The IED shall comprise hardware, time synchronization, monitoring, communication capabilities and other specifications as described in the 1MRG033843_en_Sample_specification_General_specifications_Relion_670 document.

For a complete overview of the 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 listed below are designed specifically for railway applications, and they can be specified only in RER670.

**Catenary line distance protection**

The IED shall include 5 zone catenary distance protection with quadrilateral characteristic and one measurement loop. It shall be possible to use the function both in AT and BT catenary system. Each zone shall have independent reach settings in forward and reverse direction (i.e. non-symmetrical zones). Each zone shall have user selectable orientation: forward, reverse or non-directional. Zone orientation shall be selectable by a parameter setting.

The line distance protection has to be able to provide sub-cycle trip times, as defined per IEC 60255-121.

The line distance protection shall have a non-tripping load resistance area (load encroachment). It shall have a settable load angle and resistance determining the load impedance area.

All zones with a delayed trip time shall have the possibility of selecting either the pickup from the own zone or the first starting zone as a start trigger for the trip timer.

It shall be possible to enable operation of all zones by external signal (e.g. operation of the current delta feature)

**2-Ph distance protection for HV railway supply lines**

The IED shall include 6 zone line distance protection having quadrilateral characteristic. Each zone shall have independent reach settings in forward and reverse direction (i.e. non-symmetrical zones). Each zone shall have user selectable orientation: forward, reverse or non-directional. Zone orientation shall be selectable by a parameter setting. It shall be possible to use this function for all earthing types in 2-phase power networks.

The starting element with settable circular or quadrilateral characteristic shall be available.

The line distance protection has to be able to provide sub-cycle trip times, as defined per IEC 60255-121.

The line distance protection shall fulfill the full-scheme protection concept.

The line distance protection shall have parameter settings for positive sequence reactance and resistance and RE/RL and XE/XL factors for each zone. It shall have separate operating timers for phase to ground and for phase to phase faults, for each zone. Each zone shall be possible to parameterize fully independent from any other starting or operating element.

The line distance protection shall have a non-tripping load resistance area (load encroachment). It shall have a settable load angle and resistance determining load impedance area.
All zones with a delayed trip time shall have the possibility of selecting either the pickup of the starting element or the first starting zone as a start trigger for the trip timer. All time delayed zones shall have the possibility for zone and/or loop linked start. This means that any fault type in any zone or fault loop can trigger all timers in all time delayed zones. This shall be available to provide faster operating times for evolving faults. The choice whether the timers shall be linked or independent shall be available by a parameter setting.

The line distance protection shall have the possibility of CVT type selection, in order to secure reliable operation of the line distance protection during CVT transients. This choice of CVT type shall be available by a parameter setting.

At least one line distance protection zone has to be equipped with a load compensation algorithm.

**2-Ph/1-Ph under-impedance protection for transformers**

The IED shall include 3 zone under-impedance protection having either non-directional quadrilateral or offset mho characteristic. Each zone shall have independent reach settings in forward and reverse direction (i.e. non-symmetrical zones). It shall be possible with help of additional logic to use this function as Wrong Phase Coupling protection.

**Switch onto fault**

The IED shall include a dedicated function for switch onto fault detection. This function shall issue an instantaneous trip if a non-directional overreaching zone picks up, or if an integrated undervoltage and overcurrent detector picks up, or if any of the two picks up, while the function is active. It shall be selectable by a parameter which principle shall be applied. The thresholds for the integrated undervoltage and overcurrent detector shall be configurable by a parameter setting. The function shall contain the following possibilities, configurable by the end user, that define when the function will be active:

- It shall monitor the circuit breaker position indication status, and be active whenever the circuit breaker is open, and for a set time after the circuit breaker is closed.
- It shall have the possibility to be active only for a set time after the circuit breaker close command is issued.
- It shall have the possibility to be active whenever an internal detector based on undervoltage and undercurrent declares that the line is not energized. Also, the function shall be active for a set time after the internal detector detects that the line was energized.
- It shall be capable of combining the explained principles and using them in parallel.

**Fuse failure supervision**

The IED shall contain a fuse failure supervision function, in order to avoid inadvertent operation of voltage dependent functions when a failure in the voltage measurement circuit occurs.

The fuse failure function shall comprehend of the following:

- Monitoring of the status of a MCB or a fuse protecting the secondary wiring of the VT.
- Detection of failure of voltage measurements based on change in voltage ($\Delta U$), without change in current ($\Delta I$). The levels of $\Delta U$ and $\Delta I$ shall be settable by a setting parameter.

**Communication scheme for line distance and residual overcurrent protection**

The IED shall include line distance communication schemes, including permissive overreach, permissive underreach, intertripping and blocking schemes.

The IED shall include a communication scheme and logic for weak-end infeed. This logic shall be used for lines with a strong infeed on one side and with a weak infeed on the remote line end, or for radial lines. This logic shall enable an overreaching zone to trip instantaneously if the weak infeed line end does not detect the fault.

The IED shall include current reversal logic for parallel lines that apply an overreaching permissive communication scheme, to avoid unselective tripping due to current reversal.
Fault locator
The IED shall have an accurate fault locator based on local impedance measurements, giving the distance to the fault in km or % of line length. The fault locator shall have a static accuracy of 2%, when the voltage is between 0.1 and 1.1 times rated voltage, and when the current is from 0.5 to 30 times rated current for 50Hz/60Hz railway systems.

Transmission lines that consist of up to ten sections with differences in the line parameters shall be supported. It shall be freely configurable which protection functions should trigger a fault locator calculation.

The measured phase impedance shall have the possibility to be reported to a client over MMS communication as per IEC 61850-8-1.

Single-phase railway power transformer differential protection
The IED shall include a single-phase transformer differential protection function, with a biased operate / restrain characteristic, internal CT ratio matching and settable zero sequence current elimination. The bias current shall be the highest among the measured currents. Two instances of the function shall be available.

The differential operate characteristic shall have two main areas: the restrained area, and the unrestrained area.

- The restrained area shall be defined by a settable dual slope operate/restrain characteristic.
- The unrestrained level shall have a constant pickup value, irrespective of the bias current. It shall be selectable from 0.5 up to 20 times of the base current.
- If a substantial amount of the 2nd or 5th harmonic is detected, the restrained operation of the function shall be blocked. The levels of 2nd or 5th harmonic required for blocking the operation shall be settable by the end-user. Waveform blocking shall be available to facilitate protection of new power transformer utilizing modern core still materials with very low losses.

In addition, the transformer differential protection shall include the following features:

- The differential protection shall have the possibility to temporarily desensitize by temporarily adding a DC component to the pickup level of the protection. The DC component shall be extracted from the measured instantaneous differential currents and the highest DC in all three phases shall be selected to be added to the pickup level. This feature shall be settable by a parameter setting.
- The function shall include an internal/external fault discriminator based on directional comparison principle. This feature shall be well coordinated with other features of the differential protection, in order to provide more stability and dependability for internal faults, external faults, and evolving faults.
- This function shall include additional feature for detecting low turn-to-turn faults. This feature shall be able to issue a trip without the operating point being in the restrained area.

Low-impedance restricted earth fault protection
The IED shall include restricted earth fault protection of the low impedance type, for directly or low impedance earthed windings. The function shall include internal CT ratio matching, and shall be able to cover railway auto-transformers.

The operating characteristic shall be defined by a dual slope restrain characteristic.

The protection shall have an internal/external fault discriminator based on the zero-sequence currents, and this functionality shall be automatically activated if the residual current measured at the winding HV terminals is sufficiently high. It shall have a settable angle defining the area in which zero the sequence current phasors have to be positioned in order to declare an internal or external fault.

Thermal overload protection, one time constant, temperature in Celsius
The IED shall include thermal overload protection with an I²t characteristic, a heating/cooling time constant and a thermal memory. The temperature shall be displayed in degrees Celsius. The function shall be able to measure the ambient temperature connected to the function using a mA input. The function shall have the possibility to issue a lockout for closing the breaker until the heat content reduces below a lockout reset level.
setting. The heating time constant, a separate alarm, warning and trip level shall be settable. The initial heat content shall be settable by the end user.

**Breaker failure protection**

The IED shall include breaker failure protection, to ensure fast backup tripping of the surrounding breakers in case the own breaker fails to open. It shall be current-based, contact-based or an adaptive combination of these two conditions. A current check with extremely short reset time shall be used to achieve high security against unwanted operation. The reset time shall be 15ms maximum for 50Hz/60Hz systems.

A contact check criterion can be used where the fault current through the breaker is small. Initiation shall be from an internal or external protection trip signal.

The re-trip function can be done with or without current check and also with or without contact position check. With the current check, the re-trip shall only be performed if the current through the circuit breaker is larger than the set operating current level.

A backup trip shall be initiated if the current and/or contact detection has not detected breaker opening once the back-up timer has elapsed.

**Directional phase over current protection**

The IED shall have the option of selecting the measured current and voltage signal used by overcurrent protection.

The IED shall include directional over current protection with two steps. The first step with either inverse (IDMT) or definite (DT) time delay characteristics and the second step with definite (DT) time delay characteristics only.

The operate current shall be settable between 5 – 1200% of the rated current (I₀). The accuracy of the operate current shall be at least ± 1.0% of I₀.

The function shall be possible to set directional or non-directional, independently for each of the steps. The directional function shall require voltage as reference quantity for polarization. To enable directional measurement at close-in faults, causing a low measured voltage, the polarization voltage shall be a combination of the apparent voltage and the memory voltage. The directionality criterion shall have an accuracy of at least ± 2.0 degrees.

In order to avoid unwanted operation of the protection function during transformer energization, the IED shall have blocking feature based on 2nd harmonic measurement. 2nd harmonic blocking shall be possible to enable individually for each step.

Several instances of this function shall be available in the IED.

**Non-directional phase over current protection**

The IED shall include simple, non-directional, single step over current protection. Definite (DT) time delay characteristics shall be available. Several function instances shall be available.

The function shall measure the magnitude of the maximum fundamental frequency phasor among all individual phase currents.

The operate current shall be settable between 5 – 1200% of the base current. The accuracy of the operate current shall be at least ± 1.0% of I₀.

It shall be possible to enable the function operation via separate user-defined logic.

Several instances of this function shall be available in the IED.

**Instantaneous residual overcurrent protection**

The IED shall have instantaneous earth-fault protection. The residual current shall be possible to be calculated by a summation of the two phase currents or by taking the input from a neutral point CT.
**Directional residual overcurrent protection**

The IED shall include time delayed directional earth fault protection with at least 2 steps. The first step with either inverse (IDMT) or definite (DT) time delay characteristics and the second step with definite (DT) time delay characteristics only.

The residual current shall be possible to be calculated by a summation of the two phase currents or by taking the input from a neutral point CT. The operate current shall be settable between 1 – 1200% of the rated current (I). The accuracy of the operate current shall be at least ± 1.0% of I.

The function shall include directional supervision element with independent settings. The -2Uo voltage shall be used as polarizing quantity.

A 2nd harmonic blocking functionality shall be available individually for each step.

**Two-step undervoltage protection function**

The IED shall include undervoltage protection with 2 steps, each with definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 30 ms whichever is greater for 50Hz/60Hz system.

The operate voltage shall be settable between 1.0 – 100.0% of the rated voltage (U). The accuracy of the operate voltage shall be at least ± 0.5% of U.

The undervoltage protection function shall have options for selecting one/all of the phases required for operation.

**Two step overvoltage protection function**

The IED shall include overvoltage protection with at least 2 steps, each with definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 30 ms whichever is greater for 50/60Hz system.

The operate voltage shall be settable between 1.0 – 200.0% of the rated voltage (U). The accuracy of the operate voltage shall be at least ± 0.5% of U, at U ≤ U, and ± 0.5% of U at U > U.

The overvoltage protection function shall have option of selecting one/all of the phases required for operation.

**Two step residual overvoltage protection function**

The IED shall include residual overvoltage protection with at least 2 steps, each with definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 30 ms whichever is greater for 50Hz/60Hz system.

The function shall be able to calculate the residual voltage from a two-phase voltage input transformer or measure it directly from a single voltage input transformer fed from an open delta or neutral point voltage transformer.

The operate voltage shall be settable between 1.0 – 200.0% of the rated voltage (U). The accuracy of the operate voltage shall be at least ± 0.5% of U, at U ≤ U, and ± 0.5% of U at U > U.

**Apparatus control specification and interlocking**

The IED shall ensure cost efficient solutions by being able to solve the most complicated applications with a minimum number of devices in an open, futureproof and flexible system architecture, with state-of-the-art performance by implementing the core values of IEC 61850.

The IED shall include control and interlocking for up to 15 switching devices (out of which 2 circuit breakers) for one bay. The IED shall be capable of providing the following control functionality:

- select before operate with enhanced security (SBO)
- reservation to prevent simultaneous operation of an apparatus
- selection and supervision of operator place (local, remote) and command supervision
- block of operation and of the update of position indications
- substitution of the position indications
- overriding of synchrocheck and interlocking functions
- pole discordance supervision
operation counter and breaker monitoring functions
The IED shall include several type tested interlocking modules, for different switchyard configurations.

**Autorecloser**

The IED shall include reclosing with five separately set time intervals for reclosing. Separately set reset time for the reclose cycle and for lockout shall be available.

**Synchronizing**

The IED shall include synchrocheck function, which can accommodate two voltage measurements (one line voltages and one bus voltages). The synchrocheck function shall incorporate slip frequency, close angle settings, and allow different sources of synchronizing voltage. The synchrocheck function shall have separate settings for synchronizing between synchronous/synchronous and synchronous/asynchronous networks, and also for energizing check.