SPR10

SELF POWERED / DUAL POWERED OVERCURRENT PROTECTION RELAY

OPERATING MANUAL

SOMMARIO

1 INTRODUCTION

Purpose and liability

This document describes the functions, the technical data of SPR10 devices; instructions for mounting, setting and commissioning are included..
This document may contain information on the entire Thytronic product family. Refer to the table in the manual for the functions actually present in the individual versions.

The document is constantly updated, the information relating to the revision is represented by the date of issue.
Standards, specifications and designs change periodically and therefore the information in this manual is subject to change without notice.
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Technical support

Contacts: THYTRONIC Technical Service www.thytronic.it

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Safety recommendations

It is recommended to respect the indications contained in the following document. Particular attention must be paid to the symbols listed below:

DANGER	Failure to observe may have life-threatening or serious consequences for the operator!

CAUTION	Failure to observe has consequences for the operator and/or cause damage to the device.

Installation and commissioning must be carried out by qualified personnel. Thytronic is not liable for damages caused by improper use that does not comply with all warnings and cautions listed in this manual.
In particular the following requirements must be met:

- Remove power before operating inside the device.
- Disconnect auxiliary power to the relay before connecting or disconnecting sensor connectors
- Verify the absence of voltage with suitable instrumentation on all input/output terminals, in particular pay attention to all circuits that may be powered by external power sources (digital inputs, measurement inputs, etc.).
- Care must be taken when handling metal parts (front panel, connectors).

CAUTION	Adjustments must be established on the basis of a coordination study. The values given in the calculation examples are for training purposes only and must not be used for real applications under any circumstances.

Insulation tests

Dangerous voltages (capacitor charging, etc.) can occur as a result of dielectric strength tests and/or insulation resistance measurements, it is recommended not to interrupt the test voltage abruptly, but rather to reduce it gradually until it is eliminated.

Identification

- There are labels on the product showing the technical data of the device.
- There is also a test label on the product.

Environmental conditions

The devices must be employed according to the environment conditions shown in technical data.
In case of different environment conditions, appropriate provisions must be provided before commissioning (conditioning system, humidity control, etc.).
If contaminants are present (dust, corrosive substances, etc.), filters must be provided.

Symbols

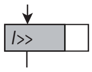
The CEI/IEC and ANSI symbols is employed where possible:
e.g.: 51 = ANSI code for the ovecurrent element

Abbreviations/definitions

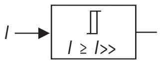
f_n	Rated frequency
I_{nH}	Relay phase rated current side H
I_{npH}	Phase CT primary rated current side H
I_{nL}	Relay phase rated current side L
I_{npL}	Phase CT primary rated current side L
I_{ng}	Protected device rated current
I_{En1}	Relay residual rated current (input 1)
I_{Enp1}	Residual CT primary rated current (input 1)
I_{En2}	Relay residual nominal current (input 2)
I_{Enp2}	Residual CT primary nominal current (input 2)
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
K1...Kx	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)
VT	Voltage Transformer
CT	Current Transformer
ThySensor	Combo device
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 a ANSI no-dot)
S1	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 quantities (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
Subnet Mask	(Ethernet nomenclature)
Sw	Software
Fw	Firmware
Upgrade	Firmware upgrade
XML	eXtensible Markup LanguageXML
Upgrade	Firmware upgrade

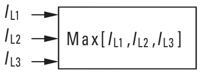
Symbols



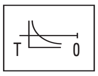
Threshold setting (e.g. pickup *I*>>).
The value is available for reading and is adjustable by means ThyVisor + MMI.



Limit block (*I*>> threshold).



Computation block (Max phase current)

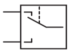


Curve type (definite/inverse time)

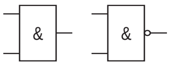
Logic internal signal (output); may be a logical state (e.g.I>> Start) or a numerical value
It is available for reading (ThyVisor + communication interface)

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

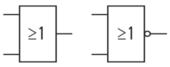
Internal signal (e.g. Breaker Failure output state concerning to the 2nd threshold of the 50 element)
It is not available for reading (missing arrow)



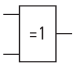
Switch



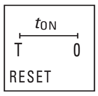
AND and NAND logic gates



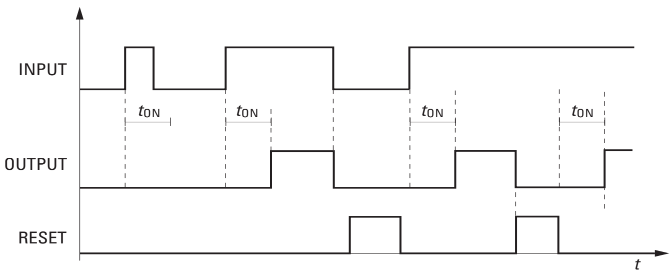
OR and NOR logic gates

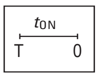


EXOR logic gate

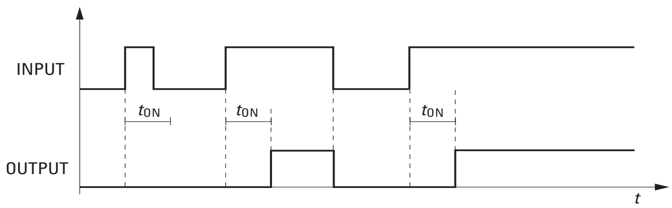


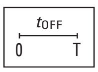
ON delay timer with reset (t_{ON} delay)



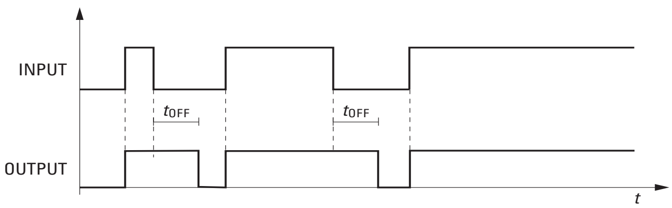


ON delay timer without reset (t_{ON} delay)

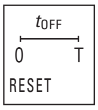




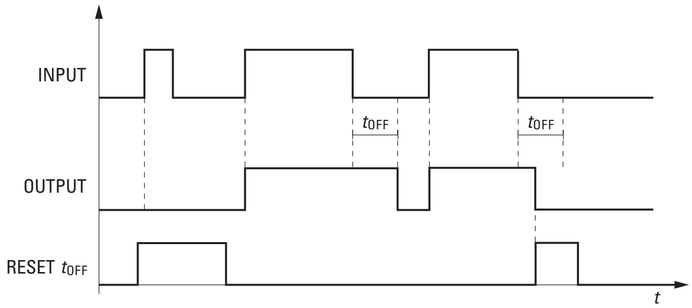
OFF delay timer (dropout) without reset (t_{OFF} delay)

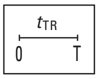


Symbols.ai

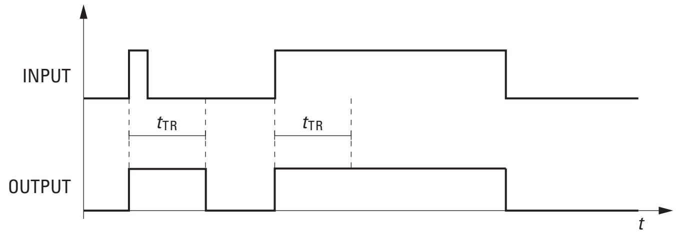


OFF delay timer (dropout) with reset (t_{OFF} delay)

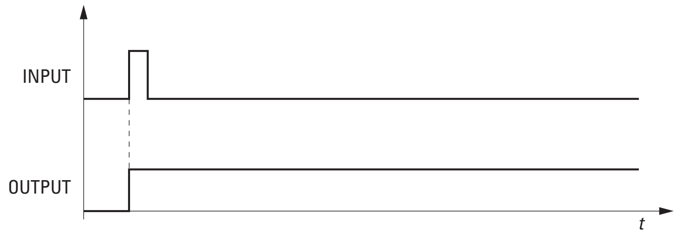


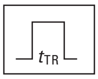


Minimum pulse width operation for output relays (t_{TR})

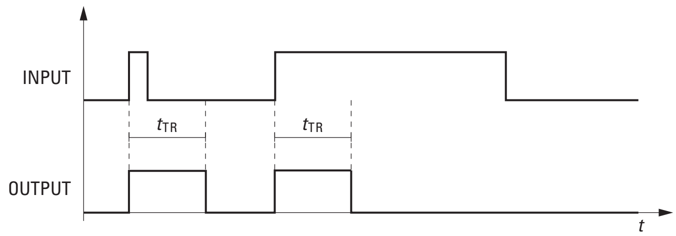


Latched operating mode for output relays and LEDs





Pulse operating mode for output relays



Symbols1 .ai

2 GENERAL

Foreword

The SPR10 numeric relay is powered by current transformers (CTs) and does not require an external power supply voltage. The energy for the operation is derived from current transformers with secondary standard 1 A or 5 A.
Two residual current inputs are available, which can be used alternatively, with the possibility of excluding the residual current from the supply circuit. In models with a fixed terminal block, the residual current is always connected to the supply circuit. In the absence of input current, the operating status (trip/no-trip) is also indicated by three electronic indicator flags. (Optional function: depending on the model, 0, 1, or 3 flags are present.)
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 negative sequence protection against asymmetrical short circuits and unbalance loads is available.

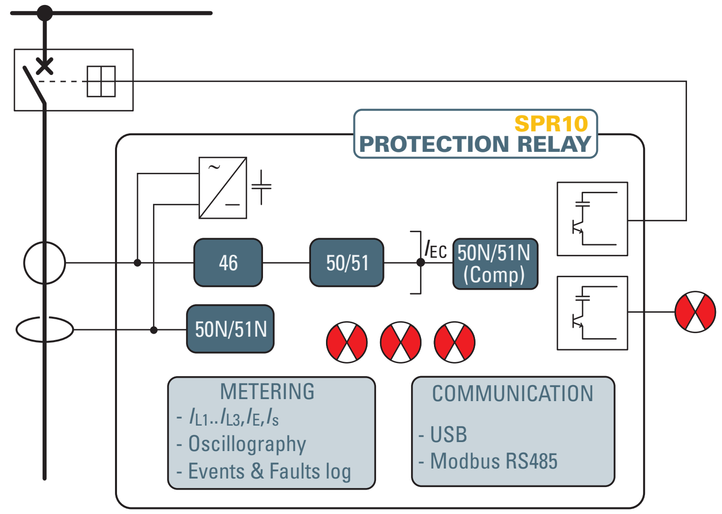
Following input circuits are available:
• Three binary inputs.
• Four electromechanical relays.
• Two solid state outputs (trip command and external flag)

Setting, programming and reading operations must be operated through USB by means of Personal Computer with Thy-Visor software or by means of remote communication interface (RS485 bus); all operations can be performed through MMI.

The relay SPR10 can be equipped with optional auxiliary power supply.

Main features

• Metallic case.
• Backlight LCD 2x16 Display.
• None, 2 or 3 Electronical flags
• Eight LEDs that may be joined with matrix criteria to many and various functions.
• RESET key to clear LED indications and flag indicator.
• Rear RS485 port, with ModBus protocol.
• USB front serial port (local communication with Thy-Visor).



Protective elements

46	Phase balance overcurrent
50/51	Phase overcurrent
50N/51N	Residual overcurrent
50N/51N(Comp)	Calculated residual overcurrent

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.	
• Flush with withdrawable cassette mounting	
External dimensions (Flush mounting)	177 x 107 x 200 (high x width x depth)
Terminals	screw connection
Mass (Flush mounting)	2.0 kg
Reference standards	EN 60529, EN 60529/A1
Degrees of protection provided by enclosures (IP Code)	
• Front	IP52
•Terminals	IP20

— Insulation

Reference standards	IEC 60255-27
High voltage test (50 Hz - 60 s)	
• Auxiliary power supply	2 kV
• Input circuits	2 kV
• Output circuits	2 kV
• Output circuits (between open contacts)	1 kV
• Commmunication interfaces USB/RS485	500 V
Impulse voltage withstand test (1.2/50 µs):	
• Auxiliary power supply	5 kV (Common mode) - 2kV (Differential mode)
• Input circuits	5 kV
• Output circuits	5 kV
• Output circuits (between open contacts)	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%)	100 ms
• Interruption (UT=0%)	50 ms
• Voltage variations (UT=80...120%)	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	ENEL REMC 02
• Normativa di compatibilità elettromeccanica per apparati e sistemi	ENEL REMC 01
Reference standards	EN 60255-26 EN 61000-4-12 EN 61000-4-18
Damped oscillatory wave	
• 0.1 MHz and 1 MHz common mode	2.5 kV
• 0.1 MHz and 1 MHz differential mode	1.0 kV
Ring wave	
• Ring wave common mode	2.0 kV
• Ring wave differential mode	1.0 kV
Reference standards	EN 60255-26 EN 61000-4-2 IEC 61000-4-2
Electrostatic discharge	
• Contact discharge	6 kV
• Air discharge	8 kV
Reference standards	EN 60255-26 EN 61000-4-3 IEC 61000-4-3

Radiated radio-frequency fields	
• 80...1000 MHz AM 80%	10 V/m
• 900 MHz Pulse modulated	10 V/m
Reference standards	EN 60255-26 EN 61000-4-4 IEC 61000-4-4
Fast transient burst (5/50 ns)	
• All the circuits	4 kV
Reference standards	EN 60255-26 EN 61000-4-5 IEC 61000-4-5
High energy pulse	
• U_{aux} (line-to-ground)	2 kV
• U_{aux} (line-to-line)	1 kV
Reference standards	EN 60255-26 EN 61000-4-6 IEC 61000-4-6
Conducted radio-frequency fields	
• 0.15...80 MHz AM 80% 1kHz	10 V
Reference standards	EN 60255-25 EN 61000-4-16 IEC 61000-4-16
Power frequency immunity tests	
• Dc voltage continously	100 V
• DC voltage 1 s	300 V
• 50 Hz continuously	100 V
• 50 Hz 1 s	300 V
• 0.015...150 kHz	10 V
Reference standards	EN 61000-4-8 IEC 61000-4-8
Magnetic field 50 Hz	
• 50 Hz continuously	100 A/m
• 50 Hz 1 s	1 kA/m
Reference standards	EN 61000-4-10 IEC 61000-4-10
Damped oscillatory magnetic field	
• Damped oscillatory wave 0.1 MHz	30 A/m
• Damped oscillatory wave 1 MHz	30 A/m

— Emission

Reference standards	EN 60255-25 IEC 60255-25 EN 61000-6-4 IEC 61000-6-4 EN 55011 CISPR 11
Electromagnetic emission tests	
• Conducted emission auxiliary power supply 0.15...0.5 MHz	79 dB µV
• Conducted emission auxiliary power supply 0.5...30 MHz	73 dB µV
• Radiated emission 30...230 MHz	40 dB µV/m
•Radiated emission 230...1000 MHz	47 dB µV/m

— Mechanical tests

Reference standards	EN 60255-21-1 EN 60255-21-2 RMEC01
Vibration, shock, bump and seismic tests on measuring relays and protection equipment	
• EN 60255-21-1 Vibration tests (sinusoidal)	Class 2
• EN 60255-21-2 Shock and bump test	Class 1

— Climatic tests

Reference standards	IEC 60068-x ENEL R CLI 01 CEI 50
Environmental testing	
Ambient temperature	-25...+70 °C
Storage temperature	-40...+85 °C
Relative humidity	10...95 %
Atmospheric pressure	70...110 kPa

— Safety

Reference standards	IEC 60255-27
Safety requirements for electrical equipment for measurement, control and laboratory use	
Pollution degree	3
Reference voltage	250 V
Overvoltage category	III

— Certifications

CE Conformity	
• EMC Directive	2014/30/EC
• Low Voltage Directive	2014/35/CE
Type tests	IEC 60255-1

3.2 INPUT CIRCUITS

— Minimum current inputs for powering [1]

Phase currents:
- One phase current — 0.2 I_n
- Two phase currents — 0.1 I_n
- Three phase currents — 0.08 I_n

Residual current
- Ground current — 0.2 I_{En}

When the vector sum of the resultant amplitude is between 0.2 and 0.6 In the following functions are active:
- acquisition and processing of the input currents,
- protection and recording functions,
- K1 relay, trip output (striker), internal and external flags,

while the following functions are disabled:
- LED and display
- K2, K3 and K4 relays
- RS485 communication

— Auxiliary power supply (Option)

Voltage	
• Nominal value (range)	24...230 V~/-
• Operative range	19...265 V~/19...300 V-
Frequency (for alternate voltage supply)	45...66 Hz
• Power consumption Maximum	5W (8VA)
Max alternating component (for dc voltage supply):	
• Full wave rectified sine wave	100 %
• Sine wave	80 %

— Phase current input circuits

Relay nominal phase current I_n	1 A or 5 A selectable at the order
Permanent overload	5 I_n
Thermal overload (1 s)	100 I_n
Dynamic overload (half cycle)	250 I_n
Rated consumption for any phase (with rated current)	≤ 2.5 VA - I_n=1 A, ≤ 3VA - I_n=5 A
Phase CTs minimum technical characteristics [2]	5VA - 10P20 for CTs I_n=1 A 10VA - 10P20 for CTs I_n=5 A

— Residual current input circuit

Relay nominal residual current I_{En}	1 A or 5 A selectable at the order
Permanent overload	5 I_n
Thermal overload (1 s)	100 I_{En}
Dynamic overload (half cycle)	250 I_{En}
Rated consumption (with rated current)	≤ 2.5 VA - I_{En}=1 A, ≤ 3 VA - I_{En}=5 A
Residual CT minimum technical characteristics	5VA - 10P20 for CTs I_n=1 A 10VA - 10P20 for CTs

I_n=5 A

— Binary input circuits

Quantity	3
Type	optocoupler
Activation threshold	18 V, 66 V (selectable by jumper)
Max consumption, energized	3 mA

3.3 OUTPUT CIRCUITS

— Relays

Quantity	4
Type of contacts K1, K2	changeover (SPDT, type C)
Type of contacts K3, K4	make (SPST-NO, type A)
Rated current	8 A
Nominal voltage/max switching voltage	250 V~/400 V~
Breaking capacity:	
• Direct current (L/R = 40 ms)	50 W
• Alternating current (λ = 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:	

Note1 The current that contributes to the supply is the resultant of the vector sum of the input currents. With auxiliary power supply or USB connection all functions are active.

Note 2 If the CTs does not supply any devices other than the SPR10 relay and connections resistance is negligible. Refer to "Current transformer requirements" in the APPENDIX for the full discussion.

• Mechanical	10^6 operations
• Electrical	10^5 operations

— CB command and signalling (flag)

Quantity	2
Type	pulse - 0.25 s
Voltage	24 V
Energy output	
• CB command	0.1 Joule
• External mechanical flag	0.01 Joule

3.4 MMI

Display	16 x 2 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	USB type B
Protocol	Modbus RTU®

— Remote port

RS485	
• Connection	screw terminals
• Baud rate	1200...57600 bps
• Protocol[1]	ModBus®RTU

3.6 GENERAL SETTINGS

Relay rated frequency (f_n)	50, 60 Hz
Relay phase rated current (I_n)	1 A or 5 A [2]
Phase CT primary rated 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 rated current (I_{En})	1 A or 5 A [1]
Residual CT primary rated 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 PROTECTION FUNCTIONS

Pickup time (device powered before fault, dual powered)	≤ 0.025 s
Pickup time (device powered onto fault, self powered) (only one relay or impulse output active)	≤ 0.080 s
Dropout ratio	0.95 ± 5%
Dropout time	≤ 0.05 s
Overshoot time	0.03 s
Pickup accuracy	± 5% at 0.2 I_n ± 2.5% at 0.6 I_n ± 1% at 1 I_n
Operate time accuracy	5% or ± 30 ms

— Negative sequence overcurrent - 46

I2> Element

Curve type	DEFINITE
Reset time delay (t2>RES)	0.00...10.00 s (step 0.01 s)

Definite time

First threshold definite time (I2>def)	0.08...4.00 In (step 0.01 I_n)
Time delay (t2>def)	0.00...200.00 s (step 0.01 s)

Note 1 Different version must be selected at ordering

Note 2 The rated current settings doesn't concern the protection elements.

Phase overcurrent - 50/51

I> Element

Curve type ($I>_{Curve}$)	DEFINITE (DMT), IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t>_{RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
First threshold definite time ($I>_{def}$)	0.20...20.00 I_n (step 0.01 I_n)
Time delay ($t>_{def}$)	0.00...200.00 s (step 0.01 s)
Inverse time[1]	
First threshold inverse time ($I>_{inv}$)	0.20...10.00 I_n (step 0.01 I_n)
Time multiplier ($t>_{inv}$)	0.02...1.60 s (step 0.01 s)

I>> Element

Curve type ($I>>_{Curve}$)	DEFINITE (DMT), IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t>>_{RES}$)	0.00...1000 s
Definite time	
Second threshold definite time ($I>>_{def}$)	0.20...20.00 I_n (step 0.01 I_n)
Time delay ($t>>_{def}$)	0.00...200.00 s (step 0.01 s)
Inverse time	
Second threshold inverse time ($I>>_{inv}$)	0.20...10.00 I_n (step 0.01 I_n)
Time multiplier ($t>_{inv}$)	0.02...1.60 s (step 0.01 s)

I>>> Element

$I>>>$ Reset time delay ($t>>>_{RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
Third threshold definite time ($I>>>_{def}$)	0.20...20.00 I_n (step 0.01 I_n)
Time delay ($t>>>_{def}$)	0.00...200.00 s (step 0.01 s)

Residual overcurrent - 50N/51N

IE> Element

Curve type ($I_E>_{Curve}$)	DEFINITE (DMT), IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t_E>_{RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
First threshold definite time ($I_E>_{def}$)	0.01...20.00 I_{En} (step 0.01 I_{En})
Time delay ($t_E>_{def}$)	0.00...200.00 s (step 0.01 s)
Inverse time[2]	
First threshold inverse time ($I_E>_{inv}$)	0.01...10.00 I_{En} (step 0.01 I_{En})
Time multiplier ($t_E>_{inv}$)	0.02...1.60 s (step 0.01 s)

IE>> Element

Curve type ($I_E>>_{Curve}$)	DEFINITE IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t_E>>_{RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
Second threshold definite time ($I_E>>_{def}$)	0.01...20.00 I_{En} (step 0.01 I_{En})
Time delay ($t_E>>_{def}$)	0.00...200.00 s (step 0.01 s)

Note 2

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):	$t = 80 \cdot t>_{inv} / [(I/I>_{inv})^2 - 1]$
Short time Inverse Time (IEC 255-STI):	$t = 0.05 \cdot t>_{inv} / [(I/I>_{inv})^{0.04} - 1]$
Long time Inverse Time (IEC 255-3/BS B LTI):	$t = 120 \cdot t>_{inv} / [(I/I>_{inv}) - 1]$

t: *operate time*
$I>_{inv}$: *pickup value*
$t>_{inv}$: *operate time setting*
Asymptotic reference value: 1.1 $I>_{nv}$
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* 30 I_n

Note 2

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):	$t = 80 \cdot t_E>_{inv} / [(I_E/I_E>_{inv})^2 - 1]$
Short time Inverse Time (IEC 255-STI):	$t = 0.05 \cdot t_E>_{inv} / [(I_E/I_E>_{inv})^{0.04} - 1]$
Long time Inverse Time (IEC 255-3/BS B LTI):	$t = 120 \cdot t_E>_{inv} / [(I_E/I_E>_{inv}) - 1]$

I_E: *residual current*
t: *operate time*
$I_E>_{inv}$: *pickup value;* $t_E>_{inv}$: *operate time setting*
Asymptotic reference value: 1.1 $I_E>$
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}

Inverse time	
Second threshold inverse time ($I_{E>>inv}$)	0.01...10.00 I_{En} (step 0.01 I_{En})
Time multiplier ($t_{E>>inv}$)	0.02...1.60 s (step 0.01 s)
IE>>> Element	
Reset time delay ($t_{E>>>RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
Third threshold definite time ($I_{E>>>def}$)	0.01...20.00 I_{En} (step 0.01 I_{En})
Time delay (tE>>>def)	0.00...200.00 s (step 0.01 s)

— Calculated residual overcurrent - 50N/51N(Comp)

IEC> Element	
Curve type ($I_{EC>Curve}$)	DEFINITE (DMT), IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t_{EC>RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
First threshold definite time ($I_{EC>def}$)	0.10...20.00 I_n (step 0.01 I_n)
Time delay ($t_{EC>def}$)	0.00...200.00 s (step 0.01 s)
Inverse time[1]	
First threshold inverse time ($I_{EC>inv}$)	0.10...10.00 I_n (step 0.01 I_n)
Time multiplier ($t_{EC>inv}$)	0.02...1.60 s (step 0.01 s)
IEC>> Element	
Curve type ($I_{EC>>Curve}$)	DEFINITE (DMT), IEC/BS SI, VI, EI, LTI, STI
Reset time delay ($t_{EC>>RES}$)	0.00...10.0 s (step 0.01 s)
Definite time	
Second threshold definite time ($I_{EC>>def}$)	0.10...20.00 I_n (step 0.01 I_n)
Time delay ($t_{EC>>def}$)	0.00...200.00 s (step 0.01 s)
Inverse time	
Second threshold inverse time ($I_{EC>>inv}$)	0.10...10.00 I_n (step 0.01 I_n)
Time multiplier ($t_{EC>>inv}$)	0.02...1.60 s (step 0.01 s)
IEC>>> Element	
Reset time delay ($t_{EC>>>RES}$)	0.00...10.00 s (step 0.01 s)
Definite time	
Third threshold definite time ($I_{EC>>>def}$)	0.10...20.00 I_n (step 0.01 I_n)
Time delay ($t_{EC>>>def}$)	0.00...200.00 s (step 0.01 s)

3.8 CONTROL AND MONITORING FUNCTIONS

— Second harmonic restraint - 2ndh-REST

Second harmonic restraint threshold ($I_{2ndh>}$)	10...50 % (step 1 %)
$I_{2ndh>}$ reset time delay ($t_{2ndh>RES}$)	0...10.0 s
Pickup accuracy $I_{2ndh>}$	± 4%
Operate time accuracy	± 5% or ± 10 ms

— Oscillography (DFR)[2]

Format	COMTRADE
Recording mode	circular
Sampling rate	32 samples / cycle
Trigger setup:	
• Pre-trigger time	0.05...1.00 s (step 0.01 s)
• Post-trigger time	0.05...5 s (step 0.05 s)
Set records:	
Sampled	i_{L1}, i_{L2}, i_{L3}, i_E
Input/Output	K1, K2, K3, K4, IN1, IN2, IN3

Note 1

Standard Inverse Time (IEC 255-3/BS142 type A or SIT):	$t = 0.14 \cdot t_{EC>inv} / [(I_{EC}/I_{EC>inv})^{0.02} - 1]$
Very Inverse Time (IEC 255-3/BS142 type B or VIT):	$t = 13.5 \cdot t_{EC>inv} / [(I_{EC}/I_{EC>inv}) - 1]$
Extremely Inverse Time (IEC 255-3/BS142 type C or EIT):	$t = 80 \cdot t_{EC>inv} / [(I_{EC}/I_{EC>inv})^2 - 1]$
Short time Inverse Time (IEC 255-STI):	$t = 0.05 \cdot t_{EC>inv} / [(I_{EC}/I_{EC>inv})^{0.04} - 1]$
Long time Inverse Time (IEC 255-3/BS B LTI):	$t = 120 \cdot t_{EC>inv} / [(I_{EC}/I_{EC>inv}) - 1]$

I_{EC}: *calculated residual current*
t: *operate time*
$I_{EC>inv}$: *pickup value;* $t_{EC>inv}$: *operate time setting*
Asymptotic reference value: 1.1 $I_{EC>}$
Equation is valid for $1.1 \le I_{EC}/I_{EC>inv} \le 20$, *with* $I_{EC>inv}$ *pickup* $\ge 0.5\ I_n$, *the upper limit is* 10 I_n

Note 2 For the DFR function a licence is required; call Thytronic for purchasing.

4 INSTALLATION

4.1 PACKAGING

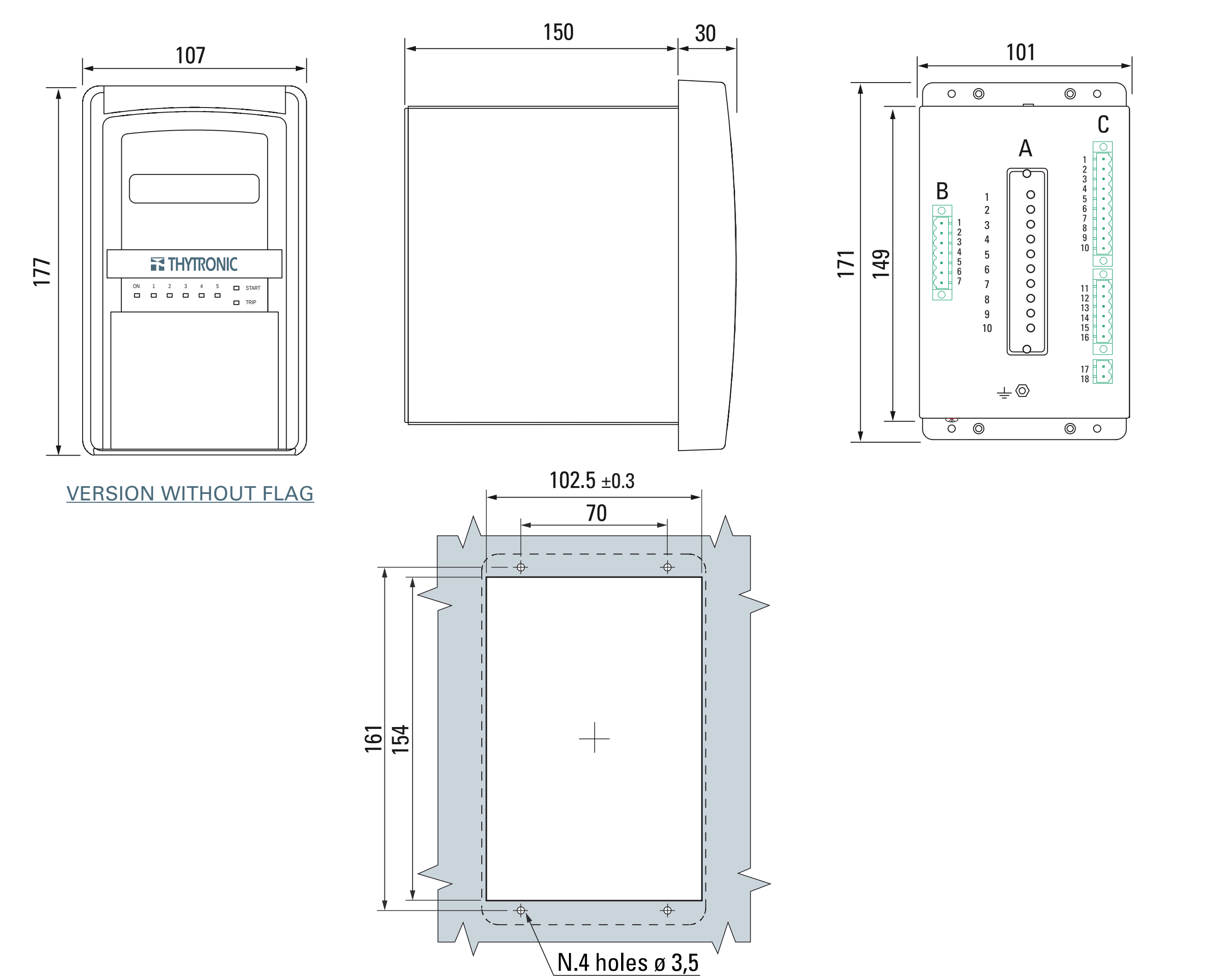
Packaging consists of a paperboard packaging guaranteeing adequate protection for transport and storage under normal environmental conditions.
The SPR10 protection relays must be stored within the required temperature limits; the relative humidity should not cause condensation or formation of frost.
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.

4.2 MOUNTING

Several mounting accessories are available:
• Flush mounting
• Projecting mounting
• Rack.
• Flush version with Cassette

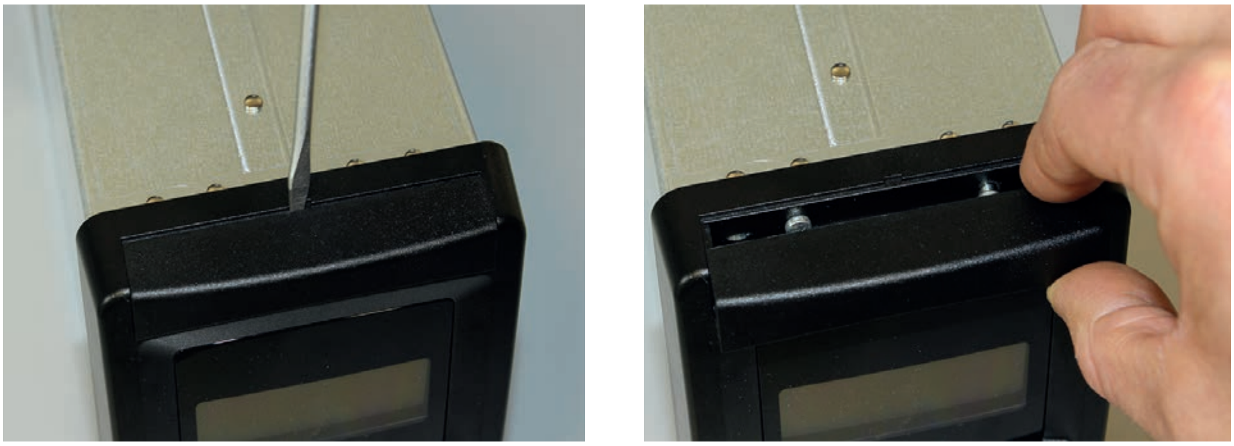
Flush mounting

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.



Flush mounting

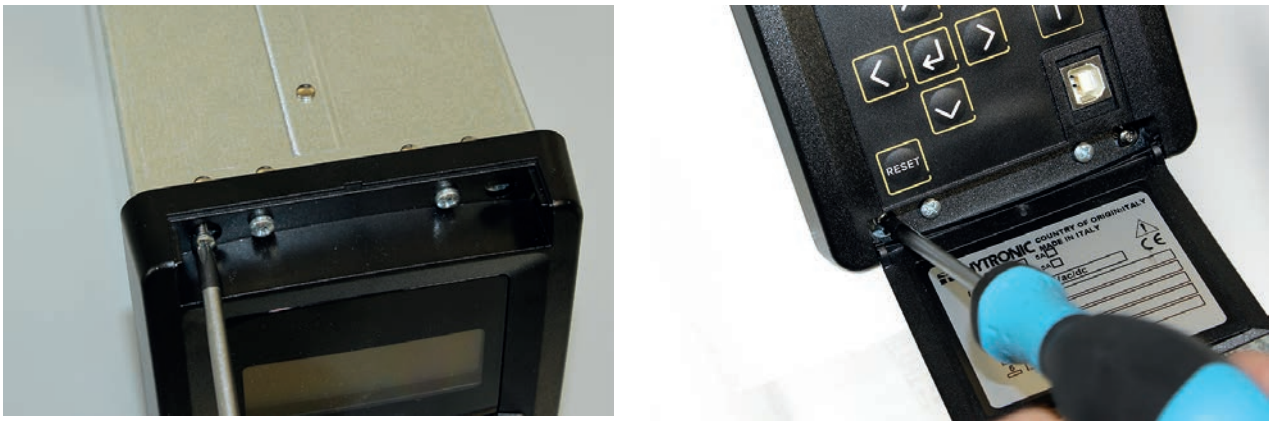
• Remove the upper tile and open the door to access the fastening screws.



Removing the top tile to access the fixing screws

Remove-tile.ai

• Fix the protection to the panel using four screws.



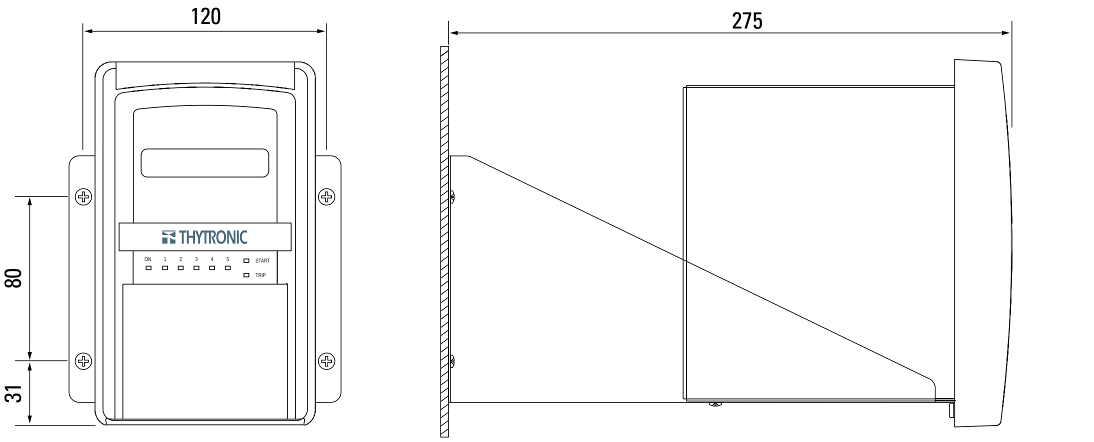
Flush mounting

Flush-mount1.ai

Projecting mounting

• Remove the earth screw and open the door to access the two fastening screws.
• Wire the terminal box and then fix the protection to the bracket, previously fixed to the wall, using the two front screws and the earth screw.

In the case of side-by-side mounting, the minimum distance is defined by the size of the bracket, increased horizontally and/or vertically to ensure an adequate tolerance margin and a tidy arrangement of the wiring.

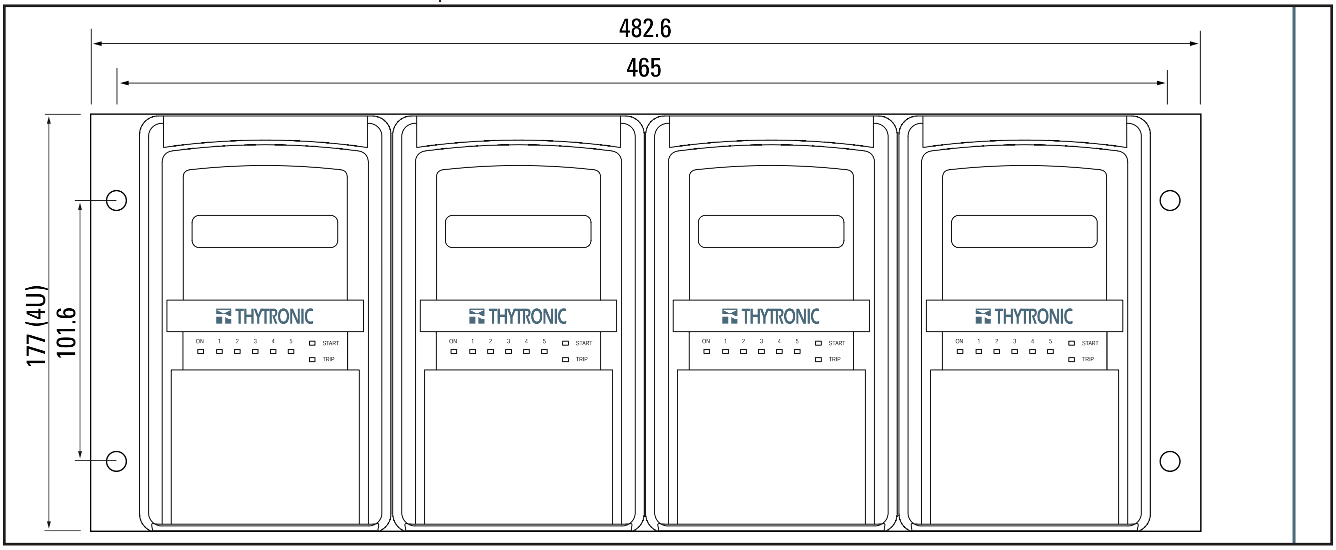


Projecting mounting

Projecting.ai

19" Rack mounting

Mounting in standard 19" racks requires the use of the MAR-type accessory that can be supplied on request.



A space of at least one unit must be provided for opening the keyboard protection flap when mounting stacked rack units.

Flush version with withdrawable Cassette

The withdrawable mounting is possible using the MAE module; the fixing system is the same as the flush-mounting system, with a different drilling template provided in the drawing below.

Fixing the MAE box:

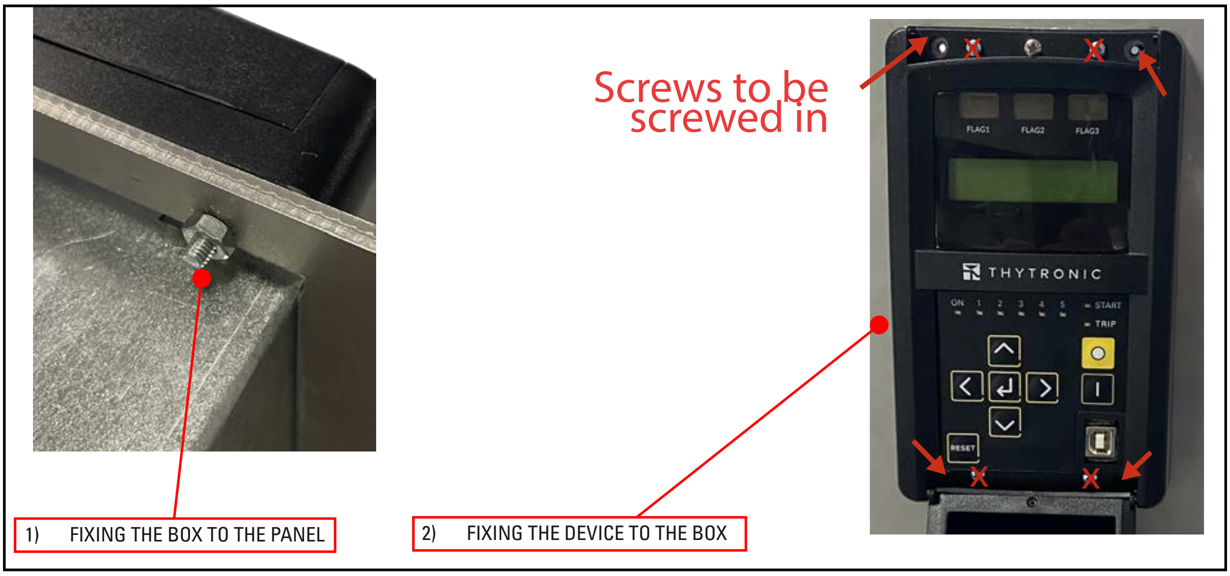
fix the box to the panel using the 4 nuts provided (the box is equipped with 4 M3 threaded inserts).

Fixing the device:

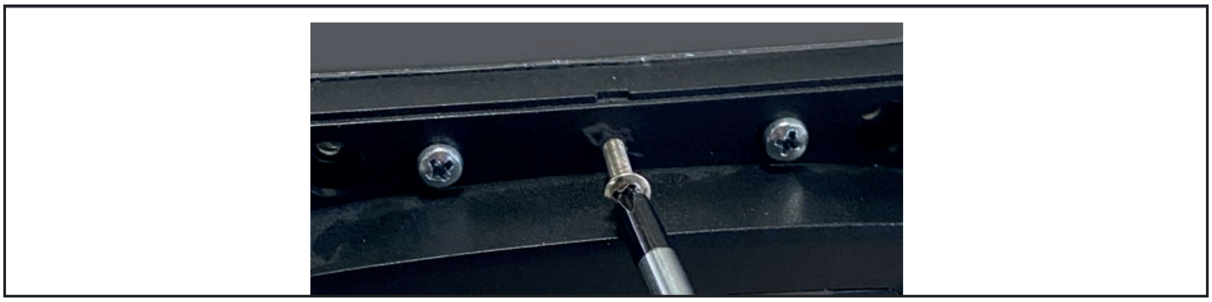
insert the device into the MAE box and secure it using the M3 screws provided.

Pay close attention to properly tightening the 4 screws marked with arrows in the drawing below to ensure correct connection of the connectors. The screws marked with red X should not be unscrewed. If present, the RS485 cable connected to the back of the device must be disconnected by hand after removing the device from the MAE cassette and reconnected before reinserting it.

See the last pages of the manual for dimensions and cutout.



To remove the device from the box, tighten in the central screw to push and separate the two parts

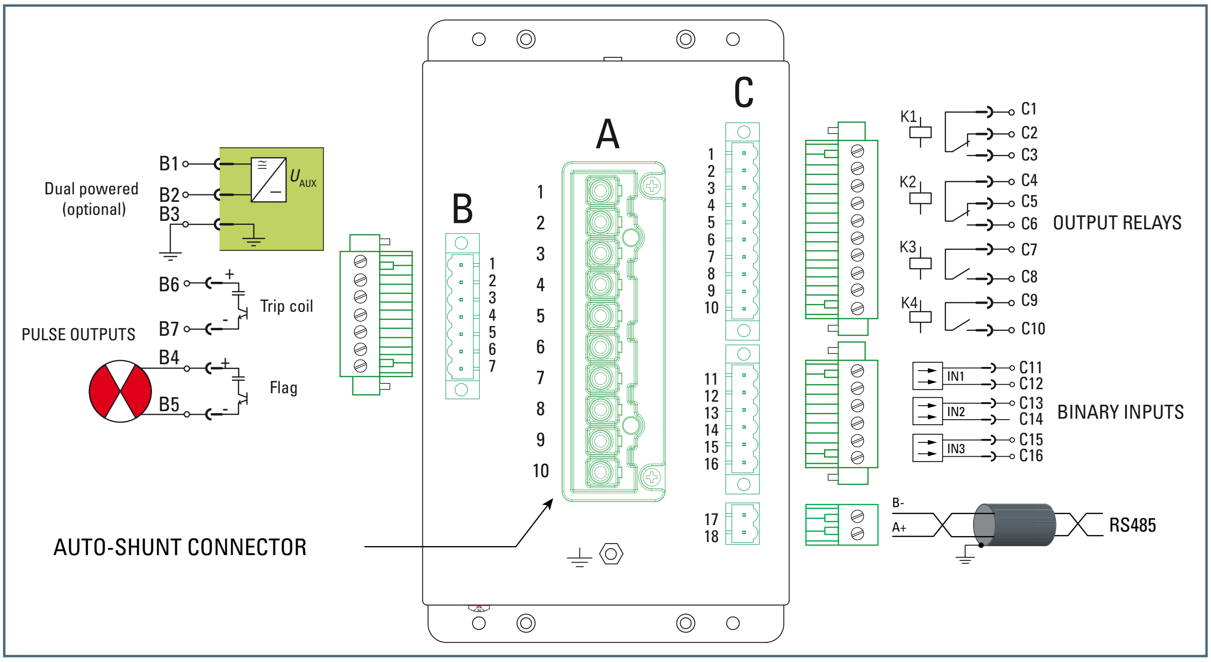


4.3 ELECTRICAL CONNECTIONS

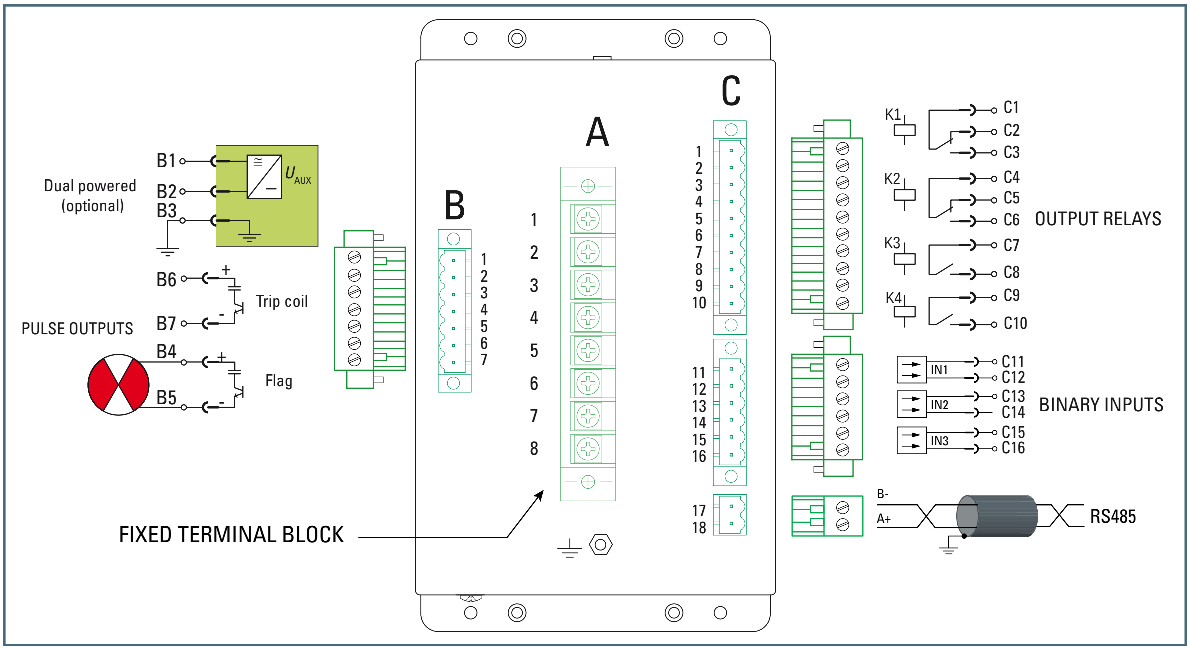
⚠ **CAUTION**	The devices must be installed and commissioned by qualified personnel. Thytronic is not liable for consequences caused by improper use.

When making electrical connections, reference must be made to the wiring diagram; if some circuits are not used, the corresponding connections must remain open.
For the A1...A10 connections, screw terminals with following characteristics are available:
- Conductor cross-section area: 0.2 to 4 mm2 (AWG 24...10) for single flexible conductors
  0.2 to 1.5 mm2 for two flexible conductors of identical cross-section
- Tightening torque: 0.5-0.6 Nm
- Stripping length: 7 mm

For connections B1...B7, C1...C18 screw terminals with following characteristics are available:
- Conductor cross-section area: 0.2 to 2.5 mm2 (AWG 26...16) for single flexible conductors
  0.2 to 1 mm2 for two flexible conductors of identical cross-section
- Tightening torque: 0.5-0.6 Nm
- Stripping length: 7 mm



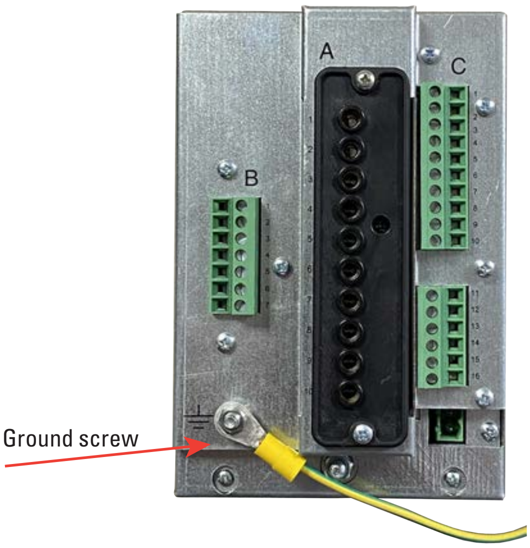
VERSION WITH AUTO-SHUNT CONNECTOR



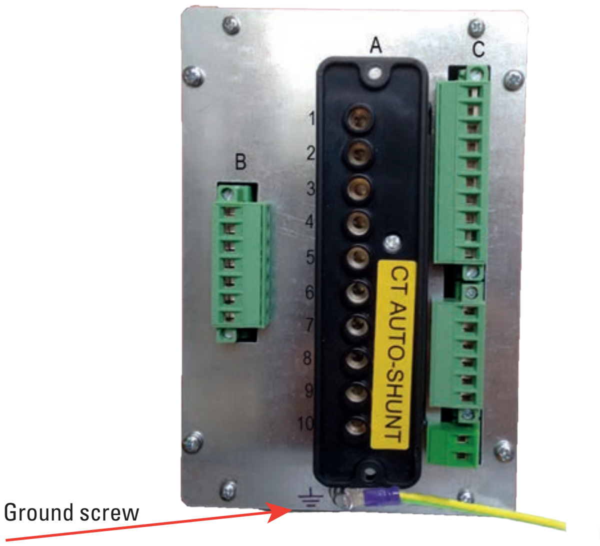
VERSION WITH FIXED TERMINAL BLOCK

Earthing

A protective earth connection is required, which must be connected to the screw provided for this purpose; the cross-section of the earth cable must be no less than 2.5 mm2.
The earthing must not be disconnected when the equipment is powered.



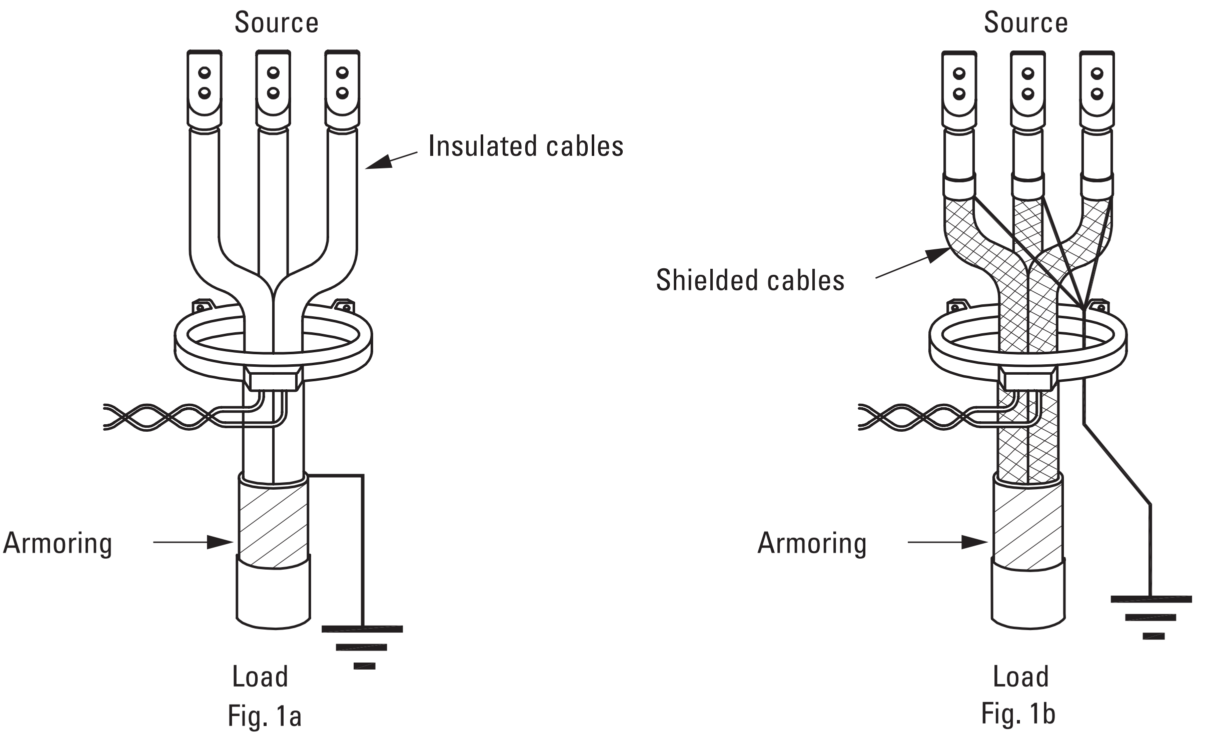
Valid for withdrawable version



Valid for all other versions

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.



Current balanced transformer

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).

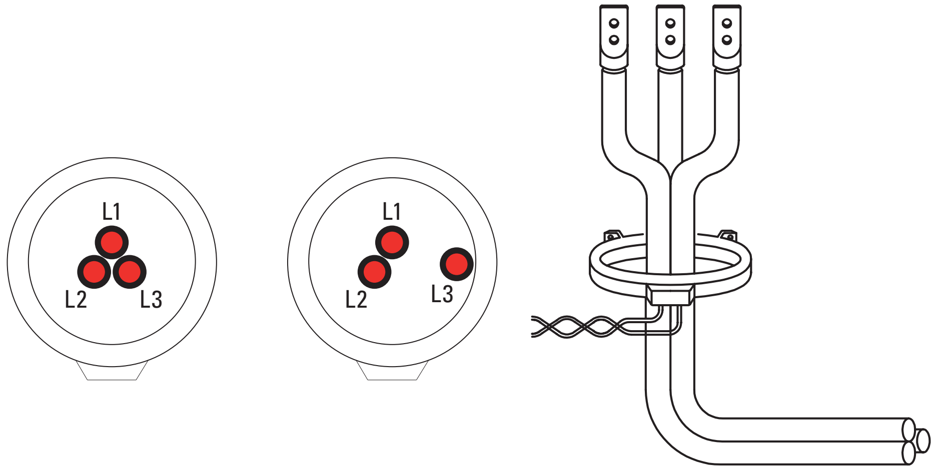


Fig. 2a   Fig. 2b   Fig. 2c

Current balanced transformer   Toroide.ai

Amperometric inputs

When the relay must be replaced or the current circuits must be open a suitable support terminal must be provided to achieve the short circuit on the secondary of CTs.
For security it is advisable to operate in the absence of current in the line.

⚠ **CAUTION**	If the secondary of a CT carrying primary current is open circuited, a high voltage can be developed across the CT terminals. CT shorting must be achieved by external means; the SPR10 does not include this feature.

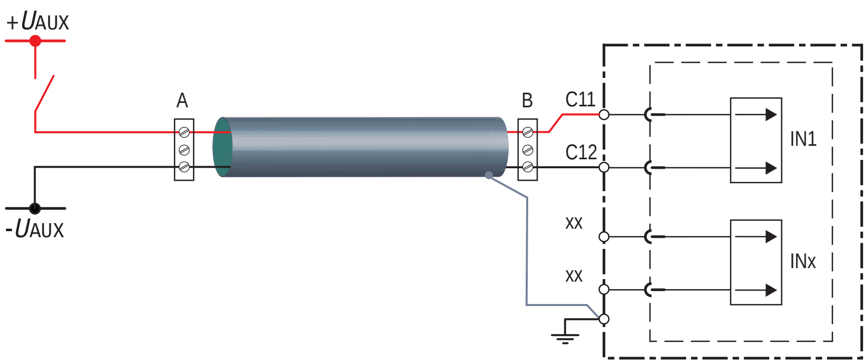
Some protective functions (Calculated residual current, negative sequence overcurrent) claim that the cyclic sequence and the polarity of the amperometric inputs are respected; otherwise the device could fail to operate. When all CTs are connected with proper polarity and sequence, without faults , unbalance current and calculated residual current will be approximately zero.
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 SPR10 protective relay, any other protective relays or measuring instruments and the resistance of the connections, must not exceed the line CT performance.
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^2.
It is recommended that cabling of a suitable thickness be used in order to limit wear of the CT secondary circuits.

Binary inputs

The input circuits are voltage-free and not polarised; activation requires a power source, preferably the same as the auxiliary voltage in the panel.
The inputs are polarity free with wide voltage range. No HW and/or SW programming is needed.



Binary inputs   Binary-sch.ai

Digital input circuits are generally immune to transient noise; however, the following recommendations should be observed:

- Position input wiring away from high energy sources avoiding parallel paths.
- Set a debounce timer (tON and/or tOFF) to alloy the transient to decay.

- Use shielded cables with earth connection on only one end (preferably at the relay side). Multiple earth connections could result in current circulation on the screen and consequently interfere the measurement. Therefore, they must be avoided.

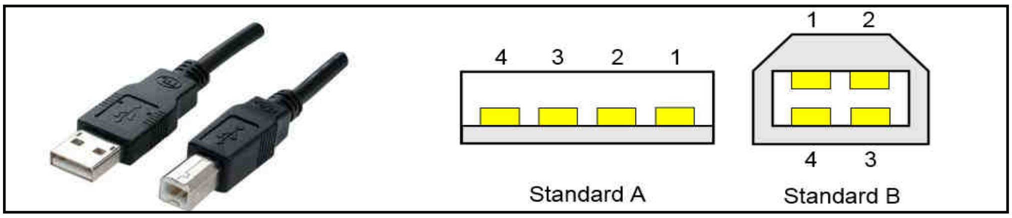
Output relays

Four 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).
All contacts are shown in de-energized state for standard reference.

⚠ **CAUTION**	It is recommeanded to check that the characteristics of the output contacts of the output relays are adequate for the intended load in terms of current, rated voltage, closing power and breaking capacity, referring to the data in the technical specifications.

USB port

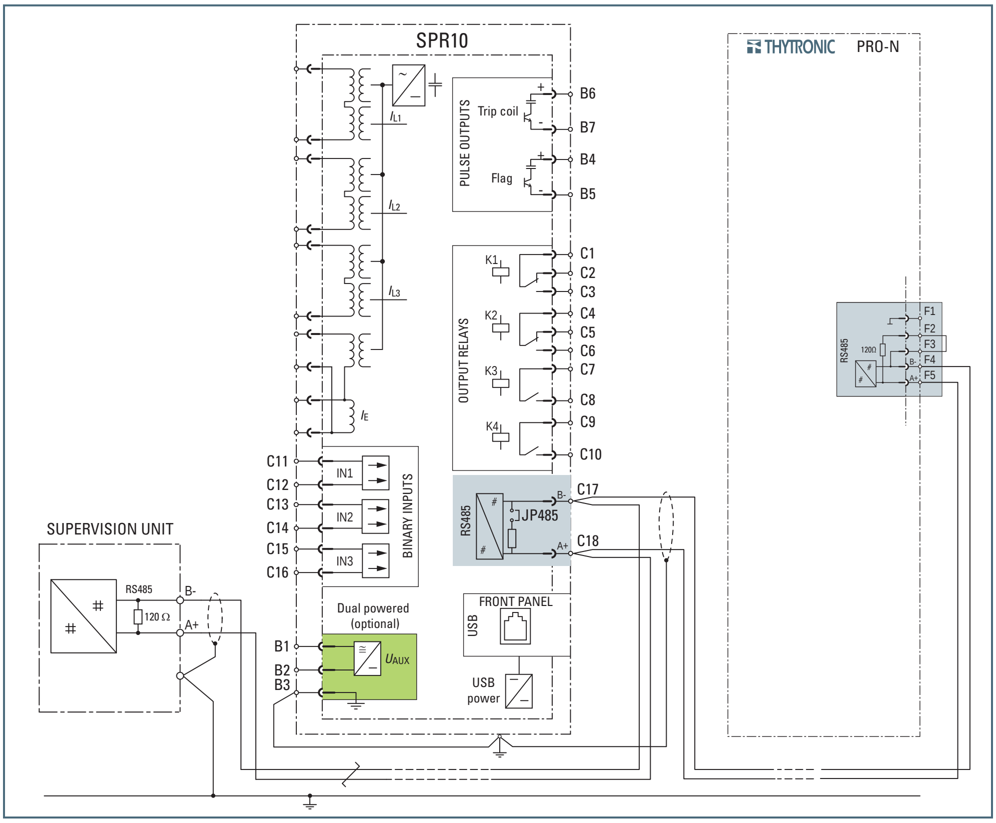
The connection between the personal computer and the local USB port must be made via the USB cable Type B - Type A, part number Thytronic L10042.



After installation of the USB port driver, the same port (typically COM4, COM5, etc.) must be selected in the ThyVisor SW communication parameter setting.
Auxiliary power must be removed and then the relay must be powered again.

RS485 port

RS485 communication circuit connections must be made using screened twisted pair cable observing 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. Termination resistors allow adjusting the impedance of the line, reducing the influence of the inductive components of the same, which might compromise good communication.
A suitable jumper (JP485), on CPU board, is available for bus termination.



.4 LED CUSTOMISATION

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.

4.5 FINAL OPERATIONS

Before energizing the electric board, it is advisable to check that:

- The auxiliary voltage (dual power versions) in the panel falls within the operative range of the SPR10 relay.
- The rated current (1 A or 5 A) of the line CT's corresponds to the setting of the SPR10 relay.
- All wirings are correct.
- All screws are tightly screwed.

5 CALIBRATION AND COMMISSIONING

Adjustments can be made:
- By Personal Computer, equipped with the supplied ThyVisor software.
- Locally via buttons and display (MMI).

WARNING

Changing some parameters requires a hardware reset of the relay for safety reasons:
- **Rated quantities.**

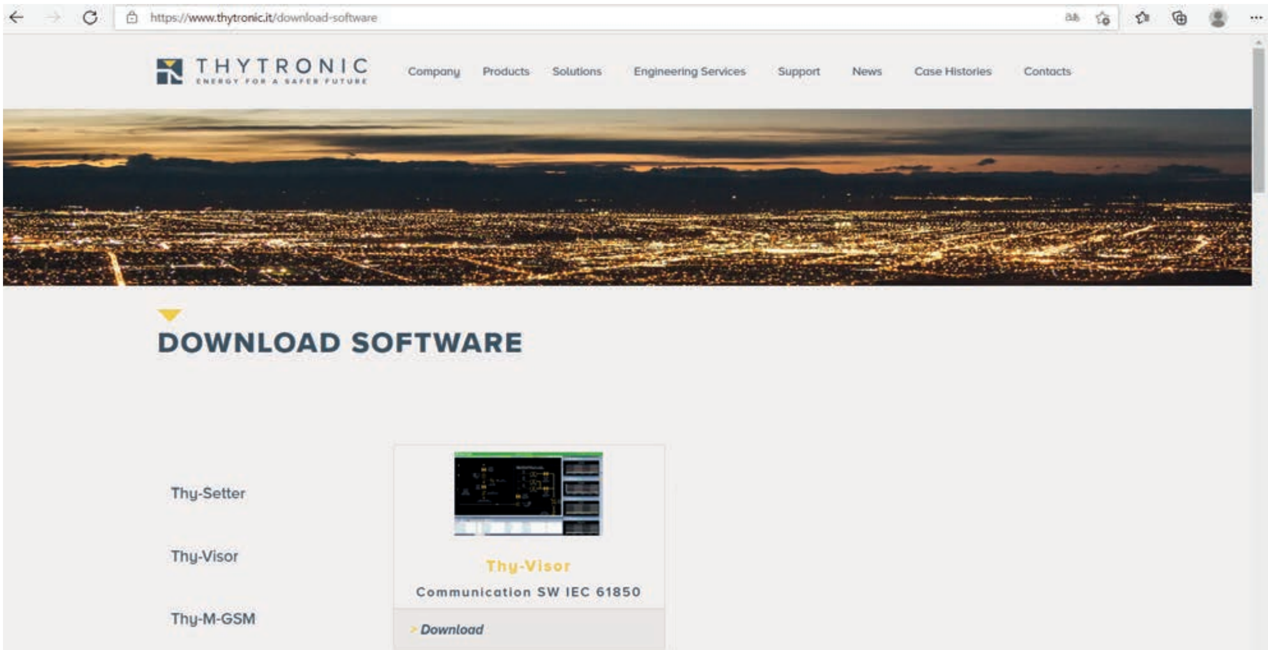
The change becomes effective after the relay is switched off and on again.

5.1 THYVISOR SW

The ThyVisor SW is a "browser" of the data (calibration, measurement, etc.) present in the relays. It implements an engine capable of rebuild the menu set up and the association of data concerning all Thytronic protective relays by means of XML files.

ThyVisor installation

The ThyVisor SW is provided by Thytronic free of charge; the latest version can be downloaded at www.thytronic.it (Download-Software / ThyVisor section).



ThyVisor use

Refer to ThyVisor user manual for detailed instructions available on www.thytronic.it (Product / Software / ThyVisor - Download area).

5.2 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.

The adjustment of the settings and the operation mode of the output relays must be performed while the unit is electrically powered.
All preset values are permanently stored in the nonvolatile memory.

The buttons take the following operations:

- (**Up**) move the cursor upwards to the previous menu options
- (**Down**) move the cursor downwards to the next menu options
- (**Left**) move the cursor out of the menu option
- (**Right**) move the cursor into the menu option
- (**Enter**) access to the selected menu with the option of modifying any given parameter
- RESET (**Reset**) Reset command
- Key disabled
- Key disabled

At power-up, the display shows:

```
"SPR10-xxx-x
date hour"
```

The lit ON LED means the device is correctly powered (permanent 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, COMMANDS, COMMUNICATION

After identifying the required menu, you can enter by using the **Right** button and then, run through the options by using the **Up** or **Down** buttons.

Reading variables (READ)

All data (measure, settings, parameters, etc.) may be displayed.
The information is sorted into functionally uniform submenus.

Setting modifying (SET)

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** buttons.
- Begin the setting phase by means of the **Enter** key; the modification in progress status is highlighted by the E letter blinking on the upper right corner of the display.
- Change the parameter by means the **Up** or **Down** buttons.
- Press the **Enter** button; an hypen appears on the upper right corner of the display.
- Press the **Left** button up to the **SET** submenu
- Press the **Down** button down to Store command
- Press the **Right** button to store the modified parameters
- Confirm the change by means of the **Enter** button. As alternative, press the **Reset** button to cancel the operation if needed.
- "OK ! " is displayed

Example

To set the K1 relay with Energized mode (Active OFF) and latched mode (Active OFF, Latched) the following sequence must be operated:

- Select the Set menu "`Set >`"by means of the **Down** key.
- Press the **Right** key; the message "`BASE >`" is displayed.
- Browse the menus with **Down**
- Select the "`RELAYS >`" menu;
- Press the **Right** key; the message "`K1 Logic, ACTIVE ON`" is displayed.
- Press the **Enter** key; the modification in progress status is highlighted by the E letter blinking on the upper right corner of the display.
- Change the parameter by means the **Up** or **Down** buttons ("`ACTIVE OFF`").
- Press the **Enter** button; an hypen appears on the upper right corner of the display.
- Press the **Down** button the message "`K1 Mode, NO LATCHED`" is displayed
- Press the **Enter** key; the modification in progress status is highlighted by the E letter blinking on the upper right corner of the display.
- Change the parameter by means the **Up** or **Down** buttons ("`LATCHED`").
- Press the **Enter** button; an hypen appears on the upper right corner of the display.
- Press the **Left** button up to the "`RELAYS >`" menu.
- Press the **Down** button up to Store command.
- Press the **Right** button to store the modified parameters.
- Confirm the change by means of the **Enter** button.
- "`OK!`" is displayed

Communication (Optional)

Inside the **COMMUNICATION** menu it is possible to read and edit only the RS485 communication protocol parameters.

Use the **Up** or **Down** keys to scroll through the menu until the required parameter is shown; to edit the parameter, press the **Enter** key.

For example, proceed as follows to set address 12 for the ModBus protocol, the sequence of operations described below:

- Select the "`Communication >`" menu and press the **Right** button.
- "`RS485 Address 1`" is shown on the display.
- Press the **Enter** key; the modification in progress status is highlighted by the E letter blinking on the upper right corner of the display.
- Change the parameter using the **Up** (increment) until the desired value is reached (12).
- Press the **Enter** button; an hypen appears on the upper right corner of the display.
- Press the **Left** button up to the "`Communication >`" menu.
- Press the **Up** button up to the "`Set >`" menu and press the **Right** button.
- Press the **Down** button up to Store command.
- Press the **Right** button to store the modified parameters.
- Confirm the change by means of the **Enter** button.
- "`OK!`" is displayed

Circuit breaker open and close commands (disabled)

The O, I circuit breaker open and close keys are disabled on SPR10 and, if pressed, show the "`KEY NOT ENABLED`" warning

5.4 MAINTENANCE

The relays do not require any particular maintenance; all circuits use high quality static components, the subassembly products undergo dynamic checks on their operation before the final assembling of the complete equipment. Dedicated circuitry and self-test firmware provide continuous monitoring of relay operation.
If the following criteria are correctly implemented, periodic inspections are not necessary:
• comprehensive functional tests during 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 Digital Fault Recorder records).
In the absence of some of the criteria listed above, it is advisable to perform periodic checks every five years.

5.5 REPAIRS

No repair of possible faults by the customer 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.

5.6 STORAGE

Protective relays must be stored under the specified temperature conditions; relative humidity must not lead to condensation or 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.

6 APPENDIX

6.1 APPENDIX A1 - CURRENT TRANSFORMER REQUIREMENTS

Scope

THIS APPENDIX CONTENT IS FOR EDUCATIONAL PURPOSE ONLY AND MUST NOT BE USED FOR TECHNICAL STUDIES CALCULATIONS

With a linear load, the voltage at the secondary winding of the CT is proportional to the primary current, therefore the error remains constant over the full range.

Conversely the voltage at the current input of the SPR10 protection relay is a non-proportional ratio to the input current (the load is significantly non-linear).

In order to guarantee good accuracy at low current levels, the magnetizing current of the CT must be low, that is the input voltage of the relay must be sufficiently low compared with the knee-point voltage V_k of the CT.

In order to determine whether a given CT is adapted to the SPR10 relay, the calculation of the accuracy limit factor for current transformer, according with two alternative methods is proposed:

- Minimum CT requirement to be sure that the protective function trips
- Minimum requirements that ensure the absence of saturation at all conditions (DC component should be taken into account in fault prospective current). This method is recommended for full functionality of the relay (trip, measurement, recording in full range, etc).

Both methods require knowledge of the non linear SPR10 current inputs burden on the operation currents range; all calculation principles and related formulas are shown with numerical examples.

The recommendations are given according the IEC 60044-1 standard.

Current Transformer's characteristics

The characteristics of a protection relay CT are based on:

- transformation ratio (I_{1n}/I_{2n}, where I_{1n} is the primary rated current, I_{2n} is the secondary rated current that is generally 1 A or 5 A),
- rated output burden expressed in VA,
- accuracy class (5P or 10P),
- the rated accuracy limit current (5, 10, 15, 20, 30).

The accuracy limit factor (K) is the ratio between the rated accuracy limit primary current and the rated primary current. Insulating voltage or the thermal behavior are also taken into account. The rated output burden, the accuracy class and the accuracy limit factor are specifications according to IEC 185 for class P transformers. Standard BS 3938 proposes a characterization in accordance with a second class known as X class which, in addition to the calculated ratio, requires a knee-point voltage V_k and an internal resistance R_{ct}.

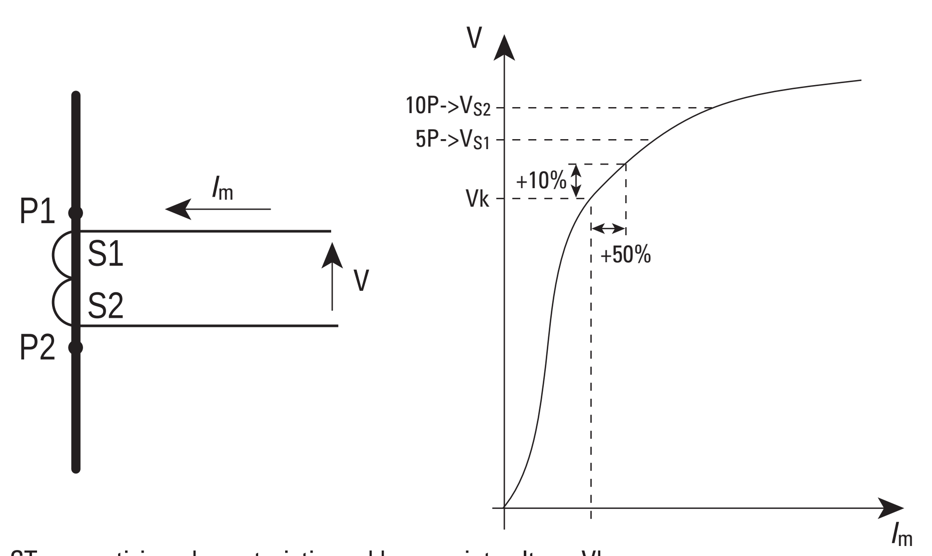
The CT's magnetization curve is characterized by the following parameters:

• The knee-point voltage V_k, which is determined by the point on the curve V=f (I_m) beyond which an increase of 10% in the voltage V results in a 50% increase of the magnetizing current.

• The voltage related to the accuracy class of the CT (accuracy limiting voltage V_S).

- For a 5PK CT (accuracy class 5P, accuracy limit factor K): at the accuracy limiting voltage V_{S1} the accuracy is 5% on the current $K \cdot I_n$.

- For a 10PK CT (accuracy class 10P, accuracy limit factor K): at the accuracy limiting voltage V_{S2} the accuracy is 10% on the current $K \cdot I_n$.



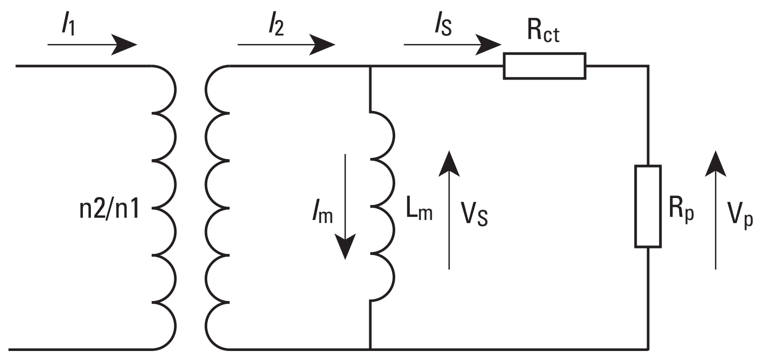
CT magnetizing characteristic and knee point voltage Vk

With standard magnetic materials:

- V_k corresponds to a magnetic induction of 1.4 tesla
- V_{S1} corresponds to a magnetic induction of 1.6 tesla
- V_{S2} corresponds to a magnetic induction of 1.9 tesla

CT's equivalent diagram

The equivalent diagram is shown below:



CT equivalent diagram

Where:

- CT turn ratio n_2/n_1, equal to the rated transformation ratio I_{1n}/I_{2n} being $n_1 \cdot I_{1n} = n_2 \cdot I_{2n}$
- L_m: CT's saturable magnetization inductance
- I_m: magnetizing current
- I_1: primary current
- I_2: secondary current = $I_1 \cdot n2/n1$
- I_S: secondary current passing through the load resistance R_p: $I_S = I_2 - I_m$
- R_{ct}: CT's secondary winding resistance (ohms)

Is the CT's magnetizing current I_m which generates a metering error (if the CT were perfect, then $I_m = 0$); it depends by the voltage generated at the secondary windings of the transformer.

Rated burden calculation of a X class CT based on Vk and Rct

The saturation voltage is computed with the formula:
$V_S = I_S \cdot (R_{ct} + R_{pn})$
The rated load impedance of the CT is:
$R_{pn} = P_n / I_n^2$
By replacing:
$V_S = I_S \cdot (R_{ct} + P_n / I_n^2)$
Then:
$P_n = (V_S / I_S - R_{ct}) \, I_n^2$

• For a CT with 5P accuracy class:
$V_{S1} / V_k = 1.6/1.4$
Thus:
$V_{S1} = 1.6/1.4 \cdot V_k$, at $I_{S1} = K \cdot I_n$
$P_n = [(1.6/1.4 \cdot V_k) / (K \cdot I_n) - R_{ct}] \cdot I_n^2$

• For a CT with 10P accuracy class:
$V_{S2} / V_k = 1.9/1.4$
Thus:
$V_{S2} = 1.9/1.4 \cdot V_k$, at $I_{S2} = K \cdot I_n$
$P_n = [(1.9/1.4 \cdot V_k) / (K \cdot I_n) - R_{ct}] \cdot I_n^2$

Definition equivalence for common CTs

The only parameters which characterize a CT are:
- the magnetizing curve (so the knee point voltage V_k or the accuracy limiting voltage V_S),
- the R_{ct} resistance
- the transformation ratio.

Therefore a CT with 5PK2 and P_{n2} power in VA can replace a CT with 5PK1 and P_{n1} power in VA.

The equivalence equations are:
$V_{S1} = (R_{ct} + P_{n1} / I_{n2}) \cdot K1 \cdot I_n = (R_{ct} + P_{n2} / I_{n2}) \cdot K2 \cdot I_n$
$P_i = R_{ct} \cdot I_n^2$ (ohmic loss of CT)
$(P_i + P_{n1}) \cdot K1 = (P_i + P_{n2}) \cdot K2$
Hence:
$K2 = [(R_{ct} \cdot I_n^2 + P_{n1}) / (R_{ct} \cdot I_n^2 + P_{n2})] \cdot K1$

knee-point voltage Vk calculation of a class P CT

- For a CT with accuracy class 5P:

$V_{S1}/V_k = 1.6/1.4$

$P_n = [(1.6/1.4 \cdot V_k)/(K \cdot I_n) - R_{ct}] \cdot I_n^2$ Hence:

$V_k = 1.4/1.6\ (P_n/I_n^2 + R_{ct}) \cdot K \cdot I_n = 0{,}88\ (P_n/I_n^2 + R_{ct}) \cdot K \cdot I_n$

- For a CT with accuracy class 10P:

$V_{S2}/V_k = 1.9/1.4$

$P_n = [(1.9/1.4 \cdot Vk)/K \cdot I_n - R_{ct}] \cdot I_n^2$ Hence:

$V_k = 1.4/1.9\ (P_n/I_n^2 + R_{ct}) \cdot K \cdot I_n = 0{,}74\ (P_n/I_n^2 + R_{ct}) \cdot K \cdot I_n$

Accuracy limit factor calculation of a class X CT

- For a CT with accuracy class 5P:

$V_{S1}/V_k = 1.6/1.4$

$P_n = [(1.6/1.4 \cdot V_k)/(K \cdot I_n) - R_{ct}] \cdot I_n^2$ Hence:

$K = 1.6/1.4\ V_k / [(P_n/I_n^2 + R_{ct}) \cdot I_n] = 1.14\ V_k / [(P_n/I_n^2 + R_{ct}) \cdot I_n]$

- For a CT with accuracy class 10P:

$V_{S2}/V_k = 1.9/1.4$

$P_n = [(1.9/1.4 \cdot V_k)/K \cdot I_n - R_{ct}] \cdot I_n^2$ Hence:

$K = 1.9/1.4\ V_k / [(P_n/I_n^2 + R_{ct}) \cdot I_n] = 1.36\ V_k / [(P_n/I_n^2 + R_{ct}) \cdot I_n]$

Burden of SPR10 relays

The Thytronic SPR10 self and dual-powered versions have a minimum self-supply starting current of 0.2 I_n. This minimum level of current is needed on at least one phase in order to enable the relay to be correctly self-powered and thus ensure the full capability of its protection functions:
The current input resistance depends on the value of the current. Table 1 shows the resistance for a single current input, for I_n =1 A and 5 A.
If earth fault current input is connected on the neutral common of the three phase CT's (Holmgreen), it is necessary to take into account a double value of the resistance because the ground fault current cross one phase current input and the earth fault current input of the relay.

Table 1

Current [pu I_n or pu I_{En}]	Self Powered version						Dual Powered version					
	I_n (I_{En}) = 1 A			I_n (I_{En}) = 5 A			I_n (I_{En}) = 1 A			I_n (I_{En}) = 5 A		
	R_p Ω	V_p [V]	P_p [VA]	R_p Ω	V_p [V]	P_p [VA]	R_p Ω	V_p [V]	P_p [VA]	R_p Ω	V_p [mV]	P_p [VA]
0.04							6.25	0.25	0.01	0.31	61.00	0.01
0.06							4.50	0.27	0.02	0.23	70.00	0.02
0.08							3.63	0.29	0.02	0.20	79.00	0.03
0.10							3.10	0.31	0.03	0.17	87.00	0.04
0.12							2.67	0.32	0.04	0.16	95.00	0.06
0.14							2.36	0.33	0.05	0.15	103.00	0.07
0.16							2.13	0.34	0.05	0.14	110.00	0.09
0.18							1.94	0.35	0.06	0.13	118.00	0.11
0.20	42.45	8.49	1.70	1.73	1.73	1.73	1.80	0.36	0.07	0.13	126.00	0.13
0.22	38.77	8.53	1.88	1.51	1.66	1.83	1.68	0.37	0.08	0.12	133.00	0.15
0.24	33.79	8.11	1.95	1.40	1.68	2.02	1.58	0.38	0.09	0.12	141.00	0.17
0.30	26.03	7.81	2.34	1.00	1.50	2.25	1.37	0.41	0.12	0.11	164.00	0.25
0.40	19.38	7.75	3.10	0.65	1.29	2.58	1.13	0.45	0.18	0.10	201.00	0.40
0.50	12.20	6.10	3.05	0.51	1.27	3.18	0.98	0.49	0.25	0.09	234.00	0.59
0.60	10.00	6.00	3.60	0.46	1.37	4.11	0.90	0.54	0.32	0.09	275.00	0.83
0.70	9.56	6.69	4.68	0.37	1.28	4.48	0.83	0.58	0.41	0.09	311.00	1.09
0.80	7.63	6.10	4.88	0.30	1.18	4.72	0.78	0.62	0.50	0.09	348.00	1.39
0.90	7.11	6.40	5.76	0.26	1.19	5.36	0.73	0.66	0.59	0.09	385.00	1.73
1.00	6.05	6.05	6.05	0.24	1.18	5.90	0.71	0.71	0.71	0.08	421.00	2.11
1.20	4.61	5.53	6.64	0.17	1.00	6.00	0.66	0.79	0.95	0.08	495.00	2.97
1.40	3.93	5.50	7.70	0.14	1.00	7.00	0.63	0.88	1.23	0.08	567.00	3.97
1.60	3.34	5.35	8.56	0.13	1.00	8.00	0.60	0.96	1.54	0.08	638.00	5.10
1.80	2.78	5.00	9.00	0.11	1.00	9.00	0.58	1.04	1.87	0.08	712.00	6.41
2.00	2.45	4.90	9.80	0.10	1.00	10.00	0.57	1.13	2.26	0.08	790.00	7.90
3.00	1.30	3.89	11.67	<0.10*	1.50*	22.50*	0.52	1.57	4.71	<0.08*	1185.00*	17.78*
4.00	0.91	3.65	14.60	<0.10*	20.00*	40.00*	0.50	1.98	7.92	<0.08*	1580.00*	31.60*
5.00	0.73	3.66	18.30	<0.10*	2.50*	62.50*	0.48	2.42	12.10	<0.08*	1975.00*	49.38*
10.0	0.51	5.11	51.10	<0.10*	5.00*	250.00*	0.46	4.61	46.10	<0.08*	3950.00*	197.50*
>10.0	<0.51*	-	-	<0.10*	-	-	<0.46*	-	-	<0.08*	-	-

*Calculated values

Calculation of required CTs

Two methods of calculation of required CT is proposed:

- The first method gives the minimum CT requirement to be sure that the protective function trips
- The second method assures that CTs will be not saturated at all conditions (DC component should be taken into account in fault prospective current). This method is recommended for full functionality of the relay (measurement, recording in full range, etc).

Symbols

- V_k Required CT knee-point voltage [V]
- I_{psc} Maximum prospective primary phase current [A]
- $I_{fp} = I_{psc} / K_n$ Maximum prospective secondary phase current [A]
- I_{pscN} Maximum prospective primary earth fault current [A]
- $I_{fn} = I_{pscN} / K_n$ Maximum prospective secondary earth fault current [A]
- I_{sp} Stage 2 and 3 setting [primary amps]
- R_{ct} Secondary CT winding resistance [Ω]
- R_l Resistance of single lead from the relay to current transformer [Ω]
- R_p Resistance of one relay current input @ the secondary current level of the table [Ω]
- R_b Total connected CT burden [Ω]
- K_n CT ratio
- I_{pn} Rated primary CT current [A]
- I_{sn} Rated secondary CT current [A]
- P_{bn} Rated CT burden [VA]
- $R_{bn}=P_{bn} / I_{sn}^2$ Rated CT burden [Ω]
- n_n Rated CT accuracy limit factor
- V_{sal} CT accuracy limiting voltage [V]

First method

The first method gives the minimum CT requirement to be sure that the protective function trips. Depending by the type of the protective function used, the requirements of the following table on the knee point voltage (Vk) for class X or the rated accuracy limit factor n_n, (for 5P or 10P class) must be satisfied. If both phase and earth fault protective functions or if several stages of one or both protective function are used, the greater value of Vk must be considered.

Assuming that the CT does not supply any circuits other than the SPR10 relay and the distance between SPR and CTs is short, the following CTs types are recommended as minimum:

- 5 VA 10P10 for 1A secondary rating
- 10 VA 10P10 for 5A secondary rating

Or, for a better accuracy:

- 5 VA 5P10 for 1A secondary rating
- 10 VA 5P10 for 5A secondary rating

Protection type	Class X CT	Class 5P CT	Class 10P CT
DT/IDMT Time delayed phase overcurrent protection	$V_k \geq I_{fp}/2\ (R_{ct}+R_l+R_p)$	$n_n \geq 0.57\, I_{psc}/I_{pn}(R_{ct}+R_l+R_p)/(R_{ct}+R_{bn})$	$n_n \geq 0.68\, I_{psc}/I_{pn}(R_{ct}+R_l+R_p)/(R_{ct}+R_{bn})$
DT/IDMT Time delayed earth fault overcurrent protection (earth fault current input connected on the neutral common of the three phase CT's)	$V_k \geq I_{fn}/2\ (R_{ct}+2R_l+2R_p)$	$n_n \geq 0.57\, I_{pscN}/I_{pnN}(R_{ct}+2R_l+2R_p)/(R_{ct}+R_{bn})$	$n_n \geq 0.68\, I_{pscN}/I_{pnN}(R_{ct}+2R_l+2R_p)/(R_{ct}+R_{bn})$
Instantaneous phase overcurrent protection	$V_k \geq I_{sp}\ (R_{ct}+R_l+R_p)$	$n_n \geq 1{,}14\ I_{sp}/I_{pn}\ (R_{ct}+R_l+R_p)/(R_{ct}+R_{bn})$	$n_n \geq 1{,}36\ I_{sp}/I_{pn}\ (R_{ct}+R_l+R_p)/(R_{ct}+R_{bn})$
Instantaneous earth fault overcurrent protection (earth fault current input connected on the neutral common of the three phase CT's)	$V_k \geq I_{fn}/2\ (R_{ct}+2R_l+2R_p)$	$n_n \geq 0.57\, I_{pscN}/I_{pnN}(R_{ct}+2R_l+2R_p)/(R_{ct}+R_{bn})$	$n_n \geq 0.68\, I_{pscN}/I_{pnN}(R_{ct}+2R_l+2R_p)/(R_{ct}+R_{bn})$

Sample calculation n. 1

The following application data are given:
CT ratio: 100 A /1 A (I_{pn} =100 A; $I_{sn} = I_n$ = 1 A)
Accuracy class 5P
Earth fault current input is connected to star point of the three phase CTs, so earth fault CT ratio is 100 A /1 A ($I_{pn}= I_{pnN}$ =100 A; $I_{snN} = I_{sn} = I_n = I_{En}$ = 1 A).
CT rated burden: P_{bn} = 2.5 VA, $R_{bn}=P_{bn}/I_{sn2}$=2,5/1^2 = 2,5 Ω
CT internal resistance R_{ct} = 0.5 Ω
Lead resistance (wires between CTs and SPR10): R_l = 0.01774 Ω (2 m one way, 2.5 mm^2 Cu)
Current inputs resistance in any case R_p = 0.51 Ω (worst case)
Max prospective short circuit value for 3-phase fault I_{psc} = 100 I_{pn} = 10 kA
Max prospective earth fault value for phase to ground fault I_{pscN} = 20 I_{pn} = 2 kA
First IDMT delayed overcurrent element I> = 1 I_n
Second DT instantaneous overcurrent element I>> = 10 I_n
First DT instantaneous earth fault element I_E> = 0.2 I_{En}

Minimum required accuracy limit factor for first overcurrent element I>
$n_n \geq 0.57 I_{psc}/I_{pn}(R_{ct}+R_l+R_p)/(R_{ct}+R_{bn}) = 0.57 \cdot 100 \cdot [(0.5+0.01774+0.51)/(0.5+2.5)] = \mathbf{19.53}$

Minimum required accuracy limit factor for second overcurrent element I>>
$n_n \geq 1,14\ I{>>}/I_{pn}\ (R_{ct}+R_l+R_p)/(R_{ct}+R_{bn}) = 1.14 \cdot 10 \cdot [(0.5+0.01774+0.51)/(0.5+2.5)] = 3.9$

Minimum required accuracy limit factor for first earth fault current element IE>
$n_n \geq 0.57 I_{pscN}/I_{pnN}\ (R_{ct}+2R_l+2R_p)/(R_{ct}+R_{bn}) = 0.57 \cdot 20 \cdot [(0.5 + 2 \cdot 0.01774 + 2 \cdot 0.51)/(0.5 + 2.5)] = 5.91$

Summary of calculation

The maximum value (for all above cases) of required accuracy limit factor is for *I>* element.
Overall, a minimum rated accuracy limit factor of 20 is required. A typical (standard) value thus would be $n_n = 20$
A typical (standard) value thus would be 2.5 VA (2.5 VA P20);
If a CT with $n_n = 10$ is to be used, it is necessary to increase the nominal power of the CT based on the following formula:

$n_{n1}\ S_{n1} = n_{n2}\ S_{n2}$

$S_{n2} = S_{n1}\ n_{n1}/n_{n2} = 2.5 \cdot 20/10 = 5$ VA

A typical (standard) value thus would be 5 VA (5 VA P10);
The new CT requirement calculation based on 5 VA P10 CT can be repeated again for double check.

Second method

The second method assures that CTs will be not saturated at all fault conditions, taken into account the maximum fault prospective current. This method is recommended for full functionality of the relay (measurement, recording in full range, etc).
Two critical cases must be considered for different faults:
- the set **current threshold value** at which the relay has to operate.
- the highest possible **short-circuit current**.

The equation is used for CT's dimensioning is:

$V_{sal} = n_n\ I_{sn}\ (R_{ct}+R_{bn}) \geq\ I_{psc}/K_n\ (R_{ct}+R_b)$

Alternatively the CT can also designed for the minimum required rated accuracy limit factor:

$\mathbf{n_n \geq Ipsc / I_{pn}\ (R_{ct}+R_b)/(R_{ct}+R_{bn})}$

The actual secondary connected burden R_b is given by:
- For phase to ground faults: $R_b = 2R_l + 2R_p$
- For phase to phase faults: $R_b = R_l + R_p$

where the relay burden R_p is given in table 1 and the lead resistance R_l is to be calculated from wire length, cross section and specific resistance.

Assuming that the CT does not supply any circuits other than the SPR10 relay and the distance between SPR and CTs is short, the following CTs types are recommended as minimum:
- 5 VA 10P20 for 1A secondary rating
- 10 VA 10P20 for 5A secondary rating

Or, for a better accuracy:
- 5 VA 5P20 for 1A secondary rating
- 10 VA 5P20 for 5A secondary rating

Sample calculation n. 2

The following application data are given:
CT ratio: 100 A /1 A (I_{pn} =100 A; $I_{sn} = I_n$ = 1A)
Earth fault current input is connected to star point of the three phase CTs, so earth fault CT ratio is 100 A /1 A ($I_{pn} = I_{pnN}$ =100 A; $I_{snN} = I_{sn} = I_n = I_{En}$ = 1 A).
CT rated burden: P_{bn} = 2.5 VA, $R_{bn} = P_{bn}/I_{sn2} = 2,5/1^2 = 2,5\ \Omega$
CT internal resistance $R_{ct} = 0.5\ \Omega$
Lead resistance (wires between CTs and SPR): $R_l = 0.01774\ \Omega$ (2 m one way, 2.5 mm^2 Cu)

Calculation	Condition	Current used for calculation		R_p (Table 1)
		Symbol	Value	
Required accuracy limit factor	Max prospective short circuit value for 3-phase fault	I_{psc}	100 I_{pn} = 10 kA	0.51 Ω @ 30 I_n (I_n=1 A) (worst case)
	Max prospective earth fault value for phase to ground fault	I_{pscN}	20 I_{pn} = 2 kA	0.51 Ω @ 20 I_n (I_n=1 A) (worst case)
Checking of CT accuracy because of the real burden	First overcurrent element	*I>*	1 I_n	6.05 Ω @ 1 I_n (I_n=1 A)
	Second overcurrent element	*I>>*	10 I_n	0.51 Ω @ 10 I_n (I_n=1 A)
	First earth fault element	I_{E}>	0.2 I_{En}	42.45 Ω @ 0.2 I_{En} (I_{En}=1 A)

Checking of accuracy limit factor at setting point value

Phase-earth fault at the first element threshold (I_E>):
$n_n \geq I_E> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 0.2 \cdot [(0.5 + 2 \cdot 0.01774 + 2 \cdot 42.45) / (0.5+2.5)] = 5.69$

Three phase fault at the first element threshold (I>):
$n_n \geq I> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 1 [(0.5 + 0.01774 + 6.05) / (0.5+2.5)] = 2.18$

Three phase fault at the second element threshold (I>>):
$n_n \geq I>> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 10 [(0.5 + 0.01774 + 0.51)/(0.5+2.5)] = 3.42$

Checking of accuracy limit factor for max current
Phase-earth fault maximum current
$n_n \geq I_{pscN} / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 20 [(0.5+2 \cdot 0.01774+2 \cdot 0.51) / (0.5+2.5)] = 10.37$

Three phase fault maximum current:
$n_n \geq I_{psc}/ I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 100 [(0.5+0.01774+0.51)/(0.5+2.5)] =$ **34.26**

Summary of calculation

The maximum value (for all above cases) of required accuracy limit factor is for three phase fault with maximum current.
Overall, a worst case minimum rated accuracy limit factor of 34.26 is required. A typical (standard) value thus could be $n_n = 30$, considering the worst case calculation approximation.
A typical (standard) value thus would be 2.5 VA (2.5 VA P30);
If a CT with $n_n = 20$ is to be used, it is necessary to increase the nominal power of the CT based on the following formula:

$n_{n1} S_{n1}= n_{n2} S_{n2}$

$S_{n2} = S_{n1} n_{n1} / n_{n2} = 2.5 \cdot 30 / 20 = 3.75$ VA

A typical (standard) value thus would be 5 VA (5 VA P20);
A further check of the CT requirement based on 5 VA P20 can be repeated again to double check.

Sample calculation n. 3

The following application data are given:
CT ratio: 100 A /5 A (I_{pn} =100 A; $I_{sn} = I_n = 5$ A)
Earth fault current input is connected to star point of the three phase CTs, so earth fault CT ratio is 100 A /5 A ($I_{pn}= I_{pnN}$ =100 A; $I_{snN} = I_{sn} = I_n = I_{En}$ = 5 A).
CT rated burden: P_{bn} = 2.5 VA, $R_{bn}=P_{bn}/I_{sn2}= 2,5/5^2= 0.1\ \Omega$
CT internal resistance $R_{ct} = 0.1\ \Omega$
Lead resistance (wires between CTs and SPR): $R_l = 0.01774\ \Omega$ (2 m one way, 2.5 mm^2 Cu)

Calculation	Condition	Current used for calculation		R_p (Table 1)
		Symbol	Value	
Required accuracy limit factor	Max prospective short circuit value for 3-phase fault	I_{psc}	100 I_{pn} = 10 kA	0.1 Ω @ 30 I_n (I_n=5 A) (worst case)
	Max prospective earth fault value for phase to ground fault	I_{pscN}	20 I_{pn} = 2 kA	0.1 Ω @ 20 I_n (I_n=5 A) (worst case)
Checking of CT accuracy because of the real burden	First overcurrent element	I>	1 I_n	0.24 Ω @ 1 I_n (I_n=5 A)
	Second overcurrent element	I>>	10 I_n	0.1 Ω @ 10 I_n (I_n=5 A)
	First earth fault element	I_E>	0.2 I_{En}	1.73 Ω @ 0.2 I_{En} (I_{En}=5 A)

Checking of accuracy limit factor at setting point value

Phase-earth fault at the first element threshold (I_E>):
$n_n \geq I_E> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 0.2 \cdot [(0.1 + 2 \cdot 0.01774 + 2 \cdot 1.73) / (0.1+0.1)] = 3.59$

Three phase fault at the first element threshold (I>):
$n_n \geq I> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 1 [(0.1 + 0.01774 + 0.24) / (0.1+0.1)] = 1.78$

Three phase fault at the second element threshold (I>>):
$n_n \geq I>> / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 10 [(0.1 + 0.01774 + 0.1)/(0.1+0.1)] = 10.88$

Checking of accuracy limit factor for max current
Phase-earth fault maximum current
$n_n \geq I_{pscN} / I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 20 [(0.1+2 \cdot 0.01774 + 2 \cdot 0.1) / (0.1+0.1)] = 33.55$

Three phase fault maximum current:
$n_n \geq I_{psc}/ I_{pn} (R_{ct}+R_b) / (R_{ct}+R_{bn}) = 100 [(0.1+0.01774+0.1)/(0.1+0.1)] =$ **108.87**

Summary of calculation

The maximum value (for all above cases) of required accuracy limit factor is for three phase fault with maximum current.
Overall, a minimum rated accuracy limit factor of 108.87 is required.
Since it is not possible to have such a high factor it is necessary to increase the nominal power of the CT based on the following formula:

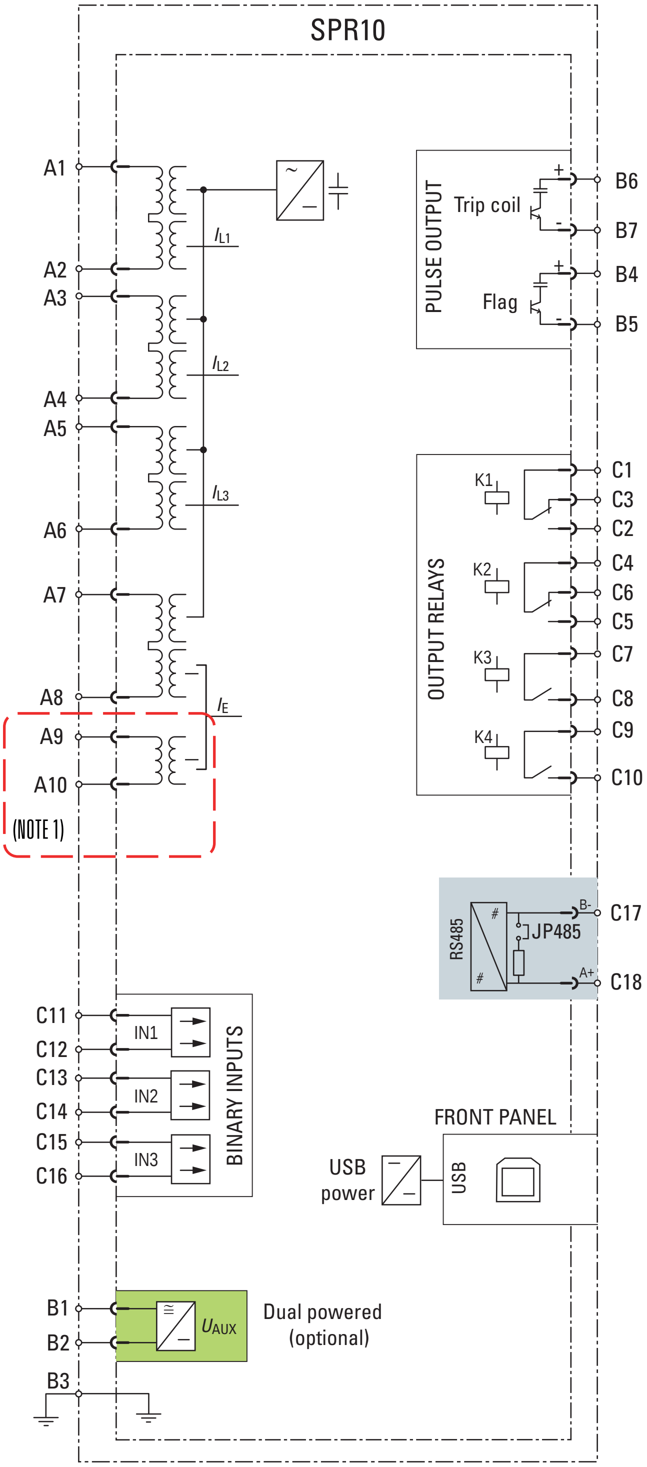
$n_{n1}\ S_{n1} = n_{n2}\ S_{n2}$

If a CT with n_n = 30 is to be used $S_{n2} = S_{n1}\ n_{n1} / n_{n2}$ = 2.5 · 109 / 30 = 9.08 VA

A typical (standard) value thus would be 10 VA (10 VA P30);

A further check of the CT requirement based on 10 VA P30 can be repeated again to double check.

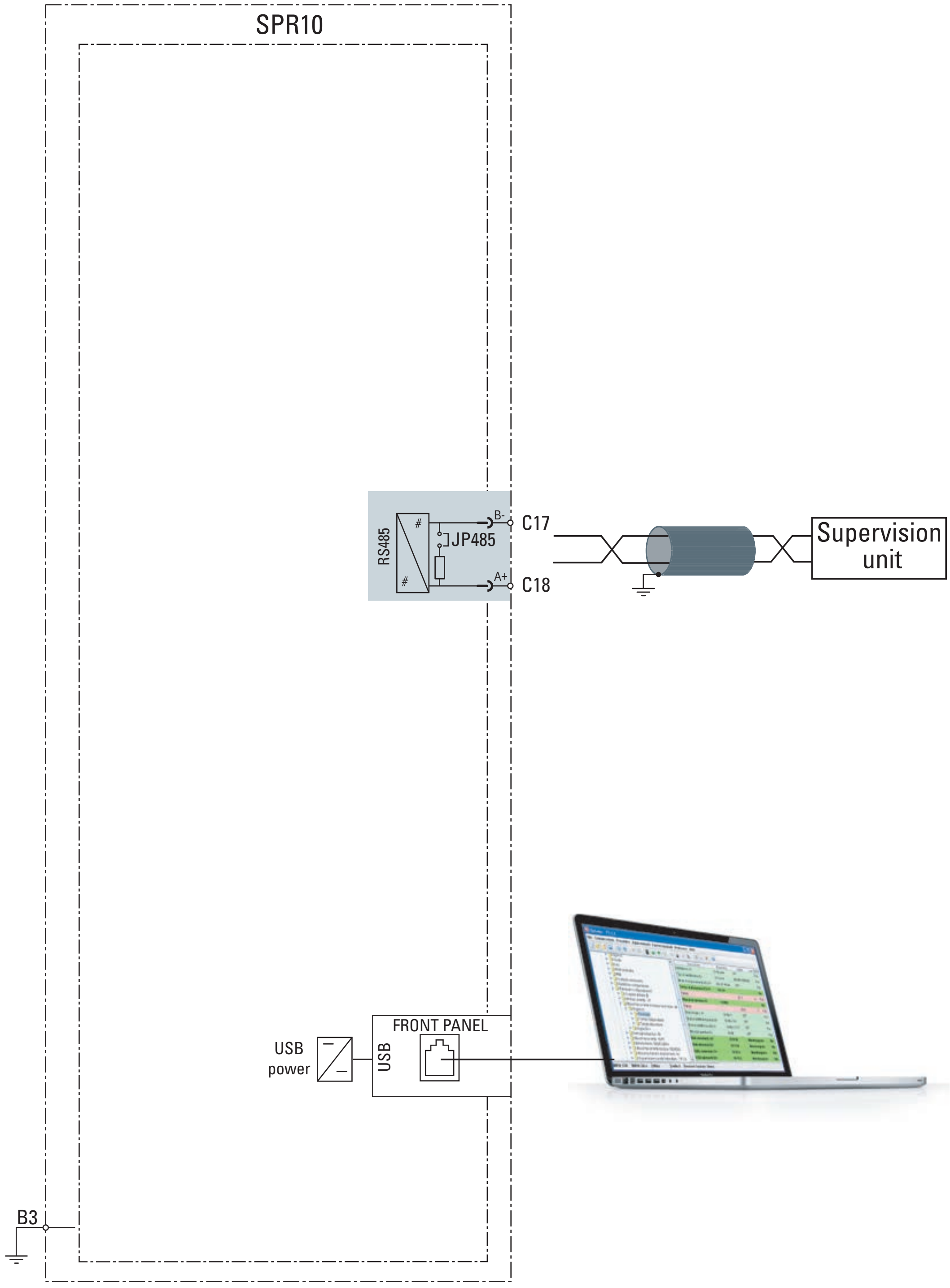
6.2 APPENDIX B1 - I/O DIAGRAM



NOTE 1: In the version with a fixed terminal block, terminals A9 and A10 are not available

I/O circuits

SPR10-I-O.ai

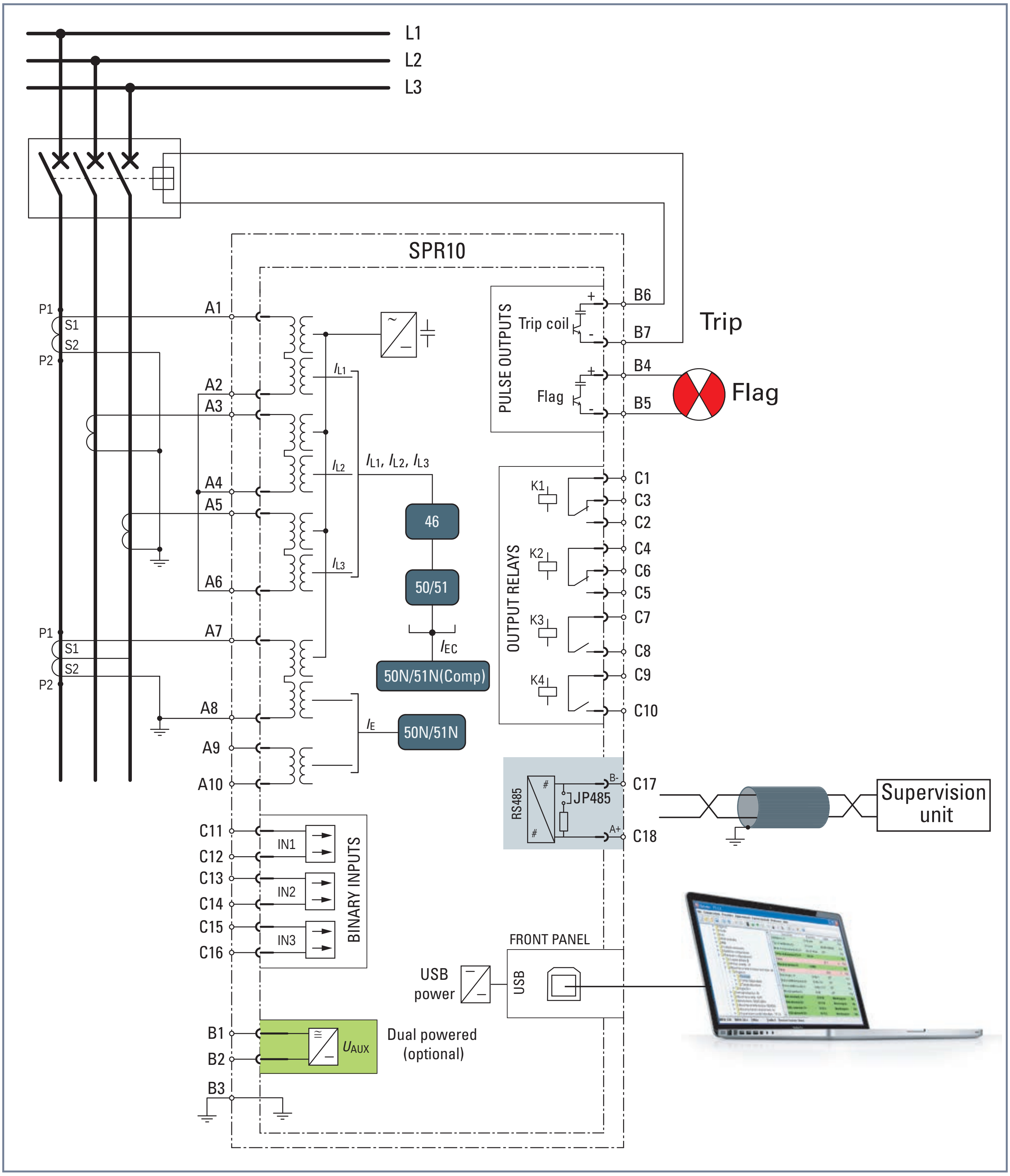

SPR10
RS485
B-
C17
JP485
A+
C18
Supervision
unit
FRONT PANEL
USB
power
USB
B3

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.

Connection diagram with three phase CTs and residual current from core balanced CT connect on input which contributes to an auxiliary power supply (terminals A7-A8)

Connection advisable when the transformation ratio of the core balanced CT is less than that of the phase CT. The connection of the core to the inputs A7-A8 allows to contribute to power supply and then detect ground faults while the phase currents are insufficient to power the SPR10 device (< 0.2 In).

Note: the core balanced CT must be properly dimensioned:
- low transformation ratio for good sensitivity
- rated burden suitable for powering the SPR10 device

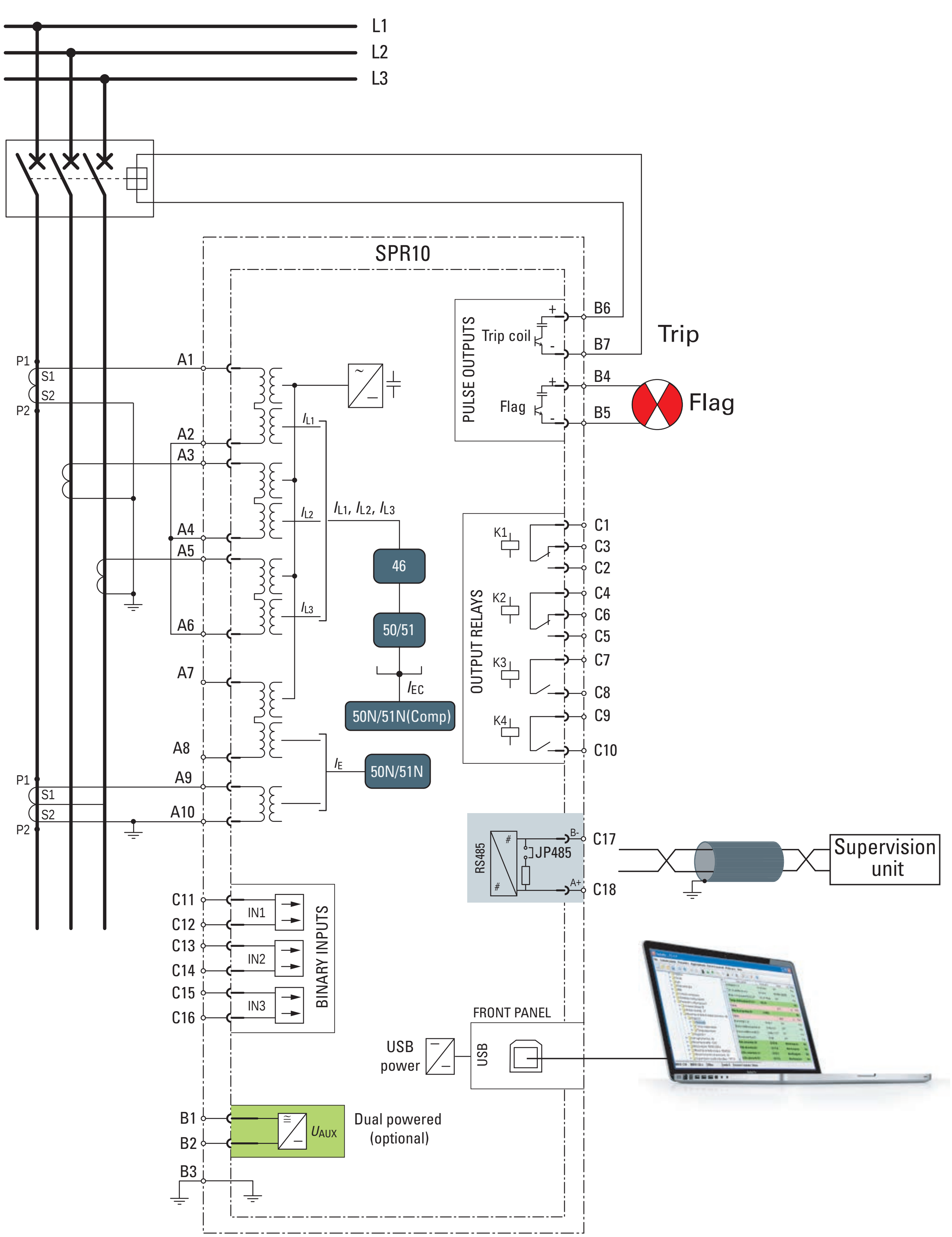


Connection diagram with three phase CTs and residual current from core balanced CT connect on input which does not contributes to an auxiliary power supply (terminals A9-A10)
VALID ONLY FOR AUTO-SHUNT CURRENT INPUT CONNECTOR VERSION

The connection of the balanced core to the inputs A9-A10 does not contribute to power supply and then to detect earth faults it is necessary that the phase currents are sufficient to power the SPR10 device (≥ 0.2 In).

Note:

- The core balanced CT must not be dimensioned for powering the SPR10 device.
- In the version with a fixed terminal block, terminals A9 and A10 are not available



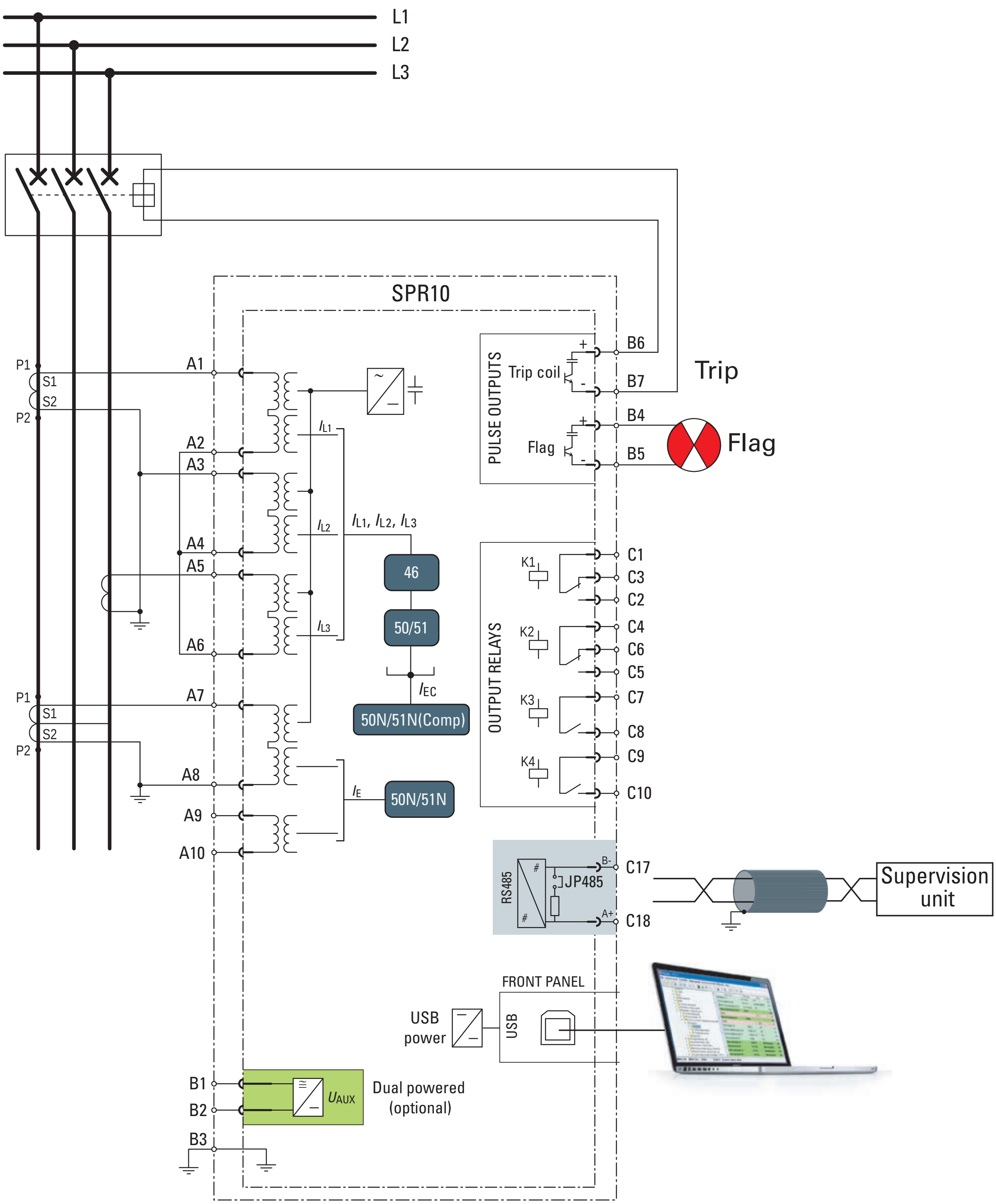
Connection diagram with three phase CTs and residual current from core balanced CT connect on input which contributes to an auxiliary power supply (terminals A7-A8)

Only two phase CTs are used (saving cost for one CT).

Connection advisable when the transformation ratio of the core balanced CT is less than that of the phase CT. The connection of the core to the inputs A7-A8 allows to contribute to power supply and then detect ground faults while the phase currents are insufficient to power the SPR10 device (< 0.2 In).

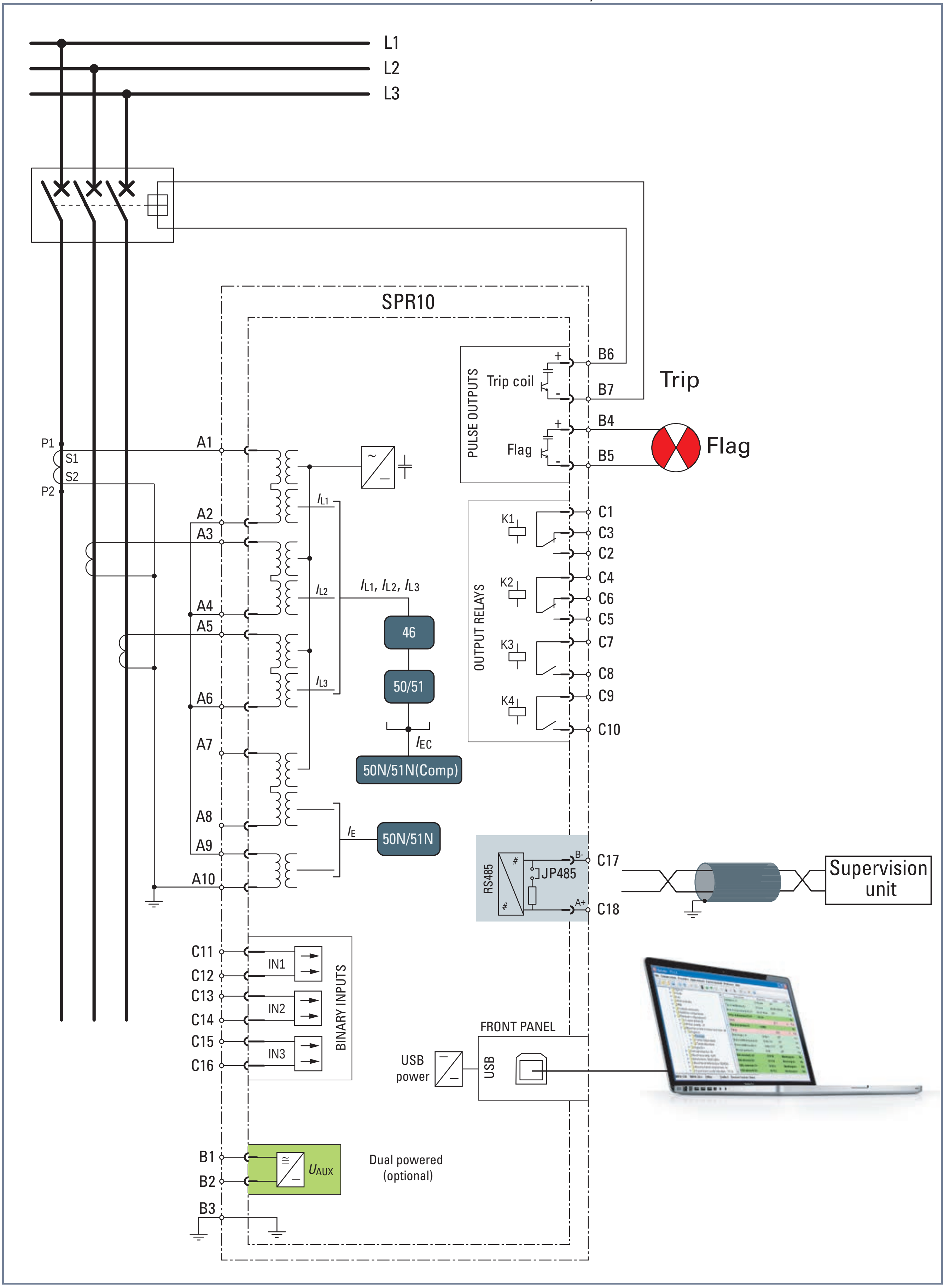
Note: the core balanced CT must be properly dimensioned:
- low transformation ratio for good sensitivity
- rated burden suitable for powering the SPR10 device

The use of two TA respect to a measure with three TA involves some limitations



Residual current input connected to the summation of three phase CTs (Holmgreen)
VALID ONLY FOR AUTO-SHUNT CURRENT INPUT CONNECTOR VERSION

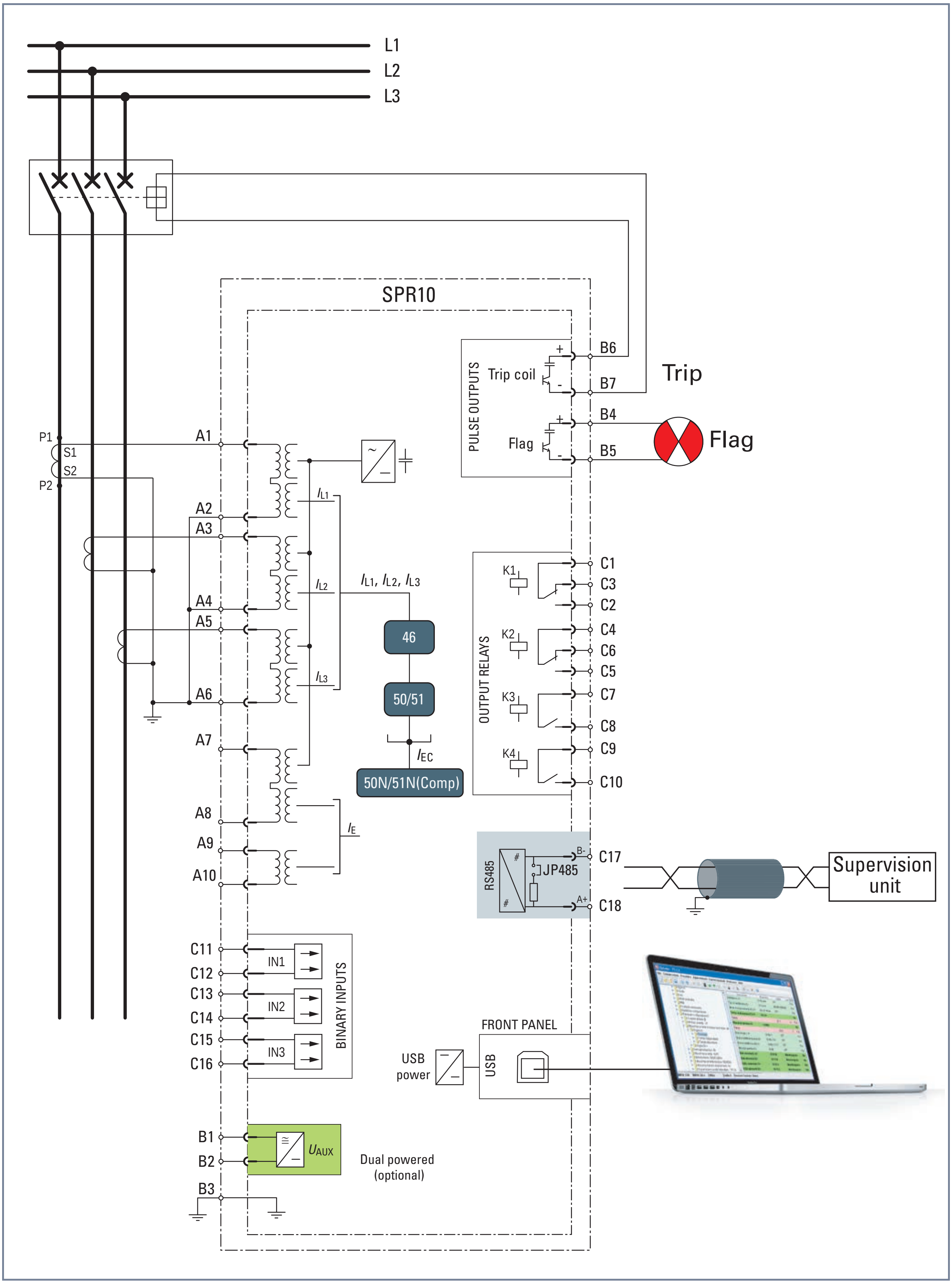
The residual current is detected with summation of the phase currents (terminal A9-A10); it does not contribute to power the SPR10 device.
The sensitivity of the residual current measurement is reduced compared to the schemes that employ the core balance CT.
NOTE: In the version with a fixed terminal block, terminals A9 and A10 are not available



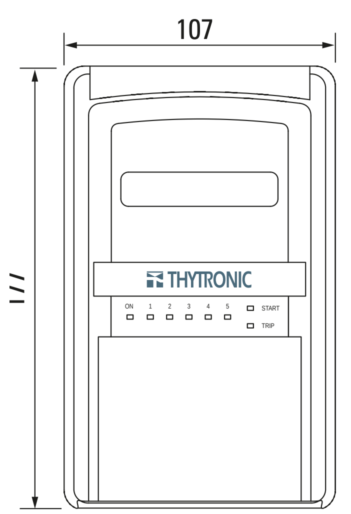
Connection diagram with three phase CTs and residual current calculated from vectorial sum of phase currents

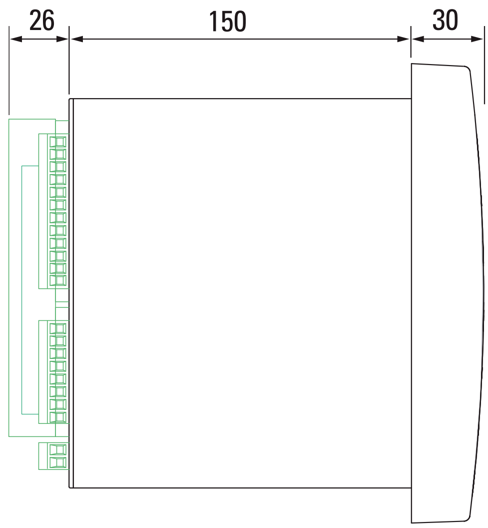
The vectorial sum of the values of the electric currents is calculated.

The sensitivity of the residual current measurement is reduced compared to the schemes that employ the core balance transformer.

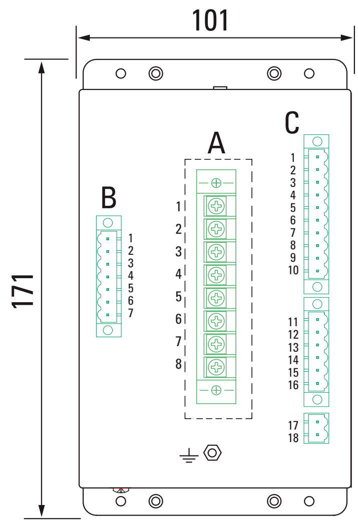


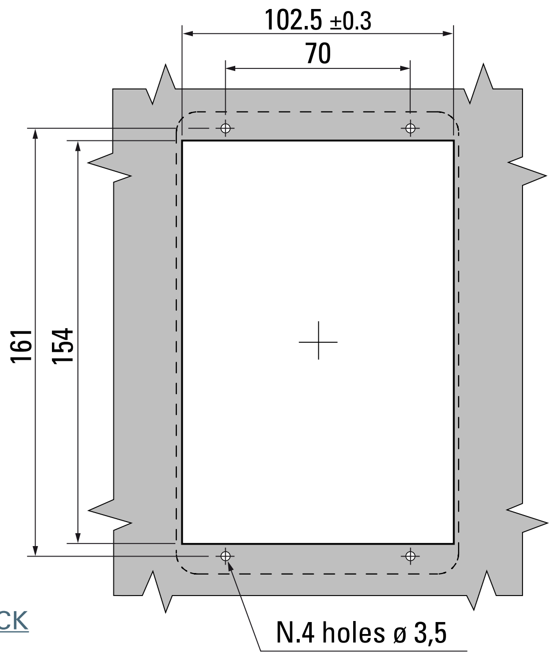
6.3 APPENDIX C1 - SPR10 DIMENSIONS





VERSION WITHOUT FLAG



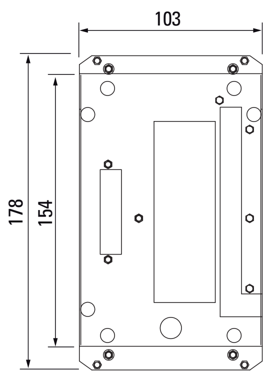


VERSION WITH FIXED TERMINAL BLOCK
PROTECTIVE CONTACT COVER

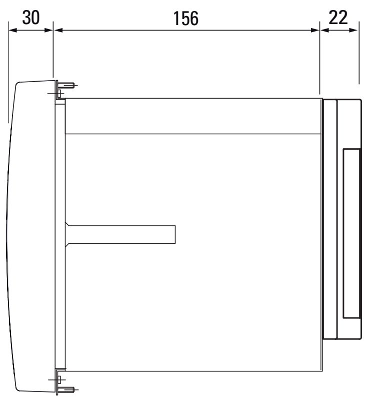
REMOVABLE VERSION WITH MAE MODULE

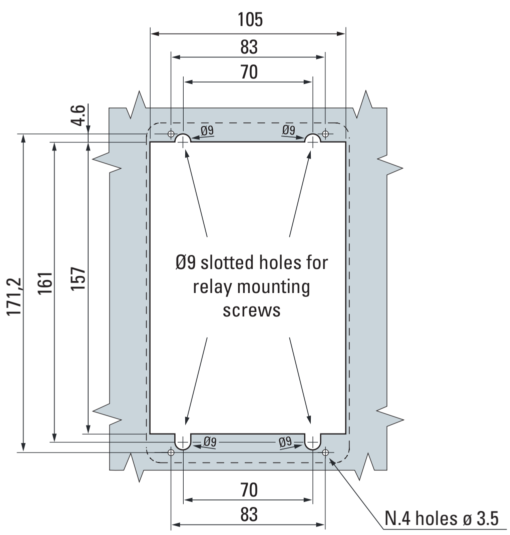
CUTOUT
WITHDRAWABLE (WITH MAE MODULE)

BACK VIEW



SIDE VIEW





6.4 CE DECLARATION OF CONFORMITY

Manufacturer:	THYTRONIC S.p.A.
Address:	Piazza Mistral 7 - 20139 MILANO

The undersigned manufacturer herewith declares that the product

Protection relay SPR10

is in conformity with the previsions of the following EC directives (including all applicable amendments) when installed in accordance with the installation instructions:

Reference n°	title
2014/35/EU 2014/30/EU	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	2019	Electromagnetic compatibility (EMC) Emission standard for industrial environments
EN 61000-6-2	2019	Electromagnetic compatibility (EMC) Immunity standard for industrial environments

- other standards and/or technical specifications:

Reference n°	Issue	Title
EN 60255-1	2023	Electrical relays General requirements for measuring relays and protection equipment

Signature ....

Name	*FIORE Mattia*
Title	*Managing director*
Date	*04-2024*

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