Line distance protection terminal for solidly grounded networks

REL 511-C1*2.3

Features

- Line impedance
  - General fault criteria (GFC)
  - Distance protection (ZM)
  - Power swing detection (PSD)
  - Scheme communication logic for distance protection functions (ZCOM)
  - Current reversal and WEI logic for distance protection (ZCAL)
  - Automatic switch onto fault logic (SOTF)
  - Local acceleration logic (ZCLC)
- Current
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  - Two step time delayed directional phase overcurrent protection (TOC3)
  - Definite and inverse time-delayed residual overcurrent protection (TEF)
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- Control
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- Logic
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- Serial communication
  - Simultaneous dual protocol serial communication facilities
- Monitoring
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  - Local Human Machine Interface (HMI)
  - Disturbance report (DRP)
  - Indications
  - Disturbance recorder
  - Event recorder
  - Fault locator (FLOC)
  - Monitoring of AC analogue measurements
  - Monitoring of DC analogue measurements
- Versatile local human-machine interface (HMI)
- Extensive self-supervision with internal event recorder
- Time synchronization with 1 ms resolution
- Four independent groups of complete setting parameters
- Powerful software PC ‘tool-box’ for monitoring, evalution and user configuration

Platform

Application

The platform hardware and common software functions are included for all REx 5xx terminals. It is the foundation on which all terminals are built. Application specific modules and functions are added to create a specific terminal type or family.

Design

The REx 5xx platform consists of a case, hardware modules and a set of basic functions.

The closed and partly welded steel case makes it possible to fulfill stringent EMC requirements. For case size 1/1x19” IP 30 applies for the top and bottom part. IP 54 can be obtained for the front area in flush applications. Mounting kits are available for rack, flush or wall mounting.

All connections are made on the rear of the case. Screw compression type terminal blocks are used for electrical connections.

Serial communication connections are made by optical fibre connectors type Hewlett Packard (HFBR) for plastic fibres or bayonet type ST for glass fibres.

A set of hardware modules are always included in a terminal. Application specific modules are added to create a specific terminal type or family.

The basic functions provide a terminal with basic functionality such as self supervision, I/O-system configurator, real time clock and other functions to support the protection and control system of a terminal.

Common functions

Description

Common functions are the software functions that always are included in the terminals.

Time synchronisation (TIME)

Application

Use the time synchronization source selector to select a common source of absolute time for the terminal when it is a part of a protection system. This makes comparison of events and disturbance data between all terminals in a system possible.

Functionality

Two main alternatives of external time synchronization are available. Either the synchronization message is applied via any of the communication ports of the terminal as a telegram message including date and time, or as a minute pulse, connected to a binary input. The minute pulse is used to fine tune already existing time in the terminals.

The REx 5xx terminal has its own internal clock with date, hour, minute, second and millisecond. It has a resolution of 1 ms.

The clock has a built-in calendar that handles leap years through 2098. Any change between summer and winter time must be handled manually or through external time synchronization. The clock is powered by a capacitor, to bridge interruptions in power supply without malfunction.

The internal clock is used for time-tagging disturbances, events in Substation monitoring system (SMS) and Substation control system (SCS), and internal events.

Setting group selection (GRP)

Application

Use the four sets of settings to optimize the terminals operation for different system conditions. By creating and switching between fine tuned setting sets, either from the human-machine interface or configurable binary inputs, results in a highly adaptable terminal that can cope with a variety of system scenarios.

Functionality

The GRP function block has four functional inputs, each corresponding to one of the setting groups stored within the terminal. Activation of any of these inputs changes the active setting group. Four functional output signals are available for configuration purposes, so that continuous information on active setting group is available.

Setting lockout (HMI)

Application

Unpermitted or uncoordinated changes by unauthorized personnel may cause severe damage to primary and secondary power circuits. Use the setting lockout function to prevent unauthorized setting changes and to control when setting changes are allowed.

By adding a key switch connected to a binary input a simple setting change control circuit can be built simply allowing only authorized keyholders to make setting changes from the built-in HMI.

Functionality
Activating the setting restriction prevents unauthorized personell to purposely or by mistake change terminal settings.

The HMI--BLOCKSET functional input is configurable only to one of the available binary inputs of a REx 5xx terminal. For this reason, the terminal is delivered with the default configuration, where the HMI--BLOCKSET signal is connected to NONE-NOSIGNAL.

The function permits remote changes of settings and reconfiguration through the serial communication ports. The setting restrictions from remote can be activated only from the local HMI.

All other functions of the local human-machine communication remain intact. This means that an operator can read all disturbance reports and other information and setting values for different protection parameters and the configuration of different logic circuits.

I/O system configurator with internal event recorder (IOP)

Application
The I/O system configurator must be used in order for the terminal’s software to recognize added modules and to create internal address mappings between modules and protections and other functions.

Self supervision (INT)

Application
Use the local HMI, SMS or SCS to view the status of the self-supervision function. The self-supervision operates continuously and includes:

- Normal micro-processor watchdog function
- Checking of digitized measuring signals
- Checksum verification of PROM contents and all types of signal communication

Logic function blocks

Application
The user can with the available logic function blocks build logic functions and configure the terminal to meet application specific requirements.

Different protection, control, and monitoring functions within the REx 5xx terminals are quite independent as far as their configuration in the terminal is concerned. The user can not change the basic algorithms for different functions. But these functions combined with the logic function blocks can be used to create application specific functionality.

Invert function block (INV)
The inverter function block INV has one input and one output, where the output is in inverse ratio to the input.

OR function block (OR)
The OR function is used to form general combinatory expressions with boolean variables. The OR function block has six inputs and two outputs. One of the outputs is inverted.

AND function block (AND)
The AND function is used to form general combinatory expressions with boolean variables.The AND function block has four inputs and two outputs. One of the inputs and one of the outputs are inverted.

Timer function block (TM)
The function block TM timer has drop-out and pick-up delayed outputs related to the input signal. The timer has a settable time delay (parameter T).

Timer long fuction block (TL)
The function block TL timer with extended maximum time delay at pick-up and at drop-out, is identical with the TM timer. The difference is the longer time delay.

Pulse timer function block (TP)
The pulse function can be used, for example, for pulse extensions or limiting of operation of outputs. The pulse timer TP has a settable length.

Extended length pulse function block (TQ)
The function block TQ pulse timer with extended maximum pulse length, is identical with the TP pulse timer. The difference is the longer pulse length.

Exclusive OR function block (XOR)
The exclusive OR function XOR is used to generate combinatory expressions with boolean variables. The function block XOR has two inputs and two outputs. One of the out-

puts is inverted. The output signal is 1 if the input signals are different and 0 if they are equal.

Set-reset with memory function block (SR)
The Set-Reset (SR) function is a flip-flop that can set or reset an output from two inputs respectively. Each SR function block has two outputs, where one is inverted.

Set-reset with memory function block (SM)
The Set-Reset function SM is a flip-flop with memory that can set or reset an output from two inputs respectively. Each SM function block has two outputs, where one is inverted. The memory setting controls if the flip-flop after a power interruption will return the state it had before or if it will be reset.

Controllable gate function block (GT)
The GT function block is used for controlling if a signal should be able to pass from the input to the output or not depending on a setting.

Settable timer function block (TS)
The function block TS timer has outputs for delayed input signal at drop-out and at pick-up. The timer has a settable time delay. It also has an Operation setting On, Off that controls the operation of the timer.

Blocking of signals during test

Application
The protection and control terminals have a complex configuration with many included functions. To make the testing procedure easier, the terminals include the feature to individually block a single, several or all functions.

This means that it is possible to see when a function is activated or trips. It also enables the user to follow the operation of several related functions to check correct functionality and to check parts of the configuration etc.

Line impedance

General fault criteria (GFC)

Application
The GFC general fault criteria function is an independent measuring function. It comprises both impedance and current-based measurement criteria. These can be used separately or at the same time. Its main purpose is to serve as an overall fault detection and phase selection element in all kinds of networks. It is not used as a start condition because the distance protection zones utilize full scheme measurement.

For the impedance measurement, the shape of the operating characteristic can be set to prevent operation of the impedance measuring elements for low load impedances, yet at the same time allow coverage of higher fault resistances with remote infeed of fault current. This makes the GFC function especially suited to cases where the fault resistance to be detected exceeds the minimum expected load impedance.

The independent measurement of impedance for each fault loop secures reliable phase selection and correct operation for complex network faults such as simultaneous faults on parallel circuits, evolving faults, etc. Independent reactive reach settings for phase-to-phase and phase-to-ground measurement secure high selectivity in networks with different protective relays used for short-circuit and earth-fault protection.

Functionality
For the impedance-based phase selection, all six fault loops are measured separately and continuously. The reaches are independently settable in the forward and reverse directions, and for phase-to-phase and phase-to-ground faults. The resistive reaches are also independently settable for phase-to-phase and phase-to-ground faults. Preventing impedance element operation due to low load impedances, but at the same time enabling the GFC function to be as sensitive as possible to faults with high fault resistances, is achieved by the inclusion of a facility that allows the resistive reach to be limited within the load impedance area only.

Checks based on the level of residual current determine which loops, i.e. phase-to-ground or phase-to-phase, are evaluated. Selection of the faulted phase(s) is determined by which of the selected loops operate. Operation of a loop occurs when the measured impedance within that loop is within the set boundaries of the characteristic.

For the current-based phase selection, all three phase currents and the residual current are measured continuously, and compared to set values. Assessment of the type of fault is based on the relationship of the measured currents to the set thresholds.

The GFC starting condition (STCND) output will activate the selected loop of the distance protection measuring zone(s) to which it is connected.

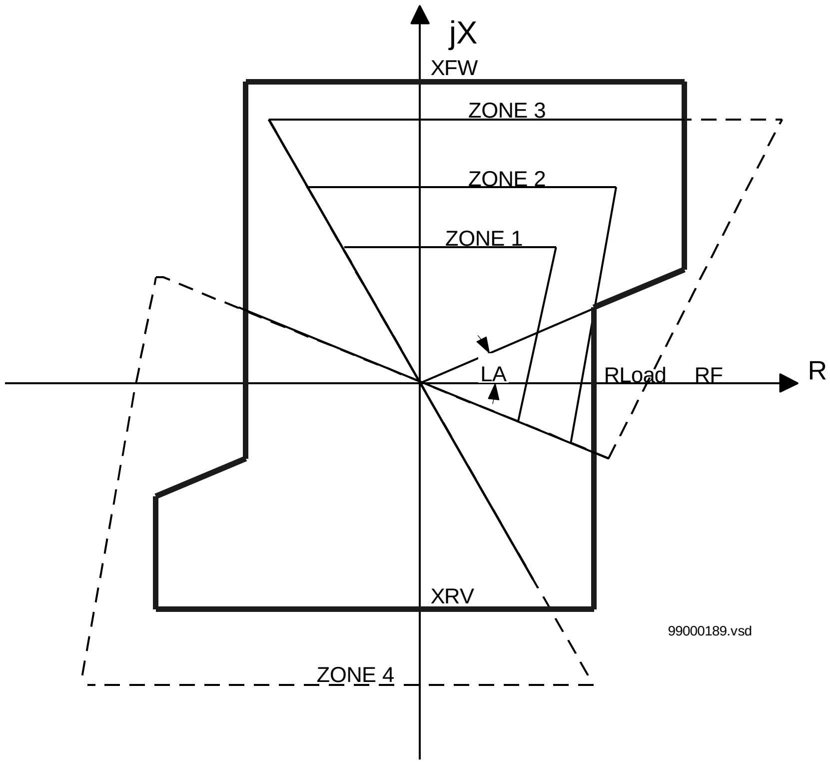


Figure 1: Operating characteristics of the GFC (impedance measuring principle) and zone measuring elements

Distance protection (ZM)

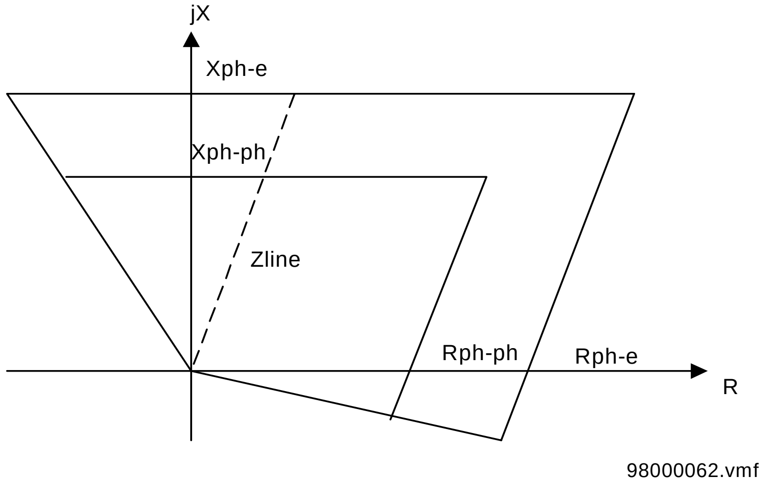
Application

The ZM distance protection function provides fast and reliable protection for overhead lines and power cables in all kinds of power networks. For each independent distance protection zone, full scheme design provides continuous measurement of impedance separately in three independent phase-to-phase measuring loops as well as in three independent phase-to-earth measuring loops.

Phase-to-phase distance protection is suitable as a basic protection function against two- and three-phase faults in all kinds of networks, regardless of the treatment of the neutral point. Independent setting of the reach in the reactive and the resistive direction for each zone separately, makes it possible to create fast and selective short circuit protection in power systems.

Phase-to-earth distance protection serves as basic earth fault protection in networks with directly or low impedance earthed networks. Together with an independent phase preference logic, it also serves as selective protection function at cross-country faults in isolated or resonantly earthed networks.

Independent reactive reach setting for phase-to-phase and for phase-to-earth measurement secures high selectivity in networks with different protective relays used for short-circuit and earth-fault protection.



Where:

X_{ph-e} = reactive reach for ph-e faults

X_{ph-ph} = reactive reach for ph-ph faults

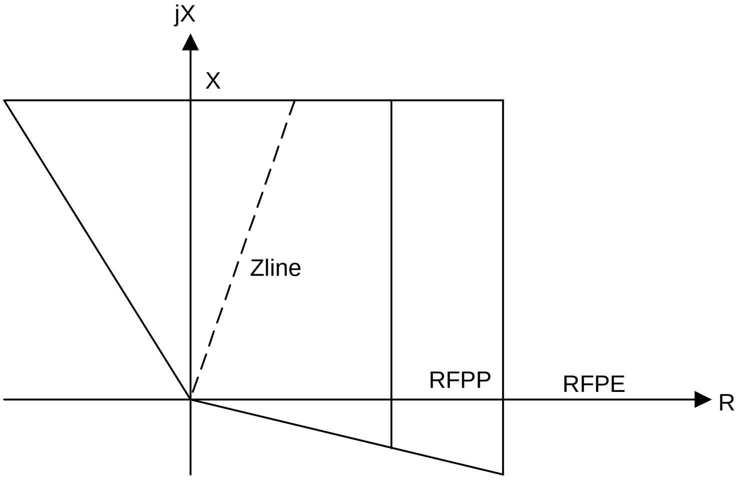
R_{ph-e} = resistive reach for ph-e faults

R_{ph-ph} = resistive reach for ph-ph faults

Z_{line} = line impedance

Figure 2: Schematic presentation of the operating characteristic for one distance protection zone in forward direction

Distance protection with simplified setting parameters is available on request. It uses the same algorithm as the basic distance protection function. Simplified setting parameters reduce the complexity of necessary setting procedures and make the operating characteristic automatically more adjusted to the needs in combined networks with off-lines and cables.



Where:

X	= reactive reach for all kinds of faults
RFPP	= resistive reach for phase-to-phase faults
RFPE	= resistive reach for phase-to-earth faults
Z_{line}	= line impedance

Figure 3: Schematic presentation of the operating characteristic for one distance protection zone in forward direction with simplified setting parameters

The distance protection zones can operate, independently of each other, in directional (forward or reverse) or non-directional mode. This makes it suitable, together with different communication schemes, for the protection of power lines and cables in complex network configurations, such as double-circuit, parallel lines, multiterminal lines, etc. Zone one, two and three can issue phase selective signals, such as start and trip.

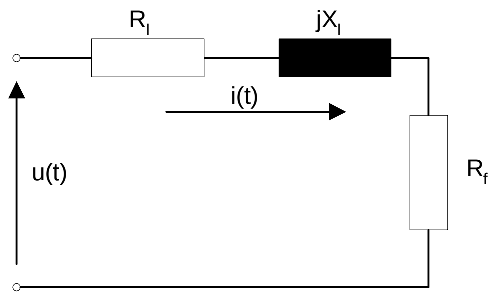
The additional distance protection zones four and five have the same basic functionality as zone one to three, but lack the possibility of issuing phase selective output signals.

Distance protection zone five has shorter operating time than other zones, but also higher transient overreach. It should generally be used as a check zone together with the SOTF switch onto fault function or as a time delayed zone with time delay set longer than 100ms.

Basic distance protection function is generally suitable for use in non-compensated networks. A special addition to the basic functions is available optionally for use on series compensated and adjacent lines where voltage reversals might disturb the correct directional discrimination of a basic distance protection.

Functionality
Separate digital signal processors calculate the impedance as seen for different measuring loops in different distance protection zones. The results are updated each millisecond, separately for all measuring loops and each distance protection zone. Measurement of the impedance for each loop follows the differential equation, which considers complete line replica impedance, as presented schematically in figure 4.

$$u(t) = (R_l + R_f) \cdot i(t) + \frac{X_l}{\omega} \cdot \frac{\Delta i(t)}{\Delta t}$$



Where:

R_l = line resistance

R_f = fault resistance

X_l = line reactance

ω = $2\pi f$

f = frequency

Figure 4: Schematic presentation of impedance measuring principle.

Settings of all line parameters, such as positive sequence resistance and reactance as well as zero-sequence resistance and reactance, together with expected fault resistance for phase-to-phase and phase-to-earth faults, are independent for each zone. The operating characteristic is thus automatically adjusted to the line characteristic angle, if the simplified operating characteristic has not been especially requested. The earth-return compensation factor for the earth-fault measurement is calculated automatically by the terminal itself.

Voltage polarization for directional measurement uses continuous calculation and updating of the positive sequence voltage for each measuring loop separately. This secures correct directionality of the protection at different evolving faults within the complex network configurations. A memory retaining the pre-fault positive-sequence voltage secures reliable directional operation at close-up three-phase faults.

The distance protection function blocks are independent of each other for each zone. Each function block comprises a number of different functional inputs and outputs, which are freely configurable to different external functions, logic gates, timers and binary inputs and outputs. This makes it possible to influence the operation of the complete measuring zone or only its tripping function by the operation of fuse-failure function, power swing detection function, etc.

Power swing detection (PSD)

Application

Power swings in the system arise due to big changes in load, or changes in power system configuration due to faults and their clearance. Distance protection detects these power swings as variations with time of the measured impedance along a locus in the impedance plane. This locus can enter the operate characteristic of the distance protection and cause its unwanted operation if no preventive measures are taken. The main purpose of the PSD power swing detection function is to detect power swings in power networks and to provide the blocking signal to the distance function to prevent its unwanted operation.

Functionality

The PSD function comprises an inner and an outer quadrilateral measurement characteristic. Its principle of operation is based on the measurement of the time it takes a power swing transient impedance to pass through the impedance area between the outer and the inner characteristics. Power swings are identified by transition times longer than timer settings. The impedance measuring principle is the same as that used for the distance protection zones. The impedance and the transient impedance time are measured in all three phases separately. One-out-of-three or two-out-of-three operating modes can be selected permanently or adaptively according to the specific system operating conditions.

The PSD function detects power swings with a swing period as low as 200 ms (i.e. with a slip frequency as high as 10% of the rated frequency on a 50 Hz basis). It detects swings under normal system operating conditions, as well as during the dead time of a single-pole automatic reclosing cycle. Different timers are used for initial and consecutive swings, securing a high degree of differentiation between power swing and fault conditions.

It is possible to inhibit the power swing detected output on detection of earth fault current. This can be used to release the operation of the distance protection function for earth faults during power swing conditions.

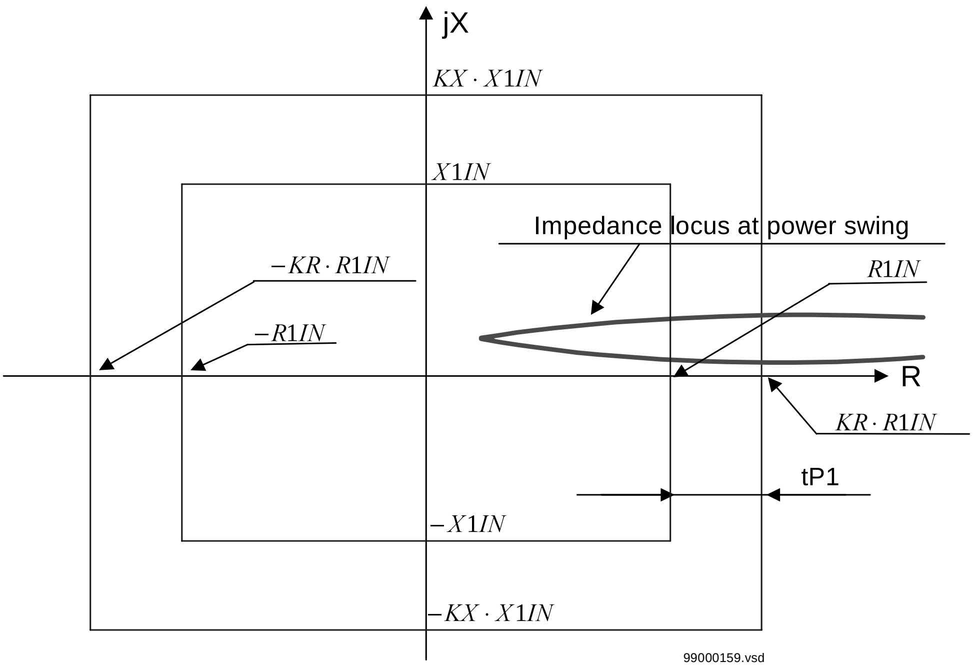


Figure 5: Operating principle and characteristic of the PSD function

Scheme communication logic for distance protection function (ZCOM)

Application

It is not possible to set a underreaching distance protection zone to cover the full length of the line, and at the same time not to overreach for faults beyond the protected line. To avoid overreaching, underreaching distance protection zones must always reach short of the remote end of the line by some safety margin of 15-20%. The main purpose of the ZCOM scheme communication logic is to supplement the distance protection function such that fast clearance of faults is also achieved at the line end for which the faults are on the part of the line not covered by its underreaching zone. To accomplish this, one communication channel, capable of transmitting an on/off signal, is required in each direction.

Functionality

The ZCOM function is a logical function built-up from logical elements. It is a supplementary function to the distance protection, requiring for its operation inputs from the distance protection and the teleprotection equipment.

The type of communication-aided scheme to be used can be selected by way of the settings. The ability to select which distance protection zone is assigned to which input of the ZCOM logic makes this logic able to support practically any scheme communication requirements regardless of their basic operating principle. The outputs to initiate tripping and sending of the teleprotection signal are given in accordance with the type of communication-aided scheme selected and the distance protection zone(s) which have operated.

When power line carrier communication channels are used, unblocking logic is provided which uses the loss of guard signal. This logic compensates for the lack of dependability due to the transmission of the command signal over the faulted line.

Current reversal WEI logic for distance protection (ZCAL)

Application

In interconnected systems, for parallel line applications, the direction of flow of the fault current on the healthy line can change when the circuit breakers on the faulty line open to clear the fault. This can lead to unwanted operation of the distance protection on the healthy line when permissive overreach schemes are used. The main purpose of the ZCAL current reversal logic is to prevent such unwanted operations for this phenomenon.

If the infeed of fault current at the local end for faults on the protected line is too low to operate the measuring elements, no trip output will be issued at the local end and no teleprotection signal will be sent to the remote end. This can lead to time delayed tripping at the remote strong infeed end. The main purpose of the ZCAL weak end infeed logic is to enhance the operation of permissive communication schemes and to avoid sequential tripping when, for a fault on the line, the initial infeed of fault current from one end is too weak to operate the measuring elements.

Functionality
The ZCAL function block provides the current reversal and weak end infeed logic functions that supplement the standard scheme communication logic, or the phase segregated scheme communication logic.

On detection of a current reversal, the current reversal logic provides an output to block the sending of the teleprotection signal to the remote end, and to block the permissive tripping at the local end. This blocking condition is maintained long enough to ensure that no unwanted operation will occur as a result of the current reversal.

On verification of a weak end infeed condition, the weak end infeed logic provides an output for sending the received teleprotection signal back to the remote sending end, and other output(s) for tripping. For terminals equipped for single-, two-, and three-pole tripping, outputs for the faulted phase(s) are provided. Undervoltage detectors are used to select the faulted phase (s).

Automatic switch onto fault logic (SOTF)

Application
The main purpose of the SOTF switch-on-to-fault function is to provide high-speed tripping when energizing a power line on to a short-circuit fault on the line.

Automatic initiating of the SOTF function using dead line detection can only be used when the potential transformer is situated on the line-side of the circuit breaker. Initiation using dead line detection is highly recommended for busbar configurations where more than one circuit breaker at one line end can energize the protected line.

Generally, directional or non-directional overreaching distance protection zones are used as the protection functions to be released for direct tripping during the activated time. When line-side potential transformers are used, the use of non-directional distance zones secures switch-on-to-fault tripping for fault situations there directional information can not be established, for example, due to lack of polarizing voltage. Use of non-directional distance zones also gives fast fault clearance when energizing a bus from the line with a short-circuit fault on the bus.

Functionality
The SOTF function is a logical function built-up from logical elements. It is a complementary function to the distance protection function.

It is enabled for operation either by the close command to the circuit breaker, by a normally closed auxiliary contact of the circuit breaker, or automatically by the dead line detection. Once enabled, this remains active until one second after the enabling signal has reset. The protection function(s) released for tripping during the activated time can be freely selected from the functions included within the terminal. Pickup of any one of the selected protection functions during the enabled condition will result in an immediate trip output from the SOTF function.

Local acceleration logic (ZCLC)

Application
The main purpose of the ZCLC local acceleration logic is to achieve fast fault clearance for faults anywhere on the whole line for those applications where no communication channel is available.

Functionality
The ZCLC function is a complementary function to the distance protection function.

The local acceleration logic can be enabled for operation in two ways. The first way uses an ‘automatic recloser ready’ signal, either from the internal recloser, or an external recloser. The second way uses loss of load detection. When enabled by either method, the local acceleration logic will produce an immediate output on pickup of the function selected to the method of acceleration enabled.

Current

Instantaneous overcurrent protection (IOC)

Application

The instantaneous residual overcurrent protection can be used in a number of applications. Below some examples of applications are given.

- Fast back-up earth fault protection for faults close to the line end.
- Enables fast fault clearance for close in earth faults even if the distance protection or the directional residual current protection is blocked from the fuse supervision function

Functionality

The current measuring element continuously measures the residual current and compares it to the set operate value IN>>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the residual current is above the set value IN>>, the residual overcurrent trip signal TRN is activated. The general trip signal TRIP is activated as well. The input signal BLOCK blocks the complete function.

Time delayed overcurrent protection (TOC)

Application

The time delayed residual overcurrent protection is intended to be used in solidly and low resistance earthed systems. The time delayed residual overcurrent protection is suitable as back-up protection for phase to earth faults, normally tripped by operation of the distance protection. The protection function can also serve as protection for high resistive phase to earth faults.

Functionality

The residual current measuring element continuously measures the residual current and compares it with the set operate value IN>. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the measured current is above the set value IN>, a start signal STN is activated. The timer tN is activated and the residual overcurrent trip signal TRN is activated after set time. The general trip signal TRIP is activated as well. The input signal BLOCK blocks the function. The input signal BLKTR blocks both trip signals TRN and TRIP.

Two step time delayed phase overcurrent protection (TOC2)

Application

The two current/time stages of overcurrent protection TOC2 improve the possibility to get fast operation for nearby faults by using a high set current stage with short time delay. The low current stage is set with appropriate time delay to get selectivity with the adjacent relays in the system. In networks with inverse time delayed relays, selectivity is generally best obtained by using the same type of inverse time characteristic for all overcurrent relays.

Functionality

The current measuring element continuously measures the current in all phases and compares it to the set operate value for the two current stages. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the current in any of the three phases is above the set value I>Low, the start signal for the low current stage is activated. With setting Characteristic = Def, the timer tLow is activated and the trip signal TRLS is activated after set time. If inverse time delay is selected, the timer tMinInv starts when the current is above the set value I>Low. If the current also is above the set value I>Inv, the inverse time evaluation starts. When both time circuits operate, the definite time circuit tLow is activated and the trip signal TRLS is activated after the additional time tLow. If the current is above the set value I>High, the timer tHigh is activated and the trip signal TRHS is activated after set time.

The input signal BLOCK blocks all functions. Each current stage can also be individually blocked.

Two step time deleyed directional phase overcurrent protection (TOC3)

Application

The two current/time stages of the TOC3 overcurrent protection, both with optional directional (Forward release or Reverse block) or non-directional function, improve the possibility to obtain selective function of the overcurrent protection relative other relays even in meshed networks. It must be realized, however, that the setting of a phase overcurrent protection system in a meshed network can be very complicated and a large number of fault current calculations are needed. In some cases, it is not possible to obtain selectivity even when using directional overcurrent protection. In such cases it is suggested to use line differential protection or distance protection function.

Functionality

The current measuring element continuously measures the current in all three phases and compares it to the set operate value for the two current stages. A filter ensures immunity to disturbances and dc components and minimizes the transient overreach. If the current in any of the three phases is above the set value I>Low, the start signal for the low current stage is activated. With setting Characteristic = Def, the timer tLow is activated and the trip signal TRLS is activated after set time. If inverse time delay is selected, the timer tMinInv starts when the current is above the set value I>Low. If the current also is above the set value I>Inv, the inverse time evaluation starts. When both time circuits operate, the definite time circuit tLow is activated and the trip signal TRLS is activated after set time.

If the current is above the set value I>High, the timer tHigh is activated and the trip signal TRHS is activated after set time.The low and the high set current stages can individually be set directional or non-directional. Directional information is calculated from positive sequence polarization voltages and the phase currents. The polarization voltage contains memory voltage to ensure directional function at close-in three-phase faults. The directional element relay characteristic angle (RCA) and operate angle are settable in wide ranges.

The input signal BLOCK blocks all functions. Trip from each current stage can also be individually blocked.

Definite and inverse time-delayed residual overcurrent protection (TEF)

Application

Use the dependent and independent time delayed residual overcurrent functions in solidly earthed systems to get a sensitive and fast fault clearance of phase to earth faults.

The directional residual overcurrent protection can be used in a number of applications:

1. Main protection for phase to earth faults on the radial lines in solidly earthed systems. Selectivity is achieved by using time delayed function according to practices in the system (independent time delay or some type of dependent time characteristic).
2. Main protection for phase to earth faults on lines in a meshed solidly earthed system. The directional function can be used in an permissive overreach communication scheme or a blocking scheme. In this application the directional residual overcurrent function is used together with the communication logic for residual overcurrent protection.
3. Back-up protection for phase to earth faults for lines in solidly earthed systems. By using the directional residual protection as back-up function, the back-up fault clearance time can be kept relatively short together with the maintained selectivity.
4. Etc.

Functionality

As an option the residual overcurrent protection can have directional function. The residual voltage is used as a polarizing quantity. This voltage is either derived as the vectorial sum of inputs U1+U2+U3 or as the input U4. The fault is defined to be in the forward direction if the residual current component in the characteristic angle 65° (residual current lagging the reference voltage, -3U0), is larger than the set operating current in forward direction. The same kind of measurement is performed also in the reverse direction.

Scheme communication logic for residual overcurrent protection

Application

The EFC directional comparison function contains logic for blocking overreaching and permissive overreaching schemes. The function is applicable together with TEF time delayed directional residual overcurrent protection in order to decrease the total operate time of a complete scheme.

One communication channel, which can transmit an on / off signal, is required in each direction. It is recommended to use the complementary additional communication logic EFCA, if the weak infeed and/or current reversal conditions are expected together with permissive overreaching scheme.

Functionality

The communication logic for residual overcurrent protection contains logics for blocking overreach and permissive overreach schemes.

In the blocking scheme a signal is sent to the remote end of the line if the directional element, in the directional residual overcurrent protection (sending end), detects the fault in the reverse direction. If no blocking signal is received and the directional element, in the directional residual overcurrent protection (receiving end), detects the fault in the forward direction, a trip signal will be sent after a settable time delay.

In the permissive overreach scheme a signal is sent to the remote end of the line if the directional element, in the directional residual overcurrent protection (sending end), detects the fault in the forward direction. If an acceleration signal is received and the directional element, in the directional residual overcurrent protection (receiving end), detects the fault in the forward direction, a trip signal will be sent, normally with no time delay. In case of risk for fault current reversal or weak end infeed, an additional logic can be used to take care of this.

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

Application

The EFCA additional communication logic is a supplement to the EFC scheme communication logic for the residual overcurrent protection.

To achieve fast fault clearing for all earth faults on the line, the TEF earth-fault protection function can be supported with logic, that uses communication channels. REx 5xx terminals have for this reason available additions to scheme communication logic.

If parallel lines are connected to common busbars at both terminals, overreaching permissive communication schemes can trip unselectively due to fault current reversal. This unwanted tripping affects the healthy line when a fault is cleared on the other line. This lack of security can result in a total loss of interconnection between the two buses.To avoid this type of disturbance, a fault current-reversal logic (transient blocking logic) can be used.

Permissive communication schemes for residual overcurrent protection, can basically operate only when the protection in the remote terminal can detect the fault. The detection requires a sufficient minimum residual fault current, out from this terminal. The fault current can be too low due to an opened breaker or high positive and/or zero sequence source impedance behind this terminal. To overcome these conditions, weak end infeed (WEI) echo logic is used.

Functionality

The reverse directed signal from the directional residual overcurrent function, starts the operation of a current reversal logic. The output signal, from the logic, will be activated, if the fault has been detected in reverse direction for more than the tPickUp time set on the corresponding timers. The tDelay timer delays the reset of the output signal. The signal blocks the operation of the overreach permissive scheme for residual current, and thus prevents unwanted operation due to fault current reversal.

The weak end infeed logic uses normally a forward and reverse signal from the directional residual overcurrent function. The weak end infeed logic echoes back the received permissive signal, if none of the directional measuring elements have been activated during the last 200 ms. Further, it can be set to give signal to trip the breaker if the echo conditions are fulfilled and the residual voltage is above the set operate value for $3U_0$>.

Voltage

Time delayed undervoltage protection (TUV)

Application

The time delayed undervoltage protection function, TUV, is applicable in all situations, where reliable detection of low phase voltages is necessary. The function can also be used as a supervision and fault detection function for some other protection functions, to increase the security of a complete protection system.

Time delayed overvoltage protection (TOV)

Application

The time delayed phase overvoltage protection is used to protect the electrical equipment and its insulation against overvoltage by measuring three phase voltages. In this way, it prevents the damage to the exposed primary and secondary equipment in the power systems.

Functionality

The phase overvoltage protection function continuously measures the three phase voltages and initiates the corresponding output signals if the measured phase voltages exceed the preset value (starting) and remain high longer than the time delay setting on the timers (trip). This function also detects the phases which caused the operation.

Power system supervision

Dead line detection (DLD)

Application

The main purpose of the dead line detection is to provide different protection, control and monitoring functions with the status of the line, i.e whether or not it is connected to the rest of the power system.

Functionality

The dead line detection function continuously measures all three phase currents and phase voltages of a protected power line. The line is declared as dead (not energized) if all three measured currents and voltages fall below the preset values for more than 200 ms.

Secondary system supervision

Fuse failure supervision (FUSE)

Application

The fuse failure supervision function, FUSE, continuously supervises the ac voltage circuits between the voltage instrument transformers and the terminal. Different output signals can be used to block, in case of faults in the ac voltage secondary circuits, the operation of the distance protection and other voltage-dependent functions, such as the synchro-check function, undervoltage protection, etc.

Different measurement principles are available for the fuse failure supervision function.

The FUSE function based on zero sequence measurement principle, is recommended in directly or low impedance earthed systems.

Functionality

The FUSE function based on the zero sequence measurement principle continuously measures the zero sequence current and voltage in all three phases. It operates if the measured zero sequence voltage increases over preset operating value, and if the measured zero sequence current remains below the preset operating value.

Three output signals are available. The first depends directly on the voltage and current measurement. The second depends on the operation of the dead line detection function, to prevent unwanted operation of the distance protection if the line has been deenergised and energised under fuse failure conditions. The third depends on the loss of all three measured voltages. A special function input serves the connection to the auxiliary contact of a miniature circuit breaker, MCB (if used), to secure correct operation of the function on simultaneous interruption of all three measured phase voltages also when the additional delta current and delta voltage algorithm is not present in the function block.

Control

Synchrocheck (SYN)

Application

The main purpose of the synchrocheck function is to provide controlled closing of circuit breakers in interconnected networks.

The main purpose of the energizing check function is to facilitate the controlled reconnection of a disconnected line or bus to, respectively, an energized bus or line.

To meet the different application arrangements, a number of identical SYN function blocks may be provided within a single terminal. The number of these function blocks that may be included within any given terminal depends on the type of terminal. Therefore, the specific circuit breaker arrangements that can be catered for, or the number of bays of a specific arrangement that can be catered for, depends on the type of terminal.

Functionality

The synchrocheck function measures the conditions across the circuit breaker and compares them to set limits. The output is only given when all measured conditions are simultaneously within their set limits.

The energizing check function measures the bus and line voltages and compares them to both high and low threshold detectors. The output is only given when the actual measured conditions match the set conditions.

For single circuit breaker, the SYN function blocks have the capability to make the necessary voltage selection. For single circuit breaker arrangements, selection of the correct voltage is made using auxiliary contacts of the bus disconnectors.

Automatic reclosing function (AR)

Application

The majority of power line faults are transient in nature, i.e. they do not recur when the line is re-energized following disconnection. The main purpose of the AR automatic reclosing function is to automatically return power lines to service following their disconnection for fault conditions.

Especially at higher voltages, the majority of line faults are single-phase-to-earth. Faults involving all three phases are rare. The main purpose of the single- and two-pole automatic reclosing function, operating in conjunction with a single- and two-pole tripping capability, is to limit the effect to the system of faults involving less than all three phases. This is particularly valuable for maintaining system stability in systems with limited meshing or parallel routing.

Functionality

The AR function is a logical function built up from logical elements. It operates in conjunction with the trip output signals from the line protection functions, the OK to close output signals from the synchrocheck and energizing check function, and binary input signals. The binary input signals can be for circuit breaker position/status or from other external protection functions.

Of the six reclosing programs, one provides for three-pole reclosing only, while the others provide for single- and two-pole reclosing as well. For the latter, only the first shot may be single- or two-pole. All subsequent shots up to the maximum number will be three-pole. For some of the programs, depending on the initial trip, no shot, or only one shot, will be permitted irrespective of the number of shots selected.

Logic

Trip logic (TR)

Application

The main purpose of the TR trip logic function is to serve as a single node through which all tripping for the entire terminal is routed.

The main purpose of the single- and two-pole extension to the basic three-pole tripping function is to cater for applications where, for reasons of system stability, single-pole tripping is required for single-phase faults, and/or two-pole tripping is required for two-phase faults, e.g. on double circuit parallel lines.

Functionality

The minimum duration of a trip output signal from the TR function is settable.

The TR function has a single input through which all trip output signals from the protection functions within the terminal, or from external protection functions via one or more of the terminal's binary inputs, are routed. It has a single trip output for connection to one or more of the terminal's binary outputs, as well as to other functions within the terminal requiring this signal.

The expanded TR function for single- and two-pole tripping has additional phase segregated inputs for this, as well as inputs for faulted phase selection. The latter inputs enable single- and two-pole tripping for those functions which do not have their own phase selection capability, and therefore which have just a single trip output and not phase segregated trip outputs for routing through the phase segregated trip inputs of the expanded TR function. The expanded TR function has two inputs for these functions, one for impedance tripping (e.g. carrier-aided tripping commands from the scheme communication logic), and one for earth fault tripping (e.g. tripping output from a residual overcurrent protection). Additional logic secures a three-pole final trip command for these protection functions in the absence of the required phase selection signals.

The expanded TR function has three trip outputs, one per phase, for connection to one or more of the terminal's binary outputs, as well as to other functions within the terminal requiring these signals.

The expanded TR function is equipped with logic which secures correct operation for evolving faults as well as for reclosing on to persistent faults. A special input is also provided which disables single- and two-pole tripping, forcing all tripping to be three-pole.

High speed binary output logic (HSBO)

Application

The time taken for signals to be transferred from binary inputs to protection functions, and from protection functions to binary outputs contributes to the overall tripping time. The main purpose of the HSBO high speed binary output logic is to minimize overall tripping times by establishing the critical connections to/from the binary outputs/inputs in a more direct way than with the regular I/O connections.

Functionality

The outputs from the HSBO logic utilize 'fast' connections to initiate binary outputs. The inputs to the HSBO logic utilize the same 'fast' connections. Input connections to the logic are derived from binary inputs, from outputs of the high speed distance protection, and from inputs to the regular trip logic and scheme communication logic. The HSBO scheme communication logic runs in parallel with the regular scheme communication logic.

The 'fast' connections to and from the HSBO logic comprise so called hard connections in software. This configuration is made internally and cannot be altered. The only exceptions are the connections to the binary outputs where limited configuration is possible, and required, on the part of the user.

Serial communication

Application

One or two optional optical serial interfaces, one with LON protocol and the other with SPA or IEC 60870-5-103 protocol, for remote communication, enables the terminal to be part of a Substation Control System (SCS) and/or Substation Monitoring System (SMS). These interfaces are located at the rear of the terminal. The two interfaces can be configured independent of each other, each with different functionalities regarding monitoring and setting of the functions in the terminal.

Serial communication, SPA (SPA-bus V 2.4 protocol)

Application

This communication bus is mainly used for SMS. It can include different numerical relays/terminals with remote communication possibilities. Connection to a personal computer (PC) can be made directly (if the PC is located in the substation) or by telephone modem through a telephone network with CCITT characteristics.

Functionality

When communicating with a PC, using the rear SPA port, the only hardware needed for a station monitoring system is optical fibres and opto/electrical converter for the PC.

Remote communication over the telephone network also requires a telephone modem. The software needed in the PC when using SPA, either locally or remotely, is SMS 510 or/and CAP 540.

SPA communication is applied when using the front communication port, but for this purpose, no special serial communication function is required in the terminal. Only the software in the PC and a special cable for front connection is needed.

Serial communication, IEC (IEC 60870-5-103 protocol)

Application
This communication protocol is mainly used when a protection terminal communicates with a third party control system. This system must have a program that can interpret the IEC 60870-5-103 communication messages.

Functionality
As an alternative to the SPA communication the same port can be used for the IEC communication. The IEC 60870-5-103 protocol implementation in REx 5xx consists of these functions:

- Event handling
- Report of analog service values (measurements)
- Fault location
- Command handling
  - Autorecloser ON/OFF
  - Teleprotection ON/OFF
  - Protection ON/OFF
  - LED reset
  - Characteristics 1 - 4 (Setting groups)
- File transfer (disturbance files)
- Time synchronization

The events created in the terminal available for the IEC protocol are based on the event function blocks EV01 - EV06 and disturbance function blocks DRP1 - DRP3. The commands are represented in a dedicated function block ICOM. This block has output signals according to the IEC protocol for all commands.

Serial communication, LON

Application
An optical network can be used within the Substation Automation system. This enables communication with the terminal through the LON bus from the operator’s workplace, from the control center and also from other terminals.

Functionality
An optical serial interface with LON protocol enables the terminal to be part of a Substation Control System (SCS) and/or Substation Monitoring System (SMS). This interface is located at the rear of the terminal. The hardware needed for applying LON communication depends on the application, but one very central unit needed is the LON Star Coupler and optic fibres connecting the star coupler to the terminals. To communicate with the terminals from a Personal Computer (PC), the SMS 510, software or/and the application library LIB 520 together with MicroSCADA is needed.

Event function (EV)

Application
When using a Substation Automation system, events can be spontaneously sent or polled from the terminal to the station level. These events are created from any available signal in the terminal that is connected to the event function block. The event function block can also handle double indication, that is normally used to indicate positions of high-voltage apparatuses. With this event function block, data also can be sent to other terminals over the interbay bus.

Functionality
As basic, 12 event function blocks EV01-EV12 running with a fast cyclicity, are available in REx 5xx. When the function Apparatus control is used in the terminal, additional 32 event function blocks EV13-EV44, running with a slower cyclicity, are available.

Each event function block has 16 connectables corresponding to 16 inputs INPUT1 to INPUT16. Every input can be given a name with up to 19 characters from the CAP 540 configuration tool.

The inputs can be used as individual events or can be defined as double indication events.

The inputs can be set individually, from the Parameter Setting Tool (PST) under the Mask-Event function, to create an event at pick-up, drop-out or at both pick-up and drop-out of the signal.

The event function blocks EV01-EV06 have inputs for information numbers and function type, which are used to define the events according to the communication standard IEC 60870-5-103.

Monitoring

Disturbance report (DRP)

Application

Use the disturbance report to provide the network operator with proper information about disturbances in the primary network. The function comprises several subfunctions enabling different types of users to access relevant information in a structured way.

Select appropriate binary signals to trigger the red HMI LED to indicate trips or other important alerts.

Functionality

The disturbance report collects data from each subsystem for up to ten disturbances. The data is stored in nonvolatile memory, used as a cyclic buffer, always storing the latest occurring disturbances. Data is collected during an adjustable time frame, the collection window. This window allows for data collection before, during and after the fault.

The collection is started by a trigger. Any binary input signal or function block output signal can be used as a trigger. The analog signals can also be set to trigger the data collection. Both over levels and under levels are available. The trigger is common for all subsystems, hence it activates them all simultaneously.

A triggered report cycle is indicated by the yellow HMI LED, which will be lit. Binary signals may also be used to activate the red HMI LED for additional alerting of fault conditions. A disturbance report summary can be viewed on the local HMI.

Indications

Application

Use the indications list to view the state of binary signals during the fault. All binary input signals to the disturbance report function are listed.

Functionality

The indications list tracks zero-to-one changes of binary signals during the fault period of the collection window. This means that constant logic zero, constant logic one or state changes from logic one to logic zero will not be visible in the indications list. Signals are not time tagged. In order to be listed in the indications list the:

1. signal must be connected to the DRP function block.
2. setting parameter, IndicationMask, for the input must be set to Show.

Output signals of other function blocks of the configuration will be listed by the signal name listed in the corresponding signal list. Binary input signals are listed by the name defined in the configuration.

The indications can be viewed on the local HMI and via SMS.

Disturbance recorder

Application

Use the disturbance recorder to record analog and binary signals during fault conditions in order to analyze disturbances. The analysis may include fault severity, fault duration and protection performance. Replay the recorded data in a test set to verify protection performance.

Functionality

The disturbance recorder records both analog and binary signal information.

Analog and digital signals can be used as triggers. A trigger signal does not need to be recorded.

A trigger is generated when the analog signal moves under and/or over set limit values. The trig level is compared to the signal’s average peak-to-peak value, making the function insensible to DC offset. The trig condition must occur during at least one full period, that is, 20 ms for a 50 Hz network.

The recorder continuously records data in a cyclic buffer capable of storing the amount of data generated during the set pre-fault time of the collection window. When triggered, the pre-fault data is saved and the data for the fault and post-fault parts of the collection window is recorded.

The RAM area for temporary storage of recorded data is divided into subareas, one for each recording. The size of a subarea depends on the set recording times. There is sufficient memory for four consecutive recordings with a maximum number of analog channels recorded and with maximum time settings. Should no subarea be free at a new disturbance, the oldest recording is overwritten.

When a recording is completed, the post recording process:

- merges the data for analog channels with corresponding data for binary signals stored in an event buffer
- compresses the data without loosing any data accuracy
- stores the compressed data in a non-volatile memory

The disturbance recordings can be viewed via SMS or SCS.

Event recorder

Application
Use the event recorder to obtain a list of binary signal events that occurred during the disturbance.

Functionality
When a trigger condition for the disturbance report is activated, the event recorder collects time tagged events from the 48 binary signals that are connected to disturbance report and lists the changes in status in chronological order. Each list can contain up to 150 time tagged events that can come from both internal logic signals and binary input channels. Events are recorded during the total recording time which depends on the set recording times and the actual fault time.

Events can be viewed via SMS and SCS.

Fault locator (FLOC)

Application
An accurate fault locator is an essential complement to the line protection. The fault locator provides distance to fault together with information about the measuring loop that has been used in the calculation.

Reliable information on fault location reduces the outage time and minimises the need for patrolling.

The function has limitations for applications with series compensated lines.

Functionality
The fault locator can be started by any internal or external binary signal. Pre-fault and fault phasors of currents and voltages, that were filtered from disturbance data stored into digital sample buffers, are then used for the distance to fault calculation. The phase selective signals from the built-in protection functions provide the necessary information for the selection of the loop to be used for the calculation. It is also possible to use the external phase selection information.

For the distance to fault calculation, a line modelling algorithm that takes into account the sources at both ends of the line, is used. In this way, the influence of the load current, the infeed from the remote end and the fault resistance, can be compensated for, resulting in a highly accurate calculation.

In case of double circuit lines, the influence of the zero-sequence mutual impedance Zm0 is compensated for by considering the residual current on the parallel line.

The function indicates the distance to the fault as a percentage of the line length, in kilometers or miles as selected.

Possibility to make recalculations with changed parameter settings exists.

Information on the last ten disturbances is stored.

Monitoring of AC analogue measurements

Application
Use the AC monitoring function to provide three phase or single phase values of voltage and current. At three phase measurement, the values of apparent power, active power, reactive power, frequency and the RMS voltage and current for each phase are calculated. Also the average values of currents and voltages are calculated.

Functionality
Alarm limits can be set and used as triggers, e.g. to generate trip signals.

The software functions to support presentation of measured values are always present in the terminal. In order to retrieve actual values, however, the terminal must be equipped with the appropriate hardware measuring module(s), i.e. Transformer Input Module (TRM) or Optical Receiver Module (ORM).

Monitoring of DC analogue measurements

Application
Use the DC monitoring function to measure and process signals from different measuring transducers. Many devices used in process control uses low currents, usually in the range 4-20 mA or 0-20 mA to represent various parameters such as frequency, temperature and DC battery voltage.

Functionality
Alarm limits can be set and used as triggers, e.g. to generate trip signals.

The software functions to support presentation of measured values are always present in the terminal. In order to retrieve actual values, however, the terminal must be equipped with the mA Input Module (MIM).

Hardware modules

Modules

Modules
Table 1: Basic, always included, modules

Module	Description
Backplane module	The size of the module depends on the size of the case.
Power supply module (PSM)	Available in two different versions, each including a regulated DC/DC converter that supplies auxiliary voltage to all static circuits. • For case size 1/2x19” and 3/4x19” a version with four binary inputs and four binary outputs are used. An internal fail alarm output is also available. • For case size 1/1x19” a version without binary I/O:s and increased output power is used.
Main processing module (MPM)	Module for overall application control. All information is processed or passed through this module, such as configuration, settings and communication.
Human machine interface (LCD-HMI)	The module consist of LED:s, a LCD, push buttons and an optical connector for a front connected PC
Signal processing module (SPM)	Module for protection algorithm processing. Carries up to 12 digital signal processors, performing all measuring functions.

Table 2: Application specific modules

Module	Description
Milliampere input module (MIM)	Analog input module with 6 independent, galvanically separated channels.
Binary input module (BIM)	Module with 16 optically isolated binary inputs
Binary output module (BOM)	Module with 24 single outputs or 12 double-pole command outputs including supervision function
Binary I/O module (IOM)	Module with 8 optically isolated binary inputs, 10 outputs and 2 fast signalling outputs.
Data communication modules (DCMs)	Modules used for digital communication to remote terminal.
Transformer input module (TRM)	Used for galvanic separation of voltage and/or current process signals and the internal circuitry.
A/D conversion module (ADM)	Used for analog to digital conversion of analog process signals galvanically separated by the TRM.
Optical receiver module (ORM)	Used to interface process signals from optical instrument transformers.
Serial communication module (SCM)	Used for SPA/LON/IEC communication
LED module (LED-HMI)	Module with 18 user configurable LEDs for indication purposes

Transformer input module (TRM)

Functionality

A transformer input module can have up to 10 input transformers. The actual number depends on the type of terminal. Terminals including only current measuring functions only have current inputs. Fully equipped the transformer module consists of:

- Five voltage transformers
- Five current transformers

The inputs are mainly used for:

- Phase currents
- Residual current of the protected line
- Residual current of the parallel circuit (if any) for compensation of the effect of the zero sequence mutual impedance on the fault locator measurement or residual current of the protected line but from a parallel core used for CT circuit supervision function or independent earth fault function.
- Phase voltages
- Open delta voltage for the protected line (for an optional directional earth-fault protection)
- Phase voltage for an optional synchronism and energizing check.

A/D-conversion module (ADM)

Functionality

The inputs of the A/D-conversion module (ADM) are fed with voltage and current signals from the transformer module. The current signals are adapted to the electronic voltage level with shunts. To gain dynamic range for the current inputs, two shunts with separate A/D channels are used for each input current. By that a 16-bit dynamic range is obtained with a 12 bits A/D converter.

The input signals passes an anti aliasing filter with a cut-off frequency of 500 Hz.

Each input signal (5 voltages and 5 currents) is sampled with a sampling frequency of 2 kHz.

The A/D-converted signals are low-pass filtered with a cut-off frequency of 250 Hz and down-sampled to 1 kHz in a digital signal processor (DSP) before transmitted to the main processing module.

Binary I/O capabilities

Application
Input channels with high EMI immunity can be used as binary input signals to any function. Signals can also be used in disturbance or event recording. This enables extensive monitoring and evaluation of the operation of the terminal and associated electrical circuits.

Functionality
Inputs are designed to allow oxide burn-off from connected contacts, and increase the disturbance immunity during normal protection operate times. This is achieved with a high peak inrush current while having a low steady-state current. Inputs are debounced by software.

Well defined input high and input low voltages ensures normal operation at battery supply earth faults.

The voltage level of the inputs is selected when ordering.

I/O events are time stamped locally on each module for minimum time deviance and stored by the event recorder if present.

Binary input module (BIM)

Application
Use the binary input module, BIM, when a large amount of inputs are needed. The BIM is available in two versions, one standard and one with enhanced pulse counting inputs to be used with the pulse counter function.

Functionality
The binary input module, BIM, has 16 optically isolated binary inputs.

A signal discriminator detects and blocks oscillating signals. When blocked, a hysteresis function may be set to release the input at a chosen frequency, making it possible to use the input for pulse counting. The blocking frequency may also be set.

Power supply module (PSM)

Application
The 20 W power supply module, PSM, with built in binary I/O is used in 1/2 and 3/4 of full width 19” units. It has four optically isolated binary inputs and five binary outputs, out of which one binary output is dedicated for internal fail.

The 30 W power supply module, PSM, is used to provide power for the extended number of modules in a full width 19” unit. It has one binary output dedicated to internal fail.

Functionality
The power supply modules contain a built-in, self-regulated DC/DC converter that provides full isolation between the terminal and the battery system.

The 20 W power supply module, PSM, has four optically isolated binary inputs and four output relays.

Human machine interface module (HMI)

Application
The human machine interface is used to monitor and in certain aspects affect the way the product operates. The configuration designer can add functions for alerting in case of important events that needs special attention from you as an operator.

Use the terminals built-in communication functionality to establish SMS communication with a PC with suitable software tool. Connect the PC to the optical connector on the local HMI with the special front communication cable including an opto-electrical converter for disturbance free and safe communication.

LED Indication module (HMI-LED)

Functionality
The human-machine interface consists of:

- the human-machine interface (HMI) module.
- the LED module.

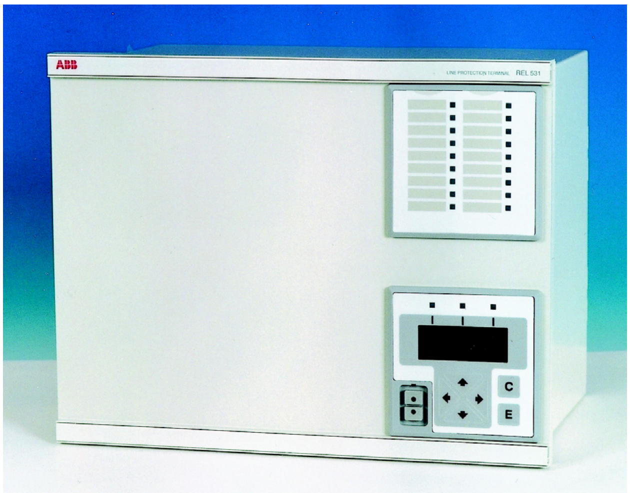


Figure 6: The figure shows the LED (upper) and the HMI (lower).

Serial communication modules (SCM)

Functionality, SPA/IEC

The serial communication module for SPA/IEC is placed in a slot at the rear part of the main processing module. The serial communication module can have connectors for two plastic fibre cables or two glass fibre cables.The incoming optical fibre is connected to the RX receiver input and the outgoing optical fibre to the TX transmitter output. When the fibre optic cables are laid out, pay special attention to the instructions concerning the handling, connection, etc. of the optical fibres. The module is identified with a number on the label on the module.

Functionality, LON

The serial communication module for LON is placed in a slot at the rear part of the Main processing module. The serial communication module can have connectors for two plastic fibre cables or two glass fibre cables The incoming optical fibre is connected to the RX receiver input and the outgoing optical fibre to the TX transmitter output. Pay special attention to the instructions concerning the handling, connection, etc. of the optical fibres. The module is identified with a number on the label on the module.

Hardware design

Layouts and dimensions

Design

Dimensions, case without rear cover

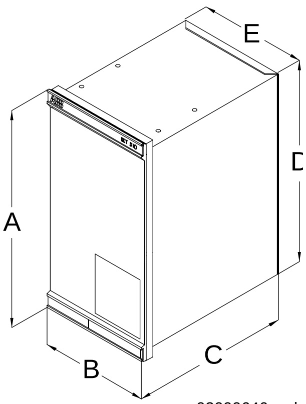


Figure 7: Case without rear cover

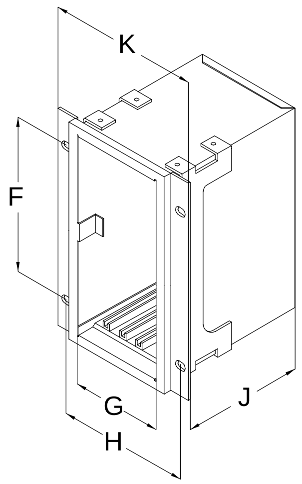


Figure 8: Case without rear cover with 19” rack mounting kit

Case size	A	B	C	D	E	F	G	H	J	K
6U, 1/2 x 19”		223.7			205.7		203.7	-		-
6U, 3/4 x 19”	265.9	336	204.1	252.9	318	190.5	316	-	186.6	-
6U, 1/1 x 19”		448.3			430.3		428.3	465.1		482.6
(mm) The H and K dimensions are defined by the 19” rack mounting kit										

Dimensions, case with rear cover

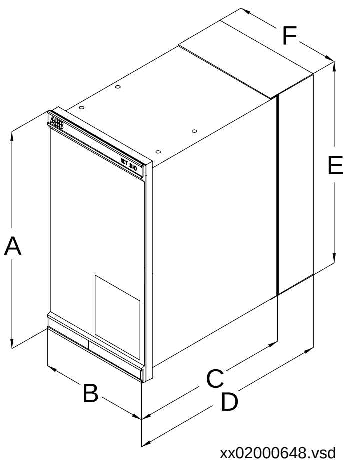


Figure 9: Case with rear cover

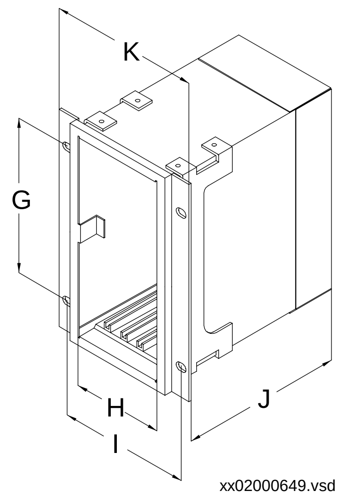


Figure 10: Case with rear cover and 19” rack mounting kit

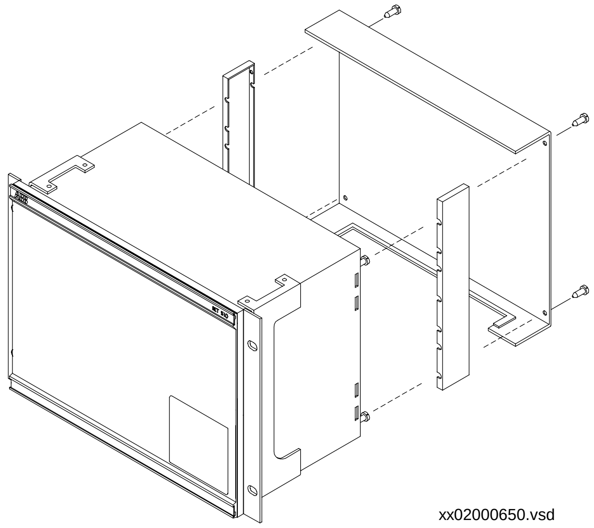


Figure 11: Case with rear cover

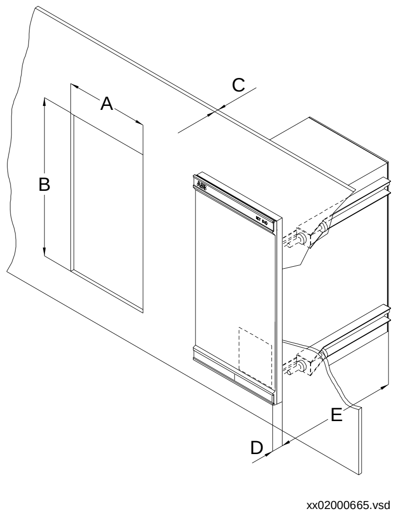
Case size	A	B	C	D	E	F	G	H	I	J	K
6U, 1/2 x 19”	265.9	223.7	204.1	245.1	255.8	205.7	190.5	203.7	-	227.6	-
6U, 3/4 x 19”		336				318		316	-		-
6U, 1/1 x 19”		448.3				430.3		428.3	465.1		482.6

(mm)

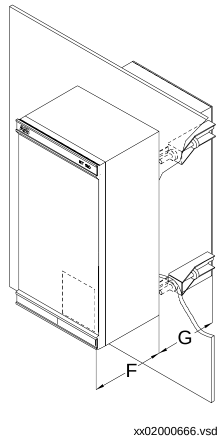
The I and K dimensions are defined by the 19” rack mounting kit.

Panel cut-outs for REx 500 series, single case

Flush mounting



Semi-flush mounting



Case size	Cut-out dimensions (mm)	
	A+/-1	**B+/-1**
6U, 1/2 x 19”	210.1	254.3
6U, 3/4 x 19”	322.4	254.3
6U, 1/1 x 19”	434.7	254.3

C = 4-10 mm

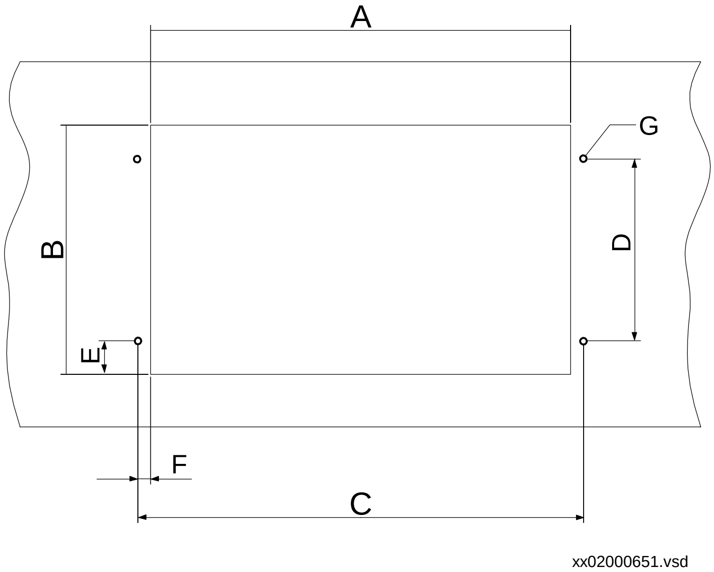
D = 16.5 mm

E = 187.6 mm without rear protection cover, 228.6 mm with rear protection cover

F = 106.5 mm

G = 97.6 mm without rear protection cover, 138.6 mm with rear protection cover

Panel cut-out for REx 500 series, side by side cases



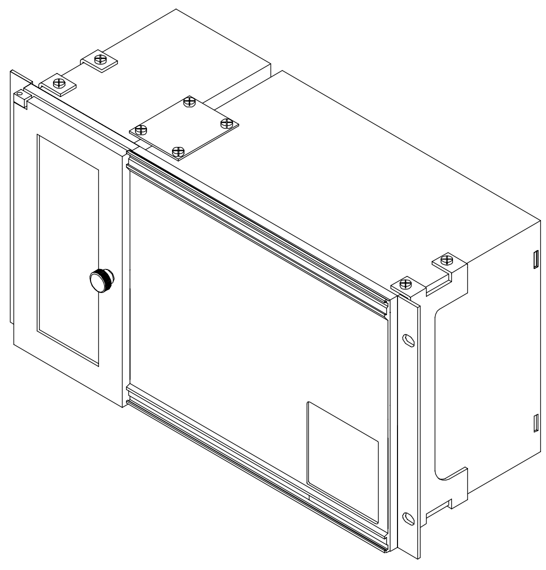
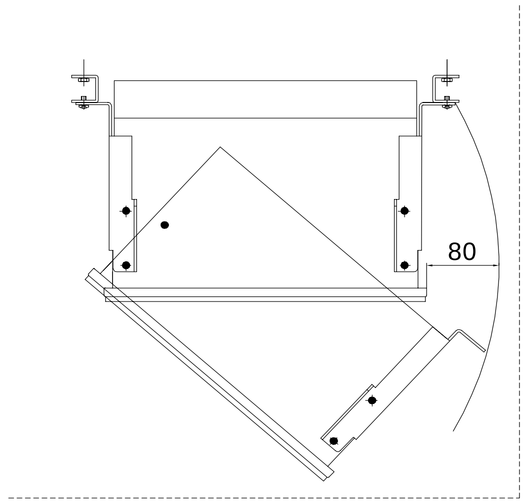


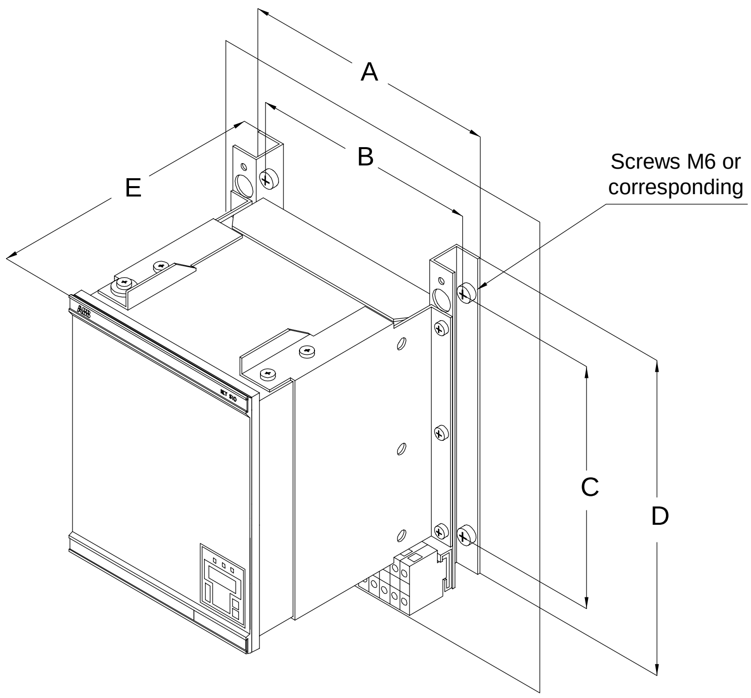
Figure 12: Flush mounting of side by side cases

Case size	Cut-out dimensions						
	A	**B**	**C**	**D**	**E**	**F**	**G**
6U, 3/4 x 19”	326.4	259.3	352.8	190.5	34.4	13.2	ø 6.4
6U, 1/1 x 19”	438.7	259.3	465.1	190.5	34.4	13.2	ø 6.4
							(mm)

Dimensions, wall mounting



xx02000653.vsd



en02000654.vsd

Figure 13: Wall mounting

Case size (mm)	A	B	C	D	E
6U, 1/2 x 19”	292	267.1	272.8	390	247
6U, 3/4 x 19”	404.3	379.4			
6U, 1/1 x 19”	516	491.1			

Terminal diagram

Drawings

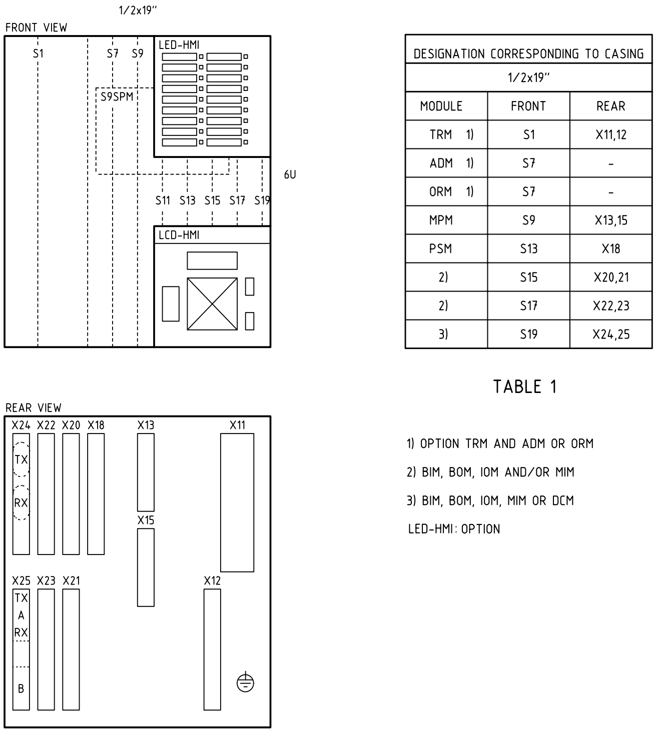


Figure 14: Hardware structure of the 1/2 of full width 19” case

Technical data

General

Definitions

Reference value:

The specified value of an influencing factor to which are referred the characteristics of the equipment.

Nominal range:

The range of values of an influencing quantity (factor) whithin which, under specified conditions, the equipment meets the specified requirements.

Operative range:

The range of values of a given energizing quantity for which the equipment, under specified conditions, is able to perform its intended functions according to the specified requirements.

Table 3: Unit

Material	Steel sheet
Front plate	Aluminium profile with cut-out for HMI and for 18 LED when included
Surface treatment	Aluzink preplated steel
Finish	Light beige (NCS 1704-Y15R)
Degree of protection	Front side: IP40, optional IP54 with sealing strip. Rear side: IP20

Table 4: Weight

Case size	Weight
6U, 1/2 x 19”	≤ 8.5 kg

Table 5: PSM 20/30 W

Quantity	Rated value	Nominal range
Auxiliary dc voltage	EL = (48 - 250) V	+/- 20%

Table 6: TRM, Energizing quantities, rated values and limits

Quantity	Rated value	Nominal range
Current Operative range Permissive overload Burden	I_r = 1 or 5 A (0.004-100) x I_r 4 × I_r cont. 100 × I_r for 1 s *) < 0.25 VA at I = 1 or 5 A	(0.2-30) × I_r
Ac voltage for the terminal Operative range Permissive overload Burden	U_r = 110 V **) or U_r = 220 V **) (0.001-1.5) x U_r 1.5 × U_r cont. 2.5 x U_r for 1 s < 0.2 VA at U_r	100/110/115/120 V 200/220/230/240 V
Frequency	f_r = 50/60 Hz	+/-5%
*) max. 350 A for 1 s when COMBITEST test switch is included. **) The rated voltage of each individual voltage input U1 to U5 is $U_r/\sqrt{3}$		

Table 7: Temperature and humidity influence

Parameter	Reference value	Nominal range	Influence
Ambient temperature Operative range	+20 °C -25 °C to +55°C	-5 °C to +55 °C	0.01%/°C
Relative humidity Operative range	10%-90% 0%-95%	10%-90%	-
Storage temperature	-40 °C to +70 °C	-	-

Table 8: Auxiliary DC supply voltage influence on functionality during operation

Dependence on:		Within nominal range
Ripple, in DC auxiliary voltage		Max 12%
Interrupted auxiliary DC voltage	Without reset	<50 ms
	Correct function	0-∞ s
	Restart time	<120 s

Table 9: Electromagnetic compatibility

Test	Type test values	Reference standards
1 MHz burst disturbance	2.5 kV	IEC 60255-22-1, Class III
Electrostatic discharge	8 kV	IEC 60255-22-2, Class III
Fast transient disturbance	4 kV	IEC 60255-22-4, Class IV
Radiated electromagnetic field disturbance	10 V/m, 25-1000 MHz	IEC 60255-22-3, Class III IEEE/ANSI C37.90.2

Table 10: Insulation

Test	Type test values	Reference standard
Dielectric test	2.0 kVAC, 1 min.	IEC 60255-5
Impulse voltage test	5 kV, 1.2/50 μs, 0.5 J	
Insulation resistance	>100 MΩ at 500 VDC	

Table 11: CE compliance

Test	According to
Immunity	EN 50082-2
Emissivity	EN 50081-2
Low voltage directive	EN 50178

Table 12: Mechanical tests

Test	Type test values	Reference standards
Vibration	Class I	IEC 60255-21-1
Shock and bump	Class I	IEC 60255-21-2
Seismic	Class I	IEC 60255-21-3

Table 13: Calendar and clock

Parameter	Range
Built-in calender	With leap years through 2098

Table 14: Internal event list

Data	Value
Recording manner	Continuous, event controlled
List size	40 events, first in-first out

Table 15: TIME, Time synchronisation

Function	Accuracy
Time tagging resolution	1 ms
Time tagging error with synchronisation at least once/60 s	+/- 1.5 ms
Drift of clock without synchronisation	+/- 3 ms/min

Table 16: Front communication

Function	Value
Protocol	SPA
Communication speed for the cable	0.3-115 Kbaud
Slave number	1 to 899
Remote change of active group allowed	Yes
Remote change of settings allowed	Yes

Table 17: Available logic function blocks as basic

Update rate	Block	Availability
6 ms	AND	30 gates
	OR	60 gates
	INV	20 inverters
	TM	10 timers
	TP	10 pulse timers
	SM	5 flip-flops
	GT	5 gates
	TS	5 timers
200 ms	TL	10 timers
	TQ	10 pulse timers
	SR	5 flip-flops
	XOR	39 gates

Line impedance

Table 18: General fault criteria

Parameter			Setting range
Impedance setting range at I_r = 1A	Reactive reach forward	Positive-sequence reactance	0.1-400 ohm/phase in steps of 0.01 ohm/phase
		Zero-sequence reactance	0.1-1200 ohm/phase in steps of 0.01 ohm /phase
	Reactive reach reverse	Positive-sequence reactance	0.1-400 ohm/phase in steps of 0.01 ohm/phase
		Zero-sequence reactance	0.1-1200 ohm/phase in steps of 0.01 ohm /phase
	Resistive reach (forward & reverse)	For phase - phase faults	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		For phase - earth faults	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		Load encroachment	0.1-400 ohm/loop in steps of 0.01 ohm/loop
		Safety load impedance angle	5-45 degrees in steps of 1 degrees

Parameter		Setting range
Overcurrent setting range	Phase currents	10-400% of Ir in steps of 1%
	Residual current	10-150% of Ir in steps of 1%
Timers	For phase-to-phase measuring elements	0.000-60.000 s in steps of 1 ms
	For phase-to-earth measuring elements	0.000-60.000 s in steps of 1 ms
Static angular accuracy at 0 degrees and 85 degrees	Voltage range (0.1-1.1) x U_r	+/-5 degrees
	Current range (0.5-30) x I_r	

Table 19: ZM1, 2, 3, 4, 5 Zone impedance measuring elements

Function			Value
Operate time	Typical		28 ms
	Min and max		Please refer to the separate isochrone diagrams
Min. operate current			(10-30) % of I1b in steps of 1 %
Resetting ratio			Typical 110 %
Resetting time			Typical 40 ms
Output signals start and trip		Zone 1-3	Three phase Single phase and/or three phase
		Zone 4, 5	Three phase start and trip
Setting accuracy			Included in the measuring accuracy
Number of zones			3, 4 or 5, direction selectable
Impedance setting range at I_r = 1 A (to be divided by 5 at I_r = 5 A)	Reactive reach	Positive-sequence reactance	(0.10-400.00) Ω/phase in steps of 0.01 Ω
		Zero sequence reactance	(0.10-1200.00) Ω/phase in steps of 0.01 Ω
	Resistive reach	Positive-sequence resistance	(0.10-400.00) Ω/phase in steps of 0.01 Ω
		Zero sequence resistance	(0.10-1200.00) Ω/phase in steps of 0.01 Ω
	Fault resistance	For phase - phase faults	(0.10-400.00) Ω/loop in steps of 0.01 Ω
		For phase-earth faults	(0.10-400.00) Ω/loop in steps of 0.01 Ω
Setting range of timers for impedance zones			(0.000-60.000) s in steps of 1 ms
Static accuracy at 0 degrees and 85 degrees	Voltage range (0.1-1.1) x U_r		+/- 5 %
	Current range (0.5-30) x I_r		

<table>
<tr><th colspan="2">Function</th><th>Value</th></tr>
<tr><td rowspan="2">Static angular accuracy at 0 degrees and 85 degrees</td><td>Voltage range (0.1-1,1) x U_r</td><td rowspan="2">+/- 5 degrees</td></tr>
<tr><td>Current range (0.5-30) x I_r</td></tr>
<tr><td colspan="2">Max dynamic overreach at 85 degrees measured with CVT’s 0.5 < SIR < 30</td><td>+ 5 %</td></tr>
</table>

Table 20: Power swing detection

<table>
<tr><th colspan="2">Parameter</th><th>Setting range</th><th>Accuracy</th></tr>
<tr><td rowspan="2">Impedance setting range at I_r =1A
(divide values by 5 for I_r = 5A)</td><td>Reactive reach, XIN</td><td>0.10-400.00 ohm/ phase in steps of 0.01 ohm/phase</td><td>–</td></tr>
<tr><td>Resistive reach, RIN</td><td>0.10-400.00 ohm/ phase in steps of 0.01ohm/phase</td><td>–</td></tr>
<tr><td colspan="2">Reach multiplication factor, KX</td><td>120-200% of XIN in steps of 1%</td><td>–</td></tr>
<tr><td colspan="2">Reach multiplication factor, KR</td><td>120-200% of RIN in steps of 1%</td><td>–</td></tr>
<tr><td colspan="2">Initial PSD timer, tP1</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Fast PSD timer, tP2</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Hold timer tW for activation of fast PSD timer</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Hold timer tH for PSD detected</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Timer tEF overcoming 1ph reclosing dead time</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Timer tR1 to time delay block by the residual current</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
<tr><td colspan="2">Timer tR2 to time delay block at very slow swings</td><td>0.000-60.000 s in steps of 1 ms</td><td>+/- 0.5 % +/- 10 ms</td></tr>
</table>

Table 21: ZCOM - Scheme communication logic for distance protection

Parameter	Setting range	Accuracy
Coordination timer, tCoord	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10ms
Minimum send time, tSendMin	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10ms
Security timer, tSec	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10ms

Table 22: Current reversal and weak end infeed logic

Parameter	Setting range	Accuracy
Pickup time for current reversal logic	0.000-60.000 s in steps of 0.001s	+/-0.5% +/-10ms
Delay time for reset of current reversal output	0.000-60.000 s in steps of 0.001s	+/-0.5% +/-10ms
Coordination time delaying receipt of carrier receive signal into weak end infeed logic	0.000-60.000 s in steps of 0.001s	+/-0.5% +/-10ms
Detection level phase to neutral voltage	10-100% of U1b	+/-5% of U_b
Detection level phase to phase voltage	20-170% of U1b	+/-5% of U_b for $U<=U_b$ +/-5% of U_b for $U>=U_b$

Table 23: SOTF - Automatic switch onto fault function

Parameter	Value	Accuracy
Delay following dead line detection input before SOTF function is automatically enabled	200 ms	+/-0.5% +/-10 ms
Time period after circuit breaker closure in which SOTF function is active	1000 ms	+/-0.5% +/-10 ms

Current

Table 24: IOC - Instantaneous overcurrent protection

Function		Setting range	Operate time	Accuracy
Operate current I>>	Phase measuring elements	(50-2000)% of I1b In steps of 1%	-	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I > I_r$
	Residual measuring elements	(50-2000)% of I1b In steps of 1%	-	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I > I_r$
Operate time at $I > 10 \times I_{set}$			Max 15ms	-
Dynamic overreach at τ< 100 ms			-	< 5%

Table 25: TOC - Time delayed overcurrent protection

Function		Setting range	Accuracy
Operate current I>	Phase measuring elements	(10-400) % of $I1_b$ in steps of 1 %	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I > I_r$
	Residual measuring elements	(10-150) % of $I4_b$ in steps of 1 %	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I > I_r$

Function		Setting range	Accuracy
Time delay	Phase measuring elements	(0.000-60.000) s in steps of 1 ms	+/- 0.5 % of t +/- 10 ms
	Residual measuring elements	(0.000-60.000) s in steps of 1 ms	+/- 0.5 % of t +/- 10 ms
Dynamic overreach at τ< 100 ms		-	< 5 %

Table 26: TOC3-Two step directional overcurrent protection

Function	Setting range	Accuracy
Operate value of low set function	(20-2000)% of I1b in steps of 1%	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I>I_r$
Base current for inverse time calculation	(20-500) % of I1b in steps of 1 %	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I>I_r$
Minimum operate time	(0.000-60.000) s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Definite time delay for low set function	(0.000-60.000) s in step of 1ms	+/- 0.5 % +/- 10 ms
Operate value of high set function	(20-2000) % of I1b in steps of 1 %	+/- 2.5 % of I_r at $I \leq I_r$ +/- 2.5 % of I at $I>I_r$
Definite time delay for high set function	(0.000-60.000) in steps of 1 ms	+/- 0.5 % +/- 10 ms
Static angular accuracy at 0 degrees and 85 degrees	Voltage range (0.1-1.1) x U_r	+/- 5 degrees
	Current range (0.5-30) x I_r	
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	IEC 60255-3 class 5 +/- 60 ms
Very inverse characteristic	$t = \frac{13.5}{I - 1} \cdot k$	IEC 60255-3 class 7.5 +/- 60 ms
Extremely inverse characteristic	$t = \frac{80}{I^2 - 1} \cdot k$	IEC 60255-3 class 7.5 +/- 60 ms
Dynamic overreach at t< 100 ms		<5%

Table 27: TOC2 - Two step time delayed overcurrent protection

Function	Setting range	Accuracy
Operate value for low set function I > Low	(5-500)% of I1b in steps of 1%	+/- 2.5% of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I>I1_r$
Base current for inverse time calculation I > Inv	(5-500) % of I1b in steps of 1%	+/- 2.5 % of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I> I1_r$
Minimum operate time tMinInv	(0.000-60.000)s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Definite time delay for low set function tLow	(0.000-60.000)s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Operate value of high set function I > High	(50-2000)% of I1b in steps of 1%	+/- 2.5% of $I1_r$ at $I \leq I1_r$ +/- 2.5 % of I at $I>I1_r$
Definite time delay for high set function tHigh	(0.000-60.000) s in steps of 1 ms	+/- 0.5 % +/- 10 ms
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02}-1} \cdot k$	IEC 60255-3 class 5+/- 60 ms
Very inverse characteristic	$t = \frac{13.5}{I-1} \cdot k$	IEC 60255-3 class 7.5+/- 60 ms
Extremely inverse characteristic	$t = \frac{80}{I^2-1} \cdot k$	IEC 60255-3 class 7.5+/- 60 ms
Dynamic overreach at t< 100 ms		<5%

Table 28: TEF - Independent and dependent time delayed residual protection function

Parameter		Setting range	Accuracy
Start current, definite time or inverse time delay I_N		5-300% of I_r in steps of 1%	+/-5% of set value
Operate value for directional current measurement	Forward I_N at φ=65 degrees	5-35% of I_r in steps of 1%	+/-1.5% of I_r
	Reverse	60% of the setting for forward operation	+/-1.5% of I_r
Definite time delay		0.000 - 60.000 s in steps of 1ms	+/- 0.5 % +/-10 ms
Time multiplier for inverse time delay k		0.05-1.10 in steps of 0.01	According to IEC 60255-3

Parameter	Setting range	Accuracy
Normal inverse characteristic $I = I_{meas}/I_{set}$	$t = \frac{0.14}{I^{0.02} - 1} \cdot k$	IEC 60255-3 class 5 +/- 60 ms
Very inverse characteristic	$t = \frac{13.5}{I - 1} \cdot k$	IEC 60255-3 class 7.5 +/- 60 ms
Extremely inverse characteristic	$t = \frac{80}{I^2 - 1} \cdot k$	IEC 60255-3 class 7.5 +/- 60 ms
Min. operate current for dependent characteristic	100-400% of IN in steps of 1%	+/-5% of I_{set}
Minimum operate time	0.000-60.000 s in steps of 1 ms	+/- 0.5 % +/-10 ms
Characteristic angles	65 degrees lagging	+/-5 degrees at 20 V and I_{set}=35% of I_r
Logarithmic characteristic	$t = 5.8\text{-}1.35 \cdot \ln I$	+/- 5 % of t at $I = (1.3\text{-}29) \times 3I_0$
Minimum polarising voltage	1 % of U_r	At 50 Hz: 1% of U_r +/-5% At 60 Hz: 1% of U_r -15% to -5%
Reset time	<70 ms	-

Table 29: EFC - Scheme communication logic for residual overcurrent protection

Parameter	Setting range	Accuracy
Coordination timer	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10 ms

Table 30: Current reversal and weak end infeed logic for residual overcurrent protection (EFCA)

Parameter	Setting range	Accuracy
Operate voltage for WEI trip	5-70 % of U1b in steps of 1%	+/-5% of U_r
Current reversal pickup timer	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10 ms
Current reversal delay timer	0.000-60.000 s in steps of 1 ms	+/-0.5% +/-10 ms

Voltage

Table 31: TUV - Time delayed undervoltage protection

Function	Setting range	Accuracy
Operate voltage UPE<	(10-100) % of U1b in steps of 1%	+/- 2.5 % of U_r
Time delay	(0.000-60.000) s in steps of 1ms	+/- 0.5 % +/- 10 ms

Table 32: TOV - Time delayed overvoltage protection

Function		Setting range	Accuracy
Operate voltage U>	Phase measuring elements	(50-200)% of U1b in steps of 1%	+/- 2.5 % of U_r at U U_r +/- 2.5 % of U at U > U_r
Time delay	Phase measuring elements	(0.000-60.000) s in steps of 1ms	+/- 0.5 % +/- 10 ms
Operate voltage 3U0>	Residual measur-ing elements	(5-100)% of U1b in steps of 1%	+/- 2.5 % of U_r at U ≤ U_r +/- 2.5 % of U at U > U_r
Time delay	Residual measur-ing elements	(0.000-60.000) s in steps of 1ms	+/- 0.5 % +/- 10 ms

Power system supervision

Table 33: DLD - Dead line detection

Function		Setting range	Accuracy
Automatic check of dead line condition	Operate phase current	(5-100) % of I1b in steps of 1%	+/- 2.5 % of I_r
	Operate phase voltage	(10-100) % of U1b in steps of 1%	+/- 2.5 % of U_r

Secondary system supervision

Table 34: FUSE - Fuse failure supervision function

Function		Setting range	Accuracy
Zero-sequence quantities:	Operate voltage $3U_0$	(10-50)% of U1b in steps of 1%	+/- 2.5 % of U_r
	Operate current $3I_0$	(10-50)% of I1b in steps of 1%	+/- 2.5 % of I_r

Control

Table 35: AR - Automatic reclosing function

Parameter	Setting range	Accuracy
Automatic reclosing open time:		
shot 1 - t1 1ph	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
shot 1 - t1 2ph	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
shot 1 - t1 3ph	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms

Parameter	Setting range	Accuracy
shot 2 - t2 3ph shot 3 - t3 3ph shot 4 - t4 3ph	0-90000.0 s in steps of 0.1 s 0-90000.0 s in steps of 0.1 s 0-90000.0 s in steps of 0.1 s	+/- 0.5% +/- 10 ms +/- 0.5% +/- 10 ms +/- 0.5% +/- 10 ms
Maximum wait time for OK to close from synchronizing function tSync	0-90000.0 s in steps of 0.1 s	+/- 0.5% +/- 10 ms
Duration of close pulse to circuit breaker tPulse	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
Duration of reclaim time tReclaim	0-90000.0 s in steps of 0.1 s	+/- 0.5% +/- 10 ms
Inhibit reclosing reset time tInhibit	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
Maximum trip pulse duration tTrip (longer trip pulse durations will either extend the dead time or interrupt the reclosing sequence)	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
Maximum wait time for release from Master tWaitForMaster	0-9000.0 s in steps of 0.1 s	+/- 0.5% +/- 10 ms
Wait time following close command before continuing with further reclosing attempts without new start signal if circuit breaker does not close tAutoWait	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms
Time delay before indicating reclosing unsuccessful tUnsuc	0-9000.0 s in steps of 0.1 s	+/- 0.5% +/- 10 ms
Time CB must be closed before AR becomes ready for a reclosing cycle tCBClosed	0.000-60.000 s in steps of 1 ms	+/- 0.5% +/- 10 ms

Table 36: Automatic reclosing function

Parameter	Value
Reclosing shots	1-4
Programs	Three pole trip: 1 Single, two and three pole trip: 6
Number of instances	Up to six depending on terminal type (different terminal types support different CB arrangements and numbers of bays)
Breaker closed before start	5 s

Logic

Table 37: TR - Trip logic

Parameter	Value	Accuracy
Setting for the minimum trip pulse length, tTripMin	0.000 - 60.000 s in steps of 0.001 s	+/-0.5% +/-10 ms

Table 38: Serial communication (SPA)

Function	Value
Protocol	SPA
Communication speed	300, 1200, 2400, 4800, 9600, 19200 or 38400 bit/s
Slave number	1 to 899
Remote change of active group allowed	yes/no
Remote change of settings allowed	yes/no
Connectors and optical fibres	glass or plastic

Table 39: Serial communication (LON)

Function	Value
Protocol	LON
Communication speed	1.25 Mbit/s
Connectors and optical fibres	glass or plastic

Table 40: Serial communication (IEC 60870-5-103)

Function	Value
Protocol	IEC 60870-5-103
Communication speed	9600, 19200 bit/s
Connectors and optical fibres	glass or plastic

Monitoring

Table 41: Disturbance report setting performance

Data	Setting range
Pre-fault time	50-300 ms in steps of 10 ms
Post-fault time	100-5000 ms in steps of 100 ms
Limit time	500-6000 ms in steps of 100 ms
Number of recorded disturbances	Max. 10

Table 42: Disturbance recorder setting performance

Function	Setting range
Overcurrent triggering	0-5000% of Inb in steps of 1%
Undercurrent triggering	0-200% of Inb in steps of 1%
Overvoltage triggering	0-200% of Unb in steps of 1% at 100 V sec.
Undervoltage triggering	0-110% of Unb in steps of 1%

Table 43: Disturbance recorder performance

Data			Value
Number of binary signals			48
Number of analog signals			10
Sampling rate			2 kHz
Recording bandwidth			5-250 Hz
Total recording time with ten analog and 48 binary signals recorded. (The amount of harmonics can affect the maximum storage time)			40 s typically
Voltage channels	Dynamic range		(0.01-2.0) x U_r at 100/200 V sec.
	Resolution		0.1% of U_r
	Accuracy at rated frequency	$U \leq U_r$	2.5% of U_r
		$U > U_r$	2.5% of U
Current channels	Dynamic range	Without DC off-set	(0.01-110) $\times$ I_r
		With full DC off-set	(0.01-60) $\times$ I_r
	Resolution		0.5 % of I_r
	Accuracy at rated frequency	$I \leq I_r$	+/-2.5 % of I_r
		$I > I_r$	+/-2.5 % of I

Table 44: Event recorder

Function		Value
Event buffering capacity	Max. number of events/distur-bance report	150
	Max. number of disturbance reports	10

Table 45: FLOC - Fault locator

<table>
<tr><th colspan="3">Function</th><th>Setting range</th><th>Accuracy</th></tr>
<tr><td rowspan="3">Distance to fault locator</td><td rowspan="2">Reach for I_r =1 A</td><td>Resistive direction</td><td>(0 - 1500) ohm/ phase</td><td rowspan="3">+/- 2.5 % (typical)</td></tr>
<tr><td>Reactive direction</td><td>(0 - 1500) ohm/ phase</td></tr>
<tr><td colspan="2">Phase selection</td><td>According to input signals</td></tr>
</table>

Table 46: Mean values (AC-monitoring)

Function	Nominal range	Accuracy
Frequency	(0.95 - 1.05) x f_r	+/- 0.2 Hz
Voltage (RMS) Ph-Ph	(0.1 - 1.5) x U_r	+/- 2.5% of U_r, at U≤ U_r +/- 2.5% of U, at U> U_r
Current (RMS)	(0.2 - 4) x I_r	+/- 2.5% of I_r, at I≤ I_r +/- 2.5% of I, at I> I_r
Active power*)	at |cos φ| ≥ 0.9	+/- 5%
Reactive power*)	at |cos φ| ≤ 0.8	+/- 7.5%
*) Measured at U_r and 20% of I_r		

Table 47: MIM - mA measuring function

Function	Setting range	Accuracy
mA measuring function	+/- 5, +/- 10, +/- 20 mA 0-5, 0-10, 0-20, 4-20 mA	+/- 0.1 % of set value +/-0.005 mA
Max current of transducer to input	(-25.00 to +25.00) mA in steps of 0.01	
Min current of transducer to input	(-25.00 to +25.00) mA in steps of 0.01	
High alarm level for input	(-25.00 to +25.00) mA in steps of 0.01	
High warning level for input	(-25.00 to +25.00) mA in steps of 0.01	
Low warning level for input	(-25.00 to +25.00) mA in steps of 0.01	
Low alarm level for input	(-25.00 to +25.00) mA in steps of 0.01	
Alarm hysteresis for input	(0-20) mA in steps of 1	
Amplitude dead band for input	(0-20) mA in steps of 1	
Integrating dead band for input	(0.00-1000.00) mA in steps of 0.01	

Hardware modules

Table 48: Binary inputs

Inputs	**RL24**	**RL48**	**RL110**	**RL220**
Binary inputs	BIM: 16, IOM: 8, PSM: 4			
Debounce frequency	5 Hz (BIM), 1 Hz (IOM)			
Oscillating signal discriminator.*	Blocking and release settable between 1-40 Hz			
Binary input voltage RL	24/30 VDC +/-20%	48/60 VDC +/-20%	110/125 VDC +/-20%	220/250 VDC +/-20%
Power consumption (max.)	0.05 W/input	0.1 W/input	0.2 W/input	0.4 W/input
*) Only available for BIM				

Table 49: Binary outputs

Function or quantity		**Trip and Signal relays**	**Fast signal relays**
Binary outputs		BOM: 24, IOM: 10, PSM: 4	IOM: 2
Max system voltage		250 V AC, DC	250 V AC, DC
Test voltage across open contact, 1 min		1000 V rms	800 V DC
Current carrying capacity	Continuous	8 A	8 A
	1 s	10 A	10 A
Making capacity at inductive load with L/R>10 ms	0.2 s	30 A	0.4 A
	1.0 s	10 A	0.4 A
Breaking capacity for AC, cos φ>0.4		250 V/8.0 A	250 V/8.0 A
Breaking capacity for DC with L/R<40ms		48 V/1 A	48 V/1 A
		110 V/0.4 A	110 V/0.4 A
		220 V/0.2 A	220 V/0.2 A
		250 V/0.15 A	250 V/0.15 A
Maximum capacitive load		-	10 nF

Table 50: SMS communication via front

Function	**Value**
Protocol	SPA
Communication speed for the terminals	300, 1200, 2400, 4800, 9600 Kbaud
Slave number	1 to 899
Change of active group allowed	Yes
Change of settings allowed	Yes

Table 51: Cable connection requirements for SPA/IEC connection

	Glass fibre	**Plastic fibre**
Cable connector	ST connector	HFBR, Snap-in connector
Fibre diameter	62.5/125 µm 50/125 µm	1 mm
Max. cable length	500 m	30 m

Table 52: LON - Cable connection requirements for LON bus connection

	Glass fibre	**Plastic fibre**
Cable connector	ST-connector	HFBR, Snap-in connector
Fibre diameter	62.5/125 µm 50/125 µm	1 mm
Max. cable length	1000 m	30 m

Ordering

Guidelines

Carefully read and follow the set of rules to ensure problem-free order management. Be aware that certain functions can only be ordered in combination with other functions and that some functions require specific hardware selections.

Basic hardware and functions

Platform and basic functionality

Basic REx 5xx platform and common functions housed in 1/2 sized 19” casing

Manuals on CD

Operator’s manual (English)
Installation and commissioning manual (English)
Technical reference manual (English)
Application manual (English)

Binary I/O capabilities

Binary I/O resided on power supply module
Binary input module
Binary output module

Measuring capabilities

A/D module
Transformer module

Line impedance

General fault criteria protection, impedance and/or current based *(GFC)*
3 zones phase-to-phase protection *(ZM1, ZM2, ZM3)*
3 zones phase-to-earth protection *(ZM1, ZM2, ZM3)*
Additional zone 4 protection *(ZM4)*
Additional zone 5 protection *(ZM5)*
Power swing detection *(PSD)*
Scheme communication logic *(ZCOM)*
Current reversal and weak end infeed logic *(ZCAL)*
Automatic switch onto fault logic *(SOTF)*
Local acceleration logic *(ZCLC)*

Current

Two step time delayed phase overcurrent protection *(TOC2)*
Two step time delayed directional phase overcurrent protection *(TOC3)*
Instantaneous overcurrent protection *(IOC)*
    Residual measurement
Time delayed overcurrent protection *(TOC)*
    Residual measurement
Definite and inverse time-delayed residual overcurrent protection *(TEF)*

Directional element

Scheme communication logic for residual overcurrent protection *(EFC)*

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

Voltage

Time delayed phase undervoltage protection *(TUV)*

Time delayed overvoltage protection *(TOV)*

Phase element

Power system supervision

Dead line detection *(DLD)*

Secondary system supervision

Fuse failure supervision *(FUSE)*

Zero sequence

Single bay control

Synchrocheck *(SYN)*

For single CB, including energizing check

Automatic reclosing function *(AR)*

For single CB, one and/or three phase reclosing

Logic

Trip logic *(TR)*

Single, two and/or three pole trip

High speed binary output logic *(HSBO)*

Monitoring

Disturbance recorder *(DRP)*

Event recorder

Fault locator *(FLOC)*

Analog AC monitor software

Analog DC monitor software (Requires optional mA-transducer module, MIM)

Product specification

REL 511-C1	Quantity:	☐	1MRK 004 492-AA

Rule: Select only one alternative.

Engergizing quantities for binary inputs on power supply module	24/30 V	☐	1MRK 002 238-AA
	48/60 V	☐	1MRK 002 238-BA
	110/125 V	☐	1MRK 002 238-CA
	220/250 V	☐	1MRK 002 238-DA

Note: Auxiliary dc voltage EL, connected to the power supply module, is (48-250) V.

Measuring capabilities
Add measuring capabilities by selecting input energizing options from the following tables.

Rule: Select only one alternative. If sensitive earth fault functionality should be used, select from next table.

Rated measuring input energizing quantities	1 A, 110 V	☐	1MRK 000 157-MB
	1 A, 220 V	☐	1MRK 000 157-VB
	5 A, 110 V	☐	1MRK 000 157-NB
	5 A, 220 V	☐	1MRK 000 157-WB

Optional functions

Additional HMI language

Note: Only one alternative is possible

Second language beside English	German	☐	1MRK 001 459-AA
	Russian	☐	1MRK 001 459-BA
	French	☐	1MRK 001 459-CA
	Spanish	☐	1MRK 001 459-DA
	Italian	☐	1MRK 001 459-EA
Customer specific language	Contact your local ABB representative for availability		

Hardware

Additional binary I/O capabilities

Binary input module, BIM (16 inputs)			
24/30 V	Quantity:	▭	1MRK 000 508-DB
48/60 V	Quantity:	▭	1MRK 000 508-AB
110/125 V	Quantity:	▭	1MRK 000 508-BB
220/250 V	Quantity:	▭	1MRK 000 508-CB

SCS and SMS communication capabilities

SMS communication, only one alternative can be selected			
SPA/IEC 60870-5-103 interface	Plastic fibers	☐	1MRK 000 168-FA
	Glass fibers	☐	1MRK 000 168-DA

SCS communication, only one alternative can be selected			
LON interface	Plastic fibers	☐	1MRK 000 168-EA
	Glass fibers	☐	1MRK 000 168-DA

Test switch

Test switch module RTXP 24 mounted side-by-side to the terminal in RHGS case			1MRK 000 371-CA
	With internal earthing		RK 926 215-BB
	With external earthing		RK 926 215-BC
On/off switch for the DC-supply			RK 795 017-AA

Protection cover

Cover for rear area including fixing screws and assembly instruction	6U, 1/2 x 19”		1MRK 000 020-AC

Mounting accessories

19” rack mounting kit	☐	1MRK 000 020-BR
Wall mounting kit	☐	1MRK 000 020-DA
Flush mounting kit	☐	1MRK 000 020-Y
Semiflush mounting kit	☐	1MRK 000 020-BS
Additional mounting seal for IP54 protection of flush and semiflush mounted terminals	☐	1MKC 980 001-2
Side-by-side mounting kit	☐	1MRK 000 020-Z

Accessories

Key switch

Key switch for setting lockout	Quantity:		1MRK 000 611-A

Front communication cable

Front connection cable for PC (Opto/9-pole D-sub)	Quantity:		1MKC 950 001-2

Manuals

One CD with Operator’s manual, Technical reference manual, Installation and commissioning manual and Application manual is always included for each terminal.

Rule: Specify the number of extra CD’s requested

CD with all manuals	Quantity:		1MRK 002 241-AA

Rule: Specify the number of printed manuals requested

Operator’s manual	Quantity:		1MRK 506 096-UEN
Technical reference manual	Quantity:		1MRK 506 097-UEN
Installation and commissioning manual	Quantity:		1MRK 506 098-UEN
Application manual	Quantity:		1MRK 506 116-UEN

Customer feedback

For our reference and statistics we would be pleased to be provided with the following application data:

Country:	End user:
Station name:	Voltage level: kV

Related documents

Technical overview brochure

Accessories for REx 5xx*2.3	1MRK 514 009-BEN
CAP 540*1.2	1MRK 511 112-BEN

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