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# 1 INSTANTANEOUS OVERCURRENT PROTECTION

## 1.1 Application

Long transmission lines often transfer great quantities of electric power from production to consumption areas. The unbalance of the produced and consumed electric power at each end of the transmission line is very large. Consequently, this means that a fault on the line can easily endanger the stability of a complete system.

The dynamic stability of a power system depends mostly on three parameters (at constantly transmitted electric power):

- The type of the fault. Three-phase faults are the most dangerous, since no power can be transmitted through the fault point during fault conditions.
- The magnitude of the fault current. A high fault current indicates that the decrease of transmitted power is high.
- The total fault clearing time. The phase angles between the EMFs of the generators on both sides of the transmission line will increase over the permitted stability limits if the total fault clearing time, which consists of the protection operating time and the breaker opening time, will be too long.

The fault current on the long transmission lines will depend mostly on the position of the fault, and will decrease with the distance from the generation point. This means that the protection must operate extremely fast for faults very close to the generation (as well as relay) point, for which very high fault currents are characteristic.

An instantaneous phase segregated overcurrent protection (HII), which can operate faster than 15 ms (50 Hz nominal system frequency) for faults characterised by very high currents, is therefore included in some of the protection terminals.

## 1.2 Measuring principle

The current measuring elements within one of the built-in digital signal processors measure continuously the currents in all three phases, and compare them with the set value I>>. A recursive Fourier filter filters the current signals, and a separate trip counter prevents high overreaching of the measuring elements. The logical value of the phase wise signals STOCL1, STOCL2 and STOCL3 respectively, will be equal to 1 if the measured phase current exceeds the pre-set value.

## 1.3 Design

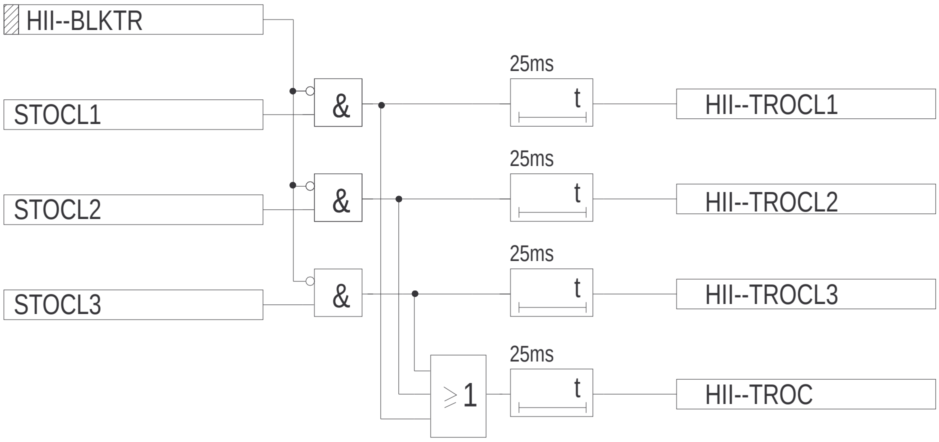


*Fig. 1 Instantaneous overcurrent protection - simplified logic diagram.*

Internally connectable signal HII--BLKTR can prevent the tripping signals HII--TROC, HII--TROCL1, HII--TROCL2 and HII--TROCL3.

The appendix to this description of the HII function gives the following information:

- a simplified terminal diagram of the HII function
- a terminal diagram for the HII function
- a description of the connection and production signals for the HII function
- a table of setting parameters for the HII function

## 1.4 Setting instructions

As for this kind of protection, it is of great importance that it operates only in a selective way, which means that it is necessary to check all system and transient conditions that could cause its faulty operation.

It is necessary to perform detailed network studies to find the operating conditions under which the highest possible fault current can be expected on the line. In most cases, this current will appear under three-phase fault conditions, but single-phase-to-earth and two-phase-to-earth conditions must be examined as well.

Transients that could cause a high increase of the line current for short times must also be studied. A typical example is a transmission line with a power transformer at the remote end, which can cause high inrush current when connected to the network and thus also operation of the instantaneous overcurrent protection.

The protected line and the source in front of it can be represented by an ideal voltage generator and positive-sequence source and line impedance connected in series. This is valid only in cases when the highest fault currents are characteristically for three-phase faults. If not so, calculations using the theory of fault calculation by symmetrical components should be performed.

The total line positive-sequence impedance will be:

$$Z_1 = \sqrt{X_1^2 + R_1^2}$$

The minimum value of the positive-sequence source impedance $Z_S$ should be considered for calculation (it gives the maximum possible fault current).

The maximum three-phase short-circuit current at the beginning of the protected line will be:

$$I_{maxA} = \frac{U}{\sqrt{3} \cdot Z_{SA}}$$

The maximum three-phase short-circuit current for the close in three phase fault in the reverse direction will be:

$$I_{maxR} = \frac{U}{\sqrt{3} \cdot (Z_{SB} + Z_1)}$$

Where $Z_{SA}$ and $Z_{SB}$ are the positive sequence source impedance, first one behind the line terminal with the terminal under observation and the second one behind the remote end respectively.

The three-phase fault current at the end of the protected line will be:

$$I_{maxE} = \frac{U}{\sqrt{3} \cdot (Z_{SA} + Z_l)}$$

5% of the safety margin should be added to this value due to the maximum static inaccuracy of the protection, and 5% due to the maximum possible transient overreach. An additional 20% of the safety margin should be added owing to the inaccuracy of the instrument transformers under transient conditions and inaccuracy in the system data. The maximum expected fault current at the end of the protected line will than be:

$$I_{max} = 1,30 \cdot I_{maxE}$$

Since the protection must normally be set to cover some 85% of the protected line, additional safety margin of 15% must be considered, when calculated the minimum necessary setting of the instantaneous O/C protection:

$$I_{min} = 1,15 \cdot I_{max} = 1,5 \cdot I_{maxE}$$

If this value is equal to or higher than the value of the short-circuit current $I_{maxA}$ at the beginning of the protected line or of the short circuit current for the close in faults in the reverse direction $I_{maxR}$, the protection can not be used for this particular application. The same is also valid for a comparison with the maximum possible transient current expected for different conditions on the protected line.

The line impedance which corresponds to this fault current is:

$$Z_{l3} = \frac{U}{\sqrt{3} \cdot I_{min}} - Z_{SA}$$

and the corresponding percentage of the line length protected by the instantaneous overcurrent protection can easily be calculated.

The primary current calculated for the secondary side of the current instrument transformers is:

$$I_{sec3} = \frac{I_{sec}}{I_{prim}} \cdot I_{min}$$

This value should be set under the setting menu:

**Settings**
**Functions**
**Group n**
**HiSetOverCurr**

The following network conditions may be expected to give a maximum fault current, determining the setting of the instantaneous overcurrent protection function:

- minimum near end source impedance, i.e. $Z_{1SAmin}$ and $Z_{0SAmin}$
- maximum remote end source impedance, i.e. $Z_{1SBmax}$ and $Z_{0SBmax}$
- minimum possible line impedance
- a single system in service; all parallel systems on the multicircuit parallel line, if any, out of service
- minimum fault resistance at the remote end.

## 1.5 Testing

It is necessary to check the operating values of the current measuring elements and corresponding functions during the commissioning, as well as during regular maintenance tests. ABB Relays recommends, although it does not absolutely request, the use of the testing equipment of type RTS 21 (FREJA) for secondary injection testing purposes.

Before testing, it is necessary to connect the testing equipment according to the valid terminal diagram of the particular REL 5xx terminal. Special attention should be paid to the correct connection of the input and output current terminals, and to the connection of the residual current.

It is necessary to perform the following steps when testing the HII protection:

1.1 Check if the input and output logical signals as presented in Fig. 1 are configured to the corresponding binary inputs and outputs of the tested terminal. If not, configure them for testing purposes. Set the operation of the HII protection to On mode.

1.2 Set the input logical signals to the logical zero and note on the local MMI unit that the logical signal HII--TROC is equal to the logical 0. Values of the logical signals belonging to the instantaneous overcurrent protection are available under menu tree:

**Service Report**
**Logical Signals**
**HiSetOverCurr**

1.3 Quickly increase the measured current in phase L1 until the signal HII--TROCL1 appears. Record the operating value. Decrease the measured current to zero (observe the maximum permitted overloading of the current circuits in the terminal). Compare the measured operating current with the set value. The result should be within the 5% accuracy limits with the addition of the accuracy class of the testing equipment used for the testing.

1.4 Measure the operating current in the remaining two phases as well.

1.5 Set quickly the measured current in one phase at approximately 1,5 times the measured operating current, and disconnect the current by means of the switch.

1.6 Switch on the fault current and measure the operating time of the HII protection. Use the signal HII--TROC from the configured binary output to stop the timer. The operating time should be less than 20 ms (for the 50 Hz nominal frequency).

1.7 Connect the rated dc voltage to the configured binary input HII--BLKTR, and switch on the fault current. No signal HII--TROC shall appear. Switch off the fault current. Disconnect the dc voltage from the HII--BLKTR binary input.

1.8 Set the operation of the protection at Off mode and switch on the fault current. Note that no corresponding binary signals should appear on the terminal.

1.9 Configure (if necessary) the terminal to its normal operating configuration.

## 1.6 Technical data

**Table 1:**

| | **Setting range** | **Operate time** | **Accuracy** |
|---|---|---|---|
| Operate current | (50-2000)% of $I_r$ in steps of 1% | - | ±2,5% of $I_r$ at $I \leq I_r$<br>±2,5% of I at $I > I_r$ |
| Dynamic overreach at $\tau$<100 ms | - | - | <5% |
| Operate time at $I > 10 \cdot I_{set}$ | | <15 ms | |

## 1.7 Appendix

### 1.7.1 Terminal diagrams

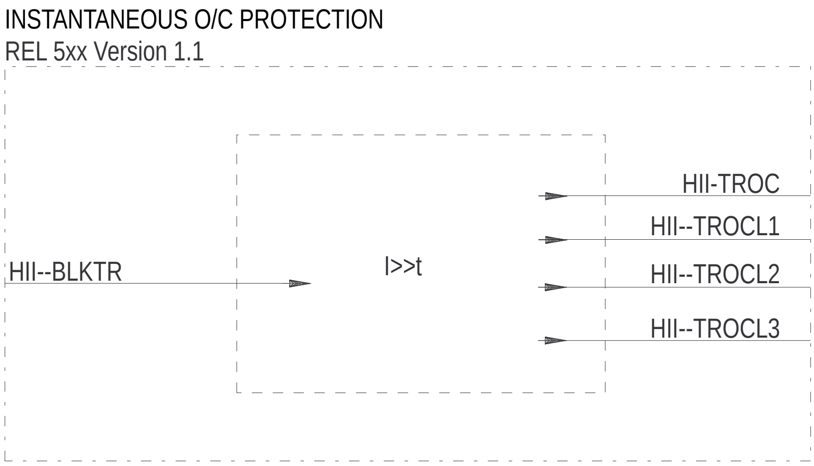


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*Fig. 2 Simplified terminal diagram for the function.*

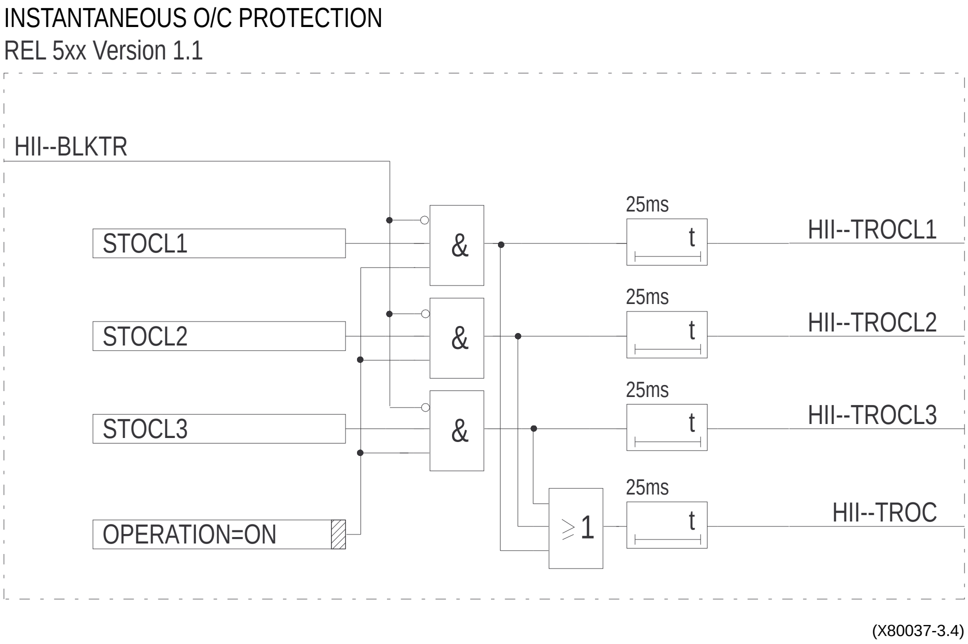


*Fig. 3 Terminal diagram for the function.*

## 1.7.2 Signal list

| **CONNECTIONS:** | **TO:** | **ACTUAL:** | **DESCRIPTION:** |
|---|---|---|---|
| HII--BLKTR | BI | | External signal that blocks the tripping action of the instantaneous overcurrent protection |
| | | | |
| **PRODUCTION:** | **TO:** | **ACTUAL:** | **DESCRIPTION:** |
| HII--TROCL1 | BO, TRIP | | Operation of the instantaneous O/C protection in phase L1 |
| HII--TROCL2 | BO, TRIP | | Operation of the instantaneous O/C protection in phase L2 |
| HII--TROCL3 | BO, TRIP | | Operation of the instantaneous O/C protection in phase L3 |
| HII--TROC | BO, TRIP | | Operation of the instantaneous O/C protection |

## 1.7.3 Setting table

| **PARAMETER:** | **SETTING RANGE:** | **SETTING** | | | | |
|---|---|---|---|---|---|---|
| | | **ACTUAL** | | | | |
| | | **Group 1** | **Group 2** | **Group 3** | **Group 4** | **DESCRIPTION:** |
| Operation | On / Off | | | | | The instantaneous O/C protection can be set On or Off |
| I>> | (50 - 2000)% of $I_r$ | | | | | Set operating value of the instantaneous O/C protection |