

**NA20**  
**PHASE, NEGATIVE SEQUENCE,  
RESIDUAL OVERCURRENT, THERMAL IMAGE  
PROTECTION RELAY**

**MANUAL**

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# 1 INTRODUCTION

## Scope and liability



This document describes the functions, the technical data of NA20 devices; instructions for mounting, setting and commissioning are included.

This manual has been checked out, however, deviations from the description cannot be completely ruled out, so that no liability in a legal sense for correctness and completeness of the information or from any damage that might result from its use is formally disclaimed.

The information given in this document is reviewed regularly; any corrections and integration will be included in subsequent editions that are identified by the date of revision.

We appreciate any suggestions for improvement.

We reserve the right to make technical improvements without notice.

## Applicability

This manual is valid for NA20 devices with firmware version 2.70 and following.

## Conformity

The product complies with the CEE directives:

- EMC Council Directives: 2014/30/EC
- Low voltage Directives: 2014/35/EC



## Copyright

All right reserved; It is forbidden to copy, modify or store material (document and sw) protected by copyright without Thytronic consent.

## Warranty

Thytronic warrants devices against defects in materials and workmanship under normal use for a period of ONE (1) YEAR from the date of retail purchase by the original end-user purchaser ("Warranty Period").

## Safety recommendations

The warning contained in this document are all-important for safety; special attention must be paid to the following symbols:



### DANGER

Death, severe personal injury or substantial property damage will result if proper precautions are not taken



### WARNING

Death, severe personal injury or substantial property damage can result if proper precautions are not taken.



### CAUTION

Minor personal injury or property damage can result if proper precautions are not taken

Installation and commissioning must be carried out by qualified person; Thytronic assumes no responsibility for damages caused from improper use that does not comply all warning and caution in this manual.

In particular the following requirements must be met:

- Remove power before opening it.
- Verify the voltage absence by means suitable instrumentation on relay connections; attention must be paid to all circuits supplied by external sources (binary input, CT, etc...)
- Care must be taken when handling metal parts.



### CAUTION

Settings must be established on the basis of a coordination study.

Numerical values inside examples have educational purpose only; they don't be used, in no way, for actual applications.

## Insulation tests

After insulation tests, hazardous voltages (capacitor charges,...) may be arise; it is advisable to gradually reduce the test voltage avoiding to erase it abruptly.

## Product identification

Each device is equipped with:

- Identification label installed on the front side with following informations: code number, phase and residual nominal currents, auxiliary voltage range and CE mark:
- Test label with following informations: data, serial number and test operator signature.

## Environment

The NA20 device must be employed according to the environment conditions shown (see technical data).

In case of different environment conditions, appropriate provisions must be provided (conditioning system, humidity control, etc...).

If contaminants are present (dust, corrosive substances, etc...), filters must be provided.

## Graphical conventions

The CEI/IEC and ANSI symbols is employed where possible:

e.g.: 51 = ANSI code concerning the overcurrent element.

Following text formats are used:

The ThyVisor<sup>(1)</sup> menu:

### Phase overcurrent -50/51

The parameter description (measures, thresholds, operate time,...) and related value:

*I* > *element*  
*Definite time*  
*I* > *def*

The display messages (MMI) are shown as:

NA20

Notes are highlighted with cursive letters inside colored bar

*Note: Useful description note*

## Glossary/definitions

$I_{En}$	Relay residual nominal current
$I_{Enp}$	Residual CT primary nominal current
$I_n$	Relay phase nominal current
$I_{np}$	Phase CT primary nominal current
$I_B$	Basic current: it represents the nominal current of the line or transformer, referred to the nominal current of the CT's for thermal image protection
37	Undercurrent ANSI code
46	Negative sequence overcurrent ANSI code
49	Thermal image ANSI code
50/51	Phase overcurrent ANSI code
50N/51N	Residual overcurrent ANSI code
BF	Circuit breaker failure ANSI code
74CT	CT supervision
74TCS	Trip Circuit Supervision
DFR	Digital Fault Recorder (Oscillography)
SER	Sequential Event Recorder
SFR	Sequential Fault Recorder
ANSI	American National Standard Institute
IEEE	Institute of Electrical and Electronics Engineers
IEC	International Electrotechnical Commission
CENELEC	Comité Européen de Normalisation Electrotechnique
52 o CB (Circuit Breaker)	Circuit Breaker
52a	Auxiliary contact in the breaker that is in the same position as the breaker. It can be assigned to a binary input to locate the CB position (Breaker failure and/or CB diagnostic functions). (52a open = CB open)
52b	Auxiliary contact in the breaker that is in the opposite position as the breaker (52b open = CB closed)
K1...K6...K10	Output relays
Pulse	Output relay with pulse operation
tTR	Output relay minimum pulse width
Latched	Output relay with latched operation (manual reset) Output relay with latched operation (automatic reset)
No-latched	Output relay with no-latched operation (automatic reset)
CT	Current Transformer
P1	IEC nomenclature for primary polarity mark of CTs (as an alternative to a ANSI dot)
P2	IEC nomenclature for primary polarity mark of CTs (as an alternative to

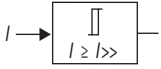
*Note 1 The graphic interface and the operation of the ThyVisor software are described in the relative chapters*

S1	a ANSI no-dot) IEC nomenclature for secondary polarity mark of CTs (as an alternative to a ANSI dot)
S2	IEC nomenclature for secondary polarity mark of CTs (as an alternative to a ANSI no-dot)
Self test	Diagnostic
Start	Leave an initial condition or reset condition (Pickup)
Trip	Operation (with operate time)
Operating time	Duration of time interval between the instant when the characteristic quantity in reset condition is changed, under specified conditions, and the instant when the relay operates
Dropout ratio	The ratio of a reset value to an operate value in well-specified conditions. The dropout ratio may be lower or greater than 1 according as an over or under element is considered
Reset time	Duration of the time interval between the instant when the characteristic quantity in operate condition is changed, under specified conditions, and the instant when the relay operates. The stated reset time is related to a step variation of characteristic quantity in operate condition to the reset condition.
Overshoot time	The critical impulse time for a relay which is in its reset condition, is the longest duration a specified change in the input energizing quantity(ies) (characteristic quantity), which will cause the relay to change to operate condition, can be applied without the relay switches. The overshoot time is the difference from the operate time and the critical impulse time. The declared values for the overshoot time are applicable with the lower setting value of the operation time.
MMI (Man Machine Interface)	Operator front panel
ThyVisor	Setting and monitoring software
Log file	A text file that lists actions that have occurred (ThyVisor).
J2SE	Java Platform Standard Edition
Subnet Mask	(Ethernet nomenclature)
Sw	Software
Fw	Firmware
Upgrade	Firmware upgrade
XML	eXtensible Markup Language

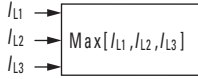
**Symbols**



Threshold setting (e.g. pickup  $I_{>>}$ ).  
The value is available for reading and is adjustable by means ThySetter + MMI.



Limit block ( $I >$  threshold).



Computation block (Max phase current)



Curve type (definite/inverse time)



Logic internal signal (output); may be a logical state (e.g.  $I_{>>}$  Start) or a numerical value  
It is available for reading (ThySetter + communication interface)



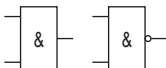
Logic external signal (input); may be a command coming from a binary input or a sw command  
It is available for reading (ThySetter + communication interface)



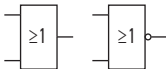
Internal signal (e.g. Breaker Failure output state concerning to the 2nd threshold of the 50 element)  
It is not available for reading (missing arrow)



Switch



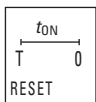
AND and NAND logic gates



OR and NOR logic gates



EXOR logic gate



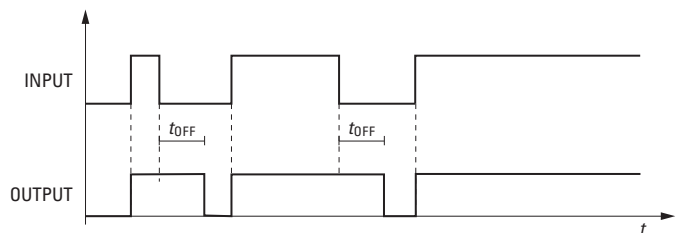
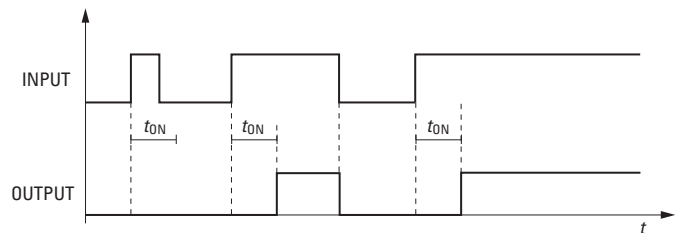
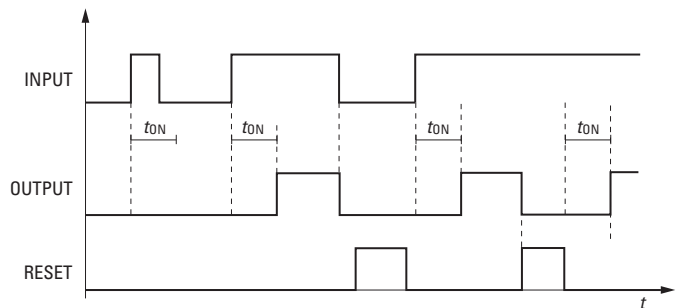
ON delay timer with reset ( $t_{ON}$  delay)

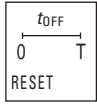


ON delay timer without reset ( $t_{ON}$  delay)

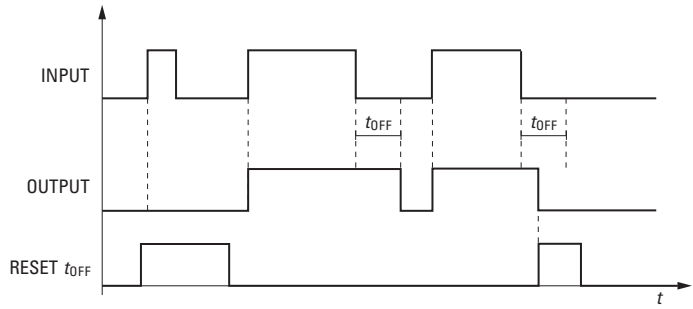


OFF delay timer (dropout) without reset ( $t_{OFF}$  delay)

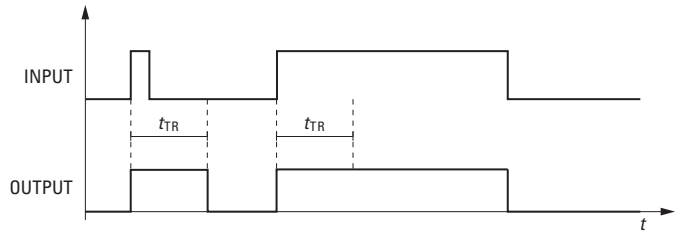




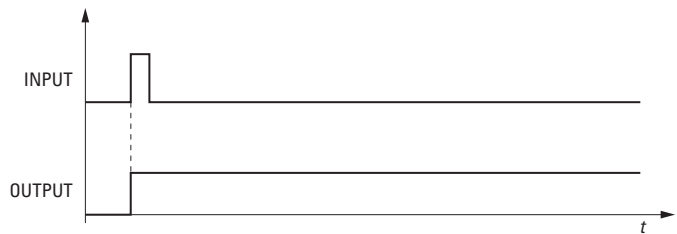
OFF delay timer (dropout) with reset ( $t_{OFF}$  delay)



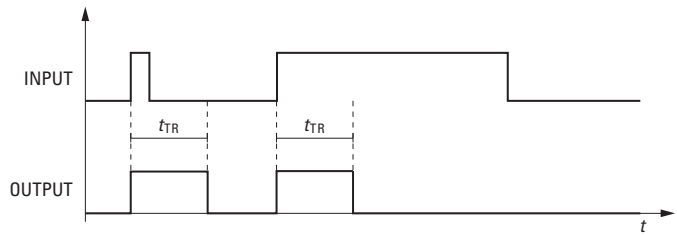
Minimum pulse width operation for output relays ( $t_{TR}$ )



Latched operating mode for output relays and LEDs



Pulse operating mode for output relays



## 2 GENERAL

### Preface

The relay type NA20 is typically used in HV, MV and LV radial networks as feeder or power transformer protection.

In solidly grounded systems the residual overcurrent protection can be used on feeders of any length, while in ungrounded or Petersen coil and/or resistance grounded systems, the residual overcurrent protection can be used on feeders of small length in order to avoid unwanted trippings due to the capacitive current contribution of the feeder on external ground fault.

Beside to the phase and residual overcurrent protection, the following protective functions are provided:

- Thermal image protection of lines and power transformers.
- Undercurrent protection for monitoring of CB opening.
- Negative sequence protection against asymmetrical short circuits and unbalance loads.
- $I_2/h$  protection against phase interruption under low-load condition.

Following input circuits are available:

- Three phase current and one residual current inputs with nominal currents independently selectable at 1 A or 5 A using dip-switch.
- Two or five (optional) binary inputs.
- One block input (logic selectivity).

In addition to the main protection element, the breaker failure (BF), CT monitoring (74CT), Trip Circuit Supervision (TCS) and programmable logic (PLC) are also provided.

Setting, programming and reading operations must be effected by means of Personal Computer with ThyVisor software or by means of remote communication interface (RS485 bus and Ethernet network or USB); all operations must be performed through MMI.

According to the hardware configurations, the NA20 protection relay can be shipped in various case styles depending on the required mounting options:

- Flush.
- Projecting mounting.
- Rack.
- With separate operator panel.

Other options are:

- Auxiliary power supply operating range.
- Communication protocols.

### Photo



## Main features

- Metallic case.
- Backlight LCD 4x16 Display.
- Eight LEDs that may be joined with matrix criteria to many and various functions.
- RESET key to clear LED indications and latched output relays.
- Two free settable binary inputs.
- Independently settable for start, trip, self-test and control six output relay (K1...K6) Each output relay may be set with normally energized or normally de-energized operating mode and manual or automatic reset (latched/no-latched).
- Rear Ethernet communication port, with MODBUS TCP/IP® protocol, with RJ45 (copper wires) or FX (optical fiber) connection.
- Rear RS485 port, with ModBus protocol.
- USB front serial port (local communication for ThyVisor).
- Real time clock with super capacitor.

The most significant constructive features are:

- Galvanically insulated input and output circuits (communication and binary circuits included).
- Optimum filtering of input signals through combined use of analog and digital filters.
- Traditional electromechanical-type final output contacts with continuous monitoring of control coil continuity.
- Auxiliary supply comprising a switching-type voltage stabilizing circuit having a very wide working range and a very small power dissipation
- Nominal frequency: 50 or 60 Hz.

The most significant operating features are:

- Programming of operating modes and parameters by means of the front keys and alphanumeric display, with a programming procedure based on carrying out guided selections and on explicit and immediate signalling of the operations being performed, so that such procedure can be carried out without coding tables or mnemonic informations.
- The feature modification operations do not interrupt the normal functions of the relay.
- Impossibility of programming unacceptable parameter values, thanks to the automatic limitation of top and bottom scale values for the relative setting ranges.
- Currents are sampled 24 times per period and measured in the effective value (RMS) of the fundamental component using the DFT (Discrete Fourier Transform) algorithm and digital filters.
- The fault recorder (SFR) runs continuously capturing in circular mode the last twenty events upon trigger of binary input/output and/or element pickup (start-trip).
- The event recorder (SER) runs continuously capturing in circular mode the last three hundred events upon trigger of binary input/output.
- Digital fault recorder (DFR) in COMTRADE format (oscillography).

## 3 TECHNICAL DATA

### 3.1 GENERAL

#### □ Product standard for measuring relays

*Reference standards*

IEC 60255-1 **Part 1: Common requirements**

#### □ Mechanical data

Mounting:

- Flush.
- Projecting.
- Rack.
- Separated operator panel.

External dimensions (Flush mounting)

177 x 107 x 235 (high x width x depth)  
screw connection

Terminals

Mass (Flush mounting)

2.0 kg

Reference standards

EN 60529, EN 60529/A1

*Degrees of protection provided by enclosures (IP Code)*

- Front
- Terminals

IP52  
IP20

#### □ Insulation

*Reference standards*

EN 60255-5, IEC 60255-27

##### High voltage test (50 Hz - 60 s)

- Auxiliary power supply
- Input circuits
- Output circuits
- Output circuits (between open contacts)
- Communication circuits

2 kV  
2 kV  
2 kV  
1 kV  
500 V

##### Impulse voltage withstand test (1.2/50 µs):

- Auxiliary power supply
- Input circuits
- Output circuits
- Output circuits (between open contacts)

5 kV (Common mode) - 2kV (Differential mode)  
5 kV  
5 kV  
1 kV

Insulation resistance

>100 MΩ

#### □ Voltage dip and interruption

*Reference standards*

EN 61000-4-29, IEC 60255-22-11

##### Voltage dips, short interruptions and voltage variations on dc input power port immunity tests

- Interruption (UT=40%)
- Interruption (UT=0%)
- Voltage variations (UT=80...120%)

100 ms  
50 ms  
10 s

#### □ EMC tests for interference immunity

*Reference standards*

IEC 60255-26, EN 60255-26

##### Product standard for measuring relays

##### Generic standards immunity for industrial environments

EN 61000-6-2

- Electromagnetic compatibility requirements for measuring relays and protection equipment

##### Apparati di automazione e controllo per centrali e stazioni elettriche

- Compatibilità elettromagnetica - Immunità
- Normativa di compatibilità elettromeccanica per apparati e sistemi

ENEL REMC 02  
ENEL REMC 01

*Reference standards*

EN 60255-22-1 IEC 60255-22-1  
EN 61000-4-12 EN 61000-4-12

##### Damped oscillatory wave

- 0.1 MHz and 1 MHz common mode
- 0.1 MHz and 1 MHz differential mode
- Ring wave common mode
- Ring wave differential mode

2.5 kV  
1.0 kV  
2.0 kV  
1.0 kV

*Reference standards*

EN 60255-22-2 IEC 60255-22-2  
EN 61000-4-2 IEC 61000-4-2

##### Electrostatic discharge

- Contact discharge
- Air discharge

6 kV  
8 kV

*Reference standards*

EN 60255-22-3 IEC 60255-22-3  
EN 61000-4-3 IEC 61000-4-3

##### Radiated radio-frequency fields

- 80...1000 MHz AM 80%

10 V/m

<ul style="list-style-type: none"> <li>• 900 MHz Pulse modulated</li> </ul>	<p>10 V/m EN 60255-22-4 IEC 60255-22-4 EN 61000-4-4 IEC 61000-4-4</p>
<p><b>Reference standards</b></p> <p><b>Fast transient burst (5/50 ns)</b></p> <ul style="list-style-type: none"> <li>• Auxiliary power supply</li> <li>• Input circuits</li> </ul>	<p>2 kV 4 kV</p>
<p><i>Reference standards</i></p> <p><b>High energy pulse</b></p> <ul style="list-style-type: none"> <li>• <math>U_{aux}</math> (line-to-ground 10 ohm, 9 <math>\mu</math>F)</li> <li>• <math>U_{aux}</math> (line-to-line 0 ohm, 18 <math>\mu</math>F)</li> <li>• I/O ports (line-to-ground 40 ohm, 0.5 <math>\mu</math>F)</li> <li>• I/O ports (line-to-line 40 ohm, 0.5 <math>\mu</math>F)</li> </ul>	<p>EN 60255-22-5 IEC 60255-22-5 EN 61000-4-5 IEC 61000-4-5</p> <p>2 kV 1 kV 2 kV 1 kV</p>
<p><i>Reference standards</i></p> <p><b>Conducted radio-frequency fields</b></p> <ul style="list-style-type: none"> <li>• 0.15...80 MHz AM 80% 1kHz</li> </ul>	<p>EN 60255-22-6 IEC 60255-22-6 EN 61000-4-6 IEC 61000-4-6</p> <p>10 V</p>
<p><i>Reference standards</i></p> <p><b>Power frequency immunity tests</b></p> <ul style="list-style-type: none"> <li>• Dc voltage</li> <li>• 50 Hz continuously</li> <li>• 50 Hz 1 s</li> <li>• 0.015...150 kHz</li> </ul>	<p>EN 60255-22-7 IEC 60255-22-7 EN 61000-4-16 IEC 61000-4-16</p> <p>30 V 30 V 300 V 30 V</p>
<p><i>Reference standards</i></p> <p><b>Magnetic field 50 Hz</b></p> <ul style="list-style-type: none"> <li>• 50 Hz continuously</li> <li>• 50 Hz 1 s</li> </ul>	<p>EN 61000-4-8 IEC 61000-4-8</p> <p>100 A/m 1 kA/m</p>
<p><i>Reference standards</i></p> <p><b>Damped oscillatory magnetic field</b></p> <ul style="list-style-type: none"> <li>• Damped oscillatory wave 0.1 MHz</li> <li>• Damped oscillatory wave 1 MHz</li> </ul>	<p>EN 61000-4-10 IEC 61000-4-10</p> <p>30 A/m 30 A/m</p>
<hr/>	
<p><b>□ Emission</b></p>	<p><i>Reference standards</i></p> <p>EN 60255-25 IEC 60255-25 EN 61000-6-4 IEC 61000-6-4 EN 55011 CISPR 11</p>
<p><b>Electromagnetic emission tests</b></p> <ul style="list-style-type: none"> <li>• Conducted emission auxiliary power supply 0.15...0.5 MHz</li> <li>• Conducted emission auxiliary power supply 0.5...30 MHz</li> <li>• Radiated emission 30...230 MHz</li> <li>• Radiated emission 230...1000 MHz</li> </ul>	<p>79 dB <math>\mu</math>V 73 dB <math>\mu</math>V 40 dB <math>\mu</math>V/m 47 dB <math>\mu</math>V/m</p>
<hr/>	
<p><b>□ Mechanical tests</b></p>	<p><i>Reference standards</i></p> <p>EN 60255-21-1 EN 60255-21-2 RMEC01</p> <p><b>Vibration, shock, bump and seismic tests on measuring relays and protection equipment</b></p> <ul style="list-style-type: none"> <li>• EN 60255-21-1 Vibration tests (sinusoidal)</li> <li>• EN 60255-21-2 Shock and bump test</li> </ul>
<hr/>	
<p><b>□ Climatic tests</b></p>	<p><i>Reference standards</i></p> <p>IEC 60068-x ENEL R CLI 01 CEI 50</p> <p><b>Environmental testing</b></p> <p>Ambient temperature -25...+70 °C Storage temperature -40...+85 °C Relative humidity 10...95 % Atmospheric pressure 70...110 kPa</p>
<hr/>	
<p><b>□ Safety</b></p>	<p><i>Reference standards</i></p> <p>IEC 60255-27</p> <p><b>Safety requirements for electrical equipment for measurement, control and laboratory use</b></p> <p>Pollution degree 3 Reference voltage 250 V Overvoltage category III</p>
<hr/>	
<p><b>□ Certifications</b></p>	<p><i>Reference standards</i></p> <p>EN 50263</p> <p><b>Product standard for measuring relays</b></p> <p><b>CE Conformity</b></p> <ul style="list-style-type: none"> <li>• EMC Directive 2014/30/EC</li> <li>• Low Voltage Directive 2014/35/EC</li> </ul> <p><b>Type tests</b></p> <p>IEC 60255-1</p>

### 3.2 INPUT CIRCUITS

#### □ Auxiliary power supply Uaux

Voltage	
Nominal value (range)	24...48 V~/115...230 V~/110...220 V-
Operative range (each one of the above nominal values)	19...60 V~/85...265 V~/75...300 V-
Inrush current (max)	
• 24 V-	6 A, 5 ms
• 48 V-	14 A, 5 ms
• 110 V-	20 A, 1 ms
• 230 V~	50 A, 1 ms
Frequency (for alternate voltage supply)	45...66 Hz
Max distortion factor ( for alternating voltage supply)	15%
Max alternating component (for dc voltage supply):	
• Full wave rectified sine wave	100 %
• Sine wave	80 %
Power consumption:	
• Maximum (energized relays, Ethernet TX)	10 W (20 VA)
• Maximum (energized relays, Ethernet FX)	15 W (25 VA)

#### □ Phase current input circuits

Relay nominal phase current $I_n$	1 A or 5 A selectable by dip-switch
Permanent overload	25 A
Thermal overload (1 s)	500 A
Dynamic overload (half cycle)	1250 A
Rated consumption (for any phase)	≤ 0.002 VA with $I_n=1$ A ≤ 0.04 VA with $I_n=5$ A

#### □ Residual current input circuit

Relay nominal residual current $I_{En}$	1 A or 5 A selectable by dip-switch
Permanent overload	25 A
Thermal overload (1 s)	500 A
Dynamic overload (half cycle)	1250 A
Rated consumption	≤ 0.006 VA with $I_{En}=1$ A ≤ 0.12 VA with $I_{En}=5$ A

#### □ Binary input circuits

Quantity	2 or 5 (optional)
Type	optocoupler
Operative range	24...265 V~/-
Min activation voltage	18 V
Max consumption, energized	3 mA

#### □ Block input (Logic selectivity)

Quantity	1
Type	polarized wet input (powered by internal isolated supply)
Max consumption, energized	5 mA

### 3.3 OUTPUT CIRCUITS

#### □ Relays

Quantity	6
Type of contacts K1, K2	changeover (SPDT, type C)
Type of contacts K3, K4, K5	make (SPST-NO, type A)
Type of contacts K6	break (SPST-NC, type B)
Nominal current	8 A
Nominal voltage/max switching voltage	250 V~/400 V~
Breaking capacity:	
• Direct current (L/R = 40 ms)	50 W
• Alternating current ( $\lambda = 0,4$ )	1250 VA
Make	1000 W/VA
Short duration current (0,5 s)	30 A
Minimum switching load	300 mW (5 V/ 5 mA)
Life:	
• Mechanical	10 <sup>6</sup> operations
• Electrical	10 <sup>5</sup> operations

#### □ Block output (Logic selectivity)

Quantity	1
Type	optocoupler

### 3.4 MMI

Display	16 x 4 alphanumeric LCD
LEDs	
Quantity	8
• ON/fail (green)	1
• Start (yellow)	1
• Trip (red)	1
• Freely allocatable (red)	5
Keyboard	8 keys

### 3.5 COMMUNICATION INTERFACES

#### □ Local port

Connection Protocol	USB Type B Modbus RTU®
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#### □ Remote ports

RS485	
• Connection	screw terminals
• Baud rate	1200...57600 bps
• Protocol <sup>[1]</sup>	ModBus®RTU IEC 60870-5-103 DNP3 <sup>[2]</sup>
Ethernet 100BaseT	
• Connection <sup>[3]</sup>	Optical fiber 1300 nm, ST 100 Base TX, RJ45
• Baud rate	100 Mbps
• Protocol	ModBus®TCP/IP

*Note 1 Different version must be selected at ordering*

*Note 2 Extended list of reading variables (eg. )*

*Note 3 Different version must be selected at ordering*

### 3.6 GENERAL SETTINGS

Relay nominal frequency ( $f_n$ )	50, 60 Hz
Relay phase nominal current ( $I_n$ )	1 A or 5 A <sup>[1]</sup>
Phase CT primary nominal current ( $I_{np}$ )	1 A...10 kA 1...499 A (step 1 A) 500...4990 A (step 10 A) 5000...10000 A (step 100 A)
Relay residual nominal current ( $I_{En}$ )	1 A or 5 A <sup>[1]</sup>
Residual CT primary nominal current ( $I_{Enp}$ )	1 A...10 kA 1...499 A (step 1 A) 500...4990 A (step 10 A) 5000...10000 A (step 100 A)

### 3.7 PROTECTIVE FUNCTIONS

#### □ Base current - IB<sup>[2]</sup>

Base current ( $I_B$ )	0.10...2.50 $I_n$ (step 0.01 $I_n$ )
------------------------	--------------------------------------

#### □ Thermal protection with Pt100 probes - 26<sup>[3]</sup>

*ThAL1...8 Alarm:*

Alarm threshold 26 PT1...PT8 ( $Th_{AL1...8}$ )	0...200 °C
Operating time ThAL1...8 ( $t_{ThAL1...8}$ )	0...100 s

*Th>1...8 Trip:*

Trip threshold 26 PT1...PT8 ( $Th_{>1...8}$ )	0...200 °C
Operating time ThAL1...8 ( $t_{Th>1...8}$ )	0...100 s

#### □ Undercurrent - 37

37 Operating logic ( <i>Logic37</i> )	AND/OR
<i>Definite time</i>	
37 First threshold definite time ( $I_{<def}$ )	0.10...1.00 $I_n$ (step 0.01 $I_n$ )
$I_{<def}$ Operating time ( $t_{<def}$ )	0.04...200 s 0.04...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...200 s (step 1 s)
Pickup time	≤ 0.03 s
Dropout ratio	1.03...1.05
Dropout time	≤ 0.05 s
Overshoot time	0.03 s
Pickup accuracy	± 0.5% with 0.1 $I_n$ , ± 0.2% with 1 $I_n$
Operate time accuracy	5% or ± 10 ms

#### □ Negative sequence overcurrent - 46

*I<sub>2</sub>> Element*

$I_{2>}$ Curve type ( $I_{2>Curve}$ )	DEFINITE IEC/BS A, B, C ANSI/IEEE MI, VI, EI $I^2t$ , EM
$I_{2CLP>}$ Activation time ( $t_{2CLP>}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
$I_{2>}$ Reset time delay ( $t_{2>RES}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
<i>Definite time</i>	
46 First threshold definite time ( $I_{2>def}$ )	0.100...10.00 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...10.00 $I_n$ (step 0.01 $I_n$ )
$I_{2>def}$ within CLP ( $I_{2CLP>def}$ )	0.100...10.00 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...10.00 $I_n$ (step 0.01 $I_n$ )
$I_{2>def}$ Operating time ( $t_{2>def}$ )	0.03...200 s 0.03...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...200 s (step 1 s)

*Note 1 The nominal current settings doesn't concern the protection elements; they must agree with hardware setting (dip-switch 1 A or 5 A).*

*Note 2 The basic current  $I_B$  represents the nominal current of the line or transformer, referred to the nominal current of the CT's for thermal image protection. If the secondary rated current of the line CT's equals the rated current of the NA20 relay, as usually happens, the  $I_B$  value is the ratio between the rated current of the protected element and the primary rated current of the CT's*

*Note 3 The 26 element is available when the MPT module is connect on Thybus and enabled*

**Inverse time <sup>[1]</sup>**

<p>46 First threshold inverse time (<math>I_{2&gt;inv}</math>)</p> <p><math>I_{2&gt;inv}</math> within CLP (<math>I_{2CLP&gt;inv}</math>)</p> <p><math>I_{2&gt;inv}</math> Operating time (<math>t_{2&gt;inv}</math>)</p>	<p>0.100...10.00 <math>I_n</math>  0.100...0.999 <math>I_n</math> (step 0.001 <math>I_n</math>)  1.00...5.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.100...10.00 <math>I_n</math>  0.100...0.999 <math>I_n</math> (step 0.001 <math>I_n</math>)  1.00...10.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.02...60.0 s  0.02...9.99 s (step 0.01 s)  10.0...60.0 s (step 0.1 s)</p>
<p><b><math>I_{2&gt;&gt;}</math> Element</b></p> <p><math>I_{2CLP&gt;&gt;}</math> Activation time (<math>t_{2CLP&gt;&gt;}</math>)</p> <p><math>I_{2&gt;&gt;}</math> Reset time delay (<math>t_{2&gt;&gt;RES}</math>)</p>	<p>0.00...100.0 s  0.00...9.99 s (step 0.01 s)  10.0...100.0 s (step 0.1 s)  0.00...100.0 s  0.00...9.99 s (step 0.01 s)  10.0...100.0 s (step 0.1 s)</p>
<p><b>Definite time</b></p> <p>46 Second threshold definite time (<math>I_{2&gt;&gt;def}</math>)</p> <p><math>I_{2&gt;&gt;def}</math> within CLP (<math>I_{2CLP&gt;&gt;def}</math>)</p> <p><math>I_{2&gt;&gt;def}</math> Operating time (<math>t_{2&gt;&gt;def}</math>)</p> <p>Pickup time</p> <p>Dropout ratio</p> <p>Dropout time</p> <p>Overshoot time</p> <p>Pickup accuracy</p> <p>Operate time accuracy</p>	<p>0.100...40.0 <math>I_n</math>  0.100...0.999 <math>I_n</math> (step 0.001 <math>I_n</math>)  1.00...40.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.100...40.0 <math>I_n</math>  0.100...0.999 <math>I_n</math> (step 0.001 <math>I_n</math>)  1.00...40.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.03...10.00 s (step 0.01 s)  ≤ 0.03 s  0.95...0.98  ≤ 0.05 s  0.03 s  1% with <math>I_2 \geq 0.5 I_n</math>  5% or ± 10 ms</p>

**□ Negative sequence / positive sequence current ratio -  $I_2 / I_1$**

$I_{21>}$  Element

<p><math>I_{21CLP&gt;}</math> Activation time (<math>t_{21CLP&gt;}</math>)</p>	<p>0.00...100.0 s  0.00...9.99 s (step 0.01 s)  10.0...100.0 s (step 0.1 s)</p>
<p><b>Definite time</b></p> <p><math>I_2 / I_1 &gt;</math> First threshold definite time (<math>I_{21&gt;def}</math>)</p> <p><math>I_2 / I_1 &gt;</math> within CLP (<math>I_{21CLP&gt;def}</math>)</p> <p><math>I_{21&gt;def}</math> Operating time (<math>t_{21&gt;def}</math>)</p> <p>Pickup time</p> <p>Dropout ratio</p> <p>Dropout time</p> <p>Overshoot time</p> <p>Pickup accuracy</p> <p>Operate time accuracy</p>	<p>0.10...1.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.10...1.00 <math>I_n</math> (step 0.01 <math>I_n</math>)  0.04...15000 s  0.04...9.99 s (step 0.01 s)  1...15000 s (step 1 s)  ≤ 0.03 s  0.95...0.98  ≤ 0.05 s  0.03 s  1% with <math>I_1</math> and <math>I_2 \geq 0.5 I_n</math>  5% or ± 10 ms</p>

**Note 1 Standard Inverse Time (IEC 255-3/BS142 type A or SIT):**

**Very Inverse Time (IEC 255-3/BS142 type B or VIT):**

**Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):**

**Moderately Inverse (ANSI/IEEE type MI):**

**Very Inverse (ANSI/IEEE type VI):**

**Extremely Inverse (ANSI/IEEE type EI):**

**I-squared-t ( $I^2t = K$ ):**

**Electromechanical (EM):**

t: operate time

$I_{2>inv}$ : pickup value

$t_{2>inv}$ : operate time setting

Asymptotic reference value: 1.1  $I_{2>nv}$

Minimum operate time: 0.1 s

Equation is valid for  $1.1 \leq I_2/I_{2>inv} \leq 20$

With  $I_{2>inv}$  pickup  $\geq 2.5 I_n$ , the upper limit is 50  $I_n$

$$t = 0.14 \cdot t_{2>inv} / [(I_2/I_{2>inv})^{0.02} - 1]$$

$$t = 13.5 \cdot t_{2>inv} / [(I_2/I_{2>inv}) - 1]$$

$$t = 80 \cdot t_{2>inv} / [(I_2/I_{2>inv})^2 - 1]$$

$$t = t_{2>inv} \cdot \{0.01 / [(I_2/I_{2>inv})^{0.02} - 1] + 0.023\}$$

$$t = t_{2>inv} \cdot \{3.922 / [(I_2/I_{2>inv})^2 - 1] + 0.098\}$$

$$t = t_{2>inv} \cdot \{5.64 / [(I_2/I_{2>inv})^2 - 1] + 0.024\}$$

$$t = 16 \cdot t_{2>inv} / (I_2/I_{2>inv})^2$$

$$t = 0.28 \cdot t_{2>inv} / [-0.236 \cdot (I_2/I_{2>inv})^{-1} + 0.339]$$

## □ Thermal image - 49

Common configuration:

	Initial thermal image $\Delta\theta_{IN}$ ( $Dth_{IN}$ )	0.0...1.0 $\Delta\theta_B$ (step 0.1 $\Delta\theta_B$ ) <sup>[1]</sup>
	Reduction factor at inrush ( $K_{INR}$ )	1.0...3.0 (step 0.1)
	Thermal time constant $\tau$ (T)	1...200 min (step 1 min)
	DthIN activation time ( $t_{dthCLP}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
<i>DthAL1 Element</i>		
	49 First alarm threshold ( $Dth_{AL1}$ )	0.3...1.0 $\Delta\theta_B$ (step 0.1 $\Delta\theta_B$ )
<i>DthAL2 Element</i>		
	49 Second alarm threshold ( $Dth_{AL2}$ )	0.5...1.2 $\Delta\theta_B$ (step 0.1 $\Delta\theta_B$ )
<i>Dth&gt; Element</i>		
	49 Trip threshold ( $Dth>$ )	1.100...1.300 $\Delta\theta_B$ (step 0.001 $\Delta\theta_B$ )
	Pickup accuracy	$\pm 1\%$ with 0.1 $I_n$ , $\pm 1\%$ with 1 $I_n$
	Operate time accuracy	5% or $\pm 10$ ms

## □ Phase overcurrent - 50/51

*I> Element*

	<i>I&gt;</i> Curve type ( <i>I&gt;</i> <sub>Curve</sub> )	DEFINITE IEC/BS A, B, C, B-LI ANSI/IEEE MI, VI, EI RECTIFIER, I <sup>2</sup> t or EM
	<i>I</i> <sub>CLP&gt;</sub> Activation time ( <i>t</i> <sub>CLP&gt;</sub> )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
	<i>I&gt;</i> Reset time delay ( <i>t</i> <sub>RES</sub> )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
	<i>Definite time</i>	
	50/51 First threshold definite time ( <i>I</i> <sub>&gt;def</sub> )	0.100...40.0 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...9.99 $I_n$ (step 0.01 $I_n$ ) 10.0...40.0 $I_n$ (step 0.1 $I_n$ )
	<i>I</i> <sub>&gt;def</sub> within CLP ( <i>I</i> <sub>CLP&gt;def</sub> )	0.100...40.0 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...9.99 $I_n$ (step 0.01 $I_n$ ) 10.0...40.0 $I_n$ (step 0.1 $I_n$ )
	<i>I</i> <sub>&gt;def</sub> Operating time ( <i>t</i> <sub>&gt;def</sub> )	0.04...200.00 s 0.04...9.99 s (step 0.01 s) 10.0...99.9 s (step 0.1 s) 100...200 s (step 1 s)
	<i>Inverse time</i> <sup>[2]</sup>	
	50/51 First threshold inverse time ( <i>I</i> <sub>&gt;inv</sub> )	0.100...20.00 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...20.00 $I_n$ (step 0.01 $I_n$ )
	<i>I</i> <sub>&gt;inv</sub> within CLP ( <i>I</i> <sub>CLP&gt;inv</sub> )	0.100...20.00 $I_n$ 0.100...0.999 $I_n$ (step 0.001 $I_n$ ) 1.00...20.00 $I_n$ (step 0.01 $I_n$ )
	<i>I</i> <sub>&gt;inv</sub> Operating time ( <i>t</i> <sub>&gt;inv</sub> )	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

Note 1  $\Delta\theta$  is the thermal image (p.u. of the basic over temperature corresponding to the basic current  $I_B$ ).

Assuming that the secondary rated current of the line CT's equals the rated current of the NA20 relay, as usually happens, the  $I_B$  value is the ratio between the rated current of the protected element and the primary rated current of the CTs

Note 1 Standard Inverse Time (IEC 255-3/BS142 type A or SIT):

Very Inverse Time (IEC 255-3/BS142 type B or VIT):

Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):

Long time Inverse Time (IEC 255-3/BS B LI):

Moderately Inverse (ANSI/IEEE type MI):

Very Inverse (ANSI/IEEE type VI):

Extremely Inverse (ANSI/IEEE type EI):

I-squared-t ( $I^2t = K$ ):

Electromechanical (EM):

RECTIFIER (RI):

*t*: operate time

*I*<sub>>inv</sub>: pickup value

*t*<sub>>inv</sub>: operate time setting

Asymptotic reference value: 1.1  $I_{>inv}$

Minimum operate time: 0.1 s

Equation is valid for  $1.1 \leq I/I_{>inv} \leq 20$

With  $I_{>inv}$  pickup  $\geq 2.5 I_n$ , the upper limit is 50  $I_n$

$$t = 0.14 \cdot t_{>inv} / [(I/I_{>inv})^{0.02} - 1]$$

$$t = 13.5 \cdot t_{>inv} / [(I/I_{>inv}) - 1]$$

$$t = 80 \cdot t_{>inv} / [(I/I_{>inv})^2 - 1]$$

$$t = 120 \cdot t_{>inv} / [(I/I_{>inv}) - 1]$$

$$t = t_{>inv} \cdot \{0.01 / [(I/I_{>inv})^{0.02} - 1] + 0.023\}$$

$$t = t_{>inv} \cdot \{3.922 / [(I/I_{>inv})^2 - 1] + 0.098\}$$

$$t = t_{>inv} \cdot \{5.64 / [(I/I_{>inv})^2 - 1] + 0.024\}$$

$$t = 16 \cdot t_{>inv} / (I/I_{>inv})^2$$

$$t = 0.28 \cdot t_{>inv} / [-0.236 \cdot (I/I_{>inv})^{-1} + 0.339]$$

$$t = 2351 \cdot t_{>inv} / [(I/I_{>inv})^{5.6} - 1]$$

*I>> Element*

*I>> Curve type (*I>>Curve*)*  
*I<sub>CLP>></sub> Activation time (*t<sub>CLP>></sub>*)*  
*I>> Reset time delay (*t>>RES*)*

DEFINITE or I<sup>2</sup>t  
 0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)  
 0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)

*Definite time*

50/51 Second threshold definite time (*I>>def*)

0.100...40.0 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...9.99 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 10.0...40.0 I<sub>n</sub> (step 0.1 I<sub>n</sub>)  
 0.100...40.0 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...9.99 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 10.0...40.0 I<sub>n</sub> (step 0.1 I<sub>n</sub>)  
 0.03...10.00 s (step 0.01 s)

*I>>def within CLP (*I<sub>CLP>>def</sub>*)*

*I>>def Operating time (*t>>def*)*

*Inverse time*

50/51 Second threshold inverse time (*I>>inv*)

0.100...20.00 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...20.00 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 0.100...20.00 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...20.00 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 0.02...10.00 s (step 0.01 s)

*I>>inv within CLP (*I<sub>CLP>>inv</sub>*)*

*I>>inv Operating time (*t>>inv*)*

*I>>> Element*

*I<sub>CLP>>></sub> Activation time (*t<sub>CLP>>></sub>*)*

0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)  
 0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)

*I>>> Reset time delay (*t>>>RES*)*

*Definite time*

50/51 Third threshold definite time (*I>>>def*)

0.100...40.0 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...9.99 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 10.0...40.0 I<sub>n</sub> (step 0.1 I<sub>n</sub>)  
 0.100...40.0 I<sub>n</sub>  
 0.100...0.999 I<sub>n</sub> (step 0.001 I<sub>n</sub>)  
 1.00...9.99 I<sub>n</sub> (step 0.01 I<sub>n</sub>)  
 10.0...40.0 I<sub>n</sub> (step 0.1 I<sub>n</sub>)  
 0.03...10.00 s (step 0.01 s)

*I>>>def within CLP (*I<sub>CLP>>>def</sub>*)*

*I>>>def Operating time (*t>>>def*)*

Pickup time  
 Dropout ratio  
 Dropout time  
 Overshoot time  
 Pickup accuracy  
 Operate time accuracy

≤ 0.03 s  
 0.95...0.98  
 ≤ 0.05 s  
 0.03 s  
 ± 0.5% with 0.1 I<sub>n</sub>, ± 0.2% with 1 I<sub>n</sub>  
 5% or ± 10 ms

**□ Residual overcurrent - 50N/51N**

*I<sub>E></sub> Element*

*I<sub>E></sub> Curve type (*I<sub>E>Curve</sub>*)*

DEFINITE  
 IEC/BS A, B, C, B-LI  
 ANSI/IEEE MI, VI, EI  
 EM

*I<sub>ECLP></sub> Activation time (*t<sub>ECLP></sub>*)*

0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)  
 0.00...100.0 s  
 0.00...9.99 s (step 0.01 s)  
 10.0...100.0 s (step 0.1 s)

*I<sub>E></sub> Reset time delay (*t<sub>E>RES</sub>*)*

*Definite time*

50N/51N First threshold definite time (*I<sub>E>def</sub>*)

0.002...10.00 I<sub>En</sub>  
 0.002...0.999 I<sub>En</sub> (step 0.001 I<sub>En</sub>)  
 1.00...10.00 I<sub>En</sub> (step 0.01 I<sub>En</sub>)  
 0.002...10.00 I<sub>En</sub>  
 0.002...0.999 I<sub>En</sub> (step 0.001 I<sub>En</sub>)  
 1.00...10.00 I<sub>n</sub> (step 0.01 I<sub>En</sub>)  
 0.04...200 s  
 0.04...9.99 s (step 0.01 s)  
 10.0...99.9 s (step 0.1 s)  
 100...200 s (step 1 s)

*I<sub>E>def</sub> within CLP (*I<sub>ECLP>def</sub>*)*

*I<sub>E>def</sub> Operating time (*t<sub>E>def</sub>*)*

### Inverse time<sup>[1]</sup>

50N/51N First threshold inverse time ( $I_{E>inv}$ )	0.002...2.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...2.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>inv}$ within CLP ( $I_{ECLP>inv}$ )	0.002...2.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...2.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>inv}$ Operating time ( $t_{E>inv}$ )	0.02...60.0 s 0.02...9.99 s (step 0.01 s) 10.0...60.0 s (step 0.1 s)

### $I_{E>>}$ Element

$I_{ECLP>>}$ Activation time ( $t_{ECLP>>}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
$I_{E>>}$ Reset time delay ( $t_{E>>RES}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)

### Definite time

50N/51N Second threshold definite time ( $I_{E>>def}$ )	0.002...10.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...10.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>>def}$ within CLP ( $I_{ECLP>>def}$ )	0.002...10.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...10.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>>def}$ Operating time ( $t_{E>>def}$ )	0.03...10.00 s (step 0.01 s)

### $I_{E>>>}$ Element

$I_{ECLP>>>}$ Activation time ( $t_{ECLP>>>}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)
$I_{E>>>}$ Reset time delay ( $t_{E>>>RES}$ )	0.00...100.0 s 0.00...9.99 s (step 0.01 s) 10.0...100.0 s (step 0.1 s)

### Definite time

50N/51N Third threshold definite time ( $I_{E>>>def}$ )	0.002...10.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...10.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>>>def}$ within CLP ( $I_{ECLP>>>def}$ )	0.002...10.00 $I_{En}$ 0.002...0.999 $I_{En}$ (step 0.001 $I_{En}$ ) 1.00...10.00 $I_{En}$ (step 0.01 $I_{En}$ )
$I_{E>>>def}$ Operating time ( $t_{E>>>def}$ )	0.03...10.00 s (step 0.01 s)
Pickup time	$\leq 0.03$ s
Dropout ratio	0.95...0.98
Dropout time	$\leq 0.05$ s
Overshoot time	0.03 s
Pickup accuracy	$\pm 0.5\%$ with 0.01 $I_{En}$ , $\pm 0.2\%$ with 1 $I_{En}$
Operate time accuracy	5% or $\pm 10$ ms

## □ Breaker failure - BF

BF Phase current threshold ( $I_{BF>}$ )	0.05...1.00 $I_n$ (step 0.01 $I_n$ )
BF Residual current threshold ( $I_{EBF>}$ )	0.01...2.00 $I_{En}$ (step 0.01 $I_{En}$ )
BF Time delay ( $t_{BF}$ )	0.06...10.00 s (step 0.01 s)
Dropout ratio	0.95...0.98
Dropout time	$\leq 0.05$ s
$I_{BF>}$ Pickup accuracy	$\pm 0.5\%$ with 0.1 $I_{nL}$ $\pm 0.2\%$ with 1 $I_{nL}$
$I_{EBF>}$ Pickup accuracy	$\pm 0.5\%$ with 0.01 $I_{En}$ $\pm 0.2\%$ with 1 $I_{En}$
Operate time accuracy	5% or $\pm 10$ ms

### Note 1

Standard Inverse Time (IEC 255-3/BS142 type A or SIT):

$$t = 0.14 \cdot t_{E>inv} / [(I_E / I_{E>inv})^{0.02} - 1]$$

Very Inverse Time (IEC 255-3/BS142 type B or VIT):

$$t = 13.5 \cdot t_{E>inv} / [(I_E / I_{E>inv}) - 1]$$

Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):

$$t = 80 \cdot t_{E>inv} / [(I_E / I_{E>inv})^2 - 1]$$

Long time Inverse Time (IEC 255-3/BS B LI):

$$t = 120 \cdot t_{E>inv} / [(I_E / I_{E>inv}) - 1]$$

Moderately Inverse (ANSI/IEEE type MI):

$$t = t_{E>inv} \cdot \{0.01 / [(I_E / I_{E>inv})^{0.02} - 1] + 0.023\}$$

Very Inverse (ANSI/IEEE type VI):

$$t = t_{E>inv} \cdot \{3.922 / [(I_E / I_{E>inv})^2 - 1] + 0.098\}$$

Extremely Inverse (ANSI/IEEE type EI):

$$t = t_{E>inv} \cdot \{5.64 / [(I_E / I_{E>inv})^2 - 1] + 0.024\}$$

Electromechanical (EM):

$$t = 0.28 \cdot t_{E>inv} / [-0.236 \cdot (I_E / I_{E>inv})^{-1} + 0.339]$$

$I_E$ : residual current input

$t$ : operate time

$I_{E>inv}$ : pickup value;  $t_{E>inv}$ : operate time setting

Asymptotic reference value: 1.1  $I_E$

Minimum operate time: 0.1 s

Equation is valid for  $1.1 \leq I_E / I_{E>inv} \leq 20$ , with  $I_{E>inv}$  pickup  $\geq 0.5 I_{En}$ , the upper limit is 10  $I_{En}$

### 3.8 CONTROL AND MONITORING

#### □ Second harmonic restraint - 2ndh-REST

Second harmonic restraint threshold ( $I_{2ndh>}$ )	10...50 % (step 1 %)
$I_{2ndh>}$ reset time delay ( $t_{2ndh>RES}$ )	0...100.0 s
	0.00...9.99 s (step 0.01 s)
	10.0...100.0 s (step 0.1 s)
Dropout ratio	0.95...0.98
Dropout time	≤ 0.04 s
Pickup accuracy $I_{2ndh>}$	± 4% ± 1% $I_n$
Operate time accuracy	5% or ± 10 ms

#### □ Trip Circuit Supervision - 74TCS

<i>Operate time:</i>	
• One binary input supervision	40 s
• Two binary inputs supervision	2 s
<i>Reset time delay:</i>	
• One binary input supervision	6 s
• Two binary inputs supervision	0.6 s

#### □ Selective block - BLOCK2

*Selective block IN:*

• BLIN1 Selective block operating mode ( <i>ModeBLIN1</i> )	OFF-ON IPh/IE-ON IPh-ON IE
• BLIN maximum activation time for phase protections ( $t_{B-IPh}$ )	0.10...10.00 s (step 0.01 s)
• BLIN maximum activation time for ground protections ( $t_{B-IE}$ )	0.10...10.00 s (step 0.01 s)

*Selective block OUT:*

• BLOUT1 Selective block operating mode ( <i>ModeBLOUT1</i> )	OFF-ON IPh/IE-ON IPh-ON IE
• BLOUT Dropout time for phase protections ( $t_{F-IPh}$ )	0.00...1.00 s (step 0.01 s)
• BLOUT Dropout time for ground protections ( $t_{F-IE}$ )	0.00...1.00 s (step 0.01 s)
• BLOUT Dropout time for ground and phase protections ( $t_{F-IPh/IE}$ )	0.00...1.00 s (step 0.01 s)

#### □ Circuit Breaker supervision

*Circuit breaker diagnostic*

Number of CB trips threshold ( $N.Open$ )	0...10000 (step 1)
Cumulative CB tripping currents threshold ( $SumI$ )	0...5000 $I_n$ (step 1 $I_n$ )
Cumulative CB tripping $I^2t$ threshold ( $SumI^2t$ )	0...5000 ( $I_n$ ) <sup>2</sup> ·s (step 1 $I_n^2$ ·s)
Circuit Breaker opening time for $I^2t$ calculation ( $t_{break}$ )	0.05...1.00 s (step 0.01 s)
Circuit Breaker maximum allowed opening time ( $t_{break>}$ )	0.05...1.00 s (step 0.01 s)

#### □ CT supervision - 74CT

74CT Threshold ( $S<$ )	0.10...0.95 (step 0.01)
74CT Overcurrent threshold ( $I^*$ )	0.10...1.00 $I_n$ (step 0.01 $I_n$ )
$S<$ Operating time delay ( $t_{S<}$ )	0.03...200 s
	0.03...9.99 s (step 0.01 s)
	10.0...99.9 s (step 0.1 s)
	100...200 s (step 1 s)
Dropout ratio for the $I^*$ pickup	0.95...0.98
Dropout time	≤ 0.05 s
Pickup accuracy $S<$	± 1% with 0.1 $I_n$ , ± 0.5% with 1 $I_n$
Pickup accuracy $I^*$	± 0.5% with 0.1 $I_n$ , ± 0.2% with 1 $I_n$
Operate time accuracy	5% or ± 10 ms

#### □ Pilot wire diagnostic

• BLOUT1 Diagnostic pulse period ( <i>PulseBLOUT1</i> )	OFF-0.1-1-5-10-60-120 s
• BLIN1 Diagnostic pulse control time interval ( <i>PulseBLIN1</i> )	OFF-0.1-1-5-10-60-120 s

#### □ Demand measures

• Fix on demand period ( $t_{FIX}$ )	1...60 min (step 1 min)
• Rolling on demand period ( $t_{ROL}$ )	1...60 min (step 1 min)
• Number of cycles for rolling on demand ( $N.ROL$ )	1...24 (step 1)

## □ Oscillography (DFR)<sup>[1]</sup>

	Format	COMTRADE
	Recording mode	circular
	Sampling rate	24 samples / cycle
<i>Trigger setup:</i>		
	<ul style="list-style-type: none"> <li>• Pre-trigger time</li> <li>• Post-trigger time</li> </ul>	0.05...1.00 s (step 0.01 s) 0.05...60.00 s (step 0.05 s)
<i>Set sample channels:</i>		$I_{L1}, I_{L2}, I_{L3}, I_E$
<i>Set analog channels:</i>	Analog 1...Analog 12	Frequency, $I_{L1}, I_{L2}, I_{L3}, I_E, I_1, I_2, I_2/I_1, I_{L1-2nd}, I_{L2-2nd}, I_{L3-2nd}, I_{-2nd}/I_L, T1...T8$ <sup>[2]</sup>
<i>Set digital channels:</i>	Digital 1...Digital 12	K1... K6, K7...K10, IN1, IN2, IN3...IN42 <sup>[3]</sup>

## □ PLC (Programmable Logic Controller)<sup>[4]</sup>

	Reference standard	IEC 61131-3
	Language <sup>[5]</sup>	IL (Instruction List)
<i>Inputs:</i>		
	Binary inputs	IN1, IN2 on board IN8...IN10 with MRI module IN11...IN26 with one MID16 module IN27...IN42 with two MID16 modules
	Delayed binary inputs <sup>[6]</sup>	IN1, IN2 on board IN8...IN10 with MRI module IN11...IN26 with one MID16 module IN27...IN42 with two MID16 modules
	Start (all elements)	Start I>, Start I>>,...etc
	Trip (all elements)	Trip I>>, Trip I>>,...etc
	Measures	IL1, IL2,...ecc
	Temperature	Pt100
	Block inputs	BLK2IN-Iph, BLK2IN-IE,...etc
<i>Outputs:</i>		
	Relays	K11...K6 on board K7...K10 with MRI module
	LEDs	START, TRIP, L1...L6 on board L7...L10 with MRI module
	Block outputs	BLK2OUT-Iph, BLK2OUT-IE,...etc
	Current converter	DAC

*Note 1 For the DFR function a licence is required; call Thytronic for purchasing.*

*Note 2 The measures of temperature are available only when the MPT module on Thybus is enabled (eight Pt100 inputs)*

*Note 3 Output relay K7...K10 and binary input IN3...IN42 states are available only when the concerning I/O circuits are implemented (MRI and MID16 modules on Thybus)*

*Note 4 For the PLC function a licence is required; call Thytronic for purchasing.*

*Note 5 With ThyVisor and compiler IEC 61131-3 V1.2.7 only the IL language is implemented (Instruction List); other languages, according with IEC 61131 standard (ST (Structured Text)), LD (Ladder Diagram), FBD (Function Block Diagram), SFC (Sequential Functional Chart), will be available soon*

*Note 6 The input state is acquired downstream the tON and tOFF timers*

### 3.9 METERING

More data (range and accuracy) are available inside Section 5 - MEASURES, LOGIC STATES AND COUNTERS

#### □ Accuracy (type tests)

MEASURE	Reference values	Accuracy	Reference values	Accuracy
Phase current	0.1 $I_n$	0.2%	1 $I_n$	0.03%
Measured residual current	0.01 $I_{En}$	0.3%	1 $I_{En}$	0.02%
Calculated residual current	0.1...1 $I_{ECn}$	2%	1 $I_{ECn}$	0.3%
Frequency	0.02 $U_n$	3 mHz	1 $U_n$	2 mHz
Positive/Negative sequence current	$I_1 = 0.5 I_n$	0.5%	$I_1 = 1 I_n$	0.5%
Pickup and operate time	1.5 x setting for fist element	5% ± 10 ms	2.5 x setting for other elements	5% ± 10 ms

#### □ Measures

##### Direct

Frequency	(f)
RMS value of fundamental component for phase currents	( $I_{L1}, I_{L2}, I_{L3}$ )
RMS value of fundamental component for residual current	( $I_E$ )

##### Calculated

Thermal image	( $D\theta$ )
Maximum current between $I_{L1}-I_{L2}-I_{L3}$	( $I_{Lmax}$ )
Minimum current between $I_{L1}-I_{L2}-I_{L3}$	( $I_{Lmin}$ )
Average current between $I_{L1}-I_{L2}-I_{L3}$	( $I_L$ )

##### Sequence

Positive sequence current	( $I_1$ )
Negative sequence current	( $I_2$ )
Negative sequence current/positive sequence current ratio ( $I_2/I_1$ )	

##### 2nd harmonic

Second harmonic of phase currents	( $I_{L1-2nd}, I_{L2-2nd}, I_{L3-2nd}$ )
Maximum of the second harmonic phase currents/ fundamental component percentage ratio $I_{2nd}/I_L$	( $I_{-2nd}/I_L$ )

##### 3rd harmonic

Third harmonic of phase currents	( $I_{L1-3rd}, I_{L2-3rd}, I_{L3-3rd}$ )
Third harmonic of residual current	( $I_{E-3rd}$ )

##### 4th harmonic

Fourth harmonic of phase currents	( $I_{L1-4th}, I_{L2-4th}, I_{L3-4th}$ )
-----------------------------------	--

##### 5th harmonic

Fifth harmonic of phase currents	( $I_{L1-5th}, I_{L2-5th}, I_{L3-5th}$ )
----------------------------------	--

##### On demand

Phase fixed currents demand	( $I_{L1FIX}, I_{L2FIX}, I_{L3FIX}$ )
Phase rolling currents demand	( $I_{L1ROL}, I_{L2ROL}, I_{L3ROL}$ )
Phase peak currents demand	( $I_{L1MAX}, I_{L2MAX}, I_{L3MAX}$ )
Phase minimum currents demand	( $I_{L1MIN}, I_{L2MIN}, I_{L3MIN}$ )

##### PT100<sup>[1]</sup>

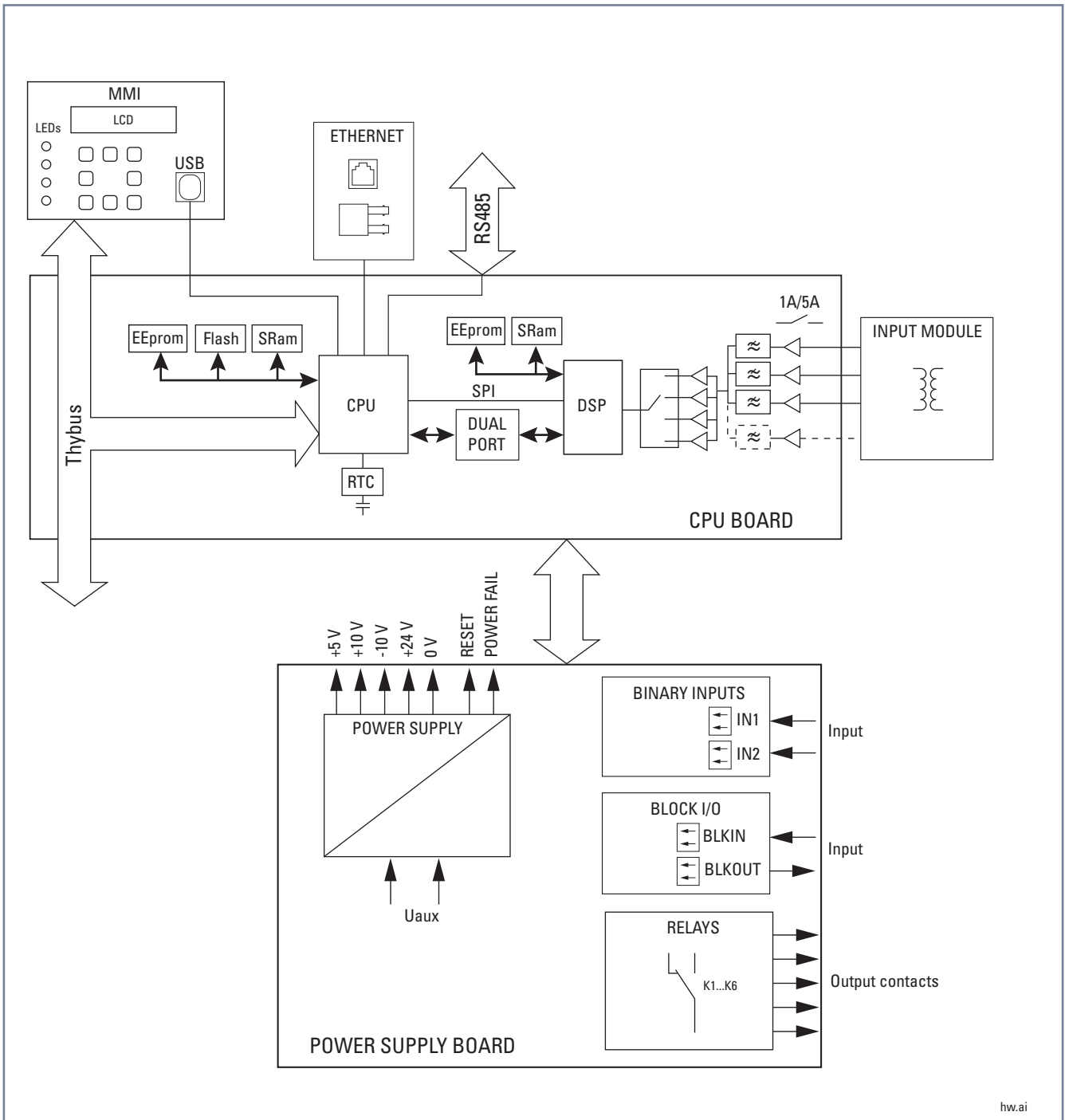
Temperature PT1	( $T_1$ )
Temperature PT2	( $T_2$ )
Temperature PT3	( $T_3$ )
Temperature PT4	( $T_4$ )
Temperature PT5	( $T_5$ )
Temperature PT6	( $T_6$ )
Temperature PT7	( $T_7$ )
Temperature PT8	( $T_8$ )

Note 1 The measures of temperature are available only when the MPT module on Thybus is enabled (eighth Pt100 inputs)

## 4 FUNCTION CHARACTERISTICS

### 4.1 HARDWARE DESCRIPTION

The following figure illustrates the device layout.



Printed boards hold the circuit components arranged according to a modular allocation of the main functions.

## Power supply board

All the components necessary for conversion and stabilization functions are present. Two versions are envisaged suited to the input ranges 24...48 V and 115...230 V. The circuit provides stabilized voltages of +10 V and -10 V, required for the analogue measurement, +24 V for relays and +5 V for supplying the digital circuits.

The circuit board additionally comprises:

### INPUT CIRCUITS:

- Two binary input circuits,
- One block input circuit (BLIN1).

The logical input circuits and the block circuits include photo-couplers which provide for galvanic separation.

### OUTPUT CIRCUITS:

- One block output circuit (BLOUT 1),
- Six output relays (k1...K6).

## CPU board

This circuit board contains all the circuits necessary for performing the analogue and digital processing of the signals.

### *Analog processing*

The following are envisaged:

- Anti aliasing filter circuits,
- Amplifier circuits for conditioning the input signals,
- Reference voltage adjustment circuits for the measurement A/D converter.

The Pro-n relays use a DSP processor operating at 40 MHz; it performs all the processing on the analogue signals and furthermore coordinates management of the TX-RX signals to the CPU.

The input currents are sampled at a frequency of 24 samples per period by means of a dual conversion system which allows the attainment of information pertaining to polarity and amplitude with high resolution. The measurement criterion allows precise measurement of even those signals having a unidirectional component, such as transient currents with overlapping exponential, which typically appear during faults.

The circuit board also houses the output relays with the corresponding command and control circuits, communication circuits, buttons, LCD display, LEDs and the key switch.

### *CPU*

A 32 bit CPU is provided.

The following are envisaged:

- Real Time Clock circuits with oscillator and super capacitor,
- USB communication port,
- RS485 communication port,
- Thybus communication circuits for external modules and MMI board,
- Network communication circuits (optional Ethernet).

Memories:

- SRam: high speed static memory, used for data and cache,
- Flash memory: used for fw storage and upgrade,
- EEprom memory: used for calibration data storage,
- Dual port Ram for data transfer between CPU and DSP.

## Input board

- Three CTs committed for phase currents acquisition,
  - One CT committed for residual current acquisition.
- The input circuits are suitable for 1 A or 5 A external CTs.<sup>[1]</sup>
- Three VTs committed for phase voltages acquisition,
  - One VT committed for residual voltage acquisition.

## MMI (keyboard, LED and display)

The MMI module (Man Machine Interface) includes:

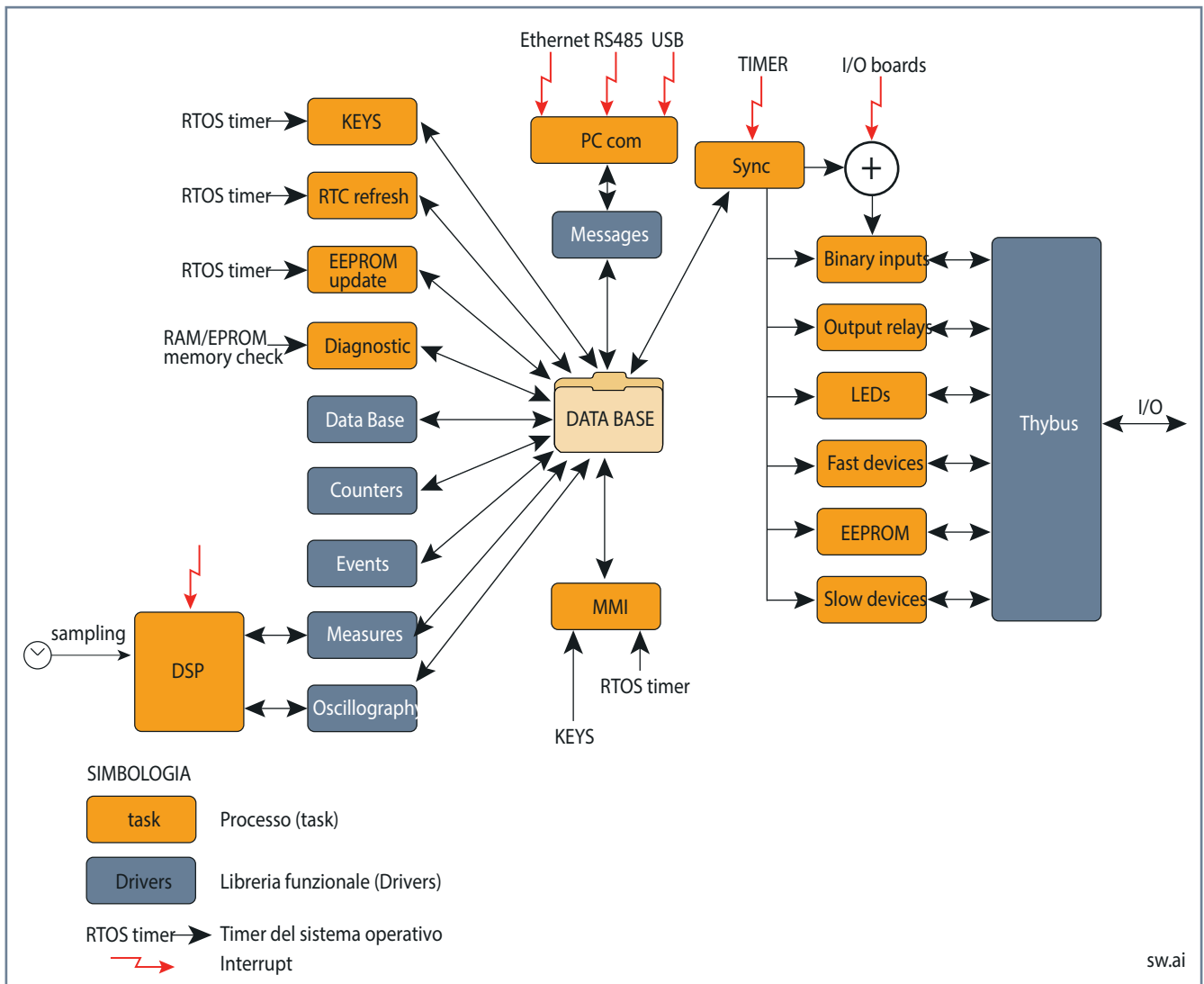
- An eight keys 8 keyboard,
- a backlight LCD display,
- Eight signalling LEDs,

The removable plug allows separation of the MMI module for free access to the CPU board when DIP-switch setting is required.

*Note 1 The phase and residual nominal currents must be adjusted by means dip-switch.*

4.2 SOFTWARE DESCRIPTION

The program which handles operation of the Pro-N relays is made up of three fundamental elements shown in the following block diagram.



Base software

Single modules are application independent with modular and scalable structure. The system can be assimilated to the PC BIOS (Basic Input-Output System); three main function are provided:

- Start-up test execution;
- RAM loading of the operating system;
- Provide a suitable interface to access the relay hardware.

Real-time operating system

An embedded operative system is employed suitable for real-time applications (RTOS). A multithread preemptive structure is able to manage several task with multiple priority levels. The kernel represents the nucleus of the system: it includes the processing functions closest to the electronic circuits.

In addition, the kernel manages a service communication protocol known as Basic Protocol (BP).

Task

The task (process e thread) are the base components.

- Example are:
- Keyboard management
  - RTC (Real Time Clock) updating
  - RAM/EEPROM updating
  - Diagnostic
  - Input acquisition
  - Output relay management
  - MMI
  - I/O updating
  - DSP data processing

### DSP Firmware

By means of Discrete Fourier Transform calculation, based on 24 samples/period, information is deduced in relation to the amplitude and phase of all the current measurements; these are constantly updated and at the disposal of all the protection and control application algorithms.

### Drivers

Inside the driver library, all the specialized module for protection and control function are provided. They are the link from kernel and application layer. Examples are:

- Data base management
- PC messages management
- TCP/IP messages management
- Basic Protocol management
- Counter management
- Event and fault management
- Measuring management
- Oscillography management

### Application Software

The software acts the specialization of the base system; all protective and control elements are inside it.

The main modules are:

- Diagnostic function for application layer,
- Input management (binary inputs),
- Protective functions,
- Event recording,
- Output management (LEDs and relays)

Each element (Kernel, Drivers and Application) may, in turn, be split into modules:

#### *Base protocol (kernel)*

The module known as the Basic Protocol (BP) manages the service communication between the kernel and the other modules through the communication buses with the following services:

- Data and information exchange,
- Calibration,
- Upgrade fw DSP,
- Upgrade application sw

#### *Communication (drivers)*

The ModBus TCP/IP protocol, with ethernet interface, the ModBus RTU, IEC 60870-5-103 and DNP3 protocol over RS485 interface and the ModBus RTU USB for ThyVisor are provided.

#### *MMI (drivers)*

The drivers deal with the menu management (MMi and/or communication messages).

### Data Base

The data base is split into three main sections:

- RAM for volatile data,
- REE and PAR for non volatile data.

### Self test (Application)

The main hw and sw function are permanently verified in background; no additional delay are introduced.

In particular the following function are tested:

- Reference voltages;
- Output relays;
- Sw flow with execution time monitoring;
- REE and PAR data congruence.

### Development tools (Builder)

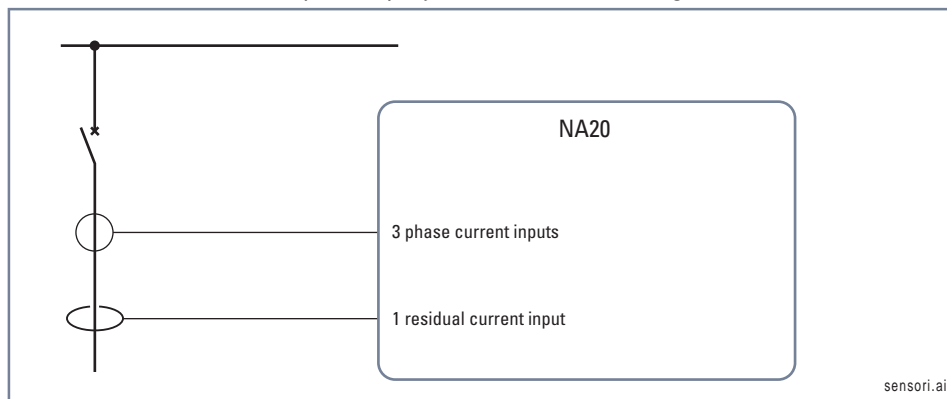
For the development of the project, a CASE instrument has been developed, responsible for the optimized production of software code for the management of collaboration, the database and the MMI data and the Xml files used for communication. The automatic code generation criteria ensures the quality of the result in terms of the reusability, verifiability and maintainability of the software life cycle.

4.3 I/O DESCRIPTION

Metering inputs

The following input are provided:

- Three phase current inputs.
- One residual current input.
- The nominal currents are independently adjustable at 1 A or 5 A through DIP-switches.



The input circuits are appropriately dimensioned in order to withstand the currents which arise when a fault occurs, both in transient and steady state condition.

Signal processing

Several processing levels are involved:

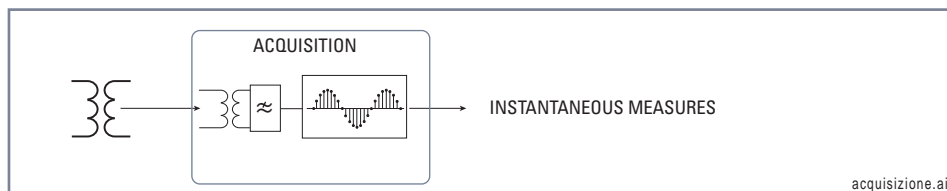
- Acquisition (base level).
- Direct measures of physical channels (first level).
- Calculated measures (second level).
- Derived (third level).

The measures concerning a level are based on data worked out in the previous level.

For each level the required resources concerning the priority for tasks (conditioning circuits, DSP and CPU) are on hand.

ACQUISITION (base level)

The input signals are sampled 24 times per period:



- $i_{L1}...i_{L3}$  Phase current instantaneous values
- $i_E$  Residual current instantaneous value

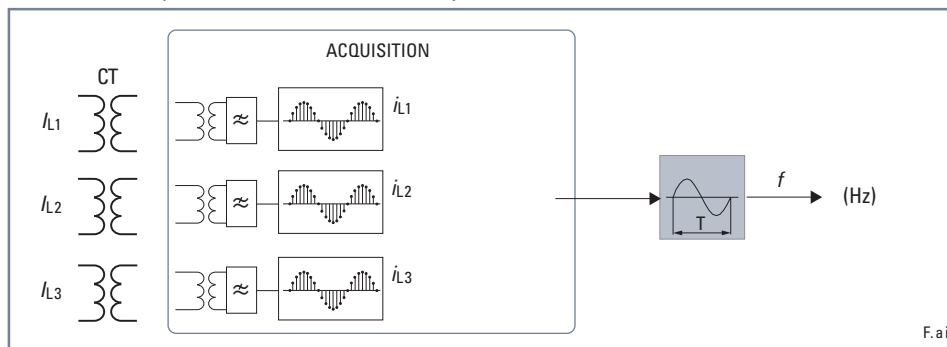
From the sampled quantities, several measures are computed for protection, monitoring and metering purposes.

- Direct
- Calculated
- Phase
- Sequence
- Harmonic
- Demand

Direct

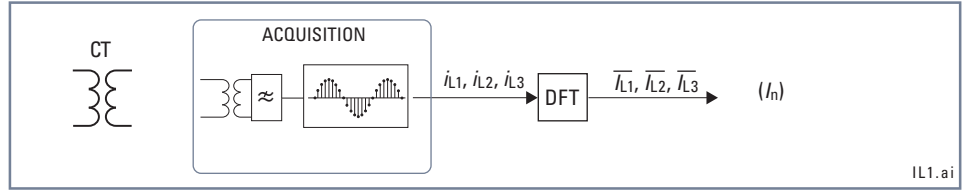
- Frequency.

The measure of period is taken from current inputs.

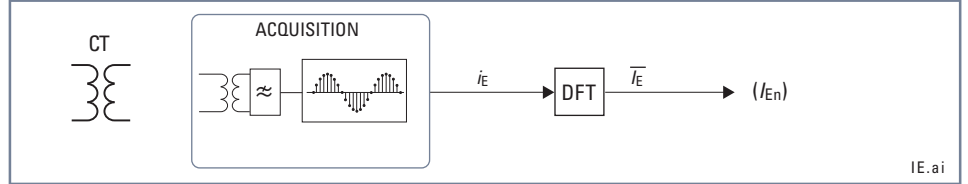


Samples are processed by means DFT (Discrete Fourier Transform) algorithm and the phase and amplitude of fundamental are computed:

- Phase currents  $I_{L1}, I_{L2}, I_{L3}$



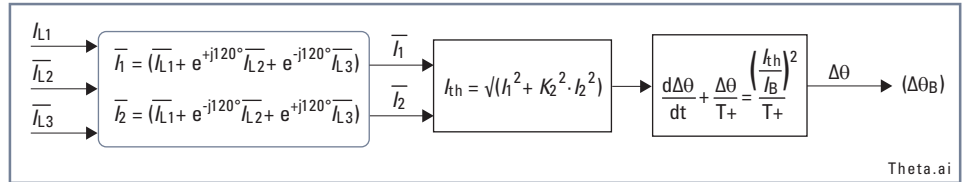
- Residual current  $I_E$



**Calculated**

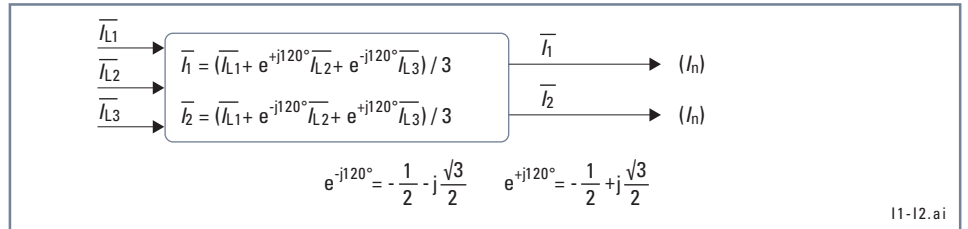
By means vector addition of direct measures the following are calculated (RMS value of fundamental components):

- Thermal image  $\Delta\theta$



**Sequence**

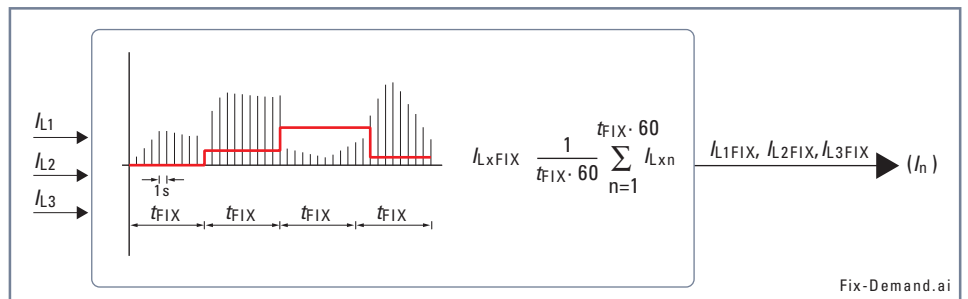
- Fundamental RMS positive sequence current:  $I_1$
- Fundamental RMS negative sequence current:  $I_2$



**On demand**

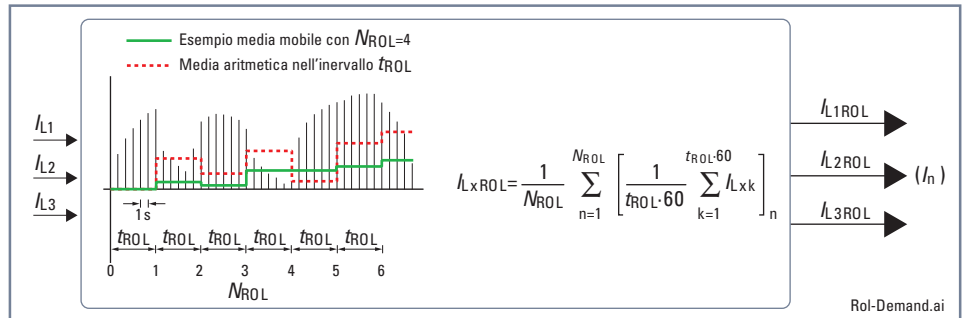
- Fixed demand ( $I_{L1FIX}, I_{L2FIX}, I_{L3FIX}, \pm P_{FIX}, \pm Q_{FIX}$ )

Inside an adjustable time interval  $t_{FIX}$ , an average magnitude is calculated for phase currents  $I_{L1}, I_{L2}, I_{L3}$ , active power  $\pm P$  and reactive power  $\pm Q$  of measures taken every second. The average values are stored at the end of the same time interval.



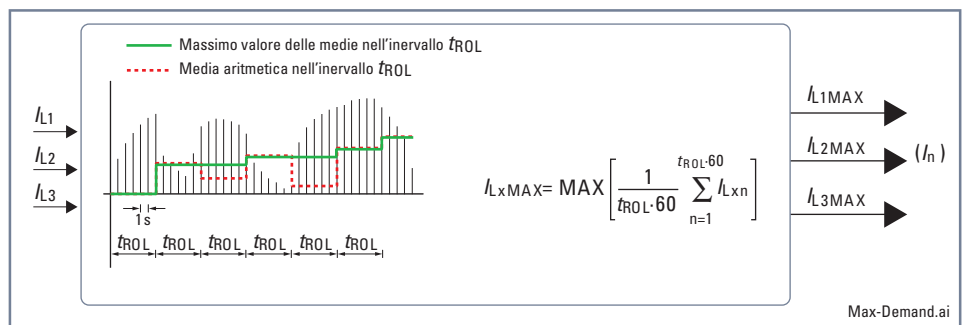
• Rolling demand ( $I_{L1ROL}, I_{L2ROL}, I_{L3ROL}, \pm P_{ROL}, \pm Q_{ROL}$ )

Inside an adjustable time interval  $N_{ROL} \cdot t_{ROL}$ , an average magnitude is calculated for phase currents  $I_{L1}, I_{L2}, I_{L3}$ , active power  $\pm P$  and reactive power  $\pm Q$  of measures taken every second, where  $t_{ROL}$  is the length of any time subinterval and  $N_{ROL}$  is the number of the time intervals. The average values are stored at the end of the same time subinterval.



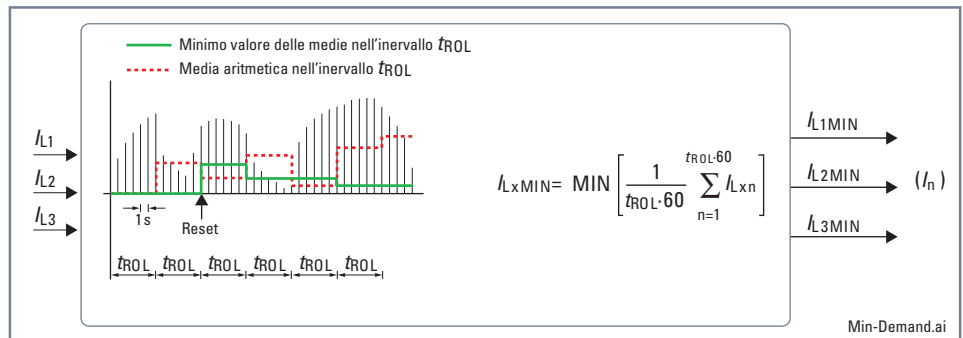
• Peak ( $I_{L1MAX}, I_{L2MAX}, I_{L3MAX}, \pm P_{MAX}, \pm Q_{MAX}$ )

Inside an adjustable time interval  $t_{ROL}$ , the maximum magnitude is calculated for phase currents  $I_{L1}, I_{L2}, I_{L3}$ , active power  $\pm P$  and reactive power  $\pm Q$  of measures taken every second. The average values are stored at the end of the same time interval  $t_{ROL}$  (Rolling demand common parameter).



• Minimum ( $I_{L1MIN}, I_{L2MIN}, I_{L3MIN}, \pm P_{MIN}, \pm Q_{MIN}$ )

Inside an adjustable time interval  $t_{ROL}$ , the minimum magnitude is calculated for phase currents  $I_{L1}, I_{L2}, I_{L3}$ , active power  $\pm P$  and reactive power  $\pm Q$  of measures taken every second. The average values are stored at the end of the same time interval  $t_{ROL}$  (Rolling demand common parameter).

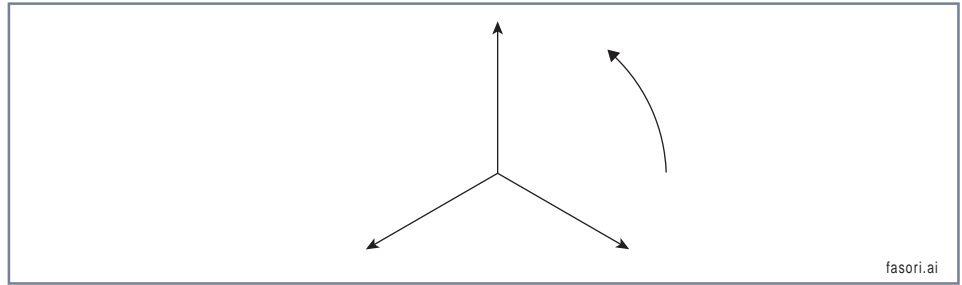


Use of over-described measures is shown in the following tables.

**Conventions**

*Phase rotation direction*

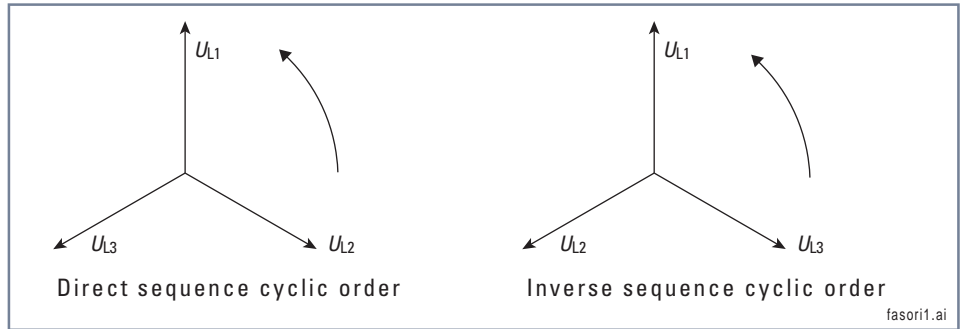
The conventional rotation direction for the current phasors is counter-clockwise.



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*Cyclic phase sequence order*

For three phase rotating currents, a direct cyclic sequence is defined when the three phases are L1, L2, L3 ordered, while an inverse cyclic sequence is defined when the three phases are L1, L3, L2 ordered.



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### Use of measured values

	f	I <sub>L1</sub> , I <sub>L2</sub> , I <sub>L3</sub>	I <sub>L1</sub> , I <sub>L2</sub> , I <sub>L3</sub>	I <sub>L1-2nd</sub> , I <sub>L2-2nd</sub> , I <sub>L3-2nd</sub>	I <sub>L1-3rd</sub> , I <sub>L3-3rd</sub> , I <sub>L3-3rd</sub>	I <sub>L1-4th</sub> , I <sub>L2-4th</sub> , I <sub>L3-4th</sub>	I <sub>L1-5th</sub> , I <sub>L2-5th</sub> , I <sub>L3-5th</sub>	I <sub>E</sub>	I <sub>E</sub>	I <sub>E-3rd</sub>	I <sub>1</sub>	I <sub>2</sub>	Temperature (PT1...PT8)	Binary inputs IN1, IN2...INx	Start (START) Relays K1...K6	Trip (TRIP) Relè K1...K6...K10	Start (START) LEDs L1...L5	Trip (TRIP) LEDs L1...L5	Selective block input - BLIN1	Selective block output - BLOUT1	Cold Load Pickup (CLP)	Second harmonic restraint	Logic block - BLOCK1	Breaker failure (BF)
<b>PROTECTION</b>																								
Thermal with Pt100 probes (26)													■											
Undercurrent (37)			■																					
Negative sequence overcurrent (46)												■												
Negative sequence-positive current ratio											■	■												
Thermal image (49)			■								■	■												
Phase overcurrent (50/51)			■																					
Residual overcurrent (50N/51N)										■														
Breaker failure (BF)			■							■														■
<b>CONTROL and MONITORING</b>																								
CT Monitoring (74CT)			■																					■
Trip Circuit Supervision (TCS)															■									
Second harmonic restraint (2NDH-REST)					■																			
Logic block (BLOCK1)															■									
Selective block (BLOCK2)															■					■	■			
Diagnostic																	■			■	■			
Element states																								
Binary input states															■									
Selective block state (Block2)																				■	■			
Output relay states															■	■	■	■						
<b>MEASURES</b>																								
Frequency	■																							
Phase currents			■																					
Residual current									■															
Positive sequence current											■													
Negative sequence current												■												
Harmonic currents				■	■	■	■			■														
Thermal image			■																					
Temperature (Pt100 on MPT module)													■											
<b>EVENT RECORDER</b>																								
Event 0															■	■	■	■						
Event 1															■	■	■	■						
Event ...															■	■	■	■						
Event 299															■	■	■	■						
<b>FAULT RECORDER</b>																								
Fault 0			■							■					■	■	■	■						
Fault 1			■							■					■	■	■	■						
Fault ...			■							■					■	■	■	■						
Fault 19			■							■					■	■	■	■						
<b>OSCILLOGRAPHY</b>																								
Record 1	■	■	■	■				■	■				■	■	■	■	■	■					■	
Record 2	■	■	■	■				■	■				■	■	■	■	■	■					■	
Record ...	■	■	■	■				■	■				■	■	■	■	■	■					■	

## Binary inputs

Two or five binary inputs are available on board, up to 40 binary inputs may be added with auxiliary modules.

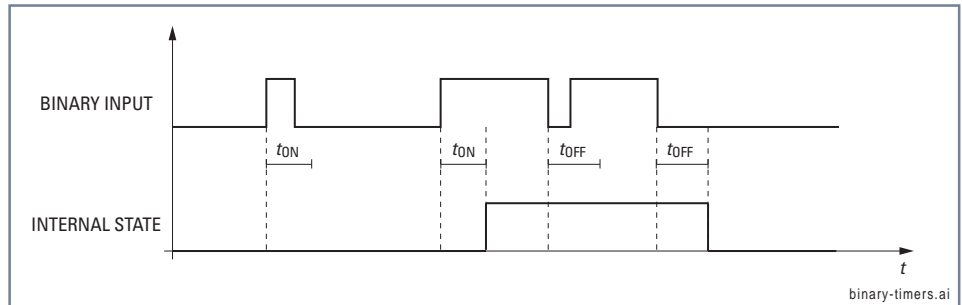
The dry inputs must be powered with an external voltage, (usually the auxiliary power supply).

The connections are shown in the schematic diagrams.

The following settings can be used to configure each input:

- Logic Active-ON (activated when powered), or Active-OFF (activated when power is turned off).
- ON Timer (OFF-to-ON time delay) and OFF Timer (ON-to-OFF time delay).
- Binary input allocation.

Adjustable debounce timer allows any transient to decay avoiding false activation of the input; the positive transition is acquired if the input is permanently high for a time interval longer than the  $t_{ON}$  setting delay; similarly for the negative transitions, the negative transition is acquired if the input is permanently high for a time interval longer than the  $t_{OFF}$  setting delay.



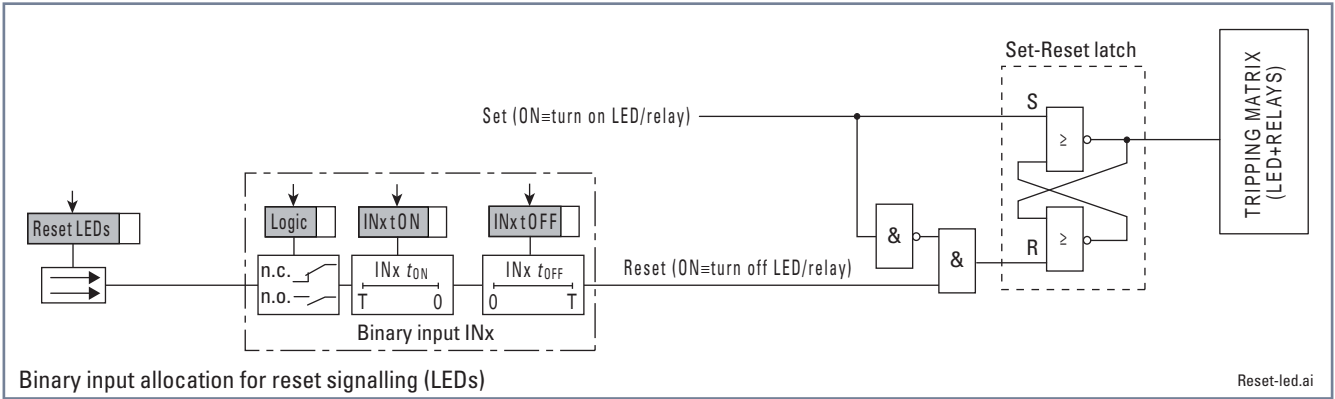
In the above shown diagram, INTERNAL STATE represents the logical state of the binary input used in the following processing.

Each binary input may be matched to one of the following default functions.

FUNCTIONS	Binary inputs		
	IN1	IN2	INx
Reset LEDs	■	■	■
Set profile (switching setting A and B)	■	■	■
Fault trigger (fault recording)	■	■	■
Block2 IPh/IE (selective block from phase and/or ground elements)	■	■	■
Block2 IPh (selective block from phase elements)	■	■	■
Block2 IE (selective block from ground elements)	■	■	■
Block1 (logic block)	■	■	■
TCS1 (Trip Circuit Supervision)	■	■	■
TCS2 (Trip Circuit Supervision)	■	■	■
Trip ProtExt (trip from external protection relays)	■	■	■
Reset counters	■	■	■
Reset CB Monitor (clear CB monitoring data)	■	■	■
52a (CB auxiliary contact)	■	■	■
52b (CB auxiliary contact)	■	■	■
Open CB	■	■	■
Close CB	■	■	■
Preset DTheta (thermal image preset)	■	■	■
Remote trip	■	■	■
Reset on demand measures	■	■	■

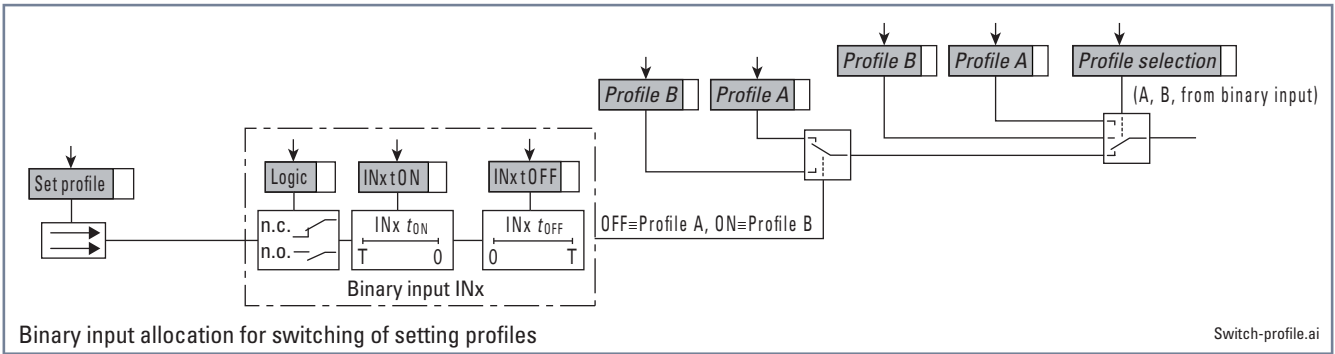
Reset LEDs

If the element tripped have gone back to rest condition, the latched LEDs and/or relays may be reset.



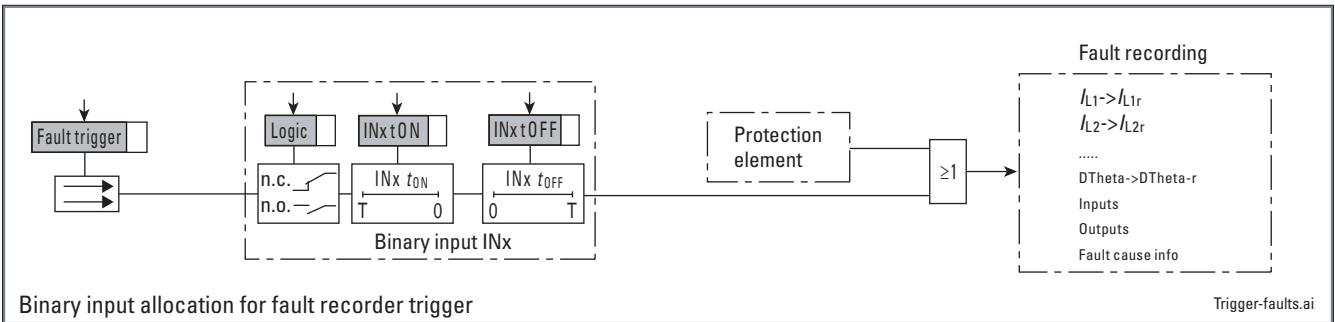
Set profile

Inside Pro-N devices, two independent setting profiles (A and B) are available. Whereas different settings are required, they are made in the setting profiles and stored in the non volatile memory of relay. Applicable setting profile is activated usually via a binary input; when the programmed input is activated, the profile B becomes operative as a replacement for the default profile A.<sup>[1]</sup>



Fault trigger

When the programmed input is activated, a trigger is issued for fault record SFR). Data storing takes place with the same procedure resulting from a trip of any protective elements



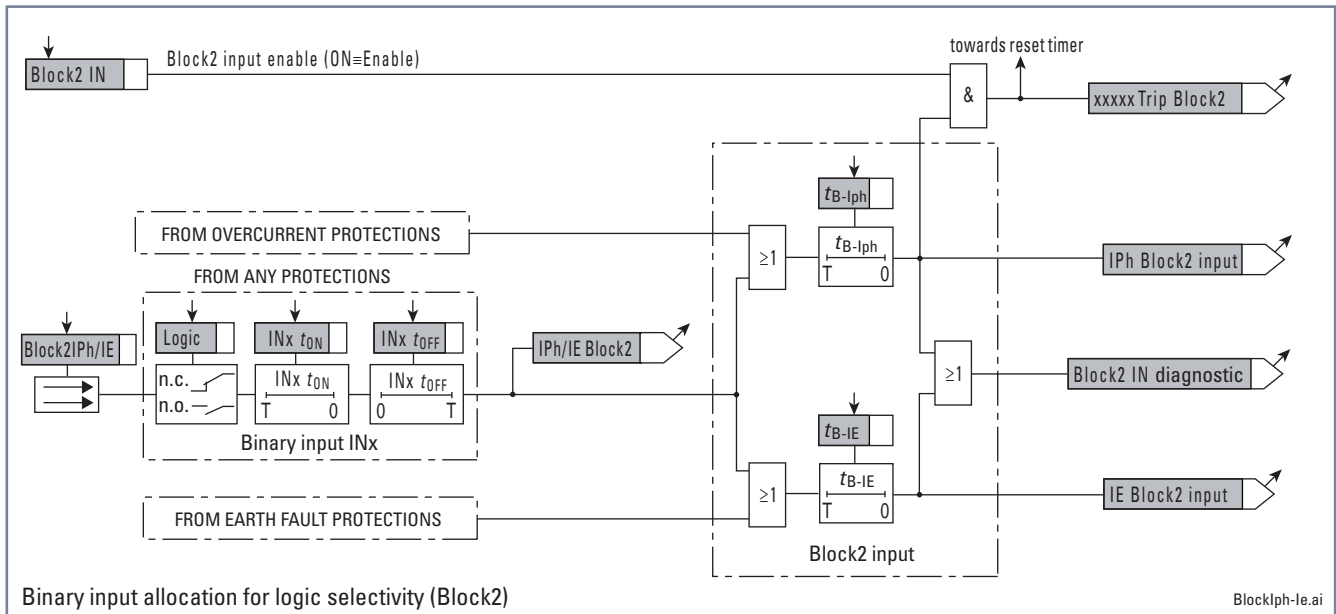
Note 1 To enable the profile switching the "Input-selected" parameter must be set inside the "Profile selection" submenu. If multiple setting groups are not required, Group A is the default selection

Block2 IPh/IE

A change in status of a binary input effects a block<sup>[1]</sup> common for the following phase and ground protective elements:

- $I_1$ ,  $I_2$  and  $I_3$  (50/51),
- $DthAL1$ ,  $DthAL2$  and  $Dth$  (49),
- $I_2$ ,  $I_2$  (46),
- $I_E$ ,  $I_E$  and  $I_E$  (50N/51N),

The application of the binary inputs for the acquisition of Block2 (selective block) coming from external protection relays is shown in the following figure (one phase overcurrent and one phase and residual overcurrent protection).



Block2 IPh

A change in status of a binary input effects a block<sup>[2]</sup> for the following phase protective elements:

- $I_1$ ,  $I_2$  and  $I_3$  (50/51),  $DthAL1$ ,  $DthAL2$  and  $Dth$  (49),  $I_2$ ,  $I_2$  (46)

Block2 IE

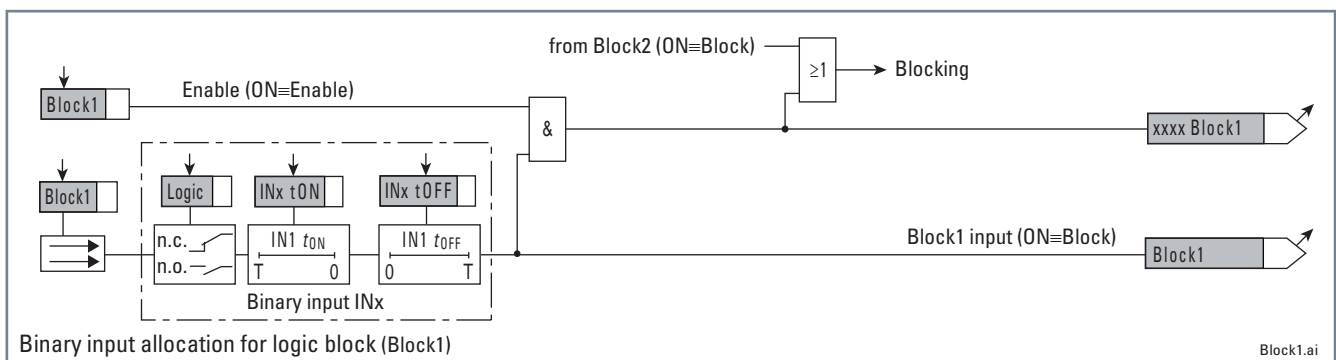
A change in status of a binary input effects a block<sup>[1]</sup> for the following earth protective elements:

- $I_E$ ,  $I_E$  and  $I_E$  (50N/51N).

Block1

A change in status of a binary input effects a block for a length of time equal to the activation of the input<sup>[3]</sup>; the element pickup that wish be blocked must be enabled (the *Block1* parameter must be set to *ON* in the concerning menu).<sup>[4]</sup>

The application of the binary input for the acquisition of the Block1 (logic block) coming from external signal is shown in the following figure; in the example the block signal is ORed with Block2 (selective block) to block the generic (xxx) element.



Note 1 The exhaustive treatment of the Block 2 function is described in the "Logic selectivity" paragraph.

Note 2 The exhaustive treatment of the Block 2 function is described in the "Logic selectivity" paragraph. The application of the inputs for the acquisition of Block2 (selective block) for Phase (Block2 Iph) and earth protective functions (Block2 IE) is similar to that illustrated in the scheme concerning the Block2 IphIE

Note 3 Unlike the Block2 (selective block), that houses a safety logic founded on programmable timers, the Block1 (logic block) keeps block of the protection for the whole time when the input is active.

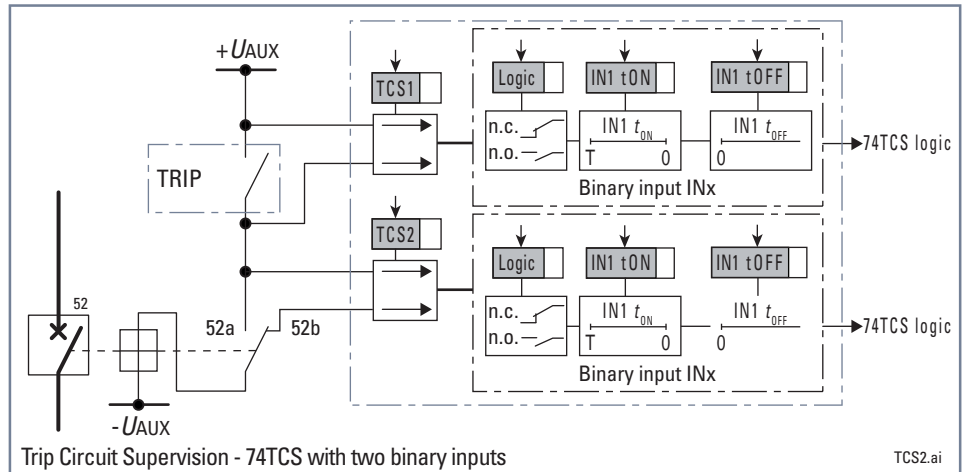
Note 4 The activation of one binary input produces indiscriminately a block of all protective elements programmed for being blocked from Block1

TCS1 and TCS2

Trip Circuit Supervision.

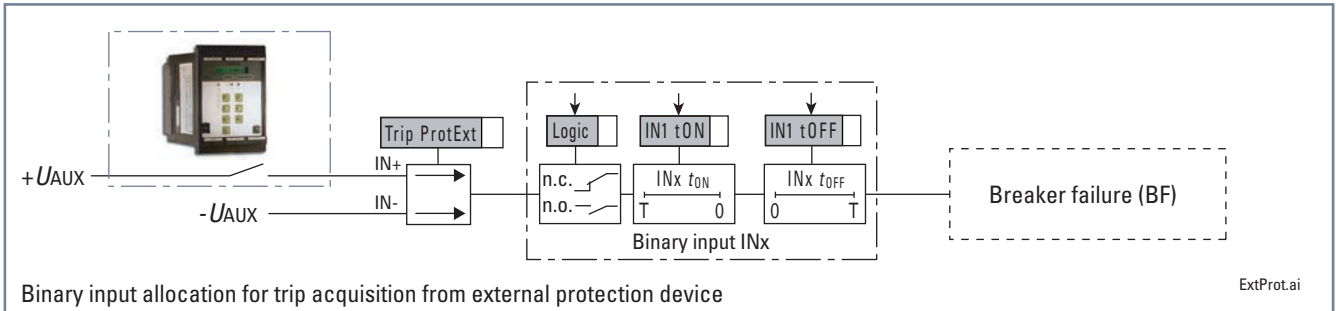
Supervision with one or two binary input can be performed.

The exhaustive treatment of the TCS function is described in the concerning paragraph.



Trip ProtExt

The binary input detects a trip coming from an external protective relay; the information is available for the breaker failure function (BF).



Reset counters

A change in status of a binary input effects a reset of all start/trip partial counters.<sup>[1]</sup>

Reset CB Monitor

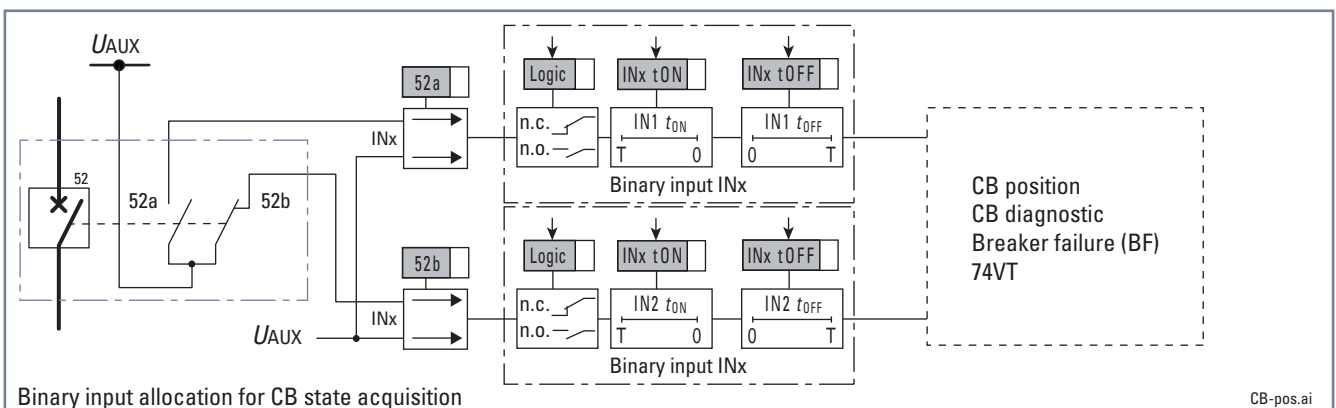
A change in status of a binary input effects a reset of all counters concerning the circuit breaker diagnostic:

- Breaking Sum phase  $I_{L1}$
- Breaking Sum phase  $I_{L2}$
- Breaking Sum phase  $I_{L3}$
- Breaking Sum $I^2t$  phase  $I_{L1}$
- Breaking Sum $I^2t$  phase  $I_{L2}$
- Breaking Sum $I^2t$  phase  $I_{L3}$
- CB Open counter

52a and 52b

The CB position can be acquired by means of binary inputs connected to the auxiliary contacts: the information is used in the following functions:

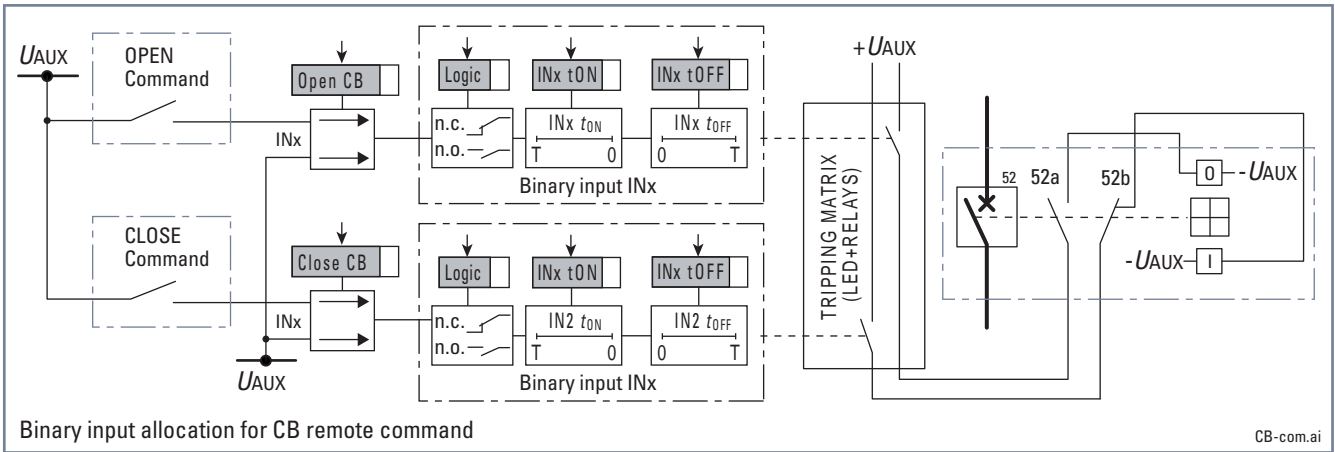
- CB position (open-closed)
- CB diagnostic (N. of operations, trip time)
- Breaker Failure (BF)



Note 1 The reset of the total counters is practicable by means ThyVisor command with Session Level 1 (available with password)

Open CB  
Close CB

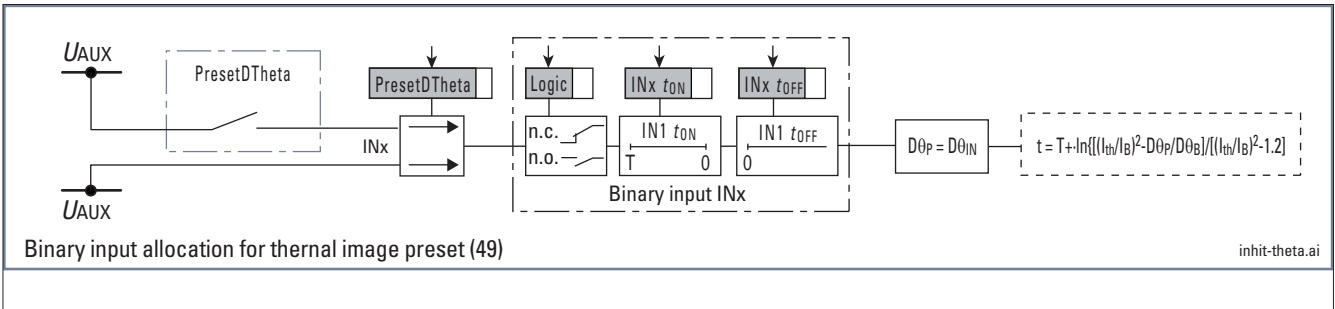
The external acquisition of remote commands allows to drive CB remotely.



Preset DTheta

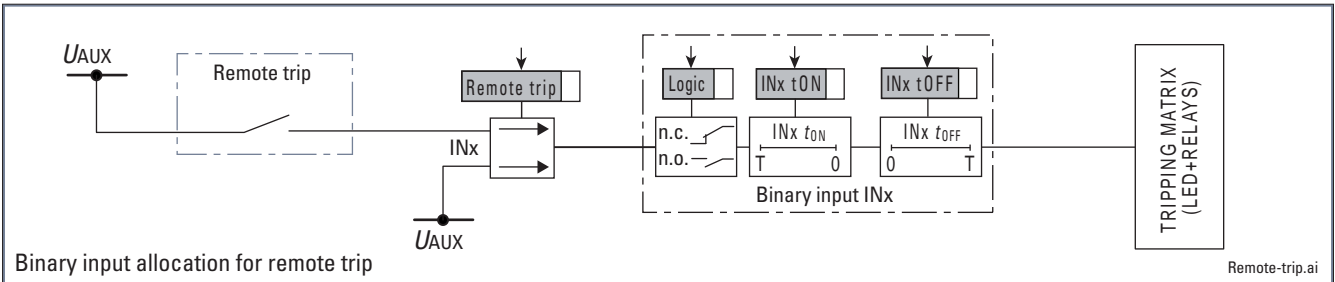
The input activation presets the thermal image (49).

The preset value can be adjusted by means the  $D\theta_{IN}$  setting. The thermal image is initialized at the  $D\theta_{IN}$  value when the device is powered or when the binary input become active.



Remote trip

The input activation drives an expressly programmed output relay.



Reset on demand measures

The input activation make a reset of all demand measures.

## Output relays

Six output relays are available on board (K1...K6).<sup>[1]</sup>

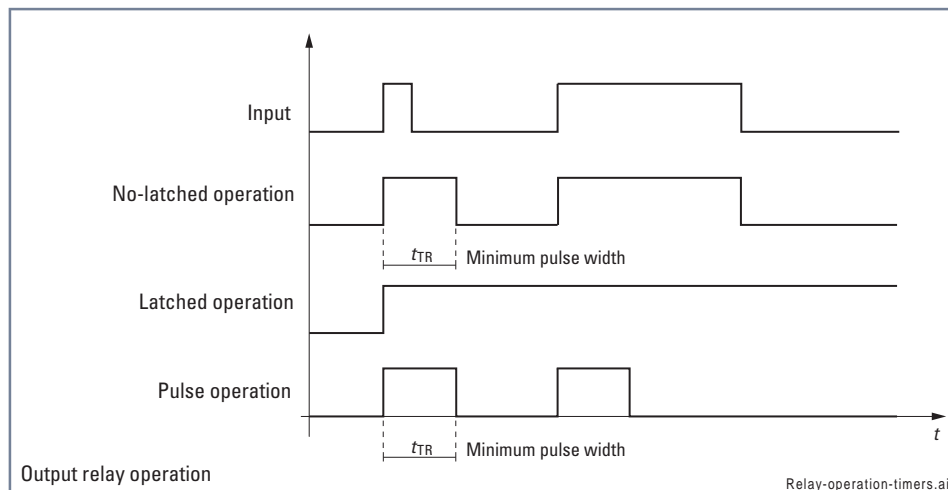
- K1 and K2 have two changeover contacts (SPDT, type C).
- K3, K4 and K5 have one make contact (SPST-NO, type A).<sup>[2]</sup>
- K6 has one break contact (SPST-NC, type B).<sup>[3]</sup>

Each output relay may be programmed with following operating mode:

- *Operation MODE (No latched, Pulse, Latched).*
- *Logic (Energized/De-energized).*

To each output relay a programmable timer is matched (*Minimum pulse width* parameter).

All parameters are available inside the **SetRelays** menu.



Any change to the settings can be affected at any time, also with the relay on duty, separately for each relay.

Notes:

- When de-energized operating mode is set, the relay remains in rest condition if no trip command is in progress.
- When energized operating mode is set, the relay remains in operating condition if no trip command is in progress and the auxiliary supply is powered on.
- When no-latched operating mode is set (*Operation MODE No latched*), the output relay reset at the end of the trip condition. To each output relay a programmable timer is matched (minimum pulse width operation).
- When latched operating mode is set (*Operation MODE Latched*), the output relay doesn't reset at the end of the trip condition; it stays ON until a reset command is issued (RESET key, ThyVisor or communication command).
- When pulse operating mode is set (*Operation MODE Pulse*), the output relay reset after a  $t_{TR}$  programmable delay regardless of the trip condition.
- It is advisable to make sure that the output contact technical data are suitable for load (Nominal current, breaking capacity, make current, switching voltage,...).

Matching every output relay to any protective element is freely programmable inside the *Setpoints* submenus according a tripping matrix structure.<sup>[4][5]</sup>

*Note 1 Schematic diagram are shown inside APPENDIX B1; more relays (K7...K10) are available with MRI auxiliary module*

*Note 2 K3 and K4 have a common terminal (A10)*

*Note 3 K5 and K6 have a common terminal (A13)*

*Note 4 Matching of the output relay to the protective and control functions can be defined so that any collision from other function is avoided. All output relay are unassigned in the default setting.*

*Note 5 Self test relay: it is advisable to plan the following settings:*

- Energized operating mode,
- No-latched ,

*in order that it stays ON for normal conditions and the other way round it goes OFF if any fault is detected and/or the auxiliary supply turns OFF.*

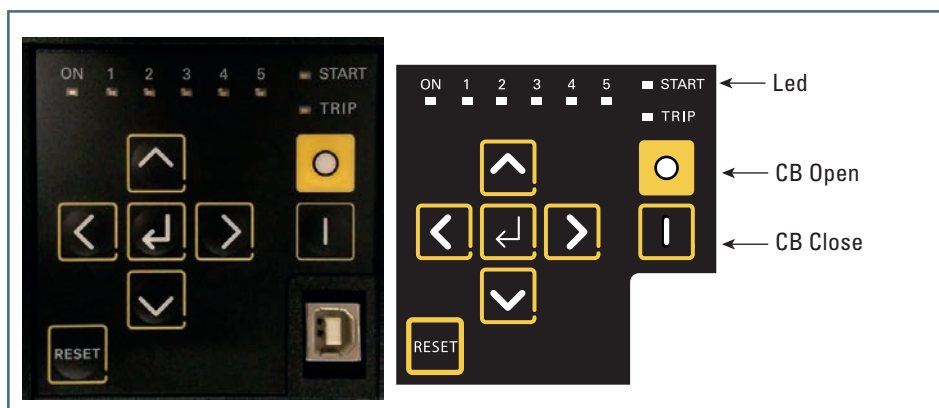
FUNCTIONS	RELAYS					
	K1	K2	K3	K4	K5	K6
Self-test relay	■	■	■	■	■	■
ThALx Alarm relays (ThAL1-K...ThAL8-K)	■	■	■	■	■	■
ThALx Trip relays (Th>1-K...Th>8-K)	■	■	■	■	■	■
I< Start relays (I<-ST-K)	■	■	■	■	■	■
I< Trip relays (I<-TR-K)	■	■	■	■	■	■
U<< Start relays (U<<-ST-K)	■	■	■	■	■	■
U<< Trip relays (U<<-TR-K)	■	■	■	■	■	■
I2> Start relays (I2>-ST-K)	■	■	■	■	■	■
I2> Trip relays (I2>-TR-K)	■	■	■	■	■	■
I2>> Start relays (I2>>-ST-K)	■	■	■	■	■	■
I2>> Trip relays (I2>>-TR-K)	■	■	■	■	■	■
DthAL1 Alarm relays (DthAL1-K)	■	■	■	■	■	■
DthAL2 Alarm relays (DthAL2-K)	■	■	■	■	■	■
Dth> Trip relays (Dth>-K)	■	■	■	■	■	■
I> Start relays (I>-ST-K)	■	■	■	■	■	■
I> Trip relays (I>-TR-K)	■	■	■	■	■	■
I>> Start relays (I>>-ST-K)	■	■	■	■	■	■
I>> Trip relays (I>>-TR-K)	■	■	■	■	■	■
I>>> Start relays (I>>>-ST-K)	■	■	■	■	■	■
I>>> Trip relays (I>>>-TR-K)	■	■	■	■	■	■
IE> Start relays (IE>-ST-K)	■	■	■	■	■	■
IE> Trip relays (IE>-TR-K)	■	■	■	■	■	■
IE>> Start relays (IE>>-ST-K)	■	■	■	■	■	■
IE>> Trip relays (IE>>-TR-K)	■	■	■	■	■	■
IE>>> Start relays (IE>>>-ST-K)	■	■	■	■	■	■
IE>>> Trip relays (IE>>>-TR-K)	■	■	■	■	■	■
I2/I1 Start relays (I1/I2>-ST-K)	■	■	■	■	■	■
I2/I1 Trip relays (I1/I2>-TR-K)	■	■	■	■	■	■
I2ndh> Start relays (I2ndh>-ST-K)	■	■	■	■	■	■
S< Trip relays (S<-TR-K)	■	■	■	■	■	■
74TCS Start relays (74TCS-ST-K)	■	■	■	■	■	■
74TCS Trip relays (74TCS-TR-K)	■	■	■	■	■	■
tB-IPh/IE Elapsed signalling relays (tB-K)	■	■	■	■	■	■
Phase protection output selective block relays (BLK2OUT-Iph-K)	■	■	■	■	■	■
Ground protection output selective block relays (BLK2OUT-IE-K)	■	■	■	■	■	■
Phase and ground protection output selective block relays (BLK2OUT-Iph/IE-K)	■	■	■	■	■	■
BF Start relays (BF-ST-K)	■	■	■	■	■	■
BF Trip relays (BF-TR-K)	■	■	■	■	■	■
PLC (PLC-K)	■	■	■	■	■	■
Number of CB trips diagnostic relays (N.Open-K)	■	■	■	■	■	■
Cumulative CB tripping currents diagnostic relays (SumI-K)	■	■	■	■	■	■
Cumulative CB tripping I <sup>2</sup> t diagnostic relays (SumI <sup>2</sup> t-K)	■	■	■	■	■	■
Circuit breaker opening time diagnostic relays (tbreak-K)	■	■	■	■	■	■
Open CB command relays (CBopen-K)	■	■	■	■	■	■
Close CB command relays (CBclose-K)	■	■	■	■	■	■
Remote tripping relays (RemTrip-K)	■	■	■	■	■	■
Not received pulses at BLIN signalling relays (PulseBLIN-K)	■	■	■	■	■	■

## LED indicators

Eight LEDs are available.

- One green LED "ON": if turned on it means that the device is properly working, if flashing the internal self-test function has detected an anomaly.
  - One yellow LED "START" tagged for START of one or more protective elements.<sup>[1]</sup>
  - One red LED "TRIP" tagged for TRIP of one or more protective elements.<sup>[1]</sup>
  - Five red LEDs "1...5" for highlight the activation of one or more user defined function.
- Each output relay may be programmed with following operating mode:
- No-latched: the LED reset at the end of the trip condition.
  - Latched: the LED doesn't reset at the end of the trip condition; it stays ON until a manual reset command is issued (RESET key, ThyVisor or communication command).

Any change to the settings can be affected at any time, also with the relay on duty, separately for each LED.



Free allocation of each LED may be set according to the matrix structure shown in the following page.<sup>[2]</sup>

*Note 1 The START and the TRIP LED are user assignable to any function; other than starting and tripping information can be assigned to them too, just the same for L1...L5*

*Note 2 All LEDs are unassigned in the default setting.*

FUNCTIONS	LEDs						
	START	TRIP	1	2	3	4	5
ThALx Alarm LEDs (ThAL1-L...ThAL8-L)	■	■	■	■	■	■	■
ThALx Trip LEDs (Th>1-L...Th>8-L)	■	■	■	■	■	■	■
I< Start LEDs (I<-ST-L)	■	■	■	■	■	■	■
I< Trip LEDs (I<-TR-L)	■	■	■	■	■	■	■
I2> Start LEDs (I2>-ST-L)	■	■	■	■	■	■	■
I2> Trip LEDs (I2>-TR-L)	■	■	■	■	■	■	■
I2>> Start LEDs (I2>>-ST-L)	■	■	■	■	■	■	■
I2>> Trip LEDs (I2>>-TR-L)	■	■	■	■	■	■	■
DthAL1 Alarm LEDs (DthAL1-L)	■	■	■	■	■	■	■
DthAL2 Alarm LEDs (DthAL2-L)	■	■	■	■	■	■	■
Dth> Trip LEDs (Dth>-L)	■	■	■	■	■	■	■
I> Start LEDs (I>-ST-L)	■	■	■	■	■	■	■
I> Trip LEDs (I>-TR-L)	■	■	■	■	■	■	■
I>> Start LEDs (I>>-ST-L)	■	■	■	■	■	■	■
I>> Trip LEDs (I>>-TR-L)	■	■	■	■	■	■	■
I>>> Start LEDs (I>>>-ST-L)	■	■	■	■	■	■	■
I>>> Trip LEDs (I>>>-TR-L)	■	■	■	■	■	■	■
IE> Start LEDs (IE>-ST-L)	■	■	■	■	■	■	■
IE> Trip LEDs (IE>-TR-L)	■	■	■	■	■	■	■
IE>> Start LEDs (IE>>-ST-L)	■	■	■	■	■	■	■
IE>> Trip LEDs (IE>>-TR-L)	■	■	■	■	■	■	■
IE>>> Start LEDs (IE>>>-ST-L)	■	■	■	■	■	■	■
IE>>> Trip LEDs (IE>>>-TR-L)	■	■	■	■	■	■	■
I2/I1 Start LEDs (I1/I2>-ST-L)	■	■	■	■	■	■	■
I2/I1 Trio LEDs (I1/I2>-TR-L)	■	■	■	■	■	■	■
I2ndh> Start LEDs (I2ndh>-ST-L)	■	■	■	■	■	■	■
I2ndh> Trip LEDs (I2ndh>-TR-L)	■	■	■	■	■	■	■
S< Trip LEDs (S<-TR-L)	■	■	■	■	■	■	■
74TCS Start LEDs (74TCS-ST-L)	■	■	■	■	■	■	■
74TCS Trip LEDs (74TCS-TR-L)	■	■	■	■	■	■	■
tB-Iph/IE Elapsed signalling LEDs (tB-L)	■	■	■	■	■	■	■
Phase protection output selective blocL LEDs (BLL2OUT-Iph-L)	■	■	■	■	■	■	■
Ground protection output selective blocL LEDs (BLL2OUT-IE-L)	■	■	■	■	■	■	■
Phase and ground protection output selective blocL LEDs (BLL2OUT-Iph/IE-L)	■	■	■	■	■	■	■
BF Start LEDs (BF-ST-L)	■	■	■	■	■	■	■
BF Trip LEDs (BF-TR-L)	■	■	■	■	■	■	■
PLC (PLC-L)							
Number of CB trips diagnostic LEDs (N.Open-L)	■	■	■	■	■	■	■
Cumulative CB tripping currents diagnostic LEDs (SumI-L)	■	■	■	■	■	■	■
Cumulative CB tripping I^2t diagnostic LEDs (SumI^2t-L)	■	■	■	■	■	■	■
Circuit breaker opening time diagnostic LEDs (tbreaL-L)	■	■	■	■	■	■	■
Open CB command LEDs (CBopen-L)	■	■	■	■	■	■	■
Close CB command LEDs (CBclose-L)	■	■	■	■	■	■	■
Remote tripping LEDs (RemTrip-L)	■	■	■	■	■	■	■
Not received pulses at BLIN signalling LEDs (PulseBLIN-L)	■	■	■	■	■	■	■

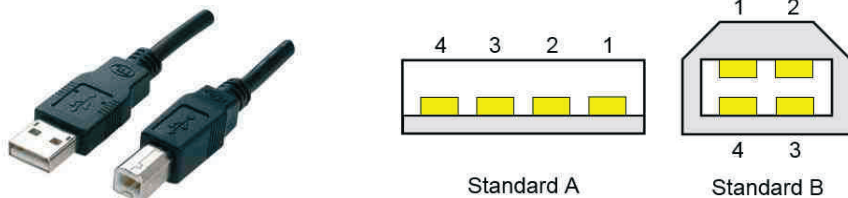
## Communication interfaces

Several communication ports are provided:

- USB port on the front side for local communication (ThyVisor).
- RS485 port on the rear side for bus communication.
- Ethernet port on the rear side for bus communication.

### USB

To connect the local port you need to use a cable USB Type B - Type A; the Thytronic cable code L10042 can be supplied.



The serial port is the simplest access for setting by means the ThyVisor software.

### RS485

Several protocol are implemented<sup>[1]</sup>:

- ModBus RTU. Modbus is a serial communications protocol. It is a de facto standard communications protocol in industry, and is now the most commonly available means of connecting industrial electronic devices also inside electric utilities and substation.
- IEC 60870-5. The IEC 60870-5 suite of protocol is used for communications from master station to substation, as well within the substation; the IEC 60870-5-103 (Protection equipment) is available together the Modbus protocol on some version of Pro-n devices (code NAXx#xxxxC x).

### Ethernet

It is provided (optionally) a communication board useful for Ethernet communication with ModBus TCP/IP protocol.<sup>[2]</sup>

Modbus/TCP basically embeds a Modbus frame into a TCP frame in a simple manner. This is a connection-oriented transaction which means every query expects a response.

This query/response technique fits well with the master/slave nature of ModBus, adding to the deterministic advantage that Switched Ethernet offers industrial users.

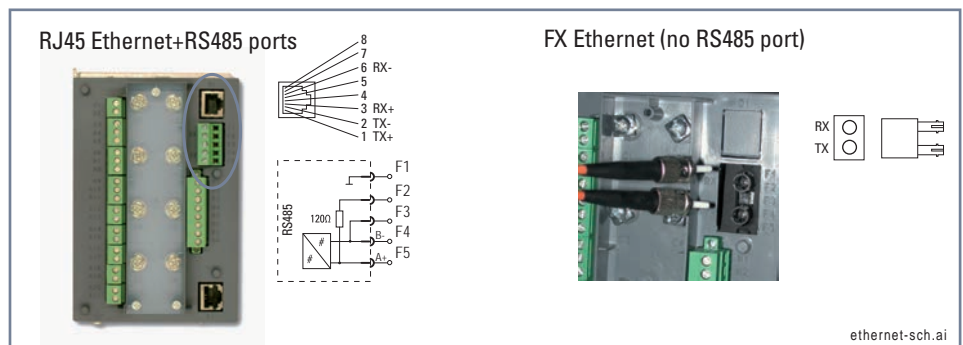
In the same way as the RS485 base Modbus, every device is identified by a personal address and the communication goes in "client-server" mode with answering request from the recipient.

The protective relay can be directly connect to the Ethernet network (no gateway, protocol converter are needed).

Two port can be implemented:

- 100BASE-TX with RJ45 connector (copper).
- 100BASE-FX with FX connector (optical fiber)<sup>[2]</sup>

For both modules no hw preset are required.



Two LEDs are on board (RJ45):

- LINK - (green): The LED lights up if the connection is active.
- TX - (yellow): The LED lights up when data transmission is active.

*Note 1 The RS485 port is not implemented on the Pro-N devices endowed with Ethernet FX port*

*Note 2 Information about the ModBus map may be find inside the "Remote programming manual"*

## 4.4 PROTECTIVE ELEMENTS

### Rated values

Inside the Base menu the following parameters can be set:

- Relay reference name.
- Relay nominal currents (phase and residual), to which the regulation are related.
- Primary nominal values, employed for measures relative to primary values.
- Measurements reading mode.

Information for settings:

- **Relay reference name.**

Alphanumeric mnemonic string (max 16 characters) useful for identification of protected plant.

- **Relay nominal frequency  $f_n$**

This nominal value must be set same as the frequency of the grid.

Example: grid frequency  $f_n = 50$  Hz

Relay nominal frequency  $f_n = 50$  Hz

- **Relay phase nominal current  $I_n$**

This nominal value must be set by means dip-switch to 1 A or 5 A, same as the secondary CTs nominal current.

Dip-switches are located on board of the CPU module; the exhaustive treatment of Dip setup is described in the "6.5 SETTING NOMINAL CURRENTS  $I_n$  AND  $I_{En}$ " paragraph.

- **Relay residual nominal current  $I_{En}$**

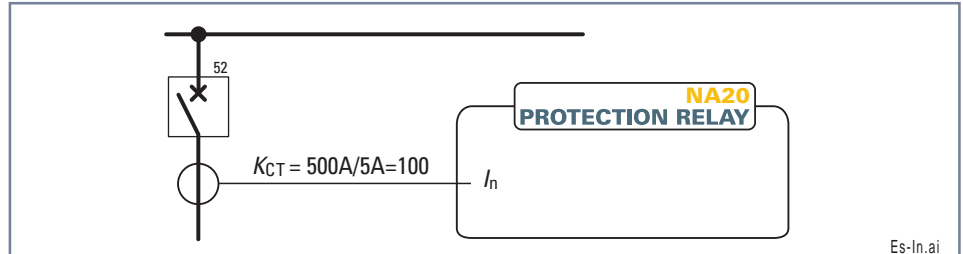
This nominal value must be set by means dip-switch to 1 A or 5 A, same as the secondary CT nominal current.

Dip-switch is located on board of the CPU module; the exhaustive treatment of Dip setup is described in the "6.5 SETTING NOMINAL CURRENTS  $I_n$  AND  $I_{En}$ " paragraph.

- **Phase CT primary current  $I_{np}$**

This parameter affects the measure of the phase currents when the primary measurement reading mode is selected. It must be programmed to the same value of the phase CT primary nominal current.

Example

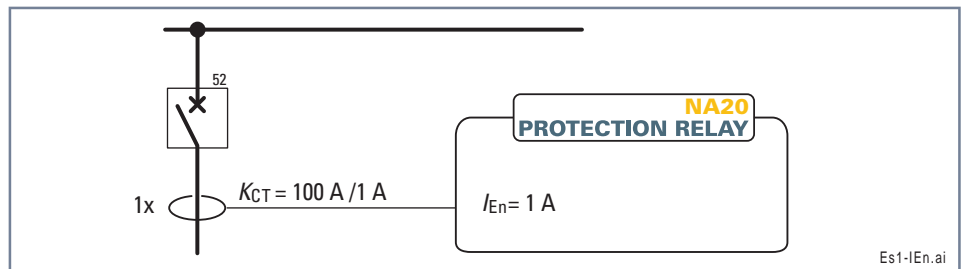


The phase CT primary current  $I_{np}$  must be set as:  $I_{np} = 500$  A

- **Residual CT primary current  $I_{Enp}$**

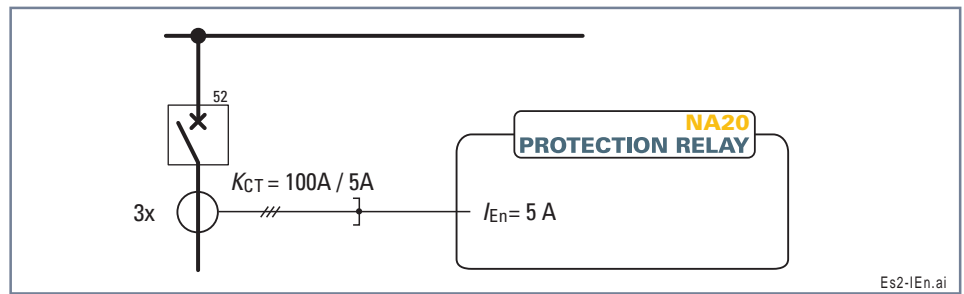
This parameter affects the measure of the residual current when the primary measurement reading mode is selected. It must be programmed to the same value of the residual CT(s) primary nominal current.

Example 1



The residual CT primary current  $I_{Enp}$  must be set as:  $I_{Enp} = 100$  A

Example 2



The residual CT primary current  $I_{Enp}$  must be set as:  $I_{Enp} = 100 A$

- **Measurement reading mode**

- Measures may be displayed according the following operating modes:
- With *RELATIVE* setting all measures are related to the nominal value,
  - With *PRIMARY* setting all measures are related to the primary value.

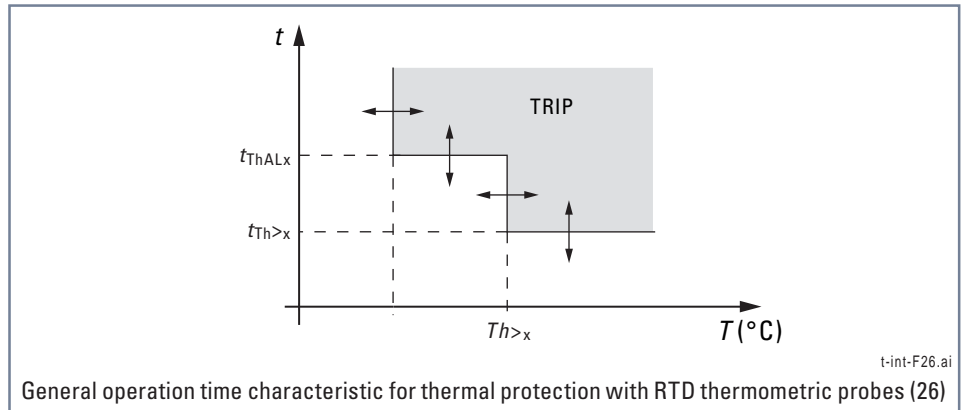
Thermal protection with RTD thermometric probes - 26

Preface

The measure of temperature is acquired by means of Pt100 (RTD Resistive Temperature sensing Devices) probed, connected to the MPT module.<sup>[1]</sup>

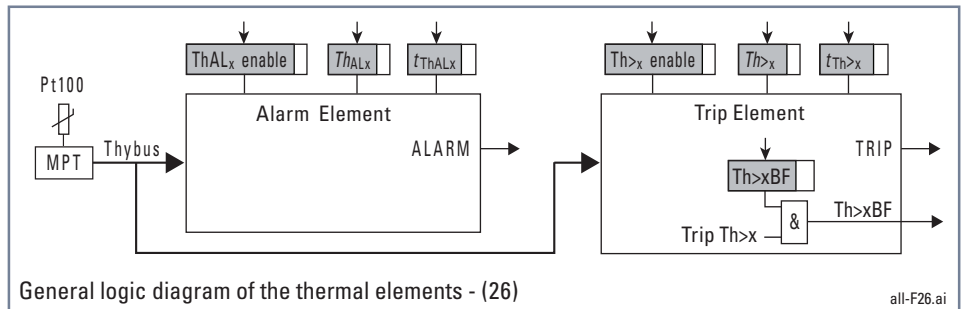
A direct thermal protection element with eight PT100 thermometric probes (RTD Resistive Thermal Device) provides protection against premature ageing or breakdown of the insulating materials through overheating.

Thermal protection using thermometric probes offers greater reliability than Thermal overload-based indirect protection, since it is not influenced by inaccuracies in the time constant for the thermal model of the machinery and by variations in the surrounding temperature.



For each thermometric probe an alarm ( $Th_{ALx}$ , where  $x=1..8$  points one of the eight probes) and one trip adjustable threshold is provided ( $Th_{>x}$ ), with adjustable operating time ( $t_{ThALx}$  and  $t_{Th>x}$ ); if the measured temperature overcomes the threshold, the relative alarm and/or trip is issued when the timer expires.

The adjustments are operable in °C.



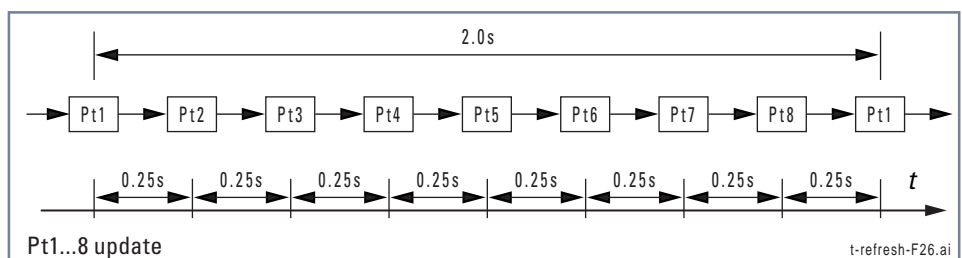
The probes should be placed in strategic points around the machinery susceptible to the greatest overheating, such as for example:

- near the generator stator windings, near the step-up transformer windings and/or in the oil, with the aim of detecting overheating produced by the overload currents,
- near the generator bearings, with the aim of detecting localised overheating due to worn or non-lubricated bearings.

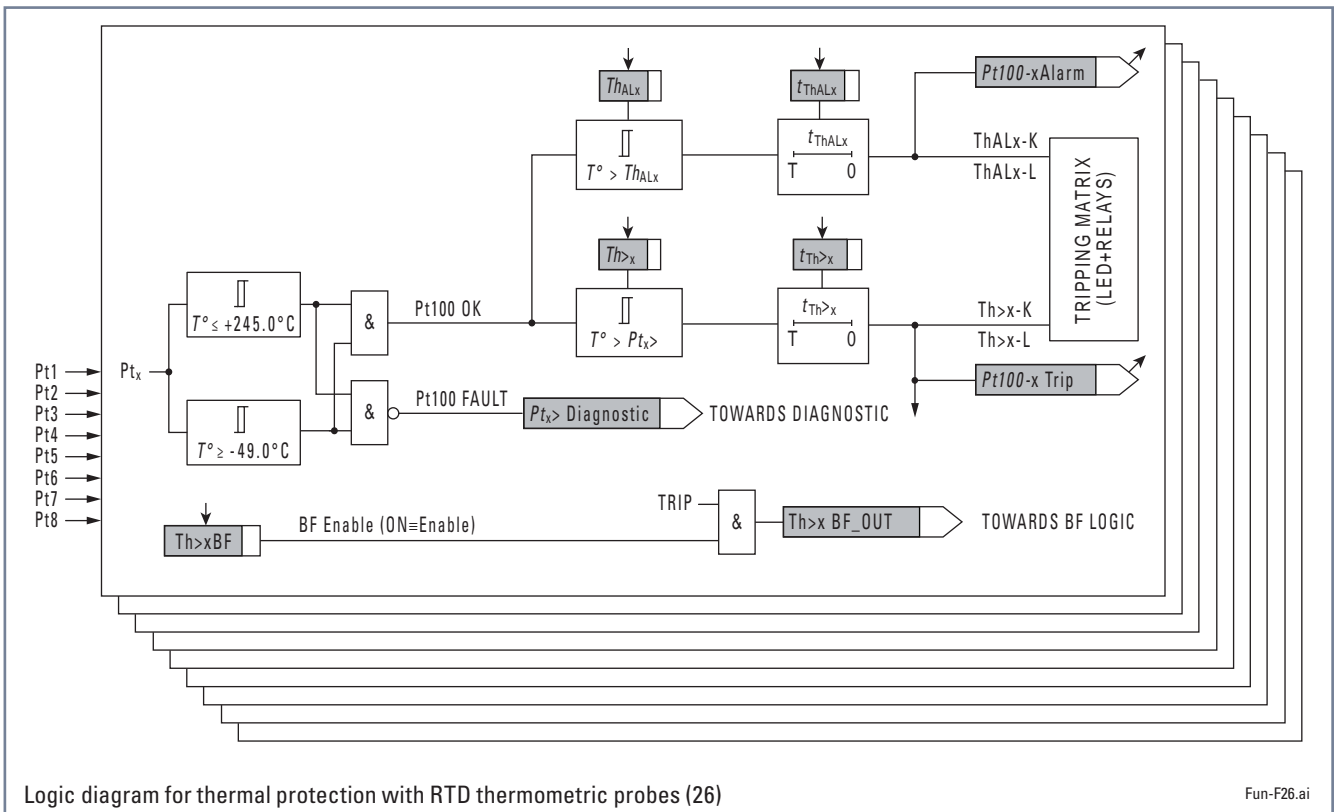
The Pt100 probes detect the temperature in the range -50 °C...+250 °C (at 0 °C its resistance is 100 ohm); an alarm indicates any interruption or short-circuiting of the probe or related connections to the MPT module; the information is available inside the **Read \ PT100** menu:

- *Ptx probe ON* to point a measure inside the range
  - *Ptx probe LOW* to point a measure lower the range (short circuit of probe and/or wires)
  - *Ptx probe HIGH* to point a measure higher the range (breaking of probe and/or wires).
- Self reset is performed when faults are cleared.

The measure of each probe is updated at 2 s time intervals.



Note 1 The 26 menu is available when the MPT module is enabled



Logic diagram for thermal protection with RTD thermometric probes (26)

Fun-F26.ai

All alarm and/or trip elements can be enabled or disabled by setting *ON* or *OFF* the *ThALx Enable* e *Th>x Enable* parameters inside the **Set \ Profile A(or B) \ Thermal protection with RTD thermometric probes - 26 \ PTx Probe \ ThALx Alarm (ThALx Trip)** where  $x = 1...8$ .

Each trip threshold ( $Th>x$ ) may be associated with the breaker failure (BF) function by setting *ON* the *Th>xBF* parameters inside the **Set \ Profile A(or B) \ Thermal protection with RTD thermometric probes - 26 \ PTx Probe \ ThALx Trip** where  $x = 1...8$ .<sup>[1]</sup>

Note 1 The common settings concerning the Breaker failure protection are adjustable inside the **Breaker Failure - BF** menu.

**Undercurrent - 37**

*Preface*

One operation threshold, adjustable ( $I_{<def}$ ) with adjustable delay ( $t_{<def}$ ).  
The threshold operates with definite time characteristic.

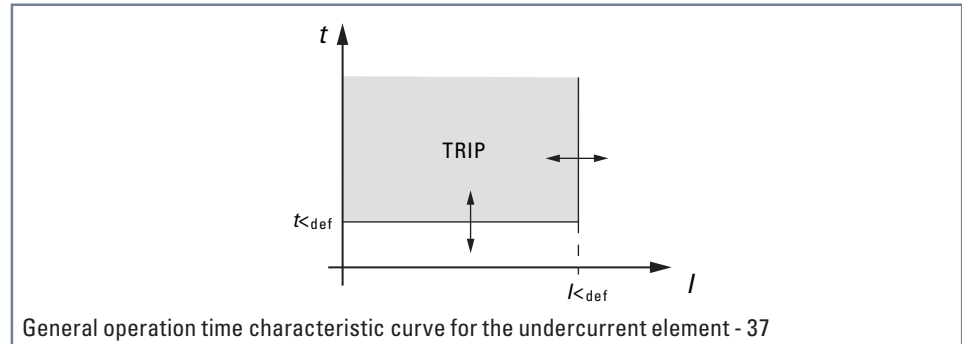
*Operation and settings*

Each of three currents are compared with the setting value ( $I_{<def}$ ). The start and trip logic may be selected *OR* or *AND*.

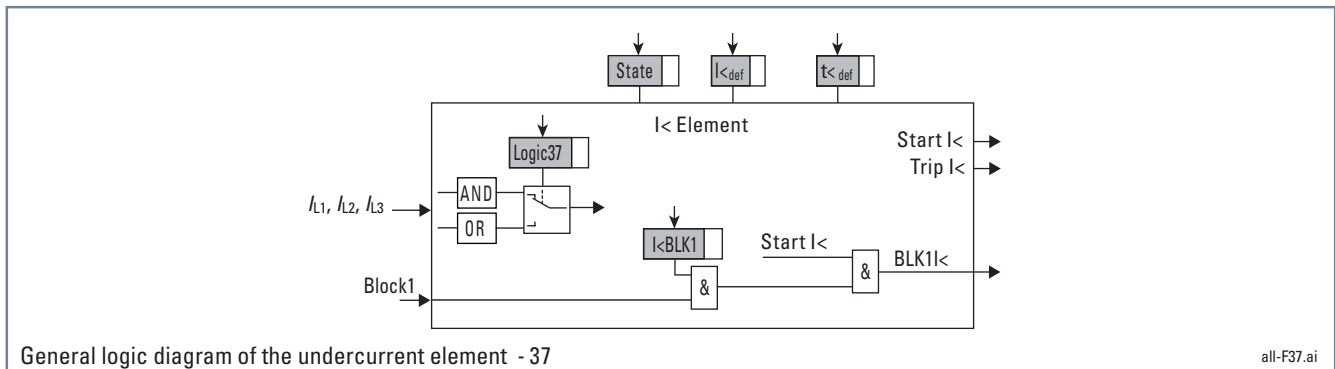
With *OR* selection, a start is issued when at least one of the three currents goes down the adjustable threshold (START); with *AND* selection, a start is issued when all the three currents go down the adjustable threshold.

After expiry of the associated operate time ( $t_{<def}$ ), a trip command is issued; if instead the currents exceed the threshold, the element is restored.

The element can be enabled or disabled by setting *ON* or *OFF* the *State* parameter inside the **Set \ Profile A(or B) \ Undercurrent-37 \ I < Element \ Definite time** menu.



The undercurrent element may be disabled by means MMI. During the command, the trip output relays I<TR-K (with latched or no-latched operation mode and, de-energized or energized logic) are forced in the rest state, the "37 DISABLED" message is displayed and all the LEDs flash until the command is ended.



The following block criteria is available:

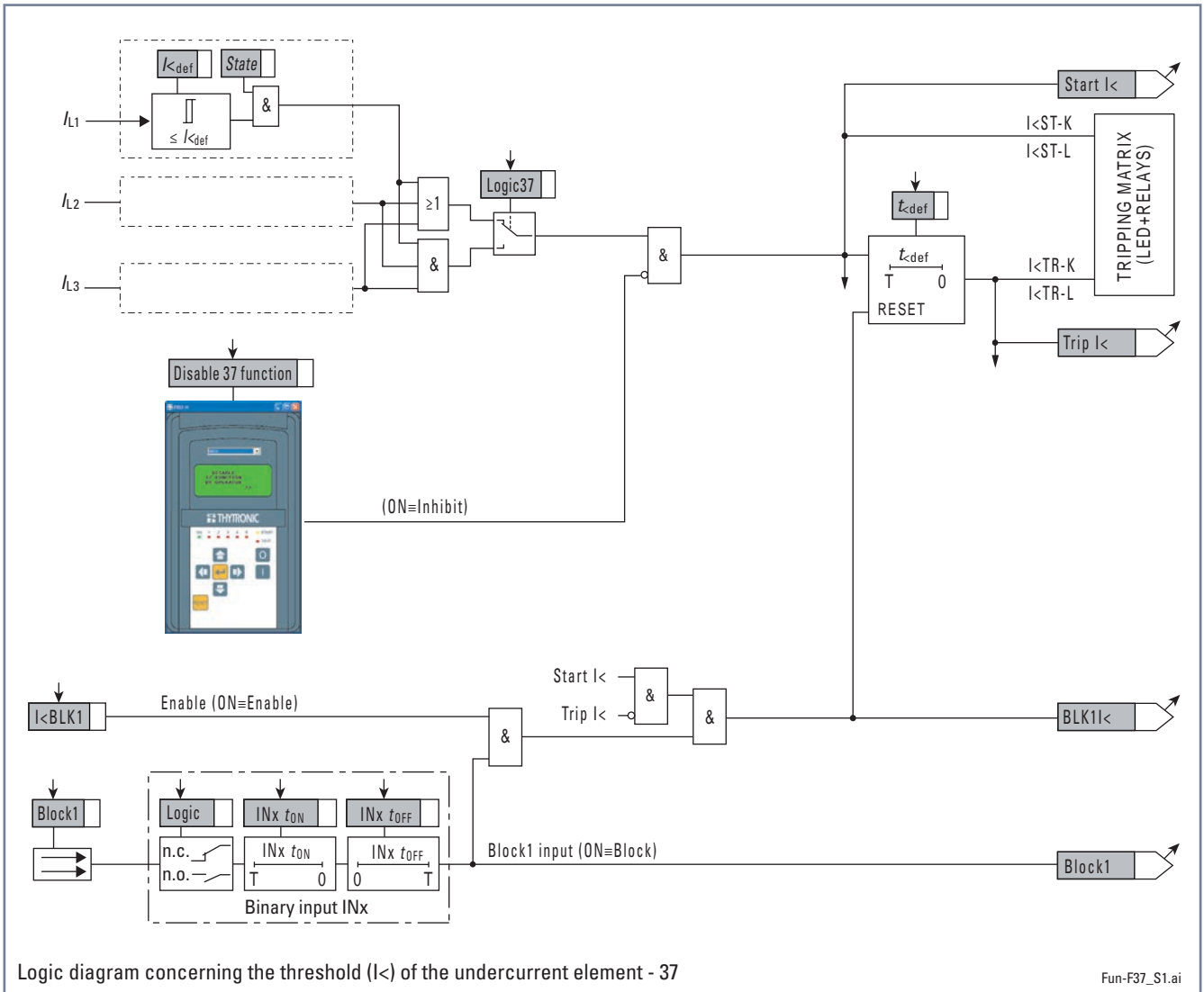
*Logical block (Block1)*

If the  $I_{<BLK1}$  enabling parameter are set to *ON* and a binary input is designed for logical block (Block1), the protection is blocked off whenever the given input is active.

The trip timer is held in reset condition, so the operate time counting starts when the input block goes down.<sup>[1]</sup> The enabling parameter is available inside the **Set \ Profile A(or B) \ Undercurrent - 37 \ I < Element \ Setpoints** menu, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input INx** menus (INx matching).

The parameter may be adjusted independently for both profiles **A** or **B**.

*Note 1* The description of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section.



Logic diagram concerning the threshold ( $I_{<}$ ) of the undercurrent element - 37

Fun-F37\_S1.ai

## Negative sequence overcurrent - 46

Preface

Two operation thresholds, independently adjustable ( $I_{2>}$ ,  $I_{2>>}$ ) with adjustable delay ( $t_{2>}$ ,  $t_{2>>}$ ).  
 The first one may be programmed with definite or inverse time according the IEC and ANSI/IEEE standard, as well as with  $I^2t$  or EM curve.  
 The second threshold has a definite time characteristic.  
 For each threshold a reset time can be set ( $t_{2>RES}$ ,  $t_{2>>RES}$ ) useful to reduce the clearing time for intermittent faults.  
 The first threshold trip may be inhibited by start of the second threshold ( $I_{2>>}$ ).

### Operation and settings

The negative sequence current is computed as:

$$I_2 = (I_{L1} + e^{-j120^\circ} \cdot I_{L2} + e^{+j120^\circ} \cdot I_{L3}) / 3$$

where  $e^{-j120^\circ} = -1/2 - j\sqrt{3}/2$ ,  $e^{+j120^\circ} = -1/2 + j\sqrt{3}/2$ .

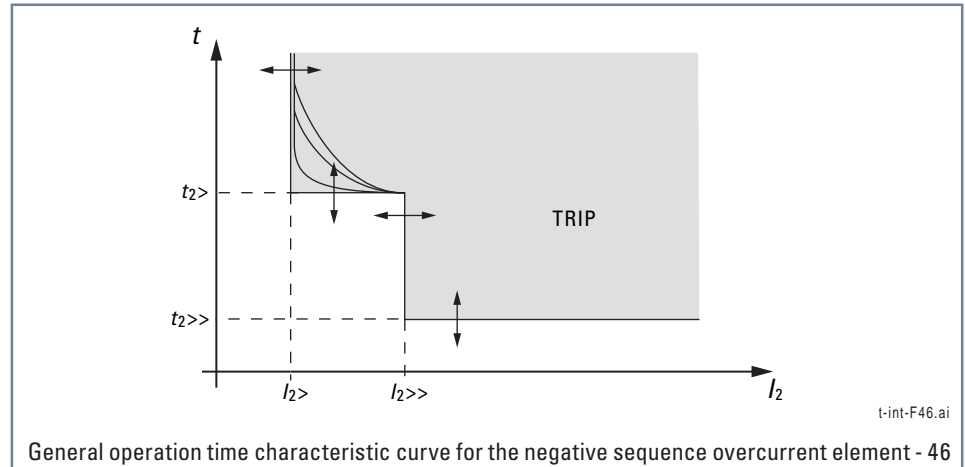
The negative sequence current is compared with the setting values. Currents above the associated pickup value are detected and a start is issued. After expiry of the associated operate time ( $t_{2>}$ ,  $t_{2>>}$ ) a trip command is issued; if instead the current drops below the threshold, the element is restored. The first threshold ( $I_{2>}$ ) may be programmed with definite or inverse time according the following characteristic curves:

- Standard Inverse Time (IEC 255-3/BS142 type A or SIT):  $t = 0.14 \cdot t_{2>inv} / [(I_2/I_{2>inv})^{0.02} - 1]$
- Very Inverse Time (IEC 255-3/BS142 type B or VIT):  $t = 13.5 \cdot t_{2>inv} / [(I_2/I_{2>inv}) - 1]$
- Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):  $t = 80 \cdot t_{2>inv} / [(I_2/I_{2>inv})^2 - 1]$
- Moderately Inverse (ANSI/IEEE type MI):  $t = t_{2>inv} \cdot \{0.01 / [(I_2/I_{2>inv})^{0.02} - 1] + 0.023\}$
- Very Inverse (ANSI/IEEE type VI):  $t = t_{2>inv} \cdot \{3.922 / [(I_2/I_{2>inv})^2 - 1] + 0.098\}$
- Extremely Inverse (ANSI/IEEE type EI):  $t = t_{2>inv} \cdot \{5.64 / [(I_2/I_{2>inv})^2 - 1] + 0.024\}$
- I-squared-t ( $I^2t = K$ ):  $t = 16 \cdot t_{2>inv} / (I_2/I_{2>inv})^2$
- Electromechanical (EM):  $t = t_{2>inv} \cdot \{0.28 / [-0.236 \cdot (I_2/I_{2>inv})^{-1} + 0.339]\}$

Where:

- $t$ : operate time
- $I_{2>inv}$ : threshold setting
- $t_{2>inv}$ : operate time setting

The second threshold has a definite time characteristic.



For all inverse time characteristics, following data applies:

- Asymptotic reference value (minimum pickup value):  $1.1 I_{2>inv}$
- Minimum operate time:  $0.1 \text{ s}$
- Range where the equation is valid:<sup>[1]</sup>  $1.1 \leq I_2/I_{2>inv} \leq 20$

For all definite time elements the upper limit for measuring is  $50 I_n$ .

All overcurrent elements can be enabled or disabled by setting *ON* or *OFF* the  $I_{2>}$  *Enable* and/or  $I_{2>>}$  *Enable* parameters inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \  $I_{2>}$  Element ( $I_{2>>}$  Element) \ Setpoints** menus.

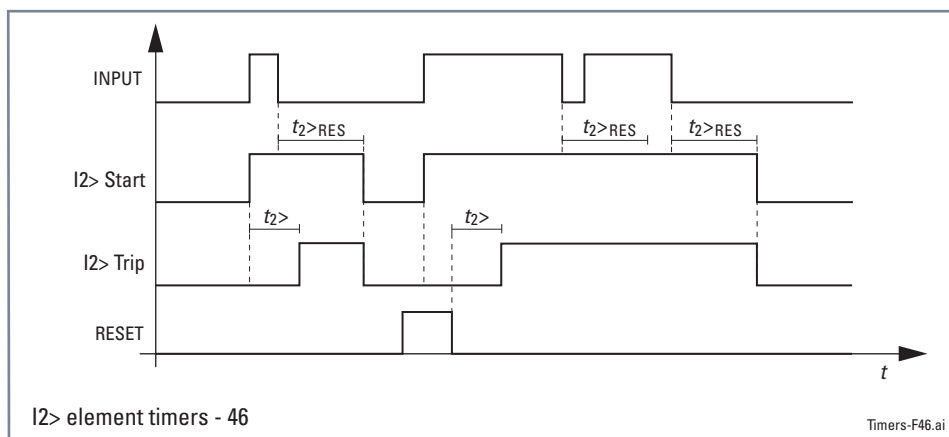
The first overcurrent element can be programmed with definite or inverse time characteristic by setting the  $I_{2>Curve}$  parameter (*DEFINITE*, *IEC/BS A*, *IEC/BS B*, *IEC/BS C*, *ANSI/IEE MI*, *ANSI/IEE VI*, *ANSI/IEE EI*, *I2t*, *EM*) available inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \  $I_{2>}$  Element \ Setpoints** menu.

The trip of  $I_{2>}$  element may be inhibited by the start of the second element ( $I_{2>>}$ ) by setting *ON* the *Disable  $I_{2>}$  by start  $I_{2>>}$*  ( $I_{2>}disbyI_{2>>}$ ) parameter available inside the **Set \ Profile A(or B) \ Negative sequence overcurrent-46 \  $I_{2>>}$  Element \ Setpoints** menu.

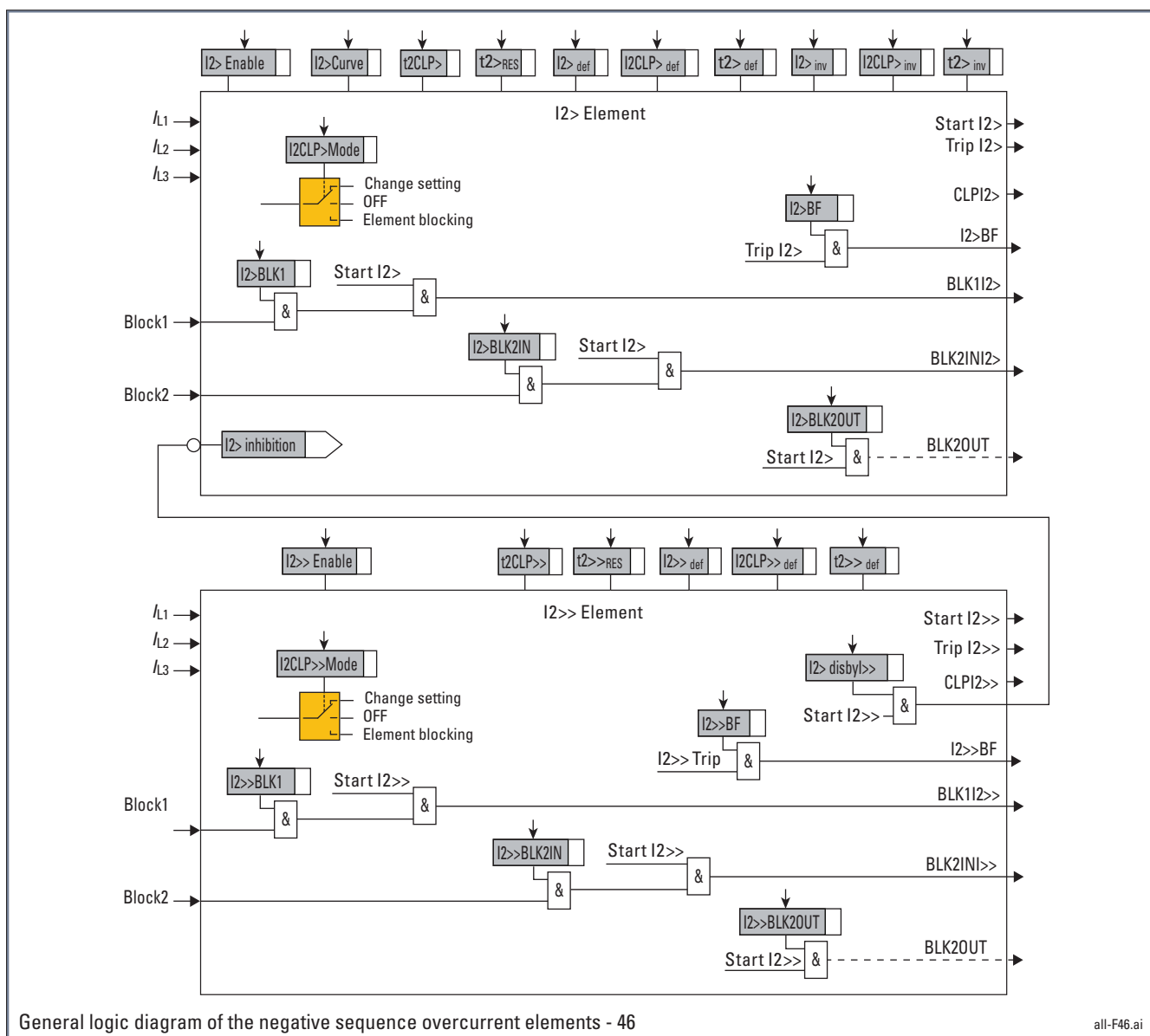
*Note 1* When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point

All the parameters can be set separately for **Profile A** and **Profile B** (Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints menus).

An adjustable reset time delay is provided for every threshold ( $t_{2>RES}$ ,  $t_{2>>RES}$ ).



Each element can produce the Breaker Failure output if the  $I2> BF$  and/or  $I2>> BF$  parameters are set to ON. The parameters are available inside the **Set \ Profile A(or B) \ negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints** menus.<sup>[1]</sup>



If the CLP function (Cold Load Pick-up) is enabled for element blocking, the selected threshold may be blocked for an adjustable time interval, starting from the circuit breaker closure.

Note 1 The common settings concerning the Breaker failure protection are adjustable inside the **Breaker Failure - BF** menu.

This operating mode may be select by setting *ON-Element blocking* the *I2CLP> Mode* and/or *I2CLP>> Mode* parameters.

If the CLP function (Cold Load Pick-up) is enabled for threshold change, the selected threshold may be changed for an adjustable time interval, starting from the circuit breaker closure.

This operating mode may be select by setting *ON-Change setting* the *I2CLP> Mode* and/or *I2CLP>> Mode* parameters, whereas the operating thresholds within the CLP may be adjusted inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element, (I2>> Element) \ Definite time (Inverse time)** menus.

For both operating modes the CLP Activation time parameters (*t2CLP>*, *t2CLP>>*) may be adjusted inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints** menus.

For both thresholds the following block criteria are available:

#### Logical block (Block1)

If the *I2>BLK1* and/or *I2>>BLK1* enabling parameters are set to *ON* and a binary input is designed for logical block (Block1), the concerning element is blocked off whenever the given input is active.<sup>[1]</sup> The enabling parameters are available inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints** menus, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input INx** menus.

#### Selective block (Block2)

All along the protective elements the selective block may be set.

The logic selectivity function may be performed by means any combination of the following I/O:

- One committed pilot wire input (BLIN1).
- One or more binary inputs designed for input selective block.
- One committed pilot wire output (BLOUT1).
- One or more output relays designed for output selective block.

Only when the committed pilot wire are used the continuity check of the pilot wire link is active.

Use of committed pilot wire input BLIN1:

- The protection is blocked off according the selectivity block criteria when the input BLIN1 is active. The information about phase or phase+earth block may be select programming the *ModeBLIN1* parameter inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block IN** menus.

Use of binary inputs:

- If the *I2>BLK2IN* and/or *I2>>BLK2IN* parameters are set to *ON* and a binary input is designed for selective block (Block2), the protection is blocked off by phase elements (Block2 Iph) or by any protection element (Block2 Iph/IE) according the selectivity block criteria.<sup>[2]</sup> The enable *I2>BLK2IN* and/or *I2>>BLK2IN* parameters are available inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints** menus, while the *Block2 Iph* and *Block2 Iph/IE* functions must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input INx** menus (IN1... matching).

Use of committed pilot wire output BLOUT1:

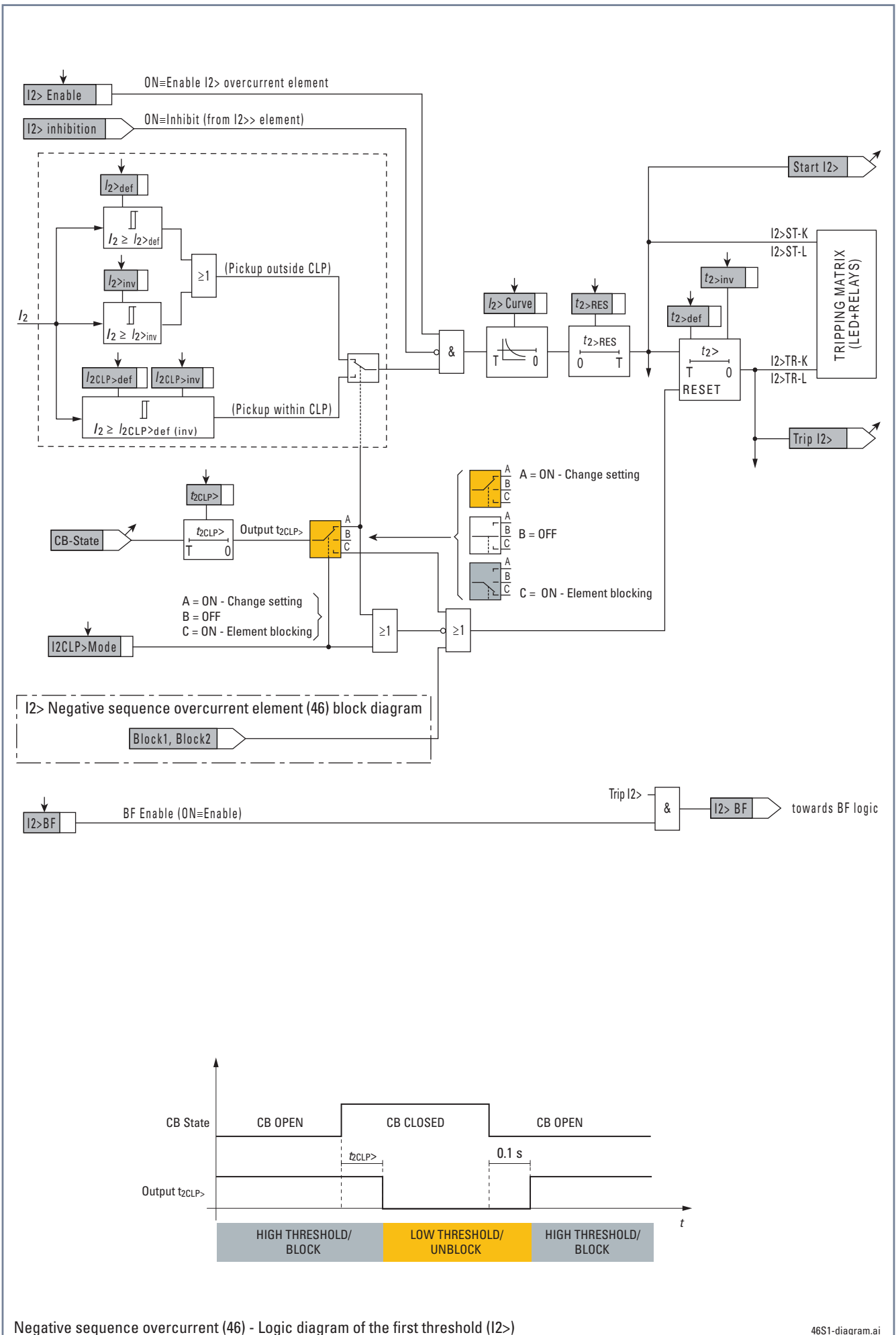
- The information about phase or phase+earth block may be select programming the *ModeBLOUT1* parameter (*OFF - ON IPh - ON IPh/IE - ON IE*) inside **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menus.

Use of output relay (K1...K6):

- If the *I2>BLK2OUT* and/or *I2>>BLK2OUT* enable parameters are set to *ON* and a output relay is designed for selective block (Block2), the protection issues a block output by phase elements (BLK2OUT-Iph) or by any protection element (BLK2OUT-Iph/IE), whenever the given element (Start I>, Start I>> e/o Start I>>>) becomes active. The enable *I2>BLK2OUT* and/or *I2>>BLK2OUT* parameters (*ON* or *OFF*) are available inside the **Set \ Profile A(or B) \ Negative sequence overcurrent - 46 \ I2> Element (I2>> Element) \ Setpoints** menus, while the *BLK2OUT-Iph-K*, *BLK2OUT-Iph/IE-K* and/or *BLK2OUT-IE-K* output relays and LEDs (*BLK2OUT-Iph-L*, *BLK2OUT-Iph/IE-L* e/o *BLK2OUT-IE-L*) must be select inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menu.

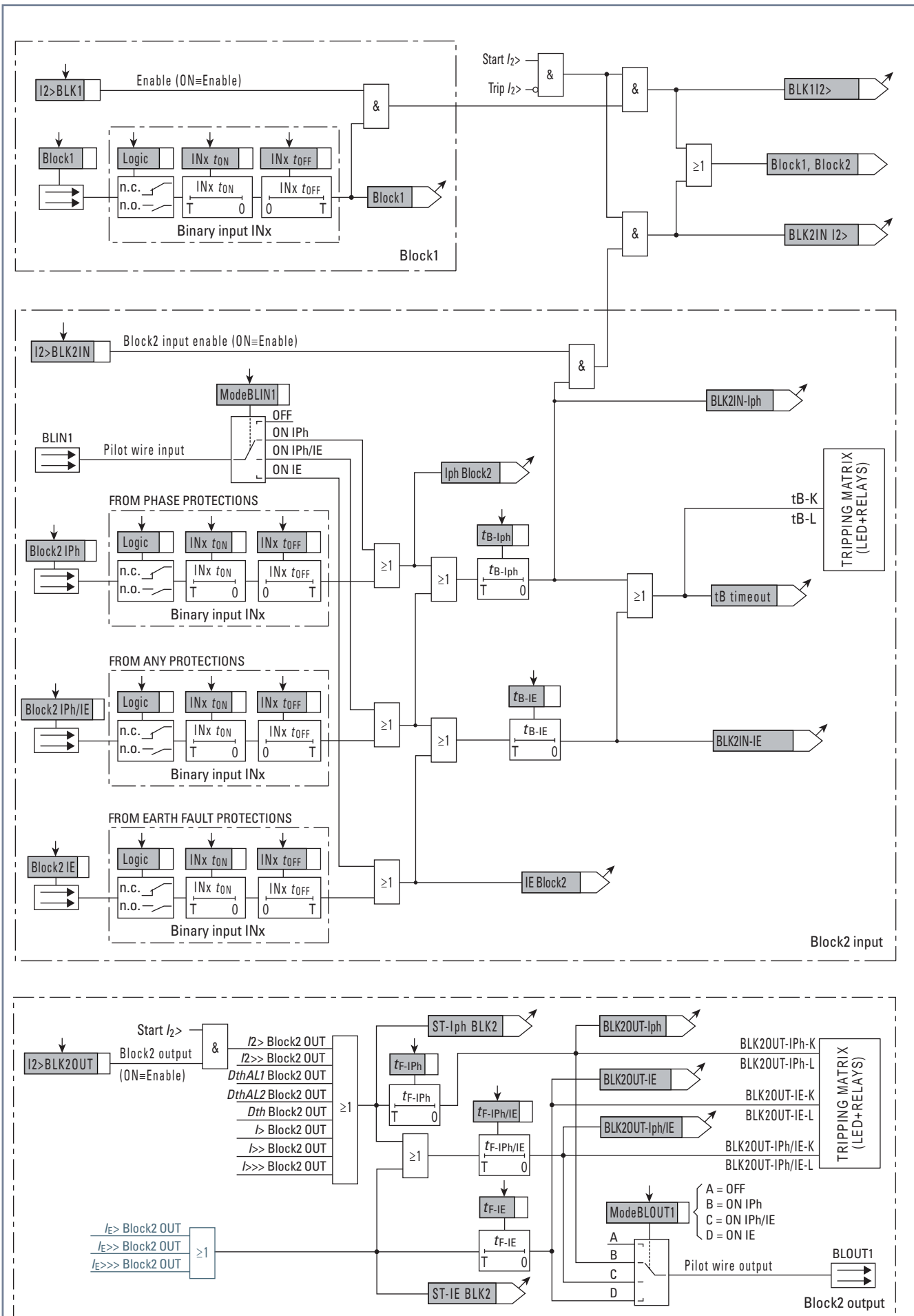
*Note 1* The exhaustive treatment of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section

*Note 2* The exhaustive treatment of the selective block (Block 2) function may be found in the "Selective Block" paragraph inside CONTROL AND MONITORING section



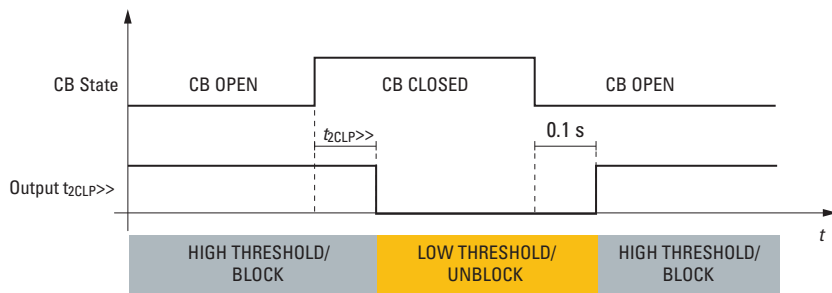
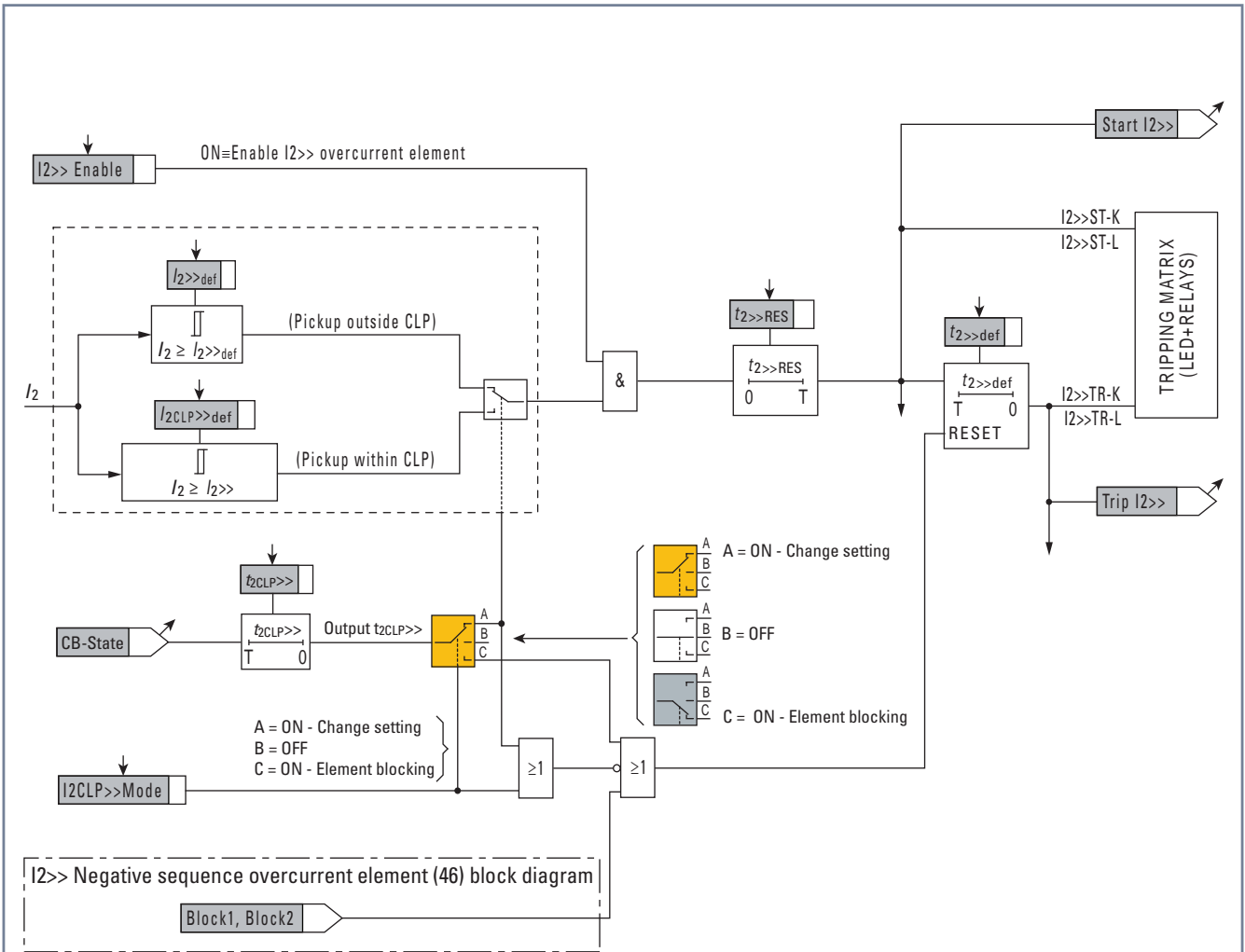
Negative sequence overcurrent (46) - Logic diagram of the first threshold (I2>)

46S1-diagram.ai

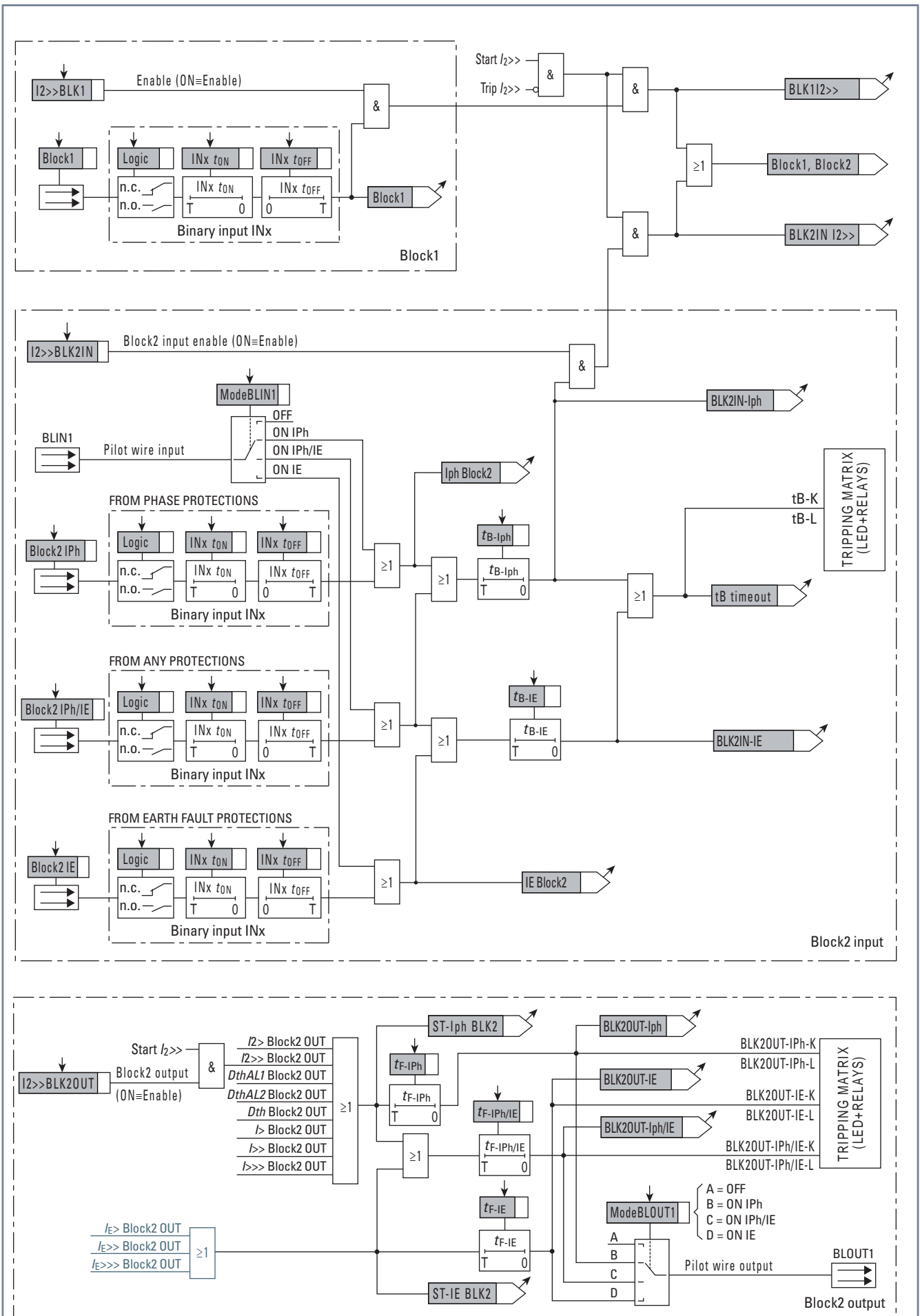


Negative sequence overcurrent (46) - Logic diagram of the blocking signals concerning the first element ( $I2 >$ )

46S1\_BL-diagram.ai



Negative sequence overcurrent (46) - Logic diagram of the second threshold (I2>>)



Negative sequence overcurrent (46) - Logic diagram of the blocking signals concerning the second element ( $I2 >>$ )

46S2\_BL-diagram.ai

## Negative sequence current / positive sequence current ratio - I2/I1

### Preface

One adjustable operation threshold  $(I_2/I_1) >$  with definite time adjustable delay  $(t_{21} >)$ .

### Operation and settings

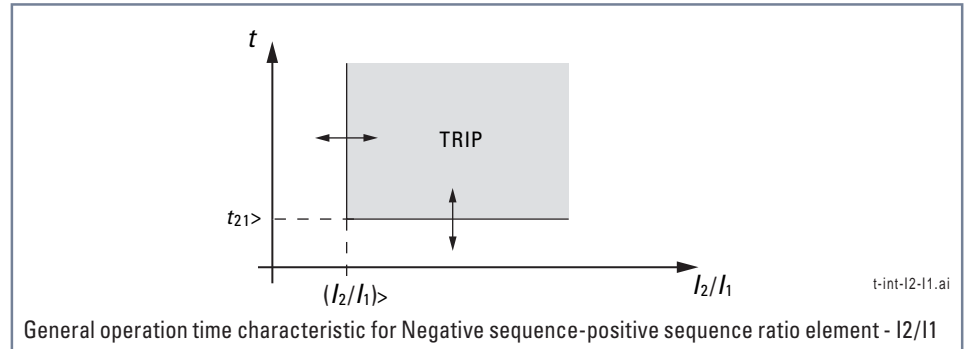
The negative and positive sequence currents are computed as:

$$I_1 = (I_{L1} + e^{+j120^\circ} \cdot I_{L2} + e^{-j120^\circ} \cdot I_{L3}) / 3$$

$$I_2 = (I_{L1} + e^{-j120^\circ} \cdot I_{L2} + e^{+j120^\circ} \cdot I_{L3}) / 3$$

where  $e^{-j120^\circ} = -1/2 - j\sqrt{3}/2$ ,  $e^{+j120^\circ} = -1/2 + j\sqrt{3}/2$ .

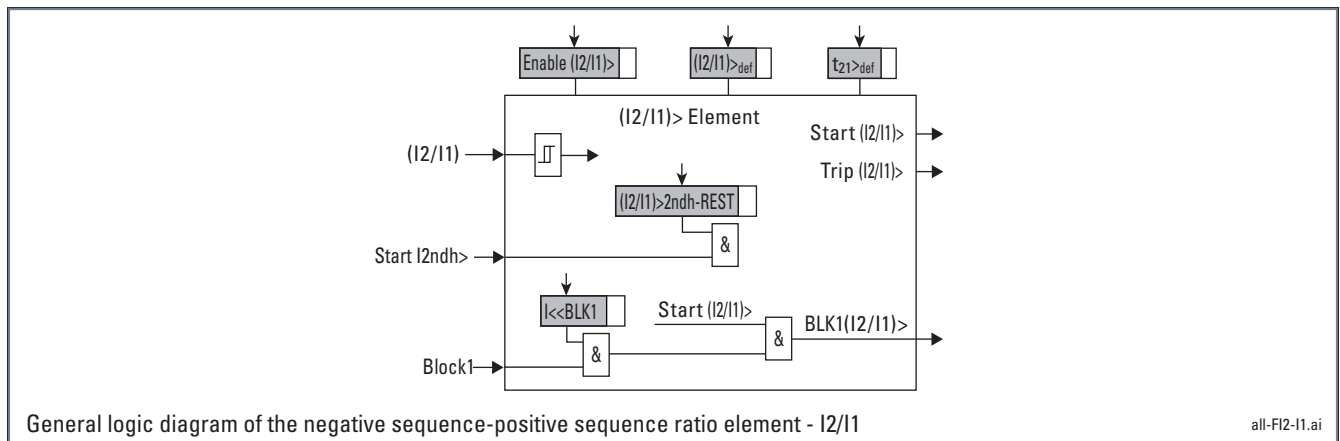
The negative sequence-positive sequence currents ratio is compared with the setting value. Ratio above the associated pickup value is detected and a start is issued. After expiry of the associated operate time  $(t_{21} >)$  a trip command is issued; if instead the it drops below the threshold, the element is restored.



The element can be enabled or disabled by setting *ON* or *OFF* the *State* parameter inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I1 > Element \ Definite time** menu.

The element can produce the Breaker Failure output if the  $(I_2/I_1) > BF$  parameter is set to *ON*. The parameter is available inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I1 > Element \ Setpoints** menus.<sup>[1]</sup>

A block from the second harmonic restraint may be set by setting *ON* the parameter inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I1 > Element \ Setpoints** menu.



If the CLP function (Cold Load Pick-up) is enabled for element blocking, the selected threshold may be blocked for an adjustable time interval, starting from the circuit breaker closure. This operating mode may be select by setting *ON-Element blocking* the  $(I_2/I_1) \text{CLP} > \text{Mode}$  parameter.

If the CLP function (Cold Load Pick-up) is enabled for threshold change, the selected threshold may be changed for an adjustable time interval, starting from the circuit breaker closure. This operating mode may be select by setting *ON-Change setting* the  $(I_2/I_1) \text{CLP} > \text{Mode}$  parameter, whereas the operating thresholds within the CLP may be adjusted inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I1 > Element \ Definite time** menu.

For both operating modes the CLP Activation time parameter  $(t_{21 \text{CLP}} >)$  may be adjusted inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I1 > Element \ Setpoints** menu.

*Note 1* The common settings concerning the Breaker failure protection are adjustable inside the **Breaker Failure - BF** menu.

The element may be blocked when the CT supervision function become active to avoid unwanted trips following any faults on CTs an amperometric input circuits;<sup>[1]</sup> the *74CT Enable* parameter may be set to *ON* inside the **Set \ CT supervision TA-74CT** menu

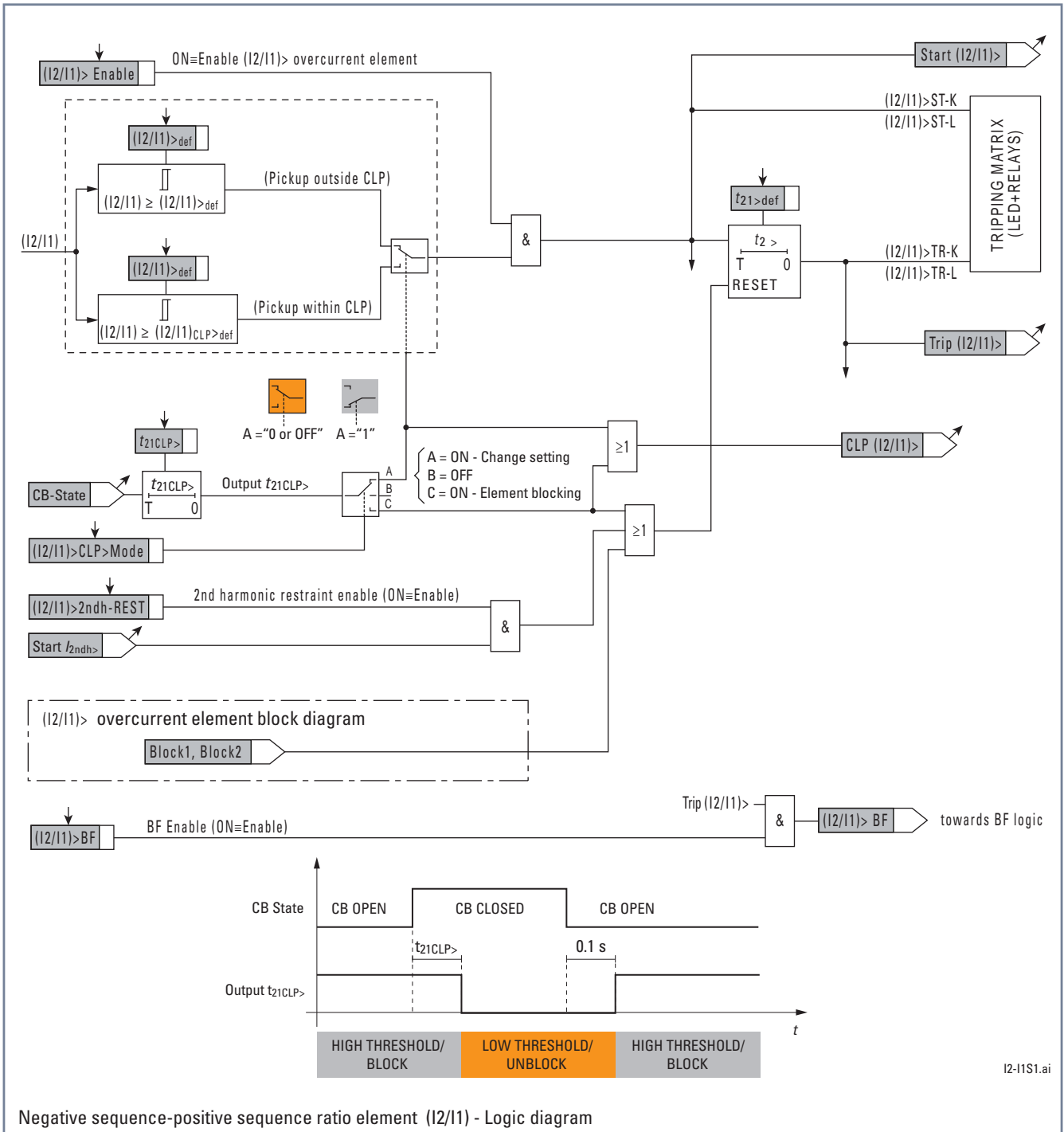
The following block criteria is available:

*Logical block (Block1)*

If the *I2/I1 > BLK1* enabling parameter are set to *ON* and a binary input is designed for logical block (Block1), the protection is blocked off whenever the given input is active.

The trip timer is held in reset condition, so the operate time counting starts when the input block goes down.<sup>[2]</sup> The enabling parameter is available inside the **Set \ Profile A(or B) \ Negative sequence current/positive sequence current ratio-I2/I1 \ I2I> Element \ Setpoints** menu, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input INx** menus (INx matching).

The parameter may be adjusted independently for both profiles **A** or **B**.



Negative sequence-positive sequence ratio element (I2/I1) - Logic diagram

Note 1 The setting may be found in the "CT supervision" paragraph inside CONTROL AND MONITORING section

Note 2 The description of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section

Preface

It is a overload protection with memory capability and three setpoints, used to protect lines and transformers against thermal overload. The phase currents are used into an algorithm reproducing a thermal replica according the IEC 60255-8 standard taking into account the Joule losses and the cooling effect due to the load reduction; in this way the previous history and the overload are taken into account. The thermal protection can be adapted to the different features of motors by setting the thermal heating  $t+$  and cooling  $t-$  constants ( the  $t+$  constant refers to motor running condition, while the  $t-$  constant, always higher than  $t+$ , refers to stop condition). The trip element has an adjustable threshold; with 1.2  $D\theta_B$  setting (ie 1.2 times the overtemperature corresponding to the nominal operation condition) the corresponding tripping current  $I_B$  is 1.1 since the temperature rise is proportional to the square of the current. The 49 element is provided with two further thresholds  $D\theta_{AL1}$  and  $D\theta_{AL2}$ , lower than the previous one. These thresholds, both adjustable, provide an alarm signal to draw attention in the event of anomalous heating, without disconnect the protected device. One of the above thresholds can be used to prevent refeeding of the system when heating approaches the trip conditions since the additional heating brought on by the inrush currents would cause the protection to operate.

Operation and settings

The thermal current used for thermal image calculation is:

$$I_{th} = \max (I_{L1}, I_{L2}, I_{L3})$$

If the second harmonic restraint is enabled, the thermal current used for thermal image calculation becomes:

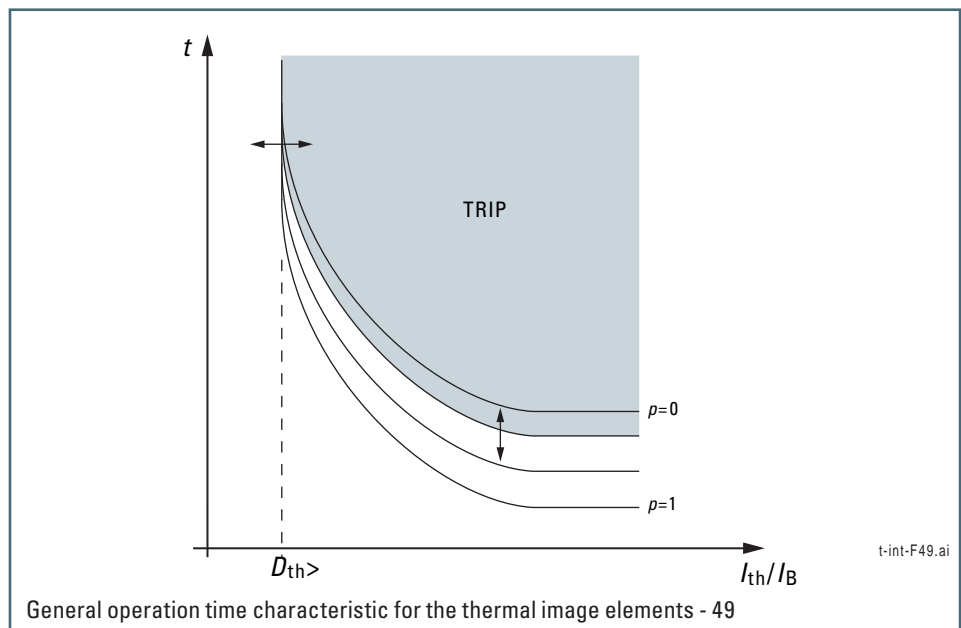
$$I_{th} = I_{LMAX} / K_{INR} = \max (I_{L1}, I_{L2}, I_{L3}) / K_{INR}$$

where  $K_{INR}$  is an adjustable parameter (1.0...3.0), useful to reduce the thermal current during the transformer energization (inrush).

According to a single-body thermal model, the thermal image is based on the differential equation:

$$dD\theta/dt + D\theta/T = (I_{th}/I_B)^2/T$$

where  $D\theta$  is the system thermal state as a percentage of base thermal capacity  $D\theta_B$  corresponding to the base current  $I_B^{[1]}$  and  $T$  is the thermal time constant (the same for heating and cooling). When the thermal image  $D\theta$  overcomes the threshold a trip is issued.



The operating characteristic (IEC 60255-8) is:

$$t = T * \ln\{[(I_{th}/I_B)^2 - D\theta_p/D\theta_B] / [(I_{th}/I_B)^2 - 1.2]\} = T * \ln\{[(I_{th}/I_B)^2 - (I_p/I_B)^2] / [(I_{th}/I_B)^2 - 1.2]\} = T * \ln\{[(I_{th}/I_B)^2 - p^2] / [(I_{th}/I_B)^2 - 1.2]\} \quad [1]$$

where:

- $t$ : operating time,
  - $\ln$ : natural logarithm,
  - $D\theta_p$  and  $I_p$  are the thermal image and the corresponding equivalent thermal current before the overload occurs.
  - $p = I_p/I_B = \sqrt{(D\theta_p/D\theta_B)}$ : prior load.
- Following data applies:
- Range where the equation is valid:  $1.1/I_B \leq I_{th} \leq 10/I_B$
  - If  $10/I_B \leq I_{th} \leq 20/I_B$ , the operating time is fixed to a value corresponding to the  $10/I_B$
  - The upper limit is  $20/I_B$ .

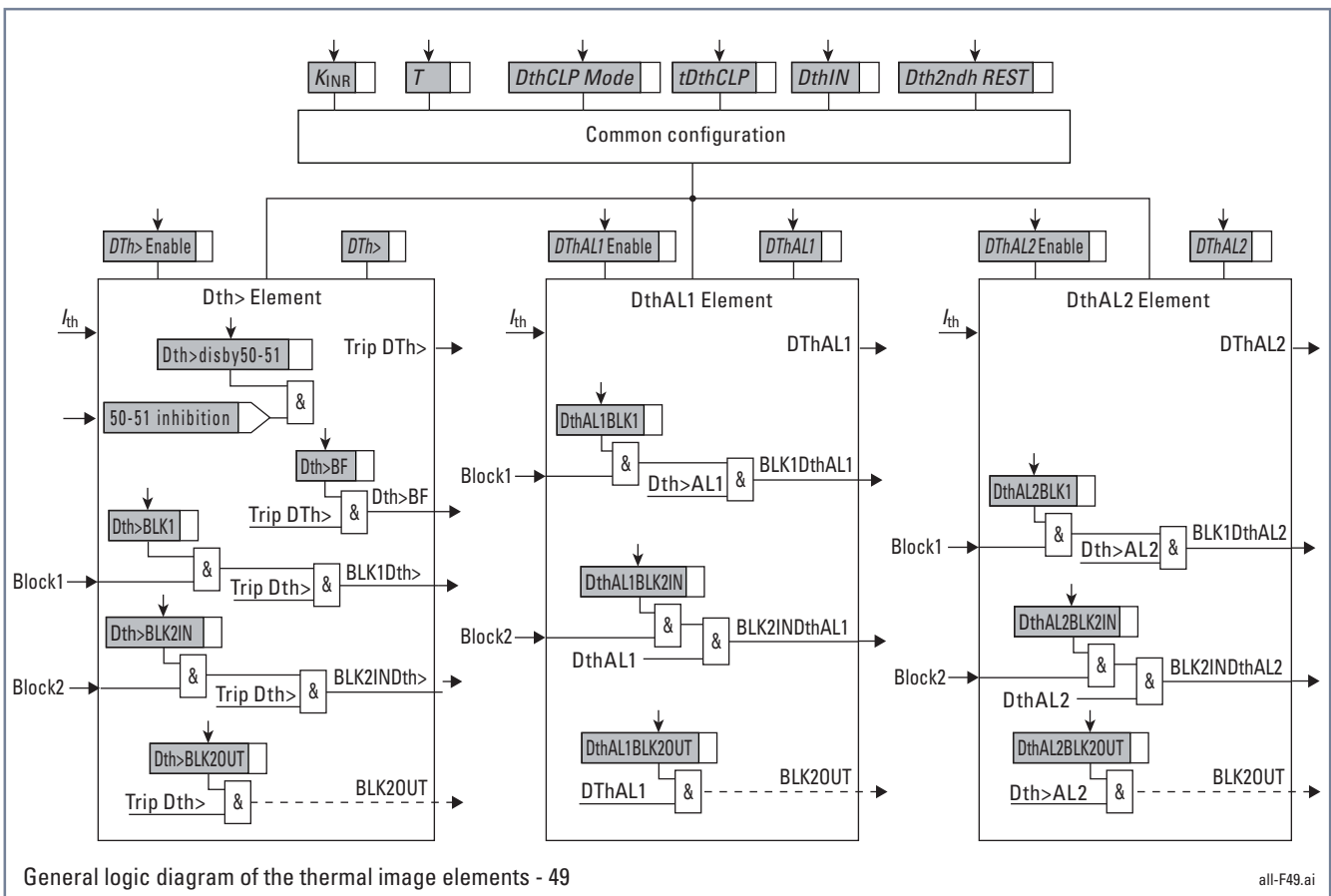
*Note 1 Assuming that the secondary rated current of the line CT's equals the rated current of the NA20 relay, as usually happens, the  $I_B$  value is the ratio between the rated current of the protected component (line, transformer,...) and the primary rated current of the CT's.*

If the CLP function (Cold Load Pick-up) is enabled for blocking 49, the thermal image is blocked for an adjustable time interval, starting from the circuit breaker closure.<sup>[1]</sup> The operating mode parameter may be select by setting *ON-Element blocking the DThCLP Mode* parameter inside the **Set \ Profile A(or B) \ Thermal image-49 \ Common configuration** menu.

If the CLP function (Cold Load Pick-up) is enabled for threshold change, the equivalent thermal current may be decreased by means a  $K_{INR}$  factor for an adjustable time interval, starting from the circuit breaker closure.<sup>[2]</sup> The operating mode parameter may be select by setting *ON-Change setting the DThCLP Mode* parameter inside the **Set \ Profile A(or B) \ Thermal image-49 \ Common configuration** menu.

For the  $D_{th>}$  threshold, a block from the second harmonic restraint may be set by setting *ON* the *DTh>2ndh-REST* parameter inside the **Set \ Profile A(or B) \ Thermal image-49 \ Common configuration** menu.

All elements can be enabled or disabled by setting *ON* or *OFF* the *DThetaAL1 Enable*, *DThetaAL2 Enable* and/or *DTheta> Enable* parameters inside the **Set \ Profile A(or B) \ Thermal image-49 \ DthAL1 Element (DthAL2 Element, Dth> Element)** menus.



The trip element ( $D_{th>}$ ) may be inhibited when a start of at least one of the overcurrent element (50/51) is active, if the *Dth>disby50-51* parameter is set *ON* inside the **Set \ Profile A(or B) \ Thermal image-49 \ Dth> Element** menu.

The  $D_{\theta IN}$  parameter sets a minimum level of previous thermal image  $D_{\theta p}$  when the protection relay is powered or when a remote (binary input) or local (keyboard or ThyVisor) command is issued. The *DthIN* parameter may be adjusted inside the **Set \ Profile A(or B) \ Thermal image-49 \ Common configuration** menu.

To active the  $D_{\theta IN}$  preset value remotely, a binary input must be programmed as *Init DTheta* function inside the **Set \ Inputs \ Binary input IN1, Binary input INx** menu.

The trip element can produce the Breaker Failure output if the *Dth> BF* parameters is set to *ON*. The parameter is available inside the **Set \ Profile A(or B) \ Thermal image-49 \ Dth> Element** menu.<sup>[3]</sup> The *IB* setting is adjustable inside the **Set \ Profile A(or B) \ Base current IB** menu.

**Note 1** The CLP function (Cold Load Pick-up) with blocking of the 49 element has priority compared with the second harmonic restraint function, so, if the equivalent thermal current is enabled, the latter is not reduced when a second harmonic restraint is active.

**Note 2** The CLP function (Cold Load Pick-up) with threshold change of the 49 element has priority compared with the second harmonic restraint function, so, if the equivalent thermal current is enabled, the latter is not reduced when a second harmonic restraint is active.

**Note 3** The common settings concerning the Breaker failure protection are adjustable inside the **Breaker Failure - BF** menu.

For every threshold the following block criteria are available:

#### *Logical block (Block1)*

If the *DthAL1BLK1*, *DthAL2BLK1* and/or *Dth>BLK1* enabling parameters are set to *ON* and a binary input is designed for logical block (Block1), the concerning element is blocked off whenever the given input is active.<sup>[1]</sup> The enabling parameters are available inside the **Set \ Profile A(or B) \ Thermal image-49 \ DthAL1 Element (DthAL2 Element, Dth> Element)** menus, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input IN1(x)** menus.

#### *Selective block (Block2)*

All along the protective elements the selective block may be set.

The logic selectivity function may be performed by means any combination of the following I/O:

- One committed pilot wire input (BLIN1).
- One or more binary inputs designed for input selective block.
- One committed pilot wire output (BLOUT1).
- One or more output relays designed for output selective block.

Only when the committed pilot wire are used the continuity check of the pilot wire link is active.

Use of committed pilot wire input BLIN1:

- The protection is blocked off according the selectivity block criteria when the input BLIN1 is active. The information about phase or phase+earth block may be select programming the *ModeBLIN1* parameter inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block IN** menus.

Use of binary inputs:

- If the *DthAL1BLK2IN*, *DthAL2BLK2IN* and/or *Dth>BLK2IN* parameter are set to *ON* and a binary input is designed for selective block (Block2), the protection is blocked off by phase elements (Block2 Iph) or by any protection element (Block2 Iph/IE) according the selectivity block criteria.<sup>[2]</sup> The enable *DthAL1BLK2IN*, *DthAL2BLK2IN* and/or *Dth>BLK2IN* parameters are available inside the **Set \ Profile A(or B) \ Thermal image-49 \ DthAL1 Element, DthAL2 Element, Dth> Element** menus, while the *Block2 Iph* and *Block2 Iph/IE* functions must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input IN1(2)** menus (IN1 or IN2 matching).

Use of committed pilot wire output BLOUT1:

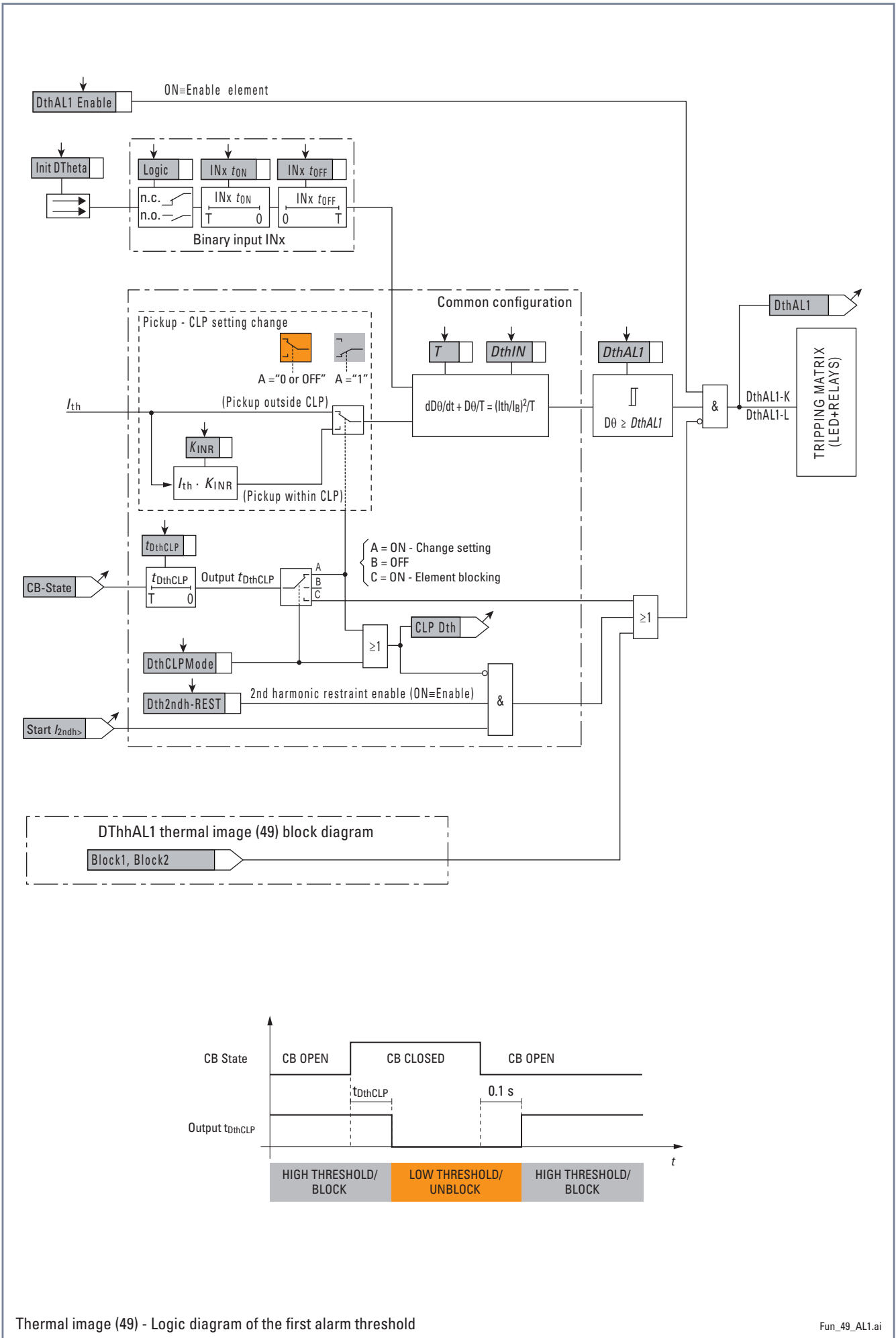
- The information about phase or phase+earth block may be select programming the *ModeBLOUT1* parameter inside **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menus.

Use of output relay (K1...K6):

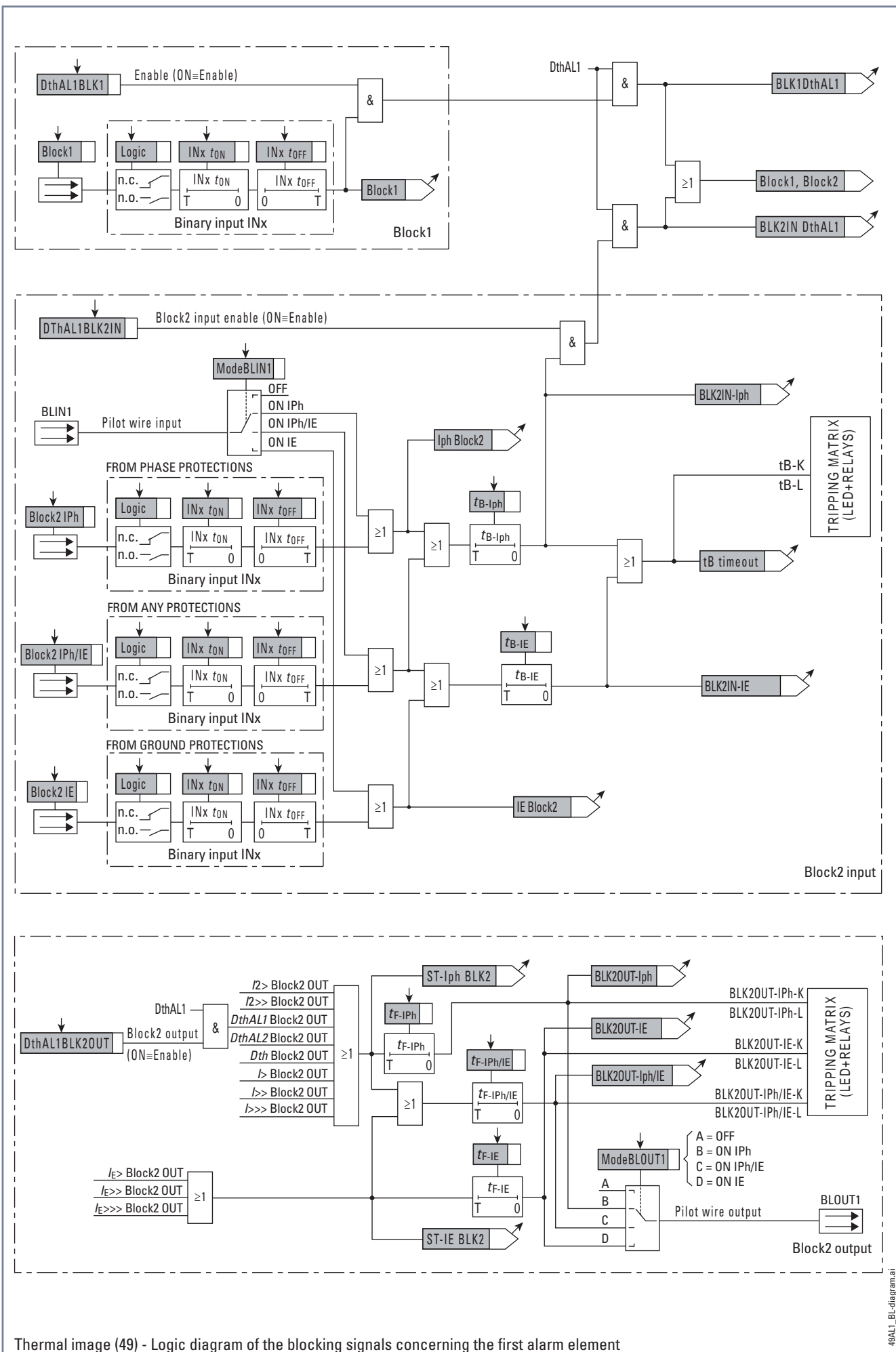
- If the *DthAL1BLK2OUT*, *DthAL2BLK2OUT* and/o *Dth>BLK2OUT* enable parameters are set to *ON* and a output relay is designed for selective block (Block2), the protection issues a block output by phase elements (BLK2OUT-Iph) or by any protection element (BLK2OUT-Iph/IE), whenever the given element (DthAL1, DthAL2 e/o Dth>) becomes active. The enable *DthAL1BLK2OUT*, *DthAL2BLK2OUT* and/or *Dth>BLK2OUT* parameters are available inside the **Set \ Profile A(or B) \ Thermal image-49 \ DthAL1 Element (DthAL2 Element, Dth> Element)** menus, while the *BLK2OUT-Iph-K*, *BLK2OUT-Iph/IE-K* and/or *BLK2OUT-IE-K* output relays must be set inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menus.

*Note 1* The exhaustive treatment of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section

*Note 2* The exhaustive treatment of the selective block (Block 2) function may be found in the "Selective Block" paragraph inside CONTROL AND MONITORING section

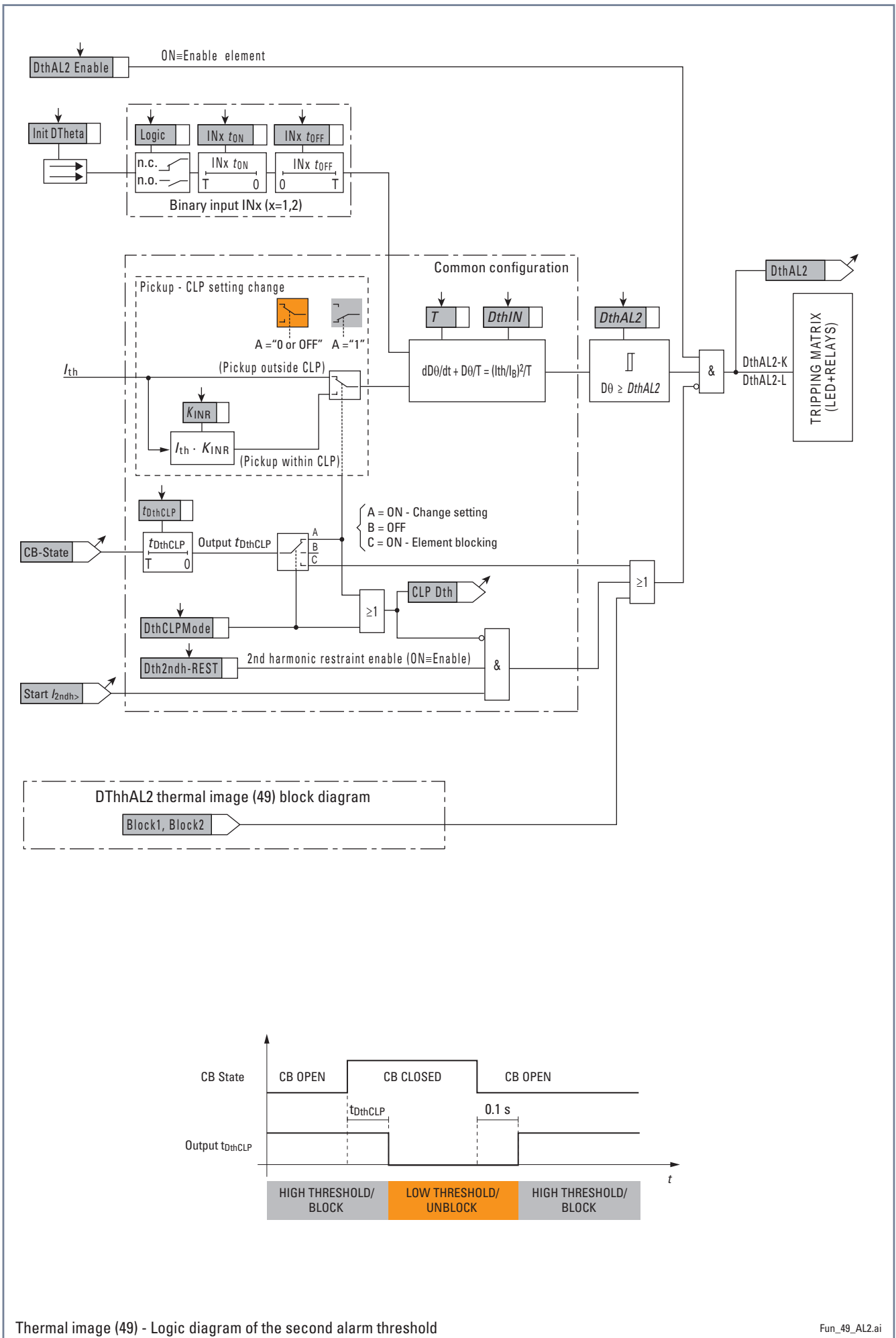


Thermal image (49) - Logic diagram of the first alarm threshold



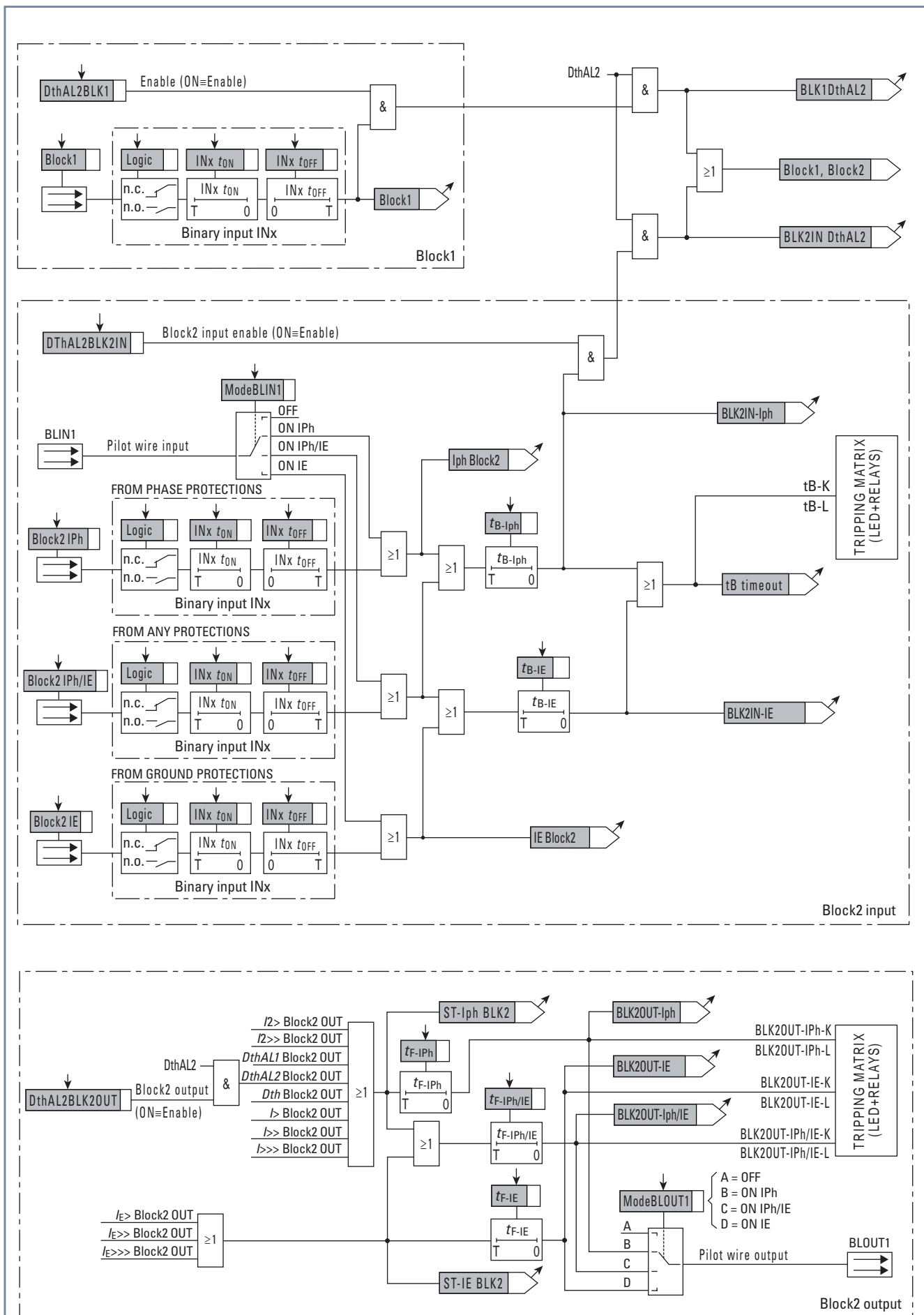
Thermal image (49) - Logic diagram of the blocking signals concerning the first alarm element

49AL1\_BI-diagram.ai



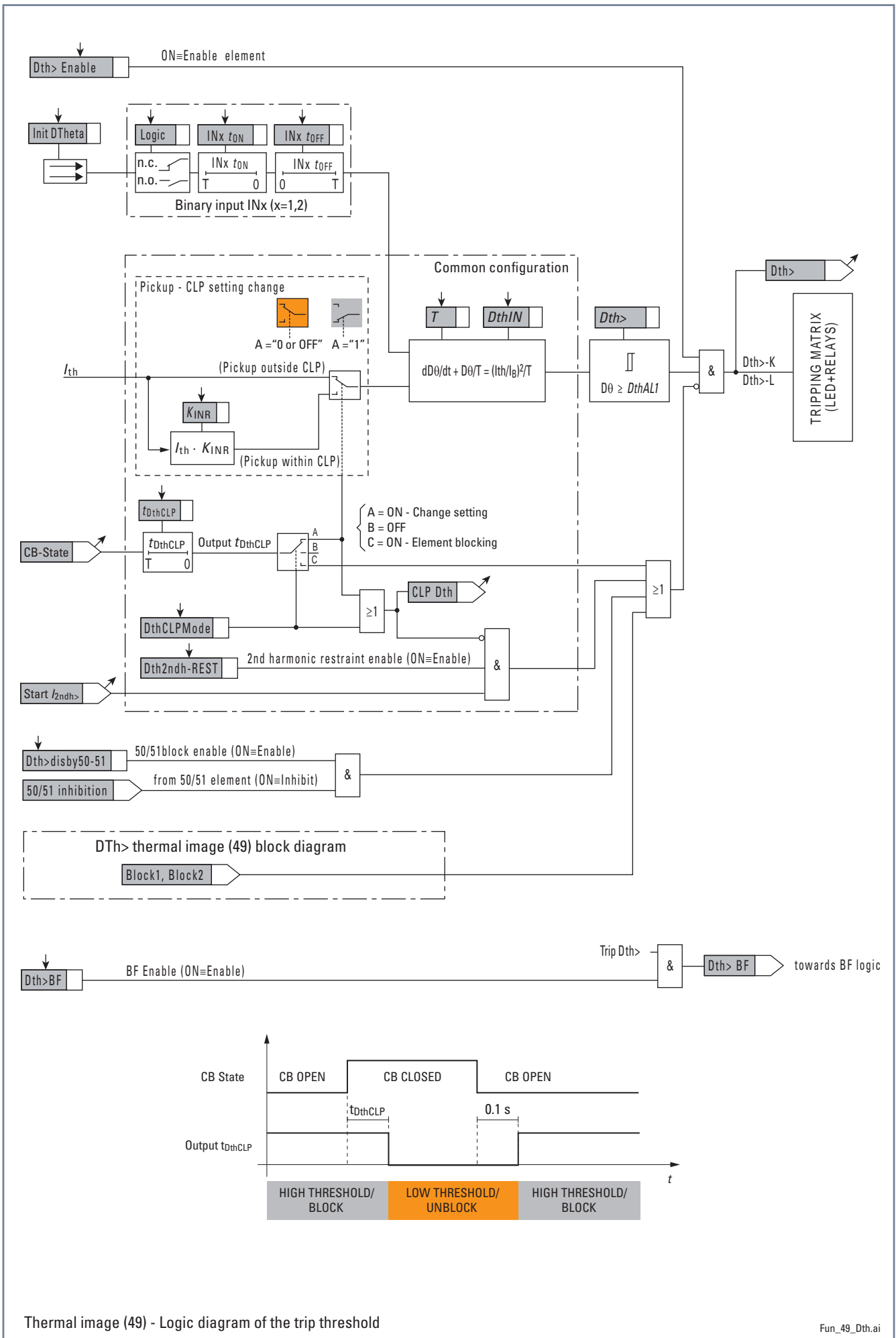
Thermal image (49) - Logic diagram of the second alarm threshold

Fun\_49\_AL2.ai



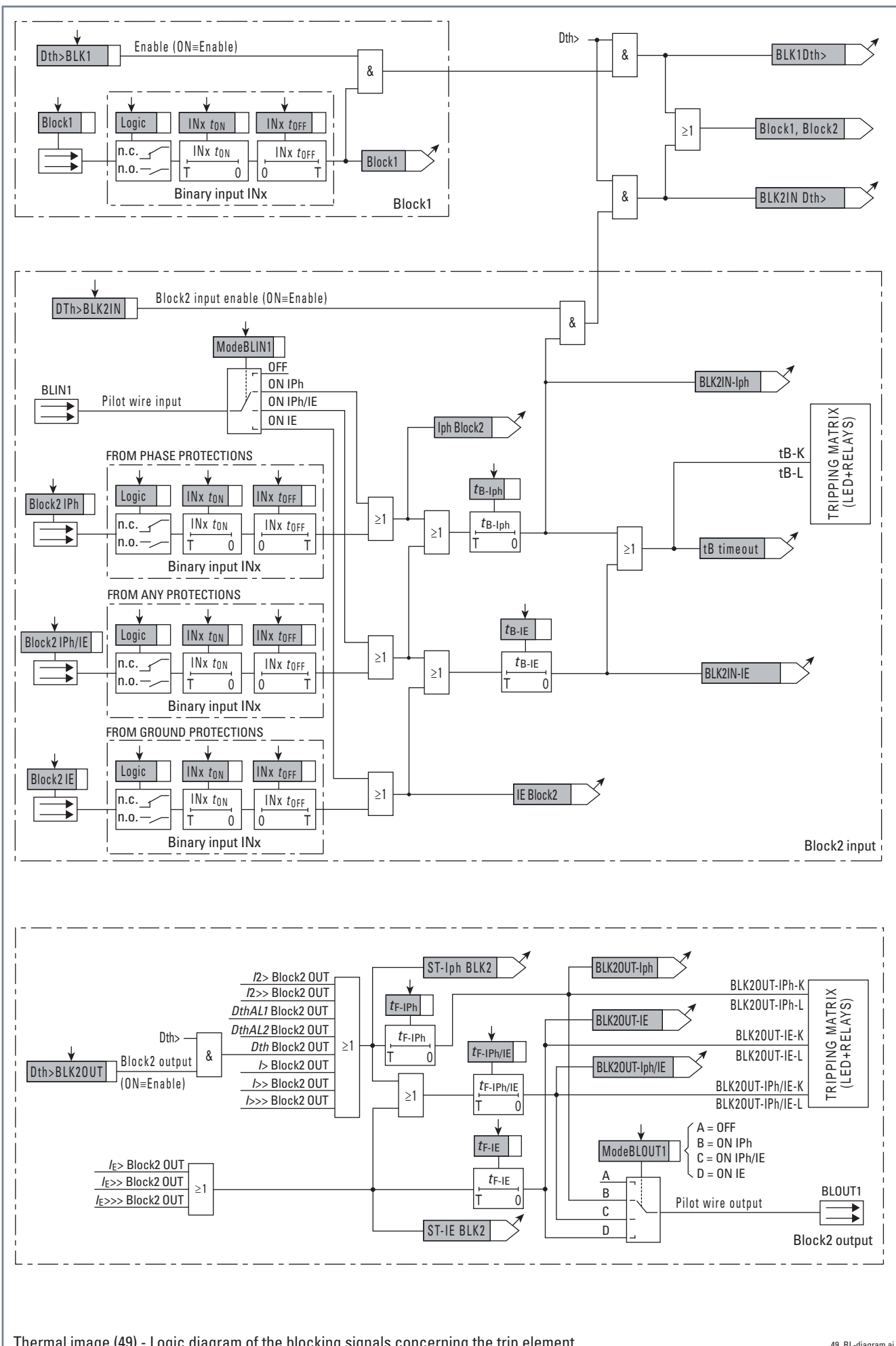
Thermal image (49) - Logic diagram of the blocking signals concerning the second alarm element

49AL2\_BL-diagram.ai



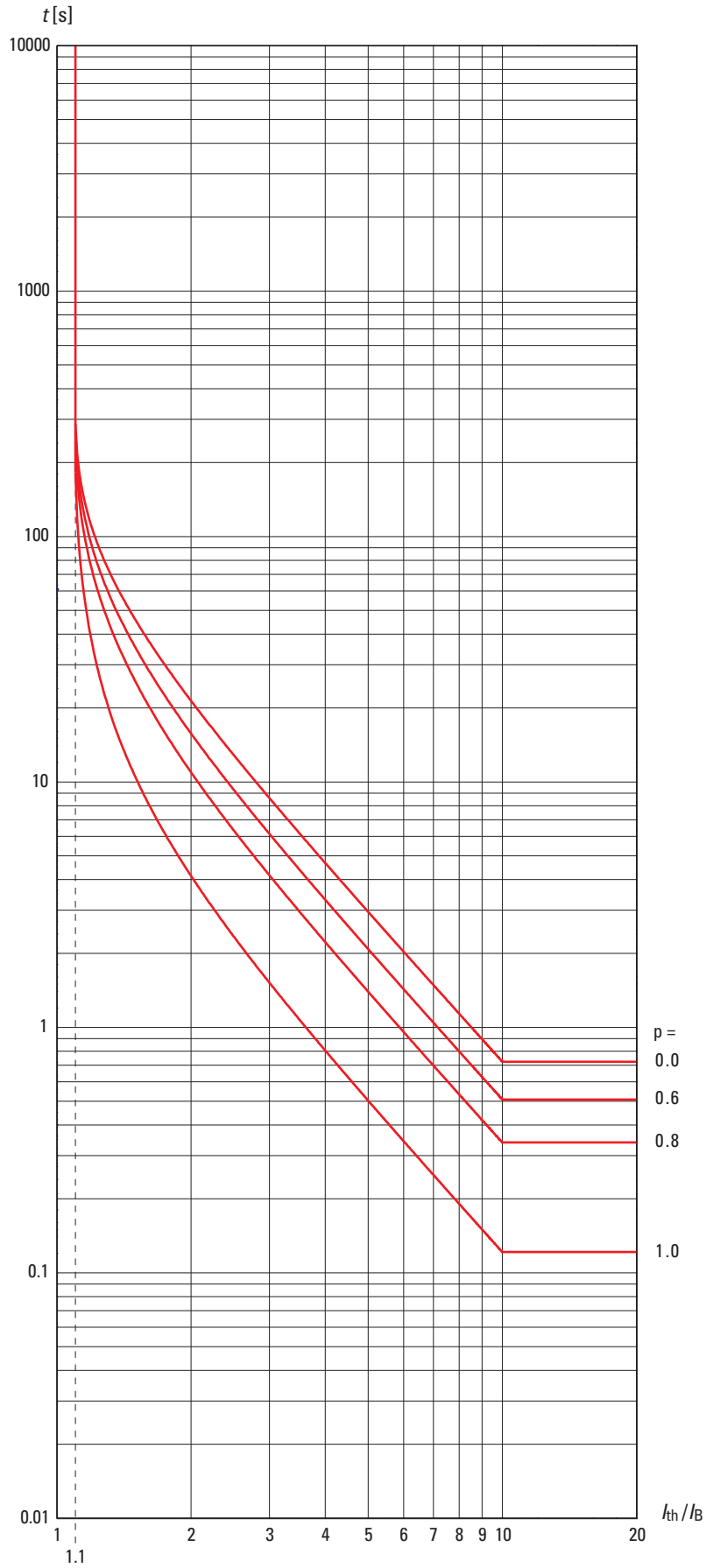
Thermal image (49) - Logic diagram of the trip threshold

Fun\_49\_Dth.ai



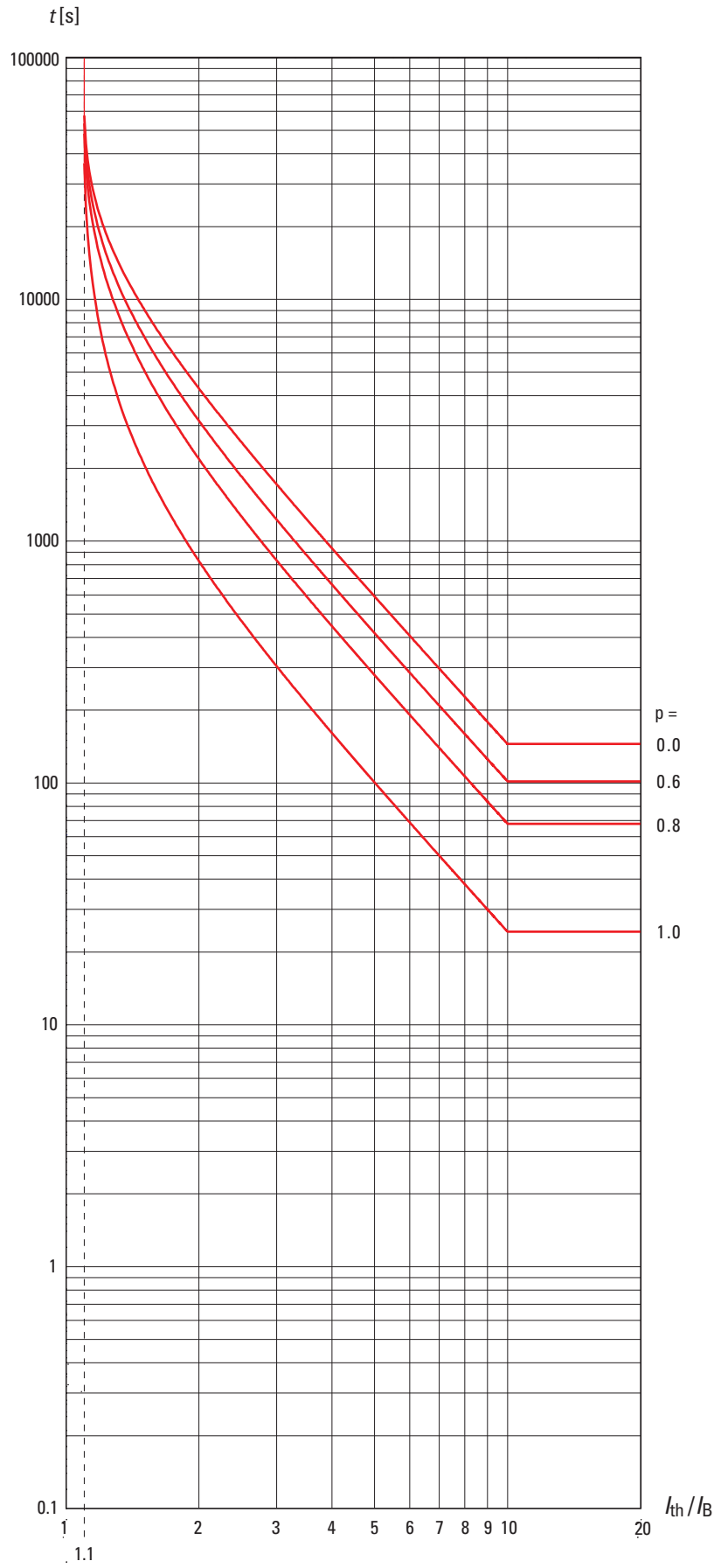
Thermal image (49) - Logic diagram of the blocking signals concerning the trip element

49\_BL-diagram.ai



Operating characteristic concerning the thermal image element (49) - T=1 min

F\_49-1min-Char.ai



Operating characteristic concerning the thermal image element (49) - T = 200 min

F\_49-200min-Char.ai

**Phase overcurrent - 50/51**

*Preface*

Three operation thresholds, independently adjustable ( $I>$ ,  $I>>$ ,  $I>>>$ ) with adjustable delay ( $t>$ ,  $t>>$ ,  $t>>>$ ).

The first one may be programmed with definite or inverse time according the IEC and ANSI/IEEE standard, as well as with rectifier,  $I^2t$  or EM curve.

The second threshold may be programmable with independent or dependent time according to the  $I^2t$  curve and the third threshold with independent time.

For each threshold a reset time can be set ( $t_{RES}$ ,  $t_{>RES}$ ,  $t_{>>RES}$ ) useful to reduce the clearing time for intermittent faults.

The first threshold trip may be inhibited by start of the second and/or third threshold ( $I>>$ ,  $I>>>$ ).

Similarly the second threshold trip may be inhibited by start of the third threshold ( $I>>>$ ).

*Operation and settings*

Each phase fundamental frequency current is compared with the setting value. Currents above the associated pickup value are detected and a start is issued. After expiry of the associated operate time a trip command is issued; if instead the current drops below the threshold, the element is restored.

The first threshold ( $I>$ ) may be programmed with definite or inverse time according the following characteristic curves:

- Standard Inverse Time (IEC 255-3/BS142 type A or SIT):  $t = 0.14 \cdot t_{>inv} / [(I/I_{>inv})^{0.02} - 1]$
- Very Inverse Time (IEC 255-3/BS142 type B or VIT):  $t = 13.5 \cdot t_{>inv} / [(I/I_{>inv}) - 1]$
- Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):  $t = 80 \cdot t_{>inv} / [(I/I_{>inv})^2 - 1]$
- Long Time Inverse (IEC 255-3/BS type B LTI):  $t = 120 \cdot t_{>inv} / [(I/I_{>inv}) - 1]$
- Moderately Inverse (ANSI/IEEE type MI):  $t = t_{>inv} \cdot \{0.01 / [(I/I_{>inv})^{0.02} - 1] + 0.023\}$
- Very Inverse (ANSI/IEEE type VI):  $t = t_{>inv} \cdot \{3.922 / [(I/I_{>inv})^2 - 1] + 0.098\}$
- Extremely Inverse (ANSI/IEEE type EI):  $t = t_{>inv} \cdot \{5.64 / [(I/I_{>inv})^2 - 1] + 0.024\}$
- Rectifier (RI):  $t = 2351 \cdot t_{>inv} / [(I/I_{>inv})^{5.6} - 1]$
- I-squared-t ( $I^2t = K$ ):  $t = 16 \cdot t_{>inv} / (I/I_{>inv})^2$
- Electromechanical (EM):  $t = t_{>inv} \cdot \{0.28 / [-0.236 \cdot (I/I_{>inv})^{-1} + 0.339]\}$

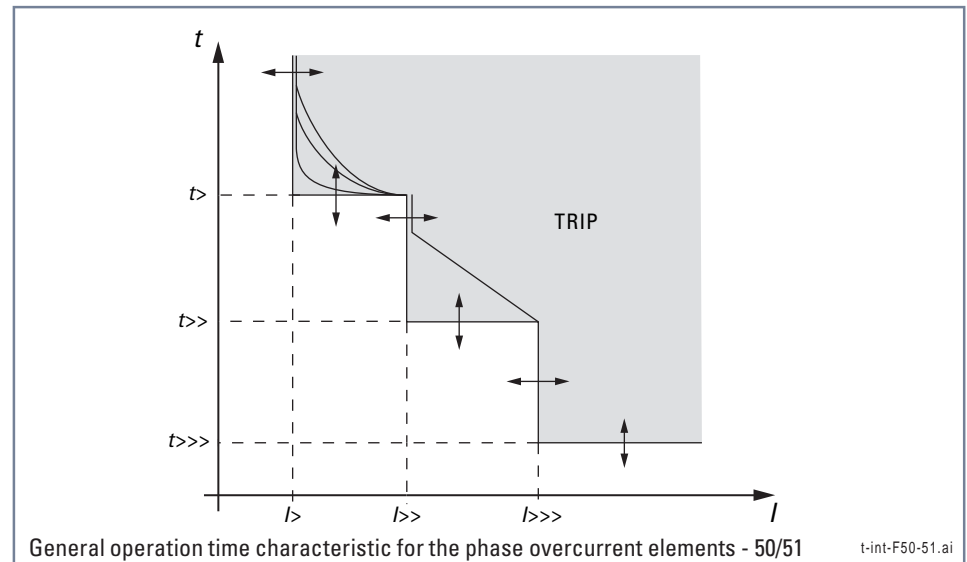
Where:

- $t$ : operate time
- $I_{>inv}$ : threshold setting
- $t_{>inv}$ : operate time setting

The second threshold ( $I>>$ ) may be programmable with definite or inverse time according to the  $I^2t$  curve:

$$t = 16 \cdot t_{>inv} / (I/I_{>>})^2$$

The third threshold ( $I>>>$ ) with definite time.



For all inverse time characteristics, following data applies:

- Asymptotic reference value (minimum pickup value):  $1.1 I_{>inv}$
- Minimum operate time: 0.1 s
- Range where the equation is valid:<sup>[1]</sup>  $1.1 \leq I/I_{>inv} \leq 20$
- If  $I_{>inv}$  pickup  $\geq 2.5 I_n$ , the upper limit is  $50 I_n$

For all definite time elements the upper limit for measuring is  $50 I_n$ .

All overcurrent elements can be enabled or disabled by setting *ON* or *OFF* the  $I>$  *Enable*,  $I>>$  *Enable* and/or  $I>>>$  *Enable* parameters inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I>> Element, I>>> Element) \ Setpoints** menus.

The first overcurrent element can be programmed with definite or inverse time characteristic by setting the  $I>$  *Curve* parameter (*DEFINITE*, *IEC/BS A*, *IEC/BS B*, *IEC/BS C*, *IEC/BS B LI*, *ANSI/IEE MI*, *ANSI/IEE VI*, *ANSI/IEE EI*, *RECTIFIER*, *I2t*, *EM*) available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element \ Setpoints** menu.

*Note 1* When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point

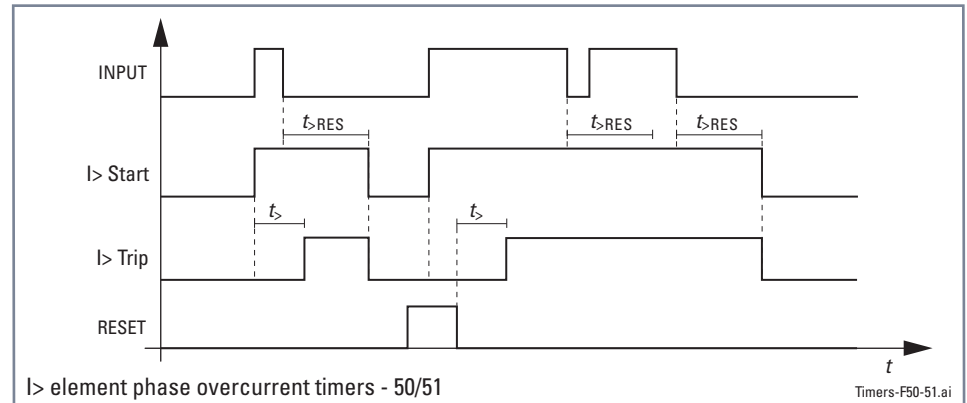
The second overcurrent element can be programmed with definite or inverse time characteristic by setting the  $I >$  Time characteristic ( $I > Curve$ ) parameter (*DEFINITE, I2t*) available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element \ Setpoints** menu.

The trip of  $I >$  element may be inhibited by the start of the second and/or third element ( $I >>$ ,  $I >>>$ ) by setting *ON* the **Disable  $I >$  by start  $I >>$ , Disable  $I >$  by start  $I >>>$  ( $I > disbyI >$ ,  $I > disbyI >>>$ )** parameters available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I >> Element (I >>> Element) \ Setpoints** menus.

Similarly the trip of the  $I >>$  element may be inhibited by start of the third element ( $I >>>$ ) by setting *ON* the **Disable  $I >>$  by start  $I >>>$  ( $I >> disbyI >>>$ )** parameter available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I >>> Element \ Setpoints** menu.

All the named parameters can be set separately for **Profile A** and **Profile B** (**Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus).

An adjustable reset time delay is provided for every threshold ( $t_{RES}$ ,  $t_{>>RES}$ ,  $t_{>>>RES}$ ).



Each overcurrent element can produce the Breaker Failure output if the  $I > BF$ ,  $I >> BF$  and/or  $I >>> BF$  parameters are set to *ON*. The parameters are available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus.<sup>[1]</sup>

For all overcurrent elements, a block from the second harmonic restraint may be set by setting *ON* the  $I > 2ndh-REST$ ,  $I >> 2ndh-REST$ ,  $I >>> 2ndh-REST$  parameters inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus.

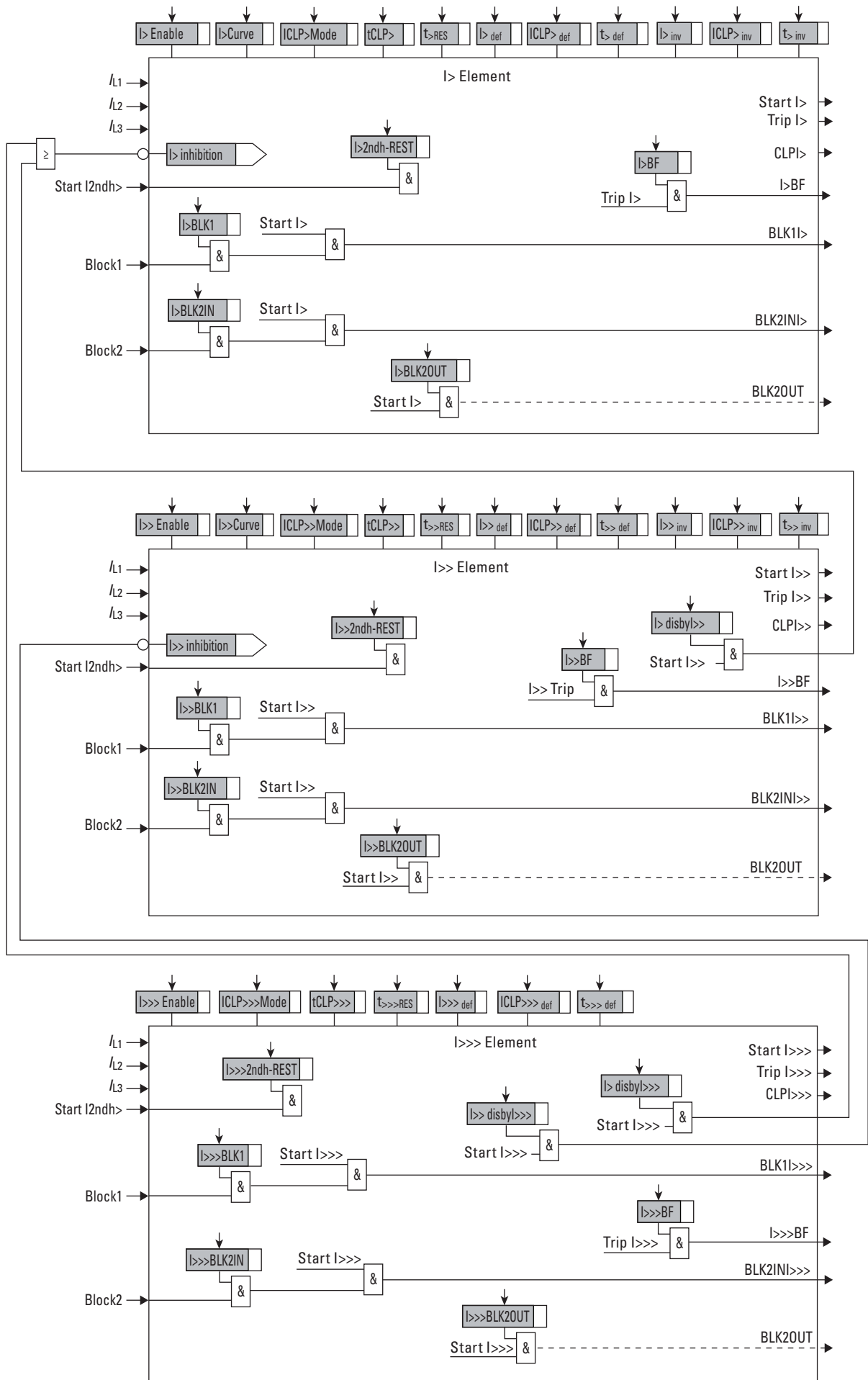
If the CLP function (Cold Load Pick-up) is enabled for element blocking, the selected threshold may be blocked for an adjustable time interval, starting from the circuit breaker closure.

This operating mode may be select by setting *ON-Element blocking* the **ICLP > Mode, ICLP >> Mode** and/or **ICLP >>> Mode** parameters.

If the CLP function (Cold Load Pick-up) is enabled for threshold change, the selected threshold may be changed for an adjustable time interval, starting from the circuit breaker closure.

This operating mode may be select by setting *ON-Change setting* the **ICLP > Mode, ICLP >> Mode** and/or **ICLP >>> Mode** parameters, whereas the operating thresholds within the CLP may be adjusted inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element, (I >> Element, I >>> Element) \ Definite time (Inverse time)** menus.

For both operating modes the CLP Activation time parameters ( $t_{CLP >}$ ,  $t_{CLP >>}$ ,  $t_{CLP >>>}$ ) may be adjusted inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus.



General logic diagram of the phase overcurrent elements - 50/51

all-F50-51.ai

For every of the three thresholds the following block criteria are available:

#### Logical block (Block1)

If the  $I > BLK1$ ,  $I >> BLK1$  and/or  $I >>> BLK1$  enabling parameters are set to *ON* and a binary input is designed for logical block (Block1), the concerning element is blocked off whenever the given input is active.<sup>[1]</sup> The enabling parameters are available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input IN1(x)** menus.

#### Selective block (Block2)

All along the protective elements the selective block may be set.

The logic selectivity function may be performed by means any combination of the following I/O:

- One committed pilot wire input (BLIN1).
- One or more binary inputs designed for input selective block.
- One committed pilot wire output (BLOUT1).
- One or more output relays designed for output selective block.

Only when the committed pilot wire are used the continuity check of the pilot wire link is active.

Use of committed pilot wire input BLIN1:

- The protection is blocked off according the selectivity block criteria when the input BLIN1 is active. The information about phase or phase+earth block may be select programming the *ModeBLIN1* parameter inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block IN** menus.

Use of binary inputs:

- If the  $I > BLK2IN$ ,  $I >> BLK2IN$  and/or  $I >>> BLK2IN$  parameters are set to *ON* and a binary input is designed for selective block (Block2), the protection is blocked off by phase elements (Block2 Iph) or by any protection element (Block2 Iph/IE) according the selectivity block criteria.<sup>[2]</sup> The enable  $I > BLK2IN$ ,  $I >> BLK2IN$  and/or  $I >>> BLK2IN$  parameters are available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus, while the *Block2 Iph* and *Block2 Iph/IE* functions must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input IN1(x)** menus (IN1 or INx matching).

Use of committed pilot wire output BLOUT1:

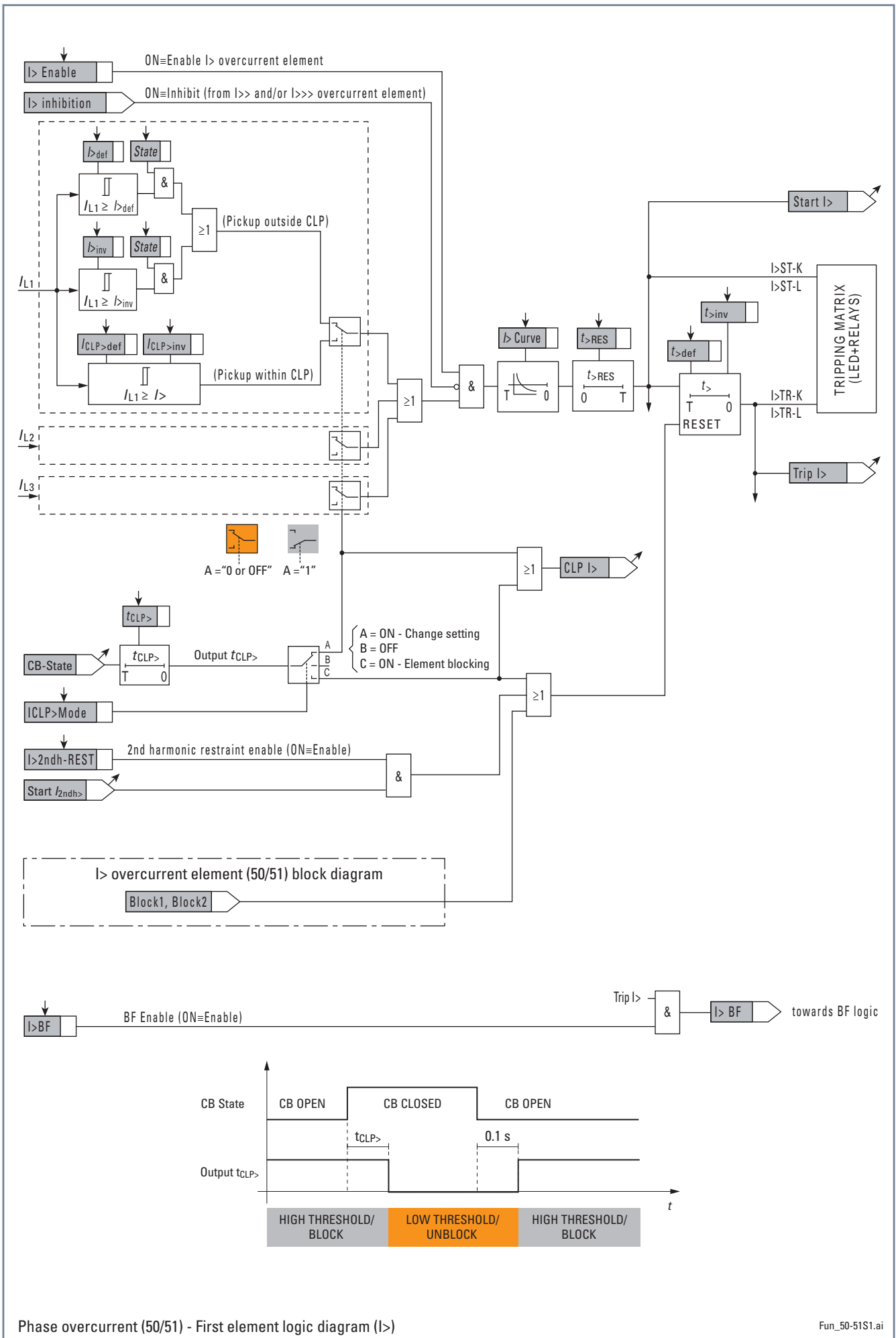
- The information about phase or phase+earth block may be select programming the *ModeBLOUT1* parameter (*OFF - ON IPh - ON IPh/IE - ON IE*) inside **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menus.

Use of output relay (K1...K6):

- If the  $I > BLK2OUT$ ,  $I >> BLK2OUT$  and/or  $I >>> BLK2OUT$  enable parameters are set to *ON* and a output relay is designed for selective block (Block2), the protection issues a block output by phase elements (BLK2OUT-Iph) or by any protection element (BLK2OUT-Iph/IE), whenever the given element (Start I>, Start I>> e/o Start I>>>) becomes active. The enable  $I > BLK2OUT$ ,  $I >> BLK2OUT$  and/or  $I >>> BLK2OUT$  parameters (*ON* or *OFF*) are available inside the **Set \ Profile A(or B) \ Phase overcurrent-50/51 \ I > Element (I >> Element, I >>> Element) \ Setpoints** menus, while the *BLK2OUT-Iph-K*, *BLK2OUT-Iph/IE-K* and/or *BLK2OUT-IE-K* output relays and LEDs (*BLK2OUT-Iph-L*, *BLK2OUT-Iph/IE-L* e/o *BLK2OUT-IE-L*) must be select inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menu.

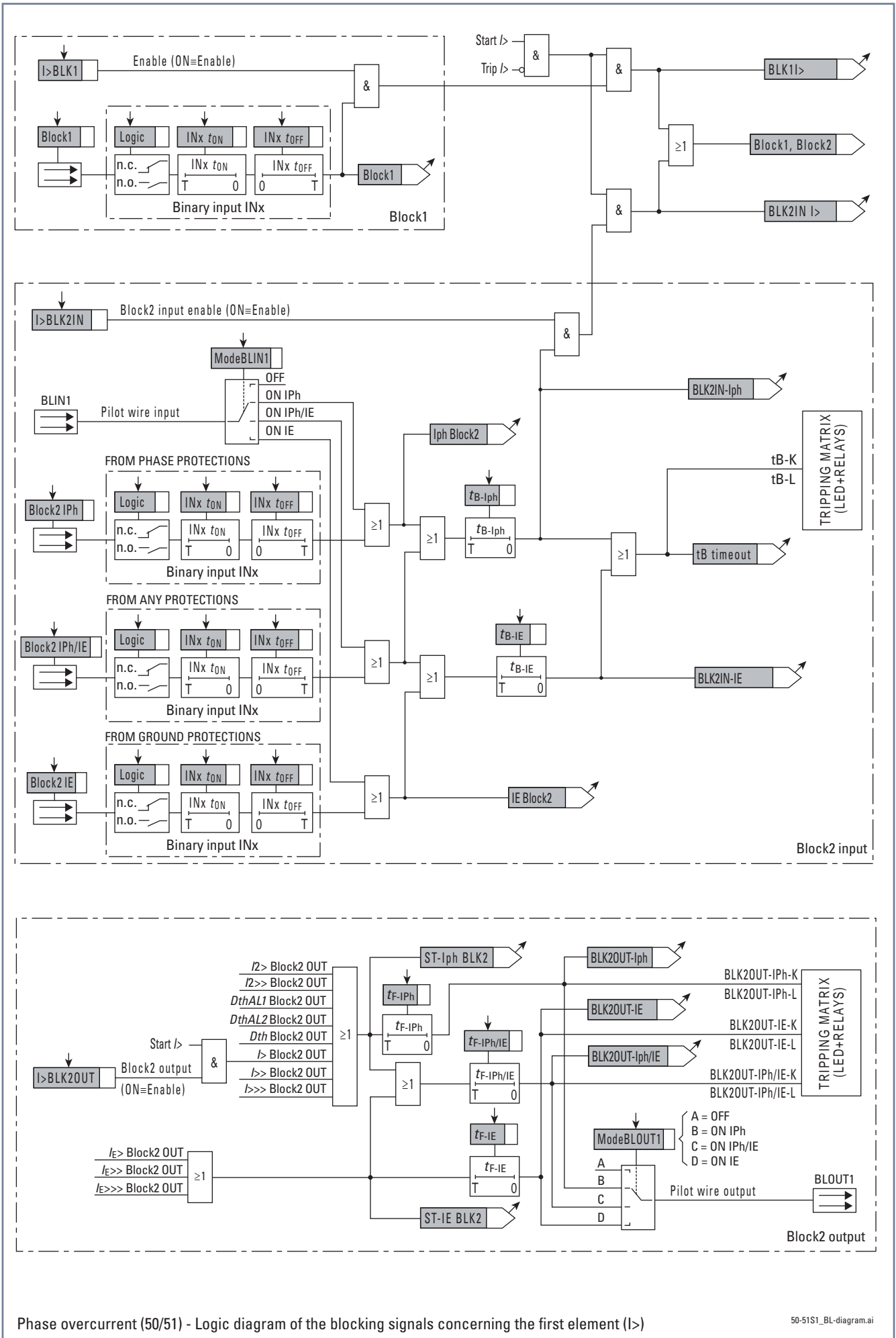
*Note 1 The exhaustive treatment of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section*

*Note 2 The exhaustive treatment of the selective block (Block 2) function may be found in the "Selective Block" paragraph inside CONTROL AND MONITORING section*



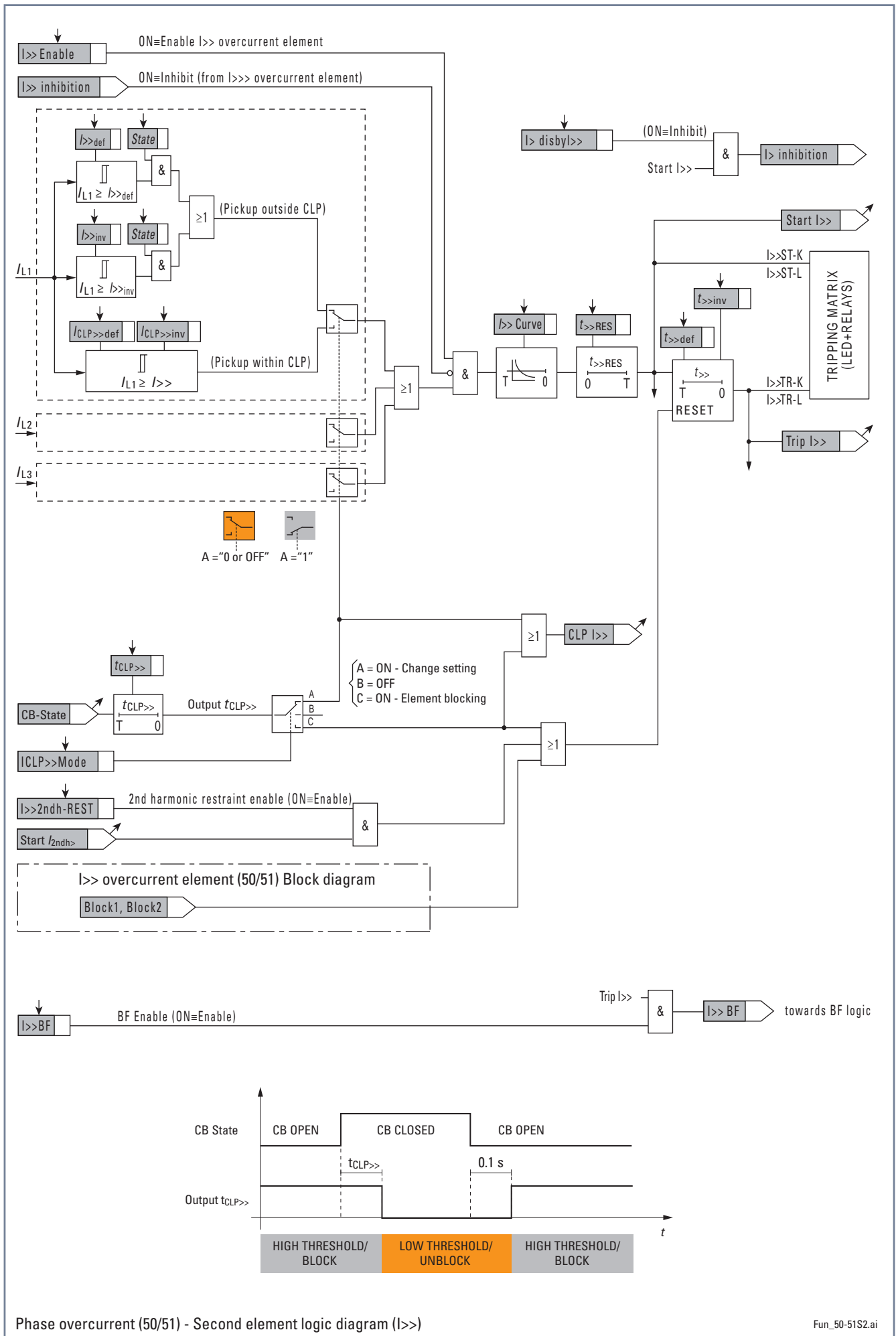
Phase overcurrent (50/51) - First element logic diagram (I>)

Fun\_50-51S1.ai



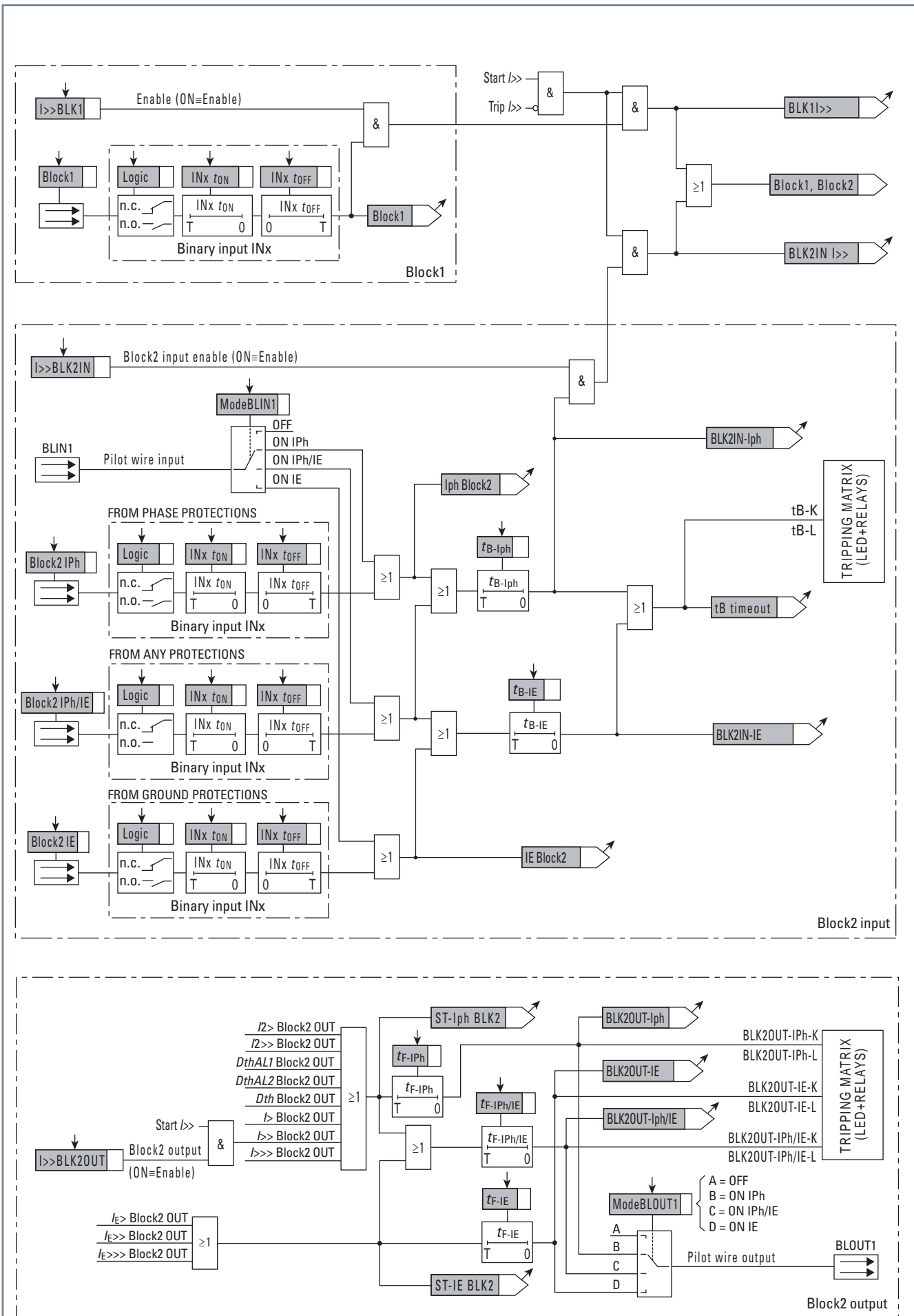
Phase overcurrent (50/51) - Logic diagram of the blocking signals concerning the first element (I>)

50-51S1\_BL-diagram.ai



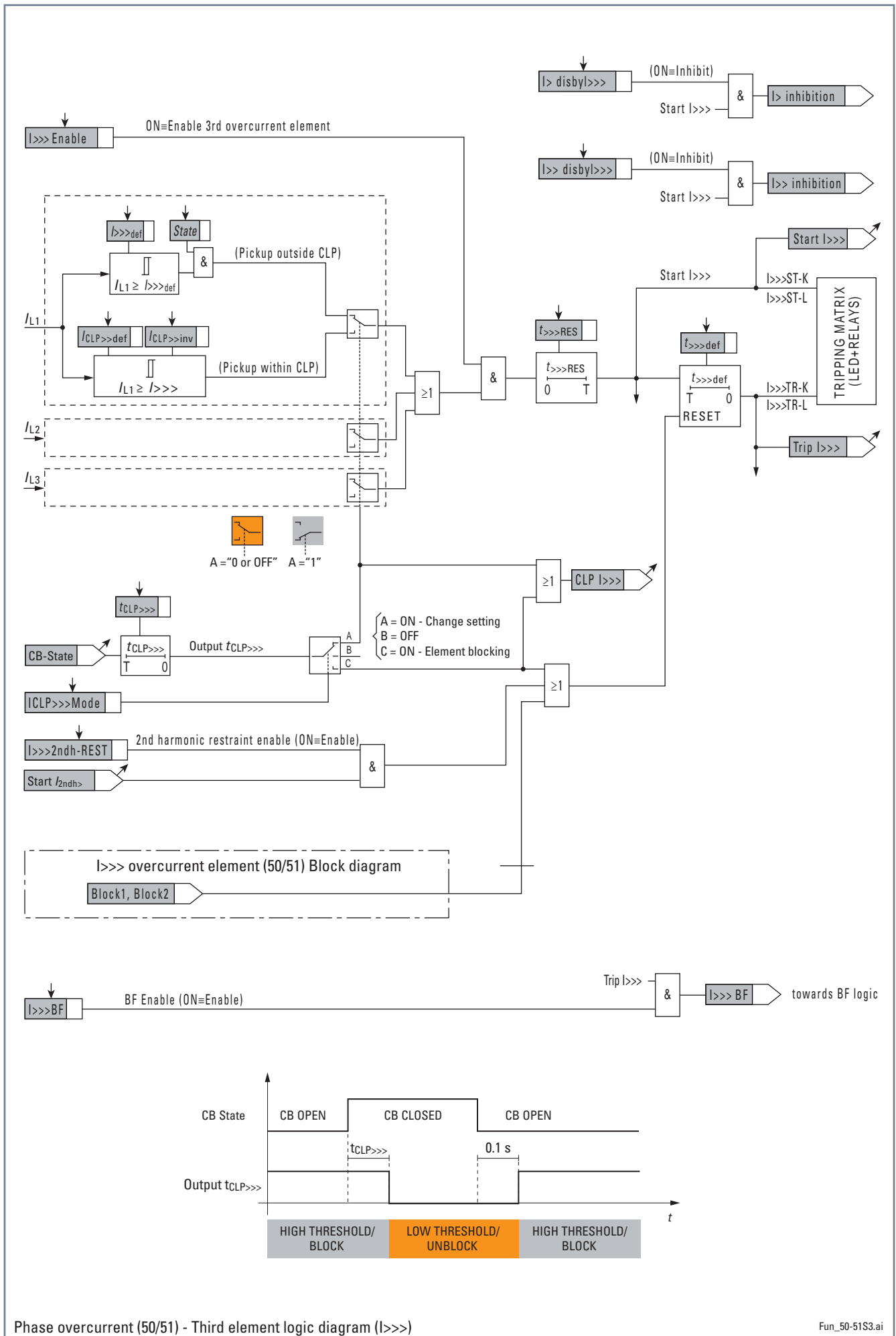
Phase overcurrent (50/51) - Second element logic diagram (I>>)

Fun\_50-51S2.ai



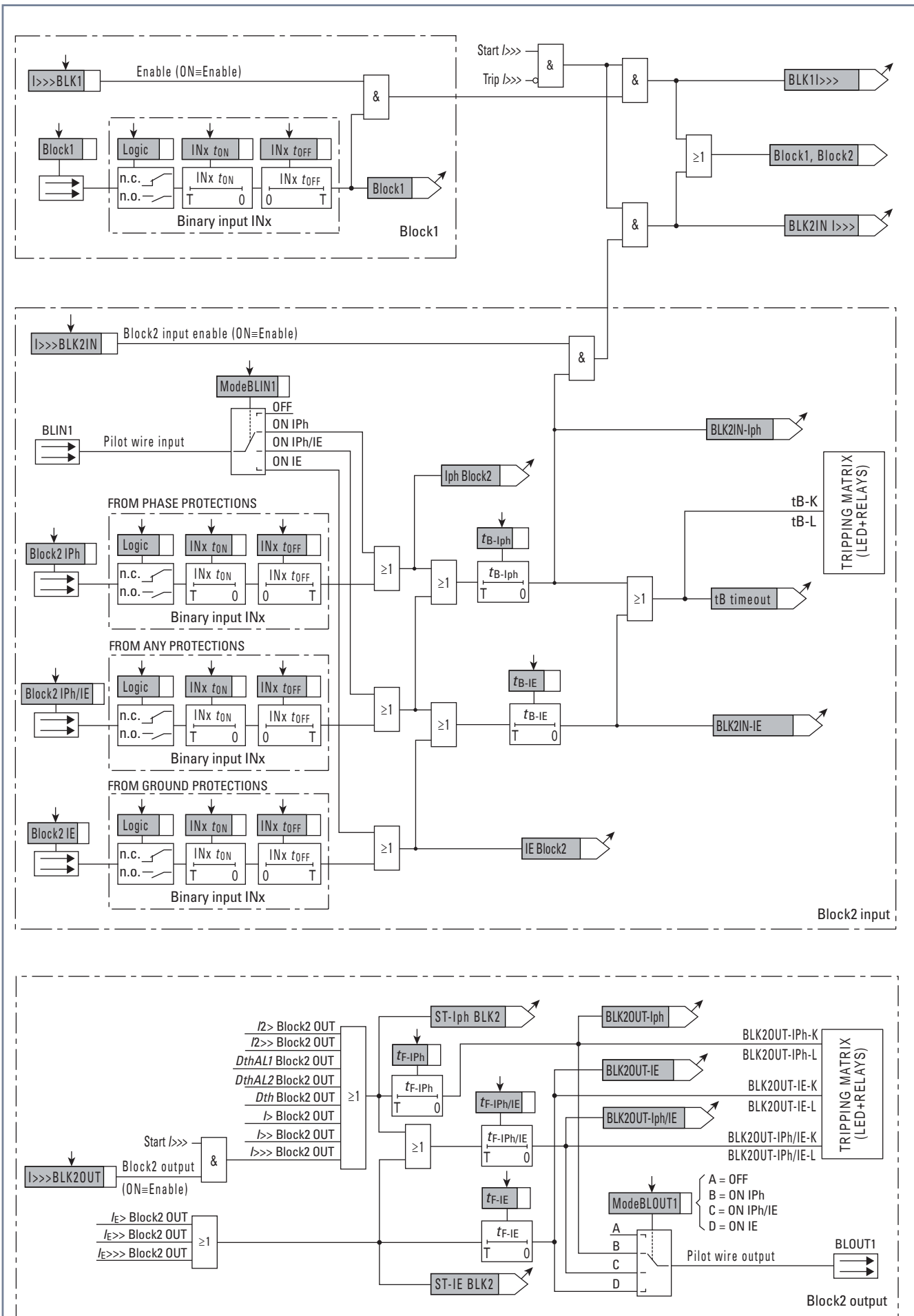
Phase overcurrent (50/51) - Logic diagram of the blocking signals concerning the second element (I>>)

50-51S2\_BL-diagram.ai



Phase overcurrent (50/51) - Third element logic diagram (I>>>)

Fun\_50-51S3.ai



Phase overcurrent (50/51) - Logic diagram of the blocking signals concerning the third element (I>>>) 50-51S3\_BLK-diagram.ai

## Residual overcurrent - 50N/51N

### Preface

Three operation thresholds, independently adjustable ( $I_{E>}$ ,  $I_{E>>}$ ,  $I_{E>>>}$ ) with adjustable delay ( $t_{E>}$ ,  $t_{E>>}$ ,  $t_{E>>>}$ ).

The first one ( $I_{E>}$ ) may be programmed with definite or inverse time according the IEC and ANSI/IEEE standard, as well as with EM curve.

The second and third thresholds ( $I_{E>>}$ ,  $I_{E>>>}$ ) with independent time.

For each threshold a reset time can be set ( $t_{E>RES}$ ,  $t_{E>>RES}$ ,  $t_{E>>>RES}$ ) useful to reduce the clearing time for intermittent faults.

The first threshold trip may be inhibited by start of the second and/or third threshold ( $I_{E>>}$ ,  $I_{E>>>}$ ).

Similarly the second threshold trip may be inhibited by start of the third threshold ( $I_{E>>>}$ ).

### Operation and settings

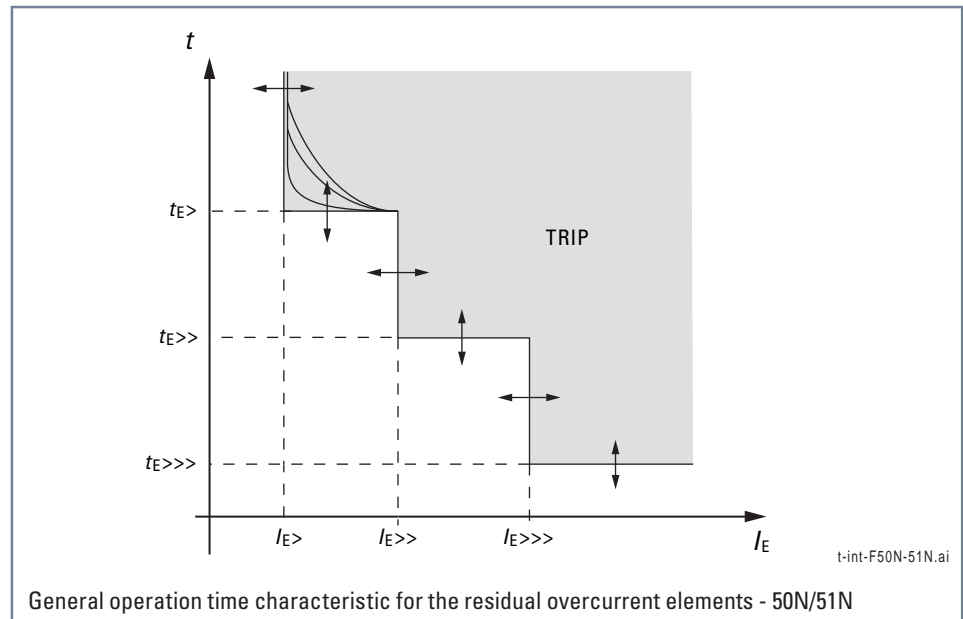
The residual fundamental frequency current is compared with the setting value. Current above the associated pickup value is detected and a start is issued. After expiry of the associated operate time a trip command is issued; if instead the current drops below the threshold, the element is restored.

The first threshold ( $I_{E>}$ ) may be programmed with definite or inverse time according the following characteristic curves:

- Standard Inverse Time (IEC 255-3/BS142 type A or SIT):  $t = 0.14 \cdot t_{E>inv} / [(I_E/I_{E>inv})^{0.02} - 1]$
- Very Inverse Time (IEC 255-3/BS142 type B or VIT):  $t = 13.5 \cdot t_{E>inv} / [(I_E/I_{E>inv}) - 1]$
- Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):  $t = 80 \cdot t_{E>inv} / [(I_E/I_{E>inv})^2 - 1]$
- Long Time Inverse (IEC 255-3/BS type B LTI):  $t = 120 \cdot t_{E>inv} / [(t_E/t_{E>inv}) - 1]$
- Moderately Inverse (ANSI/IEEE type MI):  $t = t_{E>inv} \cdot \{0.01 / [(I_E/I_{E>inv})^{0.02} - 1] + 0.023\}$
- Very Inverse (ANSI/IEEE type VI):  $t = t_{E>inv} \cdot \{3.922 / [(I_E/I_{E>inv})^2 - 1] + 0.098\}$
- Extremely Inverse (ANSI/IEEE type EI):  $t = t_{E>inv} \cdot \{5.64 / [(I_E/I_{E>inv})^2 - 1] + 0.024\}$
- Electromechanical (EM):  
 $t = t_{E>inv} \cdot \{0.28 / [-0.236 \cdot (I_E/I_{E>inv})^{-1} + 0.339]\}$

Where:

$t$ : operate time  
 $I_{E>}$ : pickup value  
 $t_{E>inv}$ : operate time setting



For all inverse time characteristics, following data applies:

- Asymptotic reference value (minimum pickup value):  $1.1 I_{E>}$
- Minimum operate time:  $0.1 \text{ s}$
- Range where the equation is valid:<sup>[1]</sup>  $1.1 \leq I_E/I_{E>inv} \leq 20$
- If  $I_{E>inv}$  pickup  $\geq 0.5 I_{En}$ , the upper limit is  $10 I_{En}$

For all definite time elements the upper limit for measuring is  $10 I_{En}$ .

All residual overcurrent elements can be enabled or disabled by setting *ON* or *OFF* the  $IE>$  *Enable*,  $IE>>$  *Enable* and/or  $IE>>>$  *Enable* parameters inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \ IE> Element (IE>> Element, IE>>> Element) \ Setpoints** menus.

The first overcurrent element can be programmed with definite or inverse time characteristic by setting the  $IE>$  *Curve* parameter (*DEFINITE*, *IEC/BS A*, *IEC/BS B*, *IEC/BS C*, *IEC/BS B LI*, *ANSI/IEE MI*, *ANSI/IEE VI*, *ANSI/IEE EI*, *EM*) available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \ IE> Element \ Setpoints** menu.

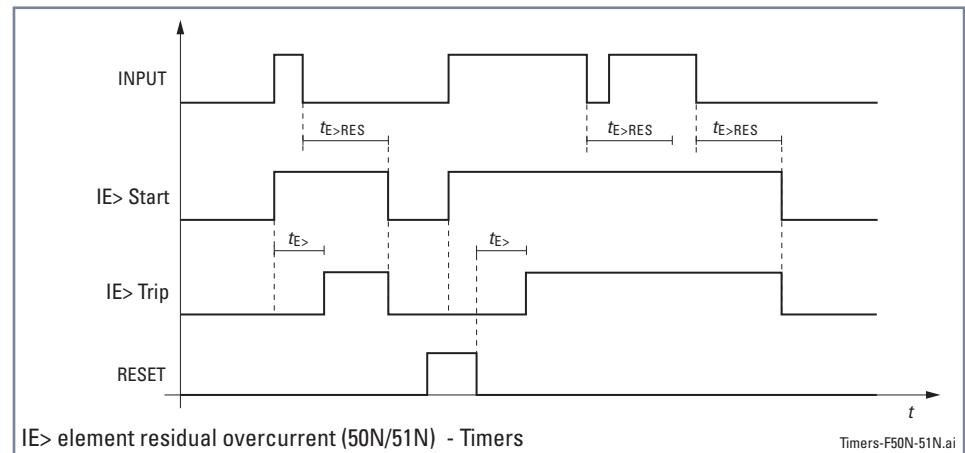
Note 1 When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point

The trip of  $I_{E>}$  element may be inhibited by the start of the second and/or third element ( $I_{E>>}$ ,  $I_{E>>>}$ ) by setting *ON* the Disable  $I_{E>}$  by start  $I_{E>>}$ , Disable  $I_{E>}$  by start  $I_{E>>>}$  ( $I_{E>}disbyI_{E>>}$ ,  $I_{E>}disbyI_{E>>>}$ ) parameters available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>>}$  Element ( $I_{E>>>}$  Element) \ Setpoints** menus.

Similarly the trip of the  $I_{E>>}$  element may be inhibited by start of the third element ( $I_{E>>>}$ ) by setting *ON* the Disable  $I_{E>>}$  by start  $I_{E>>>}$  ( $I_{E>>}disbyI_{E>>>}$ ) parameter available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>>>}$  Element \ Setpoints** menu.

All the named parameters can be set separately for **Profile A** and **Profile B** (**Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Setpoints** menus).

An adjustable reset time delay is provided for every threshold ( $t_{E>RES}$ ,  $t_{E>>RES}$ ,  $t_{E>>>RES}$ ).



Each residual overcurrent element can produce the Breaker Failure output if the  $I_{E>} BF$ ,  $I_{E>>} BF$  and/or  $I_{E>>>} BF$  parameters are set to *ON*. The parameters are available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Setpoints** menus.<sup>[1]</sup>

For all overcurrent elements, a block from the second harmonic restraint may be set by setting *ON* the  $I_{E>}2ndh-REST$ ,  $I_{E>>}2ndh-REST$ ,  $I_{E>>>}2ndh-REST$  parameters inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Setpoints** menus.

If the CLP function (Cold Load Pick-up) is enabled for element blocking, the selected threshold may be blocked for an adjustable time interval, starting from the circuit breaker closure.

This operating mode may be select by setting *ON-Element blocking* the  $I_{ECLP>} Mode$ ,  $I_{ECLP>>} Mode$ ,  $I_{ECLP>>>} Mode$  parameters.

If the CLP function (Cold Load Pick-up) is enabled for threshold change, the selected threshold may be changed for an adjustable time interval, starting from the circuit breaker closure.

This operating mode (*ON-Change setting =  $I_{ECLP>} Mode$ ,  $I_{ECLP>>} Mode$ ,  $I_{ECLP>>>} Mode$ ) and the concerning operating time within the CLP ( $t_{ECLP>}$ ,  $t_{ECLP>>}$ ,  $t_{ECLP>>>}$ ) may be adjusted inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Setpoints** menus, whereas the operating thresholds within the CLP ( $I_{ECLP>}def$ ,  $I_{ECLP>}inv$ ,...) may be adjusted inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Definite time (Inverse time)** menus.*

For every of the four thresholds the following block criteria are available:

#### Logical block (Block1)

If the  $I_{E>}BLK1$ ,  $I_{E>>}BLK1$  and/or  $I_{E>>>}BLK1$  enabling parameters are set to *ON* and a binary input is designed for logical block (Block1), the concerning element is blocked off whenever the given input is active.<sup>[2]</sup> The enabling parameters are available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \  $I_{E>}$  Element ( $I_{E>>}$  Element,  $I_{E>>>}$  Element) \ Setpoints** menus, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input IN1(x)** menus.

#### Selective block (Block2)

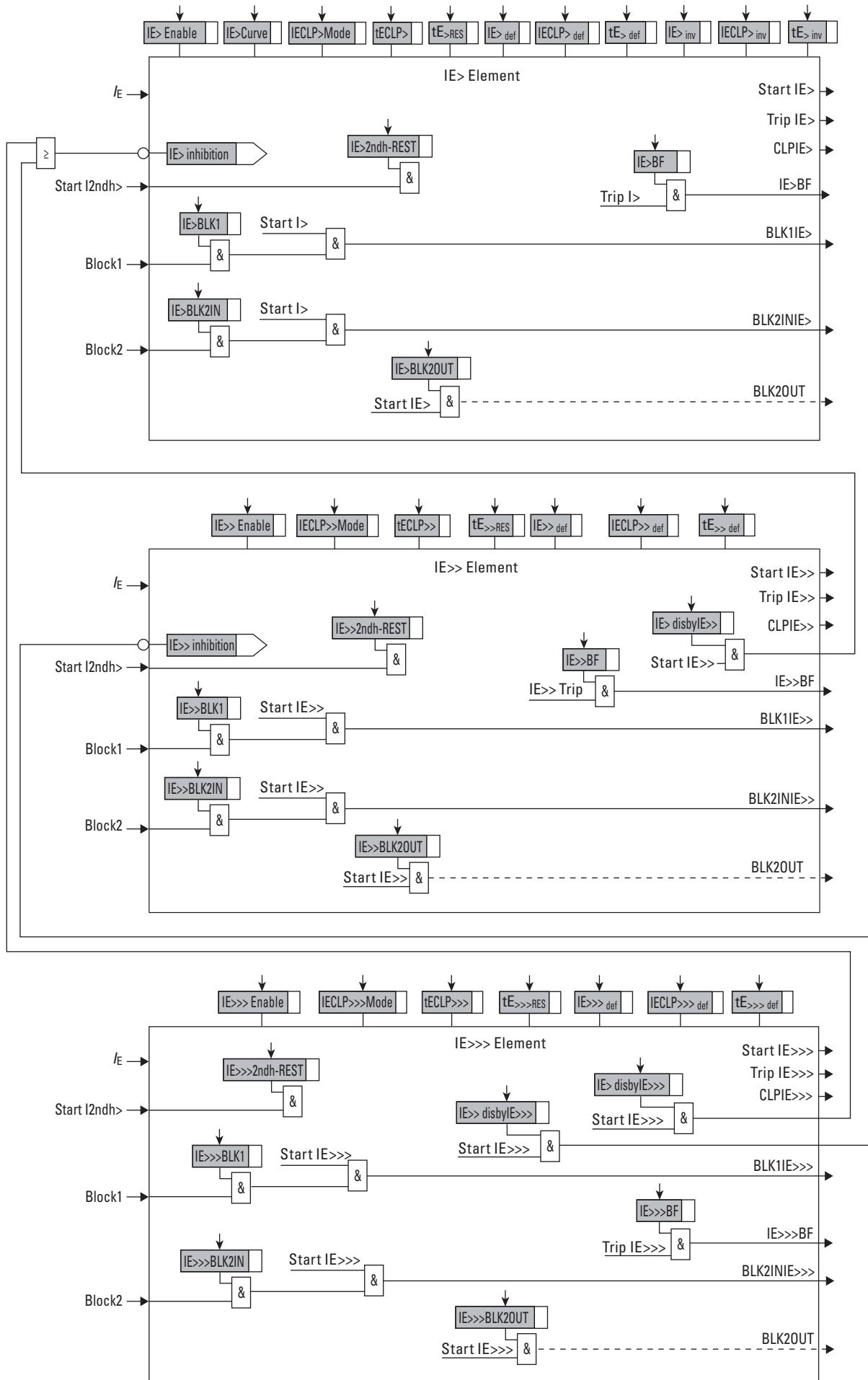
All along the protective elements the selective block may be set.

The logic selectivity function may be performed by means any combination of the following I/O:

- One committed pilot wire input (BLIN1).
- One or more binary inputs designed for input selective block.
- One committed pilot wire output (BLOUT1).
- One or more output relays designed for output selective block.

**Note 1** The common settings concerning the Breaker failure protection are adjustable inside the **Breaker Failure - BF** menu.

**Note 2** The exhaustive treatment of the logical block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section



General logic diagram of the residual overcurrent elements - 50N/51N

all-F50N-51N.ai

Only when the committed pilot wire are used the continuity check of the pilot wire link is active.

Use of committed pilot wire input BLIN1:

- The protection is blocked off according the selectivity block criteria when the input BLIN1 is active. The information about phase or phase+earth block may be select programming the *ModeBLIN1* parameter inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block IN** menus.

Use of binary inputs:

- If the *IE>BLK2IN*, *IE>>BLK2IN* and/or *IE>>>BLK2IN* parameters are set to *ON* and a binary input is designed for selective block (Block2), the protection is blocked off by phase elements (Block2 Iph) or by any protection element (Block2 Iph/IE) according the selectivity block criteria.<sup>[1]</sup> The enable *IE>BLK2IN*, *IE>>BLK2IN* and/or *IE>>>BLK2IN* parameters are available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \ IE> Element (IE>> Element, IE>>> Element) \ Setpoints** menus, while the *Block2 Iph* and *Block2 Iph/IE* functions must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input IN1(x)** menu (IN1 or INx matching).

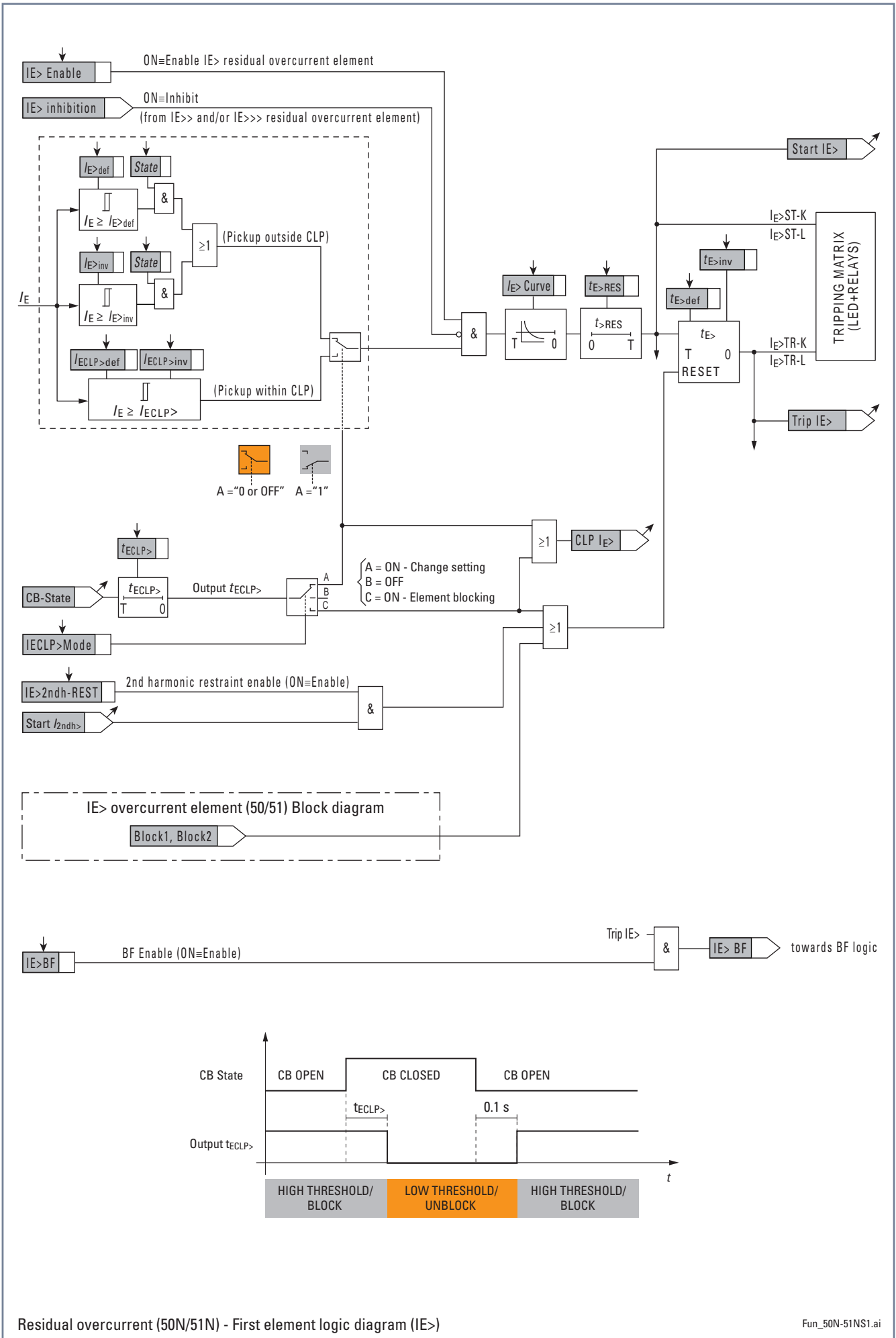
Use of committed pilot wire output BLOUT1:

- The information about phase or phase+earth block may be select programming the *ModeBLOUT1* parameter (*OFF - ON IPh - ON IPh/IE - ON IE*) inside **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menus.

Use of output relay (K1...K6):

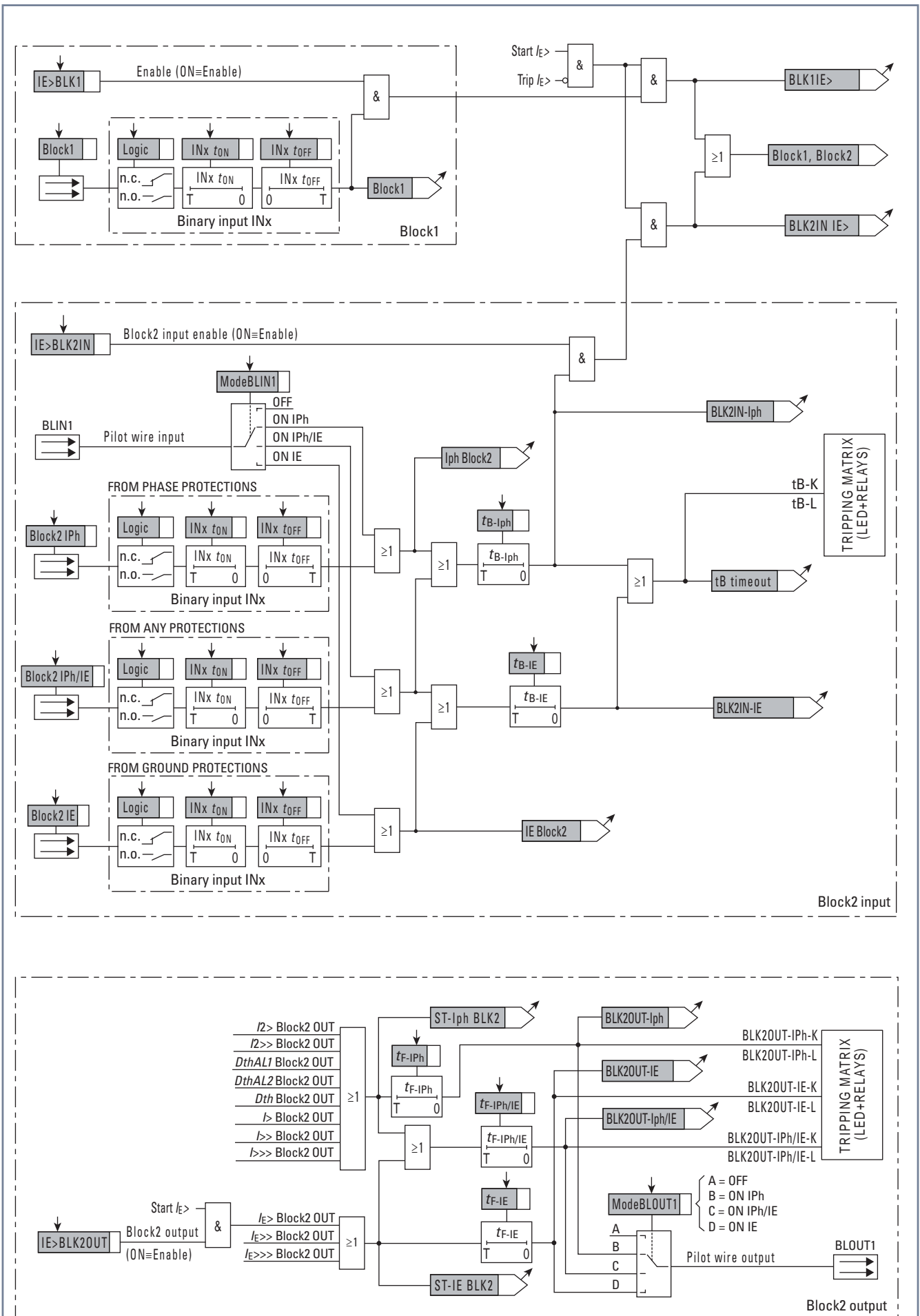
- If the *IE>BLK2OUT*, *IE>>BLK2OUT* and/or *IE>>>BLK2OUT* enable parameters are set to *ON* and a output relay is designed for selective block (Block2), the protection issues a block output by phase elements (BLK2OUT-Iph) or by any protection element (BLK2OUT-Iph/IE), whenever the given element (Start IED>, Start IED>>, Start IED>>> and/or Start IED>>>>) becomes active. The enable *IED>BLK2OUT*, *IED>>BLK2OUT*, *IED>>>BLK2OUT* and/or *IED>>>>BLK2OUT* parameters (*ON* or *OFF*) are available inside the **Set \ Profile A(or B) \ Residual overcurrent-50N/51N \ IE> Element (IE>> Element, IE>>> Element) \ Setpoints** menus, while the *BLK2OUT-Iph-K*, *BLK2OUT-Iph/IE-K* and/or *BLK2OUT-IE-K* output relays and LEDs (*BLK2OUT-Iph-L*, *BLK2OUT-Iph/IE-L* e/o *BLK2OUT-IE-L*) must be select inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block OUT** menu.

*Note 1 The exhaustive treatment of the selective block (Block 2) function may be found in the "Selective Block" paragraph inside CONTROL AND MONITORING section*



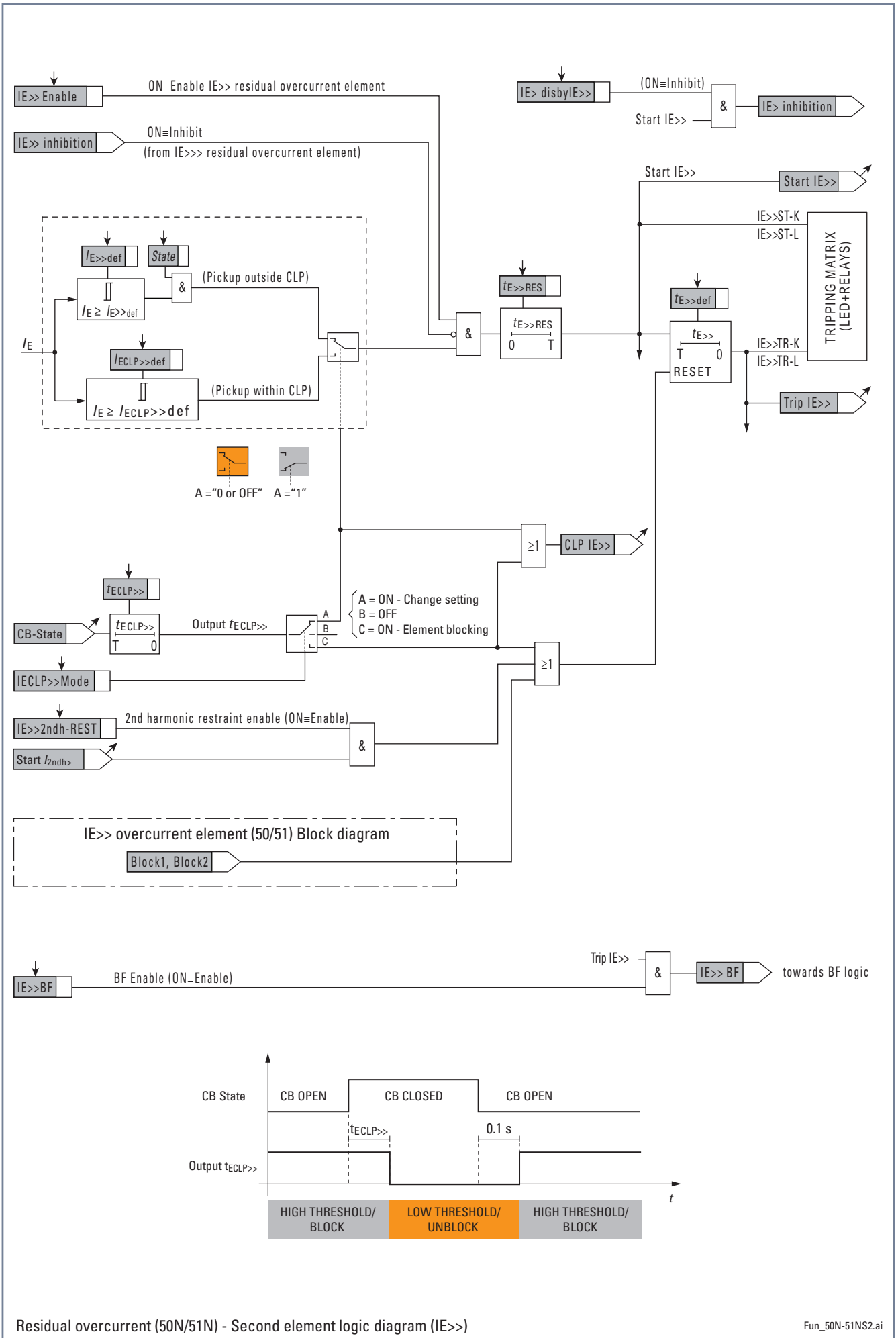
Residual overcurrent (50N/51N) - First element logic diagram (IE>)

Fun\_50N-51NS1.ai



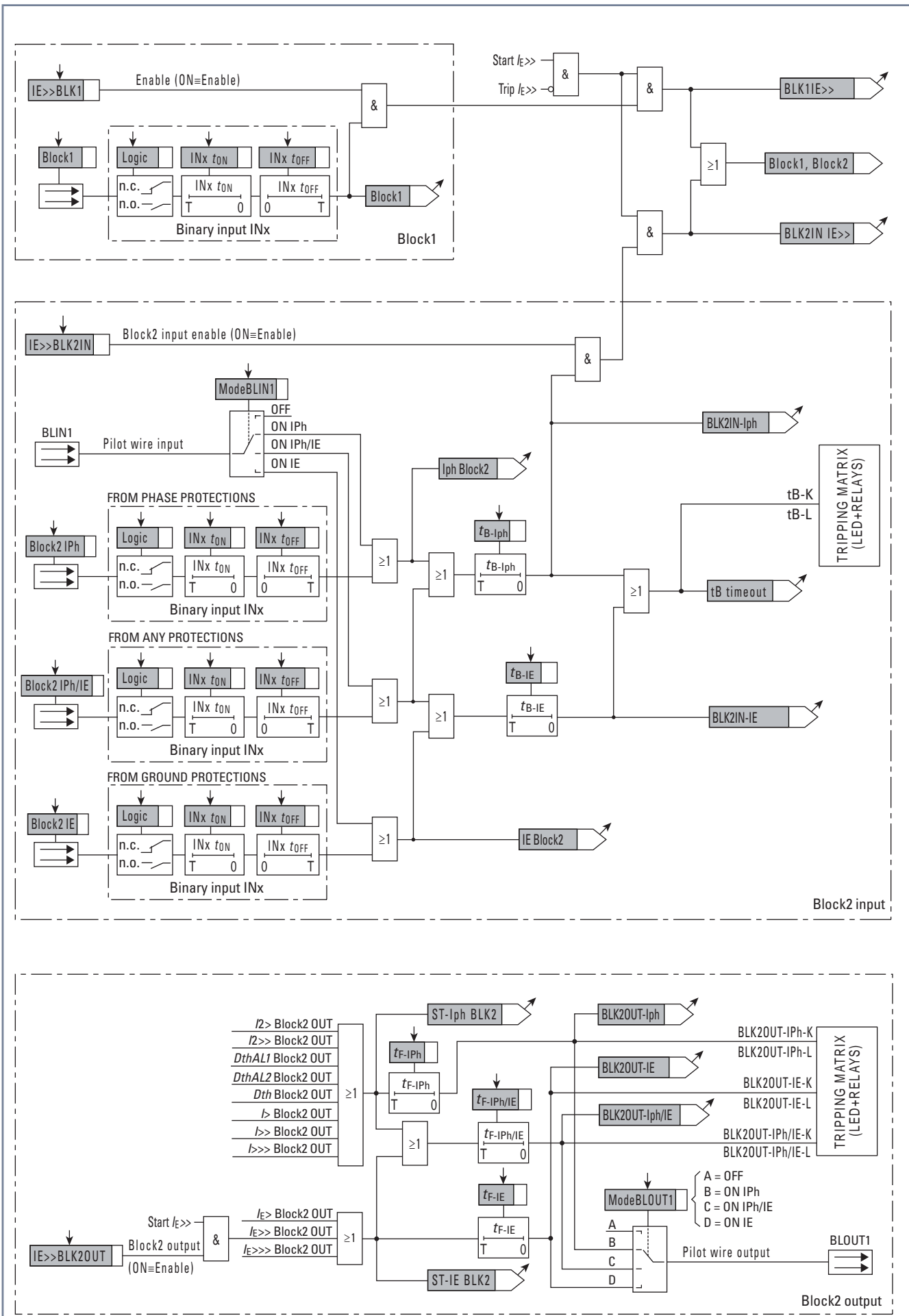
Residual overcurrent (50N/51N) - Logic diagram of the blocking signals concerning the first element (IE>)

50N-51NS1\_BL-diagram.ai



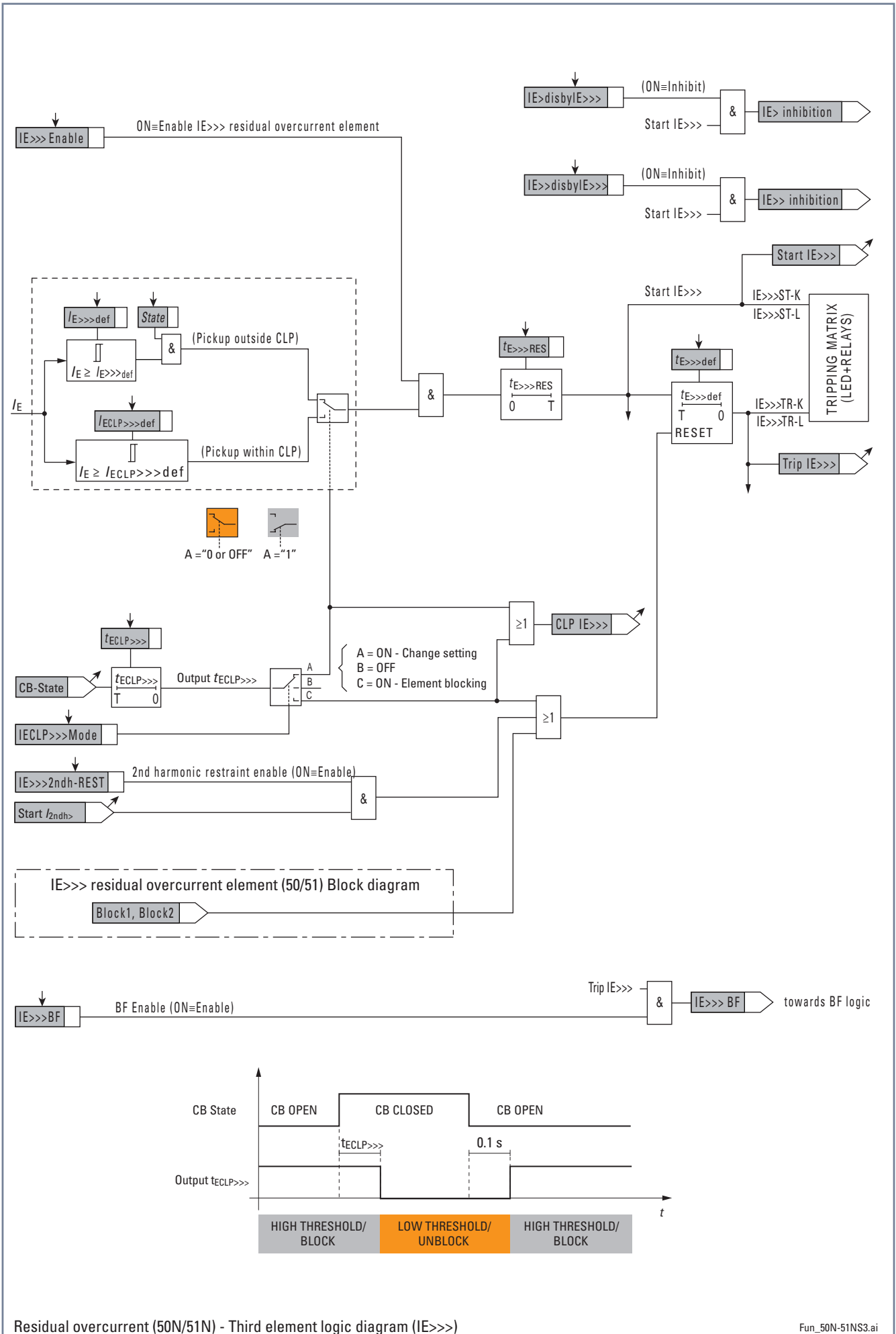
Residual overcurrent (50N/51N) - Second element logic diagram (IE>>)

Fun\_50N-51NS2.ai

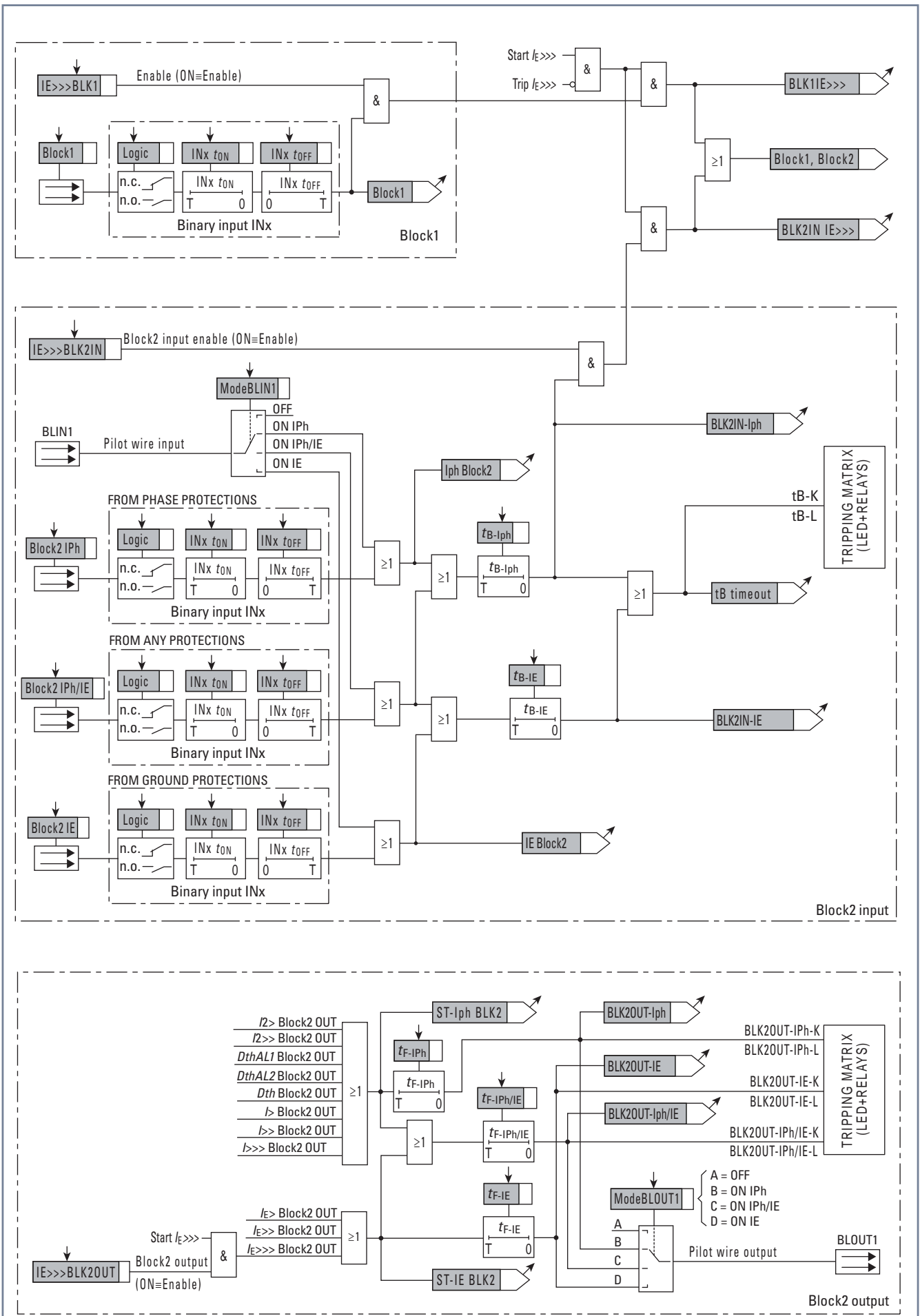


Residual overcurrent (50N/51N) - Logic diagram of the blocking signals concerning the second element (IE>>)

50N-51NS2\_BL-diagram.ai



Residual overcurrent (50N/51N) - Third element logic diagram (IE>>>)



Residual overcurrent (50N/51N) - Logic diagram of the blocking signals concerning the third element (IE>>>)

50N-51NS3\_BL-diagram.ai

## Breaker failure - BF

### Preface

When the protection issues a trip command but, because an anomaly, the circuit breaker cannot open, the breaker failure protection issues a back-up trip command to trip adjacent circuit breakers. The breaker failure function may be started by internal protective function (if associated with BF) or by external protections.

### Operation and settings

The starting of the timer occurs if both the following conditions are filled:

- A) Start and trip of internal protective elements (trip of elements matched with BF protection) or, trip of external protections acquired by means binary input, if enabled;
- B) The CB is closed (the CB state may be acquired by means two binary inputs connected to the auxiliary contacts 52a and 52b) or the fundamental component of at least one phase current  $I_{L1}$ ,  $I_{L2}$ ,  $I_{L3}$  is greater than the  $I_{BF>}$  adjustable threshold or the fundamental component of the residual current  $I_E$  is greater than the  $I_{EBF>}$  adjustable threshold.

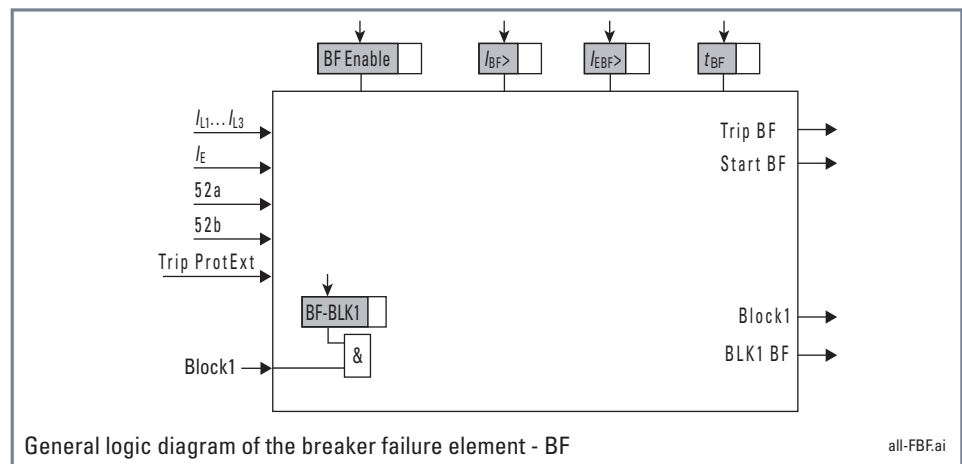
The breaker failure protection reliability is improved by means of the CB position control or phase or residual current measure; the trip can arise also for wrong auxiliary contacts state (if the current is greater than the adjustable threshold ) or for trip of external protections (frequency, voltage,..) without current (with CB closed information supplied from state of auxiliary contacts).

If the information concerning the CB position is not achievable (for instance the auxiliary contacts are unavailable), such control must be disabled.

If both conditions are held along the set operate time  $t_{BF}$ , the BF element trips at deadline, vice versa the timer is cleared and the function is restored.

To the purpose to restore the BF element as quickly as possible, with start of the same protection (see A condition), additionally to the trip of some internal protections, their starts are required (start reset is faster than trip reset).

The element may be enabled or disabled by setting *ON* the *BF Enable* parameter available inside the **Set \ Profile A(or B) \ Breaker failure-BF** menu.



All the  $I_{BF>}$ ,  $I_{EBF>}$  and  $t_{BF}$  parameters can be set separately for **Profile A** and **Profile B**; they are available inside the **Set \ Profile A(or B) \ Breaker failure-BF** menu.

### BF start from Circuit breaker

If the *CB Input* parameter (BF Start from circuit breaker) is set to *ON*, and two binary inputs are designed for acquire the 52a and 52b auxiliary contacts<sup>[1]</sup>, the control of the CB position is enabled. If the information concerning the CB position is not available, such control must be disabled by setting *OFF* the *CB Input* parameter. The parameter is available inside the **Set \ Profile A(or B) \ Breaker failure-BF** menu, the *52a* and *52b* function must be assigned to the selected binary inputs inside **Set \ Inputs \ Binary input IN1(x)** menus (IN1 or INx matching).

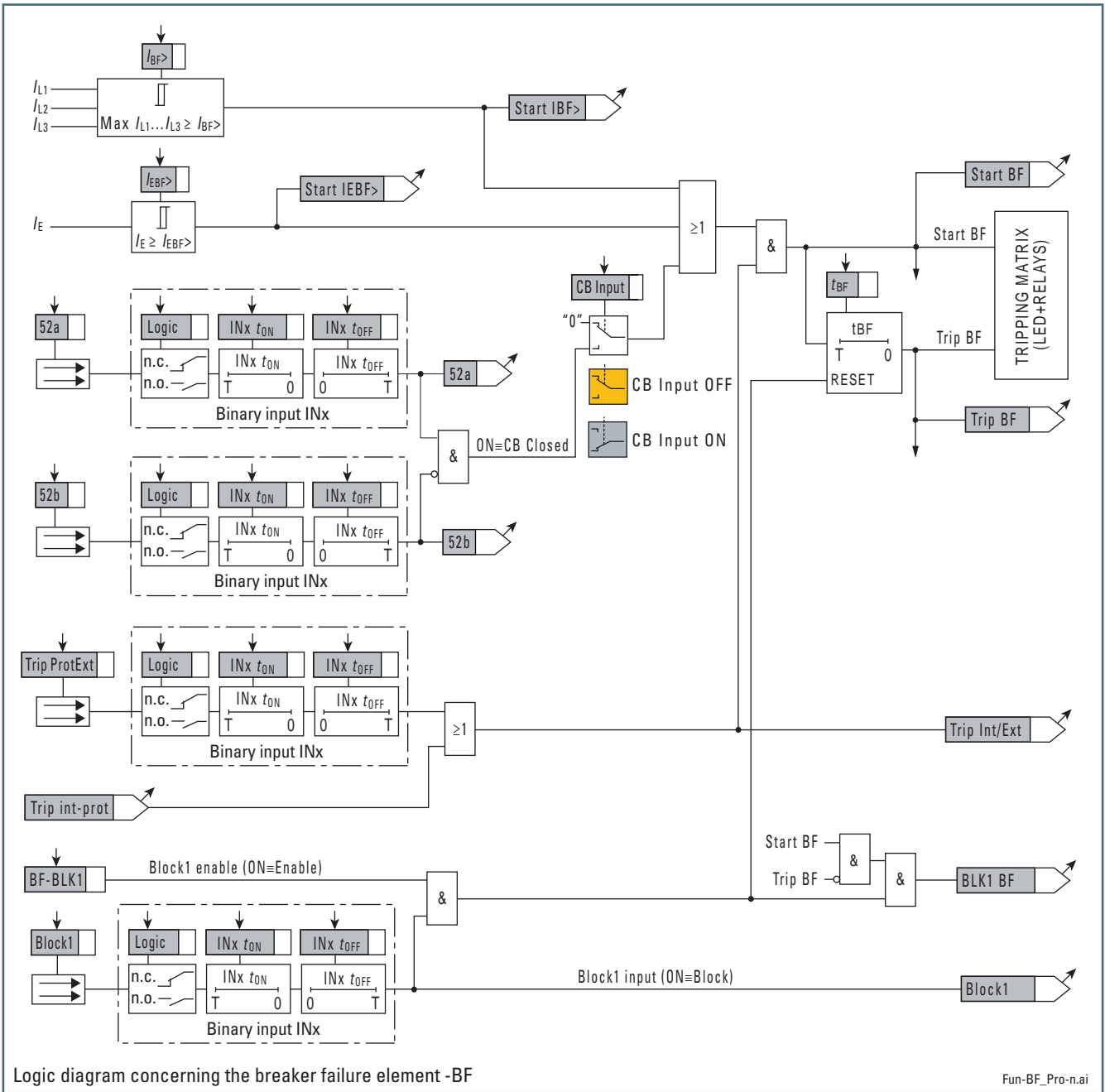
To enable the breaker failure protection to operate with trips coming from external protections, one binary input must be designed to acquire the relative contacts. The *TripProtExt* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input IN1(2...)** menus (IN1 or IN... matching).

### Logical block (Block1)

If the *BF-BLK1* parameter (BF logical block) is set to *ON*, and a binary input is designed for logical block (Block1), the breaker failure protection is blocked off whenever the given input is active. The trip timer is held in reset condition, so the operate time counting starts when the input block goes down.<sup>[2]</sup> The enabling parameter is available inside the **Set \ Profile A(or B) \ Breaker failure-BF** menu, while the *Block1* function must be assigned to the selected binary input inside the **Set \ Inputs \ Binary input IN1(x)** menus (IN1 or INx matching).

**Note 1** Both auxiliary contact state 52a and 52b must be acquired (two binary inputs are required) with Fw version previous to 1.60; with later versions, giving up an inconsistency occurs, one logical input for the acquisition of a contact (52nd or 52b ) may suffice

**Note 2** The exhaustive treatment of the logic block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section



Logic diagram concerning the breaker failure element -BF

Fun-BF\_Pro-n.ai

Logical block - BLOCK1

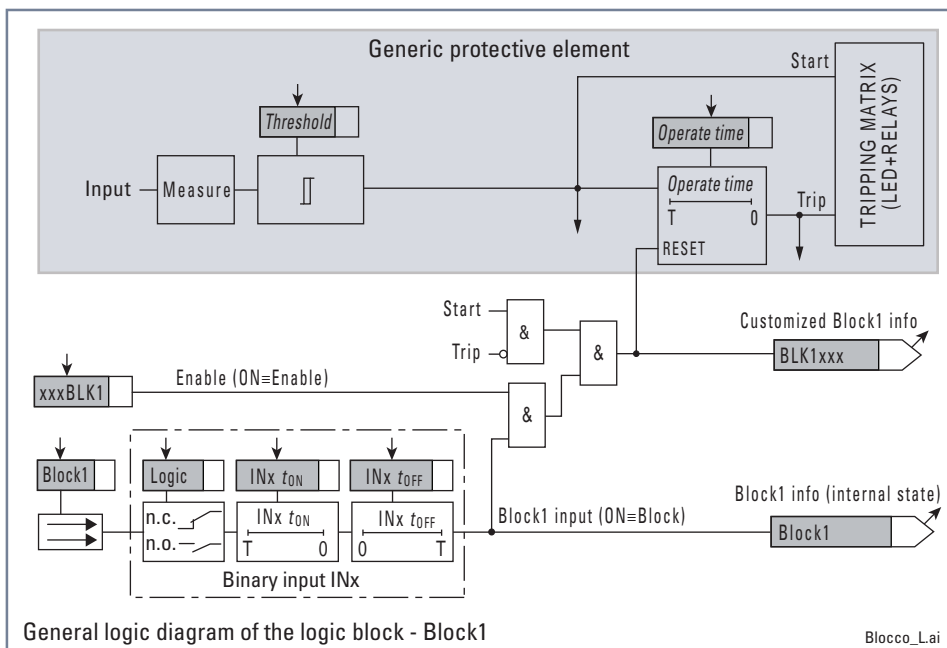
To the purpose to block off the trip of one protection element, the logical block function (Block1) may be matched with binary inputs.<sup>[1]</sup>

The binary-matching may be set inside the **Inputs** submenu; to the purpose the *Block1* parameter must be selected for *INx matching* (x=1, 2)

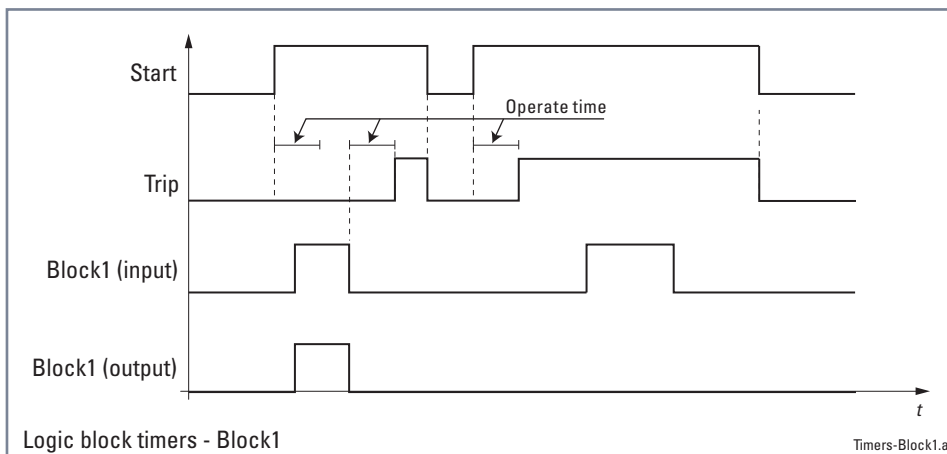
A protective element, where the logical block is enabled, is blocked off whenever the given input is ON.

For a given protective element, the logical block state is reading available (ThyVisor and communication interfaces); it is ON the following condition are at the same time observed:

- Binary input ON,
- Element start ON,
- Element Trip OFF.



The logical block it is not liable for any inhibition time-out, so the protective element is disabled for the whole time when the input is ON.<sup>[2]</sup>

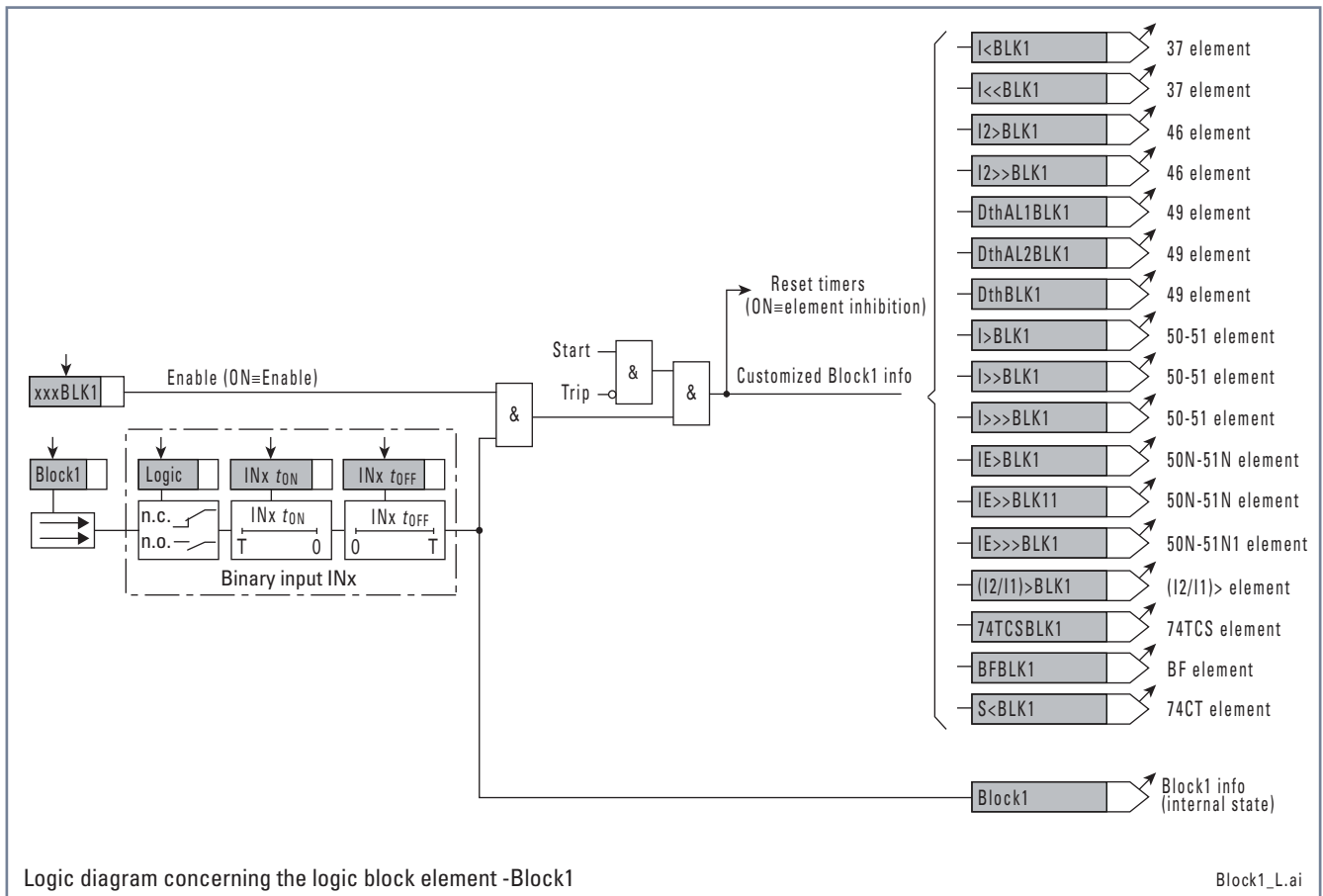


**CAUTION**

Activation of any binary input assigned to logic block (Block1) function effects a block of all the protective elements where the logical block is enabled

Note 1 In the following treatment, the logical block is defined as "Logical block" or "Block1"

Note 2 The Block 1 signal forces a timer reset



Selective block -BLOCK2

Preface

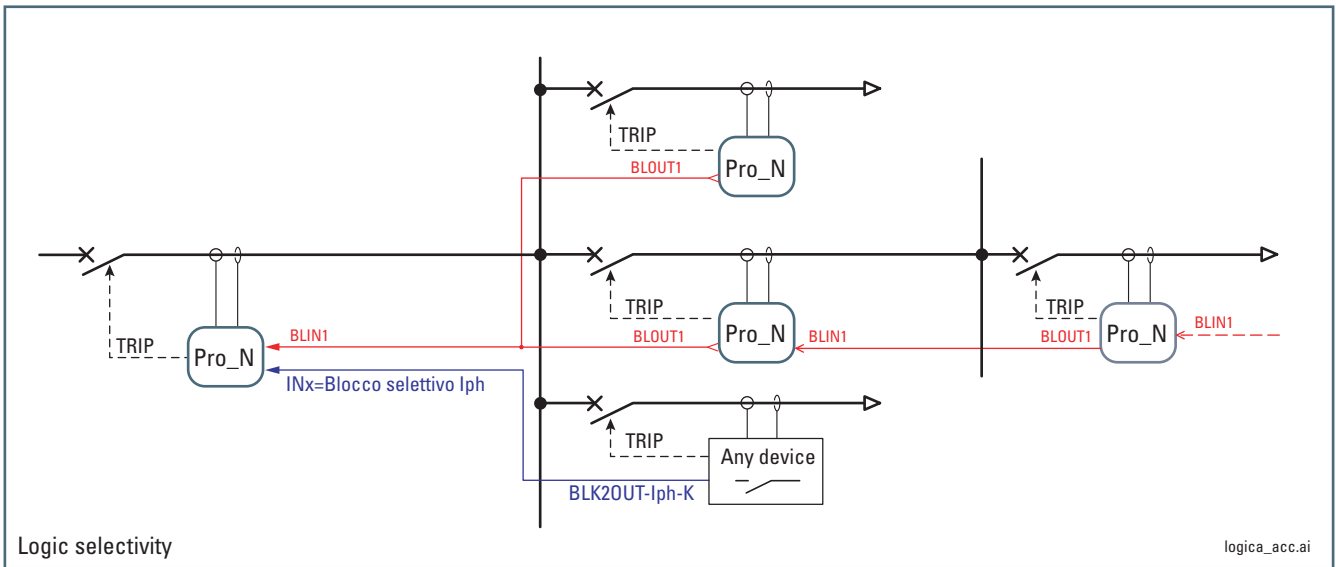
The logic selectivity function has been developed to the purpose to reduce the clearing times for faults closes to the source.

The output blocking circuits of one or several Pro\_N relays, shunted together, must be connected to the input blocking circuit of the protection relay, which is installed upwards in the electric plant. The output circuit works as a simple contact, whose condition is detected by the input circuit of the upwards protection relay.

The logic selectivity function can be realized through any combination of the following I/O circuits:

- One committed pilot wire input BLIN1...ON Iph, ON...Iph/IE, ON...IE.
- One committed pilot wire output BLOUT1...ON Iph, ON...Iph/IE, ON...IE.
- One or more than one independent binary inputs programmed with *Block2 Iph*, *Block2 Iph/IE* or *Block2 IE*.
- One or more than one independent output relays programmed with *BLK2OUT-Iph-K*, *BLK2OUT-Iph/IE-K* or *BLK2OUT-IE-K*.

In reference to the following schematic diagram, the some protection functions of the relay placed on the feeder may be blocked by downstream protective relays.



Input selective block

Use of committed pilot wire input BLIN1

The input is a polarized wet type powered by internal isolated supply; it must be drive by an output block signal coming from a Pro-N device or by a free voltage contact.

 <p><b>WARNING</b></p>	<p>Never connect power to the block input circuit; the electronic circuit can be damaged</p>
---	--

The protection is blocked off according the selectivity block criteria by phase elements (*Block2 Iph*), by earth elements (*Block2 IE*) or by any protection element (*Block2 Iph/IE*) when the input BLIN1 is active. The information about phase or phase+earth block may be select programming the *ModeBLIN1* parameter inside the **Set \ Profile A(or B) \ Selective block-BLOCK2 \ Selective block IN** menus.

Use of binary inputs

If the *xxBLK2IN* parameters (enable) are set to *ON* and a binary input is designed for selective block (*Block2*), the protection is blocked off by phase elements (*Block2 Iph*), by earth elements (*Block2 IE*) or by any protection element (*Block2 Iph/IE*), according the selectivity block criteria, when the input (*IN1* and/or *INx*) is active.

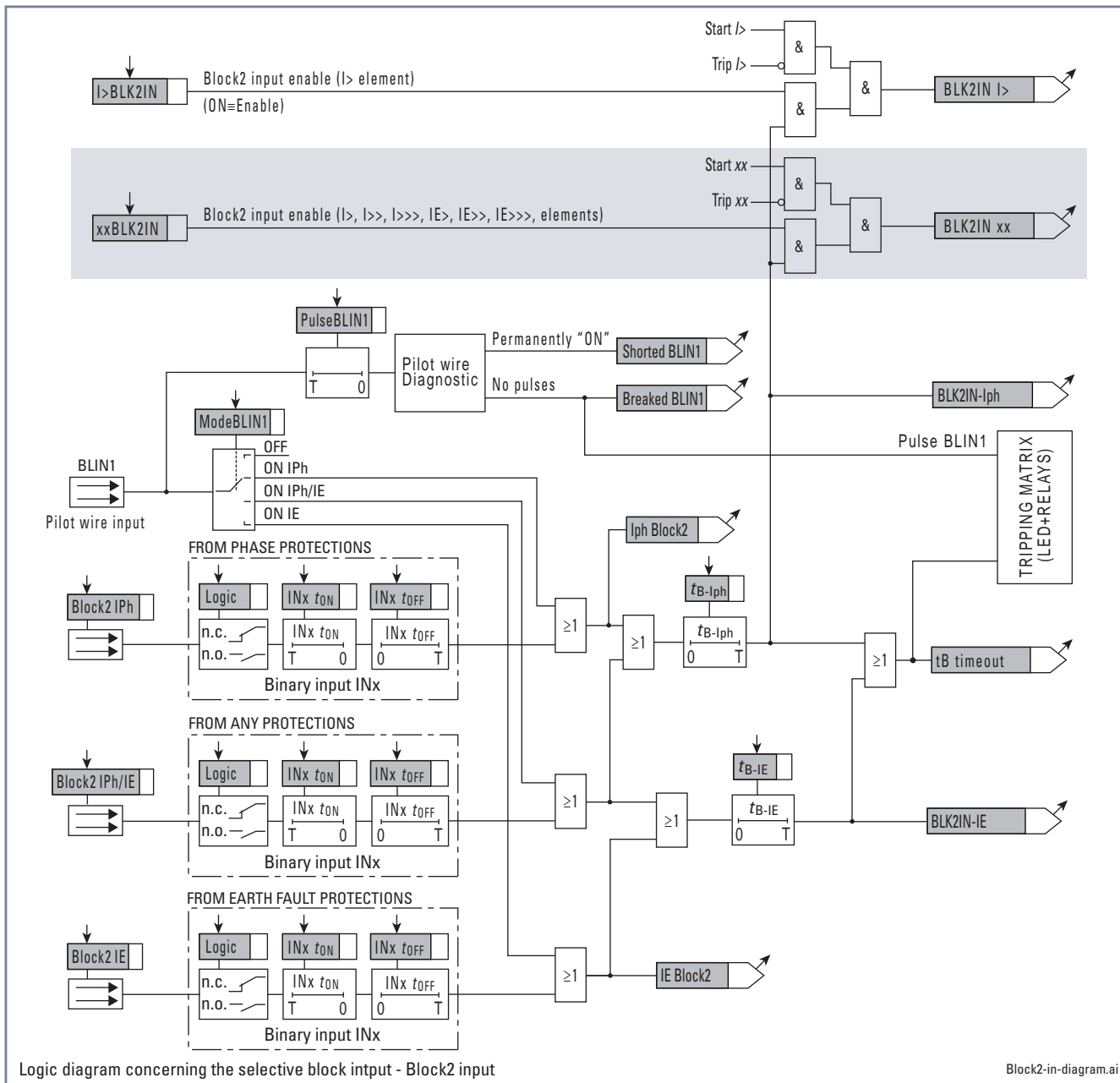
The *Block2 Iph*, *Block2 IE* and *Block2 Iph/IE* matching must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input 1** and **Set \ Inputs \ Binary input x** menus.

When a binary input is programmed for selective block input, the *IN1 tON*, *INx tON*, *IN1 tOFF* and *INx tOFF* time delays must be reset to zero; the *Logic* parameters (*ON/OFF*) must be programmed in the same way of the related output relay connected with-it.

Operation

For any protective element, three main conditions can arise:

- A) Start = OFF: the element is at rest (no trip) regardless of the input/output blocks.
- B) Start = ON: the element trips if no selective block input becomes active during the operate time.
- C) Start = ON: if the selective block input (BLIN1 and/or binary input) becomes active, the element goes in selective block state wherein the operate timer is forced to reset, so the element cannot trip. After an adjustable time  $t_{B-Iph}$  (common for phase protection elements) or  $t_{B-IE}$  (common for earth protection elements), the selective block input is disregarded and the operate timer can start again. Information about  $t_{B-Iph}$  and or  $t_{B-IE}$  expired is available for reading ( $tB$  timeout data inside **Read \ Selective block - BLOCK2 \ Block2 input** menu) and can drive an output relay and or a LED ( $tB-K$  and or  $tB-K$  parameters inside **Set \ Profile A(or B) \ Selective block - BLOCK2 \ Selective block IN** submenu).



With a setting other than 0.00 s, the  $t_{B-Iph}$  and  $t_{B-IE}$  timers may be used to have a backup protection available against pilot wire short circuit.<sup>[1]</sup>

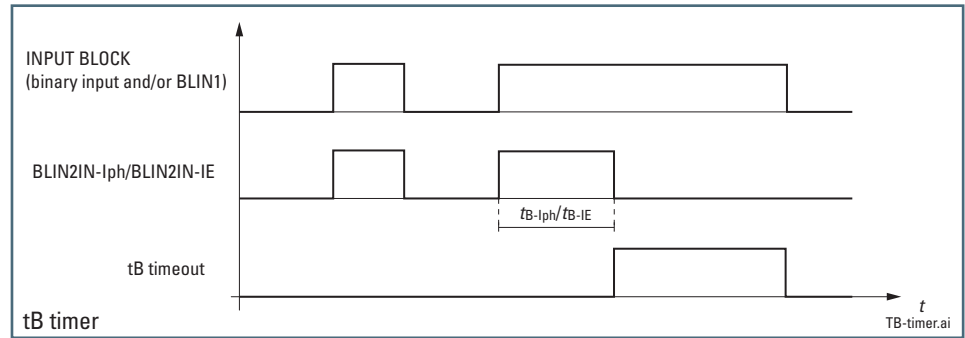
The  $t_{B-Iph}$  and/or  $t_{B-IE}$  timers must be adjusted according the following rule (example for  $t_{B-Iph}$ ):

$$t_{B-Iph} = t_{FV} + \epsilon t + \epsilon s$$

where  $t_{FV}$  is the value of block output timer related to the downstream relay (example  $t_{F-Iph}$ ),  $\epsilon t$  is a chronometric selectivity margin to apply in comparison to the  $t_{B-Iph}$  time related to the downstream relay (does not take into account if such margin has been considered for the  $t_{F-Iph}$  setting),  $\epsilon s$  is a safety margin. The chronometric selectivity applied among the  $t_{B-x}$  times of the relays in accelerated logic system allows to avoid more the contemporary circuit breaker opening after the clearing of a fault in a line of concomitant plant to the short-circuit of the pilot wires concerning the same line.

Note 1 In the absence of suitable provisions, a short circuit on a pilot wire causes the block of the receiving relay, so a possible fault (contemporary or following) inside the protected zone, cannot be cleared that being the case the protective relay blocked.

To enable the selectivity logic input for a generic xx element, the  $xxBLK2IN$  parameters must be set to *ON* inside the **Set \ Parametri di configurazione A (o B) \ xxx \ Setpoints** menus concerning all element where the selective block is available, eg:  
*I > BLK2IN* inside the **Set \ Profile A (or B) \ Phase overcurrent-50/51 \ I > Element \ Setpoints** menu.



Output selective block

Use of output relays

If the  $xxBLK2OUT$ ,  $xxBLK2OUT$  and/or  $xxBLK2OUT$  enable parameters are set to *ON* and a output relay is designed for selective block (Block2), the protection issues a block output by phase elements ( $BLK2OUT-Iph$ ), by ground elements ( $BLK2OUT-IE$ ) or by any protection element ( $BLK2OUT-Iph/IE$ ), whenever the given start is active.

The  $BLK2OUT-Iph-K$ ,  $BLK2OUT-Iph/IE-K$  and/or  $BLK2OUT-IE-K$  output relays must be set inside the **Set \ Profile A (or B) \ Selective block-BLOCK2 \ Selective block OUT** menu; the same for addressing the LED indicators ( $BLK2OUT2-Iph-L$ ,  $BLK2OUT2-IE-L$  and  $BLK2OUT2-Iph/IE_L$ ). When output relays are programmed for selective block output, the  $t_{FR}$  time delays must reset to zero; the operation mode must be set with self reset (*No-latched* inside **Set \ Relays** submenu) and the *Logic* parameters (*Energized/De-energized*) must be programmed in the same way of the related binary input connected with-it.

Use of committed pilot wire output BLOUT1

The output is a dry static relay.

The information about phase (*ON IPh*), earth (*ON IE*), or phase+earth (*ON IPh/IE*) concerning the sending block out signal may be select by means of the *ModeBLOUT1* parameter inside the **Set \ Profile A (or B) \ Selective block-BLOCK2 \ Selective block OUT** menu.

The parameters can be set separately for **A** and **B** profiles.

Operation

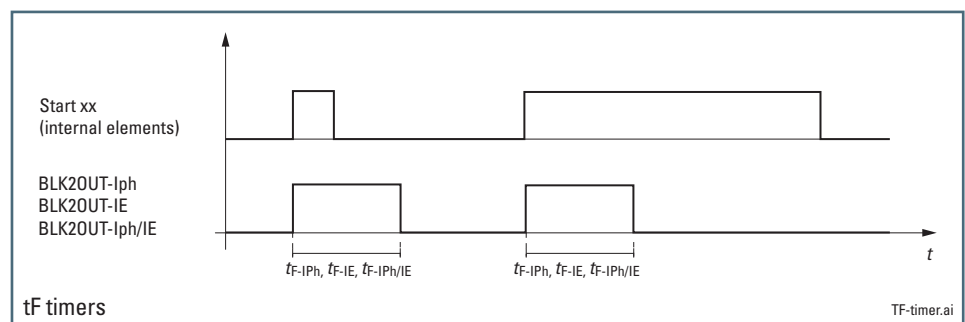
The selective block outputs go ON at the same time of the xx element start; they hold steady (even if the start reset to zero) for along the  $t_{F-IPh}$ ,  $t_{F-IE}$  and  $t_{F-IPh/IE}$  adjustable times for phase, earth and phase+earth functions.

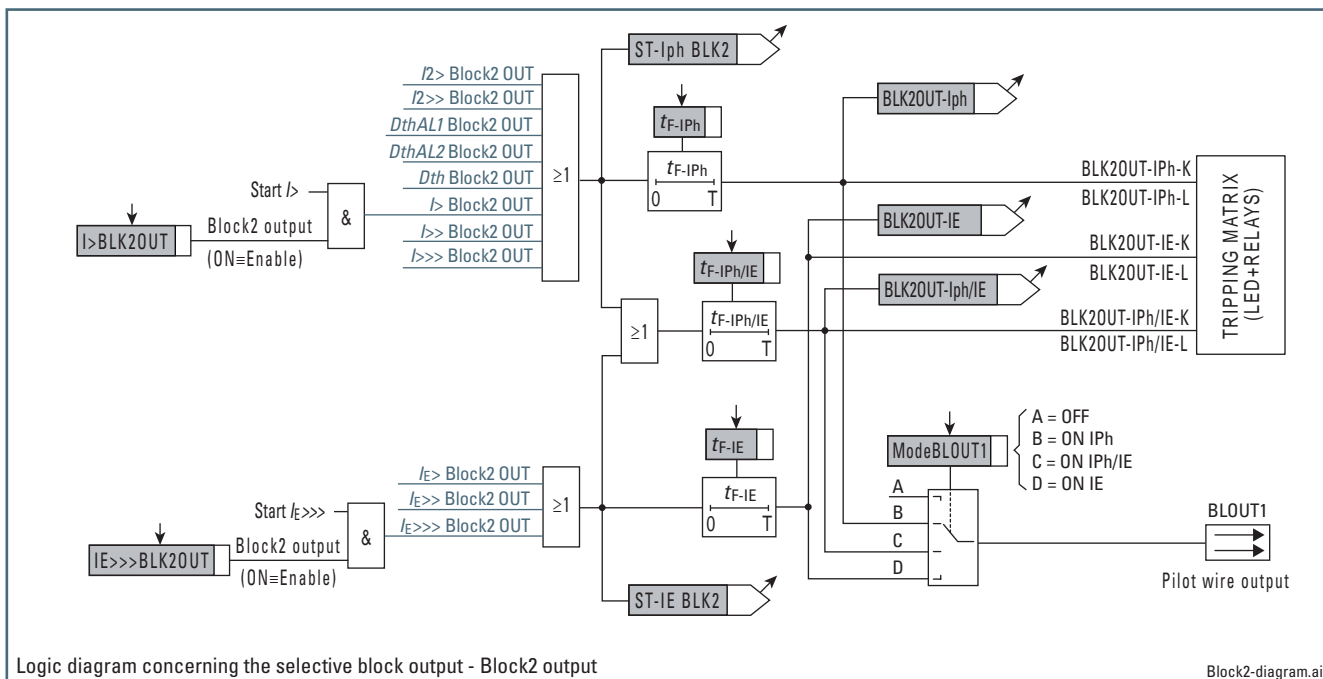
The timers starts when one or more selective block function goes ON; when a timer expires, the selective block outputs are disregarded (even if the start holds steady).

The  $t_{F-IPh}$  and  $t_{F-IE}$  counters start when the output selective block becomes active. When the counters expire the block selective output is forced off (despite the start xxx remain active).

If the  $t_{F-IPh}$ ,  $t_{F-IE}$  e  $t_{F-IPh/IE}$  timers are cleared the selective block output state is freeze up to the start xxx remain active.

With a setting other than 0.00 s, the  $t_{F-IPh}$ ,  $t_{F-IE}$  e  $t_{F-IPh/IE}$  timers may be used to provide a backup protection against breaker failure inside a selectivity logic system, as well as to hold blocked upstream protective relays up after the fault is cleared with CB opening to provide solution against unwanted trips because of a larger reset time compared with the downstream relay (the selectivity will be lost).





With traditional selective logic systems, in the absence of suitable cares, the event of a circuit breaker failure causes the block of the receiving relays situated upstream the circuit breaker, so the fault cannot be cleared.

When using the Pro-N devices inside the selective logic systems, the answer to the circuit breaker failure problem can be solved by means of, (as well as the BF-Breaker Failure element) or by means of a threshold adjusted for time selectivity, through use of the output block reset timer too with the intent that avoid permanently block of all upstream relays by downstream block signals (the only one unblocked relays deals to the fault breaker).

The  $t_{F-IPh}$ ,  $t_{F-IE}$ ,  $t_{F-IPh/IE}$  timers must be adjusted according the following rule (example for  $t_{F-IPh}$ ):

$$t_{F-IPh} = t + TAP + t_{rip} + \epsilon_t + \epsilon_s$$

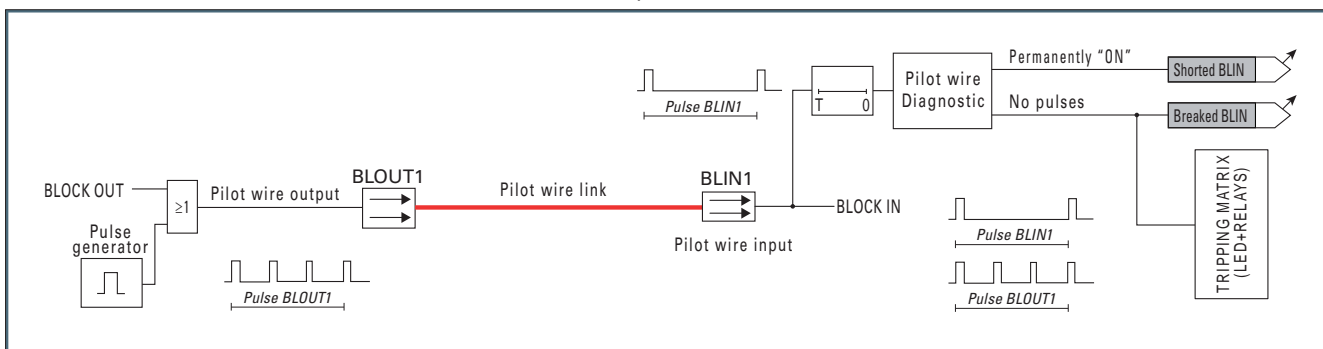
where  $t$  is the larger phase protection operate time,  $TAP$  is the circuit breaker operate time (with arc extinction),  $t_{rip}$  is the larger reset time of all protective relays inside the selective logic system,  $\epsilon_t$  is an potential selectivity margin relative to the  $t_{F-x}$  time of the downstream relays,  $\epsilon_s$  is a safety margin need to include timers errors (tolerances).

### Diagnostic

To guarantee maximum fail-safety, the relay performs a run time monitoring for pilot wire continuity and pilot wire shorting.<sup>[1]</sup>

Exactly the output blocking circuit periodically produces a pulse, having a small enough width in order to be ignored as an effective blocking signal by the input blocking circuit of the upstream protection, but suitable to prove the continuity of the pilot wire.

Furthermore a permanent activation (or better, with a duration longer than a preset time) of the blocking signal is identified, as a warning for a possible short circuit in the pilot wire or in the output circuit of the downstream protection.



The periodic pulses that are sent by output circuit may be enabled or disabled by means the *Pulse-BLOUT1* parameter available inside the **Set \ Pilot wire diagnostic** menu; with OFF setting the pulses are disabled.<sup>[2]</sup>

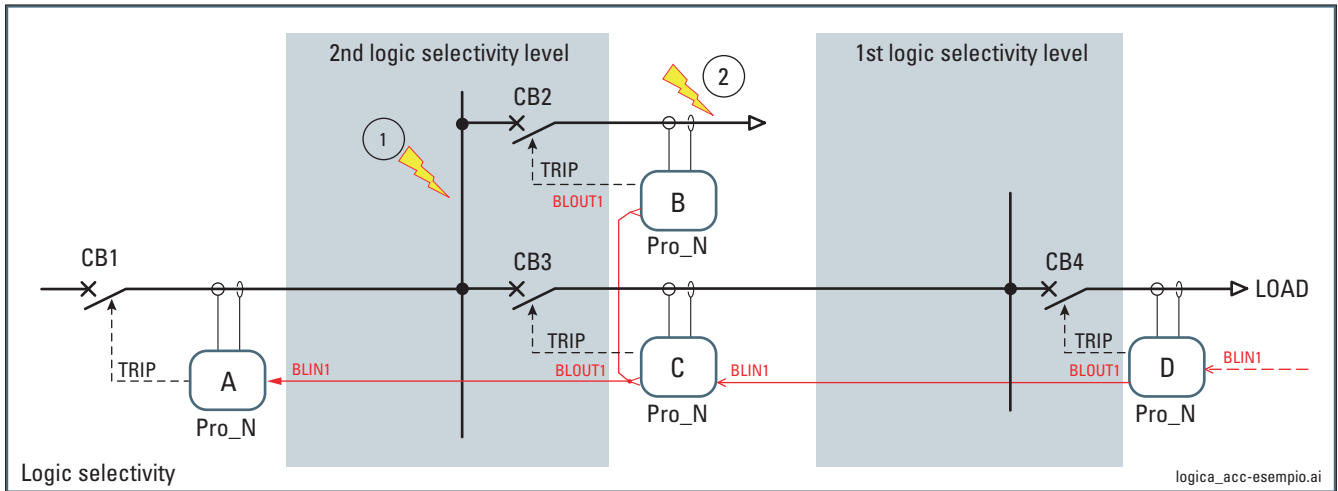
If no pulses are received inside an adjustable time window at the selective block input circuit, a break pilot wire alarm is issued; the information is available for reading (*Broken BLIN1* data inside **Read \ Pilot wire diagnostic** submenu) and can drive an output relay and or a LED (*PulseBLIN-K* and or a *PulseBLIN-L* parameters inside **Set \ Pilot wire diagnostic** submenu).

Note 1 Full diagnostic of pilot wires is only available when committed pilot wire input/outputs are employed

Note 2 When several outputs are parallel linked the pulse emission must be enabled inside one device only, sooner inside the outermost device

The control window may be programmed for OFF (no control) - 0.1 - 1 - 5 - 10 - 60 - 120 s; the *Pulse BLIN1* parameter is available inside the **Set \ Pilot wire diagnostic** menu; with OFF setting of the the *PulseBLIN1* parameter the pulse control is disabled.  
The same setting must be for input and output (*PulseBLIN1* and *PulseBLOUT1*).

In the following example the output pulses must be enabled inside the device B only (2nd logic selectivity level) and D (1st logic selectivity level).



### Setting example

In reference to the above shown schematic diagram, the logic selectivity is performed by means of the dedicated I/O for the short circuit elements of A, B and C protective relays, so that if a fault arises in (2), the open order or circuit breaker CB2 is issued and no trip is issued by A device. A command must be issued for the main circuit breaker CB1 by the A relay with a fault in (1).

#### A Protection

I>> element with definite time set to  $4.5 I_n$  with operate time to 0.10 s blocked by start of B and/or C protection.

Settings:

- $I_{>>def} = 4.5 I_n$
- $t_{>>def} = 0.100$  s
- *PulseBLOUT1* = OFF
- *PulseBLIN1* = 1 s
- *I>>BLK2IN* = ON
- *I>>BLK2OUT* = OFF
- $t_{B-IPh} = 0.30$  s

#### B Protection

I>> element with definite time set to  $4.0 I_n$  with operate time to 0.10 s with emission of block output toward A protection relay.

Settings:

- $I_{>>def} = 4.0 I_n$
- $t_{>>def} = 0.100$  s
- *I>>BLK2IN* = OFF
- *I>>BLK2OUT* = ON
- *PulseBLIN1* = OFF
- *PulseBLOUT1* = 1 s
- $t_{F-IPh} = 0.25$  s

#### C Protection

I>> element with definite time set to  $4.0 I_n$  with operate time to 0.10 s with emission of block output toward A device and block input from D protection relay.

Settings:

- $I_{>>def} = 4.0 I_n$
- $t_{>>def} = 0.100$  s
- *I>>BLK2IN* = ON
- *I>>BLK2OUT* = ON
- *PulseBLIN1* = 1 s
- *PulseBLOUT1* = OFF
- $t_{F-IPh} = 0.25$  s
- $t_{B-IPh} = 0.30$  s

## Remote tripping

### Preface

Some output relays may be programmed for remote trip function resulting from a command coming from a binary input.

If a binary input is designed for remote trip acquisition, an output relay allocated to the same function is triggered when the input (IN1 and/or IN2) is active.

### Operation and settings

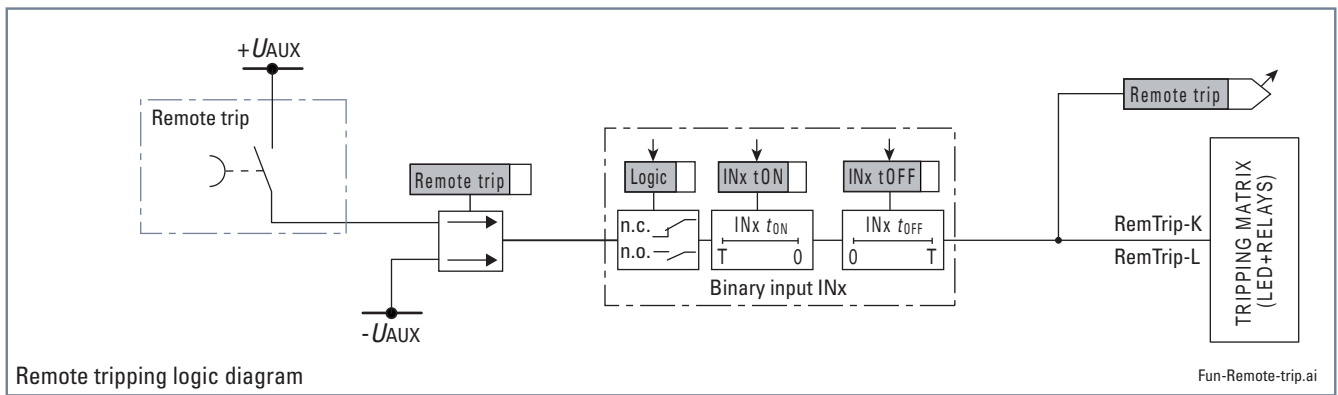
The *Remote trip* matching must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input1** or **Set \ Inputs \ Binary inputx** menus.

When a binary input is programmed for remote trip acquisition, the *IN1 tON*, *IN2 tON*, *IN1 tOFF* and *IN2 tOFF* time delays must be reset to zero; the *Logic* parameters (*ON/OFF*) must be programmed in the same way of the related circuit connected with-it.

The *RemTrip-K* matching must be assigned to the selected output relays inside the **Set \ Remote tripping** submenu; the same for addressing the LED indicators (*RemTrip-L*).

When output relays are programmed for remote tripping, the  $t_{TR}$  time delays must reset to zero; the operation mode must be set with self reset (*No-latched* inside **Set \ Relays** submenu) and the *Logic* parameters (*Energized/De-energized*) must be programmed in the same way of the related binary input connected with-it.

All the parameters are common for A and B Profiles.



### Frequency tracking

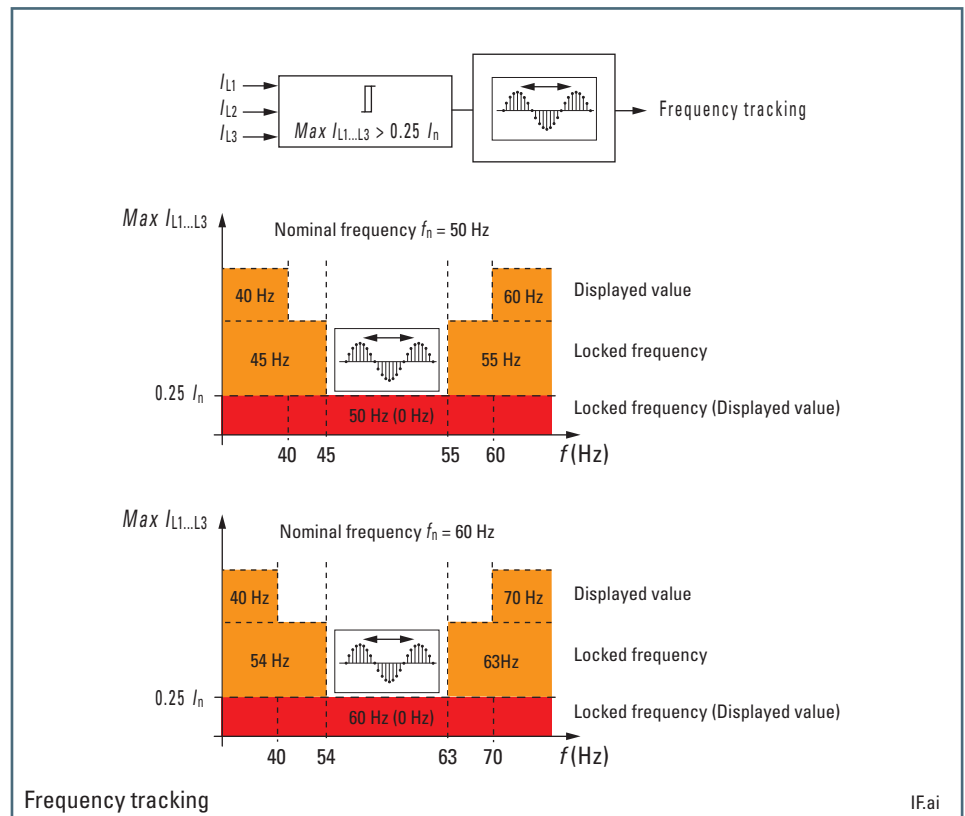
Within the frequency range 45...55 Hz ( $f_n = 50$  Hz). or 54...63 Hz ( $f_n = 60$  Hz), a frequency tracking algorithm adjusts the currents sampling frequency, so as to keep the number of samples in any given period constant.

With 24 samples for periods the sampling rate is adjusted from 1.08 kHz with  $f = 45$  Hz to 1.512 kHz with  $f = 63$  Hz

For a frequency step change the tracking response time is 10 Hz/s.

The frequency measure is based on the largest phase current.

- If the larger phase input current is lower than 25%  $I_n$  the sampling frequency is fixed to  $f_n$  (50 or 60 Hz).
- If the measured frequency is outside the locking range, the sampling frequency is fixed to the lower or upper value (45 or 55 Hz with  $f_n = 50$  Hz, 54 or 63 Hz with  $f_n = 60$  Hz).



All protective elements are always operative; accuracy is guaranteed inside locked frequency band.

## Second Harmonic Restraint - 2ndh-REST

### Preface

When a power transformer is energized, as well know an inrush current flow in the side that have been energized with an amount and duration that depend by many factors which:

- Instantaneous value of the supply voltage at the time where the transformer is energized
- Transformer design, magnetization characteristic and size
- Residual flux

The maximum amount of the inrush current is produced by energizing the transformer at the zero point of the voltage wave, when it increase or decrease with the residual flux respectively positive or negative. Moreover the ratio between the maximum amount of the inrush current and the nominal current of the transformer decrease if the size of transformer increase, whereas the duration of the inrush current increase with the size of transformer.

Some types of instantaneous protections as overcurrent, residually connected ground fault and differentials, are affected by this inrush current and their unwanted tripping can occur on transformer energizing.

The second harmonic restraint is available to restraint any selected threshold of NA21 protective relay:

- Negative sequence overcurrent - 46
- Negative sequence-positive sequence current ratio - I2/I1
- Thermal image - 49
- Phase overcurrent - 50/51
- Residual overcurrent - 50N/51N

Moreover one or more output contacts may be allocated to the 2NDH-REST function in order to block any external protection relays where second harmonic restraint is not available.

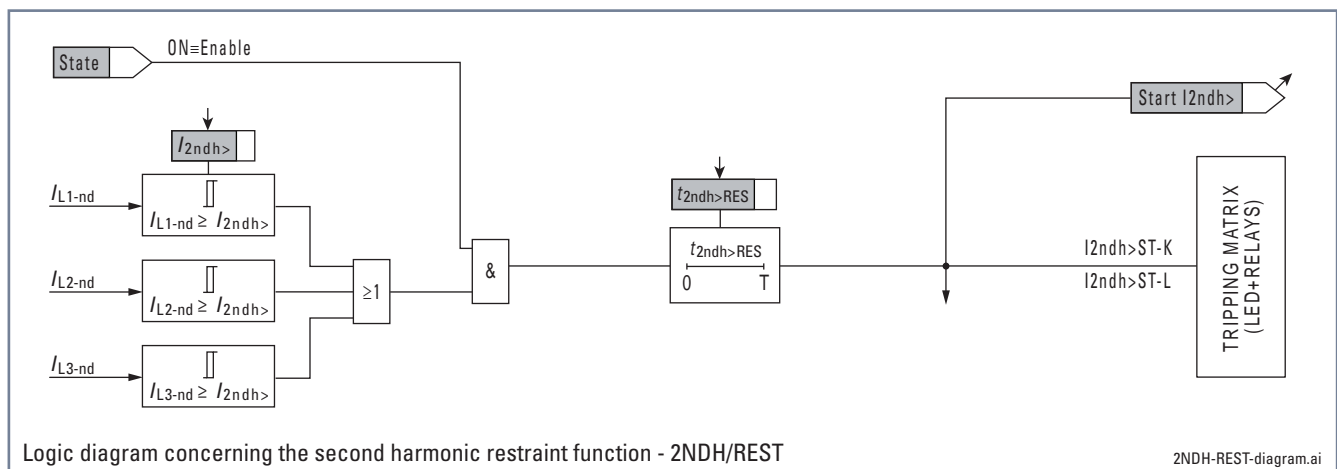
### Operation and settings

Each second harmonic component of phase currents ( $I_{L1-2nd}$ ,  $I_{L2-2nd}$ ,  $I_{L3-2nd}$ ) is compared with the  $I_{2ndh}>$  adjustable threshold.

When one or more currents overcome the setting threshold a start is issued.

The start may be employed to block-off one or more 50/51/50N/51N elements or to block-off external protections by means output relays (this can be usefully used in order to restraint external protection relays where second harmonic restraint is not available).

For the purpose to keep in block state the selected elements, an adjustable  $t_{2ndh}>RES$  reset delay is provided.



The setting of  $I_{2ndh}>$  and  $t_{2ndh}>RES$  parameters are available inside the **Set \ Profile A(B) \ Second Harmonic Restraint** menu.

The second harmonic element may be enabled or disabled; to enable it, the *Statee* parameter must be set to *ON* inside the **Set \ Profile A(B) \ Second Harmonic Restraint** menu.

All the parameters can be set separately for **Profile A** and **Profile B**.

The output may be assigned to the selected  $I_{2ndh}>-ST-K$  output relays inside the **Set \ Profile A(B) \ Second Harmonic Restraint** menu; the same for addressing the LED indicators ( $I_{2ndh}>-ST-L$ ).

When output relays are programmed for second harmonic element output, the  $t_{TR}$  time delays must be reset to zero; the operation mode must be set with self reset (*No-latched* inside **Set \ Relays** menu) and the *Logic* parameters (*Energized/De-energized*) must be programmed in the same way of the related binary input connected with-it.

Cold Load Pickup - CLP

Preface

CLP feature allows selected thresholds of phase and ground overcurrent protections to be changed or blocked for a set time in order to overcome transient overcurrents. The trigger of the CLP feature is the logical condition of circuit breaker closed, that Pro-N relay detect by means of two digital inputs connected to the circuit breaker auxiliary contacts 52a and 52b.

When the circuit breaker closed condition is detected, the CLP timer set in the submenu of CLP function is initiated and, throughout the CLP set time:

- The threshold is blocked if CLP is set to ON threshold block.
- The threshold is changed to the value that is set if CLP is set to ON threshold change.

When CLP timer has elapsed, the threshold is unblocked if CLP is set to ON threshold block or the threshold is revert back to the original value if CLP is set to ON threshold change.

Note that when the circuit breaker is open, the threshold is already blocked if CLP is set to ON threshold block or the threshold is already changed to the value if CLP is set to ON threshold change: this is useful in order to avoid unwanted tripping due to unblocked threshold or threshold with his original value for cases where a delay of the circuit breaker closing happen, i.e. where the three poles of the CB do not close at the same time or during long CB closing time.

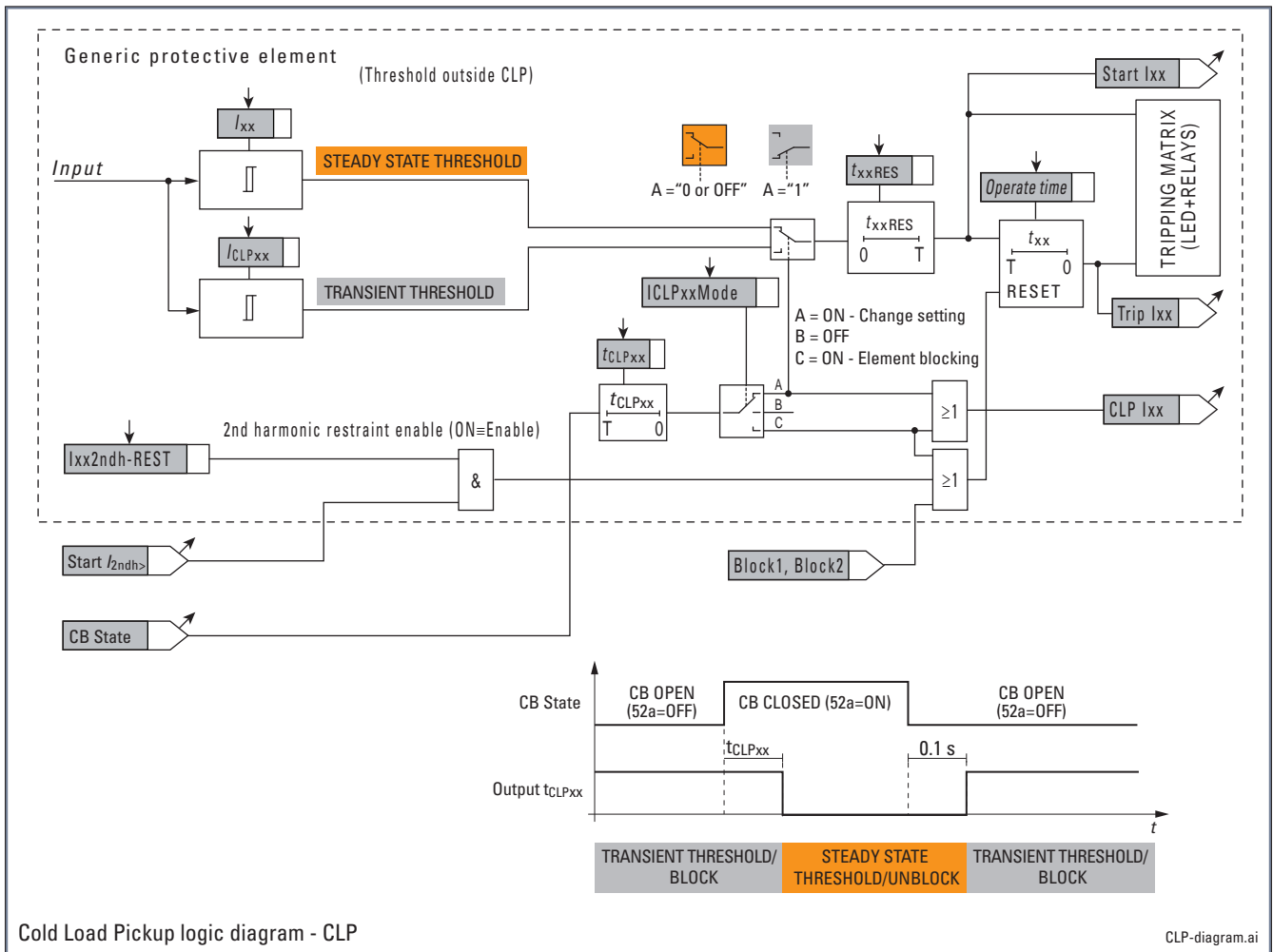
Typical applications where the CLP feature may be useful are for overcurrent protections on feeders where the circuit breaker closing starts air conditioning/heating loads after a long cooling time, motors or more generally momentary large loads.

The CLP may be also useful for instantaneous ground fault overcurrent protections on motors starting, because it is likely that incorrect operation of the protection would occur on imbalance transient secondary current due to asymmetric line CTs saturation.

Depending upon the magnitude and duration of the starting current, it may be necessary to block operation of thresholds or raising his setting. Also a combination of both blocking some thresholds and raising others may be adopted.

For each threshold the CLP function may be disabled (OFF), enabled with threshold blocking (ON-Element blocking) or enabled with threshold change (ON-Change setting) by means the xx-CLPx Mode parameter.

The operating mode and the relative activation time concerning each threshold of the 49, 50/51, 50N/51N, 67 and 67N elements are adjustable inside the Set\Profile A(or B)\xxx-xx\xxx Element\Setpoints menus.



CLP-diagram.ai

Example: to change the first threshold of the definite time overcurrent element 50/51 within CLP during a 0.1 s time interval:

- the *ICLP*> *Mode* parameter must be set as *ON-Change setting*,
- the *tCLP*> parameter must be adjusted to a wanted value (0.1 s) inside the **Set \ Profile A(or B) \ Phase overcurrent - 50/51 \ I > Element \ Setpoints** menu,
- The threshold within CLP parameter *ICLP*>*def* must be adjusted to a wanted value inside the **Set \ Profile A(or B) \ Phase overcurrent - 50/51 \ I > Element \ Definite time** menu.

CB position can be acquired by means one or two binary inputs; allocation of *52a* and *52b* functions is available inside the **Set \ Inputs \ Binary input1(x)** menu.

CT supervision - 74CT

Preface

The CT monitoring function is employed to issue an alarm when secondary phase CTs and/or phase input of the relay failures are detected. Interruptions are detected by means of a symmetry criterion of the  $I_{L1}$ ,  $I_{L2}$ ,  $I_{L3}$  input currents. The symmetry factor is calculated comparing the minimum and maximum of the fundamental components of the three phase currents ( $I_{LMIN} / I_{LMAX}$ ).

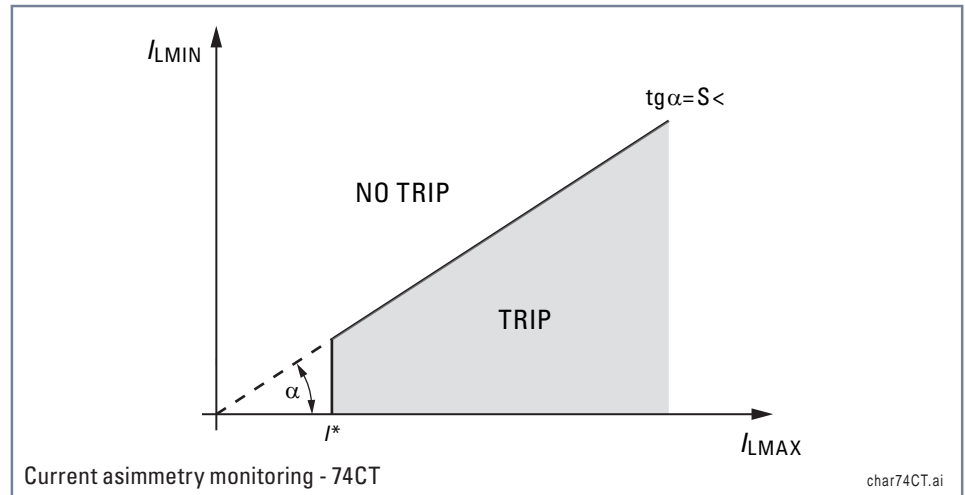
Operation and settings

The starting of the timer occurs if both the following conditions are filled:  
 A)  $(I_{LMIN} / I_{LMAX}) < S_{<}$  that is the symmetry factor is lower than the  $S_{<}$  adjustable threshold;  
 B)  $I_{LMAX} > I^*$

Where

- $I^*$ : maximum phase current threshold
- $S_{<}$ : element pickup value
- $t_{S_{<}}$ : operate time

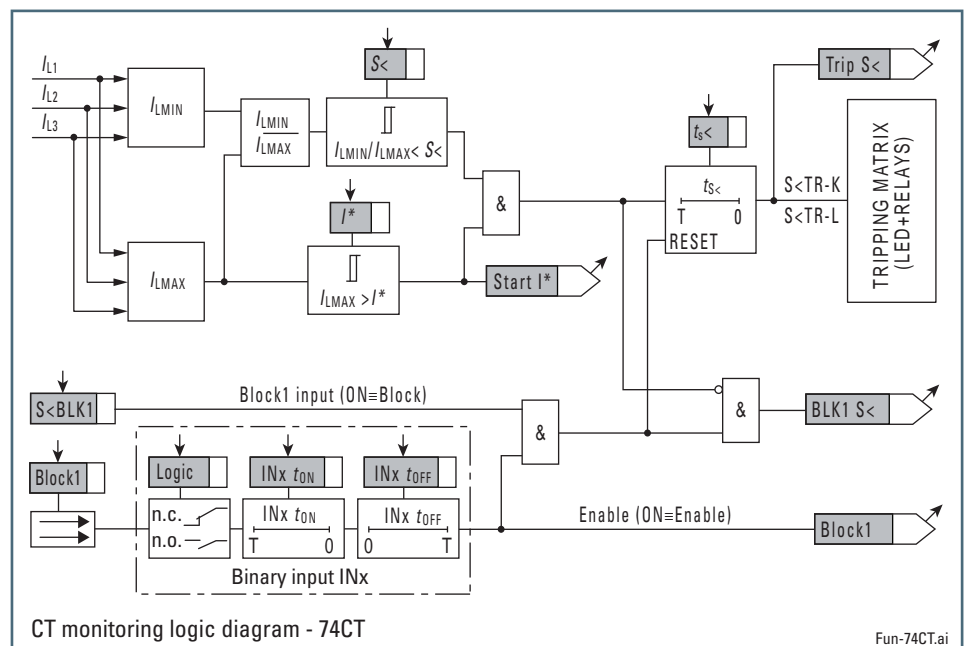
If both conditions are filled over the  $t_{S_{<}}$  adjustable time an alarm is issued.



The output may be assigned to the selected  $S_{<TR-K}$  output relays inside the **Set \ CT supervision-74CT** submenu; the same for addressing the LED indicators  $S_{<TR-L}$ .

If the  $S_{<BLK1}$  parameter is set to *ON*, and a binary input is designed for logical block (Block1), the CT supervision function is blocked off whenever the given input is active. The trip timer is held in reset condition, so the operate time counting starts when the input block goes down.<sup>[1]</sup> The  $S_{<BLK1}$  parameter is available inside the **Set \ CT supervision-74CT** menu.

All the parameters are common for A and B Profiles.



Note 1 The exhaustive treatment of the logic block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section

## Trip circuit supervision - 74TCS

### Preface

The trip circuit can be monitored to signal possible anomalies that would lead to the missing opening of circuit breaker when trip and/or operator command are issued.

Circuit interruption as well as missing of auxiliary voltage and/or coil faults are detected.

Supervision with one or two binary inputs can be selected; depending on association of binary inputs, the corresponding logic is automatically selected.

For this purpose the *TCS1* and *TCS2* (if two binary input are used) matching must be assigned to the selected binary inputs inside the **Set \ Inputs \ Binary input IN1** and **Set \ Inputs \ Binary input INx** menus.

When a binary input is programmed for the TCS function, the *IN1 tON*, *INx tON*, *IN1 tOFF* and *INx tOFF* time delays must be reset to zero and the *Logic* parameter must be set to *Active-ON* inside the **Set \ Inputs \ Binary input IN1** and **Set \ Inputs \ Binary input INx** menus.

### Operation and settings

The 74TCS element may be enabled or disabled; to enable it, the *74TCS Enable* parameter must be set to *ON* inside the **Set \ Profile A(B) \ Trip circuit supervision-74TCS** submenu.

A logic block can be set from one binary input.<sup>[1]</sup>

If the *74TCS-BLK1* parameter is set to *ON*, and a binary input is designed for logical block (Block1), the TCS supervision function is blocked off whenever the given input is active. The trip timer is held in reset condition, so the operate time counting starts when the input block goes down. The *74TCS-BLK1* parameter is available inside the **Set \ Profile A(B) \ Trip circuit supervision-74TCS** submenu.

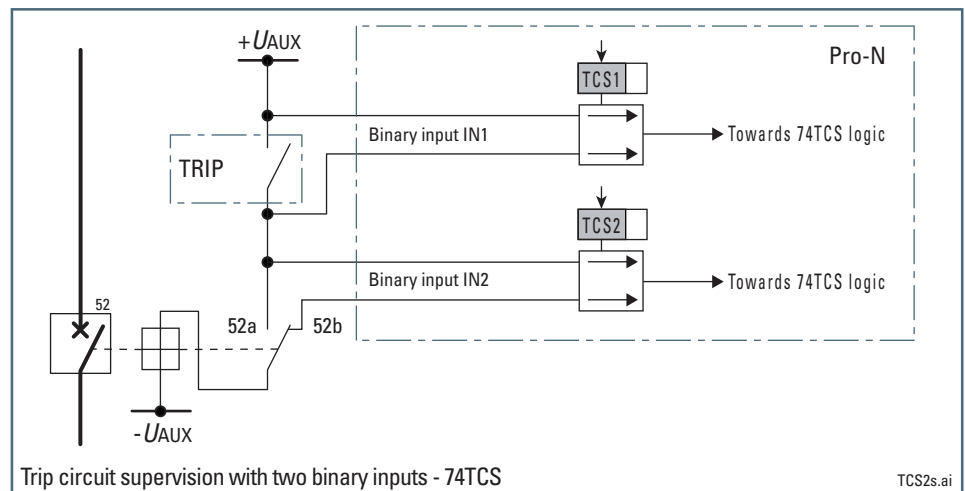
All the parameters can be set separately for **Profile A** and **Profile B**.

### Two inputs supervision

With two binary input all malfunctions are detected (inclusive of mechanics faults).

The binary inputs are connected to the trip and to the 52b contacts.

The CB auxiliary voltage must be 36 V at least (twice the minimum threshold for every binary input).



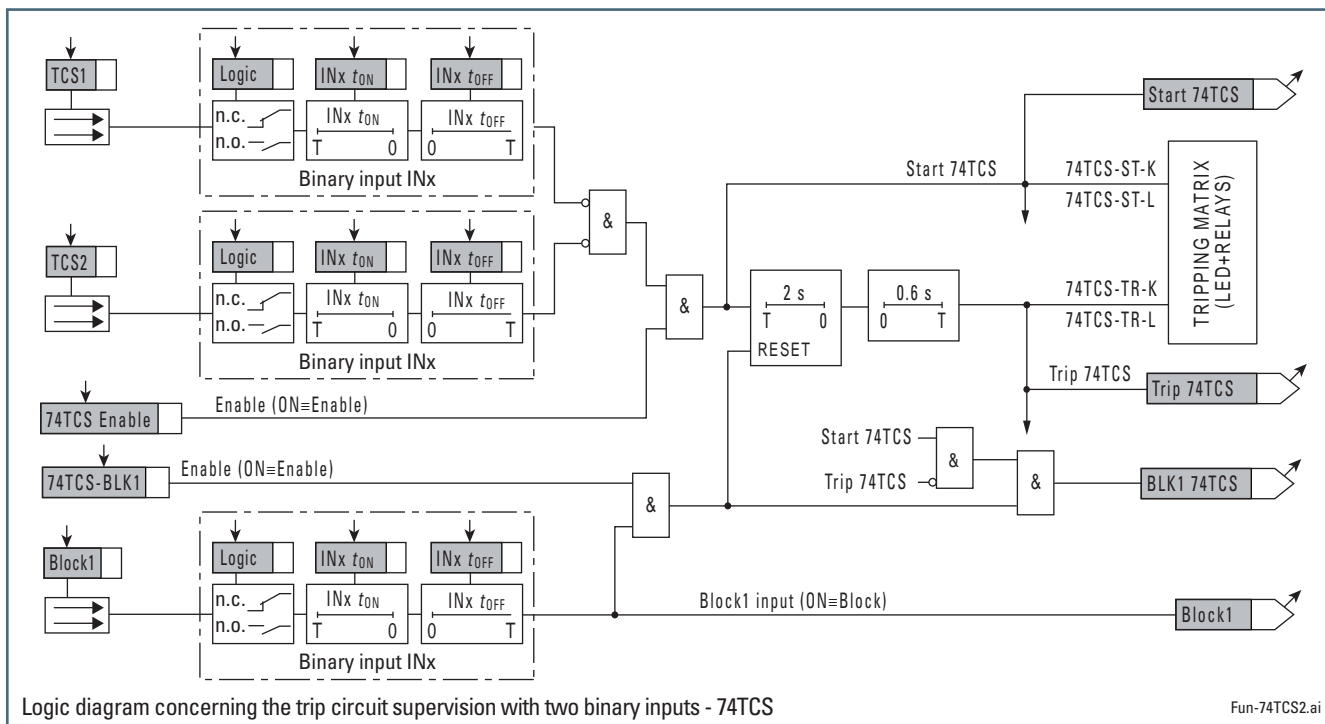
The faulty condition is detected occurs if both the following conditions are filled:

- A) The TRIP contact is closed (external protection relay tripped);
- B) The circuit breaker is closed (52a closed and 52b open).

Because such conditions can arise with healthy circuit too (e.g. a trip command is issued by the protection relay but the CB opening time is still in progress), to avoid untimely operations the previous condition are checked every 80 ms and the output is issued after a 2 s delay; outputs are reset to zero if at least the A or B condition become false after 0.6 s delay.<sup>[2]</sup>

*Note 1* Since two binary inputs are just used (*TCS1* and *TCS2*), an external I/O module is required for the logic block function. The exhaustive treatment of the logic block (Block 1) function may be found in the "Logic Block" paragraph inside CONTROL AND MONITORING section

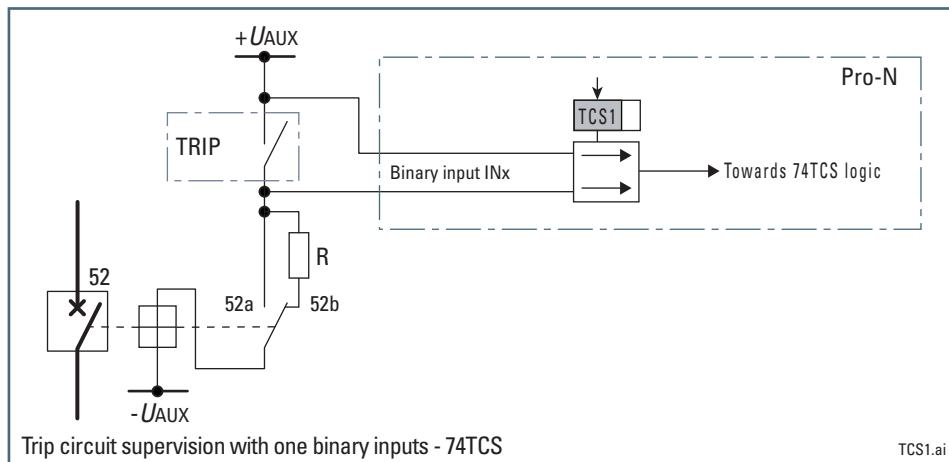
*Note 2* Following assumption are considered for the framework:  
*Logic*: ON,  
*Timers t<sub>ON</sub>* and *t<sub>OFF</sub>*: reset to zero  
*TRIP* contact of the protection: DE-energized, No latched



### One input supervision

By means of the right sizing of a resistor, the trip circuit supervision may be performed even with lower control voltage (e.g. when the control voltage is less than 36 V required for driving of two binary inputs, typically  $U_{AUX} = 24V$ ).

The binary input is connected to the trip and an external resistor must be connected the 52b auxiliary contact.



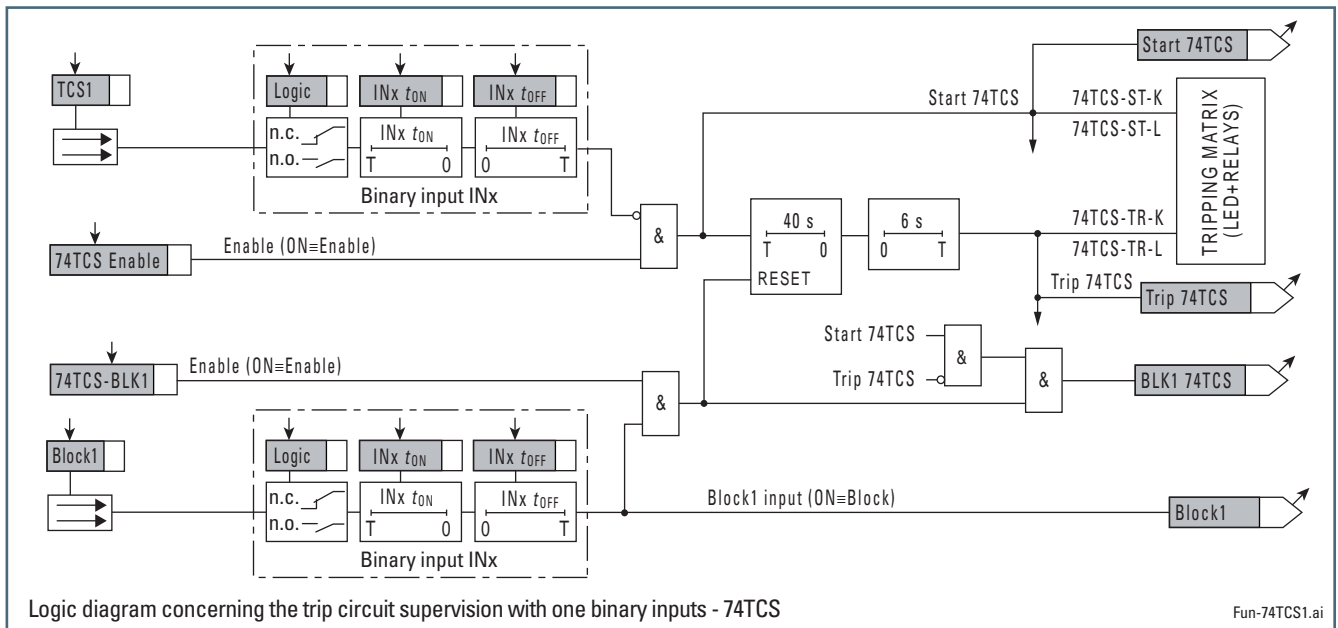
The fault condition of the trip circuit is detected by binary input power down.

With healthy circuit and TRIP contact closed, the binary input is feed across the 52a path (CB closed) or across the resistor R and 52b path (CB open).

When the TRIP contact turns ON, the binary input becomes short-circuited; to avoid untimely operations the previous condition are checked every 80 ms and the output is issued after a 40 s delay in order to allow the fault clearing and the consequent reset of the TRIP protection.

Outputs are reset to zero after 6 s from the TRIP contact open.<sup>[1]</sup>

Note 1 The trip contact (TRIP) of the protection relays must be set with automatic reset (No-latched operating mode).



### How to calculate resistance

Both the following conditions must be filled:

- 1) The circuit breaker coil must not be powered when the CB is open and an open command is issued;
- 2) The binary input is energized when the trip contact open.

- 1) If the circuit breaker is just open an unnecessary excitation must be avoided; the most critical event arises when the TRIP contact is closed (e.g. manual or test command), so with minimal series resistance. To avoid an unwanted excitation the series resistance must be higher than a minimum value defined as:

$$R_{min} = R_{TC} \cdot (U_{AUX} - U_{TCmin}) / U_{TCmin}$$

where:

$U_{TCmin}$ : minimum coil excitation voltage  
 $U_{AUX}$ : auxiliary voltage  
 $R_{TC}$ : coil resistance

- 2) To energize the binary input circuit when the TRIP contact and CB open, the series resistance must be lowerer than a maximum value defined as:

$$R_{max} = [(U_{AUX} - U_{DIGmin}) / I_{DIG}] - R_{TC}$$

where:

$U_{DIGmin}$ : minimum binary input excitation voltage (18 V)  
 $U_{AUX}$ : auxiliary voltage  
 $R_{TC}$ : coil resistance  
 $I_{DIG}$ : binary input excitation current (0.003 A)

To satisfy the above requirements, the R value must be chosen between the  $R_{min}$  and  $R_{max}$  values; typically the normalized value nearest the arithmetic mean:

$$R = (R_{min} + R_{max}) / 2$$

The power dissipated by the R resistor is:

$$P_R = R \cdot I^2 = R \cdot [U_{AUX} / (R + R_{TC})]^2$$

### Example

$U_{AUX} = 110$  Vcc (auxiliary voltage)  
 $P_{TC} = 50$  W (coil power)  
 $R_{TC} = U_{AUX}^2 / P_{TC} = 242 \Omega$  (coil resistance)  
 $U_{TCmin} = 77$  V (minimum coil excitation voltage = 70%  $U_{AUX}$ )  
 $U_{DIGmin} = 18$  V (minimum binary input excitation voltage)  
 $I_{DIG} = 0.003$  A (binary input excitation current)

$$R_{min} = R_{TC} \cdot (U_{AUX} - U_{TCmin}) / U_{TCmin} = 242 \cdot (110 - 77) / 77 = 103.7 \Omega$$

$$R_{max} = [(U_{AUX} - U_{DIGmin}) / I_{DIG}] - R_{TC} = [(110 - 18) / 0.003] - 242 = 30425 \Omega$$

$$R = (R_{min} + R_{max}) / 2 = (103.7 + 30425) / 2 = 15264 \Omega \sim 15 \text{ k}\Omega$$

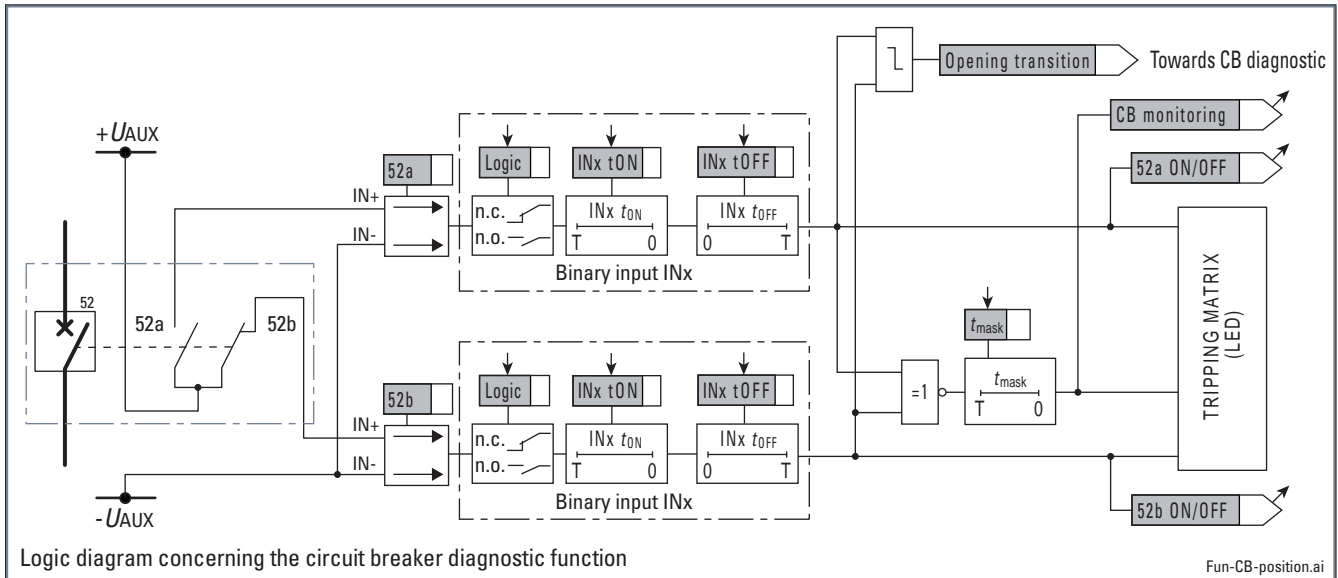
$$P_R \text{ (Power dissipated by the R resistor)} = U_{AUX}^2 / R = 110^2 / 15000 = 0.8 \text{ W}$$

## Circuit breaker supervision

### Preface

Several diagnostic metering and monitoring function are available:

- By means 52a and 52b auxiliary contacts, the CB position is acquired. Depending on such information the Open and/or Close commands can be safely issued by user.
- An adjustable threshold can be set for a wear estimate of the breaker contacts; the current values ( $\Sigma I$  or  $\Sigma I^2$ ) are summed and compared to a user-adjustable threshold. When the threshold or the number of operations is exceeded the relay can activate an output relay. The function helps to adjust maintenance planning.
- By means 52a and 52b auxiliary contacts, the opening time is calculated and compared to a user-adjustable threshold. If the threshold is exceeded the relay can activate an output relay.



### Operation and settings

According to the conventional contact position

- 52a is the auxiliary contact that is in the same position as the circuit breaker, (52a open = CB open),
- 52b is the auxiliary contact that is in the opposite position as the circuit breaker, (52a open = CB closed).

To acquire the CB position, the 52a and 52b function must be set inside the **Set \ Inputs \ Binary input 1** and **Set \ Inputs \ Binary input x** menus. The *IN1 tON*, *IN2 tON*, *IN1 tOFF* and *IN2 tOFF* time delays must be reset to zero and the *Logic* parameter must be set to *Active-ON* inside the **Set \ Inputs \ Binary input IN1** and **Set \ Inputs \ Binary input INx** menus.

### CIRCUIT BREAKER COMMANDS

Two output relays can be set to command CB opening and closing; the *CBopen-K* and *CBclose-K* function must be set inside the **Set \ Circuit breaker supervision \ LEDs-relays allocation** menu; the CB position can be visualized by means two LEDs (*CBopen-L* and *CBclosed-L* parameters). One or more CB state diagnostic relays may be assigned for failures signalling.

All the parameters are common for **Profile A** and **Profile B**.

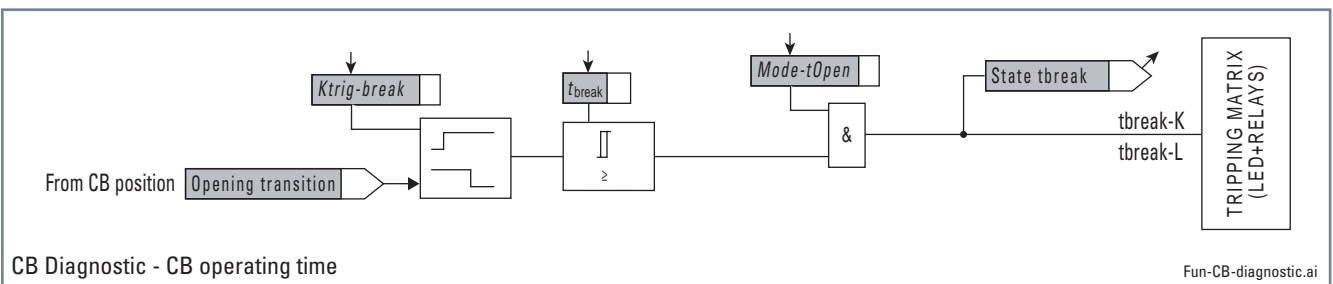
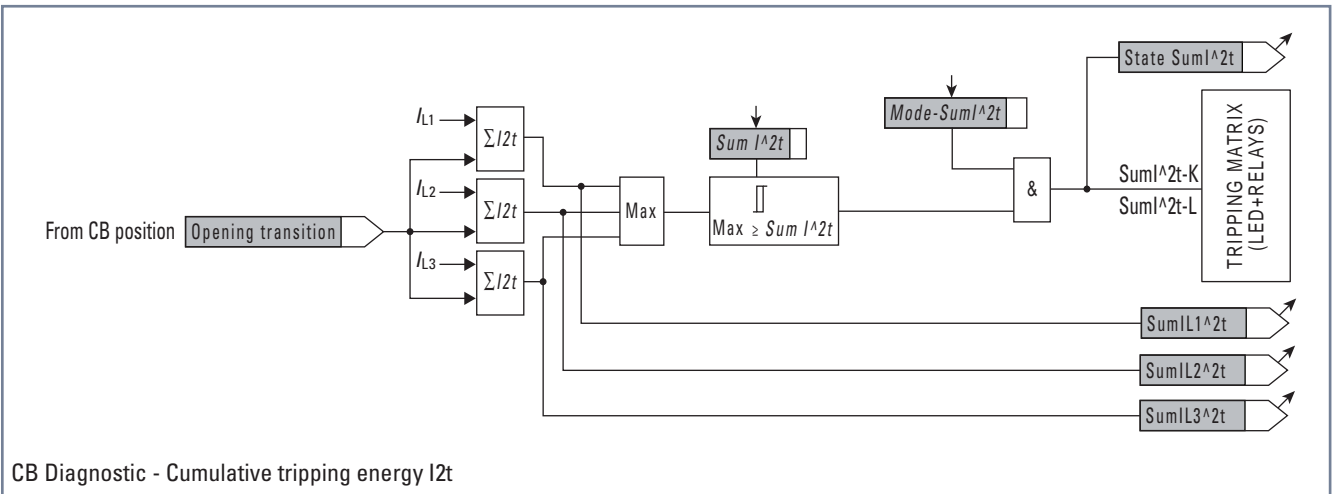
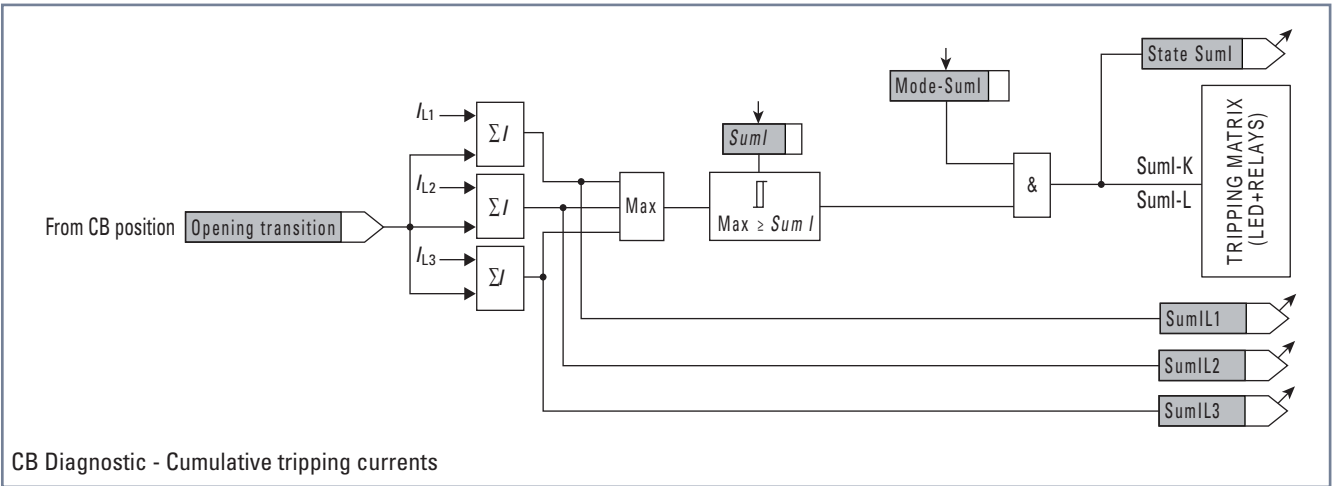
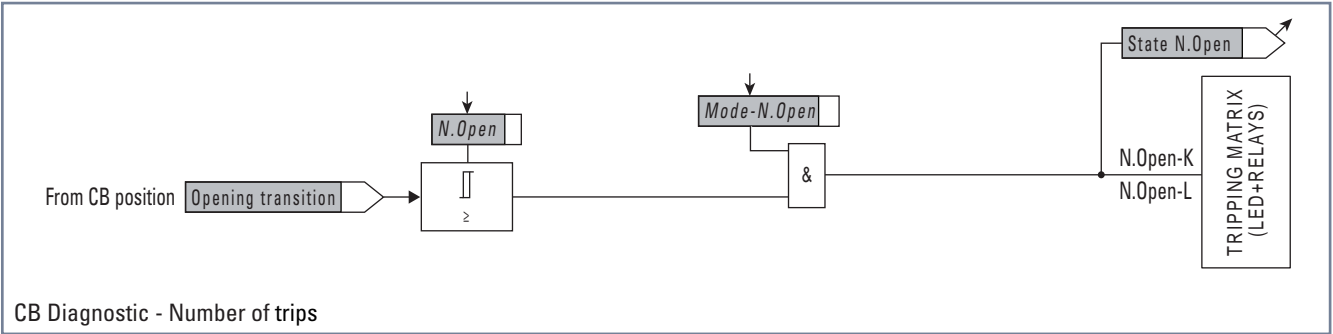
### CIRCUIT BREAKER DIAGNOSTIC

Four different criteria can be select.

- 1) Number of CB trip mode (*ModeN.Open OM*). When the number of operations (*N.Open*) is exceeded, an output relay and/or LED can be activated.
- 2) Cumulative CB currents mode (*ModeSumI ON*). When the per-phase value exceeds the threshold, an output relay and/or LED can be activated.
- 3) Cumulative CB  $I^2t$  mode (*ModeSumI^2t OM*). The tripping energy  $I^2t$  is calculated on the base of current measure at the time of the open command on the base of the circuit breaker opening time provided for  $I^2t$  calculation (*tbreak*). When the per-phase value exceeds the threshold, an output relay and/or LED can be activated.
- 4) CB operating time mode (*Mode-tOpen OM*). The time interval between the trip command and the CB open acquisition is calculated on the base of a programmable relay (*Ktrig-break*). When the time interval (*tbreak*) is exceeded, an output relay and/or LED can be activated.

The four criteria can be contemporaneously or separately set.

All the named parameters are available inside the **Set \ Circuit Breaker supervision \ CB Diagnostic** menu.



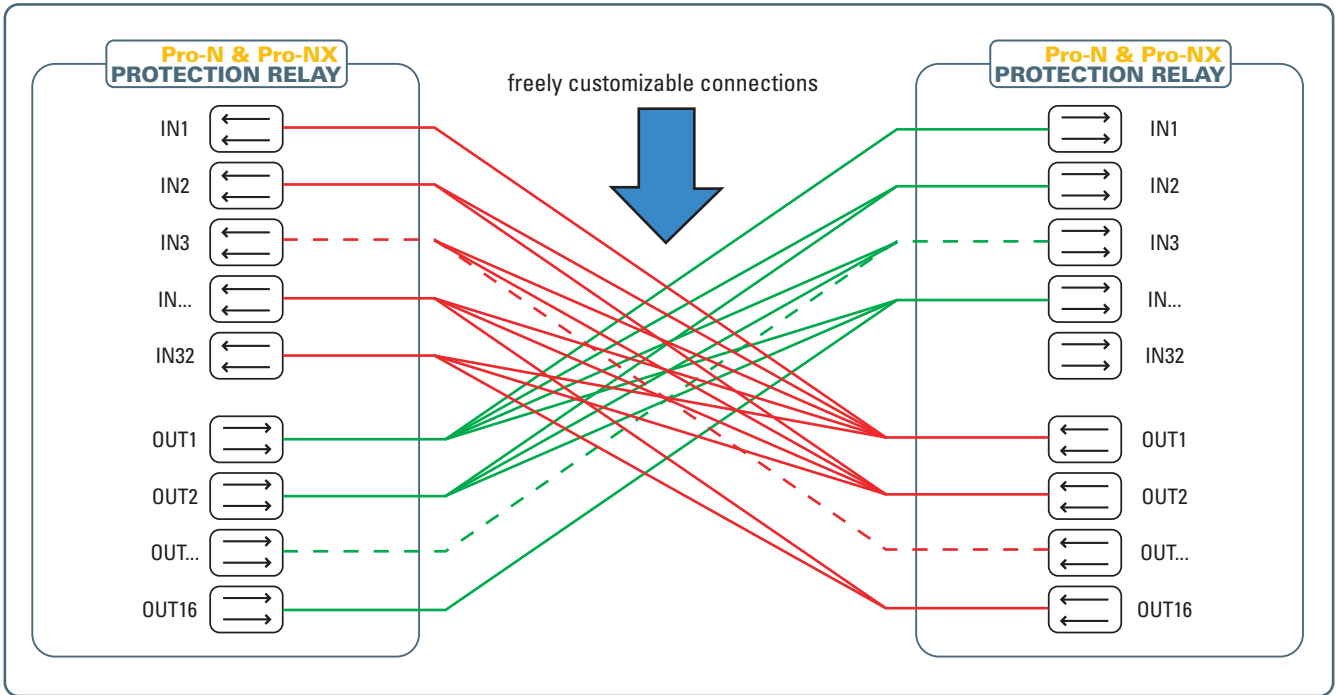
Fun-CB-diagnostic.ai

Preface

By ThyVisor and ThyVisor software tools the type of operation and links between outputs (Virtual Output - VOUT1 ... 16) and virtual inputs (Virtual Inputs - VIN1 ... VIN32) may be defined using RPC or IEC 61850 communication protocols over Ethernet network.

The system allows:<sup>[1]</sup>

- Availability of sixteen inputs and thirty-two outputs independently programmable by the user
- Simplify wiring using one channel as the Ethernet
- Eliminate the need to install communication devices and / or external conversion
- Significantly reduce costs
- Dynamically change from sw connections and associated functions.



Applications

With Pro-N and Pro-XX relay the virtual I / O can be usefully employed for:

- Transmit information between protections installed in significant distance where the traditional connections are critical in terms of reliability.
- Making OR logic for opening control of multiple DDI (simultaneous control of all DDI operated by each SPI) in cases of multiple interface protections (Smart Grids)
- Achieve accelerated logic discrimination in which some protection elements can be blocked by the activation of the downstream protection start; this allows to reduce the clearing time that, in time logic systems require trip time significantly long in correspondence of the power source.
- Circuit breaker commands
- Selection of setting profiles
- Remote trip
- Include I / O in the programmable logic (PLC)
- etc. ..

Note 1 For a detailed description please refer to the application notes

## Demand measures

Demand measures are calculated as:

### Fixed demand

Fixed demand  $I_{L1FIX}$ ,  $I_{L2FIX}$ ,  $I_{L3FIX}$

Every fixed demand period  $t_{FIX}$  an average magnitude is calculated based on samples taken every 1 second. Update is carried out at the end of the same period. The fixed demand measures may be reset to zero by means the **Reset on demand measures command** (ThyVisor **Commands** menu).

The  $t_{FIX}$  parameter (Fixed demand period) is available inside the **Set \ Demand measures** menu.

### Rolling demand

Rolling demand  $I_{L1ROL}$ ,  $I_{L2ROL}$ ,  $I_{L3ROL}$

The average magnitude is calculated inside a mobile window of  $N \cdot T$  length where:

- $N$  is the user-defined number of cycles and,
- $T$  is the user-defined sub-period.

An average magnitude is calculated based on samples taken every 1 second; update is carried out at the end of the every sub-period. The rolling demand measures may be reset to zero by means the **Reset on demand measures command** (ThyVisor **Commands** menu).

The  $t_{ROL}$  (Rolling demand period) and  $N_{.Rol}$  (Number of cycles for rolling on demand) parameters are available inside the **Set \ Demand measures** menu.

### Peak demand

Peak demand  $I_{L1MAX}$ ,  $I_{L2MAX}$ ,  $I_{L3MAX}$

Every sub-period  $t_{ROL}$  the maximum value of the average magnitude is calculated based on samples taken every 1 second. Update is carried out at the end of the same period. The peak demand measures may be reset to zero by means the **Reset on demand measures command** (ThyVisor **Commands** menu).

The  $t_{ROL}$  (Rolling demand period) parameter is the same for rolling demand setting.

### Minimum demand

Minimum demand  $I_{L1MIN}$ ,  $I_{L2MIN}$ ,  $I_{L3MIN}$

Every sub-period  $t_{ROL}$  the minimum value of the average magnitude is calculated based on samples taken every 1 second. Update is carried out at the end of the same period. The peak demand measures may be reset to zero by means the **Reset on demand measures command** (ThyVisor **Commands** menu).

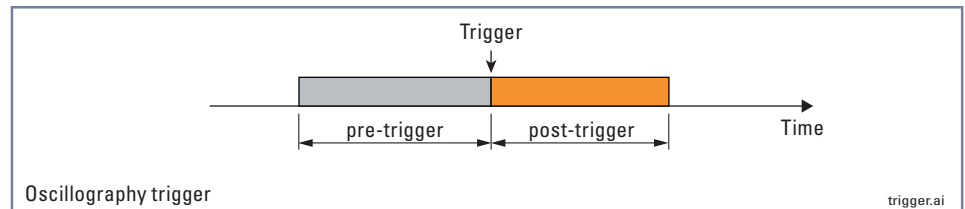
The  $t_{ROL}$  (Rolling demand period) parameter is the same for rolling demand setting.

## Oscillography

### Trigger Setup

Following parameters, available inside the **Set \ Oscillography \ Trigger Setup** menu, are user-programmable:

- *Pre-trigger time* and *Post-trigger time*.



- *Element pickup trigger*; the information recording starts when a state transition on any protective element occurs if the parameter is set to *ON*.
- *Trigger from outputs*; the information recording starts when a state transition on the selected output relay occurs if the parameter is set (K1...K6).
- *Binary input trigger*; the information recording starts when a state transition on the selected binary input occurs if the parameter is set to *ON*.
- *Trigger from inputs*; the information recording starts when a state transition on the selected binary input occurs if the parameter is set (IN1...INx).
- *80% Buffer alarm*; when the 80% of the buffer space is reached an alarm may be issued if the parameter is set to *ON*.

### Set sampled channels

The desired sampled quantities may be select inside the **Set \ Oscillography \ Set sampled channels** menu ( $i_{L1}$ ,  $i_{L2}$ ,  $i_{L3}$ ,  $i_E$ ).

### Set analog channels

The desired sampled quantities may be select inside the **Set \ Oscillography \ Set analog channels** menu.

Everyone of twelve analog channel may be associated to one of the selected measures (Frequency,  $I_{L1}$ ,  $I_{L2}$ ,  $I_{L3}$ ,  $i_E$ ,  $h_1$ ,  $h_2$ ,  $I_{L1-2nd}$ ,  $I_{L2-2nd}$ ,  $I_{L3-2nd}$ ,  $I_{2nd/L}$ ,  $T_1...T_8^{[1]}$ ).

### Set digital channels

The desired digital quantities may be select inside the **Set \ Oscillography \ Set digital channels** menu.

Everyone of twelve digital channel may be associated to one of the selected I/O signal (K1... K6, K7... K10, IN1, IN2, IN3...IN45<sup>[2]</sup>).

Nota 1 The 26 menu is available when the MPT module is enabled

Nota 2 The output relay K7...K10 and binary input IN3...IN45 states is meaningful when the I/O circuits are present (MRI and MID16 modules)

## 5 MEASURES, LOGIC STATES AND COUNTERS

### Measures

#### Direct

- Frequency  $(f)$
- RMS value of fundamental component for phase currents  $(I_{L1}, I_{L2}, I_{L3})$
- RMS value of fundamental component for residual current  $(I_E)$

#### Calculated

- Thermal image  $(D\theta)$
- Maximum current between  $I_{L1}-I_{L2}-I_{L3}$   $(I_{Lmax})$
- Minimum current between  $I_{L1}-I_{L2}-I_{L3}$   $(I_{Lmin})$
- Average current between  $I_{L1}-I_{L2}-I_{L3}$   $(I_L)$

#### Sequence

- Positive sequence current  $(I_1)$
- Negative sequence current  $(I_2)$
- Negative sequence current/positive sequence current ratio  $(I_2/I_1)$

#### 2nd harmonic

- Second harmonic phase currents  $(I_{L1-2nd}, I_{L2-2nd}, I_{L3-2nd})$
- Maximum of the second harmonic phase currents/  
fundamental component percentage ratio  $I_{2nd}/I_L$   $(I_{2nd}/I_L)$

#### 3rd harmonic

- Third harmonic phase currents  $(I_{L1-3rd}, I_{L2-3rd}, I_{L3-3rd})$
- Third harmonic of residual current  $(I_{E-3rd})$

#### 4th harmonic

- Fourth harmonic phase currents  $(I_{L1-4th}, I_{L2-4th}, I_{L3-4th})$

#### 5th harmonic

- Fifth harmonic phase currents  $(I_{L1-5th}, I_{L2-5th}, I_{L3-5th})$

#### On demand

- Phase fixed currents demand  $(I_{L1FIX}, I_{L2FIX}, I_{L3FIX})$
- Phase rolling currents demand  $(I_{L1ROL}, I_{L2ROL}, I_{L3ROL})$
- Phase peak currents demand  $(I_{L1MAX}, I_{L2MAX}, I_{L3MAX})$
- Phase minimum currents demand  $(I_{L1MIN}, I_{L2MIN}, I_{L3MIN})$

### Protection

For each protection threshold, the following data are available:

- Start *ON/OFF*
- Trip *ON/OFF*
- Logic block (Block1) *ON/OFF*
- Selective block (Block2) *ON/OFF*
- Cold Load Pickup *ON/OFF*

### Delayed inputs

The binary input states, acquired downstream the delay timers are available:

- IN1 *ON/OFF*
- IN2 *ON/OFF*
- INx *ON/OFF*

### Internal states

The state of the functions assigned to binary inputs are available:

- Reset LEDs *ON/OFF*
- Profile selection *ON/OFF*
- Fault trigger *ON/OFF*
- IE /IPh Block2 *ON/OFF*
- IPh Block2 *ON/OFF*
- IE Block2 *ON/OFF*
- Block1 *ON/OFF*
- Tcs1 *ON/OFF*
- Tcs2 *ON/OFF*
- Trip External protections *ON/OFF*
- Reset partial counters *ON/OFF*
- Reset CB monitoring data *ON/OFF*
- 52a *ON/OFF*
- 52b *ON/OFF*
- Open CB *ON/OFF*
- Close CB *ON/OFF*
- Thermal image presetting *ON/OFF*
- Remote trip *ON/OFF*
- Reset on demand measures *ON/OFF*

## Relays

For every output relay, the output operating state and diagnostic are available (**ReadRelays** menu):

• K1 State	ON/OFF
• K1 Diagnostic	OK/NOT OK
• K2 State	ON/OFF
• K2 Diagnostic	OK/NOT OK
• .....	
• Kx State	ON/OFF
• Kx Diagnostic	OK/NOT OK

## Counters

For every element two set of counters are available (Partial counters and Total counters); the partial counters can be cleared by the user level, while the Total counter reset can be achieved with password (Session Level 1).

Every partial counter is reset to zero when ten thousand count is passed.

All partial counters can be cleared by means a single command; for this purpose the Reset partial counters command must be issued (**CommandsReset** submenu).

- 37 - counter
- 46 - counter
- I2/I1 - counter
- 49 - counter
- 50/51 - counter
- 50N/51N - counter
- 2ndh-REST - counter
- 74TCS - counter
- CB - counter
- 74CT - counter
- BF - counter

### Partial counters

• xx Start partial counter (xx = I>, I>>,...)	0...9999
• xx Trip partial counter (xx = I>, I>>,...)	0...9999
• xx Block1 partial counter (xx = I>, I>>,...)	0...9999
• xx Block2 partial counter (xx = I>, I>>,...)	0...9999

### Total counters

• xx Start total counter (xx = I>, I>>,...)	0...9999
• xx Trip total counter (xx = I>, I>>,...)	0...9999
• xx Block1 total counter (xx = I>, I>>,...)	0...9999
• xx Block2 total counter (xx = I>, I>>,...)	0...9999

## Self test

Lower level diagnostic (MINOR) can be output or ignored; for this purpose the *MINOR Fail alarm* parameter can be set *ON* or *OFF* inside the **SetSelf test relay** submenu.

Following anomalies (MINOR) are not relevant (the protective elements continue to work):

- Errors concerning the digital fault recorder.
- Internal bus.

The self test information are:

• Protection and controls	ON SERVICE/OUT OF SERVICE
• System diagnostic	OK/NOT OK
• Device diagnostic	OK/NOT OK
• Program diagnostic	OK/NOT OK
• Data-base boot	OK/NOT OK
• Data-base runtime	OK/NOT OK
• DSP boot	OK/NOT OK
• DSP run-time	OK/NOT OK
• Memory boot	OK/NOT OK
• Memory run-time	OK/NOT OK
• Data Bus heavy	OK/NOT OK
• Data Bus minor	OK/NOT OK
• Oscillography run-time	OK/NOT OK
• PLC boot	OK/NOT OK
• PLC run-time	OK/NOT OK
• Protection I/O assigned verify startup	OK/NOT OK
• Protection I/O assigned verify run-time major	OK/NOT OK
• Protection I/O assigned verify run-time minor	OK/NOT OK
• Total protection I/O assigned not-matching	0
• Protection I/O assigned not-matching	
• PLC I/O assigned not-matching	OK/NOT OK
• PLC I/O assigned not-matching run-time major	OK/NOT OK
• PLC I/O assigned not-matching run-time minor	OK/NOT OK
• Total PLC I/O assigned not-matching	0
• PLC I/O assigned not-matching	
• MMI module Boot	OK/NOT OK
• MMI module Run-time	OK/NOT OK
• MRI module Boot	OK/NOT OK
• MRI module Run-time	OK/NOT OK

- MID16-1 module Boot OK/NOT OK
- MID16-1 module Run-time OK/NOT OK
- MID16-2 module Boot OK/NOT OK
- MID16-2 module Run-time OK/NOT OK
- PT100 module Boot OK/NOT OK
- PT100 module Run-time OK/NOT OK
- Current loop module Boot OK/NOT OK
- Current loop Run-time OK/NOT OK
- Oscillography run-time OK/NOT OK

The diagnostic alarms can be allocated to an output relay; for this purpose the *Self-test relay* parameter can be set ( $K1...K6$ ) inside the **Set \ Self-test Relay** submenu.

### Pilot wire diagnostic

Detailed diagnostic information about the pilot wire are available. (**Read \ Pilot wire diagnostic**).

- BLIN1 pilot wire breaking diagnostic state ON/OFF
- Pilot wire BLIN1 shorted ON/OFF

### Selective Block - BLOCK2

The input and output state concerning the selective block are available (**Read \ Selective block-BLOCK2**).

#### Block2 input

- Phase protections input selective block state  $BLK2IN-Iph$  ON/OFF
- Ground protections input selective block state  $BLK2IN-IE$  ON/OFF
- tB-Iph/IE Elapsed state  $tB\ timeout$  ON/OFF

#### Block2 output

- Starting state of phase protections enabled for external selective block on output  $ST-Iph-BLK2$  ON/OFF
- Starting state of ground protections enabled for external selective block on output  $ST-IE-BLK2$  ON/OFF
- Phase protections output selective block state  $BLK2-OUT-Iph$  ON/OFF
- Ground protections output selective block state  $BLK2-OUT-IE$  ON/OFF
- Phase and ground protections output selective block state  $BLK2-OUT-Iph/IE$  ON/OFF

### Fault recording - SFR

Recording is triggered by one or more causes (up to 8 simultaneous):

- Activation (OFF-ON transition) of any relay programmed for trip of protection or control element
- External trigger (binary input programmed as *Fault trigger*)

Twenty events are recorded into a circular FIFO (First In, First Out) buffer.<sup>[1][2]</sup>

Following information are stored in every record:

- Fault counter<sup>[3]</sup>
- Date and time
- Fault cause (element trip)
- Phase currents  $I_{L1r}, I_{L2r}, I_{L3r}$
- Residual current  $I_{Er}$
- Thermal image  $Dtheta-r$
- Negative sequence current  $I_{2r}$
- Negative sequence current/positive sequence current ratio  $(I_2/I_1)_r$
- Inputs IN1-IN5
- Outputs K1-K6
- Fault cause info (eg. faulted phase)

### Event recording - SER

Recording is triggered by one or more causes:

- Start and/or trip of any enabled protection or control element
- Binary input activation (OFF-ON or ON-OFF transition)
- Power-on or power-down (Auxiliary power supply)
- Setting change.

Three hundred events are recorded into a circular FIFO (First In, First Out) buffer.<sup>[2][4]</sup>

Following information are stored in every record:

- Event counter<sup>[5]</sup>
- Date and time
- Event cause (binary input/output relay/setting changes)

*Note 1* Fault 0 is the newest fault, while the Fault 19 is the oldest fault

*Note 2* Data are stored into non-volatile memory; they are retained once power is turned off.

*Note 3* Counter is updated at any new record; it may be cleared by means ThyVisor

*Note 4* Event 0 is the newest event, while the Event 299 is the oldest event

*Note 5* Counter is updated at any new record; it may be cleared by means ThyVisor

## Oscillography - DFR

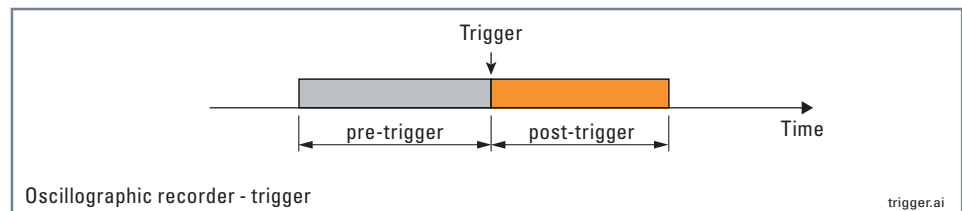
Upon programmable trigger, the fault records are recorded in COMTRADE format; the sampled measures (24 sample per cycle) are stored in a circular shift memory buffer.

The fault records are self-triggered; they are stored in sequential order up the allocated memory is used up after which the oldest memory is overwritten.

An operating procedure example for the digital fault recording is illustrated inside the ThyVisor section.

Following parameters are user-programmable:

- Pre-trigger and post-trigger time
- Selected sampled quantities.
- Analog channels (1...12) allocation.
- Digital channels (1...12) allocation (output relay and/or binary inputs).
- Trigger setup; the information storage starts when a state transition on the selected signal occurs. (protective element start and/or trip, output relay and/or binary input switching).
- Alarm: when the 80% of the buffer space is reached an alarm may be issued. The system being of linear type, the records are back-to-back recorded to the end of available memory; the alarm output is a warning in order that the user may download data<sup>[1]</sup> to clear memory for new records.



## COMTRADE

Records are recorded in COMTRADE format; (Common Format for Transient Data); This is a standard for the data exchange for various types of tests or simulation datas, etc, for power system applications.

The measurements are recorded in ASCII or BINARY format. COMTRADE files always come by pairs:

- The ".CFG"-file describing the configuration: number of analog and digital channels, sampling rate, scale factors, etc.
- The ".DAT"-file containing the data

The COMTRADE is part of IEC 60255-24 standard.

The recording can be analyzed by mean of ThyVisor sw or any other standard compliant viewer.

The record quantity is depending on settings of following parameters:

- Pre-trigger and post-trigger times
- Number of allocated channels.

By means of the following formula the record quantity may be evaluated:

$$N = \text{int} \left[ \frac{12000}{(34 + 20 \cdot v_i + 4 \cdot v_{\text{RMS}} + n_B) \cdot (t_{\text{pre}} + t_{\text{post}}) (\text{s})} \cdot \frac{50 (\text{Hz})}{f (\text{Hz})} \right]$$

where:

- $N$  record quantity
- $v_i$  sampled measures
- $v_{\text{RMS}}$  analog measures (RMS)
- $n_B$  logic variables (2 up to 16 variables)
- $t_{\text{pre}}$  pre-trigger time interval
- $t_{\text{post}}$  post-trigger time interval
- $f$  frequency

### Example 1

With the following setting:

- Pre-trigger: 0.25 s
- Post-trigger: 0.25 s
- Sampled measures:  $i_{L1}, i_{L2}, i_{L3}, i_E$
- Analog measures:  $U_{L1}, U_{L2}, U_{L3}, U_E$
- Logic variables: K1, K2, K3, K4, K5, K6, IN1, IN2

up to 180 record can be stored if  $f = 50 \text{ Hz}$ , since:

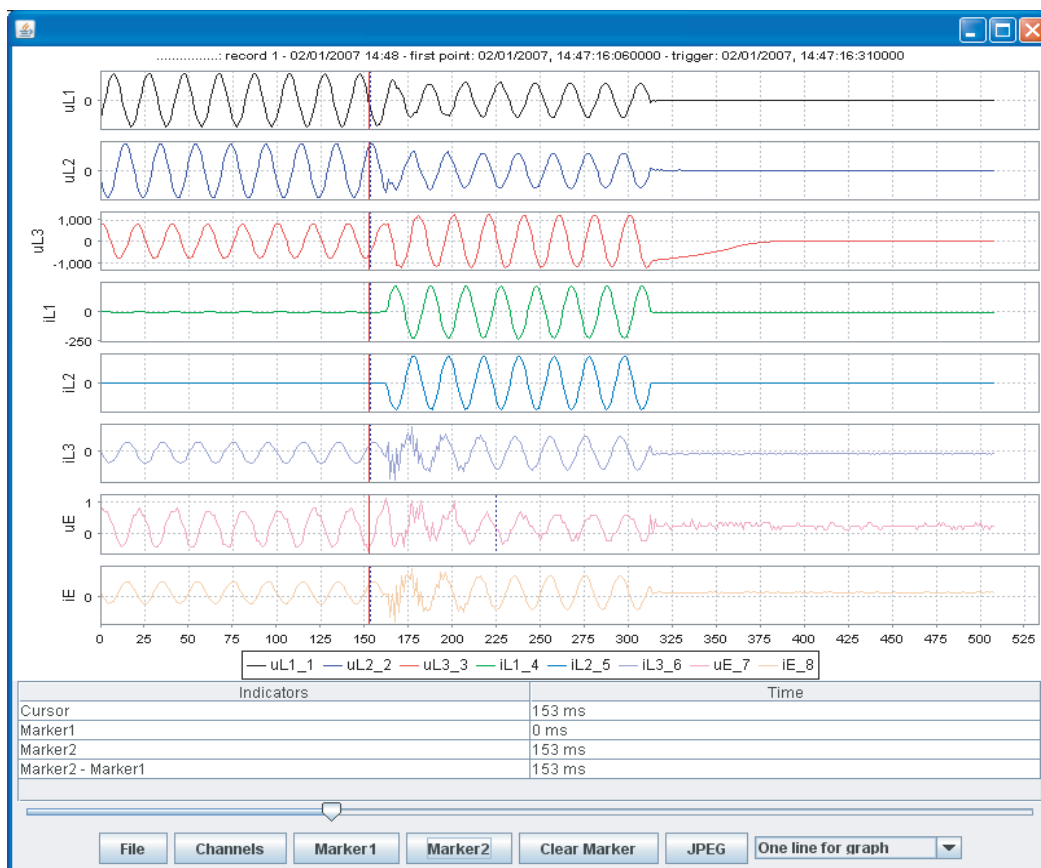
$$N = \text{int} \left[ \frac{12000}{(34 + 20 \cdot 4 + 4 \cdot 4 + 2) \cdot (0.25 + 0.25)} \cdot \frac{50 (\text{Hz})}{50 (\text{Hz})} \right] = 180$$

### Example 2

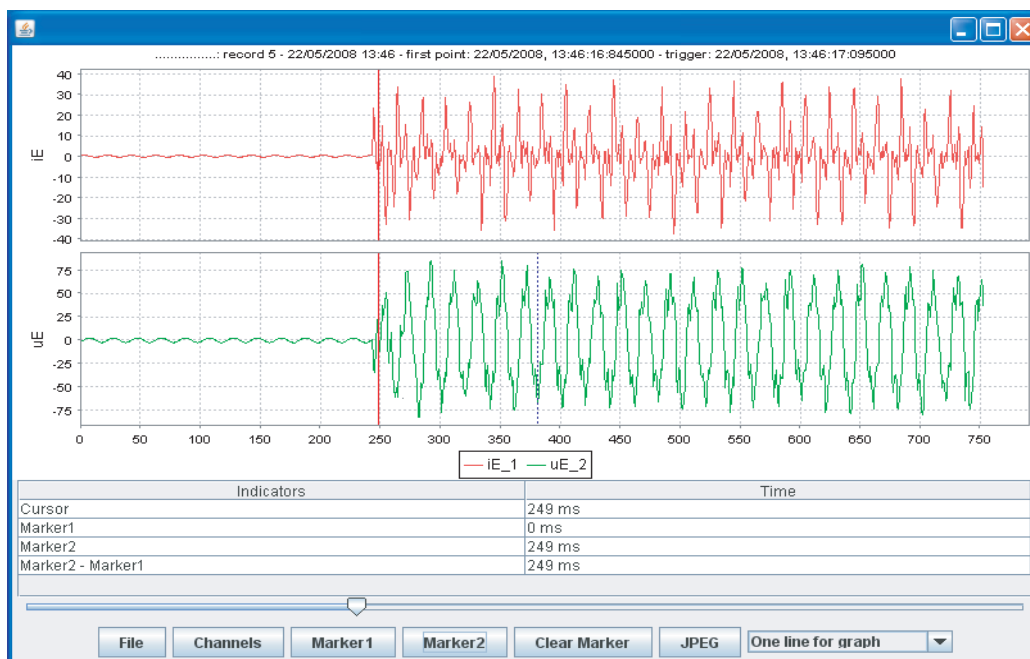
With following setting:

- Pre-trigger: 0.5 s
  - Post-trigger: 0.5 s
  - Sampled data:  $\dot{i}_{L1}, \dot{i}_{L2}, \dot{i}_{L3}, \dot{i}_E$
  - Analog channels:  $\dot{u}_{L1}, \dot{u}_{L2}, \dot{u}_{L3}, \dot{u}_E$
  - Digital channels: K1, K2, K3, K4, K5, K6, IN1, IN2
- up to 75 records can be stored if  $f = 60$  Hz, since:

$$N = \text{int} \left[ \frac{12000}{(34 + 20 \cdot 4 + 4 \cdot 4 + 2) \cdot (0.50 + 0.50)} \cdot \frac{50 \text{ (Hz)}}{60 \text{ (Hz)}} \right] = 75$$



Phase/to/phase fault record



Phase/to/earth fault record

## 6 INSTALLATION

### 6.1 PACKAGING

Packaging consists of a paperboard packaging guaranteeing adequate protection for transport and storage under normal environmental conditions.

The Pro-N protection relays must be stored within the required temperature limits; the relative humidity should not cause condensation or formation of frost.

It is recommended that the devices are stored in their packaging; in the case of long storage, especially in extreme climatic conditions.

It is recommended that the packaging not be disposed of into the environment, but kept in case the relay should be moved at some later time.

### 6.2 MOUNTING

The Pro-N protection relays are housed inside metal cases suitable for various kinds of assembly:

- Flush mounting
- Projecting mounting
- With separate operator panel
- Rack.

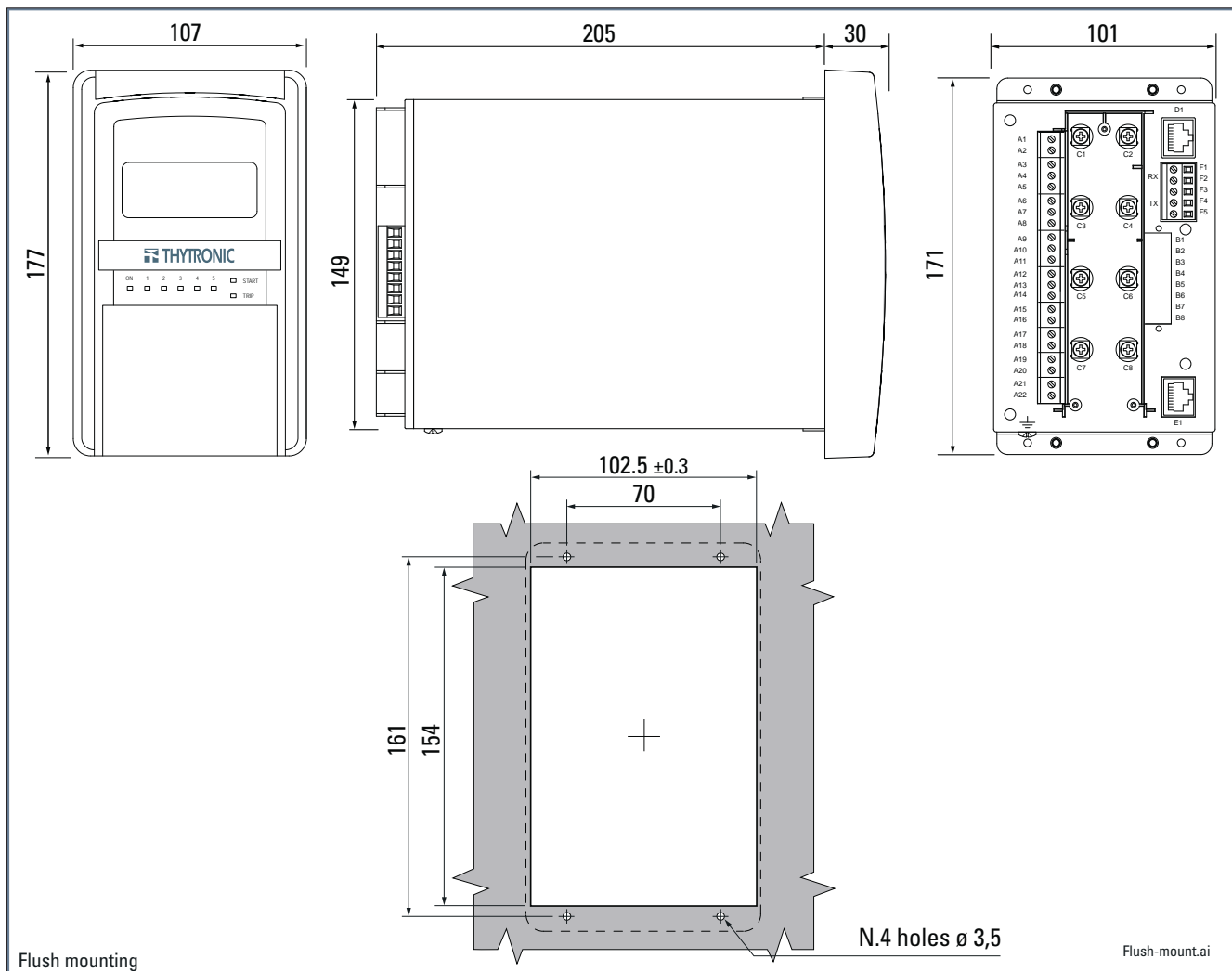
Removability is ensured to facilitate maintenance operations so that the electronic module can be replaced; this provides minimum downtime and maximum protection availability.

#### *Flush mounting*

The fixed case, fitted with special fastening brackets, is mounted on the front of electric control board, previously drilled as indicated in the drawing.

In case of side-by-side mounting of several relays the minimum drilling distance is determined by the front dimensions indicated in the overall dimensions drawing, increased by 3 mm, to ensure an adequate tolerance and gasket space between adjacent relays.

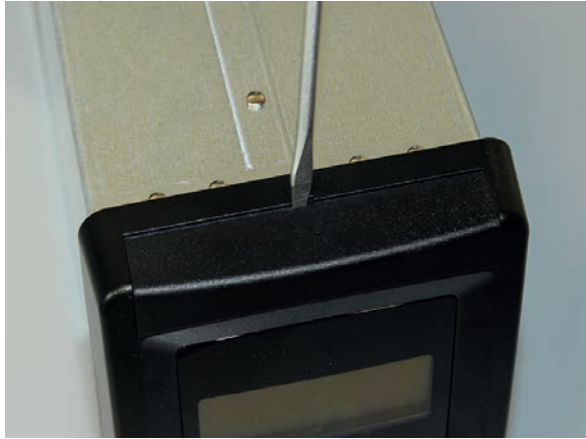
The depth dimension, as indicated in the drawing, must be increased by as much as needed to allow room for the wiring.



#### NOTE

Separation of fixed and removable parts is NOT required

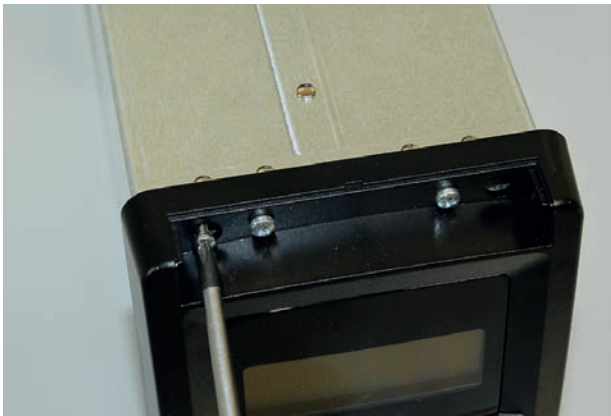
- Remove the upper tile and open the little door to access the fastening screws.



Removing tie to access the fastening screws

Remove-tile.ai

- The fixed case is fastened by means of four screws onto the panel as indicated in the drawing.

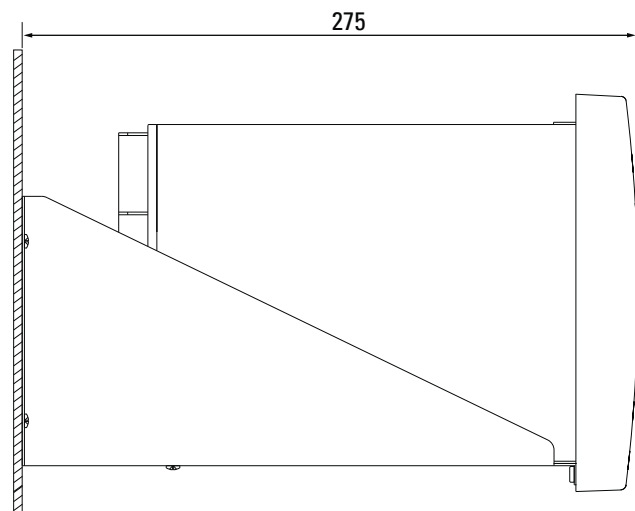
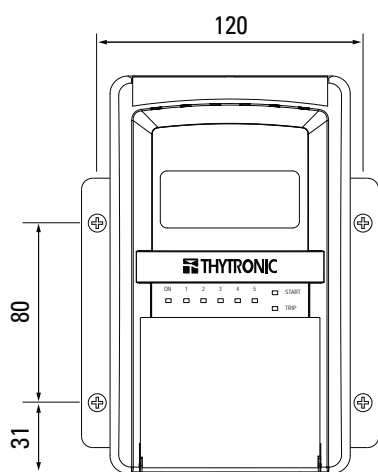


Four screws

Flush-mount1.ai

*Projecting mounting*

- Remove the ground screw and open the little door to access the fastening screws.
  - Make all connections and join the relay to the framework with front and earth screws.
- In case of side-by-side mounting of several relays, the minimum fixing distance is determined by the dimensions of the mounting plate indicated in the overall dimensions drawing, increased horizontally and vertically by as much as needed to allow room for the wiring and to ensure an adequate tolerance between devices.



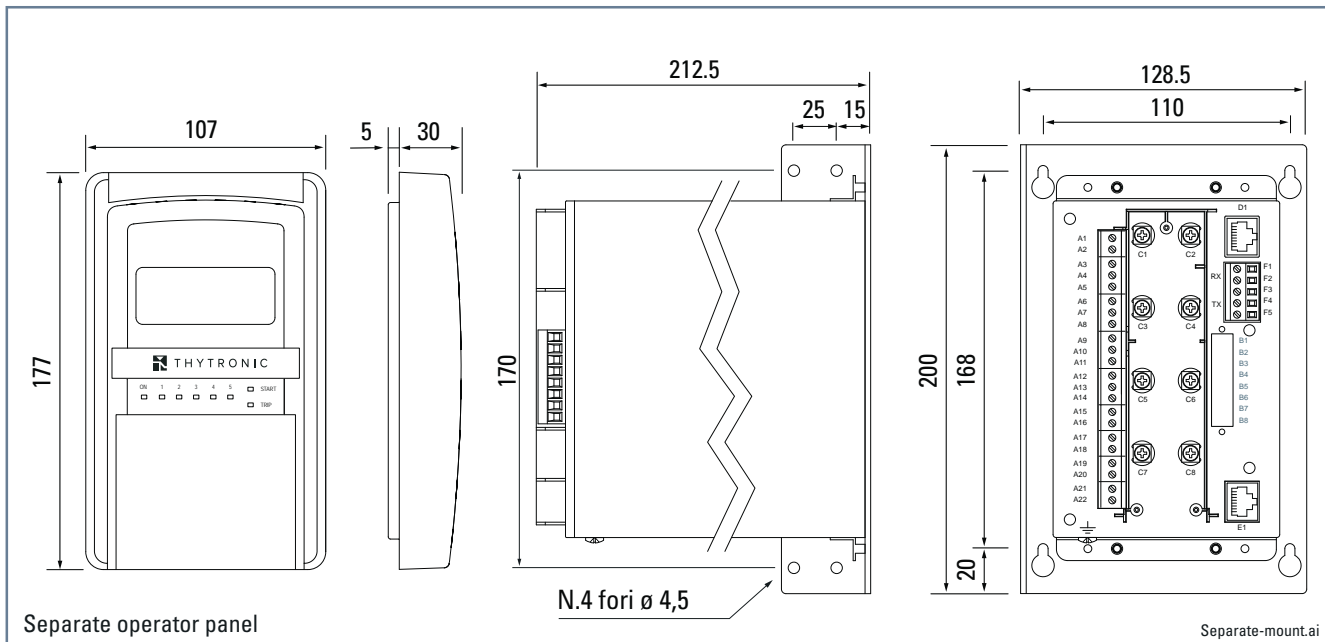
Projecting mounting

Projecting.ai

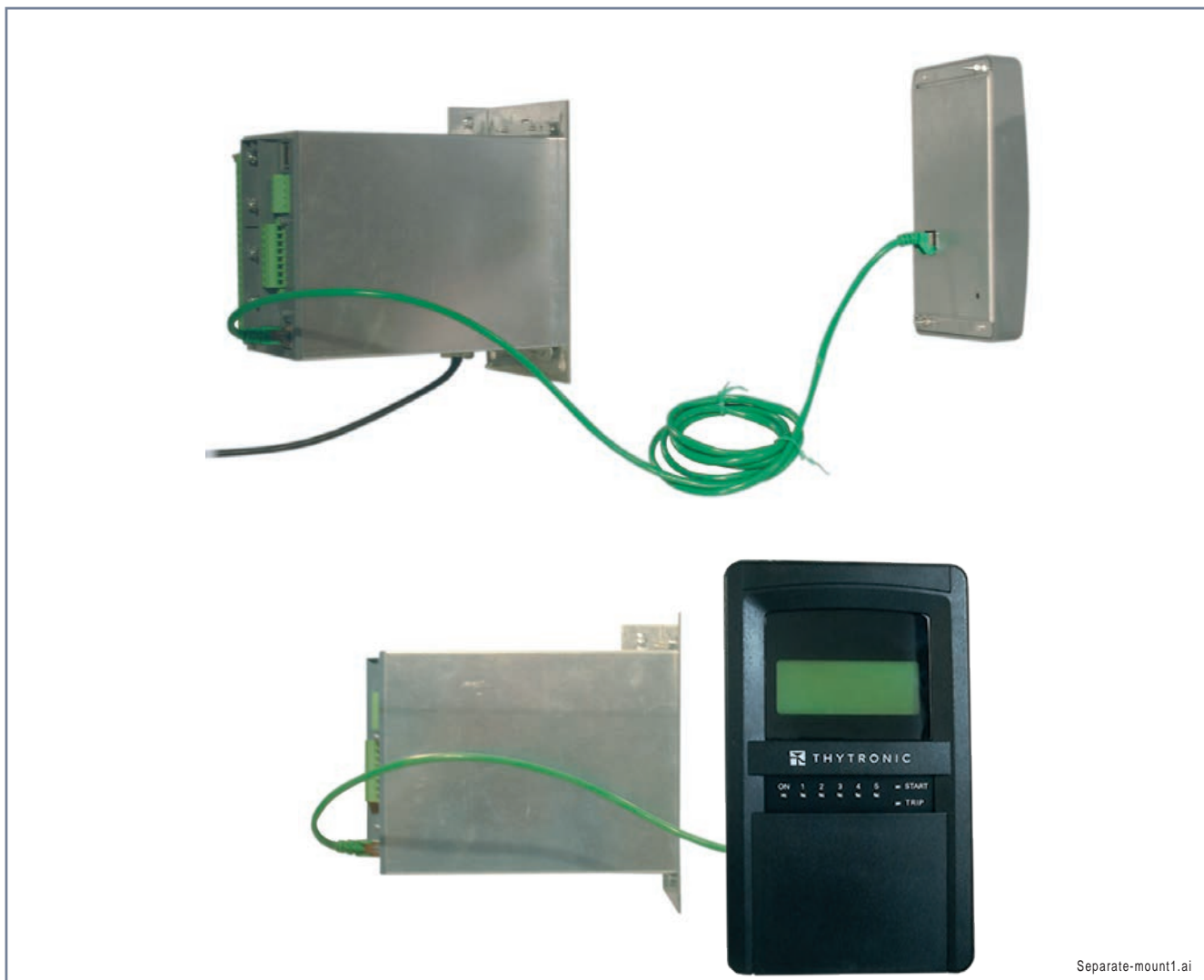
Separate operator panel

The solution with projecting assembly and a separate operator panel is particularly suitable for limited in depth installations.

Cutout dimension and mounting steps concerning the separate operator panel are the same for the flushing mounting (see previous pages).

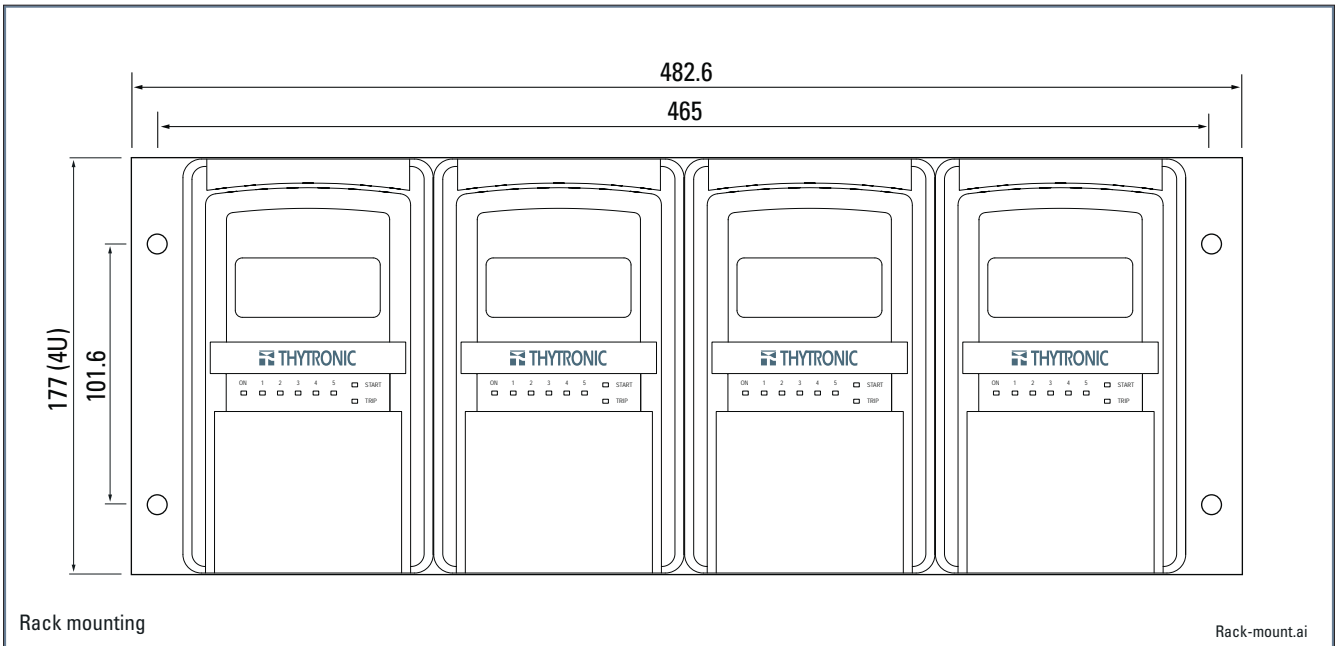


A standard direct shielded cable with RJ45 connectors must be used for connections.



*Rack mounting*

For mounting inside a standardized 19-inch system (EIA 310-D, IEC 60297 and DIN 41494 SC48D), the MAR adapter is required (available on request).



To allow opening of the keyboard door a one unit space must be provided when several rack are overlapping mounted.

6.3 ELECTRICAL CONNECTIONS

Electrical connections should be made by referring to the connection diagram; in cases where certain of the circuits (communication, block, or others) are not used, the relevant connections must remain open. Examples of connection diagrams are reported on Appendix to this manual.



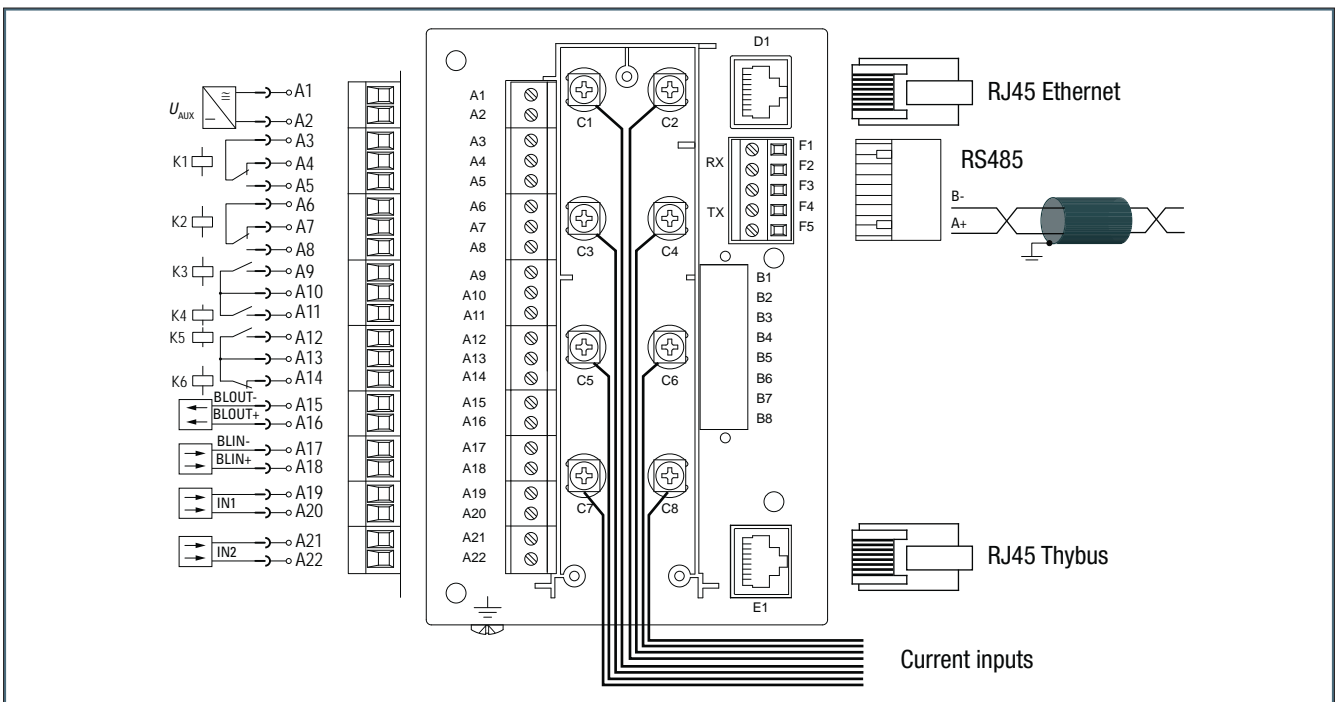
**CAUTION**

Devices must be installed by qualified personnel only.  
No liability is accepted from Thytronic due to improper use.

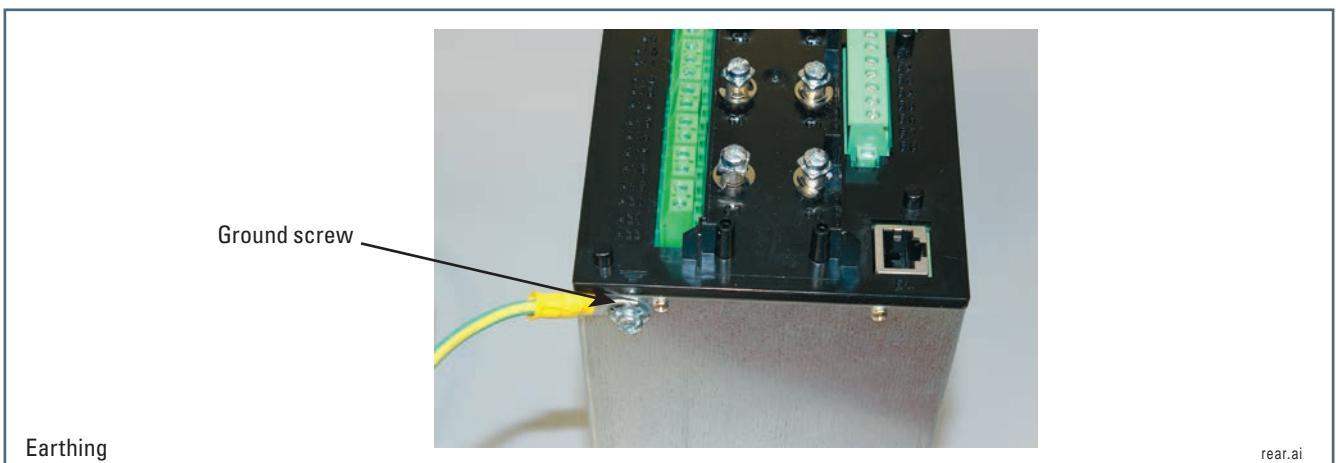
- For the A1...A22 connections, screw terminals with following characteristics are available:
- Nominal cross section: 0.14...2.5 mm<sup>2</sup> (AWG 26...16) for single conductor  
da 0.14 a 0.75 mm<sup>2</sup> for two conductors with same cross section
  - Tightening torque: 0.5-0.6 Nm
  - Stripping length: 8 mm

- For the F1...F5 (RS485) connections, screw terminals with following characteristics are available:
- Nominal cross section: da 0.2 a 2.5 mm<sup>2</sup> (AWG 24...12) for single conductor  
da 0.2 a 1.5 mm<sup>2</sup> for two conductors with same cross section
  - Tightening torque: 0.5-0.6 Nm
  - Stripping length: 10 mm

The connections to the current signal inputs C1...C8 can be made by ring lugs suitable for M4 screws and an insulating panel covering the terminals may be mounted for safety purposes.

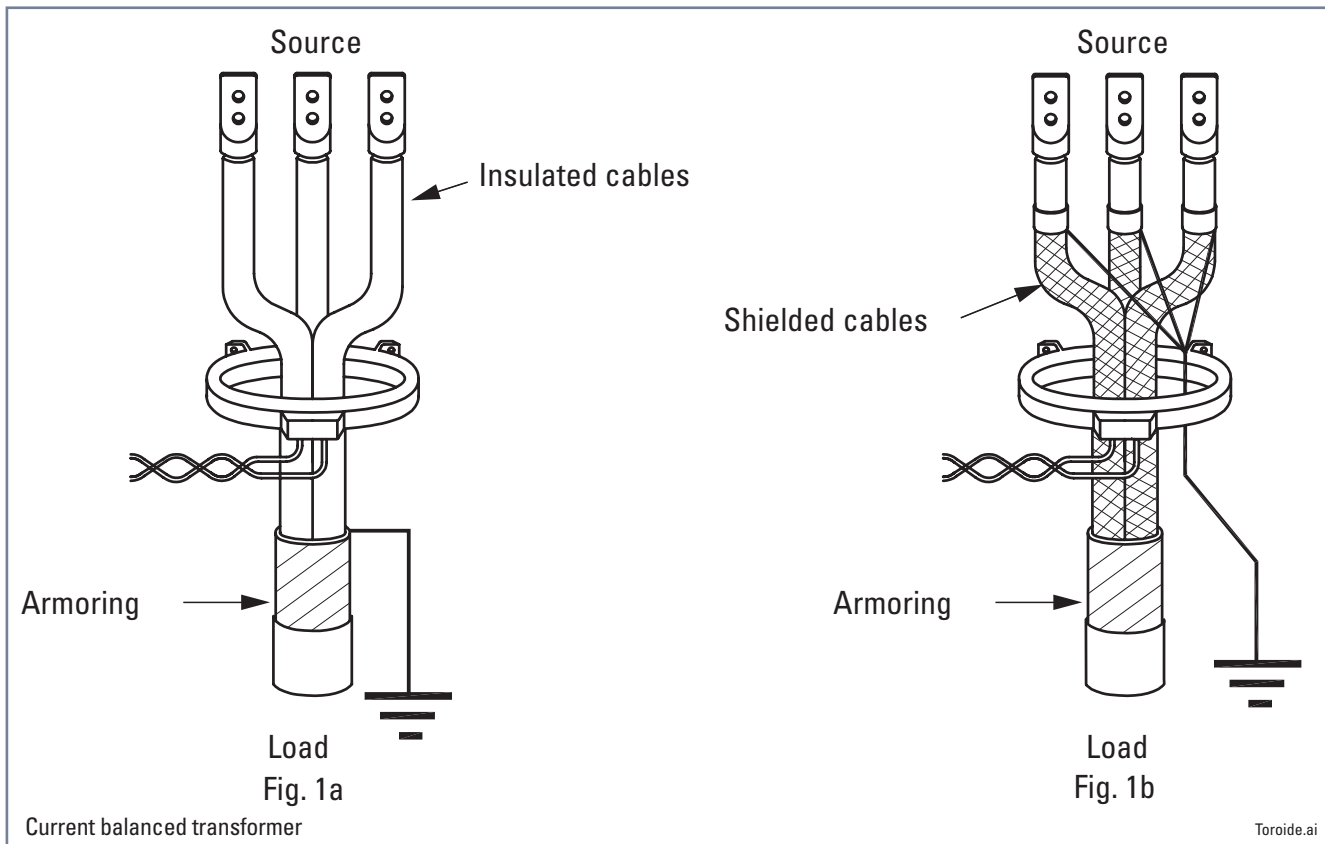


A protective ground connection is required, which must be connected to the suitable screw with a separate lead of at least 2.5 mm<sup>2</sup>.



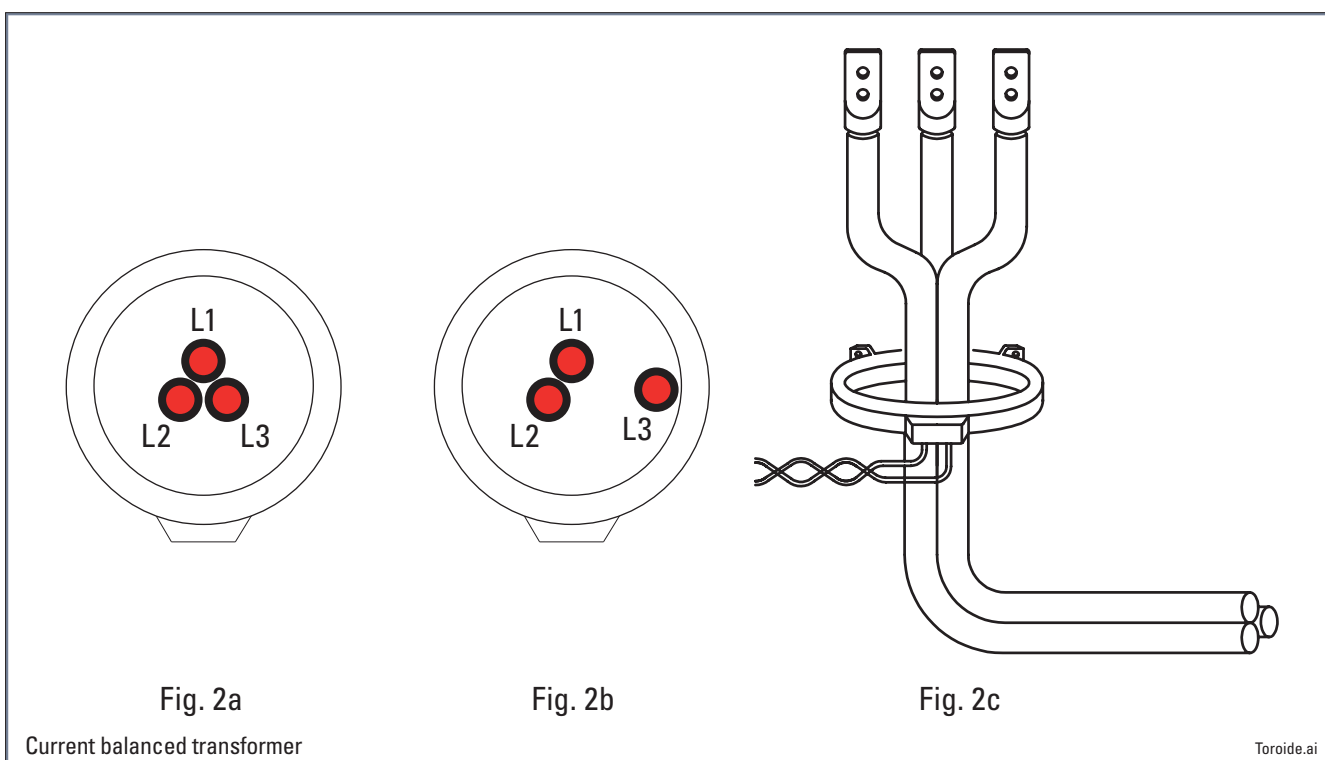
Core balanced CT

The current balance transformer, when used for measuring residual current, must be crossed in the same direction by all active conductors and hence, also by the neutral conductor if distributed, with the exception of the ground connection protective conductor. The drawing below shows cases of assembly of the toroid on unscreened and screened cables; prior to proceeding with assembly, it is necessary to check that there are no screen-to-ground connections upstream of the sensor.



In order to ensure a linear response from the sensor, the cables must be positioned in the centre of the transformer so that the magnetic effect of the three cables is perfectly compensated in the absence of residual current (Fig.2a).

Hence, the assembly indicated in the drawing of fig.2b, in which phase L3 causes local magnetic saturation whereby the vectorial sum of the three currents would be non-null, should be avoided. The same considerations also apply when the sensor is positioned near bends in the cabling. It is recommended that the transformer be placed away from bends in the conductors).



### Amperometric inputs

The amperometric input circuits are assembled inside the fixed module, so no short circuit on the secondary CT must be provided when the removable module is pulled out.



## CAUTION

In case of disconnection CT wiring to the case, pay attention must to do not open live circuits.

When making the current connections, attention must be paid to not exceeding the performance of the line current transformers. To be exact, the total load, constituted by the NA21 protective relay, any other protective relays or measuring instruments and the resistance of the connections, must not exceed the line CT performance. In particular, consumption of the NA21 relay input circuit must not exceed 0.2 VA while the load (expressed in VA) constituted by the conductors is given by:

$$0.018 \times L \times I_n^2 / S$$

where:

L the overall length, expressed in m, of the two conductors in relation to each phase;

$I_n$  nominal current of the line CT expressed in A;

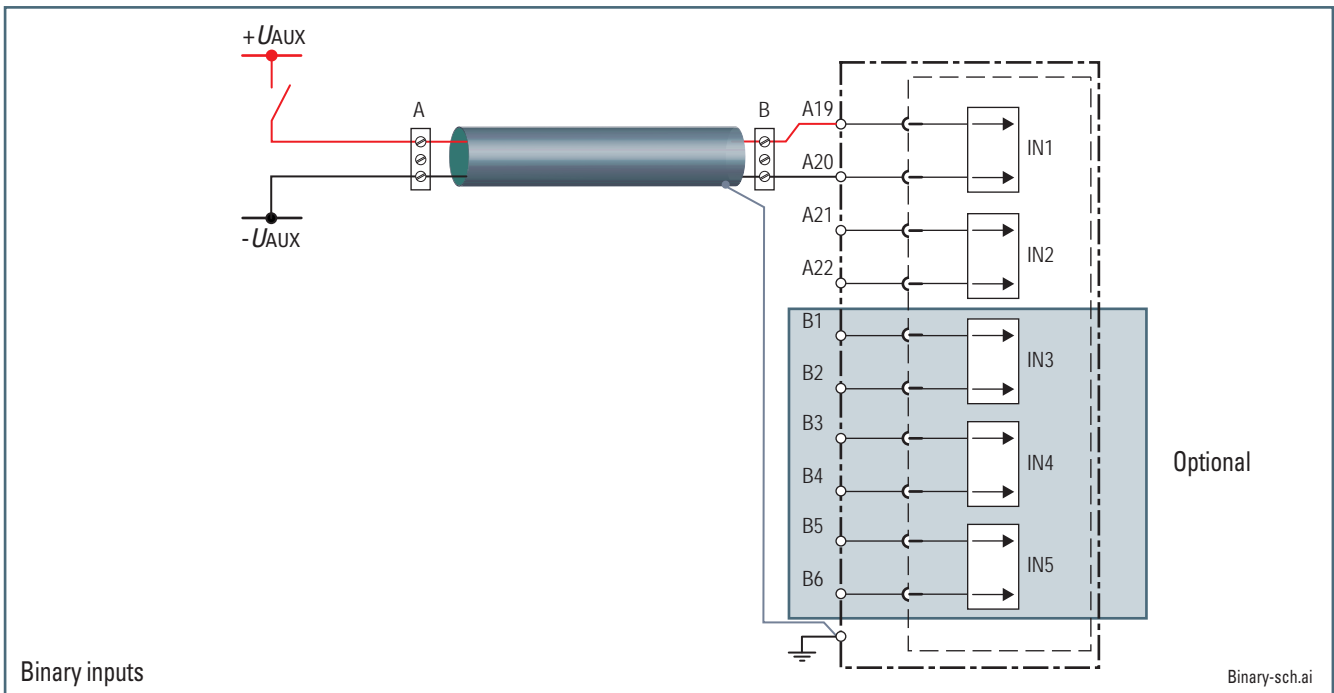
S cross sectional area of the current conductors expressed in mm<sup>2</sup>.

It is recommended that cabling of a suitable thickness be used in order to limit wear of the CT secondary circuits.

### Binary inputs

The dry input circuits, despite being galvanically isolated, must preferably be supplied with the same auxiliary voltage of the control panel.

The inputs are polarity free with wide voltage range.



The optoisolated inputs are immune to transitory interferences, however the following recommendation must be considered in high disturbed environments:

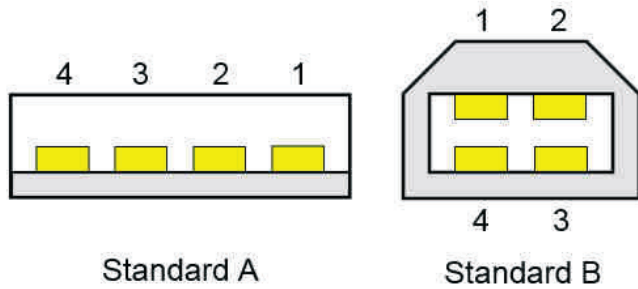
- Position input wiring away from high energy sources.
- Set a debounce timer (tON and/or tOFF) to allow the transient to decay.
- Use shielded cables with ground connection on only one end (preferably at the relay side).

Output relays

Six output relays are available on board.  
 It is advisable to verify that the technical characteristic of the contacts be suitable for the applied load (about current, nominal voltage, make and break current, etc..).  
 Output relay K1 and K2 have one change over contacts (SPDT, type C).  
 Output relay K3 and K4 have one make contact (SPST-NO, type A) and a common reference (A10 terminal).  
 Output relay K5 and K6 have one make contact (SPST-NO, type A for K5), one break contact (SPST-NC, type B for K6) and a common reference (A13 terminal).  
 All contacts are shown in de-energized state for standard reference.

USB port

The link from PC and NA10 USB port must be established by means a L10042 cable.



After installation, the same communication port must be selected to define the ThyVisor parameters (typically COM4, COM5,...).

Ethernet port

One RJ45 (copper) or FX (optics fiber) port may be provided.  
 Connections to the TX (RJ45) port must be made with shielded cable FTP Cat.5e category or higher.  
 For testing a PC may be directly connect to the Ethernet port (D1) on the rear side.  
 With TX interface a cross cable must be employed, while an Ethernet-optical fiber converter, suitable for 100 Mb data rate must be employed if an FX port is implemented.

The link must be enabled by means ThyVisor sw and USB connection:

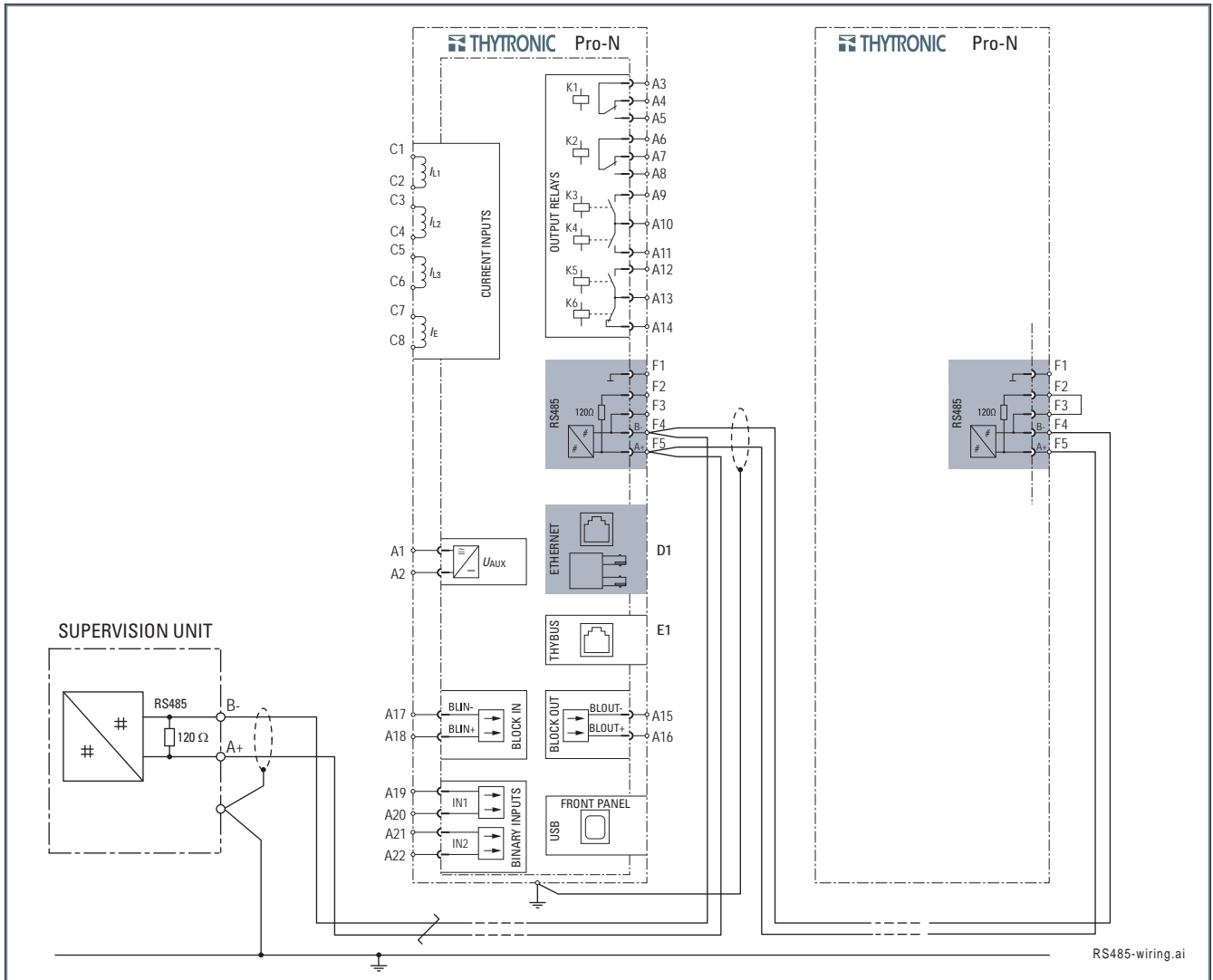
- Set the IP address (*Host IP address e IP net mask*) in order that the NA10 and PC parameters are matched; the parameters are inside the **Communication \ Ethernet** submenu.
- Set to *OFF* the *Autonegotiation* parameter of NA10 device (*Autonegotiation* parameter inside **Communication \ Ethernet** submenu).

For security reasons, a change of the Ethernet communication parameters become active only after an hw reset.

RS485 port

RS485 communication circuit connections must be made using screened twisted pair cable observ-

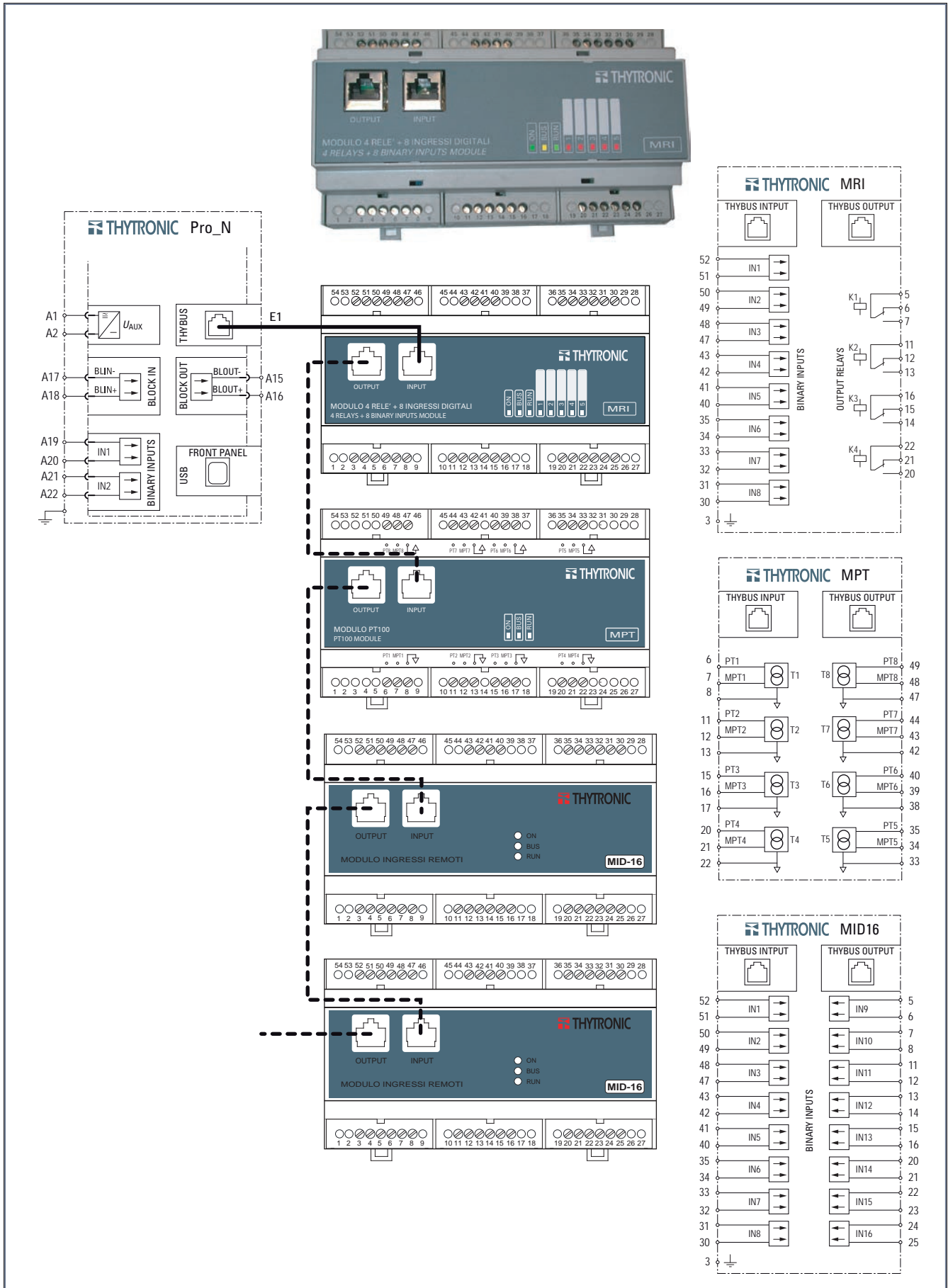
ing the polarities; screening must only be connected to the end terminating at the RS485 interface circuit pertaining to the monitoring unit.  
 It is recommended to terminate the line at the extremities of the same; this must be performed on the RS485 line control unit and on the NA21 device placed at the furthest point connecting the specially provided resistor; termination can be made by means a jumper between the F2-F3 terminals.  
 Termination resistors allow adjusting the impedance of the line, reducing the influence of the inductive components of the same, which might compromise good communication.



*Thybus port*

In order to extend I/O capability, the Pro\_N relays can be customized through external auxiliary mod-

ules; moreover 4...20 mA converter and temperature measuring modules are provided. The modules do not need external auxiliary supply. It is fed directly by Thybus port. The Thybus link must be carried out by means category 5 shielded cable with RJ45 connectors.



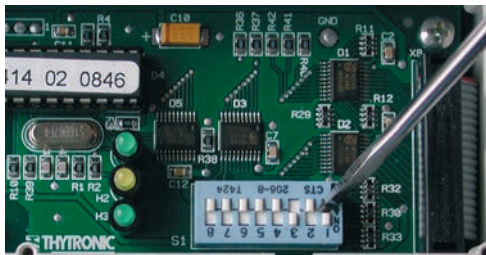
The maximum length of the Pro-N device - module link is:

- 2 m for MRI module (max one module)
- 20 m for MMOS-4 module (max one MMI module)
- 30 m for MID16 and MPT modules
- 2 m for MPT module (max one Pt100 module)
- 2 m for MCI module (max one current converter module)

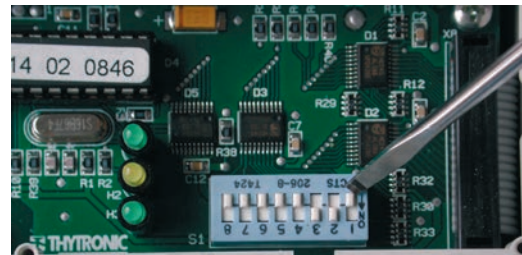
For upgrading, that may be operated at any time with in service devices too, the following operations must be performed:

- Turn OFF power supply
- Connect the auxiliary modules to the Thybus port in daisy chain mode following the INPUT-OUTPUT sequence.<sup>[1]</sup>

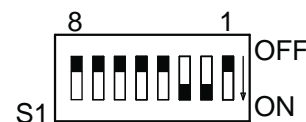
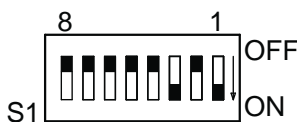
If two MID16 (binary inputs) are installed, the hardware address must be set to avoid communication collisions on the Thybus; for this purpose the default address must be changed on one module, by means of dip-switch on the top circuit board (front plate must be removed).



default address



modified address (2nd MID16 module)



MID16 hardware address setting

DIP-MID16.ai

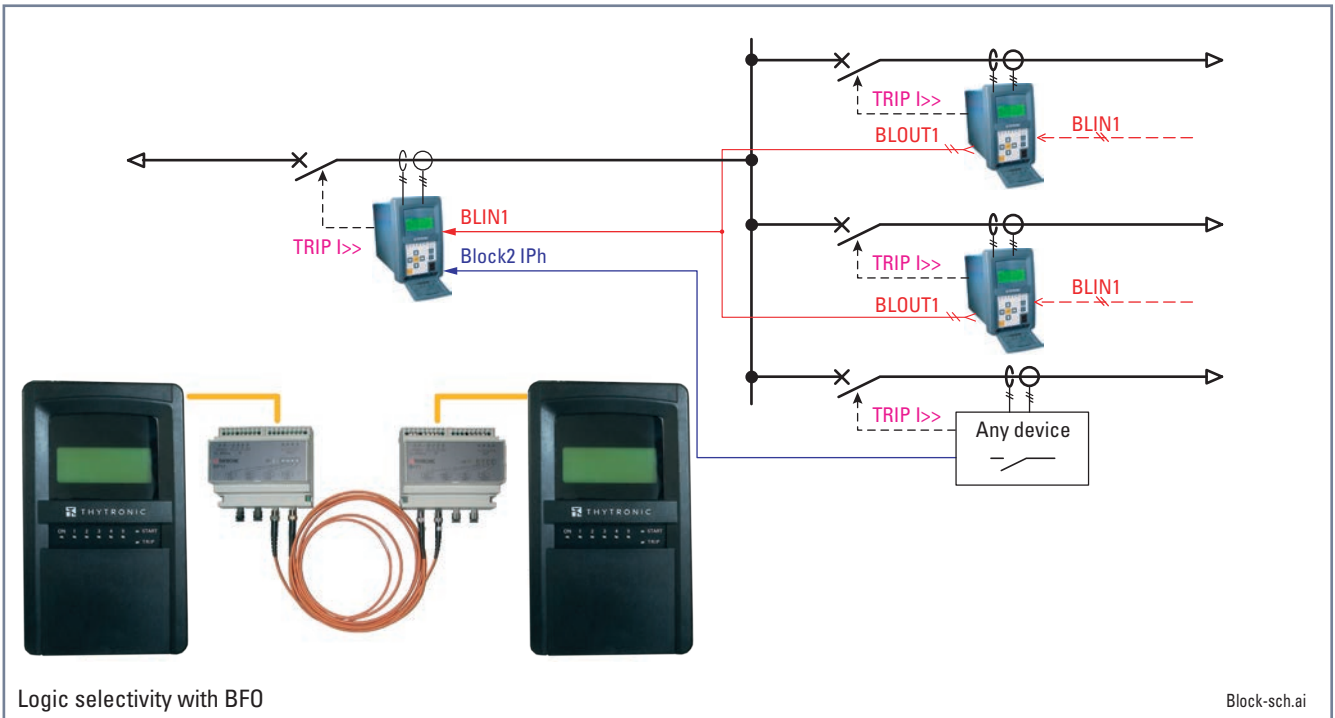
- Turn on power
- Go on to the sw setting (see SETTING section of instruction manual).

*Note 1 The insertion order is free.*

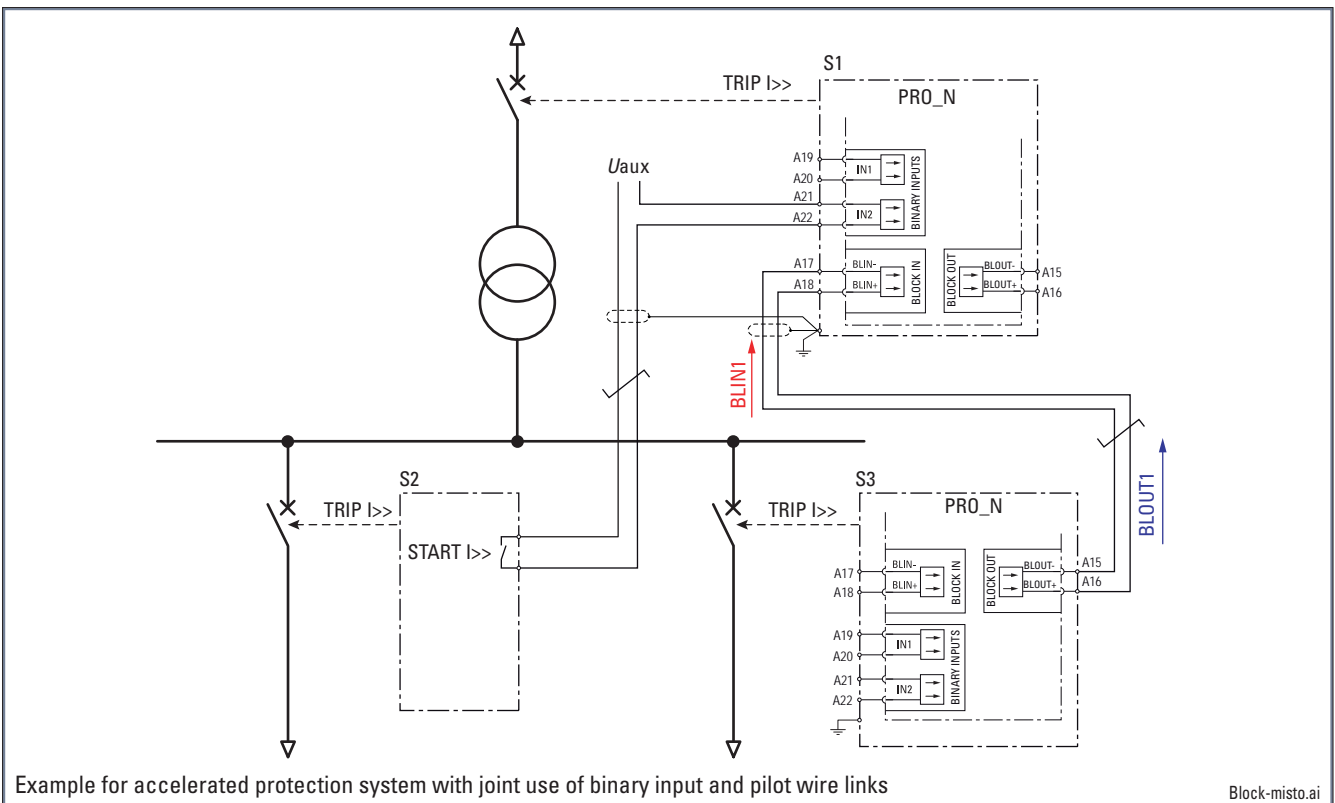
*One MRI module, two MID16 modules, one MPT module, one MCI module and one MMI module (separate operator panel) can be connect at the same time to the Thybus port (maximum expansion).*

Block circuits

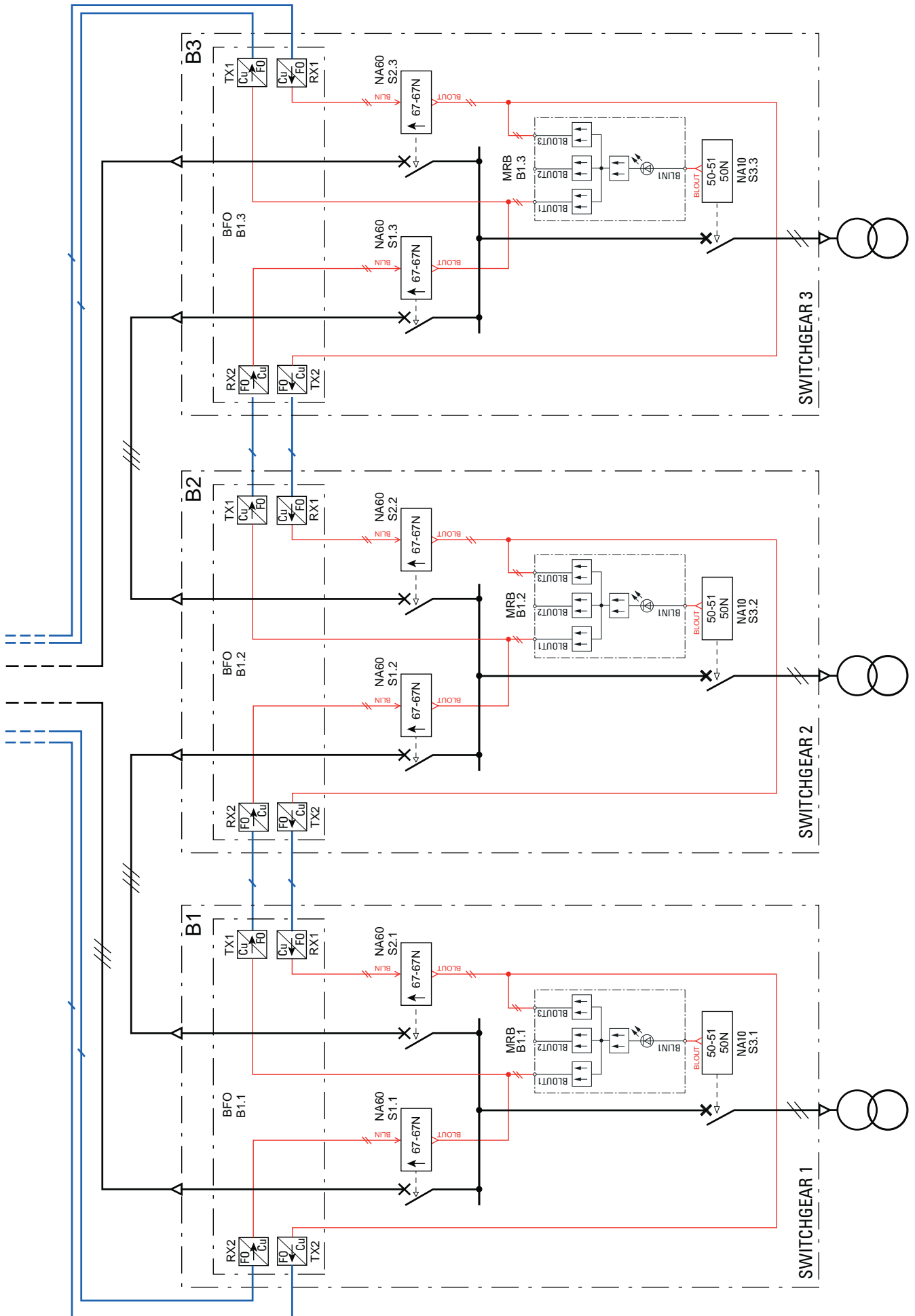
Block circuits may be connected to equipment located in a different switchboard: For the aim of reliability, it is recommended to use conductors having a cross sectional thickness of at least 1 mm<sup>2</sup> and to not exceed 5 km in length. For connections that are particularly critical in terms of electro-magnetic pollution, it is recommended to use BFO adaptor modules with fibre optic connection.



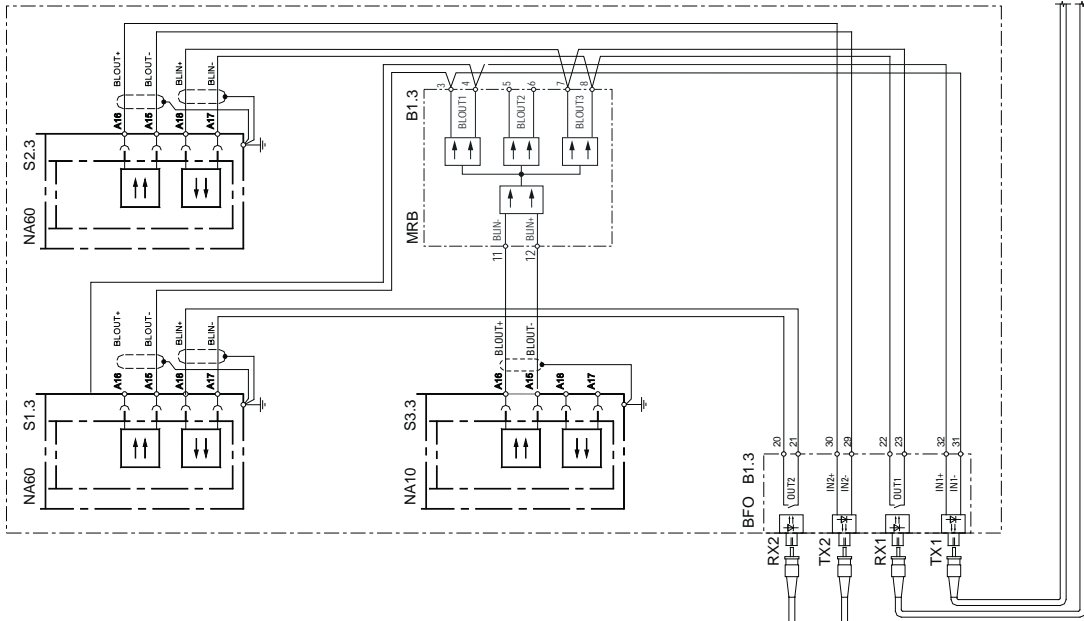
When devices without committed pilot wire circuits must be embedded (devices other than Pro\_N), or in the event that further I/O circuits are need, output relays and binary inputs can be customized to work in the logic selectivity system together with the committed pilot wire circuits.



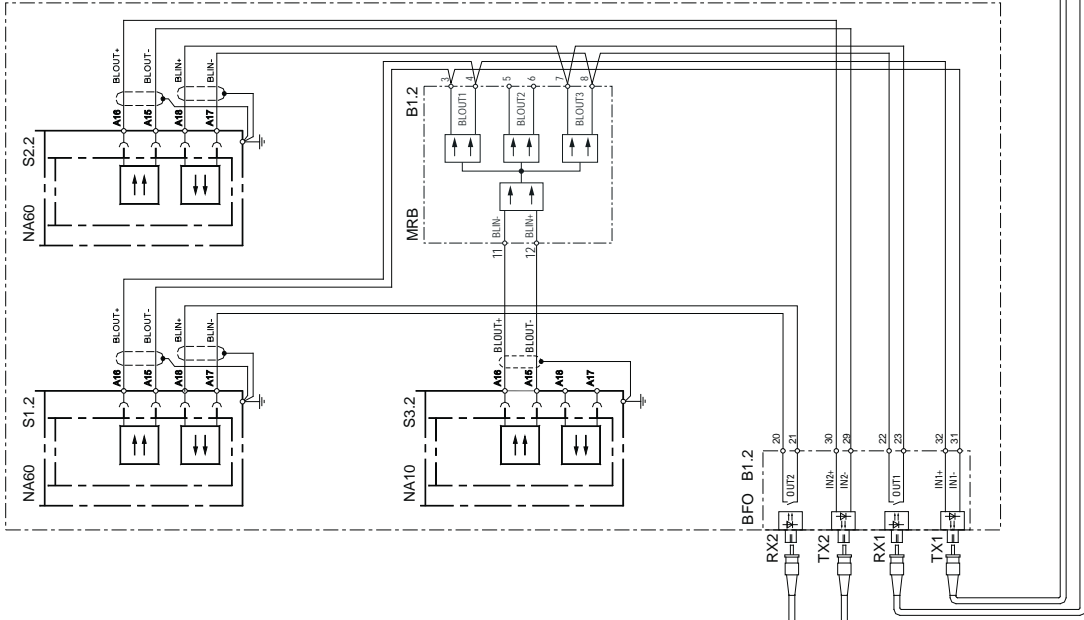
A ring network example<sup>[1]</sup> is shown on the following pages. Block out signals concerning the NA21 devices (S3.1, S3.2 e S3.3) are split on two isolated outputs by means of MRB devices (B2.1, B2.2 and B2.3) to allow proper selectivity logic operation.



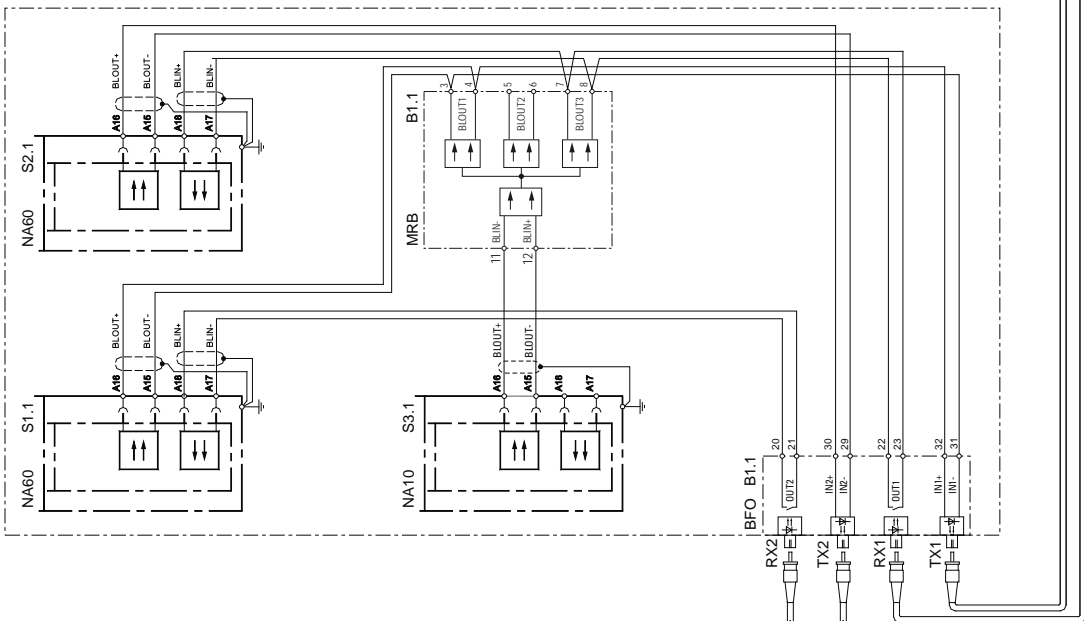
SWITCHGEAR 3



SWITCHGEAR 2



SWITCHGEAR 1



Accelerated logic example

## 6.4 NOMINAL CURRENT $I_n$ AND $I_{En}$ SETTING

Factory default settings:

- Nominal phase current  $I_n$ : 5 A
- Nominal residual current  $I_{En}$ : 1 A

To modify settings the plug-in module must be extracted from the case.



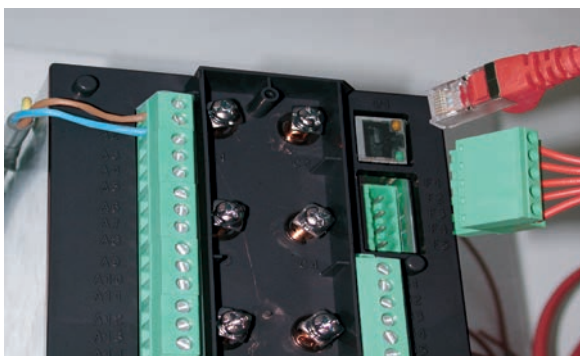
### CAUTION

Turn off power supply before extracting or re-inserting the relay.

If an attempt is made to insert a relay into an un-matching case, a mechanical code will prevent full insertion. Damage can result if excessive force is applied.

The following operations must be performed:

- Remove the auxiliary supply
- Unplug the RS485, RJ45 cables (Ethernet and/or Thybus).



- Remove the upper tile and open the little door to access the fastening screws.

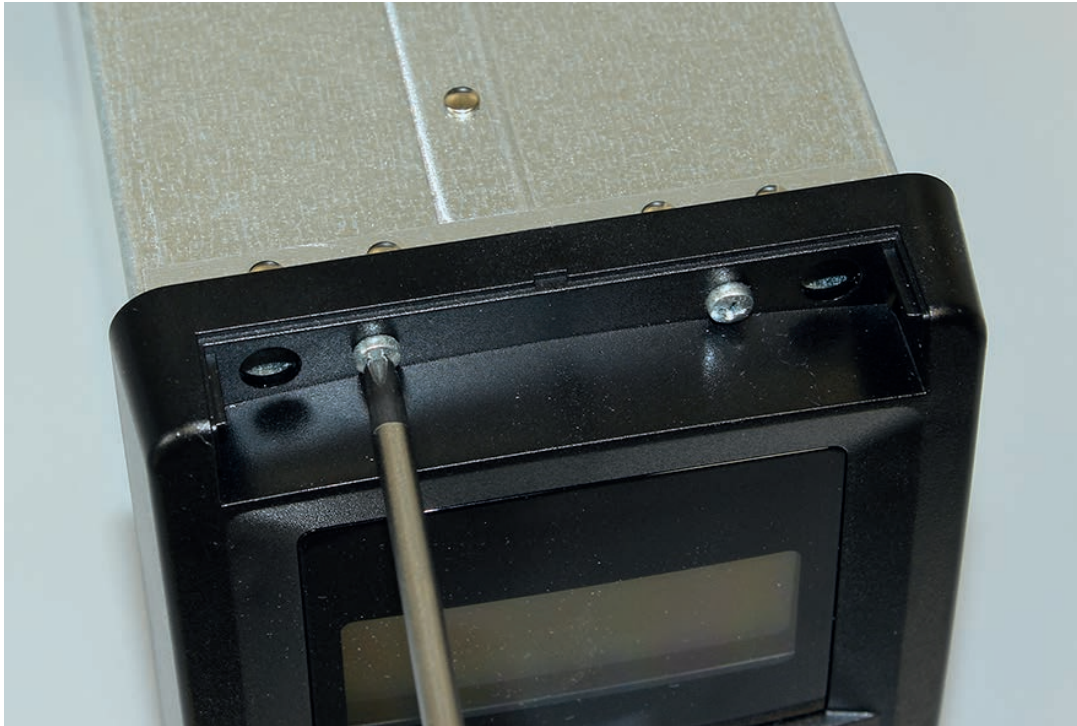


Removing tie to access the fastening screws



Remove-tile.ai

- Unscrew gradually back to back the four fastening screw in order avoid loss of the internal washer.  
Unmounting of the case from the switchboard is not needed.



Unmounting

set-in.ai

- Split the MMI module and disconnect cable



Split MMI module from fixed module

Split-MMI.ai

- Pull out the removable module grabbing the metal handles.



Pull-out the module from the case

extract.ai

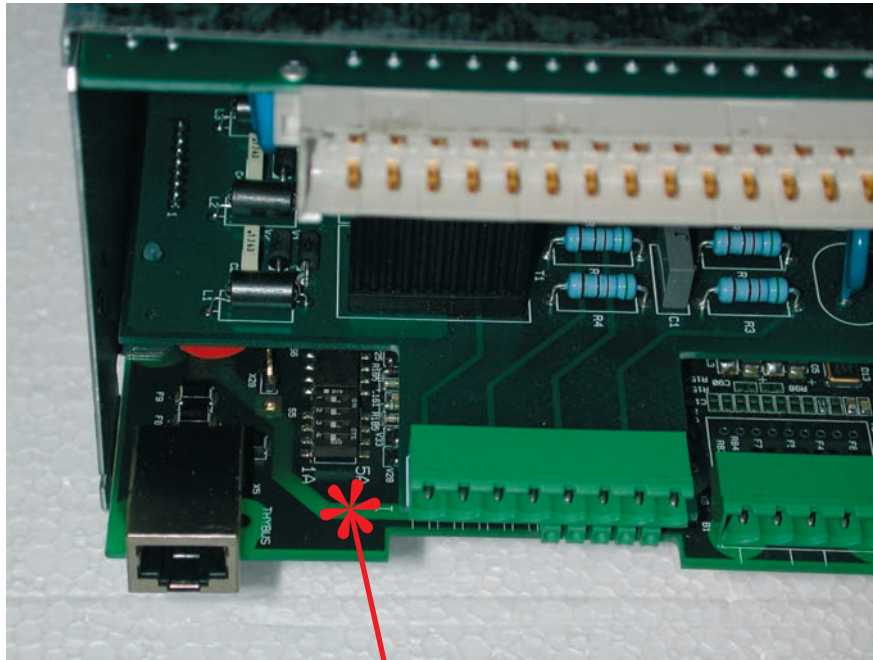
- Lean out the module on the grounded surface<sup>[1]</sup>,
- Set the dip-switches on the right-hand circuit board in accordance with the drawing shown below,

*Note 1* There are components present which are sensitive to electrostatic discharge.

When the module is removed, it is important to pay particular attention to avoid any accidental contact with the internal components.

In order to avoid the static electricity accumulated in the human body from causing damage, it is recommended to observe the following precautions:

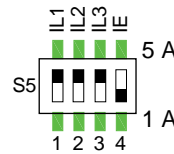
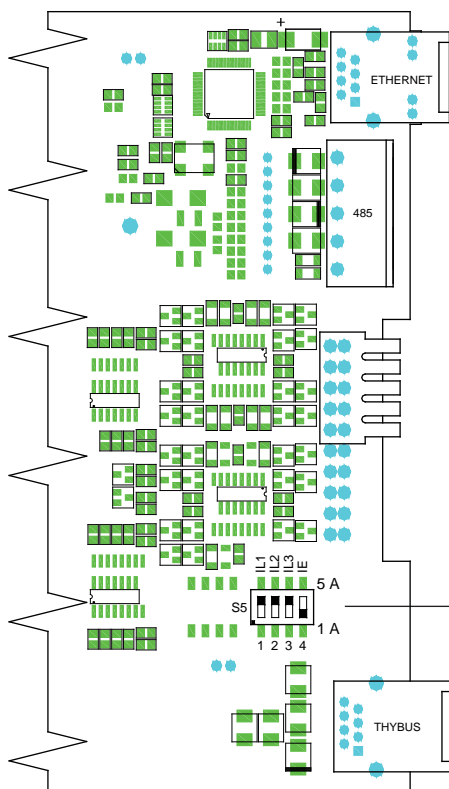
- eliminate any potential differences between the human body and the device by touching the metallic case,
- avoid touching the printed circuit and connections (tracks, component terminals),
- avoid handing the device to others,
- set the programming DIPs by using antistatic tools.



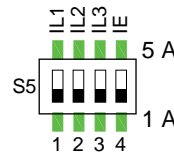
Dip-switch localization concerning the nominal current setting inside the CPU board

set-in-0.ai

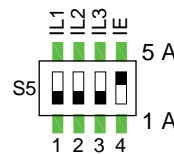
- Move dip-switches according the following layout.



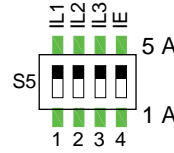
Default settings:  
-  $I_n = 5 \text{ A}$   
-  $I_{En} = 1 \text{ A}$



Settings:  
-  $I_n = 1 \text{ A}$   
-  $I_{En} = 1 \text{ A}$



Settings:  
-  $I_n = 1 \text{ A}$   
-  $I_{En} = 5 \text{ A}$



Settings:  
-  $I_n = 5 \text{ A}$   
-  $I_{En} = 5 \text{ A}$

Dip-switch localization concerning the nominal current setting inside the CPU board

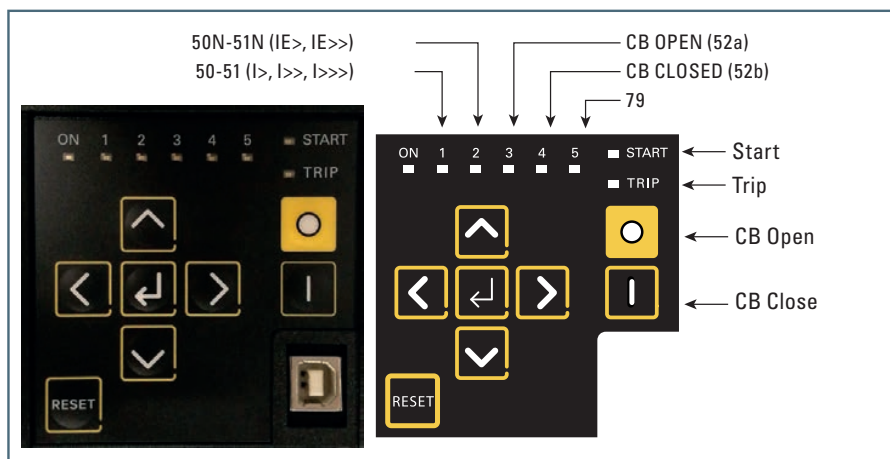
set-In.ai

- Reassemble all parts with the previous operations in reverse order.
- Reconnect the RS485 and RJ45 cables (Ethernet and/or Thybus).

## 6.5 LED ALLOCATION

Following indicator LEDs are available on the front panel:

- LED ON (green): if no diagnostic anomalies are detected, the green LED is turned ON while any fault is highlighted by flashing.
- LEDs 1...5 (red) are freely assignable from the user to any protective and/or control functions.
- LED START (yellow) committed for start information of any protective functions.
- LED TRIP (red) committed for trip information of any protective functions.



## 6.6 FINAL OPERATIONS

Before energizing the electric board, it is advisable to check that:

- The auxiliary voltage in the panel falls within the operative range of Pro\_N relays.
- The rated current (1 A or 5 A) of the line CT's corresponds to the setting of Pro\_N relays.
- All wirings are correct.
- All screws are tightly screwed.

## 7 PROGRAMMING AND SETTINGS

All relay programming and adjustment operations may be performed through MMI (keyboard and display) or using a Personal Computer with the aid of the ThyVisor software.



### WARNING

For safety reasons, a change of the following parameters become active only after an hw reset:

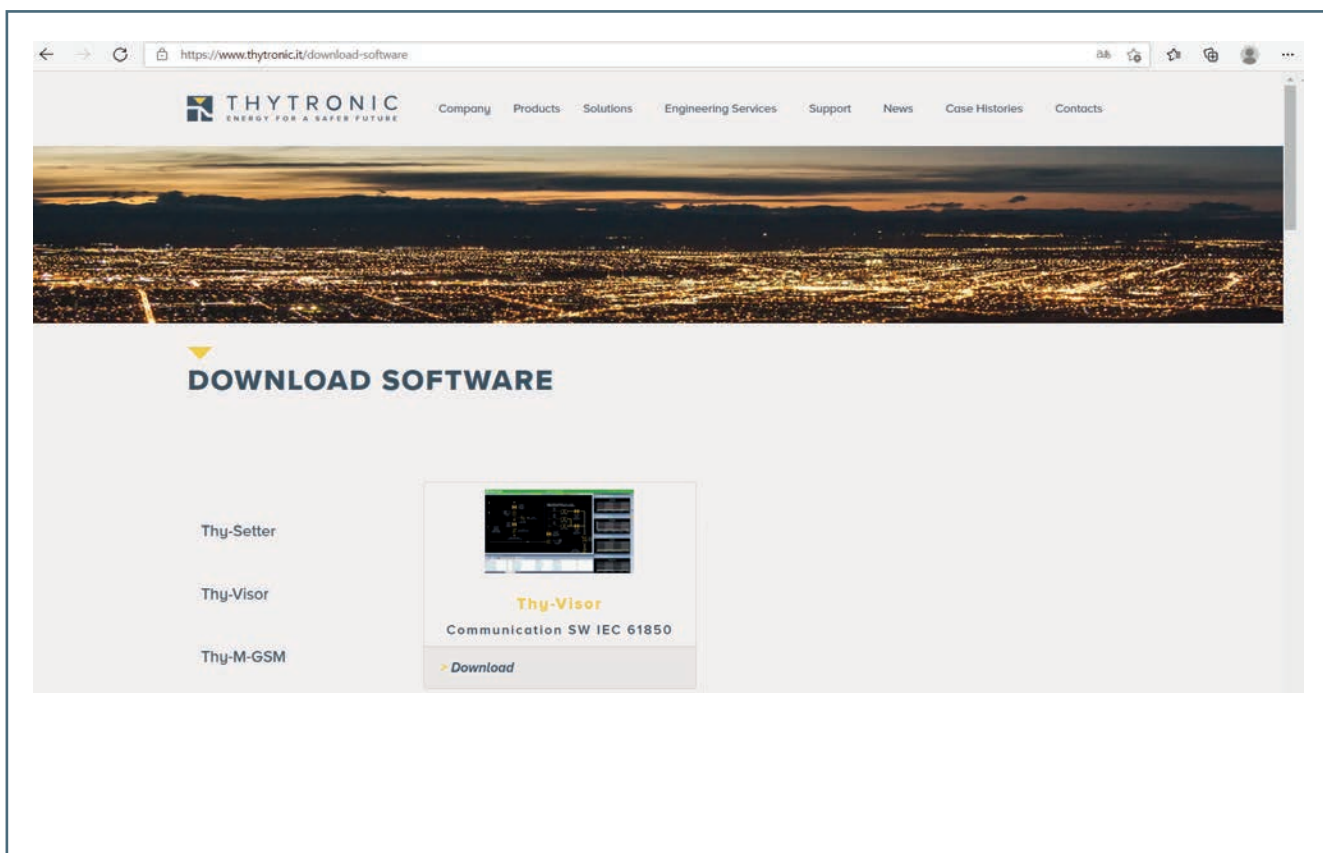
- Relay nominal frequency ( $f_n$ )
- The changes become operational after the relay is turned off and on again.

### 7.1 SW ThyVisor

The ThyVisor sw is a “browser” of data (setting, measure, etc..); it implements an engine that is afford to rebuild the menu set up and the relationships to data concerning all Thytronic protective relays by means of XML files.

#### ThyVisor installation

The latest release of ThyVisor can be downloaded free of charge from the [www.thytronic.it](http://www.thytronic.it) site (Products - Software).<sup>[1]</sup>



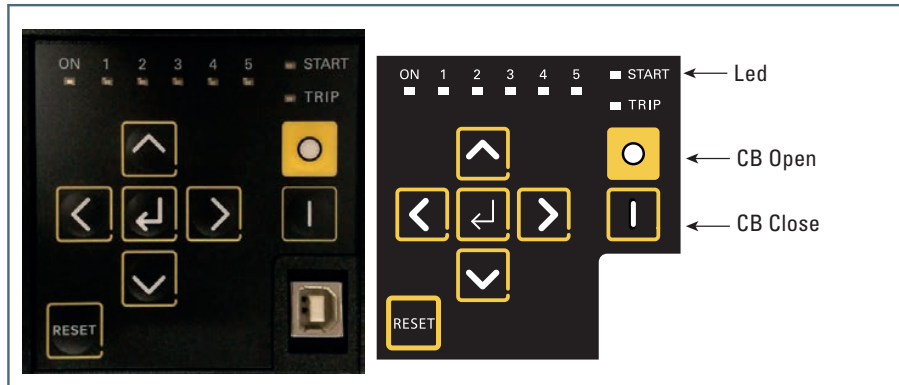
#### ThyVisor use

Please refer to ThyVisor user manual for detailed instructions.  
The document is available on [www.thytronic.it](http://www.thytronic.it) (Product / Software / ThyVisor - Download area).

*Note 1 Starting from the 3.5.9 release it is necessary to download and install not only the application setup but the Template setup also. In case of updating download and install only the new release.*

7.2 MMI (Man Machine Interface)

On the front panel there are eight buttons which allow the user to perform all the settings, reading and modification operations.<sup>[1]</sup>



The adjustment of the settings and the operation mode of the output relays must be performed while the unit is electrically powered; the alphanumeric display shows the necessary information with reference to the operations performed through the keyboard. One minute after the keyboard is not more in use, the display backlight switches automatically to OFF. All preset values are permanently stored in the nonvolatile memory.

The buttons take the following operations:

- **(Up)** move the cursor upwards to the preceding menu options
- **(Down)** move the cursor downwards to the subsequent menu options
- **(Left)** move the cursor upwards to the preceding menu options
- **(Right)** move the cursor downwards to the subsequent menu options
- **(Enter)** access to the selected menu with the option of modifying any given parameter
- **(Reset)** abort the current changes and/or accessing the previous menu
- **Circuit breaker Open command**
- **Circuit breaker Close command**

At power-up, the display shows the text:

```
"THYTRONIC
PRO-NA10-xxx-x serial number
date and time: (01/01/2000 00:00"
```

The ON green Led points out the auxiliary power supply voltage (permanent lighted) and possible faults (blink lighted).

The display backlight is automatically activated when any key switch is set.

By means of the **Up** or **Down** buttons, it is possible to cyclically browse through the menu options:

**READ, SET, COMMUNICATION, TEST**

Having identified the sub-menu of interest, it is possible to gain access by using the **Right** button and then analogously, run through the relevant options by using the **Up** or **Down** buttons.

The full menu tree and some examples are showed in the following pages (numerical values and settings are pointed out as examples and does not agree with real situations).

**Reading variables (READ)**

All data (measure, settings, parameters, etc...) may be displayed:

```
"SERIAL NUMBER >>"
"INFO >>"
"MEASURES >>"
"ACTIVE PROFILE >>"
"PROTECTIONS >>"
"PLC >>"
"CIRCUIT BREAKER SUPERVISION >>"
"DELAYED INPUTS >>"
"INTERNAL STATES >>"
"RELAYS >>"
"PARTIAL COUNTERS >>"
"TOTAL COUNTERS >>"
"SELF-TEST >>"
"PILOT WIRE DIAGNOSTIC >>"
"SELECTIVE BLOCK BLOCK2 >>"
"FAULT RECORDING >>"
"EVENTS RECORDING >>"
```

**Setting modifying (SET)**

*Note 1 Setting changes are enabled when the La mEnabling setting by MMI parameter is set*

All changes in the setting parameters are carried out through MMI only if the Enable setting by MMI parameter is ON. (ENABLE SETTING BY MMI submenu inside the SET menu).

To effect a change, having identified the parameter intended for change, the following procedure must be performed:

- Select the parameter going through the menus by means the **Up**, **Down** and **Right** keys.
  - Press the **Enter** button for a few seconds; the modification in progress status is highlighted by flashing of the START and TRIP LEDs and by appearance of the pointer on the bottom.
  - Move the cursor over the parameter intended for change using the **Enter** button,
  - Change the parameter by means the **Up** (increment) or **Down** (decrement) buttons,
  - Press the **Enter** button to move the cursor over the last parameter in the display,
  - Press the **Enter** button once again; the cursor and the LED TRIP turn off (the LED START keeps flashing),
  - Press the **Enter** button for a few seconds; new message appears: "Confirm settings?"
  - Answer to the message ENTER: YES to confirm changes or RESET: NO to abort.
- The end of the START LED blinking points out the end of procedure; the changes become right now active.

The abort command may be used to abandon changes (prior to use of the ENTER: YES); the same effect is achieved by removing the auxiliary power supply to the relay.

As example, to set the operating mode of the K1 output relay as ENERGIZED, LATCHED, the following procedure must be issued:

- By means **Down** button select the Set menu "SET >>",
  - Press the **Right** button to enter; the following submenu title is displayed: "BASE >>"
  - Scroll menus by means **Down** button
 

"INPUTS	>>"
"RELAYS	>>"
"LEDS	>>"
"SELF-TEST RELAY	>>"
"MMI	>>"
"PROFILE SELECTION	>>"
"PROFILE A	>>"
"PROFILE B	>>"
"PLC	>>"
"CIRCUIT BREAKER SUPERVISION 52	>>"
"CT SUPERVISION 74CT	>>"
"REMOTE TRIPPING	>>"
"PILOT WIRE DIAGNOSTIC	>>"
"DEMAND MEASURES	>>"
  - Select the Set menu "RELAYS >>", the "K1 relay Setpoints >>" message is displayed,
  - Press the **Right** button to enter; the following messages are displayed: "Logic DE-ENERGIZED Mode NO LATCHED"
  - Press the **Enter** button for a few seconds; the modification in progress status is highlighted by the both START and TRIP flashing.
  - Move the cursor over the parameter intended for change using the **Enter** button, (in our case on the message "Logic DE-ENERGIZED",
  - Change the parameters by means the **Up** (increment) or **Down** (decrement) buttons, "Logic EN-ENERGIZED",
  - Press the **Enter** button to move the cursor over the last parameter in the display, "Mode NO LATCHED",
  - Change the parameters by means the **Up** (increment) or **Down** (decrement) buttons, "Mode LATCHED",
  - Press the **Enter** button once again; the cursor and the LED TRIP turn off (the LED START keeps flashing),
  - Press the **Enter** button for a few seconds; new message appears: "Confirm settings?"
  - Answer to the message ENTER: YES to confirm changes or RESET: NO to abort.
- The end of the LED blinking points out the end of procedure.

## TEST

The operational tests with command of the selected output relays may be activated.

By means of **Up** or **Down** buttons it is possible to browse the main menu till the “TEST” message; to enter you must press the **Right** button.<sup>[1]</sup>

The display message “Test state: OFF” shows the test state (OFF or test in progress).

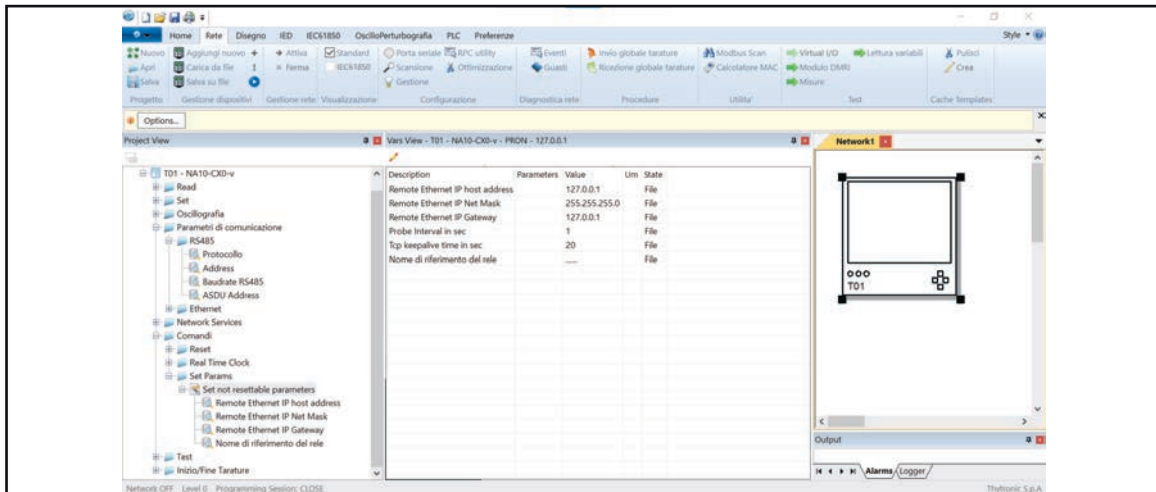
- Test K2
- Test K3
- Test K4
- Test K5
- Test K6

As example, to start the test of K1, the following procedure must be issued:

- Select the Start test menu “Start test >>”.
- Press the **Right** button to start; the test in progress status is highlighted by activation of all LEDs,
- Come back by pressing the **Left** button and select the relay to be tested by means the **Up** or **Down** buttons until the message “Test K1 >>” is displayed.
- Press the **Right** button to start the test.
- To terminate the test, it is necessary to select the “Stop test >>” message and press the **Right** button to end the test. In any case the test will be automatically terminated after a delay of one minute.

## COMMUNICATION

Inside the **COMMUNICATION** menu it is possible to read/modify the setting data of the RS485 Protocol and Ethernet parameters.



By means of **Up** or **Down** buttons it is possible to browse the main menu till the “RS485 Protocol >>” or “Ethernet parameters >>” message; to enter you must press the **Right** button.

As example, to select the address 12 for the ModBus protocol, the following procedure must be issued:

- Select the Communication menu “COMMUNICATION >>”.
  - By means **Down** button select the “RS485 Protocol >>”.
  - Press the **Right** button to enter; the following message is displayed:  
“Protocol MODBUS”  
“Address 1”  
“9600 baud”
  - Start the procedure to effect a change explained in the Setting modifying (SET) paragraph:
  - Press the **Enter** button for a few seconds; the modification in progress status is highlighted by the both START and TRIP flashing.
  - Move the cursor over the parameter intended for change using the **Enter** button, (in the example on the 1 address),
  - Change the parameters by means the **Up** (increment) button (up to 12 address),
  - Press the **Enter** button to move the cursor over the last parameter in the display,
  - Press the **Enter** button once again; the cursor and the LED TRIP turn off (the LED START keeps flashing),
  - Press the **Enter** button for a few seconds; new message appears: “Confirm settings?”
  - Answer to the message ENTER: YES to confirm changes or RESET: NO to abort.
- The end of the LED blinking points out the end of procedure.

*Note 1 Instantly all the relays are switched in rest state, including relays programmed as “normally energized”*

## Circuit breaker commands

By means of the **Open command** and **Close command** keys, the circuit breaker commands may be issued.

The committed output relays must be enabled inside the **Circuit Breaker supervision \ LEDs-relays allocation** menu.

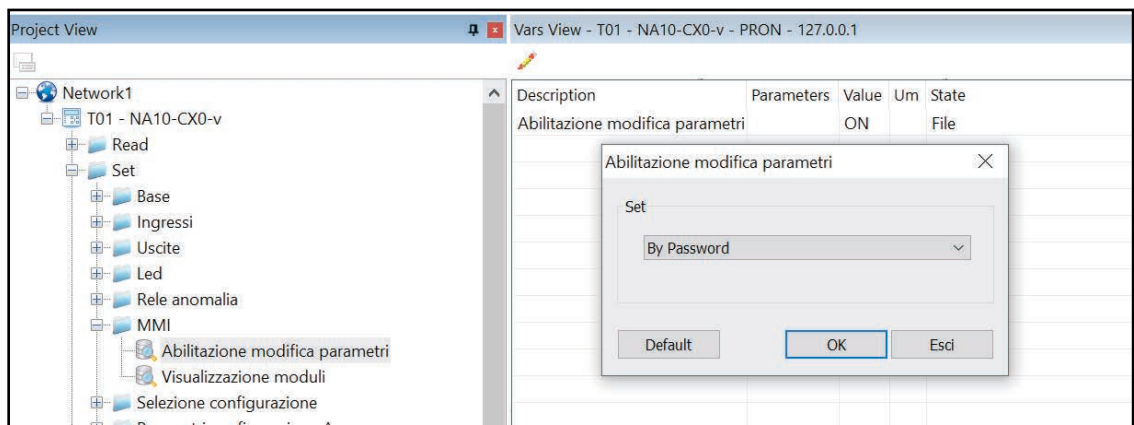
## Enable / block changes via keyboard - Password

All parameters (measurements and settings) are available for reading from the operator panel (MMI), while the setting changes are enabled or disabled depending on possible operation modes:

- Enable without password (factory setting)
- Enable with password
- Disabled

The choice of operation modes is possible only through ThyVisor operating at the session level 1:

- Connect the PC serial port to the relay socket on the RJ10 front panel
- Run the ThyVisor sw (the latest version latest version available on the site is recommended).
- Select the *Preference - Session* menu; when you start the session level is set to 0 as shown in the bottom of the window
- Select the level 1. Prompted for a password (the default *level1*) to move to level 1. Confirm twice with "OK". (Level 1, as shown in the bottom of the window).
- Open the communication session by executing the menu command *Communication - Open*. Verify that inside the modality box *Serial* and *Automatic* are selected
- ThyVisor will search automatically the relay from the template, regardless of what is selected in the *device family*.
- Inside the Serial Configuration panel select the COM port (eg COM1, COM4 etc), give the *Start* command and wait for the opening of the new window
- Save the file. Choose the location to save the file and give the *Save* command. The configuration data of the relay are transferred to the PC (the progress bar is displayed from 0 ... 100%). A folder on a yellow background with the name of the file is highlighted on the left side of the windows. The serial connection is operative, at the bottom of the screen the word *ON-LINE* is highlighted in green field.
- Select the **Set \ MMI** folder (MMI stands for Man-Machine-Interface = keyboard). On the right side of the window (first row) select *Parameter setting enable*; with a "click" on the column value 3 options are available:
  - *OFF* = keyboard enabled only for reading
  - *By password* = keyboard enabled for reading and setting by means of password
  - *ON* = keyboard enabled for reading and setting without password



To modify any parameter the calibration session must be open by means of *Start setting* command from the menu or directly by clicking on F4 key. the opening of the session setting is highlighted by its *Programming state:Open* on yellow field on the bottom bar. To save the monifiche it is necessary to send the command from the menu "IED / close" or directly by clicking on F5 key.

## Operation with Password

If the *By password* mode is selected a new menu *password* is inserted at the top of the display menu.

- Press the **Right** key the: `password not ok >>` message is displayed and any changes of parameters is disabled
- Press the **Right** key; you can enter the password page `enter password` where you are prompted to enter the 4 characters password (the default password is 0000)
- Press the **Enter** button for a few seconds; the modification in progress status is highlighted by flashing of the START and TRIP LEDs and by appearance of the pointer on the bottom
- Change the parameters by means the **Up** (increment) or **Down** (decrement) buttons, using the **Left** and **Right** keys to move to the previous or next character

- Press the **Enter** button; the cursor and the LED TRIP turn off (the LED START keeps flashing),
- Press the **Enter** button for a few seconds; new message appears: `Confirm settings?`
- Answer to the message `ENTER: YES` to confirm changes or `RESET: NO` to abort.
- The message: `password ok >>` is displayed
- To exit from password menu use **Left** or **Up** keys: if you press the **Right** button you go back in the password menu and the password must be entered. The parameter changes are enabled from the keyboard. After any confirming with (Enter) or abandoning the change (reset button) the password must be entered again.
- The possibility of modifying the parameters from the keyboard is automatically disabled after about 3 minutes elapsed without pressing any button. If you do not want to wait three minutes of waiting, it must go back to the password menu and come out without input any data ( **Left** and **Right** until the the message `password not ok >>` is displayed.

### Changing the password

Changing the password is possible only after entering the correct password (`password ok >>` message); press the **Down** key, a new menu is displayed `change password` that you access with the **Right** key. Inside this menu the password can be changed.

- Press the **Enter** button for a few seconds; the modification in progress status is highlighted by flashing of the START and TRIP LEDs and by appearance of the pointer on the bottom
- Change the parameters by means the **Up** (increment) or **Down** (decrement) buttons, using the **Left** and **Right** keys to move to the previous or next character
- Press the **Enter** button; the cursor and the LED TRIP turn off (the LED START keeps flashing),
- Press the **Enter** button for a few seconds; new message appears: `Confirm settings?`
- Answer to the message `ENTER: YES` to confirm changes or `RESET: NO` to abort.

### Lost password

If password is lost the data base of the device must be restored, proceed with the following steps:

- Activate the session level 1
- Send `Set default settings` command available inside the **Command \ Default settings** menu.




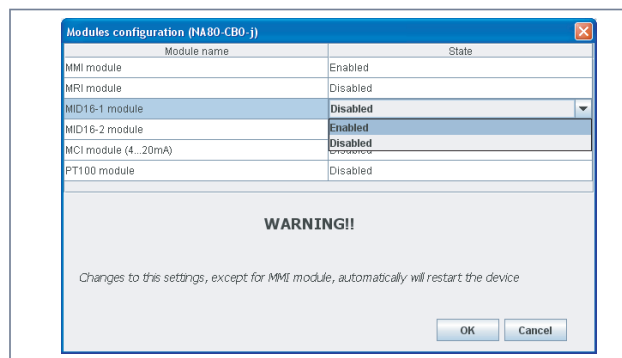
## WARNING

The command `Set default settings` restores the factory settings, all user- defined adjustments are cleared. Be carefully to enter the correct parameter !  
The device serial number should be set to avoid IP address conflicts for devices connected to the Ethernet network.

Following the `Set default settings` command the password is reset to `0000`.

## 7.3 MODULES MANAGEMENT

After installation, the modules must be enabled (working with level 1 session level). The Thybus modules may be set inside the `Procedure` menu (or by means a click on the  icon). Following up any module configuration an automatic reset is issued and the I/O devices are included inside the device menu. <sup>[1]</sup> When two MID16 modules are enabled, the hardware address must be set; the dip-switch layout is showed inside the `INSTALLATION` section.



**Note 1** Binary inputs and output names (ThyVisor):

*Binary inputs for devices with two inputs onboard*

*IN1, IN2 on board  
IN3...IN10 with MRI module  
IN11...IN26 with one MID16 module  
IN27...IN42 with two MID16 modules*

*Binary inputs for devices with five inputs onboard*

*IN1...IN5 on board  
IN6...IN13 with MRI module  
IN14...IN29 with one MID16 module  
IN30...IN45 with two MID16 modules*

*Output relays*

*K1...K6 on board  
K7...K10 with MRI module*

*LEDs:*

*ON, START, TRIP, L1...L5 on board  
L6...L10 with MRI module*

## 7.4 MAINTENANCE

The Pro-N relays do not require any particular maintenance; all circuits use high quality static components, the subassembly products undergo dynamic checks on their functioning before the final assembling of the complete equipment. The dedicated circuits and the firmware for the self-test function continuously check the relay operation; the continuously operating auto-zeroing function dynamically corrects the measuring errors due to offset, heat dependent drifts, aging of components, etc. The processor is equipped with a watch-dog circuit which restores the correct operation of the firmware in case of fault.

If the following criteria are properly implemented:

- comprehensive functional tests at commissioning,
  - absence of significant modification on the protection system,
  - activation and permanent remote control of self-test alarms through supervision,
  - control of self-test undetectable failures (comparing of measures with the external instruments, auxiliary voltage control, etc ..)
  - analysis of the stored information (faults and events, and oscillographic records),
- periodic checks can be avoided. In the absence of some of the criteria listed above, it is advisable to perform periodic checks every five years.

## 7.5 REPAIR

No repair of possible faults by the client is foreseen; if following to any irregularity of operation, the above tests confirm the presence of a fault, it will be necessary to send the relay to the factory for the repair and the consequent settings and checks.

## 7.6 PACKAGING

The Pro-N devices must be stored within the required temperature limits; the relative humidity should not cause condensation or formation of frost.

It is recommended that the devices are stored in their packaging; in the case of long storage, especially in extreme climatic conditions, it is recommended that the device is supplied with power for some hours before the commissioning, in order to bring the circuits to the rating conditions and to stabilize the operation of the components.

## 8 APPENDIX

### 8.1 APPENDIX A1 - Inverse time IEC curves

#### □ Mathematical formula

The mathematical formula, according to the IEC 60255-3/BS142 standards is:<sup>[1]</sup>

$$t = t_{>inv} \cdot \left[ \frac{K}{[(I/I_{>inv})^{\alpha} - 1]} \right]$$

Where:

- $t$  = operate time (in seconds)
- $t_{>inv}$  = setting time multiplier (in seconds)
- $I$  = input current
- $I_{>inv}$  = threshold setting

$K$  = coefficient:

- $K = 0.14$  for IEC-A curve (Normal inverse)
- $K = 13.5$  for IEC-B curve (Very inverse)
- $K = 80$  for IEC-C curve (Extremely inverse)

$\alpha$  = curve shape constant:

- $\alpha = 0.02$  for IEC-A curve (Normal inverse)
- $\alpha = 1$  for IEC-B curve (Very inverse)
- $\alpha = 2$  for IEC-C curve (Extremely inverse)

For all inverse time characteristics, following data applies:

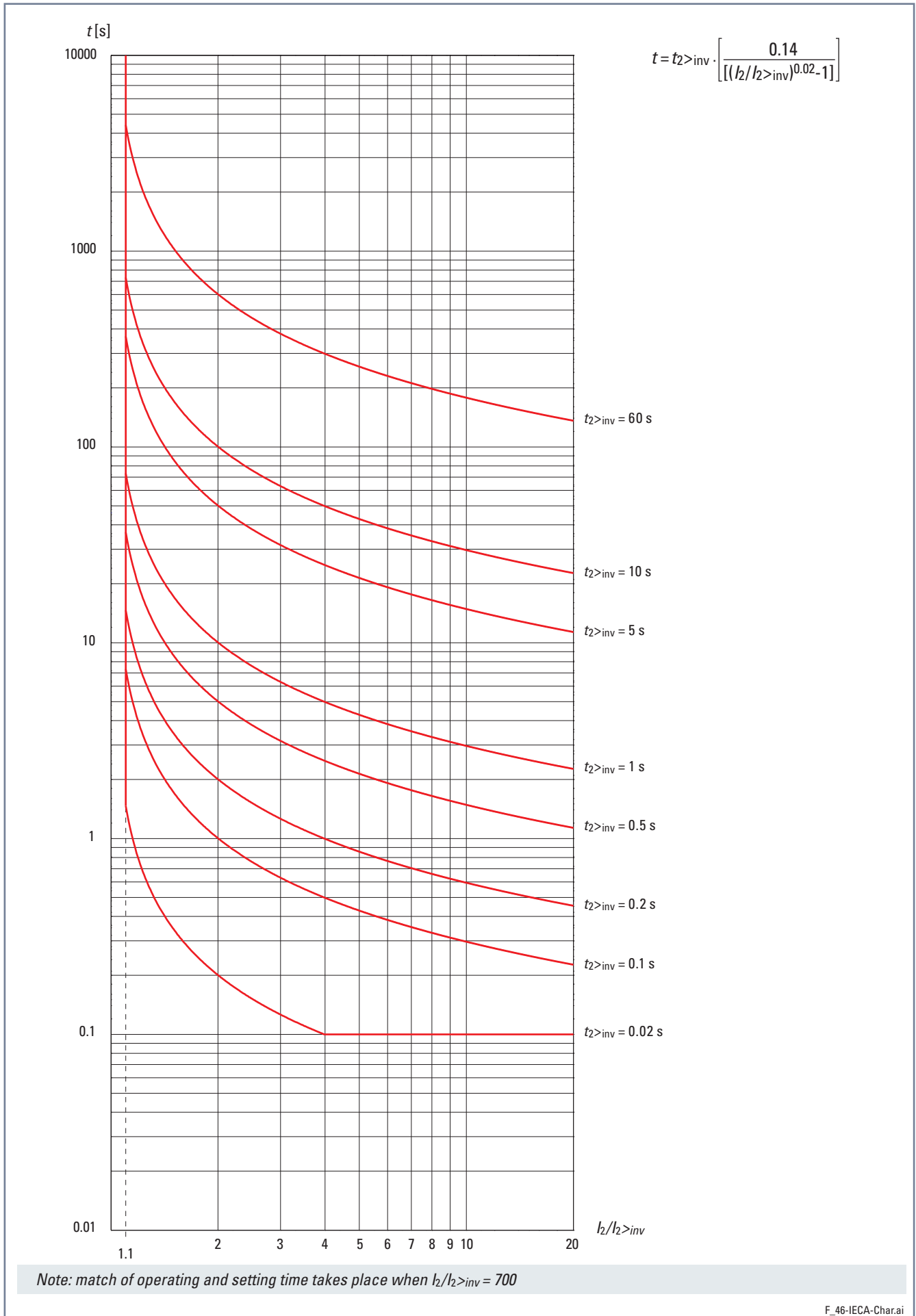
- Asymptotic reference value (minimum pickup value):  $1.1 I_{>inv}$
- Minimum operate time: 0.1 s
- Range where the equation is valid:<sup>[2][3]</sup>  $1.1 \leq I/I_{>inv} \leq 20$
- If  $I >$  pickup  $\geq 2.5 I_n$ , the upper limit is  $50 I_n$

*Note 1* Symbols are concerning the overcurrent element. The comprehensive overview of the inverse time characteristics concerning the 50/51 and 50N/51N elements is dealt within the PROTECTIVE ELEMENTS section

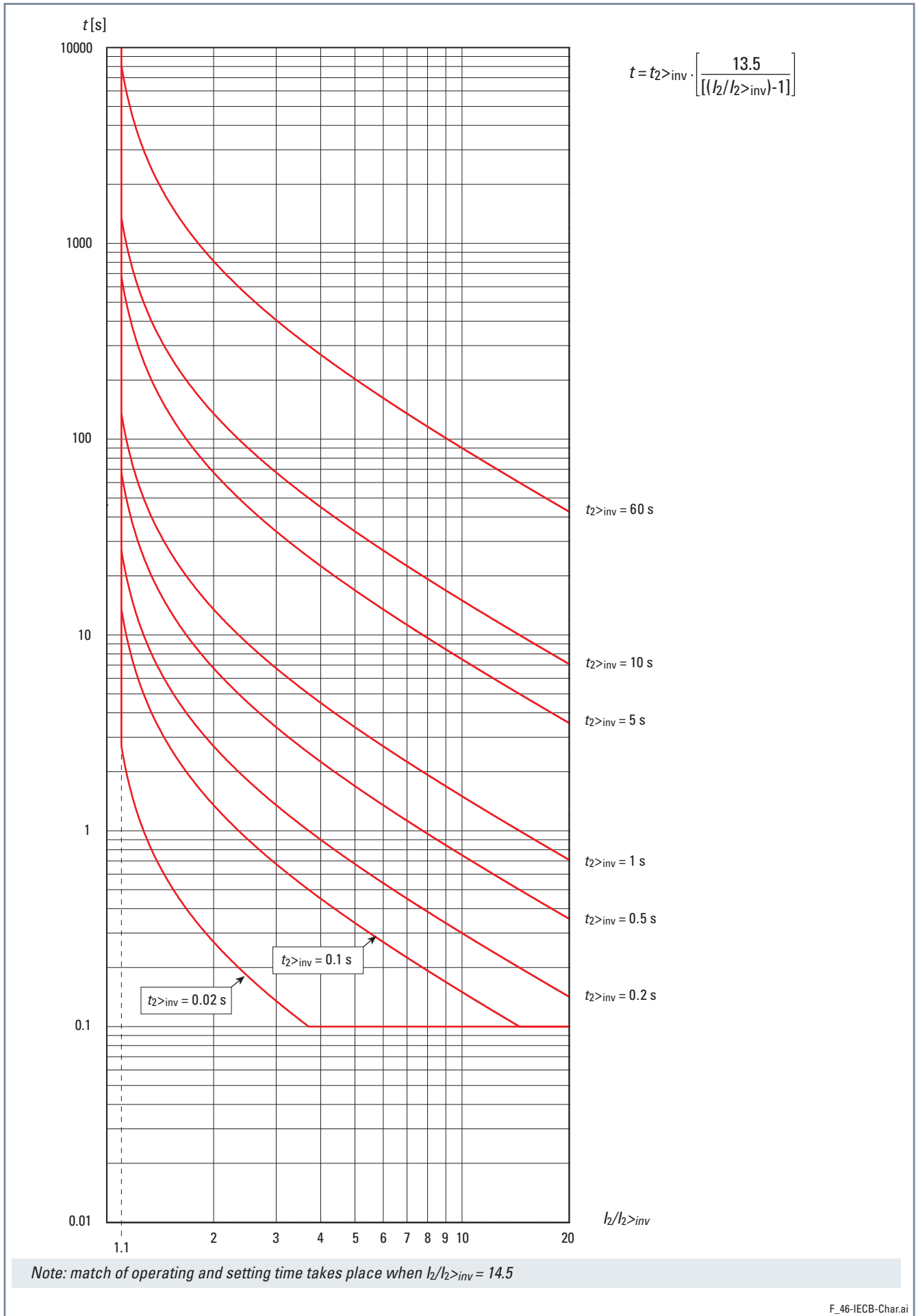
*Note 2* When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point

*Note 3* With setting more than  $2.5 I_n$  for the 50/51 elements and  $0.5 I_{En}$  for the 50N/51N elements, the upper limit of the measuring range is limited to  $50 I_n$  and  $10 I_{En}$  respectively.

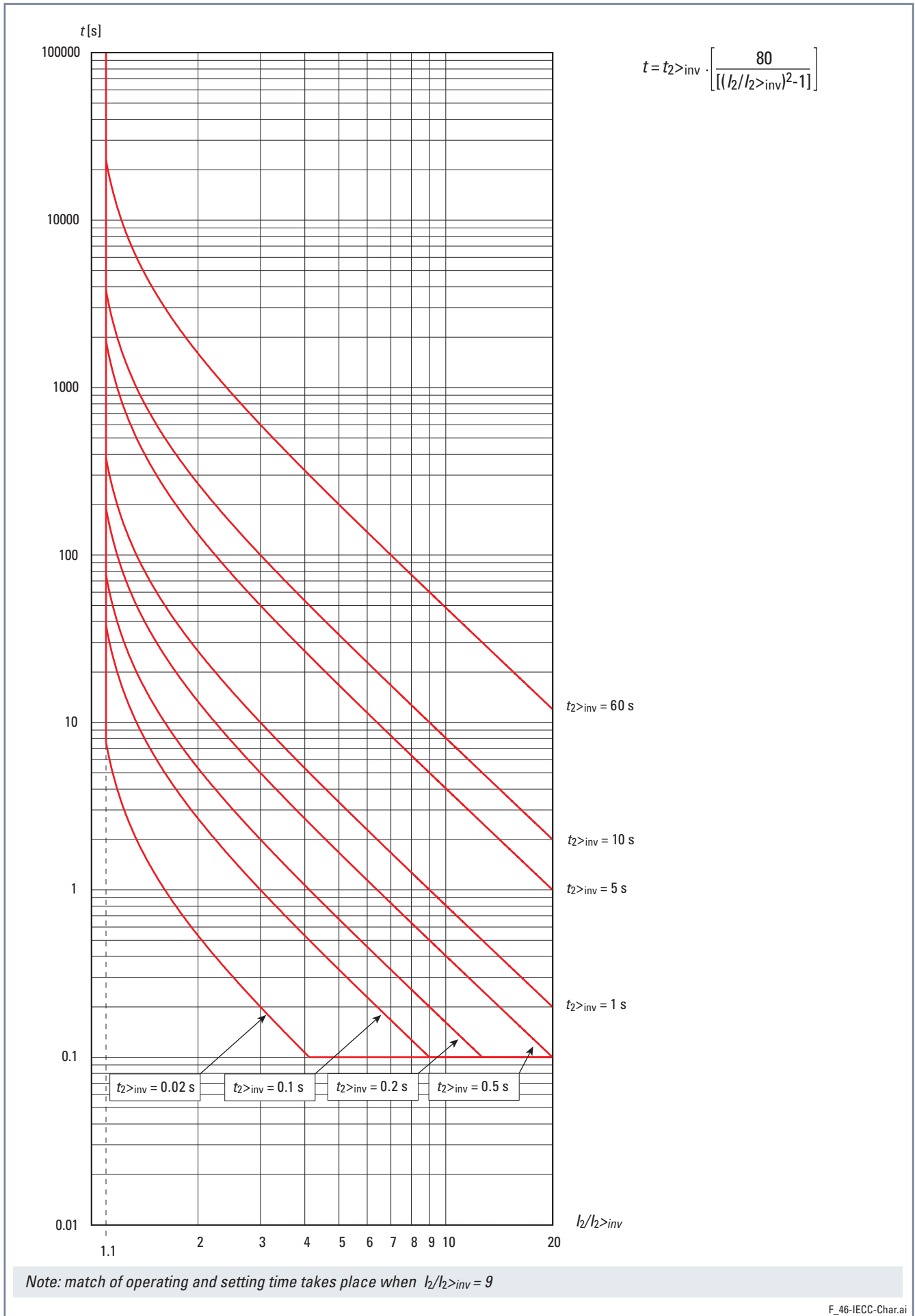
□ Negative sequence overcurrent 46 - Standard inverse time curve (IEC 60255-3/BS142 type A)



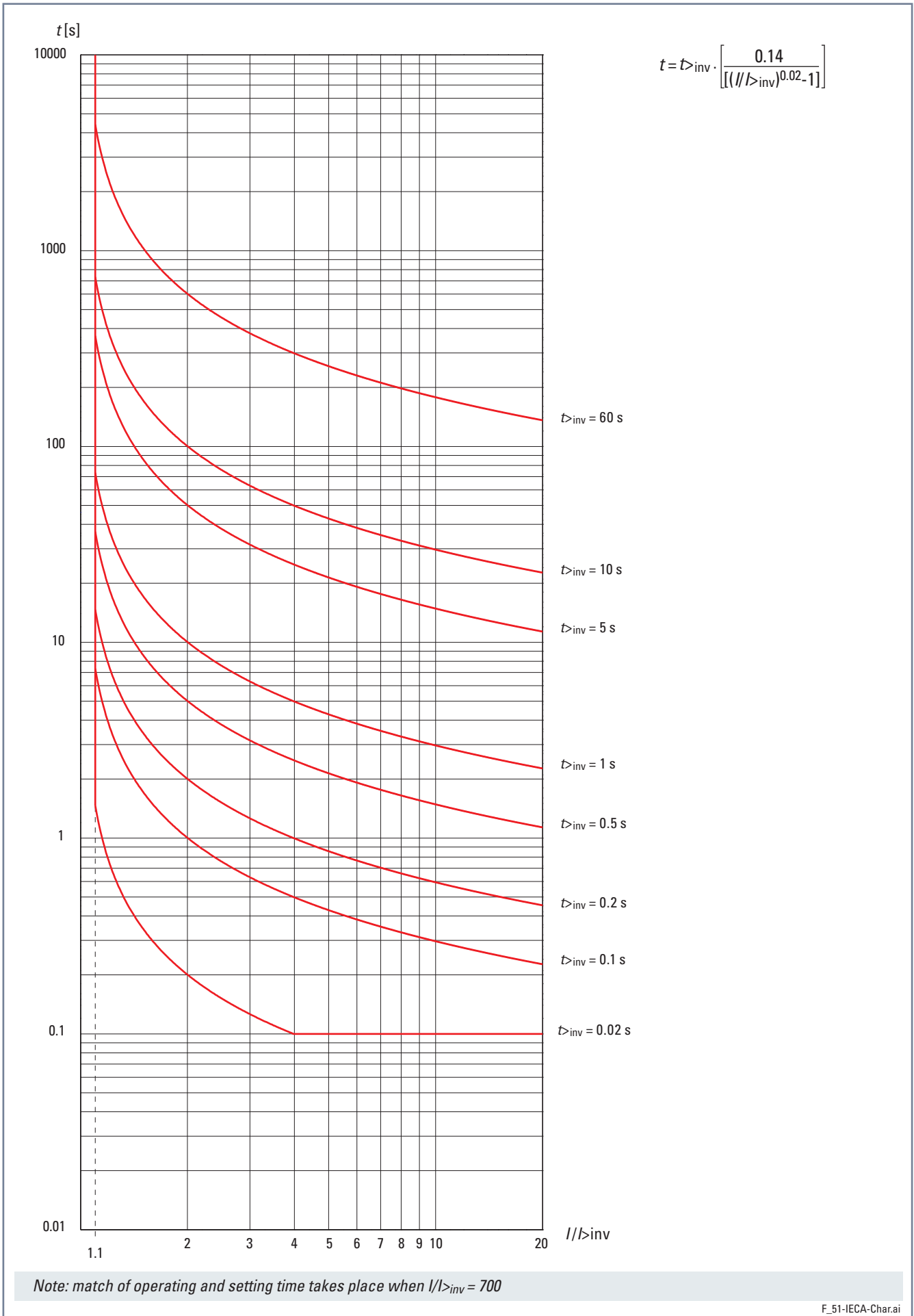
❑ Negative sequence overcurrent 46 - Very inverse time curve (IEC 60255-3/BS142 type B)



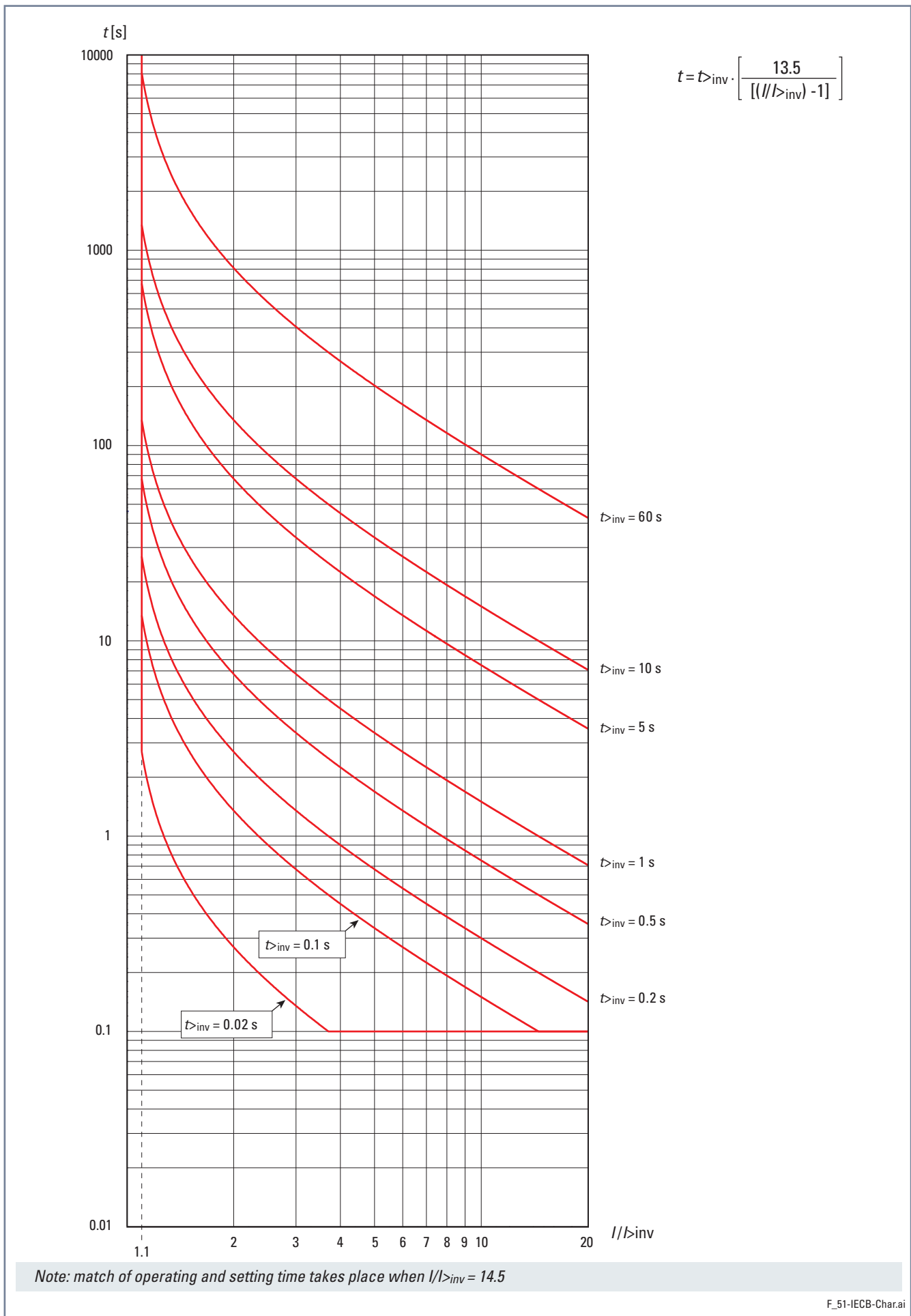
❑ Negative sequence overcurrent 46 - Extremely inverse time curve (IEC 60255-3/BS142 type C)



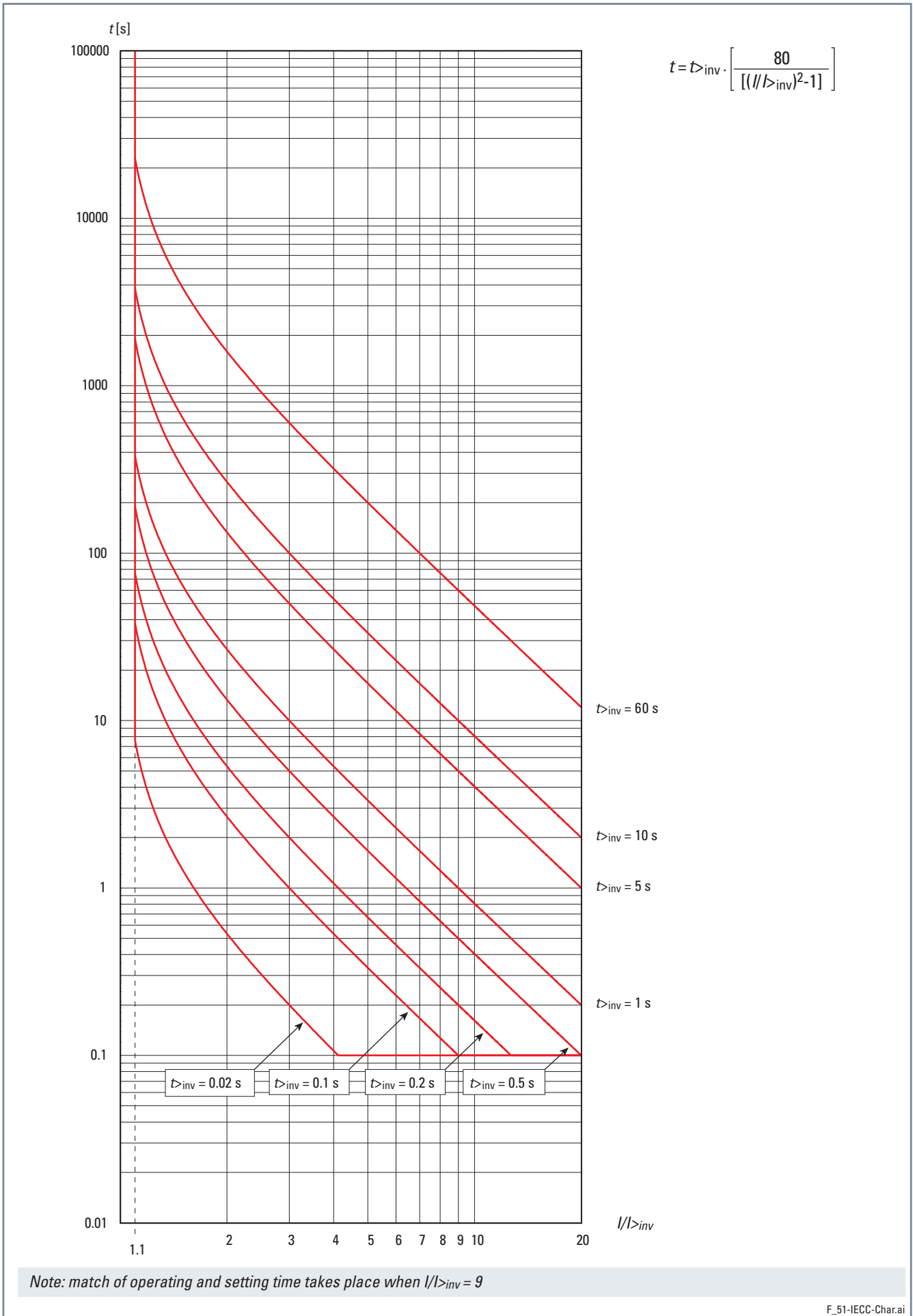
Phase overcurrent 50/51 - Standard inverse time curve (IEC 60255-3/BS142 type A)



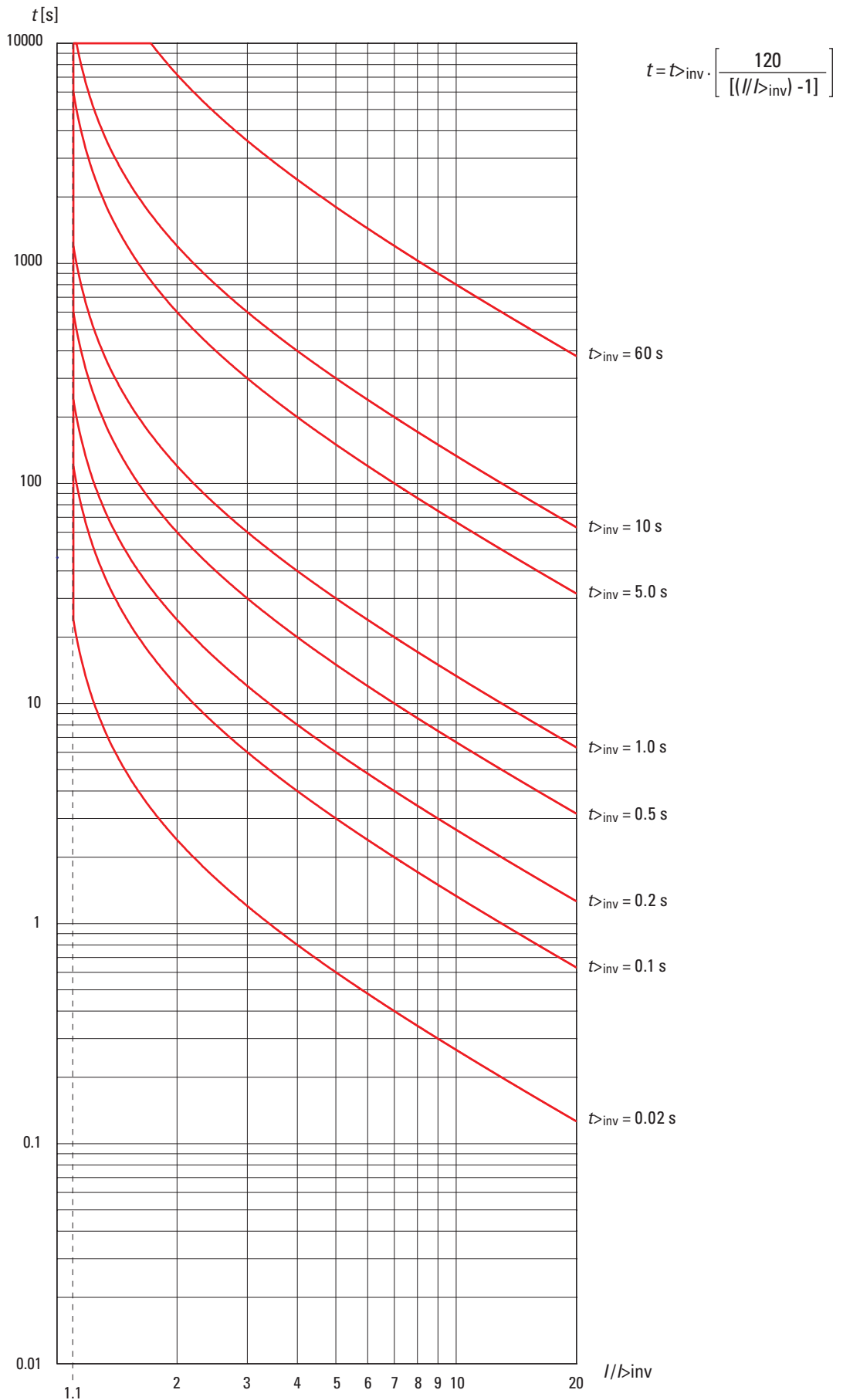
Phase overcurrent 50/51 - Very inverse time curve (IEC 60255-3/BS142 type B)



Phase overcurrent 50/51 - Extremely inverse time curve (IEC 60255-3/BS142 type C)

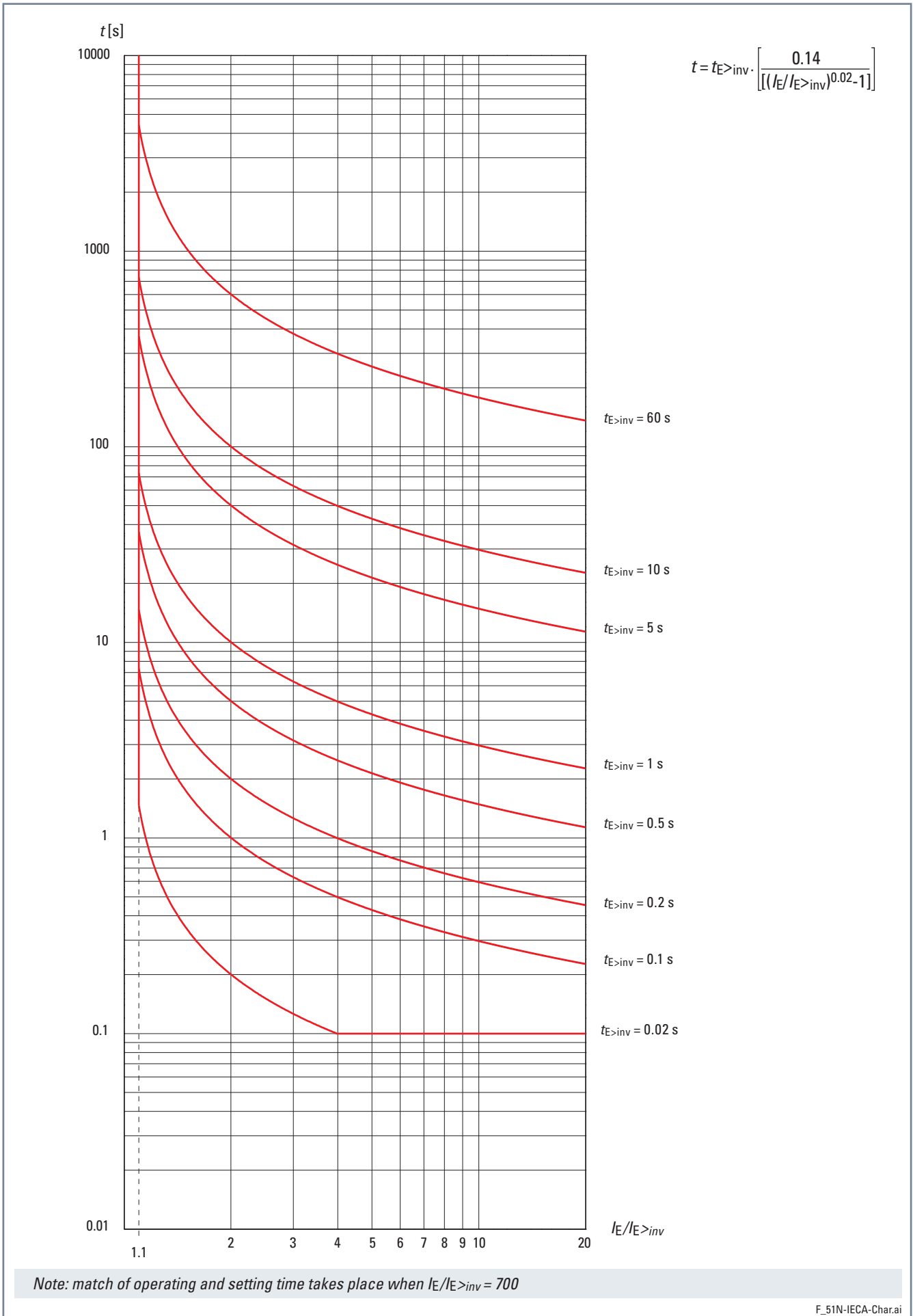


Phase overcurrent 50/51 - long time inverse curve (IEC BS B LI)

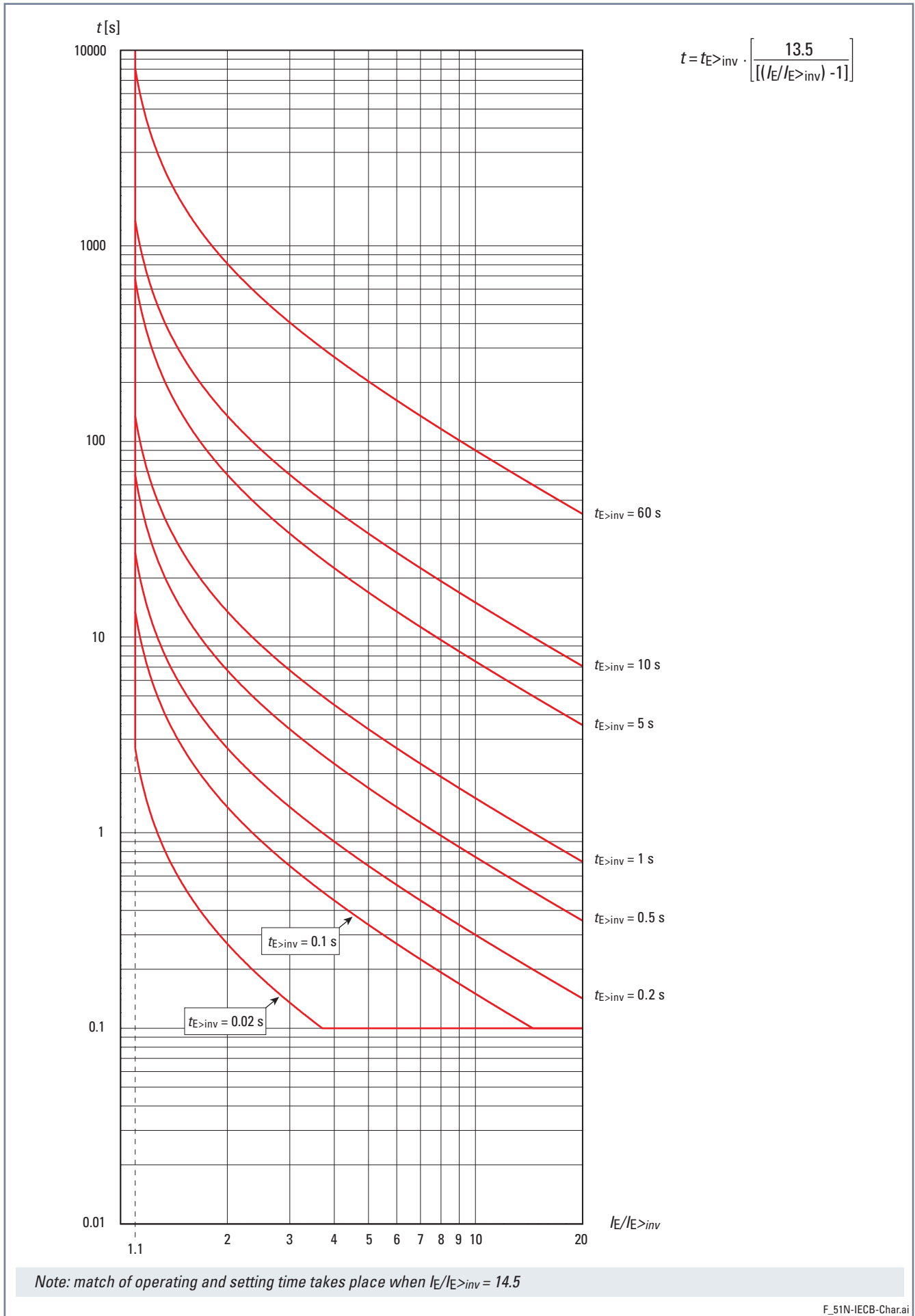


Note: match of operating and setting time takes place when  $I/I_{inv} = 121$

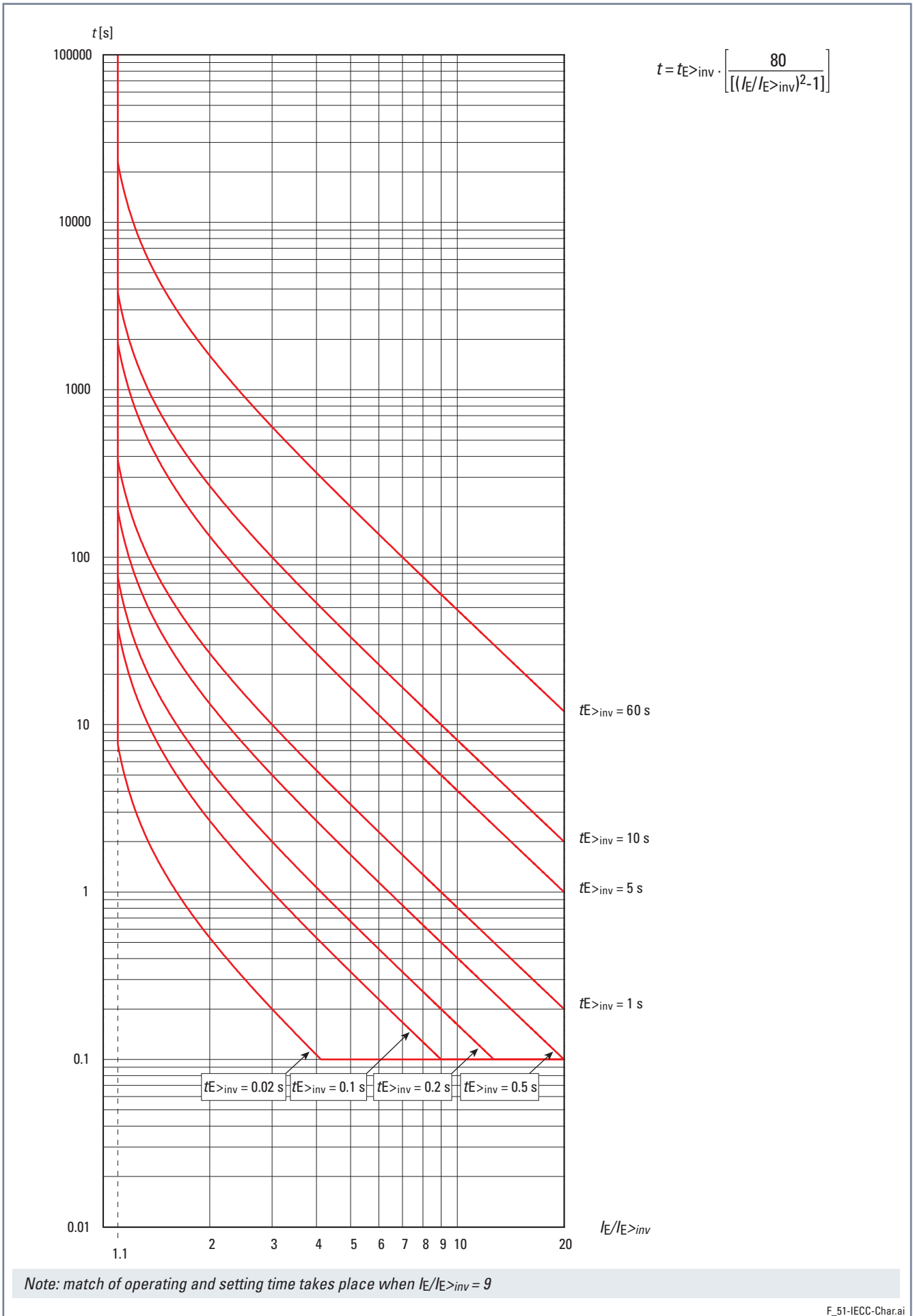
Residual overcurrent 50N/51N - Standard inverse time curve (IEC 60255-3/BS142 type A)



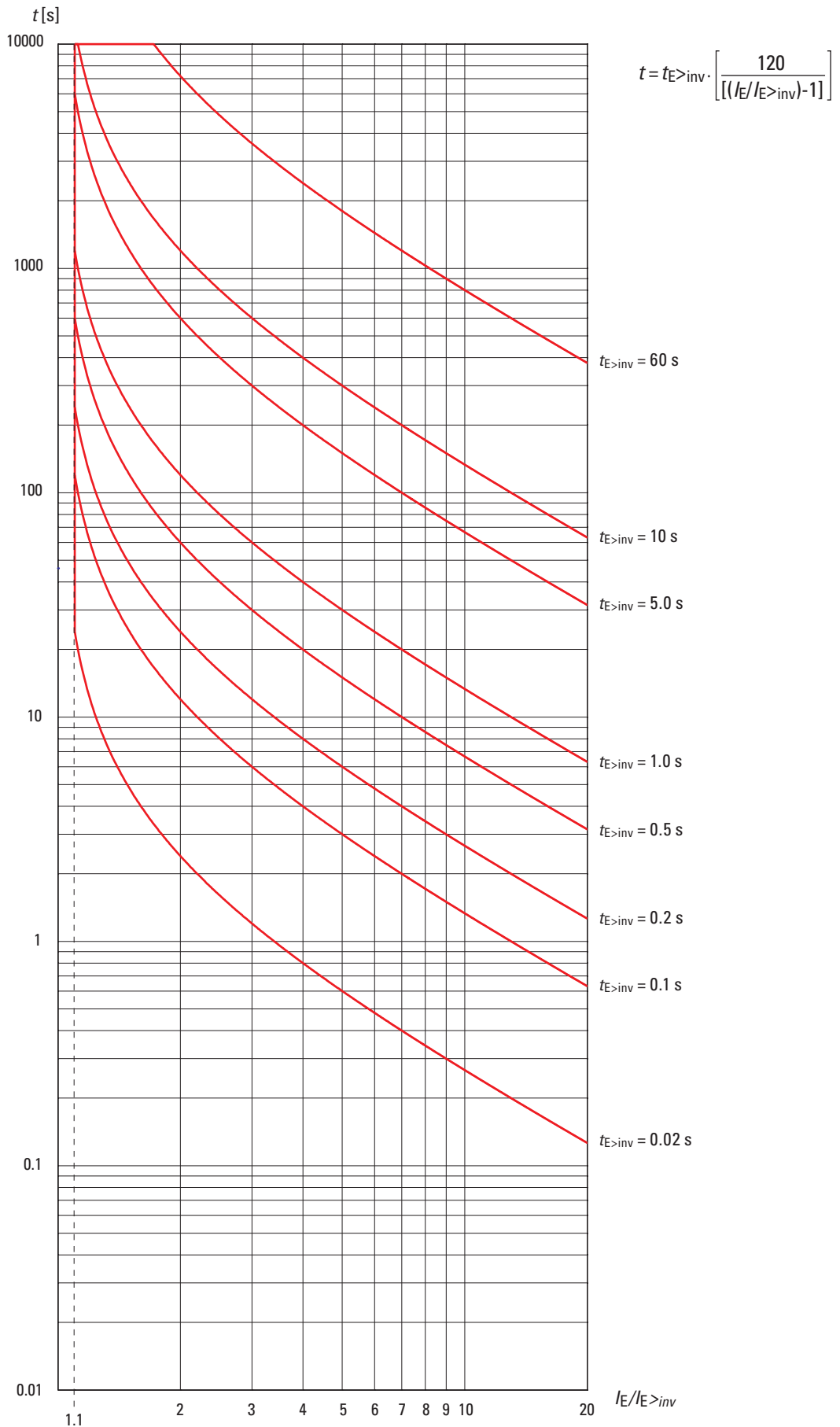
Residual overcurrent 50N/51N - Very inverse time curve (IEC 60255-3/BS142 type B)



Residual overcurrent 50N/51N - Extremely inverse time curve (IEC 60255-3/BS142 type C)



Residual overcurrent 50N/51N - long time inverse curve (IEC BS B LI)



Note: match of operating and setting time takes place when  $I_E/I_{E>inv} = 121$

## 8.2 APPENDIX A2 - Inverse time ANSI/IEEE curves

### □ Mathematical formula

The mathematical formula, according the ANSI/IEEE standards is:<sup>[1]</sup>

$$t = t_{>inv} \cdot \left[ \frac{K}{\left[ \left( I / I_{>inv} \right)^{\alpha} - 1 \right]} + L \right]$$

Where:

- $t$  = operate time (in seconds)
- $t_{>inv}$  = setting time multiplier (in seconds)
- $I$  = input current
- $I_{>inv}$  = threshold setting

$K$  = coefficient:

- $K = 0.01$  for ANSI/IEEE Moderately inverse curve
- $K = 3.922$  for ANSI/IEEE Very inverse curve
- $K = 5.64$  for ANSI/IEEE Extremely inverse curve

$\alpha$  = curve shape constant:

- $\alpha = 0.02$  for ANSI/IEEE Moderately inverse curve
- $\alpha = 2$  for ANSI/IEEE Very inverse curve
- $\alpha = 2$  for ANSI/IEEE Extremely inverse curve

$L$  = coefficient:

- $L = 0.023$  for ANSI/IEEE Moderately inverse curve
- $L = 0.098$  for ANSI/IEEE Very inverse curve
- $L = 0.024$  for ANSI/IEEE Extremely inverse curve

For all inverse time characteristics, following data applies:

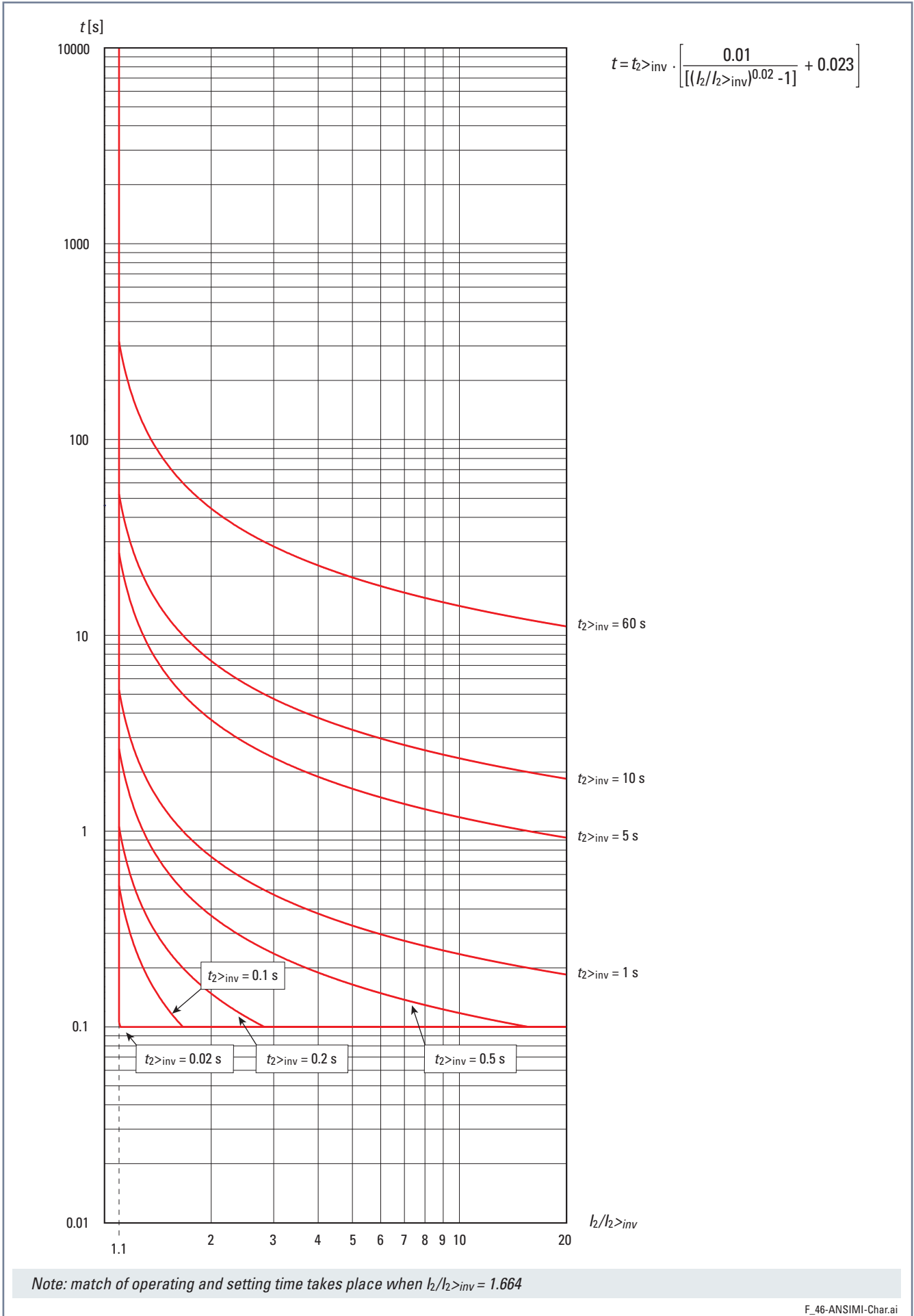
- Asymptotic reference value (minimum pickup value):  $1.1 I_{>inv}$
- Minimum operate time:  $0.1$  s
- Range where the equation is valid:<sup>[2][3]</sup>  $1.1 \leq I / I_{>inv} \leq 20$
- If  $I > \text{pickup} \geq 2.5 I_n$ , the upper limit is  $50 I_n$

*Note 1 Symbols are concerning the overcurrent element. The comprehensive overview of the inverse time characteristics concerning the 50/51 and 50N/51N elements is dealt within the PROTECTIVE ELEMENTS section*

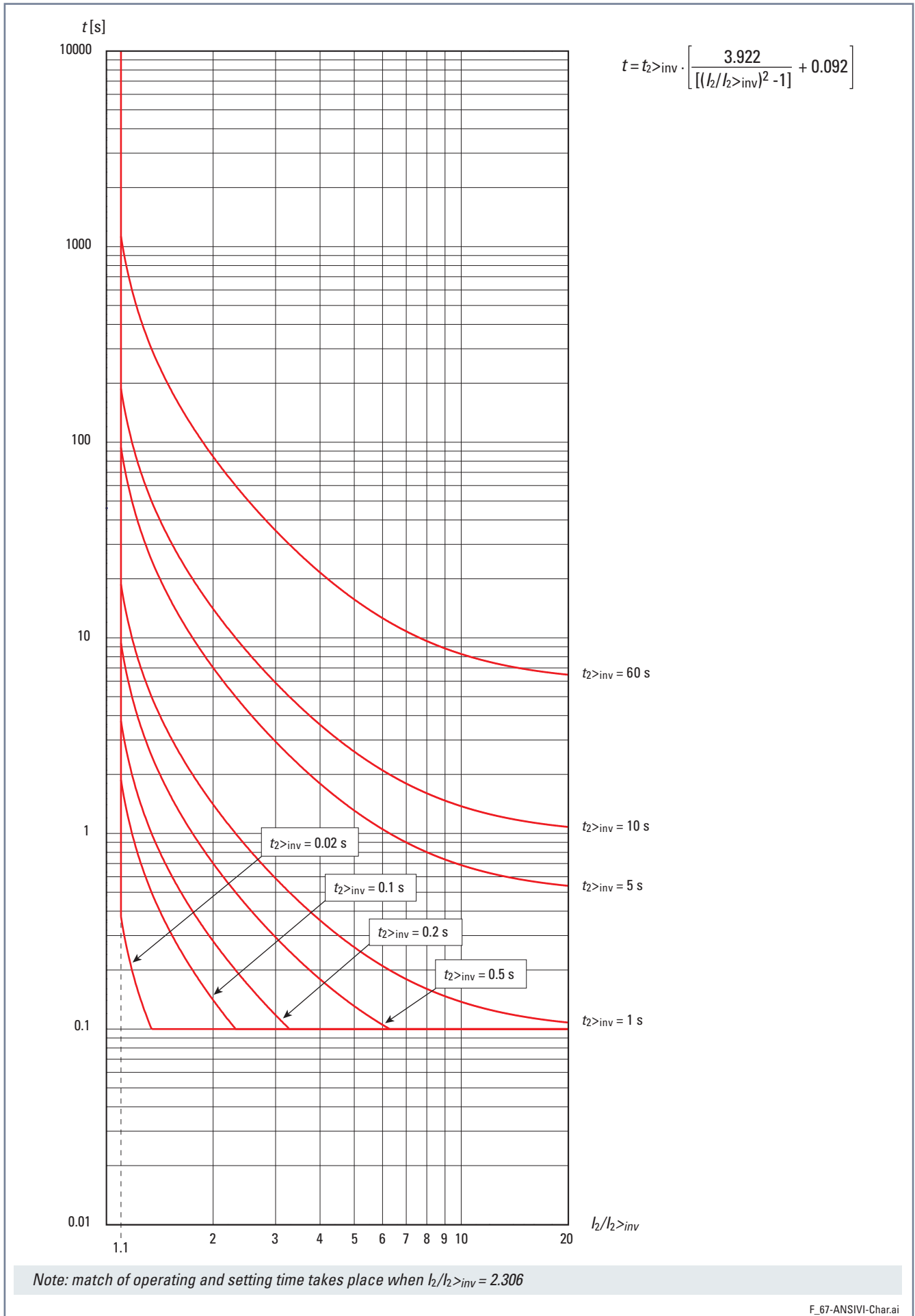
*Note 2 When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point*

*Note 3 With setting more than  $2.5 I_n$  for the 50/51 elements and  $0.5 I_n$  for the 50N/51N elements, the upper limit of the measuring range is limited to  $50 I_n$  and  $10 I_n$  respectively.*

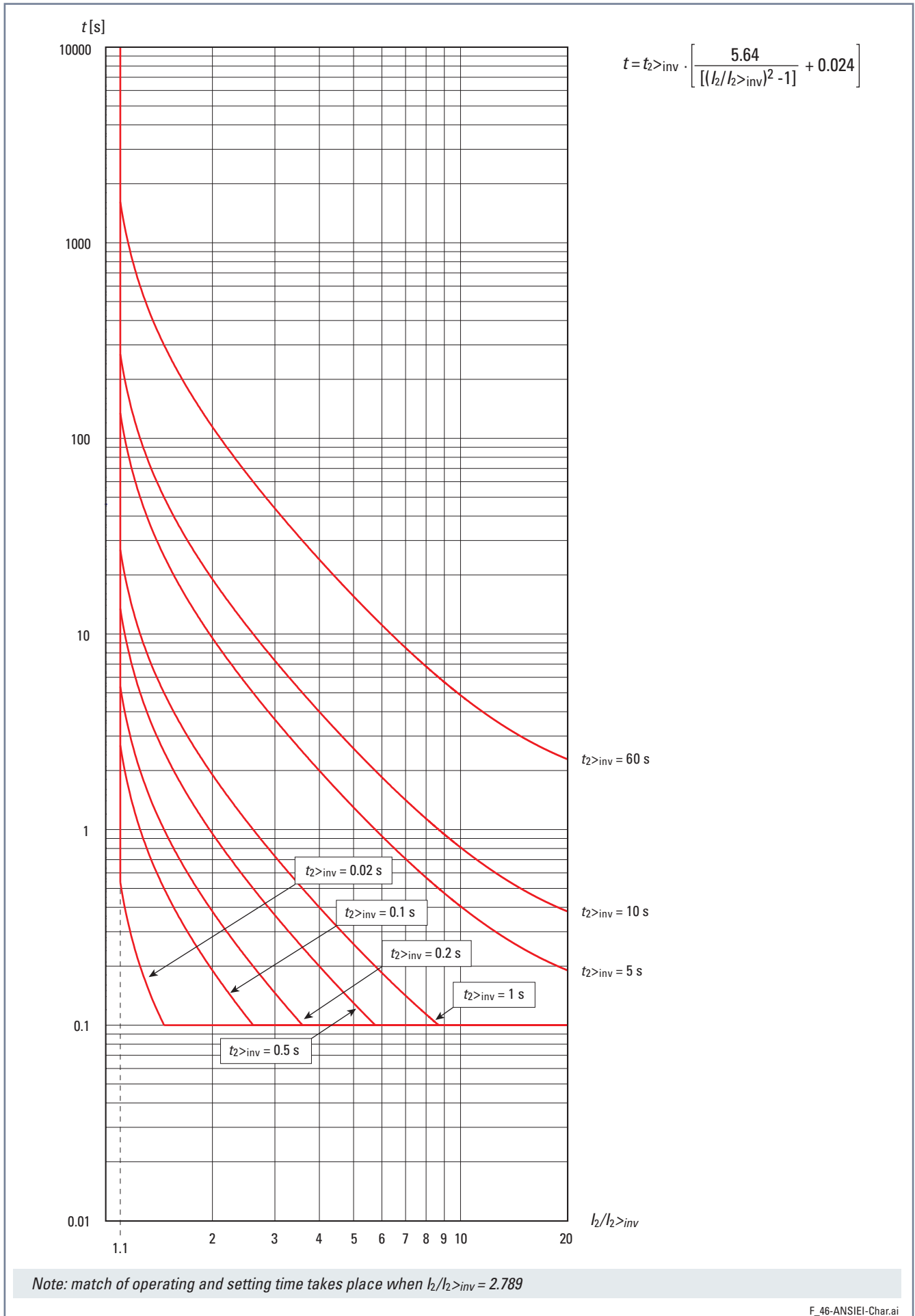
□ Negative sequence overcurrent 461 - Moderately inverse time curve (ANSI/IEEE type MI)



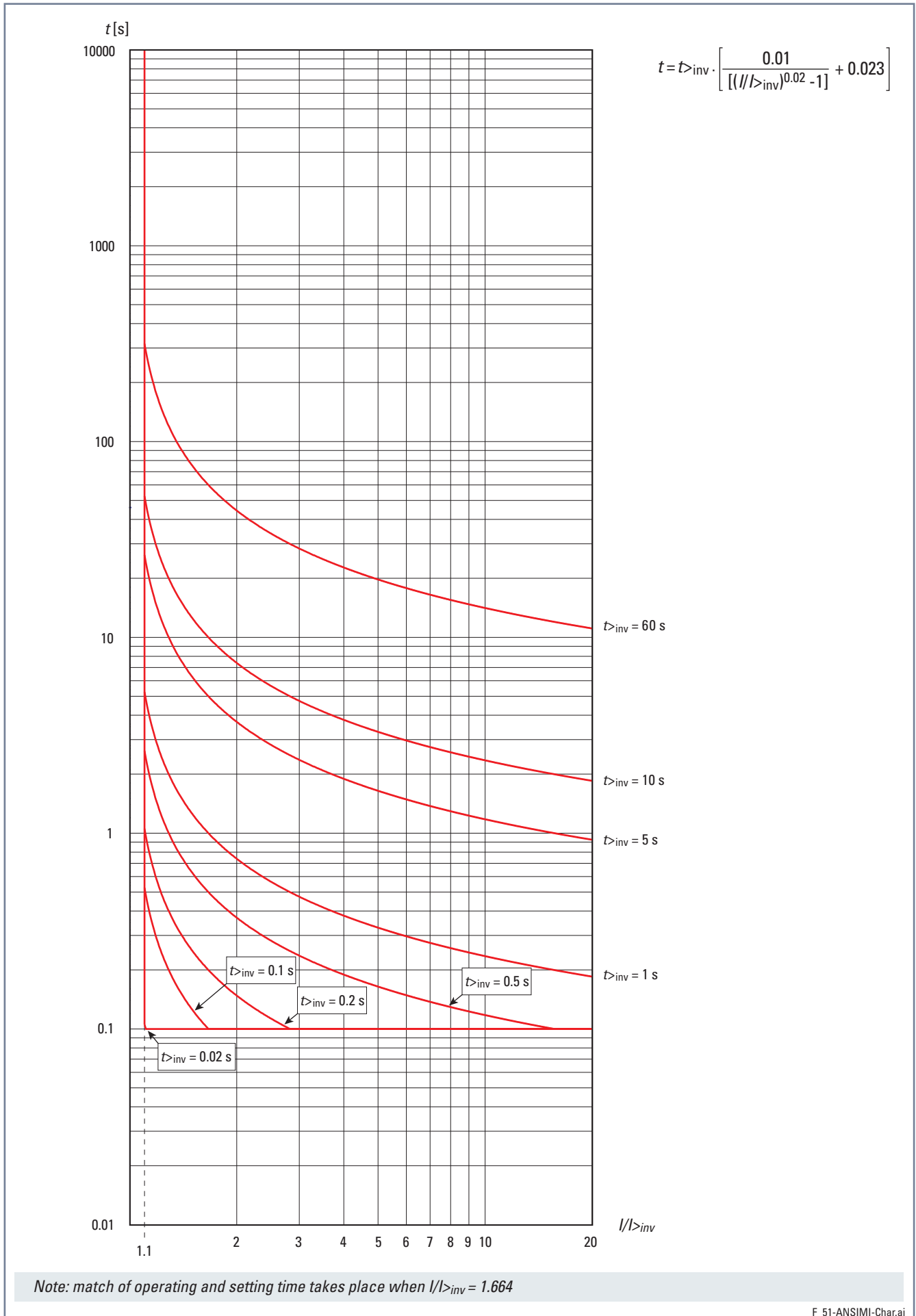
❑ Negative sequence overcurrent 46 - Very inverse time curve (ANSI/IEEE type VI)



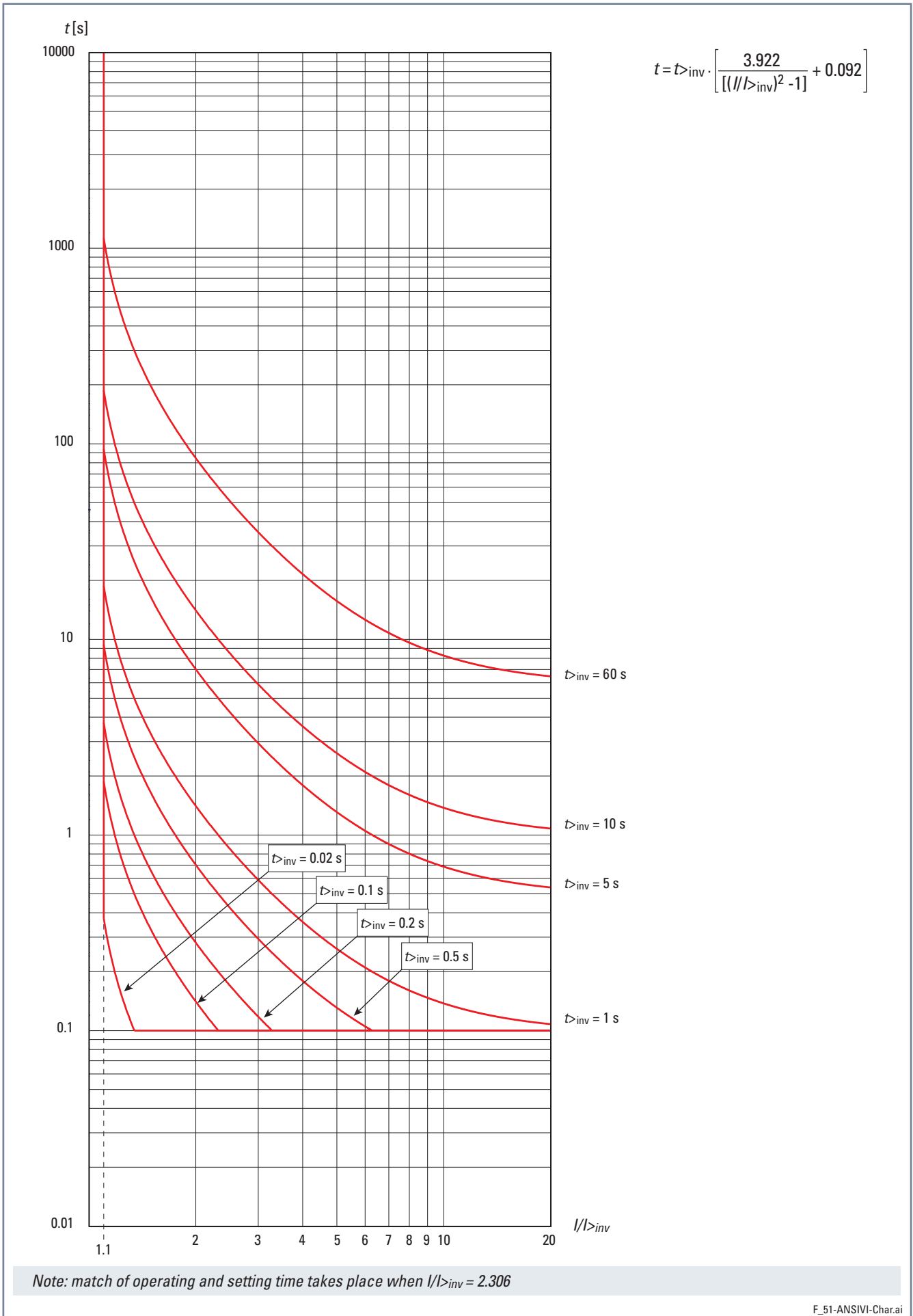
❑ Negative sequence overcurrent 46 - Extremely inverse time curve (ANSI/IEEE type EI)



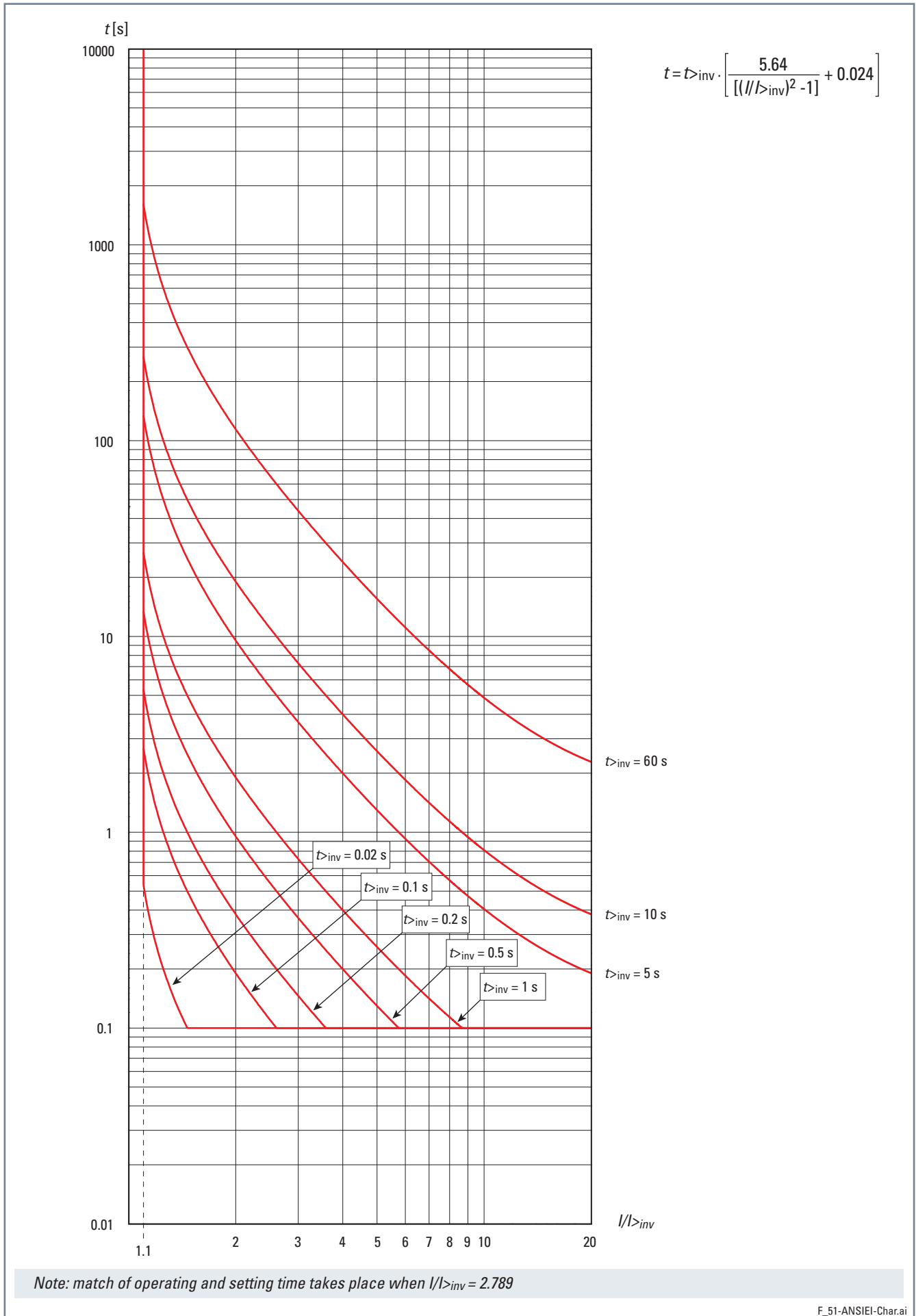
Phase overcurrent 50/51 - Moderately inverse time curve (ANSI/IEEE type MI)



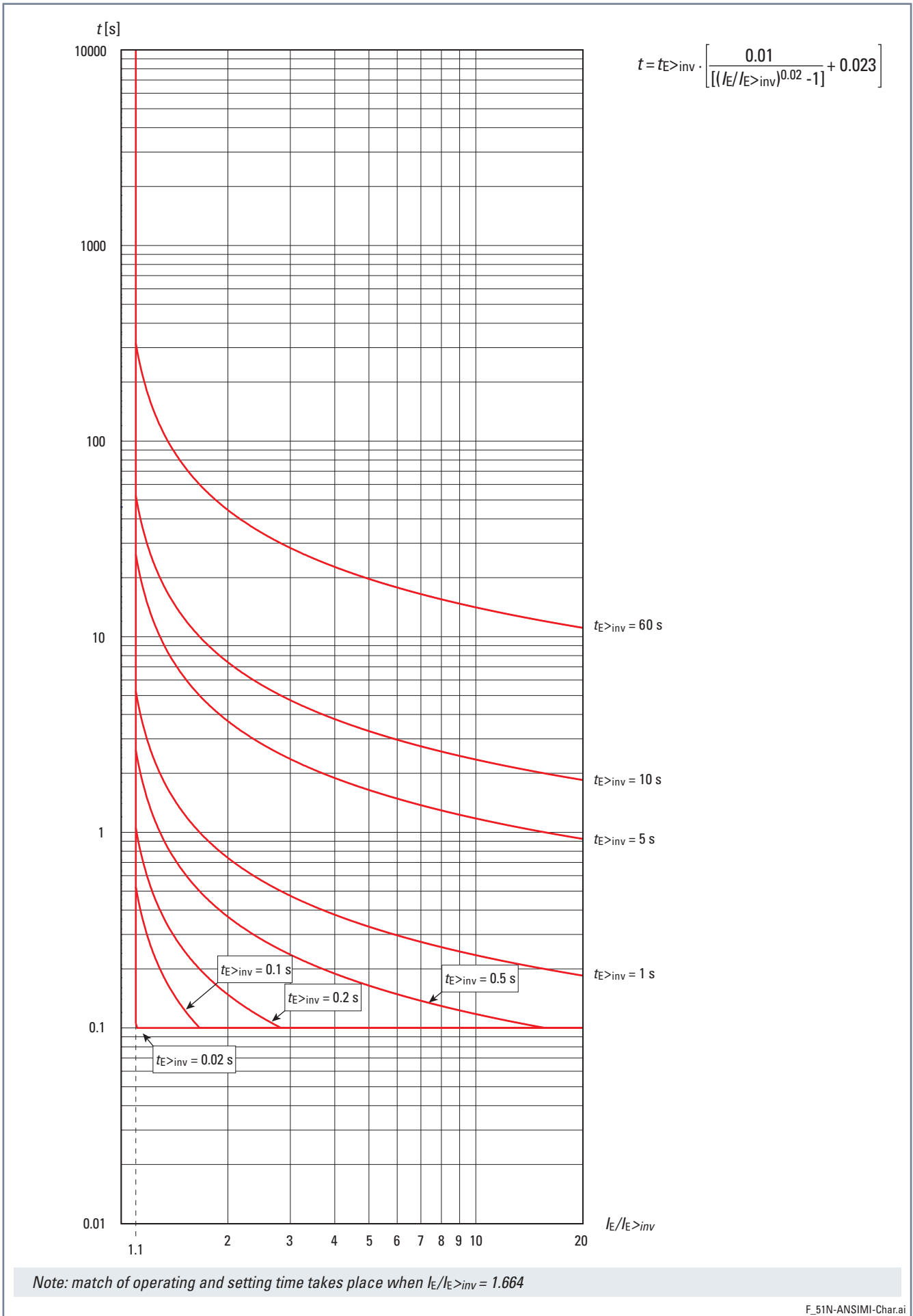
Phase overcurrent 50/51 - Very inverse time curve (ANSI/IEEE type VI)



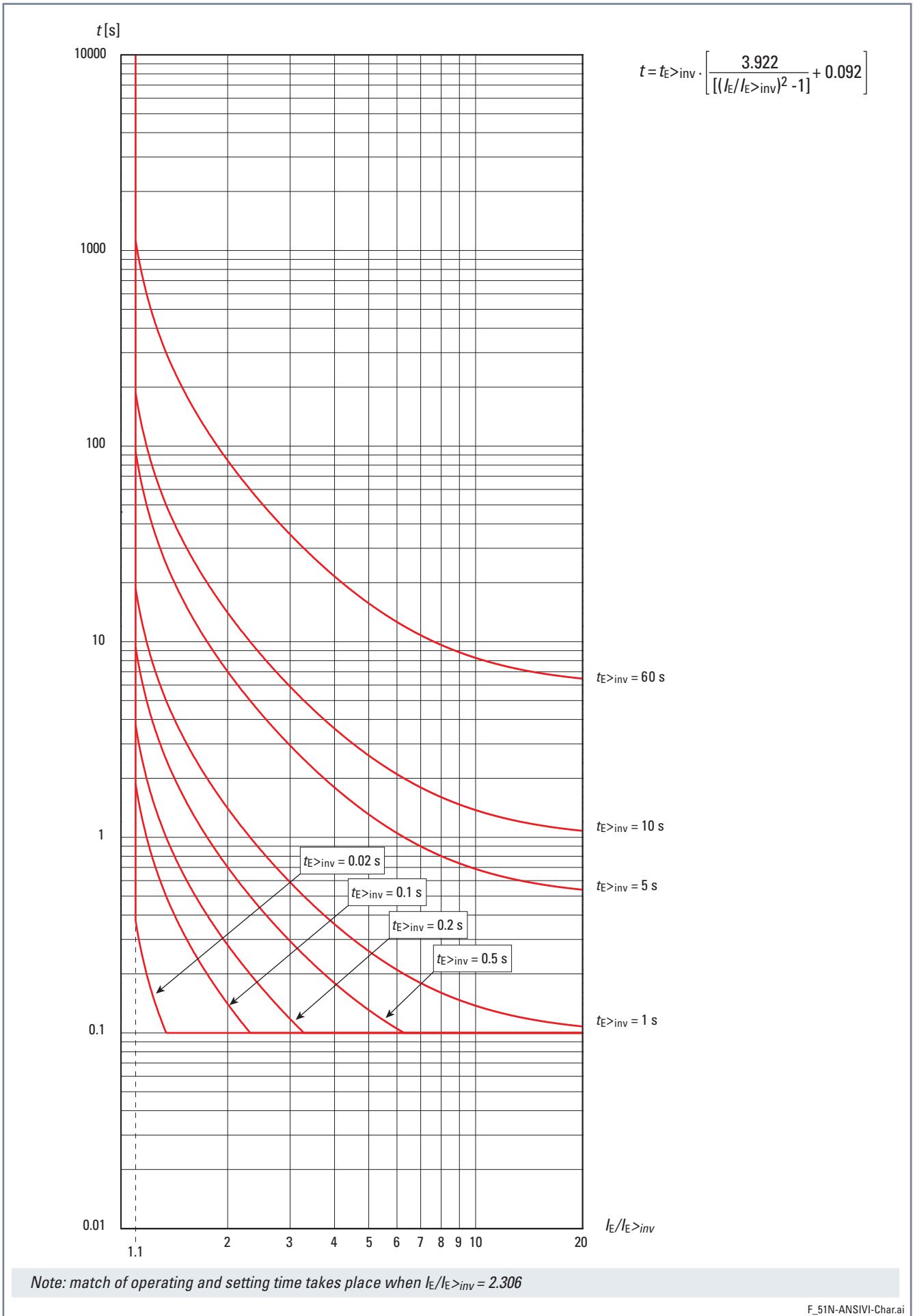
Phase overcurrent 50/51 - Extremely inverse time curve (ANSI/IEEE type EI)



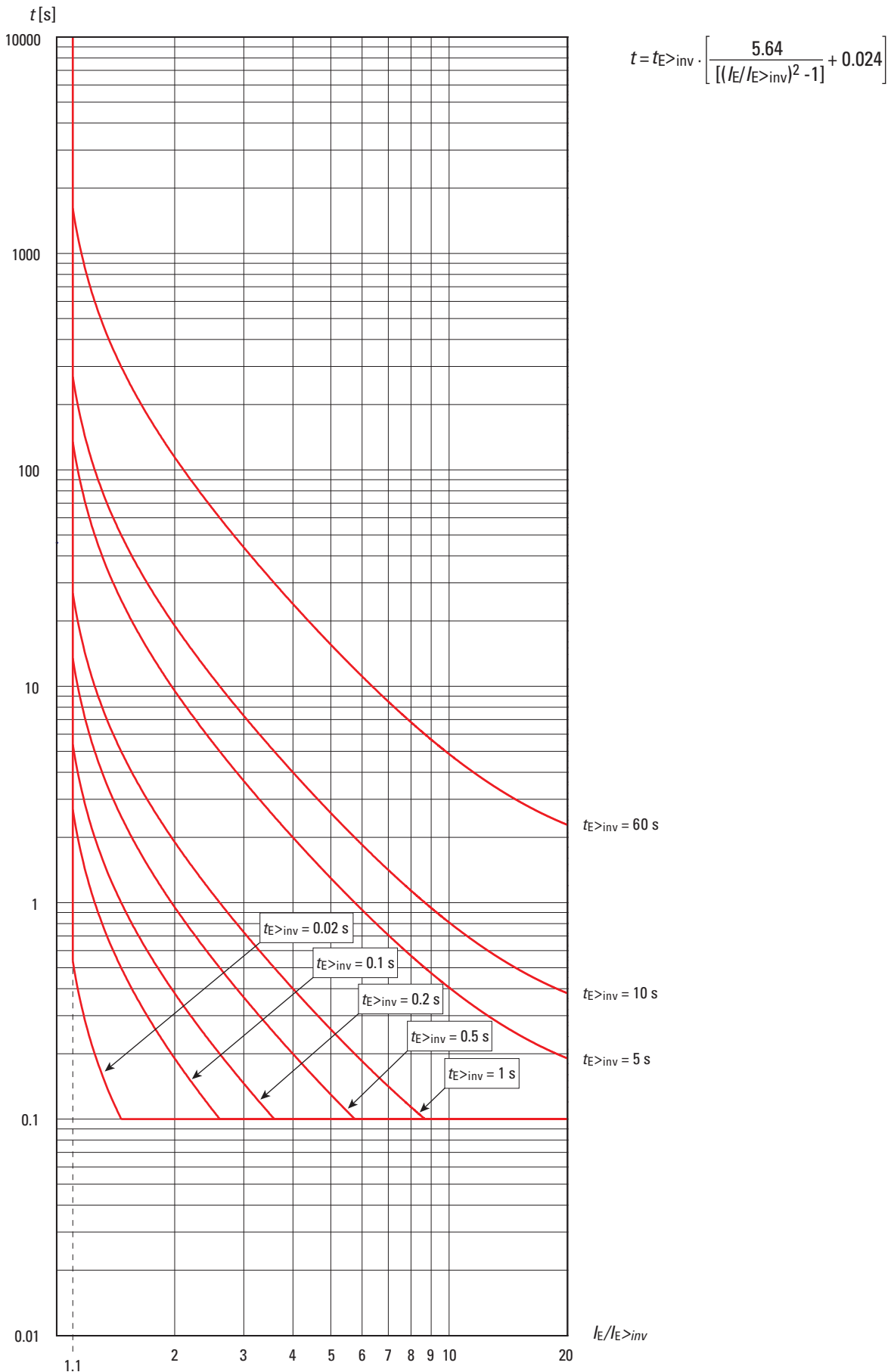
Residual overcurrent 50N/51N - Moderately inverse time curve (ANSI/IEEE type MI)



Residual overcurrent 50N/51N - Very inverse time curve (ANSI/IEEE type VI)



Residual overcurrent 50N/51N - Extremely inverse time curve (ANSI/IEEE type EI)



Note: match of operating and setting time takes place when  $I_E/I_{E>inv} = 2.789$

**8.3 APPENDIX A3 - Inverse time - RECTIFIER, I<sup>2</sup>t and EM curves**
**□ Mathematical formula**

The mathematical formula for RECTIFIER, I-squared-t (I<sup>2</sup>t) and Electromechanical curves (EM) is:<sup>[1]</sup>

$$t = t_{>inv} \cdot \left[ \frac{K}{A \cdot (I/I_{>inv})^{\alpha} - B} \right]$$

Where:

- $t$  = operate time (in seconds)
- $t_{>inv}$  = setting time multiplier (in seconds)
- $I$  = input current
- $I_{>inv}$  = threshold setting

$K$  = coefficient:

- $K = 2351$  for RECTIFIER curve (RI)
- $K = 16$  for I<sup>2</sup>t curve
- $K = 0.28$  for Electromechanical curve (EM)

$\alpha$  = curve shape constant:

- $\alpha = 5.6$  for RECTIFIER curve (RI)
- $\alpha = 2$  for I-squared-t (I<sup>2</sup>t) curve
- $\alpha = -1$  for Electromechanical curve (EM)

$A$  = coefficient:

- $A = 1$  for RECTIFIER curve (RI)
- $A = 1$  for I-squared-t (I<sup>2</sup>t) curve
- $A = -0.236$  for Electromechanical curve (EM)

$B$  = coefficient:

- $B = 1$  for RECTIFIER curve (RI)
- $B = 0$  for I-squared-t (I<sup>2</sup>t) curve
- $B = -0.339$  for Electromechanical curve (EM)

For all inverse time characteristics, following data applies:

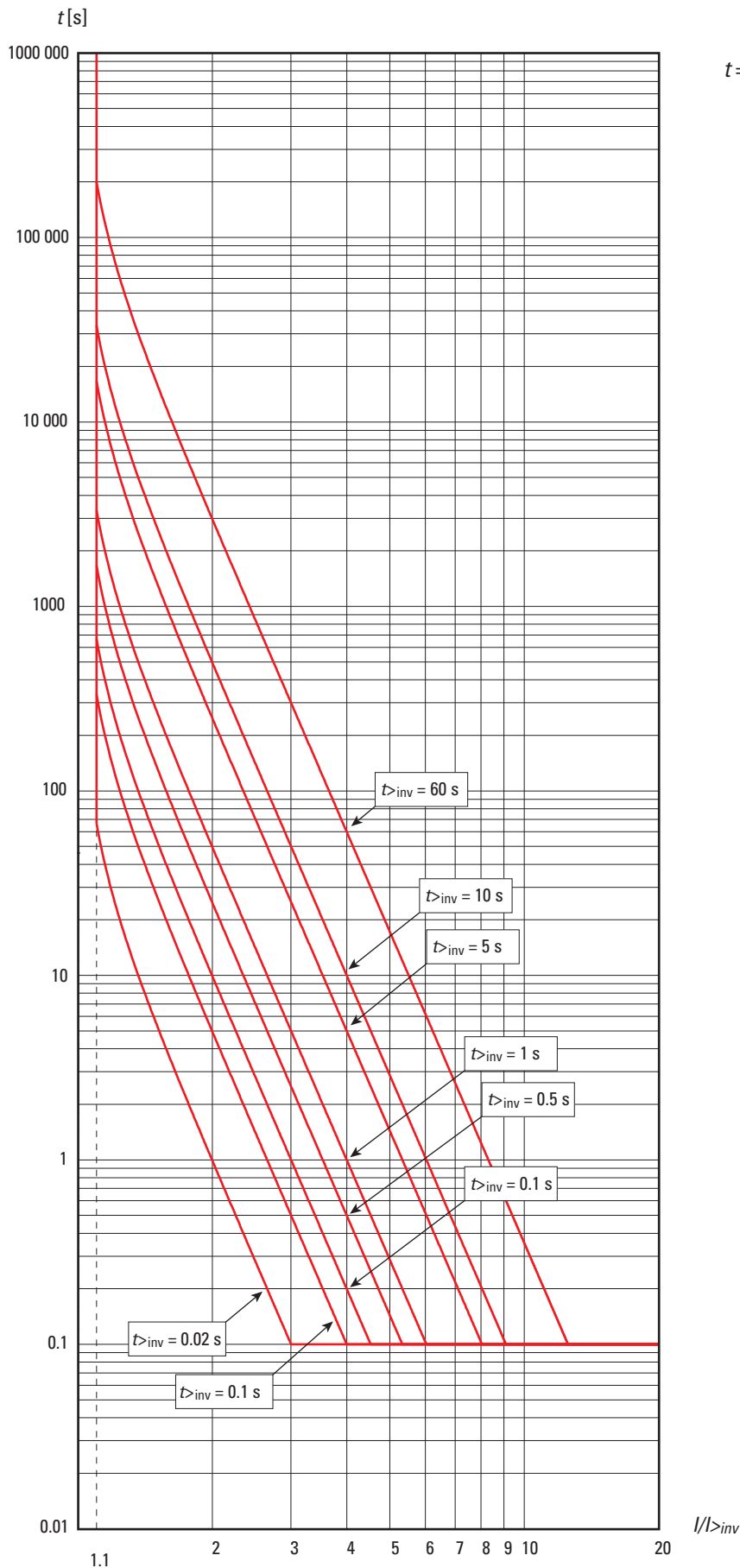
- Asymptotic reference value (minimum pickup value):  $1.1 I_{>inv}$
- Minimum operate time:  $0.1$  s
- Range where the equation is valid:<sup>[2][3]</sup>  $1.1 \leq I/I_{>inv} \leq 20$
- If  $I > \text{pickup} \geq 2.5 I_n$ , the upper limit is  $50 I_n$

*Note 1 Symbols are concerning the overcurrent element. The comprehensive overview of the inverse time characteristics concerning the 50/51 and 50N/51N elements is dealt within the PROTECTIVE ELEMENTS section*

*Note 2 When the input value is more than 20 times the set point, the operate time is limited to the value corresponding to 20 times the set point*

*Note 3 With setting more than 2.5  $I_n$  for the 50/51 elements and 0.5  $I_n$  for the 50N/51N elements, the upper limit of the measuring range is limited to 50  $I_n$  and 10  $I_n$  respectively.*

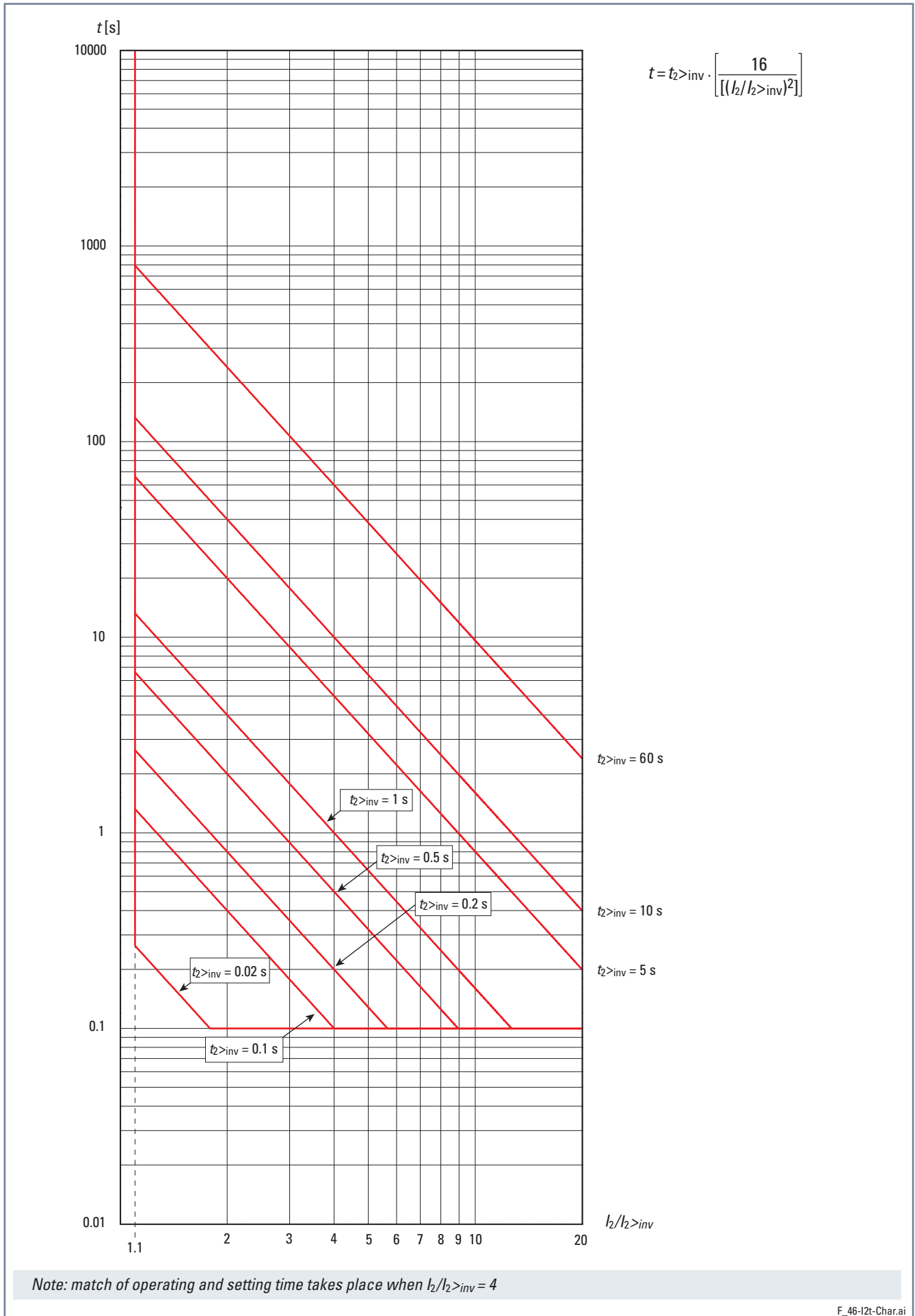
Phase overcurrent 50/51 - Rectifier curves



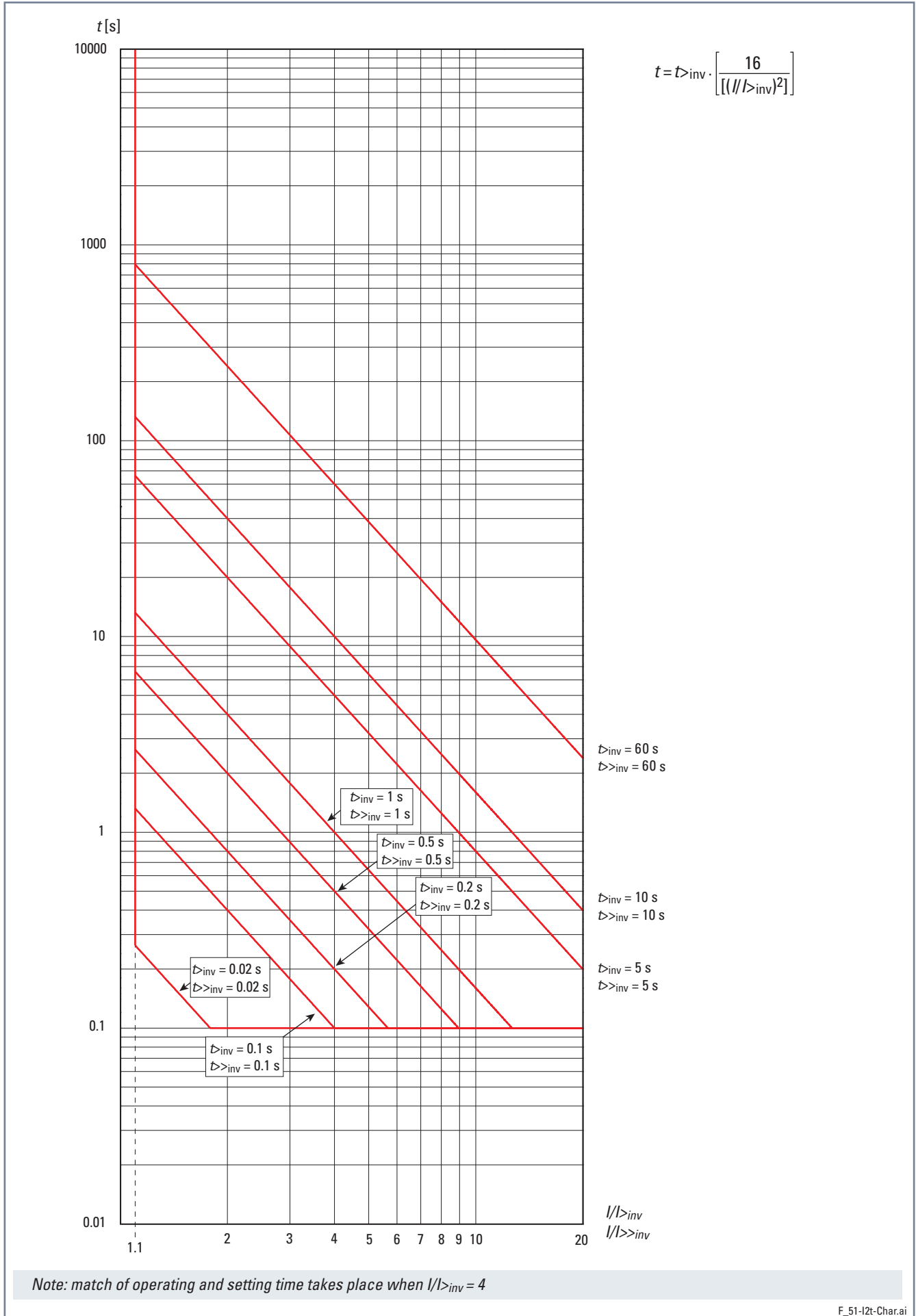
$$t = t_{>inv} \cdot \left[ \frac{2351}{\left[ \left( \frac{I}{I_{>inv}} \right)^{5.6} - 1 \right]} \right]$$

Note: match of operating and setting time takes place when  $I/I_{>inv} = 4$

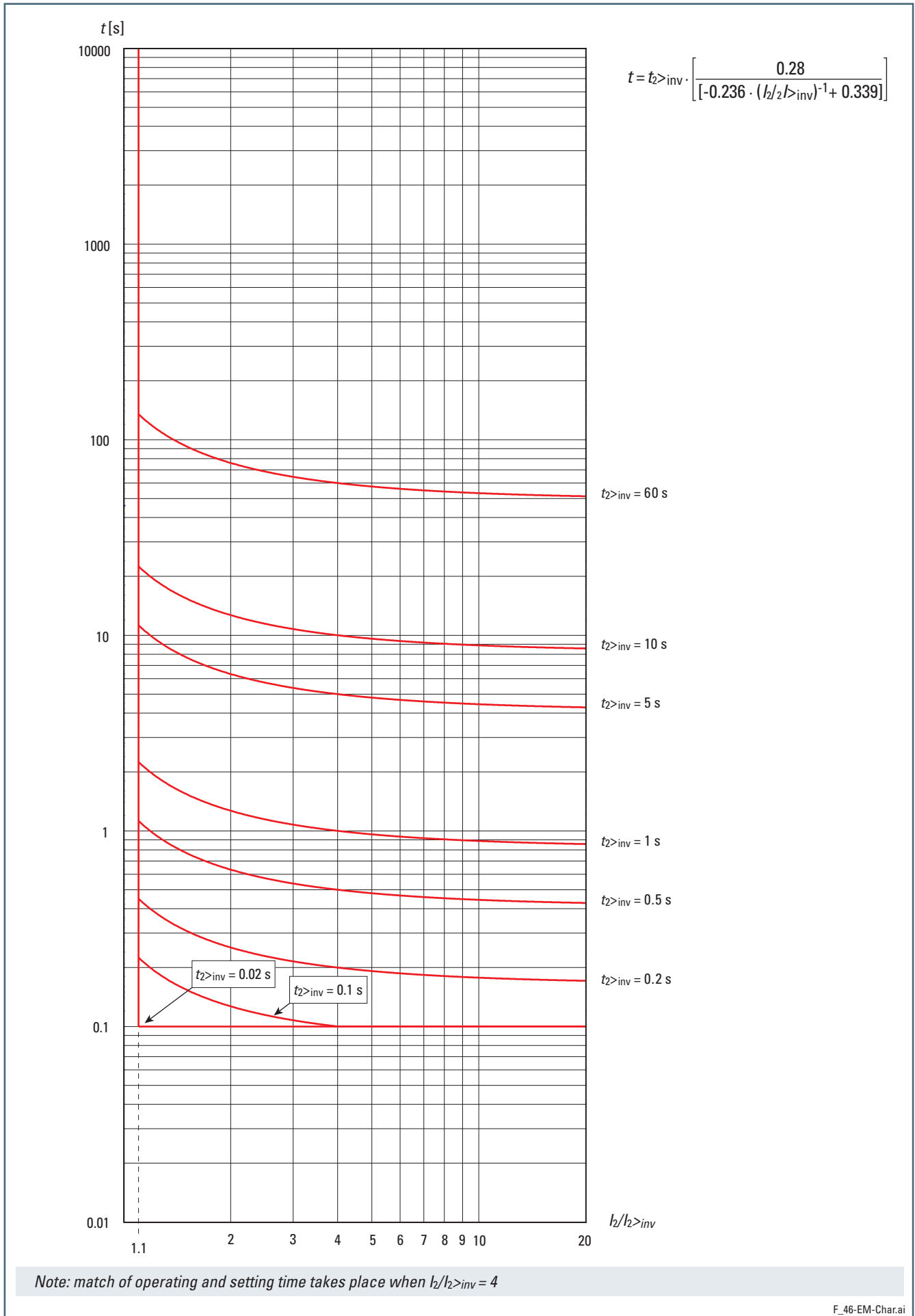
□ Negative sequence overcurrent 46 -  $I_2^2t$  inverse curves ( $I_2t=K$ )



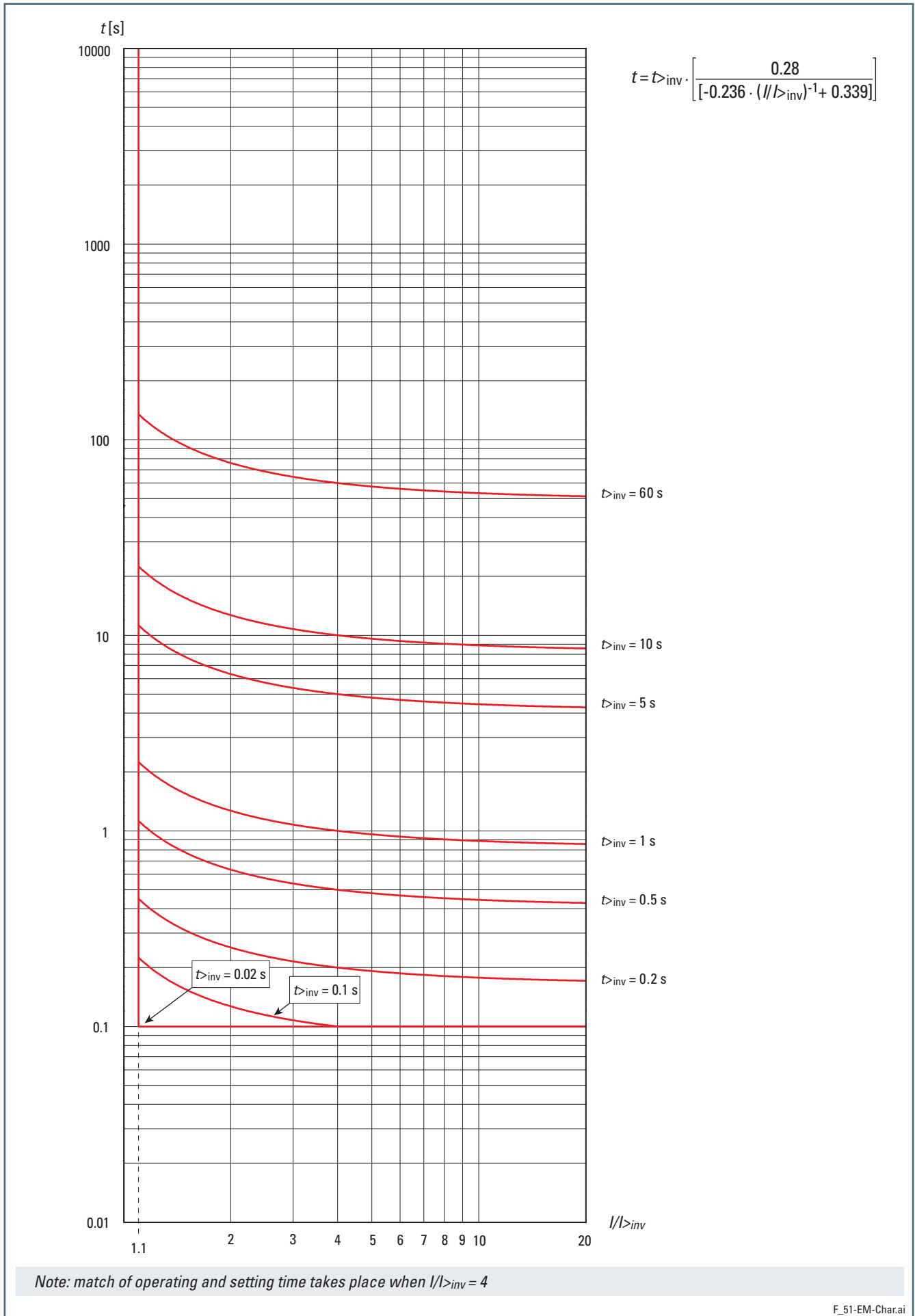
Phase overcurrent 50/51 - I<sup>2</sup>t inverse curves (I<sup>2</sup>t=K)



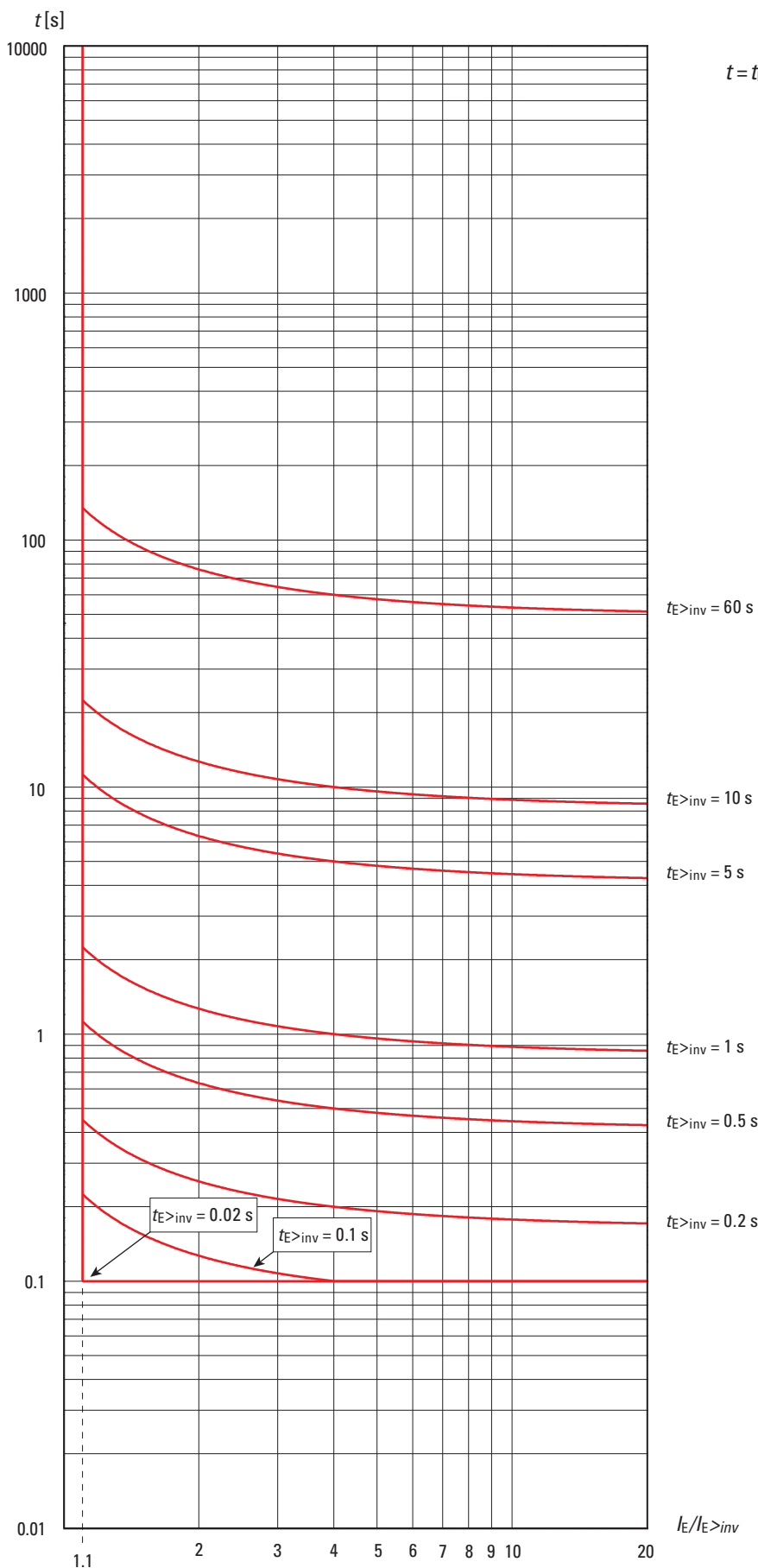
□ Negative sequence overcurrent 46 - Electromechanical inverse curves (EM)



Phase overcurrent 50/51 - Electromechanical inverse curves (EM)

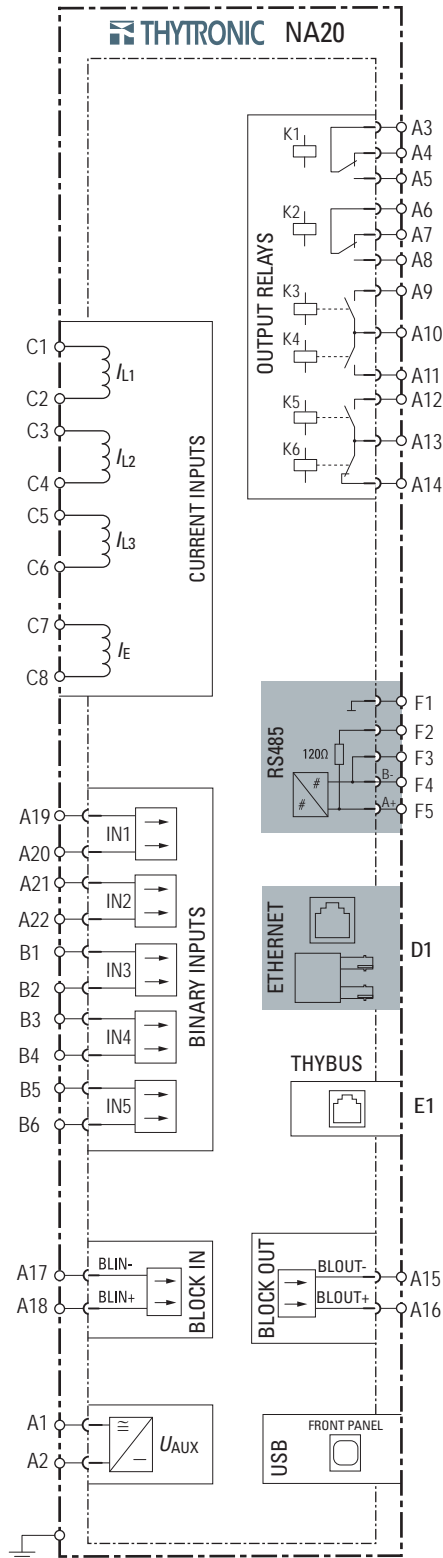


Residual overcurrent 50N/51N - Electromechanical inverse curves (EM)

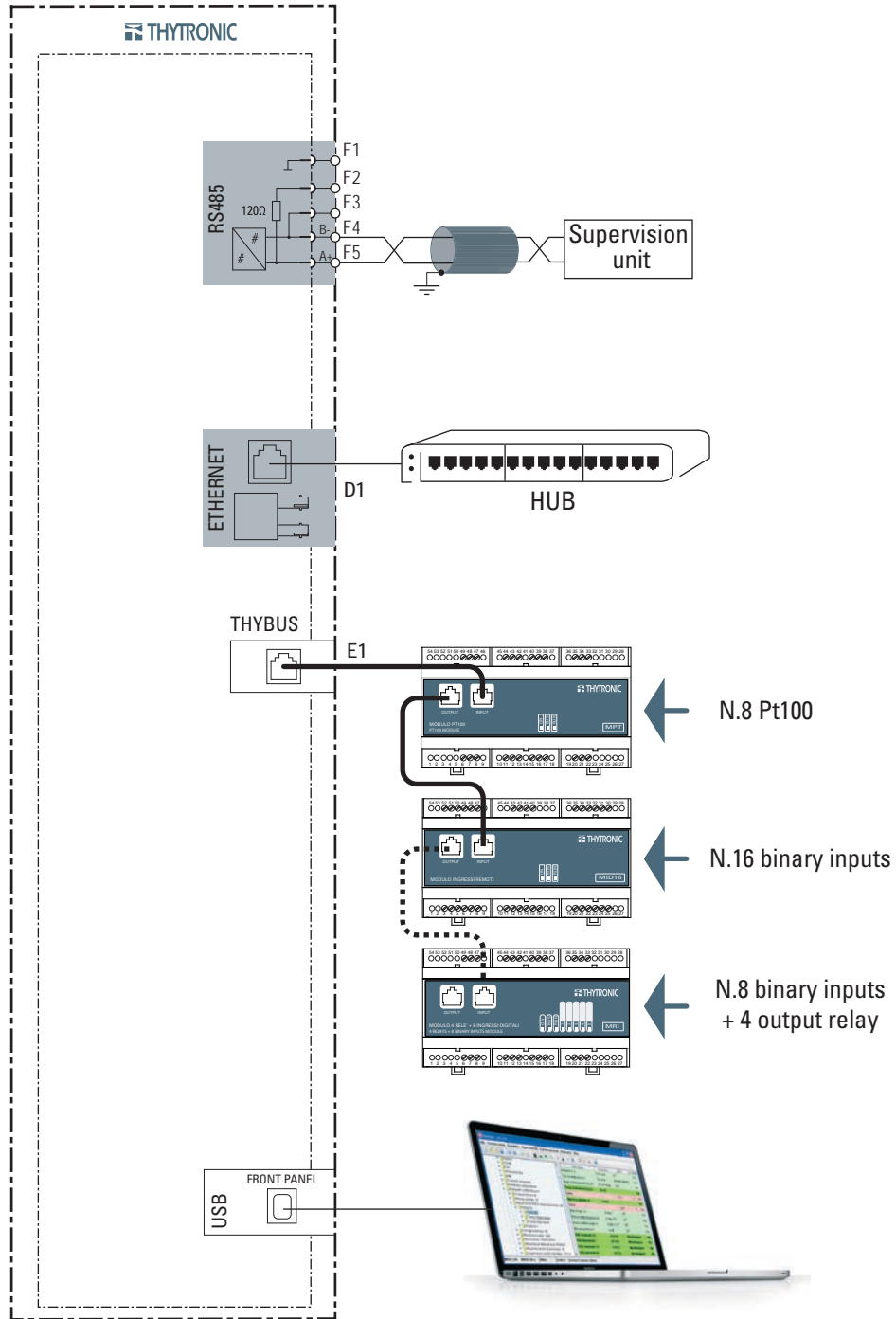


$$t = t_{E>inv} \cdot \left[ \frac{0.28}{[-0.236 \cdot (I_E/I_{E>inv})^{-1} + 0.339]} \right]$$

Note: match of operating and setting time takes place when  $I_E/I_{E>inv} = 4$

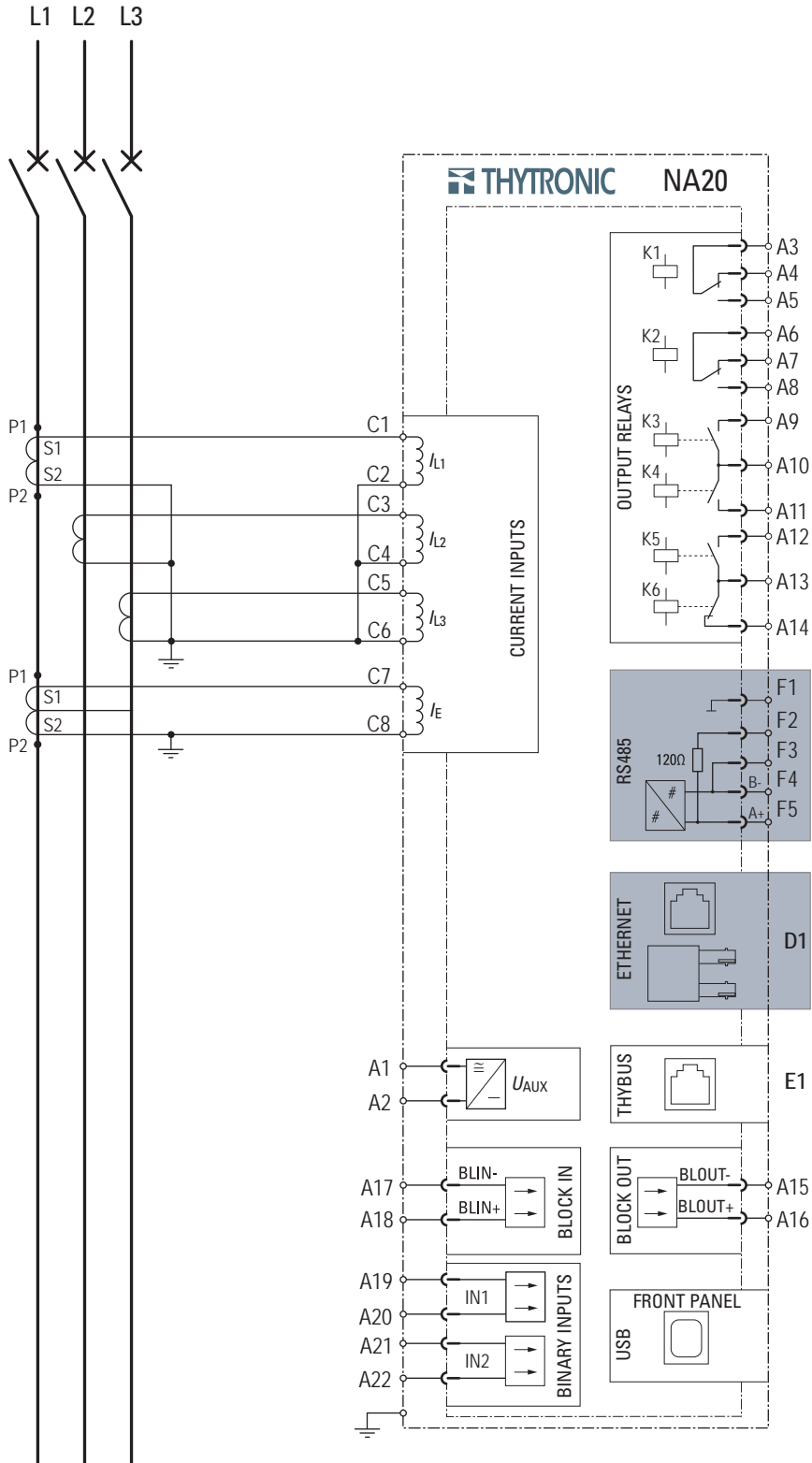


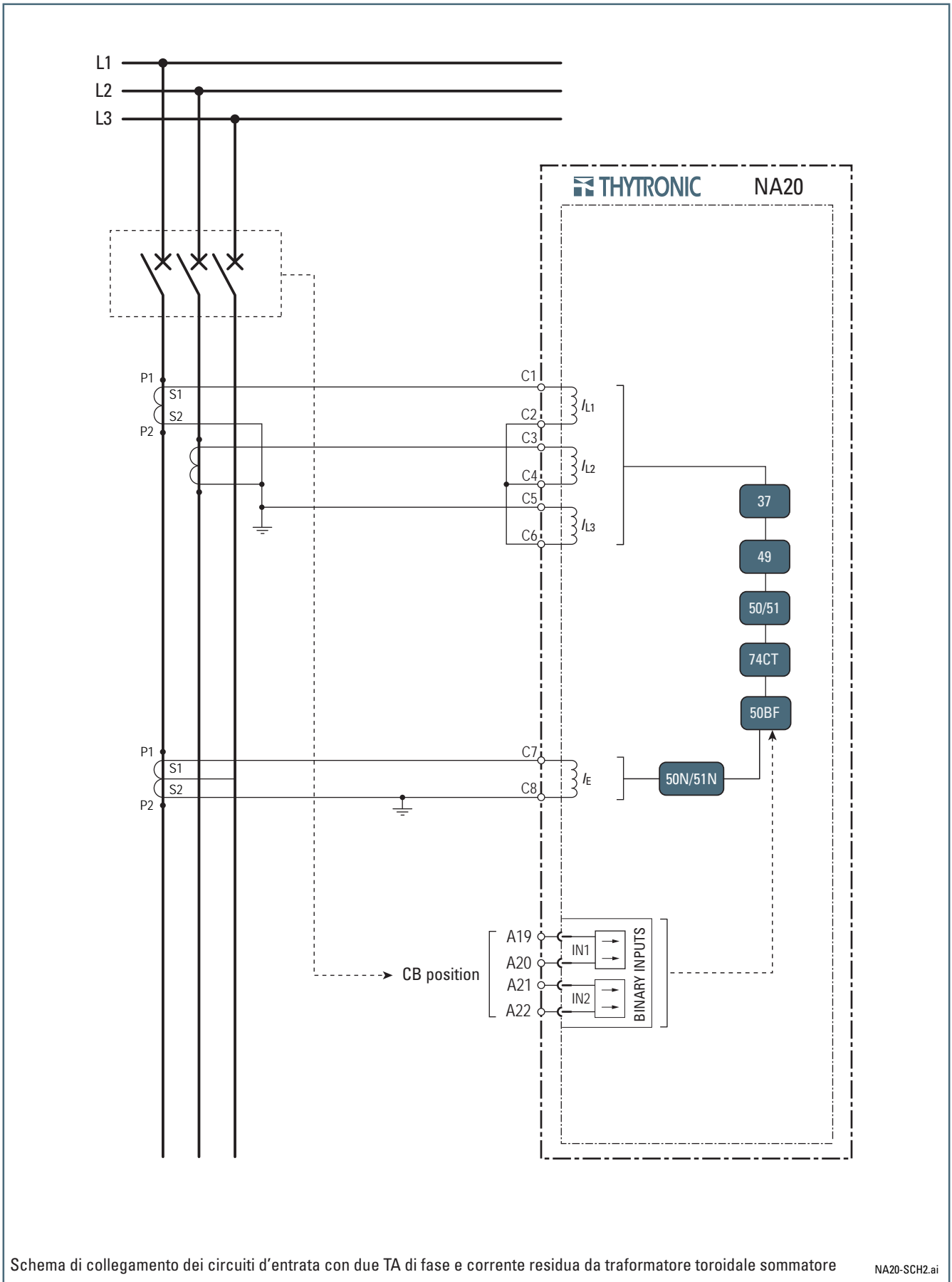
I/O schematic diagram (five binary inputs version)



8.6 APPENDIX B3- Connection diagrams

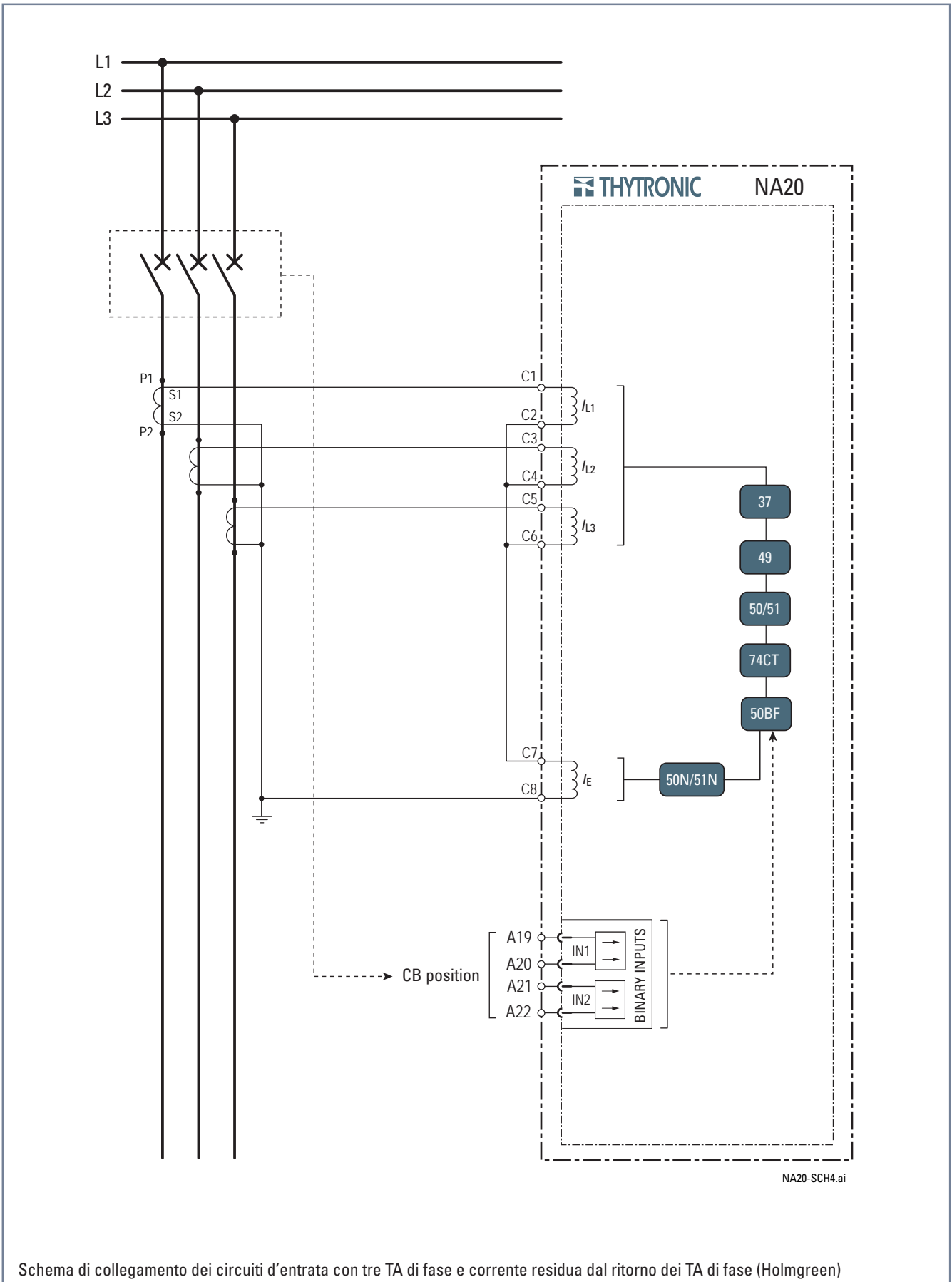
Note: Some typical connection diagram are shown.  
 All diagram must be considered just as example; they cannot be comprehensive for real applications.  
 For all diagrams the output contacts are shown in de-energized state for standard reference.





Schema di collegamento dei circuiti d'entrata con due TA di fase e corrente residua da trasformatore toroidale sommatore

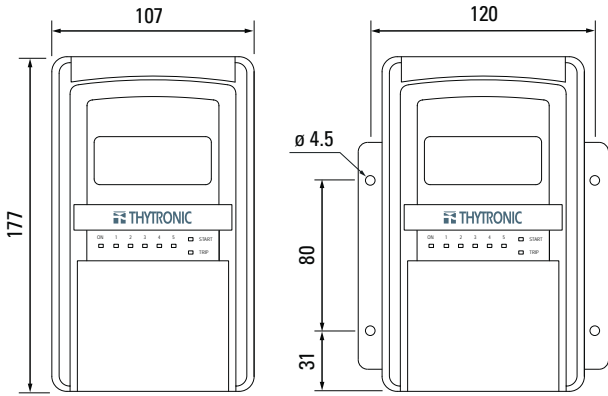
NA20-SCH2.ai



Schema di collegamento dei circuiti d'entrata con tre TA di fase e corrente residua dal ritorno dei TA di fase (Holmgreen)

8.7 APPENDIX C - Dimensions

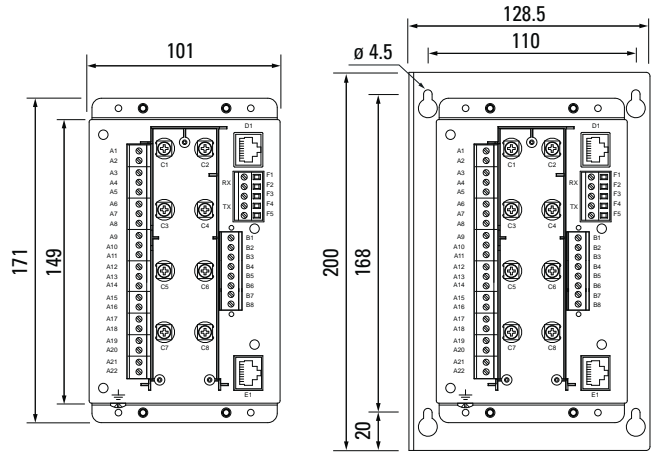
FRONT VIEWS



FLUSH MOUNTING

PROJECTING MOUNTING

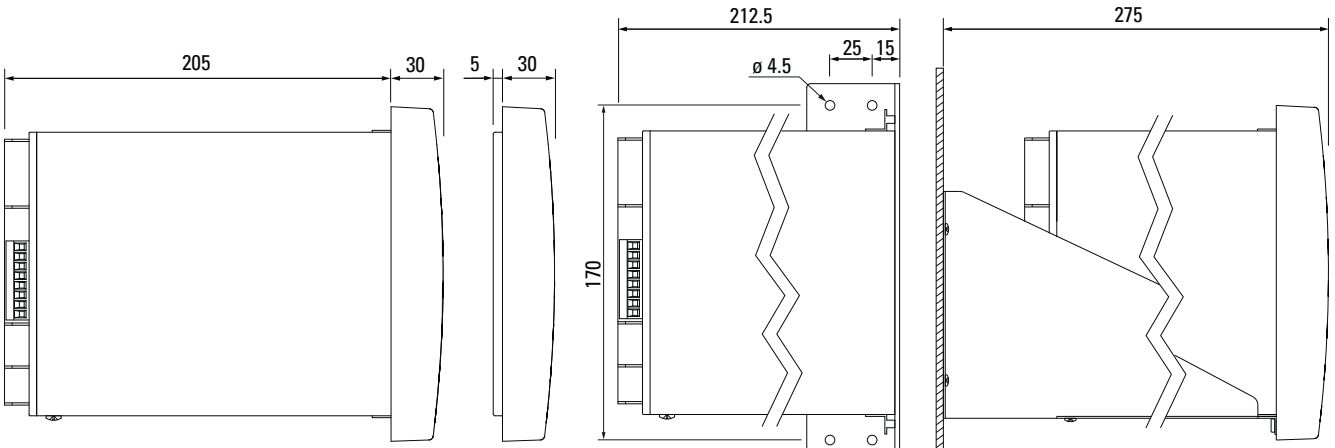
REAR VIEWS



FLUSH MOUNTING

PROJECTING MOUNTING  
(Separate operator panel)

SIDE VIEWS



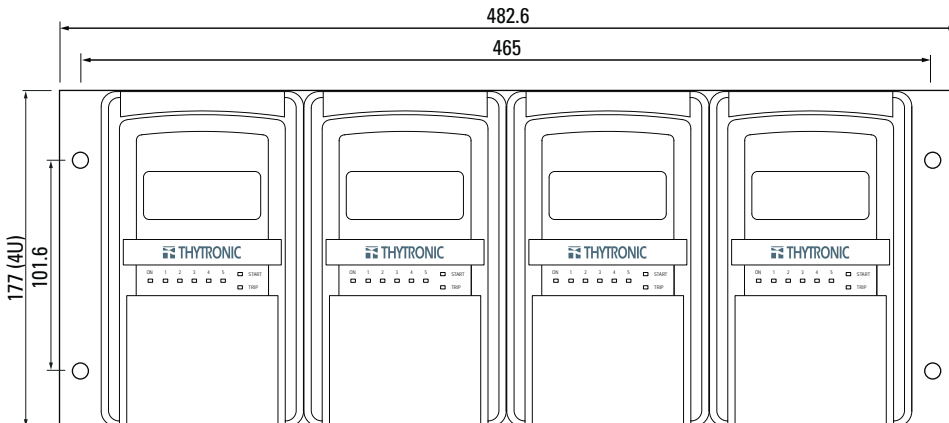
FLUSH MOUNTING

SEPARATE  
OPERATOR PANEL

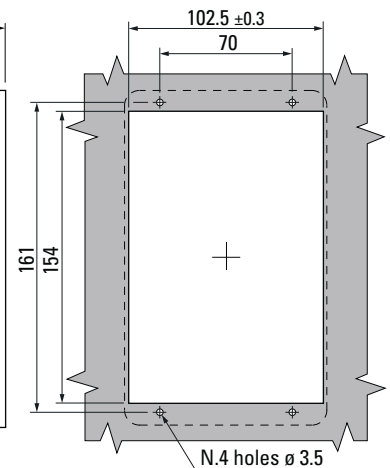
PROJECTING MOUNTING  
(Separate operator panel)

PROJECTING MOUNTING  
(Stand alone)

RACK MOUNTING



FLUSH MOUNTING CUTOUT



**8.8 APPENDIX D - Setting table**

*Note The 26 element, the output relay and LEDs K7...K10, L6...L10 and the binary input IN3...IN42 settings are available only when the concerning I/O circuits are implemented (MPT, MRI and MID16 modules on Thybus)*

Description	Parameter	Unit	Setting range
<b>Set</b>			
<b>Base</b>			
Relay reference name			
Relay nominal frequency - fn		Hz	50 ... 60 step = 10
Relay phase nominal current - In			1 A   5 A
Relay residual nominal current - IEn			1 A   5 A
Phase CT primary nominal current - Inp		A	1 ... 499 step = 1 500 ... 4990 step = 10 5000 ... 10000 step = 100
Residual CT primary nominal current - IEnp		A	1 ... 499 step = 1 500 ... 4990 step = 10 5000 ... 10000 step = 100
Measurements reading mode			RELATIVE   PRIMARY
Language			English
<b>Inputs</b>			
<b>Binary input IN1</b>			
<b>IN1</b>			
Logic			Active-ON   Active-OFF
<b>IN1 tON</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
<b>IN1 tOFF</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN1 matching			Reset LEDs   Set profile   Fault trigger   Block2 IPh/IE   Block2 IPh   Block2 IE   Block1   TCS1   TCS2   Trip ProtExt   Reset counters   Reset CB Monitor   52a   52b   Open CB   Close CB   Preset DTheta   Remote trip   Reset on demand measures   None
<b>Binary input IN2</b>			
<b>IN2</b>			
Logic			Active-ON   Active-OFF
<b>IN2 tON</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
<b>IN2 tOFF</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN2 matching			Reset LEDs   Set profile   Fault trigger   Block2 IPh/IE   Block2 IPh   Block2 IE   Block1   TCS1   TCS2   Trip ProtExt   Reset counters   Reset CB Monitor   52a   52b   Open CB   Close CB   Preset DTheta   Remote trip   Reset on demand measures   None
<b>Binary input IN3</b>			
<b>IN3</b>			
Logic			Active-ON   Active-OFF
<b>IN3 tON</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
<b>IN3 tOFF</b>			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1

IN3 matching			Reset LEDs   Set profile   Fault trigger   Block2 IPh/IE   Block2 IPh   Block2 IE   Block1   TCS1   TCS2   Trip ProtExt   Reset counters   Reset CB Monitor   52a   52b   Open CB   Close CB   Preset DTheta   Remote trip   Reset on demand measures   None
Binary input IN4			
IN4			
Logic			Active-ON   Active-OFF
IN4 tON			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN4 tOFF			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN4 matching			Reset LEDs   Set profile   Fault trigger   Block2 IPh/IE   Block2 IPh   Block2 IE   Block1   TCS1   TCS2   Trip ProtExt   Reset counters   Reset CB Monitor   52a   52b   Open CB   Close CB   Preset DTheta   Remote trip   Reset on demand measures   None
Binary input IN5			
IN5			
Logic			Active-ON   Active-OFF
IN5 tON			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN5 tOFF			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IN5 matching			Reset LEDs   Set profile   Fault trigger   Block2 IPh/IE   Block2 IPh   Block2 IE   Block1   TCS1   TCS2   Trip ProtExt   Reset counters   Reset CB Monitor   52a   52b   Open CB   Close CB   Preset DTheta   Remote trip   Reset on demand measures   None
Binary input IN6			
Relays			
K1			
Logic			De-energized   Energized
Operation MODE			No-latched   Pulse   Latched
Minimum pulse width		ms	0 ... 500 step = 5
K2			
Logic			De-energized   Energized
Operation MODE			No-latched   Pulse   Latched
Minimum pulse width		ms	0 ... 500 step = 5
K3			
Logic			De-energized   Energized
Operation MODE			No-latched   Pulse   Latched
Minimum pulse width		ms	0 ... 500 step = 5
K4			
Logic			De-energized   Energized
Operation MODE			No-latched   Pulse   Latched
Minimum pulse width		ms	0 ... 500 step = 5
K5			
LEDs			
START			
Type			No-latched   Latched
TRIP			
Type			No-latched   Latched
L1			

Type			No-latched   Latched
L2			
Type			No-latched   Latched
L3			
Type			No-latched   Latched
L4			
Type			No-latched   Latched
L5			
Type			No-latched   Latched
Analog outputs			
Current loop 1			
Loop 1 Measure assigned	Loop1-Mis		Frequency   IL1   IL2   IL3   IE   IL   I1   I2   PLC   None
Loop 1 Output range	Loop1-Range		0-5 mA   0-20 mA   4-20 mA
Loop 1 Output type	Loop1-Type		Unipolar   Bipolar
Loop 1 Nominal multiplier	Loop1-M		0.01 ... 100.00 step = 0.01
Loop 1 Terminals polarity	Loop1-Polarity		Normal   Reverse
Current loop 2			
Loop 2 Measure assigned	Loop2-Mis		Frequency   IL1   IL2   IL3   IE   IL   I1   I2   PLC   None
Loop 2 Output range	Loop2-Range		0-5 mA   0-20 mA   4-20 mA
Loop 2 Output type	Loop2-Type		Unipolar   Bipolar
Loop 2 Nominal multiplier	Loop2-M		0.01 ... 100.00 step = 0.01
Loop 2 Terminals polarity	Loop2-Polarity		Normal   Reverse
Current loop 3			
Loop 3 Measure assigned	Loop3-Mis		Frequency   IL1   IL2   IL3   IE   IL   I1   I2   PLC   None
Loop 3 Output range	Loop3-Range		0-5 mA   0-20 mA   4-20 mA
Loop 3 Output type	Loop3-Type		Unipolar   Bipolar
Loop 3 Nominal multiplier	Loop3-M		0.01 ... 100.00 step = 0.01
Loop 3 Terminals polarity	Loop3-Polarity		Normal   Reverse
Current loop 4			
Loop 4 Measure assigned	Loop4-Mis		Frequency   IL1   IL2   IL3   IE   IL   I1   I2   PLC   None
Loop 4 Output range	Loop4-Range		0-5 mA   0-20 mA   4-20 mA
Loop 4 Output type	Loop4-Type		Unipolar   Bipolar
Loop 4 Nominal multiplier	Loop4-M		0.01 ... 100.00 step = 0.01
Loop 4 Terminals polarity	Loop4-Polarity		Normal   Reverse
Self-test Relay			
MINOR Fail alarm			NO   YES
Self-test relay			K1   K2   K3   K4   K5   K6
MMI			
Display modules			Assigned modules   All modules
Profile selection			
Active profile			A   B   By INPUT
Profile A			
Base current IB			
Base current	IB	In	0.10 ... 2.50 step = 0.01
Thermal protection with RTD thermometric probes - 26			
PT1 Probe			
ThAL1 Alarm			
ThAL1 Enable	ThAL1 Enable		OFF   ON
26 PT1 Alarm threshold	ThAL1	^C	0 ... 200 step = 1
ThAL1 Operating time			
Value		s	0 ... 100 step = 1

ThAL1 Alarm relays	ThAL1-K		K1   K2   K3   K4   K5   K6
ThAL1 Alarm LEDs	ThAL1-L		START   TRIP   L1   L2   L3   L4   L5
Th>1 Trip			
Th>1 Enable	Th>1 Enable		OFF   ON
26 PT1 Trip threshold	Th>1	^C	0 ... 200 step = 1
Th>1 Operating time			
Value		s	0 ... 100 step = 1
Th>1 Breaker failure	Th>1BF		OFF   ON
Th>1 Trip relays	Th>1-K		K1   K2   K3   K4   K5   K6
Th>1 Trip LEDs	Th>1-L		START   TRIP   L1   L2   L3   L4   L5
PT2 Probe			
ThAL2 Alarm			
ThAL2 Enable	ThAL2 Enable		OFF   ON
26 PT2 Alarm threshold	ThAL2	^C	0 ... 200 step = 1
ThAL2 Operating time			
Value		s	0 ... 100 step = 1
ThAL2 Alarm relays	ThAL2-K		K1   K2   K3   K4   K5   K6
ThAL2 Alarm LEDs	ThAL2-L		START   TRIP   L1   L2   L3   L4   L5
Th>2 Trip			
Th>2 Enable	Th>2 Enable		OFF   ON
26 PT2 Trip threshold	Th>2	^C	0 ... 200 step = 1
Th>2 Operating time			
Value		s	0 ... 100 step = 1
Th>2 Breaker failure	Th>2BF		OFF   ON
Th>2 Trip relays	Th>2-K		K1   K2   K3   K4   K5   K6
Th>2 Trip LEDs	Th>2-L		START   TRIP   L1   L2   L3   L4   L5
PT3 Probe			
ThAL3 Alarm			
ThAL3 Enable	ThAL3 Enable		OFF   ON
26 PT3 Alarm threshold	ThAL3	^C	0 ... 200 step = 1
ThAL3 Operating time			
Value		s	0 ... 100 step = 1
ThAL3 Alarm relays	ThAL3-K		K1   K2   K3   K4   K5   K6
ThAL3 Alarm LEDs	ThAL3-L		START   TRIP   L1   L2   L3   L4   L5
Th>3 Trip			
Th>3 Enable	Th>3 Enable		OFF   ON
26 PT3 Trip threshold	Th>3	^C	0 ... 200 step = 1
Th>3 Operating time			
Value		s	0 ... 100 step = 1
Th>3 Breaker failure	Th>3BF		OFF   ON
Th>3 Trip relays	Th>3-K		K1   K2   K3   K4   K5   K6
Th>3 Trip LEDs	Th>3-L		START   TRIP   L1   L2   L3   L4   L5
PT4 Probe			
ThAL4 Alarm			
ThAL4 Enable	ThAL4 Enable		OFF   ON
26 PT4 Alarm threshold	ThAL4	^C	0 ... 200 step = 1
ThAL4 Operating time			
Value		s	0 ... 100 step = 1
ThAL4 Alarm relays	ThAL4-K		K1   K2   K3   K4   K5   K6
ThAL4 Alarm LEDs	ThAL4-L		START   TRIP   L1   L2   L3   L4   L5
Th>4 Trip			
Th>4 Enable	Th>4 Enable		OFF   ON
26 PT4 Trip threshold	Th>4	^C	0 ... 200 step = 1
Th>4 Operating time			

Value		s	0 ... 100 step = 1
Th>4 Breaker failure	Th>4BF		OFF   ON
Th>4 Trip relays	Th>4-K		K1   K2   K3   K4   K5   K6
Th>4 Trip LEDs	Th>4-L		START   TRIP   L1   L2   L3   L4   L5
PT5 Probe			
ThAL5 Alarm			
ThAL5 Enable	ThAL5 Enable		OFF   ON
26 PT5 Alarm threshold	ThAL5	^C	0 ... 200 step = 1
ThAL5 Operating time			
Value		s	0 ... 100 step = 1
ThAL5 Alarm relays	ThAL5-K		K1   K2   K3   K4   K5   K6
ThAL5 Alarm LEDs	ThAL5-L		START   TRIP   L1   L2   L3   L4   L5
Th>5 Trip			
Th>5 Enable	Th>5 Enable		OFF   ON
26 PT5 Trip threshold	Th>5	^C	0 ... 200 step = 1
Th>5 Operating time			
Value		s	0 ... 100 step = 1
Th>5 Breaker failure	Th>5BF		OFF   ON
Th>5 Trip relays	Th>5-K		K1   K2   K3   K4   K5   K6
Th>5 Trip LEDs	Th>5-L		START   TRIP   L1   L2   L3   L4   L5
PT6 Probe			
ThAL6 Alarm			
ThAL6 Enable	ThAL6 Enable		OFF   ON
26 PT6 Alarm threshold	ThAL6	^C	0 ... 200 step = 1
ThAL6 Operating time			
Value		s	0 ... 100 step = 1
ThAL6 Alarm relays	ThAL6-K		K1   K2   K3   K4   K5   K6
ThAL6 Alarm LEDs	ThAL6-L		START   TRIP   L1   L2   L3   L4   L5
Th>6 Trip			
Th>6 Enable	Th>6 Enable		OFF   ON
26 PT6 Trip threshold	Th>6	^C	0 ... 200 step = 1
Th>6 Operating time			
Value		s	0 ... 100 step = 1
Th>6 Breaker failure	Th>6BF		OFF   ON
Th>6 Trip relays	Th>6-K		K1   K2   K3   K4   K5   K6
Th>6 Trip LEDs	Th>6-L		START   TRIP   L1   L2   L3   L4   L5
PT7 Probe			
ThAL7 Alarm			
ThAL7 Enable	ThAL7 Enable		OFF   ON
26 PT7 Alarm threshold	ThAL7	^C	0 ... 200 step = 1
ThAL7 Operating time			
Value		s	0 ... 100 step = 1
ThAL7 Alarm relays	ThAL7-K		K1   K2   K3   K4   K5   K6
ThAL7 Alarm LEDs	ThAL7-L		START   TRIP   L1   L2   L3   L4   L5
Th>7 Trip			
Th>7 Enable	Th>7 Enable		OFF   ON
26 PT7 Trip threshold	Th>7	^C	0 ... 200 step = 1
Th>7 Operating time			
Value		s	0 ... 100 step = 1
Th>7 Breaker failure	Th>7BF		OFF   ON
Th>7 Trip relays	Th>7-K		K1   K2   K3   K4   K5   K6
Th>7 Trip LEDs	Th>7-L		START   TRIP   L1   L2   L3   L4   L5
PT8 Probe			
ThAL8 Alarm			

ThAL8 Enable	ThAL8 Enable		OFF   ON
26 PT8 Alarm threshold	ThAL8	^C	0 ... 200 step = 1
ThAL8 Operating time			
Value		s	0 ... 100 step = 1
ThAL8 Alarm relays	ThAL8-K		K1   K2   K3   K4   K5   K6
ThAL8 Alarm LEDs	ThAL8-L		START   TRIP   L1   L2   L3   L4   L5
Th>8 Trip			
Th>8 Enable	Th>8 Enable		OFF   ON
26 PT8 Trip threshold	Th>8	^C	0 ... 200 step = 1
Th>8 Operating time			
Value		s	0 ... 100 step = 1
Th>8 Breaker failure	Th>8BF		OFF   ON
Th>8 Trip relays	Th>8-K		K1   K2   K3   K4   K5   K6
Th>8 Trip LEDs	Th>8-L		START   TRIP   L1   L2   L3   L4   L5
Diagnostic			
PT100 probe diagnostic relays	PT100Diag-K		K1   K2   K3   K4   K5   K6
PT100 probe diagnostic LEDs	PT100Diag-L		START   TRIP   L1   L2   L3   L4   L5
Undercurrent - 37			
I< Element			
Setpoints			
37 Operating logic	Logic37		OR   AND
I< Logical block	I<BLK1		OFF   ON
I< Start relays	I<ST-K		K1   K2   K3   K4   K5   K6
I< Trip relays	I<TR-K		K1   K2   K3   K4   K5   K6
I< Start LEDs	I<ST-L		START   TRIP   L1   L2   L3   L4   L5
I< Trip LEDs	I<TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
37 First threshold definite time			
State			OFF   ON
Pickup value		In	0.10 ... 1.00 step = 0.01
I<def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Negative sequence overcurrent - 46			
I2> Element			
Setpoints			
I2> Enable	I2> Enable		OFF   ON
I2> Curve type	I2>Curve		IEC/BS A   IEC/BS B   IEC/BS C   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   I2t   EM   DEFINITE
I2CLP> Mode	I2CLP> Mode		OFF   ON - Element blocking   ON - Change setting
I2CLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2> Logical block	I2>BLK1		OFF   ON
I2> Input selective block	I2>BLK2IN		OFF   ON
I2> Output selective block	I2>BLK2OUT		OFF   ON
I2> Second harmonic restraint	I2>2ndh-REST		OFF   ON
I2> Breaker failure	I2>BF		OFF   ON
I2> Start relays	I2>ST-K		K1   K2   K3   K4   K5   K6
I2> Trip relays	I2>TR-K		K1   K2   K3   K4   K5   K6
I2> Start LEDs	I2>ST-L		START   TRIP   L1   L2   L3   L4   L5

I2> Trip LEDs	I2>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
46 First threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>def within CLP	I2CLP>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>def Operating time			
Value		s	0.03 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
46 First threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>inv within CLP	I2CLP>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>inv Operating time	t2>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
I2>> Element			
Setpoints			
I2>> Enable	I2>> Enable		OFF   ON
I2CLP>> Mode	I2CLP>> Mode		OFF   ON - Element blocking   ON - Change setting
I2CLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2>> Logical block	I2>>BLK1		OFF   ON
I2>> Input selective block	I2>>BLK2IN		OFF   ON
I2>> Output selective block	I2>>BLK2OUT		OFF   ON
I2>> Second harmonic restraint	I2>>2ndh-REST		OFF   ON
I2>> Breaker failure	I2>>BF		OFF   ON
I2> Disabling by I2>> start	I2>disbyI2>>		OFF   ON
I2>> Start relays	I2>>ST-K		K1   K2   K3   K4   K5   K6
I2>> Trip relays	I2>>TR-K		K1   K2   K3   K4   K5   K6
I2>> Start LEDs	I2>>ST-L		START   TRIP   L1   L2   L3   L4   L5
I2>> Trip LEDs	I2>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
46 Second threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 40.00 step = 0.01
I2>>def within CLP	I2CLP>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 40.00 step = 0.01
I2>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Negative sequence current / positive sequence current ratio - I2/I1			
I21> Element			
Setpoints			
I21CLP> Mode	I21CLP> Mode		OFF   ON - Element blocking   ON - Change setting
I21CLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1

I21> Logical block	I21>BLK1		OFF   ON
I21> Second harmonic restraint	I21>2ndh-REST		OFF   ON
I21> Breaker failure	I21>BF		OFF   ON
I21> Start relays	I21>ST-K		K1   K2   K3   K4   K5   K6
I21> Trip relays	I21>TR-K		K1   K2   K3   K4   K5   K6
I21> Start LEDs	I21>ST-L		START   TRIP   L1   L2   L3   L4   L5
I21> Trip LEDs	I21>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
I2/1/1 First threshold definite time			
State			OFF   ON
Pickup value			0.10 ... 1.00 step = 0.01
I21>def within CLP	I21CLP>def		0.10 ... 1.00 step = 0.01
I21>def Operating time			
Value		s	0.04 ... 0.99 step = 0.01 1 ... 15000 step = 1
Thermal image - 49			
Common configuration			
Initial thermal image	DthIN	DThe- taB	0.0 ... 1.0 step = 0.1
Reduction factor at inrush	KINR		1.0 ... 3.0 step = 0.1
Thermal time constant	T	min	1 ... 200 step = 1
DthCLP Operating mode	DthCLP Mode		OFF   ON - Element blocking   ON - Change setting
DthCLP Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
49 Second harmonic restraint	Dth2ndh-REST		OFF   ON
DthAL1 Element			
DthAL1 Enable	DthAL1 Enable		OFF   ON
49 First alarm threshold	DthAL1	DThe- taB	0.3 ... 1.0 step = 0.1
DthAL1 Logical block	DthAL1BLK1		OFF   ON
DthAL1 Input selective block	DthAL1BLK2IN		OFF   ON
DthAL1 Output selective block	DthAL1BLK2OUT		OFF   ON
DthAL1 Alarm relays	DthAL1-K		K1   K2   K3   K4   K5   K6
DthAL1 Alarm LEDs	DthAL1-L		START   TRIP   L1   L2   L3   L4   L5
DthAL2 Element			
DthAL2 Enable	DthAL2 Enable		OFF   ON
49 Second alarm threshold	DthAL2	DThe- taB	0.5 ... 1.2 step = 0.1
DthAL2 Logical block	DthAL2BLK1		OFF   ON
DthAL2 Input selective block	DthAL2BLK2IN		OFF   ON
DthAL2 Output selective block	DthAL2BLK2OUT		OFF   ON
DthAL2 Alarm relays	DthAL2-K		K1   K2   K3   K4   K5   K6
DthAL2 Alarm LEDs	DthAL2-L		START   TRIP   L1   L2   L3   L4   L5
Dth> Element			
Dth> Enable	Dth> Enable		OFF   ON
49 Trip threshold	Dth>	DThe- taB	1.100 ... 1.300 step = 0.001
Dth> Logical block	Dth>BLK1		OFF   ON
Dth> Input selective block	Dth>BLK2IN		OFF   ON
Dth> Output selective block	Dth>BLK2OUT		OFF   ON
Dth> Breaker failure	Dth>BF		OFF   ON
Disabling Dth> by 50-51 start	Dth>disby50-51		OFF   ON
Dth> Trip relays	Dth>-K		K1   K2   K3   K4   K5   K6

Dth> Trip LEDs	Dth>-L		START   TRIP   L1   L2   L3   L4   L5
Phase overcurrent - 50/51			
↳ Element			
Setpoints			
↳ Enable	↳ Enable		OFF   ON
↳ Curve type	↳Curve		IEC/BS A   IEC/BS B   IEC/BS C   IEC/BS B LI   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   RECTIFIER   I2t   EM   DEFINITE
ICLP> Mode	ICLP> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Logical block	↳BLK1		OFF   ON
↳ Input selective block	↳BLK2IN		OFF   ON
↳ Output selective block	↳BLK2OUT		OFF   ON
↳ Second harmonic restraint	↳2ndh-REST		OFF   ON
↳ Breaker failure	↳BF		OFF   ON
↳ Start relays	↳ST-K		K1   K2   K3   K4   K5   K6
↳ Trip relays	↳TR-K		K1   K2   K3   K4   K5   K6
↳ Start LEDs	↳ST-L		START   TRIP   L1   L2   L3   L4   L5
↳ Trip LEDs	↳TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 First threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
↳def within CLP	ICLP>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
↳def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
50/51 First threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
↳inv within CLP	ICLP>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
↳inv Operating time	t>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
↳ Element			
Setpoints			
↳ Enable	↳ Enable		OFF   ON
↳ Curve type	↳Curve		I2t   DEFINITE
ICLP>> Mode	ICLP>> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Logical block	↳BLK1		OFF   ON

l>> Input selective block	l>>BLK2IN		OFF   ON
l>> Output selective block	l>>BLK2OUT		OFF   ON
l>> Second harmonic restraint	l>>2ndh-REST		OFF   ON
l>> Breaker failure	l>>BF		OFF   ON
l> Disabling by l>> start	l>disbyl>>		OFF   ON
l>> Start relays	l>>ST-K		K1   K2   K3   K4   K5   K6
l>> Trip relays	l>>TR-K		K1   K2   K3   K4   K5   K6
l>> Start LEDs	l>>ST-L		START   TRIP   L1   L2   L3   L4   L5
l>> Trip LEDs	l>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 Second threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
l>>def within CLP	ICLP>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
l>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Inverse time			
50/51 Second threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
l>>inv within CLP	ICLP>>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
l>>inv Operating time	t>>inv	s	0.02 ... 10.00 step = 0.01
l>>> Element			
Setpoints			
l>>> Enable	l>>> Enable		OFF   ON
ICLP>>> Mode	ICLP>>> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP>>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
l>>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
l>>> Logical block	l>>>BLK1		OFF   ON
l>>> Input selective block	l>>>BLK2IN		OFF   ON
l>>> Output selective block	l>>>BLK2OUT		OFF   ON
l>>> Second harmonic restraint	l>>>2ndh-REST		OFF   ON
l>>> Breaker failure	l>>>BF		OFF   ON
l> Disabling by l>>> start	l>disbyl>>>		OFF   ON
l>> Disabling by l>>> start	l>>disbyl>>>		OFF   ON
l>>> Start relays	l>>>ST-K		K1   K2   K3   K4   K5   K6
l>>> Trip relays	l>>>TR-K		K1   K2   K3   K4   K5   K6
l>>> Start LEDs	l>>>ST-L		START   TRIP   L1   L2   L3   L4   L5
l>>> Trip LEDs	l>>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 Third threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1

I>>>def within CLP	ICLP>>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
I>>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Residual overcurrent - 50N/51N			
IE> Element			
Setpoints			
IE> Enable	IE> Enable		OFF   ON
IE> Curve type	IE>Curve		IEC/BS A   IEC/BS B   IEC/BS C   IEC/BS B LI   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   EM   DEFINITE
IECLP> Mode	IECLP> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IE> Logical block	IE>BLK1		OFF   ON
IE> Input selective block	IE>BLK2IN		OFF   ON
IE> Output selective block	IE>BLK2OUT		OFF   ON
IE> Second harmonic restraint	IE>2ndh-REST		OFF   ON
IE> Breaker failure	IE>BF		OFF   ON
IE> Start relays	IE>ST-K		K1   K2   K3   K4   K5   K6
IE> Trip relays	IE>TR-K		K1   K2   K3   K4   K5   K6
IE> Start LEDs	IE>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE> Trip LEDs	IE>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N First threshold definite time			
State			OFF   ON
Pickup value		IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I>>>def within CLP	IECLP>>>def	IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I>>>def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
50N/51N First threshold definite time			
State			OFF   ON
Pickup value		IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 2.00 step = 0.01
I>>>inv within CLP	IECLP>>>inv	IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 2.00 step = 0.01
I>>>inv Operating time	tE>>>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
IE>> Element			
Setpoints			
IE>> Enable	IE>> Enable		OFF   ON
IECLP>> Mode	IECLP>> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1

IE>> Logical block	IE>>BLK1		OFF   ON
IE>> Input selective block	IE>>BLK2IN		OFF   ON
IE>> Output selective block	IE>>BLK2OUT		OFF   ON
IE>> Second harmonic restraint	IE>>2ndh-REST		OFF   ON
IE>> Breaker failure	IE>>BF		OFF   ON
IE> Disabling by IE>> start	IE>disbyIE>>		OFF   ON
IE>> Start relays	IE>>ST-K		K1   K2   K3   K4   K5   K6
IE>> Trip relays	IE>>TR-K		K1   K2   K3   K4   K5   K6
IE>> Start LEDs	IE>>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE>> Trip LEDs	IE>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N Second threshold definite time			
State			OFF   ON
Pickup value		IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>def within CLP	IECLP>>def	IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
IE>>> Element			
Setpoints			
IE>>> Enable	IE>>> Enable		OFF   ON
IECLP>>> Mode	IECLP>>> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP>>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE>>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IE>>> Logical block	IE>>>BLK1		OFF   ON
IE>>> Input selective block	IE>>>BLK2IN		OFF   ON
IE>>> Output selective block	IE>>>BLK2OUT		OFF   ON
IE>>> Second harmonic restraint	IE>>>2ndh-REST		OFF   ON
IE>>> Breaker failure	IE>>>BF		OFF   ON
IE> Disabling by IE>>> start	IE>disbyIE>>>		OFF   ON
IE>> Disabling by IE>>> start	IE>>disbyIE>>>		OFF   ON
IE>>> Start relays	IE>>>ST-K		K1   K2   K3   K4   K5   K6
IE>>> Trip relays	IE>>>TR-K		K1   K2   K3   K4   K5   K6
IE>>> Start LEDs	IE>>>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE>>> Trip LEDs	IE>>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N Third threshold definite time			
State			OFF   ON
Pickup value		IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>>def within CLP	IECLP>>>def	IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Second Harmonic Restraint - 2ndh-REST			
Second harmonic restraint threshold			
State			OFF   ON
Pickup value		%	10 ... 50 step = 1
I2ndh> reset time delay			

Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2ndh> Start relays	I2ndh>ST-K		K1   K2   K3   K4   K5   K6
I2ndh> Start LEDs	I2ndh>ST-L		START   TRIP   L1   L2   L3   L4   L5
Trip circuit supervision - 74TCS			
74TCS Enable	74TCS Enable		OFF   ON
74TCS Logical block	74TCS-BLK1		OFF   ON
74TCS Start relays	74TCS-ST-K		K1   K2   K3   K4   K5   K6
74TCS Trip relays	74TCS-TR-K		K1   K2   K3   K4   K5   K6
74TCS Start LEDs	74TCS-ST-L		START   TRIP   L1   L2   L3   L4   L5
74TCS Trip LEDs	74TCS-TR-L		START   TRIP   L1   L2   L3   L4   L5
Selective block - BLOCK2			
Selective block IN			
BLIN1 Selective block operating mode	ModeBLIN1		OFF   ON IPh/IE   ON IPh   ON IE
BLIN maximum activation time for phase protections			
Value		s	0.10 ... 10.00 step = 0.01
BLIN maximum activation time for ground protections			
Value		s	0.10 ... 10.00 step = 0.01
tB-Iph/IE Elapsed signalling relays	tB-K		K1   K2   K3   K4   K5   K6
tB-Iph/IE Elapsed signalling LEDs	tB-L		START   TRIP   L1   L2   L3   L4   L5
Selective block OUT			
BLOUT Dropout time for phase protections			
Value		s	0.00 ... 1.00 step = 0.01
BLOUT Dropout time for ground protections			
Value		s	0.00 ... 1.00 step = 0.01
BLOUT Dropout time for ground and phase protections			
Value		s	0.00 ... 1.00 step = 0.01
BLOUT1 Selective block operating mode	ModeBLOUT1		OFF   ON IPh/IE   ON IPh   ON IE
Phase protections output selective block relays	BLK2OUT-Iph-K		K1   K2   K3   K4   K5   K6
Ground protections output selective block relays	BLK2OUT-IE-K		K1   K2   K3   K4   K5   K6
Phase and ground protections output selective block relays	BLK2OUT-Iph/IE-K		K1   K2   K3   K4   K5   K6
Phase protections output selective block LEDs	BLK2OUT-Iph-L		START   TRIP   L1   L2   L3   L4   L5
Ground protections output selective block LEDs	BLK2OUT-IE-L		START   TRIP   L1   L2   L3   L4   L5
Phase and ground protections output selective block LEDs	BLK2OUT-Iph/IE-L		START   TRIP   L1   L2   L3   L4   L5
Breaker failure - BF			
BF Enable	BF Enable		OFF   ON
BF Phase current threshold			
State			OFF   ON
Pickup value		In	0.05 ... 1.00 step = 0.01
BF Residual current threshold			
State			OFF   ON
Pickup value		IEn	0.01 ... 2.00 step = 0.01
BF Time delay			
Value		s	0.06 ... 10.00 step = 0.01
BF Logical block	BF-BLK1		OFF   ON
BF Start from circuit breaker	CB Input		OFF   ON
BF Start relays	BF-ST-K		K1   K2   K3   K4   K5   K6
BF Trip relays	BF-TR-K		K1   K2   K3   K4   K5   K6
BF Start LEDs	BF-ST-L		START   TRIP   L1   L2   L3   L4   L5
BF Trip LEDs	BF-TR-L		START   TRIP   L1   L2   L3   L4   L5
Profile B			
Base current IB			

Base current	IB	In	0.10 ... 2.50 step = 0.01
Thermal protection with RTD thermometric probes - 26			
PT1 Probe			
ThAL1 Alarm			
ThAL1 Enable	ThAL1 Enable		OFF   ON
26 PT1 Alarm threshold	ThAL1	^C	0 ... 200 step = 1
ThAL1 Operating time			
Value		s	0 ... 100 step = 1
ThAL1 Alarm relays	ThAL1-K		K1   K2   K3   K4   K5   K6
ThAL1 Alarm LEDs	ThAL1-L		START   TRIP   L1   L2   L3   L4   L5
Th>1 Trip			
Th>1 Enable	Th>1 Enable		OFF   ON
26 PT1 Trip threshold	Th>1	^C	0 ... 200 step = 1
Th>1 Operating time			
Value		s	0 ... 100 step = 1
Th>1 Breaker failure	Th>1BF		OFF   ON
Th>1 Trip relays	Th>1-K		K1   K2   K3   K4   K5   K6
Th>1 Trip LEDs	Th>1-L		START   TRIP   L1   L2   L3   L4   L5
PT2 Probe			
ThAL2 Alarm			
ThAL2 Enable	ThAL2 Enable		OFF   ON
26 PT2 Alarm threshold	ThAL2	^C	0 ... 200 step = 1
ThAL2 Operating time			
Value		s	0 ... 100 step = 1
ThAL2 Alarm relays	ThAL2-K		K1   K2   K3   K4   K5   K6
ThAL2 Alarm LEDs	ThAL2-L		START   TRIP   L1   L2   L3   L4   L5
Th>2 Trip			
Th>2 Enable	Th>2 Enable		OFF   ON
26 PT2 Trip threshold	Th>2	^C	0 ... 200 step = 1
Th>2 Operating time			
Value		s	0 ... 100 step = 1
Th>2 Breaker failure	Th>2BF		OFF   ON
Th>2 Trip relays	Th>2-K		K1   K2   K3   K4   K5   K6
Th>2 Trip LEDs	Th>2-L		START   TRIP   L1   L2   L3   L4   L5
PT3 Probe			
ThAL3 Alarm			
ThAL3 Enable	ThAL3 Enable		OFF   ON
26 PT3 Alarm threshold	ThAL3	^C	0 ... 200 step = 1
ThAL3 Operating time			
Value		s	0 ... 100 step = 1
ThAL3 Alarm relays	ThAL3-K		K1   K2   K3   K4   K5   K6
ThAL3 Alarm LEDs	ThAL3-L		START   TRIP   L1   L2   L3   L4   L5
Th>3 Trip			
Th>3 Enable	Th>3 Enable		OFF   ON
26 PT3 Trip threshold	Th>3	^C	0 ... 200 step = 1
Th>3 Operating time			
Value		s	0 ... 100 step = 1
Th>3 Breaker failure	Th>3BF		OFF   ON
Th>3 Trip relays	Th>3-K		K1   K2   K3   K4   K5   K6
Th>3 Trip LEDs	Th>3-L		START   TRIP   L1   L2   L3   L4   L5
PT4 Probe			
ThAL4 Alarm			
ThAL4 Enable	ThAL4 Enable		OFF   ON
26 PT4 Alarm threshold	ThAL4	^C	0 ... 200 step = 1

ThAL4 Operating time			
Value		s	0 ... 100 step = 1
ThAL4 Alarm relays	ThAL4-K		K1   K2   K3   K4   K5   K6
ThAL4 Alarm LEDs	ThAL4-L		START   TRIP   L1   L2   L3   L4   L5
Th>4 Trip			
Th>4 Enable	Th>4 Enable		OFF   ON
26 PT4 Trip threshold	Th>4	^C	0 ... 200 step = 1
Th>4 Operating time			
Value		s	0 ... 100 step = 1
Th>4 Breaker failure	Th>4BF		OFF   ON
Th>4 Trip relays	Th>4-K		K1   K2   K3   K4   K5   K6
Th>4 Trip LEDs	Th>4-L		START   TRIP   L1   L2   L3   L4   L5
PT5 Probe			
ThAL5 Alarm			
ThAL5 Enable	ThAL5 Enable		OFF   ON
26 PT5 Alarm threshold	ThAL5	^C	0 ... 200 step = 1
ThAL5 Operating time			
Value		s	0 ... 100 step = 1
ThAL5 Alarm relays	ThAL5-K		K1   K2   K3   K4   K5   K6
ThAL5 Alarm LEDs	ThAL5-L		START   TRIP   L1   L2   L3   L4   L5
Th>5 Trip			
Th>5 Enable	Th>5 Enable		OFF   ON
26 PT5 Trip threshold	Th>5	^C	0 ... 200 step = 1
Th>5 Operating time			
Value		s	0 ... 100 step = 1
Th>5 Breaker failure	Th>5BF		OFF   ON
Th>5 Trip relays	Th>5-K		K1   K2   K3   K4   K5   K6
Th>5 Trip LEDs	Th>5-L		START   TRIP   L1   L2   L3   L4   L5
PT6 Probe			
ThAL6 Alarm			
ThAL6 Enable	ThAL6 Enable		OFF   ON
26 PT6 Alarm threshold	ThAL6	^C	0 ... 200 step = 1
ThAL6 Operating time			
Value		s	0 ... 100 step = 1
ThAL6 Alarm relays	ThAL6-K		K1   K2   K3   K4   K5   K6
ThAL6 Alarm LEDs	ThAL6-L		START   TRIP   L1   L2   L3   L4   L5
Th>6 Trip			
Th>6 Enable	Th>6 Enable		OFF   ON
26 PT6 Trip threshold	Th>6	^C	0 ... 200 step = 1
Th>6 Operating time			
Value		s	0 ... 100 step = 1
Th>6 Breaker failure	Th>6BF		OFF   ON
Th>6 Trip relays	Th>6-K		K1   K2   K3   K4   K5   K6
Th>6 Trip LEDs	Th>6-L		START   TRIP   L1   L2   L3   L4   L5
PT7 Probe			
ThAL7 Alarm			
ThAL7 Enable	ThAL7 Enable		OFF   ON
26 PT7 Alarm threshold	ThAL7	^C	0 ... 200 step = 1
ThAL7 Operating time			
Value		s	0 ... 100 step = 1
ThAL7 Alarm relays	ThAL7-K		K1   K2   K3   K4   K5   K6
ThAL7 Alarm LEDs	ThAL7-L		START   TRIP   L1   L2   L3   L4   L5
Th>7 Trip			
Th>7 Enable	Th>7 Enable		OFF   ON

26 PT7 Trip threshold	Th>7	^C	0 ... 200 step = 1
Th>7 Operating time			
Value		s	0 ... 100 step = 1
Th>7 Breaker failure	Th>7BF		OFF   ON
Th>7 Trip relays	Th>7-K		K1   K2   K3   K4   K5   K6
Th>7 Trip LEDs	Th>7-L		START   TRIP   L1   L2   L3   L4   L5
PT8 Probe			
ThAL8 Alarm			
ThAL8 Enable	ThAL8 Enable		OFF   ON
26 PT8 Alarm threshold	ThAL8	^C	0 ... 200 step = 1
ThAL8 Operating time			
Value		s	0 ... 100 step = 1
ThAL8 Alarm relays	ThAL8-K		K1   K2   K3   K4   K5   K6
ThAL8 Alarm LEDs	ThAL8-L		START   TRIP   L1   L2   L3   L4   L5
Th>8 Trip			
Th>8 Enable	Th>8 Enable		OFF   ON
26 PT8 Trip threshold	Th>8	^C	0 ... 200 step = 1
Th>8 Operating time			
Value		s	0 ... 100 step = 1
Th>8 Breaker failure	Th>8BF		OFF   ON
Th>8 Trip relays	Th>8-K		K1   K2   K3   K4   K5   K6
Th>8 Trip LEDs	Th>8-L		START   TRIP   L1   L2   L3   L4   L5
Diagnostic			
PT100 probe diagnostic relays	PT100Diag-K		K1   K2   K3   K4   K5   K6
PT100 probe diagnostic LEDs	PT100Diag-L		START   TRIP   L1   L2   L3   L4   L5
Undercurrent - 37			
I< Element			
Setpoints			
37 Operating logic	Logic37		OR   AND
I< Logical block	I<BLK1		OFF   ON
I< Start relays	I<ST-K		K1   K2   K3   K4   K5   K6
I< Trip relays	I<TR-K		K1   K2   K3   K4   K5   K6
I< Start LEDs	I<ST-L		START   TRIP   L1   L2   L3   L4   L5
I< Trip LEDs	I<TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
37 First threshold definite time			
State			OFF   ON
Pickup value		In	0.10 ... 1.00 step = 0.01
I<def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Negative sequence overcurrent - 46			
I2> Element			
Setpoints			
I2> Enable	I2> Enable		OFF   ON
I2> Curve type	I2>Curve		IEC/BS A   IEC/BS B   IEC/BS C   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   I2t   EM   DEFINITE
I2CLP> Mode	I2CLP> Mode		OFF   ON - Element blocking   ON - Change setting
I2CLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1

I2> Logical block	I2>BLK1		OFF   ON
I2> Input selective block	I2>BLK2IN		OFF   ON
I2> Output selective block	I2>BLK2OUT		OFF   ON
I2> Second harmonic restraint	I2>2ndh-REST		OFF   ON
I2> Breaker failure	I2>BF		OFF   ON
I2> Start relays	I2>ST-K		K1   K2   K3   K4   K5   K6
I2> Trip relays	I2>TR-K		K1   K2   K3   K4   K5   K6
I2> Start LEDs	I2>ST-L		START   TRIP   L1   L2   L3   L4   L5
I2> Trip LEDs	I2>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
46 First threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>def within CLP	I2CLP>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>def Operating time			
Value		s	0.03 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
46 First threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>inv within CLP	I2CLP>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
I2>inv Operating time	t2>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
I2>> Element			
Setpoints			
I2>> Enable	I2>> Enable		OFF   ON
I2CLP>> Mode	I2CLP>> Mode		OFF   ON - Element blocking   ON - Change setting
I2CLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2>> Logical block	I2>>BLK1		OFF   ON
I2>> Input selective block	I2>>BLK2IN		OFF   ON
I2>> Output selective block	I2>>BLK2OUT		OFF   ON
I2>> Second harmonic restraint	I2>>2ndh-REST		OFF   ON
I2>> Breaker failure	I2>>BF		OFF   ON
I2> Disabling by I2>> start	I2>disbyI2>>		OFF   ON
I2>> Start relays	I2>>ST-K		K1   K2   K3   K4   K5   K6
I2>> Trip relays	I2>>TR-K		K1   K2   K3   K4   K5   K6
I2>> Start LEDs	I2>>ST-L		START   TRIP   L1   L2   L3   L4   L5
I2>> Trip LEDs	I2>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
46 Second threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 40.00 step = 0.01
I2>>def within CLP	I2CLP>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 40.00 step = 0.01

I2>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Negative sequence current / positive sequence current ratio - I2/I1			
I21> Element			
Setpoints			
I21CLP> Mode	I21CLP> Mode		OFF   ON - Element blocking   ON - Change setting
I21CLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I21> Logical block	I21>BLK1		OFF   ON
I21> Second harmonic restraint	I21>2ndh-REST		OFF   ON
I21> Breaker failure	I21>BF		OFF   ON
I21> Start relays	I21>ST-K		K1   K2   K3   K4   K5   K6
I21> Trip relays	I21>TR-K		K1   K2   K3   K4   K5   K6
I21> Start LEDs	I21>ST-L		START   TRIP   L1   L2   L3   L4   L5
I21> Trip LEDs	I21>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
I2/I1 First threshold definite time			
State			OFF   ON
Pickup value			0.10 ... 1.00 step = 0.01
I21>def within CLP	I21CLP>def		0.10 ... 1.00 step = 0.01
I21>def Operating time			
Value		s	0.04 ... 0.99 step = 0.01 1 ... 15000 step = 1
Thermal image - 49			
Common configuration			
Initial thermal image	DthIN	DThe- taB	0.0 ... 1.0 step = 0.1
Reduction factor at inrush	KINR		1.0 ... 3.0 step = 0.1
Thermal time constant	T	min	1 ... 200 step = 1
DthCLP Operating mode	DthCLP Mode		OFF   ON - Element blocking   ON - Change setting
DthCLP Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
49 Second harmonic restraint	Dth2ndh-REST		OFF   ON
DthAL1 Element			
DthAL1 Enable	DthAL1 Enable		OFF   ON
49 First alarm threshold	DthAL1	DThe- taB	0.3 ... 1.0 step = 0.1
DthAL1 Logical block	DthAL1BLK1		OFF   ON
DthAL1 Input selective block	DthAL1BLK2IN		OFF   ON
DthAL1 Output selective block	DthAL1BLK2OUT		OFF   ON
DthAL1 Alarm relays	DthAL1-K		K1   K2   K3   K4   K5   K6
DthAL1 Alarm LEDs	DthAL1-L		START   TRIP   L1   L2   L3   L4   L5
DthAL2 Element			
DthAL2 Enable	DthAL2 Enable		OFF   ON
49 Second alarm threshold	DthAL2	DThe- taB	0.5 ... 1.2 step = 0.1
DthAL2 Logical block	DthAL2BLK1		OFF   ON
DthAL2 Input selective block	DthAL2BLK2IN		OFF   ON
DthAL2 Output selective block	DthAL2BLK2OUT		OFF   ON
DthAL2 Alarm relays	DthAL2-K		K1   K2   K3   K4   K5   K6
DthAL2 Alarm LEDs	DthAL2-L		START   TRIP   L1   L2   L3   L4   L5
Dth> Element			
Dth> Enable	Dth> Enable		OFF   ON

49 Trip threshold	Dth>	DThe- taB	1.100 ... 1.300 step = 0.001
Dth> Logical block	Dth>BLK1		OFF   ON
Dth> Input selective block	Dth>BLK2IN		OFF   ON
Dth> Output selective block	Dth>BLK2OUT		OFF   ON
Dth> Breaker failure	Dth>BF		OFF   ON
Disabling Dth> by 50-51 start	Dth>disby50-51		OFF   ON
Dth> Trip relays	Dth>-K		K1   K2   K3   K4   K5   K6
Dth> Trip LEDs	Dth>-L		START   TRIP   L1   L2   L3   L4   L5
Phase overcurrent - 50/51			
↳ Element			
Setpoints			
↳ Enable	↳ Enable		OFF   ON
↳ Curve type	↳Curve		IEC/BS A   IEC/BS B   IEC/BS C   IEC/BS B L1   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   RECTIFIER   I2t   EM   DEFINITE
ICLP> Mode	ICLP> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
↳ Logical block	↳BLK1		OFF   ON
↳ Input selective block	↳BLK2IN		OFF   ON
↳ Output selective block	↳BLK2OUT		OFF   ON
↳ Second harmonic restraint	↳2ndh-REST		OFF   ON
↳ Breaker failure	↳BF		OFF   ON
↳ Start relays	↳ST-K		K1   K2   K3   K4   K5   K6
↳ Trip relays	↳TR-K		K1   K2   K3   K4   K5   K6
↳ Start LEDs	↳ST-L		START   TRIP   L1   L2   L3   L4   L5
↳ Trip LEDs	↳TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 First threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
↳def within CLP	ICLP>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
↳def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
50/51 First threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
↳inv within CLP	ICLP>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
↳inv Operating time	t>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
↳ Element			
Setpoints			
↳ Enable	↳ Enable		OFF   ON

I>> Curve type	I>>Curve		I2t   DEFINITE
ICLP>> Mode	ICLP>> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I>> Logical block	I>>BLK1		OFF   ON
I>> Input selective block	I>>BLK2IN		OFF   ON
I>> Output selective block	I>>BLK2OUT		OFF   ON
I>> Second harmonic restraint	I>>2ndh-REST		OFF   ON
I>> Breaker failure	I>>BF		OFF   ON
I> Disabling by I>> start	I>disbyI>>		OFF   ON
I>> Start relays	I>>ST-K		K1   K2   K3   K4   K5   K6
I>> Trip relays	I>>TR-K		K1   K2   K3   K4   K5   K6
I>> Start LEDs	I>>ST-L		START   TRIP   L1   L2   L3   L4   L5
I>> Trip LEDs	I>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 Second threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
I>>def within CLP	ICLP>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
I>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Inverse time			
50/51 Second threshold inverse time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
I>>inv within CLP	ICLP>>inv	In	0.100 ... 0.999 step = 0.001 1.00 ... 20.00 step = 0.01
I>>inv Operating time	I>>inv	s	0.02 ... 10.00 step = 0.01
I>>> Element			
Setpoints			
I>>> Enable	I>>> Enable		OFF   ON
ICLP>>> Mode	ICLP>>> Mode		OFF   ON - Element blocking   ON - Change setting
ICLP>>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I>>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I>>> Logical block	I>>>BLK1		OFF   ON
I>>> Input selective block	I>>>BLK2IN		OFF   ON
I>>> Output selective block	I>>>BLK2OUT		OFF   ON
I>>> Second harmonic restraint	I>>>2ndh-REST		OFF   ON
I>>> Breaker failure	I>>>BF		OFF   ON
I> Disabling by I>>> start	I>disbyI>>>		OFF   ON
I>> Disabling by I>>> start	I>>disbyI>>>		OFF   ON
I>>> Start relays	I>>>ST-K		K1   K2   K3   K4   K5   K6
I>>> Trip relays	I>>>TR-K		K1   K2   K3   K4   K5   K6

I>>> Start LEDs	I>>>ST-L		START   TRIP   L1   L2   L3   L4   L5
I>>> Trip LEDs	I>>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50/51 Third threshold definite time			
State			OFF   ON
Pickup value		In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
I>>>def within CLP	ICLP>>>def	In	0.100 ... 0.999 step = 0.001 1.00 ... 9.99 step = 0.01 10.0 ... 40.0 step = 0.1
I>>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Residual overcurrent - 50N/51N			
IE> Element			
Setpoints			
IE> Enable	IE> Enable		OFF   ON
IE> Curve type	IE>Curve		IEC/BS A   IEC/BS B   IEC/BS C   IEC/BS B LI   ANSI/IEEE MI   ANSI/IEEE VI   ANSI/IEEE EI   EM   DEFINITE
IECLP> Mode	IECLP> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IE> Logical block	IE>BLK1		OFF   ON
IE> Input selective block	IE>BLK2IN		OFF   ON
IE> Output selective block	IE>BLK2OUT		OFF   ON
IE> Second harmonic restraint	IE>2ndh-REST		OFF   ON
IE> Breaker failure	IE>BF		OFF   ON
IE> Start relays	IE>ST-K		K1   K2   K3   K4   K5   K6
IE> Trip relays	IE>TR-K		K1   K2   K3   K4   K5   K6
IE> Start LEDs	IE>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE> Trip LEDs	IE>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N First threshold definite time			
State			OFF   ON
Pickup value		IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>def within CLP	IECLP>def	IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>def Operating time			
Value		s	0.04 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
Inverse time			
50N/51N First threshold definite time			
State			OFF   ON
Pickup value		IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 2.00 step = 0.01
IE>inv within CLP	IECLP>inv	IE <sub>n</sub>	0.002 ... 0.999 step = 0.001 1.00 ... 2.00 step = 0.01
IE>inv Operating time	tE>inv	s	0.02 ... 9.99 step = 0.01 10.0 ... 60.0 step = 0.1
IE>> Element			
Setpoints			

IE>> Enable	IE>> Enable		OFF   ON
IECLP>> Mode	IECLP>> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IE>> Logical block	IE>>BLK1		OFF   ON
IE>> Input selective block	IE>>BLK2IN		OFF   ON
IE>> Output selective block	IE>>BLK2OUT		OFF   ON
IE>> Second harmonic restraint	IE>>2ndh-REST		OFF   ON
IE>> Breaker failure	IE>>BF		OFF   ON
IE> Disabling by IE>> start	IE>disbyIE>>		OFF   ON
IE>> Start relays	IE>>ST-K		K1   K2   K3   K4   K5   K6
IE>> Trip relays	IE>>TR-K		K1   K2   K3   K4   K5   K6
IE>> Start LEDs	IE>>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE>> Trip LEDs	IE>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N Second threshold definite time			
State			OFF   ON
Pickup value		IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>def within CLP	IECLP>>def	IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
IE>>> Element			
Setpoints			
IE>>> Enable	IE>>> Enable		OFF   ON
IECLP>>> Mode	IECLP>>> Mode		OFF   ON - Element blocking   ON - Change setting
IECLP>>> Activation time			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
tE>>> Reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
IE>>> Logical block	IE>>>BLK1		OFF   ON
IE>>> Input selective block	IE>>>BLK2IN		OFF   ON
IE>>> Output selective block	IE>>>BLK2OUT		OFF   ON
IE>>> Second harmonic restraint	IE>>>2ndh-REST		OFF   ON
IE>>> Breaker failure	IE>>>BF		OFF   ON
IE> Disabling by IE>>> start	IE>disbyIE>>>		OFF   ON
IE>> Disabling by IE>>> start	IE>>disbyIE>>>		OFF   ON
IE>>> Start relays	IE>>>ST-K		K1   K2   K3   K4   K5   K6
IE>>> Trip relays	IE>>>TR-K		K1   K2   K3   K4   K5   K6
IE>>> Start LEDs	IE>>>ST-L		START   TRIP   L1   L2   L3   L4   L5
IE>>> Trip LEDs	IE>>>TR-L		START   TRIP   L1   L2   L3   L4   L5
Definite time			
50N/51N Third threshold definite time			
State			OFF   ON
Pickup value		IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01
IE>>>def within CLP	IECLP>>>def	IEn	0.002 ... 0.999 step = 0.001 1.00 ... 10.00 step = 0.01

IE>>>def Operating time			
Value		s	0.03 ... 10.00 step = 0.01
Second Harmonic Restraint - 2ndh-REST			
Second harmonic restraint threshold			
State			OFF   ON
Pickup value		%	10 ... 50 step = 1
I2ndh> reset time delay			
Value		s	0.00 ... 9.99 step = 0.01 10.0 ... 100.0 step = 0.1
I2ndh> Start relays	I2ndh>ST-K		K1   K2   K3   K4   K5   K6
I2ndh> Start LEDs	I2ndh>ST-L		START   TRIP   L1   L2   L3   L4   L5
Trip circuit supervision - 74TCS			
74TCS Enable	74TCS Enable		OFF   ON
74TCS Logical block	74TCS-BLK1		OFF   ON
74TCS Start relays	74TCS-ST-K		K1   K2   K3   K4   K5   K6
74TCS Trip relays	74TCS-TR-K		K1   K2   K3   K4   K5   K6
74TCS Start LEDs	74TCS-ST-L		START   TRIP   L1   L2   L3   L4   L5
74TCS Trip LEDs	74TCS-TR-L		START   TRIP   L1   L2   L3   L4   L5
Selective block - BLOCK2			
Selective block IN			
BLIN1 Selective block operating mode	ModeBLIN1		OFF   ON IPh/IE   ON IPh   ON IE
BLIN maximum activation time for phase protections			
Value		s	0.10 ... 10.00 step = 0.01
BLIN maximum activation time for ground protections			
Value		s	0.10 ... 10.00 step = 0.01
tB-Iph/IE Elapsed signalling relays	tB-K		K1   K2   K3   K4   K5   K6
tB-Iph/IE Elapsed signalling LEDs	tB-L		START   TRIP   L1   L2   L3   L4   L5
Selective block OUT			
BLOUT1 Selective block operating mode	ModeBLOUT1		OFF   ON IPh/IE   ON IPh   ON IE
BLOUT Dropout time for phase protections			
Value		s	0.00 ... 1.00 step = 0.01
BLOUT Dropout time for ground protections			
Value		s	0.00 ... 1.00 step = 0.01
BLOUT Dropout time for ground and phase protections			
Value		s	0.00 ... 1.00 step = 0.01
Phase protections output selective block relays	BLK2OUT-Iph-K		K1   K2   K3   K4   K5   K6
Ground protections output selective block relays	BLK2OUT-IE-K		K1   K2   K3   K4   K5   K6
Phase and ground protections output selective block relays	BLK2OUT-Iph/IE-K		K1   K2   K3   K4   K5   K6
Phase protections output selective block LEDs	BLK2OUT-Iph-L		START   TRIP   L1   L2   L3   L4   L5
Ground protections output selective block LEDs	BLK2OUT-IE-L		START   TRIP   L1   L2   L3   L4   L5
Phase and ground protections output selective block LEDs	BLK2OUT-Iph/IE-L		START   TRIP   L1   L2   L3   L4   L5
Breaker failure - BF			
BF Enable	BF Enable		OFF   ON
BF Phase current threshold			
State			OFF   ON
Pickup value		In	0.05 ... 1.00 step = 0.01
BF Residual current threshold			
State			OFF   ON
Pickup value		IEn	0.01 ... 2.00 step = 0.01
BF Time delay			
Value		s	0.06 ... 10.00 step = 0.01
BF Logical block	BF-BLK1		OFF   ON

BF Start from circuit breaker	CB Input	OFF   ON
BF Start relays	BF-ST-K	K1   K2   K3   K4   K5   K6
BF Trip relays	BF-TR-K	K1   K2   K3   K4   K5   K6
BF Start LEDs	BF-ST-L	START   TRIP   L1   L2   L3   L4   L5
BF Trip LEDs	BF-TR-L	START   TRIP   L1   L2   L3   L4   L5
<b>PLC</b>		
Setpoints		
Enable	PLC Enable	OFF   ON
Relays	PLC-K	K1   K2   K3   K4   K5   K6
LEDs	PLC-L	START   TRIP   L1   L2   L3   L4   L5
Switches		
Switch 1		0   1
Switch 2		0   1
Switch 3		0   1
Switch 4		0   1
Switch 5		0   1
Switch 6		0   1
Switch 7		0   1
Switch 8		0   1
Switch 9		0   1
Switch 10		0   1
Switch 11		0   1
Switch 12		0   1
Switch 13		0   1   2
Switch 14		0   1   2
Switch 15		0   1   2
Switch 16		0   1   2
Switch 17		0   1   2
Switch 18		0   1   2
Switch 19		0   1   2
Switch 20		0   1   2
Switch 21		0   1   2   3
Switch 22		0   1   2   3
Switch 23		0   1   2   3
Switch 24		0   1   2   3
Switch 25		0   1   2   3   4   5   6   7   8   9
Switch 26		0   1   2   3   4   5   6   7   8   9
Switch 27		0   1   2   3   4   5   6   7   8   9
Switch 28		0   1   2   3   4   5   6   7   8   9
Switch 29		0   1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60   61   62   63   64   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79   80   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95   96   97   98   99

Switch 30			0   1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60   61   62   63   64   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79   80   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95   96   97   98   99
Switch 31			0   1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60   61   62   63   64   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79   80   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95   96   97   98   99
Switch 32			0   1   2   3   4   5   6   7   8   9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24   25   26   27   28   29   30   31   32   33   34   35   36   37   38   39   40   41   42   43   44   45   46   47   48   49   50   51   52   53   54   55   56   57   58   59   60   61   62   63   64   65   66   67   68   69   70   71   72   73   74   75   76   77   78   79   80   81   82   83   84   85   86   87   88   89   90   91   92   93   94   95   96   97   98   99
Timers			
Timer 1		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 2		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 3		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 4		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 5		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 6		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 7		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 8		s	0.00 ... 0.99 step = 0.01 1.0 ... 60.0 step = 0.1
Timer 9		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 10		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 11		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 12		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 13		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 14		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10

Timer 15		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 16		s	0.0 ... 59.9 step = 0.1 60 ... 299 step = 1 300 ... 3600 step = 10
Timer 17		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 18		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 19		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 20		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 21		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 22		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 23		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Timer 24		s	0 ... 59 step = 1 60 ... 3540 step = 60 3600 ... 86400 step = 600
Circuit Breaker supervision			
LEDs-relays allocation			
Open CB command relays	CBopen-K		K1   K2   K3   K4   K5   K6
Close CB command relays	CBclose-K		K1   K2   K3   K4   K5   K6
CB Closed LEDs	CBclose-L		START   TRIP   L1   L2   L3   L4   L5
CB Open LEDs	CBopen-L		START   TRIP   L1   L2   L3   L4   L5
CB State diagnostic relays	CBdiag-K		K1   K2   K3   K4   K5   K6
CB Diagnostic			
Number of CB trips mode	ModeN.Open		OFF   ON
Number of CB trips threshold	N.Open		0 ... 10000 step = 1
Cumulative CB tripping currents mode	ModeSumI		OFF   ON
Cumulative CB tripping currents threshold	SumI	In	0 ... 5000 step = 1
Cumulative CB tripping I <sup>2</sup> t mode	ModeSumI <sup>2</sup> t		OFF   ON
Circuit breaker opening time for I <sup>2</sup> t calculation	tbreak	s	0.05 ... 1.00 step = 0.01
Cumulative CB tripping I <sup>2</sup> t threshold	SumI <sup>2</sup> t	In <sup>2</sup> s	0 ... 5000 step = 1
CB operating time mode	Mode-tOpen		OFF   ON
Trigger relay for CB opening time trigger measurement	Ktrig-break		K1   K2   K3   K4   K5   K6
Circuit breaker maximum allowed opening time			
Value		s	0.05 ... 1.00 step = 0.01
Number of CB trips diagnostic relays	N.Open-K		K1   K2   K3   K4   K5   K6
Cumulative CB tripping currents diagnostic relays	SumI-K		K1   K2   K3   K4   K5   K6
Cumulative CB tripping I <sup>2</sup> t diagnostic relays	SumI <sup>2</sup> t-K		K1   K2   K3   K4   K5   K6
Circuit breaker opening time diagnostic relays	tbreak-K		K1   K2   K3   K4   K5   K6
Number of CB trips diagnostic LEDs	N.Open-L		START   TRIP   L1   L2   L3   L4   L5
Cumulative CB tripping currents diagnostic LEDs	SumI-L		START   TRIP   L1   L2   L3   L4   L5
Cumulative CB tripping I <sup>2</sup> t diagnostic LEDs	SumI <sup>2</sup> t-L		START   TRIP   L1   L2   L3   L4   L5
Circuit breaker opening time diagnostic LEDs	tbreak-L		START   TRIP   L1   L2   L3   L4   L5
CT supervision - 74CT			

74CT Enable	74CT Enable		OFF   ON
74CT Threshold	S<		0.10 ... 0.95 step = 0.01
74CT Overcurrent threshold			
State			OFF   ON
Pickup value		In	0.10 ... 1.00 step = 0.01
S< Operating time			
Value		s	0.03 ... 9.99 step = 0.01 10.0 ... 99.9 step = 0.1 100 ... 200 step = 1
S< Logical block	S<BLK1		OFF   ON
S< Trip relays	S<TR-K		K1   K2   K3   K4   K5   K6
S< Trip LEDs	S<TR-L		START   TRIP   L1   L2   L3   L4   L5
Remote tripping			
Remote tripping relays	RemTrip-K		K1   K2   K3   K4   K5   K6
Remote tripping LEDs	RemTrip-L		START   TRIP   L1   L2   L3   L4   L5
Pilot wire diagnostic			
BLOUT1 Diagnostic pulses period	PulseBLOUT1		OFF   100ms   1s   5s   10s   60s   120s
BLIN1 Diagnostic pulses control time interval	PulseBLIN1		OFF   100ms   1s   5s   10s   60s   120s
Not received pulses at BLIN signalling relays	PulseBLIN-K		K1   K2   K3   K4   K5   K6
Not received pulses at BLIN signalling LEDs	PulseBLIN-L		START   TRIP   L1   L2   L3   L4   L5
Demand measures			
Fixed demand period	tFIX	min	1 ... 60 step = 1
Rolling demand period	tROL	min	1 ... 60 step = 1
Number of cycles for rolling on demand	N.ROL		1 ... 24 step = 1
TimeZone			
Time Zone			(UTC+0) - Greenwich Dublin Edinburgh Lisbon London   (UTC+1) - Amsterdam Berlin Bern Rome Stockholm Vienna   (UTC+2) - Athens Bucharest Cairo Istanbul   (UTC+3) - Addis Abeba Baghdad Moscow Nairobi S.Petersburg   (UTC+4) - Baku Dubai Mauritius Samara Tbilisi   (UTC+5) - Karachi Maldives Tashkent Yekaterinburg   (UTC+6) - Almaty Dhaka Omsk   (UTC-1) - Azores CapoVerde   (UTC-2) - Mid Atlantic   (UTC-3) - Brasilia BuenosAires Georgetown Greenland   (UTC-4) - Atlantic-Time LaPaz Manuas Santiago   (UTC-5) - Eastern-Time (US Canada) Indiana   (UTC-6) - CentralTime (US Canada) CentralAmerica
Daylight saving time			Disable   Europe   Russia   Jordan   Syria   Egypt
Oscillography			
Readings			
State			Initialization   Upload from serial flash   Reset   Wait   Store to serial flash   Start recording   Acquire   Trigger   Stopped   Fail   Off
Serial flash state			OFF   Upload from serial flash   Store to serial flash   Reset serial flash
Serial flash overrun			OFF   ON
Records			0 ... 0 step = 0
Buffer storage		%	0 ... 0 step = 0
Trigger Setup			
Pre-trigger time		s	0.05 ... 1.00 step = 0.01
Post-trigger time		s	0.05 ... 60.00 step = 0.05
Element pickup trigger			ON   OFF
Trigger from outputs			K1   K2   K3   K4   K5   K6
Binary input trigger			ON   OFF

Trigger from inputs IN1-IN32			IN1   IN2   IN3   IN4   IN5   IN6   IN7   IN8   IN9   IN10   IN11   IN12   IN13   IN14   IN15   IN16   IN17   IN18   IN19   IN20   IN21   IN22   IN23   IN24   IN25   IN26   IN27   IN28   IN29   IN30   IN31   IN32
Trigger from inputs IN33-IN45			IN33   IN34   IN35   IN36   IN37   IN38   IN39   IN40   IN41   IN42   IN43   IN44   IN45
80% Buffer alarm			OFF   ON
Set sample channels			
iL1			On   Off
iL2			On   Off
iL3			On   Off
iE			On   Off
Set analog channels			
Analog 1			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 2			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 3			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 4			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 5			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 6			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 7			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 8			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 9			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 10			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 11			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Analog 12			Frequency   IL1   IL2   IL3   IE   I1   I2   I2/I1   IL1-2nd   IL2-2nd   IL3-2nd   I-2nd/IL   T1   T2   T3   T4   T5   T6   T7   T8   Off
Set digital channels			
Binary 1			K1   K2   K3   K4   K5   K6     IN1   IN2   IN3   IN4   IN5   IN6   IN7   IN8   IN9   IN10   IN11   IN12   IN13   IN14   IN15   IN16   IN17   IN18   IN19   IN20   IN21   IN22   IN23   IN24   IN25   IN26   IN27   IN28   IN29   IN30   IN31   IN32   IN33   IN34   IN35   IN36   IN37   IN38   IN39   IN40   IN41   IN42   IN43   IN44   IN45   Off



Binary 11			K1   K2   K3   K4   K5   K6     IN1   IN2   IN3   IN4   IN5   IN6   IN7   IN8   IN9   IN10   IN11   IN12   IN13   IN14   IN15   IN16   IN17   IN18   IN19   IN20   IN21   IN22   IN23   IN24   IN25   IN26   IN27   IN28   IN29   IN30   IN31   IN32   IN33   IN34   IN35   IN36   IN37   IN38   IN39   IN40   IN41   IN42   IN43   IN44   IN45   Off
Binary 12			K1   K2   K3   K4   K5   K6     IN1   IN2   IN3   IN4   IN5   IN6   IN7   IN8   IN9   IN10   IN11   IN12   IN13   IN14   IN15   IN16   IN17   IN18   IN19   IN20   IN21   IN22   IN23   IN24   IN25   IN26   IN27   IN28   IN29   IN30   IN31   IN32   IN33   IN34   IN35   IN36   IN37   IN38   IN39   IN40   IN41   IN42   IN43   IN44   IN45   Off
<b>Communication</b>			
<b>RS485</b>			
Protocol			MODBUS   DNP3
Address			1 ... 254 step = 1
Baudrate RS485			1200 baud   2400 baud   4800 baud   9600 baud   19200 baud   38400 baud   57600 baud
<b>DNP3</b>			
Device Profile			
Source (Slave) address			1 ... 254 step = 1
Unsolicited Responses			
IP Networking			
<b>Ethernet</b>			
IP host address			
IP net mask			
IP gateway			
Autonegotiation			OFF   ON
<b>NTP</b>			
General			
Enable			OFF   ON
Type			Local Network   Internet   User
NTP synchronization LED			None   START   TRIP   L1   L2   L3   L4   L5
Internet Type			
NTP Server			Zurich(Europe)   Berlin(Europe)   Italy(Europe)   Fukuoka1(Japan)   Fukuoka2(Japan)   Pushchino(Russia)   Lagos(Nigeria)   South Africa
User Type			
NTP Server address			
Status			
<b>Network management</b>			
Enable			OFF   ON
Type			Multicast   Broadcast
Multicast address			
Broadcast address			
Rx port			0 ... 20000 step = 1
Tx port			0 ... 20000 step = 1
TimeToLive(Multicast)			0 ... 20 step = 1



**8.9 APPENDIX E - EC Declaration of conformity**

Manufacturer:	THYTRONIC S.p.A.
Address:	Piazza Mistral 7 - 20139 MILANO

*The undersigned manufacturer herewith declares that the product*

Protection relay - type NA20

*is in conformity with the provisions of the following EC directives (including all applicable amendments) when installed in accordance with the installation instructions:*

Reference n°	Title
2014/35/EC 2014/30/EC	Low Voltage Directive EMC Directive

*Reference of standards and/or technical specifications applied for this declaration of conformity or parts thereof:*

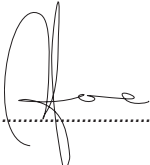
*- harmonized standards:*

Reference n°	Issue	Title
EN 61010-1	2010	Safety requirements for electrical equipment for measurement, control and laboratory use
EN 50263	2000	Electromagnetic compatibility (EMC) Product standard for measuring relays and protection equipments
EN 61000-6-4	2007-2011	Electromagnetic compatibility (EMC) Emission standard for industrial environments
EN 61000-6-2	2005	Electromagnetic compatibility (EMC) Immunity standard for industrial environments

*- other standards and/or technical specifications:*

Reference n°	Issue	Title
EN 60255-1	2011	Electrical relays Part 6: General requirements for measuring relays and protection equipment

*Year of CE marking: 2005*

Signature ..... 

Name **FIORE Mattia**  
Title **Managing director**  
Date **12-2005**



CUI:RO17366414 - RC:J2005000752229

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