INSTRUCTION MANUAL

LINE DIFFERENTIAL RELAY

GRL150

TOSHIBA CORPORATION

(Ver. 0.9)

Safety Precautions

Before using this product, please read this chapter carefully.

This chapter describes the safety precautions recommended when using the GRL150. 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.

⚠ 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

Invisible laser radiation
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 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.

- Disposal

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

环保使用期限标识是根据《电子信息产品污染控制管理办法》以及《电子信息产品污染控制标识要求》(SJ/T11364-2006)、《电子信息产品环保使用期限通则》制定的，适用于中国境内销售的电子信息产品的标识。

只要按照安全及使用说明内容在正常使用电子信息产品情况下，从生产日期算起，在此期限内产品中含有的有毒有害物质不致发生外泄或突变，不致对环境造成严重污染或对其人身、财产造成严重损害。

产品正常使用后，要废弃在环保使用年限内或者刚到年限的产品，请根据国家标准采取适当的方法进行处置。

另外，此期限不同于质量/功能的保证期限。

The Mark and Information are applicable for People's Republic of China only.

Contents

■ The data given in this manual are subject to change without notice. (Ver. 0.9)

1. Introduction

GRL150 provides fully numerical, multi-function phase-segregated line differential protection for use with pilot wire or direct fibre optic communication.

GRL150 has two model series which differ according to the communication interface, see Table 1.1.

Table 1.1 – GRL150 Models

Model	Configuration
GRL150-100 series	Pilot wire applications
GRL150-400 series	Pilot wire or direct fibre optic applications

Model 100 series is for pilot wire applications. Model 400 series provides both pilot wire and fibre optic interface and the application of communication is selectable by manual setting.

All models include multiple, high accuracy, phase-segregated protection elements with integrated overcurrent guard scheme and continuous channel supervision.

Each of the local and remote terminals has a differential calculation function and performs arithmetical operation independently and simultaneously.

In addition, GRL150 provides back-up overcurrent protection (for phase and/or earth fault) with inverse time and definite time delay functions and optional sensitive earth fault protection.

All models provide continuous monitoring of internal circuits and of software. External circuits are also monitored, by trip circuit supervision, CT supervision, and CB condition monitoring features.

A user-friendly HMI is provided through a backlit LCD, programmable LEDs, keypad and menu-based operating system. PC access is also provided, either for local connection via a front-mounted RS232 port, or for remote connection via a rear-mounted RS485 or fibre optic port.

The communication system allows the user to read and modify the relay settings, and to access data gathered by the relay's metering and recording functions.

Password protection is provided to change settings. Four active setting groups are provided. This allows the user to set one group for normal operating conditions while other groups may be set to cover alternative operating conditions. Any one setting group of four different setting groups can be selected by PLC (Programmable Logic Control) function.

Data available either via the relay HMI or communications ports includes the following functions.

- Metering
- Fault recording
- Event recording
- Disturbance recording

GRL150 provides the IEC60870-5-103 communication protocol for use with substation control and automation systems.

Table 1.1.2 shows the members of the GRL150 series and identifies the functions to be provided by each member.

Table 2.1.2 Series Members and Functions

Model Number	GRL150 -					
	100	110	120	400	410	420
Phase-segregated Differential Current Protection DIF (87)	✓	✓	✓	✓	✓	✓
Phase Overcurrent OC (50P/51P)	✓	✓	✓	✓	✓	✓
Earth Fault EF (50N/51N)		✓			✓	✓
Sensitive Earth Fault SEF (50N/51N)			✓			✓
Thermal Overload THM (49)	✓	✓	✓	✓	✓	✓
Phase Undercurrent UC (37P)	✓	✓	✓	✓	✓	✓
Broken Conductor BCD (BC)	✓	✓	✓	✓	✓	✓
Circuit Breaker Fail CBF (50BF)	✓	✓	✓	✓	✓	✓
Cold Load Protection	✓	✓	✓	✓	✓	✓
Trip circuit supervision	✓	✓	✓	✓	✓	✓
Self supervision	✓	✓	✓	✓	✓	✓
CB State Monitoring	✓	✓	✓	✓	✓	✓
Trip Counter Alarm	✓	✓	✓	✓	✓	✓
$\sum I^y$ Alarm	✓	✓	✓	✓	✓	✓
CB Operate Time Alarm	✓	✓	✓	✓	✓	✓
Metering	✓	✓	✓	✓	✓	✓
Fault records	✓	✓	✓	✓	✓	✓
Event records	✓	✓	✓	✓	✓	✓
Disturbance records	✓	✓	✓	✓	✓	✓

2. Application Notes

2.1 Protection schemes

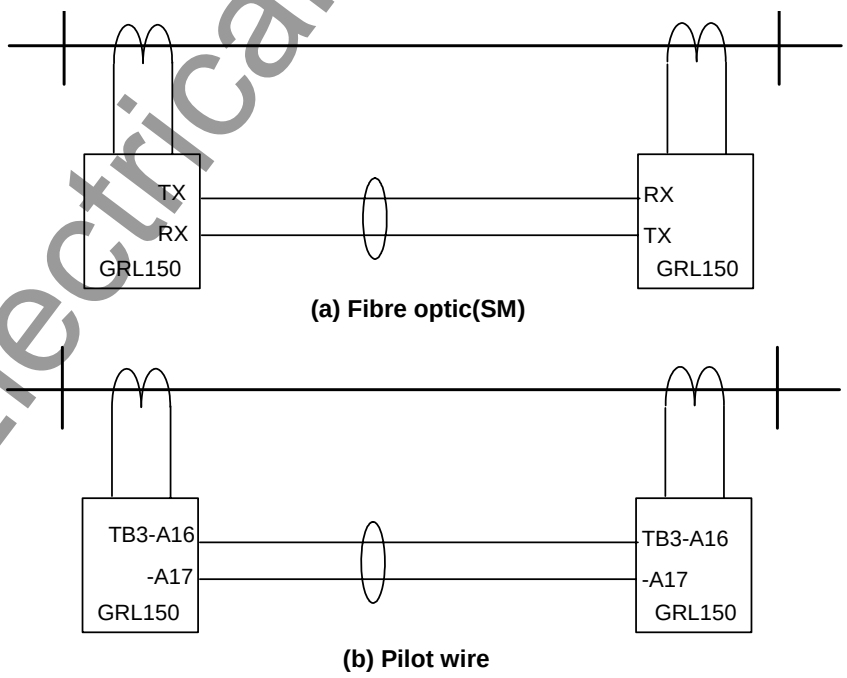
The GRL150 provides the following protection schemes:

- Segregated-phase current differential protection
- Phase fault overcurrent protection
- Earth fault protection
- Sensitive earth fault protection
- Phase undercurrent protection
- Thermal overload protection
- Broken conductor protection
- Circuit breaker failure protection
- Cold load protection

2.2 Current Differential Protection

GRL150 is applied as a segregated-phase current differential protection for use with pilot wire or direct fibre optic communication as shown in Figure 2.2.1.

For pilot wire communication, GRL150 can be applied to circuits up to 8 km in length for 0.91mmϕ and provides built-in 5kV and optional 20kV isolation. For direct fibre optic communication, GRL150 can be applied to circuits up to 20km in length. The fibre optic cable is single-mode (SM) 10/125μm type.



(a) Fibre optic(SM)

(b) Pilot wire

Figure 2.2.1 Current Differential Protection

2.2.1 Operation of Current Differential Protection

Current differential protection compares the currents flowing into and out of the protected line. The difference of the currents, that is, the differential current, is almost zero when a fault is external or there is no fault, and is equal to the fault current when the fault is internal. The differential protection operates when the difference of the currents exceeds a set value.

The GRL150 relay installed at each line terminal samples the local currents and transmits the current data to the remote terminal via pilot wire or direct fibre optic communication. The GRL150 performs master/master type current differential protection using the current data from all terminals.

The GRL150 utilises the individual three phase currents to perform segregated-phase current differential protection. The segregated-phase differential protection transmits the three phase currents to the remote terminal, calculates the individual differential currents and detects both phase-to-phase and phase-to-earth faults on a per phase basis.

Figure 2.2.1.1 shows the scheme logic of the segregated-phase current differential protection. Output signals of differential elements DIF-A, -B and -C perform instantaneous three-phase tripping. (See Figure 2.12.1.) The output signals of DIF-A, -B and -C are blocked when a communication circuit failure is detected by the data error check, sampling synchronism check or interruption of the received signals. For DIF-A_FS, -B_FS and -C_FS signals, see Section 2.2.3.

ICD is the inrush current detector ICD, which detects second harmonic inrush current during transformer energisation, and can block the DIF element if activated by the scheme switch [DIF-ICD]. If the inrush current detection signal COM4-R1_UF is received from the remote terminal, the DIF is also blocked. (See Section 2.10.) The logic sequence is configured by the PLC.

The DIF protection can be disabled by the scheme switch [DIFEN] or by the PLC command DIF_BLOCK.

Note: For the symbols used in the scheme logic, see Appendix K.

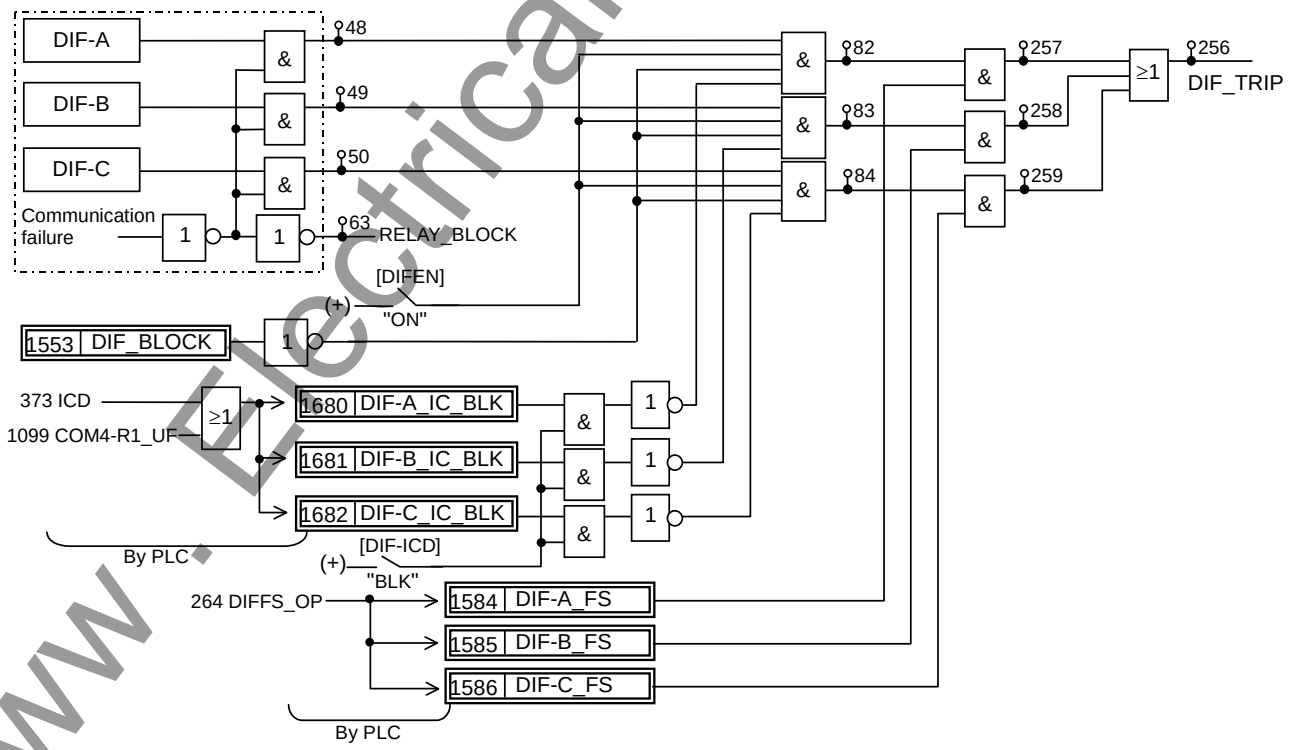


Figure 2.2.1.1 Scheme Logic of Segregated-phase Current Differential Protection

2.2.2 Characteristic of Current Differential Element DIF

The differential elements DIF have a percentage restraining characteristic with weak restraint in the small current region and strong restraint in the large current region, to cope with CT saturation.

The DIF elements have dual percentage restraint characteristics. Figure 2.2.2.1 shows the characteristics on the differential current (Id) and restraining current (Ir) plane. Id is the vector summation of the phase current of all terminals and Ir is the scalar summation of the phase current of all terminals.

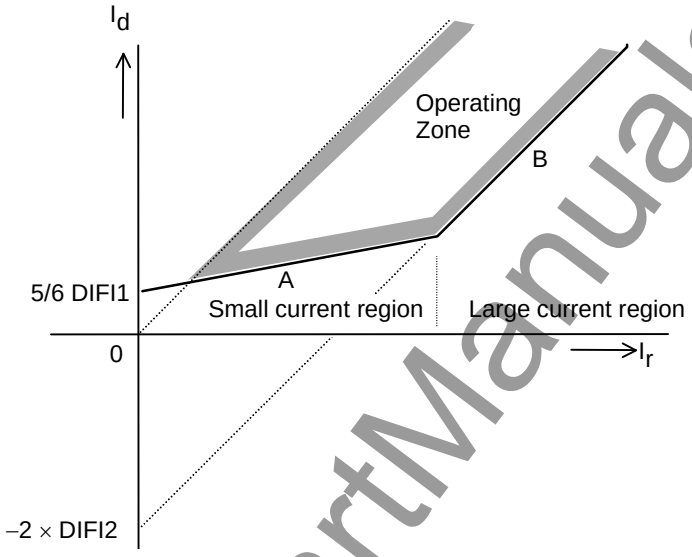


Figure 2.2.2.1 DIF Element (I_r-I_d Plane)

Characteristic A of the DIF element is expressed by the following equation:

$$I_d \geq (1/6)I_r + (5/6)DIFI1$$

where DIFI1 is a setting and defines the minimum internal fault current.

This characteristic has weaker restraint and ensures sensitivity to low-level faults.

Characteristic B is expressed by the following equation:

$$I_d \geq I_r - 2 \times DIFI2$$

where DIFI2 is a setting and its physical meaning is described later.

This characteristic has stronger restraint and prevents the element from operating falsely in response to the erroneous differential current which is caused by saturation or transient errors of the CT during an external fault. If the CT saturation occurs at the external fault in a small current region of the characteristics and continues, the element may operate falsely caused by increasing the erroneous differential current. The DIF prevents the false operation by enhancing the restraining quantity for the DIF calculation, depending on the magnitude of restraining current in the large current region characteristic B.

The figure shows how the operation sensitivity varies depending on the restraining current.

The same characteristic can be represented on the outflowing current (I_{out}) and infeeding current (I_{in}) plane as shown in Figure 2.2.2.2.

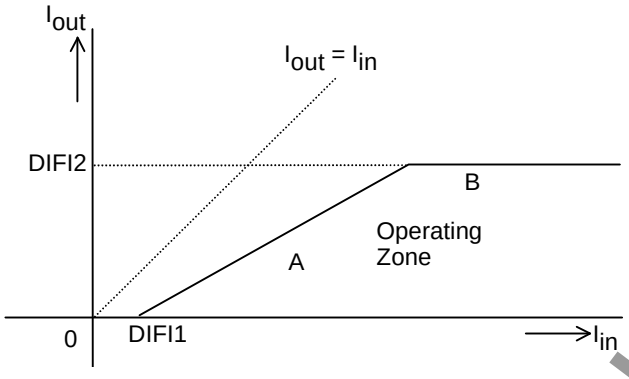


Figure 2.2.2.2 DIF Element (I_{in}-I_{out} Plane)

Characteristic A is expressed by the following equation:

$$I_{out} \leq (5/7)(I_{in} - DIFI1)$$

Characteristic B is expressed by the following equation:

$$I_{out} \leq DIFI2$$

2.2.3 Fail-safe Function (Overcurrent Guard Scheme)

GRL150 provides OC5 and OCD elements which provide an overcurrent guard scheme for fail-safe operation. OC5 is a phase overcurrent element and its sensitivity can be set. OCD is a phase current change detection element and its sensitivity is fixed.

The scheme logic is shown in Figure 2.2.3.1. The output of DIFFS_OP is connected to DIF-A_FS, DIF-B_FS, DIF-C_FS respectively by PLC function.

The fail-safe function is disabled by the [DIF-FS] switch. By [DIF-FS], OC5 or OCD or both elements can be selected. If the switch is set to "OFF", the signal of DIFFS_OP is "1" and the fail-safe is disabled.

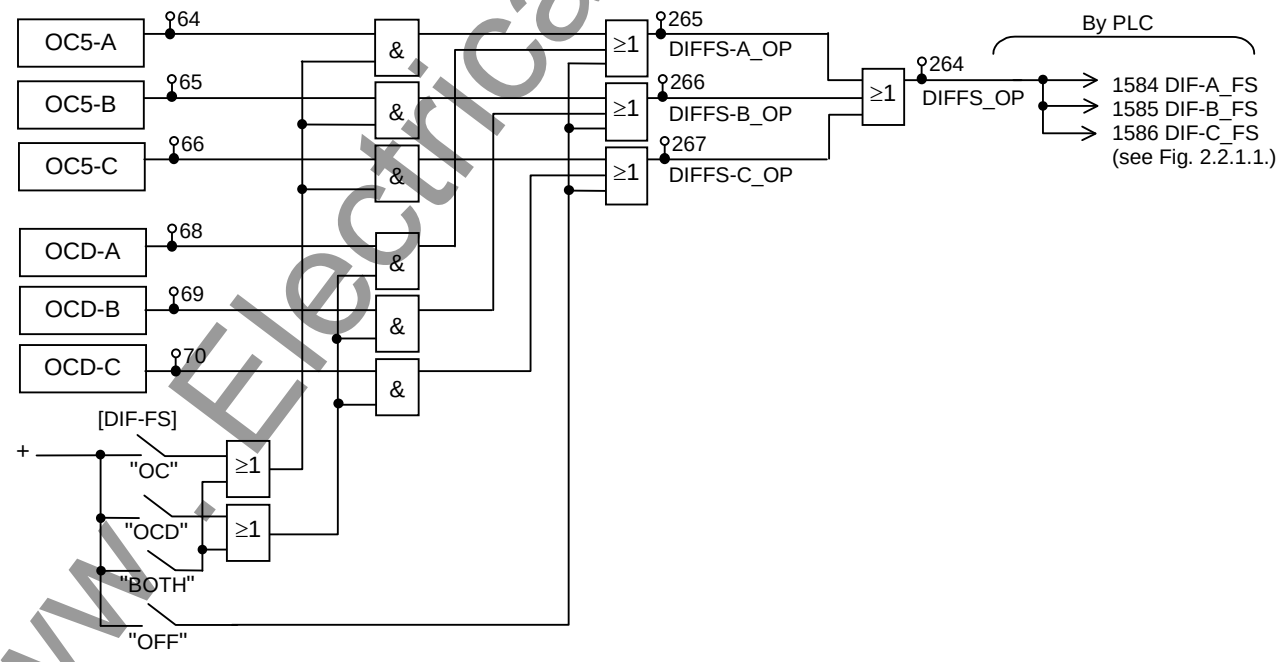


Figure 2.2.3.1 Fail-safe Logic

Current change detection element OCD

The OCD operates if the vectorial difference between currents I_M and I_N observed one cycle apart is larger than the fixed setting. Therefore, the operating sensitivity of this element is not affected by the quiescent load current and can detect a fault current with high sensitivity.

The operation decision is made according to the following equation:

$$|I_M - I_N| > I_S$$

where,

I_M = present current

I_N = current one cycle before

I_S = fixed setting (8% of rated current)

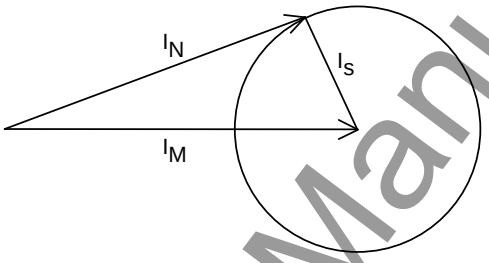


Figure 2.2.3.2 Current Change Detection

2.2.4 Open Terminal (Out-of-Service) Detection

Erroneous current data may be transmitted from the remote terminal when the remote relay is out-of-service for testing or other purposes. To prevent false operation in this case, the relay sets the receiving current data to zero in the differential current calculation upon detecting that the remote terminal is out-of-service.

Figure 2.2.4.1 shows the remote terminal out-of-service detection logic. The local terminal can detect that the remote terminal is out-of-service if it receives no interlink signal I.LINK-R1 from the remote terminal. The interlink signal is configured from the circuit breaker CB and disconnector DS status signal shown in Figure 2.2.4.2. Each terminal detects the out-of-service condition and transmits its signal I.LINK to the other. Thus, out-of-service is detected when either the circuit breaker or disconnector are open in all three phases.

The local terminal detects that the remote terminal is out-of-service by receiving a signal L.TEST-R1 which is transmitted when the scheme switch [L. TEST] is set to "ON" at the terminal under test.

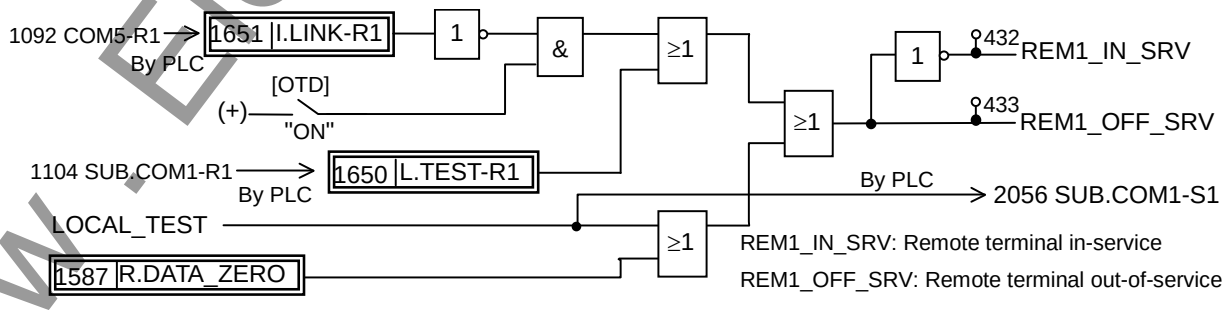


Figure 2.2.4.1 Out-of-Service Detection Logic

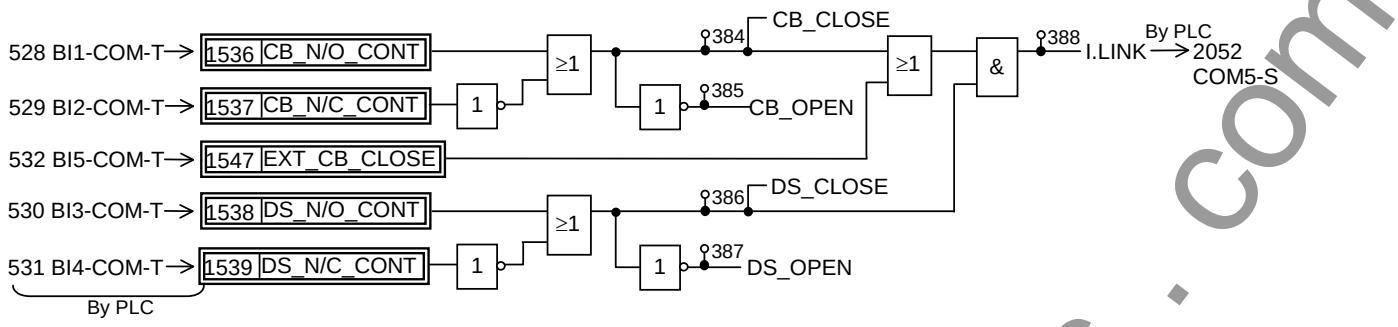


Figure 2.2.4.2 Inter-Link detection

2.2.5 Transmission Data

The following data are transmitted every 60 electrical degrees for pilot wire communication or every 30 electrical degrees for direct fibre optic communication to the remote terminal:

A-phase current
B-phase current
C-phase current
Sampling synchronization control signal
Synchronized test trigger signal
User-programmable commands

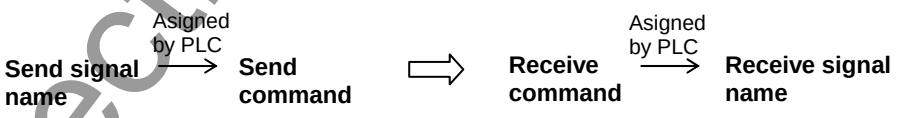
Sampled current data, for the current and previous samples, are transmitted to the remote terminal in pairs.

In addition to the above data, cyclic redundancy check bits are transmitted to monitor the communication channel. If a communication failure is detected at the local terminal, the output of differential protection is blocked.

A synchronized test trigger signal is used to test the differential protection simultaneously at all terminals. For details, see Section 4.2.7.4.

User programmable commands

Any signals (On/off data) shown in Appendix B can be assigned to COM1 to COM5, SUB_COM1 to SUB_COM5 and SUB2_COM1 to SUB2_COM12 as user programmable commands by using the PLC function. The default setting is as follows:



Default signal No.	Default signal Name	Command (send)	Command (receive)	Default signal No.	Default signal Name
--	--	COM1-S	COM1-R1 / -R1_UF	--	--
--	--	COM2-S	COM2-R1 / -R1_UF	--	--
--	--	COM3-S	COM3-R1 / -R1_UF	--	--
374	ICD_BLK-S	COM4-S	COM4-R1_UF	See	Figure 2.2.1.1.
388	I.LINK	COM5-S	COM5-R1	1651	I.LINK-R1
390	LOCAL_TEST	SUB_COM1-S	SUB_COM1-R1	1650	L.TEST-R1
	(reserved) (*)	SUB_COM2-S	SUB_COM2-R1	--	--
	(reserved) (*)	SUB_COM3-S	SUB_COM3-R1	--	--
--	--	SUB_COM4-S	SUB_COM4-R1	--	--
--	--	SUB_COM5-S	SUB_COM5-R1	--	--

Default signal No.	Default signal Name	Command (send)	Command (receive)	Default signal No.	Default signal Name
--	--	SUB2_COM1-S	SUB2_COM1-R1	--	--
--	--	SUB2_COM2-S	SUB2_COM2-R1	--	--
--	--	SUB2_COM3-S	SUB2_COM3-R1	--	--
--	--	SUB2_COM4-S	SUB2_COM4-R1	--	--
--	--	SUB2_COM5-S	SUB2_COM5-R1	--	--
--	--	SUB2_COM6-S	SUB2_COM6-R1	--	--
--	--	SUB2_COM7-S	SUB2_COM7-R1	--	--
--	--	SUB2_COM8-S	SUB2_COM8-R1	--	--
--	--	SUB2_COM9-S	SUB2_COM9-R1	--	--
--	--	SUB2_COM10-S	SUB2_COM10-R1	--	--
--	--	SUB2_COM11-S	SUB2_COM11-R1	--	--
--	--	SUB2_COM12-S	SUB2_COM12-R1	--	--

Note(∗): used in the relay system.

2.2.6 Synchronized Sampling

The GRL150 performs synchronized simultaneous sampling at all terminals of the protected line. This synchronized sampling requires neither an external reference clock nor synchronization of the internal clocks of the relays at different terminals.

The sampling synchronization is realized through timing synchronization control.

Timing synchronization

One of the terminals is selected as the time reference terminal and set as the master terminal. The other terminal is set as the slave terminal. The scheme switch [SP.SYN] is used for the settings.

Note: The master and slave terminals are set only for the convenience of the sampling timing synchronization. The GRL150s at both terminals perform identical protection functions and operate simultaneously.

Timing synchronization is performed using the receiving time for a data frame.

To perform timing synchronization for the slave terminal, the timing signal is sent from the master terminal to the slave terminal and the sampling time of the slave terminal relay is synchronized with the receiving time at the slave terminal.

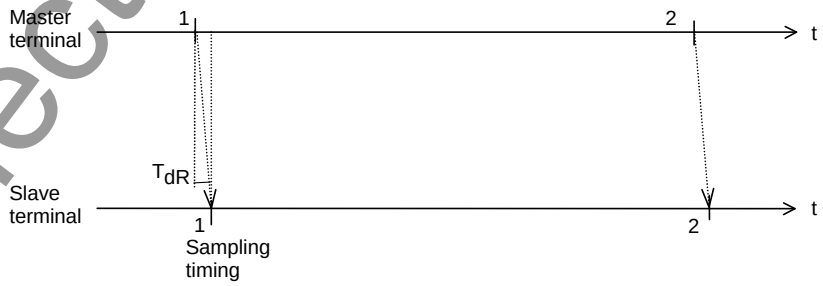


Figure 2.2.6.1 Timing Synchronization

2.2.7 Telecommunication Circuit

The GRL150 can be provided with two types of telecommunications interface, an electrical interface (pilot wire) and a fibre optic interface. For pilot wire communication, GRL150 can be applied to circuits up to 8 km in length on 0.9 mmϕ pilot wire cable or up to 2.5 km length on 0.5 mmϕ pilot wire cable.

Note: GRL150 operation depends on the transmission performance of the pilot wire cable and the noise environment, and where these are poor the circuit lengths quoted above may not be achievable.

The GRL150-100 series is applied to pilot wire communication only. The GRL150-400 series can be applied to pilot wire communication or fibre optic communication by scheme switch [COM.I/F]. In the case of pilot wire communication, the [COM.I/F] is set to "PW". For fibre optic communication, it is set to "OPT".

In pilot wire communication, a receiving signal adjusting function is provided, since the receiving level is influenced by pilot-wire cable size, distance and installation environment. The receiving signal can be adjusted automatically (Auto) or manually (Manual) by the scheme switch [RL-MODE]. When "Auto" is selected, the optimum signal receiving level, which has the least CF (Communication Failure), is automatically set according to the receiving level (peak value). "Auto" is generally selected in normal operation. However, if a severe noise environment prevents correct operation of GRL150, then "Manual" can be selected and the receiving level is chosen manually. (Refer to Section 4.2.3.4, 4.2.6.5 and 6.6.2.)

If the transmitting signal interferes with other communication signals in a multi-core pilot wire cable, the optional G1RE1 resistor box is available for reducing the transmission level. (Refer to Appendix N.)

2.2.8 Telecommunication Channel Monitoring

If a failure occurs or noise causes a disturbance in the telecommunication channel, they may interrupt the data transmission or generate erroneous data, thus causing the relay to operate incorrectly.

The GRL150 detects data failures by performing a cyclic redundancy check on the data. The checks are carried out for every sample. (See Section 3.3.5.)

If the failure lasts for ten seconds, a communication failure alarm is issued.

Current differential protection is blocked instantaneously upon detection of a communication failure. The output blocking ceases instantly when the failure recovers.

2.2.9 Setting

The following shows the setting elements necessary for the current differential protection and their setting ranges. The settings can be made on the LCD screen or PC screen.

Element		Range	Step	Default	Remarks
DIF					Phase current
	DIFI1	0.50 – 10.00A	0.01A	5.00A	Small current region
		(0.10 – 2.00A	0.01A	1.00A)(*1)	
	DIFI2	1.0 – 120.0A	0.1A	15.0A	Large current region
		(0.2 – 24.0A	0.1A	3.0A)	
OC5		0.1 – 250.0A	0.1A	2.5A	OC5 threshold setting for fail-safe
		(0.02 – 50.00A	0.01 A	0.5A)	
DIFSV		50 – 100%	1%	50%	Differential current Id monitoring
TIDSV		0 – 60s	1s	10s	Timer for Id monitoring
[SP.SYN]		Master/Slave		Master(*2)	Sampling synchronization
[COM.I/F]		PW / OPT		OPT	Only for model 400 series

[RL-MODE]	Auto / Manual		Auto	Signal receiving level adjusting mode
M. RL	1.0 – 100.0%	0.1%	20.0%	Signal receiving level (% of peak value)
[OTD]	ON/OFF		OFF	Open terminal detection
[DIFEN]	ON/OFF		ON	DIF enable
[DIF-FS]	OFF / OC / OCD / Both		OFF	Fail-safe function
[DIF-ICD]	NA / BLK		NA	DIF blocked by inrush current

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

(*2) In the actual setting, one terminal is set to "Master" and the other terminal to "Slave".

CT Ratio matching

If the CT ratios at the local and remote terminals are different, then CT ratio matching can be applied as follows:

The differential element settings are respectively set to the setting values so that the primary fault detecting current is the same value at all terminals. Figure 2.2.9.1 shows an example of CT ratio matching. The settings for DIFI2 and DIFSV should also be set with relation to the primary current in the same manner of the DIFI1 setting.

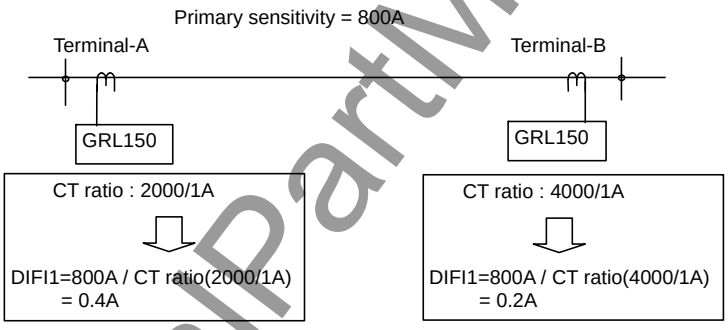


Figure 2.2.9.1 Example of CT Ratio Matching

If the CT secondary ratings at the local and remote terminals are different, relay model suitable for the CT secondary rating is used at each teminal and then CT ratio matching can be applied the same as above. The differential element settings are respectively set to the setting values so that the primary fault detecting current is the same value at all terminals. Figure 2.2.9.2 shows an example of CT ratio matching. The settings for DIFI2 and DIFSV should also be set with relation to the primary current in the same manner of the DIFI1 setting.

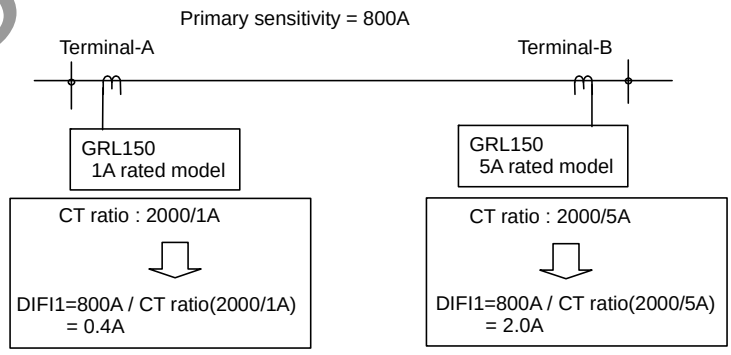


Figure 2.2.9.2 Example of CT Ratio Matching incase of Different CT secondary Rating

DIFI1 setting and Full-scale

GRL150 transmits current data to the remote terminal after the CT matching. The current data is normalized by the DIFI1 setting value. Therfore, the full-scale of the current data is expressed by the following equation depending on the DIFI1 setting.

I_{FS} = DIFI1 × 32 (A)

where, I_{FS}: Full-scale of current data

When setting DIFI1, it must be ensured that I_{FS} is greater than the maximum fault current.

Setting of DIFI1

The setting of DIFI1 is determined considering the minimum internal fault current for which the relay should operate and the maximum erroneous differential current (mainly the internal charging current) during normal service conditions for which the relay should not operate.

DIFI1 should therefore be set to satisfy the following equation:

$$K \cdot Ic < DIFI1 < I_f / K$$

where,

K: Setting margin (K = 1.2 to 1.5)
Ic: Internal charging current
I_f: Minimum internal fault current

Setting of DIFI2

The setting of DIFI2 is determined from the following three criteria:

- Maximum erroneous current generated by CT saturation in case of an external fault
- Maximum load current
- Maximum outflow current in case of an internal fault

In the case of the first criterion, DIFI2 should be set as small as possible so that unwanted operation is not caused by the maximum erroneous current generated by CT saturation during heavy through current for an external fault. It is recommended normally to set DIFI2 to 2×In (In: secondary rated current) for this criterion.

For the second criterion, DIFI2 should be set large enough such that it does not encroach on load current.

For the third criterion, the maximum outflow current must be considered. DIFI2 should be set larger than the largest possible value of outflow current in the case of an internal fault.

In two terminal network, the maximum outflow current is the maximum load current.

Setting of DIFSV

When using the differential current monitoring function, the setting of DIFSV is determined from the maximum erroneous differential current during normal service conditions.

$$K \cdot Ierr < DIFSV < DIFI1 / (1.5 \text{ to } 2)$$

Ierr: maximum erroneous differential current

Setting of [SP.SYN]

One terminal must be set to "Master" and the other terminal to "Slave".

2.3 Phase Fault Overcurrent Protection

GRL150 provides three phase overcurrent protection with four independent overcurrent thresholds OC1 to OC4. The first threshold OC1 may be set for inverse time or definite time operation. If inverse time is selected, then any one of nine curves may be chosen, including IEC and IEEE/ANSI standard characteristics.

OC1 has a programmable reset feature, selectable for instantaneous, definite time or dependent time reset. This feature can be used to protect against flashing fault conditions, or to grade correctly with electromechanical overcurrent relays.

The other overcurrent thresholds OC2 to OC4 may be set for definite time, or instantaneous operation. These elements are immune to the effects of transformer magnetising inrush and dc offset transient over-reach.

All elements can be inhibited by binary input signals for operation in blocked overcurrent schemes.

2.3.1 Inverse Time (IDMT) Operation

The overcurrent protection element OC1 has the IDMT characteristics defined by equation (1):

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

where:

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

I = energising current (amps),

Is = overcurrent setting (amps),

TMS = time multiplier setting,

k, a, c = constants defining curve.

Nine curve types are available as defined in Table 2.3.1.1. They are illustrated in Figure 2.3.1.1. Detail curves for each IDMT are shown in Appendix L.

Any one curve can selected for each IDMT element by scheme switches [M***] and [M***C-**].

Table 2.3.1.1 Specification of IDMT Curves

Curve Description	Operating characteristic			Resetting characteristic	
	k	a	c	kr	b
IEC Normal Inverse (NI)	0.14	0.02	0	-	-
IEC Very Inverse (VI)	13.5	1	0	-	-
IEC Extremely Inverse (EI)	80	2	0	-	-
UK Long Time Inverse (LTI)	120	1	0	-	-
IEEE Moderately Inverse (MI)	0.0515	0.02	0.114	4.85	2
IEEE Very Inverse (VI)	19.61	2	0.491	21.6	2
IEEE Extremely Inverse (EI)	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

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

In addition to the above nine curve types, the OC1 can provide a user configurable IDMT curve. If required, set the scheme switch [M***] to "CON" and set the curve defining constants k, a, c, kr and b. The following table shows the setting ranges of the curve defining constants.

Table 2.3.1.2 Setting Range of IDMT Curves

Curve defining constants	Range	Step	Remarks
k	0.00 – 300.00	0.01	Operating characteristic
a	0.00 – 5.00	0.01	([M***]=CON setting)
c	0.000 – 5.000	0.001	
kr	0.00 – 300.00	0.01	Resetting characteristic
b	0.00 – 5.00	0.01	([M***]=CON, and [***R]=DEP setting)

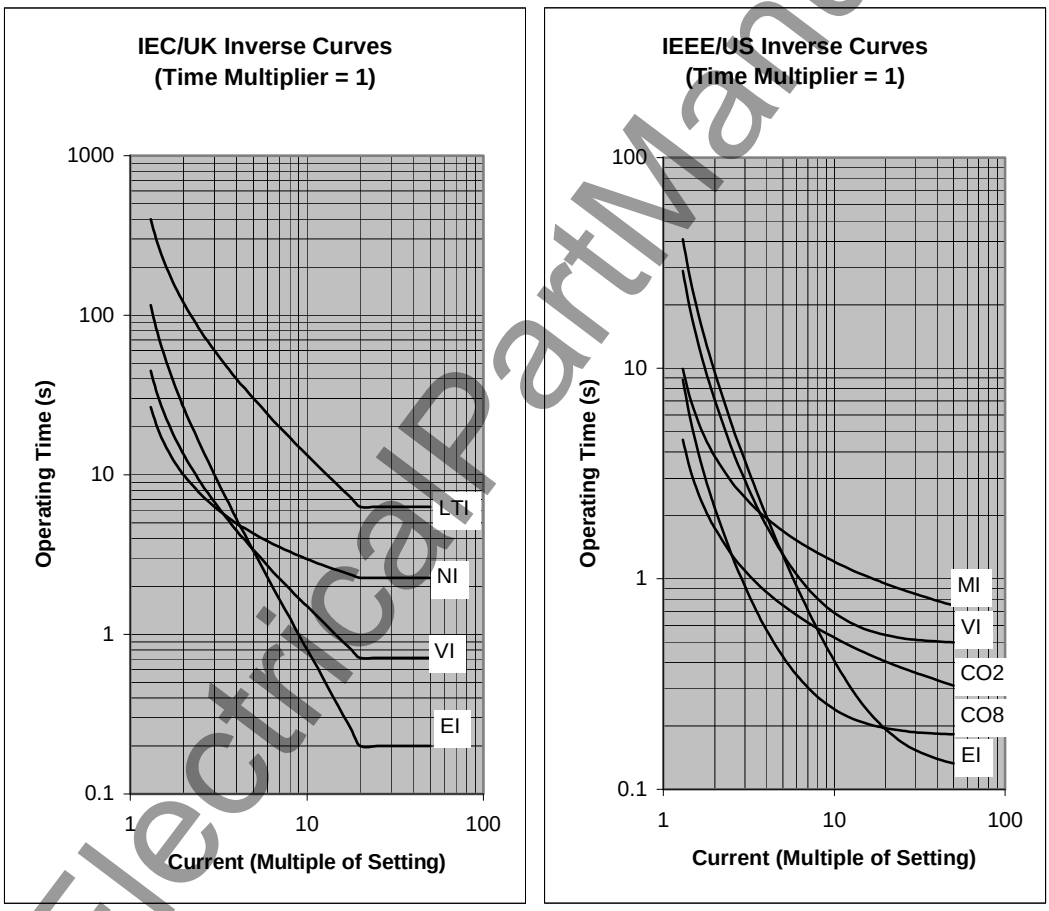


Figure 2.3.1.1 IDMT Characteristics

Programmable Reset Characteristics

OC1 has 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 dependent time delayed 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.

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:

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

where:

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

I = energising current (amps),

Is = overcurrent setting (amps),

kr = time required to reset fully after complete operation when the energising current is zero (see Table 2.3.1.1),

RTMS = reset time multiplier setting.

b = constant defining curve.

Figure 2.3.1.2 illustrates the dependent time reset characteristics.

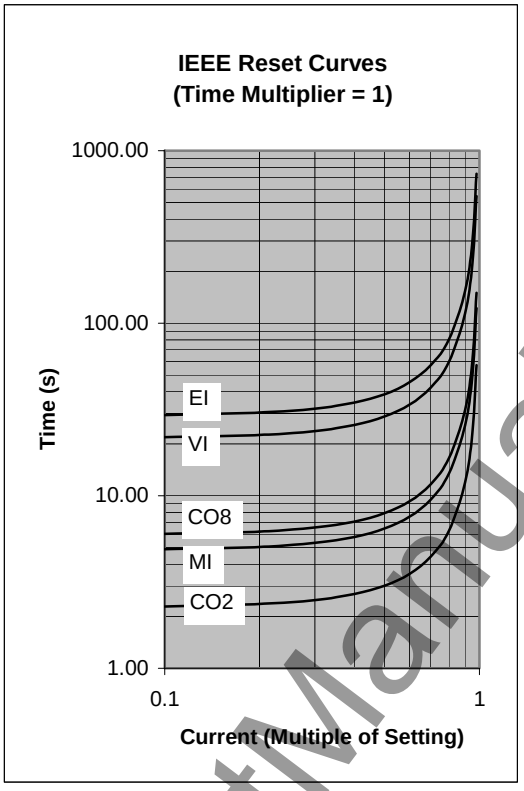


Figure 2.3.1.2 Dependent Time Reset Characteristics

2.3.2 Scheme Logic

Figures 2.3.2.1 to 2.3.2.2 show the scheme logic of the phase overcurrent protection OC1 to OC4.

OC1 protection provides selective definite time or inverse time characteristic as shown in Figure 2.3.1.1. The definite time protection is selected by setting [MOC1] to "DT" and trip signal OC1 TRIP is given through the delayed pick-up timer TOC1. The inverse time protection is selected by setting [MOC1] to any one of "IEC", "IEEE", "US" or "CON" and then setting [MOC1C] according to the required IDMT characteristic, and trip signal OC1 TRIP is given.

Figure 2.3.2.3 to Figure 2.3.2.4 show the scheme logic of the definite time phase overcurrent protection OC2 to OC4. The OC2 to OC4 give trip and alarm signals OC2 TRIP, OC3 TRIP and OC4 ALARM through the delayed pick-up timers TOC2 to TOC4 respectively.

The signal OC1-INST to OC4-INST are available to trip instantaneously for a fault.

The OC1 to OC4 protection can be disabled by the scheme switches [OC1EN] to [OC4EN] or the binary input signals OC1 BLOCK to OC4 BLOCK respectively.

ICD is the inrush current detector ICD, which detects second harmonic inrush current during transformer energisation, and can block the OC elements by the scheme switch [OC-ICD]. See Section 2.10. The logic sequence is configured by the PLC.

Note: For the symbols used in the scheme logic, see Appendix K.

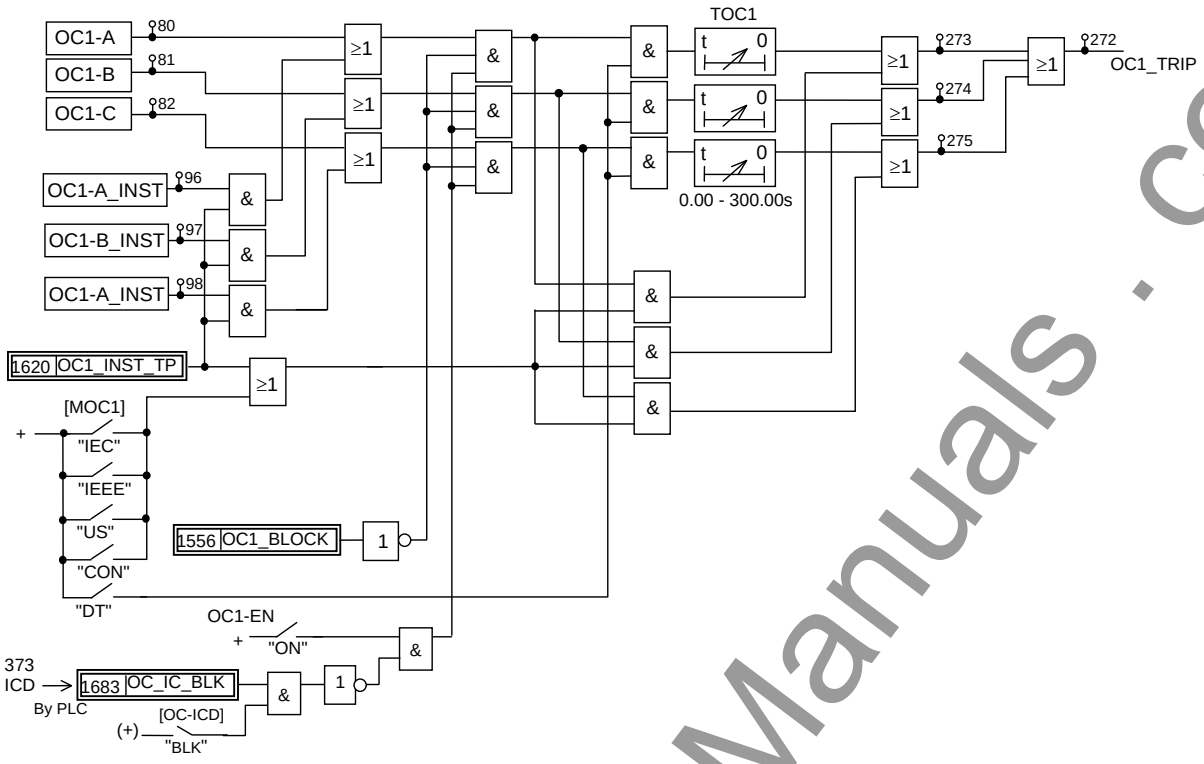


Figure 2.3.2.1 OC1 Phase Fault Overcurrent Protection

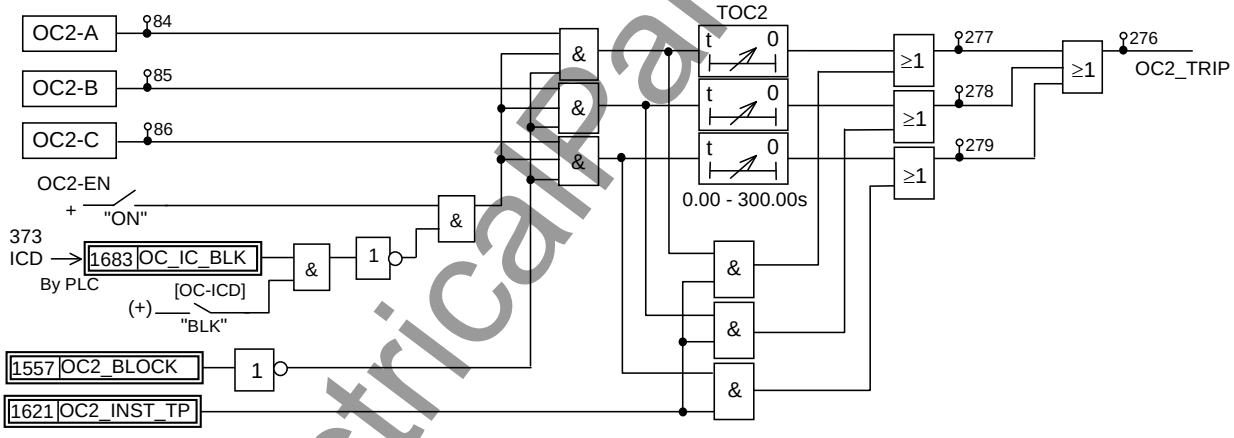


Figure 2.3.2.2 OC2 Phase Fault Overcurrent Protection

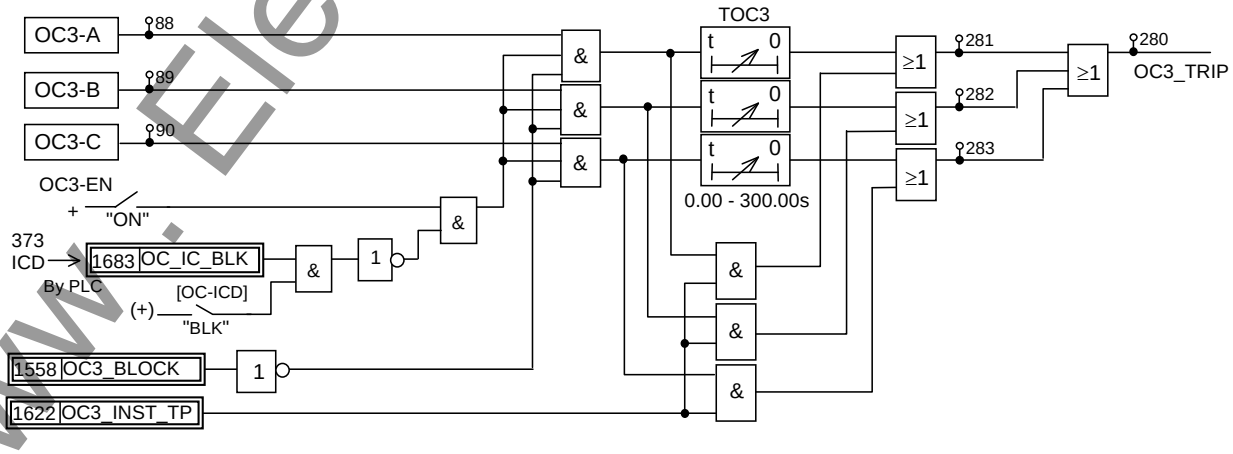


Figure 2.3.2.3 OC3 Phase Overcurrent Protection

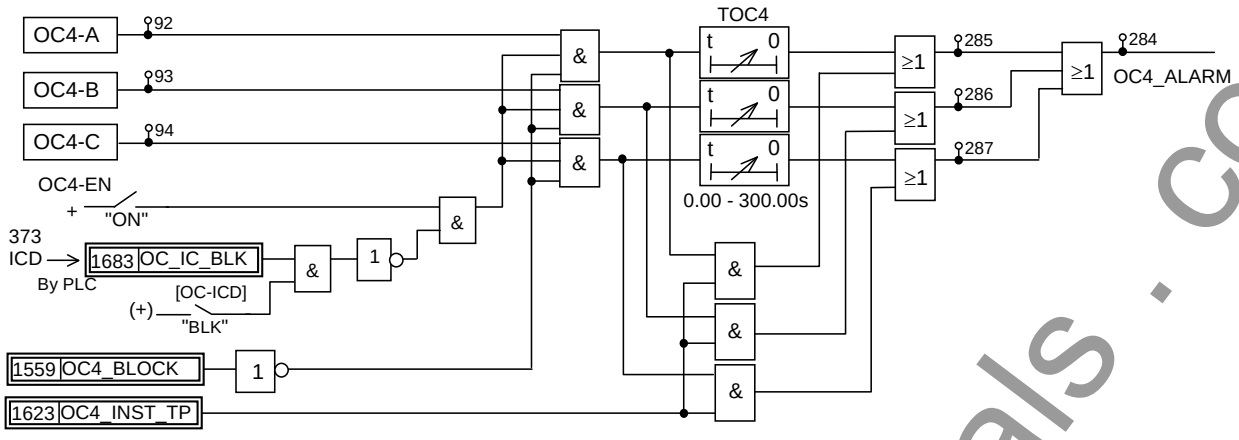


Figure 2.3.2.4 OC4 Phase Overcurrent Protection

2.3.3 Setting

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

Element	Range	Step	Default	Remarks
OC1	0.1 – 25.0 A (0.02 – 5.00 A)(*)	0.1 A (0.01 A)	5.0 A (1.00 A)	OC1 threshold setting
TOC1	0.00 – 300.00 s	0.01 s	1.00 s	OC1 definite time setting. Required if [MOC1] = DT.
TOC1M (TMS)	0.010 – 1.500	0.001	1.000	OC1 time multiplier setting. Required if [MOC1] = IEC, IEEE, US or CON.
TOC1R	0.0 – 300.0 s	0.1 s	0.0 s	OC1 definite time delayed reset. Required if [OC1R] = DEF.
TOC1RM (RTMS)	0.010 – 1.500	0.001	1.000	OC1 dependent time delayed reset time multiplier. Required if [OC1R] = DEP.
OC2	0.1 – 25.0 A (0.02 – 5.00 A)(*)	0.1 A (0.01 A)	5.0 A (1.00 A)	OC2 threshold setting
TOC2	0.00 – 300.00 s	0.01 s	1.00 s	OC2 definite time setting.
OC3	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	50.0 A (10.00 A)	OC3 threshold setting
TOC3	0.00 – 300.0 s	0.01 s	1.00 s	OC3 definite time setting
OC4	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	100.0 A (20.00 A)	OC4 threshold setting
TOC4	0.0 – 300.0 s	0.01 s	1.00 s	OC4 definite time setting
[OC1EN]	Off / On		On	OC1 Enable
[MOC1]	DT/IEC/IEEE/US/CON		DT	OC1 time 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.
[OC1R]	DEF / DEP		DEF	OC1 reset characteristic. Required if [MOC1] = IEEE, US or CON.
[OC2EN]	Off / On		Off	OC2 Enable

Element	Range	Step	Default	Remarks
[OC3EN]	Off / On		Off	OC3 Enable
[OC4EN]	Off / On		Off	OC4 Enable
[OC-ICD]	NA / BLK		NA	OC/EF/SEF blocked by irush current

(*) 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.

Inverse Time Protection

Current setting

In Figure 2.3.3.1, 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 considering also backup protection of a fault within the adjacent lines, it is set lower than the minimum fault current in the event of a fault at remote end F3. 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 is restricted so as not to operate on false zero-sequence currents caused by an unbalance in the load current, errors in the current transformer circuits or zero-sequence mutual coupling of parallel lines.

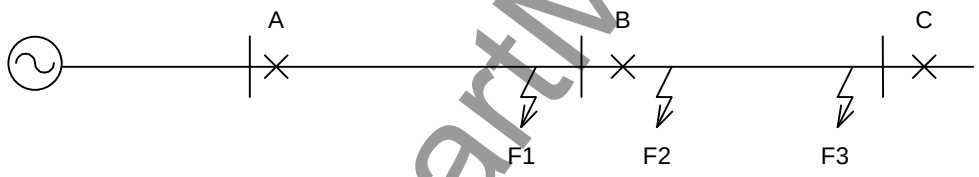


Figure 2.3.3.1 Current Settings in Radial System

Time setting

Time setting is performed to provide selectivity in relation with the relays on the adjacent lines. Suppose a minimum source impedance when the current flowing in the relay becomes the maximum. In Figure 2.3.3.1, in the event of a fault at near end F2 of the adjacent line, 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 the maximum is that if time coordination is obtained for large fault current, then time coordination can also be obtained for 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 2.3.3.1.

$$Tc = T1 + T2 + M$$

where, T1: circuit breaker clearance time at B
T2: relay reset time at A
M: margin

When single-phase autoreclose is used, the minimum time of the earth fault overcurrent protection must be set longer than the time from fault occurrence to reclosing of the circuit breaker. This is to prevent three-phase final tripping from being executed by the overcurrent protection during a single-phase autoreclose cycle.

Definite Time Protection

In a system in which a fault current does not vary significantly with the position of the fault, the advantages of the IDMT characteristics are less apparent. In this case, definite time overcurrent protection is applied. The operating time can be set irrespective of the magnitude of the fault current.

Definite time overcurrent protection consists of instantaneous overcurrent elements with on-delay timers.

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

The operating time of the overcurrent element of each terminal is constant irrespective of the magnitude of the fault current and selective protection is implemented by graded settings of the on-delay timer. As a result, the circuit breaker of the terminal most remote from the power source is tripped in the shortest time.

When setting the on-delay timers, time grading margin Tc is obtained in the same way as explained in the inverse time protection setting.

2.4 Earth Fault Protection

The standard earth fault protection is available in models 110/410, and provides four independent overcurrent thresholds EF1 to EF4. Protection functionality is the same as for the phase fault elements, only with more sensitive current thresholds.

For models 110/410, the earth fault quantity is measured directly by connecting the input in the residual circuit of the phase CTs.

2.4.1 Scheme Logic

Figure 2.4.1.1 to Figure 2.4.1.4 show the scheme logic of the earth fault protection EF1 to EF4.

The EF1 protection provides selective definite time or inverse time characteristic as shown in Figure 2.4.1.1. The definite time protection is selected by setting [MEF1] to "DT", and the trip signal EF1 TRIP is given through the delayed pick-up timer TEF1. The inverse time protection is selected by setting [MEF1] to any one of "IEC", "IEEE", "US" or "CON" and then setting [MEF1C] according to the required IDMT characteristic, and the trip signal EF1 TRIP is given.

Figure 2.4.1.2 to Figure 2.4.1.4 show the scheme logic of the definite time earth fault protection EF2 to EF4. The EF2 to EF4 give trip and alarm signals EF2 TRIP, EF3 TRIP and EF4 ALARM through the delayed pick-up timers TEF2, TEF3 and TEF4 respectively.

The signal EF1-INST to EF4-INST are available to trip instantaneously for a fault.

The EF1 to EF4 protection can be disabled by the scheme switches [EF1EN] to [EF4EN] or the binary input signals EF1 BLOCK to EF4 BLOCK respectively.

ICD is the inrush current detector ICD, which detects second harmonic inrush current during transformer energisation, and can block the EF elements by the scheme switch [OC-ICD]. See Section 2.10. The logic logic sequence is configured by the PLC.

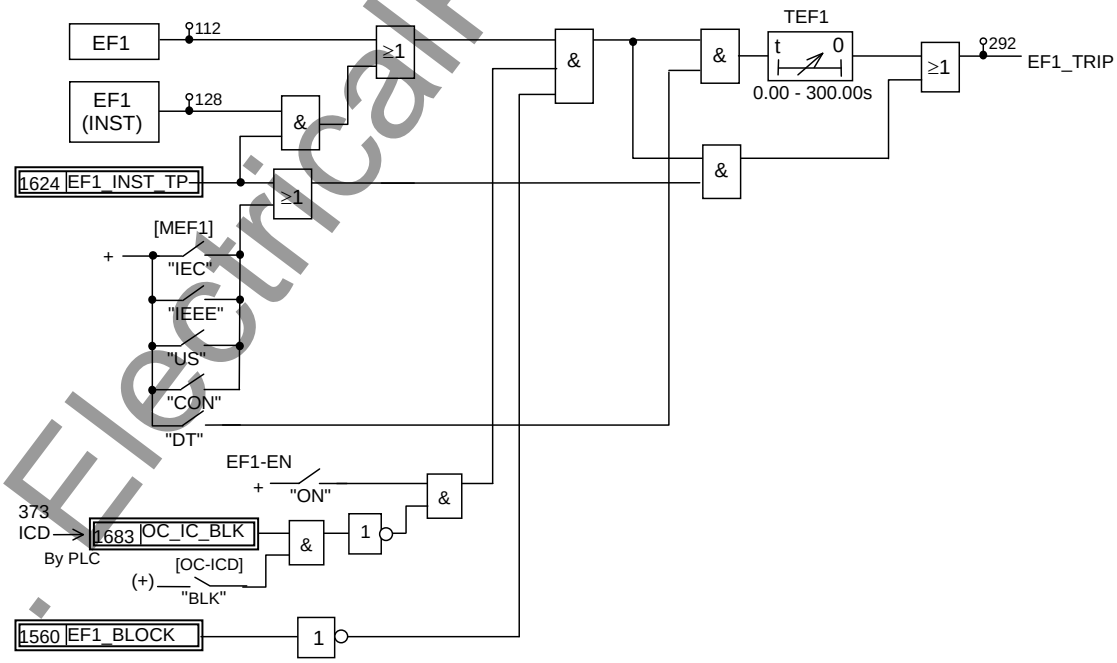


Figure 2.4.1.1 EF1 Earth Fault Protection

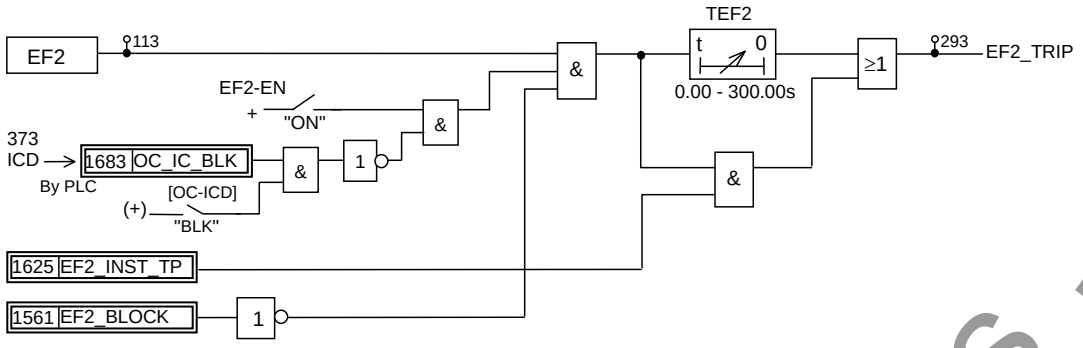


Figure 2.4.1.2 EF2 Earth Fault Protection

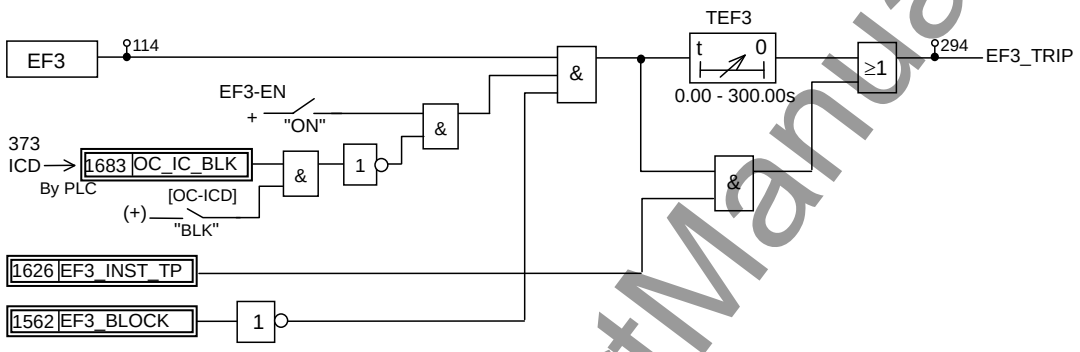


Figure 2.4.1.3 EF3 Earth Fault Protection

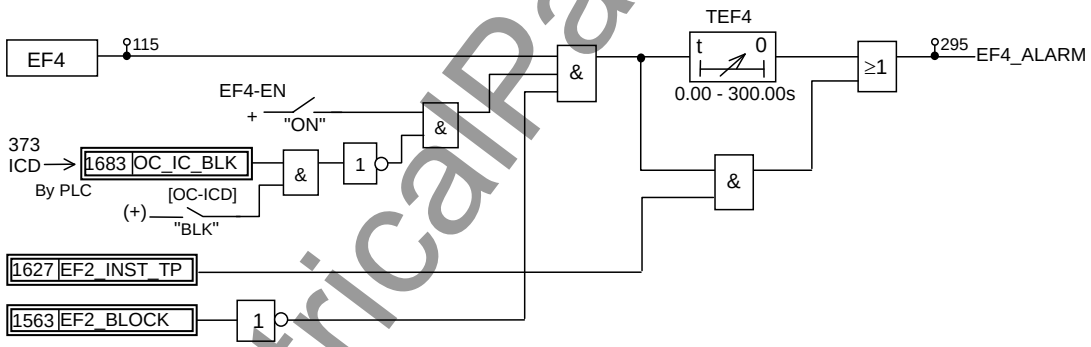


Figure 2.4.1.4 EF4 Earth Fault Protection

2.4.2 Setting

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

Element	Range	Step	Default	Remarks
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	0.00 – 300.00 s	0.01 s	1.00 s	EF1 definite time setting. Required if [MEF1] = DT.
TEF1M (TMS)	0.010 – 1.500	0.001	1.000	EF1 time multiplier setting. Required if [MEF1] = IEC, IEEE, US or CON.
TEF1R	0.0 – 300.0 s	0.1 s	0.0 s	EF1 definite time delayed reset. Required if [EF1R] = DEF.

Element	Range	Step	Default	Remarks
TEF1RM (RTMS)	0.010 – 1.500	0.001	1.000	EF1 dependent time delayed reset time multiplier. Required if [EF1R] = DEP.
EF2	0.1 – 25.0 A (0.02 – 5.00 A)	0.1 A (0.01 A)	1.5 A (0.30 A)	EF2 threshold setting
TEF2	0.00 – 300.00 s	0.01 s	1.00 s	EF2 definite time setting.
EF3	0.1 – 250.0 A (0.02 – 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	1.00 s	EF3 definite time setting
EF4	0.1 – 250.0 A (0.02 – 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	1.00 s	EF4 definite time setting
[EF1EN]	Off / On		On	EF1 Enable
[MEF1]	DT/IEC/IEEE/US/CON		DT	EF1 time 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, US or CON.
[EF2EN]	Off / On		Off	EF2 Enable
[EF3EN]	Off / On		Off	EF3 Enable
[EF4EN]	Off / On		Off	EF4 Enable
[OC-ICD]	NA / BLK		NA	OC/EF/SEF blocked by inrush current

(*) 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.

2.5 Sensitive Earth Fault Protection

GRL150-120/420 provides earth fault protection with more sensitive settings for use in applications where the fault current magnitude may be very low. A four-stage overcurrent function is provided, with the first stage programmable for inverse time or definite time operation. Three additional overcurrent thresholds are provided, each with a definite time delay.

The sensitive earth fault quantity is measured directly, using a dedicated core balance earth fault CT.

The SEF elements provide 20 times more sensitive setting ranges (25 mA to 125 mA in 5A rating) than the regular earth fault protection.

Since very low levels of current setting may be applied, there is a danger of unwanted 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 Model 120 and 420 series which have a dedicated earth fault input circuit.

The element SEF1 provides inverse time or definite time selective two-stage protection. SEF2 to SEF4 provide definite time protection.

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.

2.5.1 Scheme Logic

Figure 2.5.1.1 to 2.5.1.4 show the scheme logic of sensitive earth fault protection.

Figure 2.5.1.1 shows the scheme logic of sensitive earth fault protection SEF1 with inverse time or definite time selective two-stage overcurrent protection. The definite time protection is selected by setting [MSE1] to "DT". The element SEF1 is enabled for sensitive earth fault protection and stage 1 trip signal SEF1 TRIP is given through the delayed pick-up timer TSE1. The inverse time protection is selected by setting [MSE1] to either "IEC", "IEEE", "US" or "CON" and then setting [MEF1C] according to the required IDMT characteristic. The element SEF1 is enabled and stage 1 trip signal SEF1 TRIP is given.

Both protections provide stage 2 trip signal SEF1-S2 through a delayed pick-up timer TSE12.

Figure 2.5.1.2 to Figure 2.5.1.4 show the scheme logic of the definite time sensitive earth fault protection SEF2 to SEF4. SEF2 to SEF4 give trip and alarm signals SEF2 TRIP, SEF3 TRIP and SEF4 ALARM through delayed pick-up timers TSE2, TSE3 and TSE4 respectively.

The signal SE1-INST to SE4-INST are available to trip instantaneously for a fault.

The SEF1 to SEF4 protections can be disabled by the scheme switches [SE1EN] to [SE4EN] or binary input signals SEF1 BLOCK to SEF4 BLOCK. The SEF1 stage 2 trip of standby earth fault protection can be disabled by the scheme switch [SE1S2].

ICD is the inrush current detector ICD, which detects second harmonic inrush current during transformer energisation, and can block the SEF elements by the scheme switch [OC-ICD]. See Section 2.10. The logic logic sequence is configured by the PLC.

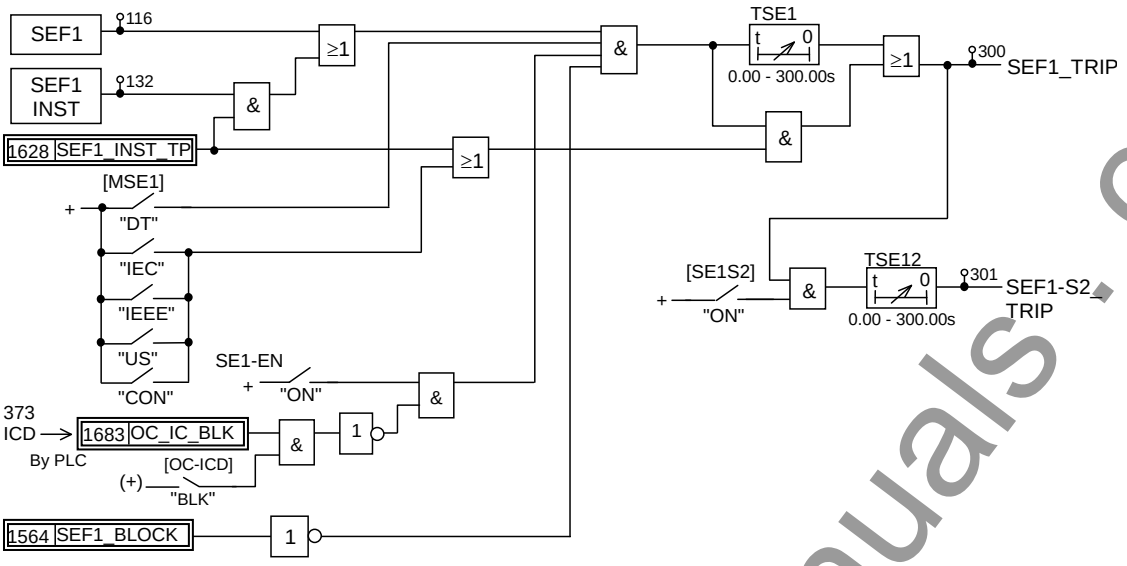


Figure 2.5.1.1 SEF1 Sensitive Earth Fault Protection

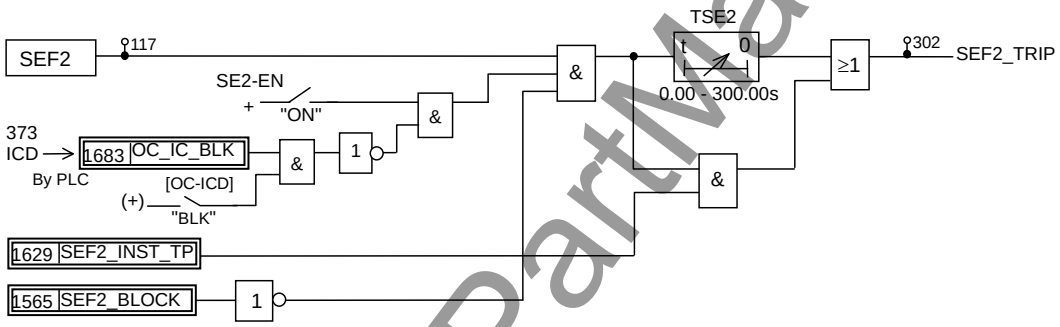


Figure 2.5.1.2 SEF2 Sensitive Earth Fault Protection

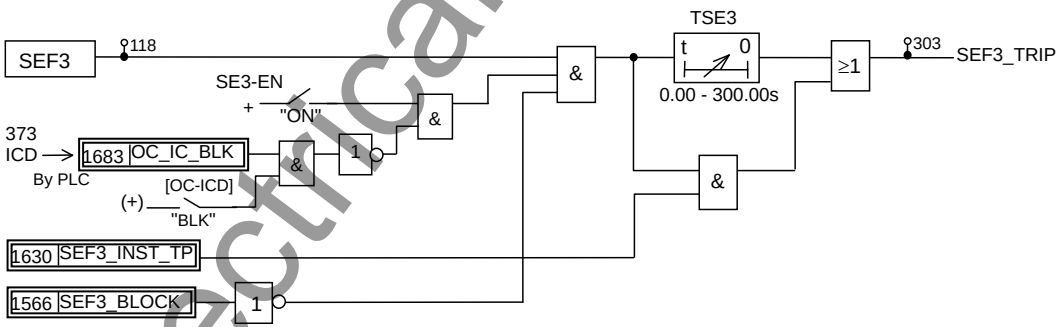


Figure 2.5.1.3 SEF3 Sensitive Earth Fault Protection

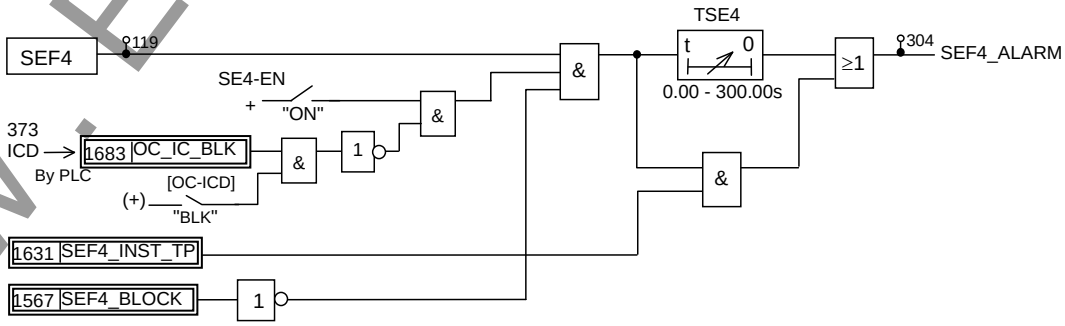


Figure 2.5.1.4 SEF4 Sensitive Earth Fault Protection

2.5.2 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	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.050 A (0.010 A)	SEF1 threshold setting
TSE1M (TMS)	0.010 – 1.500	0.001	1.000	SEF1 inverse time multiplier setting. Required if [MSE1] = IEC, IEEE, US or CON.
TSE1	0.00 – 300.00 s	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 [SE1R] = DEF.
TSE1RM (RTMS)	0.010 – 1.500	0.001	1.000	SEF1 dependent time delayed reset time multiplier. Required if [SE1R] = DEP.
TSE12	0.00 – 300.00 s	0.01 s	1.00 s	SEF1 stage 2 definite time setting
SE2	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.050 A (0.010 A)	SEF2 threshold setting
TSE2	0.00 – 300.00 s	0.01 s	1.00 s	SEF2 definite time setting.
SE3	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.050 A (0.010 A)	SEF3 threshold setting
TSE3	0.00 – 300.00 s	0.01 s	1.00 s	SEF3 definite time setting.
SE4	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.050 A (0.010 A)	SEF4 threshold setting
TSE4	0.00 – 300.00 s	0.01 s	1.00 s	SEF4 definite time setting.
[SE1EN]	Off / On		Off	SEF1 Enable
[MSE1]	DT/IEC/IEEE/US/CON		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
[SE3EN]	Off / On		Off	SEF3 Enable
[SE4EN]	Off / On		Off	SEF4 Enable
[OC-ICD]	NA / BLK		NA	OC/EF/SEF blocked by irush current

(*) 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.

2.6 Phase Undercurrent Protection

Phase undercurrent protection is used to detect a decrease in current caused by a loss of load. Two independent stages UC1 and UC2 are provided, each with a programmable definite time delay.

The undercurrent element operates for current falling through the threshold level. The operation can be blocked by UCDO element when the current falls below 4 % of CT secondary rating to discriminate the loss of load from the feeder tripping by other protection. The UCDO element output is input by PLC. Figure 2.6.1.1 shows the undercurrent element characteristic.

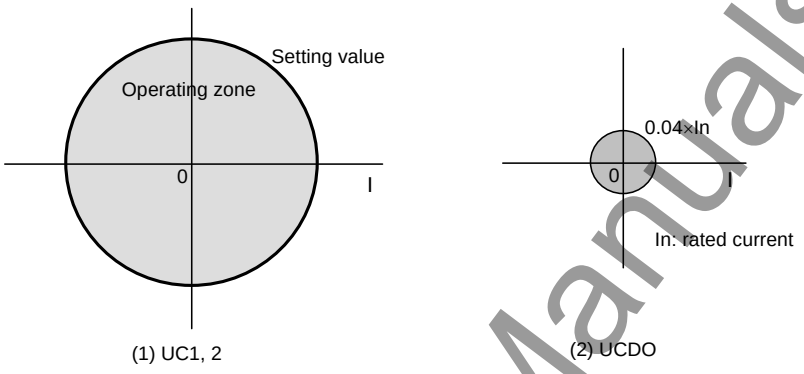


Figure 2.6.1.1 Undercurrent Element Characteristic

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.

2.6.1 Scheme Logic

Figure 2.6.1.2 shows the scheme logic of the phase undercurrent protection.

The undercurrent elements UC1 and UC2 output UC1 TRIP and UC2 ALARM through delayed pick-up timers TUC1 and TUC2.

This protection can be disabled by the scheme switch [UC1EN] and [UC2EN] or binary input signals UC1 BLOCK and UC2 BLOCK.

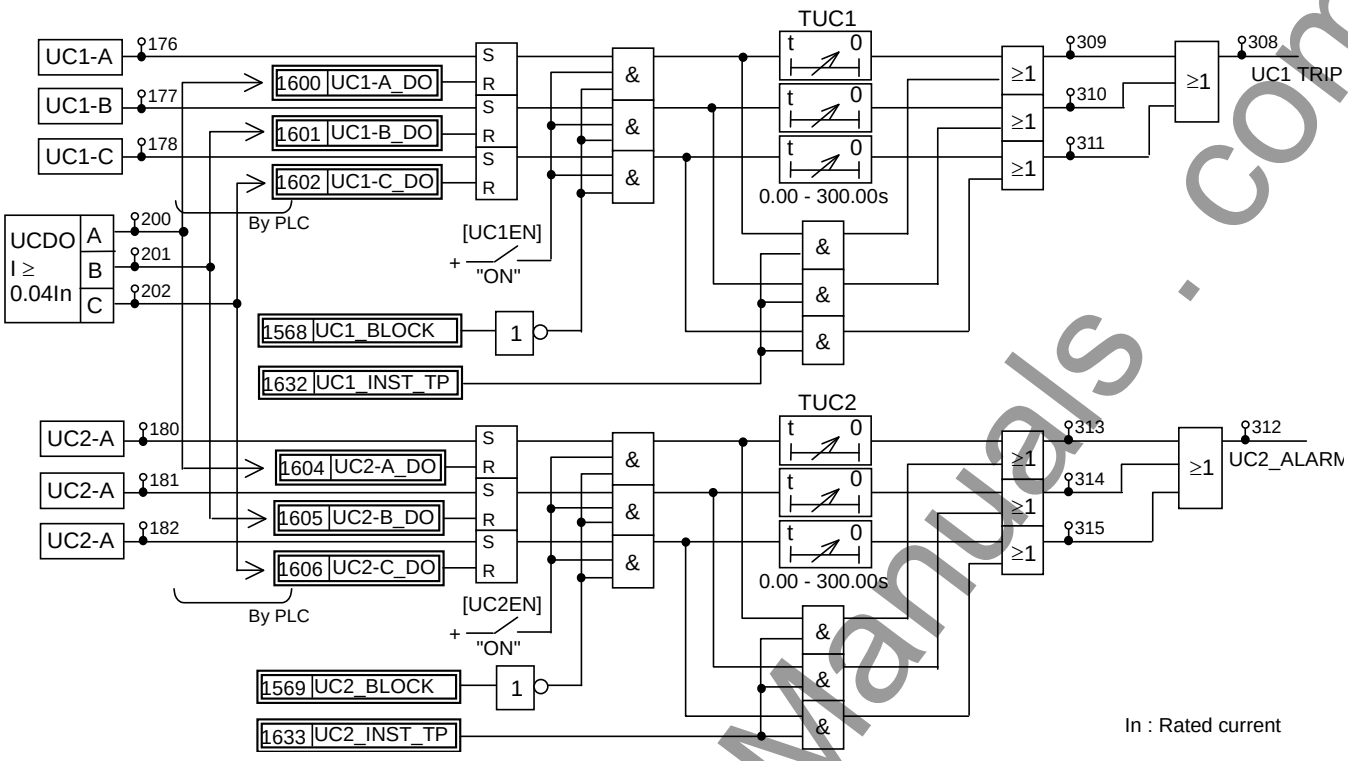


Figure 2.6.1.2 Undercurrent Protection Scheme Logic

2.6.2 Setting

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

Element	Range	Step	Default	Remarks
UC1	0.5 – 10.0 A (0.10 – 2.00 A)(*)	0.1 A (0.01 A)	1.0 A (0.20 A)	UC1 threshold setting
TUC1	0.00 – 300.00 s	0.01 s	1.00 s	UC1 definite time setting
UC2	0.5 – 10.0 A (0.10 – 2.00 A)	0.1 A (0.01 A)	2.0 A (0.40 A)	UC2 threshold setting
TUC2	0.00 – 300.00 s	0.01 s	1.00 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.

2.7 Thermal Overload Protection

The thermal overload feature provides protection for cables and other plant against the effects of prolonged operation under excess load conditions. A thermal replica algorithm is applied to create a model for the thermal characteristics of the protected plant. Tripping times depend not only on the level of overload current, but also on the level of prior load current, the thermal replica providing 'memory' of previous conditions.

The temperature of electrical plant rises according to an I^2t function and the thermal overload protection in GRL150 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 $\theta = 100\%$.

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 the thermal overload element is defined by equation (2) and equation (3) for 'cold' and 'hot'. The cold curve is a special case of 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 2.7.1.1 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 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.

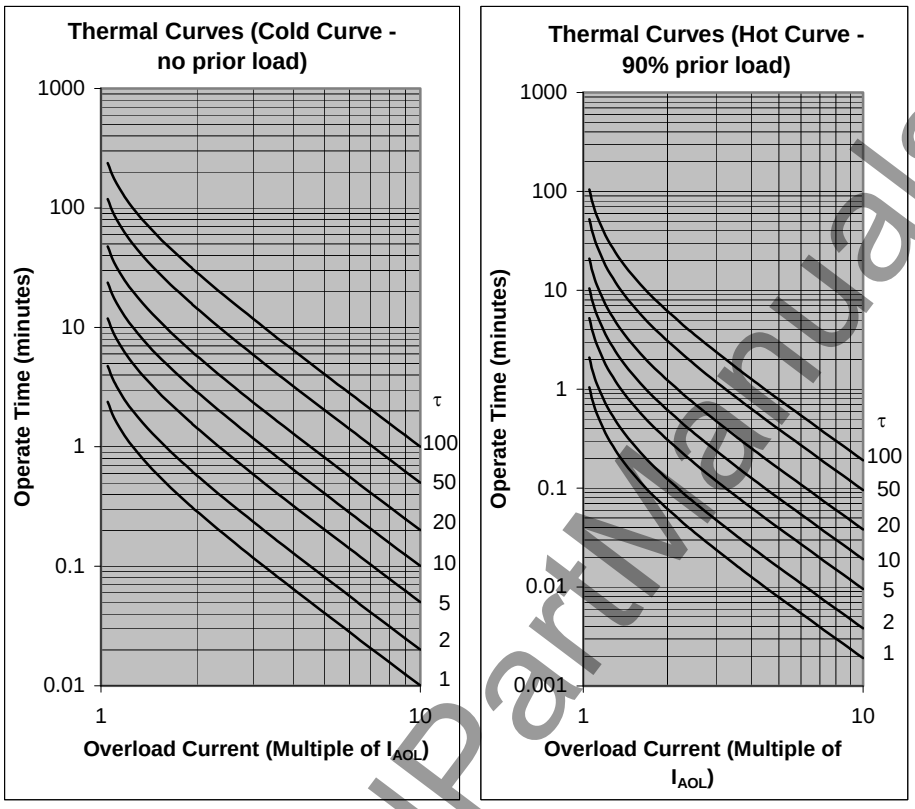


Figure 2.7.1.1 Thermal Curves

2.7.1 Scheme Logic

Figure 2.7.1.2 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 [THMAL] and [THMT] respectively or binary input signals THMA BLOCK and THM BLOCK.

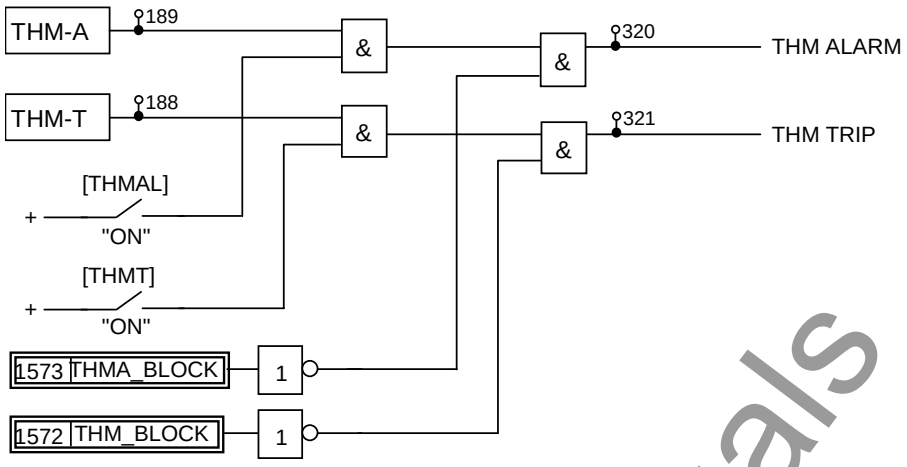


Figure 2.7.1.2 Thermal Overload Protection Scheme Logic

2.7.2 Setting

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)	Previous load current
TTHM	0.5 - 300.0 min	0.1 min	10.0 min	Thermal time constant
THMA	50 – 99 %	1 %	80 %	Thermal alarm setting. (Percentage of THM setting.)
[THMT]	Off / On		Off	Thermal OL enable
[THMAL]	Off / On		Off	Thermal alarm enable
[THMRST]	Off / On		Off	Thermal element test

(*) 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 only active when testing the element ([THRMST] = “ON”).

2.8 Broken Conductor Protection

The unbalance condition caused by an open circuited conductor is detected by the broken conductor protection. An unbalance threshold with programmable definite time delay is provided.

Figure 2.8.1.1 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 $(1 - k_0)$.

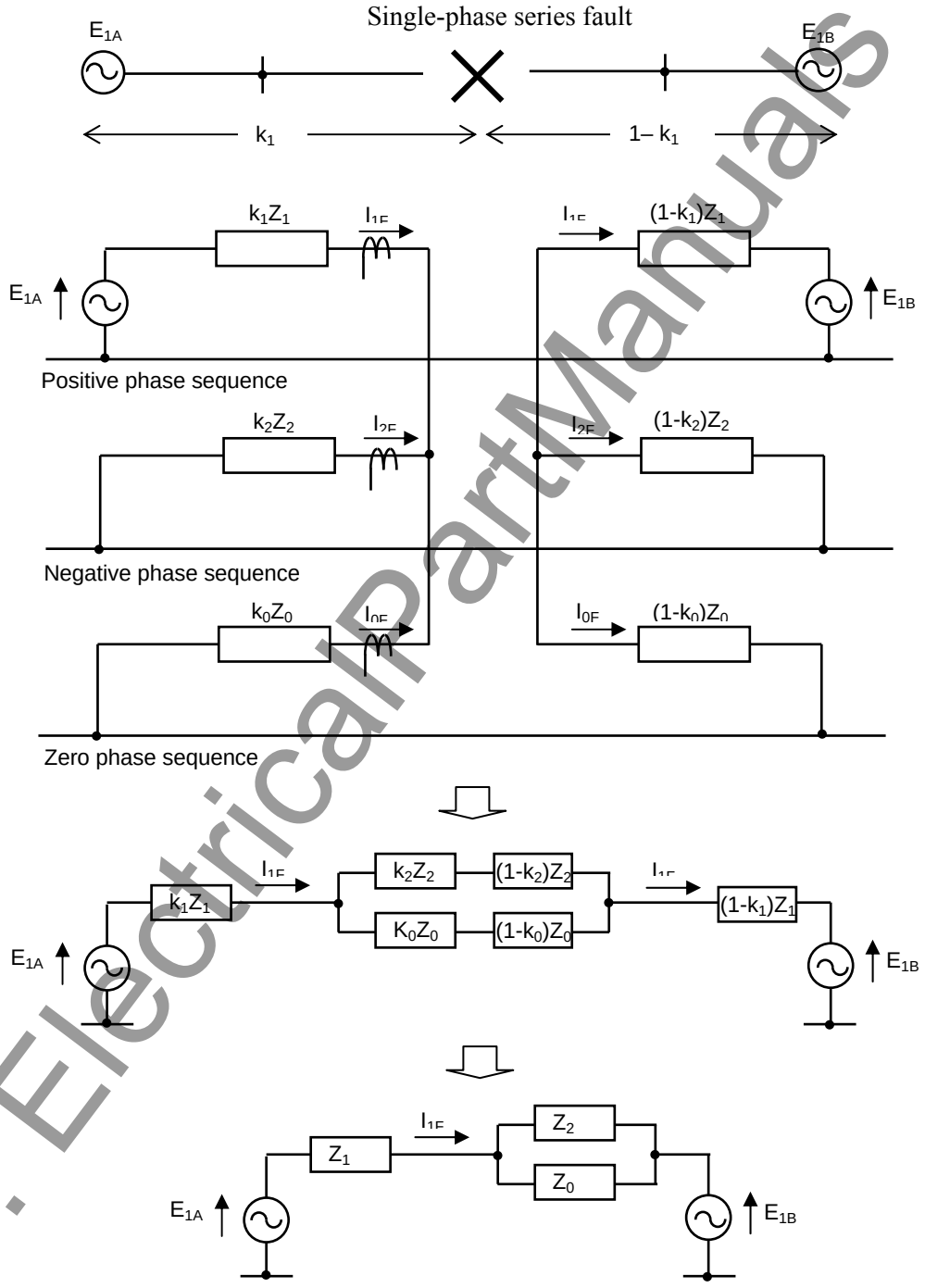


Figure 2.8.1.1 Equivalent Circuit for a Single-phase Series Fault

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 2.8.1.2 to obtain the stable operation.

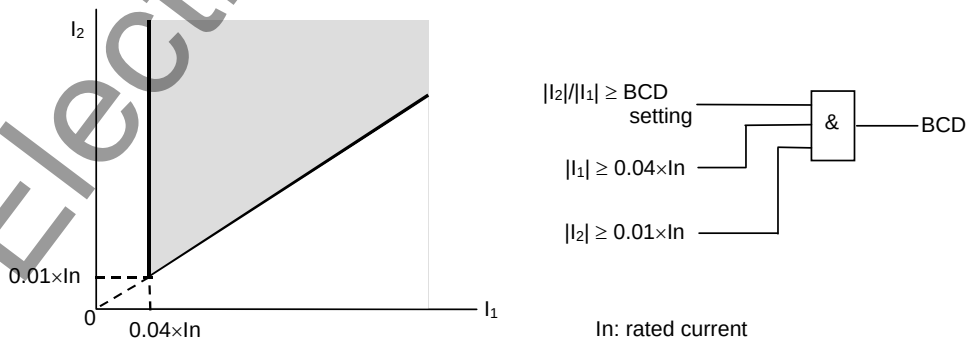


Figure 2.8.1.2 BCD Element Characteristic

2.8.1 Scheme Logic

Figure 2.8.1.3 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] or binary input signal BCD BLOCK.

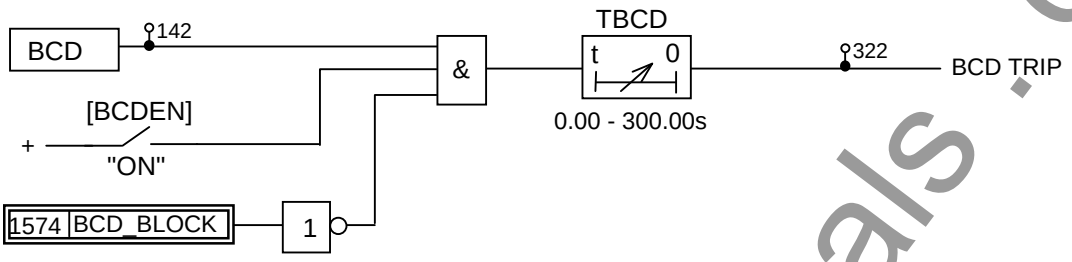


Figure 2.8.1.3 Broken Conductor Protection Scheme Logic

2.8.2 Setting

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

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.

2.9 Breaker Failure Protection

Two stage breaker failure protection provides outputs for re-tripping of the local circuit breaker and/or back-tripping to upstream circuit breakers. The functions can also be initiated by external protections via a binary input if required.

When fault clearance fails due to a breaker failure, the breaker failure protection (BFP) clears the fault by back-tripping 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 upstream breakers, the BFP has the optional function of re-tripping the local breaker. To make sure that the breaker has actually failed, a trip command is made to the local breaker again before tripping the upstream breakers to prevent unnecessary tripping of the upstream breakers following the erroneous start-up of the BFP. It is possible to choose not to use re-tripping at all, or use re-tripping with trip command plus delayed pick-up timer, or re-tripping 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.

2.9.1 Scheme Logic

The BFP is performed on per-phase basis. Figure 2.9.1.1 shows the scheme logic for the BFP. The BFP is started by the PLC logic per-phase base signals [CBF_INIT-A] to [CBF_INIT-C] or three-phase base signal [CBF_INIT]. The BFP can be disabled by the PLC logic signal [CBF_BLOCK]. These signals must continuously exist as long as the fault is present. The BFP can be disabled by the PLC logic signal [CBF_BLOCK].

The back-tripping signal to the upstream 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 upstream breakers can be blocked with the scheme switch [BTC].

There are two kinds of modes of the re-trip signal to the local breaker CBF RETRIP, the mode in which re-trip is controlled by the overcurrent element CBF, and the direct trip mode in which re-trip is not controlled. The re-trip 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 2.9.1.2 shows a sequence diagram for the BFP when a re-trip 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 re-trip command is given to the local breaker after the setting time of TRTC. Unless the breaker fails, the CBF is reset by re-trip. 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 local breaker is unavoidable.

If the local breaker fails, re-trip has no effect and the CBF continues operating and the TBTC finally picks up. A trip command CBF TRIP is given to the upstream breakers and the BFP is completed.

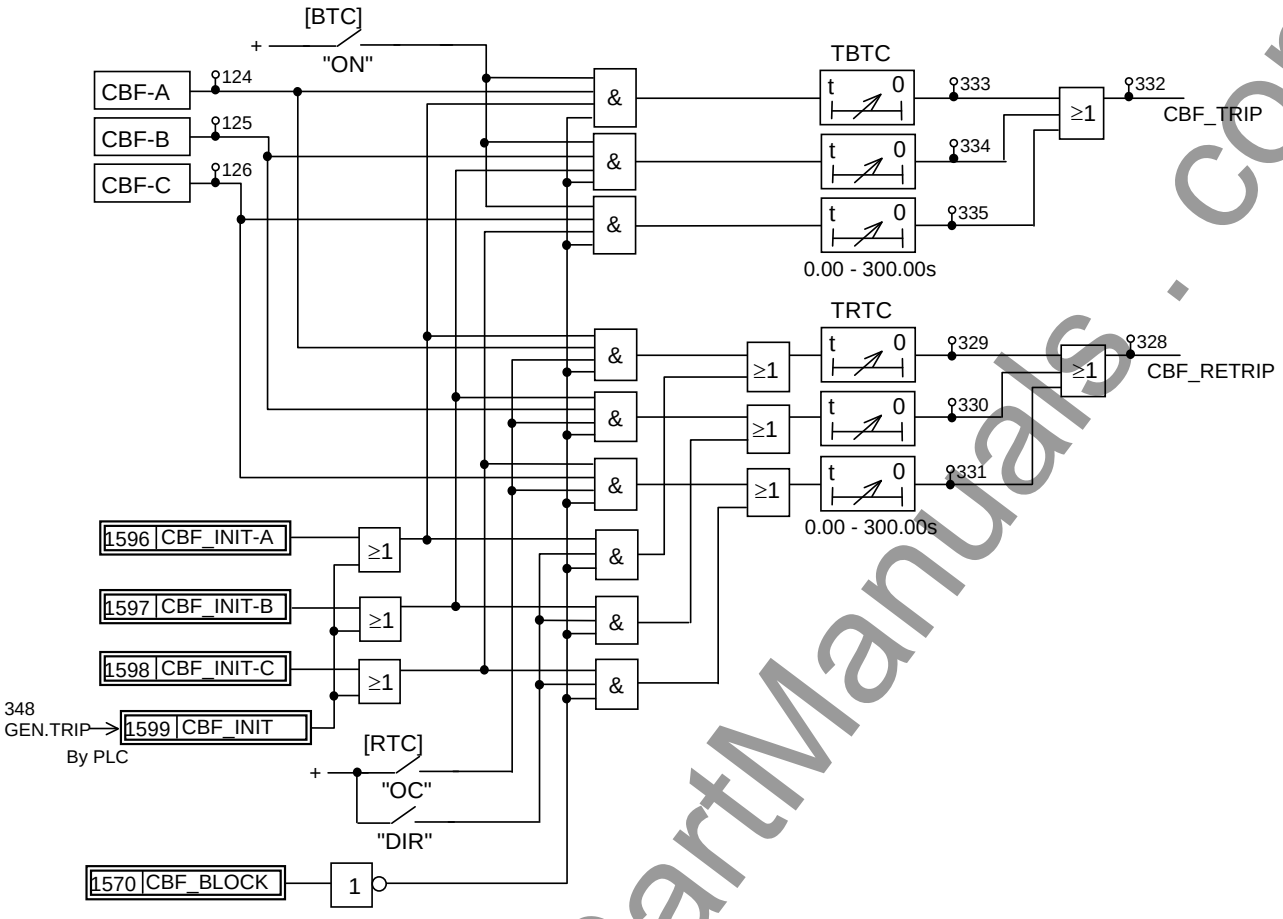


Figure 2.9.1.1 Breaker Failure Protection Scheme Logic

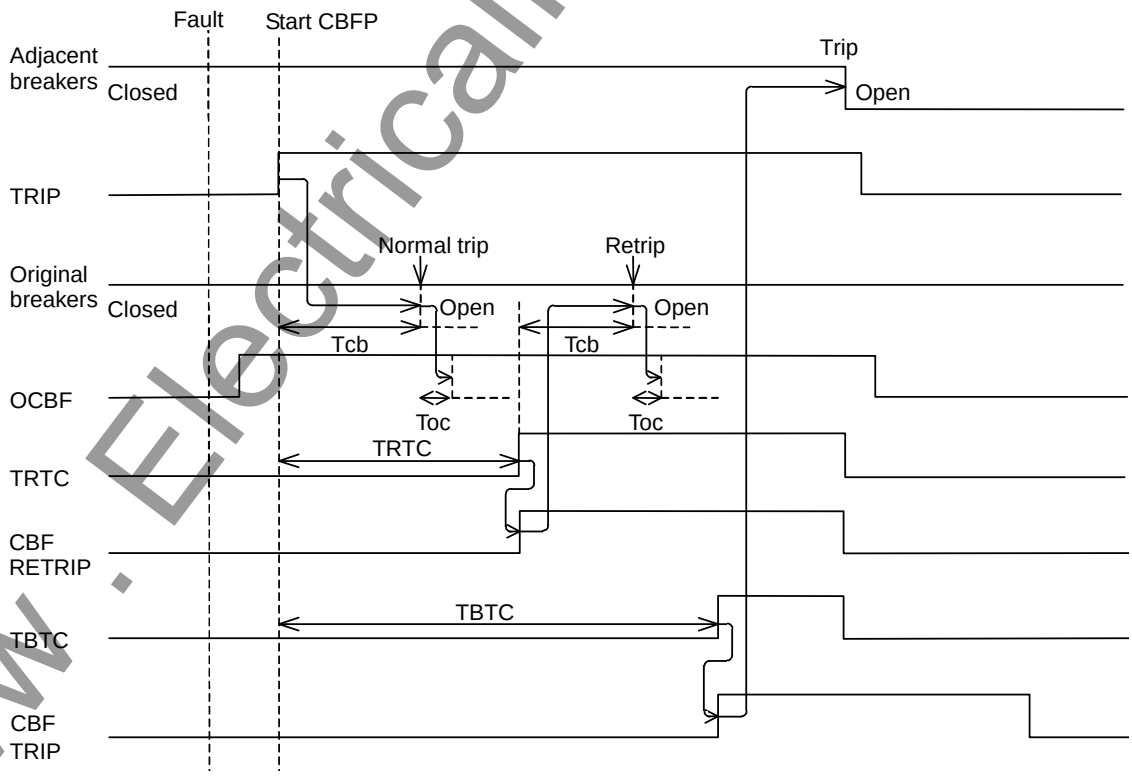


Figure 2.9.1.2 Sequence Diagram

2.9.2 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 2.9.1.2) and the reset time of the overcurrent element (Toc in Figure 2.9.1.2). 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)

2.10 Countermeasures for Magnetising Inrush

GRL150 provides the following two schemes to prevent incorrect operation from a magnetising inrush current during transformer energisation.

- Protection block by inrush current detector
- Cold load protection

2.10.1 Inrush Current Detector

Inrush current detector ICD detects second harmonic inrush current during transformer energisation and blocks the following protections:

- DIF
- OC1 to OC4
- EF1 to EF4
- SEF1 to SEF4

The ICD is used to protect a line with an in-zone transformer ('Teed' transformer) as shown in Figure 2.10.1.1.

Note: DIFI1 should be set to take account of the transformer load current.

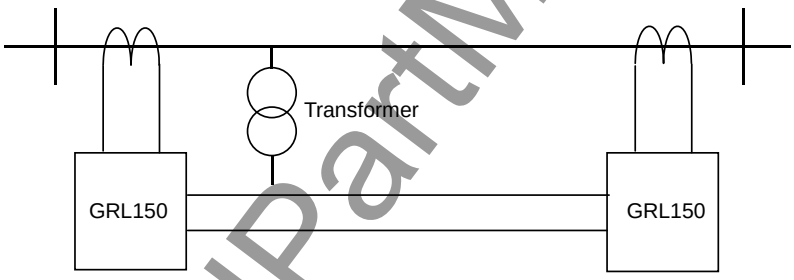


Figure 2.10.1.1 Protection with In-zone Transformer

The blocking can be enabled or disabled by setting the scheme switches [DIF-ICD] and [OC-ICD].

The ICD detects the ratio ICD-2f between second harmonic current I2f and fundamental current I1f in each phase current, and operates if its ratio is larger than the setting value. Figure 2.10.1.2 shows the characteristic of the ICD element and Figure 2.10.1.3 shows the ICD block scheme. When ICD operates, the local terminal DIF, OC, EF and SEF elements are blocked, and the signal ICD_BLK-S is sent to the remote terminal for blocking the remote terminal DIF element. The ICD_BLK-S is assigned to 2051:COM4-S by PLC function. The scheme logic of each element is shown in the previous sections.

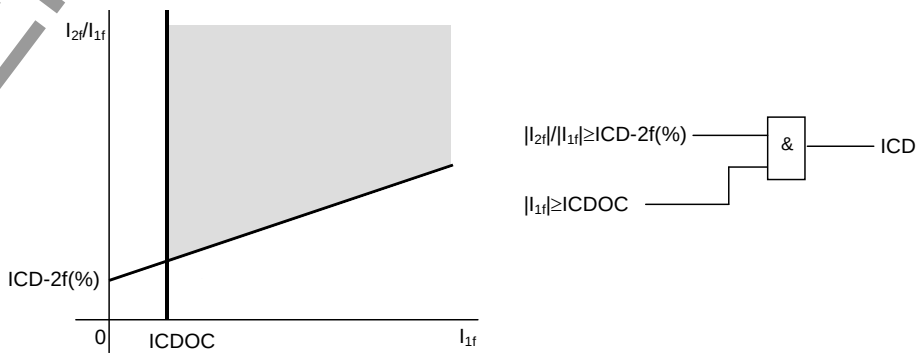


Figure 2.10.1.2 ICD Element Characteristic

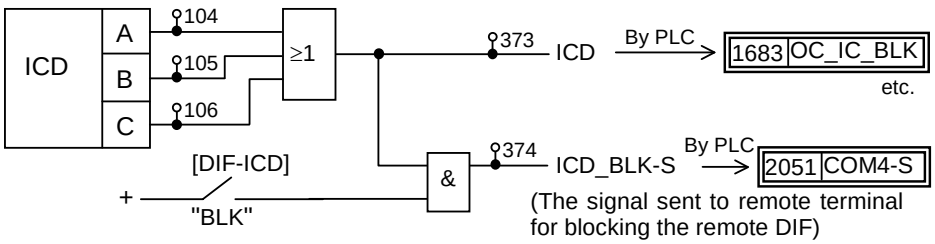


Figure 2.10.1.3 ICD Block Scheme

Setting

The setting elements necessary for the ICD and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
ICD-2f	10 – 50%	1%	15%	Second harmonic detection
ICDOC	0.5 – 25.0 A (0.10 - 2.00 A)(*)	0.1 A (0.01 A)	0.5 A (0.10 A)	ICD threshold setting

(*) 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.

2.10.2 Cold Load Protection

The cold load function modifies the overcurrent protection settings for a period after energising the system. This feature is used to prevent unwanted protection operation when closing on to the type of load which takes a high level of current for a period after energisation.

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.

2.10.2.1 Scheme Logic

A state transition diagram and its scheme logic are shown in Figure 2.10.2.1 and Figure 2.10.2.2 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, another settings for the cold load protection are 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 [CLEN] to "OFF".

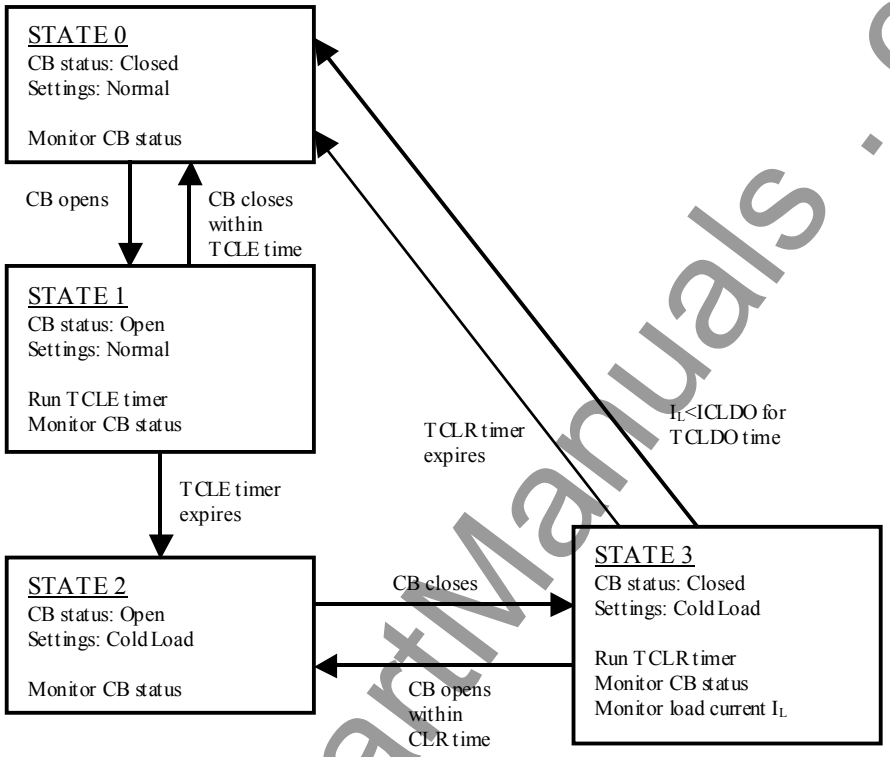


Figure 2.10.2.1 State Transition Diagram for Cold Load Protection

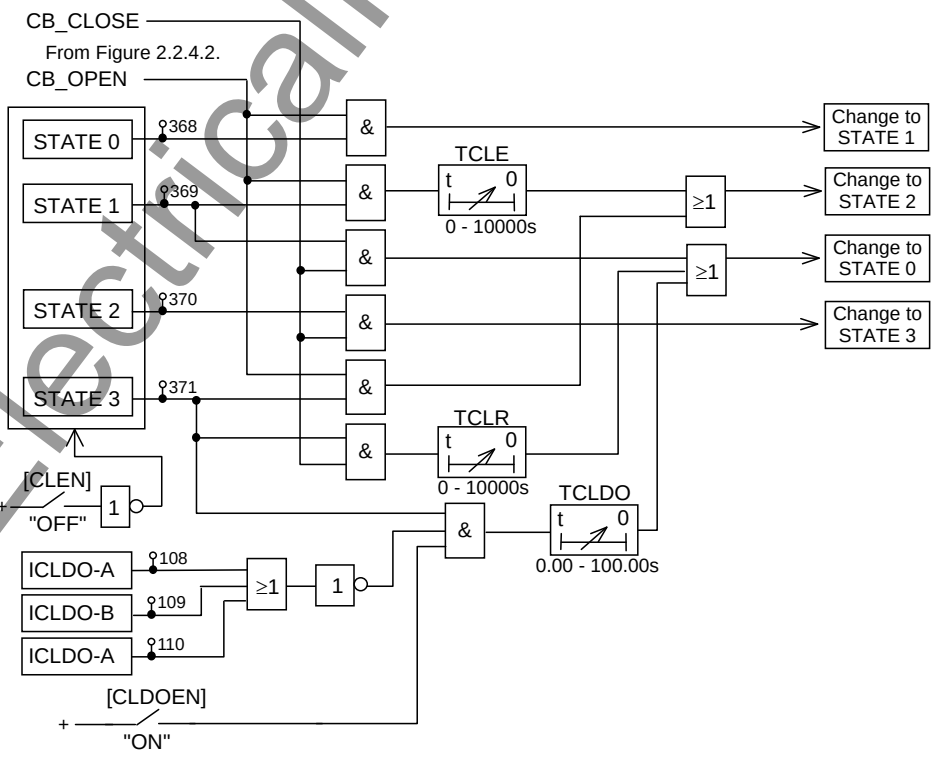


Figure 2.10.2.2 Scheme Logic for Cold Load Protection

2.10.2 Setting

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
[CLEN]	Off / On		Off	Cold load protection enable
[CLDOEN]	Off / On		Off	Cold load drop-off enable
DIFI1	0.50 – 10.00A (0.10 – 2.00A	0.01A 0.01A	10.00A 2.00A)(*1)	Small current region
DIFI2	1.0 – 120.0A (0.2 – 24.0A	0.1A 0.1A	30.0A 6.0A)	Large current region
OC1	0.1 – 25.0 A (0.02 – 5.00 A)(*)	0.1 A (0.01 A)	10.0 A (2.00 A)	OC1 threshold setting
OC2	0.1 – 25.0 A (0.02 – 5.00 A)(*)	0.1 A (0.01 A)	25.0 A (5.00 A)	OC2 threshold setting
OC3	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	100.0 A (20.00 A)	OC3 threshold setting
OC4	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	200.0 A (40.00 A)	OC4 threshold setting
OC5	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	20.0 A (4.00 A)	OC5 threshold setting
EF1	0.1 – 25.0 A (0.02 – 5.00 A)	0.01 A (0.01 A)	10.0 A (2.00 A)	EF1 threshold setting
EF2	0.1 – 25.0 A (0.02 – 5.00 A)	0.01 A (0.01 A)	25.0 A (5.00 A)	EF2 threshold setting
EF3	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	100.0 A (20.00 A)	EF3 threshold setting
EF4	0.1 – 250.0 A (0.02 – 50.00 A)(*)	0.1 A (0.01 A)	200.0 A (40.00 A)	EF4 threshold setting
SE1	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.100 A (0.020 A)	SEF1 threshold setting
SE2	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.100 A (0.020 A)	SEF2 threshold setting
SE3	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.100 A (0.020 A)	SEF3 threshold setting
SE4	0.025 – 0.125 A (0.005 – 0.025 A)(*)	0.001 A (0.001 A)	0.100 A (0.020 A)	SEF4 threshold setting
BCD	0.10 – 1.00	0.01	0.20	I_2 / I_1

(*) 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.

2.11 Transfer Trip Function

The GRL150 provides the transfer trip function which receives a trip signal from the remote terminal and outputs a trip command. Two transfer trip commands are provided. The scheme logic is shown in Figure 2.11.1. When the scheme switch [TTSW∗] is set to "TRIP", the binary output for tripping is driven. When set to "BO", the binary output for tripping is not driven and only user-configurable binary output is driven.

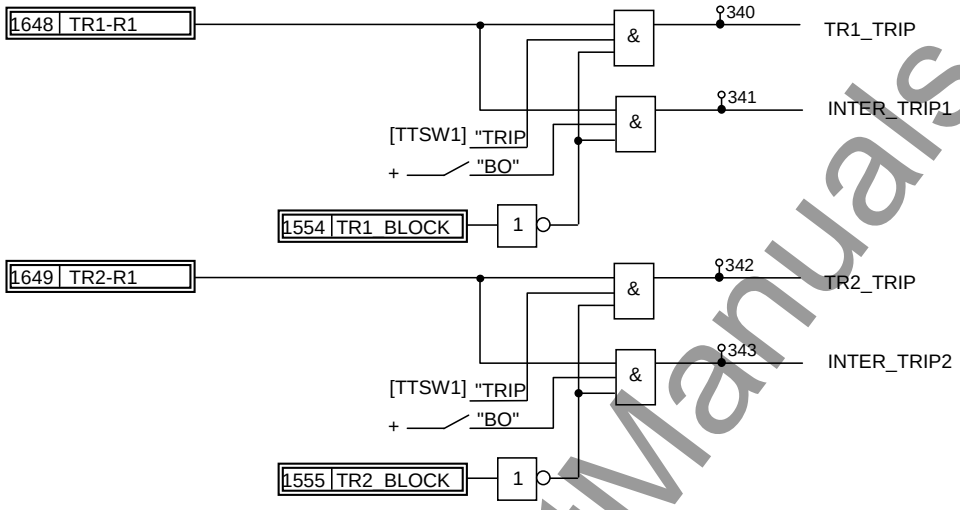


Figure 2.11.1 Transfer Trip Scheme Logic

Setting

The setting elements necessary for the transfer trip function and their setting ranges are as follows:

Element	Range	Step	Default	Remarks
[TTSW1]	Off / Trip / BO		Off	Transfer trip for CH1
[TTSW2]	Off / Trip / BO		Off	Transfer trip for CH2

2.12 Trip and Alarm Signal Output

GRL150 provides various trip and alarm signal outputs such as three-phase and single-phase trip and alarm for each protection. Figures 2.12.1 and 2.12.2 show gathered trip and alarm signals for each protection.

GRL150 provides 8 auxiliary relays which are composed of two tripping output relays TP1 and TP2, one auxiliary relay FAIL for relay fail output, and five programmable auxiliary relays BO1 to BO5. BO1 to BO5 can be programmed by setting. (Refer to Section 3.2.3.)

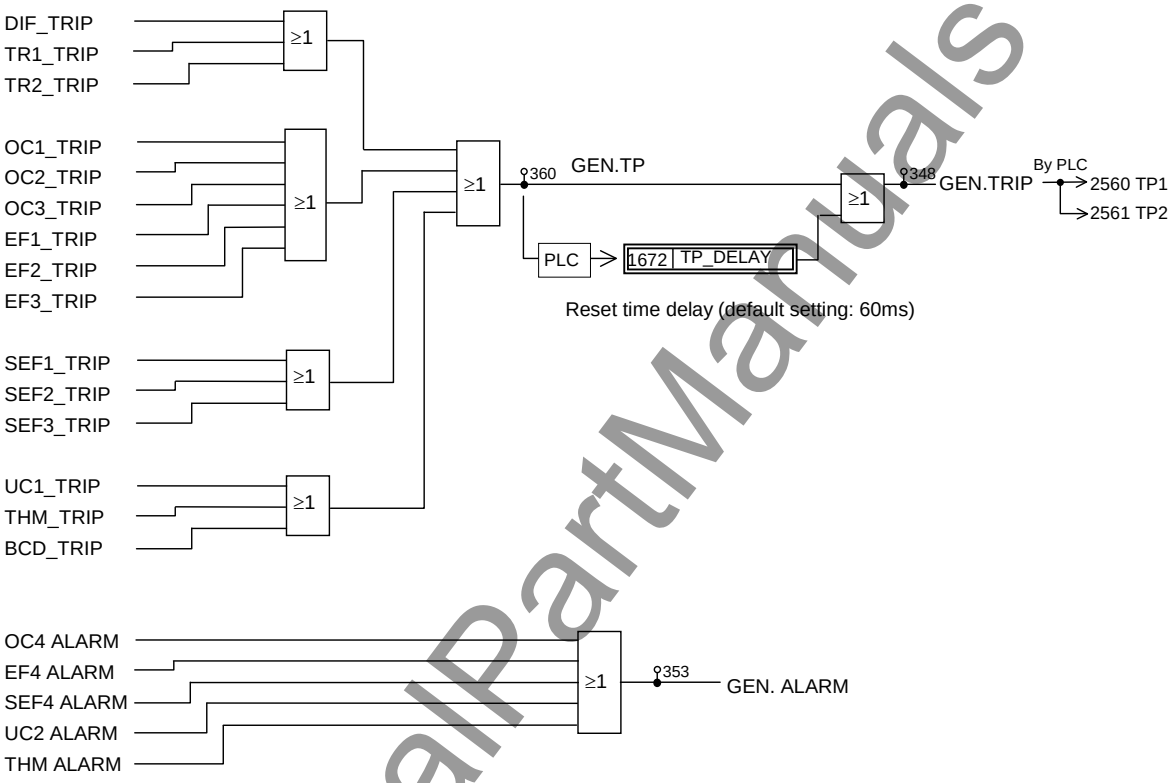


Figure 2.12.1 Three-Phase Output

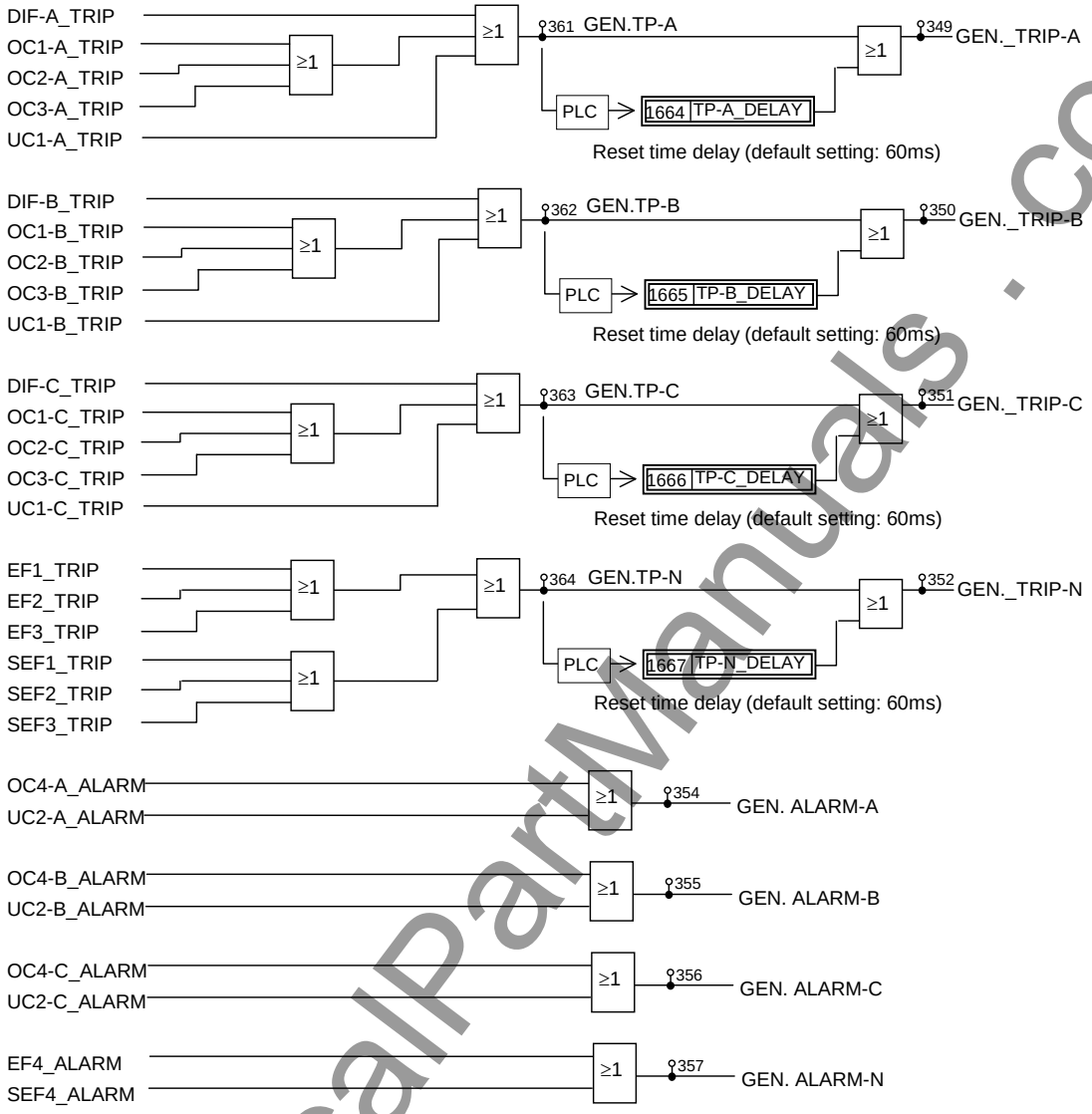


Figure 2.12.2 Single-Phase Output

3. Technical Description

3.1 Hardware Description

3.1.1 Outline of Hardware Modules

The case outline of GRL150 is shown in Appendix E.

The hardware structure of GRL150 is shown in Figure 3.1.1.1.

The GRL150 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 (SPMP)
- Human machine interface module (HMI)

The hardware block diagram of GRL150 is shown in Figure 3.1.1.2.

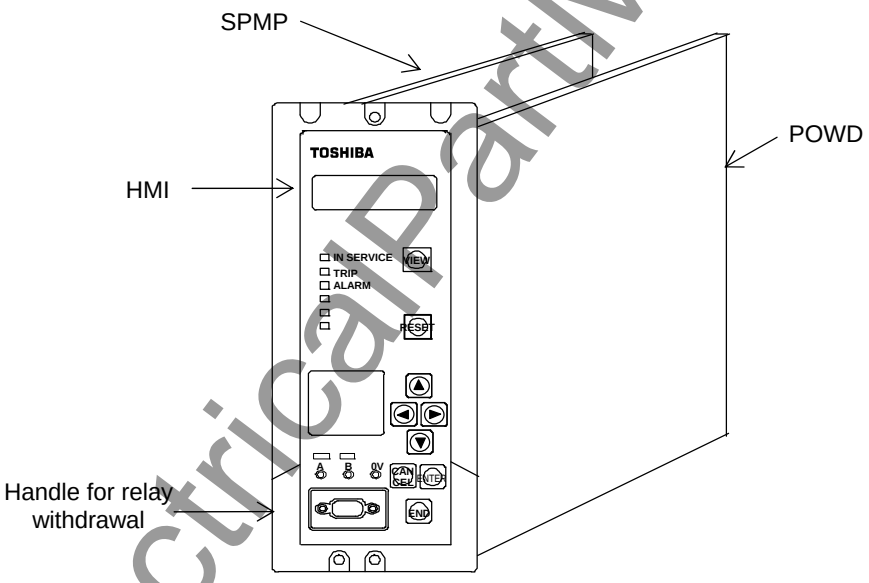


Figure 3.1.1.1 Hardware Structure without Case

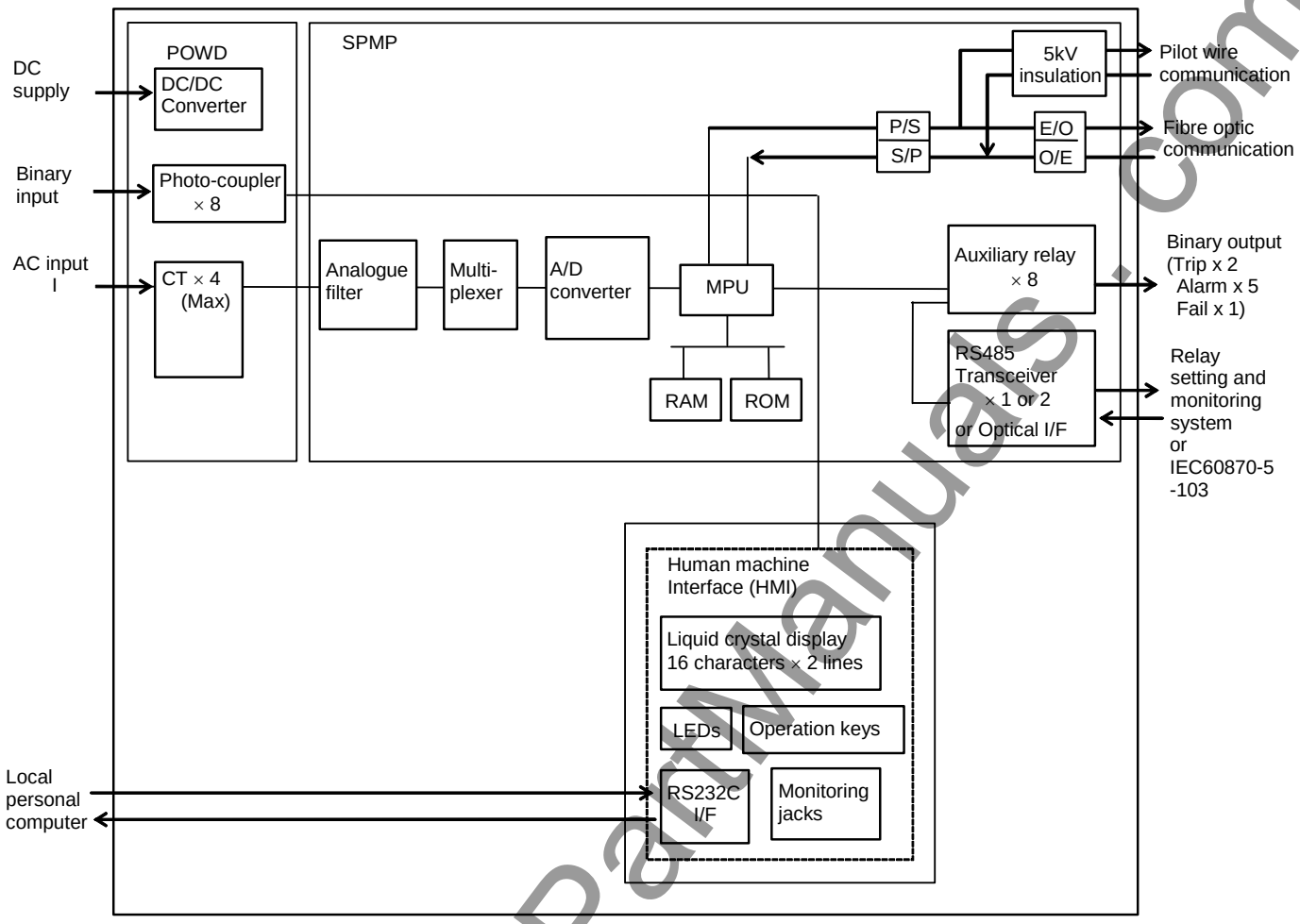


Figure 3.1.1.2 Hardware Block Diagram

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 8 photo-coupler circuits for binary input signals.

The available input voltage ratings of the DC/DC converter are, 24V, 48V, 110V/125V or 220/250V. The normal range of input voltage is –20% to +20%.

SPMP Module

The SPMP 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, and also executes communication control processing of local and received data, memories (RAM and ROM), parallel-to-serial and serial-to-parallel data converter, and electrical-to-optical and optical-to-electrical converter.

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).

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

The SPMP module also incorporates 2 auxiliary relays TP1 and TP2 for tripping, 6 auxiliary relays (BO1-BO5 and FAIL) for binary output signals and an RS485 transceiver.

TP1 and TP2 have two normally open contacts.

BO1 to BO4 are user configurable output signals and each has one normally open contact. BO5 is also a user-configurable output signal and has one normally open and one normally closed 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 GRL150 via the human machine interface (HMI) module. As shown in Figure 3.1.1.3, the HMI panel has a liquid crystal display (LCD), light emitting diodes (LED), view and reset keys, operation keys, monitoring jacks 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	Configurable LED to assign signals with or without latch when relay operates.
(LED2)	Yellow	Configurable LED to assign signals with or without latch when relay operates.
(LED3)	Yellow	Configurable LED to assign signals with or without latch when relay operates.

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. For the setting, see Section 4.2.6.10. For the operation, see Section 4.2.1.

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.

The monitoring jacks and two pairs of LEDs, A and B, on top of the jacks can be used while the test mode is selected in the LCD window. Signals can be displayed on LED A or LED B by selecting the signal to be observed from the "Signal List" and setting it in the window and the signals can be transmitted to an oscilloscope via the monitoring jacks. (For the "Signal List", see Appendix B.)

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

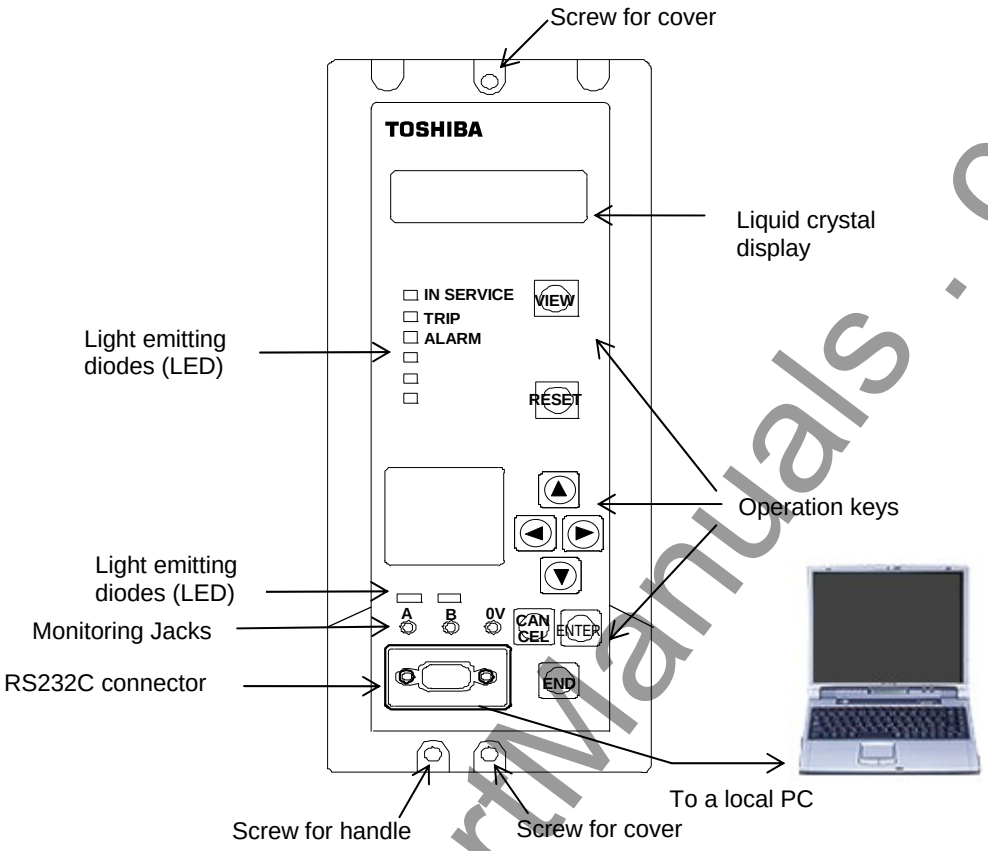


Figure 3.1.1.3 Front Panel

3.2 Input and Output Signals

3.2.1 AC Input Signals

Table 3.2.1.1 shows the AC input signals necessary for the GRL150 model and their respective input terminal numbers.

Table 3.2.1.1 AC Input Signals

Term. No. of TB1	Model		
	100, 400	110, 410	120, 420
1-2	A phase current	A phase current	A phase current
3-4	B phase current	B phase current	B phase current
5-6	C phase current	C phase current	C phase current
7-8	---	Residual current (E)	Zero sequence current (SE)

3.2.2 Binary Input Signals

The GRL150 provides eight programmable binary input circuits. Each binary input circuit is programmable by PLC function, and provided with the function of Logic level inversion.

The binary input circuit of the GRL150 is provided with a logic level inversion function and a pick-up and drop-off delay timer function as shown in Figure 3.2.2.1. 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 follows:

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.

The binary input signals can be programmed to switch between four settings groups. Change of active setting group is performed by PLC (Signal No. 2640 to 2643).

Four alarm messages (Alarm1 to Alarm4) 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. These alarm output signals are signal Nos. 2652 to 2655.

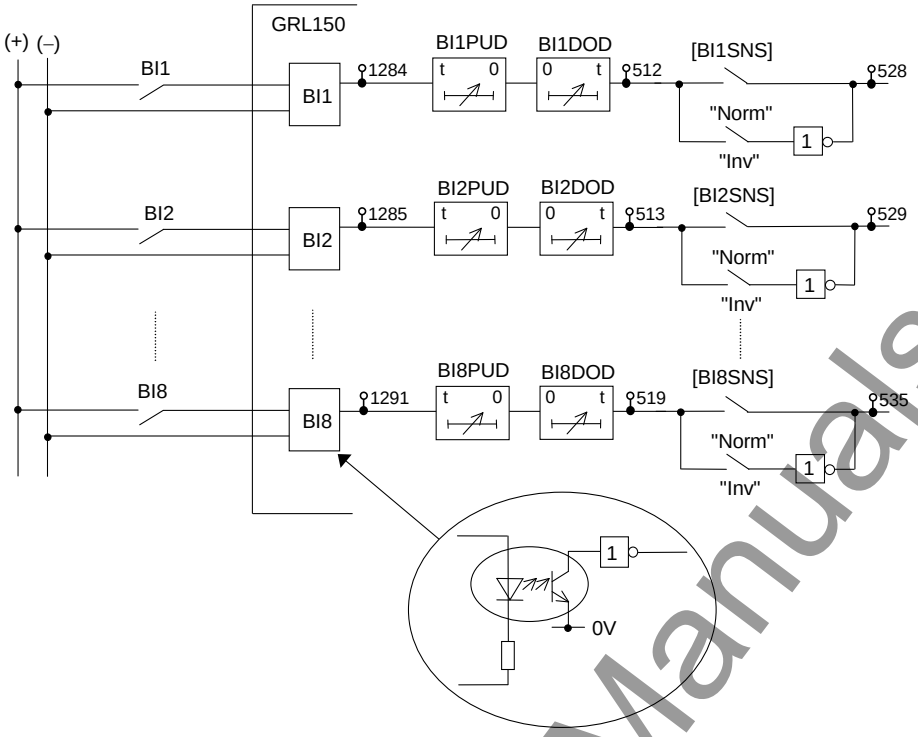


Figure 3.2.2.1 Logic Level Inversion

3.2.3 Binary Output Signals

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

GRL150 provides 8 auxiliary relays which is composed of two tripping output relay TP1 and TP2, one auxiliary relay FAIL for relay fail output and five programmable auxiliary relays BO1 to BO5. TP1 and TP2 can be programmed by PLC function. BO1 to BO5 can be programmed by setting.

The reset time of the tripping output relay following fault clearance can be programmed by PLC function. The setting is respective for each output relay.

For example, when the "GEN.TRIP" signal of the protection is linked to the binary output auxiliary relay TP1, the PLC logic is assigned to the signal No. 348 of GEN.TRIP for PLC input and the signal No. 2560 of TP1 for PLC output as shown in Figure 3.2.3.1 by the PLC tool. For the PLC tool, refer to PLC tool instruction manual.

In the case of the tripping output relay, 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.

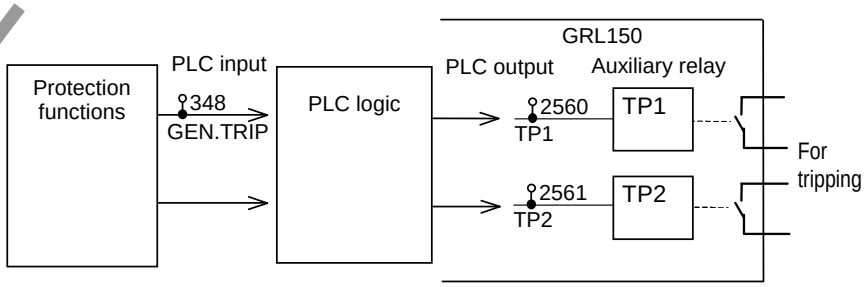


Figure 3.2.3.1 Binary Output Circuit

The signals shown in the signal list in Appendix B can be assigned to the output relays BO1 to BO5 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 3.2.3.2. The output circuit can be configured according to the setting menu. Appendix C shows the factory default settings.

Further, each BO has a programmable reset characteristic, settable for instantaneous drop-off "Ins", for delayed drop-off "Dl", for dwell operation "Dw" or for latching operation "Lat" by the scheme switch [RESET]. The time of the delayed drop-off "Dl" or dwell operation "Dw" can be set by TBO.

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

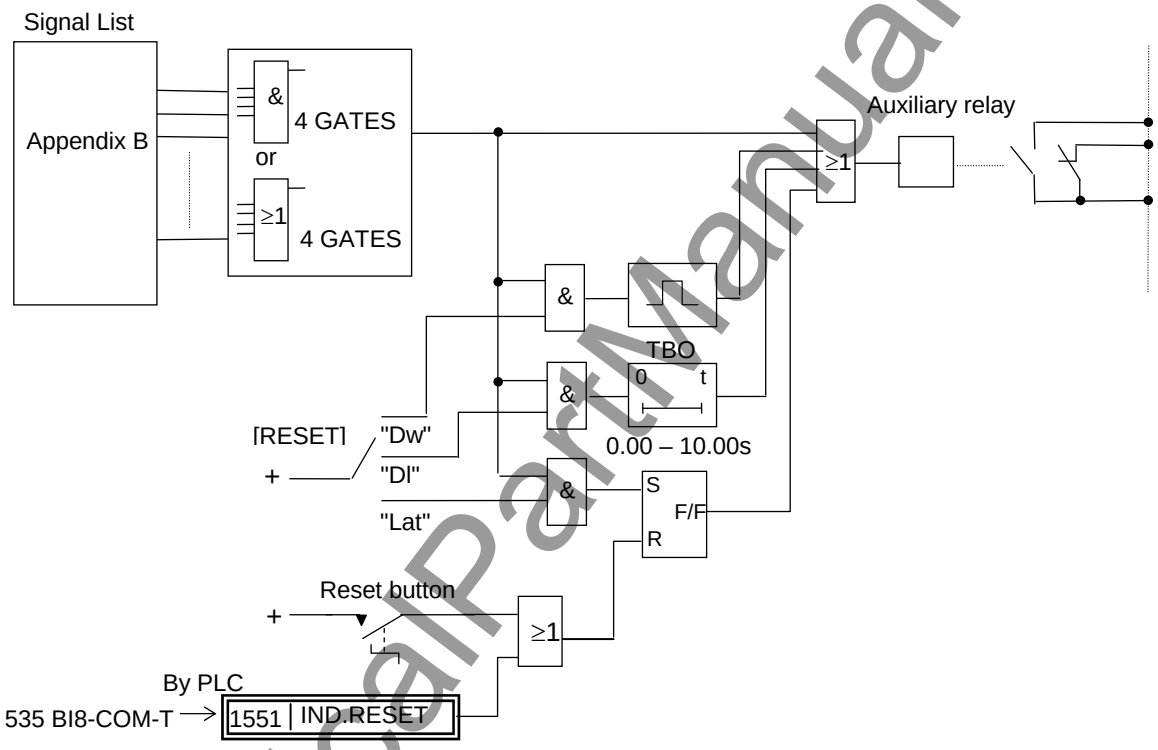


Figure 3.2.3.2 Configurable Output

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

3.2.4 PLC (Programmable Logic Controller) Function

GRL150 is provided with a PLC function allowing user-configurable sequence logics on binary signals. The sequence logics with timers, flip-flops, AND, OR, XOR, NOT logics, etc. can be produced by using the PC software "PLC tool" and linked to signals corresponding to relay elements or binary circuits.

Configurable binary inputs and binary outputs, and the initiation trigger of fault record and disturbance record are programmed by the PLC function. Temporary signals are provided for complicated logics or for using a user-configured signal in many logic sequences.

PLC logic is assigned to protection signals by using the PLC tool. For PLC tool, refer to PLC tool instruction manual.

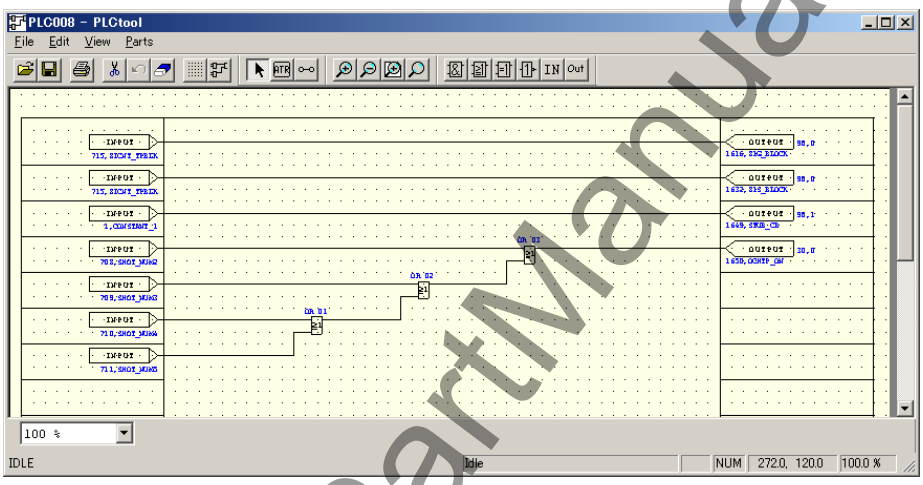


Figure 3.2.4.1 Sample Screen of PLC Tool

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 GRL150 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, it is recorded as Alarm record, 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

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

- 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. This monitoring can be disabled by the scheme switch [CTSVEN].

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.

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 3.3.3.1 shows a typical scheme. A binary input BIn is assigned to No.1548:TCSV signal by PLC. When the trip circuit is complete, a small current flows through the binary input and the trip circuit. Then logic signal of the binary input circuit BIn is "1".

If the trip supply is lost or if a connection becomes an open circuit, then the binary input resets and the BIn output is "0". A trip circuit fail alarm T_FAIL is output when the BIn output is "0".

If the trip circuit failure is detected, then “ALARM” LED is lit and “Err: TC” is displayed in LCD message.

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.

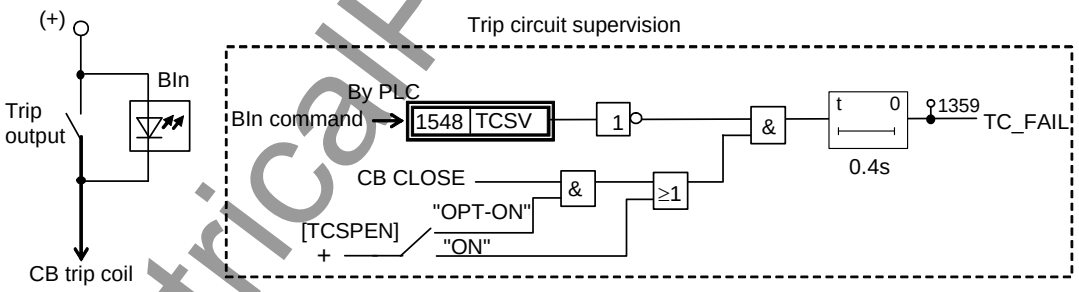


Figure 3.3.3.1 Trip Circuit Supervision Scheme Logic

3.3.4 Differential Current (Id) Monitoring

The DIFSV element is provided to detect any erroneous differential current appearing as a result of CT circuit failure. The tripping output signal of the DIF elements can be blocked when the DIFSV element output is maintained for the setting time of TIDSV. To block the tripping output with DIFSV operation, set scheme switch [IDSVEN] to “ALM&BLK”. To alarm only, set to “ALM”.

3.3.5 Telecommunication Channel Monitoring

The telecommunication channel is monitored at each terminal by employing a cyclic redundancy check of the received data. The check is carried out for every sample.

If a communication failure is detected continuously for ten seconds at a terminal, a communication failure alarm "Com fail" is issued at the terminal.

GRL150 provides the function to check the frequency of communication failures. The function has FERALM, FERAEN and CF-PER settings, and FER, CF and CF-L counts are displayed as a result of the checking. The function is maily used to check a quality of the pilot wire communication route. If the FER (Frame Error Rate) exceeds the FERALM setting value, the FER_ALM alarm signal is output. The FER is calculated by the following equation:

FER: Frame Error Rate
FER = {CF-L / (The number of received frame for CF-PER period)} × 100 (%)

CF: counts the number of communication failure occurrence for every sampling time.

CF-L: records and displays the number of communication failure occurrence for CF-PER setting.
The CF-L is used when the failure is out of count. (See Section 4.2.3.4 and 4.2.6.5.)

CF-PER: period time setting for counting up the communication failure.

The FER can be disabled by the scheme switch [FERAEN].

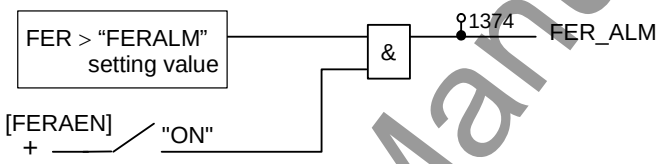


Figure 3.3.5.1 Frame Error Rate Alarm

3.3.6 Disconnector Monitoring

The disconnector is monitored because the disconnector contact signal is used for the out-of-service terminal detection.

To monitor the disconnector, one pair of normally open contact and normally closed contact is introduced. Disconnector failure is detected when both contacts are simultaneously in the open or closed state for the prescribed period.

The monitoring is blocked by setting the scheme switch [DSSMEN] to OFF. The default setting of [DSSMEN] is OFF to prevent a false failure detection when the disconnector contacts are not introduced.

3.3.7 Circuit Breaker Monitoring

The relay provides the following circuit breaker monitoring functions.

Circuit Breaker State Monitoring

Circuit breaker state monitoring is provided for checking the health of circuit breaker (CB). If two binary inputs are programmed to the functions 'CB_N/O_CONT' and 'CB_N/C_CONT', then the CB state monitoring function becomes active. In normal circumstances these inputs are in opposite states. Figure 3.3.7.1 shows the scheme logic. If both show the same state during five seconds, then a CB state alarm CBSV operates 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].

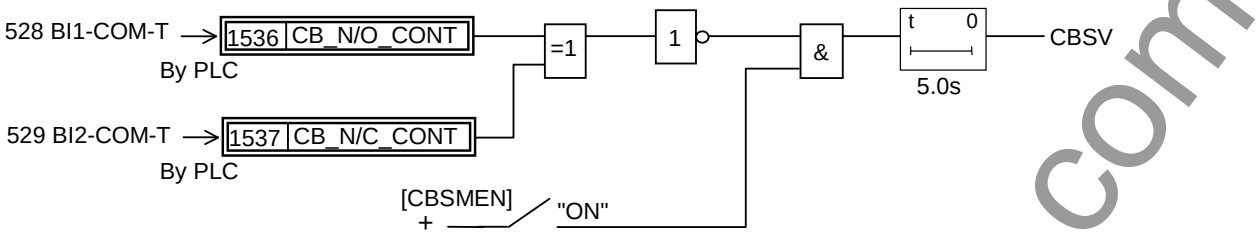


Figure 3.3.7.1 CB State Monitoring Scheme Logic

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 assigned to "CB_N/O_CONT" and "CB_N/C_CONT" by PLC.

Circuit Breaker Condition Monitoring

Periodic maintenance of CB is required for checking 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 the 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. 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 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].

The maintenance program should comply 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 inputs assigned to No.1588:EXT_TRIP-A, No.1589:EXT_TRIP-B, No.1590:EXT_TRIP-C and No.1591:EXT_TRIP by PLC as shown in Figure 3.3.7.2.

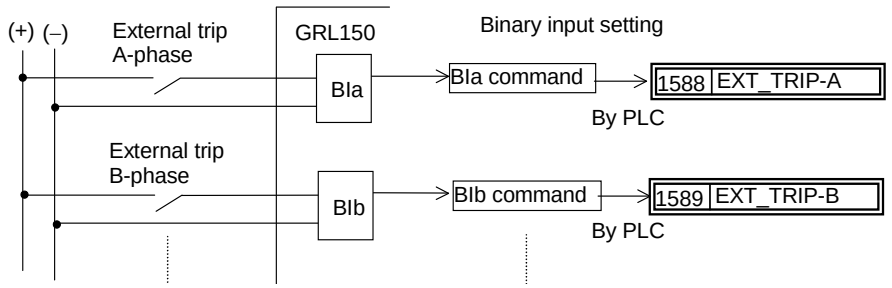


Figure 3.3.7.2 Binary Input Setting for CB Condition Monitoring

3.3.8 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	Alarm record Message
AC input imbalance monitoring	Err:CT	On/Off (2)	On	(4)	Relay fail or Relay fail-A (2)
A/D accuracy check	Err:A/D	Off	On	(4)	Relay fail
Memory monitoring	Err:SUM, Err:RAM, Err:BRAM, Err:EEP	Off	On	(4)	Relay fail
Watchdog Timer	----	Off	On	(4)	----
DC supply monitoring	Err:DC	Off	(3)	Off	Relay fail-A
Telecommunication monitoring	Err:COM	on	on	(5)	Com. fail
Sampling Synchronization monitoring	Err:SYN	on	on	(4)	Sync. fail
Ready signal monitoring	Err:RDY	on	on	(5)	Term. rdy off
Disconnector monitoring	Err:DS	on	on	(5)	DS fail
Id monitoring	Err:Id	on/off (6)	On	(5)	Relay fail or Relay fail-A (2)
Trip circuit supervision	Err:TC	On	On	Off	Relay fail-A
CB state monitoring	Err:CB	On	On	Off	Relay fail-A
CB operating time monitoring	ALM:OP time	On	On	Off	Relay fail-A
Trip count alarm	ALM:TP COUNT	On	On	Off	Relay fail-A
∑Iy count alarm	ALM:∑IY	On	On	Off	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 [CTSVEN] 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 [CTSVEN] 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.
(5): The user-configurable binary output relays operate if assigned.
(6): The LED is on when the scheme switch [IDSVEN] is set to "ALM" and off when set to "ALM & BLK".

The relationship between the LCD message and the location of the failure is shown in Table 6.7.1 in Section 6.7.2.

3.3.9 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
- Telecommunication channel monitoring

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

3.3.10 Setting

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

Element	Range	Step	Default	Remarks
[CTSVEN]	OFF/ALM&BLK/ALM		ALM&BLK	Alarming and blocking or alarming only
[IDSVEN]	OFF/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
[$\sum I^y$AEN]	OFF/ON		OFF	$\sum I^y$ count alarm
[OPTAEN]	OFF/ON		OFF	Operate time alarm
[FERAEN]	OFF/ON		OFF	Frame error rate alarm
DIFSV	50 – 100 %	1 %	50 %	DIFSV threshold setting (% of DIF setting)
TIDSV	0 – 60 s	1 s	10 s	DIFSV timer
TCALM	1 - 10000	1	10000	Trip count alarm threshold setting
$\sum I^y$ALM	10 – 10000 E6	E6	10000	$\sum I^y$ 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
CF-PER	1 – 60	1 s	10 s	CF period threshold
FERALM	0.0 – 50.0	0.1 %	20.0 %	Frame error rate alarm level

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

3.4 Recording Function

The GRL150 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 GRL150 and the following items are recorded for one fault:

Date and time

Trip mode

Operating phase

Power system quantities

User configurable initiation

User can configure four fault record triggers (Signal No.:2624 to 2627) by PLC. Any of input signals as shown in Appendix B is assigned to these fault record trigger signals.

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.

Operating phase

This is the phase to which an 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 residual current (I_e)(*)
- Magnitude of positive, negative and zero sequence currents (I_1, I_2, I_0)
- The ratio of negative to positive sequence current (I_2/I_1)
- Magnitude of phase current at remote terminal (I_{aR}, I_{bR}, I_{cR})
- Magnitude of phase differential current (I_{da}, I_{db}, I_{dc})
- Percentage of thermal capacity (THM%)

Note (*): The displayed power system quantity Ie depends on relay model. Ie is not displayed in

models 100 and 400, is a residual current for EF in models 110 and 410, and is a current for SEF fed from core balance CT in models 120 and 420.

3.4.2 Event Recording

The events shown are recorded with a 1 ms resolution time-tag when the status changes. The user can set a maximum of 128 recording items, and their status change mode. The event items can be assigned to a signal number in the signal list. The status change mode is set to "On" (only recording On transitions) or "On/Off"(recording both On and Off transitions) mode by setting. The "On/Off" mode events are specified by "Bi-trigger events" setting. If the "Bi-trigger events" is set to "100", No.1 to 100 events are "On/Off" mode and No.101 to 128 events are "On" mode.

The name of an event can be set by RSM100. Maximum 22 characters can be set, but the LCD displays only 11 characters. Therefore, it is recommended the maximum 11 characters are set. The set name can be viewed on the Set.(view) screen.

The elements necessary for event recording and their setting ranges are shown in the table below. The default setting of event record is shown in Appendix G.

Element	Range	Step	Default	Remarks
BITRN	0 - 128	1	100	Number of bi-trigger(on/off) events
EV1 – EV128	0 - 3071			Assign the signal number

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. Further, disturbance recording is started when a start command by PLC is initiated. User can configure four disturbance record triggers (Signal No.:2632 to 2635) by PLC.

The records include four local analogue data (I_a, I_b, I_c, I_e), three local analogue data (I_{aL}, I_{bL}, I_{cL}) sent to remote terminal, three remote analogue data (I_{aR}, I_{bR}, I_{cR}) sent from remote terminal, 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.

Note: The current data I_{aR}, I_{bR}, I_{cR} is for reference. If the detail of remote current data is required, the local current data stored at the remote terminal relay should be checked.

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.

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	0.5-250.0 A	0.1 A	3.0 A	Earth fault detection
	(0.10-50.00 A	0.01 A	0.60A)	
SEF	0.01-1.00 A	0.01 A	1.00 A	Sensitive earth fault detection
	(0.002-0.200 A	0.001 A	0.200 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
[OC]	OFF/ON		ON	Start by OC operation
[EF]	OFF/ON		ON	Start by EF operation
[SEF]	OFF/ON		ON	Start by SEF operation

3.5 Metering Function

The GRL150 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 residual current (I_e)(*)
- Magnitude of positive, negative and zero sequence currents (I_1, I_2, I_0)
- The ratio of negative to positive sequence current (I_2/I_1)
- Magnitude of phase current at remote terminal (I_{aR}, I_{bR}, I_{cR})
- Magnitude of phase differential current (I_{da}, I_{db}, I_{dc})
- Magnitude of phase restraint current (I_{ra}, I_{rb}, I_{rc})
- Magnitude of pickup current (I_{pua}, I_{pub}, I_{puc})
- Percentage of thermal capacity (THM%)
- Maximum phase current ($I_a$max, $I_b$max, $I_c$max)
- Maximum residual current ($I_e$max) (*)
- Maximum negative and zero sequence currents (I_2max, I_0max)
- Maximum ratio of negative to positive sequence current (I_{21} max)

Note (*): The displayed power system quantity Ie depends on relay model. The Ie is not displayed in model 100 and 400, is a residual current for EF in model 110 and 410, and is a current for SEF fed from core balance CT.

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.

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 RS-232C 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.
TRIP	Red	Lit when a trip command is issued.
ALARM	Red	Lit when a failure is detected.
(LED1)	Yellow	Configurable LED to assign signals with or without latch when relay operates.
(LED2)	Yellow	Configurable LED to assign signals with or without latch when relay operates.
(LED3)	Yellow	Configurable LED to assign signals with or without latch when relay operates.

The TRIP LED lights up once the relay is operating and remains lit even after the trip command goes off. For the operation, see Section 4.2.1.

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.

Monitoring jacks

The two monitoring jacks A and B and their respective LEDs can be used when the test mode is selected on the LCD screen. By selecting the signal to be observed from the "Signal List" and setting it on the screen, the signal can be displayed on LED A or LED B, or transmitted to an oscilloscope via a monitoring jack.

RS232C connector

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

4.1.2 Communication Ports

The following interfaces are provided as communication ports:

- RS232C port
- RS485 port or optional fibre optic
- IRIG-B port (provided for model 4** series only)
- Interface port for telecommunication system

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 and display functions can be performed from the personal computer.

RS485 port

One or two serial communication ports can be provided. In the single-port type, it is connected to the RSM (Relay Setting and Monitoring system) via the protocol converter G1PR2 or 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.)

In the case of the two-port type, one port can be used for the relay setting and monitoring (RSM) system or IEC60870-5-103 communication, while the other port is used for IEC60870-5-103 communication only.

Screw terminals for RS485 or ST connectors for fibre optic interface (option) are provided on the back of the relay.

IRIG-B port

The IRIG-B port collects serial IRIG-B format data from the external clock to synchronize the relay calendar clock. The IRIG-B port is isolated from the external circuit by a photo-coupler.

This port is on the back of the relay, as shown in Figure 4.1.2.1.

Interface port for telecommunication system

The pilot wire and/or fibre optic port for telecommunication system is provided on the back of the relay as shown in Figure 4.1.2.1. In the case of fibre optic port, LC connector is provided.

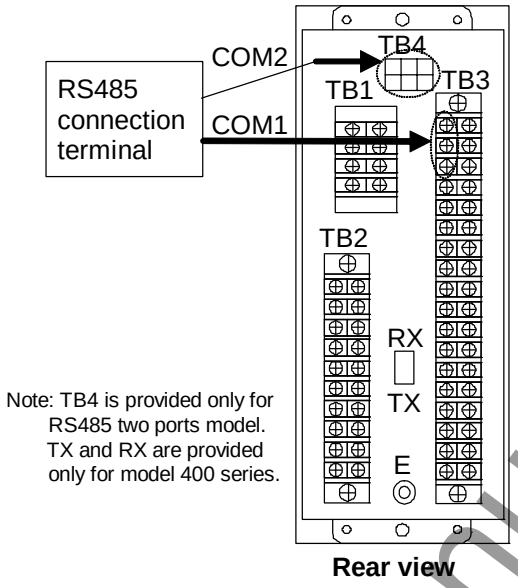


Figure 4.1.2.1 Location of Communication Port

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

Indication

```
I N D 1 [ 0 0 0 0   0 0 0 0 ]
I N D 2 [ 0 0 0 1   0 0 0 0 ]
```

Metering 1

```
I a          * * . * * k A
```

Metering 2

```
I b          * * . * * k A
```

Metering 3

```
I c          * * . * * k A
```

Metering 4

```
I e          * * . * * k A
```

Available for models 110 and 410.

Metering 5

```
I s e        * * * . *   A
```

Available for models 120 and 420.

Metering 6

```
I a R        * * * . * * k A
               * * * . *  °
```

Metering 7

```
I b R        * * * . * * k A
               * * * . *  °
```

Metering 8

```
I c R        * * * . * * k A
               * * * . *  °
```

Metering 9

```
I d a        * * * . * * k V
               * * * . *  °
```

Metering 10

```
I d b        * * * . * * k V
               * * * . *  °
```

Metering 11

```
I d c        * * * . * * k V
               * * * . *  °
```

When the GRL150 is operating normally, the green "IN SERVICE" LED is lit and the LCD is off.

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

Press the [RESET] key to turn off the LCD.

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 [ 0000  0000 ]
IND2 [ 0001  0000 ]
```

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

Displays in tripping

Latest fault

```
Phase   ABC      : Faulted phases
OC1              : 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.

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)

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.

4.2.2 Relay Menu

Figure 4.2.1 shows the menu hierarchy in the GRL150. The menu has five sub-menus, "Record", "Status", "Set.(view)", "Set.(change)", and "Test". For details of the menu hierarchy, see Appendix D.

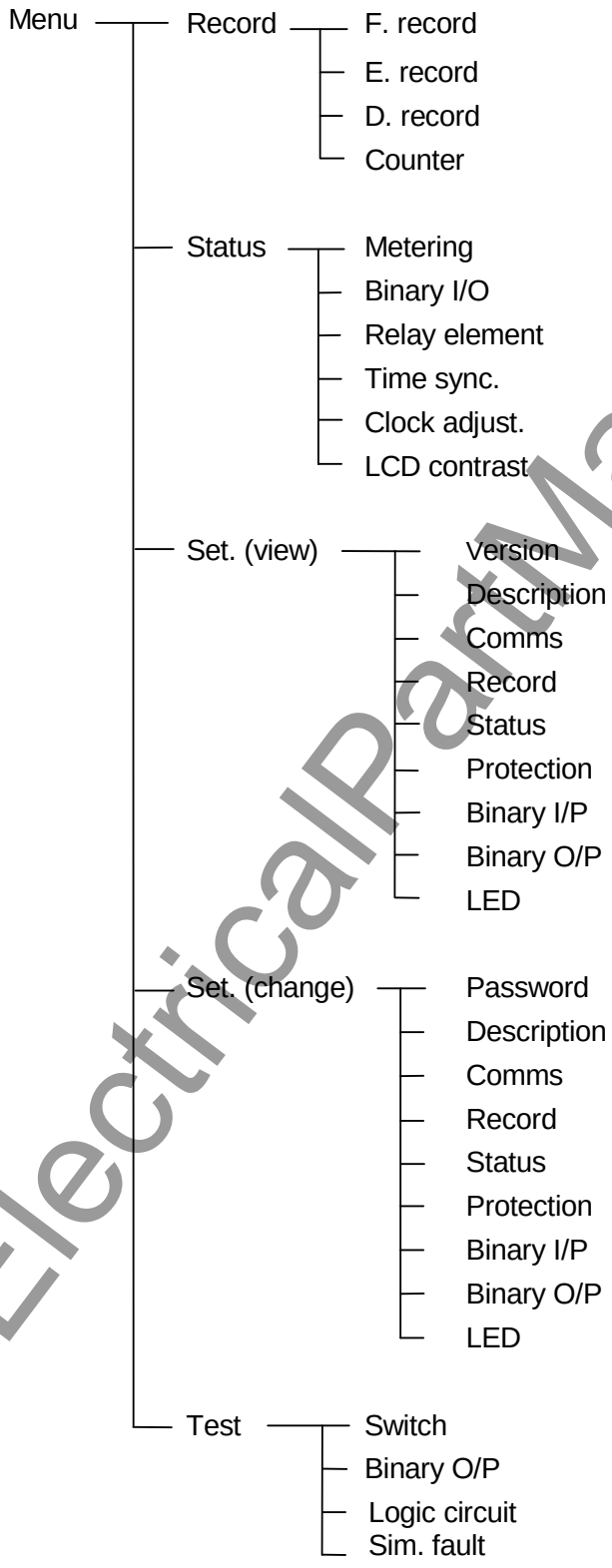


Figure 4.2.1 Relay Menu

Record

In the "Record" menu, the fault records event records, disturbance records and counts such as trip count.

Status

The "Status" menu displays the power system quantities, binary input and output status, relay measuring element status, signal source for time synchronisation (BI, RSM or IEC60870-5-103), clock adjustment and LCD contrast.

Set. (view)

The "Set.(view)" menu displays the relay version, description, relay address and baud rate in RSM or IEC60870-5-103 communication, the current settings of record, status, protection, binary inputs, configurable binary outputs and configurable LEDs.

Set. (change)

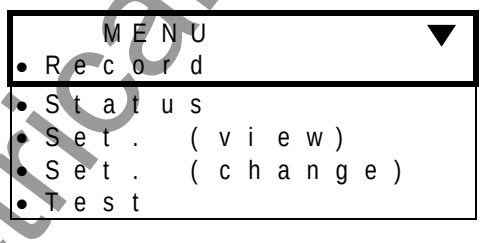
The "Set.(change)" menu is used to change the settings of password, description, relay address and baud rate in RSM or IEC60870-5-103 communication, record, status, protection, binary inputs, configurable binary outputs and configurable LEDs.

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.

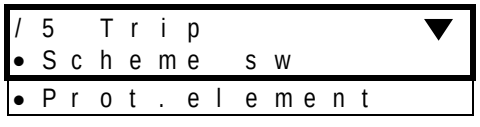


To display the "MENU" screen when the digest screen is displayed, press the [RESET] key to turn off the LCD, then press any key other than the [VIEW] and [RESET] keys.

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.



To return to the higher screen or move from the right side screen to the left side screen in Appendix

D, 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.

```
/4  F. record  #1             ▼
01/Jan/2002                          Date
18:13:57.031                         Time
DIF                                  Trip element
Phase  ABC                           Faulted phase
Prefault values
Ia          **.**kA
            ***.*°
```

Ib	***.**kA	
	****.*°	
Ic	***.**kA	
	****.*°	
Ie	***.**kA	Available for model 110 and 410.
	****.*°	
Ie	*****.* A	Available for model 120 and 420.
	****.*°	
I1	***.**kA	
	****.*°	
I2	***.**kA	
	****.*°	
I0	***.**kA	
	****.*°	
I2/I1	***.**	
IaR	***.**kA	
	****.*°	
IbR	***.**kA	
	****.*°	
IcR	***.**kA	
	****.*°	
Ida	***.**kA	
Idb	***.**kA	
Idc	***.**kA	
Fault values		
Ia	***.**kA	
	****.*°	
Ib	***.**kA	
	****.*°	
Ic	***.**kA	
	****.*°	
Ie	***.**kA	Available for model 110 and 410.
	****.*°	
Ie	*****.* A	Available for model 120 and 420.
	****.*°	
I1	***.**kA	
	****.*°	
I2	***.**kA	
	****.*°	
I0	***.**kA	
	****.*°	
I2/I1	***.**	
IaR	***.**kA	
	****.*°	
IbR	***.**kA	
	****.*°	
IcR	***.**kA	
	****.*°	
Ida	***.**kA	
Idb	***.**kA	
Idc	***.**kA	
THM	****.* %	

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
• 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
DIF trip     On
13:22:45.109
DIF-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 . r e c o r d          ▼
• D i s p l a y
• C l e a r
```

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

```
/ 3  D . r e c o r d          ▼

# 1  1 6 / J u l / 2 0 0 1
     1 8 : 1 3 : 5 7 . 4 0 1
# 2  2 0 / M a y / 2 0 0 1
     1 5 : 2 9 : 2 2 . 3 8 8
# 3  0 4 / F e b / 2 0 0 1
     1 1 : 5 4 : 5 3 . 4 4 4
# 4  2 8 / J a n / 2 0 0 1
     0 7 : 3 0 : 1 8 . 8 7 6
```

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.

```
C l e a r  r e c o r d s ?
E N D = Y    C A N C E L = 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  C o u n t e r            ▼
• D i s p l a y
• C l e a r  T r i p s
• C l e a r  T r i p s  A     (*)
• C l e a r  T r i p s  B     (*)
• C l e a r  T r i p s  C     (*)
• C l e a r  Σ I ^ y A
```

```
• Clear  ΣI^yB
• Clear  ΣI^yC
• Clear  CF
```

(*) 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      *****
TripsA     *****                (*1)
TripsB     *****                (*1)
TripsC     *****                (*1)
ΣI^yA      ******E6
ΣI^yB      ******E6
ΣI^yC      ******E6
CF         ******
CF-L       ******               (*2)
FER        ***.*%
```

Note (*1): These settings are only available when single phase External Trip BI functions are used. In this case, the main "Trips" option is not available.
(*2): This count is the number of CF for CF-PER setting time and cannot be reset manually..

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  TripsA?
END=Y  CANCEL=N
```

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

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

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

```
Clear  TripsC?
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
```

- Select "Clear CF (Communication failure)" to display the following confirmation screen.

```
Clear  CF?
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.

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.

```
/1 Status                ▼
• Metering
• Binary I/O
• Relay element
• Time sync.
• Clock adjust.
• LCD contrast
```

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

```
/2 Metering              ▼
• Current
• Demand
```

- Select "Current" to display the current power system quantities on the "Metering" screen.

```
/3 Current               ▼
Ia          **.***kA
            ***.*°
Ib          **.***kA
            ***.*°
Ic          **.***kA
            ***.*°
Ie        **.***kA          Available for model 110 and 410.
            ***.*°
Ie      *****.*  A          Available for model 120 and 420.
            ***.*°
I1          **.***kA
```

	* * * . * °	
I 2	* * . * * k A	
	* * * . * °	
I 0	* * . * * k A	
	* * * . * °	
I 2 / I 1	* * . * *	
I a R	* * . * * k A	Remote terminal current, A-phase
	* * * . * °	
I b R	* * . * * k A	ditto, B-phase
	* * * . * °	
I c R	* * . * * k A	ditto, C-phase
	* * * . * °	
I d a	* * . * * k A	
I d b	* * . * * k A	
I d c	* * . * * k A	
I r a	* * . * * k A	
I r b	* * . * * k A	
I r c	* * . * * k A	
I p u a	* * . * * k A	
I p u b	* * . * * k A	
I p u c	* * . * * k A	
T H M	* * * . * %	
R L	* * * . * %	

- Select "Demand" to display the current demand on the "Metering" screen.

/ 3 Demand		▼
I a m a x	* * . * * k A	
I b m a x	* * . * * k A	
I c m a x	* * . * * k A	
I e m a x	* * . * * k A	Available for model 110 and 410.
I e m a x	* * * * . * A	Available for model 120 and 420.
I 2 m a x	* * . * * k A	
I 0 m a x	* * . * * k A	
I 2 1 m a x	* * . * *	

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.

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

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

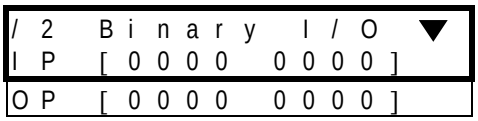
If the primary side unit (A) is required, select 2(=Pri-A) on the "Metering" screen. See Section 4.2.6.6.

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.



The display format is shown below.

	[■	■	■	■	■	■	■	■]
Input (IP)	BI1	BI2	BI3	BI4	BI5	BI6	BI7	BI8
Output (OP)	TP1	TP2	BO1	BO2	BO3	BO4	BO5	FAIL

Line 1 shows the binary input status. BI1 to BI8 correspond to each binary input signal. All binary input signals are configurable. The status is expressed with logical level "1" or "0" at the photo-coupler output circuit.

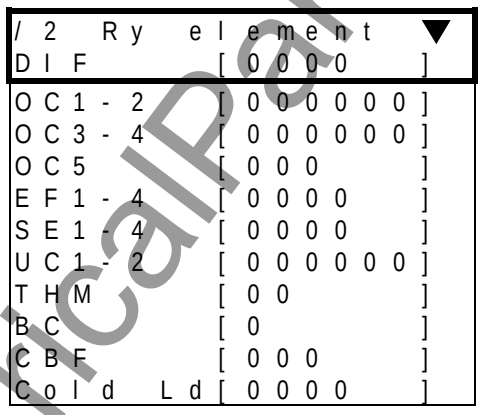
Line 2 shows the binary output status. All binary outputs BO1 to BO5 are configurable. The status of these outputs is expressed with logical level "1" or "0" at the input circuit of the output relay driver. That is, the output relay is energised when the status is "1".

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.



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

The operation status of measuring elements are shown as below.

	[■	■	■	■	■	■]	
DIF	A	B	C				DIF element
OC1-2	OC1-A	OC1-B	OC1-C	OC2-A	OC2-B	OC2-C	OC1, OC2 elements
OC3-4	OC3-A	OC3-B	OC3-C	OC4-A	OC4-B	OC4-C	OC3, OC4 elements
OC5	OC5-A	OC5-B	OC5-C				
EF1-4	EF1	EF2	EF3	EF4			
SE1-4	SE1	SE2	SE3	SE4			
NC	NC1	NC2	-	-			
UC1-2	UC1-A	UC1-B	UC1-C	UC2-A	UC2-B	UC2-C	UC1, UC2 elements
THM	Alarm	Trip	-	-			
BC	BC	-	-	-			

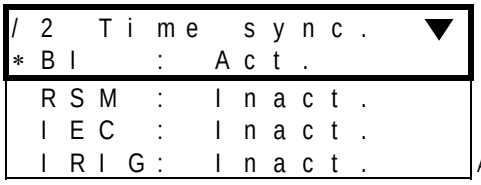
CBF	A	B	C	-	
Cold Ld	0	1	2	3	Cold Load state

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 GRL150 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.



Available for model 4** series only.

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.

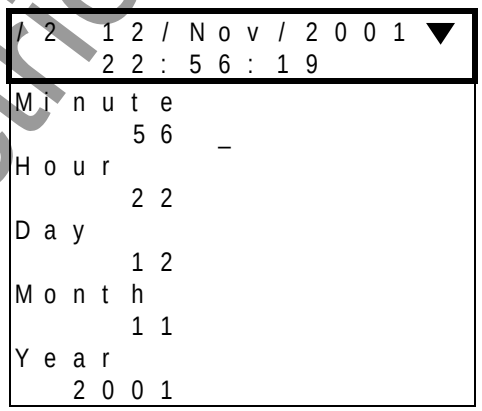
Note: If the Binary input signal has not been detected for one hour or more after the last detection, the status becomes "inactive".

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.



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], [IEC] or [IRIG] 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.

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

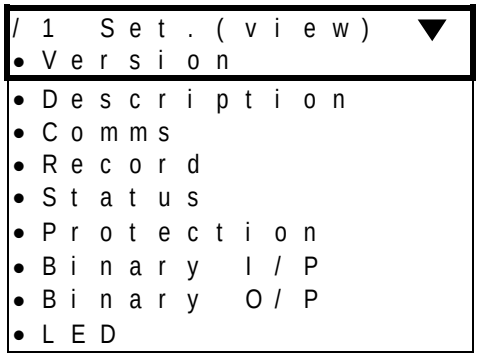
LED setting

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

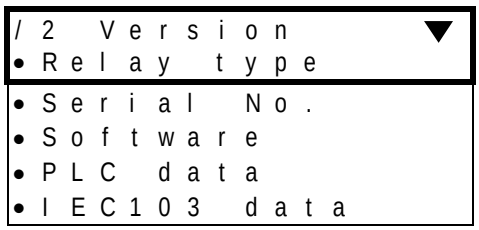
4.2.5.1 Relay Version

To view the relay version, do the following.

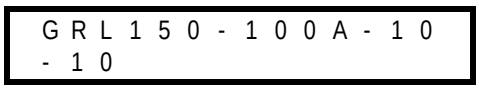
- Press the "Set.(view)" on the main menu.



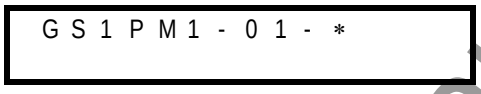
- Press the "Version" on the "Set.(view)" menu.



- 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.



- Select "PLC data" to display the PLC data.
- Select "IEC103 data" to display the IEC103 configuration data.

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

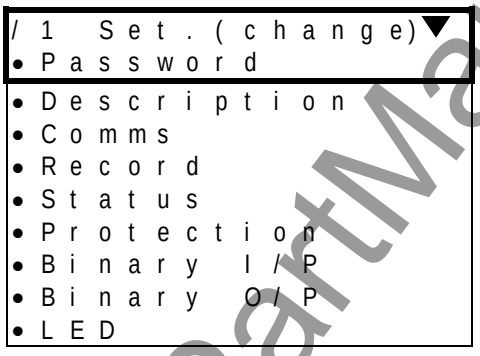
There are three setting methods as follows:

- To enter a selected item
- 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.

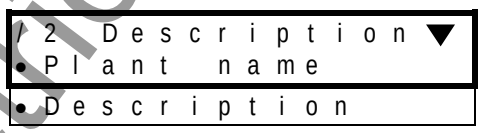
The cursor can be moved to upper or lower lines within the screen by pressing the ▲ and ▼ keys. If setting (change) is not required, skip the line with the ▲ and ▼ keys.



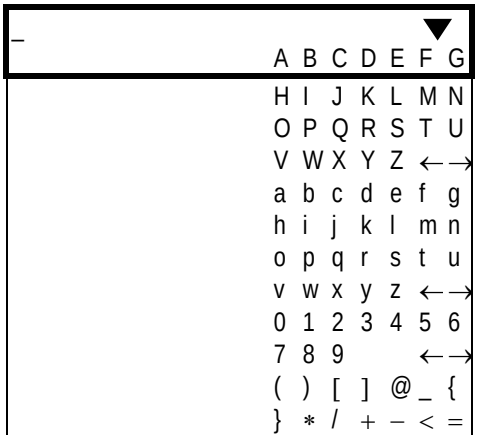
- Move the cursor to a setting item.
- Press the [ENTER] key.

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.
- 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.

```
/ 4  T i m e / s t a r t e r ▼

T i m e                    s
    2 . 0
O C                        A
    2 . 0 0
E F                        A
    0 . 6 0
S E F                      A
    0 . 2 0 0
```

- 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 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 "Set.(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.

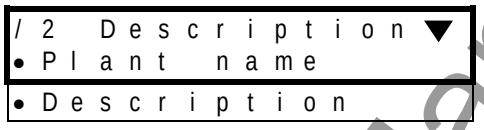
If you forget the password

Press [CANCEL] and [RESET] keys together for one second on the top "MENU" screen. The screen goes off, and the password protection of the GRL150 is canceled. Set the password again.

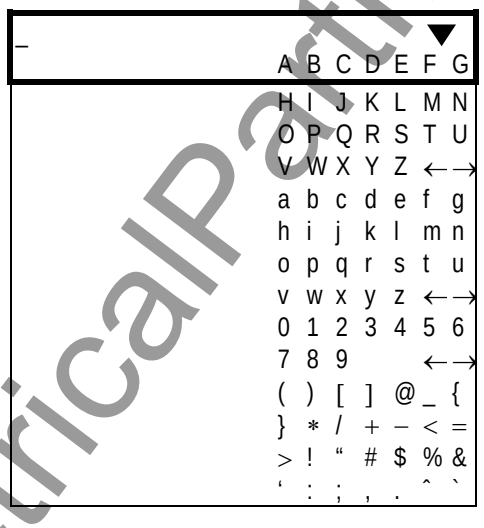
4.2.6.3 Plant Name

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.

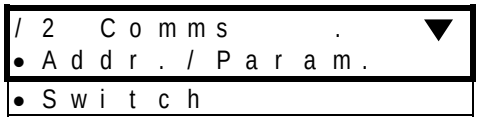


- Enter the text string.

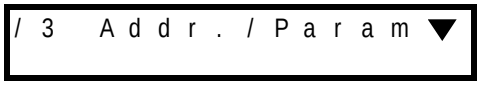
4.2.6.4 Communication

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.



```
HDLC
          1   _
IEC
          2
```

- 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.

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

```
/3 Switch .          ▼

Protocol          0   _
HDLC/IEC
232C              0
9.6/19.2/57.6
IECBR             1
9.6/19.2
IECBLK            0
Normal/Blocked
```

- 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>

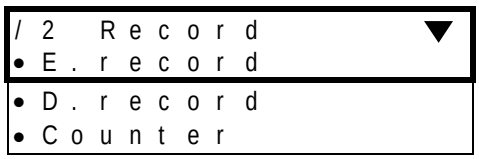
Enter 1(=Blocked) to block the monitor direction in the IEC60870-5-103 communication.

4.2.6.5 Setting the Recording

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

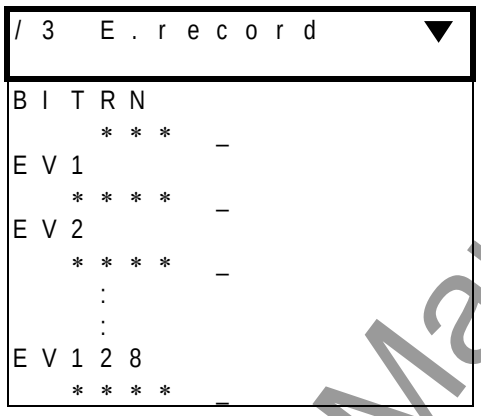
- Select "Set.(change)" on the main "MENU" screen to display the "Set.(change)" screen.

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



Setting the event recording

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



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

<BITRN>

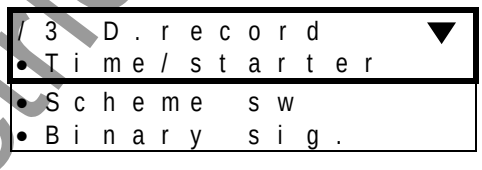
- Enter the number of bi-trigger (on/off) trigger events.

<EV*>

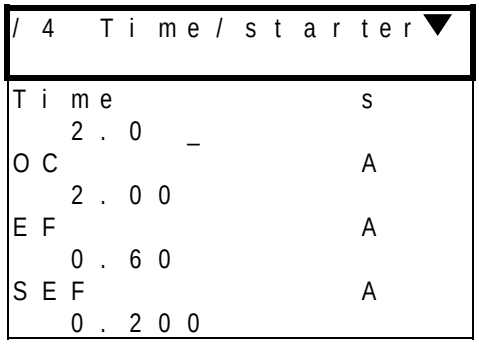
- Enter the signal number to be assigned.

Setting the disturbance recording

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



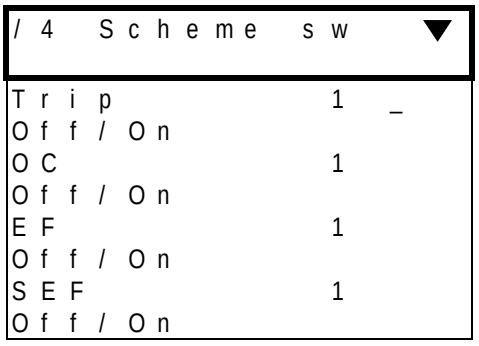
- Select "Time/starter" to display the "Time/starter" screen.



- Enter the recording time and starter element settings.

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

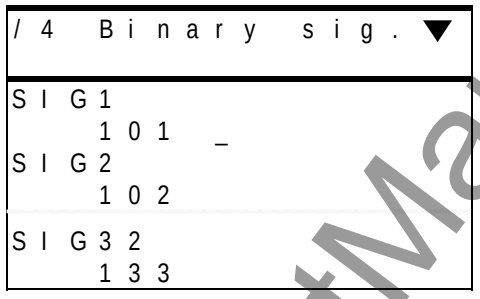
- Select "Scheme sw" on the "D. record" screen to display the "Scheme sw" screen.



- 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:

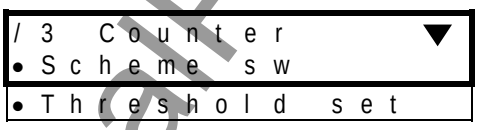
- Select "Binary sig." on the "D. record" screen to display the "Binary sig." screen.



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

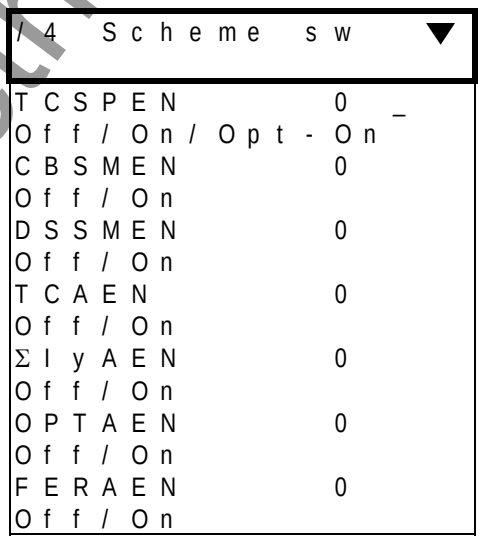
Setting the counter

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



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.



- 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 "Threshold set" on the "Counter" screen to display the "Threshold" screen.

```
/ 4  Threshold          ▼

TCALM
  10000  _
ΣIyALM              E6
  10000
YVALUE
     2.0
OPTALM              ms
   1000
CF-PER              s      (*)
      60
FERALM              %
   20.0
```

(*)Note: This is used to count CF which occurs for a period time (CF-PER setting).
The result is displayed on the CF-L of " Record→Counter→Display " menu.

- 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  Status             ▼
• Metering
• Time sync.
• Time zone                Option
```

Setting the metering

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

```
/ 3  Metering           ▼

Display          1  _
Pri/Sec/Pri-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  Time sync.         ▼

Time sync.   0  _
Off/BI/RS/IE/IR    RS:RSM, IE:IEC, IR:IRIG-B(available for model 4** series only)
```

- 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(=RS) to be synchronised with the RSM clock.

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

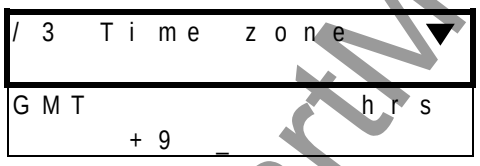
  Enter 3(=IR) to be synchronised with IRIG-B.

  Note: When selecting BI, RSM, IEC or IRIG-B, 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, IEC or IRIG-B, the calendar clock runs locally.

Setting the time zone

When the calendar clock is synchronized with the IRIG-B time standard, it is possible to transform GMT to the local time.

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

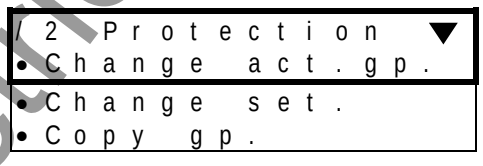


- Enter the difference between GMT and local time and press the [ENTER] key.

4.2.6.7 Protection

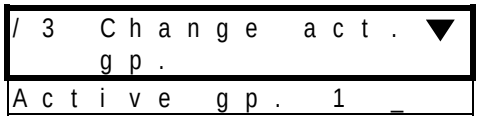
The GRL150 can have 4 setting groups for protection in order to accommodate changes in the operation of the power system, one setting group is assigned active. To set the protection, do the following:

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



Changing the active group

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

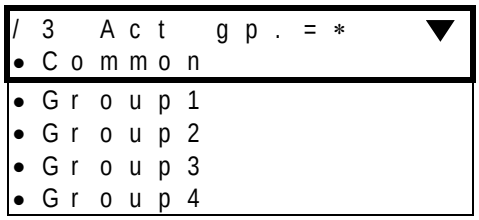


- Enter the group number and press the [ENTER] key.

Changing the settings

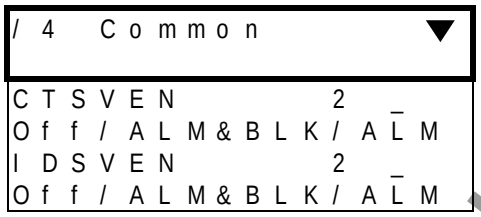
Almost all the setting items have default values that are set when the product is shipped. For the default values, see Appendix G. To change the settings, do the following:

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



Changing the Common settings

- Select "Common" to set the AC input imbalance monitoring and the differential current monitoring, and press the [ENTER] key.



<CTSVEN>

To set AC input imbalance monitoring enable, do the following.

- Enter 0(=Off) or 1(=ALM&BLK) or 2(=ALM) by pressing the ◀ or ▶ key and press the [ENTER] key.

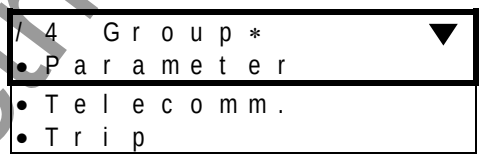
< IDSVEN>

To set differential current monitoring enable, do the following.

- Enter 0(=Off) or 1(=ALM&BLK) or 2(=ALM) by pressing the ◀ or ▶ key and press the [ENTER] key.

Changing the Group settings

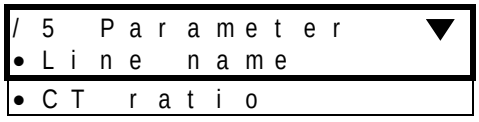
- Select the "Group∗" on the "Act gp.= *" screen to change the settings and press the [ENTER] key.



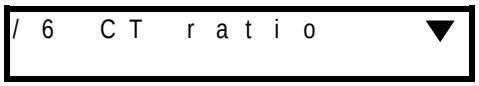
Setting the parameter

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.



```
C T
    4 0 0   _
E F C T
    4 0 0   _
```

Available for model 120 and 420

Setting the telecommunication

To set the telecommunication, do the following.

- Select "Telecomm." on the "Group ∗" screen to display the "Telecomm." screen.

```
/ 5  T e l e c o m m .   ▼
• S c h e m e  s w
• T h r e s h o l d  s e t
```

Setting the scheme switch of telecommunication

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

```
/ 6  S c h e m e  s w   ▼

S P . S Y N          0   _
M a s t e r / S l a v e
C O M . I / F        0   _
P W / O P T
R L - M O D E        0   _
A u t o / M a n u a l
```

Available for model 400, 410 and 420.

<SP.SYN>

To set Master or Slave terminal in sampling synchronisation, do the following.

- Enter 0(=Master) or 1(=Slave) by pressing the ◀ or ▶ key and press the [ENTER] key.

< COM.I/F>

To set PW (pilot-wire) or OPT (fibre optic) in communication system, do the following.

- Enter 0(=PW) or 1(=OPT) by pressing the ◀ or ▶ key and press the [ENTER] key.

< RL-MODE>

To set the receiving signal mode, do the following.

- Enter 0(=Auto) or 1(=Manual) by pressing the ◀ or ▶ key and press the [ENTER] key.

Setting the threshold of telecommunication

- Select "Threshold set" on the "Telecomm." screen to display the "Threshold" screen.

```
/ 6  T h r e s h o l d   ▼

M . R L                  %
    2 0 . 0   _
```

- Enter the numerical value 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.

```
/ 5  Trip                    ▼
• Scheme sw
• Prot. element
```

Setting the scheme switch

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

```
/ 6  Scheme sw               ▼
• Application
• DIF
• OC
• EF
• SEF
• Misc
• CLP/ICD
```

Available for model 110 and 410.
Available for model 120 and 420.

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   _
D/IEC/IEEE/US/C
MEF1                  1   _
D/IEC/IEEE/US/C
MSE1                  1   _
D/IEC/IEEE/US/C
OTD                   1   _
Off/On
```

<MOC1>, <MEF1>, <MSE1>

To set the OC1, EF1 and SEF1 time delay characteristic type, do the following.

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

<OTD>

- Enter 1(=On) to set the open terminal detection OTD enable. If disabling the OTD, enter 0(=Off) and press the [ENTER] key.

Setting the DIF protection

The settings for the DIF protection are as follows:

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

```
/ 7  DIF                     ▼

DIFEN                 1   _
Off/On
DIF-FS                0   _
Off/On
```

<DIFEN>

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

<DIF-FS>

- Enter 1(=On) to enable the fail-safe function DIF-FS and press the [ENTER] key. If disabling the DIF-FS, enter 0(=Off) and press the [ENTER] key.

Setting the OC protection

The settings for the OC protection are as follows:

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

```
/ 7   O C                          ▼

O C 1 E N                 1    _
O f f / O n
M O C 1 C - I E C         0
N I / V I / E I / L T I
M O C 1 C - I E E E       0
M I / V I / E I
M O C 1 C - U S           0
C O 2 / C O 8
O C 1 R                   0
D E F / D E P
O C 2 E N                 0
O f f / O n
O C 3 E N                 0
O f f / O n
O C 4 E N                 0
O f f / O n
```

<OC∗EN>

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

<MOC1C>

To set the OC1 Inverse Curve Type, do the following.

- If [MOC1] is 1(=IEC), enter 0(=NI) or 1(=VI) or 2(=EI) or 3(=LTI) and press the [ENTER] key.
- If [MOC1] is 2(=IEEE), enter 0(=MI) or 1(=VI) or 2(=EI) and press the [ENTER] key.
- If [MOC1] is 3(=US), enter 0(=CO2) or 1(=CO8) and press the [ENTER] key.

<OC1R>

To set the Reset Characteristic, do the following.

- If [MOC1] is 2(=IEEE) or 3(=US), enter 0(=DEF) or 1(=DEP) 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 EF protection for model 110 and 410

The settings for the EF protection are as follows:

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

```
/ 7  EF                    ▼

EF1EN              1       _
Off / On / POP
MEF1C-IEC          0
NI / VI / EI / LTI
MEF1C-IEEE         0
MI / VI / EI
MEF1C-US           0
CO2 / CO8
EF1R               0
DEF / DEP
EF2EN              0
Off / On
EF3EN              0
Off / On
EF4EN              0
Off / On
```

<EF∗EN>

- Enter 1(=On) to use an earth fault protection and press the [ENTER] key. If disabling the EF∗, enter 0(=Off) and press the [ENTER] key.

<MEF1C>

To set the EF1 Inverse Curve Type, do the following.

- If [MEF1] is 1(=IEC), enter 0(=NI) or 1(=VI) or 2(=EI) or 3(=LTI) and press the [ENTER] key.
- If [MEF1] is 2(=IEEE), enter 0(=MI) or 1(=VI) or 2(=EI) and press the [ENTER] key.
- If [MEF1] is 3(=US), enter 0(=CO2) or 1(=CO8) and press the [ENTER] key.

<EF1R>

To set the Reset Characteristic, do the following.

- If [MEF1] is 2(=IEEE) or 3(=US), enter 0(=DEF) or 1(=DEP) 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 SEF protection for model 120 and 420

The settings for the SEF protection are as follows:

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

```
/ 7   S E F                    ▼

S E 1 E N              1   _
O f f / O n
M S E 1 C - I E C      0
N I / V I / E I / L T I
M S E 1 C - I E E E    0
M I / V I / E I
M S E 1 C - U S        0
C O 2 / C O 8
S E 1 R                0
D E F / D E P
S E 1 S 2              0
O f f / O n
S E 2 E N              0
O f f / O n
S E 3 E N              0
O f f / O n
S E 4 E N              0
O f f / O n
```

<SE*EN>

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

<MSE1C>

To set the SEF1 Inverse Curve Type, do the following.

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

<SE1R>

To set the Reset Characteristic, do the following.

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

<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.

- 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 the miscellaneous protection are as follows:

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

```
/7 Misc.                    ▼

UC1EN                  0    _
Off/On
UC2EN                  0
Off/On
THMEN                  0
Off/On
THMAEN                 0
Off/On
BCDEN                  0
Off/On
BTC                    0
Off/On
RTC                    0
Off/DIR/OC
TTSW1                  0
Off/Trip/BO
TTSW2                  0
Off/Trip/BO
```

<UC*EN>

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

<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.

<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.

<TTSW*>

- Enter 1(=Trip) to assign a transfer trip command to the binary output for tripping and enter 2(=BO) to assign a transfer trip command to a configurable binary output, and press the [ENTER] key. If disabling the transfer trip function, enter 0(=Off) and press the [ENTER] key.

Setting the CLP / ICD

The settings for the CLP/ICD are as follows:

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

```
/ 7   CLP/ICD          ▼
CLEN                0  _
Off / On
CLDOEN              0
Off / On
DIF-ICD             0
NA/BLK
OC-ICD              0
NA/BLK
```

<CLEN>

To set the Cold load function enable, do the following.

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

<DIF-ICD>

- Enter 1(=BLK) to block the DIF tripping when the ICD detects inrush current. If not to block, enter 0(=NA) and press the [ENTER] key.

<OC-ICD>

- Enter 1(=BLK) to block the OC, EF and SEF tripping when the ICD detects inrush current. If not to block, enter 0(=NA) and press the [ENTER] key.
- After setting, press the [END] key to display the following confirmation screen.

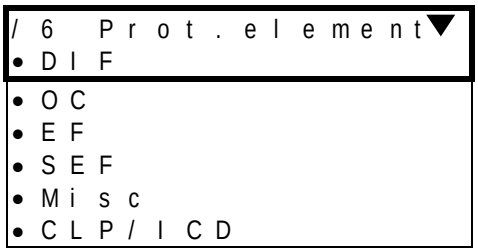
```
Change settings?
ENTER=Y  CANCEL=N
```

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

Setting the protection elements

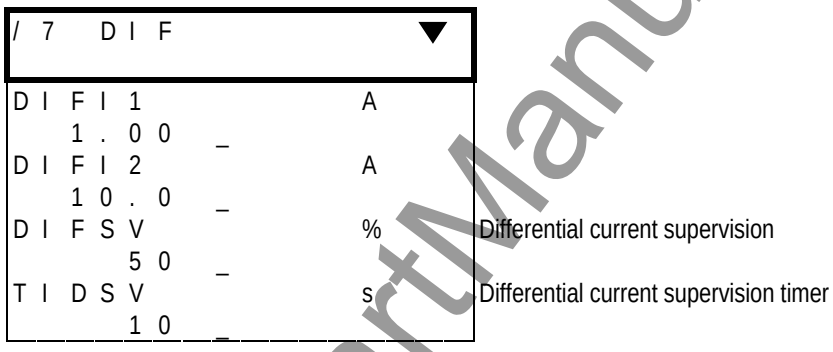
To set the protection elements, do the following.

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



Setting the DIF elements

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

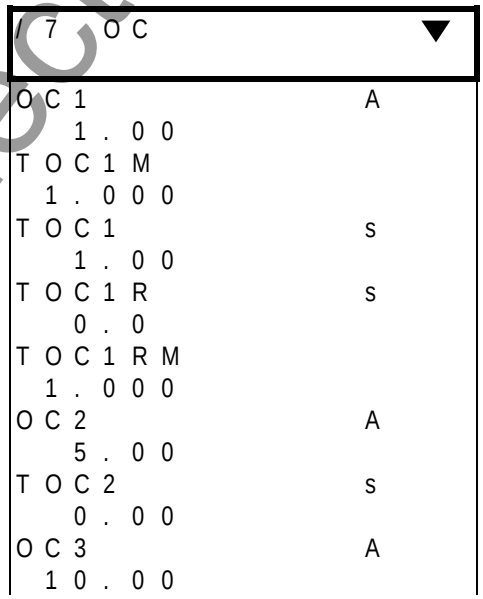


- Enter the numerical value and press the ENTER key.
- After setting, press the END key to display the following confirmation screen.

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

Setting the OC elements

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



TOC3 s	
0.00	
OC4 A	
20.00	
TOC4 s	
0.00	
OC1-k	OC1 User configurable IDMT curve setting
0.0000	
OC1-α	ditto
0.00	
OC1-C	ditto
0.0000	
OC1-kr	ditto
0.0000	
OC1-β	ditto
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 the EF elements

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

/7 EF ▼	
EF1 A	
0.30	
TEF1M	
1.0000	
TEF1 s	
1.00	
TEF1R s	
0.0	
TEF1RM	
1.0000	
EF2 A	
3.00	
TEF2 s	
1.00	
EF3 A	
5.00	
TEF3 s	
0.00	
EF4 A	
10.00	
TEF4 s	
0.00	
EF1-k	EF1 User configurable IDMT curve setting
0.0000	
EF1-α	ditto
0.00	
EF1-C	ditto

0.000	
EF1-kr	ditto
0.000	
EF1-β	ditto
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 the SEF elements

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

/7 SEF ▼	
SE1	A
0.010	
TSE1M	
1.000	
TSE1	s
1.00	
TSE1R	s
0.0	
TSE1RM	
1.000	
TS1S2	s
0.00	
SE2	A
0.010	
TSE2	s
1.00	
SE3	A
0.010	
TSE3	s
0.00	
SE4	A
0.010	
TSE4	s
0.00	
SE1-k	SE1 User configurable IDMT curve setting
0.000	
SE1-α	ditto
0.00	
SE1-C	ditto
0.000	
SE1-kr	ditto
0.000	
SE1-β	ditto
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 the Misc. protection elements

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

```
/ 7  Misc.                    ▼
UC1                           A
   0.40  _
TUC1                          s
   1.00
UC2                           A
   0.20
TUC2                          s
   1.00
THM                           A
   1.00
THMIP                         A
   0.00
TTHM                          min
   10.0
THMA                          %
      80
BCD
   0.20
TBCD                          s
   0.00
CBF                           A
   0.50
TBTC                          s
   0.50
TRTC                          s
   1.00
```

- 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 the CLP / ICD elements

- Select "CLP/ICD" on the "Prot. element" screen to display the "Cold Load" screen.

```
/ 7  CLP/ICD                  ▼
OC1                           A
   2.00  _
OC2                           A
  10.00
OC3                           A
  20.00
OC4                           A
```

```
  40.00
OC5                    A
    10.0
EF1                    A
    2.00
EF2                    A
  10.00
EF3                    A
  20.00
EF4                    A
  40.00
SE1                    A
  0.020
SE2                    A
  0.020
SE3                    A
  0.020
SE4                    A
  0.020
BCD
    0.40
TCLE                   s
    100
TCLR                   s
    100
ICLDO                  A
    0.50
TCLDO                  s
    0.00
ICD-2f                 %
       15
ICDOC                  A
    0.10
```

- 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 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
```

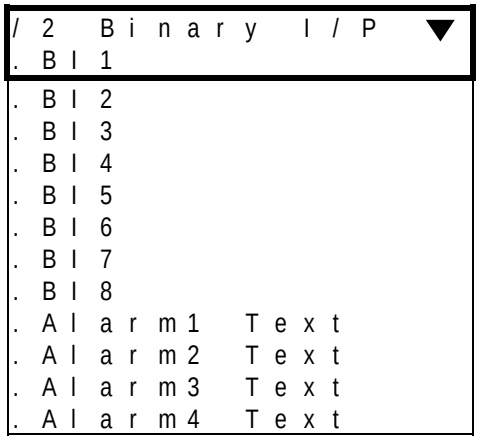
- Enter the group number to be copied in line A and press the [ENTER] key.
- Enter the group number to be overwritten by the copy in line B and press the [ENTER] key.

4.2.6.8 Binary Input

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

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.

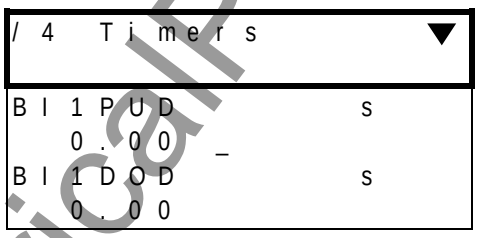


Selection of Binary Input

- Select the input relay number (BI number) and press the ENTER key to display the "BI∗" screen.

Setting timers

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



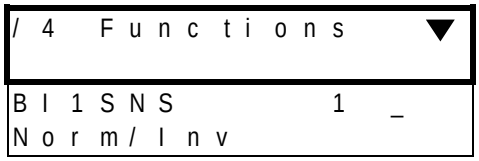
Pick-up delay setting

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.



<BI1SNS>

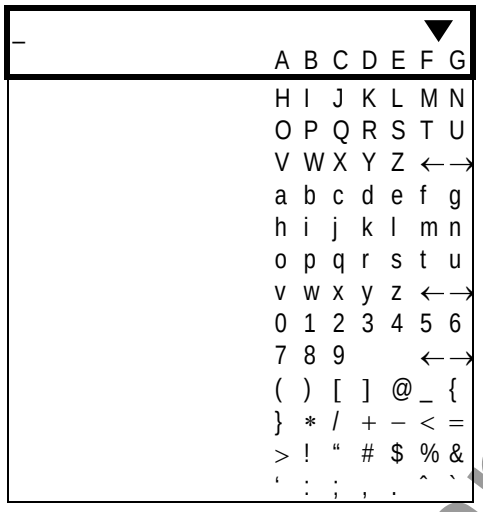
To set the Binary Input 1 Sense, do the following.

- Enter 0(=Normal) or 1(=Inverted) and press the ENTER key.
- After setting, press the END key to return to the "BI∗" screen.

Repeat the setting of other BI..

Setting Alarm * Text

- Select the Alarm* text and press the [ENTER] key to display the text input screen.



- Enter the characters (up to 22 characters) according to the text setting method.
- After setting, press the [END] key to return to the "BI*" screen.

4.2.6.9 Binary Output

All the binary outputs of the GRL150 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 C shows the factory default settings.

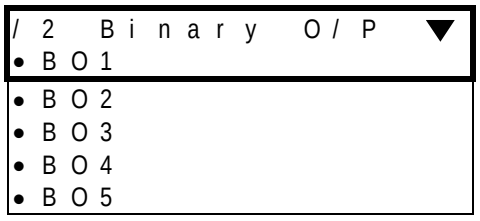
CAUTION

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

```
• Functions
```

Setting the logic gate type and timer

- Select "Logic/Reset" to display the "Logic/Reset" screen.

```
/4  Logic/Reset ▼

Logic              0  _
OR/AND
Reset              0
Ins/Dl/Dw/Lat
```

- 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.

Assigning signals

- Select "Functions" on the "BO∗" screen to display the "Functions" screen.

```
/4  Functions ▼

In  #1
      21  _
In  #2
      11
In  #3
      24
In  #4
      0
TBO                    s
   0.20
```

- Assign signals to gates (In #1 to #4) by entering the number corresponding to each signal referring to Appendix C. Do not assign the signal numbers 546 to 550 (signal names: "BO1 OP" to "BO5 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

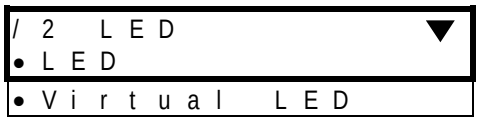
Three LEDs of the GRL150 are user-configurable. A configurable LED can be programmed to indicate the OR combination of a maximum of 4 elements, the individual statuses of which can be viewed on the LED screen as “Virtual LEDs.” The signals listed in Appendix B can be assigned to each LED as follows.

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.

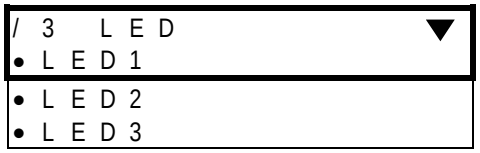
Selection of LEDs

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



Selection of real LEDs

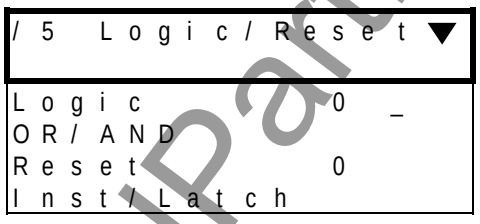
- Select "LED" on the "/2 LED" screen to display the "/3 LED" screen.



- 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.

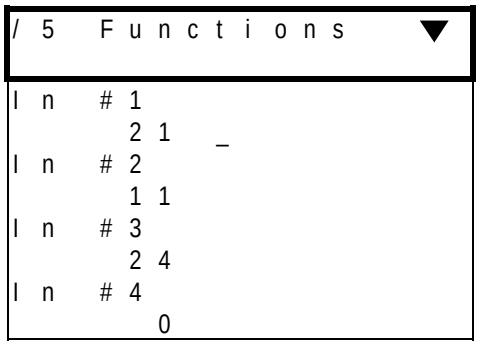


- Enter 0(=OR) or 1(=AND) to use an OR gate or AND gate and press the ENTER key.
- Enter 0(=Instantaneous) or 1(=Latched) to select the reset timing and press the ENTER key.
- Press the END key to return to the "LED∗" screen.

Note: To release the latch state, refer to Section 4.2.1.

Assigning signals

- Select "Functions" on the "LED∗" screen to display the "Functions" screen.



- Assign signals to gates (In #1 to #4) by entering the number corresponding to each signal referring to Appendix B.

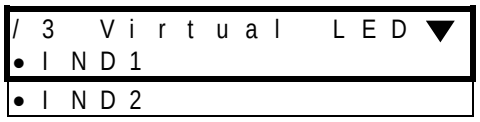
Note: If signals are not assigned to all the gates #1 to #4, enter 0 for the unassigned gate(s).

- Press the [END] key to return to the "LED*" screen.

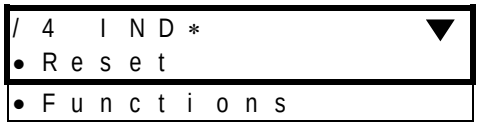
Repeat this process for the LEDs to be configured.

Selection of virtual LEDs

- Select "Virtual LED" on the "/2 LED" screen to display the "Virtual LED" screen.



- Select the IND number and press the [ENTER] key to display the "IND*" screen.



Setting the reset timing

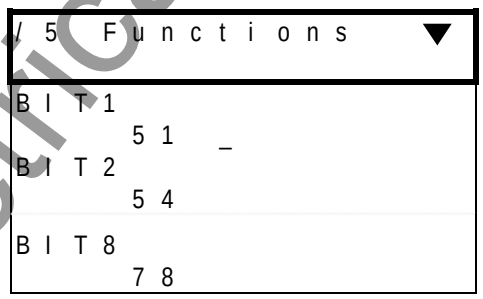
- Select "Reset" to display the "Reset" screen.

- Enter 0(=Instantaneous) or 1(=Latched) to select the reset timing and press the [ENTER] key.
- 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.

```
/ 1  Test                    ▼
• Switch
• Binary  O/P
• Logic  circuit
• Sim.  fault
```

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

```
/ 2  Switch                  ▼

A. M. F.              1      _
Off / On
CLPTST                0
Off / S0 / S3
THMRST                0
Off / On
IECTST                0
Off / On
L. Test               0
Off / On
T. Test               0
Off / On
COM1                  0
Off / On
    :
    :
COM5                  0
Off / On
SCOM1                 0
Off / On
    :
    :
SCOM5                 0
Off / On
S2COM1                0
Off / On
    :
    :
S2COM12               0
Off / On
```

<A.M.F.>

- Enter 0(=Off) to disable the A.M.F. and press the [ENTER] key.

<CLPTST>

- 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.

<THMRST>

The switch [THMRST] is used to perform the thermal overload element test because the resetting time is in the order of minutes. The thermal overload element is instantaneously reset when the [THMRST] is ON.

- Enter 1(=On) to reset forcibly the thermal overload element for testing and press the [ENTER] key.

<IECTST>

- 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.

<L.TEST>

The switch [L. test] is used for local testing. When the switch [L. test] is set to "1" (= On), the current data received from the remote terminal is set to zero. This switching is transmitted to the remote terminal and the remote terminal sets the current data received from the switching terminal to zero.

- Enter 1(=On) for local testing, and press the [ENTER] key.

<T.TEST>

The switch [T. test] is used for local testing of the current differential elements. When the [T. test] is set to "1" (=On), the local current data is looped into the receiving circuit interrupting the current data from the remote terminal as well as transmitted to the remote terminal.

Note: The switch [T. test] must be used only when all the terminals are out-of-service. If not, the local test current may cause a disturbance at the in-service remote terminal because this switching is not recognized at the remote terminal.
In case of electrical interface, the electrical cable must be removed to prevent signal interfering between sending and the receiving data. The remote terminal will detect the communication failure.

Caution

Do not test the loop back mode testing which the send data (TX) and the receive data (RX) is connected together by optical cable, because the GRL150 is applied the half duplex communication. Therefore, use the switch [T. test].

Do not use both [L.TEST] and [T.TEST] simultaneously. The [L.TEST] is for the test using only the local terminal current, and the [T.TEST] for the test using the local current and the local current looped back.

<COM∗>, <SCOM∗> and <S2COM∗>

These settings are used to forcibly send communication data [COM1] to [COM5], [SCOM1] to [SCOM5] and [S2COM1] to [S2COM12] for testing. Enter 1(=On) for a desired communication data 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  ▼
TP1                0  _
Disable/Enable
TP2                0
Disable/Enable
BO1                0
Disable/Enable
BO2                0
Disable/Enable
BO3                0
Disable/Enable
BO4                0
Disable/Enable
BO5                0
Disable/Enable
FAIL
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.

4.2.7.3 Logic Circuit

It is possible to observe the binary signal level on the signals listed in Appendix B with monitoring jacks A and B.

- Select "Logic circuit" on the "Test" screen to display the "Logic circuit" screen.

```
/ 2  Logic        ▼
     circuit
TermA
        1   _
TermB
       48   _
```

- Enter a signal number to be observed at monitoring jack A and press the [ENTER] key.
- Enter the other signal number to be observed at monitoring jack B and press the [ENTER] key.

After completing the setting, the signals can be observed by the binary logic level at monitoring

jacks A and B or by the LEDs above the jacks.

On screens other than the above screen, observation with the monitoring jacks is disabled.

4.2.7.4 Sim. fault

The "Sim. fault" on the "Test" menu is used to generate a synchronized trigger signal for end-to-end dynamic tests. The signal can be monitored when the signal FG (No.421) in the signal list is assigned to a user configurable auxiliary relay (BO) at the local and remote terminals. The auxiliary relays trigger a simultaneous test current application to the local and remote terminal differential elements when the [END] key is pressed on the "Sim. fault" screen at either terminal. The signal transmission delay time is automatically compensated in the relay and the operation time difference of the auxiliary relays is within 1ms. For the signal list, see Appendix B.

- Select "Sim. fault" on the "Test" screen to display the "Operate?" screen.

```
Operate?
ENTER=Y  CANCEL=N
```

- Keep pressing the [ENTER] key to generate the synchronized trigger signal.

  The signal FG (No.421) operates.

- Release pressing the [ENTER] key to reset the operation.
- Press the [CANCEL] key to return to the "Test" screen.

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 and voltage waveforms: 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.

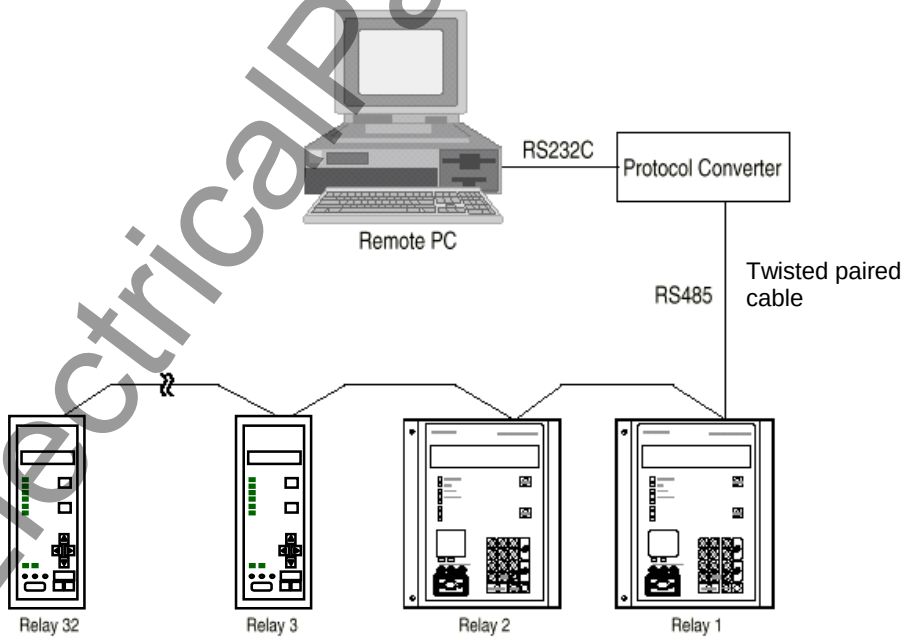


Figure 4.4.1 Relay Setting and Monitoring System

4.5 IEC 60870-5-103 Interface

The GRL150 can support 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, status data and general command from the relay to the control system.

- Measurand data: current
- Status data: events, fault indications, etc.

The IEC60870-5-103 function in the relay can be customized with the original software "IEC103 configurator". It runs on a personal computer (PC) connected to the relay, and can help setting of Time-tagged messages, General command, Metering, etc. For details of the setting method, refer to "IEC103 configurator" manual. For the default setting of IEC60870-5-103, see Appendix M.

The protocol can be used through the RS485 port on the relay rear panel and can be also used through the optional fibre optical interface.

The relay supports two baud-rates 9.6kbps and 19.2kbps.

The data transfer from the relay can be blocked by the setting.

For the settings, see the Section 4.2.6.4.

4.6 Clock Function

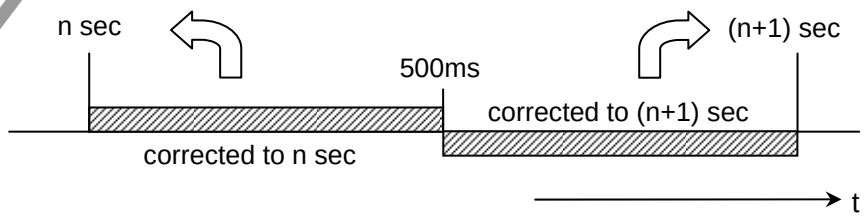
The clock function (Calendar clock) is used for time-tagging for the following purposes:

- 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, IEC60870-5-103 or IRIG-B (available for model 4** series only). This can be selected by setting.

The "clock synchronise" function synchronises the relay internal clock to the binary input signal by the following method. A binary input Bin is assigned to SYNC_CLOCK signal (No. 2648) by PLC. 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.

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 E shows the case outline.

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.

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

Typical external connections for each relay model are shown in Appendix F.

6. Commissioning and Maintenance

6.1 Outline of Commissioning Tests

The GRL150 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
Telecommunication circuit test
Tripping circuit test

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.
- 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. The internal clock must be set again.
- 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. For the settings, refer to Section 4.2.7.

Failure to observe any of the precautions above may cause damage or malfunction of the relay.

6.3 Preparations

Test equipment

The following test equipment is required for the commissioning tests.

2 Single-phase current sources
1 Dynamic three-phase test set (for protection scheme test)
1 DC power supply
2 DC voltmeters
2 AC ammeters
1 Phase angle meter
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 C Binary Output Default Setting List
Appendix G 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 instruction manual "RSM100".

6.4 Hardware Tests

The tests can be performed without external wiring, but a DC power supply and AC current and voltage sources are 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 6.4.2.1.

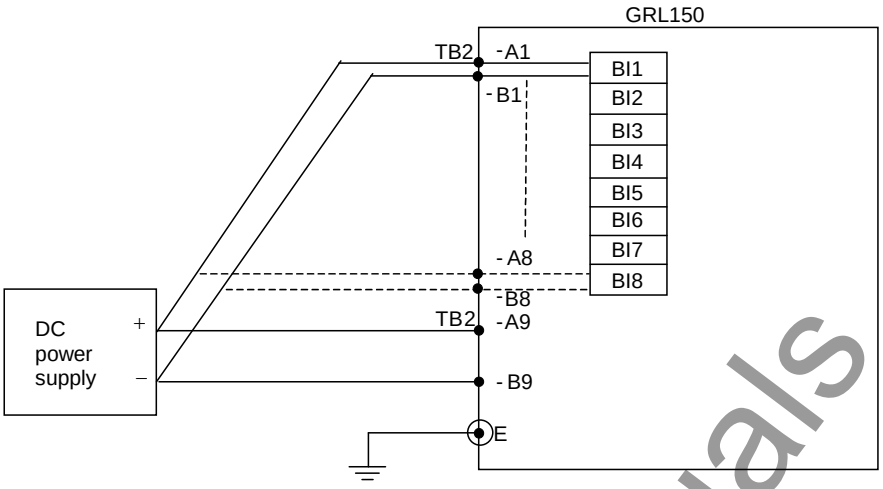


Figure 6.4.2.1 Testing Binary Input Circuit

- 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  ▼
T P 1                0  _
D i s a b l e / E n a b l e
T P 2                0
D i s a b l e / E n a b l e
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
F A I L
D i s a b l e / E n a b l e
```

- 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 6.4.4.1. A single-phase current source is required.

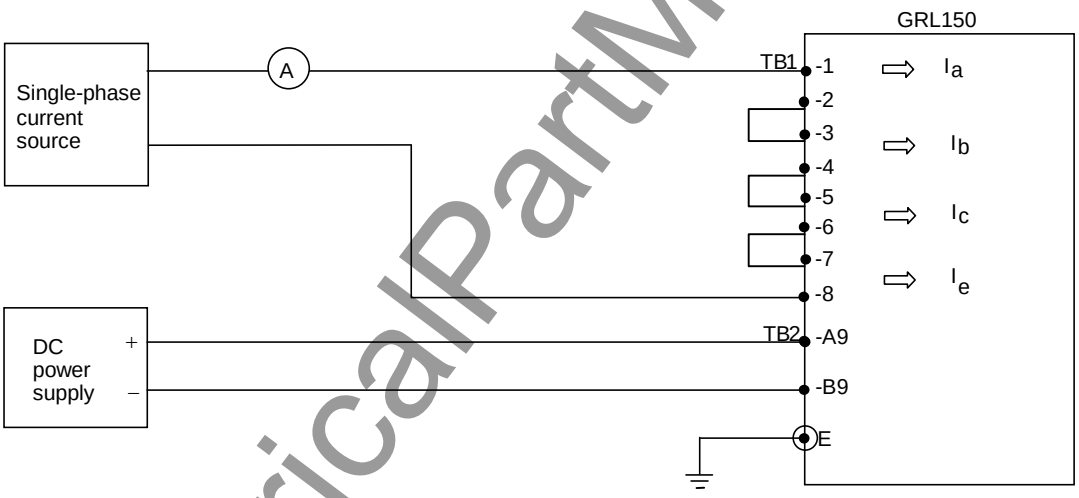


Figure 6.4.4.1 Testing AC Input Circuit

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.

6.5 Function Test

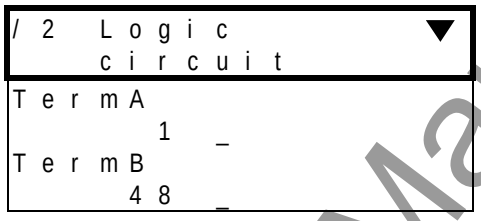
CAUTION

The function test may cause the output relays to operate including the tripping output relays. Therefore, the test must be performed with tripping circuits disconnected.

6.5.1 Measuring Element

Measuring element characteristics are realized by software, so it is possible to verify the overall characteristics by checking representative points.

Operation of the element under test is observed by the binary output signal at monitoring jacks A or B or by the LED indications above the jacks. In any case, the signal number corresponding to each element output must be set on the "Logic circuit" screen of the "Test" sub-menu.



When a signal number is entered for the Term A line, the signal is observed at monitoring jack A and when entered for the Term B line, it is observed at monitoring jack B.

Note: The voltage level at the monitoring jacks is +5V for logic level "1" and less than 0.1V for logic level "0".

CAUTION

- Use test equipment with more than 1 kΩ of internal impedance when observing the output signal at the monitoring jacks.
- Do not apply an external voltage to the monitoring jacks.
- Do not leave the A or B terminal shorted to 0V terminal for a long time.

In case of a three-phase element, it is sufficient to test for a representative phase. The A-phase element is selected hereafter.

Note: Operating time test of measuring relay elements at monitoring jack A or B is not including the operation of binary output. Whole the operating time test, if required, should be measured at a binary output relay.

6.5.1.1 Phase current differential element DIF

The phase current differential element is checked for the following items.

Operating current value

Percentage restraining characteristic

The top two items are tested locally or under an end-to-end setup of each terminal relay.

The last item is tested only under an end-to-end setup of each terminal relay.

Operating current value

Figure 6.5.1.1 shows the circuit to test the element locally.

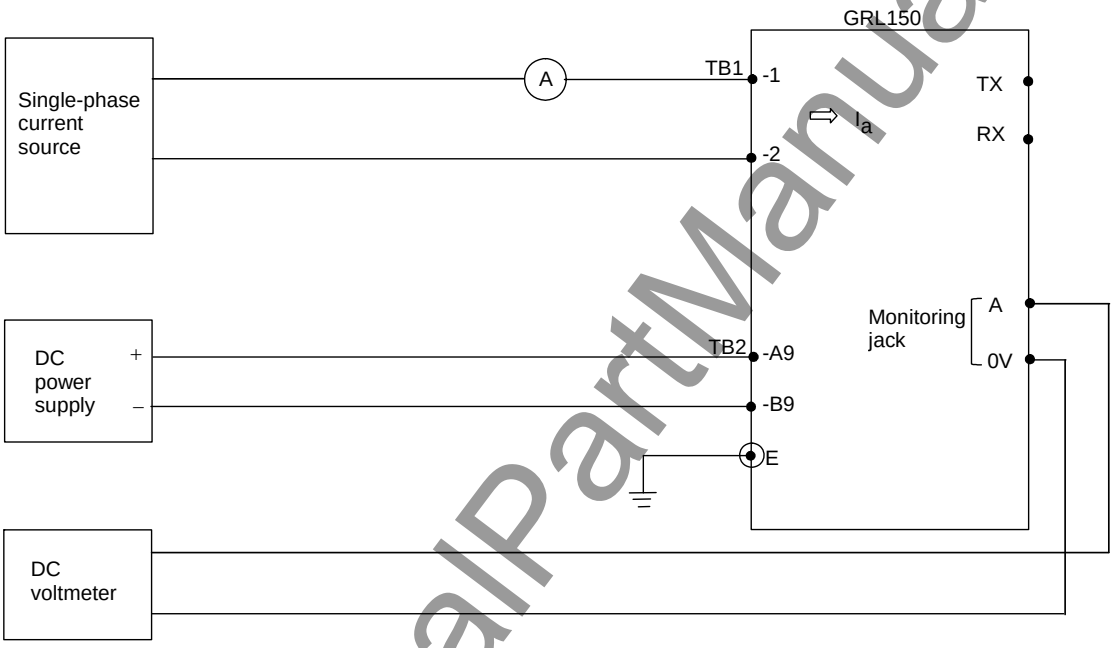


Figure 6.5.1.1 Testing Phase Current Differential Element

The output signal numbers of the DIF element are as follows.

Element	Signal number
DIF-A	48
DIF-B	49
DIF-C	50

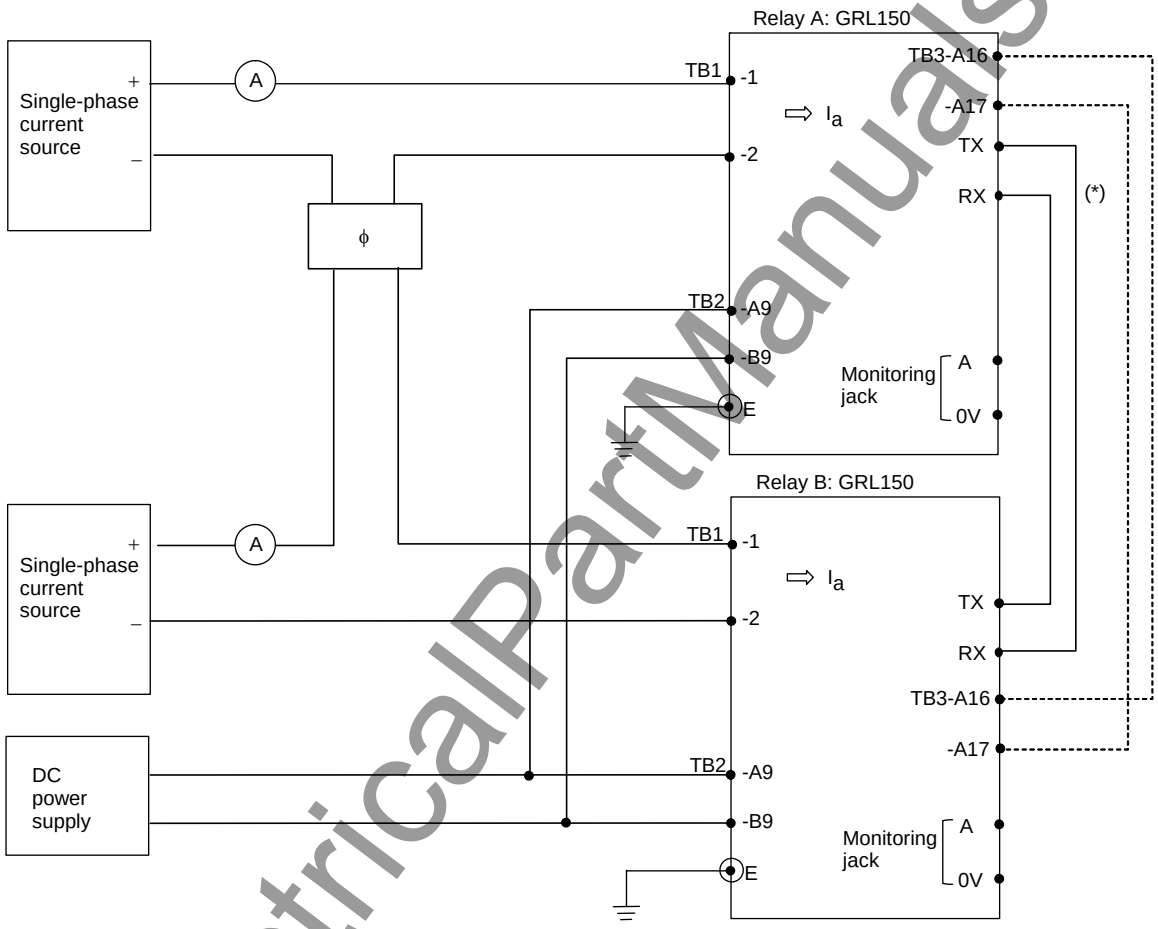
- Set the [L.test] to "1" (= On) on the "Switch" screen of the "Test" sub-menu. See Section 4.2.7.
- Select the "Logic circuit" on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 48 for Term A line to observe the DIF-A operation at monitoring jack A and press 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 7% of the setting DIFI1.

End-to-end test setup

When the percentage restraint characteristic is checked, an end-to-end setup using two relays is required.

If the relays can be collected and tested at a laboratory, the end-to-end test is possible by directly connecting their communication ports. Figure 6.5.1.2 shows the testing circuit of the laboratory end-to-end test.

The signal terminals of one relay are directly connected to those of another relay as shown in Figure 6.5.1.2.



Note(*): Connect TX and RX of the relay A to RX and TX of the relay B respectively in case of Fibre optic.
Connect TB3-A16 and -A17 of the relay A to TB3-A16 and -A17 of the relay B in case of Pilot wire.

Figure 6.5.1.2 End-to-end Test Setup at Laboratory

Percentage restraint characteristics

The percentage restraint characteristic is tested on the outflow current (I_{out}) and infeed current (I_{in}) plane as shown in Figure 6.5.1.3 by applying an infeed current to one relay and an outflow current to another relay.

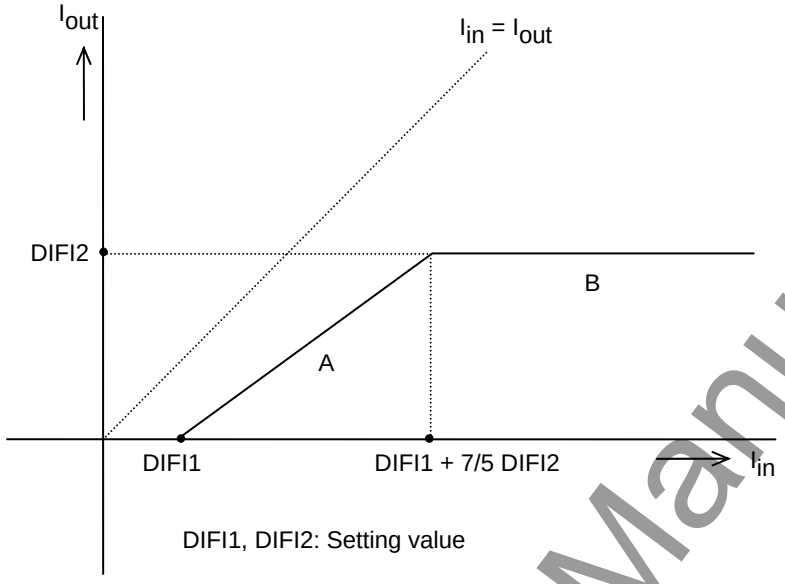


Figure 6.5.1.3 Percentage Restraining Characteristic on I_{in}-I_{out} Plane

Characteristic A is expressed by the following equation,

$$I_{out} \leq (5/7)\ (I_{in} - DIFI1)$$

Characteristic B is expressed by the following equation,

$$I_{out} \leq DIFI2$$

where, DIFI1 and DIFI2 are setting values.

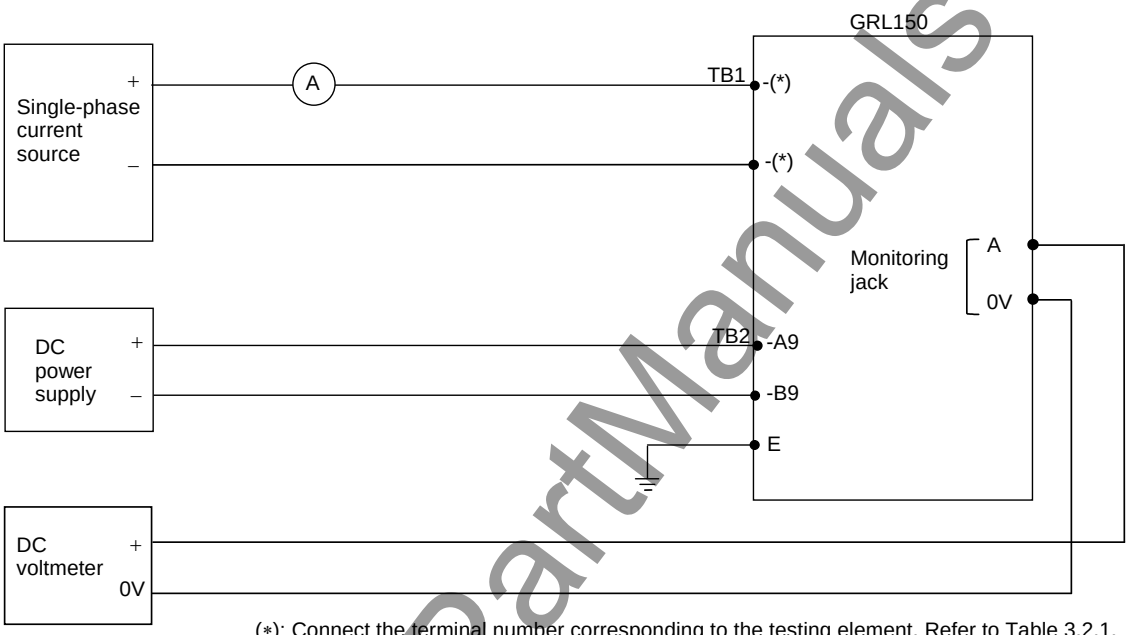
- Select the "Logic circuit" on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 48 to observe the DIF-A output at monitoring jack A and press the [ENTER] key.
- Apply a fixed infeed current to one relay. Apply an outflow current to another relay, change the magnitude of the current applied and measure the value at which the element operates.
- Repeat the above by changing the magnitude of the infeed current.
- Check that the measured value of the outflow current is within ±7% of the theoretical values obtained using the equations mentioned above. (The infeed current is more than 0.5×In).

6.5.1.2 Overcurrent and undercurrent element OC1 to OC4, OC5, UC1, UC2 and CBF and Earth fault element EF1 to EF4 and SEF1 to SEF4

The overcurrent element is checked on the operating current value and operating time for IDMT curve.

Operating current check

Figure 6.5.1.4 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. Refer to Table 3.2.1.

Figure 6.5.1.4 Operating Current Value Test

The output signal of testing element is assigned to the monitoring jack A.

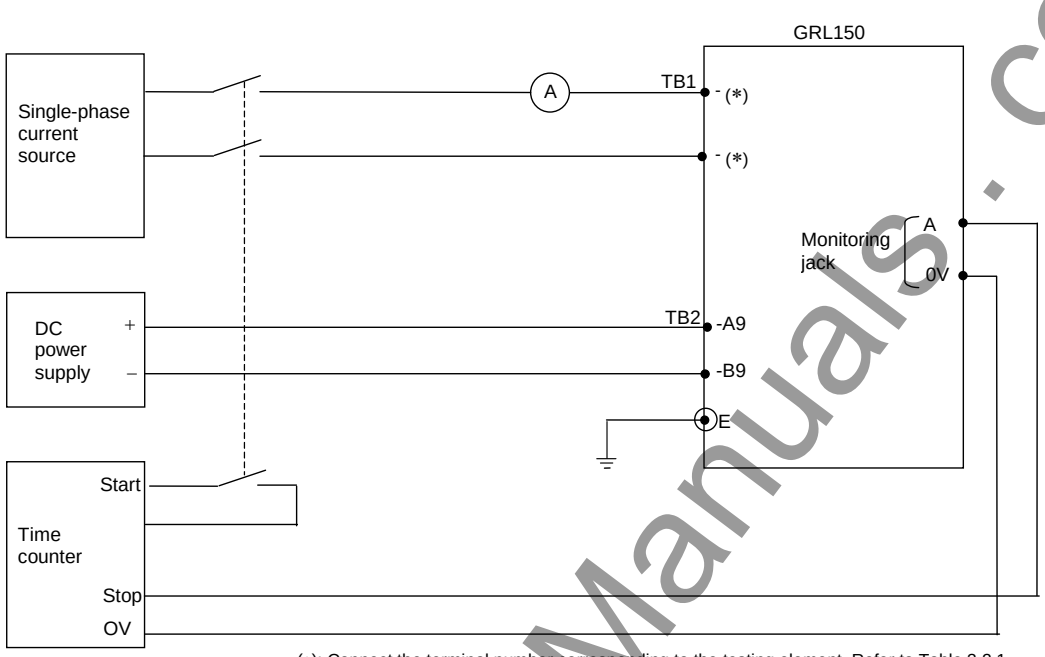
The output signal numbers of the elements are as follows:

Element	Signal No.	Element	Signal No.	Element	Signal No.	Element	Signal No.
OC1-A	80	EF1	112	SEF1	116	UC1-A	176
OC2-A	84	EF2	113	SEF2	117	UC2-A	180
OC3-A	88	EF3	114	SEF3	118	CBF-A	124
OC4-A	92	EF4	115	SEF4	119	OC5-A	64

- 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.

Operating time check for IDMT curve

The testing circuit is shown in Figure 6.5.1.5.



(*): Connect the terminal number corresponding to the testing element. Refer to Table 3.2.1.

Figure 6.5.1.5 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	80
EF1	112
SEF1	116

Fix the time characteristic to test by setting the scheme switch MOC1, MEF1 or MSE1 on the "OC", "EF" or "SEF" screen.

Example: "Settings" sub-menu → "Protection" screen → "Group*" screen → "OC" screen

The test procedure is as follows:

- Enter the signal number to observe the operating time at the monitoring jack A as shown in Section 6.5.1.
- 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 2.3.1. Check that the measured operating time is within IEC 60255-3 class 5.

6.5.1.3 Thermal overload element THM-A and THM-T

The testing circuit is same as the circuit shown in Figure 6.5.1.6.

The output signal of testing element is assigned to the monitoring jack A.

The output signal numbers of the elements are as follows:

Element	Signal No.
THM-A	189
THM-T	188

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 monitoring jack A as shown in Section 6.5.1.
- 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 2.7. Check that the measured operating time is within 5%.

6.5.1.5 Broken conductor detection element BCD

The testing circuit is shown in Figure 6.5.7.

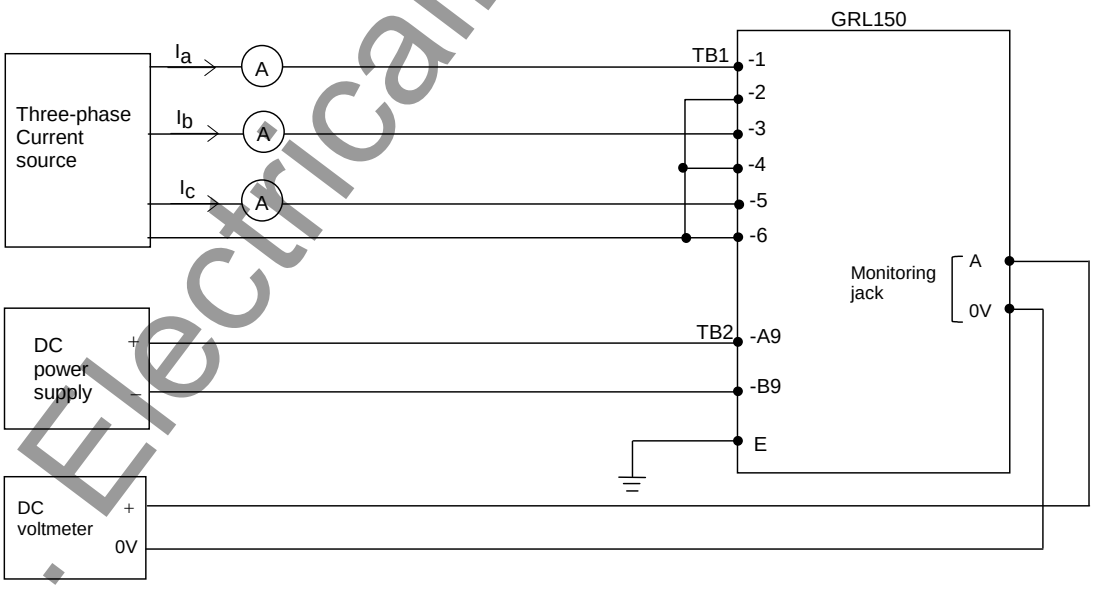


Figure 6.5.7 Testing BCD element

The output signal of testing element is assigned to the monitoring jack A.

The output signal numbers of the elements are as follows:

Element	Signal No.
BCD	142

- Enter the signal number to observe the operation at the monitoring jack A as shown in Section 6.5.1.
- 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. Test the item of OC1 shown in Section 6.5.1.1.

- 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].

6.5.1.8 Current Change Detection Element OCD

The test circuit is shown in Figure 6.5.1.6.

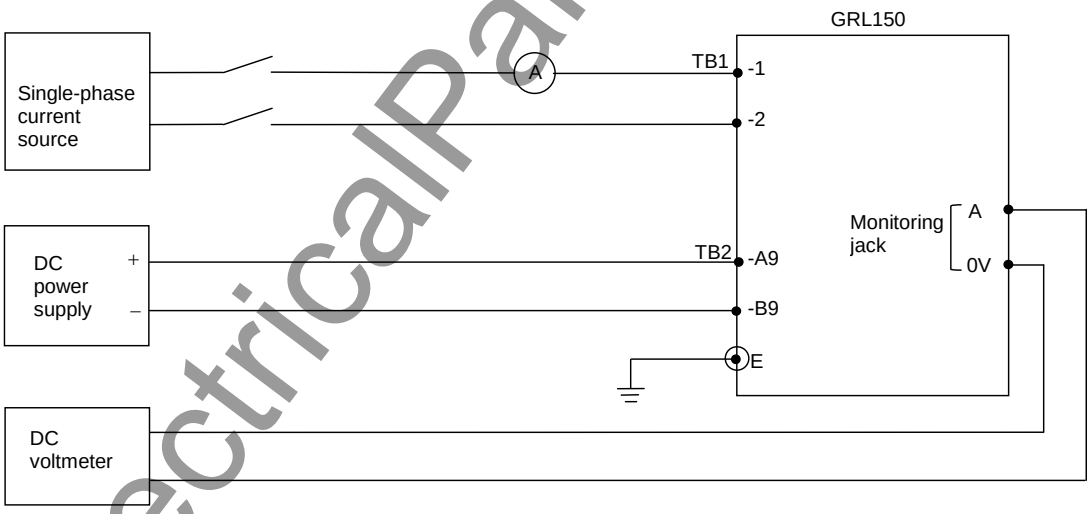


Figure 6.5.1.6 Testing Current Change Detection Element

The output signal number of the OCD is as follows:

Measuring element	Signal number
OCD-A	68

Operation must be verified by abruptly changing the test current from 0 A to 1.2 × Setting value or vice versa.

OCD has a fixed setting of 0.4 A and 0.08 A for 5 A rating and 1 A rating respectively.

6.5.2 Protection Scheme

Protection schemes implemented in GRL150 are basically for unit protection. It is recommended that the protection schemes are tested under end-to-end mode. The setup of the end-to-end synchronized test is described in Section 6.5.1.

In the protection scheme tests, a dynamic test set is required to simulate power system pre-fault, fault and post-fault conditions.

The "Sim.fault" on the LCD "Test" menu is available to test local and remote terminals synchronously. For use, see Section 4.2.7.4.

Tripping is observed with the tripping command output relays after a simulated fault occurs.

Differential tripping

When a phase current is applied, instantaneous per phase based tripping or three-phase tripping is performed depending on the fault types.

The tripping should be checked for the current which is two times or larger than the minimum operating current DIFI1. Operating time is measured by the operating time of the tripping command output relay. It will typically be 1 cycle.

Check that the indications and recordings are correct.

Check that the indications and recordings are correct.

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 TRTC and the adjacent breaker tripping output relay operates after the time setting of the TBTC.

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 "Fault record" screen and check that the descriptions are correct for the fault concerned.

Recording events are listed in Appendix G. 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 "Event 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 "Disturbance record" screen and check that the descriptions are correct.

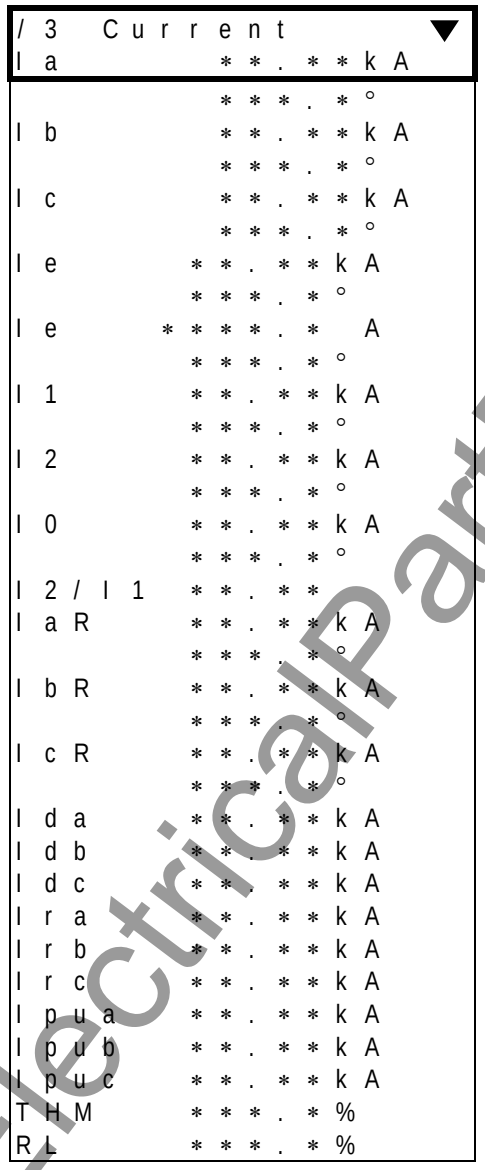
Details can be displayed on the PC. Check that the descriptions on the PC are correct. For details on how to obtain disturbance records on the PC, see the RSM100 Manual.

6.6 Conjunctive Tests

6.6.1 On Load Test

To check the polarity of the current and voltage transformers, check the load current, system voltage and their phase angle 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 above.



Available for model 110 and 410.

Available for model 120 and 420.

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 secondary side.)

6.6.2 Communication Circuit Test

Check whether the communication circuit is correctly connected between the local terminal and the remote terminal.

In pilot wire communication, a receiving signal adjusting function is provided, since the receiving level is influenced by pilot-wire cable size, distance and installation environment. The receiving signal can be adjusted automatically (Auto) or manually (Manual) by the scheme switch

[RL-MODE]. When “Auto” is selected, the optimum signal receiving level, which has the least CF (Communication Failure), is automatically set according to the receiving level (peak value). The “Auto” is generally selected in normal operation. However, if a severe noise environment prevents correct operation of GRL150, then “Manual” can be selected and the receiving level is chosen manually. (See Section 3.3.5, 4.2.3.4 and 4.2.6.5.)

To set manual receiving level to the optimum value, the following procedure is to be followed:

1. In ‘Setting Change → Protection → Change Set → Group 1 → Telecomm → Scheme Sw’ menu, set [RL-Mode] to ‘Manual’.
2. In ‘Status → Metering → Current’ menu, record the value of the receiving level ‘RL’.
3. In ‘Setting Change → Protection → Change Set → Group 1 → Telecomm → Threshold Set’ menu, set the manual receive level, M-RL, to 0.5 × RL value recorded in 2.
4. In ‘Record → Counter → Display’ menu, record value of communication failures per period, CF-L.
5. Vary the value of M-RL in increments, recording the CF-L values at each stage.
6. The value of M-RL that should be used as the final setting is that at which the lowest value of CF-L is recorded.

Input current at a remote terminal relay. Check the current by the "Metering" screen from the "Status" sub-menu at the local relay.

6.6.3 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.

- Set the breaker to be closed.
- Select "Binary O/P" on the "Test" sub-menu screen to display the "Binary O/P" screen.

```
/ 2  B i n a r y   O / P   ▼
T P 1                    0   _
D i s a b l e / E n a b l e
T P 2                    0
D i s a b l e / E n a b l e
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
F A I L
D i s a b l e / E n a b l e
```

- Enter 1 for TP1 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 TP1, BO2 to BO5 and FAIL.

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, DS or cable	Comm. channel
Err: SUM	×			
Err: RAM	×			
Err: BRAM	×			
Err: EEP	×			
Err: A/D	×			
Err: Id	×(1)	× (2)		
Err: DC	×			
Err: TC	×(1)		× (2)	
Err: CT	× (1)	× (2)		
Err: CB	× (1)		× (2)	
Err: DS	× (1)		× (2)	
Err: COM	× (2)			× (1)
Err: SYN	× (2)			× (1)
Err: RDY	× (2)			× (1)

- ( ): Probable failure location in the relay unit including its peripheral circuits.

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.

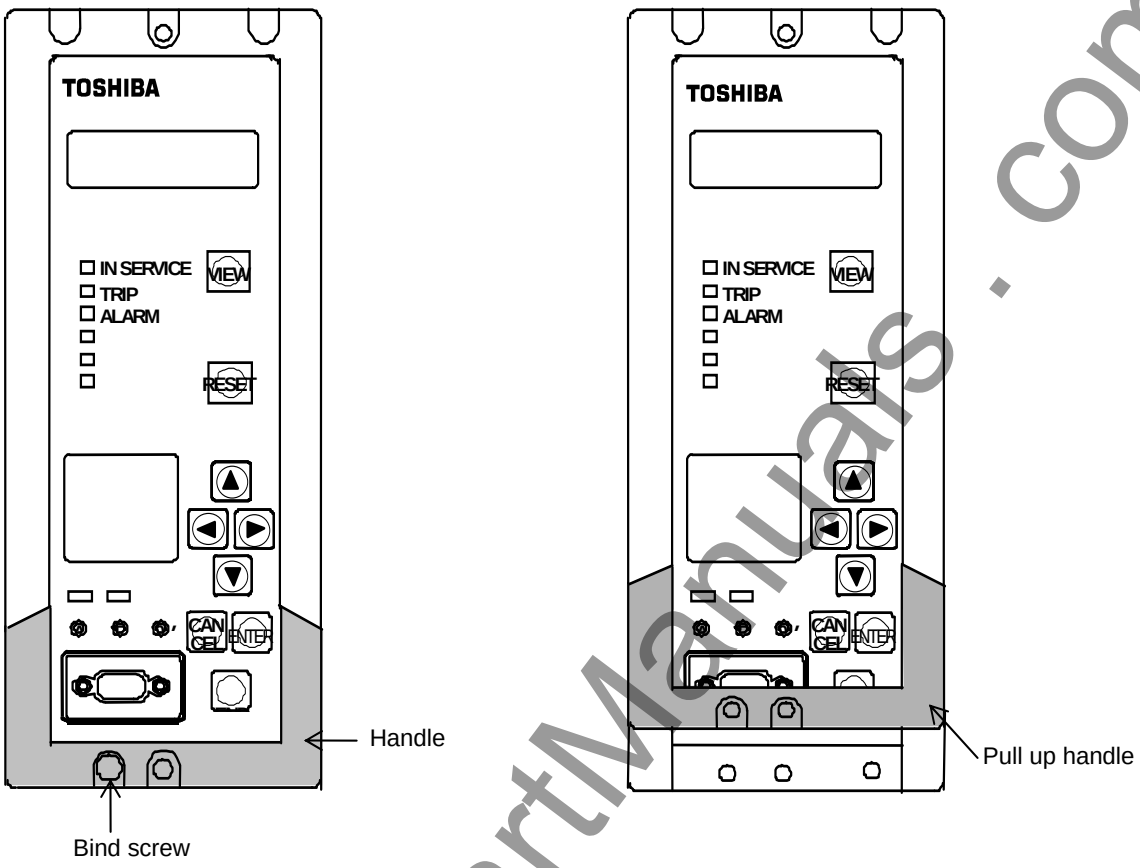


Figure 6.7.1 Handle of Relay Unit

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.

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, alarms, events, disturbances and counters which are recorded during the tests.
- If dc power has not been supplied to the relay for two days or more, then 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. Set the internal clock again.
- 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.

Whilst the relay is put into service at one terminal by supplying DC power and not yet at the other terminal, a communication failure will be detected by the automatic monitoring at the in-service terminal and a red "ALARM" LED is lit. But it will be reset when the relays are put into service at all terminals.

Appendix A

Programmable Reset Characteristics and Implementation of Thermal Model to IEC60255-8

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.

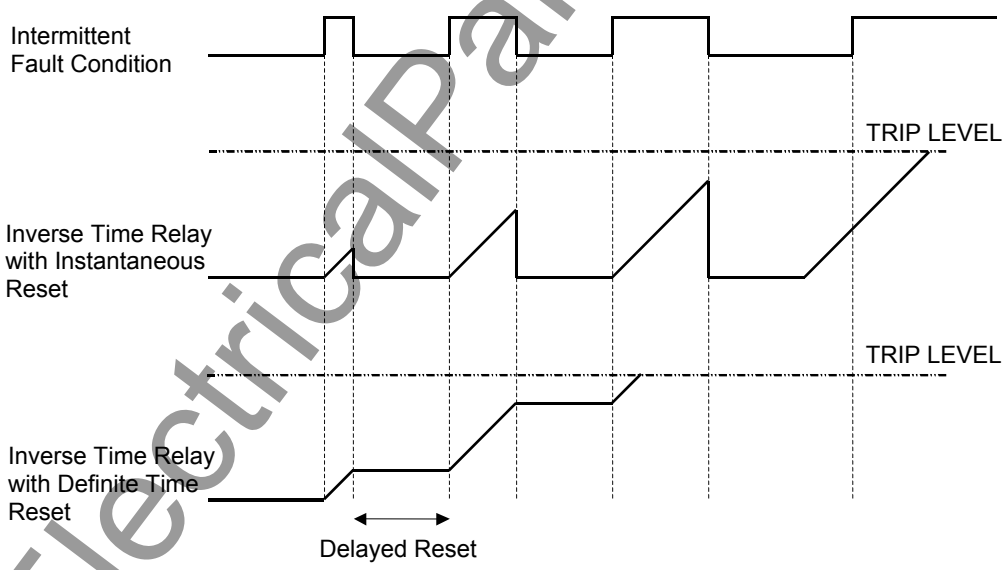


Figure A-1

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.

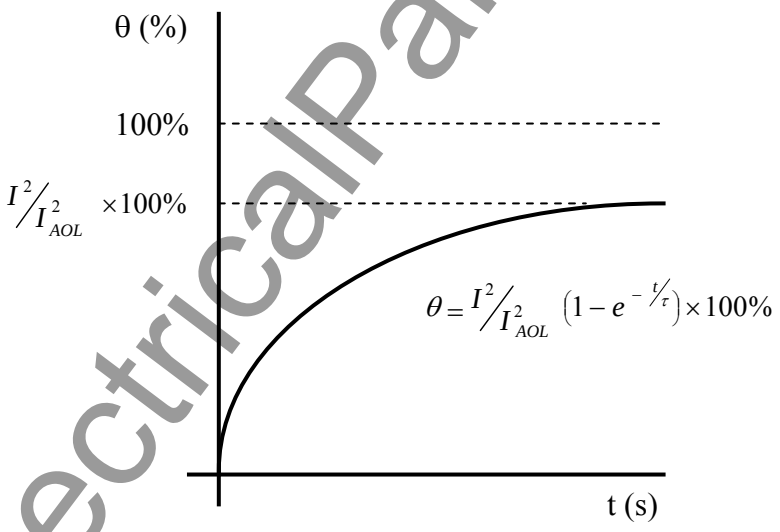


Figure A-2

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:

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.

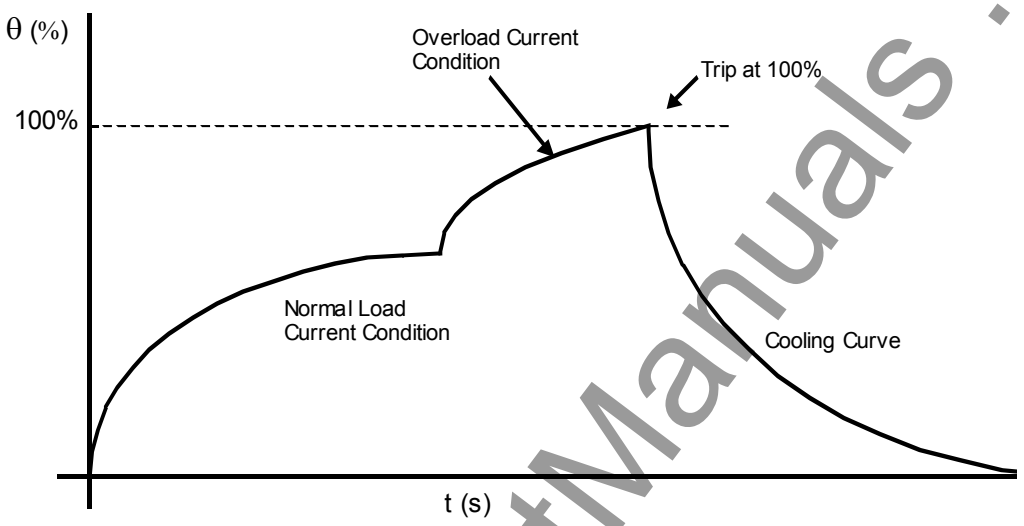


Figure A-3

Appendix B

Signal List

Signal list		
No.	Signal Name	Contents
0	CONSTANT_0	constant 0
1	CONSTANT_1	constant 1
2		
3		
4		
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45		
46		
47		
48	DIF-A	DIF-A element output
49	DIF-B	ditto
50	DIF-C	ditto
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61		
62		
63	RELAY_BLOCK	DIF relay block
64	OC5-A	OC5-A element output
65	OC5-B	ditto
66	OC5-C	ditto
67		
68	OCD-A	OCD-A element output
69	OCD-B	ditto
70	OCD-C	ditto

Signal list

No.	Signal Name	Contents
71		
72	DIFSV-A	DIFSV-A element output
73	DIFSV-B	ditto
74	DIFSV-C	ditto
75		
76		
77		
78		
79		
80	OC1-A	OC1-A element output
81	OC1-B	ditto
82	OC1-C	ditto
83		
84	OC2-A	OC2-A element output
85	OC2-B	ditto
86	OC2-C	ditto
87		
88	OC3-A	OC3-A element output
89	OC3-B	ditto
90	OC3-C	ditto
91		
92	OC4-A	OC4-A element output
93	OC4-B	ditto
94	OC4-C	ditto
95		
96	OC1-A_INST	OC1 relay element start
97	OC1-B_INST	ditto
98	OC1-C_INST	ditto
99		
100		
101		
102		
103		
104	ICD-A	Inrush current detection (Phase A)
105	ICD-B	Inrush current detection (Phase B)
106	ICD-C	Inrush current detection (Phase C)
107		
108	ICLDO-A	ICLDO relay (OC relay) element output used in "CLP scheme"
109	ICLDO-B	ditto
110	ICLDO-C	ditto
111		
112	EF1	EF1 relay element output
113	EF2	EF2 relay element output
114	EF3	EF3 relay element output
115	EF4	EF4 relay element output
116	SEF1	SEF1 relay element output
117	SEF2	SEF2 relay element output
118	SEF3	SEF3 relay element output
119	SEF4	SEF4 relay element output
120		
121		
122		
123		
124	CBF-A	CBF relay element output
125	CBF-B	ditto
126	CBF-C	ditto
127		
128	EF1_INST	EF1 relay element start
129		
130		
131		
132	SEF1_INST	SEF1 relay element start
133		
134		
135		
136		
137		
138		
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Signal list

No.	Signal Name	Contents
141		
142	BCD	BCD relay element output
143		
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175		
176	UC1-A	UC1 relay element output
177	UC1-B	ditto
178	UC1-C	ditto
179		
180	UC2-A	UC2 relay element output
181	UC2-B	ditto
182	UC2-C	ditto
183		
184		
185		
186		
187		
188	THM-T	Thermal trip relay element output
189	THM-A	Thermal alarm relay element output
190		
191		
192		
193		
194		
195		
196		
197		
198		
199		
200	UCDO-A	UCDO relay element output
201	UCDO-B	ditto
202	UCDO-C	ditto
203		
204		
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Signal list

No.	Signal Name	Contents
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256	DIF_TRIP	DIF trip command
257	DIF-A_TRIP	ditto (Phase A)
258	DIF-B_TRIP	B
259	DIF-C_TRIP	C
260		
261		
262		
263		
264	DIFFS_OP	Fail safe for DIF trip
265	DIFFS-A_OP	ditto
266	DIFFS-B_OP	ditto
267	DIFFS-C_OP	ditto
268		
269		
270		
271		
272	OC1_TRIP	OC1 trip command
273	OC1-A_TRIP	ditto (Phase A)
274	OC1-B_TRIP	B
275	OC1-C_TRIP	C
276	OC2_TRIP	OC2 trip command
277	OC2-A_TRIP	ditto (Phase A)
278	OC2-B_TRIP	B
279	OC2-C_TRIP	C
280	OC3_TRIP	OC3 trip command

Signal list

No.	Signal Name	Contents
281	OC3-A TRIP	ditto (Phase A)
282	OC3-B TRIP	B
283	OC3-C TRIP	C
284	OC4 ALARM	OC4 alarm command
285	OC4-A ALARM	ditto (Phase A)
286	OC4-B ALARM	B
287	OC4-C ALARM	C
288		
289		
290		
291		
292	EF1 TRIP	EF1 trip command
293	EF2 TRIP	2
294	EF3 TRIP	3
295	EF4 ALARM	4 alarm command
296		
297		
298		
299		
300	SEF1 TRIP	SEF1 trip command
301	SEF1-S2 TRIP	SEF1 stage2 trip command
302	SEF2 TRIP	2 trip command
303	SEF3 TRIP	3
304	SEF4 ALARM	4 alarm command
305		
306		
307		
308	UC1 TRIP	UC1 trip command
309	UC1-A TRIP	ditto (Phase A)
310	UC1-B TRIP	B
311	UC1-C TRIP	C
312	UC2 ALARM	UC2 alarm command
313	UC2-A ALARM	ditto (Phase A)
314	UC2-B ALARM	B
315	UC2-C ALARM	C
316		
317		
318		
319		
320	THM ALARM	Thermal Overload alarm command
321	THM TRIP	trip command
322	BCD TRIP	Broken Conductor trip command
323		
324		
325		
326		
327		
328	CBF RETRIP	CBF retrip command
329	CBF-A RETRIP	ditto (Phase A)
330	CBF-B RETRIP	B
331	CBF-C RETRIP	C
332	CBF TRIP	CBF back trip command
333	CBF-A TRIP	ditto (Phase A)
334	CBF-B TRIP	B
335	CBF-C TRIP	C
336		
337		
338		
339		
340	TR1 TRIP	TRANSFER TRIP-1
341	INTER TRIP1	INTER TRIP-1
342	TR2 TRIP	TRANSFER TRIP-2
343	INTER TRIP2	INTER TRIP-2
344		
345		
346		
347		
348	GEN.TRIP	General trip command with off-delay timer
349	GEN.TRIP-A	ditto (Phase A)
350	GEN.TRIP-B	B

Signal list

No.	Signal Name	Contents
351	GEN.TRIP-C	C
352	GEN.TRIP-N	N
353	GEN.ALARM	General alarm command
354	GEN.ALARM-A	ditto (Phase A)
355	GEN.ALARM-B	B
356	GEN.ALARM-C	C
357	GEN.ALARM-N	N
358		
359		
360	GEN.TP	General trip command without off-delay timer
361	GEN.TP-A	ditto (Phase A)
362	GEN.TP-B	B
363	GEN.TP-C	C
364	GEN.TP-N	N
365		
366		
367		
368	CLP_STATE0	Cold Load Protection State
369	CLP_STATE1	ditto
370	CLP_STATE2	ditto
371	CLP_STATE3	ditto
372		
373	ICD	Inrush current detection (3 phase OR)
374	ICD_BLK-S	Inrush current detection (send to remote terminal)
375		
376		
377		
378		
379		
380		
381		
382		
383		
384	CB_CLOSE	CB close condition
385	CB_OPEN	CB open condition
386	DS_CLOSE	DS close condition
387	DS_OPEN	DS open condition
388	I.LINK	Interlink signal (CB and DS both closed)
389	43C_ON	Differential protection enable
390	LOCAL_TEST	LOCAL TESTING SW ON
391		
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415		
416	READY	Local terminal ready
417	REM1_READY	Terminal 1 ready
418		
419	MASTER	Being set to master terminal
420	SLAVE	Being set to slave terminal

Signal list

No.	Signal Name	Contents
421	FG	Trigger signal for end-to-end synchronized test
422	REM1_CRC.F	CRC fail detection
423	REM1_INT.R	Interruption of receciving signal
424	REM1_SP.F	SP synchronism fail
425	REM1_SA.F	SA synchronism fail
426		
427		
428		
429		
430		
431		
432	REM1_IN_SRV	Terminal 1 "in-service"
433	REM1_OFF_SRV	Terminal 1 "out-of-service"
434		
435		
436		
437		
438	UNREADY1_ALM	Terminal 1 communication not ready
439	CFSV1	Terminal 1 CFSV
440	SPSV1	Sampling synchronization with terminal 1 failure signal
441		
442		
443		
444		
445		
446		
447		
448		
449		
450	COMM1_FAIL	Communication with terminal 1 failure signal
451		
452	READY1_ALARM	Terminal 1 ready
453		
454		
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461		
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Signal list

No.	Signal Name	Contents
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511		
512	BI1_COMMAND	Binary input signal BI1
513	BI2_COMMAND	Binary input signal BI2
514	BI3_COMMAND	Binary input signal BI3
515	BI4_COMMAND	Binary input signal BI4
516	BI5_COMMAND	Binary input signal BI5
517	BI6_COMMAND	Binary input signal BI6
518	BI7_COMMAND	Binary input signal BI7
519	BI8_COMMAND	Binary input signal BI8
520		
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527		
528	BI1_COM_T	Binary input signal BI1
529	BI2_COM_T	Binary input signal BI2
530	BI3_COM_T	Binary input signal BI3
531	BI4_COM_T	Binary input signal BI4
532	BI5_COM_T	Binary input signal BI5
533	BI6_COM_T	Binary input signal BI6
534	BI7_COM_T	Binary input signal BI7
535	BI8_COM_T	Binary input signal BI8
536		
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543		
544	TP1_OP	Binary output signal TP1
545	TP2_OP	Binary output signal TP2
546	BO1_OP	Binary output signal BO1
547	BO2_OP	Binary output signal BO2
548	BO3_OP	Binary output signal BO3
549	BO4_OP	Binary output signal BO4
550	BO5_OP	Binary output signal BO5
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Signal list

No.	Signal Name	Contents
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717	LCD_IND.	LCD indication(Virtual LED) command
718	LCD_IND1.	LCD indication1(Virtual LED) command
719	LCD_IND2.	LCD indication2(Virtual LED) command
720		
721		
722	TELE_COM_ON	IEC103 communication command
723	PROT_COM_ON	IEC103 communication command
724		
725		
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Signal list		
No.	Signal Name	Contents
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1021		
1022		
1023		
1024	GROUP1_ACTIVE	group1 active
1025	GROUP2_ACTIVE	group2 active
1026	GROUP3_ACTIVE	group3 active
1027	GROUP4_ACTIVE	group4 active
1028		
1029		
1030		
1031		
1032		
1033		
1034	LOCAL_OP_ACT	local operation active
1035	REMOTE_OP_ACT	remote operation active
1036		
1037	GEN_TRIP	General trip
1038	GEN_PICKUP	General start/pick-up
1039	IEC_TESTMODE	IEC61870-5-103 testmode
1040	IEC_MDBLK	monitor direction blocked
1041		
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Signal list		
No.	Signal Name	Contents
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1087		
1088	COM1-R1	Comm. data receive signal from remote term-1
1089	COM2-R1	ditto
1090	COM3-R1	ditto
1091	COM4-R1	ditto
1092	COM5-R1	ditto
1093		
1094		
1095		
1096	COM1-R1_UF	Comm. data receive signal from remote term-1 (unfiltered)
1097	COM2-R1_UF	ditto
1098	COM3-R1_UF	ditto
1099	COM4-R1_UF	ditto
1100	COM5-R1_UF	ditto
1101		
1102		
1103		
1104	SUB_COM1-R1	Sub comm. data receive signal from term-1
1105	SUB_COM2-R1	ditto
1106	SUB_COM3-R1	ditto
1107	SUB_COM4-R1	ditto
1108	SUB_COM5-R1	ditto
1109		
1110		
1111		
1112	SUB2_COM1-R1	Sub comm. data2 receive signal from term-1
1113	SUB2_COM2-R1	ditto
1114	SUB2_COM3-R1	ditto
1115	SUB2_COM4-R1	ditto
1116	SUB2_COM5-R1	ditto
1117	SUB2_COM6-R1	ditto
1118	SUB2_COM7-R1	ditto
1119	SUB2_COM8-R1	ditto
1120	SUB2_COM9-R1	ditto
1121	SUB2_COM10-R1	ditto
1122	SUB2_COM11-R1	ditto
1123	SUB2_COM12-R1	ditto
1124		
1125		
1126		
1127		
1128		
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Signal list		
No.	Signal Name	Contents
1261		
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1266	CT_err_UF	CT error(unfiltered)
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1284	BI1_COM_UF	Binary input signal BI1 (unfiltered)
1285	BI2_COM_UF	Binary input signal BI2 (unfiltered)
1286	BI3_COM_UF	Binary input signal BI3 (unfiltered)
1287	BI4_COM_UF	Binary input signal BI4 (unfiltered)
1288	BI5_COM_UF	Binary input signal BI5 (unfiltered)
1289	BI6_COM_UF	Binary input signal BI6 (unfiltered)
1290	BI7_COM_UF	Binary input signal BI7 (unfiltered)
1291	BI8_COM_UF	Binary input signal BI8 (unfiltered)
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Signal list

No.	Signal Name	Contents
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1342		
1343	BO_block	Binary output block signal
1344	A.M.F.OFF	Automatic monitoring function off
1345	RELAY_FAIL	Relay failure & trip blocked alarm
1346	RELAY_FAIL-A	Relay failure alarm (Trip not blocked)
1347		
1348	SUM_err	The checksum value of written data checking error
1349		
1350	SRAM_err	SRAM memory monitoring error
1351	BU-RAM_err	BU-RAM memory monitoring error
1352	Data_lost	BU-RAM data lost
1353	EEPROM_err	EEPROM memory monitoring error
1354	A/D_err	A/D accuracy checking error
1355		
1356	CT_err	CT circuit current monitoring error
1357		
1358	DC_err	DC supply monitoring error
1359	TC_fail	Trip circuit fail
1360	CB_err	CB contact monitoring error
1361	TP_COUNT_ALM	Trip count alarm
1362	OP_time_ALM	Operate time alarm
1363	Sigma_I^y_ALM	ΣI^y count alarm
1364		
1365		
1366	Id_err	Differential current monitoring err
1367		
1368		
1369	DS_err	DS contact monitoring err
1370	ROM_data_err	The checksum value of written ROM data checking error
1371	Term1_rdy_off	Communication ready off
1372	COM1_fail	Communication failure
1373	Sync1_fail	Sampling synchronization failure
1374	FER_ALM	Frame error rate alarm
1375		
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Signal list		
No.	Signal Name	Contents
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1412	NORM_LED_ON	NORMAL LED ON
1413	ALM_LED_ON	ALARM LED ON
1414	TRIP_LED_ON	TRIP LED ON
1415		
1416		
1417		
1418	TP_LED_RST	TRIP LED RESET
1419	KEY-VIEW	VIEW key status
1420	KEY-RESET	RESET Key status
1421		
1422		
1423		
1424		
1425	KEY-ENTER	ENTER key status
1426	KEY-END	END key status
1427	KEY-CANCEL	CANCEL key status
1428		
1429		
1430	KEY-UP	UP key status
1431	KEY-DOWN	DOWN key status
1432	KEY-LEFT	LEFT key status
1433	KEY-RIGHT	RIGHT key status
1434		
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1447		
1448	DEMAND_CLR	Demand clear
1449	F.Record_DONE	
1450	F.Record_CLR	Fault record clear
1451		
1452	E.Record_CLR	Event record clear
1453	D.Record_CLR	Disturbance record clear
1454	CF_count_CLR	CF counter clear
1455		Reserved for counter clear
1456	D.REC_FULL	Disturbance record full
1457		Reserved for disturbance record status
1458		Reserved for disturbance record status
1459		Reserved for disturbance record status
1460	PC_DIST_TRIG	Trigger for disturbance recorder from PC
1461	PLC_data_CHG	PLC data change
1462	TP_COUNT_CLR	Trips count clear
1463	I^y_COUNT_CLR	ΣI^y count clear
1464	Sys.set_change	System setting change
1465	Rly.set_change	Relay setting change
1466	Grp.set_change	Group setting change
1467		
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Signal list

No.	Signal Name	Contents
1536	CB N/O CONT	CB normally open contact
1537	CB N/C CONT	CB normally close contact
1538	DS N/O CONT	DS normally open contact
1539	DS N/C CONT	DS normally close contact
1540		
1541		
1542		
1543		
1544		
1545		
1546		
1547	EXT CB CLOSE	External CB close command
1548	TC FAIL	Trip circuit supervision command
1549		
1550		
1551	IND.RESET	Indication reset command
1552	PROT BLOCK	Protection block command
1553	DIF BLOCK	DIF trip block command
1554	TR1 BLOCK	Transfer trip1 block command
1555	TR2 BLOCK	Transfer trip2 block command
1556	OC1 BLOCK	OC1 trip block command
1557	OC2 BLOCK	2
1558	OC3 BLOCK	3
1559	OC4 BLOCK	4
1560	EF1 BLOCK	EF1 trip block command
1561	EF2 BLOCK	2
1562	EF3 BLOCK	3
1563	EF4 BLOCK	4
1564	SEF1 BLOCK	SEF1 trip block command
1565	SEF2 BLOCK	2
1566	SEF3 BLOCK	3
1567	SEF4 BLOCK	4
1568	UC1 BLOCK	UC1 trip block command
1569	UC2 BLOCK	2
1570	CBF BLOCK	CBF protection block command
1571		
1572	THM BLOCK	Thermal Overload trip block command
1573	THMA BLOCK	Thermal Overload alarm block command
1574	BCD BLOCK	Broken conductor trip block command
1575		
1576		
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1581		
1582		
1583		
1584	DIF-A FS	Fail safe command for DIF-A trip
1585	DIF-B FS	Fail safe command for DIF-B trip
1586	DIF-C FS	Fail safe command for DIF-C trip
1587	R.DATA ZERO	Remote term. data zero-ampere control command
1588	EXT TRIP-A	External trip command for counter initiation
1589	EXT TRIP-B	ditto
1590	EXT TRIP-C	ditto
1591	EXT TRIP	ditto
1592		
1593		
1594		
1595		
1596	CBF INIT-A	CBF initiation command (A-Phase)
1597	CBF INIT-B	CBF initiation command (B-Phase)
1598	CBF INIT-C	CBF initiation command (C-Phase)
1599	CBF INIT	CBF initiation command
1600	UC1-A DO	UC1-A trip drop-off command
1601	UC1-B DO	UC1-B trip drop-off command
1602	UC1-C DO	UC1-C trip drop-off command
1603		
1604	UC2-A DO	UC2-A trip drop-off command
1605	UC2-B DO	UC2-B trip drop-off command
1606	UC2-C DO	UC2-C trip drop-off command

Signal list

No.	Signal Name	Contents
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1620	OC1_INST_TP	OC1 instantly trip command
1621	OC2_INST_TP	OC2 instantly trip command
1622	OC3_INST_TP	OC3 instantly trip command
1623	OC4_INST_TP	OC4 instantly trip command
1624	EF1_INST_TP	EF1 instantly trip command
1625	EF2_INST_TP	EF2 instantly trip command
1626	EF3_INST_TP	EF3 instantly trip command
1627	EF4_INST_TP	EF4 instantly trip command
1628	SEF1_INST_TP	SEF1 instantly trip command
1629	SEF2_INST_TP	SEF2 instantly trip command
1630	SEF3_INST_TP	SEF3 instantly trip command
1631	SEF4_INST_TP	SEF4 instantly trip command
1632	UC1_INST_TP	UC1 instantly trip command
1633	UC2_INST_TP	UC2 instantly trip command
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1648	TR1-R1	Transfer trip-1 command from remote term
1649	TR2-R1	Transfer trip-2 command from remote term
1650	L.TEST-R1	Local testing command from remote term
1651	I.LINK-R1	CB & DS close command from remote term (use for OTD)
1652		
1653		
1654		
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1663		
1664	TP-A_DELAY	Trip command off-delay timer setting
1665	TP-B_DELAY	ditto
1666	TP-C_DELAY	ditto
1667	TP-N_DELAY	ditto
1668		
1669		
1670		
1671		
1672	TP_DELAY	Trip command off-delay timer setting
1673		
1674		
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Signal list

No.	Signal Name	Contents
1678		
1679		
1680	DIF-A_IC_BLK	DIF-A blocked command by inrush current
1681	DIF-B_IC_BLK	DIF-B blocked command by inrush current
1682	DIF-C_IC_BLK	DIF-C blocked command by inrush current
1683	OC_IC_BLK	OC/EF/SEF blocked command by inrush current
1684		
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Signal list

No.	Signal Name	Contents
2041		
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2047		
2048	COM1-S	Communication on/off data send command
2049	COM2-S	ditto
2050	COM3-S	ditto
2051	COM4-S	ditto
2052	COM5-S	ditto
2053		
2054		
2055		
2056	SUB_COM1-S	Sub communication on/off data send command
2057	SUB_COM2-S	ditto
2058	SUB_COM3-S	ditto
2059	SUB_COM4-S	ditto (reserved)
2060	SUB_COM5-S	ditto (reserved)
2061		
2062		
2063		
2064	SUB2_COM1-S	Sub communication on/off data 2 send command
2065	SUB2_COM2-S	ditto
2066	SUB2_COM3-S	ditto
2067	SUB2_COM4-S	ditto
2068	SUB2_COM5-S	ditto
2069	SUB2_COM6-S	ditto
2070	SUB2_COM7-S	ditto
2071	SUB2_COM8-S	ditto
2072	SUB2_COM9-S	ditto
2073	SUB2_COM10-S	ditto
2074	SUB2_COM11-S	ditto
2075	SUB2_COM12-S	ditto
2076		
2077		
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Signal list

No.	Signal Name	Contents
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2559		
2560	TP1	Binary output signal of TP1
2561	TP2	TP2
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Signal list

No.	Signal Name	Contents
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2623		
2624	F.RECORD1	Fault record stored command 1
2625	F.RECORD2	2
2626	F.RECORD3	3
2627	F.RECORD4	4
2628		
2629		
2630		
2631		
2632	D.RECORD1	Disturbance record stored command 1
2633	D.RECORD2	2
2634	D.RECORD3	3
2635	D.RECORD4	4
2636		
2637		
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2639		
2640	SET.GROUP1	Active setting group changed command (Change to group1)

Signal list

No.	Signal Name	Contents
2641	SET.GROUP2	2
2642	SET.GROUP3	3
2643	SET.GROUP4	4
2644		
2645		
2646		
2647		
2648	SYNC_CLOCK	Clock synchronized command
2649		
2650		
2651		
2652	ALARM1	Alarm-1 indicated command
2653	ALARM2	2
2654	ALARM3	3
2655	ALARM4	4
2656	CON_TPMD1	User configurable trip mode in fault record
2657	CON_TPMD2	ditto
2658	CON_TPMD3	ditto
2659	CON_TPMD4	ditto
2660	CON_TPMD5	ditto
2661	CON_TPMD6	ditto
2662	CON_TPMD7	ditto
2663	CON_TPMD8	ditto
2664		
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2684		
2685	TEL_COM_RECV	Teleprotection inactivate command received
2686	PROT_COM_RECV	protection inactivate command received
2687		
2688	TPLED_RST_RCV	TRIP LED RESET command received
2689	ALMLED_RST_RCV	ALARM LED RESET command received
2690	TPALM_RST_RCV	TRIP/ALARM LED RESET command received
2691		
2692		
2693		
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2875		
2876	TEMP001	
2877	TEMP002	
2878	TEMP003	
2879	TEMP004	
2880	TEMP005	
2881	TEMP006	
2882	TEMP007	
2883	TEMP008	
2884	TEMP009	
2885	TEMP010	
2886	TEMP011	
2887	TEMP012	
2888	TEMP013	
2889	TEMP014	
2890	TEMP015	
2891	TEMP016	
2892	TEMP017	
2893	TEMP018	
2894	TEMP019	
2895	TEMP020	
2896	TEMP021	
2897	TEMP022	
2898	TEMP023	
2899	TEMP024	
2900	TEMP025	
2901	TEMP026	
2902	TEMP027	
2903	TEMP028	
2904	TEMP029	
2905	TEMP030	
2906	TEMP031	
2907	TEMP032	
2908	TEMP033	
2909	TEMP034	
2910	TEMP035	

Signal list

No.	Signal Name	Contents
2911	TEMP096	
2912	TEMP097	
2913	TEMP098	
2914	TEMP099	
2915	TEMP100	
2916	TEMP101	
2917	TEMP102	
2918	TEMP103	
2919	TEMP104	
2920	TEMP105	
2921	TEMP106	
2922	TEMP107	
2923	TEMP108	
2924	TEMP109	
2925	TEMP110	
2926	TEMP111	
2927	TEMP112	
2928	TEMP113	
2929	TEMP114	
2930	TEMP115	
2931	TEMP116	
2932	TEMP117	
2933	TEMP118	
2934	TEMP119	
2935	TEMP120	
2936	TEMP121	
2937	TEMP122	
2938	TEMP123	
2939	TEMP124	
2940	TEMP125	
2941	TEMP126	
2942	TEMP127	
2943	TEMP128	
2944	TEMP129	
2945	TEMP130	
2946	TEMP131	
2947	TEMP132	
2948	TEMP133	
2949	TEMP134	
2950	TEMP135	
2951	TEMP136	
2952	TEMP137	
2953	TEMP138	
2954	TEMP139	
2955	TEMP140	
2956	TEMP141	
2957	TEMP142	
2958	TEMP143	
2959	TEMP144	
2960	TEMP145	
2961	TEMP146	
2962	TEMP147	
2963	TEMP148	
2964	TEMP149	
2965	TEMP150	
2966	TEMP151	
2967	TEMP152	
2968	TEMP153	
2969	TEMP154	
2970	TEMP155	
2971	TEMP156	
2972	TEMP157	
2973	TEMP158	
2974	TEMP159	
2975	TEMP160	
2976	TEMP161	
2977	TEMP162	
2978	TEMP163	
2979	TEMP164	
2980	TEMP165	

Signal list

No.	Signal Name	Contents
2981	TEMP166	
2982	TEMP167	
2983	TEMP168	
2984	TEMP169	
2985	TEMP170	
2986	TEMP171	
2987	TEMP172	
2988	TEMP173	
2989	TEMP174	
2990	TEMP175	
2991	TEMP176	
2992	TEMP177	
2993	TEMP178	
2994	TEMP179	
2995	TEMP180	
2996	TEMP181	
2997	TEMP182	
2998	TEMP183	
2999	TEMP184	
3000	TEMP185	
3001	TEMP186	
3002	TEMP187	
3003	TEMP188	
3004	TEMP189	
3005	TEMP190	
3006	TEMP191	
3007	TEMP192	
3008	TEMP193	
3009	TEMP194	
3010	TEMP195	
3011	TEMP196	
3012	TEMP197	
3013	TEMP198	
3014	TEMP199	
3015	TEMP200	
3016	TEMP201	
3017	TEMP202	
3018	TEMP203	
3019	TEMP204	
3020	TEMP205	
3021	TEMP206	
3022	TEMP207	
3023	TEMP208	
3024	TEMP209	
3025	TEMP210	
3026	TEMP211	
3027	TEMP212	
3028	TEMP213	
3029	TEMP214	
3030	TEMP215	
3031	TEMP216	
3032	TEMP217	
3033	TEMP218	
3034	TEMP219	
3035	TEMP220	
3036	TEMP221	
3037	TEMP222	
3038	TEMP223	
3039	TEMP224	
3040	TEMP225	
3041	TEMP226	
3042	TEMP227	
3043	TEMP228	
3044	TEMP229	
3045	TEMP230	
3046	TEMP231	
3047	TEMP232	
3048	TEMP233	
3049	TEMP234	
3050	TEMP235	

Signal list

No.	Signal Name	Contents
3051	TEMP236	
3052	TEMP237	
3053	TEMP238	
3054	TEMP239	
3055	TEMP240	
3056	TEMP241	
3057	TEMP242	
3058	TEMP243	
3059	TEMP244	
3060	TEMP245	
3061	TEMP246	
3062	TEMP247	
3063	TEMP248	
3064	TEMP249	
3065	TEMP250	
3066	TEMP251	
3067	TEMP252	
3068	TEMP253	
3069	TEMP254	
3070	TEMP255	
3071	TEMP256	

Appendix C

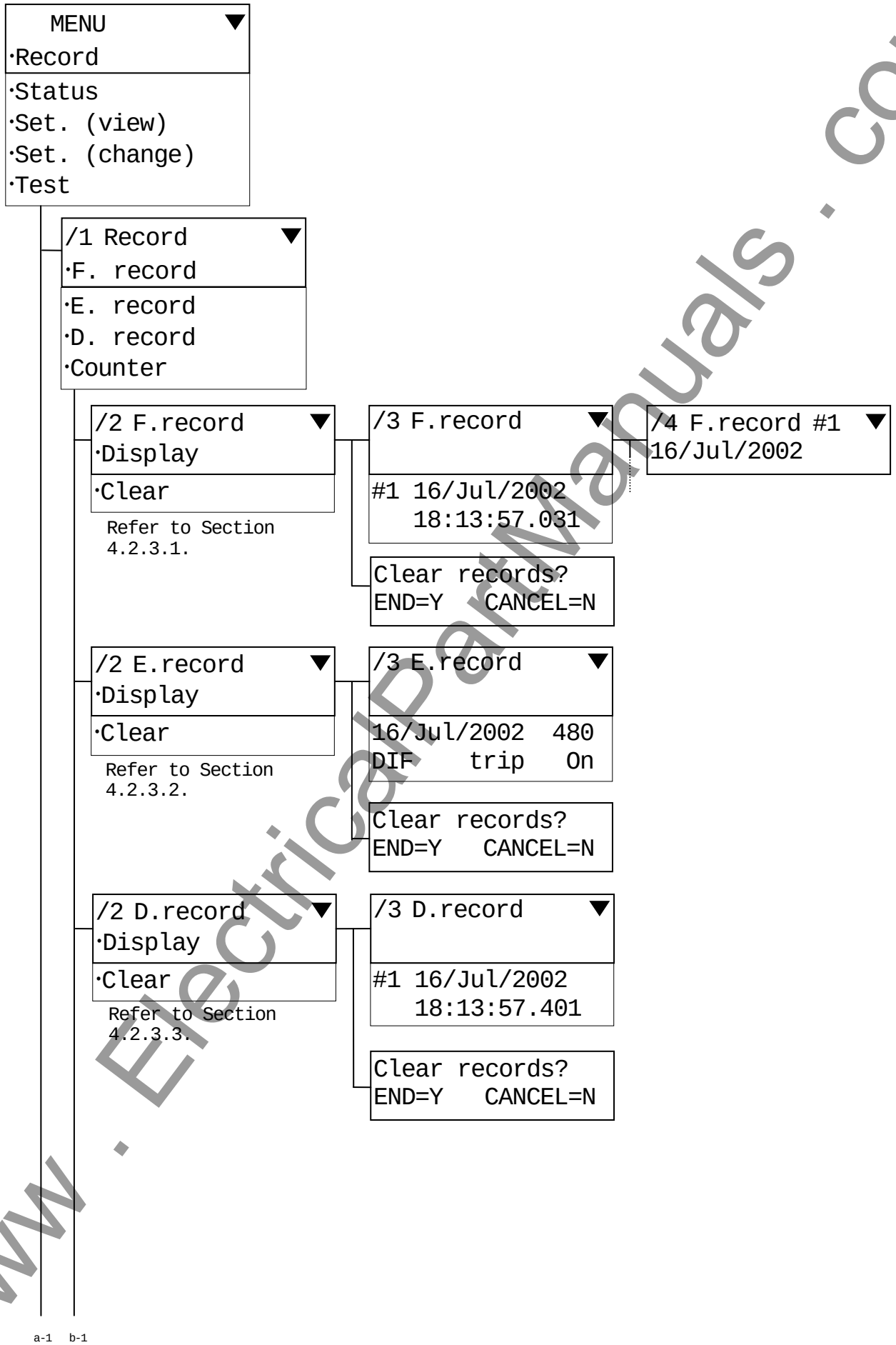
Binary Output Default Setting List

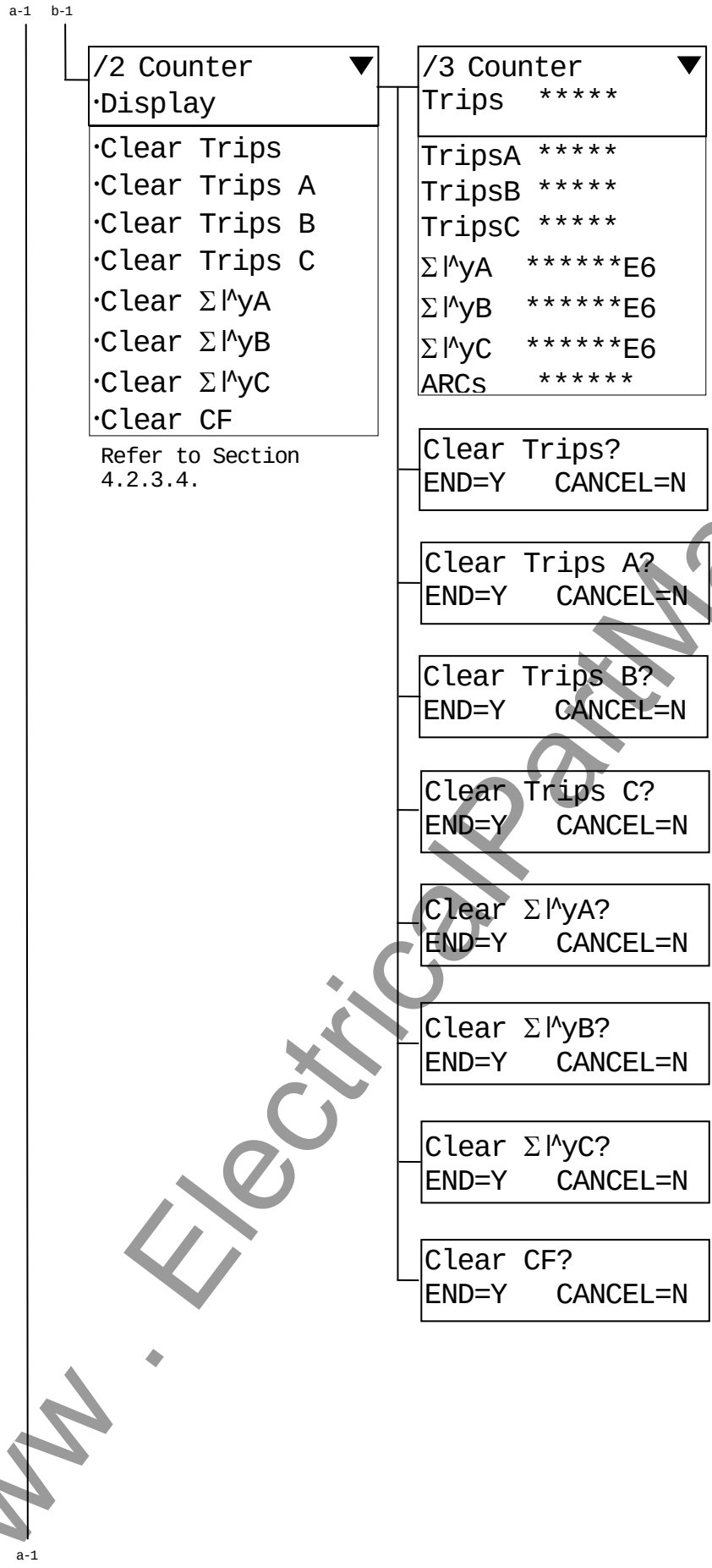
Binary Output Default Setting List

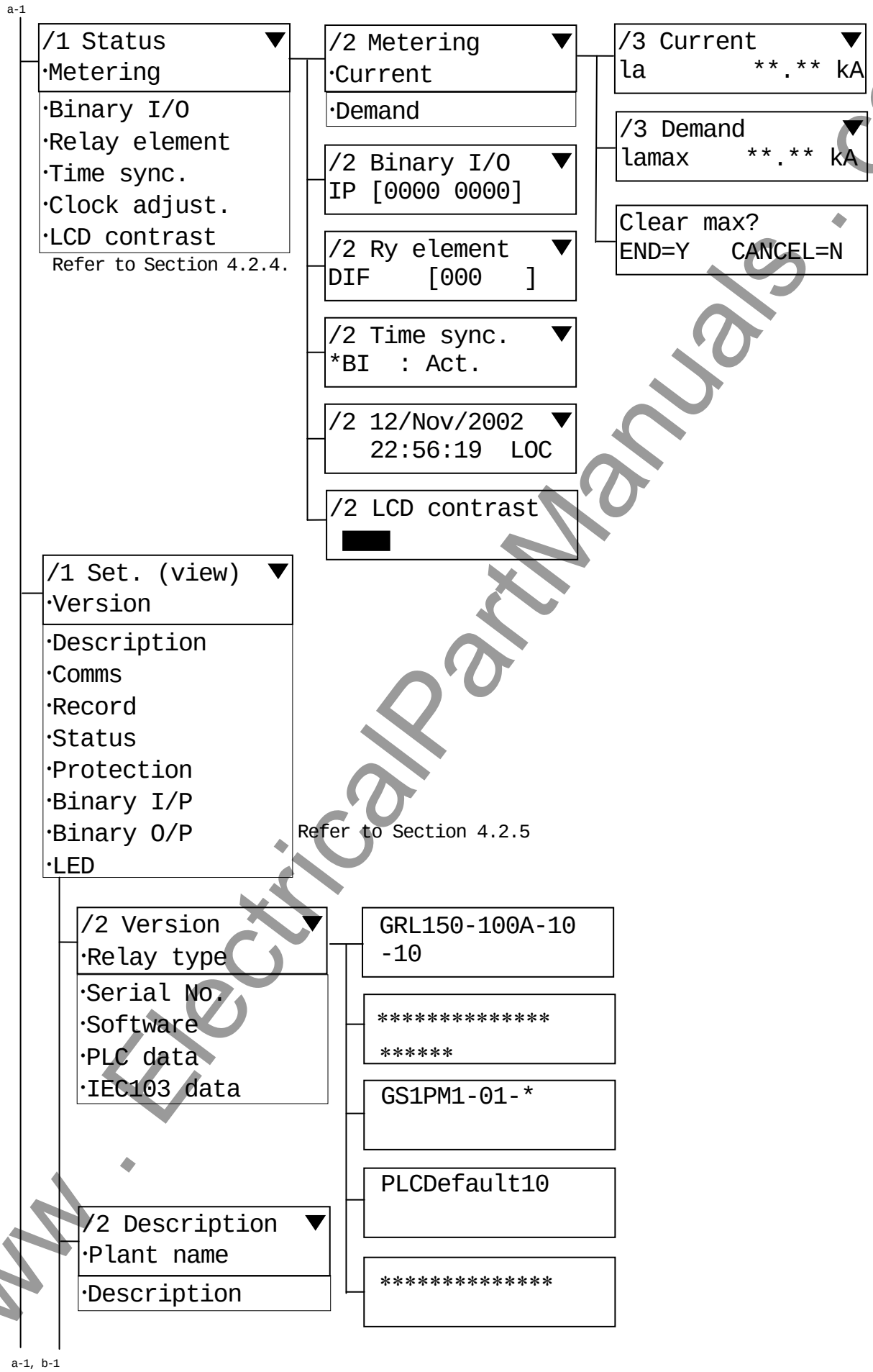
№	Setting range					Model					Setting				
						100, 110, 120, 400, 410, 420									
	BO	Logic	Reset	Functions		Logic	BOTD	Functions			Logic	BOTD	Functions		
1	BO1	OR / AND	Ins/DI/Dw/Lat	In #1	0-3071	OR	Del	In #1	348	GEN.TRIP			In #1		
				In #2	0-3071			In #2	0				In #2		
				In #3	0-3071			In #3	0				In #3		
				In #4	0-3071			In #4	0				In #4		
		Timer	0.00 - 10.00			0.20									
2	BO2	OR / AND	Ins/DI/Dw/Lat	In #1	0-3071	OR	Del	In #1	348	GEN.TRIP			In #1		
				In #2	0-3071			In #2	0				In #2		
				In #3	0-3071			In #3	0				In #3		
				In #4	0-3071			In #4	0				In #4		
		Timer	0.00 - 10.00			0.20									
3	BO3	OR / AND	Ins/DI/Dw/Lat	In #1	0-3071	OR	Del	In #1	256	DIF_TRIP			In #1		
				In #2	0-3071			In #2	0				In #2		
				In #3	0-3071			In #3	0				In #3		
				In #4	0-3071			In #4	0				In #4		
		Timer	0.00 - 10.00			0.20									
4	BO4	OR / AND	Ins/DI/Dw/Lat	In #1	0-3071	OR	Del	In #1	256	DIF_TRIP			In #1		
				In #2	0-3071			In #2	0				In #2		
				In #3	0-3071			In #3	0				In #3		
				In #4	0-3071			In #4	0				In #4		
		Timer	0.00 - 10.00			0.20									
5	BO5	OR / AND	Ins/DI/Dw/Lat	In #1	0-3071	OR	Del	In #1	1346	RELAY_FAIL-A			In #1		
				In #2	0-3071			In #2	450	COMM1_FAIL			In #2		
				In #3	0-3071			In #3	440	SPSV1			In #3		
				In #4	0-3071			In #4	0				In #4		
		Timer	0.00 - 10.00			0.20									

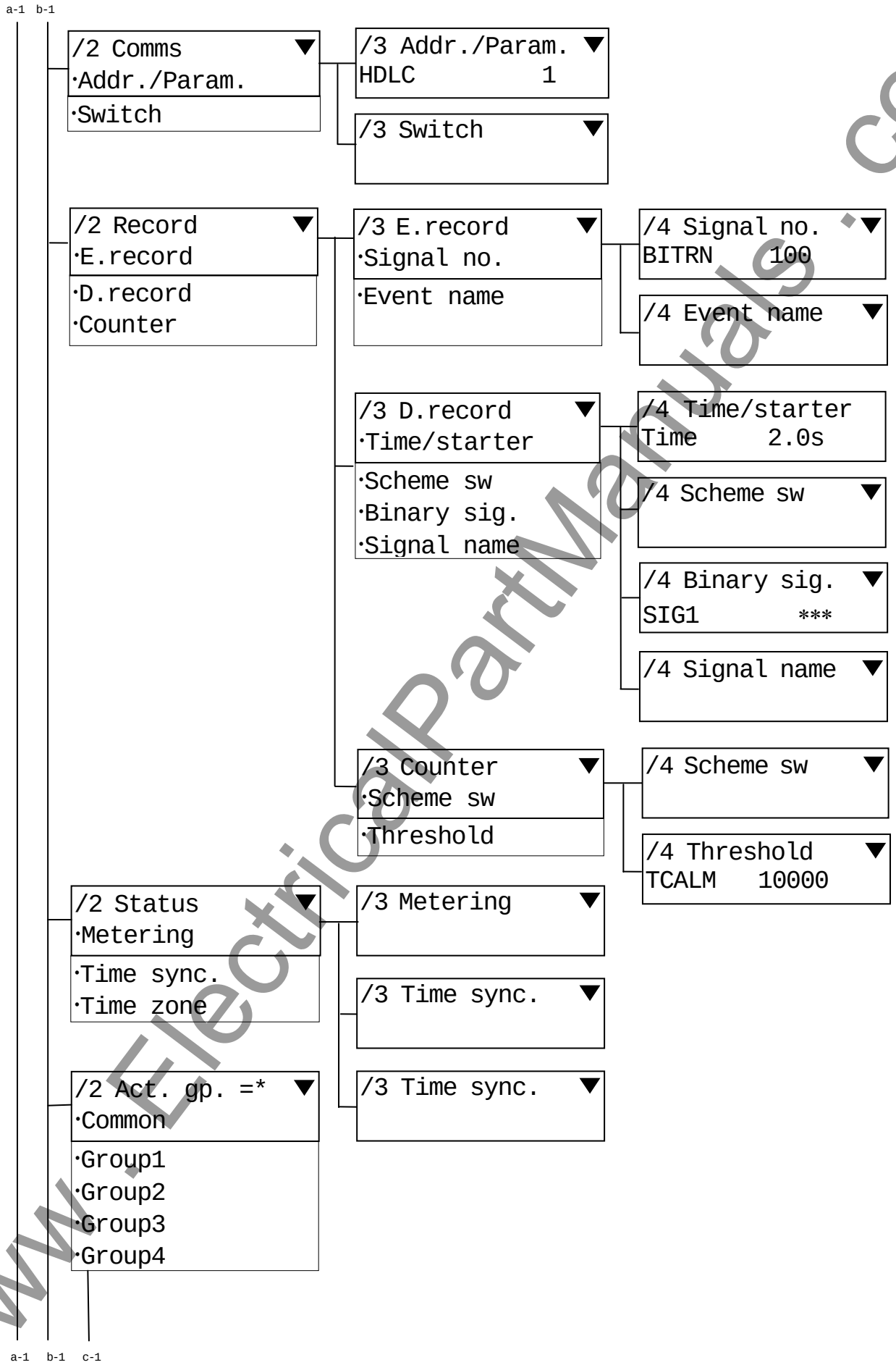
Appendix D

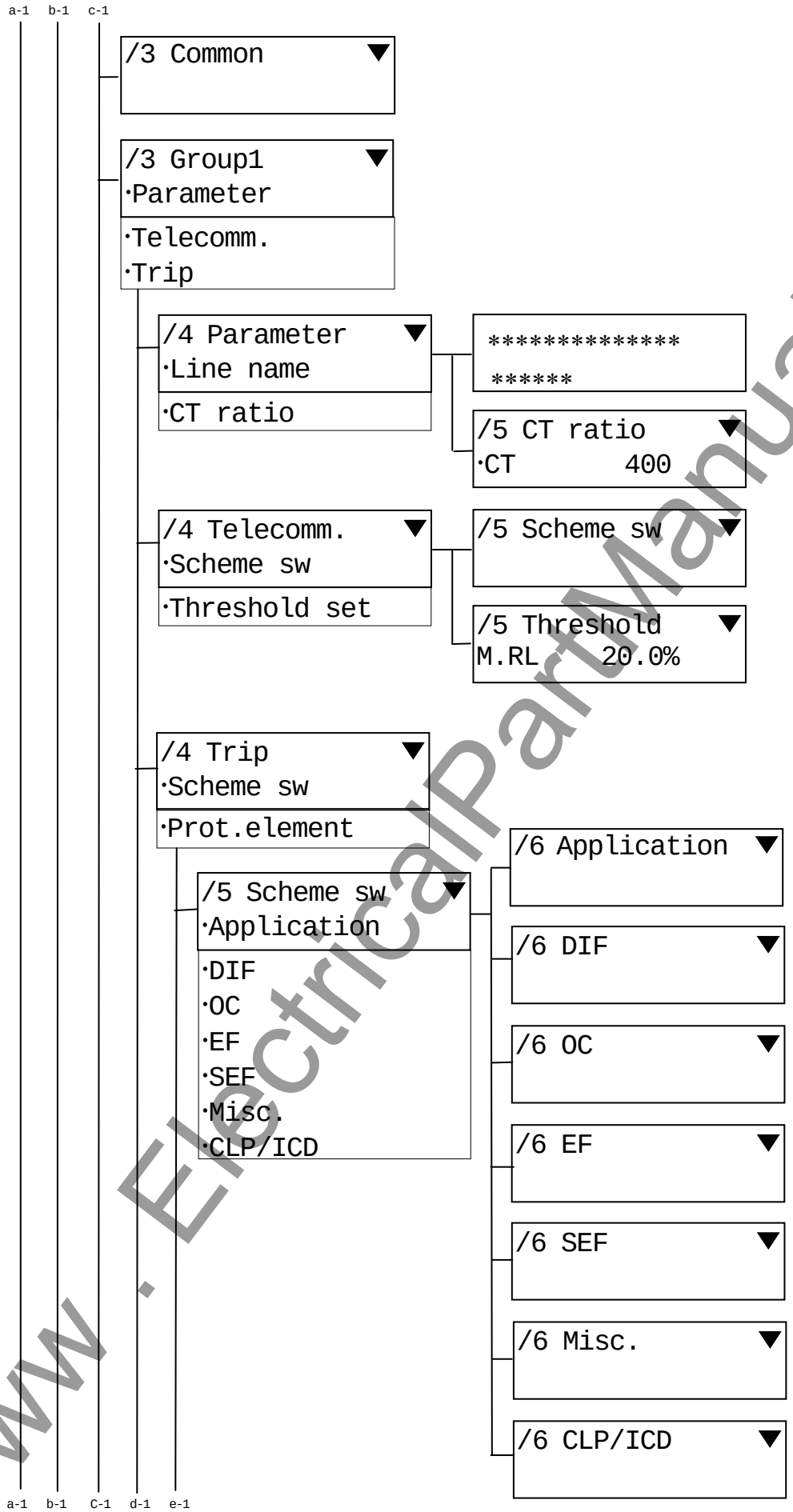
Details of Relay Menu

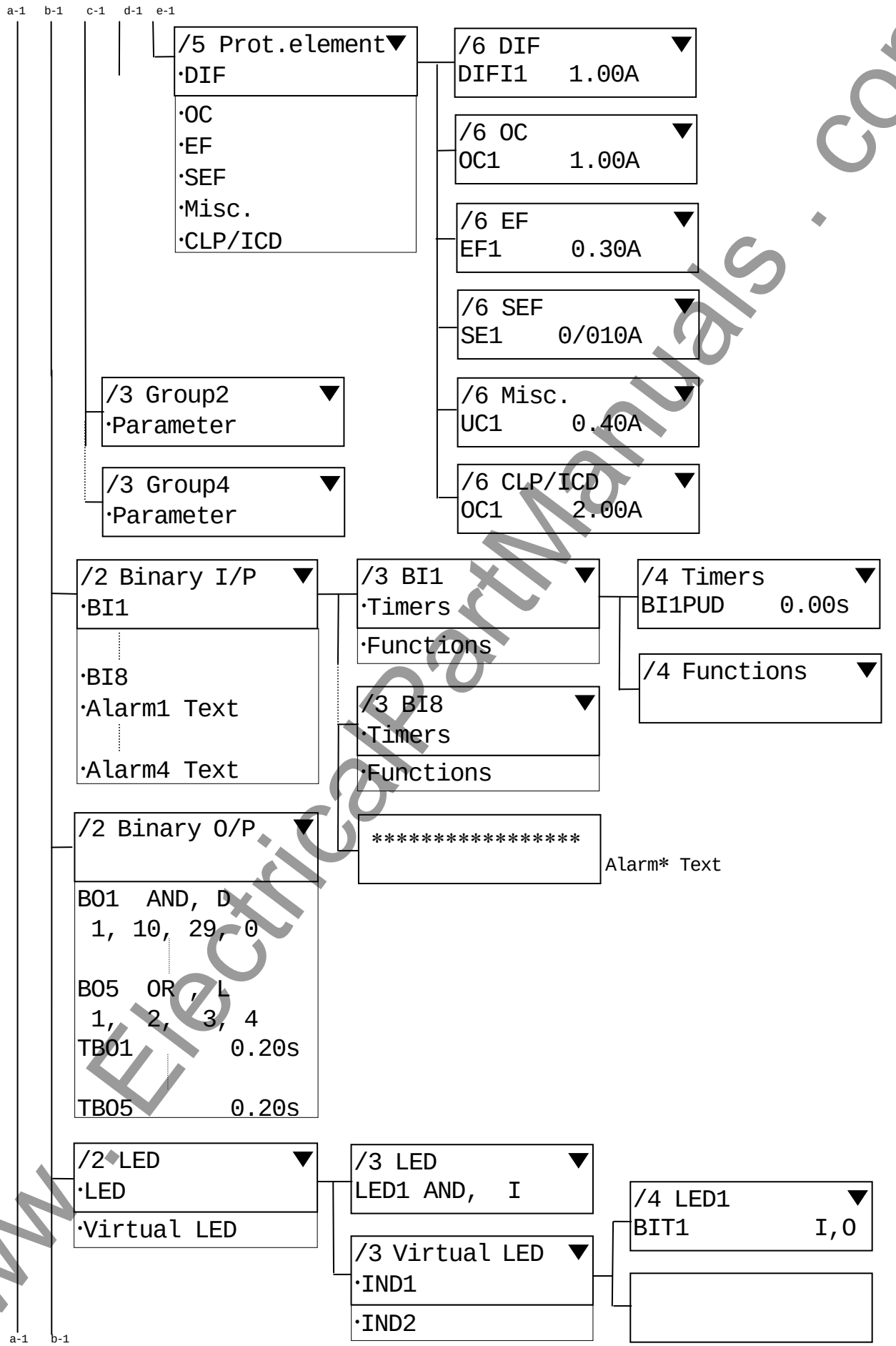


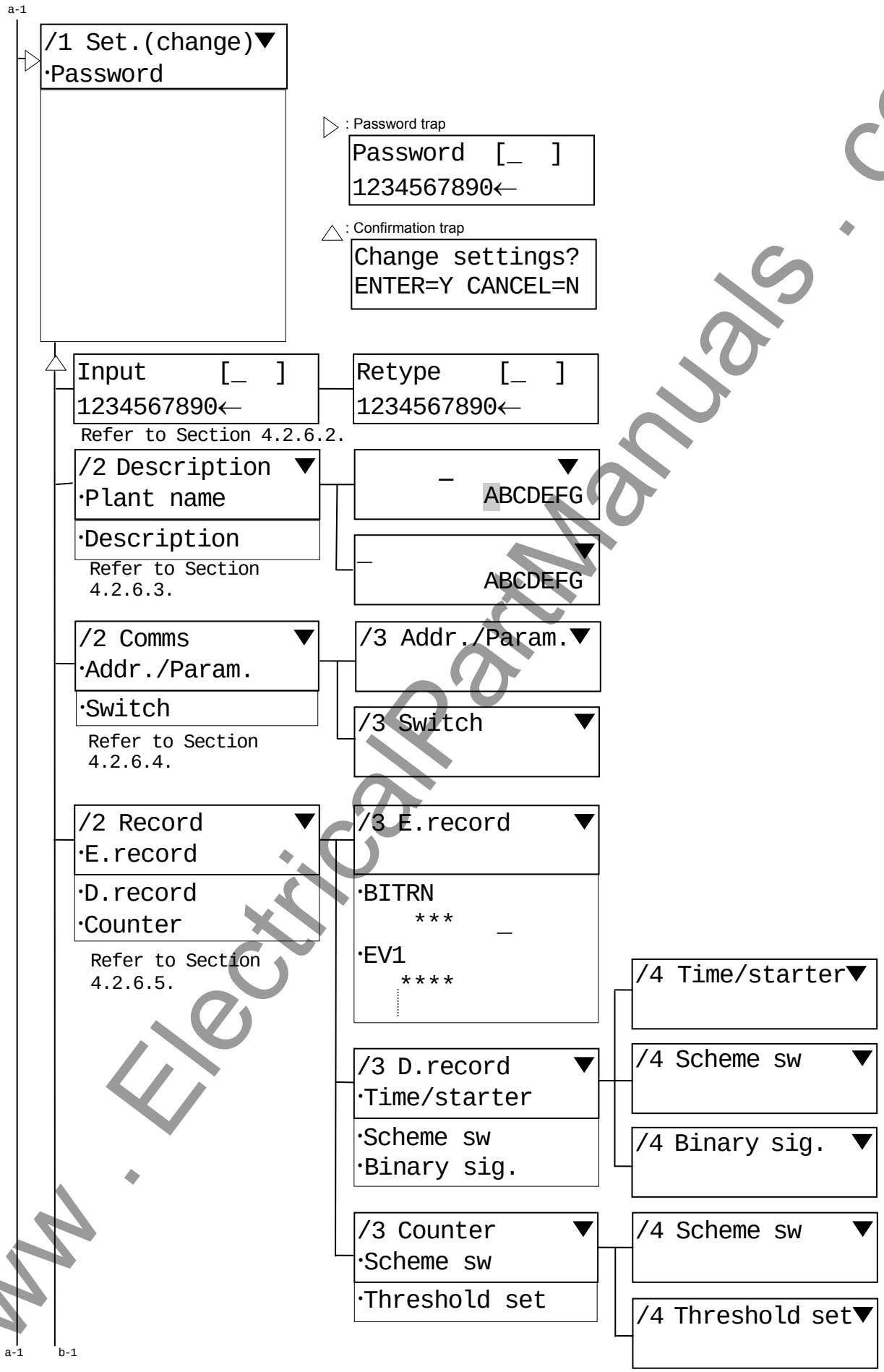


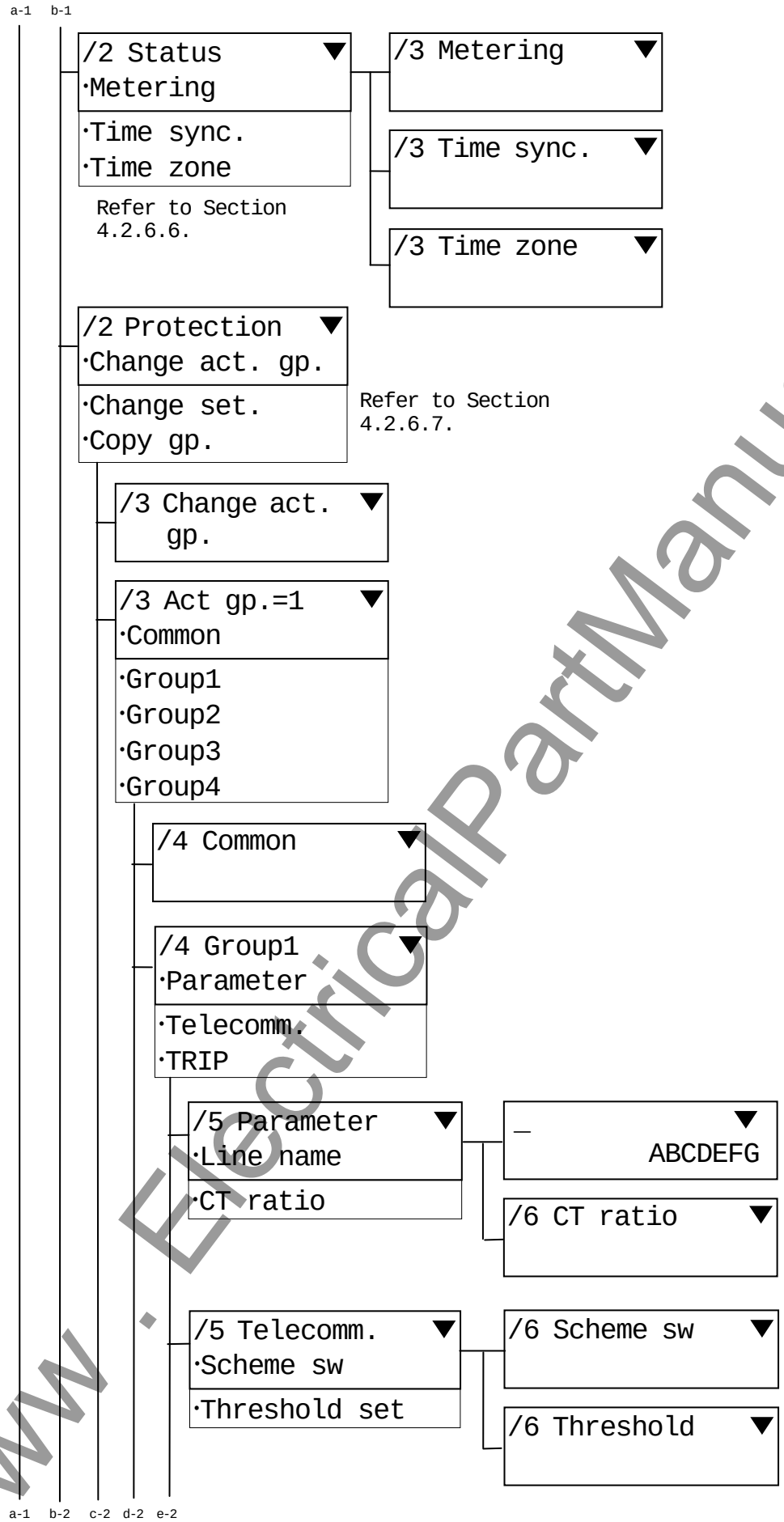


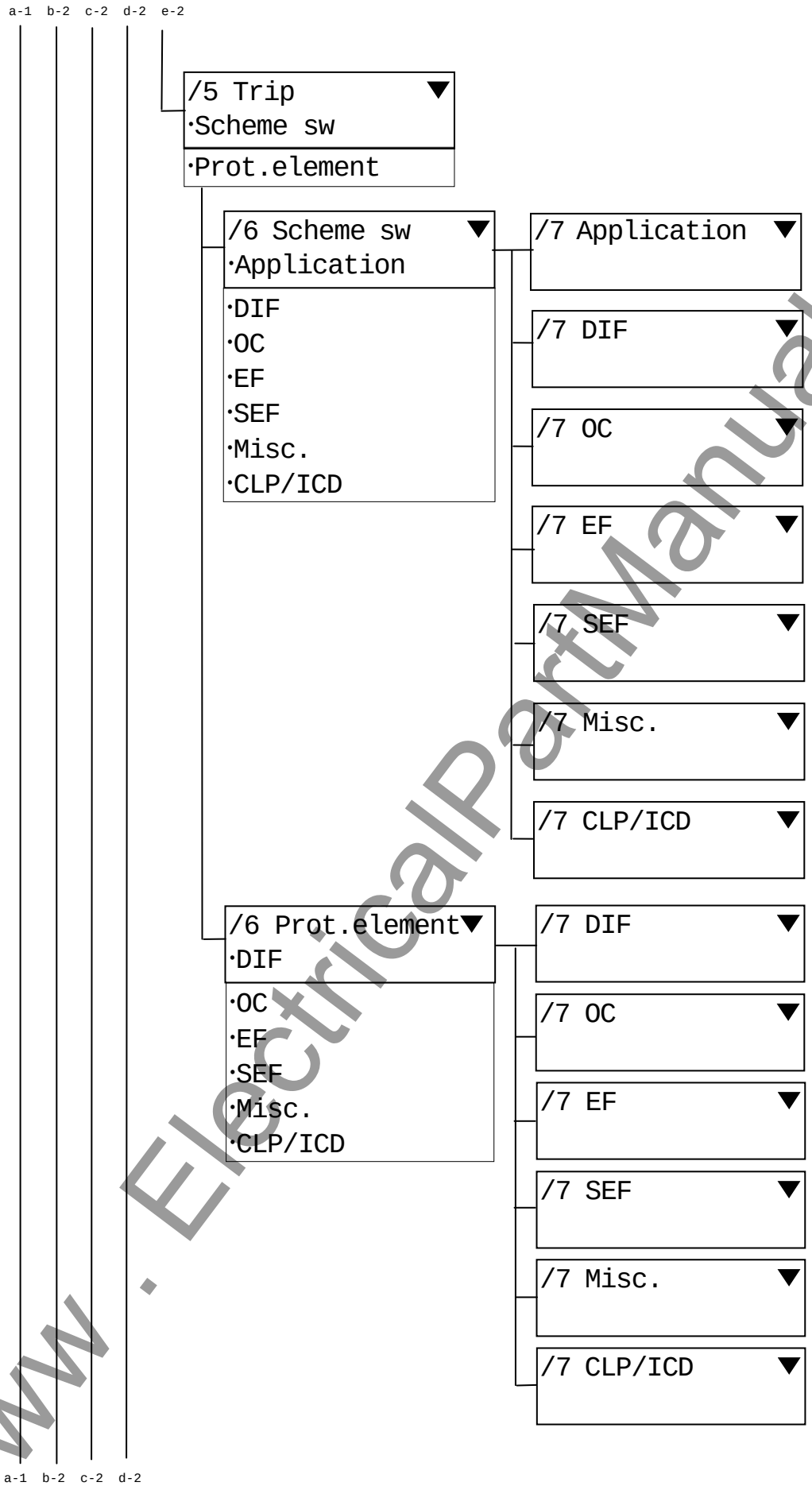


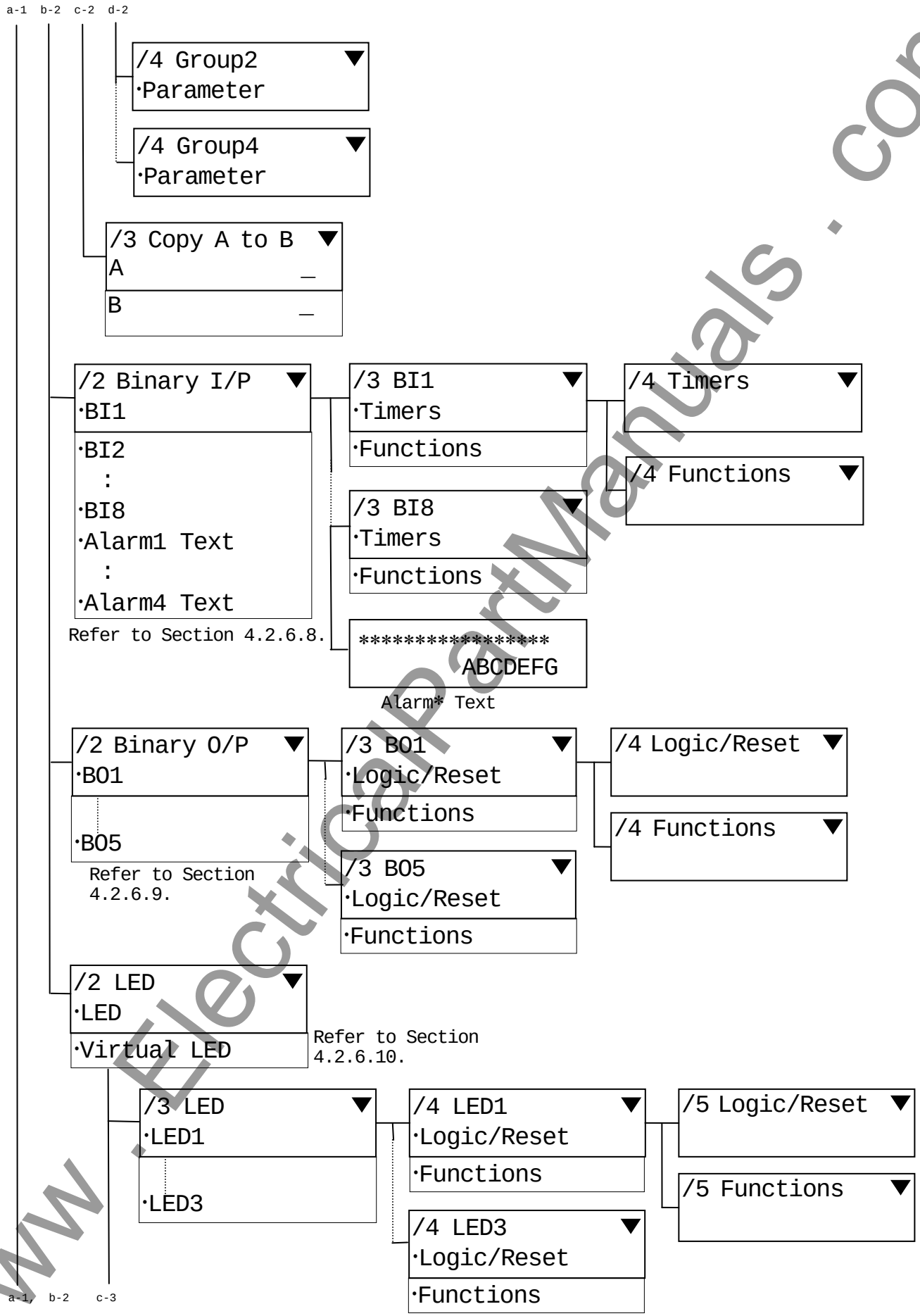


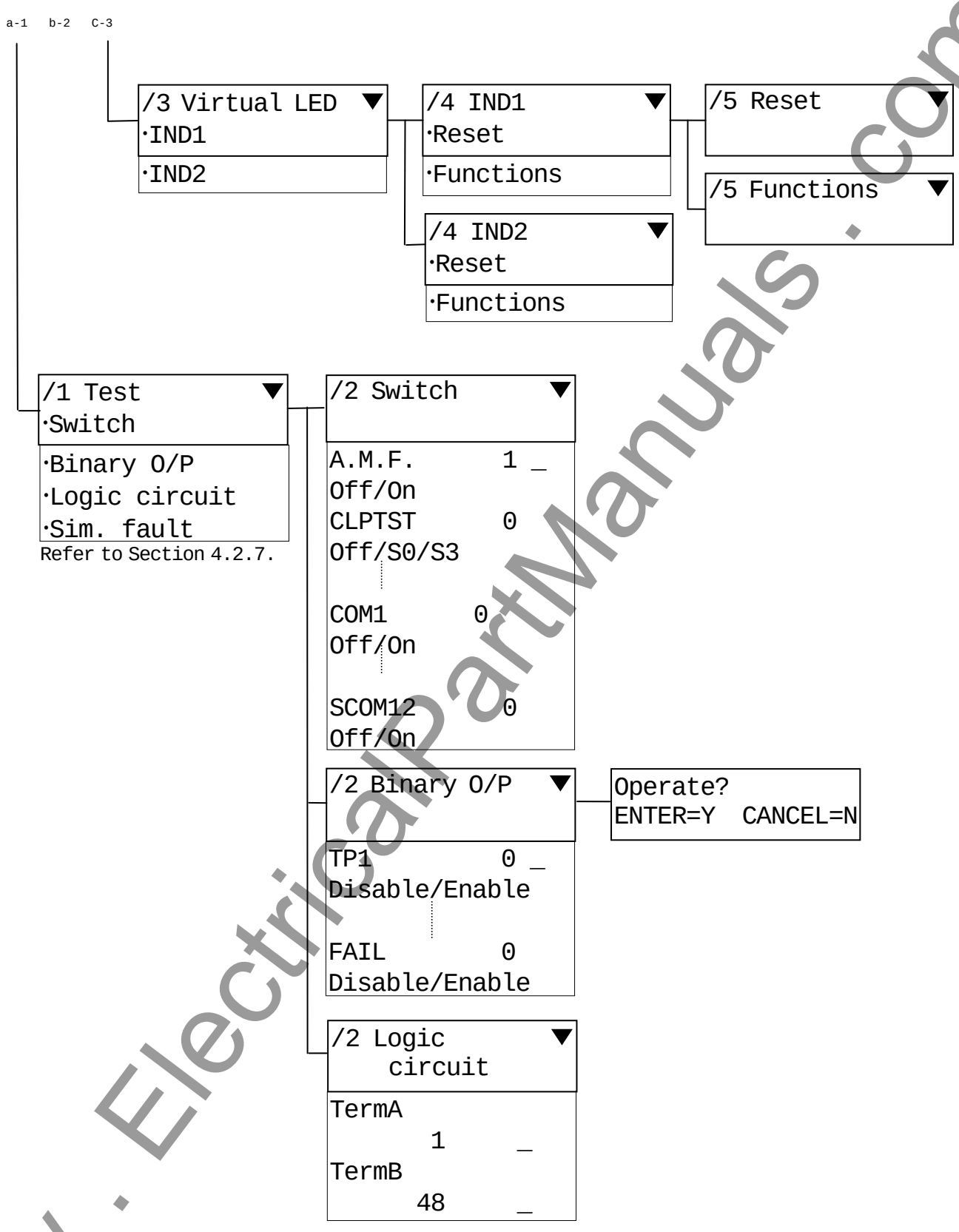




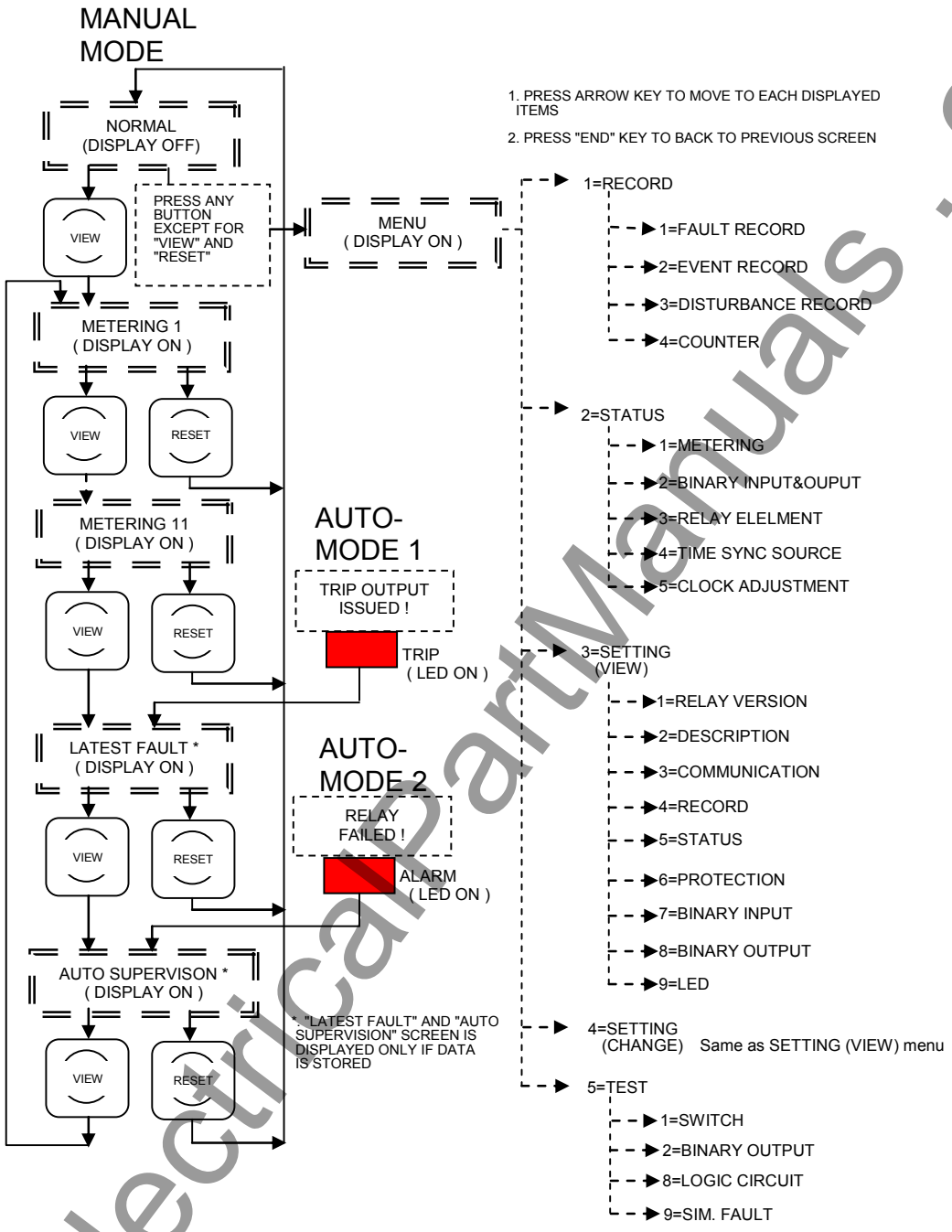








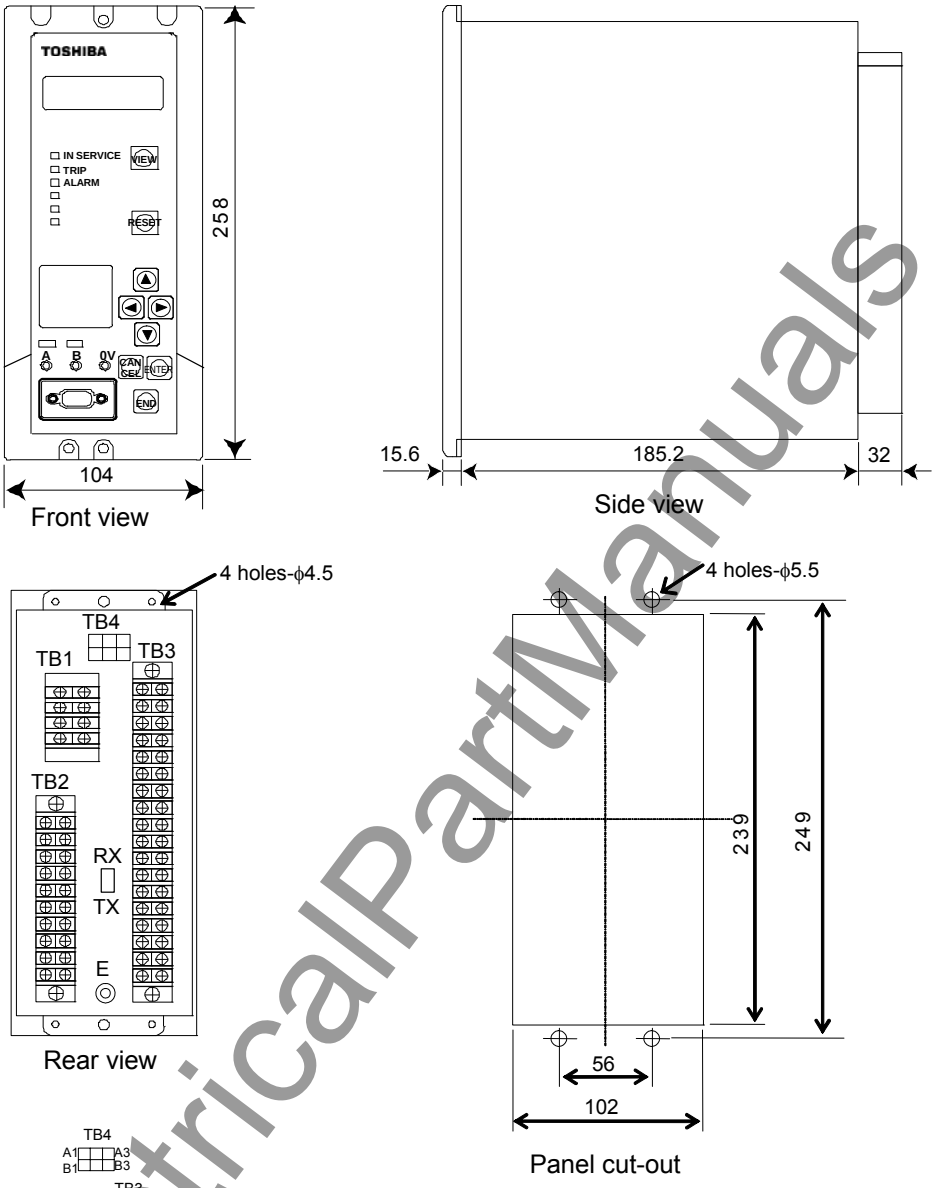
LCD AND BUTTON OPERATION INSTRUCTION



Appendix E

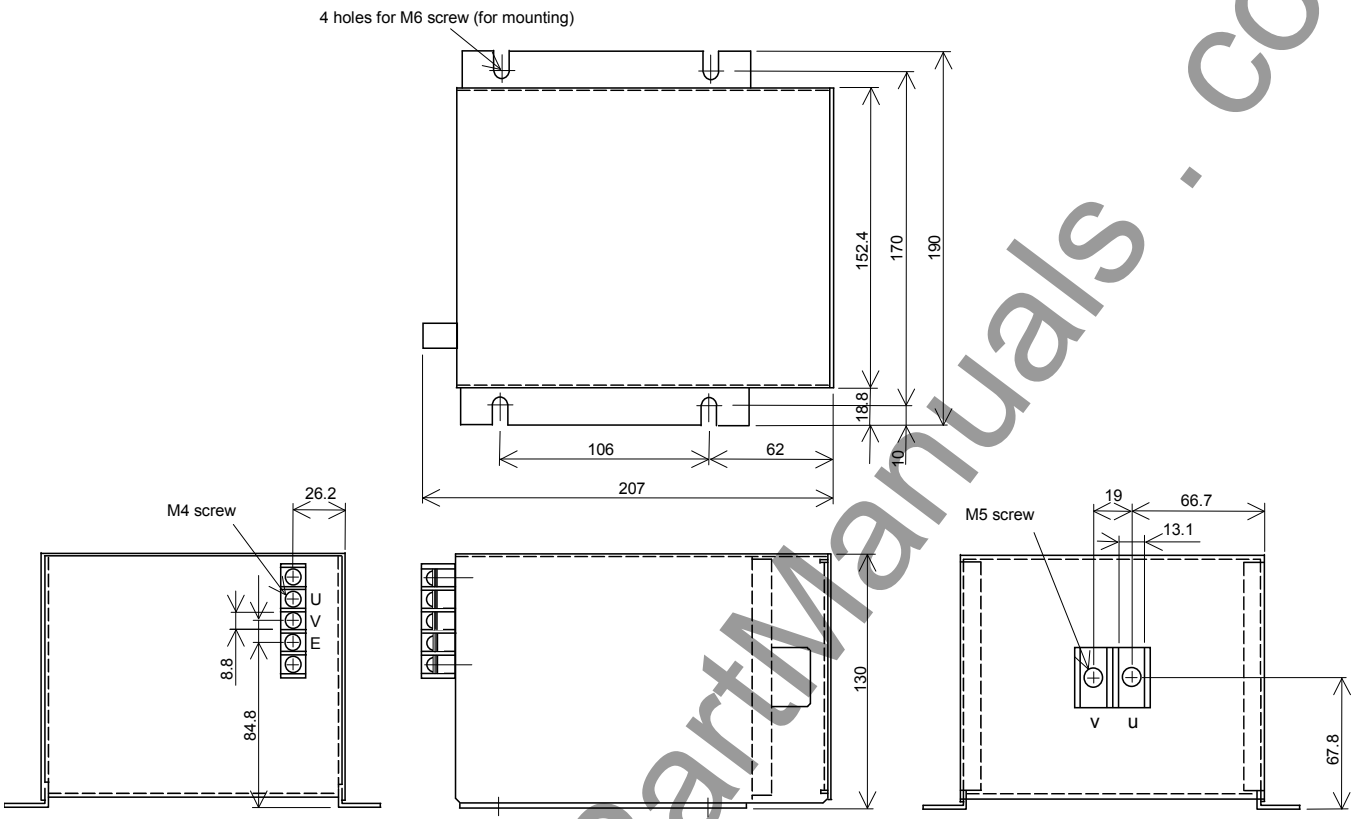
Case Outline

GRL150

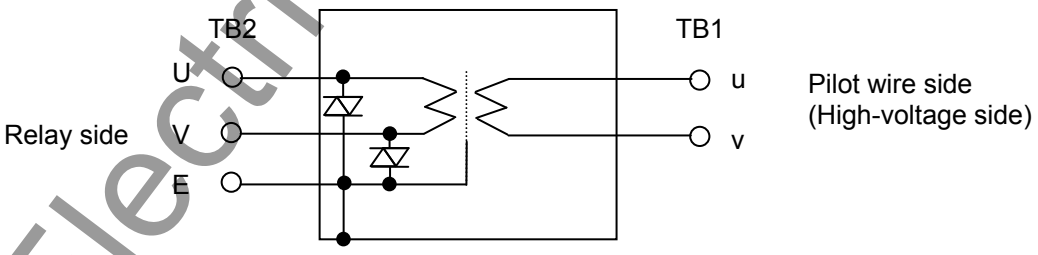


Case Outline of GRL150

External 20kV Isolation Transformer EB-110 (Option)



Outline & Dimensions

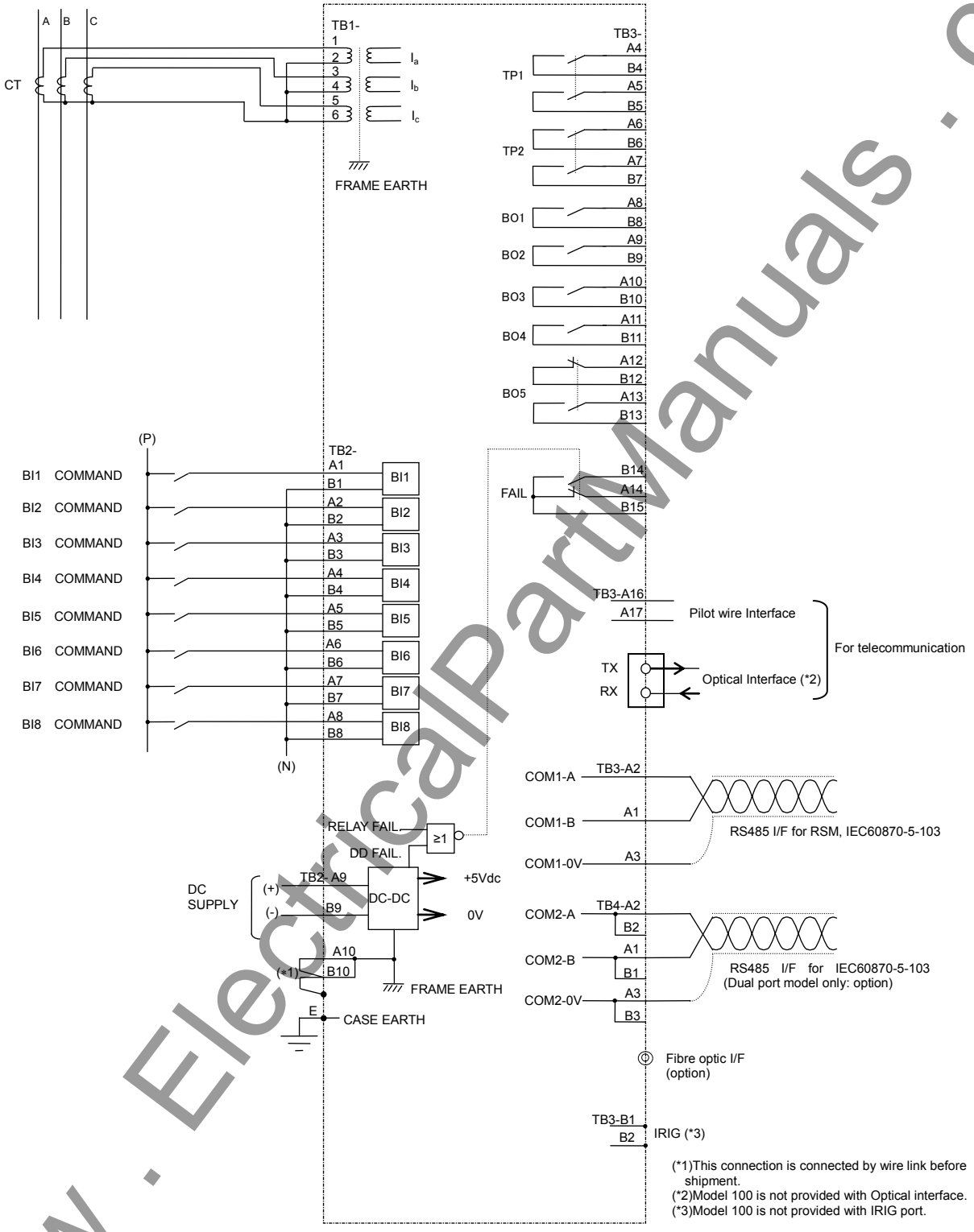


External Connections

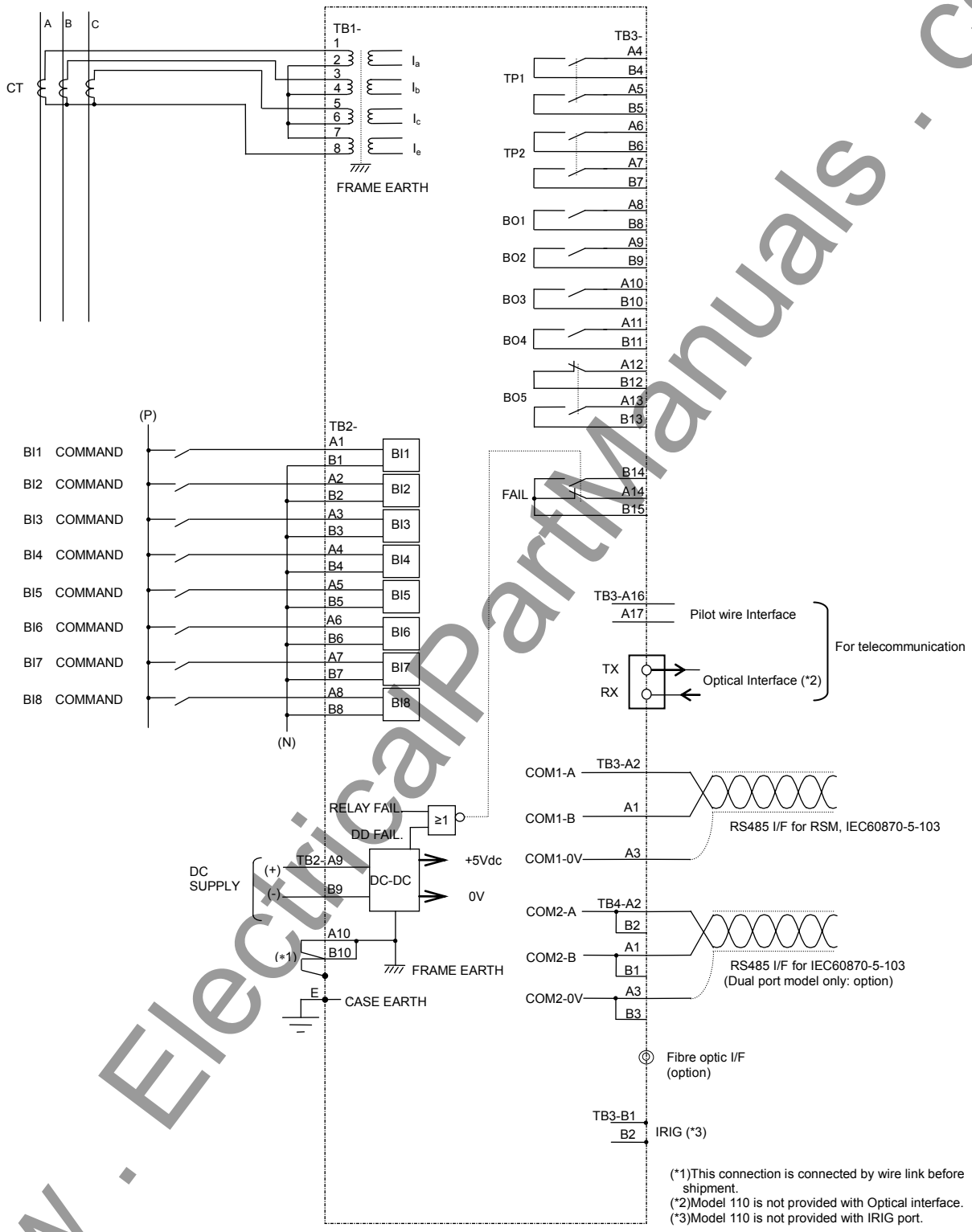
Appendix F

Typical External Connections

GRL150 – 100 / 400

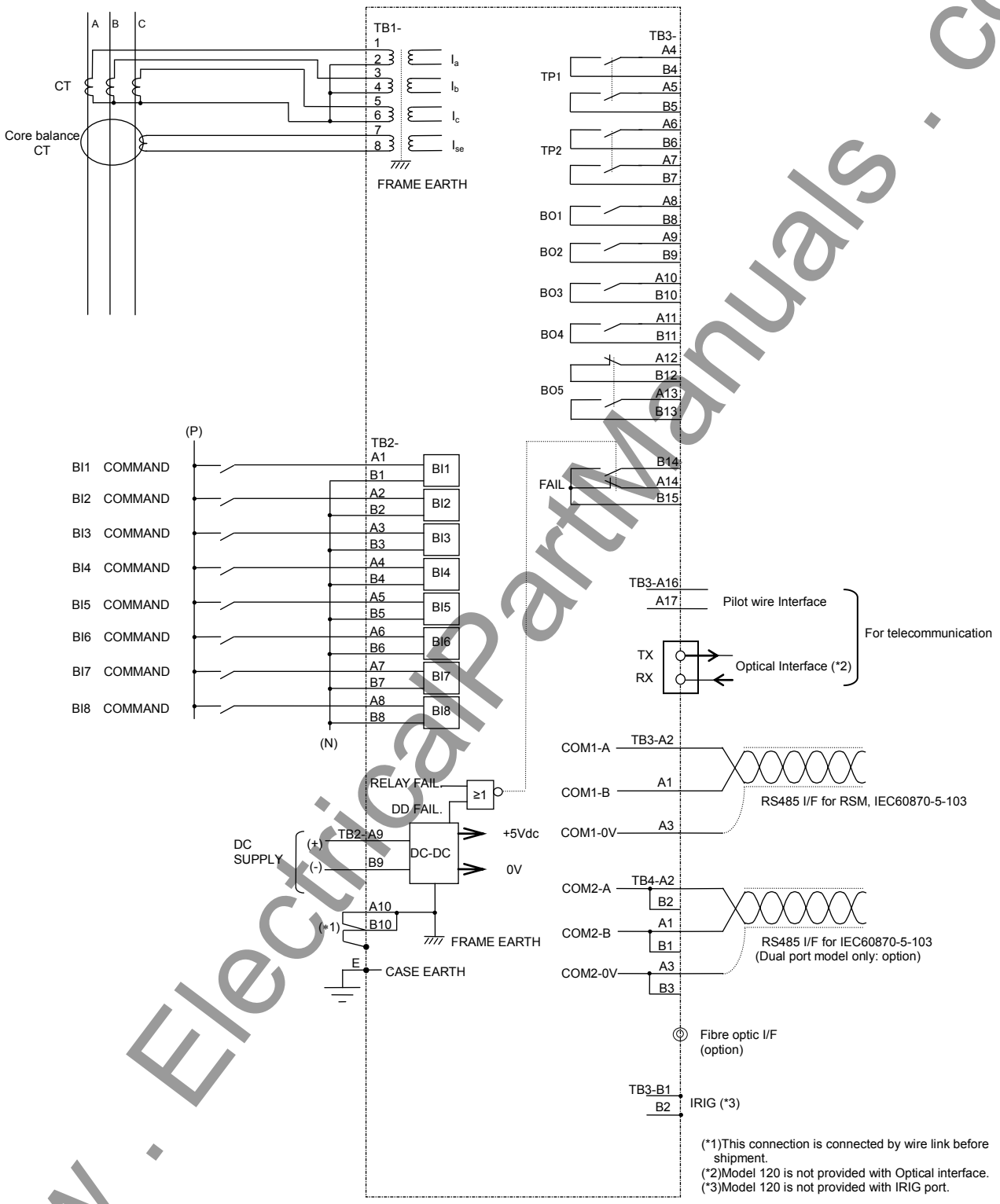


GRL150 – 110 / 410



(*1)This connection is connected by wire link before shipment.
(*2)Model 110 is not provided with Optical interface.
(*3)Model 110 is not provided with IRIG port.

GRL150 – 120 / 420



Appendix G

Relay Setting Sheet

1. Relay Identification
2. Line parameter
3. Binary output setting
4. Relay setting
5. Disturbance record signal setting
6. LED setting

Relay Setting Sheets

1. Relay Identification Date:

Relay type _____ Serial Number _____

Frequency _____ CT rating _____

_____ dc supply voltage _____

Password _____

Active setting group _____

2. Transmission line parameters

CT ratio DIF: OC: EF: SEF: _____

3. Binary output setting

Model 100, 110, 120, 400, 410, 420

Setting range					Default Setting 110					Setting				
BO	Logic	Reset	Functions		Logic	BOTD	Functions			Logic	BOTD	Functions		
BO1	OR / AND	Ins/DI/Dw /Lat	In #1	0-500	OR	Del	In #1	348	GEN.TRIP			In #1		
			In #2	0-500			In #2	0				In #2		
			In #3	0-500			In #3	0				In #3		
			In #4	0-500			In #4	0				In #4		
	Timer	0.00 - 10.00			0.20									
BO2	OR / AND	Ins/DI/Dw /Lat	In #1	0-500	OR	Del	In #1	348	GEN.TRIP			In #1		
			In #2	0-500			In #2	0				In #2		
			In #3	0-500			In #3	0				In #3		
			In #4	0-500			In #4	0				In #4		
	Timer	0.00 - 10.00			0.20									
BO3	OR / AND	Ins/DI/Dw /Lat	In #1	0-500	OR	Del	In #1	256	DIF_TRIP			In #1		
			In #2	0-500			In #2	0				In #2		
			In #3	0-500			In #3	0				In #3		
			In #4	0-500			In #4	0				In #4		
	Timer	0.00 - 10.00			0.20									
BO4	OR / AND	Ins/DI/Dw /Lat	In #1	0-500	OR	Del	In #1	256	DIF_TRIP			In #1		
			In #2	0-500			In #2	0				In #2		
			In #3	0-500			In #3	0				In #3		
			In #4	0-500			In #4	0				In #4		
	Timer	0.00 - 10.00			0.20									
BO5	OR / AND	Ins/DI/Dw /Lat	In #1	0-500	OR	Del	In #1	1346	RELAY_FAIL-A			In #1		
			In #2	0-500			In #2	450	COMM1_FAIL			In #2		
			In #3	0-500			In #3	440	SPSV1			In #3		
			In #4	0-500			In #4	0				In #4		
	Timer	0.00 - 10.00			0.20									

4. Default setting

Setting 1

No.	Name		Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)						User Setting
							Model1			Model2			
			5A rating	1A rating			100	110	120	400	410	420	
1	Active gp.		1 - 4		--	Active group	1						
2	Common	CTSVEN	Off / ALM&BLK / ALM		--	AC input imbalance Super Visor Enable	ALM						
3		IDSVEN	Off / ALM&BLK / ALM		--	Id monitoring control	ALM						
4	Parame	Line name	Specified by user		--	Line name	no-name						
5	ters	CT	1 - 20000		--	CT ratio	400						
6		EFCT	1 - 20000		--	SEF CT ratio	400						
7	Telecom.	SP.SYN.	Master / Slave		--	SP synchronization setting	Master						
8		COM.I/F	PW / OPT		--	Communication inter-face mode	--			OPT			
9		RL-MODE	Auto / Manual		--	Adjusting mode of the receiving level	Auto						
10		M.RL	1.0 - 100.0		%	The receiving level value in manually adjusting mode	20.0						
11	Appl.	MOC1	D / IEC / IEEE / US / C		--	OC1 Delay Type (if OC1EN=On)	DT						
12		MEF1	D / IEC / IEEE / US / C		--	EF1 Delay Type (if EF1EN=On)	--	D	--	--	D	--	
13		MSE1	D / IEC / IEEE / US / C		--	SEF1 Delay Type (if SE1EN=On)	--		D			D	
14		OTD	Off / On		--	The function of open terminal detection use or not	Off						
15	DIF	DIFEN	Off / On		--	DIF Enable	On						
16		DIF-FS	Off / OC / OCD / Both		--	DIF Fail Safe Enable	Off						
17	OC	OC1EN	Off / On		--	OC1 Enable	On						
18		MOC1C-IEC	NI / VI / EI / LTI		--	OC1 IEC Inverse Curve Type (if MOC1=IEC)	NI						
19		MOC1C-IEEE	MI / VI / EI		--	OC1 IEEE Inverse Curve Type (if MOC1=IEEE)	MI						
20		MOC1C-US	CO2 / CO8		--	OC1 US Inverse Curve Type (if MOC1=US)	CO2						
21		OC1R	DEF / DEP		--	OC1 Reset Characteristic (if MOCI=IEEE,orUS)	DEF						
22		OC2EN	Off / On		--	OC2 Enable	Off						
23		OC3EN	Off / On		--	OC3 Enable	Off						
24		OC4EN	Off / On		--	OC4 Enable	Off						
25	EF	EF1EN	Off / On		--	EF1 Enable	--	On	--	--	On	--	
26		MEF1C-IEC	NI / VI / EI / LTI		--	EF1 IEC Inverse Curve Type (if MEF1=IEC)	--	NI	--	--	NI	--	
27		MEF1C-IEEE	MI / VI / EI		--	EF1 IEEE Inverse Curve Type (if MEF1=IEEE)	--	MI	--	--	MI	--	
28		MEF1C-US	CO2 / CO8		--	EF1 US Inverse Curve Type (if MEF1=US)	--	CO2	--	--	CO2	--	
29		EF1R	DEF / DEP		--	EF1 Reset Characteristic (if MEFI=IEEE,orUS)	--	DEF	--	--	DEF	--	
30		EF2EN	Off / On		--	EF2 Enable	--	Off	--	--	Off	--	
31		EF3EN	Off / On		--	EF3 Enable	--	Off	--	--	Off	--	
32		EF4EN	Off / On		--	EF4 Enable	--	Off	--	--	Off	--	
33	SEF	SE1EN	Off / On		--	SEF1 Enable	--		On	--		On	
34		MSE1C-IEC	NI / VI / EI / LTI		--	SEF1 IEC Inverse Curve Type (if MSE1=IEC)	--		NI	--		NI	
35		MSE1C-IEEE	MI / VI / EI		--	SEF1 IEEE Inverse Curve Type (if MSE1=IEEE)	--		MI	--		MI	
36		MSE1C-US	CO2 / CO8		--	SEF1 US Inverse Curve Type (if MSE1=US)	--		CO2	--		CO2	
37		SE1R	DEF / DEP		--	SEF1 Reset Characteristic (if MSEI=IEEE,orUS)	--		DEF	--		DEF	
37		SE1S2	Off / On		--	SEF1 Stage 2 Timer Enable (if MSE1EN=On)	--		Off	--		Off	
38		SE2EN	Off / On		--	SEF2 Enable	--		Off	--		Off	
39		SE3EN	Off / On		--	SEF3 Enable	--		Off	--		Off	
40		SE4EN	Off / On		--	SEF4 Enable	--		Off	--		Off	
41	UC	UC1EN	Off / On		--	UC1 Enable	Off						
42		UC2EN	Off / On		--	UC2 Enable	Off						
43	Thermal	THMEN	Off / On		--	Thermal OL Enable	Off						
44		THMAEN	Off / On		--	Thermal Alarm Enable	Off						
45	BCD	BCDEN	Off / On		--	Broken Conductor Enable	Off						
46	CBF	BTC	Off / On		--	Back-trip control	Off						
47		RTC	Off / DIR / OC		--	Re-trip control	Off						
48	Transfer	TTSW1	Off / Trip / BO		--	Transfer trip Enable(CH1)	Off						
49		TTSW2	Off / Trip / BO		--	Transfer trip Enable(CH2)	Off						
50	CLP/ICD	CLEN	Off / On		--	Cold Load Protection Enable	Off						
51		CLDOEN	Off / On		--	Cold Load drop-off Enable	Off						
52		DIF-ICD	NA / BLK		--	DIF trip blocked or not by inrush current detection	NA						
53		OC-ICD	NA / BLK		--	OC/EF/SEF trip blocked or not by inrush current detection	NA						
54	DIF	DIFI1	0.50 - 10.00	0.10 - 2.00	A	DIF1 Threshold setting (if DIFEN=On)	5.00 / 1.00						
55		DIFI2	1.0 - 120.0	0.2 - 24.0	A	DIF2 Threshold setting (if DIFEN=On)	15.0 / 3.0						
56		DIFSV	50 - 100		%	Minimum operating current of DIFSV	50						
57		TIDSV	0 - 60		s	Id err detected timer	10						
58	OC	OC1	0.1 - 25.0	0.02 - 5.00	A	OC1 Threshold setting (if OC1EN=On)	5.0 / 1.00						
59		TOC1	0.00 - 300.00		s	OC1 Definite time setting (if MOC1=DT)	1.00						
60		TOC1M	0.010 - 1.500		--	OC1 Time multiplier setting (if MOC1=IEC,IEEE,US)	1.000						
61		TOC1R	0.0 - 300.0		s	OC1 Definite time reset delay (if OC1R =DEF)	0.0						
62		TOC1RM	0.010 - 1.500		--	OC1 Dependent time reset time multiplier (if OC1R=DEP)	1.000						
63		OC2	0.1 - 25.0	0.02 - 5.00	A	OC2 Threshold setting (if OC2EN=On)	25.0 / 5.00						
64		TOC2	0.00 - 300.00		s	OC2 Definite time setting (if MOC2=DT)	1.00						
65		OC3	0.1 - 250.0	0.02 - 50.00	A	OC3 Threshold setting (if OC3EN=On)	50.0 / 10.00						
66		TOC3	0.00 - 300.00		s	OC3 Definite time setting (if OC3EN=On)	1.00						
67		OC4	0.1 - 250.0	0.02 - 50.00	A	OC4 Threshold setting (if OC4EN=On)	100.0 / 20.00						
68		TOC4	0.00 - 300.00		s	OC4 Definite time setting (if OC4EN=On)	1.00						
69		OC5	0.1 - 250.0	0.02 - 50.00	A	OC5 Threshold setting	2.5 / 0.50						
70		OCD	0.4 (Fixed)	0.08 (Fixed)	A	OCD Threshold setting	--						
71		OC1-k	0.00 - 300.00		--	Configurable IDMT Curve setting of OC1.	0.00						
72		OC1-α	0.00 - 5.00		--	ditto	0.00						
73		OC1-C	0.000 - 5.000		--	ditto	0.000						
74		OC1-kr	0.00 - 300.00		--	ditto	0.00						
75		OC1-β	0.00 - 5.00		--	ditto	0.00						

No.	Name		Range 5A rating	Range 1A rating	Units	Contents	Default Setting of Relay Series(5A rating / 1A rating) Model1 100	Model1 110	Model1 120	Model2 400	Model2 410	Model2 420	User Setting
76	EF	EF1	0.1 - 25.0	0.02 - 5.00	A	EF1 Threshold setting (if EF1EN=On)	--	1.5 / 0.30	--	--	1.5 / 0.30	--	
77		TEF1	0.00 - 300.00		s	EF1 Definite time setting. (if MEF1=DT)	--	1.00	--	--	1.00	--	
78		TEF1M	0.010 - 1.500		--	EF1 Time multiplier setting (if MEF1=IEC,IEEE,US)	--	1.000	--	--	1.000	--	
79		TEF1R	0.0 - 300.0		s	EF1 Definite time reset delay (if EF1R =DEF)	--	0.0	--	--	0.0	--	
80		TEF1RM	0.010 - 1.500		--	EF1 Dependent time reset time multiplier (if EF1R=DEP)	--	1.000	--	--	1.000	--	
81		EF2	0.1 - 25.0	0.02 - 5.00	A	EF2 Threshold setting (if EF2EN=On)	--	15.0 / 3.00	--	--	15.0 / 3.00	--	
82		TEF2	0.00 - 300.00		s	EF2 Definite time setting.(if MEF2=DT)	--	1.00	--	--	1.00	--	
83		EF3	0.1 - 250.0	0.02 - 50.00	A	EF3 Threshold setting (if EF3EN=On)	--	25.0 / 5.00	--	--	25.0 / 5.00	--	
84		TEF3	0.00 - 300.00		s	EF3 Definite time setting.(if EF3EN=On)	--	1.00	--	--	1.00	--	
85		EF4	0.1 - 250.0	0.02 - 50.00	A	EF4 Threshold setting (if EF4EN=On)	--	50.0 / 10.00	--	--	50.0 / 10.00	--	
86		TEF4	0.00 - 300.00		s	EF4 Definite time setting.(if EF4EN=On)	--	1.00	--	--	1.00	--	
87		EF1-k	0.00 - 300.00		--	Configurable IDMT Curve setting of EF1.	--	0.00	--	--	0.00	--	
88		EF1-α	0.00 - 5.00		--	ditto	--	0.00	--	--	0.00	--	
89		EF1-C	0.000 - 5.000		--	ditto	--	0.000	--	--	0.000	--	
90		EF1-kr	0.00 - 300.00		--	ditto	--	0.00	--	--	0.00	--	
91		EF1-β	0.00 - 5.00		--	ditto	--	0.00	--	--	0.00	--	
92	SEF	SE1	0.01 - 1.00	0.002 - 0.200	A	SEF1 Threshold setting (if SE1EN=On)	--		0.05 / 0.010	--		0.05 / 0.010	
93		TSE1	0.00 - 300.00		s	SEF1 Definite time setting.(if MSE1=DT)	--		1.00	--		1.00	
94		TSE1M	0.010 - 1.500		--	SEF1 Time multiplier setting (if MSE1=IEC,IEEE,US)	--		1.000	--		1.000	
95		TSE1R	0.0 - 300.0		s	SEF1 Definite time reset delay (if SE1R =DEF)	--		0.0	--		0.0	
96		TSE1RM	0.010 - 1.500		--	SEF1 Dependent time reset time multiplier (if SE1R=DEP)	--		1.000	--		1.000	
96		TS1S2	0.00-300.00		s	SEF1 Stage 2 definite timer settings (if SE1EN=On and SE1S2=On)	--		1.00	--		1.00	
97		SE2	0.01 - 1.00	0.002 - 0.200	A	SEF2 Threshold setting (if SE2EN=On)	--		0.05 / 0.010	--		0.05 / 0.010	
98		TSE2	0.00 - 300.00		s	SEF2 Definite time setting.(if MSE2=DT)	--		1.00	--		1.00	
99		SE3	0.01 - 1.00	0.002 - 0.200	A	SEF3 Threshold setting (if SE3EN=On)	--		0.05 / 0.010	--		0.05 / 0.010	
100		TSE3	0.00 - 300.00		s	SEF3 Definite time setting (if SE3EN=On)	--		1.00	--		1.00	
101		SE4	0.01 - 1.00	0.002 - 0.200	A	SEF4 Threshold setting (if SE4EN=On)	--		0.05 / 0.010	--		0.05 / 0.010	
102		TSE4	0.00 - 300.00		s	SEF4 Definite time setting.(if SE4EN=On)	--		1.00	--		1.00	
103		SE1-k	0.00 - 300.00		--	Configurable IDMT Curve setting of SEF1.	--		0.00	--		0.00	
104		SE1-α	0.00 - 5.00		--	ditto	--		0.00	--		0.00	
105		SE1-C	0.000 - 5.000		--	ditto	--		0.00	--		0.00	
106		SE1-kr	0.00 - 300.00		--	ditto	--		0.00	--		0.00	
107		SE1-β	0.00 - 5.00		--	ditto	--(0.00)		0.00	--(0.00)		0.00	
108	UC	UC1	0.5 - 10.0	0.10 - 2.00	A	UC1 Threshold setting (if UC1EN=On)	1.0 / 0.20						
109		TUC1	0.00 - 300.00		s	UC1 Definite time setting (if UC1EN=On)	1.00						
110		UC2	0.5 - 10.0	0.10 - 2.00	A	UC2 Threshold setting (if UC2EN=On)	2.0 / 0.40						
111		TUC2	0.00 - 300.00		s	UC2 Definite time setting (if UC2EN=On)	1.00						
112	Thermal	THM	2.0 - 10.0	0.40 - 2.00	A	Thermal overload setting (if OLTEN=On)	5.0 / 1.00						
113		THMIP	0.0 - 5.0	0.00 - 1.00	A	Pre Current value (if OLTEN=On)	0.0 / 0.00						
114		TTHM	0.5 - 500.0		min	Thermal Time Constant (if OLTEN=On)	10.0						
115		THMA	50 - 99		%	Thermal alarm setting (if OLTEN =On & ALTEN=On)	80						
116	BCD	BCD	0.10 - 1.00		--	Broken Conductor Threshold setting (if BCDEN=On)	0.20						
117		TBCD	0.00 - 300.00		s	Broken Conductor Definite time setting. (if BCDEN=On)	1.00						
118	CBF	CBF	0.5 - 10.0	0.10 - 2.00	A	CBF Threshold setting (if CBFEN=On)	2.5 / 0.50						
119		TBTC	0.00 - 300.00		s	Back trip Definite time setting	0.50						
120		TRTC	0.00 - 300.00		s	Re-trip Definite time setting	0.40						
121	CLP/ICD	OC1	0.1 - 25.0	0.02 - 5.00	A	OC1 Threshold setting in CLP mode.	10.0 / 2.00						
122		OC2	0.1 - 25.0	0.02 - 5.00	A	OC2 Threshold setting in CLP mode.	25.0 / 5.00						
123		OC3	0.1 - 250.0	0.02 - 50.00	A	OC3 Threshold setting in CLP mode.	100.0 / 20.00						
124		OC4	0.1 - 250.0	0.02 - 50.00	A	OC4 Threshold setting in CLP mode.	200.0 / 40.00						
125		OC5	0.1 - 250.0	0.02 - 50.00	A	OC5 Threshold setting in CLP mode.	20.0 / 4.00						
126		EF1	0.1 - 25.0	0.02 - 5.00	A	EF1 Threshold setting in CLP mode.	--	10.0 / 2.00	--	--	10.0 / 2.00	--	
127		EF2	0.1 - 25.0	0.02 - 5.00	A	EF2 Threshold setting in CLP mode.	--	25.0 / 5.00	--	--	25.0 / 5.00	--	
128		EF3	0.1 - 250.0	0.02 - 50.00	A	EF3 Threshold setting in CLP mode.	--	100.0 / 20.00	--	--	100.0 / 20.00	--	
129		EF4	0.1 - 250.0	0.02 - 50.00	A	EF4 Threshold setting in CLP mode.	--	200.0 / 40.00	--	--	200.0 / 40.00	--	
130		SE1	0.01 - 1.00	0.002 - 0.200	A	SEF1 Threshold setting in CLP mode.	--		0.10 / 0.020	--		0.10 / 0.020	
131		SE2	0.01 - 1.00	0.002 - 0.200	A	SEF2 Threshold setting in CLP mode.	--		0.10 / 0.020	--		0.10 / 0.020	
132		SE3	0.01 - 1.00	0.002 - 0.200	A	SEF3 Threshold setting in CLP mode.	--		0.10 / 0.020	--		0.10 / 0.020	
133		SE4	0.01 - 1.00	0.002 - 0.200	A	SEF4 Threshold setting in CLP mode.	--		0.10 / 0.020	--		0.10 / 0.020	
134		BCD	0. 1 0 - 1.00		--	Broken Conductor Threshold setting in CLP mode.	0.40						
135		TCLE	0 - 10000		s	Cold load enable timer (if CLEN=On)	100						
136		TCLR	0 - 10000		s	Cold load reset timer (if CLEN=On)	100						
137		ICLDO	0.5 - 10.0	0.10 - 2.00	A	Cold load drop-out threshold setting (if CLDOEN=On)	2.5 / 0.50						
138		TCLDO	0.00 - 100.00		s	Cold load drop-out timer (if CLDOEN=1)	0.00						
139		ICD-2f	10 - 50		%	Sensitivity of 2f	15						
140		ICDOC	0.5 - 25.0	0.10 - 5.00	A	Threshold of fundamental current	0.5 / 0.10						

Setting 2

No.	Name		Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)						User Setting
							Model1			Model2			
			5A rating	1A rating			100	110	120	400	410	420	
1	Passwd	Setting Password	-		--	Password for Setting menu	0000						
2	Notes	Plant name	-		--	Plant name	no-name						
3	Des.	Description	-		--	Description	no-data						
4	Com.	HDLC	1 - 32		--	Address for RSM100	1						
5		IEC	0 - 254		--	Address for IEC103	2						
6		Protocol	HDLC / IEC		--	Switch for communications	HDLC						
7		232C	9.6 / 19.2 / 57.6		--	ditto	9.6						
8		IECBR	9.6 / 19.2		--	ditto	19.2						
9		IECBLK	Normal / Blocked		--	ditto	Normal						
10	Record	BITRN	0 - 128		--	Number of bi-trigger (on/off) events	100						
11		Time	0.1 - 3.0		s	Record time	2.0						
12		OC	0.1 - 250.0	0.02 - 50.00	A	OC	10.0 / 2.00						
13		EF	0.1 - 250.0	0.02 - 50.00	A	EF	--	3.0 / 0.60	--	--	3.0 / 0.60	--	
14		SEF	0.01 - 1.00	0.002 - 0.200	A	SEF	--		1.00 / 0.200	--		1.00 / 0.200	
15		Trip	Off / On		--	Disturbance trigger Trip	On						
16		OC	Off / On		--	Disturbance trigger OC	On						
17		EF	Off / On		--	Disturbance trigger EF	--	On	--	--	On	--	
18		SEF	Off / On		--	Disturbance trigger SEF	--		On	--		On	
19		SIG1	0 - 3071		--	Disturbance record binary signal #1	Refer to the "GRL150(Disturbance)" sheet.						
20		SIG2	0 - 3071		--	Disturbance record binary signal #2	ditto						
21		SIG3	0 - 3071		--	Disturbance record binary signal #3	ditto						
22		SIG4	0 - 3071		--	Disturbance record binary signal #4	ditto						
23		SIG5	0 - 3071		--	Disturbance record binary signal #5	ditto						
24		SIG6	0 - 3071		--	Disturbance record binary signal #6	ditto						
25		SIG7	0 - 3071		--	Disturbance record binary signal #7	ditto						
26		SIG8	0 - 3071		--	Disturbance record binary signal #8	ditto						
27		SIG9	0 - 3071		--	Disturbance record binary signal #9	ditto						
28		SIG10	0 - 3071		--	Disturbance record binary signal #10	ditto						
29		SIG11	0 - 3071		--	Disturbance record binary signal #11	ditto						
30		SIG12	0 - 3071		--	Disturbance record binary signal #12	ditto						
31		SIG13	0 - 3071		--	Disturbance record binary signal #13	ditto						
32		SIG14	0 - 3071		--	Disturbance record binary signal #14	ditto						
33		SIG15	0 - 3071		--	Disturbance record binary signal #15	ditto						
34		SIG16	0 - 3071		--	Disturbance record binary signal #16	ditto						
35		SIG17	0 - 3071		--	Disturbance record binary signal #17	ditto						
36		SIG18	0 - 3071		--	Disturbance record binary signal #18	ditto						
37		SIG19	0 - 3071		--	Disturbance record binary signal #19	ditto						
38		SIG20	0 - 3071		--	Disturbance record binary signal #20	ditto						
39		SIG21	0 - 3071		--	Disturbance record binary signal #21	ditto						
40		SIG22	0 - 3071		--	Disturbance record binary signal #22	ditto						
41		SIG23	0 - 3071		--	Disturbance record binary signal #23	ditto						
42		SIG24	0 - 3071		--	Disturbance record binary signal #24	ditto						
43		SIG25	0 - 3071		--	Disturbance record binary signal #25	ditto						
44		SIG26	0 - 3071		--	Disturbance record binary signal #26	ditto						
45		SIG27	0 - 3071		--	Disturbance record binary signal #27	ditto						
46		SIG28	0 - 3071		--	Disturbance record binary signal #28	ditto						
47		SIG29	0 - 3071		--	Disturbance record binary signal #29	ditto						
48		SIG30	0 - 3071		--	Disturbance record binary signal #30	ditto						
49		SIG31	0 - 3071		--	Disturbance record binary signal #31	ditto						
50		SIG32	0 - 3071		--	Disturbance record binary signal #32	ditto						
51		TCSPEN	Off / On / Opt-On		--	Trip Circuit Supervision Enable	Off						
52		CBSMEN	Off / On		--	CB condition super visor enable	Off						
53		DSSMEN	Off / On		--	DS condition super visor enable	Off						
54		TCAEN	Off / On		--	Trip CounterAlarm Enable	Off						
55		ΣI^yAEN	Off / On		--	Σ I^y Alarm Enable	Off						
56		OPTAEN	Off / On		--	Operate Time Alarm Enable	Off						
57		FERAEN	Off / On		--	Frame error rate alarm enable	Off						
58		TCALM	1 - 10000		--	Trip Count Alarm Threshold	10000						
59		ΣI^yALM	10 - 10000		E6	Σ I^y Alarm	10000						
60		YVALUE	1.0 - 2.0		--	Y value	2.0						
61		OPTALM	100 - 5000		ms	Operate Time Alarm Threshold	1000						
62		CF-PER	1 - 60		s	CF period threshold	10						
63		FERALM	0.0 - 50.0		%		20.0						

No.	Name			Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)						User Setting
								Model1			Model2			
				5A rating	1A rating			100	110	120	400	410	420	
64	Status	Display		Prim / Second.		--	metering	Prim.						
65		Time sync.		Off / BI / RS / IE / IR		--	time sync source	Off						
66		GMT		-12 - +12		hrs	time zone	--			0			
67	Binary	BI1	BI1PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
68	Input		BI1DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
69			BI1SNS	Norm / Inv		--	Binary Input Sense	Norm						
70		BI2	BI2PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
71			BI2DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
72			BI2SNS	Norm / Inv		--	Binary Input Sense	Norm						
73		BI3	BI3PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
74			BI3DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
75			BI3SNS	Norm / Inv		--	Binary Input Sense	Norm						
76		BI4	BI4PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
77			BI4DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
78			BI4SNS	Norm / Inv		--	Binary Input Sense	Norm						
79		BI5	BI5PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
80			BI5DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
81			BI5SNS	Norm / Inv		--	Binary Input Sense	Norm						
82		BI6	BI6PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
83			BI6DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
84			BI6SNS	Norm / Inv		--	Binary Input Sense	Norm						
85		BI7	BI7PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
86			BI7DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
87			BI7SNS	Norm / Inv		--	Binary Input Sense	Norm						
88		BI8	BI8PUD	0.00 - 300.00		s	Binary Input Pick-up delay	0.00						
89			BI8DOD	0.00 - 300.00		s	Binary Input Drop-off delay	0.00						
90			BI8SNS	Norm / Inv		--	Binary Input Sense	Norm						
91		Alarm1 Text		Specified by user		--	Alarm1 Text	ALARM1						
92		Alarm2 Text		Specified by user		--	Alarm2 Text	ALARM2						
93		Alarm3 Text		Specified by user		--	Alarm3 Text	ALARM3						
94		Alarm4 Text		Specified by user		--	Alarm4 Text	ALARM4						
95	LED	LED1	Logic	OR / AND		--	LED Logic Gate Type	OR						
96			Reset	Inst / Latch		--	LED Reset operation	Inst						
97			In #1	0 - 3071		--	LED Functions	0						
98			In #2	0 - 3071		--	ditto	0						
99			In #3	0 - 3071		--	ditto	0						
100			In #4	0 - 3071		--	ditto	0						
101		LED2	Logic	OR / AND		--	LED Logic Gate Type	OR						
102			Reset	Inst / Latch		--	LED Reset operation	Inst						
103			In #1	0 - 3071		--	LED Functions	0						
104			In #2	0 - 3071		--	ditto	0						
105			In #3	0 - 3071		--	ditto	0						
106			In #4	0 - 3071		--	ditto	0						
107		LED3	Logic	OR / AND		--	LED Logic Gate Type	OR						
108			Reset	Inst / Latch		--	LED Reset operation	Inst						
109			In #1	0 - 3071		--	LED Functions	0						
110			In #2	0 - 3071		--	ditto	0						
111			In #3	0 - 3071		--	ditto	0						
112			In #4	0 - 3071		--	ditto	0						
113		IND1	Reset	Inst / Latch		--	IND Reset operation	Inst						
114			BIT1	0 - 3071		--	Virtual LED	0						
115			BIT2	0 - 3071		--	ditto	0						
116			BIT3	0 - 3071		--	ditto	0						
117			BIT4	0 - 3071		--	ditto	0						
118			BIT5	0 - 3071		--	ditto	0						
119			BIT6	0 - 3071		--	ditto	0						
120			BIT7	0 - 3071		--	ditto	0						
121			BIT8	0 - 3071		--	ditto	0						
122		IND2	Reset	Inst / Latch		--	IND Reset operation	Inst						
123			BIT1	0 - 3071		--	Virtual LED	0						
124			BIT2	0 - 3071		--	ditto	0						
125			BIT3	0 - 3071		--	ditto	0						
126			BIT4	0 - 3071		--	ditto	0						
127			BIT5	0 - 3071		--	ditto	0						
128			BIT6	0 - 3071		--	ditto	0						
129			BIT7	0 - 3071		--	ditto	0						
130			BIT8	0 - 3071		--	ditto	0						

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
###	CB N/O CONT	X				[528]BI1 COM T									X
###	CB N/C CONT	X				[529]BI2 COM T									X
###	DS N/O CONT	X				[530]BI3 COM T									X
###	DS N/C CONT	X				[531]BI4 COM T									X
###															
###															
###															
###															
###															
###															
###															
###	EXT CB CLOSE	X				[532]BI5 COM T									X
###	TC FAIL														
###															
###															
###	IND.RESET	X				[535]BI8 COM T									X
###	PROT BLOCK														
###	DIF BLOCK														
###	TR1 BLOCK														
###	TR2 BLOCK														
###	OC1 BLOCK														
###	OC2 BLOCK														
###	OC3 BLOCK														
###	OC4 BLOCK														
###	EF1 BLOCK														
###	EF2 BLOCK														
###	EF3 BLOCK														
###	EF4 BLOCK														
###	SEF1 BLOCK														
###	SEF2 BLOCK														
###	SEF3 BLOCK														
###	SEF4 BLOCK														
###	UC1 BLOCK														
###	UC2 BLOCK														
###	CBF BLOCK														
###															
###	THM BLOCK														
###	THMA BLOCK														
###	BCD BLOCK														
###															
###															
###															
###															
###															
###															
###															
###															
###															
###	DIF-A FS	X				[264]DIFFS OP									X
###	DIF-B FS	X				[264]DIFFS OP									X
###	DIF-C FS	X				[264]DIFFS OP									X
###	R.DATA ZERO														
###	EXT TRIP-A														
###	EXT TRIP-B														
###	EXT TRIP-C														
###	EXT TRIP														
###															
###															
###															
###															
###	CBF INIT-A														
###	CBF INIT-B														
###	CBF INIT-C														
###	CBF INIT	X				[348]GEN.TRIP									X
###	UC1-A DO	X				[200]UCDO-A									X
###	UC1-B DO	X				[201]UCDO-B									X
###	UC1-C DO	X				[202]UCDO-C									X

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
1603															
1604	UC2-A DO	X				[200]UCDO-A									X
1605	UC2-B DO	X				[201]UCDO-B									X
1606	UC2-C DO	X				[202]UCDO-C									X
1607															
1608															
1609															
1610															
1611															
1612															
1613															
1614															
1615															
1616															
1617															
1618															
1619															
1620	OC1 INST TP														
1621	OC2 INST TP														
1622	OC3 INST TP														
1623	OC4 INST TP														
1624	EF1 INST TP														
1625	EF2 INST TP														
1626	EF3 INST TP														
1627	EF4 INST TP														
1628	SEF1 INST TP														
1629	SEF2 INST TP														
1630	SEF3 INST TP														
1631	SEF4 INST TP														
1632	UC1 INST TP														
1633	UC2 INST TP														
1634															
1635															
1636															
1637															
1638															
1639															
1640															
1641															
1642															
1643															
1644															
1645															
1646															
1647															
1648	TR1-R1														
1649	TR2-R1														
1650	L.TEST-R1	X				[1104]SUB_COM1-R1									X
1651	I.LINK-R1	X				[1092]COM5-R1									X
1652															
1653															
1654															
1655															
1656															
1657															
1658															
1659															
1660															
1661															
1662															
1663															
1664	TP-A DELAY	X				[361]GEN.TP-A				X			60	ms	
1665	TP-B DELAY	X				[362]GEN.TP-B				X			60	ms	
1666	TP-C DELAY	X				[363]GEN.TP-C				X			60	ms	
1667	TP-N DELAY	X				[364]GEN.TP-N				X			60	ms	
1668															
1669															
1670															

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
1671															
1672	TP DELAY	X				[360]GEN.TP				X			60	ms	
1673															
1674															
1675															
1676															
1677															
1678															
1679															
1680	DIF-A IC BLK	X				[373]ICD + [1099]COM4-R1 UF									X
1681	DIF-B IC BLK	X				[373]ICD + [1099]COM4-R1 UF									X
1682	DIF-C IC BLK	X				[373]ICD + [1099]COM4-R1 UF									X
1683	OC IC BLK	X				[373]ICD									X
1684															
1685															
1686															
1687															
1688															
1689															
1690															
1691															
1692															
1693															
1694															
1695															
1696															
1697															
1698															
1699															
1700															
1701															
1702															
1703															
1704															
1705															
1706															
1707															
1708															
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1711															
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1714															
1715															
1716															
1717															
1718															
1719															
1720															
1721															
1722															
1723															
1724															
1725															
1726															
1727															
1728															
1729															
1730															
1731															
1732															
1733															
1734															
:															
:															
2038															
2039															
2040															

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2041															
2042															
2043															
2044															
2045															
2046															
2047															
2048	COM1-S														
2049	COM2-S														
2050	COM3-S														
2051	COM4-S	X				[374]ICD_BLK-S									X
2052	COM5-S	X				[388]I.LINK									X
2053															
2054															
2055															
2056	SUB_COM1-S	X				[390]LOCAL_TEST									X
2057	SUB_COM2-S														
2058	SUB_COM3-S														
2059	SUB_COM4-S														
2060	SUB_COM5-S														
2061															
2062															
2063															
2064	SUB2_COM1-S														
2065	SUB2_COM2-S														
2066	SUB2_COM3-S														
2067	SUB2_COM4-S														
2068	SUB2_COM5-S														
2069	SUB2_COM6-S														
2070	SUB2_COM7-S														
2071	SUB2_COM8-S														
2072	SUB2_COM9-S														
2073	SUB2_COM10-S														
2074	SUB2_COM11-S														
2075	SUB2_COM12-S														
2076															
2077															
2078															
2079															
2080															
2081															
2082															
2083															
2084															
2085															
2086															
2087															
2088															
2089															
2090															
2091															
2092															
2093															
2094															
2095															
2096															
2097															
2098															
2099															
2100															
2101															
2102															
2103															
2104															
⋮															
⋮															
2548															
2549															
2550															

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2551															
2552															
2553															
2554															
2555															
2556															
2557															
2558															
2559															
2560	TP1	X				[348]GEN.TRIP									X
2561	TP2	X				[348]GEN.TRIP									X
2562															
2563															
2564															
2565															
2566															
2567															
2568															
2569															
2570															
2571															
2572															
2573															
2574															
2575															
2576															
2577															
2578															
2579															
2580															
2581															
2582															
2583															
2584															
2585															
2586															
2587															
2588															
2589															
2590															
2591															
2592															
2593															
2594															
2595															
2596															
2597															
2598															
2599															
2600															
2601															
2602															
2603															
2604															
2605															
2606															
2607															
2608															
2609															
2610															
2611															
2612															
2613															
2614															
2615															
2616															
2617															
2618															
2619															
2620															

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2621															
2622															
2623															
2624	F.RECORD1														
2625	F.RECORD2														
2626	F.RECORD3														
2627	F.RECORD4														
2628															
2629															
2630															
2631															
2632	D.RECORD1														
2633	D.RECORD2														
2634	D.RECORD3														
2635	D.RECORD4														
2636															
2637															
2638															
2639															
2640	SET.GROUP1														
2641	SET.GROUP2														
2642	SET.GROUP3														
2643	SET.GROUP4														
2644															
2645															
2646															
2647															
2648	SYNC_CLOCK														
2649															
2650															
2651															
2652	ALARM1														
2653	ALARM2														
2654	ALARM3														
2655	ALARM4														
2656	CON_TPMD1														
2657	CON_TPMD2														
2658	CON_TPMD3														
2659	CON_TPMD4														
2660	CON_TPMD5														
2661	CON_TPMD6														
2662	CON_TPMD7														
2663	CON_TPMD8														
2664															
2665															
2666															
2667															
2668															
2669															
2670															
2671															
2672															
2673															
2674															
2675															
2676															
2677															
2678															
2679															
2680															
2681															
2682															
2683															
2684	ARC_COM_RECV														
2685	TEL_COM_RECV														
2686	PROT_COM_RECV														
2687															
2688	TPLED_RST_RCV														
2689	ALMLED_RST_RCV														
2690	TPALM_RST_RCV														

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2691															
2692															
:															
:															
2813															
2814															
2815															
2816	TEMP001														
2817	TEMP002														
2818	TEMP003														
2819	TEMP004														
2820	TEMP005														
2821	TEMP006														
2822	TEMP007														
2823	TEMP008														
2824	TEMP009														
2825	TEMP010														
2826	TEMP011														
2827	TEMP012														
2828	TEMP013														
2829	TEMP014														
2830	TEMP015														
2831	TEMP016														
2832	TEMP017														
2833	TEMP018														
2834	TEMP019														
2835	TEMP020														
2836	TEMP021														
2837	TEMP022														
2838	TEMP023														
2839	TEMP024														
2840	TEMP025														
2841	TEMP026														
2842	TEMP027														
2843	TEMP028														
2844	TEMP029														
2845	TEMP030														
2846	TEMP031														
2847	TEMP032														
2848	TEMP033														
2849	TEMP034														
2850	TEMP035														
2851	TEMP036														
2852	TEMP037														
2853	TEMP038														
2854	TEMP039														
2855	TEMP040														
2856	TEMP041														
2857	TEMP042														
2858	TEMP043														
2859	TEMP044														
2860	TEMP045														
2861	TEMP046														
2862	TEMP047														
2863	TEMP048														
2864	TEMP049														
2865	TEMP050														
2866	TEMP051														
2867	TEMP052														
2868	TEMP053														
2869	TEMP054														
2870	TEMP055														
2871	TEMP056														
2872	TEMP057														
2873	TEMP058														
2874	TEMP059														
2875	TEMP060														

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2876	TEMP061														
2877	TEMP062														
2878	TEMP063														
2879	TEMP064														
2880	TEMP065														
2881	TEMP066														
2882	TEMP067														
2883	TEMP068														
2884	TEMP069														
2885	TEMP070														
2886	TEMP071														
2887	TEMP072														
2888	TEMP073														
2889	TEMP074														
2890	TEMP075														
2891	TEMP076														
2892	TEMP077														
2893	TEMP078														
2894	TEMP079														
2895	TEMP080														
2896	TEMP081														
2897	TEMP082														
2898	TEMP083														
2899	TEMP084														
2900	TEMP085														
2901	TEMP086														
2902	TEMP087														
2903	TEMP088														
2904	TEMP089														
2905	TEMP090														
2906	TEMP091														
2907	TEMP092														
2908	TEMP093														
2909	TEMP094														
2910	TEMP095														
2911	TEMP096														
2912	TEMP097														
2913	TEMP098														
2914	TEMP099														
2915	TEMP100														
2916	TEMP101														
2917	TEMP102														
2918	TEMP103														
2919	TEMP104														
2920	TEMP105														
2921	TEMP106														
2922	TEMP107														
2923	TEMP108														
2924	TEMP109														
2925	TEMP110														
2926	TEMP111														
2927	TEMP112														
2928	TEMP113														
2929	TEMP114														
2930	TEMP115														
2931	TEMP116														
2932	TEMP117														
2933	TEMP118														
2934	TEMP119														
2935	TEMP120														
2936	TEMP121														
2937	TEMP122														
2938	TEMP123														
2939	TEMP124														
2940	TEMP125														
2941	TEMP126														
2942	TEMP127														
2943	TEMP128														
2944	TEMP129														
2945	TEMP130														

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
2946	TEMP131														
2947	TEMP132														
2948	TEMP133														
2949	TEMP134														
2950	TEMP135														
2951	TEMP136														
2952	TEMP137														
2953	TEMP138														
2954	TEMP139														
2955	TEMP140														
2956	TEMP141														
2957	TEMP142														
2958	TEMP143														
2959	TEMP144														
2960	TEMP145														
2961	TEMP146														
2962	TEMP147														
2963	TEMP148														
2964	TEMP149														
2965	TEMP150														
2966	TEMP151														
2967	TEMP152														
2968	TEMP153														
2969	TEMP154														
2970	TEMP155														
2971	TEMP156														
2972	TEMP157														
2973	TEMP158														
2974	TEMP159														
2975	TEMP160														
2976	TEMP161														
2977	TEMP162														
2978	TEMP163														
2979	TEMP164														
2980	TEMP165														
2981	TEMP166														
2982	TEMP167														
2983	TEMP168														
2984	TEMP169														
2985	TEMP170														
2986	TEMP171														
2987	TEMP172														
2988	TEMP173														
2989	TEMP174														
2990	TEMP175														
2991	TEMP176														
2992	TEMP177														
2993	TEMP178														
2994	TEMP179														
2995	TEMP180														
2996	TEMP181														
2997	TEMP182														
2998	TEMP183														
2999	TEMP184														
3000	TEMP185														
3001	TEMP186														
3002	TEMP187														
3003	TEMP188														
3004	TEMP189														
3005	TEMP190														
3006	TEMP191														
3007	TEMP192														
3008	TEMP193														
3009	TEMP194														
3010	TEMP195														
3011	TEMP196														
3012	TEMP197														
3013	TEMP198														
3014	TEMP199														
3015	TEMP200														

PLC Default setting

Output		Timing				Logic expression	Delay Time / Flip Flop								
		Cycle					Flip Flop			Timer					
№	Signal	30	90	User	Turn	All models	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
3016	TEMP201														
3017	TEMP202														
3018	TEMP203														
3019	TEMP204														
3020	TEMP205														
3021	TEMP206														
3022	TEMP207														
3023	TEMP208														
3024	TEMP209														
3025	TEMP210														
3026	TEMP211														
3027	TEMP212														
3028	TEMP213														
3029	TEMP214														
3030	TEMP215														
3031	TEMP216														
3032	TEMP217														
3033	TEMP218														
3034	TEMP219														
3035	TEMP220														
3036	TEMP221														
3037	TEMP222														
3038	TEMP223														
3039	TEMP224														
3040	TEMP225														
3041	TEMP226														
3042	TEMP227														
3043	TEMP228														
3044	TEMP229														
3045	TEMP230														
3046	TEMP231														
3047	TEMP232														
3048	TEMP233														
3049	TEMP234														
3050	TEMP235														
3051	TEMP236														
3052	TEMP237														
3053	TEMP238														
3054	TEMP239														
3055	TEMP240														
3056	TEMP241														
3057	TEMP242														
3058	TEMP243														
3059	TEMP244														
3060	TEMP245														
3061	TEMP246														
3062	TEMP247														
3063	TEMP248														
3064	TEMP249														
3065	TEMP250														
3066	TEMP251														
3067	TEMP252														
3068	TEMP253														
3069	TEMP254														
3070	TEMP255														
3071	TEMP256														

Event record default setting

No.	Name	Range	Unit	Contents	Default setting			User setting		
					Sig. NO.	Signal name	type			
1	EV1	0 - 3071	—	Event record signal	348	GEN.TRIP	On/Off			
2	EV2	0 - 3071	—	ditto	353	GEN.ALARM	On/Off			
3	EV3	0 - 3071	—	ditto	256	DIF_TRIP	On/Off			
4	EV4	0 - 3071	—	ditto	272	OC1_TRIP	On/Off			
5	EV5	0 - 3071	—	ditto	276	OC2_TRIP	On/Off			
6	EV6	0 - 3071	—	ditto	280	OC3_TRIP	On/Off			
7	EV7	0 - 3071	—	ditto	284	OC4_ALARM	On/Off			
8	EV8	0 - 3071	—	ditto	292	EF1_TRIP	On/Off			
9	EV9	0 - 3071	—	ditto	293	EF2_TRIP	On/Off			
10	EV10	0 - 3071	—	ditto	294	EF3_TRIP	On/Off			
11	EV11	0 - 3071	—	ditto	295	EF4_ALARM	On/Off			
12	EV12	0 - 3071	—	ditto	300	SEF1_TRIP	On/Off			
13	EV13	0 - 3071	—	ditto	301	SEF1-S2_TRIP	On/Off			
14	EV14	0 - 3071	—	ditto	302	SEF2_TRIP	On/Off			
15	EV15	0 - 3071	—	ditto	303	SEF3_TRIP	On/Off			
16	EV16	0 - 3071	—	ditto	304	SEF4_ALARM	On/Off			
17	EV17	0 - 3071	—	ditto	308	UC1_TRIP	On/Off			
18	EV18	0 - 3071	—	ditto	312	UC2_ALARM	On/Off			
19	EV19	0 - 3071	—	ditto	320	THM_ALARM	On/Off			
20	EV20	0 - 3071	—	ditto	321	THM_TRIP	On/Off			
21	EV21	0 - 3071	—	ditto	322	BCD_TRIP	On/Off			
22	EV22	0 - 3071	—	ditto	328	CBF_RETRIP	On/Off			
23	EV23	0 - 3071	—	ditto	332	CBF_TRIP	On/Off			
24	EV24	0 - 3071	—	ditto	340	TR1_TRIP	On/Off			
25	EV25	0 - 3071	—	ditto	341	INTER_TRIP1	On/Off			
26	EV26	0 - 3071	—	ditto	342	TR2_TRIP	On/Off			
27	EV27	0 - 3071	—	ditto	343	INTER_TRIP2	On/Off			
28	EV28	0 - 3071	—	ditto	0		On/Off			
29	EV29	0 - 3071	—	ditto	0		On/Off			
30	EV30	0 - 3071	—	ditto	0		On/Off			
31	EV31	0 - 3071	—	ditto	0		On/Off			
32	EV32	0 - 3071	—	ditto	0		On/Off			
33	EV33	0 - 3071	—	ditto	48	DIF-A	On/Off			
34	EV34	0 - 3071	—	ditto	49	DIF-B	On/Off			
35	EV35	0 - 3071	—	ditto	50	DIF-C	On/Off			
36	EV36	0 - 3071	—	ditto	368	CLP_STATE0	On/Off			
37	EV37	0 - 3071	—	ditto	369	CLP_STATE1	On/Off			
38	EV38	0 - 3071	—	ditto	370	CLP_STATE2	On/Off			
39	EV39	0 - 3071	—	ditto	371	CLP_STATE3	On/Off			
40	EV40	0 - 3071	—	ditto	0		On/Off			
41	EV41	0 - 3071	—	ditto	512	BI1_COMMAND	On/Off			
42	EV42	0 - 3071	—	ditto	513	BI2_COMMAND	On/Off			
43	EV43	0 - 3071	—	ditto	514	BI3_COMMAND	On/Off			
44	EV44	0 - 3071	—	ditto	515	BI4_COMMAND	On/Off			
45	EV45	0 - 3071	—	ditto	516	BI5_COMMAND	On/Off			
46	EV46	0 - 3071	—	ditto	517	BI6_COMMAND	On/Off			
47	EV47	0 - 3071	—	ditto	518	BI7_COMMAND	On/Off			
48	EV48	0 - 3071	—	ditto	519	BI8_COMMAND	On/Off			
49	EV49	0 - 3071	—	ditto	0		On/Off			
50	EV50	0 - 3071	—	ditto	0		On/Off			
51	EV51	0 - 3071	—	ditto	0		On/Off			
52	EV52	0 - 3071	—	ditto	0		On/Off			
53	EV53	0 - 3071	—	ditto	0		On/Off			
54	EV54	0 - 3071	—	ditto	0		On/Off			
55	EV55	0 - 3071	—	ditto	0		On/Off			
56	EV56	0 - 3071	—	ditto	0		On/Off			
57	EV57	0 - 3071	—	ditto	0		On/Off			
58	EV58	0 - 3071	—	ditto	0		On/Off			
59	EV59	0 - 3071	—	ditto	0		On/Off			
60	EV60	0 - 3071	—	ditto	0		On/Off			
61	EV61	0 - 3071	—	ditto	0		On/Off			
62	EV62	0 - 3071	—	ditto	0		On/Off			
63	EV63	0 - 3071	—	ditto	0		On/Off			
64	EV64	0 - 3071	—	ditto	0		On/Off			

Event record default setting

No.	Name	Range	Unit	Contents	Default setting			User setting		
					Sig. NO.	Signal name	type			
65	EV65	0 - 3071	–	ditto	0		On/Off			
66	EV66	0 - 3071	–	ditto	0		On/Off			
67	EV67	0 - 3071	–	ditto	0		On/Off			
68	EV68	0 - 3071	–	ditto	0		On/Off			
69	EV69	0 - 3071	–	ditto	0		On/Off			
70	EV70	0 - 3071	–	ditto	0		On/Off			
71	EV71	0 - 3071	–	ditto	1345	RELAY_FAIL	On/Off			
72	EV72	0 - 3071	–	ditto	1346	RELAY_FAIL-A	On/Off			
73	EV73	0 - 3071	–	ditto	1348	SUM_err	On/Off			
74	EV74	0 - 3071	–	ditto	1350	SRAM_err	On/Off			
75	EV75	0 - 3071	–	ditto	1351	BU-RAM_err	On/Off			
76	EV76	0 - 3071	–	ditto	1353	EEPROM_err	On/Off			
77	EV77	0 - 3071	–	ditto	1354	A/D_err	On/Off			
78	EV78	0 - 3071	–	ditto	1356	CT_err	On/Off			
79	EV79	0 - 3071	–	ditto	1358	DC_err	On/Off			
80	EV80	0 - 3071	–	ditto	1359	TC_fail	On/Off			
81	EV81	0 - 3071	–	ditto	1360	CB_err	On/Off			
82	EV82	0 - 3071	–	ditto	1361	TP_COUNT_ALM	On/Off			
83	EV83	0 - 3071	–	ditto	1362	OP_time_ALM	On/Off			
84	EV84	0 - 3071	–	ditto	1363	Iy_ALM	On/Off			
85	EV85	0 - 3071	–	ditto	1366	Id_err	On/Off			
86	EV86	0 - 3071	–	ditto	1369	DS_err	On/Off			
87	EV87	0 - 3071	–	ditto	1370	ROM_data_err	On/Off			
88	EV88	0 - 3071	–	ditto	1371	Unready1_ALM	On/Off			
89	EV89	0 - 3071	–	ditto	1372	COM1_fail	On/Off			
90	EV90	0 - 3071	–	ditto	1373	Sync1_fail	On/Off			
91	EV91	0 - 3071	–	ditto	452	Term1_rdy	On/Off			
92	EV92	0 - 3071	–	ditto	0		On/Off			
93	EV93	0 - 3071	–	ditto	0		On/Off			
94	EV94	0 - 3071	–	ditto	0		On/Off			
95	EV95	0 - 3071	–	ditto	0		On/Off			
96	EV96	0 - 3071	–	ditto	0		On/Off			
97	EV97	0 - 3071	–	ditto	0		On/Off			
98	EV98	0 - 3071	–	ditto	0		On/Off			
99	EV99	0 - 3071	–	ditto	0		On/Off			
100	EV100	0 - 3071	–	ditto	0		On/Off			
101	EV101	0 - 3071	–	ditto	1024	SET.GROUP1	On			
102	EV102	0 - 3071	–	ditto	1025	SET.GROUP2	On			
103	EV103	0 - 3071	–	ditto	1026	SET.GROUP3	On			
104	EV104	0 - 3071	–	ditto	1027	SET.GROUP4	On			
105	EV105	0 - 3071	–	ditto	0		On			
106	EV106	0 - 3071	–	ditto	0		On			
107	EV107	0 - 3071	–	ditto	0		On			
108	EV108	0 - 3071	–	ditto	0		On			
109	EV109	0 - 3071	–	ditto	1464	Sys.set_change	On			
110	EV110	0 - 3071	–	ditto	1465	Rly.set_change	On			
111	EV111	0 - 3071	–	ditto	1466	Grp.set_change	On			
112	EV112	0 - 3071	–	ditto	1352	Data_lost	On			
113	EV113	0 - 3071	–	ditto	0		On			
114	EV114	0 - 3071	–	ditto	0		On			
115	EV115	0 - 3071	–	ditto	0		On			
116	EV116	0 - 3071	–	ditto	0		On			
117	EV117	0 - 3071	–	ditto	0		On			
118	EV118	0 - 3071	–	ditto	0		On			
119	EV119	0 - 3071	–	ditto	1461	PLC_data_CHG	On			
120	EV120	0 - 3071	–	ditto	0		On			
121	EV121	0 - 3071	–	ditto	1418	LED_RST	On			
122	EV122	0 - 3071	–	ditto	1448	DEMAND_CLR	On			
123	EV123	0 - 3071	–	ditto	1450	F.Record_CLR	On			
124	EV124	0 - 3071	–	ditto	1452	E.Record_CLR	On			
125	EV125	0 - 3071	–	ditto	1453	D.Record_CLR	On			
126	EV126	0 - 3071	–	ditto	1454	CF_count_CLR	On			
127	EV127	0 - 3071	–	ditto	1462	TP_COUNT_CLR	On			
128	EV128	0 - 3071	–	ditto	1463	Iy_COUNT_CLR	On			

Disturbance record default setting

No.	Name	Range	Unit	Contents	Default setting		User setting
					NO.	Signal name	
1	SIG1	0 - 3071	—	disturbance record trigger	48	DIF-A	
2	SIG2	0 - 3071	—	ditto	49	DIF-B	
3	SIG3	0 - 3071	—	ditto	50	DIF-C	
4	SIG4	0 - 3071	—	ditto	264	DIFFS_OP	
5	SIG5	0 - 3071	—	ditto	256	DIF_TRIP	
6	SIG6	0 - 3071	—	ditto	63	RELAY_BLOCK	
7	SIG7	0 - 3071	—	ditto	0	NA	
8	SIG8	0 - 3071	—	ditto	0	NA	
9	SIG9	0 - 3071	—	ditto	0	NA	
10	SIG10	0 - 3071	—	ditto	0	NA	
11	SIG11	0 - 3071	—	ditto	0	NA	
12	SIG12	0 - 3071	—	ditto	0	NA	
13	SIG13	0 - 3071	—	ditto	0	NA	
14	SIG14	0 - 3071	—	ditto	0	NA	
15	SIG15	0 - 3071	—	ditto	0	NA	
16	SIG16	0 - 3071	—	ditto	348	GEN.TRIP	
17	SIG17	0 - 3071	—	ditto	0	NA	
18	SIG18	0 - 3071	—	ditto	0	NA	
19	SIG19	0 - 3071	—	ditto	0	NA	
20	SIG20	0 - 3071	—	ditto	0	NA	
21	SIG21	0 - 3071	—	ditto	0	NA	
22	SIG22	0 - 3071	—	ditto	0	NA	
23	SIG23	0 - 3071	—	ditto	512	BI1_COMMAND	
24	SIG24	0 - 3071	—	ditto	513	BI2_COMMAND	
25	SIG25	0 - 3071	—	ditto	514	BI3_COMMAND	
26	SIG26	0 - 3071	—	ditto	515	BI4_COMMAND	
27	SIG27	0 - 3071	—	ditto	516	BI5_COMMAND	
28	SIG28	0 - 3071	—	ditto	517	BI6_COMMAND	
29	SIG29	0 - 3071	—	ditto	518	BI7_COMMAND	
30	SIG30	0 - 3071	—	ditto	519	BI8_COMMAND	
31	SIG31	0 - 3071	—	ditto	388	I.LINK	
32	SIG32	0 - 3071	—	ditto	432	REM1_IN_SRV	

Appendix H

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 check
4. Function test
   - 4.1 Phase current differential element DIF test
   - 4.2 Inverse definite minimum time overcurrent element(IDMT) OC, EF and SEF test
   - 4.3 Thermal overload element
   - 4.4 CBF and UC element test
   - 4.5 BCD element check
   - 4.6 Cold load function check
5. Protection scheme test
6. Metering and recording check
7. Conjunctive test

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 ☐

4. Function test

4.1 Phase current differential element DIF test

(1) Minimum operating value test

Tap setting	I	Measured current

(2) Percentage restraining characteristic test

Tap setting	I	Measured current (I_2)
	× Tap	
	× Tap	
	20 × Tap	

4.2 Inverse definite minimum time overcurrent element (IDMT) OC, EF and SEF test

Element	Test current	Measured operating time
OC	$1.2 \times I_s$	
	$20 \times I_s$	
EF	$1.2 \times I_s$	
	$20 \times I_s$	
SEF	$1.2 \times I_s$	
	$20 \times I_s$	

4.3 Thermal overload element test

Element	Test current	Measured operating time
THM-A	$1.2 \times I_s$	
THM-T	$10 \times I_s$	

4.4 CBF and UC element test

Element	Tap setting	I	Measured current
CBF			
UC			

4.5 BCD element check

4.6 Cold load function check

5. Protection scheme test

Scheme	Results

6. Metering and recording check

7. Conjunctive test

Scheme	Results
On load check	
Signaling circuit	
Tripping circuit	

Appendix I

Return Repair Form

RETURN / REPAIR FORM

Please fill in this form and return it to Toshiba Corporation with the GRL150 to be repaired.

TOSHIBA CORPORATION Fuchu Complex

1, Toshiba-cho, Fuchu-shi, Tokyo, Japan

For: Power Systems Protection & Control Department

Quality Assurance Section

Type: GRL150 Model: _____

(Example: Type: GRL150 Model: 110A-22-10)

Product No.: _____

Serial No. : _____

Date: _____

1. Why the relay is being returned ?
   - ☐ mal-operation
   - ☐ 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 inform us of this information in respect to in the incident on a Floppy Disk, or by completing the Fault Record sheet and Relay Setting sheet attached.

Fault Record

Date/Month/Year Time / / / : : .

(Example: 04/ Nov./ 2004 15:09:58.442)

Faulty phase:

Prefault values

I_a:	A	I_{aR}:	A
I_b:	A	I_{bR}:	A
I_c:	A	I_{cR}:	A
I_e:	A	I_{da}:	A
I_1:	A	I_{db}:	A
I_2:	A	I_{dc}:	A
I_0:	A		
I_2 / I_1 :			

Fault values

I_a:	A	I_{aR}:	A
I_b:	A	I_{bR}:	A
I_c:	A	I_{cR}:	A
I_e:	A	I_{da}:	A
I_1:	A	I_{db}:	A
I_2:	A	I_{dc}:	A
I_0:	A		
THM:	%		

3. What was the message on the LCD display at the time of the incident.

4. Please write the detail of the incident.

5. Date of the incident occurred.
   Day/ Month/ Year: / / /
   (Example: 10/ Nov./ 2004)

6. Please write any comments on the GRL150, including the document.

Customer

Name:
Company Name:
Address:

Telephone No.:
Facsimile No.:
Signature:

Appendix J

Technical Data

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) 24/30Vdc (Operative range: 19.2 - 36Vdc)
Superimposed AC ripple on DC supply:	≤ 12%
DC supply interruption:	upto 50ms at 110V
Binary input circuit DC voltage:	110/125Vdc 220/250Vdc 48/54/60Vdc 24/30Vdc
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
Phase-segregated current differential protection	
DIFI1 (Small current region):	0.10 to 2.00A in 0.01A steps (1A rating) 0.50 to 10.00A in 0.01A steps (5A rating)
DIFI2 (Large current region):	0.2 to 24.0A in 0.1A steps (1A rating) 1.0 to 120.0A in 0.1A steps (5A rating)
Operating time:	less than 35ms at 300% of DIFI1
Phase Overcurrent Protection	
P/F 1st and 2nd Overcurrent thresholds:	OFF, 0.02 - 5.00A in 0.01A steps (1A rating) OFF, 0.1 - 25.0A in 0.1A steps (5A rating)
P/F 3rd and 4th Overcurrent thresholds:	OFF, 0.02 - 50.00A in 0.01A steps (1A rating) OFF, 0.1 -250.0A in 0.1A steps (5A rating)
Delay type (for 1st threshold) :	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
DTL delay:	0.00 - 300.00s in 0.01s
IDMTL Time Multiplier Setting TMS:	0.010 - 1.500 in 0.001 steps
Reset Type (for 1st threshold):	Definite Time or Dependent Time.
Reset Definite Delay:	0.0 - 300.0s in 0.1s steps
Reset Time Multiplier Setting RTMS:	0.010 - 1.500 in 0.001 steps

Earth Fault Protection	
E/F 1st and 2nd Overcurrent thresholds:	OFF, 0.02 - 5.00A in 0.01A steps (1A rating) OFF, 0.1 - 25.0A in 0.1A steps (5A rating)
E/F 3rd and 4th Overcurrent thresholds:	OFF, 0.02 - 50.00A in 0.01A steps (1A rating) OFF, 0.1 -250.0A in 0.1A steps (5A rating)
Delay type (for 1st threshold):	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
DTL delay:	0.00 - 300.00s in 0.01s steps
IDMTL Time Multiplier Setting TMS:	0.010 - 1.500 in 0.001 steps
Reset Type (for 1st threshold):	Definite Time or Dependent Time.
Reset Definite Delay:	0.00 - 300.00s in 0.01s steps
Reset Time Multiplier Setting RTMS:	0.010 - 1.500 in 0.001 steps
Sensitive Earth Fault Protection	
SEF 1st, 2nd 3rd, & 4th Overcurrent thresholds:	OFF, 0.002 - 0.200A in 0.001A steps (1A rating) OFF, 0.01 - 1.00A in 0.01A steps (5A rating)
Delay Type (for 1st threshold):	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
DTL delay:	0.00 - 300.00s in 0.01s steps
TMS:	0.010 - 1.500 in 0.001 steps
Reset Type:	Definite Time or Dependent Time.
Reset Definite Delay:	0.00 - 300.00s in 0.01s steps
RTMS:	0.010 - 1.500 in 0.001 steps
Phase Undercurrent Protection	
Undercurrent 1st, 2nd thresholds:	OFF, 0.10 - 2.00A in 0.01A steps (1A rating) OFF, 0.5 - 10.0A in 0.1A steps (5A rating)
DTL Delay:	0.00 - 300.00s in 0.01A steps
Inrush Current Detector	
Second harmonic ratio setting (I_{2f}/ I_{1f}):	10 - 50% in 1% steps
Overcurrent thresholds:	0.10 - 2.00A in 0.01A steps (1A rating) 0.5 - 25.0A in 0.1A steps (5A rating)
Thermal Overload Protection	
$I_\theta = k.I_{FLC}$ (Thermal setting):	OFF, 0.40 - 2.00A in 0.01A steps (1A rating) OFF, 2.0 - 10.0A in 0.1A steps (5A rating)
Time constant:	0.5 - 500.0mins in 0.1min steps
Thermal alarm:	OFF, 50% to 99% in 1% steps
Broken Conductor Protection	
Broken conductor threshold (I_2/I_1):	OFF, 0.10 - 1.00 in 0.01 steps
DTL delay:	0.00 - 300.00s in 0.01s steps
CBF Protection	
CBF threshold:	OFF, 0.10 - 2.00A in 0.01A steps (1A rating) OFF, 0.5 - 10.0A in 0.1A steps (5A rating)
CBF stage 1 DTL:	0.00 - 300.00s in 0.01s steps
CBF stage 2 DTL:	0.00 - 300.00s in 0.01s steps
Direct fibre optic interface	
Type of fibre:	Single mode 10/125 μm
Connector:	LC
Wave length	1300nm
Transmission distance:	< 20km

Pilot wire interface	
Recommended Cable type:	Twisted pair Max pilot length using AWG24 (0.51mmϕ): 3.0km Max pilot length using AWG21 (0.72mmϕ): 6.0km Max pilot length using AWG19 (0.90mmϕ): 8.0km
Connector:	M3.5 screw terminals
Isolation:	5kV ac (integral) 20kV ac (with external isolation transformer)
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:	1kVac for 1 min.
Transmission rate:	64kpbs for RSM system 9.6, 19.2kbps for IEC60870-5-103
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
Time synchronization port	
Connection: Time code: IRIG-B (AM modulated, TTL)	Screw terminals
Binary Inputs	
Number of inputs	8
Operating voltage	Typical 74Vdc (min. 70Vdc) for 110/125Vdc rating Typical 138Vdc (min. 125Vdc) for 220/250Vdc rating Typical 31Vdc (min. 28Vdc) for 48/54V/60Vdc rating Typical 15Vdc (min. 13Vdc) for 24/30Vdc rating
Binary Outputs	
Number	7
Ratings: TP1, TP2 for tripping	Make and carry: 4A continuously Make and carry: 10A, 220Vdc for 0.5s (L/R≥5ms) Break: 0.1A, 220Vdc (L/R=40ms)
Ratings: BO1 to BO5	Make and carry: 4A continuously Make and carry: 10A, 220Vdc for 0.2s(Resistive load) Break: 0.1A, 220Vdc (L/R=40ms)
Mechanical design	
Weight	5kg
Case color	2.5Y7.5/1(approximation to Munsell value)
Installation	Flush mounting

ENVIRONMENTAL PERFORMANCE CLAIMS

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 PSU and I/O ports: 2kV/1kV RS485 port: 1kV/ -
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

Test	Standards	Details
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.

Appendix K

Symbols Used in Scheme Logic

Symbols used in the scheme logic and their meanings are as follows:

Signal names

Marked with ▭ : Measuring element output signal

Marked with ○● : Signal number

Marked with ▭▭: Signal number and name of binary input by PLC function

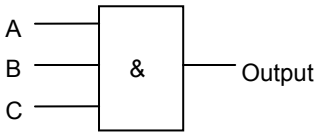
Signal No. Signal name

Marked with [ ] : Scheme switch

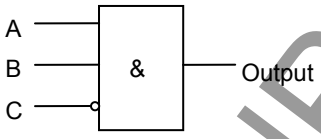
Marked with " " : Scheme switch position

Unmarked : Internal scheme logic signal

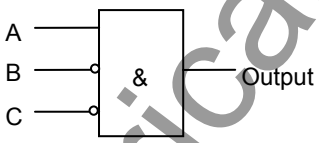
AND gates



A	B	C	Output
1	1	1	1
Other cases			0

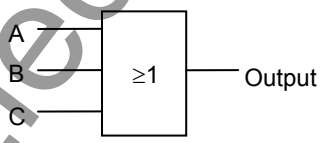


A	B	C	Output
1	1	0	1
Other cases			0

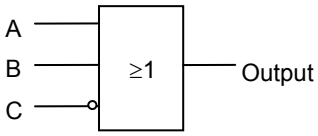


A	B	C	Output
1	0	0	1
Other cases			0

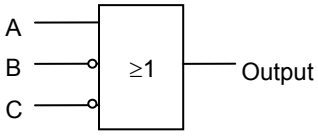
OR gates



A	B	C	Output
0	0	0	0
Other cases			1

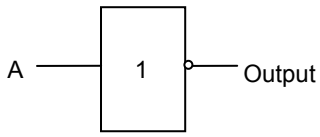


A	B	C	Output
0	0	1	0
Other cases			1



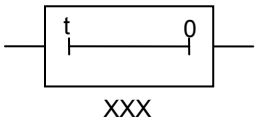
A	B	C	Output
0	1	1	0
Other cases			1

Signal inversion



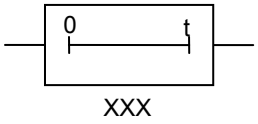
A	Output
0	1
1	0

Timer



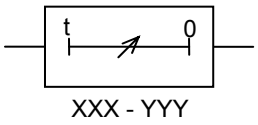
Delaye pick-up timer with fixed setting

XXX: Set time



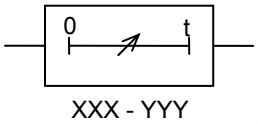
Delayed drop-off timer with fixed setting

XXX: Set time



Delaye pick-up timer with variable setting

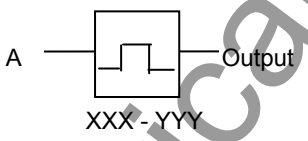
XXX - YYY: Setting range

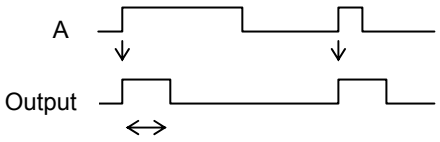


Delayed drop-off timer with variable setting

XXX - YYY: Setting range

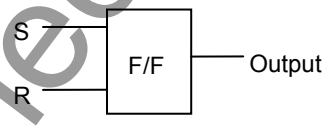
One-shot timer





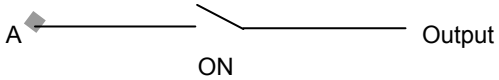
XXX - YYY: Setting range

Flip-flop

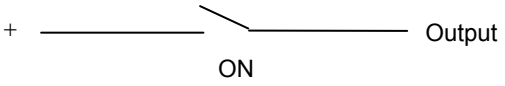


S	R	Output
0	0	No change
1	0	1
0	1	0
1	1	0

Scheme switch



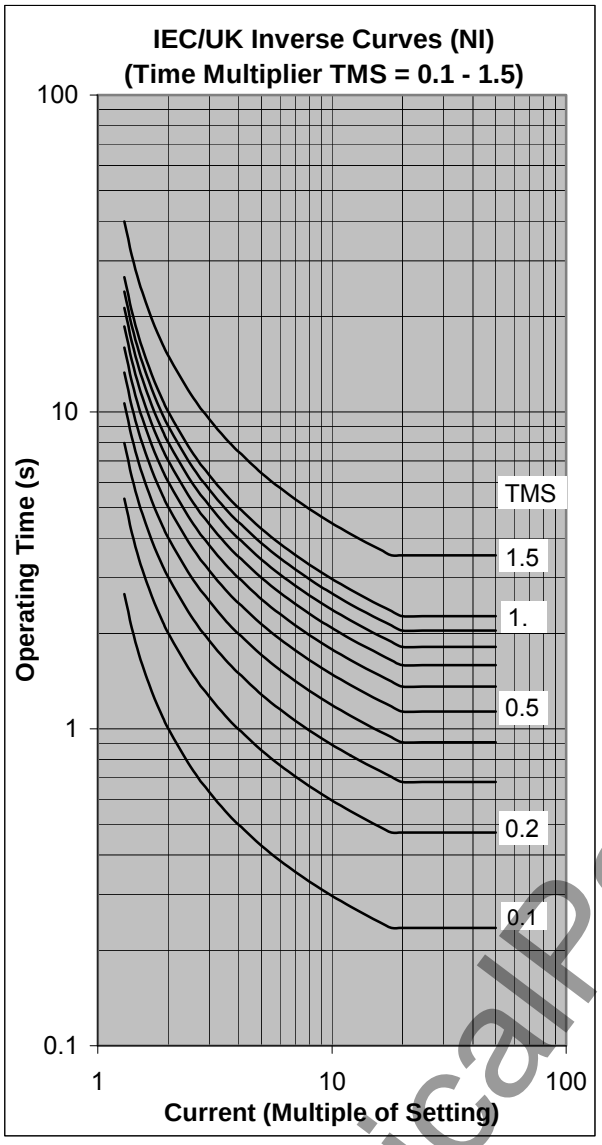
A	Switch	Output
1	ON	1
Other cases		0



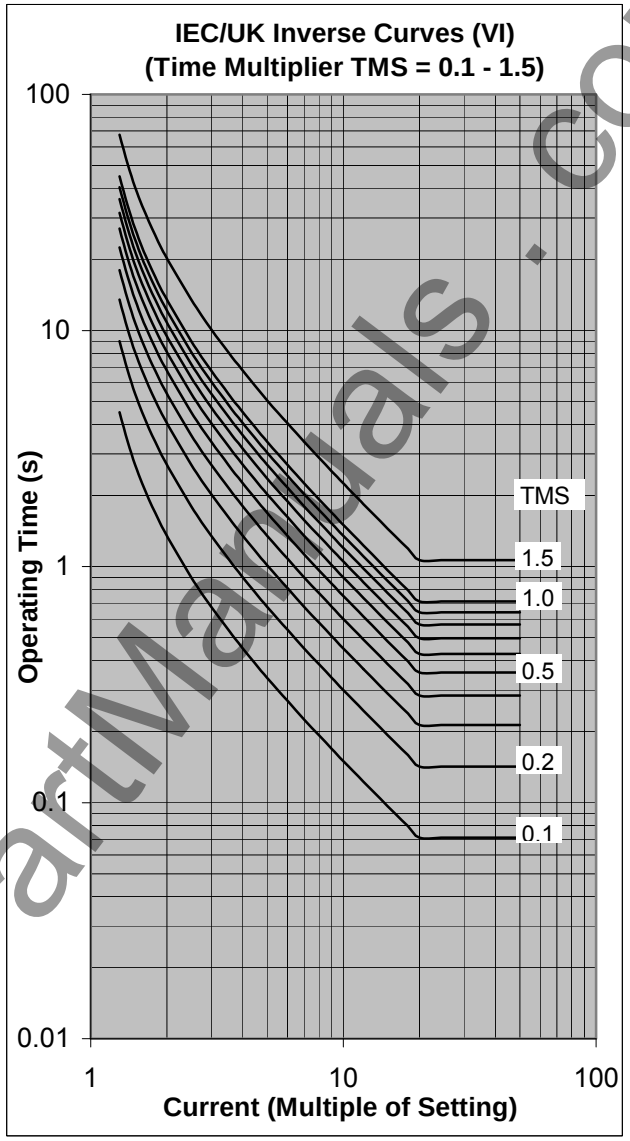
Switch	Output
ON	1
OFF	0

Appendix L

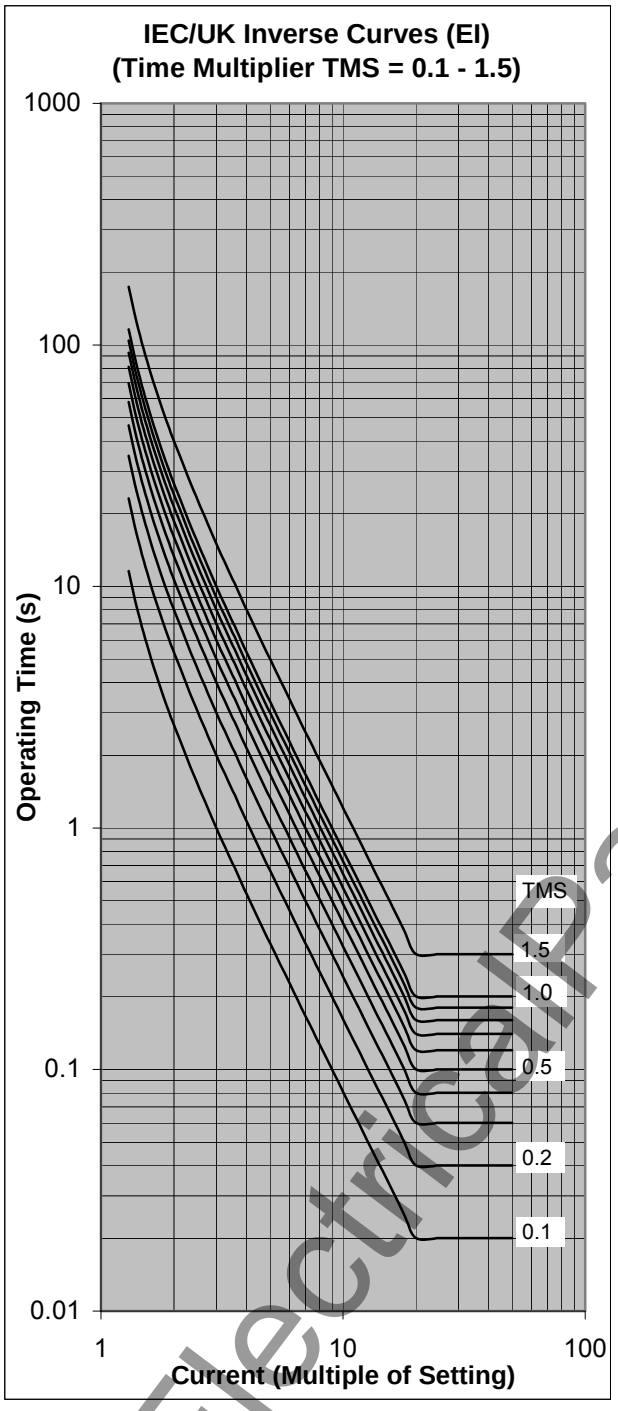
Inverse Time Characteristics



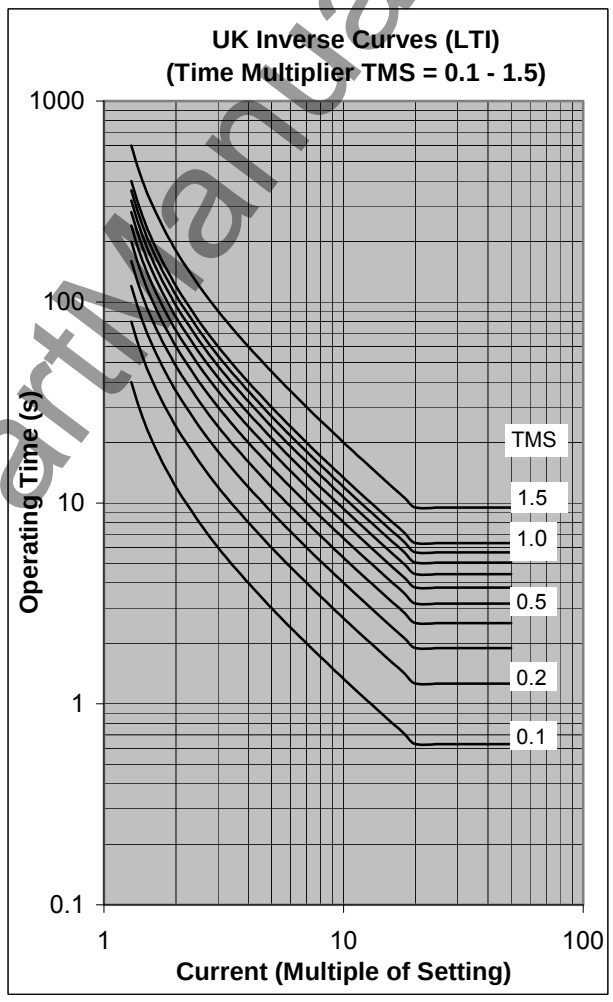
Normal Inverse



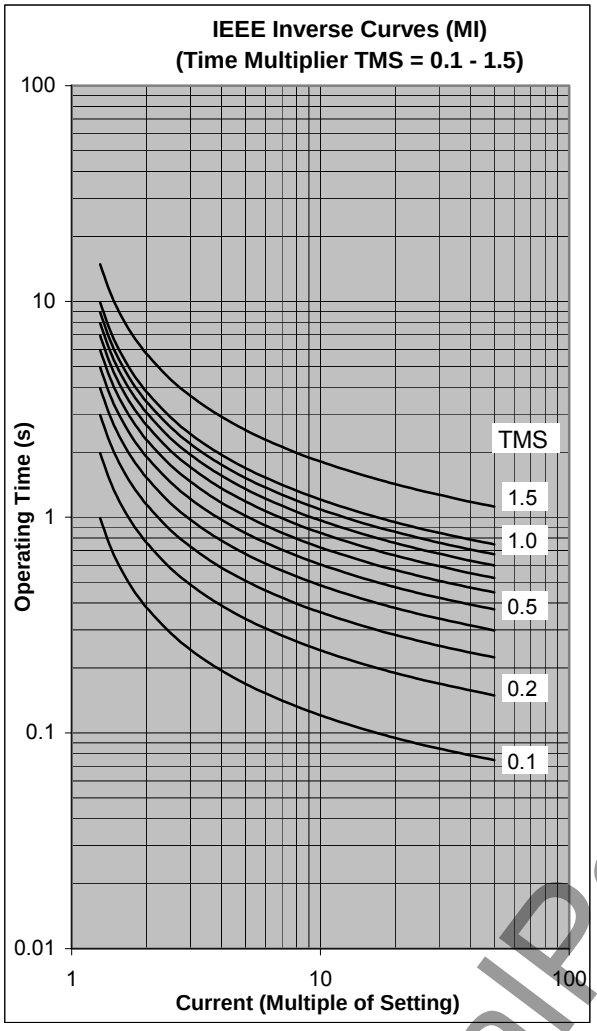
Very Inverse



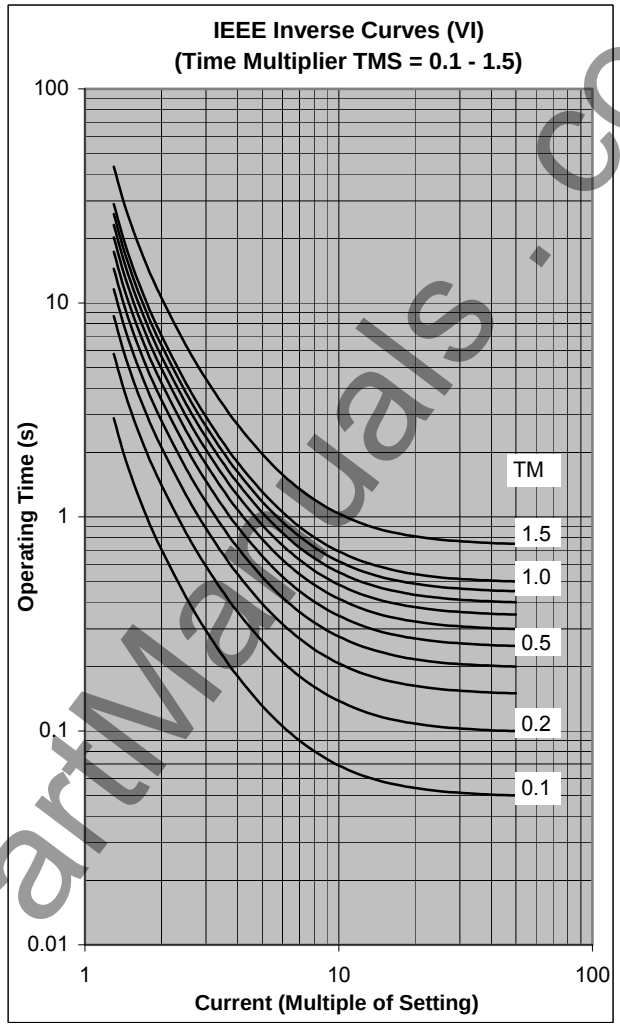
Extremely Inverse



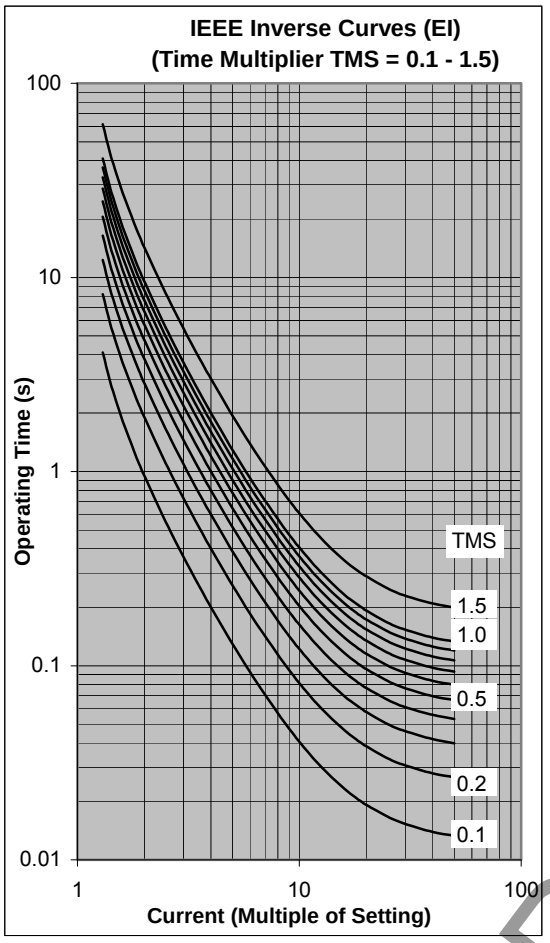
Long Time Inverse



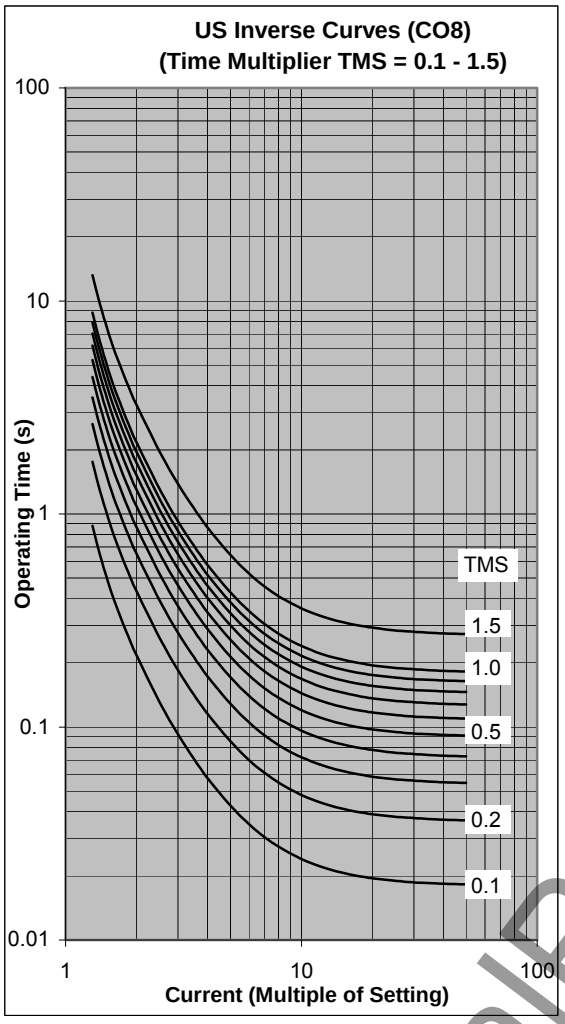
Moderately Inverse



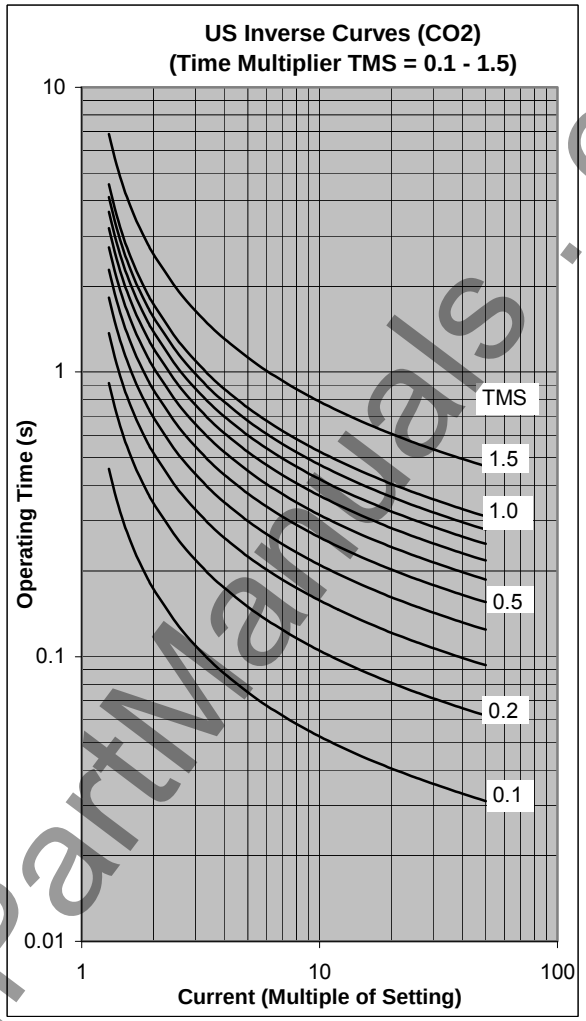
Very Inverse



Extremely Inverse



CO8 Inverse



CO2 Short Time Inverse

Appendix M

IEC60870-5-103: Interoperability

IEC60870-5-103 Configurator

IEC103 configurator software is included in a same CD as RSM100, and can be installed easily as follows:

Installation of IEC103 Configurator

Insert the CD-ROM (RSM100) into a CDROM drive to install this software on a PC.

Double click the "Setup.exe" of the folder "\IEC103Conf" under the root directory, and operate it according to the message.

When installation has been completed, the IEC103 Configurator will be registered in the start menu.

Starting IEC103 Configurator

Click [Start]→[Programs]→[IEC103 Configurator]→[IECConf] to the IEC103 Configurator software.

Note: The instruction manual of IEC103 Configurator can be viewed by clicking [Help]→[Manual] on IEC103 Configurator.

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. List of Information

The following items can be customized with the original software tool "IEC103 configurator". (For details, refer to "IEC103 configurator" manual No.6F2S0839.)

- Items for "Time-tagged message": Type ID(1/2), INF, FUN, Transmission condition(Signal number), COT
- Items for "Time-tagged measurands": INF, FUN, Transmission condition(Signal number), COT, Type of measurand quantities
- Items for "General command": INF, FUN, Control condition(Signal number)
- Items for "Measurands": Type ID(3/9), INF, FUN, Number of measurand, Type of

measurand quantities

- Common setting
  - Transmission cycle of Measurand frame
  - FUN of System function
  - Test mode, etc.

CAUTION: To be effective the setting data written via the RS232C, turn off the DC supply of the relay and turn on again.

3.1 IEC60870-5-103 Interface

3.1.1 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.

3.1.2 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.

For details, refer to the standard IEC60870-5-103 section 7.4.3.

3.1.3 Cyclic measurements

The relay will produce measured values using Type ID=3 or 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 can be customized.

3.1.4 Commands

The supported commands can be customized. The relay will respond to non-supported commands with a cause of transmission (COT) of negative acknowledgement of a command.

For details, refer to the standard IEC60870-5-103 section 7.4.4.

3.1.5 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 section 7.4.5.

3.1.6 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 section 7.4.6.

3.2 List of Information

The followings are the default settings.

List of Information

INF	Description	Contents	IEC103 Configurator Default setting						
			GI	Type ID	COT	FUN	DPI		
							Signal No.	OFF	ON
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	192	--	--	--
3	Reset CU	Reset CU ACK	--	5	4	192	--	--	--
4	Start/Restart	Relay start/restart	--	5	5	192	--	--	--
5	Power On	Relay power 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.	GI	1	1, 9, 12	192	722	1	2
18	Protection active	If the protection is available, this item is set to active. If not, set to inactive.	GI	1	1, 9, 12	192	723	1	2
19	LED reset	Reset of latched LEDs	--	1	1, 11, 12	192	1418	--	2
20	Monitor direction blocked	Block the 103 transmission from a relay to control system. IECBLK: "Blocked" settimg.	GI	1	9, 11	192	1040	1	2
21	Test mode	Transmission of testmode situation froma relay to control system. IECTST "ON" setting.	GI	1	9, 11	192	1039	1	2
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, 9, 11, 12	192	1024	1	2
24	Characteristic2	Setting group 2 active	GI	1	1, 9, 11, 12	192	125	1	2
25	Characteristic3	Setting group 3 active	GI	1	1, 9, 11, 12	192	1026	1	2
26	Characteristic4	Setting group 4 active	GI	1	1, 9, 11, 12	192	1027	1	2
27	Auxiliary input1	Binary input 1	No set						
28	Auxiliary input2	Binary input 2	No set						
29	Auxiliary input3	Binary input 3	No set						
30	Auxiliary input4	Binary input 4	No set						
Supervision Indications									
32	Measurand supervision I	Zero sequence current supervision	GI	1	1, 9	192	1356	1	2
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, 9	192	1359	1	2
37	I>>backup operation		Not supported						
38	VT fuse failure	VT failure	Not supported						
39	Teleprotection disturbed	CF(Communication system Fail) supervision	GI	1	1, 9	192	439	1	2
46	Group warning	Only alarming	GI	1	1, 9	192	1346	1	2
47	Group alarm	Trip blocking and alarming	GI	1	1, 9	192	1343	1	2
Earth Fault Indications									
48	Earth Fault L1	A phase earth fault	No set						
49	Earth Fault L2	B phase earth fault	No set						
50	Earth Fault L3	C phase earth fault	No set						
51	Earth Fault Fwd	Earth fault forward	Not supported						
52	Earth Fault Rev	Earth fault reverse	Not supported						

INF	Description	Contents	IEC103 Configurator Default setting						
			GI	Type ID	COT	FUN	DPI		
							Signal NO.	OFF	ON
Fault Indications									
64	Start/pick-up L1	A phase, A-B phase or C-A phase element pick-up	No set						
65	Start/pick-up L2	B phase, A-B phase or B-C phase element pick-up	No set						
66	Start/pick-up L3	C phase, B-C phase or C-A phase element pick-up	No set						
67	Start/pick-up N	Earth fault element pick-up	No set						
68	General trip	Any trip	--	2	1	192	1037	--	2
69	Trip L1	A phase, A-B phase or C-A phase trip	No set						
70	Trip L2	B phase, A-B phase or B-C phase trip	No set						
71	Trip L3	C phase, B-C phase or C-A phase trip	No set						
72	Trip I>>(back-up)	Back up trip	Not supported						
73	Fault location X In ohms	Fault location	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	No set						
85	Breaker Failure	CBF trip or CBF retrip	--	2	1	192	332	--	2
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	No set						
91	Trip I>>	Definite time OC trip	No set						
92	Trip IN>	Inverse time earth fault OC trip	No set						
93	Trip IN>>	Definite time earth fault OC trip	No set						
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						

INF	Description	Contents	IEC103 configurator Default setting				
			GI	Type ID	COT	FUN	Max. No.
Measurands							
144	Measurand I	<meaurand I>	No				0
145	Measurand I,V	<meaurand I>	No				0
146	Measurand I,V,P,Q	<meaurand I>	No				0
147	Measurand IN,VEN	<meaurand I>	No				0
148	Measurand IL1,2,3, VL1,2,3, P,Q,f	Ia, Ib, Ic, Va, Vb, Vc, P, Q, f measurand <meaurand II>	--	9	2, 7	192	9
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				

Details of MEA settings in IEC103 configurator

INF	MEA	Tbl	Offset	Data type	Limit		Coeff
					Lower	Upper	
148	Ia	7	52	long	0	4096	3.41333
	Ib	7	56	long	0	4096	3.41333
	Ic	7	60	long	0	4096	3.41333

INF	Description	Contents	IEC103 Configurator Default setting			
			Control direction	Type ID	COT	FUN
Selection of standard information numbers in control direction						
System functions						
0	Initiation of general interrogation		--	7	9	255
0	Time synchronization		--	6	8	255
General commands						
16	Auto-recloser on/off		Not supported			
17	Teleprotection on/off		ON/OFF	20	20	192
18	Protection on/off	(*1)	ON/OFF	20	20	192
19	LED reset	Reset indication of latched LEDs.	ON	20	20	192
23	Activate characteristic 1	Setting Group 1	ON	20	20	192
24	Activate characteristic 2	Setting Group 2	ON	20	20	192
25	Activate characteristic 3	Setting Group 3	ON	20	20	192
26	Activate characteristic 4	Setting Group 4	ON	20	20	192
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			

(*1) Note: While the relay receives the "Protection off" command, " IN SERVICE LED" is off.

Details of Command settings in IEC103 configurator

INF	DCO			
	Sig off	Sig on	Rev	Valid time
17	2685	2685	✓	0
18	2686	2686	✓	0
19	0	2688		200
23	0	2640		1000
24	0	2641		1000
25	0	2642		1000
26	0	2643		1000

✓: signal reverse

	Description	Contents	GRL150 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	Configurable	
	Current L2	Ib	Configurable	
	Current L3	Ic	Configurable	
	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	

Details of Common settings in IEC103 configurator

- Remote operation valid time [ms]: 4000
- Local operation valid time [ms]: 4000
- Measurand period [s]: 2
- Function type of System functions: 192
- Signal No. of Test mode: 1039
- Signal No. for Real time and Fault number: 1038

[Legend]

GI: General Interrogation (refer to IEC60870-5-103 section 7.4.3)

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

FUN: Function type (refer to IEC60870-5-103 section 7.2.5.1)

DPI: Double-point Information (refer to IEC60870-5-103 section 7.2.6.5)

DCO: Double Command (refer to IEC60870-5-103 section 7.2.6.4)

IEC103 setting data is recommended to be saved as follows:

(1) Naming for IEC103setting data

The file extension of IEC103 setting data is ".csv". The version name is recommended to be provided with a revision number in order to be changed in future as follows:

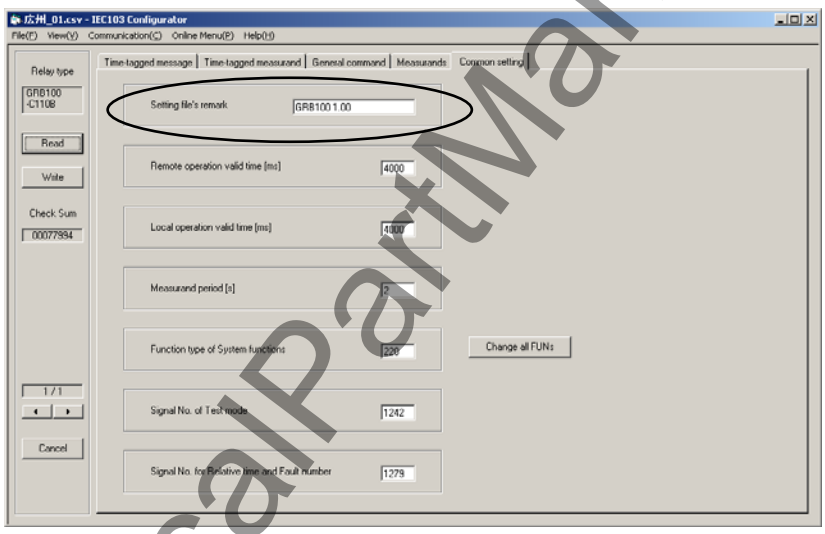
First draft: ******_01.csv

Second draft: ******_02.csv

Third draft: ******_03.csv

Revision number

The name "******" is recommended to be able to discriminate the relay type such as GRZ100 or GRL100, etc. The setting files remark field of IEC103 is able to enter up to 12 one-byte characters. It is utilized for control of IEC103 setting data.



(2) Saving theIEC103 setting data

The IEC103 setting data is recommended to be saved in external media such as FD (floppy disk) or CD-R, not to remain in the folder.

Troubleshooting

<table>
<tr><th rowspan="2">No.</th><th rowspan="2">Phenomena</th><th rowspan="2">Supposed causes</th><th colspan="2">Check / Confirmation</th></tr>
<tr><th>Object</th><th>Procedure</th></tr>
<tr><td rowspan="10">1</td><td rowspan="10">Communication trouble（IEC103 communication is not available.）</td><td>Address setting is incorrect.</td><td>BCU
RY</td><td>Match address setting between BCU and relay.
Avoid duplication of address with other relay.</td></tr>
<tr><td>Transmission baud rate setting is incorrect.</td><td>BCU
RY</td><td>Match transmission baud rate setting between BCU and relay.</td></tr>
<tr><td>Start bit, stop bit and parity settings of data that BCU transmits to relay is incorrect.</td><td>BCU</td><td>Go over the following settings by BCU. Relay setting is fixed as following settings.
- Start bit: 1bit
- Stop bit: 1bit
- Parity setting: even</td></tr>
<tr><td>The PRTCL1 setting is incorrect. (The model with PRTCL1 setting.)</td><td>RY</td><td>Change the PRTCL1 setting. Relation between PRTCL1 setting and available transmission protocol is referred to the following table.
<table>
<tr><th>RS485 port at the back of the relay</th><th>PRTCL1 =HDLC</th><th>PRTCL1 =IEC</th></tr>
<tr><td>COM1 (CH1)</td><td>HDLC</td><td>IEC</td></tr>
<tr><td>COM2 (CH2)</td><td>IEC</td><td>—</td></tr>
</table></td></tr>
<tr><td>RS485 or optical cable interconnection is incorrect.</td><td>Cable</td><td>- Check the connection port.(CH1/CH2)
- Check the interconnection of RS485 A/B/COM
- Check the send and received interconnection of optical cable.</td></tr>
<tr><td>The setting of converter is incorrect. (RS485/optic conversion is executed with the transmission channel, etc.)</td><td>Converter</td><td>In the event of using G1IF2, change the DIPSW setting in reference to INSTRUCTION MANUAL (6F2S0794).</td></tr>
<tr><td>The relationship between logical “0/1” of the signal and Sig.on/off is incorrect. (In the event of using optical cable)</td><td>BCU</td><td>Check the following;
Logical0 : Sig.on
Logical1:Sig.off</td></tr>
<tr><td>Terminal resistor is not offered. (Especially when RS485 cable is long.)</td><td>cable</td><td>Impose terminal resistor (150[ohms]) to both ends of RS 485 cable.</td></tr>
<tr><td>Relay cannot receive the requirement frame from BCU.
(The timing coordination of sending and receiving switch control is irregular in half-duplex communication.)</td><td>BCU</td><td>Check to secure the margin more than 15ms between receiving the reply frame from the relay and transmitting the next requirement frame on BCU.</td></tr>
<tr><td>The requirement frame from BCU and the reply frame from relay contend.
(The sending and receiving timing coordination is irregular in half-duplex communication.)</td><td>BCU</td><td>Check to set the time-out of reply frame from the relay.
Time-out setting: more than 100ms (acceptable value of response time 50ms plus margin)</td></tr>
</table>

No.	Phenomena	Supposed causes	Check / Confirmation	
			Object	Procedure
2	HMI does not display IEC103 event on the SAS side.	The relevant event sending condition is not valid.	RY	Change the event sending condition (signal number) of IEC103 configurator if there is a setting error. When the setting is correct, check the signal condition by programmable LED, etc.
		The relevant event Information Number (INF) and/or Function Type (FUN) may be different between the relay and SAS.	RY SAS	Match the relevant event Information Number (INF) or Function Type (FUN) between the relay and SAS.
		The relay is not initialised after writing IEC103 configurator setting.	RY	Check the sum value of IEC103 setting data from the LCD screen. When differing from the sum value on IEC103 configurator, initialise the relay.
		It changes to the block mode.	RY	Change the IECBR settling to Normal.
3	Time can be synchronised with IEC103 communication.	BCU does not transmit the frame of time synchronisation.	BCU	Transmit the frame of time synchronisation.
		The settling of time synchronisation source is set to other than IEC.	RY	Change the settling of time synchronisation source to IEC.

(Note) BCU: Bay control unit, RY: Relay

Appendix N

Resistor Box (Option)

Resistor Box G1RE1-01

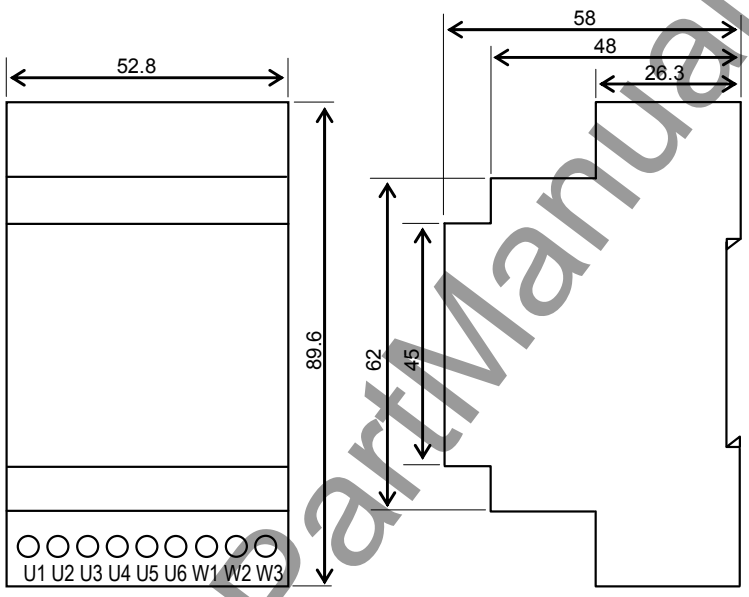
G1RE1 resistor box is available for reducing the transmission level of GRL150 if the transmitting signal interferes with other communication signals in a multi-core pilot wire cable.

Specification

5kVac for 1 min. between all terminals and DIN rail.

Outline and Mounting

Outline:



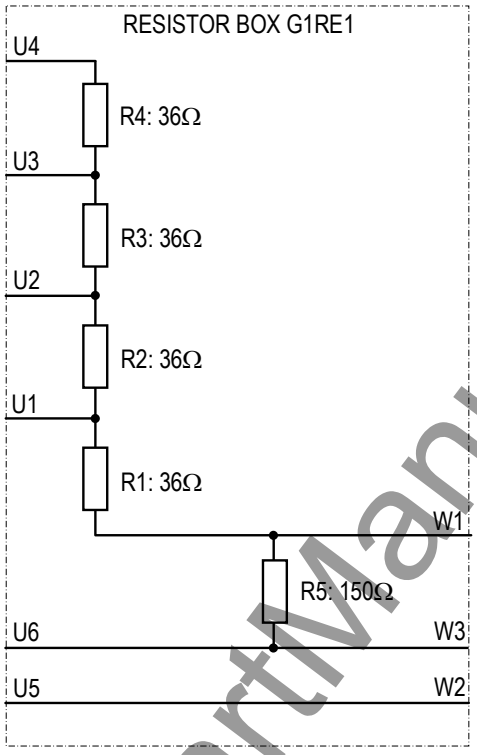
Mounting: DIN rail (35 mm)

Note: DIN rail is not supplied. User prepares DIN rail.

Connection terminal: M3 screw, Maximum wire size; 2.1mm (14AWG) for solid wire or 3.3mm (12AWG) for stranded wire

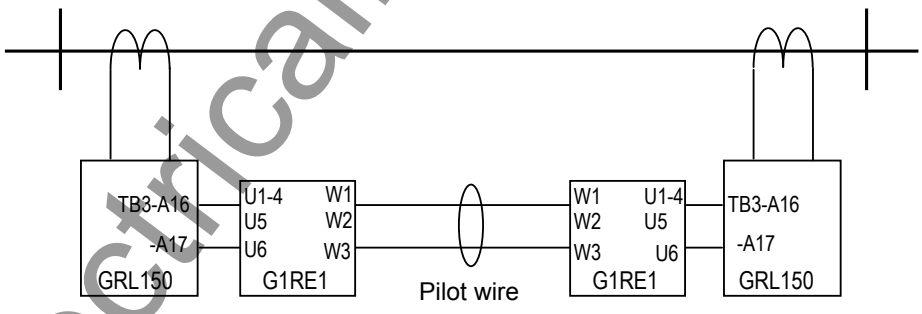
Connections

Internal connection:



External connection:

The transmission level of GRL150 can be adjusted by selecting a terminal among U1 to U4.



Note: If U5 and W2 selected, the transmission level of GRL150 is not reduced.

Appendix O

Ordering

Line Differential Protection GRL150 Information Required with Ordering

	1	2	3	4	5	6	7	8	9	10	11		12	13		14	15		
	G	R	L	1	5	0	–			0	A	–		0	–		0	–	
Model																			
Telecommunication																			
Pilot wire interface								1											
Both pilot wire and optical interface								4											
Back-up Scheme																			
Back-up Phase OC Protection									0										
Back-up Phase OC and EF Protection									1										
Back-up Phase OC and Sensitive EF Protection									2										
CT, Frequency, Vdc Rating																			
1A, 50Hz, 110/125Vdc													1						
1A, 60Hz, 110/125Vdc													2						
5A, 50Hz, 110/125Vdc													3						
5A, 60Hz, 110/125Vdc													4						
1A, 50Hz, 220/250Vdc													5						
1A, 60Hz, 220/250Vdc													6						
5A, 50Hz, 220/250Vdc													7						
5A, 60Hz, 220/250Vdc													8						
1A, 50Hz, 48/54/60Vdc													A						
1A, 60Hz, 48/54/60Vdc													B						
5A, 50Hz, 48/54/60Vdc													C						
5A, 60Hz, 48/54/60Vdc													D						
1A, 50Hz, 24/30Vdc													E						
1A, 60Hz, 24/30Vdc													F						
5A, 50Hz, 24/30Vdc													G						
5A, 60Hz, 24/30Vdc													H						
Rear communication port																			
RS485																1			
Fibre Optic																2			
Dual RS485																3			
RS485 + Fibre Optic																9			
Miscellaneous																			
None																	0		
LED label																			
Standard																			None
Option: User configurable LED label																			J

Accessory

(1) Isolation Trans. for Pilot Wire Comm. (option)	
External 15kV Isolation Transformer for Pilot Wire Interface	EB-110
(2) Resistor Box (option)	
Resistor boox	G1RE1-01

Version-up Records

Version No.	Date	Revised Section	Contents
0.0	Jul. 22, 2005	--	First issue
0.1	Sep. 06, 2005	1 2.2.1, 2.2.3, 2.2.4 2.2.5, 2.2.6, 2.2.9 2.3.2, 2.4.1, 2.5.1 2.6.1, 2.9.1 2.10.1 2.12 3.2.3, 3.3.3, 3.3.7 3.3.5 Appendices	Modified Table 1.1. Modified Figures 2.2.1.1, 2.2.3.1, 2.2.4.1 and 2.2.4.2. Modified the description. Modified Figures 2.3.2.1 to 2.3.2.4, 2.4.1.1 to 2.4.1.4, and 2.5.1.1 to 2.5.1.4. Modified Figures 2.6.1.2 and 2.9.1.1. Modified the description and Figure 2.10.1.3. Modified Figures 2.12.1 and 2.12.2. Modified Figures 3.2.3.1, 3.3.3.1, 3.3.7.1 and 3.3.7.2. Modified the description. Modified Appendix E, G, J and M.
0.2	Nov. 18, 2005	2.2.5 2.2.9 Appendices	Modified the description. Modified the description. ('DIFI1 setting and Full-scale' and 'Setting of DIFI2') Modified Appendix I and J.
0.3	Feb. 2, 2006	4.1.2 Appendices	Modified the description. (Interface port: MU → LC connector) Modified Appendix J.
0.4	Mar. 31, 2006	3.3.5 3.3.10 4.1.2 4.2.3.4, 4.2.6.5, 4.2.6.7 Appendices	Modified the description. Modified the setting range table. Modified Figure 4.1.2.1. Modified LCD sample screens. Modified Appendix B, E and G.
0.5	Jun. 22, 2006	4.2.3.1, 4.2.4.1 4.2.6.6 Appendices	Added the description and 'Note'. Modified the description and LCD sample screens in 'Setting the metering'. Modified Appendix N.
0.6	Jul. 19, 2006	2.2.9	Modified the description of the 'CT Ratio matching'. Corrected figure number. Figure 2.4.14.1→2.2.9.1, Figure 2.4.14.2→2.2.9.2
0.7	Sep. 11, 2006	2.2 2.2.2 2.2.5 2.2.9 3.1.1, 4.1.1 4.2.1 4.2.6.10 4.2.7.1 6.5.1.1 Appendices	Modified Figure 2.2.1. (Added Figure (b).) Modified the description. Modified the table of user configurable commands. Added 'Setting of [SP.SYN]. Modified the description. (LED) Modified the description of 'Displays in tripping'. Modified the description. Modified the description of [T.TEST] Caution. Modified the description and Figure 6.5.1.2. Modified Appendix B and G.
0.8	Apr. 24, 2008	Safety Precaution 2.2.7 2.7.2 2.8 4.2.1 4.4 6.6.2 Appendices	Added the description. Added the description. Modified the description. Added Figure 2.8.1.2. Modified the description. Modified the description. Modified the description. Added Appendix N and modified Appendix D, J, M and O.
0.9	Jun. 27, 2008	4.1.2 4.2.4.4, 4.2.6.6 4.6 Appendices	Modified the description. Modified the description. Modified the description. Modified Appendix F.

TOSHIBA CORPORATION