
**Relion® 605 series**

# Self-powered feeder protection REJ603 Application Manual

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Document ID: 1MDU07221-YN
Issued: 2017-10-30
Revision: D
Product version: 3.0

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# Conformity

This product complies with the directive of the Council of the European Communities on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive 2004/30/EU) and concerning electrical equipment for use within specified voltage limits (Low-voltage directive 2014/35/EU). This conformity is the result of tests conducted by ABB in accordance with the product standards EN 60255-26 for the EMC directive, and with the product standards EN 60255-1 and EN 60255-27 for the low voltage directive. The relay is designed in accordance with the international standards of the IEC 60255 series.

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# Section 1 General

## 1.1 This manual

This manual contains application and functionality descriptions and connection diagrams, input and output signals, setting parameters and technical data. The manual can be used as a technical reference during the engineering phase, installation and commissioning phase, and during normal service. The manual can also be used when calculating settings. The manual provides instructions on how to operate the relay during normal service once it has been commissioned and to find out how to handle disturbances or view calculated and measured network data in order to determine the cause of a fault.

## 1.2 Intended audience

This manual addresses system engineers, installation and commissioning personnel, who use technical data during engineering, installation and commissioning, and in normal service. System engineer must have a thorough knowledge of protection systems, protection equipment, protection functions and the configured functional logics in the relays. The installation and commissioning personnel must have a basic knowledge in handling electronic equipment.

This manual addresses Protection and control engineer responsible for planning, pre-engineering and engineering. The protection and control engineer must be experienced in electrical power engineering and have knowledge of related technology, such as communication and protocols.

The manual also addresses the operator, who operates the relay on a daily basis. The operator must be trained in and have a basic knowledge of how to operate protection equipment. The manual contains terms and expressions commonly used to describe this kind of equipment.

## 1.3 Document revision history

| Document revision/date | Product version | Document history |
|---|---|---|
| A / 04.09.2015 | 3.0 | Release of REJ603 with conventional current transformer support |
| B / 11.04.2016 | 3.0 | Content updated |
| C / 28.03.2017 | 3.0 | Content updated |
| D / 30.10.2017 | 3.0 | Content updated |

## 1.4 Document symbol and conventions

This publication includes the following icons that point out safety-related conditions or other important information:

### Safety indication symbols

The information icon alerts the reader to important facts and conditions.

Non-observance can result in death, personal injury or substantial property damage

Breaking the sealing tape on the upper handle of the device will result in loss of warranty and proper operation will no longer be guaranteed.

When the plug-in unit has been detached from the case, do not touch the inside of the case. The relay case internals may contain high voltage potential and touching these may cause personal injury.

The warning icon indicates the presence of a hazard which could result in personal injury.

Dangerous voltages can occur on the connectors, even though the auxiliary voltage has been disconnected.

National and local electrical safety regulations must always be followed.

The device contains components which are sensitive to Electrostatic discharge. Unnecessary touching of electronic components must therefore be avoided.

Only a competent electrician is allowed to carry out the electrical installation.

The caution icon indicates important information or warning related to the concept discussed in the text. It might indicate the presence of a hazard which could result in corruption of software or damage to equipment or property.

The tip icon indicates advice on, for example, how to design your project or how to use a certain function.

# Section 2 REJ603 overview

## 2.1 Overview

REJ603 is a self-powered feeder protection relay, intended for the protection of utility substations and industrial power systems, in secondary distribution networks. REJ603 is a member of ABB's Relion® product family and part of its 605 series.

The feeder protection relay REJ603 is designed to be a part of Ring Main Units (RMU) and secondary distribution switchgears. The REJ603 relay is a self-powered numerical relay, which receives power from the main current transformers. This way REJ603 is an ideal choice for installations where an auxiliary supplies are not available and hence is suitable for unmanned distribution substations having no auxiliary supplies.

The common features of REJ603 includes:

- Relay power up through front USB port in absence of CT supply
- Built-in hand-reset electromagnetic flag for trip indication
- Capacitor discharge impulse output for low energy trip coil
- Bi-stable signal output for trip indication to external system
- Disturbance recording facility with date and time even in CT powered mode
- Compact size and ease of use
- Standard 1A or 5A CT input for phase current measurement
- Earth current measurement internally or externally through CT (1A or 5A)
- Test facility with USB power for testing entire scheme including relay and activation of bistable trip output.
- Disconnecting type CT terminals with CT shorting arrangement helping to reduce MTTR (mean time to repair)
- Relay self-supervision
- 250 event logs with date and time stamping
- On-line current measurements in primary or secondary value
- Multi-line HMI display
- Optional remote trip function through binary input with universal auxiliary supply
- Optional universal auxiliary supply enables measurement at low load current, providing sensitive earth fault protection and reduce trip time of instantaneous functions
- Non-volatile memory for settings, events and disturbance records
- Suitable for frequency 50 / 60 Hz
- Configurable outputs contacts
- Two setting groups

The protection features of REJ603 includes:

- Three-stage overcurrent protection
- Two-stage earth-fault protection
- Inrush detection for stability during transformer charging
- Thermal overload protection

## 2.2 Product version history

| Product version | Release date | Product History |
|---|---|---|
| 1.0 | 18.03.2008 | Product released |
| 1.0 SP1 | 01.10.2010 | Service Pack released |
| 1.0 HMI | 29.10.2010 | HMI version released |
| 1.5 Base and HMI | 04.04.2012 | Version 1.5 released |
| 3.0 | 28.09.2015 | Version 3.0 released with support of conventional CT |

## 2.3 Operation Functionality

### 2.3.1 Relay functions

REJ603 offers pre-configured functionality which facilitates easy and fast commissioning of secondary switchgear. To emphasize the simplicity of relay's usage, only application specific parameters needs to set within the relay's intended area of application. The relay offers protection and measurement functionality.

The table indicates the functions supported by the relay.

*Table 1: Relay functions*

| Functionality | ANSI | IEC | B |
|---|---|---|---|
| Non-directional overcurrent protection, low-set stage | 51 | 3I> | ● |
| Non-directional overcurrent protection, high-set stage | 50-1 | 3I>> | ● |
| Non-directional overcurrent protection, instantaneous stage | 50-2 | 3I>>> | ● |
| Earth-fault protection, low-set stage | 51N | Io> | ● |
| Earth-fault protection, high-set stage | 50N | Io>> | ● |
| Three phase transformer inrush detector | 68 | 3I2f> | - |
| Three-phase thermal protection for feeders, cables, distribution transformers and motor | 49 | 3Ith> | ● |
| Two setting group | - | - | ● |
| Remote trip with external power supply | - | - | o |
| **Measurement** | | | |
| Three-phase current measurement | 3I | 3I | ● |
| Residual current measurement | In | Io | ● |
| Thermal level | ϑ | ϑ | ● |
| Disturbance recorder | | | ● |

● = Included, o = optional at the time of ordering

### 2.3.2 Optional function

The relay has add-on function of remote trip through binary input with selection of auxiliary power version.

## 2.4 Other Functions

### 2.4.1 Self-Supervision

The relay is provided with an extensive self-supervision system which continuously supervises the software and the hardware. It handles run-time fault situations and informs the user about a fault via the LHMI.

Internal fault indications have the highest priority on the LHMI. None of other LHMI indications can override the internal fault indication.

At normal condition (no internal fault and minimum load current for operation is available or auxiliary power supply is available), the green Ready LED glow.

The internal faults were categorizes into “WARNINGS” and “ERRORS”.

- Ready LED will blink in case of warnings unit or insufficient load current
- Ready LED get turned off in case of error.

Warnings are behavior where the protection functions are still ensured.

Remark: Insufficient load current to power relay will not lead to a warning but is signalized same as a warning.

Errors are behaviors, where the functionality is not ensured.

In both cases trip circuit is not blocked, means in case of trip condition is reached, the relay tries to send trip energy to circuit breaker.

The internal fault code indicates the type of internal protection relay fault, which can be accessed through internal events.

*Table 2: Internal fault - WARNINGS*

| Internal fault code | Type of fault |
|---|---|
| 1 | HMI memory warning |
| 2 | HMI watchdog reset occurred |
| 4 | AIM watchdog reset occurred |
| 32 / 0x20 | Clock not set |

*Table 3: Internal fault - ERRORS*

| Internal fault code | Type of fault |
|---|---|
| 1 | HMI memory error |
| 2 | AIM memory error |
| 4 | Error in low energy trip output |
| 8 | Internal Power Bus voltage error |
| 16/0x10 | Calibration error |
| 32 / 0x20 | Error in internal communication Bus 1 |
| 64 / 0x40 | Error in internal communication Bus 2 |

## 2.4.2 Disturbance recorder

### 2.4.2.1 Functionality

REJ 603 features an integrated disturbance recorder for recording monitored quantities. The recorder captures the wave forms of the currents as well as the status of various configured digital signals with date and time stamping which gets stored in the memory. Total number of records stored in relay are 10 numbers.

The protection relay is provided with a disturbance recorder with 4 analog and configurable 8 binary signal channels for recording. Each binary signal can be configured from signals from various available signals list and same is used to trigger the start of disturbance recording. Additionally disturbance record can be manually triggered.

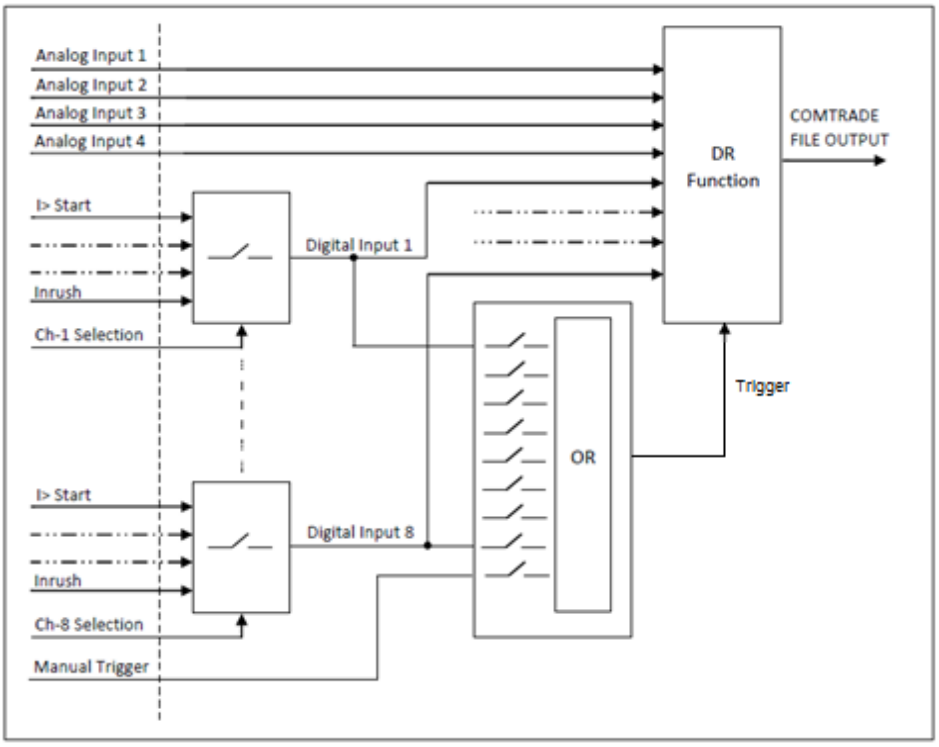



*Figure 1: Functional block of disturbance record*

### 2.4.2.2 Principle of operation

Disturbance record shall contains pre and post analog and binary channels value / status in non-volatile memory as COMTRADE file format. As soon as the recorder has been triggered and the recording has finished, the recording can be uploaded and analyzed by means of a PC / Laptop. User will be able to access this file from front USB port.

The pre-trigger and post-trigger time is 0.040 sec, the length of disturbance record can be settable as per requirement.

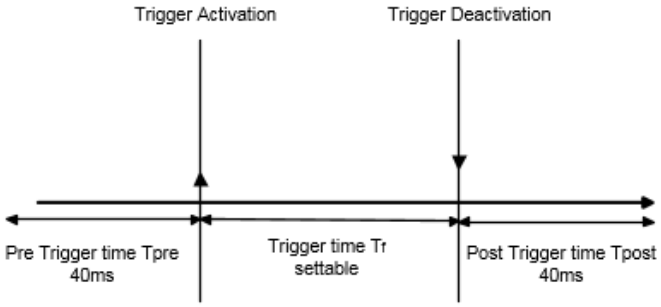



*Figure 2: Length of disturbance record*

Disturbance recorder has two operation modes: saturation and overwrite mode. The user can change the operation mode of the disturbance recorder with the “DR Overwrite” parameter.

When “DR Overwrite” parameter is set to “No’ the operation mode gets selected as saturation wherein the captured recordings cannot be overwritten with new recordings. When “DR Overwrite” parameter is set to “Yes’ the operation mode gets selected as overwrite wherein when the recording memory is full, the oldest recording is overwritten with the pre-trigger data collected for the next recording.

### 2.4.2.3 Settings of disturbance recorder

*Table 4: Settings of disturbance recorder*

| Parameter | Range | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Pre-Trigger Time | 0.04 | S | - | 0.04 | Pre-trigger record length |
| Trigger Time | 0.10….1.00 | S | 0.01 | 1.00 | Record length |
| Trigger Post Time | 0.04 | S | - | 0.04 | Post-trigger record length |
| Trigger CHx | ON/OFF | - | 1 | OFF | Trigger CHx ON/OFF |
| CHx signal | (see table below) | - | 1 | 0-7 | CHx signal selection |
| Manual Trigger | Yes/No | - | 1 | No | Trigger new DR manually |
| DR Overwrite | Yes/No | - | 1 | No | Enable clearing of older file when memory is full |
| Clear All | Yes/No | - | 1 | No | To clear all DR file |
| Station Name ID | Alphanumeric (max.10character) | - | - | REJ603 | Will be used in .CFG file |

*Table 4: Settings of disturbance recorder, continue*

| Parameter | Range | Unit | Step | Default | Description |
|---|---|---|---|---|---|
| Station name Selection | Factory Default User Define | - | 1 | Factory Default | Selection for station name to use |
| Device ID | Alphanumeric (max.10character) | - | - | RDRE2 | Will be used in .CFG file |
| Device ID selection | Factory Default User Define | - | 1 | Factory Default | Selection for Device ID to use |

### 2.4.2.4 Signals available for disturbance recorder

*Table 5: List of signals for disturbance recorder CHx*

| Signal Name | Description |
|---|---|
| General start | Start from any protection function |
| I> start | I> protection function start |
| I>> start | I>> protection function start |
| I>>> start | I>>> protection function start |
| I0> start | I0> protection function start |
| I0>> start | I0>> protection function start |
| General Trip | Trip from any protection function |
| Ext. trip | External trip |
| Inrush | Inrush detection |

## 2.4.3 Event log

Protection relay supports event logs (SoE), which are categorize as external and internal and stores separately in a non-volatile memory. External events are the application related events and internal events are internal relay related events. In non-volatile memory, 250 numbers of external events can be logged and 100 numbers of internal events. Each event log includes type of event along with date and time stamping. The event logs are stored sequentially, the most recent being first and so on. From the non-volatile memory “Erase All” option for external events are provide, however internal events cannot be erased and only gets overwritten after rollover.

The SoE information are accessible locally via LHMI.

*Table 6: List of external event types and related description*

| Sr. No. | Event type | Description | Data considered |
|---|---|---|---|
| 1 | Protection Start | Start activate and deactivated of each protection functions | Start I> ↑ & ↓<br>Start I>> ↑ & ↓<br>Start I>>> ↑ & ↓<br>Start I0> ↑ & ↓<br>Start I0>> ↑ & ↓<br>3Ith> Alarm ↑ & ↓<br>Inrush ↑ & ↓<br>General Start↑ & ↓ |

*Table 6: List of external event types and related description, continued*

| Sr. No. | Event type | Description | Data considered |
|---|---|---|---|
| 2. | Protection Trip | Trip activate and deactivated of each protection functions | Trip I> ↑ & ↓<br>Trip I>> ↑ & ↓<br>Trip I>>> ↑ & ↓<br>Trip I0> ↑ & ↓<br>Trip I0>> ↑ & ↓<br>3Ith> Trip ↑ & ↓<br>General Trip ↑ & ↓ |
| 3. | Protection Block | Blocking activate and deactivated of each protection functions | Block I> ↑ & ↓<br>Block I>> ↑ & ↓<br>Block I>>> ↑ & ↓<br>Block I0> ↑ & ↓<br>Block I0>> ↑ & ↓<br>3Ith> Block ↑ & ↓ |
| 4. | Protection settings changed | Any settings changed for a protection function will be registered as protection settings changed | Settings Change I>, I>>, I>>>, Io>, Io>>,3Ith> |
| 5 | Active Setting Group changed | Active setting groups changed. | SG 1 ↑<br>SG 2 ↑ |
| 6 | Disturbance records settings change | Any settings changed for a disturbance records settings | setting change - DR |
| 7 | BI events | Binary inputs activated & deactivated | BI1 ↑ & ↓ |
| 8 | CB Remote Trip | CB Remote Trip Event when external trip is issued. | CB Remote Trip |
| 9 | Configuration changed | Configuration of binary input, binary output, IED, and system time is changed | Config – BI<br>Config – BO<br>Config – IED<br>Config - Time |
| 10 | Clear key press | Clear kept press when sufficient power is available. | Clear key |
| 11 | Factory default | Factory default set | Factory default |
| 12 | Password changed | Password changed for different users | Password change |
| 13 | Test mode | Test mode activated and deactivated | Test ↑ & ↓ |

*Table 7: List of internal event types and related description*

| Sr. No. | Event type | Description | Data considered |
|---|---|---|---|
| 1 | Error | Any kind of internal relay error occurred | Error with error code |
| 2. | Warning | Any kind of internal relay warning occurred | Warning with warning code |
| 3. | Disturbance records clear | Disturbance records gets cleared. | DR clear |
| 4. | External events clear | External events are cleared | External events cleared |

## 2.4.4 Real Time Clock

Relay comes with a real time clock with user settable date and time. Date can be set in “DD/MM/YYYY” format and time can be set in “HH:MM:SS” format. The time stamping have 1 ms resolution. RTC is used for time stamping the event logs and as well as fault records. The RTC is in case of power failure RTC will be maintained by battery provided in HMI module of relay. Initial time setting is

"01/01/2011" and "00:00:00:0000". It is recommended to replace battery which is only use to maintain RTC, every ten years.

### 2.4.5 Access Control

To protect the relay from unauthorized access and to maintain the integrity of information, the relay is armed with a three level, role-based user authentication system with individual password for the operator, engineer (Setting level) and administrator level. The relay supports alphanumeric password handling.

### 2.4.6 Relay power on

For deriving the operational power, the relay requires minimum current flow of 0.07 times the rated current CT secondary current in all three phases or 0.18 times the rated CT secondary current at least one phase.

## 2.5 Relay outputs

The relay has one impulse trip output for tripping breaker with low energy trip coil. Additionally relay shall have two bi-stable signaling trip output contacts. The bi-stable contacts are activated from coil and contacts remains in operated state till reset command provided from relay local HMI.

The bi-stable contact can be reset from local HMI when the relay is in energized condition either through CT power, front USB connection or external auxiliary supply (optional feature) as well in un-energized condition for maximum 3 days at room temperature.

Incase of insufficient energy flag may not be able to reset (e.g. during SOTF testing).

The signals available for triggering trip output and bi-stable signaling output which can be configurable depending on requirement are as follows:

- Individual start of protection functions I>, I>>, I>>>, Io>, Io>> and thermal overload alarm.
- Individual trip of protection functions I>, I>>, I>>>, Io> Io>, Io>> and thermal overload protection trip.
- External trip signal wired at binary input (optional function)

The signal routed in default configuration for bi-stable contacts shall be trip of protection functions I>, I>>, I>>>, Io>, Io>>, thermal overload protection trip and remote trip.

## 2.6 Trip and LED indications

The relay electromagnetic flag which turns to red in case of relay trip, the flag retain its operation status even in absence of current. The flag turns to green after reset.

The relay has additionally Ready and Start LEDs. When minimum current required for operation is available the green ‘Ready’ LED glows indicating the relay is in operation. In case of any internal relay failure, the “Ready” LED turns off. Start LED turn in to Orange in case of any protection start.

## 2.7 Binary Input

The relay is available with add-on optional card which has provision of one binary input with universal auxiliary supply which is used for providing remote trip function. The signals from transformer like Buchholz, winding temperature, oil temperature etc. or any remote trip signal can be wired to binary input. The relay impulse trip output is activated on energization of this binary input. Bi-stable signal output if configured also get activated on energization of binary input.

The binary inputs BI1 support Inverted (I) operation.

# Section 3 Technical Data

For detailed technical data please refer the product guide.

# Section 4 Protection Function

## 4.1 Three Phase Overcurrent Protection

### 4.1.1 Functionality

The three-phase overcurrent protections can be used as three phase non-directional overcurrent and short-circuit protection for feeders.

The operate time characteristics for low stage can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The high and instantaneous stage always operates with the definite time (DT) characteristics.

### 4.1.2 Principle of Operation

The three-phase overcurrent unit continuously measures all three phase currents of the protected object. The maximum current of the three phases is evaluated by the low stage (I> / 51), high stage (I>> / 50-1) and instantaneous stage (I>>> / 50-2) of phase overcurrent functions.

On occurrence of fault, fulfilling the trip condition of respective stage, the electromagnetic flag will be activated. Additionally the output relays (Impulse trip output and bi-stable signalization) will be activated.

Each of the stages could be blocked by settings of the relay.

### 4.1.3 Setting range of Three Phase Overcurrent Protection

*Table 8: Non-directional overcurrent protection, Low stage 3I>, 51*

| Parameter | Value (Range) |
|---|---|
| Setting range of pick-up current 'I >' | 0.1[1)]...32 x In in steps 0.001, infinite |
| Operation accuracy | ± 3.0% x In for value < 1.2 In ,<br>± 3.0% x I for value ≥ 1.2 In |
| Operate time delay (DMT) 't >' | 0.04...64 s in steps of 0.01 |
| Operation time accuracy [2)] | ± 2.0% of set value or ± 30 ms |

*Table 8: Non-directional overcurrent protection, Low stage 3I>, 51, Continue*

| Parameter | Value (Range) |
|---|---|
| Operating curve type | IEC 60255-151:<br>Normal inverse, Very inverse, Extremely inverse, Long-time inverse<br>ANSI C37.112:<br>Moderate inverse, Normal Inverse, Very inverse, Extremely inverse<br>Special curves:<br>RI inverse, HR fuse, FR fuse |
| Time multiplier setting 'k' | 0.02...1.6, in steps of 0.01 |
| Operation time accuracy<br>• IEC and ANSI characteristics [2) 3)]<br>• RI characteristics | class E(5) or ± 30 ms,<br>class E(7.5) or ± 30 ms for set value < 0.2<br>± 5.0% of set value or ± 30 ms |
| Reset ratio | IDMT : 0.96 and DT : 0.98 |

[1)] Relay minimum powering current is 0.07 x In when current in three phase and 0.18 x In when current in single phase.

[2)] Operation time accuracy for protection functions when relay is in energised condition.

[3)] For details refer section 4.5.6.

*Table 9: Non-directional overcurrent protection, High stage 3I>>, 50-1*

| Parameter | Value (Range) |
|---|---|
| Setting range of pick-up current 'I>>' | 0.2...32.0 x In in steps 0.001, infinite |
| Operation accuracy | ± 3.0% x In for value < 1.2 In ,<br>± 3.0% x I for value ≥ 1.2 In |
| Operation mode | Definite time, Instantaneous |
| Operate time delay (DMT) 't >>' | 0.04...64 s in steps of 0.01 |
| Operation time accuracy [1)] | ± 2.0% of set value or ± 30 ms |
| Reset ratio | 0.98 |

[1)] Operation time accuracy for protection functions when relay is in energised condition.

*Table 10: Non-directional overcurrent protection, Instantaneous stage 3I>>>, 50-2*

| Parameter | Value (Range) |
|---|---|
| Setting range of pick-up current 'I>>' | 0.2...32.0 x In in steps 0.001, infinite |
| Operation accuracy | ± 3.0% x In for value < 1.2 In ,<br>± 3.0% x I for value ≥ 1.2 In |
| Operation mode | Definite time, Instantaneous |
| Operate time delay (DMT) 't >>>' | 0.04...64 s in steps of 0.01 |
| Operation time accuracy [1)] | ± 2.0% of set value or ± 15 ms |
| Reset ratio | 0.98 |

[1)] Operation time accuracy for protection functions when relay is in energised condition.

# 4.2 Earth Fault Protection

## 4.2.1 Functionality

The earth-fault protection function is used as non-directional earth-fault protection for feeders.

The earth current can be calculated internally in the relay from phase current or measured externally through core balance current transformer or through residual connection.

The operate time characteristics for low stage can be selected to be either definite time (DT) or inverse definite minimum time (IDMT). The high stage always operates with the definite time (DT) characteristics.

## 4.2.2 Principle of Operation

The earth fault protection function continuously measures the neutral current of the protected object. The current is evaluated by the low stage (I0> / 51N) and high stage (I0>> / 50N) of earth fault over current functions.

On occurrence of fault, fulfilling the trip condition of respective stage, the electromagnetic flag will be activated. Additionally the output relays (Impulse trip output and bi-stable signalization) will be activated.

Each of the stages could be blocked by settings of the relay.

## 4.2.3 Setting range of Earth Fault Protection

*Table 11: Setting ranges Non-directional earth fault protection, Low stage Io>, 51N*

| Parameter | Value (Range) |
|---|---|
| Setting range of pick-up current 'Io>' | External earth measurement (through CBCT or Residual connection) :<br>0.01...2.0 x In in steps 0.01, infinite<br>Internal earth measurement :<br>0.1...2.0 x In in steps 0.01, infinite |
| Operation accuracy | External earth measurement : ± 3.0% x In for value < 1.2 In , ± 3.0% x I for value ≥ 1.2 In<br>Internal earth measurement : ± 9.0% x In for value < 1.2 In , ± 9.0% x I for value ≥ 1.2 In |
| Operate time delay (DMT) 't >' | 0.04...64 s in steps of 0.01 |
| Operation time accuracy [1)] | External earth measurement : ± 2.0% of set value or ± 30 ms<br>Internal earth measurement : ± 10.0% of set value or ± 30 ms |

*Table 11: Setting ranges Non-directional earth fault protection, Low stage Io>, 51N, continue*

| Parameter | Value (Range) |
|---|---|
| Operating curve type | IEC 60255-151:<br>Normal inverse, Very inverse, Extremely inverse, Long-time inverse<br>ANSI C37.112:<br>Moderate inverse, Normal Inverse, Very inverse, Extremely inverse<br>Special curves:<br>RI inverse, HR fuse, FR fuse |
| Time multiplier setting 'k' | 0.02...1.6, in steps of 0.01 |
| Operation time accuracy [1) 2)]<br>• IEC and ANSI characteristics<br>• RI characteristics<br>• IEC and ANSI characteristics<br>• RI characteristics | <br>External earth measurement : class E(5) or ± 30 ms<br>External earth measurement : class E(7.5) or ± 30 ms<br>Internal earth measurement : ± 5.0% of set value or ± 30 ms<br>Internal earth measurement : ± 10.0% of set value or ± 30 ms |
| Reset ratio | IDMT : 0.96 and DT : 0.98 |

1) For details refer section 4.5.6.

2) Operation time accuracy for protection functions when relay is in energised condition.

*Table 12: Setting ranges Non-directional earth fault protection, High stage Io>>, 50N*

| Parameter | Value (Range) |
|---|---|
| Setting range of pick-up current 'Io >>' | External earth measurement (through CBCT or Residual connection) : 0.01...12.5 x In in steps 0.001, infinite<br>Internal earth measurement : 0.1...12.5 x In in steps 0.001, infinite |
| Operation accuracy | External earth measurement : ± 3.0% x In for value < 1.2 In , ± 3.0% x I for value ≥ 1.2 In<br>Internal earth measurement : ± 9.0% x In for value < 1.2 In , ± 9.0% x I for value ≥ 1.2 In |
| Operation mode | Definite time, Instantaneous |
| Operate time delay (DMT) 'to >>' | 0.04...64 s in steps of 0.01 |
| Operation time accuracy [1)] | External earth measurement : ± 2.0% of set value or ± 30 ms<br>Internal earth measurement : ± 10.0% of set value or ± 30 ms |
| Reset ratio | 0.98 |

1) Operation time accuracy for protection functions when relay is in energised condition.

## 4.3 Three Phase Inrush Detector

The transformer inrush detection is used to block protection during transformer inrush situations in distribution networks.

Transformer inrush detection is based on the ratio of 2nd harmonic current and the fundamental frequency. When an inrush case is detected, then the phase overcurrent and earth fault protection functions are immediately blocked.

Inrush logic detects inrush conditions and activates Inrush Detected output if following conditions are satisfied.

a) Fundamental current should be greater than 10% of nominal current and less than *I inr max* current setting.

b) Inrush ratio I2/I1 should be greater than *Inrush ratio* setting.

The output remains activated as long as these conditions are satisfied. For overcurrent or earth fault function to be blocked by inrush it is required that setting *Blocked by inrush* is set as "Yes" in respective protection function.

The inrush function resets in 20-30 ms, after inrush condition mentioned in a or b deactivates, the resetting of inrush function will deactivate the Inrush output.

Activation and deactivation of inrush output gets registered as external event.

*Table 13: Setting ranges Transformer Inrush detection, 3I2f>, 68*

| Parameter | Value (Range) |
|---|---|
| Inrush threshold value | 0.2...32 x In, in steps of 0.01 |
| Ratio Setting | 10%...50%, in steps of 1% |

# 4.4 Thermal overload protection

## 4.4.1 Functionality

The thermal overload protection protects the apparatus from overheating, which causes the premature insulation failures of apparatus like cables, feeders and transformers. The function models the thermal behavior of apparatus on the basis of the measured load current and disconnects the apparatus when stored thermal energy has reached the level of set value.

The maximum permanently stored energy at maximum load current is defined as 100%.

Additionally the user can set an alarm level $\vartheta_{alm}$ to indicate the potential risk.

## 4.4.2 Principle of operation

The function use for the calculation of the function the highest load current of the three phases.

Thermal model:

The thermal model can be divided into three conditions:

1. warming of apparatus – (diabatic behavior or adiabatic behavior),
2. no change in thermal image
3. Cooling of the apparatus.

**1. Warming of the protected object:**

Warming of the protected object can be segregated into two types, diabatic and adiabatic behavior. In diabatic behavior, the protected object have a heat dissipation with the environment during warming itself due to the load current.

For current greater than twice the base current $I_b$ (also known as rated current or full load current) the behavior is classified as adiabatic, this means, that the heat exchange with the environment during warming is considerable small related to the heating.

Warming is defined as:

$$\vartheta_0 < \left(\frac{I}{I_b}\right) * 100[\%]$$

$\vartheta_0$ = present value of thermal image
I = maximum value of measured phase currents
$I_b$ = base current (rated current/full load current defined by setting).
Thermal characteristic warming condition at diabatic behavior:

$$\vartheta_1 = \vartheta_0 + \left(\left(\frac{I}{I_b}\right)^2 - \vartheta_0\right) * \left(1 - e^{-\left(\frac{\Delta t}{\tau\uparrow}\right)}\right)$$

$\vartheta_1$ = new value of thermal image
$\vartheta_0$ = present value of thermal image
I = maximum value of measured phase currents
$I_b$ = base current (rated current/full load current defined by setting).
$\Delta t$ = time interval between $\vartheta_0$ and $\vartheta_1$
$\tau\uparrow$ = Heating time constant

Thermal characteristic warming condition at adiabatic behavior:

$$\vartheta_1 = \vartheta_0 + \left(\frac{I}{I_b}\right)^2 * \left(\frac{\Delta t}{\tau_\uparrow}\right)$$

The value of $\vartheta_0$ at the start of the function (i.e. at power on of the relay is defined by a setting).

**2. Constant thermal image of protected object:**

During this condition, the dissipated heat is equal to heat generated by the current flowing through the protected object.

The thermal model for this conditions is as follow:

$$\vartheta_1 = \vartheta_0$$

whereas:

$$\vartheta_0 = \left(\frac{I}{I_b}\right)^2 * 100[\%]$$

$\vartheta_1$ = new value of thermal image
$\vartheta_0$ = present value of thermal image
I = maximum value of measured phase currents
$I_b$ = base current (rated current/full load current defined by setting).

**3. Cooling of protected object:**

When the current reduces compared to previous condition or the apparatus is switched off it results into cooling of an apparatus.

Cooling condition is defined when:

$$\vartheta_0 > \left(\frac{I}{I_b}\right)^2 * 100[\%]$$

The thermal model used during cooling condition for standing objects (cable / transformer / standing motor) is:

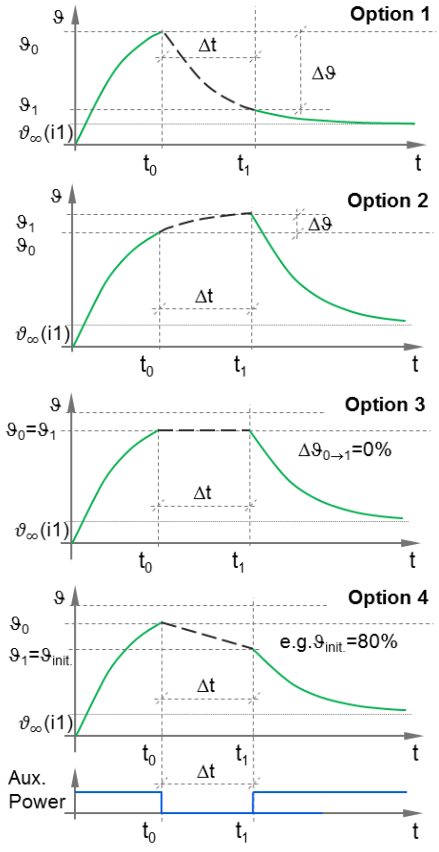
$$\vartheta_1 = \left(\frac{I}{I_b}\right)^2 + \left(\vartheta_0 - \left(\frac{I}{I_b}\right)^2\right) * e^{-\left(\frac{\Delta t}{\tau_{\downarrow S}}\right)}$$

The thermal value of at the start of the function (i.e. at power on of the relay is defined by a setting).

**Behavior of thermal image during power down condition of relay:**

Condition arises where in the power supplied to the relay is interrupted. The user could select four different behaviors / options to calculate the thermal level when the power is restored. These options are selectable by the setting Mode $\vartheta_{powerOFF}$.

The thermal image along with time is stored every 60 sec. (and for option 1 also the actual maximum phase current).




Option 1: When the power is restored after Δt, the new value of current after power on will be considered (which can be more or less compared to when power was interrupted) to calculate new value of thermal image for Δt.

Option 2. When the power is restored after Δt, the new value of thermal image is calculated for Δt considering that the current has remained constant at the value when the power was interrupted.

Option 3: Power interruption of the relay assumes no change of thermal image during interruption period.

Option 4: Power interruption of the relay resets the thermal image to the set value defined by setting $\vartheta_0$.

*Figure 3: Behavior of thermal image during power down condition*

### 4.4.2.1 Setting range for thermal overload protection

*Table 14: Setting range for thermal overload protection 3Ith, 49*

| Parameter | Description | Range | Unit | Step | Default |
|---|---|---|---|---|---|
| ϑ0 | Initial thermal level of the apparatus | 0…100 | % | 1 | 80 |
| Ib | Reference current leading to thermal calculation | 0.1 … 1.5 | x In | 0.1 | 1.0 |
| τ↑ | Heating time constant of machine | 1 … 300 | min | 1 | 45 |
| τ↓s | Cooling time constant of static machine | 1 … 300 | min | 1 | 45 |
| Θalm | Alarm value | 50 … 200 | % | 1 | 121 |
| Θtrip | Operate value | 50 … 200 | % | 1 | 144 |
| ϑstartinhibit | Start inhibit value | 50 … 200 | % | 1 | 105 |
| ϑEM | Percentage by which ϑtrip will be increased in emergency mode | 10… 100 | % | 1 | 50 |
| Mode ϑpowerOFF | Options for calculating thermal value during power interruption | 1…4 | - | 1 | 4 |

Options for calculating thermal image during power interruption shall be as below

1 := On restoration of power, new value of current after power on will be considered to calculate new value of thermal image for interruption period Δt.

2 := On restoration of power, new value of thermal image is calculated for interruption period Δt considering that current has remained constant value during power interruption.

3 := Power interruption of the relay assumes no change of thermal image during interruption period.

4 := Power interruption of the relay resets the thermal image to the set value defined by setting ϑ0.

### 4.4.2.2 Configurable inputs to thermal overload protection

*Table 15: Configurable inputs to thermal overload protection 3Ith, 49*

| Name | Type | Description |
|---|---|---|
| RESET | BOOL | Reset protection |
| BLOCK | BOOL | Block protection |

### 4.4.2.3 Configurable outputs of thermal overload protection

*Table 16: Configurable inputs to thermal overload protection 3Ith, 49*

| Name | Type | Description |
|---|---|---|
| ALARM | BOOL | Alarm |
| OPERATE | BOOL | Operate |
| Θ | REAL | Value of thermal image |

# 4.5 Protection characteristics

## 4.5.1 Time / Current characteristics

Relay offers three-stage overcurrent and two stage earth-fault protection functions. The low-set stage of overcurrent protection and earth-fault protection are equipped with standard Inverse Definite Minimum Time (IDMT) characteristics – (Normal Inverse (NI), Extreme Inverse (EI), Long Inverse (LI), and Very Inverse (VI)) along with definite time (DT) characteristics for better co-ordination with rest of the network. Additionally special characteristic curve RI is also provided. The high stage and instantaneous stage for over current protection and high stage earth fault protection come with DT characteristics.

When IDMT characteristic has been selected, the operating time of the stage will be a function of the current; the higher the current, the shorter the operating time. The stage includes ten different time/current curve sets – four according to IEC 60255-151 standards namely normal inverse, very inverse, extremely inverse, longtime inverse, four according ANSI C37.112 standard namely moderate inverse, normal inverse, very inverse, extremely inverse and one special curve, named RI type curve along with DT characteristics.

The maximum permitted continuous current carrying capacity of the energizing inputs 4 x $I_n$, 20 x In for 10 sec and 100 x In for 1 sec which needs to be considered while performing setting co-ordinations / simulating testing of characteristics.

## 4.5.2 IEC 60255-151 IDMT characteristic

The relationship between current and time for standard normal inverse, very inverse, extremely inverse and long-time inverse complies with the IEC 60255-151 standards and can be expressed as follows:

$$t = \frac{(K * \beta)}{(\frac{I}{Iset})^{\alpha} - 1}$$

Where,

*t* = operate time in seconds

*K* = time multiplier

*I* = measured current value

*Iset* = set start current value

The slope of the time/current characteristics shall be determined by the constants **α** and **ß** as indicated below:

*Table 17: Values of constant α and β*

| Slope of the time/current curve set | α | β |
|---|---|---|
| IEC – Normal inverse | 0.02 | 0.14 |
| IEC – Very inverse | 1.0 | 13.5 |
| IEC – Extremely inverse | 2.0 | 80 |
| IEC – Long time inverse | 1.0 | 120 |

### 4.5.2.1 Normal inverse-time characteristics curve

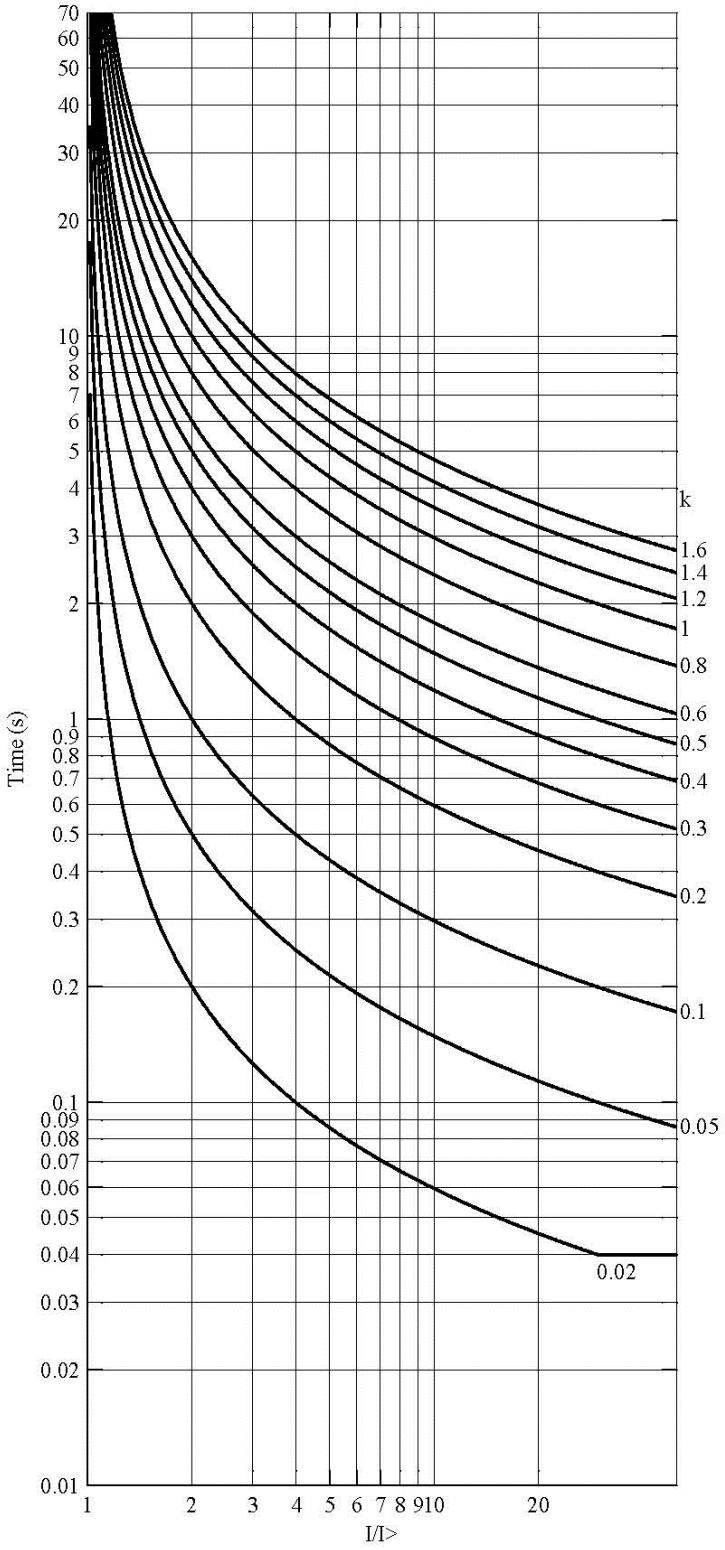



*Figure 4: Normal inverse-time characteristics of relay REJ603*

### 4.5.2.2 Very inverse-time characteristics curve

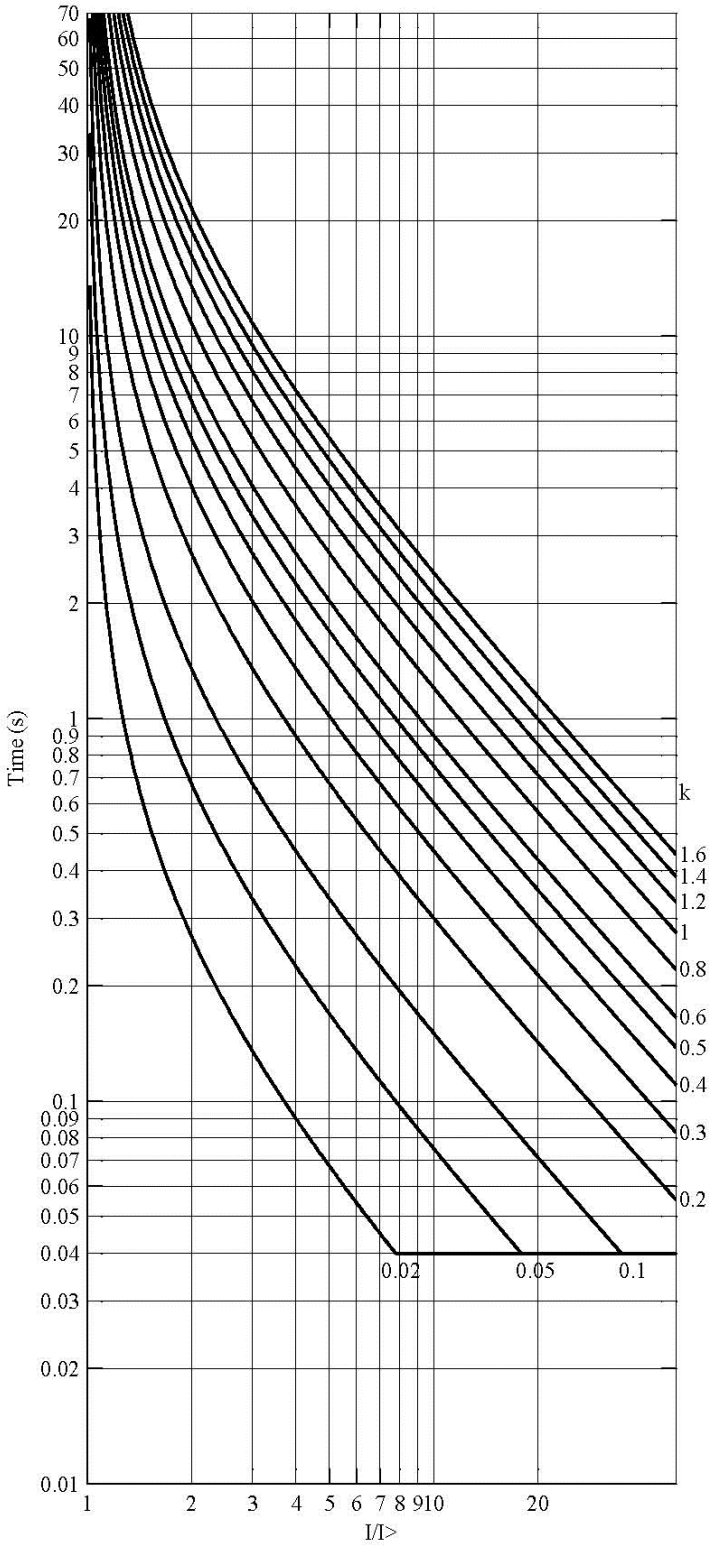



*Figure 5: Very inverse-time characteristics of relay REJ603*

### 4.5.2.3 Extremely inverse-time characteristics curve

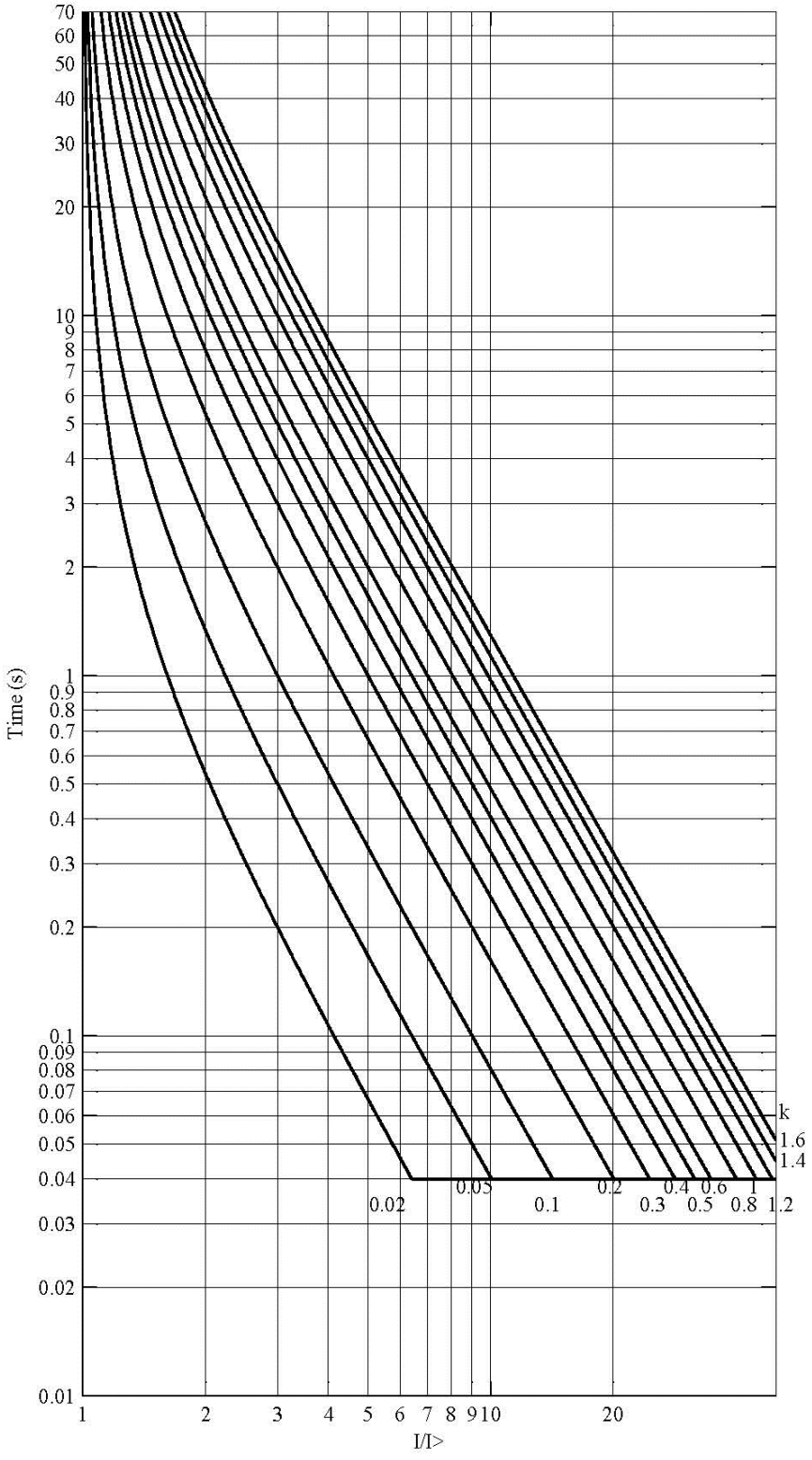



*Figure 6: Extremely inverse-time characteristics of relay REJ603*

### 4.5.2.4 Long-time inverse-time characteristics curve

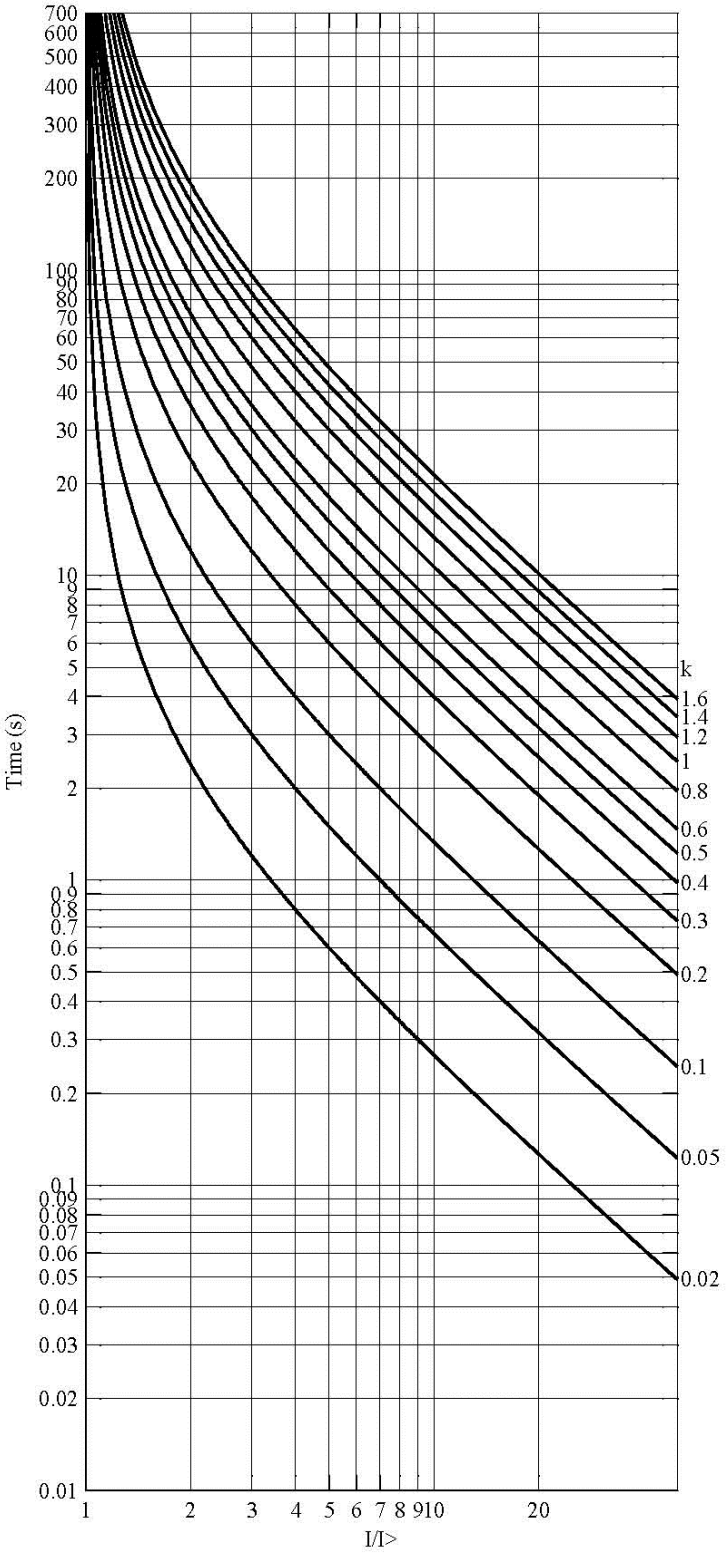



*Figure 7: Extremely inverse-time characteristics of relay REJ603*

## 4.5.3 ANSI C37.112 IDMT characteristic

The relationship between current and time for standard moderate inverse, normal inverse, very inverse, extremely inverse complies with the ANSI C37.112 standards and can be expressed as follows:

Where:

$$t = \left( \frac{\beta}{\left(\frac{I}{Iset}\right)^{\alpha} - 1} + \gamma \right) * K$$

Where,

*t* = operate time in seconds

*K* = time multiplier

*I* = measured current value

*Iset* = set start current value

The slope of the time/current characteristics shall be determined by the constants $\alpha$ and $\beta$ and $\gamma$ as indicated below:

*Table 18: Values of constants α, β and γ*

| Slope of the time/current curve set | α | β | γ |
|---|---|---|---|
| ANSI – Moderate inverse | 0.02 | 0.0515 | 0.1140 |
| ANSI – Normal inverse | 0.02 | 0.0086 | 0.0185 |
| ANSI – Very inverse | 2.0 | 19.61 | 0.491 |
| ANSI – Extremely inverse | 2.0 | 28.2 | 0.1217 |

### 4.5.3.1 ANSI Moderate inverse-time characteristics curve

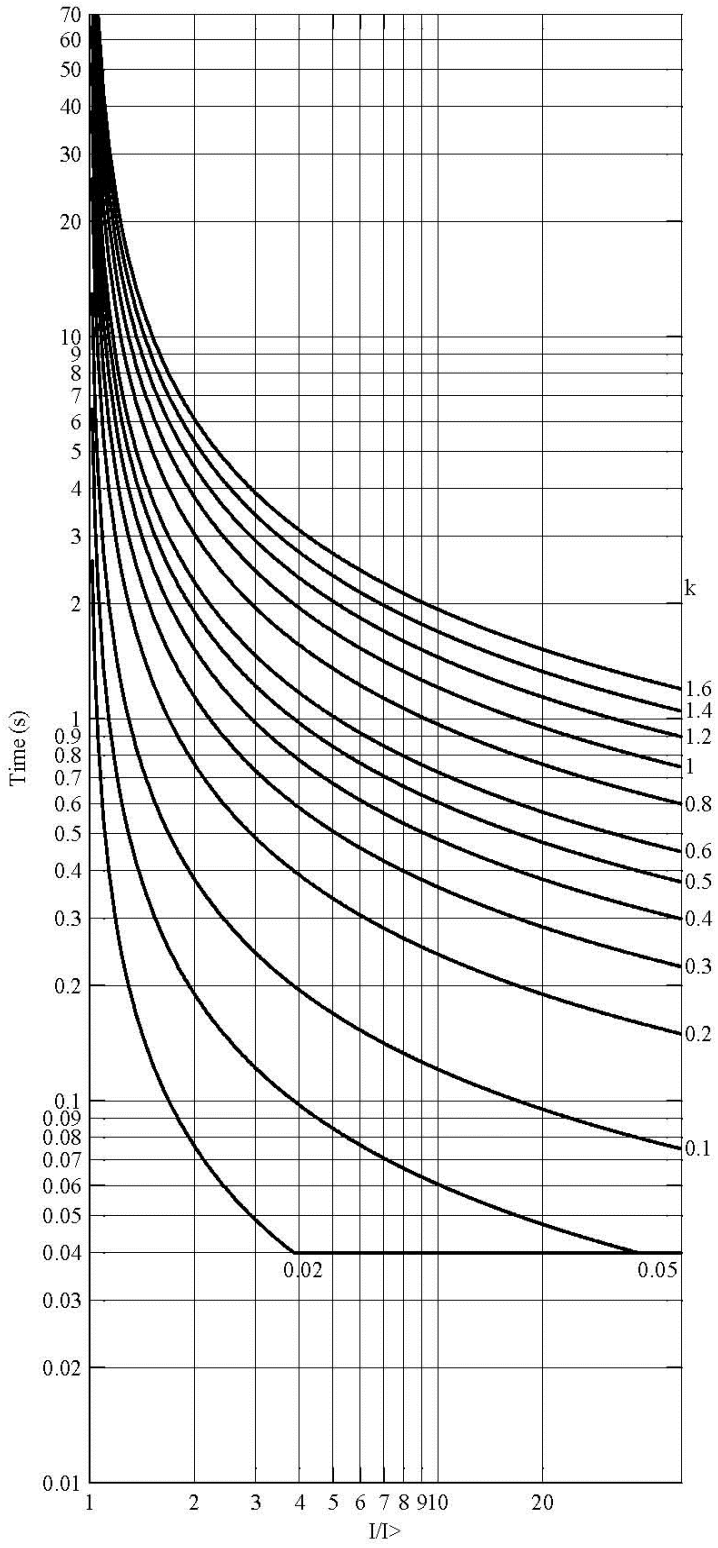



*Figure 8: ANSI Moderate inverse-time characteristics of relay REJ603*

### 4.5.3.2 ANSI Normal inverse-time characteristics curve

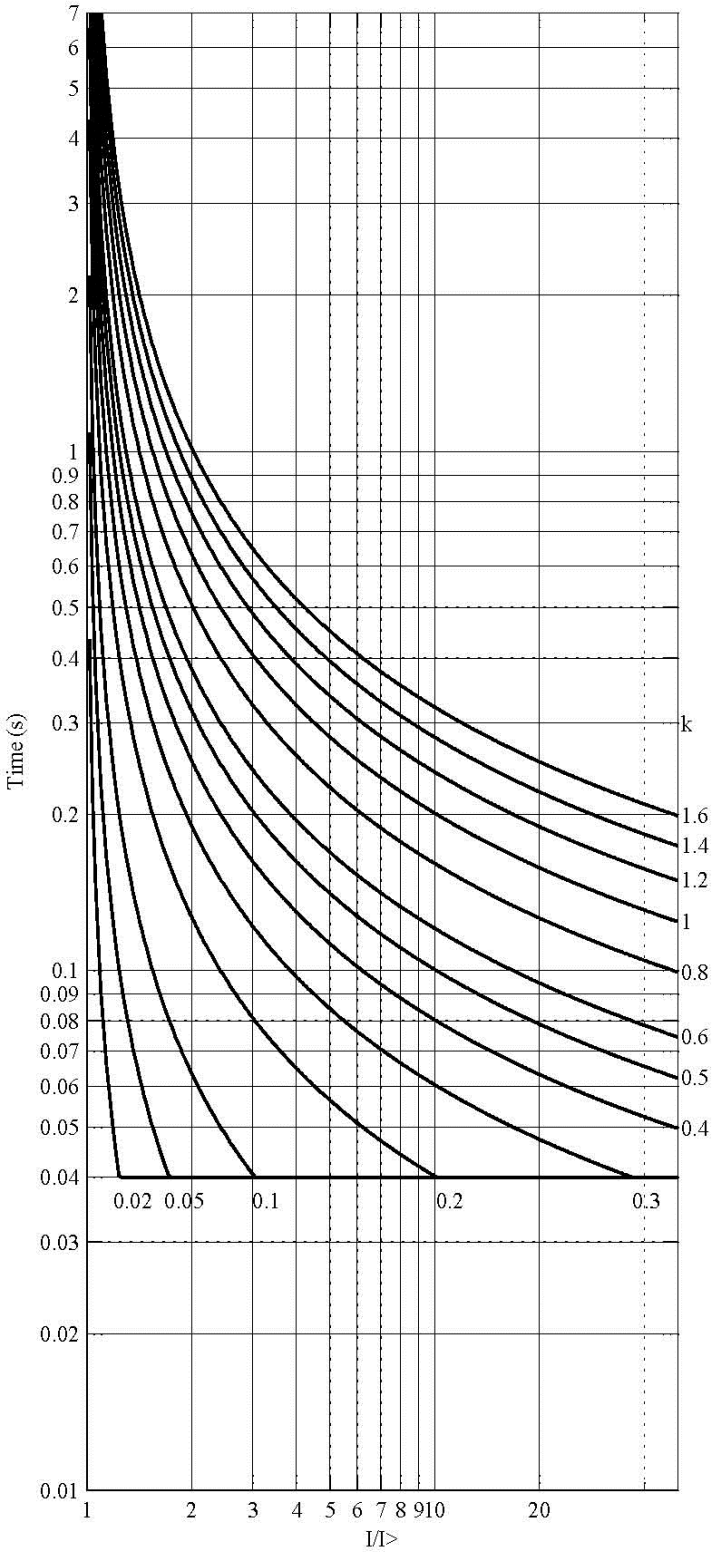



*Figure 9: ANSI Normal inverse-time characteristics of relay REJ603*

### 4.5.3.3 ANSI Very inverse-time characteristics curve

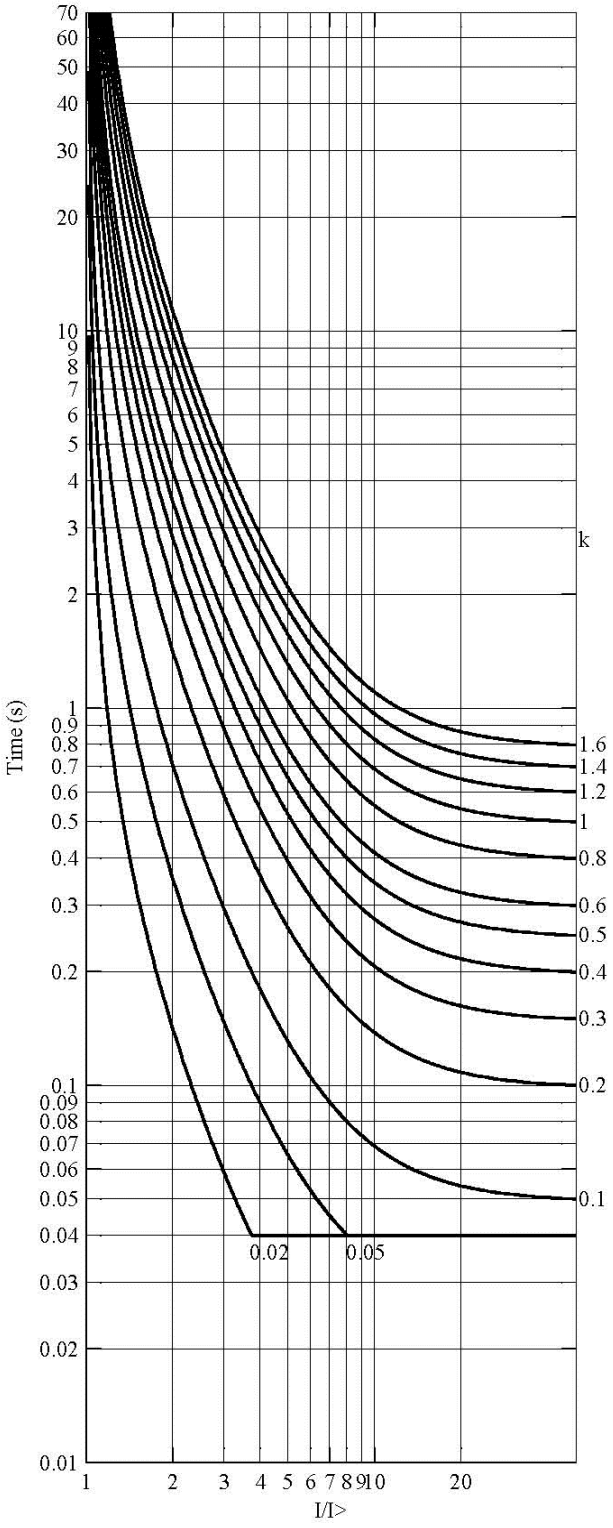



*Figure 10: ANSI Very inverse-time characteristics of relay REJ603*

### 4.5.3.4 ANSI Extremely inverse-time characteristics curve

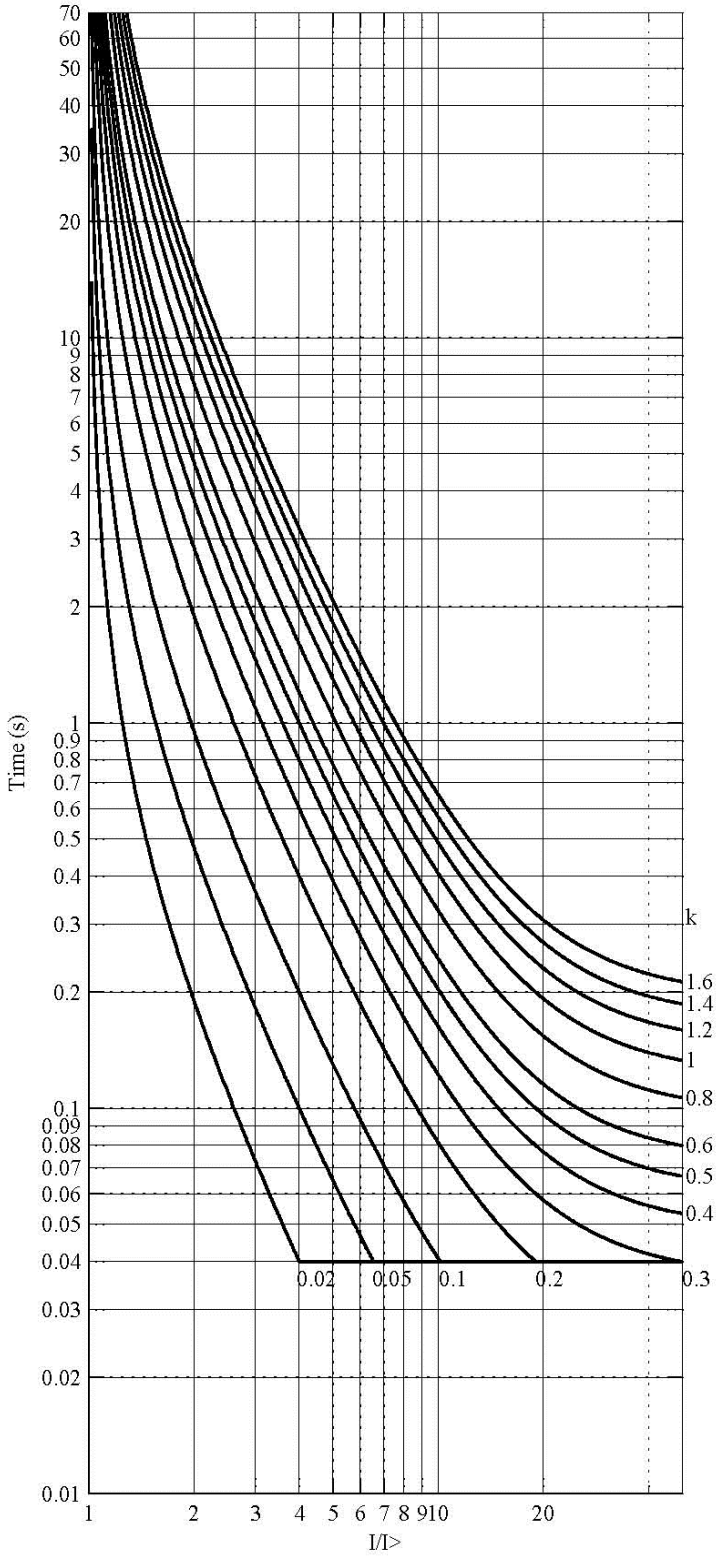



*Figure 11: ANSI Extremely inverse-time characteristics of relay REJ603*

## 4.5.4 RI type characteristic

The RI-type characteristic is a special characteristic used mainly in combination with existing mechanical relays. The characteristic is based on the following mathematical expression:

$$t = \frac{K}{\alpha - \beta(\frac{Iset}{I})}$$

Where,

t = operate time in seconds

K = time multiplier

I = measured current value

Iset = set start current value

α = 0.339

β = 0.236

### 4.5.4.1 RI type characteristic

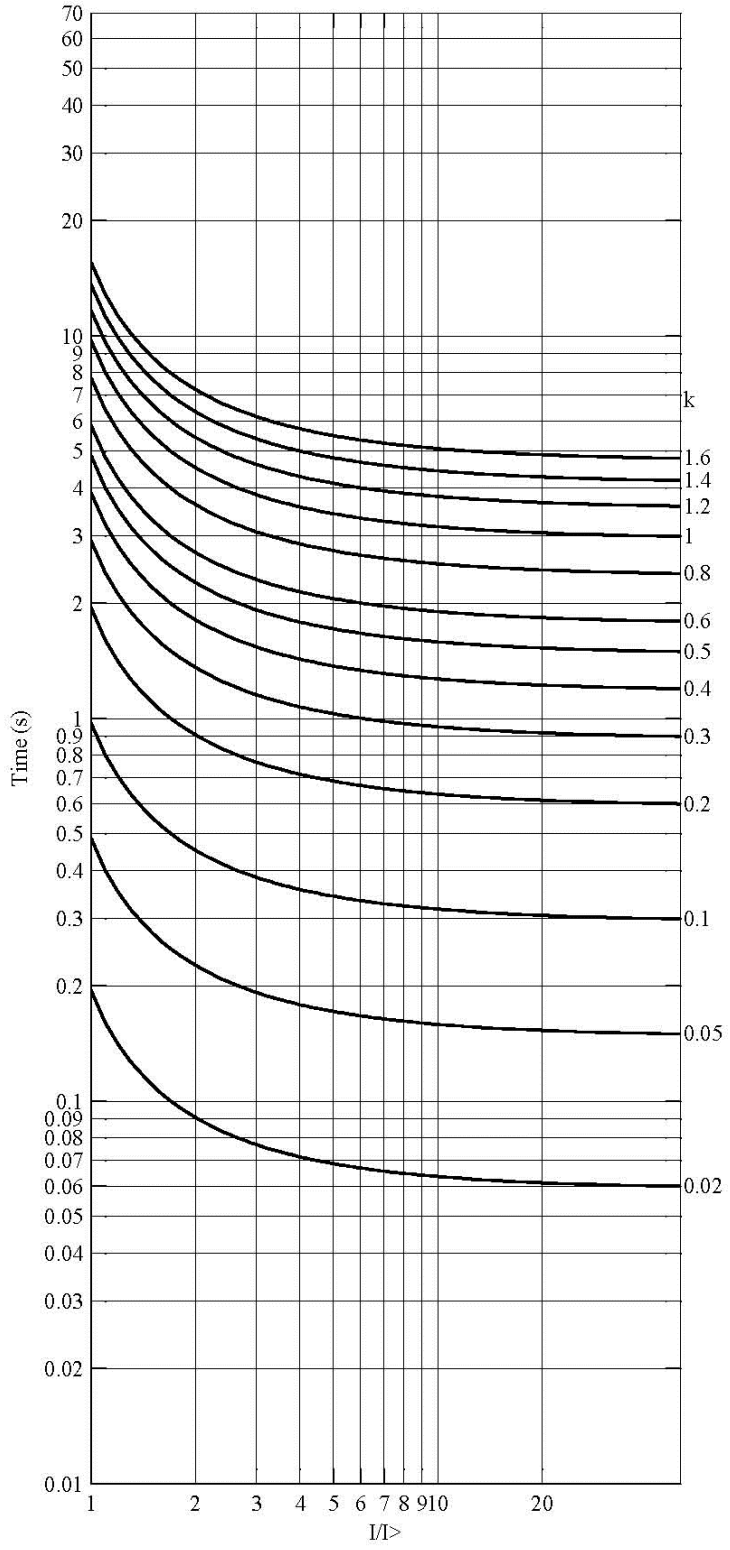



*Figure 12: RI inverse-time characteristics of relay REJ603*

## 4.5.5 HR Fuse and FR Fuse type characteristics

The HR and FR Fuse type characteristic is a special characteristic used mainly in combination with fuses. The characteristic is based on the following mathematical expression:

HR Fuse type characteristic is based on the following mathematical expression:

$$t = \left(\frac{\alpha}{0.1}\right) * 10^{\left[\left(\log\left(2*\frac{I}{Iset}\right)*(-3.832)\right)+3.66\right]}$$

FR Fuse type characteristic is based on the following mathematical expression:

$$t = \left(\frac{\alpha}{0.1}\right) * 10^{\left[\left(\log\left(\frac{I}{Iset}\right)*(-7.16)\right)+3.0\right]} \quad \text{for} \quad \frac{I}{Iset} = 1 \ldots 2$$

$$t = \left(\frac{\alpha}{0.1}\right) * 10^{\left[\left(\log\left(\frac{I}{Iset}\right)*(-5.4)\right)+2.47\right]} \quad \text{for} \quad \frac{I}{Iset} = 2 \ldots 2.66$$

$$t = \left(\frac{\alpha}{0.1}\right) * 10^{\left[\left(\log\left(\frac{I}{Iset}\right)*(-4.24)\right)+1.98\right]} \quad \text{for} \quad \frac{I}{Iset} > 2.66$$

### 4.5.5.1 HR Fuse type characteristics

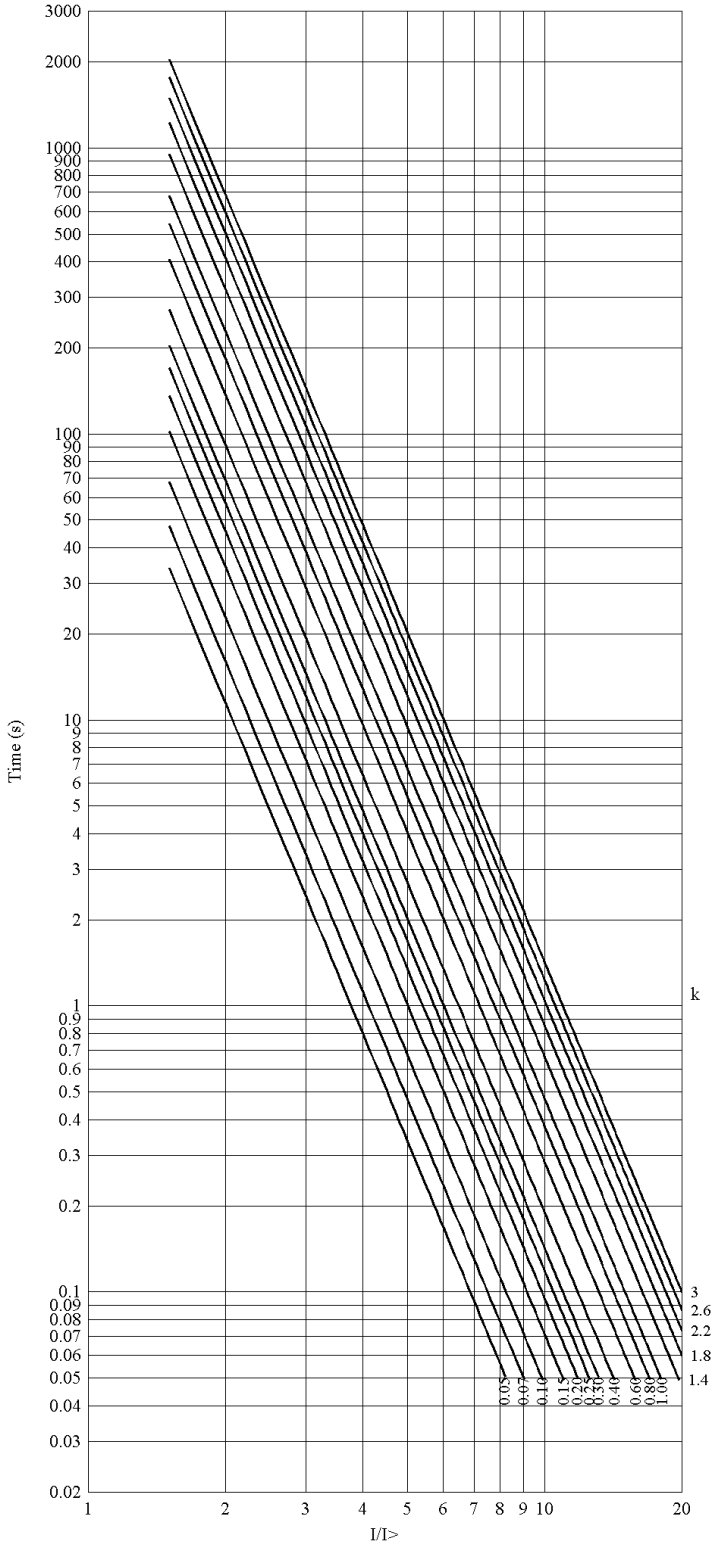



*Figure 13: HR Fuse characteristics of relay REJ603*

### 4.5.5.2 FR Fuse type characteristics

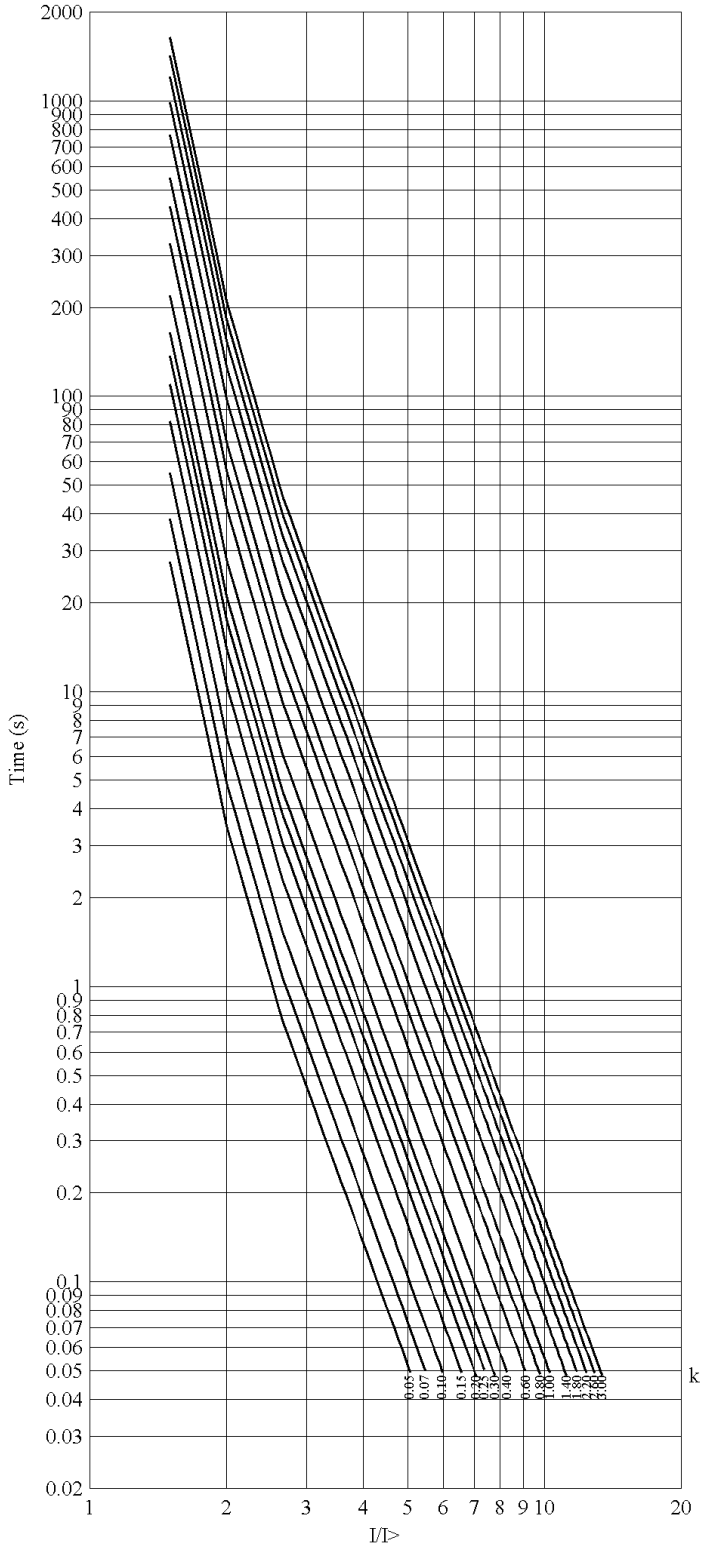



*Figure 14: FR Fuse characteristics of relay REJ603*

## 4.5.6 Operation time tolerance for IEC and ANSI IDMT characteristic

The operate time tolerances for IEC and ANSI inverse-time characteristics for relay shall be as indicated below which is derived based on old BS 142.1966 standard (E denotes accuracy in per cent, - = not specified):

| I/I> | Normal inv. | Very inv. | Extremely inv. | Long-time inv. | Moderate inv. |
|---|---|---|---|---|---|
| 2 | 2.22 E | 2.34 E | 2.44 E | 2.34 E | 2.34 E |
| 5 | 1.13 E | 1.26 E | 1.48 E | 1.26 E | 1.26 E |
| 10 | 1.01 E | 1.01 E | 1.02 E | 1.00 E | 1.00 E |
| 20 | 1.00 E | 1.00 E | 1.00 E | 1.00 E | 1.00 E |

Hence as per Class E(5) the accuracy shall be as indicated below:

| I/I> | Normal inv. | Very inv. | Extremely inv. | Long-time inv. | Moderate inv. |
|---|---|---|---|---|---|
| ≤ 2.00 | 11.1 | 11.7 | 12.2 | 11.7 | 11.7 |
| 2.01 - 5.00 | 5.65 | 6.30 | 7.40 | 6.30 | 6.30 |
| 5.01 - 10.00 | 5.05 | 5.05 | 5.10 | 5.00 | 5.00 |
| > 10.01 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 |

**Example:**

For adapted setting I> = 1.0 x In, k = 0.02, IEC Very Inverse curve

When the test current injected is **2.0 x In**,

I/I> = 2 and the theoretical operate time = 0.27s

According to above tolerance limit, the time tolerance in this class is 2.34 x E where E denotes accuracy in % (5% in our case, class 5).

So calculated time limits is 0.27 x (+ 2.34 x 5%) = 0.03159s resulting into time range as 0.2384s …. 0.3015s.

(It needs to consider the range as either 0.03159sec or 0.03s whichever is higher, here 0.03159s is higher).

Operation time accuracy for protection functions shall be as indicated above is when relay is in energised condition. The operation time when relay is in un-energised condition, shall be as per switch-on to fault characteristics Table 19 and Figure 15.

# 4.6 Switch-on to fault (SOTF) characteristic

*Table 19: Switch-on to fault characteristics timings*

| Description | Value |
|---|---|
| At minimum value of pick-up current and minimum operate time, minimum typical value of tripping time when switch-on to fault | 80 ms |

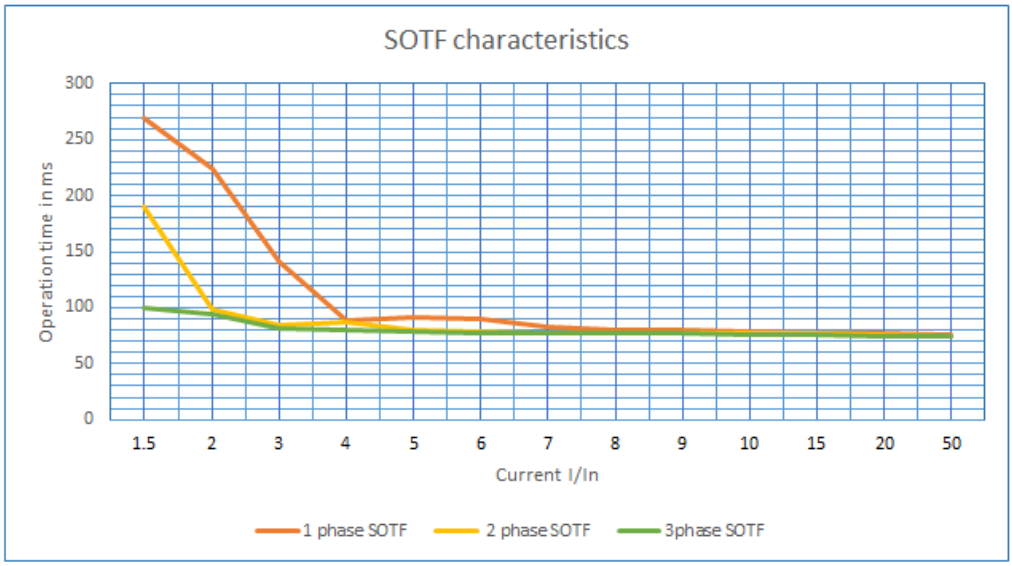



*Figure 15: Switch-on to fault characteristics of relay REJ603*

# Section 5 Use of LHMI

## 5.1 Overview

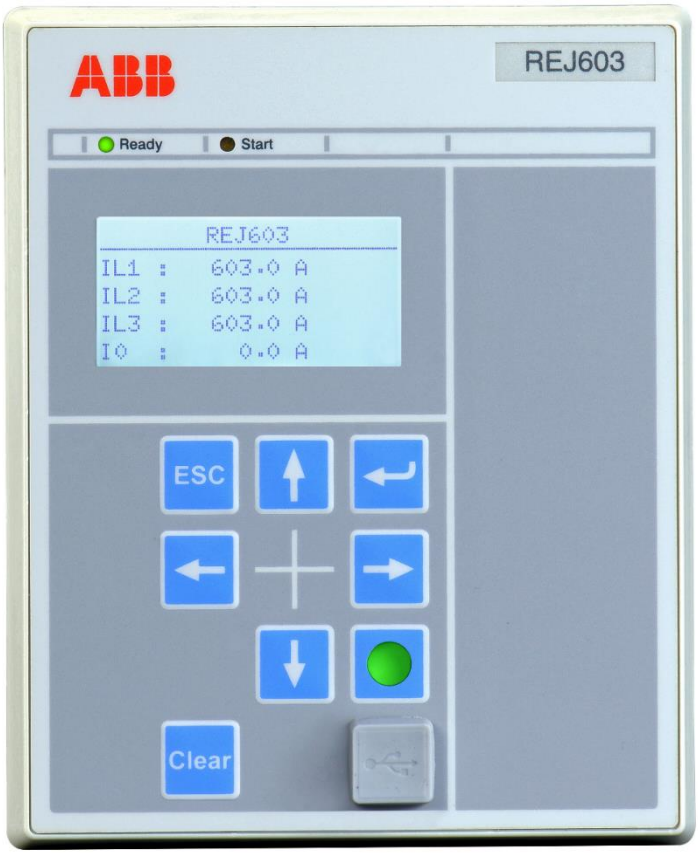



*Figure 16: Local HMI of relay REJ603*

The local HMI of the relay contains following elements:

- LCD display
- LED indicators
- Electromagnetic flag
- Navigation buttons / keys

The LHMI is used for setting and monitoring.

### 5.1.1 LED's

LED's displays following information respective status

Ready: Green LED

Start: Yellow LED lights after any start of a protection function

## 5.1.2 Electromagnetic Flag

The relay electromagnetic flag which turns to red in case of relay trip, the flag retain its operation status even in absence of current. The flag turns to green after reset by pressing CLEAR button

## 5.1.3 LCD display

The LHMI includes a graphical LCD display which supports English characters.

## 5.1.4 Navigation

The LHMI keypad consists of push buttons which are used to navigate in different views or menus.

*Table 20: LHMI push buttons*

| Key Picture | Key Name | Description |
|---|---|---|
|  | Up | Used for incrementing of parameter value while editing, or provides up level selection of menu item. |
|  | Down | Used for decrementing of parameter value while editing, or provides down level selection of menu item. |
|  | Back | Used for going to higher level of menu item from its lower level submenu. |
|  | Next | Used for going to lower level submenu from higher level menu. |
|  | Enter | Press key Enter to edit the relay parameter from LHMI and used for saving of edited parameter value. |
|  | Clear | To reset the relay from LHMI |
|  | Escape/Cancel | a) Used for discarding changed parameter value in edit mode<br>b) Used for going back to main menu from any level of menu navigation. 2nd pressing “ESC” will lead to default view. |

## 5.1.5 Authorization

To protect the relay from unauthorized access and to maintain the integrity of information, the relay is armed with a three level, role based user authentication system with individual password for operator, engineer and administrator level.

To access the relay by any category of user, alpha-numeric password protection is provided in relay which is achieved by six letter password. The password shall be set in password configuration menu.

The rights per user category and their default password are listed in following table:

*Table 21: User authorization and default password*

| Sr No. | Features | Operator Level User | Engineer Level User | Admin Level User |
|---|---|---|---|---|
| 1 | Menu viewing | Yes | Yes | Yes |
| 2 | Protection settings editing | - | Yes (Parameters only) | Yes |
| 3 | Perform test | - | Yes | Yes |
| 4 | Relay Configuration editing | - | - | Yes |
| 5 | External Events and DR clearing | - | - | Yes |
| 6 | Password editing | - | - | Yes |
| 7 | Alpha numeric password protection: | Other than Admin/setting | Alphanumeric | Alphanumeric |
| 8 | Default password | No password | 0003 | 0004 |

The selection of user category is done via password at entering the main menu.

In case of wrong password being entered by the user, automatically the operator user category is selected.

The sequence of the selection of the user shall be as below:

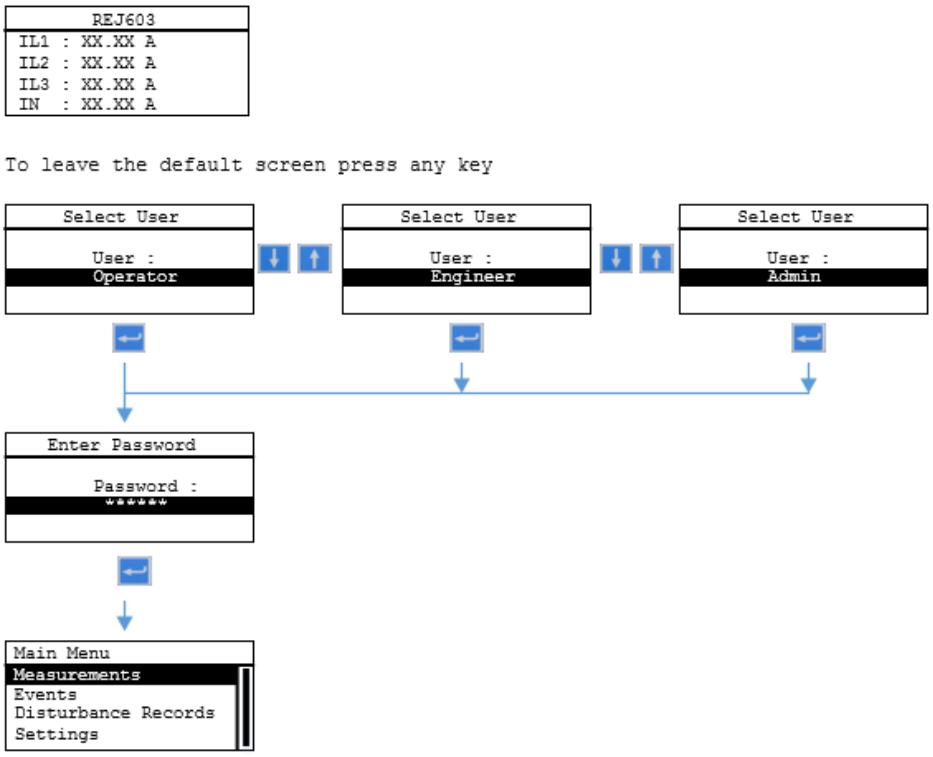



*Figure 17: Login process of relay REF601 / REJ601/REM601*

**Password configuration**

The password could be changed under the Main Menu -> Access Level.

In access level menu, password can be set for both setting & admin level. In edit mode, cursor position can be set by ← or ← arrow key and allowed password symbol can be selected by ↑ or ↓ arrow key. Finally by ENTER key password can be set.


*Figure 18: Password configuration in relay*

# 5.2 LHMI menu navigation

## 5.2.1 Default screen

The default view of the relay displays the phase current and earth current which is indicated in Fig. 10. The relay returns to default screen after 5 minutes if no key is pressed.

Current values are displayed in this view for phase current and earth current in “A” as shown in following figure.

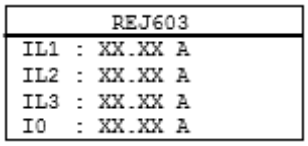



*Figure 19: Default screen of relay*

## 5.2.2 Main menu

The main menu appears after entering the password with the user rights depended on the entered password. Following view shows the main menu of the relay.

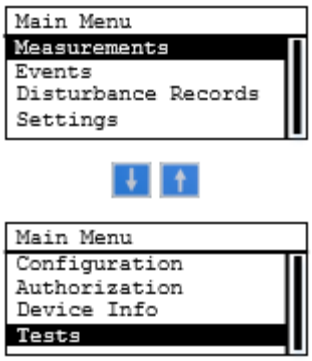



*Figure 20: Main menu of relay*

## 5.2.3 Menu – Measurement

Submenu Measurement shows analogue input values as primary or as secondary values according to primary and secondary current of current transformer selected in the submenu configuration – settings. Also it shows binary input and output status at the relay terminal.

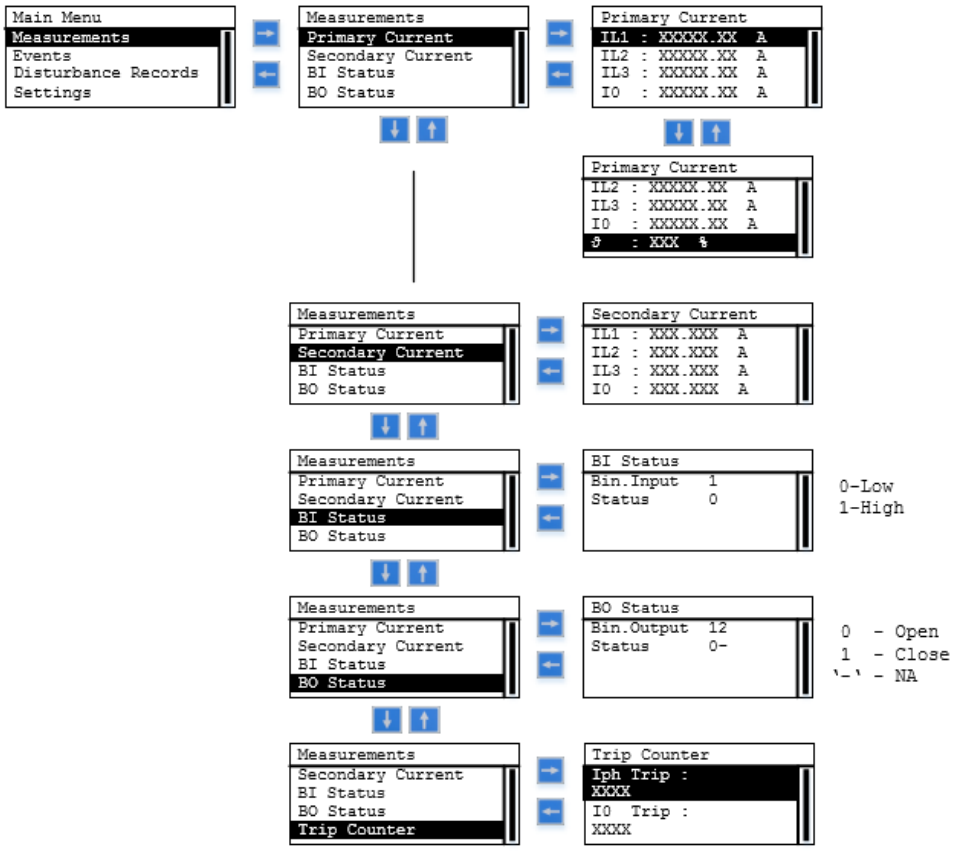



*Figure 21: Measurement menu of relay*

## 5.2.4 Menu - Events

Events menu is categorized as internal & external type of events. Relay will store 100 internal events and 250 external events in non-volatile memory with details in respective submenu. Event 1 will always contain data of most recent event.

From sub menu of Clear only all external events can be cleared from memory. And internal events cannot be cleared from memory, automatically the events older than 100 one shall be cleared.

The event menu can be access as below.

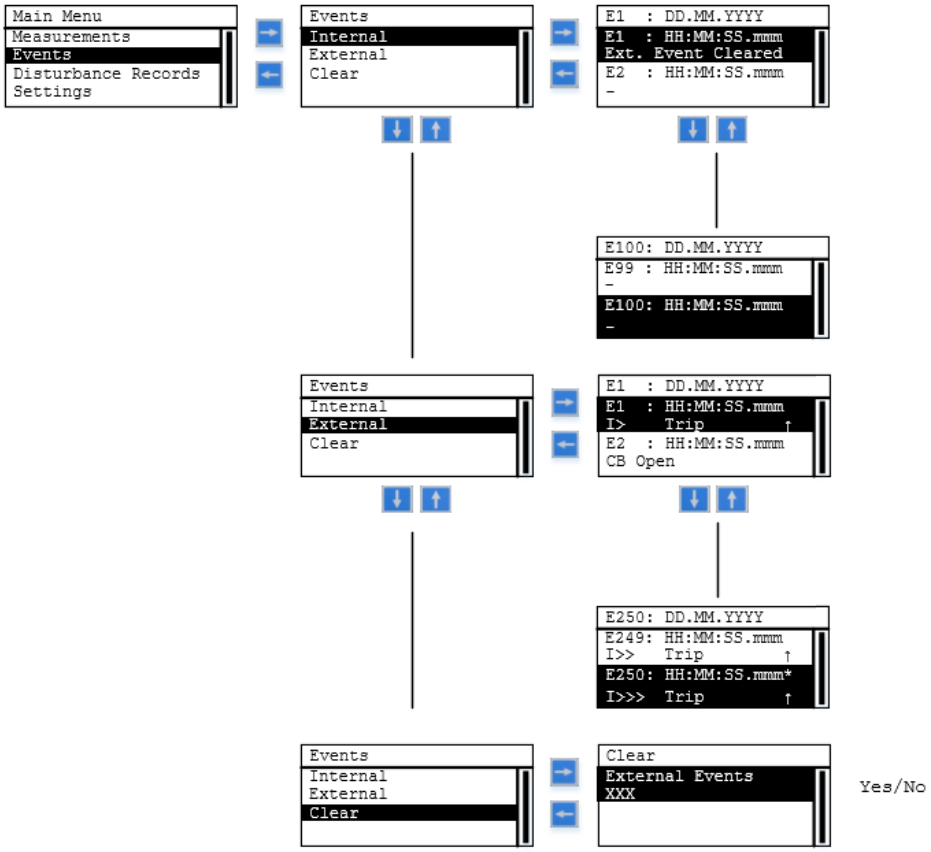



*Figure 22: Event menu of relay*

## 5.2.5 Menu – Disturbance record

Disturbance record menu allows to configure the parameters and triggers to have a disturbance record file in a standard COMTRADE format. The disturbance record file can be downloaded from relay via front USB port. An option to clear all disturbance record file is provided in submenu.

The event menu can be access as below.

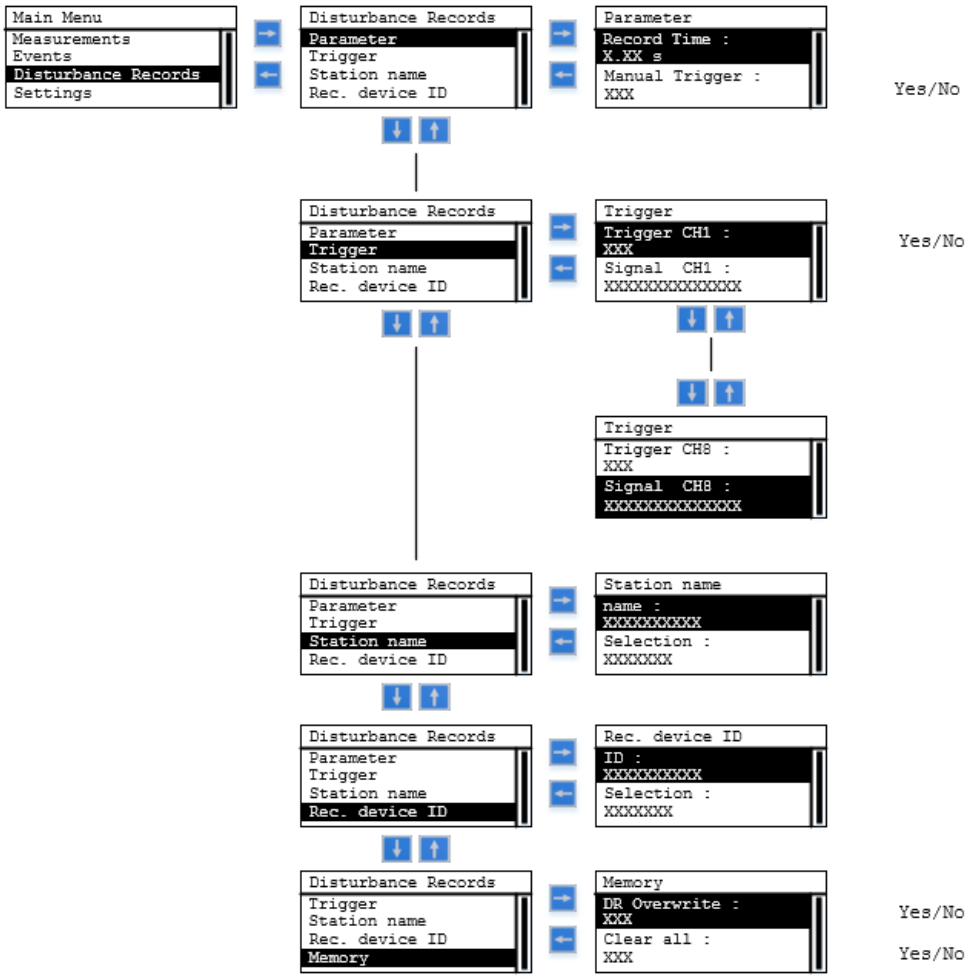



*Figure 23: Disturbance record menu of relay*

## 5.2.6 Menu – Setting

Settings and respective submenus shows and allows depending on the user right to change all protection parameters and communication parameters.

To modify configuration settings needs user rights of Admin user.

- To modify selected setting start with key, press “enter key”
- To save changed setting with key
- To discard and exit a modified setting with key

Following menu structure is used to navigate to the respective settings:

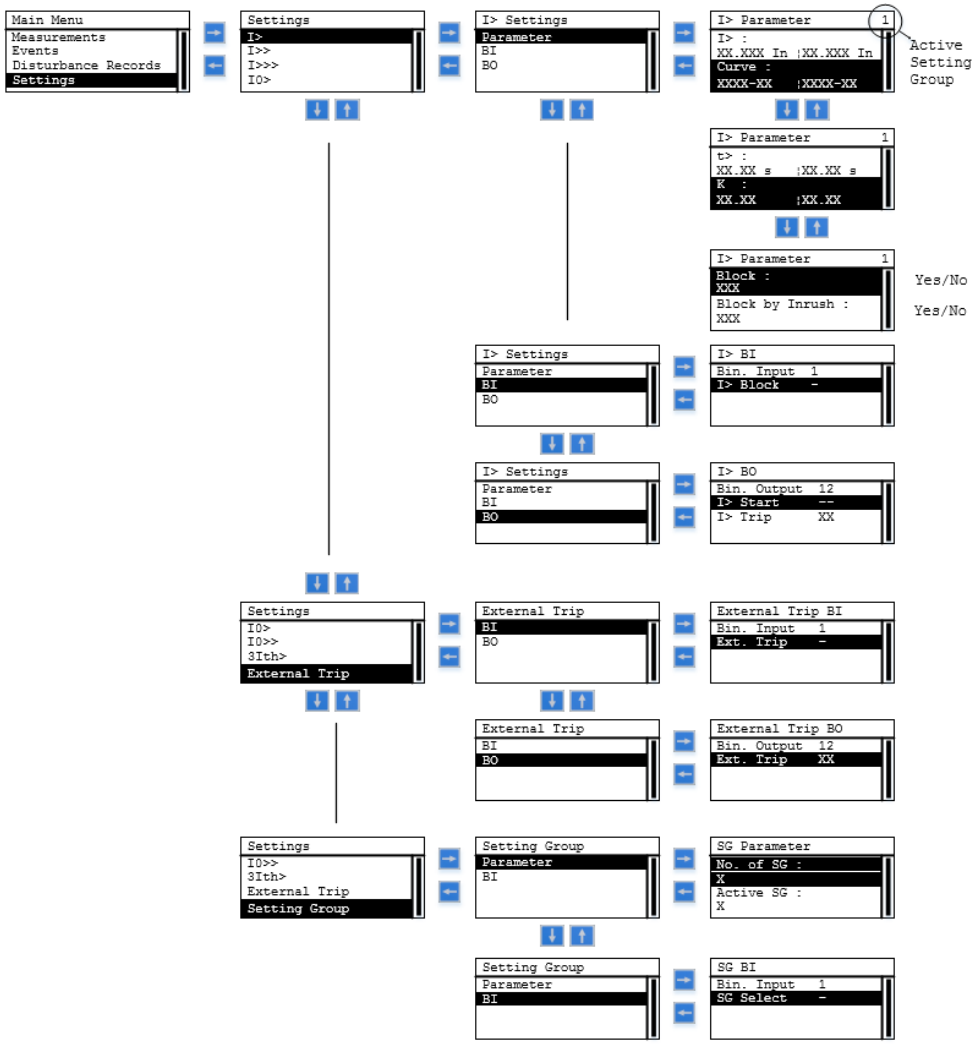



*Figure 24: Setting menu of relay*

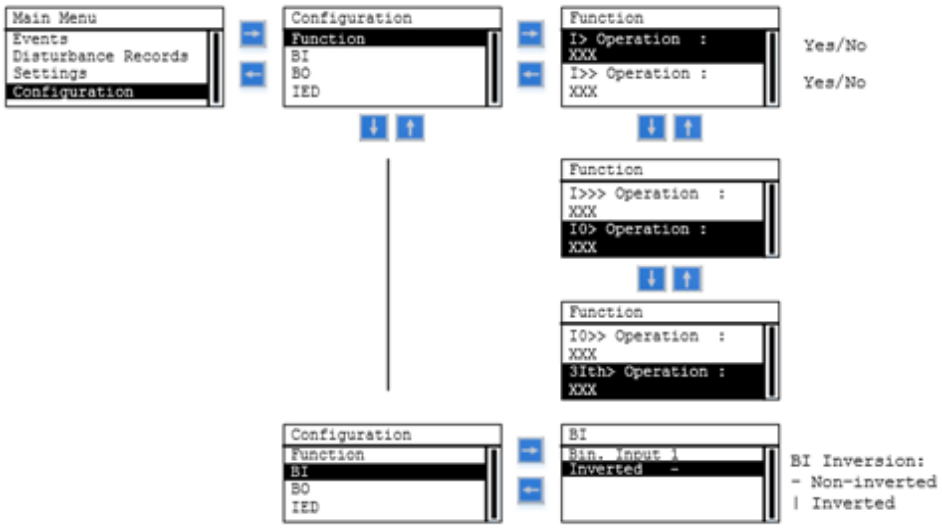
## 5.2.7 Menu – Configuration

- Configuration menu and respective submenus shows and allows depending on the user right to change
- Enabling operation of particular protection stage
- Relay configuration settings like Frequency, earth current calculation method
- Inrush protection related settings
- Selection for loading factory settings (protection parameters only)

To modify configuration settings needs user rights of Admin user.

- To modify selected setting start with key, press “enter key”
- To save changed setting with key
- To discard and exit a modified setting with key ESC

Following menu structure is used to navigate to the respective configuration settings:



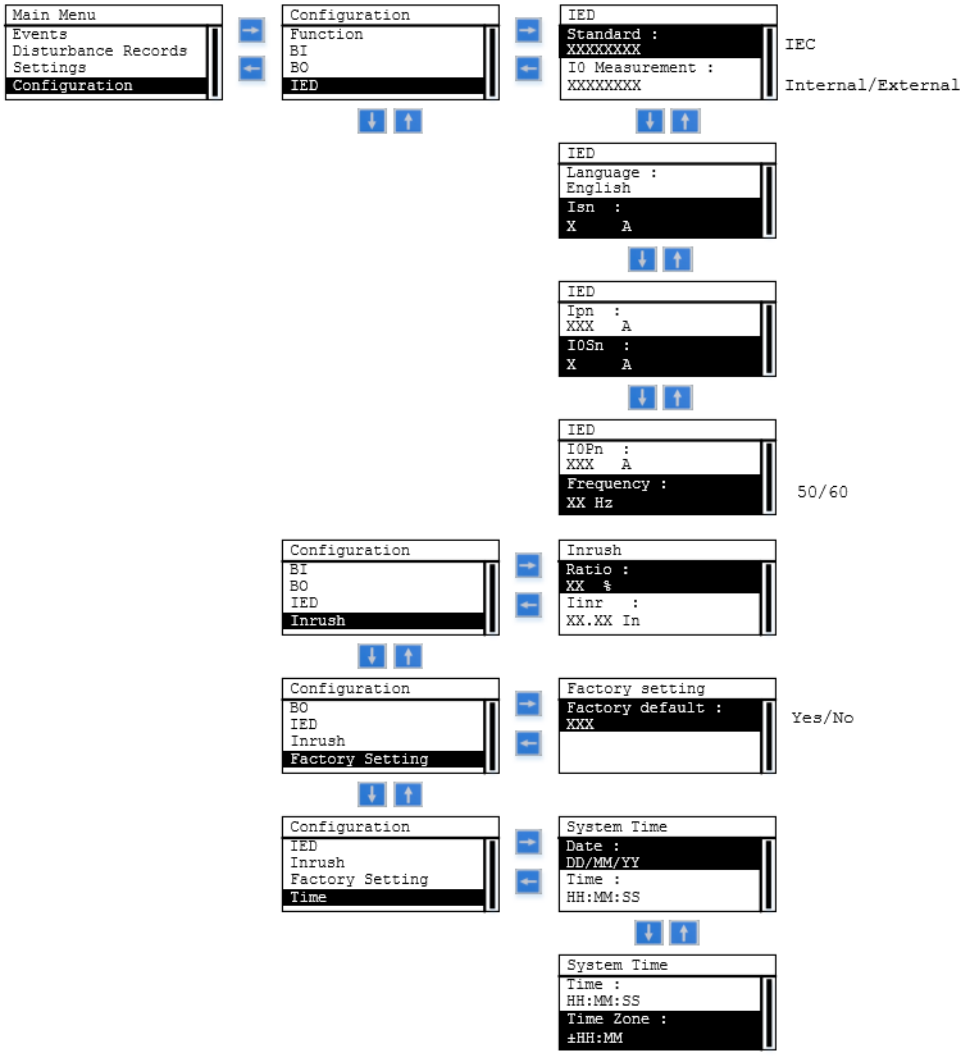



*Figure 25: Configuration menu of relay*

## 5.2.8 Access level

This menu provides the password change facility for the different access levels. Only Admin can change the password of the other access levels. User can then enter new password. Enter button must be pressed before timeout period after changing the password. Password can be of six alphanumeric character combinations. Allowed characters are “A” to “Z” in capital only and “0” to “9” numbers.

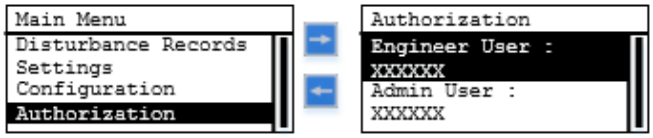



*Figure 26: Access level menu*

## 5.2.9 Version information

This menu provides information regarding the Product type selected and Software version being presently loaded into the product.

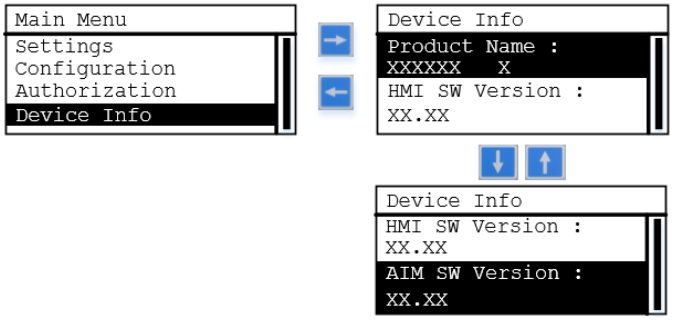



*Figure 27: Version information menu*

## 5.2.10 Menu – Test

Submenu Test and respective submenus shows and allows depending on the user right to perform several kind of tests to verify the protection relay functionality:

**Hardware:** Enables Internal Hardware Tests, which includes LCD check, Keyboard check, LEDs and Binary output check. User can skip particular checks using interactive menu selection.

**Functional:** Enables each protection function tests by loading fixed analog values for five seconds and ignoring actual analog inputs. User can test all protection stages and accordingly its relay configuration by having a simulated analog values for 5 seconds.

The details of functions available in test mode are described as under the respective section.

To modify settings needs user rights of Setting or Admin user.

Following menu structure is used to navigate to the respective test settings:

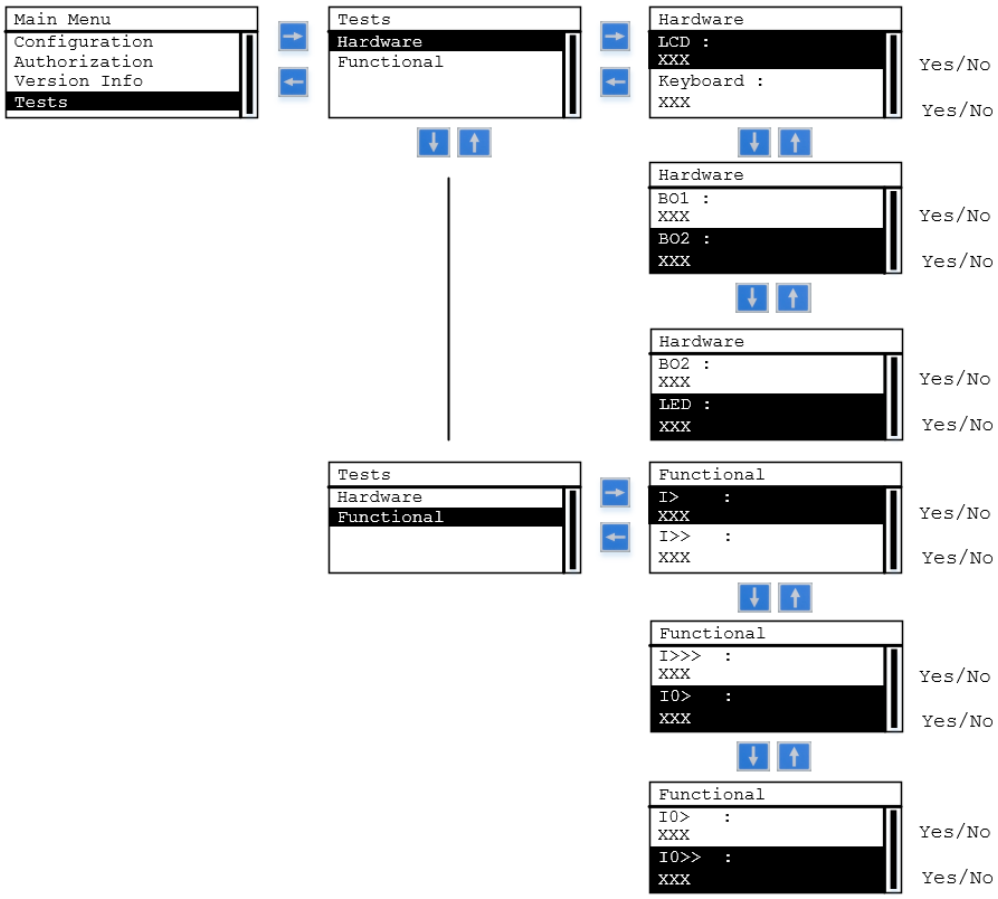



*Figure 28: Test menu of relay*

## 5.3 Disturbance recording uploading

The disturbance records are stored in COMTRADE format with date and time stamping in the non-volatile memory of the relay. The recorded COMTRADE file(s) can be copied from the relay memory to the laptop/PC using the front USB port of relay. The upload of disturbance records does not require any software. When laptop / PC is connected to relay front port, user can directly access the relay (read-only) memory and copy required files.

# Section 6 Installation

## 6.1 Unpacking and inspecting the device

Protection relay, although of robust construction, require careful handling prior to installation on site. The delivered products should always be examined to ensure that no damage has been sustained during transit.

Remove transport packing carefully without force. Appropriate tools needs to be used.

Check the relay for transport damages. If the product has been damaged, a claim should be made to the transport contractor and the local representative of ABB should be promptly notified. Compare the type designation of the product with the ordering information to verify that you have received the right product.

Electrostatic discharge (ESD)

The products contain components that are sensitive to electrostatic discharge. The electronic circuits are well protected by the relay case and therefore the rear panel may not be removed.

## 6.2 Storage

On receipt, the apparatus must be carefully unpacked and checked as described under chapter 6.1. Should installation not be carried out immediately, the apparatus must be repacked using the original packing material. Should the original packing material no longer be available, store the apparatus in a dry, dust-free, covered area which is non-corrosive and has a temperature of between – 40 °C and + 85 °C.

## 6.3 Checking environmental condition and mounting space

The mechanical and electrical environmental conditions at the installation site must be within the limits described in the technical data.

- Avoid installation in dusty, damp places.
- Avoid places susceptible to rapid temperature variations, powerful vibrations and shocks, surge voltages of high amplitude and fast rise time, strong induced magnetic fields or similar extreme conditions.
- Check that sufficient space is available.
- To allow access for maintenance and future modifications a sufficient space is needed in front and at side of the relay.
- Suitably qualified personnel with adequate knowledge of the apparatus must carry out all the installation operations.
- The relay should be disconnected before carrying out any work on relay.

## 6.4 Relay mounting and dimensions

The REJ603 have been supplied with mounting clamps facilitating the easy flush mounting on the panel. With appropriate mounting accessories the REJ603 can also be mounted on the secondary circuit breakers and Ring Main Units.

The details of relay dimensions shall be as under:

| | |
|---|---|
| Overall dimensions (H x W x D) | : 167 x 132.5 x 182.5 mm |
| Cutout dimensions (H x W) | : 137 ± 1.0 x 122.5 ± 1.0 mm |
| Depth behind the panel | : 162.5 mm |
| Weight | : 2.96 kg |
| Thickness of panel | : 1.5 – 4.0 mm |

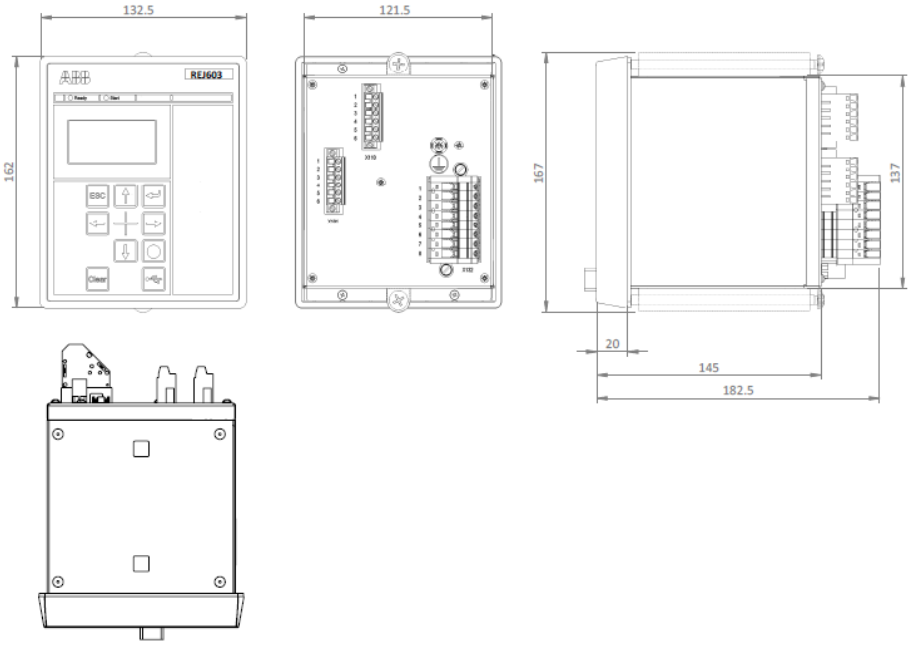



*Figure 29: Overall mounting dimension*

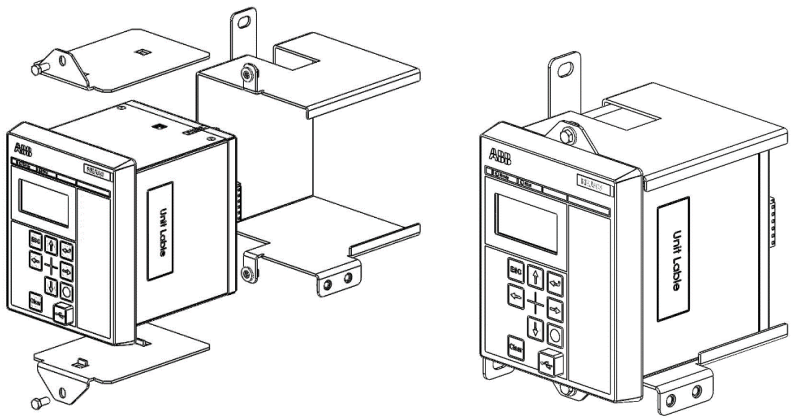



*Figure 30: Typical mounting of relay in RMU (Mounting plate and bracket not supplied along with relay)*

## 6.4.1 Flush mounting of relay

### 6.4.1.1 Required tools

- PZ2 screwdriver for mounting the clamps and connecting protective earthing

Only use adjustable torque screwdrivers.

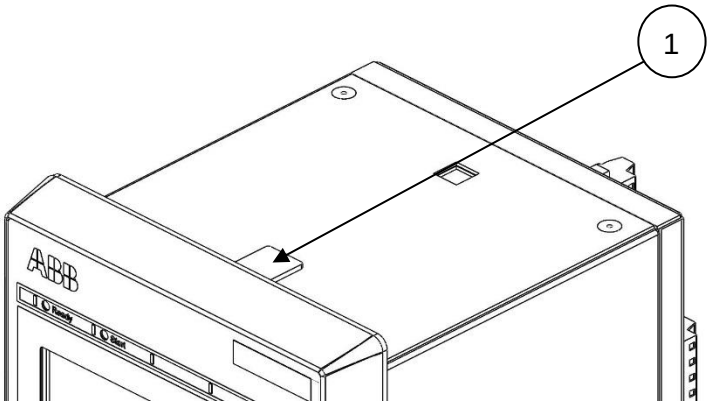
### 6.4.1.2 Mounting the relay

Requirements for installation:

- Panel cut-out of 137 ± 1.0 x 122.5 ± 1.0 mm
- Depth behind panel 165 mm

1. Remove four plastic caps covering the opening provided for fixing the mounting brackets in relay casing.

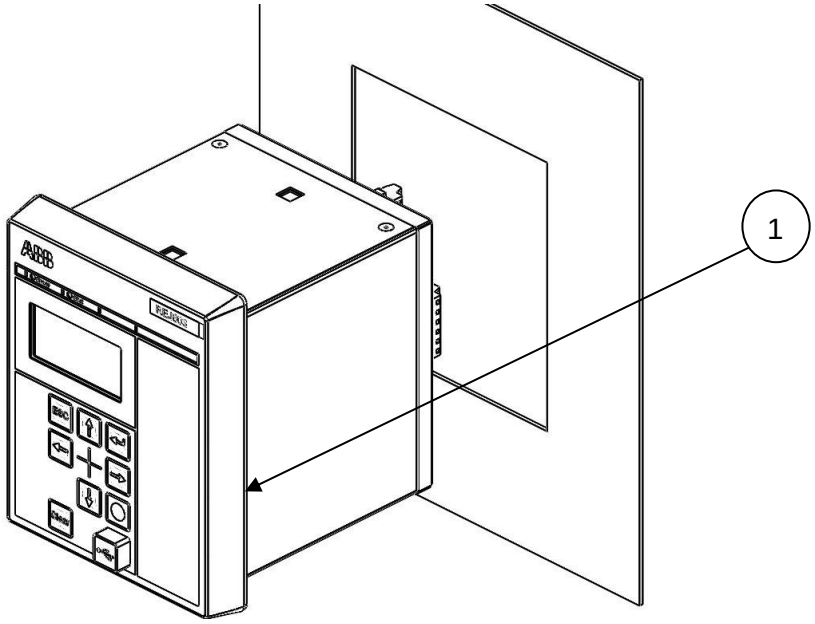
   The relay has four opening provided on casing for fixing the mounting brackets, two on top surface and two on bottom surface. These openings are covered by plastic cap to avoid ingress of external components inside relay. Before mounting relay in panel door, it is needed to remove these 4 nos. caps as shown in Figure-31.




1 Plastic caps covering opening for fixing mounting brackets

*Figure 31: Location of plastic caps of relay case*

2. Insert the relay in panel cut-out.
   Insert relay in panel cutout gently and ensure that HMI sealing ring is properly placed in its groove of plastic part.




1 HMI sealing ring

*Figure 32: Insertion of relay case in cut-out*

3. Position of mounting clamp screw in mounting clamp
   The relay is supplied with 2 sets of mounting clamps with screws. The position of mounting screw should be as indicated in Figure 33.

Ensure that the screw should not be coming out of other end of mounting clamp before fixing the clamp of relay.

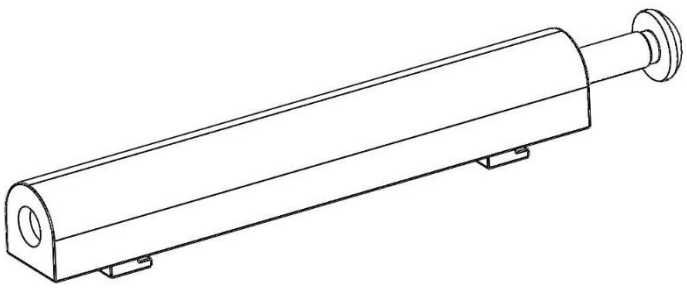


*Figure 33: Mounting clamp with screw*

4. Fixing the mounting clamp on relay.

   Place the mounting clamp along with screw at certain angle in a way that first rear part (L-shape fixing portion) gets inserted in relay. Once rear portion is inserted in relay, gently apply force and insert the front part clamp in relay.

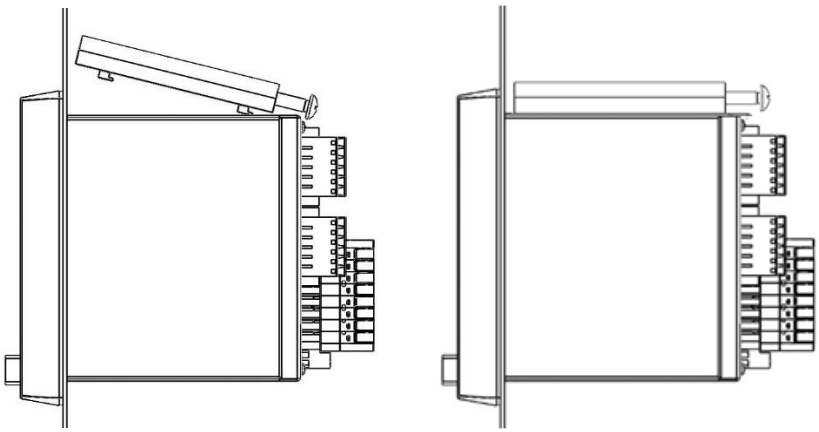


*Figure 34: Fixing the mounting clamp on relay*

Follow same steps 3 to 4 for relay mounting clamp at bottom side.

5. Tightening of mounting clamp screw.

   Start tightening of mounting screws. While tightening of screw the little pressure from top is required to provide on the mounting clamp to ensure that it not get lifted up due to rotatory movement of screw on panel door.

The required range for the fixing screws' tightening torque is 1.4...1.7 Nm.

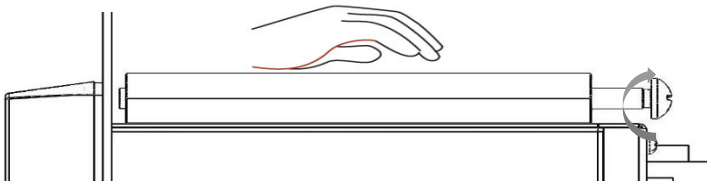


*Figure 35: Tightening of mounting clamp screw*

## 6.5 Relay wiring

The connection wiring to the relay should be made by using single strand wire or stranded wire with the use of insulated crimp terminal to maintain the insulation requirements. The wire with below indicated cross-section should be used for control wiring:

- 0.2 - 2.5 $mm^2$ finely stranded
- 0.2 - 2.5 $mm^2$ single-core
- 2 x 0.2 – 1.0 $mm^2$

For short circuit terminals for conventional CT the wire with below indicated cross-section should be used for wiring:

- 0.5 – 6.0 $mm^2$ finely stranded
- 0.5 – 6.0 $mm^2$ single-core
- 2 x 0.5 - 2.5 $mm^2$

## 6.6 Terminal diagram

Relay terminal / connection diagram for the relay shall be as shown in Figure 31, 32, 33.

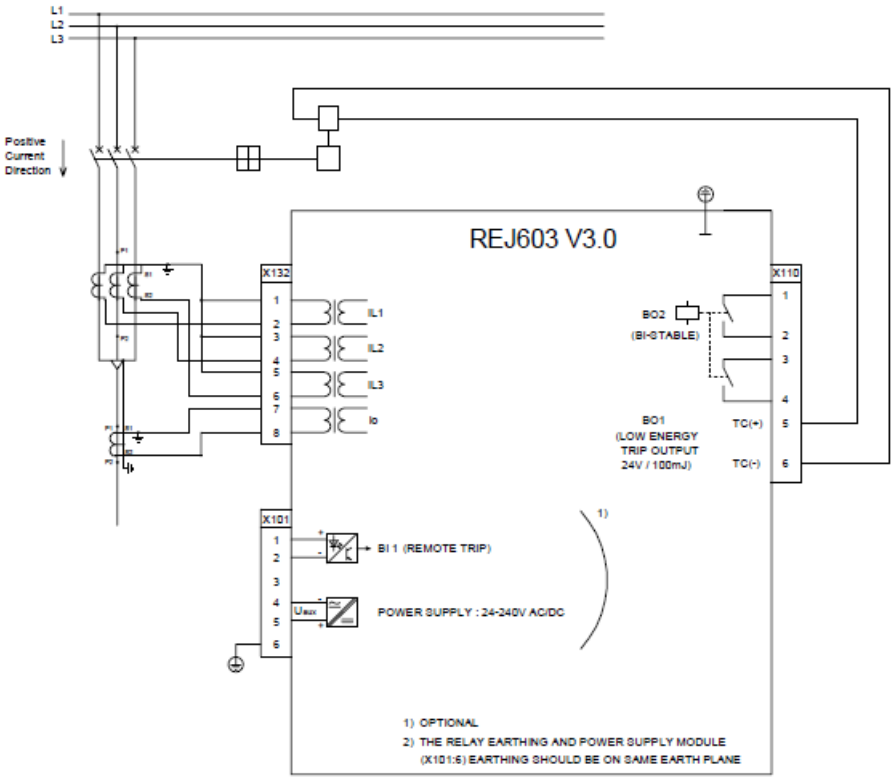



*Figure 36: Connection diagram of relay REJ603 V3.0, External earth connection through CBCT*

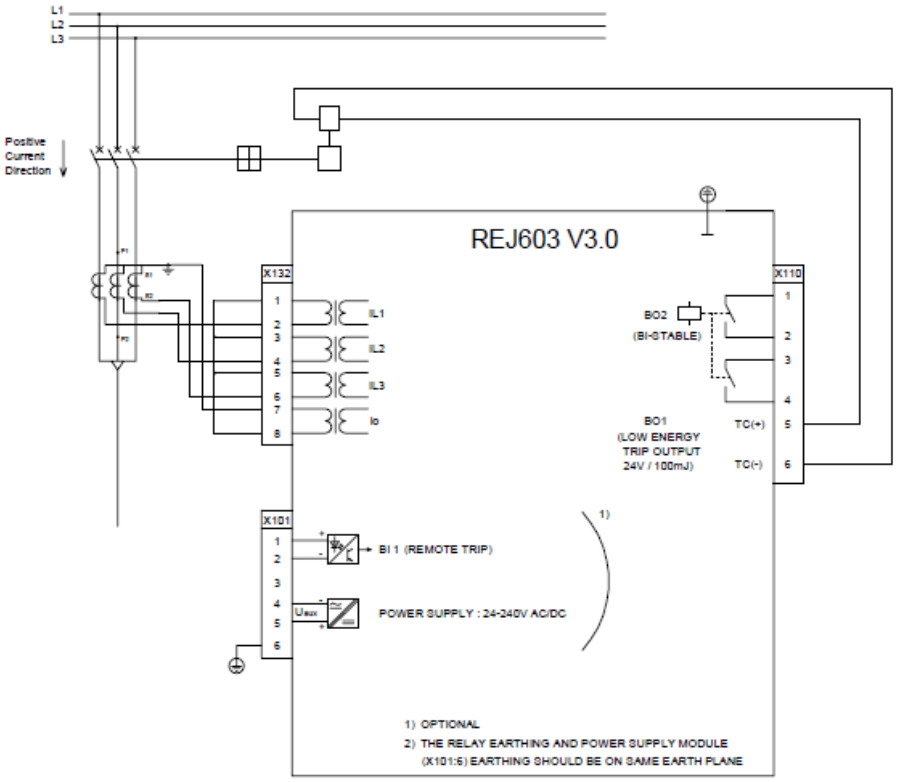



*Figure 37: Connection diagram of relay REJ603 V3.0, External earth connection through Residual connection*

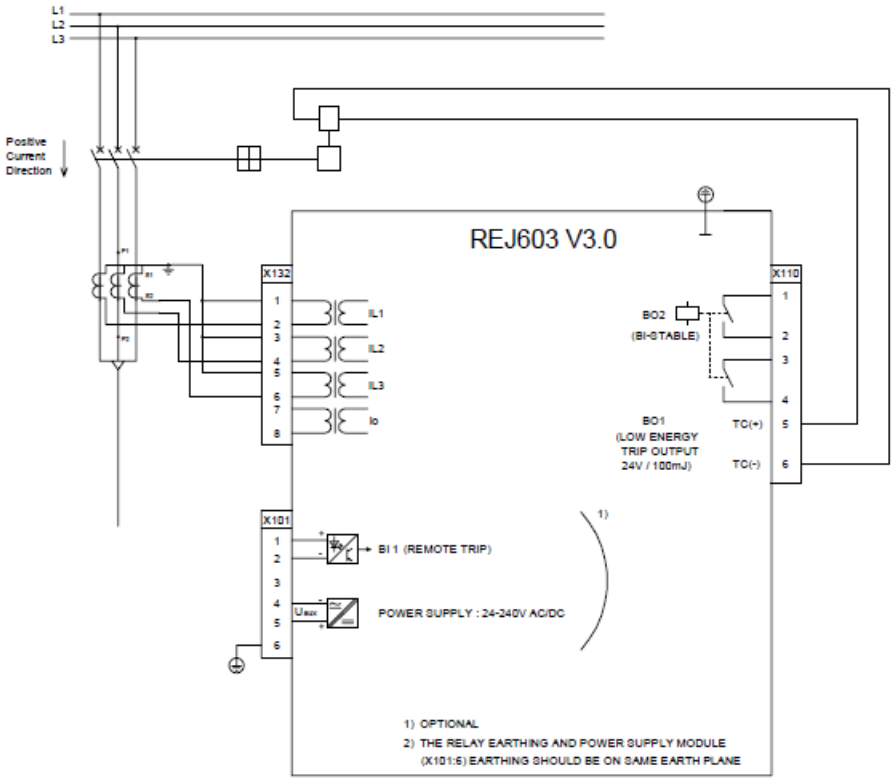



*Figure 38: Connection diagram of relay REJ603 V3.0, Internal earth connection*

# 6.7 Relay ordering information

The relay type and serial number label identifies the protection relay. An order number label is placed on the side of the relay. The order number consists of a string of codes generated from the hardware and software modules of the relay. The serial number and order number label is placed on side of relay.

| | Example Code | | REJ | 603 | B | 1 | N | N | 1 | N | B | 3 | 4 | N | N | J |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| # | Description | | | | | | | | | | | | | | | |
| 1-3 | **Relay type**<br>Feeder overcurrent protection | REJ | | | | | | | | | | | | | | |
| 4-6 | **Relay series identity**<br>Self-powered or dual powered relay | 603 | | | | | | | | | | | | | | |
| 7 | **Standard**<br>IEC | B | | | | | | | | | | | | | | |
| 8 | **Analog input / output**<br>Phase and Earth current input – 1A<br>Phase and Earth current input – 5A | 1<br>2 | | | | | | | | | | | | | | |
| 9 | **Spare**<br>None | N | | | | | | | | | | | | | | |
| 10 | **Binary input / output slot 2**<br>None | N | | | | | | | | | | | | | | |
| 11 | **Binary input / output slot 1**<br>None<br>1Binary Input including power supply 24-240V AC/DC (1VA)[1)] | N<br>1 | | | | | | | | | | | | | | |
| 12 | **Communication**<br>None | N | | | | | | | | | | | | | | |
| 13 | **Application configuration**<br>Configuration B | B | | | | | | | | | | | | | | |
| 14 | **Power supply**<br>Self-supplied<br>Dual-powered with 24-250V AC/DC(1VA)[1)] | 3<br>4 | | | | | | | | | | | | | | |
| 15 | **Housing configuration**<br>Midsized housing for REJ603 | 4 | | | | | | | | | | | | | | |
| 16 | **Configuration**<br>None<br>Ring lug terminals | N<br>2 | | | | | | | | | | | | | | |
| 17 | **For future use** | N | | | | | | | | | | | | | | |
| 18 | **Version**<br>Product version 3.0 | J | | | | | | | | | | | | | | |

1) With binary input =1, dual powered option = 4 needs to be selected

Example order code: REJ603 B 1 N N 1 N B 3 4 N N J

Your ordering code:

| Digit (#) | 1-3 | 4-6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | REJ | 603 | | | | | | | | | | | | |

*Figure 39: Ordering information of relay REJ603 V3.0*

# 6.8 Setting table

*Table 22: Settings*

| Parameter | Actual value | Default value | Unit | Range | Resolution |
|---|---|---|---|---|---|
| **3I> / 51** | | | | | |
| I> | | 01.50 | In | 0.1...32; infinite* | 0.001 |
| t> | | 01.00 | s | 0.04…64 | 0.010 |
| I> Curve | | DT | - | DT, IEC NI, IEC VI, IEC LI, IEC EI, RI, ANSI NI, ANSI VI, ANSI MI, ANSI EI, HR, FR | - |
| k | | 00.50 | | 0.02 – 1.6 | 0.010 |
| **3I>> / 50-1** | | | | | |
| I>> | | 04.00 | In | 0.2…32; infinite* | 0.001 |
| t>> | | 00.30 | S | 0.04…64 | 0.010 |
| **3I>>> / 50-2** | | | | | |
| I>> | | 10.00 | In | 0.2…32; infinite* | 0.001 |
| t>> | | 00.04 | s | 0.05…64 | 0.010 |
| **I0> / 51N** | | | | | |
| I0> | | 00.50 | In | Ext.: 0.01...2.0; infinite*<br>Int.: 0.1…2.0; infinite* | 0.001 |
| t0> | | 01.50 | s | 0.04...64 | 0.010 |
| I0> Curve | | DT | - | DT, IEC NI, IEC VI, IEC LI, IEC EI, RI, ANSI NI, ANSI VI, ANSI MI, ANSI EI,HR,FR | - |
| k0 | | 00.10 | | 0.02 – 1.6 | 0.010 |
| **I0>> / 50N** | | | | | |
| I0>> | | 04.00 | In | Ext.: 0.01…12.5; infinite*<br>Int.: 0.1…12.5; infinite* | 0.001 |
| t0>> | | 00.05 | s | 0.04…64 | 0.010 |
| **3Ith> / 49** | | | | | |
| ϑ0 | | 080 | % | 0.0…100% | 1% |
| ϑpowerOFF | | 4 | - | 1…4 | 1 |
| Ib | | 1.0 | In | 0.1 … 1.5 | 0.100 |
| τ↑ | | 045 | min | 1.0…300 | 1.000 |
| τ↓s | | 045 | min | 1.0…300 | 1.000 |
| Θalm | | 121 | % | 50…200%, | 1% |
| Θtrip | | 144 | % | 50…200%, | 1% |
| ϑstartinhibit | | 105 | % | 50…200%, | 1% |
| Mode | | 1 | - | 1 | - |

* Infinite: protection not in use / blocked

*Table 23: Configuration*

| Configuration Parameter | Actual value | Default value | Unit | Range | Resolution |
|---|---|---|---|---|---|
| Earth type / I0 meas. | | External | | Internal; External | - |
| CT Ipn | | 1000 | A | 20 … 9999 | 1 |
| CT Isn | | 1 | A | 1; 5 | - |
| Frequency | | 50 | Hz | 50; 60 | - |

*Table 24: Binary Input configuration*

| Binary input / Connected to signal | BI1 |
|---|---|
| Input behavior: inversion | (-) |
| Block : I> / 51 | |
| Block : I>> / 50-1 | |
| Block : I>>> / 50-2 | |
| Block : Io> / 51N | |
| Block : Io>> / 50N | |
| Blocking: 3Ith> / 49 | |
| External Trip | (x) |
| SG Select | |

Input behavior: "-" = Non inverted, "I" = Inverted
Remark: "(..)" = Default setting

*Table 25: Binary Output configuration*

| Binary output / Signal to activate output | BO1 | BO2 |
|---|---|---|
| Output behavior: inversion | (-) | (-) |
| Output behavior: duration | (P) | (H) |
| Start : I> / 51 | | |
| Start : I>> / 50-1 | | |
| Start : I>>> / 50-2 | | |
| Start : Io> / 50N-1 | | |
| Start : Io>> / 50N-2 | | |
| 3Ith > Alm | | |
| 3Ith> Blkcl | | |
| Trip : I> / 51 | (x) | (x) |
| Trip : I>> / 50-1 | (x) | (x) |
| Trip : I>>> / 50-2 | (x) | (x) |
| Trip : Io> / 51N | (x) | (x) |
| Trip : Io> / 50N | (x) | (x) |
| 3Ith > Trip | (x) | (x) |
| External Trip | (x) | (x) |

Output behavior: "-" = Non inverted
Remark: "(..)" = Default setting

## 6.9 Earthing of relay

The earth lead must be at least 6.0 mm2. If the length of the earth lead is long, the cross section of the wire must be increased.

To improve the immunity against high frequency distortion it is recommended to use flat braided copper wire as the earth lead.

To connect a separate earth protection lead:

1. Loosen the protective earth screw to connect a separate earth protection lead.

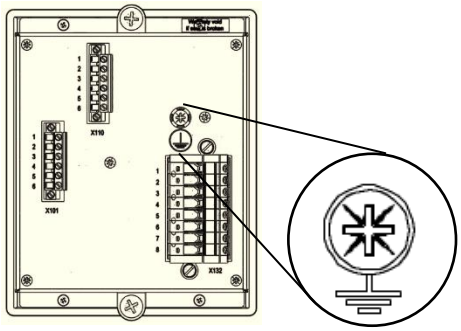


*Figure 40: Location of protective earth screw*

The earth lead should be as short as possible but notice that extra length is required for door mounting.

Each protection relay must have its own earth lead connected to the earth circuit connector.

2. Connect the earth lead to the earth bar. Use either stripped wire screwed between a washer cup and the protective earth screw or a ring-lug.

   Select a suitable ring-lug to fit under the M4 screw.

3. Tighten the protective earth screw.

4. For product variant with auxiliary power supply module, PIN 6 of X101 (please refer terminal diagram) should also to be connected to the same earth plane.

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