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 the common protection, control, monitoring functionalities please refer to 1MRG033842_en_Sample_specification_Common_functions_Relion_670 document.

The IED shall support protection and control functionality. Control functionalities are described in 1MRG033840_en_Sample_specification_Bay_control_REC670.

The IED shall also support protection of the generator, step-up transformer or the entire unit or block. For the transformer protection functionalities please refer to the document 1MRG033847_en_Sample_specification_Transformer_protection_RET670.

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 REG670, but are available for selection in other types as well, as per the comments under each description.

**Generator differential protection**

The IED shall contain generator differential protection of the low impedance type, with internal CT ratio matching. The function shall contain up to four CT inputs overall: two sets of CT inputs for the generator terminal side and two sets of CT inputs for the generator neutral side CTs. It shall be possible for the function to be released or blocked by any kind of logic created by the end user.

The differential currents shall be calculated as the vector summation of the fundamental frequency measured currents from two sides of the protected generator.

The bias current shall be the magnitude of the highest measured current from both sides of the protected generator. One common fundamental frequency bias current shall be used, which shall not be allowed to drop instantaneously, but shall decay exponentially with a predefined time constant.

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

- The restrained area shall contain three sections, the first of which shall have the constant operating level independent from the bias current, while the other two sections shall have settable slopes.
- The unrestrained level shall have a constant pickup value, irrespective of the bias current, and shall be selectable from 1 up to 50 times of the base current.
- If a substantial amount of the second or fifth harmonic is detected, the restrained operation of the function shall be blocked; the levels of second or fifth harmonic required for blocking the operation shall be settable by the end-user.
- If any blocking condition is detected in one phase, the end user shall have the flexibility to block the operation of the differential protection only in that phase, or in all three phases; this feature shall be settable by a parameter setting.
• If the operating point is above the unrestrained level, the function shall issue a trip signal without checking the harmonic content of the function, and it shall be possible to release or block the unrestrained characteristic with any kind of logic created by the end user.

• It shall be possible for the function to temporarily decrease sensitivity of the differential protection, triggered by a binary signal, and the desensitized trip level in this case shall be settable by the end user. During the period when the binary signal is triggered, the function shall be able to introduce additional trip time delay, settable by the end user.

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

• It shall be possible for the differential protection 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 for addition to the pickup level; this feature shall be settable by a parameter setting.

• The function shall be able to calculate the fundamental frequency negative sequence differential current, and it shall be possible to record this value in the disturbance recorder, reported as a service value.

• The function shall include the internal/external fault discriminator based on the negative sequence currents. This feature shall be settable by the end-user. It shall also have settable minimum amount of the negative sequence current required for the calculation, as well as the angle defining the area in which negative sequence current phasors have to be positioned in order to declare internal or external fault. This function 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 an additional feature, an independent negative sequence based tripping element, which shall be able to issue a trip without operating point being in the restrained or unrestrained area of differential characteristic. The internal/external fault discriminator and the independent negative sequence based tripping element, shall share the same set of parameter settings, and shall have the possibility to be released or blocked, independently, by any kind of logic created by the end user.

• The function shall be capable of detecting an open CT circuit and consequently block the operation of the transformer differential protection. This signal shall have the possibility to be recorded in the disturbance recorder, and reported. This functionality shall be settable by the user. The configuration shall be capable of enabling the end user also to trip the breaker with the CT open detection signal, while blocking the differential protection.

• The function shall continuously monitor the fundamental frequency differential current level, and in the case all three differential currents are above the set threshold, and after a set time delay, an alarm shall be issued. The value of the threshold and the time delay for the differential protection alarm shall be settable by the end user.

• The function shall be able to extract the DC component from the differential current and made available for monitoring purposes.

This function is available only in REG670.

**Pole-slip protection**

The IED shall include pole-slip protection functionality. It shall have a two-zone impedance characteristic, with settable values of impedance. The function shall be capable of measuring rotor angle in the impedance plane, and issue an alarm when the rotor angle reaches a settable value. The function shall issue a trip once the trip angle has been reached, after a defined number of slips, separately for each zone. The trip angle and number of slips per zone shall be settable by the end user.

This function is available in the following product types: RED670, REG670, REL670 and RET670.
Out-of-step protection

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

_In 670 series, this function is available in the following product types: RED670, REG670, REL670, RES670 and RET670._

Loss-of-excitation

The IED shall include a loss-of-excitation function, where the measurement loop of apparent impedance shall be chosen as the positive sequence loop or any one of the three phase-to-phase loops depending on the available current and voltage signals. The function shall have two settable Mho impedance zones, and each of the zones shall provide settable offset, diameter and operate time delay. The function shall also contain the directional blinder, with the offset and directional angle settable by the end user.

_This function is available only in REG670._

Sensitive rotor earth fault protection, injection based

The function shall include injection-based rotor earth fault protection, with a settable injection frequency. The function shall be able to detect and alarm earth faults in DC and AC excitation circuits, and indicate them separately. The function shall also be able to measure resistance and reactance to the ground, at the selected frequency, and report it to disturbance recorder.

The function shall have up to two different reference impedances that can be calibrated using the same software tool that is used to configure the IED. It shall be possible to activate any of the reference impedances by freely configurable logic, and shall also be possible to determine compensation factor for series impedance by calibration. The function shall have settable levels of resistance for alarm and trip, and a resistance scale factor for faults on the AC side of the exciter, with a settable time trip time delay for earth faults on the AC side. The trip time for earth faults in the DC circuit shall have a linear dependency on the filter length time that shall be settable by the end user.

_This function is available only in REG670._

100% stator earth fault protection, injection-based

The function shall include injection-based stator earth fault protection, with a settable injection frequency. The function shall have settable levels of resistance for alarm and trip.

The trip time for the stator earth faults shall have linear dependency on the filter length time that shall be settable by the end user. An alarm time delay shall also be settable by the end user.

The function shall be able to measure and report the following values to the disturbance recorder: average measured resistance and reactance to earth, frequency of the injected signal, and the estimated fault resistance. The function shall have up to five different reference impedances that can be calibrated using the same software tool that is used to configure the IED. It shall be possible to activate any of the reference impedances by freely configurable logic. The function shall be able to determine the compensation factor for series impedance by calibration.

_This function is available only in REG670._

100% stator earth fault protection, third harmonic-based

The IED shall include third harmonic-based 100% stator earth fault protection, where the differential voltage is calculated as a vector sum of the third harmonic voltages from the generator terminals and generator neutral point.

In order to improve stability, the function shall include a bias voltage, as the product of the generator neutral voltage and an end-user settable factor. It shall be possible for the factor to change its value, depending on the breaker position. The function shall have the flexibility to measure the generator terminal voltage as residual voltage, three-phase to earth voltage, or any single phase to ground voltage. This shall be settable by a parameter setting.

The trip shall be issued once the vector sum between the generator terminal and neutral voltages is equal or higher than the bias voltage, and when the angle between the two voltages is in the defined range for tripping. The function shall also have a settable time delay for trip.
It shall be possible for the function to be blocked once the generator terminal voltage is below a settable threshold. If no terminal voltage is available, the function shall be able to operate as a neutral point third harmonic undervoltage protection.

The function shall be able to measure and display both terminal and neutral third harmonic voltages, the angle between them, and the differential and bias voltages.

*This function is available only in REG670.*

**Underimpedance protection for generators and transformers**

The IED shall include three-zone, full-scheme impedance protection with offset mho characteristics. Each zone shall have a settable forward and reverse reach, as well as a trip time delay. The function shall be limited to the following parameters: the impedance angle that is common for all the zones, and the load angle and the load resistance for the load-encroachment feature. The load-encroachment feature shall be settable for zones 2 and 3 separately.

It shall be possible to turn each zone on or off. Zone 1 shall include only phase-to-phase measuring loops, while for zones 2 and 3 it shall be possible to measure phase-to-phase loops, or measure phase-to-ground loops. This shall be settable by a parameter. If phase-to-ground loops are selected, the loop with the highest phase current shall be calculated, combined with the compensation of the zero-sequence voltage. The function shall include functionality for undervoltage seal-in, with a settable threshold and time delay. The undervoltage seal-in shall be triggered by zone 2 or zone 3 pickup.

*This function is available in the following product types: REG670 and RET670.*

**Accidental energizing protection for synchronous generator**

The IED shall have a voltage supervised overcurrent protection, for detection of inadvertent energization of the generator. The protection shall be able to use all three phase-to-phase voltages from the generator terminal, as well as all three phase currents, either from the generator terminals or from the generator neutral. The protection shall activate its overcurrent element automatically once the highest of all three phase-to-phase voltages drops below the settable value, for the settable amount of time. The trip signal shall be issued once the highest of the phase currents is above the settable level, for the settable amount of time.

Conversely, the function shall deactivate its overcurrent element automatically once the highest of all three phase-to-phase voltages is larger than the settable limit, for the settable amount of time. The settable voltage thresholds and the time delays shall be separate for activating and deactivating of the overcurrent element.

*This function is available only in REG670.*

**Stator overload protection**

The IED shall have a current-based protection against stator overload, based on the standard IEEE-C50.13:2014. The current measurements shall be taken either from the generator terminal, or from the generator neutral.

The function shall have a settable option to operate either with the RMS current or with the weighted sum of the positive and negative sequence components of the measured current. The function shall have a linear reset characteristic, as well as a settable option for the lockout. If the lockout is activated, the re-energization of the generator shall be allowed by the function once the linear reset characteristic has reached a settable point.

*This function is available only in REG670.*

**Rotor overload protection**

The IED shall have a current-based protection against rotor overload, based on the standard IEEE-C50.13:2014. The current measurements shall be taken either from either from the high voltage (HV) side, or from the low voltage (LV) side, of the excitation transformer. Ratings of the excitation transformer shall be settable, for the measurements taken from the HV side of the excitation transformer.

The operation of the function shall be based either on the RMS current value from the three-phase input currents, or on the calculated rotor winding DC current calculated from the connected three-phase input currents. The selection between the two alternatives shall be selectable in the parameters.
The function shall have a linear reset characteristic, as well as a settable option for the lockout. If the lockout is activated, the re-energization of the generator shall be allowed by the function once the linear reset characteristic has reached a settable point.

The function shall also have one undercurrent protection instance with a settable operate level and a settable definite time delay.

This function is available only in REG670.

**Frequency time accumulation protection**

The IED shall include functionality that will calculate time during which the frequency is within certain limits. These frequency limits shall be settable by the end user. It shall be possible for the function to be released, depending on the current level, voltage level, the breaker status or any kind of logic created by the end user.

The function shall contain two counters: the individual event timer, which shall be the continuous time spent within the given frequency band, and the accumulation timer, which shall be the cumulative time spent within the given frequency band. Each of the counters shall have their own timers, and the function shall be able to issue the trip once the time thresholds are reached.

This function is available in the following product types: REC670, REG670 and RES670.

**Frequency tracking**

The IED shall be able to track the power system frequency, in a wide range for both, 50 Hz and 60 Hz power systems. The following functions shall operate correctly in the aforementioned frequency range:

- generator differential protection
- transformer differential protection
- four-step overcurrent protection
- four-step residual overcurrent protection
- over/under voltage protection
- residual overvoltage protection
- overexcitation protection
- general current and voltage protection
- directional over/under power protection
- measurement functions

Frequency tracking is available in the following product types (for the functions listed above): REB670, REC670, RED670, REG670, REL670, RES670 and RET670.

**Multipurpose filter**

The IED shall include filtering functionality that is capable of extracting a settable frequency component from the input signal. The input signal shall be current or voltage, and the frequency component shall be settable in the range from 2 Hz to 500 Hz. The function shall include a settable frequency band around the set frequency, as well as a settable length of the filtering window. It shall be possible for the function to set how often the new phasor shall be calculated during the set time window. The following values shall be available for each of the calculated phasors:

- magnitude
- phase angle
- exact frequency of the extracted signal
- phasors for the individual phases as well as phase-to-phase phasors
- true RMS value of the input signal over all samples available in the memory
- positive sequence phasor
- negative sequence phasor
- zero sequence phasor

It shall be possible to connect the extracted signals to current, voltage and power protection functions.

This function is available in the following product types: REC670, RED670, REG670, REL670, RES670 and RET670.