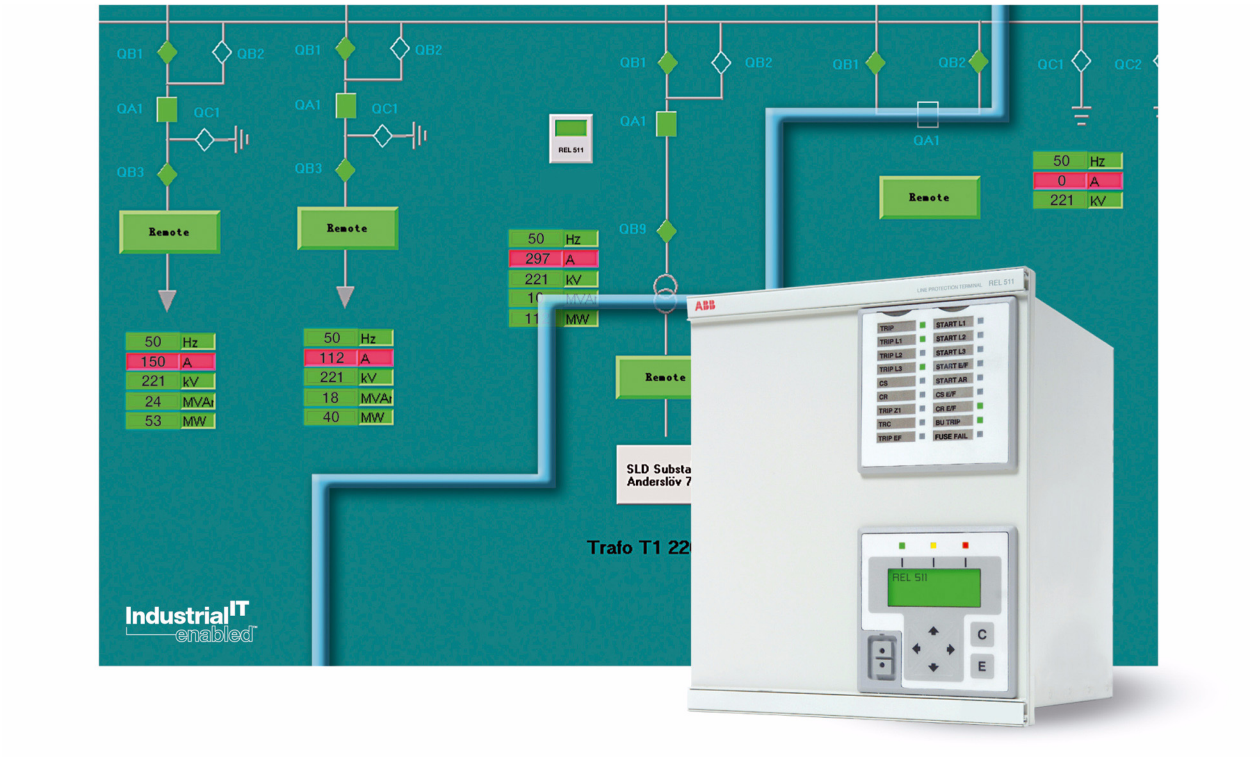
Installation and commissioning manual

Protect^{IT} Line distance protection terminal for solidly earthed systems
REL 511-C1*2.5



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Line distance protection terminal for solidly earthed systems

REL 511-C1*2.5

About this manual

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Chapter 1 Introduction

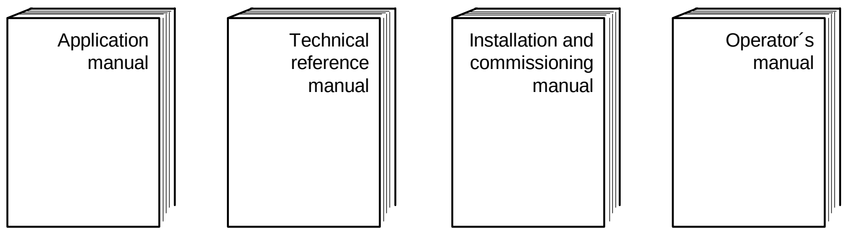
About this chapter

This chapter introduces the user to the manual.

1 Introduction to the installation and commissioning manual

1.1 About the complete set of manuals for a terminal

The users manual (UM) is a complete set of four different manuals:



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The Application Manual (AM) contains descriptions, such as application and functionality descriptions as well as setting calculation examples sorted per function. The application manual should be used when designing and engineering the protection terminal to find out when and for what a typical protection function could be used. The manual should also be used when calculating settings and creating configurations.

The Technical Reference Manual (TRM) contains technical descriptions, such as function blocks, logic diagrams, input and output signals, setting parameter tables and technical data sorted per function. The technical reference manual should be used as a technical reference during the engineering phase, installation and commissioning phase, and during the normal service phase.

The Operator's Manual (OM) contains instructions on how to operate the protection terminal during normal service (after commissioning and before periodic maintenance tests). The operator's manual can be used to find out how to handle disturbances or how to view calculated and measured network data in order to determine the cause of a fault.

The Installation and Commissioning Manual (ICM) contains instructions on how to install and commission the protection terminal. The manual can also be used as a reference if a periodic test is performed. The manual covers procedures for mechanical and electrical installation, energizing and checking of external circuitry, setting and configuration as well as verifying settings and performing a directional test. The chapters and sections are organized in the chronological order (indicated by chapter/section numbers) in which the protection terminal should be installed and commissioned.

1.2 About the installation and commissioning manual

The installation and commissioning manual contains the following chapters:

- The chapter *"Safety information"* presents warning and note signs, which the user should pay attention to.

- The chapter *“Overview”* gives an overview over the major tasks when installing and commissioning the terminal.
- The chapter *“Unpacking and checking the terminal”* contains instructions on how to receive the terminal.
- The chapter *“Installing the terminal”* contains instructions on how to install the terminal.
- The chapter *“Checking the external circuitry”* contains instructions on how to check that the terminal is properly connected to the protection system.
- The chapter *“Energising the terminal”* contains instructions on how to start-up the terminal.
- The chapter *“Setting and configuring the terminal”* contains instructions on how to download settings and configuration to the terminal.
- The chapter *“Establishing connection and verifying the SPA/IEC-communication”* contains instructions on how to enter SPA/IEC settings and verifying the SPA/IEC communication.
- The chapter *“Establishing connection and verifying the LON communication”* contains a reference to another document.
- The chapter *“Verifying settings by secondary injection”* contains instructions on how to verify that each included function operates correctly according to the set values.
- The chapter *“Primary injection testing”* describes a test with primary current through the protected zone.
- The chapter *“Testing the protection system”* contains instructions on how to test that the terminal is in contact with the primary system.
- The chapter *“Fault tracing and repair”* contains instructions on how to fault trace.

1.3 Intended audience

1.3.1 General

The installation and commissioning manual is addressing the installation, commissioning and maintenance personnel responsible for taking the protection into normal service and out of service.

1.3.2 Requirements

The installation and commissioning personnel must have a basic knowledge in handling electronic equipment. The commissioning and maintenance personnel must be well experienced in using protection equipment, test equipment, protection functions and the configured functional logics in the protection.

1.4 Related documents

Documents related to REL 511-C1*2.5	Identity number
Operator's manual	1MRK 506 196-UEN
Installation and commissioning manual	1MRK 506 198-UEN
Technical reference manual	1MRK 506 197-UEN
Application manual	1MRK 506 199-UEN
Buyer's guide	1MRK 506 195-BEN

1.5 Revision notes

Revision	Description
B	Minor updates in chapter: • Configuring the 56/64 kbit data communication modules / Configuring the fibre optical modem • Verifying settings by secondary injection / Line differential protection, phase segregated (DIFL)

1.6 Acronyms and abbreviations

AC	Alternating Current
ACrv2	Setting A for programmable overvoltage IDMT curve, step 2
A/D converter	Analog to Digital converter
ADBS	Amplitude dead-band supervision
AIM	Analog input module
ANSI	American National Standards Institute
ASCT	Auxiliary summation current transformer
ASD	Adaptive Signal Detection
AWG	American Wire Gauge standard
BIM	Binary input module
BLKDEL	Block of delayed fault clearing
BOM	Binary output module
BR	Binary transfer receive over LDCM
BS	British Standard
BSR	Binary Signal Receive (SMT) over LDCM
BST	Binary Signal Transmit (SMT) over LDCM
BT	Binary Transfer Transmit over LDCM

C34.97	
CAN	Controller Area Network. ISO standard (ISO 11898) for serial communication
CAP 531	Configuration and programming tool
CB	Circuit breaker
CBM	Combined backplane module
CCITT	Consultative Committee for International Telegraph and Telephony. A United Nations sponsored standards body within the International Telecommunications Union.
CCS	Current circuit supervision
CEM	Controller area network emulation module
CIM	Communication interface module
CMPPS	Combined Mega Pulses Per Second
CO cycle	Close-Open cycle
Co-directional	Way of transmitting G.703 over a balanced line. Involves two twisted pairs making it possible to transmit information in both directions
Contra-directional	Way of transmitting G.703 over a balanced line. Involves four twisted pairs of with two are used for transmitting data in both directions, and two pairs for transmitting clock signals
CPU	Central Processor Unit
CR	Carrier Receive
CRC	Cyclic Redundancy Check
CRL	POR carrier for WEI logic
CS	Carrier send
CT	Current transformer
CT1L1	Input to be used for transmit CT group 1line L1 in signal matrix tool
CT1L1NAM	Signal name for CT-group 1line L1 in signal matrix tool
CT2L3	Input to be used for transmission of CT-group 2 line L3 to remote end
CT2N	Input to be used for transmission of CT-group 2 neutral N to remote end.
CVT	Capacitive voltage transformer
DAR	Delayed auto-reclosing
db	dead band
DBDL	Dead bus dead line
DBLL	Dead bus live line
DC	Direct Current
DIN-rail	Rail conforming to DIN standard
DIP-switch	Small switch mounted on a printed circuit board

DLLB	Dead line live bus
DSP	Digital signal processor
DTT	Direct transfer trip scheme
EHV network	Extra high voltage network
EIA	Electronic Industries Association
EMC	Electro magnetic compatibility
ENGV1	Enable execution of step one
ENMULT	Current multiplier used when THOL is used for two or more lines
EMI	Electro magnetic interference
ESD	Electrostatic discharge
FOX 20	Modular 20 channel telecommunication system for speech, data and protection signals
FOX 512/515	Access multiplexer
FOX 6Plus	Compact, time-division multiplexer for the transmission of up to seven duplex channels of digital data over optical fibers
FPGA	Field Programmable Gate Array
FRRATED	Rated system frequency
FSMPL	Physical channel number for frequency calculation
G.703	Electrical and functional description for digital lines used by local telephone companies. Can be transported over balanced and unbalanced lines
G.711	Standard for pulse code modulation of analog signals on digital lines
GCM	Communication interface module with carrier of GPS receiver module
GI	General interrogation command
GIS	Gas insulated switchgear.
GOOSE	Generic Object Orientated Substation Event
GPS	Global positioning system
GR	GOOSE Receive (interlock)
HDLC protocol	High level data link control, protocol based on the HDLC standard
HFBR connector type	Fibre connector receiver
HMI	Human-Machine Interface
HSAR	High-Speed Auto-Reclosing
HV	High voltage
HVDC	High voltage direct current
HysAbsFreq	Absolute hysteresis for over and under frequency operation
HysAbsMagn	Absolute hysteresis for signal magnitude in percentage of Ubase
HysRelMagn	Relative hysteresis for signal magnitude

HystAbs	Overexcitation level of absolute hysteresis as a percentage
HystRel	Overexcitation level of relative hysteresis as a percentage
IBIAS	Magnitude of the bias current common to L1, L2 and L3
IDBS	Integrating dead-band supervision
IDMT	Minimum inverse delay time
IDMTtmin	Inverse delay minimum time in seconds
IdMin	Operational restrictive characteristic, section 1 sensitivity, multiple Ibase
IDNSMAG	Magnitude of negative sequence differential current
Idunre	Unrestrained prot. limit multiple of winding1 rated current
ICHARGE	Amount of compensated charging current
IEC	International Electrical Committee
IEC 186A	
IEC 60044-6	IEC Standard, Instrument transformers – Part 6: Requirements for protective current transformers for transient performance
IEC 60870-5-103	Communication standard for protective equipment. A serial master/slave protocol for point-to-point communication
IEEE	Institute of Electrical and Electronics Engineers
IEEE 802.12	A network technology standard that provides 100 Mbits/s on twisted-pair or optical fiber cable
IEEE P1386.1	PCI Mezzanine Card (PMC) standard for local bus modules. References the CMC (IEEE P1386, also known as Common Mezzanine Card) standard for the mechanics and the PCI specifications from the PCI SIG (Special Interest Group) for the electrical
EMF	Electro magnetic force
IED	Intelligent electronic device
I-GIS	Intelligent gas insulated switchgear
IL1RE	Real current component, phase L1
IL1IM	Imaginary current component, phase L1
IminNegSeq	Negative sequence current must be higher than this to be used
INAMPL	Present magnitude of residual current
INSTMAGN	Magnitude of instantaneous value
INSTNAME	Instance name in signal matrix tool
IOM	Binary Input/Output module
IPOSIM	Imaginary part of positive sequence current
IPOSRE	Real component of positve sequence current
IP 20	Enclosure protects against solid foreign objects 12.5mm in diameter and larger but no protection against ingression of liquid according to IEC60529. Equivalent to NEMA type 1.

IP 40	Enclosure protects against solid foreign objects 1.0mm in diameter or larger but no protection against ingression of liquid according to IEC60529.
IP 54	Degrees of protection provided by enclosures (IP code) according to IEC 60529. Dust protected. Protected against splashing water. Equivalent to NEMA type 12.
Ip>block	Block of the function at high phase current in percentage of base
IRVBLK	Block of current reversal function
IRV	Activation of current reversal logic
ITU	International Telecommunications Union
k2	Time multiplier in IDMT mode
kForIEEE	Time multiplier for IEEE inverse type curve
LAN	Local area network
LIB 520	
LCD	Liquid chrystal display
LDCM	Line differential communication module
LDD	Local detection device
LED	Light emitting diode
LNT	LON network tool
LON	Local operating network
MAGN	Magnitude of deadband value
MCB	Miniature circuit breaker
MCM	Mezzanine carrier module
MIM	Milliampere Input Module
MIP	
MPPS	
MPM	Main processing module
MV	Medium voltage
MVB	Multifunction vehicle bus. Standardized serial bus originally developed for use in trains
MVsubEna	Enable substitution
NegSeqROA	Operate angle for internal/external negative sequence fault discriminator.
NSANGLE	Angle between local and remote negative sequence currents
NUMSTEP	Number of steps that shall be activated
NX	
OCO cycle	Open-Close-Open cycle
PCI	Peripheral Component Interconnect

PCM	Pulse code modulation
PISA	Process interface for sensors & actuators
PLD	Programmable Logic Device
PMC	
POTT	Permissive overreach transfer trip
PPS	Precise Positioning System
Process bus	Bus or LAN used at the process level, that is, in near proximity to the measured and/or controlled components
PSM	Power supply module
PST	Parameter setting tool
PT ratio	Potential transformer or voltage transformer ratio
PUTT	Permissive underreach transfer trip
R1A	Source resistance A (near end)
R1B	Source resistance B (far end)
RADSS	Resource Allocation Decision Support System
RASC	Synchrocheck relay, from COMBIFLEX range.
RCA	Functionality characteristic angle
REVAL	Evaluation software
RFPP	Resistance of phase-to-phase faults
RFPE	Resistance of phase-to-earth faults
RISC	Reduced instruction set computer
RMS value	Root mean square value
RS422	A balanced serial interface for the transmission of digital data in point-to-point connections
RS485	Serial link according to EIA standard RS485
RS530	A generic connector specification that can be used to support RS422, V.35 and X.21 and others
RTU	Remote Terminal Unit
RTC	Real Time Clock
SA	Substation Automation
SC	Switch or push-button to close
SCS	Station control system
SLM	Serial communication module. Used for SPA/LON/IEC communication
SMA connector	Sub Miniature version A connector
SMS	Station monitoring system
SPA	Strömberg Protection Acquisition, a serial master/slave protocol for point-to-point communication

SPGGIO	Single Point Gxxxxx Generic Input/Output
SRY	Switch for CB ready condition
ST3UO	RMS voltage at neutral point
STL1	Start signal from phase L1
ST	Switch or push-button to trip
SVC	Static VAr compensation
t1 1Ph	Open time for shot 1, single phase
t1 3PhHS	Open time for shot 1, high speed reclosing three phase
tAutoContWait	Wait period after close command before next shot
tCBCLosedMin	Minimum time that the circuit breaker must be closed before new sequence is permitted
tExtended t1	Open time extended by this value if Extended t1 is true
THL	Thermal Overload Line cable
THOL	Thermal overload
tInhibit	Reset reclosing time for inhibit
tPulse	Pulse length for single command outputs
TP	Logic Pulse Timer
tReporting	Cycle time for reporting of counter value
tRestore	Restore time delay
TCS	Trip circuit supervision
TNC connector	Type of bayonet connector, like BNC connector
TPZ, TPY, TPX, TPS	Current transformer class according to IEC
tReclaim	Duration of the reclaim time
TRIPENHA	Trip by enhanced restrained differential protection
TRIPRES	Trip by restrained differential protection
TRL1	Trip signal from phase 1
truck	Isolator with wheeled mechanism
tSync	Maximum wait time for synchrocheck OK
TTRIP	Estimated time to trip (in minutes)
UBase	Base setting for phase-phase voltage in kilovolts
U/I-PISA	Process interface components that delivers measured voltage and current values
UNom	Nominal voltage in % of UBase for voltage based timer
UPS	Measured signal magnitude (voltage protection)
UTC	Coordinated Universal Time. A coordinated time scale, maintained by the Bureau International des Poids et Mesures (BIPM), which forms the basis of a coordinated dissemination of standard frequencies and time signals

V.36	Same as RS449. A generic connector specification that can be used to support RS422 and others
VDC	Volts Direct Current
WEI	Week-end infeed logic
VT	Voltage transformer
VTSZ	Block of trip from weak-end infeed logic by an open breaker
X1A	Source reactance A (near end)
X1B	Source reactance B (far end)
X1L	Positive sequence line reactance
X.21	A digital signalling interface primarily used for telecom equipment
XLeak	Winding reactance in primary ohms
XOL	Zero sequence line reactance
ZCOM-CACC	Forward overreaching zone used in the communication scheme
ZCOM-CR	Carrier Receive Signal
ZCOM-TRIP	Trip from the communication scheme
ZCOM-LCG	Alarm Signal LIne-check Guard

Chapter 2 Safety information

About this chapter

This chapter contains safety information. Warning signs are presented which attend the user to be careful during certain operations in order to avoid human injuries or damage to equipment

1 Warning signs

Warning!

Strictly follow the company and country safety regulations. Working in a high voltage environment requires serious approach to avoid human injuries and damage to equipment.

Warning!

Do not touch circuitry during operation. Potentially lethal voltages and currents are present.

Warning!

Always avoid to touch the circuitry when the cover is removed. The product contains electronic circuitries which can be damaged if exposed to static electricity (ESD). The electronic circuitries also contain high voltage which is lethal to humans.

Warning!

Always use suitable isolated test pins when measuring signals in open circuitry. Potentially lethal voltages and currents are present.

Prohibition!

Never connect or disconnect a wire and/or a connector to or from a IED during normal operation. Hazardous voltages and currents are present that may be lethal. Operation may be disrupted and IED and measuring circuitry may be damaged.

Warning!

Always connect the IED to protective earth, regardless of the operating conditions. This also applies to special occasions such as bench testing, demonstrations and off-site configuration. Operating the IED without proper earthing may damage both IED and measuring circuitry and may cause injuries in case of an accident.

Warning!

Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer’s secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.

Warning!

Never remove any screw from a powered IED or from a IED connected to powered circuitry. Potentially lethal voltages and currents are present.

2 Caution signs

Caution!

Always transport modules using certified conductive bags. Always handle modules using a conductive wrist strap connected to protective ground and on a suitable antistatic surface. Electrostatic discharge (ESD) may cause damage to the module.

Caution!

Do not connect live wires to the IED. Internal circuitry may be damaged

Caution!

Always use a conductive wrist strap connected to protective ground when replacing modules. Electrostatic discharge (ESD) may damage the module and IED circuitry.

Caution!

Take care to avoid electrical shock if accessing wiring and connection IEDs when installing and commissioning.

Caution!

Changing the active setting group will inevitably change the IED’s operation. Be careful and check regulations before making the change.

3 Note signs

Note!

The protection assembly is designed for a maximum continuous current of four times rated value.

Note!

Activating the setting lockout function, which prevents unauthorised changes of the settings, without proper configuration may seriously affect the IED's operation.

Chapter 3 Overview

About this chapter

This chapter introduces the user to the installation and commissioning tasks.

1 Commissioning and installation overview

The settings for each function must be calculated before the commissioning task can start. A configuration, made in the configuration and programming tool, must also be available if the terminal does not have a factory configuration downloaded.

The terminal is unpacked and visually checked. It is preferably mounted in a cubicle or on a wall. The connection to the protection system has to be checked in order to verify that the installation was successful.

The installation and commissioning task starts with configuring the digital communication modules, if included. The terminal can then be configured and set, which means that settings and a configuration has to be applied if the terminal does not have a factory configuration downloaded. Then the operation of each included function according to applied settings has to be verified by secondary injection. A complete check of the configuration can then be made. A conformity test of the secondary system has also to be done. When the primary system has been energised a directionality check should be made.

Chapter 4 Unpacking and checking the terminal

About this chapter

This chapter contains instructions on how to receive the terminal.

1 Receiving, unpacking and checking

Procedure

1. **Remove the transport casing.**
2. **Visually inspect the terminal.**
3. **Check that all items are included in accordance with the delivery documents.**

   The user is requested to check that all software functions are included according to the delivery documents after the terminal has been energised.

4. **Check for transport damages.**

   In case of transport damage appropriate action must be taken against the latest carrier and the nearest ABB office or representative should be informed. ABB should be notified immediately if there are any discrepancies in relation to the delivery documents.

   Store the terminal in the original transport casing in a dry and dust free place, if the terminal is not to be installed or commissioned immediately. Observe the environmental requirements stated in the technical data.

Chapter 5 Installing the terminal

About this chapter

This chapter describes how to install the terminal.

1 Overview

The mechanical and electrical environmental conditions at the installation site must be within permissible range according to the technical data of the terminal. Dusty, damp places, places liable to rapid temperature variations, powerful vibrations and shocks, surge voltages of high amplitude and fast rise time, strong induced magnetic fields or similar extreme conditions should be avoided.

Sufficient space must be available in front of and at rear of the terminal to allow access for maintenance and future modifications. Flush mounted terminals should be mounted so that terminal modules can be added and replaced without excessive demounting.

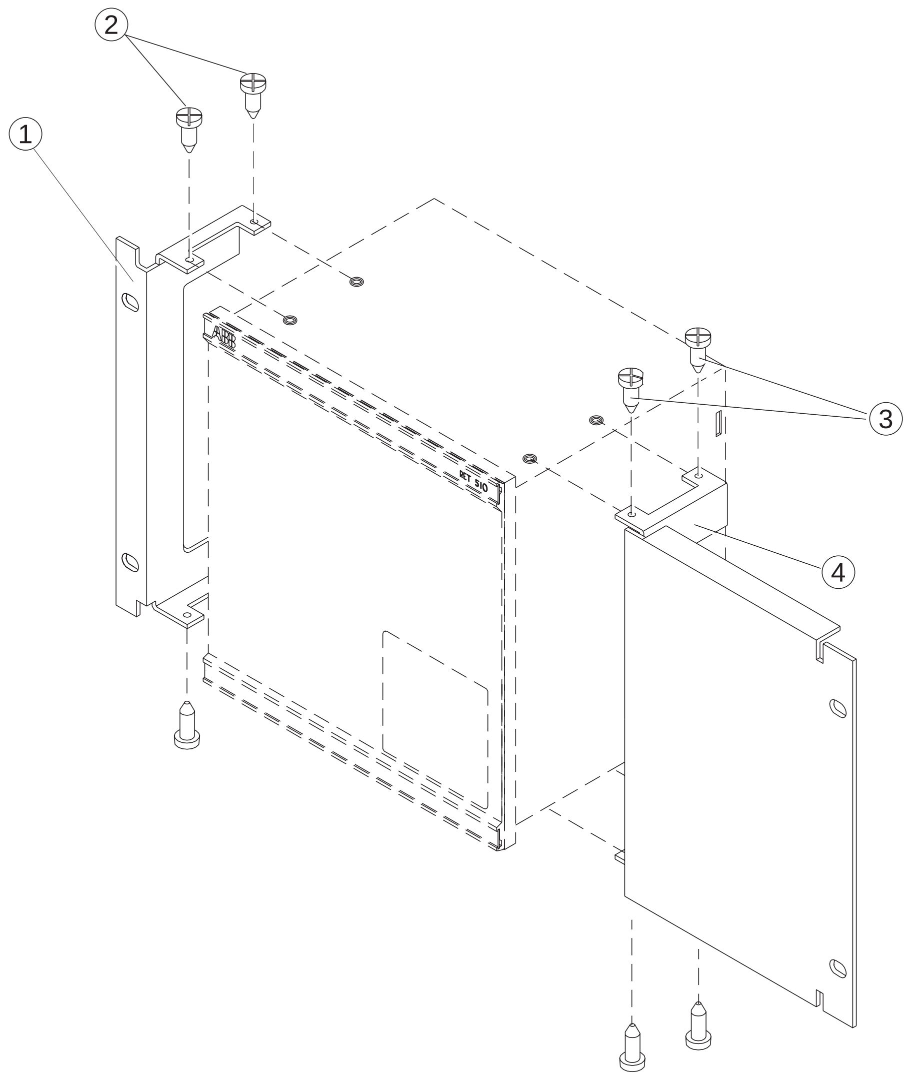
2 Mounting the terminal

Most of the REx 5xx terminals can be rack, flush, semi-flush or wall mounted with the use of different mounting kits. An additional box of type RHGS can be mounted to one side of a 1/2 or 3/4 terminal. The 19-inch 1/1 wide terminal cannot be semi-flush mounted because the mounting distance frame will cover the ventilation openings at the top and bottom.

A suitable mounting kit is available. Mounting kits include instruction sheets and all parts needed including screws. The following mounting kits are available:

- 19-inch rack mounting kits, 1/2, 3/4 and 1/1 terminal width variants. See section 2.1 "Mounting in a 19-inch rack".
- Side-by-side mounting kit. See section 2.2 "Mounting in a 19-inch rack with an additional box type RHGS".
- Flush mounting kit. See section 2.3 "Mounting in a flush or semi-flush installation".
- Semi-flush mounting kit. See section 2.3 "Mounting in a flush or semi-flush installation".
- Wall mounting kit. See section 2.4 "Mounting on a wall".

2.1 Mounting in a 19-inch rack



PosNo	Description
1 and 4	Mounting angle
2 and 3	TORX T20 screws

Figure 1: 19-inch rack mounting

Procedure

1. **Carefully fasten the mounting angles to the sides of the terminal.**

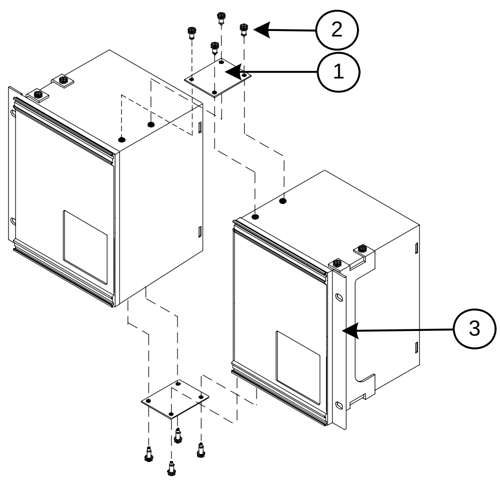
   Use the TORX T20 screws available in the mounting kit.

2. **Place the terminal assembly in the rack.**
3. **Fasten the mounting angles with appropriate screws.**

2.2 Mounting in a 19-inch rack with an additional box type RHGS

Make sure a side-by-side mounting kit and a suitable 19-inch rack mounting kit are available before proceeding.

Assemble the two terminals by using a side-by-side mounting kit. Then mount the brackets and install the assembled terminals in the rack as described in section 2.1 "Mounting in a 19-inch rack".



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PosNo	Description
1	Side-by-side mounting plate
2	Screws (TORX T20)
3	Mounting angle

Figure 2: Side-by-side assembly

Procedure

1. **Place the two terminals next to each other on a flat surface.**

2. **Fasten a side-by-side mounting plate (PosNo 1).**

   Use four of the delivered screws.

3. **Carefully turn the two terminals up-side down.**
4. **Fasten the second side-by-side mounting plate.**

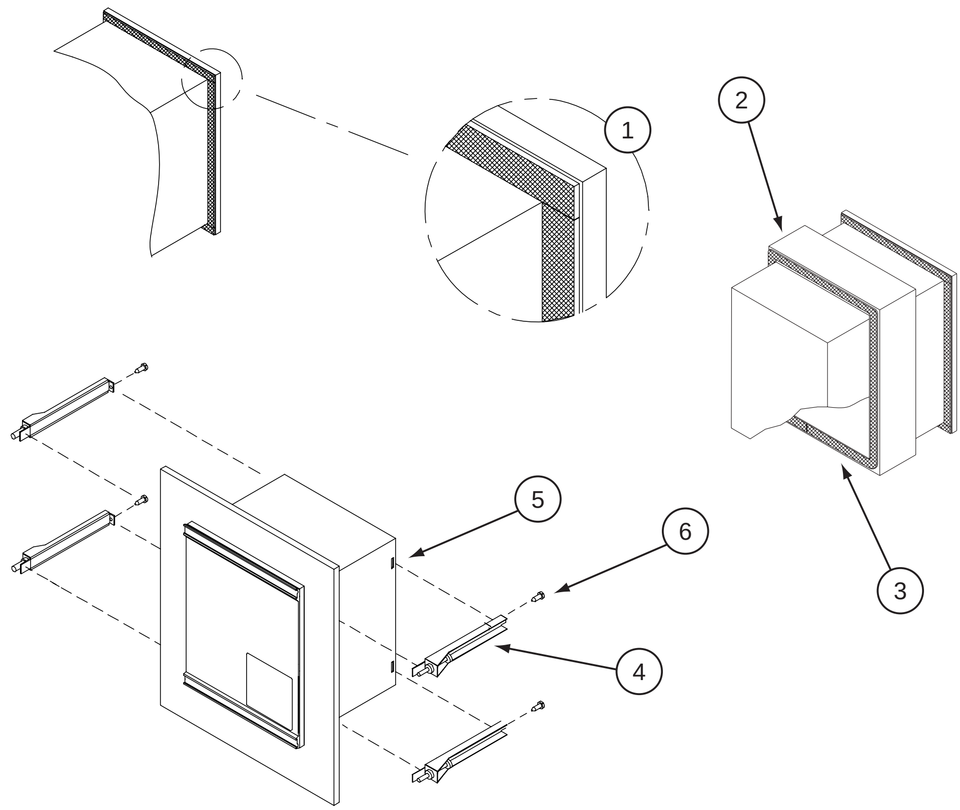
   Use the remaining four screws.

5. **Follow the instructions in section 2.1 "Mounting in a 19-inch rack" to mount the mounting angles (PosNo 5) and install the side-by-side assembly in the rack.**

2.3 Mounting in a flush or semi-flush installation

Make sure a flush or semi-flush mounting kit is available before proceeding.

The procedure for flush and semi-flush mounting is mainly the same. In semi-flush mounts a distance frame is added. The delivered mounting seal is only necessary to fulfil IP 54.



PosNo	Description
1	Sealing strip
2	Distance frame (only for semi-flush)
3	Sealing strip for distance frame (only for semi-flush)
4	Side holder
5	Groove
6	Locking screw (TORX T10)

Figure 3: Flush and semi-flash mounting

Note!

Flush or semi-flush mount cannot be used for side-by-side mounted terminals when IP 54 must be fulfilled.

Procedure

1. **Cut the sealing strip in appropriate lengths.**

   The strip is delivered with the mounting kit. In the semi-flush mounting kit two strips are delivered, one for the terminal and one self-adhering for the distance frame. The length of the strip is enough for the largest available terminal.

   Cut the strip into four, one part for each side of the terminal. When cutting, make sure no gaps will be present between each part. Preferably, seal the joints at the corners (posNo 1).

   Repeat the procedure for the self-adhering strip which are to be adhered to the distance frame.

2. **Dispose the strip remains.**

   The remains should be source separated as soft plastic.

3. **Carefully press the cut strips into the front panel groove.**

4. **Adhere the cut strips (posNo 3) to the edge of the distance frame (posNo 2).**

   semi-flush mounting only.

5. **Make a panel cut-out.**

   See the Technical reference manual for cut-out dimensions.

6. **Insert the terminal into the cut-out.**

7. **Add and lock the side holders (PosNo 4) to the terminal.**

   Thread a side holder into the groove (posNo 5) at the back end of the terminal. Insert and lightly fasten the locking screw (posNo 6). Next, thread a side holder on the other side of the terminal, and lightly fasten its locking screw.

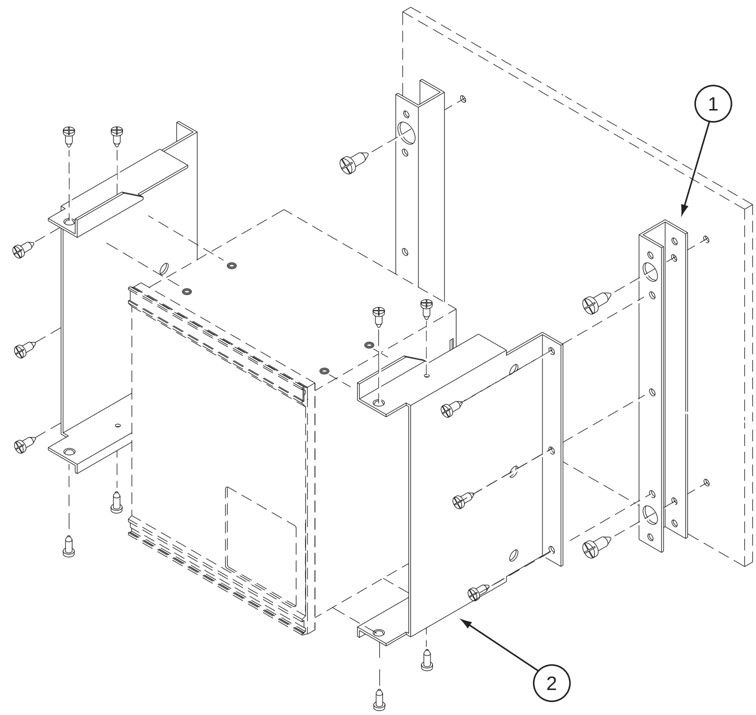
   Repeat this with the remaining two side holders.

8. **Lock the terminal to the cut-out.**

   Firmly tighten the locking screws. It is important that all four side holder locking screws are tightened the same in order to maintain a good and even seal in IP 54 environments.

2.4 Mounting on a wall

The mounting bars are prepared for adding DIN-rails or equivalent above and below the mounted terminal. If used, make sure all necessary parts such as rails and terminal blocks are available before starting. Make sure the wall mounting kit is available.



PosNo	Description
1	Mounting bar
2	Side plate

Figure 4: Wall mounting

2.4.1 Mounting the terminal on a wall

Procedure

1. **Mount the bars (posNo 1) onto the wall.**

   See the Technical reference manual for measurements.

   Depending on the wall different preparations may be needed, like drilling and inserting plastic or expander plugs (concrete/plasterboard walls) or threading (metal sheet wall).

2. **Mount the DIN-rail(s) on the mounting bars.**
3. **Mount the terminal blocks on the DIN-rail(s).**

   It is much easier to do this without the unit in place.

4. **Make all external electrical connections to the terminal blocks.**

   It is much easier to do this without the unit in place.

5. **Mount the side plates (posNo 2) to the terminal.**

6. **Mount the terminal to the mounting bars.**

2.4.2 Preparing a wall mounted terminal for electrical installation

Procedure

1. **Remove all screws from one side plate.**

2. **Remove two screws from the other side plate.**

3. **Careful swing the terminal out from the wall.**

   See figure 5.

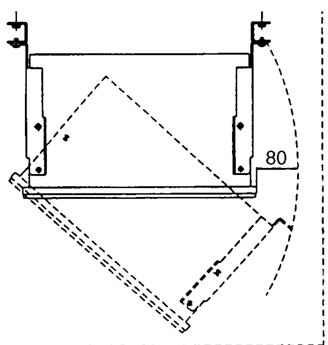


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Figure 5: View from above over a wall mounted terminal that is prepared for electrical connection.

3 Making the electrical connections

Always make sure established guidelines for this type of terminal is followed during installation. When necessary use screened twisted-pair cables to minimize susceptibility. Otherwise use any kind of regular nonscreened tinned cable or equivalent.

When using screened cabling always use 360° full screen cable bushings to ensure screen coupling. Ensure that all signals of a single circuit are in the same single cable. Avoid mixing current and voltage measuring signals in the same cable. Also use separate cables for control and measuring circuits.

Note!

Screened and twisted pair cables are a requirement for galvanic communications in application with 56/64 kbit/s. The screen must be earthed according to figures in the sections "Making the screen connection" and "Installing the communication cables".

3.1 Connecting the CT circuits

CTs are connected using back-side mounted screw connectors.

Use a solid conductor with a cross section area between 2.5-6 mm^2 (AWG14-10) or a stranded conductor with a cross section area between 2.5-4 mm^2.

If the terminal is equipped with a test-switch of type RTXP 24 COMBIFLEX wires with 20 A sockets must be used to connect the CT circuits.

3.2 Connecting the auxiliary power, VT and signal connectors

Auxiliary power, VTs and signals are connected using COMBICON (Phoenix technology) plug-in screw connectors.

Procedure

1. **Connect signals to the COMBICON plug.**
2. **Plug the connector to the corresponding back-side mounted receptable.**
3. **Lock the plug to the receptable by fastening the lock screws.**

   Use a solid or stranded conductor with a cross section area between 0.5-2.5 mm^2 (AWG20-14). Use a ferrule with plastic collar to connect two conductors, cross section area between 0.5-1.5 mm^2 (AWG20-16).

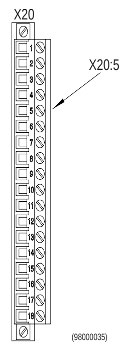
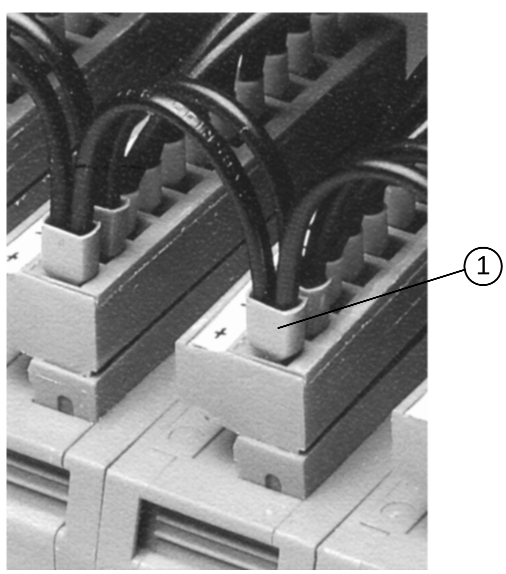


Figure 6: Voltage connector, showing connection point X20:5



Where: 1 is ferrule

Figure 7: Connected cables with ferrules

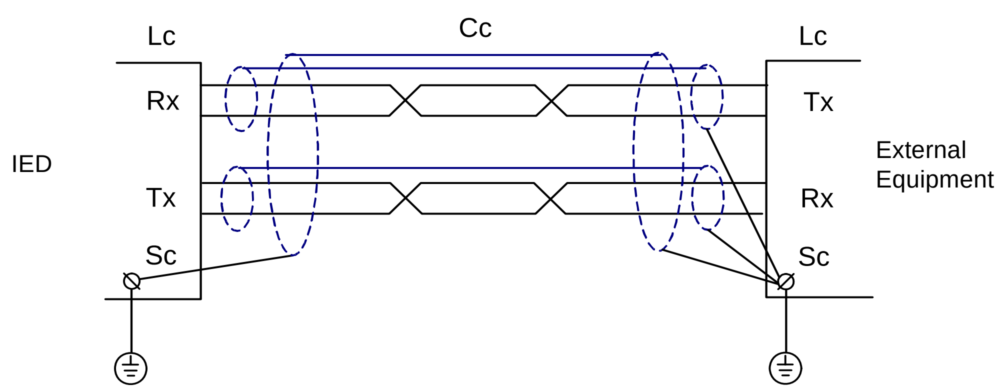
If the terminal is equipped with a test-switch of type RTXP 24 COMBIFLEX wires with 20 A sockets must be used to connect the VT circuits and the auxiliary power.

3.3 Connecting to protective earth

Connect the unit to the earthing bar of the cubicle with a green/yellow conductor, cross section at least 1.5 mm^2 (AWG16), connected to the protective earth connector at the back of the terminal.

3.4 Making the screen connection

When using screened cables always make sure screens are earthed and connected in according to applicable engineering methods. This may include checking for appropriate earthing points near the terminal, for instance, in the cubicle and/or near the source of measuring. Ensure that earth connections are made with short (max. 10 cm) conductors of an adequate cross section, at least 6 mm^2 (AWG10) for single screen connections.



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4 Installing the optical fibres

Connectors are generally color coded; connect blue or dark grey cable connectors to blue or dark grey (receive) back-side connectors. Connect black or grey cable connectors to black or grey (transmit) back-side connectors.

Caution!

The fibre optical cables are very sensitive to handling. Do not bend too sharply. The minimum curvature radius is 15 cm for the plastic fibre cables and 25 cm for the glass fibre cables. If cable straps are used to fix the cables, apply with loose fit.

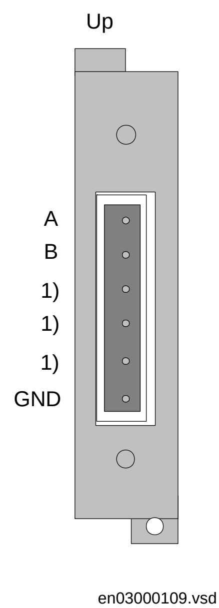
Always hold the connector, never the cable, when connecting or disconnecting optical fibres. Do not twist, pull or bend the fibre. Invisible damage may increase fibre attenuation thus making communication impossible.

Note!

Please, strictly follow the instructions from the manufacturer for each type of optical cables/connectors.

5 Installing the serial communication cable for RS485 SPA/IEC

5.1 RS485 serial communication module



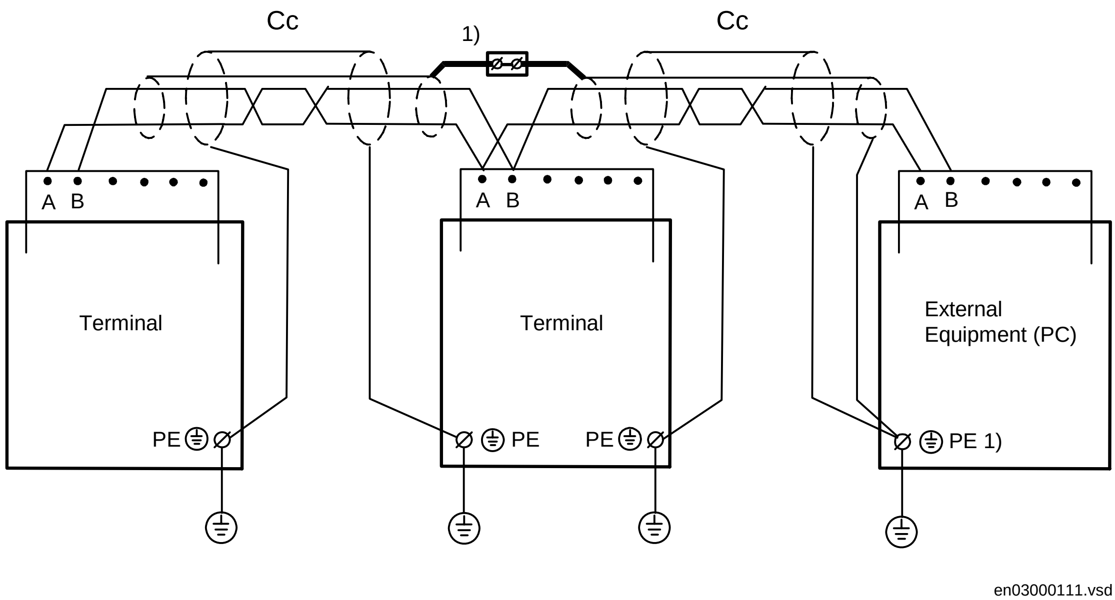
Where:

A	Signal A
B	Signal B
1)	Do not use
GND	Ground

Figure 8: Pin arrangement on modem terminal. Baud rate: 9600

The distance between earth points should be < 100 m, see figure 9. Only the outer shielding is connected to the protective earth at the terminal. The inner and outer shieldings are connected to the protective earth at the external equipment. Use insulating tape for the inner shield to prevent contact with the protective earth. Make sure that the terminals are properly earthed with as short connections as possible from the earth screw, for example to an earthed frame.

The terminal and the external equipment should preferably be connected to the same battery.



Where:

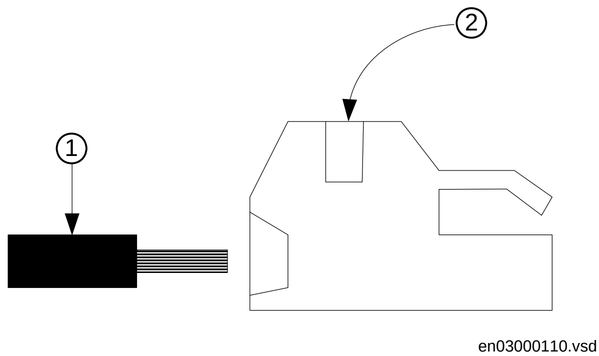
1 The inner shields shall be connected together (with an isolated terminal block) and only have **one earthing point** in the whole system, preferably at the external equipment (PC).

The outer shield shall be connected to Protective Earth (PE) in every cable end i.e. to PE at all relay terminals and to PE at External equipment (PC). The first **terminal** will have only one cable end but all others of course two.

Cc Communication cable

PE Protective earth screw

Figure 9: Communication cable installation



Where:

1 is cable

2 is screw

Figure 10: Cable contact, Phoenix: MSTB2.5/6-ST-5.08 1757051

The EIA standard RS-485 specifies the RS485 network. An informative excerpt is given in section 5.2.

5.2 Informative excerpt from EIA Standard RS-485

Informative excerpt from EIA Standard RS-485 - Electrical Characteristics of Generators and Receivers for Balanced Digital Multipoint Systems

RS-485 Wire - Media dependent Physical layer

1 Normative references

EIA Standard RS-485 - Electrical Characteristics of Generators and Receivers for Balanced Digital Multipoint Systems

2 Transmission method

RS-485 differential bipolar signaling

2.1 Differential signal levels

Two differential signal levels are defined:

A+ =line A positive with respect to line B

A- =line A negative with respect to line B

2.2 Galvanic isolation

The RS485 circuit shall be isolated from earth by:

Riso ≥ 10 MΩ

Ciso ≤ 10 pF

Three isolation options exist:

a) The entire node electronics can be galvanically isolated

b) The bus interface circuit can be isolated form the rest of node electronics by optoisolators, transformer coupling or otherwise.

c) The RS485 chip can include built-in isolation

2.3 Bus excitation and signal conveyance

2.3.1 Requirements

a) The RS485 specification requires the Signal A and Signal B wires.

b) Each node also requires (5 V) Excitation of the RS485 termination network.

c) Vim - the common mode voltage between any pair of RS485 chips may not exceed 10 V.

d) A physical ground connection between all RS485 circuits will reduce noise.

2.3.2 Bus segment termination network

The termination network below required at each end of each Bus Ph-segment.

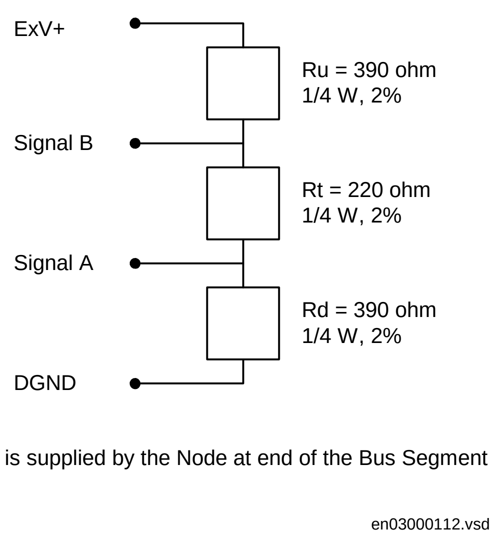


Figure 11: RS-485 bus segment termination

ExV is supplied by the Node at end of the Bus Segment

The specifications of the components are:

a) Ru	+ 5 V to Signal B	= 390 Ω, 0.25 W ±2.5%
b) Rt	Signal B to Signal A	= 220 Ω, 0.25 W ±2.5%
c) Rd	Signal A to GND	= 390 Ω, 0.25 W ±2.5%

2.3.3 Bus power distribution

The end node in each Ph-segment applies 5 V bus excitation power to the Termination network via the Excitation pair (ExV+ and GND) used in the Type 3 Physical layer specification.

5.3 Data on RS485 serial communication module cable

Type:	Twisted-pair S-STP (Screened – Screened Twisted Pair)
Shield:	Individual foil for each pair with overall copper braid
Length:	Maximum 100 m from one system earth to the next system earth (includes length from platform point to system earth on both sides)
Temp:	According to application
Impedance:	120 Ω
Capacitance:	Less than or equal to 42 pF/m
Example:	Belden 9841

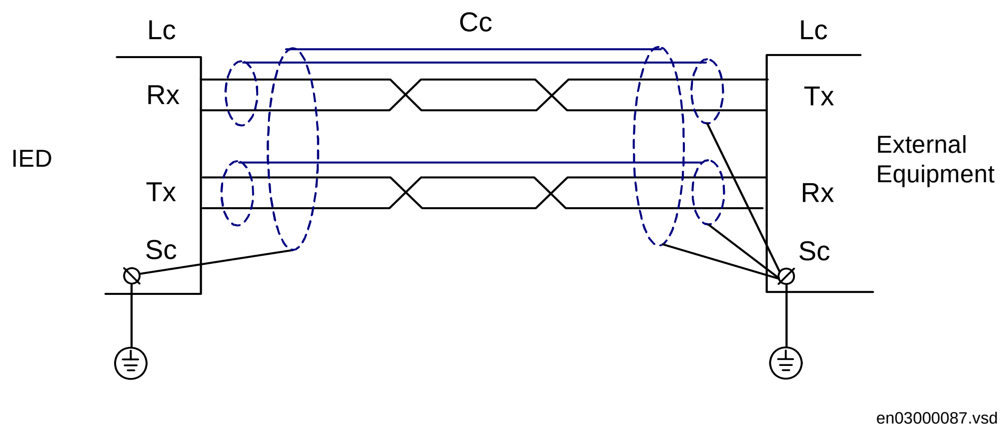
6 Installing the 56/64 kbit data communication cables

When using galvanic connection between protection terminal and communication equipment or point to point galvanic connection between two protection terminals it is essential that the cable installation is carefully done. This is true regardless of type of module used, G.703, V.36, short range galvanic etc., only the possible length of the cable differs. The factors that must be taken into account are the susceptibility for noise disturbance, due to that the levels of the communication signal are very low.

For best result a cable with twisted pairs and double screens should be used, one screen for each twisted pair and one surrounding all pairs. Each signal shall utilizie its own twisted pair as in figure 12. The screen for each separate pair shall be connected to internal screen or ground connection of equipment in one and the same end only, if available, or in other case connected to earth close to the equipment.

The outer screen surrounding all pairs shall be connected to a solid earth at *each* end close to the equipment.

Note also that recommendation about cable lengths given for modules according ITU/EIA interface, excluding the short range galvanic module, are under the assumption that the two devices, the protection terminal and the communication terminal, are within the same building and that the earthing system of the building is of good quality. It also presumes that the environment is relatively free from electromagnetic interference.



Cc	Communication cable
Lc	Line connector
Rx	Receive input
Sc	Screen (or earth/ground) connection
Tx	Transmit output

Figure 12: Communication cable installation

Chapter 6 Checking the external circuitry

About this chapter

This chapter describes what to check and which checks that should be made to ensure a correct connection to the external circuitry, such as auxiliary power supply, CT’s and VT’s. These checks must be made with the protection terminal de-energised.

1 Overview

The user must check the installation which includes verifying that the terminal is connected to the other parts of the protection system. This is done with the terminal and all connected circuits de-energised.

2 Checking the CT and VT circuits

Check that the wiring is in strict accordance with the supplied wiring diagram.

Note!

Do not continue further until any errors are corrected.

Test the circuitry. The following tests are recommended:

- Polarity check.
- CT circuit current measurement (primary injection test).
- Earthing check.

The polarity check verifies the integrity of the circuits and the phase relationship. The check should be performed as close as possible to the terminal.

The primary injection test verifies the CT ratio and the wiring all the way through from the primary system to the terminal. Injection must be performed for each phase-to-neutral circuit and each phase-to-phase pair. In each case currents in all phases and the neutral line are measured.

3 Checking the power supply

Check that the value of the auxiliary supply voltage remains within the permissible range under all operating conditions. Check that the polarity is correct.

4 Checking the binary I/O circuits

4.1 Binary input circuits

Preferably, disconnect the binary input connector from the binary input cards. Check all connected signals so that both input level and polarity are in accordance with the terminal's specifications.

4.2 Binary output circuits

Preferably, disconnect the binary output connector from the binary output cards. Check all connected signals so that both load and polarity are in accordance with the terminal's specifications.

Chapter 7 Energising the terminal

About this chapter

This chapter describes the start up sequence and what to check after the terminal has been enerigsed.

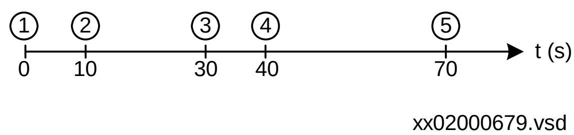
1 Overview

Before the procedures in this chapter can be carried out the connection to external circuitry must have been checked which ensures that the installation was made correctly.

The user must energise the power supply to the terminal to start it up. This could be done in number of ways, from energising a whole cubicle to energising a single terminal. The user should reconfigure the terminal to activate the hardware modules in order to enable the self supervision function detect eventual hardware errors. Then the terminal time must be set. The self supervision function should also be checked to verify that the terminal unit operates properly. The user could also check the software version, the terminals serial number and the installed modules and their ordering number to ensure that the terminal is according to delivery and ordering specifications.

2 Energising the terminal

When the terminal is energised the window on the local HMI remains dark. After 10 seconds the green LED starts flashing and after approximately 30 seconds the window lights up. After another 10 seconds the window displays ‘Terminal Startup’ and after about 30 seconds the main menu is displayed. The upper row should indicate ‘Ready’. A steady green light indicates a successful startup.



1 Terminal energised. Liquide Crystal Display (LCD) is dark.

2 Green Light Emitting Diod (LED) starts flashing

3 LCD lights up

4 "Terminal startup" is displayed

5 The main menu is displayed. A steady green light indicates a successful startup.

Figure 13: Typical terminal startup sequence

If the upper row in the window indicates ‘Fail’ instead of ‘Ready’ and the green LED is flashing an internal failure in the terminal has been detected. See the self supervision function in this chapter to investigate the fault.

After startup the appearance of the local HMI should be as shown in figure 14.

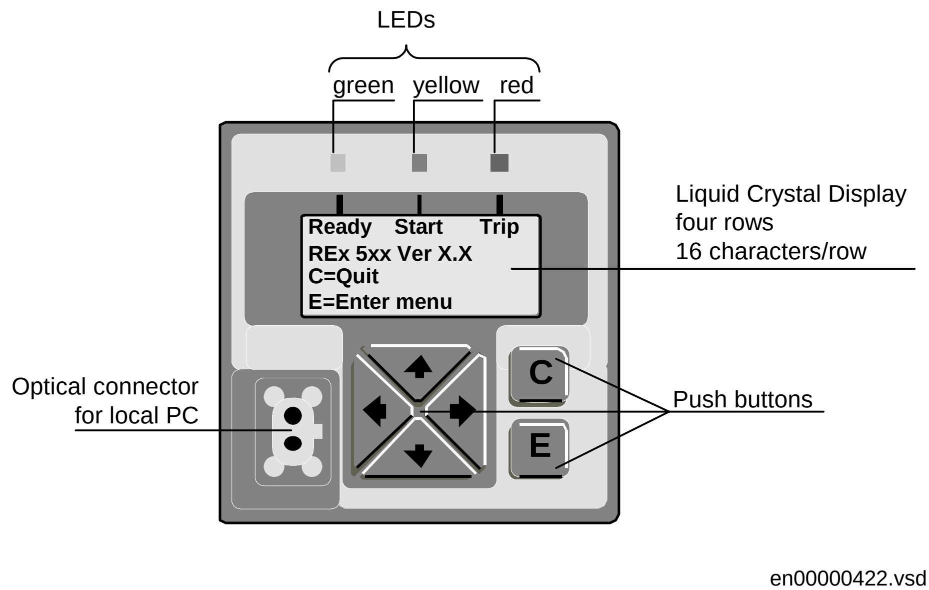


Figure 14: Example of the local HMI531.

3 Checking the self supervision signals

3.1 Reconfiguring the terminal

I/O modules configured as logical I/O modules (BIM, BOM, IOM, DCM, IOPSM or MIM) are supervised. Not configured I/O modules are not supervised.

Each logical I/O module has an error flag that is set if anything is wrong with any signal or the whole module. The error flag is also set when there is no physical I/O module of the correct type present in the connected slot.

Procedure

1. **Browse to the 'Reconfigure' menu.**

   The Reconfigure menu is located in the local HMI under:

   Configuration/I/O-modules/Reconfigure

2. **Select 'Yes' and press 'E'.**

3.2 Setting the terminal time

This procedure describes how to set the terminal time.

1. **Display the set time dialog.**

   Navigate the menus to:

   Settings/Time

   Press the *E* button to enter the dialog.

2. **Set the date and time.**

   Use the *Left* and *Right* arrow buttons to move between the time and date values (year, month, day, hours, minutes and seconds). Use the *Up* and *Down* arrow buttons to change the value.

3. **Confirm the setting.**

   Press the *E* button to set the calendar and clock to the new values.

3.3 Checking the self supervision function

3.3.1 Navigating the menus

This procedure describes how to navigate the menus in order to find the reason of an internal failure when indicated by the flashing green LED of the HMI module.

Procedure

1. Display the self supervision menu.

Navigate the menus to:

TerminalReport
SelfSuperv

2. Scroll the supervision values to identify the reason of the failure.

Use the *Left* and/or *Right* arrow buttons to scroll between values.

3.4 Self supervision HMI data

Table 1: Output signals for the self supervision function

Indicated result	Possible reason	Proposed action
InternFail = OK	No problem detected.	None.
InternFail = Fail	A failure has occurred.	Check the rest of the indicated results to find the fault.
InternWarning = OK	No problem detected.	None.
InternWarning = Warning	A warning has been issued.	Check the rest of the indicated results to find the fault.
MPM-modFail = OK	No problem detected.	None.
MPM-modFail = Fail	The main processing module has failed.	Contact your ABB representative for service.
MPM-modWarning = OK	No problem detected.	None.
MPM-modWarning = Warning	There is a problem with: • the real time clock. • the time synchronization.	Set the clock. If the problem persists, contact your ABB representative for service.
ADC-module = OK	No problem detected.	None.
ADC-module = Fail	The A/D conversion module has failed.	Contact your ABB representative for service.
Slot04BIM1 = Fail (Example data, see following section for details)	I/O module has failed.	Check that the I/O module has been configured and connected to the IOP1- block. If the problem persists, contact your ABB representative for service.
RealTimeClock = OK	No problem detected.	None.
RealTimeClock = Warning	The real time clock has been reset.	Set the clock.
TimeSync = OK	No problem detected.	None.
TimeSync = Warning	No time synchronization.	Check the synchronization source for problems. If the problem persists, contact your ABB representative for service.

Chapter 8 Configuring the 56/64 kbit data communication mo dules

About this chapter

This chapter contains instructions on how to configure the 56/64 kbit data communication modules, such as galvanic and optical modems.

1 Calculation of optical power budget

Refer to table 2 and table 3 for maximum distance in a back-to-back application

Table 2: Input data for calculation of optical power budget

	General data	Attenuation
Type of optical Tx/Rx-module	0	
Bit rate	64 kbit/s	
Transmission code	MCMI	
Optical fibre	Single mode	
Optical connector	FC-PC	
Optical wavelength	1300 nm	
Spectral bandwidth	30.0 nm	
Transmitter Tx	LED	
Optical min output power (S)		-22 dBm
Receiver Rx	Pin Diode	
Sensitivity for BER 0 10^{10} (R)		-38 dBm
Available power budget		-16 dB

Table 3: Examples of optical power budget calculation

Terminal equipment		**Example 1**	**Example 2**
Available power budget (S_R)		16 dB	16 dB
Equipment margin		Included	Included
Type of optical connectors	FC-PC for single mode		
Terminal box			
Patch panel connectors	FC-PC for single mode	0	0
Connectors for S-R	0.5 dB each	Included	Included
Total available optical power		16 dB	16 dB
Optical cable			
Type of optical fibre	Single mode 1300 nm		
Fibre attenuation (installed)		0.22 dB/km	0.34 dB/km
Splice attenauation	0.08 dB per splice		
Av. cable length between splices	3.0 km		
Average number of splices	0.33 splice/km	0.027 dB/km	0.027 dB/km
Number of repair splices	0.10 splice/km	0.008 dB/km	0.008 dB/km
Fibre margin		0.010 dB/km	0.010dB/km
Total fibre attenuation per km		0.265 dB/km	0.385 dB/km
Maximum optical transmission distance		60 km	41 km

2 Fault tracing

Procedure

1. **Check that the settings are correct.**
2. **Check that the optical budget is correct.**
3. **COMFAIL occurs for the following reasons:**

The COMFAIL signal will be triggered when there is a problem in the communication link between the two terminals, depending on type of 56/64 modem. Also, normal actions such as a change of setting, switch off of remote terminal during maintenance etc., can cause COMFAIL.

2.0.1 Comfail function

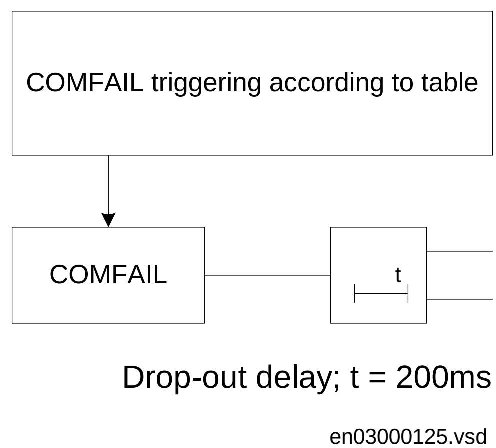


Figure 15: Comfail triggering.

The 200 ms alarm dropout delay is, for example, required as hysteresis for terminals with reserve overcurrent, REL 551 or distance reserve function REL 561, if the differential function is blocked by communication delays and interruptions etc.

The communication failure signal, COMFAIL, depends on the following internal signals (variables) in each terminal for REx 5xx. Table 4 shows a summary with additional explanations below.

Table 4: Summary

No.	COMFAIL triggering	COMFAIL triggering time (Drop-out delay 200 ms)	Remark
1	Transmit error	≥ 50 ms	Messages can not be sent
2	Receive error	≥ 100 ms	No valid messages received
3	Block differential protection	0 ms	Block of the differential protection due to setting changes etc.
4	Remote terminal COMFAIL	0 ms	COMFAIL from the remote terminal. For error no 1, 2, 3, and no 5, 6, 7, 8, 9, 10 the COMFAIL is sent in the second consecutive message (within 10 ms)
5	Time synchronization error	≥ 2 s	Problems in the synchronization of internal differential clock in the differential protection. The clock refers to the synchronized counters 0-39999 μs in each terminal. The clock is independent of the real time clock in the terminal.
6	Differential clock drift	> 0 ms	Unacceptable drift of the internal differential clock in the slave terminal compared to the internal differential clock in the master terminal (slave- master -slave)
7	Communication channel loop delay - instantaneous	0 ms	Checks if the loop time (slave - master -slave) in the differential communication channel 31 ms
8	Communication channel loop delay - time delayed	≥ 2 s	Checks if the loop time (local - remote- local) in the differential communication channel 24 ms
9	Abnormal clock deviation	0 ms	Internal differential clock deviation (slave-master - slave)
10	Data flow **Only in version *2.3**	0 ms	Long time between attempts to send messages and adjustment of the real time terminal clock . The terminal clock is the real time clock in the terminal for time tagging of events etc.

2.0.2 Explanation of contents in column 2 of table 42

1. Transmit errors are due to that the terminal cannot send messages via the telecommunication channel (PCM). The line differential function initiates the sending of one message every 5 ms. If this command can not be executed for 10 consecutive times (= 10 x 5 ms) due to blocked, missing or unsynchronized communication channel, COMFAIL is triggered. For non-consecutive interruptions, an integration algorithm is used that prolongs the COMFAIL triggering time.
2. Receive errors occur when no expected messages are received. The line differential function expects to receive one message every 5 ms. If this does not occur 10 consecutive times (= 10x5 ms), COMFAIL is triggered. For non-consecutive interruptions, an integration algorithm is used that prolongs the COMFAIL triggering time.

3. Block differential protection. Block of differential protection occurs during change of settings or setting group.
4. Remote terminal COMFAIL. For error No 1, 2, 3 and No 5, 6, 7, 8, 9, 10 the COMFAIL is sent in the second consecutive message (within 10 ms). Thus, some short interruptions can be recorded only in one terminal. The communication channel must be in operation to be able to receive this signal.
5. Time synchronization error refers to synchronization check and is only performed by the terminal set as Slave for the internal differential clocks synchronization. If 50 time synchronization messages (included with every 8 line differential function message) are not correctly received (= 8 x 5 ms x 50 = 2000 ms), COMFAIL will be triggered. If more than 750 synchronization messages are not correctly received, a re-synchronization of the internal differential clock will be made. For non-consecutive interruptions, an integration algorithm prolongs the COMFAIL triggering time.
6. Differential Clock drift refers to a difference > 50 ms between the internal differential clocks in the differential protection in the terminal set as Slave and the one set as Master for synchronization of the internal differential clock. The COMFAIL triggering time depends on a number of factors from a drift compensation algorithm. This check is normally not activated unless the communication channel has been lost for a long time.
7. Communication channel loop delay-instantaneous is checked every 40 ms (at each synchronization message). If the communication channel loop (Slave-Master-Slave) delay is more than 31ms for one message, COMFAIL is triggered instantaneously. This check is done in the terminal set as Slave for the internal differential clock by a comparison with the real time clock in the terminal at sending and receiving of a looped message.
8. Communication channel loop delay-time delayed checks if the communication channel delay for transmitted and received signal is >24 ms (Local-Remote-Local). The check is performed every 40 ms (at each synchronization message) by comparing the real time clock time at sending and receiving of a looped message. COMFAIL is triggered after 50 consecutive messages with excessive loop time. COMFAIL triggering time = 2000 ms (= 50x40 ms). For non-consecutive messages with excessive loop time, an integration algorithm is used that prolongs the COMFAIL triggering.
9. Abnormal clock deviation checks if the synchronization in the Slave of the internal differential clocks in the differential protection have an abnormal deviation, (Slave-Master–Slave). COMFAIL is triggered instantaneously, but will probably only occur after long interruptions in the communication channel. However, the start or re synchronization procedure can also activate COMFAIL due to this function.
10. Data flow checks if the time between initiations of the sending messages from the line differential function is longer than 20 ms, using the real time clock for the check. This check will also trigger the COMFAIL if the external time synchronization of the real time clock by minute pulse or SPA/LON from Station Clock or GPS, adjusts the terminal clock forward > 15 ms. The COMFAIL triggering is instantaneous. The channel interruption measurements for short, medium and long interruptions, presented on the HMI are based on measurements of timing from the real time clock which are made independently in each terminal. These measurements are also independent from the internal differential clock. The mea-

surements presented on the front HMI are not connected to COMFAIL or by indications of channel delay exceeding 12 ms, since the delay is not a channel interrupt, the channel is still working.

Chapter 9 Setting and configuring the terminal

About this chapter

This chapter describes how to set the terminal, either through a PC or the local HMI, and download a configuration to the terminal in order to make commissioning possible.

The chapter does not contain instructions on how to create a configuration or calculate settings. Please consult the application manual for further information about how to calculate settings.

1 Overview

The customer specific values for each setting parameter and a configuration file has to be available before the terminal can be set and configured, if the terminal is not delivered with a configuration.

Use the CAP 531 configuration tool to verify if the terminal has the expected configuration. A new configuration is performed with the CAP tool. The binary outputs can be selected from a signal list where the signals are grouped under their function names. It is also possible to specify a user-defined name for each input and output signal.

The configuration can be downloaded through the front connector on the local HMI or via the rear SPA port.

Each function included in the terminal has several setting parameters which have to be set in order to make the terminal behave as intended. A default value is provided for each parameter from factory. A setting file can be prepared using the parameter setting tool (PST), which is available in the CAP 540 package.

All settings can be:

- Entered manually through the local HMI.
- Downloaded from a PC, either locally or remotely using SMS/SCS. Front or rear port communication has to be established before the settings can be downloaded.

Note!

Be sure to configure the functional input HMI--BLOCKSET to only one of the available binary inputs before setting the parameter SettingRestrict to Block in the local HMI.

2 Entering settings through the local HMI

Each of the included functions in the terminal has to be set and this can be performed through the local HMI. The user must browse to the desired function and enter the appropriate value. The parameters for each function can be found in the local HMI. See the technical reference manual for a complete list of setting parameters for each function. Some of the included functions may not be used. In this case the user can set the parameter “Operation” to “Off” to disable the function.

Some settings can only be set through the local HMI, such as the setting access, the slave number and baud rate when communicating with a PC software. The setting access can be blocked by the binary input signal HMI--BLOCKSET. When this signal is active the user can still read all information, including the setting values.

3 Configuring the setting restriction of HMI function

Configuring the HMI--BLOCKSET functional signal can only be done from the local HMI.

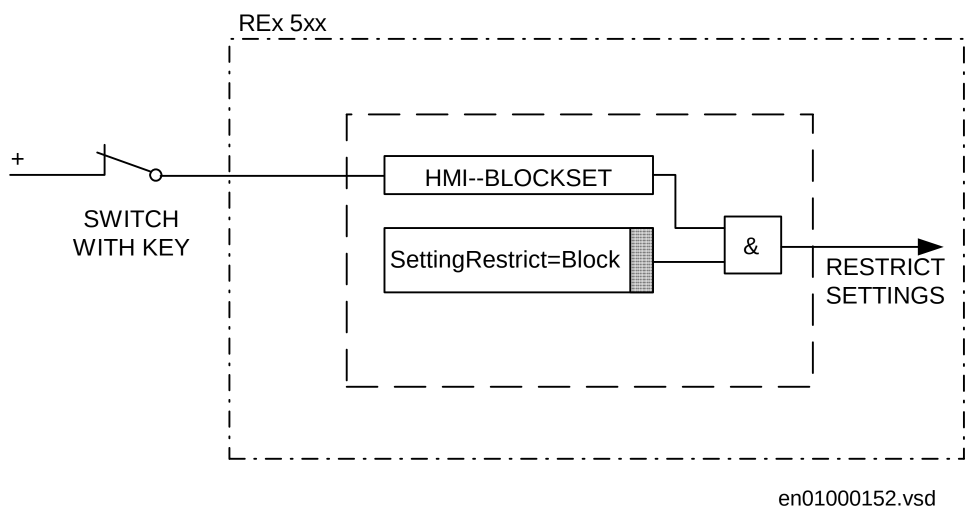


Figure 16: Connection and logic diagram for the HMI--BLOCKSET functional signal

Procedure

1. Navigate the menus to:

Configuration/BuiltInHMI/HMI--BLOCKSET

2. Select a binary input

Select a binary input not used or reserved for any other purpose.

Connect the selected binary input to the DC control voltage via a normally closed contact of a control switch, which can be locked by a key. Only when the normally closed contact is open, the change of settings and configuration of the REx 5xx terminal is possible. See figure 16.

4 Activating the restriction of setting

4.1 Local HMI

Activating the restriction of setting via local HMI can only be done from the local HMI.

Procedure

1. **Navigate the menus to:**

   Configuration/BuiltInHMI/SettingRestrict

2. **Set SettingRestrict = Block.**

Note!

The HMI--BLOCKSET functional input must be configured to the selected binary input before setting the setting restriction function in operation. Carefully read the instructions.

4.2 Serial communication, change of active group

Activating the restriction of setting, or change of active group via the rear communication port, can only be done from the local HMI.

Procedure

1. **Navigate the menus to:**

   Configuration/TerminalCom/SPACom/Rear/ActGrpRestrict

2. **Set ActGrpRestrict = Block**

4.3 Serial communication, setting

Activating the restriction of setting or change of active group, can only be done from the local HMI.

Procedure

1. **Navigate the menus to:**

   Configuration/TerminalCom/SPACom/Rear/SettingRestrict

2. **Set SettingRestrict = Block**

5 Downloading settings and configuration from a PC

5.1 Establishing front port communication

When a PC is used to download settings and configuration, you need the terminal toolbox CAP 540 (including CAP 531 and PST).

A special cable is needed when connecting a PC to the front of the REx 5xx terminal. This cable can be ordered from ABB. It must be plugged into the optical contact on the left side of the local HMI. The other end of the cable shall be plugged directly into the COM-port on the PC. The cable includes an optical contact, an opto/electrical converter and an electrical cable with a standard 9-pole D-sub contact. This ensures a disturbance-free and safe communication with the terminal.

When communicating from a PC, the slave number and baud rate (communication speed) settings must be equal in the PC-program and in the REx 5xx terminal.

Procedure

1. **Plug the cable to the optical contact on the local HMI.**
2. **Plug the other end of the cable to the COM port of the PC.**
3. **Set the slave number and baud rate in the terminal.**

   The slave number and baud rate settings in the REx 5xx terminal is done on the local HMI at:

   Configuration/TerminalCom/SPACom/Front

4. **Set the slave number and baud rate in the PC-program.**

   The slave number and baud rate must be the same as in the terminal. See the CAP 540 manual.

5.2 Establishing rear port communication

Settings can be performed via any of the optical ports at the rear of the REx 5xx terminal. When a PC is connected to the SMS system, the CAP 540 and the PST softwares are used. Settings can also be done via the SCS system, based on MicroLIBRARY.

5.2.1 Using the SPA/IEC rear port

For all settings and configuration via the SPA communication bus, the SPA/IEC 60870-5-103 port on the rear, it is necessary to first deactivate the restriction for settings. Otherwise, no setting is allowed. This setting only applies for the SPA/IEC 60870-5-103 port during SPA bus communication. The parameter can only be set on the local HMI, and is located at:

Configuration/TerminalCom/SPACom/Rear/SettingRestrict

It is also possible to permit changes between active setting groups with ActGrpRestrict in the same menu section.

Selecting the protocols for the rear ports

To define the protocols to be used, a setting is done on the local HMI under the menu:

Configuration/TerminalCom/SPA-IEC-LON

When the protocols have been selected the terminal will automatically restart.

When communicating with SMS or SCS with the SPA or IEC 60870-5-103 protocol the slave number and baud rate (communication speed) settings must be equal in the PC-program and in the REx 5xx terminal.

Using the SPA rear port

The slave number and baud rate settings of the rear SPA port on the REx 5xx terminal, for SPA bus communication, is done on the local HMI at:

Configuration/TerminalCom/SPACom/Rear

Using IEC 870-5-103 rear port

The slave number and baud rate settings of the rear IEC 60870-5-103 port on the REx 5xx terminal, for IEC 870-5-103 bus communication, is done on the local HMI at:

Configuration/TerminalCom/IECCom/Communication

5.2.2 Using LON rear port

The LON port is not affected by eventual restricted settings valid for the SPA/IEC port. When communicating via the LON port, the settings are done with the LNT, LON Network Tool. The settings are shown on the local HMI at:

Configuration/TerminalCom/LON Com

From this menu, it is also possible to send the “ServicePinMsg” to the LNT.

5.3 Downloading the configuration and setting files

When downloading a configuration to the REx 5xx terminal with the CAP 531 configuration tool, the terminal is automatically set in configuration mode. When the terminal is set in configuration mode, all functions are blocked. The red LED on the terminal flashes, and the green LED is lit while the terminal is in the configuration mode.

When the configuration is downloaded and completed, the terminal is automatically set into normal mode. For further instructions please refer to the users manuals for CAP 540 and PST.

Chapter 10 Requirement of trig condition for disturbance report

About this chapter

This chapter describes how to override the limitation on the storage capacity of the flash memory.

1 Requirement of trig condition for disturbance report

Disturbance reports, setting and internal events in REx 5xx are stored in a non volatile flash memory. Flash memories are used in many embedded solutions for storing information due to high reliability, high storage capacity, short storage time and small size.

In REx 5xx there is a potential failure problem, caused by too many write operations to the flash memory.

Our experience shows that after storing more than fifty thousand disturbances, settings or internal events the flash memory exceeds its storing capacity and the component is finally defected.

When the failure occurs there is no risk of unwanted operation of the protection terminal due to the self-supervision function that detects the failure. The terminal will give a signal for internal fail and go into blocking mode.

The above limitation on the storage capacity of the flash memory gives the following recommendation for the disturbance report trig condition:

- Cyclic trig condition more often then once/day not recommended.
- Minute pulse input is not used as a trig condition.
- Total number of stored disturbance reports shall not exceed fifty thousand.

Chapter 11 Establishing connection and verifying the SPA/IEC-communication

About this chapter

This chapter contains instructions on how to establish connection and verify that the SPA/IEC-communication operates as intended, when the terminal is connected to a monitoring or control system via the rear SPA/IEC port.

1 Entering settings

If the terminal is connected to a monitoring or control system via any of the rear SPA and/or IEC ports, the applicable selection of protocols for the rear ports must be made.

1.1 Entering SPA settings

When using the SPA protocol, the rear SPA/IEC port must be set for SPA use.

The SPA/IEC port is located at terminal X13 on the rear side of the terminal. Three types of interfaces can be used:

- for plastic fibres with connector type HFBR
- for glass fibres with connectors type ST
- for galvanic RS485

Procedure

1. Set the operation of the rear SPA/IEC port to “SPA”.

The operation of the rear SPA/IEC port can be found on the local HMI at:

Configuration/TerminalCom/SPA-IEC-LON

When the setting is entered the terminal will automatically restart. After the restart the SPA/IEC port operates as a SPA port.

2. Set the slave number and baud rate for the rear SPA port

The slave number and baud rate can be found on the local HMI at:

Configuration/TerminalCom/SPACom/Rear

Set the same slave number and baud rate as set in the SMS system for the terminal.

1.2 Entering IEC settings

When using the IEC protocol, one of the rear ports must be set for IEC use. The selected port can be located at terminal X13 or terminal X15 on the rear side of the terminal. Valid interface depends on selected port.Three types of interfaces can be used:

- for plastic fibres with connector type HFBR
- for glass fibres with connectors type ST
- for galvanic RS485

Procedure

1. Set the operation of one of the rear ports to “IEC”.

The operation of the rear ports can be found on the local HMI at:

Configuration/TerminalCom/SPA-IEC-LON

When the setting is entered the terminal will automatically restart. After the restart the selected IEC port operates as a IEC port.

2. **Set the slave number and baud rate for the rear IEC port**

   The slave number and baud rate can be found on the local HMI at:

   Configuration/TerminalCom/IECCom/Communication

   Set the same slave number and baud rate as set in the IEC master system for the terminal.

3. **Set the main function type of the terminal.**

   The main function type can be found on the local HMI at:

   Configuration/TerminalCom/IECCom/FunctionType

   The main function type can be set to values from 1 to 255 according to the standard. The value zero is default and corresponds to not used. Examples of values that can be used are:

Table 5: Main function type examples

Value	Function type according to IEC 60870-5-103
128	Distance protection
160	Overcurrent protection
192	Line differential protection

If the setting “OpFnType” is set to “ON” then the set value for function type will be used for all event blocks and the disturbance recorder, otherwise the setting on each event block and the disturbance recorder will decide the function type of that function block.

2 Verifying the communication

To verify that the rear communication with the SMS/SCS system is working, there are some different methods. Choose one of the following.

2.1 Verifying SPA communication

Procedure

1. **Use a SPA-emulator and send “RF” to the terminal. The answer from the terminal should be “REx500 25”.**
2. **Generate one binary event by activating a function which is configured to an event block where the used input is set to generate events on SPA. The configuration must be made with the CAP5xx software. Verify that the event is presented in the SMS/SCS system.**

During the following tests of the different functions in the terminal, verify that the events and indications in the SMS/SCS system are as expected.

2.2 Verifying IEC communication

To verify that the IEC communication with the IEC master system is working, there are some different methods. Choose one of the following.

Procedure

1. **Check that the master system time-out for response from the terminal, for example after a setting change, is > 40 seconds.**
2. **Use a protocol analyzer and record the communication between the terminal and the IEC master. Check in the protocol analyzer’s log that the terminal answers the master messages.**
3. **Generate one binary event by activating a function which is configured to an event block where the used input is set to generate events on IEC. The configuration must be made with the CAP5xx software. Verify that the event is presented in the IEC master system.**

During the following tests of the different functions in the terminal, verify that the events and indications in the IEC master system are as expected.

3 Optical budget calculation for serial communication with SPA/IEC

Table 6: Example

	Distance 1 km **Glass**	**Distance 25 m** **Plastic**
Maximum attenuation for REx 5xx	- 11 dB	- 7 dB
4 dB/km multi mode: 820 nm - 62.5/125 um	4 dB	-
0.16 dB/m plastic: 620 nm - 1mm	-	4 dB
Margins for installation, aging etc.	5 dB	1 dB
Losses in connection box, two contacts (0.7 dB/contact)	1.4 dB	-
Losses in connection box, two contacts (1 dB/contact)	-	2 dB
Margin for repair splices (0.5 dB/splice)	0.5 dB	-
Maximum total attenuation	11 dB	7 dB

Chapter 12 Establishing connection and verifying the LON communication

About this chapter

This chapter referes to another document.

1 Reference

We refere to document: LNT 505 Operator's Manual 1MRS751706-MUM, Issued: 31.10.99, Program rev: 1.1.1 Doc. version: B.

1.1 Verification of the optical budget

1.1.1 Optical budget calculation for serial communication with LON

Table 7: Example

	Distance 1 km **Glass**	**Distance 20 m** **Plastic**
Maximum attenuation for REx 5xx	-11 dB	- 7 dB
4 dB/km multi mode: 820 nm - 62.5/125 um	4 dB	-
0.2 dB/m plastic: 620 nm - 1mm	-	4 dB
Margins for installation, aging etc.	5 dB	1 dB
Losses in connection box, two contacts (0.7 dB/contact)	1.4 dB	-
Losses in connection box, two contacts (1dB/contact)	-	2 dB
Margin for repair splices (0.5 dB/splice)	0.5 dB	-
Maximum total attenuation	11 dB	7 dB

Chapter 13 Verifying settings by secondary injection

About this chapter

This chapter describes how to verify that the protection functions operates correctly according to the settings. Only the tested function should be in operation.

1 Overview

Required tools for testing of a terminal:

- Calculated settings
- Configuration diagram
- Terminal diagram
- Technical reference manual
- Three-phase test equipment

The terminal has to be set and configured before the testing can start.

The terminal diagram, available in the Technical reference manual, is a general diagram for the terminal. But note that the same diagram is not always applicable for each specific delivery (especially for the configuration of all the binary inputs and outputs). It is for this reason necessary to check before testing that the available terminal diagram corresponds to the terminal.

The Technical reference manual contains application and functionality summaries, function blocks, logic diagrams, input and output signals, setting parameters and technical data sorted per function.

The test equipment should be able to provide a three-phase supply of voltages and currents. The magnitude of voltage and current as well as the phase angle between voltage and current must be variable. The voltages and currents from the test equipment must be obtained from the same source and they must have a very small harmonic contents. If the test equipment cannot indicate the phase angle, a separate phase-angle meter is necessary.

Prepare the terminal for test before testing a particular function. Consider the logic diagram of the tested protection function when performing the test. All included functions in the terminal are tested according to the corresponding test instructions in this chapter. The functions can be tested in any order according to user preferences and the test instructions are therefor presented in alphabetical order. Only the functions that are used (Operation is set to On) should be tested.

The response from a test can be viewed in different ways:

- Binary outputs signals
- Service values in the local HMI (logical signal or phasors)
- A PC with CAP (configuration software) in debug mode

All used setting groups should be tested.

Note!

This terminal is designed for a maximum continuous current of four times the rated current.

Note!

Please observe the measuring accuracy of the terminal, the test equipment and the angular accuracy for both of them.

Note!

Please consider the configured logic from the function block to the output contacts when measuring the operate time.

2 Preparing for test

2.1 Overview

This section describes how to prepare the terminal in order to verify settings.

The preparation starts with making the connections to the test switch if included. This means connecting the test equipment according to a valid terminal diagram for the specific REx 5xx terminal. The terminal can then be set in test mode in order to facilitate the test of individual functions and prevent unwanted operation from functions other than the tested. The test switch should then be connected to the terminal. The user could also verify the connection and that the analog inputs signals are measured correctly by injecting currents and voltages as required by the specific REx 5xx terminal. The tested function should then be released. The disturbance report settings could be checked to ensure that correct indications are given. The user could also identify the function to test in the technical reference manual to retrieve signals and parameters names etc.

2.2 Preparing the connection to the test equipment

The REx 5xx terminal can be equipped with a test switch of type RTXP 24. The test switch and its associated test plug handle (RTXH 24) are a part of the COMBITEST system which gives a secure and convenient testing of the terminal.

When the test-plug handle is inserted into the test switch, preparations for testing are automatically carried out in the proper sequence (i.e. blocking of tripping circuits, short circuiting of CT’s, opening of voltage circuits, making relay terminals available for secondary injection). Terminals 1 and 12 of the test switch are not disconnected as they are used for dc supply of the protection terminal.

The test-plug handle leads may be connected to any type of test equipment or instrument. When a number of protection terminals of the same type are tested, the test-plug handle need be moved only from the test switch of one protection terminal to the test switch of the other, without altering previously made connections.

To prevent unwanted tripping when the handle is withdrawn, latches on the handle secure it in the half withdrawn position. In this position, all voltages and currents are restored to the protection terminal and any reenergizing transients are given a chance to decay before the trip circuits are restored. When the latches are released, the handle can be completely withdrawn form the test switch, restoring the trip circuits to the protection terminal.

If a test switch is not used necessary actions need to be taken according to circuit diagram.

Warning!

Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer's secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.

2.3 Setting the terminal in test mode

The terminal can be set in test mode before test. This means that all included functions can be blocked or released as decided during the test. In this way, it is possible to test slower back-up measuring functions without the interference of faster measuring functions. Test mode is indicated when the yellow LED is flashing.

Procedure

1. **Browse to the ‘Operation’ menu and press ‘E’.**

   The Operation menu is located in the local HMI under:

   Test/TestMode/Operation

2. **Choose ‘On’ and press ‘E’.**
3. **Press ‘C’ twice to exit the menu.**

   The dialog ‘Save testGroup?’ appears.

4. **Choose ‘Yes’ and leave the menu.**

   The window repeatedly displays ‘Busy’ and after that the yellow LED starts flashing which indicates that the terminal is in test mode.

2.4 Connecting test equipment to the terminal

Before testing, connect the testing equipment according to the valid terminal diagram for each specific REx 5xx terminal. Pay special attention to the correct connection of the input and output current terminals, and to the connection of the residual current. Check that the input and output logical signals in the logic diagram for the tested function are configured to the corresponding binary inputs and outputs of the tested terminal.

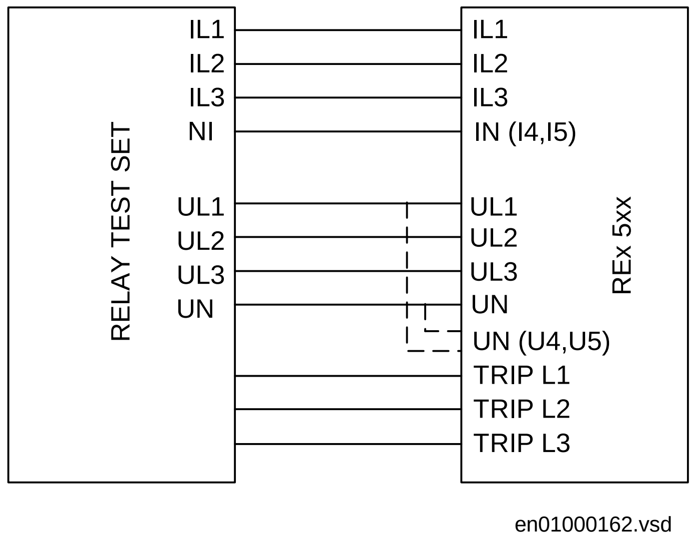


Figure 17: Connection of the test set to the REx 5xx terminal.

2.5 Verifying the connection and the analog inputs

The user must verify that the connection and that the analog signals are measured correctly.

Procedure

1. **Compare the injected value with the measured value.**

   The phasor menu is located in the local-HMI under:

   ServiceReport/Phasors/Primary and Secondary

   Consider set ratio factors for CT’s and VT’s.

2. **Compare the frequency reading with the set frequency and the direction of the power with the injected power.**

   The frequency and active power are located in the local-HMI under:

   ServiceReport/ServiceValues

3. **Inject a unsymmetrical three-phase current and voltage at rated value in two phases.**

4. **Compare the injected value with the measured value.**

   The phasor menu is located in the local-HMI under:

ServiceReport/Phasors/Primary and Secondary

2.6 Releasing the function(s) to be tested

The user can release the function(s) to be tested. This is done in order to set only the tested function(s) in operation and prevent other functions from operating. The user can release the tested function(s) by setting the corresponding parameter under BlockFunctions to NO in the local HMI. When testing a function in this blocking feature, remember that not only the actual function must be activated, but the whole sequence of interconnected functions (from measuring inputs to binary output contacts), including logic and so on. Before starting a new test mode session the user should scroll through every function to ensure that only the function to be tested (and the interconnected ones) are set to NO. A function is also blocked if the BLOCK input signal on the corresponding function block is active, which depends on the configuration. The user should therefore ensure that the logical status of the BLOCK input signal is equal to 0 for the tested function. The user could also individually block event blocks to ensure that no events are reported to remote station during the test.

Note!

The function is blocked if the corresponding setting under the BlockFunctions menu remains on and the TEST-INPUT signal remains active. All functions that where blocked or released from previous test mode session are still valid when a new test mode session is entered.

Procedure

1. **Browse to the ‘BlockFunctions’ menu.**

   The BlockFunctions menu is located in the local HMI under:

   Test/TestMode/BlockFunctions

2. **Browse to the function that should be released.**

   Use the left and right arrow buttons. Press ‘E’ when the desired function has been found.

3. **Select ‘No’.**
4. **Press ‘C’ twice to leave the menu.**

   The ‘Save TestGroup?’ dialog appears.

5. **Choose ‘Yes’ leave the menu.**

2.7 Checking the disturbance report settings

The terminal must be set in testmode (Operation=ON) to activate the disturbance report settings.

The user can select how the disturbances are indicated on the local HMI during the test. The user can for example select if the disturbance summary should be stored, scrolled on the local HMI or if LED information should be stored. Scroll to the disturbance report settings which are located in the local HMI under:

Test/TestMode/DisturbReport

Table 8: Disturbance report settings

Operation	DisturbSummary	Then the results are...
Off	Off	• Disturbances are not stored. • LED information is not displayed on the HMI and not stored. • No disturbance summary is scrolled on the HMI.
Off	On	• Disturbances are not stored. • LED information (yellow - start, red - trip) are displayed on the local HMI but not stored in the terminal. • Disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared. • The information is not stored in the terminal.
On	On or Off	• The disturbance report works as in normal mode. • Disturbances are stored. Data can be read from the local HMI, a front-connected PC, or SMS.- LED information (yellow - start, red - trip) is stored. • The disturbance summary is scrolled automatically on the local HMI for the two latest recorded disturbances, until cleared. • All disturbance data that is stored during test mode remains in the terminal when changing back to normal mode.

2.8 Identifying the function to test in the technical reference manual

The user can use the technical reference manual (TRM) to identify function blocks, logic diagrams, input and output signals, setting parameters and technical data.

3 Automatic switch onto fault logic (SOTF)

Prepare the terminal for verification of settings as outlined in section “Preparing for test” in this chapter.

The SOTF is checked by secondary injection tests together with the distance or overcurrent protection function and with the DLD function. The switch-onto-fault function is activated either by the external input SOTF-BC, or by the internal DLD function. The latter is done by a prefault condition with the phase voltages and currents at zero.A reverse three-phase fault with zero impedance and a three-phase fault with an impedance corresponding to the whole line is applied. For this fault an instantaneous trip shall be achieved together with the indication SOTF-TRIP.

3.1 External activation of SOTF function

Procedure

1. **Activate the switch-onto-fault (SOTF-BC) input.**

   During normal operating conditions, the SOTF-BC input is de-energised.

2. **Apply a three phase fault condition corresponding to a fault at approximately 45% of the line or with an impedance at 50% of used zone setting and current greater than 30% of I_r.**
3. **Check that the correct trip outputs, external signals and indication are obtained.**

3.2 Automatic initiation of SOTF

Procedure

1. **Deactivate the switch-onto-fault (SOTF-BC) input.**
2. **Set current and voltage inputs to 0 for at least 1 second.**
3. **Apply a three phase fault condition corresponding to a fault at approximately 45% of the line or with an impedance at 50% of used zone setting and current greater than 30% of I_r.**
4. **Check that the correct trip outputs, external signals and indication are obtained.**

3.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

4 Autorecloser (AR)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The test is performed together with protection and trip functions. Figure 18 illustrates a recommended testing scenario, where the circuit breaker is simulated by an external bistable relay (BR), for example an RXMVB2 or an RXMVD. The following switches are needed:

- Switch close (SC)
- Switch trip (ST)
- Switch ready (SRY).

SC and ST can be push-buttons with spring return. If no bistable relay is available, replace it with two self-reset auxiliary relays and use self-holding connection.

Use a secondary injection relay test set to operate the protection function. It is possible to use the BR to control the injected analogue quantities so that the fault only appears when the BR is picked up—simulating a closed breaker position.

To make the arrangement more elaborate, include the simulation of the operation gear condition, AR01-CBREADY, for the sequences Close-Open (CO) and Open-Close-Open (OCO).

The AR01-CBREADY condition at the CO sequence type is usually low for a recharging time of 5-10 s after a closing operation. Then it is high. The example in figure 18 shows that it is simulated with SRY, a manual switch.

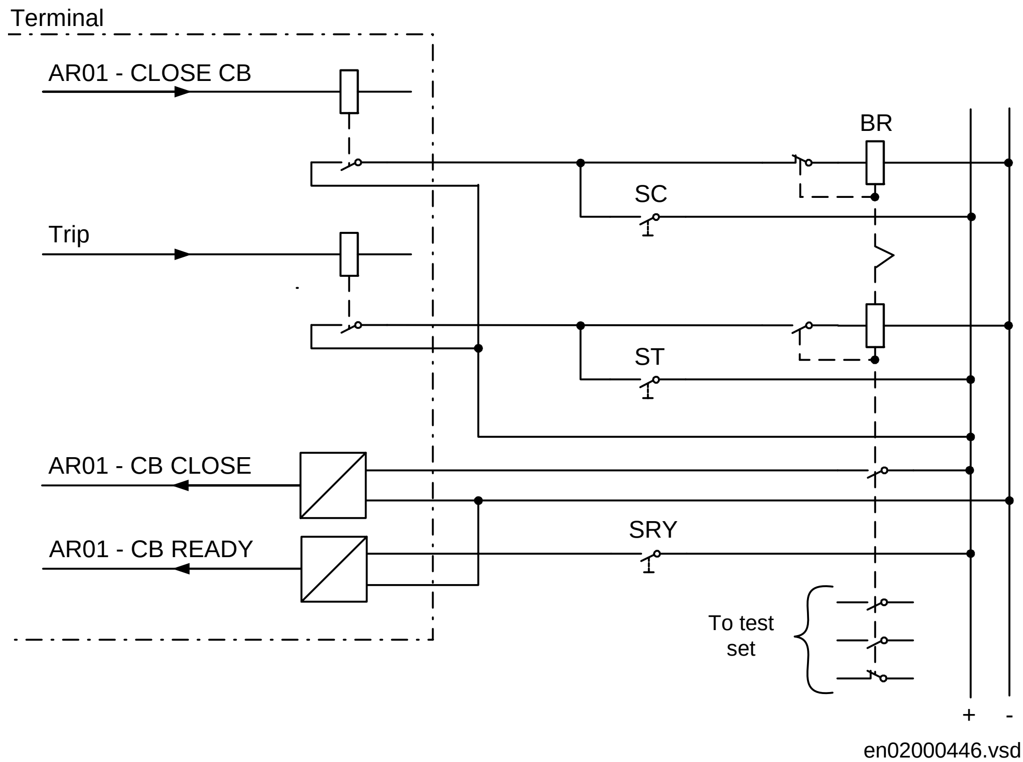


Figure 18: Simulating breaker operation with two auxiliary relays.

4.1 Preparing

1. **Check the settings of the autorecloser (AR) function.**

   The operation can be set at Stand-by (Off) in HMI tree:

   Settings/Functions/Group n/AutoRecloser/AutoRecloser n

   If any timer setting is changed so as to speed-up or facilitate the testing, they must be set to normal after the testing. A verification test has to be done afterwards.

2. **Check that the functional input signal SYNC is set to TRUE if the internal or external synchrocheck is not used.**
3. **Read and note the reclosing operate counters from the HMI tree:**

ServiceReport/Functions/AutoRecloser/AutoRecloser n/Counters

4. **The AR01-CBCLOSED breaker position, the commands Trip and Closing, AR01-CLOSECB, and other signals should preferably be arranged for event recording provided with time measurements.**

   Otherwise, a separate timer or recorder can be used to check the AR open time and other timers.

4.2 Checking the AR functionality

1. **Ensure that the voltage inputs to Synchro-check, when applied, give accepted conditions at open breaker (BR).**

   They can, for example, be Live busbar and Dead line.

2. **Set the operation at On.**
3. **Make a BR pickup by a closing pulse, the SC-pulse.**
4. **Close SRY, Breaker ready and leave it closed.**
5. **Inject AC quantities to give a trip and start AR in phase L1.**

   Observe or record the BR operation. The BR relay should trip and reclose. After the closing operation, the SRY switch could be opened for about 5 s and then closed.

   The AR open time and the operating sequence should be checked, for example, in the event recording.

   Check the operate indications and the operate counters.

   Should the operation not be as expected, the reason must be investigated. It could be due to an AR Off state or wrong program selection, or not accepted synchro-check conditions.

4.3 Checking the reclosing condition

The number of cases can be varied according to the application. Examples of selection cases are:

4.3.1 Checking the Inhibit signal

1. **Check that the function is operative and that the breaker conditions are okay.**
2. **Apply an AR01-INHIBIT input signal and start the reclosing function.**
3. **Check that there is no reclosing.**

4.3.2 Checking the closing onto a fault

1. **Set the breaker simulating relay, BR, in position open.**
2. **Then close it with the SC switch and start the AR within one second.**
3. **Check that there is no reclosing.**

4.3.3 Checking the breaker not ready

1. **Close the BR breaker relay and see that everything except for AR01-CBREADY is in normal condition (SRY is open).**
2. **Start the AR function.**
3. **Check that there is no reclosing.**

4.4 Testing the multi-breaker arrangement

If a multi-breaker arrangement is used for the application and priorities are given for the master (high) and slave (low) terminals, test that correct operation takes place and that correct signals are issued. The signals WFMASTER, UNSUC, WAIT and INHIBIT should be involved.

4.5 Completing the test

After the test, restore the equipment to normal or desired state. Especially check these items:

1. **Check and record the counter contents (Reset if it is the user's preference).**

   The counters menu is located in the local HMI under:

   ServiceReport/Functions/AutoRecloser/AutoRecloser n/Counters/Clear Counters

2. **Reset the setting parameters as required.**
3. **Disconnect the test switch or disconnected links of connection terminals.**
4. **Reset indications and events.**

   The ClearDistRep menu is located in the local HMI under:

   DisturbReport/ClearDistRep

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

5 Current reversal and weak end infeed logic (ZCAL)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The testing instructions are related to each separate phase, when phase segregated scheme communication logic ZC1P is used. Only one type of fault is necessary, when three-phase scheme communication logic ZCOM is used.

The current reversal logic and the week end infeed functions are tested during the secondary injection test of the impedance or overcurrent protection zones together with the scheme communication logic for the distance protection function (ZCOM or ZC1P).

5.1 Current reversal logic

It is possible to check the delay of the ZCOM-CS (ZC1P-CSLn) carrier send signal with tDelay by changing from a reverse to a forward fault.

By continuously activating the ZCOM-CR (ZC1P-CRLn) input and changing from a reverse to a forward fault, the delay tDelay can be checked.

5.1.1 Checking of current reversal

Note!

The reverse zone timer must not operate before the forward zone fault is applied. The user might need to block the reverse zone timer during testing of current reversal.

Note!

The forward zone timer must be set longer than 90 ms.

Procedure

1. **Activate the carrier receive (ZCOM-CRLn) signal.**
2. ***Set the healthy condition to an impedance at 50% of the reach of the reverse zone connected to ZCAL-IRVLn.***
3. **After the start condition is obtained for reverse zone, apply a fault at 50% of the reach of the forward zone connected to ZCAL-WEIBLKLn.**
4. **Check that correct trip outputs and external signals are obtained for the type of fault generated.**

   The operation time should be about the tDelay setting longer than the carrier accelerated trip (ZCOM-TRIP or ZC1P-TRLn) previously recorded for permissive scheme communication.

5. **Repeat the procedure for other phases.**

   Only when ZC1P is used.

6. **Restore the forward and reverse zone timer to its original setting.**

5.2 Weak end infeed logic

5.2.1 WEI logic at permissive schemes

Procedure

1. **Check the blocking of the echo with the injection of a ZCOM-CR or ZC1P-CRLn signal >40 ms after a reverse fault is applied.**
2. **Measure the duration of the echoed signal by applying a ZCOM-CR or ZC1P-CRLn carrier receive signal.**
3. **Check the trip functions and the voltage level for trip by reducing a phase voltage and applying a ZCOM-CR or ZC1P-CRLn carrier receive signal.**
4. **Repeat the procedure for other phases.**

   Only when ZC1P is used.

5.2.2 Testing conditions

Only one type of fault is sufficient, with ZCOM function. Apply three faults (one in each phase), when ZC1P function is used. For phase L1-N fault, set these parameters:

Table 9:

Phase	I (Amps)	Phase-angle (Deg)	V (Volts)	Phase-angle (Deg)
L1	0	0	Set less than UPN<	0
L2	0	240	63	240
L3	0	120	63	120

Change all settings cyclically for other faults (L2-N and L3-N).

Weak end infeed set for trip

1. **Apply input signals according table 9.**
2. **Activate the carrier receive (ZCOM-CR or ZC1P-CRLn) signal of the terminal.**
3. **After the relay has operated, turn off the input signals.**
4. **Check that trip, carrier-send signal, and indication are obtained.**
5. **Repeat the procedure for other phases.**

   Only when ZC1P is used.

Weak end infeed set for echo

1. **Apply input signals according table 9.**
2. **Activate the carrier receive (ZCOM-CR or ZC1P-CRLn) signal of the terminal.**
3. **After the relay has operated turn off the input signals.**
4. **Check that the carrier send signal is obtained.**
5. **Repeat the procedure for other phases.**

   Only when ZC1P is used.

5.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

6 Current reversal and weak end infeed logic for residual overcurrent protection (EFCA)

Prepare the terminal for verification of settings as outlined in section2 "Preparing for test" in this chapter.

First, test the time delayed residual overcurrent protection according to the corresponding instruction. Then continue with the instructions below.

Logical signals for current reversal and WEI logic for residual overcurrent protection are available under menu tree:

Service Report/Functions/EarthFault/ComlRevWeiEF/FuncOutputs

6.1 Testing the current reversal logic

Procedure

1. **Inject the polarising voltage 3U0 to 5% of Ub and the phase angle between voltage and current to 155°, the current leading the voltage.**
2. **Inject current (155° leading the voltage) in one phase to about 110% of the setting operating current (IN>Dir).**
3. **Check that the EFCA-IRVL output is activated after the set time (tPickUp).**
4. **Abruptly reverse the current to 65° lagging the voltage, to operate the forward directional element.**
5. **Check that the EFCA-IRVL output still is activated after the reversal with a time delay that complies with the setting (tDelay).**
6. **Switch off the polarising voltage and the current.**

6.2 Testing the weak-end-infeed logic

6.2.1 If setting parameter WEI=Echo

Procedure

1. **Inject the polarising voltage 3U0 to 5% of Ub and the phase angle between voltage and current to 155°, the current leading the voltage.**
2. **Inject current (155° leading the voltage) in one phase to about 110% of the setting operating current (IN>Dir).**
3. **Activate the EFCA-CRL binary input.**

   No EFCA-ECHO and EFC--CS should appear.

4. **Abruptly reverse the current to 65° lagging the voltage, to operate the forward directional element.**

   No EFCA-ECHO and EFC--CS should appear.

5. **Switch off the current and check that the EFCA-ECHO and EFC--CS appears on the corresponding binary output or on the local HMI unit, about 200 ms after resetting the directional element.**
6. **Switch off the EFCA-CRL binary input.**
7. **Activate the EFCA-BLOCK binary input.**
8. **Activate the EFCA-CRL binary input.**

   No EFCA--ECHO and EFC--CS should appear.

9. **Switch off the polarising voltage and reset the EFCA-BLOCK and EFCA-CRL binary input.**

6.2.2 If setting WEI=Trip

Procedure

1. **Inject the polarising voltage 3U0 to about 90% of the setting (Ugr) operating voltage.**
2. **Activate the EFCA-CRL binary input.**

   No EFCA-ECHO, EFC--CS and EFCA-TRWEI outputs should appear.

3. **Increase the injected voltage to about 110% of the setting (Ugr) operating voltage.**
4. **Activate the EFCA-CRL binary input.**
5. **Check that the EFCA-ECHO, EFC--CS and EFCA-TRWEI appears on the corresponding binary output or on the local HMI unit.**
6. **Reset the EFCA-CRL binary input.**
7. **Activate the EFCA-BLOCK binary input.**
8. **Activate the EFCA-CRL binary input.**

   No EFCA-ECHO, EFC--CS and EFCA-TRWEI outputs should appear.

9. **Reset the EFCA-CRL and EFCA-BLOCK binary input.**
10. **Inject the polarising voltage 3U0 to about 110% of the setting (Ugr) and the phase angle between voltage and current to 155°, the current leading the voltage.**
11. **Inject current (155° leading the voltage) in one phase to about 110% of the setting operating current (IN>Dir).**
12. **Activate the EFCA-CRL binary input.**

    No EFCA-ECHO, EFC--CS and EFCA-TRWEI should appear.

13. **Abruptly reverse the current to 65° lagging the voltage, to operate the forward directional element.**

    No EFCA-ECHO, EFC--CS and EFCA-TRWEI should appear.

14. **Switch off the current and check that the EFCA-ECHO, EFC--CS and EFCA-TRWEI appears on the corresponding binary output or on the local HMI unit, about 200 ms after resetting the directional element.**
15. **Switch off the polarising voltage and reset the EFCA-CRL binary input.**

6.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

7 Dead line detection (DLD)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Measure the set operate values for currents and voltages. Observe the functional output signals on the local HMI under the menu:

ServiceReport/Functions/DeadLineDet/FuncOutputs

It is also possible to configure the output signals to the binary outputs for testing purposes.

Procedure

1. **Set the currents and voltages in phases L1, L2, and L3 to their rated values.**
2. **Decrease the current in phase L1 slowly, until the DLD--STIL1 signal changes to a logical 1.**

   Observe the functional output signal DLD--STIL1 on the HMI.
3. **Record the value and compare it with the set value IP<.**
4. **Increase the current to its original value.**
5. **Repeat steps 2 to 4 for phases L2 (signal DLD--STIL2) and L3 (signal DLD--STIL3).**
6. **Decrease the voltage in phase L1 slowly, until the DLD--STUL1 signal changes to a logical 1.**

   Observe the functional output signal DLD--STUL1 on the HMI.
7. **Record the value and compare it with the set value UP<.**
8. **Increase the voltage to its original value.**
9. **Repeat steps 6 to 8 for phases L2 (signal DLD--STUL2) and L3 (signal DLD--STUL3).**
10. **Make sure that all signals are reconfigured to their initial state.**
11. **Continue to test another function or complete the test by setting the test mode to off.**

8 Time delayed residual overcurrent protection (TEF)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Normally, the test of the earth-fault overcurrent protection is made in conjunction with the testing of the distance protection functions, using the same multiphase test-set. Observe that the polarising voltage is equal to -3Uo.

8.1 Checking the operate values of the current measuring elements

Procedure

1. **Set the logical input signals to logical 0 and note on the local HMI that the TEF--TRIP and the TEF--TRSOTF signal is not activated (= logical 0).**

   Values of the logical signals belonging to the time delayed residual overcurrent protection are available under menu tree:

   ServiceReport/Functions/EarthFault/TimeDelayEF

2. **Set the polarising voltage to 2% of U_b and the phase angle between voltage and current to 65°, the current lagging the voltage.**
3. **Check that the operate current of the forward directional element is equal to the IN> Dir setting.**

   The IN> Dir function activates the TEF--STFW output.

4. **Check with angles φ = 20° and 110° that the measuring element operates when $3I_0$ cos (65° - φ) >= IN> Dir.**
5. **Reverse the polarising voltage (φ = 180° + 65° = 245°) and check that the operate current of the reverse directional element is 0.6 · IN> Dir.**

   The function activates the TEF--STRV output.

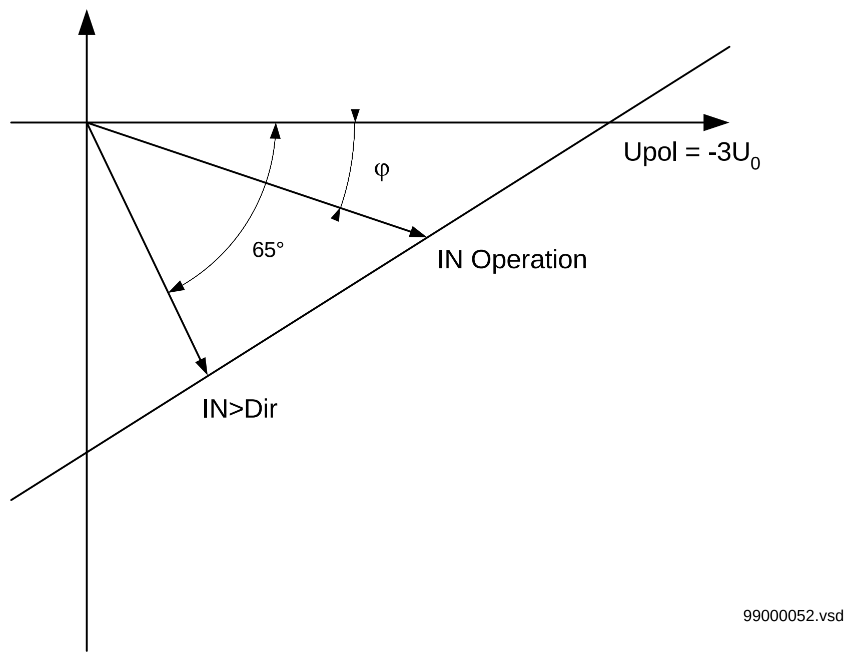


Figure 19: Measuring characteristic of the directional element.

6. **To activate the directional function, set Direction = Directional.**
7. **Set the polarising voltage to 2% of U_b and the phase angle between voltage and current to 65°.**
8. **Check the operate current of the IMin function.**

   The function activates the TEF--START output.

9. **When independent time delay (definite) is selected, check the operate time of the t1 timer by injecting a current two times the set IMin operate value.**

   When inverse time delay is selected, check the operate time at three points of the inverse characteristic. The formulas for operate time for different types of inverse time delay curves are shown in table 10.

Table 10: Operate time formulas

Characteristics	**Operate time (s)**
Normal inverse	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$ (Equation 1)
Very inverse	$t = \frac{13.5}{I - 1} \cdot k$ (Equation 2)
Extremely inverse	$t = \frac{80}{I^2 - 1} \cdot k$ (Equation 3)
Logarithmic inverse	$t = 5.8 - (1.35 \cdot \ln I)$ (Equation 4)

Where:

I is a multiple of set current $3I_0$>

k is a time multiplying factor, settable in the range of 0.05 to 1.10

Also check the tMin (minimum operate time) and IMin (minimum operate current) functions.

10. **Activate the TEF--BC input to check the function of the switch-on-to-fault logic.**
11. **Check that the TEF--TRSOTF output is activated with a 300 ms time delay when injecting a current two times the set IMin operate value in forward direction.**
12. **Set the phase angle of the polarising voltage to φ =245° and check that the directional current function and the switch-onto-fault logic gives no operation when the current is in the reverse direction.**
13. **Connect the rated DC voltage to the TEF--BLOCK configured binary input and switch on the fault current.**

    No TEF--TRIP nor TEF--START signal should appear.
14. **Switch off the fault current.**
15. **Connect the rated DC voltage to the TEF--BLKTR configured binary input and switch on the fault current.**

    No TEF--TRIP nor TEF--TRSOTF should appear. But the output TEF--START shall be activated.
16. **Continue to test another function or complete the test by setting the test mode to off.**

9 Distance protection (ZMn)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter. Consider to release Zone 1, the PHS and the TR0n. If the autorecloser is not released and in service, trip will always be three phase.

Measure operating characteristics during constant current conditions. Keep the measured current as close as possible to its rated value or lower. But ensure that it is higher than 30% of the rated current.

Ensure that the maximum continuous current of a terminal does not exceed four times its rated value, if the measurement of the operating characteristics runs under constant voltage conditions.

To verify the settings for the operating points according to figure 20, 21 or 22 and (table 11 and 12) the following fault types should be tested:

- One phase-to-phase fault (when the Ph-Ph measurement included in terminal)
- One phase-to-earth fault (when the Ph-E measurement included in terminal)

The shape of the operating characteristic depends on the values of the setting parameters.

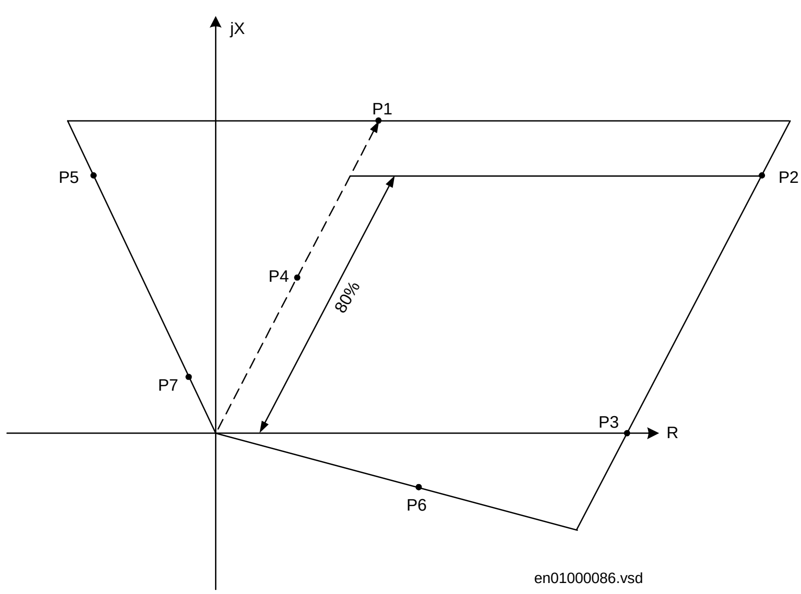


Figure 20: Test points for the distance protection (ZMn), operating characteristic case 1

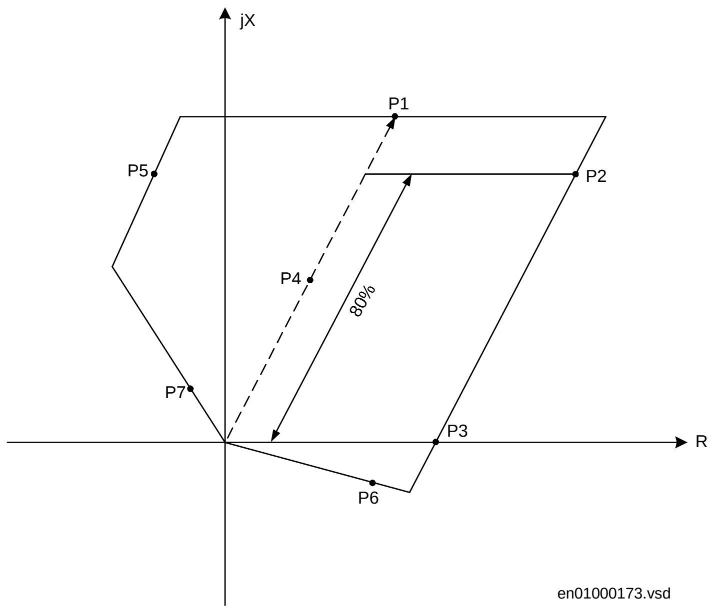


Figure 21: Test points for the distance protection (ZMn), operating characteristic case 2

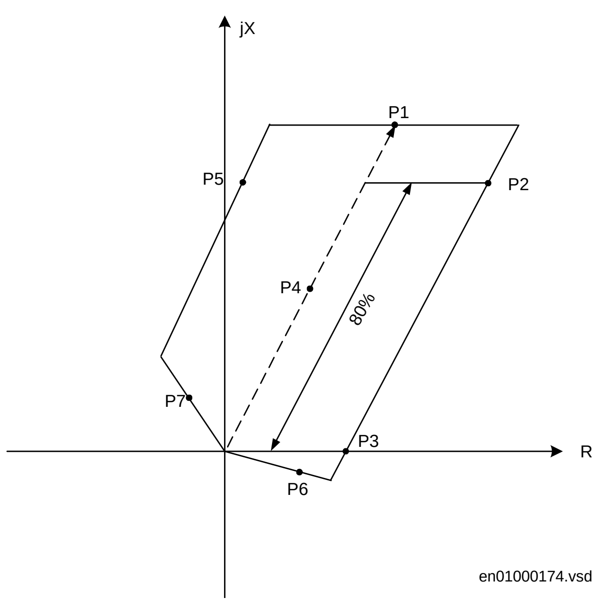


Figure 22: Test points for the distance protection (ZMn), operating characteristic case 3

Table 11: Test points for phase-to-phase loops L1-L2 (Ohm/Loop)

Test point	Reach	Set value	According to figure
P1	X	$2 \cdot X1PP_{set}$	20, 21 and 22
	R	$2 \cdot R1PP_{set}$	
P2	X	$0.8 \cdot X1PP_{set} \cdot 2$	20, 21 and 22
	R	$0.8 \cdot R1PP_{set} \cdot 2 + RFPP_{set}$	
P3	X	0	20, 21 and 22
	R	$RFPP_{set}$	
P4	X	$0.5 \cdot 2 \cdot X1PP_{set}$	20, 21 and 22
	R	$0.5 \cdot 2 \cdot R1PP_{set}$	
P5	X	$P2_X$	20
	arg	$ArgNegRes_{set}$ (for directional zone)	
P5	X	$P2_X$	21 and 22
	R	$P2_R - 2 \cdot RFPP_{set}$	
P6	arg	$ArgDir_{set}$ (for directional zone)	20, 21 and 22
P7	X	$0.1 \cdot P1_X$	20, 21 and 22
	arg	$ArgNegRes_{set}$ (for directional zone)	

Table 12: Test points for phase-to-earth L3-E (Ohm/Loop)

Test point	Reach	Set value	According to figure
P1	X	$\frac{2 \cdot X1PE_{set} + X0PE_{set}}{3}$	20, 21 and 22
	R	$\frac{2 \cdot R1PE_{set} + R0PE_{set}}{3}$	
P2	X	$0.8 \cdot \frac{2 \cdot X1PE_{set} + X0PE_{set}}{3}$	20, 21 and 22
	R	$0.8 \cdot \frac{2 \cdot R1PE_{set} + R0PE_{set}}{3} + RFPE_{set}$	
P3	X	0	20, 21 and 22
	R	$RFPE_{set}$	
P4	X	$0.5 \cdot \frac{2 \cdot X1PE_{set} + X0PE_{set}}{3}$	20, 21 and 22
	R	$0.5 \cdot \frac{2 \cdot R1PE_{set} + R0PE_{set}}{3}$	
P5	X	$P2_X$	20
	arg	$ArgNegRes_{set}$ (for directional zone)	

Test point	Reach	Set value	According to figure
P5	X	$P2_X$	21 and 22
	R	$P2_R$ - 2·$RFPE_{set}$	
P6	arg	$ArgDir_{set}$ (for directional zone)	20, 21 and 22
P7	X	0.1·$P1_X$	20, 21 and 22
	arg	$ArgNegRes_{set}$ (for directional zone)	

9.1 Measuring the operate limit of set values

Procedure

1. **Supply the terminal with healthy conditions for at least two seconds.**
2. **Apply the fault condition and slowly decrease the measured impedance to find the operating value for the phase-to-phase loop for zone 1 according to test point P1 in table table 11. Compare the result of the measurement with the set value.**
3. **Repeat steps 1 to 2 to find the operating value for test point P2, P3 in table table 11 and the operating value for the phase-to-earth loop according to test point P1, P2, P3 in table table 12.**
4. **Supply the terminal with healthy conditions for at least two seconds.**
5. **Apply the fault condition and slowly increase the measured resistance to find the operating value for test point P5 in table 11. Compare the result of the measurement with the set value.**
6. **Repeat steps 4 to 5 to find the operating value for test point P7 in table tabel 11 and P5 and P7 in table 12.**
7. **Supply the terminal with healthy conditions for at least two seconds.**
8. **Apply the fault condition and slowly increase the measured reactance to find the operating value for test point P6 in table 11. Compare the result of the measurement with the set value.**
9. **Repeat steps 7 to 8 to find the operating value for test point P6 in table 12.**
10. **Repeat steps 1 to 3 for all other used measuring zones.**

    Observe that the zone that are not tested has to be blocked and the zone that is tested has to be released.

Note!

Test points 6 and 7 are intended to test the directional lines of impedance protection. Since directionality is a common function for all 5 measuring zones, in order to test the accuracy of directionality (directional angles), it is enough to test points 6 and 7 one time only in forward direction (the largest reverse zone can be used to facilitate the test). Directional functionality (trip inside, no-trip outside) should always be carried for all ZM zones set with directionality (forward or reverse).

9.2 Measuring the operate time of distance protection zones

Procedure

1. **Supply the terminal with healthy conditions for at least two seconds.**
2. **Apply the fault condition to find the operating time for the phase-to-phase loop according to test point P4 in table table 11 for zone 1. Compare the result of the measurement with the setting t1PP.**
3. **Repeat steps 1 to 2 to find the operating time for the phase-to-earth loop according to test point P4 in table 12. Compare the result of the measurement with the setting t1PE.**
4. **Repeat steps 1 to 3 to find the operating time for all other used measuring zones.**

   Observe that the zone that are not tested has to be blocked and the zone that is tested has to be released.

9.3 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

10 Disturbance recorder (DR)

Evaluation of the results from the disturbance recording function requires access to a workstation either permanently connected to the terminal or temporarily connected to the serial port on the front. The CAP tool software package must be installed in the workstation.

Disturbance upload can be performed by the use of SMS 510, CAP 540 or by any third party tool with IEC 60870-5-103 protocol. Disturbance files can be analyzed by any tool reading Comtrade formatted disturbance files including REVAL and WinEve.

It could be useful to have a printer for hard copies. The behavior of the disturbance recording function can be checked when protective functions of the terminal are tested. When the terminal is set to operate in test mode, there is a separate setting for operation of the disturbance report, which also affects the disturbance recorder.

A manual trig can be started any time. This results in a snap-shot of the actual values of all recorded channels.

11 Event function (EV)

During testing, the terminal can be set in test mode from the PST. The functionality of the event reporting during test mode is set from the PST as follows:

- Use event masks
- Report no events
- Report all events

In Test Mode, individual event blocks can be blocked from the PST.

Individually event blocks can also be blocked from the local HMI under the menu:

Test/TestMode/BlockEventFunc

12 Event recorder (ER)

During testing, the event recorder can be switched off if desired. This is found in the SMS or Substation Control System (SCS).

13 Fault locator (FLOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The distance to fault, as calculated for each fault separately, will automatically be displayed on the local HMI for each fault that also causes the non-delayed tripping operation and has been detected by the built-in, phase-selection function. The FLOC- function will not calculate the distance to the fault if faults are repeated in periods shorter than 10 seconds. The values of the currents and voltages are stored in the terminal memory as new disturbances. Start of the calculation of a distance to fault can always be manually initiated.

Distances to faults for the last 10 recorded disturbances can be found on the local HMI under the menu:

DisturbReport/Disturbances/Disturbance n (n=1-10)/FaultLocator

Table 13: Test settings

Parameter:	Condition:
I	Higher than 30% I_r
Healthy conditions	U = 63,5 V, I = 0 A & ZF = 0°
Impedance |Z|	Test point Note: • $Z_x \leq (X0 + 2 \cdot X1)/3$For single-phase faults • $Z_x \leq X1$For three and two phase faults • $Z_x \leq (X0 + 2 \cdot X1\ XM)/3$For single-phase fault with mutual zero-sequence current
Impedance angle ZΦ	Test angle • ZΦ arctan[(X0 + 2 · X1) / (R0 + 2R1)] For single-phase faults • ZΦ arctan(X1/R1)For two-phase faults

13.1 Measuring the operate limit

Procedure

1. **Set the test point (|Z| fault impedance and ZΦ impedance phase angle) for a condition that meets the requirements in table 13.**
2. **Supply the relay with healthy conditions for at least two seconds.**
3. **Apply a fault condition.**

   Check that the distance-to-fault value displayed on the HMI complies with the following equations (the error should be less than five percent):

$$p = \frac{Z_x}{X1} \cdot 100$$

(Equation 5)

in % for two- and three-phase faults

$$p = \frac{3 \cdot Z_x}{X0 + 2 \cdot X1} \cdot 100$$

(Equation 6)

in % for single-phase-to-earth faults

$$p = \frac{3 \cdot Z_x}{X0 + 2 \cdot X1 \pm XM} \cdot 100$$

(Equation 7)

in % for single-phase-to-earth faults with mutual zero sequence current.

Where:

p	= the expected value of a distance to fault in percent
Z_x	= set test point on the test set
X0	= set zero-sequence reactance of a line
X1	= set positive-sequence reactance of a line
XM	= set mutual zero-sequence impedance of a line

13.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

14 Fuse failure supervision (FUSE)

Prepare the terminal for verification of settings as outlined in sectction 2 "Preparing for test" in this chapter.

The verification is divided in two main parts. The first part is common to all fuse failure supervision options, and checks that binary inputs and outputs operate as expected according to actual configuration. In the second part the relevant set operate values are measured.

The corresponding binary signals that inform the operator about the operation of the FUSE function are available on the local human-machine interface (HMI) unit under the menu:

Service Report/Functions/FuseFailure/FuncOutputs

14.1 Checking that the binary inputs and outputs operate as expected

Procedure

1. **Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.**
2. **Connect the nominal dc voltage to the FUSE-DISC binary input.**
   - The signal FUSE-VTSU should appear with almost no time delay.
   - No signals FUSE-VTSZ and FUSE-VTF3PH should appear on the terminal.
   - Only the distance protection function operates.
   - No other undervoltage-dependent functions must operate.
3. **Disconnect the dc voltage from the FUSE-DISC binary input terminal.**
4. **Connect the nominal dc voltage to the FUSE-MCB binary input.**
   - The FUSE-VTSU and FUSE-VTSZ signals should appear without any time delay.
   - No undervoltage-dependent functions must operate.
5. **Disconnect the dc voltage from the FUSE-MCB binary input terminal.**
6. **Disconnect one of the phase voltages and observe the logical output signals on the terminal binary outputs.**

   FUSE-VTSU and FUSE-VTSZ signals should simultaneously appear.
7. **After more than 5 seconds disconnect the remaining two phase voltages and all three currents.**
   - There should be no change in the high status of the output signals FUSE-VTSU and FUSE-VTSZ.
   - The signal FUSE-VTF3PH will appear.

8. **Simultaneously establish normal voltage and current operating conditions and observe the corresponding output signals.**

   They should change to the logical 0 as follows:

   - Signal FUSE-VTF3PH after about 25 ms
   - Signal FUSE-VTSU after about 50 ms
   - Signal FUSE-VTSZ after about 200 ms

14.2 Measuring the operate value for the negative sequence function

Measure the operate value for the negative sequence function, if included in the terminal.

Procedure

1. **Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.**
2. **Slowly decrease the measured voltage in one phase until the FUSE-VTSU signal appears.**
3. **Record the measured voltage and calculate the corresponding negative-sequence voltage according to the equation.**

   Observe that the voltages in the equation are phasors:

$$3 \cdot \overline{U_2} = \overline{U_{L1}} + a^2 \cdot \overline{U_{L2}} + a \cdot \overline{U_{L3}}$$

(Equation 8)

Where:

$\overline{U_{L1}}$ $\overline{U_{L2}}$ and $\overline{U_{L3}}$ = the measured phase voltages

$$a = 1 \cdot e^{j\frac{2 \cdot \pi}{3}} = -0,5 + j\frac{\sqrt{3}}{2}$$

4. **Compare the result with the set value (consider that the set value 3U2> is in percentage of the base voltage U1b) of the negative-sequence operating voltage.**

14.3 Measuring the operate value for the zero sequence function

Measure the operate value for the zero sequence function, if included in the terminal.

Procedure

1. **Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.**
2. **Slowly decrease the measured voltage in one phase until the FUSE-VTSU signal appears.**
3. **Record the measured voltage and calculate the corresponding zero-sequence voltage according to the equation.**

   Observe that the voltages in the equation are phasors.

$$3 \cdot \overline{U_0} = \overline{U_{L1}} + \overline{U_{L2}} + \overline{U_{L3}}$$

(Equation 9)

Where:

$\overline{U_{L1}}$, $\overline{U_{L2}}$ and $\overline{U_{L3}}$ = the measured phase voltages.

4. **Compare the result with the set value (consider that the set value 3U0> is in percentage of the base voltage U1b) of the zero-sequence operating voltage.**

14.4 Checking the operation of the du/dt, di/dt based function

Check the operation of the du/dt, di/dt based function, if included in the terminal.

Procedure

1. **Simulate normal operating conditions with the three-phase currents in phase with their corresponding phase voltages and with all of them equal to their rated values.**
2. **Connect the nominal dc voltage to the FUSE-CBCLOSED binary input.**
3. **Change the voltages and currents in all three phases simultanously.**

   The voltage change should be greater then set DU> and the current change should be less than the set DI<.

   - The FUSE-VTSU and FUSE-VTSZ signals appear without any time delay. If the remaining voltage levels are higher than the set U< of the DLD function, only a pulse is achieved.
   - FUSE-VTF3PH should appear after 5 seconds, if the remaining voltage levels are lower than the set U< of the DLD function.

4. **Apply normal conditions as in step 1.**

   The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should reset, if activated. See step 3.

5. **Change the voltages and currents in all three phases simultanously.**

   The voltage change should be greater then set DU> and the current change should be greater then the set DI<.

   The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should not appear.

6. **Disconnect the dc voltage to the FUSE-CBCLOSED binary input.**
7. **Apply normal conditions as in step 1.**
8. **Repeat step 3.**
9. **Connect the nominal voltages in all three phases and feed a current below the operate level in all three phases.**
10. **Keep the current constant. Disconnect the voltage in all three phases simultaneously.**

    The FUSE-VTSU, FUSE-VTSZ and FUSE-VTF3PH signals should not appear.

14.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

15 General fault criteria (GFC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The GFC measuring elements operate in underimpedance mode according to the same measuring principles as the impedance measuring zones. It is therefore necessary to follow the same principles when performing the secondary injection tests.

15.1 Testing the underimpedance mode

The measured loop reactance in forward direction should correspond to the following expression:

$$X_m = \frac{1}{3} \cdot (2 \cdot X1FwPE + X0FwPE)$$

(Equation 10)

A similar expression also applies to the measured loop impedance in reverse direction:

$$X_m = \frac{1}{3} \cdot (2 \cdot X1RvPE + X0RvPE)$$

(Equation 11)

The measured loop resistances in forward and reverse direction should correspond directly to the set values for the single-phase-to-earth-faults: RFPE and RLd.

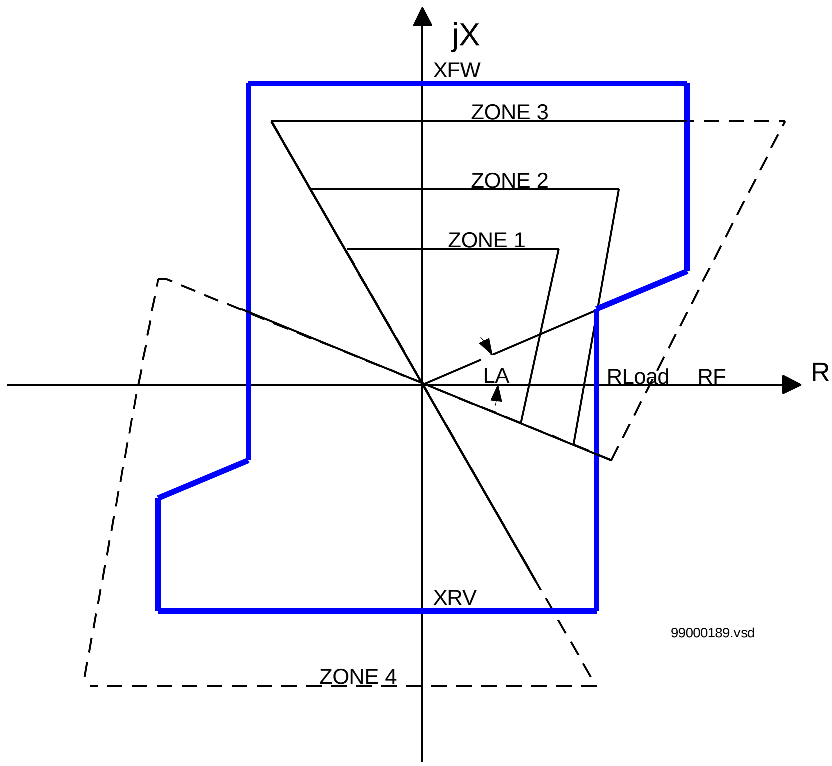


Figure 23: Operating characteristics of the GFC and zone measuring elements

The measured phase reactance in forward direction should correspond directly to the set value X1FwPP. Similar applies also to the measured phase reactance in reverse direction, which must correspond directly to the set value X1RvPP.

The measured phase resistances in forward and reverse direction should correspond to the following expressions:

$$R_m = \frac{1}{2} \cdot RFPP$$

(Equation 12)

and

$$R_m = \frac{1}{2} \cdot RLd$$

(Equation 13)

The test is proposed to be carried out with constant current equal to rated current and lower the voltage until operation of the GFC.

The testing procedure for the manual testing of the operating characteristics of different impedance measuring zones and different faults is:

Procedure

1. **Configure all the GFC start signals (GFC--STFWL1, GFC--STFWL2, GFC--STFWL3, GFC--STFWPE and so on to the selected binary outputs.**
2. **Set up the test equipment for three-phase impedance configuration and choose impedance plain when applicable.**
3. **Connect the corresponding GFC--STFn signal to the test equipment binary input No.1.**
4. **Set the test equipment to these parameters in the 3PZ display:**
5. **Set Z fault impedance and Z impedance angle for the GFC under test at +10% of the zone setting for one of the suggested testing points.**
6. **Supply the terminal with healthy conditions for at least two seconds.**
7. **Apply fault conditions.**
8. **Slowly decrease the measured Z impedance until the tested zone operates.**
9. **Check that the correct signal (GFC--STFWLn) appears on the HMI.**
10. **Compare the result of the measurement with the setting values.**
11. **Repeat steps 5 to 8 for other measuring points of the same GFC measuring zone in both forward and reverse direction.**
12. **Repeat steps 1 to 11 for all combinations of phase to ground fault.**
13. **Repeat 1 to 11 for phase to phase faults for all combinations when applicable.**

15.2 Testing the overcurrent operating mode

The basic configuration of the measuring equipment and the tested terminal should be the same as that for the measurement of operating characteristics under the impedance measuring mode. The initial conditions for the measurement should also be the same.

When testing the GFC measuring elements in the corresponding phases it is necessary to slowly increase the current in the measured phase until the corresponding phase's selection signal (for the non-directional operation of the GFC) appears on the local HMI unit. If the two-phase or three-phase operation is of interest, the corresponding currents should be increased simultaneously. Compare the operating value with the set value for IP>.

When testing the residual current measuring element, it is necessary to slowly increase the measured current in one phase-to-earth-fault loop until the signal GFC--STPE appears on the local HMI unit. Compare the operating value with the set value for IN>.

Procedure

1. **The test equipment must be set up for the “General” three-phase voltage and current source.**
2. **Configure the GFC--STLn signals to the corresponding binary outputs of the terminal, and connect them one after another to the corresponding binary inputs on the test equipment (when applicable).**
3. **Configure the binary input of the test equipment, corresponding to the signal condition from GFC--STLn.**
4. **On the six generators, set nominal current and voltage conditions in all three phases with 120 degrees phase shift between the phases (L1 reference).**
5. **Lower the voltage manually in phase L1 until the appropriate signal appears on the binary input on the test equipment.**
6. **Compare the measured results with the corresponding setting values IP> and IN>.**
7. **Repeat the measurement in the other two phases and compare the results with the setting values IP> and IN>.**
8. **Repeat the measurement in one phase and observe the GFC--STPE signal that indicates the operation of the measuring element for the residual current.**
9. **Compare the measured results with the corresponding setting values.**

15.3 Testing the phase preference logic

The phase preference logic is tested with a three-phase testing equipment for distance protections. Initiating a two-phase-to-earth fault with the current disconnected in one of the faulty phases performs the test. Tripping is allowed only in a phase with preference to the disconnected, in accordance with the preference scheme. The test is repeated with all three types of two-phase-to-earth faults, and one of the faulty phases disconnected from the current, one by one (totally 6 shots).

15.4 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

16 High speed binary output logic (HSBO)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Since the high-speed binary out logic is dependent upon other function blocks (HS---, ZM1-, ZC1P-, ZCOM- and TRIP-) in order to operate, those functions have to be set into operating mode (On).

16.1 HSBO- trip from communication logic

Whenever a trip appears during these tests, it should be possible to block it through the function input HSBO-BLKZCTR. Activation of either HSBO-BLKHSTR or HSBO-BLKHSCS should not block the trip outputs in this case. It should also be possible to block the trip signals at the backing function from which the internal signals are derived (ZC1P, ZCOM or TRIP).

Note!

No carrier send should appear during the tests in this section.

Test for three of the trip schemes in ZC1P (Blocking Scheme not included).

Procedure

1. **Apply inputs in different combinations to ZC1P-CACCLn, ZC1P-CR-Lm / ZC1P-CRMPH and check the outputs of HSBO-TRLx. For each trip, test the blocking action for all three HSBO blocking inputs and ZC1P-BLOCK.Check results according to the used scheme.**

   ZC1P/SchemeType = *Intertrip*

   No local trip condition is required (-CACCLn). Trip output HSBO-TRLx will be activated directly according to corresponding -CRLx. Activation of -CRMPH should result in a three-phase trip.

   ZC1P/SchemeType = *PermissiveUR*

   When -CACCLn is applied in the same time as -CRLn (same phases), a trip output should appear in the n-phase(s), HSBO-TRLn. If -CRMPH is applied instead of -CRLn, a trip should appear in the same phase as -CACCLn.

   ZC1P/SchemeType = *PermissiveOR*

   Same result as for the permissive underreach test should be obtained.

2. **Remove applied signals.**

16.2 ZCOM trip schemes

Test for three of the trip schemes in ZCOM (Blocking Scheme not included) together with TRIP.

Procedure

1. **Apply inputs in different combinations to TRIP-PSLn, ZCOM-CACC and ZCOM-CR and check the outputs of HSBO-TRLx. For each trip test the blocking action for all three HSBO blocking inputs, ZCOM-BLOCK and TRIP-BLOCK. Check results according to the used scheme and trip program.**

   - ZCOM/SchemeType = *Intertrip*
   - TRIP/Program = *1/2/3ph*

   When -PSLn is applied in the same time as -CR, a trip output should appear in the n-phase(s), HSBO-TRLn.

   - ZCOM/SchemeType = *PermissiveUR*
   - TRIP/Program = *1/3ph*

   When -PSLn is applied in the same time as -CACC and -CR, a trip output should appear in the n-phase(s), HSBO-TRLn.

   - ZCOM/SchemeType = *PermissiveOR*
   - TRIP/Program = *3ph*

   Each time -CACC and -CR are activated at the same time, a three-phase trip should be obtained, independent of any phase selection (-PSLn).

2. **Remove applied signals.**

16.3 HSBO- trip from the distance protection zone 1 function (ZM1)

In order to test the performance of the high-speed binary out function alone without any interference from other functions the binary outputs configured for the HSBO function must not carry any other signals. For example, if the outputs are shared with the TRIP function the TRIP function should be switched off.

Switch the HS function off as well.

Whenever a trip appears during these tests, it should be possible to block it through the function input HSBO-BLKHSTR.

Note that no carrier send will be issued from the distance protection function zone 1. Activation of HSBO-BLKZCTR or HSBO-BLKHSCS should not block any outputs in this test.

Use the 3-phase test set to achieve the specified conditions.

Suggested fault characteristics, for all types of faults:

- Prefault conditions: $U_{phase} = U_b$ V, 0° I = 0.0 A, 0°
- Fault conditions: Within set operating characteristic of ZM1 function.

Procedure

1. **Apply faults according to table 14. Trip and carrier send outputs should appear as indicated (with YES).**
2. **Remove applied signals.**
3. **Set the terminal in normal service.**

Table 14: Output signals for different fault types

	Fault type						
Signal	**L1**	**L2**	**L3**	**L1,L2**	**L2,L3**	**L3,L1**	**L1,L2,L3**
HSBO-TRL1	YES			YES		YES	YES
HSBO-TRL2		YES		YES	YES		YES
HSBO-TRL3			YES		YES	YES	YES
HSBO-CSL1							
HSBO-CSL2							
HSBO-CSL3							
HSBO-CSMPH							

16.4 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

17 Instantaneous non-directional overcurrent protection (IOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

Ensure that the maximum continuous current of the terminal does not exceed four times its rated value.

17.1 Measuring the operate limit of set values

17.1.1 Phase overcurrent protection

Procedure

1. **Inject a phase current in the terminal with start below the setting value.**
2. **Increase the injected current in the L*n* phase until the IOC--TRL*n* (*n*=1-3) signal appears.**
3. **Switch off the fault current.**

   Observe the maximum permitted overloading of the current circuits in the terminal.
4. **Compare the measured operating current with the set value.**

17.1.2 Residual overcurrent protection (non-dir.)

Procedure

1. **Inject a phase current in the terminal with start below the setting value.**
2. **Increase the injected current in the L*n* phase until the IOC--TRN signal appears.**
3. **Switch off the fault current.**

   Observe the maximum permitted overloading of the current circuits in the terminal.
4. **Compare the measured operating current with the set value.**

17.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

18 Local acceleration logic (ZCLC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The logic is checked during the secondary injection test of the impedance measuring zones.

Procedure

1. **Supply the terminal with healthy conditions for at least two seconds.**
2. **Deactivate the conditions for accelerated function.**
3. **Apply a phase to earth fault at 100% of line impedance.**
4. **Check that the fault is tripped with the second zone time delay.**
5. **Supply the terminal with healthy conditions for at least two seconds.**
6. **Activate the condition for accelerated function either by the auto-recloser or by the loss of load.**
7. **Apply a phase to earth fault at 100% of line impedance.**
8. **Check that the fault is tripped “instantaneously”.**
9. **Continue to test another function or complete the test by setting the test mode to off.**

19 Supervision of AC input quantities (DA)

Stabilized ac current and voltage generators and corresponding current, voltage, power and frequency meters with very high accuracy are necessary for testing the alternating quantity measuring function. The operating ranges of the generators must correspond to the rated alternate current and voltage of each terminal.

Prepare the terminal for verification of settings as outlined in section "Preparing for test" in this chapter. Connect the generators and instruments to the corresponding input terminals of a unit under test.

19.1 Verifying the settings

Procedure

1. **Supply the terminal with voltages and currents.**

   Check that the values presented on the HMI unit correspond to the magnitude of input measured quantities within the limits of declared accuracy. The mean service values are available under the submenu:

   Service Report/ServiceValues

   The phasors of up to five input currents and voltages are available under the submenu:

   Service Report/Phasors/Primary

2. **Check the operation of ADBS or IDBS when applicable. Compare with the expected values.**

   The operation of ADBS or IDBS function can be checked separately with the RepInt = 0 setting. The value on the HMI follows the changes in the input measuring quantity continuously.

3. **Check the set operate levels of the monitoring function by changing the magnitude of input quantities and observing the operation of the corresponding output relays.**

   The output contact changes its state when the changes in the input measuring quantity are higher than the set values HIWARN, HIALARM, or lower than the set values LOWWARN, LOWALARM.

19.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

20 Power swing detection (PSD)

The aim of this instruction is to verify the setting of PSD and to verify that the PSD covers all impedance zones that shall be blocked by the PSD.

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Before start of this process, all impedance measuring zones shall be set and in operation. The inner zone of the PSD must cover all zones to be blocked by the PSD with at least 10% margin. Se figure 24 below.

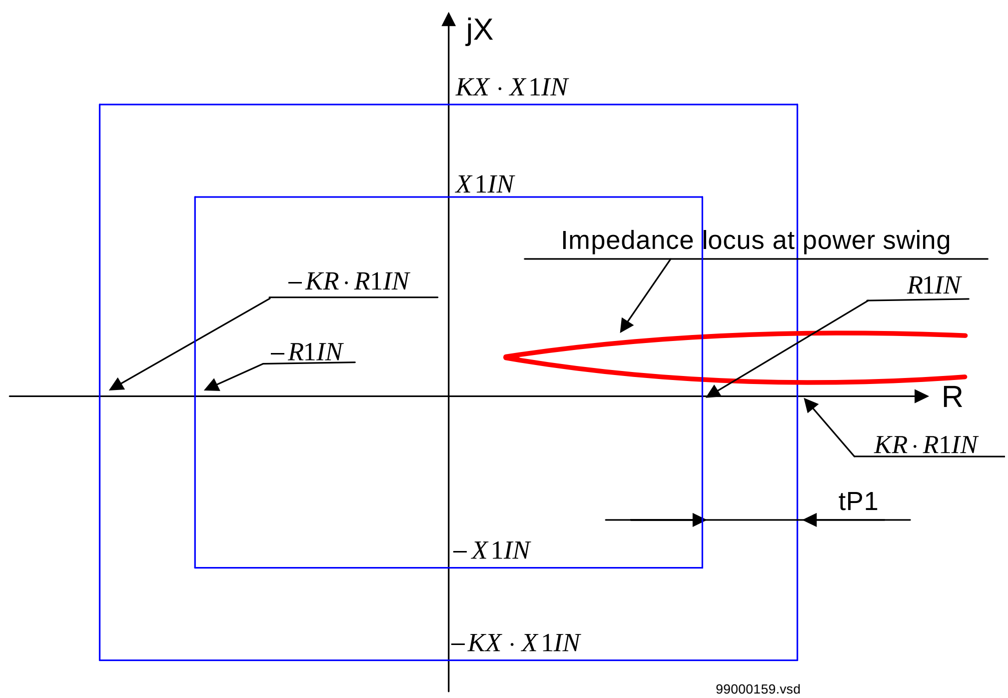


Figure 24: Operating principle and characteristic of the PSD function

The PSD can operate in two modes by the configuration; “one of three phase operation” and “two out of three phase operation”. Look into the configuration to see which one is valid the terminal.

20.1 Testing overview

Procedure

1. **Re-configure the binary output from the PSD--ZOUT signal to the PSD--START signal of the PSD function.**

   It is also possible to observe the PSD--START signal on the regular output terminals, if provided during the engineering stage. Check the corresponding terminal documentation.

2. **Decrease slowly the measured voltages in all three phases until the W-meter detects the appearance of the PSD--START signal.**
3. **Increase the measured voltages to their rated values.**
4. **Decrease instantaneously voltages in all three phases to the values, which are for approximately 20% lower than the set value R1IN.**

   The START signal must not appear.

5. **Increase the measured voltages to their rated values.**

20.2 Testing the one-of-three-phase operation

Procedure

1. **Check the existing (default) configuration of the following function input signals:**

   PSD--REL1PH, PSD--BLK1PH, PSD--REL2PH, PSD--BLK2PH and record the connections.

2. **Reconfigure the terminal according to the following list:**
   - PSD--REL1PH to FIXD-ON
   - PSD--BLK1PH to FIXD-OFF
   - PSD--REL2PH to FIXD-OFF
   - PSD--BLK2PH to FIXD-ON
3. **Disconnect the L2 and L3 currents from the terminal and check that they are short-circuited on the output terminal of the testing equipment.**
4. **Decrease slowly the measured voltages until the PSD--START signal appears.**
5. **Increase the measured voltages to their rated values.**

20.3 Testing the two-of-three-phase operation

Procedure

1. **Reconfigure the terminal according to the following list:**

- PSD--REL1PH to FIXD-OFF
- PSD--BLK1PH to FIXD-ON
- PSD--REL2PH to FIXD-ON
- PSD--BLK2PH to FIXD-OFF

2. **Decrease slowly the measured voltages to the value, which is for approximately 20% lower than the operation value for the R1IN measuring point.**

   No PSD--START signal must appear.

3. **Increase the measured voltages to their rated values.**
4. **Connect the phase L2 current to the terminal again.**
5. **Decrease the measured voltages until the PSD--START signal appears.**
6. **Increase the measured voltages to their rated values.**
7. **Connect the phase L3 current to the terminal.**
8. **Return the original configuration for the functional inputs PSD--REL1PH, PSD--BLK1PH, PSD--REL2PH, and PSD--BLK2PH.**

20.4 Testing the tEF timer and functionality

Procedure

1. **Check and record the default configuration for the PSD--TRSP, PSD--I0CHECK, PSD--BLKI01, PSD--BLKI02, and PSD--BLOCK functional inputs.**
2. **Re-configure the functional inputs PSD--TRSP and PSD--I0CHECK to two empty binary inputs of a terminal.**
3. **Configure functional inputs PSD--BLKI01, and PSD--BLKI02 to the FIXD-ON functional output and the PSD--BLOCK functional input to the FIXD-OFF functional input.**
4. **Connect the binary input towards the PSD--I0CHECK functional input via an open switch to the constant positive dc voltage.**
5. **Connect the binary input towards the PSD--TRSP functional input via a closed switch to the constant positive dc voltage.**
6. **Decrease the measured voltages slowly until the START signal appears.**
7. **Close the switch towards the binary input with PSD--I0CHECK connection and observe the PSD--START signal.**

   It must reset instantaneously.

8. **Open the switch towards the PSD--I0CHECK functional input.**

9. **Open the switch towards the PSD--TRSP functional input and close with some time delay the switch towards the PSD--I0CHECK functional input.**

   The PSD--START signal resets, if the time difference between opening the first and closing the second switch is shorter than the time delay set on the tEF timer. The PSD--START signal does not reset in the opposite case.

10. **Increase the measured voltages to their rated values.**

20.5 Testing the tR1 timer

Procedure

1. **Disconnect the dc voltage from the binary inputs connected to the PSD--TRSP and PSD--I0CHECK functional inputs.**
2. **Connect the binary input towards the PSD--I0CHECK functional input via an open switch to the constant positive dc voltage.**
3. **Re-configure the PSD--BLKI02 functional input to the FIXD-OFF functional output.**
4. **Decrease the measured voltages slowly until the PSD--START signal appears.**
5. **Close the switch towards the PSD--I0CHECK binary input and observe the PSD--START signal.**

   It must reset with the time delay set on the tR1 timer. It is also possible to measure this time delay with timer, which starts with closing of a switch and stops with the reset of a PSD--START signal on the corresponding binary output.

6. **Increase the measured voltages to their rated values.**

20.6 Testing the tR2 timer

Procedure

1. **Disconnect the dc voltage from the binary input connected to the PSD--I0CHECK functional input.**
2. **Re-configure the functional input PSD--BLKI02 to the FIXD-ON functional input and PSD--BLKI01 to the FIXD-OFF functional output.**
3. **Decrease slowly the measured voltages until the PSD--START signal appears.**

   It should reset after the time delay, set on tR2 timer. It is also possible to measure the time delay tR2.

4. **Connect for this purpose the timer to the binary output with the PSD--START signal.**

5. **Start the timer with change of the signal from 0 to 1 and stop it with the change from 1 to 0.**
6. **Increase the measured voltages to their rated values**

20.7 Testing the block input

Procedure

1. **Re-configure the functional input PSD--BLOCK to the binary input, to which the PSD--I0CHECK has been configured so far.**
2. **Re-configure the functional input PSD--BLKI01 to the FIXD-ON functional input.**
3. **Decrease slowly the measured voltages in all three phases until the PSD--START signal appears.**
4. **Close the switch towards the PSD--BLOCK binary input and observe the PSD--START signal.**

   It must reset instantaneously.
5. **Increase the measured voltages to their rated values.**
6. **Re-configure the functional inputs PSD--TRSP, PSD--I0CHECK, PSD--BLKI01, PSD--BLKI02, and PSD--BLOCK to their original configuration.**

20.8 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

21 Setting lockout (HMI)

21.1 Verifying the settings

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Procedure

1. **Configure the HMI--BLOCKSET functional input to the binary input, which is determined by the engineering or the input that is not used by any other function.**
2. **Set the setting restriction to SettingRestrict = Block.**
3. **Connect rated DC voltage to the selected binary input.**
4. **Try to change the setting of any parameter for one of the functions.**

   Reading of the values must be possible.

   The terminal must not respond to any attempt to change the setting value or configuration.
5. **Disconnect the control DC voltage from the selected binary input.**
6. **Repeat the attempt under step 4.**

   The terminal must accept the changed setting value or configuration.
7. **Depending on the requested design for a complete REx 5xx terminal, leave the function active or reconfigure the function into the default configuration and set the setting restriction function out of operation to SettingRestrict = Open.**

21.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

22 Scheme communication logic (ZCOM)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Check the scheme logic during the secondary injection test of the impedance or overcurrent protection functions. For details see the ordering sheets for each particular REx 5xx terminal.

Activating the different zones verifies that the ZCOM-CS signal is issued from the intended zones. The ZCOM-CS signal from the independent tripping zone must have a tSendMin minimum time.

Check the tripping function by activating the ZCOM-CR and ZCOM-CRG inputs with the overreaching zone used to achieve the ZCOM-CACC signal.

It is sufficient to activate the zones with only one type of fault with the secondary injection.

22.1 Testing permissive underreach

Procedure

1. **Activate carrier receive (ZCOM-CR) signal of the terminal.**
2. **Supply the relay with healthy conditions for at least two seconds.**
3. **Apply a fault condition within the permissive zone.**
4. **Check that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.**
5. **Check that other zones operate according to their zone timer and that the carrier send (ZCOM-CS) signal is obtained only for the zone configured to give the actual signal.**
6. **Deactivate the carrier receive (ZCOM-CR) signal of the terminal.**
7. **Check that the trip time complies with the zone timers and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.**

22.2 Testing permissive overreach

Procedure

1. **Activate the carrier receive (ZCOM-CR) signal of the terminal.**
2. **Supply the relay with healthy conditions for at least two seconds.**
3. **Apply a fault condition within the permissive zone.**
4. **Check that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.**

5. **Check that the other zones operate according to their zone timer and that the carrier send (ZCOM-CS) signal is obtained only for the zones that are configured to give the actual signal.**
6. **Deactivate the carrier receive (ZCOM-CR) signal of the terminal.**
7. **Supply the relay with healthy conditions for at least two seconds.**
8. **Apply a fault condition within the permissive zone.**
9. **Check that trip time complies with the zone timers and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.**

22.3 Testing blocking scheme

Procedure

1. **Deactivate the carrier receive (ZCOM-CR) signal of the terminal.**
2. **Supply the relay with healthy conditions for at least two seconds.**
3. **Apply a fault condition within the forward directed zone used for scheme communication tripping.**
4. **Check that correct trip outputs and external signals are obtained for the type of fault generated and that the operate time complies with the tCoord timer (plus relay-measuring time).**
5. **Check that the other zones operate according to their zone times and that a carrier send (ZCOM-CS) signal is only obtained for the reverse zone.**
6. **Activate the carrier receive (ZCOM-CR) signal of the terminal.**
7. **Apply a fault condition in the forward directed zone used for scheme communication tripping.**
8. **Check that the no trip from scheme communication occurs.**
9. **Check that trip time from the forward directed zone used for scheme communication tripping complies with the zone timer and that correct trip outputs, external signals, and indication are obtained for the actual type of fault generated.**

22.4 Checking of unblocking logic

Check the unblocking function (if the function is required) when you check the communication scheme.

22.4.1 Command function with continuous unblocking (Unblock = 1)

Procedure

1. **Activate the carrier guard input signal (ZCOM-CRG) of the terminal.**

2. **Using the scheme selected, check that a carrier accelerated trip (ZCOM-TRIP) is obtained when the carrier guard signal is deactivated.**

22.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

23 Scheme communication logic for residual overcurrent protection (EFC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter. Before testing the communication logic for residual overcurrent protection, the residual overcurrent protection has to be tested according to the corresponding instruction. Then continue with the instructions below.

If the current reversal and weak-end-infeed logic for earth-fault protection is included, proceed with the testing according to the corresponding instruction after the test of the communication logic for residual overcurrent protection. The current reversal and weak-end-infeed functions shall be tested together with the permissive scheme.

23.1 Testing the directional comparison logic function

23.1.1 Blocking scheme

Procedure

1. **Inject the polarising voltage 3U0 to 5% of Ub and the phase angle between voltage and current to 65°, the current lagging the voltage.**
2. **Inject current (65° lagging the voltage) in one phase to about 110% of the setting operating current, and switch off the current with the switch.**
3. **Switch on the fault current and measure the operating time of the EFC logic.**

   Use the EFC--TRIP signal from the configured binary output to stop the timer.
4. **Compare the measured time with the set value tCoord.**
5. **Activate the EFC--CR binary input.**
6. **Check that the EFC--CRL output is activated when EFC--CR input is activated.**
7. **Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.**

   No EFC--TRIP signal should appear.
8. **Switch off the fault current.**
9. **Reset the EFC--CR binary input.**
10. **Activate the EFC--BLOCK digital input.**
11. **Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.**

    No EFC--TRIP signal should appear.
12. **Switch off the fault current and the polarising voltage.**

13. **Reset the EFC--BLOCK digital input.**

23.1.2 Permissive scheme

Procedure

1. **Inject the polarising voltage 3U0 to 5% of Ub and the phase angle between voltage and current to 65°, the current lagging the voltage.**
2. **Inject current (65° lagging the voltage) in one phase to about 110% of the setting operating current, and switch off the current with the switch.**
3. **Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.**

   No EFC--TRIP signal should appear, and the EFC--CS binary output should be activated.
4. **Switch off the fault current.**
5. **Activate the EFC--CR binary input.**
6. **Switch on the fault current (110% of the setting) and measure the operating time of the EFC logic.**

   Use the EFC--TRIP signal from the configured binary output to stop the timer.
7. **Compare the measured time with the set value tCoord.**
8. **Activate the EFC--BLOCK digital input.**
9. **Switch on the fault current (110% of the setting) and wait longer than the set value tCoord.**

   No EFC--TRIP signal should appear.
10. **Switch off the fault current and the polarising voltage.**
11. **Reset the EFC--CR binary input and the EFC--BLOCK digital input.**

23.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

24 Four parameter setting groups (GRP)

24.1 Verifying the settings

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Procedure

1. **Check the configuration of binary inputs that control the selection of active setting group.**
2. **Browse the 'ActiveGroup' menu to achieve information about the active setting group.**

   The ActiveGroup menu is located in the local HMI under:

   ServiceReport/ActiveGroup

3. **Connect the appropriate dc voltage to the corresponding binary input of the terminal and observe the information presented on the HMI display.**

   The displayed information must always correspond to the activated input.

4. **Check that corresponding output indicates the active group.**
5. **Continue to test another function or complete the test by setting the test mode to off.**

25 Synchrocheck and energizing check (SYN)

This section contains instructions on how to test the synchro-check and energizing check for single and double CB with/without phasing function and for 1 1/2 breaker arrangements.

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test"in this chapter.

At periodical checks, the functions should preferably be tested with the used settings. To test a specific function, it might be necessary to change some setting parameters, for example:

- AutoEnerg = On/Off/DLLB/DBLL/Both
- ManEnerg = Off
- Operation = Off, On
- Activation of the voltage selection function if applicable

The tests explained in the test procedures below describe the settings, which can be used as references during testing before the final settings are specified. After testing, restore the equipment to the normal or desired settings.

A secondary injection test set with the possibility to alter the phase angle by regulation of the resistive and reactive components is needed. Here, the phase angle meter is also needed. To perform an accurate test of the frequency difference, a frequency generator at one of the input voltages is needed.

Figure 25shows the general test connection principle, which can be used during testing. This description describes the test of the version intended for one bay.

Figure 26shows the general test connection for a 1 1/2 CB diameter with one-phase voltage connected to the line side.

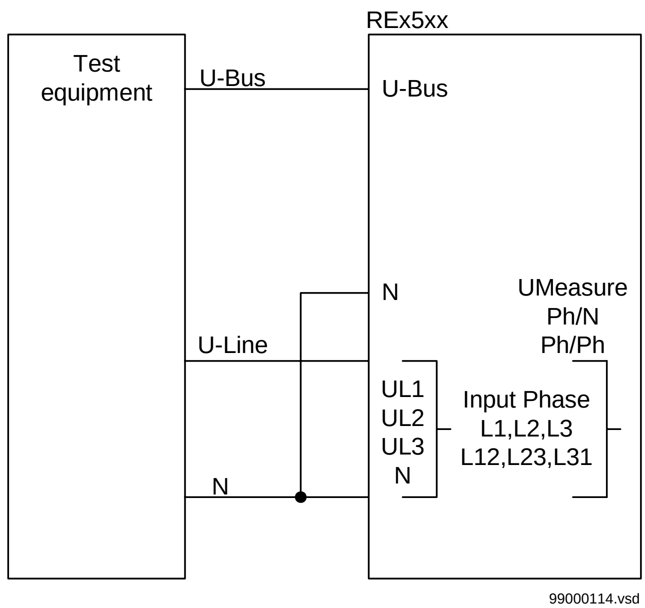


Figure 25: General test connection with three-phase voltage connected to the line side.

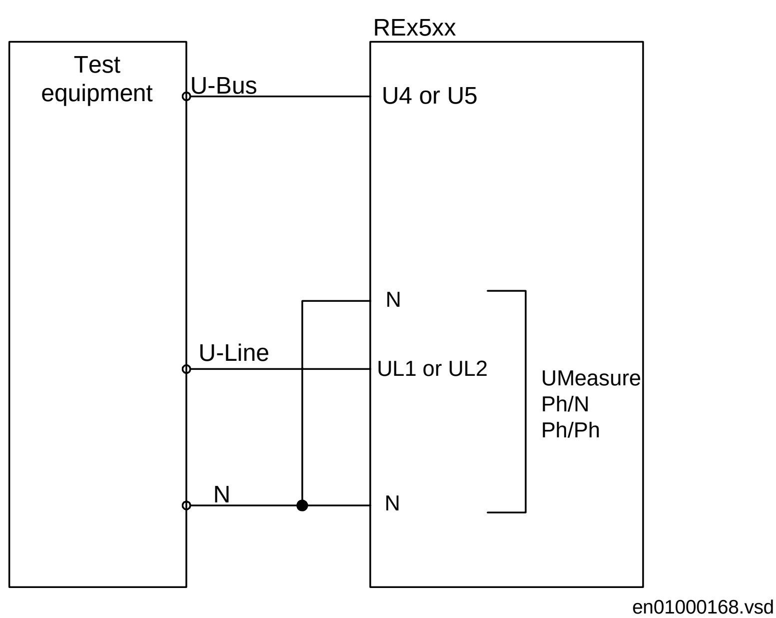


Figure 26: General test connection for a 1 1/2 CB diameter with one-phase voltage connected to the line side.

25.1 Testing the phasing function

(Applicable only if the phasing function is included in the terminal.)

These voltage inputs are used:

U-line	UL1, UL2 or UL3 voltage input on the terminal.
U-bus	U5 voltage input on the terminal

The settings in table 15can be used during the test if the final setting is not determined.

Table 15: Test settings for phasing

Parameter	Setting
Operation	Off
InputPhase	UL1
PhaseShift	0 deg
URatio	1.00
USelection	SingleBus
AutoEnerg	Off
ManEnerg	Off
ManDBDL	Off
UHigh	70% U1b
ULow	40% U1b
FreqDiff	0.05 Hz
PhaseDiff	45°
UDiff	30% U1b
tAutoEnerg	0.5 s
tManEnerg	0.5 s
OperationSynch	On
ShortPulse	Off
FreqDiffSynch	0.40 Hz
tPulse	0.20 s
tBreaker	0.20 s
VTConnection	Line
tSync	Os
FreqDiffBlock	Off

The settings are located in the local HMI under:

Settings/Functions/Group n (n=1-4)/SynchroCheck/SynchroCheck1

25.1.1 Testing the frequency difference

The frequency difference is set at 0.40 Hz on the HMI, and the test should verify that operation is achieved when the FreqDiffSynch frequency difference is lower than 0.40 Hz.

Procedure

1. **Apply voltages U-line (UL1) = 80% U1b, f-line=50.0 Hz and U-Bus (U5) = 80% U1b, f-bus=50.3 Hz.**
2. **Check that a closing pulse is submitted with length=0.20 seconds and at closing angle=360 * 0.20 * 0.40=29 deg.**
3. **Repeat with U-Bus (U5) = 80% U1b, f-bus=50.5 Hz to verify that the function does not operate when freq.diff is above limit.**
4. **Repeat with different settings on tBreaker and FreqDiffSynch.**
5. **Make sure that the calculated closing angle is less than 60 deg.**
6. **Verify that closing command is issued at the correct phase angle when the frequency difference is less than the set value.**

25.2 Testing the synchrocheck

During test of the synchrocheck function for a single bay arrangement, these voltage inputs are used:

U-line	UL1, UL2 or UL3 voltage input on the terminal.
U-bus	U5 voltage input on the terminal

25.2.1

At test of the synchrocheck function for a 1 1/2 CB diameter the following alternative voltage inputs can be used for the three synchrocheck functions. The voltage is selected by activation of different inputs in the voltage selection logic:

SYN1	U-line	UL1	Activate SYN1_FD1CLD
		UL2	Activate SYN1_CB2CLD
		U4	Activate SYN1_CB2CLD and CB3CLD
	U-bus	U5	No activation of inputs necessary
SYN2	U-line	UL2	Activate SYN2_FD2CLD
		U4	Activate SYN2_CB3CLD
	U-bus	UL1	Activate SYN2_FD1CLD

		U5	Activate SYN2_CB1CLD
SYN3	U-line	UL1	Activate SYN3_CB2CLD
		UL2	Activate SYN3_FD2CLD
		U5	Activate SYN3_CB1CLD and CB2CLD
	U-bus	U4	No activation of inputs necessary

25.2.2 Testing the voltage difference

Set the voltage difference at 30% U1b on the HMI, and the test should check that operation is achieved when the voltage difference UDiff is lower than 30% U1b.

The settings in table 16can be used during the test if the final setting is not determined.

Table 16: Test settings for voltage difference (NA=Not applicable)

Parameter	Setting	Single bay	Single bay with phasing	Multiple bays
Operation	On			
InputPhase	UL1			
UMeasure	Ph/N	NA	NA	
PhaseShift	0 deg			
URatio	1.00			
USelection	SingleBus			
AutoEnerg	Off			
ManEnerg	Off			
ManDBDL	Off			
UHigh	70% U1b			
ULow	40% U1b			
FreqDiff	0,05 Hz			
PhaseDiff	45°			
UDiff	30% U1b			
tAutoEnerg	0.5 s			
tManEnerg	0.5 s			
OperationSynch	Off	NA		NA
ShortPulse	Off	NA		NA
FreqDiffSynch	0.4 Hz	NA		NA
tPulse	0.2 s	NA		NA
tBreaker	0.2 s	NA		NA
VTConnection	Line			NA
tSync	Os			
FreqDiffBlock	Off	NA		NA

The settings are located in the local HMI under:

Settings/Functions/Group n (n=1-4)/SynchroCheck/SynchroCheck1

Test with UDiff = 0%

1. **Apply voltages U-line (UL1) = 80% U1b and U-Bus (U5) = 80% U1b.**
2. **Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.**
3. **The test can be repeated with different voltage values to verify that the function operates within UDiff <30%.**

Test with UDiff = 40%

1. **Increase the U-bus (U5) to 120% U1b, and the U-line (UL1) = 80% U1b.**
2. **Check that the two outputs are *NOT* activated.**

Test with UDiff = 20%, Uline < UHigh

1. **Decrease the U-line (UL1) to 60% U1b and the U-bus (U5) to be equal to 80% U1b.**
2. **Check that the two outputs are *NOT* activated.**

Test with URatio=0.20

1. **Run the tests under procedures "Test with UDiff = 0%", "Test with UDiff = 40%" and "Test with UDiff = 20%, Uline < UHigh" but with U-bus voltages 5 times lower.**

Test with URatio=5.00

1. **Run the tests under procedures "Test with UDiff = 0%", "Test with UDiff = 40%" and "Test with UDiff = 20%, Uline < UHigh" but with U-line voltages 5 times lower.**

25.2.3 Testing the phase difference

The phase difference is set at 45° on the HMI, and the test should verify that operation is achieved when the PhaseDiff (phase difference) is lower than 45°.

Set these HMI settings:

Table 17: Test settings for phase difference (NA=Not applicable)

Parameter	Setting	Single bay	Single bay with phas-ing	Multiple bays
Operation	On			
InputPhase	UL1			
UMeasure	Ph/N	NA	NA	
PhaseShift	0 deg			
URatio	1.00			
USelection	SingleBus			
AutoEnerg	Off			
ManEnerg	Off			
ManDBDL	Off			
UHigh	70% U1b			
ULow	40% U1b			
FreqDiff	0,05 Hz			
PhaseDiff	45°			
UDiff	15% U1b			
tAutoEnerg	0.5 s			
tManEnerg	0.5 s			
OperationSynch	Off	NA		NA
ShortPulse	Off	NA		NA
FreqDiffSynch	0.4 Hz	NA		NA
tPulse	0.2 s	NA		NA
tBreaker	0.2 s	NA		NA
VTConnection	Line			NA
tSync	Os			
FreqDiffBlock	Off	NA		NA

Test with UDiff = 0%

1. **Apply voltages U-line (UL1) = 100% U1b and U-bus (U5) = 100% U1b, with a phase difference equal to 0° and a frequency difference that is lower than 50 mHz.**
2. **Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.**

   The test can be repeated with other PhaseDiff values to verify that the function operates for values lower than the set ones. By changing the phase angle on U1 connected to U-bus, between ± 45°. The user can check that the two outputs are activated for a PhaseDiff lower than 45°. It should not operate for other values. See Figure 27.

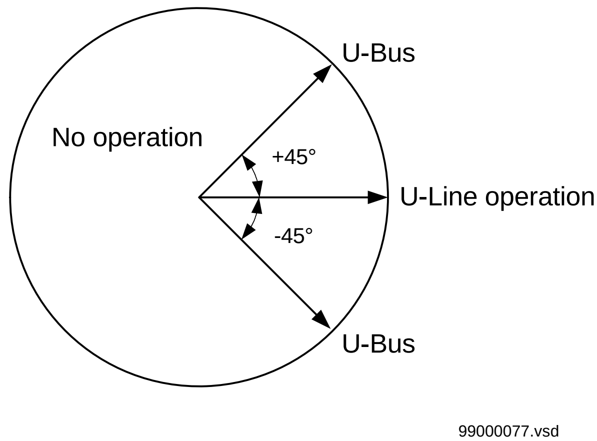


Figure 27: Test of phase difference.

3. **Apply a PhaseShift setting of 10 deg.**
4. **Change the phase angle between +55 and -35 and verify that the two outputs are activated for phase differences between these values but not for phase differences outside. See Figure 28.**
5. **Change the PhaseShift setting to 350 deg. Change the phase angle between +35 and -55 and verify as above.**

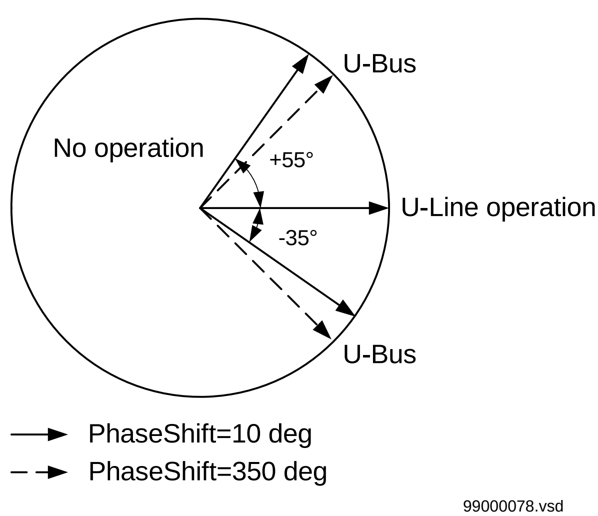


Figure 28: Test of phase difference.

25.2.4 Testing the frequency difference

The frequency difference is set at 50 mHz on the HMI, and the test should verify that operation is achieved when the FreqDiff frequency difference is lower than 50 mHz.

Use the same HMI setting as in section 25.2.3 "Testing the phase difference".

Test with FreqDiff = 0 mHz

1. **Apply voltages U-Line (UL1) equal to 100% U1b and U-Bus (U5) equal to 100% U1b, with a frequency difference equal to 0 mHz and a phase difference lower than 45°.**
2. **Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.**

Test with FreqDiff = 1Hz

1. **Apply voltage to the U-line (UL1) equal to 100% U1b with a frequency equal to 50 Hz and voltage U-bus (U5) equal to 100% U1b, with a frequency equal to 49 Hz.**
2. **Check that the two outputs are *NOT* activated.**

   The test can be repeated with different frequency values to verify that the function operates for values lower than the set ones. If the FREJA program, *Test of synchronizing relay*, is used the frequency can be changed continuously.

Note!

A frequency difference also implies a floating mutual-phase difference. So the SYN1-AUTOOK and SYN1-MANOK outputs might NOT be stable, even though the frequency difference is within set limits, because the phase difference is not stable!

25.2.5 Testing the reference voltage

1. **Use the same basic test connection as in Figure 25.**

   The UDiff between the voltage connected to U-bus and U-line should be 0%, so that the SYN1-AUTOOK and SYN1-MANOK outputs are activated first.

2. **Change the U-Line voltage connection to UL2 without changing the setting on the HMI.**
3. **Check that the two outputs are *NOT* activated.**
4. **The test can also be repeated by moving the U-line voltage to the UL3 input.**

25.3 Testing the energizing check

During test of the energizing check function for a single bay arrangement, these voltage inputs are used:

U-line	UL1, UL2 or UL3 voltage input on the terminal.
U-bus	U5 voltage input on the terminal

25.3.1

At test of the energizing check function for a 1 1/2 CB diameter the following alternative voltage inputs can be used for the three energizing check functions. The voltage is selected by activation of different inputs in the voltage selection logic:

SYN1	U-line	UL1	Activate SYN1_FD1CLD and UF1OK
		UL2	Activate SYN1_CB2CLD and UF2OK
		U4	Activate SYN1_CB2CLD, CB3CLD and UB2OK
	U-bus	U5	Activate SYN1_UB1OK
SYN2	U-line	UL2	Activate SYN2_FD2CLD and UF2OK
		U4	Activate SYN2_CB3CLD and UB2OK
	U-bus	UL1	Activate SYN2_FD1CLD and UF1OK
		U5	Activate SYN2_CB1CLD and UB1OK
SYN3	U-line	UL1	Activate SYN3_CB2CLD and UF1OK
		UL2	Activate SYN3_FD2CLD and UF2OK
		U5	Activate SYN3_CB1CLD, CB2CLD and UB1OK
	U-bus	U4	Activate SYN3_UB2OK

25.3.2 Testing the dead line live bus (DLLB)

The test should verify that the energizing function operates for a low voltage on the U-Line and for a high voltage on the U-bus. This corresponds to an energizing of a dead line to a live bus.

The settings in table 18can be used during the test if the final setting is not determined.

Table 18: Test settings for DLLB (NA=Not applicable)

Parameter	Setting	Single bay	Single bay with phasing	Multiple bays
Operation	On			
InputPhase	UL1			
UMeasure	Ph/N	NA	NA	
PhaseShift	0 deg			
URatio	1.00			

Parameter	Setting	Single bay	Single bay with phasing	Multiple bays
USelection	SingleBus			
AutoEnerg	DLLB			
ManEnerg	DLLB			
ManDBDL	Off			
UHigh	80% U1b			
ULow	40% U1b			
FreqDiff	0,05 Hz			
PhaseDiff	45°			
UDiff	15% U1b			
tAutoEnerg	0.5 s			
tManEnerg	0.5 s			
OperationSynch	Off	NA		NA
ShortPulse	Off	NA		NA
FreqDiffSynch	0.4 Hz	NA		NA
tPulse	0.2 s	NA		NA
tBreaker	0.2 s	NA		NA
VTConnection	Line			NA
tSync	Os			
FreqDiffBlock	Off	NA		NA

1. **Apply a single-phase voltage 100% U1b to the U-bus (U5), and a single-phase voltage 30% U1b to the U-line (UL1).**
2. **Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.**
3. **Increase the U-Line (UL1) to 60% U1b and U-Bus(U5) to be equal to 100% U1b. The outputs should *NOT* be activated.**

   The test can be repeated with different values on the U-Bus and the U-Line.

25.3.3 Testing the dead bus live line (DBLL)

The test should verify that the energizing function operates for a low voltage on the U-bus and for a high one on the U-line. This corresponds to an energizing of a dead bus from a live line.

1. **Change the HMI settings AutoEnerg and ManEnerg to DBLL.**
2. **Apply a single-phase voltage of 30% U1b to the U-bus (U5) and a single-phase voltage of 100% U1b to the U-line (UL1).**

3. **Check that the SYN1-AUTOOK and SYN1-MANOK outputs are activated.**
4. **Decrease the U-line to 60% U1b and keep the U-bus equal to 30% U1b.**

   The outputs should *NOT* be activated.
5. **The test can be repeated with different values on the U-bus and the U-line.**

25.3.4 Testing both directions (DLLB or DBLL)

1. **Change the HMI settings AutoEnerg and ManEnerg to Both.**
2. **Apply a single-phase voltage of 30% U1b to the U-line (UL1) and a single-phase voltage of 100% U1b to the U-bus (U5).**
3. **Check that the “SYN1-AUTOOK” and “SYN1-MANOK” outputs are activated.**
4. **Change the connection so that the U-line (UL1) is equal to100% U1b and the U-bus (U5) is equal to 30% U1b.**

   The outputs should still be activated.
5. **The test can be repeated with different values on the U-bus and the U-line.**
6. **Restore the equipment to normal or desired settings.**

25.3.5 Testing the dead bus dead line (DBDL)

The test should verify that the energizing function operates for a low voltage on both the U-bus the U-line, i.e closing of the breaker in a non energised system.

1. **Set AutoEnerg to Off and ManEnerg to DBLL.**
2. **Set ManDBDL to On.**
3. **Apply a single-phase voltage of 30% U1b to the U-bus (U5) and a single-phase voltage of 30% U1b to the U-line (UL1).**
4. **Check that the SYN1-MANOK output is activated.**
5. **Increase the U-bus to 80% U1b and keep the U-line equal to 30% U1b.**

   The outputs should *NOT* be activated.
6. **Repeat the test with ManEnerg set to DLLB and Both, and different values on the U-bus and the U-line.**

25.4 Testing the voltage selection

The settings in table 19can be used during the test if the final setting is not determined.

Table 19: Test settings for voltage selection (NA=Not applicable)

Parameter	Setting	Single bay	Single bay with phasing	Multiple bays
Operation	On			
InputPhase	UL1			
UMeasure	Ph/N	NA	NA	
PhaseShift	0 deg			
URatio	1.00			
USelection	DbleB			
AutoEnerg	Both			
ManEnerg	Both			
ManDBDL	Off			
UHigh	80% U1b			
ULow	40% U1b			
FreqDiff	0,05 Hz			
PhaseDiff	45°			
UDiff	15% U1b			
tAutoEnerg	0.5 s			
tManEnerg	0.5 s			
OperationSynch	Off	NA		NA
ShortPulse	Off	NA		NA
FreqDiffSynch	0.4 Hz	NA		NA
tPulse	0.2 s	NA		NA
tBreaker	0.2 s	NA		NA
VTConnection	Line			NA
tSync	Os			
FreqDiffBlock	Off	NA		NA

25.4.1 Testing the voltage selection for single CB arrangements

This test should verify that the correct voltage is selected for the measurement in the energizing function used in a double-bus arrangement. Apply a single-phase voltage of 30% U1b to the U-line (UL1) and a single-phase voltage of 100% U1b to the U-bus (U5).

If the SYN1-UB1/2OK inputs for the fuse failure are used, normally they must be activated, thus activated and deactivated must be inverted in the description of tests below.

1. **Connect the signals below to binary inputs and binary outputs.**

2. **Apply signals according to the tables and verify that correct output signals are generated.**

Table 20: Voltages

Signal														
Voltage from bus1 U5	1	1	1	1	1	1	1	0	0	0	0	0	0	0
Voltage from bus2 U4	0	0	0	0	0	0	0	1	1	1	1	1	1	1

Table 21: Binary inputs

Signal														
CB1OPEN	1	0	0	0	0	0	1	0	0	1	1	1	1	0
CB1CLD	0	1	1	1	1	1	0	1	1	0	0	0	0	1
CB2OPEN	1	1	1	1	1	0	0	1	0	0	0	0	0	0
CB2CLD	0	0	0	0	0	1	1	0	1	1	1	1	1	1
UB1FF	0	0	1	0	0	0	0	0	0	0	1	0	0	0
UB2FF	0	0	0	1	0	0	0	0	0	0	0	1	0	0
VTSU	0	0	0	0	1	0	0	0	0	0	0	0	1	0

Table 22: Binary outputs

Signal														
AUTOOK	1	1	0	1	0	1	0	0	0	1	1	0	0	0
MANOK	1	1	0	1	0	1	0	0	0	1	1	0	0	0
VSUB1	1	1	1	1	1	1	0	1	1	0	0	0	0	1
VSUB2	0	0	0	0	0	0	1	0	0	1	1	1	1	0

25.4.2 Testing the voltage selection for 1 1/2 circuit breaker diameter

This test should verify that correct voltage is selected for the measurement in the energizing function used for a diameter in a one and a half breaker arrangement. Apply single-phase voltages to the inputs according to the tables below. “H” means a voltage of 100% U1b and “L” means a voltage of 30% U1b. Verify that correct output signals are generated.

1. **Connect the signals below to binary inputs and binary outputs.**
2. **Apply signals according to the tables and verify that correct output signals are generated.**

Table 23: Voltage to input

Signal	SYN1						SYN2				SYN3					
BUS1 U5	H	H	H	H	H	H	-	-	H	L	H	H	H	H	H	H
BUS2 U4	-	-	-	-	H	L	-	-	H	H	-	-	-	-	H	L
LINE1 UL1	H	L	-	-	-	-	H	L	-	-	H	L	-	-	-	-
LINE2 UL2	-	-	H	L	-	-	H	H	-	-	-	-	H	L	-	-

Table 24: Binary inputs SYN1, SYN2 and SYN3

Signal	SYN1						SYN2				SYN3					
FD1CLD	1	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1
FD1OPEN	0	0	1	1	1	1	0	0	1	1	1	1	0	0	0	0
FD2CLD	0	0	1	1	1	1	1	1	0	0	1	1	0	0	0	0
FD2OPEN	1	1	0	0	0	0	0	0	1	1	0	0	1	1	1	1
CB1CLD	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1
CB1OPEN	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0
CB2CLD	0	0	1	1	0	0	-	-	-	-	0	0	1	1	0	0
CB2OPEN	1	1	0	0	1	1	-	-	-	-	1	1	0	0	1	1
CB3CLD	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-
CB3OPEN	0	0	0	0	0	0	0	0	0	0	-	-	-	-	-	-

Table 25: Binary outputs SYN1, SYN2, SYN3

Signal	SYN1						SYN2				SYN3					
VSUF1	1	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0
VSUF2	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0	0
VSUB1	-	-	-	-	-	-	0	0	1	1	0	0	0	0	1	1
VSUB2	0	0	0	0	1	1	0	0	1	1	-	-	-	-	-	-
AUTOOK	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

25.5 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

26 Definite time non-directional overcurrent protection (TOC)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

Ensure that the maximum continuous current of the terminal does not exceed four times its rated value.

26.1 Measuring the operate limit of set values

26.1.1 Time delayed phase overcurrent

Procedure

1. **Inject a phase current in the terminal with start below the setting value.**
2. **Increase the injected current (measured current) in the L*n* phase until the starting signal TOC--STL*n* (*n*=1-3) appears.**
3. **Switch off the fault current.**

   Observe the maximum permitted overloading of the current circuits in the terminal.
4. **Compare the measured operating current with the set value IP>.**
5. **Set the fault current to about 1.5 times the measured operating current.**
6. **Switch on the fault current and measure the operating time of the TOC protection. Use the TOC--TRP signal.**
7. **Compare the measured time with the set value tP.**

26.1.2 Time delayed residual overcurrent (non-dir.)

Procedure

1. **Inject a phase current in the terminal with start below the setting value.**
2. **Increase the injected residual current (measured current) in the L*n* phase until the starting signal TOC--STN appears.**
3. **Switch off the fault current.**

   Observe the maximum permitted overloading of the current circuits in the terminal.

4. **Compare the measured operating current with the set value IN>.**
5. **Set the fault current to about 1.5 times the measured operating current.**
6. **Switch on the fault current and measure the operating time of the TOC protection. Use the TOC--TRN signal.**
7. **Compare the measured time with the set value tN.**

26.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

27 Time delayed overvoltage protection (TOV)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault types should be tested:

- One for a single-phase voltage feeding.

27.1 Verifying the settings

27.1.1 Time delayed phase overvoltage protection

Procedure

1. **Apply the single phase voltage with start below the setting value.**
2. **Slowly increase the voltage until the TOV--STPE signal appears.**
3. **Note the operate value and compare it with the set value.**
4. **Switch off the applied voltage.**
5. **Set and apply about 20% higher voltage than the measured operate value for one-phase.**
6. **Measure the time delay for the TOV--TRPE signal and compare it with the set value.**

27.1.2 Time delayed residual overvoltage protection (non-dir.)

Procedure

1. **Apply the single phase voltage with start below the setting value.**
2. **Slowly increase the voltage until the STN appears.**
3. **Note the operate value and compare it with the set value.**
4. **Switch off the applied voltage.**
5. **Set and apply about 20% higher voltage than the measured operate value for one-phase.**
6. **Measure the time delay for the TOV--TRN signal and compare it with the set value.**

27.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

28 Time delayed undervoltage protection (TUV)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

To verify the settings the following fault type should be tested:

- Decrease of voltage in one phase

28.1 Verifying the settings

Procedure

1. **Supply the terminal with three-phase voltages to their rated values.**
2. **Slowly decrease the voltage in one of the phases, until the TUV-START signal appears.**
3. **Note the operate value and compare it with the set value.**
4. **Increase the measured voltage to rated operate conditions.**
5. **Instantaneously decrease the voltage in one-phase to a value about 20% lower than the measured operate value.**
6. **Measure the time delay for the TUV-TRIP signal, and compare it with the set value.**

28.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

29 Tripping logic (TR)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

The function is tested functionally together with other protection functions (distance protection ZMn--, line differential protection DIFL-, earth-fault overcurrent protection IOC-- or TOC--, etc.) within the REx 5xx terminals. It is recommended to test the function together with the autoreclosing function, when built into the terminal or when a separate external unit is used for the reclosing purposes.

29.1 3ph operating mode

The function must issue a three-phase trip in all cases, when trip is initiated by any protection or some other built-in or external function. The following functional output signals must always appear simultaneously: TRIP-TRIP, TRIP-TRL1, TRIP-TRL2, TRIP-TRL3 and TRIP-TR3P.

29.2 1ph/3ph operating mode

The following tests should be carried out in addition to some other tests, which depends on the complete configuration of a terminal:

Procedure

1. **Initiate one-by one different single-phase-to-earth faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a single-phase trip should occur for each separate fault and only one of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR1P should be active at each fault. No other outputs should be active.

2. **Initiate different phase-to-phase and three-phase faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a three-phase trip should occur for each separate fault and all of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR3P should be active at each fault. No other outputs should be active.

3. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the same fault once again within the reclaim time of the used autoreclosing function.**

   A three-phase trip must be initiated for the second fault.

   Check that the corresponding trip signals appear after both faults.

If not the autoreclosing function is used the functional outputs TRIP-TRIP, TRIP-TR1P and the corresponding phase signal (TRIP-TRLn) should be active at each fault.

4. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the second single-phase-to-earth fault in one of the remaining phases within the time interval, shorter than two seconds and shorter than the dead-time of the autoreclosing function, when included in protection scheme.**

   Check that the second trip is a three-phase trip.

29.3 1ph/2ph/3ph operating mode

The following tests should be carried out in addition to some other tests, which depends on the complete configuration of a terminal:

Procedure

1. **Initiate one-by one different single-phase-to-earth faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a single-phase trip should occur for each separate fault and only one of the trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR1P should be active at each fault. No other outputs should be active.

2. **Initiate one-by one different phase-to-phase faults.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a two-phase trip should occur for each separate fault and only corresponding two trip outputs (TRIP-TRLn) should be activated at a time. Functional outputs TRIP-TRIP and TRIP-TR2P should be active at each fault. No other outputs should be active.

3. **Initiate a three-phase fault.**

   Consider sufficient time interval between the faults, to overcome a reclaim time of eventually activated autoreclosing function. Only a three-phase trip should occur for the fault and all trip outputs (TRIP-TRLn) should be activated at the same time. Functional outputs TRIP-TRIP and TRIP-TR3P should be active at each fault. No other outputs should be active.

4. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the same fault once again within the reclaim time of the used autoreclosing function.**

   A three-phase trip must be initiated for the second fault.

   Check that the corresponding trip signals appear after both faults.

If not the autoreclosing function is used the functional outputs TRIP-TRIP, TRIP-TR1P and the corresponding phase signal (TRIP-TRLn) should be active at each fault.

5. **Initiate a single-phase-to-earth fault and switch it off immediately when the trip signal is issued for the corresponding phase. Initiate the second single-phase-to-earth fault in one of the remaining phases within the time interval, shorter than two seconds and shorter than the dead-time of the autoreclosing function, when included in protection scheme.**

   Check that the second trip is a single-phase trip in a second initiated phase.

6. **Initiate a phase-to-phase fault and switch it off immediately when the trip signal is issued for the corresponding two phases. Initiate another phase-to-phase fault (not between the same phases) within the time, shorter than 2 seconds.**

   Check, that the output signals, issued for the first fault, correspond to two-phase trip for included phases.

   The output signals for the second fault must correspond to the three-phase tripping action.

29.4 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

30 Two step time delayed directional phase overcurrent protection (TOC3)

Prepare the terminal for verification of settings as outlined in section 2 "Preparing for test" in this chapter.

Consider to apply an three-phase symmetrical voltage at rated value and ZΦ=0° if the settings are directional. If distance protection (ZMn) not are included in the terminal test of directional lines has to be carried out.

Ensure that the maximum continuos current of a terminal does not exceed four times its rated value, if the measurement of the operating characteristics runs under constant voltage conditions.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

30.1 Measuring the operate and time limit for set values

30.1.1 Measuring the operate limit of the low step overcurrent protection

Procedure

1. **Inject a phase current slightly smaller than the functional value I>Low.**
2. **Increase the current slowly and check the function value by observing when the signal TOC3-STNDLS appears.**
3. **Compare the result of the measurement with the set value.**

30.1.2 Measuring the definite time delay of the low set stage

1. **Set a current 1.5 times I>Low on the injection test equipment and three-phase symmetrical voltage if directional.**
2. **Switch the current on and compare the operation time on TOC3-TRLS with the set value tLow.**

   The operate time shall be tRelay+tLow.

30.1.3 Measuring the inverse time delay of the low set stage

1. **Set temporarily tLow = 0.000 s.**

   If I>Low is set higher than I>Inv, check that there is no trip signal TOC3-TRLS when the current is less than I>Low.

2. **Check the time delay at two points of the inverse time curve.**

   Check with the current I>Low or 2·I>Inv (the highest value of these two) and the current that according to the inverse time curve corresponds to tMin.

3. **Increase the current 10% and check that the operation time is equal to tMin.**
4. **Set tLow to the correct value and check with a high current that the operation time is equal to tMin+tLow.**

30.1.4 Measuring the operate limit of the high step overcurrent protection

1. **Set temporarily tHigh=0.000 s.**
2. **Inject a phase current slightly smaller than the operation value I>High and three-phase symmetrical voltage if directional.**
3. **Increase the current slowly and check the operation value by observing when the signal TOC3-TRHS appears.**
4. **Compare the result of the measurement with the set value.**
5. **Set tHigh to the correct value.**
6. **Set a current 1.5 times I>High on the injection test equipment**
7. **Switch the current on and compare the operation time with the set value tHigh.**

30.1.5 Measuring the operate limit of the directional lines.

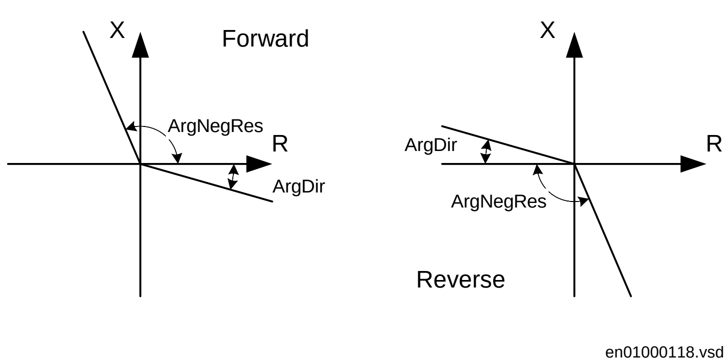


Figure 29: Definitions for forward and reverse directions

Procedure

1. **Inject a current 1.2 times I>Low and a three-phase symmetrical voltage.**

2. **Slowly decrease the impedance angle to find the operating value according to figure 29.**
3. **Compare the result of the measurement with the set value.**

30.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off.

31 Two step time delayed non-directional phase overcurrent protection (TOC2)

Prepare the terminal for test as outlined in section 2 "Preparing for test" in this chapter.

Ensure that the maximum continuos current of a terminal does not exceed four times its rated value, if the measurement od the operating characteristics runs under constant voltage conditions.

To verify the settings the following fault type should be tested:

- One for a phase-to-earth fault

31.1 Measuring the operate and time limit for set values

31.1.1 Measuring the operate limit of the low step overcurrent protection

Procedure

1. **Inject a phase current slightly smaller than the functional value I>Low.**
2. **Increase the current slowly and check the function value by observing when the signal TOC2-STLS appears.**
3. **Compare the result of the measurement with the set value.**

31.1.2 Measuring the definite time delay of the low set stage

Procedure

1. **Set a current 1.5 times I>Low on the injection test equipment.**
2. **Switch the current on and compare the operation time on TOC2-TRLS with the set value tLow.**

   The operate time shall be tLow+operate time of the low set stage.

31.1.3 Measuring the inverse time delay of the low set stage

Procedure

1. **Set temporarily tLow = 0.000 s.**

   If I>Low is set higher than I>Inv, check that there is no trip signal TOC2-TRLS when the current is less than I>Low.

2. **Check the time delay at two points of the inverse time curve.**

   Check with the current I>Low or 2·I>Inv (the highest value of these two) and the current that according to the inverse time curve corresponds to tMin.

3. **Increase the current 10% and check that the operation time is equal to tMin.**

4. **Set tLow to the correct value and check with a high current that the operation time is equal to tMin+tLow.**

31.1.4 Measuring the operate limit of the high step overcurrent protection

1. **Set temporarily tHigh=0.000 s.**
2. **Inject a phase current slightly smaller than the operation value I>High.**
3. **Increase the current slowly and check the operation value by observing when the signal TOC2-TRHS appears.**
4. **Compare the result of the measurement with the set value.**
5. **Set tHigh to the correct value.**
6. **Set a current 1.5 times I>High on the injection test equipment**
7. **Switch the current on and compare the operation time with the set value tHigh.**

31.2 Completing the test

Continue to test another function or complete the test by setting the test mode to off. Restore connections and settings to the original values, if they were changed for testing purpose.

Chapter 14 Verifying the internal configuration

About this chapter

The aim of this chapter is to verify that the internal communications and output signals are according to the specification and normal protection praxis. This means that all included protection functions must be in operation.

1 Overview

Before start of this process, all individual devices that are involved in the fault clearance process must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

The shaping of the test process is dependent on the complexity of the design of the switchyard. Hereby follows some items which could be used as guidelines.

2 Testing the interaction of the distance protection

This procedure describes how to test the interaction of the distance protection zone 1 at phase L1-earth fault in forward direction. It is recommended that all other distance protection zones and other protection functions are tested in a similar way. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that all personnel is informed, also in remote station.

Procedure

1. **Make sure that the protection terminal and fitting breaker(s) to be tested are in service.**
2. **Connect the test equipment to the terminal.**
3. **Set the test equipment so that the impedance present to the relay is half the set value.**
4. **Energise the protection terminal and evaluate the result i.e.**
    - Check that correct trip has been accomplished according to configuration and philosophy.
    - Check that all binary output signals that should be activated have been activated.
    - Check that all other protection functions that should be activated by this type of fault have been activated.
    - Check that no other protection functions that should not be activated have not been activated.
    - Check whenever applicable that the disturbance report, event list and disturbance recorder have been activated and performed correct information.

Chapter 15 Testing the protection system

About this chapter

This chapter describes how to verify the conformity of the protection system without the protected object energised.

1 Overview

Before start of this process, all individual devices that are involved in the fault clearance process of the protected object must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

Scheme performance test is the final test that should be carried out before the protected object is taken into service.

Due to the complexity in combination with already performed tests, it is not necessary to test all protection functions and all fault types in this process. The most important protection functions in the terminal for single line to earth fault and phase-phase fault could be used for the test.

The shaping of the test process is dependent on the complexity of the design of the switchyard. Hereby follows some items which could be used as guidelines.

2 Testing the interaction of the distance protection

This procedure describes how to test the interaction of distance protection zone 1 at a transient phase L1-L2 fault in forward direction. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that involved personnel is informed also in remote station.

This procedure describes how to test the interaction of an overcurrent protection stage at a transient phase L1-L2 fault in forward direction. The test must be done without the test switch in order to verify the interaction between the terminal and surrounding equipment. Make sure that involved personnel is informed also in remote station.

Procedure

1. **Make sure that the protection terminal and related breaker(s) to be tested are in service.**
2. **Connect the test equipment to the terminal.**
3. **Set the test equipment so that the impedance present to the relay is half the set value of zone 1.**
4. **Prepare a transient fault sequence.**
5. **Simulate the condition for the synchro-check as for live bus and dead line.**
6. **Energise the protection terminal and evaluate the result i.e.**
   - Check that correct trip has been accomplished according to configuration and philosophy.
   - Check that the autoreclosure have made an reclosing of the protected object.
   - Check that activation of all other external devices have been accomplished according to configuration and protection philosophy.
     - Check, whenever applicable, that carrier receive signal has arrived at remote end.
     - Check, whenever applicable, that start of external disturbance recorder has been accomplished.
     - Check that event and alarm signals has been given etc.
   - Check that no abnormal events have occurred.
   - Notice the AR dead time and do corrections if needed.
7. **Make a new fault case for permanent fault and repeat the steps 1 - 6 above.**

   Specially note that a permanent trip should occur after the last attempt according to the programming of the AR.

   It is recommended to repeat the procedure 1 - 6 for a protection function which detects earth-faults i.e. residual overcurrent protection.

Chapter 16 Checking the directionality

About this chapter

This chapter describes how to check that the directionality is correct for each directional dependent functions. The scope is also to verify that all analog values are correct. This must be done with the protection system in operation, the protected object energized and the load current above the min operation current of the terminal.

1 Overview

Before start of this process, all individual devices that are involved in the fault clearance process of the protected object must have been tested as individuals and set in operation. The breaker must be ready for an open-close-open cycle.

As a condition for the test, the following must be fulfilled:

- The magnitude of the load current must be more than 5% of the terminal nominal rate current.
- The load impedance must have an angle -15°<φ<115° or 165<φ <295°.

The directionality test is performed when the protected object is energized and certain minimum load current with known direction is floating through the protected object.

The design of the test procedure depends on type of protection function to be tested. Here follows some items which could be used as guidelines.

2 Testing the directionality of the distance protection

The test, which also is valid as test of the directional phase overcurrent protection, is performed under the menues:

Service Report/Functions/Impedance/General/ImpDirection and .../ImpValues.

Procedure

1. **Make sure that all control and protection functions that are belonging to the object that are going to be energised are tested and set in operation.**
2. **Check that the load current will be more than 5% of the terminal nominal rate current.**

   After energizing the line, the local HMI displays if the current direction in each phase is in forward or reverse direction. The measurement is based on ULx/ILx.

   Menu for display is located in the menu

   ServiceReport/Functions/Impedance/General/ImpDirection

   For forward direction the display indicates: angle $-15° < \varphi < 115°$

   - L1 = Forward
   - L2 = Forward
   - L3 = Forward

   For reverse direction of the three measuring loops, the display shows: angle $165° < \varphi < 295°$

   - L1 = Reverse
   - L2 = Reverse
   - L3 = Reverse

   If one of the loops is in the opposite direction than the other two, this indicates that the phase sequence of the incoming voltage or current is incorrect.

   The actual impedance measured is shown in the menu

   ServiceReport/Functions/Impedance/General/ImpValues

   XL1 = 0,00 Ohm

   RL1 = 63,5 Ohm

XL2 = 0,00 Ohm

RL2 = 63,5 Ohm

XL3 = 0,00 Ohm

RL3 = 63,5 Ohm

The actual values of the current and voltage phasors can also be used to check the directionality of the distance protection on the HMI under the menu:

Service Report/Phasors/Primary (Secondary)

Chapter 17 Fault tracing and repair

About this chapter
This chapter describes how to carry out fault tracing and eventually, a change of circuit board.

1 Fault tracing

1.1 Using information on the local HMI

If an internal fault has occurred, the local HMI displays information under:

TerminalReport
SelfSuperv

Under these menus the indications of eventual internal failure (serious fault) or internal warning (minor problem) are listed.

Shown as well, are the indications regarding the faulty unit according to table 26.

Table 26: HMI information

HMI information	Signal name	Activates summary signal	Description
InternFail	INT--FAIL		Internal fail summary
Intern Warning	INT--WARNING		Internal warning summary
CPU-modFail	INT--CPUFAIL	INT--FAIL	Main processing module failed
CPU-modWarning	INT--CPUWARN	INT--WARNING	Main processing module warning (failure of clock, time synch., fault locator or disturbance recorder)
ADC-module	INT--ADC	INT--FAIL	A/D conversion module failed
Slotnn-XXXyy	INT--IOyy	INT--FAIL	I/O module yy failed
Real Time Clock	INT--RTC	INT--WARNING	Internal clock is reset - Set the clock
Time Sync	INT--TSYNC	INT--WARNING	No time synchronisation

Also the internal signals, such as INT--FAIL and INT--WARNING can be connected to binary output contacts for signalling to a control room.

In the Terminal Status - Information, the present information from the self-supervision function can be viewed. Indications of failure or warnings for each hardware module are provided, as well as information about the external time synchronisation and the internal clock. All according to table 27. Loss of time synchronisation can be considered as a warning only. The REx 5xx terminal has full functionality without time synchronisation.

1.2 Using front-connected PC or SMS

- Self-supervision summary = INT--FAIL and INT--WARNING
- CPU-module status summary = INT--CPUFAIL and INT--CPUWARN

When an internal fault has occurred, extensive information can be retrieved about the fault from the list of internal events. The list is available in the TERM-STS Terminal Status part of the CAP tool. This time-tagged list has information with the date and time of the last 40 internal events.

The internal events in the list do not only refer to faults in the terminal, but also to other activities, such as change of settings, clearing of disturbance reports and loss of external time synchronisation

The following events are logged as Internal events:

Table 27: Internal events

Event message	Description	Set/reset event
INT--FAILOff	Internal fail status	Reset event
INT--FAILOn		Set event
INT--WARNINGOff	Internal warning status	Reset event
INT--WARNINGOn		Set event
INT--CPUFAILOff	Main processing module fatal error status	Reset event
INT--CPUFAILOn		Set event
INT--CPUWARNOff	Main processing module non-fatal error status	Reset event
INT--CPUWARNOn		Set event
INT--ADCOff	A/D conversion module status	Reset event
INT--ADCOn		Set event
INT--IOnOff	In/Out module No. n status	Reset event
INT--IOn On		Set event
INT--RTC Off	Real Time Clock (RTC) status	Reset event
INT--RTC On		Set event
INT--TSYNC Off	External time synchronisation status	Reset event
INT--TSYNC On		Set event
DREP-MEMUSED On	>80% of the disturbance recording memory used	Set event
SETTING CHANGED	Any settings in terminal changed	
DISTREP CLEARED	All disturbances in Disturbance report cleared	

The events in the internal event list are time tagged with a resolution of 1 ms.

This means that when using the PC for fault tracing, it provides information on the:

- Module that should be changed.
- Sequence of faults, if more than one unit is faulty.
- Exact time when the fault occurred.

2 Repair instruction

Warning!

Never disconnect a secondary connection of current transformer circuit without short-circuiting the transformer's secondary winding. Operating a current transformer with the secondary winding open will cause a massive potential build-up that may damage the transformer and may cause injuries to humans.

Warning!

Never connect or disconnect a wire and/or a connector to or from a terminal during normal service. Hazardous voltages and currents are present that may be lethal. Operation may be disrupted and terminal and measuring circuitry may be damaged.

An alternative is to open the terminal and send only the faulty circuit board to ABB for repair. When a printed circuit board is sent to ABB, it must always be placed in a metallic, ESD-proof, protection bag. The user can also purchase separate modules for replacement.

Note!

Strictly follow the company and country safety regulations.

Caution!

Always use a conductive wrist strap connected to protective earth when replacing modules. Electrostatic discharge (ESD) may damage the module and terminal circuitry.

Most electronic components are sensitive to electrostatic discharge and latent damage may occur. Please observe usual procedures for handling electronics and also use an ESD wrist strap. A semi-conducting layer must be placed on the workbench and connected to earth.

Disassemble and reassemble the REx 5xx terminal accordingly:

1. Switch off the dc supply.
2. Short-circuit the current transformers and disconnect all current and voltage connections from the terminal.
3. Disconnect all signal wires by removing the female connectors.
4. Disconnect the optical fibres.
5. Unscrew the main back plate of the terminal.
6. If the transformer module is to be changed — unscrew the small back plate of the terminal.
7. Pull out the faulty module.
8. Check that the new module has correct identity number.

9. Check that the springs on the card rail have connection to the corresponding metallic area on the circuit board when the new module is inserted.
10. Reassemble the terminal.

If the REx 5xx terminal has the optional increased measuring accuracy, a file with unique calibration data for the transformer module is stored in the Main processing module. Therefore it is not possible to change only one of these modules with maintained accuracy.

3 Repair support

If a REx 5xx terminal needs to be repaired, the whole terminal must be removed and sent to ABB Logistic Center. Before returning the material, an inquiry must be sent to ABB Logistic Center.

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