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 a complete overview of Relion 670 series product functions available, please refer to the applicable Product Guides. For more details about the design of the functions and their applications, please refer to the Technical Manual and the Application Manual respectively.

**This specification applies to the following 650 series products**

- REB670: High-impedance busbar protection
- REC670: Bay control
- RED670: Line differential protection
- REL670: Line distance protection
- REQ670: Circuit breaker protection
- RET670: Transformer protection

**Common protection functions in 650 series**

The functions specified in this document are common for the 650 series. Availability of a function per product type is listed in the comments under each description.

**Instantaneous phase overcurrent protection**

The IED shall include instantaneous phase overcurrent function for short tripping time during high fault current conditions. This shall be used as high set short-circuit protection function.

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

**Directional phase overcurrent protection**

The IED shall include directional overcurrent protection with at least four steps, each with separate inverse (IDMT) and definite (DT) time delay characteristics for each step. IDMT curves shall be available as specified in IEC 60255-151/IEEE C37.112, and with a user-defined time characteristic. The accuracy of the IDMT curve and the DT element shall be at least ± 2.0% or ± 35 ms whichever is greater.

The operating current shall be settable between 5 – 2,500% of the rated current (I_r).

The function shall be set as 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 a memory voltage. The directionality criterion shall have an accuracy of at least ± 2.0 degrees.
Instantaneous, IEC and IEEE reset curves according to IEC 60255-151/IEEE C37.112 shall be available.

In order to avoid unwanted operation of the protection function during transformer energization, the IED shall have a restrain feature based on the second harmonic measurement. It shall be possible to set the second harmonic restrain individually for each step. It shall be possible for the IED to raise the current pick-up level with a multiplication factor by a binary input signal.

The IED shall have the option of selecting the number of phases required for operation; 1 out of 3 phases, 2 out of 3 phases, or 3 out of 3 phases.

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

**Instantaneous residual overcurrent protection**

The IED shall have instantaneous earth-fault protection. It shall be possible to calculate the residual current by summing the three-phase currents, or by taking the input from a neutral point CT.

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

**Directional residual overcurrent protection**

The IED shall include time delayed directional earth fault protection with at least 4 steps, each with inverse (IDMT) and definite (DT) time delay characteristics separately for each step. IDMT curves shall be available as specified in IEC 60255-151 / IEEE C37.112 and with a user defined time characteristic. The accuracy of the IDMT curve and the DT element shall be at least ± 2.0\% or ± 35 ms whichever is greater.

It shall be possible to calculate the residual current by summing the three phase currents or by taking the input from a neutral point CT. The operating current shall be settable between 1 – 2,500\% of the rated current (I_r).

It shall be possible to set the function to directional or non-directional, independently for each of the steps. The polarization quantity available shall be voltage polarization, current polarization or dual polarization.

A second harmonic restrain functionality shall be available individually for each step. The second harmonic restrain can be set to seal-in until residual current disappears.

The function shall have the possibility of raising the current pick-up level with a multiplication factor by a binary input signal.

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

**Directional negative phase sequence overcurrent protection**

The IED shall include negative phase sequence overcurrent protection with at least 4 steps, each with inverse (IDMT) and definite (DT) time delay characteristics separately for each step. IDMT curves shall be available as specified in IEC 60255-151 / IEEE C37.112 and with a user-defined time characteristic. The accuracy of the IDMT curve operate time shall be at least ± 2.0\% or ± 40 ms, whichever is greater. The accuracy of the DT element shall be at least ± 0.2\% or ± 35 ms, whichever is greater.

The operating current shall be settable between 5 – 2,500\% of the rated current (I_r).

It shall be possible to set the function to 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 a memory voltage. The directionality criterion shall have accuracy of at least ± 2.0 degrees.

Instantaneous, IEC and IEEE reset curves according to IEC 60255-151 / IEEE C37.112 shall be available. The accuracy of the IDMT curve reset time shall be at least ± 2.0\% or ± 40 ms, whichever is greater.

It shall be possible for the function to raise the current pick-up level with a multiplication factor by a binary input signal.

In 650 series, this function is available in the following product types: REB650, REL650, and REQ650.
Thermal overload protection, one time constant, temperature in Celsius
The IED shall include thermal overload protection with an $I^2t$ characteristic, a heating and 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 using a milliampere input and compensate for variations. 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, cooling time constant, two separate alarms, warning and trip level shall be settable. The initial heat content shall be settable by the end user.

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

Thermal overload protection, one time constant, temperature in Fahrenheit
The IED shall include thermal overload protection with an $I^2t$ characteristic, a heating and cooling time constant and a thermal memory. The temperature shall be displayed in degrees Fahrenheit. The function shall be able to measure the ambient temperature using a milliampere input and compensate for variations. It shall be possible for the function to issue a lockout for closing the breaker until the heat content decreases below a lockout reset level setting. The heating time constant, cooling time constant, two separate alarms, warning and trip level shall be settable. The initial heat content shall be settable by the end user.

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

Thermal overload protection, two time constants
The IED shall include a thermal overload protection that measures three-phase current RMS values, and calculates the projected temperature rise from the largest of the three phase currents, based on a thermal heating constant.

The function shall contain two settable heating time constants, one of which is applied when the transformer is cooled naturally, and the other one when the transformer is forcibly cooled.

The function shall be able to issue two separate alarms, a warning and a trip signal. It shall also be possible for the function to issue a lockout signal until the thermal memory is reset, based on a thermal cooling time constant. The levels for the alarms, warning, trip and the lockout shall be settable by the end user.

The initial heat content shall be settable by the end user.

_In 650 series, this function is available in the following product types: REB650, and RET650._

Pole discordance protection function
The IED shall include pole discordance protection. The function shall operate based on information from auxiliary contacts of the circuit breaker for the three phases, with additional criteria from unsymmetrical phase currents when required. Each phase current through the circuit breaker shall be measured.

If the difference between the phase currents is larger than the set unsymmetrical phase current threshold, this is an indication of pole discordance, and the protection shall operate. The operating current shall be settable between 0 – 100% of the rated current ($I_r$).

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

Two-step undervoltage protection function
The IED shall include undervoltage protection with at least two steps, each with inverse or definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 40 ms, whichever is greater.

The operating voltage shall be settable between 1.0 – 100.0% of the rated voltage ($U_r$). The function shall have a settable reset ratio. The absolute hysteresis shall be settable between 0.0 and 50.0% of $U_r$. The hysteresis shall have an accuracy of at least 10.5% of $U_r$.

The undervoltage protection function shall have the option of selecting the number of phases required for operation as 1 out of 3, or 2 out of 3, or 3 out of 3.

_In 650 series, this function is available in the following product types: REB650, RED650, REL650, REQ650, and RET650._
Two-step overvoltage protection function
The IED shall include overvoltage protection with at least two steps, each with inverse or definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 45 ms, whichever is greater.

The operating voltage shall be settable between 1.0 – 200.0% of the rated voltage (U_r). The function shall have a settable reset ratio. The absolute hysteresis shall be settable between 0.0 and 50.0% of U_r. The hysteresis shall have an accuracy of at least ± 0.5% of U_r.

The overvoltage protection function shall have the option of selecting the number of phases required for operation as 1 out of 3, or 2 out of 3, or 3 out of 3.

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

Two-step residual overvoltage protection function
The IED shall include residual overvoltage protection with at least two steps, each with inverse or definite time delay. The accuracy of the time delay element shall be at least ± 0.2 % or ± 45 ms, whichever is greater.

The function shall be able to calculate the residual voltage from a three-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 operating voltage shall be settable between 1.0 – 200.0% of the rated voltage (U_r). The function shall have a settable reset ratio. The absolute hysteresis shall be settable between 0.0 and 50.0% of U_r. The hysteresis shall have an accuracy of at least ± 0.5% of U_r.

The overvoltage protection function shall have the option of selecting the number of phases required for operation as 1 out of 3, or 2 out of 3, or 3 out of 3.

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

Underfrequency protection function
The IED shall include underfrequency protection. The function shall have separate definite time delays for operate and reset, and shall be provided with undervoltage blocking. The operation shall be based on positive sequence voltage measurement and require two phase-phase or three phase neutral voltages to be connected.

The operate value shall be settable between 35.00 and 75.00 Hz. The accuracy of the operate element shall be ± 2.0 mHz. The start time at f_set + 0.02 Hz to f_set - 0.02 Hz shall reliably be below 95ms for 50Hz, and 80ms for 60Hz.

The operate time delay shall be settable. The accuracy of the operate time delay element at f_set + 0.02 Hz to f_set - 0.02 Hz shall be at least ± 0.2 % or ± 100 ms, whichever is greater.

The reset time delay shall be settable. The accuracy of the reset time delay element at f_set + 0.02 Hz to f_set - 0.02 Hz shall be at least ± 0.2 % or ± 120 ms, whichever is greater.

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

Overfrequency protection function
The IED shall include overfrequency protection. The function shall have separate definite time delays for operate and reset, and shall be provided with undervoltage blocking. The operation shall be based on positive sequence voltage measurement and require two phase-phase or three phase neutral voltages to be connected.

The operating value shall be settable between 35.00 and 75.00 Hz. The accuracy of the operating element shall be ± 2.0 mHz. The start time at f_set + 0.02 Hz to f_set - 0.02 Hz shall reliably be below 95ms for 50Hz, and 80ms for 60Hz.

The operate time delay shall be settable. The accuracy of the operate time delay element at f_set + 0.02 Hz to f_set - 0.02 Hz shall be at least ± 0.2 % or ± 100 ms, whichever is greater.

The reset time delay shall be settable. The accuracy of the reset time delay element at f_set + 0.02 Hz to f_set - 0.02 Hz shall be at least ± 0.2 % or ± 120 ms, whichever is greater.

In 650 series, this function is available in the following product types: RED650, REL650, and RET650.
Rate-of-change of frequency protection function

The IED shall include rate-of-change of frequency protection. The function shall be used to detect fast power system frequency changes at an early stage as an indication of a main disturbance in the system. The operation shall be based on positive sequence voltage measurement, and requires two phase-phase or three phase-neutral voltages to be connected.

The operating value shall be settable between -10.00 and 10.00 Hz/s. The accuracy of the operating element shall be ± 10.0 mHz/s.

The operating time delay shall be settable. The accuracy of the operating time delay element shall be at least ± 0.2 % or ± 120 ms, whichever is greater.

The reset time delay shall be settable. The accuracy of the reset time delay element shall be at least ± 0.2 % or ± 250 ms, whichever is greater.

This function shall discriminate between a positive or negative rate of change of frequency. A definite time delay shall be provided with an undervoltage blocking, in order to avoid an unwanted trip due to uncertain frequency measurement at low voltage magnitude. If the frequency recovers, a restore signal shall be issued. The restoration time delay shall be settable. The accuracy of the restoration time delay element shall be at least ± 0.2 % or ± 100 ms, whichever is greater.

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