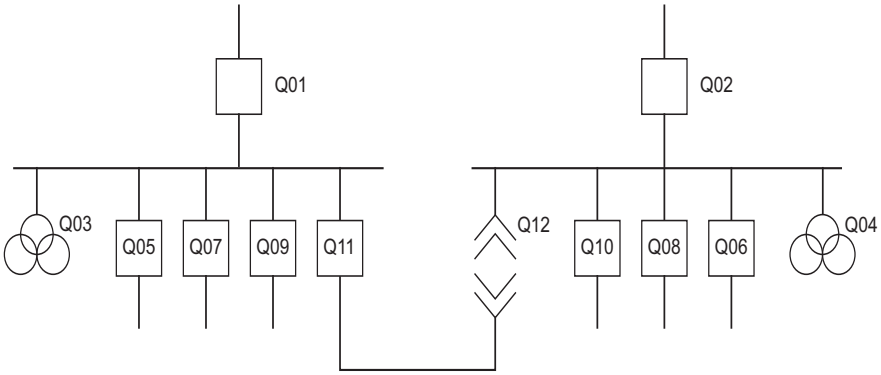
Application Recommendations

REF 542*plus*

Application and Setting Guide

Copyrights

Standard indoor switchgear: 2 sections, 10 cubicles per section.



Q01, Q02 - incoming cubicles

Q03, Q04 - voltage transformer cubicles

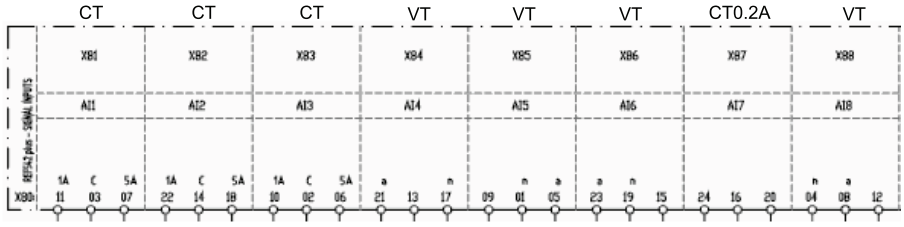
Q05 - Q10 - outgoing feeders

Q11 - bus coupler

Q12 - bus riser

A typical application of REF542plus:

1. Define the auxiliary power supply:
   - 110 VDC
   - 220 VDC
   - range 48-220 VDC
2. Define if 4…20 mA signals need to be used in the switchgear to convert some signals or to transfer information signals (current, voltage, frequency, power) to the NCC. All these signals can also be sent via the communication board.
3. Select the right analog input board. The analog input board is used to get analog signals from the current transformers or voltage transformers (neutral current and voltage as well). The board has eight analog measurement inputs in different combinations: current inputs (1/5 A), voltage inputs (100-150 V), current inputs for connection to the sensitive earth-fault protection (0.2 A). The following board is the most frequently used:

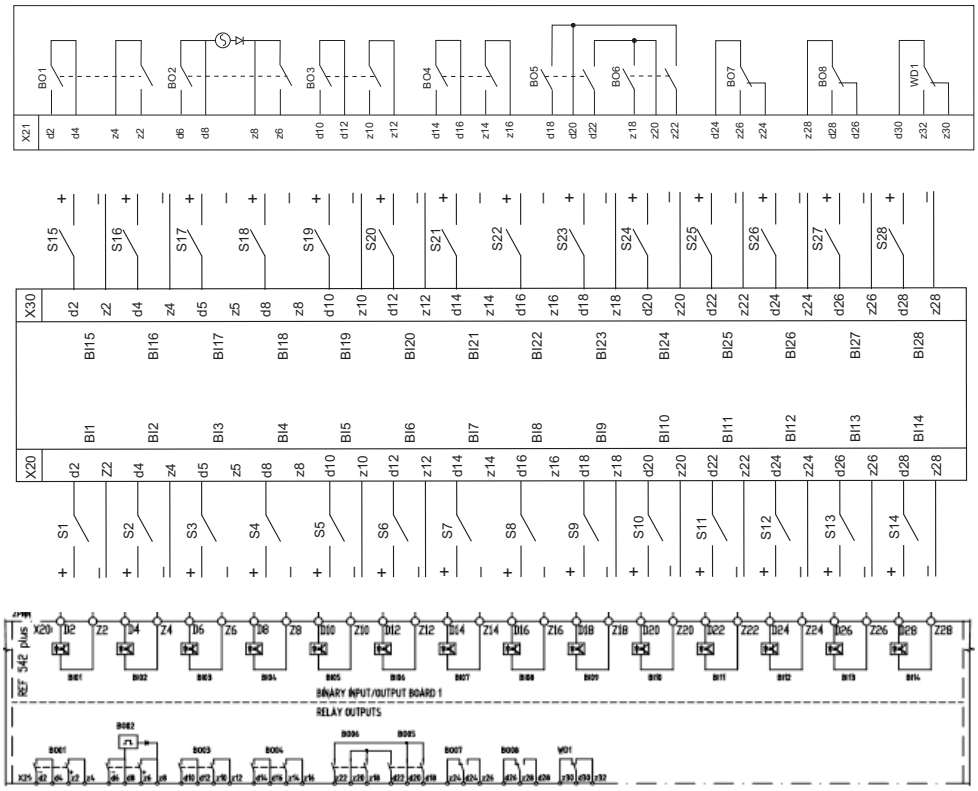


Three current inputs for phase currents, three voltage inputs for voltages (you can use phase-to-phase or phase-to-earth voltage), one current input for sensitive earth-fault protection (from neutral current transformer), and one for the open delta voltage signal.

4. Select the binary input-output board. You can select the board for 110 VDC or 220 VDC and verify whether is it necessary to use a static channel for the impulse signals.

The most often used boards are the one for 220 VDC and the following board:

Binary I/O3 - 80…250 V/143 V Standard. It has 14 binary inputs and 8 output relays. One output has an internal pulse generator to monitor the connected circuit (usually used for Trip Coil Supervision, TCS). The voltage input threshold is 143 V (according to GOST).



For incomings and bus couplers, it is recommended to use 3 I/O boards to have an option for designing a complex logical scheme. For the outgoings, it is recommended to use two boards.

5. Define the communication board (if needed). REF 542plus has an embedded WEB server. In addition, the MODBUS TCP communication protocol can be used via the Ethernet RJ 45 interface. An additional multi-communication system can be built using the following protocols:
   - MODBUS RTU RS485 (used for SPA as well)
   - MODBUS RTU Fiber Optic with ST connectors (used for SPA as well)
   - SPA Plastic Fiber version snap-in connectors
   - SPA Glass Fiber with SMA connectors
   - SPA Glass Fiber with ST connectors
   - COM-L (LON - LAG 1.4)

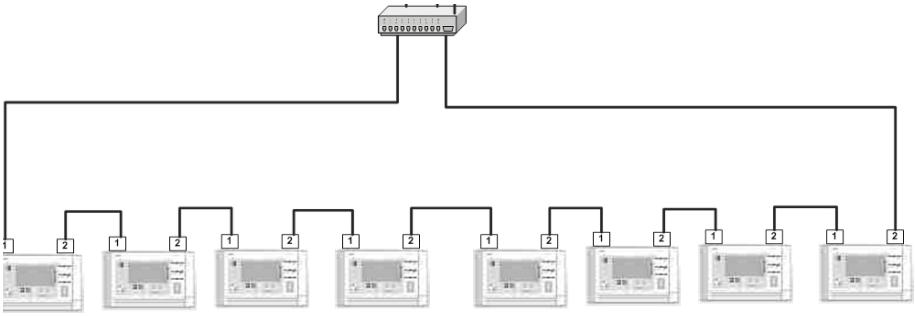
- COM-I (IEC 60870-5-103)
- Ethernet module for IEC 61850

The difference between the communication systems is the topology, the amount of devices, and the SCADA system of the NCC.

The most common protocol is the standard **MODBUS RTU** (baud rate 19.2-76.8 kb/s). Connetion to a third party communication system is therefore possible. This protocol has two interfaces: optical (ST connector) and electrical (RS485).

SPA is an ABB proprietary protocol, and it is also used to build communication systems. The baud rate is specified to 9600 kbit/sec. SPA has a lower baud rate but it is more flexible because of different types of converters or concentrators available. The network topology can be star of loops, loop of stars, or just loop or star. The info flow speed depends on the topology and it is not strictly defined. Usually, devices are split up by sections or other primary features.

In the figure below, an example of a ring topology, where the IEDs are connected in a loop.

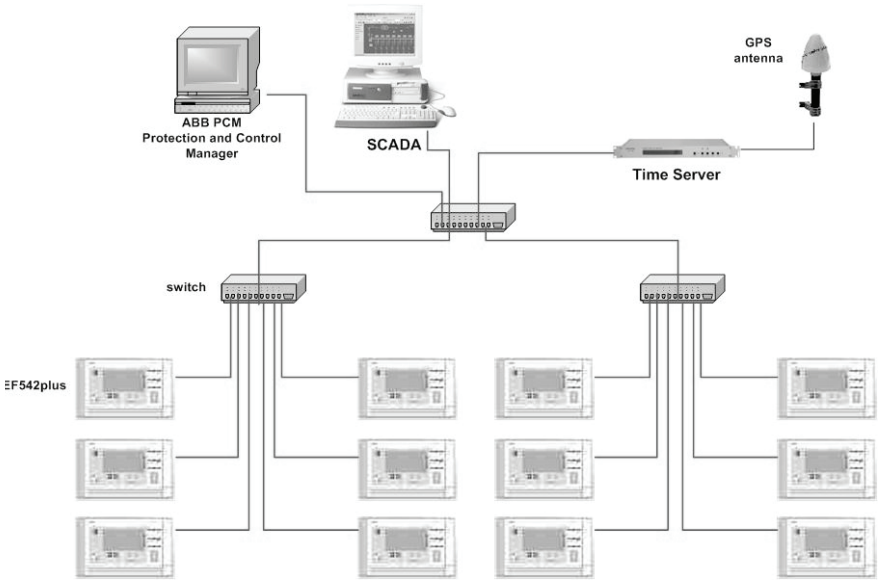


The number of IEDs is limited when using SPA in a ring topology. The more IEDs you connect to the ring, the slower is the information flow. A larger number of devices can be used, but in this case, it is recommended to make several loops and to use a concentrator before the connection to SCADA. Do not connect more than 8-12 devices to the loop, otherwise the communication slows. If more devices are required, it is recommended to use the start topology. The maximum length of the pilot wire (RS485) is 1200 m (no more than 800 recommended). An optical connection can be used as well.

The ABB **LON per LAG** 1.4 (LON Application Guide) protocol is an ABB proprietary protocol too, and it is based on the IEC 60870-5-101 standard. This protocol uses a 1 Mb/s communication bus and enables horizontal interbay communication. This means, that a station wide interlocking is possible with this communication protocol. The engineering of the communication system shall be carried out according to the related application guide LAG 1.4.

IEC 60870-5-103 with the extension for sending commands is the first open protocol for microprocessor based protection in substations. In 1998, the standard was extended by the association of German utilities to apply to an IED (Intelligent Electronic Device) integrating protection and control in one device. Third party communication system can be connected without problems.

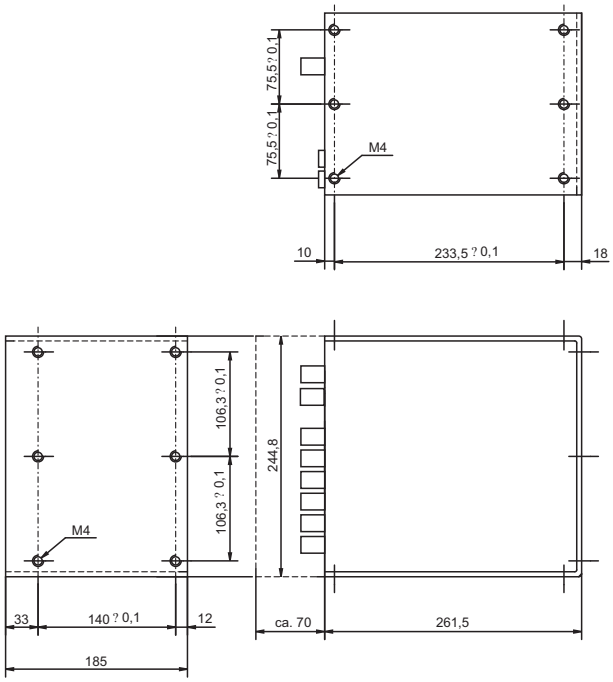
The **IEC 61850** protocol is the most up-to-date communication standard. It can be connected to 10 or 100 Mb network. It is the fastest protocol used today. It has two RJ45 ports for normal LAN cables. A fiber-optic connection with LC connectors can also be used. Due to the engineering tool provided, it is easy to design the connection to the communication system. Only the star topology shall be used. In this case, it is necessary to use an industrial switch with IEC61850 and support. The recommended switch type is Ruggedcom. On the switch level, additionally a ring can be defined, if required.



6. Select the required housing. The two available types are: wide and normal.

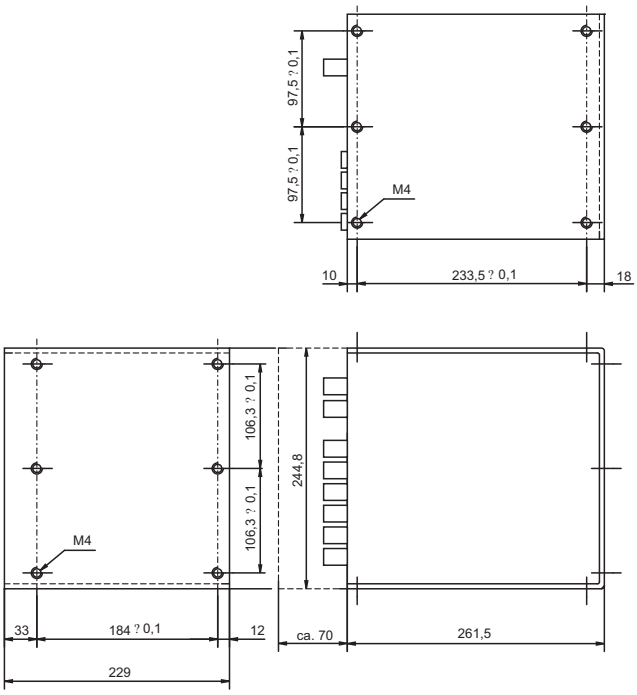
Standard housing

- One power supply
- One mainboard module
- One analog input module
- Two binary input and output modules at the maximum
- As an option, a communication module or a 4/0...20 mA analog output



Wide housing

- One power supply
- One mainboard module
- One analog input module
- Three binary input and output modules at the maximum
- As an option, a communication module
- As an option, a 4...20 mA analog input module or a 4/0...20 mA analog output module



7. Select an HMI for the protection. Select the voltage level for the power supply: 48…110 VDC or 110…220 VDC, and select if a protection cover is needed for the LCD. A typical choice is HMI V5 110…220 VDC without a cover.
8. Selection of functionality level:

Table 1.1 Functionality levels of REF 542plus

ANSI CODE		Protection functions for REF542plus	Basic Low	Basic	Multi Low	Multi	Differential	Distance	Hsts
68	Prot	Inrush current blocking	x	x	x	x	x	x	x
68	Prot	Inrush harmonic	x	x	x	x	x	x	x
51	Prot	Non-directional overcurrent IDMT	x	x	x	x	x	x	x
51	Prot	Non-directional overcurrent low	x	x	x	x	x	x	x
51	Prot	Non-directional overcurrent high	x	x	x	x	x	x	x

Table 1.1 Functionality levels of REF 542plus (Continued)

ANSI CODE		Protection functions for REF542plus	Basic Low	Basic	Multi Low	Multi	Differential	Distance	Hsts
50	Prot	Non-directional overcurrent instantaneous	x	x	x	x	x	x	x
67	Prot	Directional overcurrent low	not available	x	x	x	not to be used	x	x
67	Prot	Directional overcurrent high	not available	x	x	x	not to be used	x	x
51N	Prot	Non-directional earth-fault IDMT	x	x	x	x	x	x	x
51N	Prot	Non-directional earth-fault low	x	x	x	x	x	x	x
51N	Prot	Non-directional earth-fault high	x	x	x	x	x	x	x
67N	Prot	Directional earth-fault sensitive	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault low	not available	x	x	x	x	x	
67N	Prot	Directional earth-fault high	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 1)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 2)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 3)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 4)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 5)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 6)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 7)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 8)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 9)	not available	x	x	x	x	x	x
67N	Prot	Directional earth-fault sector (stage 10)	not available	x	x	x	x	x	x
59	Prot	Overvoltage low	not available	not available	x	x	not to be used	x	x
59	Prot	Overvoltage high	not available	not available	x	x	not to be used	x	x
59	Prot	Overvoltage instantaneous	not available	not available	x	x	not to be used	x	x
27	Prot	Undervoltage low	not available	not available	x	x	not to be used	x	x
27	Prot	Undervoltage high	not available	not available	x	x	not to be used	x	x
27	Prot	Undervoltage instantaneous	not available	not available	x	x	not to be used	x	x
59N	Prot	Residual overvoltage low	not available	x	x	x	x	x	x
59N	Prot	Residual overvoltage high	not available	x	x	x	x	x	x
49	Prot	Thermal overload	not available	not available	not available	x	x	x	x
51	Prot	Motor start-up	not available	not available	not available	x	x	x	x
51LR	Prot	Blocking rotor	not available	not available	not available	x	x	x	x

Table 1.1 Functionality levels of REF 542plus (Continued)

ANSI CODE		Protection functions for REF542plus	Basic Low	Basic	Multi Low	Multi	Differential	Distance	Hsts
66	Prot	Number of starts	not available	not available	not available	x	x	x	x
21+79	Prot	Distance	not available	not available	not available	not available	not to be used	x	x
87	Prot	Transformer differential	not available	not available	not available	not available	x	not to be used	not to be used
87N	Prot	Restricted Earth-Fault (low impedance)	not available	not available	not available	not available	x	x	x
46	Prot (CNeg-PhaseSe-quence)	Unbalanced load	not available	not available	x	x	x	x	x
32	Prot	Directional power	not available	not available	not available	x	not to be used	x	x
37	Prot	Low load	not available	not available	not available	x		x	x
81	Prot	Frequency supervision	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 1, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 2, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 3, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 4, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 5, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 6, network 1)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 1, network 2)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 2, network 2)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 3, network 2)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 4, network 2)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 5, network 2)	not available	not available	not available	x	not to be used	x	x
81	Prot	Frequency protection (stage 6, network 2)	not available	not available	not available	x	not to be used	x	x
25	Prot	Synchronism check	x	x	x	x	not to be used	x	x
79	Primi	Autorecloser	x	x	x	x	not to be used	x	
	Primi	Power factor controller	not available	not available	not available	x	not to be used	x	x
	Prot	Switching resonance protection	not available	not available	not available	x	not to be used	x	x
	Primi	High harmonic protection	not available	not available	not available	x		x	x
	Primi	Fault recorder	x	x	x	x	x	x	x

Typical protections for the following switchgear:

Incomings:

Overcurrent (low and high stages), residual voltage (low and high stages), minimum voltage (low and high stage), earth-fault current protection (low and high stage).

Bus coupler:

Overcurrent (low and high stages), residual voltage (low and high stages), minimum voltage (low and high stage), earth-fault current protection (low and high stage), synchrocheck.

Outgoings:

Overcurrent (low and high stages), earth-fault current protection (low and high stage), sometimes minimum voltage and residual voltage protections.

VT cubicle:

Protection functions are not needed in this kind of cubicles, because voltage wires can be connected to other REF 542 plus IEDs and the protections can be used separately.

Usually, the bus coupler and incoming feeder are the same type of REF542plus. It should have as many binary inputs and outputs as possible to have additional functionality and ability to extend the switchgear in the future.

Let's assume, the power supply is 220 VDC.

REF 542plus code for panels: Q01, Q02, Q11: **76B2NFFF301WB26**

REF542plus [76], Mainboard - basic version [**B**], Power supply - rated voltage 220 VDC [**2**], No analog I/O [**N**], Binary I/O3 - 80…250 V/143V Standard [**F**], Binary I/O3 - 80…250 V/143V Standard [**F**], Binary I/O3 - 80…250 V/143V Standard [**F**], Analog input 3CT+3VT+1CT0.2A+1VT [**30**], Modbus RTU/SPAbus RS485 communication board [1], Housing - Wide [**W**], HMI V5 - IEC [**B**] auxiliary voltage 110-220 VDC, HMI cable 2.5 m [**2**], Software Multi License [**6**].

As for outgoing, the difference is usually only the number of I/O boards:

REF 542plus code for panels Q05-Q10: **76B2NFFN301WB26**

REF542plus [**76**], Mainboard - basic version [**B**], Power supply - rated voltage 220 VDC [**2**], No analog I/O [**N**], Binary I/O3 - 80…250 V/143V Standard [**F**], Binary I/O3 - 80…250 V/143V Standard [**F**], Binary I/O slot 3 - empty slot [**N**],

Analog input 3CT+3VT+1CT0.2A+1VT [**30**], Modbus RTU/SPAbus RS485 communication board [**1**], Housing - Wide [**W**], HMI V5 - IEC [**B**] auxiliary voltage 110-220 VDC, HMI cable 2.5 m [**2**], Software Multi License [**6**].

Table 1.2 Code definition table

REF 542plus	**7**													
Operations field														
Standard	6													
Mainboard														
Basic		B												
Standard		S												
Full		F												
Power supply														
Rated voltage 110 VDC			1											
Rated voltage 220 VDC			2											
Wide range Voltage 48 to 220 VDC			3											
Analog - Input or Out														
No Analog I/O				N										
Analog Input board 4..20 mA				A										
Analog Output board 4..20mA				B										
Binary IO Slot 1														
Binary I/O3 - 80..250 V/59V - Standard					9									
Binary I/O3 - 80..250 V/59V - with Static Channel					A									
Binary I/O3 - 80..250 V/143V - Standard					F									
Binary I/O3 - 80..250 V/143V - with Static Channel					G									
Binary IO Slot 2														
None						N								
Binary I/O3 - 80..250 V/59V - Standard						9								
Binary I/O3 - 80..250 V/59V - with Static Channel						F								
Binary I/O3 - 80..250 V/143V - Standard						A								
Binary I/O3 - 80..250 V/143V - with Static Channel						G								
Binary IO Slot 3							N							
Binary I/O3 - 80..250 V/59V - Standard							9							
Binary I/O3 - 80..250 V/59V - with Static Channel							A							
Binary I/O3 - 80..250 V/143V - Standard							F							
Binary I/O3 - 80..250 V/143V - with Static Channel							G							
Analog Input XX:														
3 CT + 3 VT + 1 CT 0.2A + 1 VT								30						
3 VT + 3 VT + 1 CT 0.2A + 1 CT 0.2A								31						
3 CT + 3 CT + 1 CT 0.2A + 1 VT								33						
3 CT + 3 VY + 1 CT + 1 VT								36						
3 CT + 3 VT + 1 CT 0.2A + 1 CT 0.2A								39						

Table 1.2 Code definition table (Continued)

REF 542plus	7													
3 CT + 3 VT + 1 VT + 1 VT									40	|	|	|	|	|
3 CT + 3 CT + 1 CT + 1 CT									41	|	|	|	|	|
3 CT + 3 CT + 1 CT + 1 VT									42	|	|	|	|	|
3 CT + 3 VT + 1 CT + 1 CT									43	|	|	|	|	|
										|	|	|	|	|
Communication - X (DNV)										|	|	|	|	|
None										N	|	|	|	|
MOD-BUS RTU / SPAbus RS485										1	|	|	|	|
MOD-BUS RTU / SPAbus Fiber Optic										2	|	|	|	|
SPABUS Plastic Fiber version										3	|	|	|	|
SPABUS Glass Fiber with SMA connectors										4	|	|	|	|
SPABUS Glass Fiber with ST connectors										5	|	|	|	|
											|	|	|	|
Housing											|	|	|	|
Normal											S	|	|	|
Wide											W	|	|	|
												|	|	|
RHMI - X (ANSI / IEC)												|	|	|
HMI V5 - IEC, auxiliary voltage (48...110V)												A	|	|
HMI V5 - IEC, auxiliary voltage (110...220V)												B	|	|
No HMI												N	|	|
													|	|
Cable													|	|
No cable													N	|
HMI cable - 1.8 m													1	|
HMI cable - 2.5 m													2	|
HMI cable - 3.5 m													3	|
HMI cable - 4.5 m													4	|
														|
SwLicence														|
Basic Low														3
Basic														4
Multi Low														5
Multi														6
Differential														7
Distance														8

Recommendations for wiring:

When selecting miniature circuit breakers for powering REF542plus, it is recommended to have separate circuits for the main unit and the HMI supply:

Table 1.3 Main unit supply

Voltage level	I_{nom} of MCB	Ratio	MCB recom. type
110 VDC	6	8-10	S202-K6
220 VDC	4	8-10	S282-UC-K4

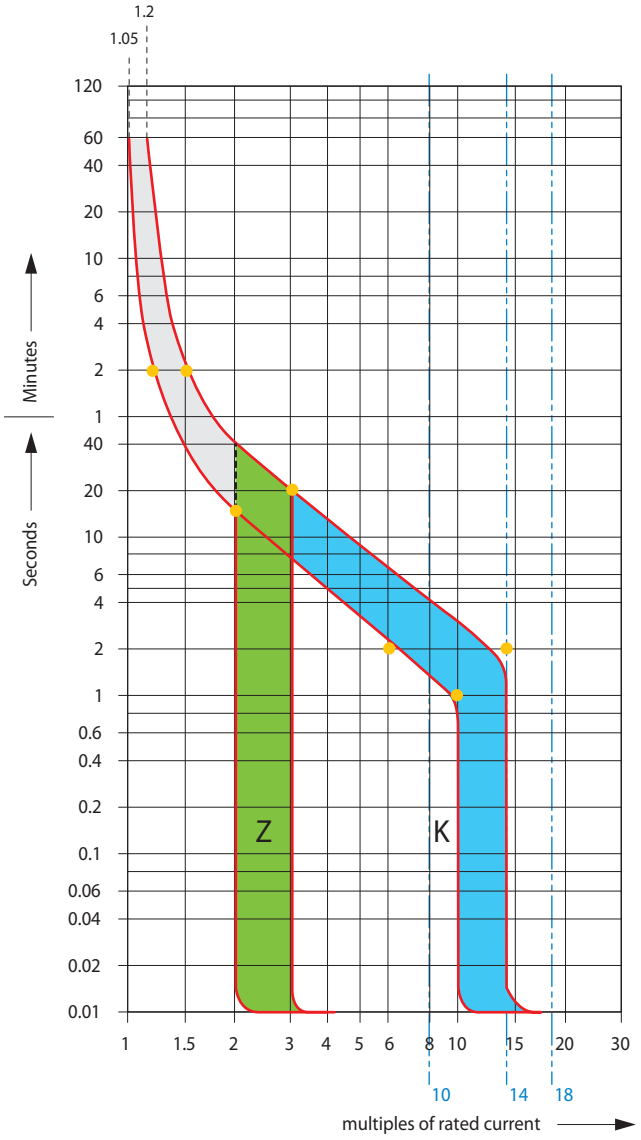
Table 1.4 Power supply range and power unit characteristics

Rated voltage	110 VDC (-30%, +10%)
	220 VDC (-30%, +10%) or
	48 to 220 VDC (-15%, +10%)
Power consumption	20 W (Typical, 2 BIOSs)
Inrush current	Module 759 168: 10 A, 1 ms; 35 A, 100 ms Module 750 126: 8.3 A, 4 ms; 21 A 100 ms
Admissible ripple	Less than 10%

Table 1.5 HMI

Rated voltage	48 ... 110 VDC (-15%, +10%)
	110 ... 220 VDC (-15%, +10%)
Power consumption	6 W
Admissible ripple	Less than 10%

The HMI is recommended to be powered from the signaling circuits of the switchgear.



Separate galvanic binary input and output circuits from the signaling circuits and the power supply.

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