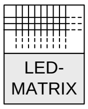
Geometric voltage sum of all the voltage phasors.
Result: $(\underline{U}_{L1L2} + a^2.\underline{U}_{L2L3} + a.\underline{U}_{L3L1}) / 3 =$
= (NEG. PHASE SEQU. VOLT. of PH-PH-VOLTAGES)

IF: MT313

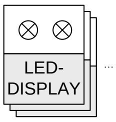
MT313: a) supervision LED at frontplate of PROCESSING (1. ROW / red LED) will flash
b) «RELAY FAIL.» OUTPUT-contact OUT31 will close
c) no TRIP-MATRIX, no LED-MATRIX

IF: MT317

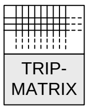
MT317: a) this function acts like a standard DRS-protective function: LED-MATRIX, TRIP-MATRIX, TEST-INPUT, BLOCKING-INPUT, FUNCTION OUTPUT.
b) trigger conditions: same as MT313
c) OPTIONALLY (see set value „TRANSF. SUPERVISION“): supervision LED (same as MT313) «RELAY FAIL.» OUT31 (same as MT313)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING-board (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

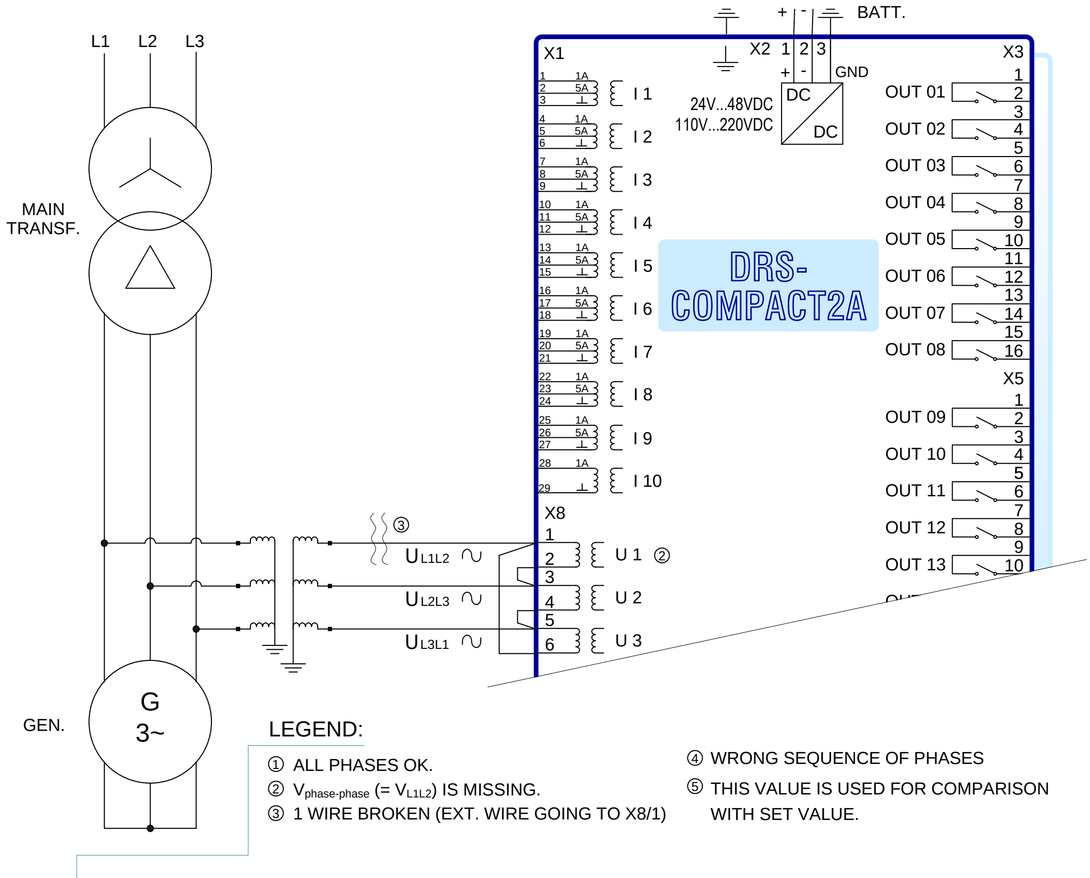
TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MT313 V.T. MONITORING 3-PH. DELTA LOGIC DIAGRAM PROCESSING / LEGEND
MT317 NEG. PHASE SEQU. OV LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 257 MT313 V.T. Monitoring 3-PH. Delta Logic Diagram Processing / Legend MT317 Neg. Phase Sequ. OV Logic Diagram Processing / Legend



	VOLTAGES	PHASE-PHASE				
	V_{L1L2}	V_{L2L3}	V_{L3L1}	PHASOR DIAGRAM	$\underline{V}_2$ = ($\underline{V}_{L1L2}$ + $\underline{a}^2$.$\underline{V}_{L2L3}$ + $\underline{a}$.$\underline{V}_{L3L1}$) / 3	NOTEBOOK DISPLAY: ⑤ |$\underline{V}_2$| = |NEG.PH.SEQU.VOLT.|
① EXAMPLE no. 1	100V	100V	100V	V_{L3L1} V_{L1L2} V_{L2L3}	0V	0V
② EXAMPLE no. 2	0V	100V	100V	V_{L3L1} V_{L1L2} =0 V_{L2L3}	33,3V	33,3V
③ EXAMPLE no. 3	approx. 50V	100V	approx. 50V	V_{L3L1} V_{L1L2} V_{L2L3}	50V	50V
④ EXAMPLE no. 4	100V	100V	100V	V_{L3L1} V_{L2L3} V_{L1L2}	100V	100V

MT313 V.T. MONITORING 3-PH. DELTA
MT317 NEG. PHASE SEQU. OV } EXAMPLE

Fig. 258 MT313 V.T. Monitoring 3-PH. Delta MT317 Neg. Phase Sequ. OV } Example

18.5. FUNCTION

18.5.1. General Basics MT212/ MT312/ MT315/ MT313/ MT317

VT supervision functions are applied for the internal DRS monitoring features to check the VT external plant circuits but also to verify the correct internal signal processing.
Monitoring is based on the fact that in high voltage systems under normal operating conditions there are no negative phase sequence- or zero sequence components except for the duration of system disturbances or faults.

All function analogue signals are sampled 12 times each cycle. Via Fourier Analysis (DSP) the corresponding vectors (value and phase angle) for the 1^{st} harmonic are determined.

At each sample interval the CPU evaluates the zero sequence- or NPS system and compares whether the initiating conditions are above the operating setting. If the initiating conditions are exceeding the set values during 24 consecutive samples (= 2 cycles) then the time delay is started. After the configured time delay expiry the fault alarm is given and in the DRS fault status the condition “CT/VT Fault” entered.

VT Supervision.
Differences Between the Various Functions.

MT212 evaluates:	2 x zero sequence voltage = 1 x neutral voltage = vector voltage sum. Note: For 2 phase systems. Use of phase voltages.
MT312 evaluates:	3 x zero sequence voltage = 1 x neutral voltage = vector voltage sum. Note: For 3 phase systems. Only for phase to neutral voltages (not for phase to phase voltages).
MT315:	As MT312, however with additional outputs to the software LED matrix and the software trip matrix. Can be therefore be applied just like a normal protective function. A VT supervision function as per MT312 can optionally be provided (red status LED in the first row) und may be enabled or disabled via the “Setting Parameters” window.
MT313 evaluates:	1 x NPS system voltage = $\lvert \underline{U}_2 \rvert = \lvert \underline{U}_{L1L2} + a^2 . \underline{U}_{L2L3} + a . \underline{U}_{L3L1} \rvert / 3$. Note: For 3 phase systems suitable with phase to phase voltages. Please note: In case of phase to phase voltages the voltage sum will always remain zero. An unbalanced system can therefore only be detected via the NPS system computation.
MT317:	As MT331, however with additional outputs to the software LED matrix and the software trip matrix. Can be therefore be applied just like a normal protective function. A VT supervision function as per MT313 can optionally be provided (red status LED in the first row) und may be enabled or disabled via the “Setting Parameters” window.

18.5.2. MT300

18.5.2.1. General Basics:

VT Broken Conductor function MT300 is applied for the internal DRS monitoring features to check the VT external plant circuits (broken conductor …) and the VT condition (shortcircuited windings …).
Please mind that in case of broken wires there is possibility of malfunction of some protective functions (for example impedance protection or power measurement). Of course the cause for a missing voltage can also be a blown fuse or a tripped mcb.
The "trip" – output of the MT300 can be used to block other sensible protective functions to avoid an emergency trip. Usually the power station will then be shut down by standard procedures (depends on back-up configuration etc).

The function MT300 is a broken-wire supervision for 3-phase VT-circuits which are connected by phase-phase voltage wiring to the protective relay (3 wires). It detects one-, two- and threephase interruptions of the voltage wiring circuits.

MT300 calculates the following actual values:

U_{PPS} … Positive Sequence System of Phase-Phase-Voltage
U_{NPS} … Negative Sequence System of Phase-Phase-Voltage
I_{PPS} … Positive Sequence System of Phase-Current
I_{NPS} … Negative Sequence System of Phase-Current

The relay decides for the following faulty conditions of the VT-circuit:

a.
Detection of Single phase broken wire, if:

$U_{PPS} > (0{,}1 \times U_{nom})$
$I_{PPS} > (0{,}1 \times I_{nom})$
$(I_{NPS} / I_{PPS}) < (\text{set value } (I_{NPS} / I_{PPS}))$
$(U_{NPS} / U_{PPS}) \geq (\text{set value } (U_{NPS} / U_{PPS}))$

Please note:
In case of single phase broken wire the symmetry of the voltages will be disordered, but not the symmetry of the currents. During a real fault in the power station (primary fault) there will be a NPS – system coming up for both (voltage and current) systems.

b.
Detection of 2- or 3-phase broken wire, if:

$U_{PPS} < (0{,}1 \times U_{nom})$
$U_{NPS} < (0{,}1 \times U_{nom})$
(Current Change of I_{PPS}) < (set value (Current Change))
Blocking Input "BLK" = "0" (note: for example: if GCB is off then BLK = "1"; additionally there also exists an automatic internal blocking of the function if at the same time the voltages (U1) and currents (I1) equal zero.

Please note:
It does not make a difference for the protective function whether there is a 2- or 3-phase broken wire condition present. As already mentioned above we are using a phase-phase connection of the 3-phase VT. Therefore even in case of only 2-wires broken the relay will not see any input voltage.
The principle of detection of 2- (or 3-) phase wire faults is different from the single wire fault algorithm.

The function supervises the change of the current system. If the voltages drop to zero but the currents don't change then there probably will be a broken wire condition. If the currents should go up (when the voltages drop) then there will probably be some shortcircuit. As a consequence the function will be blocked automatically in this case. Additionally it is recommended to use alarms of other protective functions which are dependent on current measuring to block the MT300.
During standstill of the power plant there will be no voltage and no current. Accordingly there is another automatic blocking applied in case the Positive Sequence Voltage and the Positive Sequence Current are below 10% of their nominal value.

Blocking:

The function is blocked if:

a)
Internal or external blocking signal

b)
At least one of the phase currents exceed 150% of relay nominal current

c)
All phase currents are below the "release" value of 10% relay nominal current
(valid for single phase faults of the VT only)

Set Value "Blocking Delay":

defines how long a (internal or external) blocking of the function is extended.

Set Value "Transformer Supervision":

a)
"No" … the protective function does not initiate the alarm "Device Fault" (1st row/ red LED).
Note: the "trip" output is not affected by this parameter.

b)
"Yes" … the alarm "Device Fault" is activated in case of "Broken Wire" – condition.

18.5.2.2. Function Test

Practical example (using an Omicron CMC256, or similar):

a)
Omicron Settings:
V L1-E ... 57,7 V
V L2-E ... 57,7 V
V L3-E ... 57,7 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

b)
Connect phase-phase voltages and phase currents to the protection relay.
The "Measured Value Window" of the DRS Protective Relay will show:
V L1-L2 ... 100 V
V L2-L2 ... 100 V
V L3-L1 ... 100 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

c)
The "Prot. Function Measured Values Window" of the MT300 Prot. Function will show the internal calculated values:

V inv / V	= 0 p.u.
I inv / I	= 0 p.u.
NPS Voltage	= 0 V
PPS Voltage	= 100 V
NPS Current	= 0 A
PPS Current	= 1 A

d)
The next step is to shortcircuit the L1-winding of the VT. This is done by setting the V L1-E of the Omicron to zero (the wiring is not touched). This is exactly the situation of a shorcircuited VT-winding. The Omicron settings now look like:
V L1-E ... 0 V
V L2-E ... 57,7 V
V L3-E ... 57,7 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

e)
The "Measured Value Window" of the DRS Protective Relay will show:
V L1-L2 ... 57,5 V
V L2-L2 ... 100 V
V L3-L1 ... 57,5 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

f)
The "Prot. Function Measured Values Window" of the MT300 Prot. Function will show the internal calculated values:

V inv / V	= 0,5 p.u.
I inv / I	= 0 p.u.

NPS Voltage	= 33,3 V
PPS Voltage	= 66,6 V
NPS Current	= 0 A
PPS Current	= 1 A

g)
The next feature to be tested will be the VT Broken Conductor Detection.
We adjust the following Omicron settings (standard values):
V L1-E ... 57,7 V
V L2-E ... 57,7 V
V L3-E ... 57,7 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

h)
Now the wire of phase L1 going to the protection relay is interrupted ("broken conductor").
The "Measured Value Window" of the DRS Protective Relay will show:
V L1-L2 ... 50 V
V L2-L2 ... 100 V
V L3-L1 ... 50 V
I L1 ... 1 A
I L2 ... 1 A
I L3 ... 1 A

i)
The "Prot. Function Measured Values Window" of the MT300 Prot. Function will show the internal calculated values:

V inv / V	= 1 p.u.
I inv / I	= 0 p.u.
NPS Voltage	= 50 V
PPS Voltage	= 50 V
NPS Current	= 0 A
PPS Current	= 1 A

j)
Now we check the correct calculation of the NPS current:
We adjust the following Omicron settings:
V L1-E ... 57,7 V
V L2-E ... 57,7 V
V L3-E ... 57,7 V
I L1 ... 0 A
I L2 ... 1 A
I L3 ... 1 A

k)
The "Measured Value Window" of the DRS Protective Relay will show:
V L1-L2 ... 100 V
V L2-L2 ... 100 V
V L3-L1 ... 100 V
I L1 ... 0 A
I L2 ... 1 A
I L3 ... 1 A

l)
The "Prot. Function Measured Values Window" of the MT300 Prot. Function will show the internal calculated values:

V inv / V	= 0 p.u.

I inv / I	= 0,5 p.u.
NPS Voltage	= 0 V
PPS Voltage	= 100 V
NPS Current	= 0,33 A
PPS Current	= 0,66 A

Discussion of SETTINGS for the above specified MT300 tests:

a)
Setting: V2/V1 < 1 p.u. … Broken Conductor will be detected (see above/ example (g)).

b)
Setting: V2/V1 < 0,5 p.u. … Shortcircuit of VT winding will be detected (see above/ example (d));
Broken Conductor will be detected (see above/ example (g)).

18.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix is to be configured according to the external connections.

The parameters for the operating value and time delay have to be set to the designed values.
For the "VT Test 3 Phase, Δ" function also the corresponding phase rotation has to be configured.

Function tests are preferably performed with the primary plant out of service.

Single phase inject 1.1 times the voltage operating value into the system. By correct function response after the set time delay following annunciations occur.

Fault alarm category 1
Fault indication, i.e. red "Fault" LED flashing

With protective functions MT315 and MT317 additionally also the configured LED’s and outputs are activated.

From the User program via the menu options "System" ⇒"DRS Fault Status" read out the entry "☒ CT/VT Fault".
Switch off the injected test voltage and reset the fault alarm operating the blue reset key until the yellow and red LED row indication is altering alternatively.

Primary Commissioning Tests:

During the primary tests the correct function operation of the protective scheme during normal system conditions. For checking the VT supervisions it is recommended to carry out open circuit off-load tests in order to prevent any other protective functions from operating when temporary opening a VT circuit to verify the supervision function.

To perform the tests please proceed as follows:

Start up generator to rated speed and excite to nominal voltage.
Block any protective function trips which may occur when opening a VT circuit.
When off-load open one phase of the VT set being supervised at the cubicle terminals until the system fault indication appears.
From the User program via the menu options "System" ⇒"DRS Fault Status" read out the entry "☒ CT/VT Fault".
Restore the VT connection and reset the fault alarm.
After completion of the tests disable blocking of any protective function trip outputs and perform shut-down the generator.

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19. MT... CT SUPERVISION

19.1. OVERVIEW

List of the Available MT . . . – CT Supervision Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MT . . .	FNNR	TYPE	ANSI	Application
CT Broken Conductor 2-phase. Broken conductor supervision for 2-phase CT circuits to detect single phase interruption with indication of the faulty phase. "Broken Conductor": One of the phase currents is above the "Current Interlock"-set value and the other one is below 2,5% of nominal current.	1141	MT210	-	C2,M
CT supervision 2 phase. Current sum evaluation. Note: No outputs to trip matrix. Only common fault alarm.	1102	MT211	-	C2,M,L
CT Broken Connector 3-phase. Broken conductor supervision for 3-phase CT circuits to detect single and two phase interruptions with indication of the faulty phases. "Broken Conductor": At least one of the phase currents is above the "Current Interlock"-set value and one or two of the phase currents are below 2,5% of nominal current.	1140	MT310	-	C2,M
CT supervision 3 phase, Y-connection. Note: No outputs to trip matrix. Only common fault alarm.	1100	MT311	-	C2,M,L
CT supervision 3 phase, D-connection. NPS current evaluation. Caution: But phase currents are applied! This system is to be used when only 2 phase currents are measured directly and the 3rd one is determined by external wiring connection whereby the current sum will always amount to zero	1105	MT314	-	C2,M

Current sum evaluation 3 phase. Computation of the current sum similar to CT supervision 3 phase, Y-connection however with outputs like a normal protective function	1106	MT316	-	C2,M,L
Inverse time CT supervision 3 phase. NPS current evaluation similar to CT supervision 3 phase, D-connection (MT314), however with outputs like a normal protective function. Note: Input matrix should be configured: Phase L1-L2 Phase L2-L3 Phase L3-L1 Caution: But phase currents are applied!	1109	MT318	-	C2,M
Inverse time CT supervision 3 phase. NPS current evaluation similar to CT supervision 3 phase, D-connection (MT314), however with outputs like a normal protective function. Note: Input matrix should be configured: Phase L1-L2 Phase L2-L3 Phase L3-L1 Caution: But phase currents are applied! Function to be used with device: Standard LIGHT.	2105	MT31C	-	L

19.2. TECHNICAL DATA

19.2.1. CT Supervision 2 Phase

PROTECTIVE FUNCTION: MT211	FNNR	TYPE	ANSI	Application
CT supervision 2 phase Current sum evaluation Note: No outputs to trip matrix Only common fault alarm	1102	MT211	-	C2,M,L

CT supervision of a 2 pole CT set for symmetry (current sum evaluation).

<u>MT211</u>
<u>Technical Data</u>

Inputs

Analogue:	Current phase L1
	Current phase L3

Outputs

Red fault LED, 1st row :	“DRS Fault“ Note: CT fault

Setting parameters

Operating value:	0.10 ... 0.50 xIn in 0.01 xIn steps
Operating time:	1 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Current sum (2 x Io):	In A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

19.2.2. CT Supervision 3 Phase, Y - Connection

PROTECTIVE FUNCTION: MT311	FNNR	TYPE	ANSI	Application
CT supervision 3 phase, Y-connection Note: No outputs to trip matrix Only common fault alarm	1100	MT311	-	C2,M,L

CT supervision of a 3 pole CT set for symmetry, current sum evaluation, Y - connection.
Computation of the current sum (3 x zero sequence current).

MT311
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3

Outputs

Red fault LED, 1st row :	“DRS Fault“ Note: CT fault

Setting parameters

Operating value:	0.10 ... 0.50 xIn in 0.01 xIn steps
Operating time:	1 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Current sum (3 x Io):	In A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

19.2.3. Current Sum Evaluation 3 Phase, Y – Connection with Optional CT Supervision

PROTECTIVE FUNCTION: MT316	FNNR	TYPE	ANSI	Application
Current sum evaluation 3 phase Computation of the current sum similar to CT supervision 3 phase, Y-connection however with outputs like a normal protective function	1106	MT316	-	C2,M,L

Current sum evaluation of a 3 pole CT set for symmetry (3 x zero sequence current),
Y – connection with optional CT supervision (“Fault LED Indication”).

MT314
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
Binary:	Blocking input
	Test input

Outputs

Binary:	Alarm
	Trip
Red fault LED, 1st row :	“DRS Fault“ (optional / see setting parameters "Fault Evaluation"). Note: CT fault.

Setting parameters

Operating value:	0.1 ... 5 xIn in 0.01 xIn steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Fault evaluation:	Yes / No

Window Display for Relay Internal
Determined and Computed Values

Current sum (3 x Io): Note: Current sum of phase currents	In A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

19.2.4. CT Supervision 3 Phase, D - Connection

PROTECTIVE FUNCTION: MT314	FNNR	TYPE	ANSI	Application
CT supervision 3 phase, D-connection NPS current evaluation Caution: But phase currents are applied! This system is to be used when only 2 phase currents are measured directly and the 3rd one is determined by external wiring connection whereby the current sum will always amount to zero	1105	MT314	-	C2,M,L

CT supervision of a 3 pole CT set for symmetry, D - connection.
Computation of the NPS current system.

<u>MT314</u>
<u>Technical Data</u>

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3 Note: This phase current is not directly measured but obtained by a suitable external connection method (L3 = -L1-L2)

Outputs

Red fault LED, 1st row :	“DRS Fault“ Note: CT fault

Setting parameters

Operating value:	0.10 ... 0.50 xIn in 0.01 xIn steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Phase rotation:	Right / Left

Window Display for Relay Internal Determined and Computed Values

NPS current system:	In A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

19.2.5. Inverse Time CT Supervision 3 Phase, D – Connection with Optional LED Fault Indication

PROTECTIVE FUNCTION: MT318	FNNR	TYPE	ANSI	Application
Inverse time CT supervision 3 phase NPS current evaluation similar to CT supervision 3 phase, D-connection however with outputs like a normal protective function Note: Input matrix should be configured: Phase L1-L2 Phase L2-L3 Phase L3-L1 Caution: But phase currents may be applied too in special utilization: This function to be used if there are measured just 2 of 3 phases, while the 3rd phase is hardware-calculated by proper wiring. As a consequence the current sum always equals zero.	1109	MT318	-	C2,M,L

Inverse time current evaluation of a 3 pole CT set for symmetry, D - connection.
Also to be used for phase currents if there are only measured 2 phase currents in a 3 – phase system (explanation: see above!).
Computation of the NPS current system and optional LED fault indication.

MT318
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3 Note: This phase current is not directly measured but obtained by a suitable external connection method (L3 = -L1-L2)

Outputs

Binary:	Alarm
	Trip
Red fault LED, 1st row :	“DRS Fault“ (optional / see setting parameters "Fault Evaluation") Note: CT fault

Setting parameters

Operating value:	0.10 ... 0.50 xIn in 0.01 xIn steps
Operating time:	1 ... 30 seconds in 0.05 sec steps
Fault evaluation:	Yes / No
Phase rotation:	Right / Left

Window Display for Relay Internal Determined and Computed Values

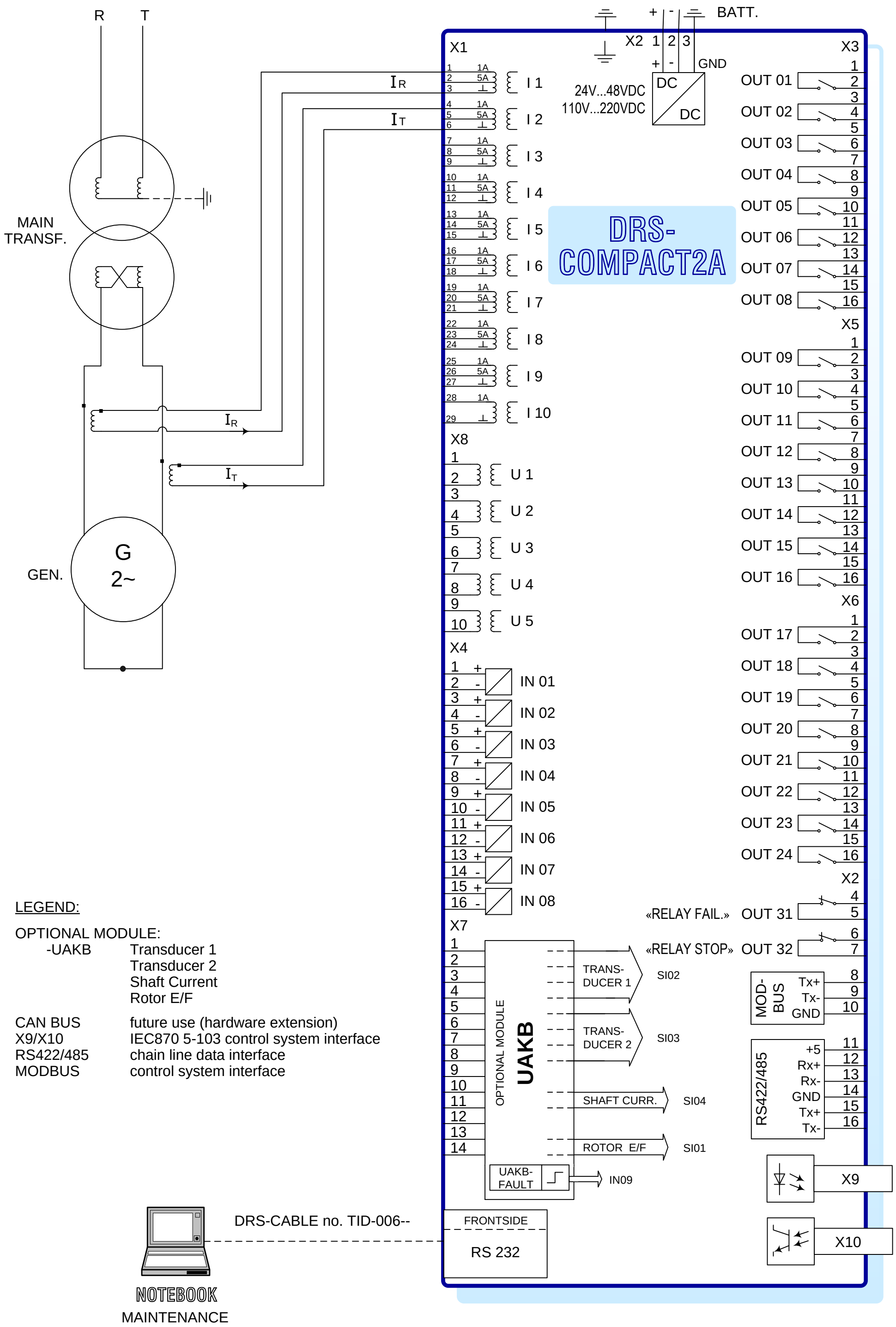
NPS current system: Note: The NPS current system of the phase currents when the 3rd phase is evaluated by external connection, respectively the NPS system of the phase current inputs	In A

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% I_n

19.3. CONNECTION DIAGRAMS

19.3.1. MT211



MT211 C.T. MONITORING 2.PH. WIRING DIAGRAM

Fig. 259 MT211 C.T. Monitoring 2.PH. Wiring Diagram

19.3.2. MT311/ MT316

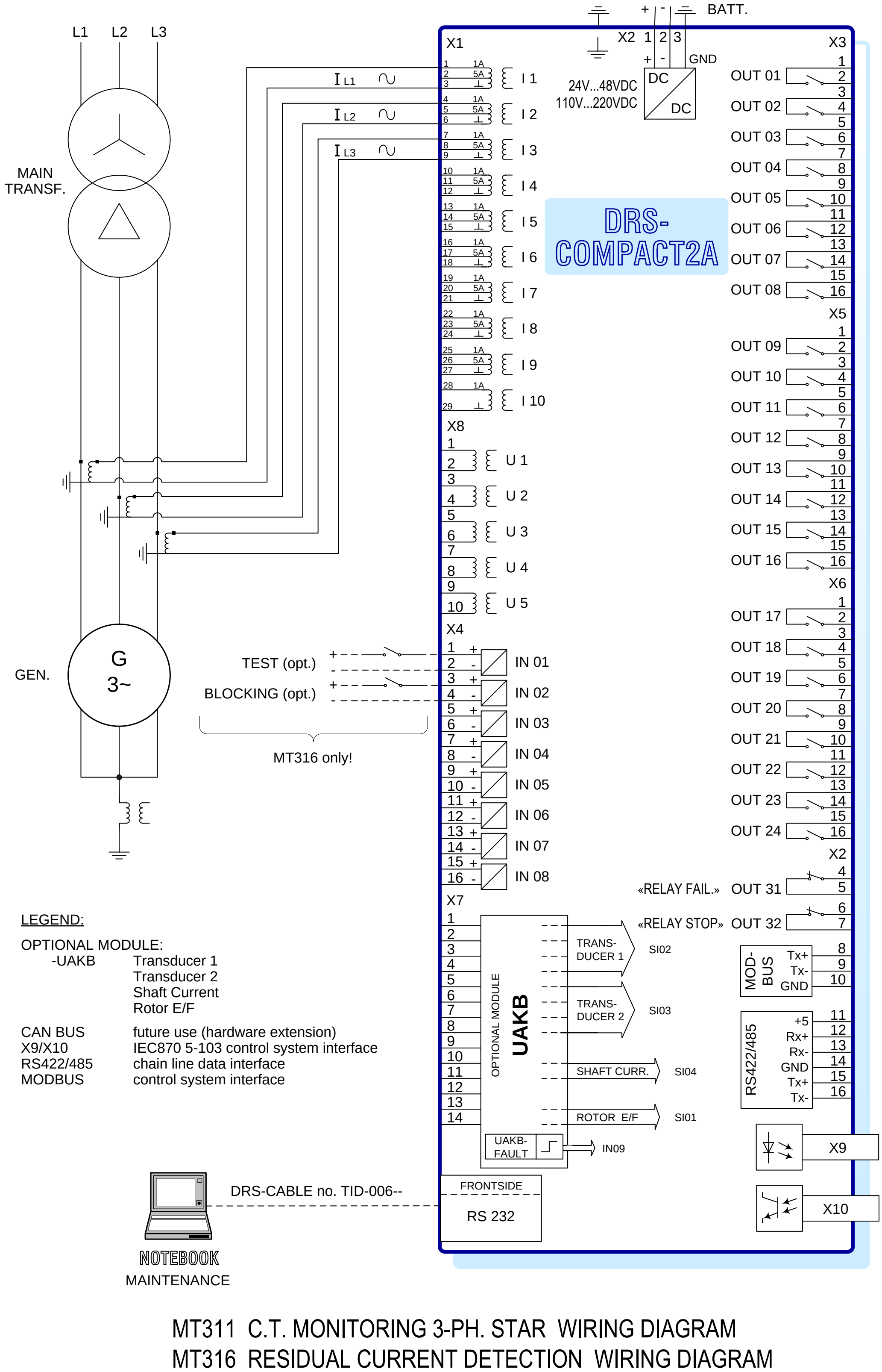


Fig. 260 MT311 C.T. Monitoring 3-PH. Star Wiring Diagram MT316 Residual Current Detection Wiring Diagram

19.3.3. MT314/ MT318

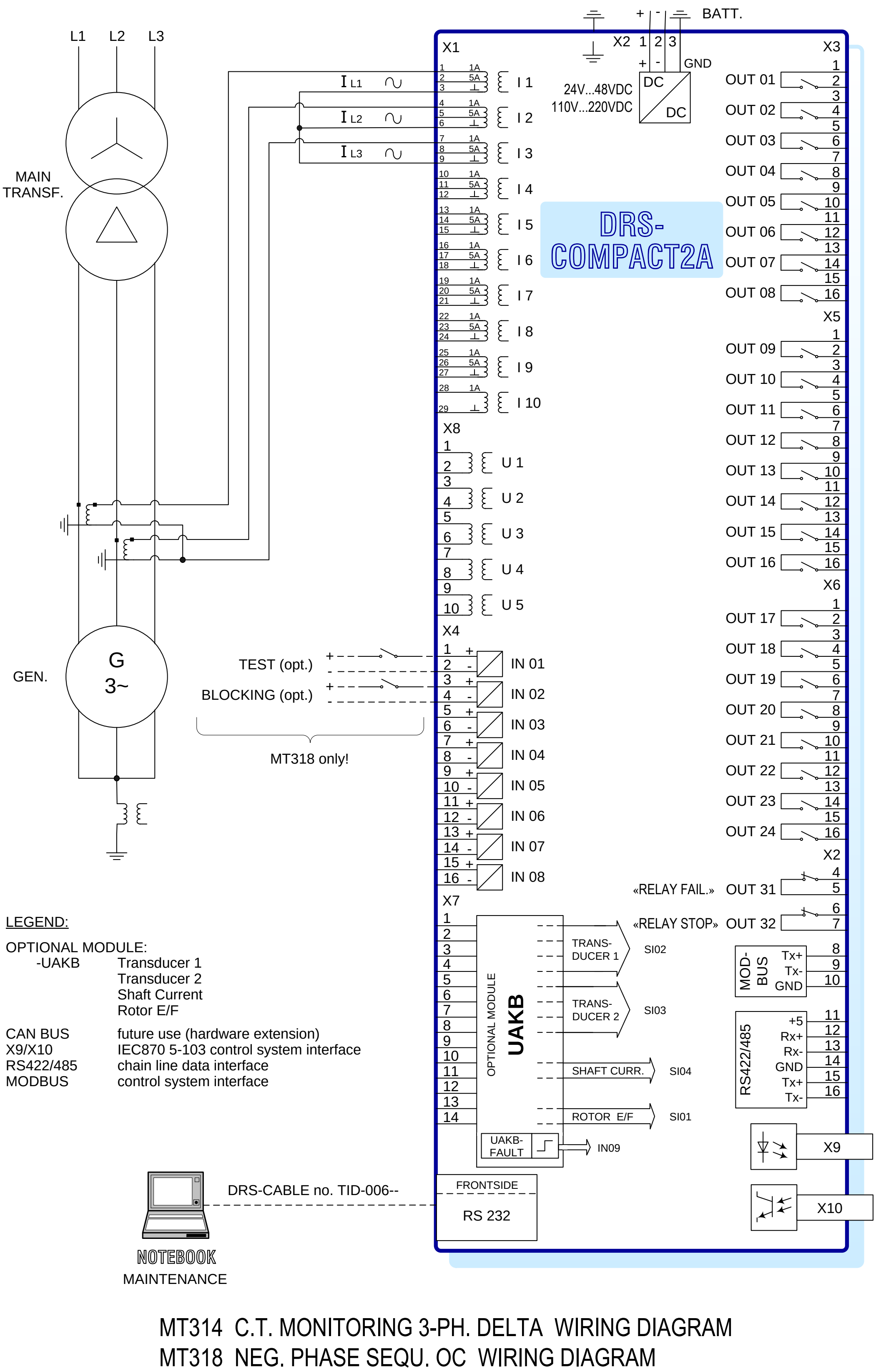


Fig. 261 MT314 C.T. Monitoring 3-PH. Delta Wiring Diagram MT318 Neg. Phase Sequ. OC Wiring Diagram

19.4. LOGIC DIAGRAMS

19.4.1. MT211

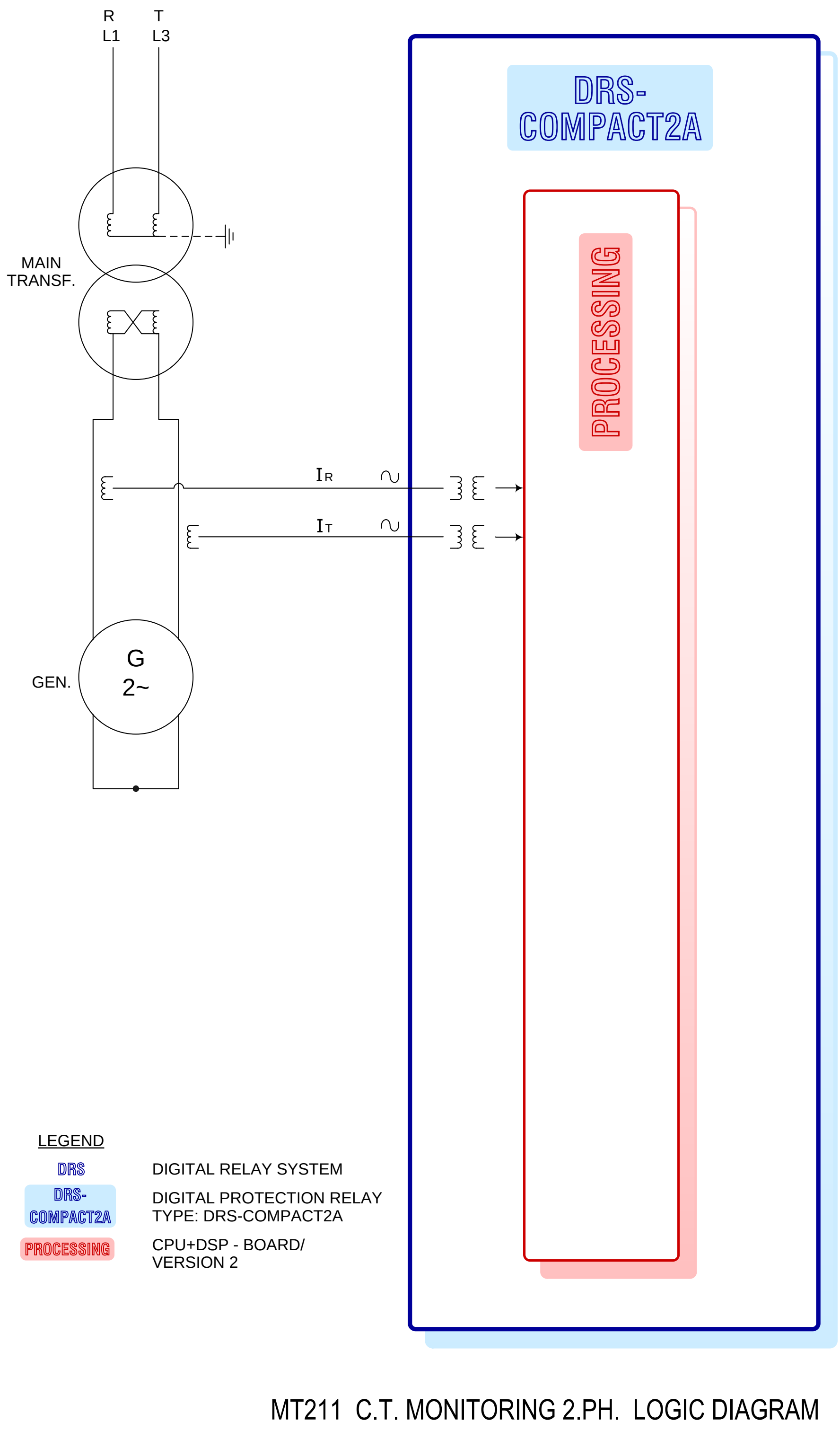
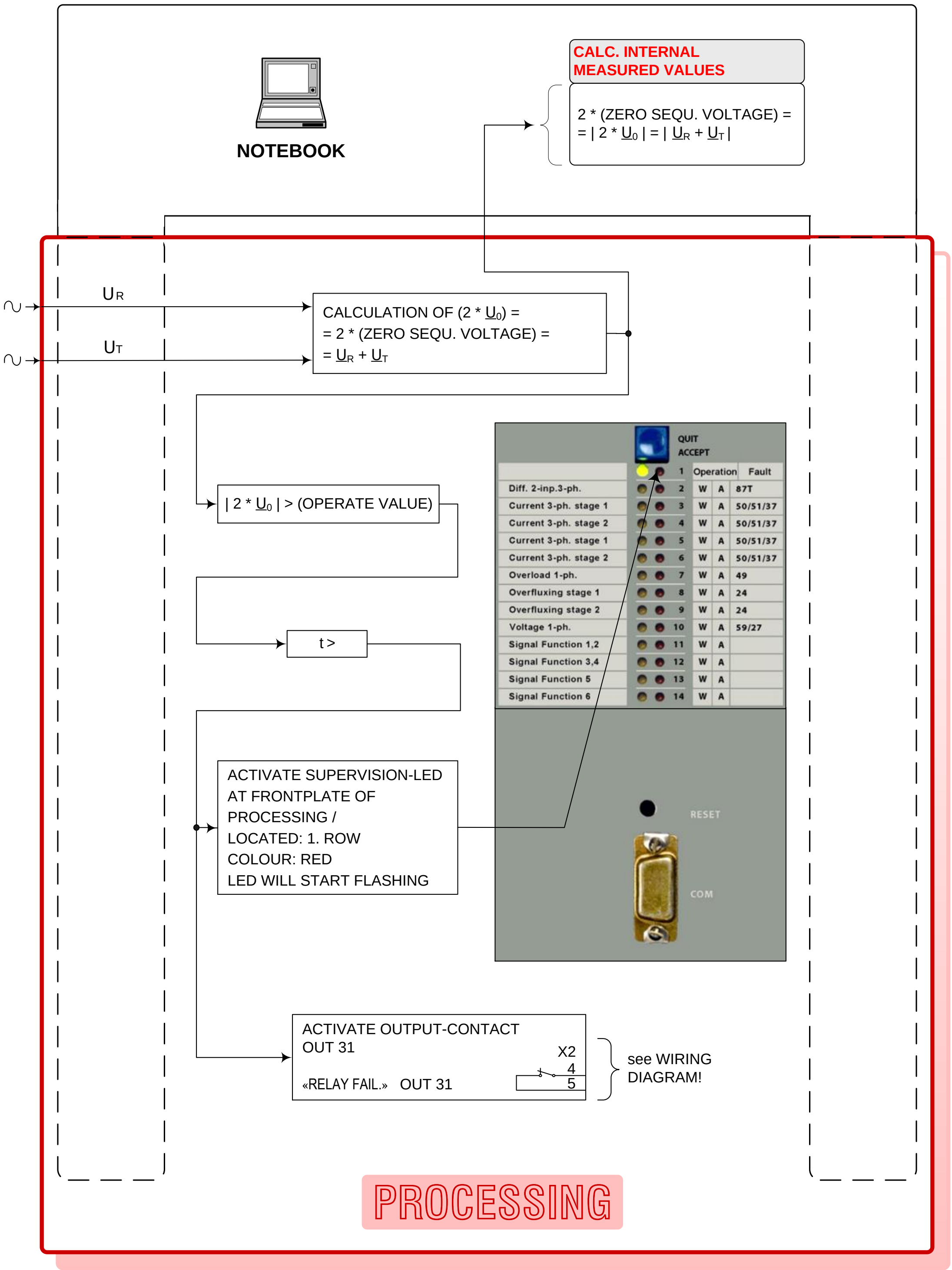


Fig. 262 MT211 C.T. Monitoring 2.PH. Logic Diagram

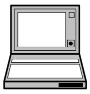


MT212 V.T. MONITORING 2.PH. LOGIC DIAGRAM PROCESSING

Fig. 263 MT212 V.T. Monitoring 2.PH. Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MT211



Online simulation
via notebook

CALCULATION OF (2 * $\underline{I}_0$) =
= | 2 * (ZERO SEQU. CURRENT) | =
= | $\underline{I}_R + \underline{I}_T$ |

Geometric sum of the current phasors:

$\underline{I}_R + \underline{I}_T = 2 * \underline{I}_0$.

ACTIVATE SUPERVISION-LED
AT FRONTPLATE OF PROCESSING/
LOCATED: 1. ROW
COLOUR: RED
LED WILL START FLASHING

The red LED in the first row at the frontplate of the PROCESSING-module will start to flash in case of C.T.-fault.

ACTIVATE OUTPUT-CONTACT
OUT 31 X2
4
«RELAY FAIL.» OUT 31 5

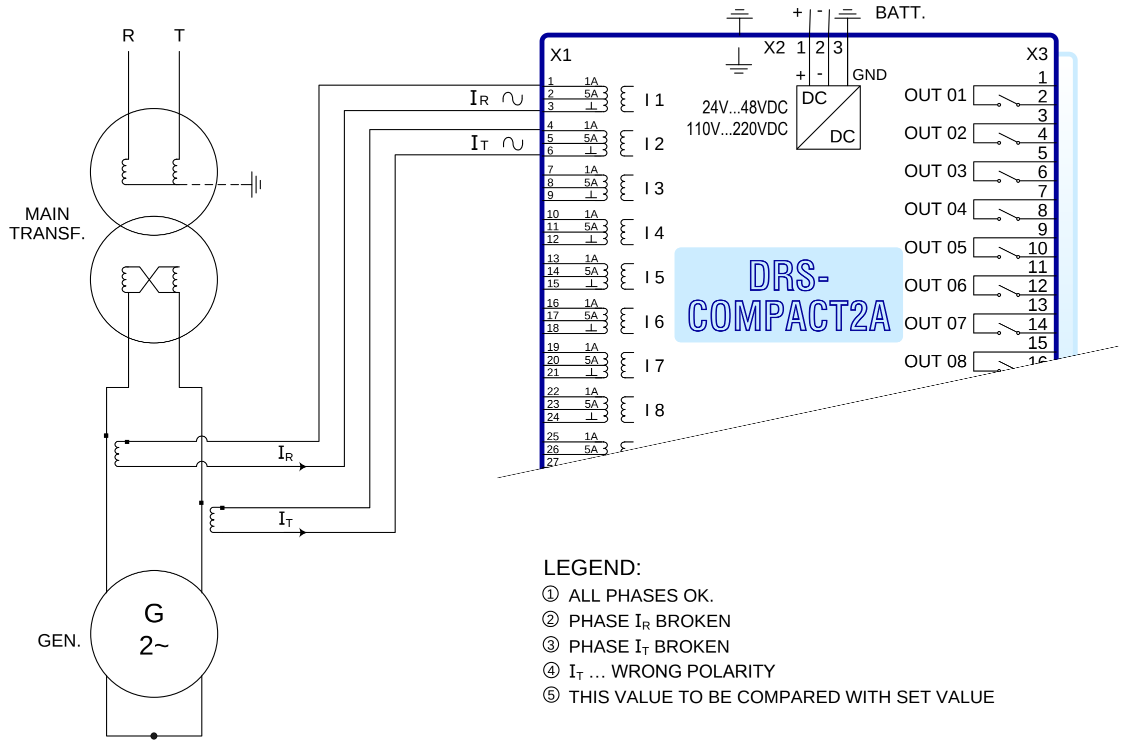
OUT31: «RELAY FAIL.».

NOTE: This «RELAY FAIL.» -signal is the sum of many possible single signals. In case of „C.T.-fault“ it is not a fault of the PROTECTION RELAY itself, usually the fault will be outside of the DRS COMPACT. Please connect the notebook to find out what alone is the exact reason for the alarm „RELAY FAIL“!

>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MT211 C.T. MONITORING 2.PH. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 264 MT211 C.T. Monitoring 2.PH. Logic Diagram Processing / Legend



	PHASE	CURRENTS			
	measured: I_R	measured: I_T	PHASOR DIAGRAM	I_0 = (I_R + I_T) / 2	NOTEBOOK ⑤ DISPLAY: |2 * I_0| = |ZERO SEQU.CURR.|
① EXAMPLE no. 1	1A	1A	I_R ↑ ↓ I_T	0A	0A
② EXAMPLE no. 2	0A	1A	I_R = 0, I_T ↓	0,5A	1A
④ EXAMPLE no. 3	1A	0A	I_R ↑, I_T = 0	0,5A	1A
⑤ EXAMPLE no. 4	1A	1A	I_R ↑↑ I_T	1A	2A

MT211 C.T. MONITORING 2.PH. EXAMPLE

Fig. 265 MT211 C.T. Monitoring 2.PH. Example

19.4.2. MT311/ MT316

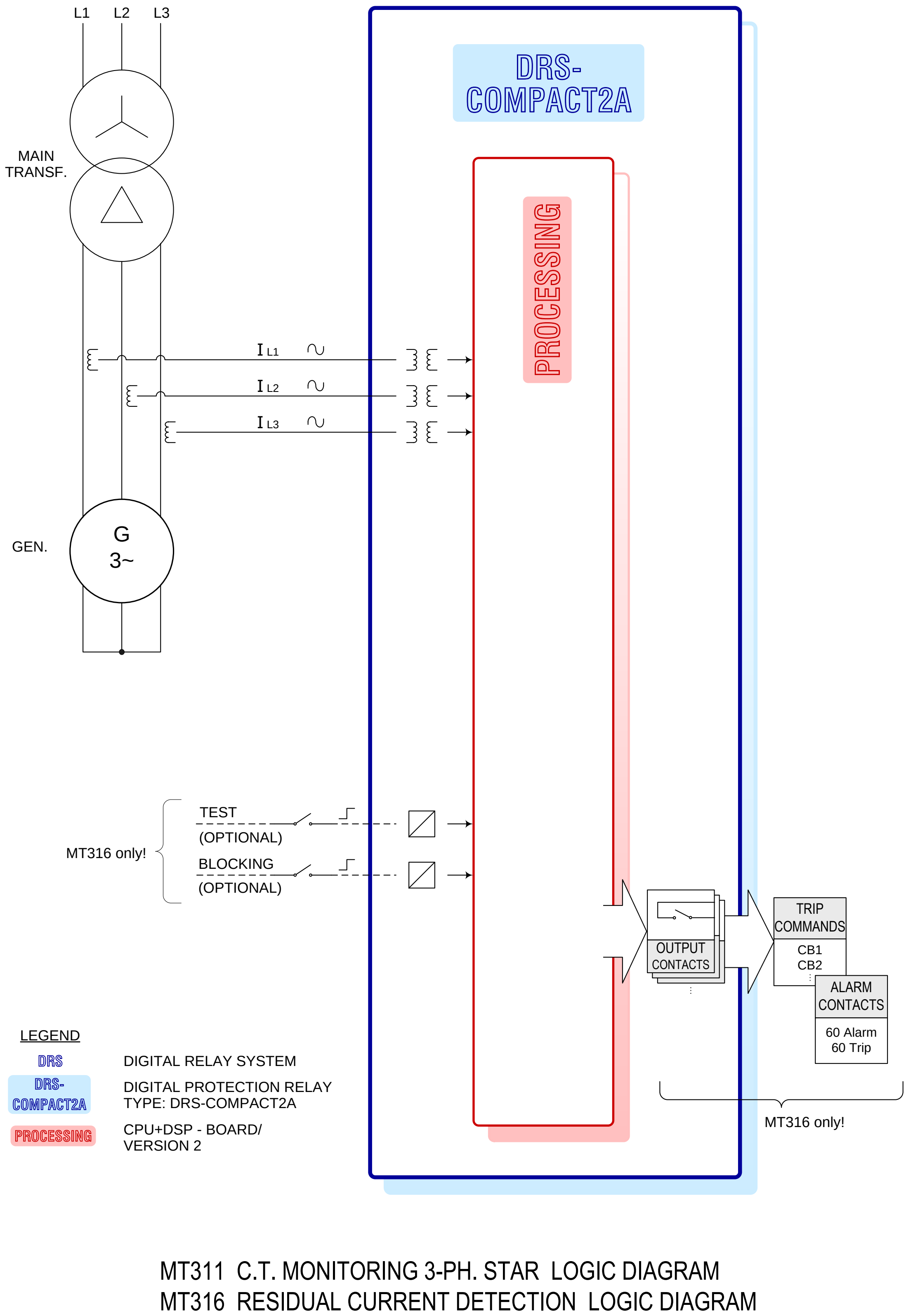
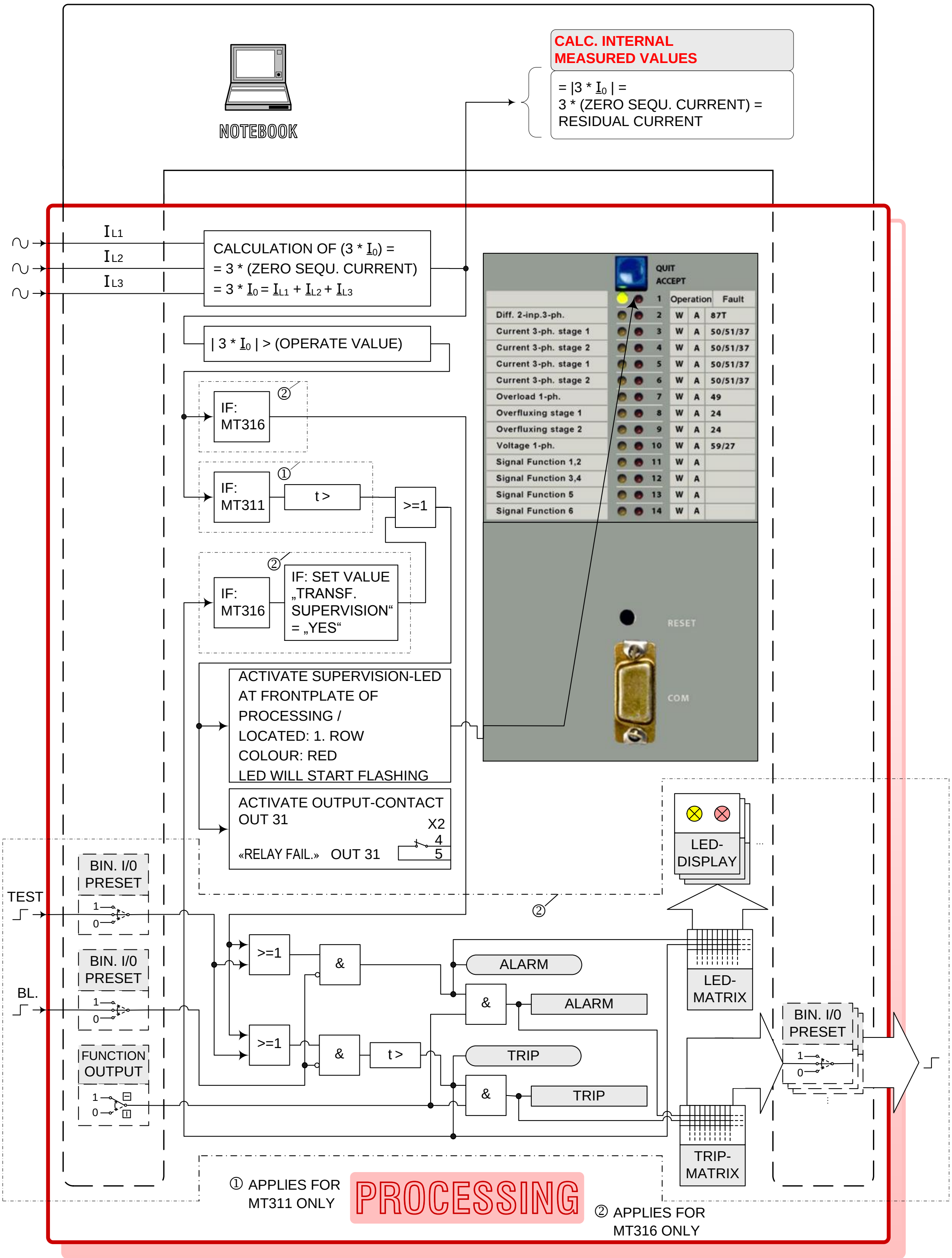


Fig. 266 MT311 C.T. Monitoring 3-PH.Star Logic Diagram MT316 Residual Current Detection Logic Diagram



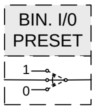
MT311 C.T. MONITORING 3-PH. STAR LOGIC DIAGRAM PROCESSING
MT316 RESIDUAL CURRENT DETECTION LOGIC DIAGRAM PROCESSING

Fig. 267 MT311 C.T. Monitoring 3-PH. Star Logic Diagram Processing MT316 Residual Current Detection Logic Diagram Processing

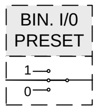
LEGEND PROCESSING

FIRMWARE-MODULE: MT311, MT316

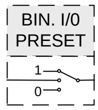
Online simulation via notebook | CALC. INTERNAL MEASURED VALUES ..... | Online-indication of DRS-internal calculated values on notebook-screen



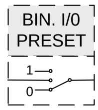
Online-simulation of DIG. IN-/OUTPUTS via notebook:



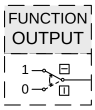
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MT311, MT316

- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎕ all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION OF (3 * $\underline{I}_0$) =
= 3 * (ZERO SEQU. CURRENT)
= 3 * $\underline{I}_0 = \underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}$

Geometric current sum of all 3 phase-current phasors.

Note: $\underline{I}_0 = (\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}) / 3$

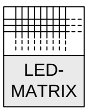
$3 * \underline{I}_0 = (\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}\ (= \underline{I}_{neutral})$

IF: MT311

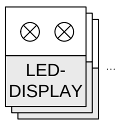
MT311: a) supervision LED at frontplate of PROCESSING (1. ROW / red LED) will flash
b) «RELAY FAIL.» OUTPUT-contact OUT1
c) no TRIP-MATRIX, no LED-MATRIX

IF: MT316

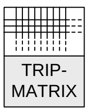
MT316: a) this function acts like a standard DRS-protective function: LED-MATRIX, TRIP-MATRIX, TEST-INPUT, BLOCKING-INPUT, FUNCTION OUTPUT.
b) trigger conditions: same as MT311
c) OPTIONALLY (see set value „TRANSF. SUPERVISION“): supervision LED (same as MT311)
«RELAY FAIL.» OUT31 (same as MT311)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING-board (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

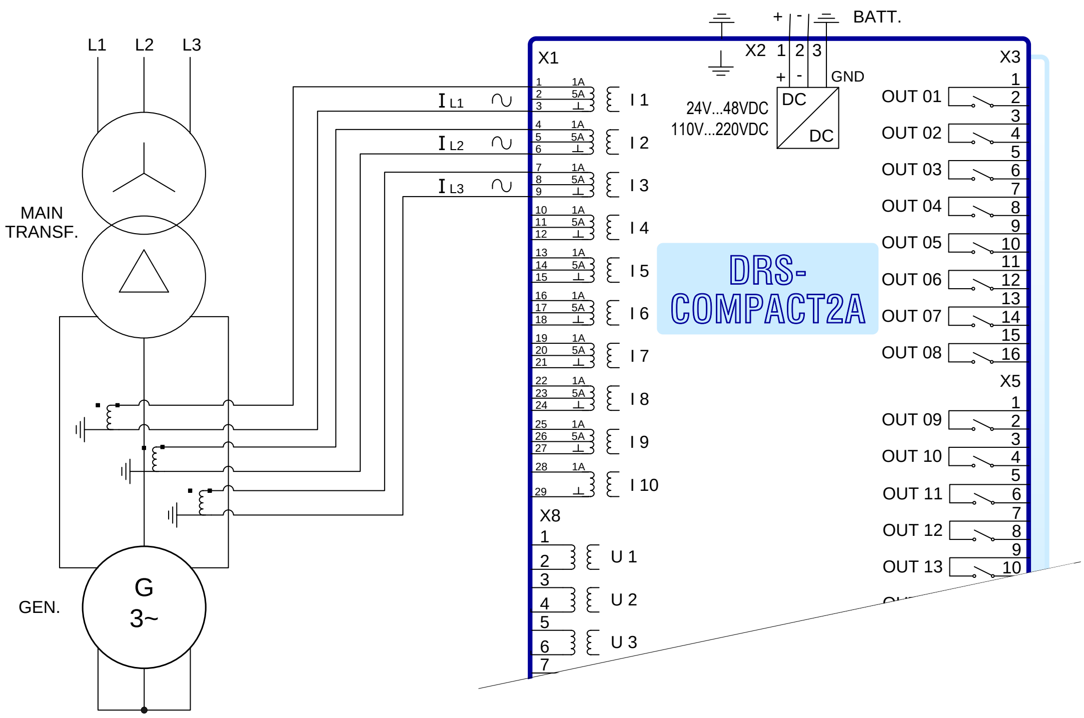
TRIP — FUNCTION OUTPUT: Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MT311 C.T. MONITORING 3-PH. STAR LOGIC DIAGRAM PROCESSING / LEGEND
MT316 RESIDUAL CURRENT DETECTION LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 268 MT311 C.T. Monitoring 3-PH. Star Logic Diagram Processing / Legend MT316 Residual Current Detection Logic Diagram Processing / Legend



	PHASE	CURRENTS				
	I_{L1}	I_{L2}	I_{L3}	PHASOR DIAGRAM	$\|\underline{I}_0\| = (\underline{I}_{L1} + \underline{I}_{L2} + \underline{I}_{L3}) / 3$	NOTEB. DISPLAY: $\|3 * \underline{I}_0\| = 3 *$ |ZERO. SEQU.CURR.|
① EXAMPLE no. 1	1A	1A	1A	I_{L1}, I_{L3}, I_{L2}	0A	0A
② EXAMPLE no. 2	0A	1A	1A	$I_{L1} = 0$, I_{L3}, I_{L2}	0,33A	1A
③ EXAMPLE no. 3	0A	0A	1A	$I_{L1} = I_{L2} = 0$, I_{L3}	0,33A	1A
④ EXAMPLE no. 4	1A	1A	1A	I_{L1}, I_{L2}, I_{L3}	0A	0A

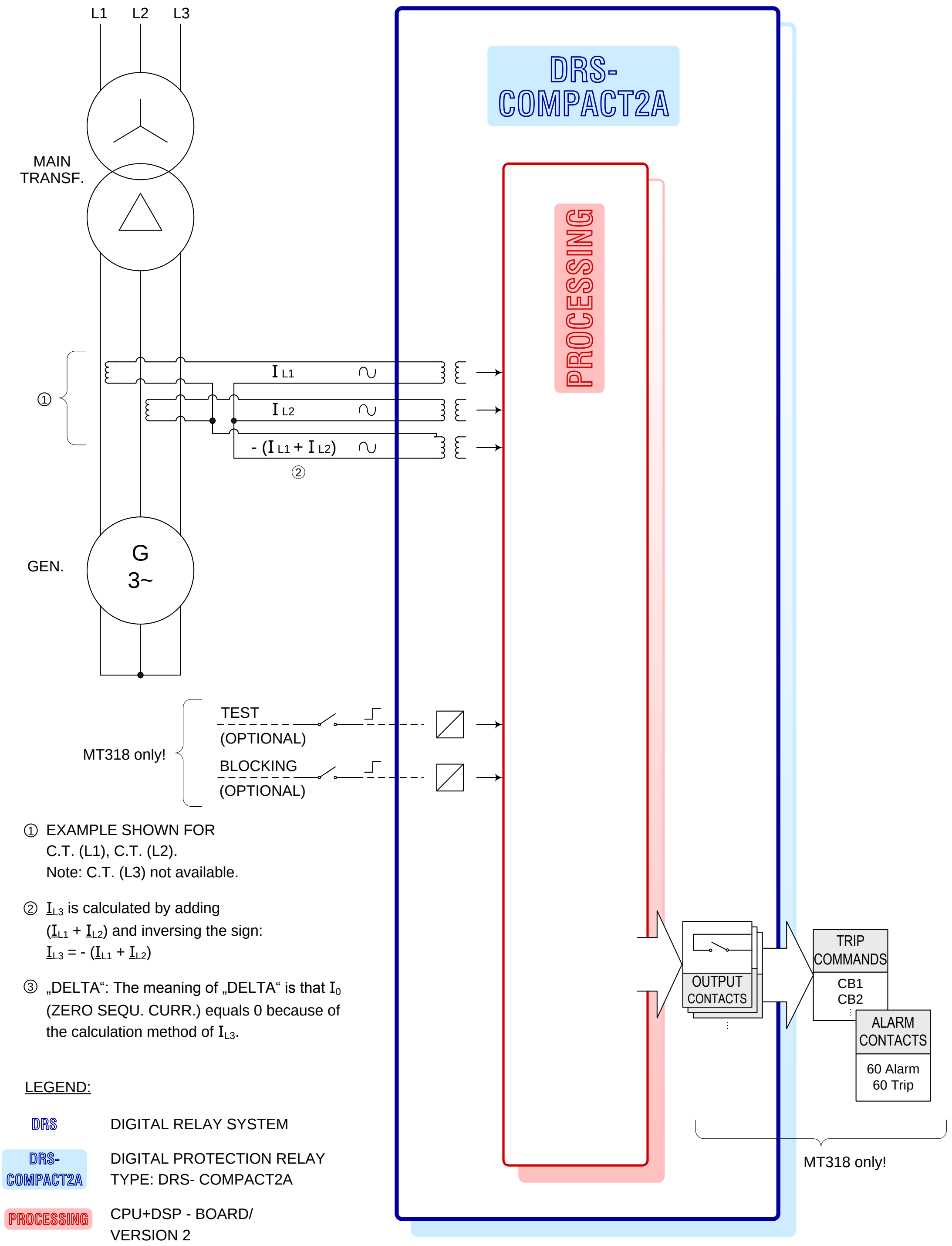
LEGEND:

① ALL PHASES OK.
② PHASE I_{L1} BROKEN
③ PHASES I_{L1}, I_{L2} BROKEN
④ WRONG SEQU. OF CURRENT PHASES (NOT DETECTED BY $\underline{I}_0$-METHOD)

MT311 C.T. MONITORING 3-PH. STAR
MT316 RESIDUAL CURRENT DETECTION } EXAMPLE

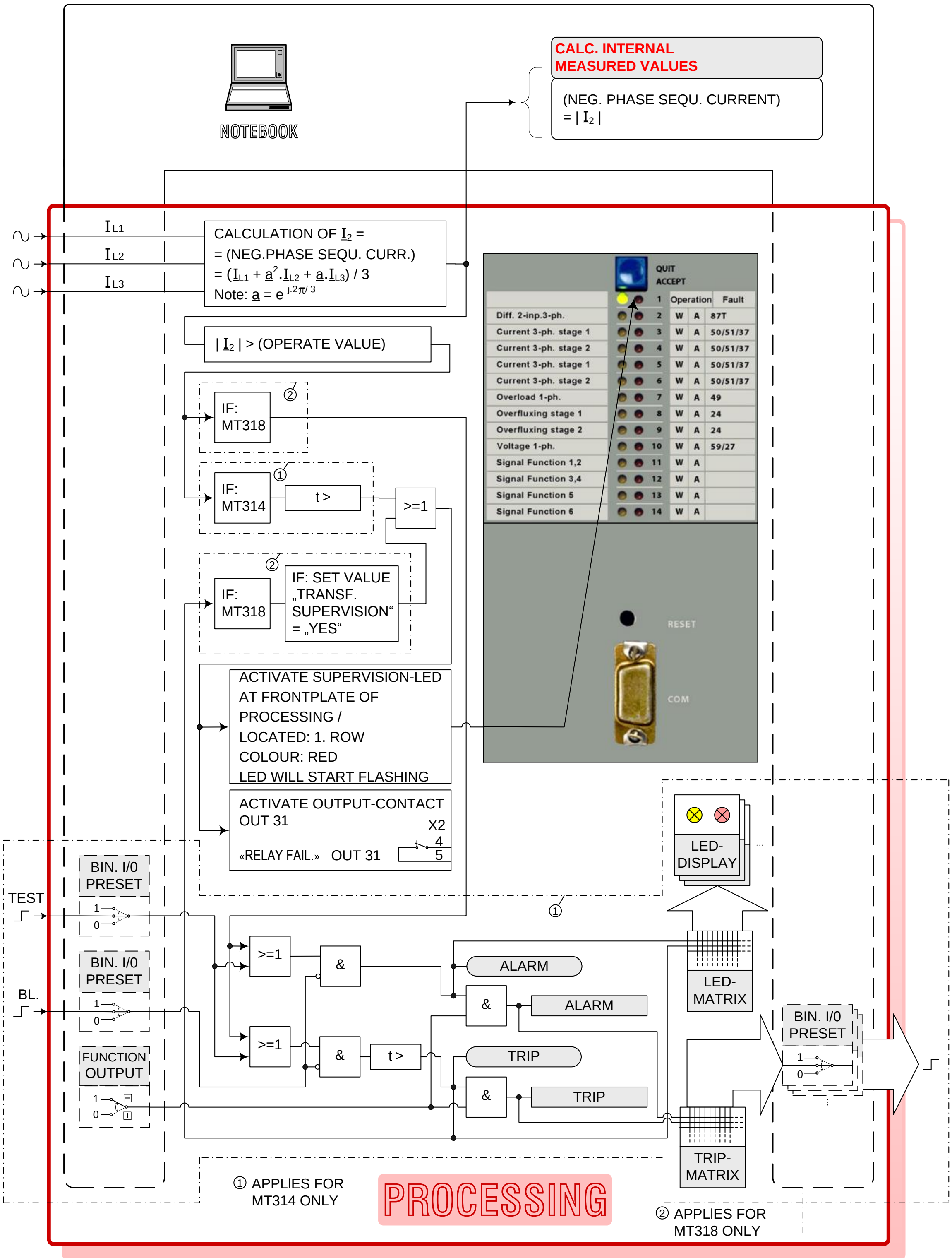
Fig. 269 MT311 C.T. Monitoring 3-PH. Star MT316 Residual Current Detection } Example

19.4.3. MT314/ MT318



MT314 C.T. MONITORING 3-PH. DELTA LOGIC DIAGRAM
MT318 NEG. PHASE SEQU. OC LOGIC DIAGRAM

Fig. 270 MT314 C.T. Monitoring 3-PH. Delta Logic Diagram MT318 Neg. Phase Sequ. OC Logic Diagram

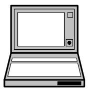


MT314 C.T. MONITORING 3-PH. DELTA LOGIC DIAGRAM PROCESSING
MT318 NEG. PHASE SEQU. OC LOGIC DIAGRAM PROCESSING

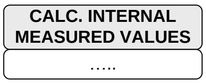
Fig. 271 MT314 C.T. Monitoring 3-PH. Delta Logic Diagram Processing MT318 Neg. Phase Sequ. OC Logic Diagram Processing

LEGEND PROCESSING

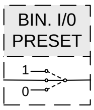
FIRMWARE-MODULE: MT314, MT318



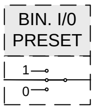
Online simulation via notebook



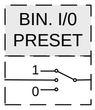
Online-indication of DRS-internal calculated values on notebook-screen



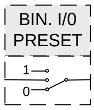
Online-simulation of DIG. IN-/OUTPUTS via notebook:



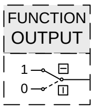
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MT314, MT318

- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

CALCULATION OF $\underline{I}_2$ = = (NEG.PHASE SEQU. CURR.) = $(\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3}) / 3$ Note: $\underline{a} = e^{\,j.2\pi/3}$

Geometric sum of the phasors:

$(\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3}) / 3 = \underline{I}_2$

Note: $\underline{a} = e^{\,j.2\pi/3}$

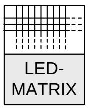
Explanation: The I_0-current (zero sequence current) must not be used for detection of c.t.-fault because the (originally) missing phase current is calculated by using the formula: $I_0 = 0$.

IF: MT314

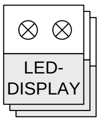
MT314: a) supervision LED at frontplate of PROCESSING (1. ROW / red LED) will flash
b) «RELAY FAIL.» OUTPUT-contact OUT1
c) no TRIP-MATRIX, no LED-MATRIX

IF: MT318

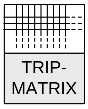
MT318: a) this function acts like a standard DRS-protective function:
LED-MATRIX, TRIP-MATRIX, TEST-INPUT, BLOCKING-INPUT, FUNCTION OUTPUT.
b) trigger conditions: same as MT314
c) OPTIONALLY (see set value „TRANSF. SUPERVISION“):
supervision LED (same as MT314)
«RELAY FAIL.» OUT31 (same as MT314)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING-board (row 2...14)

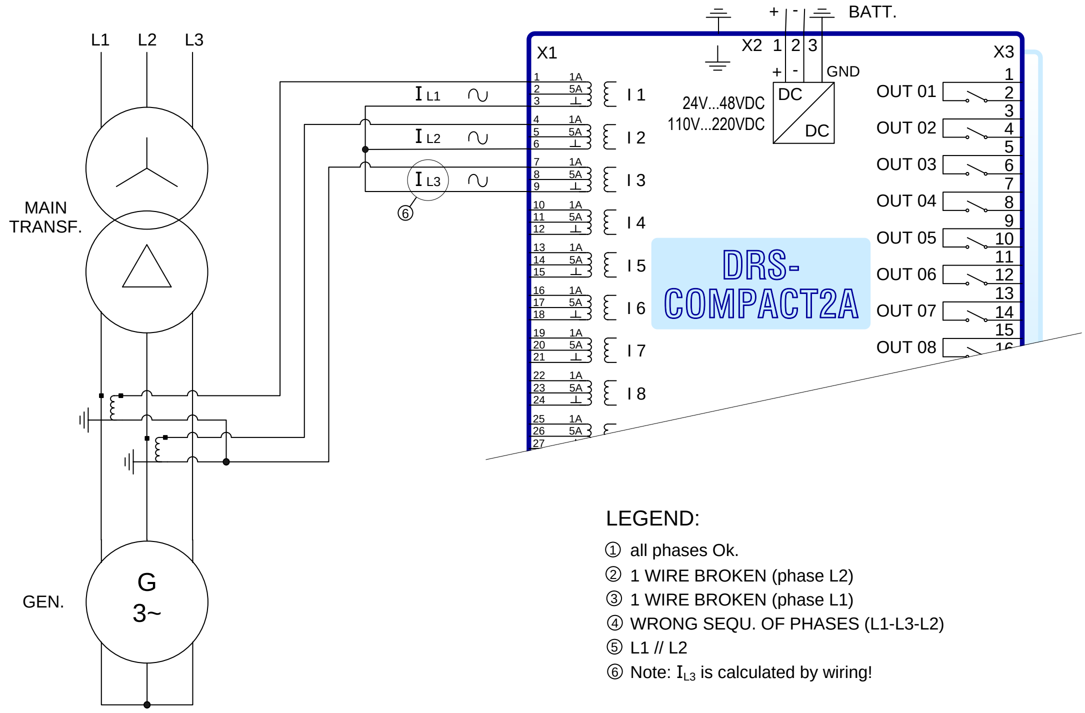


Programmable software-matrix for the output-contacts (OUT1...OUT30)

Symbol	Meaning
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM	FUNCTION OUTPUT: Alarm
TRIP	FUNCTION OUTPUT: Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MT314 C.T. MONITORING 3-PH. DELTA LOGIC DIAGRAM PROCESSING / LEGEND
MT318 NEG. PHASE SEQU. OC LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 272 MT314 C.T. Monitoring 3-PH. Delta Logic Diagram Processing / Legend MT318 Neg. Phase Sequ. OC Logic Diagram Processing / Legend



	PHASE CURRENTS					
	measured: I_{L1}	measured: I_{L2}	calculated by wiring: ⑥ $I_{L3} = -(I_{L1} + I_{L2})$	PHASOR DIAGRAM ⑥	$\lvert \underline{I}_2 \rvert = (\underline{I}_{L1} + \underline{a}^2 . \underline{I}_{L2} + \underline{a} . \underline{I}_{L3}) / 3$	NOTEBOOK DISPLAY: $\lvert \underline{I}_2 \rvert$ = |NEG.PH. SEQU.CURR.|
① EXAMPLE no. 1	1A	1A	1A	I_{L1}, I_{L3}, I_{L2}	0A	0A
② EXAMPLE no. 2	1A	0A	1A	I_{L1}, $I_{L2} = 0$, I_{L3}	0,577A	0,577A
③ EXAMPLE no. 3	0A	1A	1A	I_{L3}, $I_{L1} = 0$, I_{L2}	0,577A	0,577A
④ EXAMPLE no. 4	1A	1A	1A	I_{L1}, I_{L2}, I_{L3}	1A	1A
⑤ EXAMPLE no. 5	1A	1A	2A	I_{L2}, I_{L1}, I_{L3}	1A	1A

MT314 C.T. MONITORING 3-PH. DELTA
MT318 NEG. PHASE SEQU. OC } EXAMPLE

Fig. 273 MT314 C.T. Monitoring 3-PH. Delta MT318 Neg. Phase Sequ. OC } Example

19.5. FUNCTION

General Basics:

CT supervision functions are applied for the internal DRS monitoring features to check the CT external plant circuits but also to verify the correct internal signal processing.
Monitoring is based on the fact that in high voltage systems under normal operating conditions there are no negative phase sequence- or zero sequence components except for the duration of system disturbances or faults

All function analogue signals are sampled 12 times each cycle. Via Fourier Analysis (DSP) the corresponding vectors (value and phase angle) for the 1st harmonic are determined.

At each sample interval the CPU evaluates the zero sequence- or NPS system and compares whether the initiating conditions are above the operating setting. If the initiating conditions are exceeding the set values during 24 consecutive samples (= 2 cycles) then the time delay is started. After the configured time delay expiry the fault alarm is given and in the DRS fault status the condition "CT/VT Fault" entered.

CT Supervision.
Differences Between the Various Functions.

MT211 evaluates: 2 x zero sequence current = 1 x neutral current.
Note: For 2 phase systems.

MT311 evaluates: 3 x zero sequence current = 1 x neutral current.
Note: For 3 phase systems.

MT314 evaluates: 1 x NPS current system.
Note: Suitable for 3 phase systems whereby only 2 direct current inputs are realised and the 3rd phase current is obtained from the external wire connections according to Kirchhoff's Law. In that case the current sum will always be zero and unsymmetrical conditions can only be detected by consideration of the NPS system.

MT316: As MT311, however provided with additional outputs to the software LED matrix and the software trip matrix and can therefore be applied just like a normal protective function.
The CT supervision function as per MT311 is optional, i.e. a red status LED in the first row and can be enabled or disabled via the setting parameters.

MT318: As MT314, however provided with additional outputs to the software LED matrix and the software trip matrix and can therefore be applied just like a normal protective function.
The CT supervision function as per MT314 is optional, i.e. a red status LED in the first row and can be enabled or disabled via the setting parameters.

19.5.1. MT211

The function is computing the vector current sum (= 2 x zero sequence current).
The window display for the “Internal Measured Values“ also shows the current sum.

Example 1:
Current phase L1 = 1 A,
Current phase L3 = 0.
Display window shows 1 A (= current sum).

Example 2:
Current phase L1 = 1 A,
Current phase L3 = 1 A, 0° angle displacement with phase L1.
Display window shows 2 A (= current sum).

Example 3:
Current phase L1 = 1 A
Current phase L3 = 1 A, 180° angle displacement with phase L1.
Display window shows 0 (= current sum).
Note: Refers to normal operating conditions.

19.5.2. MT311

The function is computing the vector current sum (= 3 x zero sequence current).
The window display for the “Internal Measured Values“ also shows the current sum.

Example 1:
Current phase L1 = 1 A
Current phase L2 = 0
Current phase L3 = 0
Display window shows 1 A (= current sum)

Example 2:
Current phase L1 = 1 A
Current phase L2 = 1 A (120° electrical lagging L1)
Current phase L3 = 0
Display window shows 1 A (= current sum)

Example 3:
Current phase L1 = 1 A,
Current phase L2 = 1 A (equal phase angle L1)
Current phase L3 = 1 A (equal phase angle L1)
Display window shows 3 A (= current sum)

Example 4:
Current phase L1 = 1 A,
Current phase L2 = 1 A (120° electrical lagging L1)
Current phase L3 = 1 A (240° electrical lagging L1)
Display window shows 0 (= current sum)
Note: Refers to normal operating conditions

19.5.3. MT314

The function computes the NPS current system: $\underline{I}_2 = (\underline{I}_{L1} + \underline{a}^2.\underline{I}_{L2} + \underline{a}.\underline{I}_{L3}) / 3$.
The window display for the “Internal Measured Values“ also shows the NPS system.

Example 1:
Current phase L1 = 1 A
Current phase L2 = 0
Current phase L3 = 0
Display window shows 0.33 A (= NPS system)

Example 2:
Current phase L1 = 1 A
Current phase L2 = 1 A (180° electrical lagging L1)
Current phase L3 = 0.
Display window shows 0.577 A (= NPS system)

Example 3:
Current phase L1 = 1 A
Current phase L2 = 1 A (120° electrical lagging L1)
Current phase L3 = 0
Display window shows 0.33 A (= NPS system)

Example 4:
Current phase L1 = 1 A,
Current phase L2 = 1 A (equal phase angle L1)
Current phase L3 = 1 A (equal phase angle L1)
Display window shows 0 A (= NPS system)
Note: A purely zero sequence current system

Example 5:
Current phase L1 = 1 A,
Current phase L2 = 1 A (240° electrical lagging L1)
Current phase L3 = 1 A (120° electrical lagging L1)
Display window shows 1 A (= NPS system)
Note: A purely NPS current system

Example 6:
Current phase L1 = 1 A,
Current phase L2 = 1 A (120° electrical lagging L1)
Current phase L3 = 1 A (240° electrical lagging L1).
Display window shows 0 (= NPS system).
Note: Normal operation being a purely positive sequence system

Application of This Function:

a)
Phase to phase currents of a 3 phase system (Note: Zero sequence system is always zero).
b)
Phase currents whereby only the CT current inputs of 2 phases are actually measured and the 3rd current is obtained by suitable external wire connections (Kirchhoff’s Law). In this case the

zero sequence system remains always zero. A possible unsymmetrical condition can only be detected via the NPS system.

19.5.4. MT316

Inputs and internal computation as MT311 however provided with additional outputs to the software LED matrix and the software trip matrix and can therefore be applied just like a normal protective function.
The CT supervision function as per MT311 is optional, i.e. a red status LED in the first row and can be enabled or disabled via the setting parameters.

19.5.5. MT318

Inputs and internal computation as MT314 however provided with additional outputs to the software LED matrix and the software trip matrix and can therefore be applied just like a normal protective function.
The CT supervision function as per MT314 is optional, i.e. a red status LED in the first row and can be enabled or disabled via the setting parameters.

19.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix is to be configured according to the external connections.

The parameters for the operating value and time delay have to be set to the designed values.
For the "VT Test 3 Phase, Δ" function also the corresponding phase rotation has to be configured.

Function tests are preferably performed with the primary plant out of service.

Single phase inject 1.1 times the current operating value into the system. By correct function response after the set time delay following annunciations occur.

Fault alarm category 1
Fault indication, i.e. red "Fault" LED flashing

With protective functions MT316 and MT318 additionally also the configured LED's and outputs are activated.

From the User program via the menu options "System" ⇒"DRS Fault Status" read out the entry "☒ CT/VT Fault".

Switch off the injected test current and reset the fault alarm by operating the blue reset key until the yellow and red LED row indication is altering alternatively

Primary Commissioning Tests:

During the primary tests the correct function operation of the protective scheme during normal system conditions. For checking the CT supervisions it is recommended to carry out short circuit off-load tests in order to prevent any other protective functions from operating when temporary opening a VT circuit to verify the supervision function.

To perform the tests please proceed as follows:

Start up generator to rated speed and excite to nominal voltage.
Block any protective function trips which may occur when shorting a CT circuit.
Short out one phase of the CT set being supervised at the cubicle terminals until the system fault indication appears.
From the User program via the menu options "System" ⇒"DRS Fault Status" read out the entry "☒ CT/VT Fault".
Remove the CT short connection and reset the fault alarm.
After completion of the tests disable blocking of any protective function trip outputs and perform a shut-down of the generator.

20. MU... SYNCHRONISING CHECK / VOLTAGE BALANCE 1 / VOLTAGE BALANCE 2

20.1. OVERVIEW

List of the Available MU . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A
M	... DRS-MODULAR
L	... DRS-LIGHT
FNNR	... Function number (VE-internal number of the protective function)
TYPE	... Function type (short name of the protective function)
ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MU . . .	FNNR	TYPE	ANSI	Application
Synchronising check	1077	MU211	25	C2,M
Voltage balance 1	1069	MU611	60	C2,M
Voltage balance 2	1072	MU312	60	C2,M

20.2. TECHNICAL DATA

20.2.1. Synchronising Check

PROTECTIVE FUNCTION: MU211	FNNR	TYPE	ANSI	Application
Synchronising check	1077	MU211	25	C2,M

Synchronizing check relay for network paralleling live and dead power systems.

MU211
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip

Setting Parameters

Voltage Threshold:	5.0 …80.0 V in 0.5 V steps
Differential Voltage:	2.0 … 20.0 in 0.5 V - steps
Operating Mode:	Dead/ Live
Tyime Delay:	1.00 ... 30.00 seconds in 0.05 sec steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% V_n

20.2.2. Voltage Balance 1

PROTECTIVE FUNCTION: MU611	FNNR	TYPE	ANSI	Application
Voltage balance 1	1069	MU611	60	C2,M

3 phase, 1 stage voltage balance function with comparison features between two 3 phase VT's indicating the faulty VT set.

MU611
Technical Data

Inputs

Analogue:	Voltage system 1/ L1-L2, or: Voltage system 1/ L1-0
	Voltage system 1/ L1-L2, or: Voltage system 1/ L2-0
	Voltage system 1/ L1-L2, or: Voltage system 1/ L3-0
	Voltage system 2/ L1-L2, or: Voltage system 1/ L1-0
	Voltage system 2/ L1-L2, or: Voltage system 1/ L2-0
	Voltage system 2/ L1-L2, or: Voltage system 1/ L3-0
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation L1
	Trip L1
	Initiation L2
	Trip L2
	Initiation L3
	Trip L3
	System 1 (Indication: VT system 1 faulty)
	System 2 (Indication: VT system 1 faulty)

Setting Parameters

Operate value:	2 ... 50 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
VT voltage:	10 ... 90 V in 1 V steps

Window Display for Relay Internal
Determined and Computed Values

Diff. Voltage Ph. A	in [V]
Diff. Voltage Ph. B	in [V]
Diff. Voltage Ph. C	in [V]

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% V_n

20.2.3. Voltage Balance 2

PROTECTIVE FUNCTION: MU312	FNNR	TYPE	ANSI	Application
Voltage balance 2	1072	MU312	60	C2,M

3 phase, 1 stage voltage balance function with blocking features during unsymmetrical load conditions.

MU312
Technical Data

Inputs

Analogue:	Current phase L1
	Current phase L2
	Current phase L3
	Voltage system 1-2
	Voltage system 2-3
	Voltage system 3-1
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value I:	0.1 ... 3 xIn in 0.05 xIn steps
Operating value U:	5 ... 100 V in 0.5 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Phase rotation:	Right/Left

Window Display for Relay Internal Determined and Computed Values

Neg. Phase Sequ. Current:	in [A]
Neg. Phase Sequ. Voltage:	in [V]

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% V_n

20.3. CIRCUIT DIAGRAMS

20.3.1. MU211

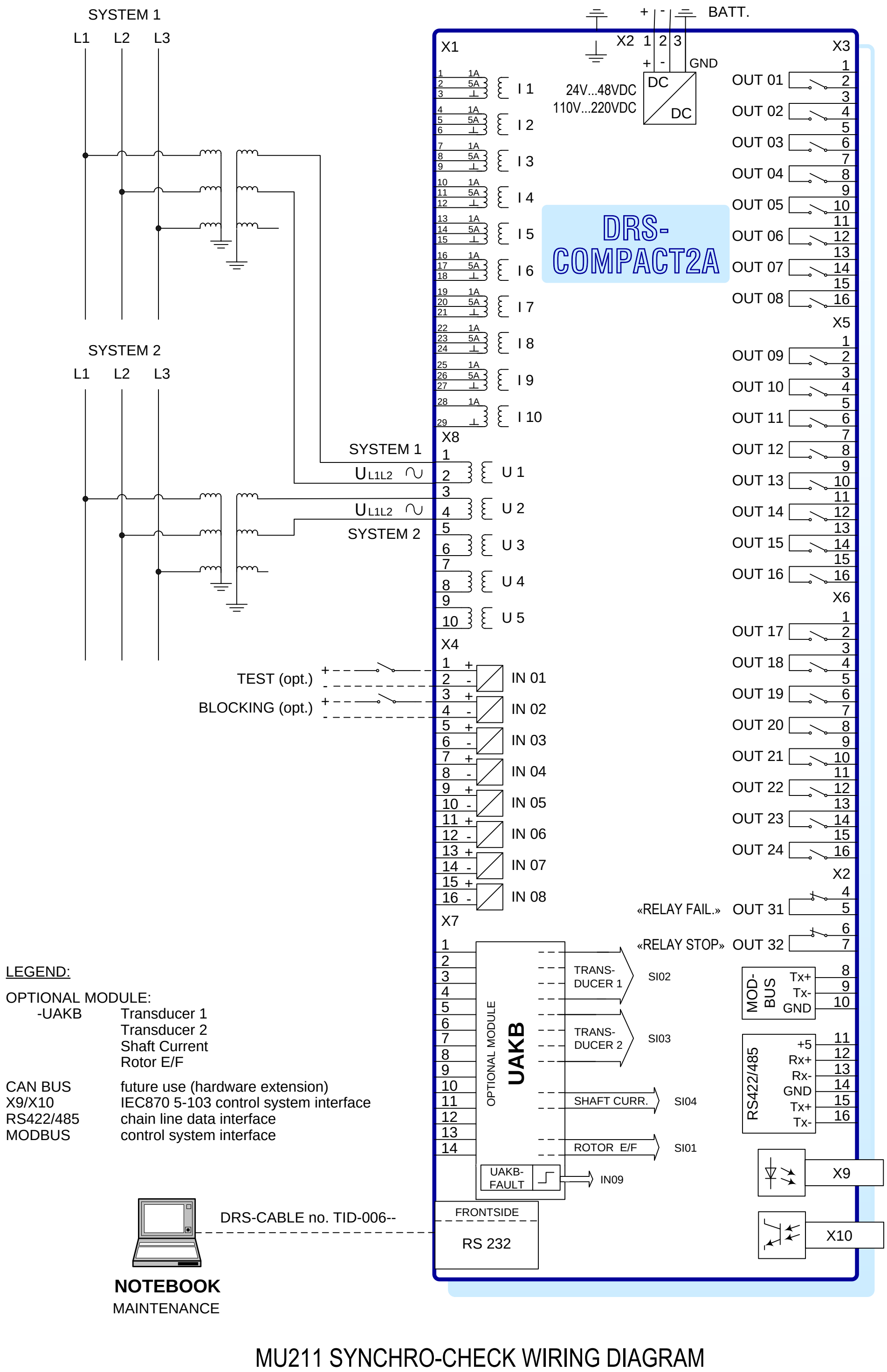


Fig. 274 MU211 Synchro – Check Wiring Diagram

20.3.2. MU611

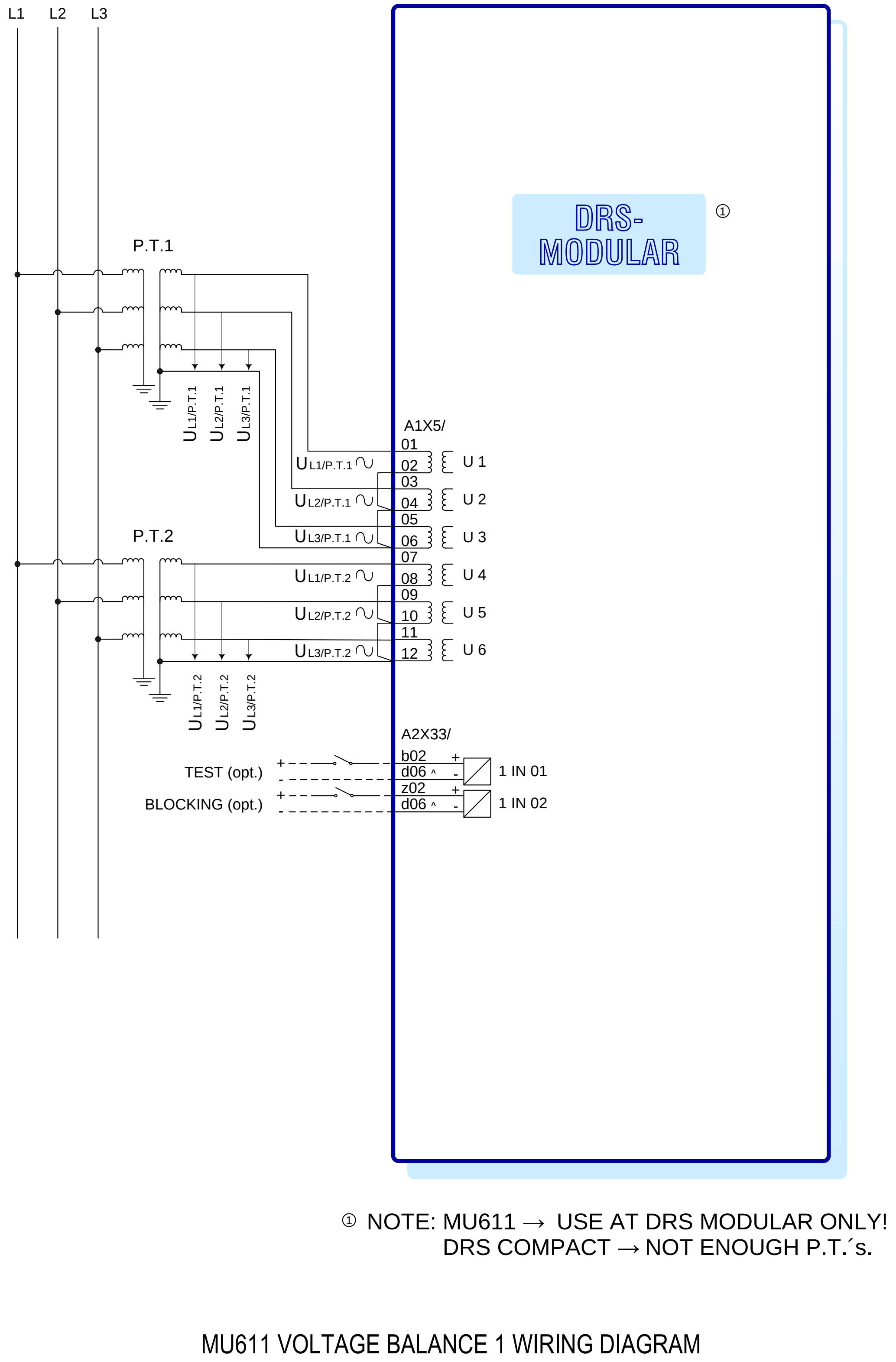
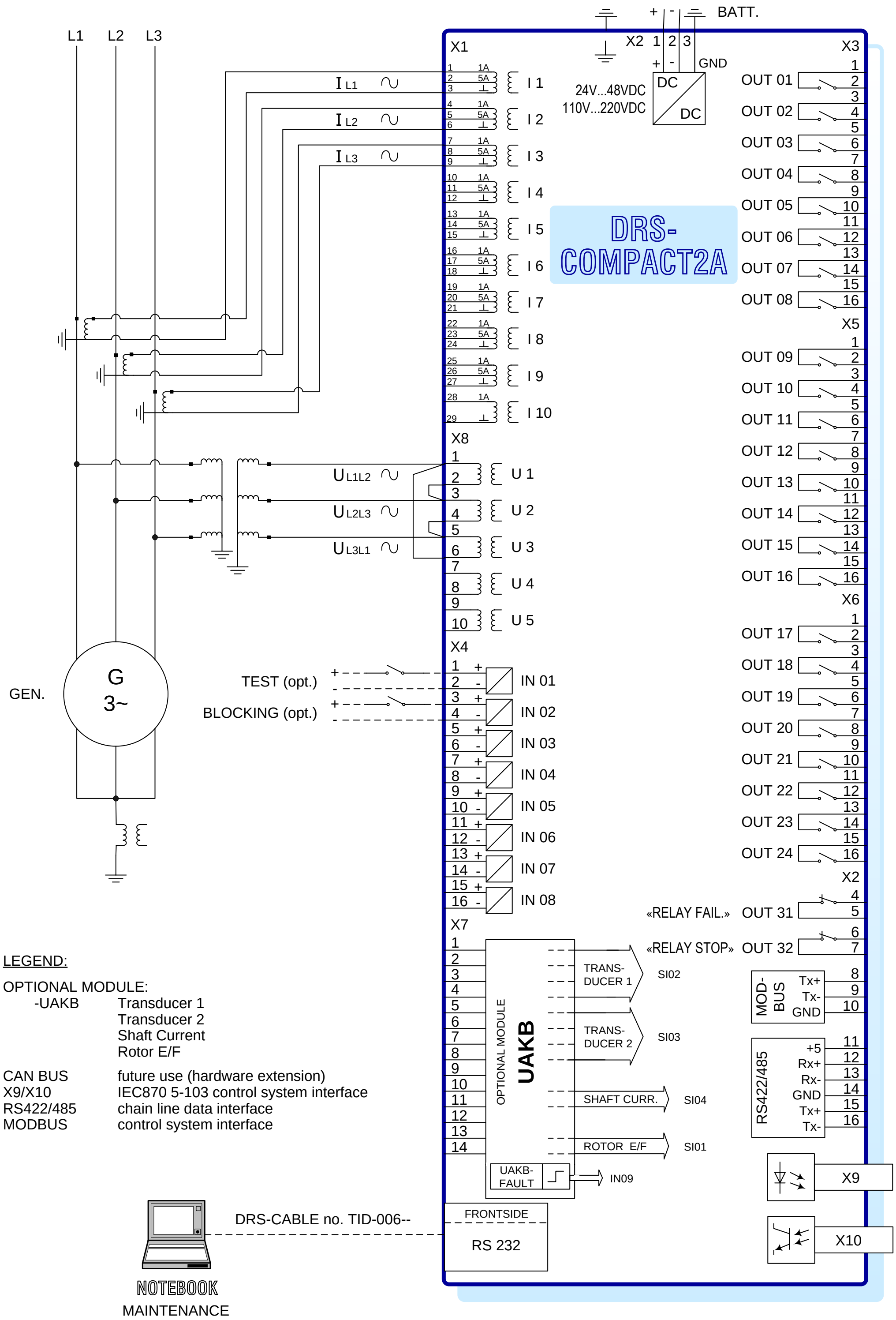


Fig. 275 MU611 Voltage Balance 1 Wiring Diagram

20.3.3. MU312



MU312 VOLTAGE BALANCE2 WIRING DIAGRAM

Fig. 276 MU312 Voltage Balance 2 Wiring Diagram

20.4. LOGIC DIAGRAMS

20.4.1. MU211

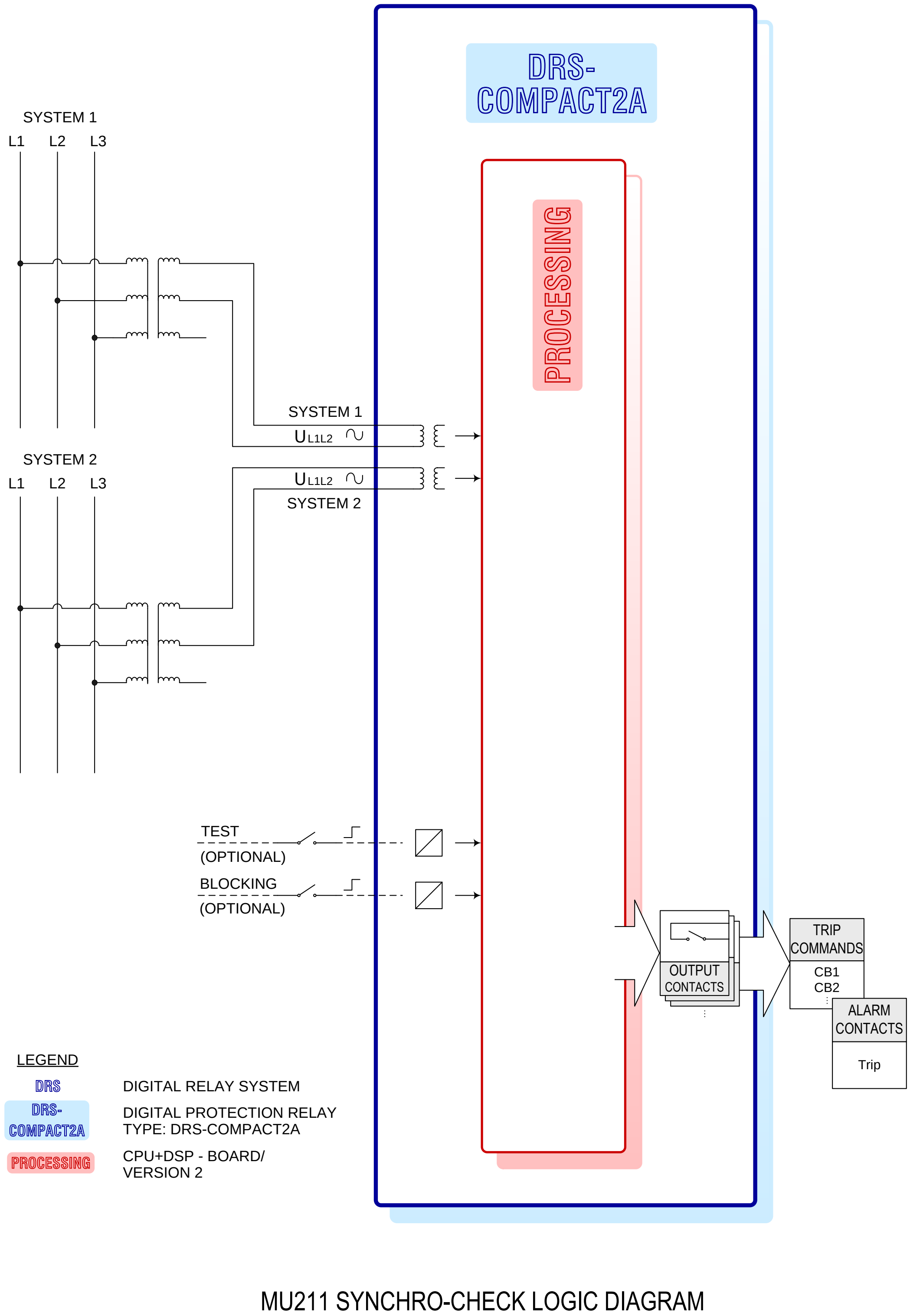
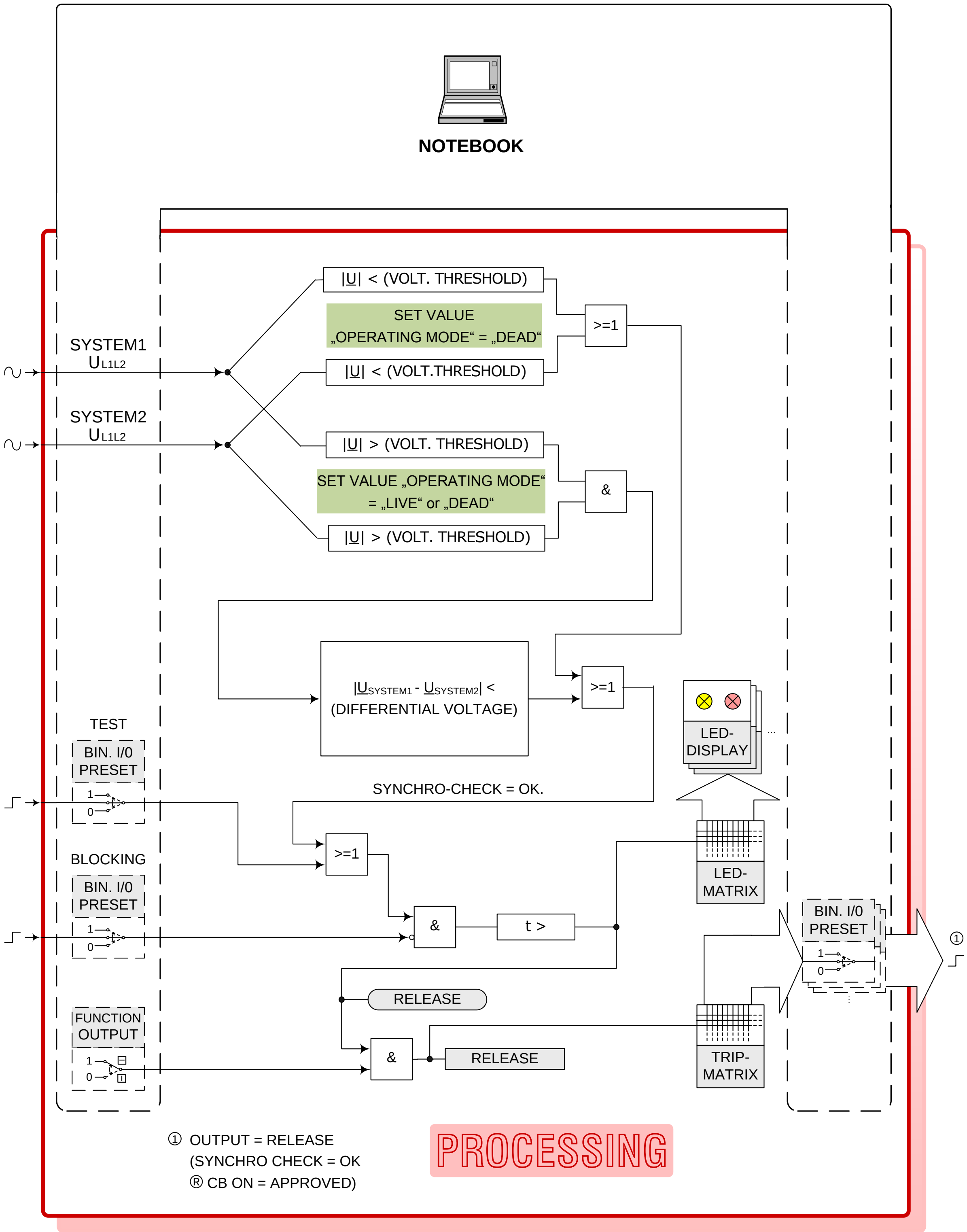


Fig. 277 MU211 Synchro – Check Logic Diagram



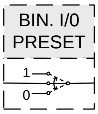
MU211 SYNCHRO-CHECK LOGIC DIAGRAM / PROCESSING

Fig. 278 MU211 Synchro – Check Logic Diagram / Processing

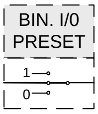
LEGEND PROCESSING

FIRMWARE MODULE: MU211

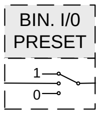
Online simulation
via notebook



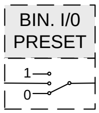
Online-simulation of DIG. IN-/OUTPUTS via notebook:



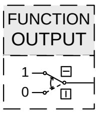
regular function



always „1"



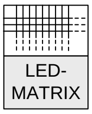
always „0"



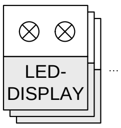
Online-simulation of the FUNCTION OUTPUTS of the protective function MU211
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊞ all FUNCTION OUTPUTS disabled (test-operation)

SET VALUE = „DEAD“ — One or both voltages have to be below the set value „VOLTAGE THRESHOLD“.

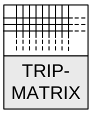
SET VALUE = „LIVE“ — Both voltages have to be above the set value „VOLTAGE THRESHOLD“ and the difference of the two voltages has to be smaller than the set value „DIFFERENTIAL VOLTAGE“.



Programmable software-matrix for the LED-indications
(row 2...14) of PROCESSING



LED-indications of
PROCESSING
(row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

RELEASE — FUNCTION OUTPUT: RELEASE (INTERLOCK IS APPROVED)

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MU211 SYNCHRO-CHECK LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 279 MU211 Synchro – Check Logic Diagram Processing / Legend

20.4.2. MU611

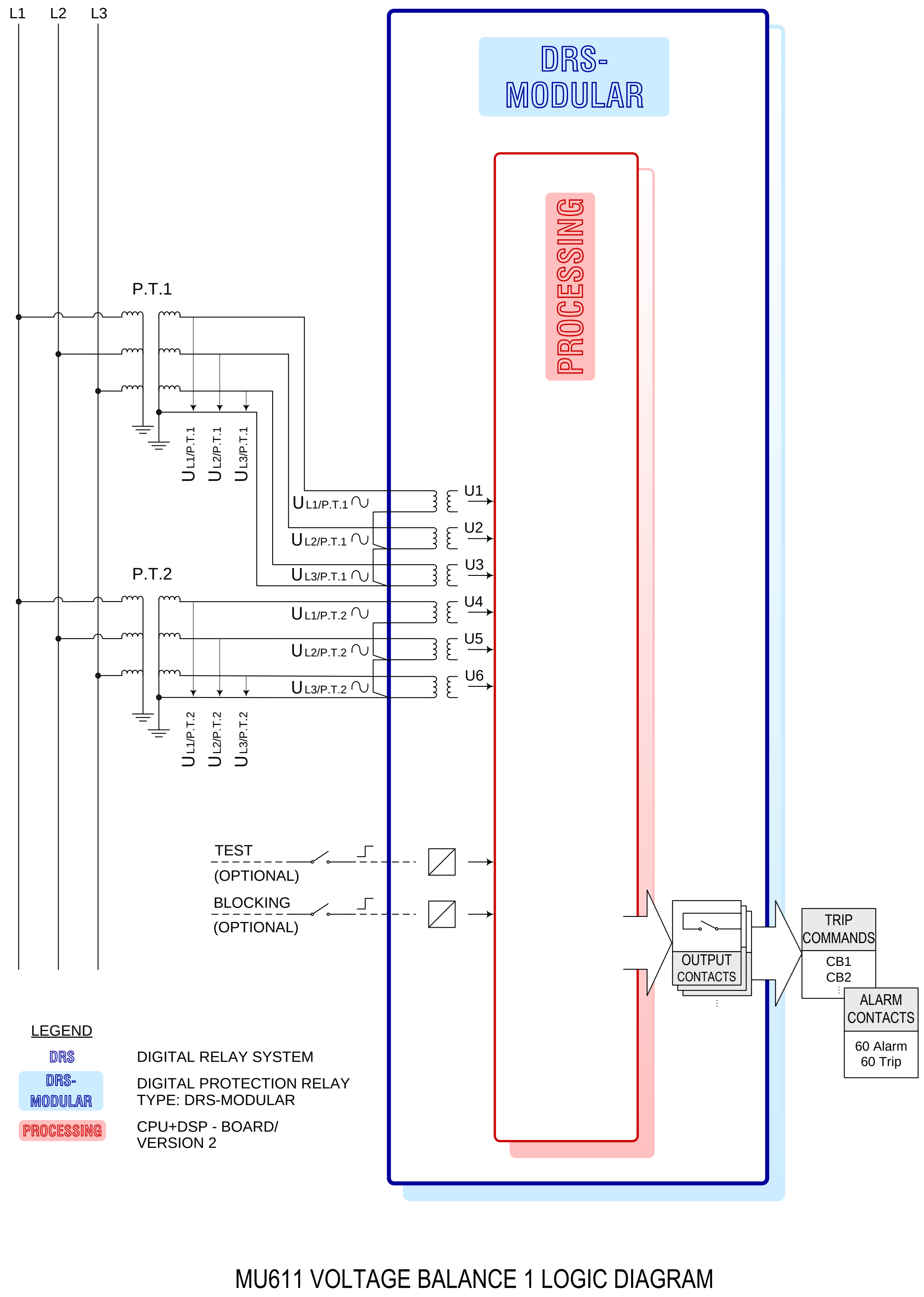
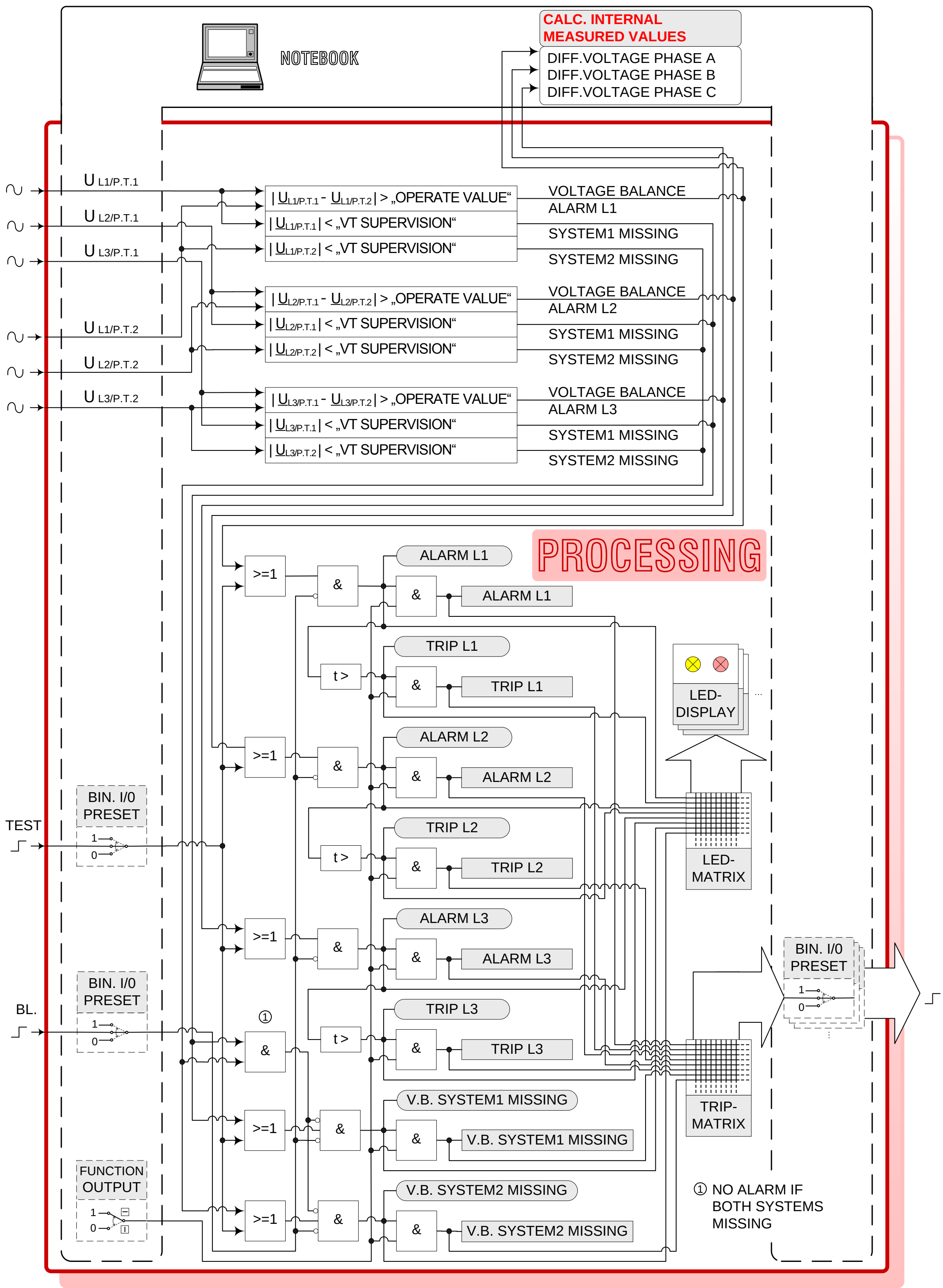


Fig. 280 MU611 Voltage Balance 1 Logic Diagram



MU611 VOLTAGE BALANCE 1 LOGIC DIAGRAM PROCESSING

Fig. 281 MU611 Voltage Balance 1 Logic Diagram Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MU611

Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MU611
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

| $U_{L1/P.T.1}$ - $U_{L1/P.T.2}$ | > „OPERATE VALUE" — Voltage difference between System 1 and System 2 phases L1 exceeds the Set Value.

| $U_{L1/P.T.1}$ | < „VT SUPERVISION" — Voltage U_{L1} of System 1 drops below the minimum value given by the Set Value.
Note: ALARM is blocked if both Systems go low at the same time.

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: 60 Alarm

TRIP — FUNCTION OUTPUT: 60 Trip

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MU611 VOLTAGE BALANCE 1 LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 282 MU611 Voltage Balance 1 Logic Diagram Processing / Legend

20.4.3. MU312

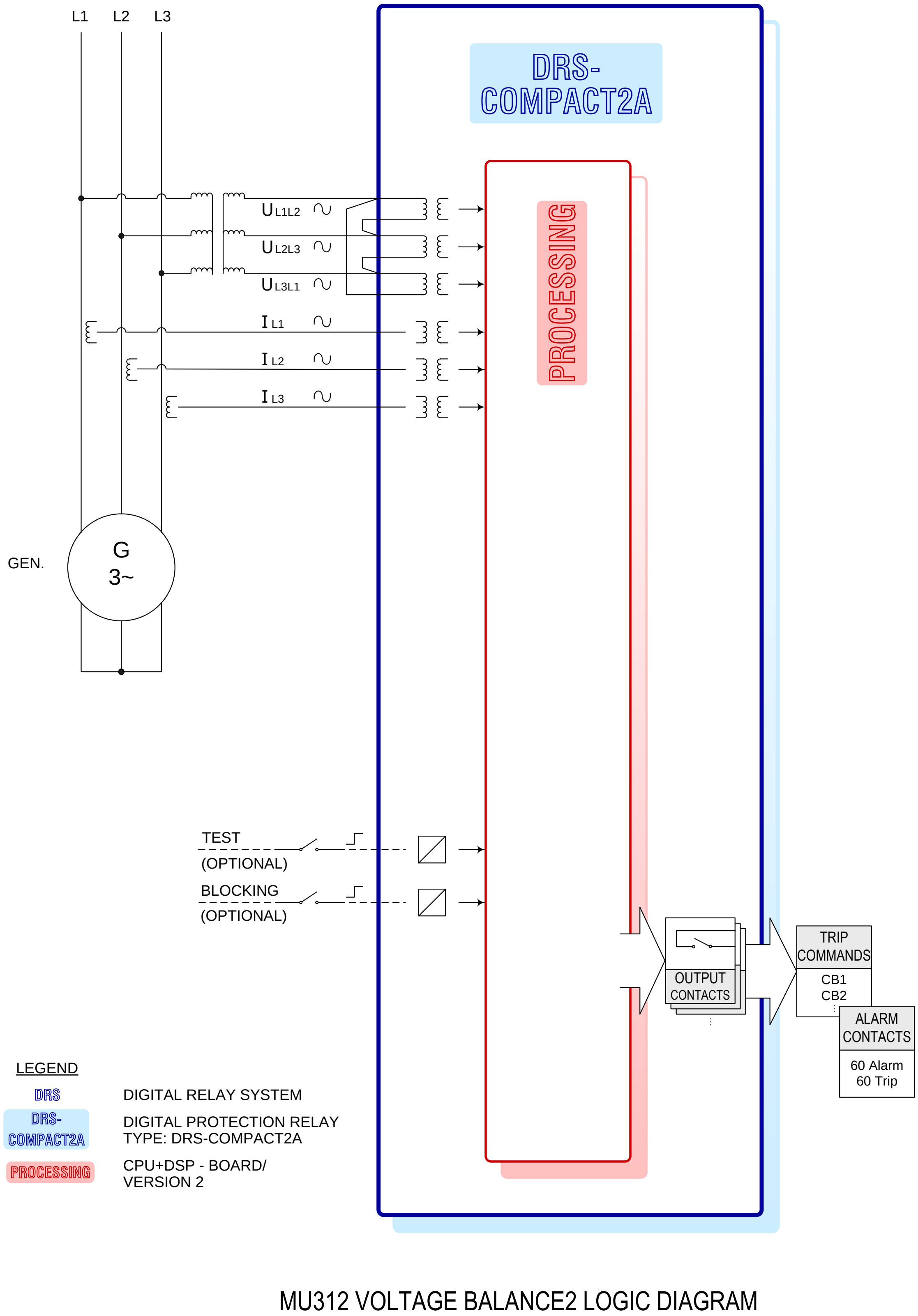
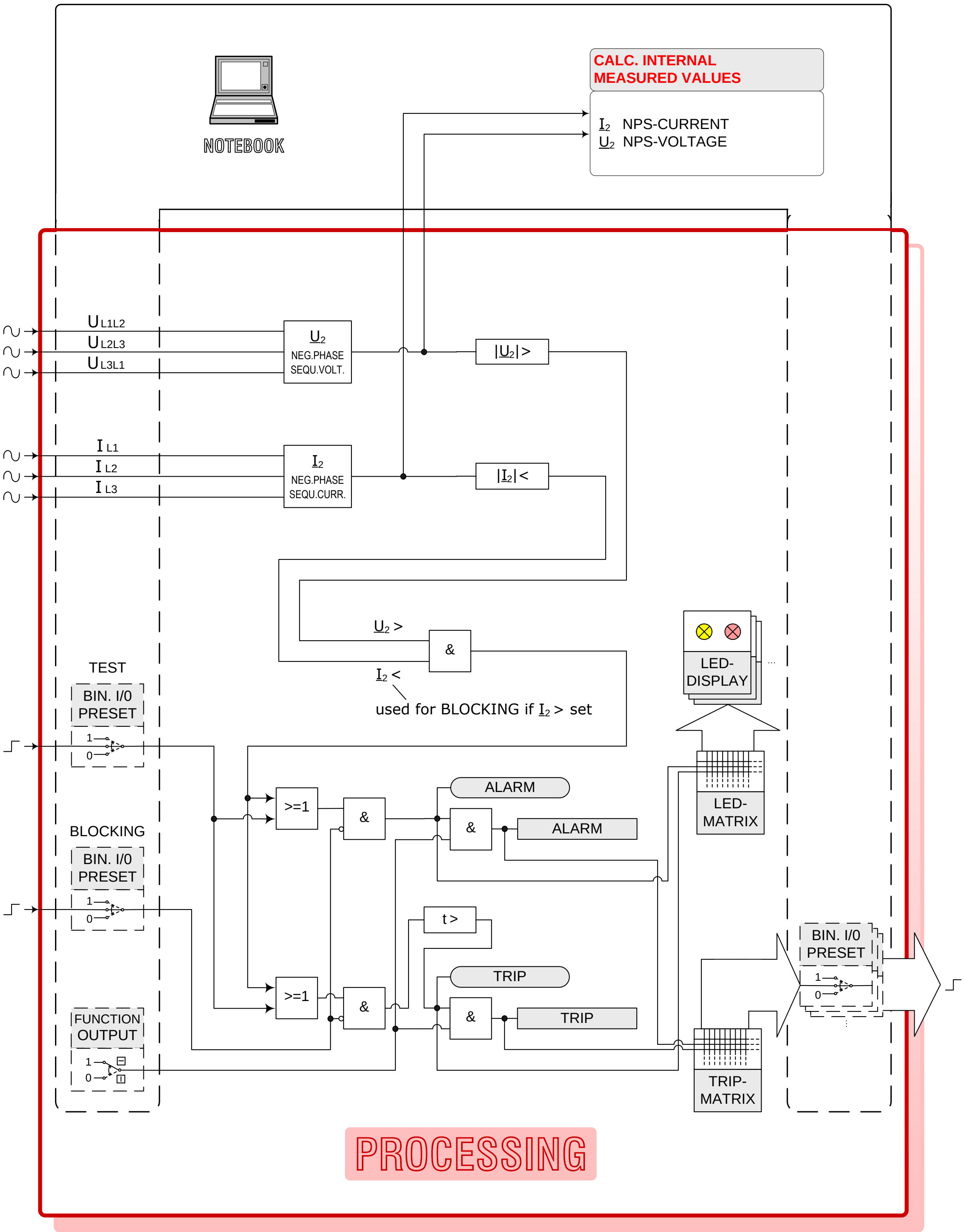


Fig. 283 MU312 Voltage Balance 2 Logic Diagram

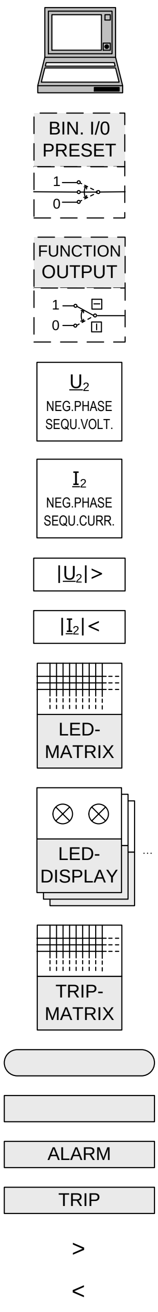


MU312 VOLTAGE BALANCE2 LOGIC DIAGRAM / PROCESSING

Fig. 284 MU312 Voltage Balance 2 Logic Diagram / Processing

LEGEND PROCESSING

CPU+DSP - BOARD/ VERSION 2 // FIRMWARE-MODULE: MU312



Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ..... — Online-indication of DRS-internal calculated values on notebook-screen

Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

Online-simulation of the FUNCTION OUTPUTS of the protective function MU312
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

Calculation of „NEGATIVE PHASE SEQUENCE VOLTAGE“ $\underline{U}_2$
$\underline{U}_2 = (\underline{U}_{L1L2} + a \cdot \underline{U}_{L2L3} + a^2 \cdot \underline{U}_{L3L1}) / 3$
NOTE: $a = e^{j \cdot 2P/3}$

Calculation of „NEGATIVE PHASE SEQUENCE CURRENT“ $\underline{I}_2$
$\underline{I}_2 = (\underline{I}_{L1} + a \cdot \underline{I}_{L2} + a^2 \cdot \underline{I}_{L3}) / 3$
NOTE: $a = e^{j \cdot 2P/3}$

Check $|\underline{U}_2| >$ set

Check $|\underline{I}_2| <$ set
NOTE: ($\underline{I}_2 >$ set) corresponds with BLOCKING condition

Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-indications of PROCESSING-board (row 2...14)

Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

FUNCTION OUTPUT: Alarm

FUNCTION OUTPUT: Trip

Type of function: over-detection (actual value > set value)

Type of function: under-detection (actual value < set value)

MU312 VOLTAGE BALANCE2 LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 285 MU312 Voltage Balance 2 Logic Diagram Processing / Legend

20.5. FUNCTION

20.5.1. MU211

Synchronising check function providing an interlock for paralleling live line and/or dead bus power systems.
The function is computing the absolute voltage vector difference of the two VT voltages.

Principle:

A.
"Dead" Line And/Or Dead Bus Mode (see Set Value "Operating Mode"):
a)
Both input voltages have to be below the "Voltage Threshold" setting value.
b)
One input voltage has to be below the "Voltage Threshold" setting value.
c)
Both input voltages have to be above the "Voltage Threshold" setting value and the absolute value of the differential voltage vector must be smaller than the "Differential Voltage" setting.

B.
"Live" Line/Live Bus Mode (see Set Value "Operating Mode"):
a)
Both input voltages have to be above the "Voltage Threshold" setting value and the absolute value of the differential voltage vector must be smaller than the "Differential Voltage" setting.

A. + B.
Note:
Therefore the "Voltage Threshold" setting value for either operating mode is to be approached in opposite ways.

20.5.2. MU611

Voltage Balance 1

3 phase, 1 stage voltage balance function with comparison features between two 3 phase VT's indicating the faulty VT set.
This function can either be applied for phase to phase or phase to neutral voltages.

Principle:

The function is evaluating the absolute voltage vector difference (amplitude difference and phase angle are considered) for all 3 VT voltages and when the setting value of one phase is exceeded
a corresponding initiation signal output, and after the set time delay a trip output signal is given for each individual phase.
Also a VT fault indication is provided for either of the two VT systems:

"System 1"
"System 2" ...

... Specification of the function outputs "System 1" and "System 2":

"System 1" means: The VT of Systems 1 is faulty, i.e. at least one of the three voltages is below the "VT Voltage" setting.

"System 2" means: The VT of Systems 2 is faulty, i.e. at least one of the three voltages is below the "VT Voltage" setting. Note: Also operating when "System 1" is faulty.

As outlined above, the failure of a VT set is additionally supervised by an integrated undervoltage function which will operate when the "VT Voltage" configuration is falling below the setting value ("System 1" or "System 2").
Please note: The above alarm annunciations do not definitely mean a VT fault- or differential voltage condition but only indicates that one of the input voltage is below the set "VT Voltage" minimum.

Function Application:

Only applicable for DRS-MODULAR since 6 VT inputs are required.

20.5.3. MU312

3 phase, 1 stage voltage balance function with blocking features during unsymmetrical load conditions.
This function is based on the evaluation of the negative phase sequence voltage component (NPS voltage).

Principle:

The protective function is evaluating the Negative Phase Sequence Voltage (NPS) and from the results derives the voltage symmetry. The PC window display for the "Internal Measured Values" shows the computed V- and I- inverse values.
The Negative Phase Sequence Current Component serves for function blocking.

Istruction for function calibration and determination of the setting values:

By single phase injection of a 100 V the "Internal Measured Values" display shows 33 V.
The nominal input voltages are 3 x 100 V phase to phase.
Also phase to neutral voltage input connections are permissible, however the “Alarm“ and “Trip“ settings are to be reduced accordingly.

When injecting a single phase current of 1 A the "Internal Measured Values" display is showing 0.33 A whereby the nominal phase input currents are 3 x 1 A.

Summary:
The 100% reference amounts to:
- NPS current system: Anti-clockwise, system 3 phase, 3 x 1A ... Display = I_2 = 1A.
- NPS voltage system: Anti-clockwise, system 3 phase, 3 x 100 V ... Display = V_2 = 100V.

Determination of the NPS component:

The function is evaluating all three phases and by a three phase system therefore all three phases have to be connected to the VT inputs since a missing phase input is not considered by the function since the measured input quantities are directly evaluated.
The connected voltages, respectively currents to the input matrix are taken for evaluating the negative phase sequence component. For the algorithm of the function it makes no difference whether phase to phase or phase to neutral voltages are applied. The function evaluates the external voltage inputs configured in the input matrix whereby the setting values have to be determined according to the external wiring connections.

20.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

20.6.1. MU211

Disconnect Trip output and make test synchronisation. Check correctly function of trip output with output LED and digital multimeter.

20.6.2. MU311 / MU611

Disconnect one of the input voltages during normal operation (recommended: idling operation):
function will operate

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21. MU... OVER/UNDERVOLTAGE DT

21.1. OVERVIEW

List of the Available MU . . . – Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MU . . .	FNNR	TYPE	ANSI	Application
Over/undervoltage protection,1 phase, 1 stage, with configurable reset ratio.	1009	MU111	59/27	C2,M,L
Over/undervoltage protection,1 phase, 2 stage, with configurable reset ratio.	1011	MU121	59/27	C2,M,L
Over/undervoltage protection, DC, 1 phase, 2 stage	1051	MU120	59/27	C2,M
Over/undervoltage protection, 3 phase, 1 stage separate outputs	1008	MU311	59/27	C2,M
Over/undervoltage protection,3 phase, 1 stage common outputs, with configurable reset ratio.	1057	MU313	59/27	C2,M,L
Over/undervoltage protection, 3 phase, 1 stage separate outputs, with reduced reset ratio.	1089	MU314	59/27	C2,M
Over/undervoltage protection, 3 phase, 1 stage common outputs, with reduced reset ratio. *Note: MU315 is preferred to MU314* *(common outputs)*	1090	MU315	59/27	C2,M,L
Over/undervoltage protection, 3 phase, 2 stage separate outputs	1010	MU321	59/27	C2,M
Over/undervoltage protection, 3 phase, 2 stage common outputs, with configurable reset ratio. *Note: MU323 is now obsolete*	1053	MU322	59/27	C2,M
Fast Overvoltage Protection based on sampled values, 4 phase, 1 stage.	2997	MU421	59	L

21.2. TECHNICAL DATA

21.2.1. Over/Undervoltage DT 1 Phase, 1 Stage

PROTECTIVE FUNCTION: MU111	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 1 phase, 1 stage, with configurable reset ratio.	1009	MU111	59/27	C2,M,L

1 phase, 1 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation, with configurable reset ratio.

MU111
Technical Data

Inputs

Analogue:	Voltage
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 200 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/under evaluation
Reset ratio:	Normal/ Reduced

Measuring

Reset ratio:	0.96875/0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

21.2.2. Over/ Undervoltage DT 1 Phase, 2 Stage

PROTECTIVE FUNCTION: MU121	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 1 phase, 2 stage	1011	MU121	59/27	C2,M,L

1 phase, 2 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation, with configurable reset ratio.

MU121
Technical Data

Inputs

Analogue:	Voltage
Binary:	Blocking input stage 1
	Test input stage 1
	Blocking input stage 2
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	2 ... 200 V in 0.2 V steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 1:	2 ... 200 V in 0.2 V steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/ Under evaluation
Reset ratio:	Normal/ Reduced

Measuring

Reset ratio:	0.96875/0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

PROTECTIVE FUNCTION: MU120	**FNNR**	**TYPE**	**ANSI**	**Application**
Over/undervoltage protection, DC, 1 phase, 2 stage	1051	MU120	59/27	C2,M

2 stage definite time delayed (DT) DC voltage function with selectable
over- or undervoltage evaluation.

MU120
Technical Data

Inputs

Analogue:	DC input (DC voltage)
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Initiation stage 2
	Trip stage 1
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.01 ... 50 V in 0.01 V steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	0.01 ... 50 V in 0.01 V steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/under evaluation
Setting range:	0.1 ... 10 V/V in 0.01 V steps
Voltage at 0 V:	0.000 ... 4.995 V in 0.005 V steps

Measuring

Reset ratio:	0.96875
Operating time:	3 cycles typical at PROCESSING sample frequency
Accuracy:	≤ 2% Vn

21.2.3. Over/ Undervoltage DT 3 Phase, 1 Stage

PROTECTIVE FUNCTION: MU311	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 3 phase, 1 stage separate outputs	1008	MU311	59/27	C2,M

3 phase, 1 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation with separate outputs.

MU311
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation system 1
	Trip system 1
	Initiation system 2
	Trip system 2
	Initiation system 3
	Trip system 3

Setting Parameters

Operating value:	2 ... 200 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/under evaluation

Measuring

Reset ratio:	0.96875
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

PROTECTIVE FUNCTION: MU313	FNNR	TYPE	ANSI	Application
Over/undervoltage protection,3 phase, 1 stage common outputs, with configurable reset ratio.	1057	MU313	59/27	C2,M,L

3 phase, 1 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation with common outputs, with configurable reset ratio.

MU313
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 200 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/ Under evaluation
Reset ratio:	Normal/ Reduced

Measuring

Reset ratio:	0.96875/0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

PROTECTIVE FUNCTION: MU314	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 3 phase, 1 stage separate outputs, with reduced reset ratio.	1089	MU314	59/27	C2,M

3 phase, 1 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation and reduced reset ratio, with separate outputs.

MU314
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation system 1
	Trip system 1
	Initiation system 2
	Trip system 2
	Initiation system 3
	Trip system 3

Setting Parameters

Operating value:	2 ... 200 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/under evaluation

Measuring

Reset ratio:	0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

PROTECTIVE FUNCTION: MU315	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 3 phase, 1 stage common outputs, with reduced reset ratio. *Note: MU315 is preferred to MU314 (common outputs)*	1090	MU315	59/27	C2,M,L

3 phase, 1 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation and reduced reset ratio, with common outputs.

MU315
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input
	Test input

Outputs

Binary:	Initiation
	Trip

Setting Parameters

Operating value:	2 ... 200 V in 0.2 V steps
Operating time:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/ Under evaluation

Measuring

Reset ratio:	0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

21.2.4. Over/ Undervoltage DT 3 Phase, 2 Stage

PROTECTIVE FUNCTION: MU321	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 3 phase, 2 stage separate outputs	1010	MU321	59/27	C2,M

3 phase, 2 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation and separate outputs.

MU321
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1/ system 1
	Trip stage 1/ system 1
	Initiation stage 1/ system 2
	Trip stage 1/ system 2
	Initiation stage 1/ system 3
	Trip stage 1/ system 3
	Initiation stage 2/ system 1
	Trip stage 2/ system 1
	Initiation stage 2/ system 2
	Trip stage 2/ system 2
	Initiation stage 2/ system 3
	Trip stage 2/ system 3

Setting Parameters

Operating value stage 1:	2 ... 200 V in 0.2 V steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	2 ... 200 V in 0.2 V steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/under evaluation

Measuring

Reset ratio:	0.96875
Operating time:	$\geq$ 2 cycles
Accuracy:	$\leq$ 2% Vn

PROTECTIVE FUNCTION: MU322	FNNR	TYPE	ANSI	Application
Over/undervoltage protection, 3 phase, 2 stage common outputs, with configurable reset ratio *Note: MU323 is now obsolete*	1053	MU322	59/27	C2,M

3 phase, 2 stage definite time delayed (DT) voltage function with selectable over- or undervoltage evaluation and common outputs, with configurable reset ratio.

MU322
Technical Data

Inputs

Analogue:	Voltage system 1
	Voltage system 2
	Voltage system 3
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	2 ... 200 V in 0.2 V steps
Operating time stage 1:	0 ... 30 seconds in 0.05 sec steps
Operating value stage 2:	2 ... 200 V in 0.2 V steps
Operating time stage 2:	0 ... 30 seconds in 0.05 sec steps
Type:	Over/ Under evaluation
Reset ratio:	Normal/ Reduced

Measuring

Reset ratio:	0.96875/0.992
Operating time:	≥ 2 cycles
Accuracy:	≤ 2% Vn

21.2.5. Fast Overvoltage Protection DT 4-phase 1-stage

PROTECTIVE FUNCTION: MU322	FNNR	TYPE	ANSI	Application
Fast Overvoltage Protection based on sampled values, 4 phase, 1 stage.	2997	MU421	59	L (DRSLIGHT- File: DRS_1V42)

4 phase, 1 stage voltage function with fast response (no time delay), based on sampled values.
The protective function contains 4 independent channels (4 analogue inputs and 4 trip outputs).

MU421
Technical Data

Inputs

Analogue:	Voltage A
	Voltage B
	Voltage C
	Voltage D
Binary:	Blocking input
	Test input

Outputs

Binary:	Trip A
	Trip B
	Trip C
	Trip D

Setting Parameters

Operating value A:	5 ... 200 V in 1 V steps Please note: The Set Values represent RMS – Values (for example 100 V RMS). The Protective Function will calculate the Peak Values (for example 141 V), which will be used for tripping.
Operating value B:	5 ... 200 V in 1 V steps
Operating value C:	5 ... 200 V in 1 V steps
Operating value D:	5 ... 200 V in 1 V steps

Measuring

Reset ratio:	approx.: 1,00. Explanation: On-Counter: 2 Samples are above Set Value. Off-Counter: 254 Samples are below Set Value. Therefore no hysteresis is required.
Operating time:	2 Samples (1,66 ms) + Ouput Relay (3 ms) Explanation: Sample Rate: 1200 samples/ sec. (constant sample rate). [Please note: Sample Rate does not depend on the frequency of the analogue input signal.] 1 Sample … 0,833 ms 2 Samples … 1,66 ms … internal trip time Total Trip Time: 1,66 ms + 3 ms
Accuracy:	≤ 3% Vn

21.3. CONNECTION DIAGRAMS

21.3.1. MU111/ MU121/ MU311/ MU313/ MU314/ MU315/ MU321/ MU322

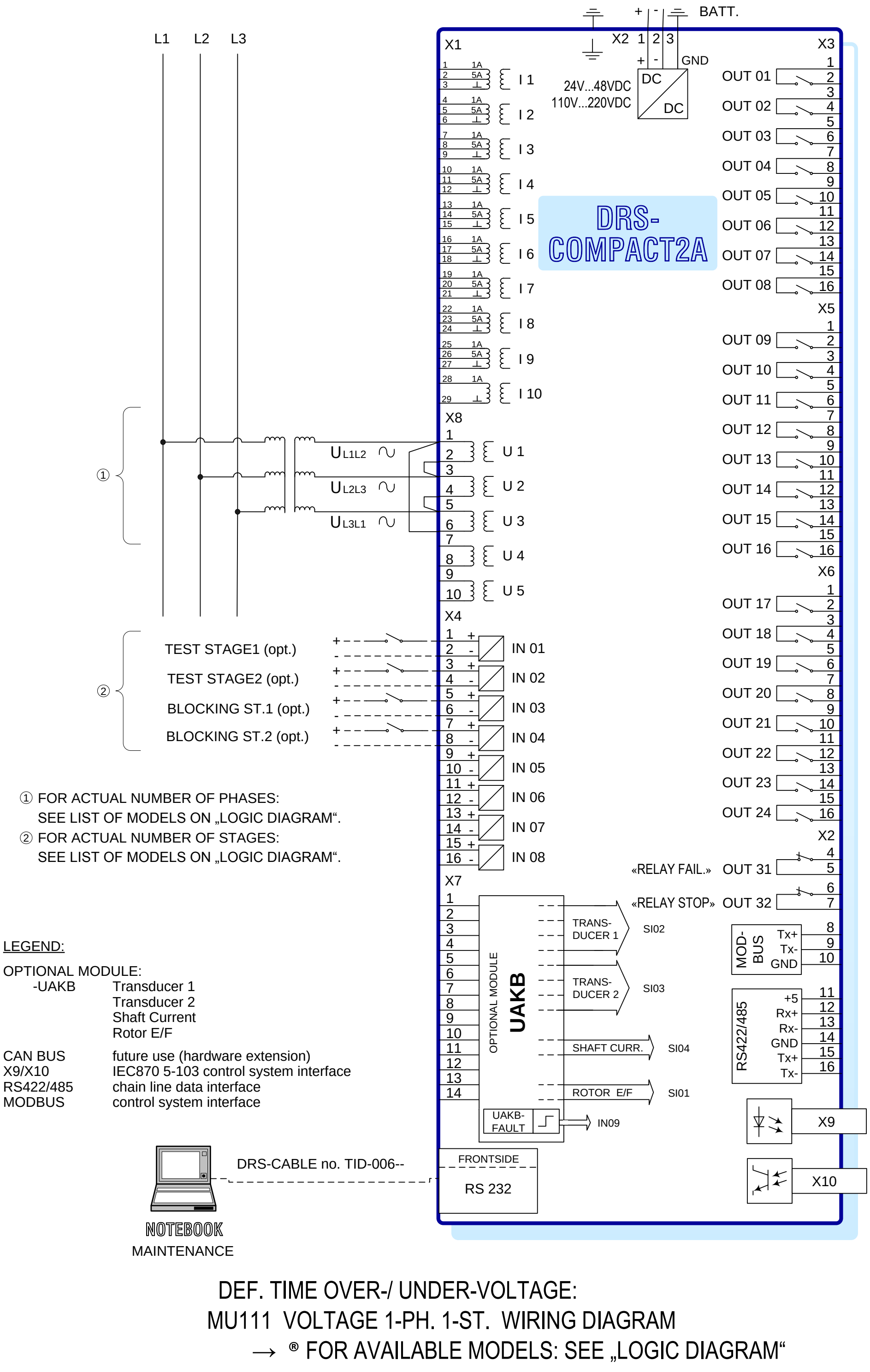
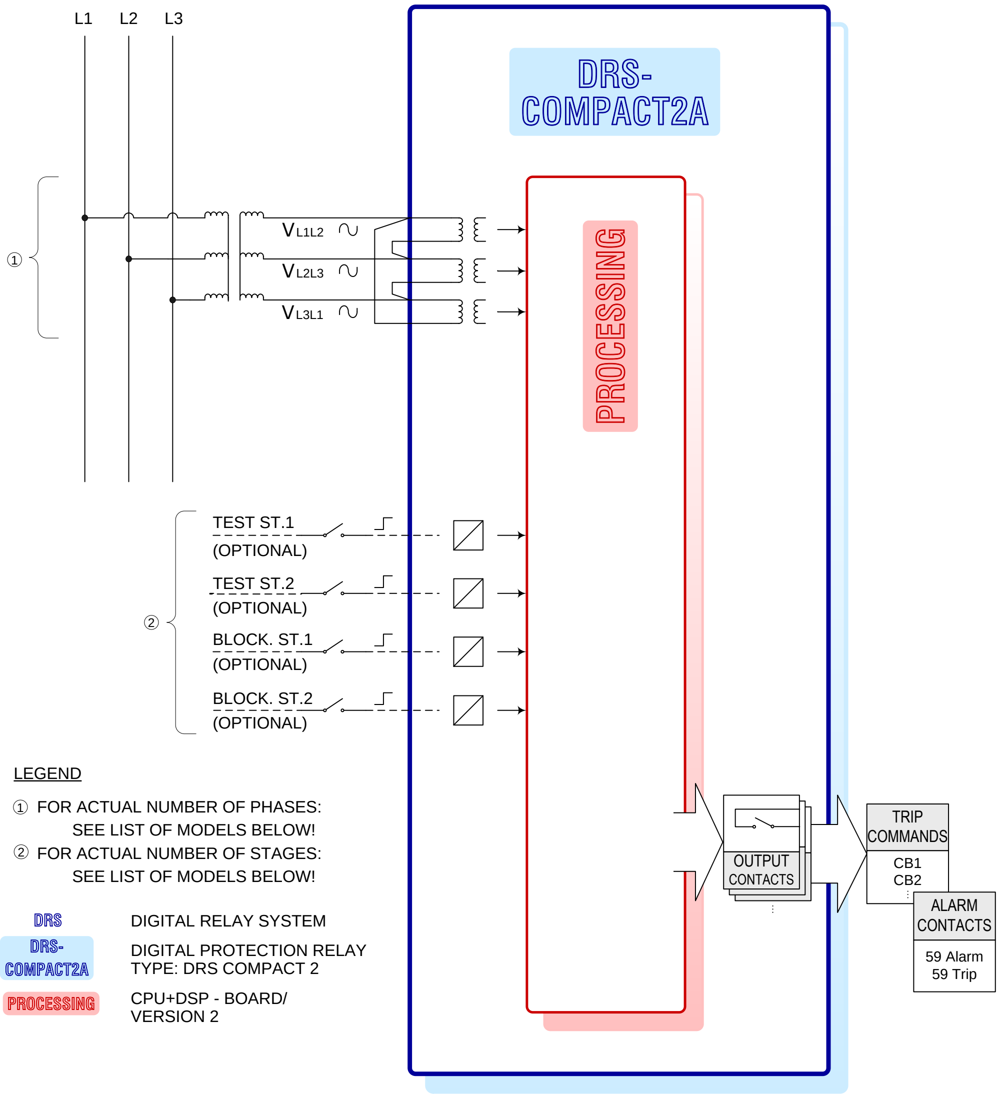


Fig. 286 Def. Time Over-/Under – Voltage: MU111 Voltage 1-PH. 1-ST. Wiring Diagram
→ For Available Models: See „Logic Diagram''

21.4. LOGIC DIAGRAMS

21.4.1. MU111/ MU121/ MU311/ MU313/ MU314/ MU315/ MU321/ MU322



DEF. TIME OVER-/ UNDER-VOLTAGE:

MU111 VOLTAGE 1-PH. 1-ST. LOGIC DIAGRAM
MU121 VOLTAGE 1-PH. 2-ST. LOGIC DIAGRAM
MU311 VOLTAGE 3-PH. 1-ST. LOGIC DIAGRAM
MU313 VOLTAGE 3-PH. 1-ST. LOGIC DIAGRAM
MU314 VOLTAGE 3-PH. 1-ST. LOGIC DIAGRAM
MU315 VOLTAGE 3-PH. 1-ST. LOGIC DIAGRAM
MU321 VOLTAGE 3-PH. 2-ST. LOGIC DIAGRAM
MU322 VOLTAGE 3-PH. 2-ST. LOGIC DIAGRAM

Fig. 287 Def. Time Over-/Under-Voltage Logic Diagram

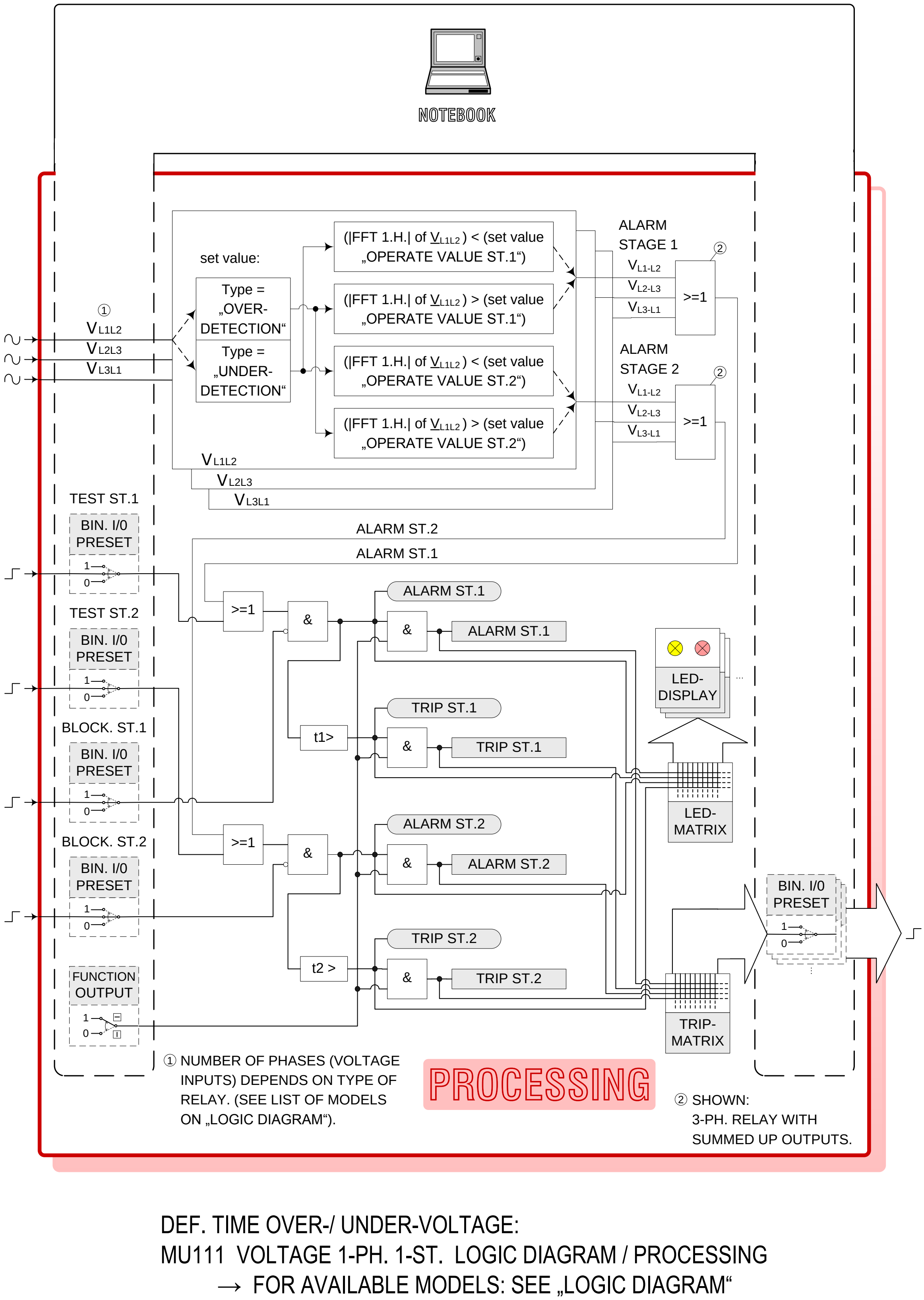


Fig. 288 Def. Time Over-/Under-Voltage: MU111 Voltage 1-PH. 1-ST. Logic Diagram / Processing
→ For Available Models: See ,, Logic Diagram’’

LEGEND PROCESSING

FIRMWARE-MODULE: MU111...MU322

Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET

Online-simulation of DIG. IN-/OUTPUTS via notebook:

BIN. I/0 PRESET — regular function

BIN. I/0 PRESET — always „1"

BIN. I/0 PRESET — always „0"

FUNCTION OUTPUT

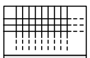
Online-simulation of the FUNCTION OUTPUTS of the protective function MU111 ... MU322
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

Type = „OVER-DETECTION“ / Type = „UNDER-DETECTION“ — OVER- or UNDERVOLTAGE - relay function to be choosen via set value.

(|FFT 1.H.| of U_{L1L2}) > (set value „OPERATE VALUE ST.1“)

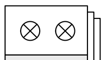
The measured voltage signal U_{L1L2} is analyzed by use of FAST FOURIER TRANSFORMATION (FFT).
The relay function uses the 1.Harmonic of U_{L1L2} only.

MU322 — MODEL-NUMBERS (FIRMWARE-FUNCTIONS) EXAMPLE:
- consecutive number
- number of stages
- number of phases
- type of function (e.g. V … voltage)
- microprocessor - based hardware



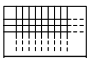
LED-MATRIX

Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-DISPLAY

LED-indications of PROCESSING (row 2...14)



TRIP-MATRIX

Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

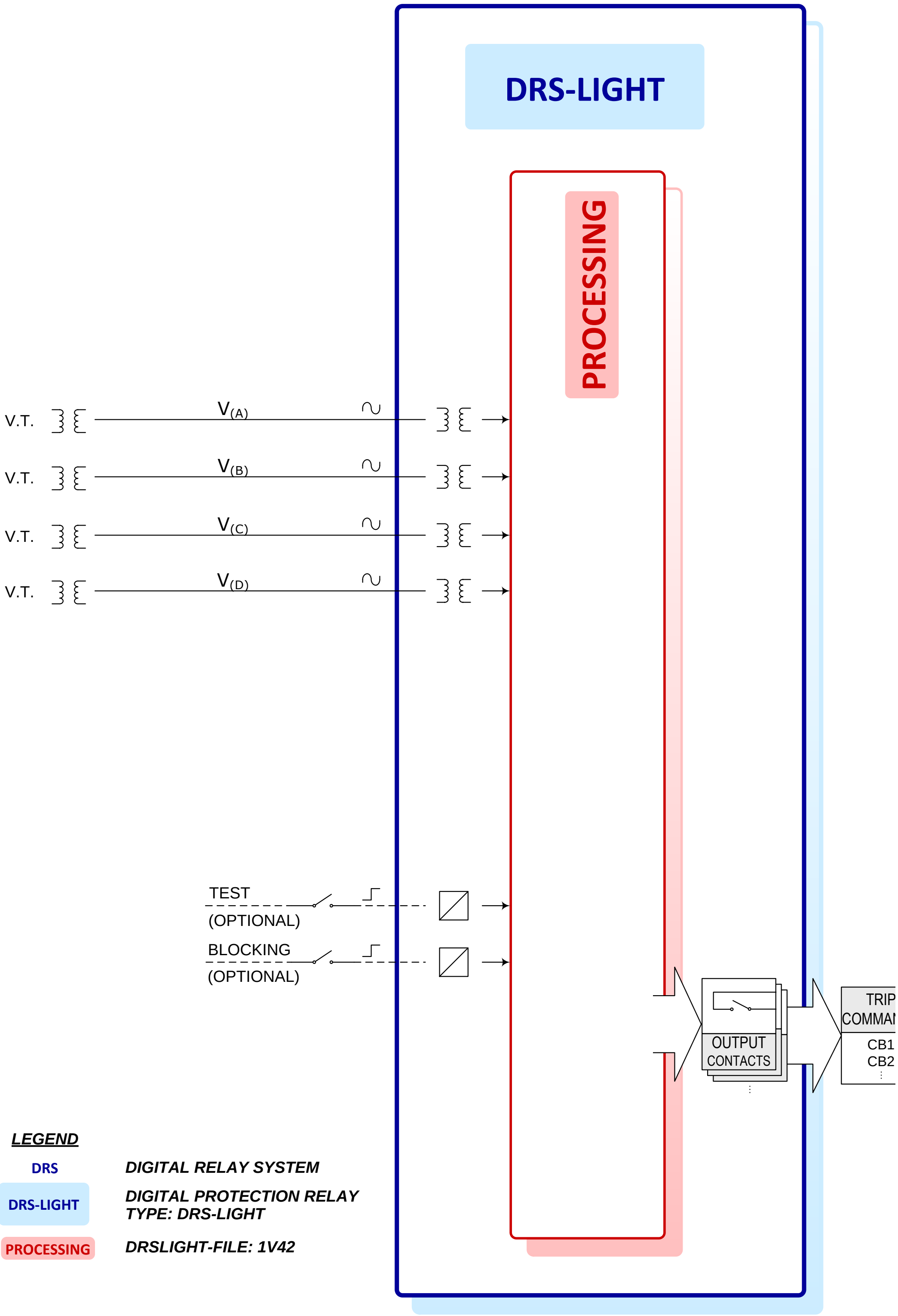
> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

DEF. TIME OVER-/ UNDER-VOLTAGE:
MU111 VOLTAGE 1-PH. 1-ST. LOGIC DIAGRAM PROCESSING / LEGEND
→ FOR AVAILABLE MODELS: SEE „LOGIC DIAGRAM“

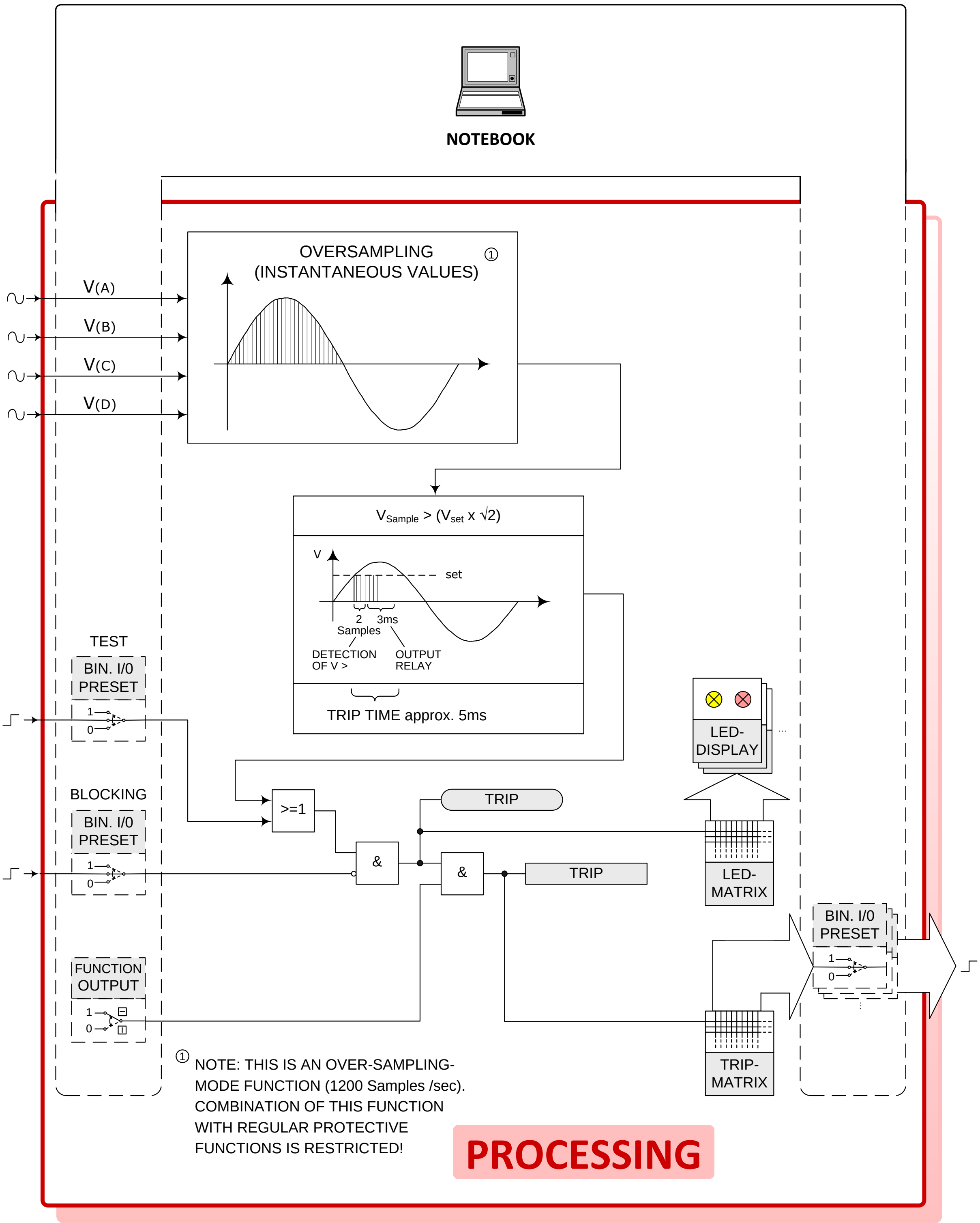
Abb. 289 Def. Time Over-/Under-Voltage: MU111 Voltage 1-PH. 1-ST. Logic Diagram Processing / Legend → for available models: see "Logic Diagram"

21.4.2. MU421



MU421 „VOLTAGE 4-PH 1-ST“ (V>>>) LOGIC DIAGRAM

Fig. 290 MU421 Voltage 4-ph 1-st (V>>>) Logic Diagramm

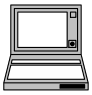


MU421 „VOLTAGE 4-PH. 1-ST.“ (V>>>) LOGIC DIAGRAM PROCESSING

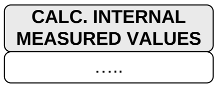
Fig. 291 MU421 Voltage 4-ph 1-st (V>>>) Logic Diagramm Processing

LEGEND PROCESSING

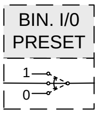
FIRMWARE MODULE: MU421 (DRSLIGHT-File: 1V42)



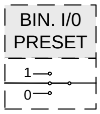
Online simulation via notebook



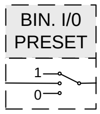
Online-indication of DRS-internal calculated values on notebook-screen



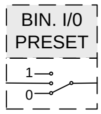
Online-simulation of DIG. IN-/OUTPUTS via notebook:



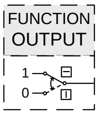
regular function



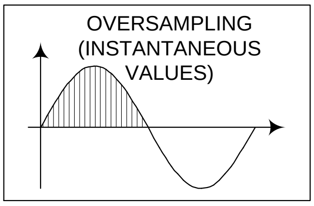
always „1"



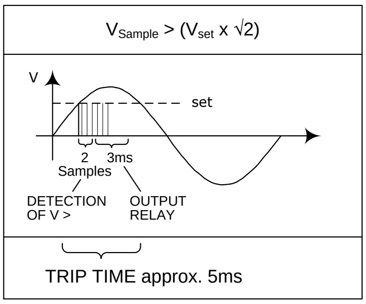
always „0"



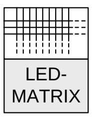
Online-simulation of the FUNCTION OUTPUTS of the protective function MU421
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎕ all FUNCTION OUTPUTS disabled (test-operation)



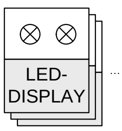
MU421 USES AN OVERSAMPLING MODE (1200 SAMPLES/SEC) IN ORDER TO QUICKEN TRIPPING.



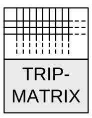
MU421 IS A FAST OPERATING OVERVOLTAGE RELAY WHICH GENERATES A (INTERNAL) TRIP ALREADY AFTER 2 SAMPLES. THERE IS NO ALARM-STAGE. BECAUSE OF THE INCREASED SAMPLE-RATE THE INTERNAL TRIP OCCURS ALREADY AFTER APPROX. 1,7 MS. THE OUTPUT RELAIS ADDITIONALLY NEEDS APPROX. 3 MS.
TOTAL TRIP TIME: 5 MS.



Programmable software-matrix for the LED-indications (row 2...5) of PROCESSING



LED-indications of PROCESSING (row 2...5)



Programmable software-matrix for the output-contacts (OUT1...OUT3)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

TRIP — FUNCTION OUTPUT: Trip (no blocking active)

MU421 „VOLTAGE 4-PH. 1-ST." (V>>>) LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 292 MU421 Voltage 4-ph 1-st (V>>>) Logic Diagramm Processing / Legend

21.5. FUNCTION

21.5.1. MU111/ MU121/ MU311/ MU321

Over/undervoltage time delayed protective functions with a DT characteristic are applied where a suitable time delay for a co-ordinated shut down of the respective plant equipment is necessary in case of over- or undervoltage conditions above or below the pre-set voltage limit values. Besides the normal voltage supervision this also includes special applications such as earth fault protection or interturn faults by generators.

All analogue signals of the function are sampled 12 times each cycle. From the measured results the amplitude of the basic harmonic is considered for each system according to the standard algorithm (Fourier Transformation).
For each sample interval the computed amplitude value is compared with the configured settings (above setting by over evaluation and below setting by under evaluation).
When initiating conditions persist during 24 consecutive samples, i.e. 2 cycles, the instantaneous output is set and the time delay started. After expiry of the set time delay the trip output is activated. The delay is according to the applied DT characteristic independent from the input signal value.
Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

21.5.2. MU421

DRSLIGHT-File:
DRS_1V42

Overvoltage protective function, based on sampled values (not Fourier Analysis), no delay time, instantanuous tripping.
This is a special purpose function. It will trip when 2 samples are above the setting. It will drop off when 254 samples are below the setting. Note: the drop delay ensures a minimum length for the trip-puls given to the circuit breaker.
The sample rate is 1200 samples per second, so the internal tripping time (2 samples) is calculated: 1,66 ms.
The relay output requires approx.. 3 ms to close. In total we get a tripping time of: 1,66 ms + 3 ms.

On/Off-Counter:
On-Counter defines how many samples have to be above the setting in order trip.
Off-Counter defines how many samples have to be below the setting in order to drop off.

Internal settings (not shown at the Function Parameter – table) for On/Off – Counters:
Using DRSWIN:
choose: System
choose: Maintenenance
choose: Function MU421 (U>>>)
Address: 64 … On-Counter (standard setting: 2 samples)
Address: 65 … Off-counter (standard setting: 254 samples); this setting assures a minimum duration of the trip pulse.

Note:

The Disturbance Data File records 1200 Samples/sec. too.

Note:
Because of the special sampling frequency the protection relay MU421 needs its own DRS LIGHT device. It cannot be operated together with standard rate protective functions. Exception: Signal Functions, etc.

The protective function MU421 provides 4 independet channels. Every channel has its own analogue input und trip output.

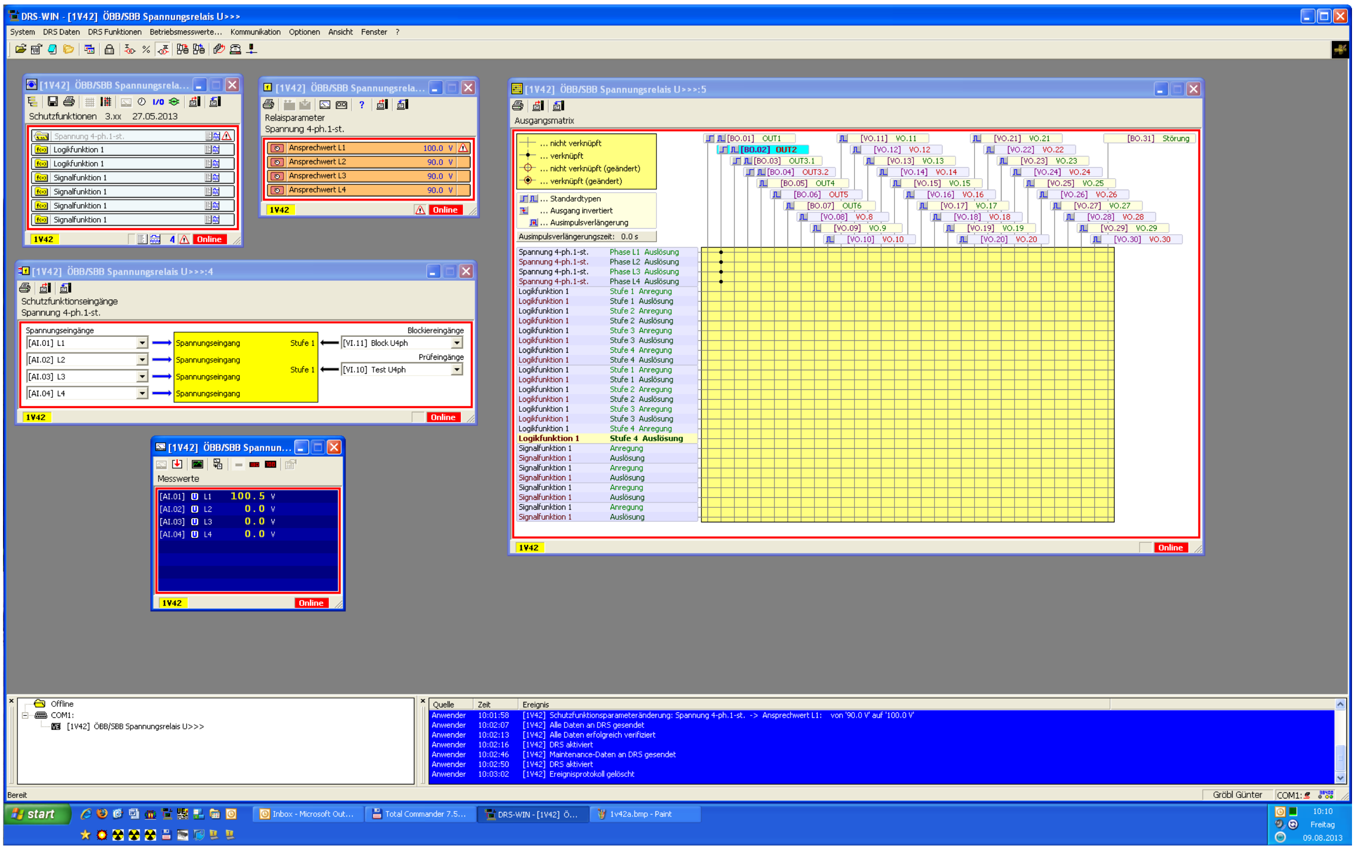
Set Value "Operating Value L1" (… L2/L3/L4):
This is a RMS-value (for easier referencing). The protective function internally will calculate the peak value of this RMS-value. The peak value is used for the trip decision:

Peak = RMS x $\sqrt{2}$

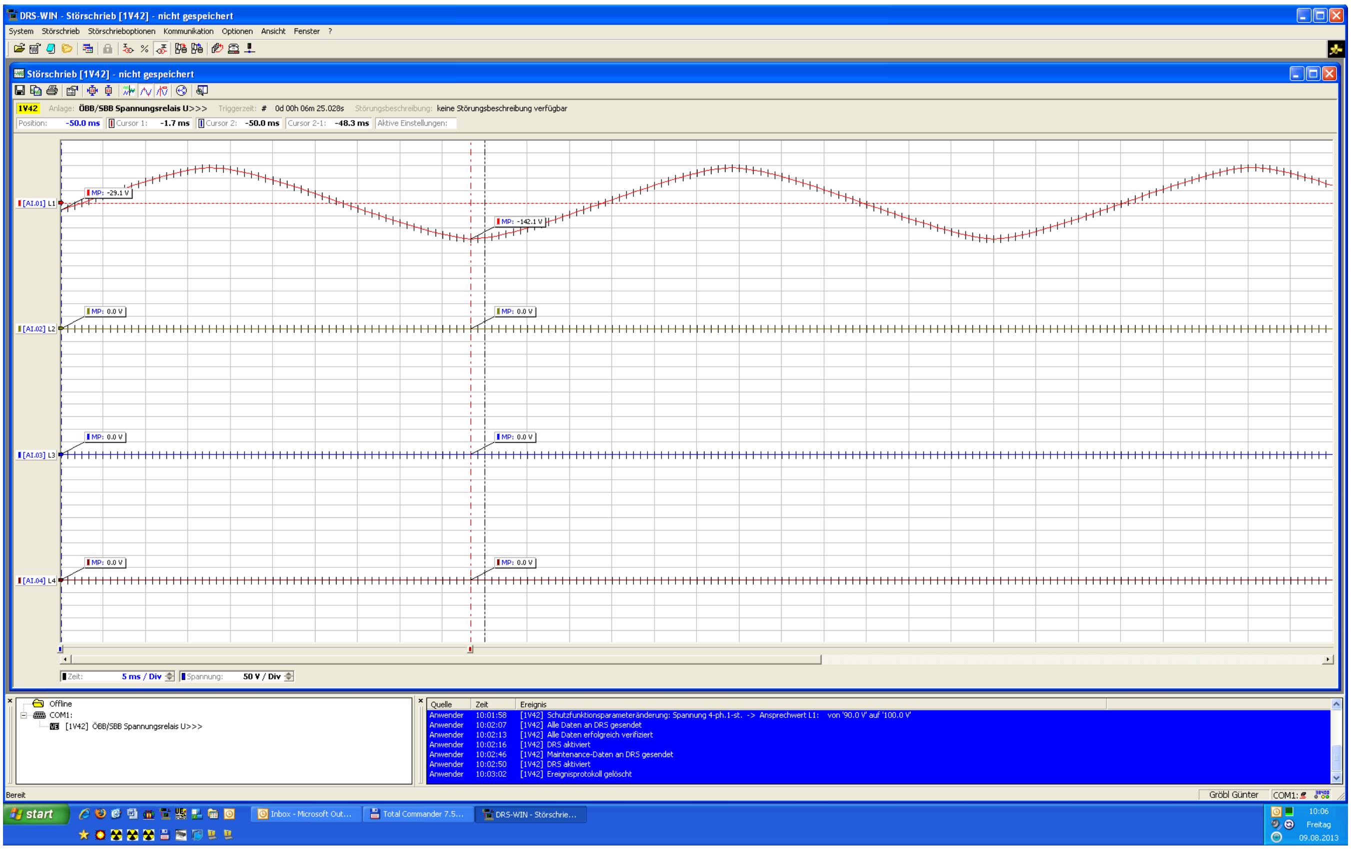
For example:
Set = 100 V RMS
Peak = 141 V
Result:
The function will trip when two sample values are above 141 V.

These features are demonstrated by the following screenshots:

<u>Screenshot no. 1:</u>
DRSWIN // MU421
Please mind: the setting is 100V(RMS!)



<u>Screenshot no. 2:</u>
MU421 // Recorded Curves (History)
Please mind: MU421 trips at 142 V peak (corresponds with setting 100V RMS).



21.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

21.6.1. MU111/ MU121/ MU311/ MU321

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry and the operating value set according to requirements.

The function checks are preferably performed with the primary protected plant being out of service.

The operating value- and time delay parameters are to be set to the designed values (→protection co-ordination requirements).

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

To perform the tests with a relay test set inject the appropriate voltage quantity into, e.g. VT input system 1 and adjust the level to produce operation of the function.

Note the operating value in the commissioning sheets.
Alter the test voltage into the reset direction of the function and record the drop-off value.

Please note that the external measured values can also be viewed in the internal measured value display of the User program.

Carry out the tests for the other systems and/or stages and record the test results into the commissioning sheets.

The trip- and alarm signals and the LED indications should be confirmed according to the relay configuration and the connection diagrams.

With 1.1 times the operating setting value verify the time delay for each phase and/or stage by using a suitable timer and record the measured results in the test sheets.

A test of the configured function blocking input should be done in conjunction with a continuously initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal can be verified without any external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and restored after the tests to the plant setting values according to the plant requirements.

After the checks all temporary setting changes have to be restored to the original values.

Primary Commissioning Tests:

During the primary tests the function of the protective scheme is checked under regular operation.
As far as system conditions permit following tests for the over- or undervoltage protective functions are recommended:

- Open Circuit Tests:

These tests must only be carried out after completion of the primary short circuit- and earth fault tests when generator and the associated plant can safely be excited to nominal voltage.
Block trip outputs of the voltage functions.
Insert measuring instruments into the VT circuits and/or compare the internal measured values of the DRS User program.
Run up the generator to rated speed and manually excite by either raising or lowering the voltage until the respective function operates. For overvoltage functions it is advised to reduce the setting value during the test procedure.
Record the operating values in the test sheets.
For multistage functions repeat the test for each stage as outlined above.
Re-activate the trip outputs of the voltage functions.
If system conditions permit shut down the generator via a live protection trip.

- Load Rejection Tests:

With the generator under full load conditions, i.e. also with maximum inductive load perform a full load rejection by tripping the generator CB.
In this case with the excitation system on auto-control an overvoltage protective function must not produce a trip output otherwise the setting has to be modified according to the generator open circuit excitation characteristic curve.
For primary earth fault test procedures please refer to the relevant documents.

22. MX... OVERFLUXING

22.1. OVERVIEW

List of the Available MX . . . – Protective Functions

Abbreviations:

C2	... DRS-COMPACT2A	
M	... DRS-MODULAR	
L	... DRS-LIGHT	
FNNR	... Function number (VE-internal number of the protective function)	
TYPE	... Function type (short name of the protective function)	
ANSI	... ANSI device number (international protective function number)	

PROTECTIVE FUNCTIONS: MX . . .	FNNR	TYPE	ASNI	Application
Overfluxing protection 2 stage	1035	MX121	81	C2,M,L
Overfluxing protection inverse time	1079	MX125	81	C2,M,L

22.2. TECHNICAL DATA

22.2.1. Overfluxing DT 2 Stage

PROTECTIVE FUNCTION: MX121	FNNR	TYPE	ANSI	Application
Overfluxing protection 2 stage	1035	MX121	81	C2,M,L

Two stage overfluxing function with definite time (DT) V/f evaluation.

MX121
Technical Data

Inputs

Analogue:	Voltage *Note:* *Flux = V/f* *whereby: V … input voltage of this (see above!) channel* *f … frequency of the SYNC – channel (Fourier Analysis)* *Note: For frequency evaluation the SYNC channel of the PROCESSING is always taken. The voltage input only provides the actual voltage signal for the computation of the fluxing level (V/f ratio).* *The SYNC channel and the voltage measuring input need not necessarily be the same.*
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1
	Trip stage 1
	Initiation stage 2
	Trip stage 2

Setting Parameters

Operating value stage 1:	0.8 ... 1,5 in 0.01 steps
Operating time stage 1:	0 ... 300 s in 0.05 s steps
Operating value stage 2:	0.8 ... 1,5 in 0.01 steps
Operating time stage 2:	0 ... 100 s in 0.05 s steps
Nominal voltage:	70 ... 140 V in 1 V steps
Nominal frequency:	16,7 ... 60 Hz in 0.1 Hz steps

Window Display for Relay Internal Determined and Computed Values

Saturation:	In p.u. (referred to the nominal voltage/nominal frequency).

Measuring

Reset ratio:	3% of Set Value "Nominal Voltage" resp. "Nominal Frequency" (note.: U/f = Saturation)
Operating time:	Depending on the frequency shift. *Condition: The SYNC channel must already be active for about 1 s.*
Accuracy:	≤ 0.01 Hz ≤ 2% V_n

22.2.2. Overfluxing Inverse Time

PROTECTIVE FUNCTION: MX125	FNNR	TYPE	ANSI	Application
Overfluxing protection inverse time	1079	MX125	81	C2,M,L

1 phase overfluxing protection with inverse time V/f tripping characteristic.

MX125
Technical Data

Inputs

Analogue:	Voltage Note: Flux = V/f whereby: V … input voltage of this (see above!) channel f … frequency of the SYNC – channel (Fourier Analysis) Note: For frequency evaluation the SYNC channel of the PROCESSING is always taken. The voltage input only provides the actual voltage signal for the computation of the fluxing level (V/f ratio). The SYNC channel and the voltage measuring input need not necessarily be the same.
Binary:	Blocking input stage 1
	Test input stage 1

Outputs

Binary:	Alarm
	Trip

Setting Parameters

Time constant:	1 ... 100 min in 0.5 min steps
Saturation limit:	10 ... 100 % in 1 % steps
Saturation alarm:	25 ... 150 % in 1 % steps
Saturation trip:	25 ... 150 % in 1 % steps
Nominal voltage:	70 ... 140 V in 1 V steps
Nominal frequency:	16,7 ... 60 Hz in 0.1 Hz steps

Window Display for Relay Internal Determined and Computed Values

Saturation:	In p.u. (refered to the nominal voltage/nominal frequency).

Measuring

Reset ratio:	3% of Set Value U resp. f (note.: U/f = Saturation)
Operating time:	Depending on the frequency shift. *Condition: The SYNC channel must already be active for about 1 s.*
Accuracy:	≤ 0.01 Hz ≤ 2% V_n

22.3. CONNECTION DIAGRAMS

22.3.1. MX121

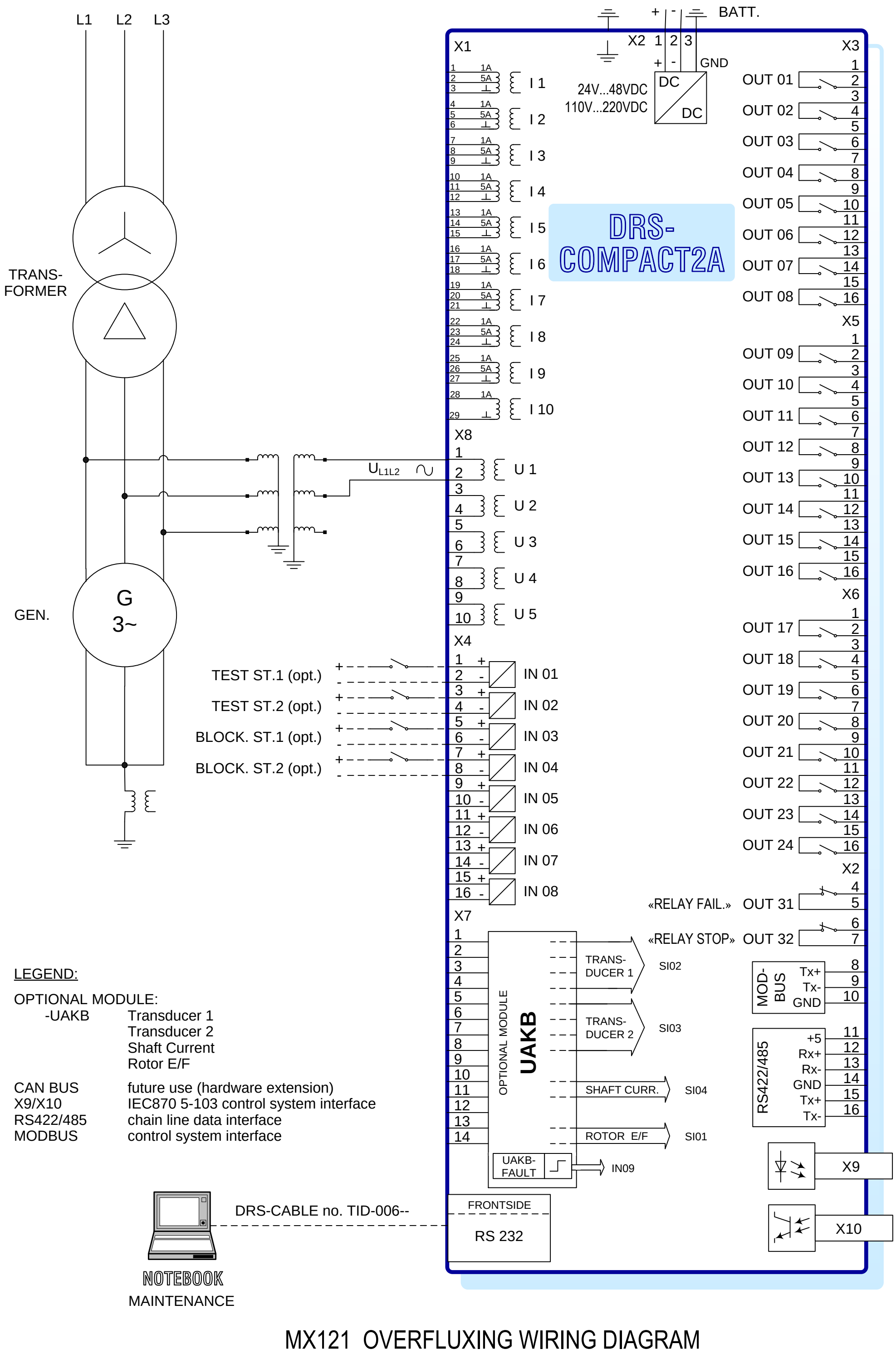


Fig. 293 MX121 Overfluxing Wiring Diagram

22.3.2. MX125

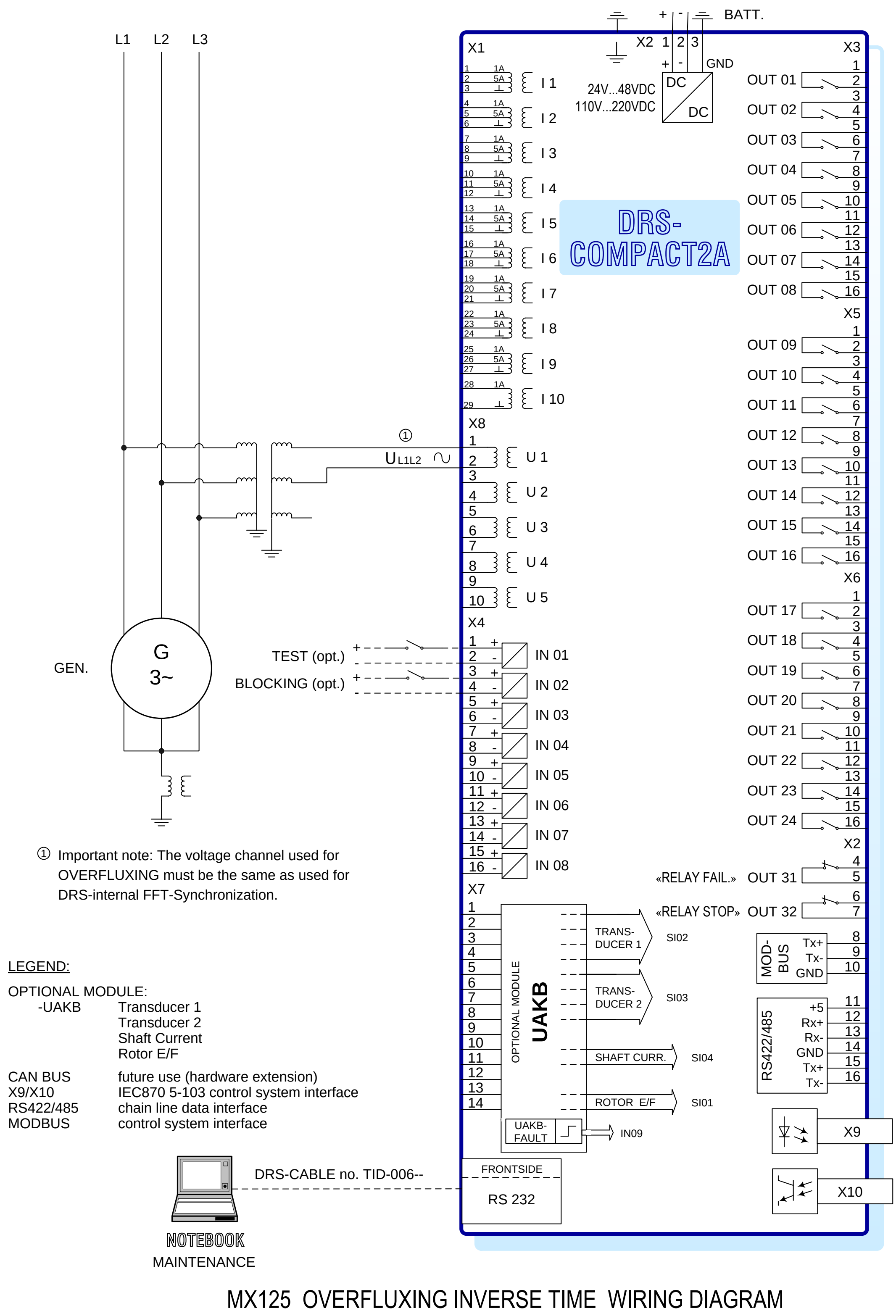


Fig. 294 MX125 Overfluxing Inverse Time Wiring Diagram

22.4. LOGIC DIAGRAMS

22.4.1. MX121

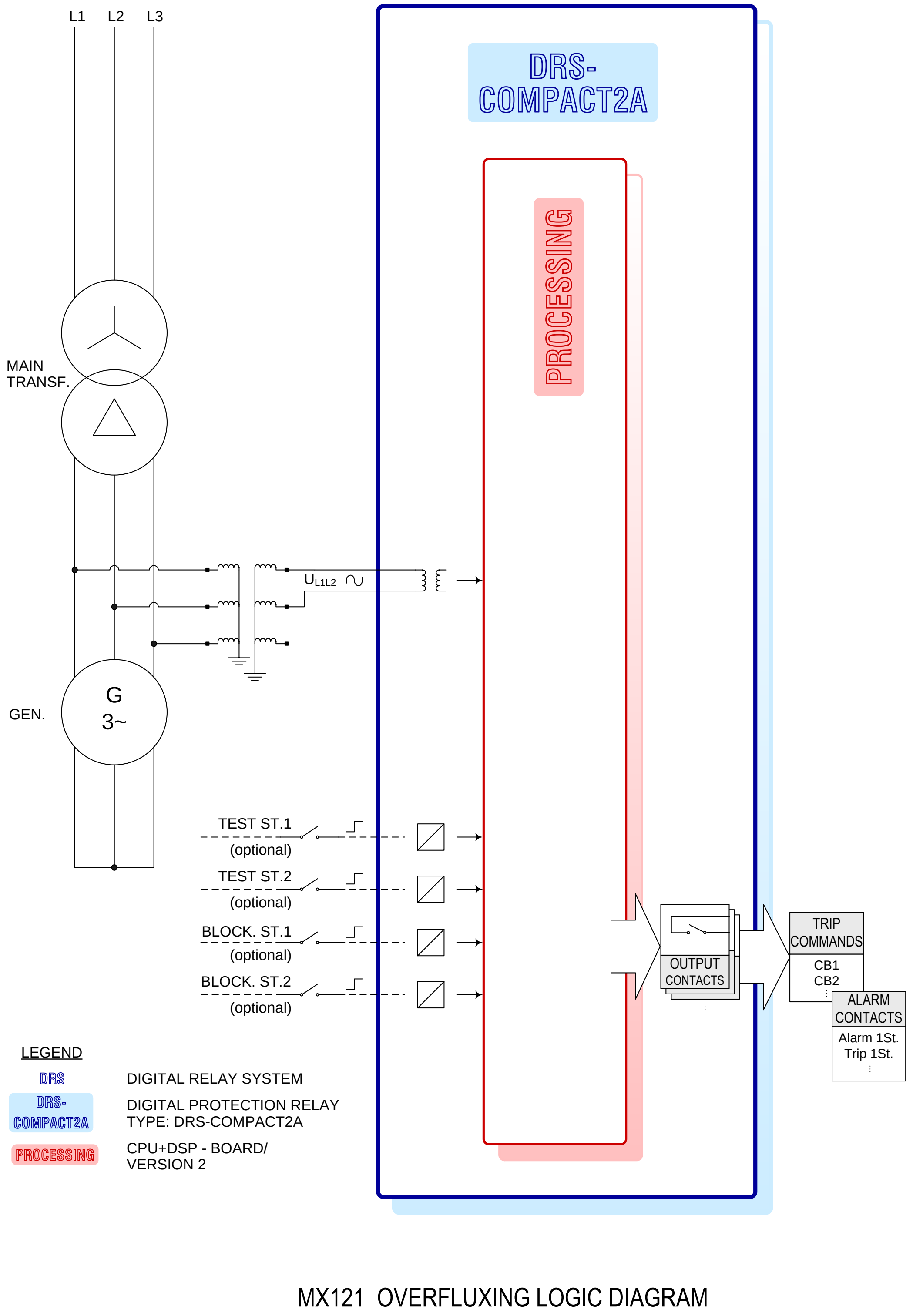
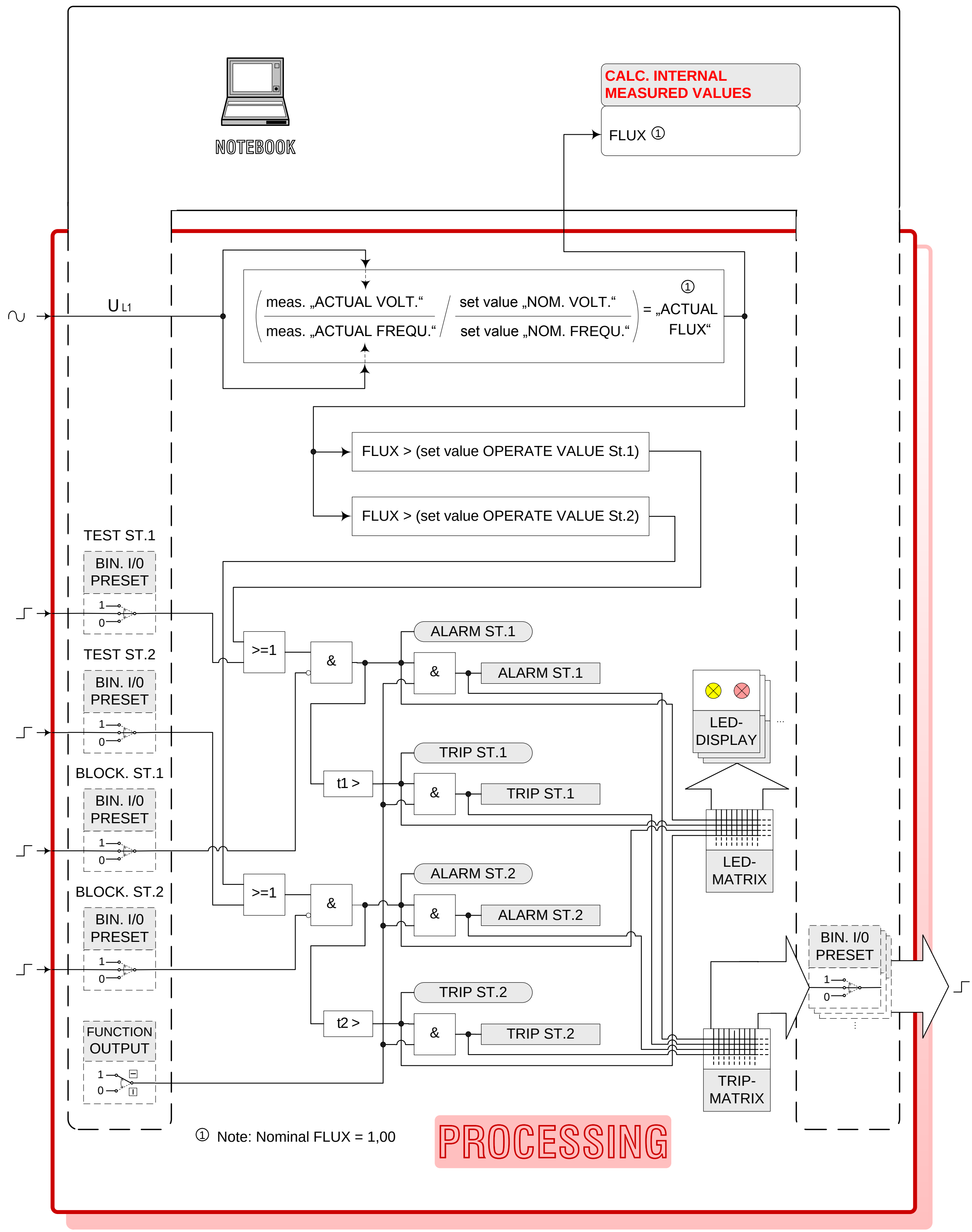


Fig. 295 MX121 Overfluxing Logic Diagram

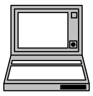


MX121 OVERFLUXING LOGIC DIAGRAM / PROCESSING

Fig. 296 MX121 Overfluxing Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MX121

Symbol	Description
	Online simulation via notebook — CALC. INTERNAL MEASURED VALUES ….. — Online-indication of DRS-internal calculated values on notebook-screen
BIN. I/0 PRESET (1 / 0)	Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"
FUNCTION OUTPUT (1 / 0)	Online-simulation of the FUNCTION OUTPUTS of the protective function MX121 ⊟ all FUNCTION OUTPUTS enabled (regular-operation) ⊡ all FUNCTION OUTPUTS disabled (test-operation)
(meas. „ACTUAL VOLT.“ / meas. „ACTUAL FREQU.“) / (set value „NOM. VOLT.“ / set value „NOM. FREQU.“) = „ACTUAL FLUX“	Calculation of the ACUAL FLUX referred to NOM. FLUX (= 1 p.u.).
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
⊗ ⊗ LED-DISPLAY	LED-indications of PROCESSING (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
ALARM ST.1	(ACTUAL FLUX) > set stage 1
ALARM ST.2	(ACTUAL FLUX) > set stage 2
TRIP ST.1	t1 > set (stage 1)
TRIP ST.2	t2 > set (stage 2)
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MX121 OVERFLUXING LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 297 MX121 Overfluxing Logic Diagram Processing / Legend

22.4.2. MX125

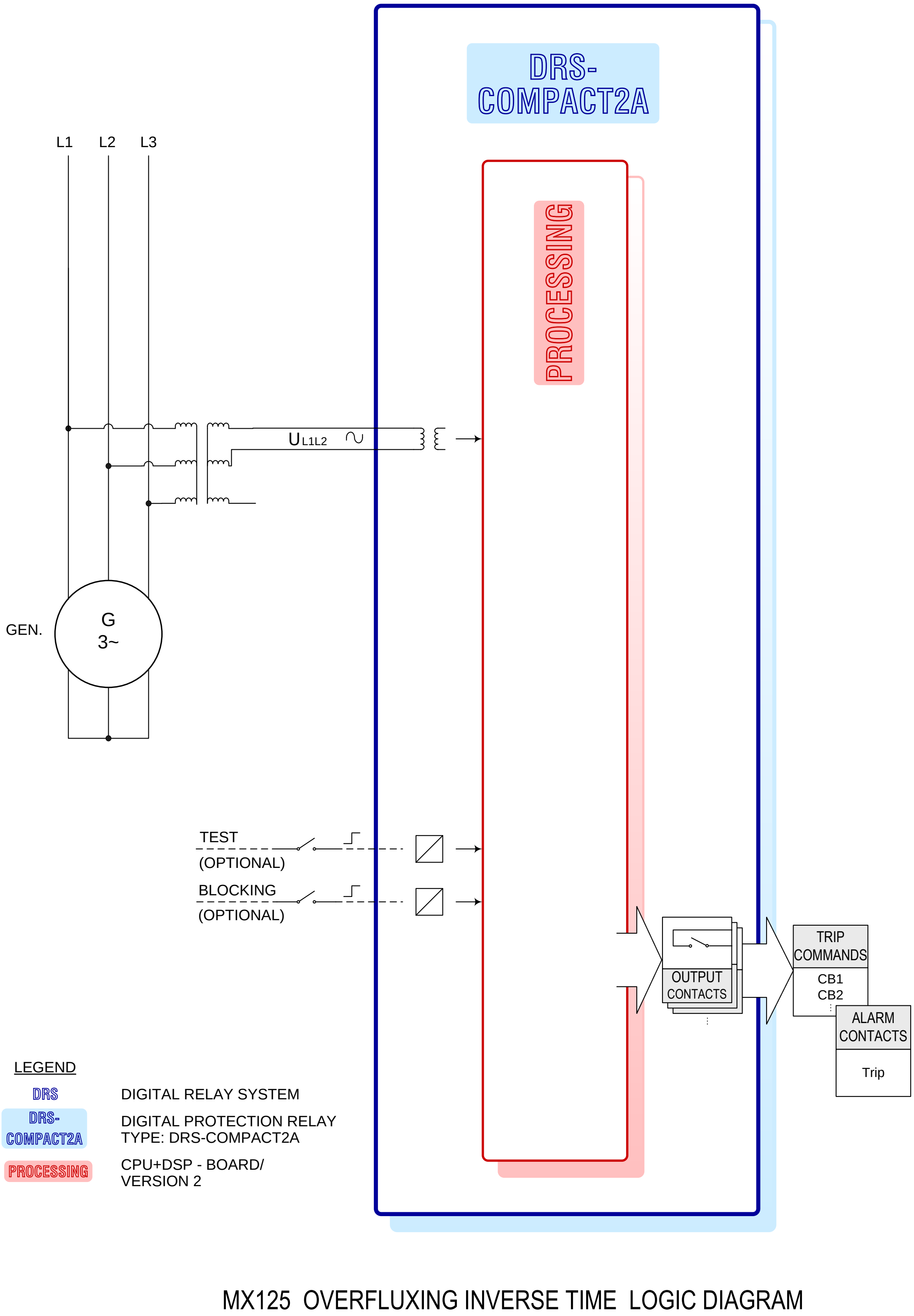
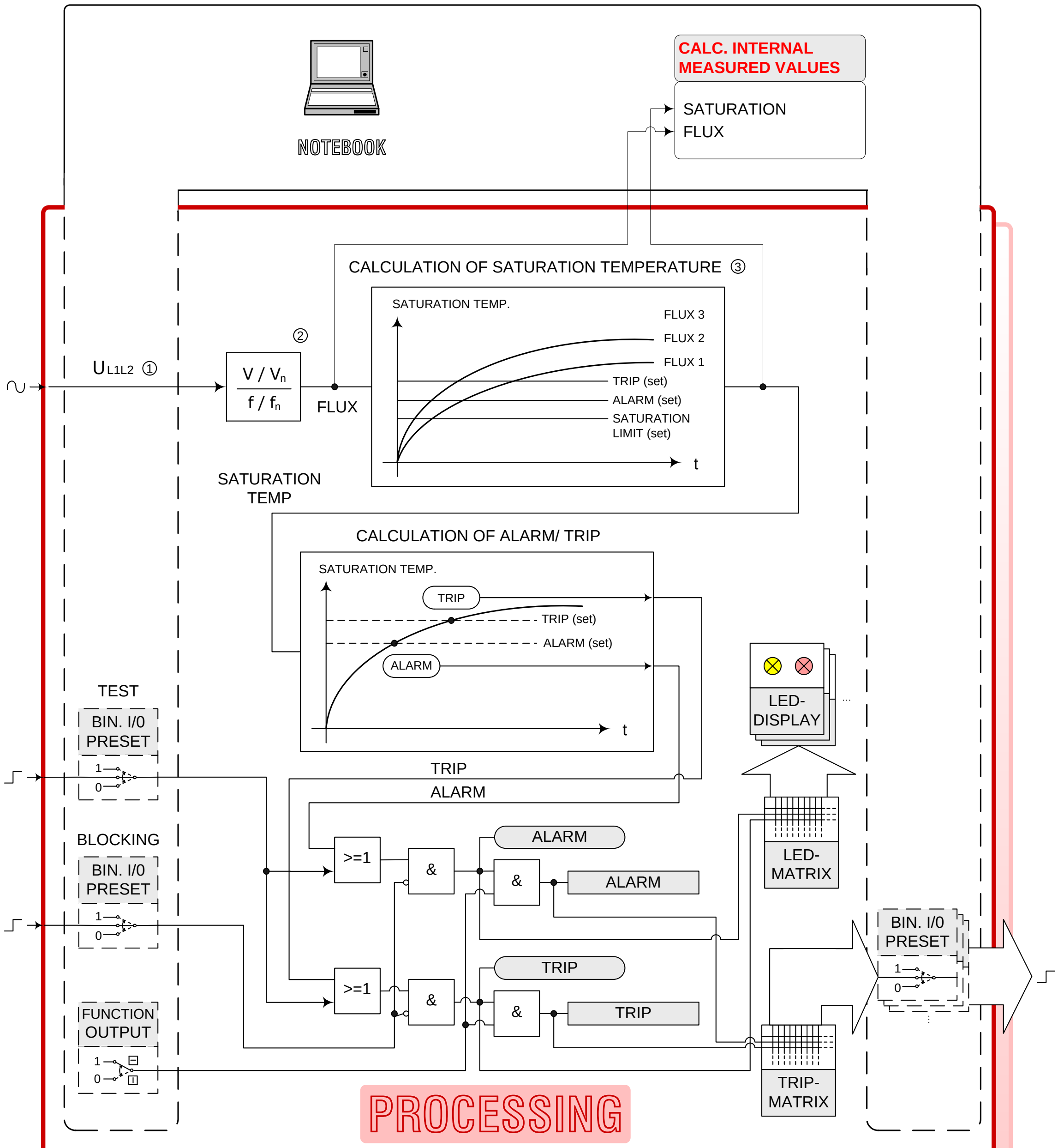


Fig. 298 MX125 Overfluxing Inverse Time Logic Diagram



① $U_{phase\text{-}phase}$ used for saturation detection must be the FFT-synchronising channel (see DRS/ page 0).

② V, f … actual values V$_n$, f$_n$ … nom. values (see settings)

③ SATURATION TEMPERATURE = (SATURATION TEMPERATURE LIMIT) * $(1 - e^{-t / (\text{TIME CONSTANT})})$

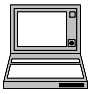
- SATURATION TEMPERATURE: actual saturation temp. in [%] referred to nom. saturation temp. (V$_n$, f$_n$, t = ∞).
- (SATURATION TEMPERATURE LIMIT): set value = final loading for continuous permissible overfluxing in [%] refered to nominal saturation temp. (U$_n$, f$_n$, t = ¥). Note: The setting for „SATURATION (TEMP.) LIMIT" is generally set to 100% (recommended; corresponds with U$_n$, f$_n$, t = ∞).
- $(1 - e^{-t / (\text{TIME CONSTANT})})$: time constant of protected device. This time constant is referred to the set value „SATURATION (TEMP) LIMIT". Note: U$_n$, f$_n$ ® the „SATUR. LIMIT" is reached at t = ∞. See example/ Fig. ..

MX125 OVERFLUXING INVERSE TIME LOGIC DIAGRAM / PROCESSING

Fig. 299 MX125 Overfluxing Inverse Time Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE MODULE: MX125

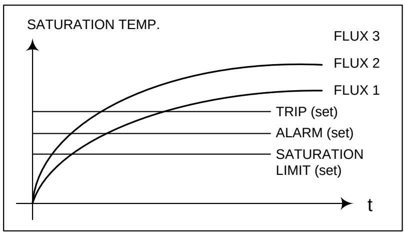


Online simulation via notebook

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MX125
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

V / V_n / f / f_n — Calculation of actual flux [%] referred to nom. values of protected device (V_n, f_n).



Calculation of SATURATION (TEMP.) by using the actual flux (FLUX 1 or FLUX 2 or FLUX 3).

Settings: SATURATION LIMIT: set to 100%
ALARM: acc. gen. manufacturer
TRIP: acc. gen. manufacturer
TIME CONSTANT: acc. gen. manufacturer

LED-MATRIX — Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING

LED-DISPLAY — LED-indications of PROCESSING (row 2...14)

TRIP-MATRIX — Programmable software-matrix for the output-contacts (OUT1...OUT30)

(rounded box) — Denomination of FUNCTION OUTPUTS going to LED-MATRIX

(rectangular box) — Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

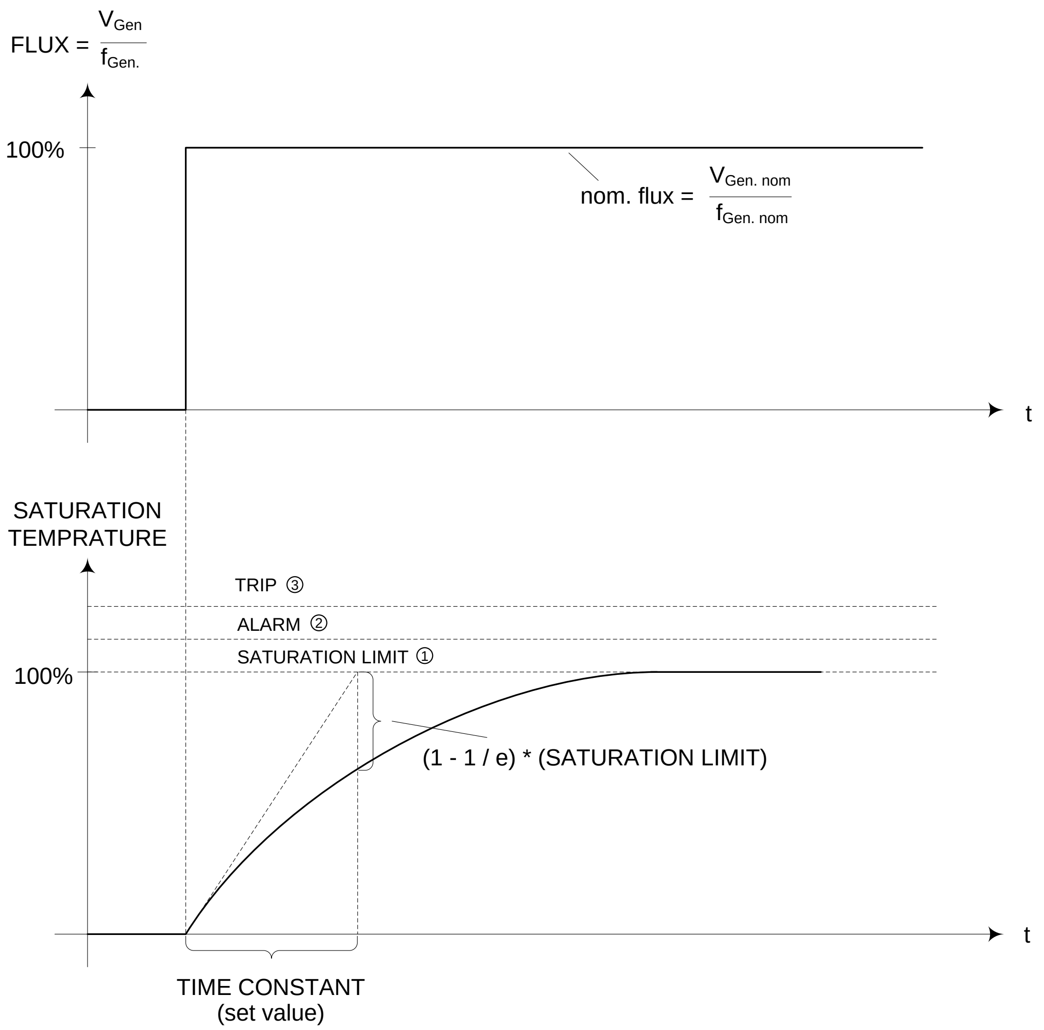
RELEASE — FUNCTION OUTPUT: RELEASE (INTERLOCK IS APPROVED)

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MX125 OVERFLUXING INVERSE TIME LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 300 MX125 Overfluxing Inverse Time Logic Diagram Processing / Legend



LEGEND:

① Recommended standard settings:
SET VALUE „SATURATION LIMIT" is choosen „100% nom. saturation temperature"
(corresponds with $V_{Gen\ nom}$, $f_{Gen\ nom}$, $t = \infty$).
This value is reached at $t = \infty$ at nom. operation of generator or transformer.

② ALARM level:
Example: Generator Volt. Nom. Range: $V_{G\ nom} \pm 5\%$ (assume).
SET VALUE „ALARM": 106%. See note below!

③ TRIP level:
Example: Generator Volt. Nom. Rage: $V_{G\ nom} \pm 5\%$ (assume).
SET VALUE „TRIP": 109% See note below!

②,③ Important note: Set values „Alarm", „Trip", „Time constant" to be correlated with OVERVOLTAGE PROTECTION SETTINGS and with SPECIFICATION of GEN. MANUFACTERER.

MX125 OVERFLUXING INVERSE TIME EXAMPLE FOR STANDARD SETTINGS

Fig. 301 MX125 Overfluxing Inverse Time Example For Standard Settings

22.5. FUNCTION

22.5.1. MX121

Electrical plants such as generators or transformers are designed and rated for a maximum occurring flux density. When the value is exceeded, e.g. due to excitation regulator fault under off-load conditions or power system voltage rise overheating of the machines with resulting damages may occur. For instance, the big increase of the magnetising current with a large higher harmonic component will not only cause overheating of the generator-transformer but will also cause non-permissible induced voltage peaks in the generator rotor circuit.

The overfluxing protection is a single phase function and the voltage input signal is sampled 12 times each cycle. Via the Fourier Transformation the signal voltage level and frequency is determined for each sample interval from which the instant V/f value is computed. This value is compared with the nominal V_N/f_N setting and thus the saturation value S derived according to following formula.

$$S = \frac{V \times f_N}{V_N \times f}$$

For each sample interval the computed amplitude value is compared with the configured settings for each stage and when initiating conditions persist during 13 consecutive samples, i.e. approx. 1 cycle, the instantaneous output for the relevant stage is set and the time delay started. After expiry of the set time delay the corresponding the trip output is activated.

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

22.5.2. MX125

Setting Values:

a)
"Saturation Limit".
Definition: At rated voltage and nominal frequency the flux level after the time constant period is following:
Saturation = (1-1/e) x Saturation Limit.
The saturation limit is given in % of the nominal flux density whereby the nominal flux density at rated voltage is theoretically approached asymptotic after an infinite time.
Caution: Also the “Permissible Saturation Limit“ is independent from the function setting approaching the permissible flux after an infinite time!!
Example: When a "Saturation Limit" setting is chosen to be 50% than the flux loading value is also increasing correspondingly slower and will reach the 50% setting after an infinite approach.

b)
"Saturation Alarm": Is given as a %-age value of the nominal saturation limit (see (a)).

c)
"Saturation Trip": Is given as a %-age value of the nominal saturation limit (see (a)).

Display Window (Notebook):

"Saturation Load" ... Time integral over the flux saturation.
"Saturation" ... $= (V/V_n)/(f/f_n)$, whereby: V ... Voltage; f ... Frequeny.

22.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

22.6.1. MX121

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry and the operating value set according to requirements.

The function checks are preferably performed with the primary protected plant being out of service.

The operating value- and time delay parameters are to be set to the designed values
(→protection co-ordination requirements).

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

With a suitable relay test set or alternatively an external voltage source having a multimeter also with frequency evaluation connected parallel to the respective voltage input inject rated voltage
with nominal frequency.
Compare the instrument readings with the DRS “Internal Measured Values“ of the PROCESSING Control Unit whereby the internal saturation indication should show a value of “1“.
Raise the test voltage up to the operating value of the function and record the result in the
“Nominal Frequency Test“ column of the test sheets.
The function reset value is obtained by reducing the input voltage and the result should be recorded as above.
At nominal voltage input the frequency is lowered to produce initiation of Stage 1 and by raising the frequency again the function reset value is determined.
Both frequency values should be recorded in the commissioning test sheets.
During all tests the internal “Saturation“ measured values has to be observed and by substituting
the results into the above formula verified by calculation.

Stage 2 should also be tested as outlined above.

The trip- and alarm signals and the LED indications should be confirmed according to the relay configuration and the connection diagrams.

With 1.5 times the operating setting value verify the time delay for both stages by
using a suitable timer and record the measured results in the test sheets.

A test of the configured function blocking input should be done in conjunction with a continuously initiated trip signal whereby the trip signal is has to reset.

Checking of the configured relay test input by applying a test signal can be verified without any
external initiation.

Please note that during tests of the described protective function other functions may be operating when not previously blocked via the software according to the User application and after these tests the original parameter settings have to be set to the original values and
restored according to the plant requirements

Primary Commissioning Tests:

During the primary tests the function of the protective scheme is checked under regular operating conditions.
As far as system conditions permit following tests for the protective function is recommended:

-Open circuit tests:

Block trip outputs of the overfluxing protection.
Insert a multimeter with frequency evaluation capabilities to the VT input.
Run up generator to rated speed and manually excite off-load to rated voltage.
By lowering the speed and/or increasing the voltage verify the initiating limits of the protective function.
The saturation value is displayed in the internal measured values of the function.
Note the operating values and the corresponding voltages into the commissioning sheets.
Check that the configured saturation level stays within the permissible values.
When system conditions permit shut down the generator unit via a live trip.

22.6.2. MX125

With the aid of the "Internal Measured Values" window display the correct function behaviour can simply be confirmed during normal system operation.
At rated voltage and nominal frequency the saturation level shows 100 %.
The “Saturation Burden“ is described in the PROCESSING logic diagrams.

23. MY... ENERGISING FUNCTION

23.1. OVERVIEW

List of the Available MY . . . – Protective Functions

Abbreviations:	C2	... DRS-COMPACT2A
	M	... DRS-MODULAR
	L	... DRS-LIGHT
	FNNR	... Function number (VE-internal number of the protective function)
	TYPE	... Function type (short name of the protective function)
	ANSI	... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MY 111	**FNNR**	**TYPE**	**ANSI**	**Application**
Energising function	1097	MY111		C2,M,L

23.2. TECHNICAL DATA

PROTECTIVE FUNCTION: MY111	FNNR	TYPE	ANSI	Application
Energising function	1097	MY111		C2,M,L

Single – Phase Transformer energizing: Close CB main contacts at voltage peak (Minimisation of Inrush Current).

MY111
Technical Data

Inputs

Analogue:	Measuring voltage R-T (16 2/3 Hz system). Note: this voltage will be used for calculating the CB close command for the transformer; the system frequency will be derived from the SYNC-channel. It is recommended to use the same voltage for both purposes (if suitable).
	Rotor current (AC side)
	Generator voltage L1-L3
Binary:	Blocking input
	Test input
	CB close command

Outputs

Binary:	Operation interlock
	Preventive interlock
	Closing without reference voltage

Setting Parameters

Minimum voltage:	50 ... 100 V in 1 V steps
Maximum voltage:	100 ... 140 V in 1 V steps
Time delay:	0 ... 170 ms in 5 ms steps

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% V_n
Accuracy of CB close command (timing):	typ. +/- 2,5 ms, max. 5 ms. Note: Frequency = 16 2/3 Hz.

23.3. CONNECTION DIAGRAMS

23.3.1. MY111

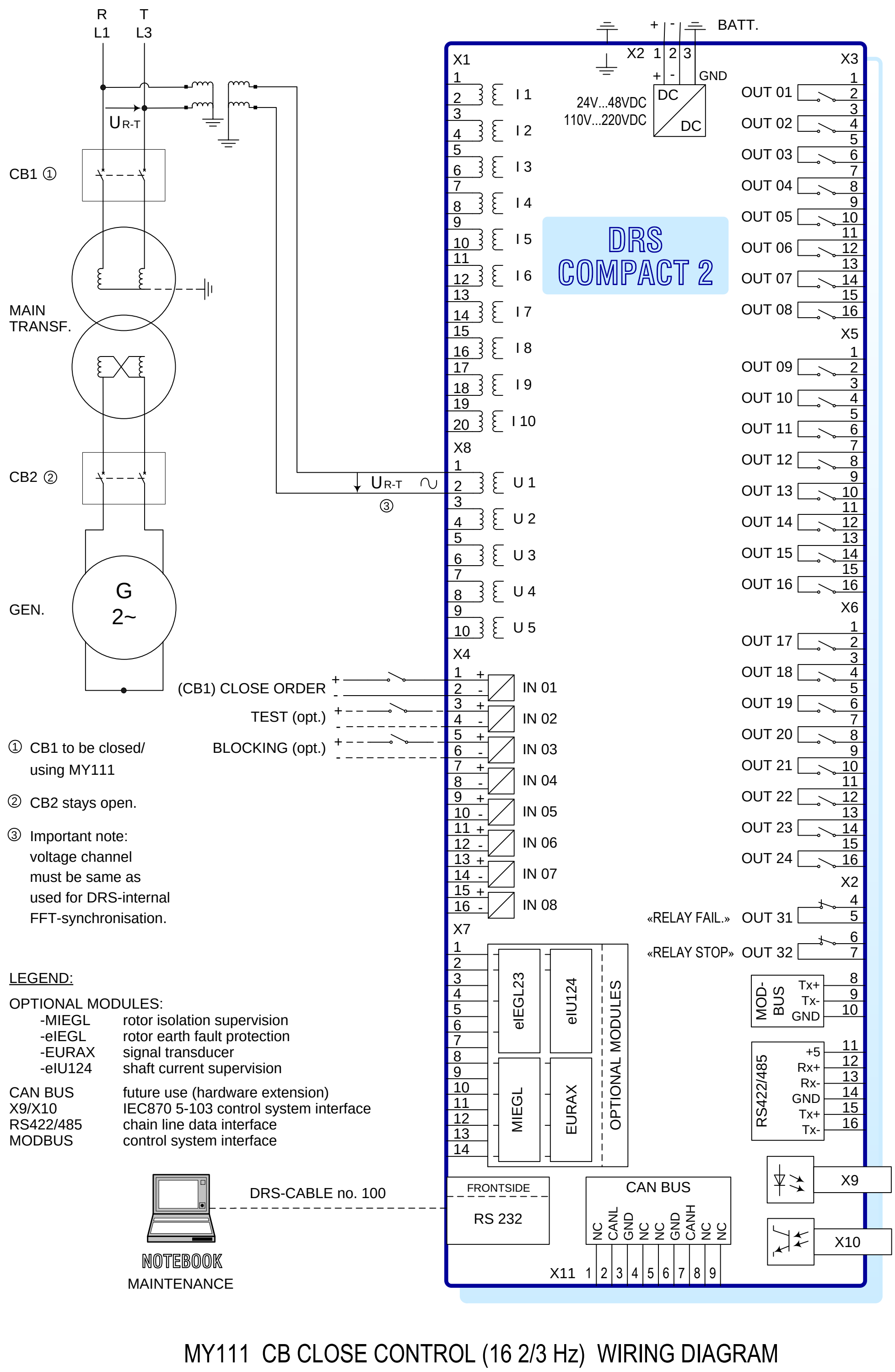


Fig. 302 MY111 CB Close Control (16 2/3 Hz) Wiring Diagram

23.4. LOGIC DIAGRAMS

23.4.1. MY111

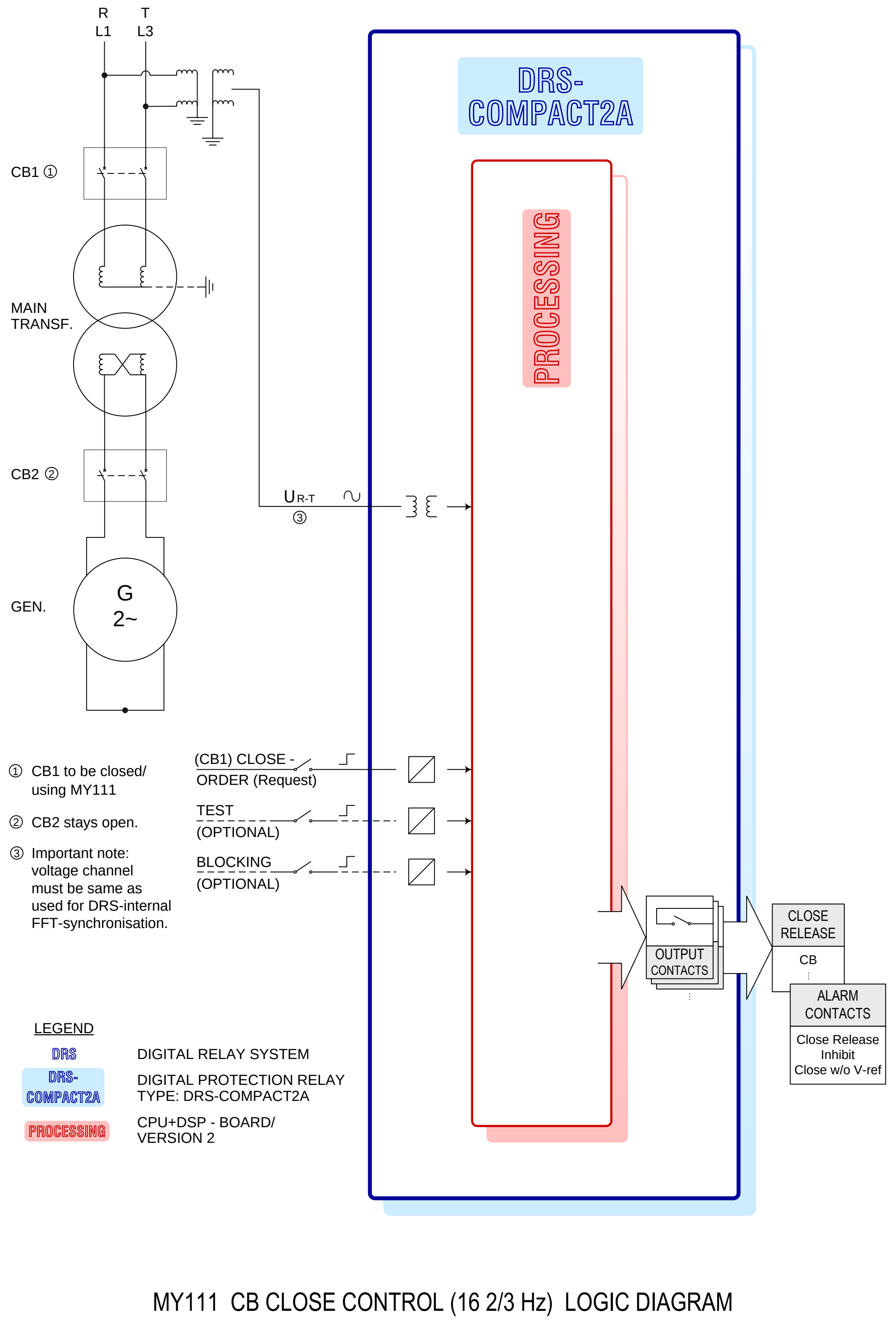
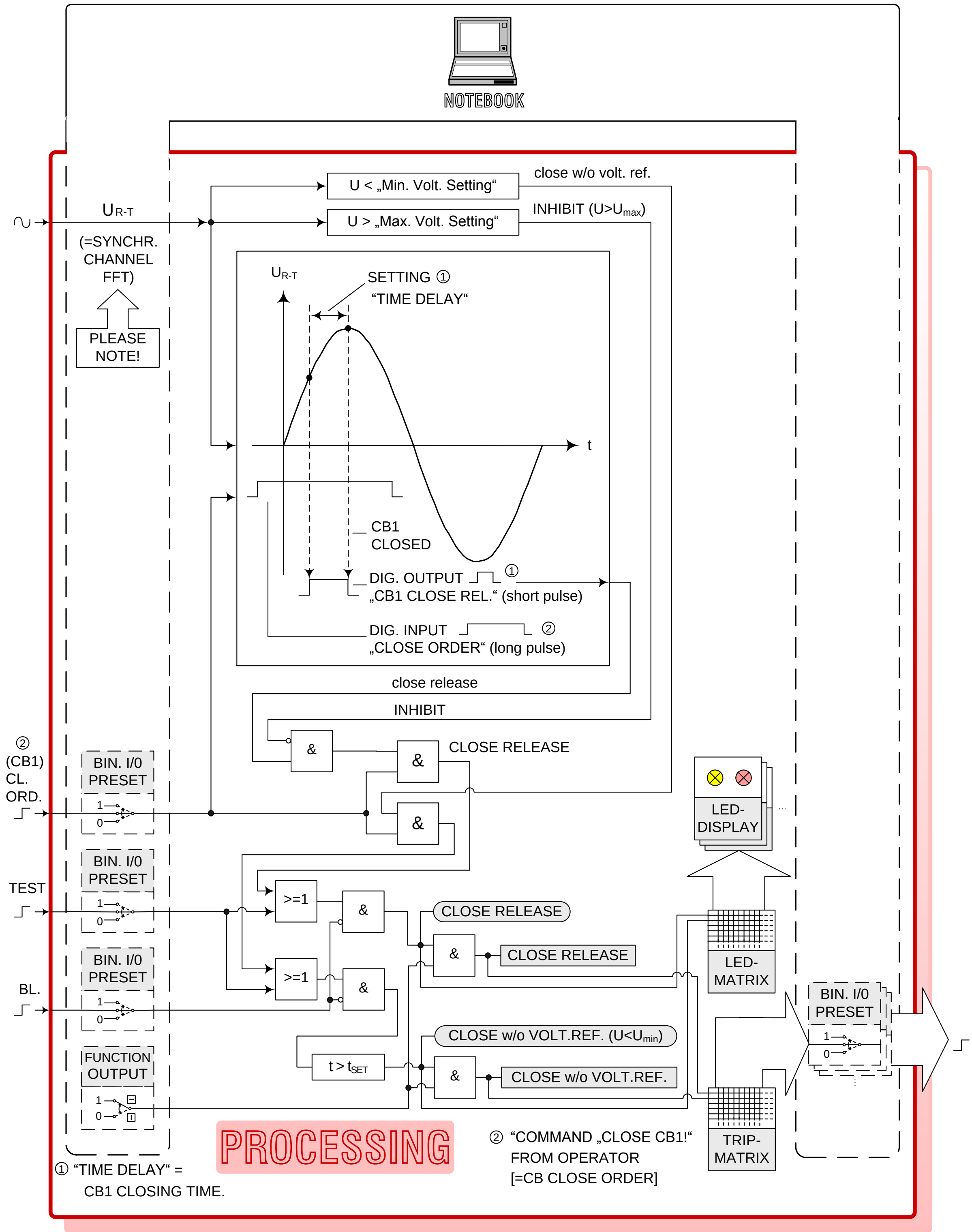


Fig. 303 MY111 CB Close Control (16 2/3 Hz) Logic Diagram



Note: not shown in diagram: Output „Inhibit“.

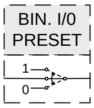
MY111 CB CLOSE CONTROL (16 2/3 Hz) LOGIC DIAGRAM PROCESSING

Fig. 304 MY111 CB Close Control (16 2/3 Hz) Logic Diagram Processing

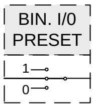
LEGEND PROCESSING

FIRMWARE-MODULE: MY111

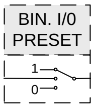
Online simulation via notebook



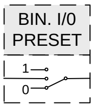
Online-simulation of DIG. IN-/OUTPUTS via notebook:



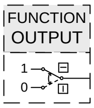
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MY111

- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎕ all FUNCTION OUTPUTS disabled (test-operation)

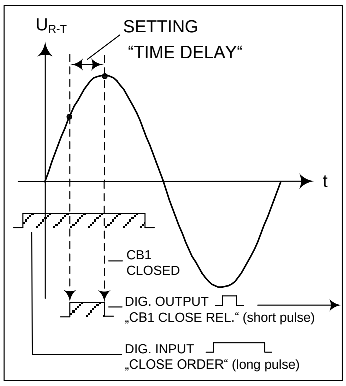
U < „Min. Volt. Setting“ — In case the measured voltage is smaller than the set value „Min. Volt. Setting“ and the input „ CLOSE ORDER“ is active then the command „CLOSE w/o VOLT. REF“ is generated.

U > „Max. Volt. Setting“ — The „CLOSE ORDER“-output is blocked if the measured voltage is too high.

U_{R-T} — Voltage between phase R and phase T (2-phase system!).
This voltage must be used DRS-internal for FFT-synchronisation too!
Please check (DRS PROCESSING page 0)!

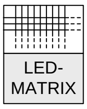
CLOSE ORDER — Digital input signal, coming from plant control.

CLOSE RELEASE
CLOSE w/o VOLT. REF. — Digital output signals, going to „CB ON-COIL“.

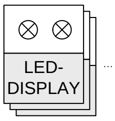


„TIME DELAY“ setting.
„close release“ has to be given in advance in order to compensate for the CB closing time.
Please calculate this setting by using the recorded curves-feature.

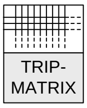
CB closing procedure is finished exactly when the voltage reaches the amplitude (= max. elongation).
Result: „Transformer Inrush Current“ is minimized.



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

> — Type of function: over-detection (actual value > set value)

< — Type of function: under-detection (actual value < set value)

MY111 CB CLOSE CONTROL (16 2/3 Hz) LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 305 MY111 CB Close Control (16 2/3 Hz) Logic Diagram Processing / Legend

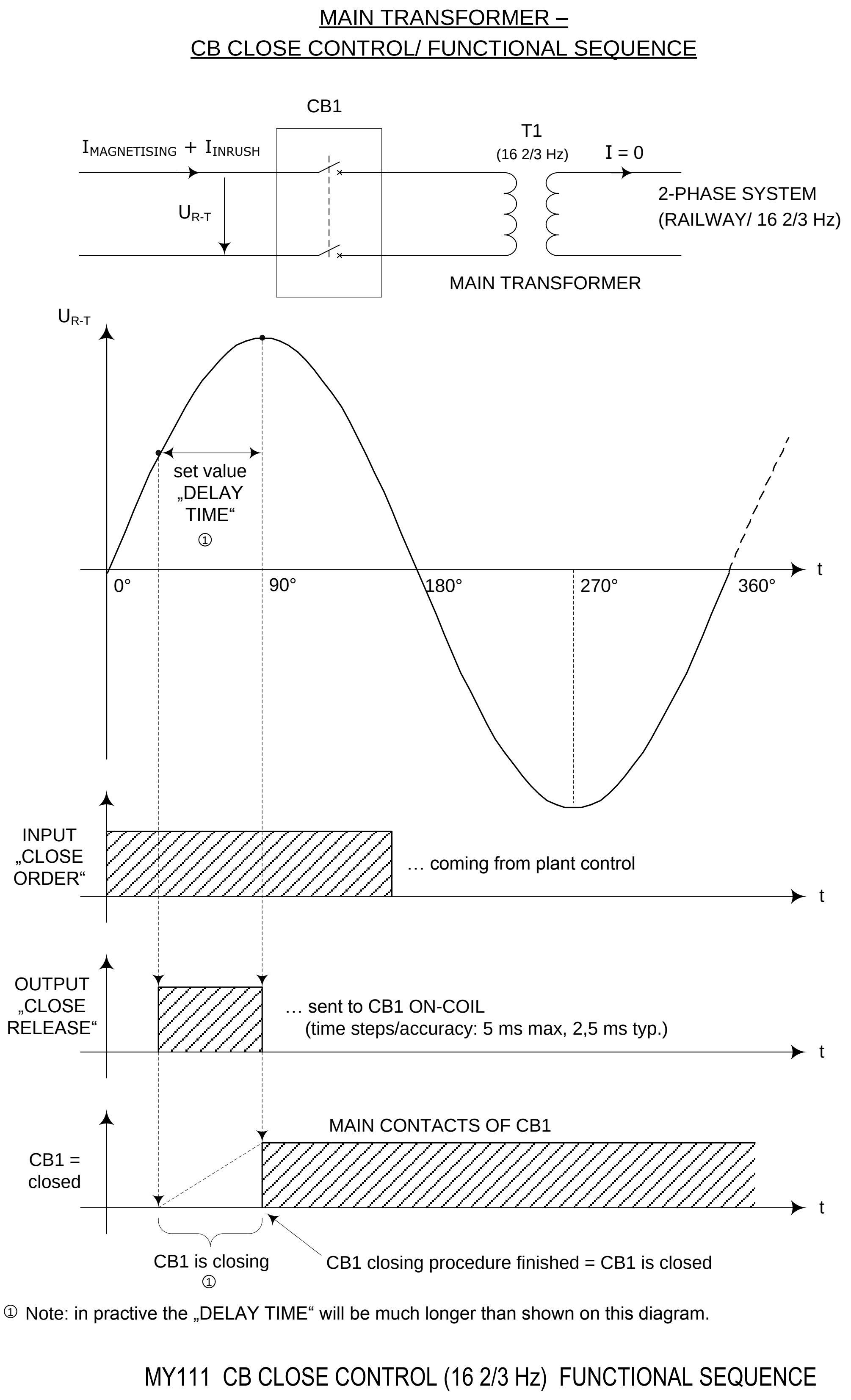


Fig. 306 MY111 CB Close Control (16 2/3 Hz) Functional Sequence

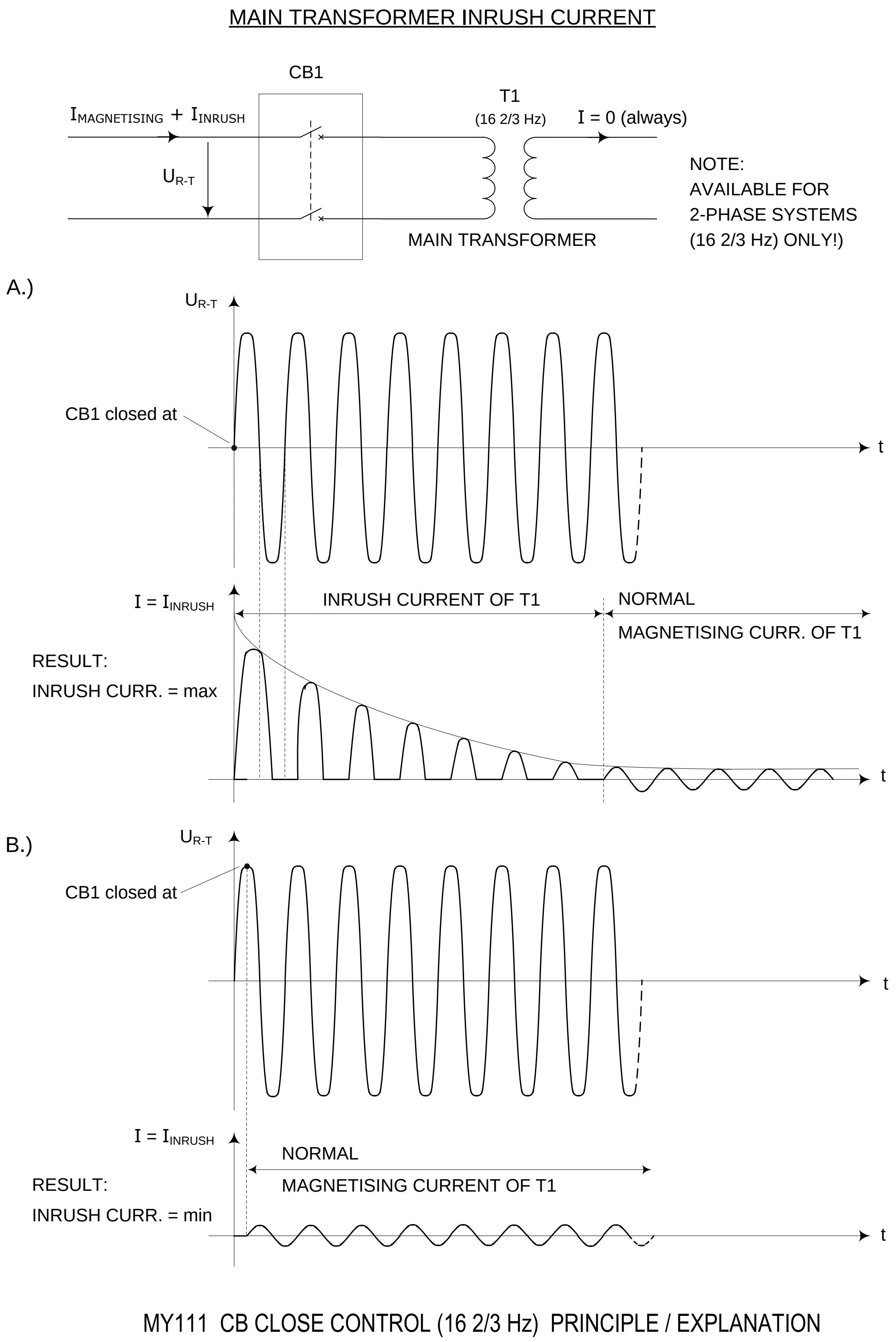


Fig. 307 MY111 CB Close Control (16 2/3 Hz) Principle / Explanation

23.5. FUNCTION

23.5.1. MY111

Application of this function: For railway traction systems / 16 2/3 Hz/ 2 phase.
Note: Railway systems are generally not earthed at the LV side and are 2 phase floating systems whereas at the HV side one phase is connected to ground.
The function is monitoring the phase to phase voltages of this system.
Please note that this particular protective function may not be applied for 50 Hz systems and not for three phase systems.

Function operating sequence:
The function is energising the single phase transformer at the instant of 90° phase to phase voltage.
Note: At 16 2/3 Hz the sample interval the measured values is about 5 ms (Fourier Analysis) whereby the function is normally selecting the sample close to the voltage maximum value.

Also the function is switching-on the transformer at a V = 0 value after exactly one sample after request.

Operating logic:

$V>V_{max}$: “Interlock“
$V_{min}<V<V_{max}$: Switch-on at voltage maximum of phase to phase voltage.
$V<V_{min}$: Interlock disable without reference voltage whereby after 1 sample the CB closing command is initiated.

23.6. COMMISSIONING

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

23.6.1. MY111

Several repeated energising test of the transformer have to be carried out to verify the correct performance of the DRS Energising Function to verify the correct performance with the aid
of the DRS Recorded Curves feature, i.e. “Internal Recorded Curves”.
But most important: Please observe the transformer design rating.
Note: The MY111 parameter "Function Initiates Fault Record" has to be configured.

24. MZ... MINIMUM IMPEDANCE / UNDERVOLTAGE - OVERCURRENT / . VOLTAGE RESTRAINT OVERCURRENT

24.1. OVERVIEW

List of the Available MZ . . . – Protective Functions

Abbreviations:

C2 ... DRS-COMPACT2A
M ... DRS-MODULAR
L ... DRS-LIGHT
FNNR ... Function number (VE-internal number of the protective function)
TYPE ... Function type (short name of the protective function)
ANSI ... ANSI device number (international protective function number)

PROTECTIVE FUNCTIONS: MZ . . .	FNNR	TYPE	ANSI	Application
Minimum impedance protection with circular characteristic, 2-phase, 2-stage, separate outputs Note: Preferred function is MZ222 with common outputs.	1026	MZ221	21	C2,M
Minimum impedance protection with circular characteristic, 2-phase, 2-stage with common outputs Note: MZ222 is preferred to MZ221 since common outputs	1059	MZ222	21	C2,M,L
Minimum impedance protection with circular characteristic, 3-phase, 2-stage with separate outputs Note: MZ322 is preferred to MZ321 since common outputs	1025	MZ321	21	C2,M
Minimum impedance protection with circular characteristic, 3-phase, 2-stage, with common outputs Note: MZ322 is preferred to MZ321 since common outputs	1058	MZ322	21	C2,M,L
Undervoltage Overcurrent, 3-phase	1074	MZ311	51/27	C2,M
Compound Voltage Overcurrent (I_1>) .AND. ((V_1<) .OR. (V_2>)), 3-phase, whereby: U_1 ... Pos. Phase Sequ. System Voltage U_2 ... Neg. Phase Sequ. System Voltage I_1 ... Pos. Phase Sequ. System Current	1095	MZ312	51/27	C2,M

24.2. TECHNICAL DATA

24.2.1. Minimum Impedance Circular Characteristic, 2 phase, 2 stage - separate output

PROTECTIVE FUNCTION: MZ 221	FNNR	TYPE	ANSI	Application
Minimum impedance protection with circular characteristic, 2-phase, 2-stage, separate outputs	1026	MZ221	21	C2,M

Minimum impedance function (Z<t) and overcurrent function (I>t) for two-phase systems, with separate outputs.

MZ221
Technical Data:

Inputs

Analogue:	Current input system 1 phase L1
	Current input system 2 phase L2
	Voltage input system 1
	Voltage input system 2
Binary:	Blocking input stage 1 (Z<t)
	Blocking input stage 2 (I>t)
	Test input stage 1 (Z<t)
	Test input stage 2 (I>t)

Outputs

Binary:	Initiation stage 1, stage 1 (Z<t)
	Trip stage 1, stage 1 (Z<t)
	Initiation stage 2, stage 1 (Z<t)
	Trip stage 2, stage 1 (Z<t)
	Initiation L1, stage 2 (I>t)
	Trip L1, stage 2 (I>t)
	Initiation L2, stage 2 (I>t)
	Trip L2, stage 2 (I>t)

Setting Parameters

Operating value stage 1 (impedance):	0.1 ... 30.0 Ohm in 0.1 Ohm steps
Operating value stage 2 (current interlock + overcurrent):	0.1 ... 5.0 x I_n in 1% steps
Time delay stage 1:	0 ... 30 seconds in 0.05 sec steps
Time delay stage 2:	0 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Impedance system 1	in Ohm
Impedance system 2	in Ohm

Measuring

Reset ratio:	1.03
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% of current value
	≤ 6% of impedance setting value

24.2.2. Minimum Impedance Circular Characteristic, 2 Phase, 2 Stage -common output

PROTECTIVE FUNCTION: MZ 222	FNNR	TYPE	ANSI	Application
Minimum impedance protection with circular characteristic, 2-phase, 2-stage with common outputs	1059	MZ222	21	C2,M,L

Minimum impedance function (Z<t) and overcurrent function (I>t) for two-phase systems with common outputs.

MZ222
Technical Data:

Inputs

Analogue:	Current input system 1 phase L1
	Current input system 2 phase L3
	Voltage input system 1
	Voltage input system 2
Binary:	Blocking input stage 1
	Blocking input stage 2
	Test input stage 1
	Test input stage 2

Outputs

Binary:	Initiation stage 1 (Z<t)
	Trip stage 1 (Z<t)
	Initiation stage 2 (I>t)
	Trip stage 2 (I>t)

Setting Parameters

Operating value stage 1 (impedance):	0.1 ... 30.0 Ohm in 0.1 Ohm steps
Operating value stage 2 (current interlock + overcurrent):	0.1 ... 5.0 x I_n in 1% steps
Time delay stage 1:	0 ... 30 seconds in 0.05 sec steps
Time delay stage 2:	0 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Impedance system 1	in Ohm
Impedance system 2	in Ohm

Measuring

Reset ratio:	1.03
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% of current value
	≤ 6% of impedance setting value

24.2.3. Minimum Impedance Circular Characteristic, 3 Phase, 2 Stage -separate output

PROTECTIVE FUNCTION: MZ 321	FNNR	TYPE	ANSI	Application
Minimum impedance protection with circular characteristic, 3-phase, 2-stage with separate outputs	1025	MZ321	21	C2,M

Minimum impedance function (Z<t) and overcurrent function (I>t) for three-phase systems, with separate outputs.

MZ321
Technical Data:

Inputs

Analogue:	Current input system 1 phase L1
	Current input system 2 phase L2
	Current input system 3 phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Blocking input stage 1 (Z<t)
	Blocking input stage 2 (I>t)
	Test input stage 1 (Z<t)
	Test input stage 2 (I>t)

Outputs

Binary:	Initiation stage 1, stage 1 (Z<t)
	Trip stage 1, stage 1 (Z<t)
	Initiation stage 2, stage 1 (Z<t)
	Trip stage 2, stage 1 (Z<t)
	Initiation stage 3, stage 1 (Z<t)
	Trip stage 3, stage 1 (Z<t)
	Initiation L1, stage 2 (I>t)
	Trip L1, stage 2 (I>t)
	Initiation L2, stage 2 (I>t)
	Trip L2, stage 2 (I>t)
	Initiation L3, stage 2 (I>t)
	Trip L3, stage 2 (I>t)

Setting Parameters

Operating value stage 1 (impedance):	0.1 ... 20.0 Ohm in 0.1 Ohm steps
Operating value stage 2 (current interlock + overcurrent):	0.1 ... 5.0 x I_n in 1% steps
Time delay stage 1:	0 ... 30 seconds in 0.05 sec steps
Time delay stage 2:	0 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Impedance system 1	In Ohm
Impedance system 2	In Ohm
Impedance system 3	In Ohm

Measuring

Reset ratio:	1.03
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current value
	≥ 6% of impedance setting value

24.2.4. Minimum Impedance Circular Characteristic, 3 Phase, 2 Stage -common output

PROTECTIVE FUNCTION: MZ322	FNNR	TYPE	ANSI	Application
Minimum impedance protection with circular characteristic, 3-phase, 2-stage, with common outputs	1058	MZ322	21	C2,M,L

Minimum impedance function (Z<t) and overcurrent function (I>t) for three-phase systems, with common outputs.

MZ322
Technical Data:

Inputs

Analogue:	Current input system 1 phase L1
	Current input system 2 phase L2
	Current input system 3 phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Blocking input stage 1 (Z<t)
	Blocking input stage 2 (I>t)
	Test input stage 1 (Z<t)
	Test input stage 2 (I>t)

Outputs

Binary:	Initiation stage 1 (Z<t)
	Trip stage 1 (Z<t)
	Initiation stage 2 (I>t)
	Trip stage 2 (I>t)

Setting Parameters

Operating value stage 1 (impedance):	0.1 ... 20.0 Ohm in 0.1 Ohm steps
Operating value stage 2 (Current interlock + overcurrent):	0.1 ... 5.0 x I_n in 1% steps
Time delay stage 1:	0 ... 30 seconds in 0.05 sec steps
Time delay stage 2:	0 ... 30 seconds in 0.05 sec steps

Window Display for Relay Internal Determined and Computed Values

Impedance system 1	in Ohm
Impedance system 2	in Ohm
Impedance system 3	in Ohm

Measuring

Reset ratio:	1.03
Operating time:	≥ 2 cycles
Accuracy:	≥ 3% of setting value or ≥ 2% of current value
	≥ 6% of impedance setting value

24.2.5. Undervoltage/Overcurrent 3 Phase

PROTECTIVE FUNCTION: MZ 311	FNNR	TYPE	ANSI	Application
Undervoltage-Overcurrent, 3-phase	1074	MZ311	51/27	C2,M

3 phase Unvoltage-Overcurrent function selectable to with - or without current latching feature.

MZ311
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Test input voltage function
	Blocking input voltage function
	Test input current function
	Blocking input current function

Outputs

Binary:	Undervoltage/overcurrent initiation
	Undervoltage/overcurrent trip

Setting Parameters

Operating value U:	60 ... 150 V in 0.2 V steps
Operating value I:	0.1 ... 5.0 x I_n in 1% steps
Time Delay:	0 ... 30 seconds in 0.05 sec steps
Current Memory:	Yes/No
End of Current Memory:	External blocking signal/End of Trip Pulse (300 ms)

Measuring

Reset ratio:	1.03
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% of current value

24.2.6. Compound Voltage Overcurrent (I> .AND. (U< .OR. U_{NPS}>))

PROTECTIVE FUNCTION: MZ 312	FNNR	TYPE	ANSI	Application
Compound Voltage Overcurrent (I_1>) .AND. ((V_1<) .OR. (V_2>)), 3-phase, whereby: U_1 ... Pos. Phase Sequ. System Voltage U_2 ... Neg. Phase Sequ. System Voltage I_1 ... Pos. Phase Sequ. System Current	1095	MZ312	51/27	C2,M

Definite time delayed overcurrent protection with two timing stages. The current interlock is enabled in case of undervoltage or inverse time overvoltage conditions.

MZ312
Technical Data:

Inputs

Analogue:	Current input phase L1
	Current input phase L2
	Current input phase L3
	Voltage input system 1-2
	Voltage input system 2-3
	Voltage input system 3-1
Binary:	Test input voltage function
	Blocking input voltage function
	Test input current function
	Blocking input current function

Outputs

Binary:	Undervoltage/overcurrent initiation
	Undervoltage/overcurrent trip

Setting Parameters

Operating value I>:	0.1 ... 5.0 x I_n in 0.01 x I_n steps
Operating value V<:	2 ... 200 V in 0.2 V steps
Operating value V_{inv}:	5 ... 50 V in 0.2 V steps
Operating time 1:	0 ... 180 seconds in 0.05 sec steps
Operating time 2:	0 ... 180 seconds in 0.05 sec steps
Phase rotation:	Clockwise/Anti-clockwise
End latched interlock:	External blocking signal/trip reset

Window Display for Relay Internal Determined and Computed Values

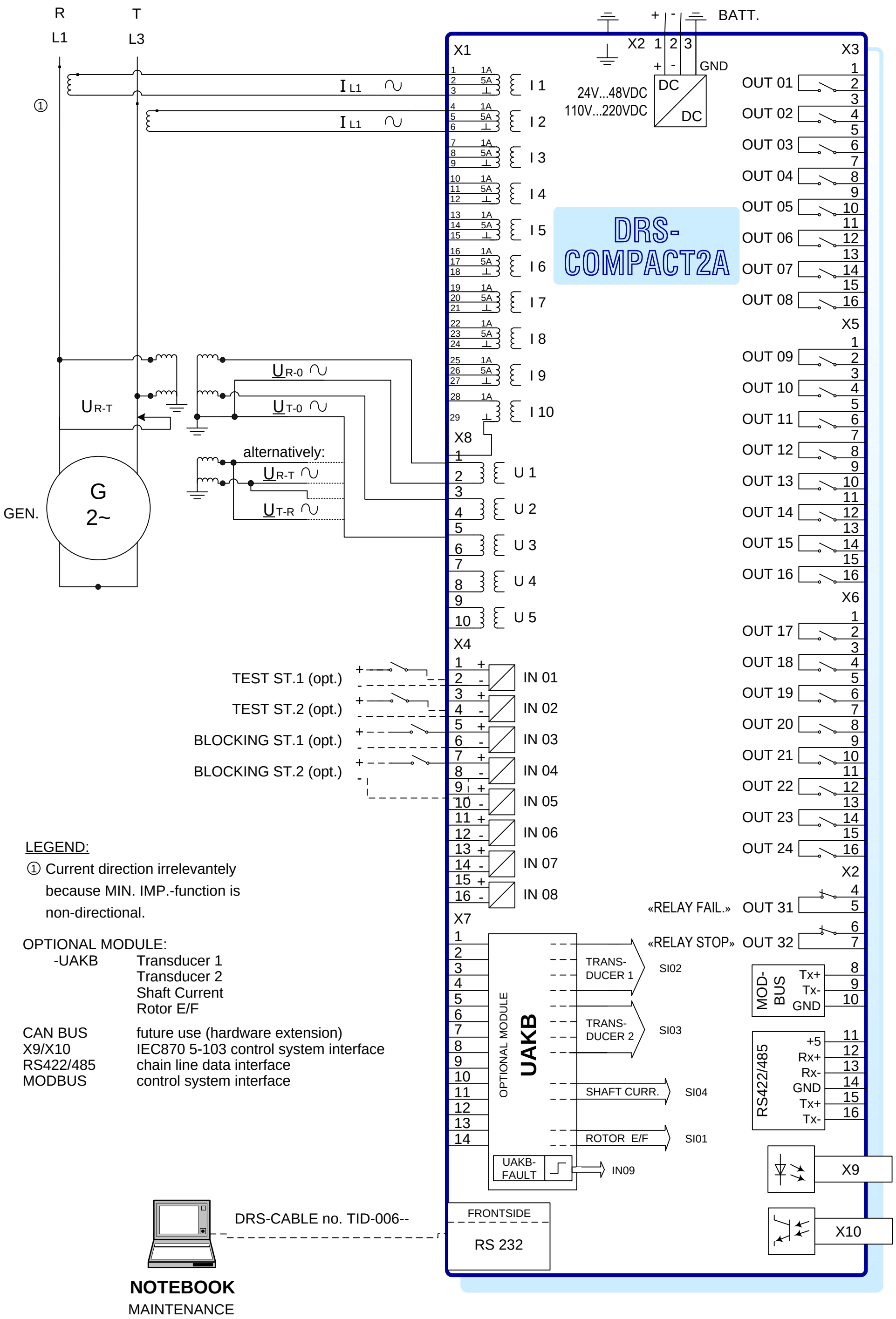
V_{inv} (NPS voltage)	In %

Measuring

Reset ratio:	0.97
Operating time:	≥ 2 cycles
Accuracy:	≤ 3% of setting value or ≤ 2% of current value

24.3. CONNECTION DIAGRAMS

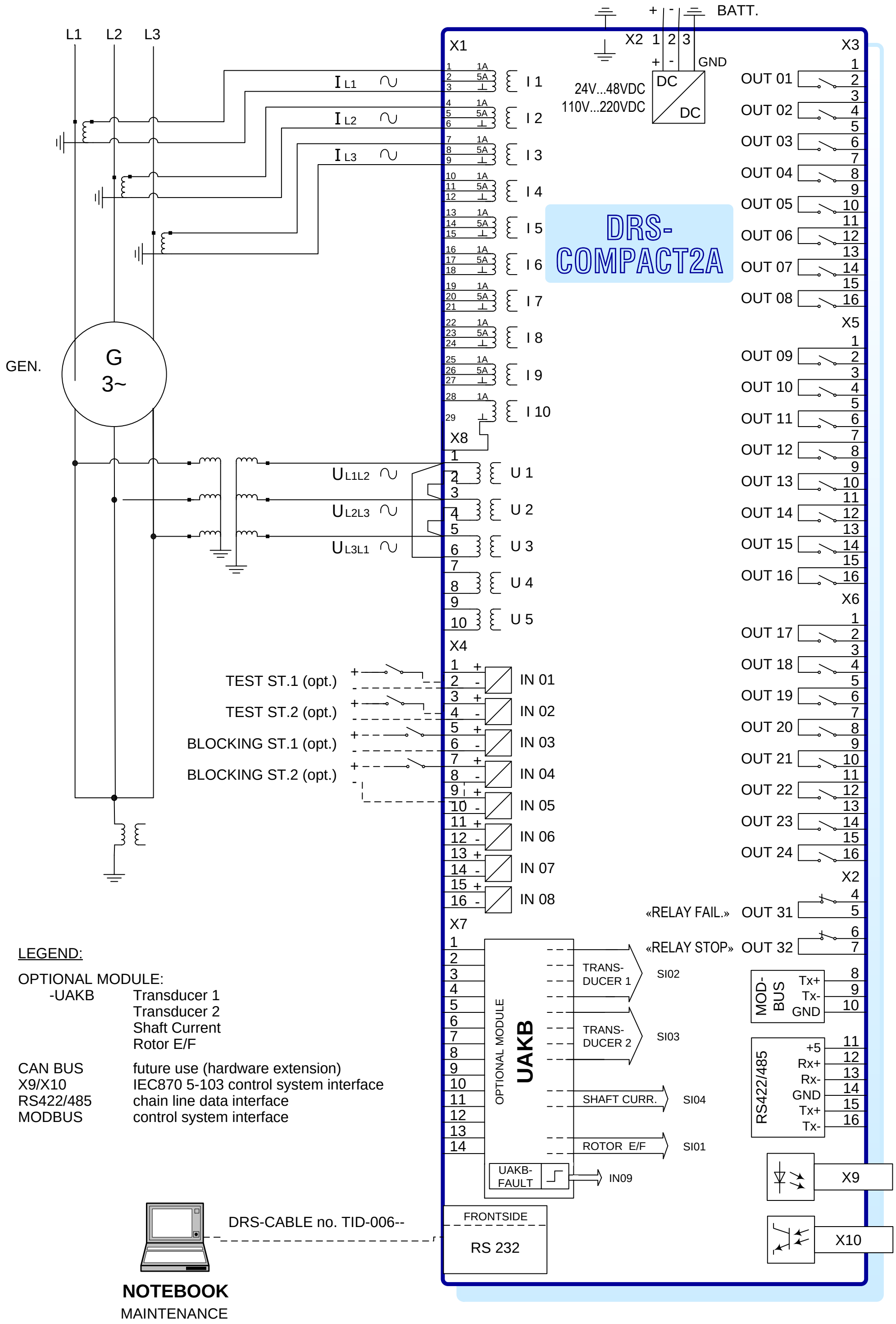
24.3.1. MZ221/ MZ222



MZ221 MIN IMPEDANCE 2-PH. 2-ST. WIRING DIAGRAM
MZ222 MIN IMPEDANCE 2-PH. 2-ST. WIRING DIAGRAM

Fig. 308 MZ221 Min Impedance 2-PH. 2-ST. Wiring Diagram MZ222 Min Impedance 2-PH. 2ST. Wiring Diagram

24.3.2. MZ321/ MZ322



MZ321 MIN IMPEDANCE 3-PH. 2-ST. WIRING DIAGRAM
MZ322 MIN IMPEDANCE 3-PH. 2-ST. WIRING DIAGRAM

Fig. 309 MZ321 Min Impedance 3-PH. 2.-ST. Wiring Diagram MZ322 Min Impedance 3-PH. 2-ST. Wiring Diagram

24.3.3. MZ311

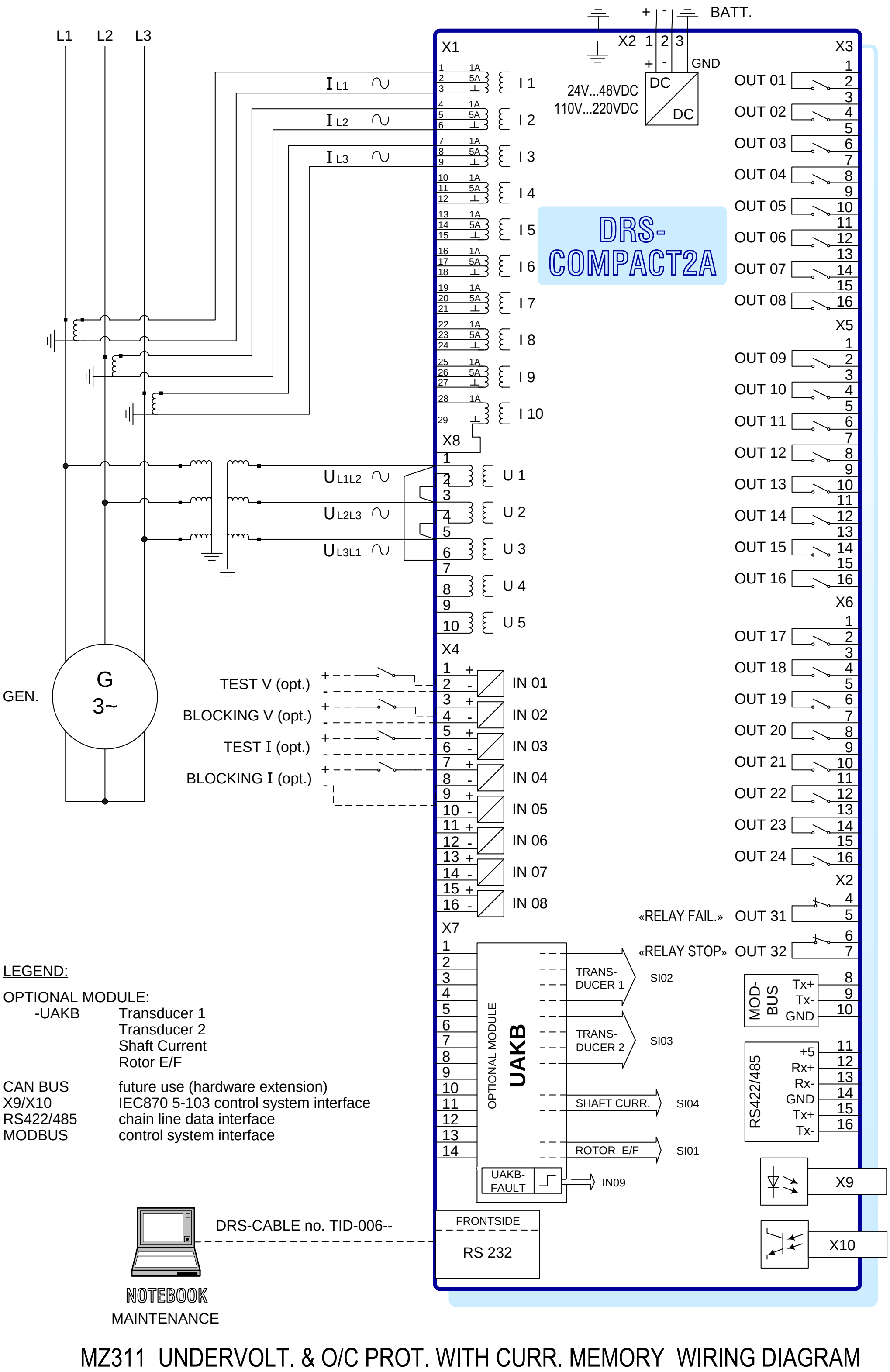


Fig. 310 MZ311 Undervolt. & O/C Prot. With Curr. Memory Wiring Diagram

24.3.4. MZ312

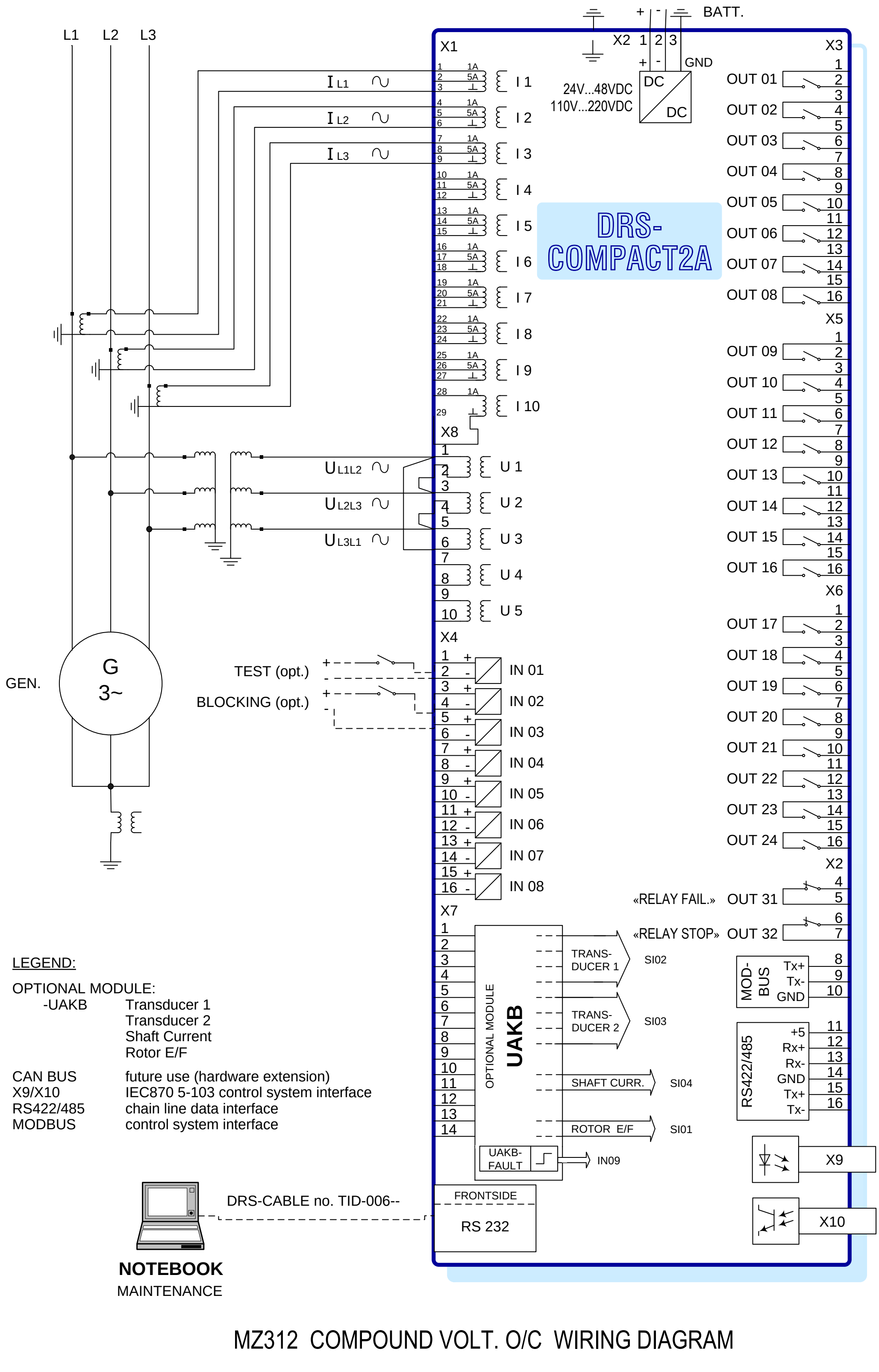
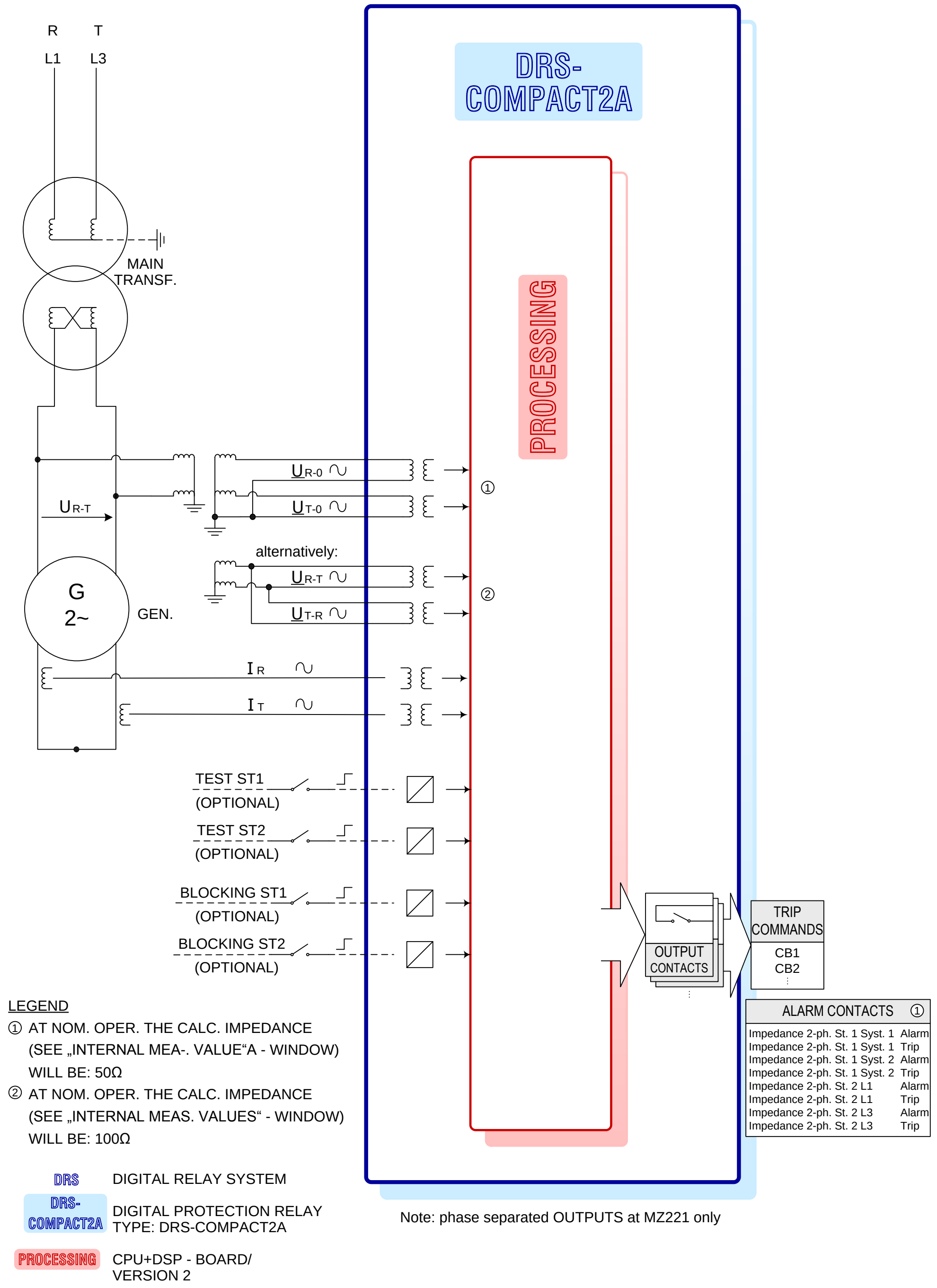


Fig. 311 MZ312 Compound Volt. O/C Wiring Diagram

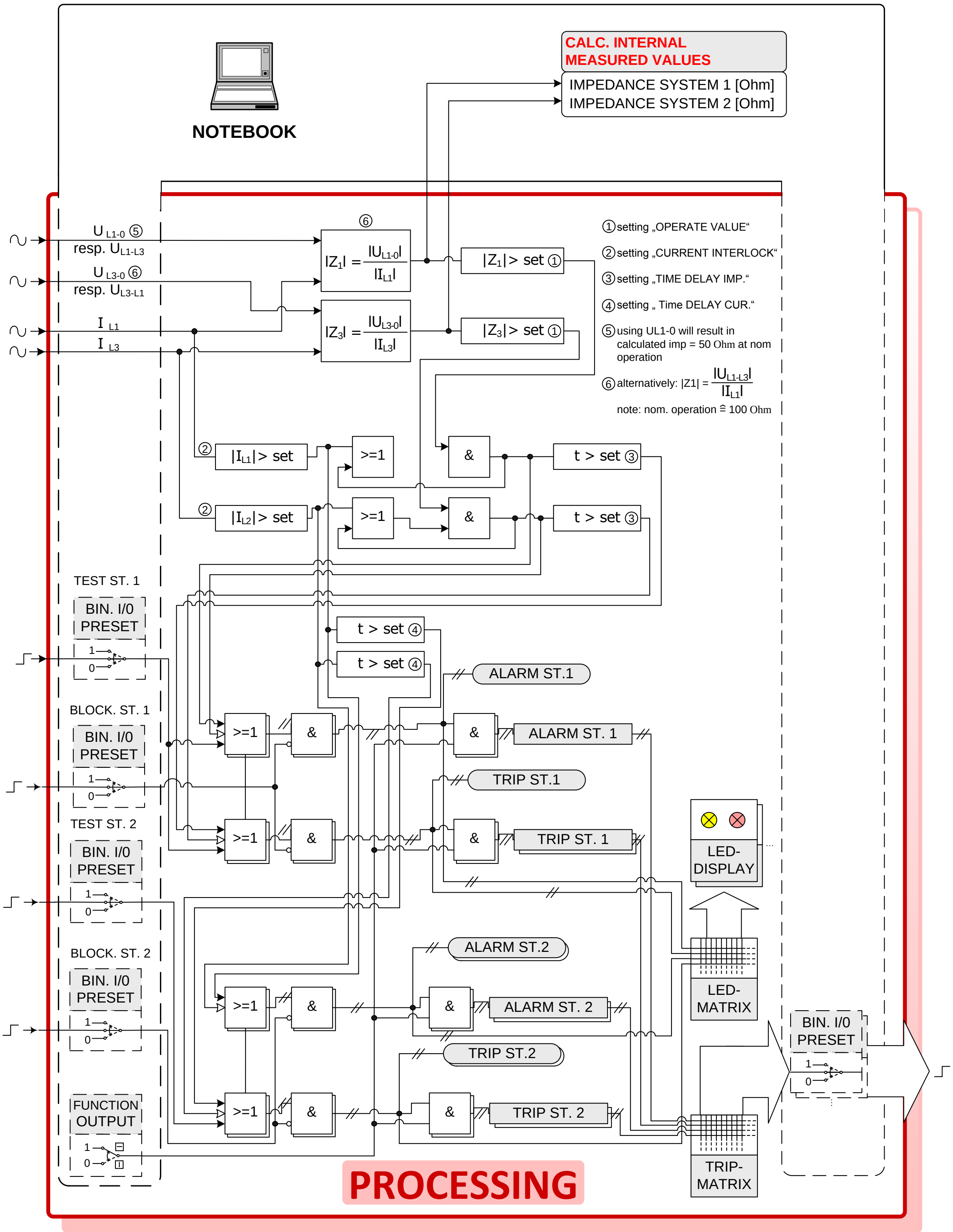
24.4. LOGIC DIAGRAMS

24.4.1. MZ221/ MZ222



MZ221 MIN. IMPEDANCE 2-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC,
WITH PHASE-SEPARATED OUTPUTS
MZ222 MIN. IMPEDANCE 2-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC,
WITH JOINT PHASE OUTPUTS

Fig. 312 MZ221 Min. Impedance 2-PH. 2ST. With Circular Characteristic, with Phase – Separated Outputs
MZ222 Min. Impedance 2-PH. 2ST. With Circular Characteristic, with Joint Phase Outputs



MZ221 MIN IMPEDANCE 2-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC WITH PHASE SEPARATED OUTPUTS LOGIC DIAGRAM / PROCESSING

Fig. 313 MZ221 Min Impedance 2-PH. 2ST. With Circular Characteristic With Phase Separated Outputs Logic Diagram / Processing

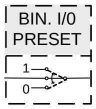
LEGEND PROCESSING

FIRMWARE-MODULE: MZ212, MZ222

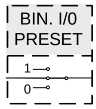
Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

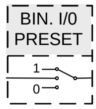
Online-indication of DRS-internal calculated values on notebook-screen



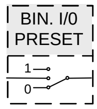
Online-simulation of DIG. IN-/OUTPUTS via notebook:



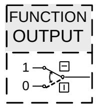
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MZ212
MZ222

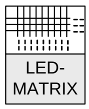
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⎕ all FUNCTION OUTPUTS disabled (test-operation)

$|\underline{I}_{L1}|>$ SET

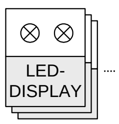
Check $|\underline{I}_{L1}|>$ set value:
a) used for STAGE 2 (TRIP I>)
b) used for STAGE 1 (Release of Z < Trip)
note: Memory Function of I> implemented !

$$|Z_1| = \frac{|U_{L1\text{-}0}|}{|I_{L1}|}$$

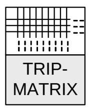
Calculation of impedance vector of System 1 (used for Stage 1)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM — FUNCTION OUTPUT: Alarm

TRIP — FUNCTION OUTPUT: Trip

$>$ — Type of function: over-detection (actual value > set value)

$<$ — Type of function: under-detection (actual value < set value)

MZ221 MIN. IMPEDANCE 2-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MZ222 MIN. IMPEDANCE 2-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 314 MZ221 Min Impedance 2-ph 2-st Logic Diagram Processind /Legend
MZ222 Min. Impedance 2-ph 2-st Logic Diagram Processing/ Legend

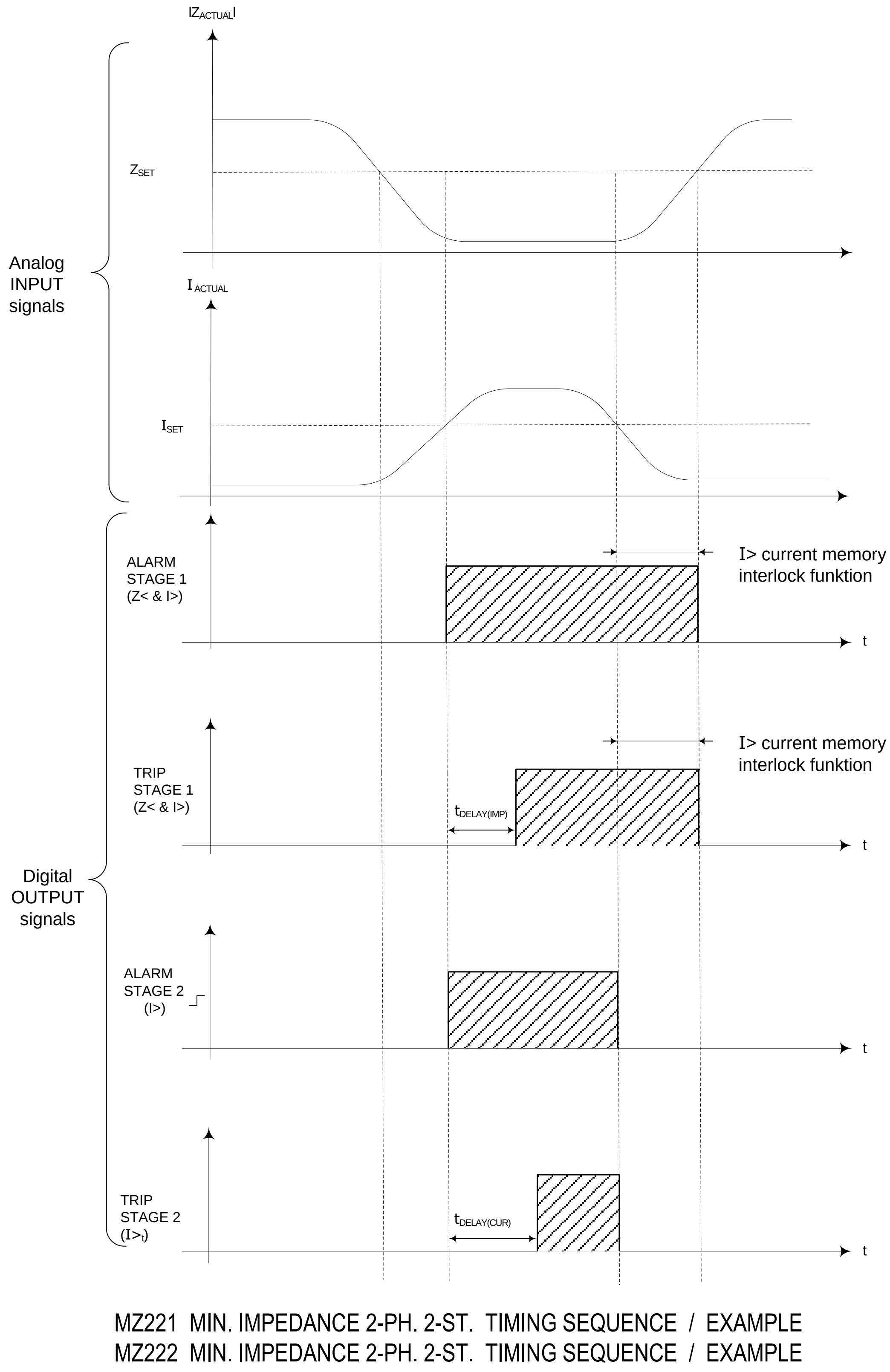
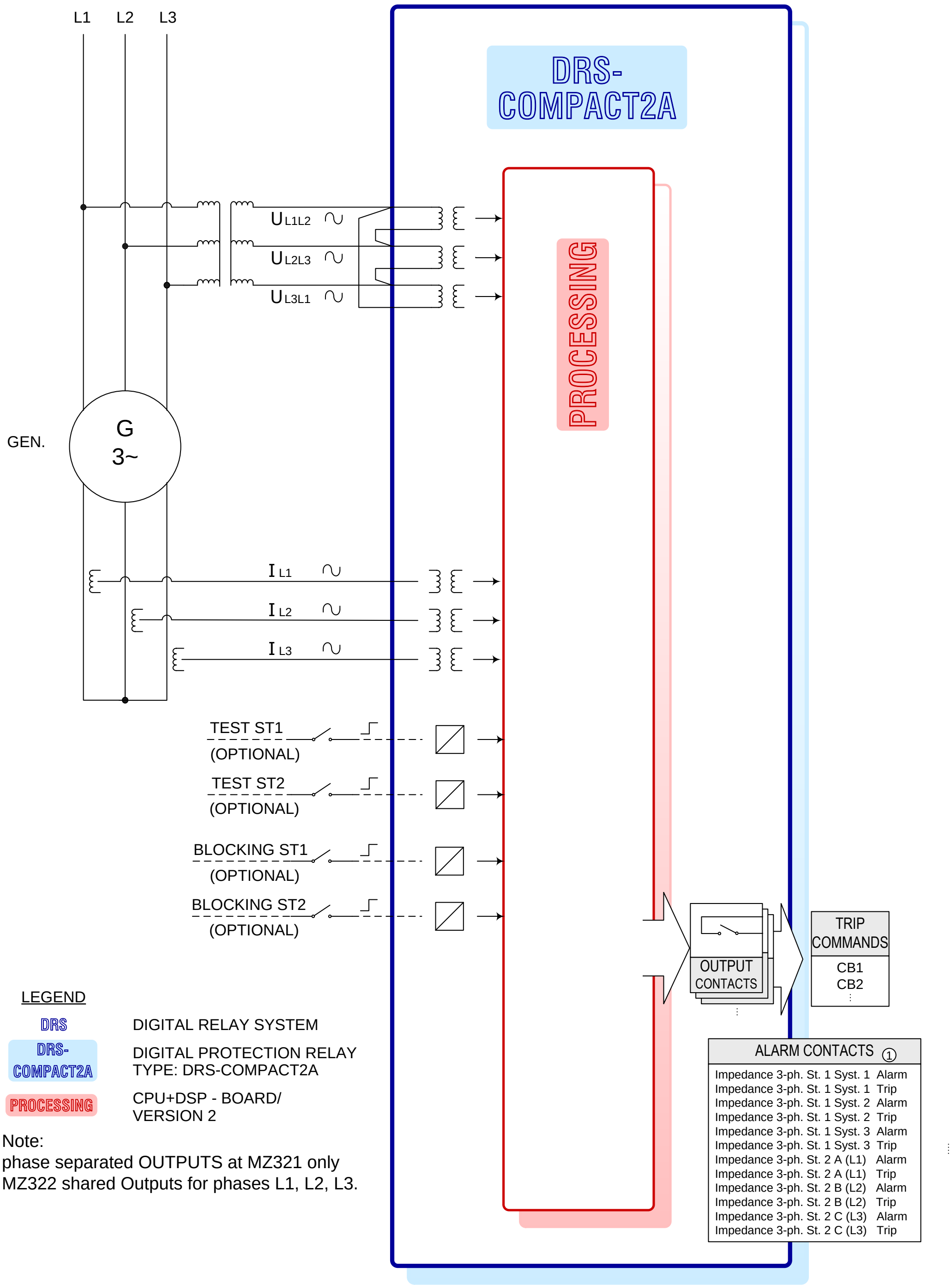


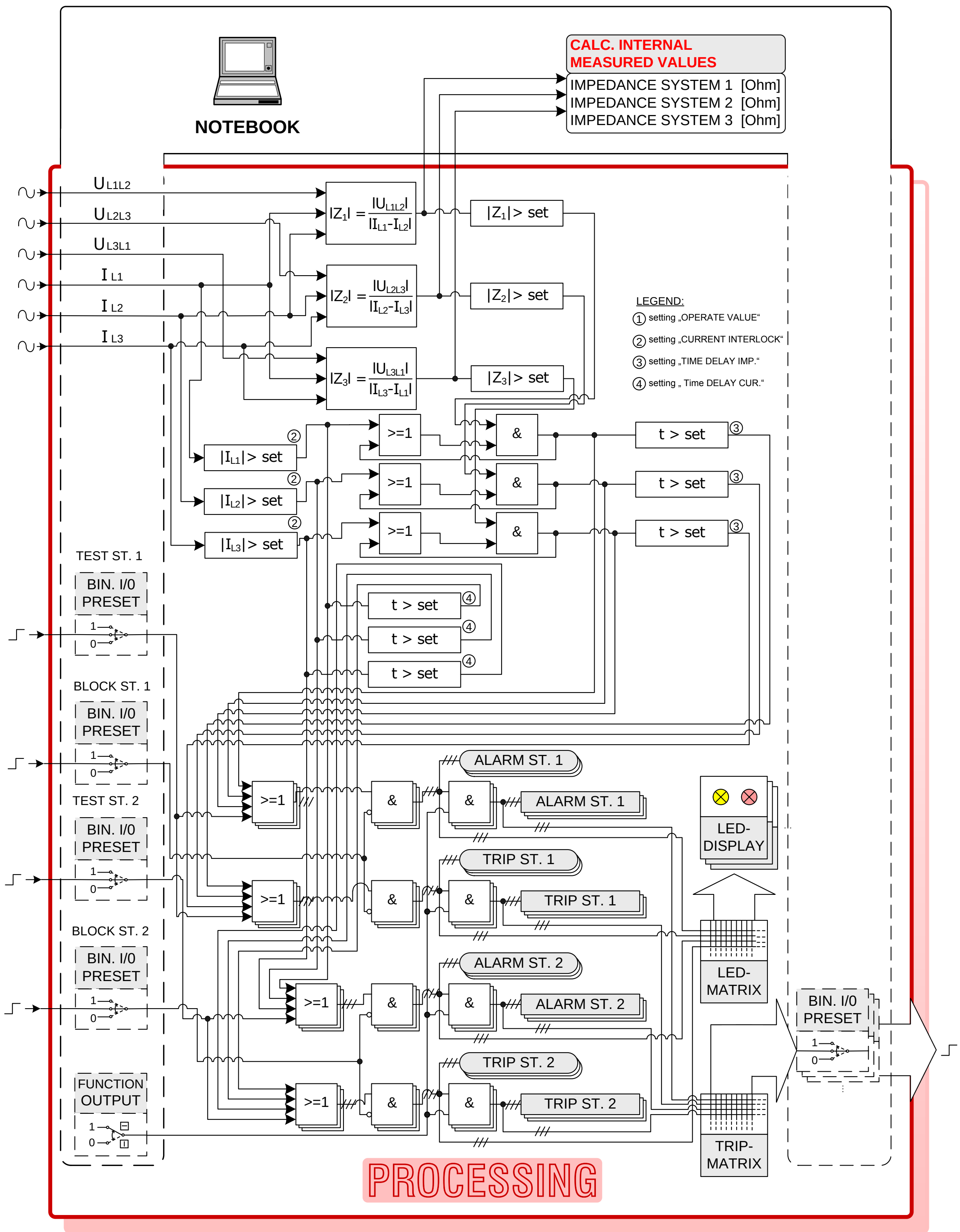
Fig. 315 MZ221 Min. Impedance 2-PH. 2-ST. Timing Sequence / Example MZ222 Min Impedance 2-PH. 2-ST. Timing Sequence / Example

24.4.2. MZ321/ MZ322



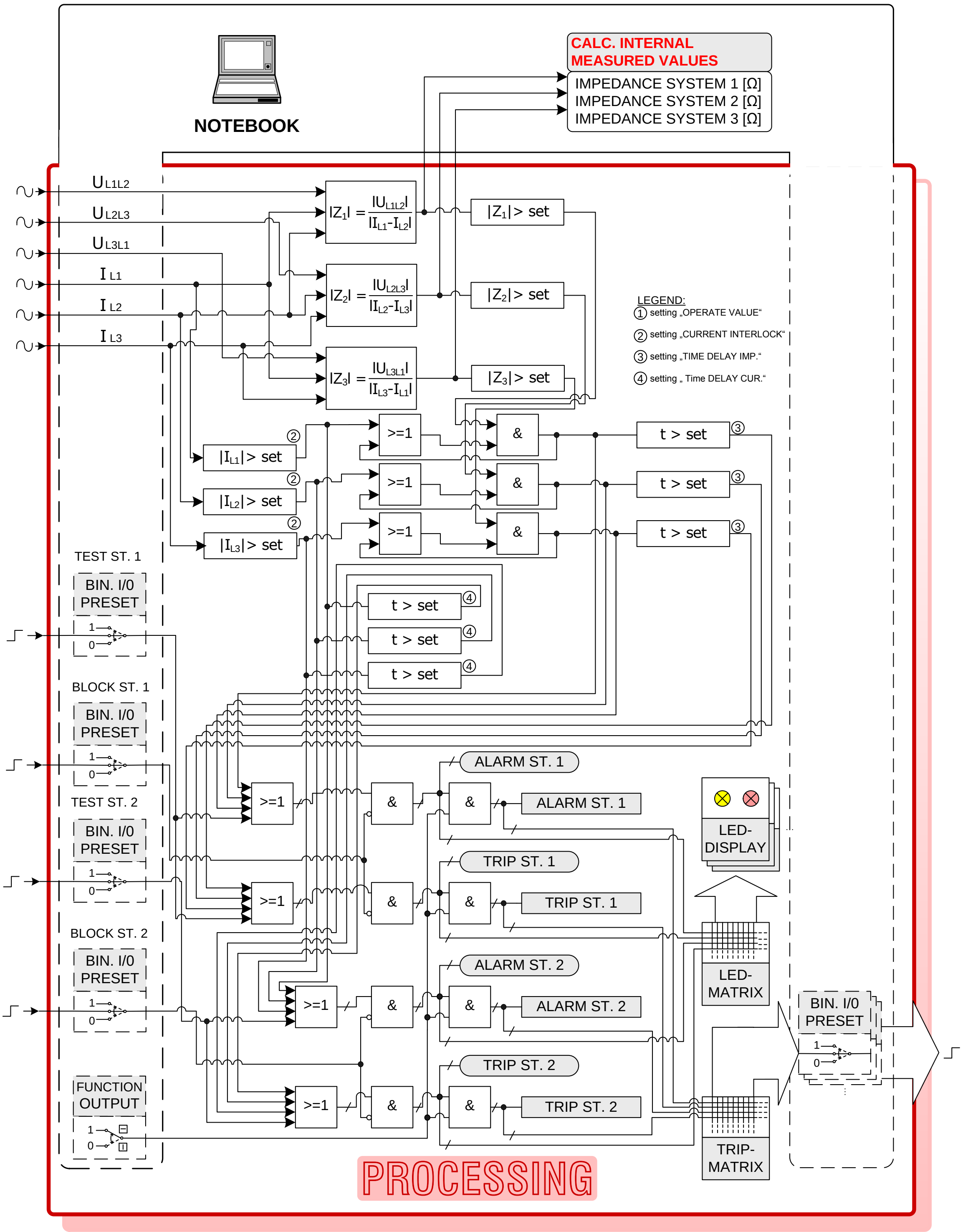
MZ321 MIN. IMPEDANCE 3-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC,
WITH PHASE-SEPARATED OUTPUTS
MZ322 MIN. IMPEDANCE 3-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC,
WITH PHASE COMMON OUTPUTS

Fig. 316 MZ321 Min. Impedance 3-PH. 2-ST. With Circular Characteristic, With Phase – Separated Outputs
MZ322 Min. Impedance 3-PH. 2-ST. With Circular Characteristic With Phase Common Outputs



MZ321 MIN IMPEDANCE 3-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC WITH PHASE SEPARATED OUTPUTS LOGIC DIAGRAM / PROCESSING

Fig. 317 MZ321 Min Impedance 3-PH. 2-ST. With Circular Characteristic With Phase Separated Outputs Logic Diagram / Processing



MZ322 MIN IMPEDANCE 3-PH. 2-ST. WITH CIRCULAR CHARACTERISTIC
WITH PHASE COMMON OUTPUTS FOR PHASES L1, L2, L3
LOGIC DIAGRAM / PROCESSING

Fig. 318 MZ322 Min Impedance 3-PH. 2-ST. With Cicular Characteristic With Phase Common Outputs For Phases L1, L2, L3
Logic Diagram / Processing

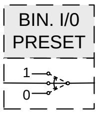
LEGEND PROCESSING

FIRMWARE-MODULE: MZ321, MZ322

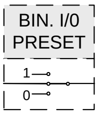
Online simulation via notebook

CALC. INTERNAL MEASURED VALUES
.....

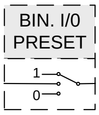
Online-indication of DRS-internal calculated values on notebook-screen



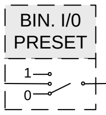
Online-simulation of DIG. IN-/OUTPUTS via notebook:



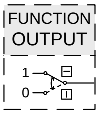
regular function



always „1"



always „0"



Online-simulation of the FUNCTION OUTPUTS of the protective function MZ321 MZ322

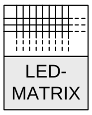
- all FUNCTION OUTPUTS enabled (regular-operation)
- all FUNCTION OUTPUTS disabled (test-operation)

$|I_{L1}|$> set

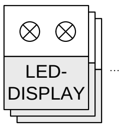
Check $|I_{L1}|$> set value:
a) used for STAGE 2 (TRIP I>)
b) used for STAGE 1 (Release of Z < Trip)
note: I> current interlock memory function implemented!

$$|Z_1| = \frac{|U_{L1L2}|}{|I_{L1}-I_{L2}|}$$

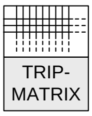
Calculation of IMPEDANCE of System 1 (used for Stage 1)



Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING



LED-indications of PROCESSING (row 2...14)



Programmable software-matrix for the output-contacts (OUT1...OUT30)

Denomination of FUNCTION OUTPUTS going to LED-MATRIX

Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX

ALARM	FUNCTION OUTPUT: 21 Alarm
TRIP	FUNCTION OUTPUT: 21 Trip
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MZ321 MIN. IMPEDANCE 3-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND
MZ322 MIN. IMPEDANCE 3-PH. 2-ST. LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 319 MZ321 Min. Impedance 3-PH. 2-ST. Logic Diagram Processing / Legend MZ322 Min Impedance 3-PH. 2-ST. Logic Diagram Processing / Legend

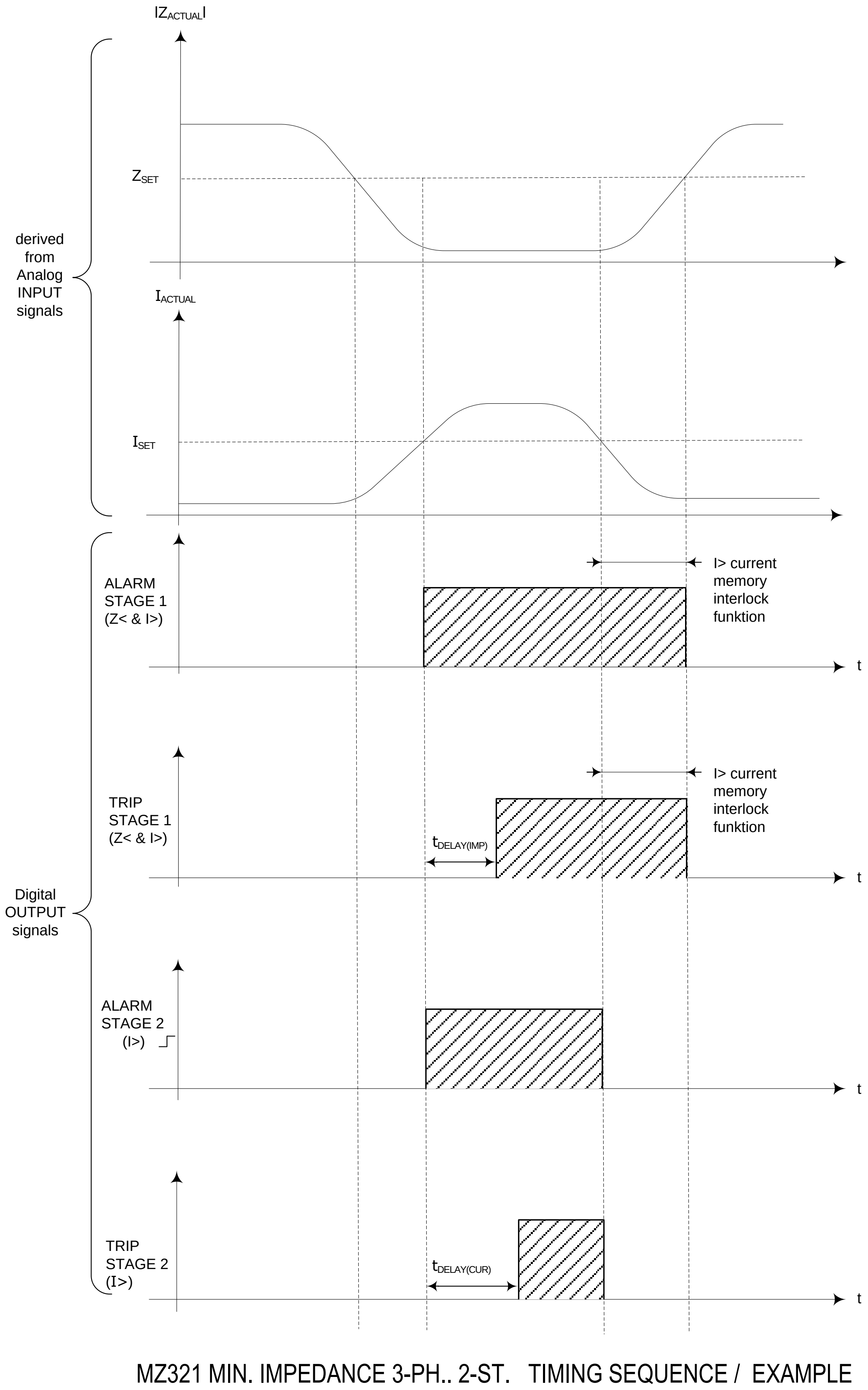
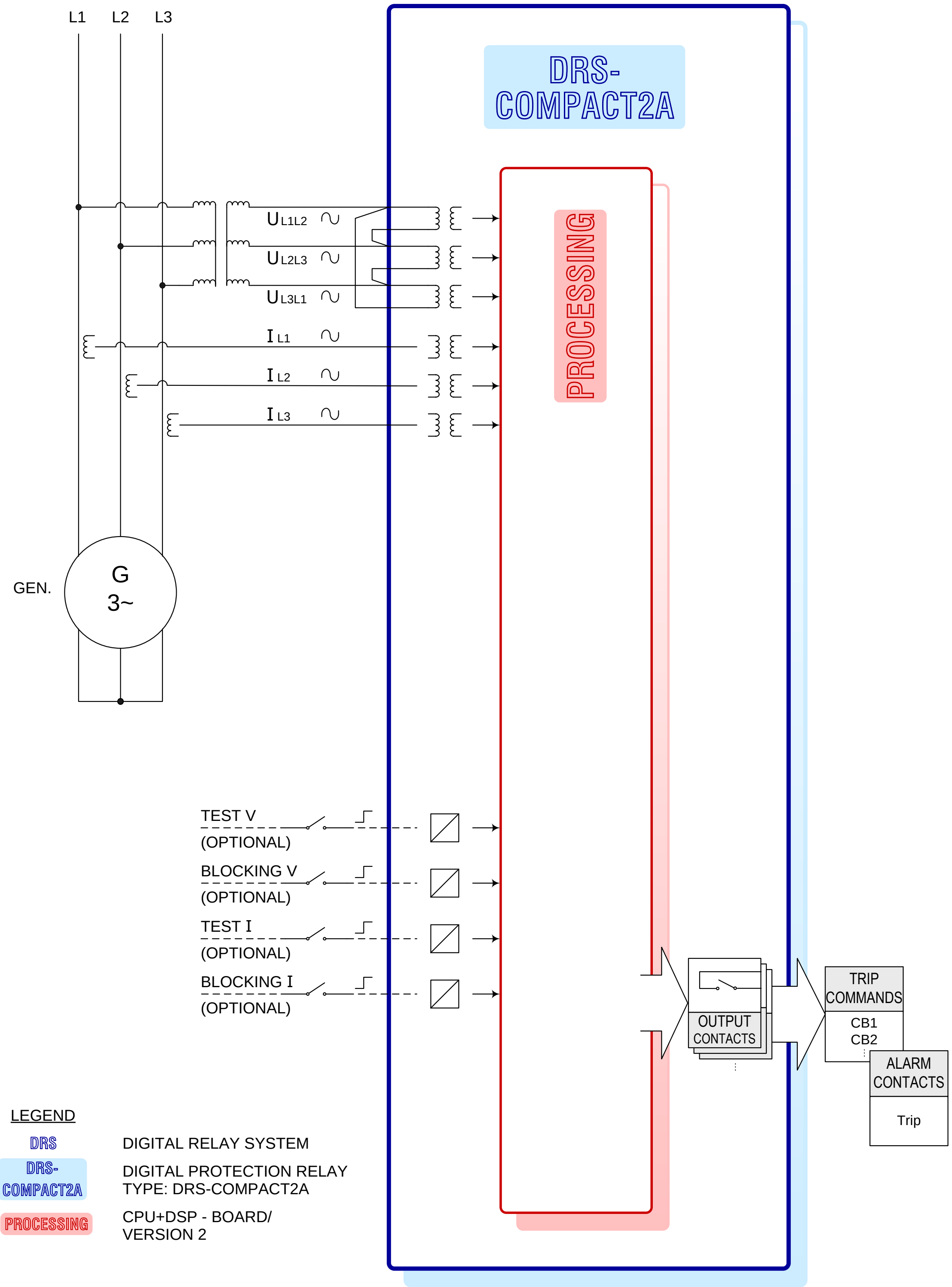


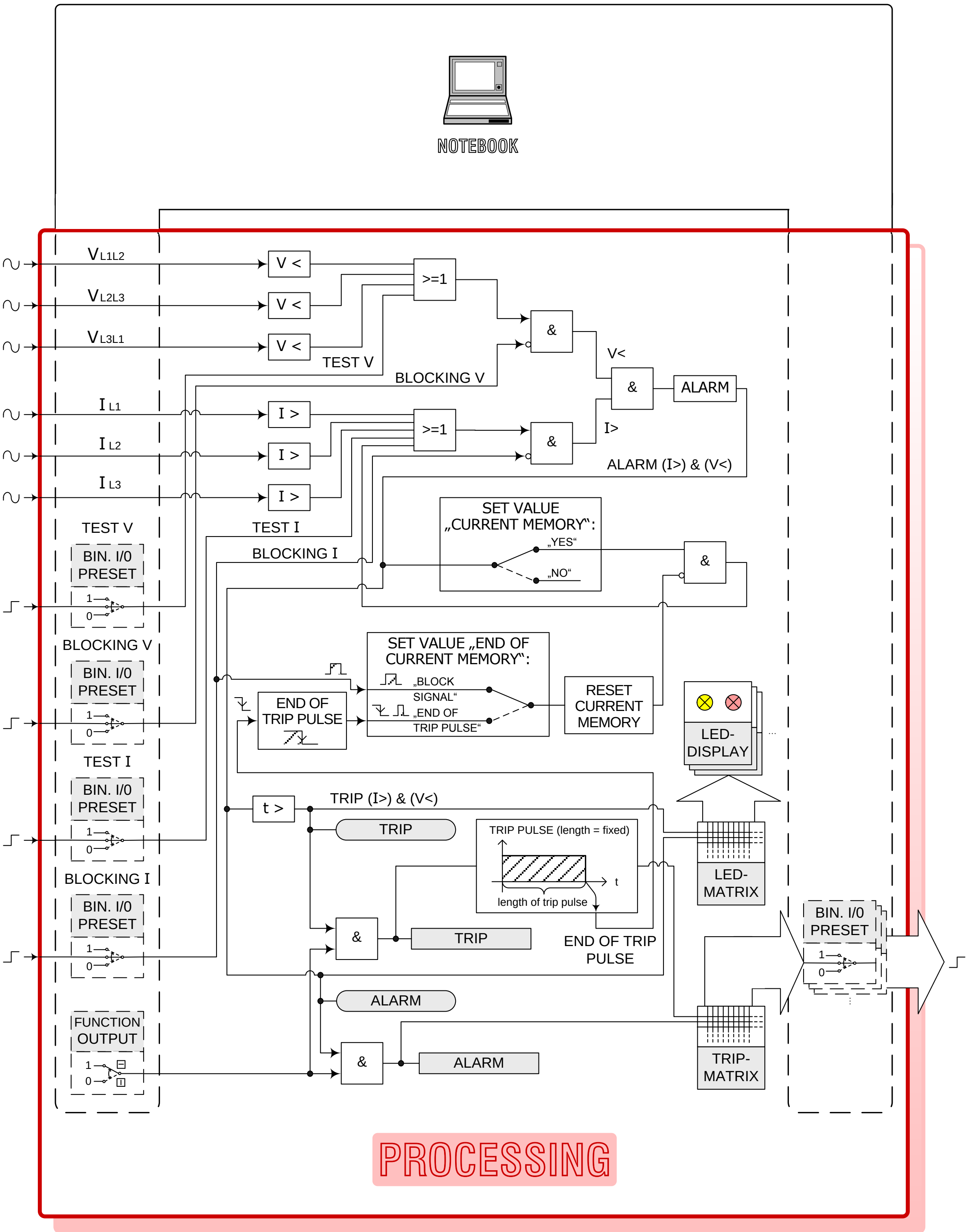
Fig. 320 MZ321 Min. Impedance 3-PH. 2-ST. Timing Sequence / Example

24.4.3. MZ311



MZ311 UNDERVOLT. & O/C PROT. WITH CURR. MEMORY LOGIC DIAGRAM

Fig. 321 MZ311 Undervolt. & O/C Prot. With Curr. Memory Logic Diagram



MZ311 UNDERVOLT. & O/C PROT. WITH CURR. MEMORY
LOGIC DIAGRAM/ PROCESSING

Fig. 322 MZ311 Undervolt. & O/C Prot. With Curr. Memory Logic Diagram / Processing

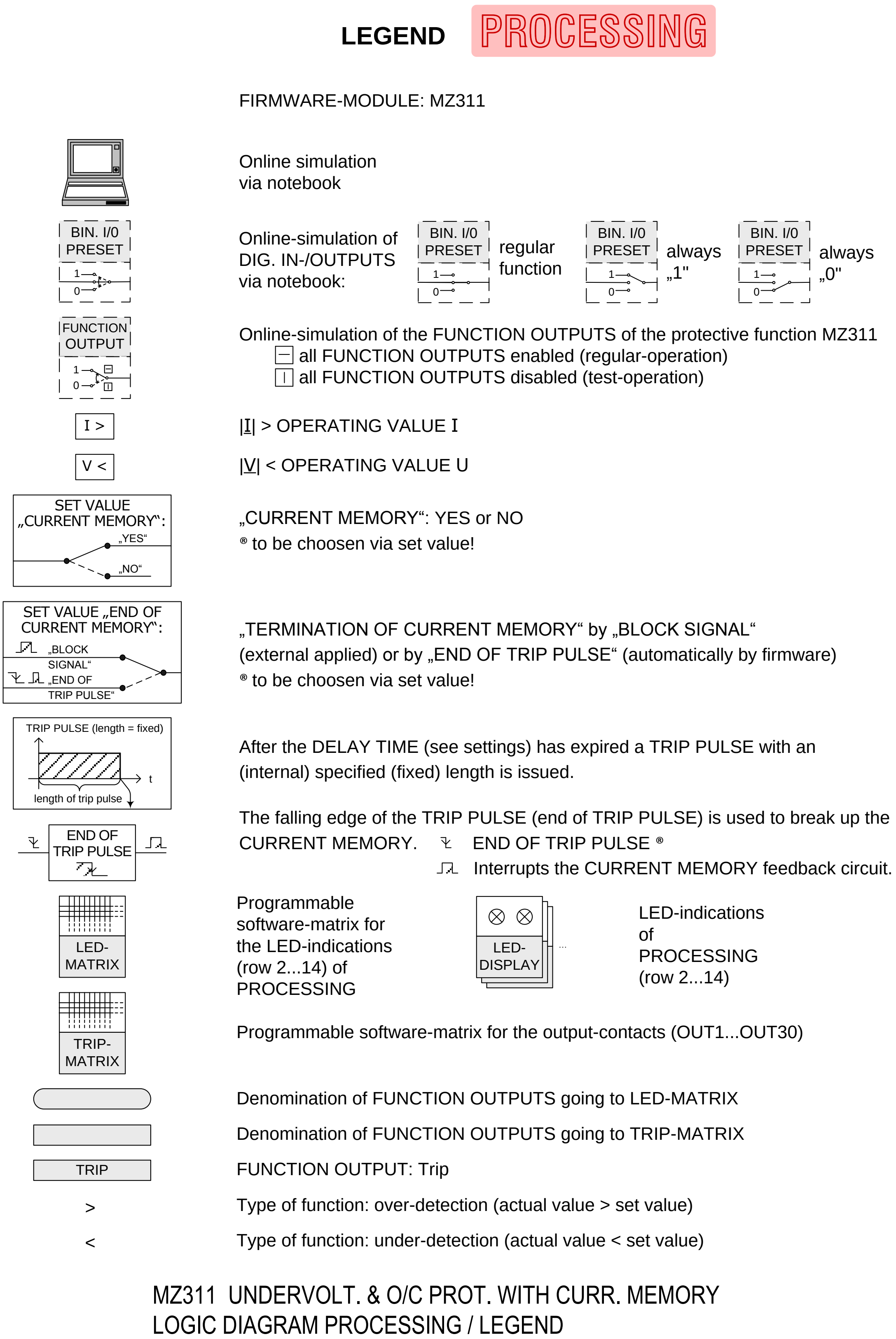
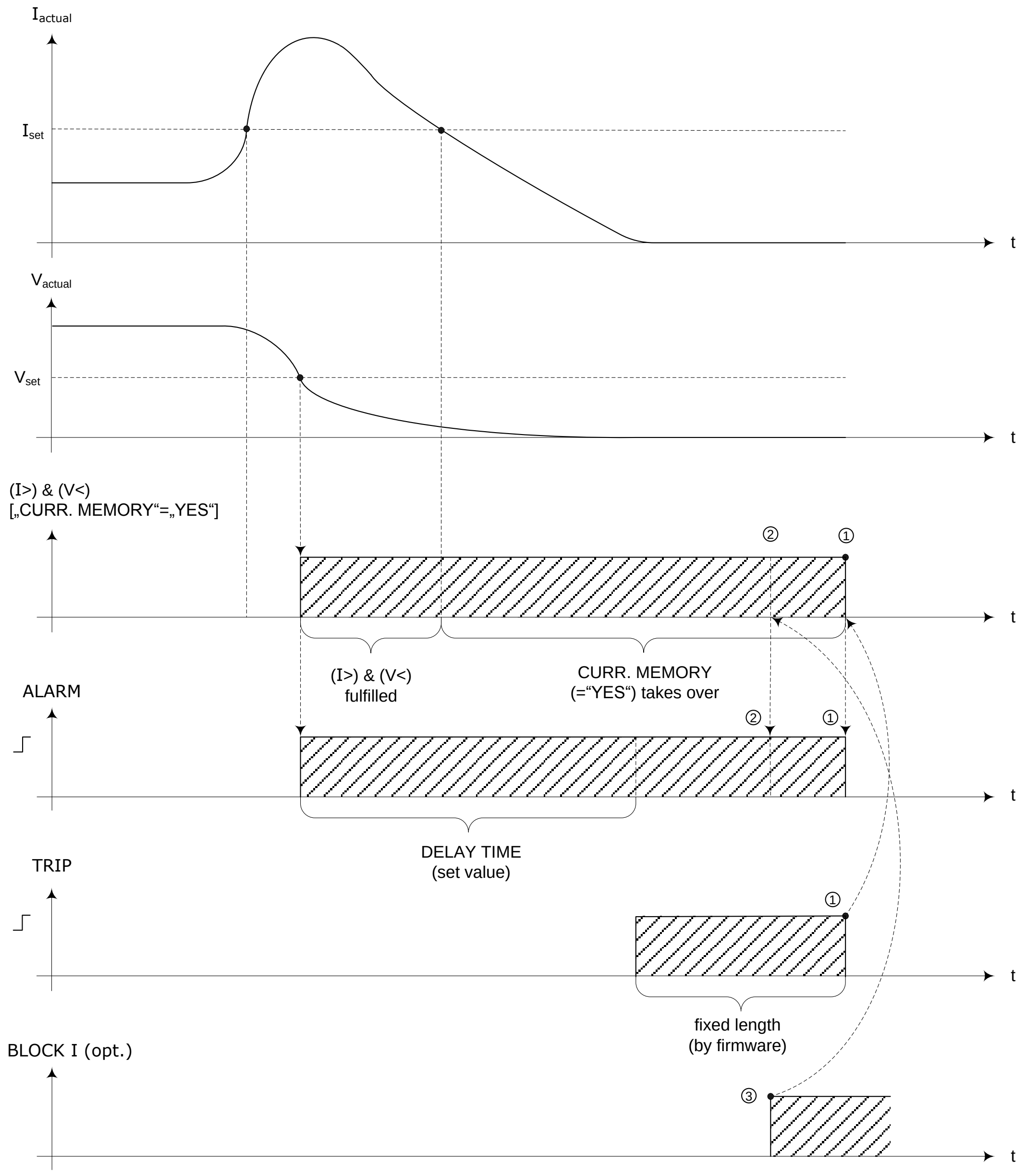


Fig. 323 MZ311 Undervolt. & O/C Prot. With Curr. Memory Logic Diagram Processing / Legend



LEGEND:

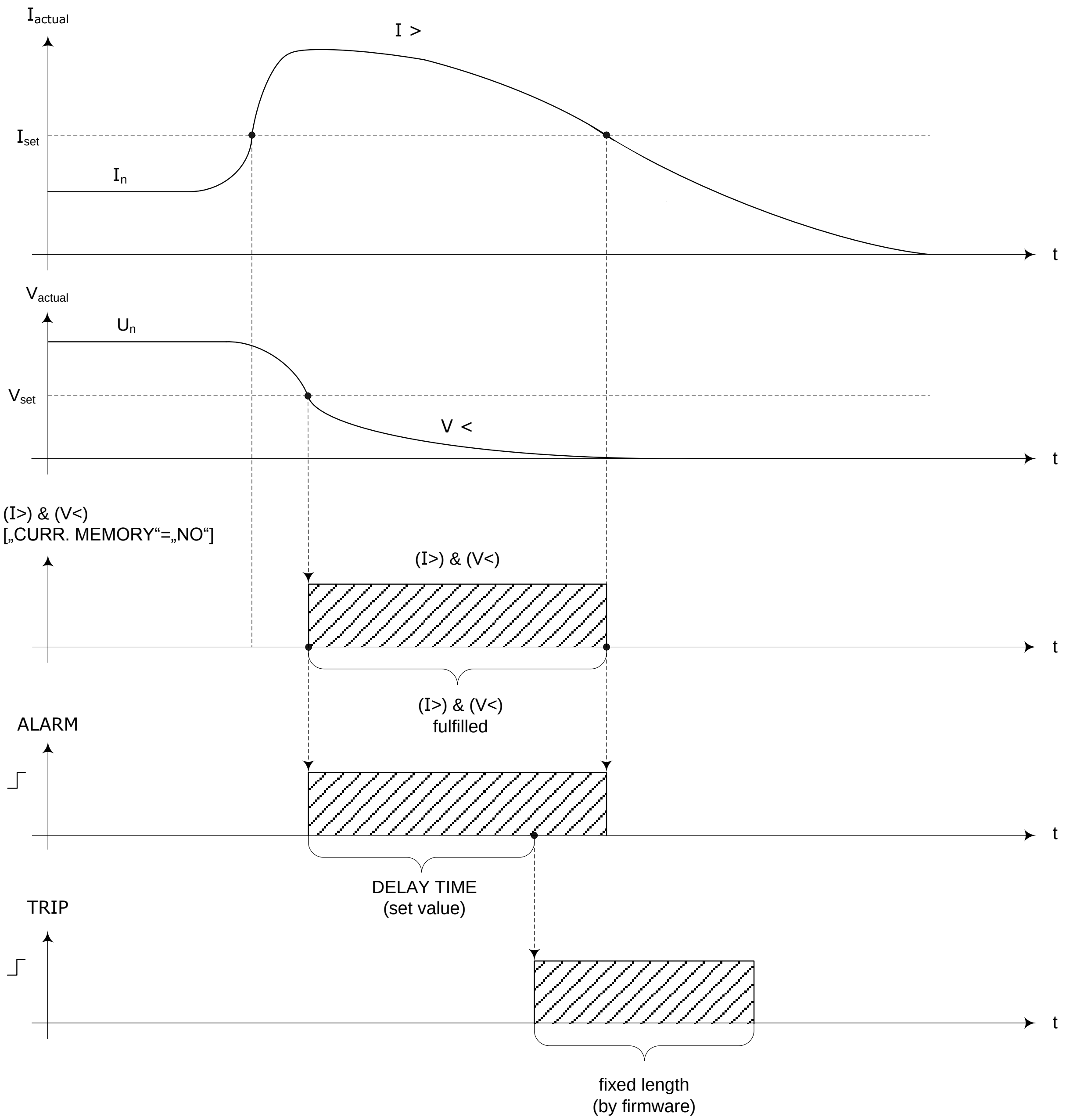
① Termination of „CURRENT MEMORY“ feedback circuit by „END OF TRIP PULSE“ acc. to set value:
„END OF CURRENT MEMORY“ = „End of Trip Pulse“
Note: Length of trip pulse is fixed (DRS firmware).

② Termination of „CURRENT MEMORY“ - feedback circuit by external applied „BLOCK SIGNAL“
Note: „BLOCK SIGNAL“ usually to be derived from ®

③ ® “CB = OFF“ - aux. contact.

MZ311 UNDERVOLT. & O/C PROT./ TIMING SEQUENCE / EXAMPLE:
SET VALUE „CURR. MEMORY“ = „YES“.

Fig. 324 MZ311 Undervolt. & O/C Prot./ Timing Sequence / Example : Set Value ,,Curr. Memory'' = ,,YES''.



MZ311 UNDERVOLT. & O/C PROT./ TIMING SEQUENCE / EXAMPLE:
SET VALUE „CURR. MEMORY“ = „NO“.

Fig. 325 MZ311 Undervolt. & O/C Prot./ Timing Sequence / Example: Set Value ,,Curr. Memory’’ = ,,No’’.

24.4.4. MZ312

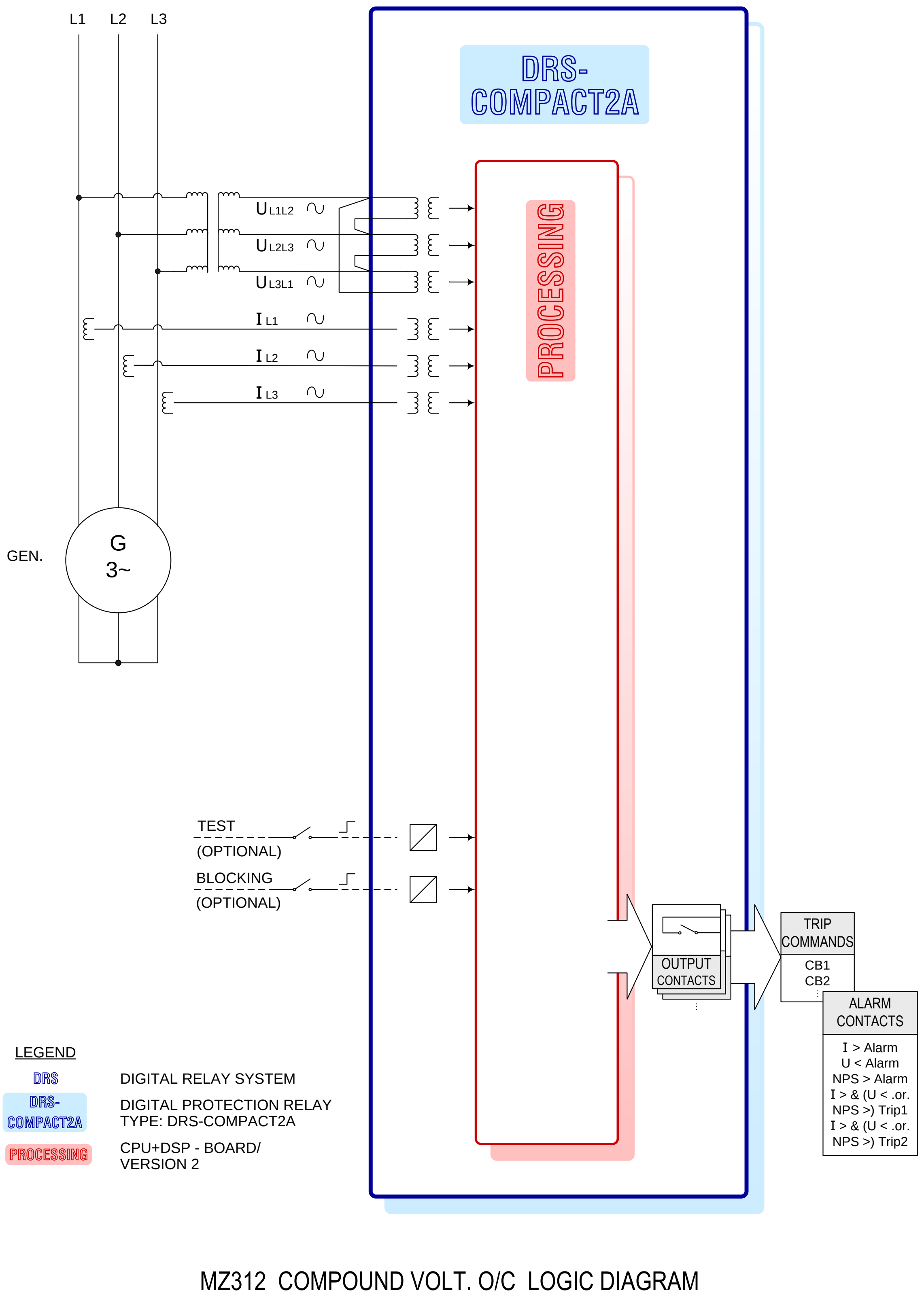
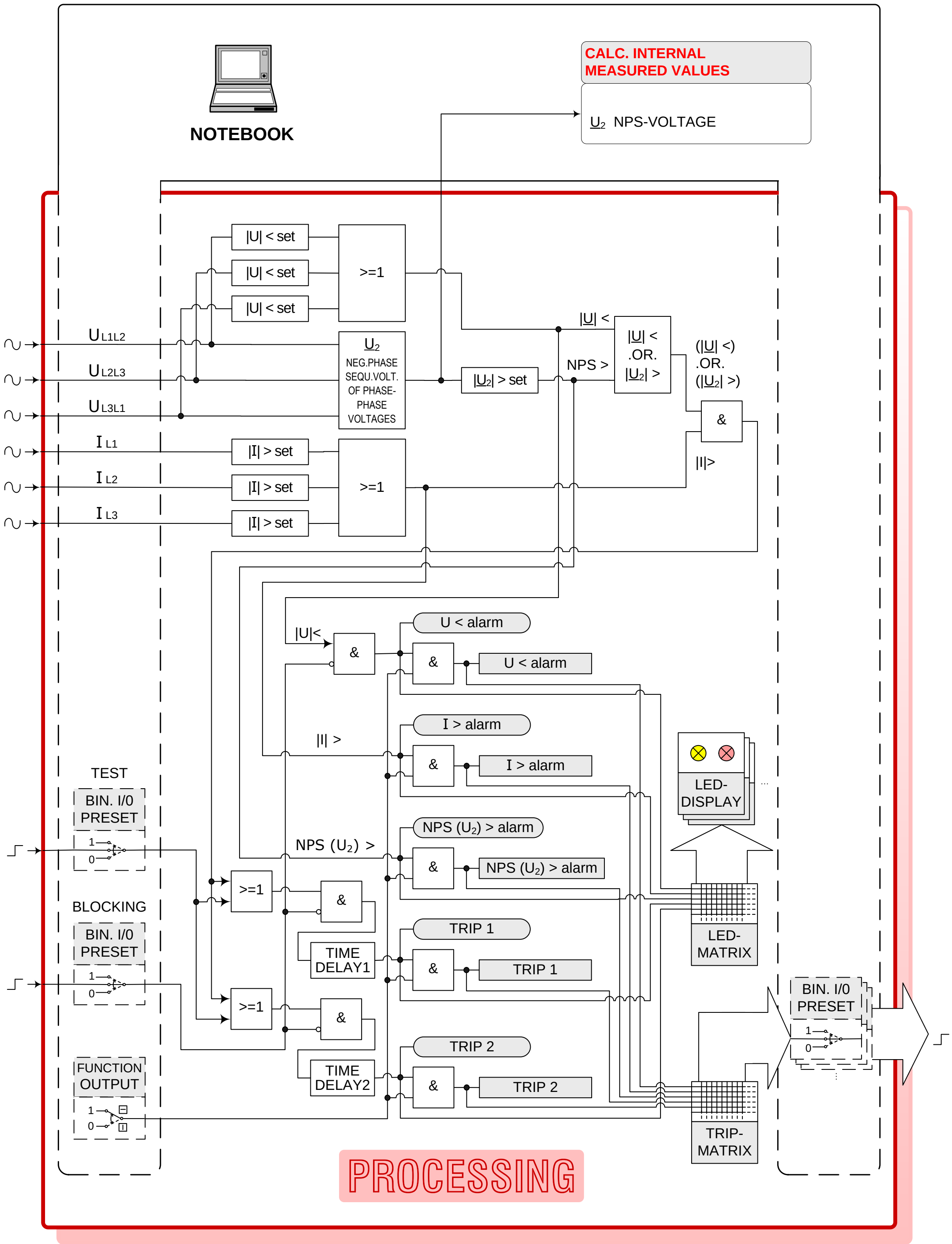


Fig. 326 MZ312 Compound Volt. O/C Logic Diagram

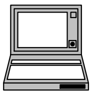


MZ312 COMPOUND VOLT. O/C LOGIC DIAGRAM / PROCESSING

Fig. 327 MZ312 Compound Volt. O/C Logic Diagram / Processing

LEGEND PROCESSING

FIRMWARE-MODULE: MZ312



Online simulation via notebook — **CALC. INTERNAL MEASURED VALUES** ..... — Online-indication of DRS-internal calculated values on notebook-screen

BIN. I/0 PRESET — Online-simulation of DIG. IN-/OUTPUTS via notebook: BIN. I/0 PRESET regular function; BIN. I/0 PRESET always „1"; BIN. I/0 PRESET always „0"

FUNCTION OUTPUT — Online-simulation of the FUNCTION OUTPUTS of the protective function MZ312
- ⊟ all FUNCTION OUTPUTS enabled (regular-operation)
- ⊞ all FUNCTION OUTPUTS disabled (test-operation)

$\underline{U}_2$ NEG.PHASE SEQU.VOLT. OF PHASE-PHASE VOLTAGES — Calculation of „NEGATIVE PHASE SEQUENCE VOLTAGE“ $\underline{U}_2$

$\underline{U}_2 = (\underline{U}_{L1L2} + a \cdot \underline{U}_{L2L3} + a^2 \cdot \underline{U}_{L3L1}) / 3$

NOTE: $a = e^{j \cdot 2\pi / 3}$

$\lvert\underline{U}_2\rvert$ > set	Check $\lvert\underline{U}_2\rvert$ > set
$\lvert I\rvert$ > set	Check $\lvert I\rvert$ > set
$\lvert U\rvert$ < set	Check $\lvert U\rvert$ < set
LED-MATRIX	Programmable software-matrix for the LED-indications (row 2...14) of PROCESSING
LED-DISPLAY	LED-indications of PROCESSING-board (row 2...14)
TRIP-MATRIX	Programmable software-matrix for the output-contacts (OUT1...OUT30)
(rounded box)	Denomination of FUNCTION OUTPUTS going to LED-MATRIX
(rectangular box)	Denomination of FUNCTION OUTPUTS going to TRIP-MATRIX
TRIP 1	FUNCTION OUTPUT: TRIP 1
TRIP 2	FUNCTION OUTPUT: TRIP 2
>	Type of function: over-detection (actual value > set value)
<	Type of function: under-detection (actual value < set value)

MZ312 COMPOUND VOLT. O/C LOGIC DIAGRAM PROCESSING / LEGEND

Fig. 328 MZ312 Compound Volt. O/C Logic Diagram Processing / Legend

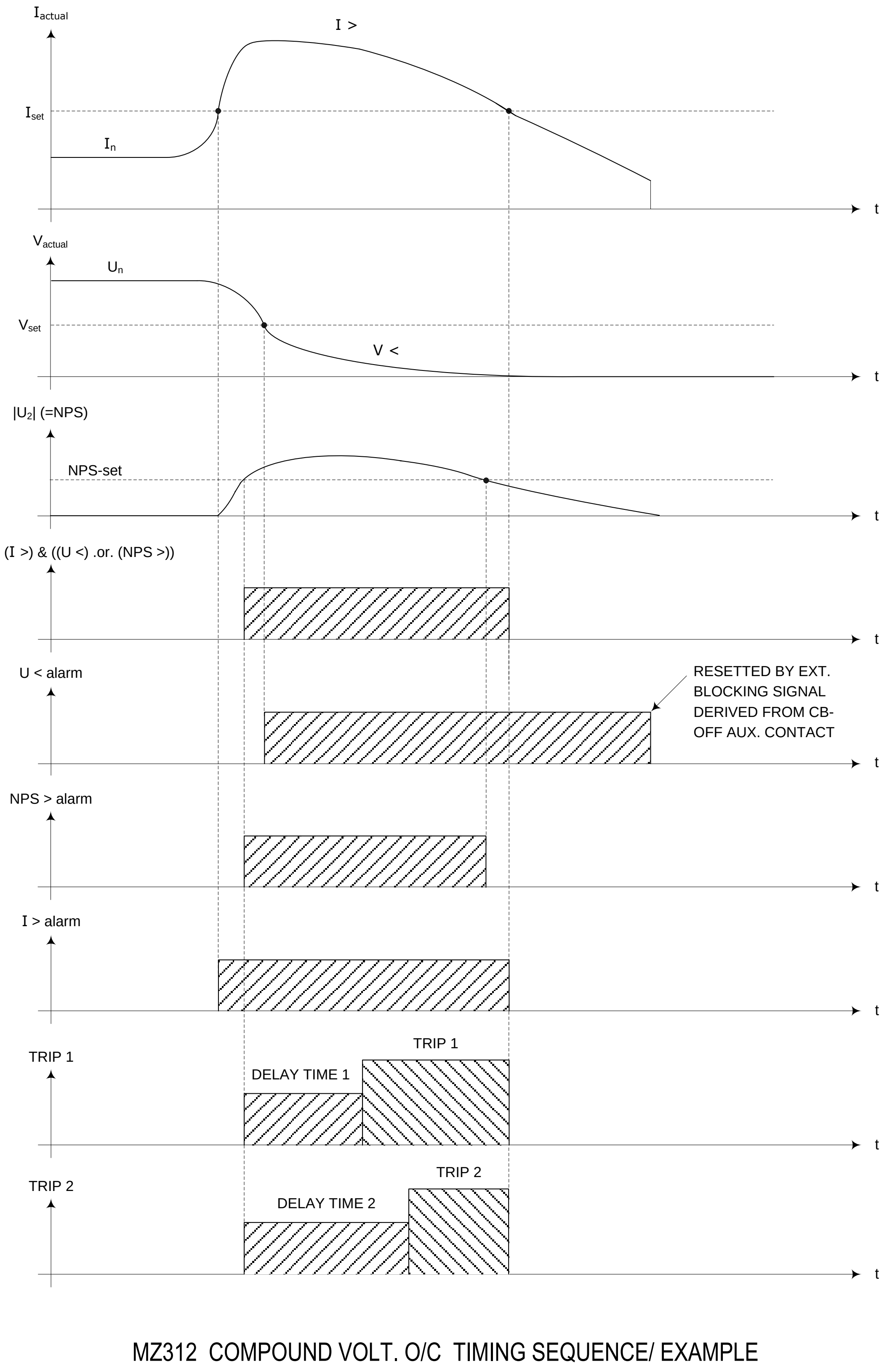


Fig. 329 MZ312 Compound Volt. O/C Timing Sequence / Example

24.5. FUNCTION

24.5.1. MZ221/ MZ222/ MZ321/ MZ322

Minimum impedance functions are applied as back-up protection instead of a distance protection in the generator bus circuit or as a back-up for other plants where fault direction does not matter and protection co-ordination with overcurrent functions will not provide a sufficient coverage.

The three phase minimum impedance protection is designed for isolated- or high impedance- or Peterson Coil earthed power systems whereby the two phase model may also be applied in solid grounded systems.

In order to cope for all fault conditions, with the exception of double earth faults, the three phase model function is using, e.g. for measuring system 1 the phase currents I_{L1} and I_{L2} with vector-wise substraction and the impedance value of system 1 with the phase to phase voltages V_{L1-L2} according to the following formula below.

$$|Z_1| = \frac{|\vec{U}_{L1L2}|}{|\vec{I}_{L1} - \vec{I}_{L2}|}$$

The same applies for the other two measuring systems by corresponding insertion of the relevant measured values.
It can be validated that with this method any three phase- and two phase faults with- or without ground connection are determined correctly.

The two phase function model is calculating for, e.g. system 1 according to following formula.

$$|Z_1| = \frac{|\vec{U}_{L1}|}{|\vec{I}_{L1}|}$$

For the impedance measurement an overcurrent interlock with latching features is applied which means that if even the initiating current is falling below the set value the function will be active as long as the impedance evaluation is not above the trigger value.
The overcurrent function interlock is also operating as a second stage time delayed overcurrent protection.
The computation of the CT/VT input signals, i.e. phase currents and phase to phase voltages are are carried out by the measuring algorithm 12 times each cycle.
Currents of the three phase function model are sampled for each system and substracted as per above formula.
Afterwards with each sample interval the impedance of the 3 fault loops is calculated and phase-wise verified whether the initiating condition is above the set value.
If the initiating conditions are above the current interlock and below the underimpedance configuration during 24 consecutive sample intervals initiation of stage 2 is given first and the corresponding time delay started whereby stage 1 is independent from the interlock setting staying initiated as long as the impedance criteria are fulfilled.
After expiry of the time delay stage 1 a trip signal “Trip Stage 1” is being produced.
Also after stage 2 delay a "Trip Stage 2" is given.

Via the “Test“ and “Blocking“ inputs the various stages of the minimum impedance function can be tested and/or blocked during the commissioning procedures.

Initiation and at the same time active trip outputs will reset (valid for DRS-COMPACT2A/ VE2) when during 25 consecutive samples, i.e. 2 cycles, the initiating conditions are no longer present (trip output extension).
Note: 37 consecutive samples at DRS-LIGHT and DRS-COMPACT /VE1.

24.5.2. MZ311

Undervoltage/Overcurrent, 3 Phase.

Function:

At least one of the three phase to phase voltages must be smaller and at least one of the three current inputs must be larger than the configured setting values whereby voltage and current inputs need not be associated.

Algorithm:

a)
V< (=Undervoltage) .AND. I> (=Overcurrent)
Have to occur simultaneously to initiate the function. It is sufficient when one of the three phase to phase voltages is below the setting and any of the three phase currents is exceeding the configured value.
Currents and voltages need not belong to a certain phase relation which also is not necessary.

b)
When setting parameter "Current Interlock" is reached then during the time delay sequence the current value can fall below setting but a TRIP signal will still be initiated after the delay (Setting Parameters "Operating time").
During the whole operating sequence the undervoltage initiation has to remain otherwise with even the overcurrent stage being still activated the function would reset immediately.

c)
When the current interlock "Latched" parameter is not enabled then during the whole time delay the conditions V< (undervoltage) .AND. I> (overcurrent) have to be present to produce a trip.

d)
After expiry of the time delay the trip output is initiated. After CB trip V< and I< are applicable. Since I< (undercurrent) is no longer required for the function memory mode (see setting parameter "Latched") the trip conditions after a generator shut-down would not reset. Therefore it is necessary to reset the latched trip sequence after a trip by suitable means.

In the DRS User program a "End Latched Interlock" can be configured ensuring a trip output reset under stand-still conditions:

"End Latched Interlock" = "External Blocking Signal": Blocking input "Voltage Function" must be set via external contact inputs.

"End Latched Interlock" = "Trip Reset": In this case the trip output duration is fixed to the function internal memory feature of 300 ms.
Simultaneously with trip reset the undercurrent memory is disabled.

e)
Blocking inputs:
Voltage blocking: Is always active.

Current blocking input:	Is only active when the current interlock function setting has not passed the latched current configuration. This blocking feature does not reset the undercurrent interlock and therefore is not suitable for an “End Latched Interlock” external input (refer to item “d”).

24.5.3. MZ312

Definite time overcurrent protection with 2 time delay stages. The current interlock is enabled by either undervoltage- or NPS overvoltage conditions.

Function:

At least one phase current has to be above the setting and simultaneously at least one of the phase to phase voltages must be below the configured settings or the NPS voltage being above setting during the whole time delay sequence.

Algorithm:

a)
I> (=Overcurrent)
.AND.
(U< (=Undervoltage) .OR. V2> Negative Phase Sequence Component is Above Setting Value

Must be present during the whole time delay up to trip initiation.
It is sufficient when any one of the phase to phase voltages is smaller than the setting value or the NPS component has exceeded the setting when any of the phase currents is above configuration setting.
Voltage and current input signals need not conform to the phase relation which can also not definitely defined by phase to phase voltages and phase currents.
Please note: Function MZ312 is not latched by memory.

b)
Calibration of the NPS voltage system:
NPS voltage = $|\underline{U}_2| = |\underline{U}_{L1L2} + a^2.\underline{U}_{L2L3} + a.\underline{U}_{L3L1}| / 3$.

Example 1:
By single phase injection with 100 V nominal the DRS internal display window will indicate a value of 33.3 V.

Example 2:
By an external wire break the window display will show about 50 V.
Please note: Phase to phase voltages are applied and if one of the three VT connections is interrupted the other two phases will back-feed in a 50% to 50% relation into the faulty phase to phase circuit, i.e. the corresponding two analogue inputs will display an internal measured value of approximately 50 V whereby the sum is a 100 V. The resulting negative phase sequence voltage amounts to approximately 50 V.

c)
Function outputs:

- Current function	... one of the three phase currents is above "Operating value I>" setting.
- Voltage function	... one of the three phase to phase voltages is below the "Operating Value V<".
- V_{inv} voltage function	... the NPS voltage value is larger than the "Operating value V_{inv}" setting.
- Trip 1	... is carried out after the "Operating Time 1" delay.
- Trip 2	... is carried out after the "Operating Time 2" delay Note: Both trip signals are apart from the two time delays performing the same shut-down sequence.

Note: MZ312 function is not provided with an initiating output.

d)
Blocking input is disabling the trip outputs:
- Voltage function
- Trip 1
- Trip 2

Blocking input does not disable the trip outputs:
- Current function
- Negative phase sequence voltage function

e)
Test input sets the outputs:
- Trip 1
- Trip 2

Test input does not enable the outputs:
- Current function
- Voltage function
- Negative phase sequence voltage function

f)
Change of function output sets all 5 outputs to "0":
- Current function
- Voltage function
- Negative phase sequence voltage function
- Trip 1
- Trip 2

g)
Setting Parameters "Phase Rotation":
Is referred to the voltage inputs.
Note: Necessary for the computation of the NPS voltage system.

h)
Note:
When the "Function Output" is displayed as output = "1" it does not necessarily mean that the function has operated. It could also be that only an undervoltage condition is appearing. Please note that all function outputs are supervised by an OR logic which issues the "Function Output = 1" – status.

24.6. COMMISSIONING

24.6.1. MZ221/ MZ222/ MZ321/ MZ322

!Note: During All Commissioning Activities The Relevant Safety Regulations Have to Be Strictly Observed and Applied!

Pre-Commissioning:

At first the correct external connections have to be verified.

The input matrix has to be configured according to the external circuitry and the operating value set according to requirements.

The function checks are preferably performed with the primary protected plant being out of service.

The operating value- and time delay parameters are to be set to the designed values (→protection co-ordination requirements).

Also the relay outputs have to be set for the LED matrix and the TRIP matrix according to plant requirements.

The function tests are preferably performed with the primary plant out of service.

With a relay test set, for example inject a test current into phase L1 and L2 and apply a test voltage with nominal rating to system 1 $V_{L1\text{-}L2}$.

Increase the current input into the interlock direction (= Stage 2) of the impedance stage

and observe the operating response in the DRS optional “Actual Measured Values”

function display window.

Note the current interlock operating value (= Stage 2) in the commissioning sheets.
By injection of 1.2 times the configured current interlock value reduce the voltage until operation of the impedance function.
Verify the result according to the above formula and also observe the optional “Actual Measured Values” impedance window display.
Record the impedance stage operating value (= Stage 1) into the commissioning sheets.
Raise the test voltage input until the impedance stage (= Stage 1) resets and record the value into the commissioning sheets.
Reduce the test current until the current interlock reset value and record the result in the commissioning sheets.

Please note that all external measured inputs, i.e. CT/VT quantities can be observed in the DRS User program displays.

Proceed with the same measurements for the other phases and record the values into the commissioning sheets.

Observe the trip and alarm signals, respectively the LED indications according to the parameter settings and the circuit diagrams.

Check the operating time at 1.5 times resp. 0,5 times the setting for each phase and stage with a suitable timer and enter the results into the test sheets.

Check the configured function blocks for each stage by applying the blocking signal when the protection is operating and the function trip output has to reset.

Check the configured function test feature for each stage by initiating the test signal and the protective function, respectively the stage has to operate without any external current input.

Caution should be taken since during the tests that also other protective functions may operate which have to be blocked during the test procedure.

After pre-commissioning all modified test parameters must be re-configured to the original plant parameter settings.

Primary Commissioning Tests:

During primary tests the function of the protection system is verified during the plant in service and following check should be carried out when operating conditions permit:

- Short circuit test:

Apply a short circuit of adequate rating located at a position where primary current can flow through the respective CT set.
Disable protection trips.
Insert measuring instruments into the CT/VT and/or open the internal measured values window in the DRS User program.
Run up the generator to rated speed and manually adjust excitation until the current interlock is operating.
Temporarily configure the function if necessary with reduced setting.
Record operating values.
For multi-stage protective functions also test each stage the same way.
Restore protection trips.
If possible shut down the generator via a live protective function trip and remove the short circuit and the external multimeters.
Restore the original function settings suitable for normal service operation.

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25. DRS SYSTEM / POLARITY OF VT AND CT QUANTITIES

25.1. DEFINITIONS / VOLTAGE- AND CURRENT VECTORS

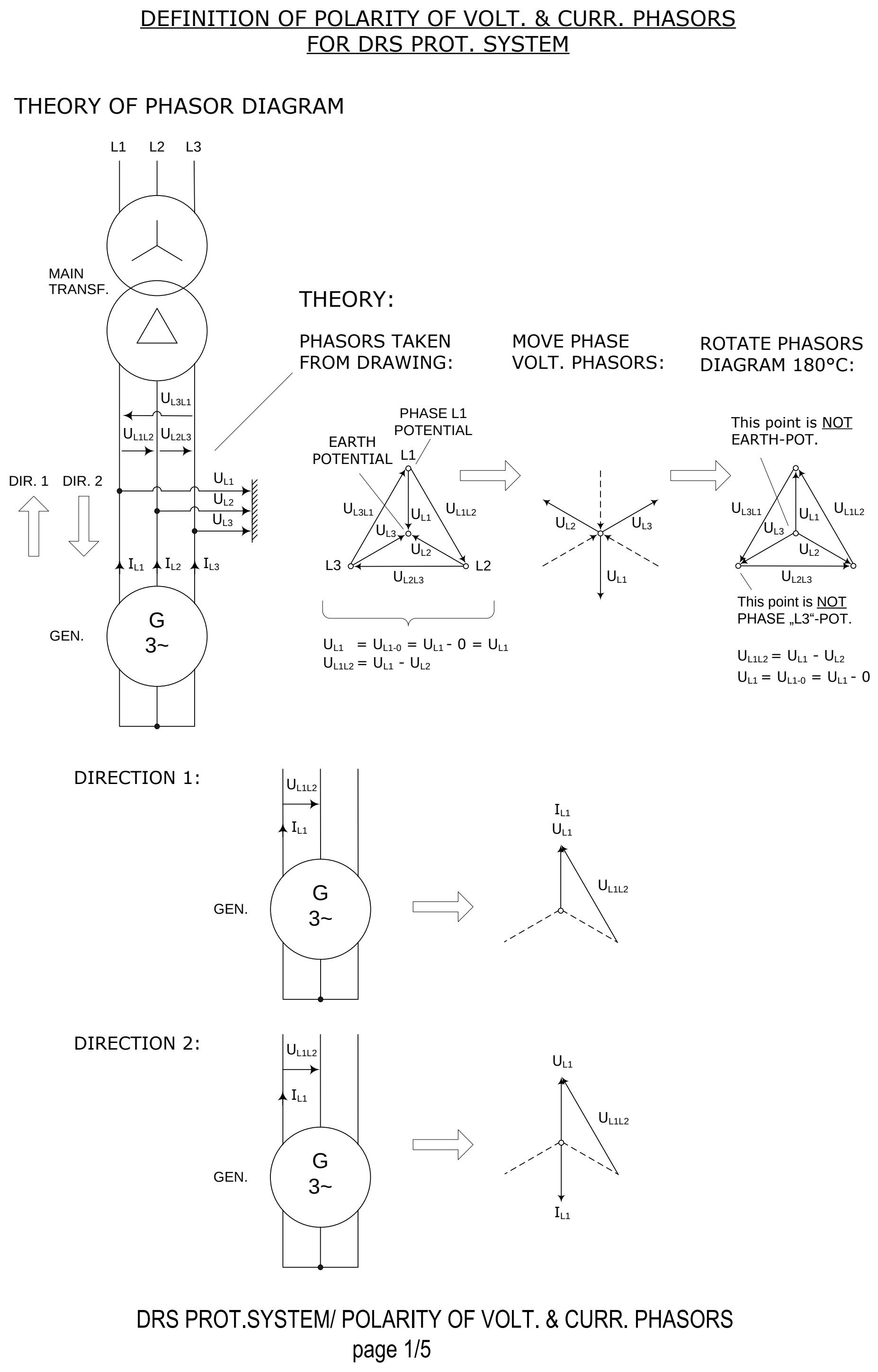
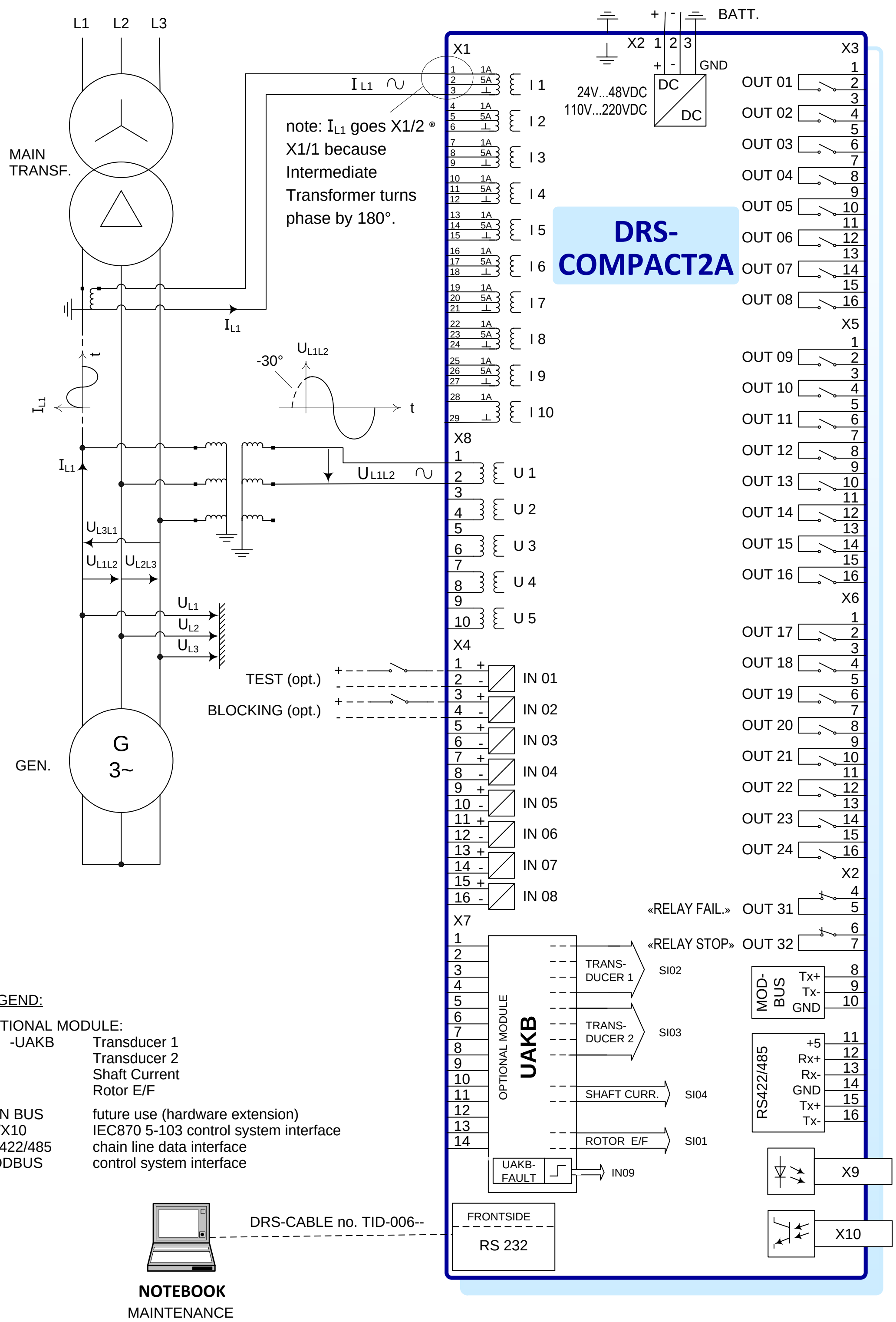


Fig. 330 DRS Prot. System/ Polarity of Volt. & Curr. Phasors

25.2. DRS COMPACT/ POLARITY OF VOLTAGES AND CURRENTS



LEGEND:

OPTIONAL MODULE:

-UAKB	Transducer 1 Transducer 2 Shaft Current Rotor E/F
CAN BUS	future use (hardware extension)
X9/X10	IEC870 5-103 control system interface
RS422/485	chain line data interface
MODBUS	control system interface

DRS PROT.SYSTEM/ POLARITY OF VOLT. & CURR. PHASORS

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Fig. 331 DRS Prot. System/ Polarity of Volt. & Curr. Phasors

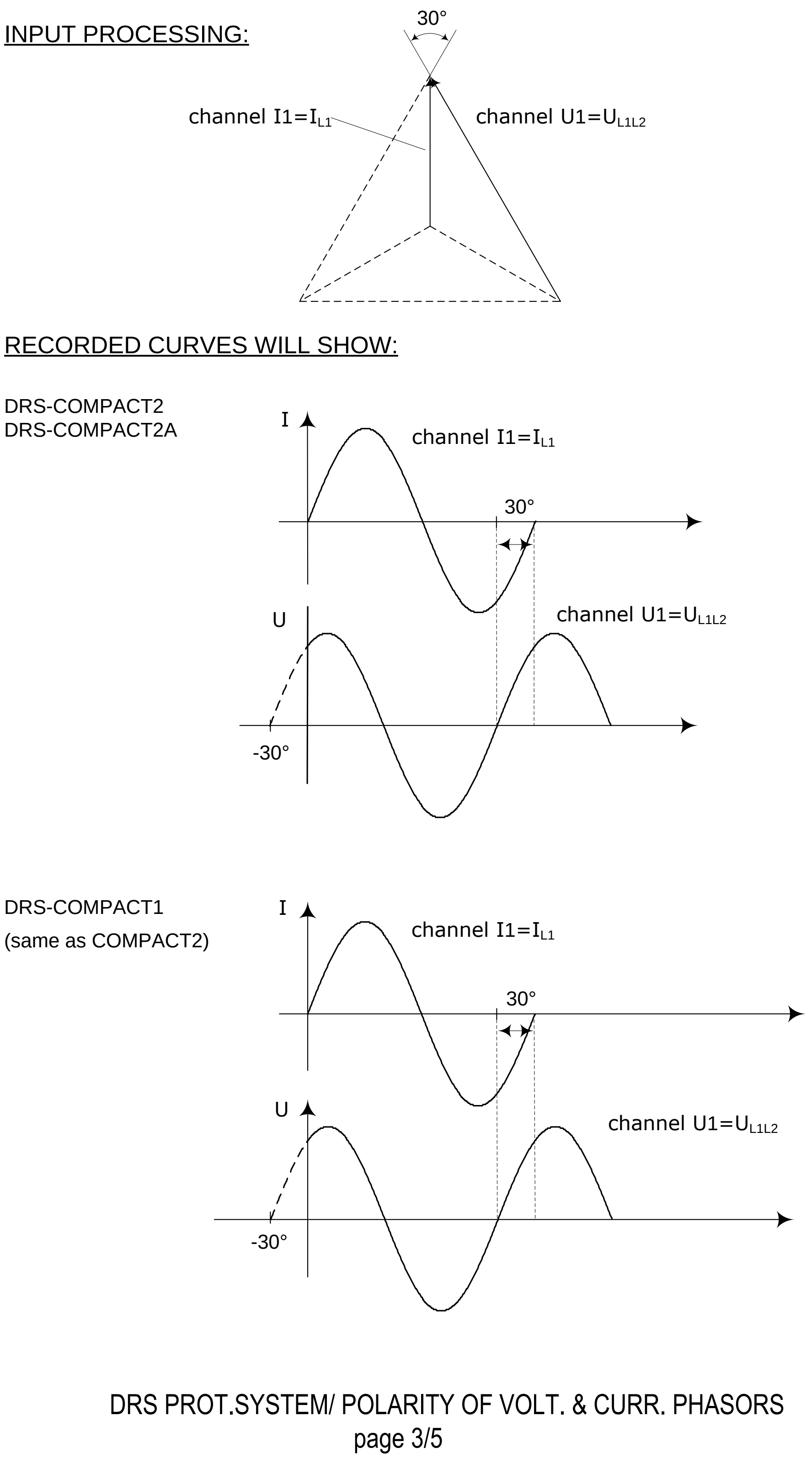


Fig. 332 DRS Prot. System/ Polarity of Volt. & Curr. Phasors

25.3. DRS-MODULAR / POLARITY OF VOLTAGES AND CURRENTS

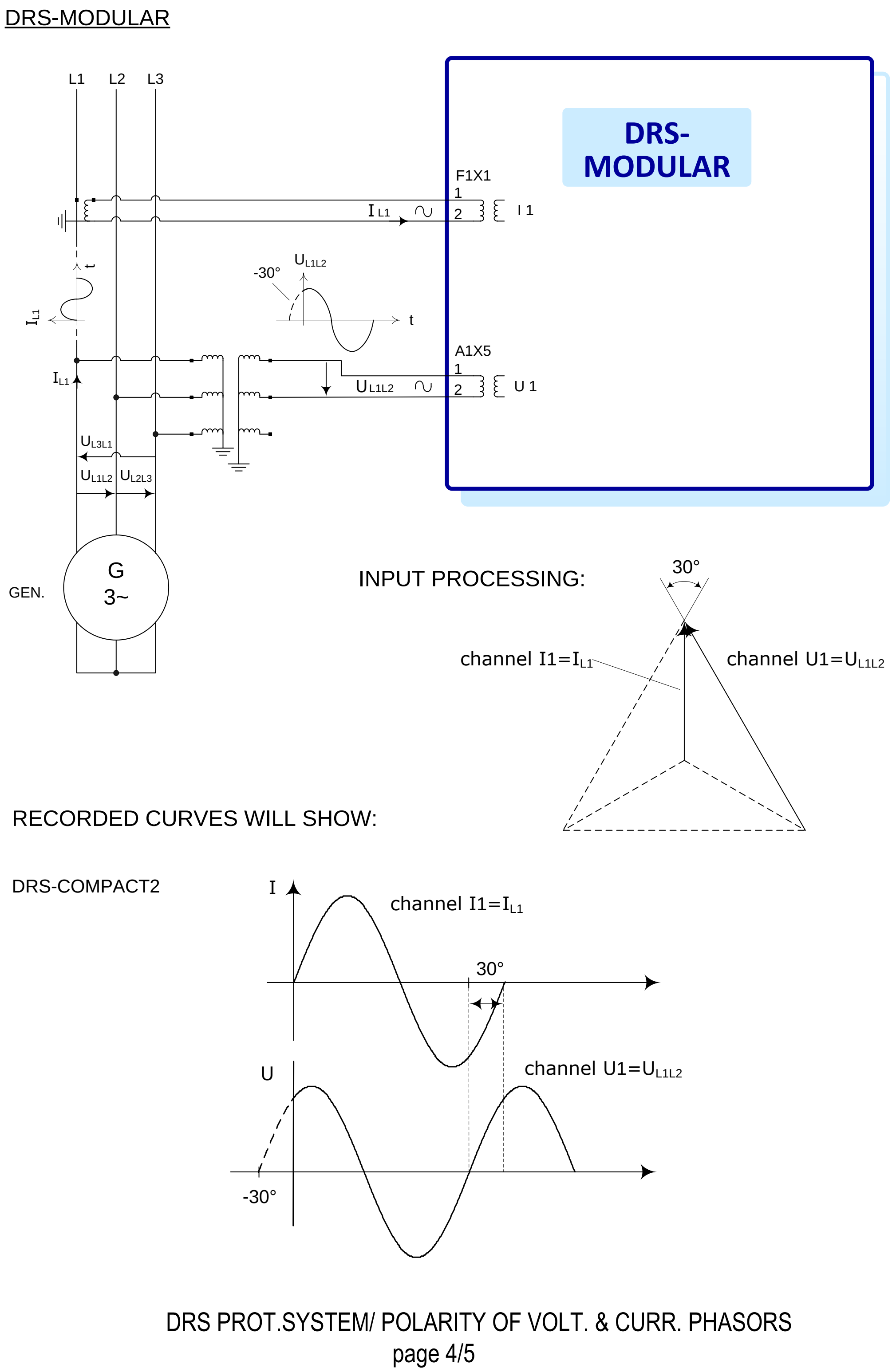
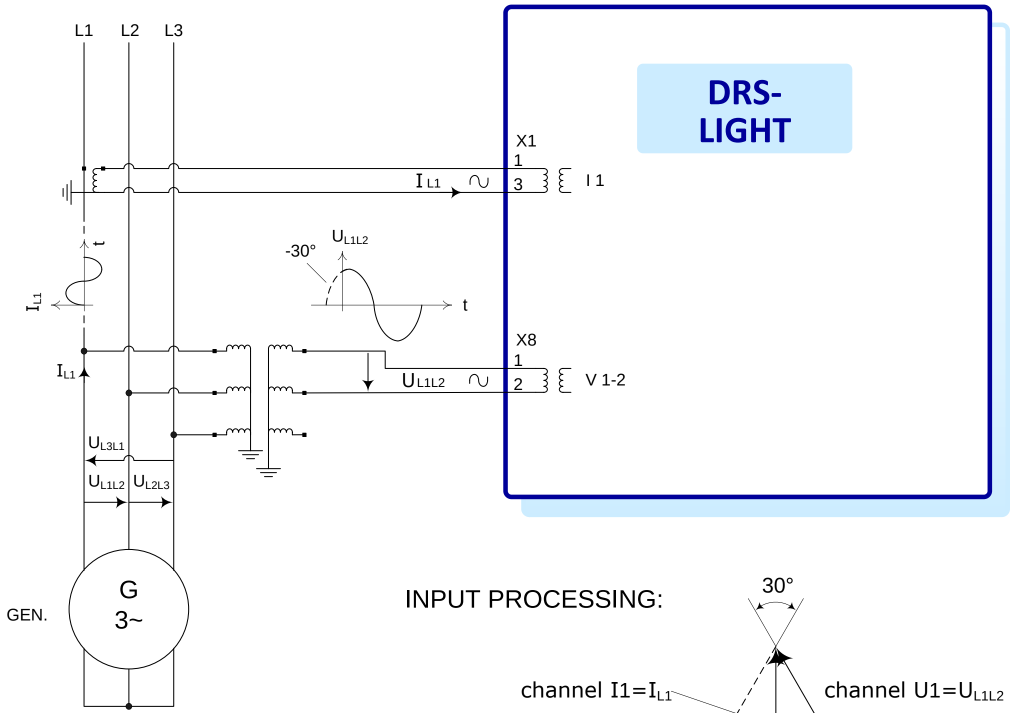


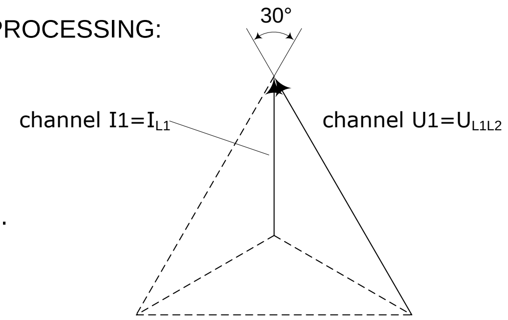
Fig. 333 DRS Prot. System/ Polarity of Volt. & Curr. Phasors

25.4. DRS-LIGHT / POLARITY OF VOLTAGES AND CURRENTS

DRS-LIGHT



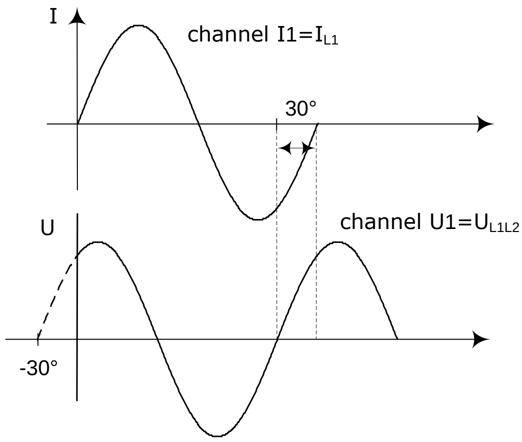
INPUT PROCESSING:



Adjustable via page 0/ address 72:
parameter = „POS“ ® same as COMPACT 2.

RECORDED CURVES WILL SHOW:

DRS-LIGHT



DRS PROT.SYSTEM/ POLARITY OF VOLT. & CURR. PHASORS
page 5/5

Fig. 334 DRS Prot. System/ Polarity of Volt. & Curr. Phasors

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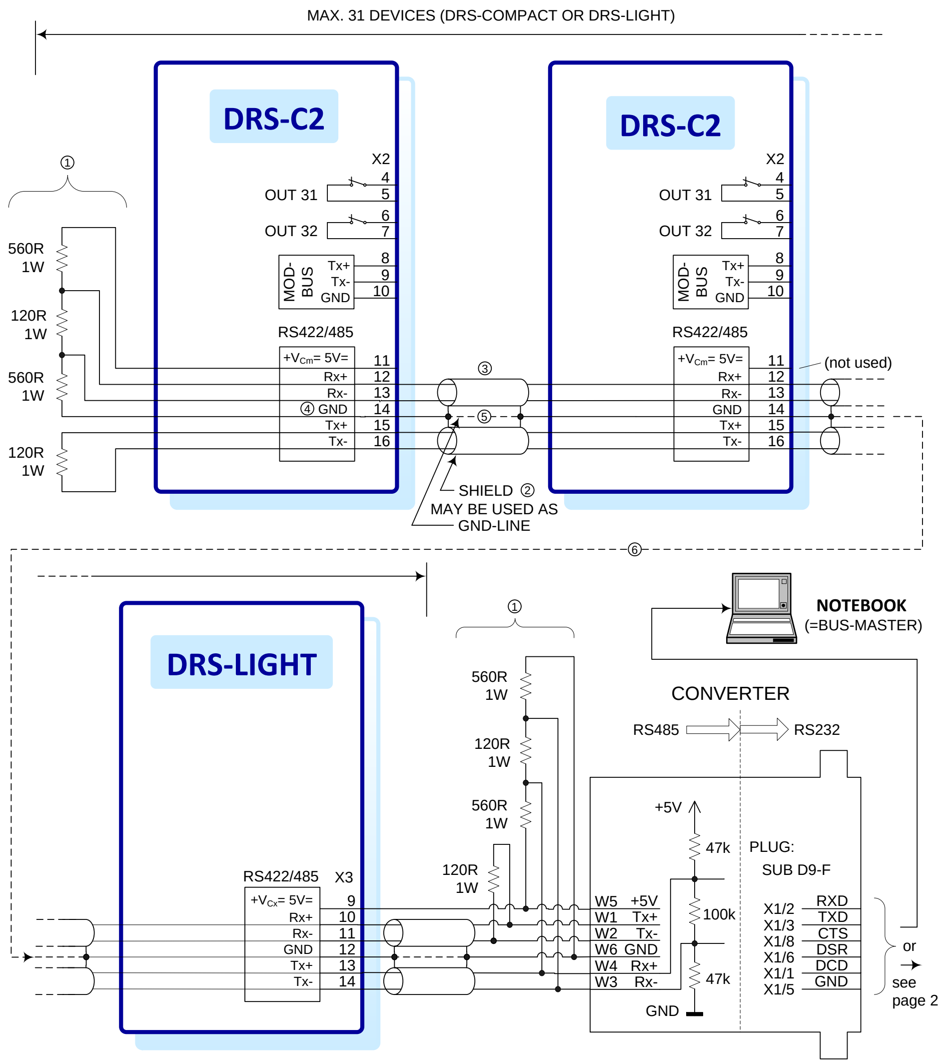
26. DRS SYSTEM / COMMUNICATION RS422-485

26.1. RS485 - BUS

DRS COMMUNICATIONS DRS-COMPACT2 & DRS-LIGHT/ RS422/ 485



① TERMINATING RESISTORS (120 OHM) & PULL-UP- & PULL-DOWN-RESISTOR (560 OHM):
MAY BE CANCELLED IF TOTAL LENGTH OF BUS < 30 m.
NOTE: CANCEL ALL OR NOTHING! IT IS NOT RECOMMENDED TO USE TERMINATING RESISTORS WITHOUT PULL-UP/DOWN-RESISTORS! PULL-UP/DOWN-RESISTORS AT Rx-SIDE ONLY!

② FOR SHORT CONNECTIONS (IF TOTAL < 30 m) NO SHIELD NECESSARY, JUST GND-LINE. USE STD. CUBICLE WIRING.

③ CABLES (IF TOTAL > 30 m): STANDARD TWISTED PAIR CABLE (2 x 0,6 mm²) WITH SHIELD (USED AS GND-WIRE).
R = 100 OHM / 1 kM, MAX. C = 750 pF (MAX. 38400 Bd), CHARACTERISTIC IMPEDANCE = 120 OHM

④ GND-CONNECTION: 100 R NOT NECESSARY BECAUSE GND IS POTENTIAL-FREE AT DRS-COMPACT AND DRS-LIGHT.

⑤ USE SHIELD OR GND-WIRE

⑥ BUS: USE SERIAL CONNECTION AND NOT STAR-CONNECTION.

DRS COMMUNICTION / RS485-BUS ←→ NOTEBOOK
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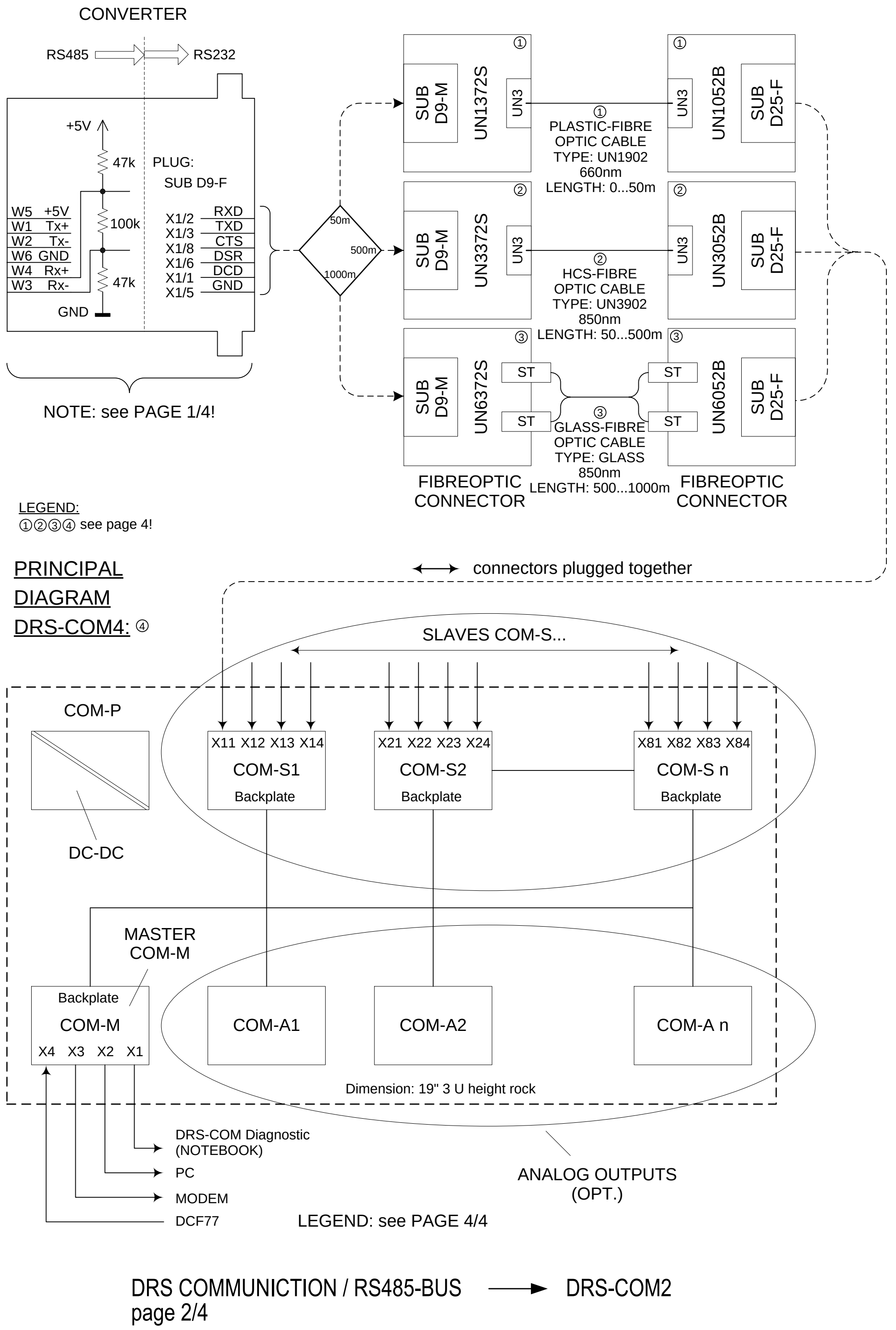
Fig. 335 DRS Communication / RS485-BUS ←→ Notebook

26.2. RS485 -- DRSCOM



②

Fig. 336 DRS Communication / RS485-BUS ←→ DRS-COM2

26.3. RS485 -- CONTROL SYSTEM ↔ PC

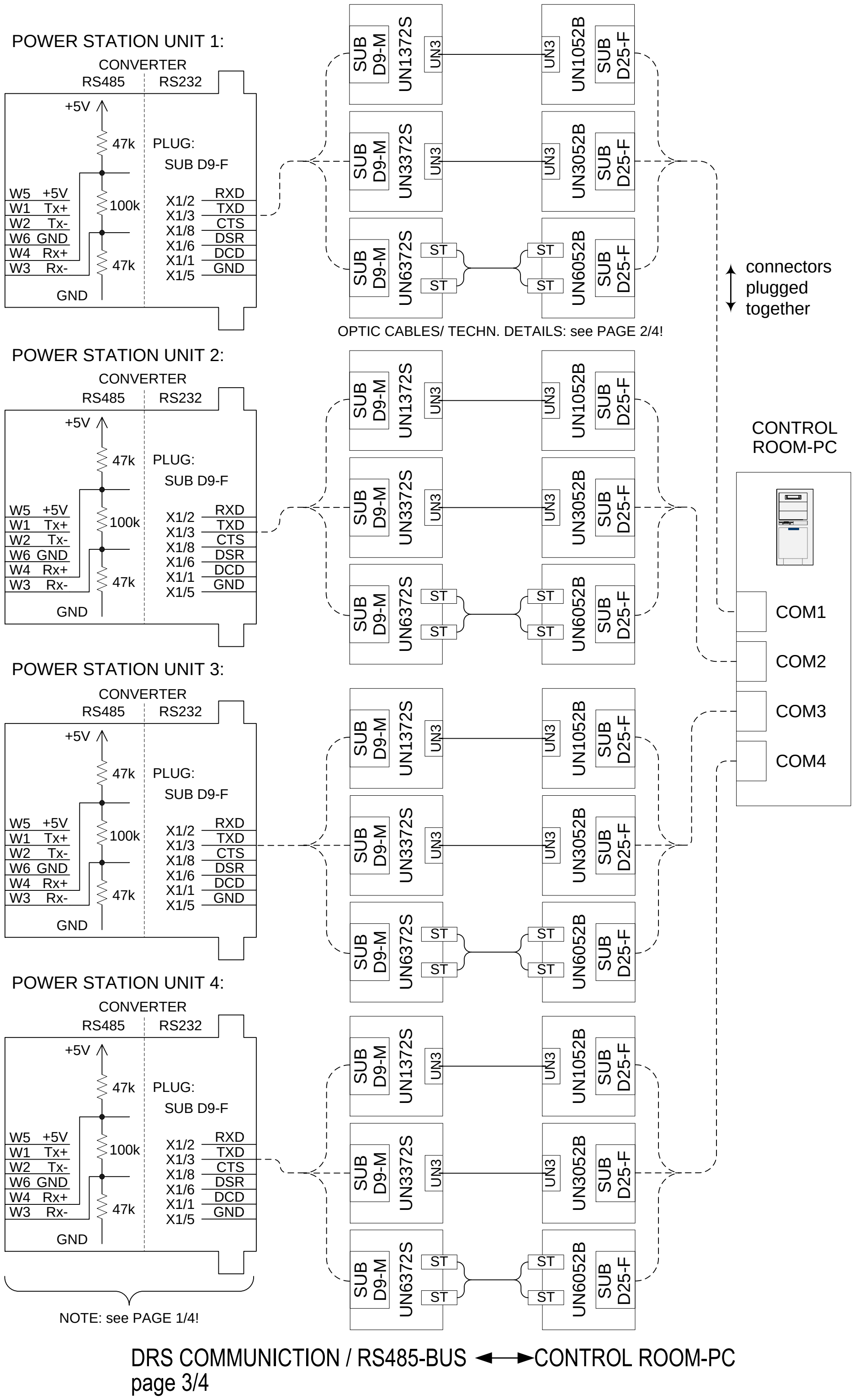
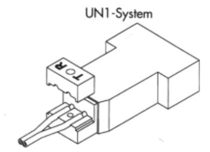


Fig. 337 DRS Communication / RS485-BUS ←→ Control Room - PC

26.4. RS485 -- DRSCOM / LEGEND

LEGEND to page 2

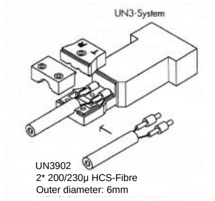
① PLASTIC FIBRE OPTIC CABLE 660nm, TYPE: UN 1902



HOW TO CHOOSE TYPE OF FIBREOPTIC CONNECTORS (DEPENDING ON LENGTH): see PAGE 2

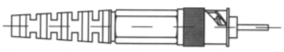
UN1902
2* 1000µ PMMA-Fibre

② HCS-FIBRE OPTIC CABLE 850nm, TYPE: UN 3902



HOW TO CHOOSE TYPE OF FIBREOPTIC CONNECTORS (DEPENDING ON LENGTH): see PAGE 2

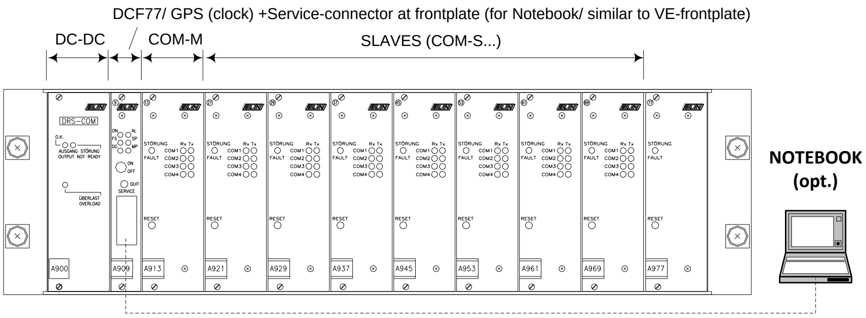
③ GLASS-FIBRE OPTIC CABLE WITH „ST“-CONNECTORS 850nm// 62,5/125µ, TYPE: UN 3944



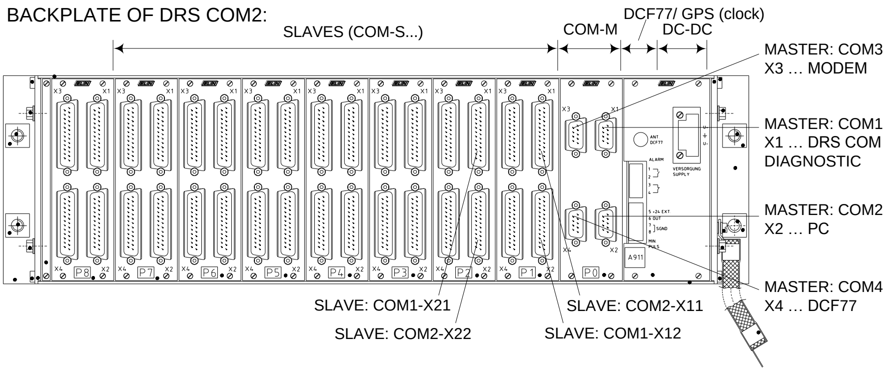
HOW TO CHOOSE TYPE OF FIBREOPTIC CONNECTORS (DEPENDING ON LENGTH): see PAGE 2

OPTIC CONNECTOR TYPE: 2pc. ST/UN 4442 (red)
+2pcs. ST/UN 4443 (green)

④ FRONTPANEL OF DRS COM2:



BACKPLATE OF DRS COM2:



DRS COMMUNICTION / RS485-BUS ◄—► DRS-COM2 / LEGEND
page 4/4

Fig. 338 DRS Communication / RS485-BUS ←→ DRS-COM2/ Legend

27. DRS SYSTEM / DIFFERENCES DRS COMPACT2 - DRS COMPACT2A

27.1. BASICS

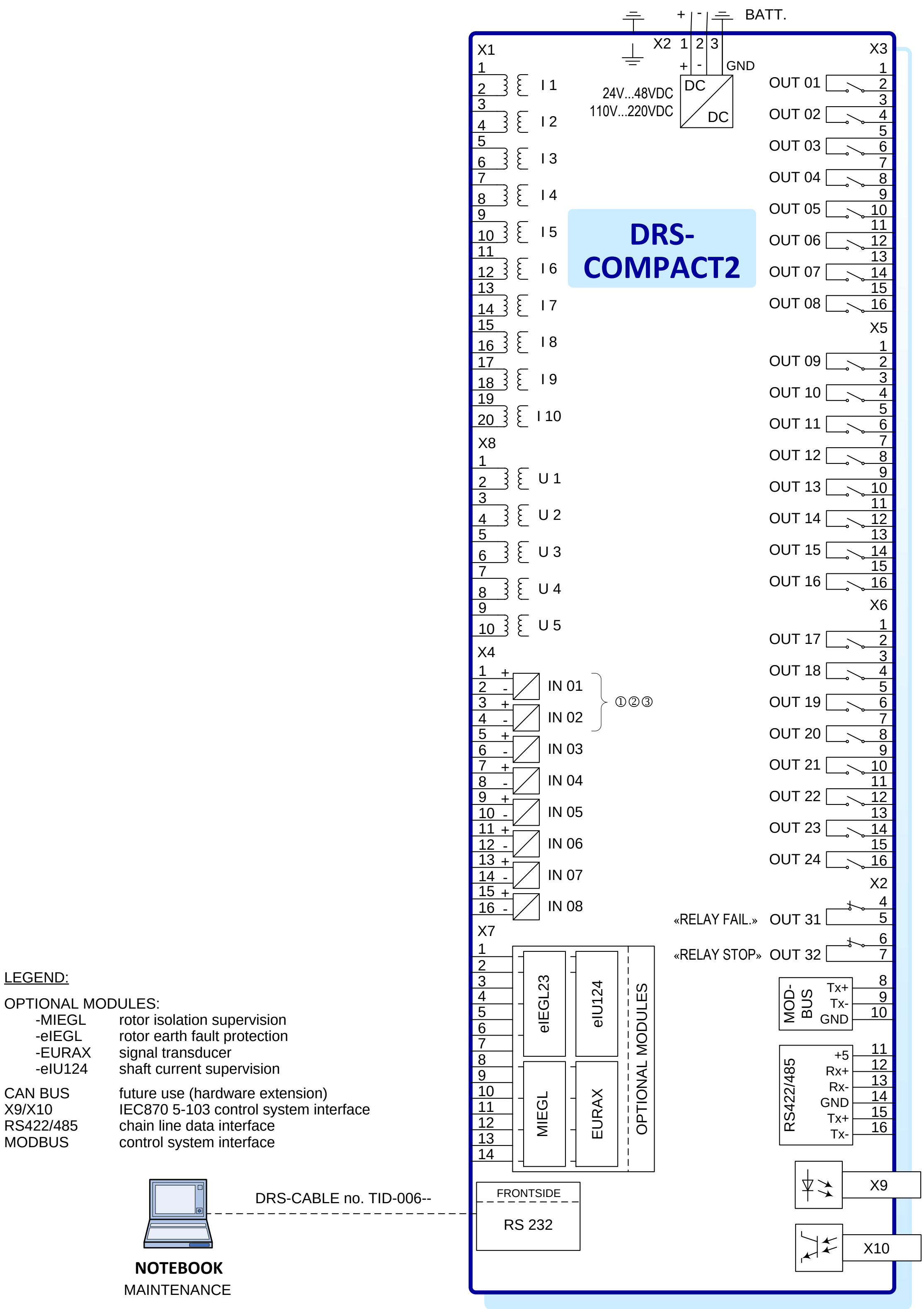
The digital protection system DRS COMPACT2A is a further improvement to the well known DRS COMPACT2 superseding the latter. Both relay models are to a large extent performing the same functionality and the differences are outlined in the following sections.

27.2. RELAY CASE DIMENSIONS

Both devices have the same numbers of Unit Height and Unit Width. The COMPACT2A is regarding the case size a little bit smaller but is provided with the same front dimensions and construction mass as the COMPACT2.

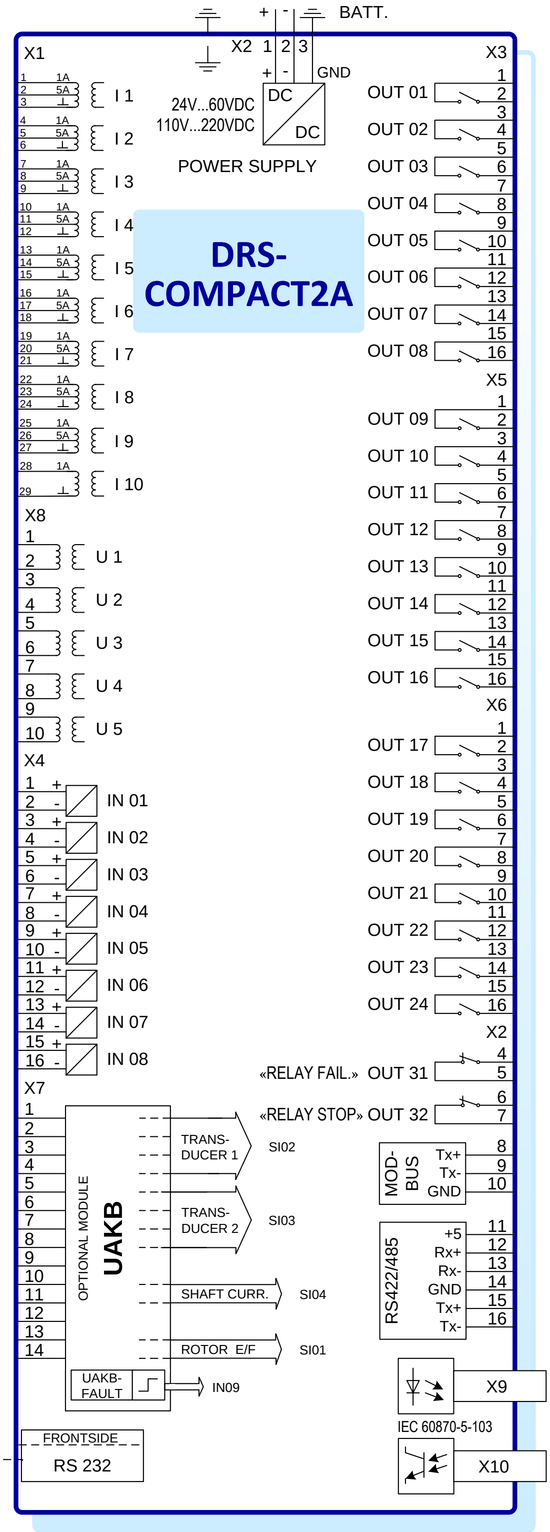
27.3. IN- / OUTPUTS

An overview over the various input- and output channels is shown in the following diagrams:



DRS-COMPACT2

Fig. 339 DRS-COMPACT2

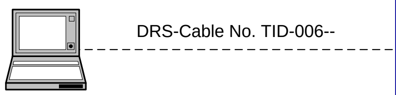


LEGEND:

OPTIONAL MODULE:

-UAKB	Transducer 1	
	Transducer 2	
	Shaft Current	
	Rotor E/F	

CAN BUS	future use (hardware extension)
X9/X10	IEC870 5-103 control system interface
RS422/485	chain line data interface
MODBUS	control system interface



NOTEBOOK
MAINTENANCE

DRS-COMPACT2A

Fig. 340 DRS-COMPACT2A

27.3.1. ANALOGUE INPUTS FOR CT AND VT CIRCUITS

Both models have the same number of current and voltage inputs:

10 x current
5 x voltage

For the CT inputs it has to be considered that in case of the DRS COMPACT2A the external CT inputs can either be connected to the 1A- or 5A tap on the same relay model, whereas the COMPACT2 can only be delivered in either a 1A or 5A version.

Therefore the DRS COMPACT2A is provided with 3 CT terminal connections instead of only 2 in case of the COMPACT2:

1A tap
5A tap
Neutral

As a consequence this requires a different terminal number arrangement which has to be considered when replacing and changing the relay model.

27.3.2. DIGITAL INPUT AND OUTPUTS

The same number applies for both relay models.

27.3.3. COMMUNICATION INTERFACE

The same type and number for both relay models.

27.3.4. OPTIONAL MODULES

DRS-COMPACT2		DRS-COMPACT2A	
MIEGL	Rotor insulation	UAKB	Rotor insulation Rotor earth fault Signal transducer Shaft current
eIEGL	Rotor earth fault		
EURAX	Signal transducer		
eIU124	Shaft current		

For the DRS COMPACT2 there are 4 additional module types available of which not more than 2 can be included in the same device as shown on the diagram above.

The DRS COMPACT2A is provided with only one additional module UAKB which covers all functions (software configuration and jumper settings required). The output circuitry of the UAKB is internally standardised wired according to the diagram above.

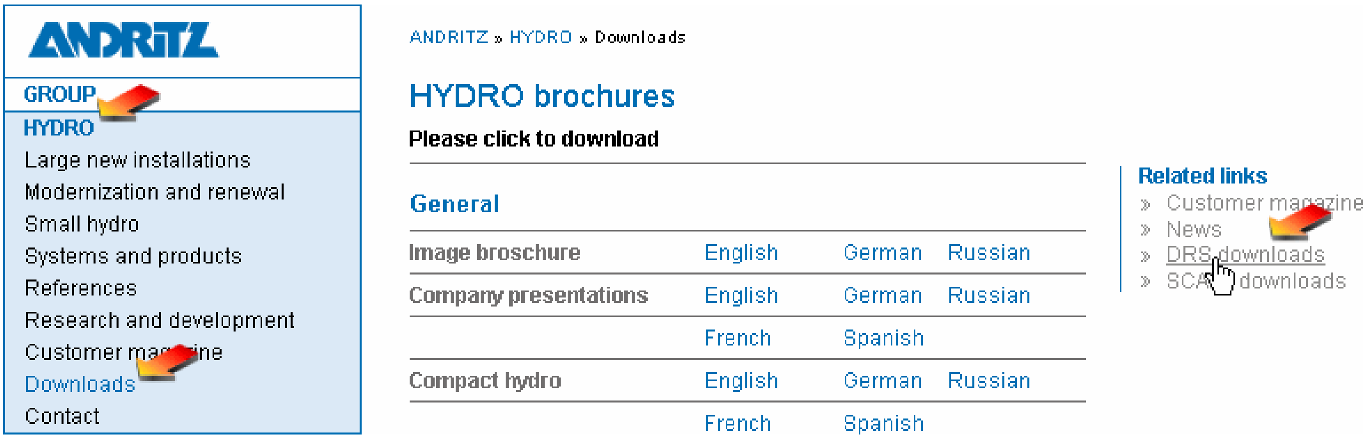
28. DRS FAMILY – FURTHER DOCUMENTS

Further publications on DRS family products can be found in the list below. With reference to the item number they can be ordered in an electronic or hardcopy version.

28.1. Download-Portal im WWW

An anytime up-to-date download portal is available for everyone.

Open in your browser www.andritz.com and click on business area **HYDRO**. Click next on item **Downloads** on the menu. Click on this page on top right corner on the link **DRS downloads**, see the arrows on following image.



DRS Downloads: http://www.andritz.com/hydro/hy-downloads/hy-drs-download.htm

ANDRITZ

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DRS downloads

Manual and documentation

Description	DRS-LIGHT	DRS-COMPACT2	DRS-LLD	DRS-BB	DRS-C2BB
Device Front Labels - Template for LED indication labelling	Word	Word			
Technical description	German English				
Functional description			Geman English	German English	German English
Local operation with display and keyboard	German English	German English			
Operational manual	German English	German English			

Printing instruction for front labels

Both *_LED.doc files contain templates for the adhesive labels for the LED lettering of the DRS-COMPACT2 and DRS-LIGHT. These pages can be printed with a laser printer onto an adhesive transparent label.
We recommend following label material: Canon adhesive label dull; CF 6-6025 dull, A4

Druckhinweise für Front Labels

*Die beiden *_LED.doc Dateien enthalten Vorlagen für die Klebeschildchen zur LED-Beschriftung von DRS-COMPACT2 und DRS-LIGHT. Diese Seiten können auf selbstklebende transparente Folien mit Laserdruckern ausgedruckt werden. Wir empfehlen als Folienmaterial: Canon Selbstklebefolien Matt;: CF 6-6025 matt, A4*

Definition files

Version	
Function definition files version 128	German English
Terminal definition files	German English
Installation instruction	German English

Operation and engineering tool

Description	
DRS-WIN	German English

DRS-COMPACT2

Contact
ANDRITZ HYDRO GmbH
Phone: +43 (1) 81195 6700»
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28.2. DRS-MODULAR

Documents

Document		Reference
DRS-MODULAR	DRS-MODULAR Operation Manual	DIM-001-1
DRS-MODULAR	DRS-MODULAR Description of Hardware	DIM-000-1
DRS-MODULAR	DRS-MODULAR Technical Data (e)	DIM-021-1

28.3. DRS-COMPACT2 • DRS-COMPACT2A

Documents

Document		Item Number
DRS-COMPACT2A	DRS-COMPACT2A Gerätebeschreibung (e)	MIC-007-1
DRS-COMPACT2A	DRS-COMPACT2A device description (ru)	MIC-008-1
DRS-COMPACT2A	DRS-COMPACT2A Techn. Data sheet	GIC-000-A.XX/90
DRS-COMPACT2A	DRS-COMPACT2A Maßzeichnungen	DIC00811_C2A-Außenrohr.pdf
DRS-COMPACT2	DRS-COMPACT2 Flyer (e)	MIC-005-1
DRS-COMPACT2	DRS-COMPACT2 O & M Manual (e)	DIC-025-1
DRS-COMPACT2	DRS-COMPACT2 technical short description	DIC-018-1
DRS-COMPACT2	DRS-COMPACT2 Local Operation (e)	DIC-006-1
DRS-COMPACT2	DRS-COMPACT2 Connecting Diagram	DIC-011-1
DRS-COMPACT2	DRS-COMPACT2 Device back view terminals	DIC-013-1
DRS-COMPACT2	DRS-COMPACT2 Replace VE2 Card	DIC-026-1

28.4. DRS-LIGHT

Documents

Document		Item Number
DRS-LIGHT	DRS-LIGHT Operation Manual (e)	DIL-000-1
DRS-LIGHT	DRS-LIGHT Operation Manual (s)	DIL-005-1
DRS-LIGHT	DRS-LIGHT Techn. Short Description (e)	MIL-001-1
DRS-LIGHT	DRS-LIGHT Techn. Short. Description (f)	MIL-002-1
DRS-LIGHT	DRS-LIGHT Local Operation (e)	DIL-001-1
DRS-LIGHT	DRS-LIGHT Local Operation (i)	DIL-020-1
DRS-LIGHT	DRS-LIGHT Configurator	DIL-014-1
DRS-LIGHT	DRS-LIGHT Function list per version	DIL-019-1
DRS-LIGHT	DRS-LIGHT Type Code	DIL-007-1
DRS-LIGHT	Wiring diagram DRS-LIGHT	DIL-009-1
DRS-LIGHT	DRS-LIGHT Dim. Draw. F. flush panel moun	DIL-018-1
DRS-LIGHT	DRS-LIGHT Dimensions Drawing	DIL-008-1
DRS-LIGHT	DRS-LIGHT Mech kit f projection mounting	TIL-032--.XX/10
DRS-LIGHT	ZE DRS-LIGHT Certificate	GIL-000-A.XX/79

DRS-LIGHT	DRS-LIGHT Auto reclose tech. Description	DIL-010-1

28.5. DRS-WIN

Documents

Document		Item Number
DRS-WIN4	DRS-WIN4 User Manual (e)	SID-401-1.XX/93
DRS-WIN4	DRS-WIN4 User Manual (i)	SID-401-1.XX/92
DRS-WIN4	DRS-WIN4 User Manual (n)	SID-401-1.XX/91
DRS-WIN4	DRS-WIN4 operation manual (ru)	SID-401-1.XX/94
DRS-WIN4	DRS-WIN4 DEMO Version (e)	SID-101-1.XX/60
DRS-WIN	DRS-WIN und Windows7 User information(e)	DID-043-1
DRS-WIN	DRS-WIN update instr. How spare parte	DID-039-1
DRS-WIN3	DRS-WIN3 User Manual (e)	SID-301-1.XX/93

NOTES