RELION® REB500

Distributed busbar protection REB500 Version 8.3 IEC

Product guide

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Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/108/EC) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2006/95/EC). This conformity is the result of tests conducted by Hitachi Energy in accordance with the product standard EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The product is designed in accordance with the international standards of the IEC 60255 series.

Contents

1. Document revision history

Revision history

Document revision	Date	Product revision	History
B	2019-07	8.3.0	First release
C	2020-10	8.3.1	Updates and extensions
D	2020-11	8.3.1	Updates
E	2022-01	8.3.2	Redundant PSM added, updates and extensions

2. Application

REB500

The numerical busbar protection REB500 is designed for the high-speed (sub-cycle), selective protection of MV, HV and EHV busbar installations at a nominal frequency of 50, 60 Hz

The modular system structure is enabling the protection to be easily configured to suit the layout of the primary system.

The flexibility of the system enables all configurations of busbars from single to quadruple, with transfer buses or ring busbars and 1½ breaker schemes to be protected. In 1½ breaker schemes the busbars and entire diameters, including Stub/T-Zone can be protected. An integrated tripping scheme allows saving external logics as well as wiring.

The system is scalable for up to 60 feeders (bay units) and a total of 32 busbar zones.

The numerical busbar protection REB500 detects all phase and earth faults in solidly grounded and resistive-grounded power systems and phase faults in ungrounded systems and systems with Petersen coils.

The main CTs supplying the currents to the busbar protection have to fulfill only modest performance requirements (see Section 8.5). The protection operates discriminatively for all faults inside the zone of protection and remains reliably stable for all faults outside the zone of protection.

REB500 bay protection (optional)

The system provides an option to extend the functional scope of REB500 by a set of predefined bay protection functions used as main 2 or back-up line protection.

Version Line variant L-V2 includes distance, directional/ non directional overcurrent and directional earth-fault protection functions (see Table 2).

Version Line variant L-V4 comprises the functional scope of Line variant L-V2 extended with synchrocheck and autoreclosure functionality (see Table 2).

As regards the level of voltages and frequencies busbar and station protection have the same application area.

For details on application and technical data refer to the *REB500 Application Manual* for bay protection functions.

Typical substation layouts

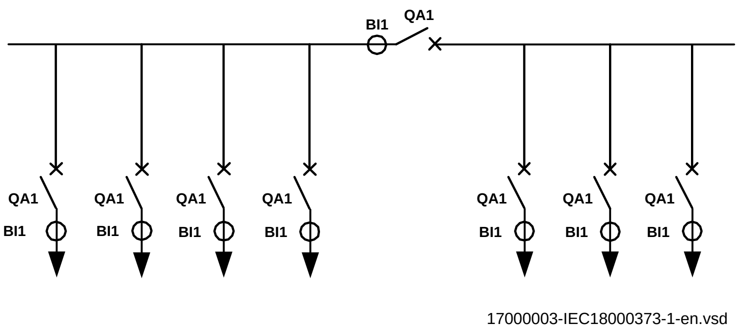

Figure 1. Single busbar

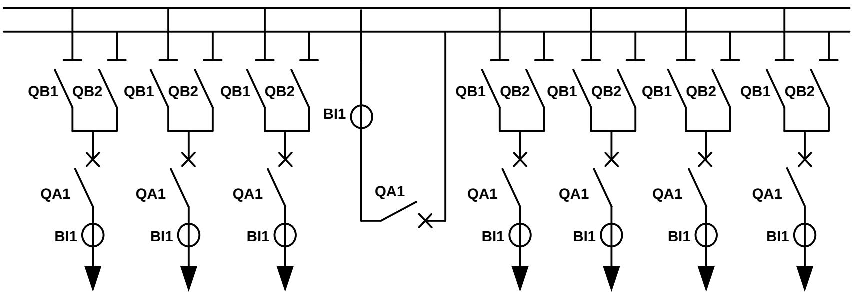

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Figure 2. Double busbar

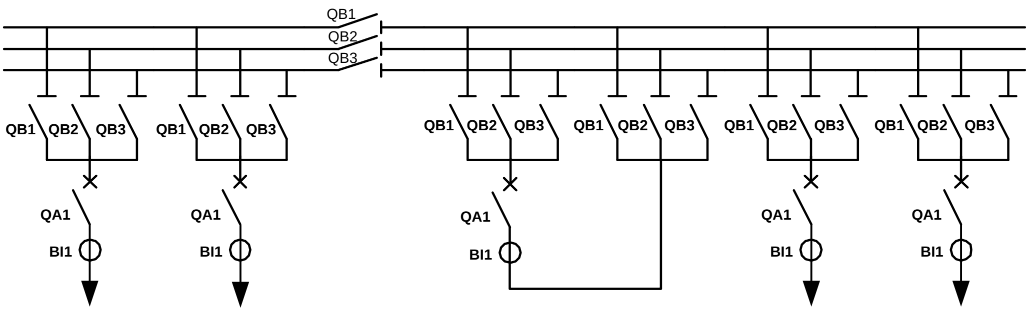

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Figure 3. Triple busbar

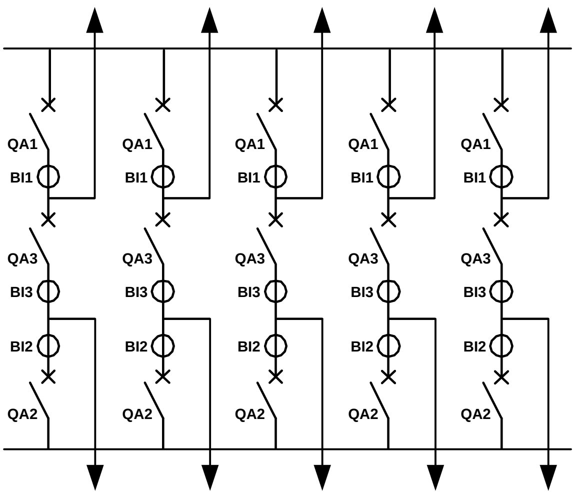

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Figure 4. 1 ½ breaker system

Functional overview

Table 1. Included functionalities

	Protection function			
Main functionality	**IEEE**	**REB500**	**IEC 61850**	
Busbar protection	87B	BBP	PDIF	●
Busbar protection with neutral current	87BN	I0	PDIF	○
Breaker failure protection including neutral current detection	50BF	BFP	RBRF	○
End-fault protection	51/62EF	EFP	PTOC	○
Breaker pole discrepancy	51/62PD	PDF	PTOC	○
Overcurrent release feature	51		PTOC	○
Voltage release feature	59/27		GAPC	○
Check zone	87CZ	BBP CZ	PDIF	●
Current plausibility check				●
Overcurrent protection (definite time)	51	OCDT	PTOC	○
Trip command redirection	94RD		PSCH	●
Software matrix for inputs, outputs, and trip matrix				●
Event recording up to 1000 events		ER		●
Disturbance recorder (4×I, 5×U) up to 20 s	95DR	DR	RDRE	●
Disturbance recorder (busbar protection data) up to 20 s	95DR	DR	RDRE	●
Communication interface IEC 61850-8-1		Com		○
Communication interface IEC 60870-5-103		Com		○
Time synchronization (SNTP, IRIG-B, PPS, IEC 60870-5-103)				●
Redundant power supply for central unit				○
Isolator supervision				●
Differential current supervision				●
Comprehensive self-supervision				●
Dynamic Busbar replica with display of currents				●
Test generator for commissioning and maintenance				●
Detached Local HMI				●
Delay/Integrator function				●
Binary logic and flip-flop functions				●

(● standard, ○ optional)

Table 2. Bay protection functions of line variant L-V2 (optional)

	Bay protection function			Line variant	
Main functionality	**IEEE**	**REB500**	**IEC 61850**	**L-V2**	**L-V4**
Distance protection	21	DIST	PDIS	●	●
Definite time over and undercurrent protection	51	OCDT	PTOC	●	●
Inverse time overcurrent protection	51	OCINV	PTOC	●	●
Directional overcurrent definite time protection	67	DIROCDT	PTOC	●	●
Directional overcurrent inverse time protection	67	DIROCINV	PTOC	●	●
Definite time over and undervoltage protection	59/27	OVDT	PTOV	●	●
Synchrocheck	25	SYNC	RSYN	○	●
Autoreclosure	79	AR	RREC	○	●
Direct. sensitive EF prot. for grounded systems	67N	DIREFGND	PTOC	●	●
Inverse time earthfault overcurrent protection	51N	I0INV	PTOC	●	●
Three-phase current plausibility	46	CHKI3PH	PTOC	●	●
Three-phase voltage plausibility	47	CHKU3PH	PTOV	●	●
Peak value over and undercurrent protection	50	OCINST	PTOC	●	●

(● included, ○ not included)

3. Main features

Low-impedance busbar protection

- High functional reliability due to two independent measurement criteria:
  - stabilized differential current algorithm
  - directional current comparison algorithm
- Short tripping times independent of the plant's size or busbar configuration
- Phase Segregated measurement
- Stub and T-zone protection
- Reduced CT performance requirements
  - High through-fault stability even in case of CT saturation
  - No switching of CT circuits

Modular and flexible architecture

- Multiple modes of installation
  - Centralized layout:
    Installation of bay units and central unit in one or several cubicles
  - Distributed layout:
    Bay units distributed with short connections to CTs, isolators, circuit breakers, and so on.
- Interference-proof connections between bay units and central unit by fiber-optic cables (max. 2000 m)
- Replacement of existing busbar protection schemes without restrictions, for example, in case of substation extensions
- Easily extensible
- Only one hardware version for
  - Settable 1 A and 5 A rated current inputs
  - Nominal frequencies of 50 Hz and 60 Hz
- Minimum number of spare parts needed due to standardization and low number of varying units

Seamless substation automation integration

- User-friendly, PC-based interface (HMI)
- Operator integration into PCM600 for readout of configuration, events and disturbance records
- Communication with substation monitoring and control system
  - via IEC 61850-8-1 Edition 1 or Edition 2
  - via IEC 60870-5-103
- Local HMI with comprehensive system information on every unit

Supervision

- Fully numerical signal processing
- Comprehensive self-supervision
- Integrated event recording
- Integrated disturbance recording for power system currents and voltages
- Optional redundant power supply for central units

Cyber security

- Secure communication
- User Access Management
- User Activity Logging
- Centralized account management
- Verified robustness

Additional options

- Breaker failure protection
- Check-zone protection
- End-fault protection
- Definite time overcurrent protection
- Breaker pole discrepancy protection
- Current and voltage release criteria for busbar protection
- Separate I0 measurement for impedance-grounded networks
- Advanced user configurable logic capability

4. Mode of installation

There are three versions of installing the numerical busbar protection REB500.

Distributed installation

In this case, the bay units are installed in casings or cubicles in the individual switchgear bays distributed around the station and are connected to the central processing unit by optical fiber cables (see Figure 5). The central processing unit is normally located in a central cubicle or in a central relay room.

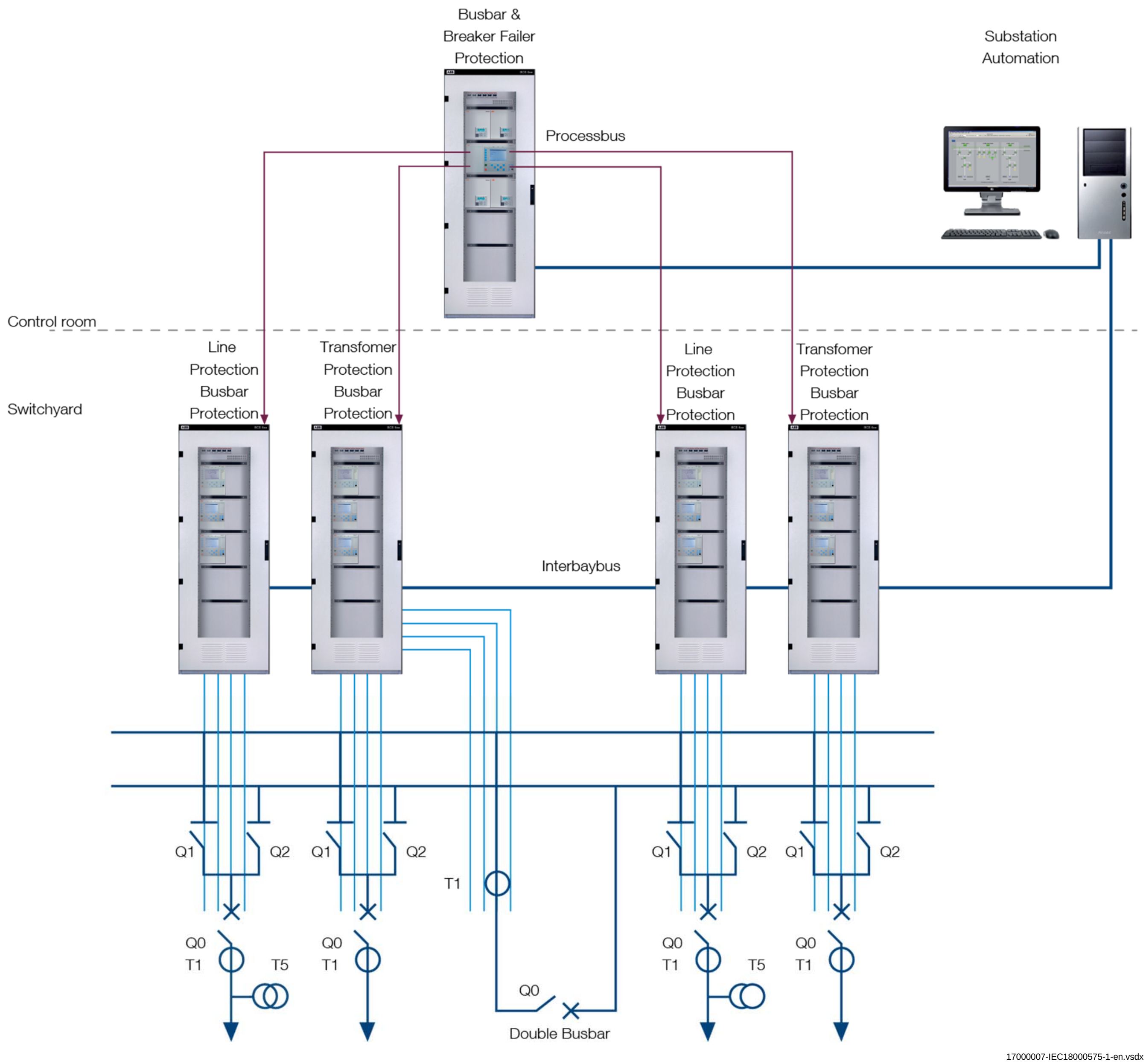

Figure 5. Distributed installation

Centralized installation

The central processing unit and the bay units are mounted in 19"racks (up to two bay units each rack), according to the size of the busbar system in one or more cubicles (see Figure 6). A centralized installation is the ideal solution for upgrading existing stations, since very little additional wiring is required and compared with older kinds of busbar protection, much more functionality can be packed into the same space.

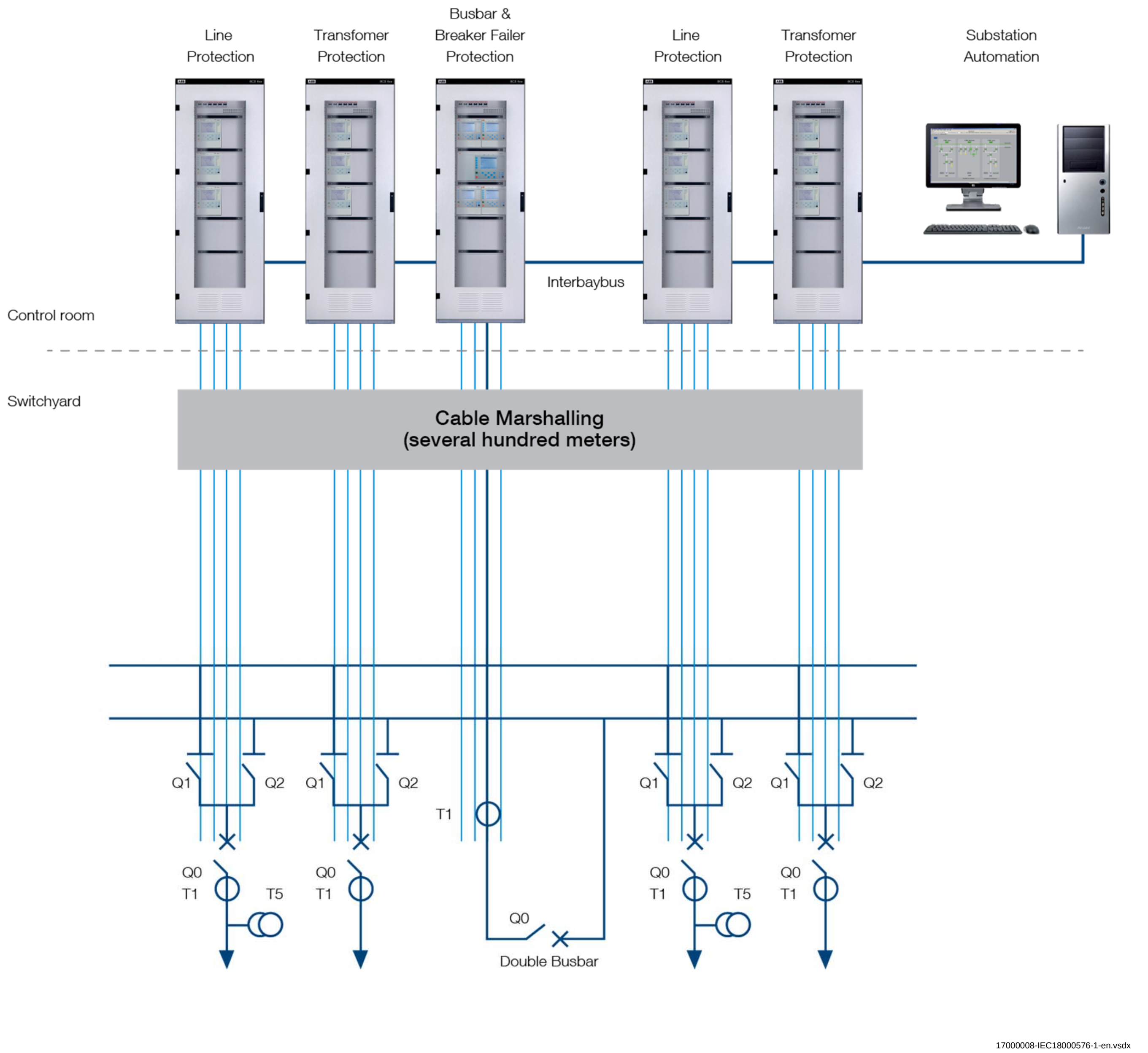

Figure 6. Centralized installation

Combined centralized and distributed installation

Basically, the only difference between a distributed and a centralized scheme is the mounting location of the bay units and therefore it is possible to mix the two philosophies.

5. System design

Bay unit (500BU04)

The bay unit is the interface between the protection and the primary system process comprised of the main CTs, isolators and circuit-breaker and performs the associated data acquisition, pre-processing, control functions and bay level protection functions. It also provides the electrical insulation between the primary system and the internal electronics of the protection.

The bay unit contains four input CTs for measuring phase and neutral currents with terminals for 1 A and 5 A. Additional interposing CTs are not required, because any differences between the CT ratios are compensated by appropriately configuring the software parameter of the respective bay units.

The bay unit optionally contains five input voltage transformers for the measurement of the three-phase voltages and two busbar voltages to allow the recording of voltage disturbances. (see Section 11).

After acquisition, the analogue current and voltage signals are converted to numerical signals which are preprocessed and filtered. Zero-sequence voltage and zerocurrent signals are also calculated internally. The process data are transferred at regular intervals from the bay units to the central processing unit via the REB500 process bus.

Every bay unit has a minimum of 21 binary inputs and 19 binary outputs. The binary I/O module can be used to detect and process the positions of isolators and couplers, blocking signals, starting signals, external resetting signals and so on.

The binary input channels operate according to a patented pulse modulation principle in a nominal range of 24 to 250 V DC. The PC-based HMI program provides settings for the threshold voltage of the binary inputs.

Out of 19 binary outputs, 6 are equipped with power output relays and 13 are signal output relays (see contact data in Section 11).

Additional 12 inputs and 6 precision outputs are available as an option. The precision outputs are based on MOSFET technology and offer an improved trip-time performance.

A software logic enables the input and output channels to be assigned to the various functions. A time stamp is attached to all the data such as currents, voltages, binary inputs, events and diagnostic information acquired by a bay unit.

Where more analogue and binary inputs are needed, several bay units can be combined to form a feeder/bus coupler bay (for example, a bus coupler bay with CTs on both sides of the bus-tie breaker requires two bay units).

The bay unit is provided with local intelligence and performs local protection (for example, breaker failure, end fault, breaker pole discrepancy) as well as the event and disturbance recording.

In the event that the central unit is out of operation or the optical fiber communication is disrupted an alarm is generated. The bay unit will continue to operate and all local protection as well as the recorders (event and disturbance) will remain fully functional (stand-alone operation).

The hardware structure is based on a closed, monolithic casing and presented in two mounting solutions:
- Without LHMI: ideal solution if convenient access to all information via the central unit or by an existing substation automation system is sufficient.
- With LHMI and 15 programmable LEDs (Figure 7): ideal solution for distributed and kiosk mounting (AIS), since all information is available in the bay. For this option it is possible to have the LHMI either built in or connected via a flexible cable to a fixed mounting position.

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Figure 7. Bay Unit

Additional plug-and-play functionality
Bay units can be added to an existing REB500 system in a simple way. Due to the modular and flexible architecture of the software, integration of new units is easily achieved.

In the event of a failure, a bay unit can be easily replaced. During system startup the new bay unit requests its address, this can be entered directly via its LHMI. The necessary setting values and configuration data are then downloaded automatically.

Central unit (500CU04)
The hardware structure is based on a closed, monolithic casing.

The central unit is the system manager, that is, it configures the system, contains the busbar replica, assigns bays within the system, manages the sets of operating parameters, acts as REB500 process bus controller, assures synchronization of the system and communicates with the station control and monitoring system.

The variables for the busbar protection function are derived dynamically from the process data provided by the bay units.

The process data is transferred to the central processor via the REB500 process bus interface. The central unit is able to handle data from up to 60 bay units and evaluate up to 32 bus zones.

In addition to processing the protection zone data, the central unit provides a disturbance recorder for all 32 bus zones, recording the main data of the busbar protection to facilitate quick fault analysis.

The central unit offers 9 binary inputs and 19 binary outputs for central commands and signals (for example, external bus zone trip, trip-reset etc.). Additional 9 binary inputs and 9 binary outputs are optional available.

The central unit comprises a local HMI with 15 programmable LEDs (Figure 8) including a front Ethernet port for HMI connection within the local area network.

Figure 8. Central Unit

6. Functionality

Busbar protection

The protection algorithms are based on two well-proven measuring principles which have been applied successfully in earlier ABB low-impedance busbar protection systems:

- Stabilized differential current measurement principle
- Phase comparison measurement principle

The algorithms process complex current vectors which are obtained by Fourier analysis and only contain the fundamental frequency component. Any DC component and harmonics are suppressed.

Stabilized differential current measurement
The first measuring principle uses a stabilized differential current algorithm. The currents are evaluated individually for each of the phases and each section of a busbar (protection zone).

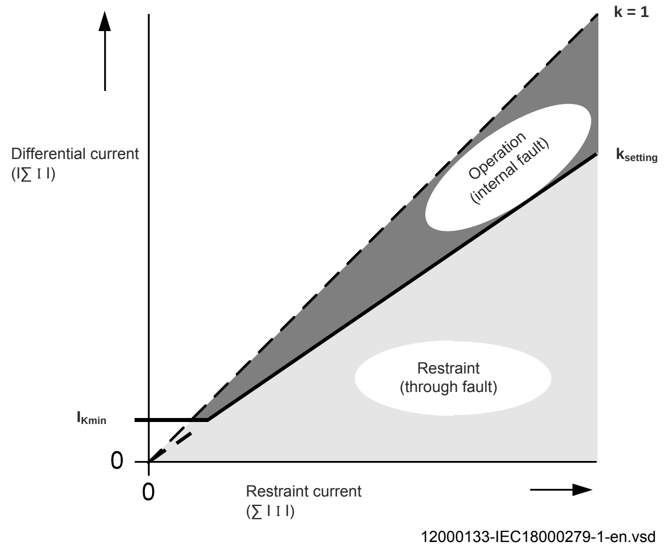

Figure 9. Tripping characteristic of the stabilized differential current algorithm

In Figure 9, the differential current is:

$$I_{Diff} = \left| \sum_{n=1}^{N} \underline{I}_{L_n} \right|$$

and the restraint current is:

$$I_{Rest} = \sum_{n=1}^{N} \left| \underline{I}_{L_n} \right|$$

where N is the number of feeders.

The following two conditions have to be accomplished for the detection of an internal fault:

$$k_{st} = \frac{I_{Diff}}{I_{Rest}} > k_{st\,max} \quad \text{AND} \quad I_{Diff} > I_{K\,min}$$

where

k_{st}	stabilizing factor
$k_{st\ max}$	stabilization factor limit (typically 0.80)
$I_{K\ min}$	differential current pick-up value

The above calculations and evaluations are performed by the central unit.

Phase comparison
The second measuring principle determines the direction of energy flow and involves comparing the phases of the currents of all the feeders connected to a busbar section.

The fundamental frequency current phasors φ_1 , ... , φ_n are compared. In the case of an internal fault, all of the feeder currents have almost the same phase angle, while in normal operation or during an external fault at least one current is approximately 180° out of phase with the others.

$$\varphi_n = \arctan\left[\frac{\mathrm{Im}(\underline{I}_{L_n})}{\mathrm{Re}(\underline{I}_{L_n})}\right]$$

The algorithm detects an internal fault when the difference between the phase angles of all the feeder currents lies within the tripping angle of the phase comparator (see Figure 10).

Processing
The task of processing the algorithms is shared between the bay units and the central processing unit. Each of the bay units continuously monitors the currents of its own feeder, preprocesses them accordingly and then filters the resulting data according to a Fourier function. The analogue data filtered in this way is then transferred at regular intervals to the central processing unit running the busbar protection algorithms.

Depending on the phase-angle of the fault, the tripping time at I_{Diff} / $I_{K\ min}$ ≥ 5 is typically 15 ms including the auxiliary tripping relay.

Optionally, the tripping signal can be interlocked by a current or voltage release criterion in the bay unit that enables tripping only when a current above a certain minimum is flowing, or the voltage is below a certain value, respectively.

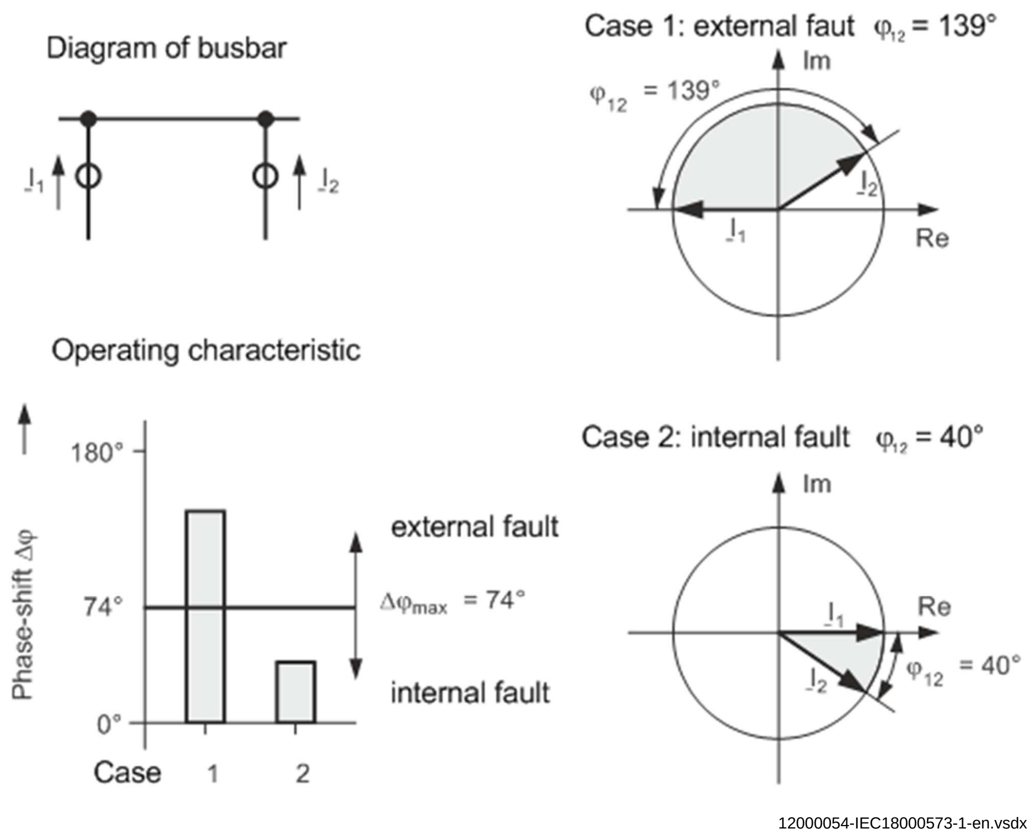

Figure 10. Characteristic of the phase comparator for determining energy direction

Breaker failure protection

The breaker failure functions in the bay units monitor both phase currents and neutral current independently of the busbar protection. They have two timers with individual settings. Operation of the breaker failure function is enabled either:

- internally by the busbar protection algorithm (and, if configured, by other local protection functions)
- externally via a binary input, for example, by the line protection, transformer protection and so on.
- via the station bus using GOOSE signals of other IEDs.

After the delay of the first timer has expired, a tripping command can be applied to a second tripping coil on the circuit-breaker and a remote tripping signal transmitted to the station at the opposite end of the line.

This first timer operates in a stand-alone mode in the bay unit.

If the fault still persists at the end of the second time delay, the breaker failure function uses the busbar replica to trip all the other feeders supplying the same section of busbar via their bay units.

A remote tripping signal can be configured in the software to be transmitted after the first or second timer.

Phase-segregated measurements in each bay unit allow for correct behavior in case of evolving faults.

End fault protection

In order to protect the dead zone between an open circuit-breaker and the associated CTs, a signal derived from the breaker position and the close command is applied.

The end fault protection is enabled a certain time after the circuit-breaker has been opened. In the event of a short circuit in the dead zone the adjacent circuit-breakers are tripped.

Overcurrent function

A definite time overcurrent back-up protection scheme can be integrated in each bay unit. (The operation of the function, if parameterized, may start the local breaker failure protection scheme.)

Current release criteria

The current release criterion is only performed in the bay unit. It is effective for a busbar protection trip and for an intertripping signal (including end fault and breaker failure) and prevents those feeders from being tripped that are conducting currents lower than the setting of the current release criteria.

Voltage release criteria

The voltage criteria are measured in the bay unit. The function can be configured as release criterion per zone through internal linking in the central unit.

This necessitates the existence of one set of voltage transformers per zone in one of the bay units. Tripping is only possible if the voltage drops below (U<) and / or exceeds (U_0>) the set value.

Additionally this release criterion can be configured for each feeder. For details, see Table 32.

Check zone criterion

The check zone algorithm can be used as a release criterion for the zone-discriminating low-impedance busbar protection system. It is based on a stabilized differential current measurement, which only acquires the feeder currents of the complete busbar. The isolator / breaker positions are not relevant for this criterion.

Neutral current detection I_0

Earth fault currents in impedance-grounded systems may be too low for the stabilized differential current and phase comparison functions to detect. A function for detecting the neutral current is therefore also available, but only for single phase-to-earth faults.

Pole discrepancy

A pole discrepancy protection algorithm supervises that all three poles of a circuit-breaker open within a given time.

This function monitors the discrepancy between the threephase currents of the circuit-breaker.

When it picks up, the function does not send an intertripping signal to the central unit, but, if configured, it starts the local breaker failure protection (BFP logic 3).

This function is also performed in a standalone mode in the bay unit.

Event recording

The events are recorded in each bay unit. A time stamp with a resolution of 1 ms is attached to every binary event. Events are divided into the following three groups:

- system events
- protection events
- test events

The events are stored locally in the bay unit or in the central unit.

Disturbance recording

Disturbance records contain the currents and the binary inputs and outputs in each bay. Voltages can also be recorded.

A record can be triggered by either the leading or lagging edges of all binary signals or by events generated by the internal protection algorithms. Up to 10 general-purpose binary inputs may be configured to enable external signals to trigger a disturbance record. In addition, there is a binary input in the central and the bay unit for starting the disturbance recorders of all bay units.

The number of analogue channels that can be recorded, the sampling rate and the recording period are given in Table 37.

The total recording time can be divided by a maximum of 40 recording intervals per bay unit.

Each bay unit can record a maximum of 32 binary signals, 12 of them can be configured as trigger signals.

The function can be configured to record the pre-fault and post-fault states of the signals.

This function is performed in a stand-alone mode in the bay unit.

Central disturbance recording

In addition to the individual recordings on each bay unit, a central disturbance recorder can be configured on the central unit. These records will contain the differential and restraint currents and optional the max. phase difference for up to 32 bus zones as used within the busbar protection algorithm.

Stored disturbance data can be transferred via the central unit to other computer systems for evaluation. Files are transferred in the COMTRADE format.

Communication interface

Communication with the station automation system (SAS) is possible via the central unit. The interface supports the station communication protocols IEC 61850-8-1 Edition 1 or Edition 2 and IEC 60870-5-103.

The IEC 61850-8-1 interface transfers the following data to the station communication via an optical connection:

- differential current of each protection zone
- monitoring information from REB500 central unit and bay units
- binary events (signals, trips and diagnostic)
- trip reset command
- disturbance records (via MMS file transfer protocol)
- time synchronization with Simple Network Time Protocol (SNTP). Two independent time servers are supported. Server 2 is used as backup time.

The central unit supports redundant station bus communication according to the Parallel Redundancy Protocol IEC 62439-3. The setting of the parallel redundant communication is available in the HMI500 configuration tool.

REB500 supports reception of IEC 61850 GOOSE Signals to start the breaker failure protection. It also supports sending of tripping information by GOOSE.The IEC 60870-5-103 station communication transfers via optical connection:

- time synchronization
- selected events listed in the public part
- all binary events assigned to a private part
- all binary events in the generic part
- trip reset command

Test generator

The HMI program (HMI500) which runs on a PC connected to either a bay unit or the central processing unit includes a test generator.

During commissioning and system maintenance, the test generator function enables the user to:

- activate binary input and output signals
- monitor system response
- test the trip circuit up to and including the circuit-breaker

Isolator supervision

The isolator replica is a software feature without any mechanical switching elements. The software replica logic determines dynamically the boundaries of the protected busbar zones (protection zones). The system monitors any inconsistencies of the binary input circuits connected to the isolator auxiliary contacts and generates an alarm after a set time delay.

In the event of an isolator alarm, it is possible to select the behavior of the busbar protection:

- blocked
- zone-selective blocked
- remain in operation

Table 3. Isolator image

Primary equipment		Status in prot. system	Alarm facility	
N/O contact: Isolator CLOSED	N/C contact: Isolator OPEN		Alarm after settable time	Information on local HMI
open	open	Last position stored (for busbar protection)	isolator alarm + switch inhibit signal	invalid
open	closed	OPEN	no	open
closed	open	CLOSED	no	closed
closed	closed	CLOSED	isolator alarm + switch inhibit signal	invalid

For certain busbar and end-fault protection configurations, it is also necessary to know the status of the circuit breakers. Where CB positions signals are configured as inputs, it is extremely important for the **CB Close** command to be correctly connected.

Differential current supervision

The differential current is permanently supervised. Any differential current triggers a time-delayed alarm. In the event of a differential current alarm, it is possible to select the behavior of the busbar protection:

- blocked
- zone-selective blocked
- remain in operation

Trip redirection

A binary input channel can be provided to which the external signal monitoring the circuit-breaker air pressure is connected. Tripping is not possible without active signal.

When it is inactive, a trip generated by the respective bay unit is automatically redirected to the station at the opposite end of the line and also to the intertripping logic to trip all the circuit-breakers connected to the same section of busbar.

The trip redirection can also be configured with a current criterion (current release criteria).

Human machine interface (HMI)

The busbar protection is configured and maintained with the aid of human machine interfaces at three levels.

Local HMI

The local display interface installed in the central unit and in the bay units comprises:

- a graphical monochrome LCD with a resolution of 320x240 pixels each for displaying system data and error messages
- keys for entering and display as well as LEDs for the indication of trips, alarms and normal operation
- in addition 15 freely programmable three color LEDs for user-specific displays on the bay unit 500BU04 and central unit 500CU04.

The following information can be displayed:

- measured input currents and voltages
- measured differential currents (for the busbar protection)
- system status, alarms
- switchgear and isolator positions (within the busbar protection function)
- starting and tripping signals of protection functions

HMI500 Operator

More comprehensive and convenient control is provided by the external HMI software running on a PC connected to either the central unit or a bay unit. The software facilitates configuration of the entire busbar protection, the setting of parameters and full functional checking and testing. The HMI500 can also be operated via the station bus on MicroSCADA, for example, thus eliminating a separate connection to the central unit.

The HMI500 runs under: Windows 8.1, Windows 10 and Windows Server.

HMI500 is equipped with a comfortable database comparison function enables a detailed comparison between two configuration files (for example, between the PC and the central unit or between two files on the PC).

PCM600 Connectivity Package

After installation and commissioning, PCM600 offers easy access to the installed base of ABB substation automation products within the substation. The connectivity package for the REB500 supports this with an operator mode, where most of the reporting and monitoring features of the REB500 are available read-only within the PCM600 framework.

WebHMI

As an alternative to HMI500 and PCM600, the WebHMI offers easy access to all current data within the REB500 system using the browsers Google Chrome 49, Microsoft Internet Explorer 11, Mozilla Firefox 44, or later versions.

7. Additional features

Self-supervision

All the system functions are continuously monitored to ensure the maximum reliability and availability of the protection. In the event of a failure, incorrect response or inconsistency, the corresponding action is taken to establish a safe status, an alarm is given and an event is registered for subsequent diagnostic analysis.

Important items of hardware (for example, auxiliary supplies, A/D converters and main and program memories) are subjected to various tests when the system is switched on and also during operation. A watchdog continuously monitors the integrity of the software functions and the exchange of data via the REB500 process bus is also continuously supervised.

Extension of the system

The system functions are determined by software, configured using the software configuration tool.

The system can be completely engineered in advance to correspond to the final state of the station. The software modules for new bays or features can be activated using the HMI500 when the primary plant is installed or the features are needed.

Additional system functions, for example, breaker failure or end fault protection can be easily activated at any time without extra hardware.

Resetting the trip commands/signals

The following resetting modes can be selected for each binary output (tripping or signal outputs):

- Latches until manually reset
- Resets automatically after a delay

Inspection/maintenance

A binary input can be assigned that excludes a bay unit from evaluation by the protection system. It is used while performing maintenance or inspection activities on the primary equipment respectively.

Redundant power supplies (Optional)

The central unit may be ordered with a redundant power supply.

Time synchronization

The absolute time accuracy with respect to an external time reference depends on the method of synchronization.

Table 4. Typical time synchronization accuracy

Method	Accuracy
No external time synchronization	1 min / month
IRIG-B	±1 ms
SNTP	±1 ms typ.
Optical or electrical second pulse on central unit	±1 ms
Periodic time telegram IEC 60870-5-103±5 ms typ.Periodic time telegram IEC 60870-5-103 with additional second pulse	±1 ms

8. Requirements

Optical fiber cables

A distributed busbar protection layout requires optical fiber cables and connectors with the following characteristics:

- 2 optical fiber cores per bay unit
- glass fibers with gradient index
- diameter of core 62.5/50 µm, sheath 125 µm
- maximum permissible attenuation ≤ 8 dB/6dB
- LC connector (for 62.5/50 µm optical fibers)
- rodent protected and longitudinally waterproof if in cable ducts

Please observe the permissible bending radius when laying the cables.

The following attenuation figures are typical values which may be used to determine an approximate attenuation balance for each bay:

Table 5. Typical attenuation

Optical equipment	Typical attenuation
glass fiber 62.5/125 µm	3.5 dB/km
glass fiber 50/125 µm	2.5 dB/km
per connector	0.7 dB
per cable joint	0.2 dB

Isolator auxiliary contacts

Auxiliary contacts on the isolators are connected to binary inputs on the bay units and control the status of the busbar replica in the numerical busbar protection.

One potentially-free N/O and N/C contact are required on each isolator. The N/O contact signals that the isolator is **CLOSED** and the N/C contact that the isolator is **OPEN**. During the closing movement, the N/O contact must close before the isolator main contact gap reaches its flashover point.

Conversely, during the opening movement, the N/O contact must not open before the isolator main contact gap exceeds its flashover point.

If this is not the case, that is, the contact signals ‘no longer closed’ beforehand, then the N/C contact may not signal **OPEN** before the flashover point has been exceeded. In such cases a *Not Open = Closed* scheme might be applicable.

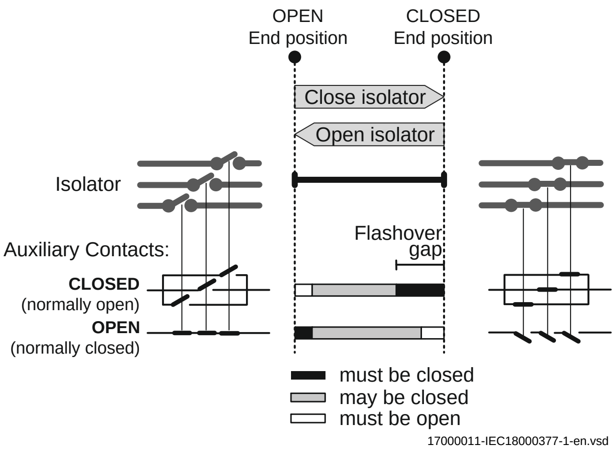

Figure 11. Switching sequence of the auxiliary contacts that control the busbar replica

Circuit-breaker replica

When the circuit-breaker replica is read in the feeder or the bus-tie breaker, the circuit-breaker CLOSE command must also be connected.

Main current transformer

The algorithms and stabilization features used make the busbar protection largely insensitive to CT saturation phenomena. Main CTs types TPS (B.S. class x), TPX, TPY, 5P. or 10P. are permissible.

TPX, TPY and TPZ CTs may be mixed within one substation in phase-fault schemes. The relatively low CT performance needed for the busbar protection makes it possible for it to share protection cores with other protection devices.

Current transformer requirements for stability during external faults (Busbar protection)

The minimum CT requirements for 3-phase systems are determined by the maximum fault current. The effective accuracy limit factor (n') must be checked to ensure the stability of the busbar protection during external faults.

The rated accuracy limit factor is given by the CT manufacturer. Taking account of the burden and the CT losses, the effective accuracy limit factor n' becomes:

$$n' = n \cdot \frac{P_N + P_E}{P_B + P_E}$$

where:

n	rated accuracy limit factor
P_N	rated CT power
P_N	CT losses
P_B	burden at rated current

In the case of schemes with phase-by-phase measurement, n' must satisfy the following inequalities:

$$n' \geq \frac{I_{K\max}}{5 \cdot I_{1N}}$$

$$n' \geq 10 \rightarrow \ for \ \ T_N \leq 120ms$$

$$n' \geq 20 \quad for \ \ 120 \ \ ms \leq T_N \leq 300ms$$

I_{Kmax}	Maximum primary through-fault current
I_{1N}	Rated primary CT current
T_N	DC time constant

Pick-up for internal faults

In the case of internal busbar faults, CT saturation is less likely, because each CT only conducts the current of its own feeder. Should nevertheless CT saturation be possible, it is important to check that the minimum fault current exceeds the setting for I_{Kmin}.

9. REB500 Process bus configuration

	Switch 1 (SW1)					Switch 2 (SW2)			Switch 3 (SW3)			Switch 4 (SW4)			Switch 5 (SW5)		
Switch IP address	192.168.175.3					192.168.175.4			192.168.175.5			192.168.175.6			192.168.175.7		
Switch Port	1	2	3..14	15	16	1..14	15	16	1..14	15	16	1..14	15	16	1..14	15	16
Config. up to 14 BUs	CU X1	CU X1005	BU 1..14														
Configuration file	Master_1.cli																
Config. up to 26 BUs *)	CU X1	CU X1005	BU 1..12	SW2 16	SW2 15	BU 13..26	SW1 16	SW1 15									
Configuration file	Master_2.cli					Slave_1.cli											
Config. up to 40 BUs	CU X1	CU X1005	BU 1..12	SW3 16	SW2 15	BU 13..26	SW1 16	SW3 15	BU 27..40	SW2 16	SW1 15						
Configuration file	Master_3.cli					Slave_1.cli			Slave_2.cli								
Config. up to 54 BUs	CU X1	CU X1005	BU 1..12	SW4 16	SW2 15	BU 13..26	SW1 16	SW3 15	BU 27..40	SW2 16	SW4 15	BU 41..54	SW3 16	SW1 15			
Configuration file	Master_4.cli					Slave_1.cli			Slave_2.cli			Slave_3.cli					
Config. up to 60 BUs	CU X1	CU X1005	BU 1..12	SW5 16	SW2 15	BU 13..26	SW1 16	SW3 15	BU 27..40	SW2 16	SW4 15	BU 41..54	SW3 16	SW5 15	BU 55..60	SW4 16	SW1 15
Configuration file	Master_5.cli					Slave_1.cli			Slave_2.cli			Slave_3.cli			Slave_4.cli		

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Figure 12. Switch configuration of the REB500 process bus

*) Figure 13 gives an example for a system configuration with up to 26 Bay Units.

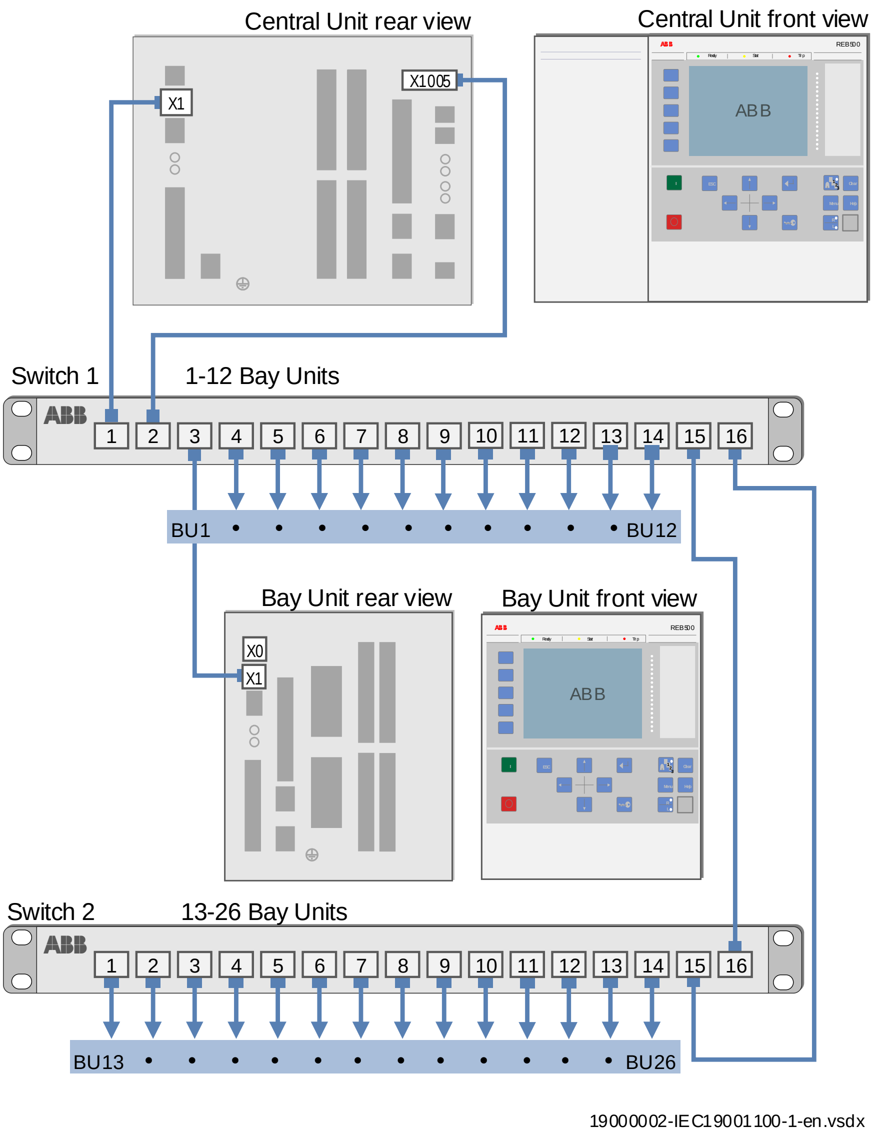


Figure 13. Example: Network topology (Ethernet) of a system configuration with up to 26 Bay Units

10. Hardware description

Hardware description

The following mounting alternatives are available (IP40 protection from the front):

Bay Unit	Central Unit
• Flush mounting kit • 19” rack mounting kit • 19" dual rack mounting kit	• 19” rack mounting kit

See ordering for details about available mounting alternatives.

Layout and dimensions Bay Unit

Flush mounted IED

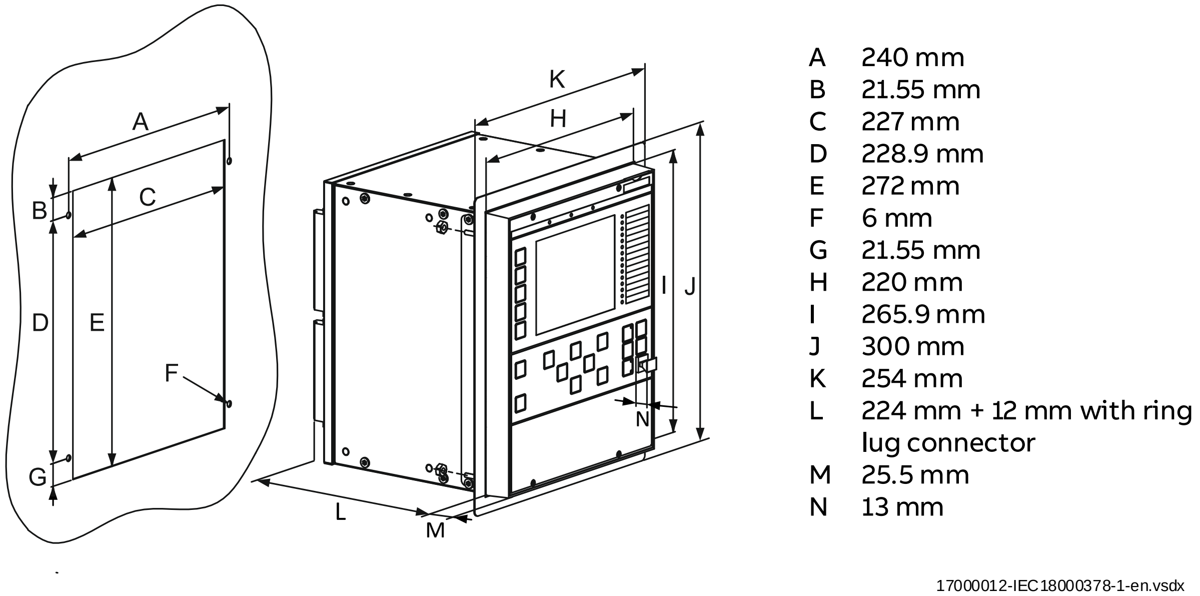


Figure 14. Flush mounted Bay Unit into a panel cutout

Rack mounted IED

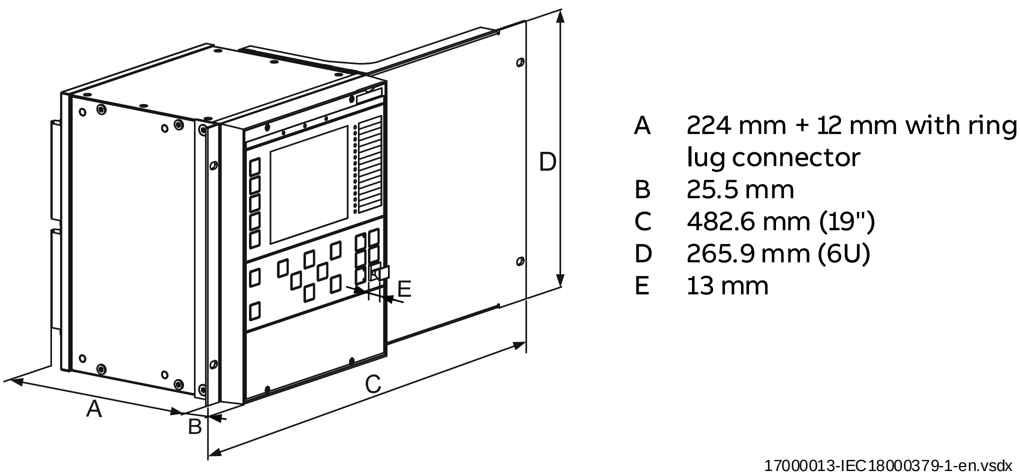
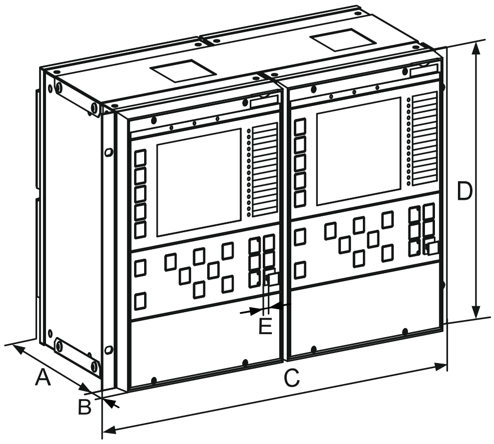


Figure 15. Rack mounted Bay Unit

Two rack mounted IEDs



A 224 mm + 12 mm with ring lug
B 25.5 mm
C 482.6 mm (19”)
D 265.9 mm (6U)
E 13 mm

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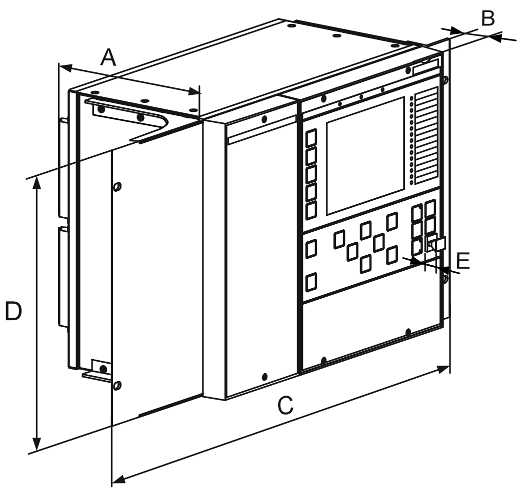
Figure 16. Two rack mounted Bay Units side by side

Layout and dimensions Central Unit

Rack mounted IED



A 224 mm + 12 mm with ring lug connector
B 25.5 mm
C 482.6 mm (19")
D 265.9 mm (6U)
E 13 mm

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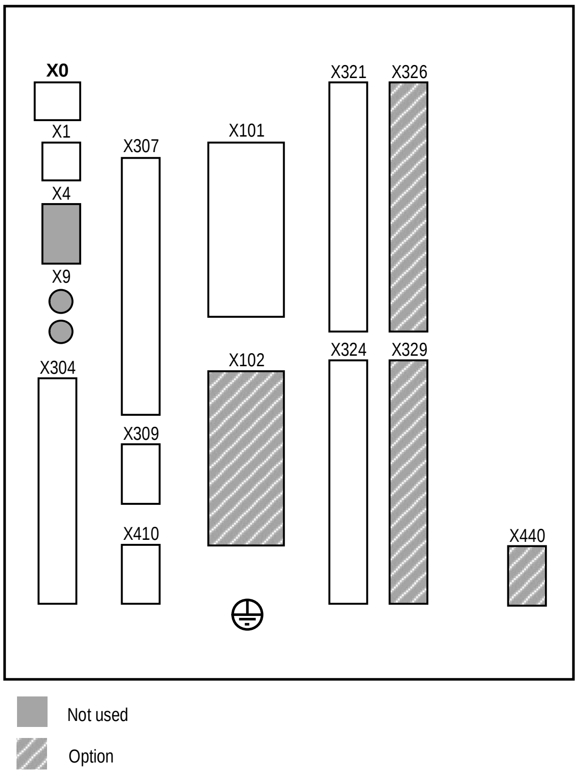
Figure 17. Rack mounted Central Unit

11. Connection diagrams

Rear view Bay Unit



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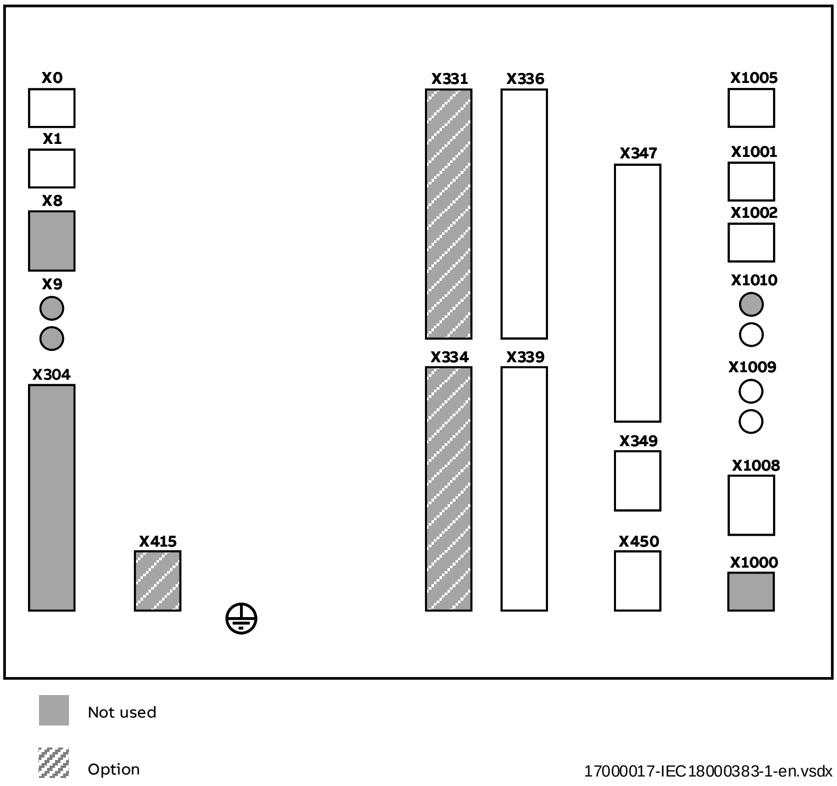
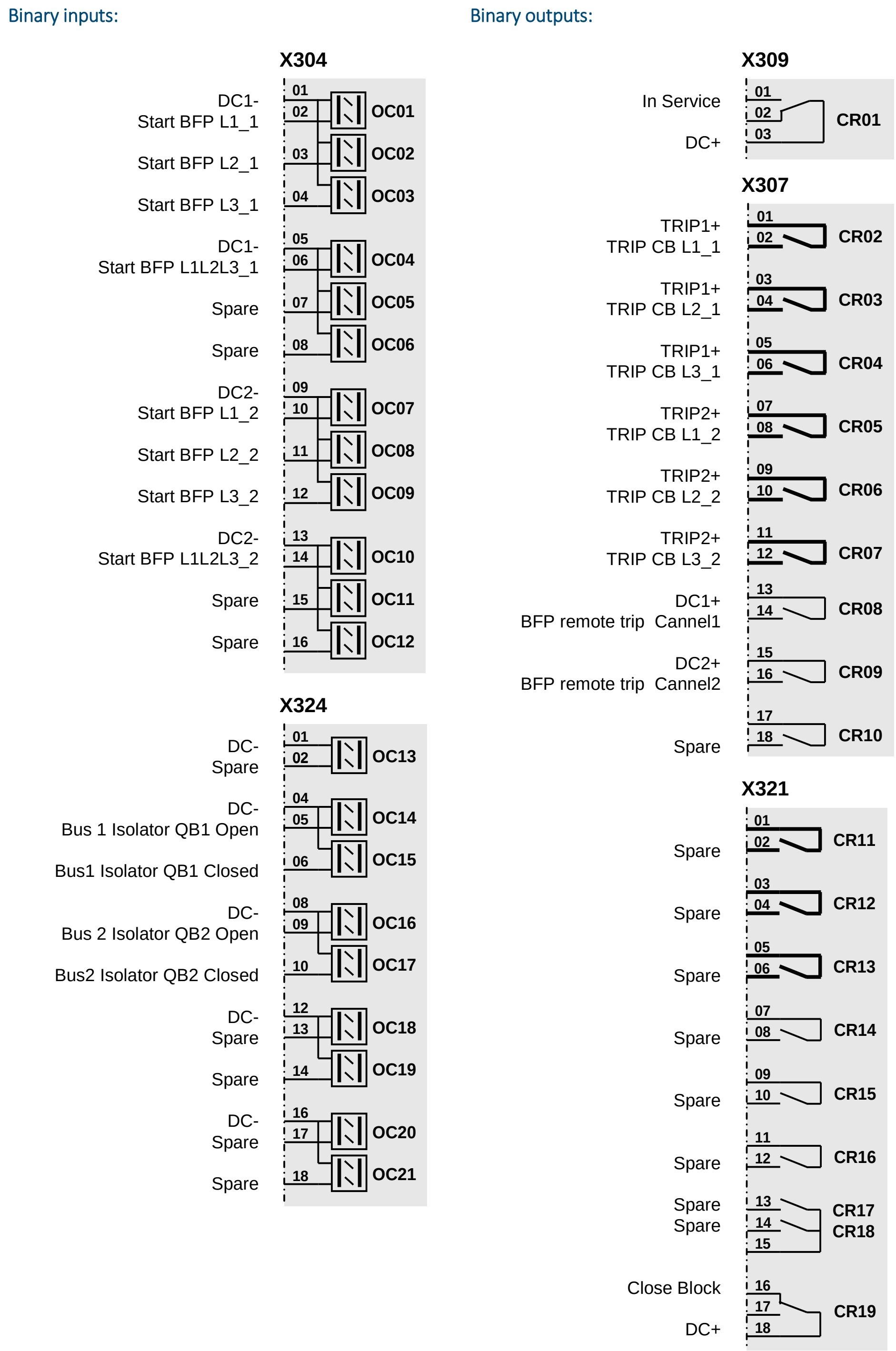
Rear view Central Unit



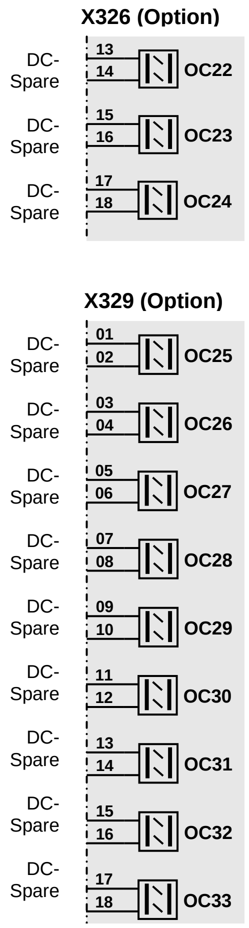
Connection diagrams Bay Unit



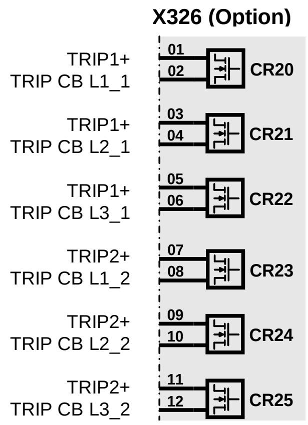
CR02-CR07 and CR11-CR13 Power output relays (see Table 11)

Remark: The signal configuration is an example only, the binary I/Os can be freely configured.

Binary inputs:



Precision binary outputs:



CR20-CR25 Precision tripping outputs

Analogue inputs:

Currents — X101

Input	Terminals	Transformer	Busbar protection	Breaker failure protection	End fault protection	Pole discrepancy protection	Voltage check	Disturbance recorder	Measured value
Current input L1 / Current input L1_0	01 / 02	CT1	●	●	●	●		●	Phase current L1 (Line)
Current input L2 / Current input L2_0	03 / 04	CT2	●	●	●	●		●	Phase current L2 (Line)
Current input L3 / Current input L3_0	05 / 06	CT3	●	●	●	●		●	Phase current L3 (Line)
Current input N / Current input N_0	07 / 08	CT4	○					●	Neutral current L0 (Line)
	09								
	10								

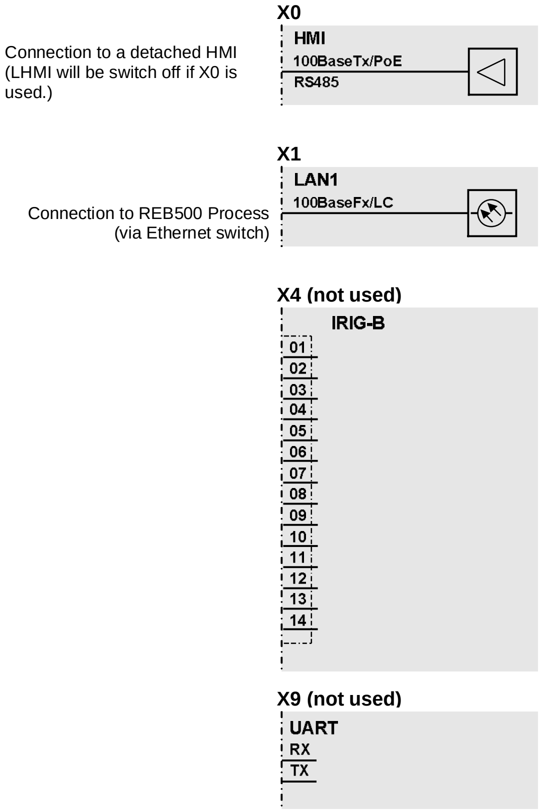
Voltages — X102 (Option)

Input	Terminals	Transformer	Busbar protection	Breaker failure protection	End fault protection	Pole discrepancy protection	Voltage check	Disturbance recorder	Measured value
Voltage input L1 / Voltage input L1_0	01 / 02	VT1					●	●	Phase voltage L1 (Line)
Voltage input L2 / Voltage input L2_0	03 / 04	VT2					●	●	Phase voltage L2 (Line)
Voltage input L3 / Voltage input L3_0	05 / 06	VT3					●	●	Phase voltage L3 (Line)
Voltage input L2-E (Bus 1) / Voltage input L2-E (Bus 1)_0	07 / 08	VT4						●	Phase voltage L2 (Bus1 / 1ph →L2-E)
Voltage input L2-E (Bus 2) / Voltage input L2-E (Bus 2)_0	09 / 10	VT5						●	Phase voltage L2 (Bus2 / 1ph →L2-E)

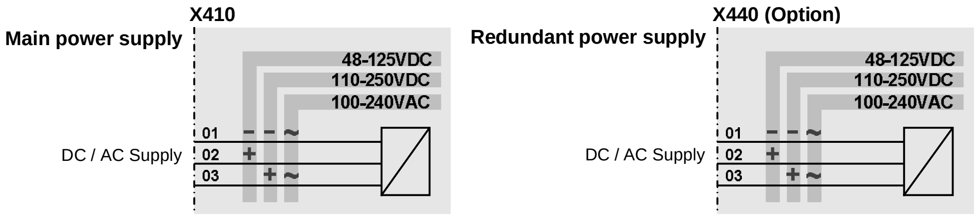
● Current/ voltage transformer fixed assignment

○ Only for busbar protection Io measurement (optional function)

Interfaces:

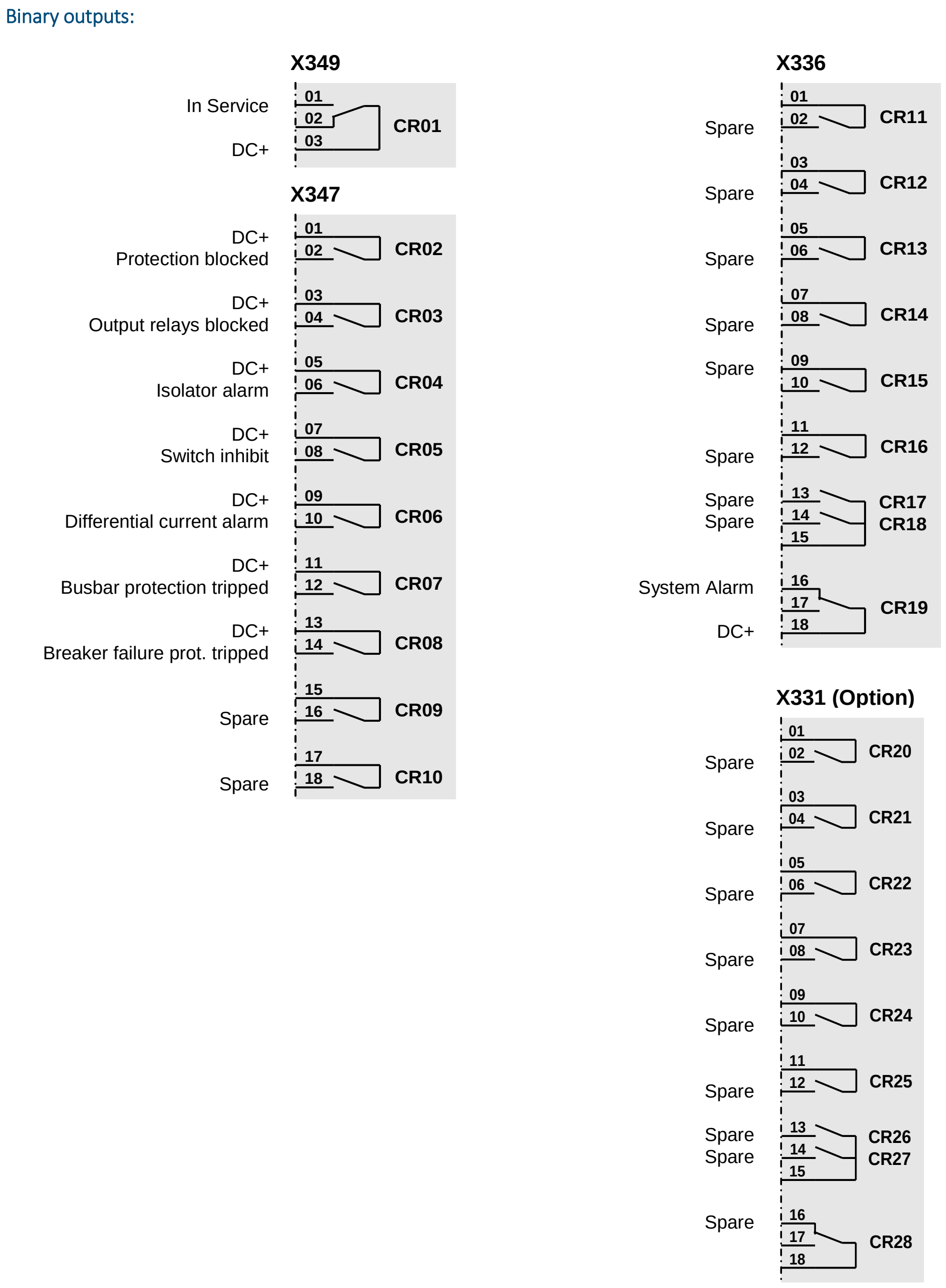


Power Supply:



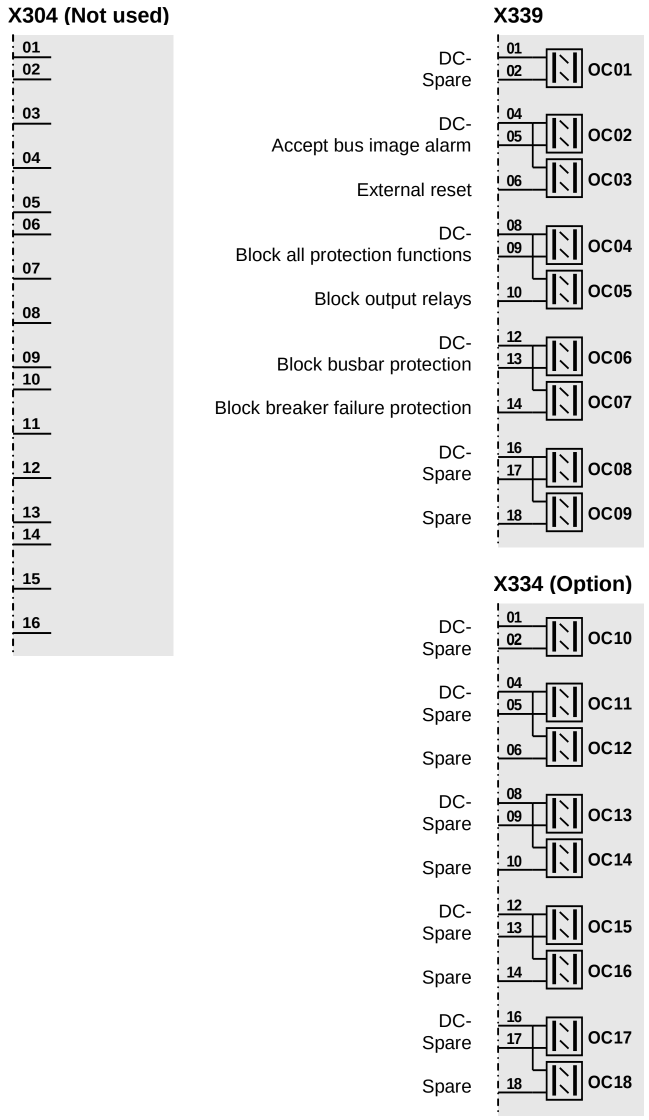
110-250VDC and 100-240VAC → Power supply version A
48-125VDC → Power supply version B

Connection diagrams Central Unit



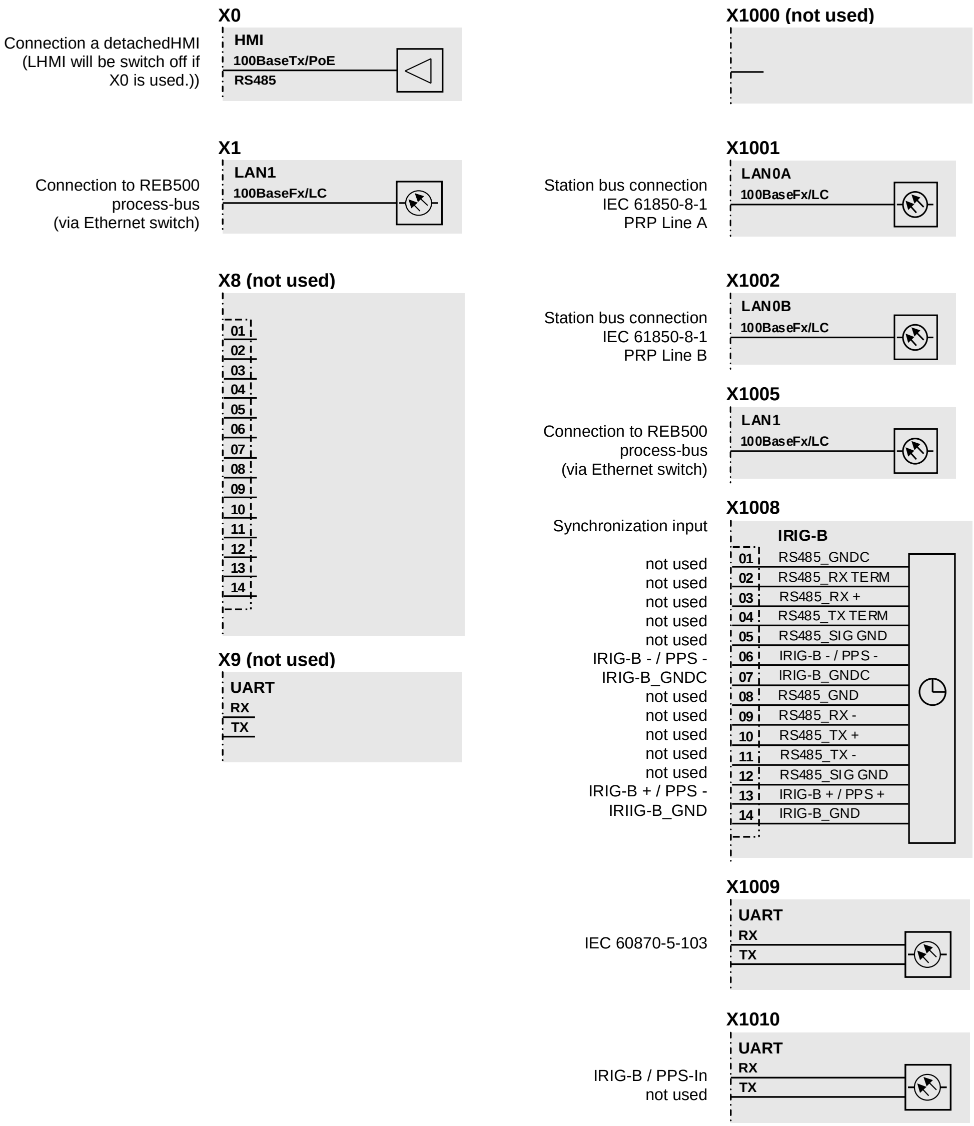
Remark: The signal configuration is an example only, the binary outputs can be freely configured.

Binary inputs:

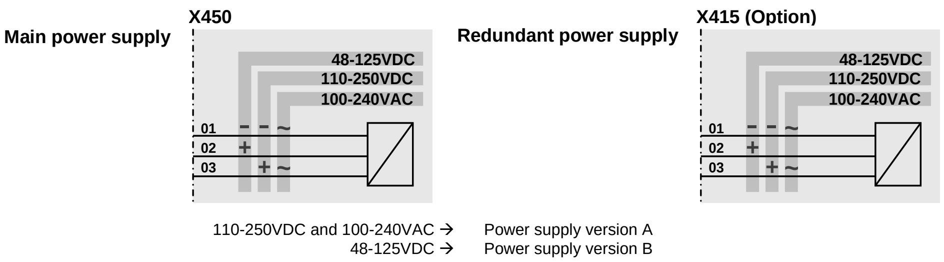


Remark: The signal configuration is an example only, the binary inputs can be freely configured.

Interfaces:



Power supply:



12. Technical Data

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) within 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

Inputs, Outputs, Power Supply

Table 6. Analogue inputs

Description		Value
Rated frequency f_r		50 or 60 Hz
Operating range		f_r ± 10 %
Current inputs	Rated current, In	1 or 5 A2*)
	Operating range	0 – 500 A
	Thermal withstand capability:	
	Continuously For 1 min For 10 s For 1 s	20 A 40 A 100 A 500 A*)
	Dynamic current withstand: Half-wave value	 1250A
	Burden:	
	At I_r = 5 A At I_r = 1 A	< 200 mVA < 10 mVA
*) max. 350 A for 1s when COMBITEST test switch is included		
Voltage inputs **)	Rated voltage Ur	100 or 220 V
	Operating range	0 to 420 V
	Thermal withstand:	
	For 10 s Continuous	450 V 420 V
	Burden:	
	At 220 V At 110 V	< 50 mVA < 150 mVA

**) All values for individual voltage inputs

Table 7. Power supply

Description	PSM02	PSM03
U_{aux}nominal	48-125 V DC	100, 110, 120, 220, 240V AC 50/60 Hz 110, 125, 220, 250V DC
U_{aux}variation	80...120% of Un (38.4...150 V DC)	80...120% of Un (88...300 V DC) 80...115% of Un (80...276 V AC)
Maximum load of auxiliary voltage supply	50 W for DC 70 VA for AC	
Ripple in the DC auxiliary voltage	Max 15% of the DC value (at frequency of 100 and 120 Hz)	
Maximum interruption time in the auxiliary DC voltage without resetting the IED	50 ms at U_{aux} IEC 60255-11 (1979), VDE 0435, Part 303	
Recommended MCB	S202M-C2UC 2CDS272061R0024	

Table 8. Binary input

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	24...250 V DC
Current drain	1.6...1.8 mA
Power consumption/input	<0.38 W
Threshold voltage	24, 48, 60, 110, 125, 220 and 250V DC

Table 9. Precision binary input

Description	Value
Operating range	Maximum input voltage 300 V DC
Rated voltage	33...288 V DC
Current drain	0...0.5 mA
Power consumption/input	<0.15 W
Threshold voltage	24, 48, 60, 110, 125, 220 and 250V DC

Table 10. Signal output and IRF[1)] output

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	5 A
Make and carry for 3.0 s	10 A
Make and carry 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/ R<40 ms, at U< 48/110/220 V DC	≤0.5 A/≤0.1 A/≤0.04 A
Burden per CR: CR2 - CR7, CR11 - CR13, CR20 - CR22	258 mW

1) Internal fault relay – change over contact

Table 11. Power output relays

Description	Value
Rated voltage	250 V AC/DC
Continuous contact carry	8 A
Make and carry for 3.0 s	15 A
Make and carry for 0.5 s	30 A
Breaking capacity when the control-circuit time constant L/ R<40 ms, at U< 48/110/220 V DC 1 contact	≤1 A (48 V) ≤ 0.3 A (110 V) ≤0.1 A (220 V)
Reset response programmable per output	latched automatic reset (delay 0..60 s)
Burden per CR: CR1, CR8 - CR10, CR14 - CR19, CR23 - CR28	153 mW

Table 12. Precision binary output

Description	Value
Rated voltage	33…288 V DC
Continuous contact carry	0.5 A DC
DC make and carry t_{on} < 1 s (single shot, t_{off} > 600 s) L/R < 10 ms U_{SW} ≤ 150 V	10 A DC
DC make and carry t_{on} < 1 s (single shot, t_{off} > 600 s) L/R < 10 ms U_{SW} > 150 V	6 A DC
Impedance in On state	0.5 Ω
Impedance in Off state	100 kΩ
Burden per CR: CR20 – CR 25	69 mW

Interfaces

Table 13. Ethernet interfaces

Ethernet interfaces	Protocol	Cable	Data transfer rate
100BASE-FX	IEC 61850-8-1 REB500 Process Bus TCP/IP	Fiber-optic cable with LC connector	100 MBit/s

Table 14. Fiber-optic communication link

Wave length	Fiber type	Connector	Permitted path attenuation[1)]	Distance
1300 nm	MM 62.5/125 µm MM 50/125 µm glass fiber core	LC LC	<8 dB <6 dB	2 km 2 km

1) Maximum allowed attenuation caused by connectors and cable together

Table 15. IRIG-B interface

Type	Protocol	Cable
Tension clamp terminal	IRIG-B	Shielded twisted pair cable Recommended: CAT 5, Belden RS-485 (9841- 9844) or Alpha Wire (Alpha 6222-6230)
Optical interface (X1010)	IRIG-B	MM 62,5/125 µm glass fiber core, ST connector

Table 16. IRIG-B

Type	Value	Accuracy
Input impedance	430 Ω	—
Minimum input voltage HIGH	4.3 V	—
Maximum input voltage LOW	0.8 V	—

Table 17. Serial rear interface

Type	Counter connector
Serial port (X1009)	Optical serial port, type ST for IEC 60870-5-103 serial

Table 18. Optical serial port (X1009)

Wavelength	Fiber type	Connector	Permitted path attenuation1)
820 nm	MM 62,5/125 µm glass fiber core	ST	6.8 dB (approximately, 1700 m length with 4 dB/km fiber attenuation)
820 nm	MM 50/125 µm glass fiber core	ST	2.4 dB (approximately, 600 m length with 4 dB/km fiber attenuation)

1) Maximum allowed attenuation caused by fiber

Influencing factors

Table 19. Environmental conditions

Description	Value
Operating temperature range	-25...+55 °C (continuous)
Short-time service temperature range	-40...+70 °C (<16h) Degradation in MTBF and HMI performance outside the temperature range of -25...+55 °C
Relative humidity	5..95%, non-condensing
Atmospheric pressure	minimum 76 kPa
Altitude	up to 2000 m
Transport and storage temperature range	-40...+85 °C

Table 20. Environmental test

Description		Type test value	Reference
Cold tests	operation storage	96 h at -25 °C 16 h at -40 °C 96 h at -40 °C	IEC 60068-2-1/ANSI C37.90-2005 (chapter 4)
Dry heat tests	operation storage	16 h at +70 °C 96 h at +85 °C	IEC 60068-2-2/ANSI C37.90-2005 (chapter 4)
Damp heat tests	steady state cyclic	240 h at +40 °C humidity 93% 6 cycles at +25 to +55 °C humidity 93...95%	IEC 60068-2-78 IEC 60068-2-30

Type Tests according to standards

Table 21. Electromagnetic compatibility tests

Description	Type test value	Reference
100 kHz and 1 MHz burst disturbance test Common mode Differential mode	 2.5 kV 2.5 kV	IEC 60255-26 IEC 61000-4-18, level 3 ANSI C37.90.1-2002
Electrostatic discharge test Contact discharge Air discharge	 8 kV 15 kV	IEC 60255-26 IEC 61000-4-2, level 4 ANSI C37.90.3-2001
Radio frequency interference tests Conducted, common mode Radiated, amplitude-modulated	 10 V (emf), f=150 kHz...80 MHz 20 V/m (rms), f=80...1000 MHz and f=1.4...2.7 GHz	 IEC 60255-26 IEC 61000-4-6 , level 3 IEC 60255-26 IEC 61000-4-3, level 3 ANSI C37.90.2-2004
Fast transient disturbance tests Communication ports Other ports	 4 kV 4 kV	IEC 60255-26 IEC 61000-4-4, level 4 ANSI C37.90.1-2002
Surge immunity test Communication ports Auxiliary power supply Other ports	 2 kV line-to-earth 4 kV line-to-earth, 2 kV line-to-line 2 kV line-to-earth, 1 kV line-to-line	IEC 60255-26 IEC 61000-4-5, level 3 level 4/3 level 3/2
Power frequency (50 Hz) magnetic field 3 s Continuous	 1000 A/m 100 A/m	IEC 61000-4-8, level 5
Power frequency immunity test Common mode Differential mode	 300 V rms 150 V rms	IEC 60255-26 IEC 61000-4-16

Table 21. Electromagnetic compatibility tests, continued

Description	Type test value	Reference
Voltage dips and short interruptions on DC power supply	Dips: 40%/200 ms 70%/500 ms Interruptions: 0-50 ms: No restart 0...∞ s: Correct behavior at power down	IEC 60255-26 IEC 61000-4-29
Voltage dips and interruptions on AC power supply	Dips: 40% 10/12 cycles at 50/60 Hz 70% 25/30 cycles at 50/60 Hz Interruptions: 0–50 ms: No restart 0...∞ s: Correct behavior at power down	IEC 60255–26 IEC 61000–4–11
Electromagnetic emission tests Conducted, RF-emission (mains terminal) 0.15...0.50 MHz 0.5...30 MHz Radiated RF-emission 30...230 MHz 230...1000 MHz	 < 79 dB(µV) quasi peak < 66 dB(µV) average < 73 dB(µV) quasi peak < 60 dB(µV) average < 40 dB(µV/m) quasi peak, measured at 10 m distance < 47 dB(µV/m) quasi peak, measured at 10 m distance	IEC 60255-26 EN 55011, class A CISPR 22, class A

Table 22. Insulation tests

Description	Type test value	Reference
Dielectric tests: Test voltage	 2 kV, 50 Hz, 1 min 1 kV, 50 Hz, 1 min, communication ports	IEC 60255-27 ANSI C37.90-2005
Impulse voltage test: Test voltage	 5 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J 1 kV, unipolar impulses, waveform 1.2/50 µs, source energy 0.5 J, communication	IEC 60255-27 ANSI C37.90-2005
Insulation resistance measurements Isolation resistance	 >100 MΩ, 500 V DC	IEC 60255-27 ANSI C37.90-2005
Protective bonding resistance Resistance	 <0.1 Ω (60 s)	IEC 60255-27

Table 23. Mechanical tests

Description	Reference	Requirement
Vibration response tests (sinusoidal)	IEC 60255-21-1	Class 1
Vibration endurance test	IEC 60255-21-1	Class 1
Shock response test	IEC 60255-21-2	Class 1
Shock withstand test	IEC 60255-21-2	Class 1
Bump test	IEC 60255-21-2	Class 1
Seismic test	IEC 60255-21-3	Class 2

Table 24. Product safety

Description	Reference	Requirement
LV directive	2006/95/EC	
Standard	IEC 60255-27 (2013)	Overvoltage category III

Table 25. EMC compliance

Description	Reference
EMC directive	2004/108/EC
Standard	EN 60255-26(2013)

Station level functions (applicable for nominal frequencies of 50 Hz and 60 Hz)

Table 26. Busbar protection 87B (PDIF)

Function/ Parameter	Range/ Value	Accuracy
Min. fault current pick-up setting (I_{kmin})	200 to 6000 A in steps of 100 A	±5% of I_N at $I_{kmin} < I_N$ ±5% of I_{kmin} at $I_{kmin} > I_N$ [1)]
Neutral current detection	100 to 6000 A in steps of 100 A	±5% of I_N at $I_{kmin} < I_N$ ±5% of I_{kmin} at $I_{kmin} > I_N$
Stabilizing factor (k)	0.7 to 0.9 in steps of 0.05	-
Differential current alarm operate current	5 to 50% x I_{kmin} in steps of 5%	-
Differential current alarm time delay	2 to 50 s in steps of 1 s	-
Isolator alarm time delay	0.5 to 90 s	-
Typical tripping time	typically 15 ms at IDiff ≥ 5 x I_{kmin}; for f_N = 50, 60 Hz, incl. tripping relays	-
CT ratio per feeder	50 to 10000/1 A, 50 to 10000/5 A, adjustable via HMI	-
Reset time	40 to 100 ms at $I_{Diff} \geq 1\ I_{kmin}$ for f_N = 50, 60 Hz	-

1) For details about pickup accuracy, see *REB500 Application Note - Verification of pickup values* available in the *REB500 Product media*, Section *Application Notes*.

Table 27. Breaker failure protection 50BF (PBRF)

Function/ Parameter	Range/ Value	Accuracy
Operate current	0.1 to 2 x I_N in steps of 0.1 x I_N	±5% of I_N
Timer t1	10 to 5000 ms in steps of 10 ms	-
Timer t2	0 to 5000 ms in steps of 10 ms	-
Remote trip pulse	100 to 2000 ms in steps of 10 ms	-
Reset ratio	80% of I_k at $I_k \geq 5$ x I_N 80% of I_N at $I_k \leq 5$ x I_N	±5% of I_N

Table 28. End-fault protection 51/62EF (PTOC)

Function/ Parameter	Range/ Value	Accuracy
Operate current	0.1 to 2 x I_N in steps of 0.1 I_N	±5% of I_N at $I_{Set} < I_N$ ±5% of I_{Set} at $I_{Set} \geq I_N$
Time delay	100 to 10,000 ms in steps of 100 ms	-
Pick up time	50..100 ms	
Reset ratio	95%	±4% of I_N at $I_{Set} \leq I_N$ -±1% of I_{Set} at $I_{Set} \geq I_N$
Reset time	70 to 140 ms at I_k = 1.2 – 20 x I_N for f_N = 50, 60 Hz	-

Table 29. Overcurrent Protection 51 (PTOC)

Function/ Parameter	Range/ Value	Accuracy
Characteristic	definite time	-
Operate current	0.1 to 20 x I_N in steps of 0.1 x I_N	±5% of I_N at $I_{set} < I_N$ ±5% of I_{set} at $I_{set} \geq I_N$
Time delay	10 ms to 20 s in steps of 10 ms	-
Reset ratio	95%	±4% of I_N at $I_{Set} < I_N$ -±1% of I_{Set} at $I_{Set} \geq I_N$
Reset time	20 to 50 ms at I_k = 1.2 – 20 x I_N for f_N = 50, 60 Hz	-

Table 30. Breaker pole discrepancy 51/62PD (PTOC)

Function/ Parameter	Range/ Value	Accuracy
Operate current	0.1 I_N to 2.0 x I_N in steps of 0.1 x I_N,	±5% of I_N at $I_{Set} < I_N$ ±5% of I_{Set} at $I_{Set} \geq I_N$
Time delay	100 ms to 10000 ms in steps of 100 ms	-
Discrepancy factor	0.01 to 0.99 x I_{max} in steps of 0.01 x I_{max}	-
For feeders with single phase tripping and autoreclosure, the time setting for the breaker pole discrepancy protection must be greater than the reclosure time. The discrepancy factor is the maximum permissible difference between the amplitudes of two phases.		

Table 31. Current release criterion 51 (PTOC)

Function/ Parameter	Range/ Value	Accuracy
Operate current	0.1 to 4.0 x I_N in steps of 0.1 x I_N	±5% of I_N at $I_{Set} < I_N$ ±5% of I_{Set} at $I_{Set} > I_N$
The current release criterion only allows the trip of a circuit breaker if the feeder current value is above the setting value of the enabling current. This value can be individually selected for each bay.		

Table 32. Voltage release criteria 27/59 (PTOV/PTUV)

Function/ Parameter	Range/ Value	Accuracy
Operate voltage U<	0.2 to 1.0 x U_N in steps of 0.05 x U_N	±5% of U_N
Operate voltage U0>	0.1 to 1.0 x U_N in steps of 0.05 x U_N	±5% of 0.2 U_N at $U_{Set} < 0.2\ U_N$ ±5% of U_{Set} at $U_{Set} > 0.2\ U_N$
If the voltage release criteria are not activated the tripping command (“21110_TRIP”) is given independent from voltage (standard setting).		
The voltage release criteria are used as additional criteria for busbar protection (as well as for the other station protection functions) and operates per zone. They can be used as U< or U0> or in combination.		

Table 33. Check zone criterion 87CZ (PDIF)

Function/ Parameter	Range/ Value	Accuracy
Min. fault current pick-up setting (I_{kmin}) neutral current detection	500 to 6000 A in steps of 200 A	±5% of I_N at $I_{kmin} < I_N$ ±5% of I_{kmin} at $I_{kmin} > I_N$ [1)]
Stabilizing factor (k)	0.0 to 0.9 in steps of 0.05	-
CT ratio per feeder	50 to 10000/1 A, 50 to 10000/5 A, adjustable via HMI	-
The check zone is used as an additional release criterion for busbar protection and operates zone-independent.		

1) For details about pickup accuracy, see *REB500 Application Note - Verification of pickup values* available in the *REB500 Product media*, Section *Application Notes*.

Bay level functions for Back-up/Main 2

Table 34. Autoreclosure 79 (RREC)

Function/Parameter	Range/Value	Accuracy
1st reclosure	none	-
	1P fault - 1P reclosure	
	1P fault - 3P reclosure	
	1P/3P fault - 3P reclosure	
	1P/3P fault - 1P/3P reclosure	
2nd to 4th reclosure	none	-
	two reclosure cycles	
	three reclosure cycles	
	four reclosure cycles	
Single-phase dead time	0.05 to 300 s	±0.1% or ±40 ms, whichever is greater
Three-phase dead time	0.05 to 300 s	±0.1% or ±40 ms, whichever is greater
Dead time extension by ext. signal	0.05 to 300 s	±0.1% or ±40 ms, whichever is greater
Dead times for 2nd, 3rd and 4th reclosures	0.05 to 300 s	±0.1% or ±40 ms, whichever is greater
Fault duration time	0.05 to 300 s	±0.1% or ±10 ms, whichever is greater
Inhibit time	0.05 to 300 s	±0.1% or ±15 ms, whichever is greater
Blocking time	0.05 to 300 s	±0.1% or ±50 ms, whichever is greater
Closing time	0.05 to 300 s	±0.1% or ±15 ms, whichever is greater
Timeout	0.05 to 300 s	±0.1% or ±40 ms, whichever is greater
Single and three-phase discrimination times	0.1 to 300 s	±0.1% or ±40 ms, whichever is greater
	All settings in steps of 0.01 s	
Single and three-phase autoreclosure		
Operation in conjunction with distance, overcurrent and synchrocheck functions and also with external protection and synchrocheck relays		
Logic for first and second main protections, duplex and master/follower schemes		
Up to four fast or slow reclosure shots		
Detection of evolving faults		
Four independent parameter sets		

Table 35. Synchrocheck 25 (RSYN)

Function/ Parameter	Range/Value	Accuracy
Max. voltage difference	0.05 to 0.4 UN in steps of 0.05 UN	±1.0% of UN
Reset ratio, Max. voltage difference	>90%	
Min. voltage	0.6 to 1 UN in steps of 0.05 UN	±2.0% of UN
Reset ratio, Min. voltage	>95%	
Max. voltage	0.1 to 1 UN in steps of 0.05 UN	±2.0% of UN
Reset ratio, Max. voltage	<105%	
Max. phase difference	5 to 80° in steps of 5°	±1.0 degrees
Max. frequency difference	0.05 to 0.4 Hz in steps of 0.05 Hz	±40 mHz
Supervision time	0.05 to 5 s in steps of 0.05 s	±40 ms
Resetting time	0 to 1 s in steps of 0.05 s	±60 ms
Determination of synchronism Single phase measurement. The differences between the amplitudes, phase-angles and frequencies of two voltage vectors are determined.		
Voltage supervision Single or three-phase measurement Evaluation of instantaneous values and therefore wider frequency range Determination of maximum and minimum values in the case of three-phase inputs		
Phase selection for voltage inputs		
Provision for switching to a different voltage input (double busbar systems)		
Remote selection of operating mode		
Four independent parameter sets		

Recording facilities

Table 36. Event recorder

Event recorder	Bay unit	Central unit
System events Protection events Test events	100	1000
User activity events	-	2048

Table 37. Disturbance recorder (RDRE)

Options	Analogue channel	fn	Recording period Sample rate selectable		
	4 currents and 5 voltages	50 Hz 60 Hz	4000 Hz 4800 Hz	2000 Hz 2400 Hz	1000 Hz 1200 Hz
Standard	X	-	1.5 s	3 s	6 s
Extended	X	-	20 s	20 s	20 s
Number of disturbance records = total recording time / set recording period (max.40) Buffer overflow behavior is first in first out.					
Independent settings for pre-fault and post-fault period (min. setting 200 ms).					
Format: COMTRADE 99					

Table 38. Central disturbance recorder (RDRE)

Options	Analogue channels	Recording period (sample rate fixed)
Standard	X	1.5 s
Extended	X	20 s
Recording of differential and restraint currents and optional of max. phase differences per current phase (max. 4) and per bus zone (max. 32)		
Number of disturbance records = total recording time / set recording period (max.40) Buffer overflow behavior is first in first out.		
Independent settings for pre-fault and post-fault period (min. setting 200 ms).		
Format: COMTRADE 99		

Station communication

Table 39. Station communication protocols

IEC 61850-8-1	
IEC 61850-8-1 supports	• Edition 1 and Edition 2 of the standard, configurable in HMI • Time synchronization via SNTP: typical accuracy ± 1 ms • Two independent time servers are supported. Server 2 is used as backup time • Optical connection • Differential current of each protection zone • Monitoring information from REB500 central unit and bay unit • Binary events (signals, trips and diagnostic) • Trip reset command • Single connection point to REB500 central unit • Disturbance recorder access for bay unit and central unit via MMS file transfer protocol • Export of ICD - file, based on Substation Configuration Language SCL • GOOSE reception for use as BFP start signals
IEC 60870-5-103	
IEC 60870-5-103 supports	• Time synchronization: typical accuracy ±5 ms • Optical connection 9600 or 19200 Bd • Subset of binary events as specified in IEC Private range: Support of all binary events Generic mode: Support of all binary events • Trip reset command • Disturbance recording data (bay unit only)
Address setting of station address	0...254
Sub address setting, common address of ADSU	0...255 (CAA) CAA per bay unit freely selectable

Hardware IED

Table 40. Degree of protection of rack-mounted IED

Description	Value
Front side	IP 40
Rear side, connection terminals	IP 20

Table 41. Degree of protection of the LHMI

Description	Value
Front side	IP40

Table 42. Dimensions of the IED – 6U ½ 19" Bay Unit / 6U ¾ 19" Central Unit

Description	Value Bay Unit	Value Central Unit
Width	220 mm (8.66 inches)	330 mm (13 inches)
Height	265.9 mm (19.47 inches), 6U	265.9 mm (19.47 inches), 6U
Depth	224 mm (8.82 inches)	224 mm (8.82 inches)
Weight box	8 kg (<16.64 lbs)	10.5 kg (<23.15 lbs)
Weight LHMI	1.3 kg (2.87 lbs)	1.3 kg (2.87 lbs)

Mounting

Table 43. Cubicle design

Description	Type		
Cubicle	Standard type RESP97 (for details see 1MRB520159-BEN)		
Dimensions w x d x h	800 x 800 x 2200 mm (single cubicle) 1600 x 800 x 2200 mm (double cubicle) 2400 x 800 x 2200 mm (triple cubicle) *) *) largest shipping unit		
Total weight (with all units inserted)	approx. 400-600 kg per cubicle		
Clearance between IEDs	2U (vertical)		
Terminals	Terminal type	Connection data	
		Solid	Strand
CTs	Phoenix URTK/S	0.5 .. 10 mm^2	0.5 .. 6 mm^2
VTs	Phoenix URTK/S	0.5 .. 10 mm^2	0.5 .. 6 mm^2
Power supply	Phoenix UK 6 N	0.2 .. 10 mm^2	0.2 .. 6 mm^2
Tripping	Phoenix UK 10-TWIN	0.5 .. 16 mm^2	0.5 .. 10 mm^2
Binary I/Os	Phoenix UKD 4-MTK-P/P	0.2 .. 4 mm^2	0.2 .. 2.5 mm^2
Internal wiring gauges			
CTs	2.5 mm^2 stranded		
VTs	1.5 mm^2 stranded		
Power supply	1.5 mm^2 stranded		
Binary I/Os	1.5 mm^2 stranded		

13. Ordering for customized IED

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.

Central Unit Order Code rules

Software option	multiple selection is possible
LHMI language and LHMI additional language	selection must be combined
Connection type and Power Supply	selection must be combined

Bay Unit Order Code rules

Software option	multiple selection is possible
Connection type and Power Supply	selection must be combined
Analogue input and Analogue connection	selection must be combined

Ordering code Central Unit

Example: REB500* 8.3 - CU04 - S10 A1A2 - B1X0 - E K - SA A - F - A A - A C

REB500* 8.3 - CU04 - S - B1X0 - E - - F - A - A C

see cont'd

Software	
Version 8.3	8.3

Product variant	
Distributed busbar protection	CU04

Software options	
Protection system up to 10 BU	S10
Protection system up to 20 BU	S20
Protection system up to 30 BU	S30
Protection system up to 40 BU	S40
Protection system up to 50 BU	S50
Protection system up to 60 BU	S60

Communication	
No communication	X0
IEC 61850-8-1	A1
IEC 60870-5-103	A2

LHMI first language	
English IEC / German / French	B1

LHMI additional language	
No additional HMI language	X0

Casing	
Rack casing 6U 3/4 x 19”	E

Mounting details	
No mounting	X
Rack mounting kit for 6U 3/4 x 19”case	K

Connection type for Power supply, I/O and Communication modules	
Compression terminals	S
Ringlug terminals	R

Power supply	
PSM03: 100VAC-240VAC, 110VDC-250VDC	A
PSM02: 48VDC-125 VDCs	B

Power supply (redundant)	
No redundant power supply	X
PSM03: 100VAC-240VAC, 110VDC-250VDC	A
PSM02: 48VDC-125VDC	B

Human Machine Interface	
LHMI: OL5100, IEC 6U ¾ 19”, Basic	F

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Example: REB500* 8.3 -CU04 - S10 A1A2 - B1X0 - E K - SA A - F - A A - A C

REB500* 8.3 -CU04 - S - B1X0 - E - - F - A - A C

Binary inputs / outputs	
9 binary inputs and 19 binary outputs	A
No additional inputs/outputs	X
Additional 9 binary inputs and 9 binary outputs	A

Communication and processing module	
CPM: IRIG-B, RS485, Ethernet, LC optical, ST connector	A
CPM: IRIG-B, RS485, 3 Ethernet LC optical, ST serial, ST PPS slave	C

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Ordering code Bay Unit

Example: REB500 * 8.3 - BU04 - C1C2C5D1 - B1X0 - C A - SA A - A X0 - SA3 - A - A

REB500 * 8.3 - BU04 - - B1X0 - C - - - - A - A

see cont'd

Software	
Version 8.3	8.3

BU - Product variant	
Distributed busbar protection	BU04

Software options	
No Option	X0
Current protection	
Breaker failure protect.	C1
End fault protection	C2
Overcurrent protection	C3
Pole discrepancy	C4
Overcurrent release	C5
Neutral current measurement for BBP	C6
Voltage protection:	
Undervoltage release	D1
Multipurpose protection:	
Bay protection L-V2	F2
Bay protection L-V4	F4

LHMI first language	
English IEC / German / French	B1

LHMI additional lang.	
No additional HMI language	X0

Casing	
Rack casing 6U ½ x 19"	C

Mounting details	
No mounting	X
Rack mounting kit for 6U 1/2x19" case	A
Flush mounting kit 6U 1/2x19" case	E
Wall mounting bracket	G

Connection type for Power supply, I/O and Communication modules	
Compression terminals	S
Ringlug terminals	R

Power Supply	
PSM03: 100VAC-240VAC, 110VDC-250VDC, 9BO	A
PSM02: 48VDC-125 VDC, 9BO	B

Power Supply (redundant)	
No redundant power supply	X
PSM03: 100VAC-240VAC, 110VDC-250VDC	A
PSM02: 48VDC-125 VDC	B

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Example: REB500 * 8.3 - BU04 - C1C2C5D1 - B1X0 - C A - SA A - A X0 - SA3 - AX - A

REB500 * 8.3 - BU04 - - - - - - - A - A

Human machine interface	
No LHMI	X
LHMI: OL3000, IEC 6U 1/2 19", Basic	A

Detached Local human machine interface	
No detached mounting of LHMI	X0
Detached mounting of LHMI incl. Ethernet cable, 1m	B1
Detached mounting of LHMI incl. Ethernet cable, 2m	B2
Detached mounting of LHMI incl. Ethernet cable, 3m	B3
Detached mounting of LHMI incl. Ethernet cable, 4m	B4
Detached mounting of LHMI incl. Ethernet cable, 5m	B5

Connection type for analog modules	
Compression terminals	S
Ringlug terminals	R

Analog input module	
TRM01: 4I, 1/5A + 1I, 0.1/0.5A +5U, 100/220V	A3
TRM01: 4I, 1/5A	A5

Binary input / output module		
21 binary inputs and 19 binary outputs	A	
No additional inputs and outputs		X
Additional 12 binary inputs and 6 precision binary outputs (PIO01 module)*		P

Communication and processing	
CPM: IRIG-B, RS485, Ethernet, LC optical, ST connector	A

* PIO01 module (Option P) is only available in combination with analog input module TRM01: 4I, 1/5A + 1I, 0.1/0.5A +5U, 100/220V (Options SA3/RA3)

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Order code Switches/Transceivers

Switch AFS677: x 1MRK010500-

System				
up to 14 BU	1	n BU's	+2 =	
up to 26 BU	2	n BU's	+6 =	
up to 40 BU	3	n BU's	+8 =	
up to 54 BU	4	n BU's	+10 =	
up to 60 BU	5	n BU's	+12 =	

Transceiver x 1MRK010501- AA

Switch data	
24/36/48V DC no redundant power supply module	AA
24/36/48V DC redundant power supply module	BA
110/250 V DC / 110/230 V AC no redundant power supply module	CA
110/250 V DC / 110/230 V AC redundant power supply module	DA

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Remark: All switches of the system shall be from the same type (same order number) Technical details of the switch are listed in the respective manual 1KHD641605.

Example for a system with 26 Bay Units:

Switch AFS677: 2 x 1MRK010500- CA | **Transceiver 32 x 1MRK010501- AA**

System					
up to 26 BU	2	n BU's	26	+6 =	32

Switch data	
110/250 V DC / 110/230 V AC no redundant power supply module	CA

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For details about REB500 process bus/switch configuration, see Section 8.

Accessories

Table 44. Available Accessories and engineering facilities

Equipment	Ordering no
Rack mounting kit 6U 3/4x19" case	1KHL400527R0001
Rack mounting kit 6U 1/2x19" case	1KHL400239R0001
Two rack mount kit 6U 1x19" case	1KHL400240R0001
Flush mounting kit 6U 1/2x19" case	1KHL400228R0001
Wall mounting bracket	1KHL400317R0001
Product media (USB Stick) HMI500 Operator ver. 8.3 including user documentation, LED label template	1MRK010010-AE
Product media (USB Stick) HMI500 Configurator ver. 8.3 including user documentation, LED label template	1MRK010011-AE
Front connection cable between LCD-HMI and PC	1MRK001665-CA
LED Label special paper A4	1MRK002038-CA
LED Label special paper Letter	1MRK002038-DA

14. Manuals

Manual	Document number
Product guide	1MRK 505 402-BEN
Application manual	1MRK 505 399-UEN
Technical manual	1MRK 505 400-UEN
Operation manual	1MRK 500 132-UEN
Engineering manual	1MRK 511 452-UEN
Commissioning manual	1MRK 505 401-UEN
Application manual for bay protection functions	1MRK 505 403-UEN
Technical manual for bay protection functions	1MRK 505 406-UEN
Cyber security deployment guideline	1MRK 511 453-UEN
Communication protocol manual IEC 61850	1MRK 511 450-UEN
Communication protocol manual IEC 60870-5-103	1MRK 511 451-UEN
Getting started guide	1MRK 505 404-UEN

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