The IED shall include hardware, time synchronization, monitoring, communication capabilities and other specifications as described in the 1MRG033859_en_Sample_specification_General_specifications_REB500 document.

For a complete overview of functions available in this device, please refer to the Product Guide. For more details about the design of the functions and their applications, please refer to the Technical Manual and the Application Manual respectively.

The functions described in this document are available only in REB500.

**General description for busbar protection**

The IED shall be applicable for installation in medium-voltage (MV), high-voltage (HV) and extra-high voltage (EHV) substation installations at a power system frequency of 50Hz or 60Hz. The IED shall have phase-segregated measurement and provide fast, selective security for the protected object. The IED shall be adaptable dynamically to most common busbar configurations, and facilitate efficient merging of differential zones when required by substation topology during zone interconnection or during load-transfer conditions. The built-in software-based zone selection shall provide dynamic linking between CT inputs and differential protection zones, while selectively routing back zone trip signals to individual bay circuit breakers. The IED shall be able to include or exclude measured currents from differential zones, and the differential protection shall be integrated with so-called dynamic zone selection to adapt dynamically to the changing topology of the substation for multi-zone application.

The IED shall be intended for protection and monitoring of the busbar, T-connection and meshed corner, and provide selective, reliable and fast fault clearance for all types of internal phase-to-phase and phase-to-earth faults in solidly earthed or low-impedance earthed power systems, as well as all internal multi-phase faults in isolated or high-impedance earthed power systems. For detection of earth-faults in low impedance grounded systems, the IED shall include a separate sensitive differential protection which should be released from, for example, open delta voltage, and be blocked at heavy phase to phase faults. In high impedance grounded systems, the IED shall detect multi-phase faults. The IED shall be equipped with differential element-measuring zones, and check the zone as well as the possibility of integrating breaker failure protection and end-fault protection for every CT input. It shall be possible to select the CTs which should be connected to the check zone, and it shall also be possible, by setting, to switch off the check zone. The IED shall have the option to connect VT inputs to enable voltage-based protections and directional features.

The IED shall have low requirements on the main current transformers, and no interposing CT shall be necessary. It shall be possible to have a ratio difference of up to ten for the CTs connected to the same protection zone. No switching in CT secondary circuits is allowed. The IED shall include a function for fast detection of open or shorted CT secondary circuits and it shall be possible to set the function to block the differential protection zone, or switch it off. The relay shall include an automatic detection feature and selective busbar protection blocking for trouble in CT secondary circuits.

The zone selection should also handle load transfer for double/triple/quadruple busbars, and routing of trip commands from differential protection and breaker failure back-up trip to all breakers connected to the faulty zone. Selective operation of busbar differential protection shall ensure tripping of only the faulty part of the busbar system. The operate time for internal faults shall be typically less than a power cycle, and the differential protection shall be stable for through faults even at heavy CT saturation, and also at maximum remanence in a CT core and auto-reclosing. The breaker failure protection shall feature fast resetting, allow single and/or three-phase starting, perform re-trip of the breaker after a short, settable time delay, and perform a back-up trip of surrounding breakers. The end fault protection shall be activated when the breaker has been opened.
The offered relay shall support the following requirements:

- For a fault to be reliably and isolated without delay, the healthy bus section shall not be tripped.
- When the busbar current stabilized percentage differential current and the phase (directional) comparison of currents in the respective bay units are fulfilled:
  - during the closing movement of the isolator, NO contact shall close before the isolator main contact gap reaches its flashover point
  - during the opening movement of the isolator, NO contact shall not open until the isolator main contact gap has exceeded its flashover point

The busbar protection shall be insensitive to transients and harmonics, and fully reliable and selective even under extreme CT saturation conditions.

The busbar protection shall be capable of operating with CT’s having widely different ratios and with different rated secondary currents. The matching of CT ratios in each bay shall be done by a simple setting via the HMI without the use of external auxiliary CT’s.

To enhance security, the busbar protection scheme shall have two independent measurement and tripping criteria. A trip signal is only to be initiated if both criteria are fulfilled. Preferably, the two criteria shall be the current stabilized percentage differential current and the phase (directional) comparison of currents in the different bays.

For impedance grounded networks where busbar phase-ground faults cannot always be detected using settings necessary for detecting phase-phase faults, a separate neutral current Io measurement criterion shall be included. The system shall ensure that the Io measurement criterion is not evaluated for phase-phase faults.

It must be possible to set the busbar protection to pick up at 120% of the full load current or 80% of the minimum busbar short-circuit current (the busbar protection is usually set to the lower of these two values).

Stability during external faults shall be ensured under the following conditions:
- up to the short circuit ratings of the switchgear, irrespective of the distribution of the current between individual circuits
- under heavy CT saturation in any of the outgoing feeders

When the bus-tie breaker is equipped with only one set of CT’s and the breaker is in the open position, the busbar protection shall exclude this CT from evaluation in the busbar protection measurement. This will ensure that for a fault occurring between the CT and the open breaker, the faulted bus section will be tripped selectively and isolated without delay. The healthy bus section shall not be tripped.

For REB500 8.2 Specific
The offered relay shall support a maximum of up to 32 zones, 60 bays, and distributed solution...
The busbar differential protection function should consist of multiple protection algorithms:
- stabilized differential current measurement principle
- phase comparison measurement principle
- different CT ratios should be supported by the offered relay

As well as various release criterions:
- check zone algorithm,
- open CT detection
- undervoltage/overvoltage release
- via binary inputs

**Differential busbar protection**

The IED shall be based on the well-proven percentage restraint stabilization principle, with an extra stabilization feature for very heavy CT saturation. Stability for external faults shall be guaranteed if a CT is not saturated for at least two milliseconds during each power system cycle. All current inputs shall be indirectly provided with a restraint feature. The busbar differential protection function shall be intended for fast and selective tripping of faults within the protected zones. The busbar differential protection function shall operate on at least two different algorithms (for example “Stabilized differential current measurement principle” and “Phase comparison measurement principle”).

**Neutral current detection I₀**

For impedance grounded networks where busbar phase-ground faults cannot always be detected using settings necessary for detecting phase-phase faults, a separate neutral current I₀ measurement criterion shall be included. The system shall ensure that the I₀ measurement criterion is not evaluated for phase-phase faults.

It must be possible to set the busbar protection to pick up at 120% of the full load current or 80% of the minimum busbar short-circuit current (the busbar protection is usually set to the lower of these two values). Stability during external faults shall be ensured under the following conditions:
- up to the short circuit ratings of the switchgear, irrespective of the distribution of the current between individual circuits
- under heavy CT saturation in any of the outgoing feeders

**Check zone**

The IED shall have an integrated overall differential zone, a so-called check zone, as an inbuilt feature to secure stability of the busbar differential protection mainly for multiple busbar stations. At the same time, this check zone feature shall avoid unwanted operation of the differential protection scheme. The built-in check zone current measurement shall not be dependent on the disconnector status, this feature shall ensure stability of Busbar differential protection even for completely wrong status indication from the busbar disconnectors or in case of problem with disconnector auxiliary contacts or stuck contacts or wiring problems. The overall check zone shall only supervise the usual differential protection operation. The external trip commands, breaker failure backup-trip commands and sensitive differential protection operation are not supervised by the overall check zone. The overall check zone shall have a simple current operating algorithm, which ensures check zone operation for all internal faults regardless of the fault current distribution. The check zone operation principle shall use a slightly different operating characteristic compared to the usual discriminating zones. The check zone minimum differential operational level shall be kept equal to or less than the corresponding operating level of the usual discriminating zones. The check zone operation shall have the option to activate externally by a binary signal. The inbuilt check zone feature shall be more essential for busbar protection in stations with double or triple busbars when dynamic zone selection is needed.

**Differential protection supervision**

Monitoring of differential protection status is available. The monitoring feature operates after a settable time delay when the differential current is higher than the user settable level.

**Zone selection**

Typically, all CT secondary circuits from every bay in the station are connected to the busbar protection. The IED shall have a built-in software feature called “Zone Selection” which provides a simple but efficient control over the connected CTS to the busbar protection IED in order to supply a fully operational differential protection scheme for multi-zone applications on both small and large buses.
Switch status monitoring

The IED shall have inbuilt switch status monitoring. The information about busbar disconnector position in every bay is crucial information to provide busbar protection in stations with a complex primary layout. The positions of these disconnectors then actually determine which CT input (that is, bay) is connected to which differential protection zone. For some more advanced features like end-fault or blind-spot protection, the actual status of the circuit breaker in some or even all bays can be vital information for busbar protection as well. The switch function block shall be used to take the status of two auxiliary contacts from the primary device, evaluate them and then deliver the device primary contact position to the rest of the zone selection logic. For such applications, typically two auxiliary contacts (that is, normally open and normally closed auxiliary contacts) from each relevant primary switching object shall be connected to the IED. Then the status for every individual primary switching object will be determined. The IED shall have a time-delayed disconnector/circuit breaker status supervision alarm. The behavior of the integrated differential protection zones when the disconnector alarm appears shall be freely configurable in the IED. It shall be possible by a parameter setting to override the primary object status as either permanently open or permanently closed.

Zone interconnection (load transfer)

The IED shall have a feature known as zone interconnection. When this feature is activated, the two integrated differential protection zones shall merge into one common overall differential zone. This feature shall be applicable in double, triple as well as quadruple busbar stations when in any of the feeder bays, both busbar disconnectors are closed at the same time (that is, load transfer). This feature can be started automatically (when zone selection logic determines that both busbar disconnectors in one feeder bay are closed at the same time) or externally via dedicated binary signal. If this feature is active for long, the IED shall issue an alarm signal at a preset time.

Trip command redirection for SF6 circuit breakers

The protection system shall include a trip command redirection. In an SF6 gas-insulated circuit breaker, a dangerous situation might occur due to insufficient operating pressure. The circuit breaker is then blocked and, in the event of a fault, the circuit breaker cannot open. This information should be available in the protection system. As soon as a trip command is given, all allocated feeders in that protection zone receive direct intertripping, and a remote trip is send to the opposite connected breaker to clear the fault without any time delay.

Logic and delay/integrator

The protection system shall offer simple logic functions at the bay units to enable logical combinations of signals to be created (AND, OR, RS-FF). A delay/integrator shall allow the pick-up and reset of binary signals to be delayed before being displayed or used to control other functions.

[OPTIONAL] Breaker failure protection

The IED shall include breaker failure protection to ensure fast backup tripping of surrounding breakers, in the event its own breaker fails to open. It shall be current-based, contact-based or an adaptive combination of these two conditions.

Breaker failure protection shall be initiated from the protection trip command, either from the internal protection function trip signal or from an external protection trip signal. 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, e.g. by the line protection, transformer protection etc.

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 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.

The phase selective start signal shall enable single pole retrip function. The retrip function can be done with or without current check. With current check, the retrip is only performed if the current through the circuit
breaker is larger than the set operating current level. The function detects the successful breaker opening, either by detecting low current through RMS evaluation and a special adapted current algorithm, or by open contact indication. The special algorithm enables very fast detection of a successful breaker opening, that is, a fast resetting of the current. A current check with extremely short reset time is used as a check criterion to achieve high security against unwanted operation, or contact check criteria can be used where the fault current through the breaker is small. If the current and/or contact detection has not detected a breaker opening before the backup timer has run its time, a backup trip is initiated. It shall be single or three-phase initiated to allow use in single phase tripping applications.

**[OPTIONAL] End-fault protection**

The protection system shall include an end-fault protection function for detecting and clearing faults between an open circuit breaker and its associated CT.

- If the CT is situated on the feeder side (CB on bus side):
  - If a fault develops between the open circuit breaker and the CT, the busbar protection shall not be involved. On detecting a fault, however, the end-fault protection shall send a signal instantly to the remote end of the feeder, in order to trip the remote-end infeed and hence clear the fault.
- If the CT is situated on bus side (CB on line side):
  - A fault between the CT and the open circuit breaker shall be cleared by the End Fault Protection via a further trip command that is instantly sent to the adjacent breakers connected to the same bus zone. This ensures the switchgear and connected equipment are not exposed to fault current for an unnecessarily long time, thereby prolonging their life.

**[OPTIONAL] Breaker-pole discrepancy protection**

Circuit-breaker pole discrepancy protection shall be incorporated in the bay unit and shall supervise the simultaneous opening and closing of the three circuit breaker poles. Pole discrepancy shall evaluate the phase currents as well as the position of the circuit-breaker auxiliary contacts.

**[OPTIONAL] Bay protection**

The system shall include protection functions to safeguard line feeders for single, double, triple and quadruple busbar configurations, as 'main 2' or 'backup-protection' for feeders, and it shall be suitable for use at all voltage levels, from MV to EHV.

Bay protection shall function correctly independent of the central unit, i.e., even if communication to the central unit fails, bay protection shall remain unaffected and in service. Furthermore, it shall be possible to make changes to the protection setting values independent of the central unit.

Bay protection shall support up to four parameter sets.

**[OPTIONAL] Bay protection: distance protection**

Distance protection shall comprise the functionality commonly available in stand-alone distance relays, such as:

- Overcurrent and underimpedance starting
- Five measurement zones each for forward or backward measurement
- Overreach and backward zones for a teleprotection scheme
- Single- and three-pole tripping, short-zone (STUB) protection
- VT supervision, power swing blocking
- Switch on to fault (SOTF) protection as well as customary teleprotection schemes, such as PUTT (permissive underreaching transfer trip), non-directional, forward or overreaching, POTT (permissive overreaching transfer trip), and blocking schemes (BLOCK).

A 6-loop measurement shall be included for fast detection and clearance of evolving faults. The ground fault situation shall be detected by the zero sequence of the voltage and/or by the zero and negative sequence of the currents. Each zone shall be independently settable. Zero sequence compensation shall also be settable independently for each zone.

The distance protection shall be prepared with error compensation of the PT inputs for fast tripping and precise measuring even with very high SIR and phase-to-phase faults.
For transmission of very high load, the distance protection shall be applicable to sources with varying load angles.

The typical tripping time shall be less than 25ms.

**[OPTIONAL] Bay protection: direct sensitive EF protection for grounded systems**

The directional sensitive EF protection for grounded systems shall detect high-resistance faults in solidly or low-resistance grounded networks. The protection shall be based on the measurement of the neutral current and voltage. The communication scheme with the remote station shall be either a permissive or blocking mode.

It shall be possible to combine signaling to the remote station for distance and directional earth fault protection in one common communication channel, or to use it separately.

**[OPTIONAL] Bay protection: three-phase autoreclosure**

The autoreclose function shall permit up to four three-phase reclosure cycles to be carried out. There shall be independently adjustable dead times for fast and slow autoreclose cycles. Where single-phase reclosure is being applied, the first reclosure cycle shall be set to single-phase, and the others to three-phase.

**[OPTIONAL] Bay protection: synchro-check**

In order to check synchronization criteria of two parts of an electrical system, thereby enabling them to be switched together, a synchro-check function shall measure the amplitudes, phase angles and frequency of two voltage vectors.

Checks for dead line, dead bus, dead line and bus shall also be included.

**[OPTIONAL] Bay protection: definite time-over and undercurrent protection**

The protection system shall offer overcurrent protection with a definite time delay for feeder backup protection, with either single or three-phase measurement. It shall also be possible to use this protection function as undercurrent protection.

**[OPTIONAL] Bay protection: directional overcurrent definite time protection**

The protection system shall offer directional overcurrent protection with a definite time delay for backup protection, e.g., for ring feeders. This protection shall be based on the measurement of the phase currents and the line voltages. A voltage memory shall be included for correctly tripping close-in faults.

**[OPTIONAL] Bay protection: inverse time overcurrent protection**

The protection system shall offer overcurrent protection with normal inverse, very inverse, extremely inverse and long-time inverse characteristics according to British Standard 142 (IEC60255-3), as well as the RXIDG characteristic (settable).

**[OPTIONAL] Bay protection: inverse time earth fault overcurrent protection**

The protection system shall offer earth fault overcurrent protection with normal inverse, very inverse, extremely inverse and long-time inverse characteristics according to British Standard 142 (IEC60255-3), as well as the RXIDG characteristic (settable).

The function shall be configurable, to work with an external 3I0 current input, or with an internally derived signal from the addition of the relevant phase currents.
[OPTIONAL] Bay protection: definite time-over and undervoltage protection

The protection system shall offer overvoltage protection with a definite time delay, with either single or three-phase measurement. It shall also be possible to use this protection function as undervoltage protection.

[OPTIONAL] Bay protection: three-phase current plausibility

The protection system shall offer a function to detect system asymmetries, e.g. in the secondary circuits of CT’s. The functions shall check the sum and the phase sequence of the three phase currents.

[OPTIONAL] Bay protection: three-phase voltage plausibility

The protection system shall offer a function to detect system asymmetries, e.g. in the secondary circuits of VT’s. The functions shall check the sum and the phase sequence of the three phase voltages.