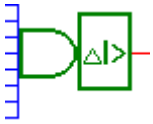
*u*REG
UNIVERSAL PROTECTION RELAY & BAY CONTROLLER

Differential protection uREG DIFFER I> (ANSI 87, 87T, 87G) – version 01a

1. Functional description.

The logic element, called **DIFFER I>** functor  is used to provide differential protection of two and three winding transformers, generators and motors in high-voltage (HV), medium-voltage (MV) and low-voltage (LV) systems. This protection eliminates the necessity to use matching instrument transformers. As part of a modular and programmable protective system, it ensures free configuration and easy addition of typical associated functionalities to the differential protection or deactivation of functionalities, which are unwanted in your application.

In **applications involving transformers**, the protection provides selection of two or three current measuring paths, current amplitude tuning by defining rated voltages in windings and current transformation ratios of instrument transformers used in circuits of such windings. For correction of phase revolutions, the logic element provides selection of an adequate vector group for each pair of the primary winding (on a higher side) and the secondary winding. For the present version, the HV winding requires the Y vector group.

In **applications involving generators and motors**, the protection also provides selection of one out of two current circuits of measuring paths. In this case, however, it is not necessary to make full selection of the vector group; amplitude tuning is usually limited to tuning of transformation ratios of current transformers.

The logic element comes as an integrated three-phase protection. It applies a stabilised start-up characteristic curve with three programmable current sections with a constant and varying slope. The selection of the start-up threshold on each phase is defined independently of other values, based on the restraint current value. The inflexion points on the characteristic curve are defined in settings as derivatives of rated current, whereas the slope of the two inclined sections is expressed in percentage.

The restraint current is determined as the higher value out of both currents of the phase, measured at the ends of the protected zone.

2. Settings.

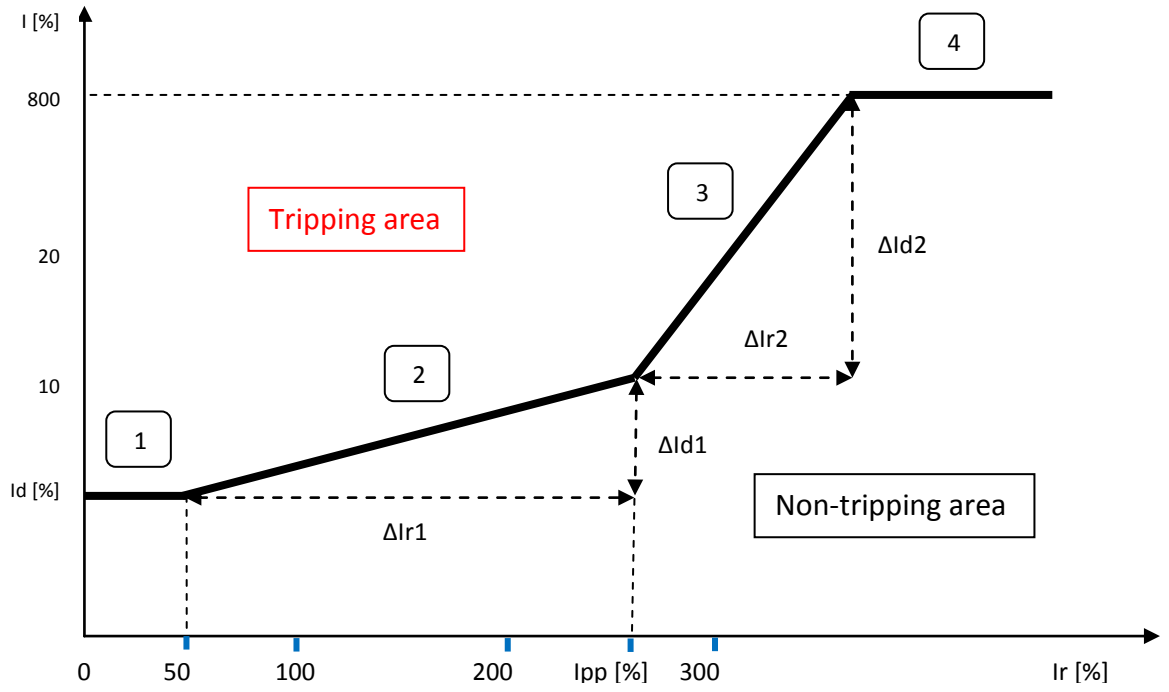
Settings of the **DIFFER I>** functor include:

- **Sel I** selected configuration of current measuring paths:
  - **0: [2]-[3] → [2]:HV [3]:MV, both in the VT-7 or VT-B module;**
  - **1: [1]-[2]-[3] → [1]:HV in the CT-0 module and [2]:MV1 [3]:MV2 in the VT-7 or VT-B module;**
  - **2: [1]-[2] → [1]:HV in the CT-0 module and [2]:MV in VT-3, VT-4, VT-5, VT-7,VT-B.**
- **In [mA]** rated current, reference value to determine the differential tripping current Id; typically, In = 1000 mA.
- **Id> [%]** tripping current Id within the range of low values of the restraint current Ir, i.e. within the first sub-range of 0 to In/2, defined as percentage of the current In.
- **kpId>** resetting ratio.
- **fs [%]** slope of the second section on the characteristic curve for average values of the current Ir, i.e. within the sub-range of In/2 up to the knee-point Ipp.
- **ss [%]** slope of the third section on the characteristic curve for high values of the current Ir, ie. within the sub-range of Ipp to 8*In.
- **Ipp [%]** point of the second inflexion on the start-up characteristic curve Id, defined as percentage of rated current.
- **GP HV-MV1** Vector group of the HV primary winding and MV1 secondary winding; this setting is used to select one out of six typical groups: Yy0, Yy6, Yd1, Yd5, Yd7 and Yd11.
- **GP HV-MV2** Vector group of the HV primary winding and MV2 second secondary winding (if exists); this setting is used to select one out of six typical groups: Yy0, Yy6, Yd1, Yd5, Yd7 and Yd11.
- **Corr I0** Correction of the zero current component, used conditionally for the determination of the current on the respective transformer side; for the primary winding Pri and the secondary winding Sec, it is calculated when the respective factor has the positive sign. The correction is used only for the vector groups Yy0 and Yy6.

Proper implementation of the logic element **DIFFER I>** requires specification of additional parameters, provided in the application by logic elements of external parameters from the '**System**' group. These are settings of rated voltages for each transformer winding side and transformation ratios of phase current transformers used in individual current groups of measurement inputs.

The following rules apply:
- **Un HV** and **thetaIp** for the group [**1**] are defined in the logic element of pattern 45 '***Parametry S1'***;
- **Un MV1** and **thetaIp** for the group [**2**] are defined in the logic element of pattern 37 '***Parametry S2***';
- **Un MV2** and **thetaIp** for the group [**3**] are defined in the logic element of pattern 16 '***Parametry S3***'.

Voltage settings in this case are only required to determine the transformation ratio thetaT; for protection of other equipment (e.g. generators), they should be the same.



Id [%] = (Id / In) * 100%

fs [%] = (ΔId1 / ΔIr1) * 100%

ss [%] = (ΔId2 / ΔIr2) * 100%

Ipp [%] = (Ipp / In) * 100%

1 $$It = \left(\frac{Id[\%]}{100}\right) * In\ [A]$$

2 $$It = \left(\frac{Id[\%]}{100} + \left(\frac{Ir}{In} - 0.5\right) * \frac{fs[\%]}{100}\right) * In\ [A]$$

3 $$It = \left(\frac{Id[\%]}{100} + \left(\frac{Ipp[\%]}{100} - 0.5\right) * \frac{fs[\%]}{100} + \left(\frac{Ir}{In} - \frac{Ipp[\%]}{100}\right) * \frac{ss[\%]}{100}\right) * In\ [A]$$

4 $$It = 8 * In\ [A]$$

It – tripping level of differential current Id [A]

Current ratios must be set in accordance with ratios of the instrument transformers for each zone side.
The set values of transformation ratios are used to calculate the correction coefficient k, which is necessary to tune amplitudes of measured currents, i.e. for the reference to common units.
The coefficient is determined accordingly to the value of the '**Sel I**' setting, and hence accordingly to the applied groups of measurement inputs.

Example: for '**Sel I = 2**', the calculation is performed in accordance with the following formulae:

k = ((thetaIp [1] * thetaT) / thetaIp [2]),

where thetaT = Un HV [1] / Un MV1 [2].

Admissible values of the coefficient k must range from 0.125 to 8.0 each time.
The logic element **DIFFER I>** can be operated together with auxiliary logic elements '**F100Hz**' and '**F250Hz**', which interlock activation at a high level (adjustable) of the 2^{nd} and 5^{th} current harmonic, respectively.