INSTRUCTION MANUAL

OVERCURRENT PROTECTION RELAY

GRD110

TOSHIBA CORPORATION

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(Ver. 3.1)

Safety Precautions

Before using this product, please read this chapter carefully.

This chapter describes the safety precautions recommended when using the GRD110. Before installing and using the equipment, this chapter must be thoroughly read and understood.

Explanation of symbols used

Signal words such as DANGER, WARNING, and two kinds of CAUTION, will be followed by important safety information that must be carefully reviewed.

⚠ DANGER	Indicates an imminently hazardous situation which will result in death or serious injury if you do not follow the instructions.
⚠WARNING	Indicates a potentially hazardous situation which could result in death or serious injury if you do not follow the instructions.
⚠CAUTION	Indicates a potentially hazardous situation which if not avoided, may result in minor injury or moderate injury.
CAUTION	Indicates a potentially hazardous situation which if not avoided, may result in property damage.

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⚠ DANGER

- **Current transformer circuit**

Never allow the current transformer (CT) secondary circuit connected to this equipment to be opened while the primary system is live. Opening the CT circuit will produce a dangerously high voltage.

⚠WARNING

- **Exposed terminals**

Do not touch the terminals of this equipment while the power is on, as the high voltage generated is dangerous.

- **Residual voltage**

Hazardous voltage can be present in the DC circuit just after switching off the DC power supply. It takes approximately 30 seconds for the voltage to discharge.

- **Fiber optic**

Do not view directly with optical instruments.

⚠CAUTION

- **Earth**

The earthing terminal of the equipment must be securely earthed.

CAUTION

- **Operating environment**

The equipment must only used within the range of ambient temperature, humidity and dust detailed in the specification and in an environment free of abnormal vibration.

- **Ratings**

Before applying AC voltage and current or the DC power supply to the equipment, check that they conform to the equipment ratings.

- **Printed circuit board**

Do not attach and remove printed circuit boards when the DC power to the equipment is on, as this may cause the equipment to malfunction.

- **External circuit**

When connecting the output contacts of the equipment to an external circuit, carefully check the supply voltage used in order to prevent the connected circuit from overheating.

- **Connection cable**

Carefully handle the connection cable without applying excessive force.

- **DC power**

If dc power has not been supplied to the relay for two days or more, then all fault records, event records and disturbance records and internal clock may be cleared soon after restoring the power. This is because the back-up RAM may have discharged and may contain uncertain data.

- **Modification**

Do not modify this equipment, as this may cause the equipment to malfunction.

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- **Short-link**

Do not remove a short-link which is mounted at the terminal block on the rear of the relay before shipment, as this may cause the performance of this equipment such as withstand voltage, etc., to reduce.

- **Disposal**

When disposing of this equipment, do so in a safe manner according to local regulations.

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1. Introduction

GRD110 series relays provide non-directional overcurrent protection for radial distribution networks, and back-up protection for transmission and distribution networks.

Note: GRD110 series relays are non-directional, and are applicable to systems where a fault current flows in a fixed direction, or flows in both directions but there is a significant difference in magnitude. In systems where a fault current flows in both directions and there is not a significant difference in the magnitude of the fault current, the *directional* overcurrent protection provided by GRD140 facilitates fault selectivity.

The GRD110 series has three models and provides the following protection schemes in all models.

- Overcurrent protection for phase and earth faults with definite time or inverse time characteristics
- Instantaneous overcurrent protection for phase and earth faults

The GRD110 series provides the following protection schemes depending on the models.

- Sensitive earth fault protection
- Undercurrent protection
- Thermal overload protection
- Negative phase sequence overcurrent protection
- Broken conductor detection
- Circuit breaker failure protection
- Cold load pick-up feature
- Blocked overcurrent and blocked busbar protection

The GRD110 series provides the following functions for all models.

- Four settings groups
- Configurable binary inputs and outputs
- Circuit breaker condition monitoring
- Trip circuit supervision
- Automatic self-supervision
- Menu-based HMI system
- Configurable LED indication
- Metering and recording functions
- Front mounted RS232 serial port for local PC communications
- Rear mounted one or two RS485 serial ports for remote PC communications

Table 1.1.1 shows the members of the GRD110 series and identifies the functions to be provided by each member.

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Table 1.1.1 Series Members and Functions

: Scheme switch [APPL] setting

Model Number	GRD110 -						
	110	400			420		
		3P	2P	1P	3P	2P	1P
Current input	E + SE	3P + E	2P + E	E	3P + E(*) + SE	2P + E + SE	E + SE
IDMT O/C (OC1, OC2)		✓	✓		✓	✓	
DT O/C (OC1 – 4)		✓	✓		✓	✓	
Instantaneous O/C (OC1 – 4)		✓	✓		✓	✓	
IDMT O/C (EF1, EF2)	✓	✓	✓	✓	✓	✓	✓
DT O/C (EF1 – 4)	✓	✓	✓	✓	✓	✓	✓
Instantaneous O/C (EF1 – 4)	✓	✓	✓	✓	✓	✓	✓
SEF protection	✓				✓	✓	✓
Phase U/C		✓	✓		✓	✓	
Thermal O/L		✓	✓		✓	✓	
NPS O/C		✓			✓		
Broken conductor protection		✓			✓		
CBF protection		✓			✓		
Cold load protection		✓	✓		✓	✓	
Trip circuit supervision	✓	✓	✓	✓	✓	✓	✓
Self supervision	✓	✓	✓	✓	✓	✓	✓
CB state monitoring	✓	✓	✓	✓	✓	✓	✓
Trip counter alarm	✓	✓	✓	✓	✓	✓	✓
$\sum I^y$ alarm		✓			✓		
CB operate time alarm	✓	✓	✓	✓	✓	✓	✓
Multiple settings groups	✓	✓	✓	✓	✓	✓	✓
Metering	✓	✓	✓	✓	✓	✓	✓
Fault records	✓	✓	✓	✓	✓	✓	✓
Event records	✓	✓	✓	✓	✓	✓	✓
Disturbance records	✓	✓	✓	✓	✓	✓	✓
Communication	✓	✓	✓	✓	✓	✓	✓

E: current from residual circuit
E(*): current (Io) calculated from three-phase current in relay internal
SE: current from core balance CT
3P: three-phase current
2P: two-phase current
IDMT: inverse definite minimum time

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DT: definite time
O/C: overcurrent protection
OC∗: phase overcurrent element
EF∗: earth fault element
SEF: sensitive earth fault
U/C: undercurrent protection
O/L: overload protection
NPS: negative phase sequence
CBF: circuit breaker failure

Model 110 provides normal earth fault protection and sensitive earth fault protection.

Model 400 provides three-phase or two-phase phase protection and earth fault protection or earth fault protection depending on the scheme switch [APPL] setting.

Model 420 provides three-phase or two-phase phase protection and earth and sensitive earth protection or earth and sensitive earth fault protection depending on the scheme switch [APPL] setting.

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2. Application Notes

2.1 Phase Overcurrent and Residual Overcurrent Protection

GRD110 provides radial distribution network protection with phase fault and earth fault overcurrent elements OC1 and EF1 for stage-1, which have selective inverse time and definite time characteristics. The protection of local and downstream terminals is coordinated with the current setting, time setting, or both.

2.1.1 Inverse Time Overcurrent Protection

In a system for which the fault current is practically determined by the fault location, without being substantially affected by changes in the power source impedance, it is advantageous to use inverse definite minimum time (IDMT) overcurrent protection. This protection provides reasonably fast tripping, even at a terminal close to the power source where the most severe faults can occur.

Where ZS (the impedance between the relay and the power source) is small compared with that of the protected section ZL, there is an appreciable difference between the current for a fault at the far end of the section (ES/(ZS+ZL), ES: source voltage), and the current for a fault at the near end (ES/ZS). When operating time is inversely proportional to the current, the relay operates faster for a fault at the end of the section nearer the power source, and the operating time ratio for a fault at the near end to the far end is ZS/(ZS + ZL).

The resultant time-distance characteristics are shown in Figure 2.1.1 for radial networks with several feeder sections. With the same selective time coordination margin TC as the download section, the operating time can be further reduced by using a more inverse characteristic.

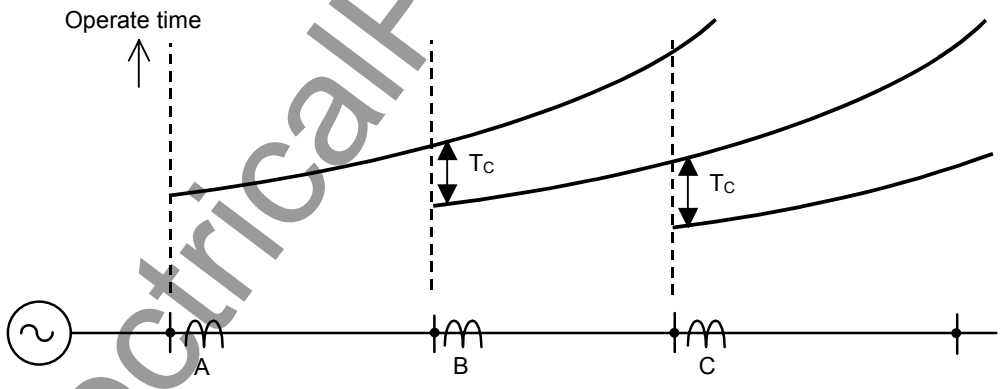

Figure 2.1.1 Time-distance Characteristics of Inverse Time Protection

The OC1 and EF1 have the IDMT characteristics defined by equation (1):

$$t = TMS \times \left\{ \left[\frac{k}{\left(I / Is \right)^{\alpha} - 1} \right] + c \right\} \qquad (1)$$

where:

t = operating time for constant current I (seconds),

I = energising current (amps),

Is = overcurrent setting (amps),

TMS = time multiplier setting,

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k, α, c = constants defining curve.

Nine curve types are available as defined in Table 2.1.1. They are illustrated in Figure 2.1.2.

In addition to the above nine curve types, the OC1 and EF1 can provides user configurable IDMT curve. If required, set the scheme switch [M***] to "C" and set the curve defining constants k, α and c. The following table shows the setting ranges of the curve defining constants. OC2 and EF2 for stage-2 also provide the same inverse time protection as OC1 and EF1.

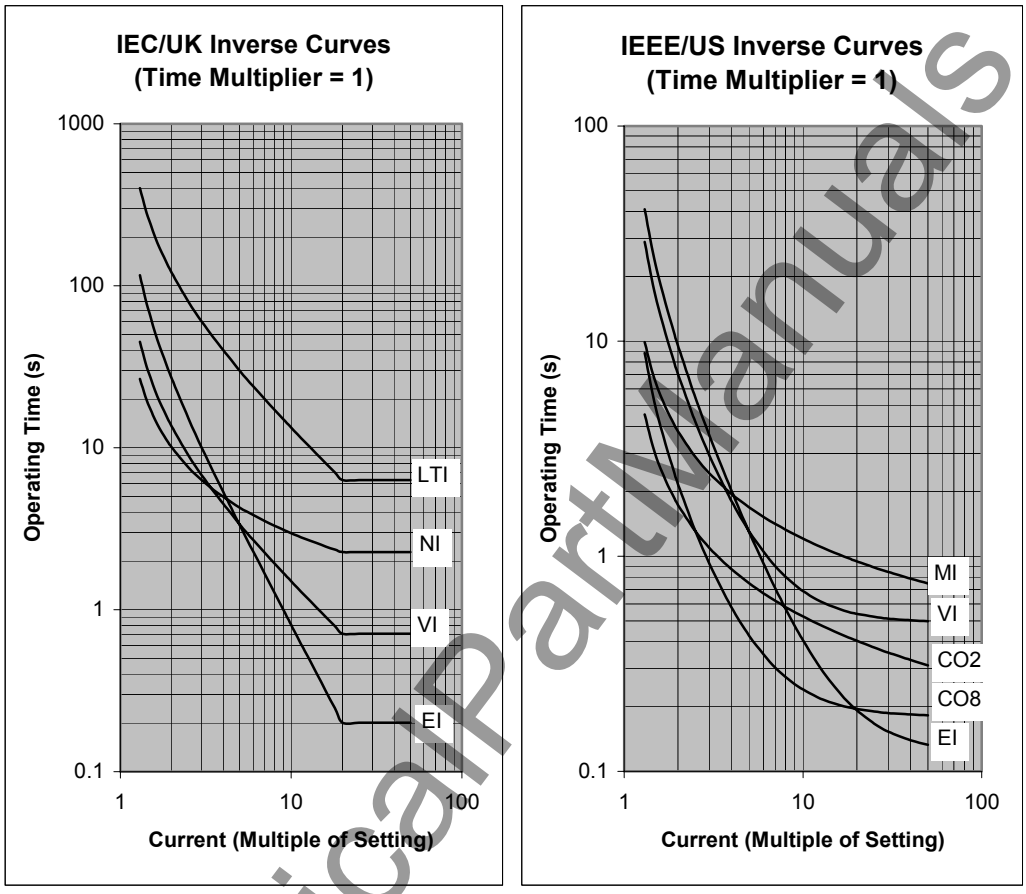

Figure 2.1.2 IDMT Characteristics

Programmable Reset Characteristics

OC1 and EF1 have a programmable reset feature: instantaneous, definite time delayed, or dependent time delayed reset. (Refer to Appendix A for a more detailed description.)

Instantaneous resetting is normally applied in multi-shot auto-reclosing schemes, to ensure correct grading between relays at various points in the scheme.

The inverse reset characteristic is particularly useful for providing correct coordination with an upstream induction disc type overcurrent relay.

The definite time delayed reset characteristic may be used to provide faster clearance of intermittent ('pecking' or 'flashing') fault conditions.

Definite time reset

The definite time resetting characteristic is applied to the IEC/IEEE/US operating characteristics.

If definite time resetting is selected, and the delay period is set to instantaneous, then no intentional delay is added. As soon as the energising current falls below the reset threshold, the element returns to its reset condition.

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If the delay period is set to some value in seconds, then an intentional delay is added to the reset period. If the energising current exceeds the setting for a transient period without causing tripping, then resetting is delayed for a user-definable period. When the energising current falls below the reset threshold, the integral state (the point towards operation that it has travelled) of the timing function (IDMT) is held for that period.

This does not apply following a trip operation, in which case resetting is always instantaneous.

Dependent time reset

The dependent time resetting characteristic is applied only to the IEEE/US operate characteristics, and is defined by the following equation:

$$t = RTMS \times \left[\frac{kr}{1 - \left(I / I_S \right)^{\beta}} \right] \qquad (2)$$

where:

t = time required for the element to reset fully after complete operation (seconds),

I = energising current (amps),

Is = overcurrent setting (amps),

k_r = time required to reset fully after complete operation when the energising current is zero (see Table 2.1.1),

RTMS = reset time multiplier setting,

k, β, c = constants defining curve.

Figure 2.1.3 illustrates the dependent time reset characteristics.

The dependent time reset characteristic also can provide user configurable IDMT curve. If required, set the scheme switch [M***] to "C" and set the curve defining constants kr and β. Table 2.1.1 shows the setting ranges of the curve defining constants.

Table 2.1.1 Specification of IDMT Curves

Curve Description	IEC ref.	k	α	c	k_r	β
IEC Normal Inverse	A	0.14	0.02	0	-	-
IEC Very Inverse	B	13.5	1	0	-	-
IEC Extremely Inverse	C	80	2	0	-	-
UK Long Time Inverse	-	120	1	0	-	-
IEEE Moderately Inverse	D	0.0515	0.02	0.114	4.85	2
IEEE Very Inverse	E	19.61	2	0.491	21.6	2
IEEE Extremely Inverse	F	28.2	2	0.1217	29.1	2
US CO8 Inverse	-	5.95	2	0.18	5.95	2
US CO2 Short Time Inverse	-	0.02394	0.02	0.01694	2.261	2
User configurable curve	-	0.00 – 300.00	0.00 – 5.00	0.000 – 5.000	0.00 – 300.00	0.00 – 5.00

Note: kr and β are used to define the reset characteristic. Refer to equation (2).

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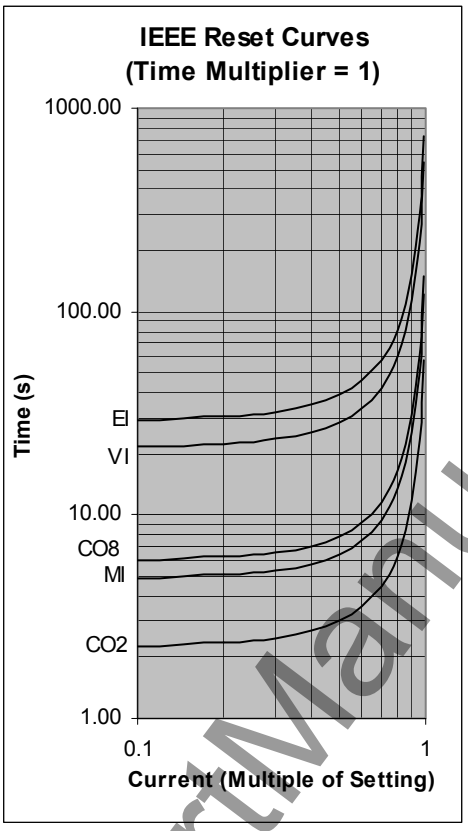

Figure 2.1.3 Dependent Time Reset Characteristics

2.1.2 Definite Time Overcurrent Protection

In a system in which the fault current does not vary a great deal in relation to the position of the fault, that is, the impedance between the relay and the power source is large, the advantages of the IDMT characteristics are not fully utilised. In this case, definite time overcurrent protection is applied. The operating time can be constant irrespective of the magnitude of the fault current.

The definite time overcurrent protection consists of instantaneous overcurrent measuring elements OC1 and EF1 and delayed pick-up timers started by the elements, and provides selective protection with graded setting of the delayed pick-up timers. Thus, the constant time coordination with the downstream section can be maintained as shown in Figure 2.1.4 As is clear in the figure, the nearer to the power source a section is, the greater the delay in the tripping time of the section. This is undesirable particularly where there are many sections in the series.

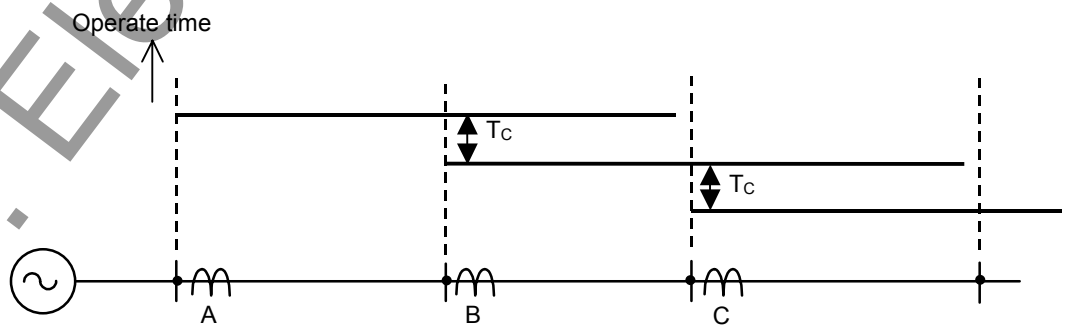

Figure 2.1.4 Definite Time Overcurrent Protection

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2.1.3 Scheme Logic

Figure 2.1.5 and Figure 2.1.6 show the scheme logic of the phase fault and earth fault overcurrent protection with selective definite time or inverse time characteristic.

The definite time protection is selected by setting [MOC1] and [MEF1] to “DT”. Definite time overcurrent elements OC1-D and EF1-D are enabled for phase fault and earth fault protection respectively, and trip signal OC1 TRIP and EF1 TRIP are given through the delayed pick-up timer TOC1 and TEF1.

The inverse time protection is selected by setting [MOC1] and [MEF1] to either “IEC”, “IEEE” or “US” according to the IDMT characteristic to employ. Inverse time overcurrent elements OC1-I and EF1-I are enabled for phase fault and earth fault protection respectively, and trip signal OC1 TRIP and EF1 TRIP are given.

The signals OC1 HS and EF1 HS are used for blocked overcurrent protection and blocked busbar protection (refer to Section 2.11).

These protections can be disabled by the scheme switches [OC1EN] and [EF1EN] or binary input signals OC1 BLOCK and EF1 BLOCK.

OC2 and EF2 are provided with the same logic of OC1 and EF1. However, HS signals for blocked overcurrent protection and blocked busbar protection are not provided.

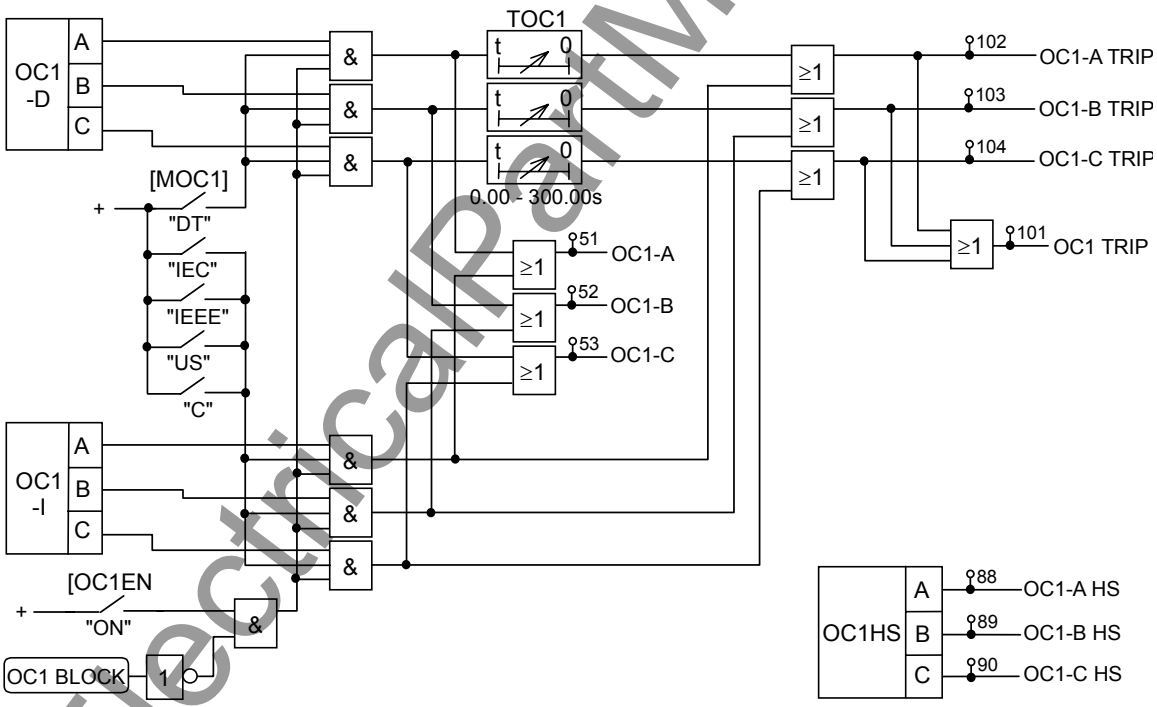

Figure 2.1.5 Phase Fault Overcurrent Protection OC1

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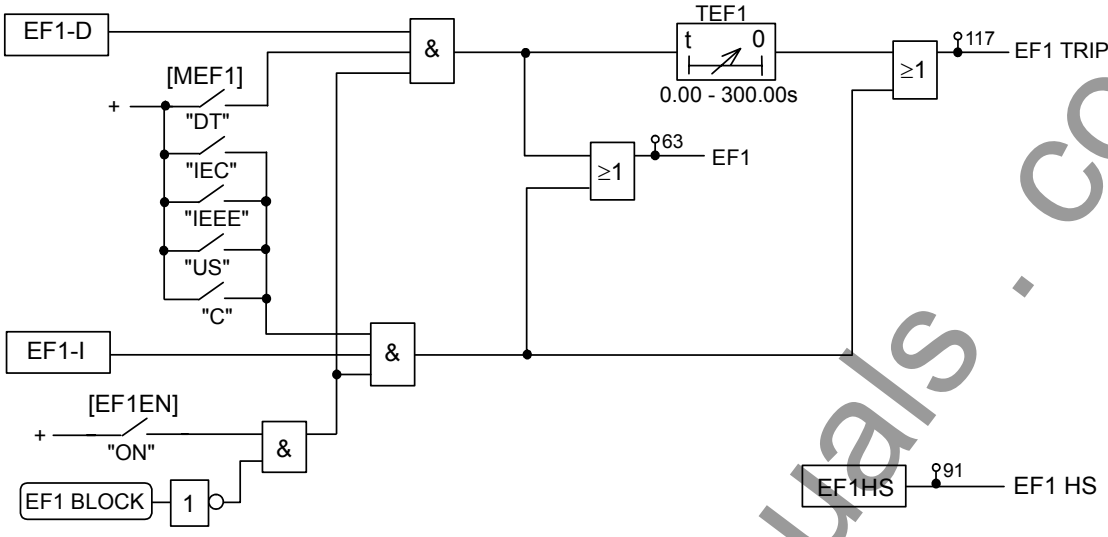

Figure 2.1.6 Earth Fault Overcurrent Protection EF1

2.1.4 Settings

The table shows the setting elements necessary for the phase and residual overcurrent protection and their setting ranges.

Element	Range	Step	Default	Remarks
OC1	0.2 – 25.0 A (0.04 – 5.00 A)(*1)	0.1 A (0.01 A)	5.0 A (1.00 A)	OC1 threshold setting
TOC1	0.010 – 1.500	0.001	1.000	OC1 time multiplier setting. Required if [MOC1] = IEC, IEEE, US or C.
	0.00 – 300.00 s	0.01 s	1.00 s	OC1 definite time setting. Required if [MOC1] = DT.
TOC1R	0.0 – 300.0 s	0.1 s	0.0 s	OC1 definite time delayed reset. Required if [MOC1] = IEC or if [OC1R] = DEF.
TOC1RM	0.010 – 1.500	0.001	1.000	OC1 dependent time delayed reset time multiplier. Required if [OC1R] = DEP.
EF1	0.1 – 25.0 A (0.02 – 5.00 A)	0.1 A (0.01 A)	1.5 A (0.30 A)	EF1 threshold setting
TEF1	0.010 – 1.500	0.001	1.000	EF1 time multiplier setting. Required if [MEF1] = IEC, IEEE, US or C.
	0.00 – 300.00 s	0.01 s	1.00 s	EF1 definite time setting. Required if [MEF1] =DT.
TEF1R	0.0 – 300.0 s	0.1 s	0.0 s	EF1 definite time delayed reset. Required if [MEF1] = IEC or if [EF1R] = DEF.
TEF1RM	0.010 – 1.500	0.001	1.000	EF1 dependent time delayed reset time multiplier. Required if [EF1R] = DEP.
[OC1EN]	Off / On		On	OC1 Enable
[MOC1]	DT / IEC / IEEE / US / C		DT	OC1 characteristic
[MOC1C]				OC1 inverse curve type.
MOC1C-IEC	NI / VI / EI / LTI		NI	Required if [MOC1] = IEC.
MOC1C-IEEE	MI / VI / EI		MI	Required if [MOC1] = IEEE.
MOC1C-US	CO2 / CO8		CO2	Required if [MOC1] = US.

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Element	Range	Step	Default	Remarks
[OC1R]	DEF / DEP		DEF	OC1 reset characteristic. Required if [MOC1] = IEEE or US.
[EF1EN]	Off / On		On	EF1 Enable
[MEF1]	DT / IEC / IEEE / US / C		DT	EF1 characteristic
[MEF1C]				EF1 inverse curve type.
MEF1C-IEC	NI / VI / EI / LTI		NI	Required if [MEF1] = IEC.
MEF1C-IEEE	MI / VI / EI		MI	Required if [MEF1] = IEEE.
MEF1C-US	CO2 / CO8		CO2	Required if [MEF1] = US.
[EF1R]	DEF / DEP		DEF	EF1 reset characteristic. Required if [MEF1] = IEEE or US.
[Optime]	Normal / Fast(*2)		Normal	Operating time selection for all OC and EF elements

(*1) Current values shown in the parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

(*2) If high-speed operation of OC and EF is required for time coordination with other relays or protections, "Fast" can be selected. When "Fast" selected, all OC and EF elements operate at high-speed (approximately 20ms).

Settings for Inverse Time Overcurrent protection

Current setting

In Figure 2.1.7, the current setting at terminal A is set lower than the minimum fault current in the event of a fault at remote end F1. Furthermore, when also considering backup protection for a fault on the next feeder section, it is set lower than the minimum fault current in the event of a fault at remote end F3.

To calculate the minimum fault current, phase-to-phase faults are assumed for the phase overcurrent element, and phase to earth faults for residual overcurrent element, assuming the probable maximum source impedance. When considering the fault at F3, the remote end of the next section is assumed to be open.

The higher the current setting, the more effective the inverse characteristic. On the other hand, the lower the setting, the more dependable the operation. The setting is normally 1 to 1.5 times or less of the minimum fault current.

For grading of the current settings, the terminal furthest from the power source is set to the lowest value and the terminals closer to the power source are set to a higher value.

The minimum setting of the phase overcurrent element is restricted so as not to operate for the maximum load current, and that of the residual overcurrent element is restricted so as to not operate on false zero-sequence current caused by an unbalance in the load current, errors in the current transformer circuits, or zero-sequence mutual coupling of parallel lines.

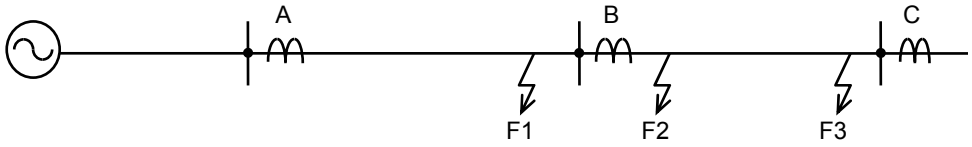

Figure 2.1.7 Current Settings in Radial Feeder

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Time setting

Time setting is performed to provide selectivity in relation to the relays on adjacent feeders. Consider a minimum source impedance when the current flowing through the relay reaches a maximum. In Figure 2.1.7, in the event of a fault at F2, the operating time is set so that terminal A may operate by time grading Tc behind terminal B. The current flowing in the relays may sometimes be greater when the remote end of the adjacent line is open. At this time, time coordination must also be kept.

The reason why the operating time is set when the fault current reaches a maximum is that if time coordination is obtained for a large fault current, then time coordination can also be obtained for the small fault current as long as relays with the same operating characteristic are used for each terminal.

The grading margin Tc of terminal A and terminal B is given by the following expression for a fault at point F2 in Figure 2.1.7.

$$T_c = T_1 + T_2 + T_m$$

where, T_1: circuit breaker clearance time at B

T_2: relay reset time at A

T_m: time margin

Settings of Definite Time Overcurrent protection

Current setting

The current setting is set lower than the minimum fault current in the event of a fault at the remote end of the protected feeder section. Furthermore, when also considering backup protection for a fault in a next feeder section, it is set lower than the minimum fault current, in the event of a fault at the remote end of the next feeder section.

Identical current values can be set for terminals, but graded settings are better than identical settings, in order to provide a margin for current sensitivity. The farther from the power source the terminal is located, the higher the sensitivity (i.e. the lower setting) that is required.

The minimum setting of the phase overcurrent element is restricted so as not to operate for the maximum load current, and that of the residual overcurrent element is restricted so as to not operate on false zero-sequence current caused by an unbalance in the load current, errors in the current transformer circuits, or zero-sequence mutual coupling of parallel lines. Taking the selection of instantaneous operation into consideration, the settings must be high enough not to operate for large motor starting currents or transformer inrush currents.

Time setting

When setting the delayed pick-up timers, the time grading margin Tc is obtained in the same way as explained in “Settings for Inverse Time Overcurrent Protection”.

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2.2 Instantaneous and Staged Definite Time Overcurrent Protection

In conjunction with inverse time overcurrent protection, definite time overcurrent elements OC2 to OC4 and EF2 to EF4 provide instantaneous overcurrent protection. OC2 and EF2 also provide the same inverse time protection as OC1 and EF1.

OC2 to OC4 and EF2 to EF4 are phase fault and earth fault protection elements, respectively. Each element is programmable for instantaneous or definite time delayed operation. The phase fault elements operate on a phase segregated basis, although tripping is for three phase only.

2.2.1 Selective Instantaneous Overcurrent Protection

When they are applied to radial networks with several feeder sections where ZL (impedance of the protected line) is large enough compared with ZS (the impedance between the relay and the power source), and the magnitude of the fault current in the local end fault is much greater (3 times or more, or (ZL+ZS)/ZS≧3, for example) than that in the remote end fault under the condition that ZS is maximum, the pick-up current can be set sufficiently high so that the operating zone of the elements do not reach the remote end of the feeder, and thus instantaneous and selective protection can be applied.

This high setting overcurrent protection is applicable and effective particularly for feeders near the power source where the setting is feasible, but the longest tripping times would otherwise have to be accepted.

As long as the associated inverse time overcurrent protection is correctly coordinated, the instantaneous protection does not require setting coordination with the downstream section.

Figure 2.2.1 shows operating times for instantaneous overcurrent protection in conjunction with inverse time overcurrent protection. The shaded area shows the reduction in operating time by applying the instantaneous overcurrent protection. The instantaneous protection zone decreases as ZS increases.

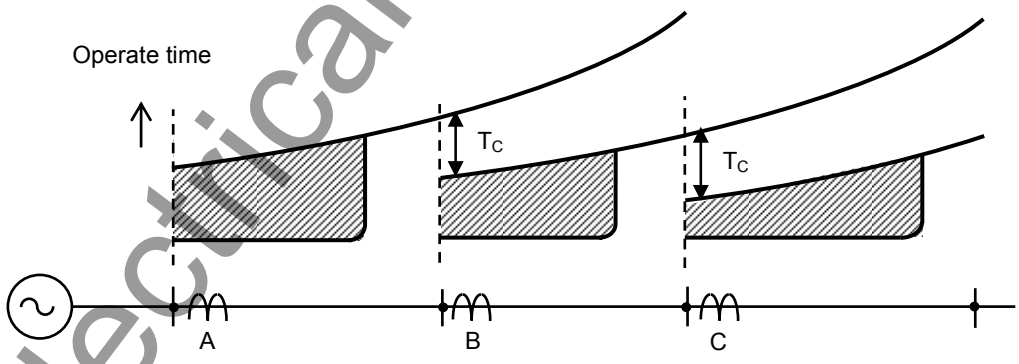

Figure 2.2.1 Conjunction of Inverse and Instantaneous Overcurrent Protection

The current setting is set 1.3 to 1.5 times higher than the probable maximum fault current in the event of a fault at the remote end. The maximum fault current for elements OC2 to OC4 is obtained in case of three-phase faults, while the maximum fault current for elements EF2 to EF4 is obtained in the event of single phase earth faults.

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2.2.2 Staged Definite Time Overcurrent Protection

When applying inverse time overcurrent protection for a feeder system as shown in Figure 2.2.2, well coordinated protection with the fuses in branch circuit faults and high-speed protection for the feeder faults can be provided by adding staged definite time overcurrent protection with time-graded OC2 and OC3 or EF2 and EF3 elements.

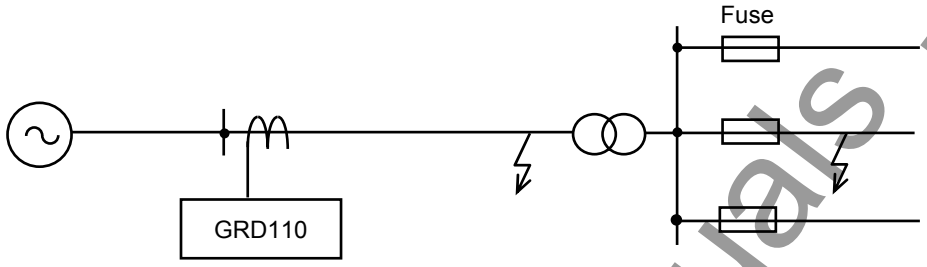

Figure 2.2.2 Feeder Protection Coordinated with Fuses

Configuring the inverse time element OC1 (and EF1) and time graded elements OC2 and OC3 (or EF2 and EF3) as shown in Figure 2.2.3, the characteristic of overcurrent protection can be improved to coordinate with the fuse characteristic.

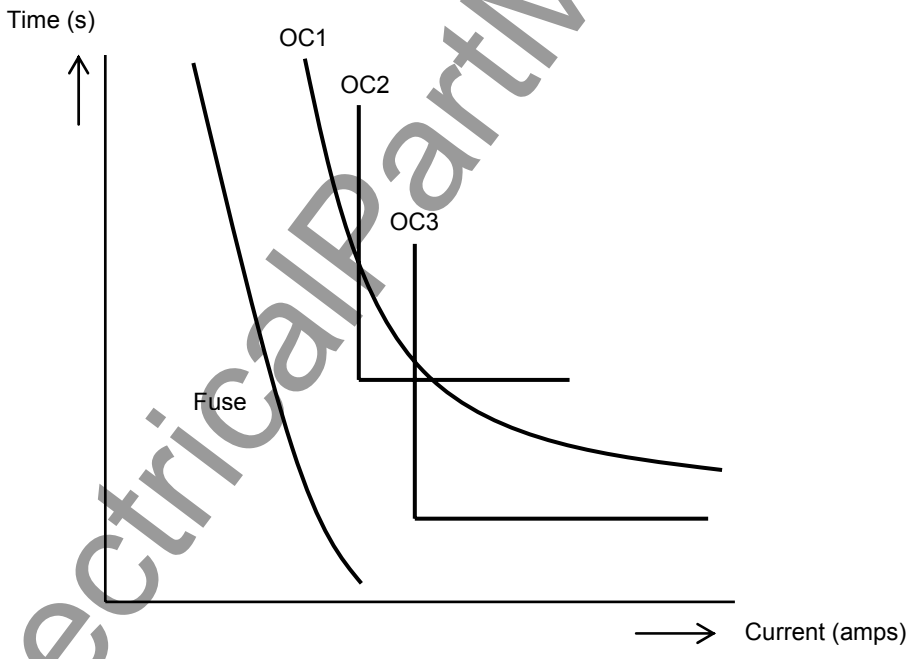

Figure 2.2.3 Staged Definite Time Protection

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2.2.3 Scheme Logic

As shown in Figure 2.2.4 to Figure 2.2.9, OC2 to OC4 and EF2 to EF4 have independent scheme logics. OC2 and EF2 provide the same logic of OC1 and EF1. OC3 and EF3 give trip signals OC3 TRIP and EF3 TRIP through delayed pick-up timers TOC3 and TEF3. OC4 and EF4 are used to output alarm signals OC4 ALARM and EF4 ALARM. Each trip and alarm can be blocked by incorporated scheme switches [OC2EN] to [EF4EN] and binary input signals OC2 BLOCK to EF4 BLOCK.

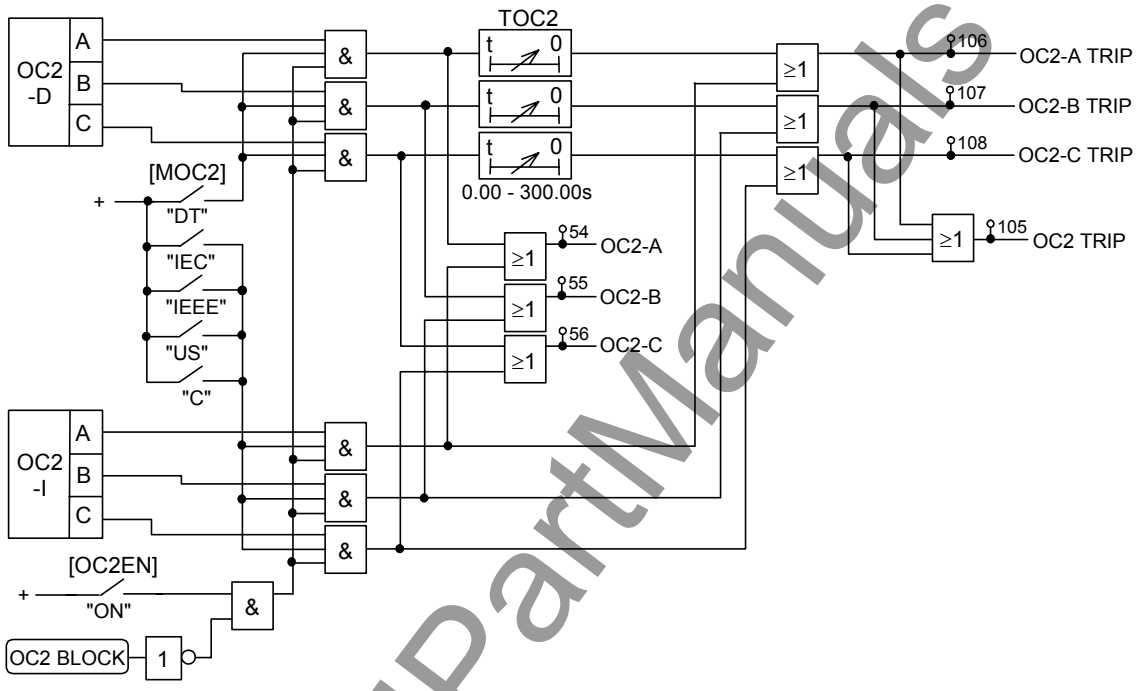

Figure 2.2.4 Phase Overcurrent Protection OC2

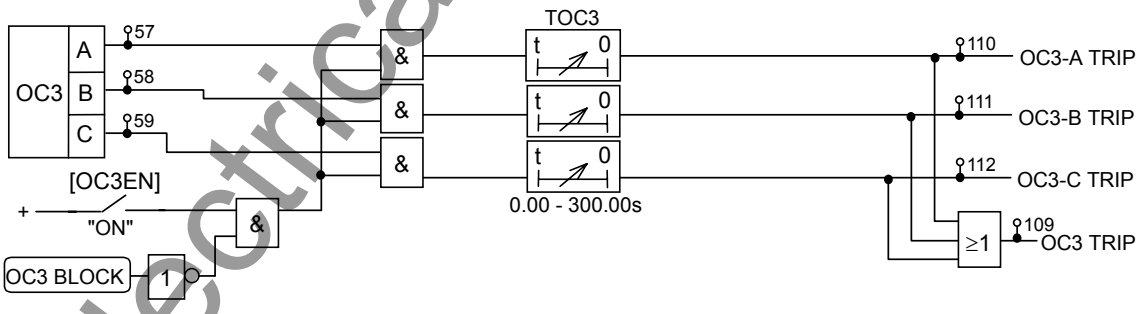

Figure 2.2.5 Phase Overcurrent Protection OC3

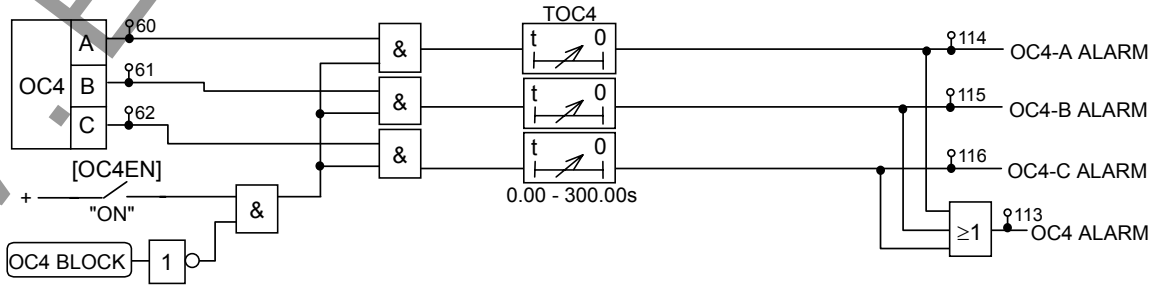

Figure 2.2.6 Phase Overcurrent Protection OC4

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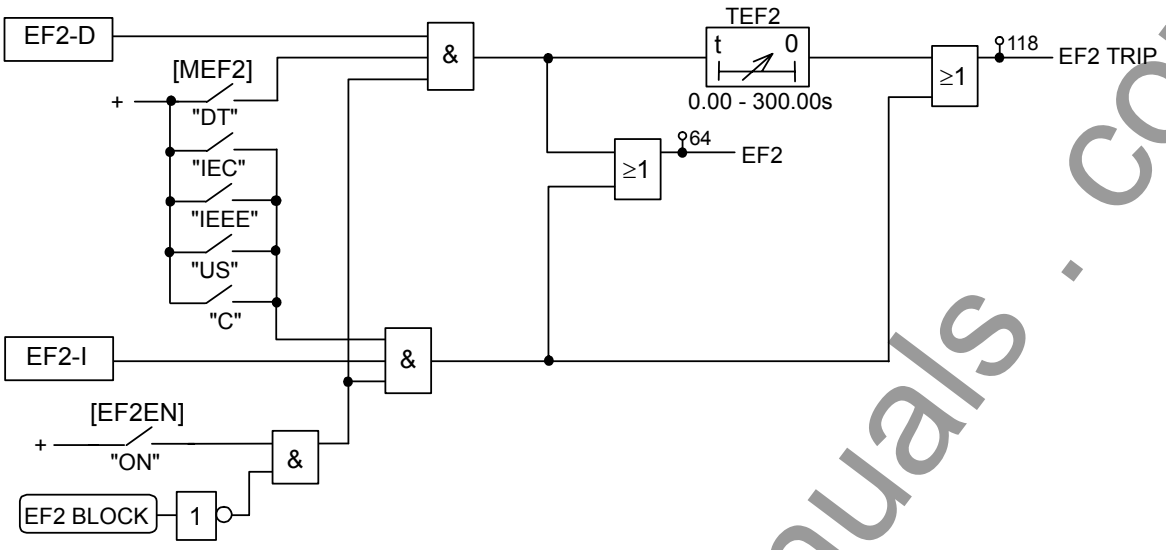

Figure 2.2.7 Earth fault Protection EF2

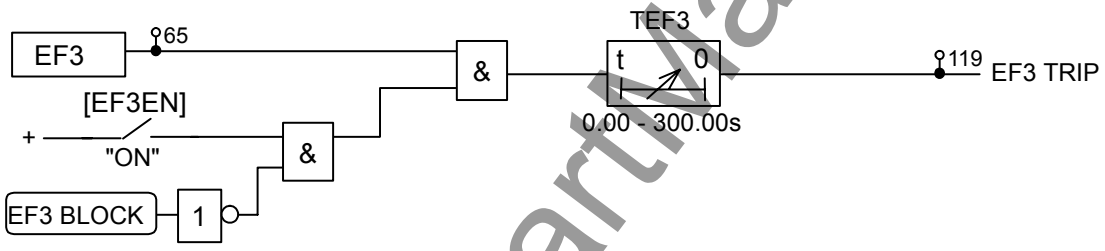

Figure 2.2.8 Earth fault Protection EF3

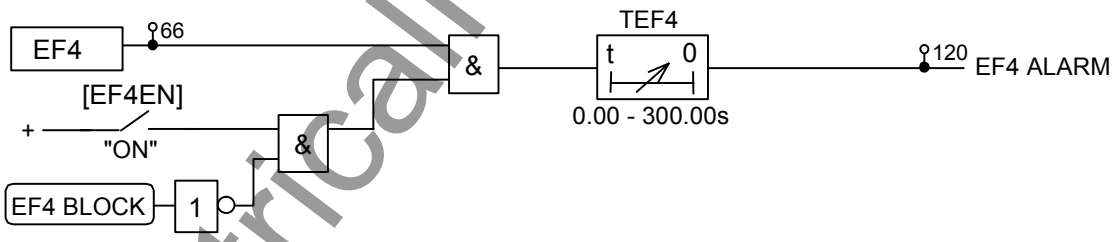

Figure 2.2.9 Earth fault Protection EF4

2.2.4 Setting

The table shows the setting elements necessary for the instantaneous and definite time overcurrent protection and their setting ranges.

Element	Range	Step	Default	Remarks
OC2	0.2 – 250.0 A (0.04 – 50.00 A)(*1)	0.1 A (0.01 A)	25.0 A (5.00 A)	OC2 threshold setting
TOC2	0.010 – 1.500	0.001	1.000	OC2 time multiplier setting. Required if [MOC2] = IEC, IEEE, US or C.
	0.00 – 300.00 s	0.01 s	0.00 s	OC2 definite time setting.
TOC2R	0.0 – 300.0 s	0.1 s	0.0 s	OC2 definite time delayed reset. Required if [MOC2] = IEC or if [OC2R] = DEF.

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Element	Range	Step	Default	Remarks
TOC2RM	0.010 – 1.500	0.001	1.000	OC2 dependent time delayed reset time multiplier. Required if [OC2R] = DEP.
OC3	0.5 – 250.0 A (0.10 – 50.00 A)	0.1 A (0.01 A)	50.0 A (10.00 A)	OC3 threshold setting
TOC3	0.00 – 300.00 s	0.01 s	0.00 s	OC3 definite time setting.
OC4	0.5 – 250.0 A (0.10 – 50.00 A)	0.1 A (0.01 A)	100.0 A (20.00 A)	OC4 threshold setting
TOC4	0.00 – 300.00 s	0.01 s	0.00 s	OC4definite time setting.
EF2	0.1 – 250.0 A (0.02 – 50.00 A)	0.1 A (0.01 A)	15.0 A (3.00 A)	EF2 threshold setting
TEF2	0.010 – 1.500	0.001	1.000	EF2 time multiplier setting. Required if [MEF2] = IEC, IEEE, US or C.
	0.00 – 300.00 s	0.01 s	0.00 s	EF2 definite time setting.
TEF2R	0.0 – 300.0 s	0.1 s	0.0 s	EF2 definite time delayed reset. Required if [MEF2] = IEC or if [EF2R] = DEF.
TEF2RM	0.010 – 1.500	0.001	1.000	EF2 dependent time delayed reset time multiplier. Required if [EF2R] = DEP.
EF3	0.2 – 250.0 A (0.04 – 50.00 A)	0.1 A (0.01 A)	25.0 A (5.00 A)	EF3 threshold setting
TEF3	0.00 – 300.00 s	0.01 s	0.00 s	EF3 definite time setting.
EF4	0.2 – 250.0 A (0.04 – 50.00 A)	0.1 A (0.01 A)	50.0 A (10.00 A)	EF4 threshold setting
TEF4	0.00 – 300.00 s	0.01 s	0.00 s	EF4 definite time setting.
[OC2EN]	Off / On		Off	OC2 Enable
[MOC2]	DT / IEC / IEEE / US / C		DT	OC2 characteristic
[MOC2C]				OC2 inverse curve type.
MOC2C-IEC	NI / VI / EI / LTI		NI	Required if [MOC2] = IEC.
MOC2C-IEEE	MI / VI / EI		MI	Required if [MOC2] = IEEE.
MOC2C-US	CO2 / CO8		CO2	Required if [MOC2] = US.
[OC2R]	DEF / DEP		DEF	OC2 reset characteristic. Required if [MOC2] = IEEE or US.
[OC3EN]	Off / On		Off	OC3 Enable
[OC4EN]	Off / On		Off	OC4 Enable
[EF2EN]	Off / On		Off	EF2 Enable
[MEF2]	DT / IEC / IEEE / US / C		DT	EF2 characteristic
[MEF2C]				EF2 inverse curve type.
MEF2C-IEC	NI / VI / EI / LTI		NI	Required if [MEF2] = IEC.
MEF2C-IEEE	MI / VI / EI		MI	Required if [MEF2] = IEEE.
MEF2C-US	CO2 / CO8		CO2	Required if [MEF2] = US.
[EF2R]	DEF / DEP		DEF	OC2 reset characteristic. Required if [MEF2] = IEEE or US.
[EF3EN]	Off / On		Off	EF3 Enable

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Element	Range	Step	Default	Remarks
[EF4EN]	Off / On		Off	EF4 Enable
[Optime]	Normal / Fast(*2)		Normal	Operating time selection for all OC and EF elements

(*1) Current values shown in the parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

(*2) If high-speed operation of OC and EF is required for time coordination with other relays or protections, “Fast” can be selected. When “Fast” selected, all OC and EF elements operate at high-speed (approximately 20ms).

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2.3 Sensitive Earth Fault Protection

The sensitive earth fault (SEF) protection is applied for distribution systems earthed through high impedance, where very low levels of fault current are expected in earth faults. Furthermore, the SEF elements of GRD110 are also applicable to the "standby earth fault protection" and the "high impedance restricted earth fault protection of transformers".

The SEF elements provide more sensitive setting ranges (20 mA to 5 A in 5A rating) than the regular earth fault protection.

Since very low levels of current setting may be applied, there is a danger of mal-operation due to harmonics of the power system frequency, which can appear as residual current. Therefore the SEF elements operate only on the fundamental component, rejecting all higher harmonics.

The SEF protection is provided in Models 110 and 420 which have a dedicated earth fault input circuit.

The element SEF1 provides inverse time or definite time selective two-stage earth fault protection. Stage 2 of the two-stage earth fault protection is used only for the standby earth fault protection. SEF2 provides inverse time or definite time selective earth fault protection. SEF3 and SEF4 provide definite time earth fault protection.

When SEF employs IEEE, US or C (Configurable) inverse time characteristics, two reset modes are available: definite time or dependent time resetting. If the IEC inverse time characteristic is employed, definite time resetting is provided. For other characteristics, refer to Section 2.1.1.

In applications of SEF protection, it must be ensured that any erroneous zero-phase current is sufficiently low compared to the fault current, so that a highly sensitive setting is available.

The erroneous current may be caused with load current due to unbalanced configuration of the distribution lines, or mutual coupling from adjacent lines. The value of the erroneous current during normal conditions can be acquired on the metering screen of the relay front panel.

The earth fault current for SEF may be fed from a core balance CT, but if it is derived from three phase CTs, the erroneous current may be caused also by the CT error in phase faults. Transient false functioning may be prevented by a relatively long time delay.

Standby earth fault protection

The SEF is energised from a CT connected in the power transformer low voltage neutral, and the standby earth fault protection trips the transformer to backup the low voltage feeder protection, and ensures that the neutral earthing resistor is not loaded beyond its rating. Stage 1 trips the transformer low voltage circuit breaker, then stage 2 trips the high voltage circuit breaker(s) with a time delay after stage 1 operates.

The time graded tripping is valid for transformers connected to a ring bus, banked transformers and feeder transformers.

Restricted earth fault protection

The SEF elements can be applied in a high impedance restricted earth fault scheme (REF), for protection of a star-connected transformer winding whose neutral is earthed directly or through impedance.

As shown in Figure 2.3.1, the differential current between the residual current derived from the three-phase feeder currents and the neutral current in the neutral conductor is introduced into the SEF elements. Two external components, a stabilising resistor and a varistor, are connected as shown in the figure. The former increases the overall impedance of the relay circuit and stabilises

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the differential voltage, and the latter suppresses any overvoltage in the differential circuit.

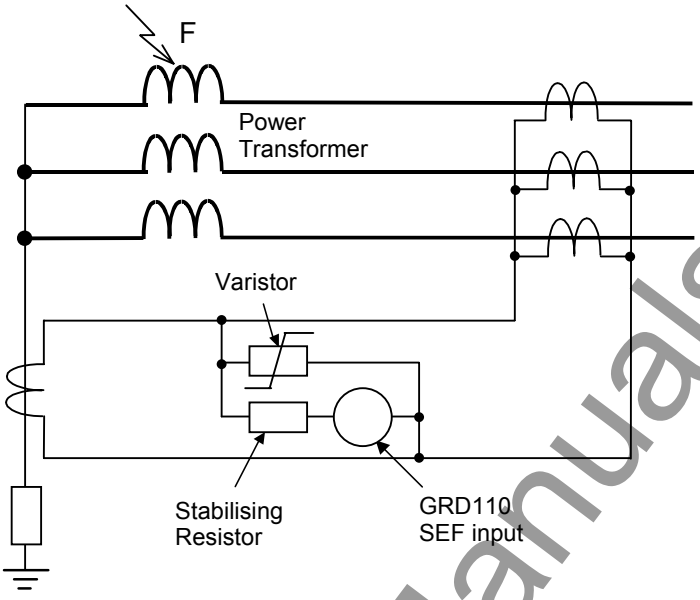

Figure 2.3.1 High Impedance REF

Scheme Logic

Figure 2.3.2 to Figure 2.3.5 show the scheme logic of inverse time or definite time selective earth fault protection and definite time earth fault protection.

In Figures 2.3.2 and 2.3.3, the definite time protection is selected by setting [MSE1] and [MSE2] to “DT”. The element SEF1 is enabled for sensitive earth fault protection and stage 1 trip signal SEF1-S1 TRIP is given through the delayed pick-up timer TSE1. The element SEF2 is enabled and trip signal SEF2 TRIP is given through the delayed pick-up timer TSE2.

The inverse time protection is selected by setting [MSE1] and [MSE2] to either “IEC”, “IEEE”, “US” or “C” according to the inverse time characteristic to employ. The element SEF1 is enabled and stage 1 trip signal SEF1-S1 TRIP is given. The element SEF2 is enabled and trip signal SEF2 TRIP is given.

The SEF1 protection provide stage 2 trip signal SEF1-S2 through a delayed pick-up timer TSE1 S2.

When the standby earth fault protection is applied by introducing earth current from the transformer low voltage neutral circuit, stage 1 trip signals are used to trip the transformer low voltage circuit breaker. If SEF1-D or SEF1-I continues operating after stage 1 has operated, the stage 2 trip signal can be used to trip the transformer high voltage circuit breaker(s).

The signal SEF1 HS is used for blocked overcurrent protection and blocked busbar protection (refer to Section 2.11).

SEF protection can be disabled by the scheme switch [SE1EN] and [SE2EN] or binary input signal SEF1 BLOCK and SEF2 BLOCK. Stage 2 trip of standby earth fault protection can be disabled by the scheme switch [SE1S2].

In Figures 2.3.4 and 2.3.5, SEF3 and SEF4 protections are programmable for instantaneous or definite time delayed operations with setting of delayed pick-up timers TSE3 and TSE4 and give trip signals SEF3 TRIP and SEF4 ALARM.

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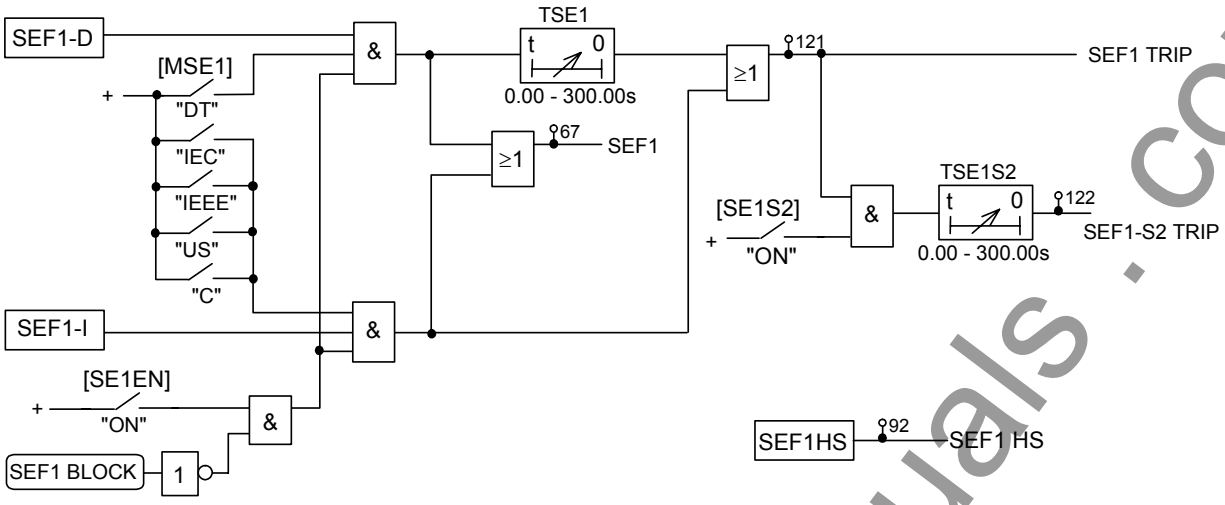

Figure 2.3.2 Inverse Time or Definite Time SEF Protection SEF1

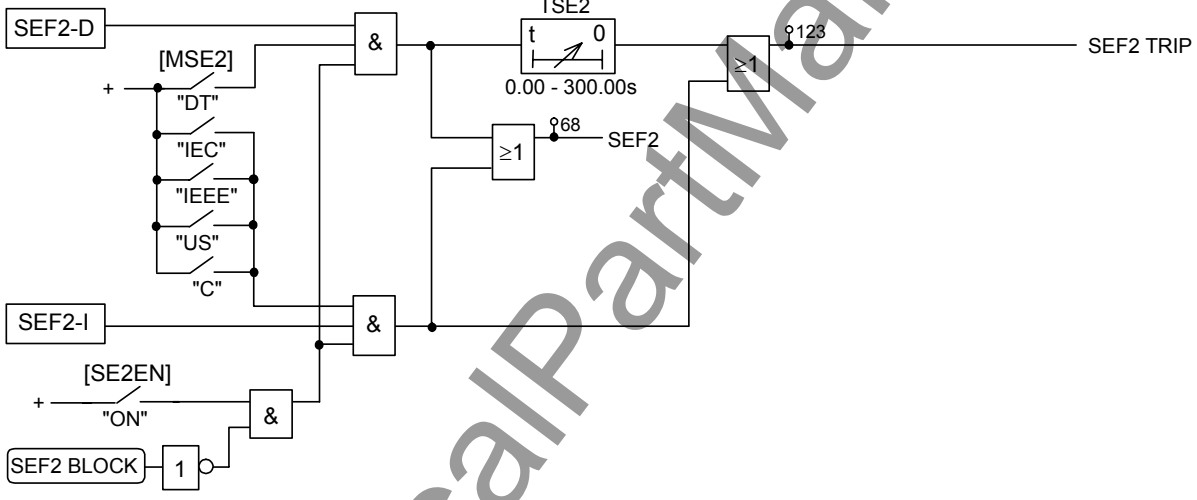

Figure 2.3.3 Inverse Time or Definite Time SEF Protection SEF2

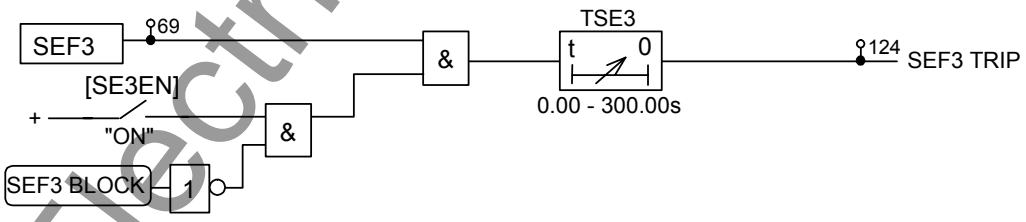

Figure 2.3.4 Definite Time SEF Protection SEF3

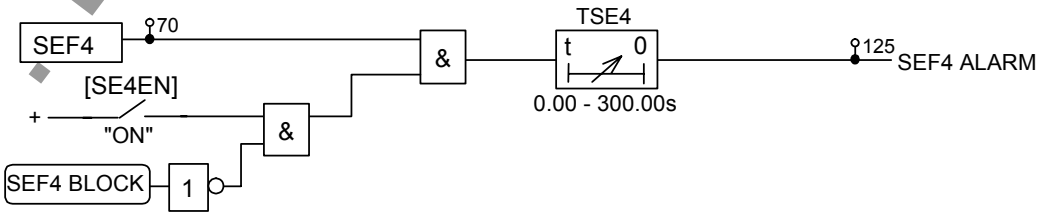

Figure 2.3.5 Definite Time SEF Scheme Logic

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Setting

The table below shows the setting elements necessary for the sensitive earth fault protection and their setting ranges.

Element	Range	Step	Default	Remarks
SE1	0.02 – 5.00 A (0.004 – 1.000 A)(*1)	0.01 A (0.001 A)	0.50 A (0.100 A)	SEF1 threshold setting
TSE1	0.010 – 1.500	0.001	1.000	SEF1 inverse time multiplier setting
	0.00 – 300.00 s (*2)	0.01 s	1.00 s	SEF1 definite time setting. Required if [MSE1] =DT.
TSE1R	0.0 – 300.0 s	0.1 s	0.0 s	SEF1 definite time delayed reset. Required if [MSE1] =IEC or if [SE1R] = DEF.
TSE1RM	0.010 – 1.500	0.001	1.000	SEF1 dependent time delayed reset time multiplier. Required if [SE1R] = DEP.
TSE1S2	0.00 – 300.00 s (*2)	0.01 s	0.00 s	SEF1 stage 2 definite time setting
SE2	0.02 – 5.00 A (0.004 – 1.000 A)(*1)	0.01 A (0.001 A)	2.50 A (0.500 A)	SEF2 threshold setting
TSE2	0.010 – 1.500	0.001	1.000	SEF2 inverse time multiplier setting
	0.00 – 300.00 s (*2)	0.01 s	0.00 s	SEF2 definite time setting.
TSE2R	0.0 – 300.0 s	0.1 s	0.0 s	SEF2 definite time delayed reset. Required if [MSE2] =IEC or if [SE2R] = DEF.
TSE2RM	0.010 – 1.500	0.001	1.000	SEF2 dependent time delayed reset time multiplier. Required if [SE2R] = DEP.
SE3	0.02 – 5.00 A (0.004 – 1.000 A)(*1)	0.01 A (0.001 A)	2.50 A (0.500 A)	SEF3 threshold setting
TSE3	0.00 – 300.00 s (*2)	0.01 s	0.00 s	SEF3 definite time setting.
SE4	0.02 – 5.00 A (0.004 – 1.000 A)(*1)	0.01 A (0.001 A)	2.50 A (0.500 A)	SEF4 threshold setting
TSE4	0.00 – 300.00 s (*2)	0.01 s	0.00 s	SEF4 definite time setting.
[SE1EN]	Off / On		On	SEF1 Enable
[MSE1]	DT / IEC / IEEE / US / C		DT	SEF1 characteristic
[MSE1C]				SEF1 inverse curve type.
MSE1C-IEC	NI / VI / EI / LTI		NI	Required if [MSE1] = IEC.
MSE1C-IEEE	MI / VI / EI		MI	Required if [MSE1] = IEEE.
MSE1C-US	CO2 / CO8		CO2	Required if [MSE1] = US.
[SE1R]	DEF / DEP		DEF	SEF1 reset characteristic. Required if [MSE1] = IEEE or US.
[SE1S2]	Off / On		Off	SEF1 stage 2 timer enable
[SE2EN]	Off / On		Off	SEF2 Enable
[MSE2]	DT / IEC / IEEE / US / C		DT	SEF2 characteristic
[MSE2C]				SEF2 inverse curve type.
MSE2C-IEC	NI / VI / EI / LTI		NI	Required if [MSE2] = IEC.
MSE2C-IEEE	MI / VI / EI		MI	Required if [MSE2] = IEEE.
MSE2C-US	CO2 / CO8		CO2	Required if [MSE2] = US.

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[SE2R]	DEF / DEP	DEF	SEF2 reset characteristic. Required if [MSE2] = IEEE or US.
[SE3EN]	Off / On	Off	SEF3 Enable
[SE4EN]	Off / On	Off	SEF4 Enable

(*1) Current values shown in parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

(*2) Time setting of TSE1 – TSE4 should be set in consideration of the SEF drop-off time 80-100ms.

SEF

SEF is set smaller than the available earth fault current and larger than the erroneous zero-phase current. The erroneous zero-phase current exists under normal conditions due to the unbalanced feeder configuration. The zero-phase current is normally fed from a core balance CT on the feeder, but if it is derived from three phase CTs, the erroneous current may be caused also by the CT error in phase faults.

The erroneous steady state zero-phase current can be acquired on the metering screen of the relay front panel.

High impedance REF protection

CT saturation under through fault conditions results in voltage appearing across the relay circuit. The voltage setting of the relay circuit must be arranged such that it is greater than the maximum voltage that can occur under through fault conditions. The worst case is considered whereby one CT of the balancing group becomes completely saturated, while the others maintain linear operation. The excitation impedance of the saturated CT is considered to approximate a short-circuit.

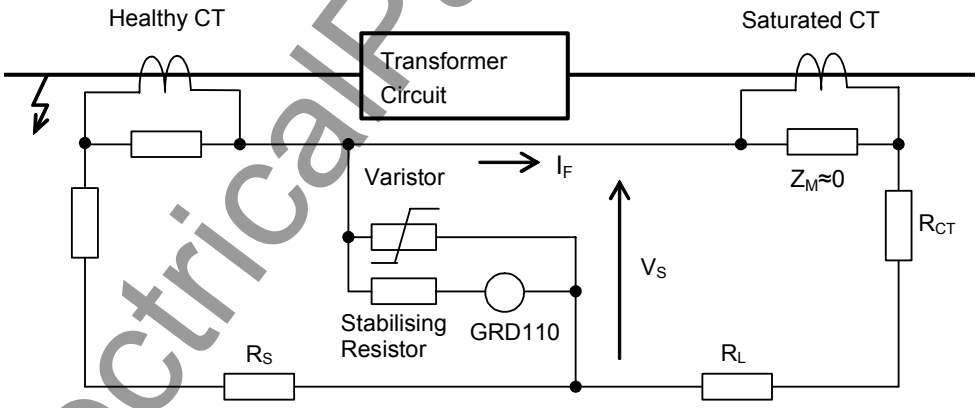

Figure 2.3.4 Maximum Voltage under Through Fault Condition

The voltage across the relay circuit under these conditions is given by the equation:

$V_S = I_F \times (R_{CT} + R_L)$

where:

V_S = critical setting voltage (rms)

I_F = maximum prospective secondary through fault current (rms)

R_{CT} = CT secondary winding resistance

R_L = Lead resistance (total resistance of the loop from the saturated CT to the relaying point)

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A series stabilising resistor is used to raise the voltage setting of the relay circuit to VS. No safety margin is needed since the extreme assumption of unbalanced CT saturation does not occur in practice. The series resistor value, Rs, is selected as follows:

$$R_S = V_S / I_S$$

Is is the current setting (in secondary amps) applied to the GRD110 relay. However, the actual fault setting of the scheme includes the total current flowing in all parallel paths. That is to say that the actual primary current for operation, after being referred to the secondary circuit, is the sum of the relay operating current, the current flowing in the varistor, and the excitation current of all the parallel connected CTs at the setting voltage. In practice, the varistor current is normally small enough that it can be neglected. Hence:

$$I_S \leqq I_P / N - 4I_{mag}$$

where:

I_S = setting applied to GRD110 relay (secondary amps)

I_P = minimum primary current for operation (earth fault sensitivity)

N = CT ratio

I_{mag} = CT magnetising (excitation) current at voltage V_S

More sensitive settings for Is allow for greater coverage of the transformer winding, but they also require larger values of Rs to ensure stability, and the increased impedance of the differential circuit can result in high voltages being developed during internal faults. The peak voltage, Vpk, developed may be approximated by the equation:

$$V_{pk} = 2 \times \sqrt{2 \times V_k \times (I_F R_S - V_k)}$$

where:

V_k = CT knee point voltage

I_F = maximum prospective secondary current for an internal fault

When a Metrosil is used for the varistor, it should be selected with the following characteristics:

$$V = CI^{\beta}$$

where:

V = instantaneous voltage

I = instantaneous current

β = constant, normally in the range 0.20 - 0.25

C = constant.

The C value defines the characteristics of the metrosil, and should be chosen according to the following requirements:

1. The current through the metrosil at the relay voltage setting should be as low as possible, preferably less than 30mA for a 1Amp CT and less than 100mA for a 5Amp CT.
2. The voltage at the maximum secondary current should be limited, preferably to 1500Vrms.

Restricted earth fault schemes should be applied with high accuracy CTs whose knee point voltage V_k is chosen according to the equation:

$$V_k \geqq 2 \times V_S$$

where V_S is the differential stability voltage setting for the scheme.

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2.4 Phase Undercurrent Protection

The phase undercurrent protection is used to detect a decrease in current caused by a loss of load, typically motor load.

The undercurrent element operates for current falling through the threshold level. But the operation is blocked when the current falls below 4 % of CT secondary rating to discriminate the loss of load from the feeder tripping by other protection.

Each phase has two independent undercurrent elements for tripping and alarming. The elements are programmable for instantaneous or definite time delayed operation.

The undercurrent element operates on per phase basis, although tripping and alarming is three-phase only.

The tripping and alarming outputs can be blocked by scheme switches or a binary input signal.

Scheme Logic

Figure 2.4.1 shows the scheme logic of the phase undercurrent protection.

Two undercurrent elements UC1 and UC2 output trip and alarm signals UC1 TRIP and UC2 ALARM through delayed pick-up timers TUC1 and TUC2.

Those protections can be disabled by the scheme switches [UC1EN] and [UC2EN] or binary input signal UC BLOCK.

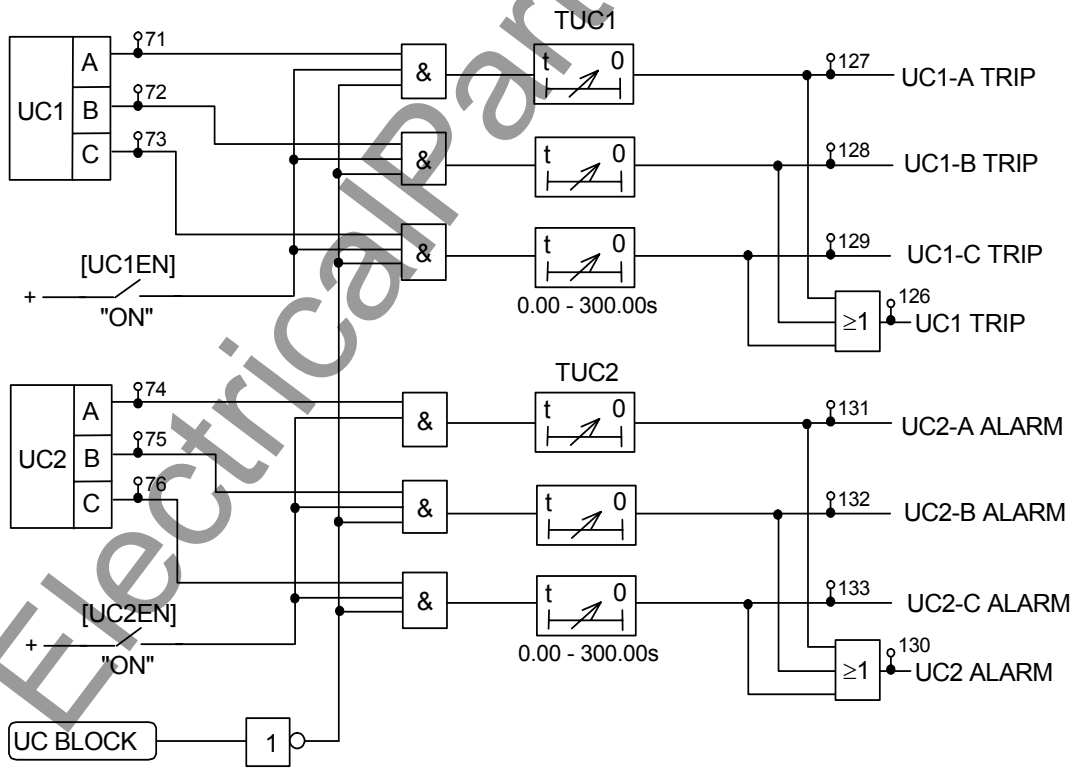

Figure 2.4.1 Undercurrent Protection Scheme Logic

Settings

The table below shows the setting elements necessary for the undercurrent protection and their setting ranges.

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Element	Range	Step	Default	Remarks
UC1	0.5 – 10.0 A (0.10 – 2.00 A)(*)	0.1 A (0.01 A)	2.0 A (0.40 A)	UC1 threshold setting
TUC1	0.00 – 300.00 s	0.01 s	0.00 s	UC1 definite time setting
UC2	0.5 – 10.0 A (0.10 – 2.00 A)	0.1 A (0.01 A)	1.0 A (0.20 A)	UC2 threshold setting
TUC2	0.00 – 300.00 s	0.01 s	0.00 s	UC2 definite time setting
[UC1EN]	Off / On		Off	UC1 Enable
[UC2EN]	Off / On		Off	UC2 Enable

(*) Current values shown in parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

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2.5 Thermal Overload Protection

The temperature of electrical plant rises according to an I^2t function and the thermal overload protection in GRD110 provides a good protection against damage caused by sustained overloading. The protection simulates the changing thermal state in the plant using a thermal model.

The thermal state of the electrical system can be shown by equation (1).

$$\theta = \frac{I^2}{I_{AOL}^2}\left(1 - e^{-t/\tau}\right) \times 100\% \qquad (1)$$

where:

θ = thermal state of the system as a percentage of allowable thermal capacity,

I = applied load current,

I_{AOL} = allowable overload current of the system,

τ = thermal time constant of the system.

The thermal state 0% represents the cold state and 100% represents the thermal limit, which is the point at which no further temperature rise can be safely tolerated and the system should be disconnected. The thermal limit for any given system is fixed by the thermal setting I_{AOL}. The relay gives a trip output when θ = 100%.

The thermal overload protection measures the largest of the three phase currents and operates according to the characteristics defined in IEC60255-8. (Refer to Appendix A for the implementation of the thermal model for IEC60255-8.)

Time to trip depends not only on the level of overload, but also on the level of load current prior to the overload - that is, on whether the overload was applied from 'cold' or from 'hot'.

Independent thresholds for trip and alarm are available.

The characteristic of thermal overload element is defined by equation (2) and equation (3) for 'cold' and 'hot'. The cold curve is a special case for the hot curve where prior load current Ip is zero, catering to the situation where a cold system is switched on to an immediate overload.

$$t = \tau \cdot Ln\left[\frac{I^2}{I^2 - I_{AOL}^2}\right] \qquad (2)$$

$$t = \tau \cdot Ln\left[\frac{I^2 - I_P{}^2}{I^2 - I_{AOL}^2}\right] \qquad (3)$$

where:

t = time to trip for constant overload current I (seconds)

I = overload current (largest phase current) (amps)

I_{AOL} = allowable overload current (amps)

I_P = previous load current (amps)

τ = thermal time constant (seconds)

Ln = natural logarithm

Figure 2.5.1 illustrates the IEC60255-8 curves for a range of time constant settings. The left-hand chart shows the 'cold' condition where an overload has been switched onto a previously

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un-loaded system. The right-hand chart shows the 'hot' condition where an overload is switched onto a system that has previously been loaded to 90% of its capacity.

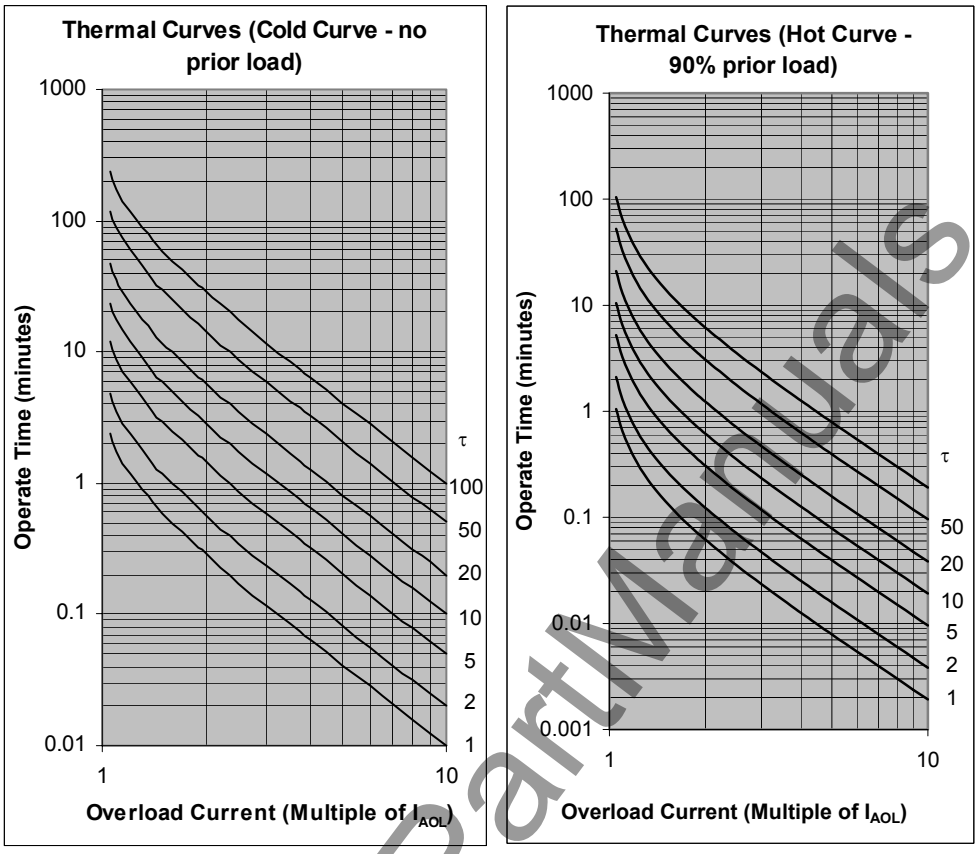

Figure 2.5.1 Thermal Curves

Scheme Logic

Figure 2.5.2 shows the scheme logic of the thermal overload protection.

The thermal overload element THM has independent thresholds for alarm and trip, and outputs alarm signal THM ALARM and trip signal THM TRIP. The alarming threshold level is set as a percentage of the tripping threshold.

The alarming and tripping can be disabled by the scheme switches [THMAEN] and [THMTEN] respectively or binary input signal THM BLOCK.

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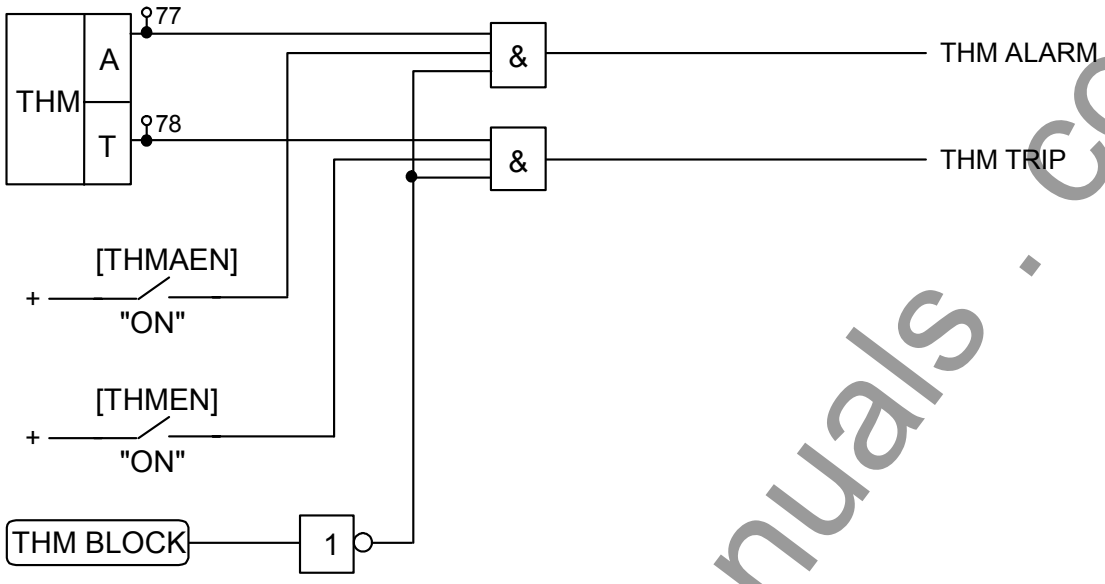

Figure 2.5.2 Thermal Overload Protection Scheme Logic

Settings

The table below shows the setting elements necessary for the thermal overload protection and their setting ranges.

Element	Range	Step	Default	Remarks
THM	2.0 – 10.0 A (0.40 – 2.00 A)(*)	0.1 A (0.01 A)	5.0 A (1.00 A)	Thermal overload setting. (THM = I_{AOL}: allowable overload current)
THMIP	0.0 – 5.0 A (0.00 – 1.00 A)(*)	0.1 A (0.01 A)	0.0 A (0.00 A)	Prior load setting.
TTHM	0.5 - 500.0 min	0.1 min	10.0 min	Thermal time constant
THMA	50 – 99 %	1 %	80 %	Thermal alarm setting. (Percentage of THM setting.)
[THMEN]	Off / On		Off	Thermal OL enable
[THMAEN]	Off / On		Off	Thermal alarm enable

(*) Current values shown in the parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

Note: THMIP sets a minimum level of previous load current to be used by the thermal element, and is typically used when testing the element. For the majority of applications, THMIP should be set to its default value of zero, in which case the previous load current, Ip, is calculated internally by the thermal model, providing memory of conditions occurring before an overload.

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2.6 Negative Sequence Overcurrent Protection

The negative sequence overcurrent protection (NSOP) is used to detect asymmetrical faults (phase-to-phase and phase-to-earth faults) with high sensitivity in conjunction with phase overcurrent protection and residual overcurrent protection. It also used to detect load unbalance conditions.

Phase overcurrent protection is forced to be set to lower sensitivity when the load current is large but NSOP sensitivity is not affected by magnitude of the load current, except in the case of erroneous negative sequence current due to the unbalanced configuration of the distribution lines.

For some earth faults, small zero sequence current is fed while the negative sequence current is comparatively larger. This is probable when the fault occurs at the remote end with a small reverse zero sequence impedance and most of the zero sequence current flows to the remote end.

In these cases, NSOP backs up the phase overcurrent and residual overcurrent protection. The NSOP also protects the rotor of a rotating machine from over heating by detecting a load unbalance. Unbalanced voltage supply to a rotating machine due to a phase loss can lead to increases in the negative sequence current and in machine heating.

Two independent negative sequence overcurrent elements are provided for tripping and alarming. The elements are programmable for instantaneous or definite time delayed operation.

The tripping and alarming outputs can be blocked by scheme switches or a binary input signal.

Scheme Logic

Figure 2.6.1 shows the scheme logic of the NSOP. Two negative sequence overcurrent elements NPS1 and NPS2 with independent thresholds output trip signal NPS1 TRIP and alarm signal NPS2 ALARM through delayed pick-up timers TNPS1 and TNPS2.

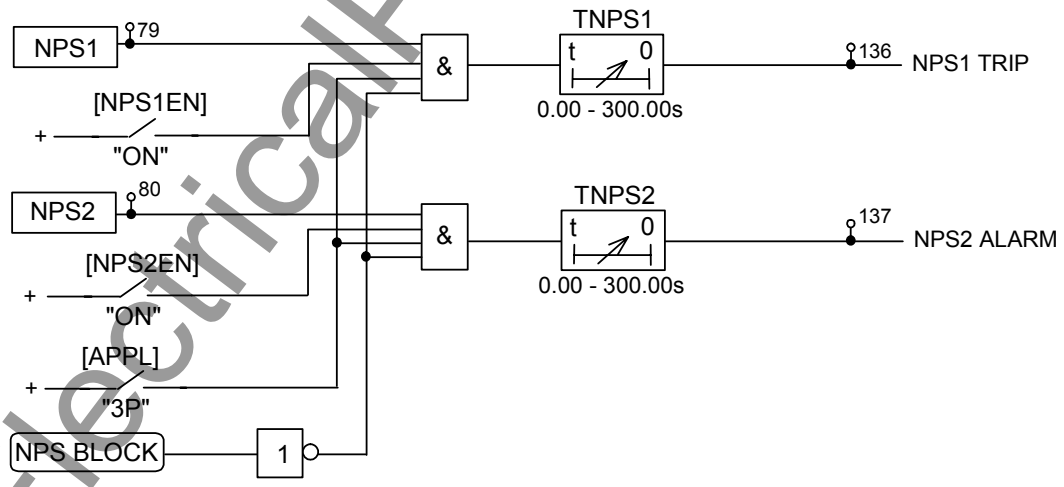

Figure 2.6.1 Negative Sequence Overcurrent Protection Scheme Logic

The tripping and alarming can be disabled by the scheme switches [NPS1EN], [NPS2EN], [APPL] or binary input signal NPS BLOCK.

The scheme switch [APPL] is available in Model 400 and 420 in which three-phase or two-phase overcurrent protection can be selected. The NSOP is enabled when three-phase current is introduced and [APPL] is set to "3P" in those models.

Note: Because the APPL setting is concerned in hardware configuration, it can be set only from the LCD screen. (It cannot be changed or checked by RSM100.)

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Settings

The table below shows the setting elements necessary for the NSOP protection and their setting ranges.

Element	Range	Step	Default	Remarks
NPS1	0.5 -10.0 A (0.10 – 2.00 A)(*)	0.1 A (0.01 A)	1.0 A (0.20 A)	NPS1 threshold setting for tripping.
NPS2	0.5 -10.0 A (0.10 – 2.00 A)	0.1 A (0.01 A)	2.0 A (0.40 A)	NPS2 threshold setting for alarming.
TNPS1	0.00 – 300.00 s	0.01 s	0.00 s	NPS1 definite time setting
TNPS2	0.00 – 300.00 s	0.01 s	0.00 s	NPS2 definite time setting
[NPS1EN]	Off / On		Off	NPS1 Enable
[NPS2EN]	Off / On		Off	NPS2 Enable
[APPL]	3P / 2P / 1P		3P	Three-phase current input. Only required in Model 400 and 420.

(*) Current values shown in the parenthesis are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

Sensitive setting of NPS1 and NPS2 thresholds is restricted by the negative phase sequence current normally present on the system. The negative phase sequence current is measured in the relay continuously and displayed on the metering screen of the relay front panel along with the maximum value. It is recommended to check the display at the commissioning stage and to set NPS1 and NPS2 to 130 to 150% of the maximum value displayed.

The delay time setting TNPS1 and TNPS2 is added to the inherent delay of the measuring elements NPS1 and NPS2. The minimum operating time of the NPS elements is around 200ms.

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2.7 Broken Conductor Protection

Series faults or open circuit faults which do not accompany any earth faults or phase faults are caused by broken conductors, breaker contact failure, operation of fuses, or false operation of single-phase switchgear.

Figure 2.7.1 shows the sequence network connection diagram in the case of a single-phase series fault assuming that the positive, negative and zero sequence impedance of the left and right side system of the fault location is in the ratio of k_1 to $(1 - k_1)$, k_2 to $(1 - k_2)$ and k_0 to $(1 - k_0)$.

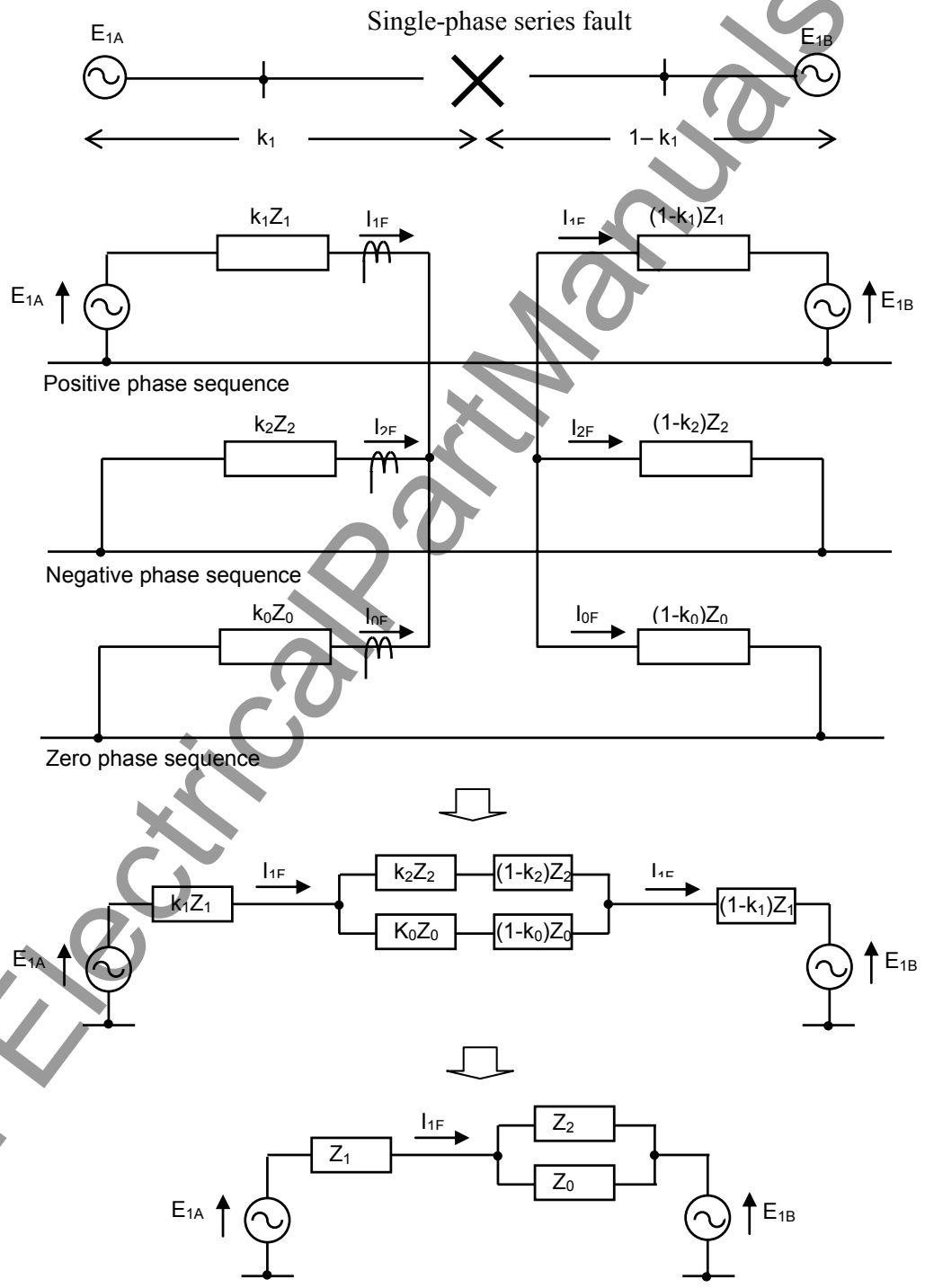

Figure 2.7.1 Equivalent Circuit for a Single-phase Series Fault

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Positive phase sequence current I_{1F}, negative phase sequence current I_{2F} and zero phase sequence current I_{0F} at fault location in an single-phase series fault are given by:

$$I_{1F} + I_{2F} + I_{0F} = 0 \quad (1)$$

$$Z_{2F}I_{2F} - Z_{0F}I_{0F} = 0 \quad (2)$$

$$E_{1A} - E_{1B} = Z_{1F}I_{1F} - Z_{2F}I_{2F} \quad (3)$$

where,

E_{1A}, E_{1B}: power source voltage

Z_1: positive sequence impedance

Z_2: negative sequence impedance

Z_0: zero sequence impedance

From the equations (1), (2) and (3), the following equations are derived.

$$I_{1F} = \frac{Z_2 + Z_0}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

$$I_{2F} = \frac{-Z_0}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

$$I_{0F} = \frac{-Z_2}{Z_1Z_2 + Z_1Z_0 + Z_2Z_0}(E_{1A} - E_{1B})$$

The magnitude of the fault current depends on the overall system impedance, difference in phase angle and magnitude between the power source voltages behind both ends.

Broken conductor protection element BCD detects series faults by measuring the ratio of negative to positive phase sequence currents (I_{2F} / I_{1F}). This ratio is given with negative and zero sequence impedance of the system:

$$\frac{I_{2F}}{I_{1F}} = \frac{|I_{2F}|}{|I_{1F}|} = \frac{Z_0}{Z_2 + Z_0}$$

The ratio is higher than 0.5 in a system when the zero sequence impedance is larger than the negative sequence impedance. It will approach 1.0 in a high-impedance earthed or a one-end earthed system.

The characteristic of BCD element is shown in Figure 2.7.2 to obtain the stable operation.

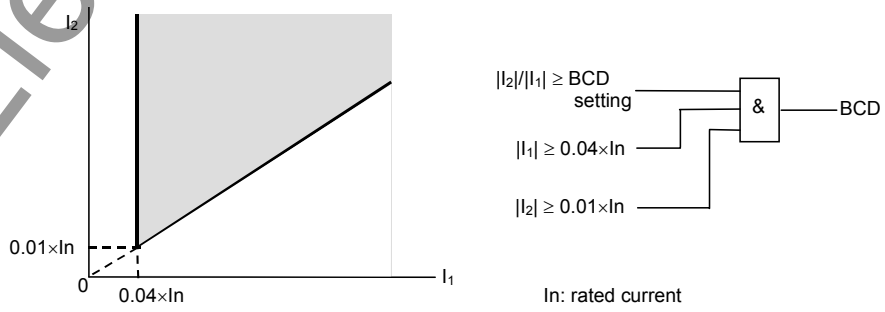

Figure 2.7.2 BCD Element Characteristic

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Scheme Logic

Figure 2.7.3 shows the scheme logic of the broken conductor protection. BCD element outputs trip signals BCD TRIP through a delayed pick-up timer TBCD.

The tripping can be disabled by the scheme switch [BCDEN], [APPL] or binary input signal BCD BLOCK. The scheme switch [APPL] is available in Model 400 and 420 in which three-phase or two-phase phase overcurrent protection can be selected. The broken conductor protection is enabled when three-phase current is introduced and [APPL] is set to "3P" in those models.

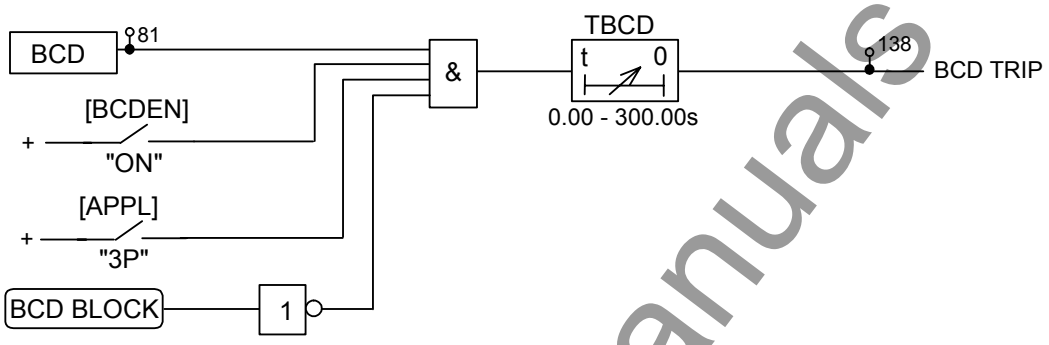

Figure 2.7.3 Broken Conductor Protection Scheme Logic

Settings

The table below shows the setting elements necessary for the broken conductor protection and their setting ranges.

Element	Range	Step	Default	Remarks
BCD	0.10 – 1.00	0.01	0.20	I_2 / I_1
TBCD	0.00 – 300.00s	0.01s	0.00 s	BCD definite time setting
[BCDEN]	Off / On		Off	BCD Enable
[APPL]	3P / 2P / 1P		3P	Three-phase current input. Only required in Model 400 and 420.

Minimum setting of the BC threshold is restricted by the negative phase sequence current normally present on the system. The ratio I_2 / I_1 of the system is measured in the relay continuously and displayed on the metering screen of the relay front panel, along with the maximum value of the last 15 minutes I_{21} max. It is recommended to check the display at the commissioning stage. The BCD setting should be 130 to 150% of I_2 / I_1 displayed.

Note: It must be noted that I_2 / I_1 is displayed only when the positive phase sequence current (or load current) in the secondary circuit is larger than 2 % of the rated secondary circuit current.

TBCD should be set to more than 1 cycle to prevent unwanted operation caused by a transient operation such as CB closing.

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2.8 Breaker Failure Protection

When fault clearance fails due to a breaker failure, the breaker failure protection (BFP) clears the fault by backtripping adjacent circuit breakers.

If the current continues to flow even after a trip command is output, the BFP judges it as a breaker failure. The existence of the current is detected by an overcurrent element provided for each phase. For high-speed operation of the BFP, a high-speed reset overcurrent element (less than 20ms) is used. The element resets when the current falls below 80% of the operating value.

In order to prevent the BFP from starting by accident during maintenance work and testing, and thus tripping adjacent breakers, the BFP has the optional function of retripping the original breaker. To make sure that the breaker has actually failed, a trip command is made to the original breaker again before tripping the adjacent breakers to prevent unnecessary tripping of the adjacent breakers following the erroneous start-up of the BFP. It is possible to choose not to use retripping at all, or use retripping with trip command plus delayed pick-up timer, or retripping with trip command plus overcurrent detection plus delayed pick-up timer.

An overcurrent element and delayed pick-up timer are provided for each phase which also operate correctly during the breaker failure routine in the event of an evolving fault.

Scheme logic

The BFP is performed on per-phase basis. Figure 2.8.1 shows the scheme logic for the BFP. The BFP is started by per-phase base trip signals EXT TRIP-A to -C or three-phase base trip signal EXT TRIP3PH of the external line protection or an internal trip signal CBF INIT. These trip signals must continuously exist as long as the fault is present.

The backtripping signal to the adjacent breakers CBF TRIP is output if the overcurrent element CBF operates continuously for the setting time of the delayed pick-up timer TBTC after initiation. Tripping of adjacent breakers can be blocked with the scheme switch [BTC].

There are two kinds of modes of the retrip signal to the original breaker CBF RETRIP, the mode in which retrip is controlled by the overcurrent element CBF, and the direct trip mode in which retrip is not controlled. The retrip mode together with the trip block can be selected with the scheme switch [RTC]. In the scheme switch [RTC], “DIR” is the direct trip mode, and “OC” is the trip mode controlled by the overcurrent element CBF.

Figure 2.8.2 shows a sequence diagram for the BFP when a retrip and backup trip are used. If the circuit breaker trips normally, the CBF is reset before timer TRTC or TBTC is picked up and the BFP is reset. As TRTC and TBTC start at the same time, the setting value of TBTC should include that of TRTC.

If the CBF continues to operate, a retrip command is given to the original breaker after the setting time of TRTC. Unless the breaker fails, the CBF is reset by retrip. TBTC does not time-out and the BFP is reset. This sequence of events may happen if the BFP is initiated by mistake and unnecessary tripping of the original breaker is unavoidable.

If the original breaker fails, retrip has no effect and the CBF continues operating and the TBTC finally picks up. A trip command CBF TRIP is given to the adjacent breakers and the BFP is completed.

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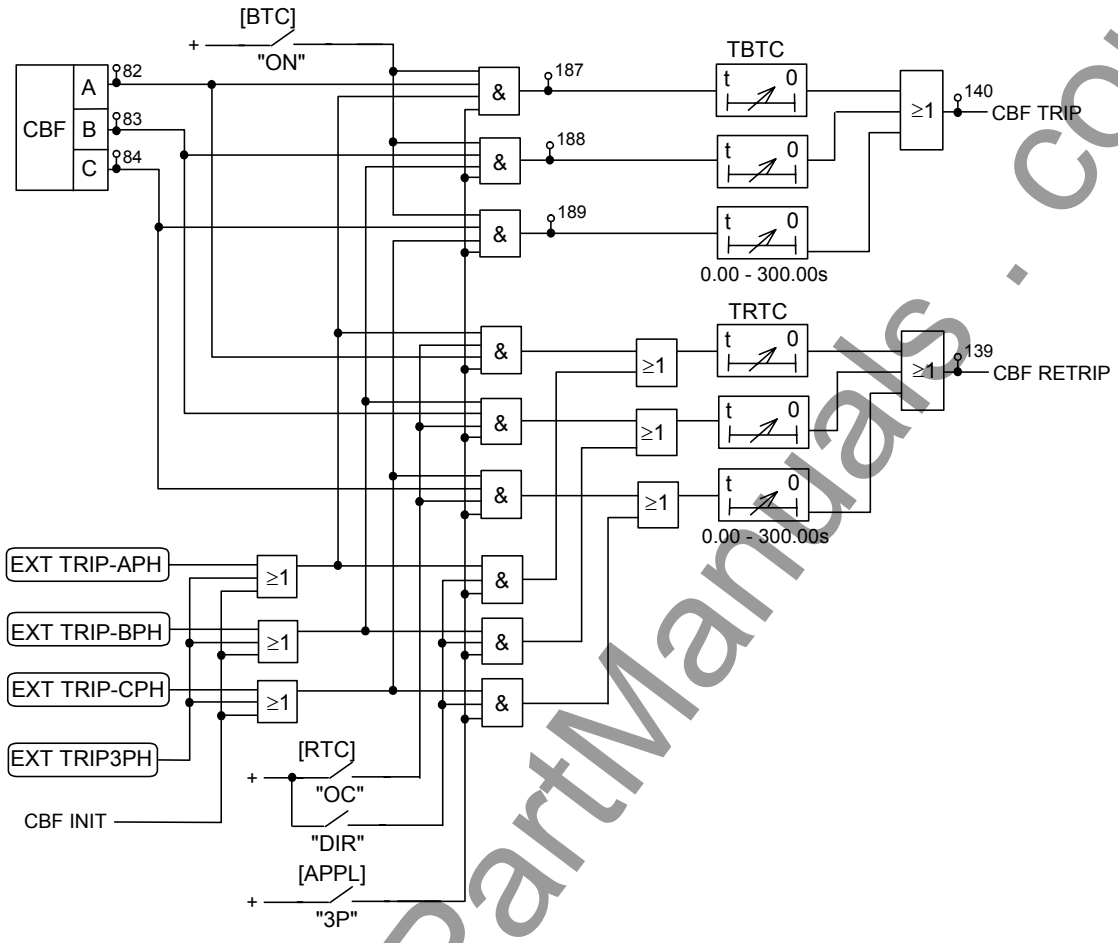

Figure 2.8.1 Breaker Failure Protection Scheme Logic

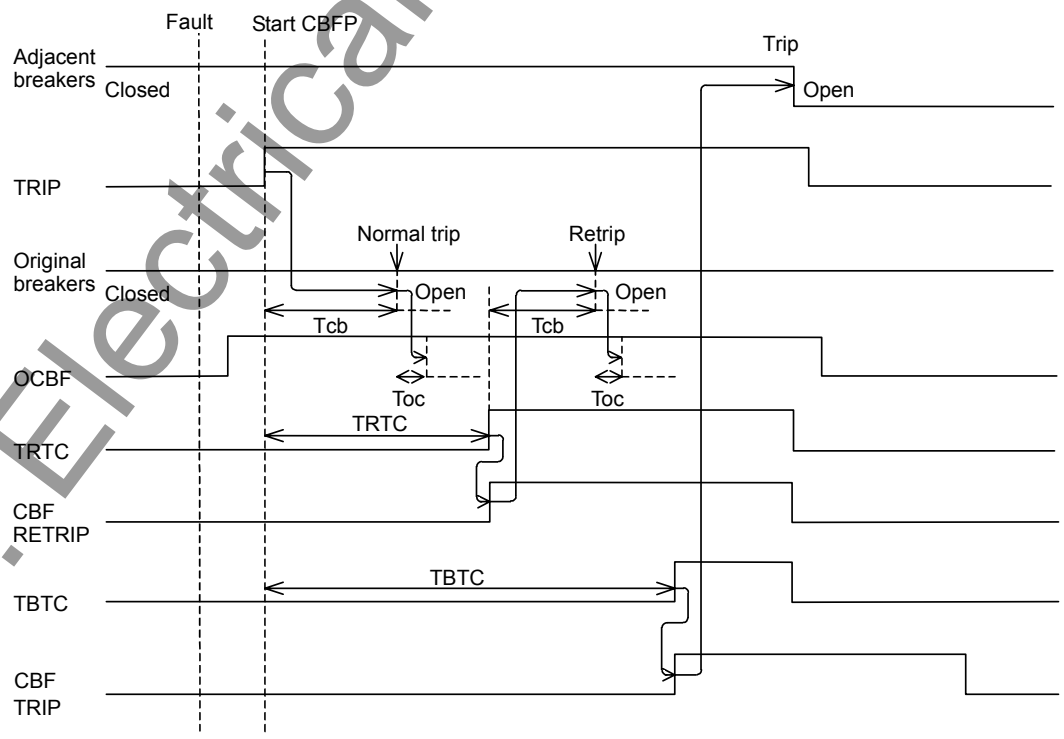

Figure 2.8.2 Sequence Diagram

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Setting

The setting elements necessary for the breaker failure protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
CBF	0.5 – 10.0 A	0.1 A	2.5 A	Overcurrent setting
	(0.10 - 2.00 A)(*)	(0.01 A)	(0.50 A)	
TRTC	0.00 – 300.00 s	0.01 s	0.50 s	Retrip time setting
TBTC	0.00 – 300.00 s	0.01 s	1.00 s	Back trip time setting
[RTC]	Off / DIR / OC		Off	Retrip control
[BTC]	Off / On		Off	Back trip control

(*) Current values shown in the parentheses are in the case of 1 A rating. Other current values are in the case of 5 A rating.

The overcurrent element CBF checks that the circuit breaker has opened and that the current has disappeared. Therefore, since it is allowed to respond to load current, it can be set to 10 to 200% of the rated current.

The settings of TRTC and TBTC are determined by the opening time of the original circuit breaker (Tcb in Figure 2.8.2) and the reset time of the overcurrent element (Toc in Figure 2.8.2). The timer setting example when using retrip can be obtained as follows.

Setting of TRTC = Breaker opening time + CBF reset time + Margin
= 40ms + 10ms + 20ms
= 70ms

Setting of TBTC = TRTC + Output relay operating time + Breaker opening time + CBF reset time + Margin
= 70ms + 10ms + 40ms + 10ms + 10ms
= 140ms

If retrip is not used, the setting of the TBTC can be the same as the setting of the TRTC.

The actual tripping time after BFP start will be added the time (approx. 15 to 20ms) consumed by motion of binary input and output to above timer's settings. (Response time of binary inputs: less than 8ms, Operating time of binary outputs: less than 10ms)

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2.9 Cold Load Protection

In normal operation, the load current on the distribution line is smaller than the sum of the rated loads connected to the line. But it amounts to several times the maximum load current for a moment when all of the loads are energised at once after a long interruption, and decreases to 1.5 times normal peak load after three or four seconds.

To protect those lines with overcurrent element, it is necessary to use settings to discriminate the inrush current in cold load restoration and the fault current.

This function modifies the overcurrent protection settings for a period after closing on to the type of load that takes a high level of load on energisation. This is achieved by a 'Cold Load Settings Group', in which the user can use alternative settings of measuring elements in other setting group. Normally the user will choose higher current settings and/or longer time delays and/or disable elements altogether within this group. The 'Cold Load Settings' can be set in any of the four setting groups provided for protection and the group is specified by the scheme switch [CLSG] setting.

A state transition diagram and its scheme logic are shown in Figure 2.9.1 and Figure 2.9.2 for the cold load protection. Note that the scheme requires the use of two binary inputs, one each for CB OPEN and CB CLOSED.

Under normal conditions, where the circuit breaker has been closed for some time, the scheme is in STATE 0, and the normal default settings group is applied to the overcurrent protection.

If the circuit breaker opens then the scheme moves to STATE 1 and runs the Cold Load Enable timer TCLE. If the breaker closes again while the timer is running, then STATE 0 is re-entered. Alternatively, if TCLE expires then the load is considered cold and the scheme moves to STATE 2, and stays there until the breaker closes, upon which it goes to STATE 3.

In STATE 2 and STATE 3, the 'Cold Load Settings Group' is applied.

In STATE 3 the Cold Load Reset timer TCLR runs. If the circuit breaker re-opens while the timer is running then the scheme returns to STATE 2. Alternatively, if TCLR expires then it goes to STATE 0, the load is considered warm and normal settings can again be applied.

Accelerated reset of the cold load protection is also possible. In STATE 3, the phase currents are monitored by overcurrent element ICLDO and if all phase currents drop below the ICLDO threshold for longer than the cold load drop off time (TCLDO) then the scheme automatically reverts to STATE 0. The accelerated reset function can be enabled with the scheme switch [CLDOEN] setting.

Cold load protection can be disabled by setting [CLSG] to "Off".

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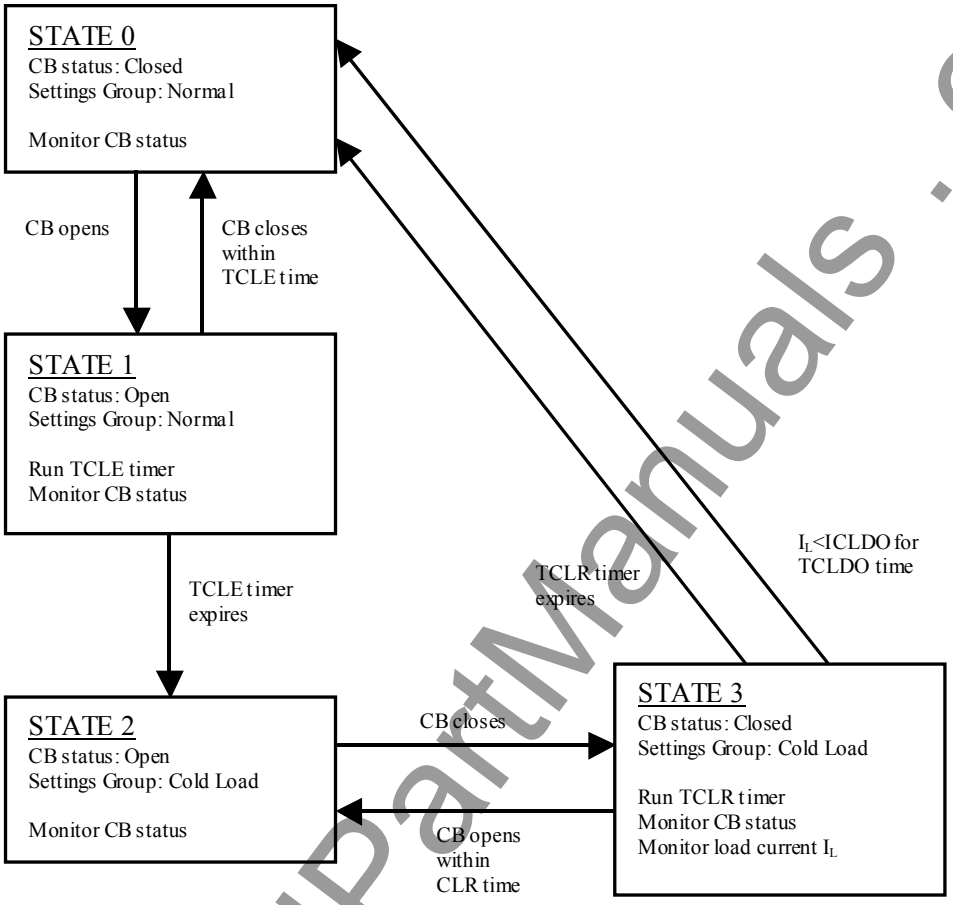

Figure 2.9.1 State Transition Diagram for Cold Load Protection

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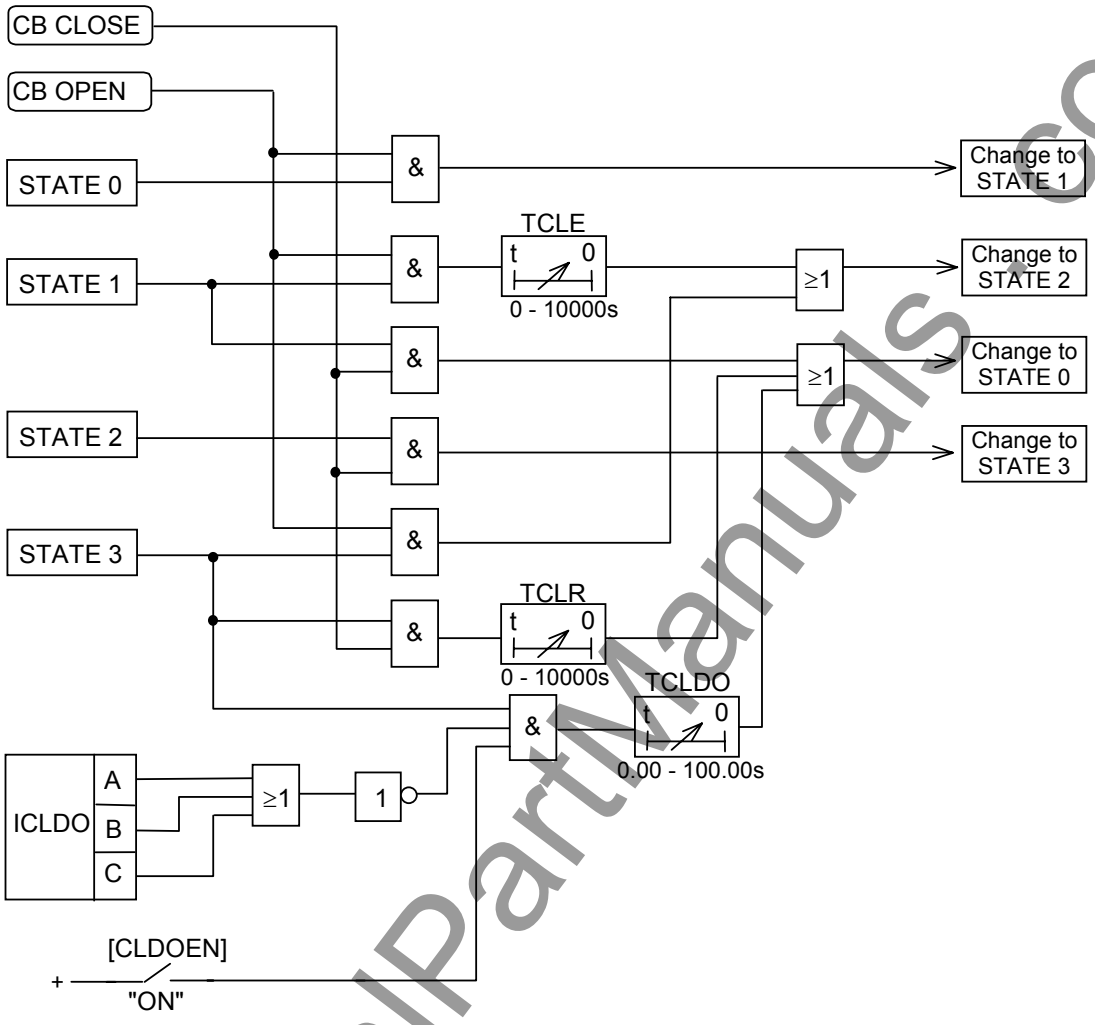

Figure 2.9.2 Scheme Logic for Cold Load Protection

Settings

The setting elements necessary for the cold load protection and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
ICLDO	0.5 – 10.0 A (0.10 - 2.00 A)(*)	0.1 A (0.01 A)	2.5 A (0.50 A)	Cold load drop-off threshold setting
TCLE	0-10000 s	1 s	100 s	Cold load enable timer
TCLR	0-10000 s	1 s	100 s	Cold load reset timer
TCLDO	0.00-100.00 s	0.01 s	0.00 s	Cold load drop-off timer
[CLSG]	Off / 1 / 2 / 3 / 4		Off	Cold load setting group
[CLDOEN]	Off / On		Off	Cold load drop-off enable

(*) Current values shown in the parentheses are in the case of a 1 A rating. Other current values are in the case of a 5 A rating.

These settings are required for all setting groups and the same settings must be entered for the setting elements above.

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2.10 Trip Signal Output

As shown in Figure 2.10.1, all the trip signals are introduced into one of the seven user configurable binary output circuits. One tripping output relay with a pair of normally open and closed contacts is provided to trip the local circuit breaker. If the breaker failure protection is applied, the back-trip signal CBF TRIP is introduced into another binary output circuit to trip adjacent circuit breakers, as shown in Figure 2.10.2.

After the trip signal disappears by clearing the fault, the reset time of the tripping output relay can be set with the scheme switch [Reset] to "instantaneous(Inst)", "delayed(Dl)", "dwell(Dw)" or "latched(Latch)". The time of the delayed drop-off "Dl" or dwell operation "Dw" can be set by TBO. The setting is respective for each output relay.

When the relay is latched, it is reset with the RESET key on the relay front panel or a binary input signal REMOTE RESET. This resetting resets all the output relays collectively.

When instantaneous reset of the tripping output relay is selected, it must be checked that the tripping circuit is opened with a circuit breaker auxiliary contact prior to the tripping output relay resetting, in order to prevent the tripping output relay from directly interrupting the circuit breaker tripping coil current.

The tripping output relay has a pair of normally open and closed contact.

Settings

The setting elements necessary for the trip signal output and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
[RESET]	Inst / Dl / Dw / Latch		Del	Output relay reset time. Instantaneous, dwell, delayed or latched.
TBO	0.00 – 10.00s	0.01s	0.20s	

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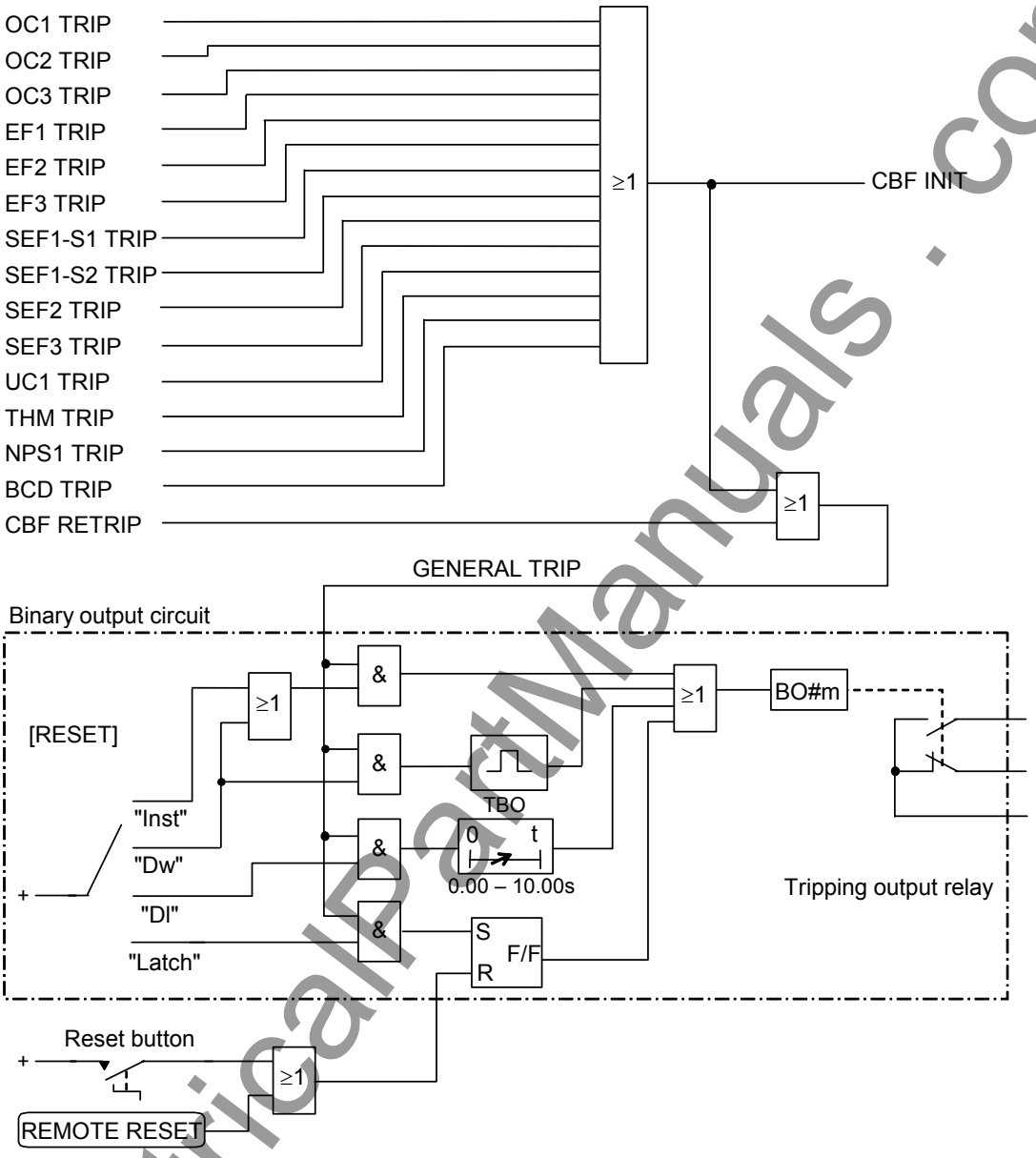

Figure 2.10.1 Tripping Output for Local Circuit Breaker

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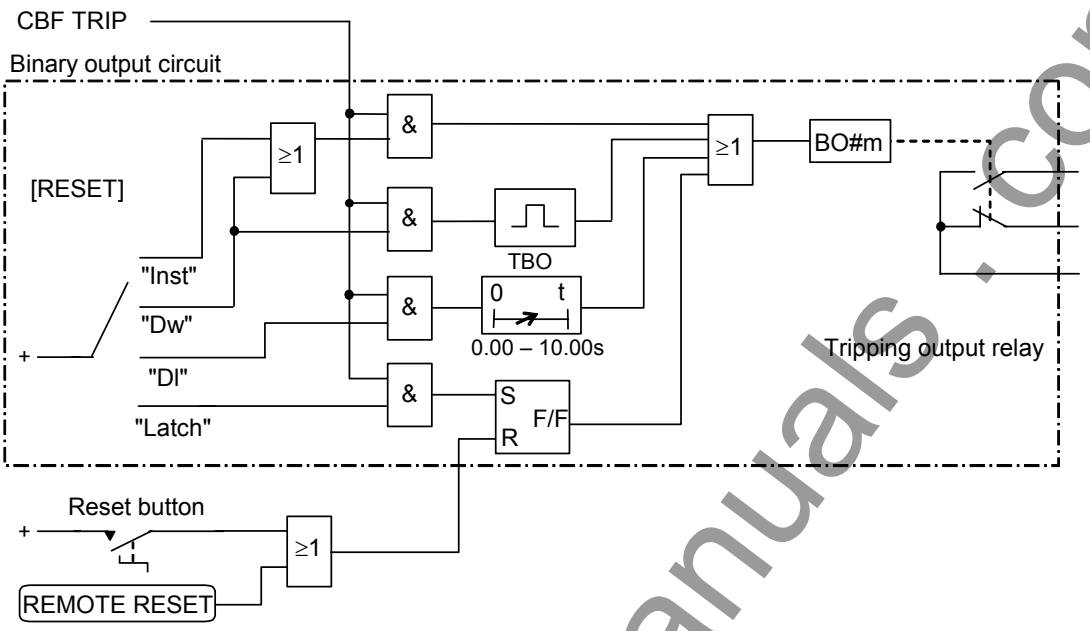

Figure 2.10.2 Tripping Output for Adjacent Circuit Breakers

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2.11 Application of Protection Inhibits

All GRD110 protection elements can be blocked by a binary input signal. This feature is useful in a number of applications.

2.11.1 Blocked Overcurrent Protection

Conventional time-graded definite time overcurrent protection can lead to excessive fault clearance times being experienced for faults closest to the source. The implementation of a blocked overcurrent scheme can eliminate the need for grading margins and thereby greatly reduce fault clearance times. Such schemes are suited to radial feeder circuits, particularly where substations are close together and pilot cables can be economically run between switchboards.

Figure 2.11.1 shows the operation of the scheme.

Instantaneous phase fault and earth fault pick-up signals OC1 HS, and EF1 HS of OC1 and EF1 elements are allocated to any of the binary output relays and used as a blocking signal. OC2 and EF2 protections are set with a short delay time. (For pick-up signals, refer to Figure 2.1.5 and 2.1.6.)

For a fault at F as shown, each relay sends the blocking signal to its upstream neighbor. The signal is input as a binary input signal OC2 BLOCK and EF2 BLOCK at the receiving end, and blocks the OC2 and EF2 protection. Minimum protection delays of 50ms are recommended for the OC2 and EF2 protection, to ensure that the blocking signal has time to arrive before protection operation.

Inverse time graded operation with elements OC1 and EF1 are available with the scheme switch [MOC1] setting, thus providing back-up protection in the event of a failure of the blocked scheme.

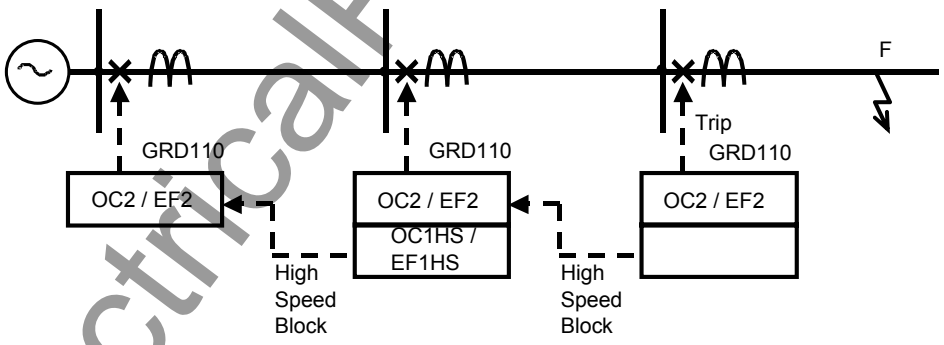

Figure 2.11.1 Blocked Overcurrent Protection

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2.11.2 Blocked Busbar Protection

GRD110 can be applied to provide a busbar zone scheme for a simple radial system where a substation has only one source, as illustrated in Figure 2.11.2.

For a fault on an outgoing feeder F1, the feeder protection sends a hardwired blocking signal to inhibit operation of the incomer, the signal OC1 HS and EF1 HS being generated by the instantaneous phase fault, and earth fault pick-up outputs of OC1 and EF1 allocated to any of the binary output relays. Meanwhile, the feeder is tripped by the OC1 and EF1 elements, programmed with inverse time or definite time delays and set to grade with downstream protections.

The incomer protection is programmed to trip via its instantaneous elements OC2 and EF2 set with short definite time delay settings (minimum 50ms), thus providing rapid isolation for faults in the busbar zone F2.

At the incomer, inverse time graded operation with elements OC1 and EF1 are available with the scheme switch [MOC1] setting, thus providing back-up protection in the event of failure of the blocked scheme.

GRD110 integrated circuit breaker failure protection can be used to provide additional back-trips from the feeder protection to the incomer, and from the incomer to the HV side of the power transformer, in the event of the first trip failing to clear the earth fault.

In the case of more complex systems where the substation has two incomers, or where power can flow into the substation from the feeders, then directional protection must be applied (refer to GRD140 directional overcurrent protection).

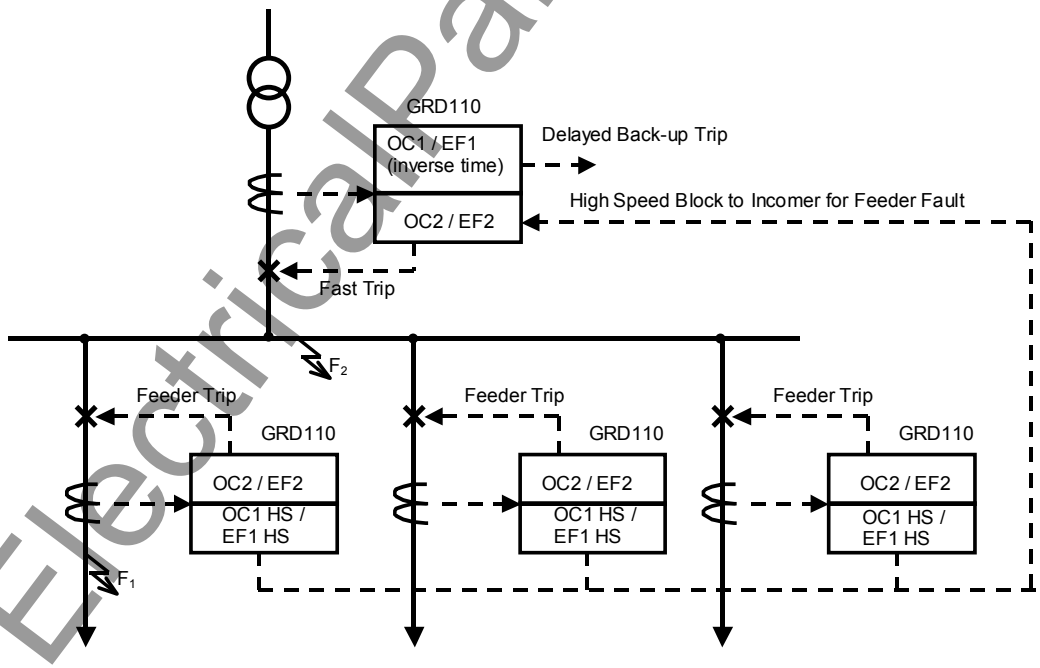

Figure 2.11.2 Blocked Busbar Protection

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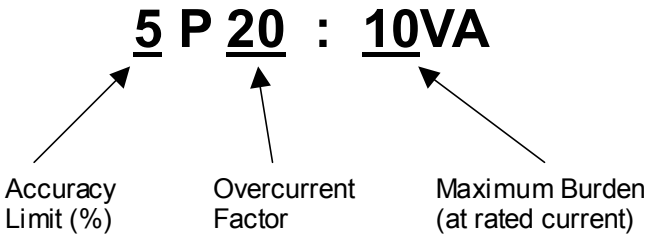
2.12 CT Requirements

2.12.1 Phase Fault and Earth Fault Protection

Protection class current transformers are normally specified in the form shown below. The CT transforms primary current within the specified accuracy limit, for primary current up to the overcurrent factor, when connected to a secondary circuit of the given burden.



Accuracy limit : Typically 5 or 10%. In applications where current grading is to be applied and small grading steps are desirable, then a 5% CT can assist in achieving the necessary accuracy. In less onerous applications, a limit of 10% may be acceptable.

Overcurrent factor : The multiple of the CT rating up to which the accuracy limit is claimed, typically 10 or 20 times. A value of 20 should be specified where maximum fault current is high and accurate inverse time grading is required. In applications where fault current is relatively low, or where inverse time grading is not used, then an overcurrent factor of 10 may be adequate.

Maximum burden : The total burden calculated at rated secondary current of all equipment connected to the CT secondary, including relay input burden, lead burden, and taking the CT's own secondary resistance into account. GRD110 has an extremely low AC current burden, typically less than 0.1VA for a 1A phase input, allowing relatively low burden CTs to be applied. Relay burden does not vary with settings.

If a burden lower than the maximum specified is connected, then the practical overcurrent factor may be scaled accordingly. For the example given above, at a rated current of 1A, the maximum value of CT secondary resistance plus secondary circuit resistance (RCT + R2) should be 10Ω. If a lower value of, say, (RCT + R2) = 5Ω is applied, then the practical overcurrent factor may be increased by a factor of two, that is, to 40A.

In summary, the example given of a 5P20 CT of suitable rated burden will meet most applications of high fault current and tight grading margins. Many less severe applications may be served by 5P10 or 10P10 transformers.

2.12.2 Minimum Knee Point Voltage

An alternative method of specifying a CT is to calculate the minimum knee point voltage, according to the secondary current which will flow during fault conditions:

$$V_k \geq I_f (R_{CT} + R_2)$$

where:

V_k = knee point voltage

I_f = maximum secondary fault current

R_{CT} = resistance of CT secondary winding

R_2 = secondary circuit resistance, including lead resistance.

When using this method, it should be noted that it is often not necessary to transform the

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maximum fault current accurately. The knee point should be chosen with consideration of the settings to be applied and the likely effect of any saturation on protection performance. Further, care should be taken when determining R2, as this is dependent on the method used to connect the CTs (E.g. residual connection, core balanced CT connection, etc).

2.12.3 Sensitive Earth Fault Protection

A core balance CT should be applied, with a minimum knee point calculated as described above.

2.12.4 Restricted Earth Fault Protection

High accuracy CTs should be selected with a knee point voltage Vk chosen according to the equation:

$$V_k \geq 2\times V_s$$

where Vs is the differential stability voltage setting for the scheme.

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3. Technical Description

3.1 Hardware Description

3.1.1 Outline of Hardware Modules

The case outline of GRD110 is shown in Appendix F.

The hardware structure of GRD110 is shown in Figure 3.1.1.

The GRD110 relay unit consists of the following hardware modules. These modules are fixed in a frame and cannot be taken off individually. The human machine interface module is provided with the front panel.

- Power module (POWD)
- Signal processing module (SPMD)
- Human machine interface module (HMI)

The hardware block diagram of GRD110 is shown in Figure 3.1.2.

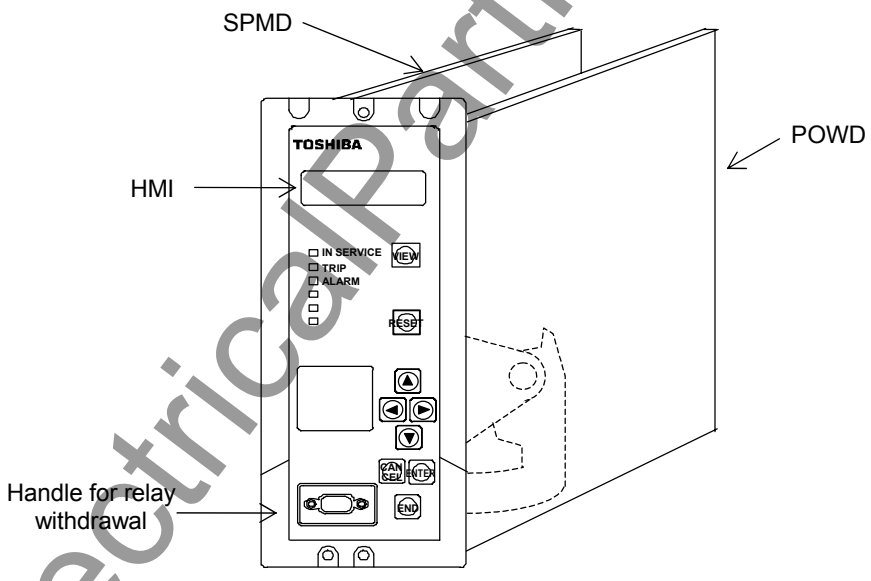

Figure 3.1.1 Hardware Structure without Case

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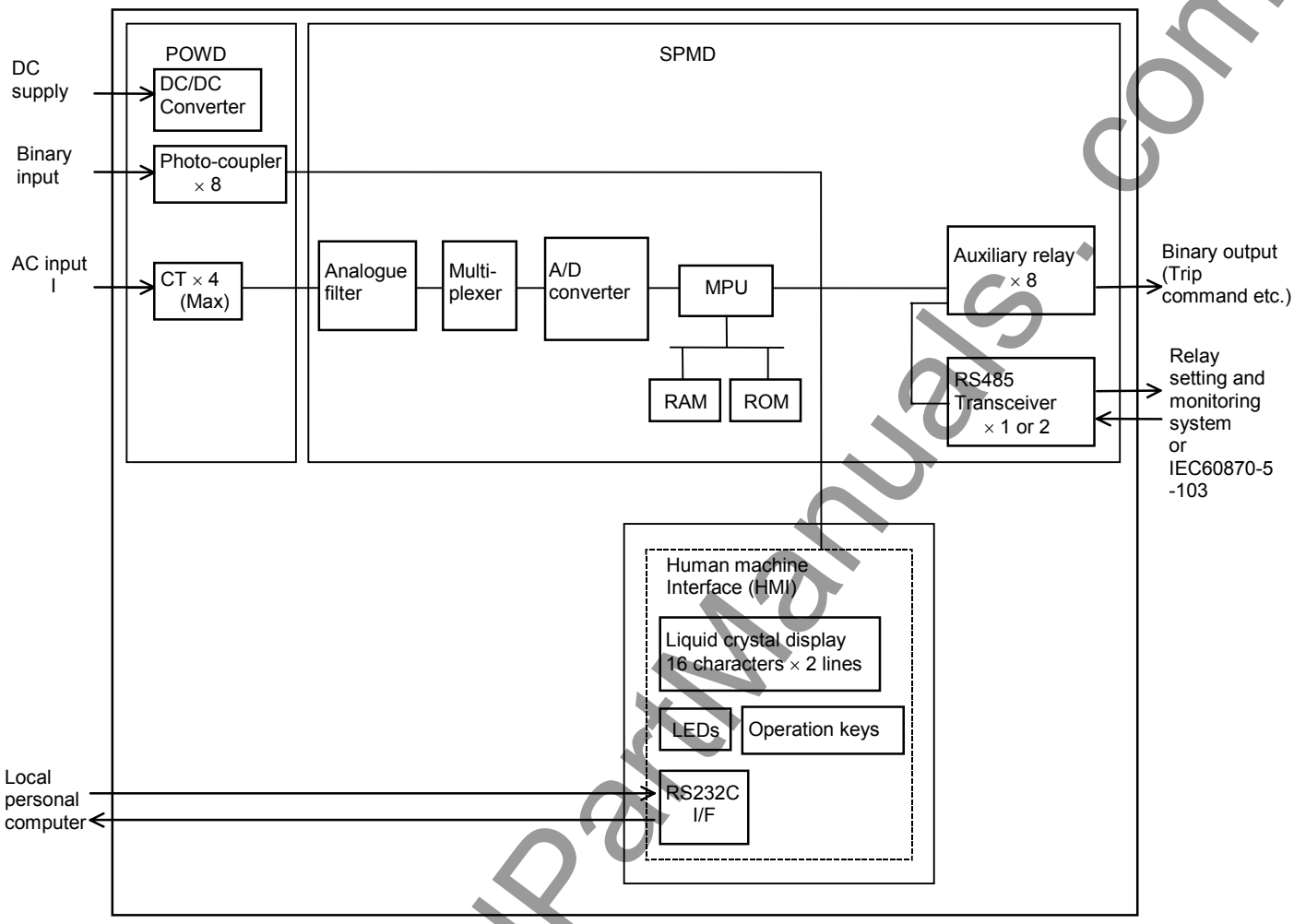

Figure 3.1.2 Hardware Block Diagram

POWD Module

The POWD module insulates between the internal and external circuits through an auxiliary transformer and transforms the magnitude of AC input signals to suit the electronic circuits. The AC input signals may be one to three phase currents and a residual current depending on the relay model.

This module incorporates max. 4 auxiliary CTs, DC/DC converter and photo-coupler circuits for binary input signals.

The available input voltage ratings of the DC/DC converter are, 48V, 110V/125V or 220/250V. The normal range of input voltage is –20% to +20%.

SPMD Module

The SPMD module consists of analogue filter, multiplexer, analogue to digital (A/D) converter, main processing unit (MPU), random access memory (RAM) and read only memory (ROM) and executes all kinds of processing such as protection, measurement, recording and display.

The analogue filter performs low-pass filtering for the corresponding current signals.

The A/D converter has a resolution of 12 bits and samples input signals at sampling frequencies of 2400 Hz (at 50 Hz) and 2880 Hz (at 60 Hz).

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The MPU implements more than 240 MIPS and uses a RISC (Reduced Instruction Set Computer) type 32-bit microprocessors.

The SPMD module also incorporates 8 auxiliary relays (BO1-BO7 and FAIL) for binary output signals and an RS485 transceiver.

BO1 to BO6 are user configurable output signals and have one normally open and one normally closed contact. BO7 is also a user-configurable output signal and has one normally open contact.

The auxiliary relay FAIL has one normally open and one normally closed contacts, and operates when a relay failure or abnormality in the DC circuit is detected.

The RS485 transceiver is used for the link with the relay setting and monitoring (RSM) system or IEC60870-5-103 communication. The external signal is isolated from the relay's internal circuits.

Human Machine Interface (HMI) Module

The operator can access the GRD110 via the human machine interface (HMI) module. As shown in Figure 3.1.3, the HMI panel has a liquid crystal display (LCD), light emitting diodes (LED), view and reset keys, operation keys and an RS232C connector on the front panel.

The LCD consists of 16 columns by 2 rows with a back-light and displays recording, status and setting data.

There are a total of 6 LED indicators and their signal labels and LED colors are defined as follows:

Label	Color	Remarks
IN SERVICE	Green	Lit when the relay is in service and flickered when the relay is in "Test" menu.
TRIP	Red	Lit when a trip command is issued.
ALARM	Red	Lit when a failure is detected.
(LED1)	Yellow	
(LED2)	Yellow	
(LED3)	Yellow	

LED1, LED2 and LED3 are user-configurable. Each is driven via a logic gate which can be programmed for OR gate or AND gate operation. Further, each LED has a programmable reset characteristic, settable for instantaneous drop-off, or for latching operation. A configurable LED can be programmed to indicate the OR combination of a maximum of 4 elements, the individual statuses of which can be viewed on the LCD screen as "Virtual LEDs." For the setting, see Section 4.2.6.10. For the operation, see Section 4.2.1.

The TRIP LED and an operated LED if latching operation is selected, must be reset by user, either by pressing the RESET key, by energising a binary input which has been programmed for 'Remote Reset' operation, or by a communications command. Other LEDs operate as long as a signal is present. The RESET key is ineffective for these LEDs. Further, the TRIP LED is controlled with the scheme switch [AOLED] whether it is lit or not by an output of alarm element such as OC4 ALARM, EF4 ALARM, etc..

The VIEW key starts the LCD indication and switches between windows. The RESET key clears the LCD indication and turns off the LCD back-light.

The operation keys are used to display the record, status and setting data on the LCD, input the settings or change the settings.

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The RS232C connector is a 9-way D-type connector for serial RS232C connection. This connector is used for connection with a local personal computer.

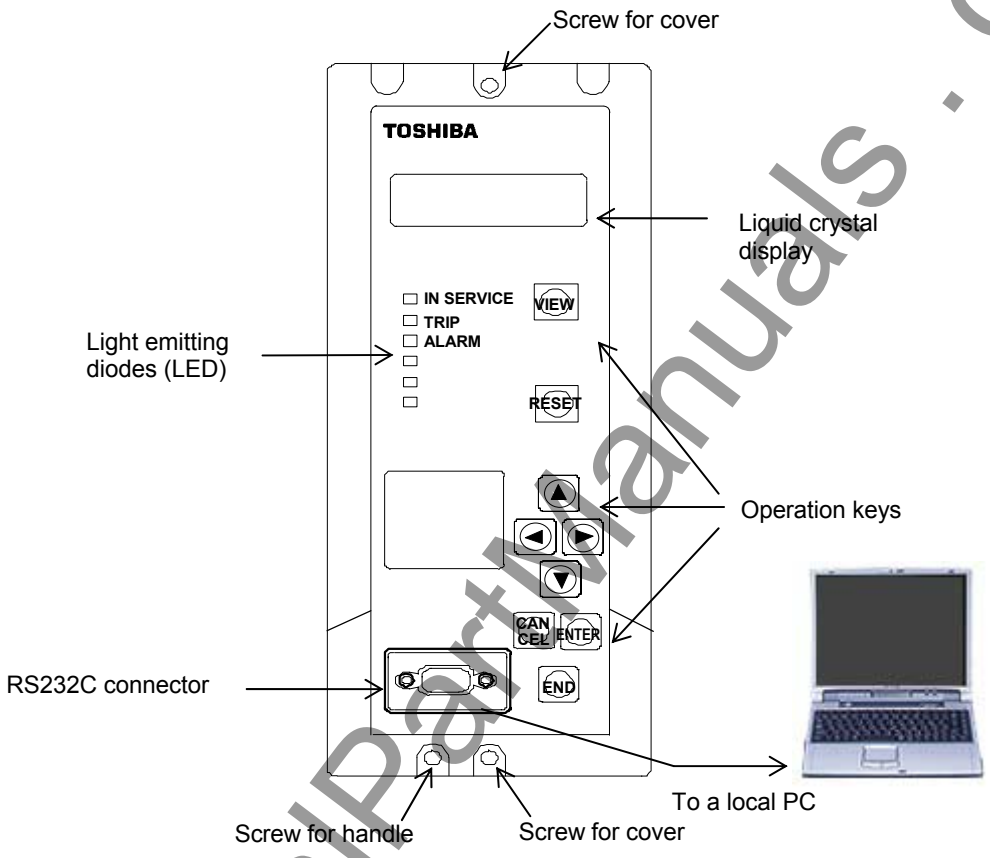

Figure 3.1.3 Front Panel

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3.2 Input and Output Signals

3.2.1 AC Input Signals

Table 3.2.1 shows the AC input signals necessary for the GRD110 model and their respective input terminal numbers. Model 400 and 420 depend on their scheme switch [APPL] setting.

Table 3.2.1 AC Input Signals

: Scheme switch [APPL] setting

Term. No. of TB1	Model						
	110	400	400	400	420	420	420
		3P	2P	1P	3P	2P	1P
1-2	---	A phase current	A phase current	---	A phase current	A phase current	---
3-4	---	B phase current	C phase current	---	B phase current	C phase current	---
5-6	Residual current (E)	C phase current	Residual current (E)	Residual current (E)	C phase current	Residual current (E)	Residual current (E)
7-8	Zero sequence current (SE)	Residual current (E)	---	---	Zero sequence current (SE)	Zero sequence current (SE)	Zero sequence current (SE)

3.2.2 Binary Input Signals

The GRD110 provides eight programmable binary input circuits. Each binary input circuit is programmable, and provided with the function of Logic level inversion and Function selection.

Logic level inversion

The binary input circuit of the GRD110 is provided with a logic level inversion function and a pick-up and drop-off delay timer function as shown in Figure 3.2.1. Each input circuit has a binary switch BISNS which can be used to select either normal or inverted operation. This allows the inputs to be driven either by normally open or normally closed contacts. Where the driving contact meets the contact conditions then the BISNS can be set to "Norm" (normal). If not, then "Inv" (inverted) should be selected. The pick-up and drop-off delay times can be set 0.0 to 300.00s respectively.

Logic level inversion function, and pick-up and drop-off delay timer settings are as follow:

Element	Contents	Range	Step	Default
BI1SNS - BI8SNS	Binary switch	Norm/ Inv		Norm
BI1PUD - BI8PUD	Delayed pick-up timer	0.00 - 300.00s	0.01s	0.00
BI1DOD - BI8DOD	Delayed drop-off timer	0.00 - 300.00s	0.01s	0.00

The operating voltage of binary input signal is typical 74V DC at 110V/125V DC rating and 138V DC at 220/250V DC. The minimum operating voltage is 70V DC at 110/125V DC rating and 125V DC at 220/250V DC.

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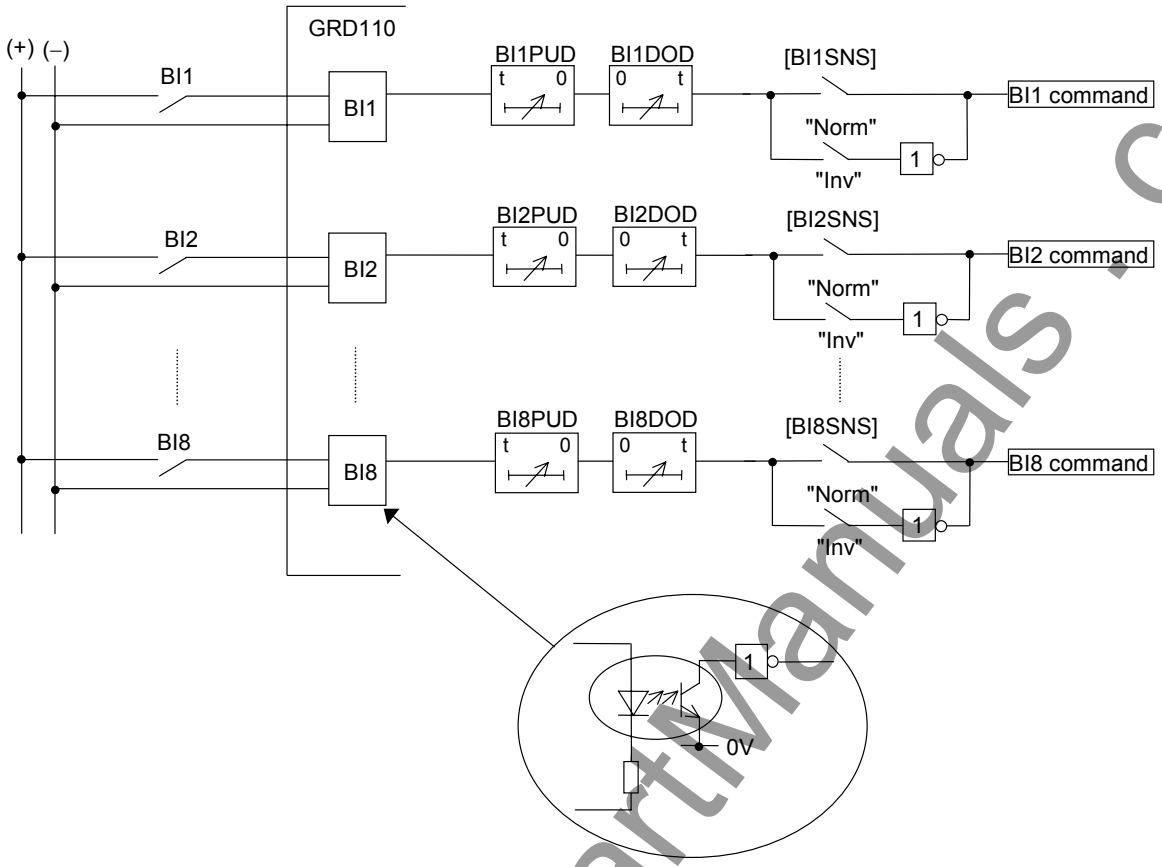

3.2.1 Logic Level Inversion

Function selection

The input signals BI1 COMMAND to BI8 COMMAND are used for the functions listed in Table 3.2.2. Each input signal can be allocated for one or some of those functions by setting. For the setting, refer to Section 4.2.6.8.

The Table also shows the signal name corresponding to each function used in the scheme logic and LCD indication and driving contact condition required for each function.

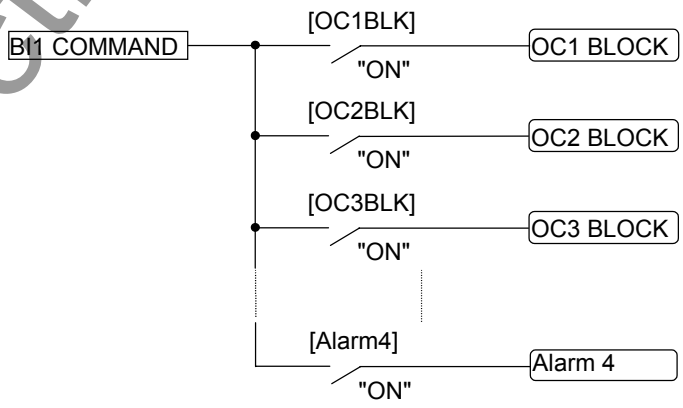

Figure 3.2.2 Function Scheme Logic

The logic of BI2 COMMAND to BI8 COMMAND are the same as that of BI1 COMMAND as shown in Figure 3.2.2.

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Table 3.2.2 Function of Binary Input Signals

Functions	Signal Names (*1)	Driving Contact Condition
OC1 protection block	OC1 BLOCK / OC1BLK	Closed to block
OC2 protection block	OC2 BLOCK / OC2BLK	Closed to block
OC3 protection block	OC3 BLOCK / OC3BLK	Closed to block
OC4 protection block	OC4 BLOCK / OC4BLK	Closed to block
EF1 protection block	EF1 BLOCK / EF1BLK	Closed to block
EF2 protection block	EF2 BLOCK / EF2BLK	Closed to block
EF3 protection block	EF3 BLOCK / EF3BLK	Closed to block
EF4 protection block	EF4 BLOCK / EF4BLK	Closed to block
SEF1 protection block	SEF1 BLOCK / SEF1BLK	Closed to block
SEF2 protection block	SEF2 BLOCK / SEF2BLK	Closed to block
SEF3 protection block	SEF3 BLOCK / SEF3BLK	Closed to block
SEF4 protection block	SEF4 BLOCK / SEF4BLK	Closed to block
Undercurrent protection block	UC BLOCK / UCBLK	Closed to block
Thermal overload protection block	THM BLOCK / THMBLK	Closed to block
Negative sequence OC Broken conductor protection block	NPS BLOCK / NPSBLK	Closed to block
Broken conductor protection	BCD BLOCK / BCDBLK	Closed to block
Trip circuit supervision	TC FAIL / TCFALM	Trip supply
State transition for cold load protection, trip supervision and CB monitoring	CB CONT OPN / CBOPN	CB normally open contact
CB monitoring	CB CONT CLS / CBCLS	CB normally closed contact.
Breaker failure protection initiate	EXT TRIP3PH / EXT3PH	External trip - 3 phase.
Breaker failure protection initiate	EXT TRIP-APH / EXTAPH	External trip - A phase.
Breaker failure protection initiate	EXT TRIP-BPH / EXTBPH	External trip - B phase
Breaker failure protection initiate	EXT TRIP-CPH / EXTCPH	External trip - C phase
Indication remote reset	REMOTE RESET / RMTRST	Closed to reset TRIP LED indication and latch of binary output relays
Disturbance record store	STORE RECORD / STORCD	Closed to store the record
Alarm 1	Alarm 1 / Alarm1	Closed to display Alarm 1 text.
Alarm 2	Alarm 2 / Alarm2	Closed to display Alarm 2 text.
Alarm 3	Alarm 3 / Alarm3	Closed to display Alarm 3 text.
Alarm 4	Alarm 4 / Alarm4	Closed to display Alarm 4 text.

(*1) : Signal names are those used in the scheme logic / LCD indication.

The binary input signals can be programmed to switch between four settings groups.

Element	Contents	Range	Step	Default
BI1SGS – BI8SGS	Setting group selection	OFF / 1 / 2 / 3 / 4		OFF

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Four alarm messages can be set. The user can define a text message within 16 characters for each alarm. The messages are valid for any of the input signals BI1 to BI8 by setting. Then when inputs associated with that alarm are raised, the defined text is displayed on the LCD.

3.2.3 Binary Output Signals

The number of binary output signals and their output terminals are as shown in Appendix G. All outputs, except the relay failure signal, can be configured.

The signals shown in the signal list in Appendix B can be assigned to the output relays BO1 to BO7 individually or in arbitrary combinations. Signals can be combined using either an AND circuit or OR circuit with 4 gates each as shown in Figure 3.2.3. The output circuit can be configured according to the setting menu. Appendix H shows the factory default settings.

Further, each BO has a programmable reset characteristic, settable for instantaneous drop-off "Inst", for delayed drop-off "Dl", for dwell operation "Dw" or for latching operation "Latch" by the scheme switch [RESET]. The time of the delayed drop-off "Dl" or dwell operation "Dw" can be set by TBO. When "Dw" selected, the BO outputs for the TBO set time if the input signal does not continue on the TBO set time. If the input signal continues more, the BO output is continuous for the input signal time.

The relay failure contact closes when a relay defect or abnormality in the DC power supply circuit is detected.

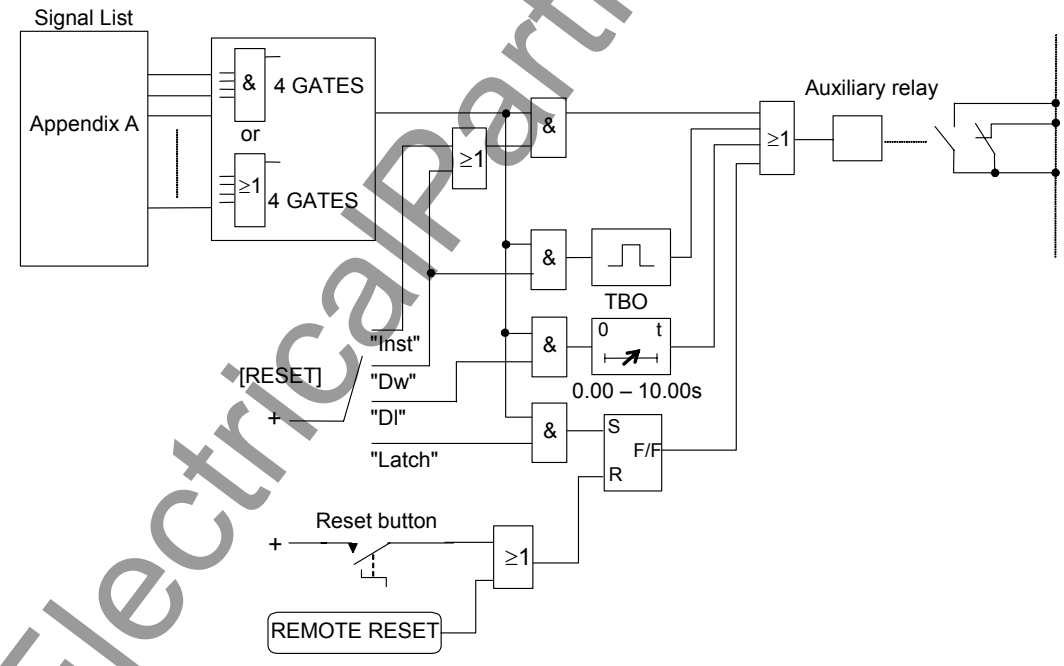

Figure 3.2.3 Configurable Output

Settings

The setting elements necessary for binary output relays and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
[RESET]	Inst / Dl / Dw /Latch		See Appendix C	Output relay reset time. Instantaneous, delayed, dwell or latched.
TBO	0.00 – 10.00s	0.01s	See Appendix C	

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3.3 Automatic Supervision

3.3.1 Basic Concept of Supervision

Though the protection system is in a non-operating state under normal conditions, it waits for a power system fault to occur at any time, and must operate for the fault without fail. Therefore, the automatic supervision function, which checks the health of the protection system during normal operation, plays an important role. The GRD110 implements an automatic supervision function, based on the following concepts:

- The supervising function should not affect the protection performance.
- Perform supervision with no omissions wherever possible.
- When a failure occurs, the user should be able to easily identify the location of the failure.

3.3.2 Relay Monitoring

The relay is supervised by the following functions.

AC input imbalance monitoring

This monitoring is provided for models 400 and 420 and is available only for [APPL] = "3P" setting.

The AC current input is monitored to check that the following equation is satisfied and the health of the AC input circuit is verified.

- CT circuit current monitoring

  $\text{Max}(|I_a|, |I_b|, |I_c|) - 4 \times \text{Min}(|I_a|, |I_b|, |I_c|) \geq k_0$

  where,

  $\text{Max}(|I_a|, |I_b|, |I_c|)$ = Maximum amplitude among I_a, I_b and I_c

  $\text{Min}(|I_a|, |I_b|, |I_c|)$ = Minimum amplitude among I_a, I_b and I_c

  k_0 = 20% of rated current

The CT circuit current monitoring allows high sensitivity detection of failures that have occurred in the AC input circuit. If the imbalance detected, the relay issues an alarm shown in Table 3.3.1.

A/D accuracy checking

An analog reference voltage is input to a prescribed channel in the analog-to-digital (A/D) converter, and it is checked that the data after A/D conversion is within a prescribed range, and that the A/D conversion characteristics are correct.

Memory monitoring

Memory is monitored as follows, depending on the type of memory, and checks are done to verify that memory circuits are healthy:

- Random access memory monitoring: Writes/reads prescribed data and checks the storage function.
- Program memory monitoring: Checks the checksum value of the written data.
- Setting value monitoring: Checks discrepancies between the setting values stored in duplicate.

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Watchdog Timer

A hardware timer that is cleared periodically by the software is provided, which checks that the software is running normally.

DC Supply Monitoring

The secondary voltage level of the built-in DC/DC converter is monitored, and is checked to see that the DC voltage is within a prescribed range.

The alarms are issued when the failure continues for a predetermined time. The times for each monitoring item are as follows;

- A/D accuracy checking, memory monitoring, Watch Dog Timer, DC supply monitoring: less than 1s
- AC input imbalance monitoring, sampling synchronization monitoring : 15s

3.3.3 Trip Circuit Supervision

The circuit breaker tripping control circuit can be monitored by a binary input. Figure 3.3.1 shows a typical scheme. When the trip circuit is complete, a small current flows through the binary input, the circuit breaker auxiliary contacts and the trip coil. This current flows for both the breaker open and closed conditions. Then logic signal of the binary input circuit TC FAIL is "1".

If the trip supply is lost or if a connection becomes an open circuit, then the binary input resets and TC FAIL is "0". Figure 3.3.2 shows the scheme logic. A trip circuit fail alarm TCSV is output when TC FAIL is "0".

The monitoring is enabled by setting the scheme switch [TCSPEN] to "ON" or "OPT-ON". When "OPT-ON" is selected, the monitoring is enabled only while CB is closed.

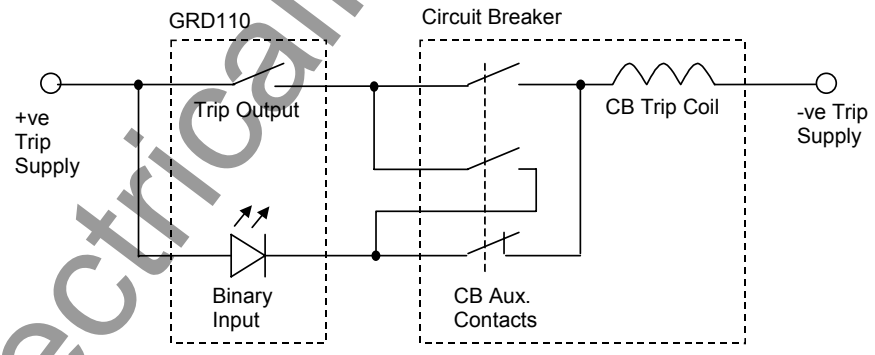

Figure 3.3.1 Trip Circuit Supervision

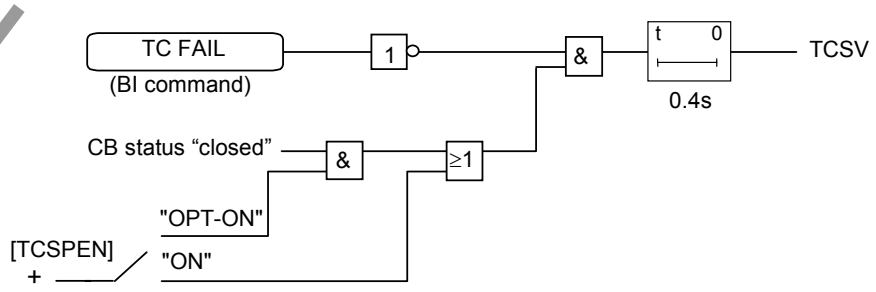

Figure 3.3.2 Supervision Scheme Logic

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3.3.4 Circuit Breaker Monitoring

The relay provides the following circuit breaker monitoring functions.

Circuit Breaker State Monitoring

Circuit breaker state monitoring is provided for checking healthy of circuit breaker (CB). If two binary inputs are programmed to the functions 'CB CONT OPN'(CBOPN) and 'CB CONT CLS'(CBCLS), then the CB state monitoring function becomes active. In normal circumstances these inputs are in opposite states. Figure 3.3.3 shows the scheme logic. If both show the same state during five seconds, then a CB state alarm CBSV outputs and "Err:CB" and "CB err" are displayed in LCD message and event record message respectively.

The monitoring can be enabled or disabled by setting the scheme switch [CBSMEN].

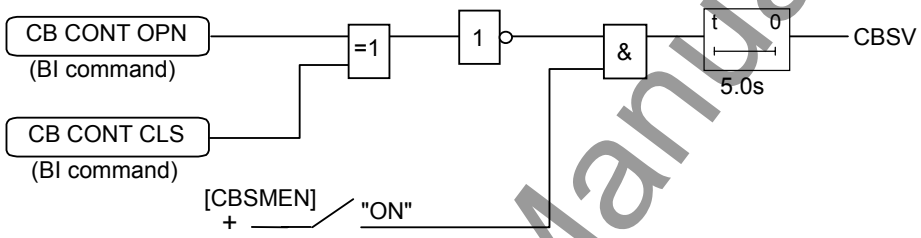

Figure 3.3.3 CB State Monitoring Scheme Logic

Normally open and normally closed contacts of the CB are connected to binary inputs BIm and BIn respectively, and functions of BIm and BIn are set to "CBOPN=ON" and "CBCLS=ON". (Refer to Section 4.2.6.8.)

Circuit Breaker Condition Monitoring

Periodic maintenance of CB is required for checking healthy of the trip circuit, the operation mechanism and the interrupting capability. Generally, maintenance is based on a time interval or a number of fault current interruptions.

The following CB condition monitoring functions are provided to determine time for maintenance of CB:

- Trip is counted for maintenance of the trip circuit and CB operation mechanism. The trip counter increments the number of tripping operations performed. An alarm is issued and informs user of time for maintenance when the count exceeds a user-defined setting TCALM. The trip count alarm can be enabled or disabled by setting the scheme switch [TCAEN].
- Sum of the broken current quantity $\sum I^y$ is counted for monitoring the interrupting capability of CB. The $\sum I^y$ counter increments the value of current to the power 'y', recorded at the time of issue of the tripping signal, on a phase by phase basis. For oil circuit breakers, the dielectric withstand of the oil generally decreases as a function of $\sum I^2t$, and maintenance such as oil changes, etc., may be required. 'I' is the fault current broken by CB. 't' is the arcing time within the interrupter tank and it cannot be determined accurately. Therefore, 'y' is normally set to 2 to monitor the broken current squared. For other circuit breaker types, especially those for HV systems, 'y' may be set lower, typically 1.0. An alarm is issued when the count for any phase exceeds a user-defined setting $\sum I^y$ALM. This feature is not available in GRD110-110. The $\sum I^y$ count alarm can be enabled or disabled by setting the scheme switch [$\sum I^y$AEN].
- Operating time monitoring is provided for CB mechanism maintenance. It checks CB operating time and the need for mechanism maintenance is informed if the CB operation is slow. The operating time monitor records the time between issuing the tripping signal and the phase currents falling to zero. An alarm is issued when the operating time for any phase

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exceeds a user-defined setting OPTALM. The operating time is set in relation to the specified interrupting time of the CB. The operating time alarm can be enabled or disabled by setting the scheme switch [OPTAEN].

For maintenance program, it should be complied with the switchgear manufacturer's instructions.

The CB condition monitoring functions are triggered each time a trip is issued, and they can also be triggered by an external device via binary input EXT TRIP3PH (EXT3PH) or EXT TRIP∗PH (EXT∗PH) as shown in Figure 3.3.4. (Refer to Section 4.2.6.8.)

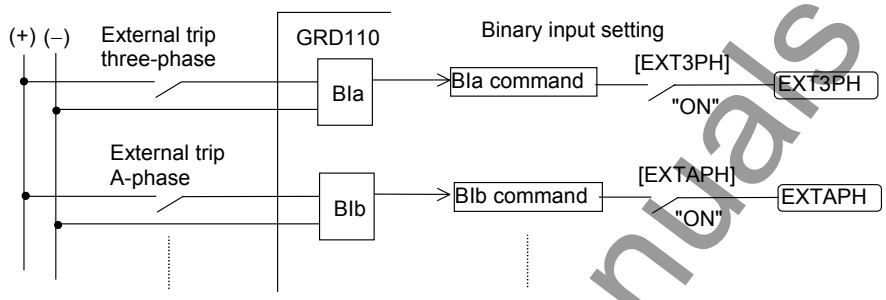

Figure 3.3.4 Binary Input Setting for CB Condition Monitoring

3.3.5 Failure Alarms

When a failure is detected by the automatic supervision, it is followed with an LCD message, LED indication, external alarm and event recording. Table 3.3.1 summarizes the supervision items and alarms.

The LCD messages are shown on the "Auto-supervision" screen, which is displayed automatically when a failure is detected or displayed by pressing the VIEW key. The event record messages are shown on the "Event record" screen by opening the "Record" sub-menu.

The alarms are retained until the failure is recovered.

The alarms can be disabled collectively by setting the scheme switch [AMF] to "OFF". The setting is used to block unnecessary alarms during commissioning, test or maintenance.

When the Watchdog Timer detects that the software is not running normally, LCD display and event recording of the failure may not function normally.

Table 3.3.1 Supervision Items and Alarms

Supervision Item	LCD Message	LED "IN SERVICE"	LED "ALARM"	External alarm	Event record Message
AC input imbalance monitoring	Err: CT	On/Off (2)	On	(4)	CT err Relay fail or Relay fail-A (2)
A/D accuracy check	(1)	Off	On	(4)	Relay fail
Memory monitoring					
Watchdog Timer	----	Off	On	(4)	----
DC supply monitoring	Err: DC	Off	(3)	Off	Relay fail-A
Trip circuit supervision	Err:TC	On	On	Off	TC err, Relay fail-A
CB state monitoring	Err:CB	On	On	Off	CB err, Relay fail-A
CB condition monitoring Trip count alarm	ALM:TP COUNT	On	On	Off	TP COUNT ALM, Relay fail-A

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Supervision Item	LCD Message	LED "IN SERVICE"	LED "ALARM"	External alarm	Event record Message
Operating time alarm	ALM: OP time	On	On	Off	OP time ALM, Relay fail-A
∑I^y count alarm	ALM:∑IY	On	On	Off	∑IY-A ALM, ∑IY-B ALM or ∑IY-C ALM, Relay fail-A

(1): Diverse messages are provided as expressed with " Err:---" in the table in Section 6.7.2.
(2): The LED is on when the scheme switch [SVCNT] is set to "ALM" and off when set to "ALM & BLK" (refer to Section 3.3.6). The message "Relay fail-A" is recorded when the scheme switch [SVCNT] is set to "ALM".
(3): Whether the LED is lit or not depends on the degree of the voltage drop.
(4): The binary output relay "FAIL" operates except for DC supply fail condition.

3.3.6 Trip Blocking

When a failure is detected by the following supervision items, the trip function is blocked as long as the failure exists, and is restored when the failure is removed.

- A/D accuracy check
- Memory monitoring
- Watchdog Timer

When a fault is detected by the AC input imbalance monitoring, the scheme switch [SVCNT] setting can be used to determine if both tripping is blocked and an alarm is output (ALM&BLK), or if only an alarm is output (ALM).

3.3.7 Setting

The setting element necessary for the automatic supervision and its setting range are shown in the table below.

Element	Range	Step	Default	Remarks
[SVCNT]	ALM&BLK / ALM		ALM&BLK	Alarming and blocking or alarming only
[TCSPEN]	OFF/ON/OPT-ON		OFF	Trip circuit supervision
[CBSMEN]	OFF/ON		OFF	CB state monitoring
[TCAEN]	OFF/ON		OFF	Trip count alarm
[∑I^yAEN]	OFF/ON		OFF	∑I^y count alarm
[OPTAEN]	OFF/ON		OFF	Operate time alarm
TCALM	1 - 10000	1	10000	Trip count alarm threshold setting
∑I^yALM	10 – 10000 E6	E6	10000	∑I^y alarm threshold setting
YVALUE	1.0 – 2.0	0.1	2.0	y value setting
OPTALM	100 – 5000 ms	10 ms	1000 ms	Operate time alarm threshold setting

The scheme switch [SVCNT] is set in the "Application" sub-menu. Other scheme switches are set in the "Scheme sw" sub-menu.

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3.4 Recording Function

The GRD110 is provided with the following recording functions:

Fault recording

Event recording

Disturbance recording

These records are displayed on the LCD of the relay front panel or on the local or remote PC.

3.4.1 Fault Recording

Fault recording is started by a tripping command of the GRD110 and the following items are recorded for one fault:

Date and time

Trip mode

Faulted phase

Power system quantities

Up to the 8 most-recent faults are stored as fault records. If a new fault occurs when 8 faults have been stored, the record of the oldest fault is deleted and the record of the latest fault is then stored.

Date and time occurrence

This is the time at which a tripping command has been initiated.

The time resolution is 1 ms using the relay internal clock.

Trip mode

This shows the protection scheme that output the tripping command.

Faulted phase

This is the phase to which a operating command is output.

Power system quantities

The following power system quantities in pre-faults and post-faults are recorded.

- Magnitude of phase current (I_a, I_b, I_c)
- Magnitude of zero sequence current (I_e, I_{se})
- Magnitude of positive and negative sequence currents (I_1, I_2)
- The ratio of negative to positive sequence current (I_2/I_1)
- Percentage of thermal capacity (THM%)

The displayed power system quantities depend on relay model and its [APPL] setting as shown in Table 3.4.1.

The zero sequence current I_e in "3P" setting of the model 420 is calculated from the three phase input currents and the calculated I_e (I_0) is displayed. The I_e in other settings and models is displayed the current fed from CT.

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Table 3.4.1 Displayed Power System Quantities

Power system quantities	Model 100	Model 400			Model 420		
		3P	2P	1P	3P	2P	1P
Phase current	—	I_a, I_b, I_c	I_a, I_c	—	I_a, I_b, I_c	I_a, I_c	—
Zero sequence current	I_e, I_{se}	I_e	I_e	I_e	I_e, I_{se}	I_e, I_{se}	I_e, I_{se}
Positive and negative sequence current	—	I_1, I_2	—	—	I_1, I_2	—	—
Ratio of Negative to positive sequence current	—	I_2 / I_1	—	—	I_2 / I_1	—	—
Percentage of thermal capacity	—	THM	THM	—	THM	THM	—

3.4.2 Event Recording

The events shown in Appendix C are recorded with the 1 ms resolution time-tag when the status changes. For BI1 to BI8 command, the user can select the recording items and their status change mode to initiate recording as below.

One of the following four modes is selectable.

Modes	Setting
Not to record the event.	N
To record the event when the status changes to "operate".	O
To record the event when the status changes to "reset".	R
To record the event when the status changes both to "operate" and "reset".	B

For the setting, see the Section 4.2.6.5. The default setting is "B"

Up to 480 records can be stored. If an additional event occurs when 480 records have been stored, the oldest event record is deleted and the latest event record is then stored.

3.4.3 Disturbance Recording

Disturbance recording is started when the overcurrent starter element operates or a tripping command is initiated. The records include maximum four analogue signals (I_a, I_b, I_c, I_e), 32 binary signals and the dates and times at which recording started. Any binary signal shown in Appendix B can be assigned by the binary signal setting of disturbance record.

The LCD display only shows the dates and times of disturbance records stored. Details can be displayed on a PC. For how to obtain disturbance records on the PC, see the PC software instruction manual.

The pre-fault recording time is fixed at 0.3s and post-fault recording time can be set between 0.1 and 3.0s.

The number of records stored depends on the post-fault recording time. The approximate relationship between the post-fault recording time and the number of records stored is shown in Table 3.4.2.

Note: If the recording time setting is changed, the records stored so far are deleted.

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Table 3.4.2 Post Fault Recording Time and Number of Disturbance Records Stored

Recording time	0.1s	0.5s	1.0s	1.5s	2.0s	2.5s	3.0s
50Hz	40	25	15	10	9	7	6
60Hz	40	20	10	9	7	6	5

Settings

The elements necessary for initiating a disturbance recording and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
OC	0.5-250.0 A	0.1 A	10.0 A	Overcurrent detection
	(0.10-50.00 A	0.01 A	2.00 A) (*)	
EF	0.5-125.0 A	0.1 A	3.0 A	Earth fault detection
	(0.10-25.00 A	0.01 A	0.60A)	
SE	0.02-5.00 A	0.01 A	1.00 A	Sensitive earth fault detection
	(0.004-1.000 A	0.001 A	0.200 A)	
NPS	0.5-10.0 A	0.1 A	2.0 A	Negative sequence overcurrent detection
	(0.10-2.00 A	0.01 A	0.40 A)	

(*) Current values shown in the parentheses are for the case of a 1A rating. Other current values are for the case of a 5A rating.

Starting the disturbance recording by a tripping command or the starter element listed above is enabled or disabled by setting the following scheme switches.

Element	Range	Step	Default	Remarks
[Trip]	OFF/ON		ON	Start by tripping command
[BI]	OFF/ON		ON	Start by Binary Input signal
[OC]	OFF/ON		ON	Start by OC operation
[EF]	OFF/ON		ON	Start by EF operation
[SEF]	OFF/ON		ON	Start by SEF operation
[NPS]	OFF/ON		ON	Start by NPS operation

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3.5 Metering Function

The GRD110 performs continuous measurement of the analogue input quantities. The measurement data shown below is renewed every second and displayed on the LCD of the relay front panel or on the local or remote PC.

- Magnitude of phase current (I_a, I_b, I_c)
- Magnitude of zero sequence current (I_e, I_{se})
- Magnitude of positive and negative sequence currents (I_1, I_2)
- The ratio of negative to positive sequence current (I_2/I_1)
- Percentage of thermal capacity (THM%)
- Maximum phase current ($I_a$max, $I_b$max, $I_c$max)
- Maximum zero sequence current ($I_e$max, I_{se}max)
- Maximum negative sequence currents (I_2max)
- Maximum ratio of negative to positive sequence current (I_{21} max)

The above system quantities are displayed in values on the primary side or on the secondary side as determined by a setting. To display accurate values, it is necessary to set the CT ratio as well. For the setting method, see "Setting the metering" in 4.2.6.6 and "Setting the parameter" in 4.2.6.7. In the case of the maximum value displays above, the measured quantity is averaged over a rolling 15 minute time window, and the maximum recorded average value is shown on the display screen.

The displayed power system quantities depend on relay model and its [APPL] setting as shown in Table 3.4.1.

The zero sequence current I_e in “3P” setting of the model 420 is calculated from the three phase input currents and the calculated I_e (I_0) is displayed. The I_e in other settings and models is displayed the current fed from CT.

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4. User Interface

4.1 Outline of User Interface

The user can access the relay from the front or rear panel.

Local communication with the relay is also possible using a personal computer (PC) via an RS232C port. Furthermore, remote communication is also possible using RSM (Relay Setting and Monitoring) or IEC60870-5-103 communication via RS485 port.

This section describes the front panel configuration and the basic configuration of the menu tree of the local human machine communication ports and HMI (Human Machine Interface).

4.1.1 Front Panel

As shown in Figure 3.1.3, the front panel is provided with a liquid crystal display (LCD), light emitting diodes (LED), operation keys, and RS232C connector.

LCD

The LCD screen, provided with a 2-line, 16-character display and back-light, provides the user with information such as records, statuses and settings. The LCD screen is normally unlit, but pressing the [VIEW] key will display the digest screen and pressing any key other than [VIEW] and [RESET] will display the menu screen.

These screens are turned off by pressing the [RESET] key or [END] key. If any display is left for 5 minutes or longer without operation, the back-light will go off.

LED

There are 6 LED displays. The signal labels and LED colors are defined as follows:

Label	Color	Remarks
IN SERVICE	Green	Lit when the relay is in service and flickered when the relay is in “Test” menu.
TRIP	Red	Lit when a trip command is issued.
ALARM	Red	Lit when a failure is detected.
(LED1)	Yellow	
(LED2)	Yellow	
(LED3)	Yellow	

LED1, LED2 and LED3 are configurable. For the setting, see Section 4.2.6.10.

The TRIP LED lights up once the relay is operating and remains lit even after the trip command goes off. The TRIP LED can be turned off by pressing the [RESET] key. Other LEDs are lit as long as a signal is present and the [RESET] key is invalid while the signal is being maintained.

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Operation keys

The operation keys are used to display records, status, and set values on the LCD, as well as to input or change set values. The function of each operation key is as follows:

① ▼, ▲, ◀, ▶: Used to move between lines displayed on a screen and to enter numerical values and text strings.

② [CANCEL]: Used to cancel entries and return to the upper screen.

③ [END]: Used to end the entering operation, return to the upper screen or turn off the display.

④ [ENTER]: Used to store or establish entries.

[VIEW] and [RESET] keys

Pressing [VIEW] key displays digest screens such as "Metering", "Latest fault", "Auto-supervision", "Alarm display" and "Indication".

Pressing [RESET] key turns off the display.

RS232C connector

The RS-232C connector is a 9-way D-type connector for serial RS232C connection with a local personal computer.

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4.1.2 Communication Ports

The following two interfaces are mounted as communication ports:

- RS232C port
- RS485 port

RS232C port

This connector is a standard 9-way D-type connector for serial port RS232C transmission and is mounted on the front panel. By connecting a personal computer to this connector, setting operation and display functions can be performed.

RS485 port

The RS485 port is used for the RSM (Remote Setting and Monitoring system) via the protocol converter G1PR2 and IEC60870-5-103 communication via BCU/RTU (Bay Control Unit / Remote Terminal Unit) to connect between relays and to construct a network communication system. (See Figure 4.4.1 in Section 4.4.)

One or two RS485 ports (COM1 and COM2) is provided on the rear of the relay as shown in Figure 4.1.1. In the relay provided with two RS485 ports, COM1 is used for the RSM or IEC60870-5-103 communication, and COM2 used for IEC60870-5-103 communication. When the COM1 is used for IEC60870-5-103 communication, the COM2 cannot be used for IEC60870-5-103 communication.

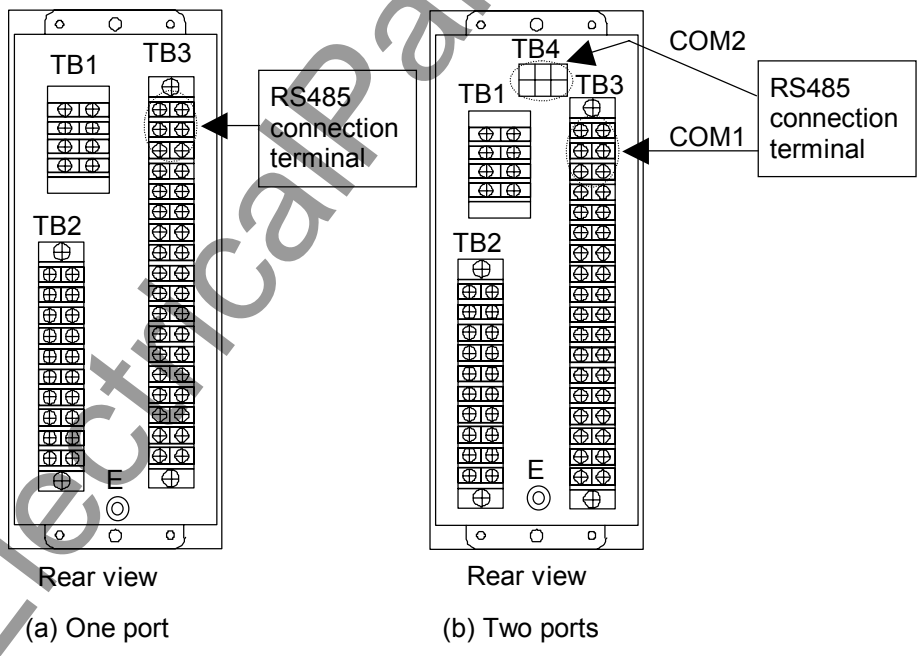

Figure 4.1.1 Location of RS485 Port

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4.2 Operation of the User Interface

The user can access such functions as recording, measurement, relay setting and testing with the LCD display and operation keys.

4.2.1 LCD and LED Displays

Displays during normal operation

When the GRD110 is operating normally, the green "IN SERVICE" LED is lit and the LCD is off.

Press the [VIEW] key when the LCD is off to display the digest screens which are "Indication", "Metering1", "Metering2", "Metering3", "Metering4", "Metering5", "Latest fault", "Auto-supervision" and "Alarm Display" screens in turn. "Latest fault", "Auto-supervision" and "Alarm Display" screens are displayed only when there is some data. The following are the digest screens and can be displayed without entering the menu screens.

Indication

```
IND1 [ 0 0 0 0   0 0 0 0 ]
IND2 [ 0 0 0 1   0 0 0 0 ]
```

Metering1

```
Ia          **.**kA
```

Not available for model 110 and APPL=1P setting in models 400 and 420.

Metering2

```
Ib          **.**kA
```

Not available for models 110, and APPL=1P and 2P settings in models 400 and 420.

Metering3

```
Ic          **.**kA
```

Not available for model 110 and APPL=1P setting in models 400 and 420.

Metering4

```
Ie          **.**kA
```

Metering5

```
Ise         **.***kA
```

Not available for models 400.

To clear the latched indications (latched LEDs, LCD screen of Latest fault), press [RESET] key for 3 seconds or more.

For any display, the back-light is automatically turned off after five minutes.

Indication

This screen shows the status of elements assigned as a virtual LED.

```
IND1 [ 0 0 0 0   0 0 0 0 ]
IND2 [ 0 0 0 1   0 0 0 0 ]
```

Status of element,
Elements depend on user setting. 1: Operate, 0: Not operate (Reset)

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Displays in tripping

Latest fault

```
Phase   A B C E
OC1
```

: Faulted phases. Not displayed for model 110
: Tripping element

If a fault occurs and a tripping command is output when the LCD is off, the red "TRIP" LED and other configurable LED if signals assigned to trigger by tripping

Press the [VIEW] key to scroll the LCD screen to read the rest of messages.

Press the [RESET] key to turn off the LEDs and LCD display.

Notes:

1) When configurable LEDs (LED1 through LED3) are assigned to latch signals by trigger of tripping, press the [RESET] key more than 3s until the LCD screens relight. Confirm turning off the configurable LEDs. Refer to Table 4.2.1 Step 1.
2) Then, press the [RESET] key again on the "Latest fault" screen in short period, confirm turning off the "TRIP" LED. Refer to Table 4.2.1 Step 2.
3) When only the "TRIP" LED is go off by pressing the [RESET] key in short period, press the [RESET] key again to reset remained LEDs in the manner 1) on the "Latest fault" screen or other digest screens. LED1 through LED3 will remain lit in case the assigned signals are still active state.

Table 4.2.1 Turning off latch LED operation

	Operation	LED lighting status	
		"TRIP" LED	Configurable LED (LED1 – LED3)
Step 1	Press the [RESET] key more than 3s on the "Latest fault" screen	continue to lit	turn off
Step 2	Then, press the [RESET] key in short period on the "Latest fault" screen	turn off	

When any of the menu screens is displayed, the [VIEW] and [RESET] keys do not function.

To return from menu screen to the digest "Latest fault" screen, do the following:

- Return to the top screen of the menu by repeatedly pressing the [END] key.
- Press the [END] key to turn off the LCD.
- Press the [VIEW] key to display the digest "Latest fault" screen.

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Displays in automatic supervision operation

Auto-supervision

```
Err:ROM,A/D
```

If the automatic supervision function detects a failure while the LCD is off, the "Auto-supervision" screen is displayed automatically, showing the location of the failure, and the "ALARM" LED lights.

Press the [VIEW] key to display other digest screens in turn including the "Metering" and "Latest fault" screens.

Press the [RESET] key to turn off the LEDs and LCD display. However, if the failure continues, the "ALARM" LED remains lit.

After recovery from a failure, the "ALARM" LED and "Auto-supervision" display turn off automatically.

If a failure is detected while any of the screens is displayed, the current screen remains displayed and the "ALARM" LED lights.

Notes:

1) When configurable LEDs (LED1 through LED3) are assigned to latch signals by issuing an alarm, press the [RESET] key more than 3s until all LEDs reset except "IN SERVICE" LED.
2) When configurable LED is still lit by pressing [RESET] key in short period, press [RESET] key again to reset remained LED in the above manner.
3) LED1 through LED3 will remain lit in case the assigned signals are still active state.

While any of the menu screens is displayed, the [VIEW] and [RESET] keys do not function. To return to the digest "Auto-supervision" screen, do the following:

- Return to the top screen of the menu by repeatedly pressing the [END] key.
- Press the [END] key to turn off the LCD.
- Press the [VIEW] key to display the digest screen.
- Press the [RESET] key to turn off the LCD.

Alarm Display

Alarm Display (ALM1 to ALM4)

```
**********
********  :ALM1
```

The four alarm screens can be provided, and their text messages are defined by user. (For setting, see Section 4.2.6.8) These alarms are raised by associated binary inputs.

Press the [VIEW] key to display other digest screens in turn including the "Metering" and "Latest fault" screens.

To clear the Alarm Display, press [RESET] key. The clearing is available after displaying up to ALM4.

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4.2.2 Relay Menu

Figure 4.2.1 shows the menu hierarchy in the GRD110. The menu has five sub-menus, "Record", "Status", "Set. (view)", "Set. (change)", and "Test". For details of the menu hierarchy, see Appendix E.

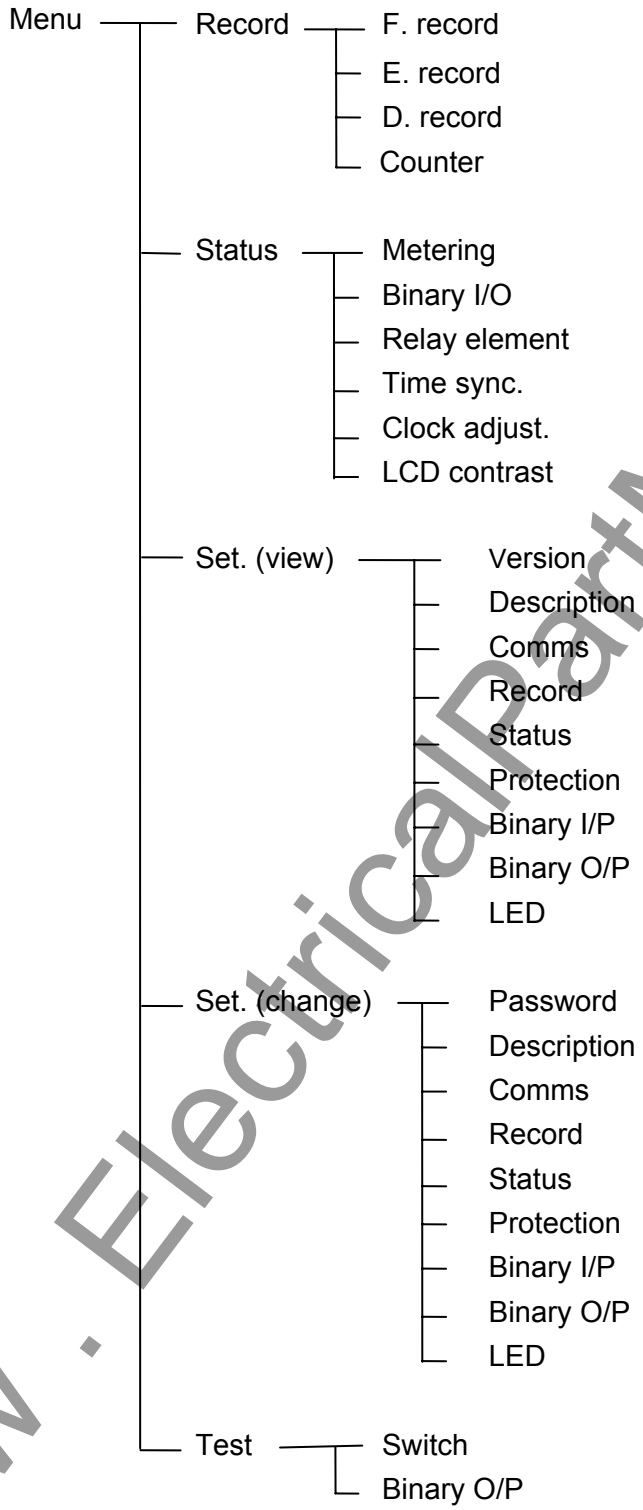

Figure 4.2.1 Relay Menu

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Record

In the "Record" menu, the fault records event records, disturbance records and counts such as trip count and ΣIy count can be displayed or erased.

Status

The "Status" menu displays the power system quantities, binary input and output status, relay measuring element status, signal source for time synchronisation (BI or RSM), adjusts a clock and LCD contrast.

Set. (view)

The "Set. (view)" menu displays the relay version, description, relay address and baud rate in RSM, the current settings of record, status, protection, binary inputs, configurable binary outputs and configurable LEDs.

Set. (change)

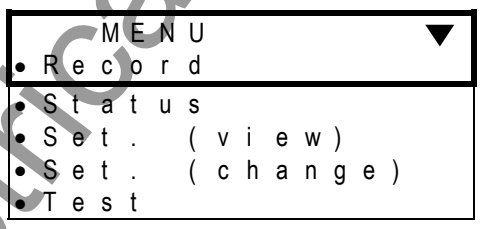
The "Set. (change)" menu is used to change the settings of password, description, relay address and baud rate in RSM or IEC60870-5-103 communication, record, status, protection, binary inputs, configurable binary outputs and configurable LEDs.

Since this is an important menu and is used to change settings related to relay tripping, it has password security protection.

Test

The "Test" menu is used to set testing switches and to forcibly operate binary output relays.

When the LCD is off, press any key other than the [VIEW] and [RESET] keys to display the top "MENU" screen and then proceed to the relay menus.

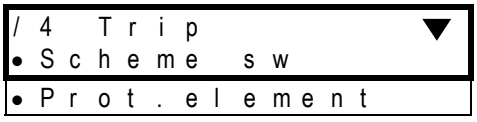


To display the "MENU" screen when the digest screen is displayed, press the [RESET] key to turn off the LCD, then press any key other than the [VIEW] and [RESET] keys.

Press the [END] key when the top screen is displayed to turn off the LCD.

An example of the sub-menu screen is shown below. The top line shows the hierarchical layer. The last item is not displayed for all the screens. "▼" or "▲" displayed on the far right shows that lower or upper lines exist.

To move the cursor downward or upward for setting or for viewing other lines not displayed on the window, use the ▼ and ▲ keys.



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To return to the higher screen or move from the right side screen to the left side screen in Appendix E, press the END key.

The CANCEL key can also be used to return to the higher screen but it must be used carefully because it may cancel entries made so far.

To move between screens of the same hierarchical depth, first return to the higher screen and then move to the lower screen.

4.2.3 Displaying Records

The sub-menu of "Record" is used to display fault records, event records, disturbance records and counts such as trip count and ΣIy count.

4.2.3.1 Displaying Fault Records

To display fault records, do the following:

- Open the top "MENU" screen by pressing any keys other than the VIEW and RESET keys.
- Select "Record" to display the "Record" sub-menu.

```
/ 1   Record                ▼
• F. record
• E. record
• D. record
• Counter
```

- Select "F. record" to display the "F. record" screen.

```
/ 2   F. record             ▼
• Display
• Clear
```

- Select "Display" to display the dates and times of fault records stored in the relay from the top in new-to-old sequence.

```
/ 3   F. record             ▼

# 1   16/Jul/2001
      18:13:57.031
# 2   20/May/2001
      15:29:22.101
# 3   04/Feb/2001
      11:54:53.299
# 4   28/Jan/2001
      07:30:18.412
```

- Move the cursor to the fault record line to be displayed using the ▲ and ▼ keys and press the ENTER key to display the details of the fault record.

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/4 F.record #1 ▼	
16/Jul/2001	
18:13:57.031	
OC1	Trip element
Phase ABC	Not available for model 110.
Prefault values	
Ia ***.***kA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ib ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
Ic ***.***kA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ie ***.***kA	
Ise **.****kA	Not available for models 400.
I1 ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2 ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2/I1 ***.**	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
Fault values	
Ia ***.***kA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ib ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
Ic ***.***kA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ie ***.***kA	
Ise **.****kA	Not available for models 400.
I1 ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2 ***.***kA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2/I1 ***.**	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
THM ****.*%	Not available for model 110 and APPL=1P setting in models 400 and 420.

The lines which are not displayed in the window can be displayed by pressing the ▲ and ▼ keys.

To clear all the fault records, do the following:

- Open the "Record" sub-menu.
- Select "F. record" to display the "F. record" screen.
- Select "Clear" to display the following confirmation screen.

```
Clear records?
END=Y    CANCEL=N
```

- Press the END (= Y) key to clear all the fault records stored in non-volatile memory.

If all fault records have been cleared, the "Latest fault" screen of the digest screens is not displayed.

Note: When changing the units (kA/A) of primary side current with RSM100, press the "Units" button which is indicated in the primary side screen.

4.2.3.2 Displaying Event Records

To display event records, do the following:

- Open the top "MENU" screen by pressing any keys other than the VIEW and RESET keys.
- Select "Record" to display the "Record" sub-menu.
- Select "E. record" to display the "E. record" screen.

```
/2 E.record ▼
• Display
```

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```
• Clear
```

- Select "Display" to display the events with date from the top in new-to-old sequence.

```
/3  E.record          ▼

21/Sep/2002  480
OC1-A trip    On
21/Sep/2002  479
OC1-A         On
```

The time is displayed by pressing the ▶ key.

```
/3  E.record          ▼

13:22:45.211
OC1-A trip    On
13:22:45.211
OC1-A         On
```

Press the ◀ key to return the screen with date.

The lines which are not displayed in the window can be displayed by pressing the ▲and ▼ keys.

To clear all the event records, do the following:

- Open the "Record" sub-menu.
- Select "E. record" to display the "E. record" screen.
- Select "Clear" to display the following confirmation screen.

```
Clear records?
END=Y    CANCEL=N
```

- Press the [END] (= Y) key to clear all the event records stored in non-volatile memory.

4.2.3.3 Displaying Disturbance Records

Details of disturbance records can be displayed on the PC screen only (*); the LCD displays only the recorded date and time for all disturbances stored in the relay. They are displayed in the following sequence.

(*) For the display on the PC screen, refer to RSM100 manual.

- Open the top "MENU" screen by pressing any keys other than the [VIEW] and [RESET] keys.
- Select "Record" to display the "Record" sub-menu.
- Select "D. record" to display the "D. record" screen.

```
/2  D.record          ▼
• Display
• Clear
```

- Select "Display" to display the date and time of the disturbance records from the top in new-to-old sequence.

```
/3  D.record          ▼
```

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```
# 1   16/Jul/2001
      18:13:57.401
# 2   20/May/2001
      15:29:22.388
# 3   04/Feb/2001
      11:54:53.444
# 4   28/Jan/2001
      07:30:18.876
```

The lines which are not displayed in the window can be displayed by pressing the ▲ and ▼ keys.

To clear all the disturbance records, do the following:

- Open the "Record" sub-menu.
- Select "D. record" to display the "D. record" screen.
- Select "Clear" to display the following confirmation screen.

```
Clear records?
END=Y    CANCEL=N
```

- Press the [END] (= Y) key to clear all the disturbance records stored in non-volatile memory.

4.2.3.4 Displaying Counter

- Open the top "MENU" screen by pressing any keys other than the [VIEW] and [RESET] keys.
- Select "Record" to display the "Record" sub-menu.
- Select "Counter" to display the "Counter" screen.

```
/2 Counter                    ▼
• Display
• Clear Trips
• Clear Trips A          (*)
• Clear Trips B          (*)
• Clear Trips C          (*)
• Clear ΣI^yA
• Clear ΣI^yB
• Clear ΣI^yC
```

(*) Note: These settings are only available when single phase External Trip BI functions are used. In this case, the main "Clear Trips" option is not available.

- Select "Display" to display the counts stored in the relay.

```
/3 Counter                    ▼
Trips      *****
Trips A    *****          (*)
Trips B    *****          (*)
Trips C    *****          (*)
ΣI^yA    ******E6
ΣI^yB    ******E6
ΣI^yC    ******E6
```

(*) Note: These settings are only available when single phase External Trip BI functions are used. In this case, the main "Trips" option is not available.

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The lines which are not displayed in the window can be displayed by pressing the ▲ and ▼ keys.

To clear each count, do the following:

- Open the "Record" sub-menu.
- Select "Counter" to display the "Counter" screen.
- Select "Clear Trips" to display the following confirmation screen.

```
Clear  Trips?
END=Y    CANCEL=N
```

- Select "Clear Trips A" to display the following confirmation screen.

```
Clear  Trips  A?
END=Y    CANCEL=N
```

- Select "Clear Trips B" to display the following confirmation screen.

```
Clear  Trips  B?
END=Y    CANCEL=N
```

- Select "Clear Trips C" to display the following confirmation screen.

```
Clear  Trips  C?
END=Y    CANCEL=N
```

- Select "Clear Σ I^yA" to display the following confirmation screen.

```
Clear  ΣI^yA?
END=Y    CANCEL=N
```

- Select "Clear Σ I^yB" to display the following confirmation screen.

```
Clear  ΣI^yB?
END=Y    CANCEL=N
```

- Select "Clear Σ I^yC" to display the following confirmation screen.

```
Clear  ΣI^yC?
END=Y    CANCEL=N
```

- Press the [END] (= Y) key to clear the count stored in non-volatile memory.

4.2.4 Displaying the Status

From the sub-menu of "Status", the following status condition can be displayed on the LCD:

Metering data of the protected line, apparatus, etc.

Status of binary inputs and outputs

Status of measuring elements output

Status of time synchronisation source

Status of clock adjustment

Status of LCD contrast

The data are updated every second.

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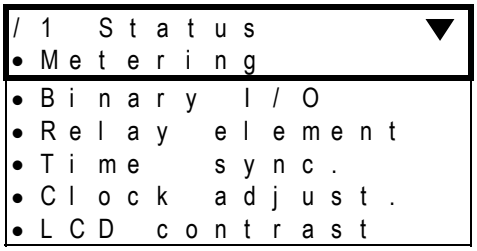
4.2.4.1 Displaying Metering Data

To display metering data on the LCD, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.

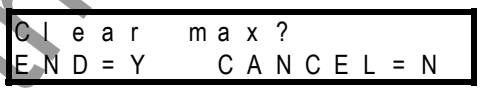


- Select "Metering" to display the "Metering" screen.

/2 Metering		
Ia	***.** KA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ib	***.** KA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
Ic	***.** KA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ie	***.** KA	
Ise	***.*** KA	Not available for models 400.
I1	***.** KA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2	***.** KA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I2/I1	***.**	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
THM	***.* %	Not available for model 110 and APPL=1P setting in models 400 and 420.
Iamax	***.** KA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Ibmax	***.** KA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
Icmax	***.** KA	Not available for model 110 and APPL=1P setting in models 400 and 420.
Iemax	***.** KA	
Isemax	***.*** KA	Not available for models 400.
I2max	***.** KA	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.
I21max	***.**	Not available for models 110 and APPL=1P and 2P settings in models 400 and 420.

To clear all max data, do the following:

- Press the RESET key on any max demand screen (primary or secondary) to display the following confirmation screen.



- Press the END (= Y) key to clear all max data stored in non-volatile memory.

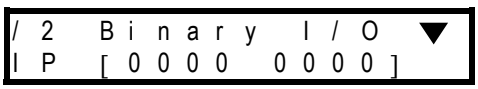
If the primary side unit (A) is required, select 2(=Pri-A) on the "Metering" screen. See Section 4.2.6.6.

Note: When changing the units (kA/A) of primary side current with RSM100, press the "Units" button which is indicated in the primary side screen.

4.2.4.2 Displaying the Status of Binary Inputs and Outputs

To display the binary input and output status, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.
- Select "Binary I/O" to display the binary input and output status.



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```
OP  [ 0 0 0 0   0 0 0 0 ]
```

The display format is shown below.

	[■	■	■	■	■	■	■	■]
Input (IP)	BI1	BI2	BI3	BI4	BI5	BI6	BI7	BI8
Output (OP)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	FAIL

Line 1 shows the binary input status. BI1 to BI8 correspond to each binary input signal. For the binary input signal, see Appendix B and G. The status is expressed with logical level "1" or "0" at the photo-coupler output circuit.

Line 2 shows the binary output status. All binary outputs BO1 to BO7 are configurable. The status of these outputs is expressed with logical level "1" or "0" at the input circuit of the output relay driver. That is, the output relay is energised when the status is "1".

To display all the lines, press the ▲ and ▼ keys.

4.2.4.3 Displaying the Status of Measuring Elements

To display the status of measuring elements on the LCD, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.
- Select 3 "Ry element" to display the status of the relay elements.

```
/2  Ry  el ement          ▼
A   OC1-4 [ 0 0 0 0       ]
B   OC1-4 [ 0 0 0 0       ]
C   OC1-4 [ 0 0 0 0       ]
EF1-4     [ 0 0 0 0       ]
SE1-4     [ 0 0 0 0       ]
A   UC1-2 [ 0 0           ]
B   UC1-2 [ 0 0           ]
C   UC1-2 [ 0 0           ]
THM       [ 0 0           ]
NPS,BC    [ 0 0   0       ]
CBFABC    [ 0 0 0         ]
Cold Ld   [ 0 0 0 0       ]
```

The displayed elements depend on relay model. (See Table 1.1.1 in Section 1.)

The operation status of phase and residual overcurrent elements are shown as below.

	[■	■	■	■	]
A OC1-4	OC1	OC2	OC3	OC4	A phase OC elements
B OC1-4	OC1	OC2	OC3	OC4	B phase OC elements
C OC1-4	OC1	OC2	OC3	OC4	C phase OC elements
EF1-4	EF1	EF2	EF3	EF4	
SE1-4	SE1	SE2	SE3	SE4	
A UC1-2	UC1	UC2	-	-	A phase UC elements
B UC1-2	UC1	UC2	-	-	B phase UC elements
C UC1-2	UC1	UC2	-	-	C phase UC elements
THM	Alarm	Trip	-	-	
NPS, BC	NPS1	NPS2	-	BC	

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CBFABC	A	B	C	-	
Cold Ld	0	1	2	3	Cold Load state

The status of each element is expressed with logical level "1" or "0". Status "1" means the element is in operation.

4.2.4.4 Displaying the Status of the Time Synchronisation Source

The internal clock of the GRD110 can be synchronised with external clocks such as the binary input signal clock, RSM (relay setting and monitoring system) clock or IEC60870-5-103. To display on the LCD whether these clocks are active (=Act.) or inactive (=Inact.) and which clock the relay is synchronised with, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.
- Select "Time sync." to display the status of time synchronisation sources.

```
/2 Time sync.      ▼
*BI:       Act.
 RSM:      Inact.
 IEC:      Inact.
```

The asterisk on the far left shows that the internal clock is synchronised with the marked source clock. If the marked source clock is inactive, the internal clock runs locally.

Note: If the Binary input signal has not been detected for one hour or more after the last detection, the status becomes "inactive".

For details of the setting time synchronisation, see Section 4.2.6.6.

4.2.4.5 Clock Adjustment

To adjust the clock when the internal clock is running locally, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.
- Select "Clock adjust." to display the setting screen.

```
/2 12/Nov/2001     ▼
   22:56:19
Minute
      56 _
Hour
      22
Day
      12
Month
      11
Year
    2001
```

Line 1 and 2 show the current date and time. The time can be adjusted only when the clock is running locally. When [BI], [RSM] or [IEC] is active, the adjustment is invalid.

- Enter a numerical value for each item and press the [ENTER] key. For details to enter a numerical value, see 4.2.6.1.
- Press the [END] key to adjust the internal clock to the set hours without fractions and return to the previous screen.

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If a date which does not exist in the calendar is set and [END] is pressed, "**** Error ****" is displayed on the top line and the adjustment is discarded. Return to the normal screen by pressing the [CANCEL] key and adjust again.

4.2.4.6 LCD Contrast

To adjust the contrast of LCD screen, do the following:

- Select "Status" on the top "MENU" screen to display the "Status" screen.
- Select "LCD contrast" to display the setting screen.

- Press the ◀ or ▶ key to adjust the contrast. The characters on the screen become thin by pressing the ◀ key and deep by pressing the ▶ key.

4.2.5 Viewing the Settings

The sub-menu "Set. (view)" is used to view the settings made using the sub-menu "Set. (change)".

The following items are displayed:

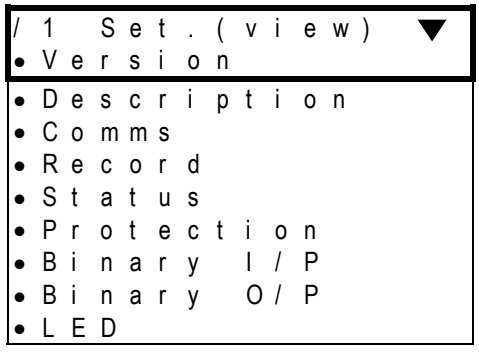
Relay version
Description
Relay address and baud rate in the RSM (relay setting and monitoring system) or IEC60870-5-103 communication
Record setting
Status setting
Protection setting
Binary input setting
Binary output setting
LED setting

Enter an item on the LCD to display each item as described in the previous sections.

4.2.5.1 Relay Version

To view the relay version, do the following.

- Press the "Set.(view)" on the main menu.



- Press the "Version" on the "Set.(view)" menu.

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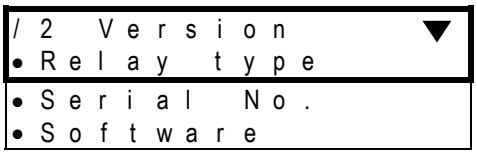
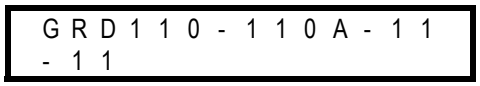
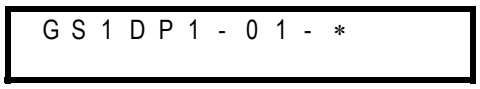


- Select "Relay type" to display the relay type form and model number.



- Select "Serial number" to display the relay manufacturing number.
- Select "Software" to display the relay software type form and version.



4.2.5.2 Settings

The "Description", "Comms", "Record", "Status", "Protection", "Binary I/P", "Binary O/P" and "LED" screens display the current settings input using the "Set. (change)" sub-menu.

4.2.6 Changing the Settings

The "Set. (change)" sub-menu is used to make or change settings for the following items:

Password
Description
Relay address and baud rate in the RSM or IEC60870-5-103 communication
Recording setting
Status setting
Protection setting
Binary input setting
Binary output setting
LED setting

All of the above settings except the password can be seen using the "Set. (view)" sub-menu.

CAUTION

Modification of settings : Care should be taken when modifying settings for "active group", "scheme switch" and "protection element" in the "Protection" menu. Dependencies exist between the settings in the various menus, with settings in one menu becoming active (or inactive) depending on the selection made in another menu. Therefore, it is recommended that all necessary settings changes be made while the circuit breaker tripping circuit is disconnected.

Alternatively, if it is necessary to make settings changes with the tripping circuit active, then it is recommended to enter the new settings into a different settings group, and then change the "active group" setting, thus ensuring that all new settings become valid simultaneously.

4.2.6.1 Setting Method

There are three setting methods as follows:

- To enter a selected item

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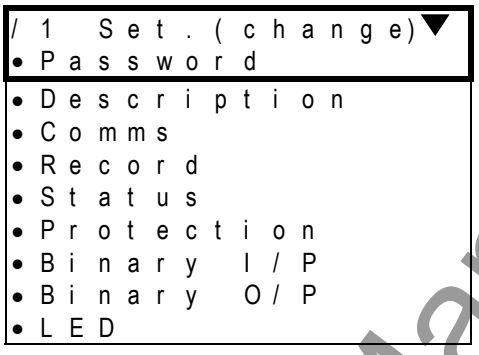
- To enter a text string
- To enter numerical values

To enter a selected item

If a screen as shown below is displayed, perform setting as follows.

The cursor can be moved to upper or lower lines within the screen by pressing the ▲ and ▼ keys. If setting (change) is not required, skip the line with the ▲ and ▼ keys.

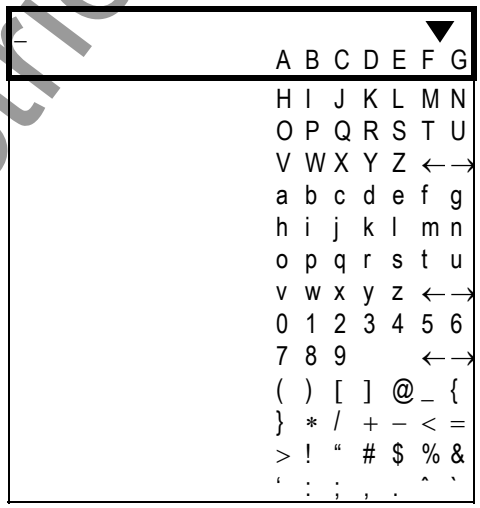


- Move the cursor to a setting item.
- Press the [ENTER] key.

To enter a text string

Texts strings are entered under "Plant name" or "Description" screen.

To select a character, use keys ▼, ▲, ◀ and ▶ to move blinking cursor down, up, left and right. "→" and "←" on each of lines 4, 8 and 10 indicate a space and backspace, respectively. A maximum of 22 characters can be entered.



- Set the cursor position in the bracket by selecting "→" or "←" and pressing the [ENTER] key.
- Move the blinking cursor to a selecting character.
- Press the [ENTER] key to enter the blinking character at the cursor position in the brackets.

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- Press the [END] key to confirm the entry and return to the upper screen.

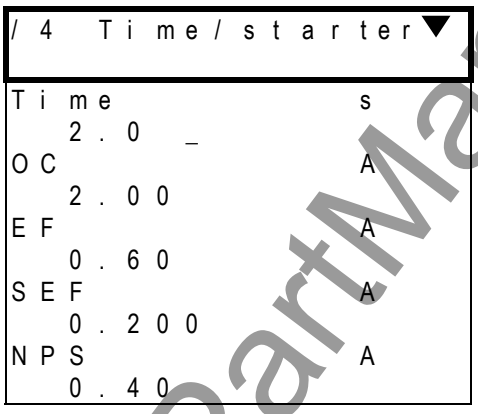
To correct the entered character, do either of the following:

- Discard the character by selecting "←" and pressing the [ENTER] key and enter the new character.
- Discard the whole entry by pressing the [CANCEL] key and restart the entry from the first.

To enter numerical values

When the screen shown below is displayed, perform setting as follows:

The number to the left of the cursor shows the current setting or default setting set at shipment. The cursor can be moved to upper or lower lines within the screen by pressing the ▲ and ▼ keys. If setting (change) is not required, skip the line with the ▲ and ▼ keys.



- Move the cursor to a setting line.
- Press the ◀ or ▶ key to set a desired value. The value is up or down by pressing the ▶ or ◀ key.
- Press the [ENTER] key to enter the value.
- After completing the setting on the screen, press the [END] key to return to the upper screen.

To correct the entered numerical value, do the following.

- If it is before pressing the [ENTER] key, press the [CANCEL] key and enter the new numerical value.
- If it is after pressing the [ENTER] key, move the cursor to the correcting line by pressing the ▲ and ▼ keys and enter the new numerical value.

Note: If the [CANCEL] key is pressed after any entry is confirmed by pressing the [ENTER] key, all the entries made so far on the screen concerned are canceled and screen returns to the upper one.

To complete the setting

Enter after making entries on each setting screen by pressing the [ENTER] key, the new settings are not yet used for operation, though stored in the memory. To validate the new settings, take the following steps.

- Press the [END] key to return to the upper screen. Repeat this until the confirmation screen

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shown below is displayed. The confirmation screen is displayed just before returning to the "Set. (change)" sub-menu.

```
Change settings?
ENTER=Y  CANCEL=N
```

- When the screen is displayed, press the [ENTER] key to start operation using the new settings, or press the [CANCEL] key to correct or cancel entries. In the latter case, the screen turns back to the setting screen to enable re-entries. Press the [CANCEL] key to cancel entries made so far and to turn to the "Set. (change)" sub-menu.

4.2.6.2 Password

For the sake of security of setting changes, password protection can be set as follows:

- Select "Set. (change)" on the main "MENU" screen to display the "Setting change" screen.
- Select "Password" to display the "Password" screen.
- Enter a 4-digit number within the brackets after "Input" and press the [ENTER] key.

```
Input          [ _      ]
1 2 3 4 5 6 7 8 9 0 ←
```

- For confirmation, enter the same 4-digit number in the brackets after "Retype".

```
Retype         [ _      ]
1 2 3 4 5 6 7 8 9 0 ←
```

- Press the [END] key to display the confirmation screen. If the retyped number is different from that first entered, the following message is displayed on the bottom of the "Password" screen before returning to the upper screen.

  "Unmatch passwd!"

  Re-entry is then requested.

Password trap

After the password has been set, the password must be entered in order to enter the setting change screens.

If "Set. (change)" is entered on the top "MENU" screen, the password trap screen "Password" is displayed. If the password is not entered correctly, it is not possible to move to the "Setting (change)" sub-menu screens.

```
Password       [ _      ]
1 2 3 4 5 6 7 8 9 0 ←
```

Canceling or changing the password

To cancel the password protection, enter "0000" in the two brackets on the "Password" screen. The "Set. (change)" screen is then displayed without having to enter a password.

The password can be changed by entering a new 4-digit number on the "Password" screen in the same way as the first password setting.

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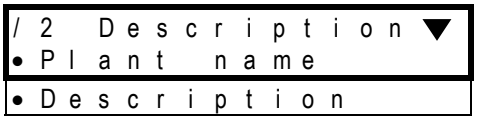
If you forget the password

Press CANCEL and RESET keys together for one second on the top "MENU" screen. The screen goes off, and the password protection of the GRD110 is canceled. Set the password again.

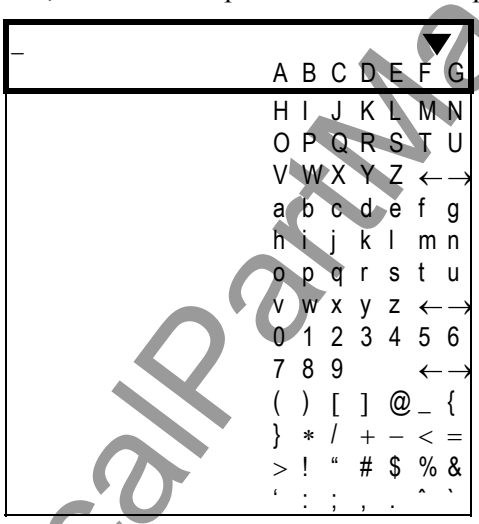
4.2.6.3 Plant Name

To enter the plant name and other data, do the following. These data are attached to records.

- Select "Set. (change)" on the main "MENU" screen to display the " Set. (change)" screen.
- Select "Description" to display the "Description" screen.



- To enter the plant name, select "Plant name" on the "Description" screen.
- To enter special items, select "Description" on the "Description" screen.

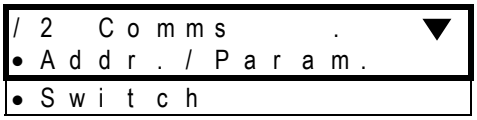


- Enter the text string.

4.2.6.4 Communication

If the relay is linked with RSM (relay setting and monitoring system) or IEC60870-5-103 communication, the relay address must be set. Do this as follows:

- Select "Set. (change)" on the main "MENU" screen to display the "Set. (change)" screen.
- Select "Comms" to display the "Comms" screen.



- Select "Addr./Param." on the "Comms" screen to enter the relay address number.

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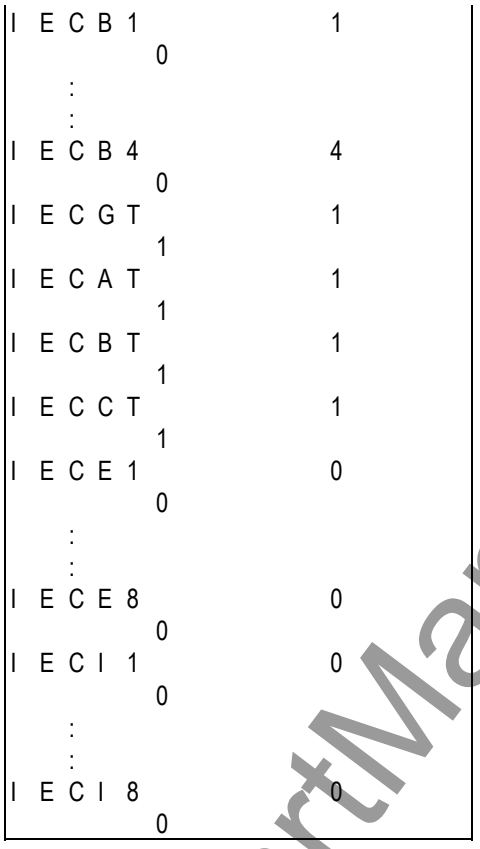


- Enter the relay address number on "HDLC" line for RSM or "IEC" line for IEC60870-5-103 and press the [ENTER] key.

  CAUTION Do not overlap the relay address number.

Settings for IEC60870-5-103 communication

The lines "IECB1" to "IECB4" are used for auxiliary inputs of IEC103 events INF27 to INF30 in Appendix M. Assign signals to the columns "IECB1" to "IECB4" by entering the number corresponding to each signal referring to Appendix B.

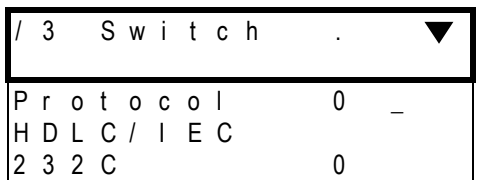
The lines "IECGT" to "IECCT" are used for fault indications of IEC103 events INF68 to INF71 in Appendix M. Assign signals to the columns "IECGT" to "IECCT" by entering the BO numbers (1 to 7) corresponding to the binary output settings.

The lines "IECE1" to "IECE8" are used to assign the signals for user customization. Assign signals to the columns "IECE1" to "IECE8" by entering the number corresponding to each signal referring to Appendix B.

Note: Assign "0" to the column when this function is not used.

The lines "IECI1" to "IECI8" are used to assign the above signals of "IECE1" to "IECE8" to each INF number. Enter the INF number to the columns "IECI1" to "IECI8".

- Select "Switch" on the "Comms" screen to select the protocol and transmission speed (baud rate), etc., of the RSM and IEC60870-5-103.



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```
9.6/19.2/57.6
IECBR              1
9.6/19.2
IECBLK             0
Normal/Blocked
IECNFI             0
1.2/2.4
IECGI1             0
No/Yes
    :
    :
IECGI8             0
No/Yes
```

- Select the number and press the ENTER key.

<Protocol>

This setting is for changing the protocol (HDLC or IEC) of the channel 1 (COM1 port). In the model with two channels (COM1 and COM2 ports), this setting for COM1 should be “HDLC”.

- When the remote RSM system applied, select 0(=HDLC). When the IEC60870-5-103 applied, select 1(=IEC103).

CAUTION When changing the setting to the HDLC during the IEC103 operation, the IEC103 command INF18 in Appendix M is canceled.
The output of IEC103 command INF18 can be observed by assigning their signal numbers to LEDs or binary output relays (see Sections 4.2.6.9 and 4.2.6.10).

<232C>

This line is to select the RS-232C baud rate when the RSM system applied.

Note: The default setting of the 232C is 9.6kbps. The 57.6kbps setting, if possible, is recommended to serve user for comfortable operation. The setting of RSM100 is also set to the same baud rate.

<IECBR>

This line is to select the baud rate when the IEC60870-5-103 system applied.

<IECBLK>

Enter 1(=Blocked) to block the monitor direction in the IEC60870-5-103 communication.

<IECNFI >

This line is to select the normalized factor (1.2 or 2.4) of the current measurand.

<IECGI1 - 8 >

These lines are to use the GI (General Interrogation) or not for user customized signals. If use the GI, enter 1(=Yes).

4.2.6.5 Setting the Recording

To set the recording function as described in Section 4.2.3, do the following:

- Select "Set. (change)" on the main "MENU" screen to display the "Set. (change)" screen.
- Select "Record" to display the "Record " screen.

```
/2 Record                ▼
```

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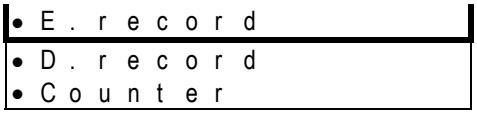
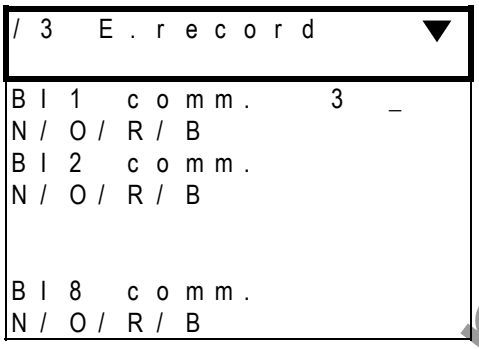


Setting the event recording

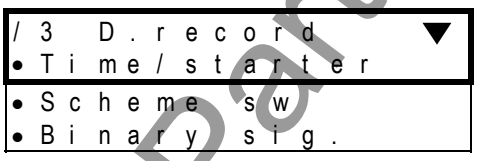
- Select "E. record" to display the "E. record" screen.



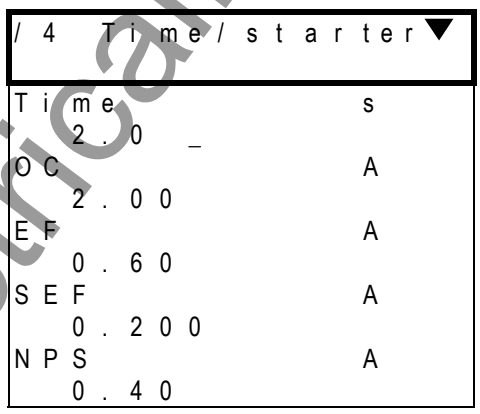
- Enter 0(=None) or 1(=Operate) or 2(=Reset) or 3(=Both) for BI command trigger setting and press the ENTER key.

Setting the disturbance recording

- Select "D. record" to display the "D. record" screen.



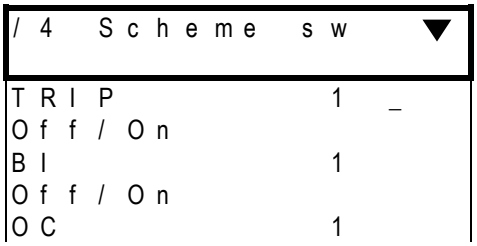
- Select "Time/starter" to display the "Time/starter" screen.



- Enter the recording time and starter element settings.

To set each starter to use or not to use, do the following:

- Select "Scheme sw" on the "D. record" screen to display the "Scheme sw" screen.



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```
Off / On
EF                  1
Off / On
SEF                 1
Off / On
NPS                 1
Off / On
```

- Enter 1 to use as a starter. If not to be used as a starter, enter 0.

To set each signal number to record binary signals, do the following:

- Select "Binary sig." on the "D. record" screen to display the "Binary sig." screen.

```
/4  Binary sig.  ▼

SIG1
    101  _
SIG2
    102
SIG32
    133
```

- Enter the signal number to record binary signals in Appendix B.

Setting the counter

- Select "Counter" to display the "Counter" screen.

```
/3  Counter      ▼
• Scheme sw
• Alarm set
```

To set each counter to use or not to use, do the following:

- Select "Scheme sw" on the "Counter" screen to display the "Scheme sw" screen.

```
/4  Scheme sw    ▼

TCSPEN          0  _
Off / On / OPT-On
CBSMEN          0
Off / On
TCAEN           0
Off / On
ΣIyAEN          0
Off / On
OPTAEN          0
Off / On
```

- Enter 1 to use as a counter. If not to be used as a counter, enter 0.

To set threshold setting, do the following:

- Select "Alarm set" on the "Counter" screen to display the "Alarm set" screen.

```
/4  Alarm set    ▼

TCALM
   10000  _
ΣIyALM          E6
```

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```
    1 0 0 0 0
Y V A L U E
    2 . 0
O P T A L M          m s
    1 0 0 0
```

- Enter the threshold settings.

4.2.6.6 Status

To set the status display described in Section 4.2.4, do the following:

Select "Status" on the "Set. (change)" sub-menu to display the "Status" screen.

```
/ 2  S t a t u s                ▼
• M e t e r i n g
• T i m e  s y n c .
```

Setting the metering

- Select "Metering" to display the "Metering" screen.

```
/ 3  M e t e r i n g            ▼

D i s p l a y        1 _
P r i / S e c / P r i - A
```

- Enter 0 or 1 or 2 and press the [ENTER] key.

  Enter 0(=Pri) to display the primary side current in kilo-amperes(kA).

  Enter 1(=Sec) to display the secondary side current.

  Enter 2(=Pri-A) to display the primary side current in amperes(A).

Setting the time synchronisation

The calendar clock can run locally or be synchronised with the binary input signal, RSM clock, or by an IEC60870-5-103. This is selected by setting as follows.

- Select "Time sync." to display the "Time sync" screen.

```
/ 3  T i m e  s y n c .         ▼

T i m e  s y n c .  0 _
O f f / B I / R S M / I E C
```

- Enter 0, 1, 2 or 3 and press the [ENTER] key.

  Enter 0(=off) not to be synchronised with any external signals.

  Enter 1(=BI) to be synchronised with the binary input signal.

  Enter 2(=RSM) to be synchronised with the RSM clock.

  Enter 3(=IEC) to be synchronised with IEC60870-5-103.

  Note: When selecting BI, RSM or IEC, check that they are active on the "Status" screen in "Status" sub-menu.
  If BI is selected, the BI command trigger setting should be “None” because event records will become full soon. (See Section 4.2.6.5.)
  If it is set to an inactive BI, RSM or IEC, the calendar clock runs locally.

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4.2.6.7 Protection

The GRD110 can have 4 setting groups for protection in order to accommodate changes in the operation of the power system, one setting group is assigned active. To set the protection, do the following:

- Select "Protection" on the "Set. (change)" screen to display the "Protection" screen.

```
/ 2  Protection          ▼
• Change act. gp.
• Change set.
• Copy gp.
```

Changing the active group

- Select "Change act. gp." to display the "Change act. gp." screen.

```
/ 3  Change act. gp.     ▼
Active gp.  1  _
```

- Enter the group number and press the [ENTER] key.

Changing the settings

Almost all the setting items have default values that are set when the product is shipped. For the default values, see Appendix D and H. To change the settings, do the following:

- Select "Change set." to display the "Act gp.= *" screen.

```
/ 3  Act gp.= *          ▼
• Common
• Group 1
• Group 2
• Group 3
• Group 4
```

Setting the common

To set the application setting of GRD110-400 and 420, do the following.

- Select "APPL" on the "Protection" screen to display the "APPL" screen.

```
/ 4  Common              ▼

APPL                 0   _      GRD110-400 and -420
3P/2P/1P                        3 phase / 2 phase / 1 pole
AOLED                1
Off/On
```

<APPL>

To set the APPL setting

- Enter 0(=3P, three phase) or 1(=2P, two phase) or 2(=1P, single pole) and press the [ENTER] key.

<AOLED>

This switch is used to control the “TRIP” LED lighting when an alarm element outputs.

- Enter 1 (=On) to light the “TRIP” LED when an alarm element outputs, and press the

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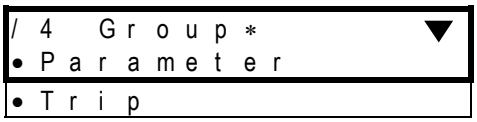
ENTER key. If not, enter 0 (=Off) and press the ENTER key.

Setting the group

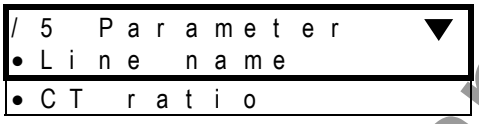
- Select the group to change the settings and press the ENTER key.



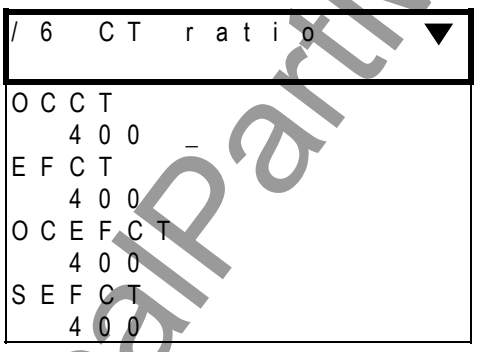
Setting the parameter

Enter the line name and the CT ratio as follows:

- Select "Parameter" on the "Group *" screen to display the "Parameter" screen.



- Select "Line name" to display the "Line name" screen.
- Enter the line name as a text string and press the END key.
- Select "CT ratio" to display the "CT ratio" screen.



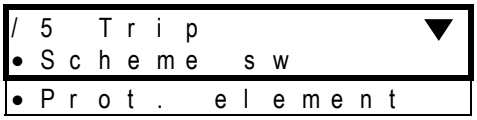
Note: The "CT ratio" screen depends on the APPL setting.

- Enter the CT ratio and press the ENTER key.

Setting the trip function

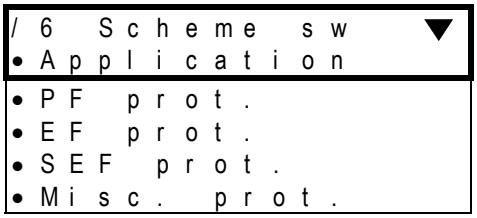
To set the scheme switches and protection elements, do the following.

- Select "Trip" on the "Group *" screen to display the "Trip" screen.



Setting the scheme switch

- Select "Scheme sw" to display the "Scheme sw" screen.



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Setting the application

To set the application setting, do the following.

- Select "Application" on the " Scheme sw" screen to display the "Application" screen.

```
/ 7  Application ▼

MOC1                1
DT/IEC/IEEE/US/C
MEF1                1
DT/IEC/IEEE/US/C
MSE1                1
DT/IEC/IEEE/US/C
MOC2                1
DT/IEC/IEEE/US/C
MEF2                1
DT/IEC/IEEE/US/C
MSE2                1
DT/IEC/IEEE/US/C
SVCNT               0
ALM&BLK/ALM
```

<MOC1>, <MEF1>, <MSE1>, <MOC2>, <MEF2>, <MSE2>

To set the OC1, EF1, SE1, OC2, EF2 and SE2 time delay characteristic type, do the following.

- Enter 0(=DT) or 1(=IEC) or 2(=IEEE), 3(=US) or 4(=C, Configurable) and press the [ENTER] key.

<SVCNT>

Set the alarming and tripping block, or only alarming when a failure is detected by the automatic supervision.

- Enter 0(=ALM&BLK, alarming and tripping block) or 1(=ALM, only alarming) and press the [ENTER] key.

Setting the PF protection

- Select "PF prot." to display the "PF prot." screen.

```
/ 7 PF prot.        ▼

OC1EN               1   _
Off/On
MOC1C-IEC           0
NI/VI/EI/LTI
MOC1C-IEEE          0
MI/VI/EI
MOC1C-US            0
CO2/CO8
OC1R                0
DEF/DEP
OC2EN               0
Off/On
MOC2C-IEC           0
NI/VI/EI/LTI
MOC2C-IEEE          0
```

This setting is displayed if [MOC1] is 1(=IEC).

This setting is displayed if [MOC1] is 2(=IEEE).

This setting is displayed if [MOC1] is 3(=US).

This setting is displayed if [MOC1] is 2(=IEEE), 3(=US) or 4(=C).

This setting is displayed if [MOC2] is 1(=IEC).

This setting is displayed if [MOC2] is 2(=IEEE).

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MI / VI / EI		
MOC2C-US	0	This setting is displayed if [MOC2] is 3(=US).
CO2 / CO8		
OC2R	0	This setting is displayed if [MOC2] is 2(=IEEE), 3(=US) or 4(=C).
DEF / DEP		
OC3EN	0	
Off / On		
OC4EN	0	
Off / On		
UC1EN	0	
Off / On		
UC2EN	0	
Off / On		

<OC1EN>, <OC2EN>

- Enter 1(=On) to enable the OC1 or OC2 and press the ENTER key. If disabling the OC1 or OC2, enter 0(=Off) and press the ENTER key.

<MOC1C>, <MOC2C>

To set the Inverse Curve Type, do the following.

- If [MOC1C] or [MOC2C] is 1(=IEC), enter 0(=NI) or 1(=VI) or 2(=EI) or 3(=LTI) and press the ENTER key.
- If [MOC1C] or [MOC2C] is 2(=IEEE), enter 0(=MI) or 1(=VI) or 2(=EI) and press the ENTER key.
- If [MOC1C] or [MOC2C] is 3(=US), enter 0(=CO2) or 1(=CO8) and press the ENTER key.

<OC1R>, <OC2R>

To set the Reset Characteristic, do the following.

- If [MOC1C] or [MOC2C] is 2(=IEEE), 3(=US) or 4(=C), enter 0(=DEF) or 1(=DEP) and press the ENTER key.

<OC3EN, OC4EN, UC1EN, UC2EN>

- Enter 1(=On) to enable the OC3 and press the ENTER key. If disabling the OC3, enter 0(=Off) and press the ENTER key. The OC4, UC1 and UC2 are the same.
- After setting, press the END key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the ENTER (=Y) key to change settings and return to the "Scheme sw" screen.

Setting the EF protection

- Select "EF prot." to display the "EF prot." screen.

/7 EF prot. ▼		
EF1EN	1 _	
Off / On		
MEF1C-IEC	0	This setting is displayed if [MEF1] is 1(=IEC).
NI / VI / EI / LTI		

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MEF1C-IEEE 0 MI/VI/EI		This setting is displayed if [MEF1] is 2(=IEEE).
MEF1C-US 0 CO2/CO8		This setting is displayed if [MEF1] is 3(=US).
EF1R 0 DEF/DEP		This setting is displayed if [MEF1] is 2(=IEEE), 3(=US) or 4(=C).
EF2EN 0 Off/On		
MEF2C-IEC 0 NI/VI/EI/LTI		This setting is displayed if [MEF2] is 1(=IEC).
MEF2C-IEEE 0 MI/VI/EI		This setting is displayed if [MEF2] is 2(=IEEE).
MEF2C-US 0 CO2/CO8		This setting is displayed if [MEF2] is 3(=US).
EF2R 0 DEF/DEP		This setting is displayed if [MEF2] is 2(=IEEE), 3(=US) or 4(=C).
EF3EN 0 Off/On		
EF4EN 0 Off/On		

<EF1EN>, <EF2EN>

- Enter 1(=On) to enable the EF1 or EF2 and press the [ENTER] key. If disabling the EF1 or EF2, enter 0(=Off) and press the [ENTER] key.

<MEF1C>, <MEF2C>

To set the Inverse Curve Type, do the following.

- If [MEF1C] or [MEF2C] is 1(=IEC), enter 0(=NI) or 1(=VI) or 2(=EI) or 3(=LTI) and press the [ENTER] key.
- If [MEF1C] or [MEF2C] is 2(=IEEE), enter 0(=MI) or 1(=VI) or 2(=EI) and press the [ENTER] key.
- If [MEF1C] or [MEF2C] is 3(=US), enter 0(=CO2) or 1(=CO8) and press the [ENTER] key.

<EF1R>, <EF2R>

To set the Reset Characteristic, do the following.

- If [MEF1C] or [MEF2C] is 2(=IEEE), 3(=US) or 4(=C), enter 0(=DEF) or 1(=DEP) and press the [ENTER] key.

<EF3EN, EF4EN>

- Enter 1(=On) to enable the EF3 and press the [ENTER] key. If disabling the EF3, enter 0(=Off) and press the [ENTER] key. The EF4 is the same.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the "Scheme sw" screen.

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Setting the SEF protection

- Select "SEF prot." to display the "SEF prot." screen.

/7 SEF prot. ▼		
SE1EN	1 _	
Off / On		
MSE1C-IEC	0	This setting is displayed if [MSE1] is 1(=IEC).
NI / VI / EI / LTI		
MSE1C-IEEE	0	This setting is displayed if [MSE1] is 2(=IEEE).
MI / VI / EI		
MSE1C-US	0	This setting is displayed if [MSE1] is 3(=US).
CO2 / CO8		
SE1R	0	This setting is displayed if [MSE1] is 2(=IEEE), 3(=US) or 4(=C).
DEF / DEP		
SE1S2	0	
Off / On		
SE2EN	0	
Off / On		
MSE2C-IEC	0	This setting is displayed if [MSE2] is 1(=IEC).
NI / VI / EI / LTI		
MSE2C-IEEE	0	This setting is displayed if [MSE2] is 2(=IEEE).
MI / VI / EI		
MSE2C-US	0	This setting is displayed if [MSE2] is 3(=US).
CO2 / CO8		
SE2R	0	This setting is displayed if [MSE2] is 2(=IEEE), 3(=US) or 4(=C).
DEF / DEP		
SE3EN	0	
Off / On		
SE4EN	0	
Off / On		

<SE1EN>, <SE2EN>

- Enter 1(=On) to enable the SEF1 or SEF2 and press the [ENTER] key. If disabling the SEF1, enter 0(=Off) and press the [ENTER] key.

<MSE1C>, <MSE2C>

To set the Inverse Curve Type, do the following.

- If [MSE1] or [MSE2] is 1(=IEC), enter 0(=NI) or 1(=VI) or 2(=EI) or 3(=LTI) and press the [ENTER] key.
- If [MSE1] or [MSE2] is 2(=IEEE), enter 0(=MI) or 1(=VI) or 2(=EI) and press the [ENTER] key.
- If [MSE1] or [MSE2] is 3(=US), enter 0(=CO2) or 1(=CO8) and press the [ENTER] key.

<SE1R>, <SE2R>

To set the Reset Characteristic, do the following.

- If [MSE1] or [MSE2] is 2(=IEEE) or 3(=US), enter 0(=DEF) or 1(=DEP) and press the [ENTER] key.

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<SE1S2>

To set the Stage 2 Timer Enable, do the following.

- Enter 1(=On) to enable the SE1S2 and press the [ENTER] key. If disabling the SE1S2, enter 0(=Off) and press the [ENTER] key.

<SE3EN, SE4EN>

- Enter 1(=On) to enable the SEF3 and press the [ENTER] key. If disabling the SEF3, enter 0(=Off) and press the [ENTER] key. The SEF4 is the same.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the "Scheme sw" screen.

Setting the Misc. protection

The settings for miscellaneous protection are as follows:

- Select "Misc. prot." to display the "Misc. prot." screen.

```
/7 Misc. prot. ▼

THMEN              0
Off/On
THMAEN             0
Off/On
NPS1EN             0
Off/On
NPS2EN             0
Off/On
BCDEN              0
Off/On
BTC                0
Off/On
RTC                0
Off/DIR/OC
CLSG               0
Off/1/2/3/4
CLDOEN             0
Off/On
```

<THMEN>

- Enter 1(=On) to enable the Thermal OL and press the [ENTER] key. If disabling the Thermal OL, enter 0(=Off) and press the [ENTER] key.

<THMAEN>

- Enter 1(=On) to enable the Thermal Alarm and press the [ENTER] key. If disabling the Thermal Alarm, enter 0(=Off) and press the [ENTER] key.

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<NPS1EN>

- Enter 1(=On) to enable the NPS1EN and press the [ENTER] key. If disabling the NPS1EN, enter 0(=Off) and press the [ENTER] key.

<NPS2EN>

- Enter 1(=On) to enable the NPS2EN and press the [ENTER] key. If disabling the NPS2EN, enter 0(=Off) and press the [ENTER] key.

<BCDEN>

- Enter 1(=On) to enable the Broken Conductor and press the [ENTER] key. If disabling the Broken Conductor, enter 0(=Off) and press the [ENTER] key.

<BTC>

- Enter 1(=On) to set the Back-trip control and press the [ENTER] key. If not setting the Back-trip control, enter 0(=Off) and press the [ENTER] key.

<RTC>

To set the Re-trip control, do the following.

- Enter 0(=Off) or 1(=Direct) or 2(=OC controlled) and press the [ENTER] key.

<CLSG>

To set the Cold Load settings group, do the following.

- Enter 0(=Off) or 1(=1) or 2(=2) or 3(=3) or 4(=4) and press the [ENTER] key.

<CLDOEN>

- Enter 1(=On) to enable the Cold Load drop-off and press the [ENTER] key. If disabling the Cold Load drop-off, enter 0(=Off) and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the "Scheme sw" screen.

Setting the protection elements

- Select "Prot. element" on the "Trip" screen to display the "Prot. element" screen.

```
/ 6 Prot. element▼
• PF prot.
• EF prot.
• SEF prot.
• Misc. prot.
```

Setting the PF protection

- Select "PF prot." to display the "PF prot." screen.

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/7 PF prot. ▼		
OC1	A	
1.00 _		
TOC1		OC1 Time multiplier setting. Display if [MOC1] = 1, 2, 3 or 4.
1.000		
TOC1	s	OC1 Definite time setting. Display if [MOC1]= 0.
1.00		
TOC1R	s	OC1 Definite time reset delay. Display if [MOC1] = 1 or [OC1R] = 0.
0.0		
TOC1RM		OC1 Dependent time reset time multiplier. Display if [OC1R] = 1.
1.000		
OC2	A	
5.00		
TOC2		OC2 Time multiplier setting. Display if [MOC2] = 1, 2, 3 or 4.
1.000		
TOC2	s	OC2 Definite time setting. Display if [MOC2]= 0.
0.00		
TOC2R	s	OC2 Definite time reset delay. Display if [MOC2] = 1 or [OC1R] = 0.
0.0		
TOC2RM		OC2 Dependent time reset time multiplier. Display if [OC2R] = 1.
1.000		
OC3	A	
10.00		
TOC3	s	
0.00		
OC4	A	
20.00		
TOC4	s	
0.00		
OC1-k		IDMT curve setting of OC1
0.00		
OC1-α		IDMT curve setting of OC1
0.00		
OC1-c		IDMT curve setting of OC1
0.000		
OC1-kr		IDMT curve setting of OC1
0.00		
OC1-β		IDMT curve setting of OC1
0.00		
OC2-k		IDMT curve setting of OC2
0.00		
OC2-α		IDMT curve setting of OC2
0.00		
OC2-c		IDMT curve setting of OC2
0.000		
OC2-kr		IDMT curve setting of OC2
0.00		
OC2-β		IDMT curve setting of OC2
0.00		
UC1	A	
0.20		
TUC1	s	
0.00		
UC2	A	
0.40		
TUC2	s	

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```
    0 . 0 0
```

- Enter the numerical value and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the " Prot. element" screen.

Note: Default current settings are shown for a 1A rated relay. They must be multiplied by 5 in the case of a 5A rated version.

Setting the EF protection

- Select "EF prot." to display the "EF prot." screen.

```
/ 7  EF prot.                    ▼
```

EF1	A	
0.30 _		
TEF1		EF1 Time multiplier setting. Display if [MEF1] = 1, 2, 3 or 4.
1.000		
TEF1	s	EF1 Definite time setting. Display if [MEF1] =0.
1.00		
TEF1R	s	EF1 Definite time reset delay. Display if [MEF1] = 1 or [EF1R] = 0.
0.0		
TEF1RM		EF1 Dependent time reset time multiplier. Display if [EF1R] = 1.
1.000		
EF2	A	
3.00		
TEF2		EF2 Time multiplier setting. Display if [MEF2] = 1, 2, 3 or 4.
1.000		
TEF2	s	EF2 Definite time setting. Display if [MEF2] =0.
1.00		
TEF2R	s	EF2 Definite time reset delay. Display if [MEF2] = 1 or [EF1R] = 0.
0.0		
TEF2RM		EF2 Dependent time reset time multiplier. Display if [EF2R] = 1.
1.000		
EF3	A	
5.00		
TEF3	s	
0.00		
EF4	A	
10.00		
TEF4	s	
0.00		
EF1-k		IDMT curve setting of EF1
0.00		
EF1-α		IDMT curve setting of EF1
0.00		
EF1-c		IDMT curve setting of EF1
0.000		
EF1-kr		IDMT curve setting of EF1
0.00		
EF1-β		IDMT curve setting of EF1
0.00		

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E F 2 - k 0 . 0 0	IDMT curve setting of EF2
E F 2 - α 0 . 0 0	IDMT curve setting of EF2
E F 2 - c 0 . 0 0 0	IDMT curve setting of EF2
E F 2 - k r 0 . 0 0	IDMT curve setting of EF2
E F 2 - β 0 . 0 0	IDMT curve setting of EF2

- Enter the numerical value and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the " Prot. element" screen.

Setting the SEF protection

- Select "SEF prot." to display the "SEF prot." screen.

/7 SEF prot. ▼		
S E 1 0 . 1 0 0 _	A	
T S E 1 1 . 0 0 0		SEF1 Time multiplier setting. Display if [MSE1] = 1, 2, 3 or 4.
T S E 1 1 . 0 0	s	SEF1 Definite time setting. Display if [MSE1] = 0.
T S E 1 R 0 . 0	s	SEF1 Definite time reset delay. Display if [MSE1] = 1 or [SE1R] = 0.
T S E 1 R M 1 . 0 0 0		SEF1 Dependent time reset time multiplier. Display if [SE1R] = 1.
T S E 1 S 2 0 . 0 0	s	SEF1 Stage 2 Definite time setting.
S E 2 0 . 5 0 0	A	
T S E 2 1 . 0 0 0		SEF2 Time multiplier setting. Display if [MSE2] = 1, 2, 3 or 4.
T S E 2 0 . 0 0	s	SEF2 Definite time setting. Display if [MSE2] = 0.
T S E 2 R 0 . 0	s	SEF2 Definite time reset delay. Display if [MSE2] = 1 or [SE2R] = 0.
T S E 2 R M 1 . 0 0 0		SEF2 Dependent time reset time multiplier. Display if [SE2R] = 1.
S E 3 0 . 5 0 0	A	
T S E 3 0 . 0 0	s	
S E 4 0 . 5 0 0	A	
T S E 4 0 . 0 0	s	
S E 1 - k 0 . 0 0		IDMT curve setting of SE1

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SE1-α 0.00	IDMT curve setting of SE1
SE1-c 0.000	IDMT curve setting of SE1
SE1-kr 0.00	IDMT curve setting of SE1
SE1-β 0.00	IDMT curve setting of SE1
SE2-k 0.00	IDMT curve setting of SE2
SE2-α 0.00	IDMT curve setting of SE2
SE2-c 0.000	IDMT curve setting of SE2
SE2-kr 0.00	IDMT curve setting of SE2
SE2-β 0.00	IDMT curve setting of SE2

- Enter the numerical value and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the " Prot. element" screen.

Setting the Misc. protection

- Select "Misc. prot." to display the "Misc. prot." screen.

```
/7 Misc. prot. ▼

THM                    A
  1.00
THMIP                  A
  0.00
TTHM                   min
  10.0
THMA                   %
  80
NPS1                   A
  0.40
TNPS1                  s
  0.00
NPS2                   A
  0.20
TNPS2                  s
  0.00
BCD
  0.20
TBCD                   s
  0.00
CBF                    A
  0.50
TBTC                   s
  0.50
```

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```
TRTC                s
   1.00
TCLE                s
   100
TCLR                s
   100
ICLDO               A
   0.50
TCLDO               s
   0.00
```

- Enter the numerical value and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

```
Change settings?
ENTER=Y  CANCEL=N
```

- Press the [ENTER] (=Y) key to change settings and return to the " Prot. element" screen.

Setting APPL

To set the current input state for GRD110-400 and –420 and set the operating time setting, do the following:

- Select "APPL" on the "Protection" screen to display the "APPL" screen.

```
/3 APPL                    ▼

APPL                0   _
3P/2P/1P
Optime              0
Normal/Fast
```

- Enter 0(=3P : 3 phase), 1(=2P : 2 phase) or 2(=1P : 1 pole) to set the current input state and press the [ENTER] key.
- Enter 0(=Normal : Definite time or Inverse time), 1(=Fast : High speed operation) to set the operating time and press the [ENTER] key.

Note: If "Fast" selected, all OC and EF elements operate at high-speed (approximately 20ms).

Setting group copy

To copy the settings of one group and overwrite them to another group, do the following:

- Select "Copy gp." on the "Protection" screen to display the "Copy A to B" screen.

```
/3 Copy A to B ▼

A                       _
B
```

- Enter the group number to be copied in line A and press the [ENTER] key.
- Enter the group number to be overwritten by the copy in line B and press the [ENTER] key.

4.2.6.8 Binary Input

The logic level of binary input signals can be inverted by setting before entering the scheme logic.

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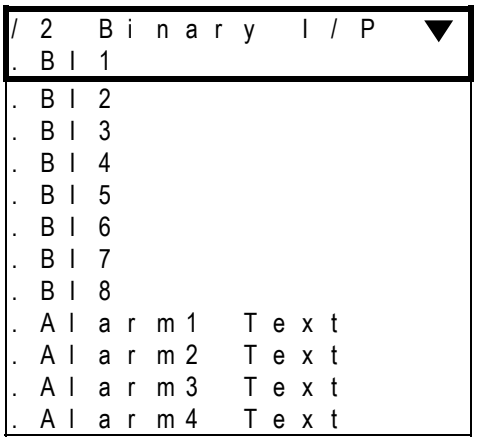
Inversion is used when the input contact cannot meet the requirements described in Table 3.2.2.

- Select "Binary I/P" on the "Set. (change)" sub-menu to display the "Binary I/P" screen.



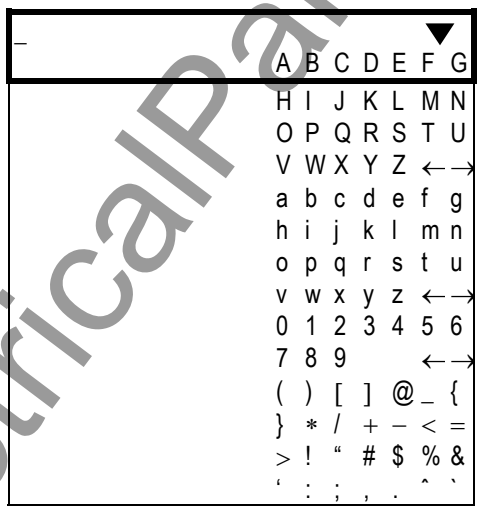
Selection of Binary Input

- Select the input number (BI number) on the "Binary I/P" screen.

Setting Alarm ∗ Text

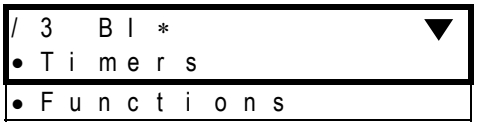
If the BI selected is used for an alarm, alarm message can be set.

- Select the Alarm∗ text and press the ENTER key to display the text input screen.



- Enter the characters (up to 16 characters) according to the text setting method.

After setting, press the ENTER key to display the "BI∗" screen.



Setting timers

- Select "Timers" on the "BI" screen to display the "Timers" screen.

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0.00 _ BI1DOD s 0.00	Drop-off delay setting

- Enter the numerical value and press the (ENTER) key.
- After setting, press the (END) key to return to the "BI*" screen.

Setting Functions

- Select "Functions" on the "BI" screen to display the "Functions" screen.

/4 Functions ▼	
BI1SNS	1 _
Norm/Inv	
BI1SGS	0
Off/1/2/3/4	
OC1BLK	0
Off/On	
OC2BLK	0
Off/On	
OC3BLK	0
Off/On	
OC4BLK	0
Off/On	
EF1BLK	0
Off/On	
EF2BLK	0
Off/On	
EF3BLK	0
Off/On	
EF4BLK	0
Off/On	
SE1BLK	0
Off/On	
SE2BLK	0
Off/On	
SE3BLK	0
Off/On	
SE4BLK	0
Off/On	
UCBLK	0
Off/On	
THMBLK	0
Off/On	
NPSBLK	0
Off/On	
BCDBLK	0
Off/On	
TCFALM	0
Off/On	
CBOPN	0
Off/On	

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C B C L S	0
O f f / O n	
E X T 3 P H	0
O f f / O n	
E X T A P H	0
O f f / O n	
E X T B P H	0
O f f / O n	
E X T C P H	0
O f f / O n	
R M T R S T	0
O f f / O n	
S Y N C L K	0
O f f / O n	
S T O R C D	0
O f f / O n	
A l a r m 1	0
O f f / O n	
A l a r m 2	0
O f f / O n	
A l a r m 3	0
O f f / O n	
A l a r m 4	0
O f f / O n	

<BI1SNS>

To set the Binary Input 1 Sense, do the following.

- Enter 0(=Normal) or 1(=Inverted) and press the [ENTER] key.

<BI1SGS>

To set the Binary Input 1 Settings Group Select, do the following.

- Enter 0(=Off) or 1(=1) or 2(=2) or 3(=3) or 4(=4) and press the [ENTER] key.

<Others>

- Enter 1(=On) to set the function and press the [ENTER] key. If not setting the function, enter 0(=Off) and press the [ENTER] key.
- After setting, press the [END] key to return to the "BI∗" screen.

4.2.6.9 Binary Output

All the binary outputs of the GRD110 except the relay failure signal are user-configurable. It is possible to assign one signal or up to four ANDing or ORing signals to one output relay. Available signals are listed in Appendix B.

It is also possible to attach Instantaneous or delayed or latched reset timing to these signals.

Appendix D shows the factory default settings.

CAUTION

When having changed the binary output settings, release the latch state on a digest screen by

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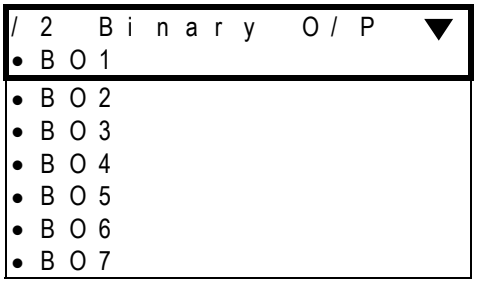
pressing the [RESET] key for more than 3 seconds.

To configure the binary output signals, do the following:

Selection of output relay

- Select "Binary O/P" on the "Set. (change)" screen to display the "Binary O/P" screen.



Note: The setting is required for all the binary outputs. If any of the binary outputs are not used, enter 0 to logic gates #1 to #4 in assigning signals.

- Select the output relay number (BO number) and press the [ENTER] key to display the "BO∗" screen.

Setting the logic gate type and timer

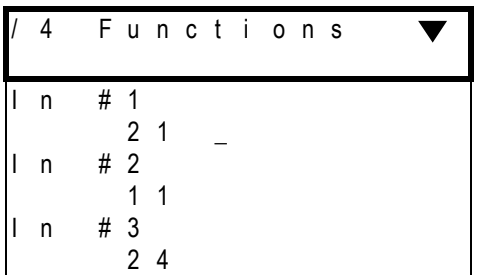
- Select "Logic/Reset" to display the "Logic/Reset" screen.

- Enter 0(=OR) or 1(=AND) to use an OR gate or AND gate and press the [ENTER] key.
- Enter 0(=Instantaneous) or 1(=Delayed) or 2(=Dwell) or 3(=Latched) to select the reset timing and press the [ENTER] key.
- Press the [END] key to return to the "BO∗" screen.

Note: To release the latch state, push the [RESET] key for more than 3 seconds on a digest screen.

Assigning signals

- Select "Functions" on the "BO∗" screen to display the "Functions" screen.



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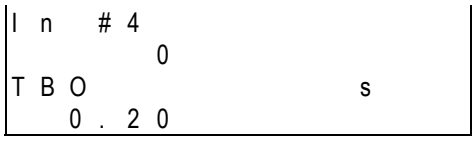


- Assign signals to gates (In #1 to #4) by entering the number corresponding to each signal referring to Appendix B. Do not assign the signal numbers 170 to 176 (signal names: "BO1 OP" to "BO7 OP"). And set the delay time of timer TBO.

  Note: If signals are not assigned to all the gates #1 to #4, enter 0 for the unassigned gate(s).

Repeat this process for the outputs to be configured.

4.2.6.10 LEDs

Three LEDs of the GRD110 are user-configurable. A configurable LED can be programmed to indicate the OR combination of a maximum of 4 elements, the individual statuses of which can be viewed on the LED screen as "Virtual LEDs." The signals listed in Appendix B can be assigned to each LED as follows.

CAUTION

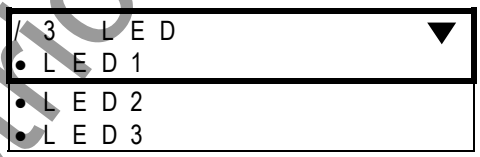
When having changed the LED settings, must release the latch state on a digest screen by pressing the [RESET] key for more than 3 seconds.

Selection of LEDs

- Select "LED" on the "Set. (change)" screen to display the "LED" screen.

Selection of real LEDs

- Select "LED" on the "/2 LED" screen to display the "/3 LED" screen.

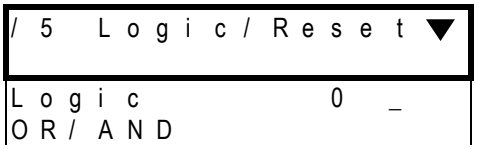


Note: The setting is required for all the LEDs. If any of the LEDs are not used, enter 0 to logic gates #1 to #4 in assigning signals.

- Select the LED number and press the [ENTER] key to display the "LED∗" screen.

Setting the logic gate type and timer

- Select "Logic/Reset" to display the "Logic/Reset" screen.



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```
Reset              0
Inst/Latch
```

- Enter 0(=OR) or 1(=AND) to use an OR gate or AND gate and press the [ENTER] key.
- Enter 0(=Instantaneous) or 1(=Latched) to select the reset timing and press the [ENTER] key.
- Press the [END] key to return to the "LED∗" screen.

Note: To release the latch state, push the [RESET] key for more than 3 seconds.

Assigning signals

- Select "Functions" on the "LED∗" screen to display the "Functions" screen.

```
/5 Functions                    ▼

In #1
     21 _
In #2
     11
In #3
     24
In #4
      0
```

- Assign signals to gates (In #1 to #4) by entering the number corresponding to each signal referring to Appendix B.

Note: If signals are not assigned to all the gates #1 to #4, enter 0 for the unassigned gate(s).

- Press the [END] key to return to the "LED∗" screen.

Repeat this process for the outputs to be configured.

Selection of virtual LEDs

- Select "Virtual LED" on the "/2 LED" screen to display the "Virtual LED" screen.

```
/3 Virtual LED                  ▼
• IND1
• IND2
```

- Select the IND number and press the [ENTER] key to display the "IND∗" screen.

```
/4 IND∗                         ▼
• Reset
• Functions
```

Setting the reset timing

- Select "Reset" to display the "Reset" screen.

```
/5 Reset                        ▼

Reset              0 _
Inst/Latch
```

- Enter 0(=Instantaneous) or 1(=Latched) to select the reset timing and press the [ENTER] key.

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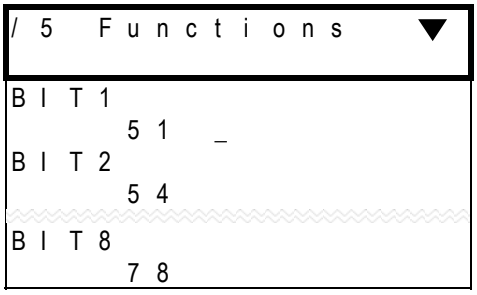
- Press the END key to return to the "IND∗" screen.

Note: To release the latch state, push the [RESET] key for more than 3 seconds.

Assigning signals

- Select "Functions" on the "IND∗" screen to display the "Functions" screen.



- Assign signals to bits (1 to 8) by entering the number corresponding to each signal referring to Appendix B.

Note: If signals are not assigned to all the bits 1 to 8, enter 0 for the unassigned bit(s).

- Press the END key to return to the "IND∗" screen.

Repeat this process for the outputs to be configured.

4.2.7 Testing

The sub-menu "Test" provides such functions as disabling the automatic monitoring function and forced operation of binary outputs.

Note: When operating the "Test" menu, the "IN SERVICE" LED is flickering. But if an alarm occurs during the test, the flickering stops. The "IN SERVICE" LED flickers only in a lighting state.

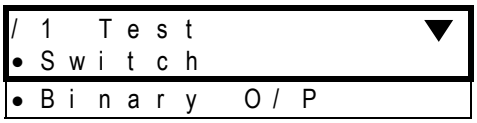
4.2.7.1 Scheme Switch

The automatic monitor function (A.M.F.) can be disabled by setting the switch [A.M.F] to "OFF".

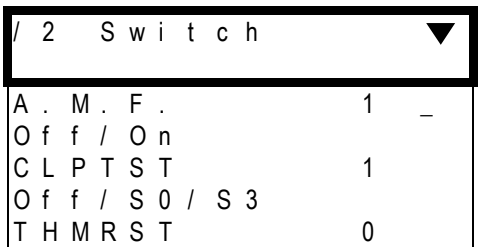
Disabling the A.M.F. inhibits trip blocking even in the event of a failure in the items being monitored by this function. It also prevents failures from being displayed on the "ALARM" LED and LCD described in Section 4.2.1. No events related to A.M.F. are recorded, either.

Disabling A.M.F. is useful for blocking the output of unnecessary alarms during testing.

- Select "Test" on the top "MENU" screen to display the "Test" screen.



- Select "Switch" to display the "Switch" screen.



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```
Off / On
IECTST              0
Off / On
```

- Enter 0 or 1 to disable the A.M.F. or not and press the [ENTER] key.
- Enter 0(=Off) or 1(=State0) or 2(=State3) to set forcibly the test condition of the Cold Load Protection (CLPTST) and press the [ENTER] key.
- Enter 1(=On) to reset forcibly the thermal overload element for testing (THMRST) and press the [ENTER] key.
- Enter 1(=On) for IECTST to transmit 'test mode' to the control system by IEC60870-5-103 communication when testing the local relay, and press the [ENTER] key.
- Press the [END] key to return to the "Test" screen.

4.2.7.2 Binary Output Relay

It is possible to forcibly operate all binary output relays for checking connections with the external devices. Forced operation can be performed on one or more binary outputs at a time.

- Select "Binary O/P" on the "Test" screen to display the "Binary O/P" screen. Then the LCD displays the name of the output relay.

```
/2  Binary O/P  ▼

BO1                 0  _
Disable/Enable
BO2                 0
Disable/Enable
BO3                 0
Disable/Enable
BO4                 0
Disable/Enable
BO5                 0
Disable/Enable
BO6                 0
Disable/Enable
BO7                 0
Disable/Enable
```

- Enter 1(=Enable) and press the [ENTER] key to operate the output relays forcibly.
- After completing the entries, press the [END] key. Then the LCD displays the screen shown below.

```
Operate?
ENTER=Y  CANCEL=N
```

- Keep pressing the [ENTER] key to operate the assigned output relays.
- Release pressing the [ENTER] key to reset the operation.
- Press the [CANCEL] key to return to the upper "Binary O/P" screen.

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4.3 Personal Computer Interface

The relay can be operated from a personal computer using an RS232C port on the front panel. On the personal computer, the following analysis and display of the fault currents are available in addition to the items available on the LCD screen.

- Display of current waveform: Oscillograph display
- Symmetrical component analysis: On arbitrary time span
- Harmonic analysis: On arbitrary time span
- Frequency analysis: On arbitrary time span

For the details, see the separate instruction manual "PC INTERFACE RSM100".

4.4 Relay Setting and Monitoring System

The Relay Setting and Monitoring (RSM) system is a system that retrieves and analyses the data on power system quantities, fault and event records and views or changes settings in individual relays via a telecommunication network using a remote PC.

Figure 4.4.1 shows the typical configuration of the RSM system via a protocol converter G1PR2. The relays are connected through twisted pair cables, and the maximum 256 relays can be connected since the G1PR2 can provide up to 8 ports. The total length of twisted pair wires should not exceed 1200 m. Relays are mutually connected using an RS485 port on the relay rear panel and connected to a PC RS232C port via G1PR2. Terminal resistor (150 ohms) is connected the last relay. The transmission rate used is 64 kbits/s.

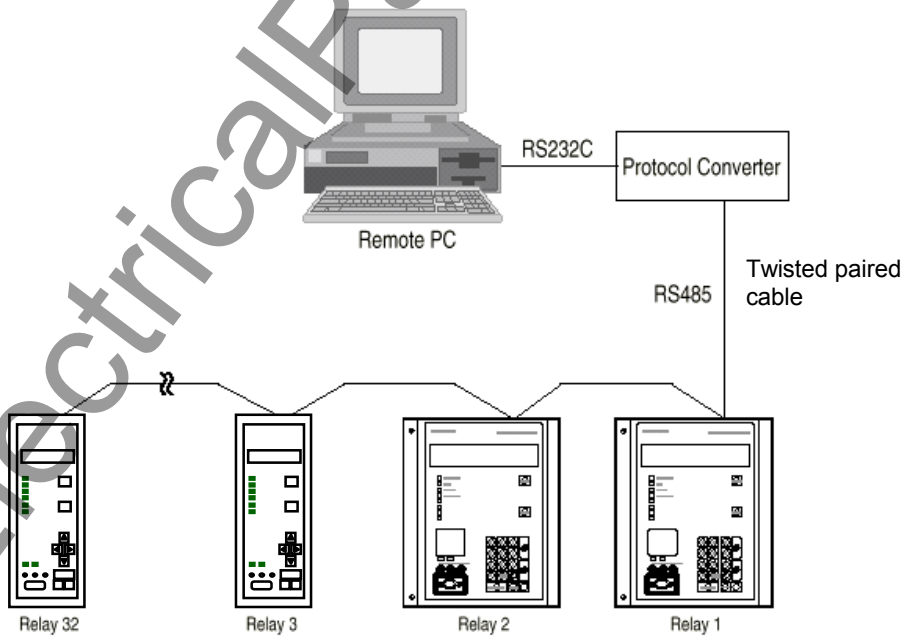

Figure 4.4.1 Relay Setting and Monitoring System

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4.5 IEC 60870-5-103 Interface

The GRD110 supports the IEC60870-5-103 communication protocol. This protocol is mainly used when the relay communicates with a control system and is used to transfer the following measurand and status data from the relay to the control system. (For details, see Appendix M.)

- Measurand data: current
- Status data: events, fault indications, etc.

The protocol can be used through the RS-485 port on the relay rear panel.

The relay supports two baud-rates 9.6kbps and 19.2kbps, and supports two normalizing factors 1.2 and 2.4 for measurand. These are selected by setting. See Section 4.2.6.4.

The data transfer from the relay can be blocked by the setting.

For the settings, see the Section 4.2.6.

4.6 Clock Function

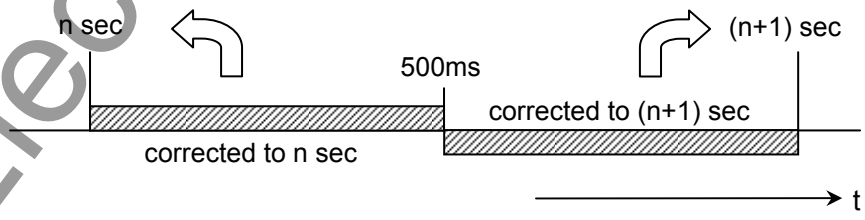
The clock function (Calendar clock) is used for time-tagging for the following purposes:

- Event records
- Disturbance records
- Fault records

The calendar clock can run locally or be synchronised with the external clock such as the binary time standard input signal, RSM clock or IEC60870-5-103. This can be selected by setting.

The "clock synchronise" function synchronises the relay internal clock to the binary input signal by the following method. Since the BI signal is an "ON" or "OFF" signal which cannot express year-month-day and hour-minute-second etc, synchronising is achieved by setting the number of milliseconds to zero. This method will give accurate timing if the synchronising BI signal is input every second.

Synchronisation is triggered by an "OFF" to "ON" (rising edge) transition of the BI signal. When the trigger is detected, the millisecond value of the internal clock is checked, and if the value is between 0~500ms then it is rounded down. If it is between 500~999ms then it is rounded up (ie the number of seconds is incremented).



When the relays are connected with the RSM system as shown in Figure 4.4.1 and selected "RSM" in the time synchronisation setting, the calendar clock of each relay is synchronised with the RSM clock. If the RSM clock is synchronised with the external time standard, then all the relay clocks are synchronised with the external time standard.

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5. Installation

5.1 Receipt of Relays

When relays are received, carry out the acceptance inspection immediately. In particular, check for damage during transportation, and if any is found, contact the vendor.

Always store the relays in a clean, dry environment.

5.2 Relay Mounting

A flush mounting relay is included. Appendix F shows the case outlines.

For details of relay withdrawal and insertion, see Section 6.7.3.

5.3 Electrostatic Discharge

⚠CAUTION

Do not take out the relay unit outside the relay case since electronic components on the modules are very sensitive to electrostatic discharge. If it is absolutely essential to take the modules out of the case, do not touch the electronic components and terminals with your bare hands. Additionally, always put the module in a conductive anti-static bag when storing it.

5.4 Handling Precautions

A person's normal movements can easily generate electrostatic potentials of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage. This damage often may not be immediately apparent, but the reliability of the circuit will have been reduced.

The electronic circuits are completely safe from electrostatic discharge when housed in the case. Do not expose them to risk of damage by withdrawing the relay unit unnecessarily.

The relay unit incorporates the highest practical protection for its semiconductor devices. However, if it becomes necessary to withdraw the relay unit, precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

⚠CAUTION

- Before removing the relay unit, ensure that you are at the same electrostatic potential as the equipment by touching the case.
- Use the handle to draw out the relay unit. Avoid touching the electronic components, printed circuit board or connectors.
- Do not pass the relay unit to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
- Place the relay unit on an anti-static surface, or on a conducting surface which is at the same potential as yourself.
- Do not place the relay unit in polystyrene trays.

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It is strongly recommended that detailed investigations on electronic circuitry should be carried out in a Special Handling Area such as described in the aforementioned IEC 60747.

5.5 External Connections

External connections for each relay model are shown in Appendix G.

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6. Commissioning and Maintenance

6.1 Outline of Commissioning Tests

The GRD110 is fully numerical and the hardware is continuously monitored.

Commissioning tests can be kept to a minimum and need only include hardware tests and the conjunctive tests. The function tests are at the user's discretion.

In these tests, user interfaces on the front panel of the relay or local PC can be fully applied.

Test personnel must be familiar with general relay testing practices and safety precautions to avoid personal injuries or equipment damage.

Hardware tests

These tests are performed for the following hardware to ensure that there is no hardware defect. Defects of hardware circuits other than the following can be detected by monitoring which circuits function when the DC power is supplied.

User interfaces
Binary input circuits and output circuits
AC input circuits

Function tests

These tests are performed for the following functions that are fully software-based.

Measuring elements
Metering and recording

Conjunctive tests

The tests are performed after the relay is connected with the primary equipment and other external equipment.

The following tests are included:

On load test: phase sequence check and polarity check
Tripping circuit test

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6.2 Cautions

6.2.1 Safety Precautions

⚠CAUTION

- The relay rack is provided with an earthing terminal.
  Before starting the work, always make sure the relay rack is earthed.
- When connecting the cable to the back of the relay, firmly fix it to the terminal block and attach the cover provided on top of it.
- Before checking the interior of the relay, be sure to turn off the power.

Failure to observe any of the precautions above may cause electric shock or malfunction.

6.2.2 Cautions on Tests

⚠CAUTION

- While the power is on, do not drawout/insert the relay unit.
- Before turning on the power, check the following:
  - Make sure the polarity and voltage of the power supply are correct.
  - Make sure the CT circuit is not open.
- Be careful that the relay is not damaged due to an overcurrent or overvoltage.
- If settings are changed for testing, remember to reset them to the original settings.

Failure to observe any of the precautions above may cause damage or malfunction of the relay.

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6.3 Preparations

Test equipment

The following test equipment is required for the commissioning tests.

1 Single-phase current source
1 Three-phase current source
1 DC power supply
3 AC ammeter
1 Time counter, precision timer
1 PC (not essential)

Relay settings

Before starting the tests, it must be specified whether the tests will use the user's settings or the default settings.

For the default settings, see the following appendixes:

Appendix D Binary Output Default Setting List
Appendix H Relay Setting Sheet

Visual inspection

After unpacking the product, check for any damage to the relay case. If there is any damage, the internal module might also have been affected. Contact the vendor.

Relay ratings

Check that the items described on the nameplate on the front of the relay conform to the user's specification. The items are: relay type and model, AC current and frequency ratings, and auxiliary DC supply voltage rating.

Local PC

When using a local PC, connect it with the relay via the RS232C port on the front of the relay. RSM100 software is required to run the PC.

For the details, see the separate volume "PC INTERFACE RSM100".

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6.4 Hardware Tests

The tests can be performed without external wiring, but a DC power supply and AC current source is required.

6.4.1 User Interfaces

This test ensures that the LCD, LEDs and keys function correctly.

LCD display

- Apply the rated DC voltage and check that the LCD is off.

  Note: If there is a failure, the LCD will display the "ERR: " screen when the DC voltage is applied.

- Press the [RESET] key for one second or more and check that black dots appear on the whole screen.

LED display

- Apply the rated DC voltage and check that the "IN SERVICE" LED is lit in green.
- Press the [RESET] key for one second or more and check that remaining five LEDs are lit in red or yellow. (Programmable LEDs are yellow.)

VIEW and RESET keys

- Press the [VIEW] key when the LCD is off and check that the "Virtual LED" and "Metering" screens are sequentially displayed on the LCD.
- Press the [RESET] key and check that the LCD turns off.

Other operation keys

- Press any key when the LCD is off and check that the LCD displays the "MENU" screen. Press the [END] key to turn off the LCD.
- Repeat this for all keys.

6.4.2 Binary Input Circuit

The testing circuit is shown in Figure 6.4.1.

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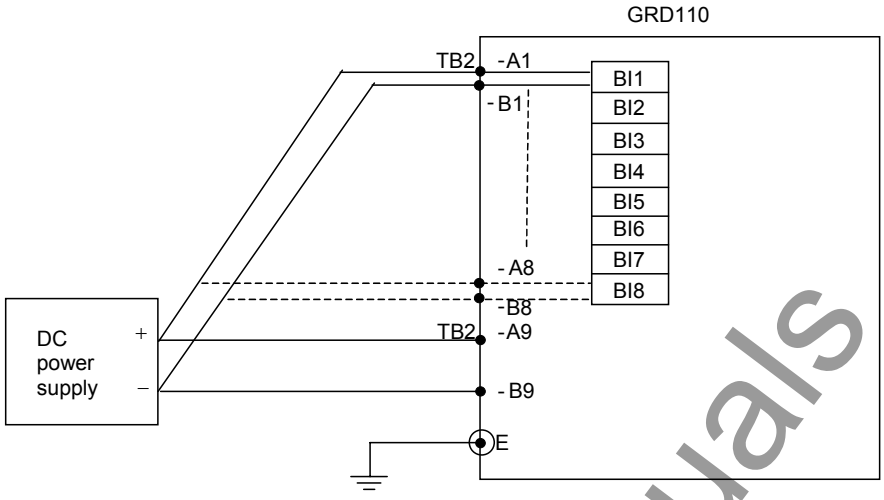

Figure 6.4.1 Testing Binary Input Circuit

- Display the "Binary I/O" screen from the "Status" sub-menu.

```
/ 2  B i n a r y  I / O
I P  [ 0 0 0 0  0 0 0 0 ]
O P  [ 0 0 0 0  0 0 0 0 ]
```

- Apply the rated DC voltage to terminal A1-B1, A2-B2, ..., A8-B8 of terminal block TB2. Check that the status display corresponding to the input signal (IP) changes from 0 to 1. (For details of the binary input status display, see Section 4.2.4.2.)

The user will be able to perform this test for one terminal to another or for all the terminals at once.

6.4.3 Binary Output Circuit

This test can be performed by using the "Test" sub-menu and forcibly operating the relay drivers and output relays. Operation of the output contacts is monitored at the output terminal. The output contact and corresponding terminal number are shown in Appendix G.

- Select "Binary O/P" on the "Test" screen to display the "Binary O/P" screen. The LCD displays the name of the output relay.

```
/ 2  B i n a r y  O / P
B O 1                0  _
D i s a b l e / E n a b l e
B O 2                0
D i s a b l e / E n a b l e
B O 3                0
D i s a b l e / E n a b l e
B O 4                0
D i s a b l e / E n a b l e
B O 5                0
D i s a b l e / E n a b l e
B O 6                0
D i s a b l e / E n a b l e
B O 7                0
D i s a b l e / E n a b l e
```

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- Enter 1 and press the [ENTER] key.
- After completing the entries, press the [END] key. The LCD will display the screen shown below. If 1 is entered for all the output relays, the following forcible operation can be performed collectively.

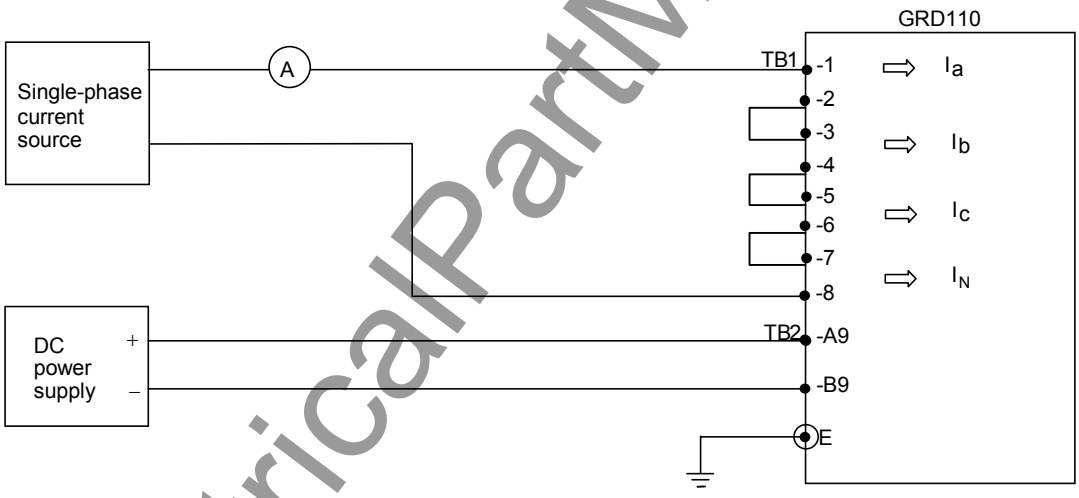
```
Operate?
ENTER=Y  CANCEL=N
```

- Keep pressing the [ENTER] key to operate the output relays forcibly.
- Check that the output contacts operate at the terminal.
- Stop pressing the [ENTER] key to reset the operation

6.4.4 AC Input Circuits

This test can be performed by applying the checking currents to the AC input circuits and verifying that the values applied coincide with the values displayed on the LCD screen.

The testing circuit is shown in Figure 6.4.2. A single-phase current source is required.



Note: AC input terminal numbers depends on model.

Figure 6.4.2 Testing AC Input Circuit

To check the metering data on the "Metering" screen, do the followings.

"Set. (view)" sub-menu → "Status" screen → "Metering" screen

If the setting is 0(= Primary), change the setting to 1(=Secondary) in the "Set. (change)" sub-menu.

"Set. (change)" sub-menu → "Status" screen → "Metering" screen

Remember to reset it to the initial setting after the test is finished.

- Open the "Metering" screen in the "Status" sub-menu.

  "Status" sub-menu → "Metering" screen

- Apply AC currents and check that the displayed values are within ±5% of the input values.

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6.5 Function Test

6.5.1 Measuring Element

Measuring element characteristics are realised by software, so it is possible to verify the overall characteristics by checking representative points.

Operation of the element under test is observed by assigning the signal number to a configurable LED or a binary output relay.

CAUTION

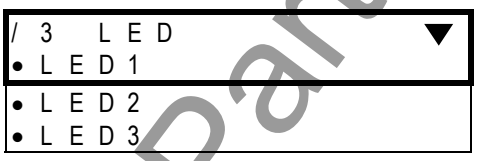
After testing, must reset settings for testing to the original settings.

In case of a three-phase element, it is sufficient to test for a representative phase. The A-phase element is selected hereafter.

Assigning signal to LED

- Select "LED" on the "Set. (change)" screen to display the "2/ LED" screen.

- Select "LED" on the "/2 LED" screen to display the "/3 LED" screen.



Note: The setting is required for all the LEDs. If any of the LEDs are not used, enter 0 to logic gates #1 to #4 in assigning signals.

- Select the LED number and press the [ENTER] key to display the "LED∗" screen.

- Select "Logic/Reset" to display the "Logic/Reset" screen.

- Enter 0 (= OR) and press the [ENTER] key.
- Enter 0 (= Instantaneous) and press the [ENTER] key.
- Press the [END] key to return to the "LED∗" screen.
- Select "Functions" on the "LED∗" screen to display the "Functions" screen.

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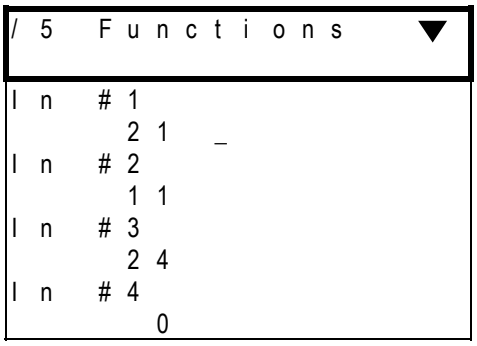
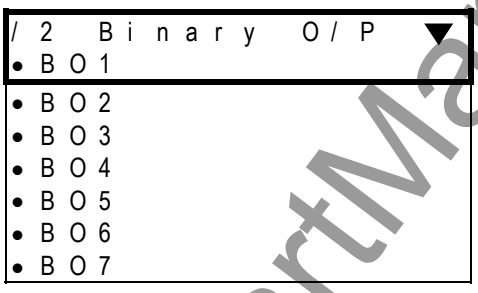


- Assign the gate In #1 the number corresponding to the testing element referring to Appendix B, and assign other gates the “0”.

Assigning signal to Binary Output Relay

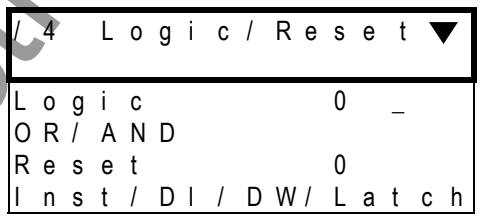
- Select "Binary O/P" on the "Set. (change)" screen to display the "Binary O/P" screen.



Note: The setting is required for all the binary outputs. If any of the binary outputs are not used, enter 0 to logic gates In #1 to #4 in assigning signals.

- Select the output relay number (BO number) and press the [ENTER] key to display the "BO∗" screen.

- Select "Logic/Reset" to display the "Logic/Reset" screen.



- Enter 0 (= OR) and press the [ENTER] key.
- Enter 0 (= Instantaneous) and press the [ENTER] key.
- Press the [END] key to return to the "BO∗" screen.
- Select "Functions" on the "BO∗" screen to display the "Functions" screen.

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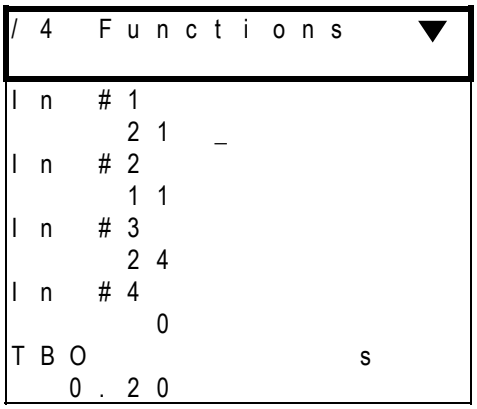

- Assign the gate In #1 the number corresponding to the testing element referring to Appendix B, and assign other gates the "0".

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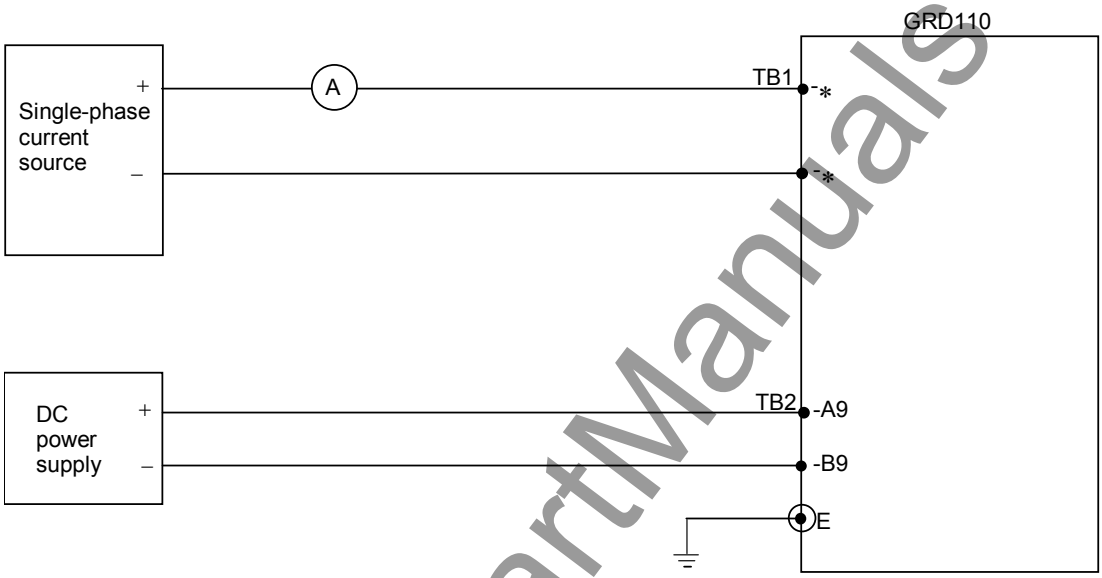
6.5.1.1 Overcurrent and undercurrent element OC1 to OC4, UC1, UC2 and CBF

The overcurrent element is checked on the operating current value and operating time for IDMT curve.

Operating current check

Figure 6.5.1 shows a testing circuit. The operating current value is checked by increasing or decreasing the magnitude of the current applied.



*: Connect the terminal number corresponding to the testing element.

Figure 6.5.1 Operating Current Value Test Circuit

The output signal of testing element is assigned a configurable LED.

The output signal numbers of the elements are as follows:

Element	Signal No.	Element	Signal No.
OC1-A	51	UC1-A	71
OC2-A	54	UC2-A	74
OC3-A	57	CBF-A	82
OC4-A	60		

- Enter the signal number to observe the operation at the LED as shown in Section 6.5.1 and press the [ENTER] key.
- Apply a test current and change the magnitude of the current applied and measure the value at which the element operates.
  Check that the measured value is within 5% of the setting value.

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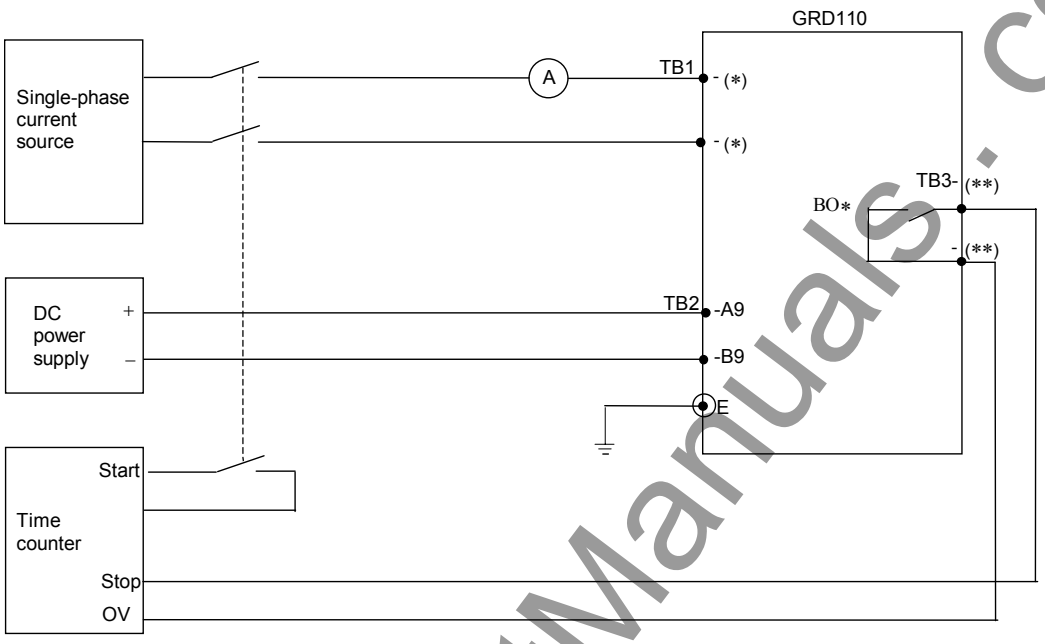
Operating time check for IDMT curve

The testing circuit is shown in Figure 6.5.2.



(*), (**) : Connect the terminal number corresponding to the testing element.

Figure 6.5.2 Testing IDMT

One of the inverse time characteristics can be set, and the output signal numbers of the IDMT elements are as follows:

Element	Signal No.
OC1-A	51
OC2-A	54

Fix the time characteristic to test by setting the scheme switch MOCI on the "PF prot." screen.

"Set.(change)" sub-menu → "Protection" screen → "Change set. (Act gp.= *)" screen → "Group*" screen → "Trip" screen → "Scheme sw" screen → "PF prot."

The test procedure is as follows:

- Enter the signal number to observe the operating time at a binary output relay as shown in Section 6.5.1 and press the ENTER key.
- Apply a test current and measure the operating time. The magnitude of the test current should be between $1.2 \times I_S$ to $20 \times I_S$, where I_S is the current setting.
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.1.1. Check that the measured operating time is within IEC 60255-3 class 5.

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6.5.1.2 Earth fault element EF1 to EF4 and SEF1 to SEF4

The earth fault element is checked on the operating current value and operating time for IDMT curve.

Operating current check

The testing circuit is shown in Figure 6.5.3.

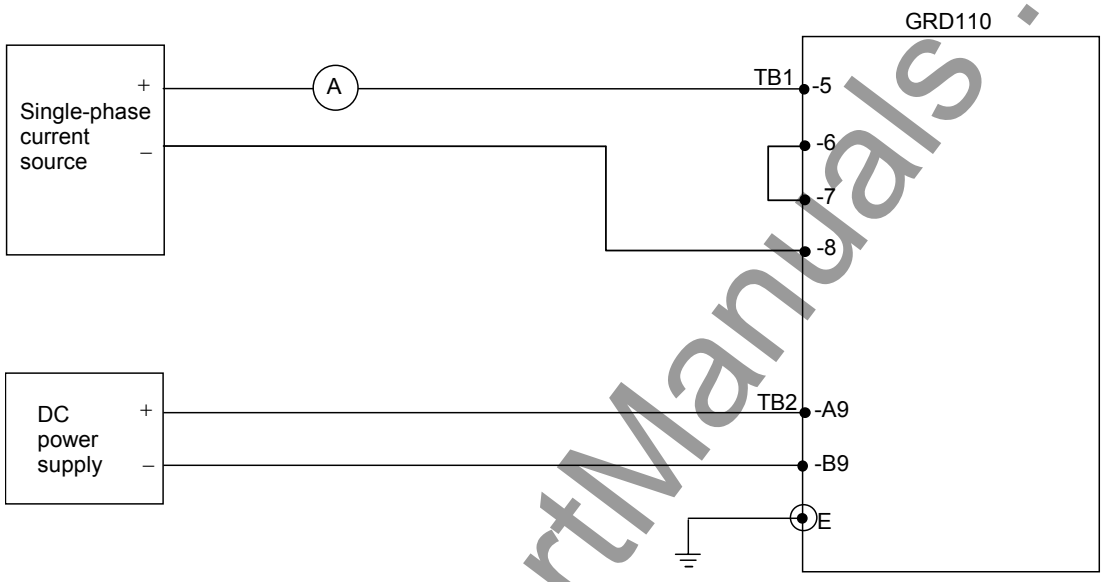

Figure 6.5.3 Test Circuit for EF and SEF Elements

The output signal of testing element is assigned a configurable LED.

The output signal numbers of the elements are as follows:

Element	Signal No.	Element	Signal No.
EF1	63	SEF1	67
EF2	64	SEF2	68
EF3	65	SEF3	69
EF4	66	SEF4	70

- Enter the signal number to observe the operation at the LED as shown in Section 6.5.1 and press the [ENTER] key.
- Apply a test current and change the magnitude of the current applied and measure the value at which the element operates.
  Check that the measured value is within 5% of the setting value.

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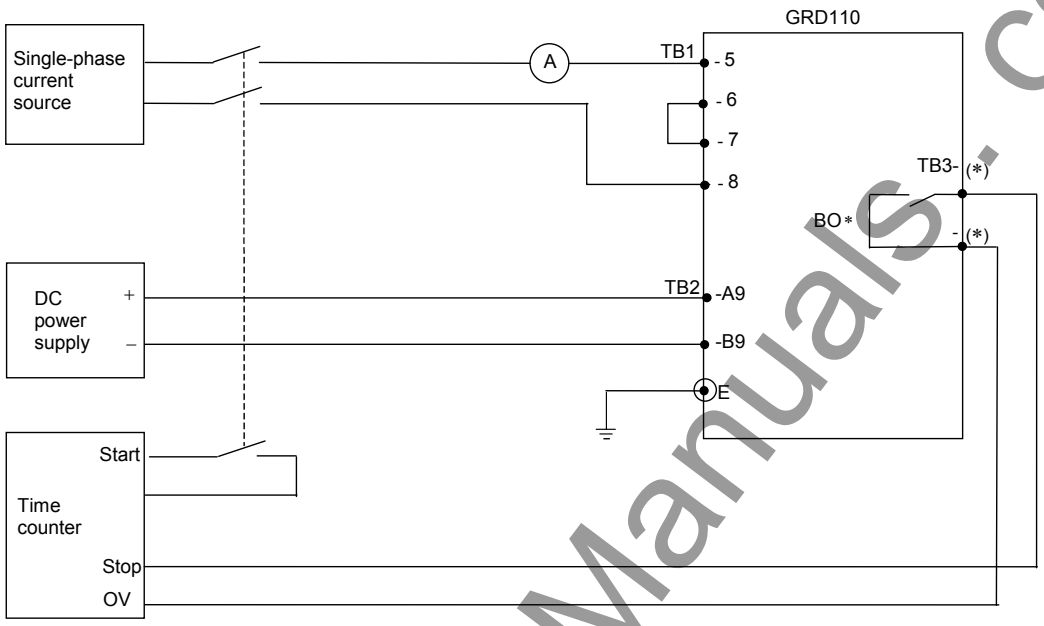
Operating time check for IDMT curve

The testing circuit is shown in Figure 6.5.4.



(*) : Connect the terminal number corresponding to the testing element.

Figure 6.5.4 Testing IDMT for EF and SEF Elements

One of the inverse time characteristics can be set, and the output signal numbers of the IDMT elements are as follows:

Element	Signal No.	Element	Signal No.
EF1	63	SEF1	67
EF2	64	SEF2	68

Fix the time characteristic to test by setting the scheme switch MEFI or MSEI on the "EF prot." or "SEF prot." screen.

"Set.(change)" sub-menu → "Protection" screen → "Change set. (Act gp.= *)" screen → "Group*" screen → "Trip" screen → "Scheme sw" screen → "EF prot." or "SEF prot." screen

The test procedure is as follows:

- Enter the signal number to observe the operating time at a binary output relay as shown in Section 6.5.1 and press the [ENTER] key.
- Apply a test current and measure the operating time. The magnitude of the test current should be between $1.2 \times I_S$ to $20 \times I_S$, where I_S is the current setting.
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.1.1. Check that the measured operating time is within IEC 60255-3 class 5.

6.5.1.3 Thermal overload element THMA and THMT

The testing circuit is same as the circuit shown in Figure 6.5.2.

The output signal of testing element is assigned a configurable LED.

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The output signal numbers of the elements are as follows:

Element	Signal No.
THMA	77
THMT	78

To test easily the thermal overload element, the scheme switch [THMRST] in the "Switch" screen on the "Test" menu is used.

- Set the scheme switch [THMRST] to "ON".
- Enter the signal number to observe the operation at the LED as shown in Section 6.5.1 and press the [ENTER] key.
- Apply a test current and measure the operating time. The magnitude of the test current should be between $1.2 \times I_S$ to $10 \times I_S$, where I_S is the current setting.

  CAUTION

  After the setting of a test current, apply the test current after checking that the THM% has become 0 on the "Metering" screen.
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.5. Check that the measured operating time is within 5%.

6.5.1.4 Negative sequence overcurrent element NPS1 and NPS2

The testing circuit is shown in Figure 6.5.5.

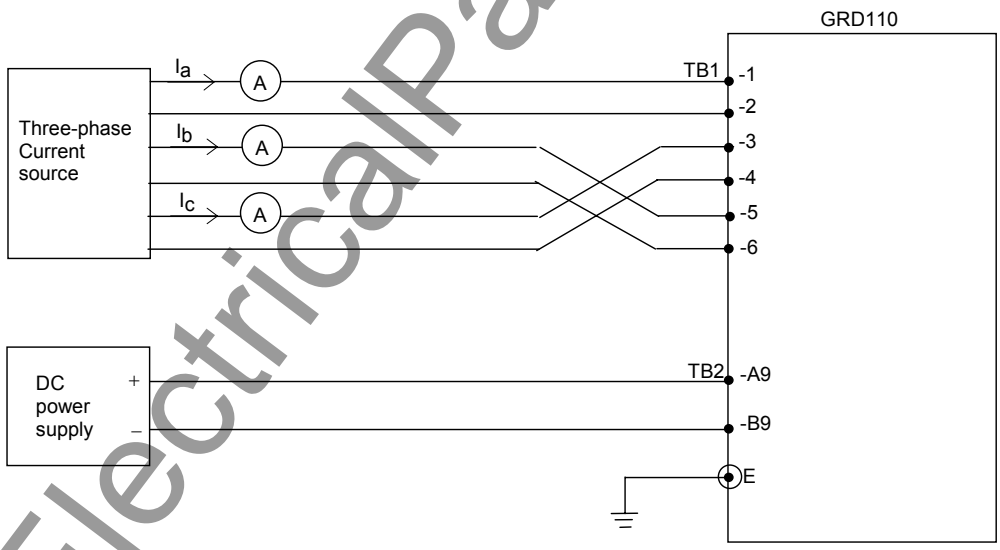

Figure 6.5.5 Testing NPS elements

The output signal of testing element is assigned a configurable LED.

The output signal numbers of the elements are as follows:

Element	Signal No.
NPS1	79
NPS2	80

- Enter the signal number to observe the operation at the LED as shown in Section 6.5.1 and

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press the [ENTER] key.

- Apply the three-phase balance current and the operating current value is checked by increasing the magnitude of the current applied.

Check that the measured value is within 5% of the setting value.

6.5.1.5 Broken conductor detection element BCD

The testing circuit is shown in Figure 6.5.6.

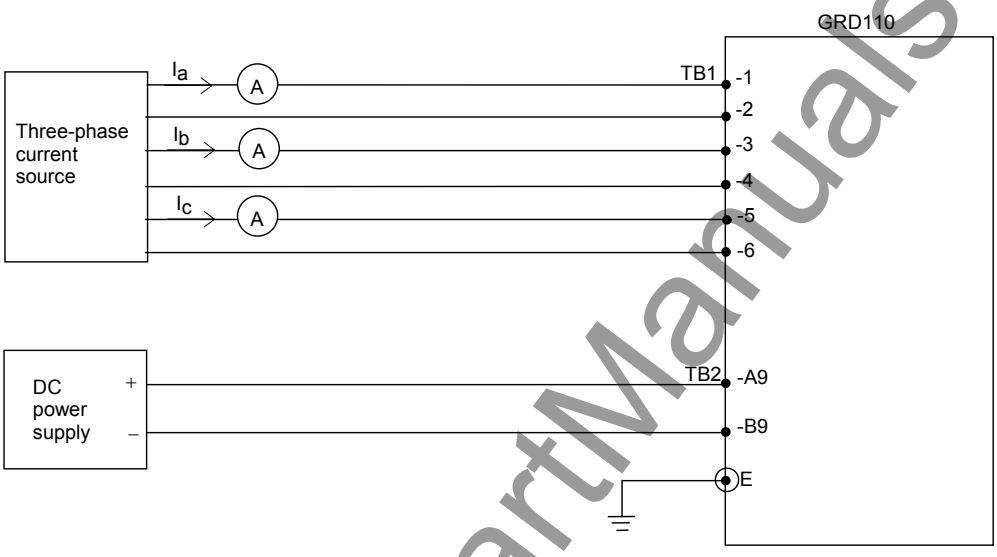

Figure 6.5.6 Testing BCD element

The output signal of testing element is assigned a configurable LED.

The output signal numbers of the elements are as follows:

Element	Signal No.
BCD	81

- Enter the signal number to observe the operation at the LED as shown in Section 6.5.1 and press the [ENTER] key.
- Apply the three-phase balance current at 10% of the rated current and interrupt a phase current.

Then, check the BCD element operates.

6.5.1.6 Cold load protection

The testing circuit is same as the circuit shown in Figure 6.5.1.

To check the cold load protection function, the scheme switch [CLPTST] in the "Switch" screen on the "Test" menu is used.

- Set the scheme switch [CLPTST] to "S0".

  Check that the OC1 operates at the setting value of normal setting group.
- Next, set the scheme switch [CLPTST] to "S3".

  Check that the OC1 operates at the setting value of cold load setting group [CLSG].

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6.5.2 Protection Scheme

In the protection scheme tests, a dynamic test set is required to simulate power system pre-fault, fault and post-fault conditions.

Tripping is observed with the tripping command output relays.

Circuit Breaker failure tripping

- Set the scheme switch [BTC] to "ON" and [RTC] to "DIR" or "OC".
- Apply a fault, retain it and input an external trip signal. Check that the retrip output relays operate after the time setting of the TCBF1 and the adjacent breaker tripping output relay operates after the time setting of the TCBF2.

6.5.3 Metering and Recording

The metering function can be checked while testing the AC input circuit. See Section 6.4.4.

Fault recording can be checked while testing the protection schemes. Open the "F. record" screen and check that the descriptions are correct for the fault concerned.

Recording events are listed in Appendix C. There are internal events and external events by binary input commands. Event recording on the external event can be checked by changing the status of binary input command signals. Change the status in the same way as the binary input circuit test (see Section 6.4.2) and check that the description displayed on the "E. Record" screen is correct. Some of the internal events can be checked in the protection scheme tests.

Disturbance recording can be checked while testing the protection schemes. The LCD display only shows the date and time when a disturbance is recorded. Open the "D. record" screen and check that the descriptions are correct.

Details can be displayed on the PC. Check that the descriptions on the PC are correct. For details on how to obtain disturbance records on the PC, see the RSM100 Manual.

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6.6 Conjunctive Tests

6.6.1 On Load Test

To check the polarity of the current transformers, check the load current with the metering displays on the LCD screen.

- Open the "Auto-supervision" screen check that no message appears.
- Open the following "Metering" screen from the "Status" sub-menu to check the load current.

```
/2  Metering                ▼
Ia          **.**   KA
Ib          **.**   KA
Ic          **.**   KA
Ie          **.**   KA
Ise         **.***  KA
I1          **.**   KA
I2          **.**   KA
I2/I1       **.**
THM         ***.*   %
Iamax       **.**   KA
Ibmax       **.**   KA
Icmax       **.**   KA
Iemax       **.**   KA
Isemax      **.***  KA
I2max       **.**   KA
I21max      **.**
```

Note: The magnitude of current can be set in values on the primary side or on the secondary side by the setting. (The default setting is the primary side.)

6.6.2 Tripping Circuit Test

The tripping circuit including the circuit breaker is checked by forcibly operating the output relay and monitoring the circuit breaker to confirm that it is tripped. Forcible operation of the output relay is performed on the "Binary O/P " screen of the "Test" sub-menu as described in Section 6.4.3.

Tripping circuit

- Set the breaker to be closed.
- Select "Binary O/P" on the "Test" sub-menu screen to display the "Binary O/P" screen.

```
/2  Binary O/P              ▼

BO1                 0   _
Disable/Enable
BO2                 0
Disable/Enable
BO3                 0
Disable/Enable
BO4                 0
Disable/Enable
BO5                 0
Disable/Enable
BO6                 0
```

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```
Disable/Enable
BO7              0
Disable/Enable
```

BO1 to BO7 are output relays with one normally open contact.

- Enter 1 for BO1 and press the [ENTER] key.
- Press the [END] key. Then the LCD displays the screen shown below.

```
Operate?
ENTER=Y  CANCEL=N
```

- Keep pressing the [ENTER] key to operate the output relay BO1 and check that the A-phase breaker is tripped.
- Stop pressing the [ENTER] key to reset the operation.
- Repeat the above for BO2 to BO7.

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6.7 Maintenance

6.7.1 Regular Testing

The relay is almost completely self-supervised. The circuits that can not be supervised are binary input and output circuits and human interfaces.

Therefore, regular testing is minimised to checking the unsupervised circuits. The test procedures are the same as described in Sections 6.4.1, 6.4.2 and 6.4.3.

6.7.2 Failure Tracing and Repair

Failures will be detected by automatic supervision or regular testing.

When a failure is detected by supervision, a remote alarm is issued with the binary output relay of FAIL and the failure is indicated on the front panel with LED indicators or LCD display. It is also recorded in the event record.

Failures detected by supervision are traced by checking the "Err: " screen on the LCD. Table 6.7.1 shows LCD messages and failure locations.

The locations marked with (1) have a higher probability than locations marked with (2).

Table 6.7.1 LCD Message and Failure Location

Message	Failure location		
	Relay Unit	AC cable	CB or cable
Err: SUM	×(Flash memory)		
Err: RAM	×(SRAM)		
Err: BRAM	×(Backup RAM)		
Err: EEP	×(EEPROM)		
Err: A/D	×(A/D converter)		
Err: DC	×(DC power supply circuit)		
Err: TC	×(Tripping circuit)(1)		× (2)
Err: CT	× (AC input circuit)(1)	× (2)	
Err: CB	× (Circuit breaker)(1)		× (2)

( ): Probable failure location in the relay unit including its peripheral circuits.

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If no message is shown on the LCD, this means that the failure location is either in the DC power supply circuit or in the microprocessors. If the "ALARM" LED is off, the failure is in the DC power supply circuit. If the LED is lit, the failure is in the microprocessors. Replace the relay unit in both cases after checking if the correct DC voltage is applied to the relay.

If a failure is detected by automatic supervision or regular testing, replace the failed relay unit.

Note: When a failure or an abnormality is detected during the regular test, confirm the following first:
- Test circuit connections are correct.
- Modules are securely inserted in position.
- Correct DC power voltage is applied.
- Correct AC inputs are applied.
- Test procedures comply with those stated in the manual.

6.7.3 Replacing Failed Relay Unit

If the failure is identified to be in the relay unit and the user has a spare relay unit, the user can recover the protection by replacing the failed relay unit.

Repair at the site should be limited to relay unit replacement. Maintenance at the component level is not recommended.

Check that the replacement relay unit has an identical Model Number and relay version (software type form) as the removed relay.

The Model Number is indicated on the front of the relay. For the relay version, see Section 4.2.5.1.

Replacing the relay unit

CAUTION After replacing the relay unit, check the settings.

The procedure of relay withdrawal and insertion is as follows:

- Switch off the DC power supply.

  ⚠ WARNING Hazardous voltage may remain in the DC circuit just after switching off the DC power supply. It takes about 30 seconds for the voltage to discharge.

- Disconnect the trip outputs.
- Short-circuit all AC current inputs.
- Unscrew the relay front cover.
- Unscrew the binding screw on the handle.
- To remove the relay unit from its case, pull up the handle and pull the handle towards you. (See Figure 6.7.1.)
- Insert the (spare) relay unit in the reverse procedure.

CAUTION To avoid risk of damage:
- Keep the handle up when inserting the relay unit into the case.
- Do not catch the handle when carrying the relay unit.
- Check that the relay unit and its case have the identical Model Number when inserting the relay unit.

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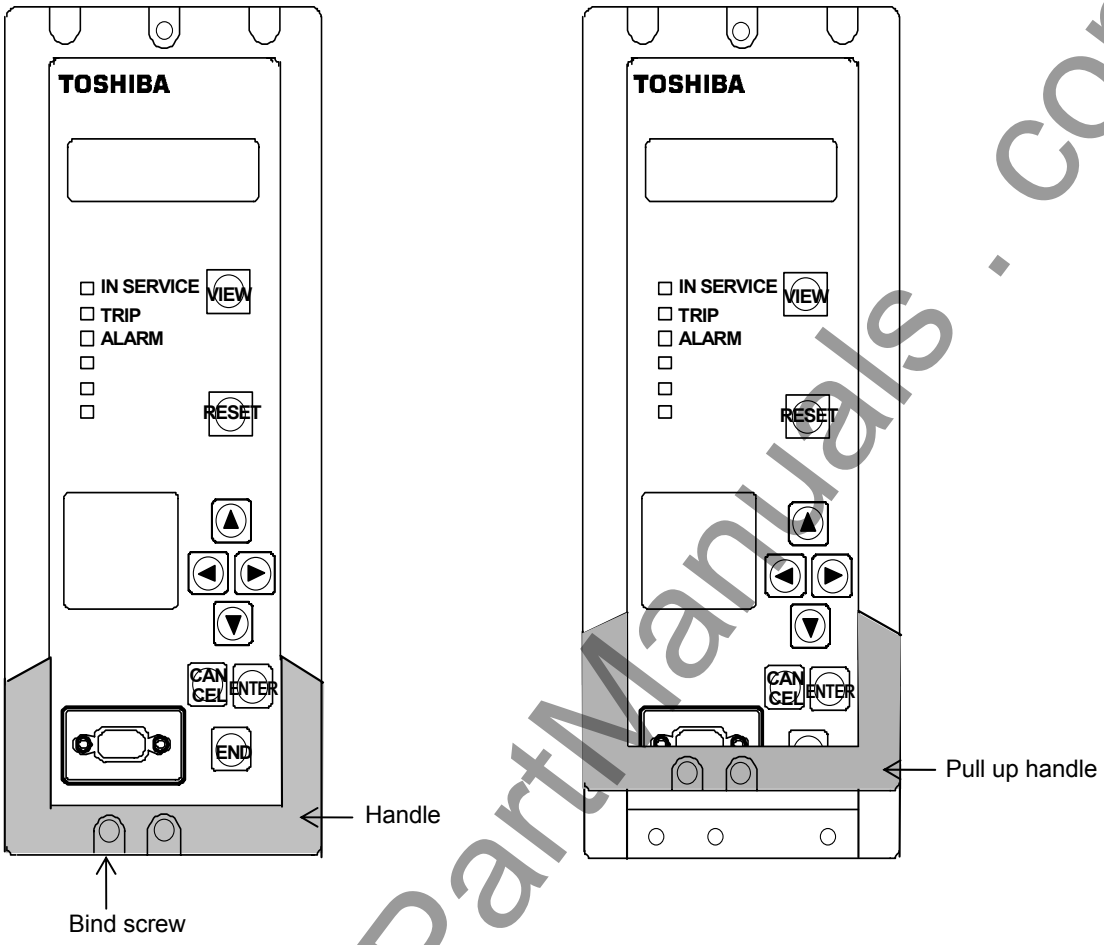

Figure 6.7.1 Handle of Relay Unit

6.7.4 Resumption of Service

After replacing the failed relay unit or repairing failed external circuits, take the following procedures to restore the relay to the service.

- Switch on the DC power supply and confirm that the "IN SERVICE" green LED is lit and the "ALARM" red LED is not lit.
- Supply the AC inputs and reconnect the trip outputs.

6.7.5 Storage

The spare relay should be stored in a dry and clean room. Based on IEC Standard 60255-6 the storage temperature should be –25°C to +70°C, but the temperature of 0°C to +40°C is recommended for long-term storage.

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7. Putting Relay into Service

The following procedure must be adhered to when putting the relay into service after finishing the commissioning tests or maintenance tests.

- Check that all the external connections are correct.
- Check the settings of all measuring elements, timers, scheme switches, recordings and clock are correct.

  In particular, when settings are changed temporarily for testing, be sure to restore them.
- Clear any unnecessary records on faults, events and disturbances which are recorded during the tests.
- Press the VIEW key and check that no failure message is displayed on the "Auto-supervision" screen.
- Check that the green "IN SERVICE" LED is lit and no other LEDs are lit on the front panel.

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Appendix A

Programmable Reset Characteristics and Implementation of Thermal Model to IEC60255-8

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Programmable Reset Characteristics

The overcurrent stages for phase and earth faults, OC1 and EF1, each have a programmable reset feature. Resetting may be instantaneous, definite time delayed, or, in the case of IEEE/US curves, inverse time delayed.

Instantaneous resetting is normally applied in multi-shot auto-reclosing schemes, to ensure correct grading between relays at various points in the scheme. On the other hand, the inverse reset characteristic is particularly useful to provide correct co-ordination with an upstream induction disc type overcurrent relay.

The definite time delayed reset characteristic may be used to provide faster clearance of intermittent ('pecking' or 'flashing') fault conditions. An example of where such phenomena may be experienced is in plastic insulated cables, where the fault energy melts the cable insulation and temporarily extinguishes the fault, after which the insulation again breaks down and the process repeats.

An inverse time overcurrent protection with instantaneous resetting cannot detect this condition until the fault becomes permanent, thereby allowing a succession of such breakdowns to occur, with associated damage to plant and danger to personnel. If a definite time reset delay of, for example, 60 seconds is applied, on the other hand, the inverse time element does not reset immediately after each successive fault occurrence. Instead, with each new fault inception, it continues to integrate from the point reached during the previous breakdown, and therefore operates before the condition becomes permanent. Figure A-1 illustrates this theory.

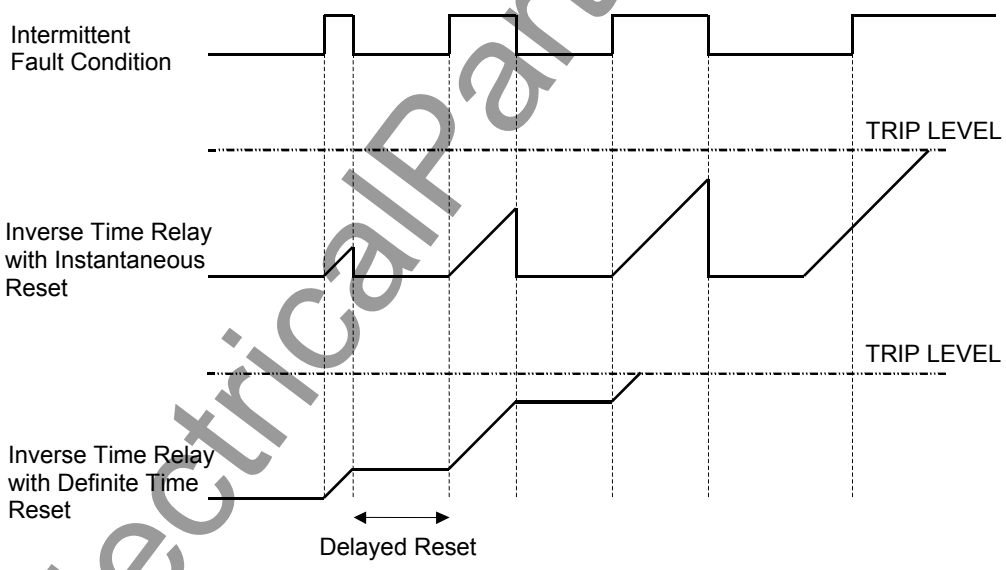

Figure A-1

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Implementation of Thermal Model to IEC60255-8

Heating by overload current and cooling by dissipation of an electrical system follow exponential time constants. The thermal characteristics of the electrical system can be shown by equation (1).

$$\theta = \frac{I^2}{I_{AOL}^2}\left(1 - e^{-t/\tau}\right) \times 100\% \qquad (1)$$

where:

θ = thermal state of the system as a percentage of allowable thermal capacity,

I = applied load current,

I_{AOL} = allowable overload current of the system,

τ = thermal time constant of the system.

The thermal state θ is expressed as a percentage of the thermal capacity of the protected system, where 0% represents the cold state and 100% represents the thermal limit, that is the point at which no further temperature rise can be safely tolerated and the system should be disconnected. The thermal limit for any given electrical plant is fixed by the thermal setting I_{AOL}. The relay gives a trip output when θ = 100%.

If current I is applied to a cold system, then θ will rise exponentially from 0% to ($I^2/I_{AOL}^2 \times 100\%$), with time constant τ, as in Figure A-2. If θ = 100%, then the allowable thermal capacity of the system has been reached.

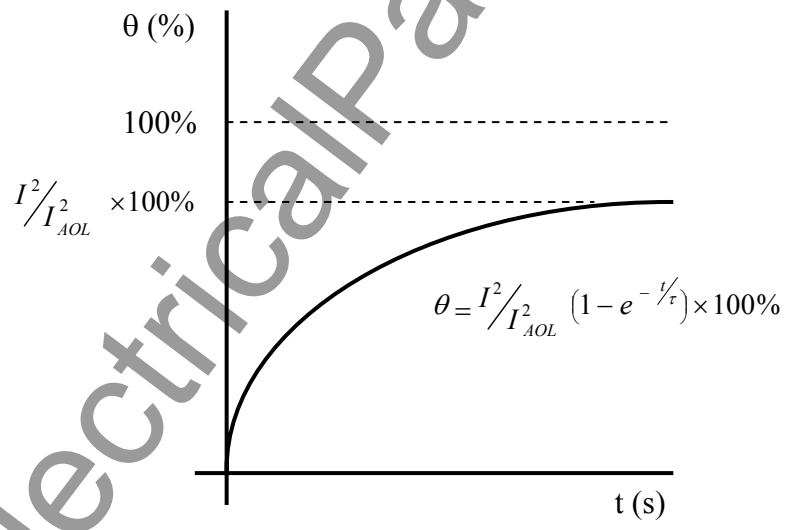

Figure A-2

A thermal overload protection relay can be designed to model this function, giving tripping times according to the IEC60255-8 'Hot' and 'Cold' curves.

$$t = \tau \cdot Ln\left[\frac{I^2}{I^2 - I_{AOL}^2}\right] \qquad (1) \quad \cdots\cdots \text{Cold curve}$$

$$t = \tau \cdot Ln\left[\frac{I^2 - I_P{}^2}{I^2 - I_{AOL}^2}\right] \qquad (2) \quad \cdots\cdots \text{Hot curve}$$

where:

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I_P = prior load current.

In fact, the cold curve is simply a special case of the hot curve where prior load current $I_P = 0$, catering for the situation where a cold system is switched on to an immediate overload.

Figure A-3 shows a typical thermal profile for a system which initially carries normal load current, and is then subjected to an overload condition until a trip results, before finally cooling to ambient temperature.

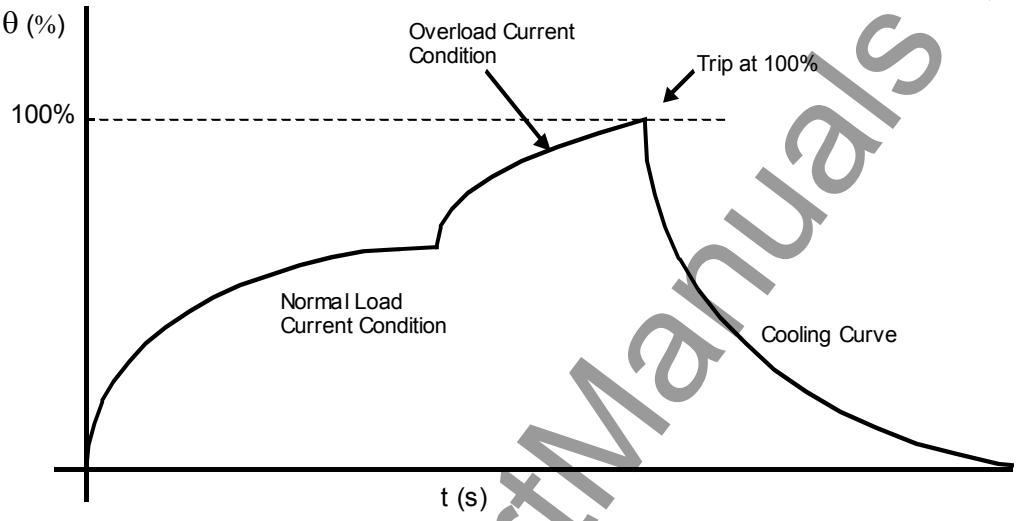

Figure A-3

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Appendix B

Signal List

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No.	SIGNAL NAME	Contents
0		Not in use
1	BI1 COMMAND	Binary input signal of BI1
2	BI2 COMMAND	Binary input signal of BI2
3	BI3 COMMAND	Binary input signal of BI3
4	BI4 COMMAND	Binary input signal of BI4
5	BI5 COMMAND	Binary input signal of BI5
6	BI6 COMMAND	Binary input signal of BI6
7	BI7 COMMAND	Binary input signal of BI7
8	BI8 COMMAND	Binary input signal of BI8
9		
10		
11	SET.GROUP1	BI command of change active setting group1
12	SET.GROUP2	BI command of change active setting group2
13	SET.GROUP3	BI command of change active setting group3
14	SET.GROUP4	BI command of change active setting group4
15	OC1 BLOCK	BI command of OC1 protection scheme block
16	OC2 BLOCK	BI command of OC2 protection scheme block
17	OC3 BLOCK	BI command of OC3 protection scheme block
18	OC4 BLOCK	BI command of OC4 protection scheme block
19	EF1 BLOCK	BI command of EF1 protection scheme block
20	EF2 BLOCK	BI command of EF2 protection scheme block
21	EF3 BLOCK	BI command of EF3 protection scheme block
22	EF4 BLOCK	BI command of EF4 protection scheme block
23	SEF1 BLOCK	BI command of SEF1 protection scheme block
24	SEF2 BLOCK	BI command of SEF2 protection scheme block
25	SEF3 BLOCK	BI command of SEF3 protection scheme block
26	SEF4 BLOCK	BI command of SEF4 protection scheme block
27	UC BLOCK	BI command of UC protection scheme block
28	THM BLOCK	BI command of Thermal overload protection scheme block
29	NPS BLOCK	BI command of NPS protection scheme block
30	BCD BLOCK	BI command of Bloken Conductor protection scheme block
31	TC FAIL	BI command of Trip circuit Fail Alarm
32	CB CONT OPN	BI command of CB N/O contact
33	CB CONT CLS	BI command of CB N/C contact
34	EXT TRIP-3PH	BI command of External trip (3 Phase)
35	EXT TRIP-APH	BI command of External trip (A Phase)
36	EXT TRIP-BPH	BI command of External trip (B Phase)
37	EXT TRIP-CPH	BI command of External trip (C Phase)
38	REMOTE RESET	BI command of Remote reset
39	SYNC CLOCK	BI command of Synchronise Clock
40	STORE RECORD	BI command of Store Disturbance Record
41	ALARM1	BI command of Alarm1
42	ALARM2	BI command of Alarm2
43	ALARM3	BI command of Alarm3
44	ALARM4	BI command of Alarm4
45		
46		
47		
48		
49		
50		

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No.	SIGNAL NAME	Contents
51	OC1-A	OC1-A relay element output
52	OC1-B	OC1-B relay element output
53	OC1-C	OC1-C relay element output
54	OC2-A	OC2-A relay element output
55	OC2-B	OC2-B relay element output
56	OC2-C	OC2-C relay element output
57	OC3-A	OC3-A relay element output
58	OC3-B	OC3-B relay element output
59	OC3-C	OC3-C relay element output
60	OC4-A	OC4-A relay element output
61	OC4-B	OC4-B relay element output
62	OC4-C	OC4-C relay element output
63	EF1	EF1 relay element output
64	EF2	EF2 relay element output
65	EF3	EF3 relay element output
66	EF4	EF4 relay element output
67	SEF1	SEF1 relay element output
68	SEF2	SEF2 relay element output
69	SEF3	SEF3 relay element output
70	SEF4	SEF4 relay element output
71	UC1-A	UC1-A relay element output
72	UC1-B	UC1-B relay element output
73	UC1-C	UC1-C relay element output
74	UC2-A	UC2-A relay element output
75	UC2-B	UC2-B relay element output
76	UC2-C	UC2-C relay element output
77	THM-A	THERMAL Alarm relay element output
78	THM-T	THERMAL Trip relay element output
79	NPS1	NPS1 relay element output
80	NPS2	NPS2 relay element output
81	BCD	BCD relay element output
82	CBF-A	CBF-A relay element output
83	CBF-B	CBF-B relay element output
84	CBF-C	CBF-C relay element output
85	ICLDO-A	ICLDO-A relay (OC relay) element output used in "CLP scheme"
86	ICLDO-B	ICLDO-B relay (OC relay) element output used in "CLP scheme"
87	ICLDO-C	ICLDO-C relay (OC relay) element output used in "CLP scheme"
88	OC1-A HS	High speed output of OC1-A relay
89	OC1-B HS	High speed output of OC1-B relay
90	OC1-C HS	High speed output of OC1-C relay
91	EF1 HS	High speed output of EF1 relay
92	SEF1 HS	High speed output of SEF1 relay
93	OC1-A_INST	OC1-A relay element start
94	OC1-B_INST	OC1-B relay element start
95	OC1-C_INST	OC1-C relay element start
96	EF1_INST	EF1 relay element start
97	SEF1_INST	SEF1relay element start
98	OC1_INST	OC1 relay element start
99		
100		

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No.	SIGNAL NAME	Contents
101	OC1 TRIP	OC1 trip command
102	OC1-A TRIP	OC1 trip command (A Phase)
103	OC1-B TRIP	OC1 trip command (B Phase)
104	OC1-C TRIP	OC1 trip command (C Phase)
105	OC2 TRIP	OC2 trip command
106	OC2-A TRIP	OC2 trip command (A Phase)
107	OC2-B TRIP	OC2 trip command (B Phase)
108	OC2-C TRIP	OC2 trip command (C Phase)
109	OC3 TRIP	OC3 trip command
110	OC3-A TRIP	OC3 trip command (A Phase)
111	OC3-B TRIP	OC3 trip command (B Phase)
112	OC3-C TRIP	OC3 trip command (C Phase)
113	OC4 ALARM	OC4 alarm command
114	OC4-A ALARM	OC4 alarm command (A Phase)
115	OC4-B ALARM	OC4 alarm command (B Phase)
116	OC4-C ALARM	OC4 alarm command (C Phase)
117	EF1 TRIP	EF1 trip command
118	EF2 TRIP	EF2 trip command
119	EF3 TRIP	EF3 trip command
120	EF4 ALARM	EF4 alarm command
121	SEF1-S1 TRIP	SEF1 Stage1 trip command
122	SEF1-S2 TRIP	SEF1 Stage2 trip command
123	SEF2 TRIP	SEF2 trip command
124	SEF3 TRIP	SEF3 trip command
125	SEF4 ALARM	SEF4 alarm command
126	UC1 TRIP	UC1 trip command
127	UC1-A TRIP	UC1 trip command (A Phase)
128	UC1-B TRIP	UC1 trip command (B Phase)
129	UC1-C TRIP	UC1 trip command (C Phase)
130	UC2 ALARM	UC2 alarm command
131	UC2-A ALARM	UC2 alarm command (A Phase)
132	UC2-B ALARM	UC2 alarm command (B Phase)
133	UC2-C ALARM	UC2 alarm command (C Phase)
134	THM ALARM	Thermal alarm command
135	THM TRIP	Thermal trip command
136	NPS1 TRIP	NPS1 trip command
137	NPS2 TRIP	NPS2 trip command
138	BCD TRIP	BCD trip command
139	CBF RETRIP	CBF retrip command
140	CBF TRIP	CBF back trip command
141	GEN.TRIP	General trip command
142	GEN.TRIP-A	General trip command (A Phase)
143	GEN.TRIP-B	General trip command (B Phase)
144	GEN.TRIP-C	General trip command (C Phase)
145	GEN.TRIP-EF	General trip command (EF)
146	CLP STATE0	Cold Load Protection State
147	CLP STATE1	Cold Load Protection State
148	CLP STATE2	Cold Load Protection State
149	CLP STATE3	Cold Load Protection State
150	GEN. ALARM	General alarm command

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No.	SIGNAL NAME	Contents
151		
152		
153	OC2-A_INST	OC2-A relay element start
154	OC2-B_INST	OC2-B relay element start
155	OC2-C_INST	OC2-C relay element start
156	EF2_INST	EF2 relay element start
157	SEF2_INST	SEF2relay element start
158	OC2_INST	OC2 relay element start
159		
160	A. M. F. OFF	Automatic monitoring function off
161	RELAY FAIL	Relay failure & trip blocked alarm
162	RELAY FAIL-A	Relay failure alarm (Trip not blocked)
163	TCSV	Trip circuit supervision failure
164	CBSV	Circuit breaker status monitoring failure
165	TC ALARM	Trip counter alarm
166	SGM_I^y ALM	ΣIY alarm
167	OT ALARM	Operate time alarm
168		
169		
170	BO1 OP	Binary output 1
171	BO2 OP	Binary output 2
172	BO3 OP	Binary output 3
173	BO4 OP	Binary output 4
174	BO5 OP	Binary output 5
175	BO6 OP	Binary output 6
176	BO7 OP	Binary output 7
177		
178		
179		
180		
181	LCD IND.	LCD indication(Virtual LED) command
182	LCD IND1.	LCD indication1(Virtual LED) command
183	LCD IND2.	LCD indication2(Virtual LED) command
184		
185		
186	TESTING	Testing LED lit output
187	CBF OP-A	CBF start signal (A phase)
188	CBF OP-B	CBF start signal (B phase)
189	CBF OP-C	CBF start signal (C phase)
190		
191		
192		
193	PROT. COM. ON	IEC103 communication command
194	IECTST	IEC103 communication test
195	IECBLK	IEC103 communication block
196		
197		
198		
199		
200		

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Appendix C

Event Record Items

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Event Record Item

No.	LCD indication		Contents
1	GEN.trip	Off/On	General trip command
2	GEN.trip-A	Off/On	ditto (A Phase)
3	GEN.trip-B	Off/On	ditto (B Phase)
4	GEN.trip-C	Off/On	ditto (C Phase)
5	GEN.trip-EF	Off/On	ditto (EF)
6	OC1-A trip	Off/On	OC1 trip command (A Phase)
7	OC1-B trip	Off/On	OC1 trip command (B Phase)
8	OC1-C trip	Off/On	OC1 trip command (C Phase)
9	OC2-A trip	Off/On	OC2 trip command (A Phase)
10	OC2-B trip	Off/On	OC2 trip command (B Phase)
11	OC2-C trip	Off/On	OC2 trip command (C Phase)
12	OC3-A trip	Off/On	OC3 trip command (A Phase)
13	OC3-B trip	Off/On	OC3 trip command (B Phase)
14	OC3-C trip	Off/On	OC3 trip command (C Phase)
15	OC4-A alarm	Off/On	OC4 alarm command (A Phase)
16	OC4-B alarm	Off/On	OC4 alarm command (B Phase)
17	OC4-C alarm	Off/On	OC4 alarm command (C Phase)
18	EF1 trip	Off/On	EF1 trip command
19	EF2 trip	Off/On	EF2 trip command
20	EF3 trip	Off/On	EF3 trip command
21	EF4 alarm	Off/On	EF4 alarm command
22	SEF1-S1 trip	Off/On	SEF1 Stage1 trip command
23	SEF1-S2 trip	Off/On	SEF1 Stage2 trip command
24	SEF2 trip	Off/On	SEF2 trip command
25	SEF3 trip	Off/On	SEF3 trip command
26	SEF4 alarm	Off/On	SEF4 alarm command
27	UC1-A trip	Off/On	UC1 trip(A Phase)
28	UC1-B trip	Off/On	UC1 trip(B Phase)
29	UC1-C trip	Off/On	UC1 trip(C Phase)
30	UC2-A alarm	Off/On	UC2 alarm(A Phase)
31	UC2-B alarm	Off/On	UC2 alarm(B Phase)
32	UC2-C alarm	Off/On	UC2 alarm(C Phase)
33	THM alarm	Off/On	Thermal alarm command
34	THM trip	Off/On	Thermal trip command
35	NPS1 trip	Off/On	NPS1 trip command
36	NPS2 alarm	Off/On	NPS2 alarm command
37	BCD trip	Off/On	BCD trip command
38	CBF retrip	Off/On	CBF retrip command
39	CBF trip	Off/On	CBF back trip command
40	OC1-A	Off/On	OC1-A relay element operating
41	OC1-B	Off/On	OC1-B relay element operating
42	OC1-C	Off/On	OC1-C relay element operating
43	OC2-A	Off/On	OC2-A relay element operating
44	OC2-B	Off/On	OC2-B relay element operating
45	OC2-C	Off/On	OC2-C relay element operating
46	OC3-A	Off/On	OC3-A relay element operating
47	OC3-B	Off/On	OC3-B relay element operating
48	OC3-C	Off/On	OC3-C relay element operating
49	OC4-A	Off/On	OC4-A relay element operating
50	OC4-B	Off/On	OC4-B relay element operating
51	OC4-C	Off/On	OC4-C relay element operating

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Event Record Item

No.	LCD indication		Contents
52	EF1	Off/On	EF1 relay element operating
53	EF2	Off/On	EF2 relay element operating
54	EF3	Off/On	EF3 relay element operating
55	EF4	Off/On	EF4 relay element operating
56	SEF1	Off/On	SEF1 relay element operating
57	SEF2	Off/On	SEF2 relay element operating
58	SEF3	Off/On	SEF3 relay element operating
59	SEF4	Off/On	SEF4 relay element operating
60	UC1-A	Off/On	UC1-A relay element operating
61	UC1-B	Off/On	UC1-B relay element operating
62	UC1-C	Off/On	UC1-C relay element operating
63	UC2-A	Off/On	UC2-A relay element operating
64	UC2-B	Off/On	UC2-B relay element operating
65	UC2-C	Off/On	UC2-C relay element operating
66	NPS1	Off/On	NPS1 relay element operating
67	NPS2	Off/On	NPS2 relay element operating
68	BCD	Off/On	BCD relay element operating
69	CLP STATE0	Off/On	Cold Load Protection State
70	CLP STATE1	Off/On	ditto
71	CLP STATE2	Off/On	ditto
72	CLP STATE3	Off/On	ditto
73	BI1 command	Off/On	Binary input signal of BI1
74	BI2 command	Off/On	Binary input signal of BI2
75	BI3 command	Off/On	Binary input signal of BI3
76	BI4 command	Off/On	Binary input signal of BI4
77	BI5 command	Off/On	Binary input signal of BI5
78	BI6 command	Off/On	Binary input signal of BI6
79	BI7 command	Off/On	Binary input signal of BI7
80	BI8 command	Off/On	Binary input signal of BI8
81	SET.group1	Off/On	BI command of change active setting group1
82	SET.group2	Off/On	BI command of change active setting group2
83	SET.group3	Off/On	BI command of change active setting group3
84	SET.group4	Off/On	BI command of change active setting group4
85	OC1 block	Off/On	BI command of OC1 protection scheme block
86	OC2 block	Off/On	BI command of OC2 protection scheme block
87	OC3 block	Off/On	BI command of OC3 protection scheme block
88	OC4 block	Off/On	BI command of OC4 protection scheme block
89	EF1 block	Off/On	BI command of EF1 protection scheme block
90	EF2 block	Off/On	BI command of EF2 protection scheme block
91	EF3 block	Off/On	BI command of EF3 protection scheme block
92	EF4 block	Off/On	BI command of EF4 protection scheme block
93	SEF1 block	Off/On	BI command of SEF1 protection scheme block
94	SEF2 block	Off/On	BI command of SEF2 protection scheme block
95	SEF3 block	Off/On	BI command of SEF3 protection scheme block
96	SEF4 block	Off/On	BI command of SEF4 protection scheme block
97	UC block	Off/On	BI command of UC protection scheme block
98	THM block	Off/On	BI command of Thermal overload protection scheme block
99	NPS block	Off/On	BI command of NPS protection scheme block
100	BCD block	Off/On	BI command of Broken Conductor protection scheme block

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Event Record Item			
No.	LCD indication		Contents
101	TC fail	Off/On	BI command of Trip circuit Fail Alarm
102	CB CONT OPN	Off/On	BI command of CB N/O contact
103	CB CONT CLS	Off/On	BI command of CB N/C contact
104	EXT trip-3PH	Off/On	BI command of External trip (3 Phase)
105	EXT trip-APH	Off/On	BI command of External trip (A Phase)
106	EXT trip-BPH	Off/On	BI command of External trip (B Phase)
107	EXT trip-CPH	Off/On	BI command of External trip (C Phase)
108	Remote reset	Off/On	BI command of Remote reset
109	Store record	Off/On	BI command of Store Disturbance Record
110	Alarm1	Off/On	BI command of Alarm1
111	Alarm2	Off/On	BI command of Alarm2
112	Alarm3	Off/On	BI command of Alarm3
113	Alarm4	Off/On	BI command of Alarm4
114	Relay fail	Off/On	Relay failure & trip blocked alarm
115	Relay fail-A	Off/On	Relay failure alarm (Trip not blocked)
116	TC err	Off/On	Trip circiut supervision failure
117	CB err	Off/On	Circuit breaker status monitoring failure
118	CT err	Off/On	CT circuit supervision failure
119	TP COUNT ALM	Off/On	Trip counter alarm
120	ΣI^yA ALM	Off/On	ΣIY A-phase alarm
121	ΣI^yB ALM	Off/On	ΣIY B-phase alarm
122	ΣI^yC ALM	Off/On	ΣIY C-phase alarm
123	OP time ALM	Off/On	Operate time alarm
124	F.record CLR	On	Clear Fault records
125	E.record CLR	On	Clear Event records
126	D.record CLR	On	Clear Disturbance records
127	TP COUNT CLR	On	Clear Trip counter
128	ΣI^y CLR	On	Clear ΣIY counter
129	Max.DEM CLR	On	Clear Max. demand(Imax)
130	IND.reset	On	Reset the indication of Trip mode,Alarm etc
131	Data lost	On	Record and time date lost bye DC power supply off for a long time
132	Sys.change	On	System setting change command
133	Rly.change	On	Relay setting change command
134	Grp.change	On	Group setting change command
135	OC1-A_INST	Off/On	OC1-A relay element start
136	OC1-B_INST	Off/On	OC1-B relay element start
137	OC1-C_INST	Off/On	OC1-C relay element start
138	EF1_INST	Off/On	EF1 relay element start
139	SEF1_INST	Off/On	SEF1relay element start
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Appendix D

Binary Output Default Setting List

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Relay Model	BO No.	Terminal No.	Signal Name	Contents	Setting		
					Signal No.	Logic (OR:0, AND:1)	Reset (Inst:0, Del:1 Latch:2)
		TB3:					
GRD110-110	BO1	A5-B4, A4	GENERAL TRIP	Relay trip (General)	141	0	1
	BO2	A6-A7, B7	GENERAL TRIP	Relay trip (General)	141	0	1
	BO3	A9-B8, A8	GENERAL TRIP	Relay trip (General)	141	0	1
	BO4	A11-A10, B10	GENERAL TRIP	Relay trip (General)	141	0	1
	BO5	A12-A13, B13	EF1 TRIP	EF1 element trip	117	0	1
	BO6	A15-A14, B14	EF1 TRIP	EF1 element trip	117	0	1
	BO7	B16-A16	SEF1-S1 TRIP	SEF1 stage1 trip	121	0	1
		TB3:					
GRD110-400	BO1	A5-B4, A4	GENERAL TRIP	Relay trip (General)	141	0	1
	BO2	A6-A7, B7	GENERAL TRIP	Relay trip (General)	141	0	1
	BO3	A9-B8, A8	GENERAL TRIP	Relay trip (General)	141	0	1
	BO4	A11-A10, B10	GENERAL TRIP	Relay trip (General)	141	0	1
	BO5	A12-A13, B13	OC1 TRIP	OC1 element trip	101	0	1
	BO6	A15-A14, B14	OC1 TRIP	OC1 element trip	101	0	1
	BO7	B16-A16	EF1 TRIP	EF1 element trip	117	0	1
		TB3:					
GRD110-420	BO1	A5-B4, A4	GENERAL TRIP	Relay trip (General)	141	0	1
	BO2	A6-A7, B7	GENERAL TRIP	Relay trip (General)	141	0	1
	BO3	A9-B8, A8	GENERAL TRIP	Relay trip (General)	141	0	1
	BO4	A11-A10, B10	GENERAL TRIP	Relay trip (General)	141	0	1
	BO5	A12-A13, B13	OC1 TRIP	OC1 element trip	101	0	1
	BO6	A15-A14, B14	EF1 TRIP	EF1 element trip	117	0	1
	BO7	B16-A16	SEF1-S1 TRIP	SEF1 stage1 trip	121	0	1

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Appendix E

Details of Relay Menu and LCD & Button Operation

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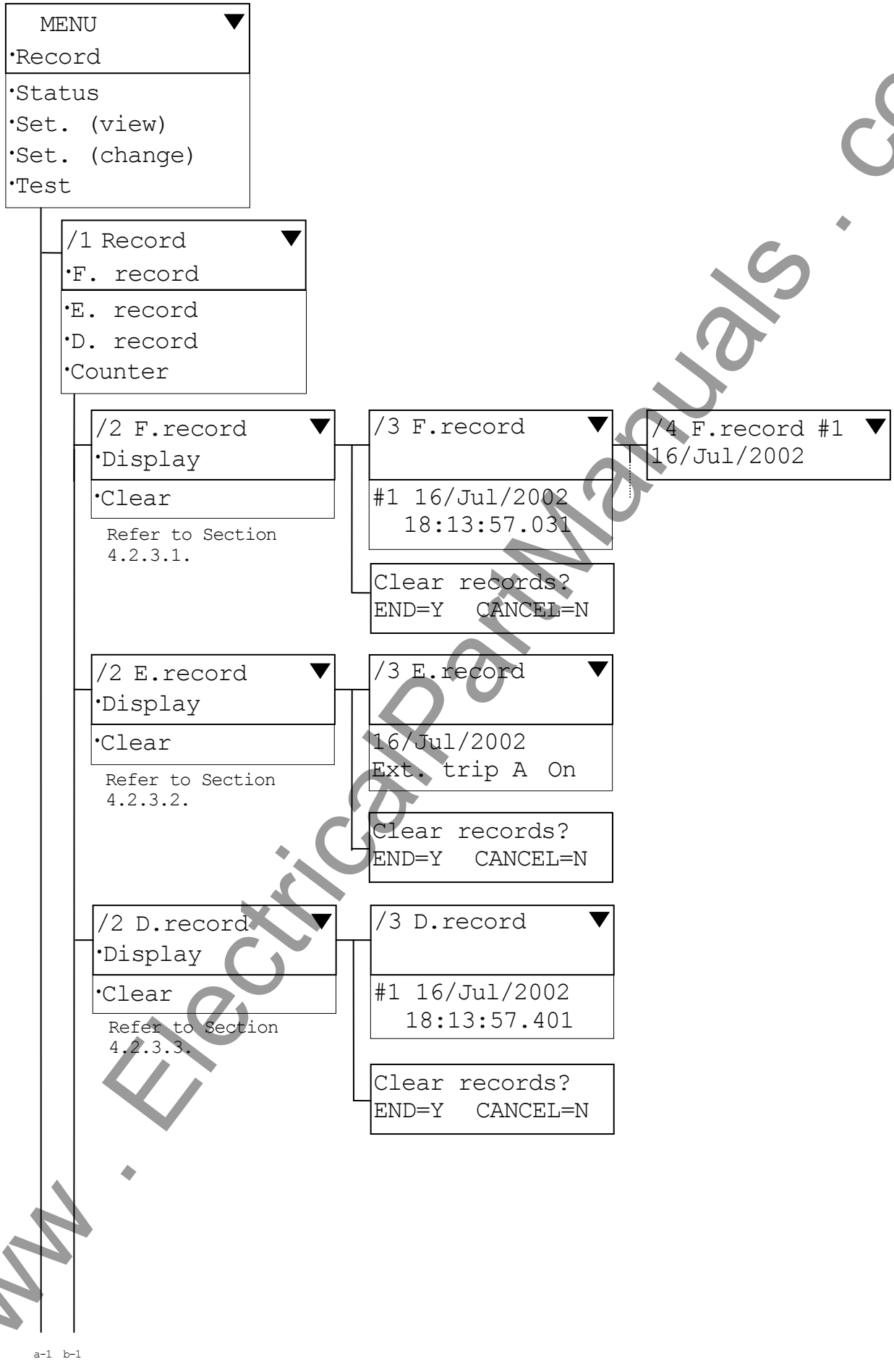

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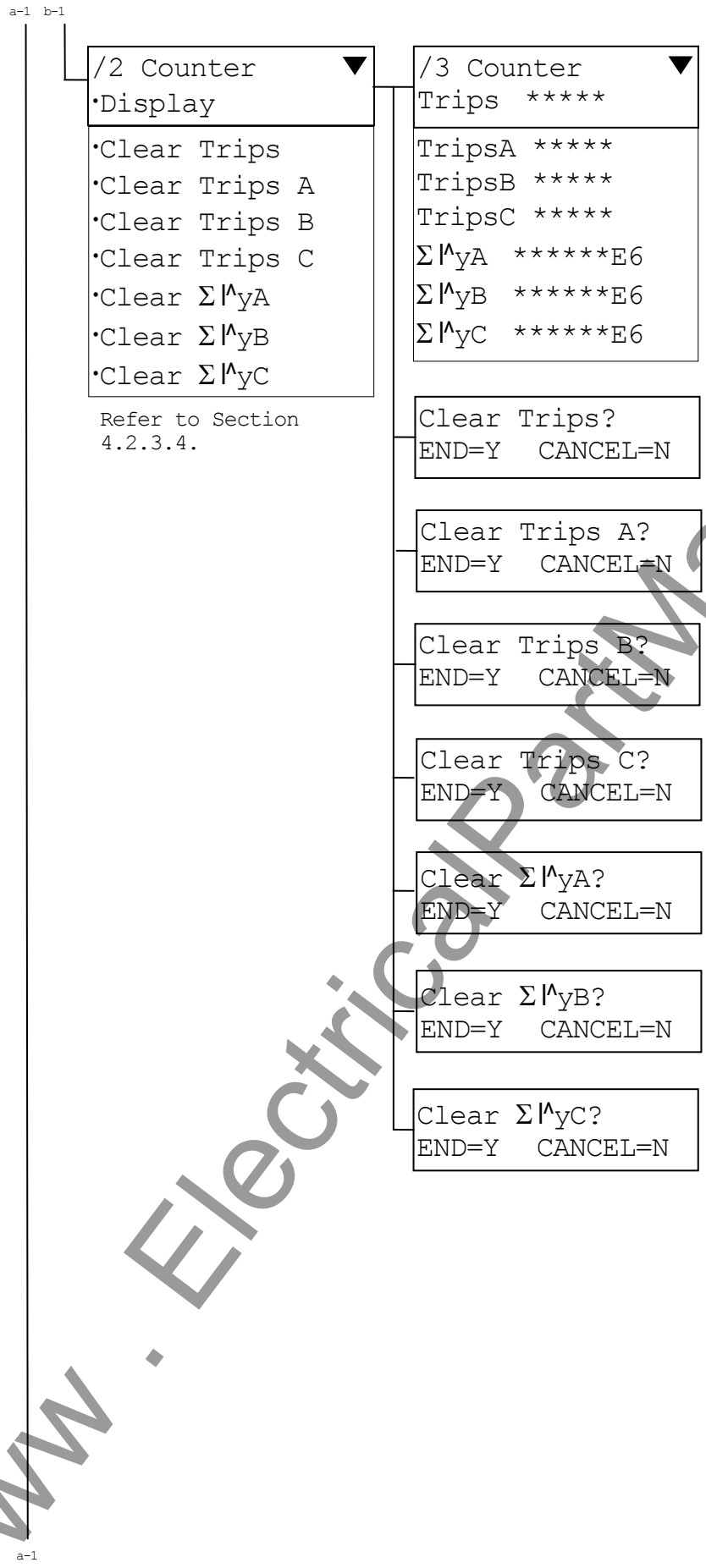

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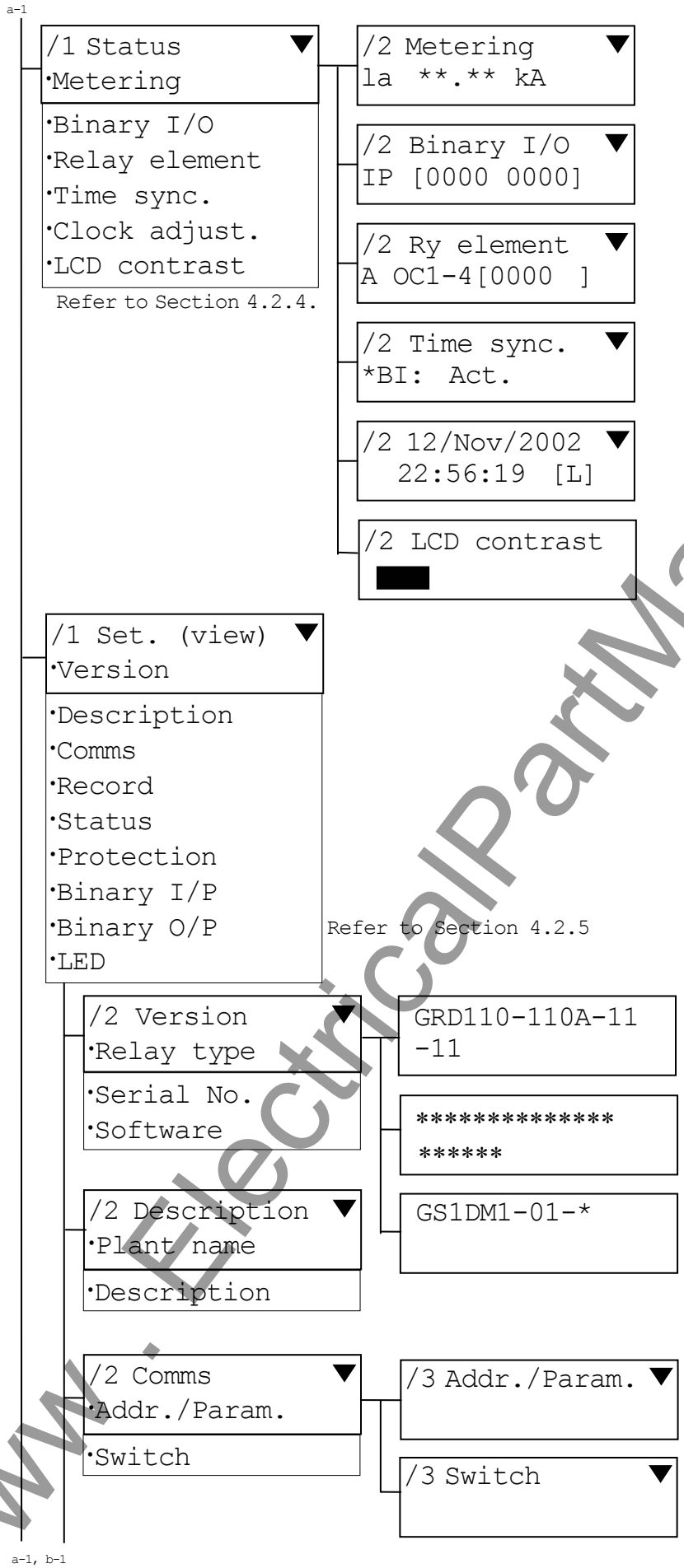

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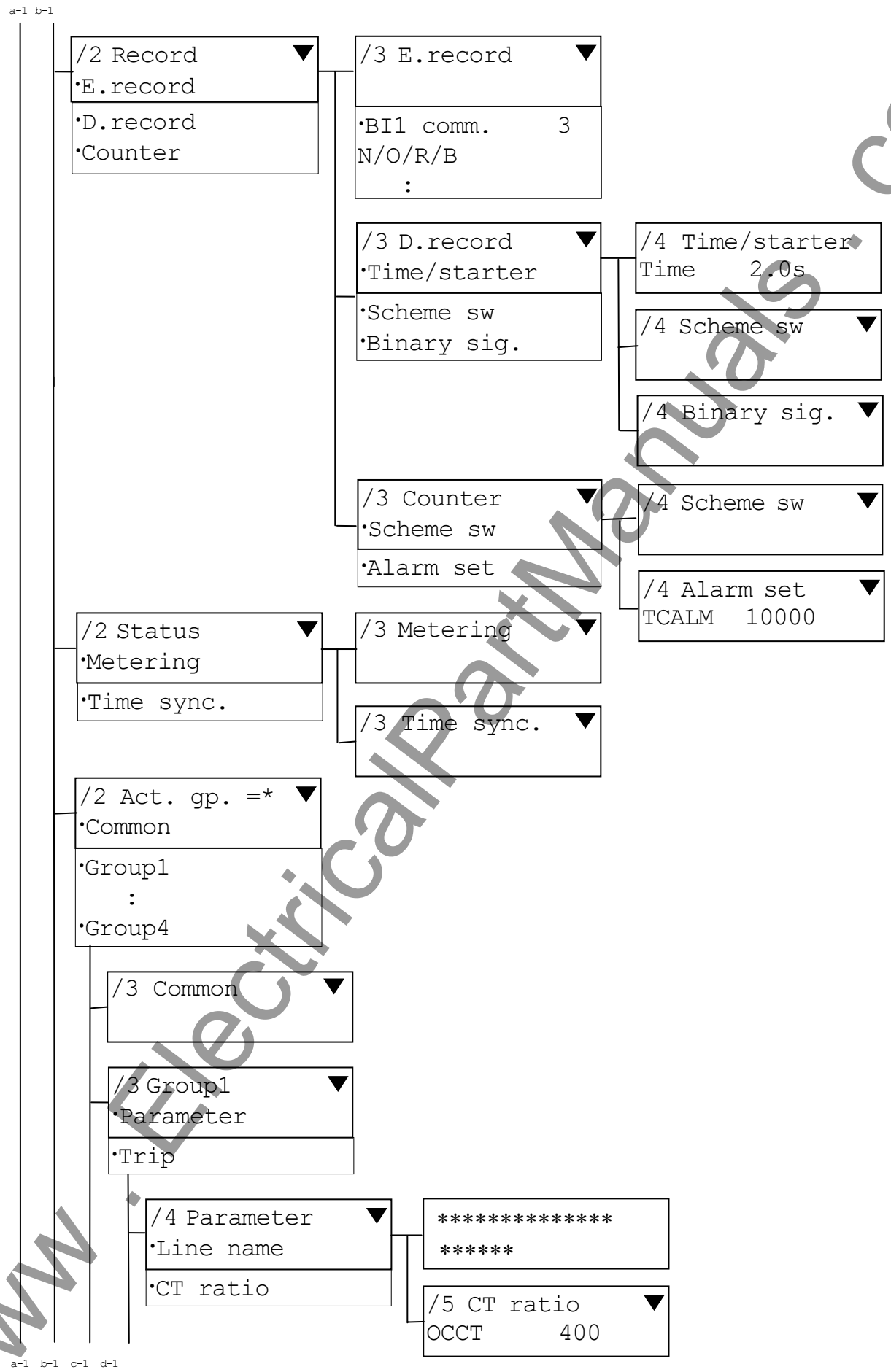

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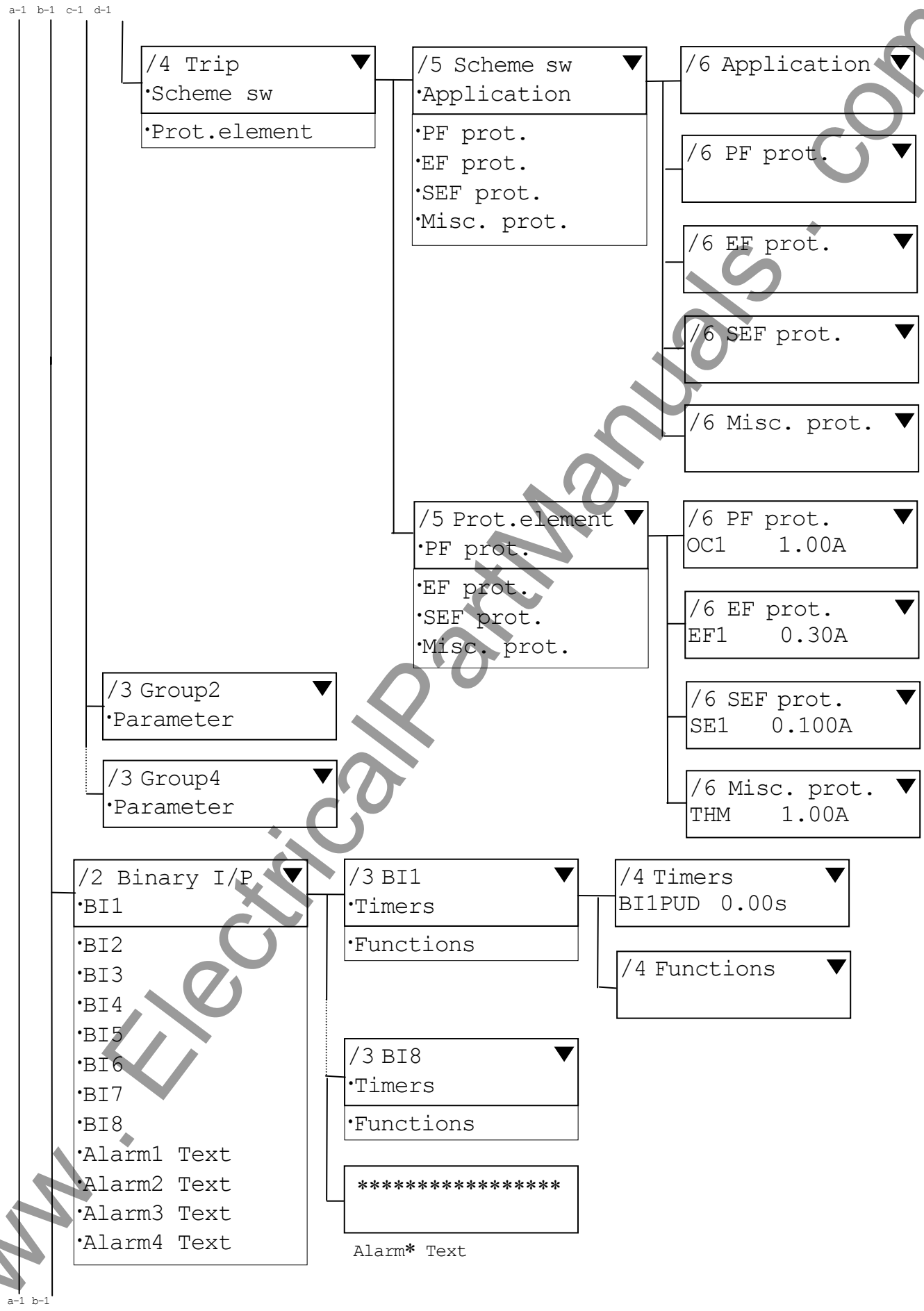

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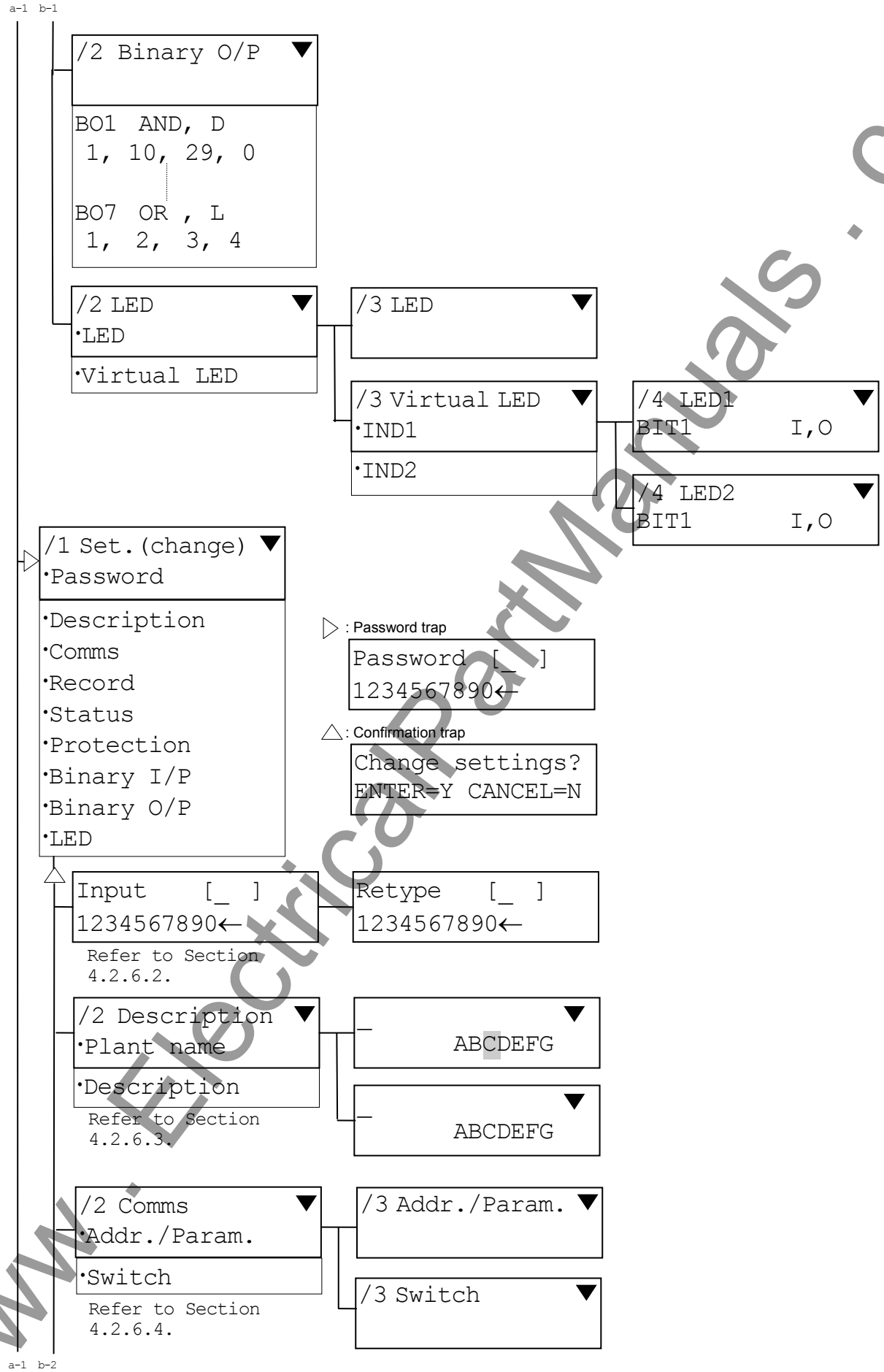

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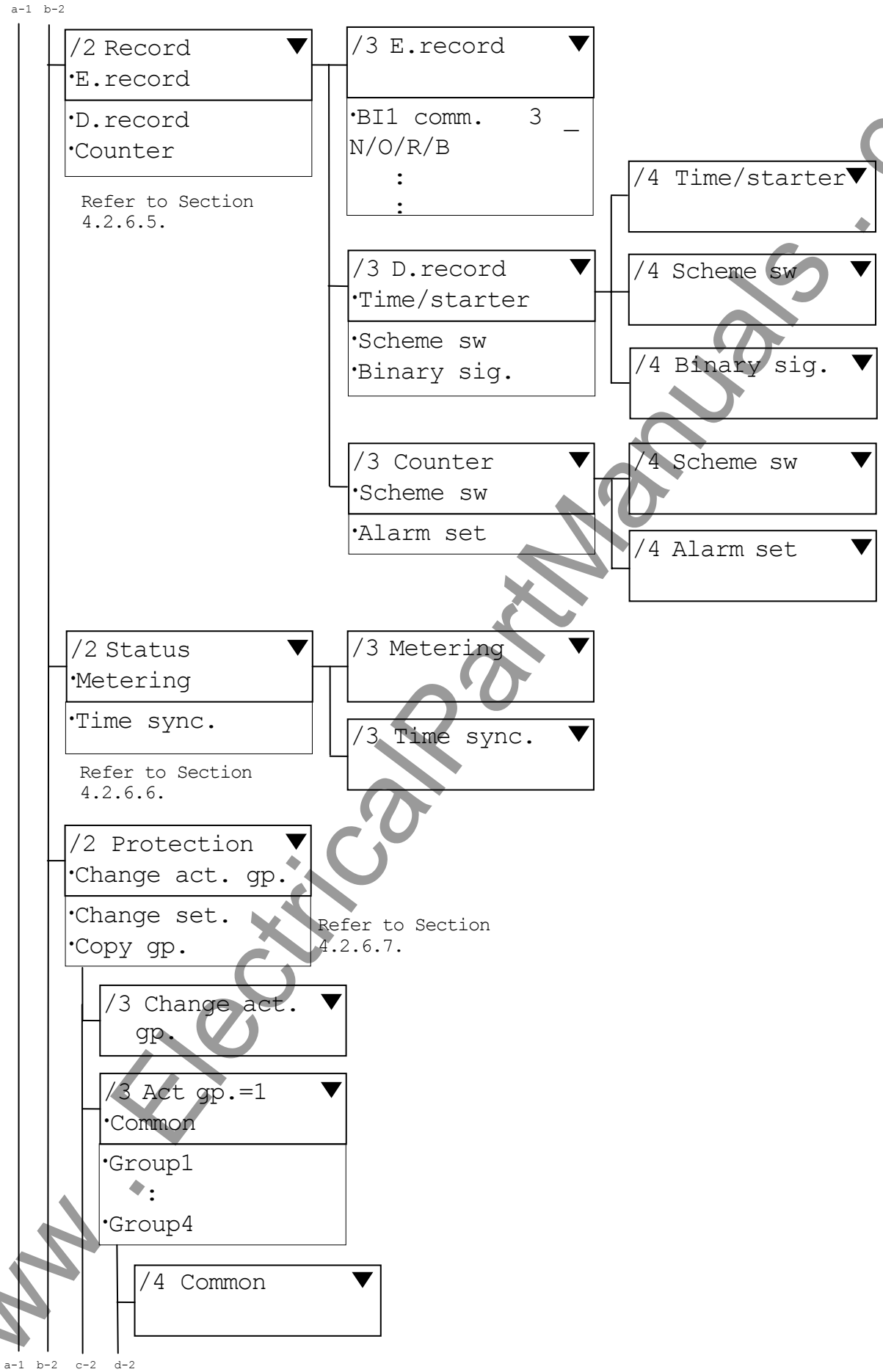

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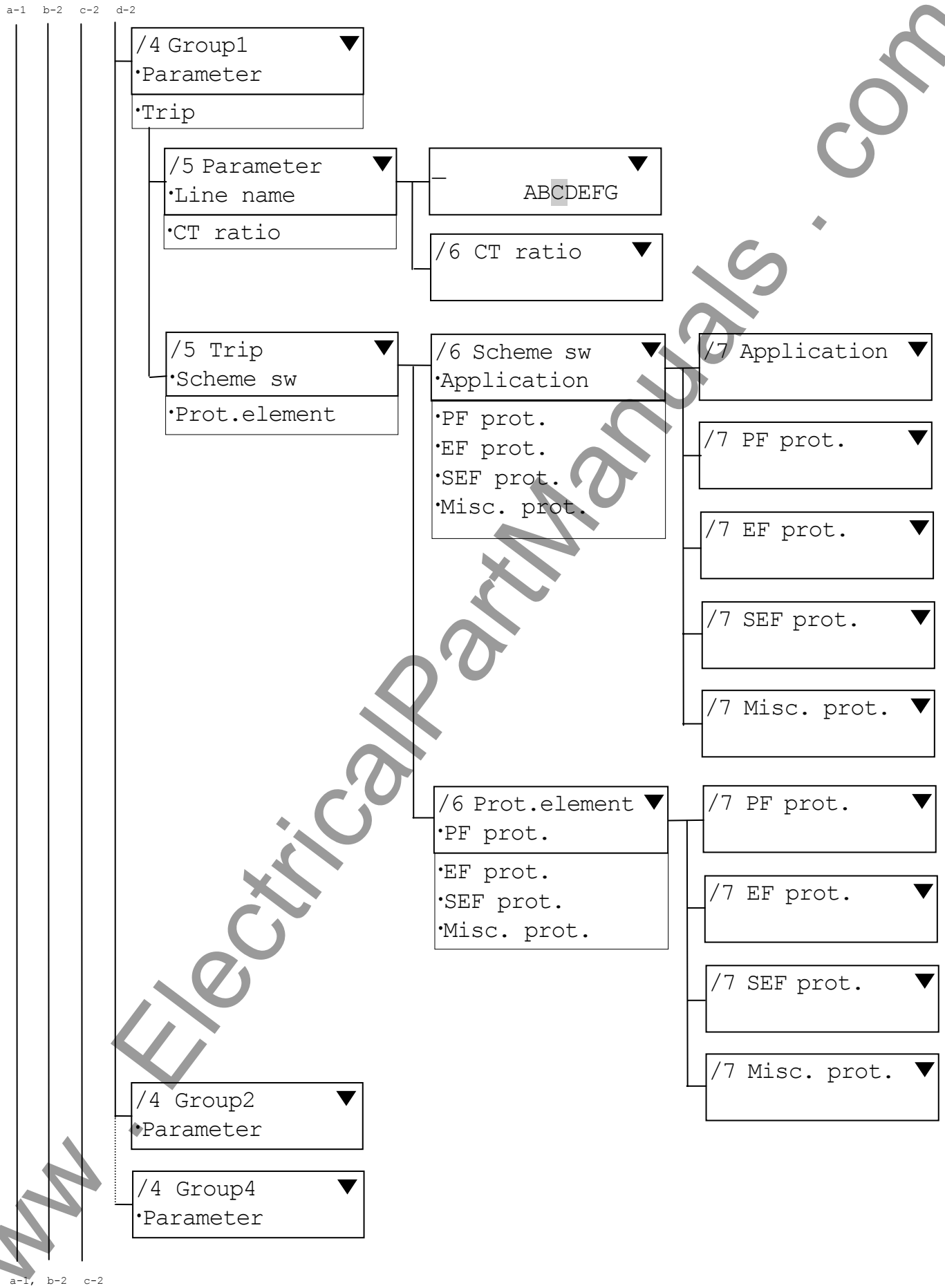

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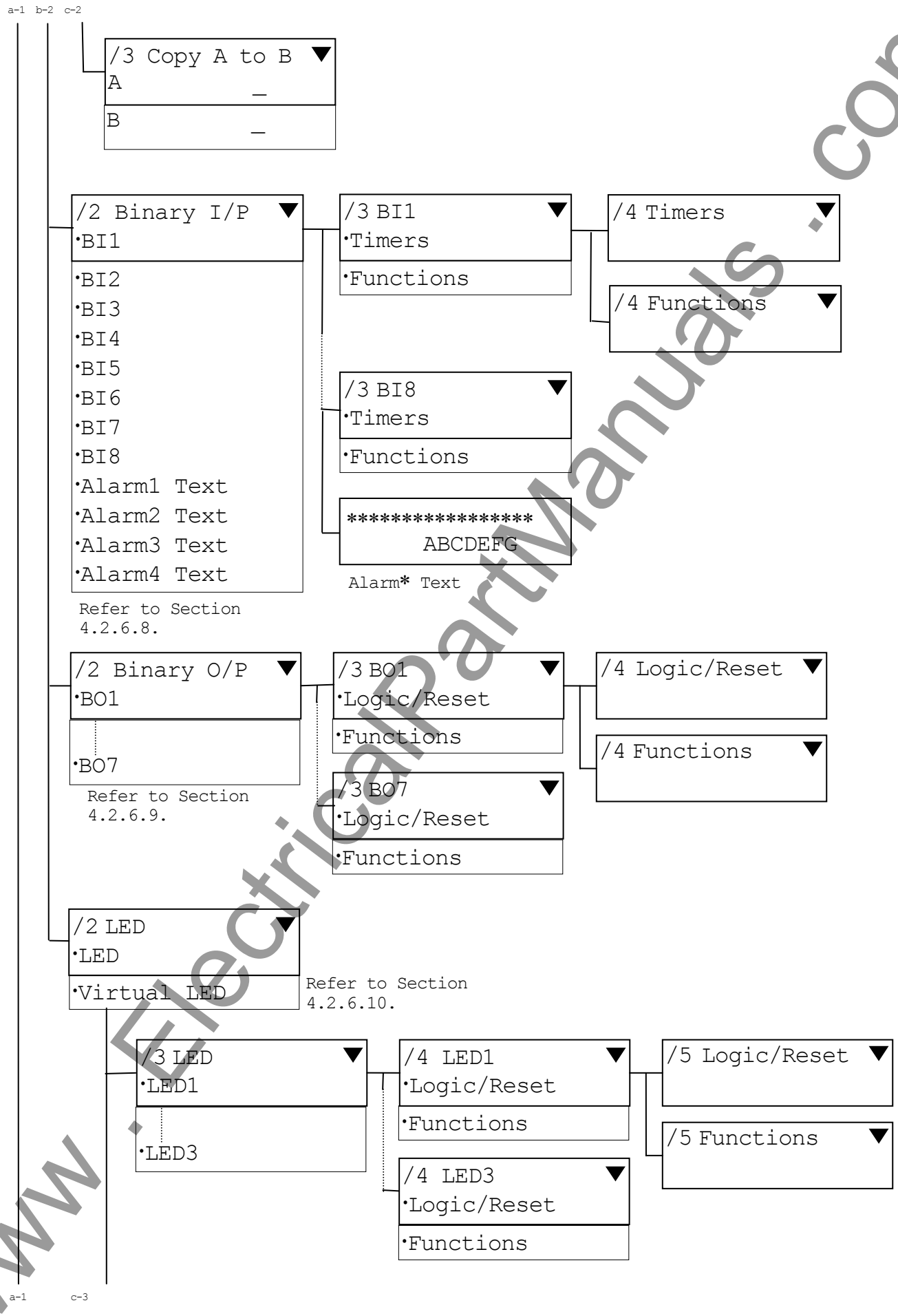

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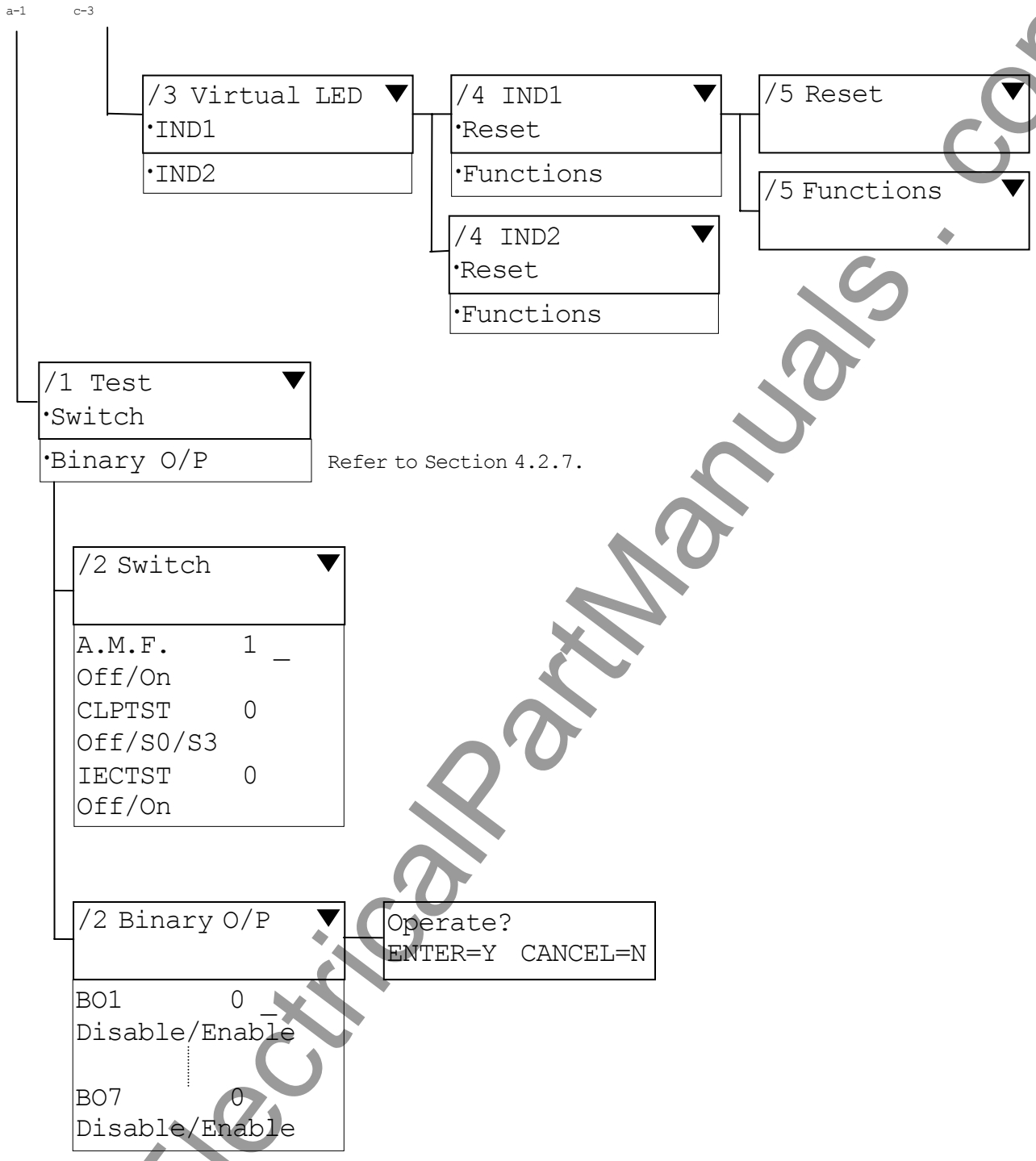

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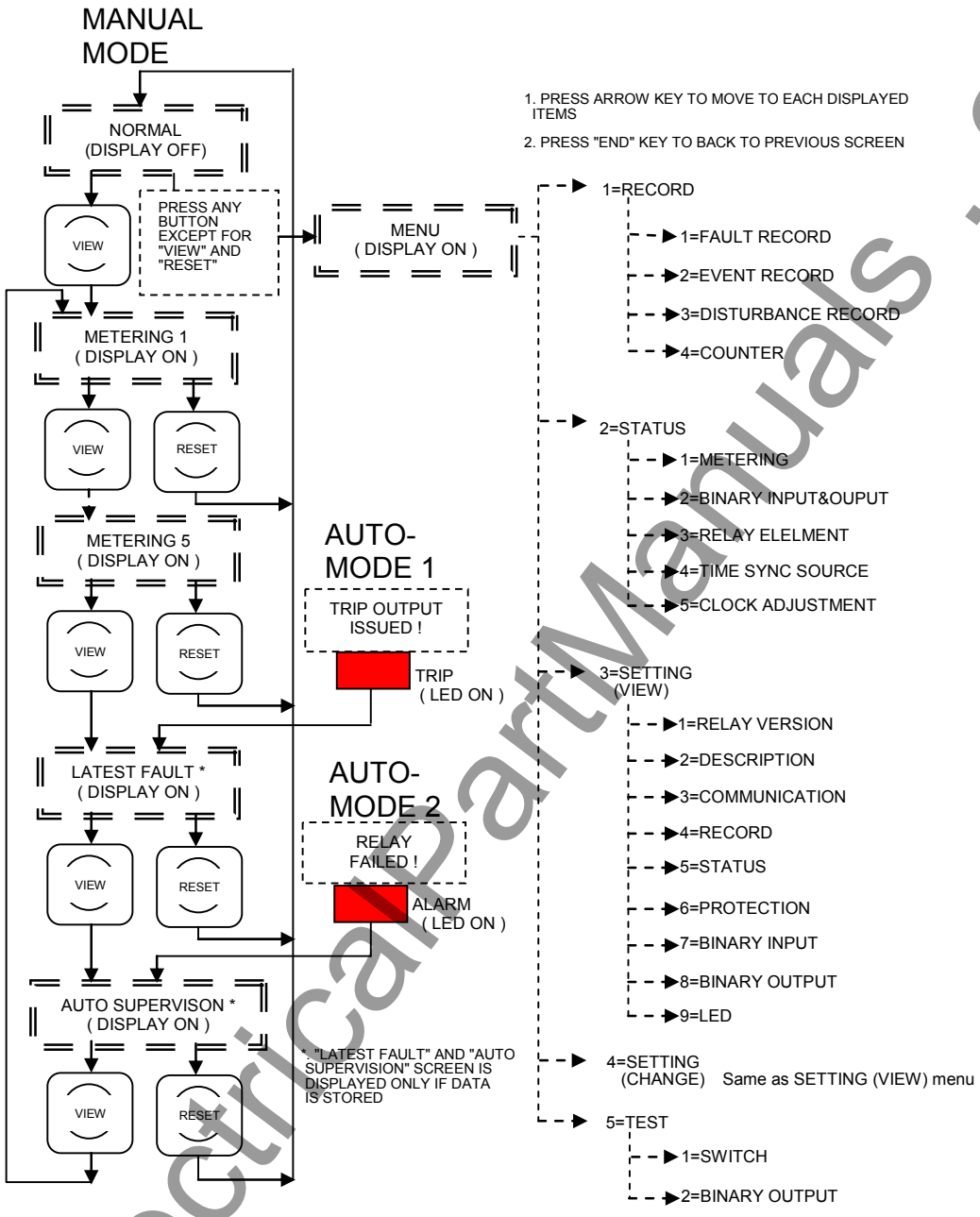
LCD AND BUTTON OPERATION INSTRUCTION



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Appendix F

Case Outline

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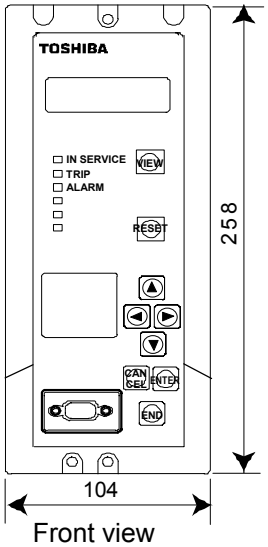
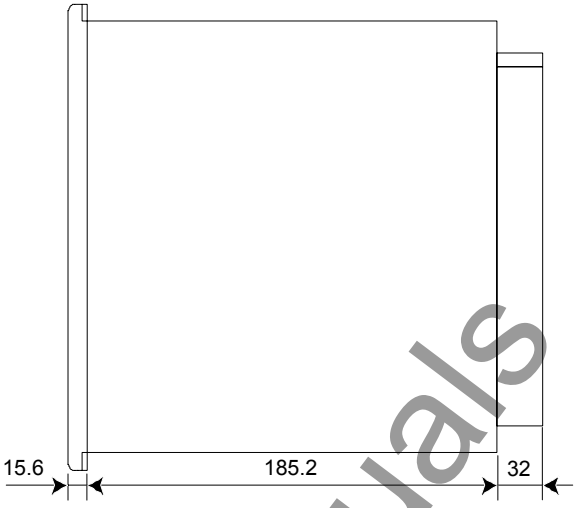
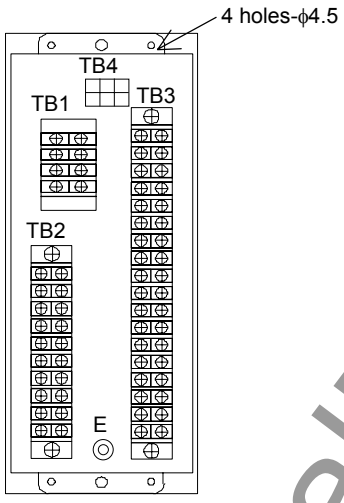


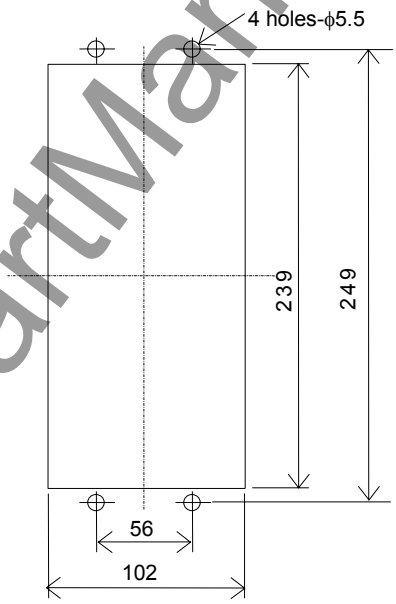
Front view



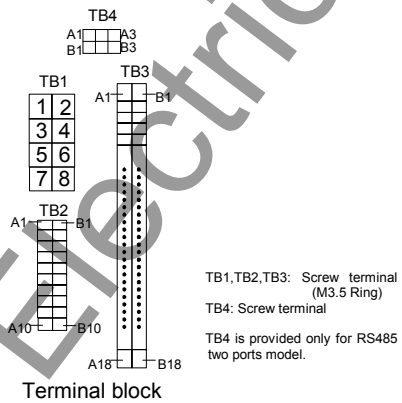
Side view



Rear view



Panel cut-out



Terminal block

Case Outline

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Appendix G

Typical External Connection

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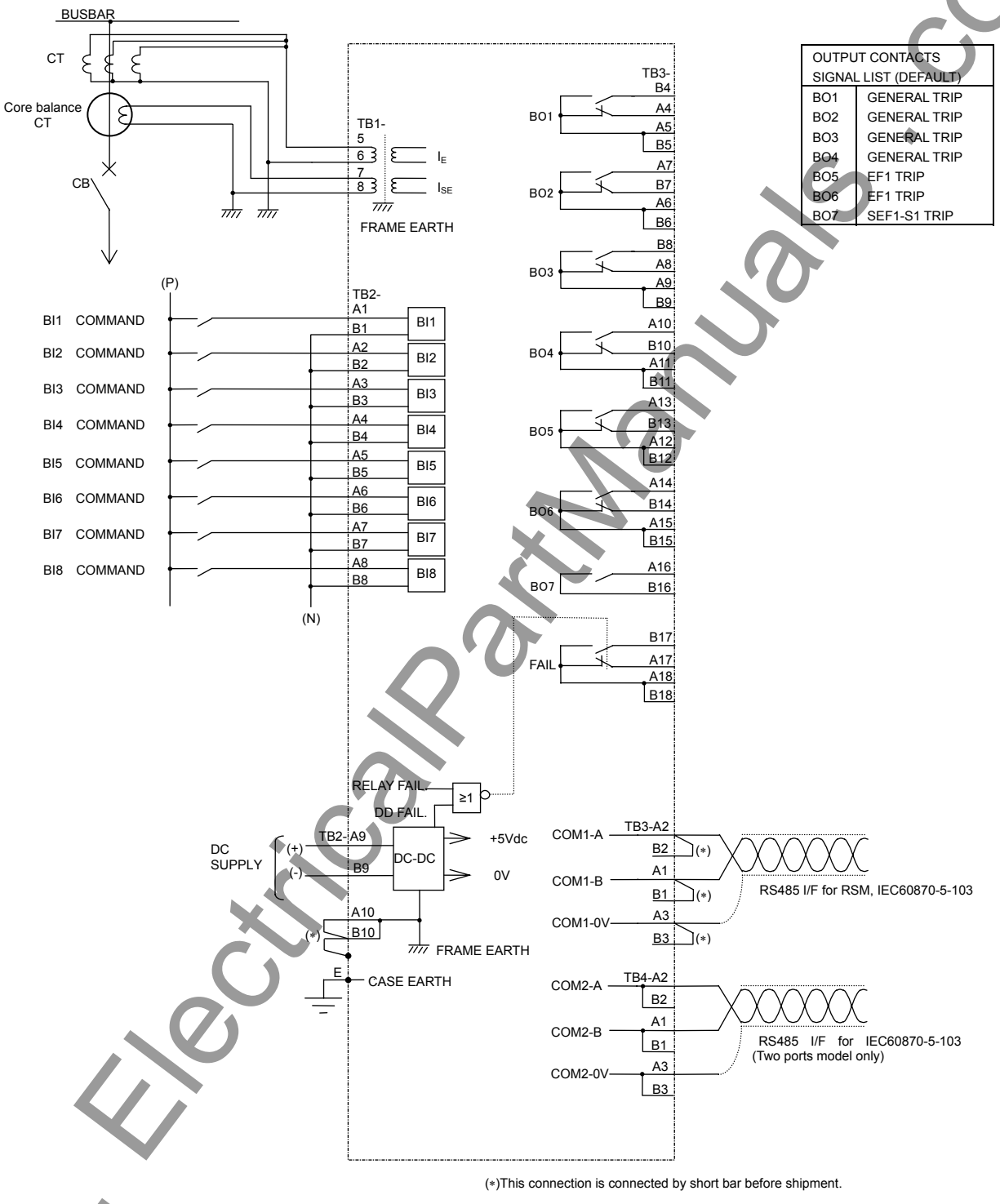
GRD110 - 110



(*)This connection is connected by short bar before shipment.

Typical External Connection

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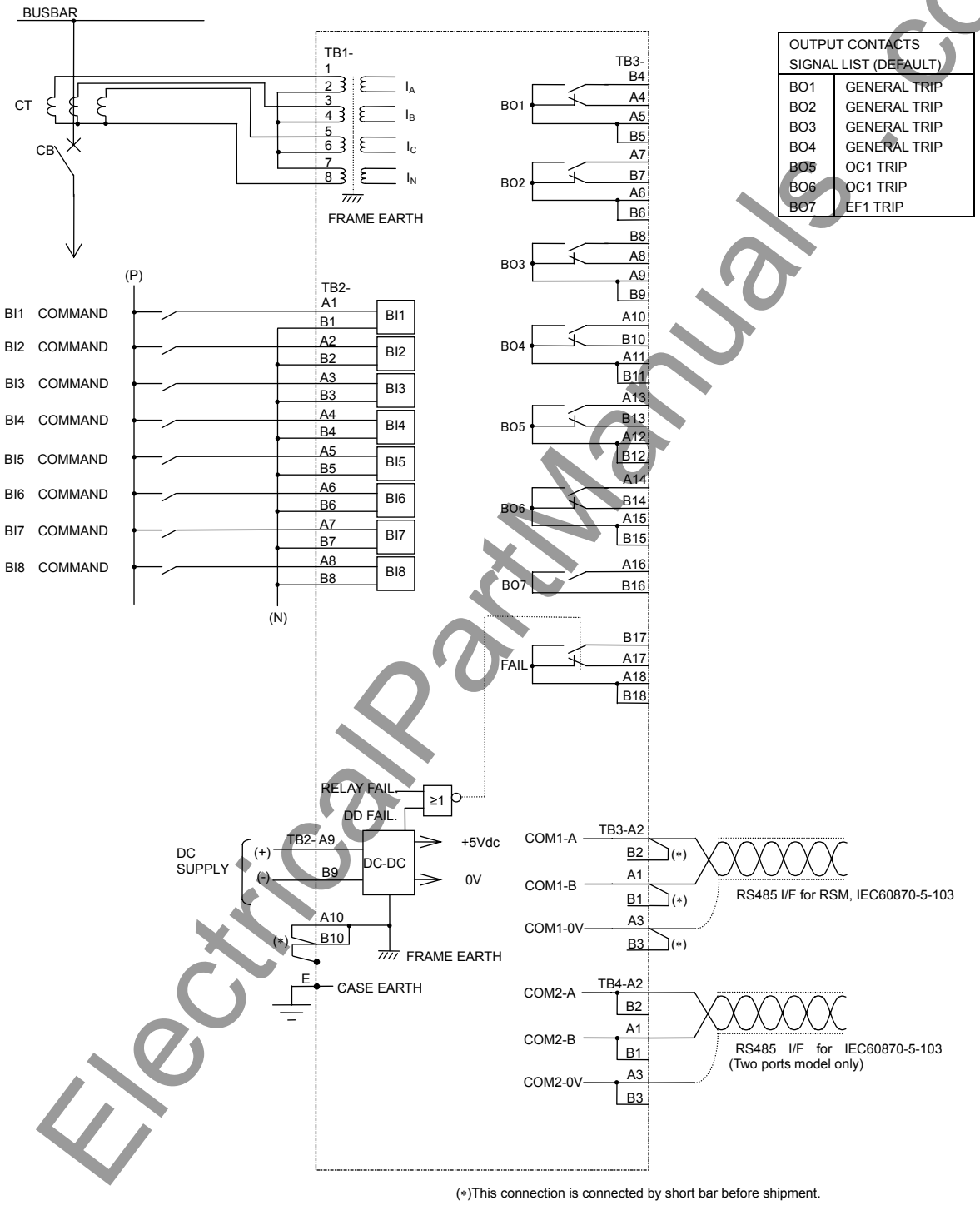
GRD110 - 400, “3P” setting



(*)This connection is connected by short bar before shipment.

Typical External Connection

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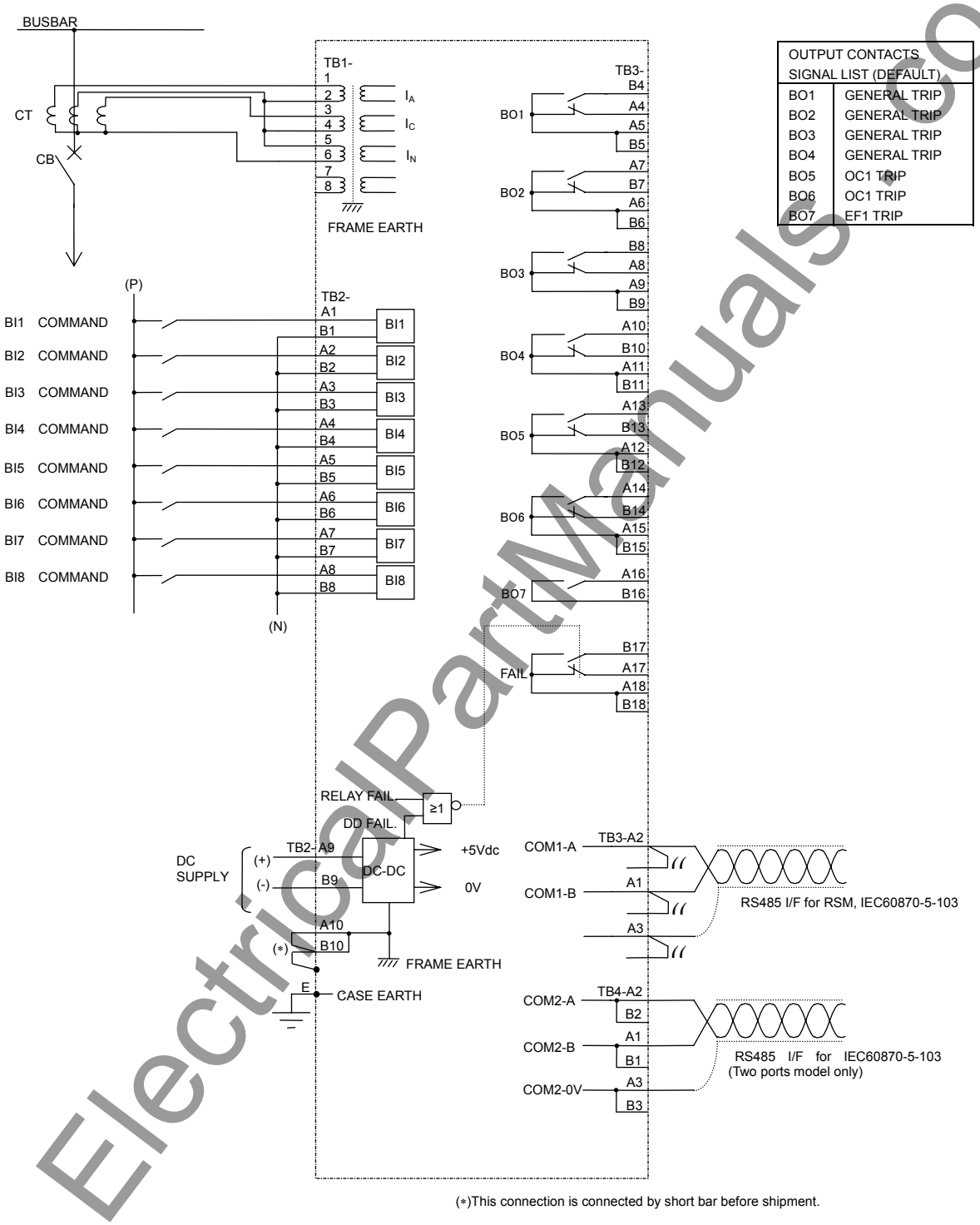
GRD110 - 400, “2P” setting



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	GENERAL TRIP
BO4	GENERAL TRIP
BO5	OC1 TRIP
BO6	OC1 TRIP
BO7	EF1 TRIP

(*)This connection is connected by short bar before shipment.

Typical External Connection

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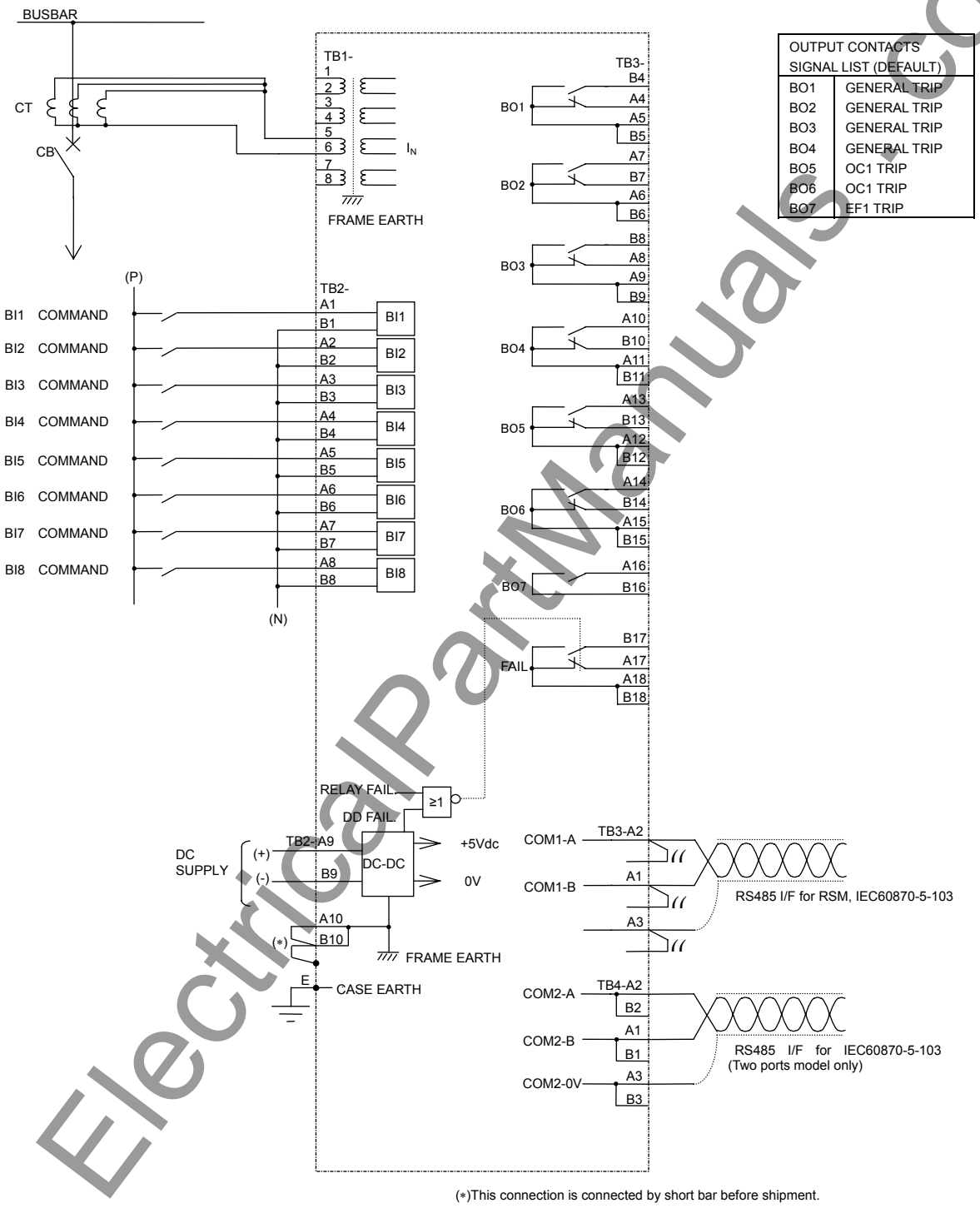
GRD110 - 400, “1P” setting



(*)This connection is connected by short bar before shipment.

Typical External Connection

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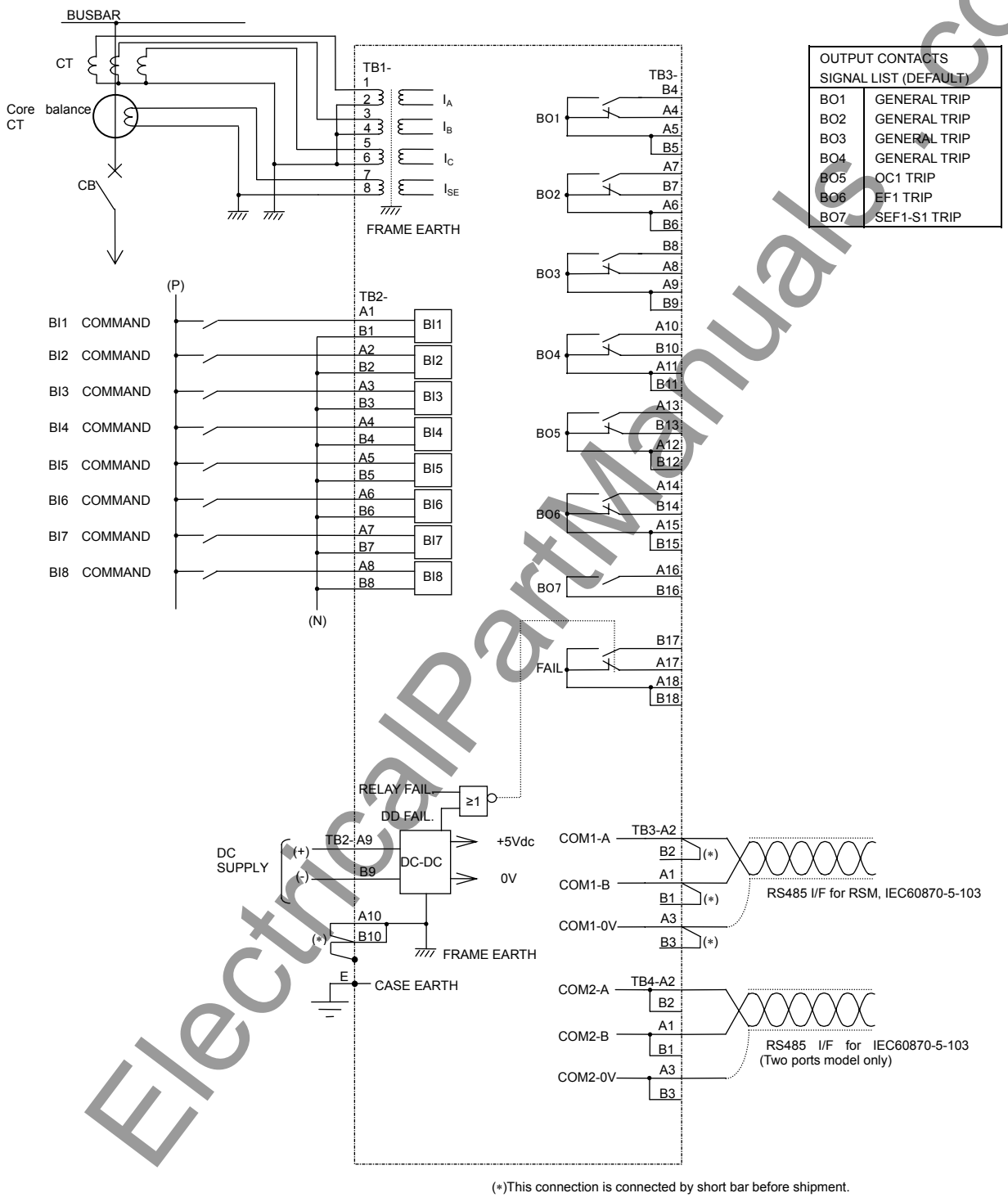
GRD110 - 420, “3P” setting



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	GENERAL TRIP
BO4	GENERAL TRIP
BO5	OC1 TRIP
BO6	EF1 TRIP
BO7	SEF1-S1 TRIP

(*)This connection is connected by short bar before shipment.

Typical External Connection

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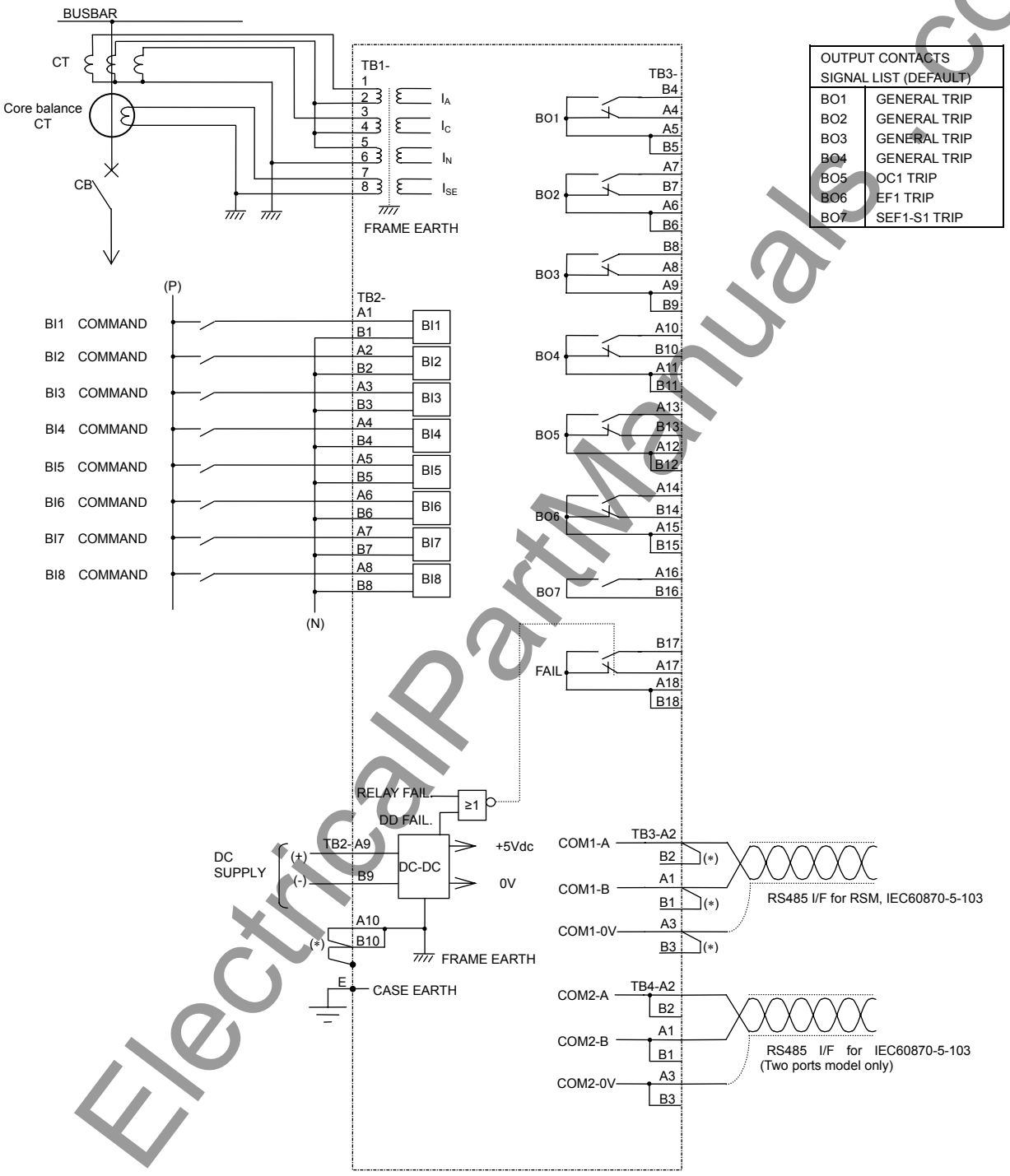
GRD110 - 420, “2P” setting



(*)This connection is connected by short bar before shipment.

Typical External Connection

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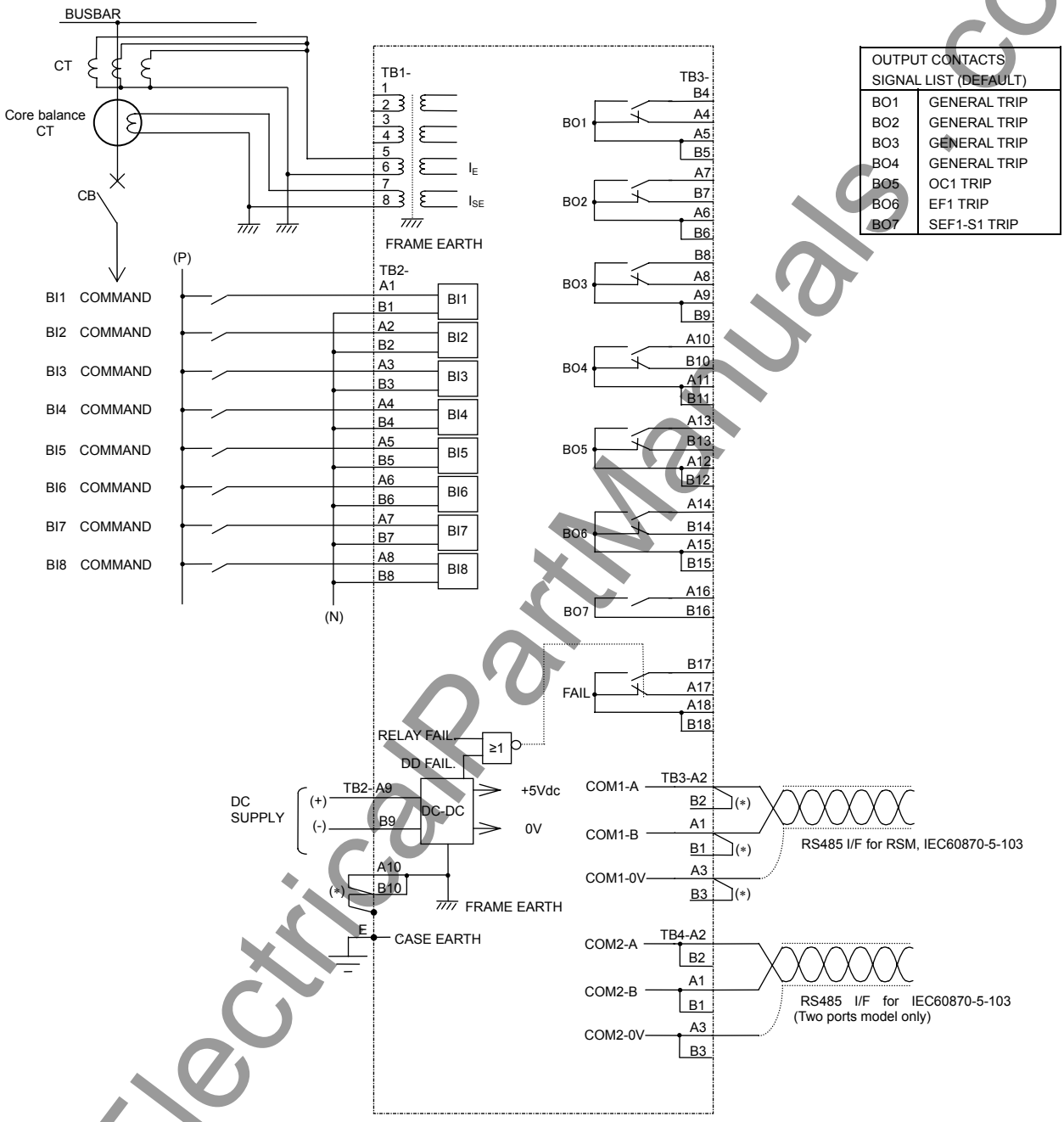
GRD110 - 420, “1P” setting



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	GENERAL TRIP
BO4	GENERAL TRIP
BO5	OC1 TRIP
BO6	EF1 TRIP
BO7	SEF1-S1 TRIP

(*)This connection is connected by short bar before shipment.

Typical External Connection

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Appendix H

Relay Setting Sheet

1. Relay Identification
2. Line parameter
3. Contacts setting
4. Relay setting sheet

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1. Relay Identification

Date:

Relay type	Serial Number
Frequency	AC current
DC supply voltage	
Password	
Active setting group	

2. Line parameter

CT ratio OC: EF: SEF:

3. Contacts setting

TB3	Terminal A5(B5)-B4, A4	
	Terminal A6(B6)-A7, B7	
	Terminal A9(B9)-B8, A8	
	Terminal A11(B11)-A10, B10	
	Terminal A12(B12)-A13, B13	
	Terminal A15(B15)-A14, B14	
	Terminal B16-A16	

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4. Relay setting sheet

№	Name		Range		Units	Contents	Default Setting of Relay Series (5A rating / 1A rating)			User Setting
			5A rating	1A rating			110	400	420	
1	Active gp.		1 - 4		—	Active setting group	1			
2	Line name		Specified by user		—	Line name	Specified by user			
3	OCCT		1 - 20000		—	CT ratio of OC	—			
4	EFCT		1 - 20000		—	CT ratio of EF	400	—		
5	OCEFCT		1 - 20000		—	CT ratio of OCEF	—	400		
6	SEFCT		1 - 20000		—	CT ratio of SEF	400	—	400	
7	APPL		3P/2P/1P		—	Application setting (400 & 420)	—	3P		
8	Optime		Normal/Fast		—	OC & EF element operating time	Normal			
9	AOLED		Off/On		—	ALARM LED lighting control at alarm output	On			
10	SVCNT		ALM&BLK/ALM		—	AC input imbalance	—	ALM&BLK		
11	OC	OC1EN	Off/On		—	OC1 Enable	—	On		
12		MOC1	DT/IEC/IEEE/US/C		—	OC1 Delay Type (if OC1EN=On)	—	DT		
13		MOC1C-IEC	NI/VI/EI/LTI		—	OC1 IEC Inverse Curve Type (if MOC1=IEC)	—	NI		
14		MOC1C-IEEE	MI/VI/EI		—	OC1 IEEE Inverse Curve Type (if MOC1=IEEE)	—	MI		
15		MOC1C-US	CO2/CO8		—	OC1 US Inverse Curve Type (if MOC1=US)	—	CO2		
16		OC1R	DEF/DEP		—	OC1 Reset Characteristic. (if MOCI=IEEE, US or C)	—	DEF		
17		OC2EN	Off/On		—	OC2 Enable	—	Off		
18		MOC2	D/IEC/IEEE/US/C		—	OC2 Delay Type (if OC2EN=On)		DT		
19		MOC2C-IEC	NI/VI/EI/LTI		—	OC1 IEC Inverse Curve Type (if MOC1=IEC)	—	NI		
20		MOC2C-	MI/VI/EI		—	OC1 IEEE Inverse Curve Type (if MOC1=IEEE)		MI		
21		MOC2C-US	CO2/CO8		—	OC1 US Inverse Curve Type (if MOC1=US)	—	CO2		
22		OC2R	DEF/DEP		—	OC1 Reset Characteristic. (if MOC1=IEEE, US or C)		DEF		
23		OC3EN	Off/On		—	OC3 Enable	—	Off		
24		OC4EN	Off/On		—	OC4 Enable	—	Off		
25		UC1EN	Off/On		—	UC1 Enable	—	Off		
26		UC2EN	Off/On		—	UC2 Enable	—	Off		
27	EF	EF1EN	Off/On		—	EF1 Enable	On			
28		MEF1	DT/IEC/IEEE/US/C		—	EF1 Delay Type (if EF1EN=On)	DT			
29		MEF1C-IEC	NI/VI/EI/LTI		—	EF1 IEC Inverse Curve Type (if MEF1=IEC)	NI			
30		MEF1C-IEEE	MI/VI/EI		—	EF1 IEEE Inverse Curve Type (if MEF1=IEEE)	MI			
31		MEF1C-US	CO2/CO8		—	EF1 US Inverse Curve Type (if MEF1=US)	CO2			
32		EF1R	DEF/DEP		—	EF1 Reset Characteristic. (if MEFI=IEEE, US or C)	DEF			
33		EF2EN	Off/On		—	EF2 Enable	Off			
34		MEF2	D/IEC/IEEE/US/C		—	EF2 Delay Type (if EF2EN=On)	DT			
35		MEF2C-IEC	NI/VI/EI/LTI		—	EF2 IEC Inverse Curve Type (if MEF2=IEC)	NI			
36		MEF2C-IEEE	MI/VI/EI		—	EF2 IEEE Inverse Curve Type (if MEF2=IEEE)	MI			
37		MEF2C-US	CO2/CO8		—	EF2 US Inverse Curve Type (if MEF2=US)	CO2			
38		EF2R	DEF/DEP		—	EF2 Reset Characteristic. (if MEF2=IEEE, US or C)	DEF			
39		EF3EN	Off/On		—	EF3 Enable	Off			
40		EF4EN	Off/On		—	EF4 Enable	Off			
41	SEF	SE1EN	Off/On			SEF1 Enable	On	—	On	
42		MSE1	DT/IEC/IEEE/US/C		—	SEF1 Delay Type (if SE1EN=On)	DT	—	DT	
43		MSE1C-IEC	NI/VI/EI/LTI		—	SEF1 IEC Inverse Curve Type (if MSE1=IEC)	NI	—	NI	
44		MSE1C-IEEE	MI/VI/EI		—	SEF1 IEEE Inverse Curve Type (if MSE1=IEEE)	MI	—	MI	
45		MSE1C-US	CO2/CO8		—	SEF1 US Inverse Curve Type (if MSE1=US)	CO2	—	CO2	
46		SE1R	DEF/DEP		—	SEF1 Reset Characteristic. (if MSE1=IEEE, US or C)	DEF	—	DEF	
47		SE1S2	Off/On		—	SEF1 Stage 2 Timer Enable (if SE1EN=On)	Off	—	Off	
48		SE2EN	Off/On		—	SEF2 Enable	Off	—	Off	
49		MSE2	DT/IEC/IEEE/US/C		—	SEF2 Delay Type (if SE2EN=On)	DT	—	DT	
50		MSE2C-IEC	NI/VI/EI/LTI		—	SEF2 IEC Inverse Curve Type (if MSE2=IEC)	NI	—	NI	
51		MSE2C-IEEE	MI/VI/EI		—	SEF2 IEEE Inverse Curve Type (if MSE2=IEEE)	MI	—	MI	
52		MSE2C-US	CO2/CO8		—	SEF2 US Inverse Curve Type (if MSE2=US)	CO2	—	CO2	
53		SE2R	DEF/DEP		—	SEF2 Reset Characteristic. (if MSE2=IEEE, US or C)	DEF	—	DEF	
54		SE3EN	Off/On		—	SEF3 Enable	Off	—	Off	
55		SE4EN	Off/On		—	SEF4 Enable	Off	—	Off	
56	Thermal	THMEN	Off/On		—	Thermal OL Enable	—	Off		
57		THMAEN	Off/On		—	Thermal Alarm Enable	—	Off		
58	NPS	NPS1EN	Off/On		—	NPS1 Enable	—	Off		
59		NPS2EN	Off/On		—	NPS2 Enable	—	Off		
60	BCD	BCDEN	Off/On		—	Broken Conducter Enable	—	Off		
61	CBF	BTC	Off/On		—	Back-trip control	—	Off		
62		RTC	Off/DIR/OC		—	Re-trip control Off/Direct/OC controlled	—	Off		
63	Cold	CLSG	Off/1/2/3/4		—	Cold Load settings group	—	Off		
64	Load	CLDOEN	Off/On		—	Cold Load drop-off enable	—	Off		
65	OC	OC1	0.2 - 25.0	0.04 - 5.00	A	OC1 Threshold setting (if OC1EN=On)	—	5.0/1.00		
66		TOC1	0.010 - 1.500		—	OC1 Time multiplier setting (if MOC1=IEC, IEEE, US or C)	—	1.000		
67		TOC1	0.00 - 300.00		s	OC1 Definite time setting.(if MOC1=DT)	—	1.00		
68		TOC1R	0.0 - 300.0		s	OC1 Definete time reset delay.(if OC1R =DEF)	—	0.0		
69		TOC1RM	0.010 - 1.500		—	OC1 Dependent time reset time multiplier(if OC1R=DEP)	—	1.000		

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№	Name		Range		Units	Contents	Default Setting of Relay Series (5A rating / 1A rating)			User Setting
			5A rating	1A rating			110	400	420	
70	OC	OC2	0.2 - 250.0	0.04 - 50.00	A	OC2 Threshold setting(if OC2EN=On)	—	25.0/5.00		
71		TOC2	0.010 - 1.500		—	OC2 Time multiplier setting (if MOC2=IEC, IEEE, US or C)	—	1.000		
72		TOC2	0.00 - 300.00		s	OC2 Definite time setting.(if OC2EN=On)	—	0.00		
73		TOC2R	0.0 - 300.0		s	OC2 Definete time reset delay (if OC2R =DEF)	—	0.0		
74		TOC2RM	0.010 - 1.500		—	OC2 Dependent time reset time multiplier (if OC2R=DEP)	—	1.000		
75		OC3	0.5 - 250.0	0.10 - 50.00	A	OC3 Threshold setting(if OC3EN=On)	—	50.0/10.00		
76		TOC3	0.00 - 300.00		s	OC3 Definite time setting.(if OC3EN=On)	—	0.00		
77		OC4	0.5 - 250.0	0.10 - 50.00	A	OC4 Threshold setting(if OC4EN=On)	—	100.0/20.00		
78		TOC4	0.00 - 300.00		s	OC4 Definite time setting.(if OC4EN=On)	—	0.00		
79		OC1-k	0.00 - 300.00		–	Configurable IDMT Curve settig of OC1.(if MOC1=C)	—	0.14		
80		OC1-α	0.00 - 5.00		–	ditto	—	0.02		
81		OC1-C	0.000 - 5.000		–	ditto	—	0.000		
82		OC1-kr	0.00 - 300.00		–	ditto	—	2.00		
83		OC1-β	0.00 - 5.00		–	ditto	—	2.00		
84		OC2-k	0.00 - 300.00		–	Configurable IDMT Curve settig of OC2.(if MOC2=C)	—	0.14		
85		OC2-α	0.00 - 5.00		–	ditto	—	0.02		
86		OC2-C	0.000 - 5.000		–	ditto	—	0.000		
87		OC2-kr	0.00 - 300.00		–	ditto	—	2.00		
88		OC2-β	0.00 - 5.00		–	ditto	—	2.00		
89	UC	UC1	0.5 - 10.0	0.10 - 2.00	A	UC1 Threshold setting(if UC1EN=On)	—	2.0/0.40		
90		TUC1	0.00 - 300.00		s	UC1 Definite time setting.(if UC1EN=On)	—	0.00		
91		UC2	0.5 - 10.0	0.10 - 2.00	A	UC2 Threshold setting (if UC2EN=On)	—	1.0/0.20		
92		TUC2	0.00 - 300.00		s	UC2 Definite time setting.(if UC2EN=On)	—	0.00		
93	EF	EF1	0.1 - 25.0	0.02 - 5.00	A	EF1 Threshold setting (if EF1EN=On)	1.5/0.30			
94		TEF1	0.010 - 1.500		—	EF1 Time multiplier setting(if MEF1=IEC, IEEE, US or C)	1.000			
95		TEF1	0.00 - 300.00		s	EF1 Definite time setting.(if MEF1=DT)	1.00			
96		TEF1R	0.0 - 300.0		s	EF1 Definite time reset delay(if EF1R =DEF)	0.0			
97		TEF1RM	0.010 - 1.500		—	EF1 Dependent time reset time multiplier. (if EF1R=DEP)	1.000			
98		EF2	0.1 - 250.0	0.02 - 50.00	A	EF2 Threshold setting (if EF2EN=On)	15.0/3.00			
99		TEF2	0.010 - 1.500		—	EF2 Time multiplier setting (if MEF2=IEC, IEEE, US or C)	1.000			
100		TEF2	0.00 - 300.00		s	EF2 Definite time setting.(if EF2EN=On)	0.00			
101		TEF2R	0.0 - 300.0		s	EF2 Definite time reset delay(if EF2R =DEF)	0.0			
102		TEF2RM	0.010 - 1.500		—	EF2 Dependent time reset time multiplier (if EF2R=DEP)	1.000			
103		EF3	0.2 - 250.0	0.04 - 50.00	A	EF3 Threshold setting (if EF3EN=On)	25.0/5.00			
104		TEF3	0.00 - 300.00		s	EF3 Definite time setting.(if EF3EN=On)	0.00			
105		EF4	0.2 - 250.0	0.04 - 50.00	A	EF4 Threshold setting(if EF4EN=On)	50.0/10.00			
106		TEF4	0.00 - 300.00		s	EF4 Definite time setting.(if EF4EN=On)	0.00			
107		EF1-k	0.00 - 300.00		–	Configurable IDMT Curve settig of EF1(if MEF1=C)	0.14			
108		EF1-α	0.00 - 5.00		–	ditto	0.02			
109		EF1-C	0.000 - 5.000		–	ditto	0.000			
110		EF1-kr	0.00 - 300.00		–	ditto	2.00			
111		EF1-β	0.00 - 5.00		–	ditto	2.00			
112		EF2-k	0.00 - 300.00		–	Configurable IDMT Curve settig of EF2 (if MEF2=C)	0.14			
113		EF2-α	0.00 - 5.00		–	ditto	0.02			
114		EF2-C	0.000 - 5.000		–	ditto	0.000			
115		EF2-kr	0.00 - 300.00		–	ditto	2.00			
116		EF2-β	0.00 - 5.00		–	ditto	2.00			
117	SEF	SE1	0.02 - 5.00	0.004 - 1.000	A	SE1 Threshold setting (if SE1EN=On)	0.50/0.100	—	0.50/0.100	
118		TSE1	0.010 - 1.500		—	SEF1 Time multiplier setting(if MSE1=IEC, IEEE, US or C)	1.000	—	1.000	
119		TSE1	0.00 - 300.00		s	SEF1 Definite time setting.(if MSE1=DT)	1.00	—	1.00	
120		TSE1R	0.0 - 300.0		s	SEF1 Definite time reset delay.(if SE1R =DEF)	0.0	—	0.0	
121		TSE1RM	0.010 - 1.500		—	SEF1 Dependent time reset time multiplier. (if SE1R=DEP)	1.000	—	1.000	
122		TSE1S2	0.00 - 300.00		s	SEF1 Stage 2 Definite time setting.	0.00	—	0.00	
123		SE2	0.02 - 5.00	0.004 - 1.000	A	SEF2 Threshold setting (if SE2EN=On)	2.50/0.500	—	2.50/0.500	
124		TSE2	0.010 - 1.500		—	SEF2 Time multiplier setting(if MSE2=IEC, IEEE, US or C)	1.000	—	1.000	
125		TSE2	0.00 - 300.00		s	SEF2 Definite time setting.(if SE2EN=On)	0.00	—	0.00	
126		TSE2R	0.0 - 300.0		s	SEF2 Definite time reset delay.(if SE2R =DEF)	0.0	—	0.0	
127		TSE2RM	0.010 - 1.500		—	SEF2 Dependent time reset time multiplier. (if SE2R=DEP)	1.000	—	1.000	
128		SE3	0.02 - 5.00	0.004 - 1.000	A	SEF3 Threshold setting (if SE3EN=On)	2.50/0.500	—	2.50/0.500	
129		TSE3	0.00 - 300.00		s	SEF3 Definite time setting.(if SE3EN=On)	0.00	—	0.00	
130		SE4	0.02 - 5.00	0.004 - 1.000	A	SEF4 Threshold setting.(if SE4EN=On)	2.50/0.500	—	2.50/0.500	
131		SE1-k	0.00 - 300.00		–	Configurable IDMT Curve settig of SE1(if MSE1=C)	0.14	—	0.14	
132		SE1-α	0.00 - 5.00		–	ditto	0.02	—	0.02	
133		SE1-C	0.000 - 5.000		–	ditto	0.000	—	0.000	
134		SE1-kr	0.00 - 300.00		–	ditto	2.00	—	2.00	
135		SE1-β	0.00 - 5.00		–	ditto	2.00	—	2.00	
136		SE2-k	0.00 - 300.00		–	Configurable IDMT Curve settig of SE2 (if MSE2=C)	0.14	—	0.14	
137		SE2-α	0.00 - 5.00		–	ditto	0.02	—	0.02	
138		SE2-C	0.000 - 5.000		–	ditto	0.000	—	0.000	
139		SE2-kr	0.00 - 300.00		–	ditto	2.00	—	2.00	
140		SE2-β	0.00 - 5.00		–	ditto	2.00	—	2.00	

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№	Name		Range		Units	Contents	Default Setting of Relay Series			User Setting
							(5A rating / 1A rating)			
			5A rating	1A rating			110	400	420	
141	Thermal	THM	2.0 - 10.0	0.40 - 2.00	A	Thermal overload setting (if OLTEN=On)	—	5.0/1.00		
142		THMIP	0.0 - 5.0	0.00 - 1.00	A	Prior load setting	—	0.0/0.00		
143		TTHM	0.5 - 500.0		min	Thermal Time Constant (if OLTEN=On)	—	10.0		
144		THMA	50 - 99		%	Thermal alarm setting.(if ALTEN=On)	—	80		
145	NPS	NPS1	0.5 - 10.0	0.10 - 2.00	A	NPS1 Threshold setting.(if NPS1EN=On)	—	1.0/0.20		
146		TNPS1	0.00 - 300.00		s	NPS1 Definite time setting.(if NPS1EN=On)	—	0.00		
147		NPS2	0.5 - 10.0	0.10 - 2.00	A	NPS2 Threshold setting.(if NPS2EN=On)	—	2.0/0.40		
148		TNPS2	0.00 - 300.00		s	NPS2 Definite time setting.(if NPS2EN=On)	—	0.00		
149	BCD	BCD	0.10 - 1.00		—	Broken Conducter Threshold setting.(if BCDEN=On)	—	0.20		
150		TBCD	0.00 - 300.00		s	Broken Conducter Definite time setting (if BCDEN=On)	—	0.00		
151	CBF	CBF	0.5 - 10.0	0.10 - 2.00	A	CBF Threshold setting.(if CBFEN=On)	—	2.5/0.50		
152		TBTC	0.00 - 300.00		s	Back trip Definite time setting	—	1		
153		TRTC	0.00 - 300.00		s	Re-trip Definite time setting	—	0.5		
154	Cold	TCLE	0 - 10000		s	Cold load enable timer. (CLSG=1,2,3,4)	—	100		
155	Load	TCLR	0 - 10000		s	Cold load reset timer.(if CLSG=1,2,3,4)	—	100		
156		ICLDO	0.5 - 10.0	0.10 - 2.00	A	Cold load drop-off threshold setting.(if CLDOEN=On)	—	2.5/0.50		
157		TCLDO	0.00 - 100.00		s	Cold load drop-off timer (if CLDOEN=1)	—	0.00		
158	Alarm1 Text		Specified by user		—	Alarm1 Text	ALARM 1			
159	Alarm2 Text		Specified by user		—	Alarm2 Text	ALARM 2			
160	Alarm3 Text		Specified by user		—	Alarm3 Text	ALARM 3			
161	Alarm4 Text		Specified by user		—	Alarm4 Text	ALARM 4			
162	BI1PUD		0.00 - 300.00		s	Binary Input 1 Pick-up delay	0.00			
163	BI1DOD		0.00 - 300.00		s	Binary Input 1 Drop-off delay	0.00			
164	BI2PUD		0.00 - 300.00		s	Binary Input 2 Pick-up delay	0.00			
165	BI2DOD		0.00 - 300.00		s	Binary Input 2 Drop-off delay	0.00			
166	BI3PUD		0.00 - 300.00		s	Binary Input 3 Pick-up delay	0.00			
167	BI3DOD		0.00 - 300.00		s	Binary Input 3 Drop-off delay	0.00			
168	BI4PUD		0.00 - 300.00		s	Binary Input 4 Pick-up delay	0.00			
169	BI4DOD		0.00 - 300.00		s	Binary Input 4 Drop-off delay	0.00			
170	BI5PUD		0.00 - 300.00		s	Binary Input 5 Pick-up delay	0.00			
171	BI5DOD		0.00 - 300.00		s	Binary Input 5 Drop-off delay	0.00			
172	BI6PUD		0.00 - 300.00		s	Binary Input 6 Pick-up delay	0.00			
173	BI6DOD		0.00 - 300.00		s	Binary Input 6 Drop-off delay	0.00			
174	BI7PUD		0.00 - 300.00		s	Binary Input 7 Pick-up delay	0.00			
175	BI7DOD		0.00 - 300.00		s	Binary Input 7 Drop-off delay	0.00			
176	BI8PUD		0.00 - 300.00		s	Binary Input 8 Pick-up delay	0.00			
177	BI8DOD		0.00 - 300.00		s	Binary Input 8 Drop-off delay	0.00			
						Repeat the following switches from binary input 2 to binary input 8.				
178	BI1SNS		Norm/Inv		—	Binary Input 1 Sense	Norm			
179	BI1SGS		Off/1/2/3/4		—	Binary Input 1 Settings Group Select	Off			
180	OC1BLK		Off/On		—	OC1 Block	—	Off		
181	OC2BLK		Off/On		—	OC2 Block	—	Off		
182	OC3BLK		Off/On		—	OC3 Block	—	Off		
183	OC4BLK		Off/On		—	OC4 Block	—	Off		
184	EF1BLK		Off/On		—	EF1 Block	Off			
185	EF2BLK		Off/On		—	EF2 Block	Off			
186	EF3BLK		Off/On		—	EF3 Block	Off			
187	EF4BLK		Off/On		—	EF4 Block	Off			
188	SE1BLK		Off/On		—	SEF1 Block	Off	—	Off	
189	SE2BLK		Off/On		—	SEF2 Block	Off	—	Off	
190	SE3BLK		Off/On		—	SEF3 Block	Off	—	Off	
191	SE4BLK		Off/On		—	SEF4 Block	Off	—	Off	
192	UCBLK		Off/On		—	Undercurrent Block	—	Off		
193	THMBLK		Off/On		—	Thermal Protection Block	—	Off		
194	NPSBLK		Off/On		—	NPS Block	—	Off		
195	BCDBLK		Off/On		—	Broken Conductor Protection Block	—	Off		
196	TCFALM		Off/On		—	Trip Circuit Fail Alarm	Off			
197	CBOPN		Off/On		—	Circuit Breaker Open	Off			
198	CBCLS		Off/On		—	Circuit Breaker Close	Off			
199	EXT3PH		Off/On		—	External Trip - 3phase	Off			
200	EXTAPH		Off/On		—	External Trip - Aphase	—	Off		
201	EXTBPH		Off/On		—	External Trip - Bphase	—	Off		
202	EXTCPH		Off/On		—	External Trip - Cphase	—	Off		
203	RMTRST		Off/On		—	Remote Reset	Off			
204	SYNCLK		Off/On		—	Synchronize clock	Off			
205	STORCD		Off/On		—	Store Disturbance Record	Off			
206	Alarm1		Off/On		—	Alarm screen 1.	Off			
207	Alarm2		Off/On		—	Alarm screen 2.	Off			
208	Alarm3		Off/On		—	Alarm screen 3.	Off			
209	Alarm4		Off/On		—	Alarm screen 4.	Off			

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№	Name	Range		Units	Contents	Default Setting of Relay Series (5A rating / 1A rating)			User Setting
		5A rating	1A rating			110	400	420	
					Repeat the following switches from LED 2 to LED 3.				
210	Logic	OR/AMD		—	LED1 Logic Gate Type	OR			
211	Reset	Inst/Latch		—	LED1 Reset operation	Inst			
212	In #1	0 - 200		—	LED Functions	0			
213	In #2	0 - 200		—	ditto	0			
214	In #3	0 - 200		—	ditto	0			
215	In #4	0 - 200		—	ditto	0			
					Repeat the following switches for IND2.				
216	Reset	Inst/Latch		—	IND1 Reset operation	Inst			
217	BIT1	0 - 200		—	Virtual LED	0			
218	BIT2	0 - 200		—	ditto	0			
219	BIT3	0 - 200		—	ditto	0			
220	BIT4	0 - 200		—	ditto	0			
221	BIT5	0 - 200		—	ditto	0			
222	BIT6	0 - 200		—	ditto	0			
223	BIT7	0 - 200		—	ditto	0			
224	BIT8	0 - 200		—	ditto	0			
225	Plant name	Specified by user		—	Plant name	Specified by user			
226	Description	ditto		—	Memorandum for user	Specified by user			
227	HDLC	1 - 32		—	Relay ID No. for RSM	1			
228	IEC	0 - 254		—	Relay ID No. for IEC	2			
229	IECB1	0 - 200		—	IEC user specified signal 1	1			
230	IECB2	0 - 200		—	IEC user specified signal 2	2			
231	IECB3	0 - 200		—	IEC user specified signal 3	3			
232	IECB4	0 - 200		—	IEC user specified signal 4	4			
233	IECGT	0 - 7		—	IEC General trip	1			
234	IECAT	0 - 7		—	IEC Trip A phase	1			
235	IECBT	0 - 7		—	IEC Trip B phase	1			
236	IECCT	0 - 7		—	IEC Trip C phase	1			
237	IECE1	0 - 200		—	IEC user event 1	0			
238	IECE2	0 - 200		—	IEC user event 2	0			
239	IECE3	0 - 200		—	IEC user event 3	0			
240	IECE4	0 - 200		—	IEC user event 4	0			
241	IECE5	0 - 200		—	IEC user event 5	0			
242	IECE6	0 - 200		—	IEC user event 6	0			
243	IECE7	0 - 200		—	IEC user event 7	0			
244	IECE8	0 - 200		—	IEC user event 8	0			
245	IECI1	0 - 255		—	IEC user INF 1	0			
246	IECI2	0 - 255		—	IEC user INF 2	0			
247	IECI3	0 - 255		—	IEC user INF 3	0			
248	IECI4	0 - 255		—	IEC user INF 4	0			
249	IECI5	0 - 255		—	IEC user INF 5	0			
250	IECI6	0 - 255		—	IEC user INF 6	0			
251	IECI7	0 - 255		—	IEC user INF 7	0			
252	IECI8	0 - 255		—	IEC user INF 8	0			
253	Protocol	HDLC/IEC		—	Switch for commmunications	HDLC			
254	232C	9.6/19.2/57.6		—	ditto	9.6			
255	IECBR	9.6/19.2		—	ditto	19.2			
256	IECBLK	Normal/Blocked		—	ditto	Normal			
257	IECNFI	1.2/2.4		—	ditto	2.4			
258	IECGI1	No/Yes		—	IEC event type setting 1	No			
259	IECGI2	No/Yes		—	IEC event type setting 2	No			
260	IECGI3	No/Yes		—	IEC event type setting 3	No			
261	IECGI4	No/Yes		—	IEC event type setting 4	No			
262	IECGI5	No/Yes		—	IEC event type setting 5	No			
263	IECGI6	No/Yes		—	IEC event type setting 6	No			
264	IECGI7	No/Yes		—	IEC event type setting 7	No			
265	IECGI8	No/Yes		—	IEC event type setting 8	No			
266	BI1 comm.	None/Operate/Reset/Both		—	BI1 command trigger setting	Both			
267	BI2 comm.	None/Operate/Reset/Both		—	BI2 command trigger setting	Both			
268	BI3 comm.	None/Operate/Reset/Both		—	BI3 command trigger setting	Both			
269	BI4 comm.	None/Operate/Reset/Both		—	BI4 command trigger setting	Both			
270	BI5 comm.	None/Operate/Reset/Both		—	BI5 command trigger setting	Both			
271	BI6 comm.	None/Operate/Reset/Both		—	BI6 command trigger setting	Both			
272	BI7 comm.	None/Operate/Reset/Both		—	BI7 command trigger setting	Both			
273	BI8 comm.	None/Operate/Reset/Both		—	BI8 command trigger setting	Both			

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№	Name	Range		Units	Contents	Default Setting of Relay Series (5A rating / 1A rating)			User Setting
		5A rating	1A rating			110	400	420	
274	Time	0.1 - 3.0		s	Disturbance record	2.0			
275	OC	0.5 - 250.0	0.10 - 50.00	A	OC element for disturbance	—	10.0 / 2.00		
276	EF	0.5 - 125.0	0.10 - 25.00	A	EF element for disturbance	3.0 / 0.60			
277	SEF	0.02 - 5.00	0.004 - 1.000	A	SEF element for disturbance	1.00 / 0.200	—	1.00 / 0.200	
278	NPS	0.5 - 10.0	0.10 - 2.00	A	NPS element for disturbance	—	2.0 / 0.40		
279	TRIP	Off/On		—	Disturbance trigger	On			
280	BI	Off/On		—	ditto	On			
281	OC	Off/On		—	ditto	—	On		
282	EF	Off/On		—	ditto	On			
283	SEF	Off/On		—	ditto	On	—	On	
284	NPS	Off/On		—	ditto	—	On		
285	SIG1	0 - 200		—	Disturbance trigger	—			
286	SIG2	0 - 200		—	ditto	—			
287	SIG3	0 - 200		—	ditto	—			
288	SIG4	0 - 200		—	ditto	—			
289	SIG5	0 - 200		—	ditto	—			
290	SIG6	0 - 200		—	ditto	—			
291	SIG7	0 - 200		—	ditto	—			
292	SIG8	0 - 200		—	ditto	—			
293	SIG9	0 - 200		—	ditto	—			
294	SIG10	0 - 200		—	ditto	—			
295	SIG11	0 - 200		—	ditto	—			
296	SIG12	0 - 200		—	ditto	—			
297	SIG13	0 - 200		—	ditto	—			
298	SIG14	0 - 200		—	ditto	—			
299	SIG15	0 - 200		—	ditto	—			
300	SIG16	0 - 200		—	ditto	—			
301	SIG17	0 - 200		—	ditto	—			
302	SIG18	0 - 200		—	ditto	—			
303	SIG19	0 - 200		—	ditto	—			
304	SIG20	0 - 200		—	ditto	—			
305	SIG21	0 - 200		—	ditto	—			
306	SIG22	0 - 200		—	ditto	—			
307	SIG23	0 - 200		—	ditto	—			
308	SIG24	0 - 200		—	ditto	—			
309	SIG25	0 - 200		—	ditto	—			
310	SIG26	0 - 200		—	ditto	—			
311	SIG27	0 - 200		—	ditto	—			
312	SIG28	0 - 200		—	ditto	—			
313	SIG29	0 - 200		—	ditto	—			
314	SIG30	0 - 200		—	ditto	—			
315	SIG31	0 - 200		—	ditto	—			
316	SIG32	0 - 200		—	ditto	—			
317	TCSPEN	Off/On/OPT-On		—	Trip Circuit Supervision Enable	Off			
318	CBSMEN	Off/On		—	Circuit Breaker State Monitoring Alarm Enable	Off			
319	TCAEN	Off/On		—	Trip Count Alarm Enable	Off			
320	ΣIyAEN	Off/On		—	ΣIy Alarm Enable	—	Off		
321	OPTAEN	Off/On		—	Operate Time Alarm Enable	Off			
322	TCALM	1 - 10000		—	Trip Count Alarm Threshold setting	10000			
323	ΣIyALM	10 - 10000		E6	ΣIy Alarm Threshold setting	—	10000		
324	YVALUE	1.0 - 2.0		—	Y value	2.0			
325	OPTALM	100 - 5000		ms	Operate Time Alarm Threshold setting	1000			
326	Display	Pri. / Sec. / Pr-A		—	Metering	Pri.			
327	Time sync	Off/BI/RSM/IEC		—	Time	Off			

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Disturbance record default setting

Name	Range	Unit	Default setting		400		420	
			Model 110		Model 400		Model 420	
			NO.	Signal name	NO.	Signal name	NO.	Signal name
SIG1	0-200	—	63	EF1	51	OC1-A	51	OC1-A
SIG2	0-200	—	67	SEF1	52	OC1-B	52	OC1-B
SIG3	0-200	—	117	EF1 TRIP	53	OC1-C	53	OC1-C
SIG4	0-200	—	121	SEF1-S1 TRIP	63	EF1	63	EF1
SIG5	0-200	—	141	GEN.TRIP	102	OC1-A TRIP	67	SEF1
SIG6	0-200	—	145	GEN.TRIP-EF	103	OC1-B TRIP	102	OC1-A TRIP
SIG7	0-200	—	0		104	OC1-C TRIP	103	OC1-B TRIP
SIG8	0-200	—	0		117	EF1 TRIP	104	OC1-C TRIP
SIG9	0-200	—	0		141	GEN.TRIP	117	EF1 TRIP
SIG10	0-200	—	0		142	GEN.TRIP-A	121	SEF1-S1 TRIP
SIG11	0-200	—	0		143	GEN.TRIP-B	141	GEN.TRIP
SIG12	0-200	—	0		144	GEN.TRIP-C	142	GEN.TRIP-A
SIG13	0-200	—	0		145	GEN.TRIP-EF	143	GEN.TRIP-B
SIG14	0-200	—	0		0		144	GEN.TRIP-C
SIG15	0-200	—	0		0		145	GEN.TRIP-EF
SIG16	0-200	—	0		0		0	
SIG17	0-200	—	0		0		0	
SIG18	0-200	—	0		0		0	
SIG19	0-200	—	0		0		0	
SIG20	0-200	—	0		0		0	
SIG21	0-200	—	0		0		0	
SIG22	0-200	—	0		0		0	
SIG23	0-200	—	0		0		0	
SIG24	0-200	—	0		0		0	
SIG25	0-200	—	0		0		0	
SIG26	0-200	—	0		0		0	
SIG27	0-200	—	0		0		0	
SIG28	0-200	—	0		0		0	
SIG29	0-200	—	0		0		0	
SIG30	0-200	—	0		0		0	
SIG31	0-200	—	0		0		0	

User setting of Virtual LED

	1	2	3	4	5	6	7	8
IND1	[							]
IND2	[							]

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Appendix I

Commissioning Test Sheet (sample)

1. Relay identification
2. Preliminary check
3. Hardware check
   - 3.1 User interface check
   - 3.2 Binary input/binary output circuit check
   - 3.3 AC input circuit
4. Function test
   - 4.1 Overcurrent elements test
   - 4.2 Operating time test (IDMT)
   - 4.3 BCD element check
   - 4.4 Cold load function check
5. Protection scheme test
6. Metering and recording check
7. Conjunctive test

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1. Relay identification

Type _____ Serial number _____

Model _____ System frequency _____

Station _____ Date _____

Circuit _____ Engineer _____

Protection scheme _____ Witness _____

Active settings group number _____

2. Preliminary check

Ratings	☐
CT shorting contacts	☐
DC power supply	☐
Power up	☐
Wiring	☐
Relay inoperative alarm contact	☐
Calendar and clock	☐

3. Hardware check

3.1 User interface check ☐

3.2 Binary input/binary output circuit check

Binary input circuit	☐
Binary output circuit	☐

3.3 AC input circuit ☐

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4. Function test

4.1 Overcurrent elements test

Element	Current setting	Measured current
OC1-A		
OC2-A		
OC3-A		
OC4-A		
EF1		
EF2		
EF3		
EF4		
SEF1		
SEF2		
SEF3		
SEF4		
UC1-A		
UC2-A		
THM-A		
THM-T		
NPS1		
NPS2		
BCD		
CBF-A		

4.2 Operating time test (IDMT)

Element	Curve setting	Multiplier setting	Measured time
OC1-A			
OC2-A			
EF1			
EF2			
SEF1			
SEF2			

4.3 BCD element check

4.4 Cold load function check

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5. Protection scheme test ☐

6. Metering and recording check

☐

7. Conjunctive test

Scheme	Results
On load check Tripping circuit	

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Appendix J

Return Repair Form

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RETURN / REPAIR FORM

Please fill in this form and return it to Toshiba Corporation with the GRD110 to be repaired.

TOSHIBA CORPORATION Fuchu Complex

1, Toshiba-cho, Fuchu-shi, Tokyo, Japan

For: Power Systems Protection & Control Department

Quality Assurance Section

Type: GRD110 Model: _____

(Example: Type: GRD110 Model: 400A)

Product No.: _____

Serial No.: _____

Date: _____

1. Reason for returning the relay
   - ☐ mal-function
   - ☐ does not operate
   - ☐ increased error
   - ☐ investigation
   - ☐ others

     _____

     _____

     _____

     _____

2. Fault records, event records or disturbance records stored in the relay and relay settings are very helpful information to investigate the incident.

   Please provide relevant information regarding the incident on floppy disk, or fill in the attached fault record sheet and relay setting sheet.

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Fault Record

Date/Month/Year Time / /
/ : : .

(Example: 04/ Jul./ 2002 15:09:58.442)

Faulty phase:

Prefault values

I_a: A
I_b: A
I_c: A
I_E: A
I_{SE}: A
I_1: A
I_2: A
I_2 / I_1 :

Fault values

I_a: A
I_b: A
I_c: A
I_E: A
I_{SE}: A
I_1: A
I_2: A
I_2 / I_1 :
THM: %

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3. What was the message on the LCD display at the time of the incident?

4. Describe the details of the incident:

5. Date incident occurred

   Day/Month/Year: / / /

   (Example: 10/July/2002)

6. Give any comments about the GRD110, including the documents:

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Customer

Name: _____

Company Name: _____

Address: _____

_____

_____

Telephone No.: _____

Facsimile No.: _____

Signature: _____

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Appendix K

Technical Data

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TECHNICAL DATA

Ratings	
AC current I_n:	1A or 5A
Frequency:	50Hz or 60Hz
DC auxiliary supply:	110/125Vdc (Operative range: 88 - 150Vdc), 220/250Vdc (Operative range: 176 - 300Vdc), 48/54/60Vdc, (Operative range: 38.4 - 72Vdc)
Superimposed AC ripple on DC supply:	≤ 12%
DC supply interruption:	≤ 50ms at 110V
Binary input circuit DC voltage:	110/125Vdc, 220/250Vdc, 48/54/60Vdc,
Overload Ratings	
AC current inputs:	3 times rated current continuous 100 times rated current for 1 second
Burden	
AC phase current inputs:	≤ 0.1VA (1A rating) ≤ 0.3VA (5A rating)
AC earth current inputs:	≤ 0.1VA (1A rating) ≤ 0.3VA (5A rating)
AC sensitive earth inputs:	≤ 0.1VA (1A rating) ≤ 0.2VA (5A rating)
DC power supply:	≤ 10W (quiescent) ≤ 15W (maximum)
Binary input circuit:	≤ 0.5W per input at 110Vdc
Current Transformer Requirements	
Phase Inputs	Typically 5P20 with rated burden according to load, (refer to section 2.12 for detailed instructions).
Standard Earth Inputs:	Core balance CT or residual connection of phase CTs.
Sensitive Earth Inputs:	Core balance CT.
Phase Overcurrent Protection (OC1 – OC4)	
OC 1st, 2nd Overcurrent threshold:	OFF, 0.04 – 5.00A Δ 0.01 (1A rating) OFF, 0.2 – 25.0A Δ 0.1 (5A rating)
Delay type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI, or Configurable IDMTL
IDMTL Time Multiplier Setting TMS:	0.010 - 1.500 Δ 0.001
DTL delay:	0.00 - 300.00s Δ 0.01
Reset Type:	Definite Time or Dependent Time.
Reset Definite Delay:	0.0 - 300.0s Δ 0.1
Reset Time Multiplier Setting RTMS:	0.010 - 1.500 Δ 0.001
P/F 3rd, 4th Overcurrent thresholds:	OFF, 0.10 - 50.00A Δ 0.01 (1A rating) OFF, 0.5 -250.0A Δ 0.1 (5A rating)
DTL delay:	0.00 - 300.00s Δ 0.01
OC elements PU time (at 200% of setting):	OC1 – OC4: less than 40ms, OCHS: less than 30ms
DO time (at 200% of setting)	OC1 – OC4: less than 50ms, OCHS: less than 30ms

Note: PU/DO time is including PU/DO time (around 10ms) of binary output contact.

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Earth Fault Protection	
E/F 1st, 2nd Overcurrent threshold:	OFF, 0.02 – 5.00A Δ 0.01 (1A rating) OFF, 0.1 – 25.0A Δ 0.1 (5A rating)
Delay type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI, or Configurable IDMTL
IDMTL Time Multiplier Setting TMS:	0.010 - 1.500 Δ 0.001
DTL delay:	0.00 - 300.00s Δ 0.01
Reset Type:	Definite Time or Dependent Time.
Reset Definite. Delay:	0.0 - 300.0s Δ 0.01
Reset Time Multiplier Setting RTMS:	0.010 - 1.500 Δ 0.001
E/F 3rd, 4th thresholds:	OFF, 0.04 - 50.00A Δ 0.01 (1A rating) OFF, 0.2 - 250.0A Δ 0.1 (5A rating)
DTL delay:	0.00 - 300.00s Δ 0.01
EF elements PU time (at 200% of setting):	EF1 – EF4: less than 40ms, EFHS: less than 30ms
DO time (at 200% of setting):	EF1 – EF4: less than 50ms, EFHS: less than 30ms
Sensitive Earth Fault Protection	
SEF 1st, 2nd Overcurrent threshold:	OFF, 0.004 – 1.000A Δ 0.001 (1A rating) OFF, 0.02 - 5.00A Δ 0.01 (5A rating)
Delay Type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
Stage 1 TMS:	0.010 - 1.500 Δ 0.001
Stage 1 DTL delay:	0.00 - 300.00s Δ 0.01
Stage 1 Reset Type:	Definite Time or Dependent Time.
Stage 1 Reset Def. Delay:	0.0 - 300.0s Δ 0.01
Stage 1 RTMS:	0.010 - 1.500 Δ 0.001
Stage 2 DTL delay:	0.00 - 300.00s Δ 0.01
SEF 3rd, 4th thresholds (GRD110-110A only):	OFF, 0.004 – 1.000A Δ 0.001 (1A rating) OFF, 0.02 - 5.00A Δ 0.01 (5A rating)
DTL delay:	0.00 - 300.00s Δ 0.01
SEF element PU time (at 200% of setting):	SEF1 – SEF4: less than 80ms, SEFHS: less than 70ms
DO time (at 200% of setting):	SEF1 – SEF4: less than 90ms, SEFHS: less than 30ms
Phase Undercurrent Protection	
Undercurrent 1st, 2nd threshold:	OFF, 0.10 - 2.00A Δ 0.01 (1A rating) OFF, 0.5 - 10.0A Δ 0.1 (5A rating)
DTL Delay:	0.00 - 300.00s Δ 0.01
Thermal Overload Protection	
$I_{AOL} = k.I_{FLC}$ (Thermal setting):	OFF, 0.40 - 2.00A Δ 0.01 (1A rating) OFF, 2.0 - 10.0A Δ 0.1 (5A rating)
Time constant (τ):	0.5 - 500.0mins Δ 0.1
Thermal alarm:	OFF, 50% to 99% Δ 1
Negative Phase Sequence Protection	
NPS 1st, 2nd threshold:	OFF, 0.10 - 2.00A Δ 0.01 (1A rating) OFF, 0.5 - 10.0A Δ 0.1 (5A rating)
DTL delay:	0.00 - 300.00s Δ 0.01
CBF Protection	
CBF threshold:	OFF, 0.10 - 2.00x In Δ 0.05
CBF stage 1 (Backup trip) DTL:	0.00 - 300.00s Δ 0.01
CBF stage 2 (Re-trip) DTL:	0.00 - 300.00s Δ 0.01
CBF element PU time and DO time:	PU time: less than 20ms DO time: less than 20ms

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Broken Conductor Protection	
Broken conductor threshold (I_2/I_1):	OFF, 0.10 - 1.00 Δ 0.01
DTL delay:	0.00 - 300.00s Δ 0.01
Accuracy	
Overcurrent Pick-ups:	100% of setting ± 5%
Overcurrent PU/DO ratio:	≥100%, CBF element: ≥125%
Undercurrent Pick-up:	100% of setting ± 5%
Undercurrent PU/DO ratio:	≤100%
Inverse Time Delays:	± 5% or 30ms (1.5 ≤ I/Is ≤ 30)
Definite Time Delays:	± 1% or 10ms
Transient Overreach for instantaneous elements:	<–5% for X/R = 100.
Frequency variation:	<± 5% (± 5% variation of rated frequency)
Communication port - local PC (RS232)	
Connection:	Point to point
Cable type:	Multi-core (straight)
Cable length:	15m (max.)
Connector:	RS232C 9-way D-type female
Communication port - remote PC (RS485)	
Connection:	Multidrop (max. 32 relays)
Cable type:	Twisted pair cable with shield
Cable length:	1200m (max.)
Connector:	Screw terminals
Isolation:	2kVac for 1 min.
Transmission rate:	64kpbs for RSM system, 9.6, 19.2kbps for IEC870-5-103
Communication port - remote PC (Fibre Optic for IEC60870-5-103)	
Cable type:	Graded-index multi-mode 50/125 or 62.5/125μm fibre
Connector:	ST
Transmission rate:	9.6, 19.2kbps for IEC60870-5-103
Binary Inputs	
Number:	8
PU voltage:	Typical 74Vdc(min.70Vdc) for 110V/125Vdc rating Typical 138Vdc(min.125Vdc) for 220V/250Vdc rating
DO voltage:	PU voltage – 20Vdc
Response time:	Less than 8ms
Binary Outputs	
Number	8
PU time:	Less than 10ms
Contact ratings:	Make and carry: 4A continuously Make and carry: 10A, 220Vdc for 0.5s (L/R≥5ms) Break: 0.1A, 220Vdc (L/R=40ms)
Durability:	Make and carry: 10000 operations Break: 100000 operations
DC Supply Monitoring	
Threshold of DC power fail:	Typical 74Vdc(min.70Vdc) for 110V/125Vdc rating Typical 138Vdc(min.125Vdc) for 220V/250Vdc rating Typical 31Vdc(min. 28Vdc) for 48Vdc rating
Mechanical design	
Weight	4.5 kg
Case color	2.5Y7.5/1(approximation to Munsell value)
Installation	Flush mounting

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ENVIRONMENTAL PERFORMANCE

Test	Standards	Details
Atmospheric Environment		
Temperature	IEC60068-2-1/2	Operating range: -10°C to +55°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC60068-2-78	56 days at 40°C and 93% relative humidity.
Enclosure Protection	IEC60529	IP51 (Rear: IP20)
Mechanical Environment		
Vibration	IEC60255-21-1	Response - Class 1 Endurance - Class 1
Shock and Bump	IEC60255-21-2	Shock Response Class 1 Shock Withstand Class 1 Bump Class 1
Seismic	IEC60255-21-3	Class 1
Electrical Environment		
Dielectric Withstand	IEC60255-5	2kVrms for 1 minute between all terminals and earth. 2kVrms for 1 minute between independent circuits. 1kVrms for 1 minute across normally open contacts.
High Voltage Impulse	IEC60255-5	Three positive and three negative impulses of 5kV(peak), 1.2/50μs, 0.5J between all terminals and between all terminals and earth.
Electromagnetic Environment		
High Frequency Disturbance / Damped Oscillatory Wave	IEC60255-22-1 Class 3, IEC61000-4-12 / EN61000-4-12	1MHz 2.5kV applied to all ports in common mode. 1MHz 1.0kV applied to all ports in differential mode.
Electrostatic Discharge	IEC60255-22-2 Class 3, IEC61000-4-2 / EN61000-4-2	6kV contact discharge, 8kV air discharge.
Radiated RF Electromagnetic Disturbance	IEC60255-22-3 Class 3, IEC61000-4-3 / EN61000-4-3	Field strength 10V/m for frequency sweeps of 80MHz to 1GHz and 1.7GHz to 2.2GHz. Additional spot tests at 80, 160, 450, 900 and 1890MHz.
Fast Transient Disturbance	IEC60255-22-4, IEC61000-4-4 / EN61000-4-4	4kV, 2.5kHz, 5/50ns applied to all inputs.
Surge Immunity	IEC60255-22-5, IEC61000-4-5 / EN61000-4-5	1.2/50μs surge in common/differential modes: HV ports: 2kV/1kV (peak) PSU and I/O ports: 2kV/1kV (peak) RS485 port: 1kV (peak)
Conducted RF Electromagnetic Disturbance	IEC60255-22-6 Class 3, IEC61000-4-6 / EN61000-4-6	10Vrms applied over frequency range 150kHz to 100MHz. Additional spot tests at 27 and 68MHz.
Power Frequency Disturbance	IEC60255-22-7, IEC61000-4-16 / EN61000-4-16	300V 50Hz for 10s applied to ports in common mode. 150V 50Hz for 10s applied to ports in differential mode. Not applicable to AC inputs.
Conducted and Radiated Emissions	IEC60255-25, EN55022 Class A, IEC61000-6-4 / EN61000-6-4	Conducted emissions: 0.15 to 0.50MHz: <79dB (peak) or <66dB (mean) 0.50 to 30MHz: <73dB (peak) or <60dB (mean) Radiated emissions (at 30m): 30 to 230MHz: <30dB 230 to 1000MHz: <37dB

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European Commission Directives		
CE	89/336/EEC	Compliance with the European Commission Electromagnetic Compatibility Directive is demonstrated according to EN 61000-6-2 and EN 61000-6-4.
	73/23/EEC	Compliance with the European Commission Low Voltage Directive is demonstrated according to EN 50178 and EN 60255-5.

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Appendix L

Symbols Used in Scheme Logic

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Symbols used in the scheme logic and their meanings are as follows:

Signal names

Marked with ▭ : Measuring element output signal

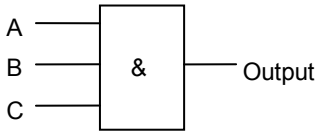
Marked with ⬭ : Binary signal input from or output to the external equipment

Marked with [ ] : Scheme switch

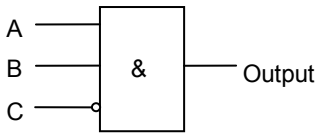
Marked with " " : Scheme switch position

Unmarked : Internal scheme logic signal

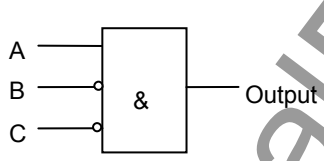
AND gates



A	B	C	Output
1	1	1	1
Other cases			0

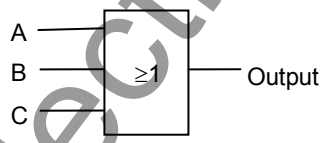


A	B	C	Output
1	1	0	1
Other cases			0

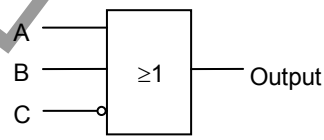


A	B	C	Output
1	0	0	1
Other cases			0

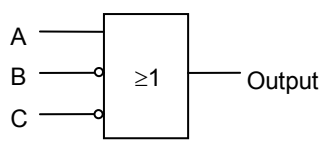
OR gates



A	B	C	Output
0	0	0	0
Other cases			1



A	B	C	Output
0	0	1	0
Other cases			1



A	B	C	Output
0	1	1	0
Other cases			1

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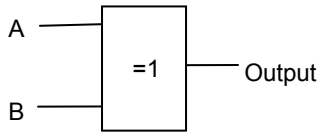
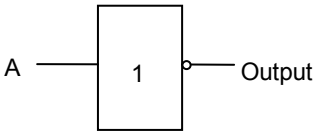
XOR gates



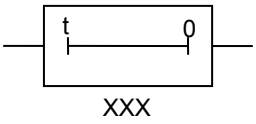
A	B	Output
0	1	1
1	0	1
Other cases		0

Signal inversion



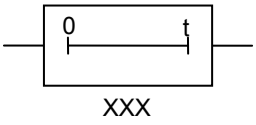
A	Output
0	1
1	0

Timer



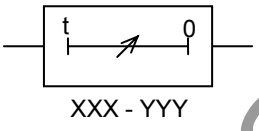
Delayed pick-up timer with fixed setting

XXX: Set time



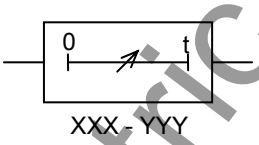
Delayed drop-off timer with fixed setting

XXX: Set time



Delayed pick-up timer with variable setting

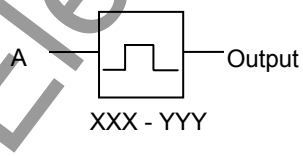
XXX - YYY: Setting range

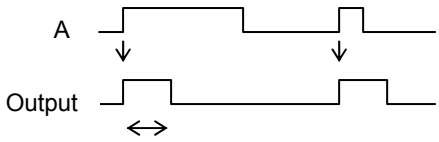


Delayed drop-off timer with variable setting

XXX - YYY: Setting range

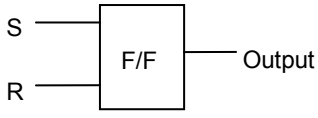
One-shot timer





XXX - YYY: Setting range

Flip-flop



S	R	Output
0	0	No change
1	0	1
0	1	0
1	1	0

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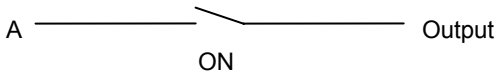
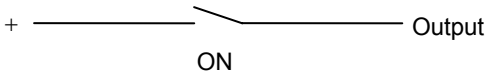
Scheme switch



A	Switch	Output
1	ON	1
Other cases		0



Switch	Output
ON	1
OFF	0

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Appendix M

IEC60870-5-103: Interoperability

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IEC60870-5-103: Interoperability

1. Physical Layer

1.1 Electrical interface: EIA RS-485

Number of loads, 32 for one protection equipment

1.2 Optical interface

Glass fibre (option)

ST type connector (option)

1.3 Transmission speed

User setting: 9600 or 19200 bit/s

2. Application Layer

COMMON ADDRESS of ASDU

One COMMON ADDRESS OF ASDU (identical with station address)

3. IEC60870-5-103 Interface

3.1 Spontaneous events

The events created by the relay will be sent using Function type (FUN) / Information numbers (INF) to the IEC60870-5-103 master station. 8 wide-use events are provided.

3.2 General interrogation

The GI request can be used to read the status of the relay, the Function types and Information numbers that will be returned during the GI cycle are shown in the table below.

3.3 Cyclic measurements

The relay will produce measured values using Type ID=3 and 9 on a cyclical basis, this can be read from the relay using a Class 2 poll. The rate at which the relay produces new measured values is 2 seconds.

It should be noted that the measurands transmitted by the relay are sent as a proportion of either 1.2 or 2.4 times the rated value of the analog value. Either 1.2 or 2.4 can be selected by the "IECNFI" setting.

3.4 Commands

A list of the supported commands is contained in the table below. The relay will respond to other commands with an ASDU 1, with a cause of transmission (COT) of negative acknowledgement of a command.

3.5 Test mode

In test mode, both spontaneous messages and polled measured values, intended for processing in the control system, are designated by means of the CAUSE OF TRANSMISSION 'test mode'. This means that CAUSE OF TRANSMISSION = 7 'test mode' is used for messages normally transmitted with COT=1 (spontaneous) or COT=2 (cyclic).

For details, refer to the standard IEC60870-5-103.

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3.6 Blocking of monitor direction

If the blocking of the monitor direction is activated in the protection equipment, all indications and measurands are no longer transmitted.

For details, refer to the standard IEC60870-5-103.

4. List of Information

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List of Information

INF	Description	Contents	GI	Type ID	COT	FUN
Standard Information numbers in monitor direction						
System Function						
0	End of General Interrogation	Transmission completion of GI items.	--	8	10	255
0	Time Synchronization	Time Synchronization ACK.	--	6	8	255
2	Reset FCB	Reset FCB(toggle bit) ACK	--	5	3	160
3	Reset CU	Reset CU ACK	--	5	4	160
4	Start/Restart	Relay start/restart	--	5	5	160
5	Pow er On	Relay pow er on.	Not supported			
Status Indications						
16	Auto-recloser active	If it is possible to use auto-recloser, this item is set active, if impossible, inactive.	Not supported			
17	Teleprotection active	If protection using telecommunication is available, this item is set to active. If not, set to inactive.	Not supported			
18	Protection active	If the protection is available, this item is set to active. If not, set to inactive.	GI	1	1, 7, 9, 12, 20, 21	160
19	LED reset	Reset of latched LEDs	--	1	1, 7, 11, 12, 20, 21	160
20	Monitor direction blocked	Block the 103 transmission from a relay to control system. IECBLK: "Blocked" setting.	GI	1	9, 11	160
21	Test mode	Transmission of testmode situation froma relay to control system. IECTST: "ON" setting.	GI	1	9, 11	160
22	Local parameter Setting	When a setting change has done at the local, the event is sent to control system.	Not supported			
23	Characteristic1	Setting group 1 active	GI	1	1, 7, 9, 11, 12, 20, 21	160
24	Characteristic2	Setting group 2 active	GI	1	1, 7, 9, 11, 12, 20, 21	160
25	Characteristic3	Setting group 3 active	GI	1	1, 7, 9, 11, 12, 20, 21	160
26	Characteristic4	Setting group 4 active	GI	1	1, 7, 9, 11, 12, 20, 21	160
27	Auxiliary input1	User specified signal 1 (Signal specified by IECB1: ON) (*1)	GI	1	1, 7, 9	160
28	Auxiliary input2	User specified signal 2 (Signal specified by IECB2: ON) (*1)	GI	1	1, 7, 9	160
29	Auxiliary input3	User specified signal 3 (Signal specified by IECB3: ON) (*1)	GI	1	1, 7, 9	160
30	Auxiliary input4	User specified signal 4 (Signal specified by IECB4: ON) (*1)	GI	1	1, 7, 9	160
Supervision Indications						
32	Measurand supervision I	Zero sequence current supervision	GI	1	1, 7, 9	160
33	Measurand supervision V	Zero sequence voltage supervision	Not supported			
35	Phase sequence supervision	Negative sequence voltage supevision	Not supported			
36	Trip circuit supervision	Output circuit supervision	GI	1	1, 7, 9	160
37	I>>backup operation		Not supported			
38	VT fuse failure	VT failure	Not supported			
39	Teleprotection disturbed	CF(Communication system Fail) supervision	Not supported			
46	Group w arning	Only alarming	GI	1	1, 7, 9	160
47	Group alarm	Trip blocking and alarming	GI	1	1, 7, 9	160
Earth Fault Indications						
48	Earth Fault L1	A phase earth fault (*2)	GI	1	1, 7, 9	160
49	Earth Fault L2	B phase earth fault (*2)	GI	1	1, 7, 9	160
50	Earth Fault L3	C phase earth fault (*2)	GI	1	1, 7, 9	160
51	Earth Fault Fw d	Earth fault forw ard (*2)	Not supported			
52	Earth Fault Rev	Earth fault reverse (*2)	Not supported			

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INF	Description	Contents	GI	Type ID	COT	FUN
Fault Indications						
64	Start/pick-up L1	A phase, A-B phase or C-A phase element pick-up	GI	2	1, 7, 9	160
65	Start/pick-up L2	B phase, A-B phase or B-C phase element pick-up	GI	2	1, 7, 9	160
66	Start/pick-up L3	C phase, B-C phase or C-A phase element pick-up	GI	2	1, 7, 9	160
67	Start/pick-up N	Earth fault element pick-up	GI	2	1, 7, 9	160
68	General trip	BO status specified by IECGT: ON (*1)	--	2	1, 7	60
69	Trip L1	BO status specified by IECAT: ON (*1)	--	2	1, 7	160
70	Trip L2	BO status specified by IECBT: ON (*1)	--	2	1, 7	160
71	Trip L3	BO status specified by IECCT: ON (*1)	--	2	1, 7	160
72	Trip I>>(back-up)	Back up trip	Not supported			
73	Fault location X In ohms	Fault location (prim. [ohm] / second. [ohm] / km selectable by IECFL)	Not supported			
74	Fault forward/line	Forward fault	Not supported			
75	Fault reverse/Busbar	Reverse fault	Not supported			
76	Teleprotection Signal transmitted	Carrier signal sending	Not supported			
77	Teleprotection Signal received	Carrier signal receiving	Not supported			
78	Zone1	Zone 1 trip	Not supported			
79	Zone2	Zone 2 trip	Not supported			
80	Zone3	Zone 3 trip	Not supported			
81	Zone4	Zone 4 trip	Not supported			
82	Zone5	Zone 5 trip	Not supported			
83	Zone6	Zone 6 trip	Not supported			
84	General Start/Pick-up	Any elements pick-up	GI	2	1, 7, 9	160
85	Breaker Failure	CBF trip or CBF retrip	--	2	1, 7	160
86	Trip measuring system L1		Not supported			
87	Trip measuring system L2		Not supported			
88	Trip measuring system L3		Not supported			
89	Trip measuring system E		Not supported			
90	Trip I>	Inverse time OC trip (OC1 trip)	--	2	1, 7	160
91	Trip I>>	Definite time OC trip (OR logic of OC1 to OC3 trip)	--	2	1, 7	160
92	Trip IN>	Inverse time earth fault OC trip (OR logic of EF1 and SEF1 trip)	--	2	1, 7	160
93	Trip IN>>	Definite time earth fault OC trip (OR logic of EF1 to EF3 and SEF1 to SEF3 trip)	--	2	1, 7	160
Autoreclose indications						
128	CB 'ON' by Autoreclose	CB close command output	Not supported			
129	CB 'ON' by long-time Autoreclose		Not supported			
130	Autoreclose Blocked	Autoreclose block	Not supported			

Note (*1): Not available if the setting is "0".
(*2): Not available when neither EF nor SEF element is used.

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INF	Description	Contents	GI	Type ID	COT	FUN
IECI1	User specified 1	Signal specified by IECE1: ON (*1)	IECG1 (yes/no)	2	1, 7	160
IECI2	User specified 2	Signal specified by IECE2: ON (*1)	IECG2 (yes/no)	2	1, 7	160
IECI3	User specified 3	Signal specified by IECE3: ON (*1)	IECG3 (yes/no)	2	1, 7	160
IECI4	User specified 4	Signal specified by IECE4: ON (*1)	IECG4 (yes/no)	2	1, 7	160
IECI5	User specified 5	Signal specified by IECE5: ON (*1)	IECG5 (yes/no)	2	1, 7	160
IECI6	User specified 6	Signal specified by IECE6: ON (*1)	IECG6 (yes/no)	2	1, 7	160
IECI7	User specified 7	Signal specified by IECE7: ON (*1)	IECG7 (yes/no)	2	1, 7	160
IECI8	User specified 8	Signal specified by IECE8: ON (*1)	IECG8 (yes/no)	2	1, 7	160
Measurands(*3)						
144	Measurand I	<meaurand I>	--	3.1	2, 7	160
145	Measurand I,V	Ib measurand <meaurand I>	--	3.2	2, 7	160
146	Measurand I,V,P,Q	Ib measurand <meaurand I>	--	3.3	2, 7	160
147	Measurand IN,VEN	Ie, Io measurand <meaurand I>	--	3.4	2, 7	160
148	Measurand IL1,2,3, VL1,2,3, P,Q,f	Ia, Ib, Ic measurand <meaurand II>	--	9	2, 7	160
Generic Function						
240	Read Headings		Not supported			
241	Read attributes of all entries of a group		Not supported			
243	Read directory of entry		Not supported			
244	Real attribute of entry		Not supported			
245	End of GGI		Not supported			
249	Write entry with confirm		Not supported			
250	Write entry with execute		Not supported			
251	Write entry aborted		Not supported			

Note (*3): depends on relay model as follows:

Model	Type ID=3.1 (INF=144)	Type ID=3.2 (INF=145)		Type ID=3.3 (INF=146)				Type ID=3.4 (INF=147)	
	IL2	IL2	VL1-VL2	IL2	VL1-VL2	3-phase P	3-phase Q	IN	VEN
Model 100	0	0	-	0	-	-	-	Ie	-
Model 400	Ib	Ib	-	Ib	-	-	-	Ie	-
Model 420	Ib	Ib	-	Ib	-	-	-	Ie	-

Model	Type ID=9 (INF=148)								
	IL1	IL2	IL3	VL1	VL2	VL3	3-phase P	3-phase Q	f
Model 100	0	0	0	-	-	-	-	-	-
Model 400	Ia	Ib	Ic	-	-	-	-	-	-
Model 420	Ia	Ib	Ic	-	-	-	-	-	-

Above values are normalized by IECNF*.

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INF	Description	Contents	COM	Type ID	COT	FUN
Selection of standard information numbers in control direction						
System functions						
0	Initiation of general interrogation		--	7	9	160
0	Time synchronization		--	6	8	160
General commands						
16	Auto-recloser on/off		ON/OFF	20	20	160
17	Teleprotection on/off		ON/OFF	20	20	160
18	Protection on/off	(*4)	ON/OFF	20	20	160
19	LED reset	Reset indication of latched LEDs.	ON	20	20	160
23	Activate characteristic 1	Setting Group 1	ON	20	20	160
24	Activate characteristic 2	Setting Group 2	ON	20	20	160
25	Activate characteristic 3	Setting Group 3	ON	20	20	160
26	Activate characteristic 4	Setting Group 4	ON	20	20	160
Generic functions						
240	Read headings of all defined groups		Not supported			
241	Read values or attributes of all entries of one group		Not supported			
243	Read directory of a single entry		Not supported			
244	Read values or attributes of a single entry		Not supported			
245	General Interrogation of generic data		Not supported			
248	Write entry		Not supported			
249	Write entry with confirmation		Not supported			
250	Write entry with execution		Not supported			
251	Write entry abort		Not supported			

Note (*4): While the relay receives the "Protection off" command, " IN SERVICE LED" is off.

	Description	Contents	GRD110 supported	Comment
Basic application functions				
	Test mode		Yes	
	Blocking of monitor direction		Yes	
	Disturbance data		No	
	Generic services		No	
	Private data		Yes	
Miscellaneous				
	Measurand		Max. MVAL = rated value times	
	Current L1	Ia	1,2 or 2,4	IECNFI setting
	Current L2	Ib	1,2 or 2,4	IECNFI setting
	Current L3	Ic	1,2 or 2,4	IECNFI setting
	Voltage L1-E	Va	No	
	Voltage L2-E	Vb	No	
	Voltage L3-E	Vc	No	
	Active power P	P	No	
	Reactive power Q	Q	No	
	Frequency f	f	No	
	Voltage L1 - L2	Vab	No	

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[Legend]

GI: General Interrogation

Type ID: Type Identification (refer to IEC60870-5-103 section 7.2.1)

1 : time-tagged message
2 : time-tagged message with relative time
3 : measurands I
4 : time-tagged measurands with relative time
5 : identification
6 : time synchronization
8 : general interrogation termination
9 : measurands II
10: generic data
11: generic identification
20: general command
23: list of recorded disturbances
26: ready for transmission for disturbance data
27: ready for transmission of a channel
28: ready for transmission of tags
29: transmission of tags
30: transmission of disturbance values
31: end of transmission

COT: Cause of Transmission (refer to IEC60870-5-103 section 7.2.3)

1: spontaneous
2: cyclic
3: reset frame count bit (FCB)
4: reset communication unit (CU)
5: start / restart
6: power on
7: test mode
8: time synchronization
9: general interrogation
10: termination of general interrogation
11: local operation
12: remote operation
20: positive acknowledgement of command
21: negative acknowledgement of command
31: transmission of disturbance data
40: positive acknowledgement of generic write command
41: negative acknowledgement of generic write command
42: valid data response to generic read command
43: invalid data response to generic read command
44: generic write confirmation

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Appendix N

Inverse Time Characteristics

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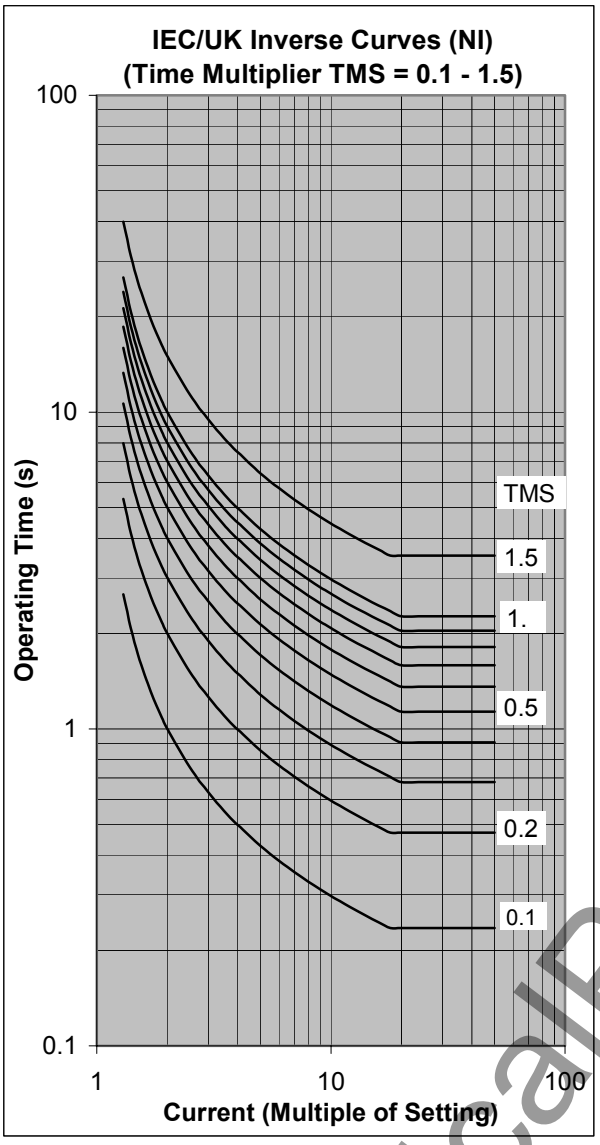
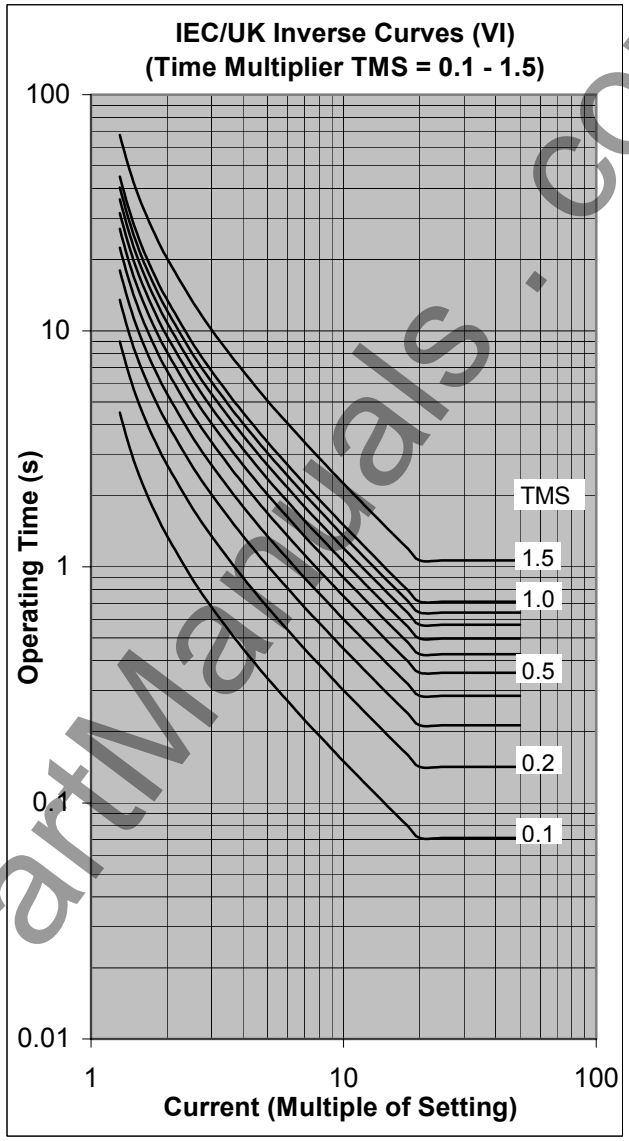


Normal Inverse



Very Inverse

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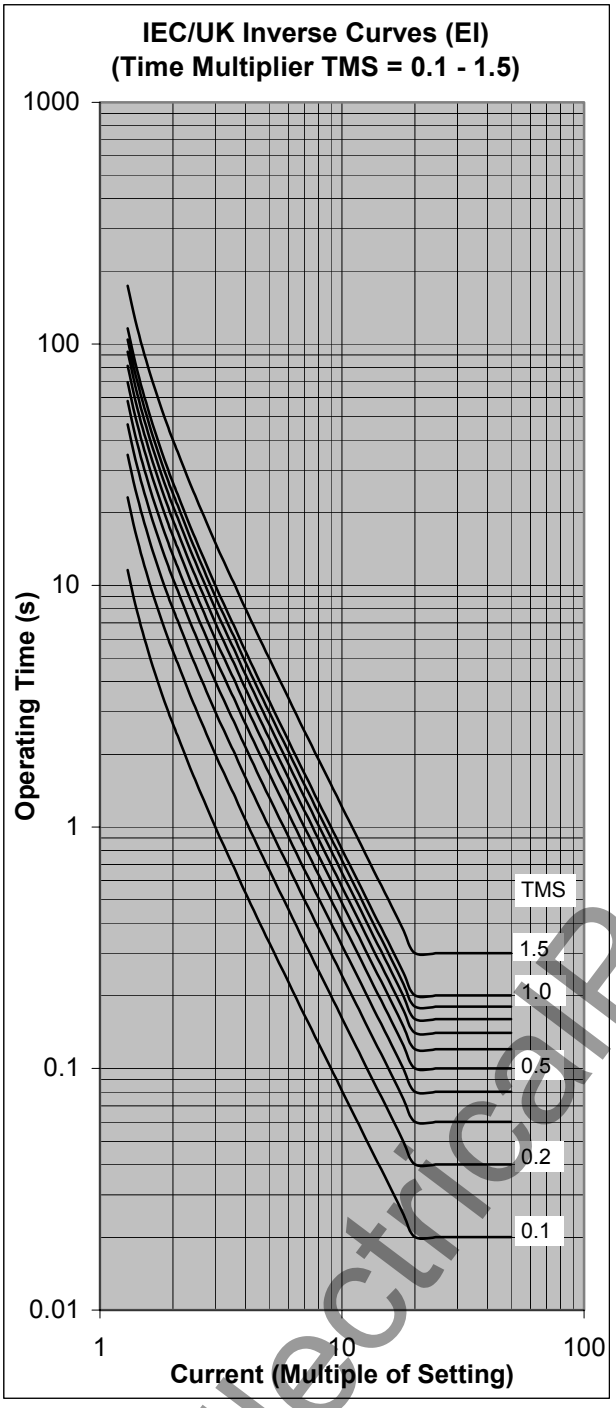
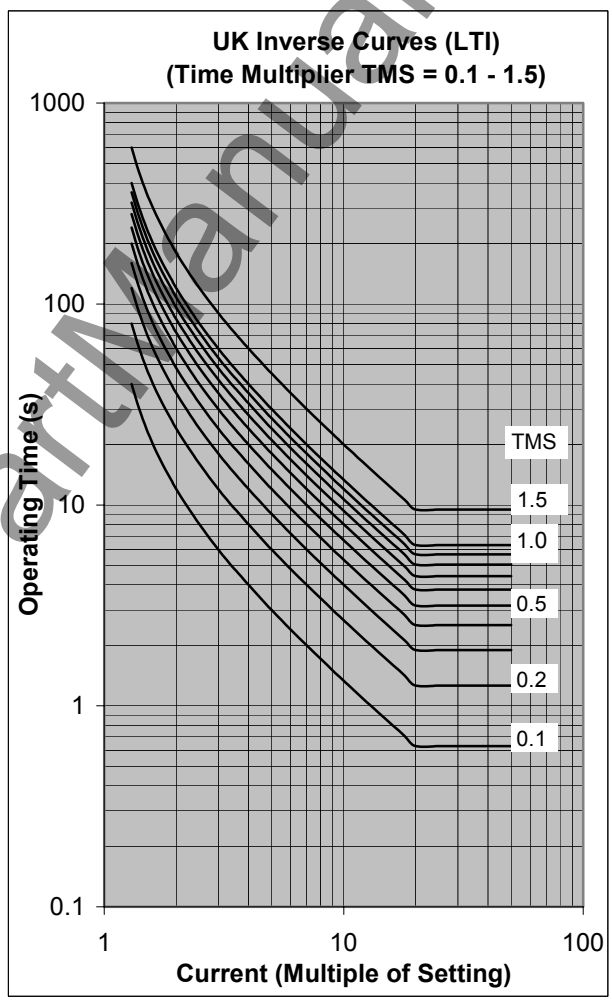


Extremely Inverse



Long Time Inverse

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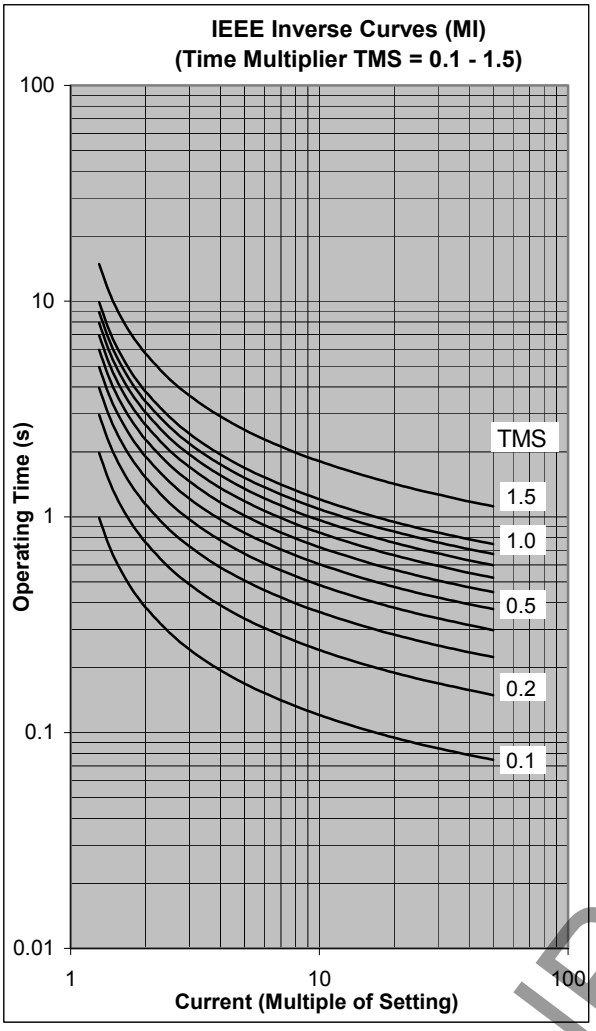
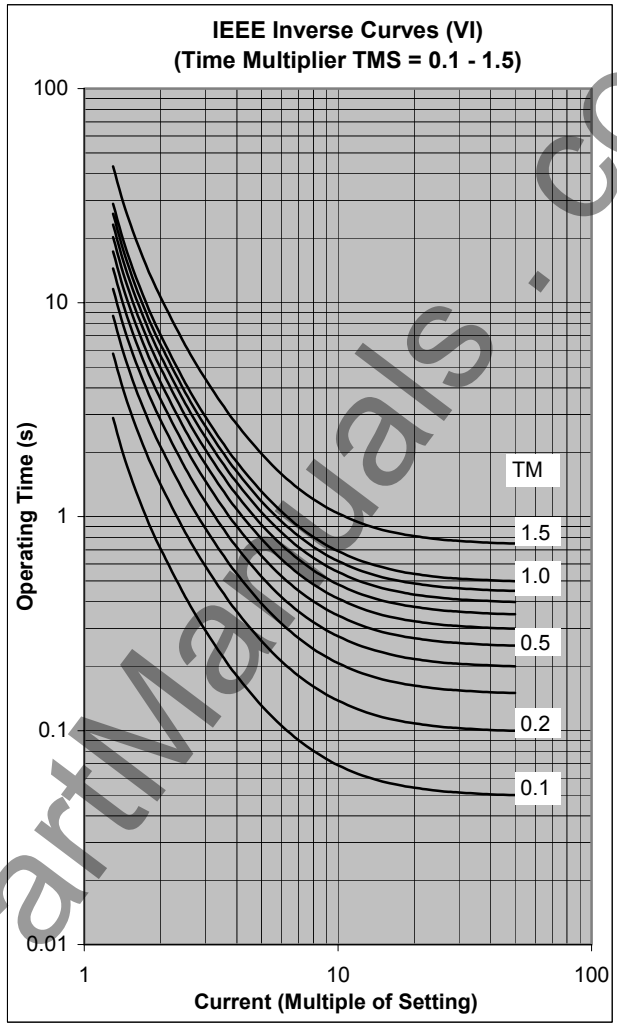


Moderately Inverse



Very Inverse

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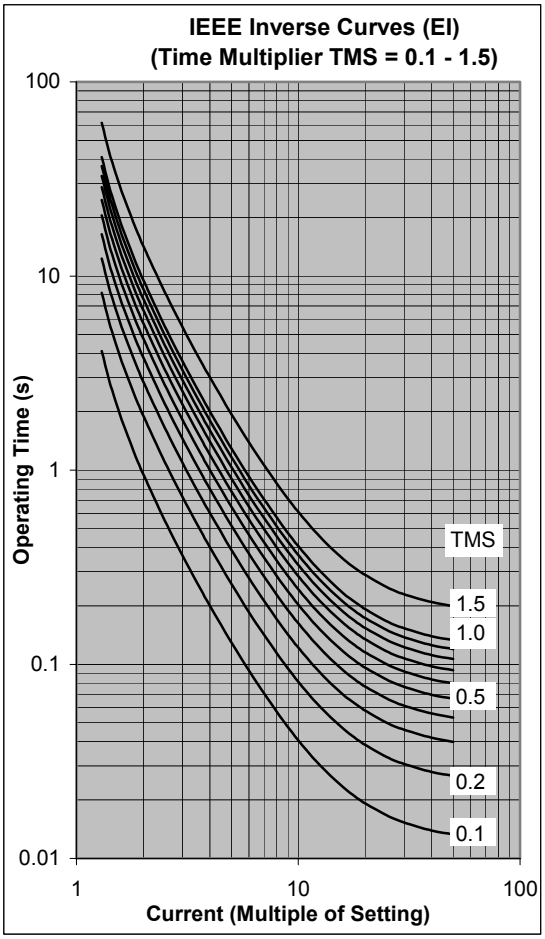

Extremely Inverse

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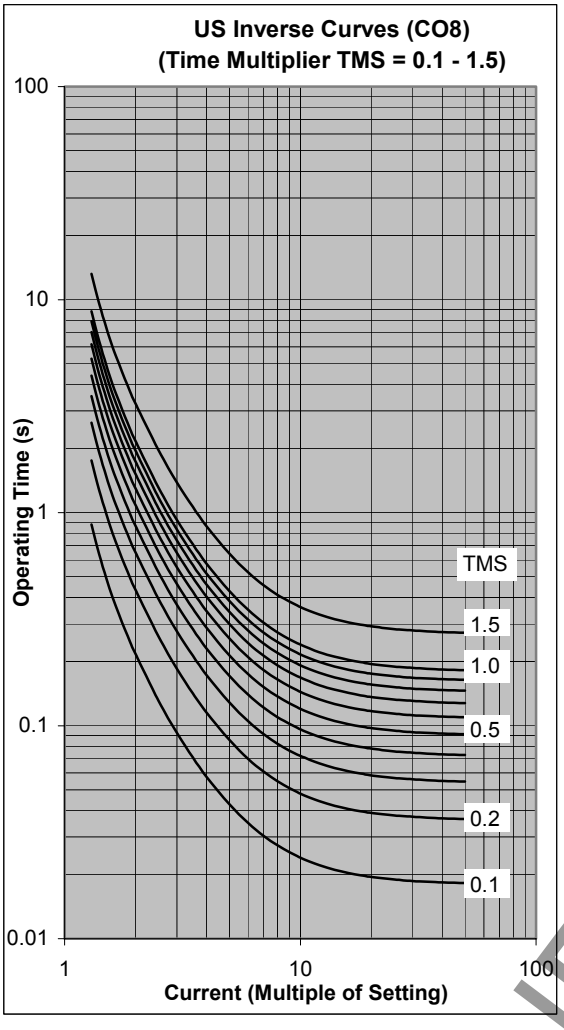
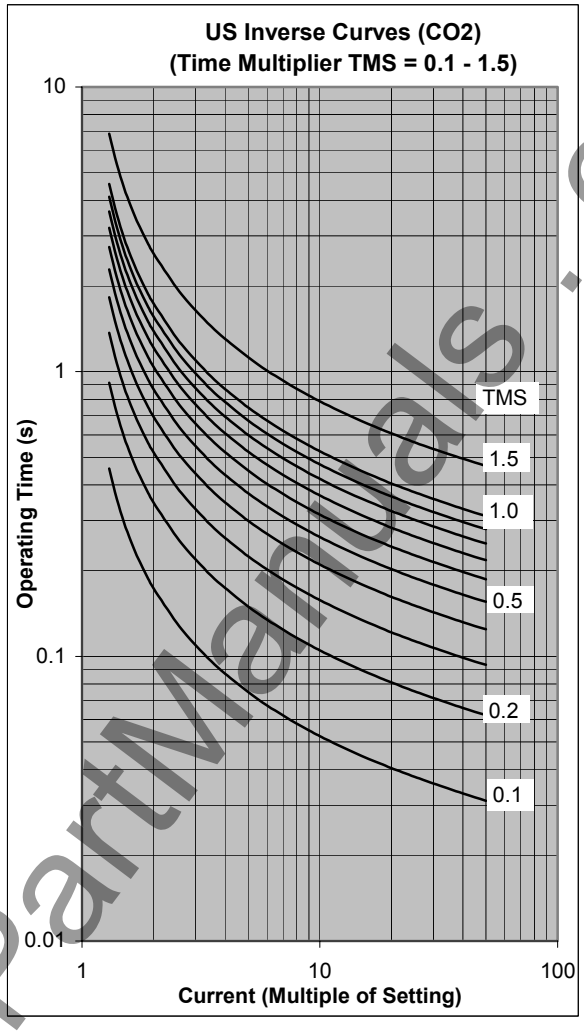


CO8 Inverse



CO2 Short Time Inverse

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Appendix O

Ordering

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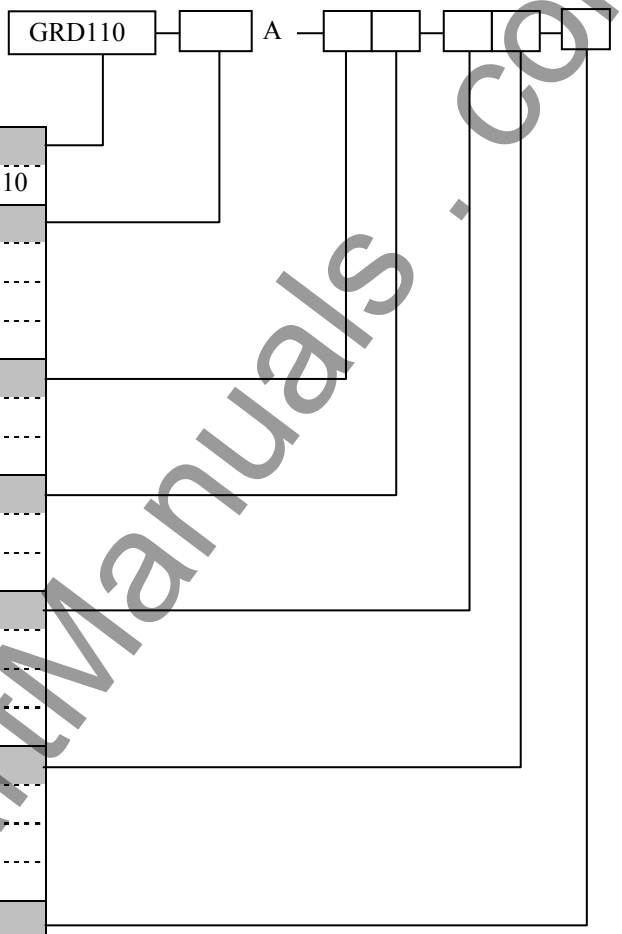
Ordering



Type:	
Overcurrent Relay	GRD110
Model:	
-Model 110: Earth fault and sensitive earth fault	110
-Model 400: Three phase and earth fault	400
-Model 420: Three phase, earth and sensitive earth fault	420
CT Rating:	
1A	1
5A	2
Frequency:	
50Hz	1
60Hz	2
DC auxiliary supply rating:	
110V/125V	1
220V/250V	2
48V	3
Rear communication port:	
RS485	1
Fibre optic	2
Dual RS485	3
LED label	
Standard	None
Option: User configurable LED label	J

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Version-up Records

Version No.	Date	Revised Section	Contents
0.0	Oct. 18, 2002	--	First issue
0.1	Nov. 7, 2002	2.2.3 4.2.3.1 4.2.4.1, 4.2.6.4 4.2.6.6, 4.2.6.7 Appendix H, I	Modified the title of Figure 2.2.4 and 2.2.5. Added Note. Modified the description and LCD screen samples. Modified the description.
0.2	Mar. 27, 2003	2.2 2.9 3.1.1 3.2.1 3.4.1 3.5 4.2.6.4, 4.2.6.6 4.2.6.9 4.4 4.5 4.6 Appendices	Modified the title of Section 2.2, Figure 2.2.4 and 2.2.5. Modified the description. Modified the description of SPMD module and Figure 3.1.2. Modified the description. Added Table 3.4.1. Modified the description. Modified the description and LCD samples. (IEC103 comm. added.) Modified the description. Modified the description. Added the Section “4.5 IEC60870-5-103 Interface”. Added the description. Modified the Appendices B, E and H. Added Appendix M.
0.3	Jun. 11, 2003	1 2.1.2 2.5 3.2 3.4, 3.5 4.2.6.7 4.2.7.1 6.5.1.3 Appendix H Appendix I Appendix M	Modified Table 1.1.1. Added the description in the setting table. (Added the [Optime].) Added the description in the setting table. (Added the THMIP.) Modified the description of Section 3.2.2 and 3.2.3. (Figure 3.2.2 added.) Added the description. (Quantity Ie) Modified the LCD sample screens. (Misc. prot. and APPL settings) Modified the LCD sample screens. (Switch setting)) Added the description of the switch [THMRST]. Modified the description. (Terminal block for RS485 interface) Modified the description in Setting sheet. (Added [Optime] and THMIP) Modified the description of “3 List of information”. (INF46, 47)
0.4	Sep. 2, 2003	1 2.8	Modified Table 1.1.1. Added the description about the reset value of CBF element and tripping time.
1.4	Jan. 28, 2004	 2.1.4, 2.2.4 2.3, 2.4, 2.6, 2.7, 2.8 2.5 3.1.1 3.2.2 3.4.2 4.1, 4.1.2 4.2.2 4.2.6.4 4.2.6.5 4.2.6.9, 4.2.6.10 4.2.7.1 Appendices	RS485 two-port type is added. Modified the setting range of OC1, EF1, EF2 and timers. Modified the setting range of timers. Modified the setting range of thermal time constant. Modified Figure 3.1.2. Modified Table 3.2.2. Modified the description. Modified the description and Figure 4.1.1. Modified the description. Modified the description and changed the LCD sample screens for communication. Added the “Setting the event recording”. Added the CAUTION for releasing the latch state when changing settings. Modified the description and changed the LCD sample screen of Switch. Modified the Appendix B, E, F, G, H, K and M.
1.5	Mar. 15, 2004	2.5 3.3.5 Appendix B Appendix M Appendix N, and O	Modified Figure 2.5.1. Modified Table 3.3.1. Modified the Signal List. (Added the No. 98.) Modified the description of “List of information”. (INF 36) Added the Appendix N and O.
1.6	Apr. 8, 2004	Appendix G	Modified the appendix G.

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Version No.	Date	Revised Section	Contents
1.7	Aug. 17, 2004	2.3 3.2.2 Appendices	Modified the description. Modified the description. Modified the appendix K and M.
1.8	Apr. 25, 2005	2.1.3 2.1.4, 2.2.4 2.3 2.7 2.8 3.3.2 3.3.4 3.3.5 4.1.1, 4.2.1 4.2.6.8 Appendices	Modified Figures 2.1.5 and 2.1.6 Modified the description of setting table. Modified Figure 2.3.2 and the description of setting table. Modified the description, Figures 2.7.1 and 2.7.2. Modified the description. Modified the description. Modified the description. Modified the description of setting table. Modified the description. Modified the description. Modified the Appendix B, C, H, K and L.
1.9	Jun. 06, 2005	2.3 3.2.2 3.2.3 3.3.4 4.2.6.9 Appendices	Modified the setting range table. Modified the description. Modified the description and Figure 3.2.3. Modified the description. Modified the description. Modified the appendix K.
2.9	Jun. 21, 2006	2.1 2.1.1 2.1.3 2.1.4 2.2 2.2.3 2.2.4 2.3 2.5 2.10 3.1.1 3.2.3 4.2.3.1, 4.2.4.1 4.2.6.6, 4.2.6.7 6.5.1 Appendices	Modified the description. Modified the description and Table 2.1.1 (user configurable curve added). Modified the description and Figures 2.1.5 and 2.1.6. Modified the setting range table. Modified the description. Modified the description and Figures 2.2.4 and 2.2.5. Modified the setting range table. Modified the description, Figures 2.3.2 and 2.3.3 and the setting range table. Added 'Note' in "Settings". Modified the description and Figures 2.10.1 and 2.10.2. Added 'Dw' to [Reset]. Modified the description in "HMI module". Modified the description and Figure 3.2.3. Added 'Note'. Modified the description and LCD sample screens. Modified LCD sample screens. Modified Appendix B, E, H, K and O.
3.0	Apr. 20, 2007	2.1.3 2.2.3 2.3 2.7 4.2.1 4.4 Appendix E	Modified the description and Figures 2.1.5 and 2.1.6. Modified the description and Figures 2.2.4 and 2.2.7. Modified the description and Figures 2.3.2 and 2.3.3. Added Figure 2.7.2. Modified the description. Modified the description. Added 'LCD & Button Operation'.
3.1	Mar. 14, 2008	2.8 Appendices	Modified Figure 2.8.1 (added signal No.187-189). Modified Appendix B (added signal No.187-189) and Appendix K.

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