Feeder Terminal REF 542plus

Product Guide

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Features

- Real-time multifunction protections and switchgear controls:
  - protections
  - fault locator
  - measurements
  - controls
  - monitoring and diagnosis
  - power quality functions
  - communication
  - self diagnosis
- Task separation for implemented protections and control scheme modifications
- Flexible installation variations due to separated HMI and base unit
- Large multilingual LCD display for single-line diagram, text messages and menu texts
- Calculated primary quantities include:
  - maximum and mean currents in the settable monitoring period 0-30 min
  - sum of interrupted currents
  - operating time
  - number of switching cycles
- Spring charging time supervision
- Trip coil supervision
- Binary input and output modules to interface with external processes
- Analog input module for primary current and voltage signals:
  - analog transformers
  - non-inductive sensors
- Life Cycle Traceability
- Optional analog input module 4-20 mA
- Optional analog output module 0(4)-20 mA
- Optional communication module for the substation automation system
- Ethernet interface for embedded web server
- Optional optical input port for time synchronization
- Part of the ABB Distribution Automation system

General

The Feeder Terminal REF 542plus is a compact protection, control, measurement and supervision terminal for the power distribution system. The same terminal can be used for feeder, transformer and motor protection and control, or solely for switchgear control. The terminal features an impressive range of protection and management functions readily available for adapting the unit to the intended application. The versatility of the REF 542plus terminal makes it a given solution for any air or gas insulated distribution substation switchgear as shown in figure 1 and in figure 2.

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Fig. 1 REF 542plus installed in gas-insulated switchgear (GIS).

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Fig. 2 REF 542plus installed in an air-insulated switchgear (AIS).

REF 542plus is composed of two parts: a base unit and a separate human machine interface (HMI). The base unit contains the power supply, the processor board, the analog input board and binary input and output (I/O) modules, as well as optional modules for supplementary functions. The base unit and a HMI are connected with a serial cable.

Block diagram

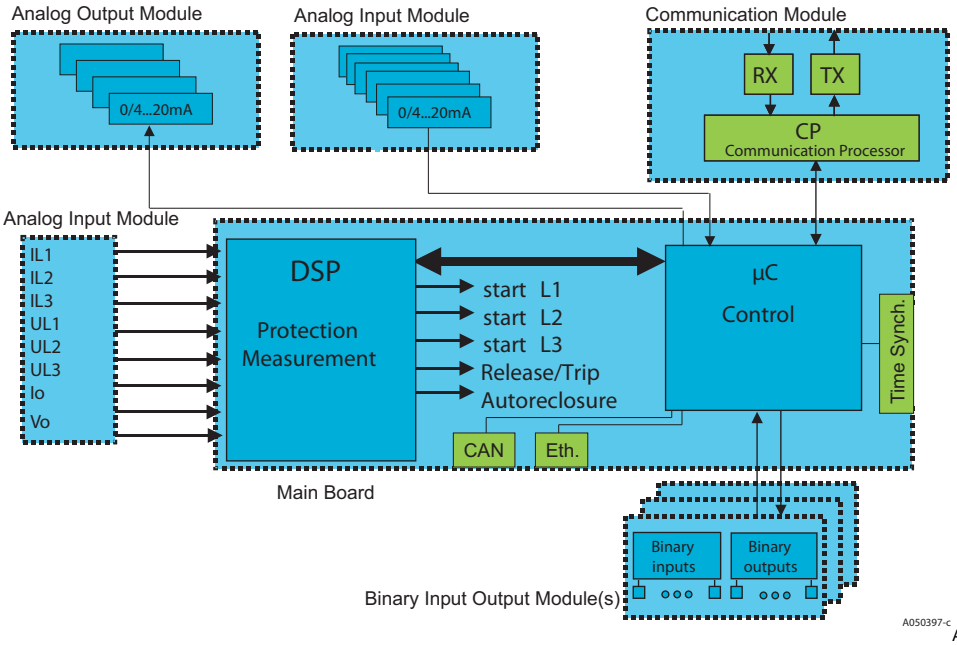

Fig. 3 REF 542plus block diagram.

HMI

The HMI is a stand-alone unit with its own power supply. It can be installed on the low voltage (LV) compartment door or in a dedicated compartment close to the base unit. The HMI can be used to set the protection parameters to locally operate the switching devices in the switchgear and to visualize events and measurements. A shielded, iso-

lated twisted pair according to the RS-485 standard interface connects the HMI to the base unit.

Fig. 4 shows an installation of the base unit and the HMI control unit in the LV compartment.

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Fig. 4 Mounting of the base unit in the LV compartment and the HMI on the door.

The HMI control unit, Fig. 5, features a back-illuminated liquid crystal display (LCD), eight push buttons, several LEDs and an electronic key interface. The language of the display can be selected by using the Configuration Tool. The same software is also used to define the protection and the control scheme.

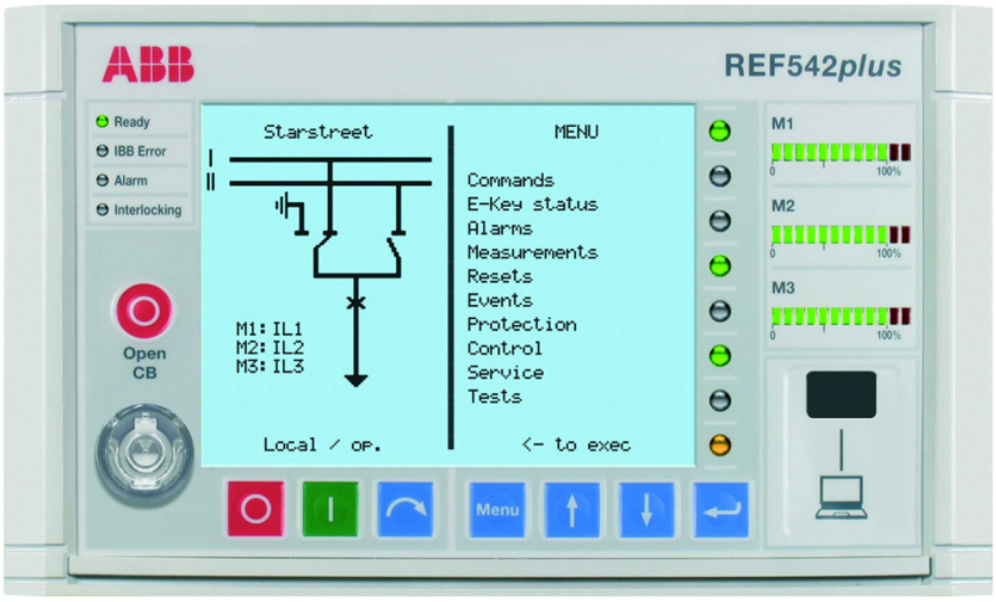

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Fig. 5 HMI control unit.

The left side of the LCD display is reserved for the single line diagram. The right side is for plain text visualization such as measurement and protection events. The LCD backlight is switched off automatically after 20 minutes of inactivity.

The HMI is a complete system for the local management of the switchgear. The HMI allows the operator to set the protection functions, operate the primary objects, visualize measurements and events, reset alarms and change the unit working mode.

Application

Monitoring and self-diagnosis

The REF 542plus offers several features for monitoring the primary part as well as self-diagnosis. The following computed quantities are available for primary part monitoring:

- maximum and mean currents in the observation period (0 ... 30 min)
- sum of interrupted currents
- operating time
- number of switching cycles (open-close circuit breaker)
- spring charging time supervision (when applicable)
- trip coil supervision

The REF 542plus is equipped with self-diagnosis routines that constantly check the hardware and software modules status. Every REF 542plus binary input and output module is equipped with a watchdog contact that triggers in case of fault or power loss. This contact can be used to detect unit failure and to initiate the appropriate actions. Analog input channels can be optionally supervised. A broken wire in the connection with an instrument transformer or a sensor can be detected and an alarm can be activated.

Protection

REF 542plus offers a wide range of functions for protection. As previously mentioned, a wide range of protection schemes for the protection of several system components can be configured. The available protection functions depend on the ordered software licenses. The licenses are Basic Low, Basic, Multi Low, Multi, Differential and Distance. In table 20 the corresponding provided protection functions are listed.

Current protection:

- inrush blocking (68)
- overcurrent instantaneous (50)
- overcurrent definite time, 2 thresholds (51)
- overcurrent directional, 2 thresholds (67)
- overcurrent IDMT (51 IDMT)
- overcurrent with free programmable trip characteristic 8 thresholds (51)
- overcurrent directional with free programmable trip characteristic 8 thresholds (67)
- earth fault, 2 thresholds (51N)
- earth fault IDMT (51 IDMT)
- earth-fault directional, 2 thresholds (67N)
- earth-fault directional sensitive (67S)
- earth-fault directional sector (67NS), 10 thresholds
- earth-fault with free programmable trip characteristic 8 thresholds (51)
- earth-fault directional with free programmable trip characteristic 8 thresholds (67)

Voltage protection:

- overvoltage instantaneous (59)
- overvoltage definite time, 2 thresholds (59)
- undervoltage Instantaneous (27)
- undervoltage definite time, 2 thresholds (27)
- residual overvoltage, 2 thresholds (59N)

Line protection:

- distance protection V1 (21)
- distance protection V2, 8 thresholds per net (21)
- fault locator, 1 threshold per net

Differential protection:

- differential protection for motors and transformer (87)
- restricted earth-fault for transformer (87N)

Thermal protection:

- for cables, motors and transformers (49)

Motor-specific protection:

- number of starts counting (66)
- locked rotor (51LR)
- motor start (51MS)
- low load (37)
- unbalanced load (46)

Power quality mitigation:

- power factor controller (55)
- switching resonance protection
- high harmonics protection

Other protections and related functions:

- frequency protection (81), 6 thresholds per net
- synchro check (25)
- fault recorder
- autoreclosure (79)
- directional power (32).

At most 24 protection functions can be installed inside the REF 542plus unit. The maximum number is anyway dependent upon the available processing power.

Control

The control and automation capabilities of the REF 542plus are extremely powerful. Comprehensive PLC functionalities are foreseen. Simple interlocking against switching errors as well as complex loadshedding schemes can be easily implemented in the REF 542plus. Even protection similar functionalities, like e.g. circuit breaker failure protection or signal comparison scheme can be programmed.

Fault locator

The fault locator in REF 542plus unit is designed as autonomous function block and can be applied, if the corresponding voltage and current measurement quantities are available. After being triggered the fault locator calculates from the fault impedance by applying the same algorithm as implemented in the distance protection. The fault reactance is also converted into km. The precondition therefore is that the line parameters (settings) also have to be known.

Fault recorder

The REF 542plus unit is equipped with a powerful and flexible fault recorder function. This function can be used to record at most eight analog input channels and thirty-two binary signals. The analog input signals are recorded with a sampling rate of 1.2 kHz for a time interval of at least 1 second and for a maximum of 5 seconds. The recording time is a combination of pre- and post-fault time. The total recording capability is 5 seconds. It can be configured 5 records of 1 seconds or a single record of 5 seconds. The recording can be started by a protection event, by a binary signal change or by any user-defined condition.

Fault records can be transferred locally to a personal computer from the HMI front port or from the so called service port on the base unit by using the Operating Tool or remotely from the communication interface. When uploaded with the Operating Tool the fault records are automatically converted into the standard COMTRADE format. When the fault records retrieve from the communication interface, they can be converted with a utility program. Fault records are stored in non-volatile memory, so they remain available also after a power failure.

Design

Software design

Analog inputs

REF 542plus feeder terminal is designed for connecting to non-conventional current and voltage sensors as well as to instrument transformers.

At most 8 analog input channels are available. Due to their linear characteristic, modern current and voltage sensors provide greater accuracy and reliability in signal measurements. Compared to instrument transformers, the new non-inductive sensors have the following advantages:

- higher linearity
- high accuracy
- compact dimensions
- wide dynamic range
- easy integration in the panels.

The current sensor is based on the Rogowsky coil principle and consists of a single air-wounded coil. Due to the lack of an iron core, the saturation effects of conventional current transformers do not exist anymore. Current sensors are thus well suited for the deployment of distance and differential protection functions.

The voltage sensor is based on the resistive divider principle. Therefore, the voltage sensor is linear throughout the whole measuring range. The output signal is a voltage, directly proportional to the primary voltage.

Binary inputs and outputs

The REF 542plus unit acquires the primary objects status with auxiliary contacts, which are read by binary inputs, and sends commands using binary outputs. Several signals coming from other components are also monitored.

Among others, the following operations are implemented using binary inputs and outputs:

- primary objects control and interlocking in the switchgear
- primary objects status acquisition (for example circuit breaker in opened/closed position)
- circuit breaker spring supervision (when applicable).

Binary inputs are isolated by opto-couplers. Binary outputs can be implemented either with mechanical relays or with static (semiconductor) devices. In a switchgear with directly driven motors, static power outputs are usually required.

Life Cycle Traceability

This feature will enable the management of the whole product life cycle, from the ordering until the refurbishment phase, by using a software structure within the ABB organization to automatically collect, store and retreive the relevant data, e.g. hardware module composition, software version etc. Therefore the firmware of each REF 542plus terminal is extended for detection of changes in the hardware composition or in the firmware. Due to the existing history record, technical support and services as well as repairs can be provided by ABB within the shortest possible time.

Interfacing a station automation system

An optional communication module can be provided for interfacing a station automation system. The four different protocols available for the REF 542plus make possible to interface any kind of station automation system, both from ABB or from third parties.

The following typical functions are possible:

- primary objects status monitoring
- primary objects control
- protections parameterization
- measurements, alarms end events acquisition
- fault recorder data acquisition.

The available protocols are:

- SPA
- ABB LON according to LON Application Guide (LAG) 1.4 definitions
- MODBUS RTU
- MODBUS TCP
- IEC 60870-5-103 with the extensions for control functions according to VDEW (Vereinigung Deutscher Elektrizitätswerke = Association of German Utilities)
- IEC 61850-8-1 (only vertical communication)

The first two protocols, SPA and LON according to LAG 1.4, are ABB specific. The LON LAG 1.4 protocol has specific features for high accuracy time synchronization. In

this case, the REF 542plus units are synchronized from the interbay bus. The other protocols, MODBUS RTU, MODBUS TCP, IEC 60870-5-103 and IEC 61850 guarantee open connectivity to any third party system. In case of communication to a Profibus DP control system is required, a corresponding gateway SPA-ZC 302 can be used.

Hardware design

Base unit versions

The REF 542plus base unit housing is made from aluminum sheets. Its surface is chromatized to protect the housing against corrosion.

Two different housings are available:

- Standard
- Wide

A minimum relay setup has one of the following:

- mainboard.
- power supply
- binary input and output module

The standard housing has two more places for:

- a second binary input and output module
- a communication module

The wide housing can additionally house:

- the third binary input and output module
- alternatively the 0(4)-20 mA analog output module or the 4-20 mA analog input-module

Standard housing dimensions, see Fig. 6.
Wide housing dimensions, see Fig. 7

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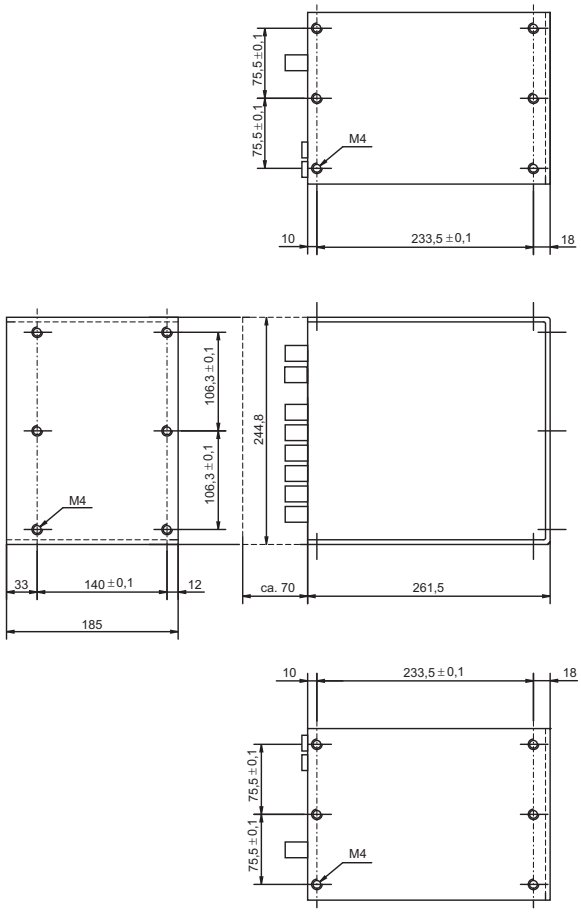

Fig. 6 Standard housing version dimensions.

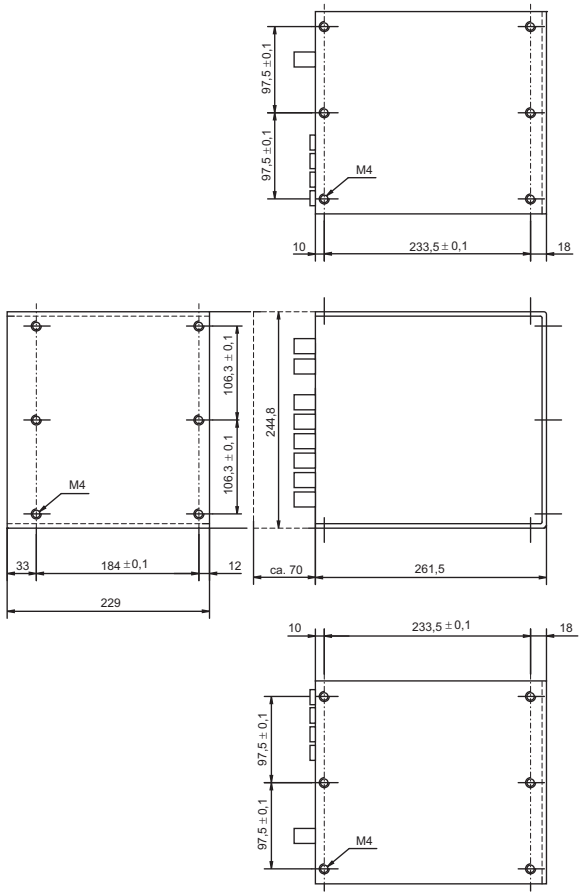

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Fig. 7 Wide housing version dimensions.

Mounting

Fig. 8 shows an example of wide housing base unit installation inside a low voltage compartment.

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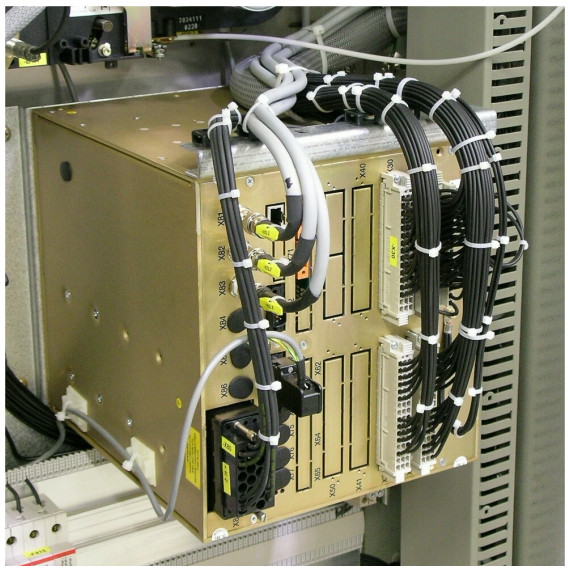
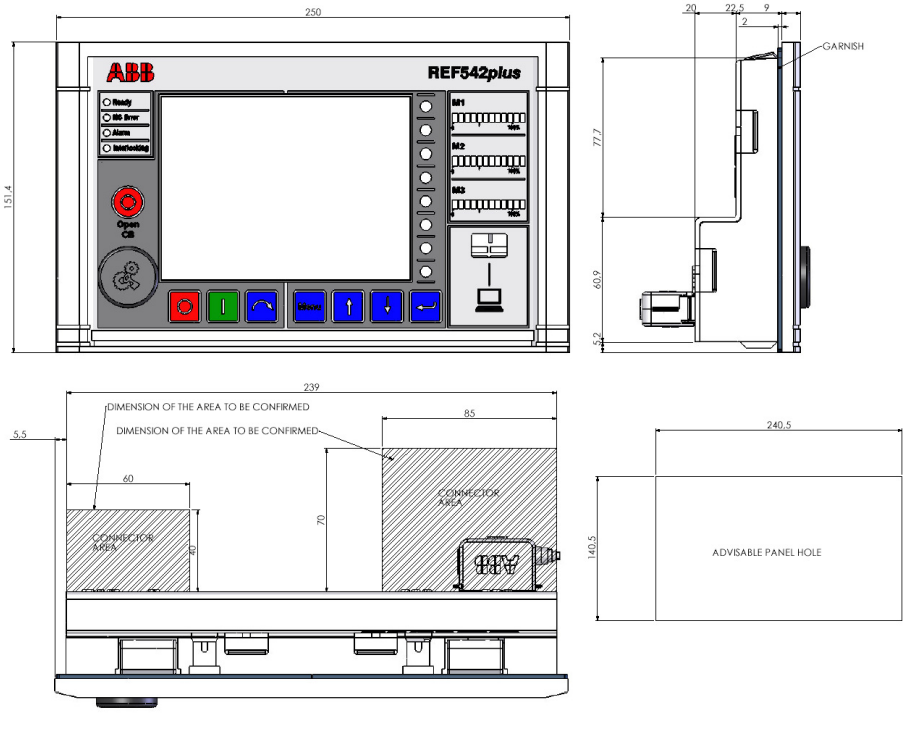


Fig. 8 Base unit installation in LV compartment of a GIS system.

HMI dimensions are illustrated in the Fig. 9 below. The upper one is the version of the HMI without cover and the lower one is with cover to achieve a better protection.



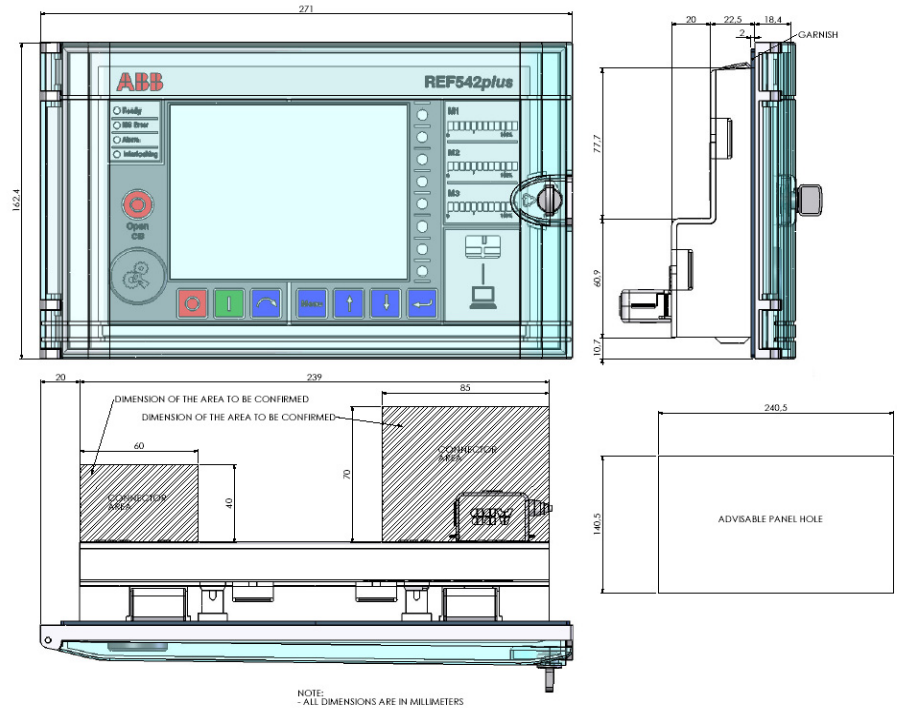


Fig. 9 HMI dimensions.

The advisable panel cut-out is 240,5 x 140,5 mm.

(The existing connectors for the former HMI version can be used.)

Technical data

Measurements

The REF 542plus uses the same analog inputs both for measurements and protections.

Table 1: Measurements

Quantity	Class	Range
Phase current, earth current	0.5	0.1 - 4 x I_n
Line voltage, phase voltage	0.5	0.2 - 1.5 x U_n
Active, reactive energy	2	-
Active, reactive, apparent power	1	-
Cos φ	1	-1 - +1
Frequency	0.02	40 - 75 Hz

Table 2: Protection functions and operation time

Quantity	Range
Protection functions	Class 3
Operation time	Class 3 or minimum ±15 ms

Table 3: Current and voltage transformer input values

Quantity	Range
Rated current I_n	0.2 A, 1.0 A, 5.0 A
Rated voltage U_n	100 - 125 V AC
Rated frequency f_n	50 Hz/60 Hz

Table 4: Thermal load capacity

Quantity	Range
Current path	250 x I_n (peak value), 100 x I_n for 1 s (dynamic), 4 x I_n (continuous)
Voltage path	2 x $U_n/\sqrt{3}$ (continuous)

Table 5: Consumption

Quantity	Range
Current path	≤0.1 VA at I_n
Voltage path	≤0.25 VA at U_n

Protection functions

Table 6: ANSI code protection functions and parameters

Current protection functions		
68	Inrush stabilization (Only in connection with 50 and 51)	N = 2.0 - 8.0 M = 3.0 - 4.0 Time = 200 -100 000 ms
68	Inrush harmonic	Minimum current threshold = 0.05 - 40.00 x I_n Fault current threshold = 0.05 - 40.00 x I_n Harmonic ratio threshold = 5 - 50%
50	Overcurrent instantaneous	I>>> = 0.100 - 40.000 x I_n t = 15 - 30 000 ms
51	Overcurrent high	I>> = 0.05 - 40.00 x I_n t = 20 - 300 000 ms
51	Overcurrent low	I> = 0.05 - 40.00 x I_n t = 20 - 300 000 ms
51 IDMT	Overcurrent IDMT (Inverse Definite Minimum Time)	Inverse time characteristics: Normal, Very, Extreme and Long-time inverse I_e = 0.050 - 40.000 x I_n K = 0.050 - 1.500

Table 6: ANSI code protection functions and parameters

50/51	Overcurrent with free programmable characteristic (8 thresholds available)	Is = 0.05 - 40.000 x I_n t (def) = 0.015 - 300.000 s A = 0.005 - 200.000 P = 0.005 - 3.000 B = 0.000 - 50.000 s Td = 0.050 - 5.000 Tr = 0.020 - 100.000 s
67	Overcurrent directional high	I>> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms Direction = backward, forward
67	Overcurrent directional low	I>> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms Direction = backward, forward
67	Overcurrent directional with free programmable characteristic (8 thresholds available)	Is = 0.05 - 40.000 x I_n t (def) = 0.040 - 300.000 s A = 0.005 - 200.000 P = 0.005 - 3.000 B = 0.000 - 50.000 s Td = 0.050 - 5.000 Tr = 0.020 - 100.000 s Direction = backward, forward
Earth fault (1)		
51N	Earth-fault high	I_0>> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms
51N	Earth-fault low	I_0> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms
51N IDMT	Earth-fault IDMT	Inverse time characteristics: Normal, Very, Extreme or Long-time inverse I_e = 0.05 - 40.00 x I_n K = 0.05 - 1.5
50N/51N	Earth-fault with free programmable characteristic (8 thresholds available)	Is = 0.05 - 40.000 x I_n t (def) = 0.015 - 300.000 s A = 0.005 - 200.000 P = 0.005 - 3.000 B = 0.000 - 50.000 s Td = 0.050 - 5.000 Tr = 0.020 - 100.000 s Direction = forward, backward Net type = isolated (sin φ), earthed (cos φ)
67N	Earth-fault directional, high	I_0>> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms U_0 = 0.02 - 0.70 x U_n Direction = forward, backward Net type = isolated (sin φ), earthed (cos φ)
67N	Earth-fault directional, low	I_0> = 0.050 - 40.000 x I_n t = 40 - 30 000 ms U_0 = 0.02 - 0.70 x U_n Direction = forward, backward Net type = isolated (sin φ), earthed (cos φ)
67S	Earth-fault directional, sensitive	I_0 = 0.050 - 2.000 x I_n t = 100 - 10 000 ms Angle alpha = 0.0 - 20.0^o Angle delta = -180.0^o - +180.0^o U_0 = 0.05 - 0.70 x U_n

Table 6: ANSI code protection functions and parameters

67N Sector	Earth-fault directional, sector (10 thresholds available)	Direction = enable/disable directional behavior Start criteria = neutral current magnitude/ neutral current basic angle I_0 = 0.002 - 8.000 x I_n U_0 = 0.004 - 0.700x U_n t = 30 - 60 000 ms Sector basic angle = -180.0^o - +180.0^o Sector width = 0.0 - 360.0^o I_0 drop off delay = 0 - 1.000 ms U_0 drop off delay = 0 - 1.000 ms
67N	Earth-fault directional with free programmable characteristic (8 thresholds available)	Is = 0.05 - 40.000 x I_n t (def) = 0.040 - 300.000 s A = 0.005 - 200.000 P = 0.005 - 3.000 B = 0.000 - 50.000 s Td = 0.050 - 5.000 Tr = 0.020 - 100.000 s
Voltage protective functions		
59	Overvoltage, instantaneous	U>>> = 0.100 - 3.000 U_n t = 15 - 300 000 ms
59	Overvoltage, high	U>> = 0.100 - 3.000 U_n t = 40 - 30 000 ms
59	Overvoltage, low	U> = 0.100 - 3.000 U_n t = 40 - 30 000 ms
27	Undervoltage, instantaneous	U<<< = 0.10 - 1.20 U_n t = 15 - 30 000 ms
27	Undervoltage,high	U<< = 0.10 ... 1.20 U_n t = 40 - 30 000 ms
27	Undervoltage, low	U< = 0.10 - 1.20 U_n t = 40 - 30 000 ms
25	Synchronism check	Delta Voltage = 0.02 - 0.40 U_n Delta phase = 5 - 50° Time = 0.20 - 1000.00 s
59N	Residual overvoltage, high	U_{NE}> = 0.05 - 3.00 U_n t = 20 - 300 000 ms
59N	Residual overvoltage, low	U_{NE}> = 0.05 - 3.00 U_n t = 20 - 300 000 ms
Motor protection functions		
49	Thermal overload protection with total memory	Nominal temperature = 50 - 400°C (nominal temperature at I_n) Nominal current (I_{Mn}) = 0.100 - 5.000 x I_n (primary value of the nominal motor current) Initial temperature = 10 - 400°C Time constant at I <0.1 x I_{Mn} = 10 - 100 000 s Time constant at 0.1 x I_{Mn} < I <2 x I_{Mn} = 10 - 20 000 s Time constant at I >2 x I_{Mn} = 10 - 20 000 s Trip Temperature = 50 - 400°C Warning temperature = 50 - 400°C Environmental temperature = 10 - 50°C Reset temperature = 10 - 400°C
51	MS Motor start	I_{Mn} = 0.200 - 2.000 x I_{Mn} (motor current) I_s = 1.000 - 20.000 x I_{Mn} (start value) t = 40 - 30 000 ms I> = 0.200 - 0.800 x Is (motor start)
51	LR Locked rotor (definite time characteristic)	I_{Mn} = 0.200 - 2.000 x I_n (motor current) I_s = 1.000 - 20.000 x I_{Mn} (start value) t = 40 - 30 000 ms

Table 6: ANSI code protection functions and parameters

66	Number of starts	n (warm) = 1 -10 (number of warm starts) n (cold) = 1 -10 (number of cold starts) t = 1.00 - 7200.00 s T (warm) = 20 - 200°C (warm start temperature thereshold)
46	Unbalance load	I_s = 0.05 - 0.30 x I_n (start value of the negative phase sequence) K = 0.5 - 30.0 t_{Reset} = 0 - 2000 s Timer decreasing rate = 0 - 100%
37	Low load	P_n = 50 - 100 000 kW (primary values) Minimal load P = 5 - 00% x P_n Minimal current I = 2 - 20 % x I_n Operation time = 1.0 - 1000.0 s
Distance Protection		
21	Distance protection V1	Net type = high/low ohmic Earth start IE> = used, unused Switching onto faults = normal, overreach zone, trip after start Signal comparison overreach scheme time set = 30 … 300 000 ms U/I start characteristic I>, IE> and IF> = 0.05 … 4.00 x In UF< = 0.05 … 0.90 x Un Phase selection = cyclic or acyclic Earth factor Factor k = 0.00 …10.00, Angle (k) = -60° … 60° 3 Impedance stages, 1 overreach stage and 1 autoreclose control stage: R = 0.05 …120.00 Ohm (secondary values) X = 0.05 …120.00 Ohm (secondary values) t = 20 … 10 000 ms Angle delta 1 = -45.00 ... 0.00 ° Angle delta 2 = 90.00 ... 135.00 ° t = 20 … 10 000 ms 1 non directional stage t = 20 … 10 000 ms

Table 6: ANSI code protection functions and parameters

21	Distance protection V2 8 thresholds per net available	Common Setting: Operating status = On/Off Common operation counter = Used/Not used Network type = High/Low ohmic Impedance calculation: Minimum current and earth fault supervision Imin> = 0.05 … 40.00 In Io> = 0.05 … 40.00 In Uo> = 0.10 … 1.20 Un Double earth fault: U< = 0.10 …1.20 Un Phase selection = cyclic or acyclic Load encroachment:: Uload> = 0.10 … 1.20 Un Rforward = 0.000 … 3.000 Zn Rbackward = 0.000 … 3.000 Zn Angle = 1 … 60° Zones setting: Status = On/Off Function in use = Tripping/Signalling/Overreach Zone Works on = Phase/Earth/Phase and Earth PTT Logic = OR/AND Trip Logic (for transfer tripping)= Op. Time/Op. Time AND PTT/Op. Time OR PTT/PTT Load encroachment = Used/Not used Reaches = Used/Not used Angles (Directional limitation) = Used/Not used Direction = Forward/Backward/Not Used Rforward = 0.000 … 3.000 Zn Xforward = 0.000 … 3.000 Zn Rbackward = 0.000 … 3.000 Zn Xbackward = 0.000 … 3.000 Zn Angle delta1 = -45 … 0° Angle delta2 = 90 … 135° Time = 0.020 … 300.000 sec Earth factor (for maximal 4 line sections) Group = 1 … 4 Modulus = 0.00 … 10.00, Angle = -60° - 60°
	Fault locator 1 threshold per net	Operating status = On/Off PTRC trigger mode = Not Used/Start/Trip Impedance calculation: Minimum current and earth fault supervision Imin> = 0.05 … 40.00 In Io> = 0.05 … 40.00 In Uo> = 0.10 … 1.20 Un Up to 4 line sections (primary values) R1 = 0.001 … 50.000 Ohm/km X1 = 0.001 … 50.000 Ohm/km Ro = 0.001 … 50.000 Ohm/km Xo = 0.001 … 50.000 Ohm/km Length = 0.01 … 100.00 km

Table 6: ANSI code protection functions and parameters

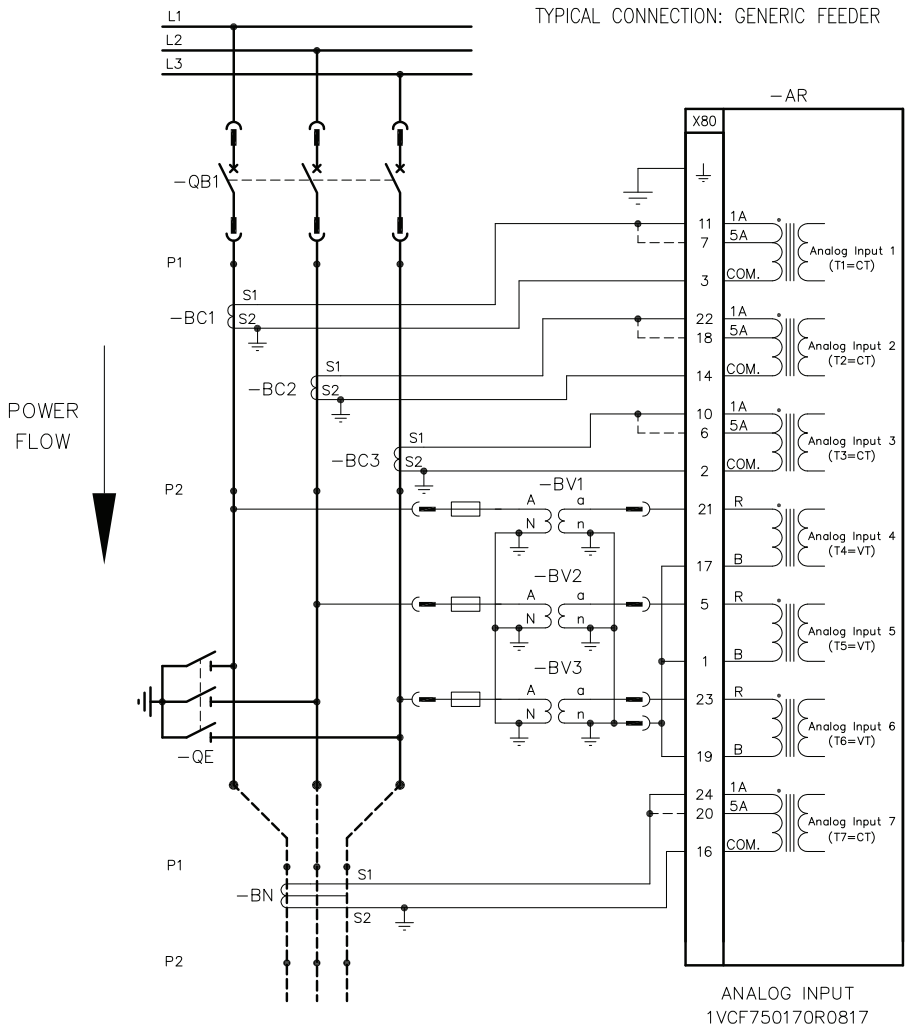
Differential protection functions		
87	Differential	Differential Transformer group = 0 - 11 Transformer earthing = primary and or secondary side Primary nominal current = 10.00 - 100 000.00 A (prim value) Secondary nominal current = 10.00 - 100 000.00 A (prim value) Threshold current = 0.10 - 0.50 x I_r (p.u.) Unbiased region limit = 0.50 - 5.00 x I_r (p.u.) Slightly biased region threshold = 0.20 - 2.00 x I_r (p.u.) Slightly biased region limit = 1.00 - 10.0 x I_r (p.u.) Slope = 0.40 - 1.00 Trip by I_d> = 5.00 - 40.00 x I_n Blocking by 2nd harmonic = 0.10 - 0.30 x I_n Blocking by 5th harmonic = 0.10 - 0.30 x I_n
87N	Restricted earth fault protection (restricted differential)	Reference nominal current = 1.00 - 100 000.00 A Unbiased region threshold= 0.05 - 0.50 x I_r Unbiased region limit = 0.01 - 1.00 x I_r Slightly biased region slope = 0.01 - 2.00 Slightly biased region limit = 0.01 - 2.00 x I_r Heavily biased region slope = 0.10 - 1.00 Relay operate angle = 60° - 180° t = 0.04 -100.00 s
Frequency protection function		
81	Frequency protection	Start value = 40.00 -- 75.00 Hz, step 0.01 Hz Frequency gradient = 0.01 - 1.00 Hz/s t = 0.10 - 30.00 s U< = 0.10 ... 1.00 U_n Trip logic = frequency only frequency AND freq. gradient frequency OR freq. gradient
Frequency supervision		
	Frequency supervision	Start value = 0.04 - 5.00 Hz Time = 1.00 - 300.00 s
Distance protection function		
21	Distance protection	Net type = high/low ohmic Earth start I_E> = used, unused Switching onto faults = normal, overreach zone, trip after start Signal comparison overreach scheme time set = 30 - 300 000 ms
	U/I -start characteristic	I>, I_E> and I_F> = 0.05 - 4.00 x I_n U_F< = 0.05 - 0.90 x U_n Phase selection = cyclic or acyclic
	Earth factor	Factor k = 0.00 -10.00, Angle (k) = -60° - 60°
	3 Impedance, 1 overreach stage, and 1 autoreclose control stage:	R = 0.05 -120.00 Ohm (secondary values) X = 0.05 - 120.00 Ohm (secondary values) t = 20 - 10 000 ms Angle delta 1 = -45.00 ... 0.00 ° Angle delta 2 = 90.00 ... 135.00 ° t = 20 - 10 000 ms 1 non directional stage t = 20 - 10 000 ms

Table 6: ANSI code protection functions and parameters

Power quality functions		
	Power factor controller	Switching sequence = linear or circular Switching histeresis,neutral zone = 105 - 200% x Q_{co} Pick up value = 0 -100% x Q_{co} Reactive power of smallest bank Qc_o = 1.000 - 20 000.000 kVar Configuration banks: 1:1:1:1, 1:1:2:2, 1:2:2:2, 1:2:4:4, 1:2:4:8 Number of banks = 1 - 4 Max. switching cycles = 1 - 10 000 Set point cos φ = 0.7 ... 1.00 ind. or cap. Limiting value cos φ = 0.00 ... 1.00 ind. or cap. Method of operation = direct, integrating Discharge blocking time = 1 - 7200 s Dead time = 1 - 120 s Power on delay = 1 - 7200 s Duration of integration = 1 - 7200 s
	High harmonic protection	Voltage THD start value = 5 - 50% Voltage THD time delay = 0.01 - 360.00 s Time = 0.05 - 360.00 s RMS voltage start value = 0.10 - 1.00 U_n
	Switching resonance protection	Voltage THD start value = 5 - 50% Delta voltage THD start value = 1 - 50 % Voltage THD time delay = 0.01 - 60.00 s t = 0.05 ... 60.00 s PFC OP time = 0.01 - 120.00 s RMS voltage start value = 0.10 - 1.00 U_n
Other functions		
	Fault recorder	Time before fault = 100 ... 2000 ms Recording time = 1000 ... 5000 ms Time after fault = 100 ... 4900 ms Max. 5 records
79	Autorecloser	Operation mode = Start and Trip controlled, Start Controlled Number of reclosing cycle = 0 ... 5. Reclaim time = 10.00 -1000.00 s Specific/operation time 1st shot = 0.04 -1000 s Dead time1st shot = 0.10 -1000 s Specific/operation time 2nd shot = 0.04 .-1000 s Dead time 2nd shot = 0.10 - 1000 s Specific/operation time 3rdshot = 0.04 -1000 s Dead time 3rd shot = 0.10 - 1000 s Specific/operation time 4th shot = 0.04 -1000 s Dead time 4th shot = 0.10 - 1000 s Specific/operation time 5th shot = 0.04 - 1000 s Dead time 5th shot = 0.10 - 1000 s
	Switch On To Fault 1 Threshold per net	Operating status = On/Off Fault criteria: I>/I> OR (IF> AND UF<)/Overreach Zone I> = 0.050 … 40.000 In IF> = 0.050 … 40.000 In UF< = 0.50 … 0.900 Un IN> = 0.050 … 40.000 In Op. Time after CB closed = 0.100 … 5.000 sec
32	Directional power	Direction = forward, backward Nominal real power P_n = 1 - 1000 000 kW (primary values) Max. reverse load P> = 1 - 50% x P_n Operation time = 1.0 - 1000.0 s

Typical connection diagrams

This picture represents a typical connection scheme for outgoing feeders when voltage and current protections are required. There is also a current balance transformer for earth-fault current sensing. Analog input channel no. 8 is not used.



A070120

Fig. 10 Generic outgoing feeder

The schematic diagram below shows a connection for a power transformer feeder with differential, earth-fault and restricted earth-fault protections.

The used analog input board has 8 inputs for currents. Channels 1 -6 are for the differential protection, channel 7 is used for the restricted earth-fault protection and channel 8 for the earth-fault protection.

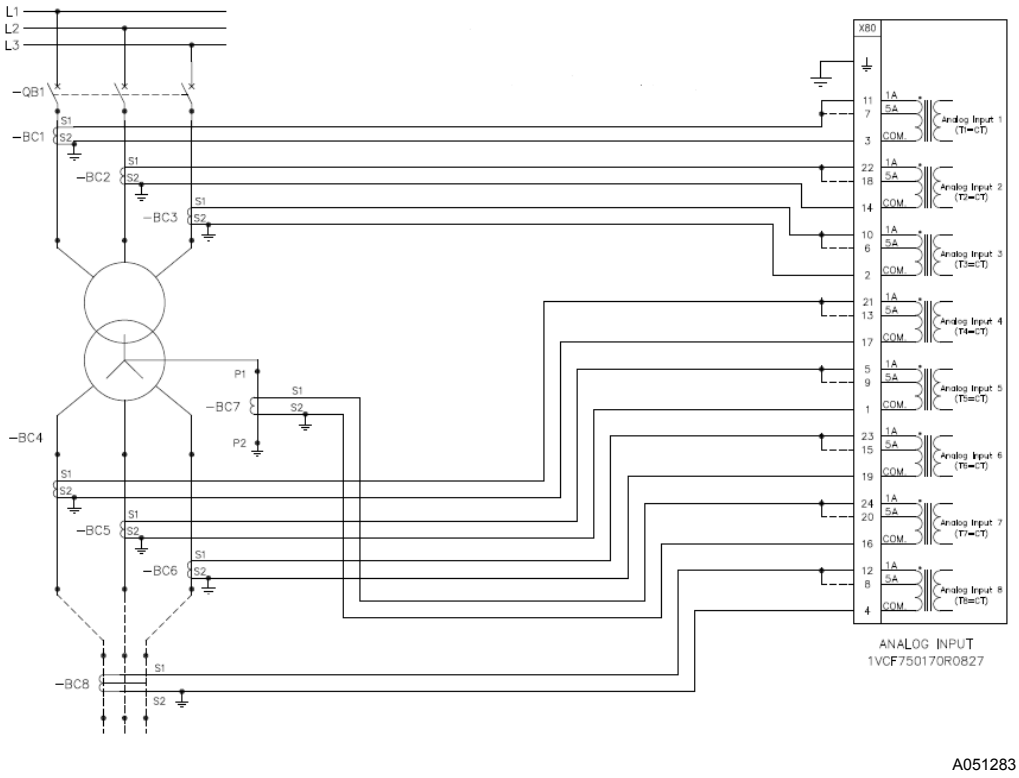


Fig. 11 Power transformer differential protection

Fig. 12 shows a possible connection diagram for a generic incoming feeder with synchrocheck function on the busbar.

Channels 1-3 are used for current sensing and channels 4-6 are used for phase to earth voltage measurements and protection of the incoming feeder. Channel 7 is used for the residual current for earth-fault protection and channel 8 is used for the busbar phase-to-phase voltage to perform the synchrocheck.

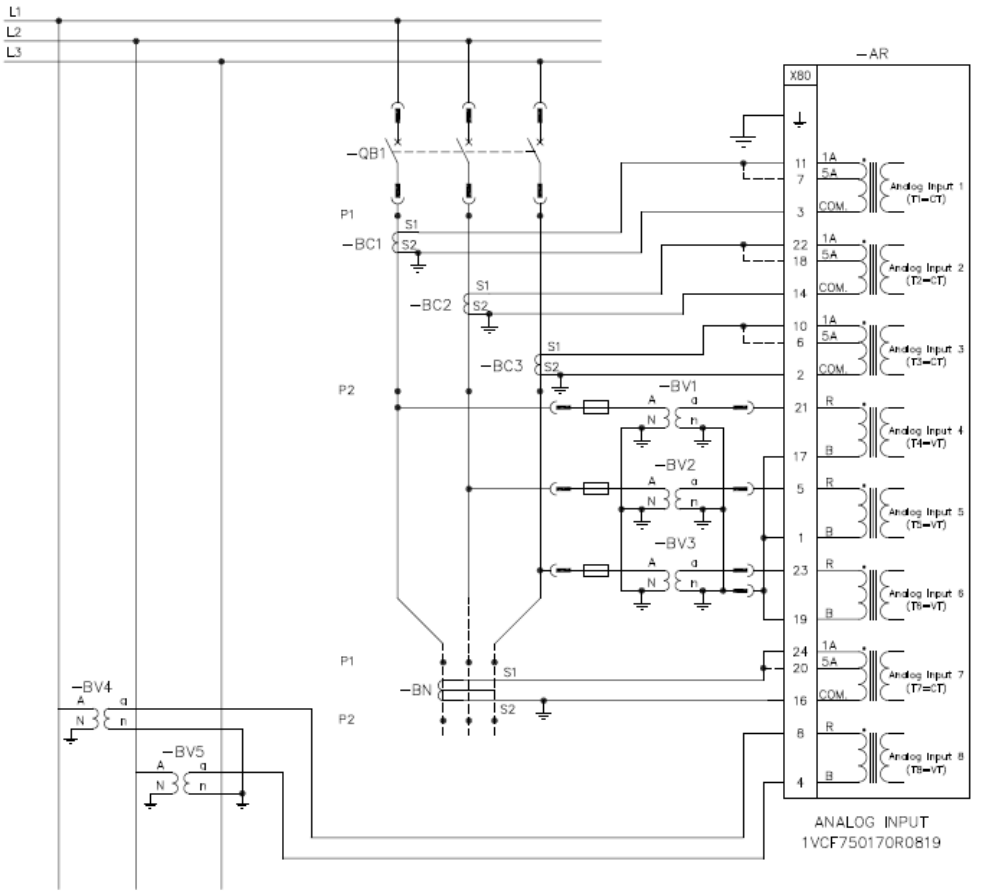
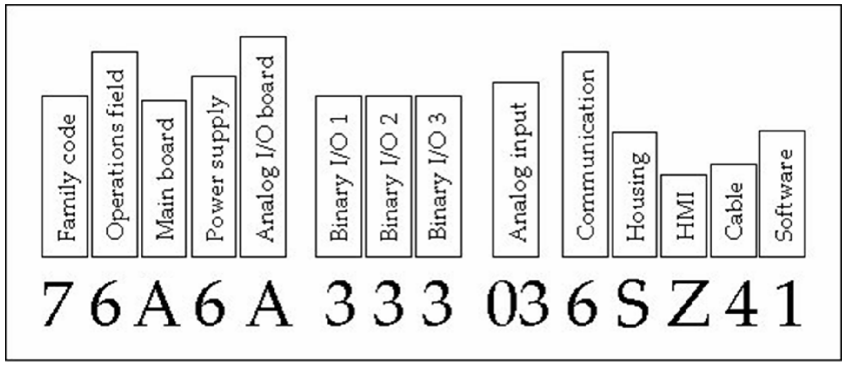


Fig. 12 Incoming feeder with synchrocheck capability.

Ordering

The different variants have their own specific order numbers that identify the type designation for the desired hardware and software combination.

The type code designation can be seen in Fig. 13



TA060505

Fig. 13 Type code designation for ordering REF 542plus.

Each code is dedicated to a specific application or module. The description for each type code is listed in the following tables. The codes mentioned below are mostly used for operations field REF 542plus. For ATEX the code is slightly different. Because ATEX certification is only valid for a specific version of the REF 542plus, it is required, after each new release to obtain a new certification. The ATEX certified unit is release 2.5 with version V4E04. The unit is delivered with the HMI V5.

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Table 7: Family code

Number	Code	Name	Description
7		REF 542plus	Product family for the feeder terminal unit REF 542plus

7 **6** A 6 A 3 3 3 03 6 S Z 4 1

Table 8: Application areas

Number	Code	Name	Description
6		REF 542plus	Normal operation
F		REF 542plus ATEX-2.5	Motor protection in explosive area (Rel. 2.5)

7 6 **A** 6 A 3 3 3 03 6 S Z 4 1

Table 9: Main board versions

Number	Code	Name	Description
B	751021/802	MB5 for ATEX only	Version with RJ 45 Ethernet port
A	014629/802	Basic	Version with RJ 45 Ethernet port
E	014629/803	Standard	Version basic with additional IRIG B
C	014629/801	Full	Version standard with additional optical links

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Table 10: Power supply versions

Number	Code	Name	Description
1	750126/801	U_n = 110 V DC	Operative range 70% to 120% of 110 V DC
2	750126/802	U_n = 220 V DC	Operative range 70% to 120% of 220 V DC
3	750168/801	U_n = 48 V DC to 220 V DC	Operative range 80% of 48 V DC to 120% of 220 V DC (preferred choice)
6	750168/802	U_n = 48 V DC to - 220 V DC	A varnished version of 750168/801

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Table 11: Analog I/O modules

Number	Code	Name	Description
N	none	No analog input or output	Empty analog I/O module slot
A	750211/801	Analog input module 4 - 20 mA	Analog input module for 4 - 20 mA installed, up to 6 inputs
B	750237/801	Analog output module 0(4) - 20 mA	Analog output module for 0(4) - 20 mA installed, up to 4 outputs

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Table 12: Binary I/O modules

Number	Code	Name	Description
1	701952/801	Static I/O	Application in GIS panel with coil supervision by control continuity check
2	701952/802	Static I/O without control continuity check	Static I/O without control continuity check
H	701952/803	Static I/O with TSC	An alternative for 701952/802, where trip coil supervision is requested on PO1 & PO2
5	750132/801	Binary I/O3 - 19-72 V/ 14 V DC, standard	Standard version with 14 V DC treshold value for application in auxiliary circuit with DC voltage range 19-72 V DC
6	750132/803	Binary I/O3 - 19-72 V/ 14 V DC, with static channel	As no. 5 + one static output channel for energy metering
7	750161/801	Binary I/O3 - 19-72 V /14 V DC, interconnected input, standard	As no. 5 + interconnected binary inputs
8	750161/803	Binary I/O3 - 19-72 V/ 14 V DC, interconnected input, with static channel	As no. 5 + interconnected binary inputs + one static output channel for energy metering
9	750132/802	Binary I/O3 - 88-132 V/ 50 V DC, standard	Standard version with 50 V DC treshold value for application in auxiliary circuit with DC voltage range 88 -132 V DC
A	750132/804	Binary I/O3 - 88-132 V/ 50 V DC, with static channel	As no. 9 + one static output channel for energy metering
B	750161/802	Binary I/O3 - 88-132 V/ 50 V DC, interconnected input, standard	As no. 9 + interconnected binary inputs

Table 12: Binary I/O modules

Number	Code	Name	Description
C	750161/804	Binary I/O3 - 88-132 V/ 50 V DC, interconnected input, with static channel	As no. 9 + interconnected binary inputs + one static output channel for energy metering
D	750132/805	Binary I/O3 - 88-132 V/ 72 V DC, standard	Standard version with 72 V DC treshold value for application in auxiliary circuit with DC voltage range 80 -132 V DC
E	750132/806	Binary I/O3 - 88-132 V/ 72 V DC, with static channel	As no. D + one static output channel for energy metering
F	750132/807	Binary I/O3 - 176-264 V/ 143 V DC, standard	Standard version with 143 V DC treshold value for application in auxiliary circuit with DC voltage range 154-264 V DC
G	750132/808	Binary I/O3 - 176-264 V/ 143 V DC, with static channel	As no. F + one static output channel for energy metering

Static I/O: 14 inputs, 7 power outputs, 2 signal outputs and 1 watchdog output.

BIO 3: 14 inputs, 6 power outputs, 2 signal outputs and 1 watchdog output. 750132/xxx boards are preferred ones.

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Binary IO Slot 2: Version of binary I/O, the possible selection depends on the selected version of binary I/O 1. If no binary I/O is needed, the slot can be left empty. The corresponding code can be taken from the table 12.

7 6 A 6 A 3 3 3 03 6 S Z 4 1

Binary IO Slot 3: Version of binary I/O, the possible selection depends on theselected version of binary I/O 1. If no binary I/O is needed, the slot can be leftempty. The corresponding code can be taken from the table 12.

7 6 A 6 A 33 3 03 6 S Z 4 1

Analog Input XX: There are three different types of analog input version which canbe selected as shown in the following tables:

Table 13: Sensors

Number	Code	Description
01	750138/803	Analog Input sensors version

Table 14: Mix of sensors and transformers

Number	Code	Description
10	750170/843	3 sensors + 3 sensors + 1 CT/0.2 A + 1 VT
11	750170/846	3 sensors + 3 VT + 1 CT/0.2 A + 1 VT
12	750170/847	3 sensors + 3 sensors + 1 CT
13	750170/851	3 sensors + 3 sensors + 1 CT+ 1 VT
14	750170/852	3 sensors + 3 sensors + 1 CT/0.2 A

Table 14: Mix of sensors and transformers

Number	Code	Description
15	750170/853	3 sensors + 3 sensors + 1 VT + 1 VT
16	750170/854	3 sensors + 3 CT + 1 CT/0.2 A + 1 VT
17	750170/855	3 sensors + 3 CT + 1 CT/0.2 A + 1 CT/0.2 A

Table 15: Mix of transformers

Number	Code	Description
30	750170/804	3 CT + 3 VT + 1 CT/0.2 A + 1 VT
31	750170/806	3 VT + 3 VT + 1 CT/0.2 A + 1 CT/0.2 A
32	750170/807	3 CT + 3 CT
33	750170/809	3 CT + 3 CT + 1 CT/0.2 A+ 1 VT
34	750170/812	3 VT + 3 VT + 1 VT
35	750170/817	3 CT + 3 VT + 1 CT
36	750170/819	3 CT + 3 VT + 1 CT + 1 VT
37	750170/821	3 CT + 0 VT + 1 CT
38	750170/822	3 CT + 0 VT + 1 CT/0.2 A
39	750170/825	3 CT + 3 VT + 1 CT/0.2 A + 1 CT/0.2 A
40	750170/826	3 CT + 3 VT + 1 VT + 1 VT
41	750170/827	3 CT + 3 CT + 1 CT + 1 CT
42	750170/828	3 CT + 3 CT + 1 CT + 1 VT
43	750170/824	3 CT + 3 VT + 1 CT + 1 CT

7 6 A 6 A 33 3 03 6 S Z 4 1

Table 16: Communication (With optional coomunication module)

Number	Code	Name	Description
N	None	Without communication	No communication is requested
1	750079/801	Modbus RTU / SPA RS 485	To be used for Modbus RTU or for SPA protocol
2	750079/802	Modbus RTU / SPA glass fibre with ST connectors	To be used for Modbus RTU or for SPA protocol
3	701842/801	SPA plastic fibre with HFBR 4503 connectors	To be used for SPA protocol
4	701842/802	SPA glass fibre with SMA connectors	
5	701842/803	SPA glass fibre with ST connectors	To be used for SPA protocol
6	750071/801	LON-LAG 1.4	To be used for ABB LON per lag 1.4 protocol
7	750071/803	IEC 60870-5-103 with ST connectors	To be used for IEC 60870-5-103 protocol
E	1VCR009634001	IEC 61850 / MODBUS TCP with RJ45	To be used for IEC 61850-8-1 and MODBUS TCP protocol
F	1VCR009634002	IEC 61850 / MODBUS TCP with LC optical connector	To be used for IEC 61850-8-1 and MODBUS TCP protocol

7 6 A 6 A 33 3 03 6 S Z 4 1

Table 17: Enclosure versions

Number	Code	Name	Description
S	750154/801	Normal base unit	Normal version
W	750102/801	Wide base unit	Wide version

7 6 A 6 A 33 3 03 6 S Z 4 1

Table 18: HMI variations

Number	Code	Name	Description
N	none	No HMI	
S	029395A0003	HMI V5[1)] - IEC	Operative range 48 V dc to 240 V dc (Direct replacement for A & B)
T	029395A0007	HMI V5 - IEC, external cover	Operative range 48 V dc to 240 V dc (Direct replacement for C & D)
U	029395A0011	HMI V5 - IEC, Chinese	Operative range 48 V dc to 240 V dc (Direct replacement for E & F)
V	029395A0015	HMI V5 - IEC, Chinese, external cover	Operative range 48 V dc to 240 V dc (Direct replacement for G & H)

1) V5 = With Unicode fonts

7 6 A 6 A 33 3 03 6 S Z 4 1

Table 19: Connection cables between the HMI and the base unit[1)]

Number	Code	Name	Description
N	none	No cable	No cable
2	750142/817	HMI cable - 2.5 m	2.5 m cable with corresponding connectors
3	750142/818	HMI cable - 3.5 m	3.5 m cable with corresponding connectors
4	750142/819	HMI cable - 4.5 m	4.5 m cable with corresponding connectors

7 6 A 6 A 33 3 03 6 S Z 4 1

Table 20: Software licenses 1)

Number	Code	Name	Description
1	1MRS090002	Software base license	Software level : Base
2	1MRS090003	Software high license	Software level : High
3	1MRS090004	Software basic low license	Software level : Basic Low
4	1MRS090005	Software basic license	Software level : Basic
5	1MRS090006	Software multi low license	Software level : Multi Low
6	1MRS090007	Software multi license	Software level : Multi
7	1MRS090008	Software differential license	Software level : Differential
8	1MRS090009	Software distance license	Software level : Distance

1) Limitation of protection functionality by software license. Please contact your local ABB organization for more detailed information.

Software level Base can only be ordered by ABB switchgear companies and is the same level as software level Distance.

Table 21: SW tool licenses

Code	Description
1MRS 151022	REF 542plus Operating Tool (Latest tools are available in ABB library)
1MRS 151062	REF 542plus Configuration Tool (Latest tools are available in ABB library)

Please use the key below to generate the type designation. The code numbers in the following example are not complete and should be taken from the corresponding tables above.

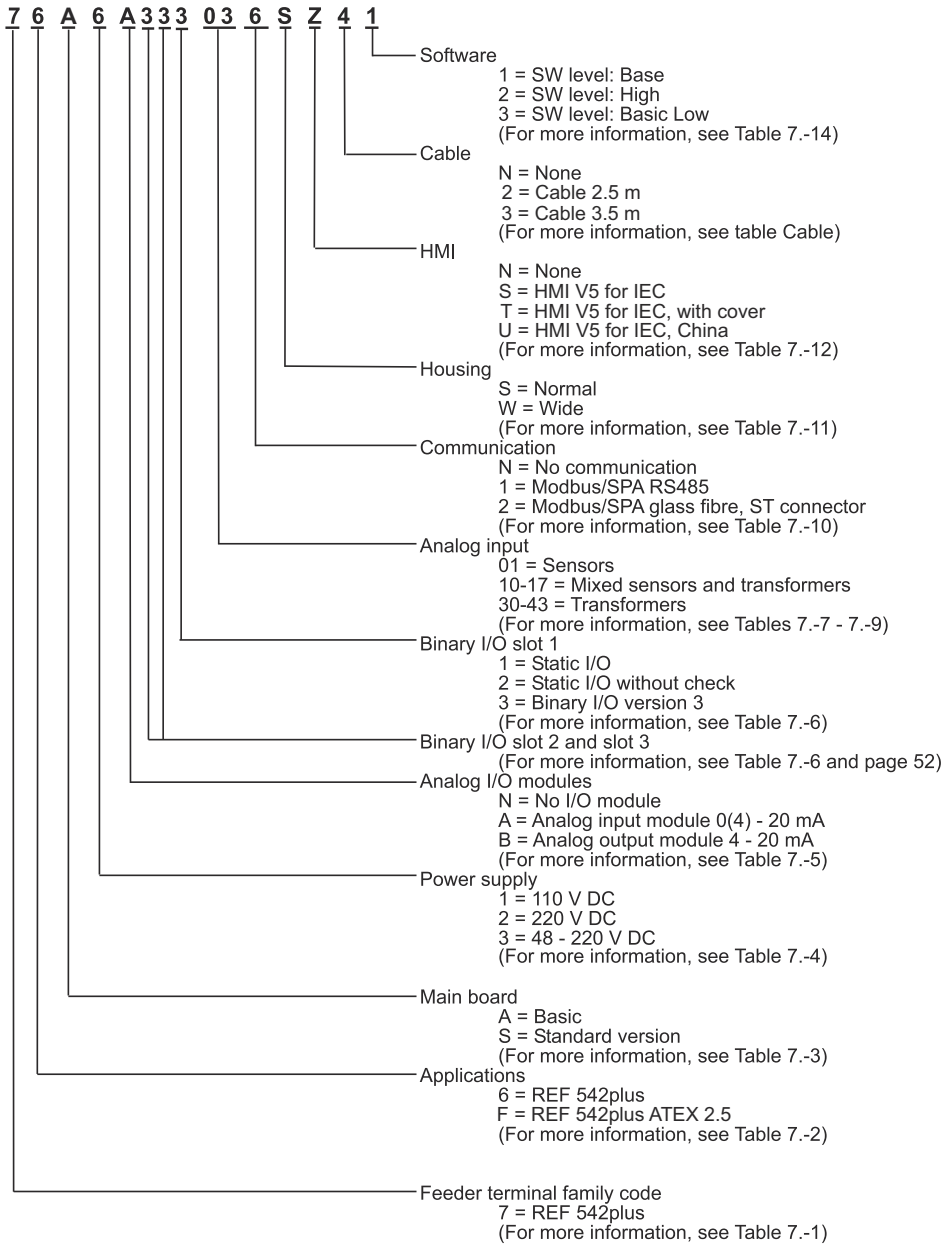


Fig. 14 The key for generating the type designation

References

Table 22: Product documentation

Name of the manual	Document ID
Installation and Commission (Manual Part 3)	1VTA100004
REF 542plus, Operator's Manual	1MRS755869
REF 542plus, Technical Reference Manual	1MRS755859
Protection Functions, Configuration and Settings	1MRS755860
Communication (Manual Part 4)	1VTA100005
Modbus RTU, Technical Reference	1MRS755868
Configuration and Operating Tool, User's Guide	1MRS755871
REF 542plus, SCL Tool, configuration manual	1MRS756342
iButton Programmer User's Guide	1MRS755863
Motor Protection with ATEX-Certification, Appl.Guide	1MRS755862
Web Interface, Installation Manual	1MRS755865
Web Interface, Operator's Manual	1MRS755864
IEC 61850 PIXIT	1MRS756360
IEC 61850 Conformance Statement	1MRS756361
IEC61850 TISSUES Conformance Statement	1MRS756362
Lifecycle Service Tool	1MRS756725

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