The IED shall comprise hardware, time synchronization, monitoring, communication capabilities and other specifications as described in the 1MRG033852_en_Sample_specification_General_specifications_Relion_650 document. For the common protection, control, monitoring functionalities please refer to 1MRG033851_en_Sample_specification_Common_functions_Relion_650 document.

For the common protection, control, monitoring functionalities please refer to 1MRG033851_en_Sample_specification_Common_functions_Relion_650 document.

The IED shall support protection and control functionality. Control functionalities are described in 1MRG033849_en_Sample_specification_Bay_control_REC650.

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 most typically specified in REL650, but are available for selection in other types as well, as per the comments under each description.

**Line distance protection**

The IED shall include six zone line distance protection, with at least three distance protection zones with user-selectable orientation: forward, reverse and non-directional. Zone direction shall be selectable by a parameter setting.

The line distance protection has to be able to provide cycle and a half 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 separate parameter settings for positive and zero sequence reactance and resistance for each zone. It shall have a separate fault impedance coverage parameter setting for phase-to-earth and phase-to-phase faults in 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), separately settable for forward and reverse direction. It shall have a settable load angle and reactance determining load impedance area. It shall be possible to set the parameter values for load resistance and load angle from an MMS client as per IEC 61850-8-1 Edition 2.

It shall be possible for the line distance protection to select between mho and quadrilateral characteristics separately for each zone. This selection shall be done by a parameter setting.

Also, it shall be possible for the line distance protection to enable or disable phase-to-ground, or phase-to-phase measuring loops, separately for each zone. Time delay shall be settable separately for phase-to-ground, and phase-to-phase loops, for each zone.

It shall be possible for all zones with a delayed trip time to select either the pickup of the phase-selector or the first starting zone as a start trigger for the trip timer. It shall be possible for all time-delayed zones to have 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.

The IED shall be able to handle analog quantities that are obtained via conventional analog measurements or IEC 61850 9-2LE sampled values. The conventional analog measurements and IEC 61850 9-2LE sampled values can be combined in the same device.

The zone blinders that are set in parameter settings shall be displayed graphically in the same software tool.

*In 650 series, this function is available in the following product types: RED650 and REL650.*

### Power swing

The IED shall include a power swing function for blocking all line distance protection zones during power swing conditions. The power swing function shall be based on the measurement of time required for the impedance operating point to pass between settable quadrilateral impedance blinders.

*In 650 series, this function is available in the following product types: RED650 and REL650.*

### Out-of-step

The IED shall include impedance-based out-of-step functionality, with a lens characteristic dividable in two impedance zones. It shall have a selectable number of slips required for the operation of each of the two zones.

*In 650 series, this function is available only in REL650.*

### 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. The principle applied shall be selectable by a parameter. 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 of being active only for a set time after the circuit breaker close command is issued.
- It shall have the possibility of being 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.

*In 650 series, this function is available in the following product types: REL650, and RED650.*

### 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 comprise the following:

- Monitoring the status of an MCB or a fuse protecting the secondary wiring of the VT.
- Detection of a failure of the voltage measurements based on symmetrical components, independent from the MCB or fuse status; this feature shall be based on the detection of a high value of zero sequence voltage (3U0>) and the absence of zero sequence current (3I0<), or the detection of a high value of negative sequence voltage (3U2>) and the absence of negative sequence current (3I2<); the end user shall select if one of the two principles shall be used, and it shall be possible to choose a
combination of the two principles as ‘AND’ or ‘OR’ logical combinations; it shall be possible for the algorithm to dynamically apply the zero-sequence algorithm if $I_0 > I_2$, and vice versa; the thresholds for $3U_0^>$, $3I_0^<$, $3U_2^>$ and $3I_2^<$ shall be settable by the end user.

- Detection of a failure of voltage measurements based on a three-phase change in voltage (DU), without a change in current (DI); this algorithm shall be independent from the other functionalities included in the function, and it shall be possible to enable by a parameter; the levels of DU and DI shall be settable by a setting parameter.

- The function shall be able to receive the position indication of the line disconnector, and block all voltage functions when the position is open.

- It shall be possible for the function to seal-in its output once it has picked up, and to store this information in non-volatile memory; the function shall reset once the voltage recovers, and the level of the reset voltage shall be settable by a parameter setting.

In 650 series, this function is available in the following product types: REL650, RED650, REB650, REC650, REQ650, and RET650.

**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 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.

In 650 series, this function is available in the following product types: RED650 and REL650.

**Fault locator**

The IED shall have an accurate fault locator based on local impedance measurements, giving the distance to the fault in km, miles or percentage of line length. The fault locator shall have compensation for load current and for the mutual zero-sequence effect on double circuit lines, and it shall include settings of the remote and local sources to calculate the distribution of fault currents from each side. 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.

It shall be freely configurable which protection functions should trigger a fault locator calculation.

It shall be possible to report the measured phase impedance to a client over MMS communication, as per IEC 61850-8-1.

In 650 series, this function is available in the following product types: REC650, RED650 and REL650.

**Autorecloser**

The IED shall include reclosing with five separately set time intervals for reclosing. The first attempt can be single-phase, two-phase and/or three-phase. Separately set reset times for the reclose cycle and for lockout shall be available.

In multi-breaker applications, the autorecloser shall have a priority circuit, which allows a breaker to close first and a second breaker to close only if a fault proves to be transient.

In 650 series, this function is available in the following product types: RED650, REL650 and REQ650.