TOSHIBA

6 F 2 S 0 8 3 5

INSTRUCTION MANUAL

LINE DIFFERENTIAL RELAY

GRL100 - ∗∗∗B

TOSHIBA CORPORATION

(Ver. 2.1)

Safety Precautions

Before using this product, please read this chapter carefully.

This chapter describes the safety precautions recommended when using the GRL100. 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.
Class 1M laser product (Transmission distance: 30km class)

- the maximum output of laser radiation:	0.2 mW
- the pulse duration:	79.2 ns
- the emitted wavelength(s):	1310 nm

⚠CAUTION

- **Earth**

The earthing terminal of the equipment must be securely earthed.

CAUTION

- **Operating environment**

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

- **Ratings**

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

- **Printed circuit board**

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

- **External circuit**

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

- **Connection cable**

Carefully handle the connection cable without applying excessive force.

- **Modification**

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

- **Short-bar**

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

- **Tripping circuit connections**

Must connect the FD (Fault Detector) output contact with A- to C-phase tripping output contacts in series in case of the model 400 and 500 series.

- **Disposal**

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

Contents

■ The data given in this manual are subject to change without notice. (Ver.2.1)

1. Introduction

The GRL100 provides high-speed phase-segregated current differential protection for use with telecommunication systems, and ensures high reliability and security for diverse faults including single-phase and multi-phase faults and double-faults on double-circuit lines, evolving faults and high-impedance earth faults.

The GRL100 is used as a main protection for the following two- or three-terminal lines in EHV or HV networks:

- Overhead lines or underground cables
- Lines with weak infeed or non-infeed terminals
- Single or parallel lines
- Lines with heavy load current
- Short- or long-distance lines

The GRL100 can be used for lines associated with one-and-a-half busbar arrangement as well as single or double busbar arrangement.

Furthermore, in addition to current differential protection, the GRL100 provides overcurrent backup, thermal overload, out-of-step and breaker failure protection.

The GRL100 actuates high-speed single-shot autoreclose or multi-shot autoreclose.

For telecommunications, dedicated optical fibres or 64 kbits/s multiplexed communication links can be employed.

The GRL100 is a member of the G-series family of numerical relays which utilise common hardware modules with the common features:

The GRL100 provides the following metering and recording functions.

- Metering
- Fault record
- Event record
- Fault location
- Disturbance record

The GRL100 provides the following menu-driven human interfaces for relay setting or viewing of stored data.

- Relay front panel; 4 × 40 character LCD, LED display and operation keys
- Local PC
- Remote PC

Password protection is provided to change settings. Eight 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.

GRL100 provides either two or three serial ports, and an IRIG-B port for an external clock connection. A local PC can be connected via the RS232C port on the front panel of the relay. Either one or two rear ports (RS485 or fibre optic) are provided for connection to a remote PC and for IEC60870-5-103 communication with a substation control and automation system. Further, Ethernet LAN port (TCP/IP protocol) can be provided as option.

Further, the GRL100 provides the following functions.

- Configurable binary inputs and outputs

- Programmable logic for I/O configuration, alarms, indications, recording, etc.
- Automatic supervision

The GRL100 has the following models:

Relay Type and Model

Relay Type:
- Type GRL100; Numerical current differential relay
Relay Model:
- For two terminal line, With No autoreclose • Model 101; 18 binary inputs, 13 binary outputs, 6 binary outputs for tripping • Model 102; 18 binary inputs, 23 binary outputs, 6 binary outputs for tripping
- For two terminal line, With autoreclose for single breaker scheme • Model 201; 25 binary inputs, 19 binary outputs, 6 binary outputs for tripping • Model 202; 28 binary inputs, 37 binary outputs, 6 binary outputs for tripping • Model 204; 22 binary inputs (12-independent), 19 binary outputs, 3 binary outputs for tripping • Model 206; 25 binary inputs (12-independent), 37 binary outputs, 3 binary outputs for tripping
- For two terminal line, With autoreclose for one-and-a-half breaker scheme • Model 301; 25 binary inputs, 19 binary outputs, 6 binary outputs for tripping • Model 302; 28 binary inputs, 37 binary outputs, 6 binary outputs for tripping
- For two terminal line, With autoreclose for single breaker scheme / With fault detector • Model 401; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping
- For two terminal line, With autoreclose for one-and-a-half breaker scheme / With fault detector • Model 501; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping • Model 503; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping, TFC function
- For three terminal line, With No autoreclose • Model 111; 18 binary inputs, 13 binary outputs, 6 binary outputs for tripping • Model 112; 18 binary inputs, 23 binary outputs, 6 binary outputs for tripping
- For three terminal line, With autoreclose for single breaker scheme • Model 211; 25 binary inputs, 19 binary outputs, 6 binary outputs for tripping • Model 212; 28 binary inputs, 37 binary outputs, 6 binary outputs for tripping • Model 214; 22 binary inputs (12-independent), 19 binary outputs, 3 binary outputs for tripping • Model 216; 25 binary inputs (12-independent), 37 binary outputs, 3 binary outputs for tripping
- For three terminal line, With autoreclose for one-and-a-half breaker scheme • Model 311; 25 binary inputs, 19 binary outputs, 6 binary outputs for tripping • Model 312; 28 binary inputs, 37 binary outputs, 6 binary outputs for tripping
- For three terminal line, With autoreclose for single breaker scheme / With fault detector • Model 411; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping
- For three terminal line, With autoreclose for one-and-a-half breaker scheme / With fault detector • Model 511; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping • Model 513; 28 binary inputs, 31 binary outputs, 6 binary outputs for tripping, TFC function

Model 100 has the minimum configuration, having only the segregated phase current differential protection, overcurrent backup protection scheme and thermal overload protection.

Models 200 through 500 have a full protection scheme including additional high-sensitivity differential protection for high-impedance earth faults, breaker failure protection, out-of-step protection, fault locator and autoreclose function. Models 200 and 400 have a single- and multi-shot autoreclose function and are used for single breaker autoreclose schemes. Models 300 and 500 have only a single-shot autoreclose function and are used for one-and-a-half breaker (two-breaker) autoreclose schemes. Models 400 and 500 have an independent fault detector in the form of a check relay, and provide the highest security. Models 503 and 513 have a CT saturation countermeasure against the external through fault current in one-and-a-half breaker schemes.

Table 1.1 GRL100 Models

(a) Two-terminal line application

Model	101B	102B	201B, 204B	202B, 206B	301B	302B	401B	501B	503B
DIF	x	x	x	x	x	x	x	x	x
BU	x	x	x	x	x	x	x	x	x
THM	x	x	x	x	x	x			
ARC			1CB	1CB	2CB	2CB	1CB	2CB	2CB
FD							x	x	x
TFC									x
DIFG			x	x	x	x	x	x	x
CCC			x	x	x	x	x	x	x
BF			x	x	x	x	x	x	x
OST			x	x	x	x	x	x	x
FL			x	x	x	x	x	x	x

(b) Three-terminal line application / Dual communication for two-terminal line application

Model	111B	112B	211B, 214B	212B, 216B	311B	312B	411B	511B	513B
DIF	x	x	x	x	x	x	x	x	x
BU	x	x	x	x	x	x	x	x	x
THM	x	x	x	x	x	x			
ARC			1CB	1CB	2CB	2CB	1CB	2CB	2CB
FD							x	x	x
TFC									x
DIFG			x	x	x	x	x	x	x
CCC			x	x	x	x	x	x	x
BF			x	x	x	x	x	x	x
OST			x	x	x	x	x	x	x
FL			x	x	x	x	x	x	x

Legend DIF: Segregated-phase current differential protection
BU: Overcurrent backup protection
THM: Thermal overload protection
ARC: Autoreclose
FD: Fault detector
TFC: Through fault current countermeasure
DIFG: Zero-phase current differential protection
CCC: Charging current compensation
BF: Breaker failure protection
OST: Out-of-step protection
FL: Fault locator

2. Application Notes

GRL100 is applicable to telecommunication systems which employ dedicated optical fibre, 64 kbit/s multiplexed communication channels or microwave links and provided with the following three communication mode settings:

- A-MODE: applied when the remote terminal relay(s) is an old version of GRL100, namely the following models.

  GRL100-101A/102A/201A/202A/301A/302A/ 401A/501A/503A
  GRL100-111A/112A/211A/212A/311A/312A/411A/511A/513A
  GRL100-201N

- B-MODE: standard operating model which provides relay address monitoring function and customisation of transmission data. (default)
- GPS-MODE: performs synchronised sampling using GPS. (This mode is suited to applications where the differential relays communicate over modern switched telecommunication networks such as Synchronous Digital Hierarchy (SDH), etc.)

Table 2.1 shows available functions of each mode. The details of functions are described later.

Table 2.1 Communication Mode and Available Function

Function	Communication Mode [COMMODE]		
	A-MODE	B-MODE	GPS-MODE
GPS-based synchronisation			×
Relay address monitoring (RYIDSV)		× (The alternative of RYIDSV or MPAR)	
Dual communication	×	×	
Remote differential trip (RDIF)		×	×
Through fault current measure (TFC)	× (for model 503B, 513B)		
Open terminal detection (OTD)	×	× (set RYIDSV to Off if applied.)	
Multi-phase autoreclosing (MPAR)	×	× (The alternative of RYIDSV or MPAR)	
Simultaneous fault signal (FG)	×	×	×
Transfer signal	2 bit (set by PLC function)	2 bit (set by PLC function.)	

GPS-MODE can be applied if the relay is provided with a GPS interface.

One of these modes can be selected by the scheme switch [COMMODE]. The default setting is "B-MODE".

(Relay Type and Model)

(eg.) GRL100 - ∗∗∗B - 13 - 1∗

→ 0: without GPS I/F

→ 1: with GPS I/F (Model 503/513 are not available)

→ 503/513: with through fault current measure (available for A-MODE only)

→ others: without through fault current measure

For details of relay models and their functions, see Table 1.1 and Appendix S.

2.1 Protection Schemes

The GRL100 provides the following protection schemes (Appendix A shows block diagrams of the GRL100 series):

- Segregated-phase current differential protection
- Zero-phase current differential protection
- Remote differential trip function
- Stub protection
- Overcurrent backup protection
- Thermal overload protection
- Out-of-step protection
- Breaker failure protection
- Transfer trip protection

Zero-phase current differential protection enables sensitive protection for high-impedance earth faults.

Overcurrent backup protection provides both inverse time overcurrent and definite time overcurrent protection for phase faults and earth faults.

Out-of-step protection performs phase comparison of the local and remote voltages and operates only when the out-of-step loci cross the protected line.

Furthermore, the GRL100 incorporates autoreclose functions for one or two breaker systems, through-current fault countermeasures for two breaker systems, charging current compensation for cable or long-distance lines and fault location. The autoreclose mode can be selected from single-phase, three-phase, single- and three-phase and multi-phase modes.

The GRL100 can enhance security by attaching fault detectors such as check relays with circuits that are independent from other circuits.

The GRL100 utilises with the microwave or fibre optic digital telecommunication systems to transmit instantaneous current values sampled synchronously at each terminal.

2.2 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 GRL100 relay installed at each line terminal samples the local currents every 7.5 electrical degrees and transmits the current data to other terminals every four samples via the telecommunication system. The GRL100 performs master/master type current differential protection using the current data from all terminals.

As synchronized sampling of all terminals is performed in the GRL100, the current data are the instantaneous values sampled simultaneously at each terminal. Therefore, the differential current can be easily calculated by summing the local and remote current data with the identical sampling address. Thus, compensation of transmission delay time is not required.

The GRL100 utilises the individual three phase currents and residual current to perform segregated-phase and zero-phase current differential protection.

2.2.2 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 2.2.2.1 shows the scheme logic of the segregated-phase current differential protection. Output signals of differential elements DIF-A, -B and -C can perform instantaneous tripping of the breaker on a per phase basis and start the incorporated autoreclose function.

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

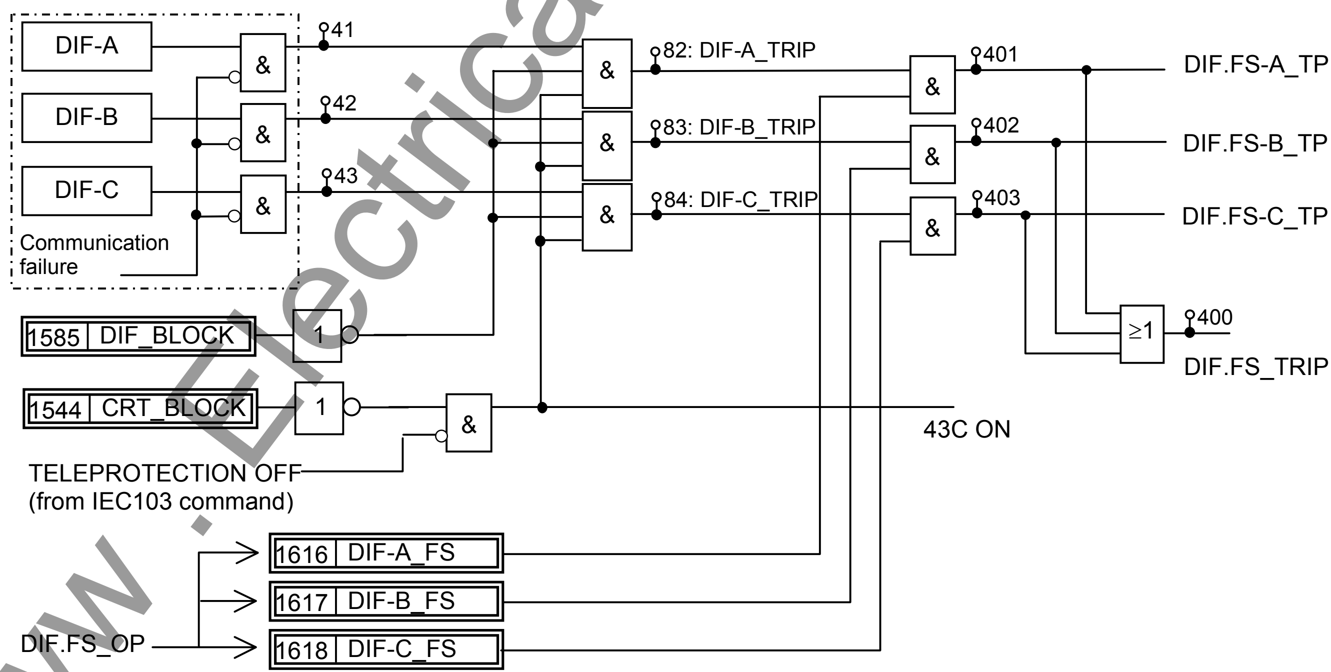


Figure 2.2.2.1 Scheme Logic of Segregated-phase Current Differential Protection

Tripping output signals can be blocked by the PLC command DIF_BLOCK and CRT_BLOCK. The output signals of DIF-A, DIF-B and DIF-C are also blocked when a communication circuit failure is detected by the data error check, sampling synchronism check or interruption of the receive signals. For DIF-A_FS, DIF-B_FS and DIF-C_FS signals, see Section 2.2.4.

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. (For details of the characteristic, see Section 2.11.)

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.

If the relay is applied to a three-terminal line, the zero setting is performed only for the current data received from an out-of-service terminal.

Figure 2.2.2.2 shows the remote terminal out-of-service detection logic. The local terminal detects that the remote terminal is out-of-service by receiving a signal LOCAL TEST which is transmitted when the scheme switch [L. TEST] is set to "ON" at the terminal under test. As an alternative means, the local terminal can detect it by using the circuit breaker and disconnector status signal CBDS-A, B and C transmitted from the remote out-of-service terminal. The signal CBDS-A is "1" when both the circuit breaker and disconnector are closed. Thus, out-of-service is detected when either the circuit breaker or disconnector is open in all three phases.

Zero setting of the receive current data is also performed at the terminal under test. If the scheme switch [L. TEST] is set to "ON" or the signal R.DATA_ZERO is input by PLC, all the receive current data transmitted from the in-service terminal is set to zero and this facilitates the local testing. The zero setting of the receive current data is not performed by the alternative way as mentioned above.

The out-of-service detection logic can be blocked by the scheme switch [OTD].

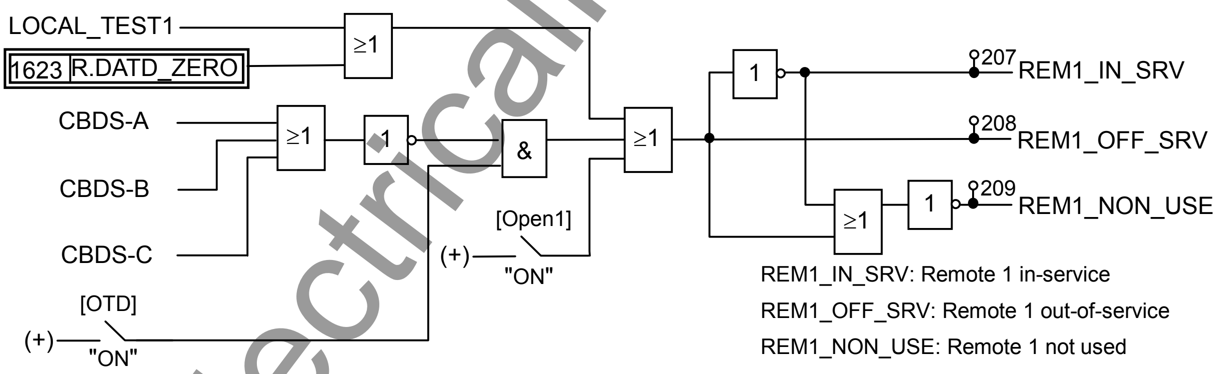


Figure 2.2.2.2 Out-of-Service Detection Logic

Note: When a communication circuit is disconnected or communication circuit failure occurs, do not close the circuit breaker. When closing it, make sure that the DIF element is blocked. (Otherwise, it may cause malfunction.)

2.2.3 Zero-phase Current Differential Protection

The GRL100 provides sensitive protection for high-impedance earth faults by employing zero-phase current differential protection. For more sensitive protection, residual current is introduced through an auxiliary CT in the residual circuit instead of deriving the zero-phase current from the three phase currents.

The zero-phase current differential element has a percentage restraining characteristic with weak restraint. For details of the characteristic, see Section 2.11.

The scheme logic is shown in Figure 2.2.3.1. The output signal of the differential element DIFG performs time-delayed three-phase tripping of the circuit breaker with the tripping output signal DIFG.FS_TRIP. DIFG.FS_TRIP can start the incorporated autoreclose function when the scheme switch [ARC-DIFG] is set to "ON".

Tripping output signal can be blocked by the PLC command DIFG_BLOCK and CRT_BLOCK. The output signal is also blocked when a communication circuit failure is detected by data error check, sampling synchronism check or interruption of the receive signals. For DIFG_FS signal, see Section 2.2.4.

Since the DIFG is used for high-impedance earth fault protection, the DIFG output signal is blocked when zero-phase current is large as shown in the following equation:

$$\Sigma|I_{01}| \geq 2 \text{ pu} \quad \text{or} \quad \Sigma|I_{02}| \geq 2 \text{ pu}$$

where,

$\Sigma|I_{01}|$: Scalar summation of zero-phase current at local terminal relay

$\Sigma|I_{02}|$: Scalar summation of zero-phase current at remote terminal relay

pu: per unit value

In GPS-mode setting and backup mode (refer to 2.2.7.2), DIFG is blocked.

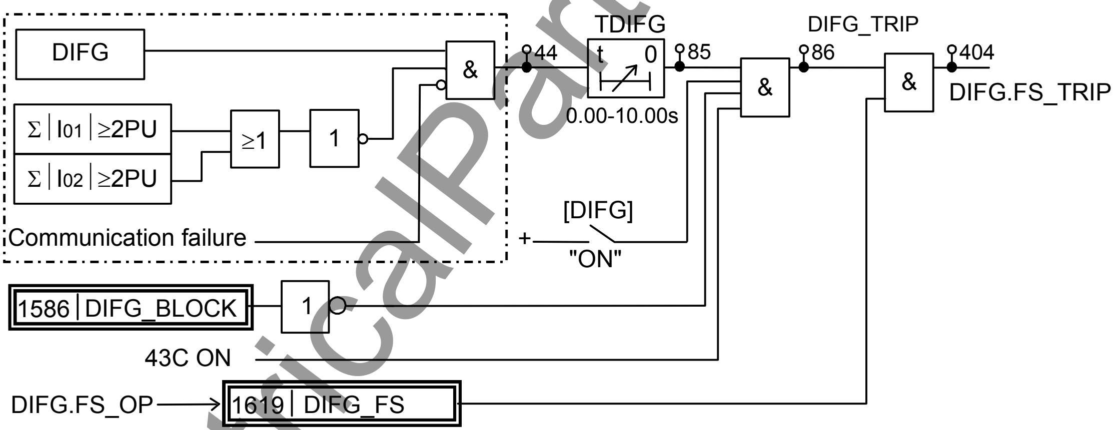


Figure 2.2.3.1 Scheme Logic of Zero-phase Current Differential Protection

2.2.4 Fail-safe Function

GRL100 provides OC1, OCD and EFD elements. These are used for fail-safe to prevent unnecessary operation caused by error data in communication failure. OC1 is phase overcurrent element and its sensitivity can be set. OCD is phase current change detection element, and EFD is zero-sequence current change detection element. Both of the OCD and EFD sensitivities are fixed. The scheme logic is shown in Figure 2.2.4.1.

The outputs of DIF.FS_OP and DIFG.FS_OP signals are connected to DIF-A_FS, DIF-B_FS, DIF-C_FS and DIFG_FS respectively by PLC function. These are connected at the default setting.

The fail-safe functions are disabled by [DIF-FS] and [DIFG-FS] switches. In the [DIF-FS], OC1 or OCD or both elements can be selected. If these switches are set to “OFF”, the signals of DIF.FS_OP and DIFG.FS_OP are “1” and the fail-safe is disabled.

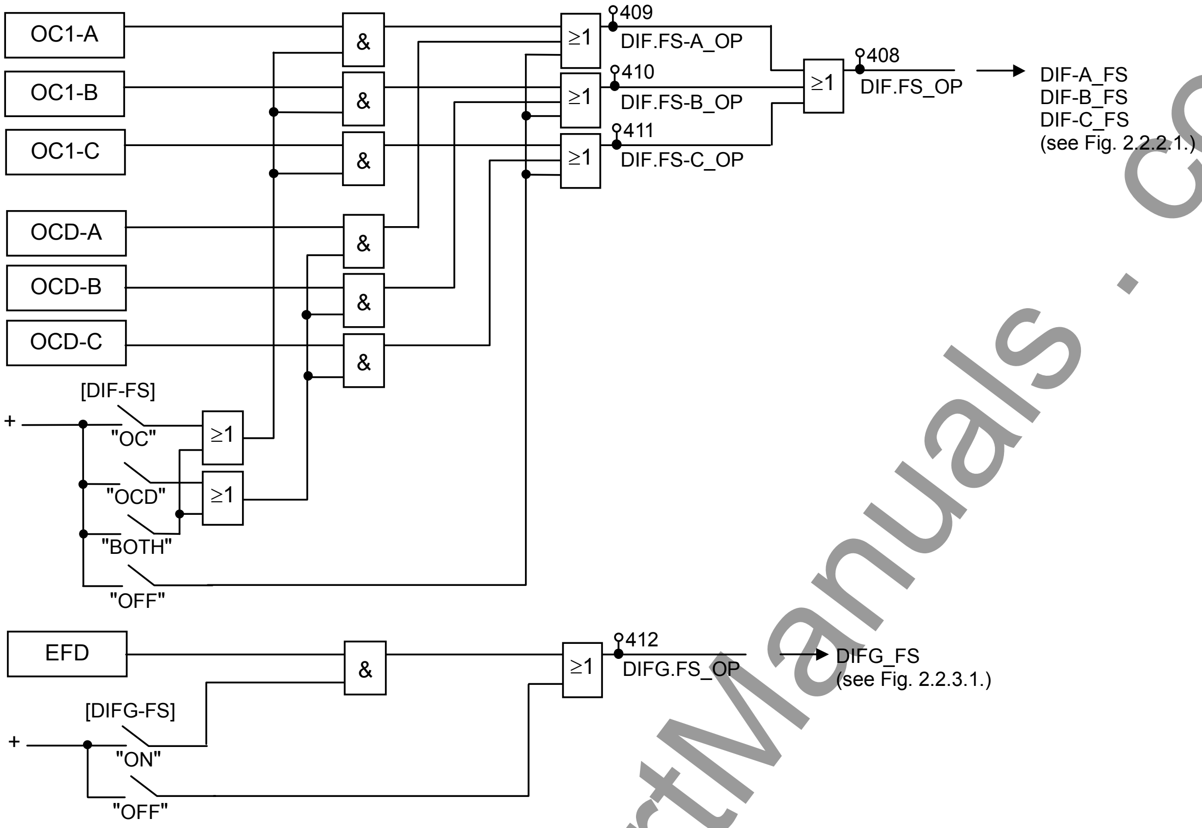


Figure 2.2.4.1 Fail-safe Logic

2.2.5 Remote Differential Trip

Note: This function is available only when the three-terminal protection is applied by setting the scheme switch [TERM] to “3-TERM”. In the case of A-MODE setting, this function is not available.

When one of the telecommunication channels fails, the terminal using the failed channel is disabled from performing current differential protection, as a result of the failure being detected through by the telecommunication channel monitoring.

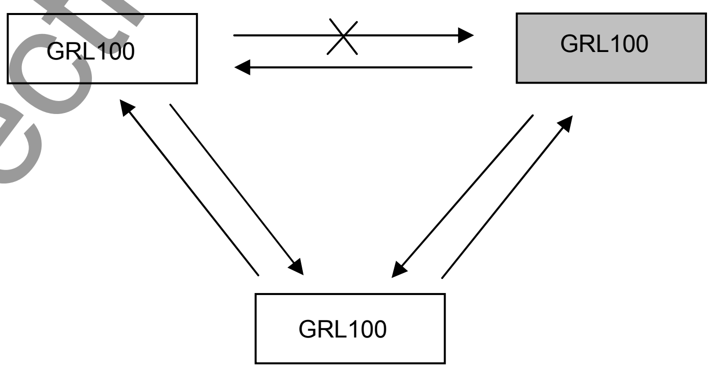


Figure 2.2.5.1 Protection Disabled Terminal with Channel Failure

The remote differential trip (RDIF) function enables the disabled terminal to trip by receiving a trip command from the sound terminal, which continues to perform current differential protection.

Figure 2.2.5.2(a) and (b) show the RDIF scheme logic at RDIF command sending terminal (= sound terminal) and command receiving terminal (= disabled terminal). The sound terminal sends the command when the tripping signals RDIF-A-S, RDIF-B-S, RDIF-C-S or RDIF-S are output locally and the scheme switches [RDIF] and [TERM] are set to "ON" and "3-TERM" respectively. The RDIF command is sent to the remote terminal via the 64kb/s digital link together with other data and signals.

The receiving terminal outputs a local three-phase trip signal RDIF-TRIP under the conditions that when the command RDIF1 or RDIF2 is received from either of the remote terminals, local differential protection does not operate, the scheme switches [RDIF] and [TERM] are set to "ON" and "3-TERM" respectively and no communication channel failure exists in the channel which received the RDIF command.

When the RDIF function is applied, the command sending signals and receiving signals must be assigned by PLC function.

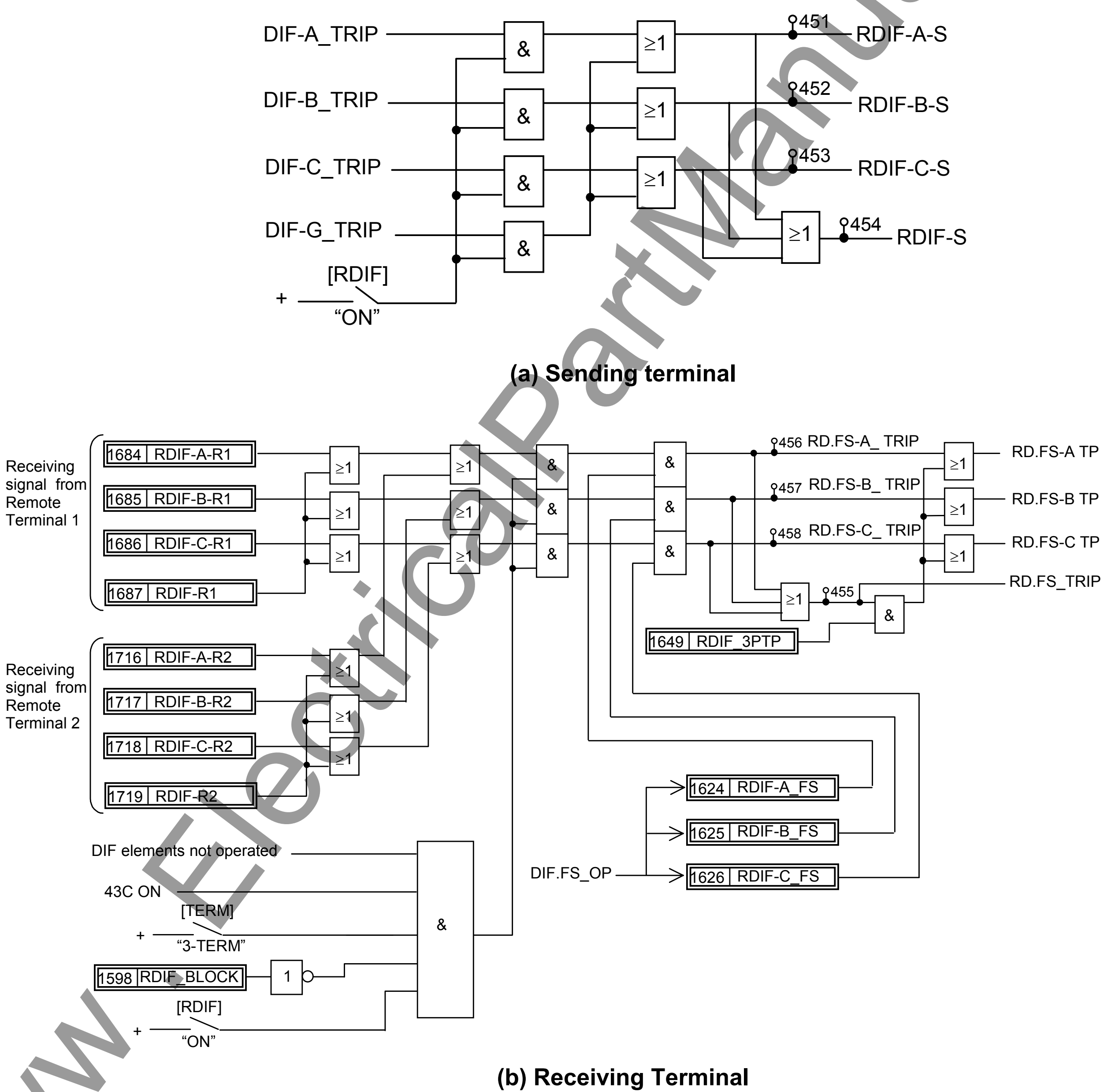


Figure 2.2.5.2 Remote Differential Trip

2.2.6 Transmission Data

The following data are transmitted to the remote terminal via the 64kb/s digital link. The data depends on the communication mode and whether a function is used or not. The details are shown in Appendix N.

A-phase current

B-phase current

C-phase current

Residual current

Positive sequence voltage

A-phase differential element output signal

B-phase differential element output signal

C-phase differential element output signal

A-phase breaker and disconnector status

B-phase breaker and disconnector status

C-phase breaker and disconnector status

Scheme switch [LOCAL TEST] status

Scheme switch [TFC] status

Reclose block command

Sampling synchronization control signal

Synchronized test trigger signal

User configurable data

Current and voltage data are instantaneous values which are sampled every 30 electrical degrees (12 times per cycle) and consist of eleven data bits and one sign bit. This data is transmitted every sample to the remote terminal.

Three differential element outputs and the transfer trip command are related to remote terminal tripping and are transmitted every sampling interval.

Other data is transmitted once every power cycle.

The data transmission format and user configurable data are also shown in Appendix N.

A synchronized test trigger signal is used to test the differential protection simultaneously at all terminals. For details, see Section 6.5.3.

In addition to the above data, cyclic redundancy check bits and fixed check bits are transmitted to monitor the communication channel. If a channel failure is detected at the local terminal, all the local and remote current and voltage data at that instant are set to zero and outputs of the differential protection and out-of-step protection are blocked, and these protections of remote terminal are also blocked because the channel failure is also detected at the remote terminal.

2.2.7 Synchronized Sampling

The GRL100 performs synchronized simultaneous sampling at all terminals of the protected line. Two methods are applied for the sampling synchronization; intra-system synchronization and GPS-based synchronization. The former is applied to communication modes A-MODE and

B-MODE, and the latter is applied to GPS-MODE.

The intra-system synchronization keeps the sampling timing error between the terminals within ±10μs or ±20μs and the GPS-based system keeps it within ±5μs or ±10μs for two- or three-terminal applications.

In both methods, the sampling synchronization is realized through timing synchronization control and sampling address synchronization control. These controls are performed once every two power cycles.

2.2.7.1 Intra-system Synchronized Sampling for A-MODE and B-MODE

The synchronized sampling is realized using sampling synchronization control signals transmitted to other terminals together with the power system data. This synchronized sampling requires neither an external reference clock nor synchronization of the internal clocks of the relays at different terminals. The transmission delay of the channel is corrected automatically.

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 GRL100s at all terminals perform identical protection functions and operate simultaneously.

To perform timing synchronization for the slave terminal, the sampling time difference between master and slave terminals is measured. The measurement principle of the sampling time difference ΔT is indicated in Figure 2.2.7.1. The master terminal and slave terminal perform their own sampling and send a signal that becomes the timing reference for the other terminal.

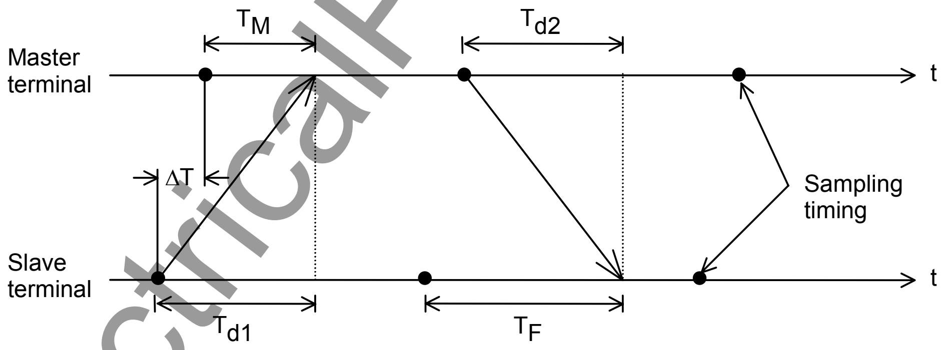


Figure 2.2.7.1 Timing Synchronization

Each terminal measures the time T_M and T_F from its own sampling instant to the arrival of the signal from the other terminal. As is evident from the figure, the times T_M and T_F can be obtained by equation (1) and (2) where T_{d1} and T_{d2} are the transmission delay of the channel in each direction. The sampling time difference ΔT can be obtained from the resulting equation (3).

$$T_M = T_{d1} - \Delta T \qquad (1)$$

$$T_F = T_{d2} + \Delta T \qquad (2)$$

$$\Delta T = \{(T_F - T_M) + (T_{d1} - T_{d2})\}/2 \qquad (3)$$

The slave terminal advances or retards its sampling timing based on the time ΔT calculated from equation (3), thereby reducing the sampling time difference with the master terminal to zero. This adjustment is performed by varying the interval of the sampling pulse generated by an oscillator in the slave terminal.

The difference of the transmission delay time T_{dd} (= $T_{d1} - T_{d2}$) is set to zero when sending and receiving take the same route and exhibit equal delays. When the route is separate and the sending and receiving delays are different, T_{dd} must be set at each terminal to be equal to the sending delay time minus the receiving delay time. The maximum T_{dd} that can be set is 10ms. (For setting, see Section 4.2.6.7. The setting elements of transmission delay time difference are TCDT1 and TCDT2.)

The time T_M measured at the master terminal is sent to the slave terminal together with the current data and is used to calculate the ΔT.

The permissible maximum transmission delay time of the channel is 10ms.

In case of the three-terminal line application, the communication ports of the GRL100 are interlinked with each other as shown in Figure 2.2.7.2, that is, port CH1 of one terminal and port CH2 of the other terminal are interlinked. For the setup of the communication system, see Section 2.12.3.

When terminal A is set as the master terminal by the scheme switch [SP.SYN], the synchronization control is performed between terminals A and B, and terminals B and C. The terminal B follows the terminal A and the terminal C follows the terminal B. The slave terminals perform the follow-up control at their communication port CH2.

When the master terminal is out-of-service in A-MODE, the slave terminal that is interlinked with port 1 of the master terminal takes the master terminal function. In the case shown in Figure 2.2.7.2, terminal B takes the master terminal function when the master terminal A is out-of-service. In B-MODE and GPS-MODE, even if the master terminal is out-of-service, the master terminal is not changed. If DC power supply of the out-of-service terminal is “OFF”, differential elements at all terminals are blocked. Therefore, the [TERM] setting change from “3TERM” to “2TERM” is required.

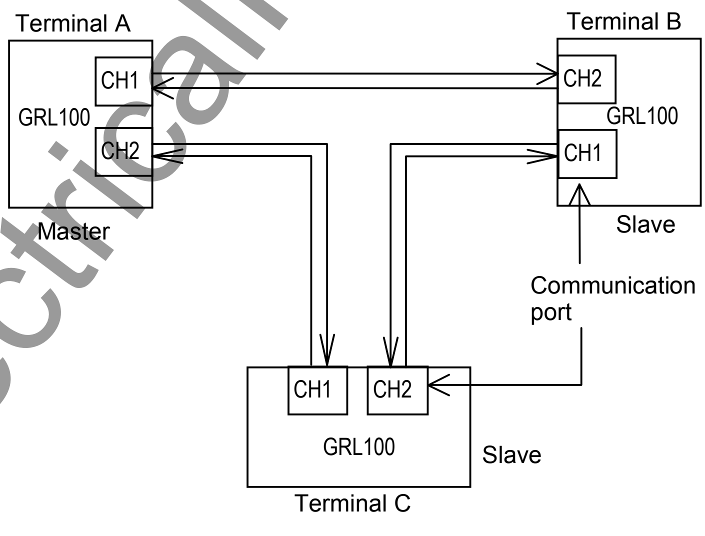


Figure 2.2.7.2 Communication Link in Three-terminal Line

Sampling address synchronization

The principle of sampling address synchronization control is indicated in Figure 2.2.7.3. After time synchronization has been established, the slave terminal measures the time from sending its own timing reference signal until it returns from the master terminal. The transmission delay time T_{d1} from slave to master terminal can be calculated from equation (4).

$$T_d = (\{T_o - (T - T_M)\}/2 + T_{dd})/2 \qquad (4)$$

The calculated transmission delay time T_{d1} is divided by the sampling interval T. The mantissa is truncated and the quotient is expressed as an integer. If the integer is set to P, the reception at the slave terminal of the signal sent from the master terminal occurs at P sampling intervals from the transmission. Accordingly, by performing control so that the sampling address of the slave terminal equals integer P when the sampling address = 0 signal is received from the master terminal, the sampling address of the slave terminal can be made the same as the master terminal.

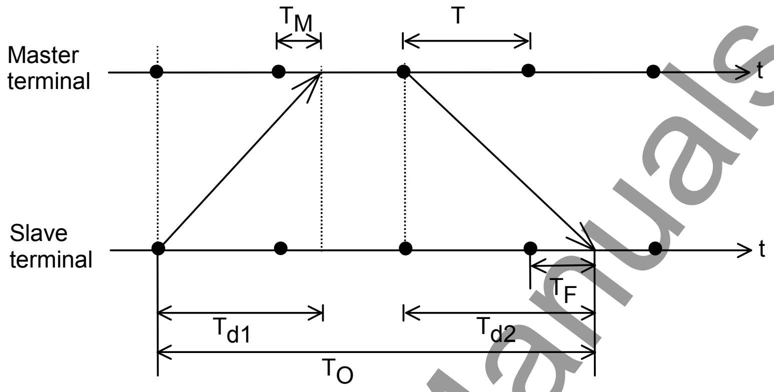


Figure 2.2.7.3 Sampling Address Synchronization

2.2.7.2 GPS-based Synchronized Sampling for GPS-MODE

The relays at all terminals simultaneously receive the GPS clock signal once every second. Figure 2.2.7.4 shows the GPS-based synchronized sampling circuit at one terminal. The GPS clock signal is received by the GPS receiver HHGP1 and input to a time difference measurement circuit in the GRL100. The circuit measures the time difference ΔT between the GPS clock and the internal clock generated from the crystal oscillator. The oscillator is controlled to synchronize with the GPS clock using the measured ΔT and outputs 2,400 Hz (50Hz rating) sampling signals to the current sampling circuit (analog to digital converter).

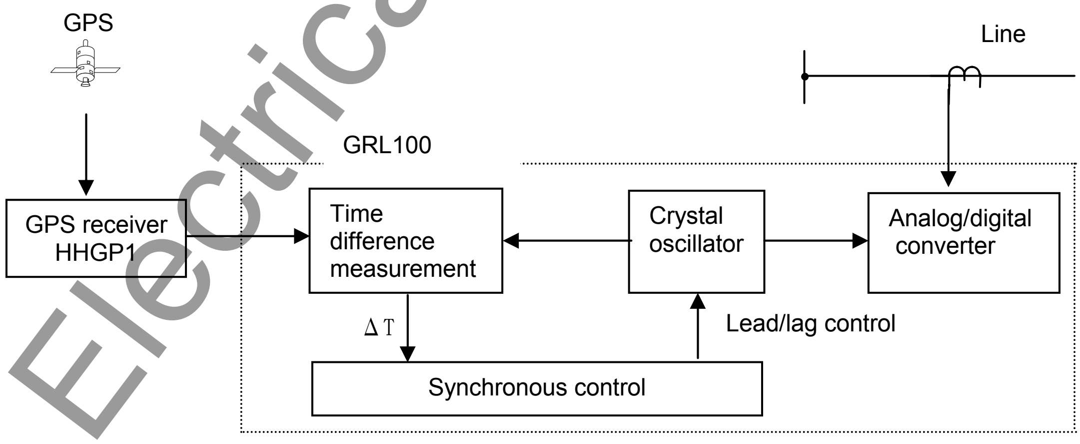


Figure 2.2.7.4 GPS Clock-based Sampling

Timing synchronization

When the GPS signal is received normally at every line terminal, the GRL100 performs synchronized sampling based on the received clock signal. The GRL100 can provide a backup synchronization system if the GPS signal is interrupted at one or more terminals, and perform synchronized sampling without any external reference clock. The backup system becomes valid by setting the scheme switch [GPSBAK] to "ON".

In the backup modes, the percentage restraint in the small current region can be increased from the normal 16.7% ((1/6)Ir in Figure 2.9.10.1) in accordance with the PDTD setting which is the probable transmission delay time difference between send and receive channels.

Backup modes, Mode 1, 2A and 2B are initialised when the backup system is set valid.

If the GPS signal interruption occurs when the backup is set invalid, the sampling runs based on the local clock. When the arrival time of the remote signal measured from local sampling instant deviates from a nominal time, the protection is blocked.

Mode 0: When the GPS signal is received normally, the sampling is performed synchronizing with the received clock signal thus realizing synchronized sampling at all terminals. Difference of the transmission delay time for the channel in each direction and fluctuation of the delay time can be permitted.

The GRL100 performs the protection based on the nominal current differential characteristics.

When the GPS signal has interrupted for more than ten seconds at any of the terminals, the mode changes to Mode 1 at all terminals.

Mode 1: The terminal which loses its GPS signal first functions as the slave terminal. If all terminals lose their signals simultaneously, then the scheme switch [SP.SYN] setting determines which terminal functions as the slave or master. The slave terminal adjusts the local sampling timing to synchronize the sampling with other terminal which is receiving the GPS signal regularly or with the master terminal.

Note: When two terminals are receiving the GPS signal regularly, the slave terminal synchronizes with the terminal that is interlinked with port 2 of the slave terminal.

When the GPS signal has been restored, the mode shifts from Mode 1 back to Mode 0.

If, during Mode 1 operation, a failure occurs in the communication system, the sampling timing adjustment is disabled and each terminal runs free. If the free running continues over the time determined by the PDTD setting or the apparent phase difference exceeds the value determined by the PDTD setting, the mode shifts from Mode 1 to Mode 2A at all terminals.

Mode 2A: In this mode, the intra-system synchronization described in 2.2.7.1 is applied assuming that the transmission delay time for the channel in each direction is identical. Fluctuation of the delay time can be permitted.

The current differential protection is blocked in this mode.

When the GPS signal has been restored, the mode shifts from Mode 2A to Mode 0.

If the GPS signal interruption occurs a set period following energisation of the relay power supply or the mode returned to Mode 0 from Mode 1, 2A or 2B, then the transmission delay time measurement will not be completed in Mode 0, and the mode changes to Mode 2A.

When the apparent current phase difference has stayed within the value determined by the PDTD setting, the scheme switch [AUTO2B] for automatic mode change is set to "ON" and [TERM] is set to "2TERM", the mode changes from Mode 2A to Mode 2B at both terminals.

The mode can be changed to Mode 2B manually through a binary input signal "Mode 2B initiation" or user interface. Before this operation, it must be checked that the transmission delay time difference between send and receive terminals is less than the PDTD setting and the SYNC ALARM LED is off. If these conditions are not satisfied, the operation may cause a false tripping.

Note: The mode change with the binary input signal is performed by either way:

- If the binary input contact is such as to be open when the relay is in service, set the BI to "Inv" (inverted). The mode changes when the contact is closed more than 2 seconds and then open.

- If the binary input contact is such as to be closed when the relay is in service, set the BI to "Norm" (normal). The mode changes when the contact is open more than 2 seconds and then closed.
  For the BISW4, see Section 3.2.1.

  In the three-terminal application, the mode change to Mode 2B is available even when one of the three communication routes is failed.

Mode 2B: The same intra-system synchronization as in Mode 2A is applied.

When the GPS signal has been restored, the mode shifts from Mode 2B to Mode 0.

If a failure occurs in the communication system, the sampling timing adjustment is disabled and each terminal runs free.

The mode shifts from Mode 2B to Mode 2A, when the apparent load current phase difference exceeds the value determined by the PDTD setting for pre-determined time.

Checking the current phase difference (For two-terminal application setting only)

The current phase difference is checked using the following equations:

$I_{1A} \cdot \cos\theta < 0$

$I_{1A} \cdot I_{1B} \sin\theta < I_{1A} \cdot I_{1B} \sin\theta s$

$I_{1A} > \mathrm{OCCHK}$

$I_{1B} > \mathrm{OCCHK}$

Where,

I_{1A} = Positive sequence component of load current at local terminal
I_{1B} = Positive sequence component of load current at remote terminal
θ = Phase difference of I_{1B} from $-I_{1A}$
θs = Critical phase difference
= $\mathrm{CHK}\theta - \mathrm{HYS}\theta$

$$\mathrm{CHK}\theta = \frac{\mathrm{PDTD}(\mu s)}{2} \times \frac{360°}{20000(\mu s)} + 8.5°$$

$\mathrm{HYS}\theta$ = Margin of phase difference checking

OCCHK = Minimum current for phase difference check

If the magnitude of I_{1A} and I_{1B} exceed the setting and the conditions for both equations above are established, then the sampling is regarded to be synchronized.

If the current phase difference exceeds a set value, the "SYNC ALARM" LED on the front panel is lit.

Checking the current phase difference is enabled by setting the scheme switches [TERM] to "2TERM" and [SRCθ] to "I".

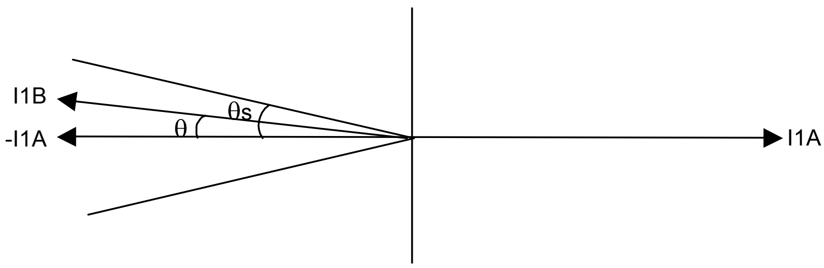


Figure 2.2.7.5 Current Phase Difference Check

Sampling address synchronization

The same method as described in section 2.2.7.1 is employed in Mode 0 and Mode 2A where the sampling synchronization must be established. It is not employed in Mode 1 and 2B because the sampling address synchronization has already been established in the previous mode.

2.2.7.3 Differential Current Calculation

Synchronized sampling allows correct calculation of differential current even in the presence of a transmission time delay. This processing is indicated in Figure 2.2.7.6. As indicated in the figure, sampling synchronization is established between terminals A and B, and both the sampling timing and sampling address match. The instantaneous current data and sampling address are both sent to the other terminal. The GRL100 refers to the sampling address affixed to the received data and uses local data with the same sampling address to calculate the differential current. This allows both terminals to use data sampled at the same instant to perform the differential current calculation, no matter how large the transmission time delay is.

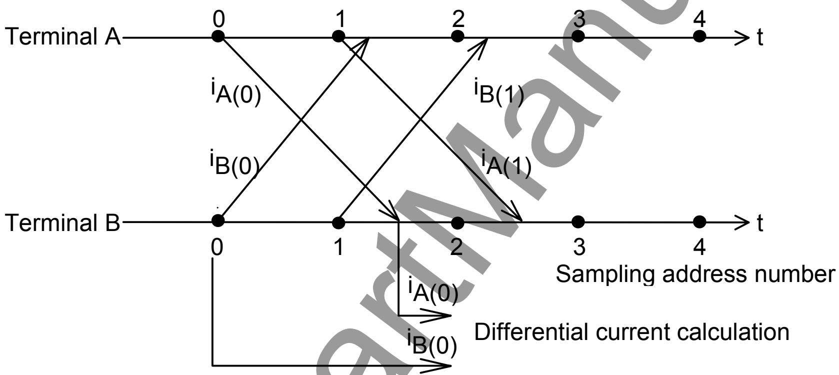


Figure 2.2.7.6 Calculation of Differential Current with Transmission Delay Time

Protection in anomalous power system operation

Even when any of the terminals is out-of-service, the GRL100 in-service terminal can still provide the differential protection using the out-of-service detection logic. For details of the out-of-service detection logic, see Section 2.2.2.

When one terminal is out-of-service in a two-terminal line, the other terminal continues the current differential protection using the local current irrespective of whether it is a master terminal or a slave terminal.

When one terminal is out-of-service in a three-terminal line, synchronized sampling is established between the remaining two terminals as follows and the differential protection is maintained.

- If the master terminal is out-of-service, one of the slave terminals takes over the master terminal synchronized sampling function and enables current differential protection between the remaining terminals to be performed.
- If the slave terminal is out-of-service, the master and another slave terminal maintain the differential protection.

When two terminals are out-of-service in a three-terminal line, the remaining terminal continues the current differential protection using the local current irrespective of whether it is a master terminal or a slave terminal.

2.2.8 Charging Current Compensation

When differential protection is applied to underground cables or long overhead transmission lines, the charging current which flows as a result of the capacitance of the line (see Figure 2.2.8.1) appears to the protection relay as an erroneous differential current.

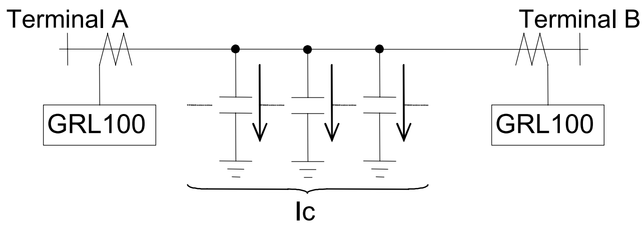


Figure 2.2.8.1 Charging Current

The charging current can be compensated for in the setting of the relay's differential protection sensitivity but only at the expense of reduced sensitivity to internal faults. In addition, the actual charging current varies with the running voltage of the line and this must be taken into account in the setting.

In order to suppress the effect of the charging current while maintaining the sensitivity of the differential protection, GRL100 is equipped with a charging current compensation function, which continuously re-calculates the charging current according to the running line voltage and compensates for it in its differential current calculation. The running line voltage is measured by VT inputs to GRL100.

The user enters values for line charging current and for the line voltage at which that charging current was determined in the settings [DIFIC] and [Vn], and these values are used by the relay to calculate the capacitance of the line. The relays at each line end share the line capacitance between them, that is they divide by two for a two-terminal line, and by three for a three-terminal line. In the case of a three-terminal line, if the relay at one terminal is out-of-service for testing (see out-of-service terminal detection), the other two terminals are automatically re-configured to divide the line capacitance by two.

Each terminal continuously calculates its share of the charging current at the running line voltage on a sample by sample basis as follows:

$$I_c = C\, {}^{dV}/_{dt}$$

where,

Ic = line charging current

C = line capacitance calculated from settings [DIFIC] and [Vn]

V = measured line voltage

The relay then calculates the line current compensated for the charging current on a sample by sample basis as follows:

$$I = I' - I_c$$

where,

- I = compensated current

I' = actual measured current

Note that since GRL100 calculates both the charging current and compensated line current on a sample by sample basis, all necessary phase information is inherently taken into account.

2.2.9 Blind Zone Protection

The GRL100 relay has "Out-of-Service Detection Logic" as described in Section 2.2.2. This logic functions automatically to detect the remote CB or DS (line disconnecting switch) opened condition as shown in Figure 2.2.9.1. If the remote CB or DS is opened, the received remote current data is set to "zero" Ampere at the local terminal, and the local relay can be operated with only local current like a simple over current relay. Therefore, this logic function is used for blind zone protection.

The zone between CB and CT at the remote terminal is the blind zone in Figure 2.2.9.1. If a fault occurs within this zone, the busbar protection should operate first and trip the CB at the remote terminal, but the fault remains and the fault current (I_F) is fed continuously from the local terminal. Since this phenomenon is an external fault for the current differential protection scheme, the blind zone fault cannot be cleared. The fault may be cleared by remote backup protection following a time delay, but there is a danger of damage being caused to power system plant. Fast tripping for this type of fault is highly desirable. The Out-of-Service Detection Logic is effective for a fault where a blind zone between CT and CB on the line exists as shown in Figure 2.2.9.1.

If the CB and DS condition are introduced at the remote terminal as shown in Figure 2.2.9.1, the GRL100 relay at the local terminal can operate with only local current and the fault can be cleared, because the remote current data is automatically cancelled as explained above.

Please note the "CB Close Command" signal must be connected to the GRL100 relay to prevent unwanted operation for a CB close operation (manual close and/or autoreclose). Unwanted operation may be caused if the close timing of the CB auxiliary contact is delayed relative to the CB main contact. Therefore, the CB close command signal resets forcibly the Out-of-Service Detection Logic before the CB main contact is closed.

CB and DS status signals are input by PLC. If the out-of-service detection is not used, its logic can be blocked by the scheme switch [OTD].

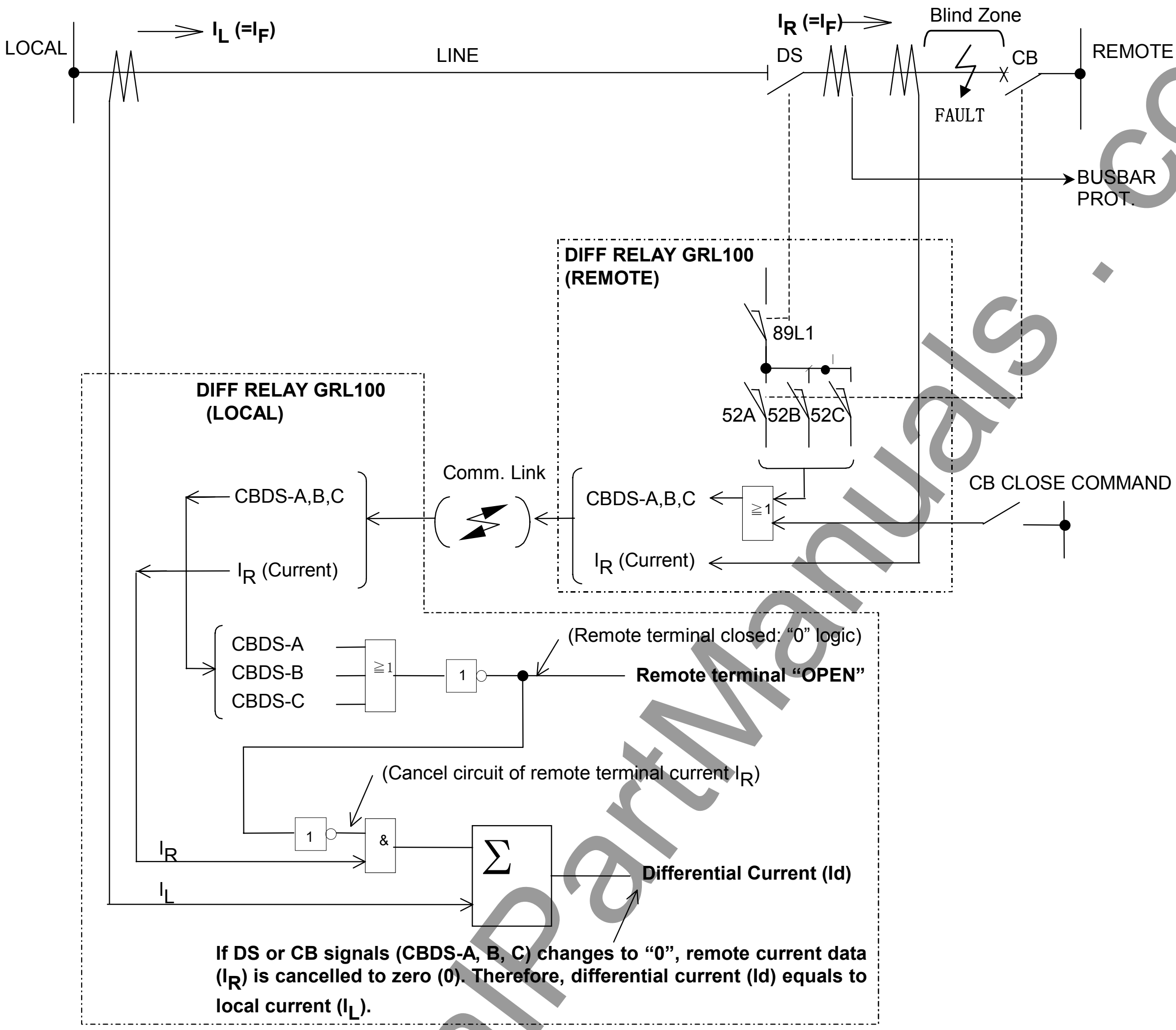


Figure 2.2.9.1 Blind Zone Protection

2.2.10 Application to Three-terminal Lines

When current differential protection is applied to a three-terminal line, special attention must be paid to the fault current flowing out of the line in the case of an internal fault and CT saturation at the outflowing terminal in case of an external fault.

Fault current outflow in case of internal fault

In case of a two-terminal line, fault current never flows out from the terminals for an internal fault. But in case of a three-terminal line with an outer loop circuit, a partial fault current can flow out of one terminal and flow into another terminal depending on the fault location and magnitude of the power source behind each terminal.

Case 1 in Figure 2.2.10.1 shows a fault current outflow in a single circuit three-terminal line with outer loop circuit. J and F in the figure indicate the junction point and fault point. A part of the fault current flowing in from terminal A flows out once from terminal C and flows in again from terminal B through the outer loop.

Case 2 shows the outflow in a double-circuit three-terminal line. The outer loop is generated when one terminal is open in the parallel line. A part of the fault current flowing in from terminal A flows out from the fault line to the parallel line at terminal C and flows in again at terminal B through the parallel line.

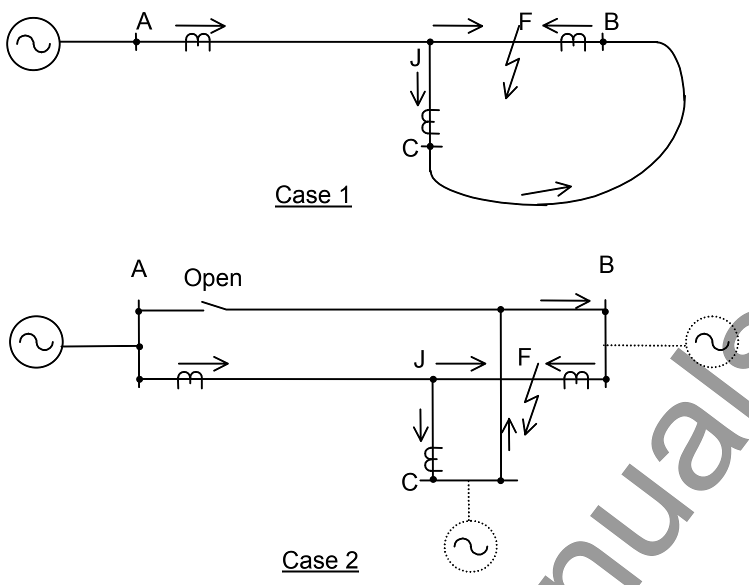


Figure 2.2.10.1 Fault Current Outflow in Internal Fault

The larger current outflows from terminal C when the fault location is closer to terminal B and the power source behind terminal C is weaker. In case of a double-circuit three-terminal line, 50% of the fault current flowing in from terminal A can flow out from terminal C if terminal C is very close to the junction and has no power source behind it.

These outflows must be considered when setting the differential element.

CT saturation for an external fault condition

In case of a two-terminal line, the magnitude of infeeding and outflowing currents to the external fault is almost the same. If the CTs have the same characteristics at the two terminals, the CT errors are offset in the differential current calculation.

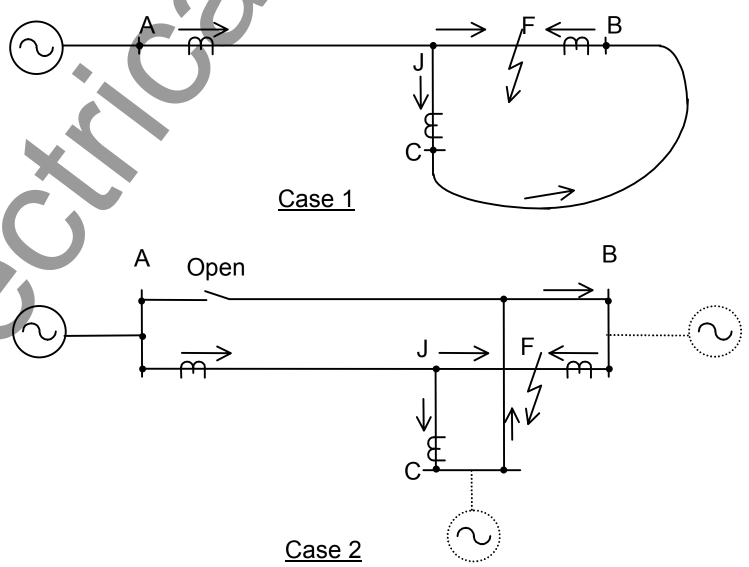


Figure 2.2.10.2 Fault Current Distribution

But in case of a three-terminal line, the magnitude of the current varies between the terminals and the terminal closest to the external fault has the largest magnitude of outflowing fault current. Thus, the CT errors are not offset in the differential current calculation. Thus, it is necessary to check whether any fault causes CT saturation, particularly in the terminal with outflow, and the saturation must be accommodated utilising the DIFI2 setting of the DIF element.

2.2.11 Dual Communication Mode

Three-terminal application models have dual communication mode (GRL100-∗1∗). By connecting the remote terminal with dual communication routes, even if one of the routes fails, it is possible to continue sampling synchronization and protection by the current differential relay. To set dual communication mode, select "Dual" in the TERM setting. Other settings are the same as that of the two-terminal. In GPS-MODE setting, however, the dual communication mode cannot be applied.

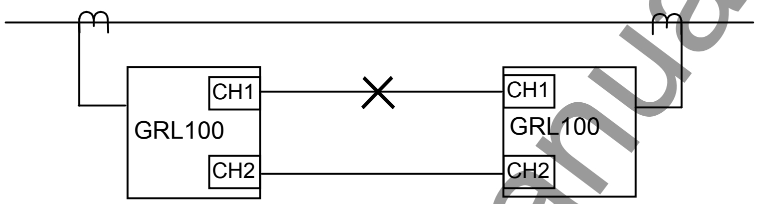


Figure 2.2.11.1 Dual Communication Mode

2.2.12 Application to One-and-a-half Breaker Busbar System

The GRL100 models 301, 311, 302, 501, 511, 503, 513, and 513 are used for lines connected via a one-and-a-half breaker busbar system, and have functions to protect against stub faults and through fault currents.

Stub fault

If a fault occurs at F1 or F2 when line disconnector DS of terminal A is open as shown in Figure 2.2.12.1, the differential protection operates and trips the breakers at both terminals.

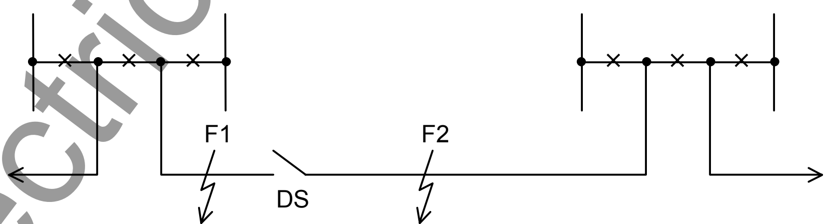


Figure 2.2.12.1 Stub Fault

A scheme switch [STUB] and stub fault detection logic as shown in Figure 2.2.12.2 are provided to avoid unnecessary trippings of the breakers in these cases.

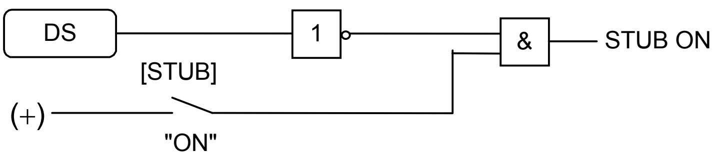


Figure 2.2.12.2 Measure for Stub Fault

If the switch is set to "ON" and the disconnector is open (DS = 0), the signal STUB ON is generated and used to reset the receiving current data from terminal B to zero. Thus, terminal A does not need to operate unnecessarily in response to fault F2.

Terminal B detects that terminal A is out-of-service with the out-of-service detection logic and resets the receiving current data from terminal A to zero, and so does not operate in response to fault F1.

The signal STUB ON also brings the local tripping into three-phase final tripping.

Through current for a close-up external fault

In the close-up external fault shown in Figure 2.2.12.3, a large fault current may flow through current transformers CT1 and CT2 at terminal A and a small fault current flows in at terminal B. This large through fault current may cause an erroneous differential current if the characteristics of CT1 and CT2 are not identical.

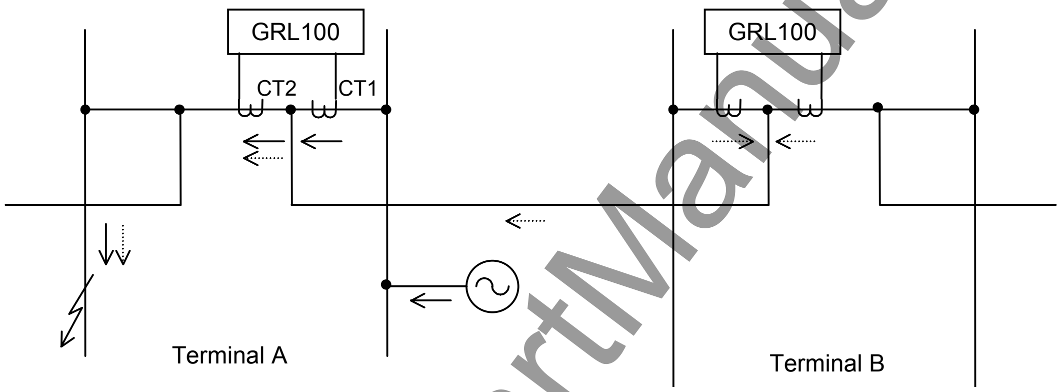


Figure 2.2.12.3 Through Fault Current

The models 503 and 513 have individual input terminals for CT1 and CT2 secondary current. Thus, sufficient restraining current can be obtained by summing the scalar values of CT1 and CT2 secondary currents.

In this manner, terminal A can have sufficient restraining current against the erroneous differential current mentioned above and demonstrate correct non-operation. But terminal B cannot have a sufficient restraining current and may operate in response to the fault incorrectly.

To cope with this, the GRL100 has a scheme switch [T.F.C] and the scheme logic of the differential protection shown in Figure 2.2.2.1 is switched to that of Figure 2.2.12.4. When the [T.F.C] is set to "ON" locally or at the remote terminal, tripping commands are output under the condition that the differential protection operates at both ends.

In this case, the tripping time is delayed by the transmission time of the remote terminal operation signal.

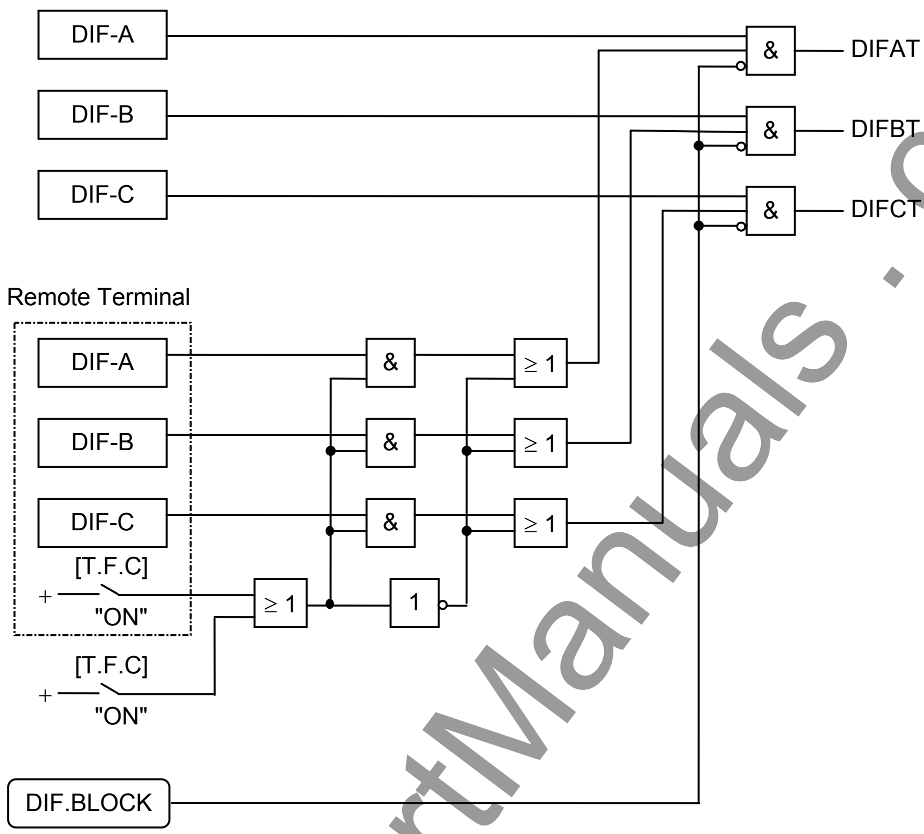


Figure 2.2.12.4 Scheme Logic for Through Fault Current

Fault current outflow in case of internal fault

As shown in Figure 2.2.12.5, the fault current may outflow in case of an internal fault of double-circuit lines. The outflow at terminal A increases as the fault location F approaches terminal B. When the fault is close to terminal B, 50% of the fault current flows out to the parallel line, though it depends on the power source conditions at terminals A and B.

This outflow must be considered when setting the differential element.

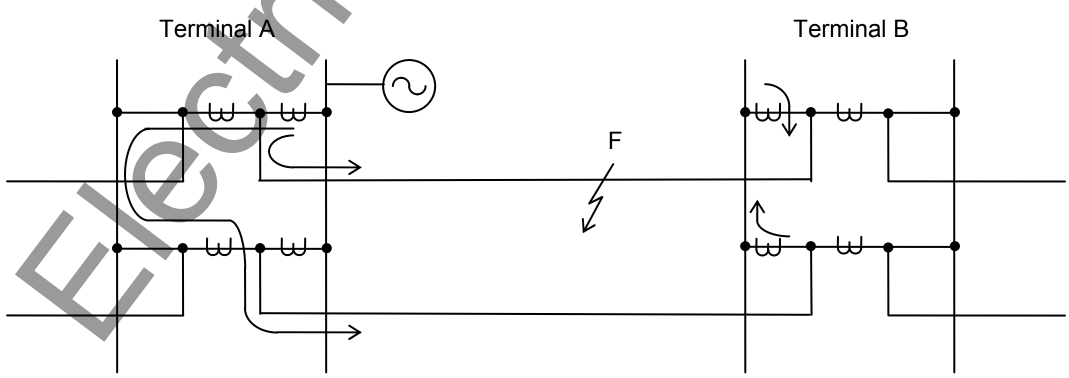


Figure 2.2.12.5 Fault Current Outflow in Internal Fault

2.2.13 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	Communication Mode A	B	GPS
DIF					Phase current			
	DIFI1	0.50 – 10.00A	0.01A	5.00A	Small current region	x	x	x
		(0.10 – 2.00A	0.01A	1.00A)(*1)				
	DIFI2	3.0 – 120.0A	0.1A	15.0A	Large current region	x	x	x
		(0.6 – 24.0A	0.1A	3.0A)				
DIFG	DIFGI	0.25 – 5.00A	0.01A	2.50A	Residual current	x	x	x
		(0.05 – 1.00A	0.01A	0.50A)				
DIFIC		0.00 – 5.00A	0.01A	0.00 A	Charging current compensation	x	x	x
		(0.00 – 1.00A	0.01A	0.00 A)				
Vn		100 - 120V	1V	110V	Rated line voltage	x	x	x
TDIFG		0.00 – 10.00s	0.01s	0.50s	Delayed tripping timer	x	x	x
DIFSV		0.25 – 10.00A	0.01A	0.50A	Differential current (Id) monitoring	x	x	x
		(0.05 – 2.00A	0.01A	0.10A)				
TIDSV		0 – 60s	1s	10s	Timer for Id detection	x	x	x
OCCHK (*5)		0.5 – 5.0A	0.1A	0.5A	Minimum current for phase difference check	--	--	x
		(0.10 – 1.00A	0.01A	0.10A)				
HYSθ (*5)		1 – 5 deg	1 deg	1 deg	Phase difference check margin	--	--	x
TDSV		100 - 16000	1μs	6000μs	Transmission delay time threshold setting for alarm (*8)	x	x	x
TCDT1		–10000 – 10000	1μs	0μs	Transmission delay time difference setting for channel 1 (*7)	x	x	x
TCDT2		–10000 – 10000	1μs	0μs	Transmission delay time difference setting for channel 2 (*7)	x	x	x
PDTD		200 - 2000μs	1μs	1000μs	Transmission delay time difference between send and receive channels (GPS synchronization only)	--	--	x
RYID		0-63		0	Local relay address	--	x	x
RYID1		0-63		0	Remote 1 relay address	--	x	x
RYID2		0-63		0	Remote 2 relay address	--	x	x
[DIFG]		ON/OFF		ON	High impedance earth fault protection	x	x	x
[STUB]		ON/OFF		ON or OFF(*2)	Measure for stub fault	x	x	x
[RDIF]		ON/OFF		ON	Remote differential protection	--	x	x
[T.F.C]		ON/OFF		ON	Measure for through fault current	x	--	--
[OTD]		ON/OFF		OFF	Open terminal detection	x	x	x
[DIF-FS]		OFF / OC / OCD / Both		OFF	Fail-safe function	x	x	x
[DIFG-FS]		ON/OFF		OFF	Fail-safe function	x	x	x
[COMMODE]		A / B / GPS		B	Communication mode	A	B	GPS
[TERM]		2TERM/3TERM /Dual (*3)		3TERM	For three-terminal application models	x	x	x
[SP.SYN]		Master/Slave		Master(*4)	Sampling synchronization	x	x	x
[CH. CON]		Normal/Exchange		Normal	Telecommunication port exchanger	x	x	x

Element	Range	Step	Default	Remarks	Communication Mode A	B	GPS
[T.SFT1]	ON/OFF		OFF	Channel 1 bit shifting for multiplexer	x	x	x
[T.SFT2]	ON/OFF		OFF	Channel 2 bit shifting for multiplexer	x	x	x
[B.SYN1]	ON/OFF		ON	Channel 1 bit synchronising for multiplexer	x	x	x
[B.SYN2]	ON/OFF		ON	Channel 2 bit synchronising for multiplexer	x	x	x
[LSSV]	ON/OFF		OFF	Disconnector contacts discrepancy check	x	x	x
[GPSBAK]	OFF/ON		ON	Backup synchronization	--	--	x
[AUTO2B] (*6)	OFF/ON		OFF	Automatic mode change	--	--	x
[SRCθ](*5)	Disable / I		I	Sampling timing deviation monitoring with current	--	--	x
[IDSV]	OFF/ALM&BLK/ALM		OFF	Id monitoring	x	x	x
[RYIDSV]	OFF/ON		ON	Relay address monitoring	--	x	x

(*1) Current values shown in parentheses are in the case of 1A rating. Other current values are in the case of 5A rating.
(*2) This setting depends on the relay model.
(*3) This setting is valid for three-terminal application models of the GRL100.
(*4) In the actual setting, one terminal is set to "Master" and other terminal(s) to "Slave".
(*5) OCCHK, [SRCθ] and HYSθ are enabled by setting the [TERM] to "2TERM".
(*6) [AUTO2B] is enabled by setting the [TERM] to "2TERM" and [SRCθ] to "I".
(*7) This setting is only used when there is a fixed difference between the sending and receiving transmission delay time. When the delay times are equal, the default setting of 0μs must be used.
(*8) If the channel delay time of CH1 or CH2 exceeds the TDSV setting, then the alarm "Td1 over" or "Td2 over" is given respectively.

CT Ratio matching

When the CT ratio is different between the local terminal and the remote terminal(s), the CT ratio matching can be done 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 2.2.13.1 shows an example of CT ratio matching. The settings for DIFI2, DIFGI, DIFSV and DIFIC should also be set with relation to the primary current in the same manner of the DIFI1 setting.

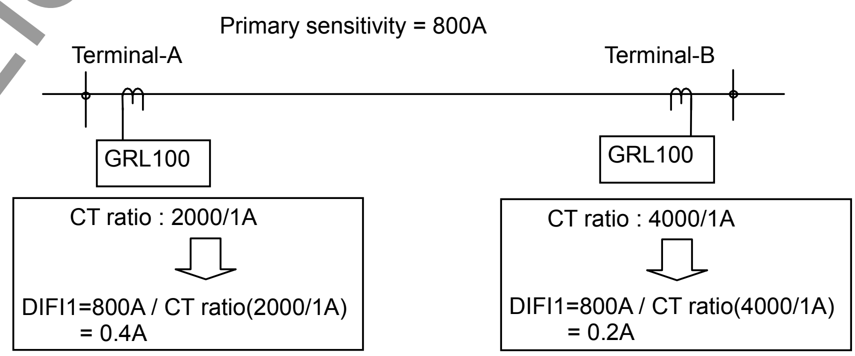


Figure 2.2.13.1 Example of CT Ratio Matching

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 terminal 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 2.2.13.2 shows an example of CT ratio matching. The settings for DIFI2, DIFGI, DIFSV and DIFC should also be set with relation to the primary current in the same manner of the DIFI1 setting.

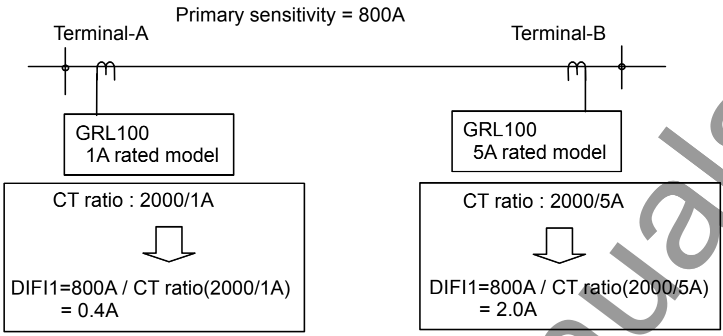


Figure 2.2.13.2 Example of CT Ratio Matching incase of Different CT secondary Rating

Setting of DIFI1

The setting of DIFI1 is determined from the minimum internal fault current to operate and the maximum erroneous differential current (mainly the internal charging current) during normal service condition not to 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

For the GRL100 provided with the charging current compensation, the condition related to the charging current can be neglected.

The setting value of DIFI1 must be identical at all terminals. If the terminals have different CT ratios, then the settings for DIFI1 must be selected such that the primary settings are identical.

Setting of DIFI2

The setting of DIFI2 is determined from the following two factors:

- 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 first factor, the DIFI2 should be set as small as possible so that unwanted operation is not caused by the maximum erroneous current generated by CT saturation on the primary side by a through current at an external fault. It is recommended normally to set DIFI2 to 2×In (In: secondary rated current) for this factor.

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

The third factor must be considered only when the GRL100 is applied to three-terminal double-circuit lines, lines with outer loop circuit, or double-circuit lines with one-and-a-half busbar system. DIFI2 should be set larger than the possible largest value of outflow current in case of an internal fault.

As the occurrence of current outflow depends on the power system configuration or operation, it is necessary to check whether it is possible for the fault current to flow out of the line. If so, the factor must be taken into consideration when making the setting.

In other applications, only the first and second factors need be considered.

Setting of DIFGI

The setting of DIFGI is determined from the high-impedance earth fault current.

The setting value of DIFGI must be identical at all terminals. If the terminals have different CT ratios, then the settings for DIFGI must be selected such that the primary settings are identical.

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 condition.

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

Ierr: maximum erroneous differential current

For the GRL100 provided with the charging current compensation, the condition related to the charging current can be neglected.

The setting value of DIFSV must be identical at all terminals. If the terminals have different CT ratios, then the settings for DIFSV must be selected such that the primary settings are identical.

Setting of DIFIC

The internal charging current under the rated power system voltage is set for DIFIC. The charging current is measured by energizing the protected line from one terminal and opening the other terminal.

If the measured power system voltage differs from the rated one, the measured charging current must be corrected.

The setting value of DIFIC must be identical at all terminals. If the terminals have different CT ratios, then the settings for DIFIC must be selected such that the primary settings are identical.

Setting of OCCHK

This setting is available for [COMMODE]='GPS-MODE' setting. The OCCHK must be set larger than any of the following three values, taking the errors due to charging current and measurement inaccuracy into consideration. If the differential current setting in the small current region DIFI1 differs between terminals due to different CT ratios, the larger DIFI1 is applied.

- 14 × charging current (A)
- 0.5 × DIFI1 setting (A)
- 0.5A (or 0.1A in case of 1A rating)

Setting of PDTD, [COMMODE], [GPSBAK], [AUTO2B], [TERM], [SRC θ] and [RYIDSV]

The setting of these items must be identical at all terminals.

COMMODE: generally set to 'B-MODE' which is standard operating mode. Set to 'A-MODE' if the opposite terminal relay is an old version of GRL100, that is GRL100-∗∗∗A, -∗∗∗N or -∗∗∗Y. If the relay is applied to the GPS-based synchronization, set to

'GPS-MODE'. The 'GPS-MODE' is only available for the relay provided with a GPS interface.

PDTD, GPSBAK, AUTO2B, SRCθ : Available for [COMMODE]='GPS-MODE' setting. See Section 2.2.7.

Note: Do not set [TERM] to "Dual" in GPS-mode.

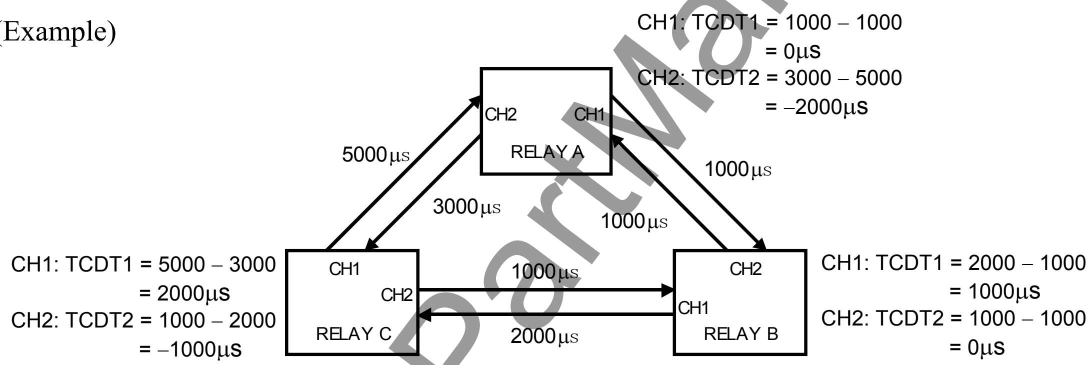
Setting of TDSV, TCDT1 and TCDT2

The TDSV is a transmission delay time threshold setting. GRL100 gives an alarm if the transmission delay time exceeds TDSV. The alarm messages are 'Td1 over' for CH1 and 'Td2 over' for CH2.

The TCDT1 and TCDT2 are transmission time delay difference settings for CH1 and CH2 respectively. If there is a permanent and constant difference of more than 100μs between the send and receive channel delay times, then the TCDT setting is used to compensate for that difference. The setting is calculated as follows:

TCDT = (Sending delay time) – (Receiving delay time)

(Example)



Setting of [SP.SYN]

One of terminals must be set to MASTER and others SLAVE.

If not, the synchronized sampling fails under the intra-system synchronized sampling or backup modes of the GPS-based synchronized sampling.

Note: As the simultaneous setting change at all terminals is not practical, it is not recommended to change the settings when the relay is in service.

Setting of [CH.CON]

In case of the two-terminal line application, the communication ports of the GRL100 are interlinked with port CH1 as shown in Figure 2.2.13.3(a) and (b). In case of three-terminal application, port CH1 of one terminal and port CH2 of the other terminal are linked as shown in Figure 2.2.13.3(c).

In these normal linkages, the communication port exchange switch [CH.CON] is set to "Normal".

Setting of [T.SFT1], [T.SFT2], [B.SYN1], and [B.SYN2]

T.SFT1: is used to synchronise the relay with multiplexer by shifting the send signal by a half-bit when the distance from the relay to the multiplexer is long. When electrical interface X.21, CCITT G.703-1.2.2 or -1.2.3 is applied and the distance (cable length from relay to multiplexer) is 300m or more, the setting is set to 'ON'. (for channel 1)

T.SFT2: same as above. (for channel 2)

B.SYN1: is set to 'ON' when the relay is linked via multiplexer, and set to 'OFF' when direct link is applied. (for channel 1)
This setting is available for CCITT G703-1.2.1, 1.2.2, 1.2.3, X21 and optical interface (short distance: 2km class). In the case of optical interface 30km and 80km class, this setting is neglected.

B.SYN2: same as above. (for channel 2)

Setting of RYID, RYID1 and RYID2

Relay address number RYID must take a different number at each terminal.

If the relay address monitoring switch [RYIDSV] is "OFF", their settings are ignored. The RYID2 setting is enabled by setting the [TERM] to "3TERM" or "Dual".

Two-terminal application: Set the local relay address number to RYID and the remote relay address number to RYID1. The RYID1 is equal to the RYID of the remote relay. See Figure 2.2.13.3.
In "Dual" setting, the RYID2 setting must be the same as the RYID1 setting.

Three-terminal application: Set the local relay address number to RYID and the remote relay 1 address number to RYID1 and the remote relay 2 address number to RYID2. The RYID1 is equal to the RYID of the remote 1 relay and the RYID2 equal to the RYID of the remote 2 relay. See Figure 2.2.13.3.

Note: The remote 1 relay is connected by CH1 and the remote 2 relay connected by CH2

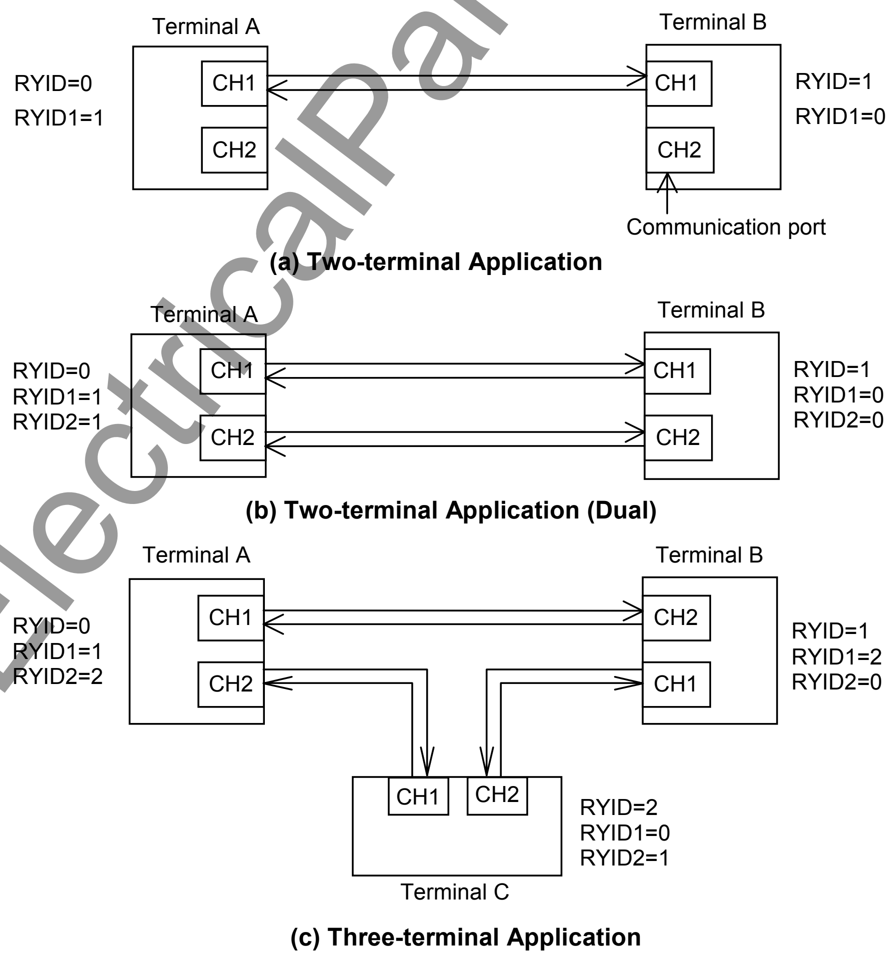


Figure 2.2.13.3 Communication Link in Three-terminal Line

Setting depending on communication mode

The setting depending on communication mode is shown in the following table.

Setting		A-MODE	B-MODE	GPS-MODE	Default setting	Remarks
Communication mode	COMMODE	Must select "A" of A/B/GPS	Must select "B" of A/B/GPS	Must select "GPS" of A/B/GPS	B	
GPS backup mode	GPSBAK	--	--	On/Off	On	
MODE2B shifted automatically	AUTO2B	--	--	On/Off	Off	
Phase difference check	SRCθ	--	--	Disable/I	I	Available for only 2TERM setting
Terminal application	TERM	2TERM/3TERM/ DUAL	2TERM/3TERM/ DUAL	2TERM/3TERM	2TERM	For 3 terminal application model
Relay address monitoring	RYIDSV	--	On/Off	On/Off	On	
Multi-phase autoreclosing	Autoreclose mode	MPAR2/MPAR3 (except for models 1∗∗/211/311)	MPAR2/MPAR3	MPAR2/MPAR3	SPAR&TPAR	RYIDSV=Off is required
Open terminal detection	OTD	On/Off	On/Off	On/Off	Off	
Through fault current measure	TFC	On/Off	--	--	On	Only for models 503 and 513
Zero-phase current differential	DIFG	On/Off	On/Off	On/Off	On	
Out-of-step tripping	OST	Trip/BO/Off	Trip/BO/Off	Trip/BO/Off	Off	
Fault locator	FL	On/Off	On/Off	On/Off	On	
Remote differential trip	RDIF	--	On/Off	On/Off	On	Available for 3TERM application

--: don't care.

Terminal application

In A-MODE and B-MODE, anyone of 2TERM, 3TERM or DUAL can be selected. In GPS-MODE, however, DUAL cannot be selected.

Multi-phase autoreclosing

To apply the multi-phase autoreclosing with MPAR2 or MPAR3, the relay address monitoring RYIDSV in B-MODE and GPS-MODE must be set to "OFF". When the RYIDSV=OFF, CBLS (CBDS) condition is sent.

If shared with the relay address monitoring, the bits for CBLS condition can be assigned instead of the bits for DIFG or OST/FL by PLC function when DIFG or OST/FL is not used.

Automatic open terminal detection OTD

In B-MODE and GPS-MODE, the RYIDSV=OFF setting for relay address monitoring is required to use the open terminal detection function (OTD=On).

If shared with the relay address monitoring, the following methods can be applied:

(1) Only one bit with open terminal condition instead of CBLS condition can be sent by sub-communication bit.

(2) If DIFG or OST/FL is not used, the bits for CBLS condition can be assigned instead of the bits for DIFG or OST/FL by PLC function.

The open terminal detection in B-MODE and GPS-MODE do not automatically change "Master" or Slave" in SP.SYN. If the master terminal becomes out-of-service, therefore, the synchronization control of slave terminal follows that of the master terminal by ON/OFF at the master terminal and the current differential protection is blocked.

When putting a terminal into out-of-service in three-terminal operation, the following setting change method is recommended:

(Example)

When putting Terminal C into out-of-service to two-terminal operation, the following four setting are changed.

SP.SYN:

If the terminal C has been "Master", change the terminal A or B to "Master". If the terminal A or C has been "Master", do not change the setting.

TERM:

Change both the terminal A and B to "2TERM".

CH.CON:

It is defined that CH1 of both terminal relays is connected each other in two-terminal application and CH1 of local relay is connected to CH2 of remote relay in three-terminal application as shown in Figure 2.2.13.3. Therefore, the communication cable connection must be changed from CH2 to CH1.

[CH.CON] is to change CH1 or CH2 signal with CH2 or CH1 signal in the relay inside. If the [CH.CON] is set to "Exchange", CH2 data is dealt with as CH1 data or in reverse. In Figure 2.2.13.3, change the terminal B to "Exchange". However, note that the display or output such as a communication failure, etc. is expressed as CH1 because CH2 data is dealt with as CH1 data at the terminal B.

RYID1:

The remote terminal 1 seen from terminal B changes from terminal C to terminal A. Therefore, change the remote terminal 1 relay address setting RYID1 from "2" to "0" at terminal B.

If the relay address monitoring switch [RYIDSV] is "OFF", the setting is invalid and setting change is not required.

Through fault current measure TFC:

This function is available only for GRL100-503/513 and COMMODE=A-MODE setting.

If the function is used, set the [COMMODE] to "A-MODE" and the [TFC] to "ON".

Remote differential trip RDIF

This function is not available for the A-MODE setting.

When this function is used, set [RDIF] and [TERM] are set to "ON" and "3-TERM" and the following must be configured by the PLC function.

Assign the remote DIF trip send signals RDIF-∗-S to user configurable data, and the receiving data from remote terminals to the trip command signals RDIF-∗-R1 and RDIF-∗-R2.

2.3 Overcurrent Backup Protection

Inverse time and definite time overcurrent protections are provided for phase faults and earth faults respectively.

Scheme logic

The scheme logic of the overcurrent backup protection is shown in Figure 2.3.1. The overcurrent protection issues single-phase tripping signals in the operation of OC and OCI, and issues a three-phase tripping signal BU-TRIP in the operation of EF or EFI element. Three-phase tripping of OC and OCI is available by PLC signals OC_3PTP and OCI_3PTP. Tripping by each element can be disabled by the scheme switches [OCBT], [OCIBT], [EFBT] and [EFIBT]. The EF element issues an alarm for the backup trip for earth fault. The alarm can be disabled by the scheme switch [EFBTAL].

The overcurrent backup protection can be blocked by the binary input signal BUT_BLOCK. Tripping by each protection can be blocked by PLC signals OC_BLOCK, OCI_BLOCK, EF_BLOCK and EFI_BLOCK. The OC and EF can trip instantaneously by PLC signals OC_INST_TP and EF_INST_TP.

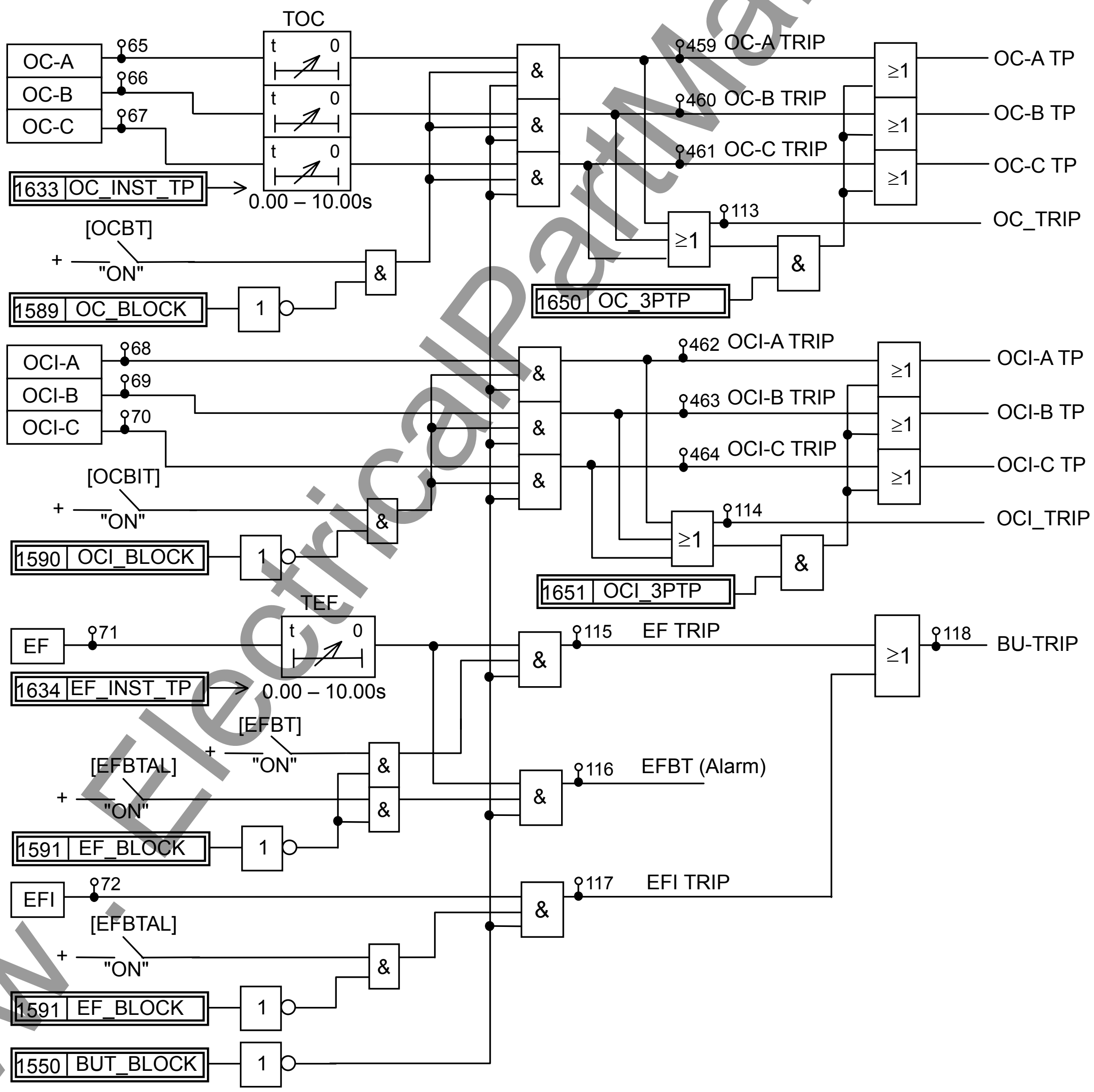


Figure 2.3.1 Overcurrent Backup Protection

2.3.1 Inverse Time Overcurrent Protection

In a system in which the fault current is mostly determined by the fault location, without being greatly affected by changes in the power source impedance, it is advantageous to use the inverse definite minimum time (IDMT) overcurrent protection. Reasonably fast tripping should be obtained even at a terminal close to the power supply by using the inverse time characteristics. In the IDMT overcurrent protection function, one of the following three IEC-standard-compliant inverse time characteristics and one long time inverse characteristic is available.

- standard inverse IEC 60255-3
- very inverse IEC 60255-3
- extremely inverse IEC 60255-3

The IDMT element has a reset feature with definite time reset.

If the reset time 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 reset time 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.

Setting

The following table shows the setting elements necessary for the inverse time overcurrent protection and their setting ranges.

Element	Range	Step	Default	Remarks
OCI	0.5 - 25.0 A	0.1 A	10.0 A	
	(0.10 - 5.00 A	0.01 A	2.00 A) (*)	
TOCI	0.05 - 1.00	0.01	0.50	OCI time setting
TOCIR	0.0 – 10.0 s	0.1 s	0.0 s	OCI definite time reset delay
[MOCI]	Long/Std/Very/Ext		Std	OCI inverse characteristic selection
[OCIBT]	ON/OFF		ON	OCI backup protection
EFI	0.5 - 5.0 A	0.1 A	5.0 A	Earth fault EFI setting
	(0.10 - 1.00 A	0.01 A	1.00 A) (*)	
TEFI	0.05 - 1.00	0.01	0.50	EFI time setting
TEFIR	0.0 – 10.0 s	0.1 s	0.0 s	EFI definite time reset delay
[MEFI]	Long/Std/Very/Ext		Std	EFI inverse characteristic selection
[EFIBT]	ON/OFF		ON	EFI backup protection

(*) 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 scheme switches [MOCI] and [MEFI] are used to select one of the four inverse time characteristics.

Current setting

In Figure 2.3.1.1, 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.

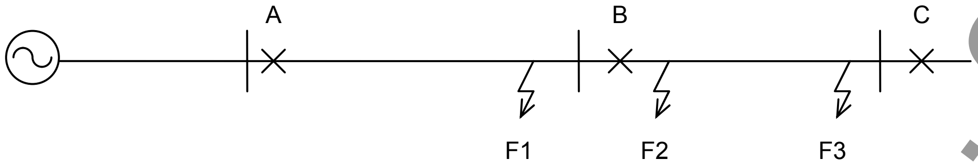


Figure 2.3.1.1 Current Settings in Radial System

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 2.3.1.1, 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 2.3.1.1.

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.

2.3.2 Definite Time Overcurrent Protection

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

The definite time overcurrent protection consists of instantaneous overcurrent elements and on-delay timers started by them.

Identical current values can be set for terminals, but graded settings are better than identical settings in order to provide a margin for current sensitivity. The farther from the power source the terminal is located, the higher 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 Section 2.3.1.

Setting

The setting elements necessary for the definite time overcurrent protection and their setting ranges are shown below.

Element	Range	Step	Default	Remarks
OC	0.5 - 100.0 A	0.1 A	10.0 A	Phase overcurrent
	(0.1 - 20.0 A	0.1 A	2.0 A) (*)	
TOC	0.00 - 10.00 s	0.01 s	3.00 s	OC delayed tripping
OCBT	ON/OFF		ON	OC backup protection
EF	0.5 - 5.0 A	0.1 A	5.0 A	Residual overcurrent
	(0.10 - 1.00 A	0.01 A	1.00 A) (*)	
TEF	0.00 - 10.00 s	0.01 s	3.00 s	EF delayed tripping
[EFBT]	ON/OFF		ON	EF backup protection
[EFBTAL]	ON/OFF		ON	EF backup trip alarm

(*) 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.

2.4 Transfer Trip Function

The GRL100 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 2.4.1. 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.

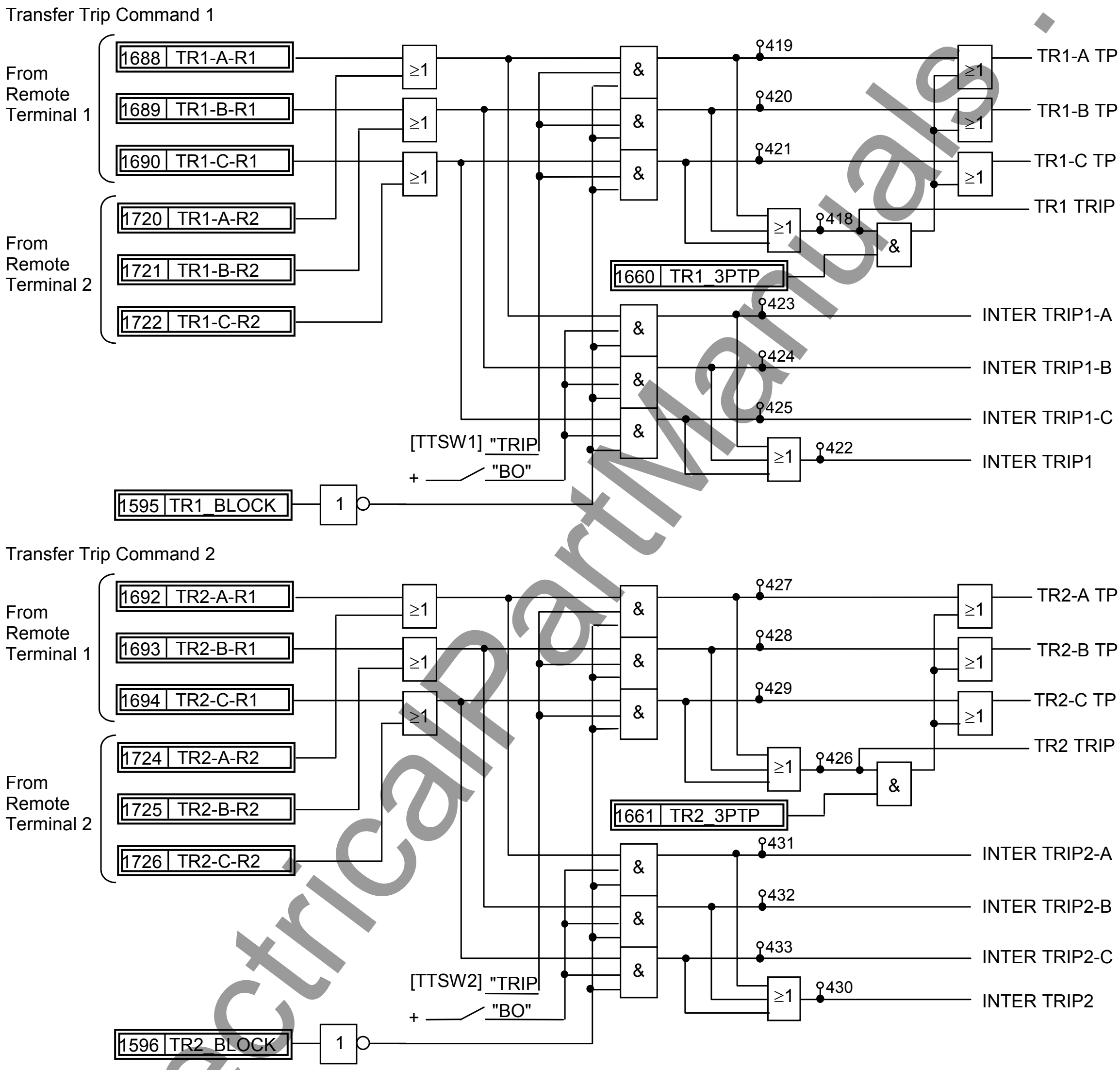


Figure 2.4.1 Transfer Trip Scheme Logic

The sending signal is configured by PLC function. If the sending signal is assigned on a per phase basis by PLC, a single-phase tripping is available.

Figure 2.4.2 shows an example of the assigning signal.

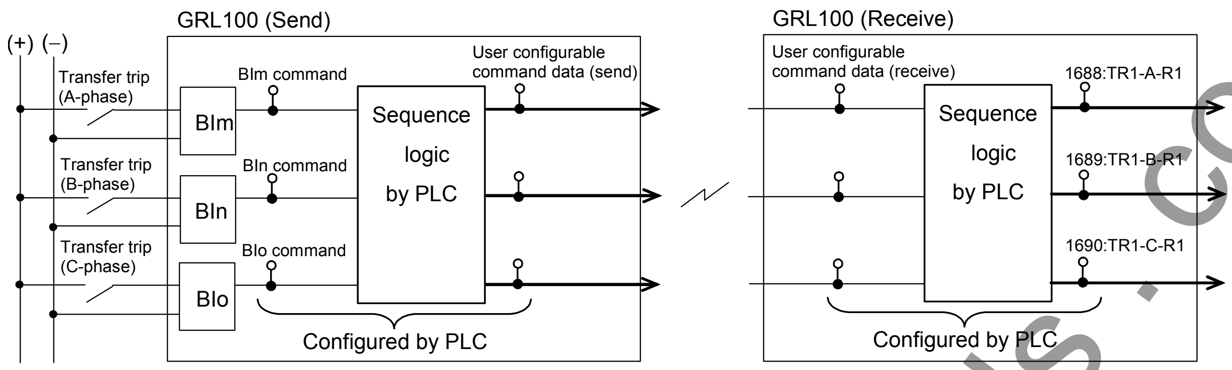


Figure 2.4.2 Example of Signal Assign

2.5 Out-of-step Protection

The GRL100 out-of-step protection (OST) operates only when the out-of-step loci cross the protected line and provides optimal power system separation in case of power system step out.

The OST compares the phase of the local and remote positive sequence voltages and detects the out-of-step when the difference in the phase angle exceeds 180°. The OST can detect any of the out-of-steps with slow or fast slip cycles.

Figure 2.5.1 show the loci of the voltage vectors measured at terminals A and B when an out-of-step occurs on the power system. P and Q are equivalent power source locations. Loci 1 and 2 are the cases when the locus crosses the protected line, and passes outside the protected line, respectively.

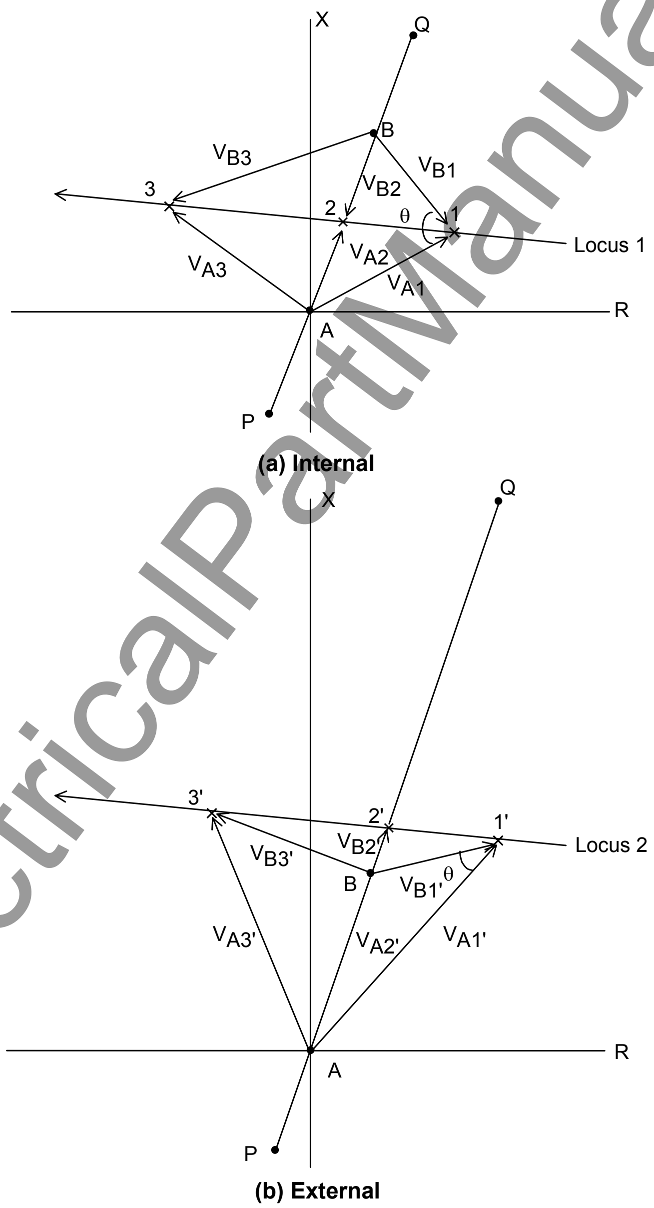


Figure 2.5.1 Out-of-step Loci

Voltage phase angle differs by θ between terminals A and B. In case of Locus 1, θ gets larger as the voltage locus approaches the protected line and becomes 180° when the locus crosses the line. In case of Locus 2, θ becomes 0° when the locus crosses the power system impedance outside the protected line.

At terminal A, the terminal voltage V_A is taken as a reference voltage. Then, the phase angle of the remote terminal voltage V_B changes as shown in Figure 2.5.2. Out-of-step is detected when V_B moves from the second quadrant to the third quadrant or vice versa.

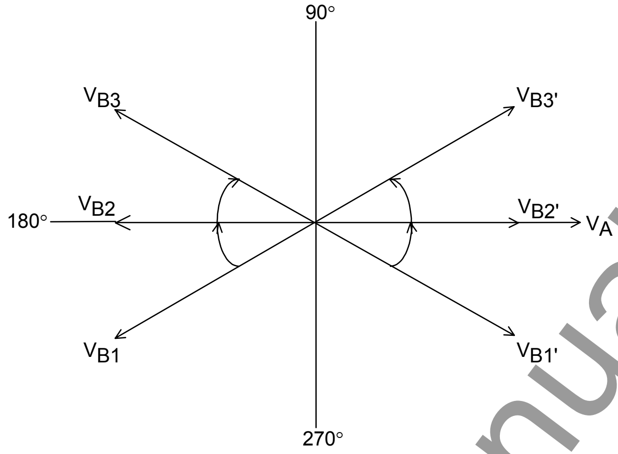


Figure 2.5.2 Voltage Phase Comparison

In the case of a three-terminal line, this phase comparison is performed between each pair of terminals. All the terminals can detect any out-of-step provided its locus crosses the protected line.

Figure 2.5.3 shows a scheme logic for the out-of-step protection. The output signal of the out-of-step element OST1 performs three-phase final tripping. The output signal is blocked when the scheme switch [OST] is set to "OFF" or binary signal OST_BLOCK is input. The tripping signal of the out-of-step protection can be separated from other protection tripping signals by the switch [OST]. In this case, the switch [OST] is set to "BO" and the tripping signal OST-BO is assigned to a desired binary output number (for details, see Section 4.2.6.9). When the tripping signal of the out-of-step protection is not separated from other protection tripping signals, the switch [OST] is set to "Trip".

The voltage of the out-of-service terminal is set to zero at the receiving terminal and the OST does not function with the out-of-service terminal.

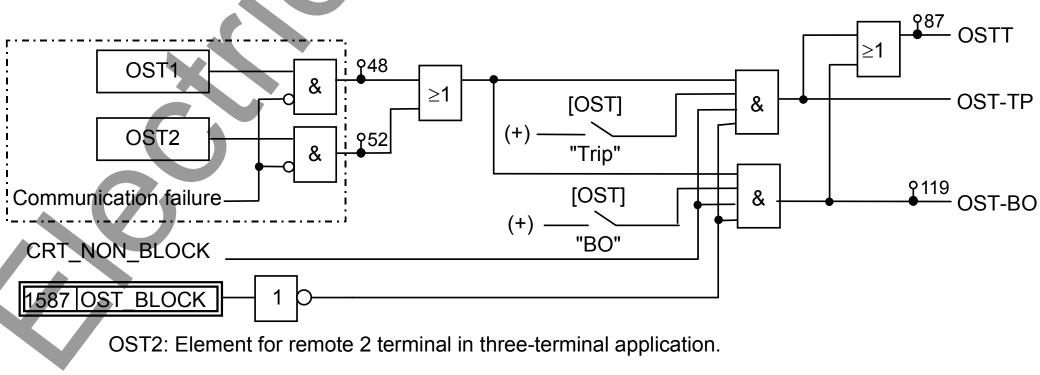


Figure 2.5.3 Scheme Logic for Out-of-step Protection

Setting

The OST measuring element has no setting items. Only the scheme switch [OST] setting is necessary for the out-of-step protection.

Element	Range	Step	Default
[OST]	OFF/Trip/BO		OFF

2.6 Thermal Overload Protection

The temperature of electrical plant rises according to an I^2t function and the thermal overload protection in GRL100 provides a good protection against damage caused by sustained overloading. The protection simulates the changing thermal state in the plant using a thermal model.

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

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

where:

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

I = applied load current,

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

τ = thermal time constant of the system.

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

The thermal overload protection measures the largest of the three phase currents and operates according to the characteristics defined in IEC60255-8. (Refer to Appendix P 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 2.6.1 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.

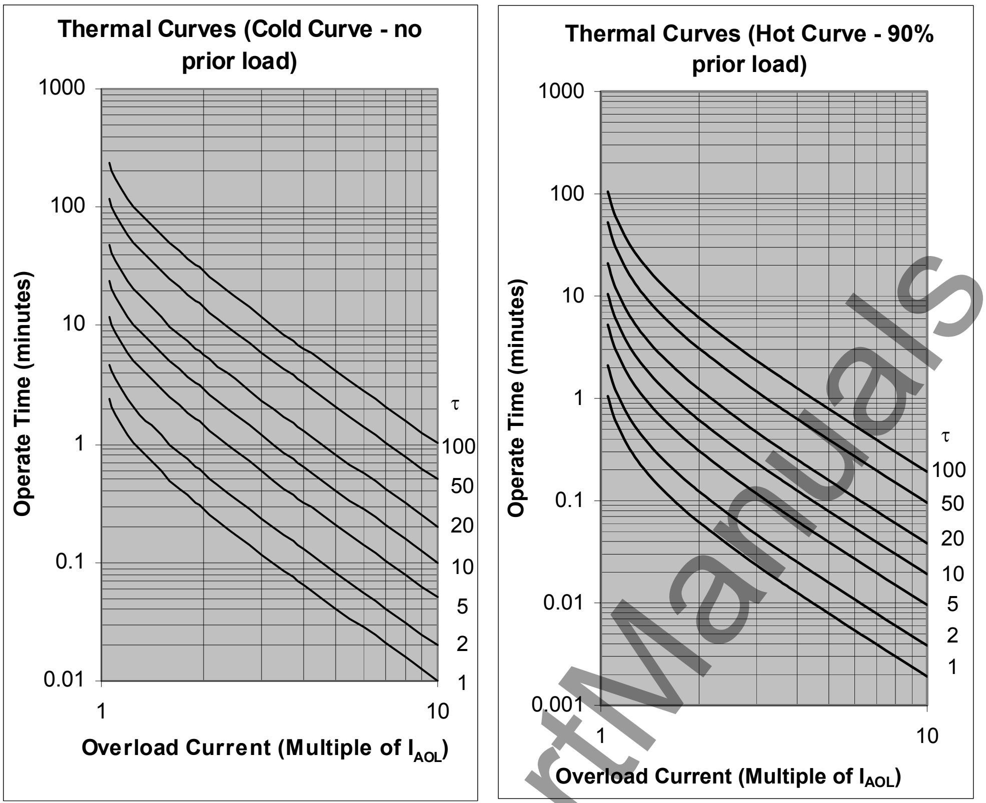


Figure 2.6.1 Thermal Curves

Scheme Logic

Figure 2.6.2 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.

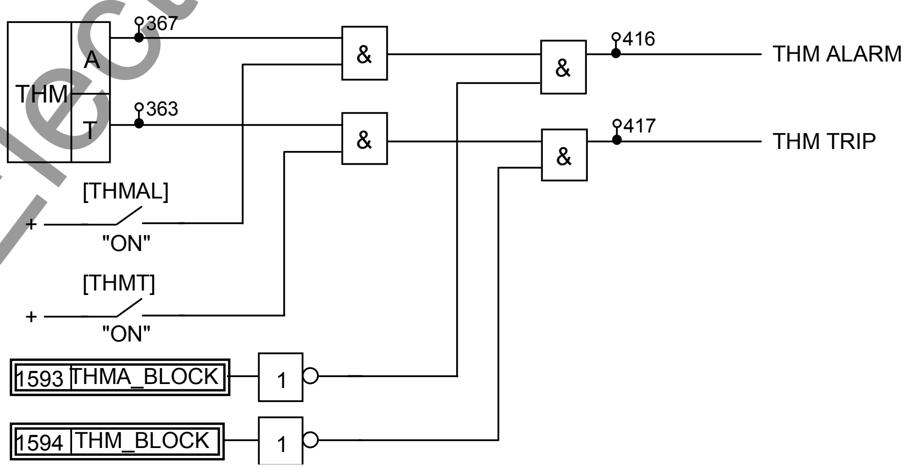


Figure 2.6.2 Thermal Overload Protection Scheme Logic

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

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

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

2.7 Breaker Failure Protection

When a fault remains uncleared due to a breaker failure, the breaker failure protection (BFP) clears the fault by backtripping the adjacent breakers.

If the current continues to flow following the output of a trip command, 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 is used.

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

Tripping by the BFP is three-phase final tripping and autoreclose is blocked.

An overcurrent element and on-delay timer are provided for each phase and they also operate correctly on the breaker failure in the event of an evolving fault.

Scheme logic

The BFP is performed on an individual phase basis. Figure 2.7.1 shows the scheme logic for one phase. The BFP is initiated by a trip signal EXT_CBFIN from the external line protection or an internal trip signal TRIP. Starting with an external trip signal can be disabled by the scheme switch [BFEXT]. These trip signals must be present exist as long as the fault persists.

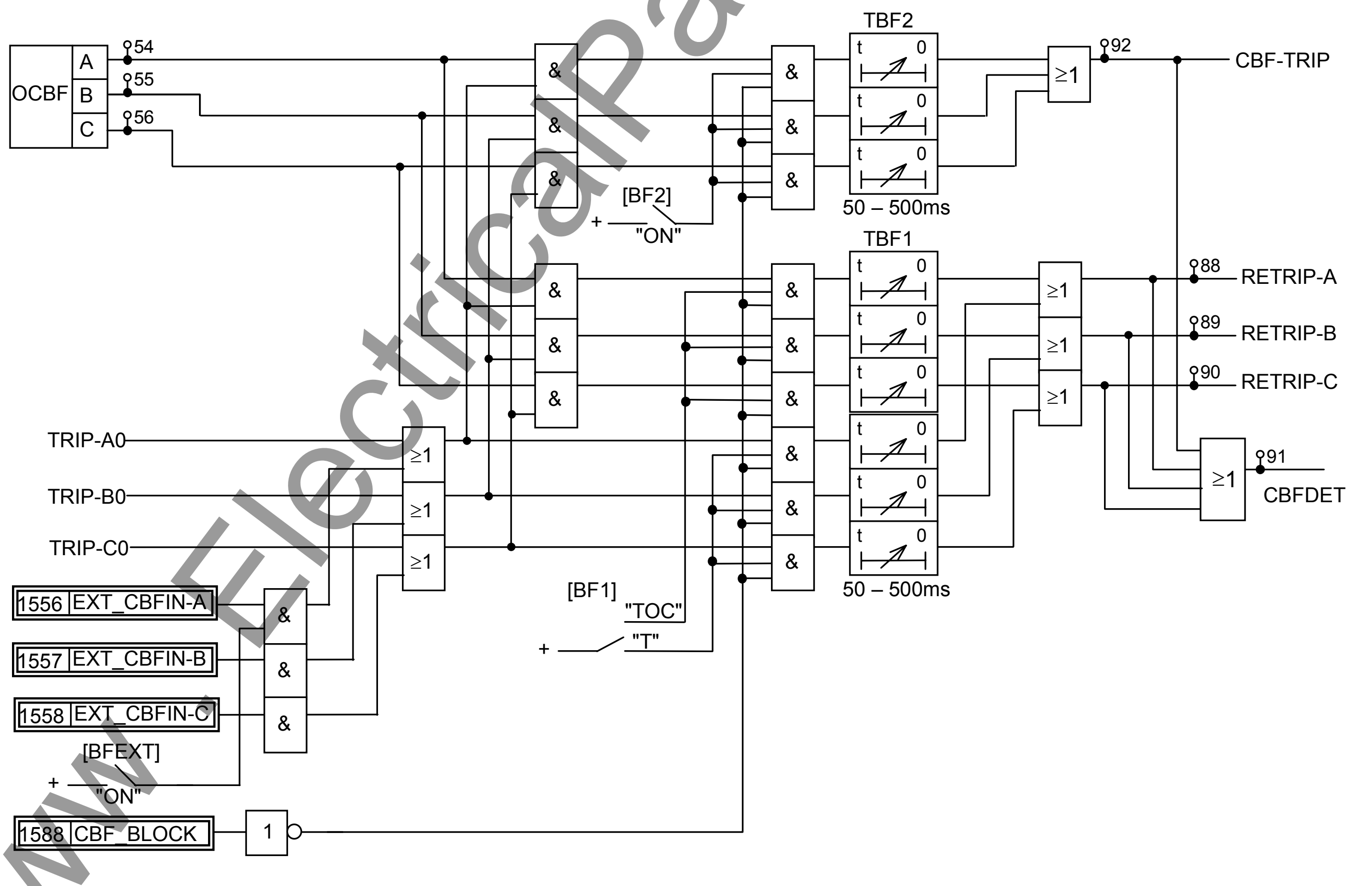


Figure 2.7.1 BFP Scheme Logic

The backtrip signal to the adjacent breakers CBF-TRIP is output if the overcurrent element OCBF operates continuously for the setting time of the delayed pick-up timer TBF2 after the start-up. Tripping of the adjacent breakers can be blocked with the scheme switch [BF2].

There are two kinds of mode of the retrip signal to the original breaker RETRIP: the mode in which RETRIP is controlled by the overcurrent element OCBF, and the direct trip mode in which RETRIP is not controlled. The retrip mode together with the trip block can be selected with the scheme switch [BF1].

Figure 2.7.2 shows a sequence diagram of the BFP when a retrip and backtrip are used. If the breaker trips normally, the OCBF is reset before timer TBF1 or TBF2 is picked up and the BFP is reset.

If the OCBF continues operating, a retrip command is given to the original breaker after the setting time of TBF1. Unless the breaker fails, the OCBF is reset by the retrip. The TBF2 is not picked up and the BFP is reset. This may happen when the BFP is started by mistake and unnecessary tripping of the original breaker is unavoidable.

If the original breaker fails, retrip has no effect and the OCBF continues operating and the TBF2 is picked up finally. A trip command CBF-TRIP is issued to the adjacent breakers and the BFP is completed.

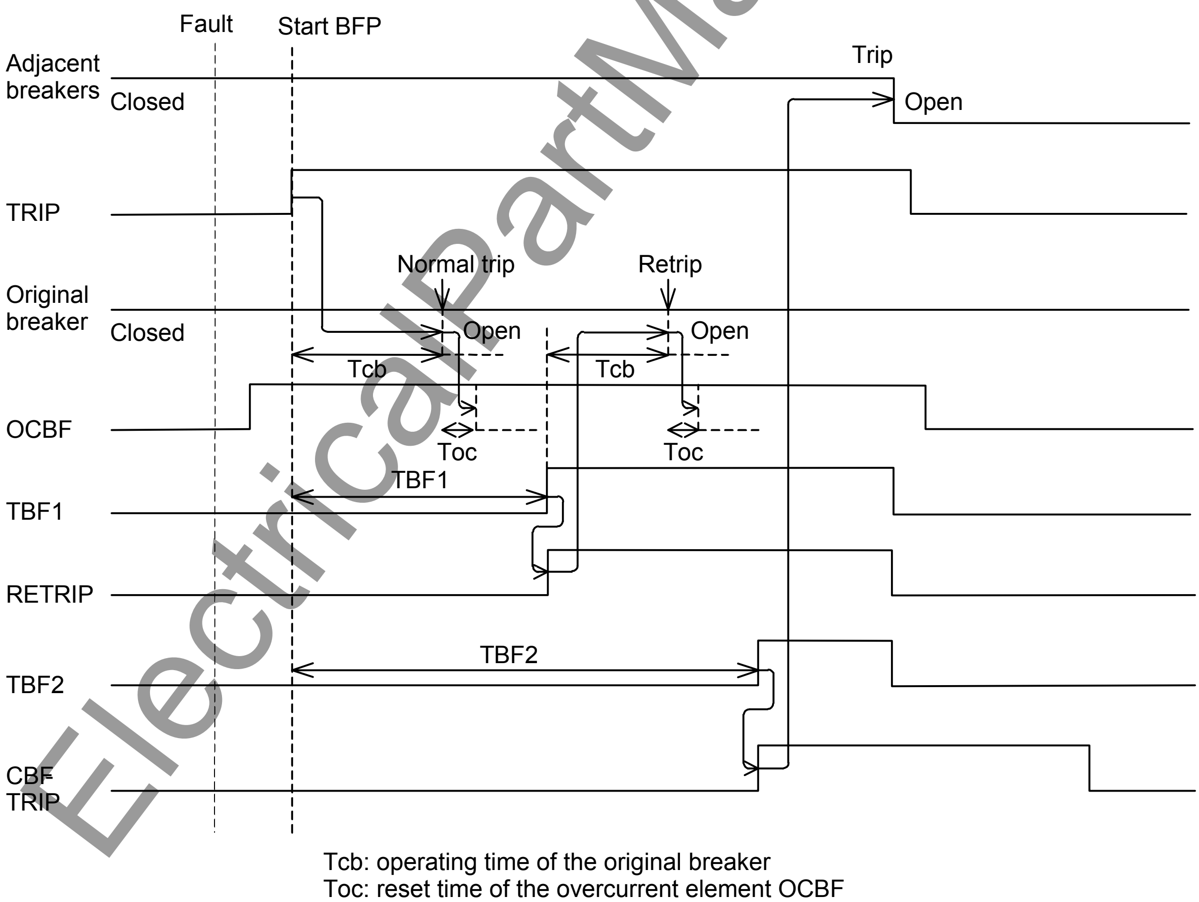


Figure 2.7.2 Sequence Diagram

Setting

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

Element	Range	Step	Default	Remarks
OCBF	0.5 – 10.0A	0.1A	4.0A	Overcurrent setting
	(0.1 – 2.0A	0.1A	0.8A) (*)	
TBF1	50 – 500ms	1ms	150ms	Retrip timer
TBF2	50 – 500ms	1ms	200ms	Adjacent breaker trip timer
[BFEXT]	ON/OFF		OFF	External start
[BF1]	T/TOC/OFF		OFF	Retrip mode
[BF2]	ON/OFF		OFF	Adjacent breaker trip

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

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

The settings of TBF1 and TBF2 are determined by the opening time of the original breaker (Tcb in Figure 2.7.2) and the reset time of the overcurrent element (Toc in Figure 2.7.2). The timer setting example when using retrip can be obtained as follows.

Setting of TBF1 = Breaker opening time + OCBF reset time + Margin
= 40ms + 10ms + 20ms
= 70ms

Setting of TBF2 = TBF1 + Output relay operating time + Breaker opening time + OCBF reset time + Margin
= 70ms + 10ms + 40ms + 10ms + 10ms
= 140ms

If retrip is not used, the setting of TBF2 can be the same as that of TBF1.

2.8 Tripping Output

Figure 2.8.1 shows the tripping logic. Segregated-phase differential protection outputs per-phase-based tripping signals such as DIF.FS-A_TP, DIF.FS-B_TP and DIF.FS-C_TP, etc. Zero-phase differential protection, thermal overload protection, earth fault backup protection and out-of-step protection output three-phase tripping signals DIFG.FS_TRIP, THM-T, BU-TRIP and OSTT.

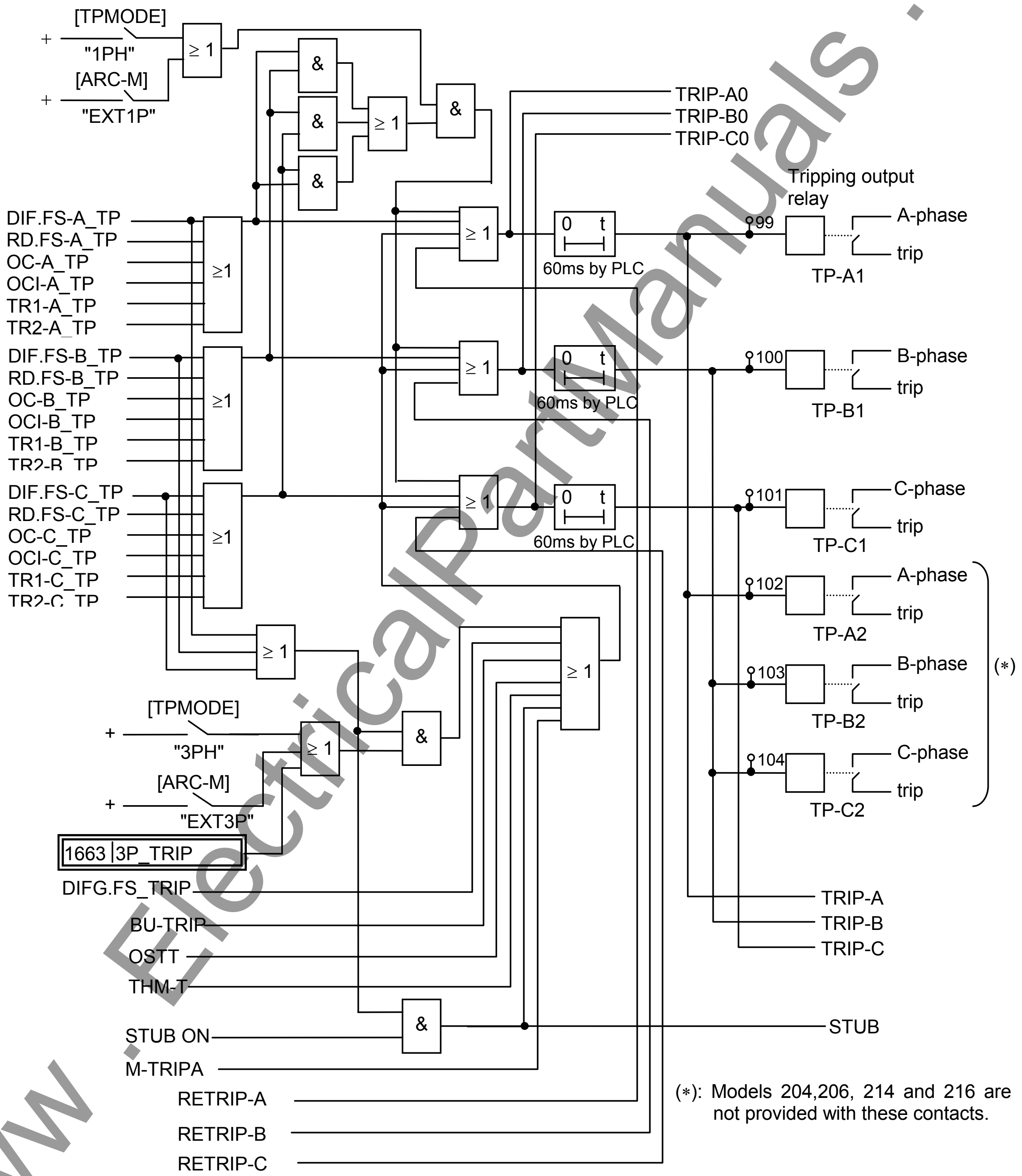


Figure 2.8.1 Tripping Logic

In the following cases, per-phase-based tripping is converted to three-phase tripping.

- When autoreclose is prohibited by a binary input signal (ARC–BLK = 1)
- When the tripping mode selection switch [TPMODE] is set to "3PH"
  (This applies to the GRL100 model 100s which does not have autoreclose.)
- When the autoreclose mode selection switch [ARC-M] is set to "EXT3P"
- When the measure for stub fault is enabled (STUB ON = 1)
  (This applies to the one-and-a-half busbar system.)
- PLC command “3P_TRIP” is established.

In the following cases, two-phase tripping is converted to three-phase tripping.

- When the switch [TPMODE] is set to "1PH"
- When the switch [ARC-M] is set to "EXT1P"

For the following trips, the logic level of M-TRIPA becomes 1, and per-phase-based tripping is converted to three-phase tripping. M-TRIPA is a logic signal in the autoreclose circuit (see Figure 2.10.2.1).

- Tripping within the reclaim time
- Tripping when reclosing and the mode selection switch [ARC-M] is set to "Disable" or "TPAR"

Signals RETRIP-A, RETRIP-B and RETRIP-C are the retripping signals of the breaker failure protection.

Tripping signals drive the high-speed tripping output relays. Two sets of output relays are provided for each phase and each relay has one normally open contact.

The tripping output relays reset 60ms(*) after the tripping signal disappears by clearing the fault. The tripping circuit must be opened with the auxiliary contact of the breaker prior to reset of the tripping relay to prevent the tripping relay from directly interrupting the tripping current of the breaker.

(*) Reset time is adjustable by PLC function. Default setting is 60ms.

A tripping output relay is user configurable for the adjacent breakers tripping signal CBF-TRIP in the breaker failure protection. For the default setting, see Appendix D. The relay is assigned to the signal number 92 with signal name CBF-TRIP.

The signals TRIP-A, TRIP-B and TRIP-C are used to start the autoreclose.

The signal TRIP-A0, TRIP-B0 and TRIP-C0 are used to start the breaker failure protection.

Setting

The setting element necessary for the tripping output circuit and its setting range is as follows:

Element	Range	Step	Default
[TPMODE]	1PH/3PH/MPH		3PH : Model 100s
			1PH : Other models

The switch [TPMODE] is used to enable the use of external autoreclose equipment with the GRL100. So it is valid in model 100s which is not provided with autoreclose.

When the external autoreclose is set to the single-phase or single- or three-phase mode, set the switch to "1PH". The GRL100 outputs a single-phase tripping command for a single-phase fault and three-phase trip command for a multi-phase fault.

When the external autoreclose is set in the three-phase mode, set the switch to "3PH". The GRL100 outputs a three-phase tripping command for a single- and multi-phase fault.

When the external autoreclose is set in the multi-phase mode, set the switch "MPH". The GRL100 outputs a tripping command on a per faulted phase basis.

When the external autoreclose is not applied, set the scheme switch [TPMODE] to "3PH" to enable three-phase final tripping.

2.9 Fault Detector

GRL100 model 400s and 500s are provided with a fault detector (FD) which functions as a check relay and enhances security, or prevents false tripping due to a single failure in the protection system.

The FD is an independent module and incorporates the following six fault detection elements. The FD output signal is an ORing of the elements output signals shown in Figure 2.9.1.

- Current change detection element (OCDF)
- Multi-level overcurrent element (OCMF)
- Earth fault overcurrent element (EFF)
- Undervoltage element for earth fault detection (UVGF)
- Undervoltage element for phase fault detection (UVSF)
- Undervoltage change detection element (UVDF)

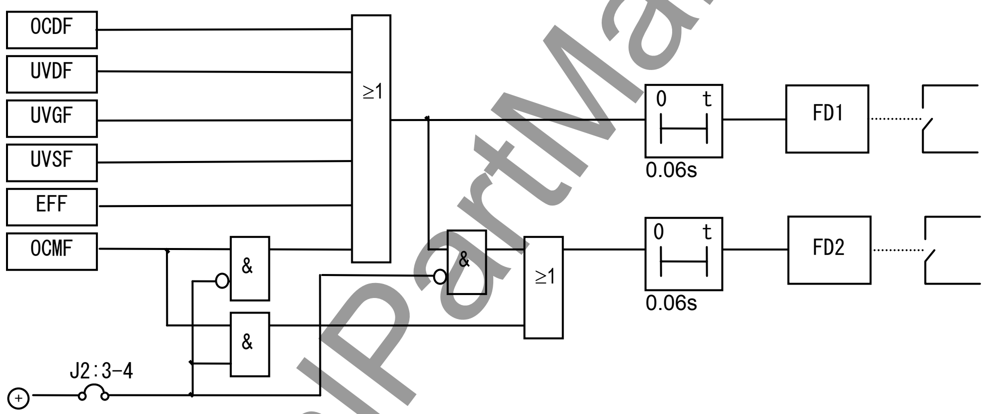


Figure 2.9.1 Fault Detector Logic

The FD output signal drives two sets of high-speed checking output relays. The checking output relay resets 60ms(*) after the fault detection elements are reset by clearing the fault.

(*) Reset time is adjustable by PLC function. Default setting is 60ms.

The OCDF operates in response to load current if it is a steeply fluctuating one. When the relay is used for a line with such a load current, the OCDF can be disabled by short-circuiting dedicated paired pins on the module with a receptacle.

All the FD elements have fixed operating threshold levels. But if the earth fault current due to unbalance in the network is significant, the EFF can be desensitized in the same way as described above.

Note: To give high independency to the module, the human machine interface on the front panel or PC has no access to the FD module except for the user configurable binary output relays mounted on it.

When it is desirable to disable the OCMF, disable the OCDF or desensitize the EFF, take the following steps:

- Pull out the FD module. For a description of how the module is removed, refer to Section 6.7.3.
- Four pairs of pins J1 and J2 are arranged lengthwise on the front at the top of the module as shown in Figure 2.9.2.

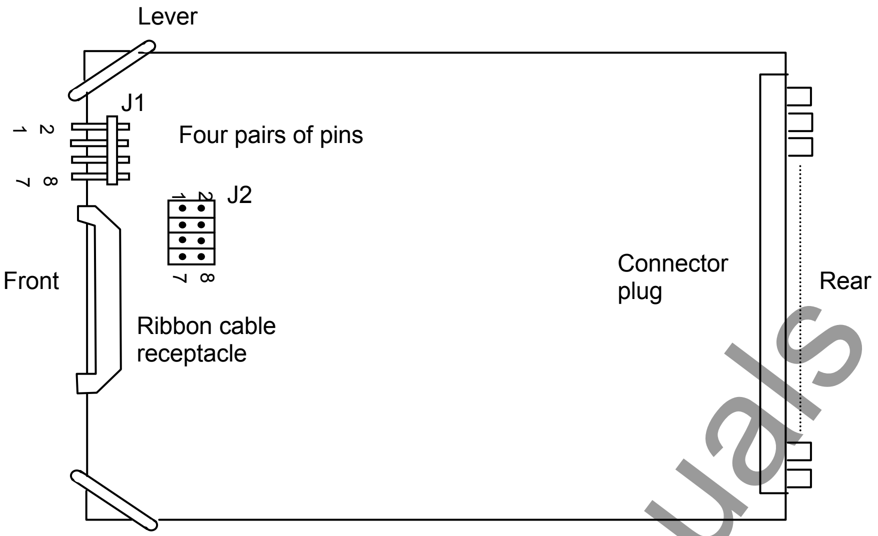


Figure 2.9.2 FD Module

- Short-circuit the pins 1-2 (located topmost) for the J1 to disable the OCMF.

  Short-circuit the pins 3-4 (located second from the top) for the J1 to disable the OCDF.
- Short-circuit the pins 3-4 for the J2 to energize the output auxiliary relay FD2 only by the OCMF.
- Short-circuit the pins 5-6 (located second from the bottom) and open-circuit the pins 7-8 (located bottom) to change the EFF operating threshold level to 15% of the rated current.

  Short-circuit pins 7-8 and open-circuit pins 5-6 to change the EFF operating threshold level to 20% of rated current.

  In other cases, the nominal operating threshold level (10% of the rated current) is kept.

  Short-circuit both of the pins 5 - 6 and 7 - 8 to disable the EFF.
- The pins 1-2 for the J2 is used to set the rated frequency. It is fixed before shipping.

  Caution: Do not change the pins 1-2 for the J2.

Element	Setting	Pairs of pins for J1				Pairs of pins for J2	
		1 - 2	3 - 4	5 - 6	7 - 8	1 - 2	3 - 4
OCMF	Enabled	Open					
	Disabled	Short					
OCDF	Enabled		Open				
	Disabled		Short				
EFF	Disabled			Short	Short		
	10% of rated current			Open	Open		
	15% of rated current			Short	Open		
	20% of rated current			Open	Short		
FD	50Hz rating					Open	
	60Hz rating					Short	
FD2	Normal						Open
	Only OCMF						Short

All the FD elements retain the nominal operating threshold when none of the paired pins are short-circuited.

Figure 2.9.3 shows the tripping output circuit when the FD is in service. The checking output contact is connected with A- to C-phase tripping output contacts in series. They are connected outside the relay as shown by the broken line.

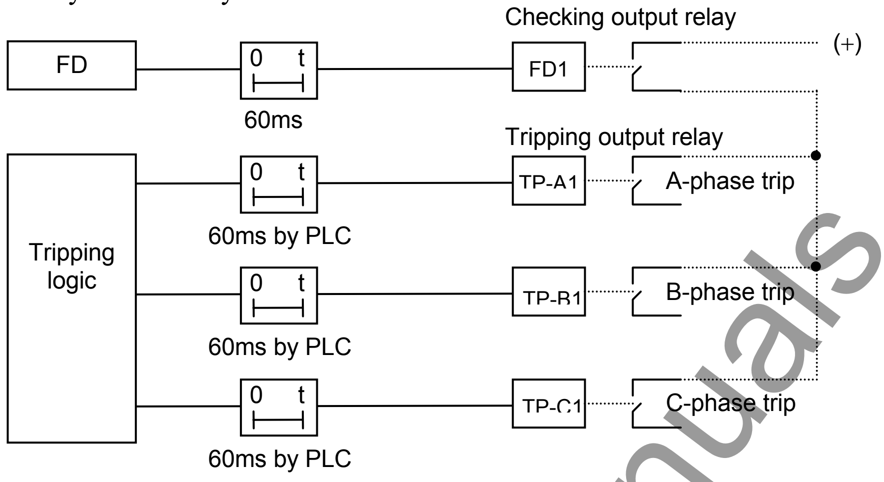


Figure 2.9.3 Tripping Output

Setting

All the fault detection elements have fixed settings as follows:

Element	Setting	Remarks
OCMF	L1:0.1In, L2:0.16In, L3:0.26In, L4:0.41In, L5:0.66In, L6:1.05In, L7:1.68In	In: Rated current
OCDF	0.1In	
EFF	0.1In, 0.15 In, 0.2 In	
UVGF	46V	$0.8 \times 100V/\sqrt{3}$
UVSF	80V	$0.8 \times 100V$
UVDF	0.93Vr	Vr: Pre-fault voltage

2.10 Autoreclose

2.10.1 Application

Most faults that occur on high-voltage or extra-high-voltage overhead lines are transient faults caused by lightning. If a transient fault occurs, the circuit breaker is tripped to isolate the fault, and then reclosed following a time delay to ensure that the hot gases caused by the fault arc have de-ionized. This makes it possible to recover power transmission.

The time between clearing the fault and reclosing the circuit breaker, that is, the dead time, should be made as short as possible to keep the power system stable. From the viewpoint of de-ionization of the fault arc, the fault arc is de-ionized more thoroughly as the period of this dead time is extended. The de-ionization commences when the circuit breakers for all terminals of the line are tripped. Therefore, the dead time can be set at its minimum level if all terminals of the line are tripped at the same time.

Autoreclose of the GRL100 is started by the current differential protection that ensures high-speed protection of all terminals.

The GRL100 provides two autoreclose systems, single-shot autoreclose and multi-shot autoreclose.

Single-shot autoreclose

Four types of single-shot autoreclose mode are provided: single-phase autoreclose, three-phase autoreclose, single- and three-phase autoreclose, and multi-phase autoreclose. An optimal mode is selected by the autoreclose mode selection switch [ARC-M]. In any case, autoreclose is performed only once. If the fault state still continues after reclosing, three-phase final tripping is activated.

Single-phase autoreclose:

In this mode, only the faulty phase is tripped, and then reclosed if a single-phase earth fault occurs. In the case of a multi-phase fault, three phases are tripped, but reclosing is not made. Since power can be transmitted through healthy phases even during the dead time, this mode is convenient for maintaining power system stability. On the other hand, the capacitive coupling effect between the healthy phase and faulty phase may cause a longer de-ionization time when compared to a three-phase autoreclose. As a result, a longer dead time is required.

It is essential to correctly determine the faulty phase. The GRL100 provides phase-segregated current differential protection to correctly determine the faulty phase(s).

For single-phase autoreclose, each phase of the circuit breaker must be segregated.

This reclosing mode is simply expressed as "SPAR" in the following descriptions.

Three-phase autoreclose:

In this autoreclose mode, three phases are tripped, and then reclosed regardless of the fault mode, whether single-phase fault or multi-phase fault. A shorter dead time can be set in this mode when compared to the single-phase autoreclose. For the three-phase autoreclose, synchronism check and voltage check between the busbar and the line are required.

This reclosing mode is simply expressed as "TPAR" in the following descriptions.

Single- and three-phase autoreclose:

In this autoreclose mode, single-phase tripping and reclosing are performed if a single-phase fault occurs, while three-phase tripping and reclosing are performed if a multi-phase fault occurs.

This reclosing mode is simply expressed as "SPAR & TPAR" in the following descriptions.

Multi-phase autoreclose:

This autoreclose mode can be applied to double-circuit lines. In this mode, only the faulted phases are tripped and reclosed when the terminals of double-circuit lines are interconnected during the dead time through at least two or three different phases.

This mode realizes high-speed reclosing for multi-phase faults without synchronism and voltage check and minimizes the possibility of outages in the case of double faults on double-circuit lines.

If the interlinking condition is not satisfied, all the phases are tripped and reclosing is not started.

This reclosing mode is simply expressed as "MPAR2" for two-phase interconnection and "MPAR3" for three-phase interconnection in the following descriptions.

For the detailed performance of the multi-phase autoreclose, see Appendix M.

In B-mode and GPS-mode, the multi-phase autoreclose can be applied if the RYIDSV function is not applied.

Single-shot autoreclose can be applied to one-breaker reclosing and two-breaker reclosing in the one-and-a-half breaker busbar system.

Multi-shot autoreclose

In the multi-shot autoreclose, any of two- to four-shot reclosing can be selected. In any case, the first shot is selected from four types of autoreclose mode as described in the above single-shot autoreclose. All successive shots (up to three times), which are applied if the first shot fails, are three-phase tripping and reclosing.

Multi-shot autoreclose cannot be applied to two-breaker reclosing in the one-and-a-half breaker busbar system.

The autoreclose can also be activated from an external line protection. At this time, all autoreclose modes described above are effective.

If a fault occurs under the following conditions, three-phase final tripping is performed and autoreclose is blocked:

- Reclosing block signal is received from an external unit locally or remotely.
- Throughout the reclaim time.

For evolving faults that occur during the dead time between single-phase tripping and reclosing, "SPAR & TPAR" functions are as follows.

For evolving faults that occur within the period of time set from the first fault, the reclosing mode enters the three-phase autoreclose mode. At this time, the total dead time becomes the dead time for three-phase autoreclose added to the dead time for single-phase autoreclose which has expired up to the point at which the evolving fault occurs.

For evolving faults that occurred after the set time, three-phase final tripping is performed, and reclosing is not performed.

If an evolving fault occurs when "SPAR" is selected, three-phase final tripping is performed, and reclosing is not performed.

If an evolving fault occurs when "MPAR2" or "MPAR3" is selected, the dead time is recounted provided the network conditions defined for linked circuits are satisfied.

2.10.2 Scheme Logic

2.10.2.1 One-breaker Autoreclose

Figure 2.10.2.1 shows the simplified scheme logic for the single-shot autoreclose. Autoreclose for a further fault incident is available when the circuit breaker is closed and ready for autoreclose (CB-RDY=1), the reclosing mode selection switch [ARC-M] is set to "SPAR", "TPAR", "SPAR & TPAR", "MPAR2" or "MPAR3" and the on-delay timer TRDY1 is picked up. TRDY1 is used to determine the reclaim time.

If the autoreclose is ready, the internal tripping signal TRIP-A, B, C or external tripping signal EXT_TRIP-A, B, C for each phase of the breaker activates the autoreclose. Whether or not the external trip signals are used to activate the reclosing is selected by the scheme switch [ARC-EXT].

Once this autoreclose is activated, it is kept by the flip-flop circuit until one reclosing cycle is completed.

Autoreclose is not activated in the following conditions and all the phases are tripped (M-TRIPA=1).

- When tripping is performed by the high-impedance earth fault protection (DIFGT=1) and the autoreclose selection switch [ARC-DIFG] is set to "OFF".
- When tripping is performed by the backup protection (BU-TRIP=1) and the autoreclose selection switch [ARC-BU] is set to "OFF".
- When tripping is performed by the out-of-step protection (OSTT=1), breaker failure protection (RETRIP=1) or stub fault protection (STUB=1).
- When an autoreclose prohibiting binary input signal is applied at either the local or remote terminal (ARC_BLOCK=1).

If autoreclosing is not ready, a three-phase tripping command M-TRIPA is output for all tripping modes. At this time, autoreclose is not activated.

Autoreclose for single-phase fault

If the switch [ARC-M] is set to "SPAR", "SPAR & TPAR" or "MPAR2", single-phase tripping is performed. If it is set to "MPAR3", single-phase tripping is performed only when the adjacent parallel line is healthy.

The dead time counter TSPR or TMPR for single-phase reclosing is started by any of the tripping signals TRIP-A to C. After the dead time has elapsed, reclosing command ARC is output. The voltage check condition can be configured by the PLC function, if the voltage check and others are required for the reclosing condition.

If [ARC-M] is set to "TPAR", three-phase tripping is performed and the dead time counter TTPR1 for three-phase reclosing is started. After the dead time has elapsed, reclosing command ARC is output based on the operating conditions of the voltage and synchronism check elements output signal SYN-OP. (The SYN-OP is assigned by the PLC as a default setting.)

If [ARC-M] is set to "Disable", three-phase tripping is performed and autoreclose is not started.

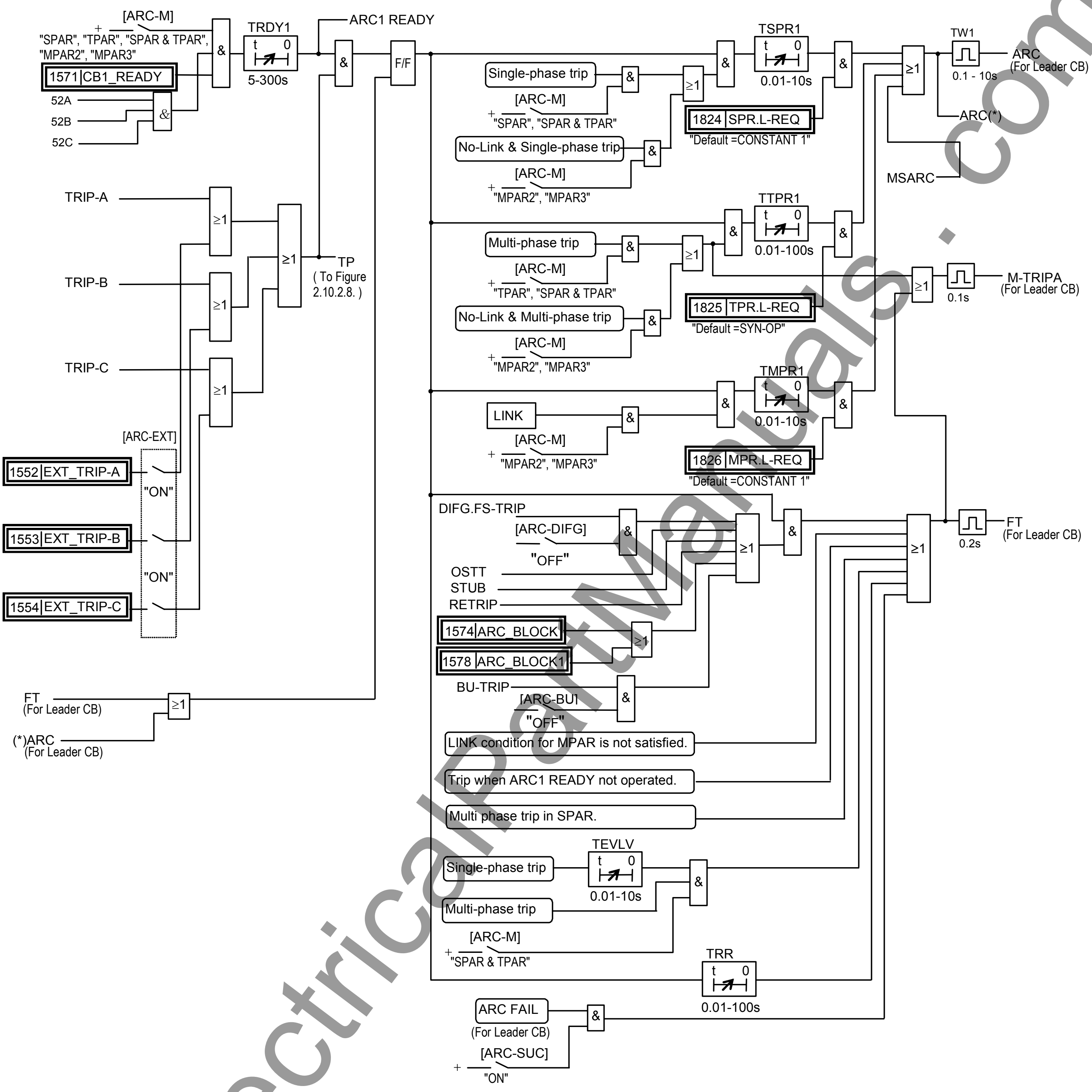


Figure 2.10.2.1 Autoreclose Scheme

Autoreclose for multi-phase fault

If [ARC-M] is set to "MPAR2" or "MPAR3", only the faulted phases are tripped and the dead time counter TMPR is started by any of the tripping signals TRIP-A to C. After the dead time has elapsed, reclosing command ARC is output, based on the status of the linked circuits check output signal LINK. The voltage check condition can be configured by the PLC function, if the voltage check and others are required for the reclosing condition.

In other reclosing modes, three-phase tripping is performed and all of TRIP-A to C are activated. If [ARC-M] is set to "TPAR" or "SPAR & TPAR", the dead time counter TTPR1 for three-phase reclosing is started. After the dead time has elapsed, reclosing command ARC is output based on the status of the voltage and synchronism check elements output signal SYN-OP. (The SYN-OP is assigned by the PLC as a default setting.)

If [ARC-M] is set to "SPAR" or "Disable", autoreclose is not activated.

In "SPAR & TPAR" or "TPAR", if the operating conditions of the voltage and synchronism check elements assigned by the PLC as default are not satisfied during three-phase reclosing, the TRR is then picked up and reclosing is reset. In "MPAR2" or "MPAR3", if the operating condition of interlinking is not satisfied, autoreclosing is not activated and three-phase final tripping is performed in case of setting [MA-NOLK] to “FT”. In case of setting [MA-NOLK] to "S" or "S+T", it is shifted to other reclose modes and three-phase final tripping is not performed.

Autoreclose for an evolving fault

Figure 2.10.2.2 shows the sequence diagram of autoreclose for an evolving fault when "SPAR & TPAR" is selected. If single-phase tripping (1ϕtrip) is performed, the evolving fault detection timer TEVLV is started at the same as the TSPR is started. If no evolving faults occur, single-phase reclosing is performed when the TSPR is picked up.

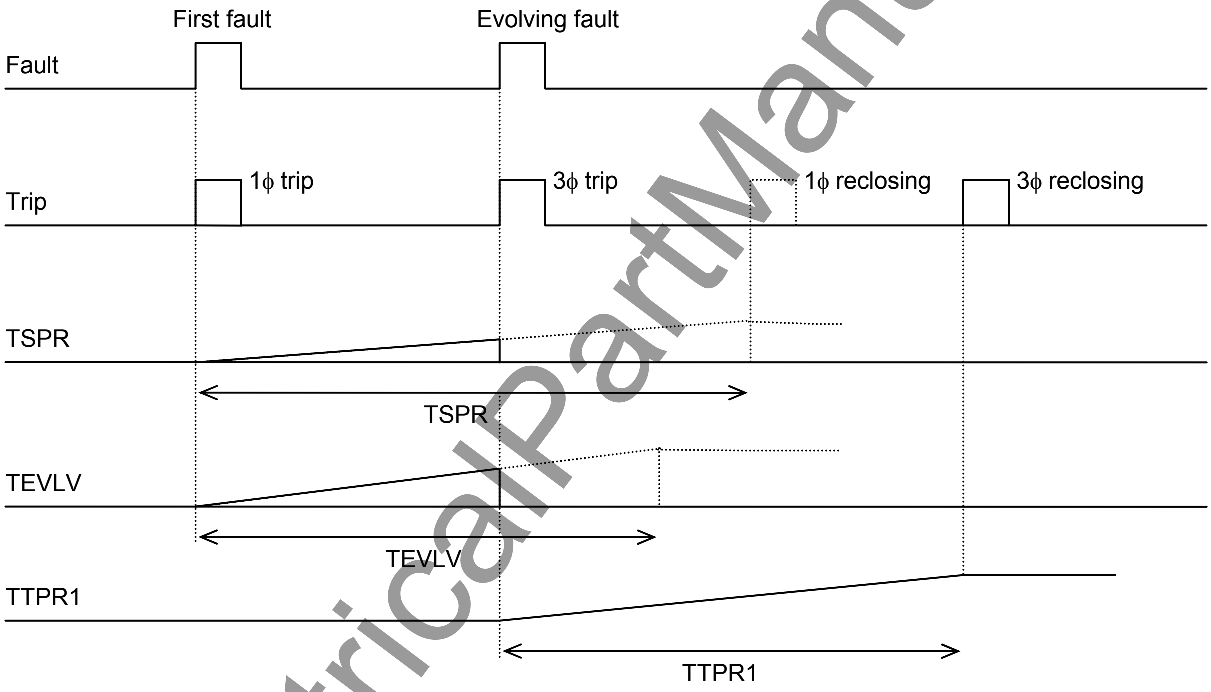


Figure 2.10.2.2 Autoreclose for Evolving Fault

As shown in the figure, if an evolving fault occurs before the TEVLV is picked up, three-phase tripping (3ϕtrip) is performed. If this occurs, the TSPR and TEVLV are reset, and the TTPR1 is now started.

After the TTPR1 is picked up, three-phase reclosing is performed based on the status of the voltage and synchronism check elements output signal SYN-OP. If an evolving fault occurs after the TEVLV has picked up, autoreclose is reset and reclosing is not performed.

In "MPAR2" or "MPAR3", an evolving fault only resets and restarts the dead time counter TSPR provided the network conditions defined for linked circuits are satisfied, though not shown in Figure 2.10.2.1.

Voltage and synchronism check

There are four voltage modes as shown below when all three phases of the circuit breaker are open. The voltage and synchronism check is applicable to voltage modes 1 to 3 and controls the energizing process of the lines and busbars in the three-phase autoreclose mode.

Voltage Mode	1	2	3	4
Busbar voltage (V_B)	live	live	dead	dead
Line voltage (V_L)	live	dead	live	dead

The synchronism check is performed for voltage mode 1 while the voltage check is performed for voltage modes 2 and 3.

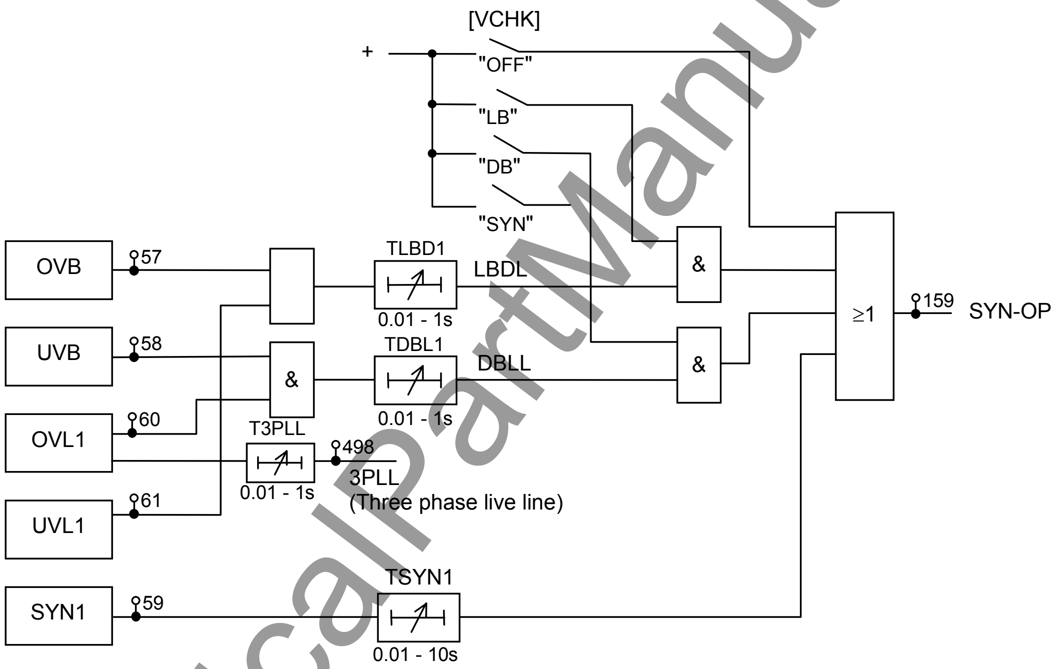


Figure 2.10.2.3 Energizing Control Scheme

Figure 2.10.2.3 shows the energizing control scheme. The voltage and synchronism check output signal SYN-OP is generated when the following conditions have been established:

- Synchronism check element SYN1 operates and on-delay timer TSYN1 is picked up.
- Busbar overvoltage detector OVB and line undervoltage detector UVL1 operate, and on-delay timer TLBD1 is picked up. (This detects the live bus and dead line condition.)
- Busbar undervoltage detector UVB and line overvoltage detector OVL1 operate, and on-delay timer TDBL1 is picked up. (This detects the dead bus and live line condition.)

Using the scheme switch [VCHK], the energizing direction can be selected.

Setting of [VCHK]	Energizing control
LB	Reclosed under the "live bus and dead line" condition or with synchronism check.
DB	Reclosed under the "dead bus and live line" condition or with synchronism check.
SYN	Reclosed with synchronism check only.
OFF	Reclosed without voltage and synchronism check.

When [VCHK] is set to "LB", the line is energized in the direction from the busbar to line under the "live bus and dead line" condition. When [VCHK] is set to "DB", the lines are energized in the direction from the line to busbar under the "dead bus and live line" condition.

When the synchronism check output exists, autoreclose is executed regardless of the position of the scheme switch.

When [VCHK] is set to "SYN", three-phase autoreclose is performed only with the synchronism check.

When [VCHK] is set to "OFF", three-phase autoreclose is performed without the voltage and synchronism check.

The voltage and synchronism check requires a single-phase reference voltage from the busbar or line. If three-phase voltages used by the current differential protection are supplied from the line voltage transformer, the reference voltage will need to be supplied from the busbar voltage transformer. On the contrary, if three-phase voltages used by the current differential protection are supplied from the busbar voltage transformer, the reference voltage will need to be supplied from the line voltage transformer.

Additionally, it is not necessary to fix the phase of the reference voltage.

To match the busbar voltage and line voltage for the voltage and synchronism check option described above, the GRL100 has the following three switches as shown in Figure 2.10.2.4:

[VTPSEL]: This switch is used to match the voltage phases. If the A-phase voltage or A-phase to B-phase voltage is used as a reference voltage, "A" is selected.

[VT-RATE]: This switch is used to match the magnitude and phase angle. "PH/G" is selected when the reference voltage is a single-phase voltage while "PH/PH" is selected when it is a phase-to-phase voltage.

[3PH-VT]: "Bus" is selected when the three-phase voltages are busbar voltages while "Line" is selected when they are line voltages.

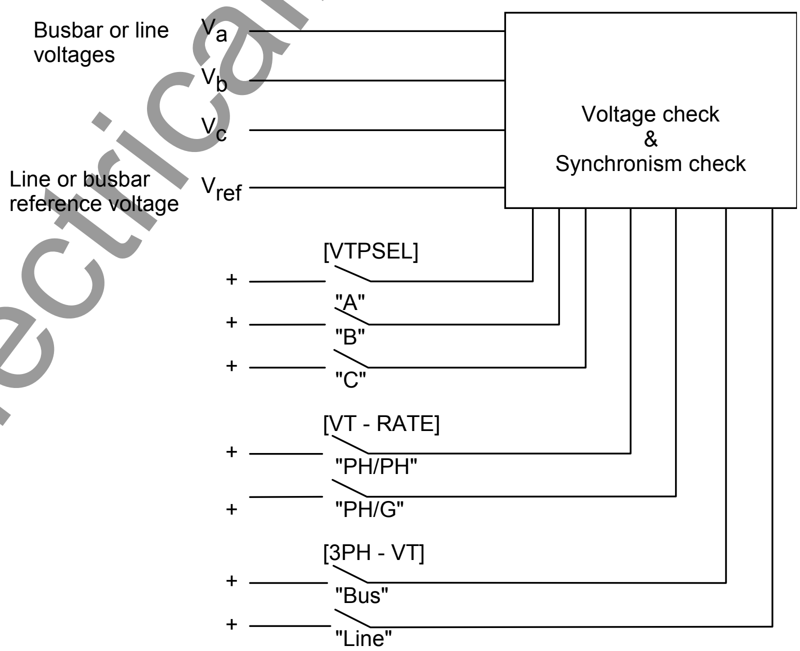


Figure 2.10.2.4 Matching of Busbar Voltage and Line Voltage

The signal 3PLL shown in Figure 2.10.2.3 is output when all three phase voltages are live, and it is available by the [3PH-VT] = LINE setting.

Autoreclosing requirement

Using PLC function, various reclose requirements can be designed. In Figure 2.10.2.1, a reclose requirement for "SPAR", "TPAR", "SPAR&TPAR" or "MPAR" can be respectively assigned to the following signals by PLC:

"SPAR":	[SPR.L-REQ]
"TPAR":	[TPR.L-REQ]
"SPAR&TPAR":	[SPR.L-REQ], [TPR.L-REQ]
"MPAR":	[MPR.L-REQ]

The default setting is as follows:

Reclose requirement	Default setting	Remarks
"SPAR"	[SPR.L-REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.L-REQ] = SYP-ON	Voltage and synchronism check
"MPAR"	[MPR.L-REQ] = CONSTANT_1	No condition

The setting example is shown in Appendix S.

Interconnection check for multi-phase autoreclose

MPAR is performed when the terminals of double-circuit lines remain interconnected during the dead time through two or three different phases. Interconnection is checked as follows.

Figure 2.10.2.5 shows the interconnection check scheme in a two-terminal line application. Each terminal originates a local interconnection check signals CBDS-A, -B and -C when disconnector DS and the circuit breaker for each phase CB1A, CB1B and CB1C are closed. These signals are transmitted to the remote terminals as well as used locally.

Interconnection signal LINK-A, -B or -C is established when both the local and remote interconnection check signals are established for their respective phases.

Interconnection through two or three different phases is checked employing signals LINK-A, -B or –C of the line and the parallel line. When [ARC-M] is set to "MPAR2", interconnection signal LINK is output if any two of LINK-A, -B and -C are established. When [ARC-M] is set to "MPAR3", LINK is output if all of LINK-A, -B and -C are established.

The interconnection signals LINK-A, -B or -C for parallel line are assigned to the binary output relays as shown in Appendix D.

In the three-terminal line application, the interconnection check is performed with two remote terminals independently.

When the interconnection check signal CBDS-A, -B, or -C is established at both the local terminal and remote terminal 1, interconnection signal LINK-A1, -B1, -C1 is established. When it is established at both the local and remote terminal 2, interconnection signal LINK-A2, -B2 or -C2 is established. Those signals are assigned to the binary output relays and output to the parallel line.

Note: In the three-terminal line application, remote terminal 1 and 2 are designated automatically through the communication circuit setup. The remote terminal 1 is a terminal to which the local communication port 1 is linked and remote terminal 2 is the terminal to which local communication port 2 is linked.

When the interconnection with either of the two remote terminals is confirmed employing the interconnection signals from the line and the parallel line, multi-phase autoreclose can be performed.

In case the interconnection condition LINK is not satisfied, the following operations can be selected by the scheme switch [MA-NOLK] setting.

Setting of [MA-NOLK]	Operation
FT	Final Trip
T	Three-phase autoreclose
S+T	Single- and Three-phase autoreclose

If "FT" is selected and the LINK is not satisfied, the final trip FT is performed. If "T" selected, the three-phase autoreclose is performed. If "S+T" selected, the single-phase or three-phase autoreclose is performed depending on the faulted phase(s).

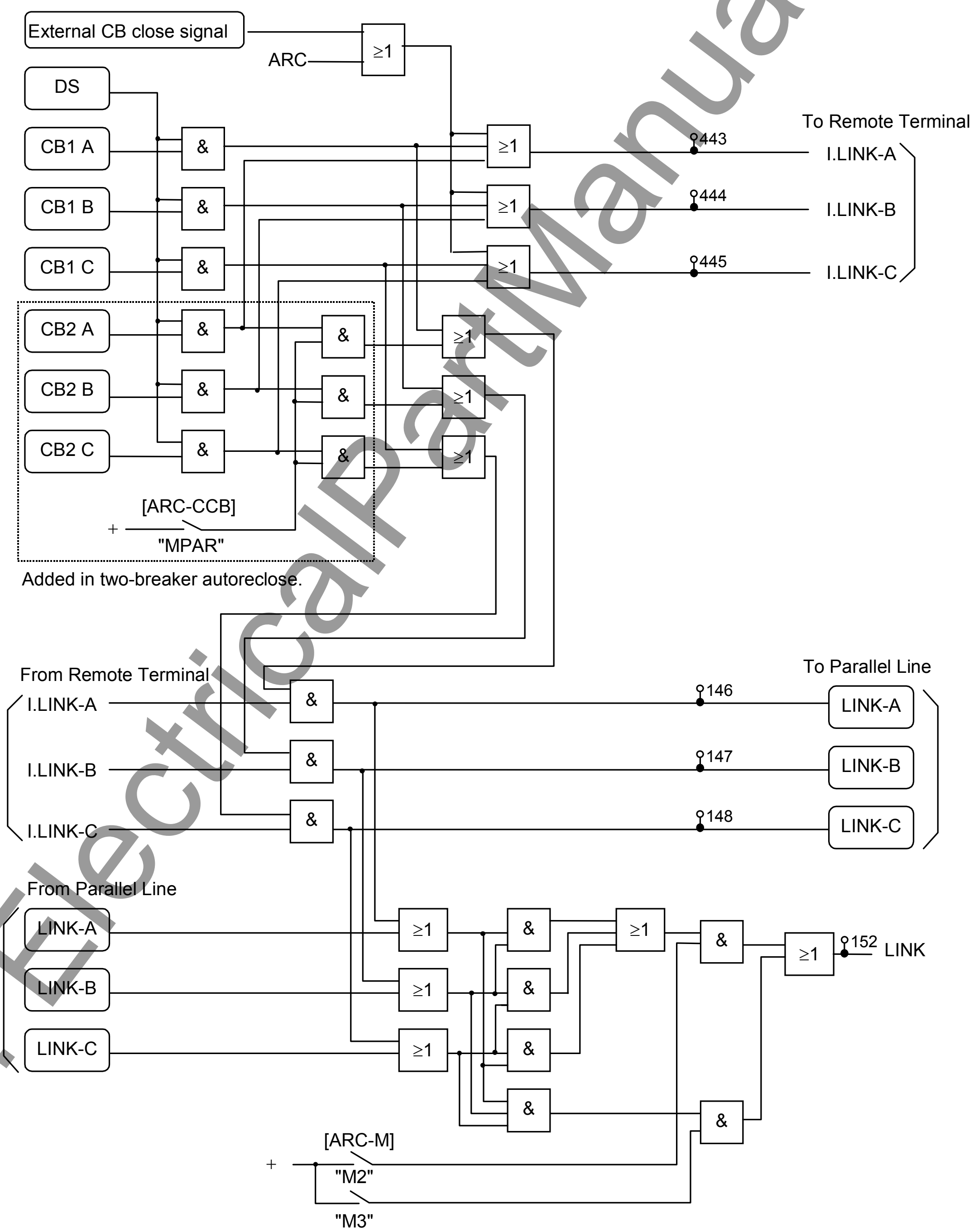


Figure 2.10.2.5 Interconnection Check Scheme

Permanent fault

When reclose-onto-a-fault is activated when a permanent fault exists, three-phase final tripping is performed. However, this operation is performed only in the single-shot autoreclose mode. In the multi-shot autoreclose mode, reclosing is retried as shown below, for multi-shot autoreclosing.

Multi-shot autoreclose

In a multi-shot autoreclose, low-speed autoreclose is executed up to three times after high-speed autoreclose fails. The first shot is high-speed autoreclose that functions in the same manner as described for single-shot autoreclose. Figure 2.10.2.6 shows the simplified scheme logic for the low-speed autoreclose of the second to fourth shot.

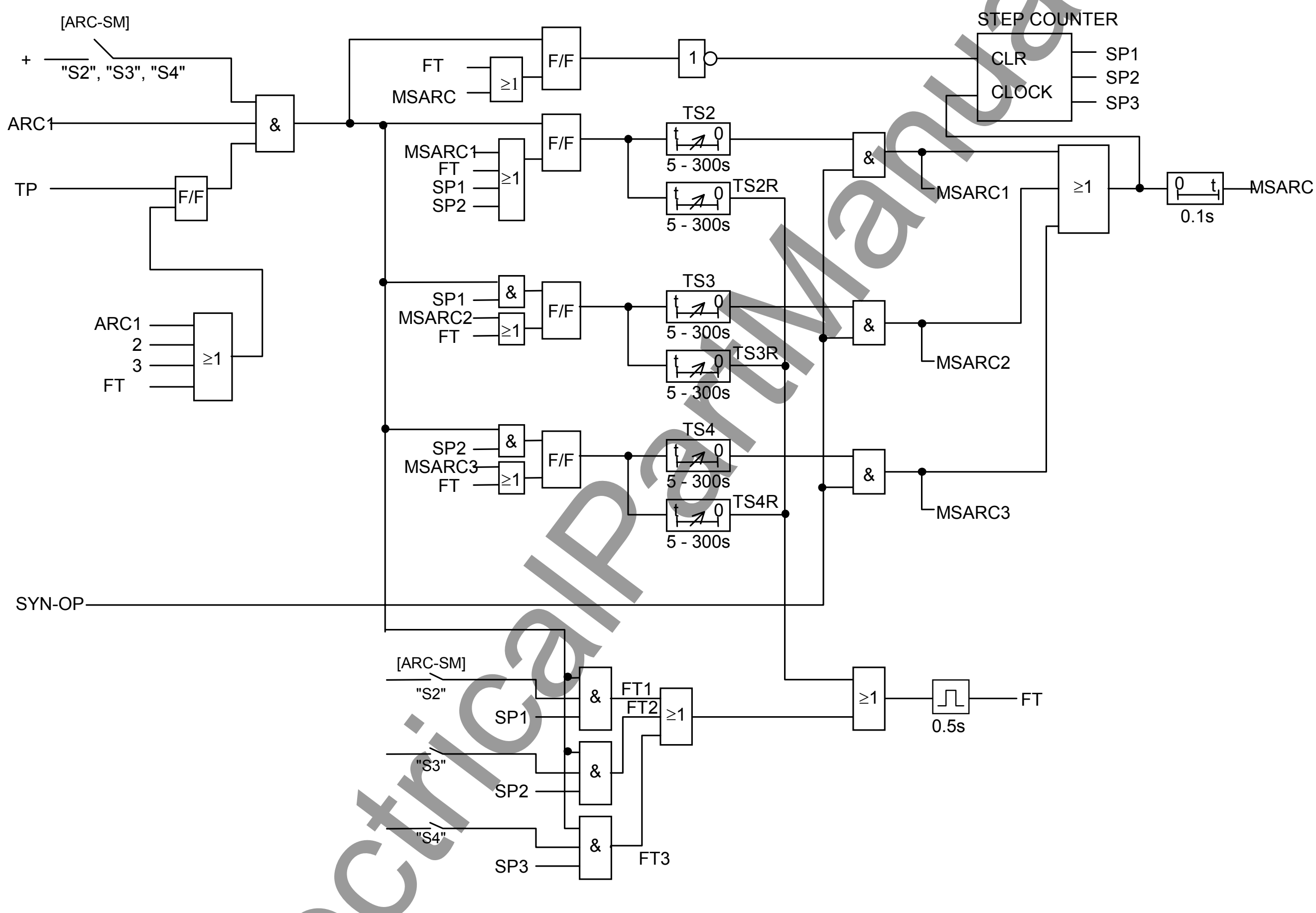


Figure 2.10.2.6 Scheme Logic for Multi-Shot Autoreclose

The multi-shot mode, two shots to four shots, is set with the scheme switch [ARC-SM].

In low-speed autoreclose, the dead time counter TS2 for the second shot is activated if high-speed autoreclose is performed (ARC = 1), but tripping occurs again (TP = 1). Second shot autoreclose is performed only when the voltage and synchronism check element operates (SYN-OP = 1) after the period of time set on TS2 has elapsed. At this time, outputs of the step counter are: SP1 = 1, SP2 = 0, and SP3 = 0.

Autoreclose is completed at this step if the two-shot mode is selected for the multi-shot mode. Therefore, the tripping following the "reclose-onto-a-fault" becomes the final tripping (FT = 1).

If the voltage and synchronism check element does not operate within the period of time set on the timer TS2R which is started at the same time as TS2 is started, the multi-shot autoreclose is cancelled (FT = 1).

When the three-shot mode is selected for the multi-shot mode, autoreclose is retried again after the above tripping occurs. At this time, the TS3 and TS3R are started. The third shot autoreclose is performed only when the voltage and synchronism check element operates after the period of time set on the TS3 has elapsed. At this time, outputs of the step counter are: SP1 = 0, SP2 = 1, and SP3 = 0.

The three-shot mode of autoreclose is then completed. Therefore, the tripping following the ""reclose-onto-a-fault"" becomes the final tripping (FT = 1).

If the voltage and synchronism check element does not function within the period of time set on the TS3R, the multi-shot autoreclose is cancelled.

When the four-shot autoreclose is selected, low-speed autoreclose is retried once again for tripping that occurs after the "reclose-onto-a-fault". This functions in the same manner as the three-shot autoreclose.

Use of external automatic reclosing equipment

To use external automatic reclosing equipment instead of the built-in autoreclose function of the GRL100, the autoreclose mode switch [ARC-M] is set to "EXT1P", "EXT3P" or "EXTMP".

When "EXT1P" is selected, the GRL100 performs single-phase tripping for a single-phase fault and three-phase tripping for a multi-phase fault. When "EXT3P" is selected, three-phase tripping is performed for all faults. When "EXTMP" is selected, fault phase tripping is performed for all faults.

One binary signal for each individual phase is output as an autoreclose start signal.

2.10.2.2 Two-breaker autoreclose

As shown in Figure 2.10.2.7, in the one-and-a-half breaker busbar arrangement, two circuit breakers, the busbar breaker and the center breaker, must be reclosed. The GRL100 series 300s and 500s are provided with the two-breaker autoreclose scheme.

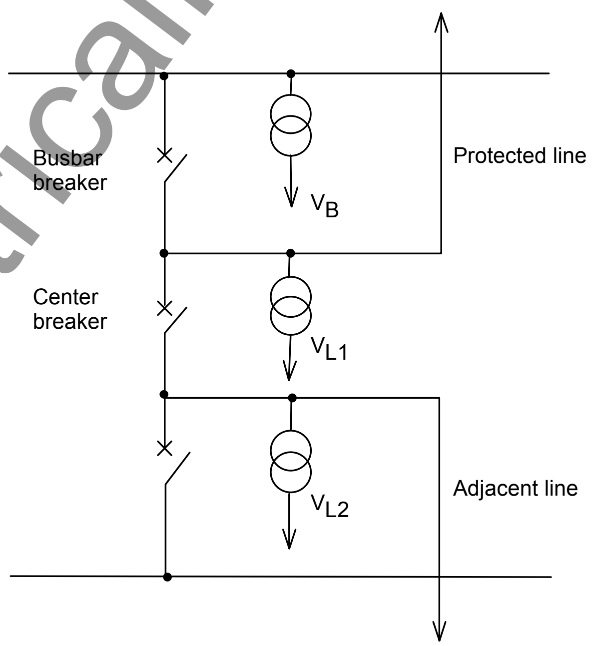


Figure 2.10.2.7 One-and-a-Half Breaker Busbar Arrangement

Multi-shot autoreclose is not applicable to two-breaker autoreclose; the scheme switch [ARC-SM] is set to "OFF" for a default setting.

Autoreclose is not activated when an autoreclose prohibiting binary input signal is applied at the local or remote terminal.

- ARC_BLOCK signal common for leader and follower CB
- ARC_BLOCK1 signal for leader CB
- ARC_BLOCK2 signal for follower CB

The autoreclose scheme is different depending on the reclosing mode.

Single-phase autoreclose and single- and three-phase autoreclose

The breaker(s) to be reclosed and the reclosing order can be set by the scheme switch [ARC-CB] as follows:

Setting of [ARC-CB]	Autoreclose mode
ONE	(Set when applied to a one-breaker system)
O1	Only the busbar breaker is reclosed and the center breaker is subjected to final tripping.
O2	Only the center breaker is reclosed and the busbar breaker is subjected to final tripping.
L1	Single-phase autoreclose: Both breakers are reclosed simultaneously. (∗1)
	Three-phase autoreclose: The busbar breaker is reclosed first. If successful, then the center breaker is reclosed.
L2	Single-phase autoreclose: Both breakers are reclosed simultaneously. (∗1)
	Three-phase autoreclose: The center breaker is reclosed first. If successful, then the busbar breaker is reclosed.

Note : "ONE" is set only when the relay is applied to a one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

(∗1): Sequential autoreclose can be applied by changing of the dead timer setting or the PLC setting.

(∗2): When [ARC-M] – MPAR is selected, the autoreclose mode depends on the [ARC-CCB] setting and the [ARC-CB] is not applied.

The autoreclose scheme logic for the two circuit breakers is independent of each other and are almost the same. The autoreclose scheme logic of the circuit breaker to be reclosed first (lead breaker) is the same as that shown in Figure 2.10.2.1. The scheme logic of the circuit breaker to be reclosed later (follower breaker) is shown in Figure 2.10.2.8.

The start of the dead time counter can be configured by the PLC. In the default setting, the single-phase autoreclose is started instantaneously after tripping, and the three-phase autoreclose is started after the ARC-SET condition is satisfied.

The "ARC-SET" is a scheme signal whose logical level becomes 1 when a leader breaker's autoreclose command is output.

In default setting, therefore, the dead time of the follower breaker is as follows:

- Three-phase autoreclose: equal to the sum of the dead time setting of the two breakers. (TTPR1 + TTPR2)
- Single-phase autoreclose: TSPR2

However, the dead time can be set that of the leader breaker by the PLC setting "RF.ST-REQ". The shortening of the dead time can be also applied when the leader breaker is final-tripped because it is no ready.

Autoreclose start requirement

Using PLC function, various autoreclose start requirements can be designed. In Figure 2.10.2.8, a reclose start requirement for "SPAR", "TPAR", "SPAR&TPAR" or "MPAR" can be respectively assigned to the following signals by PLC:

"SPAR":	[SPR.F-ST.REQ]
"TPAR":	[TPR.F-ST.REQ]
"SPAR&TPAR":	[SPR.F-ST.REQ], [TPR.F-ST.REQ]
"MPAR":	[MPR.F-ST.REQ]

The default setting for the follower CB autoreclose start requirement is as follows:

Reclose start requirement	Default setting	Remarks
"SPAR"	[SPR.F-ST.REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.F-ST.REQ] = ARC-SET or CCB-SET	ARC-SET becomes "1" when the leader CB is reclosed.
		CCB-SET becomes "1" when [ARC-M]=M2 or M3 and [ARC-CCB]=TPAR setting.
"MPAR"	[MPR.F-ST.REQ] = CONSTANT_1	No condition

Autoreclose requirement

The autoreclose requirement can be designed by assigning a reclose requirement to the signals [SPR.F- REQ], [TPR.F-REQ] and [MPR.F- REQ] same as above.

The default setting for the follower CB autoreclose requirement is as follows:

Reclose requirement	Default setting	Remarks
"SPAR"	[SPR.F-REQ] = CONSTANT_1	No condition
"TPAR"	[TPR.F-REQ] = SYP-ON	Voltage and synchronism check
"MPAR"	[MPR.F-REQ] = CONSTANT_1	No condition

Others

If the autoreclose start requirement is designed such as starting the follower CB in no-ready condition of the leader CB, it is assigned to the signal [R.F-ST.REQ].

By assigning the autoreclose start requirement to the signal [R.F-ST.REQ], both the leader CB and the follower CB are set the same dead time. The reclose requirement is assigned to the signals [SPR.F2-ST.REQ], [TPR.F2-ST.REQ] and [MPR.F2-ST.REQ].

The default setting for the follower CB is as follows:

Requirement	Default setting	
Reclose requirement	[R.F-ST.REQ] = CONSTANT_0	(No used)
Reclose start requirement		
"SPAR"	[SPR.F2-ST.REQ] = CONSTANT_0	(No used)
"TPAR"	[TPR.F2-ST.REQ] = CONSTANT_0	(No used)
"MPAR"	[MPR.F2-ST.REQ] = CONSTANT_0	(No used)

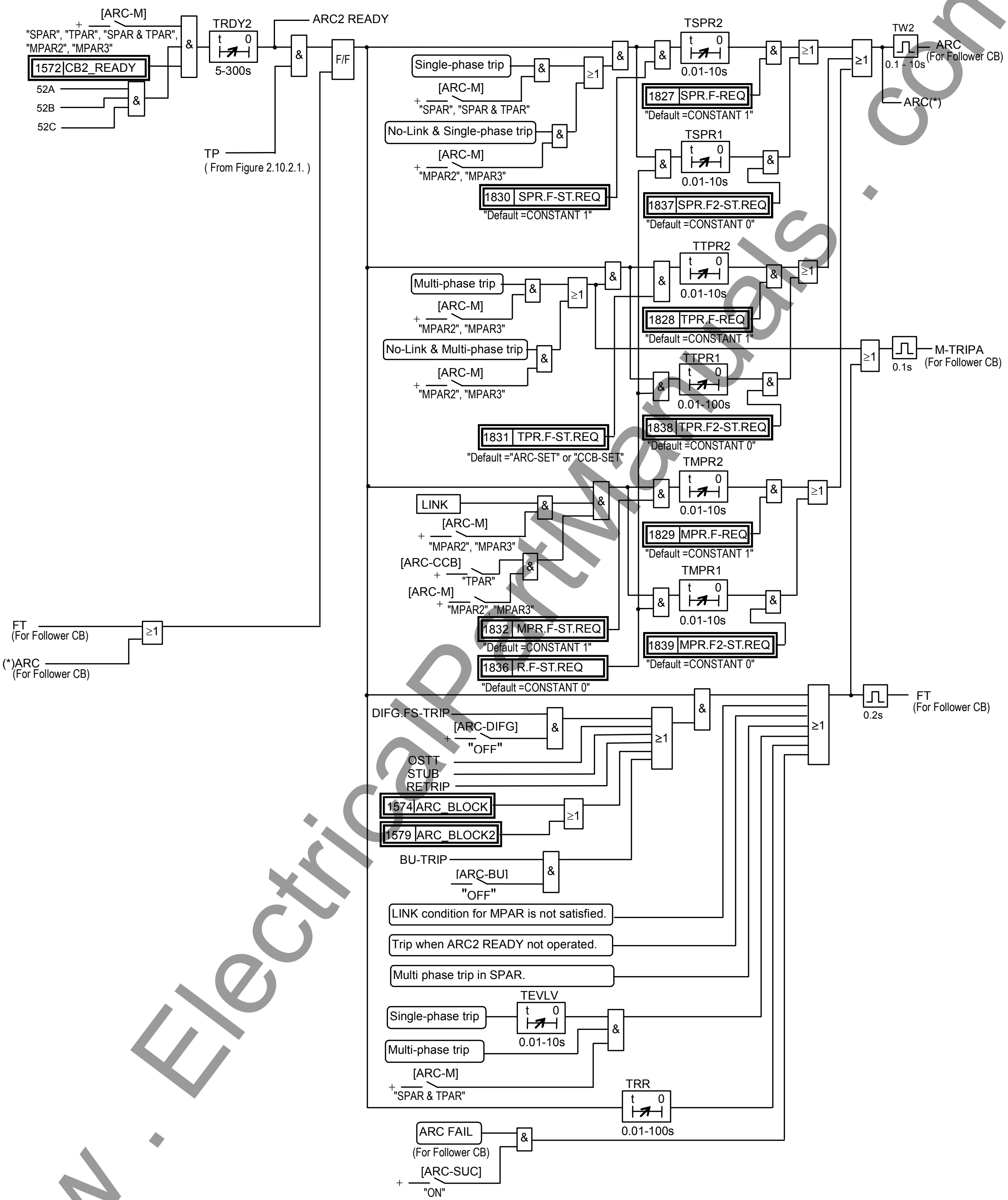
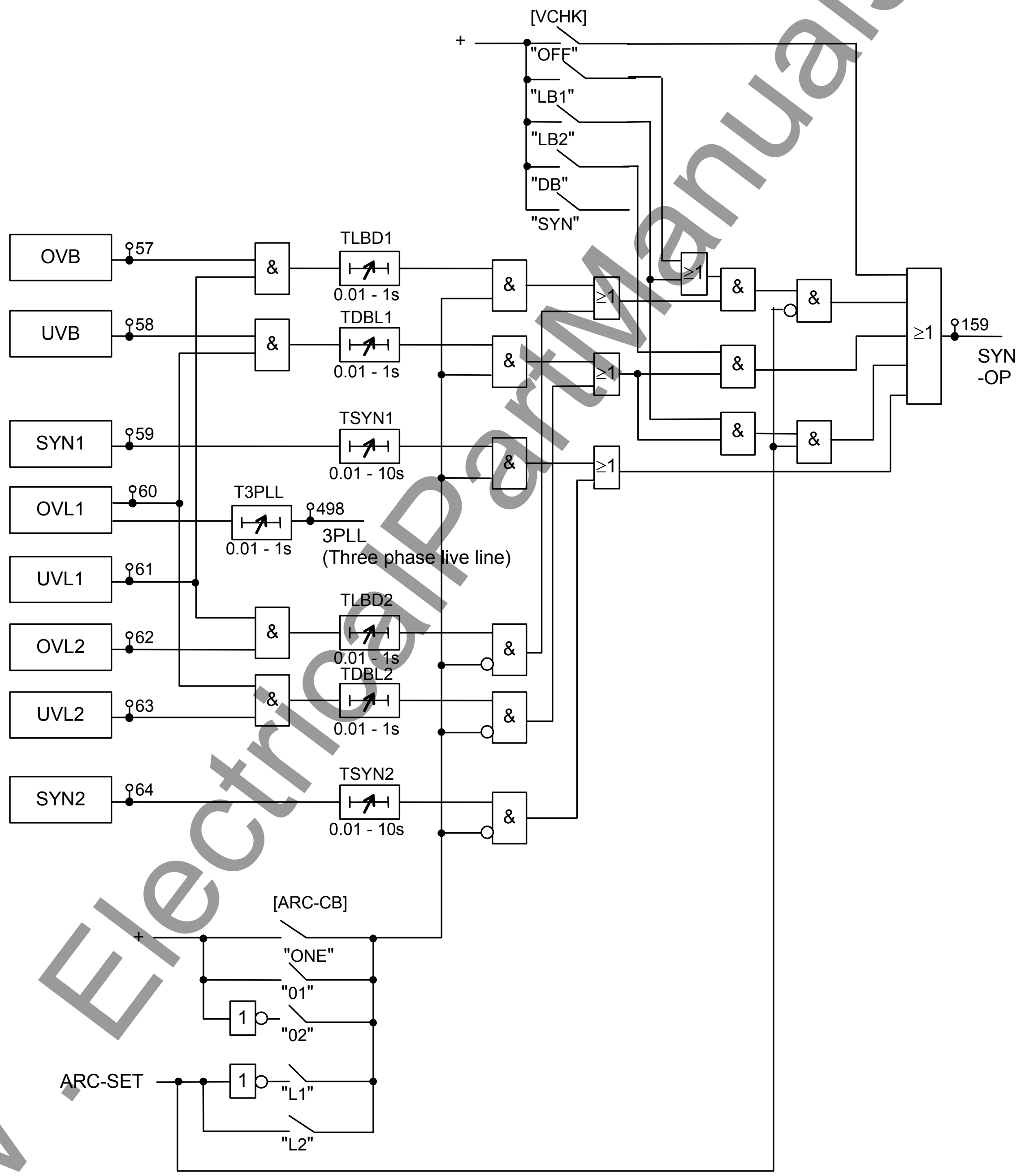


Figure 2.10.2.8 Autoreclose Scheme for Follower Breaker

Figure 2.10.2.9 shows the energizing control scheme of the two circuit breakers in the three-phase autoreclose. OVB and UVB are the overvoltage and undervoltage detectors of busbar voltage V_B in Figure 2.10.2.7. OVL1 and UVL1 are likewise the overvoltage and undervoltage detectors of line voltage V_{L1}.

OVL2 and UVL2 are likewise the overvoltage and undervoltage detectors of line voltage V_{L2}. V_{L2} in the center breaker is equivalent to the busbar voltage V_B in the busbar breaker.

SYN1 and SYN2 are the synchronism check elements to check synchronization between the two sides of the busbar and center breakers, respectively. SYN-OP is a voltage and synchronism check output.



Note : [ARC-CB] is set to "ONE" only when the relay is applied to one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

Figure 2.10.2.9 Energizing Control Scheme for Two Circuit Breakers

The voltage and synchronism check is performed as shown below according to the [ARC-CB] settings:

Setting of [ARC-CB]	Voltage and synchronism check
ONE or O1	A voltage and synchronism check is performed using voltages V_B and V_{L1}.
O2	A voltage and synchronism check is performed using voltages V_{L1} and V_{L2}.
L1	Since the logical level of ARC-SET is 0, a voltage and synchronism check is performed for the busbar breaker using voltages V_B and V_{L1}. Then, the logical level of ARC-SET becomes 1 and a voltage and synchronism check is performed for the center breaker using voltages V_{L1} and V_{L2} and a reclosing command is output to the center breaker.
L2	A voltage and synchronism check is performed for the center breaker using voltages V_{L1} and V_{L2}. Then, the logical level of ARC-SET becomes 1 and a voltage and synchronism check is performed for the busbar breaker using voltages V_B and V_{L1}.

Note : "ONE" is set only when the relay is applied to one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

The energizing control for the two circuit breakers can be set by the scheme switch [VCHK] as follows:

Setting of [VCHK]	Energizing control
LB1	The lead breaker is reclosed under the "live bus and dead line" condition or with synchronism check, and the follower breaker is reclosed with synchronism check only.
LB2	The leader breaker is reclosed under the "live bus and dead line" condition or with synchronism check, and the follower breaker is reclosed under the "dead bus and live line" condition or with synchronism check.
DB	Both breakers are reclosed under the "dead bus and live line" condition or with synchronism check.
SYN	Both breakers are reclosed with synchronism check only.
OFF	Both breakers are reclosed without voltage and synchronism check.

Multi-phase autoreclose

The scheme switch [ARC-M] is set to "MPAR2" or "MPAR3", then the busbar breaker is always reclosed in the multi-phase autoreclose mode.

The center breaker can select three-phase autoreclose, multi-phase autoreclose or three-phase final tripping by setting the scheme switch [ARC-CCB] shown in Figure 2.10.2.5.

When [ARC-CCB] is set to "TPAR", the logic level of CCB-SET signal becomes 1 and the center breaker is reclosed in the three-phase autoreclose mode only after the busbar breaker is successfully reclosed. If the voltage check condition is configured by the PLC, the energizing control for the center breaker is dependent on the setting of the scheme switch [VCHK] as follows.

Setting of [VCHK]	Energizing control
LB	Reclosed under the "live bus and dead line" condition or with synchronism check.
DB	Reclosed under the "dead bus and live line" condition or with synchronism check.
SYN	Reclosed with synchronism check only.
OFF	Reclosed without voltage and synchronism check.

Note: As this three-phase autoreclose is applied only to the center breaker, the settings of the [VCHK] is the same as that of one-breaker autoreclose.

When [ARC-CCB] is set to "MPAR", the center breaker is also reclosed in the multi-phase autoreclose mode at the time of the TMPR2 setting.

When [ARC-CCB] is set to "OFF", autoreclose does not start for the center breaker.

The scheme switch [ARC-CCB] used in single-phase autoreclose and single- and three-phase autoreclose is invalid when multi-phase autoreclose is selected as a reclose mode.

The interlinking check scheme for two-breaker autoreclose is shown in Figure 2.10.2.5. Local interlink check signals CBDS-A, -B and –C are originated by ORing the busbar and center breaker conditions.

The scheme switch [ARC-SUC] is used to check the autoreclose succeeds. If all three phase CB contacts have been closed within TSUC time after ARC shot output, it is judged that the autoreclose has succeeded (AS). If not, it is judged that the autoreclose has failed (AF), and becomes the final tripping (FT).

The relay provides the user configurable switch [UARCSW] with three-positions (P1, P2, P3) to be programmed by using PLC function. Any position can be selected. If this switch is not used for the PLC setting, it is invalid. The setting example is shown in Appendix S.

2.10.2.3 Setting

The setting elements necessary for the autoreclose and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
VT	1 - 20000	1	2000	VT ratio for line differential protection
VTs1	1 - 20000	1	2000	VT ratio for voltage and synchronism check
TSPR1	0.01 – 10.00s	0.01s	0.80s	Dead time for single-phase autoreclose and multi-phase autoreclose
TTPR1	0.01 – 100.00s	0.01s	0.60s	Dead time for three-phase autoreclose
TMPR1	0.01 – 100.00s	0.01s	0.80s	Dead time for multi-phase autoreclose
TRR	0.01 – 100.00s	0.01s	2.00s	Autoreclose reset time
TEVLV	0.01 – 10.00s	0.01s	0.30s	Dead time reset for evolving fault
TRDY1	5 – 300s	1s	60s	Reclaim time
SYN1				Synchronism check
SY1 θ	5 – 75°	1°	30°	
SY1UV	10 – 150V	1V	83V	
SY1OV	10 – 150V	1V	51V	
OVB	10 – 150V	1V	51V	Live bus check
UVB	10 – 150V	1V	13 V	Dead bus check
OVL1	10 – 150V	1V	51V	Live line check
UVL1	10 – 150V	1V	13V	Dead line check
TSYN1	0.01 – 10.00s	0.01s	1.00s	Synchronism check time
TLBD1	0.01 – 1.00s	0.01s	0.05s	Voltage check time
TDBL1	0.01 – 1.00s	0.01s	0.05s	Voltage check time

T3PLL	0.01 – 1.00s	0.01s	0.05s	Line three voltage check time
TW1	0.1 – 10.0s	0.1s	0.2s	Reclosing signal output time
TS2	5.0 – 300.0s	0.1s	20.0s	Second shot dead time
TS3	5.0 – 300.0s	0.1s	20.0s	Third shot dead time
TS4	5.0 – 300.0s	0.1s	20.0s	Fourth shot dead time
TS2R	5.0 – 300.0s	0.1s	30.0s	Second shot reset time
TS3R	5.0 – 300.0s	0.1s	30.0s	Third shot reset time
TS4R	5.0 – 300.0s	0.1s	30.0s	Fourth shot reset time
TSUC	0.1 – 10.0s	0.1s	3.0s	Autoreclose success check time
[ARC – M]	Disabled/SPAR/TPAR/ SPAR & TPAR/MPAR2/MPAR3/ EXT1P/EXT3P/EXTMP		SPAR & TPAR	Autoreclose mode
[ARCDIFG]	OFF/ON		OFF	High-resistance fault autoreclose
[ARC-BU]	OFF/ON		OFF	Backup trip autoreclose
[ARC-EXT]	OFF/ON		OFF	External start
[ARC – SM]	OFF/S2/S3/S4		OFF	Multi – shot autoreclose mode
[ARC-SUC]	OFF/ON		OFF	Autoreclose success checking
[MA-NOLK]	FT/T/S+T		FT	Control under NON-LINK in MPAR
[VCHK]	OFF/LB/DB/SYN		LB	Energizing direction
[VTPHSEL]	A/B/C		A	Phase of reference voltage
[VT – RATE]	PH/G / PH/PH		PH/G	VT rating
[3PH – VT]	BUS/LINE		LINE	Location of three – phase VTs
[UARCSW]	P1/P2/P3		(P1)(∗)	User ARC switch for PLC

(∗) If this switch is not used for PLC setting, it is invalid.

"VT" is VT ratio setting of distance protection, and "VTs1" is VT ratio setting of a reference voltage input for voltage and synchronism check element as shown in Figure 2.6.3.1.

In a voltage setting, set "SY1UV", "SY1OV", "OVB", "UVB", "OVL1" and "UVL1" based on the VT rating for voltage and synchronism check. (When a voltage rating between line VT and busbar VT is different as shown in Figure 2.10.2.10, the voltage input from "VT" is matched to the rating of "VTs1" using the setting of "VT" and "VTs1".)

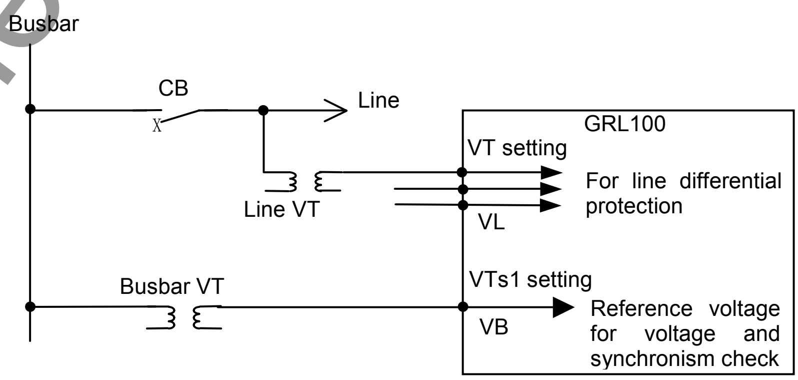


Figure 2.10.2.10 VT and VTs1 Ratio Setting for Busbar or Line Voltage

To determine the dead time, it is essential to find an optimal value while taking into consideration the de-ionization time and power system stability factors, which normally contradict each other.

Normally, a longer de-ionization time is required for a higher line voltage or larger fault current. For three-phase autoreclose, the dead time is generally 15 to 30 cycles. In single-phase autoreclose, the secondary arc current induced from the healthy phases may affect the de-ionization time. Therefore, it is necessary to set a longer dead time for single-phase autoreclose compared to that for three-phase autoreclose.

In three-phase autoreclose, if the voltage and synchronism check does not operate within the period of time set on the on-delay timer TRR, which is started at the same time as the dead time counter TTPR1 is started, reclosing is not performed and three-phase autoreclose is reset to its initial state. Therefore, for example, the TRR is set to the time setting of the TTPR1 plus 100ms.

The TEVLV determines the possibility of three-phase reclosing for an evolving fault.

When the TEVLV is set to the same setting as the TSPR, three-phase reclosing is performed for all evolving faults. As the setting for the TEVLV is made shorter, the possibility of three-phase reclosing for an evolving fault becomes smaller and that of three-phase final tripping becomes larger.

For the two-breaker autoreclose, the following additional settings are required.

Element	Range	Step	Default	Remarks
VTs2	1 - 20000	1	2000	VT ratio for voltage and synchronism checkSYN2
TSPR2	0.1 – 10.0s	0.1s	0.1s	Dead time for single-phase autoreclose of follower breaker
TTPR2	0.1 – 10.0s	0.1s	0.1s	Dead time for three-phase autoreclose of follower breaker
TMPR2	0.1 – 10.0s	0.1s	0.1s	Dead time for multi-phase autoreclose of follower breaker
TRDY2	5 – 300s	1s	60s	Reclaim time of follower breaker
SYN2				Synchronism check
SY2 θ	5 – 75°	1°	30°	
SY2UV	10 – 150V	1V	83V	
SY2OV	10 – 150V	1V	51V	
OVL2	10 – 150V	1V	51V	Live line check
UVL2	10 – 150V	1V	13V	Dead line check
TSYN2	0.01 – 10.00s	0.01s	1.00s	Synchronism check time
TLBD2	0.01 – 1.00s	0.01s	0.05s	Voltage check time
TDBL2	0.01 – 1.00s	0.01s	0.05s	Voltage check time
TW2	0.1 – 10.0s	0.1s	0.2s	Reclosing signal output time
[ARC-CB]	ONE/O1/O2/L1/L2		L1	Two breaker autoreclose mode
[ARC-CCB]	TPAR/MPAR/OFF		MPAR	Center breaker autoreclose mode
[VCHK]	OFF/LB1/LB2/DB/SYN		LB1	Energizing direction

Note : [ARC-CB] is set to "ONE" only when the relay is applied to one-breaker system. Trip and reclose commands are output only for CB1(bus CB).

2.10.3 Autoreclose Output Signals

The autoreclose scheme logic has two output reclosing signals: ARC1 and ARC2. ARC1 is a reclosing signal for single breaker autoreclose or a reclosing signal for the busbar breaker in a two-breaker autoreclose scheme.

ARC2 is the reclosing signal for the center breaker of the two-breaker autoreclose scheme.

The assignment of these reclosing signals to the output relays can be configured, which is done using the setting menu. For details, see Section 3.2.2. For the default setting, see Appendix D.

2.11 Characteristics of Measuring Elements

2.11.1 Segregated-phase Current Differential Element DIF and DIFSV

The segregated-phase current differential elements DIF have dual percentage restraint characteristics. Figure 2.11.1.1 shows the characteristics on the differential current (Id) and restraining current (Ir) plane. Id is a vector summation of the phase current of all terminals and Ir is a scalar summation of the phase current of all terminals. In these summations, charging current is eliminated from the phase currents by the charging current compensation function.

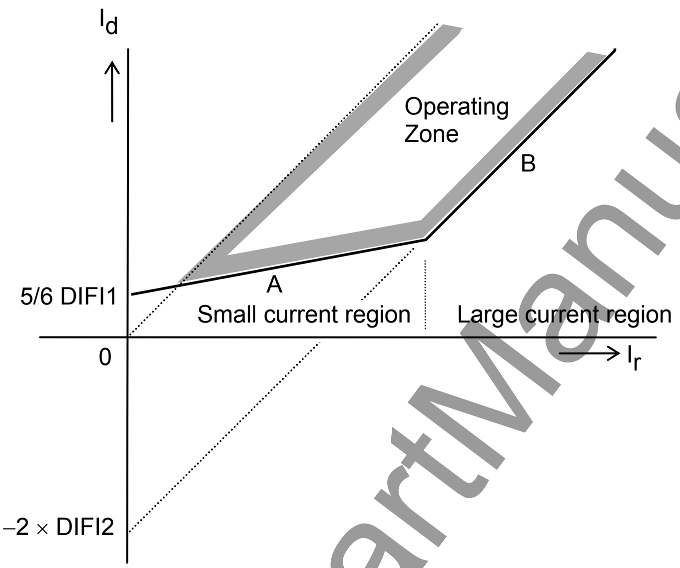


Figure 2.11.1.1 Segregated-phase Current Differential Element (I_r-I_d Plane)

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

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

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:

$$I_d \geq I_r - 2 \times \mathrm{DIFI2}$$

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 2.11.1.2.

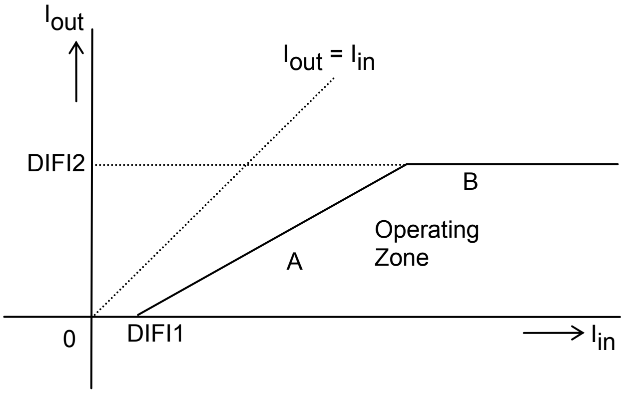


Figure 2.11.1.2 Segregated-phase Current Differential Element (Iin-Iout Plane)

Characteristic A is expressed by the following equation:

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

Characteristic B is expressed by the following equation:

$$I_{out} \le DIFI2$$

This figure shows the physical meaning of setting DIFI2, that is, DIFI2 defines the maximum outflowing current in case of an internal fault which can be detected by the relay. This outflowing current can be significant particularly in the case of a double-circuit three-terminal line or three-terminal line with outer loop circuit. Depending on the fault location, part of the fault current flows out from one terminal and flows in from another terminal. For details of the outflowing fault current, see Sections 2.2.10 and 2.2.12.

2.11.2 Zero-phase Current Differential Element DIFG

The DIF element is not too insensitive to detect a high-impedance earth fault, but to detect such faults under a heavy load current, the GRL100 is provided with a protection using a residual current.

Figure 2.11.2.1 represents the percentage restraining characteristic of the residual current differential element. Differential current (I_d) is a vector summation of the residual currents of all terminals and restraining current (I_r) is a scalar summation of the residual currents of all terminals.

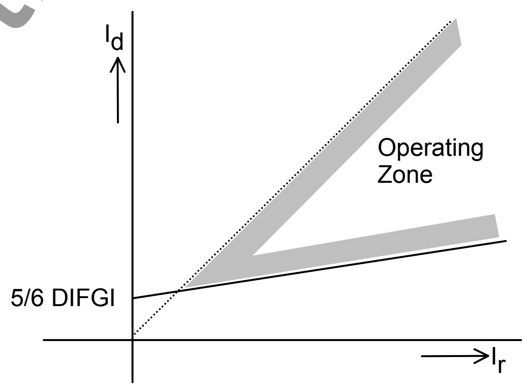


Figure 2.11.2.1 Zero-phase Current Differential Element (Ir-Id Plane)

The characteristic of the DIFG element is the same as that of the DIF element in the small current region and is expressed by the following equation:

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

where DIFGI is a setting and defines the minimum residual fault current.

2.11.3 Inverse Definite Minimum Time (IDMT) Overcurrent Element OCI and EFI

As shown in Figure 2.11.3.1, the IDMT element has one long time inverse characteristic and three inverse time characteristics in conformity with IEC 60255-3. One of these characteristics can be selected.

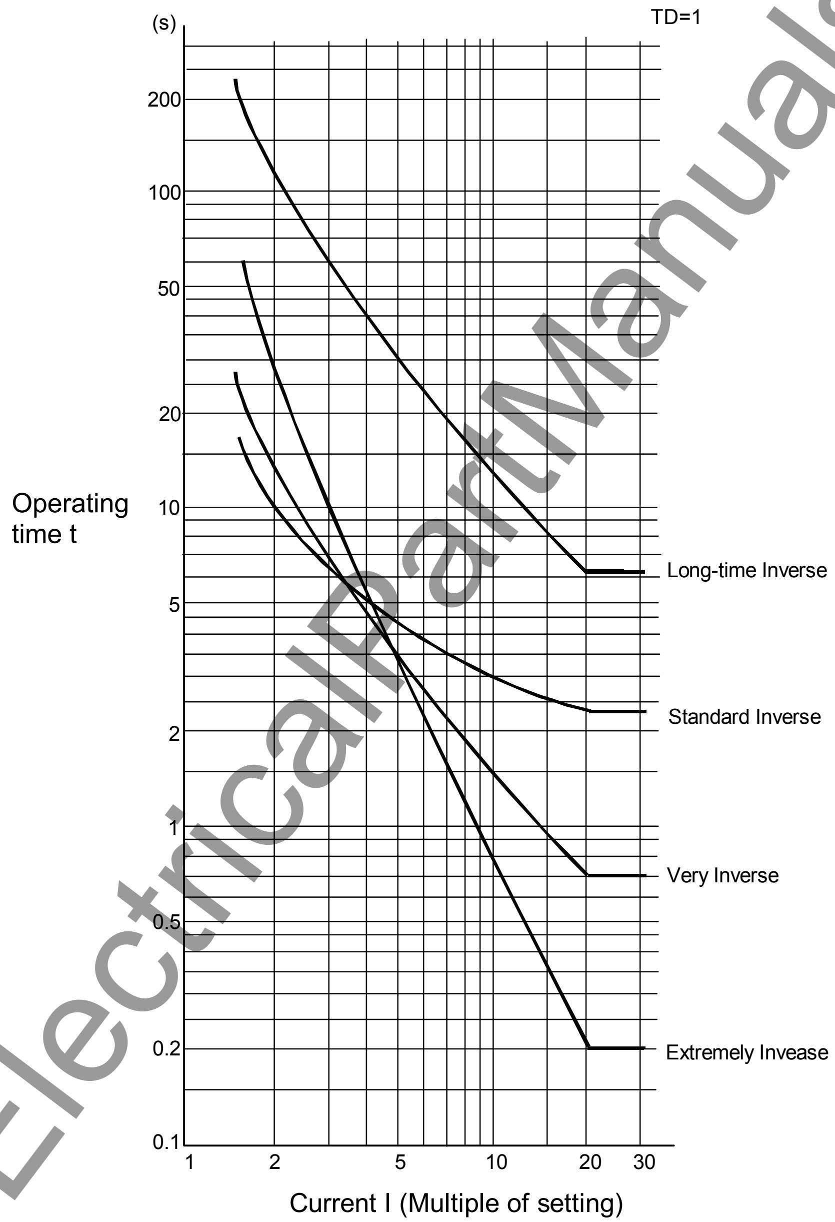


Figure 2.11.3.1 IDMT Characteristics

These characteristics are expressed by the following equations.

Long Time Inverse

$$t = T \times \frac{120}{(I/Is)-1}$$

Standard Inverse

$$t = T \times \frac{0.14}{(I/Is)^{0.02} - 1}$$

Very Inverse

$$t = T \times \frac{13.5}{(I/Is) - 1}$$

Extremely Inverse

$$t = T \times \frac{80}{(I/Is)^{2} - 1}$$

where,

t = operating time
I = fault current
Is = current setting
T = time multiplier setting

2.11.4 Thermal Overload Element

Thermal overload element operates according to the characteristics defined in IEC60255-8. (Refer to Figure 2.6.1 and Appendix P.)

2.11.5 Out-of-Step Element OST

The OST element detects the out-of-step by checking that the voltage phasor V_B of the remote terminal transits from the second quadrant (α-zone) to the third quadrant (β-zone) or vice versa when the voltage phasor V_A of the local terminal is taken as a reference.

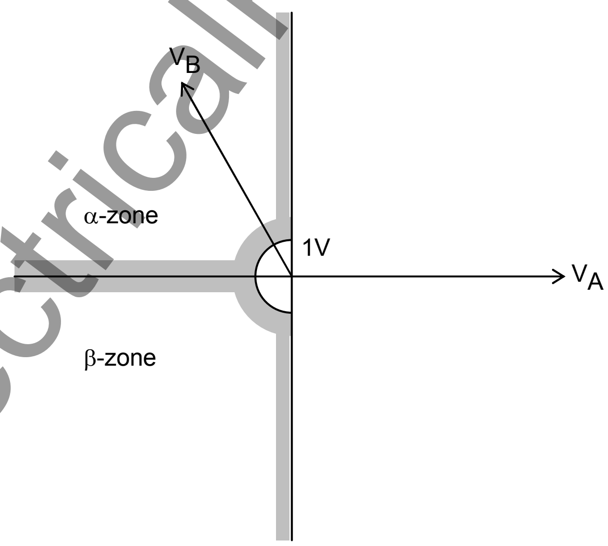


Figure 2.11.5.1 Out-of-Step Element

V_B is further required to stay at each quadrant for a set time (1.5 cycles) to avoid the influence of any VT transient.

Positive phase voltages are used and valid for V_A and V_B when their amplitudes are larger than 1V.

2.11.6 Voltage and Synchronism Check Elements OVL, UVL, OVB, UVB and SYN

The voltage check and synchronism check elements are used for autoreclose.

The output of the voltage check element is used to check whether the line and busbar are dead or live. The voltage check element has undervoltage detectors UVL and UVB, and overvoltage detectors OVL and OVB for the line voltage and busbar voltage check. The undervoltage detector checks that the line or busbar is dead while the overvoltage detector checks that it is live.

Figure 2.11.6.1 shows the characteristics of the synchronism check element used for the autoreclose if the line and busbar are live.

The synchronism check element operates if both the voltage difference and phase angle difference are within their setting values.

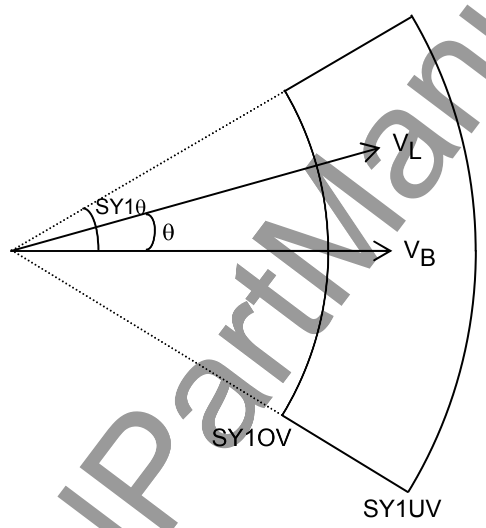


Figure 2.11.6.1 Synchronism Check Element

The voltage difference is checked by the following equations:

$$SY1OV \leq V_B \leq SY1UV$$

$$SY1OV \leq V_L \leq SY1UV$$

where,

V_B = busbar voltage

V_L = line voltage

SY1OV = lower voltage setting

SY1UV = upper voltage setting

The phase difference is checked by the following equations:

$$V_B \cdot V_L \cos\theta \geq 0$$

$$V_B \cdot V_L \sin(SY1\theta) \geq V_B \cdot V_L \sin\theta$$

where,

θ = phase difference between V_B and V_L

$SY1\theta$ = phase difference setting

Note: When the phase difference setting and the synchronism check time setting are given, a detected maximum slip cycle is determined by the following equation:

$$f = \frac{SY1\theta}{180° \times T_{SYN1}}$$

where,

f = slip cycle

SY1θ = phase difference setting (degree)

T_{SYN1} = setting of synchronism check timer (second)

2.11.7 Current change detection element OCD

The OCD operates if the vectorial difference between 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 (10% of rated current)

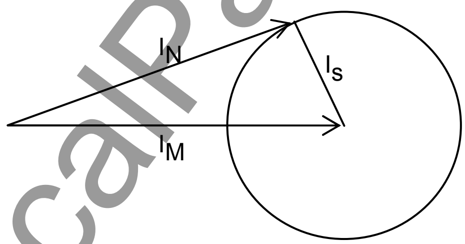


Figure 2.11.7.3 Current Change Detection

2.11.8 Level Detectors

The following level detecting elements operate by comparing the current amplitude with the relevant setting.

Definite time overcurrent element OC and EF

The OC and EF measure the phase currents and the residual current respectively and used for overcurrent backup protection.

Overcurrent element OCBF

The OCBF measures the three phase currents and used for the breaker failure protection.

2.11.9 Fault Detector Elements

The fault detector incorporates the following six fault detection elements.

Multi-level overcurrent element OCMF

The OCMF is used as a fault detector for the out-of-step protection.

The current fluctuates in an out-of-step situation. To detect this current securely, the OCMF has seven current level detectors. Each current level detector LD1 to LD7 operates when the current exceeds each setting L1 to L7 and resets when the current falls below 80% of the setting. The settings are fixed as shown in Table 2.11.9.1 as a ratio to the rated current In.

Figure 2.11.9.1 shows the characteristics of the OCMF element.

Table 2.11.9.1 Level Detector Settings

Detector	Operate	Reset
LD1	0.10×In	0.08×In
LD2	0.16	0.13
LD3	0.26	0.21
LD4	0.41	0.33
LD5	0.66	0.53
LD6	1.05	0.84
LD7	1.68	1.34

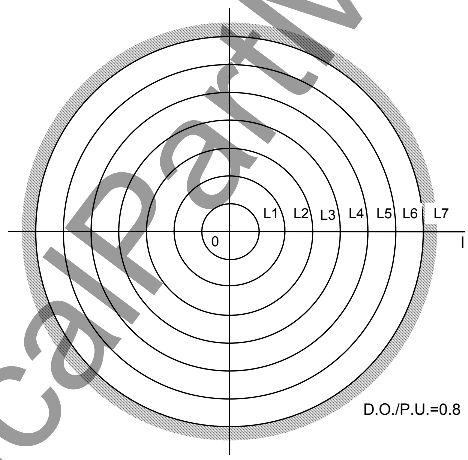


Figure 2.11.9.1 OCMF Element

Figure 2.11.9.2 shows the OCMF output logic. The OCMF operates and keeps operating for five seconds when any of the level detectors operate and reset without time delay when all of the level detectors reset.

The level detection is performed for phase-to-phase current on A- and B-phase.

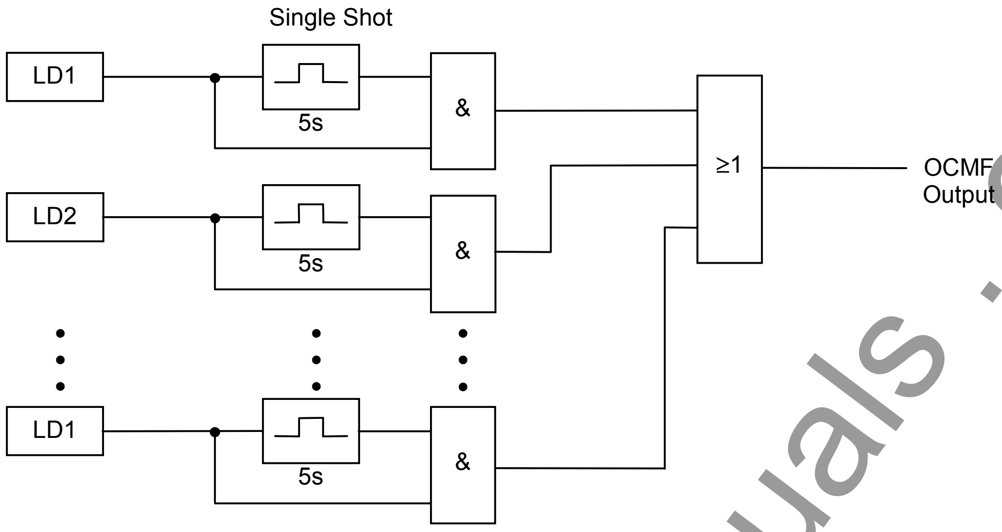


Figure 2.11.9.2 OCMF Output Logic

Current change detection element OCDF

The characteristic of OCDF is same as the OCD.

Undervoltage change detection element UVDF

The UVDF operates if a voltage drops by 7% compared to that of one cycle before. Therefore, the operating sensitivity of this element is related not to the rated voltage but to the running voltage.

The following are the level detectors and the operation decision is made by comparing the current or voltage amplitude with the relevant setting.

Earth fault overcurrent element EFF

The EFF measures the residual current and its detecting level is fixed at 10% of the rated current.

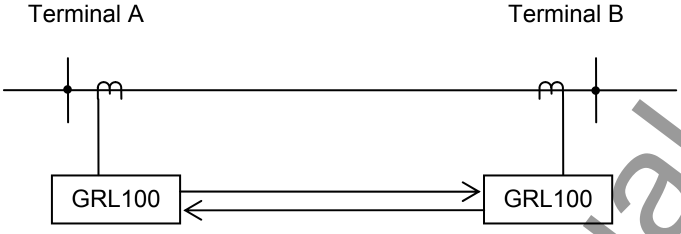
Undervoltage element UVSF and UVGF

The UVSF measures a phase-to-phase voltage while the UVGF measures a phase-to-earth voltage. Their detecting level is fixed at 80V and 46V, respectively. However, in case of fault with more than 80V, the undervoltage change detection element UVDF detects the fault.

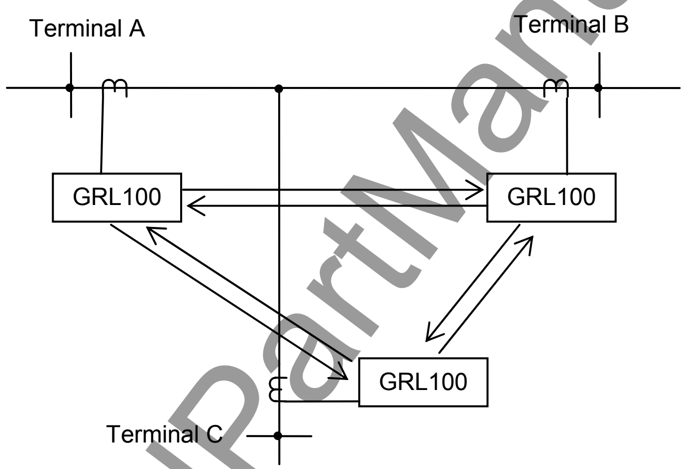
2.12 Communication System

2.12.1 Signaling Channel

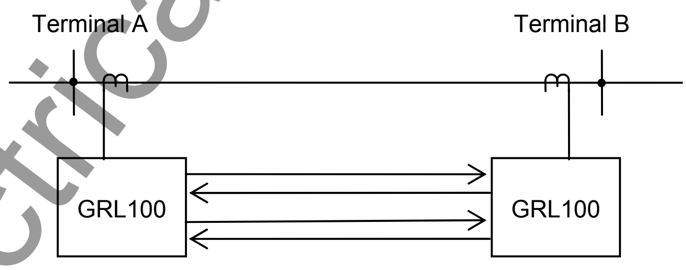
The GRL100 transmits all the local data to the remote terminal by coded serial messages. Two signaling channels are required for two-terminal line protection, six for three-terminal line protection and four for dual communication for two-terminal line as shown in Figure 2.12.1.1.



(a) Two-terminal Line



(b) Three-terminal Line



(c) Dual Communication for Two-terminal Line

Figure 2.12.1.1 Signaling Channel

The variation of the channel delay time due to switching the route of the channel is automatically corrected in the relay and does not influence the synchronized sampling provided the sending and receiving channels take the same route. If the routes are separate, the transmission delay difference time must be set (see Section 2.2.7).

When the route is switched in A- or B-mode application, the synchronized sampling recovers within 4s in case of a two- terminal line and 6s in case of a three-terminal line after the switching. The differential element is blocked until the sampling synchronization is established.

In GPS-mode application (GPS-based synchronization), the sampling synchronization is not influenced by the route switch. The differential element is only blocked for the duration of the path switching.

2.12.2 Linking to Communication Circuit

The GRL100 can be provided with one of the following interfaces by order type and linked to a dedicated optical fiber communication circuit or multiplexed communication circuit.

- Optical interface (1310nm, SM, 30km class)
- Optical interface (1550nm, DSF(Dispersion Shifted Fibre), 80km class) (*)
- Optical interface (820nm, GI, 2km class)
- Electrical interface in accordance with CCITT-G703-1.2.1
- Electrical interface in accordance with CCITT-G703-1.2.2 and 1.2.3
- Electrical interface in accordance with CCITT X.21
- Electrical interface in accordance with RS422, RS530

Note (*): When using the 80km class optical interface, it is necessary to ensure that the received optical power does not exceed −10dB, in order to avoid communication failure due to overloading of the receive.

When testing in loop-back mode, for instance, the sending terminal should be connected to the receiving terminal via an optical attenuator with 10 dB or more attenuation. Even if the sending terminal is directly connected to the receiving terminal, the optical transceiver will not be damaged, but communication failures may occur.

- Fibre Coupled Power: −5 to 0dBm
- Input Power Range: −34 to −10dBm
- Optical Damage Input Level: 3dBm

Alternative links to the telecommunication circuit are shown in Figure 2.12.2.1 (a) to (c).

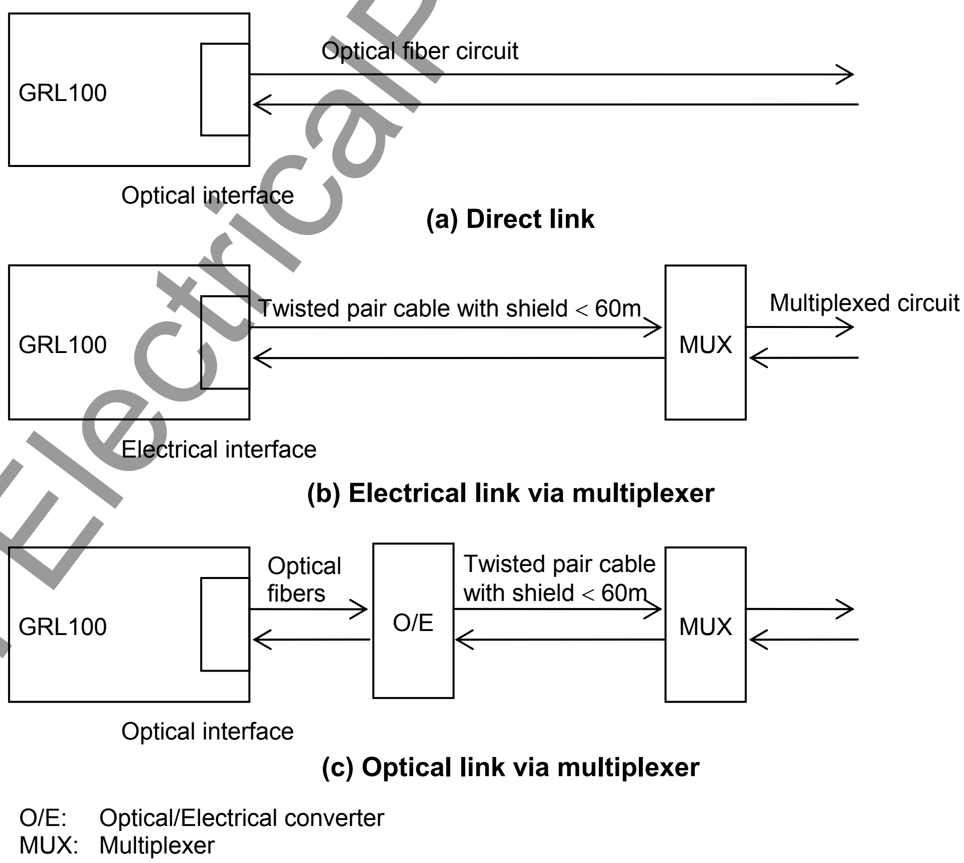


Figure 2.12.2.1 Link to Communication Circuit

Direct link

When connected to single-mode (SM) 10/125μm type of dedicated optical fiber communication circuits and using Duplex LC type connector for 30km class, the optical transmitter is an LD with output power of more than –13dBm and the optical receiver is a PIN diode with a sensitivity of less than –30dBm. For 80km class, the optical transmitter is an LD with output power of more than –5dBm and the optical receiver is a PIN diode with a sensitivity of less than –34dBm.

When connected to graded-index (GI) multi-mode 50/125μm type or 62.5/125μm type of dedicated optical fiber telecommunication circuit and using an ST type connector, the optical transmitter is an LED with output power of more than –19dBm or –16dBm and the optical receiver is a PIN diode with a sensitivity of less than –24dBm.

For details, refer to Appendix K.

Link via multiplexer

The GRL100 can be linked to a multiplexed communication circuit with an electrical or optical interface. The electrical interface supports CCITT G703-1.2.1, G703-1.2.2 and 1.2.3, X.21(RS530) or RS422. Twisted pair cable with shield (<60m) is used for connecting the relay and multiplexer.

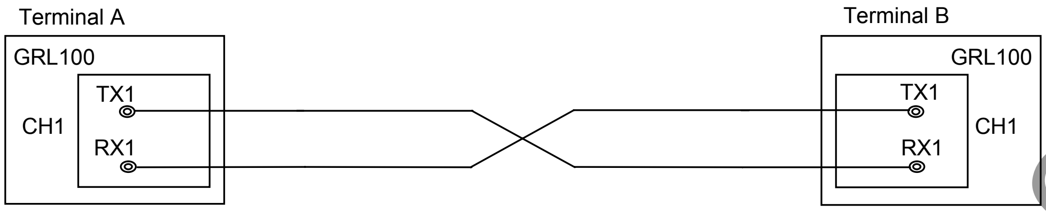
In the optical interface, optical fibers of graded-index multi-mode 50/125μm or 62.5/125μm type are used and an optical to electrical converter is provided at the end of the multiplexer. The electrical interface between the converter and the multiplexer supports CCITT G703-1.2.1, G703-1.2.2 and 1.2.3, X.21(RS530) or RS422.

A D-sub connector (DB-25) or an ST connector is used for electrical linking and optical linking, respectively.

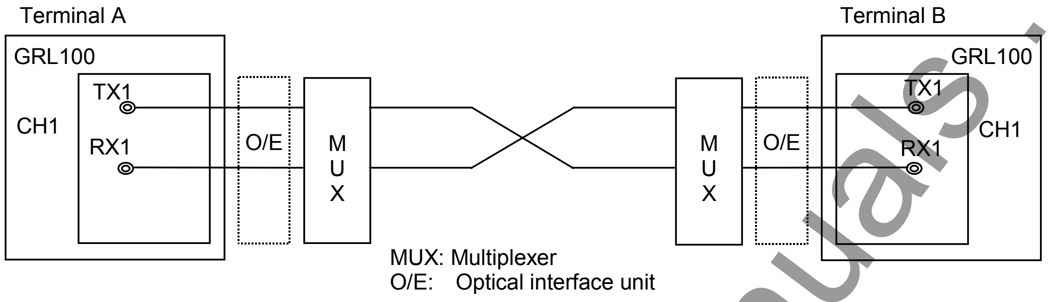
2.12.3 Setup of Communication Circuit

The GRL100 is provided with one set of transmit and receive signal terminals for two-terminal application models and two sets of signal terminals for three-terminal application models.

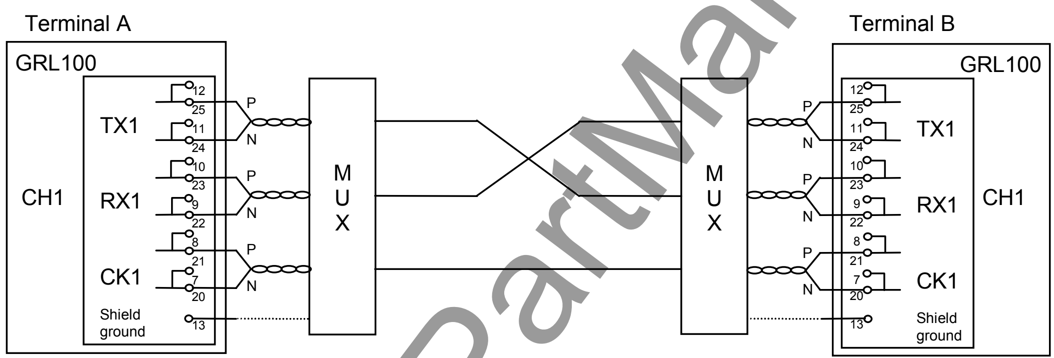
In case of two-terminal applications, the communication circuit is set as shown in Figure 2.12.3.1. In the figure, TX and RX are the transmit and receive signal terminals. CK is the receive terminal for the multiplexer clock signal and is used when the interface supports CCITT G703-1.2.2, 1.2.3 and X.21(RS530).



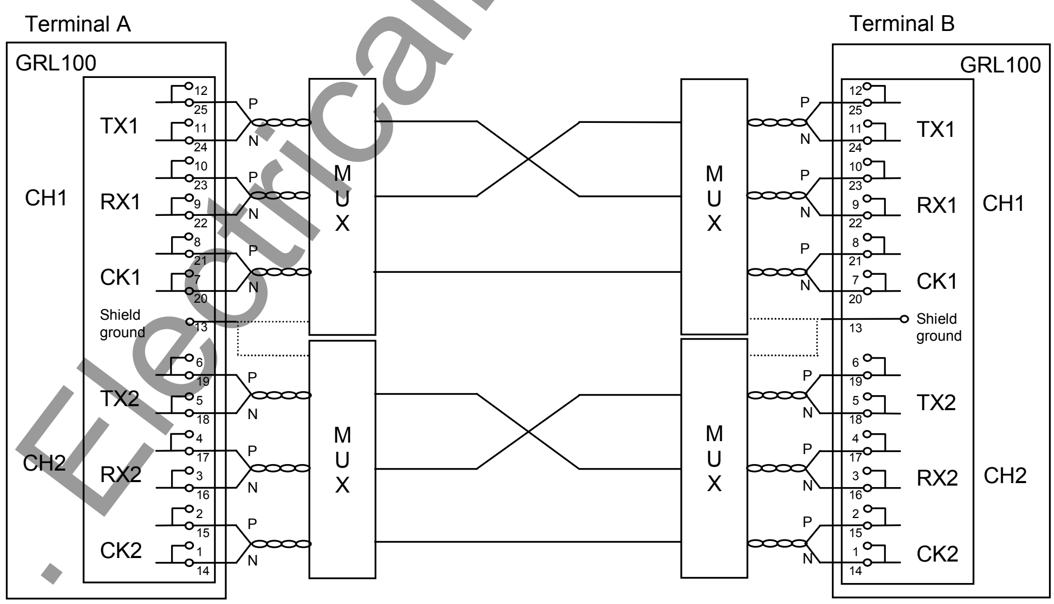
(a) Direct Link Using Optical Fiber



(b) Link via Multiplexer (Optical Interface)

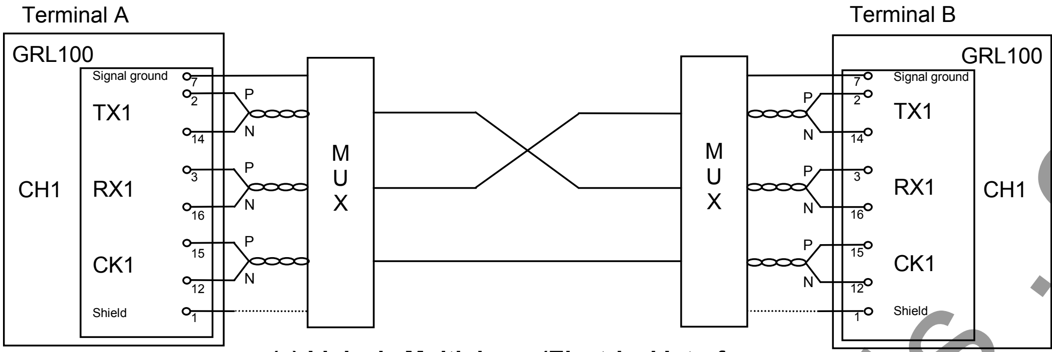


(c) Link via Multiplexer (Electrical Interface in accordance with CCITT-G703)

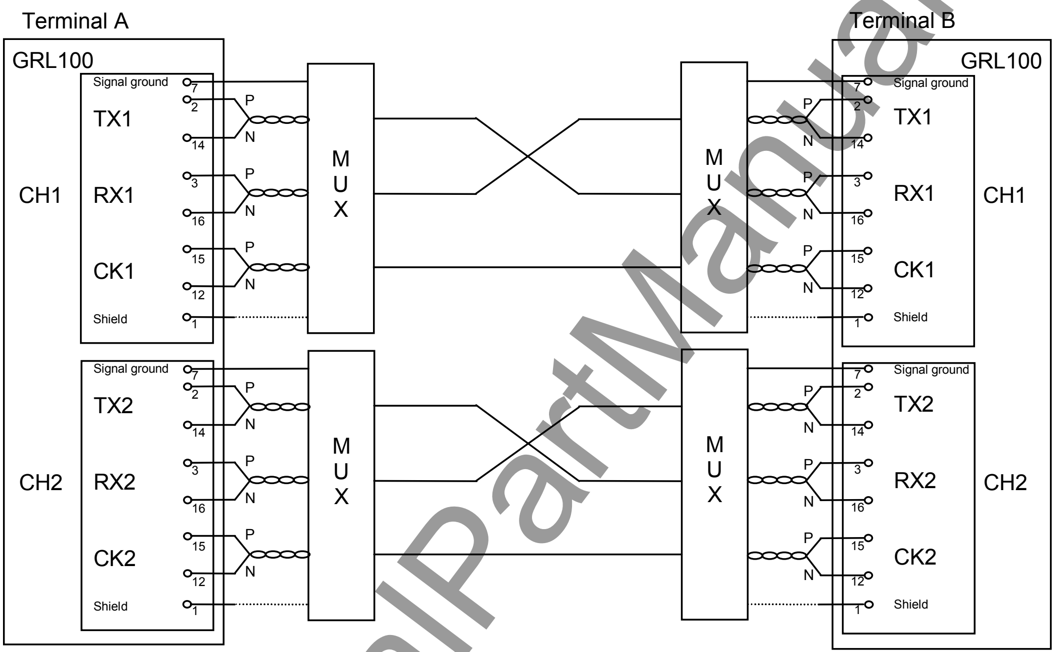


(d) Link via Multiplexer for Dual communication (Electrical Interface in accordance with CCITT-G703)

Figure 2.12.3.1 Communication Circuit Setup in Two-terminal Application



(e) Link via Multiplexer (Electrical Interface in accordance with X.21, RS530)



(f) Link via Multiplexer for Dual communication (Electrical Interface in accordance with X.21, RS530)

Figure 2.12.3.1 Communication Circuit Setup in Two-terminal Application (continued)

In case of three-terminal applications, signal terminals CH1-TX1, -RX1 and -CK1 which have the same function as CH2-TX2, -RX2 and -CK2 are added.

Figure 2.12.3.2 shows the communication circuit arrangement for three-terminal applications. Note that the CH1 signal terminals TX1, RX1 and CK1 of one terminal are interlinked with the CH2 signal terminals TX2, RX2 and CK2 of another terminal and that the scheme switch [TERM] is set to "3-TERM". If the same channel is interlinked between both terminals such as the CH1 signal terminals of one terminal are interlinked with the CH1 signal terminals of another terminal, the scheme switch setting [CH. CON] should be set to “Exchange”.

The three-terminal line application models can be applied to a two-terminal line. In this case, same channel’s TX, RX and CK of both terminals are interlinked and scheme switch [TERM] is set to "2-TERM".

The three-terminal models also have dual communication mode as shown in Figure 2.12.3.3.

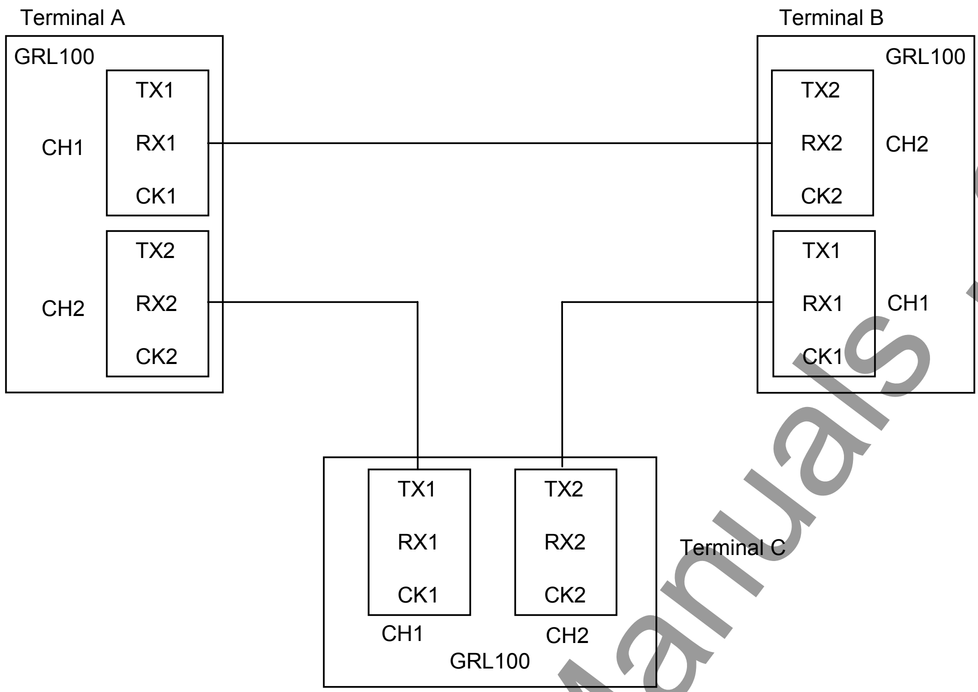
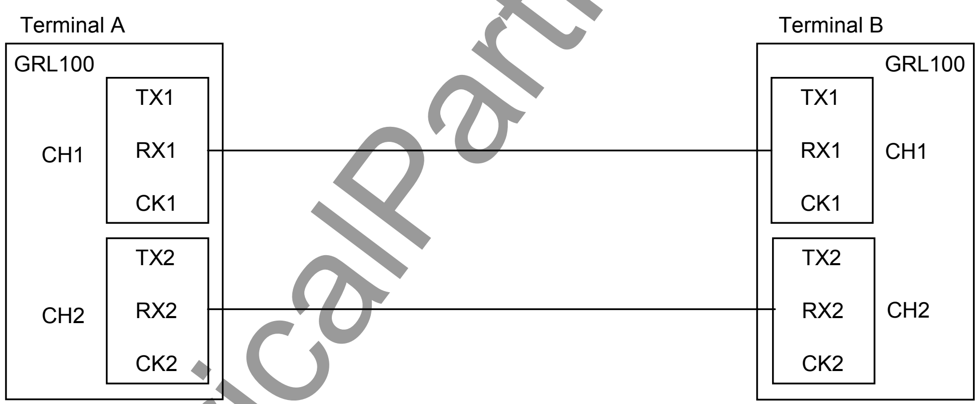


Figure 2.12.3.2 Communication Circuit Setup for Three-terminal Applications



Note: The corresponding channels are connected to each other.

Figure 2.12.3.3 Dual Communication Mode

2.12.4 Telecommunication Channel Monitoring

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

The GRL100 detects data failures by performing a cyclic redundancy check and a fixed bit check on the data. The checks are carried out for every sample.

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

The output blocking ceases instantly when the failure recovers.

2.13 Fault Locator

2.13.1 Application

When the fault point is determined by measuring the impedance to it using local voltages and currents, the measurement error is increased by the phase difference between the local and remote currents flowing into the fault point. The error is also increased when the fault is beyond the junction in a three-terminal line.

The fault locator incorporated in the GRL100 measures the distance to fault on the protected line using local and remote voltages and currents. In principle, the measurement is free from the errors that are inherent with the impedance measuring method mentioned above.

To measure the distance to fault, the fault locator requires minimum 2 cycles as fault duration time.

The fault locator utilizes the remote voltage and current that are transmitted for the current differential protection and out-of-step protection.

The measurement result is displayed as a percentage (%) of the line length and the distance (km) and is displayed on the LCD on the relay front panel. It is also output to a local PC or RSM (Relay Setting and Monitoring) system.

The measurement has a fixed error and a proportional error. The latter is proportional to the current differential protection setting DIFI1 and inversely proportional to the differential current Id. Thus, the lower the differential setting or the larger the fault current, the smaller the error is.

In the case of a two-terminal application, the nominal measurement error is within ±1km when the line length is shorter than 100km and ±1% when it is longer than 100km under the conditions that the DIFI1 setting is lower than 0.5×In (In: rated current) and the differential current is larger than 2×In. In the case of a three-terminal application, the nominal measurement error is within ± 2km when the line length is shorter than 100km and ±2% when it is longer than 100km under the condition that the DIFI1 setting is lower than 0.25×In and the differential current is larger than 2×In.

This measurement requires local and remote voltages and currents, so it does not operate for a switch-onto-fault or for a fault while the line is energized from one terminal and the other terminal is out of service.

When one of the terminals is out of service in a three-terminal application, the fault between the junction and the out-of-service terminal is located and displayed as being on the junction.

Fault location is enabled or disabled by setting "Fault locator" to "ON" or "OFF" on the "Fault record" screen in the "Record" sub-menu.

2.13.2 Calculation of Distance to Fault

Calculation Principle

In the case of a two-terminal line as shown in Figure 2.13.2.1, the relationship between the voltages at the local and remote terminals and the voltage at the fault point are expressed by Equations (1) and (2).

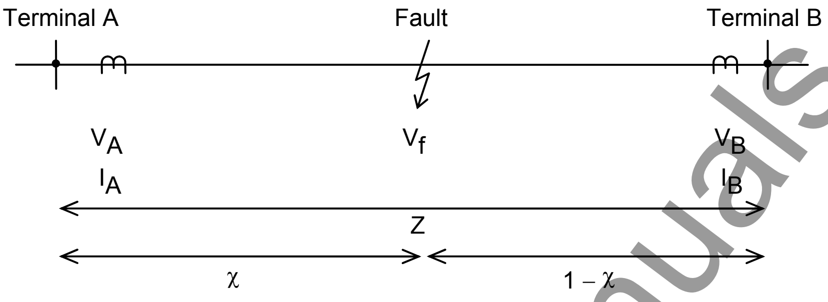


Figure 2.13.2.1 Two-terminal Model

$$V_A - \chi Z I_A = V_f \qquad (1)$$

$$V_B - (1 - \chi) Z I_B = V_f \qquad (2)$$

where, V_A = voltage at terminal A

I_A = current at terminal A

V_B = voltage at terminal B

I_B = current at terminal B

χ = distance from terminal A to fault point as a ratio to line length

V_f = voltage at fault point

Z = line impedance

The distance χ is given by Equation (3) by eliminating V_f,

$$\chi = (V_A - V_B + ZI_B) / Z(I_A + I_B) \qquad (3)$$

As $(I_A + I_B)$ is equal to differential current Id, χ is calculated with the differential current obtained in the differential protection as follows:

$$\chi = (V_A - V_B + ZI_B) / ZI_d \qquad (4)$$

The distance calculation principle mentioned above can be applied to three-terminal lines. But in case of three-terminal application, the distance measurement equation varies according to which zone the fault is in, this side or beyond the junction. Terminal A measures the distance using Equations (5), (6) or (7).

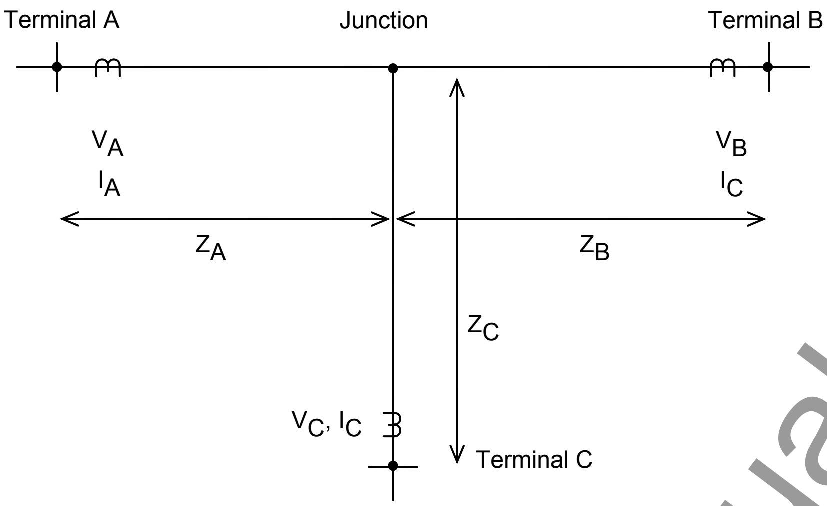


Figure 2.13.2.2 Three-terminal Model

$$\chi_A = (V_A - V_B + Z_A(I_B + I_C) + Z_B I_B) / Z_A I_d \quad (5)$$

$$\chi_{JB} = (V_A - V_B + Z_B I_B - Z_A I_A) / Z_B I_d \quad (6)$$

$$\chi_{JC} = (V_A - V_C + Z_C I_C - Z_A I_A) / Z_C I_d \quad (7)$$

where, $I_d = I_A + I_B + I_C$

V_C = voltage at terminal C

I_C = current at terminal C

χ_A = distance from terminal A to fault point as a ratio to line length from terminal A to junction

χ_{JB} , χ_{JC} = distance from junction to fault point as a ratio to line length from junction to terminal B or C

Z_A ,Z_B ,Z_C = impedance from each terminal to junction

Firstly, χ_A is calculated using Equation (5) assuming that the fault is between terminal A and the junction. If the result does not match the input line data, then χ_{JB} is calculated using Equation (6) assuming that the fault is between the junction and terminal B. If the result does not match the input line data, the calculation is repeated using Equation (7) assuming that the fault is between the junction and terminal C.

Calculation Method

In the GRL100 calculation, the sequence quantities of voltages and currents are employed instead of the phase quantities. Thus, equation (4) is combined with Equation (8) to give:

$$\chi = \frac{V_{A1} - V_{B1} + (Z_{11} I_{B1} + Z_{12} I_{B2} + Z_{10} I_{B0})}{Z_{11} I_{d1} + Z_{12} I_{d2} + Z_{10} I_{d0}} \quad (8)$$

where, V_{A1} = positive sequence voltage at terminal A

V_{B1} = positive sequence voltage at terminal B

I_{B1}, I_{B2} and I_{B0} = positive, negative and zero sequence current at terminal B

I_{d1},I_{d2} and I_{d0} = positive, negative and zero sequence differential current

Z_{11}, Z_{12} and Z_{10} are expressed by the following equations assuming that $Z_{ab} = Z_{ba}$, $Z_{bc} = Z_{cb}$ and $Z_{ca} = Z_{ac}$:

$$Z_{11} = (Z_{aa} + Z_{bb} + Z_{cc} - Z_{ab} - Z_{bc} - Z_{ca})/3$$
$$Z_{12} = (Z_{aa} + a^2 Z_{bb} + aZ_{cc} + 2(aZ_{ab} + Z_{bc} + a^2Z_{ca}))/3 \qquad (9)$$
$$Z_{10} = (Z_{aa} + aZ_{bb} + a^2Z_{cc} - a^2Z_{ab} - Z_{bc} - aZ_{ca})/3$$

where, Z_{aa}, Z_{bb} and Z_{cc} are self-impedances and Z_{ab}, Z_{bc} and Z_{ca} are mutual impedances.

If $Z_{aa} = Z_{bb} = Z_{cc}$ and $Z_{ab} = Z_{bc} = Z_{ca}$, then Z_{11} is equal to the positive sequence impedance, and Z_{12} and Z_{10} are zero.

2.13.3 Starting Calculation

The calculation is started when the segregated-phase or zero-phase current differential protection operates. The voltage and current data used for the calculation are those sampled between 15 cycles before and 5 cycles after the current differential elements operate.

2.13.4 Fault Location Display

The measurement result is stored in the "Fault record" and displayed on the LCD of the relay front panel or on the local or remote PC. For displaying on the LCD, see Section 4.2.3.1.

In the two-terminal line, the location is displayed as a distance (km) and a percentage (%) of the line length.

In the three-terminal line, the location is displayed as a distance (km). To discriminate faults in the second and the third section, the fault section is supplemented.

2.13.5 Setting

The setting items necessary for the fault location and their setting ranges are shown in the table below.

When setting the line impedance, one of the following methods can be selected.

Inputting phase impedances:

The self-impedances Z_{aa}, Z_{bb} and Z_{cc} and mutual impedances Z_{ab}, Z_{bc} and Z_{ca} are input individually using the expression of the resistive components R_{**} and reactive components X_{**}.

Inputting positive-sequence impedances:

This can be done provided that $Z_{aa} \doteqdot Z_{bb} \doteqdot Z_{cc}$ and $Z_{ab} \doteqdot Z_{bc} \doteqdot Z_{ca}$. The positive-sequence impedance is input using the expression of the resistive component R_1 and reactive component X_1.

The resistive and reactive components are input with the secondary values for the line.

Two-terminal application

Item	Range	Step	Default	Remarks
Fault locator	ON/OFF		OFF	
Line data				
$1R_1$	0.00 - 199.99 Ω (0.0 - 999.9 Ω	0.10 Ω 0.1 Ω	0.20 Ω 1.0 Ω) (*)	
$1X_1$	0.00 - 199.99 Ω (0.0 - 999.9 Ω	0.10 Ω 0.1 Ω	2.00 Ω 10.0 Ω) (*)	
1Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length
or				
$1R_{aa}$	0.00 - 199.99 Ω	0.10 Ω	0.21 Ω	
$1R_{bb}$	(0.0 - 999.9 Ω	0.1 Ω)	(1.1 Ω)	
$1R_{cc}$				
$1R_{ab}$			0.01 Ω	
$1R_{bc}$			(0.1 Ω)	
$1R_{ca}$				
$1X_{aa}$			2.10 Ω	
$1X_{bb}$			(10.5 Ω)	
$1X_{cc}$				
$1X_{ab}$			0.10 Ω	
$1X_{bc}$			(0.5 Ω)	
$1X_{ca}$				
1Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length

(*) Ohmic values shown in the parentheseis are is in the case of 1A rating.

Three-terminal application

When setting the line impedance, the three-terminal line is divided into three sections. The first section is from the local terminal to the junction, the second is from the junction to remote terminal 1 and the third is from the junction to remote terminal 2. The line constants are input for each section in the same way as the two-terminal application.

Note that remote terminals 1 and 2 are automatically set according to the communication system setup. Remote terminal 1 is a terminal to which local communication port 1 is linked and remote terminal 2 is a terminal to which local communication port 2 is linked.

Item	Range	Step	Default	Remarks
Fault locator	ON/OFF		OFF	
Line data				
Section 1				
$1R_1$	0.00 - 199.99 Ω	0.10 Ω	0.20 Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0 Ω)	(*)
$1X_1$	0.00 - 199.99 Ω	0.10 Ω	2.00 Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0 Ω)	(*)
1Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from local terminal to junction
or				
$1R_{aa}$	0.00 - 199.99 Ω	0.10 Ω	0.21 Ω	
$1X_{aa}$	(0.0 - 999.9 Ω	0.1 Ω)	(1.1 Ω)	
$1R_{bb}$				
$1X_{bb}$			0.01 Ω	
$1R_{cc}$			(0.1 Ω)	
$1X_{cc}$				
$1R_{ab}$			2.10 Ω	
$1X_{ab}$			(10.5 Ω)	
$1R_{bc}$				
$1X_{bc}$			0.10 Ω	
$1R_{ca}$			(0.5 Ω)	
$1X_{ca}$				
1Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from local terminal to junction
Section 2				
$2R_1$	0.00 - 199.99 Ω	0.10 Ω	0.20 Ω	
	(0.0 - 999.9 Ω	0.1 Ω	1.0 Ω)	(*)
$2X_1$	0.00 - 199.99 Ω	0.10 Ω	2.00 Ω	
	(0.0 - 999.9 Ω	0.1 Ω	10.0 Ω)	(*)
2Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from local terminal to junction
or				
$2R_{aa}$	0.00 - 199.99 Ω	0.10 Ω	0.21 Ω	
$2X_{aa}$	(0.0 - 999.9 Ω	0.1 Ω)	(1.1 Ω)	
$2R_{bb}$				
$2X_{bb}$			0.01 Ω	
$2R_{cc}$			(0.1 Ω)	
$2X_{cc}$				
$2R_{ab}$			2.10 Ω	
$2X_{ab}$			(10.5 Ω)	
$2R_{bc}$				
$2X_{bc}$			0.10 Ω	
$2R_{ca}$			(0.5 Ω)	
$2X_{ca}$				
2Line	0.0 - 399.9 km	0.1 km	50.0 km	Line length from junction to remote terminal 1

Section 3					
$3R_1$	0.00 - 199.99 Ω	0.10 Ω	0.20 Ω		
	(0.0 - 999.9 Ω	0.1 Ω	1.0 Ω)	(*)	
$3X_1$	0.00 - 199.99 Ω	0.10 Ω	2.00 Ω		
	(0.0 - 999.9 Ω	0.1 Ω	10.0 Ω)	(*)	
3Line	0.0 - 399.9 km	0.1 km	50.0 km		Line length from junction to remote terminal 2
or					
$3R_{aa}$	0.00 - 199.99 Ω	0.10 Ω	0.21 Ω		
$3X_{aa}$	(0.0 - 999.9 Ω	0.1 Ω)	(1.1 Ω)		
$3R_{bb}$					
$3X_{bb}$			0.01 Ω		
$3R_{cc}$			(0.1 Ω)		
$3X_{cc}$					
3Rab			2.10 Ω		
$3X_{ab}$			(10.5 Ω)		
$3R_{bc}$					
$3X_{bc}$			0.10 Ω		
$3R_{ca}$			(0.5 Ω)		
$3X_{ca}$					
3Line	0.0 - 399.9 km	0.1 km	50.0 km		Line length from junction to remote terminal 2

(*) Ohmic values shown in parentheses are in the case of 1A rating.

3. Technical Description

3.1 Hardware Description

3.1.1 Outline of Hardware Modules

The GRL100 models are classified into two types by their case size. Models 101, 111, 102, 112, 201, 204, 211, 214, 301 and 311 have type A cases, while models 202, 206, 212, 216, 302, 312, 401, 411, 501, 511, 503 and 513 have type B cases. Case outlines are shown in Appendix F.

The hardware structures of the models are shown in Figure 3.1.1.1 to Figure 3.1.1.5. The front view shows the equipment without the human machine interface module.

The GRL100 consists of the following hardware modules. The human machine interface module is provided with the front panel.

- Transformer module (VCT)
- Signal processing and communication module (SPM)
- Binary input and output module 2 (IO2)
- Human machine interface module (HMI)

The following hardware modules are added depending on the model:

- Binary input and output module 1 (IO1)
- Binary output module 3 (IO3)
- Binary output module 4 (IO4)
- Binary input and output module 5 (IO5)
- Binary input and output module 6 (IO6)
- Binary input and output module 8 (IO8)
- Fault detector module (FD)

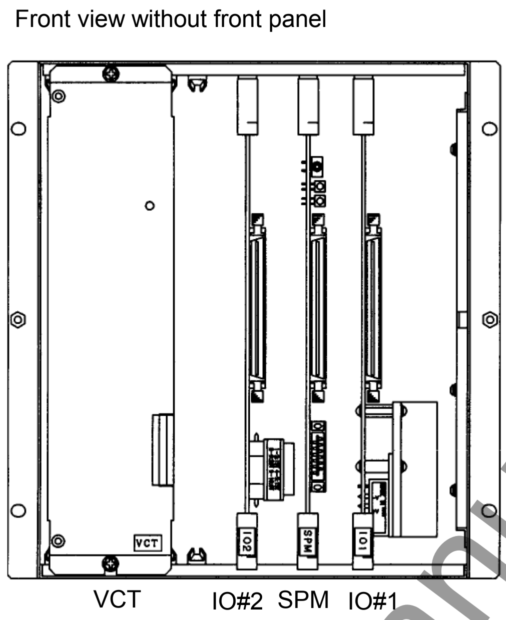


Figure 3.1.1.1 Hardware Structure (Model: 101, 111)

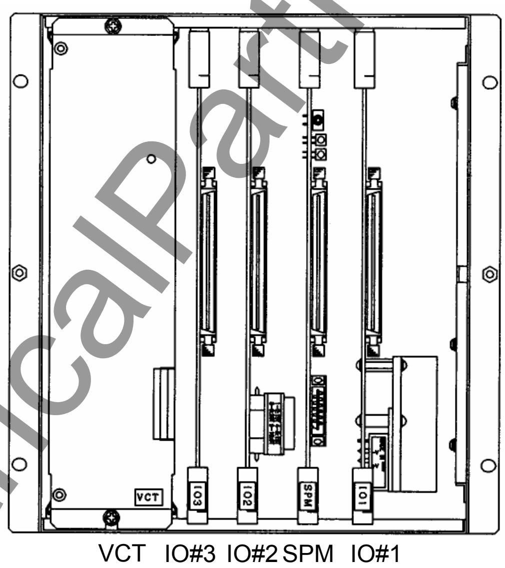
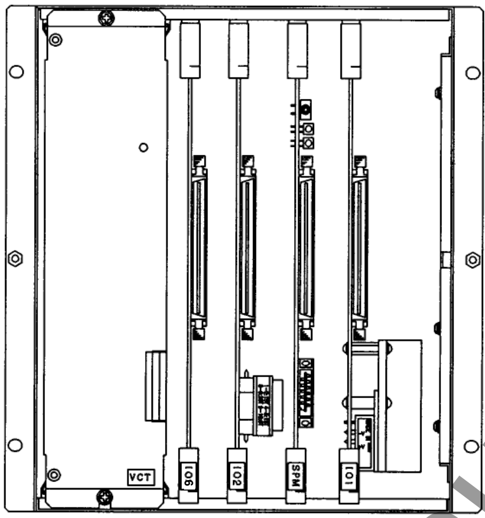
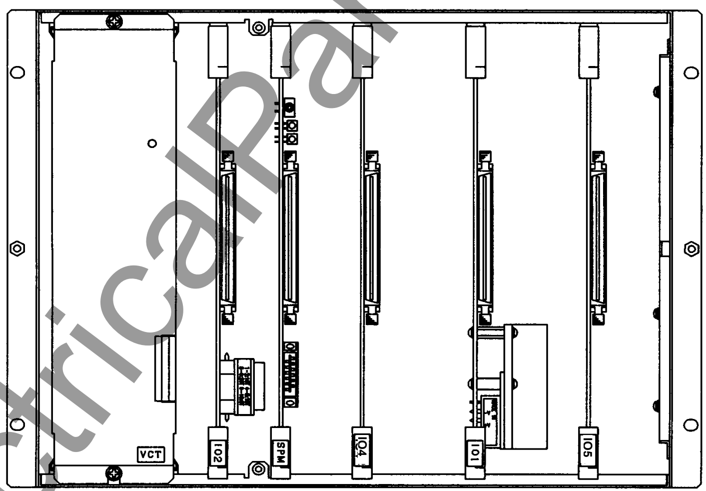


Figure 3.1.1.2 Hardware Structure (Model: 102, 112)



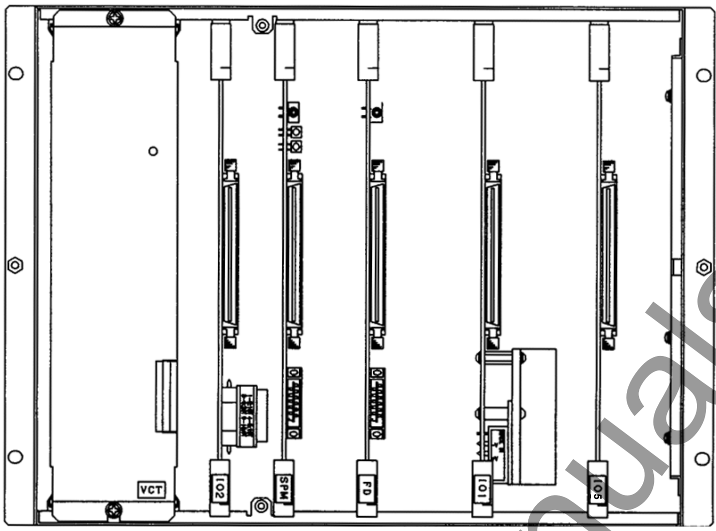
Note: IO#1 is IO1 module for models 201, 211, 301 and 311, and is IO8 module for models 204 and 214.
IO#2 and IO#3 are IO2 module and IO6 module respectively.

Figure 3.1.1.3 Hardware Structure (Model: 201, 211, 204, 214, 301, 311)



Note: IO#1 is IO1 module for models 202, 212, 302 and 311, and is IO8 module for models 206 and 216.
IO#2, IO#3 and IO#4 are IO2, IO5 and IO4 module respectively.

Figure 3.1.1.4 Hardware Structure (Model: 202, 212, 206, 216, 302, 312)



Note: IO#1, IO#2, IO#3 and IO#4 are IO1, IO2, IO5 and FD module respectively.

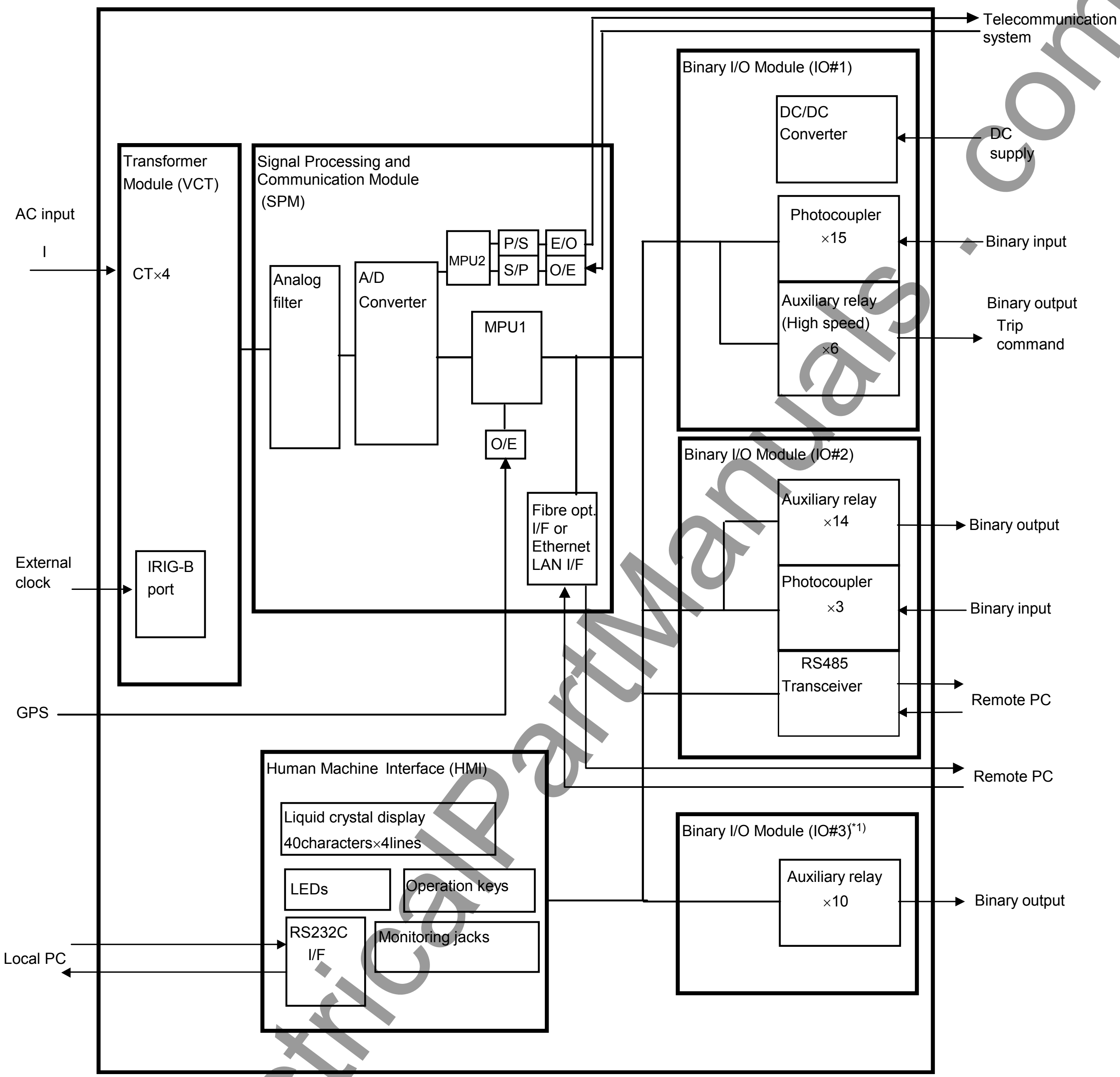
Figure 3.1.1.5 Hardware Structure (Model: 401, 411, 501, 511, 503, 513)

The correspondence between each model and module used is as follows:

Module \ Model	101 111	102 112	201 211	202 212	204 214	206 216	301 311	302 312	401 411	501 511	503 513
VCT	×	×	×	×	×	×	×	×	×	×	×
SPM	×	×	×	×	×	×	×	×	×	×	×
IO1	×	×	×	×			×	×	×	×	×
IO2	×	×	×	×	×	×	×	×	×	×	×
IO3		×									
IO4				×		×		×			
IO5				×		×		×	×	×	×
IO6			×		×		×				
IO8					×	×					
HMI	×	×	×	×	×	×	×	×	×	×	×
FD									×	×	×

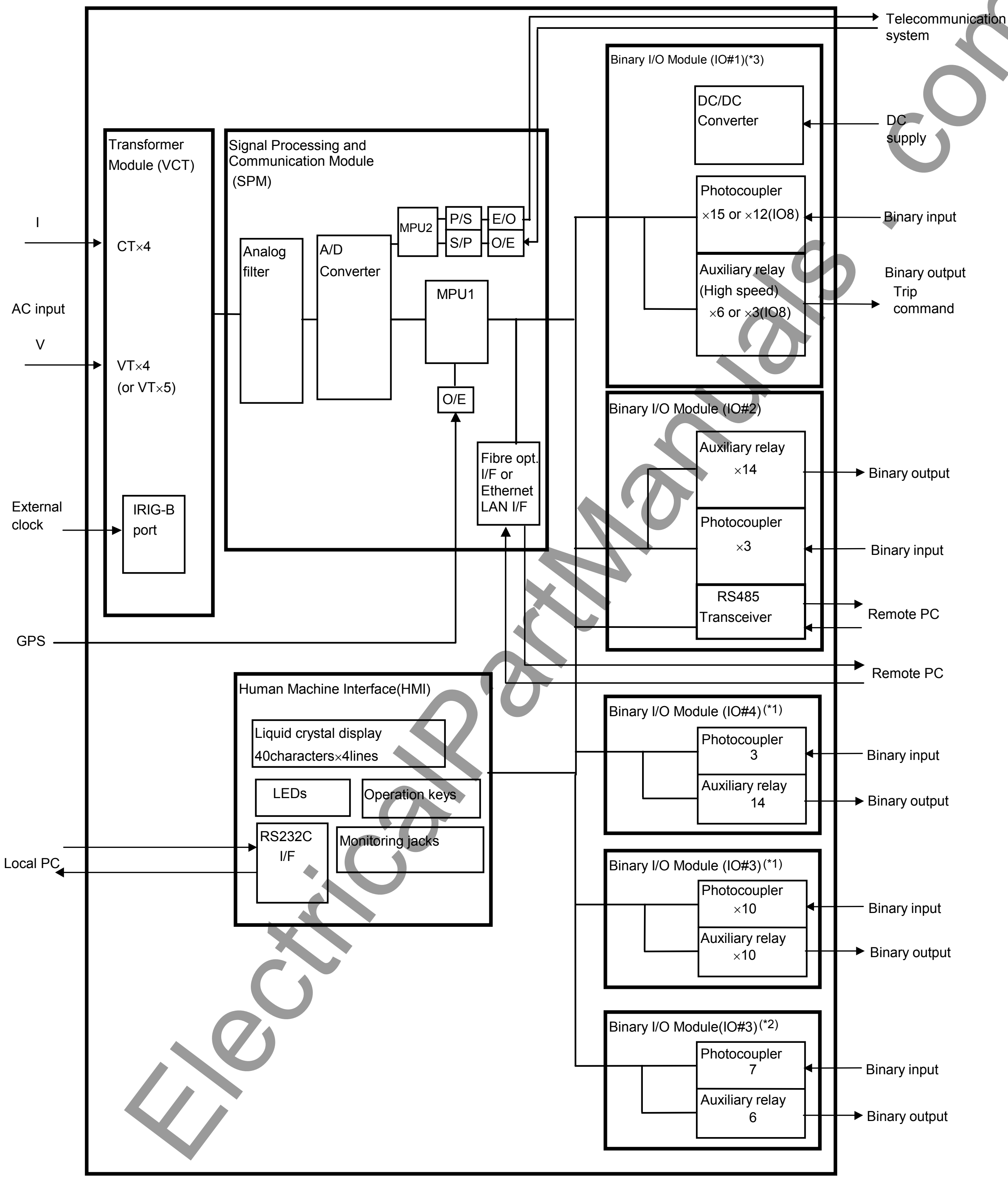
Note: The VCT and SPM modules are not interchangeable among different models.

The hardware block diagrams of the GRL100 using these modules are shown in Figure 3.1.1.6 to Figure 3.1.1.8.



(*1) required for models 102 and 112

Figure 3.1.1.6 Hardware Block Diagram (Models 100s)



(*1) : required for models 202, 212, 302, 312
(*2) : required for models 201, 211, 301, 311

Figure 3.1.1.7 Hardware Block Diagram (Models 200s and 300s)

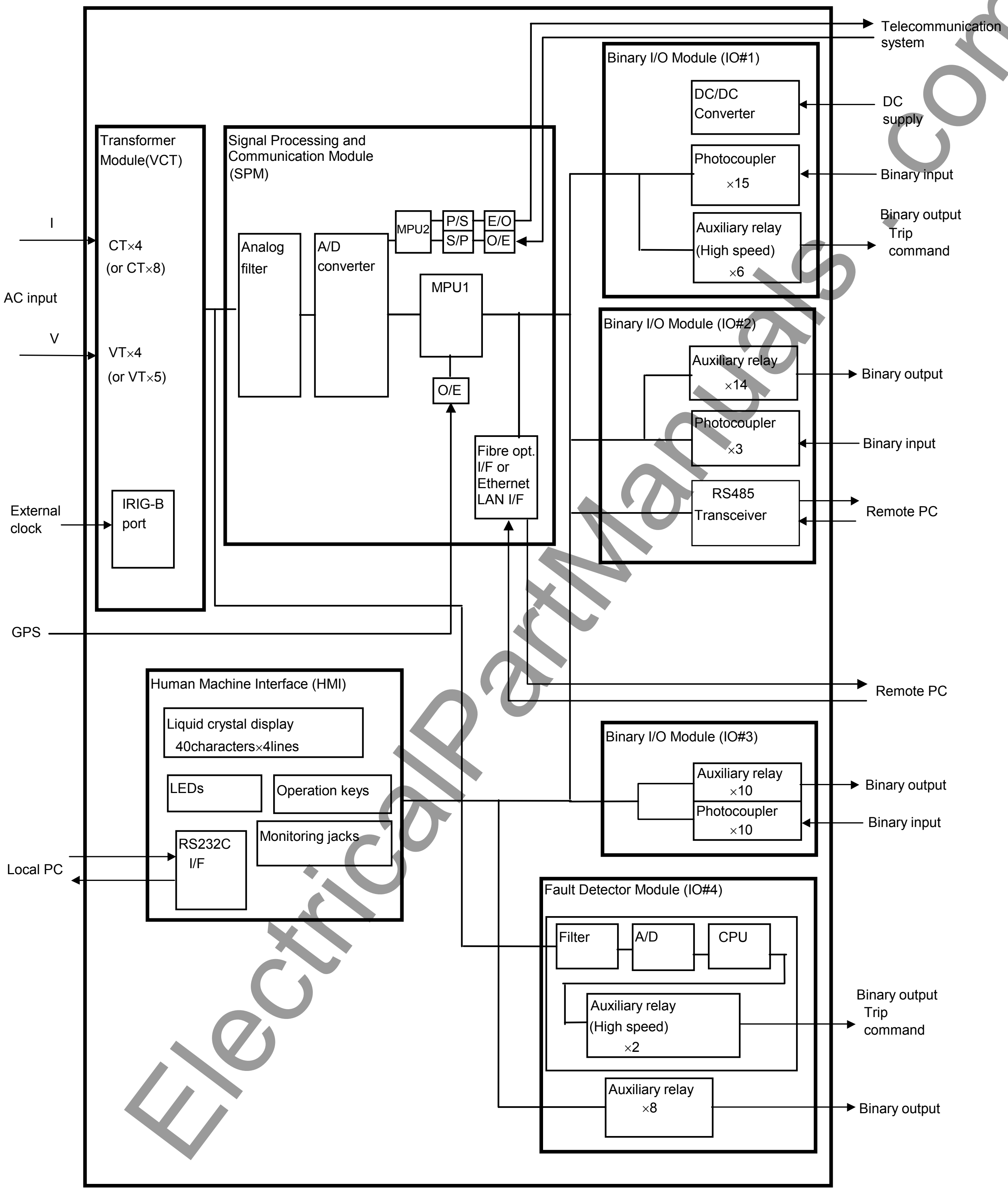


Figure 3.1.1.8 Hardware Block Diagram (Models 400s and 500s)

3.1.2 Transformer Module

The transformer module (VCT module) provides isolation between the internal and external AC circuits through an auxiliary transformer and transforms the magnitude of AC input signals to suit the electronic circuits. The AC input signals are as follows:

- three-phase currents (I_a, I_b and I_c)
- residual current ($3I_o$)
- three-phase voltages (V_a, V_b and V_c)
- autoreclose reference voltage (V_{ref1})
- autoreclose reference voltage (V_{ref2})

Figure 3.1.2.1 shows a block diagram of the transformer module. There are 4 or 8 auxiliary CTs mounted in the transformer module, and an additional 4 or 5 auxiliary VTs depending on the relay model. (The reference between the relay model and number of AC input signals is given in Table 3.2.1.1.)

V_{ref1} and V_{ref2} are the busbar or line voltages necessary for the voltage and synchronism check for the autoreclose.

The transformer module is also provided with an IRIG-B port. This port collects the serial IRIG-B format data from the external clock for synchronization of the relay calendar clock. The IRIG-B port is insulated from the external circuit by a photo-coupler. A BNC connector is used as the input connector.

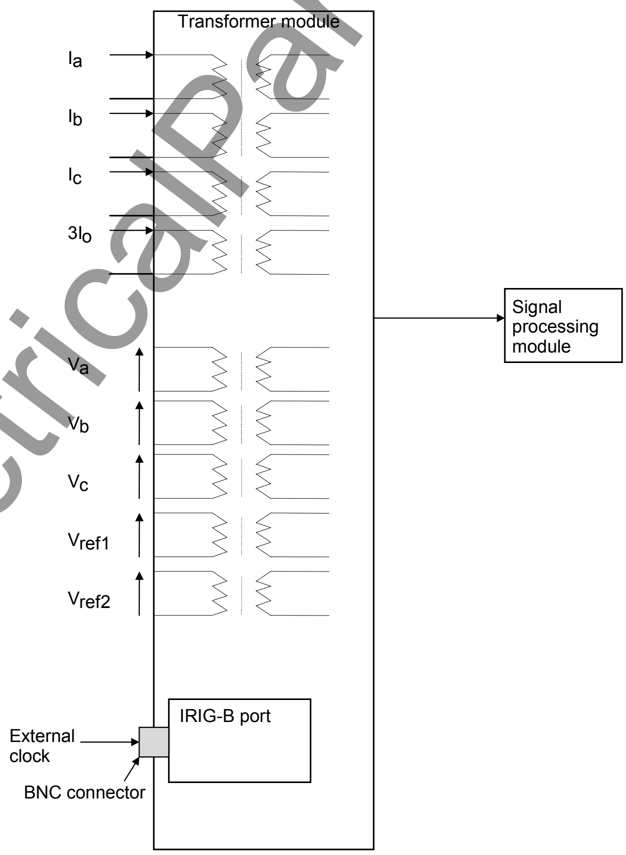


Figure 3.1.2.1 Transformer Module (e.g. Models 300s, 501 and 511)

3.1.3 Signal Processing and Communication Module

The signal processing and communication module (SPM) incorporates a signal processing circuit and a communication control circuit. Figure 3.1.3.1 shows the block diagram. The telecommunication control circuit is incorporated in the sub-module GCOM.

The signal processing circuit consists of an analog filter, multiplexer, analog to digital (A/D) converter, main processing unit (MPU1) and memories (RAM and ROM), and executes all kinds of processing including protection, measurement, recording and display.

The analog filter performs low-pass filtering for the corresponding current and voltage signals.

The A/D converter has a resolution of 16 bits and samples input signals at sampling frequencies of 2400Hz (at 50Hz) and 2880Hz (at 60Hz).

The MPU1 carries out operations for the measuring elements and scheme logic operations for protection, recording, displaying and signal transmission control. It implements 60 MIPS and uses two RISC (Reduced Instruction Set Computer) type 32-bit microprocessors.

The telecommunication control circuit consists of MPU2 executing 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 SPM can be provided with fibre optic interface, Ethernet LAN interface, RS232C etc. for serial communication system.

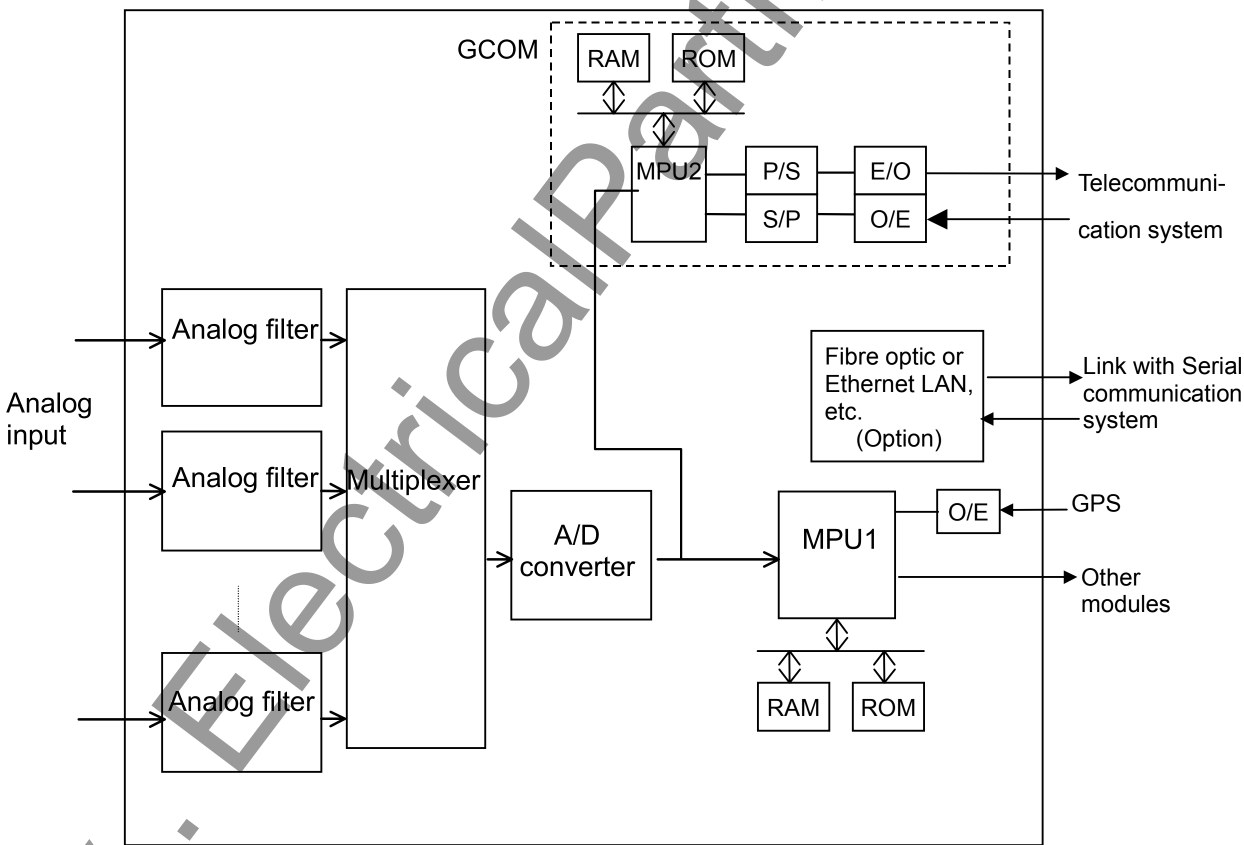


Figure 3.1.3.1 Signal Processing and Communication Module

3.1.4 Binary Input and Output Module

There are four types of binary input and output module (IO module): These modules are used depending on the model (see Section 3.1.1).

3.1.4.1 IO1 and IO8 Module

IO1 and IO8 provide a DC/DC converter, binary inputs and binary outputs for tripping.

As shown in Figure 3.1.4.1, the IO1 module incorporates a DC/DC converter, 15 photo-coupler circuits (BI) for binary input signals and 6 auxiliary relays (TP-A1 to TP-C2) dedicated to the circuit breaker tripping command.

As shown in Figure 3.1.4.2, the IO8 module incorporates a DC/DC converter, 12 photo-coupler circuits (BI) for binary input signals and 3 auxiliary relays (TP) dedicated to the circuit breaker tripping command. The 12 binary inputs have dedicated positive and negative inputs suitable for double-pole switching.

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

The six or three tripping command auxiliary relays are the high-speed operation type and have one normally open output contact.

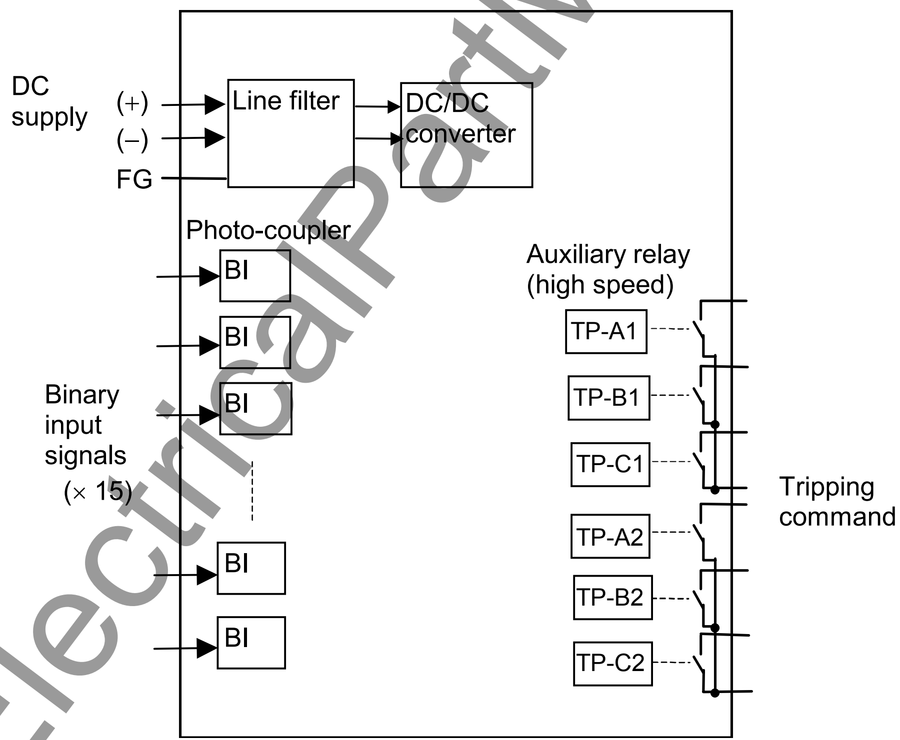


Figure 3.1.4.1 IO1 Module

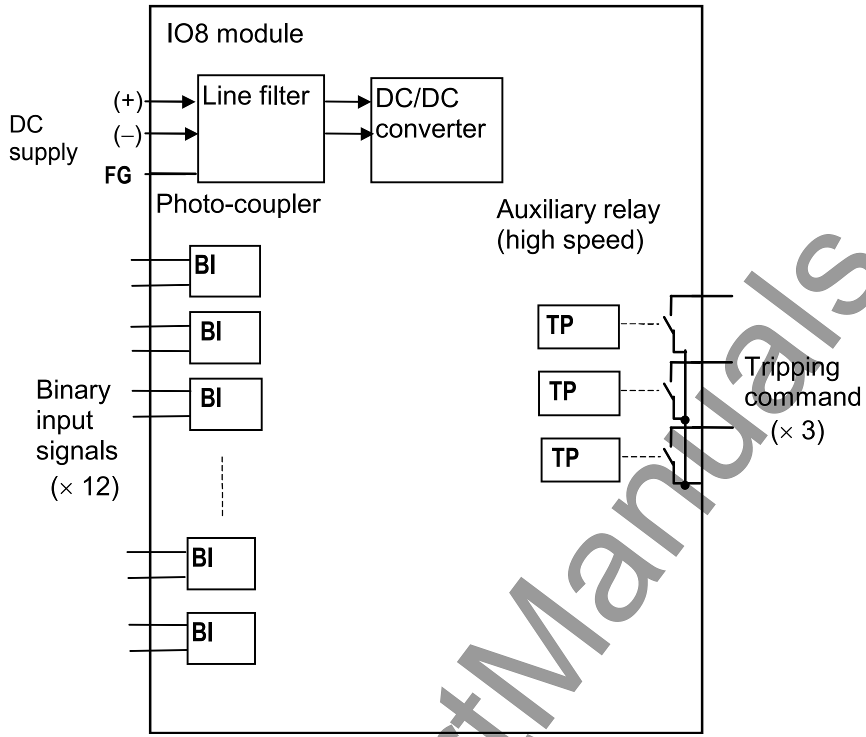


Figure 3.1.4.2 IO8 Module

3.1.4.2 IO2 Module

As shown in Figure 3.1.4.3, the IO2 module incorporates 3 photo-coupler circuits (BI) for binary input signals, 14 auxiliary relays (13 BOs and FAIL) for binary output signals and an RS485 transceiver.

The auxiliary relay FAIL has one normally closed contact, and operates when a relay failure or abnormality in the DC circuit is detected. Each BO has one normally open contact. BO13 is a high-speed operation type.

The RS485 is used for the link with communication system such as RSM (Relay Setting and Monitoring) or IEC60870-5-103 etc. The external signal is isolated from the relay internal signal.

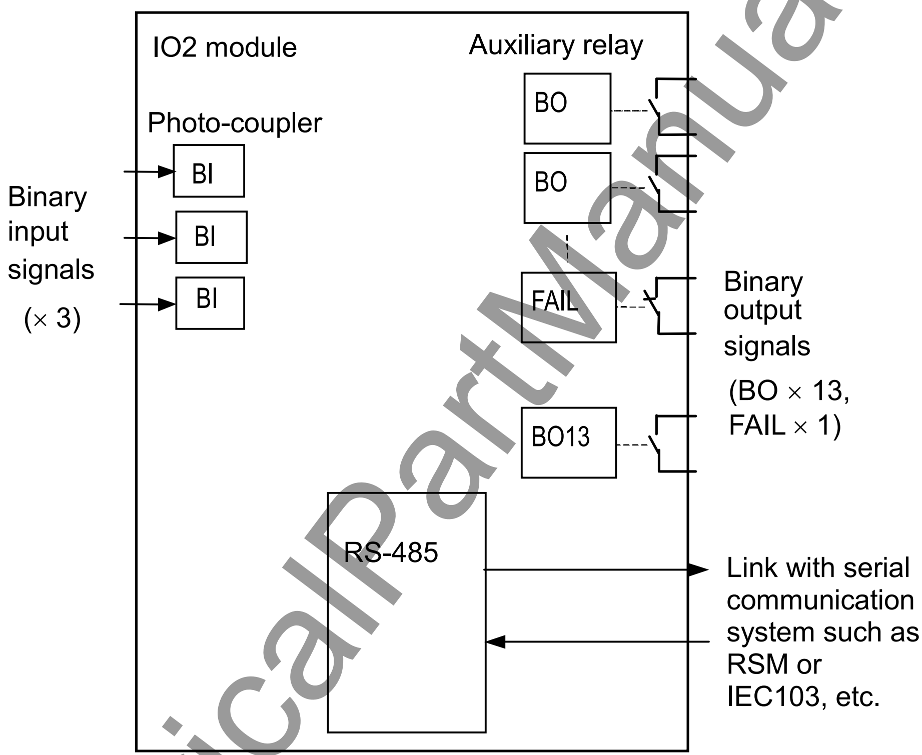


Figure 3.1.4.3 IO2 Module

3.1.4.3 IO3 and IO4 Modules

The IO3 and IO4 modules are used to increase the number of binary outputs.

The IO3 module incorporates 10 auxiliary relays (BO) for binary outputs. The IO4 module incorporates 14 auxiliary relays (BO) for binary outputs and 3 photo-coupler circuits (BI). All auxiliary relays each have one normally open contact.

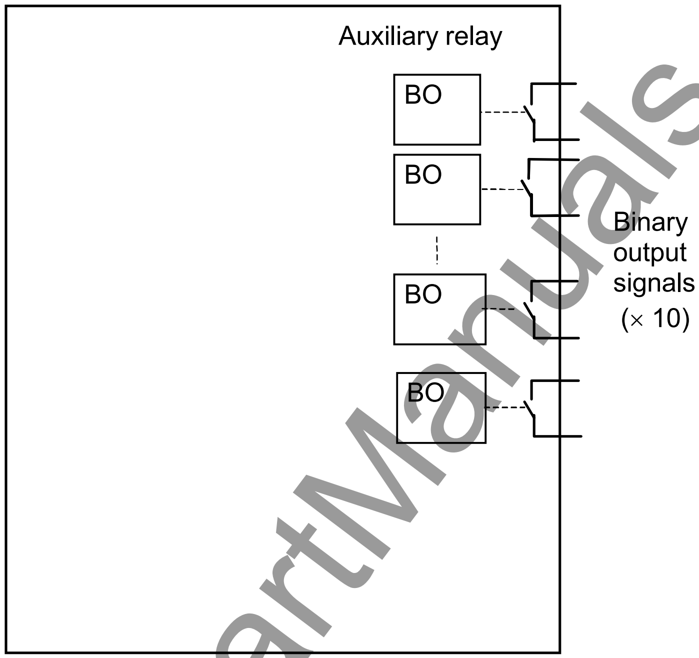


Figure 3.1.4.4 IO3 Module

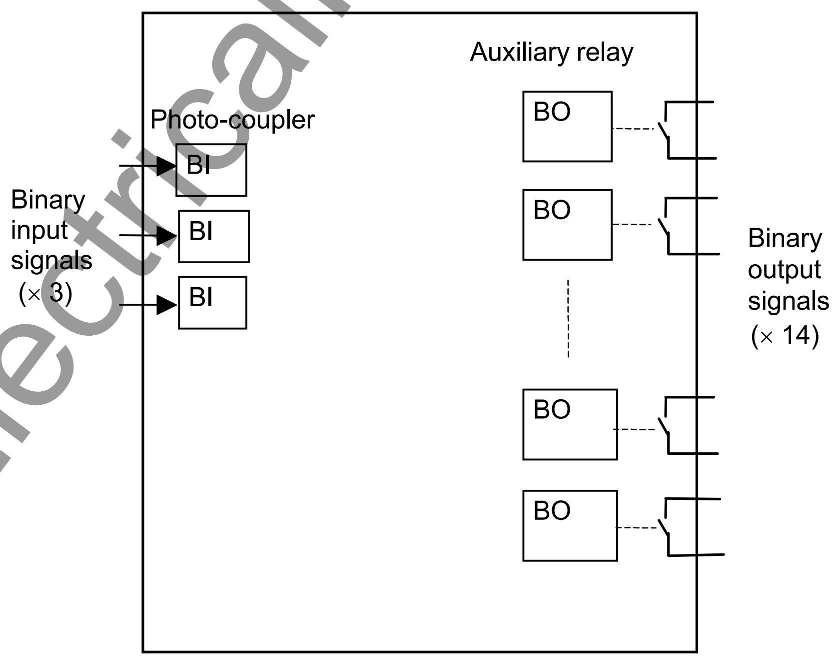


Figure 3.1.4.5 IO4 Module

3.1.4.4 IO5 and IO6 Modules

The IO5 and IO6 modules are used to increase the number of binary inputs and outputs.

The IO5 module incorporates 10 photo-coupler circuits (BI) for binary inputs and 10 auxiliary relays (BO) for binary outputs. The IO6 module incorporates 7 photo-coupler circuits (BI) for binary inputs and 6 auxiliary relays (BO) for binary outputs. All auxiliary relays each have one normally open contact.

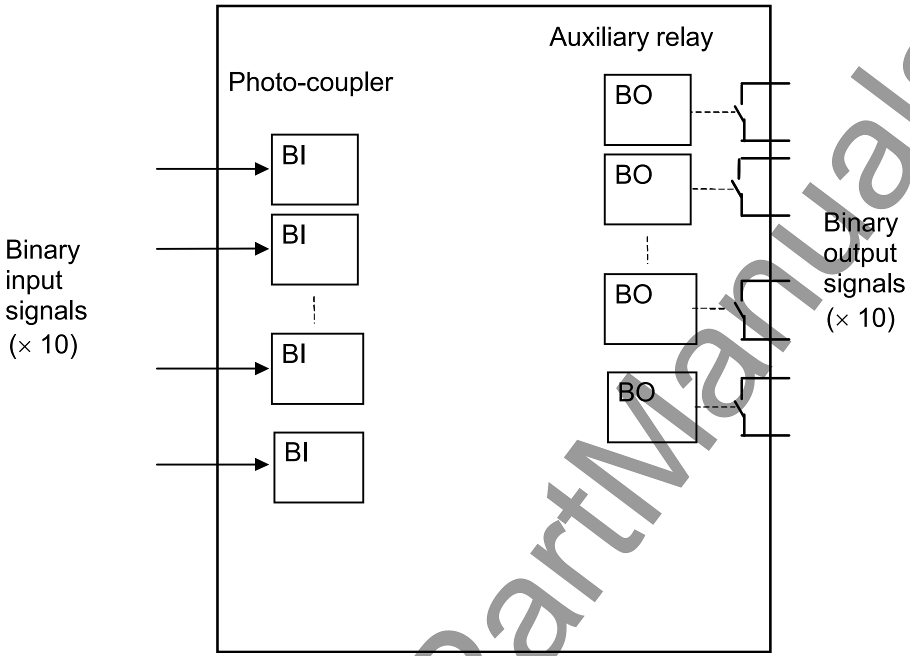


Figure 3.1.4.6 IO5 Module

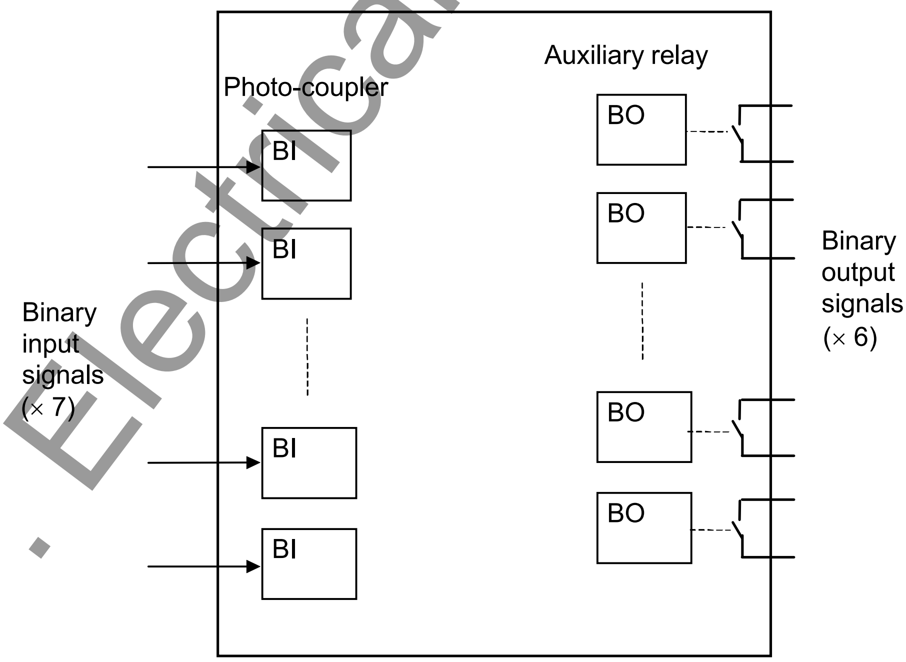


Figure 3.1.4.7 IO6 Module

3.1.5 Human Machine Interface (HMI) Module

The operator can access the GRL100 via the human machine interface (HMI) module. As shown in Figure 3.1.5.1, the HMI module 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 40 columns by 4 rows with a backlight and displays record, status and setting data.

There are a total of 8 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.
TRIP	Red	Lit when a trip command is issued.
ALARM	Red	Lit when a failure is detected.
TESTING	Red	Lit when the testing switches are in test position.
(LED1)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED2)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED3)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED4)	Red	Configurable LED to assign signals with or without latch when relay operates.

LED1 to LED4 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 model 100, 200 and 300 series provide the scheme switch [AOLED] which controls whether the TRIP LED is lit or not by an output of alarm element such as THM_ALARM, etc.

The VIEW key starts the LCD indication and switches between windows. The reset key clears the LCD indication and turns off the LCD backlight.

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" or "Variable Timer List" and setting it in the window and the signals can be output to an oscilloscope via the monitoring jacks. (For the "Signal List" or "Variable Timer List", see Appendix B or C.)

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

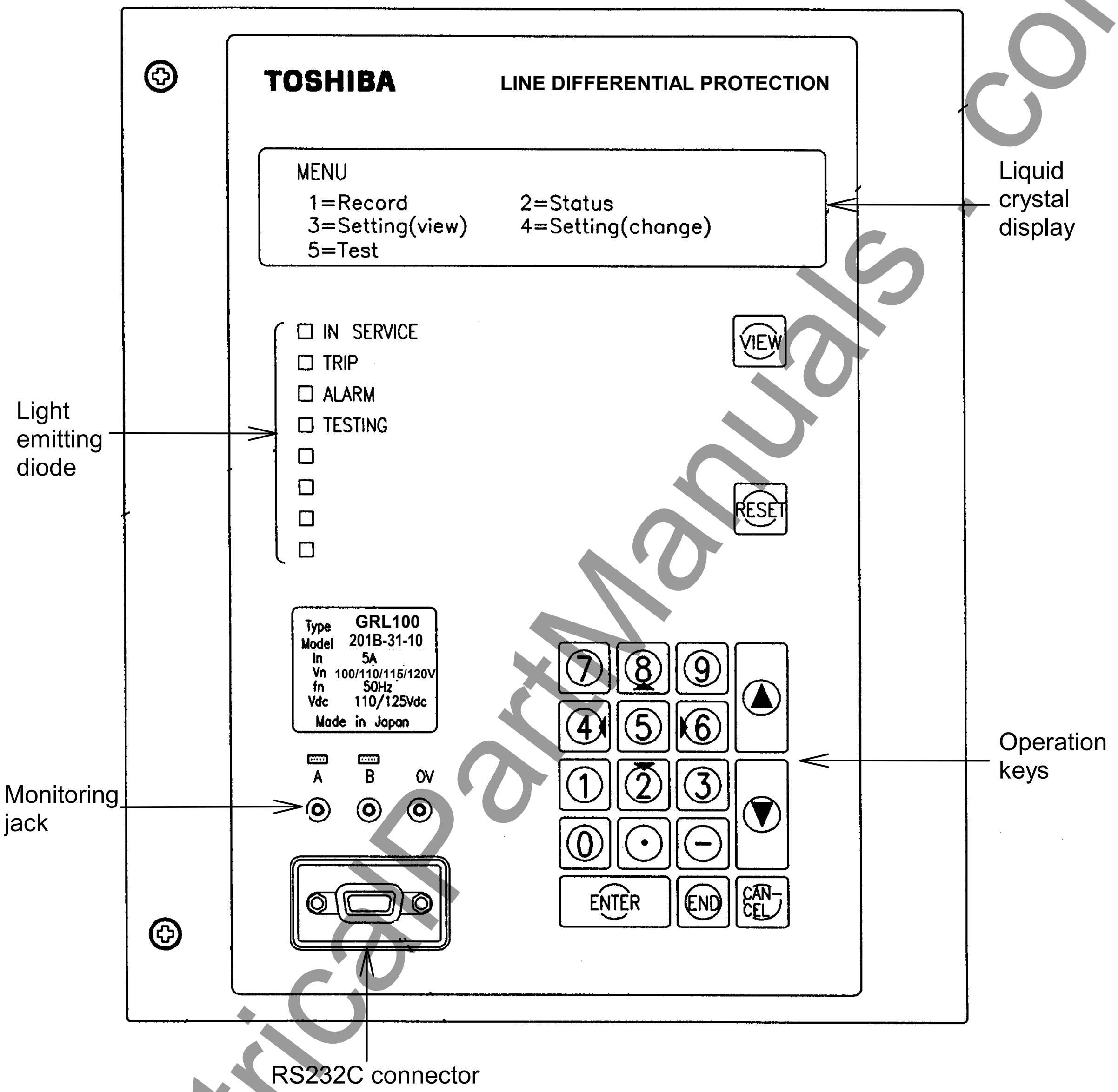


Figure 3.1.5.1 Front Panel

3.1.6 Fault Detector Module

GRL100-400 and -500 series models have an independent fault detector in the form of a check relay, and provide the highest level of security against non-power system fault tripping.

As shown in Figure 3.1.6.1, the fault detector module consists of an analog filter, multiplexer, analog to digital (A/D) converter, main processing unit (MPU) and output auxiliary relays. The entire processing from filtering to operation for the measuring elements and output control is carried out within this module.

The fault detector module receives 3 voltage (V_a, V_b, V_c) inputs and 4 current (I_a, I_b, I_c, $3I_0$) inputs. The analog filter carries out low-pass filtering for the corresponding current and voltage signals.

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

The MPU implements 60 MIPS and uses a RISC (Reduced Instruction Set Computer) type 32-bit microprocessor. Once the fault detector measuring elements start operating, the high-speed auxiliary relays FD1 and FD2 operate.

The fault detector module (FD) incorporates 8 binary output auxiliary relays (BO1-BO8) each with one normally open contact.

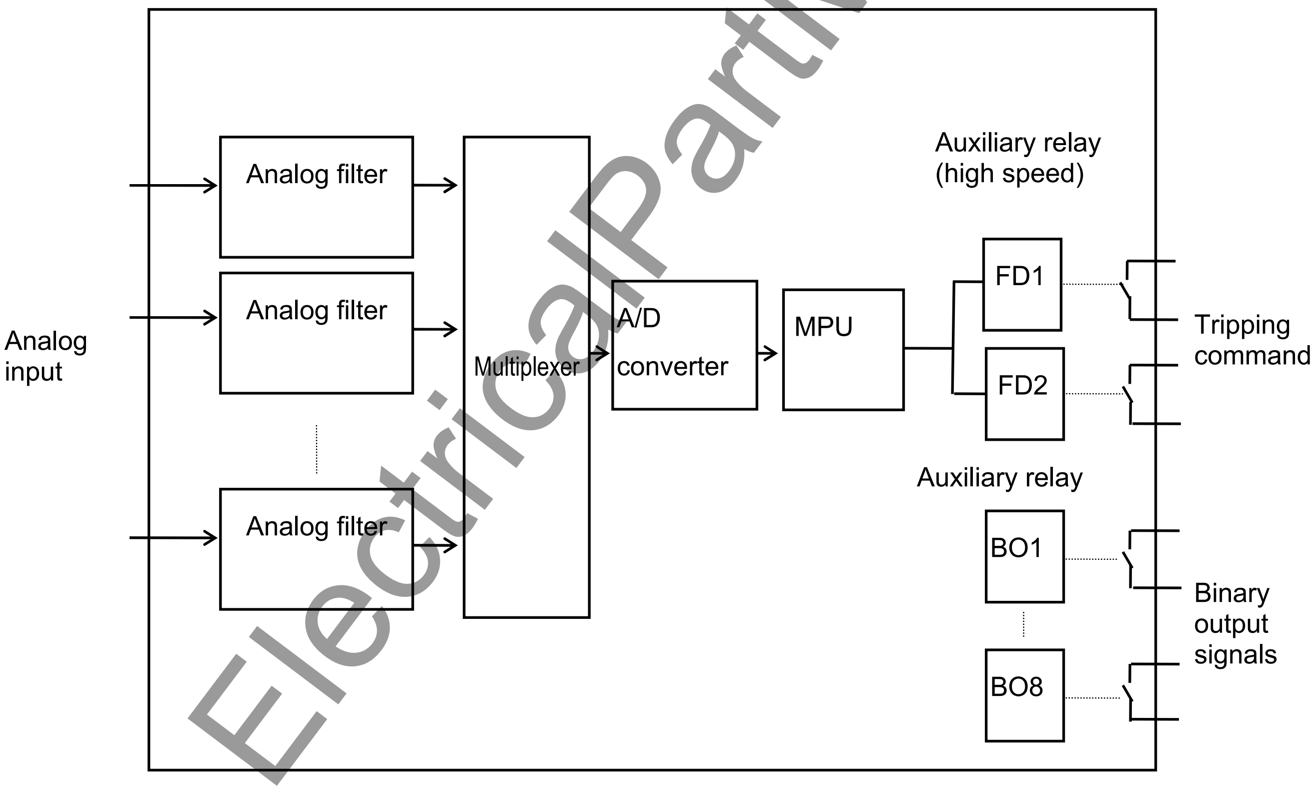


Figure 3.1.6.1 Fault Detector Module

3.2 Input and Output Signals

3.2.1 Input Signals

AC input signals

Table 3.2.1.1 shows the AC input signals necessary for each of the GRL100 models and their respective input terminal numbers. The AC input signals are input via terminal block TB1 for all models. See Appendix G for external connections.

The basic 100 series models require 4 current inputs. The 200 to 500 series models, which have charging current compensation, require a further 3 voltage inputs.

The 200 to 500 series models with the autoreclose function also require an additional voltage signal for voltage and synchronism checks. For single or double busbar applications, one voltage signal is required, while for one-and-a-half circuit breaker arrangements, two voltage signals are required.

In the latter case, the busbar or line voltage of the protected line and the line voltage of the adjacent line should be input to terminals 15 and 16 and terminals 17 and 18 for models 301, 311, 302, 312, 501 and 511, and Terminal 25-26 and 27-28 for models 503 and 513 respectively. (For the busbar and line voltages, see Figure 2.10.2.7.)

Table 3.2.1.1 AC Input Signals

Terminal No.	GRL100-101, 102, 111,112	GRL100-201, 202, 204, 206, 211, 212, 214, 216, 401, 411	GRL100-301, 302, 311, 312, 501, 511	GRL100-503, 513
1-2	A-phase Current	A-phase Current	A-phase Current	A-phase Current
3-4	B-phase Current	B-phase Current	B-phase Current	B-phase Current
5-6	C-phase Current	C-phase Current	C-phase Current	C-phase Current
7-8	Residual Current	Residual Current	Residual Current	Residual Current
9-10				
11-14		A-phase Voltage	A-phase Voltage	A-phase Current
12-14		B-phase Voltage	B-phase Voltage	B-phase Current
13-14		C-phase Voltage	C-phase Voltage	C-phase Current
15-16		Voltage for Autoreclose	Voltage for Autoreclose	Residual Current
17-18			Voltage for Autoreclose	
20	(earth)	(earth)	(earth)	
21-24				A-phase Voltage
22-24				B-phase Voltage
23-24				C-phase Voltage
25-26				Voltage for Autoreclose
27-28				Voltage for Autoreclose
30				(earth)

Binary input signals

Table 3.2.1.2 shows the binary input signals necessary for the GRL100, their driving contact conditions and functions enabled.

Input signals are configurable and depend on the GRL100 models. See Appendix G for the default settings and external connections.

Note: For the three-phase binary input signals of Interlink A, B and C, interlink signals of the parallel line are applied.
The interlink signals are assigned to the binary output relays as LINK-A1, -B1 and -C1 in two-terminal line application and as LINK-A1, -B1 and -C1 and LINK-A2, -B2 and -C2 in the three-terminal line application. For the default setting, see Appendix D.
Two-terminal line application: Apply the LINK-A1, -B1 and -C1 contacts of the parallel line to the binary input signals of Interlink A, B and C (Terminal 1).
Three-terminal line application: Apply the LINK-A1, -B1 and -C1 contacts of the parallel line to Interlink A, B and C (Terminal 1) and LINK-A2, -B2 and -C2 contacts to Interlink A, B and C (Terminal 2) respectively.

The binary input circuit of the GRL100 is provided with a logic level inversion function as shown in Figure 3.2.1.1. Each input circuit has a binary switch BISW 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 contact.

If a signal is not input, the function concerned is disabled.

Further, all binary input functions are programmable by PLC (Programmable Logic Controller) function.

The default setting of the binary input is shown in Table 3.2.1.2.

Table 3.2.1.2 Binary Input Signals for Models 1∗1, 2∗1, 2∗2, 3∗1, 3∗2, 4∗1, 5∗1 and 5∗3

Module Name	BI No.		Contents	Setting		
				Signal No. & Signal Name		Norm or Inv
IO#1	BI1		CB1 AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2		CB1 AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3		CB1 AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4		CB2 AUXILIARY CONTACT - A Ph	1539	CB2_CONT-A	
	BI5		CB2 AUXILIARY CONTACT - B Ph	1540	CB2_CONT-B	
	BI6		CB2 AUXILIARY CONTACT - C Ph	1541	CB2_CONT-C	
	BI7		DISCONNECTOR NORMALLY CLOSED	1542	DS_N/O_CONT	
	BI8		DISCONNECTOR NORMALLY OPEN	1543	DS_N/C_CONT	
	BI9		CARRIER PROTECTION BLOCK	1544	CRT_BLOCK	
	BI10		EXTERNAL CB CLOSE COMMAND	1545	CB_CLOSE	
	BI11	(*)	DC POWER SUPPLY	1546	DC_SUPPLY	
	BI12		TRANSFER TRIP COMMAND 1	1547	85S1	
	BI13		TRANSFER TRIP COMMAND 2	1548	85S2	
	BI14		INDICATION RESET	1549	IND.RESET	
	BI15		BACK UP PROTECTION BLOCK	1550	BUT_BLOCK	
IO#2	BI16		EXTERNAL TRIP - A Ph	1551	EXT_TRIP-A	
				1556	EXT_CBFIN-A	
	BI17		EXTERNAL TRIP - B Ph	1552	EXT_TRIP-B	
				1557	EXT_CBFIN-B	
	BI18		EXTERNAL TRIP - C Ph	1553	EXT_TRIP-C	
				1558	EXT_CBFIN-C	
IO#3	BI19		INTERLINK A (TERMINAL 1)	1568	INT.LINK1-A	
	BI20		INTERLINK B (TERMINAL 1)	1569	INT.LINK1-B	
	BI21		INTERLINK C (TERMINAL 1)	1570	INT.LINK1-C	
	BI22		CB1 AUTORECLISNG READY	1571	CB1_READY	
	BI23		CB2 AUTORECLISNG READY	1572	CB2_READY	
	BI24		AUTORECLOSING BLOCK COMMAND	1573	ARC_RESET	
	BI25		Spare			
	BI26		INTERLINK A (TERMINAL 2)	1575	INT.LINK2-A	
	BI27		INTERLINK B (TERMINAL 2)	1576	INT.LINK2-B	
	BI28		INTERLINK C (TERMINAL 2)	1577	INT.LINK2-C	
IO#4	BI34		Spare			
	BI35		Spare			
	BI36		Spare			

Note (∗): If the binary input of DC power supply is OFF, the ready signal of relay is OFF and the message 'Term∗ rdy off' is displayed. See Section 3.3.6.

Table 3.2.1.3 Binary Input Signals for Models 2∗4 and 2∗6

Module Name	BI No.	Contents	Setting: Signal No. & Signal Name		Setting: Norm or Inv
IO#1	BI1	CB1 AUXILIARY CONTACT - A Ph	1536	CB1_CONT-A	See the BISW setting in Relay setting sheet
	BI2	CB1 AUXILIARY CONTACT - B Ph	1537	CB1_CONT-B	
	BI3	CB1 AUXILIARY CONTACT - C Ph	1538	CB1_CONT-C	
	BI4	TRANSFER TRIP COMMAND 2	1548	85S2	
	BI5	INDICATION RESET	1549	IND.RESET	
	BI6	BACK UP PROTECTION BLOCK	1550	BUT_BLOCK	
	BI7	DISCONNECTOR NORMALLY CLOSED	1542	DS_N/O_CONT	
	BI8	DISCONNECTOR NORMALLY OPEN	1543	DS_N/C_CONT	
	BI9	CARRIER PROTECTION BLOCK	1544	CRT_BLOCK	
	BI10	EXTERNAL CB CLOSE COMMAND	1545	CB_CLOSE	
	BI11 (*)	DC POWER SUPPLY	1546	DC_SUPPLY	
	BI12	TRANSFER TRIP COMMAND 1	1547	85S1	
IO#2	BI16	EXTERNAL TRIP - A Ph	1551 1556	EXT_TRIP-A EXT_CBFIN-A	
	BI17	EXTERNAL TRIP - B Ph	1552 1557	EXT_TRIP-B EXT_CBFIN-B	
	BI18	EXTERNAL TRIP - C Ph	1553 1558	EXT_TRIP-C EXT_CBFIN-C	
IO#3	BI19	Spare			
	BI20	Spare			
	BI21	Spare			
	BI22	CB1 AUTORECLISNG READY	1571	CB1_READY	
	BI23	CB2 AUTORECLISNG READY	1572	CB2_READY	
	BI24	AUTORECLOSING BLOCK COMMAND	1573	ARC_RESET	
	BI25	Spare			
	BI26	Spare			
	BI27	Spare			
	BI28	Spare			
IO#4	BI34	Spare			
	BI35	Spare			
	BI36	Spare			

Note (∗): If the binary input of DC power supply is OFF, the ready signal of relay is OFF and the message 'Term∗ rdy off' is displayed. See Section 3.3.6.

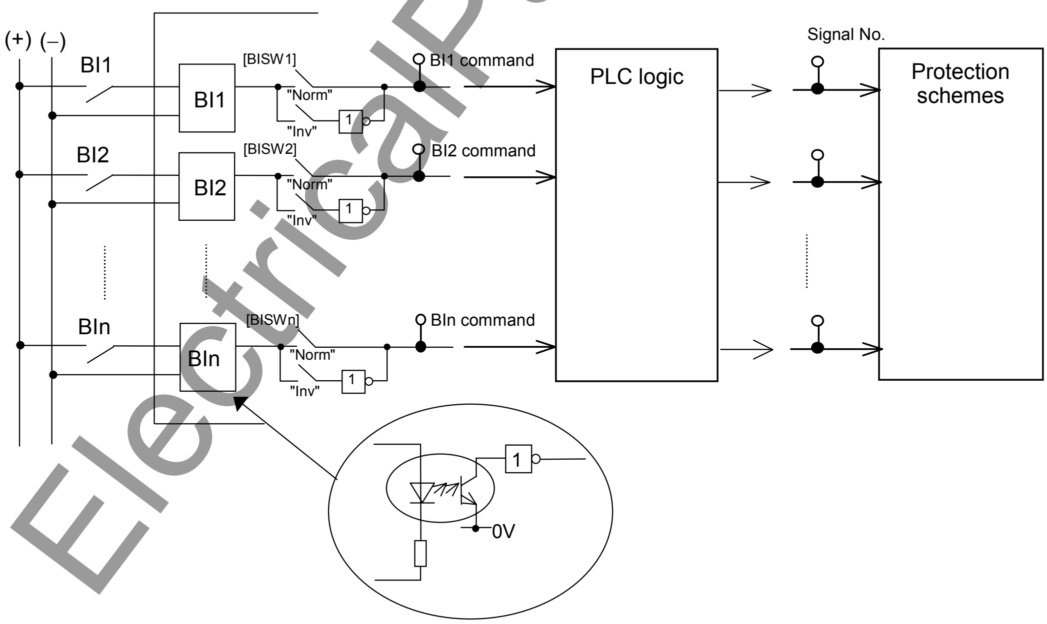


Figure 3.2.1.1 Logic Level Inversion

3.2.2 Binary Output Signals

The number of binary output signals and their output terminals vary depending on the relay model. For all models, all outputs except the tripping command and relay failure signal can be configured.

The signals shown in the signal list in Appendix B can be assigned to the output relay individually or in arbitrary combinations. Signals can be combined using either an AND circuit or OR circuit with 6 gates each as shown in Figure 3.2.2.1. The output circuit can be configured according to the setting menu. Appendix D shows the factory default settings.

A 0.2s delayed drop-off timer can be attached to these assigned signals. The delayed drop-off time is disabled by the scheme switch [BOTD].

All the models are equipped with normally open trip contacts for each phase.

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

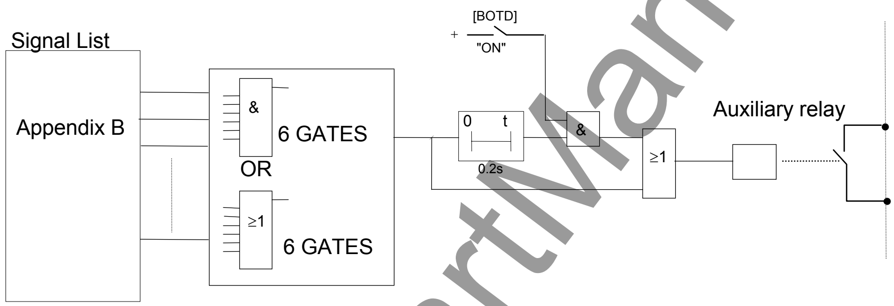


Figure 3.2.2.1 Configurable Output

3.2.3 PLC (Programmable Logic Controller) Function

GRL100 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 editor tool" and linked to signals corresponding to relay elements or binary circuits.

Configurable binary inputs, binary outputs and LEDs, and the initiation trigger of 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 editor tool. For PLC editor tool, refer to PLC editor instruction manual.

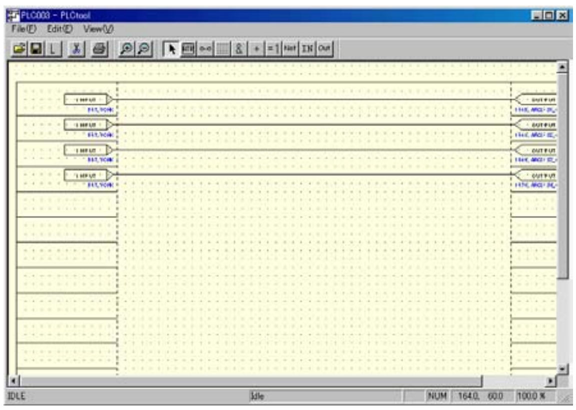


Figure 3.2.3.1 Sample Screen of PLC Editor

3.3 Automatic Supervision

3.3.1 Basic Concept of Supervision

Though the protection system is in the non-operating state under normal conditions, it is waiting for a power system fault to occur at any time and must operate for faults without fail. Therefore, the automatic supervision function, which checks the health of the protection system during normal operation, plays an important role. A numerical relay based on microprocessor operations is suitable for implementing this automatic supervision function of the protection system. The GRL100 implements the automatic supervision function taking advantage of this feature based on the following concept:

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

3.3.2 Relay Monitoring

The following items are supervised:

AC input imbalance monitoring

The AC voltage and current inputs are monitored to check that the following equations are satisfied and the health of the AC input circuits is checked.

- Zero sequence voltage monitoring

  $|V_a + V_b + V_c| / 3 \le 6.35(\mathrm{V})$

- Negative sequence voltage monitoring

  $|V_a + a^2V_b + aV_c| / 3 \le 6.35(\mathrm{V})$

  where,

  a = Phase shifter of 120°

- Zero sequence current monitoring

  $|I_a + I_b + I_c - 3I_o| / 3 \le 0.1 \times \mathrm{Max}(|I_a|, |I_b|, |I_c|) + k_0$

  where,

  $3I_o$ = Residual current

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

  k_0 = 5% of rated current

These zero sequence monitoring and negative sequence monitoring allow high-sensitivity detection of failures that have occurred in the AC input circuits.

The negative sequence voltage monitoring allows high sensitivity detection of failures in the voltage input circuit, and it is effective for detection particularly when cables have been connected with the incorrect phase sequence.

The zero sequence current monitoring allows high-sensitivity detection of failures irrespective of the presence of the zero sequence current on the power system by introduction of the residual circuit current.

Only zero sequence monitoring is carried out for the current input circuit, because zero sequence monitoring with the introduction of the residual circuit current can be performed with higher sensitivity than negative sequence monitoring.

A/D accuracy checking

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

Memory monitoring

The memories are monitored as follows depending on the type of memory, and the health of the memory circuits is checked:

- 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 for discrepancies between the setting values stored in duplicate.

Watchdog Timer

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

DC Supply monitoring

The secondary voltage level of the built-in DC/DC converter is monitored and the system checks that the DC voltage is within the prescribed range. If a failure is detected, the relay trip is blocked and the alarm is issued.

Furthermore, DC supply is monitored by using the binary input signal in the current differential protection. If the binary input signal is “OFF” (= DC supply “OFF” or “Failure”), the ready condition of the differential protection is “OFF” and both local and remote relays are blocked. (Refer to Table 3.2.1.2.) This monitoring is provided to surely block the unwanted operation of remote terminal relays caused by sending the remote terminals an uncertain data even for short time at DC supply off or failure, though the former monitoring is enough at DC supply off or failure in general.

Tripping output monitoring

The system monitors the tripping output contacts and checks that they do not maintain the "make" state exceeding the prescribed time, to ensure that there is no false operation failure in the tripping output circuit. This item is implemented for models 400s and 500s which have a fault detector (FD).

3.3.3 CT Circuit Current Monitoring

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

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

where,

$\mathrm{Max}(|I_a|, |I_b|, |I_c|)$ = Maximum amplitude among I_a, I_b and I_c
$\mathrm{Min}(|I_a|, |I_b|, |I_c|)$ = 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 [CTSV].

3.3.4 CT Circuit Failure Detection

If a failure occurs in a CT circuit, the differential elements may operate incorrectly. GRL100 incorporates a CT failure detection function (CTF) against such incorrect operation. When the CTF detects a CT circuit failure, it can block the DIF trip.

The CTF is enabled or disabled by the scheme switch [CTFEN] as follows:

- "Off": Disabled.
- "On": Enabled. If once CTF is detected, the CTF function cannot be reset until ID is reset.
- "OPT-On": Enabled. After CTF is detected, the CTF function is reset if CTFUV, CTFDV or CTFOVG operates.

The DIF trip is blocked or not by the scheme switch [CTFCNT].

- "NA": No block the DIF trip
- "BLK": Block the DIF trip

Detection logic

Figure 3.3.4.1 shows the CTF detection logic.

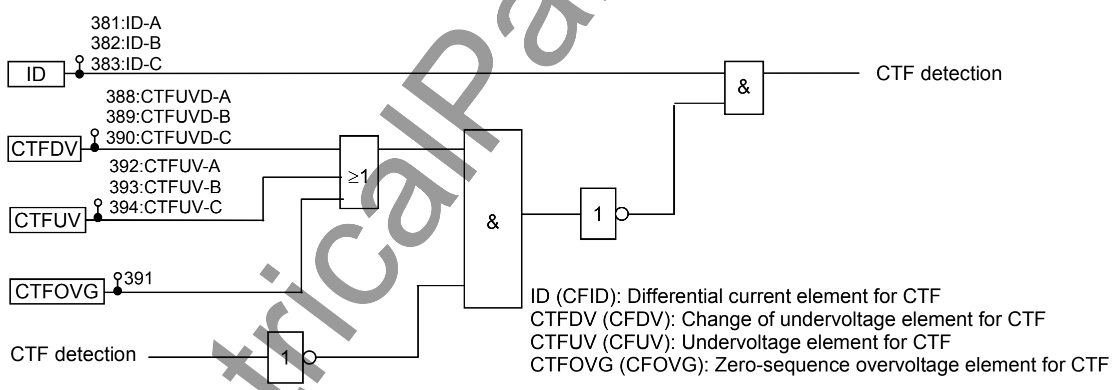


Figure 3.3.4.1 CTF Detection Logic

Setting

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

Element	Range	Step	Default	Remarks
CFID	0.25 - 5.00 A	0.1 A	0.25 A	Id current level
	(0.05 - 1.00 A	0.01 A	0.05 A) (*)	
CFUV	20 - 60 V	1 V	20 V	
CFDV	1 - 10 %	1 %	7 %	% of rated voltage
CFOVG	0.1 - 10.0 V	0.1 V	1.0 V	Zero-sequence voltage
[CTFEN]	Off/On/OPT-On		Off	CTF enabled or not
[CTFCNT]	NA / BLK		NA	Control by CTF detection

(*) 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.

3.3.5 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 [IDSV] to “ALM&BLK”. To alarm only, set to “ALM”.

3.3.6 Telecommunication Channel Monitoring

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

If a data failure occurs between the local terminal and remote terminal 1 and lasts for ten seconds, failure alarms "Com1 fail" and "Com1 fail-R" are issued at the local and remote terminals respectively. "Com1 fail" is a failure detected by the local terminal relay, and "Com1 fail-R" is a failure detected by the remote terminal relay. If the failure occurs between the local terminal and remote terminal 2, "Com2 fail" and "Com2 fail-R" are issued.

Note: The remote terminal 1 and 2 are those with which the local communication port 1 (CH1) and 2 (CH2) are linking with.

In the case that the GRL100 is linked directly to a dedicated optical fiber communication circuit, sending and receiving signal levels are monitored and error messages "TX1 level err" of CH1 or "TX2 level err" of CH2 for sending signal and "RX1 level err" of CH1 or "RX2 level err" of CH2 for receiving signal are output when the levels fall below the minimum allowed.

In the communication setup in which the GRL100 receives the clock signal from the multiplexer, an error message "CLK1 fail" of CH1 or "CLK2 fail" of CH2 is output when the signal is interrupted.

Note: Messages "Com2 fail", "RX2 level err", "TX2 level err" and "CLK2 fail" are valid in three-terminal applications.

If the ready signal of the remote terminal relay via CH1 or CH2 is OFF during ten seconds or more, the message ‘Term1 rdy off’ or ‘Term2 rdy off’ is displayed. (For the ready signal, see Appendix N.)

3.3.7 GPS Signal Reception Monitoring (For GPS-mode only)

If the GPS signal receiving from the GPS receiver unit is interrupted, an alarm is issued.

3.3.8 Relay Address Monitoring

In applications where the telecommunication channel can be switched, it is possible that the data could be communicated to the wrong terminal. To avoid this, the relay address can be assigned and monitored at each terminal to check that the data is communicated to the correct terminal.

The different address must be assigned to a relay at each terminal.

The monitoring is enabled by setting the scheme switch [RYIDSV] to "ON".

3.3.9 Disconnector Monitoring

The disconnector is monitored because the disconnector contact signal is used for the out-of-service terminal detection and for the stub fault protection in the one-and-a-half busbar system.

To monitor the disconnector, one pair of normally open contacts 89A and normally closed contacts 89B are introduced. Disconnector failure is detected when both 89A and 89B are simultaneously in the open or closed state for the prescribed period.

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

3.3.10 Failure Alarms

When a failure is detected by the automatic supervision, LCD display, LEDs indication, external alarm and event recording are performed.

Table 3.3.10.1 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. This setting is used to block unnecessary alarms during commissioning tests or maintenance.

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

A DC supply failure disables the LCD display and event recording of the failure as well.

For details of discrimination of the two failures mentioned above, see Section 6.7.2.

Table 3.3.10.1 Supervision Items and Alarms

Supervision Item	LCD message	LED "IN SERVICE"	LED "ALARM"	External alarm	Event record message
AC input imbalance monitoring Vo, V2, Io	(1)	on/off (2)	on	(4)	V0 err / V2 err / I0 err
CT circuit monitoring	(1)	on/off (7)	on	(4)	CT err
A/D accuracy checking Memory monitoring	(1)	off	on	(4)	Relay fail
Watch Dog Timer	—	off	on	(4)	—
DC supply monitoring	—	off	(3)	(4)	DC supply
Trip output monitoring	O/P circuit fail	on	on	(4)	Relay fail
Telecommunication monitoring	Com.□ fail Com.□ fail-R (*)	on on	on off	(5) (5)	Com.□ fail Com.□ fail-R (*)
Sampling Synchronization monitoring	Sync.□ fail (*)	on	on	(4)	Sync.□ fail (*)
Send signal level monitoring	TX □ level err (*)	on	off	(5)	TX □ level err (*)
Receive signal level monitoring	RX □ level err (*)	on	off	(5)	RX □ level err (*)
Clock monitoring	CLK.□ fail (*)	on	off	(5)	CLK.□ fail (*)
Ready signal monitoring	Term.□ rdy off (*)	on	on	(5)	Term.□ rdy off (*)
GPS signal reception monitoring	GPS 1PPS off	on	on	(5)	GPS 1PPS off
Disconnector monitoring	DS fail	on	on	(4)	DS fail
Id monitoring	Id err	on/off (6)	on	(4)	Relay fail
Relay address monitoring	RYID□ err	on	on	(5)	RYID□ err
CTF monitoring	CT fail	on	on	(5)	CTF

(*) □ takes 1 or 2 according to the channel linking, either with remote terminal 1 or 2.

(1) There are various messages such as "··· err" and "··· fail" as shown in the table in Section 6.7.2.

(2) The LED is on when the scheme switch [SVCNT] is set to "ALM", and off when "ALM & BLK" (refer to Section 3.3.11).
(3) Whether the LED is lit or not depends on the degree of voltage drop.
(4) The binary output relay "FAIL" operates.
(5) The user-configurable binary output relays operate if the signal assigned.
(6) The LED is on when the scheme switch [IDSV] is set to "ALM", and off when "ALM & BLK".
(7) The LED is on when the scheme switch [CTSV] is set to "ALM", and off when "ALM & BLK".

3.3.11 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 checking
- Memory monitoring
- Watch Dog Timer
- DC supply monitoring
- Telecommunication channel monitoring (blocking the differential protection trip only)

When a failure is detected by AC input imbalance monitoring, CT circuit current monitoring or differential current monitoring, the scheme switch [SVCNT], [CTSV] or [IDSV] setting can be used to determine if both tripping is blocked and an alarm is output, or, if only an alarm is output. The CT circuit current monitoring and the differential current monitoring can be disabled by the [CTSV] and [IDSV] respectively.

3.3.12 Setting

The setting elements necessary for the automatic supervision and their setting ranges are shown in the table below.

Element	Range	Step	Default	Remarks
DIFSV	0.25 – 10.00A	0.01A	0.50A	Differential current supervision
	(0.05 – 2.00A	0.01A	0.10A) (∗)	
TIDSV	0 – 60s	1s	10s	Detected time setting
RYID	0-63		0	Local relay address
RYID1	0-63		0	Remote 1 relay address
RYID2	0-63		0	Remote 2 relay address
[IDSV]	OFF/ALM&BLK/ALM		OFF	Differential current supervision
[RYIDSV]	OFF/ON		ON	Relay address supervision
[LSSV]	ON/OFF		OFF	Disconnector monitoring
[SVCNT]	ALM&BLK/ALM		ALM&BLK	Alarming and/or blocking
[CTSV]	OFF/ALM&BLK/ALM		OFF	CT circuit monitoring

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

For setting method, see Section 2.2.12.

For the setting range of CT circuit failure detection, see section 3.3.4.

3.4 Recording Function

The GRL100 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 GRL100, a tripping command of the external main protection or PLC command by user-setting (max. 4) and the following items are recorded for one fault:

Date and time of fault occurrence
Faulted phase
Tripping phase
Tripping mode
Fault location
Relevant events
Power system quantities

Up to 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 of fault occurrence

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

To be precise, this is the time at which a tripping command has been output.

Fault phase

The faulted phase is indicated by DIF, OC or OCI operating phase.

Tripping phase

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

Tripping mode

This shows the protection scheme that outputted the tripping command.

Fault location

The distance to the fault point calculated by the fault locator is recorded.

The distance is expressed in km and as a percentage (%) of the line length in two-terminal application. In case of three-terminal application, the distance in km and the section on the fault point are displayed.

For the fault locator, see Section 2.13.

Relevant events

Such events as autoreclose, re-tripping following the reclose-on-to-a fault or autoreclose and tripping for evolving faults are recorded with time-tags.

Power system quantities

The following power system quantities in pre-faults and post-faults are recorded. The power system quantities are not recorded for evolving faults.

- Magnitude and phase angle of phase voltage (V_a, V_b, V_c)
- Magnitude and phase angle of phase current at the local terminal (I_a, I_b, I_c)
- Magnitude and phase angle of phase voltage for autoreclose (V_{s1}, V_{s2})
- Magnitude and phase angle of symmetrical component voltage (V_1, V_2, V_0)
- Magnitude and phase angle of symmetrical component current at the local terminal (I_1, I_2, I_0)
- Magnitude and phase angle of positive sequence voltage at the remote terminal 1 and 2 (V_{11}, V_{12})
- Magnitude and phase angle of phase current and residual current at the remote terminal 1 (I_{a1}, I_{b1}, I_{c1}, I_{01})
- Magnitude and phase angle of phase current and residual current at the remote terminal 2 (I_{a2}, I_{b2}, I_{c2}, I_{02})
- Magnitude of phase differential current (I_{da}, I_{db}, I_{dc})
- Magnitude of residual differential current (I_{d0})
- Telecommunication delay time 1 at the remote terminal 1
- Telecommunication delay time 2 at the remote terminal 2

Phase angles above are expressed taking that of positive sequence voltage or positive sequence current when the voltage is small or no voltage is input) as a reference phase angle.

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 the maximum 128 recording items and their status change mode. The event recording is initiated by a binary input signal. The event items can be assigned to a signal number in the signal list. The status change mode is set to "On" (only recording when On.) or "On/Off"(recording when both On and Off.) mode by setting. The items of "On/Off" mode 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 event can be set by RSM100. Maximum 22 characters can be set, but LCD displays up to 11 characters of them. Therefore, it is recommended the maximum characters are set. The set name can be viewed on the Setting(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 H.

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 overcurrent or undervoltage starter elements operate or a tripping command is output, or PLC command by user-setting (max. 4: Signal No. 2632 to 2635) is outputted. The records include 19 analog signals (local terminal: V_a, V_b, V_c, I_a, I_b, I_c, $3I_0$, I_{da}, I_{db}, I_{dc}, I_{d0}, remote terminal 1: I_{a1}, I_{b1}, I_{c1}, $3I_{01}$ remote terminal 2: I_{a2}, I_{b2}, I_{c2}, $3I_{02}$), 32 binary signals and the dates and times at which recording started. Any binary signal shown in Appendix B can be assigned by signal setting of disturbance record. The default setting of binary signal is shown in Appendix H.

The name of binary signal can be set by RSM100. Maximum 22 characters can be set, but LCD displays up to 11 characters of them. Therefore, it is recommended the maximum characters are set. The set name can be viewed on the Setting(view) screen.

The LCD display only shows the dates and times of disturbance records stored. Details can be displayed on the 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 the post-fault recording time can be set between 0.1 and 3.0s and the default setting is 1.0s.

The number of records stored depends on the post-fault recording time and the relay model. The typical number of records stored in 50Hz and 60Hz power system is shown in Table 3.4.3.1.

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

Table 3.4.3.1 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	36	18	11	8	6	5	4
60Hz	30	15	9	6	5	4	3

Setting

The elements necessary for starting disturbance recording and their setting ranges are shown in the table below. The model 100 series does not provide UVP-S and UVP-G elements.

Element	Range	Step	Default	Remarks
Timer	0.1-3.0 s	0.1 s	1.0 s	Post-fault recording time
OCP-S	0.5-250.0 A	0.1 A	10.0 A	Overcurrent detection (phase fault)
	(0.1-50.0 A	0.1 A	2.0 A) (*)	
OCP-G	0.5-250.0 A	0.1 A	5.0 A	Overcurrent detection (earth fault)
	(0.1-50.0 A	0.1 A	1.0 A)	
UVP-S	0-132 V	1 V	88 V	Undervoltage detection (phase fault)
UVP-G	0-76 V	1 V	51 V	Undervoltage detection (earth fault)

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

Starting the disturbance recording by a tripping command or the starter elements listed above is enabled or disabled by setting the following scheme switches with identical names with the starter elements except the switch [TRIP].

Element	Range	Step	Default	Remarks
[TRIP]	ON/OFF		ON	Start by tripping command
[OCP-S]	ON/OFF		ON	Start by OCP-S operation
[OCP-G]	ON/OFF		ON	Start by OCP-G operation
[UVP-S]	ON/OFF		ON	Start by UVP-S operation
[UVP-G]	ON/OFF		ON	Start by UVP-G operation

3.5 Metering Function

The GRL100 performs continuous measurement of the analog input quantities. The measurement data shown below is updated every second and displayed on the LCD of the relay front panel or on the local or remote PC. The model 100 series measures current quantities only.

- Magnitude and phase angle of phase voltage (V_a, V_b, V_c)
- Magnitude and phase angle of phase current at the local terminal (I_a, I_b, I_c)
- Magnitude and phase angle of phase voltage for autoreclose (V_{s1}, V_{s2})
- Magnitude and phase angle of symmetrical component voltage (V_1, V_2, V_0)
- Magnitude and phase angle of symmetrical component current at the local terminal (I_1, I_2, I_0)
- Magnitude and phase angle of positive sequence voltage at the remote terminal 1 and 2 (V_{11}, V_{12})
- Magnitude and phase angle of phase current and residual current at the remote terminal 1 (I_{a1}, I_{b1}, I_{c1}, I_{01})
- Magnitude and phase angle of phase current and residual current at the remote terminal 2 (I_{a2}, I_{b2}, I_{c2}, I_{02})
- Magnitude of phase differential current (I_{da}, I_{db}, I_{dc})
- Magnitude of residual differential current (I_{d0})
- Percentage of thermal capacity (THM%)
- Pickup current of segregated-phase current differential element (I_{pua}, I_{pub}, I_{puc})
- Restraining current of segregated-phase current differential element (I_{ra}, I_{rb}, I_{rc})
- Telecommunication delay time 1 at the remote terminal 1
- Telecommunication delay time 2 at the remote terminal 2
- Active power and reactive power
- Frequency

Phase angles above are expressed taking that of positive sequence voltage or positive sequence current when the voltage is small or no voltage is input) as a reference phase angle, where leading phase angles are expressed as positive, (+).

The above system quantities are displayed in values on the primary side or on the secondary side determined by the setting. To display accurate values, it is necessary to set the CT ratio and VT ratio as well. For the setting method, see "Setting the line parameters" in 4.2.6.7.

The signing of active and reactive power flow direction can be set positive for either power sending or power receiving. The signing of reactive power can be also set positive for either lagging phase or leading phase. For the setting method, see Section 4.2.6.6.

4. User Interface

4.1 Outline of User Interface

The user can access the relay from the front 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, etc., via an RS485.

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 3.1.5.1, the front panel is provided with a liquid crystal display (LCD), light emitting diode (LED), operation keys, VIEW and RESET keys, monitoring jack and RS232C connector.

LCD

The LCD screen, provided with a 4-line, 40-character back-light, displays detailed information of the relay interior such as records, status 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 8 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.
TESTING	Red	Lit when the testing switches are in test position.
(LED1)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED2)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED3)	Red	Configurable LED to assign signals with or without latch when relay operates.
(LED4)	Red	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 key is as follows:

① 0-9, –: Used to enter a selected number, numerical values and text strings.

② ▼, ▲: Used to move between lines displayed on a screen.
Keys 2, 4, 6 and 8 marked with ▼, ◀, ▶ and ▲ are also used to enter text strings.

③ CANCEL: Used to cancel entries and return to the upper screen.

④ END: Used to end entry operation, return to the upper screen or turn off the display.

⑤ ENTER: Used to store or establish entries.

VIEW and RESET keys

Pressing the VIEW key displays digest screens such as "Metering", "Latest fault" and "Auto-supervision".

Pressing the 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 output 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, Fibre optic or Ethernet LAN port for serial communication
- IRIG-B port
- Interface port for telecommunication link

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, Fibre optic or Ethernet LAN 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 (COM1 or OP1) can be used for the relay setting and monitoring (RSM) system or IEC60870-5-103 communication, while the other port (COM2 or OP2) is used for IEC60870-5-103 communication only.

Screw terminal for RS485, ST connector for fibre optic or RJ45 connector for Ethernet LAN (10Base-T) is provided on the back of the relay as shown in Figure 4.1.2.1. RS232, 10BASE-FL and 100BASE-FX can be provided.

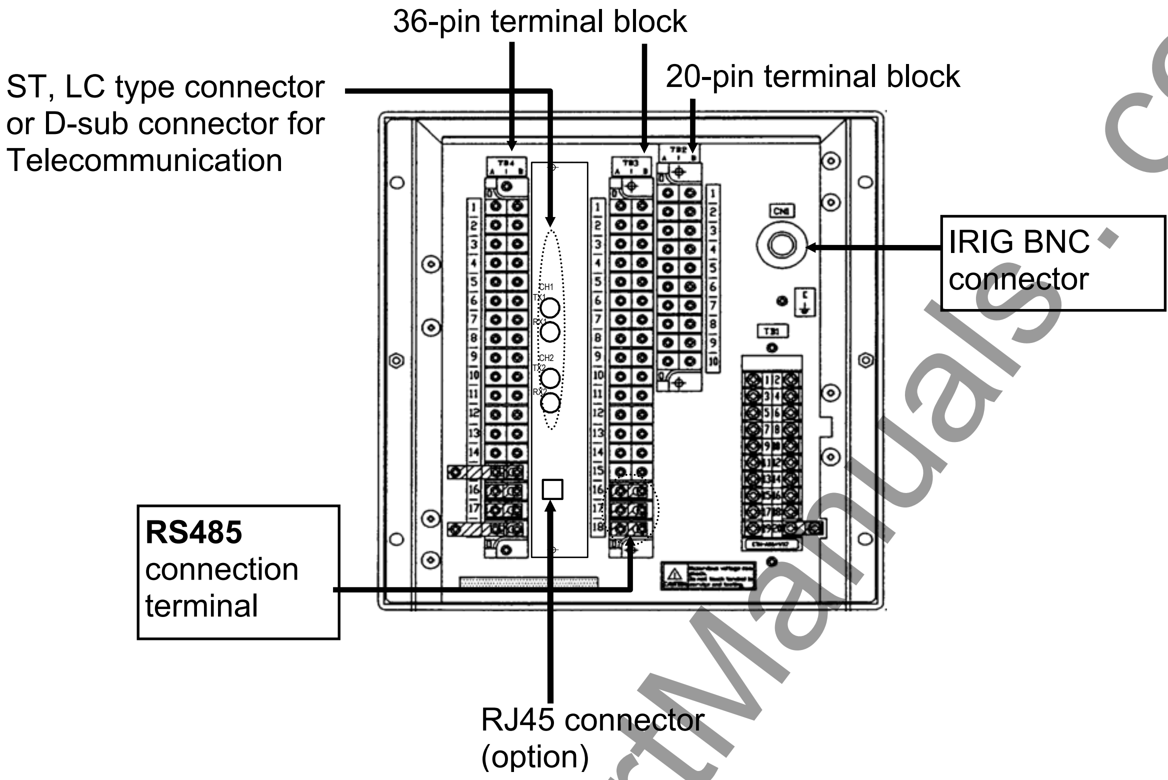
IRIG-B port

The IRIG-B port is mounted on the transformer module, and 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. A BNC connector is used as the input connector.

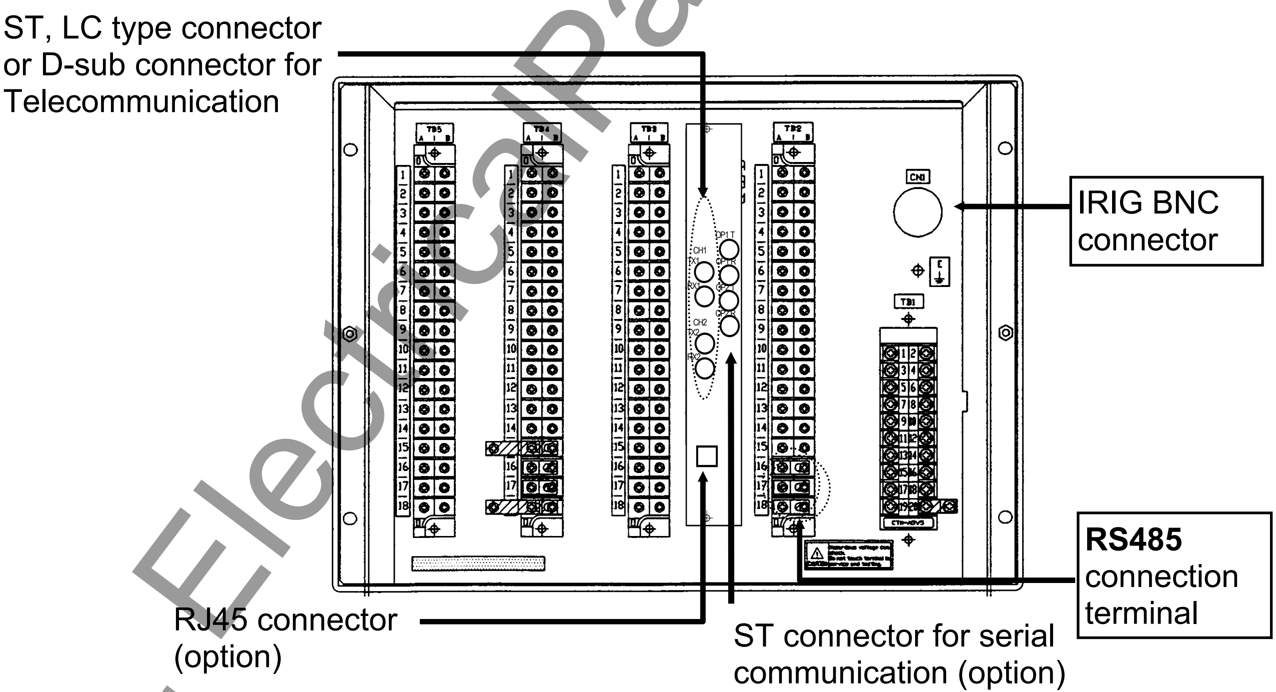
This port is on the back of the relay, as shown in Figure 4.1.2.1.

Interface port for telecommunication link

The optical or electrical interface port for telecommunication link is provided on the back of the relay as shown in Figure 4.1.2.1. The connector using for the optical interface port is the ST type (for 2 km class), LC type (for 30 km class) or Duplex LC type (for 80 km class) connector and the connector for the electrical interface port is the D-sub connector.



Relay rear view (Case Type A)



Relay rear view (Case Type B)

Figure 4.1.2.1 Locations 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.

Note: LCD screens depend on the relay model and the scheme switch setting. Therefore, LCD screens described in this section are samples of typical model.

4.2.1 LCD and LED Displays

Displays during normal operation

```
Metering1           16/Oct/1997  18:13
Va   127.0kV    Ia    2.10kA
Vb   127.0kV    Ib    2.10kA
Vc   127.0kV    Ic    2.10kA
```

Note: In the case of model 100s, V∗ are not displayed.

```
Metering2           16/Oct/1997  18:13
Ida   0.00kA    Ia1   1.05kA   Ia2   1.05kA
Idb   0.00kA    Ib1   1.05kA   Ib2   1.05kA
Idc   0.00kA    Ic1   1.05kA   Ic2   1.05kA
```

Note: I∗1 and I∗2 are phase currents of remote terminal 1 and remote terminal 2.

```
Metering3           16/Oct/1997  18:13
+ 400.11MW
-  25.51Mvar
    60.1Hz
```

Note: In the case of model 100s, this screen is not displayed.

When the GRL100 is operating normally, the green "IN SERVICE" LED is lit and the LCD is off.

Press the VIEW key when the LCD is off to display the digest screens "Metering1", "Metering2", "Metering3", "Latest fault" and "Auto-supervision" in turn. The last two screens are displayed only when there is some data. The following 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.

Displays in tripping

```
Latest fault    16/Oct/1997  18:13:45.160
Phase  ABN           Trip  ABC
DIF
47.3km (57.1%)
```

Note: In the case of model 100s, the fault location is not displayed.

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 LED4) 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 LED4 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 - LED4)
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   08/Dec/1997  22:56

 DIO err,
```

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 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 LED4) 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 LED4 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 from menu screen 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 "Auto-supervision" screen.

4.2.2 Relay Menu

Figure 4.2.2.1 shows the menu hierarchy in the GRL100. The menu has five sub-menus, "Record", "Status", "Setting (view)", "Setting (change)", and "Test". For details of the menu hierarchy, see Appendix E.

- Menu
  - Record
    - Fault record
    - Event record
    - Disturbance record
    - Autoreclose count
  - Status
    - Metering
    - Binary I/O
    - Relay element
    - Time sync source
    - Clock adjustment
    - Terminal condition
  - Setting (view)
    - Version
    - Description
    - Communication
    - Record
    - Status
    - Protection
    - Binary input
    - Binary output
    - LED
  - Setting (change)
    - Password
    - Description
    - Communication
    - Record
    - Status
    - Protection
    - Binary input
    - Binary output
    - LED
  - Test
    - Switch
    - Binary output
    - Timer
    - Logic circuit
    - Sim. fault

Figure 4.2.2.1 Relay Menu

Record

In the "Record" menu, the fault records, event records and disturbance records can be displayed or erased. Furthermore, autoreclose function can be displayed in counter form or reset.

Status

The "Status" menu displays the power system quantities, binary input and output status, relay measuring element status, signal source for time synchronization (IRIG-B, RSM, IEC or GPS), terminal condition (In- or out-of-service) and adjusts the clock.

Setting (view)

The "Setting (view)" menu displays the relay version, plant name and the current settings of relay address, IP address and RS232C baud rate in communication, record, status, protection, configurable binary inputs, configurable binary outputs and configurable LEDs.

Setting (change)

The "Setting (change)" menu is used to set or change the settings of password, plant name, relay address, IP address and RS232C baud rate in communication, record, status, protection, configurable binary inputs, configurable binary outputs and configurable LEDs.

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

Test

The "Test" menu is used to set testing switches, to test the trip circuit, to forcibly operate binary output relays, to measure variable timer time, to observe the binary signals in the logic circuit, and to set the synchronized trigger signal for end-to-end dynamic test.

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.

```
   MENU
1=Record                 2=Status
3=Setting(view)          4=Setting(change)
5=Test
```

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 of the screen, screen title and total number of lines of the screen. The last item is not displayed for all the screens. "/6" displayed on the far left means that the screen is in the sixth hierarchical layer, while "1/8" displayed on the far right means that the screen has eight lines excluding the top line and that the cursor is on the first line.

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

```
/6 Scheme switch                                  1/ 8
ARC-EXT  0=Off   1=On                             1 _
ARC-BU   0=Off   1=On                             1
ARCDIFG  0=Off   1=On                             1
VCHK     0=Off   1=LB   2=DB   3=SY               1
ARC-SM   0=Off   1=S2   2=S3   3=S4               1
VTPHSEL  1=A     2=B     3=C                      1
VT-RATE  1=PH/G    2=PH/PH                        1
3PH-VT   1=BUS     2=Line                         1
```

To move to the lower screen or move from the left-side screen to the right-side screen in Appendix E, select the appropriate number on the screen. To return to the higher screen or move from the right-side screen to the left-side screen, 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 autoreclose counts.

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 1 (= Record) to display the "Record" sub-menu.

```
/1 Record
1=Fault record          2=Event record
3=Disturbance record 4=Autoreclose count
```

- Select 1 (= Fault record) to display the "Fault record" screen.

```
/2 Fault record
1=Display     2=Clear
```

- Select 1 (= Display) to display the dates and times of fault records stored in the relay from the top in new-to-old sequence.

```
/3 Fault record                                1/ 8
#1  16/Oct/1997 18:13:57.031
#2  20/Sep/1997 15:29:22.463
#3  04/Jul/1997 11:54:53.977
```

- 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 Fault record #1                               3/45
Date and Time  -->  16/Oct/1997  18:13:57.031
Fault phase    -->  Phase ABCN               Trip  ABC  <--  Tripping phase
Tripping mode  -->  DIF
Fault location -->  ***.*km (Junction-Remote1)  *OB*NC*CF
                    Prefault values
                    Va    ***.*kV   ***.*°   Ia   **.**kA   ***.*°
                    Vb    ***.*kV   ***.*°   Ib   **.**kA   ***.*°
                    Vc    ***.*kV   ***.*°   Ic   **.**kA   ***.*°
                    Vs1   ***.*kV   ***.*°
                    V1    ***.*kV     0.0°   I1   **.**kA   ***.*°
                    V2    ***.*kV   ***.*°   I2   **.**kA   ***.*°
                    V0    ***.*kV   ***.*°   I0   **.**kA   ***.*°
                    V11   ***.*kV   ***.*°
                    V12   ***.*kV   ***.*°
                    Ia1   **.**kA   ***.*°   Ia2  **.**kA   ***.*°
                    Ib1   **.**kA   ***.*°   Ib2  **.**kA   ***.*°
                    Ic1   **.**kA   ***.*°   Ic2  **.**kA   ***.*°
                    I01   **.**kA   ***.*°   I02  **.**kA   ***.*°
                    Ida   **.**kA
                    Idb   **.**kA
                    Idc   **.**kA
                    Id0   **.**kA
Power system   -->  Fault values
quantities          Va    ***.*kV   ***.*°   Ia   **.**kA   ***.*°
                    Vb    ***.*kV   ***.*°   Ib   **.**kA   ***.*°
                    Vc    ***.*kV   ***.*°   Ic   **.**kA   ***.*°
                    Vs1   ***.*kV   ***.*°
                    V1    ***.*kV     0.0°   I1   **.**kA   ***.*°
                    V2    ***.*kV   ***.*°   I2   **.**kA   ***.*°
                    V0    ***.*kV   ***.*°   I0   **.**kA   ***.*°
                    V11   ***.*kV   ***.*°
                    V12   ***.*kV   ***.*°
                    Ia1   **.**kA   ***.*°   Ia2  **.**kA   ***.*°
                    Ib1   **.**kA   ***.*°   Ib2  **.**kA   ***.*°
                    Ic1   **.**kA   ***.*°   Ic2  **.**kA   ***.*°
                    I01   **.**kA   ***.*°   I02  **.**kA   ***.*°
                    Ida   **.**kA
                    Idb   **.**kA
                    Idc   **.**kA
                    Id0   **.**kA
                    THM   ***.*%
                    Telecomm. delay time1      *****μs
                    Telecomm. delay time2      *****μs

                    16/Oct/1997  18:13:57.531
Relevant events --> TPAR1
                    16/Oct/1997  18:13:57.531
                    DIF, FT1
```

Note: I∗1 and I∗2 are phase currents of remote terminal 1 and remote terminal 2. V11 and V12 are symmetrical component voltages of remote terminal 1 and remote terminal 2.

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 1 (= Fault record) to display the "Fault record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Fault record
Clear all fault records?
        ENTER=Yes    CANCEL=No
```

- Press the ENTER (= Yes) 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.

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 1 (= Record) to display the "Record" sub-menu.
- Select 2 (= Event record) to display the "Event record" screen.

```
/2 Event record
1=Disply     2=Clear
```

- Select 1 (= Display) to display the events with date and time from the top in new-to-old sequence.

```
/3 Event record                          3/21
23/Oct/1997 18:18:58.255  DS On
23/Oct/1997 18:13:58.028  DS Off
16/Aug/1997  6:13:57.773  Com.1 fail Off
```

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 2 (=Event record) to display the "Event record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Event record
Clear all event records?
        ENTER=Yes    CANCEL=No
```

- Press the ENTER (= Yes) 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. To display them, do the following:

(*) 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 1 (= Record) to display the "Record" sub-menu.
- Select 3 (= Disturbance record) to display the "Disturbance record" screen.

```
/2 Disturbance record
1=Disply          2=Clear
```

- Select 1 (= Display) to display the date and time of the disturbance records from the top in new-to-old sequence.

```
/3 Disturbance record                    3/12
#1  16/Oct/1997 18:13:57.031
#2  20/Sep/1997 15:29:22.463
#3  04/Jul/1997 11:54:53.977
```

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 3 (= Disturbance record) to display the "Disturbance record" screen.
- Select 2 (= Clear) to display the following confirmation screen.

```
/2 Disturbance record
Clear all disturbance records?
      ENTER=Yes     CANCEL=No
```

- Press the ENTER (= Yes) key to clear all the disturbance records stored in non-volatile memory.

4.2.3.4 Displaying Autoreclose Counts

The autoreclose output counts can be displayed or can be reset to zero as follows.

To display the autoreclose output counts on the LCD, do the following (for 200 series to 500 series models):

- Select 1 (= Record) on the top "MENU" screen to display the "Record" sub-menu.
- Select 4 (= Autoreclose count) to display the "Autoreclose count" screen.

```
/2 Autoreclose count
1=Disply        2=Reset
```

- Select 1 (= Display) to display the autoreclose counts.

```
/3 Autoreclose count
            SPAR        TPAR        MPAR
   CB1     [  46]      [  22]      [  12]
   CB2     [  46]      [  22]      [  12]
```

In the case of two breaker autoreclose (model 300s and 500s), CB1 and CB2 mean busbar breaker and center breaker, respectively. SPAR, TPAR and MPAR mean single-phase, three-phase and multi-phase autoreclose, respectively.

To reset the autoreclose output count, do the following:

- Select 2 (= Reset) on the "Autoreclose count" screen to display the "Reset autoreclose count" screen.

```
/3 Reset autoreclose count
1=CB1
2=CB2
```

- Select 1 (= CB1) or 2 (= CB2 for model 300s and 500s) to display the confirmation screen.

```
/3 Reset autoreclose count
Reset counts?
         ENTER=Yes      CANCEL=No
```

- Press the ENTER key to reset the count to zero and return to the previous screen.

4.2.4 Displaying the Status

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

Metering data of the protected line
Status of binary inputs and outputs
Status of measuring elements output
Status of time synchronization source
Status of remote terminal

The data are updated every second.

This sub-menu is also used to adjust the time of the internal clock.

4.2.4.1 Displaying Metering Data

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

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.

```
/1 Status
1=Metering                2=Binary I/O
3=Relay element           4=Time sync source
5=Clock adjustment        6=Terminal condition
```

- Select 1 (= Metering) to display the "Metering" screen.

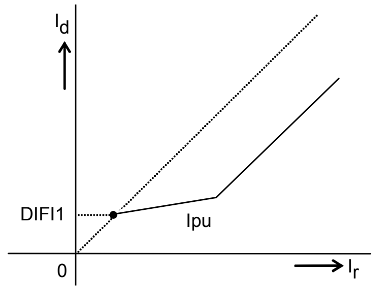
```
/2 Metering    16/Oct/1997   18:13    3/ 25
Va    ***.*kV  ***.*°   Ia    **.**kA ***.*°
Vb    ***.*kV  ***.*°   Ib    **.**kA ***.*°
Vc    ***.*kV  ***.*°   Ic    **.**kA ***.*°
Vs1   ***.*kV  ***.*°
V1    ***.*kV    0.0°   I1    **.**kA ***.*°
V2    ***.*kV  ***.*°   I2    **.**kA ***.*°
V0    ***.*kV  ***.*°   I0    **.**kA ***.*°
V11   ***.*kV  ***.*°
V12   ***.*kV  ***.*°
Ia1   **.**kA  ***.*°   Ia2   **.**kA ***.*°
Ib1   **.**kA  ***.*°   Ib2   **.**kA ***.*°
Ic1   **.**kA  ***.*°   Ic2   **.**kA ***.*°
I01   **.**kA  ***.*°   I02   **.**kA ***.*°
Ida   **.**kA  Ipua **.**kA  Ira  **.**kA
Idb   **.**kA  Ipub **.**kA  Irb  **.**kA
Idc   **.**kA  Ipuc **.**kA  Irc  **.**kA
Id0   **.**kA
THM   ***.*%
Synch.:MODE2A      GPS:OK (L)  NG (R)
Dif.RY:blocked     θdiff:+***.*° (under θ)
Telecomm delay time1        *****us
Telecomm delay time2        *****us
Active power    +****.**MW
Reactive power  -****.**Mvar
Frequency            **.*Hz
```

Note: I∗1 and I∗2 are phase currents of remote terminal 1 and remote terminal 2. V11 and V12 are symmetrical component voltages of remote terminal 1 and remote terminal 2.

In the case of two terminal line application, I∗2 and V12 are not displayed.

Id∗, Ir∗ and Ipu∗ are differential current, restraining current and pickup current respectively. Ipu∗ = DIFI1 when Id∗ = Ir∗.
When input electrical quantities at the local terminal are "0", electrical quantities at the remote terminal are displayed as "–".

Lines 6 and 7 from bottom are displayed in COMMODE=GPS setting only.



Metering data is expressed as primary values or secondary values depending on the setting. For details of the setting, see Section 4.2.6.6.

4.2.4.2 Displaying the Status of Binary Inputs and Outputs

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

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 2 (= Binary I/O) to display the binary input and output status.

```
/2 Binary input & output              3/ 5
Input (IO#1)         [000 000 000 000 000]
Input (IO#2)         [000                ]
Output(IO#1-trip)    [000 000            ]
Output(IO#2)         [000 000 000 000 00 ]
Output(IO#3)         [000 000 000 0      ]
```

The display format of IO and FD modules is shown below.

	[■	■	■	■	■	■	■	■	■	■	■	■	■	■	■]
Input (IO#1)	BI1	BI2	BI3	BI4	BI5	BI6	BI7	BI8	BI9	BI10	BI11	BI12	(BI13	BI14	BI15)
Input (IO#2)	BI16	BI17	BI18	—	—	—	—	—	—	—	—	—	—	—	—
Input (IO#3:IO5)	BI19	BI20	BI21	BI22	BI23	BI24	BI25	BI26	BI27	BI28	—	—	—	—	—
Input (IO#3:IO6)	BI19	BI20	BI21	BI22	BI23	BI24	BI25	—	—	—	—	—	—	—	—
Input (IO#4:IO4)	BI34	BI35	BI36	—	—	—	—	—	—	—	—	—	—	—	—
Output (IO#1-trip)	TPA1	TPB1	TPC1	(TPA2	TPB2	TPC2)	—	—	—	—	—	—	—	—	—
Output (IO#2)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	BO11	BO12	FAIL	BO13	—
Output (IO#3:IO3)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	—	—	—	—	—
Output (IO#3:IO5)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	—	—	—	—	—
Output (IO#3:IO6)	BO1	BO2	BO3	BO4	BO5	BO6	—	—	—	—	—	—	—	—	—
Output (IO#4:IO4)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	BO9	BO10	BO11	BO12	BO13	BO14	—
Output (IO#4:FD)	BO1	BO2	BO3	BO4	BO5	BO6	BO7	BO8	FD1	FD2	—	—	—	—	—

(*) Input and Output shown in the parentheses are not provided in the case of IO8 module.

Lines 1 and 2 show the binary input status. BI1 to BI18 correspond to each binary input signal. For details of the binary input signals, see Appendix G. The status is expressed with logical level "1" or "0" at the photo-coupler output circuit. The module names of IO#1 to IO#4 in the table depend on the model. (Refer to Appendix G.)

Lines 5 to 12 show the binary output status. TPA1 to TPC2 of line 5 correspond to the tripping command outputs. FAIL of line 6 corresponds to the relay failure output. FD1 and FD2 of line 12 correspond to the fault detector output. Other outputs expressed with BO1 to BO14 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 energized 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 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 3 (= Relay element) to display the status of the relay elements.

```
/2 Relay element                      3/ 6
DIF.DIFG             [000 0              ]
OST                  [000 000            ]
CBF                  [000                ]
OC.EF                [000 000 000 00     ]
THM                  [00                 ]
Autoreclose          [000 000 00         ]
```

The display format is as shown below.

	[■	■	■	■	■	■	■	■	■	■	■	■	■	■	■]
DIF, DIFG	A	B	C	DIFG	—	—	—	—	—	—	—	—	—	—	—
		DIF													
OST	α	β	OST	α	β	OST	—	—	—	—	—	—	—	—	—
		OST1			OST2										
OCBF	A	B	C	—	—	—	—	—	—	—	—	—	—	—	—
OC, EF	A	B	C	A	B	C	EF	EFI	A	B	C	—	—	—	—
		OC			OCI					OC1					
THM	THM-A	THM-T													
Autoreclose	OVB	UVB	SYN1	OVL1	UVL1	SYN2	OVL2	UVL2	—	—	—	—	—	—	—

Line 1 shows the operation status of current differential elements for phase faults and earth faults, respectively.

Line 2 shows the status of the out-of-step protection. α and β is "1" when the remote terminal voltage is at α-zone and β-zone respectively. OST shows the operation status of out-of-step element. OST1 and OST2 correspond to the out-of-step detection with remote terminal 1 and 2 respectively.

Line 3 shows the status of the overcurrent element for breaker failure protection.

Line 4 shows the status of the overcurrent elements and fail-safe elements.

Line 5 shows the status of the thermal overload element.

Line 6 shows the status of elements used for autoreclose.

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

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

4.2.4.4 Displaying the Status of the Time Synchronization Source

The internal clock of the GRL100 can be synchronized with external clocks such as the IRIG-B time standard signal clock or RSM (relay setting and monitoring system) clock or by an IEC60870-5-103 control system or GPS. To display on the LCD whether these clocks are active or inactive and which clock the relay is synchronized with, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 4 (= Time sync source) to display the status of time synchronization sources.

```
/2 Time synchronization source       3/ 4
*IRIG:   Active
 RSM:    Inactive
 IEC:    Inactive
 GPS:    Inactive
```

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

For the setting time synchronization, see Section 4.2.6.6.

4.2.4.5 Adjusting the Time

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

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 5 (= Clock adjustment) to display the setting screen.

```
/2   12/Feb/1998 22:56:19  [Local]  1/ 5
Minute(     0-   59):       41 _
Hour  (     0-   23):       22
Day   (     1-   31):       12
Month (     1-   12):        2
Year  ( 1990- 2089):     1998
```

Line 1 shows the current date, time and time synchronization source with which the internal clock is synchronized. The time can be adjusted only when [Local] is indicated on the top line, showing that the clock is running locally. When [IRIG] or [RSM] or [IEC] or [GPS] is indicated, the following adjustment is invalid.

- Enter a numerical value within the specified range for each item and press the ENTER key.
- 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 key is pressed, "Error: Incorrect date" is displayed on the top line and the adjustment is discarded. Adjust again.

4.2.4.6 Displaying the Terminal Condition

Terminal condition is displayed when the scheme switch [OTD] is "ON" and the out-of-service logic is used.

To display the terminal condition on the LCD, do the following:

- Select 2 (= Status) on the top "MENU" screen to display the "Status" screen.
- Select 6 (= Terminal condition) to display the status of the terminal conditions.

```
/2 Terminal condition                2/ 2
Terminal1: In service
Terminal2: Out of service
```

Note: "Out of service" is displayed when the switch [OTD] ="ON" setting.

Bottom line (Terminal 2:) is displayed only for three-terminal line application ("3TERM" setting).

4.2.5 Viewing the Settings

The sub-menu "Setting (view)" is used to view the relay version or the settings made using the sub-menu "Setting (change)".

The following items are displayed:

Relay version
Description
Communication (Relay address and baud rate in the RSM or IEC60870-5-103)
Recording setting

Status setting
Protection setting
Binary input setting
Binary output setting
LED setting

Enter a number 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 3 (= Setting (view)) on the main "MENU" screen to display the "Setting (view)" screen.

```
/1 Setting(view)
1=Version      2=Description      3=Comm.
4=Record       5=Status           6=Protection
7=Binary input   8=Binary output   9=LED
```

- Press 1 (= Version) on the "Setting (view)" screen to display the "Relay version" screen.

```
/2 Relay version                        3/ 7
Relay type:
Serial No.:
Main software:
COM software:
FD software:
PLC data:
IEC103 data :
```

4.2.5.2 Settings

The "Description", " Comm.", "Record", "Status", "Protection", "Binary input", "Binary output" and "LED" screens display the current settings input using the "Setting (change)" sub-menu.

4.2.6 Changing the Settings

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

Password
Description
Communication
Recording
Status
Protection
Binary input
Binary output
LED

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

4.2.6.1 Setting Method

There are three setting methods as follows:

- To enter a selected number
- To enter numerical values
- To enter a text string

To enter a selected number

If a screen as shown below is displayed, perform the 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.

/6 Scheme switch					1/27
TPMODE	1=3PH	2=1PH	3=MPH		1 _
STUB	0=Off	1=On			1
DIFG	0=Off	1=On			1
OST	0=Off	1=Trip	2=BO		1
OCBT	0=Off	1=On			1
OCBIT	0=Off	1=On			1
MOCI	1=Long	2=Std	3=Very	4=Ext	1
EFBT	0=Off	1=On			1
EFBTAL	0=Off	1=On			1
EFIBT	0=Off	1=On			1
MEFI	1=Long	2=Std	3=Very	4=Ext	1
BF1	0=Off	1=T	2=TOC		1
BF2	0=Off	1=On			1
BFEXT	0=Off	1=On			1
THMT	0=Off	1=On			0
THMAL	0=Off	1=On			0
TTSW1	0=Off	1=Trip	2=BO		0
TTSW2	0=Off	1=Trip	2=BO		0
RDIF	0=Off	1=On			1
OTD	0=Off	1=On			0
DIF-FS	0=Off	1=On	2=OCD	3=Both	0
DIFG-FS	0=Off	1=On			0
LSSV	0=Off	1=On			1
SVCNT	0=ALM&BLK	1=ALM			0
CTSV	0=Off	1=ALM&BLK	3=ALM		0
IDSV	0=Off	1=ALM&BLK	3=ALM		0
AOLED	0=Off	1=On			1

(*) TPMODE is not displayed in the case of the model provided with autoreclose function.

- Move the cursor to a setting line.
- Enter the selected number. (Numbers other than those displayed cannot be entered.)
- Press the ENTER key to confirm the entry and the cursor will move to the next line below. (On the lowest line, the entered number blinks.)
- After completing the setting on the screen, press the END key to return to the upper menu.

To correct the entered number, do the followings.

- If it is before pressing the ENTER key, press the CANCEL key and enter the new number.
- If it is after pressing the ENTER key, move the cursor to the correcting line by pressing the

▲ and ▼ keys and enter the new number.

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

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

The number to the right of "Current No. = " shows the current setting.

```
/6 Autoreclose mode
1=Disable  2=SPAR   3=TPAR   4=SPAR&TPAR
5=MPAR2 6=MPAR3 7=EXT1P 8=EXT3P 9=EXTMP
  Current No.= 4          Select No. = _
```

- Enter a number to the right of "Select No. = ". (Numbers other than those displayed cannot be entered.)
- Press the ENTER key to confirm the entry and the entered number blinks.
- After completing the setting on the screen, press the END key to return to the upper screen.

To correct the entered number, do the following.

- If it is before pressing the ENTER key, press the CANCEL key and enter the new number.
- If it is after pressing the ENTER key, enter the new number.

To enter numerical values

When the screen shown below is displayed, perform the 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.

```
/6 Protection element                 1/ **
DIFI1 ( 0.50- 10.00):    1.00 _       A
DIFI2 (  3.0- 120.0):     2.0         A
DIFGI ( 0.25-  5.00):    0.50         A
DIFIC ( 0.00-  5.00):    1.00         A
Vn    (  100-   120):     110         V
TDIFG ( 0.00- 10.00):    0.10         s
DIFSV ( 0.05-  1.00):    0.10         A
TIDSV (    0-    60):      10         s
OCBF  (  0.5-  10.0):     0.5         A
TBF1  (   50-   500):      50        ms
TBF2  (   50-   500):      50        ms
OC    (  0.5- 100.0):     0.5         A
TOC   ( 0.00- 10.00):    1.00         s
OC1   (  0.5- 100.0):     1.0         A
OCI   (  0.5-  25.0):     0.5         A
TOCI  ( 0.05-  1.00):    1.00
TOCIR (  0.0-  10.0):     0.0         s
EF    (  0.5-   5.0):     0.5         A
TEF   ( 0.00- 10.00):    1.00         s
EFI   (  0.5-   5.0):     0.5         A
TEFI  ( 0.05-  1.00):    1.00
TEFIR (  0.0-  10.0):     0.0         s
THM   (  2.0-  10.0):     5.0         A
THMIP (  0.0-   5.0):     0.0         A
TTHM  (  0.5- 300.0):    10.0       min
THMA  (   50-    99):      80         %
OCCHK (  0.5-   5.0):     0.5         A
HYSθ  (    1-     5):       1       deg
```

- Move the cursor to a setting line.
- Enter the numerical value.
- Press the ENTER key to confirm the entry and the cursor will move to the next line below. (If a numerical value outside the displayed range is entered, "Error: Out of range" appears on the top line and the cursor remains on the line. Press the CANCEL key to clear the entry.)
- 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 followings.

- 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 correct line by pressing the ▲ and ▼ keys and enter the new numerical value.

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

To enter a text string

Text strings are entered in the bracket under "Plant name" or "Description" screen.

To select a character, use keys 2, 4, 6 and 8 to move the blinking cursor down, left, up and right. "→" and "←" on each of lines 2 to 4 indicate a space and backspace, respectively. A maximum of 22 characters can be entered within the brackets.

```
/3 Plant name   [ _                    ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ ()[]@_     ←→
abcdefghijklmnopqrstuvwxyz {}*/+-<=>  ←→
0123456789 !"#$%&' :;,.^`             ←→
```

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

"Setting (change)" sub-menu.

```
/2 **************
Change settings?
        ENTER=Yes     CANCEL=No
```

- 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 reentries. Press the CANCEL key to cancel entries made so far and to turn to the "Setting (change)" sub-menu.

4.2.6.2 Password

For the sake of security of changing the settings, password protection can be set as follows:

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 1 (= Password) to display the "Password" screen.

```
/2 Password
     Input new password   [_    ]
    Retype new password   [     ]
```

- Enter a 4-digit number within the brackets after "Input new password" and press the ENTER key.
- For confirmation, enter the same 4-digit number in the brackets after "Retype new password" and press the ENTER key.
- 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.

"Mismatch-password unchanged"

Reentry 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 4 (= Setting (change)) is entered on the top "MENU" screen, the password trap screen "Password" is displayed. If the password is not entered correctly, it is not possible to move to the "Setting (change)" sub-menu screens.

```
 Password
         Input password   [_    ]
```

Canceling or changing the password

To cancel the password protection, enter "0000" in the two brackets on the "Password" screen. The "Setting (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 together for one second on the top "MENU" screen. The screen disappears, and the password protection of the GRL100 is canceled. Set the password again.

4.2.6.3 Description

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

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 2 (= Description) to display the "Description" screen.

```
/2 Description
1=Plant name     2=Description


```

- To enter the plant name, select 1 (= Plant name) on the "Description" screen.

```
/3 Plant name   [   _                           ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ  ()[]@_          ←→
abcdefghijklmnopqrstuvwxyz  {}*/+-<=>       ←→
0123456789 !"#$%&' :;,.^`                   ←→
```

To enter special items, select 2 (= Description) on the "Description" screen.

```
/3 Description  [   _                           ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ  ()[]@           ←→
abcdefghijklmnopqrstuvwxyz  {}*/+-<=>       ←→
0123456789 !"#$%&' :;,.^`                   ←→
```

- Enter the text string.

The plant name and special items entered are viewed with the "Setting (view)" sub-menu and attached to disturbance records when they are displayed on a local or a remote PC.

4.2.6.4 Communication

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

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 3 (= Comm.) to display the "Communication" screen.

```
/2 Communication
1=Address/Parameter
2=Switch

```

- Press 1 (= Address/Parameter) to enter the relay address number.

```
/3 Address/Parameter                        1/ 15
HDLC   (     1-      32):       1 _
IEC    (     0-     254):       2
SYADJ ( -9999-     9999):       0          ms
IP1-1 (      0-     254):       0
IP1-2 (      0-     254):       0
IP1-3 (      0-     254):       0
IP1-4 (      0-     254):       0
SM1-1 (      0-     254):       0
SM1-2 (      0-     254):       0
SM1-3 (      0-     254):       0
SM1-4 (      0-     254):       0
GW1-1 (      0-     254):       0
GW1-2 (      0-     254):       0
GW1-3 (      0-     254):       0
GW1-4 (      0-     254):       0
```

- Enter the address number on "HDLC" column for RSM and/or "IEC" column for IEC60870-5-103 and the compensation value on "SYADJ" column for adjustment of time synchronization of protocol used. (–: lags the time , +: leads the time) And enter IP address for IP1-1 to IP1-4, Subnet mask for SM1-1 to SM4, and Default gateway for GW1-1 to GW1-4.

  IP address: $\underbrace{***}_{\text{IP1-1}}, \underbrace{***}_{\text{IP1-2}}, \underbrace{***}_{\text{IP1-3}}, \underbrace{***}_{\text{IP1-4}}$

  Subnet mask SM1-1 to SM4 and Default gateway GW1-1 to GW1-4: same as above.

- Press the ENTER key.

CAUTION: Do not overlap the number in a network.

- Press 2 (= Switch) on the "Communication" screen to select the protocol and the RS232C transmission speed (baud rate), etc., of the RSM or IEC60870-5-103.

```
/3 Switch                                          1/4
PRTCL1     1=HDLC    2=IEC103                      2 _
232C       1=9.6  2=19.2  3=38.4  4=57.6           4
IECBR      1=9.6  2=19.2                           2
IECBLK     1=Normal  2=Blocked                     1
```

- Select the number corresponding to the system and press the ENTER key.

<PRTCL1>

PRTCL1 is used to select the protocol for channel 1 (COM1 or OP1) of the serial communication port RS485 or FO (fibre optic).

- When the remote RSM system applied, select 1 (=HDLC). When the IEC60870-5-103 applied, select 2 (=IEC103).

<232C>

This line is to select the RS232C 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>

Select 2 (=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:

- Press 4 (= Setting (change)) on the main "MENU" screen to display the "Setting (change)" screen.
- Press 4 (= Record) to display the "Record" screen.

```
/2 Record
1=Fault record          2=Event record
3=Disturbance record
```

Setting the fault recording

- Press 1 (= Fault record) to display the "Fault record" screen.

```
/3 Fault record                      1/ 1
Fault locator      0=Off     1=On      1 _
```

- Enter 1 (= On) to record the fault location.

  Enter 0 (= Off) not to record the fault location.
- Press the ENTER key.

Setting the event recording

- Press 2 (= Event record) to display the "Event record" screen.

```
/3 Event record                          1/129
BITRN (      0-    128):        128 _
EV1   (      0-   3071):          0
EV2   (      0-   3071):          1
EV3   (      0-   3071):          1
EV4   (      0-   3071):          1
                  :
EV128 (      0-   3071):       3071
```

<BITRN>

- Enter the number of event to record the status change both to "On" and "Off". If enter 20, both status change is recorded for EV1 to EV20 events and only the status change to "On" is recorded for EV21 to EV128 events.

<EV∗>

- Enter the signal number to record as the event in Appendix B. It is recommended that this setting can be performed by RSM100 because the signal name cannot be entered by LCD screen. (Refer to Section 3.4.2.)

Setting the disturbance recording

- Press 3 (= Disturbance record) to display the "Disturbance record" screen.

```
/3 Disturbance record
1=Recor time & starter
2=Scheme switch
3=Binary signal
```

- Press 1 (= Record time & starter) to display the "Record time & starter" screen.

```
/4 Record time & starter            1/5
Time   (   0.1-    3.0):   2.0 _     s
OCP-S(     0.5- 250.0):  10.0        A
OCP-G(     0.5- 250.0):  10.0        A
UVP-S(       0-   132):   100        V
UVP-G(       0-    76):    57        V
```

- Enter the recording time and starter element settings.

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

- Press 2 (=Scheme switch) on the "Disturbance record" screen to display the "Scheme switch" screen.

```
/4 Scheme switch                    1/ 5
TRIP     0=Off  1=On                1 _
OCP-S    0=Off  1=On                1
OCP-G    0=Off  1=On                1
UVP-S    0=Off  1=On                1
UVP-G    0=Off  1=On                1
```

- Enter 1 to use as a starter.
- Press 3 (= Binary signal) on the "Disturbance record" screen to display the "Binary signal" screen.

```
/4 Binary signal                    1/32
SIG1  (       0-   3071):      1 _
SIG2  (       0-   3071):      2
SIG3  (       0-   3071):      3
SIG4  (       0-   3071):      4
  :           :                :
SIG32(        0-   3071):      0
```

- Enter the signal number to record binary signals in Appendix B. It is recommended that this setting can be performed by RSM100 because the signal name cannot be entered by LCD screen. (Refer to Section 3.4.3.)

4.2.6.6 Status

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

- Press 5 (= Status) on the "Setting (change)" sub-menu to display the "Status" screen.

```
/2 Status
1=Metering
2=Time synchronization
3=Time zone
```

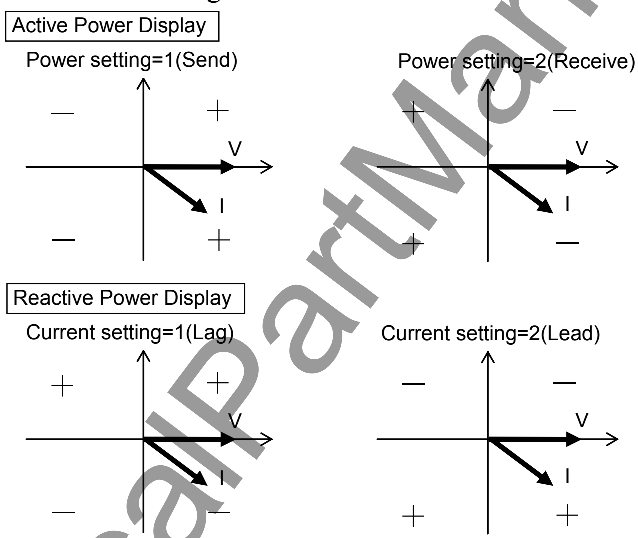
Setting the metering

- Press 1 (= Metering) to display the "Metering" screen.

```
/3 Metering                                        3/3
Display value  1=Primary  2=Secondary   1
Power (P/Q)    1=Send     2=Receive     1
Current        1=Lag      2=Lead        1 _
```

- Enter the selected number and press the ENTER key. Repeat this for all items.

Note: Power and Current setting



Setting the time synchronization

The calendar clock can run locally or be synchronized with external IRIG-B time standard signal, RSM clock, IEC60870-5-103 or GPS. This is selected by setting as follows:

- Press 2 (= Time synchronization) to display the "Time synchronization" screen.

```
/3 Time synchronization                           1/1
Sync  0=Off  1=IRIG  2=RSM  3=IEC  4=GPS    1
```

- Enter the selected number and press the ENTER key.

Note: When to select IRIG-B, RSM, IEC or GPS, check that they are active on the "Time synchronization source" screen in "Status" sub-menu. If it is set to an inactive IRIG-B, RSM, IEC or GPS, the calendar clock runs locally.

Setting the time zone

When the calendar clock is synchronized with the IRIG-B time standard signal or GPS signal, it is possible to transfer GMT to the local time.

- Press 3 (= Time zone) to display the "Time zone" screen.

```
/3 Time zone                                    1/1
GMT  (  -12-  +12):       +9 _       hrs
```

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

4.2.6.7 Protection

The GRL100 can have 8 setting groups for protection according to the change of power system operation, one of which is assigned to be active. To set protection, do the following:

- Press 6 (= Protection) on the "Setting (change)" screen to display the "Protection" screen.

```
/2 Protection
1=Change active group
2=Change setting
3=Copy group
```

Changing the active group

- Press 1 (= Change active group) to display the "Change active group" screen.

```
/3 Change active group(Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
  Current No.= *          Select No. = _
```

- Enter the selected number and press the ENTER key.

Changing the settings

Almost all the setting items have default values that are set when the GRL100 was shipped. For the default values, see Appendix D and H. To change the settings, do the following:

- Press 2 (= Change setting) to display the "Change setting" screen.

```
/3 Change setting       (Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
```

- Press the group number to change the settings and display the "Protection" screen. (In 100 series models, 4 = Autoreclose is not displayed.)

```
/4 Protection                     (Group *)
1=Line parameter
2=Telecommunication   3=Trip
4=Autoreclose
```

Setting the line parameters

Enter the line name, VT&CT ratio and settings for the fault locator as follows:

- Press 1 (= Line parameter) on the "Protection" screen to display the "Line parameter" screen.

```
/5 Line parameter                    (Group *)
1=Line name
2=VT & CT ratio
3=Fault locator
```

- Press 1 (= Line name) to display the "Line name" screen.
- Enter the line name as a text string.
- Press the END key to return the display to the "Line parameter" screen.
- Press 2 (= VT&CT ratio) to display the "VT&CT ratio" screen.

```
/6 VT & CT ratio                           1/4
VT    (    1-    20000):    2200   _
VTs1  (    1-    20000):    2200
VTs2  (    1-    20000):    2200
CT    (    1-    20000):     400
```

- Enter the VT ratio for protection function and press the ENTER key.
- Enter the VTs1 ratio and/or VTs2 ratio for autoreclose function and press the ENTER key. VTs1 is used for the VT ratio setting for voltage and synchronism check of autoreclose function. VTs2 is used for the VT ratio setting for the other voltage and synchronism check at the time of two-breaker autoreclose.
- Enter the CT ratio and press the ENTER key.
- Press the END key to return the display to the "Line parameter" screen.
- Press 3 (= Fault locator) to display the "Fault locator" screen.

```
/6 Fault locator                     (Group *)
1=Setting impedance mode
2=Line data
```

- Press 1 (= Setting impedance mode) to display the "Setting impedance mode" screen.

```
/7 Setting impedance mode            (Group *)
1=Positive sequence impedance
2=Phase impedances
  Current No.= 1             Select No. = _
```

One of the setting modes can be selected.

- Select 1 (= Positive sequence impedance), then the following "Line data" screen is displayed.

```
/7 Line data                                1/ 9
1X1   (   0.00 - 199.99) :    24.5_    Ω
1R1   (   0.00 - 199.99) :     2.8     Ω
1Line(   0.0  -  399.9) :    80.0     km
2X1   (   0.00 - 199.99) :    12.5     Ω
2R1   (   0.00 - 199.99) :     1.5     Ω
2Line(   0.0  -  399.9) :    41.3     km
3X1   (   0.00 - 199.99) :     6.0     Ω
3R1   (   0.00 - 199.99) :     0.8     Ω
3Line(   0.0  -  399.9) :    20.3     km
```

In case of two-terminal lines, enter the reactive and resistive component of the positive sequence line impedance to the items 1X1 and 1R1 and line length to 1 Line. Press the enter key for each entry.

Note: The line impedance is input with the secondary value.

In case of three-terminal lines, enter the data on the first section from the local terminal to the junction to the items expressed as 1∗∗, the data on the second section from the junction to the remote terminal 1 to 2∗∗ and the data on the third section from the junction to the remote terminal 2 to 3∗∗.

- Select 2 (= Phase impedances), then the following "Line data" screen is displayed.

In case of two-terminal lines, enter the reactive and resistive component of the self-impedances and mutual-impedances of the line to the items expressed as 1X∗∗ and 1R∗∗ and line length to 1 Line. Press the ENTER key for each entry.

In case of three-terminal lines, enter the data on the first section from the local terminal to the junction to 1∗∗∗, the data on the second section from the junction to the remote terminal 1 to 2∗∗∗ and the data on the third section from the junction to the remote terminal 2 to 3∗∗∗.

- Press the END key after completing the settings to return the display to the "Line parameter" screen

```
/7 Line data                                        1/39
1Xaa   ( 0.00 - 199.99) :  34.80                     Ω
1Xbb   ( 0.00 - 199.99) :  33.40                     Ω
1Xcc   ( 0.00 - 199.99) :  30.90                     Ω
1Xab   ( 0.00 - 199.99) :  13.60                     Ω
1Xbc   ( 0.00 - 199.99) :  11.90                     Ω
1Xca   ( 0.00 - 199.99) :   9.30                     Ω
1Raa   ( 0.00 - 199.99) :   3.36                     Ω
1Rbb   ( 0.00 - 199.99) :   3.39                     Ω
1Rcc   ( 0.00 - 199.99) :   3.52                     Ω
1Rab   ( 0.00 - 199.99) :   2.48                     Ω
1Rbc   ( 0.00 - 199.99) :   2.56                     Ω
1Rca   ( 0.00 - 199.99) :   2.48                     Ω
1Line  ( 0.0  -  399.9) :  80.0                      km
2Xaa   ( 0.00 - 199.99) :  17.40                     Ω
2Xbb   ( 0.00 - 199.99) :  16.70                     Ω
2Xcc   ( 0.00 - 199.99) :  15.50                     Ω
2Xab   ( 0.00 - 199.99) :   6.80                     Ω
2Xbc   ( 0.00 - 199.99) :   6.01                     Ω
2Xca   ( 0.00 - 199.99) :   4.70                     Ω
2Raa   ( 0.00 - 199.99) :   1.68                     Ω
2Rbb   ( 0.00 - 199.99) :   1.70                     Ω
2Rcc   ( 0.00 - 199.99) :   1.76                     Ω
2Rab   ( 0.00 - 199.99) :   1.24                     Ω
2Rbc   ( 0.00 - 199.99) :   1.28                     Ω
2Rca   ( 0.00 - 199.99) :   1.24                     Ω
2Line  ( 0.0  -  399.9) :  40.3                      km
3Xaa   ( 0.00 - 199.99) :   8.70                     Ω
3Xbb   ( 0.00 - 199.99) :   8.35                     Ω
3Xcc   ( 0.00 - 199.99) :   7.75                     Ω
3Xab   ( 0.00 - 199.99) :   3.40                     Ω
3Xbc   ( 0.00 - 199.99) :   3.01                     Ω
3Xca   ( 0.00 - 199.99) :   2.35                     Ω
3Raa   ( 0.00 - 199.99) :   0.84                     Ω
3Rbb   ( 0.00 - 199.99) :   0.85                     Ω
3Rcc   ( 0.00 - 199.99) :   0.88                     Ω
3Rab   ( 0.00 - 199.99) :   0.62                     Ω
3Rbc   ( 0.00 - 199.99) :   0.64                     Ω
3Rca   ( 0.00 - 199.99) :   0.62                     Ω
3Line  ( 0.0  -  399.9) :  20.5                      km
```

Setting the telecommunication

- Press 2 (= Telecommunication) on the "Protection" screen to display the "Telecommunication" screen.

```
/5 Telecommunication                  (Group *)
1=Scheme switch
2=Telecommunication element
```

- Press 1 (= Scheme switch) to display the "Scheme switch" screen. Set the communication mode "A", "B" or "GPS", and the "Master" or "Slave", and "2 terminal line (=2TERM)" or "3 terminal line (=3TERM)" or "Dual communication for 2 terminal line (=Dual)". Refer to

Section 2 and 2.2.2.

However "TERM", "CH.CON", "T.SFT2" and "B.SYN2" items are not displayed in the case of 2 terminal models.

For the "CH.CON" setting, refer to Sections 2.2.6 and 2.11.3.

In "B.SYN∗", set to "On" when synchronizing the sending signal of GRL100 with the external clock signal or the receiving signal from multiplexer.

For "GPSBAK", "AUTO2B" and "SRCθ", refer to Section 2.2.7.

```
/6 Scheme switch                                    1/12
COMMODE   1=A     2=B        3=GPS                  2 _
SP.SYN.   1=Master           2=Slave                1
TERM      1=2TERM            2=3TERM     3=Dual     1
CH.CON    1=Normal           2=Exchange             1
RYIDSV    0=Off              1=On                   1
T.SFT1    0=Off              1=On                   1
T.SFT2    0=Off              1=On                   1
B.SYN1    0=Off              1=On                   1
B.SYN2    0=Off              1=On                   1
GPSBAK    0=Off              1=On                   1
AUTO2B    0=Off              1=On                   0
SRCθ      0=Disable          1=I                    1
```

Note: The setting of [COMMODE], [TERM], [GPSBAK], [AUTO2B], [SRC θ] and [RYIDSV] must be identical at all terminals.

- Press 2 (= Telecommunication element) to display the "Telecommunication element" screen.

```
/6 Telecommunication element                  1/ 7
PDTD   (   200 -  2000):      1000 _    μs
RYID   (     0 -    63):         0
RYID1  (     0 -    63):         0
RYID2  (     0 -    63):         0
TDSV   (   100 - 16000):      6000      μs
TCDT1  (-10000- 10000):          0      us
TCDT2  (-10000- 10000):          0      us
```

- Enter the time delay setting values and the relay identity numbers (address numbers) and press the ENTER key for each setting.

PDTD: Setting for permissible difference of telecommunication delay time.

RYID, RYID1, RYID2: Setting for address numbers of the local (RYID) and remote (RYID1 and RYID2) relays. These items are only enabled when the switch [RYIDSV] is set to "ON". See Section 2.2.12.

TDSV: Setting for transmission delay time to be supervised.

TCDT1, TCDT2: Adjusting the transmission delay time for CH1 and CH2

- After settings, press the END key to return to the "Telecommunication" screen.

Setting the trip function

To set the scheme switches and protection elements, do the following. Protection elements are measuring elements and timers.

- Press 3 (= Trip) on the "Protection" screen to display the "TRIP" screen.

```
/5 Trip                         (Group *)
1=Scheme switch
2=Protection element
```

Note: Depending on the scheme switch setting, some of the scheme switches and protection elements are not used and so do not need to be set. The trip function setting menu of the GRL100 does not display unnecessary setting items. Therefore, start by setting the scheme switch, and set the protection elements.
As a result of the above, note that some of the setting items described below may not appear in the actual setting.

Setting the scheme switches

- Press 1 (= Scheme switch) to display the "Scheme switch" screen.

```
/6 Scheme switch                          1/27
TPMODE   1=3PH   2=1PH   3=MPH            1 _
STUB     0=Off   1=On                     1
DIFG     0=Off   1=On                     1
OST      0=Off   1=Trip  2=BO             1
OCBT     0=Off   1=On                     1
OCBIT    0=Off   1=On                     1
MOCI     1=Long  2=Std   3=Very  4=Ext    1
EFBT     0=Off   1=On                     1
EFBTAL   0=Off   1=On                     1
EFIBT    0=Off   1=On                     1
MEFI     1=Long  2=Std   3=Very  4=Ext    1
BF1      0=Off   1=T     2=TOC            1
BF2      0=Off   1=On                     1
BFEXT    0=Off   1=On                     1
THMT     0=Off   1=On                     0
THMAL    0=Off   1=On                     0
TTSW1    0=Off   1=Trip  2=BO             0
TTSW2    0=Off   1=Trip  2=BO             0
RDIF     0=Off   1=On                     1
OTD      0=Off   1=On                     0
DIF-FS   0=Off   1=On    2=OCD   3=Both   0
DIFG-FS  0=Off   1=On                     0
LSSV     0=Off   1=On                     1
SVCNT    0=ALM&BLK  1=ALM                 0
CTSV     0=Off  1=ALM&BLK  3=ALM          0
IDSV     0=Off  1=ALM&BLK  3=ALM          0
AOLED    0=Off   1=On                     1
```

Note: The setting elements on the screen depend on the relay model.

- Enter the number corresponding to the switch status to be set and press the ENTER key for each switch.
- After setting all switches, press the END key to return to the "Trip" screen.

Setting the protection elements

- Press 2 (= Protection element) to display the "Protection element" screen.

```
/6 Protection element                  1/ **
DIFI1 ( 0.50- 10.00):   1.00 _          A
DIFI2 (  3.0- 120.0):    2.0            A
DIFGI ( 0.25-  5.00):   0.50            A
DIFIC ( 0.00-  5.00):   1.00            A
Vn    (  100-   120):    110            V
TDIFG ( 0.00- 10.00):   0.10            s
DIFSV ( 0.05-  1.00):   0.10            A
TIDSV (    0-    60):     10            s
OCBF  (  0.5-  10.0):    0.5            A
TBF1  (   50-   500):     50           ms
TBF2  (   50-   500):     50           ms
OC    (  0.5- 100.0):    0.5            A
TOC   ( 0.00- 10.00):   1.00            s
OC1   (  0.5- 100.0):    1.0            A
OCI   (  0.5-  25.0):    0.5            A
TOCI  ( 0.05-  1.00):   1.00
TOCIR (  0.0-  10.0):    0.0            s
EF    (  0.5-   5.0):    0.5            A
TEF   ( 0.00- 10.00):   1.00            s
EFI   (  0.5-   5.0):    0.5            A
TEFI  ( 0.05-  1.00):   1.00
TEFIR (  0.0-  10.0):    0.0            s
THM   (  2.0-  10.0):    5.0            A
THMIP (  0.0-   5.0):    0.0            A
TTHM  (  0.5- 300.0):   10.0          min
THMA  (   50-    99):     80            %
OCCHK (  0.5-   5.0):    0.5            A
HYSθ  (    1-     5):      1          deg
CFID  ( 0.25-  5.00):   0.25            A
CFUV  (   20-    60):     20            V
CFDV  (    1-    10):      7            %
CFOVG (  0.1-  10.0):    1.0            V
```

Note: The setting elements on the screen depend on the relay model.

- Enter the numerical value and press the ENTER key for each element.
- After setting all elements, press the END key to return to the "Trip" screen.

Setting the autoreclose function

To set the autoreclose mode, scheme switches and autoreclose elements, do the following:

Note: Depending on the autoreclose mode and scheme switch setting, some of the scheme switches and autoreclose elements are not used and so do not need to be set. The autoreclose function setting menu of the GRL100 does not display unnecessary setting items. Therefore, start by setting the autoreclose mode, and proceed to set the scheme switch, then the autoreclose elements.

As a result of the above, note that some of the setting items described below may not appear in the actual setting.

- Press 4 (= Autoreclose) on the "Protection" screen to display the "Autoreclose" screen.

```
/5 Autoreclose                    (Group *)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

Setting the autoreclose mode

- Press 1 (= Autoreclose mode) to display the "Autoreclose mode" screen.

```
/6 Autoreclose mode
1=Disable  2=SPAR   3=TPAR   4=SPAR&TPAR
5=MPAR2 6=MPAR3 7=EXT1P 8=EXT3P 9=EXTMP
  Current No.= 4          Select No. = _
```

Note: The setting elements on the screen depend on the relay model.

- Select the autoreclose mode to be used by entering the number corresponding to the autoreclose mode and press the ENTER key.
- Press the END key to return to the "Autoreclose" screen.

Setting the scheme switches

- Press 2 (= Scheme switch) to display the "Scheme switch" screen.

```
/6 Scheme switch                           1/11
ARC-EXT  0=Off  1=On                       1 _
ARC-BU   0=Off  1=On                       1
ARCDIFG  0=Off  1=On                       1
VCHK     0=Off  1=LB  2=DB  3=SY           1
ARC-SM   0=Off  1=S2  2=S3  3=S4           1
ARC-SUC  0=Off  1=On                       0
MA-NOLK  0=FT  1=T  2=S+T                  0
VTPHSEL  1=A    2=B   3=C                  1
VT-RATE  1=PH/G   2=PH/PH                  1
3PH-VT   1=BUS    2=Line                   1
UARCSW   1=P1  2=P2  3=P3                  1
```

Note: The setting elements on the screen depend on the relay model.

- Enter the number corresponding to the switch status to be set and press the ENTER key for each switch.
- After setting all switches, press the END key to return to the "Autoreclose" screen.

Setting the autoreclose elements

- Press 3 (= Autoreclose element) to display the "Autoreclose element" screen.

```
/6 Autoreclose element          (Group *)
1=Autoreclose timer
2=Synchrocheck
```

Press 1 to display the "Autoreclose timer" screen or 2 to display the "Synchrocheck" screen for voltage check and synchronism check elements.

Set these elements in the same way as protection elements.

Setting group copy

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

- Press 3 (= Copy group) on the "Protection" screen to display the "Copy group A to B" screen.

```
/3 Copy group A to B  (Active group= *)
A    (    1-    8):        _
B    (    1-    8):
```

- 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 requirement described in Table 3.2.2.

- Press 7 (= Binary input) on the "Setting (change)" sub-menu to display the "Binary input" screen.

```
/2 Binary input                          1/ 31
BISW 1  1=Norm  2=Inv                        1 _
BISW 2  1=Norm  2=Inv                        1
BISW 3  1=Norm  2=Inv                        1
BISW 4  1=Norm  2=Inv                        1
BISW 5  1=Norm  2=Inv                        1
BISW 6  1=Norm  2=Inv                        1
BISW 7  1=Norm  2=Inv                        1
BISW 8  1=Norm  2=Inv                        1
BISW 9  1=Norm  2=Inv                        1
BISW10  1=Norm  2=Inv                        1
BISW11  1=Norm  2=Inv                        1
BISW12  1=Norm  2=Inv                        1
BISW13  1=Norm  2=Inv                        1
BISW14  1=Norm  2=Inv                        1
BISW15  1=Norm  2=Inv                        1
BISW16  1=Norm  2=Inv                        1
BISW17  1=Norm  2=Inv                        1
BISW18  1=Norm  2=Inv                        1
BISW19  1=Norm  2=Inv                        1
BISW20  1=Norm  2=Inv                        1
BISW21  1=Norm  2=Inv                        1
BISW22  1=Norm  2=Inv                        1
BISW23  1=Norm  2=Inv                        1
BISW24  1=Norm  2=Inv                        1
BISW26  1=Norm  2=Inv                        1
BISW27  1=Norm  2=Inv                        1
BISW28  1=Norm  2=Inv                        1
BISW34  1=Norm  2=Inv                        1
BISW35  1=Norm  2=Inv                        1
BISW36  1=Norm  2=Inv                        1
```

Note: The setting elements on the screen depend on the relay model.

- Enter 1 (= Normal) or 2 (= Inverted) and press the ENTER key for each binary input.

4.2.6.9 Binary Output

All the binary outputs of the GRL100 except the tripping command, and relay failure signal are user-configurable. It is possible to assign one signal or up to six ANDing or ORing signals to one output relay. Available signals are listed in Appendix B.

It is also possible to attach a drop-off delay time of 0.2 second to these signals. The drop-off delay time is disabled by the scheme switch [BOTD].

Appendix D shows the factory default settings.

To configure the binary output signals, do the following:

Selection of output module

- Press 8 (= Binary output) on the "Setting (change)" screen to display the "Binary output" screen. The available output module(s) will be shown. (This differs depending on the relay model; the following is for models 202 and 302.)

```
/2 Binary output
1=IO#2      2=IO#3      3=IO#4
```

- Press the number corresponding to the selected output module to display the "Binary output" screen.

```
/3 Binary output                    (*****)
Select BO             (  1- **)

                        Select No.= _
```

Note: The setting is required for all the binary outputs. If any of the binary outputs are not to be used, enter 0 for logic gates #1 to #6 when assigning signals.

Selecting the output relay

- Enter the output relay number and press the ENTER key to display the "Setting" screen.

```
/4 Setting             (BO** of *****)
1=Logic gate type & delay timer
2=Input to logic gate
```

Setting the logic gate type and timer

- Press 1 to display the "Logic gate type & delay timer" screen.

```
/5 Logic gate type & delay timer     1/ 2
Logic   1=OR   2=AND                 1 _
BOTD    0=Off  1=On                  1
```

- Enter 1 or 2 to use an OR gate or AND gate and press the ENTER key.
- Enter 0 or 1 to add 0.2s off-delay time to the output relay or not and press the ENTER key.
- Press the END key to return to the "Setting" screen.

Assigning signals

- Press 2 on the "Setting" screen to display the "Input to logic gate" screen.

```
/5 Input to logic gate                1/ 6
In #1(     0- 3071):    21 _
In #2(     0- 3071):     4
In #3(     0- 3071):    67
In #4(     0- 3071):     0
In #5(     0- 3071):     0
In #6(     0- 3071):     0
```

- Assign signals to gates (In #1 to #6) by entering the number corresponding to each signal referring to Appendix B.

  Note: If signals are not assigned to all the gates #1 to #6, enter 0 for the unassigned gate(s).

Repeat this process for the outputs to be configured.

4.2.6.10 LEDs

Four LEDs of the GRL100 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. The signals listed in Appendix B can be assigned to each LED as follows.

Selection of LED

- Press 9 (= LED) on the "Setting (change)" screen to display the "LED" screen.

```
/2 LED
Select LED            (  1-  4)

                      Select No.= _
```

- Enter the LED number and press the ENTER key to display the "Setting" screen.

```
/3 Setting              (LED1)
1=Logic gate type & reset
2=Input to logic gate
```

Setting the logic gate type and reset

- Press 1 to display the "Logic gate type and reset" screen.

```
/4 Logic gate type & reset        1/ 2
Logic   1=OR   2=AND              1 _
Reset   0=Inst 1=Latch            1
```

- Enter 1 or 2 to use an OR gate or AND gate and press the ENTER key.
- Enter 0 or 1 to select “Instantaneous reset” or “Latch reset” and press the ENTER key.
- Press the END key to return to the "Setting" screen.

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

Assigning signals

- Press 2 on the "Setting" screen to display the "Input to logic gate" screen.

```
/4 Input to logic gate           1/ 4
In #1(    0-  3071):     21 _
In #2(    0-  3071):      4
In #3(    0-  3071):     67
In #4(    0-  3071):      0
```

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

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

Repeat this process for other LEDs to be configured.

4.2.7 Testing

The sub-menu "Test" provides such functions as setting of testing switches, forced operation of binary outputs, time measurement of the variable setting timer, logic signal observation and synchronized end-to-end tests.

4.2.7.1 Testing switches

- Press 5 (= Test) on the top "MENU" screen to display the "Test" screen.

```
/1 Test
1=Switch              2=Binary output
3=Timer               4=Logic circuit
5=Sim. fault          6=Init. 2B
```

- Press 1 (= Switch) to display the switch screen.
- Enter the number corresponding to the switch status to be set and press the ENTER key for each switch.
- Press the END key to return to the "Test" screen.

```
/2 Switch                        1/**
A.M.F.    0=Off    1=On          1 _
L.test    0=Off    1=On          0
Open1     0=Off    1=On          0
Open2     0=Off    1=On          0
T.test    0=Off    1=On          0
D.test    0=Off    1=On          0
IECTST    0=Off    1=On          0
THMRST    0=Off    1=On          0
COM4      0=Off    1=On          0
COM5      0=Off    1=On          0
SCOM1     0=Off    1=On          0
SCOM2     0=Off    1=On          0
S2COM1    0=Off    1=On          0
S2COM2    0=Off    1=On          0
   :
S2COM12   0=Off    1=On          0
```

The fourth line (Open2) is displayed only for three-terminal line application ("3TERM" setting).

The automatic monitor function (A.M.F.) can be disabled by setting the switch [A.M.F] to

"OFF".

A.M.F.

Disabling the A.M.F. prevents tripping from being blocked 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.

Note: If the simulated fault inputs are applied under a failure condition and the A.M.F. is switched "OFF", the relay will issue a trip command but the operation of the relay cannot be displayed correctly.

L.TEST

The switch [L. test] is used for local testing.

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

Thus in the three-terminal application, the out-of-service terminal can carry out a local relay testing without disturbing the in-service terminals.

Note: When [L. test] is set to "1" (= On) in the two-terminal application, the current differential element can operate at both terminals if the load current is larger than the setting of DIFI1.

Open1, Open2

The switch [Open 1] and [Open 2] are used to maintain two terminal operation in three-terminal line application, when one terminal is out-of-service (i.e., breaker and/or disconnector are opened) due to relay failures or communication failures and fault investigations.

When the remote terminal 1 or 2 is out-of-service, set the switch [Open 1] or [Open 2] to "1" (=On) at the in-service terminals to remove the out-of-service remote terminal from protection. The remote terminal 1 is a terminal to which the local communication port 1 is linked and the remote terminal 2 is a terminal to that the local communication port 2 is linked.

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.

D.TEST

The switch [D. test] is used to test the relay models with an optical interface (Short wavelength light, GI, 2km class) and with an electrical interface in accordance with CCITT-G703-1.2.1, 1.2.2 and 1.2.3. Setting the [D. test] to "1" (= On) enables loop-back tests as well as end-to-end tests of the relays under the direct connection of the communication circuit. For the loop-back test or end-to-end test setup, see Section 6.5.1.1.

Note: Be sure to restore these switches after the tests are completed or three-terminal normal operation resumes. In normal operation, the switch [A.M.F] is set to "1" (=On) and other switches to "0" (=Off). In other situation, the red "TESTING" LED is lit for alarming.

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.
- Press the END key to return to the "Test" screen.

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) for testing the thermal overload element, and press the ENTER key.
- Press the END key to return to the "Test" screen.

COM∗ and SCOM∗

It is possible to forcibly send communication data [COM4], [COM5], [SCOM1], [SCOM2], [S2COM1] to [S2COM12] and [S3COM1] to [S3COM12] for testing. If testing, a desired communication data is set to "ON" 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 for each module.

- Press 2 (= Binary output) on the "Test" screen to display the "Binary output" screen.

```
/2 Binary output
1=IO#1        2=IO#2        3=IO#3
```

The LCD displays the output modules installed depending on the model.

- Enter the selected number corresponding to each module to be operated. Then the LCD displays the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.

```
/3 BO           (0=Disable 1=Enable)   1/ 6
IO#1   TP-A1                            1 _
IO#1   TP-B1                            1
IO#1   TP-C1                            1
IO#1   TP-A2                            0
IO#1   TP-B2                            0
IO#1   TP-C2                            0
```

```
/3 BO           (0=Disable 1=Enable)   1/14
IO#2   BO1                             1 _
IO#2   BO2                             1
IO#2   BO3                             1
IO#2   BO4                             0
IO#2   BO5                             0
IO#2   BO6                             0
IO#2   BO7                             0
IO#2   BO8                             0
IO#2   BO9                             0
IO#2   BO10                            0
IO#2   BO11                            0
IO#2   BO12                            0
IO#2   FAIL                            0
IO#2   BO13                            0
```

- Enter 1 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.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to operate the assigned output relays.
- Release pressing the 1 key to reset the operation.

Caution: In case of relay models with fault detector, FD module BO also operates when IO#1 module BO is forcibly operated.

- Press the CANCEL key to return to the upper screen.

4.2.7.3 Timer

The pick-up or drop-off delay time of the variable timer used in the scheme logic can be measured with monitoring jacks A and B. Monitoring jacks A and B are used to observe the input signal and output signal to the timer, respectively.

- Press 3(= Timer) on the "Test menu" screen to display the "Timer" screen.

```
/2 Timer                                1/ 1
Timer(     1-    48):       1 _
```

- Enter the number corresponding to the timer to be observed and press the ENTER key. The timers and related numbers are listed in Appendix C.
- Press the END key to display the following screen.

```
/2 Timer                                   1/ 1
Press ENTER to operate.

Press CANCEL to cancel.
```

- Press the ENTER key to operate the timer. The "TESTING" LED turns on, and timer is initiated and the following display appears. The input and output signals of the timer can be observed at monitoring jacks A and B respectively. The LEDs above monitoring jacks A or B are also lit if the input or output signal exists.

```
/2 Timer                                   1/ 1
Operating...
Press END to reset.
Press CANCEL to cancel.
```

- Press the CANCEL key to test other timers. Repeat the above testing.
- Press the END key to reset the input signal to the timer. The "TESTING" LED turns off.

To measure the drop-off delay time, press the END key after the LED above jack B lights.

4.2.7.4 Logic Circuit

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

- Press 4 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.

```
/2 Logic circuit                           1/ 2
TermA(      0-   3071):        1 _
TermB(      0-   3071):       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.

4.2.7.5 Synchronized Test Trigger

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.196) in the signal list is assigned to a user configurable high-speed type auxiliary relay (BO12 or BO13 of IO2) at the local and remote terminals.

Note: Even if a logic including the signal FG (No.196) is programmed and assigned into the BO13 of IO2, the BO13 outputs the signal FG itself instead of the result of the logic programmed.

The auxiliary relays trigger a simultaneous test current application to the local and remote terminal differential elements when the 1 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.

Note: FG signal cannot be observed at monitoring jacks A and B.

- Press 5 (= Test) on the top "MENU" screen to display the "Test" screen.

```
/1 Test
1=Switch                    2=Binary output
3=Timer                     4=Logic circuit
5=Sim. fault
```

- Press 5 (= Sim. fault) on the "Test" screen to display the "Simultaneous fault" screen

```
/2 Simultaneous fault
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to generate the synchronized trigger signal.
- Release pressing the 1 key to reset the operation.
- Press the CANCEL key to return to the "Test" screen.

4.2.7.6 Init. 2B

To change the synchronization mode to MODE 2B manually in GPS mode, do the followings.

- Press 6 (=Init.2B) on the "Test" screen to display the "Init.2B" screen.

```
/2 Initiate MODE2B
Keep pressing 1 to Initiate MODE2B.
```

- Keep pressing the 1 key for 1 second to initiate MODE2B.

When the initiation succeeded, the message "Initiated." is displayed.

```
/2 Initiate MODE2B
Keep pressing 1 to Initiate MODE2B.
Initiated.
```

If not, the message "Failed." is displayed.

```
/2 Initiate MODE2B
Keep pressing 1 to Initiate MODE2B.
Failed.
```

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 voltage and current are available in addition to the items available on the LCD screen.

- Display of voltage and current waveform: Oscillograph, vector display
- Symmetrical component analysis: On arbitrary time span
- Harmonic analysis: On arbitrary time span
- Frequency analysis: On arbitrary time span

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.

For the details, see the separate instruction manual "PC INTERFACE RSM100".

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 4.4.2 shows the configuration of the RSM system with Ethernet LAN (option). The relays are connected to HUB through UTP cable using RJ-45 connector at the rear of the relay. The relay recognizes the transmission speed automatically.

In case of the optional fiber optic interface (option), the relays are connected through graded-index multi-mode 50/125μm or 62.5/125μm type optical fiber using ST connector at the rear of the relay.

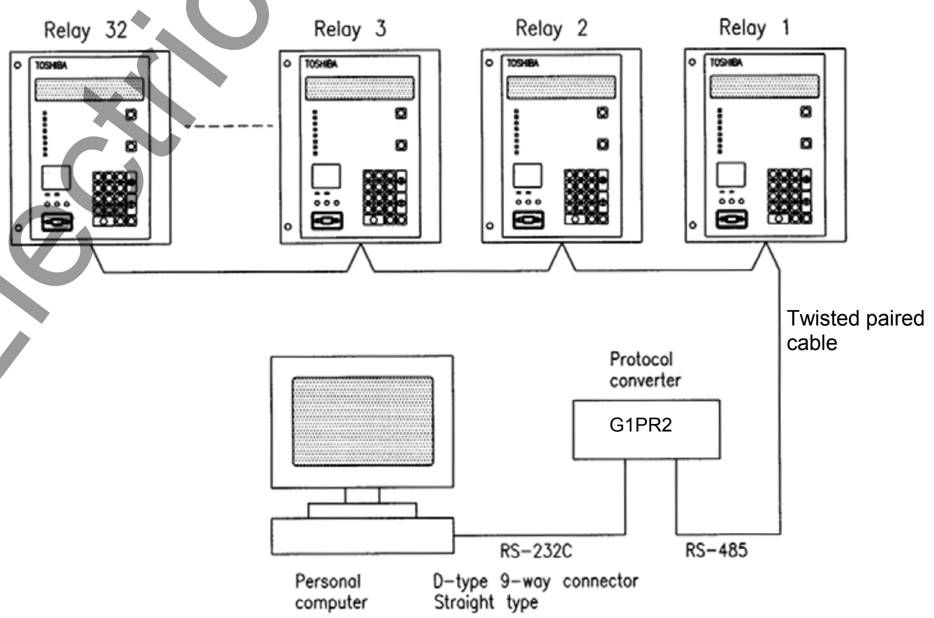


Figure 4.4.1 Relay Setting and Monitoring System (1)

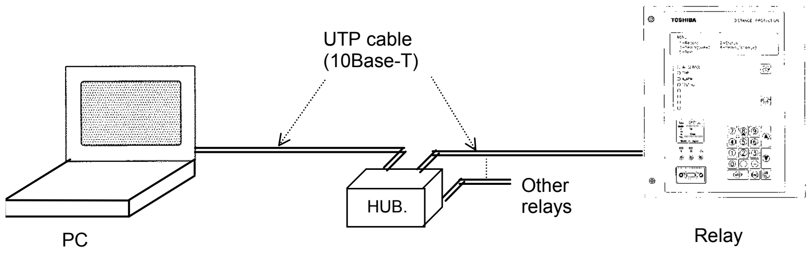


Figure 4.4.2 Relay Setting and Monitoring System (2)

4.5 IEC 60870-5-103 Interface

The GRL100 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, voltage, active power, reactive power, frequency
- 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 Q.

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 connection is similar to Figure 4.4.1.

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
- Metering
- Automatic supervision
- Display of the system quantities on the digest screen
- Display of the fault records on the digest screen
- Display of the automatic monitoring results on the digest screen

The calendar clock can run locally or be synchronized with the external IRIG-B time standard signal, RSM, IEC or GPS clock. This can be selected by setting.

If it is necessary to synchronize with the IRIG-B time standard signal or GPS signal, it is possible to transform GMT to the local time by setting.

When the relays are connected to the RSM system as shown in Figure 4.4.1, the calendar clock of each relay is synchronized with the RSM clock. If the RSM clock is synchronized with the external time standard (GPS clock etc.), then all the relay clocks are synchronized 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.

Check that the following accessories are attached.

- 3 pins for the monitoring jack, packed in a plastic bag.
- An attachment kit required in rack-mounting, if ordered. (See Appendix F.)

  1 large bracket with 5 round head screws, spring washers and washers (M4×10)
  1 small bracket with 3 countersunk head screws (M4×6)
  2 bars with 4 countersunk head screws (M3×8)

Always store the relays in a clean, dry environment.

5.2 Relay Mounting

Either a rack or flush mounting relay is delivered as designated by the customer. The GRL100 models are classified into two types by their case size, type A and type B. Appendix F shows the case outlines.

If the customer requires a rack-mounting relay, support metal fittings necessary to mount it in the 19-inch rack are also supplied with the relay.

When to mount the relay in the rack, detach the original brackets fixed on both sides of the relay and seals on the top and bottom of the relay. Attach the larger bracket and smaller bracket on the left and right side of the relay respectively and the two bars on the top and bottom of the relay.

How to mount the attachment kit, see Appendix F.

Dimensions of the attachment kits EP-101 and EP-102 is also shown in Appendix F.

5.3 Electrostatic Discharge

⚠CAUTION

Do not take out any modules 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 potential of several thousand volts. Discharge of these voltages into semiconductor devices when handling electronic circuits can cause serious damage, which 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 modules unnecessarily.

Each module incorporates the highest practicable protection for its semiconductor devices. However, if it becomes necessary to withdraw a module, precautions should be taken to preserve the high reliability and long life for which the equipment has been designed and manufactured.

⚠CAUTION

- Before removing a module, ensure that you are at the same electrostatic potential as the equipment by touching the case.
- Handle the module by its front plate, frame or edges of the printed circuit board. Avoid touching the electronic components, printed circuit board or connectors.
- Do not pass the module to another person without first ensuring you are both at the same electrostatic potential. Shaking hands achieves equipotential.
- Place the module on an anti-static surface, or on a conducting surface which is at the same potential as yourself.
- Do not place modules 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 IEC 60747.

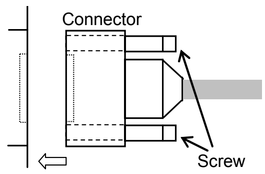
5.5 External Connections

External connections are shown in Appendix G.

Electrical interface for telecommunication

The connector should be handled as follows:

- Insert the connector horizontally and tighten both upper and lower screws alternately.
- Do not touch the connector pin with your bare hand.



In electrical interface to multiplexed communication circuit for GRL100-∗∗∗∗-∗9-∗∗, the earthing wire of electrical cable is connected to the earth terminal (E) of the relay as shown in Figure 5.5.1, if required.

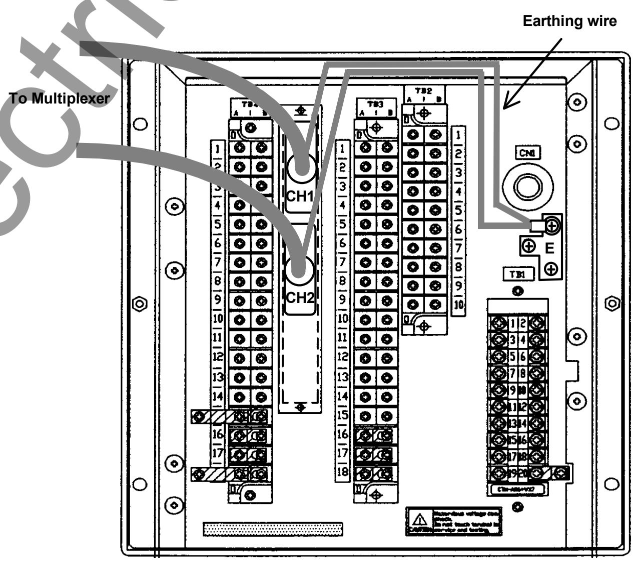
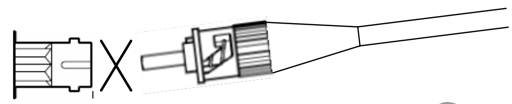
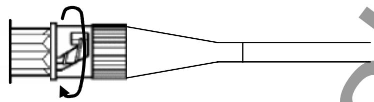
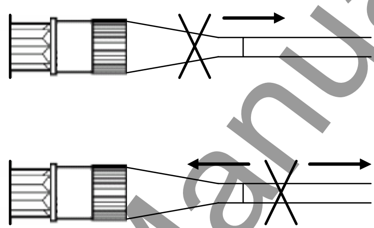
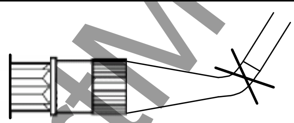
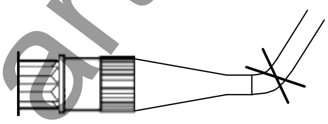
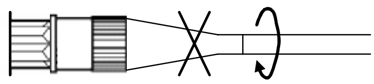
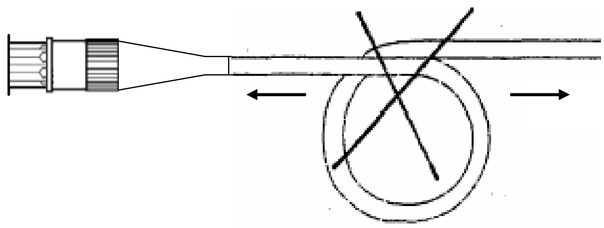
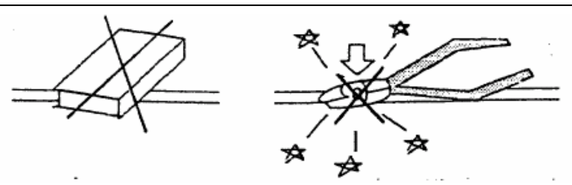
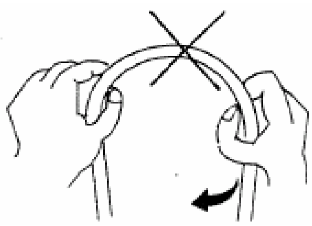


Figure 5.5.1 Connection of communication cable

Optical interface for telecommunication

The optical cables tend to come down, therefore, bending requires special attention.

Handling instructions of optical cable are as follows:

№	Instructions	
1	Do not insert the connector obliquely.	
2	Tighten the connector when connecting.	
3	Do not pull the cable.	
4	Do not bend the cable.	
5	Do not bend the neck of the connector.	
6	Do not twist the cable.	
7	Do not kink in the cable.	
8	Do not put and drop on the cable.	
9	Do not bend the cable to (*)mm or less in radius. (*)Length differs from characteristics of optical cable.	

6. Commissioning and Maintenance

6.1 Outline of Commissioning Tests

The GRL100 is fully numerical and the hardware is continuously monitored.

Commissioning tests can be kept to a minimum and need only include hardware tests and 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 functions 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. Tests of the protection schemes and fault locator require a dynamic test set.

Measuring elements
Timers
Protection schemes
Autoreclose
Metering and recording
Fault locator

Conjunctive tests

The tests are performed after the relay is connected with the primary equipment, telecommunication equipment and other external equipment.

The following tests are included in these tests:

On load test: phase sequence check and polarity check
Signaling circuit test
Tripping and reclosing circuit test

6.2 Cautions

6.2.1 Safety Precautions

⚠CAUTION

- The relay rack is provided with a grounding terminal.
  Before starting the work, always make sure the relay rack is grounded.
- 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.
- Class 1M laser radiation when remove cap for models with <30km class optical interface. Do not view directly with optical instruments.

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 connect/disconnect the flat cable on the front of the printed circuit board (PCB).
- While the power is on, do not mount/dismount the PCB.
- 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.
  - Make sure the VT circuit is not short-circuited.
- Be careful that the transformer module is not damaged due to an overcurrent or overvoltage.
- If settings are changed for testing, remember to reset them to the original settings.

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

Before mounting/dismounting the PCB, take antistatic measures such as wearing an earthed wristband.

6.3 Preparations

Test equipment

The following test equipment is required for the commissioning tests.

1 Three-phase voltage source (not required for Model 100s)
2 Single-phase current sources
1 Dynamic three-phase test set (for protection scheme test)
1 DC power supply
3 DC voltmeters
3 AC voltmeters
3 Phase angle meters
2 AC ammeters
1 Time counter, precision timer
1 PC (not essential)

Relay settings

Before starting the tests, it must be specified whether the tests will use the user's settings or the default settings.

For the default settings, see the following appendixes:

Appendix D Binary Output Default Setting List
Appendix H Relay Setting Sheet

Visual inspection

After unpacking the product, check for any damage to the relay case. If there is any damage, the internal module might also have been affected. Contact the vendor.

Relay ratings

Check that the items described on the nameplate on the front of the relay conform to the user's specification. The items are: relay type and model, AC voltage, 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 "PC INTERFACE RSM100".

6.4 Hardware Tests

The tests can be performed without external wiring, but DC power supply and AC voltage and current source 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 displays the "Auto-supervision" screen when the DC voltage is applied.

- Press the RESET key for 1 second when the LCD is off, 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 1 second when the LCD is off, and check that seven LEDs under the "IN SERVICE" LED and two LEDs for monitoring jacks A and B are lit in red.

VIEW and RESET keys

- Press the VIEW key when the LCD is off and check that the "Metering" screen is displayed on the LCD.
- Press the RESET key and check that the LCD turns off.

Keypad

- Press any key on the keypad 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.

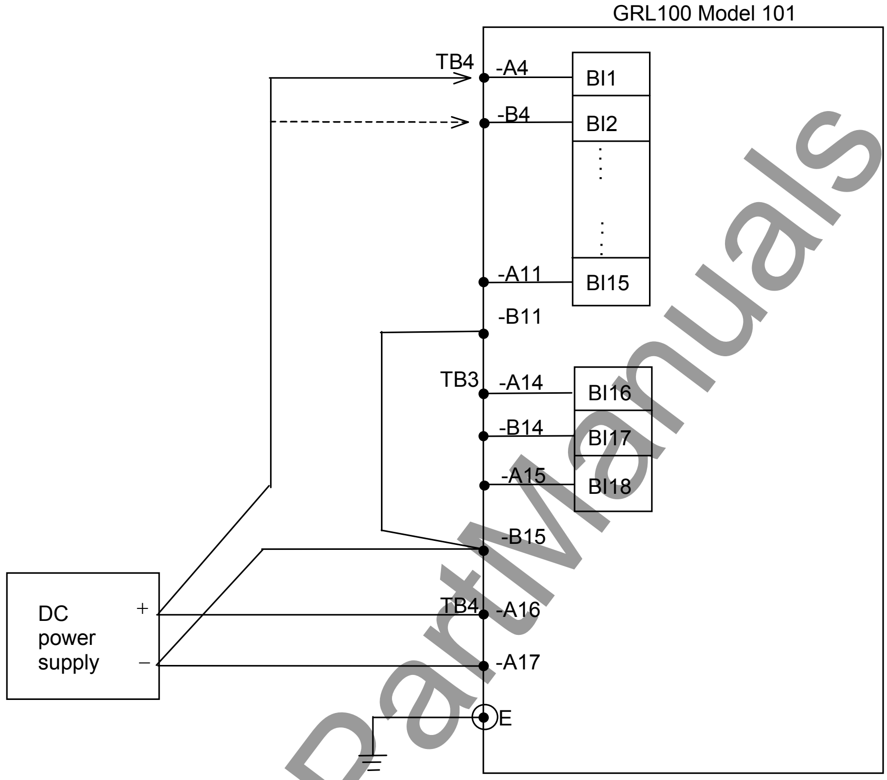


Figure 6.4.2.1 Testing Binary Input Circuit (Model 101)

- Display the "Binary input & output" screen from the "Status" sub-menu.

```
/2 Binary input & output status
Input (IO#1)          [000 000 000 000 000]
Input (IO#2)          [000                ]
```

- Apply the rated DC voltage to terminal A4, B4, ..., A11 of terminal block TB4, and A14, B14 and A15 of terminal block TB3.
  Check that the status display corresponding to the input signal changes from 0 to 1. (For details of the binary input status display, see Section 4.2.4.2.)

  Note: Different models have different terminal block and terminal number, so refer to Appendix G.

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.

- Press 2 (= Binary output) on the "Test" screen to display the "Binary output" screen. The LCD displays the output modules mounted depending on the model.
- Enter the selected number corresponding to each module to be operated. Then the LCD displays the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.
- Enter 1 and press the ENTER key.
- After completing the entries, press the END key. Then the LCD displays the screen shown below. If 1 is entered for all the output relays, the following forcible operation can be performed collectively.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to operate the output relays forcibly.
- Check that the output contacts operate at the terminal.
- Release pressing the 1 key to reset the operation.

6.4.4 AC Input Circuits

This test can be performed by applying known values of voltages and 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 three-phase voltage source and a single-phase current source are required.

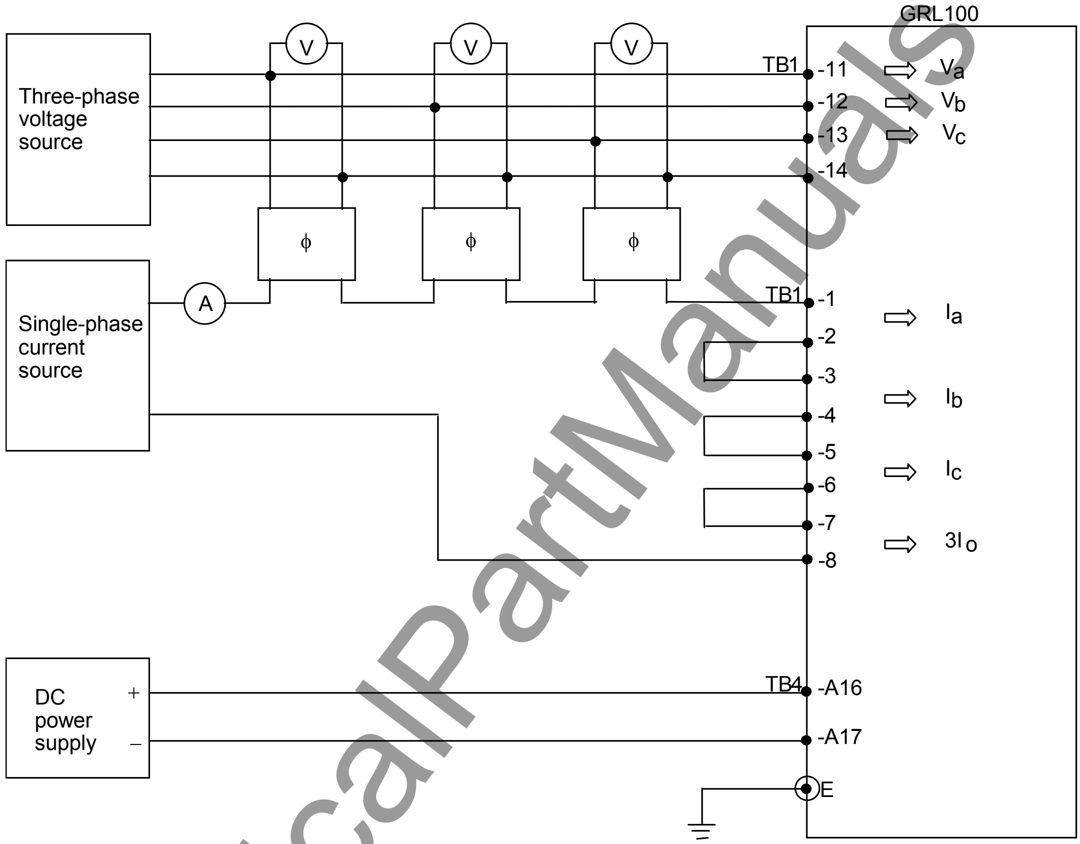


Figure 6.4.4.1 Testing AC Input Circuit

- Check that the metering data is set to be expressed as secondary values (Display value = 2) on the "Metering" screen.

  "Setting (view)" sub-menu → "Status" screen → "Metering" screen

  If the setting is Primary (Display value = 1), change the setting in the "Setting (change)" sub-menu. 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 rated voltages and 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.

```
/2 Logic circuit                       1/ 2
TermA(      0-   3071):       1 _
TermB(      0-   3071):      48
```

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

Note: The voltage level at the monitoring jacks is +15V ±3V for logic level "1" when measured by an instrument with 10kΩ input impedance, and less than 0.1V for logic level "0".

CAUTION

- Use test equipment with more than 1kΩ of internal impedance when observing the output signal at the monitoring jacks.
- Do not apply an external voltage to the monitoring jacks.

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

6.5.1.1 Phase current differential element DIF

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

Operating current value

Charging current compensation (excluding Model 100s)

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 A-phase element locally.

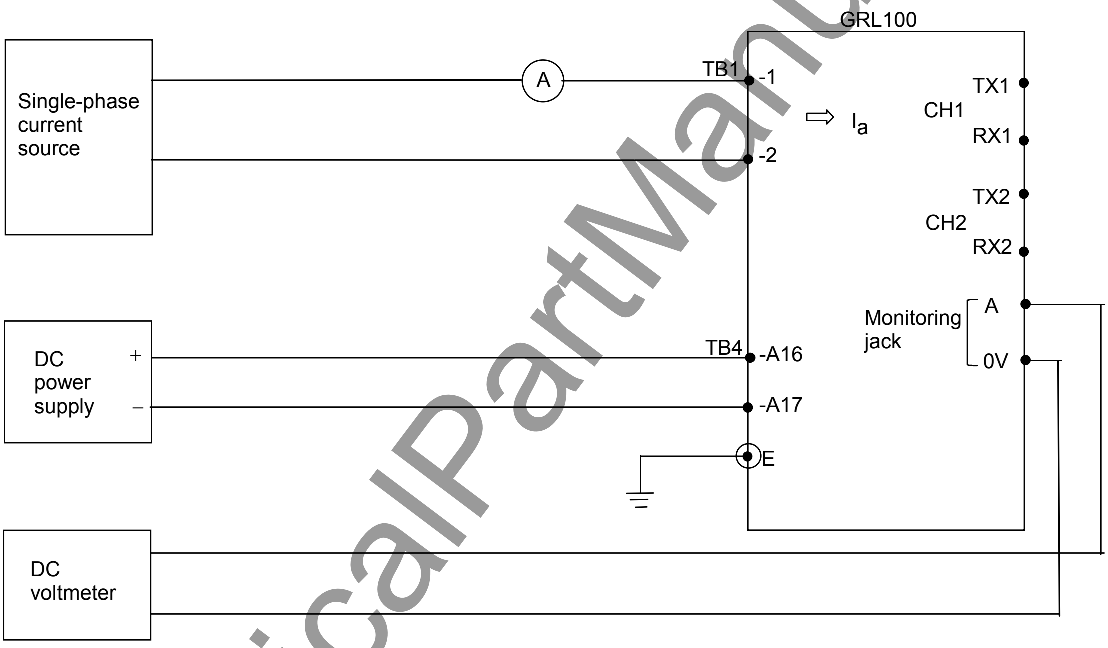


Figure 6.5.1.1 Testing Phase Current Differential Element

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

Element	Signal number
DIF-A	41
DIF-B	42
DIF-C	43

- Set the [L.test] to “1” (= On) on the “Switch” screen of the “Test” sub-menu.
- Check that the charging current compensation DIFIC is set to zero on the "Protection element" screen in the "Setting (view)" sub-menu. If not, set it to zero in the "Setting (change)" sub-menu.
- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 41 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.

Charging current compensation

The charging current compensation function is checked by displaying the differential current on the LCD.

Figure 6.5.1.2 shows the test circuit.

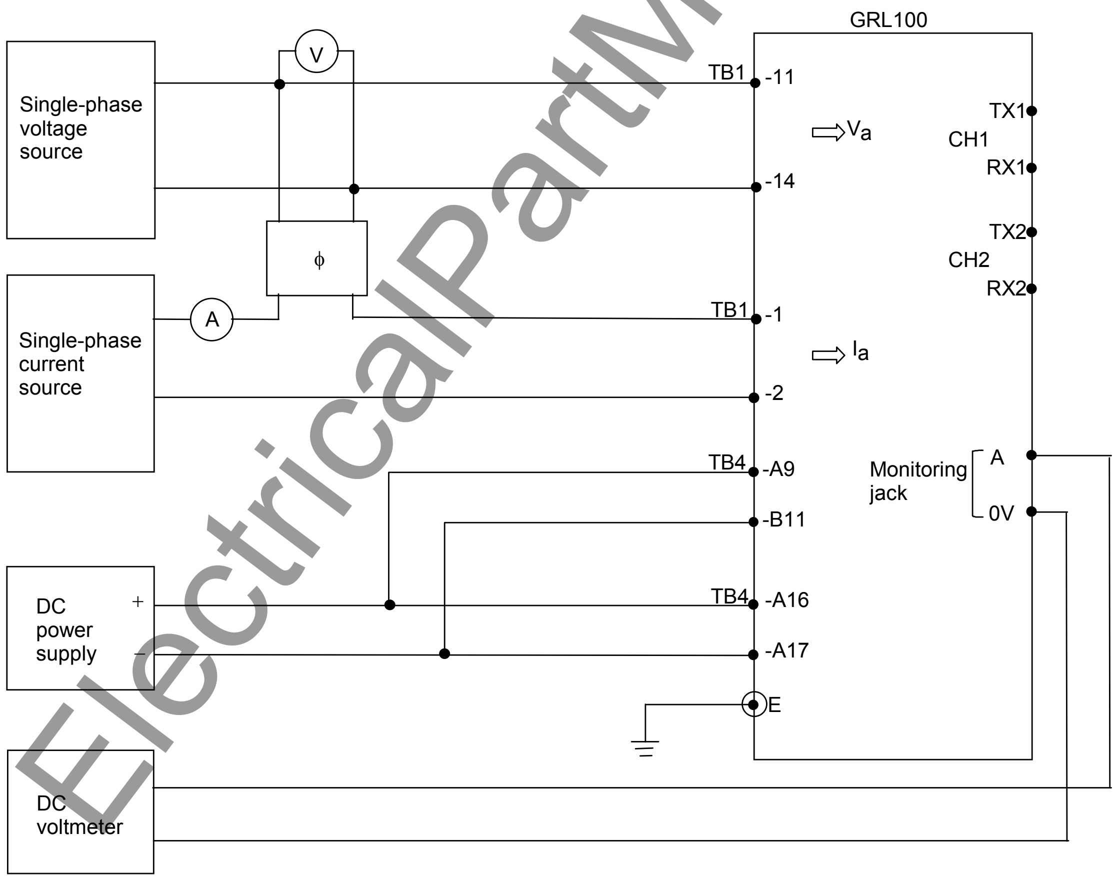


Figure 6.5.1.2 Testing Charging Current Compensation

- Set the [L.test] to "1" (= On) on the "Switch" screen of the "Test" sub-menu.

When the charging current compensation is in operation, the differential current I_d is expressed with the following equation:

$I_d = I - (1/n)$ DIFIC

where,

I = applied test current

n = 2 in case of two-terminal line application

= 3 in case of three-terminal line application

DIFIC = setting of charging current compensation

- Open the "Metering" screen in the "Status" sub-menu.
- Apply a rated phase voltage and a test current to A-phase, and adjust the voltage lagging by 90°.
- Check that the A-phase differential current I_{da} on the "Metering" screen coincides with the I_d mentioned above with an error within ±7%.

End-to-end test setup

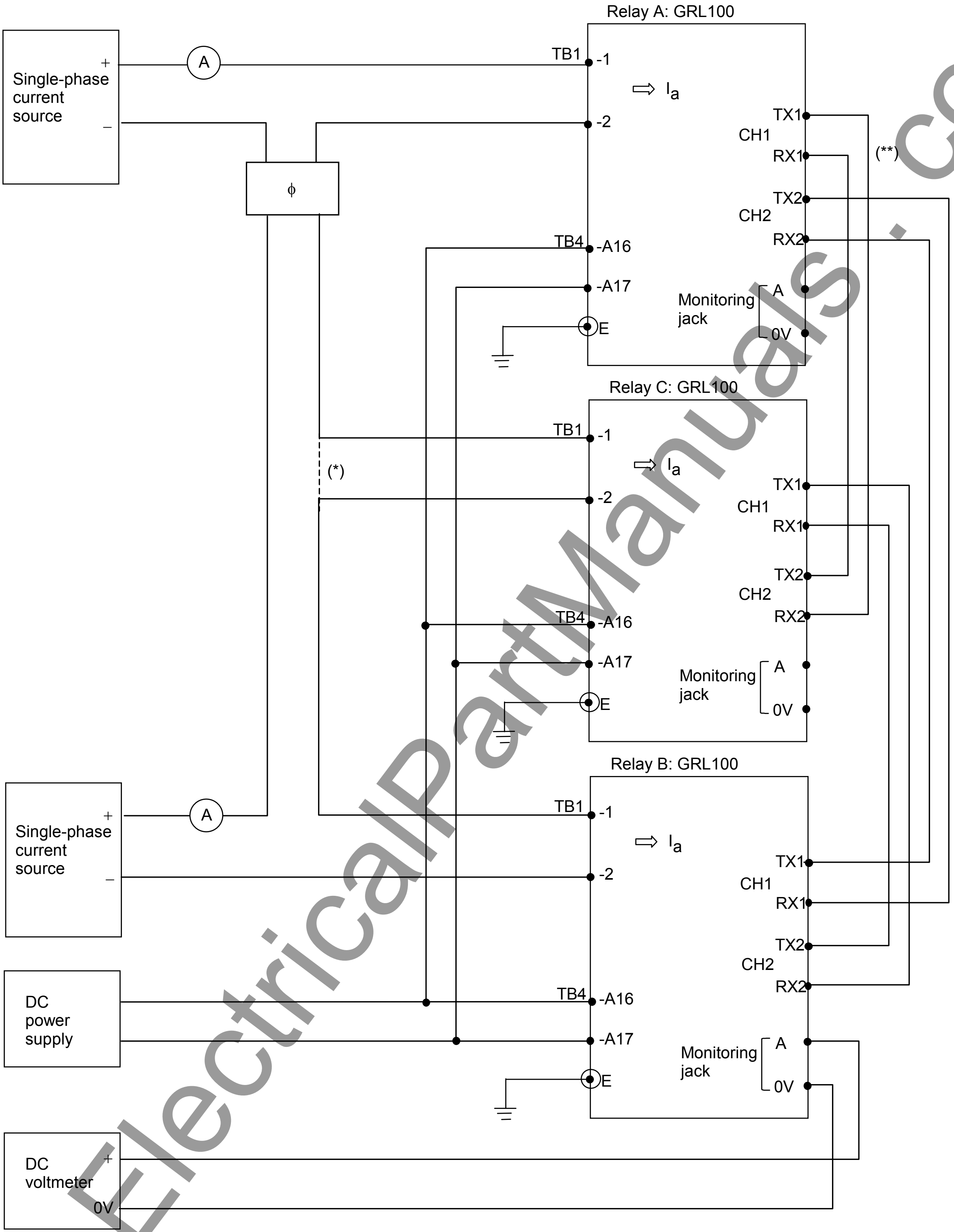
When the percentage restraint characteristic is checked, an end-to-end setup using two relays is required.

<Testing at laboratory>

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 6.5.1.3 (a) shows the testing circuit of the laboratory end-to-end test.

In case of two-terminal applications, the signal terminals CH1-TX1 and –RX1 of one relay are directly connected to CH1-RX1 and -TX1 of another relay.

Note: When the relays have an electrical telecommunications interface in accordance with CCITT-G703-1.2.1 or an optical interface (Short wavelength light, GI, 2km class), the scheme switch [D. test] must be set to "1" (= On) to test them under the direct connection of the communication circuits.



Note: In case of two-terminal applications (The relay C is not used.),
(*) Connect the dotted line.
(**) Connect CH1-TX1 and CH1-RX1 of the relay A to CH1-RX1 and CH1-TX1 of the relay B.

Figure 6.5.1.3 (a) End-to-end Test Setup at Laboratory

<Testing on site>

If the relays are tested at each installation site, the end-to-end test is performed after the telecommunication circuit between terminals is setup. Figure 6.5.1.3 (b) shows the testing circuit of the on-site end-to-end test.

In the on-site test, it is necessary to set the phase relationship between the test currents of each terminal. The pulse signal PULSE generated from the synchronized sampling clock is used as a reference phase signal at each terminal because it is in-phase between the terminals.

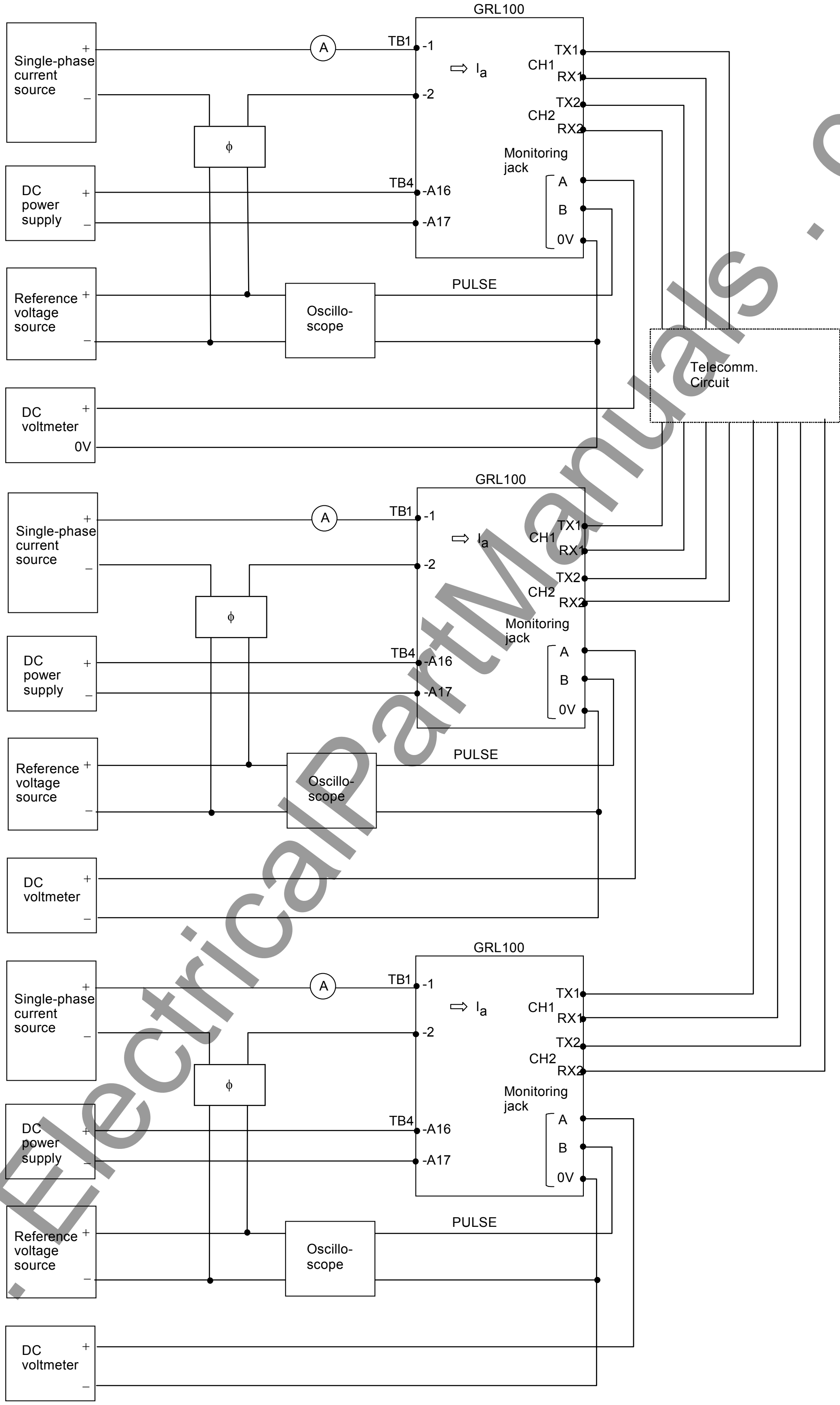


Figure 6.5.1.3 (b) On-site Setup for Testing Differential Element

- Press 4 (= Logic circuit) on the "TEST" sub-menu screen to display the "Logic circuit" screen.

- Enter a signal number 270 for Term B to observe a signal PULSE at monitoring jack B, and then press the ENTER key.

The phase of the test current is adjusted as follows.

- Adjust the reference voltage to be in-phase with the pulse signal PULSE monitoring a CRT oscilloscope.
- Adjust the test current to be in-phase with the reference voltage to simulate an infeed current and counter-phase to simulate an outflow current.

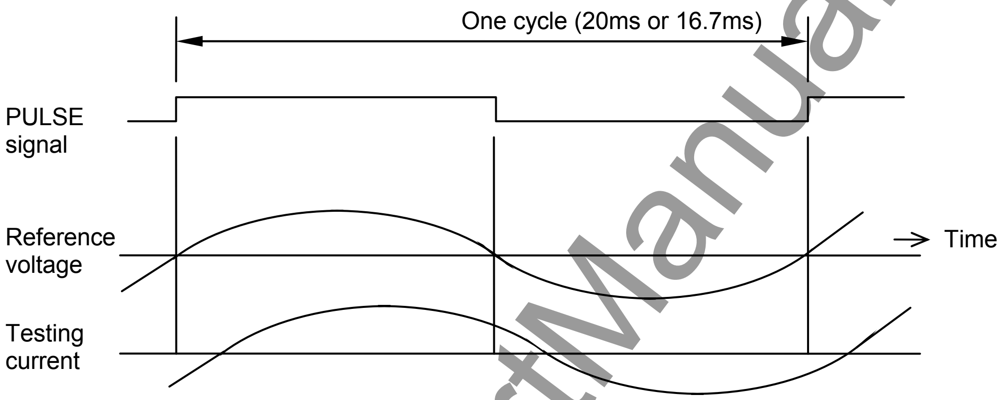


Figure 6.5.1.4 Phase Adjustment

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 6.5.1.5 by applying an infeed current to one relay and an outflow current to another relay.

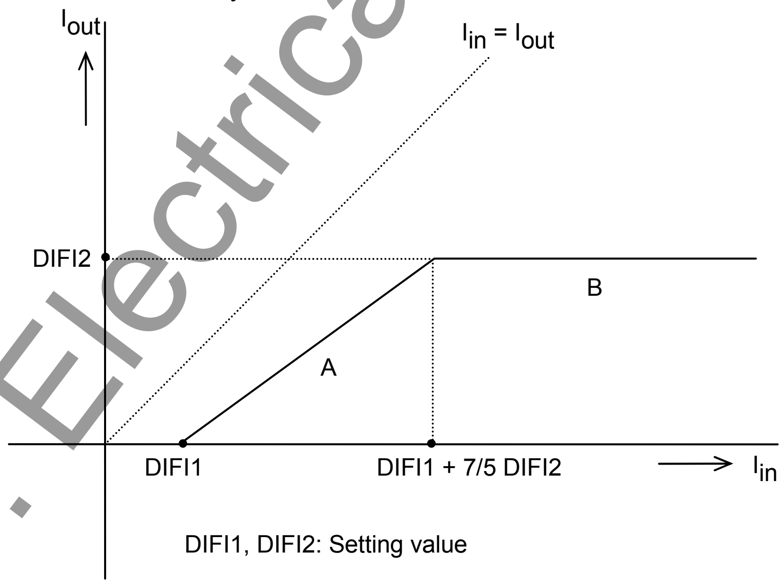


Figure 6.5.1.5 Percentage Restraining Characteristic on I_{in}-I_{out} Plane

Characteristic A is expressed by the following equation,

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

Characteristic B is expressed by the following equation,

$I_{out} \leq DIFI2$

where, DIFI1 and DIFI2 are setting values.

- Set the charging current compensation DIFIC to zero.
- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 41 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 Residual current differential element DIFG

The residual current differential element is checked on the operating current and percentage restraining characteristic in the same way as described in Section 6.5.1.1.

Element	Signal number
DIFG	44

The differences from the procedure described in Section 6.5.1.1 are as follows.

- Apply a test current to terminal 7 and 8 instead of 1 and 2.
- Enter a signal number 44 instead of 41 to observe the DIFG element operation at monitoring jack A.
- Use the settings DIFGI instead of DIFI1.

6.5.1.3 Overcurrent elements OC, EF, OC1 and inverse definite minimum time (IDMT) overcurrent elements OCI, EFI

(1) Overcurrent elements OC, EF, OC1

The testing circuit is shown in Figure 6.5.1.6 (a).

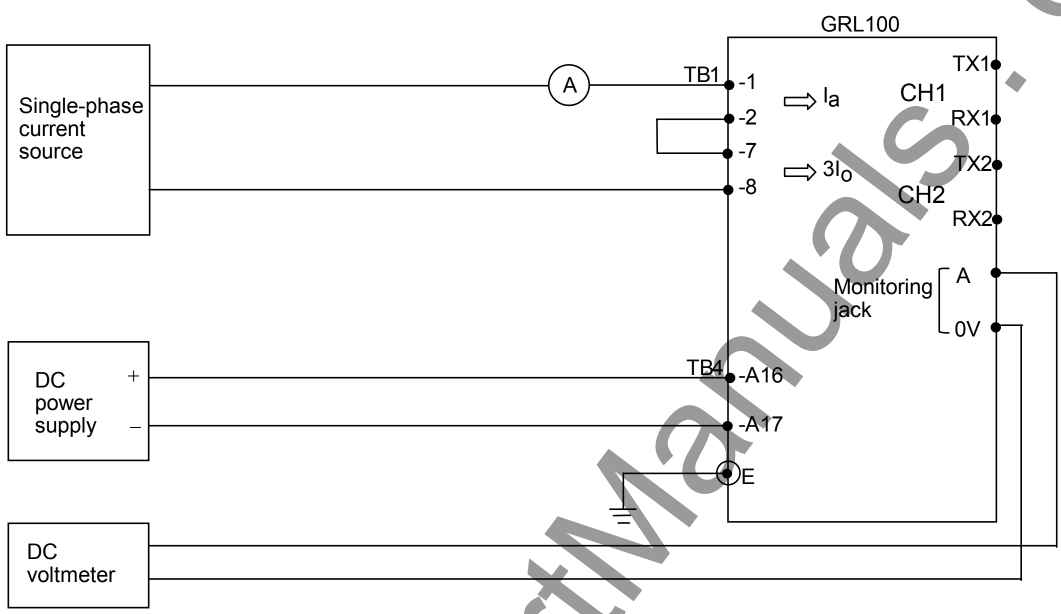


Figure 6.5.1.6 (a) Testing OC and EF

Element	Signal number	Remarks
OC-A	65	
EF	71	
OC1-A	368	

The testing procedures is as follows:

- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number to observe the OC or EF output 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 ±5% of the setting.

(2) Inverse definite minimum time (IDMT) overcurrent elements OCI, EFI

The testing circuit is shown in Figure 6.5.1.6 (b).

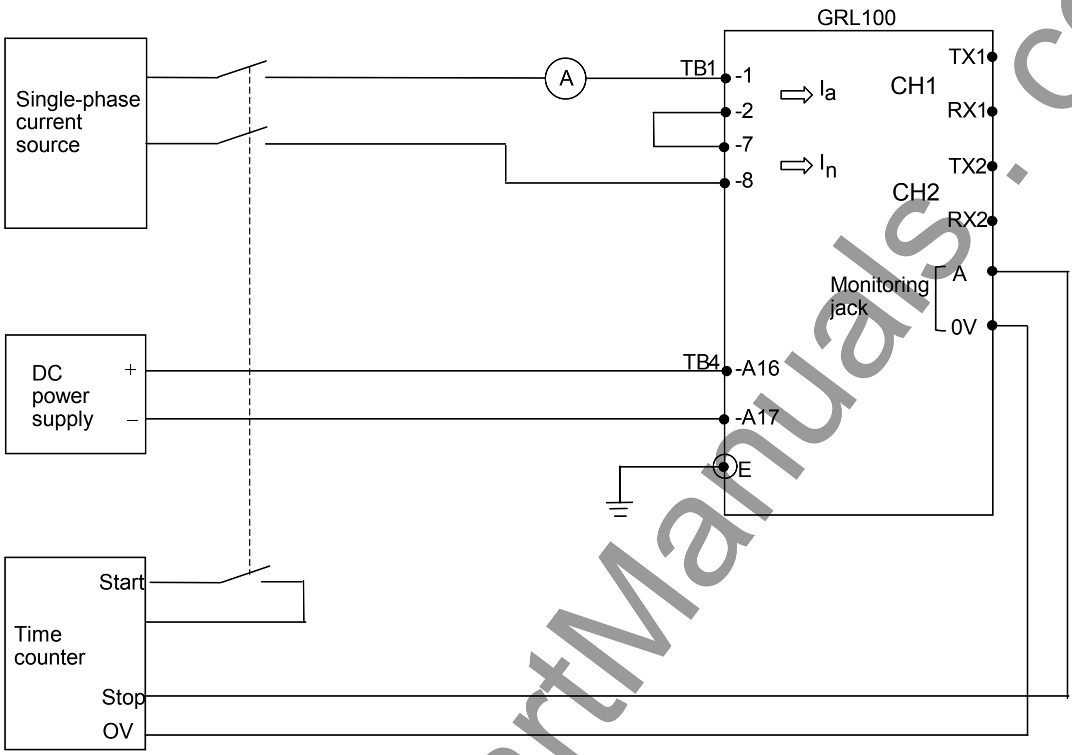


Figure 6.5.1.6 (b) Testing OCI and EFI

One of the four inverse time characteristics can be set, and the output signal numbers of the IDMT are as follows:

Element	Signal number	Remarks
OCI-A	68	
EFI	72	

Fix the time characteristic to test by setting the scheme switch MOCI or MEFI on the "Scheme switch" screen.

"Setting (change)" sub-menu → "Protection" screen → "Trip" screen → "Scheme switch" screen

The testing procedures is as follows:

- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number to observe the OCI or EFI output at monitoring jack A and press the ENTER key.
- Apply a test current and measure the operating time. The magnitude of the test current should be between 1.2 × I_S to 20 × I_S, where I_S is the current setting.
- Calculate the theoretical operating time using the characteristic equations shown in Section 2.11.3. Check that the measured operating time is within the error mentioned below.

  Accuracy: Standard, Very and Long-time inverse: IEC 60255-3 class 5
  Extremely inverse: IEC 60255-3 class7.5

6.5.1.4 Thermal overload element THM-A and THM-T

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

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	367
THM-T	363

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 × I_S to 10 × 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 2.6. Check that the measured operating time is within 5%.

6.5.1.5 Out-of-step element OST

The out-of-step element can be tested with an end-to-end setup using two relays.

Figure 6.5.1.7 (a) and (b) shows the testing circuits of the laboratory test and on-site test. For the test setup, refer to Section 6.5.1.1.

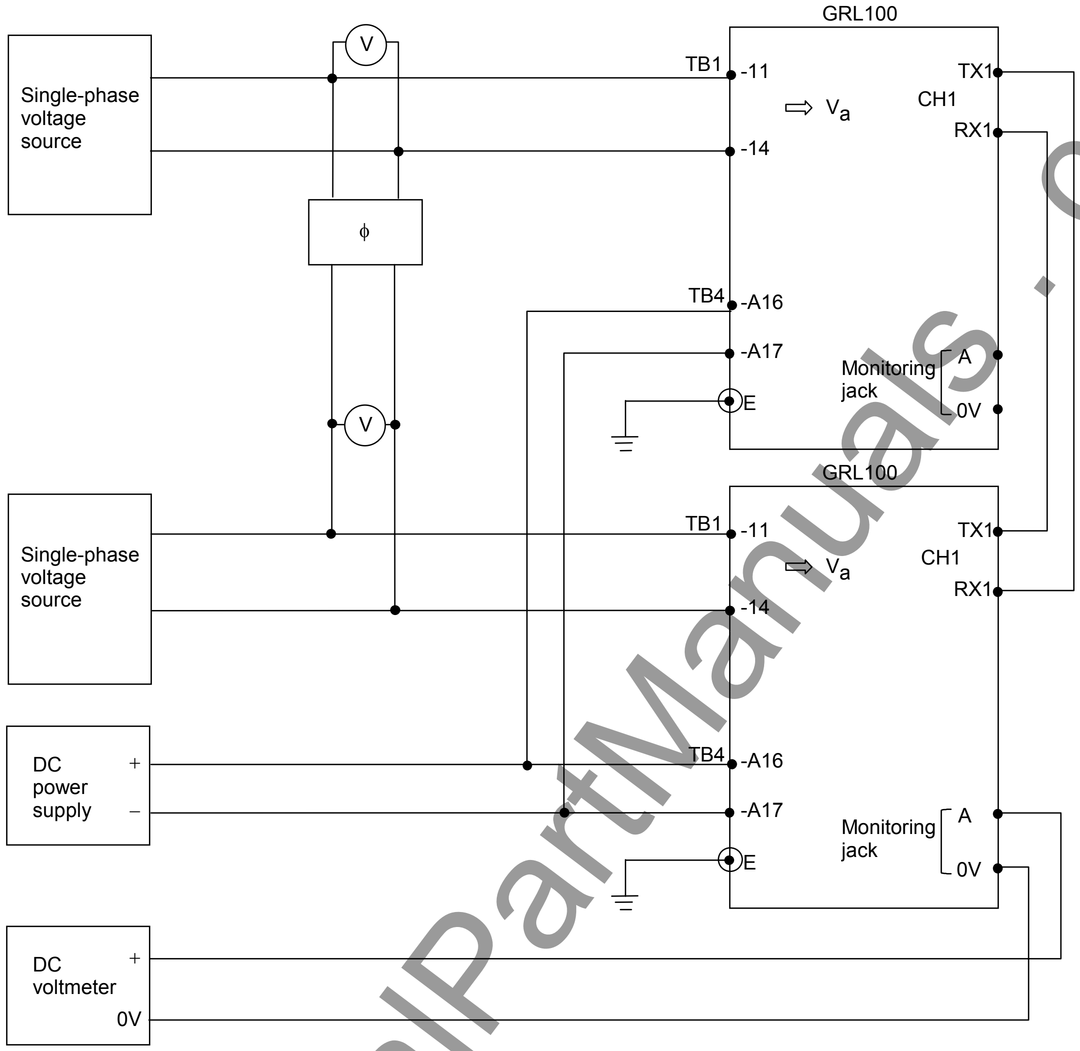


Figure 6.5.1.7 (a) Laboratory Setup for Testing Out-of-step Element

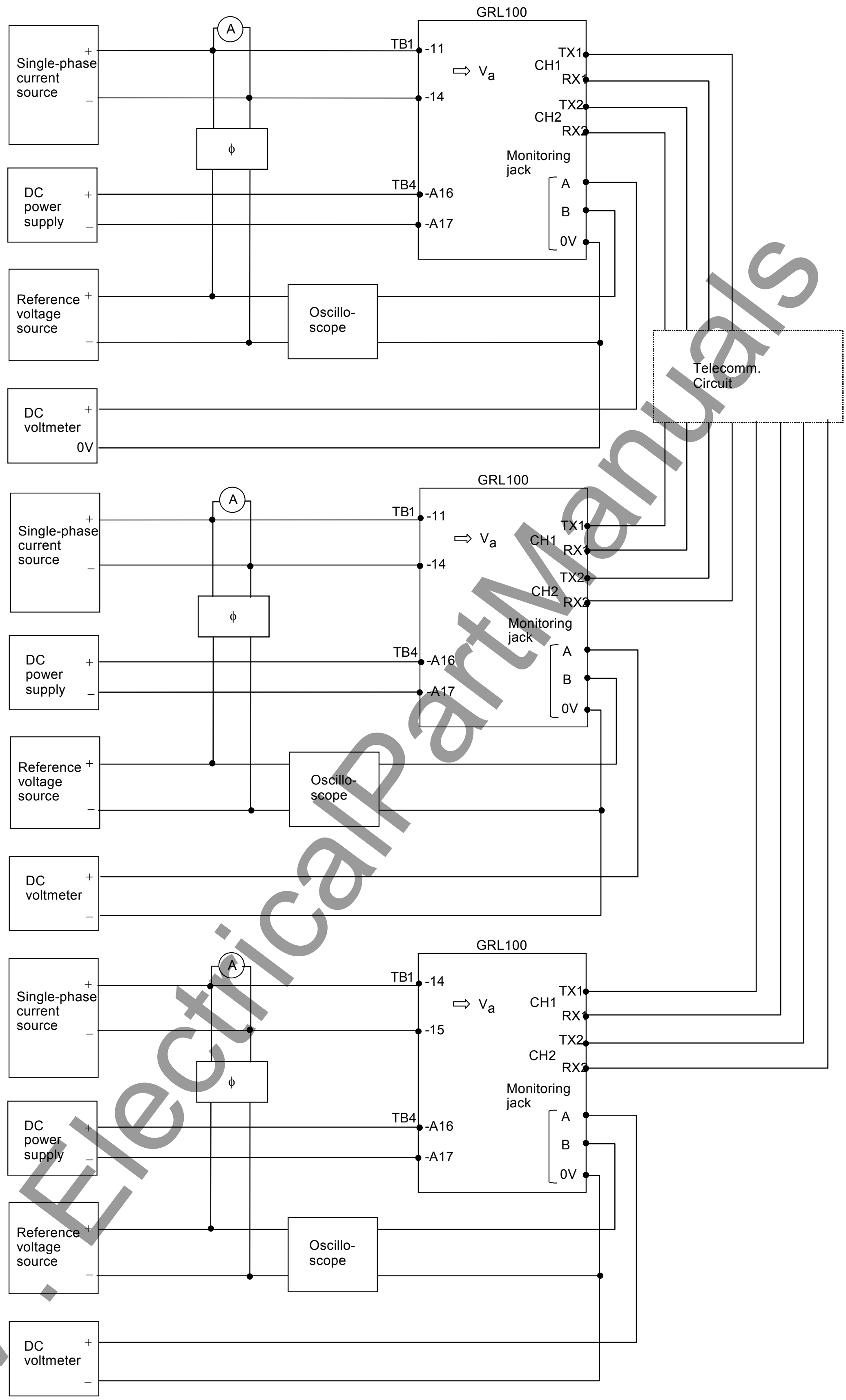


Figure 6.5.1.7 (b) On-site Setup for Testing Out-of-step Element

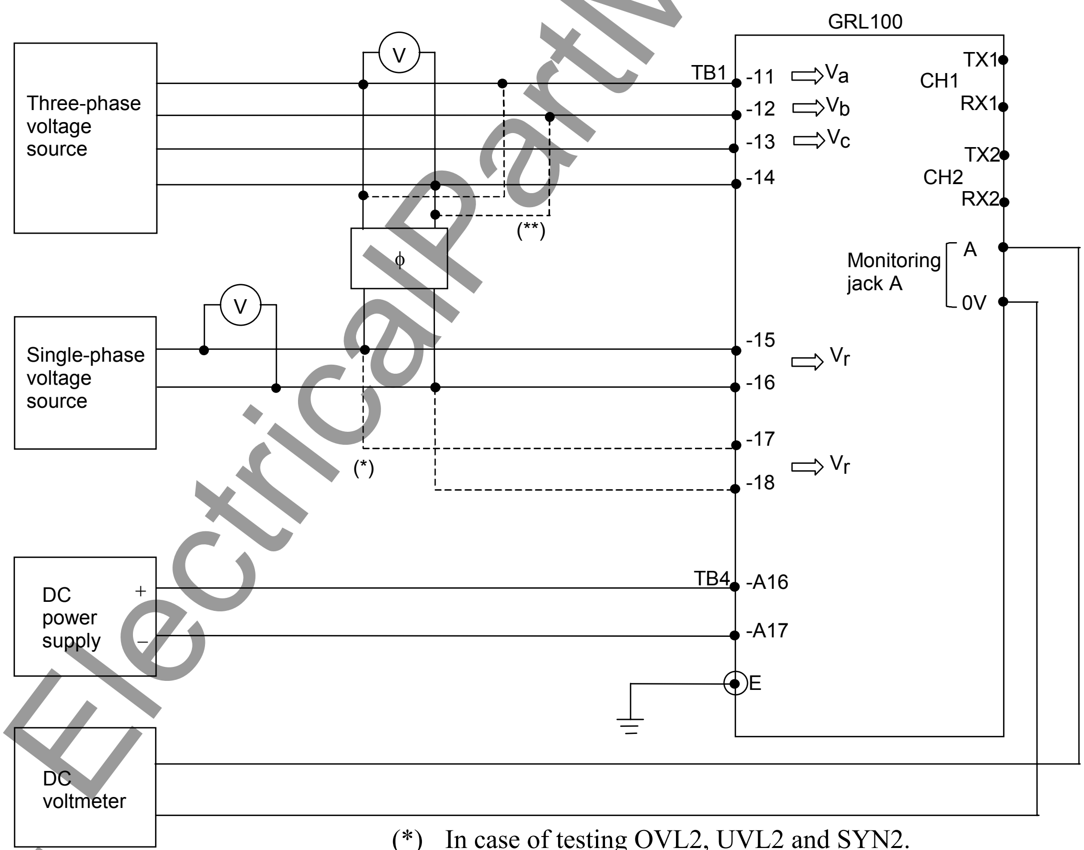
The output signal numbers of the OST element are as follows.

Element	Signal number	Remarks
OST1	47	Two-terminal and three-terminal application
OST2	51	Three-terminal application

- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 47 (OST1) or 51 (OST2) to be observed at monitoring jack A and press the ENTER key.
- Apply the rated voltage in phase with the reference voltage signal to both relays.
- Shift the applied voltage phase angle from the reference signal at one terminal, and measure the angle just at which the element operates.
- Check that the measured angle is within 180° ±5°.

6.5.1.6 Voltage and synchronism check elements

The test circuit is shown in Figure 6.5.1.8. If scheme switch "3PH-VT" is set to "Bus", the three-phase voltage simulates the busbar voltage, and the single-phase voltage simulates the line voltage. If the switch is set to "Line", the opposite is true.



(*) In case of testing OVL2, UVL2 and SYN2.
(**) In case when "VT-RATE" is set to "PH/PH".

Figure 6.5.1.8 Testing Synchronism Check Elements

When testing OVL2, UVL2 and SYN2, a single-phase voltage must be applied to terminals 17 and 18, instead of terminals 15 and 16 and "3PH-VT" is set to "Line".

Voltage and synchronism check elements and their output signal number are listed below.

OVL2, UVL2 and SYN2 are used for two-breaker autoreclose and provided in model 300s and 500s.

Element	Signal number
OVB	57
UVB	58
OVL1	60
UVL1	61
OVL2	62
UVL2	63
SYN1	59
SYN2	64

Connect the phase angle meter to the three-phase voltages taking the scheme switch "VT-RATE" and VTPH-SEL settings into consideration. The phase angle meter connection shown in Figure 6.5.1.8 is the case for the default settings, ie., "VT-RATE" and "VTPH-SEL" are set to PH/G and A, respectively.

VT-RATE setting	VTPH-SEL setting	Meter connection phase
PH/G	A	A-N
	B	B-N
	C	C-N
PH/PH	A	A-B
	B	B-C
	C	C-A

Voltage check element OVB, UVB, OVL1, UVL1, OVL2, and UVL2

- Press 4 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter a signal number for the TermA line to be observed at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage and a single-phase rated voltage as shown in Figure 6.5.1.8.

OVB and UVB:

- Change the magnitude of the three-phase voltage if the scheme switch "3PH-VT" is set to "Bus" or change the magnitude of the single-phase voltage if it is set to "Line". Measure the value at which the element operates and check that it is within ± 5% of the setting.

OVL1 and UVL1:

- Change the magnitude of the single-phase voltage if the scheme switch "3PH-VT" is set to "Bus" or change the magnitude of the three-phase voltage if it is set to "Line". Measure the value at which the element operates and check that it is within ± 5% of the setting.

OVL2 and UVL2:

- Change the magnitude of the single-phase voltage applied to terminal 17 and 18 and measure the value at which the element operates. Check that the measured value is within ± 5% of the setting.

Synchronism check element SYN1

- Press 4 (= Logic circuit) on the "Test" screen to display the "Logic circuit" screen.
- Enter a signal number for the TermA line to be observed at monitoring jack A and press the ENTER key.
- Apply a three-phase rated voltage and a single-phase rated voltage as shown in Figure 6.5.1.8.

Voltage check:

- Set the three-phase voltage to any value over the SY1OV setting. (The default setting of SY1OV is 51V.)

  Whilst keeping V_r in-phase with V_a, lower the single-phase voltage V_r from the rated value. Measure the voltage at which the element operates. Check that the measured voltage is within ± 5% of the SY1UV setting.
- Further lower Vr and measure the voltage at which the element resets. Check that the measured voltage is within ±5% of the SY1OV setting.

Phase angle check:

- Set V_a and V_r to any value between the SY1OV and SY1UV settings keeping V_a in-phase with V_r. Then the SYN1 element operates.
- Shift the angle of V_r away from that of V_a, and measure the angle at which the element resets.
- Check that the measured angle is within ±5° of the SY1 θ setting. (The default setting of SY1 θ is 30°.)
- Change V_a and V_r, and repeat the above.

Synchronism check element SYN2

- Apply single-phase rated voltage to terminals 17 and 18 as shown with broken lines in Figure 6.5.1.8 and set the scheme switch "3PH-VT" to "Line". The test can be performed taking the same steps as testing SYN1.

6.5.1.7 Overcurrent element OCBF

The overcurrent element is tested locally. The test circuit is shown in Figure 6.5.1.6(a).

The output signal number of the OCBF element is as follows.

Element	Signal number
OCBF-A	54

- Press 4 (= Logic circuit) on the "Test" sub-menu screen to display the "Logic circuit" screen.
- Enter a signal number 54 (OCBF-A) to be observed at monitoring jack A and press the ENTER key.
- Apply a test current, adjust the magnitude of the current applied and measure the values at which the element operates and resets.
- Check that the measured values are within 5% of the setting in operation and within 5% of the setting × 0.8 in reset.

6.5.1.8 Current Change Detection Element OCD

The test circuit is shown in Figure 6.5.1.9.

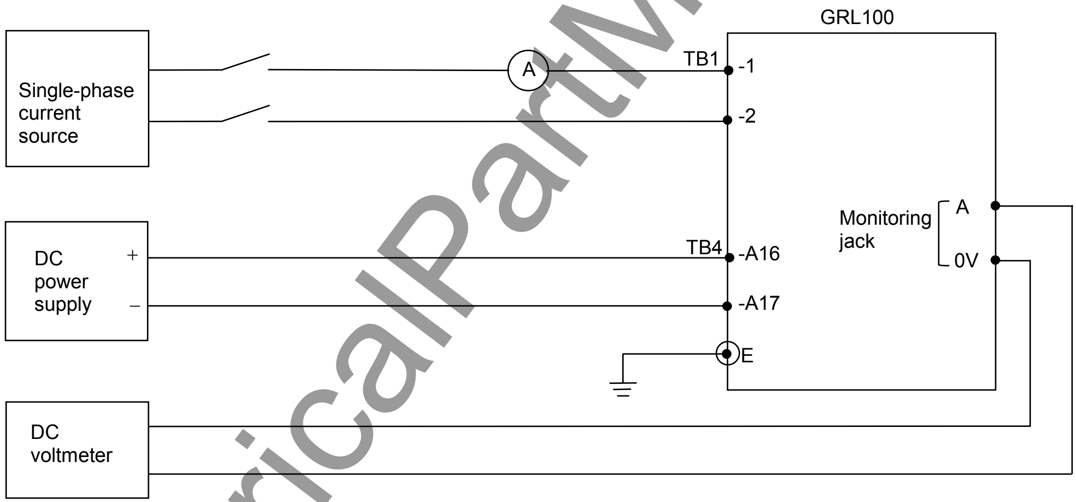


Figure 6.5.1.9 Testing Current Change Detection Element

The output signal number of the OCD is as follows:

Measuring element	Signal number
OCD-A	63

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 0.5 A and 0.1 A for 5 A rating and 1 A rating respectively.

6.5.2 Timer

The pick-up delay time of the variable timer can be measured by connecting the monitoring jacks A and B to a time counter as shown in Figure 6.5.2.1. Jacks A and B are used to observe the input signal and output signal of the timer, respectively.

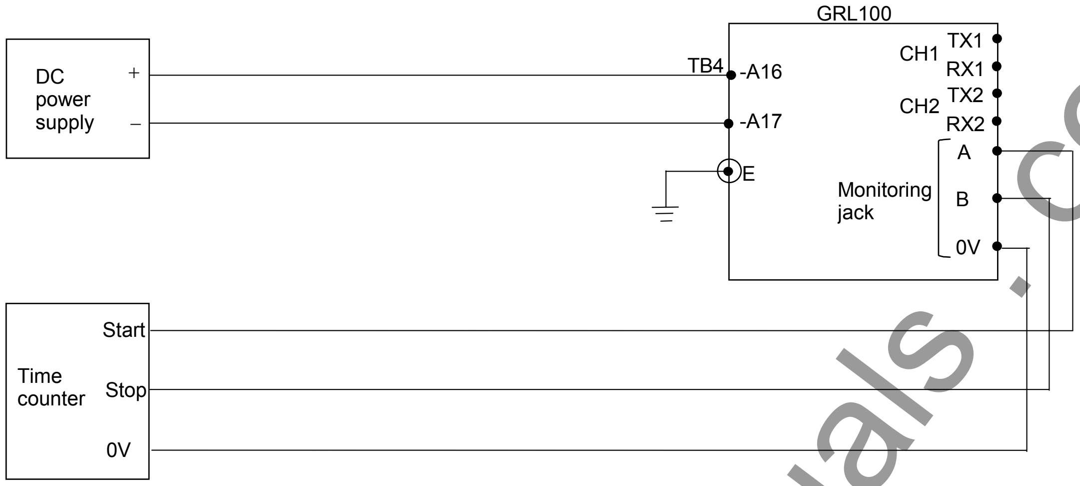


Figure 6.5.2.1 Testing Variable Timer

- Press 3 (= Timer) on the "Test" screen to display the "Timer" screen.
- Enter the number corresponding to the timer to be observed. The timers and assigned numbers are listed in Appendix C.
- Press the END key to display the following screen.

```
/2 Timer
Press ENTER to operate.

Press CANCEL to cancel.
```

  - Press the ENTER key to operate the timer. The "TESTING" LED turns on, and the timer is initiated and the following display appears. The input and output signals of the timer can be observed at monitoring jacks A and B respectively. The LEDs above monitoring jacks A or B are also lit if the input or output signal exists.

    Check that the measured time is within 10 ms of the setting time.

```
/2 Timer
Operating......
Press END to reset.
Press CANCEL to cancel.
```

- Press the END key to reset the input signal to the timer. The "TESTING" LED turns off.

  Press CANCEL key to test other timers. Repeat the above testing.

To measure the drop-off delay time, press the END key after the LED above jack B lights. The off-delay time is the time from a signal at the monitoring jack A resets till a signal at the monitoring jack B resets.

6.5.3 Protection Scheme

Protection schemes implemented in GRL100 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 with the three-phase voltage source and current source 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 4.2.7.5

The autoreclose function can be tested together with these tests. A permanent fault should be applied to test a reclose-onto-fault.

Tripping is observed with the tripping command output relays TP-A1 to -C1 and TP-A2 to -C2.

Reclosing is observed with the user configurable reclosing command output relays assigned to signals ARC1 and ARC2. For the default setting, see Appendix D.

Differential tripping

When a phase current is applied, instantaneous per phase based tripping or three-phase tripping is performed depending on the fault types, setting of the scheme switches [TPMODE], [ARC-M], and [STUB]. The switch [TPMODE] is valid for model 100s.

The tripping should be checked for the current which is two times or larger than the minimum operating current DIFI1 or DIFGI. 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.

When a residual current is applied, time-delayed three-phase tripping is performed. Operating time will be 1 cycle plus setting of timer TDIFG. The tripping or reclosing is blocked when the scheme switch [DIFG] or [ARC-DIFG] is set to "OFF".

Check that the indications and recordings are correct.

Out-of-step tripping

Set the scheme switch [OST] to "Trip".

Shift the phase angle from the second quadrant to the third quadrant or vice versa taking the remote terminal voltage as a reference voltage.

Check that the tripping output relay operates in all phases and autoreclose does not start.

Check that the indications and recordings are correct.

Shift the phase angle from the first quadrant to the fourth quadrant or vice versa taking the remote terminal voltage as a reference voltage.

Check that any of the tripping output relays do not operate.

Circuit breaker failure tripping

Set the scheme switch [BF1] to "T" or "TOC" and [BF2] to "ON".

Apply a fault and retain it. Check that the adjacent breaker tripping output relay operates after the time setting of the TBF2.

The adjacent breaker tripping output relay is user configurable and assigned to signal CBF-TRIP. For the setting, see Sections 4.2.6.9 and 4.2.7.2.

6.5.4 Metering and Recording

The metering function can be checked whilst testing the AC input circuit. See Section 6.4.4.

Fault recording can be checked whilst testing the protection schemes. Open the "Fault records" screen and check that the descriptions are correct for the applied fault.

The default setting of events is shown in Appendix H. Event recording on the external events such as CB1 ready, Ind.reset, etc., can be checked by changing the status of binary input 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 Records" screen is correct.

Note: The choice of whether to record or not can be set for each event. Change the status of the binary input signal after confirming that the related event is set to record. (The default setting enables all the events to be recorded.)

Some of the internal events such as Trip, Com1.fail, etc., 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 records" 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.

6.5.5 Fault Locator

As the fault locator requires local and remote terminal currents, the fault locator can be tested under the end-to-end synchronized test setup.

In the tests, a dynamic test set with the three-phase voltage and current source is required for each terminal to simulate power system pre-fault, fault and post-fault conditions.

The fault locator starts measurement when the current differential protection operates. Therefore, it is preferable to test it whilst testing the protection schemes by applying a fault.

The line parameter settings must be changed to meet those of the test set.

The measurement result is expressed as a percentage of the line length and the distance, and is displayed on the "Fault Record" screen of the LCD.

6.6 Conjunctive Tests

6.6.1 On Load Test

With the relay connected to the line which is carrying load current, it is possible to check the polarity of the voltage and current transformers and the phase rotation with the metering displays on the LCD screen.

- Open the following "Metering" screen from the "Status" sub-menu.

```
/2 Metering      12/Feb/1998     22:56      3/13
Va    63.5V      0.0°     Ia    2.10A      4.9°
Vb    63.4V  -120.0°     Ib    2.10A   -115.0°
Vc    63.5V   120.1°     Ic    2.15A    125.1°
...
...
Active power      +    400.11MW
Reactive power  -       25.51Mvar
Frequency               60.1 Hz
```

Note: The magnitude of voltage, current and power can be set in values on the primary side or on the secondary side by the setting. (The default setting is the primary side.)
Phase angles are expressed taking that of the positive sequence voltage as the reference angle.
The sign of the phase angle can be set positive for either lagging phase or leading phase. (In the default setting, it is set positive when the phase is leading to the reference angle.)
The sign of the power flow direction can be set positive for either power sending or power receiving. (The default setting is power sending.)

- Check that the phase rotation is correct.
- Verify the phase relationship between the voltage and current with a known load current direction.

6.6.2 Signaling Circuit Test

This test is performed when a command protection using a signaling channel is applied.

The test is to check whether the communication circuit is correctly connected between a local terminal and a remote terminal.

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

6.6.3 Tripping and Reclosing Circuit Test

The tripping and reclosing circuit including the circuit breaker is checked by forcibly operating the output relay and monitoring the circuit breaker that is tripped or reclosed. Forcible operation of the output relay is performed on the "Binary output" screen of the "Test" sub-menu as described in Section 6.4.3.

Tripping circuit

- Ensure that the circuit breaker is closed.
- Press 2 (= Binary output) on the "Test" sub-menu screen to display the "Binary output" screen. The LCD displays the output modules mounted.

- Enter 1 to select the IO#1 module, then the LCD displays the screen shown below.

```
/3 BO            (0=Disable 1=Enable)   1/ 6
IO#1   TP-A1                            1 _
IO#1   TP-B1                            1
IO#1   TP-C1                            1
IO#1   TP-A2                            0
IO#1   TP-B2                            0
IO#1   TP-C2                            0
```

TP-A1, B1 and C1 are output relays with one normally open contact, and trip the A-phase, B-phase and C-phase breakers. TP-A2 to C2 are used if two-breaker tripping is required in a one-and-a-half-breaker busbar arrangement.

- Enter 1 for TP-A1 and press the ENTER key.
- Press the END key. Then the LCD displays the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep the 1 key pressed to operate the output relay TP-A1 and check that the A-phase breaker is tripped.

  Caution: In case of relay models with fault detector, FD module BO also operates when IO#1 module BO is forcibly operated.

- Release pressing the 1 key to reset the operation.
- Repeat the above for all the phases.

Reclosing circuit

The test is applied to models 200s to 500s with autoreclose function.

- Ensure that the circuit breaker is open.
- Press 2 (= Binary output) on the "Test" sub-menu screen to display the "Binary output" screen. The LCD displays the output modules mounted.
- Enter the selected number corresponding to each module to be operated. Then the LCD displays the name of the module, the name of the output relay, the name of the terminal block and the terminal number to which the relay contact is connected.

  Note: The autoreclose command is assigned to any of the output relays by the user setting. The following description is the case for the default setting.
  In the default setting, the autoreclose command is set to BO9 and BO10 of the IO2 module. (BO9 is used in the two-breaker autoreclose.)

- Enter 2 to select the IO#2 module, then the LCD displays the screen shown below.

```
/3 BO            (0=Disable 1=Enable)   1/14
IO#2   BO1                              0 _
IO#2   BO2                              0
IO#2   BO3                              0
 ...
IO#2   BO10                             1
IO#2   BO11                             0
IO#2   BO12                             0
IO#2   FAIL                             0
IO#2   BO13                             0
```

Move the cursor by pressing the ▼ key and select BO10. BO10 is an autoreclose command output relay with one normally open contact.

- Enter 1 and press the ENTER key.
- Press the END key. Then the LCD displays the screen shown below.

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

- Keep pressing the 1 key to forcibly operate the output relay BO10 and check that the breaker is closed.
- Release pressing the 1 key to reset the operation.
- In case of two-breaker autoreclose, repeat the forcible operation for BO9.

6.7 Maintenance

6.7.1 Regular Testing

The relay is almost completely self-supervised. The circuits which cannot be supervised are binary input and output circuits and human interfaces.

Therefore regular testing can be minimized 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 signal 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.

(*) Failure signals on the external circuits, namely the signaling channel and isolator circuit, can be allotted to any of the binary output relays by the user. Failure signals of the signaling channel are set to BO11 of the IO2 module as the default setting.

Failures detected by supervision are traced by checking the "Auto-supervision" screen on the LCD.

If any messages are shown on the LCD, the failed module or failed external circuits can be located by referring to Table 6.7.2.1.

This table shows the relationship between messages displayed on the LCD and estimated failure location. Locations marked with (1) have a higher probability than locations marked with (2).

As shown in the table, some of the messages cannot identify the fault location definitely but suggest plural possible failure locations. In these cases, the failure location is identified by replacing the suggested failed modules with spare modules one by one or investigating and restoring the monitored external circuits (the signaling channel and isolator circuit) until the "ALARM" LED is turned off.

The replacement or investigation should be performed first for the module or circuit with higher probability in the table.

If there is a failure and the LCD is not working such as a screen is frozen or not displayed, the failure location is either SPM or HMI module.

Table 6.7.2.1 LCD Message and Failure Location

Message	Failure location									
	VCT	SPM (GCOM)	IO1 or IO8(*)	IO2	IO3, IO5, IO6	IO4	FD	HMI	Channel	Discon-nector	AC cable
Checksum err		×									
ROM-RAM err		×									
SRAM err		×									
BU-RAM err		×									
DPRAM err		×									
EEPROM err		×									
ROM data err		×									
A/D err		×									
V0 err	× (2)	× (1)									× (2)
V2 err	× (2)	× (1)									× (2)
I0 err	× (2)	× (1)									× (2)
Id err	× (2)	× (1)									× (2)
CT err	× (2)	× (2)									× (1)
Sampling err		×									
DIO err		× (2)	× (1)	× (1)	× (1)	× (1)					
RSM err		× (2)	× (1)								
COM_ ….err		×									
FD: … err		× (2)	× (1)				× (1)				
O/P circuit fail		× (2)	× (1)				× (1)				
DS fail		× (2)	× (2)							× (1)	
Com.1 fail, Com.2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
Sync.1 fail, Sync.2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
TX1 level err, TX2 level err		× (1)*	× (2)*	× (2)*					× (1)*		
RX1 level err, RX2 level err		× (2)*	× (2)*	× (2)*					× (1)*		
CLK 1 fail, CLK 2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
Term1 rdy off, Term2 rdy off		× (2)*							× (1)*		
RYID1 err, RYID2 err		× (2)*							× (1)*		
CT fail	× (2)	× (2)									× (1)
No-working of LCD		× (2)						× (1)			

Note: IO8 required for models 204, 206, 214 and 216.
The location marked with (1) has a higher probability than the location marked with (2).
The item of location marked with (*): also check the remote terminal relays and equipment.

If no message is shown on the LCD, it means that the failure location is either in the DC power supply circuit or in the microprocessors mounted on the SPM module. In this case, check the "ALARM" LED. If it is off, the failure is in the DC power supply circuit. If it is lit, open the relay front panel and check the LEDs mounted on the SPM module. If the LED is off, the failure is in the DC power supply circuit. If the LED is lit, the failure is in the microprocessors.

In the former case, check if the correct DC voltage is applied to the relay.

If so, replace the IO1 or IO8 module mounting the DC/DC converter and confirm that the "ALARM" LED is turned off.

In the latter case, replace the SPM module mounting the processors and confirm that the "ALARM" LED is turned off.

When a failure is detected during regular testing, it will not be difficult to identify the failed module to be replaced.

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 with correct polarity is applied and connected to the correct terminals.
- Correct AC inputs are applied and connected to the correct terminals.
- Test procedures comply with those stated in the manual.

6.7.3 Replacing Failed Modules

If the failure is identified to be in the relay module and the user has spare modules, the user can recover the protection by replacing the failed modules.

Repair at the site should be limited to module replacement. Maintenance at the component level is not recommended.

Check that the replacement module has an identical module name (VCT, SPM, IO1, IO2, etc.) and hardware type-form as the removed module. Furthermore, the SPM and FD modules should have the same software name.

The module name is indicated on the bottom front of the relay case. The hardware type-form is indicated on the module in the following format:

Module name	Hardware type-form
VCT	G1PC1 - ****
SPM	G1SP* - ****
IO1	G1IO1 - ****
IO2	G1IO2 - ****
IO3	G1IO3 - ****
IO4	G1IO2 - ****
IO5	G1IO3 - ****
IO6	G1IO3 - ****
IO8	G1IO8 - ****
FD	G1FD1 - ****
HMI	----

The software name is indicated on the memory device on the module with six letters such as GS1LM1, GS1LC1, GS1ZF1, etc.

⚠ CAUTION When handling a module, take anti-static measures such as wearing an earthed wrist band and placing modules on an earthed conductive mat. Otherwise, many of the electronic components could suffer damage.

CAUTION After replacing the SPM or FD module, check all of the settings including the data related the PLC and IEC103, etc. are restored the original settings.

The initial replacement procedure 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 approximately 30 seconds for the voltage to discharge.

- Disconnect the trip outputs.
- Short circuit all AC current inputs and disconnect all AC voltage inputs.
- Unscrew the relay front cover.

Replacing the Human Machine Interface Module (front panel)

- Open the front panel of the relay by unscrewing the binding screw located on the left side of the front panel.
- Unplug the ribbon cable on the front panel by pushing the catch outside.
- Remove the two retaining screws and one earthing screw on the relay case side, then detach the front panel from the relay case.
- Attach the replacement module in the reverse procedure.

Replacing the Transformer Module

- Open the right-side front panel (HMI module) by unscrewing the two binding screws located on the left side of the panel.
- Open the left-side front panel (blind panel) (*) by unscrewing the two binding screws located on the right side of the panel.

  (*) This blind panel is attached only to models assembled in the type B case.

- Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.
- Unplug the ribbon cable on the SPM (and FD module in models 400s and 500s) by nipping the catch.
- Remove the metal cover by unscrewing the binding screw located at the top and bottom of the cover.
- Pull out the module by grasping the handles.
- Insert the replacement module in the reverse procedure.

Replacing other modules

- Open the right-side front panel (HMI module) by unscrewing the two binding screws located on the left side of the panel.

- Open the left-side front panel (blind panel) (*) by unscrewing the two binding screws located on the right side of the panel.

  (*) This panel is attached only to models assembled in the type B case.

- Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.
- Unplug the ribbon cable running among the modules by nipping the catch (in case of black connector) and by pushing the catch outside (in case of gray connector) on the connector.
- Unplug the cable connector behind the case when replacing the SPM module.
- Pull out the module by pulling up or down on the top and bottom levers.
- Insert the replacement module in the reverse procedure.

6.7.4 Resumption of Service

After replacing the failed module or repairing failed external circuits, take the following procedures to restore the relay to 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.

  Note: Supply DC power after checking that all the modules are in their original positions and the ribbon cables are plugged in.

- If the telecommunication circuit or trip circuit was repaired, check that the circuit is normal.
- Supply the AC inputs and reconnect the trip outputs.

6.7.5 Storage

The spare relay or module should be stored in a dry and clean room. Based on IEC Standard 60255-0 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 commissioning or maintenance tests.

- Check that all external connections are correct.
- Check the settings of all measuring elements, timers, scheme switches, recordings and clock are correct.

  In particular, when settings are changed temporarily for testing, be sure to restore them.
- Clear any unnecessary records on faults, events and disturbances which are recorded during the tests.
- Reset the counter figures of autoreclose(*), if necessary. For resetting the count, see Section 4.2.3.4.

(*) Implemented in models 200s to 500s.

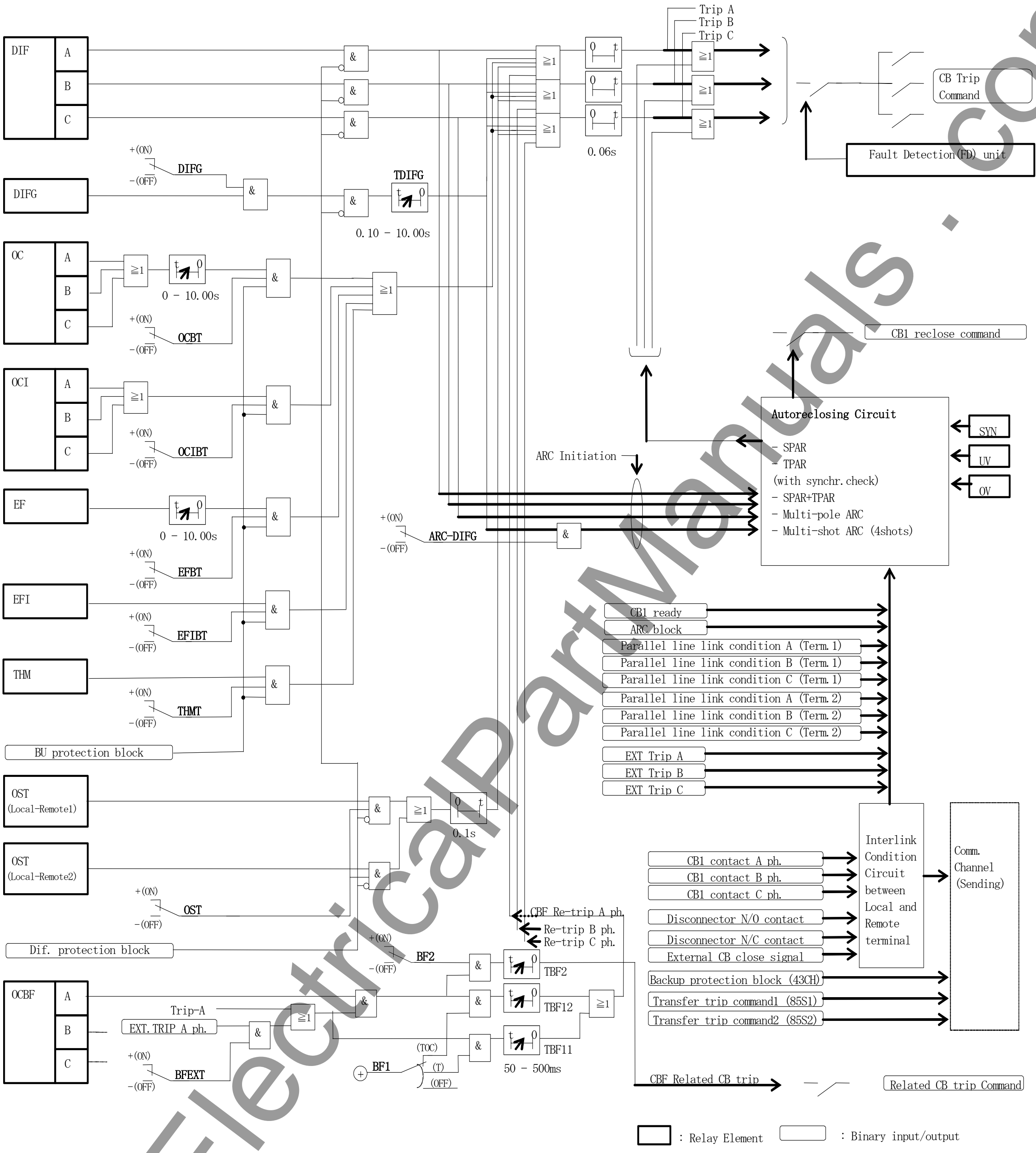
- Press the VIEW key and check that no failure message is displayed on the "Auto-supervision" screen.
- Check that the green "IN SERVICE" LED is lit and no other LEDs are lit on the front panel.

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

Block Diagram

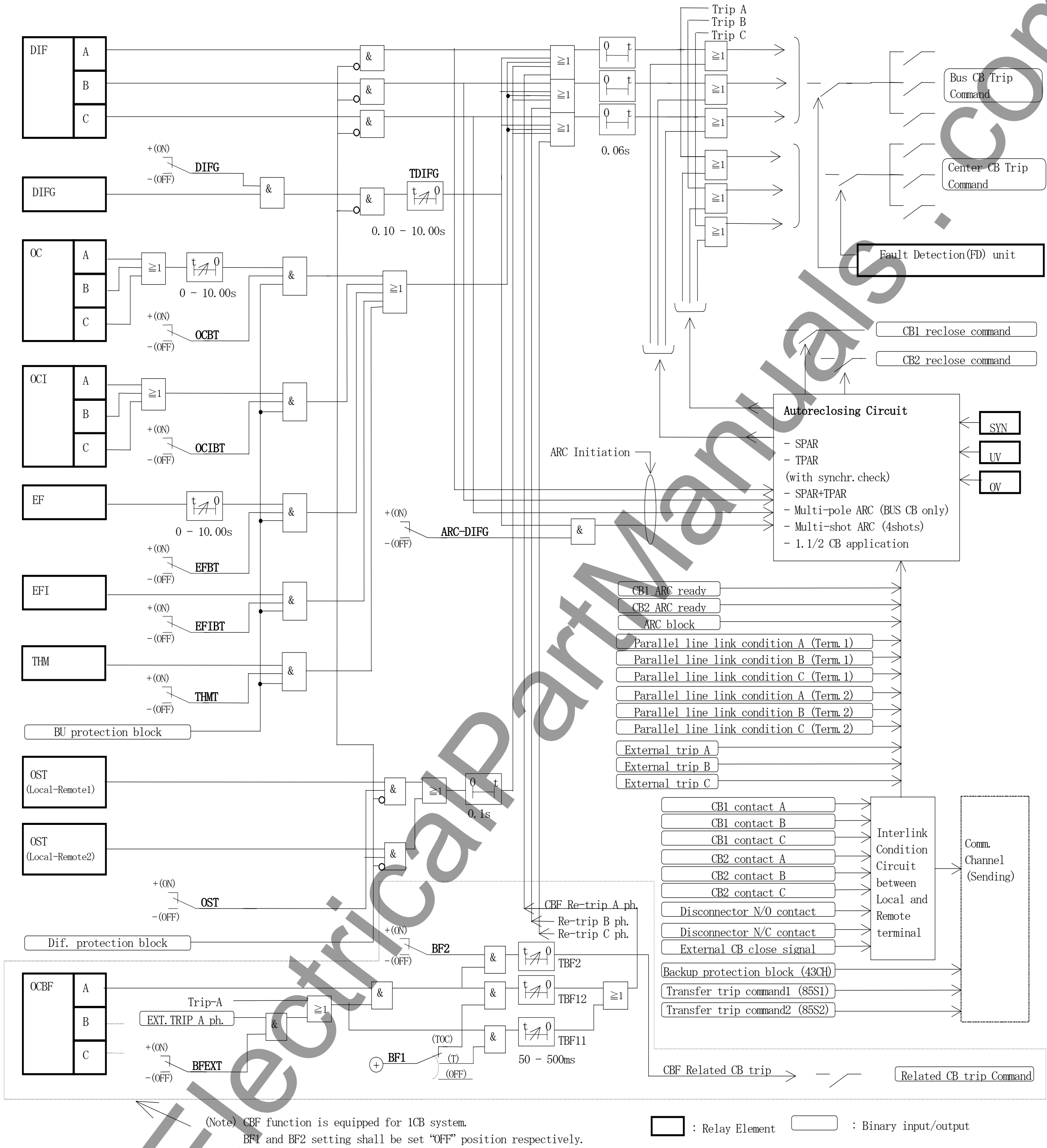
Note: These show simplified block diagrams including each protection function.
For details of each protection function, refer to Chapter 2.



Models 201, 211, 202, 212, 204, 214, 206, 216: With autoreclosing circuit / No fault detection unit

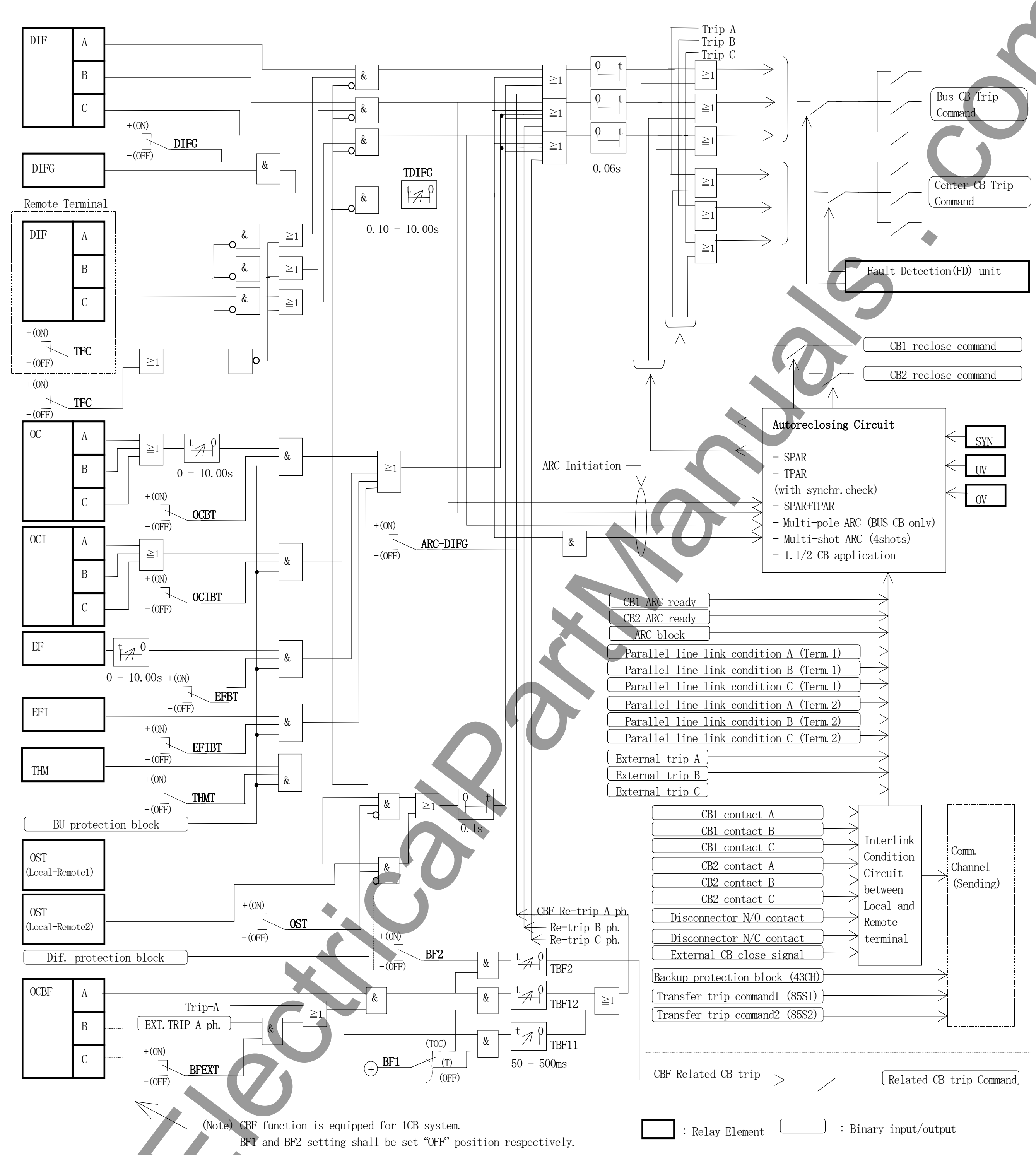
Models 401 and 411: With autoreclosing circuit / With fault detection unit

Block Diagram of Line Differential Relay GRL100-200s and 400s



Models 101, 111, 102 and 112: No autoreclosing circuit / No fault detection unit
Models 301, 302 and 312: With autoreclosing circuit / No fault detection unit
Models 501 and 511: With autoreclosing circuit / With fault detection unit

Block Diagram of Line Differential Relay GRL100-100s, 300s and 500s



Block Diagram of Line Differential Relay GRL100-503 and 513

Appendix B

Signal List

Signal list

Protection relay output

No.	Signal Name	Contents
0	CONSTANT_0	constant 0
1	CONSTANT_1	constant 1
2		
3		
4		
5		
6		
7		
8		
9	43CX	Diff.protection enable condition
10		
11		
12		
13		
14		
15	43BUX	Backup protection enable condition
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
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38	ARC_COM.ON	Autorecloser active (for IEC103)
39	TELE.COM.ON	Teleprotection active (for IEC103)
40	PROT.COM.ON	Protection active (for IEC103)
41	DIF-A	DIF-A element output
42	DIF-B	DIF-B element output
43	DIF-C	DIF-C element output
44	DIFG	DIFG element output
45	OST1A	OST1 A zone
46	OST1B	OST1 B zone
47	OST1AB	OST1 A+B zone
48	OST1	OST1 element output (OST with terminal 1)
49	OST2A	OST2 A zone
50	OST2B	OST2 B zone
51	OST2AB	OST2 A+B zone
52	OST2	OST2 element output (OST with terminal 2)
53	RELAY_BLOCK	DIF element block signal
54	OCBF-A	OCBF-A element output
55	OCBF-B	OCBF-B element output
56	OCBF-C	OCBF-C element output
57	OVB	OVB element output
58	UVB	UVB element output
59	SYN1	SYN1 element output
60	OVL1	OVL1 element output
61	UVL1	UVL1 element output
62	OVL2	OVL2 element output
63	UVL2	UVL2 element output
64	SYN2	SYN2 element output
65	OC-A	OC-A element output
66	OC-B	OC-B element output
67	OC-C	OC-C element output
68	OCI-A	OCI-A element output
69	OCI-B	OCI-B element output
70	OCI-C	OCI-C element output
71	EF	EF element output
72	EFI	EFI element output
73		
74		
75		
76		
77		
78	OVL-ABC	OVL element output (for 3phase line voltage)
79		
80	52AND2	CB2 contact AND logic

Signal list

No.	Signal Name	Contents
81	52AND	CB1 contact AND logic
82	DIF-A_TRIP	DIF trip signal A
83	DIF-B_TRIP	DIF trip signal B
84	DIF-C_TRIP	DIF trip signal C
85	TDIFG	TDIFG timer output
86	DIFG_TRIP	DIFG trip signal
87	OST_TRIP	OST trip signal
88	RETRIP-A	BFP retrip signal A
89	RETRIP-B	BFP retrip signal B
90	RETRIP-C	BFP retrip signal C
91	CBFDET	BFP operation (88+89+90+92)
92	CBF_TRIP	BFP adjacent breaker trip command
93	TRIP-A	Trip signal A
94	TRIP-B	Trip signal B
95	TRIP-C	Trip signal C
96	TRIP-DETOR	Trip signal (93+94+95)
97	TRIP	Trip signal single shot
98	STUB	Stub trip signal
99	TRIP-A1	CB1 trip command A
100	TRIP-B1	CB1 trip command B
101	TRIP-C1	CB1 trip command C
102	TRIP-A2	CB2 trip command A
103	TRIP-B2	CB2 trip command B
104	TRIP-C2	CB2 trip command C
105	FDX1	Fault detector output relay 1 driving signal
106	FDX2	Fault detector output relay 2 driving signal
107	M-OR	Main trip OR logic
108	M-AND	Main trip AND logic
109	FD	Fault detector output OR logic
110	FD-AND	Fault detector output AND logic
111	TOC	TOC timer output
112	TEF	TEF timer output
113	OC_TRIP	OC trip signal
114	OCI_TRIP	OCI trip signal
115	EF_TRIP	EF trip signal
116	EFBT	EF alarm signal
117	EFI_TRIP	EFI trip signal
118	BU_TRIP	Backup trip signal
119	OST-BO	OST trip signal for BO output
120		
121	REC_BLK12	Autoreclose block command from remote terminal
122	TRDY1	Reclaim time count up signal of leader CB
123	TSPR1	Dead time count up signal in leader CB SPAR
124	TTPR1	Dead time count up signal in leader CB TPAR
125	ARC-L	Leader CB autoreclose signal
126	TPARL-SET	TPAR output set signal in leader CB autoreclose
127	TRR1	Leader CB autoreclose reset signal
128	TRDY2	Reclaim time count up signal of follower CB
129	TSPR2	Dead time count up signal in follower CB SPAR
130	TTPR2	Dead time count up signal in follower CB TPAR
131	ARC-F	Follower CB autoreclose signal
132	TPAR-F	TPAR output set signal in follower CB autoreclose
133	TRR2	Follower CB autoreclose reset signal
134	TS2	Second shot autoreclose signal
135	TS3	Third shot autoreclose signal
136	TS4	Fourth shot autoreclose signal
137	TS2R	Second shot autoreclose reset signal
138	TS3R	Third shot autoreclose reset signal
139	TS4R	Fourth shot autoreclose reset signal
140	MULTI-ARC	Multi-shot autoreclose signal (134+135+136)
141	MAROK0	First shot autoreclose success signal
142	MAROK1	Second shot autoreclose success signal
143	MAROK2	Third shot autoreclose success signal
144	MAROK3	Fourth shot autoreclose success signal
145	MAR-FT	Multi-shot autoreclose failure signal
146	89CB-1AB	Interlink A with terminal 1
147	89CB-2AB	Interlink B with terminal 1
148	89CC-3AB	Interlink C with terminal 1
149	89CB-1AC	Interlink A with terminal 2
150	89CB-2AC	Interlink B with terminal 2
151	89CC-3AC	Interlink C with terminal 2
152	LINK	Interlink signal
153	LB.DL-1	Live bus and dead line status on CB1
154	DB.LL-1	Dead bus and live line status on CB1
155	LB.LL.SYN-1	Synchronism check output for CB1
156	LB.DL-2	Live bus and dead line status on CB2
157	DB.LL-2	Dead bus and live line status on CB2
158	LB.LL.SYN-2	Synchronism check output for CB2
159	SYN-OP	Voltage and synchronism check output (153 +--+ 158)
160	SYN-SEL	SYN element selection signal

Signal list

No.	Signal Name	Contents
161	TDBL1	TDBL1 timer output
162	TLBD1	TLBD1 timer output
163	TSYN1	TSYN1 timer output
164	TDBL2	TDBL2 timer output
165	TLBD2	TLBD2 timer output
166	TSYN2	TSYN2 timer output
167	REC-READY1	ARC ready signal in leader CB autoreclose
168	REC-READY2	ARC ready signal in follower CB autoreclose
169	BRIDGE1	Bridge condition in leader CB autoreclose
170	BRIDGE2	Bridge condition in follower CB autoreclose
171	IN-PROG1	ARC in-progress in leader CB autoreclose
172	IN-PROG2	ARC in-progress in follower CB autoreclose
173	SPAR1	Single-phase autoreclose signal for leader CB
174	SPAR2	Single-phase autoreclose signal for follower CB
175	TPAR1	Three-phase autoreclose signal for leader CB
176	TPAR2	Three-phase autoreclose signal for follower CB
177	ARC1	Autoreclose command for CB1
178	ARC2	Autoreclose command for CB2
179	94TT1	Discrepancy trip signal in leader CB autoreclose
180	94TT2	Discrepancy trip signal in follower CB ARC
181	FT1	Final trip of leader CB
182	FT2	Final trip of center CB
183	MPAR1	Multi-phase auoteclosing signal in leader CB ARC
184	TEVLV	TEVLV timer output
185	MPAR2	Multi-phase auoteclosing signal in follower CB ARC
186	TP-MPH	Multi-phase trip
187	TP-1PH	single phase trip
188	TP-2PH	two or more phase trip
189	TSPR3	Dead time count up signal in follower CB MPAR
190	TTPR3	Dead time count up signal in follower CB MPAR
191	READY	Local terminal ready
192	REM1_READY	Terminal 1 ready
193	REM2_READY	Terminal 2 ready
194	MASTER	Being set to master terminal
195	SLAVE	Being set to slave terminal
196	FG	Trigger signal for end-to-end synchronized test
197	85R1.REM1	Transfer trip command 1 receiving from terminal 1
198	85R2.REM1	Transfer trip command 2 receiving from terminal 1
199	REC-BLK1	Autoreclose blocked at terminal 1
200	TFC_ON1	TFC scheme ON setting between remote terminal 1
201	LOCAL_TEST1	Terminal 1 "under local test"
202	85R1.REM2	Transfer trip command 1 receiving from terminal 2
203	85R2.REM2	Transfer trip command 2 receiving from terminal 2
204	REC-BLK2	Autoreclose blocked at terminal 2
205	TFC_ON2	TFC scheme ON setting between remote terminal 2
206	LOCAL_TEST2	Terminal 2 "under local test"
207	REM1_IN_SRV	Terminal 1 "in-service"
208	REM1_OFF_SRV	Terminal 1 "out-of-service"
209	REM1_NON_USE	Terminal 1 "not used"
210	REM2_IN_SRV	Terminal 2 "in-service"
211	REM2_OFF_SRV	Terminal 2 "out-of-service"
212	REM2_NON_USE	Terminal 2 "not used"
213	UNREADY1	Terminal 1 communication not ready
214	CFSV1	Terminal 1 CFSV
215	SPSV1	Sampling synchronization with terminal 1 failure signal
216	TX_LEVEL1	Terminal 1 drop of transmission signal level
217	RX_LEVEL1	Terminal 1 drop of receiving signal level
218	CLK1	Terminal 1 interrupt of clock signal
219	UNREADY2	Terminal 2 communication not ready
220	CFSV2	Terminal 2 CFSV
221	SPSV2	Sampling synchronization with terminal 2 failure signal
222	TX_LEVEL2	Terminal 2 drop of transmission signal level
223	RX_LEVEL2	Terminal 2 drop of receiving signal level
224	CLK2	Terminal 2 interrupt of clock signal
225	COMM1_FAIL	Communication with terminal 1 failure signal
226	COMM2_FAIL	Communication with terminal 2 failure signal
227	TRANSFER	Transfer trip receive
228	RDIF-R1_OR	RDIF1 (Remote differential trip received from remote-1)
229	RDIF-R2_OR	RDIF2 (Remote differential trip received from remote-2)
230	CFSV1/2-L	CFSV1/2-L (Communication fail (236+238))
231	RLY_FAIL	Relay failure
232	RLY_OP_BLK	Relay output block
233	AMF_OFF	A.M.F disabling signal
234	O/P_CIR._SV	False operation of tripping output circuit
235	LSSV	DS failure signal
236	CFSV1-L	CFSV1-L (Communication with term.1 fail detected by local relay)
237	CFSV1-R	CFSV1-R (Communication with term.1 fail detected by remote relay)
238	CFSV2-L	CFSV2-L (Communication with term.2 fail detected by local relay)
239	CFSV2-R	CFSV2-R (Communication with term.2 fail detected by remote relay)
240		

Signal list

No.	Signal Name	Contents
241		
242		
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250		
251	CHECKING	During automatic checking
252	CHK_FAIL-Q	Fail-to-operate of tripping output circuit
253	CHK_STEP1	Checking step1
254	CHK_STEP2	Checking step2
255	CHK_STEP3	Checking step3
256	OC/OCI_TRIP	OC/OCI trip
257	EF/EFI_TRIP	EF/EFI trip
258	RYIDSV1	RYIDSV1 (Remote 1 relay address monitoring)
259	RYIDSV2	RYIDSV2 (Remote 2 relay address monitoring)
260		
261	TRIP-H	Trip signal hold
262		
263	DEG_ALARM	DEG ALARM output
264	AMP_ALARM	AMP ALARM output
265	DEG_OK	DEG OK output
266	CF1	Telecommunication failure detect signal for ch#1
267	CF2	Telecommunication failure detect signal for ch#2
268	TDSV1	Telecommunication delay time over of ch#1
269	TDSV2	Telecommunication delay time over of ch#2
270	50/60Hz	Pulse signal for end-to-end test
271	1PPS_OFF	1PPS signal check (instant)
272	1PPS_SV-L	1PPS signal check for a certain time at local term.
273	1PPS_SV-R	1PPS signal check for a certain time at remote term.
274	1PPS_ERROR	1PPS signal interval error
275		
276		
277		
278		ch2 used for sampling synchoronization
279	DIF#1	DIF#1 element block signal
280	DIF#2	DIF#2 element block signal
281	DIF-A#1	DIF-A#1 element output
282	DIF-B#1	DIF-B#1 element output
283	DIF-C#1	DIF-C#1 element output
284	DIFG#1	DIFG#1 element output
285	DIF-A#2	DIF-A#2 element output
286	DIF-B#2	DIF-B#2 element output
287	DIF-C#2	DIF-C#2 element output
288	DIFG#2	DIFG#2 element output
289	OVER_PH	Phase difference (over)
290	INVALID_PH	Phase difference (invalid)
291	UNDER_PH	Phase difference (under)
292		
293		
294		
295	MODE2A	Synchronisation in MODE2A
296		
297		
298		
299		
300		
301	OCMF-L1	OCMF-L1 element output
302	OCMF-L2	OCMF-L2 element output
303	OCMF-L3	OCMF-L3 element output
304	OCMF-L4	OCMF-L4 element output
305	OCMF-L5	OCMF-L5 element output
306	OCMF-L6	OCMF-L6 element output
307	OCMF-L7	OCMF-L7 element output
308	OCMF	OCMF element output “OR”
309	OCDF-A	OCDF-A element output
310	OCDF-B	OCDF-B element output
311	OCDF-C	OCDF-C element output
312	OVL-A	OVL-A element output (for 3phase line voltage)
313	OVL-B	OVL-B element output (for 3phase line voltage)
314	OVL-C	OVL-C element output (for 3phase line voltage)
315		
316	EFF	EFF element output
317	UVSF-AB	UVSF-A element output
318	UVSF-BC	UVSF-B element output
319	UVSF-CA	UVSF-C element output
320		

Signal list

No.	Signal Name	Contents
321	UVGF-A	UVGF-A element output
322	UVGF-B	UVGF-B element output
323	UVGF-C	UVGF-C element output
324		
325	UVDF-A	UVDF-A element output
326	UVDF-B	UVDF-B element output
327	UVDF-C	UVDF-C element output
328		
329		
330		
331		
332		
333	TMPR1	Dead time count up signal in leader CB MPAR
334	TMPR2	Dead time count up signal in follower CB MPAR
335	TMPR3	Dead time count up signal in follower CB MPAR
336	CF1	Telecommunication failure detect signal for ch#1
337	RXSA1_ERR	RXSA synchronisation error for ch#1
338	CF2_	Telecommunication failure detect signal for ch#2
339	RXSA2_ERR	RXSA synchronisation error for ch#2
340	1PPS_SV-R2	1PPS signal check for a certain time at remote#2 term.
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362		
363	THMT	Thermal trip element ouput
364		
365		
366		
367	THMA	Thermal alarm element ouput
368	OC1-A	OC1-A element output
369	OC1-B	OC1-B element output
370	OC1-C	OC1-C element output
371		
372	OCD-A	OCD-A element output
373	OCD-B	OCD-B element output
374	OCD-C	OCD-C element output
375	EFD	EFD element output
376		
377		
378		
379		
380		
381	CTFID-A	Id element output
382	CTFID-B	ditto
383	CTFID-C	ditto
384	DIFSV-A	DIFSV-A element output
385	DIFSV-B	DIFSV-B element output
386	DIFSV-C	DIFSV-C element output
387	CTFID	Id0 element output
388	CTFUV-A	UV element for CTF function
389	CTFUV-B	ditto
390	CTFUV-C	ditto
391	CTFOVG	OVG element for CTF function
392	CTFUVD-A	UVD element for CTF function
393	CTFUVD-B	ditto
394	CTFUVD-C	ditto
395	CTFUV	UV element for CTF function
396	CTFUVD	UVD element for CTF function
397		
398		
399		
400	DIF.FS_TRIP	DIF trip with FS

Signal list

No.	Signal Name	Contents
401	DIF.FS-A_TRIP	DIF-A trip with FS
402	DIF.FS-B_TRIP	DIF-B trip with FS
403	DIF.FS-C_TRIP	DIF-C trip with FS
404	DIFG.FS_TRIP	DIFG trip with FS
405	DIF_TRIP	DIF trip signal
406		
407		
408	DIFFS_OP	Fail safe for DIF trip
409	DIFFS-A_OP	ditto
410	DIFFS-B_OP	ditto
411	DIFFS-C_OP	ditto
412	DIFGFS_OP	Fail safe for DIFG trip
413		
414		
415		
416	THM_ALARM	Thermal alarm signal
417	THM_TRIP	Thermal trip signal
418	TR1_TRIP	TRANSFER TRIP-1
419	TR1-A_TRIP	TRANSFER TRIP-1 (A ph.)
420	TR1-B_TRIP	TRANSFER TRIP-1 (B ph.)
421	TR1-C_TRIP	TRANSFER TRIP-1 (C ph.)
422	INTER_TRIP1	INTER TRIP-1
423	INTER_TRIP1-A	INTER TRIP-1 (A ph.)
424	INTER_TRIP1-B	INTER TRIP-1 (B ph.)
425	INTER_TRIP1-C	INTER TRIP-1 (C ph.)
426	TR2_TRIP	TRANSFER TRIP-2
427	TR2-A_TRIP	TRANSFER TRIP-2 (A ph.)
428	TR2-B_TRIP	TRANSFER TRIP-2 (B ph.)
429	TR2-C_TRIP	TRANSFER TRIP-2 (C ph.)
430	INTER_TRIP2	INTER TRIP-2
431	INTER_TRIP2-A	INTER TRIP-2 (A ph.)
432	INTER_TRIP2-B	INTER TRIP-2 (B ph.)
433	INTER_TRIP2-C	INTER TRIP-2 (C ph.)
434	LOCAL_TEST	LOCAL TESTING SW ON
435	TP-A	Trip A-phase command without off-delay timer
436	TP-B	Trip B-phase command without off-delay timer
437	TP-C	Trip C-phase command without off-delay timer
438	SHOT_NUM1	Trip/Auto-Reclosing shot number1 condition
439	SHOT_NUM2	Trip/Auto-Reclosing shot number2 condition
440	SHOT_NUM3	Trip/Auto-Reclosing shot number3 condition
441	SHOT_NUM4	Trip/Auto-Reclosing shot number4 condition
442	SHOT_NUM5	Trip/Auto-Reclosing shot number5 condition
443	I.LINK-A	Interlink signal
444	I.LINK-B	ditto
445	I.LINK-C	ditto
446	TRIP_ALARM	Trip alarm
447	READY1_ALARM	Terminal 1 ready
448	READY2_ALARM	Terminal 2 ready
449	ARCMD_ALARM	PLC Autoreclosing mode discrepancy alarm
450	TFC_ON	TFC scheme ON setting
451	RDIF-A-S	Remote DIF trip sending signal
452	RDIF-B-S	ditto
453	RDIF-C-S	ditto
454	RDIF-S	ditto
455	RD.FS_TRIP	RDIF trip with FS
456	RD.FS-A_TRIP	RDIF-A trip with FS
457	RD.FS-B_TRIP	RDIF-B trip with FS
458	RD.FS-C_TRIP	RDIF-C trip with FS
459	OC-A_TRIP	OC-A trip signal
460	OC-B_TRIP	OC-B trip signal
461	OC-C_TRIP	OC-C trip signal
462	OCI-A_TRIP	OCI-A trip signal
463	OCI-B_TRIP	OCI-B trip signal
464	OCI-C_TRIP	OCI-C trip signal
465	IDSV-A	Id-A failure signal
466	IDSV-B	Id-A failure signal
467	IDSV-C	Id-A failure signal
468		
469		
470		
471		
472		
473		
474		
475		
476		
477	ARC-SET	output set signal in leader CB autoreclose
478	CCB-SET	CCB output set signal in leader CB autoreclose
479	CB_UNDRY.L_ST	Starting signal for Final Trip with CB unready
480	ARCMD_OFF	Autoreclosing mode (Disable)

Signal list

No.	Signal Name	Contents
481	ARCMD_SPAR	ditto (SPAR)
482	ARCMD_TPAR	ditto (MPAR)
483	ARCMD_S&T	ditto (SPAR & TPAR)
484	ARCMD_MAPR2	ditto (MPAR2)
485	ARCMD_MPAR3	ditto (MPAR3)
486	ARCMD_EXT1P	ditto (EXT1P)
487	ARCMD_EXT3P	ditto (EXT3P)
488	ARCMD_EXTMP	ditto (EXTMP)
489	ARC.L_SUCCESS	Leader CB autoreclose success signal
490	ARC.F_SUCCESS	Follower CB autoreclose success signal
491	TSUC1	ARC.L success reset signal
492	TSUC2	ARC.F success reset signal
493	ARC_FAIL1	Leader CB autoreclose fail signal
494	ARC_FAIL2	Follower CB autoreclose fail signal
495		
496	CTF	CTF detection
497	CTF_ALARM	CTF alarm
498	3PLL	Three phase live line element output
499	LB	Selected live bus mode
500	DB	Selected dead bus mode
501	SYN	Selected Synchronism check mode
502		
503		
504	UARCSW_P1	User ARC switch Position1
505	UARCSW_P2	User ARC switch Position2
506	UARCSW_P3	User ARC switch Position3
507		
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511		
512		
513	BI1_COMMAND	Binary input signal BI1
514	BI2_COMMAND	Binary input signal BI2
515	BI3_COMMAND	Binary input signal BI3
516	BI4_COMMAND	Binary input signal BI4
517	BI5_COMMAND	Binary input signal BI5
518	BI6_COMMAND	Binary input signal BI6
519	BI7_COMMAND	Binary input signal BI7
520	BI8_COMMAND	Binary input signal BI8
521	BI9_COMMAND	Binary input signal BI9
522	BI10_COMMAND	Binary input signal BI10
523	BI11_COMMAND	Binary input signal BI11
524	BI12_COMMAND	Binary input signal BI12
525	BI13_COMMAND	Binary input signal BI13
526	BI14_COMMAND	Binary input signal BI14
527	BI15_COMMAND	Binary input signal BI15
528	BI16_COMMAND	Binary input signal BI16
529	BI17_COMMAND	Binary input signal BI17
530	BI18_COMMAND	Binary input signal BI18
531	BI19_COMMAND	Binary input signal BI19
532	BI20_COMMAND	Binary input signal BI20
533	BI21_COMMAND	Binary input signal BI21
534	BI22_COMMAND	Binary input signal BI22
535	BI23_COMMAND	Binary input signal BI23
536	BI24_COMMAND	Binary input signal BI24
537	BI25_COMMAND	Binary input signal BI25
538	BI26_COMMAND	Binary input signal BI26
539	BI27_COMMAND	Binary input signal BI27
540	BI28_COMMAND	Binary input signal BI28
541	BI34_COMMAND	Binary input signal BI34
542	BI35_COMMAND	Binary input signal BI35
543	BI36_COMMAND	Binary input signal BI36
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Signal list

No.	Signal Name	Contents
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949		
950	MODE0	Changed to MODE0
951	MODE1	Changed to MODE1
952	MODE2A-GPS	Changed to MODE2A due to GPS failure
953	MODE2A-Td	Changed to MODE2A due to abnormal telecomm. delay time
954	MODE2A-CF	Changed to MODE2A due to telecomm. failure
955	MODE2A-ANGLE	Changed to MODE2A due to sync. failure
956	MODE2A-RMT	Changed to MODE2A due to remote end's request
957	MODE2B	Changed to MODE2B
958		
959		
960	V.COM1-R1	Comm. data(V0 data frame) receive signal from term-1

Signal list

No.	Signal Name	Contents
961	V.COM2-R1	ditto
962	V.COM3-R1	ditto
963		
964	S.V.COM1-R1	Comm. data(V0 data frame) receive signal from term-1
965	S.V.COM2-R1	ditto
966	S.V.COM3-R1	ditto
967	S.V.COM4-R1	ditto
968	S.V.COM5-R1	ditto
969	S.V.COM6-R1	ditto
970	S.V.COM7-R1	ditto
971	S.V.COM8-R1	ditto
972	S.V.COM9-R1	ditto
973	S.V.COM10-R1	ditto
974	S.V.COM11-R1	ditto
975	S.V.COM12-R1	ditto
976	V.COM1-R2	Comm. data(V0 data frame) receive signal from term-2
977	V.COM2-R2	ditto
978	V.COM3-R2	ditto
979		
980	S.V.COM1-R2	Comm. data(V0 data frame) receive signal from term-2
981	S.V.COM2-R2	ditto
982	S.V.COM3-R2	ditto
983	S.V.COM4-R2	ditto
984	S.V.COM5-R2	ditto
985	S.V.COM6-R2	ditto
986	S.V.COM7-R2	ditto
987	S.V.COM8-R2	ditto
988	S.V.COM9-R2	ditto
989	S.V.COM10-R2	ditto
990	S.V.COM11-R2	ditto
991	S.V.COM12-R2	ditto
992	I.COM1-R1	Comm. data(I0 data frame) receive signal from term-1
993	I.COM2-R1	ditto
994	I.COM3-R1	ditto
995		
996	S.I.COM1-R1	Comm. data(I0 data frame) receive signal from term-1
997	S.I.COM2-R1	ditto
998	S.I.COM3-R1	ditto
999	S.I.COM4-R1	ditto
1000	S.I.COM5-R1	ditto
1001	S.I.COM6-R1	ditto
1002	S.I.COM7-R1	ditto
1003	S.I.COM8-R1	ditto
1004	S.I.COM9-R1	ditto
1005	S.I.COM10-R1	ditto
1006	S.I.COM11-R1	ditto
1007	S.I.COM12-R1	ditto
1008	I.COM1-R2	Comm. data(I0 data frame) receive signal from term-2
1009	I.COM2-R2	ditto
1010	I.COM3-R2	ditto
1011		
1012	S.I.COM1-R2	Comm. data(I0 data frame) receive signal from term-2
1013	S.I.COM2-R2	ditto
1014	S.I.COM3-R2	ditto
1015	S.I.COM4-R2	ditto
1016	S.I.COM5-R2	ditto
1017	S.I.COM6-R2	ditto
1018	S.I.COM7-R2	ditto
1019	S.I.COM8-R2	ditto
1020	S.I.COM9-R2	ditto
1021	S.I.COM10-R2	ditto
1022	S.I.COM11-R2	ditto
1023	S.I.COM12-R2	ditto
1024		
1025		
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1040	FAULT_PHA_A	fault_phase_A

Signal list

No.	Signal Name	Contents
1041	FAULT_PHA_B	fault_phase_B
1042	FAULT_PHA_C	fault_phase_C
1043	FAULT_PHA_N	fault_phase_N
1044	FL_ERR	fault location start up error
1045	FL_OB_FWD	fault location out of bounds(forward)
1046	FL_OB_BACK	fault location out of bounds(backward)
1047	FL_NC	fault location not converged
1048	FL_COMPLETED	fault location completed
1049		
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1080		
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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

Signal list

No.	Signal Name	Contents
1121	SUB2_COM10-R1	ditto
1122	SUB2_COM11-R1	ditto
1123	SUB2_COM12-R1	ditto
1124		
1125		
1126		
1127		
1128	COM1-R2	Comm. data receive signal from remote term-2
1129	COM2-R2	ditto
1130	COM3-R2	ditto
1131	COM4-R2	ditto
1132	COM5-R2	ditto
1133		
1134		
1135		
1136	COM1-R2_UF	Comm. data receive signal from remote term-2 (unfiltered)
1137	COM2-R2_UF	ditto
1138	COM3-R2_UF	ditto
1139	COM4-R2_UF	ditto
1140	COM5-R2_UF	ditto
1141		
1142		
1143		
1144	SUB_COM1-R2	Sub comm. data receive signal from term-2
1145	SUB_COM2-R2	ditto
1146	SUB_COM3-R2	ditto
1147	SUB_COM4-R2	ditto
1148	SUB_COM5-R2	ditto
1149		
1150		
1151		
1152	SUB2_COM1-R2	Sub comm. data2 receive signal from term-2
1153	SUB2_COM2-R2	ditto
1154	SUB2_COM3-R2	ditto
1155	SUB2_COM4-R2	ditto
1156	SUB2_COM5-R2	ditto
1157	SUB2_COM6-R2	ditto
1158	SUB2_COM7-R2	ditto
1159	SUB2_COM8-R2	ditto
1160	SUB2_COM9-R2	ditto
1161	SUB2_COM10-R2	ditto
1162	SUB2_COM11-R2	ditto
1163	SUB2_COM12-R2	ditto
1164		
1165		
1166		
1167		
1168	SUB3_COM1-R1	Sub comm. data3 receive signal from term-1
1169	SUB3_COM2-R1	ditto
1170	SUB3_COM3-R1	ditto
1171	SUB3_COM4-R1	ditto
1172	SUB3_COM5-R1	ditto
1173	SUB3_COM6-R1	ditto
1174	SUB3_COM7-R1	ditto
1175	SUB3_COM8-R1	ditto
1176	SUB3_COM9-R1	ditto
1177	SUB3_COM10-R1	ditto
1178	SUB3_COM11-R1	ditto
1179	SUB3_COM12-R1	ditto
1180		
1181		
1182		
1183		
1184	SUB3_COM1-R2	Sub comm. data3 receive signal from term-2
1185	SUB3_COM2-R2	ditto
1186	SUB3_COM3-R2	ditto
1187	SUB3_COM4-R2	ditto
1188	SUB3_COM5-R2	ditto
1189	SUB3_COM6-R2	ditto
1190	SUB3_COM7-R2	ditto
1191	SUB3_COM8-R2	ditto
1192	SUB3_COM9-R2	ditto
1193	SUB3_COM10-R2	ditto
1194	SUB3_COM11-R2	ditto
1195	SUB3_COM12-R2	ditto
1196		
1197		
1198		
1199		
1200		

Signal list

No.	Signal Name	Contents
1201		
1202		
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1234		
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1239		
1240		
1241	IEC_MDBLK	monitor direction blocked
1242	IEC_TESTMODE	IEC61870-5-103 testmode
1243	GROUP1_ACTIVE	group1 active
1244	GROUP2_ACTIVE	group2 active
1245	GROUP3_ACTIVE	group3 active
1246	GROUP4_ACTIVE	group4 active
1247	GROUP5_ACTIVE	group5 active
1248	GROUP6_ACTIVE	group6 active
1249	GROUP7_ACTIVE	group7 active
1250	GROUP8_ACTIVE	group8 active
1251	RLY_FAIL	RELAY FAILURE
1252	RLY_OP_BLK_	RELAY OUTPUT BLOCK
1253	AMF_OFF_	SV BLOCK
1254		
1255		
1256	IDSV	Id failure signal
1257		
1258	RELAY_FAIL-A	
1259		
1260		
1261	TRIP-H	Trip signal hold
1262	CT_ERR_UF	CT error(unfiltered)
1263	I0_ERR_UF	I0 error(unfiltered)
1264	V0_ERR_UF	V0 error(unfiltered)
1265	V2_ERR_UF	V2 error(unfiltered)
1266	CT_ERR	CT error
1267	I0_ERR	I0 error
1268	V0_ERR	V0 error
1269	V2_ERR	V2 error
1270	I0-C_ERR_UF	I0 error(unfiltered)(For center CB on T.F.C model)
1271	I0-C_ERR	I0 error(For center CB on T.F.C model)
1272	CT-C_ERR_UF	CT error(unfiltered)(For center CB on T.F.C model)
1273	CT-C_ERR	CT error(For center CB on T.F.C model)
1274		
1275		
1276	50Hz/60Hz	Frequency pulse signal
1277		
1278		
1279	GEN_PICKUP	General start/pick-up
1280	GEN_TRIP	General trip

Signal list

No.	Signal Name	Contents
1281		
1282		
1283		
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)
1292	BI9_COM_UF	Binary input signal BI9 (unfiltered)
1293	BI10_COM_UF	Binary input signal BI10 (unfiltered)
1294	BI11_COM_UF	Binary input signal BI11 (unfiltered)
1295	BI12_COM_UF	Binary input signal BI12 (unfiltered)
1296	BI13_COM_UF	Binary input signal BI13 (unfiltered)
1297	BI14_COM_UF	Binary input signal BI14 (unfiltered)
1298	BI15_COM_UF	Binary input signal BI15 (unfiltered)
1299		
1300		
1301		
1302		
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Signal list

No.	Signal Name	Contents
1361		
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1371		
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1395		
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1400		
1401	LOCAL_OP_ACT	local operation active
1402	REMOTE_OP_ACT	remote operation active
1403	NORM_LED_ON	IN-SERVICE LED ON
1404	ALM_LED_ON	ALARM LED ON
1405	TRIP_LED_ON	TRIP LED ON
1406	TEST_LED_ON	TEST LED ON
1407		
1408	PRG_LED_RESET	Latched progammable LED RESET
1409	LED_RESET	TRIP LED RESET
1410		
1411	ARC_COM_ON	IEC103 communication command
1412	TELE_COM_ON	IEC103 communication command
1413	PROT_COM_ON	IEC103 communication command
1414	PRG_LED1_ON	PROGRAMMABLE LED1 ON
1415	PRG_LED2_ON	PROGRAMMABLE LED2 ON
1416	PRG_LED3_ON	PROGRAMMABLE LED3 ON
1417	PRG_LED4_ON	PROGRAMMABLE LED4 ON
1418		
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1433		
1434	F.Record_DONE	fault location completed
1435	F.Record_CLR	Fault record clear
1436	E.Record_CLR	Event record clear
1437	D.Record_CLR	Disturbance record clear
1438		
1439		
1440		

Signal list

No.	Signal Name	Contents
1441		
1442		
1443		
1444		
1445	PLC_data_CHG	PLC data change
1446		
1447		
1448	Sys.set_change	System setting change
1449	Rly.set_change	Relay setting change
1450	Grp.set_change	Group setting change
1451		
1452		
1453		
1454		
1455		
1456	KEY-VIEW	VIEW key status (1:pressed)
1457	KEY-RESET	RESET key status (2:pressed)
1458	KEY-ENTER	ENTER key status (3:pressed)
1459	KEY-END	END key status (4:pressed)
1460	KEY-CANCEL	CANCEL key status (5:pressed)
1461		
1462		
1463		
1464		
1465		
1466		
1467		
1468		
1469		
1470		
1471		
1472	SUM_err	Program ROM checksum error
1473		
1474	SRAM_err	SRAM memory monitoring error
1475	BU-RAM_err	BU-RAM memory monitoring error
1476		
1477	EEPROM_err	EEPROM memory monitoring error
1478		
1479	A/D_err	A/D accuracy checking error
1480		
1481		
1482		
1483		
1484	DIO_err	DIO card connection error
1485		
1486	LCD_err	LCD panel connection error
1487	ROM_data_err	Data ROM checksum error
1488		
1489	COM_DPRAMerr1	DP-RAM memory monitoring error
1490		
1491	COM_SUM_err	
1492		
1493	COM_SRAM_err	
1494	COM_DPRAMerr2	
1495	COM_A/D_err	
1496	COM_IRQ_err	
1497	Sync1_fail	
1498	Sync2_fail	
1499	Com1_fail	
1500	Com2_fail	
1501	Com1_fail-R	
1502	Com2_fail-R	
1503	CLK1_fail	
1504	CLK2_fail	
1505	Term1_rdy_off	
1506	Term2_rdy_off	
1507	TX_level1_err	
1508	TX_level2_err	
1509	RX_level1_err	
1510	RX_level2_err	
1511	Td1_over	
1512	Td2_over	
1513	RYID1_err	
1514	RYID2_err	
1515		
1516		
1517		
1518		
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1520		

Signal list

Input for protection

No.	Signal Name	Contents
1536	CB1 CONT-A	CB1 contact (A-phase)
1537	CB1 CONT-B	(B-phase)
1538	CB1 CONT-C	(C-phase)
1539	CB2 CONT-A	CB2 contact (A-phase)
1540	CB2 CONT-B	(B-phase)
1541	CB2 CONT-C	(C-phase)
1542	DS N/O CONT	DS N/O contact
1543	DS N/C CONT	DS N/C contact
1544	CRT BLOCK	Command protection out of service command
1545	CB CLOSE	External CB close signal
1546	DC SUPPLY	DC power supply
1547	85S1	Transfer trip sending command 1
1548	85S2	Transfer trip sending command 2
1549	IND.RESET	Indication reset command
1550	BUT BLOCK	Back up protection out of service command
1551		
1552	EXT TRIP-A	External trip comand (A-Phase)
1553	EXT TRIP-B	(B-phase)
1554	EXT TRIP-C	(C-phase)
1555		
1556	EXT CBFIN-A	External CBF initiation command (A-Phase)
1557	EXT CBFIN-B	(B-Phase)
1558	EXT CBFIN-C	(C-Phase)
1559		
1560		
1561		
1562		
1563		
1564		
1565		
1566		
1567		
1568	INT.LINK1-A	Interlink A with terminal 1 command
1569	INT.LINK1-B	Interlink B with terminal 1 command
1570	INT.LINK1-C	Interlink C with terminal 1 command
1571	CB1 READY	Autoreclisng ready command of bus CB
1572	CB2 READY	Autoreclisng ready command of center CB
1573	ARC RESET	Autoreclosing reset command
1574	ARC BLOCK	Autoreclosing block command
1575	INT.LINK2-A	Interlink A with terminal 2 command
1576	INT.LINK2-B	Interlink B with terminal 2 command
1577	INT.LINK2-C	Interlink C with terminal 2 command
1578	ARC BLOCK1	Autoreclosing block command
1579	ARC BLOCK2	Autoreclosing block command
1580		
1581		
1582		
1583		
1584	PROT BLOCK	Protection block command
1585	DIF BLOCK	DIF trip block command
1586	DIFG BLOCK	DIFG trip block command
1587	OST BLOCK	OST trip block command
1588	CBF BLOCK	CBF trip block command
1589	OC BLOCK	OC trip block command
1590	OCI BLOCK	OCI trip block command
1591	EF BLOCK	EF trip block command
1592	EFI BLOCK	EFI trip block command
1593	THMA BLOCK	Theremal alarm block command
1594	THM BLOCK	Theremal trip block command
1595	TR1 BLOCK	TR1 trip block command
1596	TR2 BLOCK	TR2 trip block command
1597	EXTTP BLOCK	External trip block command
1598	RDIF BLOCK	Remote DIF trip block command
1599		
1600	ARC DISABLE	Autoreclosing mode changing command
1601	ARC SPAR	ditto
1602	ARC TPAR	ditto
1603	ARC S&T	ditto
1604	ARC MAPR2	ditto
1605	ARC MPAR3	ditto
1606	ARC EXT1P	ditto
1607	ARC EXT3P	ditto
1608	ARC EXTMP	ditto
1609	CTF BLOCK	CTF block command
1610		
1611		
1612		
1613		
1614		
1615		

Signal list

No.	Signal Name	Contents
1616	DIF-A_FS	Fail safe command for DIF-A trip
1617	DIF-B_FS	Fail safe command for DIF-B trip
1618	DIF-C_FS	Fail safe command for DIF-C trip
1619	DIFG_FS	Fail safe command for DIFG trip
1620	TP-A_DELAY	Trip command off-delay timer setting
1621	TP-B_DELAY	Trip command off-delay timer setting
1622	TP-C_DELAY	Trip command off-delay timer setting
1623	R.DATA_ZERO	Remote term. data zero-ampere control command
1624	RDIF-A_FS	Fail safe command for RDIF-A trip
1625	RDIF-B_FS	Fail safe command for RDIF-B trip
1626	RDIF-C_FS	Fail safe command for RDIF-C trip
1627		
1628		
1629		
1630		
1631	INIT_MODE2B	MODE2B initiation command
1632	DIFG_INST_TP	DIFG instantly trip command
1633	OC_INST_TP	OC instantly trip command
1634	EF_INST_TP	EF instantly trip command
1635		
1636		
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1642		
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1645		
1646		
1647		
1648	DIF_3PTP	DIF 3-phase trip command
1649	RDIF_3PTP	RDIF 3-phase trip command
1650	OC_3PTP	OC 3-phase trip command
1651	OCI_3PTP	OCI 3-phase trip command
1652		
1653		
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1657		
1658		
1659		
1660	TR1_3PTP	Transfer trip 1 3-phase trip command
1661	TR2_3PTP	Transfer trip 2 3-phase trip command
1662		
1663	3P_TRIP	3-Phase trip command
1664	DIF-A-R1	DIF-A relay operating command from remote term-1 for TFC
1665	DIF-B-R1	DIF-B relay operating command from remote term-1 for TFC
1666	DIF-C-R1	DIF-C relay operating command from remote term-1 for TFC
1667	DIFG-R1	DIFG relay operating command from remote term-1 for TFC
1668		
1669		
1670		
1671		
1672	85R1-R1	Transfer command 1 from remote term-1
1673	85R2-R1	Transfer command 1 from remote term-2
1674	ARC_BLOCK-R1	Auto reclosing block command from remote term-1
1675	L.TEST-R1	Local testing command from remote term-1
1676	TFC_ON-R1	TFC enable command from remote term-1
1677		
1678		
1679		
1680	I.LINK-A-R1	Intelink command from remote term-1
1681	I.LINK-B-R1	ditto
1682	I.LINK-C-R1	ditto
1683		
1684	RDIF-A-R1	RDIF trip command from remote term-1
1685	RDIF-B-R1	ditto
1686	RDIF-C-R1	ditto
1687	RDIF-R1	ditto
1688	TR1-A-R1	Transfer trip-1 command from remote term-1
1689	TR1-B-R1	ditto
1690	TR1-C-R1	ditto
1691		
1692	TR2-A-R1	Transfer trip-2 command from remote term-1
1693	TR2-B-R1	ditto
1694	TR2-C-R1	ditto
1695		

Signal list

No.	Signal Name	Contents
1696	DIF-A-R2	DIF-A relay operating command from remote term-2 for TFC
1697	DIF-B-R2	DIF-B relay operating command from remote term-2 for TFC
1698	DIF-C-R2	DIF-C relay operating command from remote term-2 for TFC
1699	DIFG-R2	DIFG relay operating command from remote term-2 for TFC
1700		
1701		
1702		
1703		
1704	85R1-R2	Transfer command 1 from remote term-2
1705	85R2-R2	Transfer command 1 from remote term-2
1706	ARC_BLOCK-R2	Auto reclosing block command from remote term-2
1707	L.TEST-R2	Local testing command from remote term-2
1708	TFC_ON-R2	TFC enable command from remote term-2
1709		
1710		
1711		
1712	I.LINK-A-R2	Intelink command from remote term-2
1713	I.LINK-B-R2	ditto
1714	I.LINK-C-R2	ditto
1715		
1716	RDIF-A-R2	RDIF trip command from remote term-2
1717	RDIF-B-R2	ditto
1718	RDIF-C-R2	ditto
1719	RDIF-R2	ditto
1720	TR1-A-R2	Transfer trip-1 command from remote term-2
1721	TR1-B-R2	ditto
1722	TR1-C-R2	ditto
1723		
1724	TR2-A-R2	Transfer trip-2 command from remote term-2
1725	TR2-B-R2	ditto
1726	TR2-C-R2	ditto
1727		
1728		
1729		
1730		
1731		
1732		
1733		
1734		
1735		
1736	OC-A_FS	Fail safe command for OC-A trip
1737	OC-B_FS	Fail safe command for OC-B trip
1738	OC-C_FS	Fail safe command for OC-C trip
1739		
1740	OCI-A_FS	Fail safe command for OCI-A trip
1741	OCI-B_FS	Fail safe command for OCI-B trip
1742	OCI-C_FS	Fail safe command for OCI-C trip
1743		
1744		
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Signal list

No.	Signal Name	Contents
1776		
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1787		
1788		
1789		
1790		
1791		
1792	IO#1-TP-A1	Binary output signal of TP-A1
1793	IO#1-TP-B1	TP-B1
1794	IO#1-TP-C1	TP-C1
1795	IO#1-TP-A2	Binary output signal of TP-A2
1796	IO#1-TP-B2	TP-B2
1797	IO#1-TP-C2	TP-C2
1798		
1799		
1800		
1801		
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1822		
1823		
1824	SPR.L-REQ	Leader SPAR requirement
1825	TPR.L-REQ	Leader TPAR requirement
1826	MPR.L-REQ	Leader MPAR requirement
1827	SPR.F-REQ	Follower SPAR requirement
1828	TPR.F-REQ	Follower TPAR requirement
1829	MPR.F-REQ	Follower MPAR requirement
1830	SPR.F-ST.REQ	Follower SPAR starting requirement
1831	TPR.F-ST.REQ	Follower TPAR starting requirement
1832	MPR.F-ST.REQ	Follower MPAR starting requirement
1833		
1834		
1835		
1836	R.F-ST.REQ	Follower AR starting requirement
1837	SPR.F2-ST.REQ	Follower SPAR starting requirement
1838	TPR.F2-ST.REQ	Follower TPAR starting requirement
1839	MPR.F2-ST.REQ	Follower MPAR starting requirement
1840	ARC.L TERM	Leader terminal of Autoreclosing
1841	ARC.F TERM	Follower terminal of Autoreclosing
1842		
1843		
1844		
1845		
1846		
1847		
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1851		
1852		
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2015		

Signal list

No.	Signal Name	Contents
2016		
2017		
2018		
2019		
2020		
2021		
2022		
2023		
2024		
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2026		
2027		
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2043		
2044		
2045		
2046		
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
2060	SUB COM5-S	ditto
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		
2078		
2079		
2080	SUB3 COM1-S	Sub communication on/off data 3 send command
2081	SUB3 COM2-S	ditto
2082	SUB3 COM3-S	ditto
2083	SUB3 COM4-S	ditto
2084	SUB3 COM5-S	ditto
2085	SUB3 COM6-S	ditto
2086	SUB3 COM7-S	ditto
2087	SUB3 COM8-S	ditto
2088	SUB3 COM9-S	ditto
2089	SUB3 COM10-S	ditto
2090	SUB3 COM11-S	ditto
2091	SUB3 COM12-S	ditto
2092		
2093		
2094		
2095		

Signal list

No.	Signal Name	Contents
2096	V.COM1-S	Communiation on/off data(V0 data frame) send command
2097	V.COM2-S	ditto
2098	V.COM3-S	ditto
2099		
2100	S.V.COM1-S	Communiation on/off data(V0 data frame) send command
2101	S.V.COM2-S	ditto
2102	S.V.COM3-S	ditto
2103	S.V.COM4-S	ditto
2104	S.V.COM5-S	ditto
2105	S.V.COM6-S	ditto
2106	S.V.COM7-S	ditto
2107	S.V.COM8-S	ditto
2108	S.V.COM9-S	ditto
2109	S.V.COM10-S	ditto
2110	S.V.COM11-S	ditto
2111	S.V.COM12-S	ditto
2112	I.COM1-S	Communiation on/off data(I0 data frame) send command
2113	I.COM2-S	ditto
2114	I.COM3-S	ditto
2115		
2116	S.I.COM1-S	Communiation on/off data(I0 data frame) send command
2117	S.I.COM2-S	ditto
2118	S.I.COM3-S	ditto
2119	S.I.COM4-S	ditto
2120	S.I.COM5-S	ditto
2121	S.I.COM6-S	ditto
2122	S.I.COM7-S	ditto
2123	S.I.COM8-S	ditto
2124	S.I.COM9-S	ditto
2125	S.I.COM10-S	ditto
2126	S.I.COM11-S	ditto
2127	S.I.COM12-S	ditto
2128		
2129		
2130		
2131		
2132		
2133		
2134		
2135		
2136		
2137		
2138		
2139		
2140		
2141		
2142		
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2150		
2151		
2152		
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2154		
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2156		
2157		
2158		
2159		
2160		
2161		
2162		
2163		
2164		
2165		
2166		
2167		
2168		
2169		
2170		
2171		
2172		
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2575		

Signal list

No.	Signal Name	Contents
2576		
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2600		
2601		
2602		
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2607		
2608		
2609		
2610	ALARM_LED_SET	Alarm LED set
2611		
2612		
2613		
2614		
2615		
2616		
2617		
2618		
2619		
2620		
2621		
2622		
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		
2638		
2639		
2640	SET.GROUP1	Active setting group changed commamd (Change to group1)
2641	SET.GROUP2	2
2642	SET.GROUP3	3
2643	SET.GROUP4	4
2644	SET.GROUP5	5
2645	SET.GROUP6	6
2646	SET.GROUP7	7
2647	SET.GROUP8	8
2648		
2649		
2650		
2651		
2652		
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Signal list

No.	Signal Name	Contents
2656	CON_TPMD1	User configrable 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		
2665		
2666		
2667		
2668		
2669		
2670		
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2681		
2682		
2683		
2684	ARC_COM_RECV	Auto-recloser inactivate command received
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		
2690		
2691		
2692		
2693		
2694		
2695		
2696		
2697		
2698		
2699		
2700		
2701		
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Signal list

No.	Signal Name	Contents
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	
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	

Signal list

No.	Signal Name	Contents
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	
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	

Signal list

No.	Signal Name	Contents
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	
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	

Signal list

No.	Signal Name	Contents
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

Variable Timer List

Variable Timer List

Timer	Timer No.	Contents
TDIFG	1	DIFG delayed trip
TBF1A	2	BF retrip (phase A)
TBF1B	3	BF retrip (phase B)
TBF1C	4	BF retrip (phase C)
TBF2A	5	BF trip (phase A)
TBF2B	6	BF trip (phase B)
TBF2C	7	BF trip (phase C)
TOC	8	OC delayed trip
TEF	9	EF delayed trip
TIDSV	10	IDSV detected time
TEVLV	16	Autoreclose to developing fault
TRDY1	17	Reclaim time (leader breaker)
TSPR1	18	Dead time for single-phase and multi-phase autoreclose (leader breaker)
TTPR1	19	Dead time for three-phase autoreclose (leader breaker)
TW1	20	Duration of reclosing command output (leader breaker)
TRR1	21	Autoreclose reset (leader breaker)
TRDY2	22	Reclaim time (follower breaker)
TSPR2	23	Dead time for single-phase and multi-phase autoreclose (follower breaker)
TTPR2	24	Dead time for three-phase autoreclose (follower breaker)
TW2	25	Duration of reclosing command output (follower breaker)
TRR2	26	Autoreclose reset (follower breaker)
TS2	27	Second shot dead time
TS3	28	Third shot dead time
TS4	29	Fourth shot dead time
TS2R	30	Second shot reset time
TS3R	31	Third shot reset time
TS4R	32	Fourth shot reset time
TSYN1	33	Synchronism check time (busbar breaker)
TSYN2	34	Synchronism check time (center breaker)
TDBL1	35	Dead bus and live line check time (busbar breaker)
TDBL2	36	Dead bus and live line check time (center breaker)
TLBD1	37	Live bus and dead line check time (busbar breaker)
TLBD2	38	Live bus and dead line check time (center breaker)

Appendix D

Binary Output Default Setting List

Binary Output Default Setting List (1)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -101	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1,-B1,-C1C	Trip A, B or C phase	99, 100, 101	1	1
		BO11	A10-B10	OMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
GRL100 -111	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1,-B1,-C1	Trip A, B or C phase	99, 100, 101	1	1
		BO11	A10-B10	COMM1, 2_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1, REM2	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1, REM2	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--

Binary Output Default Setting List (2)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -102	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1,-B1,-C1	Trip A, B or C phase	99, 100, 101	1	1
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM2	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	TRIP-A1	Trip A phase	99	1	1
		BO5	A5-B5	TRIP-B1	Trip B phase	100	1	1
		BO6	A6-B6	TRIP-C1	Trip C phase	101	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	99	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	100	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	101	1	1
		BO10	A10-B10	DIF-A,-B,-C TRIP	DIF relay operating	82, 83, 84	1	1
			TB3:					
GRL100 -112	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1,-B1,-C1	Trip A, B or C phase	99, 100, 101	1	1
		BO11	A10-B10	COMM1, 2_FAIL	Communication failure	226, 226	1	1
		BO12	A11-B11	85R1.REM1, REM2	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R1.REM1, REM2	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	TRIP-A1	Trip A phase	99	1	1
		BO5	A5-B5	TRIP-B1	Trip B phase	100	1	1
		BO6	A6-B6	TRIP-C1	Trip C phase	101	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	99	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	100	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	101	1	1
		BO10	A10-B10	DIF-A,-B,-C_TRIP	DIF relay operating	82, 83, 84	1	1

Binary Output Default Setting List (3)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -201	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1. FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	DIF/DIFG	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST	OST trip	87	1	1
		BO6	A6-B6	CBF	CBF detection	91	1	1
			TB2:					
GRL100 -202	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
	IO#4	BO1	A2-A1	TRIP-A1	Trip A phase	146	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	147	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	148	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1	Trip A phase	99	1	1
		BO11	A10-B10	TRIP-B1	Trip B phase	100	1	1
		BO12	A11-B11	TRIP-C1	Trip C phase	101	1	1
		BO13	A12-B12	TRIP-A1,-B1,-C1	Trip A, B or C phase	99, 100, 101	1	1
		BO14	A13-B13	TRIP-A1,-B1,-C1	Trip A, B or C phase	99, 100, 101	1	1
			TB5:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO5	A5-B5	DIFG_TRIP	DIFG relay operating	86	1	1
		BO6	A6-B6	OST_TRIP	OST trip	87	1	1
		BO7	A7-B7	CBFDET	CBF detection	91	1	1
		BO8	A8-B8	SPAR1	Single pole autoreclose	173	1	1
		BO9	A9-B9	TPAR1	Three pole autoreclose	175	1	1
		BO10	A10-B10	MPAR	Multi-pole autoreclose	183	1	1

Binary Output Default Setting List (4)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting: Signal No.	Setting: LOGIC (OR:1, AND:2)	Setting: TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -204	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-∗ /DIFG_TRIP	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST_TRIP	OST trip	87	1	1
		BO6	A6-B6	CBFDET	CBF detection	91	1	1
			TB2:					
GRL100 -206	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
	IO#4	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1	Trip A phase	99	1	1
		BO11	A10-B10	TRIP-B1	Trip B phase	100	1	1
		BO12	A11-B11	TRIP-C1	Trip C phase	101	1	1
		BO13	A12-B12	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
		BO14	A13-B13	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
			TB5:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO5	A5-B5	DIFG_TRIP	DIFG relay operating	86	1	1
		BO6	A6-B6	OST_TRIP	OST trip	87	1	1
		BO7	A7-B7	CBFDET	CBF detection	91	1	1
		BO8	A8-B8	SPAR1	Single pole autoreclose	173	1	1
		BO9	A9-B9	TPAR1	Three pole autoreclose	175	1	1
		BO10	A10-B10	MPAR	Multi-pole autoreclose	183	1	1

Binary Output Default Setting List (5)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -211	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	DIF-∗ /DIFG_TRIP	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST_TRIP	OST trip	87	1	1
		BO6	A6-B6	CBFDET	CBF detection	91	1	1
			TB2:					
GRL100 -212	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
	IO#4	BO1	A2-A1	LINK-A1	Link A phase (with terminal 1)	146	1	1
		BO2	A2-B1	LINK-B1	Link B phase (with terminal 1)	147	1	1
		BO3	A2-B2	LINK-C1	Link C phase (with terminal 1)	148	1	1
		BO4	A3-B3	LINK-A2	Link A phase (with terminal 2)	149	1	1
		BO5	A4-B4	LINK-B2	Link B phase (with terminal 2)	150	1	1
		BO6	A5-B5	LINK-C2	Link C phase (with terminal 2)	151	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1	Trip A phase	99	1	1
		BO11	A10-B10	TRIP-B1	Trip B phase	100	1	1
		BO12	A11-B11	TRIP-C1	Trip C phase	101	1	1
		BO13	A12-B12	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
		BO14	A13-B13	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
			TB5:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO5	A5-B5	DIFG_TRIP	DIFG relay operating	86	1	1
		BO6	A6-B6	OST_TRIP	OST trip	87	1	1
		BO7	A7-B7	CBFDET	CBF detection	91	1	1
		BO8	A8-B8	SPAR1	Single pole autoreclose	173	1	1
		BO9	A9-B9	TPAR1	Three pole autoreclose	175	1	1
		BO10	A10-B10	MPAR	Multi-pole autoreclose	183	1	1

Binary Output Default Setting List (6)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting: Signal No.	Setting: LOGIC (OR:1, AND:2)	Setting: TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -214	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-∗ /DIFG_TRIP	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST_TRIP	OST trip	87	1	1
		BO6	A6-B6	CBFDET	CBF detection	91	1	1
			TB2:					
GRL100 -216	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
	IO#4	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	TRIP-A1	Trip A phase	99	1	1
		BO11	A10-B10	TRIP-B1	Trip B phase	100	1	1
		BO12	A11-B11	TRIP-C1	Trip C phase	101	1	1
		BO13	A12-B12	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
		BO14	A13-B13	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
			TB5:					
	IO#3	BO1	A1-B1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B2	TRIP-B1	Trip B phase	100	1	1
		BO3	A3-B3	TRIP-C1	Trip C phase	101	1	1
		BO4	A4-B4	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO5	A5-B5	DIFG_TRIP	DIFG relay operating	86	1	1
		BO6	A6-B6	OST_TRIP	OST trip	87	1	1
		BO7	A7-B7	CBFDET	CBF detection	91	1	1
		BO8	A8-B8	SPAR1	Single pole autoreclose	173	1	1
		BO9	A9-B9	TPAR1	Three pole autoreclose	175	1	1
		BO10	A10-B10	MPAR	Multi-pole autoreclose	183	1	1

Binary Output Default Setting List (7)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
GRL100 -301	IO#2		TB3:					
		BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
	IO#3		TB2:					
		BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	DIF-∗ /DIFG_TRIP	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST_TRIP	OST trip	87	1	1
		BO6	A6-B6	CBFDET	CBF detection	91	1	1
GRL100 -302	IO#2		TB2:					
		BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
	IO#4		TB3:					
		BO1	A2-A1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B1	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A2-B2	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO8	A7-B7	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO9	A8-B8	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO10	A9-B9	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO11	A10-B10	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO12	A11-B11	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO13	A12-B12	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO14	A13-B13	TRIP-B1/B2	Trip B phase	100, 103	1	1
	IO#3		TB5:					
		BO1	A1-B1	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO2	A2-B2	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO3	A3-B3	DIFG_TRIP	DIFG relay operating	86	1	1
		BO4	A4-B4	OST_TRIP	OST trip	87	1	1
		BO5	A5-B5	CBFDET	CBF detection	91	1	1
		BO6	A6-B6	SPAR1	Bus CB single pole ARC	173	1	1
		BO7	A7-B7	TPAR1	Bus CB three pole ARC	175	1	1
		BO8	A8-B8	MPAR	Bus multi-pole ARC	183	1	1
		BO9	A9-B9	SPAR2	Center CB single pole ARC	174	1	1
		BO10	A10-B10	TPAR2	Center CB three pole ARC	176	1	1

Binary Output Default Setting List (8)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB3:					
GRL100 -311	IO#2	BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB2:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	DIF-∗ /DIFG_TRIP	DIF, DIFG relay operating	82, 83, 84, 86	1	1
		BO5	A5-B5	OST_TRIP	OST trip	87	1	1
		BO6	A6-B6	CBFDET	CBF detection	91	1	1
			TB2:					
GRL100 -312	IO#2	BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A∗,B∗,C∗	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB3:					
	IO#4	BO1	A2-A1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B1	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A2-B2	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	149	1	1
		BO5	A4-B4	TRIP-B1/B2	Trip B phase	150	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	151	1	1
		BO7	A6-B6	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO8	A7-B7	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO9	A8-B8	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO10	A9-B9	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO11	A10-B10	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO12	A11-B11	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO13	A12-B12	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO14	A13-B13	TRIP-B1/B2	Trip B phase	100, 103	1	1
			TB5:					
	IO#3	BO1	A1-B1	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO2	A2-B2	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO3	A3-B3	DIFG_TRIP	DIFG relay operating	86	1	1
		BO4	A4-B4	OST_TRIP	OST trip	87	1	1
		BO5	A5-B5	CBFDET	CBF detection	91	1	1
		BO6	A6-B6	SPAR1	Bus CB single pole ARC	173	1	1
		BO7	A7-B7	TPAR1	Bus CB three pole ARC	175	1	1
		BO8	A8-B8	MPAR	Bus multi-pole ARC	183	1	1
		BO9	A9-B9	SPAR2	Center CB single pole ARC	174	1	1
		BO10	A10-B10	TPAR2	Center CB three pole ARC	176	1	1

Binary Output Default Setting List (9)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB2:					
GRL100 -401	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	TRIP-A1	Trip A phase	99	1	1
		BO5	A5-B5	TRIP-B1	Trip B phase	100	1	1
		BO6	A6-B6	TRIP-C1	Trip C phase	101	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	99	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	100	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	101	1	1
		BO10	A10-B10	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
			TB3:					
	IO#4	BO1	A1-B1	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
		BO2	A2-B2	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO3	A3-B3	DIFG_TRIP	DIFG relay operating	86	1	1
		BO4	A4-B4	OST_TRIP	OST trip	87	1	1
		BO5	A10-B10	CBFDET	CBF detection	91	1	1
		BO6	A11-B11	SPAR1	Single pole ARC	173	1	1
		BO7	A12-B12	TPAR1	Three pole ARC	175	1	1
		BO8	A13-B13	MPAR	Multi-pole ARC	183	1	1
			TB2:					
GRL100 -411	IO#2	BO1	A2-A1	TRIP-A1	Trip A phase	99	1	1
		BO2	A2-B1	TRIP-B1	Trip B phase	100	1	1
		BO3	A2-B2	TRIP-C1	Trip C phase	101	1	1
		BO4	A3-B3	TRIP-A1	Trip A phase	99	1	1
		BO5	A4-B4	TRIP-B1	Trip B phase	100	1	1
		BO6	A5-B5	TRIP-C1	Trip C phase	101	1	1
		BO7	A6-B6	TRIP-A1	Trip A phase	99	1	1
		BO8	A7-B7	TRIP-B1	Trip B phase	100	1	1
		BO9	A8-B8	TRIP-C1	Trip C phase	101	1	1
		BO10	A9-B9	ARC1	Autoreclose	177	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	89CB-1AC	Link A phase (A-C terminal)	149	1	1
		BO5	A5-B5	89CB-2AC	Link B phase (A-C terminal)	150	1	1
		BO6	A6-B6	89CB-3AC	Link C phase (A-C terminal)	151	1	1
		BO7	A7-B7	TRIP-A1	Trip A phase	99	1	1
		BO8	A8-B8	TRIP-B1	Trip B phase	100	1	1
		BO9	A9-B9	TRIP-C1	Trip C phase	101	1	1
		BO10	A10-B10	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
			TB3:					
	IO#4	BO1	A1-B1	TRIP-A1, -B1, -C1	Trip A, B or C phase	99, 100, 101	1	1
		BO2	A2-B2	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
		BO3	A3-B3	DIFG_TRIP	DIFG relay operating	86	1	1
		BO4	A4-B4	OST_TRIP	OST trip	87	1	1
		BO5	A10-B10	CBFDET	CBF detection	91	1	1
		BO6	A11-B11	SPAR1	Single pole ARC	173	1	1
		BO7	A12-B12	TPAR1	Three pole ARC	175	1	1
		BO8	A13-B13	MPAR	Multi-pole ARC	183	1	1

Binary Output Default Setting List (10)

Relay Model	Module Name	BO No.	Terminal No.	Signal Name	Contents	Setting		
						Signal No.	LOGIC (OR:1, AND:2)	TIMER (OFF:0, ON:1)
			TB2:					
GRL100 -501	IO#2	BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
GRL100 -503		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A*,B*,C*	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A*,B*,C*	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO5	A5-B5	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A6-B6	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A7-B7	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO8	A8-B8	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO9	A9-B9	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO10	A10-B10	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
			TB3:					
	IO#4	BO1	A1-B1	DIFG_TRIP	DIFG relay operating	86	1	1
		BO2	A2-B2	OST_TRIP	OST trip	87	1	1
		BO3	A3-B3	CBFDET	CBF detection	91	1	1
		BO4	A4-B4	SPAR1	Bus CB single pole ARC	173	1	1
		BO5	A10-B10	TPAR1	Bus CB three pole ARC	175	1	1
		BO6	A11-B11	MPAR	Bus CB multi-pole ARC	183	1	1
		BO7	A12-B12	SPAR2	Center CB single pole ARC	174	1	1
		BO8	A13-B13	TPAR2	Center CB three pole ARC	176	1	1
			TB2:					
GRL100 -511	IO#2	BO1	A2-A1	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO2	A2-B1	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO3	A2-B2	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO4	A3-B3	TRIP-A1/A2	Trip A phase	99, 102	1	1
GRL100 -513		BO5	A4-B4	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO6	A5-B5	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO7	A6-B6	TRIP-A*,B*,C*	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO8	A7-B7	TRIP-A*,B*,C*	Trip A, B or C phase	99, 100, 101, 102, 103, 104	1	1
		BO9	A8-B8	ARC1	Bus CB autoreclose	177	1	0
		BO10	A9-B9	ARC2	Center CB autoreclose	178	1	0
		BO11	A10-B10	COMM1_FAIL	Communication failure	225, 226	1	1
		BO12	A11-B11	85R1.REM1	Transfer trip 1 receive	197, 202	1	1
		BO13	A13-B13	85R2.REM1	Transfer trip 2 receive	198, 203	1	1
		(FAIL)	A12-B12	RELAY FAILURE	--	--	--	--
			TB5:					
	IO#3	BO1	A1-B1	89CB-1AB	Link A phase (A-B terminal)	146	1	1
		BO2	A2-B2	89CB-2AB	Link B phase (A-B terminal)	147	1	1
		BO3	A3-B3	89CB-3AB	Link C phase (A-B terminal)	148	1	1
		BO4	A4-B4	89CB-1AC	Link A phase (A-C terminal)	149	1	1
		BO5	A5-B5	89CB-2AC	Link B phase (A-C terminal)	150	1	1
		BO6	A6-B6	89CB-3AC	Link C phase (A-C terminal)	151	1	1
		BO7	A7-B7	TRIP-A1/A2	Trip A phase	99, 102	1	1
		BO8	A8-B8	TRIP-B1/B2	Trip B phase	100, 103	1	1
		BO9	A9-B9	TRIP-C1/C2	Trip C phase	101, 104	1	1
		BO10	A10-B10	DIF-A, -B, -C_TRIP	DIF relay operating	82, 83, 84	1	1
			TB3:					
	IO#4	BO1	A1-B1	DIFG_TRIP	DIFG relay operating	86	1	1
		BO2	A2-B2	OST_TRIP	OST trip	87	1	1
		BO3	A3-B3	CBFDET	CBF detection	91	1	1
		BO4	A4-B4	SPAR1	Bus CB single pole ARC	173	1	1
		BO5	A10-B10	TPAR1	Bus CB three pole ARC	175	1	1
		BO6	A11-B11	MPAR	Bus CB multi-pole ARC	183	1	1
		BO7	A12-B12	SPAR2	Center CB single pole ARC	174	1	1
		BO8	A13-B13	TPAR2	Center CB three pole ARC	176	1	1

Appendix E

Details of Relay Menu

```
MENU
1=Record              2=Status
3=Setting(view)       4=Setting(change)
5=Test
```

```
/1 Record
1=Fault record         2=Event record
3=Disturbance record 4=Autoreclose count
```

```
/2 Fault record
1=Display        2=Clear
```

```
/3 Fault record                    2/8
#1  16/Oct/1998 23:18:03.913
#2  12/Feb/1998 03:51:37.622
#3  30/Jan/1997 15:06:11.835
```

```
/4 Fault record #2                 3/33
16/Oct/1998 23:18:03.913
Phase  BC        Trip   ABC
DIF
```

```
/2 Fault record
Clear all fault records ?
      ENTER=Yes   CANCEL=No
```

```
/2 Event record
1=Display        2=Clear
```

```
/3 Event record                   2/48
16/Oct/1998 23:18:04.294 Trip     Off
16/Oct/1998 23:18:03.913 Trip      On
12/Feb/1998 03:51:37.622 Rly.set change
```

```
/2 Event record
Clear all event records ?
      ENTER=Yes   CANCEL=No
```

```
/2 Disturbance record
1=Display        2=Clear
```

```
/3 Disturbance record            1/ 11
#1  16/Oct/1998 23:18:03.913
#2  12/Feb/1998 03:51:37.622
#3  30/Jan/1997 15:06:11.835
```

```
/2 Disturbance record
Clear all disturbance records ?
      ENTER=Yes   CANCEL=No
```

```
/2 Autoreclose count
1=Display        2=Reset
```

```
/3 Autoreclose count
           SPAR       TPAR      MPAR
   CB1    [  46]     [  46]    [  12]
   CB2    [  46]     [  46]
```

```
/3 Reset autoreclose count
1=CB1
2=CB2
```

```
/3 Reset autoreclose count
Reset count ?
      ENTER=Yes   CANCEL=No
```

```
/3 Reset autoreclose count
Reset count ?
      ENTER=Yes   CANCEL=No
```

a-1

a-1

```
/1 Status
1=Metering           2=Binary I/O
3=Relay element      4=Time sync source
5=Clock adjustment   6=Terminal condition
```

```
/2 Metering    12/Feb/1998  22:56  3/13
Va  ***.*kV ***.*  Ia   **.**kA  ***.*
Vb  ***.*kV ***.*  Ib   **.**kA  ***.*
Vc  ***.*kV ***.*  Ic   **.**kA  ***.*
```

```
/2 Binary input & output          3/ 5
Input (IO#1)      [000 000 000 000 000]
Input (IO#2)      [000                ]
Output(IO#1-trip)[000 000             ]
```

```
/2 Relay element                  3/ 6
DIF, DIFG        [000 0              ]
OST              [000 00 0           ]
CBF              [000                ]
```

```
/2 Time synchronization source    3/ 4
*IRIG: Active
 RSM: Inactive
 IEC: Inactive
```

```
/2  12/Feb/1998  22:56:19 [local]  1/5
Minute (  0 -  59) :  56  _
Hour   (  0 -  23) :  22
Day    (  1 -  31) :  12
```

```
/2 Terminal condition
Terminal 1: In service
Terminal 2: Out of service
```

```
/1 Setting(view)
1=Version  2=Description 3=Comm
4=Record  5=Status      6=Protection
7=Binary input  8=Binary output  9=LED
```

```
/2 Relay version
Relay type :     ********************
Serial No. :     ********************
Main software:   ********************
```

```
/2 Description
Plant name:      ********************
Description:     ********************
```

```
/2 Communication
1=Address/Parameter
2=Switch
```

```
/3 Address/Parameter              2/ 8
HDLC  (   1   )      IEC      (   1   )
SYADJ (   0 ms)      IP1-1    (  10   )
IP1-2 (  245  )      IP1-3    (  105  )
```

```
/3 Switch                         3/ 4
PRTCL1  1=HDLC 2=IEC103             2
232C    1=9.6 2=19.2 3=38.4 4=57.6 4
IECBR   1=9.6 2=19.2                2
```

```
/2 Record
1=Fault record          2=Event record
3=Disturbance record
4=Automatic test interval
```

```
/3 Fault record                    1/ 1
Fault locator      0=Off   1=On    1
```

```
/3 Event record
1=Signal no.
2=Event name
```

```
/4 Signal no.                     3/ 65
BITRN (   128  )    EV1   (  3071  )
EV2   (     0  )    EV3   (     1  )
EV4   (     2  )    EV4   (     4  )
```

```
/4 Event name                     3/128
Event name1   [                      ]
Event name2   [                      ]
Event name3   [                      ]
```

```
/3 Disturbance record
1=Record time & starter
2=Scheme switch
3=Binary signal      4=Signal name
```

```
/4 Record time & starter          2/ 5
Time   (  3.0s )     OCP-S( 50.0A )
OCP-G ( 50.0A )      UVP-S(    0V )
UVP-G (    0V )
```

```
/4 Scheme switch                  1/ 5
Trip              0=Off   1=On    1
OCP-S             0=Off   1=On    1
OCP-G             0=Off   1=On    1
```

```
/3 Automatic test interval        1/ 1
Trip  (  7 days)
```

```
/4 Binary signal                  3/ 16
SIG1  (   128  )    SIG2  (  3071  )
SIG3  (     0  )    SIG4  (     1  )
SIG5  (     2  )    SIG6  (     4  )
```

```
/4 Signal name                    3/32
Signal name1  [                      ]
Signal name2  [                      ]
Signal name3  [                      ]
```

a-1　a-2

a-1 a-2

```
/2 Status
1=Metering
2=Time Synchronization
3=Time zone
```

```
/3 Metering                                 3/ 3
Display value 1=Primary 2=Secondary  1
Power (P/Q)   1=Send     2=Receive    1
Current       1=Lag      2=Lead       1
```

```
/3 Time synchronization              1/ 1
Sync 0=Off 1=IRIG 2=RSM 3=IEC 4=GPS 1
```

```
/3 Time zone                          1/ 1
GMT (     +9 hrs )
```

```
/2 Protection          (Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
```

```
/3 Protection                   (Group 1)
1=Line parameter
2=Telecommunication      3=Trip
4=Autoreclose
```

```
/4 Line parameter               (Group 1)
1=Line name
2=VT & CT ratio
3=Fault locator
```

```
/5 Line name                            1/ 1
Line name      ********************
```

```
/5 VT & CT ratio                        1/ 2
VT    (   2000  )      VTs1 (  2000  )
VTs2  (   2000  )      CT   (   120  )
```

```
/5 Fault locator                 (Group 1)
1=Setting impedance mode
2=Line data
```

```
/6 Setting impedance mode
1=Positive sequence impedance
2=Phase impedance
  Current No.= 1
```

```
/6 Line data                             3/ 5
1X1    (    24.5Ω )   1R1    (   2.8Ω )
1Line  (    80.0km)   2X1    (  12.5Ω )
2R1    (     1.5Ω )   2Line  (  41.3km)
```

```
/4 Telecommunication            (Group 1)
1=Scheme switch
2=Telecommunication element
```

```
/5 Scheme switch                       2/ 12
COMMODE  1=A        2=B        3=GPS  2
SP.SYN.  1=Master   2=Slave           1
TERM.    1=2TERM    2=3TERM    3=Dual 1  _
```

```
/5 Telecommunicatio element          1/ 7
PDTD  (   200 -  2000) :  1000     us
RYID  (     0 -    63) :     0
RYID1 (     0 -    63) :     0
```

```
/4 Trip                          (Group 1)
1=Scheme switch
2=Protection element
```

```
/5 Scheme switch                      3/16
TPMODE  1=3PH    2=1PH    3=MPH      1
STUB    0=Off    1=On                1
DIFG    0=Off    1=On                1
```

```
/5 Protection element                 3/11
DIFI1  (  1.00A  )  DIFI2  (   2.0A  )
DIFG1  (  0.50A  )  DIFIC  (  1.00A  )
Vn     (   110V  )  TDIFG  (  0.10s  )
```

```
/4 Autoreclose                   (Group 1)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

```
/5 Autoreclose mode
1=Disable  2=SPAR  3=TPAR  4=SPAR&TPAR
5=MPAR2 6=MPAR3 7=EXT1P 8=EXT3P 9=EXTMP
  Current No.= 4
```

```
/5 Scheme switch                      3/ 8
ARC-CB   1=00 2=01 3=02 4=L1 5=L2  1
ARC-EXT  0=Off    1=On             0
ARCDIFG  0=Off    1=On             1
```

```
/5 Autoreclose element          (Group 1)
1=Autoreclose timer
2=Synchrocheck
```

```
/6 Autoreclose timer                    3/ 8
TEVLV(   0.30 s  )    TRDY1(   60 s   )
TSPR (   0.80 s  )    TTPR1(  0.60 s  )
TRR  (   2.00 s  )    TW1  (   0.3 s  )
```

```
/6 Synchrocheck                          3/ 9
OVB   (     51 V  )   UVB   (   13 V   )
OVL1  (     51 V  )   UVL1  (   13 V   )
SY1UV(      83 V  )   SY1OV(    51 V   )
```

```
/3 Protection                   (Group 2)
1=Line parameter
2=Telecommunication     3=Trip
4=Autoreclose
```

```
/3 Protection                   (Group 8)
1=Line parameter
2=Telecommunication     3=Trip
4=Autoreclose
```

a-1 a-2

a-1 a-2

```
/2 Binary input                   3/ 31
BISW 1  1=Norm  2=Inv              1
BISW 2  1=Norm  2=Inv              1
BISW 3  1=Norm  2=Inv              1
```

```
/2 Binary output
1=IO#2     2=IO#3   3=IO#4
```

```
/3 Binary output            (IO#2)3/12
BO1 (  1,  2,  3,  4,  5,  6) AND,D
BO2 (  1,  2,  3,  4,  5,  6)  OR,
BO3 (  1,  2,  3,  4,  5,  6)  OR,D
```

```
/3 Binary output            (IO#4)3/12
BO1 (  1,  2,  3,  4,  5,  6) AND,D
BO2 (  1,  2,  3,  4,  5,  6)  OR,
BO3 (  1,  2,  3,  4,  5,  6)  OR,D
```

```
/2 LED                              3/ 4
LED1 (    1,  309,     0,     0)  AND, I
LED2 (    0,    0,     0,     0)   OR, I
LED3 (   15,   16,    17,     0)   OR, L
```

: Password trap

```
  Password
          Input password  [ _ ]
```

```
/1 Setting(change)
1=Password 2=Description  3=Comm
4=Record   5=Status       6=Protection
7=Binary input  8=Binary output  9=LED
```

: Confirmation trap

```
/2 *************
Change settings?
          ENTER=Yes   CANCEL=No
```

```
/2 Password
    Input new password    [ _  ]
    Retype new password   [    ]
```

```
/2 Description
1=Plant name  2=Description
```

```
/3 Plant name  [ _                   ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^           ← →
```

```
/3 Description  [ _                  ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^           ← →
```

```
/2 Communication
1=Address/Parameter
2=Switch
```

```
/3 Address/Parameter              1/ 15
HDLC   (   1-    32)  :        1 _
IEC    (   0-   254)  :        2
SYADJ (-9999- 9999)  :         0   ms
```

```
/3 Switch                        1/ 4
PRTCL1  1=HDLC 2=IEC103            2 _
232C    1=9.6 2=19.2 3=38.4 4=57.6 4
IECBR   1=9.6 2=19.2               2
```

```
/2 Record
1=Fault record              2=Event record
3=Disturbance record
4=Automatic test interval
```

```
/3 Fault record                   1/ 1
Fault locator     0=Off   1=On    1 _
```

```
/3 Event record                  1/129
BITRN (     0-   128)  :      128 _
EV1    (    0-  3071)  :        0
EV2    (    0-  3071)  :        1
```

```
/3 Disturbance record
1=Record time & starter
2=Scheme switch
3=Binary signal
```

```
/4 Record time & starter          1/ 3
Time   (   0.1-    3.0):     2.0 _    s
OCP-S(   0.5- 250.0):     10.0:       A
OCP-G(   0.5- 250.0):     10.0:       A
```

```
/4 Scheme switch                  1/ 5
Trip trigger        0=Off   1=On   1 _
OCP-S               0=Off   1=On   1
OCP-G               0=Off   1=On   1
```

```
/4 Binary signal                  1/ 32
SIG1    (    0-  3071)  :        1 _
SIG2    (    0-  3071)  :        2
SIG3    (    0-  3071)  :        1
```

```
/3 Automatic test interval        1/ 1
Trip   (     1-      7):     1  _   days
```

a-1 a-2

a-1 a-2

```
/2 Status
1=Metering
2=Time Synchronization
3=Time zone
```

```
/3 Metering                        1/ 3
Display value 1=Primary 2=Secondary 1_
Power (P/Q)   1=Send    2=Receive   1
Current       1=Lag     2=Lead      1
```

```
/3 Time synchronization            1/ 1
Sync 0=Off 1=IRIG 2=RSM 3=IEC 4=GPS 1 _
```

```
/3 Time zone                       1/ 1
GMT (   -12 -   +12):    +9  _     hrs
```

```
/2 Protection
1=Change active group
2=Change setting
3=Copy group
```

```
/3Change active group(Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
  Current No.= *        Select No.= _
```

```
/3 Change setting (Active group= *)
1=Group1  2=Group2  3=Group3  4=Group4
5=Group5  6=Group6  7=Group7  8=Group8
```

```
/4 Protection                (Group 1)
1=Line parameter
2=Telecommunication     3=Trip
4=Autoreclose
```

```
/5 Line parameter            (Group 1)
1=Line name
2=VT & CT ratio
3=Fault locator
```

```
/6 Line name [ _                      ]
ABCDEFGHIJKLMNOPQRSTUVWXYZ()[]@_← →
abcdefghijklmnopqrstuvwxyz{}*/+-<=>← →
0123456789!"#$%&':;,.^          ← →
```

```
/6 VT & CT ratio                   1/ 2
VT   (      1- 20000):    2000  _
VTs1 (      1- 20000):    2000
CT   (      1- 20000):     120
```

```
/6 Fault locator             (Group 1)
1=Setting impedance mode
2=Line data
```

```
/7 Setting impedance
1=Positive sequence impedance
2=Phase impedance
  Current No.= 1        Select No.= _
```

```
/7 Line data                       1/ 9
1X1   (   0.0 -  199.9):  24.5  _   Ω
1R1   (   0.0 -  199.9):   2.8      Ω
1Line(   0.0 -  199.9):  80.0      km
```

```
/5 Telecommunication         (Group 1)
1=Scheme switch
2=Telecommunication
```

```
/6 Scheme switch                  1/ 12
COMMODE 1=A       2=B       3=GPS   2 _
SP.SYN. 1=Master 2=Slave            1
TERM.   1=2TERM  2=3TERM  3=Dual    1
```

```
/6 Telecommunication               1/ 7
PDTD   (   200-  2000):     0 _    us
RYID   (     0-    63):     0
RYID1  (     0-    63):     0
```

```
/5 Trip                      (Group 1)
1=Scheme switch
2=Protection element
```

```
/6 Scheme switch                   1/16
TPMODE   1=3PH    2=1PH    3=MPH   1 _
STUB     0=Off    1=On             1
LSSV     0=Off    1=On             1
```

```
/6 Protection element              1/17
DIFI1(  0.50 -   5.00):  1.00  _    A
DIFI2(  3.0  -  120.0):   2.0       A
DIFG1(  0.25 -   5.00):  0.50       A
```

a-1 a-2 a-3 a-4 a-5

a-1 a-2 a-3 a-4 a-5

```
/5 Autoreclose                (Group 1)
1=Autoreclose mode
2=Scheme switch
3=Autoreclose element
```

```
/6 Autoreclose mode
1=Disable  2=SPAR  3=TPAR  4=SPAR&TPAR
5=MPAR2    6=MPAR3 7=EXT1P 8=EXT3P
  Current No.= 4       Select No.= _
```

```
/6 Scheme switch                   1/ 8
ARC-CB  1=00 2=01 3=03 4=L1 5=L2   1 _
ARC-EXT 0=Off   1=On               0
ARCDIFG 0=Off   1=On               1
```

```
/6 Autoreclose element       (Group 1)
1=Autoreclose timer
2=Synchrocheck
```

```
/7 Autoreclose timer                1/12
TEVLV(  0.01-  10.00):    0.30 _  s
TRDY1(     5 -   300):    60      s
TSPR (  0.01-  10.00):    0.60    s
```

```
/7 Synchrocheck                     1/18
OVB  (    10 -   100):     51 _    V
UVB  (    10 -   100):     13      V
OVL1 (    10 -   100):     51      V
```

```
/4 Protection                (Group 2)
1=Line parameter
2=Telecommunication     3=Trip
4=Autoreclose
```

```
/4 Protection                (Group 8)
1=Line parameters
2=Telecommunication     3=Trip
4=Autoreclose
```

```
/3 Copy groupA to B  (Active group= 1)
A     (    1-     8):             _
B     (    1-     8):
```

```
/2 Binary input                  1/ 31
BISW 1  1=Norm  2=Inv              1 _
BISW 2  1=Norm  2=Inv              1
BISW 3  1=Norm  2=Inv              1
```

```
/2 Binary output
1=IO#2     2=IO#3    3=IO#4
```

```
/3 Binary output              (IO#2 )
Select BO          (  1- 12)

                  Select No.= _
```

```
/4 Setting                (BO 1 of IO#2 )
1=Logic gate type & delay timer
2=Input to logic gate
```

```
/5 Logic gate type & delay timer  1/ 2
Logic    1=OR  2=AND              1 _
BOTD     0=Off  1=On              1
```

```
/4 Setting                (BO 12 of IO#2 )
1=Logic gate type & delay timer
2=Input to logic gate
```

```
/5 Input to logic gate            3/ 6
In #1 (      0 -   3071):      21
In #2 (      0 -   3071):      67
In #3 (      0 -   3071):      12  _
```

```
/4 Binary output              (IO#4 )
Select BO           (  1-  8)

                    Select No.=_
```

```
/2 LED
Select LED        (  1 -   4)

                  Select No.=_
```

```
/3 Setting                     (LED1)
1=Logic gate type & reset
2=Input to logic gate
```

```
/4 Logic gate type & delay timer  1/ 2
Logic    1=OR    2=AND            1 _
Reset    0=Inst 1=Latch           1
```

```
/3 Setting                     (LED4)
1=Logic gate type & reset
2=Input to logic gate
```

```
/4 Input to logic gate           1/ 4
In #1 (      0 -   3071):     274  _
In #2 (      0 -   3071):     289
In #3 (      0 -   3071):     295
```

a-1

a-1

```
/1 Test
1=Switch            2=Binary output
3=Timer             4=Logic circuit
5=Sim. Fault        6=Init. 2B
```

```
/2 Switch                      1/ **
A.M.F.   0=Off   1=On          1 _
L.test   0=Off   1=On          0
Open1    0=Off   1=On          0
```

```
/2 Binary output
1=IO#1  2=IO#2  3=IO#3  4=IO#4

Press number to start test
```

```
/3 BO        (0=Disable 1=Enable)  1/ 6
IO#1 TP-A1                           1 _
IO#1 TP-B1                           1
IO#1 TP-C1                           1
```

```
/3 BO
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

```
/3 BO        (0=Disable 1=Enable)  1/ 8
IO#4 BO1                           1 _
IO#4 BO2                           1
IO#4 BO3                           1
```

```
/2 Timer                        1/ 1
Timer(     1 -     48):      8 _
```

```
/2 Timer
Press ENTER to operate.

Press CANCEL to cancel.
```

```
/2 Timer
Operating . . .
Press END to reset.
Press CANCEL to cancel.
```

```
/2 Logic circuit                1/ 2
TermA(      0 -   3071):      12  _
TermB(      0 -   3071):      48
```

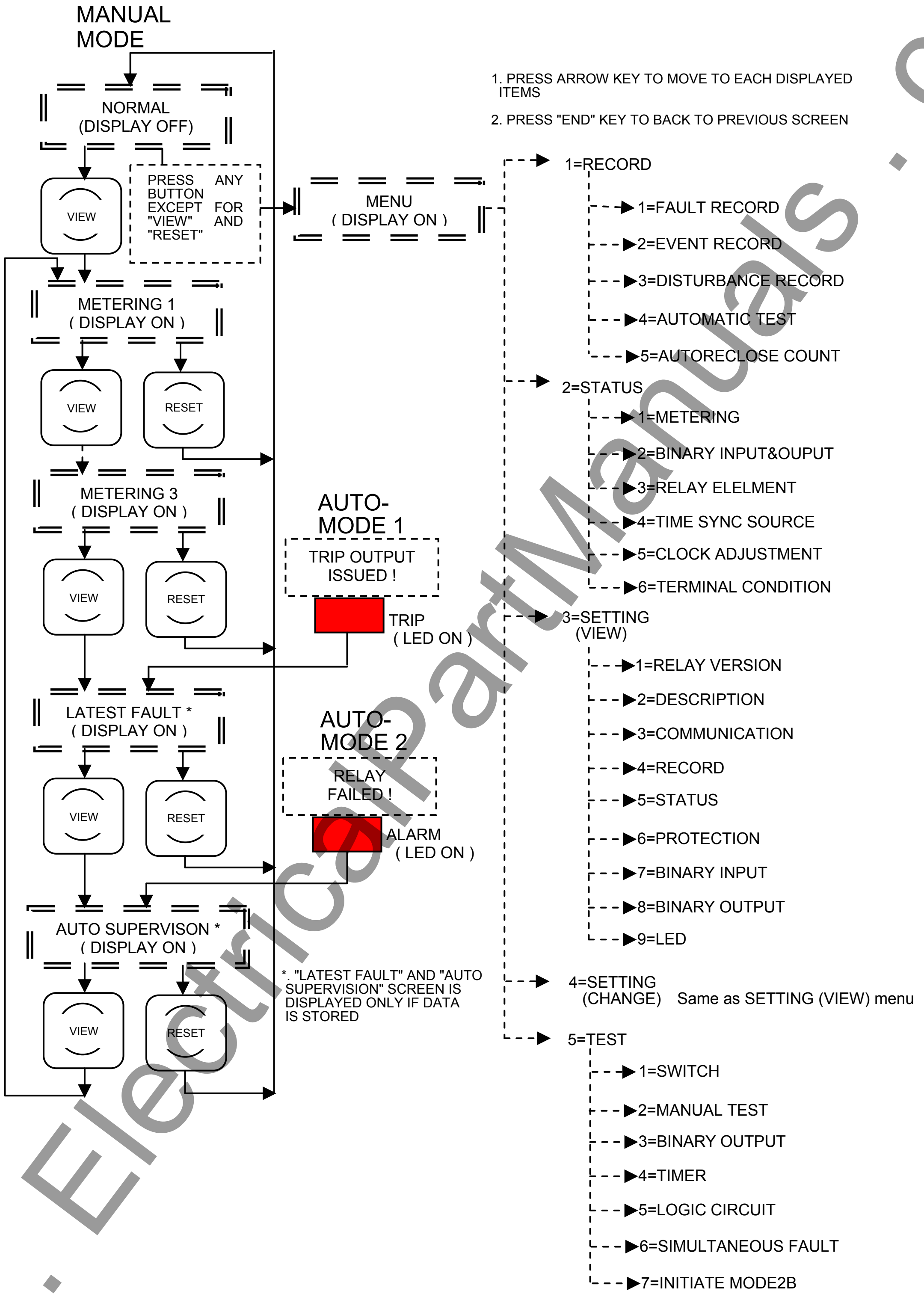
```
/2 Simultaneous fault
Keep pressing 1 to operate.

Press CANCEL to cancel.
```

```
/2 Initiate MODE2B
Keep pressing 1 to initiate MODE2B.
```

```
/2 Initiate MODE2B
Keep pressing 1 to initiate MODE2B.
Initiated
```

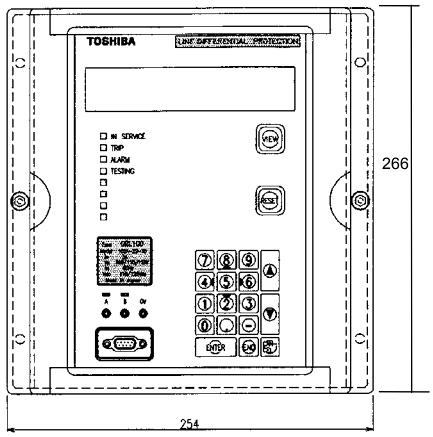
LCD AND BUTTON OPERATION INSTRUCTION



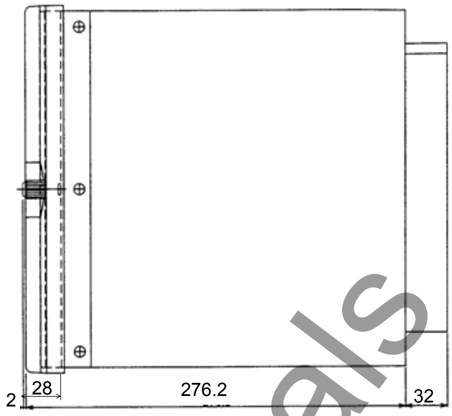
Appendix F

Case Outline

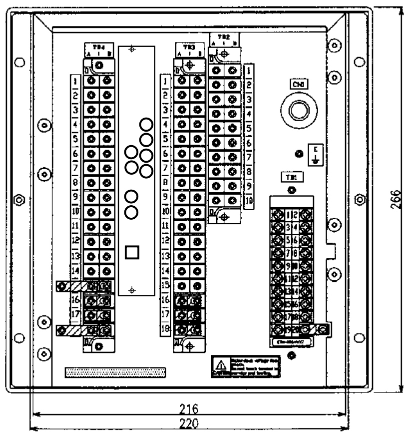
- Case Type-A: Flush Mount Type
- Case Type-B: Flush Mount Type
- Case Type-A, B: Rack Mount Type



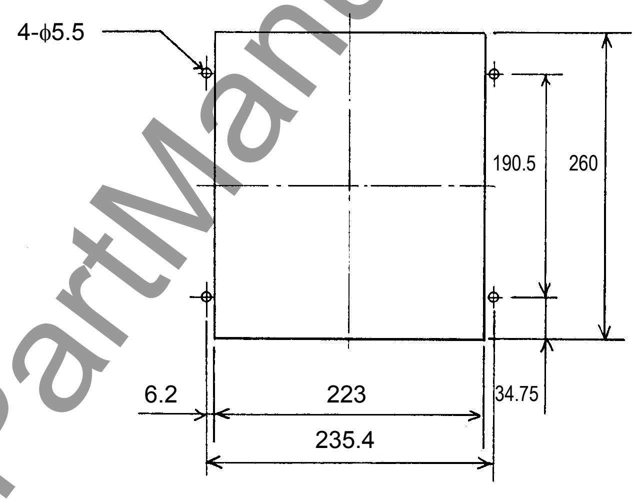
Front View



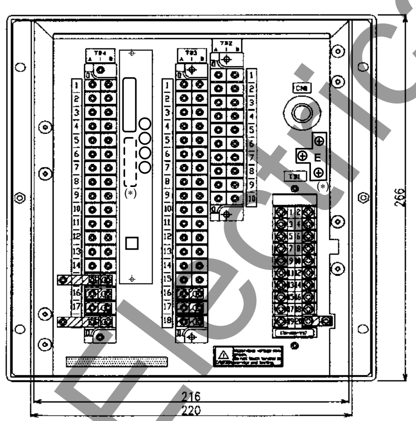
Side View



Optical interface



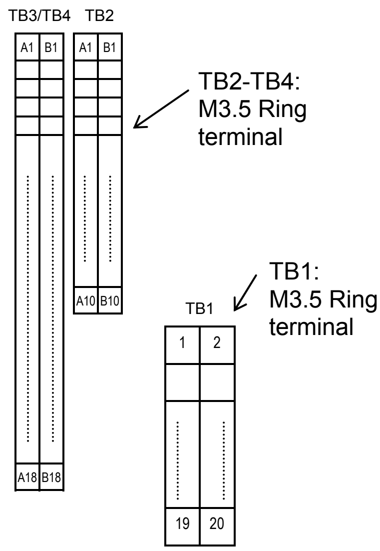
Panel Cut-out



(∗): Provided with GRL100-∗1∗∗-∗9-∗∗

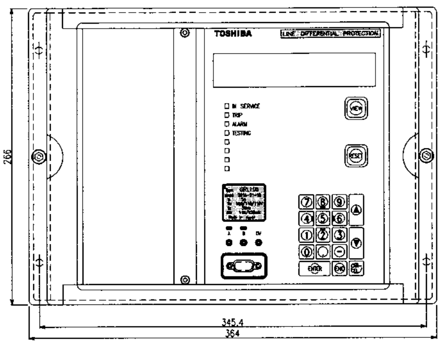
Electrical interface

Rear View

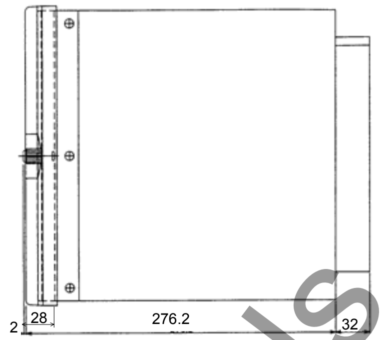


Terminal Block

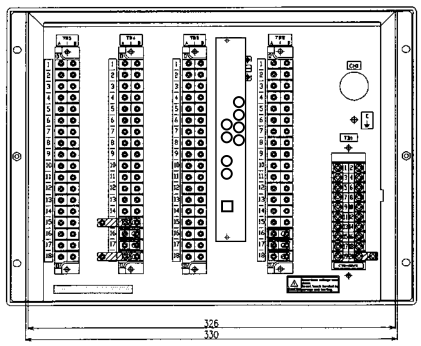
Case Type-A: Flush Mount Type for
Models 101, 102, 111, 112, 201, 204, 211, 214, 301 and 311



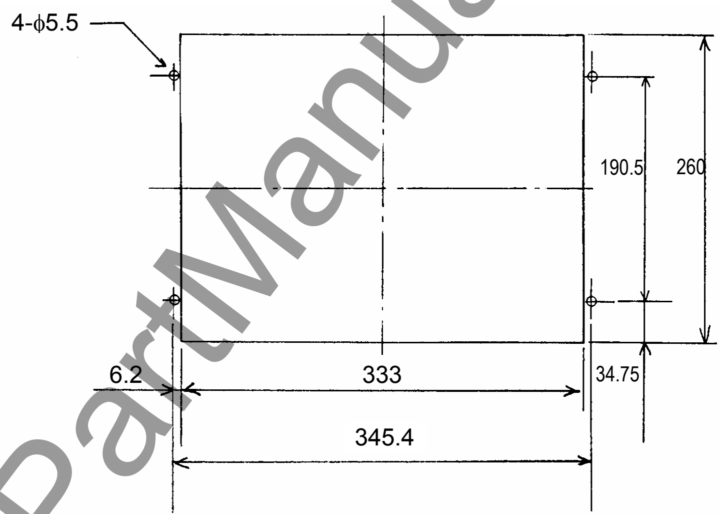
Front View



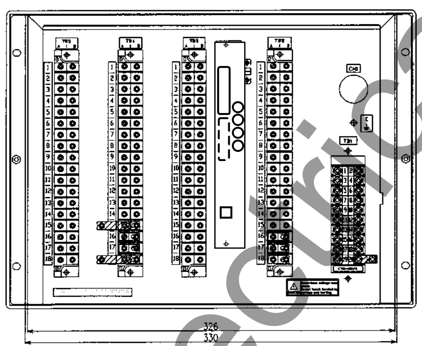
Side View



Optical interface

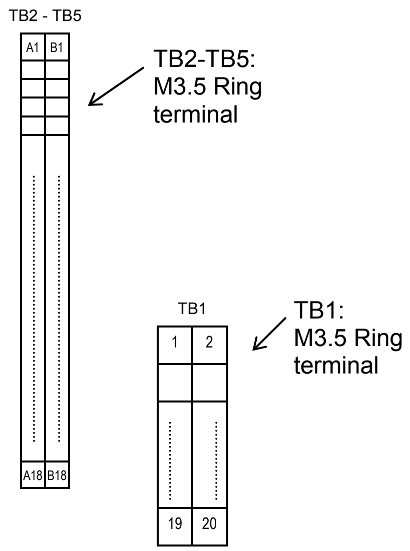


Panel Cut-out



Electrical interface

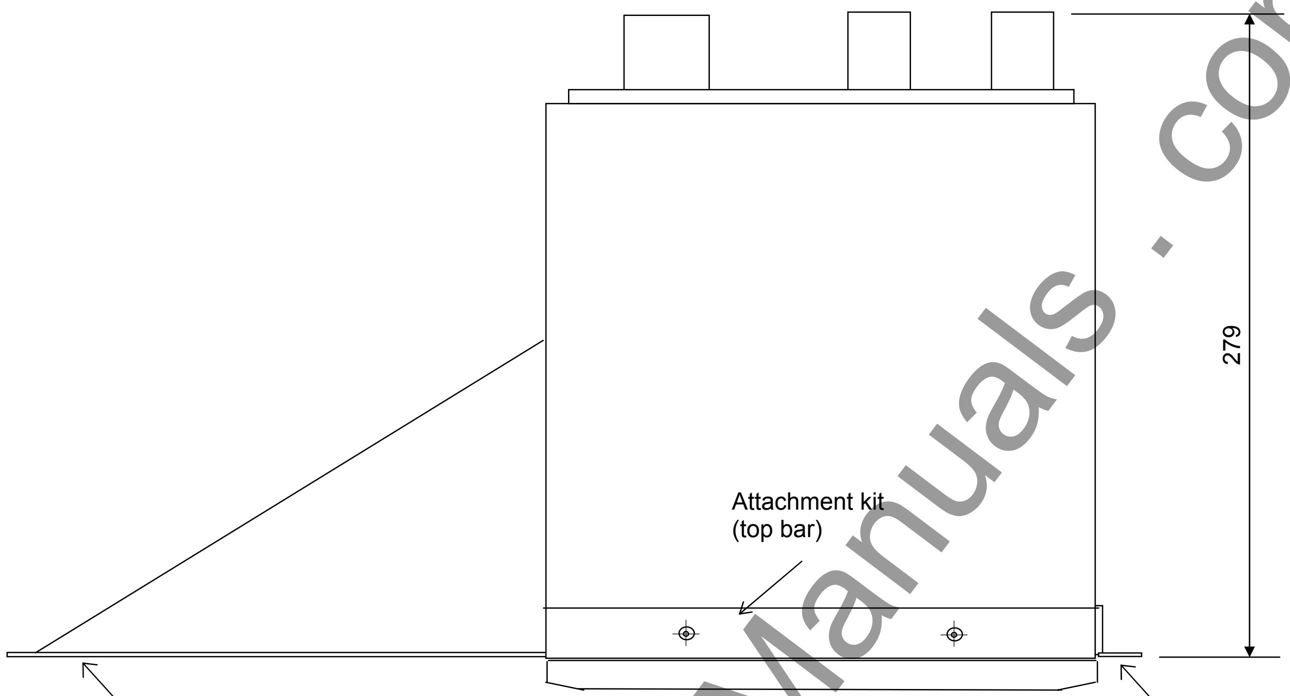
Rear View

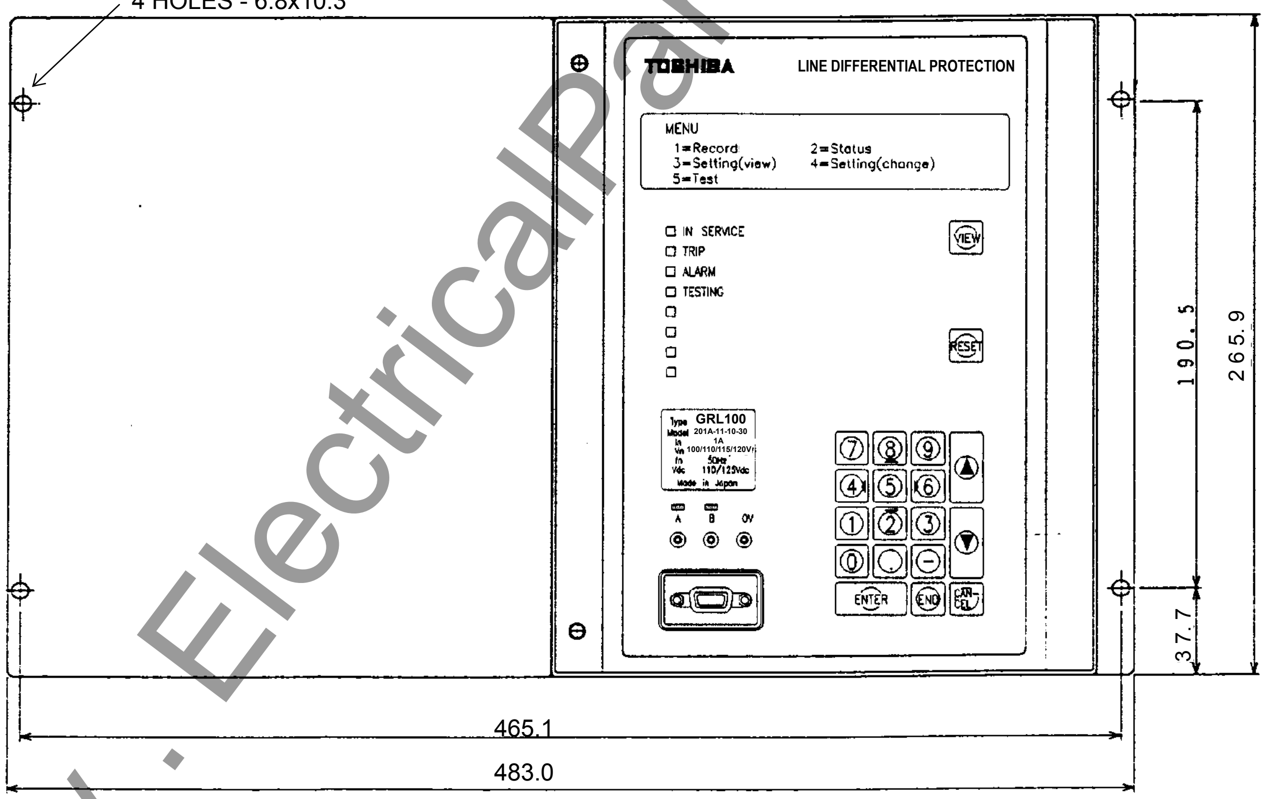


Terminal Block

Case Type-B: Flush Mount Type for
Models 202, 206, 212, 216, 302, 312, 401, 411, 501, 511, 503 and 513

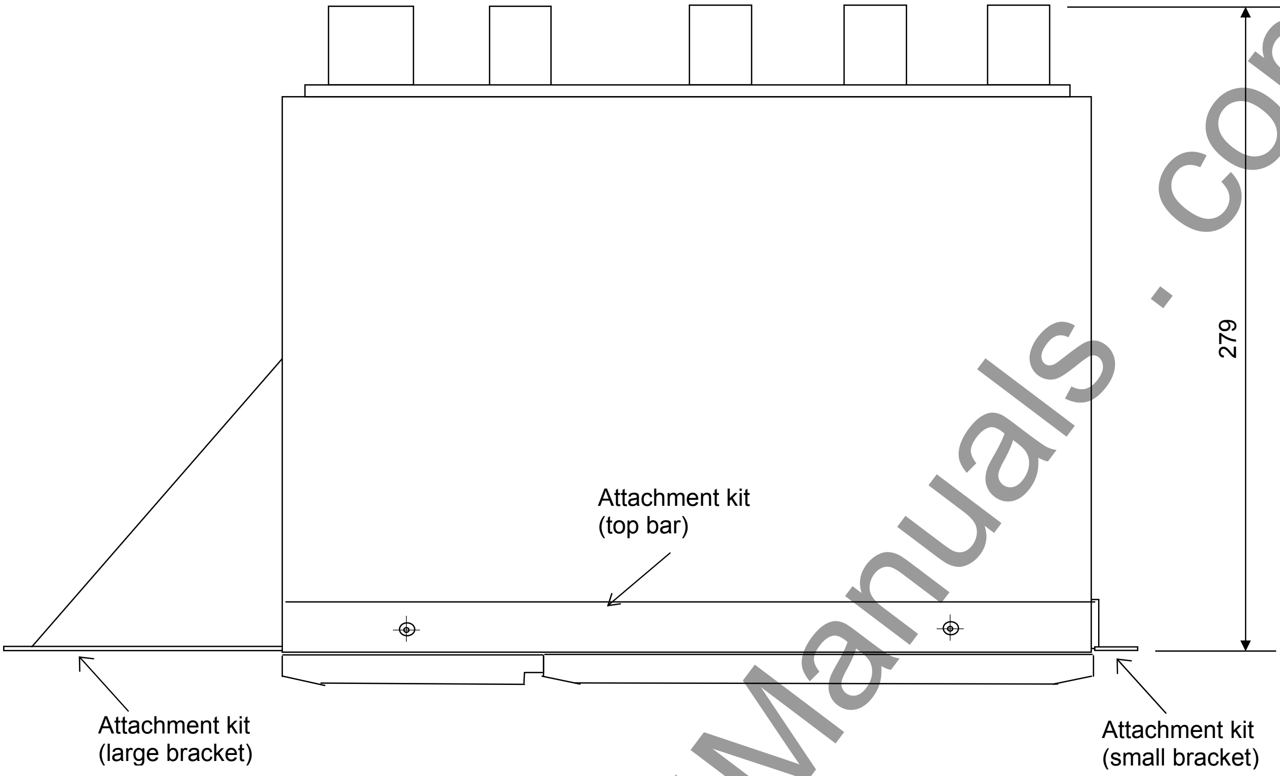
Top View



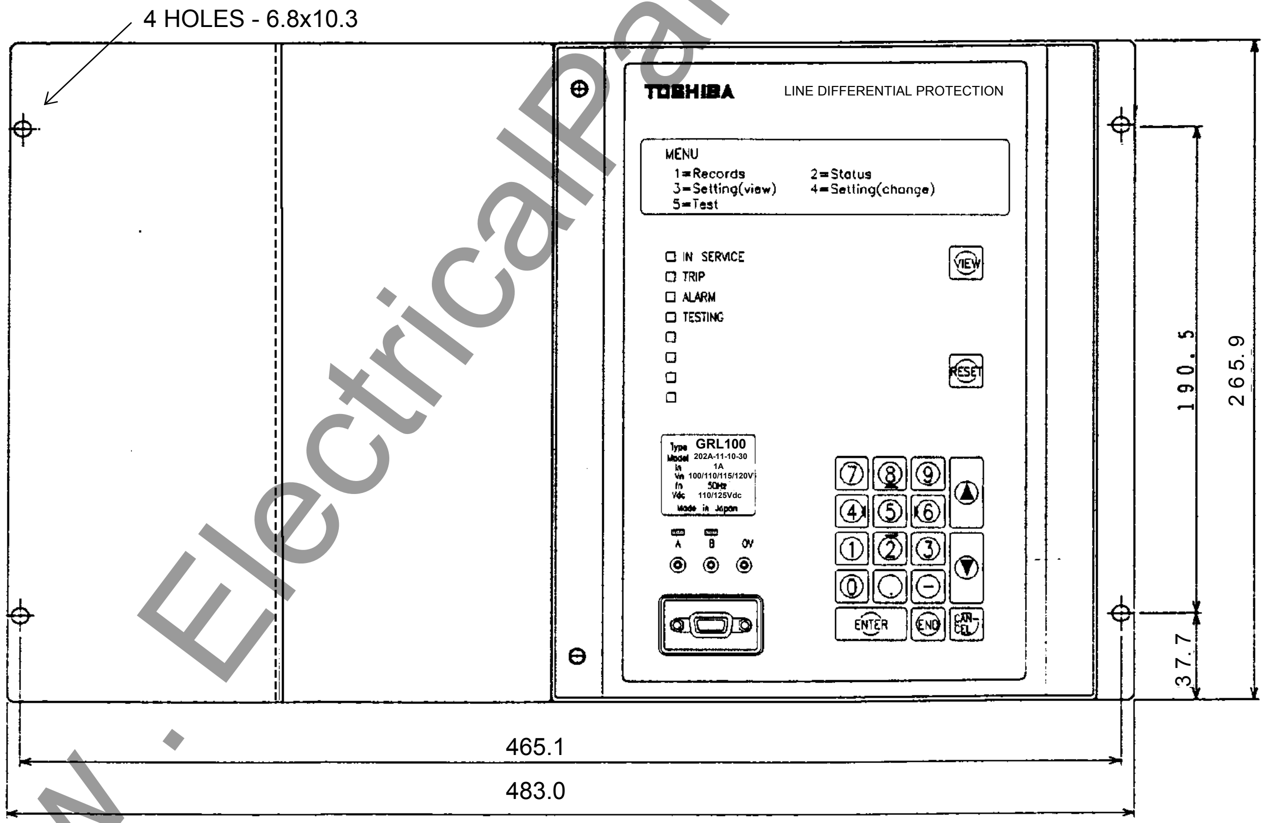


Front View

Rack Mount Type: Case Type-A

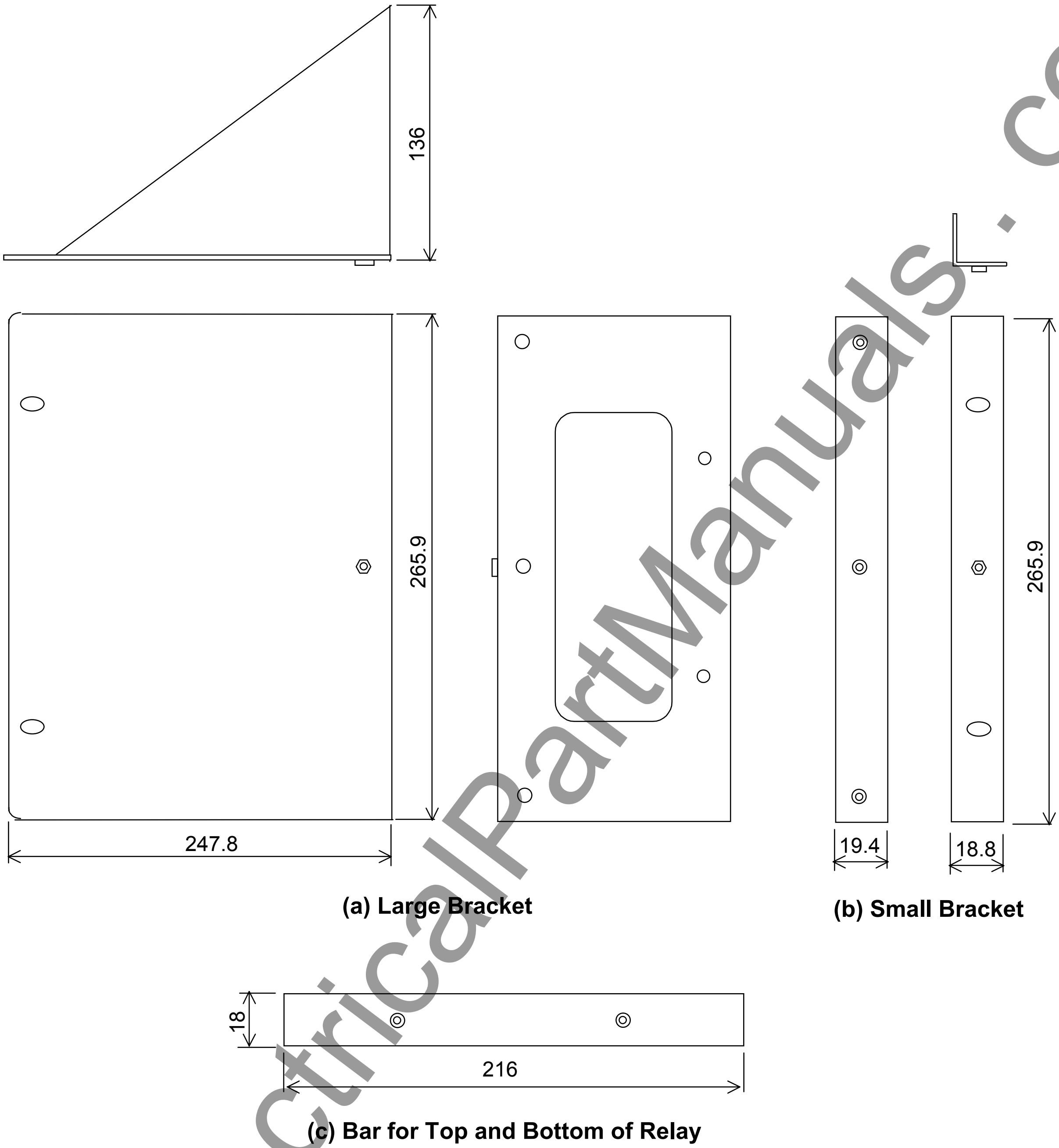


Top View



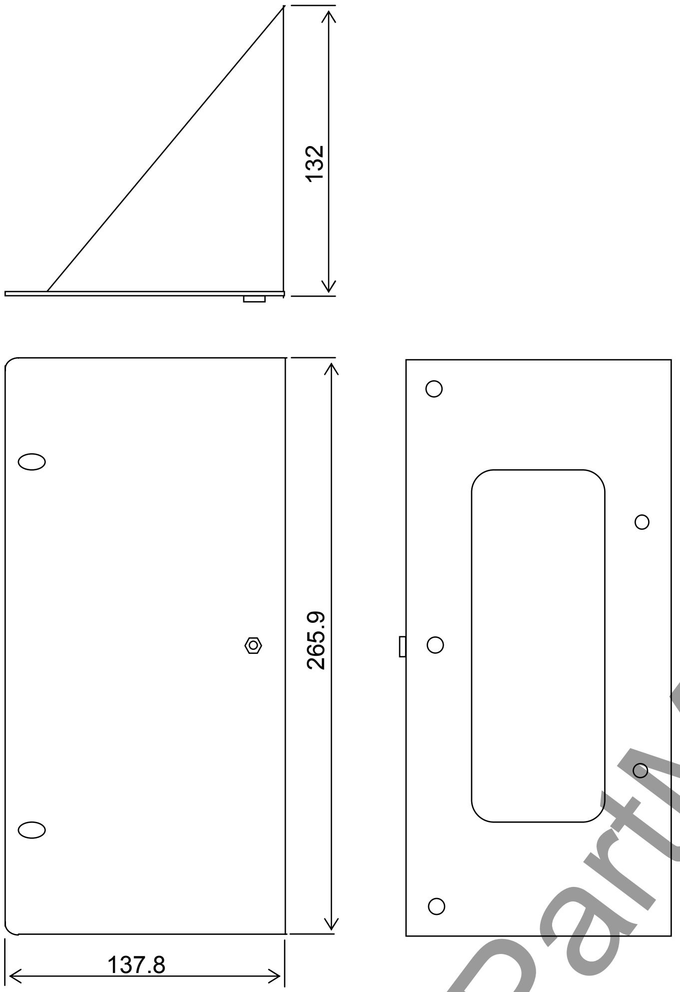
Front View

Rack Mount: Case Type-B

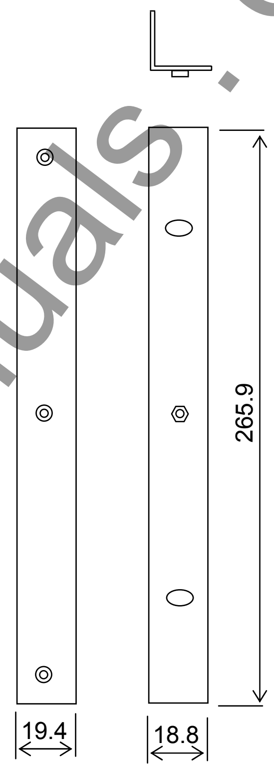


	Parts
(a)	1 Large bracket, 5 Round head screws with spring washers and washers (M4x10)
(b)	1 Small bracket, 3 Countersunk head screws (M4x6)
(c)	2 Bars, 4 Countersunk head screws (M3x8)

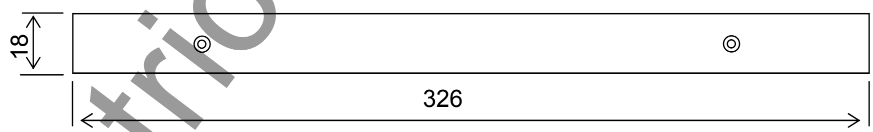
Dimensions of Attachment Kit EP-101



(a) Large Bracket



(b) Small Bracket



(c) Bar for Top and Bottom of Relay

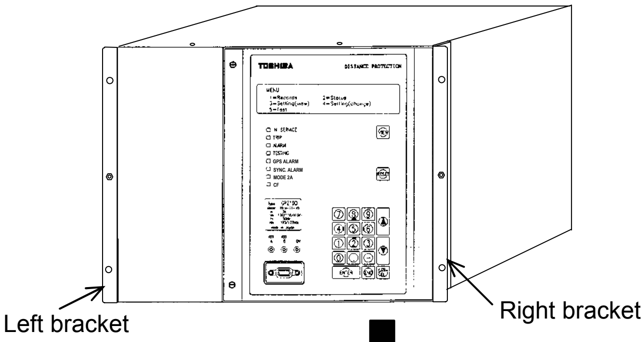
	Parts
(a)	1 Large bracket, 5 Round head screws with spring washers and washers (M4x10)
(b)	1 Small bracket, 3 Countersunk head screws (M4x6)
(c)	2 Bars, 4 Countersunk head screws (M3x8)

Dimensions of Attachment Kit EP-102

How to Mount Attachment Kit for Rack-Mounting

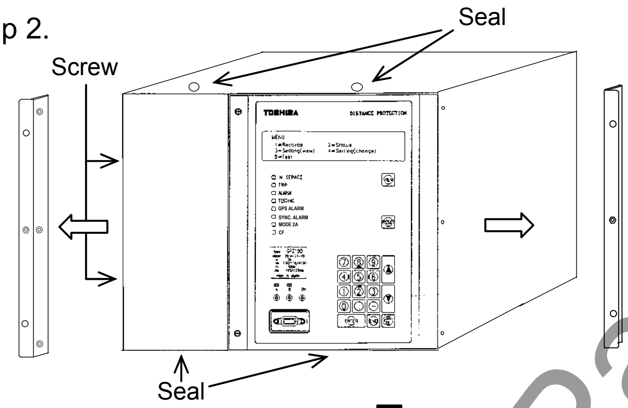
Caution: Be careful that the relay modules or terminal blocks, etc., are not damage while mounting.
Tighten screws to the specified torque according to the size of screw.

Step 1.



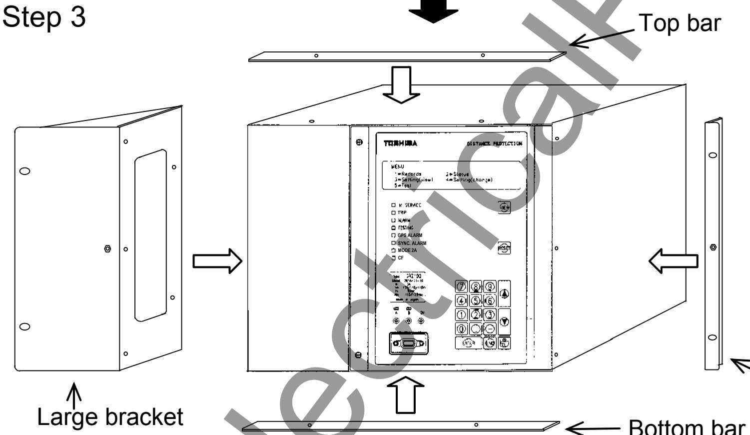
Remove case cover.

Step 2.



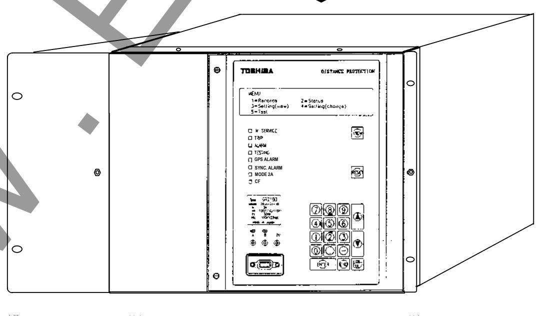
Remove the left and right brackets by unscrewing the three screws respectively, then remove two screws on left side of the relay.
And then, remove four seals on the top and bottom of the relay.

Step 3



Mount the small bracket by screwing three countersunk head screws(M4x6) and apply adhesives to the screws to prevent them from loosening.
Mount the large bracket by five round head screws(M4x10) with washer and spring washer.
And then, mount the top and bottom bars by two countersunk head screws(M3x8) respectively.

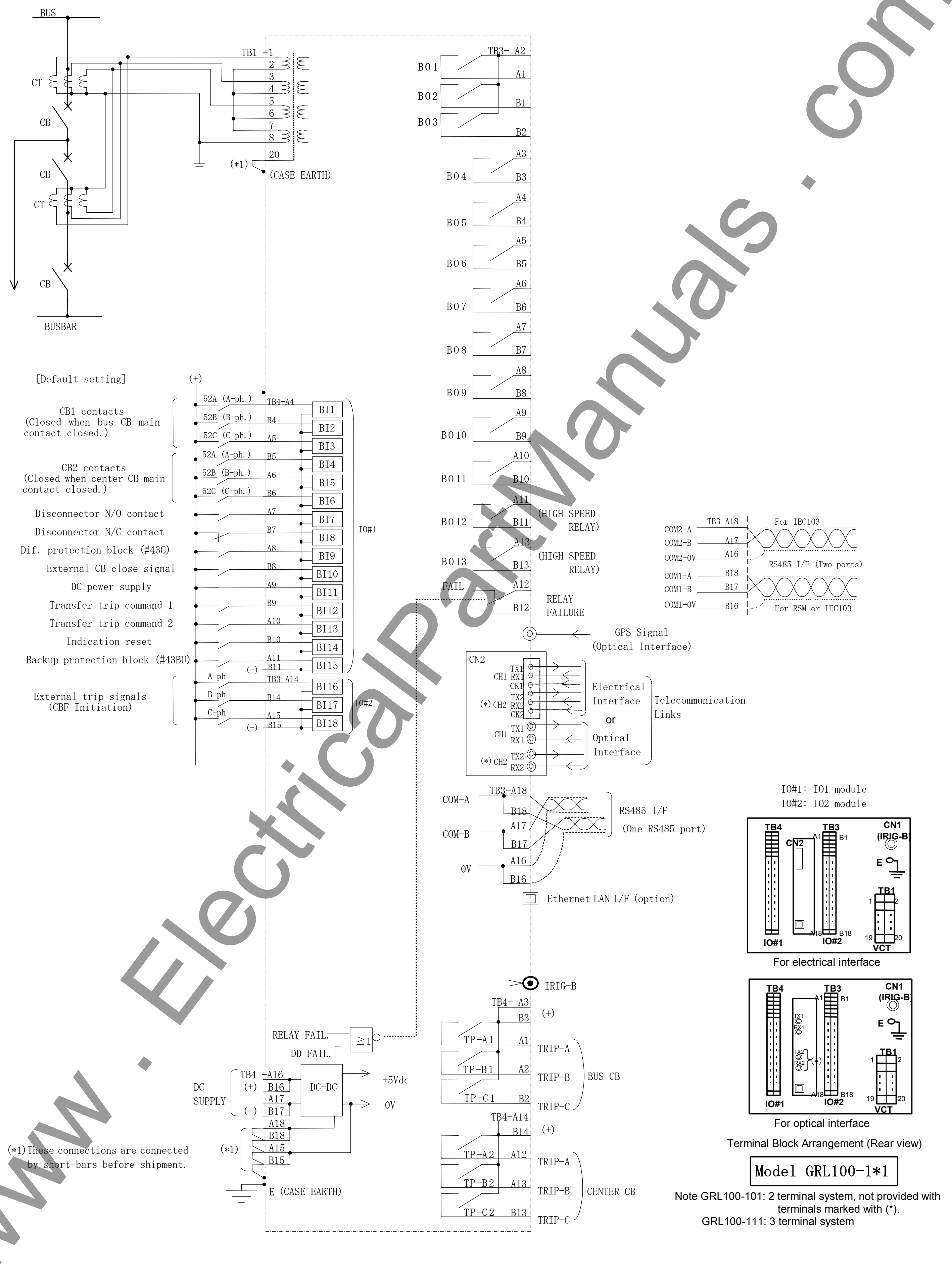
Step 4

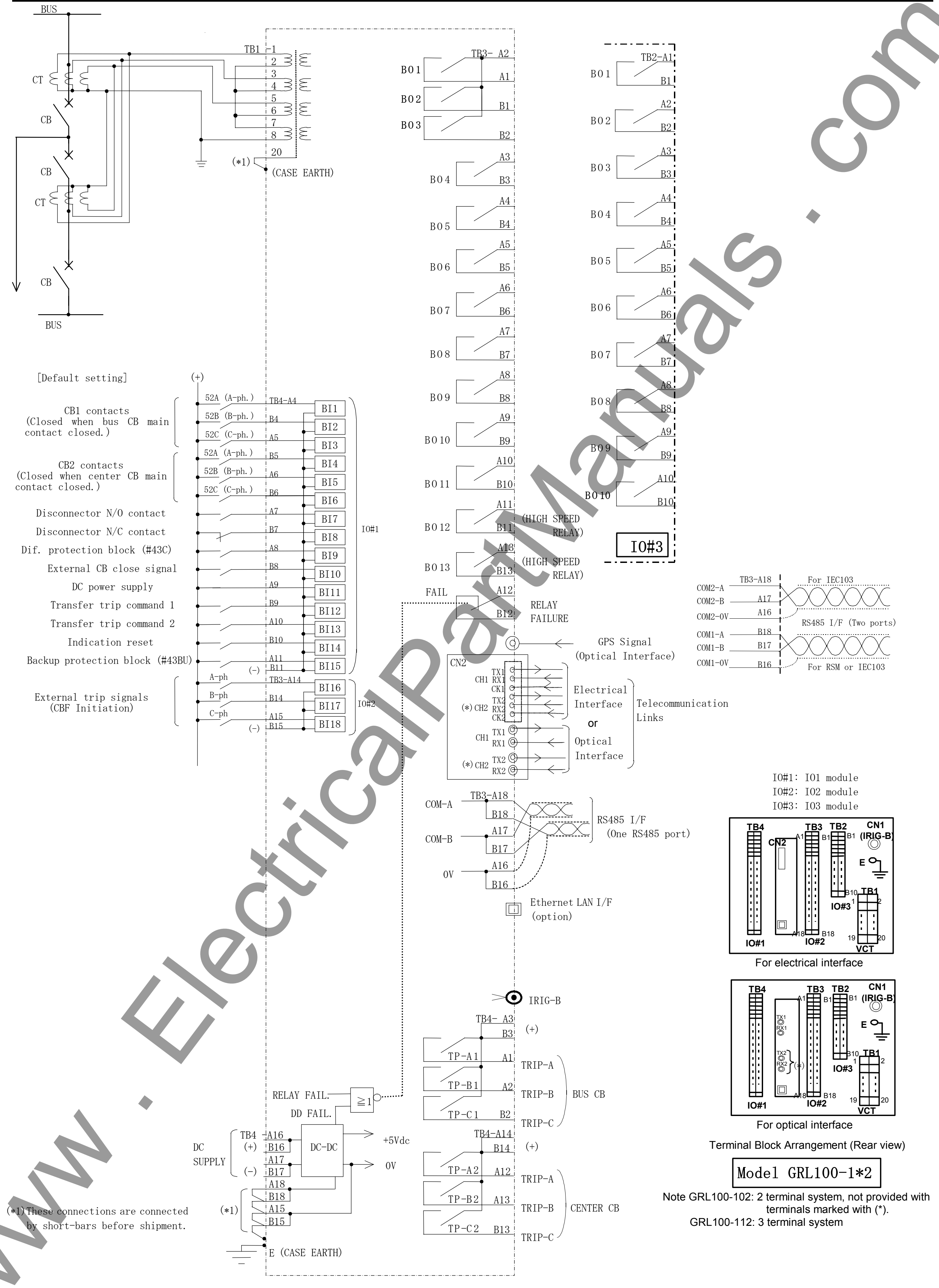


Completed.

Appendix G

Typical External Connection

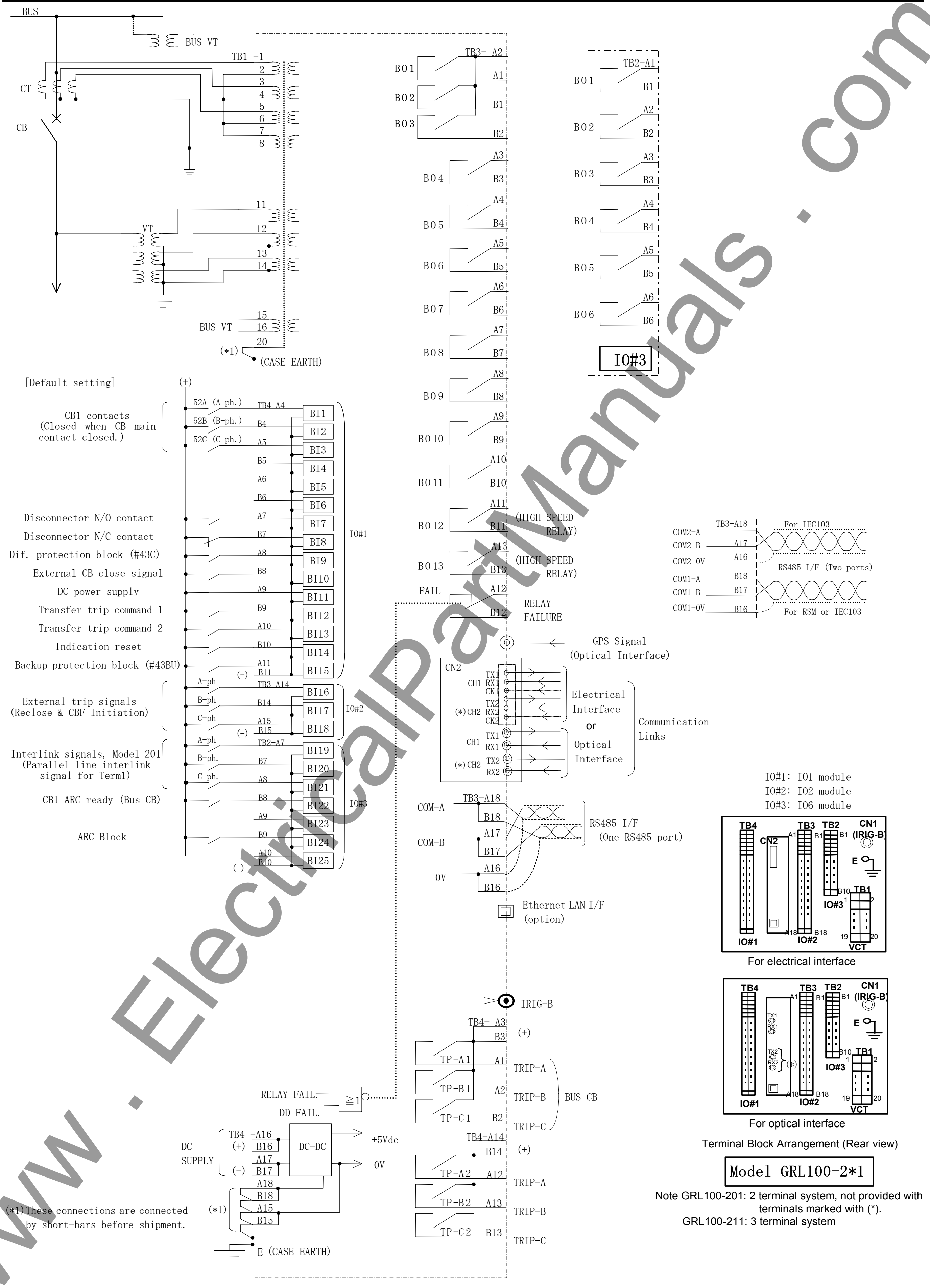

BUS
CT
CB
CB
CT
CB
BUSBAR
TB1 -1
2
3
4
5
6
7
8
20
(*1)
(CASE EARTH)
TB3- A2
A1
B1
B2
B01
B02
B03
B04
B05
B06
B07
B08
B09
B010
B011
B012
B013
FAIL
(HIGH SPEED RELAY)
(HIGH SPEED RELAY)
RELAY FAILURE
[Default setting]
(+)
CB1 contacts
(Closed when bus CB main contact closed.)
CB2 contacts
(Closed when center CB main contact closed.)
52A (A-ph.)
52B (B-ph.)
52C (C-ph.)
Disconnector N/O contact
Disconnector N/C contact
Dif. protection block (#43C)
External CB close signal
DC power supply
Transfer trip command 1
Transfer trip command 2
Indication reset
Backup protection block (#43BU)
External trip signals
(CBF Initiation)
A-ph
B-ph
C-ph
(-)
TB4-A4
TB3-A14
BI1
BI2
BI3
BI4
BI5
BI6
BI7
BI8
BI9
BI10
BI11
BI12
BI13
BI14
BI15
BI16
BI17
BI18
IO#1
IO#2
COM2-A
COM2-B
COM2-0V
COM1-A
COM1-B
COM1-0V
TB3-A18
For IEC103
RS485 I/F (Two ports)
For RSM or IEC103
GPS Signal
(Optical Interface)
CN2
CH1
(*) CH2
TX1
RX1
CK1
TX2
RX2
CK2
Electrical Interface
or
Optical Interface
Telecommunication Links
COM-A
COM-B
0V
RS485 I/F
(One RS485 port)
Ethernet LAN I/F (option)
IO#1: IO1 module
IO#2: IO2 module
TB4
TB3
CN1
(IRIG-B)
CN2
TB1
VCT
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
IRIG-B
TB4- A3
(+)
TP-A1
TP-B1
TP-C1
TRIP-A
TRIP-B
TRIP-C
BUS CB
TB4-A14
TP-A2
TP-B2
TP-C2
CENTER CB
RELAY FAIL.
DD FAIL.
≧1
DC SUPPLY
DC-DC
+5Vdc
0V
E (CASE EARTH)
(*1) These connections are connected by short-bars before shipment.
Model GRL100-1*1
Note GRL100-101: 2 terminal system, not provided with terminals marked with (*).
GRL100-111: 3 terminal system



Terminal Block Arrangement (Rear view)

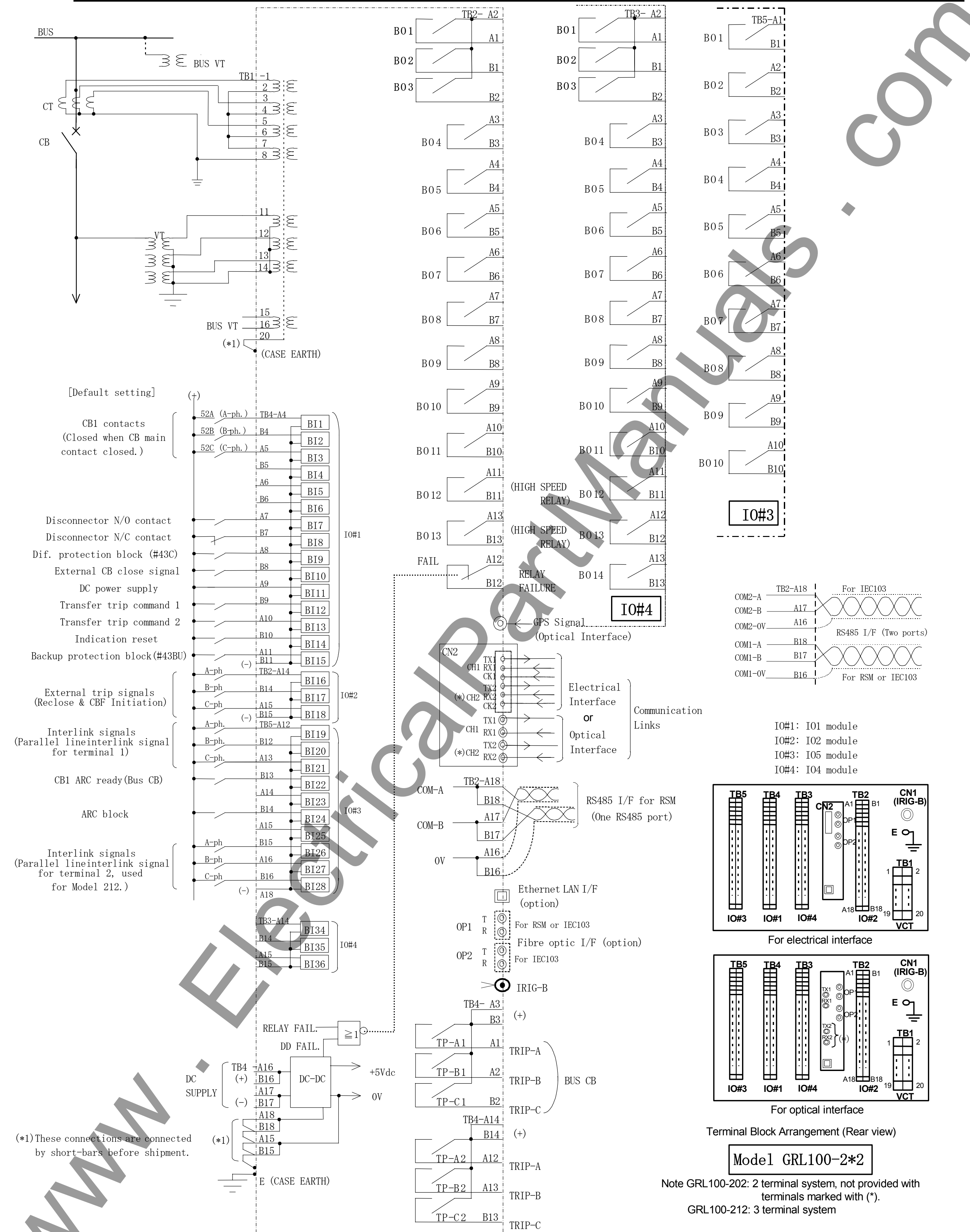
Model GRL100-1*2

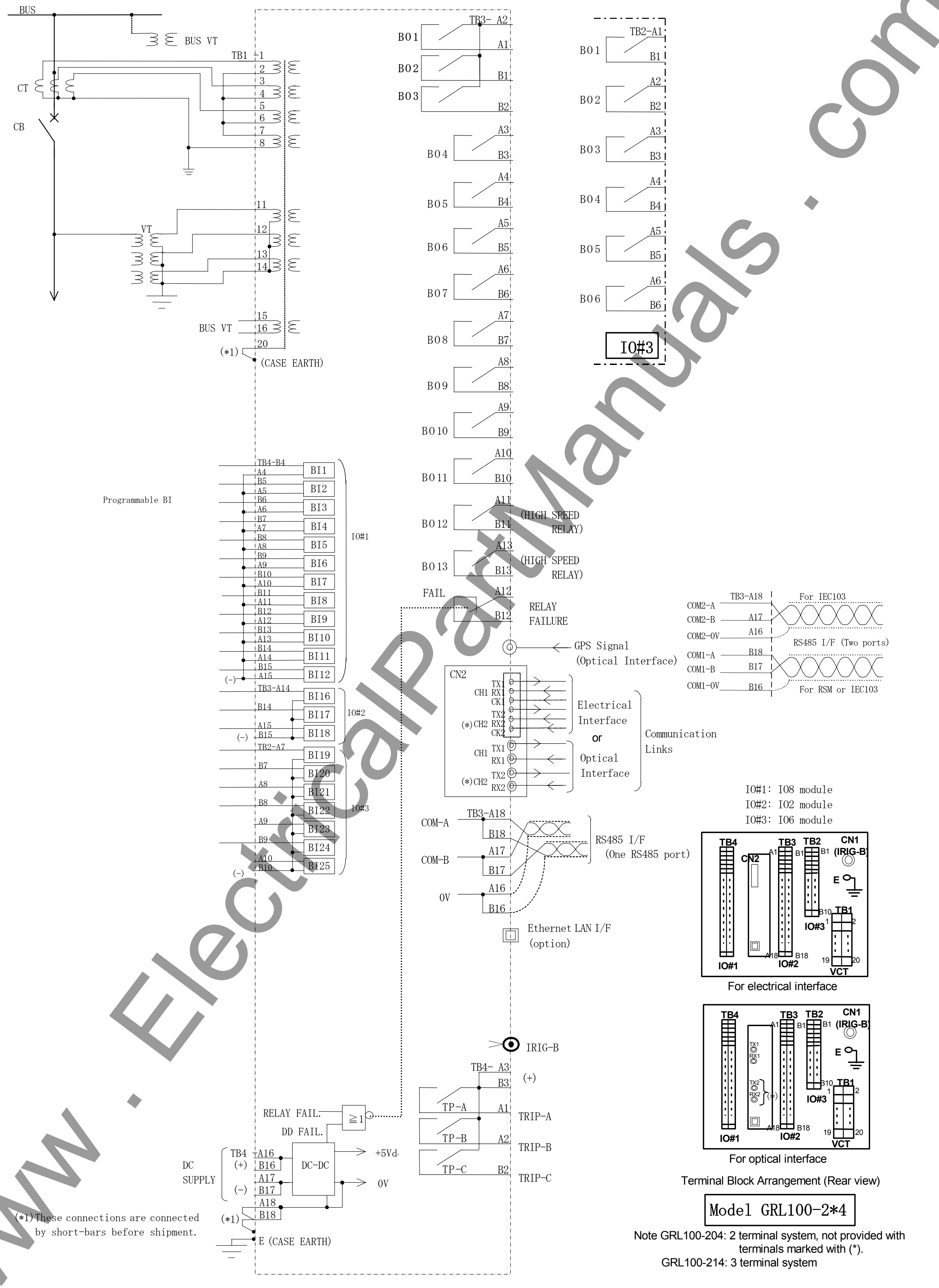
Note GRL100-102: 2 terminal system, not provided with terminals marked with (*).
GRL100-112: 3 terminal system



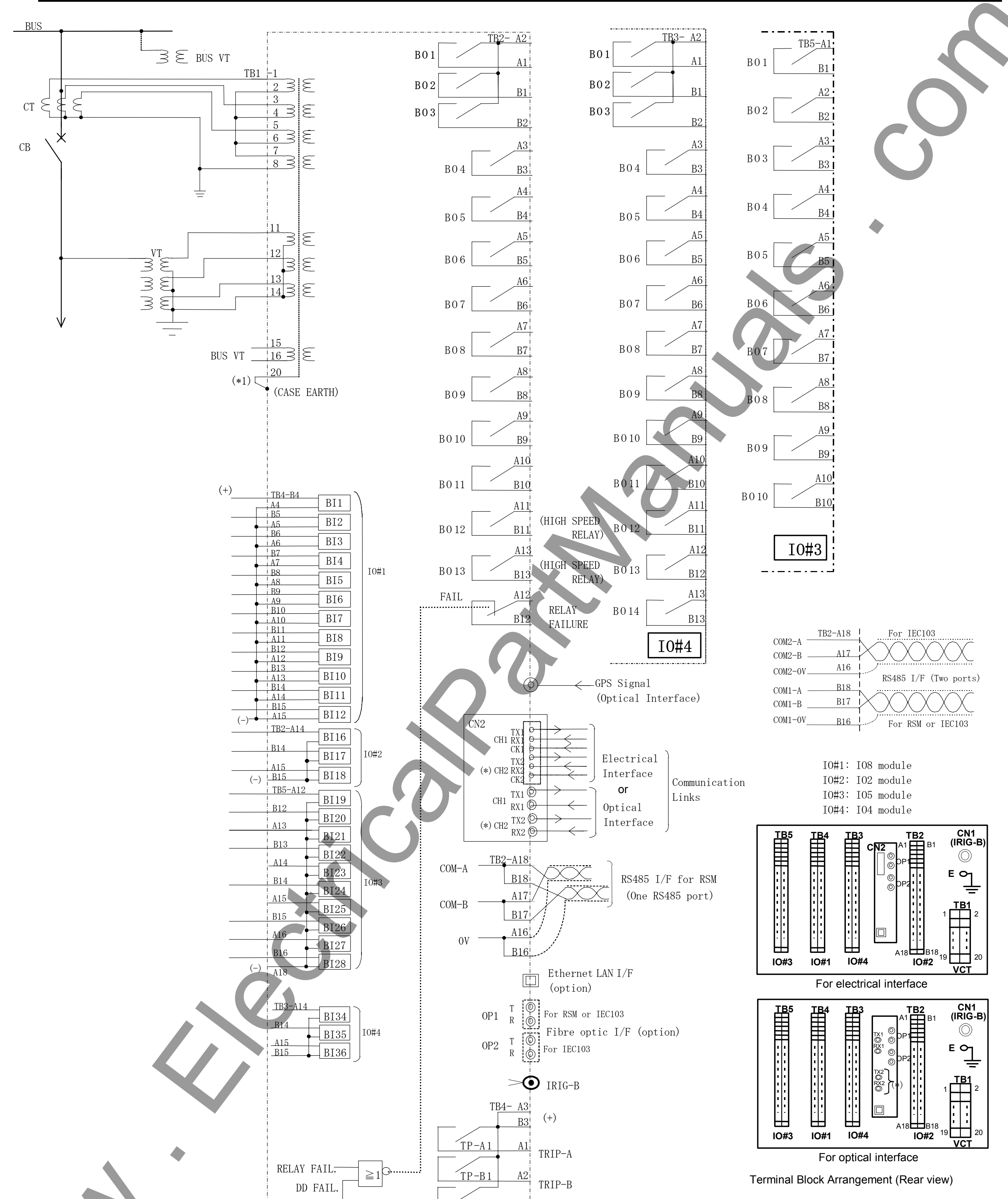
Model GRL100-2*1

Note GRL100-201: 2 terminal system, not provided with terminals marked with (*).
GRL100-211: 3 terminal system


BUS
BUS VT
CT
CB
VT
TB1
BUS VT
(*1)
(CASE EARTH)
[Default setting]
CB1 contacts
(Closed when CB main
contact closed.)
Disconnector N/O contact
Disconnector N/C contact
Dif. protection block (#43C)
External CB close signal
DC power supply
Transfer trip command 1
Transfer trip command 2
Indication reset
Backup protection block(#43BU)
External trip signals
(Reclose & CBF Initiation)
Interlink signals
(Parallel lineinterlink signal
for terminal 1)
CB1 ARC ready(Bus CB)
ARC block
Interlink signals
(Parallel lineinterlink signal
for terminal 2, used
for Model 212.)
IO#1
IO#2
IO#3
IO#4
(HIGH SPEED RELAY)
FAIL
RELAY FAILURE
GPS Signal
(Optical Interface)
Electrical Interface
or
Optical Interface
Communication Links
RS485 I/F for RSM
(One RS485 port)
Ethernet LAN I/F
(option)
For RSM or IEC103
Fibre optic I/F (option)
For IEC103
IRIG-B
RELAY FAIL.
DD FAIL.
DC SUPPLY
DC-DC
+5Vdc
0V
E (CASE EARTH)
TRIP-A
TRIP-B
TRIP-C
BUS CB
(*1)These connections are connected
by short-bars before shipment.
For IEC103
RS485 I/F (Two ports)
For RSM or IEC103
IO#1: IO1 module
IO#2: IO2 module
IO#3: IO5 module
IO#4: IO4 module
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
Model GRL100-2*2
Note GRL100-202: 2 terminal system, not provided with
terminals marked with (*).
GRL100-212: 3 terminal system



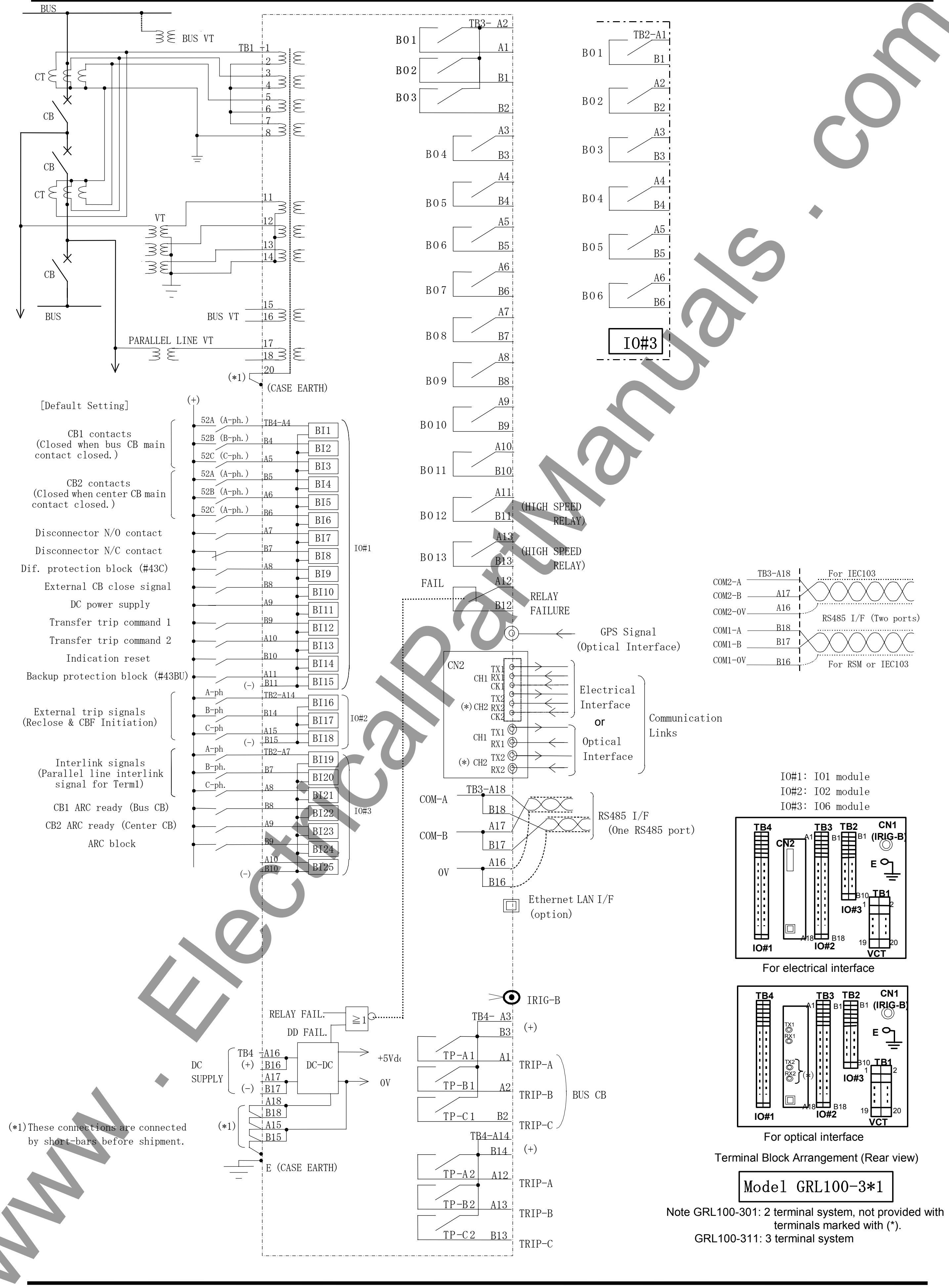
BUS
BUS VT
CT
CB
VT
TB1
BUS VT
(*1)
(CASE EARTH)
Programmable BI
IO#1
IO#2
IO#3
RELAY FAIL.
DD FAIL.
DC SUPPLY
DC-DC
+5Vdc
0V
(*1) These connections are connected by short-bars before shipment.
E (CASE EARTH)
(HIGH SPEED RELAY)
RELAY FAILURE
FAIL
GPS Signal (Optical Interface)
Electrical Interface
or
Optical Interface
Communication Links
For IEC103
RS485 I/F (Two ports)
For RSM or IEC103
RS485 I/F (One RS485 port)
Ethernet LAN I/F (option)
IRIG-B
TRIP-A
TRIP-B
TRIP-C
IO#1: IO8 module
IO#2: IO2 module
IO#3: IO6 module
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
Model GRL100-2*4
Note GRL100-204: 2 terminal system, not provided with terminals marked with (*).
GRL100-214: 3 terminal system

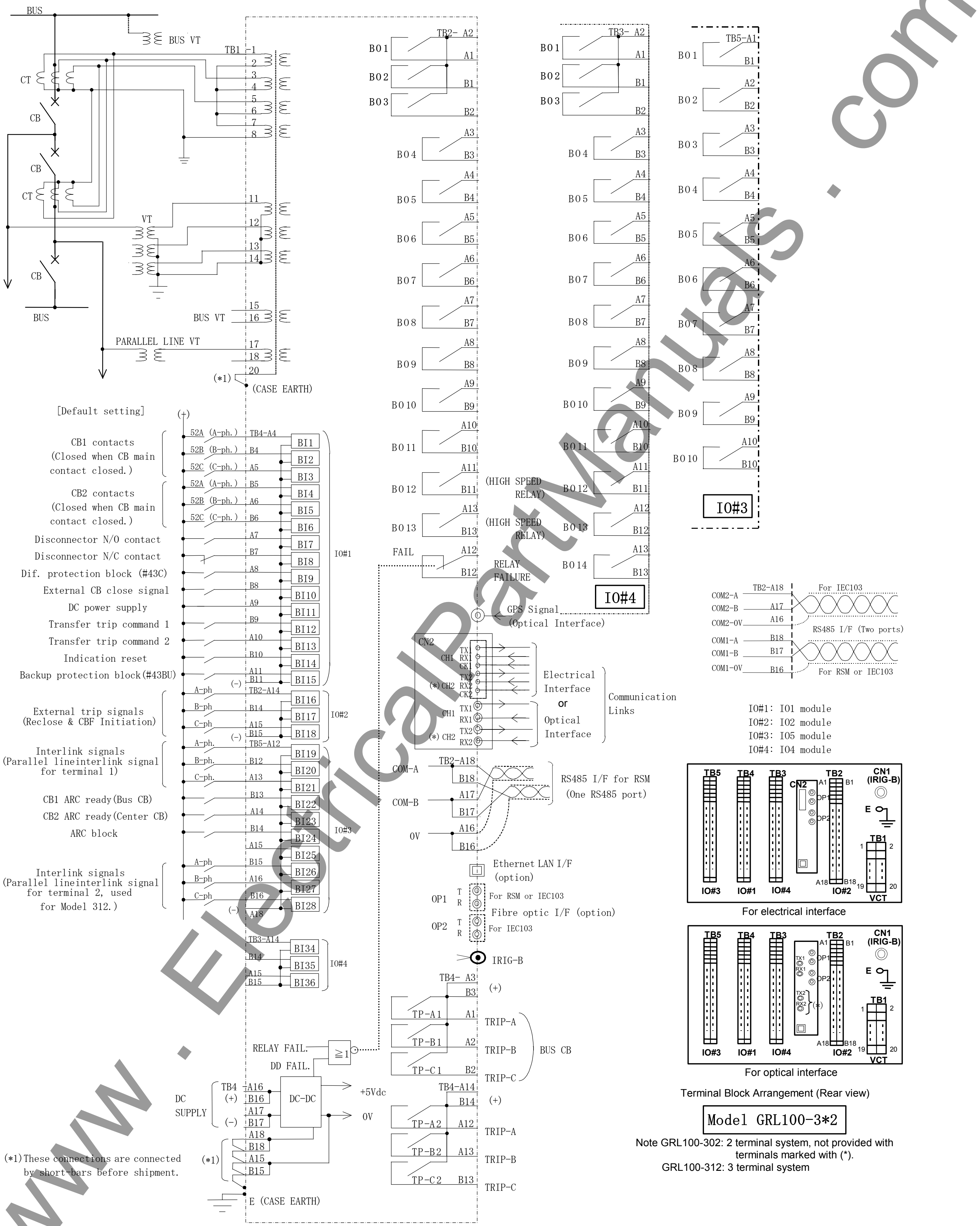


Terminal Block Arrangement (Rear view)

Model GRL100-2*6

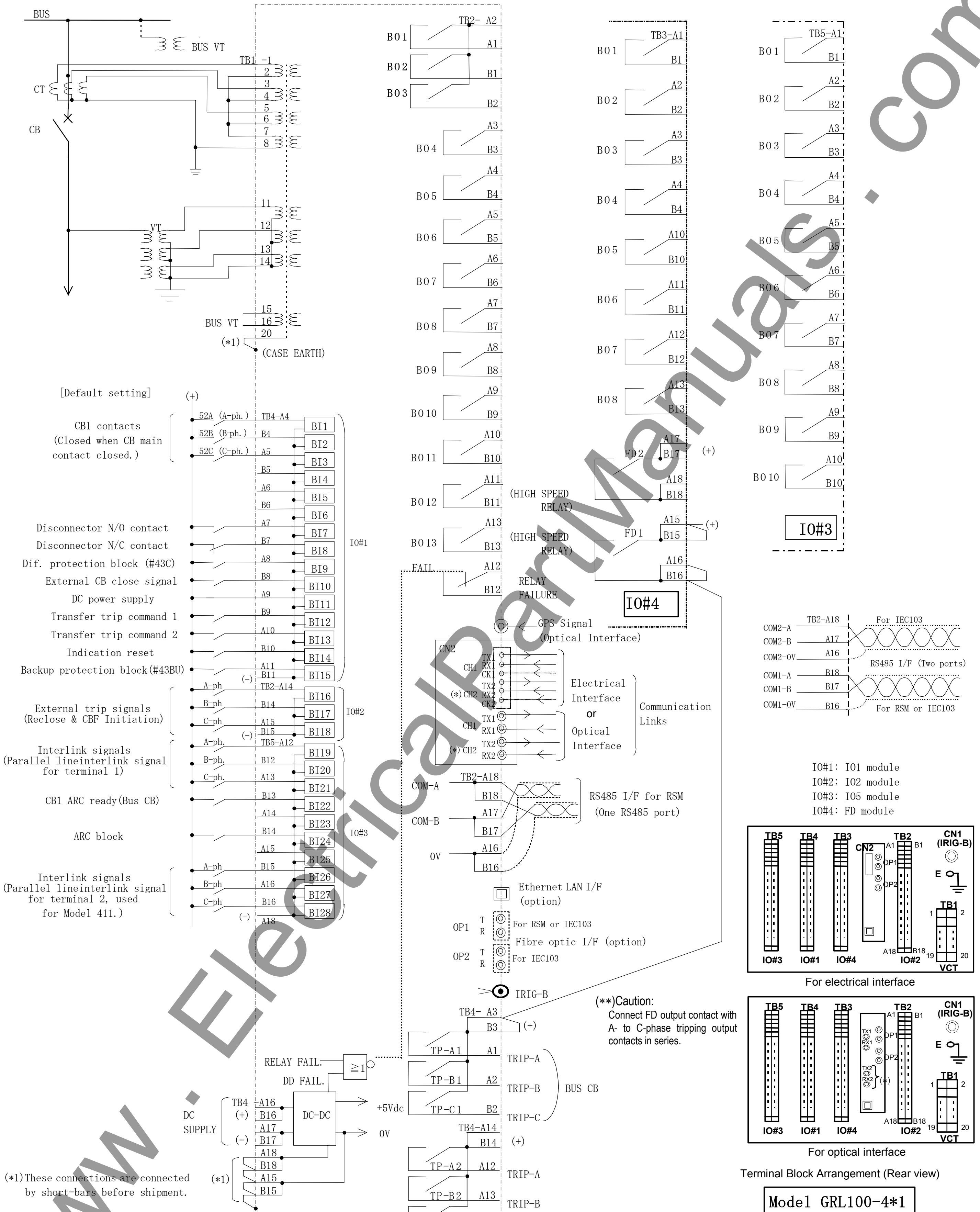
Note GRL100-206: 2 terminal system, not provided with terminals marked with (*).
GRL100-216: 3 terminal system


BUS
BUS VT
TB1
CT
CB
VT
BUS VT
PARALLEL LINE VT
(*1)
(CASE EARTH)
[Default Setting]
CB1 contacts
(Closed when bus CB main
contact closed.)
CB2 contacts
(Closed when center CB main
contact closed.)
Disconnector N/O contact
Disconnector N/C contact
Dif. protection block (#43C)
External CB close signal
DC power supply
Transfer trip command 1
Transfer trip command 2
Indication reset
Backup protection block (#43BU)
External trip signals
(Reclose & CBF Initiation)
Interlink signals
(Parallel line interlink
signal for Term1)
CB1 ARC ready (Bus CB)
CB2 ARC ready (Center CB)
ARC block
IO#1
IO#2
IO#3
TB3- A2
BO1
BO2
BO3
BO4
BO5
BO6
BO7
BO8
BO9
BO10
BO11
BO12
BO13
FAIL
(HIGH SPEED
RELAY)
RELAY
FAILURE
TB2-A1
IO#3
GPS Signal
(Optical Interface)
CN2
Electrical
Interface
or
Optical
Interface
Communication
Links
COM-A
COM-B
0V
RS485 I/F
(One RS485 port)
Ethernet LAN I/F
(option)
For IEC103
RS485 I/F (Two ports)
For RSM or IEC103
IO#1: IO1 module
IO#2: IO2 module
IO#3: IO6 module
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
Model GRL100-3*1
Note GRL100-301: 2 terminal system, not provided with
terminals marked with (*).
GRL100-311: 3 terminal system
IRIG-B
RELAY FAIL.
DD FAIL.
DC
SUPPLY
DC-DC
+5Vdc
0V
E (CASE EARTH)
(*1)These connections are connected
by short-bars before shipment.
TRIP-A
TRIP-B
TRIP-C
BUS CB



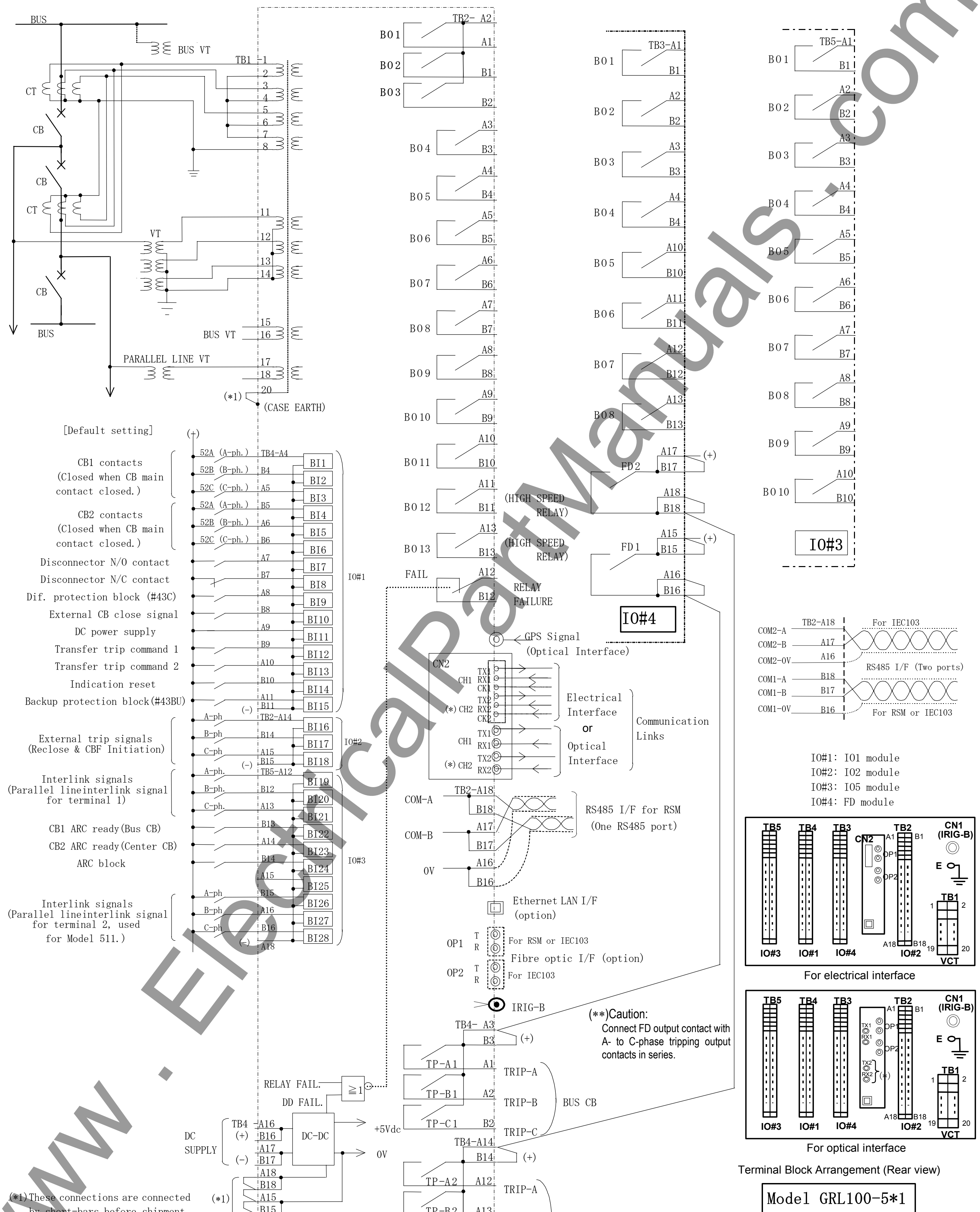
Model GRL100-3*2

Note GRL100-302: 2 terminal system, not provided with terminals marked with (*).
GRL100-312: 3 terminal system



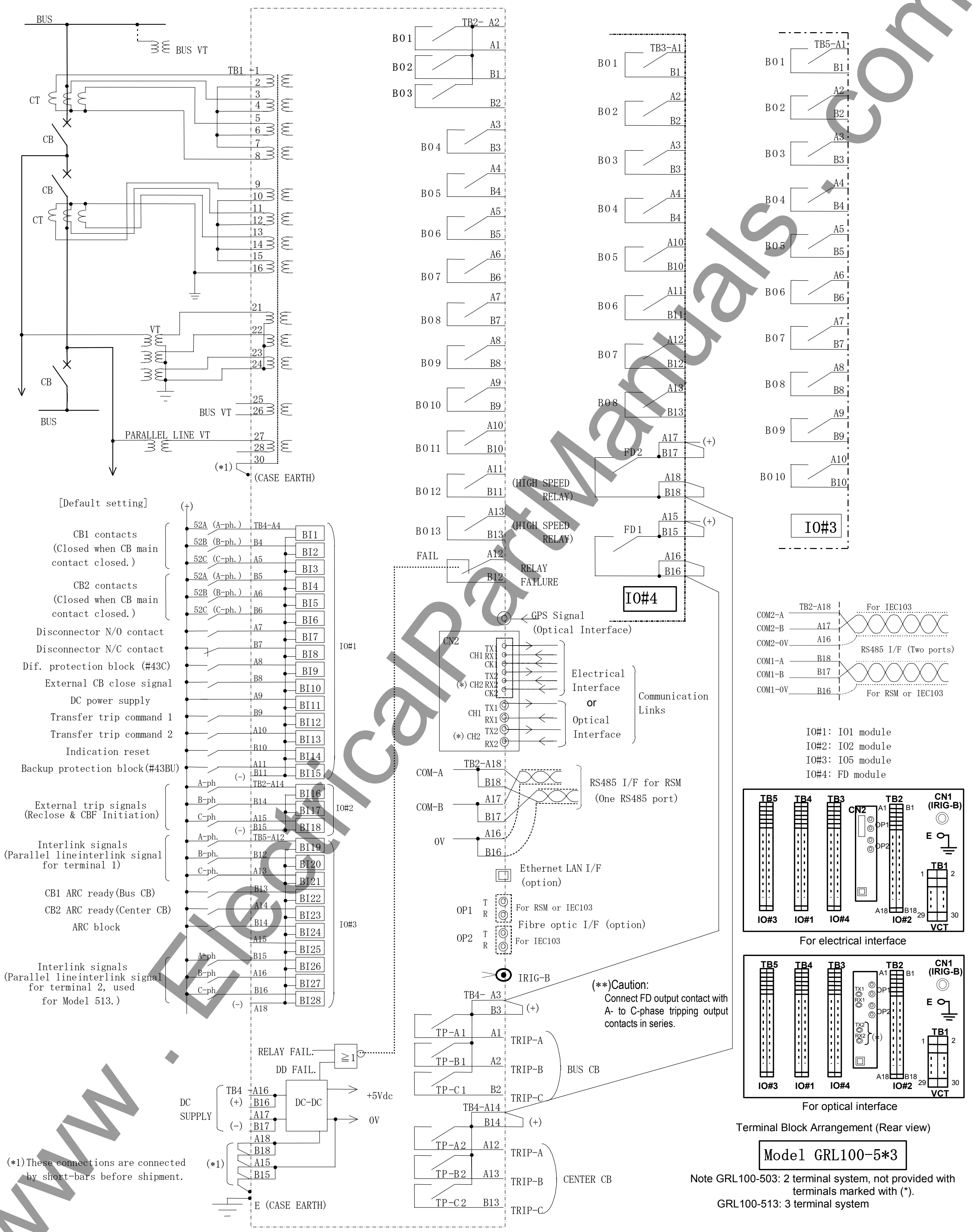
Note GRL100-401: 2 terminal system, not provided with terminals marked with (*).

GRL100-411: 3 terminal system



Model GRL100-5*1

Note GRL100-501: 2 terminal system, not provided with terminals marked with (*).
GRL100-511: 3 terminal system


BUS
BUS VT
TB1
CT
CB
VT
PARALLEL LINE VT
(CASE EARTH)
[Default setting]
CB1 contacts (Closed when CB main contact closed.)
CB2 contacts (Closed when CB main contact closed.)
Disconnector N/O contact
Disconnector N/C contact
Dif. protection block (#43C)
External CB close signal
DC power supply
Transfer trip command 1
Transfer trip command 2
Indication reset
Backup protection block(#43BU)
External trip signals (Reclose & CBF Initiation)
Interlink signals (Parallel lineinterlink signal for terminal 1)
CB1 ARC ready(Bus CB)
CB2 ARC ready(Center CB)
ARC block
Interlink signals (Parallel lineinterlink signal for terminal 2, used for Model 513.)
IO#1
IO#2
IO#3
IO#4
RELAY FAIL.
DD FAIL.
DC SUPPLY
DC-DC
+5Vdc
0V
(*1)These connections are connected by short-bars before shipment.
E (CASE EARTH)
(HIGH SPEED RELAY)
FAIL
RELAY FAILURE
GPS Signal (Optical Interface)
Electrical Interface or Optical Interface
Communication Links
RS485 I/F for RSM (One RS485 port)
Ethernet LAN I/F (option)
For RSM or IEC103
Fibre optic I/F (option)
For IEC103
IRIG-B
(**)Caution:
Connect FD output contact with A- to C-phase tripping output contacts in series.
TRIP-A
TRIP-B
TRIP-C
BUS CB
CENTER CB
For IEC103
RS485 I/F (Two ports)
For RSM or IEC103
IO#1: IO1 module
IO#2: IO2 module
IO#3: IO5 module
IO#4: FD module
For electrical interface
For optical interface
Terminal Block Arrangement (Rear view)
Model GRL100-5*3
Note GRL100-503: 2 terminal system, not provided with terminals marked with (*).
GRL100-513: 3 terminal system

Appendix H

Relay Setting Sheet

- Relay Identification
- Transmission line parameters
- Protection
- Autoreclose scheme
- Contacts setting
- Contacts setting (continued)
- Relay and Protection Scheme Setting Sheets

Relay Setting Sheets

1. Relay Identification

Date:

Relay type ____________________ Serial Number ____________________

Frequency ____________________ CT rating ____________________

VT rating ____________________ dc supply voltage ____________________

Password ____________________

Active setting group ____________________

2. Transmission line parameters

Line type ____________________ Line length ____________________

Line impedance Z1 = ____________________

Z0 = ____________________ Z0 (mutual) = ____________________

Zm = ____________________

VT ratio ____________________ CT ratio ____________________

Tripping mode 1 + 3 phase/3 phase

3. Protection

Master __________

Slave __________

2 Term __________

3 Term

4. Autoreclose scheme

Not used __________

SPAR __________

SPAR + TPAR __________

TPAR __________

MPAR 2 (for two-phase interlinking) __________

MPAR 3 (for three-phase interlinking) __________

EX1P (external autoreclose SPAR + TPAR scheme) __________

EX3P (external autoreclose TPAR scheme) __________

1CB or 2CB reclosing __________

Multi-shot autoreclose __________

1 shot, 2 shots, 3 shots or 4 shots __________

5. Contacts setting

(1) IO#2 BO1 ______
BO2 ______
BO3 ______
BO4 ______
BO5 ______
BO6 ______
BO7 ______
BO8 ______
BO9 ______
BO10 ______
BO11 ______
BO12 ______
BO13 ______

(2) IO#3 BO1 ______
BO2 ______
BO3 ______
BO4 ______
BO5 ______
BO6 ______
BO7 ______
BO8 ______
BO9 ______
BO10 ______
BO11 ______
BO12 ______
BO13 ______
BO14 ______

(3) IO#4 BO1 ______
BO2 ______
BO3 ______
BO4 ______
BO5 ______
BO6 ______
BO7 ______
BO8 ______
BO9 ______
BO10 ______
BO11 ______
BO12 ______
BO13 ______
BO14 ______

(Memo: For relay elements and scheme logic settings, the setting list as shown on the next page is made.)

Relay and Protection Scheme Setting Sheet

№	Name	Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)												User Setting
						NO-ARC,NO-FD		1CB-ARC,NO-FD		2CB-ARC,NO-FD		1CB-ARC,FD		2CB-ARC,FD		1CB-ARC,NO-FD		
						2TERM	3TERM	2TERM	3TERM	2TERM	3TERM	2TERM	3TERM	2TERM	3TERM	2TERM	3TERM	
		5A rating	1A rating			101, 102	111, 112	201 202	211 212	301 302	312	401	411	501 503	511 513	204 206	214 216	
1	Active group	1 - 8		—	Active setting group	1										1		
2	Line name	Specified by user		—	Line name	Specified by user										Specified by user		
3	VT	1 - 20000		—	VT ratio	--		2000								2000		
4	VTs1	1 - 20000		—	VT ratio	--		2000								2000		
5	VTs2	1 - 20000		—	VT ratio	--				2000		--		2000		--		
6	CT	1 - 20000		—	CT ratio	400										400		
7	Setting impedance mode	Positive sequecce impedance - Phase impedance		—	Fault location	--		Positive sequecce impedance								Positive sequecce impedance		
8	1X1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.00 / 10.0								2.00 / 10.0		
9	1R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.20 / 1.0								0.20 / 1.0		
10	1Line	0.0 - 399.9		km	ditto	--		50.0								50.0		
11	2X1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	
12	2R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	
13	2Line	0.0 - 399.9		km	ditto	--		--	50.0	--	50.0	--	50.0	--	50.0	--	50.0	
14	3X1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	--	2.00 / 10.0	
15	3R1	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	--	0.20 / 1.0	
16	3Line	0.0 - 399.9		km	ditto	--		--	50.0	--	50.0	--	50.0	--	50.0	--	50.0	
17	1Xaa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.10 / 10.5								2.10 / 10.5		
18	1Xbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.10 / 10.5								2.10 / 10.5		
19	1Xcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		2.10 / 10.5								2.10 / 10.5		
20	1Xab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.10 / 0.5								0.10 / 0.5		
21	1Xbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.10 / 0.5								0.10 / 0.5		
22	1Xca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.10 / 0.5								0.10 / 0.5		
23	1Raa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.21 / 1.1								0.21 / 1.1		
24	1Rbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.21 / 1.1								0.21 / 1.1		
25	1Rcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.21 / 1.1								0.21 / 1.1		
26	1Rab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.01 / 0.1								0.01 / 0.1		
27	1Rbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.01 / 0.1								0.01 / 0.1		
28	1Rca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		0.01 / 0.1								0.01 / 0.1		
29	1Line	0.0 - 399.9		km	ditto	--		50.0								50.0		
30	2Xaa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
31	2Xbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
32	2Xcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
33	2Xab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
34	2Xbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
35	2Xca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
36	2Raa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
37	2Rbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
38	2Rcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
39	2Rab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
40	2Rbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
41	2Rca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
42	2Line	0.0 - 399.9		km	ditto	--		--	50.0	--	50.0	--	50.0	--	50.0	--	50.0	
43	3Xaa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
44	3Xbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
45	3Xcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	--	2.10 / 10.5	
46	3Xab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
47	3Xbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
48	3Xca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	--	0.10 / 0.5	
49	3Raa	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
50	3Rbb	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
51	3Rcc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	--	0.21 / 1.1	
52	3Rab	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
53	3Rbc	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
54	3Rca	0.00 - 199.99	0.0 - 999.9	Ω	ditto	--		--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	--	0.01 / 0.1	
55	3Line	0.0 - 399.9		km	ditto	--		--	50.0	--	50.0	--	50.0	--	50.0	--	50.0	
56	COMMODE	A - B - GPS		—	communication mode	B										B		
57	SP.SYN.	Master - Slave		—	SP synchronization setting	Master										Master		
58	TERM	2TERM - 3TERM - Dual		—	Terminal selection	--	3TERM	--	3TERM	--	3TERM	--	3TERM	--	3TERM	--	3TERM	
59	CH.CON	Normal - Exchange		—	CH connection	--	Normal	--	Normal	--	Normal	--	Normal	--	Normal	--	Normal	
60	RYIDSV	Off - On		—	Relay address supervision	On										On		
61	T.SFT1	Off - On		—	CH#1 bit shifter for multiplexer link	Off										Off		
62	T.SFT2	Off - On		—	CH#2 bit shifter for multiplexer link	--	Off	--	Off	--	Off	--	Off	--	Off	--	Off	

Relay and Protection Scheme Setting Sheet

№	Name		Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)																			User Setting
							NO-ARC,NO-FD		1CB-ARC,NO-FD				2CB-ARC,NO-FD			1CB-ARC,FD		2CB-ARC,FD				1CB-ARC,NO-FD				
							2TERM	3TERM	2TERM		3TERM		2TERM		3TERM	2TERM	3TERM	2TERM		3TERM		2TERM		3TERM		
			5A rating	1A rating			101, 102	111, 112	201	202	211	212	301	302	312	401	411	501	503	511	513	204	206	214	216	
63		B.SYN1	Off - On		—	CH#1 bit sync. for multiplexer	On															On				
64		B.SYN2	Off - On		—	CH#2 bit sync. for multiplexer	--	On	--		On		--		On	--	On	--		On		--		On		
65		GPSBAK	Off - On		—	GPS backup mode	On															On				
66		AUTO2B	Off - On		—	Automatic transfer to MODE2B	Off															Off				
67		SRCθ	Disable - I		—	Phase detector selection	I															I				
68		PDTD	200 - 2000		us	Permissible telecom. delay time difference	1000															1000				
69		RYID	0 - 63		—	Relay address (local)	0															0				
70		RYID1	0 - 63		—	Relay address (remote1)	0															0				
71		RYID2	0 - 63		—	Relay address (remote2)	0															0				
72		TDSV	100 - 16000		us	SV for telecom. delay time	6000															6000				
73		TCDT1	-10000 - +10000		us	CH1 delay time difference	0															0				
74		TCDT2	-10000 - +10000		us	CH1 delay time difference	--	0	--		0		--		0	--	0	--		0		--		0		
75		TPMODE	3PH - 1PH - MPH		—	Trip mode	3PH		--													--				
76		STUB	Off - On		—	Stub protection	Off		Off				On			Off		On				Off				
77		DIFG	Off - On		—	DIFG trip	--		On													On				
78		OST	Off - Trip - BO		—	Out of step trip	--		Off													Off				
79		OCBT	Off - On		—	OC back-up trip	On															On				
80		OCIBT	Off - On		—	OCI back-up trip	On															On				
81		MOCI	Long - Std - Very - Ext		—		Std															Std				
82		EFBT	Off - On		—	EF back-up trip	On															On				
83		EFBTAL	Off - On		—	EF back-up trip alarm	On															On				
84		EFIBT	Off - On		—	EFI back-up trip	On															On				
85		MEFI	Long - Std - Very - Ext		—		Std															Std				
86		BF1	Off - T - TOC		—	CBF re-trip	--		Off													Off				
87		BF2	Off - On		—	CBF related trip	--		Off													Off				
88		BFEXT	Off - On		—	CBF initiation by ext. trip	--		Off													Off				
89		THMT	Off - On		—	Thermal trip enable	Off									--						Off				
90		THMAL	Off - On		—	Thermal alarm enable	Off									--						Off				
91		TTSW1	Off - Trip - BO		—	Transfer trip selection (CH1)	Off															Off				
92		TTSW2	Off - Trip - BO		—	Transfer trip selection (CH2)	Off															Off				
93		RDIF	Off - On		—	Remote differential protection	On															On				
94		T.F.C	Off - On		—	Through fault current protection	--											--	On	--	On	--				
95		OTD	Off - On		—	Oepn terminal detection function	Off															Off				
96		DIF-FS	Off - OC - OCD - Both		—	Fail-safe OC use or not	Off															Off				
97		DIFG-FS	Off - On		—	Fail-safe OC use or not	--		Off													Off				
98		LSSV	Off - On		—	LS monitoring	Off															Off				
99		SVCNT	ALM&BLK - ALM		—	Supervisor control	ALM&BLK															ALM&BLK				
100		CTSV	Off - ALM&BLK - ALM		—	CT supervision control	Off															Off				
101		IDSV	Off - ALM&BLK - ALM		—	Id monitoring control	Off															Off				
102		CTFEN	Off - On - OPT-On		—	CTF detect.function use or not	--		Off													Off				
103		CTFCNT	NA - BLK		—	Control by CTF detectinon	--		NA													NA				
104		AOLED	Off - On		-	LED lighting control at alarm output	On															On				
105		DIFI1	0.50 - 10.00	0.10 - 2.00	A	Minimum operating current	5.00 / 1.00															5.00 / 1.00				
106		DIFI2	3.0 - 120.0	0.6 - 24.0	A	DF2 restraint current setting	15.0 / 3.0															15.0 / 3.0				
107		DIFGI	0.25 - 5.00	0.05 - 1.00	A	Minimum operating current	--		2.50 / 0.50													2.50 / 0.50				
108		DIFIC	0.00 - 5.00	0.00 - 1.00	A	Charging current compensation	--		0.00 / 0.00													0.00 / 0.00				
109		Vn	100 - 120		V	Rated line voltage	--		110													110				
110		TDIFG	0.00 - 10.00		s	DIFG delay trip timer	--		0.50													0.50				
111		DIFSV	0.25 - 10.00	0.05 - 2.00	A	Minimum operating current of DIFSV	0.50 / 0.10															0.50 / 0.10				
112		TIDSV	0 - 60		s	Id err detected timer	10															10				
113	CBF	OCBF	0.5 - 10.0	0.1 - 2.0	A	Minimum operating current	--		4.0 /0.8													4.0 /0.8				
114		TBF1	50 - 500 (1ms step)		ms	CBF timer for re-trip	--		150													150				
115		TBF2	50 - 500 (1ms step)		ms	CBF timer for related trip	--		200													200				
116	OC	OC	0.5 - 100.0	0.1 - 20.0	A	OC element	10.0 / 2.0															10.0 / 2.0				
117		TOC	0.00 - 10.00		s		3.00															3.00				
118		OC1	0.5 - 100.0	0.1 - 20.0	A	OC element for DIF fail-safe	1.0 / 0.2															1.0 / 0.2				
119		OCD	0.40	0.08	A	OCD element for DIF fail-safe	0.04 / 0.08															0.04 / 0.08				
120	OCI	OCI	0.5 -25.0	0.10 - 5.00	A	IDMT OC element	10.0 / 2.0															10.0 / 2.0				
121		TOCI	0.05 - 1.00		—	ditto	0.50															0.50				
122		TOCIR	0.0 - 10.0		s	OC definite time reset delay	0.0															0.0				
123	EF	EF	0.5 - 5.0	0.10 - 1.00	A	Earth fault OC element	5.0 / 1.0															5.0 / 1.0				
124		TEF	0.00 - 10.00		s		3.00															3.00				
125		EFD	0.20	0.04	A	Earth fault OCD element	0.20 / 0.04															0.20 / 0.04				

Relay and Protection Scheme Setting Sheet

№	Name		Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)						User Setting
							NO-ARC,NO-FD	1CB-ARC,NO-FD	2CB-ARC,NO-FD	1CB-ARC,FD	2CB-ARC,FD	1CB-ARC,NO-FD	
							2TERM / 3TERM	2TERM / 3TERM	2TERM / 3TERM	2TERM / 3TERM	2TERM / 3TERM	2TERM / 3TERM	
			5A rating	1A rating			101, 102 / 111, 112	201 / 202 / 211 / 212	301 / 302 / 312	401 / 411	501 / 503 / 511 / 513	204 / 206 / 214 / 216	
126	EFI	EFI	0.5 - 5.0	0.10 - 1.00	A	IDMT earth fault OC element	5.0 / 1.0					5.0 / 1.0	
127		TEFI	0.05 - 1.00		—	ditto	0.50					0.50	
128		TEFIR	0.0 - 10.0		s	EF definite time reset delay	0.0					0.0	
129	Thermal	THM	2.0 - 10.0	0.40 - 2.00	A	Thermal overload setting	5.0 / 1.00			–		5.0 / 1.00	
130		THMIP	0.0 - 5.0	0.00 - 1.00	A	Prior load setting	0.0 / 0.00			–		0.0 / 0.00	
131		TTHM	0.5 - 300.0		min	Thermal Time Constant	10.0			–		10.0	
132		THMA	50 - 99		%	Thermal alarm setting	80			–		80	
133	OCCHK		0.5 - 5.0	0.10 - 1.00	A	Minimum current for θ calc.	0.5 / 0.10					0.5 / 0.10	
134	HYSθ		1 - 5		deg	Hysteresis of phase difference	1					1	
135	CFID		0.25 - 5.00	0.05 - 1.00	A	Id revel of CTF scheme	–	0.50 / 0.10				0.50 / 0.10	
136	CFUV		20 - 60		V	UV revel of CTF scheme	–	20				20	
137	CFDV		1 - 10		%	UVD revel of CTF scheme	–	7				7	
138	CFOVG		0.1 - 10.0		V	Zero pahse overvoltage of CTF scheme	–	1.0				1.0	
139	Autoreclose mode		(Off) - Disable - SPAR - TPAR - SPAR&TPAR - MPAR2 - MPAR3 - EXT1P - EXT3P - EXTMP		—	Autoreclosing mode	–	SPAR&TPAR				SPAR&TPAR	
140	ARC-CB		ONE - O1 - 02 - L1 - L2		—	ARC mode for 1.5CB system	–	–	L1	–	L1	–	
141	ARC-EXT		Off - On		—	ARC initiated by ext. trip	–	Off				Off	
142	ARCDIFG		Off - On		—	ARC by DIFG trip	–	Off				Off	
143	ARC-BU		Off - On		—	ARC by back-up trip	–	Off				Off	
144	VCHK	1CB	Off - LB - DB - SY		—	TPAR condition	–	LB	– (SYN)	LB	–	LB	
		2CB	Off - LB1 - LB2 - DB - SY				–	–	LB1	–	LB1	–	
145	ARC-SM		Off - S2 - S3 - S4		—	Multi. shot ARC mode	–	Off				Off	
146	ARC-CCB		Off - TPAR - MPAR		—	Center CB ARC mode at multi-phase ARC mode selected	–	–	MPAR	–	MPAR	–	
147	ARC-SUC		Off - On		—	ARC success reset	–	Off				Off	
148	MA-NOLK		FT - T - S+T		—	Multi ARC NO-LINK condition	–	FT				FT	
149	VTPHSEL		A - B - C		—	VT phase selection	–	A				A	
150	VT-RATE		PH/G - PH/PH		—	VT rating	–	PH/G				PH/G	
151	3PH-VT		Bus - Line		—	3ph. VT location	–	Line				Line	
152	UARCSW		P1 - P2 - P3		—	User ARC switch	–	NA				NA	
153	TEVLV		0.01 - 10.00		s	Dead timer reset timing	–	0.30				0.30	
154	TRDY1		5 - 300		s	Reclaim timer	–	60				60	
155	TSPR1		0.01 - 10.00		s	SPAR dead line timer	–	0.80				0.80	
156	TTPR1		0.01 - 100.00		s	TPAR dead line timer	–	0.60				0.60	
157	TMPR1		0.01 - 10.00		s	MPAR dead time timer	–	0.80				0.80	
158	TRR		0.01 - 100.00		s	ARC reset timer	–	2.00				2.00	
159	TW1		0.1 - 10.0		s	ARC reset timer	–	0.2				0.2	
160	TRDY2		5 - 300		s	Reclaim timer	–	–	60	–	60	–	
161	TSPR2		0.01 - 10.00		s	SPAR dead line timer	–	–	0.80	–	0.80	–	
162	TTPR2		0.1 - 10.0		s	ARC timing for follower CB	–	–	0.1	–	0.1	–	
163	TMPR2		0.01 - 10.00		s	MPAR dead time timer	–	–	0.80	–	0.80	–	
164	TW2		0.1 - 10.0		s	ARC reset timer	–	–	0.2	–	0.2	–	
165	TS2		5.0 - 300.0		s	Multi. shot dead timer	–	20.0				20.0	
166	TS2R		5.0 - 300.0		s	Multi. shot reset timer	–	30.0				30.0	
167	TS3		5.0 - 300.0		s	Multi. shot dead timer	–	20.0				20.0	
168	TS3R		5.0 - 300.0		s	Multi. shot reset timer	–	30.0				30.0	
169	TS4		5.0 - 300.0		s	Multi. shot dead timer	–	20.0				20.0	
170	TS4R		5.0 - 300.0		s	Multi. shot reset timer	–	30.0				30.0	
171	TSUC		0.1 - 10.0		s	ARC success reset timer	–	–	3.0	–	3.0	–	
172	OVB		10 - 150		V	OV element	–	51				51	
173	UVB		10 - 150		V	UV element	–	13				13	
174	OVL1		10 - 150		V	OV element	–	51				51	
175	UVL1		10 - 150		V	UV element	–	13				13	
176	SY1UV		10 - 150		V	Synchro. check (UV)	–	83				83	
177	SY1OV		10 - 150		V	Synchro. check (OV)	–	51				51	
178	SY1θ		5 - 75		deg	Synchro. check (ph. diff.)	–	30				30	
179	TSYN1		0.01 - 10.00		s	Synchronism check timer	–	1.00				1.00	
180	TDBL1		0.01 - 1.00		s	Voltage check timer	–	0.05				0.05	
181	TLBD1		0.01 - 1.00		s	Voltage check timer	–	0.05				0.05	

Relay and Protection Scheme Setting Sheet

№	Name		Range		Units	Contents	Default Setting of Relay Series(5A rating / 1A rating)																		User Settiing
							NO-ARC,NO-FD		1CB-ARC,NO-FD				2CB-ARC,NO-FD			1CB-ARC,FD		2CB-ARC,FD				1CB-ARC,NO-FD				
							2TERM	3TERM	2TERM		3TERM		2TERM		3TERM	2TERM	3TERM	2TERM		3TERM		2TERM		3TERM		
			5A rating	1A rating			101, 102	111, 112	201	202	211	212	301	302	312	401	411	501	503	511	513	204	206	214	216	
182	OVL2		10 - 150		V	OV element	--		--				51			--		51				--				
183	UVL2		10 - 150		V	UV element	--		--				13			--		13				--				
184	SY2UV		10 - 150		V	Synchro. check (UV)	--		--				83			--		83				--				
185	SY2OV		10 - 150		V	Synchro. check (OV)	--		--				51			--		51				--				
186	SY2θ		5 - 75		deg	Synchro. check (ph. diff.)	--		--				30			--		30				--				
187	TSYN2		0.01 - 10.00		s	Synchronism check timer	--		--				1.00			--		1.00				--				
188	TDBL2		0.01 - 1.00		s	Voltage check timer	--		--				0.05			--		0.05				--				
189	TLBD2		0.01 - 1.00		s	Voltage check timer	--		--				0.05			--		0.05				--				
190	T3PLL		0.01 - 1.00		s	Three phase live line check timer	--		--				0.05			--		0.05				--				
191	BISW1		Norm - Inv		—	Binary input	Norm		Norm				Norm			Norm		Norm				Norm				
192	BISW2		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
193	BISW3		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
194	BISW4		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
195	BISW5		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
196	BISW6		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
197	BISW7		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
198	BISW8		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
199	BISW9		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
200	BISW10		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
201	BISW11		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
202	BISW12		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
203	BISW13		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				--				
204	BISW14		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				--				
205	BISW15		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				--				
206	BISW16		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
207	BISW17		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
208	BISW18		Norm - Inv		—	ditto	Norm		Norm				Norm			Norm		Norm				Norm				
209	BISW19		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
210	BISW20		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
211	BISW21		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
212	BISW22		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
213	BISW23		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
214	BISW24		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
215	BISW25		Norm - Inv		—	ditto	--		Norm				Norm			Norm		Norm				Norm				
216	BISW26		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		Norm		Norm				--	Norm	--	Norm	
217	BISW27		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		Norm		Norm				--	Norm	--	Norm	
218	BISW28		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		Norm		Norm				--	Norm	--	Norm	
219	BISW34		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		--		--				--	Norm	--	Norm	
220	BISW35		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		--		--				--	Norm	--	Norm	
221	BISW36		Norm - Inv		—	ditto	--		--	Norm	--	Norm	--	Norm		--		--				--	Norm	--	Norm	
222	LED1	Logic	OR - AND		—	Configurable LEDs	OR															OR				
223		Reset	Inst - Latch		—		Inst															Inst				
224		In #1	0 - 3071		—		0															0				
225		In #2	0 - 3071		—		0															0				
226		In #3	0 - 3071		—		0															0				
227		In #4	0 - 3071		—		0															0				
228	LED2	Logic	OR - AND		—	Configurable LEDs	OR															OR				
229		Reset	Inst - Latch		—		Inst															Inst				
230		In #1	0 - 3071		—		0															0				
231		In #2	0 - 3071		—		0															0				
232		In #3	0 - 3071		—		0															0				
233		In #4	0 - 3071		—		0															0				
234	LED3	Logic	OR - AND		—	Configurable LEDs	OR															OR				
235		Reset	Inst - Latch		—		Inst															Inst				
236		In #1	0 - 3071		—		0															0				
237		In #2	0 - 3071		—		0															0				
238		In #3	0 - 3071		—		0															0				
239		In #4	0 - 3071		—		0															0				
240	LED4	Logic	OR - AND		—	Configurable LEDs	OR															OR				
241		Reset	Inst - Latch		—		Inst															Inst				
242		In #1	0 - 3071		—		0															0				
243		In #2	0 - 3071		—		0															0				
244		In #3	0 - 3071		—		0															0				
245		In #4	0 - 3071		—		0															0				

Relay and Protection Scheme Setting Sheet

№	Name	Range 5A rating	Range 1A rating	Units	Contents	Default Setting of Relay Series(5A rating / 1A rating): NO-ARC,NO-FD 2TERM 101, 102 / 3TERM 111, 112	1CB-ARC,NO-FD 2TERM 201, 202 / 3TERM 211, 212; 2CB-ARC,NO-FD 2TERM 301, 302 / 3TERM 312; 1CB-ARC,FD 2TERM 401 / 3TERM 411; 2CB-ARC,FD 2TERM 501, 503 / 3TERM 511, 513	1CB-ARC,NO-FD 2TERM 204, 206 / 3TERM 214, 216	User Setting
246	Plant name	Specified by user		—	Plant name	Specified by user		Specified by user	
247	Description	ditto		—	Memorandum for user	Specified by user		Specified by user	
248	HDLC	1 - 32		—	Relay ID No. for RSM	1		1	
249	IEC	0 - 254		—	Station address for IEC103	2		2	
250	SYADJ	-9999 - 9999		ms	Time sync. Compensation	0		0	
251	PRTCL1	HDLC - IEC103		—	CH1 Communication protocol	HDLC		HDLC	
252	IP1-1	0 - 254		—	CH1 IP address	192		192	
253	IP1-2	0 - 254		—	CH1 IP address	168		168	
254	IP1-3	0 - 254		—	CH1 IP address	19		19	
255	IP1-4	0 - 254		—	CH1 IP address	172		172	
256	SM1-1	0 - 255		—	CH1 Subnet mask	255		255	
257	SM1-2	0 - 255		—	CH1 Subnet mask	255		255	
258	SM1-3	0 - 255		—	CH1 Subnet mask	255		255	
259	SM1-4	0 - 255		—	CH1 Subnet mask	0		0	
260	GW1-1	0 - 254		—	CH1 Gateway	192		192	
261	GW1-2	0 - 254		—	CH1 Gateway	168		168	
262	GW1-3	0 - 254		—	CH1 Gateway	19		19	
263	GW1-4	0 - 254		—	CH1 Gateway	1		1	
264	232C	9.6 - 19.2 - 38.4 - 57.6		—	RS-232C baud rate	9.6		9.6	
265	IECBR	9.6 - 19.2		—	IEC103 baud rate	19.2		19.2	
266	IECBLK	Normal - Blocked		—	Monitor direction blocked	Normal		Normal	
267	Fault locator	Off - On		—	FL function use or not	--	On	On	
268	BITRN	0 - 128		—	Number of bi-trigger (on/off) events	100		100	
269	Time	0.1 - 3.0		s	Disturbance record	1.0		1.0	
270	OCP-S	0.5 - 250.0	0.1 - 50.0	A	OC element for disturbance	10.0 / 2.0		10.0 / 2.0	
271	OCP-G	0.5 - 250.0	0.1 - 50.0	A	recorder initiation	5.0 / 1.0		5.0 / 1.0	
272	UVP-S	0 - 132		V	UV element for disturbance	--	88	88	
273	UVP-G	0 - 76		V	recorder initiation	--	51	51	
274	TRIP	Off - On		—	Disturbance trigger	On		On	
275	OCP-S	Off - On		—	ditto	On		On	
276	OCP-G	Off - On		—	ditto	On		On	
277	UVP-S	Off - On		—	ditto	--	On	On	
278	UVP-G	Off - On		—	ditto	--	On	On	
279	Display value	Primary - Secondary		—	Metering	Primary		Primary	
280	Power(P/Q)	Send - Receive		—	Metering	--	Send	Send	
281	Current	Lag - Lead		—	Metering	--	Lead	Lead	
282	Sync	Off - IRIG - RSM - IEC - GPS		—	Time	Off		Off	
283	GMT	-12 - +12		hrs	Time	0		0	

Event record

No.	Name	Range	Unit	Contents	Signal No.	Signal name	Type
1	EV1	0 - 3071	–	Event record signal	1536	CB1 A	On/Off
2	EV2	0 - 3071	–	ditto	1537	CB1 B	On/Off
3	EV3	0 - 3071	–	ditto	1538	CB1 C	On/Off
4	EV4	0 - 3071	–	ditto	1539	CB2 A	On/Off
5	EV5	0 - 3071	–	ditto	1540	CB2 B	On/Off
6	EV6	0 - 3071	–	ditto	1541	CB2 C	On/Off
7	EV7	0 - 3071	–	ditto	1542	DS	On/Off
8	EV8	0 - 3071	–	ditto	1544	Dif.block	On/Off
9	EV9	0 - 3071	–	ditto	1550	BU block	On/Off
10	EV10	0 - 3071	–	ditto	1545	Ext.close	On/Off
11	EV11	0 - 3071	–	ditto	1546	DC supply	On/Off
12	EV12	0 - 3071	–	ditto	1547	Trans.trip1	On/Off
13	EV13	0 - 3071	–	ditto	1548	Trans.trip2	On/Off
14	EV14	0 - 3071	–	ditto	1549	Ind. reset	On/Off
15	EV15	0 - 3071	–	ditto	1552	Ext.trip A	On/Off
16	EV16	0 - 3071	–	ditto	1553	Ext.trip B	On/Off
17	EV17	0 - 3071	–	ditto	1554	Ext.trip C	On/Off
18	EV18	0 - 3071	–	ditto	1571	CB1 ready	On/Off
19	EV19	0 - 3071	–	ditto	1572	CB2 ready	On/Off
20	EV20	0 - 3071	–	ditto	1573	ARC block	On/Off
21	EV21	0 - 3071	–	ditto	446	Trip	On/Off
22	EV22	0 - 3071	–	ditto	177	CB1 ARC	On/Off
23	EV23	0 - 3071	–	ditto	178	CB2 ARC	On/Off
24	EV24	0 - 3071	–	ditto	231	Relay fail	On/Off
25	EV25	0 - 3071	–	ditto	1268	V0 err	On/Off
26	EV26	0 - 3071	–	ditto	1269	V2 err	On/Off
27	EV27	0 - 3071	–	ditto	1267	I0 err	On/Off
28	EV28	0 - 3071	–	ditto	235	DS fail	On/Off
29	EV29	0 - 3071	–	ditto	214	Com1 fail	On/Off
30	EV30	0 - 3071	–	ditto	215	Sync1 fail	On/Off
31	EV31	0 - 3071	–	ditto	220	Com2 fail	On/Off
32	EV32	0 - 3071	–	ditto	221	Sync2 fail	On/Off
33	EV33	0 - 3071	–	ditto	447	Term1 rdy	On/Off
34	EV34	0 - 3071	–	ditto	448	Term2 rdy	On/Off
35	EV35	0 - 3071	–	ditto	272	GPS 1PPS err	On/Off
36	EV36	0 - 3071	–	ditto	289	Angle over	On/Off
37	EV37	0 - 3071	–	ditto	1513	RYID1 err	On/Off
38	EV38	0 - 3071	–	ditto	1514	RYID2 err	On/Off
39	EV39	0 - 3071	–	ditto	1511	Td1 over	On/Off
40	EV40	0 - 3071	–	ditto	1512	Td2 over	On/Off
41	EV41	0 - 3071	–	ditto	1503	CLK1 fail	On/Off
42	EV42	0 - 3071	–	ditto	1504	CLK2 fail	On/Off
43	EV43	0 - 3071	–	ditto	1507	TX level1 err	On/Off
44	EV44	0 - 3071	–	ditto	1508	TX level2 err	On/Off
45	EV45	0 - 3071	–	ditto	1509	RX level1 err	On/Off
46	EV46	0 - 3071	–	ditto	1510	RX level2 err	On/Off
47	EV47	0 - 3071	–	ditto	1501	Com1 fail-R	On/Off
48	EV48	0 - 3071	–	ditto	1502	Com2 fail-R	On/Off
49	EV49	0 - 3071	–	ditto	489	AS1	On/Off
50	EV50	0 - 3071	–	ditto	490	AS2	On/Off
51	EV51	0 - 3071	–	ditto	228	RDIF1	On/Off
52	EV52	0 - 3071	–	ditto	229	RDIF2	On/Off
53	EV53	0 - 3071	–	ditto	1266	CT err	On/Off
54	EV54	0 - 3071	–	ditto	1256	Id err	On/Off
55	EV55	0 - 3071	–	ditto	496	CTF	On/Off
56	EV56	0 - 3071	–	ditto	493	AF1	On/Off
57	EV57	0 - 3071	–	ditto	494	AF2	On/Off
58	EV58	0 - 3071	–	ditto	1271	I0-C err	On/Off
59	EV59	0 - 3071	–	ditto	1273	CT-C err	On/Off
60	EV60	0 - 3071	–	ditto	0		
61	EV61	0 - 3071	–	ditto	0		
62	EV62	0 - 3071	–	ditto	0		
63	EV63	0 - 3071	–	ditto	0		
64	EV64	0 - 3071	–	ditto	0		

Event record

No.	Name	Range	Unit	Contents	Signal No.	Signal name	Type
65	EV65	0 - 3071	–	ditto	0		
66	EV66	0 - 3071	–	ditto	0		
67	EV67	0 - 3071	–	ditto	0		
68	EV68	0 - 3071	–	ditto	0		
69	EV69	0 - 3071	–	ditto	0		
70	EV70	0 - 3071	–	ditto	0		
71	EV71	0 - 3071	–	ditto	0		
72	EV72	0 - 3071	–	ditto	0		
73	EV73	0 - 3071	–	ditto	0		
74	EV74	0 - 3071	–	ditto	0		
75	EV75	0 - 3071	–	ditto	0		
76	EV76	0 - 3071	–	ditto	0		
77	EV77	0 - 3071	–	ditto	0		
78	EV78	0 - 3071	–	ditto	0		
79	EV79	0 - 3071	–	ditto	0		
80	EV80	0 - 3071	–	ditto	0		
81	EV81	0 - 3071	–	ditto	0		
82	EV82	0 - 3071	–	ditto	0		
83	EV83	0 - 3071	–	ditto	0		
84	EV84	0 - 3071	–	ditto	0		
85	EV85	0 - 3071	–	ditto	0		
86	EV86	0 - 3071	–	ditto	0		
87	EV87	0 - 3071	–	ditto	0		
88	EV88	0 - 3071	–	ditto	0		
89	EV89	0 - 3071	–	ditto	0		
90	EV90	0 - 3071	–	ditto	0		
91	EV91	0 - 3071	–	ditto	0		
92	EV92	0 - 3071	–	ditto	0		
93	EV93	0 - 3071	–	ditto	0		
94	EV94	0 - 3071	–	ditto	0		
95	EV95	0 - 3071	–	ditto	0		
96	EV96	0 - 3071	–	ditto	0		
97	EV97	0 - 3071	–	ditto	0		
98	EV98	0 - 3071	–	ditto	0		
99	EV99	0 - 3071	–	ditto	0		
100	EV100	0 - 3071	–	ditto	0		
101	EV101	0 - 3071	–	ditto	2640	SET.GROUP1	On
102	EV102	0 - 3071	–	ditto	2641	SET.GROUP2	On
103	EV103	0 - 3071	–	ditto	2642	SET.GROUP3	On
104	EV104	0 - 3071	–	ditto	2643	SET.GROUP4	On
105	EV105	0 - 3071	–	ditto	2644	SET.GROUP5	On
106	EV106	0 - 3071	–	ditto	2645	SET.GROUP6	On
107	EV107	0 - 3071	–	ditto	2646	SET.GROUP7	On
108	EV108	0 - 3071	–	ditto	2647	SET.GROUP8	On
109	EV109	0 - 3071	–	ditto	1448	Sys. Set change	On
110	EV110	0 - 3071	–	ditto	1449	Rly. Set change	On
111	EV111	0 - 3071	–	ditto	1450	Grp. Set change	On
112	EV112	0 - 3071	–	ditto	950	MODE0	On
113	EV113	0 - 3071	–	ditto	951	MODE1	On
114	EV114	0 - 3071	–	ditto	952	MODE2A-GPS	On
115	EV115	0 - 3071	–	ditto	953	MODE2A-Td	On
116	EV116	0 - 3071	–	ditto	954	MODE2A-CF	On
117	EV117	0 - 3071	–	ditto	955	MODE2A-ANGLE	On
118	EV118	0 - 3071	–	ditto	957	MODE2B	On
119	EV119	0 - 3071	–	ditto	1445	PLC data CHG	On
120	EV120	0 - 3071	–	ditto	956	MODE2A-REMOTE	On
121	EV121	0 - 3071	–	ditto	1409	LED RST	On
122	EV122	0 - 3071	–	ditto	1435	F.record_CLR	On
123	EV123	0 - 3071	–	ditto	0		
124	EV124	0 - 3071	–	ditto	1436	E.record_CLR	On
125	EV125	0 - 3071	–	ditto	1437	D.record_CLR	On
126	EV126	0 - 3071	–	ditto	0		
127	EV127	0 - 3071	–	ditto	0		
128	EV128	0 - 3071	–	ditto	0		

Disturbance record

No.	Name	Range	Unit	Contents	Default						
					Signal No.	Signal name	100	200	300	400	500
1	SIG1	0 - 3071	–	disturbance record triger	99	CB1_TRIP-A	✓	✓	✓	✓	✓
2	SIG2	0 - 3071	–	ditto	100	CB1_TRIP-B	✓	✓	✓	✓	✓
3	SIG3	0 - 3071	–	ditto	101	CB1_TRIP-C	✓	✓	✓	✓	✓
4	SIG4	0 - 3071	–	ditto	102	CB2_TRIP-A	✓	–	✓	–	✓
5	SIG5	0 - 3071	–	ditto	103	CB2_TRIP-B	✓	–	✓	–	✓
6	SIG6	0 - 3071	–	ditto	104	CB2_TRIP-C	✓	–	✓	–	✓
7	SIG7	0 - 3071	–	ditto	82	DIF-A_TRIP	✓	✓	✓	✓	✓
8	SIG8	0 - 3071	–	ditto	83	DIF-B_TRIP	✓	✓	✓	✓	✓
9	SIG9	0 - 3071	–	ditto	84	DIF-C_TRIP	✓	✓	✓	✓	✓
10	SIG10	0 - 3071	–	ditto	86	DIFG_TRIP	–	✓	✓	✓	✓
11	SIG11	0 - 3071	–	ditto	87	OST_TRIP	–	✓	✓	✓	✓
12	SIG12	0 - 3071	–	ditto	92	CBF_TRIP	–	✓	✓	✓	✓
13	SIG13	0 - 3071	–	ditto	53	RELAY_BLOCK	✓	✓	✓	✓	✓
14	SIG14	0 - 3071	–	ditto	177	ARC1	–	✓	✓	✓	✓
15	SIG15	0 - 3071	–	ditto	178	ARC2	–	–	✓	–	✓
16	SIG16	0 - 3071	–	ditto	1536	CB1_CONT-A	✓	✓	✓	✓	✓
17	SIG17	0 - 3071	–	ditto	1537	CB1_CONT-B	✓	✓	✓	✓	✓
18	SIG18	0 - 3071	–	ditto	1538	CB1_CONT-C	✓	✓	✓	✓	✓
19	SIG19	0 - 3071	–	ditto	1539	CB2_CONT-A	✓	–	✓	–	✓
20	SIG20	0 - 3071	–	ditto	1540	CB2_CONT-B	✓	–	✓	–	✓
21	SIG21	0 - 3071	–	ditto	1541	CB2_CONT-C	✓	–	✓	–	✓
22	SIG22	0 - 3071	–	ditto	1542	DS_N/O_CONT	✓	✓	✓	✓	✓
23	SIG23	0 - 3071	–	ditto	1571	CB1_READY	–	✓	✓	✓	✓
24	SIG24	0 - 3071	–	ditto	1572	CB2_READY	–	–	✓	–	✓
25	SIG25	0 - 3071	–	ditto	113	OC_TRIP	✓	✓	✓	✓	✓
26	SIG26	0 - 3071	–	ditto	114	OCI_TRIP	✓	✓	✓	✓	✓
27	SIG27	0 - 3071	–	ditto	115	EF_TRIP	✓	✓	✓	✓	✓
28	SIG28	0 - 3071	–	ditto	117	EFI_TRIP	✓	✓	✓	✓	✓
29	SIG29	0 - 3071	–	ditto	0						
30	SIG30	0 - 3071	–	ditto	0						
31	SIG31	0 - 3071	–	ditto	0						
32	SIG32	0 - 3071	–	ditto	0						

PLC Default Setting: GRL100-B1-04

Output №	Output Signal	Timing Cycle 30	Timing Cycle 90	Timing Cycle User	Timing Turn	Logic expression: Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Logic expression: Model 204, 206, 214, 216	Flip Flop Norm	Flip Flop Back Up	Flip Flop Release Signal	Timer Off Delay	Timer On Delay	Timer One Shot	Timer Time Value	None
1536	CB1_CONT-A	X				[513]BI1_COMMAND									X
1537	CB1_CONT-B	X				[514]BI2_COMMAND									X
1538	CB1_CONT-C	X				[515]BI3_COMMAND									X
1539	CB2_CONT-A	X				[516]BI4_COMMAND	–								X
1540	CB2_CONT-B	X				[517]BI5_COMMAND	–								X
1541	CB2_CONT-C	X				[518]BI6_COMMAND	–								X
1542	DS_N/O_CONT	X				[519]BI7_COMMAND									X
1543	DS_N/C_CONT	X				[520]BI8_COMMAND									X
1544	CRT_BLOCK	X				[521]BI9_COMMAND									X
1545	CB_CLOSE	X				[522]BI10_COMMAND									X
1546	DC_SUPPLY	X				[523]BI11_COMMAND									X
1547	85S1	X				[1295]BI12_COM_UF									X
1548	85S2	X				[1296]BI13_COM_UF	[1287]BI4_COM_UF								X
1549	IND.RESET	X				[526]BI14_COMMAND	[517]BI5_COMMAND								X
1550	BUT_BLOCK	X				[527]BI15_COMMAND	[518]BI6_COMMAND								X
1551															
1552	EXT_TRIP-A	X				[528]BI16_COMMAND									X
1553	EXT_TRIP-B	X				[529]BI17_COMMAND									X
1554	EXT_TRIP-C	X				[530]BI18_COMMAND									X
1555															
1556	EXT_CBFIN-A	X				[528]BI16_COMMAND									X
1557	EXT_CBFIN-B	X				[529]BI17_COMMAND									X
1558	EXT_CBFIN-C	X				[530]BI18_COMMAND									X
1559															
1560															
1561															
1562															
1563															
1564															
1565															
1566															
1567															
1568	INT.LINK1-A	X				[531]BI19_COMMAND	–								X
1569	INT.LINK1-B	X				[532]BI20_COMMAND	–								X
1570	INT.LINK1-C	X				[533]BI21_COMMAND	–								X
1571	CB1_READY	X				[534]BI22_COMMAND									X
1572	CB2_READY	X				[535]BI23_COMMAND									X
1573	ARC_RESET	X				[536]BI24_COMMAND									X
1574	ARC_BLOCK	X				[87]OST_TRIP + [91]CBFDET + [98]STUB + [417]THM_TRIP + [418]TR1_TRIP + [426]TR2_TRIP									X
1575	INT.LINK2-A	X				[538]BI26_COMMAND	–								X
1576	INT.LINK2-B	X				[539]BI27_COMMAND	–								X
1577	INT.LINK2-C	X				[540]BI28_COMMAND	–								X
1578															
1579															
1580															
1581															
1582															
1583															
1584	PROT_BLOCK														
1585	DIF_BLOCK														
1586	DIFG_BLOCK														
1587	OST_BLOCK														
1588	CBF_BLOCK														
1589	OC_BLOCK														
1590	OCI_BLOCK														
1591	EF_BLOCK														
1592	EFI_BLOCK														
1593	THMA_BLOCK														
1594	THM_BLOCK														
1595	TR1_BLOCK														
1596	TR2_BLOCK														
1597	EXTTP_BLOCK														
1598	RDIF_BLOCK														
1599															
1600	ARC_OFF														
1601	ARC_SPAR														
1602	ARC_TPAR														
1603	ARC_S&T														
1604	ARC_MAPR2														
1605	ARC_MPAR3														
1606	ARC_EXT1P														
1607	ARC_EXT3P														
1608	ARC_EXTMP														
1609															
1610															

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop								
		Cycle						Flip Flop			Timer					
№	Signal	30	90	User	Turn	Model 1x 1, 1x 2, 2x 1, 2x 2, 3x 1, 3x 2, 4x 1, 5x 1, 5x 3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value		None
1611																
1612																
1613																
1614																
1615																
1616	DIF-A_FS	X				[408]DIFFS_OP										X
1617	DIF-B_FS	X				[408]DIFFS_OP										X
1618	DIF-C_FS	X				[408]DIFFS_OP										X
1619	DIFG_FS	X				[412]DIFGFS_OP										X
1620	TP-A_DELAY	X				[435]TP-A					X			60	ms	
1621	TP-B_DELAY	X				[436]TP-B					X			60	ms	
1622	TP-C_DELAY	X				[437]TP-C					X			60	ms	
1623	R.DATA_ZERO															
1624	RDIF-A_FS	X				[408]DIFFS_OP + [412]DIFGFS_OP										X
1625	RDIF-B_FS	X				[408]DIFFS_OP + [412]DIFGFS_OP										X
1626	RDIF-C_FS	X				[408]DIFFS_OP + [412]DIFGFS_OP										X
1627																
1628																
1629																
1630																
1631	INIT_MODE2B															
1632	DIFG_INST_TP															
1633	OC_INST_TP															
1634	EF_INST_TP															
1635																
1636																
1637																
1638																
1639																
1640																
1641																
1642																
1643																
1644																
1645																
1646																
1647																
1648	DIF_3PTP															
1649	RDIF_3PTP															
1650	OC_3PTP		X		2	[1]CONSTANT_1										X
1651	OCI_3PTP		X		2	[1]CONSTANT_1										X
1652																
1653																
1654																
1655																
1656																
1657																
1658																
1659																
1660	TR1_3PTP															
1661	TR2_3PTP															
1662																
1663	3P_TRIP															
1664	DIF-A-R1	X				[1088]COM1-R1										X
1665	DIF-B-R1	X				[1089]COM2-R1										X
1666	DIF-C-R1	X				[1090]COM3-R1										X
1667	DIFG-R1	X				[1106]SUB_COM3-R1										X
1668																
1669																
1670																
1671																
1672	85R1-R1	X				[1091]COM4-R1										X
1673	85R2-R1	X				[1092]COM5-R1										X
1674	ARC_BLOCK-R1	X				[1104]SUB_COM1-R1										X
1675	L.TEST-R1	X				[1105]SUB_COM2-R1										X
1676	TFC_ON-R1	X				[1107]SUB_COM4-R1										X
1677																
1678																
1679																
1680	I.LINK-A-R1	X				[1112]SUB2_COM1-R1 + [1115]SUB2_COM4-R1 + [1118]SUB2_COM7-R1 + [1121]SUB2_COM10-R1										X
1681	I.LINK-B-R1	X				[1113]SUB2_COM2-R1 + [1116]SUB2_COM5-R1 + [1119]SUB2_COM8-R1 + [1122]SUB2_COM11-R1										X
1682	I.LINK-C-R1	X				[1114]SUB2_COM3-R1 + [1117]SUB2_COM6-R1 + [1120]SUB2_COM9-R1 + [1123]SUB2_COM12-R1										X
1683																
1684	RDIF-A-R1															
1685	RDIF-B-R1															

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
1686	RDIF-C-R1														
1687	RDIF-R1														
1688	TR1-A-R1														
1689	TR1-B-R1														
1690	TR1-C-R1														
1691															
1692	TR2-A-R1														
1693	TR2-B-R1														
1694	TR2-C-R1														
1695															
1696	DIF-A-R2	X				[1128]COM1-R2									X
1697	DIF-B-R2	X				[1129]COM2-R2									X
1698	DIF-C-R2	X				[1130]COM3-R2									X
1699	DIFG-R2	X				[1146]SUB_COM3-R2									X
1700															
1701															
1702															
1703															
1704	85R1-R2	X				[1131]COM4-R2									X
1705	85R2-R2	X				[1132]COM5-R2									X
1706	ARC_BLOCK-R2	X				[1144]SUB_COM1-R2									X
1707	L.TEST-R2	X				[1145]SUB_COM2-R2									X
1708	TFC_ON-R2	X				[1147]SUB_COM4-R2									X
1709															
1710															
1711															
1712	I.LINK-A-R2	X				[1152]SUB2_COM1-R2 + [1155]SUB2_COM4-R2 + [1158]SUB2_COM7-R2 + [1161]SUB2_COM10-R2									X
1713	I.LINK-B-R2	X				[1153]SUB2_COM2-R2 + [1156]SUB2_COM5-R2 + [1159]SUB2_COM8-R2 + [1162]SUB2_COM11-R2									X
1714	I.LINK-C-R2	X				[1154]SUB2_COM3-R2 + [1157]SUB2_COM6-R2 + [1160]SUB2_COM9-R2 + [1163]SUB2_COM12-R2									X
1715															
1716	RDIF-A-R2														
1717	RDIF-B-R2														
1718	RDIF-C-R2														
1719	RDIF-R2														
1720	TR1-A-R2														
1721	TR1-B-R2														
1722	TR1-C-R2														
1723															
1724	TR2-A-R2														
1725	TR2-B-R2														
1726	TR2-C-R2														
1727															
1728															
1729															
1730															
1731															
1732															
1733															
1734															
1735															
1736	OC-A_FS		X		0	[1]CONSTANT_1									X
1737	OC-B_FS		X		0	[1]CONSTANT_1									X
1738	OC-C_FS		X		0	[1]CONSTANT_1									X
1739															
1740	OCI-A_FS		X		1	[1]CONSTANT_1									X
1741	OCI-B_FS		X		1	[1]CONSTANT_1									X
1742	OCI-C_FS		X		1	[1]CONSTANT_1									X
1743															
1744															
1745															
1746															
1747															
1748															
1749															
1750															
1751															
1752															
1753															
1754															
1755															
1756															
:															
:															
:															
1780															

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
1781															
1782															
1783															
1784															
1785															
1786															
1787															
1788															
1789															
1790															
1791															
1792	IO#1-TP-A1	X				[99]TRIP-A1									X
1793	IO#1-TP-B1	X				[100]TRIP-B1									X
1794	IO#1-TP-C1	X				[101]TRIP-C1									X
1795	IO#1-TP-A2	X				[102]TRIP-A2	--								X
1796	IO#1-TP-B2	X				[103]TRIP-B2	--								X
1797	IO#1-TP-C2	X				[104]TRIP-C2	--								X
1798															
1799															
1800															
1801															
1802															
1803															
1804															
1805															
1806															
1807															
1808															
1809															
1810															
1811															
1812															
1813															
1814															
1815															
1816															
1817															
1818															
1819															
1820															
1821															
1822															
1823															
1824	SPR.L-REQ		X		0	[1]CONSTANT_1									
1825	TPR.L-REQ		X		0	[159]SYN-OP									
1826	MPR.L-REQ		X		0	[1]CONSTANT_1									
1827	SPR.F-REQ		X		2	[1]CONSTANT_1									
1828	TPR.F-REQ		X		2	[159]SYN-OP									
1829	MPR.F-REQ		X		2	[1]CONSTANT_1									
1830	SPR.F-ST.REQ		X		1	[1]CONSTANT_1									
1831	TPR.F-ST.REQ		X		1	[477]ARC-SET + [478]CCB-SET									
1832	MPR.F-ST.REQ		X		1	[1]CONSTANT_1									
1833															
1834															
1835															
1836	R.F-ST.REQ		X		1	[0]CONSTANT_0									
1837															
1838															
1839															
1840	ARC.L_TERM		X		0	[0]CONSTANT_0									
1841	ARC.F_TERM		X		0	[0]CONSTANT_0									
1842															
1843															
1844															
1845															
1846															
1847															
1848															
1849															
1850															
1851															
:															
:															
:															
2045															

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle			Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Flip Flop			Timer				None
№	Signal	30	90	User				Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	
2046															
2047															
2048	COM1-S	X				[41]DIF-A									X
2049	COM2-S	X				[42]DIF-B									X
2050	COM3-S	X				[43]DIF-C									X
2051	COM4-S	X				[1547]85S1									X
2052	COM5-S	X				[1548]85S2									X
2053															
2054															
2055															
2056	SUB_COM1-S	X				[1573]ARC_RESET									X
2057	SUB_COM2-S	X				[434]LOCAL_TEST									X
2058	SUB_COM3-S	X				[44]DIFG									X
2059	SUB_COM4-S	X				[450]TFC_ON									X
2060	SUB_COM5-S														
2061															
2062															
2063															
2064	SUB2_COM1-S	X				[443]I.LINK-A									X
2065	SUB2_COM2-S	X				[444]I.LINK-B									X
2066	SUB2_COM3-S	X				[445]I.LINK-C									X
2067	SUB2_COM4-S	X				[443]I.LINK-A									X
2068	SUB2_COM5-S	X				[444]I.LINK-B									X
2069	SUB2_COM6-S	X				[445]I.LINK-C									X
2070	SUB2_COM7-S	X				[443]I.LINK-A									X
2071	SUB2_COM8-S	X				[444]I.LINK-B									X
2072	SUB2_COM9-S	X				[445]I.LINK-C									X
2073	SUB2_COM10-S	X				[443]I.LINK-A									X
2074	SUB2_COM11-S	X				[444]I.LINK-B									X
2075	SUB2_COM12-S	X				[445]I.LINK-C									X
2076															
2077															
2078															
2079															
2080	SUB3_COM1-S														
2081	SUB3_COM2-S														
2082	SUB3_COM3-S														
2083	SUB3_COM4-S														
2084	SUB3_COM5-S														
2085	SUB3_COM6-S														
2086	SUB3_COM7-S														
2087	SUB3_COM8-S														
2088	SUB3_COM9-S														
2089	SUB3_COM10-S														
2090	SUB3_COM11-S														
2091	SUB3_COM12-S														
2092															
2093															
2094															
2095															
2096	V.COM1-S														
2097	V.COM2-S														
2098	V.COM3-S														
2099															
2100	S.V.COM1-S														
2101	S.V.COM2-S														
2102	S.V.COM3-S														
2103	S.V.COM4-S														
2104	S.V.COM5-S														
2105	S.V.COM6-S														
2106	S.V.COM7-S														
2107	S.V.COM8-S														
2108	S.V.COM9-S														
2109	S.V.COM10-S														
2110	S.V.COM11-S														
2111	S.V.COM12-S														
2112	I.COM1-S														
2113	I.COM2-S														
2114	I.COM3-S														
2115															
2116	S.I.COM1-S														
2117	S.I.COM2-S														
2118	S.I.COM3-S														
2119	S.I.COM4-S														
2120	S.I.COM5-S														

PLC Default Setting

Output №	Output Signal	Timing Cycle 30	Timing Cycle 90	Timing Cycle User	Timing Turn	Logic expression Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Logic expression Model 204, 206, 214, 216	Delay Time / Flip Flop: Flip Flop Norm	Flip Flop Back Up	Flip Flop Release Signal	Timer Off Delay	Timer On Delay	Timer One Shot	Timer Time Value	None
2121	S.I.COM6-S														
2122	S.I.COM7-S														
2123	S.I.COM8-S														
2124	S.I.COM9-S														
2125	S.I.COM10-S														
2126	S.I.COM11-S														
2127	S.I.COM12-S														
2128															
2129															
2130															
2131															
2132															
2133															
2134															
2135															
2136															
2137															
2138															
2139															
2140															
2141															
2142															
2143															
2144															
2145															
2146															
2147															
2148															
2149															
2150															
2151															
2152															
2153															
2154															
2155															
2156															
2157															
2158															
2159															
2160															
2161															
2162															
2163															
2164															
2165															
2166															
2167															
2168															
2169															
2170															
2171															
2172															
:															
:															
:															
2601															
2602															
2603															
2604															
2605															
2606															
2607															
2608															
2609															
2610	ALARM_LED_SET	X				[237]CFSV1-R + [239]CFSV2-R									X
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	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	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	SET.GROUP5														
2645	SET.GROUP6														
2646	SET.GROUP7														
2647	SET.GROUP8														
2648															
2649															
2650															
2651															
2652															
2653															
2654															
2655															
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															
2690															
2691															
2692															
:															
:															
2815															

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
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														
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														

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
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														
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														

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
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														
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														

PLC Default Setting

Output		Timing				Logic expression		Delay Time / Flip Flop							
		Cycle						Flip Flop			Timer				
№	Signal	30	90	User	Turn	Model 1x1, 1x2, 2x1, 2x2, 3x1, 3x2, 4x1, 5x1, 5x3	Model 204, 206, 214, 216	Norm	Back Up	Release Signal	Off Delay	On Delay	One Shot	Time Value	None
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														

Appendix I

Commissioning Test Sheet (sample)

1. Relay identification
2. Preliminary check
3. Hardware check
   - 3.1 User interface check
   - 3.2 Binary input/Binary output circuit check
   - 3.3 AC input circuit check
4. Function test
   - 4.1 Phase current differential element DIF test
   - 4.2 Residual current differential element DIFG test
   - 4.3 Overcurrent elements OC, EF, OCI, EFI & THM test
   - 4.4 Out-of-step element OST test
   - 4.5 Voltage and synchronism check elements test
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) Charging current compensation test

Tap setting	Measured current

(3) Percentage restraining characteristic test

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

4.2 Residual current differential element DIFG test

(1) Minimum operating value test

Tap setting	I_1	Measured current (I_2)

(2) Percentage restraining characteristic test

Tap setting	I_1	Measured current (I_2)
	5 × Tap	
	20 × Tap	

4.3 Overcurrent and thermal overload elements test

(1) OC, OC1 element

Element	Tap setting	Measured current
OC		
OC1		

(2) EF element

Element	Tap setting	Measured current
EF		

(3) OCI element

Element	Test current	Measured operating time
OCI	2 × Is	
	20 × Is	

Is: Setting value

(4) EFI element

Element	Test current	Measured operating time
EFI	2 × I_S	
	20 × I_S	

(5) THM element

Element	Test current	Measured operating time
THM-A	1.2 × I_S	
THM-T	10 × I_S	

(6) OCD, EFD element

Element	Test current	Result
OCD	1.2 × Fixed setting	
EFD	1.2 × Setting value	

4.4 Out-of-step element test

Element	Measured angle
OST1-α	
OST1-β	
OST2-α	
OST2-β	

4.5 Voltage and synchronism check elements test

(1) Voltage check element

Element	Setting	Measured voltage	Element	Setting	Measured voltage
OVB			UVL1		
UVB			OVL2		
OVL1			UVL2		

(2) Synchronism check element

① Voltage check

Element	Setting	Measured voltage	Element	Setting	Measured voltage
SYN1(SY1UV)			SYN2(SY2UV)		
SYN1(SY1OV)			SYN2(SY2OV)		

② Phase angle check

Element	Setting	Measured angle
SYN1(SY1θ)		
SYN2(SY2θ)		

5. Protection scheme test

6. Metering and recording check

7. Conjunctive test

Item	Results
On load check Tripping circuit Reclosing circuit	

Appendix J

Return Repair Form

RETURN / REPAIR FORM

Please fill in this form and return it to Toshiba Corporation with the GRL100 to be repaired.

TOSHIBA CORPORATION FUCHU COMPLEX

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

For: Power System Protection & Control Department

Quality Assurance Group

Type:___GRL100_____ Model:__________ Sub No._________

(Example: Type:____GRL100_____ Model:____201B_____ Sub No._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 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./ 1997 15:09:58.442)

Faulty phase:

Fault Locator : km (%)

Prefault values (CT ratio: kA/: A, VT ratio: kV/: V)

V_a:	kV or V∠	°	I_a:	kA or A∠	°
V_b:	kV or V∠	°	I_b:	kA or A∠	°
V_c:	kV or V∠	°	I_c:	kA or A∠	°
V_{s1}	kV or V∠	°			
V_{s2}	kV or V∠	°			
V_1:	kV or V∠	°	I_1:	kA or A∠	°
V_2:	kV or V∠	°	I_2:	kA or A∠	°
V_0:	kV or V∠	°	I_0:	kA or A∠	°
V_{11}:	kV or V∠	°			
V_{12}:	kV or V∠	°			
I_{a1}:	kA or A∠	°	I_{a2}:	kA or A∠	°
I_{b1}:	kA or A∠	°	I_{b2}:	kA or A∠	°
I_{c1}:	kA or A∠	°	I_{c2}:	kA or A∠	°
I_{01}:	kA or A∠	°	I_{02}:	kA or A∠	°
I_{da}:	kA or A∠	°			
I_{db}:	kA or A∠	°			
I_{dc}:	kA or A∠	°			
I_{d0}:	kA or A∠	°			

Fault values

Prefault values (CT ratio: kA/: A, VT ratio: kV/: V)

V_a:	kV or V∠	°	I_a:	kA or A∠	°
V_b:	kV or V∠	°	I_b:	kA or A∠	°
V_c:	kV or V∠	°	I_c:	kA or A∠	°
V_{s1}	kV or V∠	°			
V_{s2}	kV or V∠	°			
V_1:	kV or V∠	°	I_1:	kA or A∠	°
V_2:	kV or V∠	°	I_2:	kA or A∠	°
V_0:	kV or V∠	°	I_0:	kA or A∠	°
V_{11}:	kV or V∠	°			
V_{12}:	kV or V∠	°			
I_{a1}:	kA or A∠	°	I_{a2}:	kA or A∠	°
I_{b1}:	kA or A∠	°	I_{b2}:	kA or A∠	°
I_{c1}:	kA or A∠	°	I_{c2}:	kA or A∠	°
I_{01}:	kA or A∠	°	I_{02}:	kA or A∠	°
I_{da}:	kA or A∠	°			
I_{db}:	kA or A∠	°			
I_{dc}:	kA or A∠	°			
I_{d0}:	kA or A∠	°			

THM %

Telecomm. delay time 1 μs

Telecomm. delay time 2 μs

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/ July/ 1998)

6. Please write any comments on the GRL100, including the document.

Customer

Name: ______________________________

Company Name: ______________________________

Address: ______________________________

____

____

Telephone No.: ______________________________

Facsimile No.: ______________________________

Signature: ______________________________

Appendix K

Technical Data

TECHNICAL DATA

Ratings	
AC current I_n:	1A or 5A
AC voltage	100V, 110V, 115V, 120V
Frequency:	50Hz or 60Hz
DC power supply:	110Vdc/125Vdc (Operative range: 88 - 150Vdc) 220Vdc/250Vdc (Operative range: 176 - 300Vdc) 48Vdc/54Vdc/60Vdc (Operative range: 38.4 - 72Vdc) 24Vdc/30Vdc (Operative range: 19.2 - 36Vdc)
AC ripple on DC supply IEC60255-11	maximum 12%
DC supply interruption IEC60255-11	
Permissive duration of DC supply voltage interruption to maintain normal operation:	up to 50ms at 110V
Restart time:	less than 10s
Binary input circuit DC voltage:	110/125Vdc 220/250Vdc 48/54/60Vdc 24/30Vdc
Overload Ratings	
AC current input	4 times rated continuous 100 times rated for 1s
AC voltage input	2 times rated continuous
Burden	
AC current input	0.2VA per phase (at rated 5A) 0.4 VA at zero-sequence circuit (at rated 5A) 0.1VA per phase (at rated 1A) 0.3 VA at zero-sequence circuit (at rated 1A)
AC voltage input	0.1VA (at rated voltage)
DC power supply:	less than16W (quiescent) less than 25W (operation)
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 relay) 0.50 to 10.00A in 0.01A steps (5A relay)
DIFI2 (Large current region)	0.6 to 24.0A in 0.1A steps (1A relay) 3.0 to 120.0A in 0.1A steps (5A relay)
Operating time	less than 1 cycle at 300% of DIFI1
Resetting time	less than 110ms (for tripping output) less than 40ms (for signal output)
Zero-sequence Current Differential Protection for high-resistance earth	
DIFGI	0.05 to 1.00A in 0.01A steps (1A relay) 0.25 to 5.00A in 0.01A steps (5A relay)
Timer	0.00 to 10.00s in 0.01s steps
Operating time	less than 45ms
Resetting time	less than 100ms
Charging Current Compensation	
DIFIC	0.00 to 1.00A in 0.01A steps (1A relay) 0.00 to 5.00A in 0.01A steps (5A relay)
Differential Current Supervision	
DIFSV	0.05 to 2.00A in 0.01A steps (1A relay) 0.25 to 10.00A in 0.01A steps (5A relay)
Timer	0 to 60s in 1s steps

Telecommunication Interface for current differential protection	
Bit rate	64kbs
Transmission format	IEC60870-5-1
Electrical interface (Telecomm. equipment link)	
Applicable standard	CCITT-G703-1.2.1 CCITT-G703-1.2.2 or 1.2.3 X.21
Type of code	NRZ (Non-Return to Zero)
Connector type	D-sub connector
Optical interface (2 km class)	
Type of fibre	Graded-index multi-mode 50/125μm or 62.5/125μm
Connector type	ST type
Wave length	820nm
Optical transmitter	LED, more than −19dBm or −16dBm
Optical receiver	PIN diode, less than −24dBm
Optical interface (30 km class)	
Type of fibre	Single mode 10/125μm
Connector type	Duplex LC
Wave length	1310nm
Optical transmitter	Laser, more than −13dBm
Optical receiver	PIN diode, less than −30dBm
Optical interface (80 km class)	
Type of fibre	DSF 8/125μm
Connector type	Duplex LC
Wave length	1550nm
Optical transmitter	Laser, more than −5dBm
Optical receiver	PIN diode, less than −34dBm
Inverse Time Overcurrent Protection	
OCI (for phase fault protection)	0.10 to 5.00A in 0.01A steps (1A relay) 0.5 to 25.0A in 0.1A steps (5A relay)
OCI time multiplier	0.05 to 1.00 in 0.01 steps
OCI characteristic	Standard / Very / Extremely / Long-time inverse
Reset time delay	0.0 to 10.0s in 0.1s steps
EFI (for earth fault protection)	0.10 to 1.00A in 0.01A steps (1A relay) 0.5 to 5.0A in 0.1A steps (5A relay)
EFI time multiplier	0.05 to 1.00 in 0.01 steps
EFI characteristic	Standard / Very / Extremely / Long-time inverse
Reset time delay	0.0 to 10.0s in 0.1s steps
Definite Time Overcurrent Protection	
OC (for phase fault protection)	0.1 to 20.0A in 0.1A steps (1A relay) 0.5 to 100.0A in 0.1A steps (5A relay)
OC time delay	0.00 to 10.00s in 0.01s steps
EFI (for earth fault protection)	0.10 to 1.00A in 0.01A steps (1A relay) 0.5 to 5.0A in 0.1A steps (5A relay)
EF time delay	0.00 to 10.00s in 0.01s steps
Thermal overload Protection	
Thermal setting (THM = k.I_{FLC})	OFF, 0.40 – 2.00A in 0.01A steps (1A rating) OFF, 2.0 – 10.0A in 0.1A steps (5A rating)
Time constant (τ)	0.5 – 300.0mins in 0.1min steps
Thermal alarm	OFF, 50% to 99% in 1% steps
Pre-load current setting	0.00 – 1.00A in 0.01A steps (1A rating) 0.0 – 5.0A in 0.1A steps (5A rating)
Stub Protection	
Stub	ON / OFF

Breaker Failure (BF) Protection	
Overcurrent element	0.1 to 2.0A in 0.1A steps (1A relay) 0.5 to 10.0A in 0.1A steps (5A relay)
Reset	less than 80% of operating value
BF timer for retry-trip of failed circuit breaker	50 to 500ms in 1ms steps
BF timer for adjacent circuit breaker tripping	50 to 500ms in 1ms steps
Operating time of overcurrent element	less than 20ms at 50Hz or 17ms at 60Hz
Resetting time of overcurrent element	less than 15ms at 50Hz or 13ms at 60Hz
Accuracy	
Current differential protection: pick-up	$\pm$5% ($\pm$7% at I $<$ 0.3$\times$In)
Inverse time overcurrent characteristics	$\pm$5% or 30ms(1.5 to 30 times setting)
Definite time overcurrent protection: pick-up	$\pm$5%
Overcurrent element for BF: pick-up	$\pm$5%
Autoreclose function	
Number of shots	1 to 4 shots
Timer settings	
Dead time for single-phase autoreclose	0.01 to 10.00s in 0.01s steps
Dead time for three-phase autoreclose	0.01 to 100.00s in 0.01s steps
Multi-shot dead line time	5.0 to 300.0s in 0.1s steps
Multi-shot reset time	5.0 to 300.0s in 0.1s steps
Reclaim time	5 to 300s in 1s steps
Pulse width of reclosing signal output	0.1 to 10.0s in 0.1s steps
Autoreclose reset time	0.01 to 100.00s in 0.01s steps
Reset time for developing fault	0.01 to 10.00s in 0.01s steps
One-and-a-half breaker system	
Follower breaker autoreclose delay time	0.1 to 10.0s in 0.1s steps
Voltage and synchronism check element	
Synchronism check angle	5° to 75° in 1° steps
UV element	60 to 150V in 1V steps
OV element	10 to 100V in 1V steps
Busbar or line dead check	10 to 100V in 1V steps
Busbar or line live check	10 to 100V in 1V steps
Synchronism check time	0.01 to 10.00s in 0.01s steps
Voltage check time	0.01 to 1.00s in 0.01s steps
Fault Detector	
Multi-step overcurrent element	L1: 0.10A, L2: 0.16A, L3: 0.26A, L4: 0.41A, L5: 0.66A, L6: 1.05A, L7: 1.68A (1A relay) L1: 0.50A, L2: 0.80A, L3: 1.28A, L4: 2.05A L5: 3.28A, L6: 5.24A, L7: 8.39A (5A relay)
Current change detection element	0.1 times rated current
Earth fault overcurrent element	0.1 times rated current
Undervoltage element for earth fault	46V
Undervoltage element for phase fault	80V
Undervoltage change detection element	0.07 times voltage before fault
Fault Locator	
Line resistance and reactance settings	0.0 to 999.9Ω in 0.1Ω steps (1A relay) 0.00 to 199.99Ω in 0.01Ω steps (5A relay)
Line length	0.0 to 399.9km in 0.1km steps
Accuracy	
Two terminal	$\pm$1km (up to 100km) or $\pm$1% (up to 399.9km at DIFI=0.5In setting and Id=2In
Three terminal	$\pm$2km (up to 100km) or $\pm$2% (up to 399.9km at DIFI=0.25In setting and Id=2In
Minimum measuring cycles	2 cycles

Disturbance Record Initiation	
Overcurrent element	0.1 to 50.0A in 0.1A steps (1A relay) 0.5 to 250.0A in 0.1A steps (5A relay)
Undervoltage element	0 to 132V in 1V steps (for phase fault) 0 to 76V in 1V steps (for earth fault)
Pre-fault time	0.3s (fixed)
Post-fault time	0.1 to 3.0 in 0.1s steps
Communication Port	
Front communication port (local PC)	
Connection	Point to point
Cable type	Multi-core (straight)
Cable length	15m (max.)
Connector	RS232C 9-pin D-sub miniature connector female
Rear communication port (remote PC)	
RS485 I/F:	
Transmission data rate for RSM system	64kbps
Connection	Multidrop mode (max. 32 relays)
Connector	Screw terminals
Cable and length	Twisted pair cable, max. 1200m
Isolation	2kVac for 1min.
Fibre optic I/F:	ST connector, graded-index multi-mode 50/125μm or 62.5/125μm type optical fibres
Ethernet LAN I/F:	10BASE-T, RJ-45 connector
IRIG-B Port	
Connection	BNC connector
Cable type	50 ohm coaxial cable
Binary Inputs	
Operating voltage	Typical 74Vdc(min.70Vdc) for 110V/125Vdc rating Typical 138Vdc(min.125Vdc) for 220V/250Vdc rating Typical 31Vdc(min.28Vdc) for 48V/54V/60Vdc rating Typical 15Vdc(min.14Vdc) for 24Vdc rating
Contact Ratings	
Trip contacts	
Make and carry	5A continuously, 30A, 290Vdc for 0.5s (L/R=10ms)
Break	0.15A, 290Vdc (L/R=40ms)
Auxiliary contacts	
Make and carry	4A continuously, 10A, 220Vdc for 0.5s (L/R≥5ms)
Break	0.1A, 220Vdc (L/R=40ms)
Durability	
Make and carry	10,000 operations minimum
Break	100,000 operations minimum
Mechanical design	
Weight	11kg (Type-A), 14kg (Type-B)
Case colour	Munsell No. 10YR8/0.5
Installation	Flush mounting or rack mounting

CT REQUIREMENT

Ideally it would be preferable to employ current transformers that did not saturate; this is particularly desirable if operation of the protection is to be avoided during external faults. However, there are circumstances due to accommodation requirements and occasionally on the basis of cost where this is not always possible.

The type GRL100 current differential protection will remain stable for external faults provided that the characteristics of the current transformers are such that they saturate in a similar manner. Instability can occur if current transformers' having different characteristics have been used or for 3-terminal applications or for instances where the remnance flux is not negligible.

For the GRL100 appropriate setting of the large current region can prevent instability for these more onerous conditions. This report details the CT requirements for the GRL100 current differential protection.

1. General

The setting of the large current region is defined by DIFI2. Fig.K-1.1 shows the DIFI2 characteristic. As shown in Fig.K-1.1, the operating zone increases as the value of DIFI2 increases.

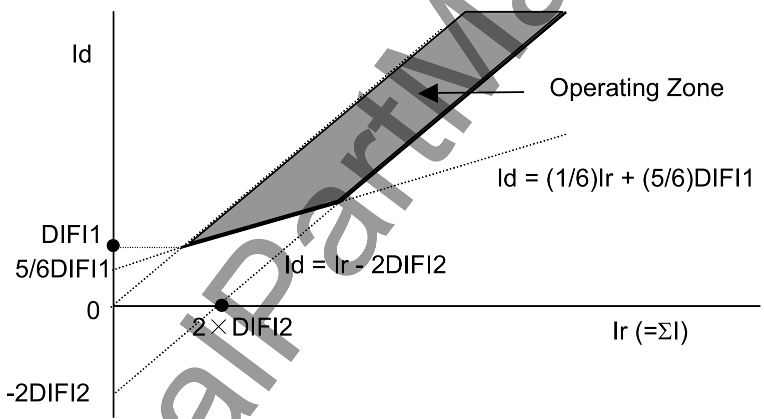


Fig.K-1.1 Definition of DIFI2

If an inferior CT is applied for differential protection, then CT saturation may be experienced during the occurrence of external faults. As a result, a differential current (Id) is produced and there is a possibility that a current differential relay may mal-operate. Therefore DIFI2 should be small to prevent mal-operation.

Conversely, DIFI2 should be larger than the anticipated load current. In addition to load current some margin is necessary to cater for the condition when CT saturation is experienced during internal faults.

Therefore the setting range of DIFI2 can be expressed as follows.

$$I_{L\max} \leq DIFI2 \leq \beta \qquad \text{(K-1.1)}$$

where,

I_{Lmax} : Maximum load current

β : Maximum value of DIFI2 to prevent mal-operation caused by CT saturation for external faults.

Whether the CT is applicable or not is determined by whether or not it is possible to achieve a setting for DIFI2. β depends on several conditions, for example, the CT specification, fault current, time constant of the primary system, etc. However, in order to confirm that a CT for a particular application is satisfactory, it is not necessary to know β and DIFI2 at this stage. Instead, the CT requirement can be obtained by following the procedure in the next section.

From the point of view of hardware limitation, secondary maximum through fault current must be smaller than full scale of measurement which is 65 times rated current.

2. CT requirement

<Step 1> Check the maximum through fault current I_{fmaxth}

$I_{fmaxth} < 65 \text{ X } I_n$

where,

I_{fmaxth} : Secondary maximum through fault current
I_n :Rated secondary current

<Step 2> Check the CT satisfies the condition given by table K-2.1 or K-2.2 depending on CT types. Each table has two requirements. Both must be satisfied.

<Knee point voltage of CTs is given>

Table K-2.1 CT Requirement defined by V_k

Td [ms]	Requirement 1	Requirement 2
35	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 3$	$V_k \geqq I_{Lmax}(R_{ct}+R_2)\times 14.4$
50	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 3$	$V_k \geqq I_{Lmax}(R_{ct}+R_2)\times 20$
75	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 4$	$V_k \geqq I_{Lmax}(R_{ct}+R_2)\times 28.8$
100	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 4$	$V_k \geqq I_{Lmax}(R_{ct}+R_2)\times 36.8$
150	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 8$	$V_k \geqq I_{Lmax}(R_{ct}+R_2)\times 50.4$

V_k : knee point voltage [V]
I_{LMAX} : Maximum secondary load current
R_{ct} : secondary CT resistance [ohms]
R_2 : Actual secondary burden [ohms]
I_{fmax} :maximum secondary fault current

<Accuracy limit factor of CTs is given>

Table K-2.2 CT Requirement defined by n'

Td [ms]	Requirement 1	Requirement 2
35	n' In ≧ 3.75 × Ifmax	n' In ≧ ILmax × 18
50	n' In ≧ 3.75 × Ifmax	n' In ≧ ILmax × 25
75	n' In ≧ 5 × Ifmax	n' In ≧ ILmax × 36
100	n' In ≧ 5 × Ifmax	n' In ≧ ILmax × 46
150	n' In ≧ 10 × Ifmax	n' In ≧ ILmax × 63

$$n' = \frac{R_{VA} / I_n^2 + R_{ct}}{R_2 + R_{ct}} \cdot n \qquad \text{(K-1.1)}$$

n' : equivalent accuracy limit factor defined by the equation above.
I_n : secondary rated current

R_{VA} : rated secondary burden [VA]
R_{ct} : secondary CT resistance [ohms]
R_2 : Actual secondary burden [ohms]
n : rated accuracy limit factor
I_{Lmax} :maximum secondary load current
I_{fmax} :maximum secondary fault current

Note : The values in the table are based on the following assumption.

- 100% DC component is superimposed.
- Only one CT is saturated.
- No remnance flux is assumed.

3. Special case

In the case of a 3 terminal-double circuit line configuration, an additional system condition must be considered. It is possible, under certain circumstances, that when an internal fault occurs, out-flowing fault current can also be experienced.

In this case, the effect of the out-flowing fault current must be considered when calculating DIFI1 and DIFI2. For example, the following application can be considered.

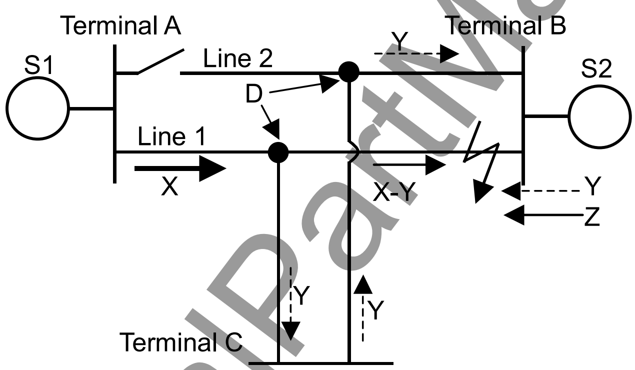


Fig K-3.1 Special case

The following conditions are assumed as shown in Fig.K-3.1.

- The three terminals, A, B and C, and the two T-connected transmission lines are assumed to be live.
- Terminal C is connected to load only.
- Line 2 CB at terminal A is open.
- An internal fault occurs on the closed line at the opposite terminal, i.e. Line 1, Terminal B.

In this case, fault current will flow as shown in Fig.K-3.1. Even though the fault is internal, the fault current Y from Line 1 at Terminal C flows out of the protected zone. Assuming the fault current from source S2 is Z, the summation of the fault current for Line1 at Terminal B is equal to Y+Z. Hence, the current at each terminal is as follows:

Terminal A : X

Terminal B : Y+Z

Terminal C : –Y

Therefore the differential and restraint currents can be calculated as follows:

differential current : X+Z

restraint current：X+2Y+Z

This point can be expressed in the Id-Ir plane as shown in Fig.K-3.2. It can be seen that the effect of the outflow current is to increase the apparent restraint quantity Ir and thereby shift the point to the right of where it would normally fall.

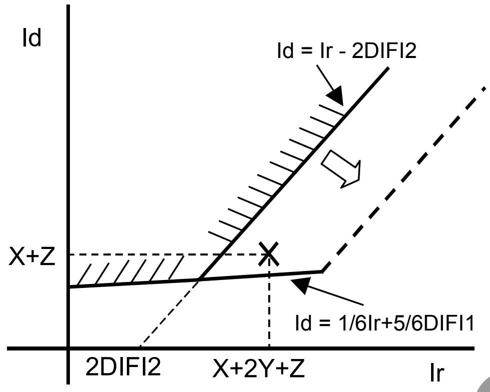


Fig.K-3.2 Internal fault in Id-Ir plane including out-flow current

In order to ensure that the GRL100 relay will operate correctly in this case, the point shown on the plot must fall within the operating zone.

According to this requirement, DIFI2 can be calculated as follows.

$X + Z > X + 2Y + Z - 2DIFI2$

$DIFI2 > Y$ (K-3.1)

This means that DIFI2 must be larger than the amount of out-flowing current.

Therefore the condition shown in Table K-2.1 and Table K-2.2 should be replaced by that in Table K-3.1 and Table K-3.2 respectively.

Table K-3.1 CT Requirement defined by V_k

Td [ms]	Requirement 1	Requirement 2
35	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 3$	$V_k > Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}\times(R_{ct}+R_2)\times 14.4$
50	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 3$	$V_k > Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}\times(R_{ct}+R_2)\times 20$
75	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 4$	$V_k > Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}\times(R_{ct}+R_2)\times 28.8$
100	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 4$	$V_k > Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}\times(R_{ct}+R_2)\times 36.8$
150	$V_k \geqq I_{fmax}(R_{ct}+R_2)\times 8$	$V_k > Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}\times(R_{ct}+R_2)\times 50.4$

$Max\{I_{LMAX}+I_{fmin}/2, I_{fmaxout}\}$: The larger of $(I_{LMAX}+I_{fmin}/2)$ and $I_{fmaxout}$.
I_{fmin}: Minimum fault current
$I_{fmaxout}$: Maximum out-flowing fault current for the special condition.

<Accuracy limit factor of CTs is given>

Table K-3.2 CT Requirement defined by n'

Td [ms]	Requirement 1	Requirement 2
35	$n' I_n \geqq 3.75 \times I_{fmax}$	$n' I_n > \mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\} \times 18$
50	$n' I_n \geqq 3.75 \times I_{fmax}$	$n' I_n > \mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\} \times 25$
75	$n' I_n \geqq 5 \times I_{fmax}$	$n' I_n > \mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\} \times 36$
100	$n' I_n \geqq 5 \times I_{fmax}$	$n' I_n > \mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\} \times 46$
150	$n' I_n \geqq 10 \times I_{fmax}$	$n' I_n > \mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\} \times 63$

$\mathrm{Max}\{I_{LMAX} + I_{fmin}/2, I_{fmaxout}\}$: The larger of $(I_{LMAX} + I_{fmin}/2)$ and $I_{fmaxout}$.
I_{fmin}: Minimum fault current
$I_{fmaxout}$: Maximum out-flowing fault current for the special condition.

Y is determined by the ratio of the impedance between node D to Terminal C and node D to Terminal B. If their impedance is assumed to be p and q respectively, Y can be obtained using the following equation.

$$Y = X \cdot \frac{q}{2p + 2q} \qquad \text{(K-3.2)}$$

For example, Y = X/4, if p=q and Y=X/2, if p=0.

ENVIRONMENTAL PERFORMANCE CLAIMS

Test	Standards	Details
Atmospheric Environment		
Temperature	I1EC60068-2-1/2	Operating range: -10°C to +55°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC60068-2-78	56 days at 40°C and 93% relative humidity.
Enclosure Protection	IEC60529	IP51 (Rear: IP20)
Mechanical Environment		
Vibration	IEC60255-21-1	Response - Class 1 Endurance - Class 1
Shock and Bump	IEC60255-21-2	Shock Response Class 1 Shock Withstand Class 1 Bump Class 1
Seismic	IEC60255-21-3	Class 1
Electrical Environment		
Dielectric Withstand	IEC60255-5	2kVrms for 1 minute between all terminals and earth. 2kVrms for 1 minute between independent circuits. 1kVrms for 1 minute across normally open contacts.
High Voltage Impulse	IEC60255-5	Three positive and three negative impulses of 5kV(peak), 1.2/50µs, 0.5J between all terminals and between all terminals and earth.
Electromagnetic Environment		
High Frequency Disturbance / Damped Oscillatory Wave	IEC60255-22-1 Class 3, IEC61000-4-12 / EN61000-4-12	1MHz 2.5kV applied to all ports in common mode. 1MHz 1.0kV applied to all ports in differential mode.
Electrostatic Discharge	IEC60255-22-2 Class 3, IEC61000-4-2 / EN61000-4-2	6kV contact discharge, 8kV air discharge.
Radiated RF Electromagnetic Disturbance	IEC60255-22-3 Class 3, IEC61000-4-3 / EN61000-4-3	Field strength 10V/m for frequency sweeps of 80MHz to 1GHz and 1.7GHz to 2.2GHz. Additional spot tests at 80, 160, 450, 900 and 1890MHz.
Fast Transient Disturbance	IEC60255-22-4, IEC61000-4-4 / EN61000-4-4	4kV, 2.5kHz, 5/50ns applied to all inputs.
Surge Immunity	IEC60255-22-5, IEC61000-4-5 / EN61000-4-5	1.2/50µs surge in common/differential modes: HV ports: 2kV/1kV (peak) PSU and I/O ports: 2kV/1kV (peak) RS485 port: 1kV (peak)
Conducted RF Electromagnetic Disturbance	IEC60255-22-6 Class 3, IEC61000-4-6 / EN61000-4-6	10Vrms applied over frequency range 150kHz to 100MHz. Additional spot tests at 27 and 68MHz.
Power Frequency Disturbance	IEC60255-22-7, IEC61000-4-16 / EN61000-4-16	300V 50Hz for 10s applied to ports in common mode. 150V 50Hz for 10s applied to ports in differential mode. Not applicable to AC inputs.
Conducted and Radiated Emissions	IEC60255-25, EN55022 Class A, IEC61000-6-4 / EN61000-6-4	Conducted emissions: 0.15 to 0.50MHz: <79dB (peak) or <66dB (mean) 0.50 to 30MHz: <73dB (peak) or <60dB (mean) Radiated emissions (at 30m): 30 to 230MHz: <30dB 230 to 1000MHz: <37dB
European Commission Directives		
	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 L

Symbols Used in Scheme Logic

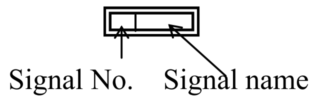
Symbols used in the scheme logic and their meanings are as follows:

Signal names

Marked with ☐ : Measuring element output signal

Marked with : Signal number

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

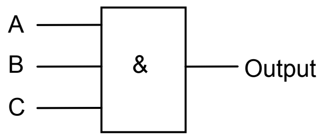


Marked with [ ] : Scheme switch

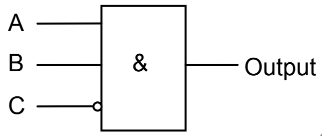
Marked with " " : Scheme switch position

Unmarked : Internal scheme logic signal

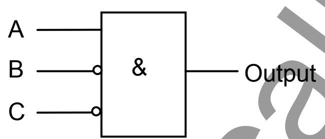
AND gates



A	B	C	Output
1	1	1	1
Other cases			0

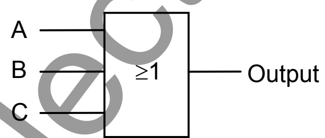


A	B	C	Output
1	1	0	1
Other cases			0

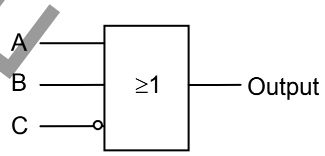


A	B	C	Output
1	0	0	1
Other cases			0

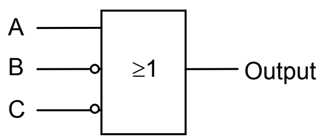
OR gates



A	B	C	Output
0	0	0	0
Other cases			1

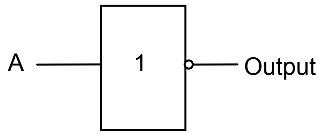


A	B	C	Output
0	0	1	0
Other cases			1



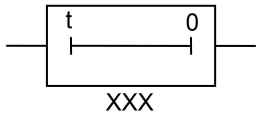
A	B	C	Output
0	1	1	0
Other cases			1

Signal inversion



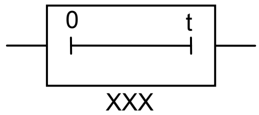
A	Output
0	1
1	0

Timer



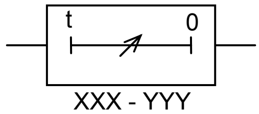
Delayed pick-up timer with fixed setting

XXX: Set time



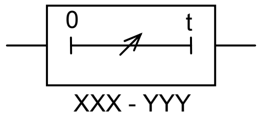
Delayed drop-off timer with fixed setting

XXX: Set time



Delayed pick-up timer with variable setting

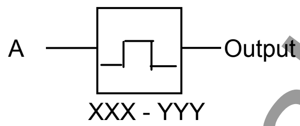
XXX - YYY: Setting range

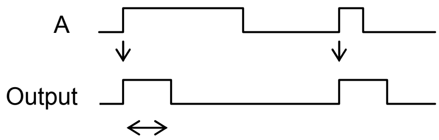


Delayed drop-off timer with variable setting

XXX - YYY: Setting range

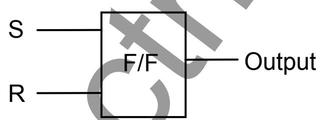
One-shot timer





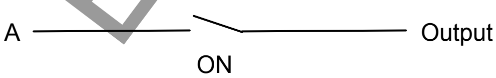
XXX - YYY: Setting range

Flip-flop

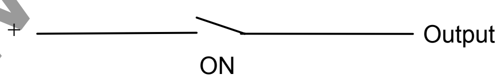


S	R	Output
0	0	No change
1	0	1
0	1	0
1	1	0

Scheme switch



A	Switch	Output
1	ON	1
Other cases		0



Switch	Output
ON	1
OFF	0

Appendix M

Multi-phase Autoreclose

Table M-1 and M-2 show operations of the multi-phase autoreclose for different faults. The operations of the autoreclose depend on the settings of [ARC-M] and [MA-NOLK].

Cases 1 to 3 show the case when one of the double circuit lines is out of service. In MPAR2 and [MA-NOLK]=FT, only case 1 results in single-phase tripping and multi-phase reclosing. Other cases result in three-phase final tripping. In MPAR2 and [MA-NOLK]=FT or S+T, case 1 results in single-phase tripping and multi-phase reclosing, and cases 2 and 3 result in three-phase tripping and three-phase reclosing. In MPAR3 and [MA-NOLK]=FT, all cases result in three-phase final tripping. In MPAR3 and [MA-NOLK]=T, all cases result in three-phase tripping and three-phase reclosing. In MPAR3 and [MA-NOLK]=S+T, case 1 results in single-phase tripping and single-phase reclosing, and cases 2 and 3 result in three-phase tripping and three-phase reclosing.

In cases 4, 6, 7, 10 and 11, three different phases remain in the power transmission state, so both MPAR2 and MPAR3 perform fault phase(s) tripping and reclosing.

In case 5, 8, 12 and 13, two different phases remain in the power transmission state, so MPAR2 performs fault phase(s) tripping and multi-phase reclosing. In MPAR3 and [MA-NOLK]=FT, all cases result in three-phase final tripping. In MPAR3 and [MA-NOLK]=T, all cases result in three-phase tripping and three-phase reclosing. In MPAR3 and [MA-NOLK]=S+T, single- or three-phase tripping and single- or three-phase reclosing is performed according to fault phase(s).

In cases 9, 14 and 15, the number of remaining different phases is less than two, so the operations of the autoreclose depends on only the [MA-NOLK] setting. In [MA-NOLK]=FT, all cases result in three-phase final tripping. In [MA-NOLK]=T or S+T, all cases result in three-phase tripping and three-phase reclosing.

Table M-1 Reclosing in MPAR2 ([ARC-M]=M2 setting)

Case	Fault phase						Tripping and Reclosing (Tripping mode → Reclosing mode)					
	#1 line			#2 line			[MA-NOLK] = FT setting		[MA-NOLK] = T setting		[MA-NOLK] = S+T setting	
No.	A	B	C	A	B	C	#1 line	#2 line	#1 line	#2 line	#1 line	#2 line
1	×			—	—	—	1φT→MPAR	—	1φT→MPAR	—	1φT→MPAR	—
2	×	×		—	—	—	3φFT	—	3φT→TPAR	—	3φT→TPAR	—
3	×	×	×	—	—	—	3φFT	—	3φT→TPAR	—	3φT→TPAR	—
4	×						1φT→MPAR		1φT→MPAR		1φT→MPAR	
5	×			×			1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR
6	×	×					2φT→MPAR		2φT→MPAR		2φT→MPAR	
7	×				×		1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR
8	×	×		×			2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR
9	×	×		×	×		3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR
10	×	×	×				3φT→MPAR		3φT→MPAR		3φT→MPAR	
11	×	×				×	2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR
12	×	×			×	×	2φT→MPAR	2φT→MPAR	2φT→MPAR	2φT→MPAR	2φT→MPAR	2φT→MPAR
13	×	×	×	×			3φT→MPAR	1φT→MPAR	3φT→MPAR	1φT→MPAR	3φT→MPAR	1φT→MPAR
14	×	×	×	×	×		3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR
15	×	×	×	×	×	×	3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR

×: Fault, —: The line is out of service
MPAR: Multi-phase reclosing TPAR: Three-phase reclosing
SPAR: Single-phase reclosing 3 φ FT: three-phase final tripping
1 φ T: single-phase tripping 2 φ T: two-phase tripping
3 φ T: three-phase tripping

Table M-2 Reclosing in MPAR3 ([ARC-M]=M3 setting)

Case	Fault phase						Tripping and Reclosing (Tripping mode → Reclosing mode)					
	#1 line			#2 line			[MA-NOLK] = FT setting		[MA-NOLK] = T setting		[MA-NOLK] = S+T setting	
No.	A	B	C	A	B	C	#1 line	#2 line	#1 line	#2 line	#1 line	#2 line
1	×			—	—	—	3φFT	—	3φT→TPAR	—	1φT→SPAR	—
2	×	×		—	—	—	3φFT	—	3φT→TPAR	—	3φT→TPAR	—
3	×	×	×	—	—	—	3φFT	—	3φT→TPAR	—	3φT→TPAR	—
4	×						1φT→MPAR		1φT→MPAR		1φT→MPAR	
5	×			×			3φFT	3φFT	3φT→TPAR	3φT→TPAR	1φT→SPAR	1φT→SPAR
6	×	×					2φT→MPAR		2φT→MPAR		2φT→MPAR	
7	×				×		1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR	1φT→MPAR
8	×	×		×			3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	1φT→SPAR
9	×	×		×	×		3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR
10	×	×	×				3φT→MPAR		3φT→MPAR		3φT→MPAR	
11	×	×				×	2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR	2φT→MPAR	1φT→MPAR
12	×	×			×	×	3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR
13	×	×	×	×			3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	1φT→SPAR
14	×	×	×	×	×		3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR
15	×	×	×	×	×	×	3φFT	3φFT	3φT→TPAR	3φT→TPAR	3φT→TPAR	3φT→TPAR

Appendix N

Data Transmission Format

Transmission Format

The data transmission format depends on the communication mode.

Figures N-1 and N-2 show the data transmission format that applies to the data transmission between terminals of the transmission lines by the relay. The individual parts of the transmission format are described below.

(1) Frame header

A signal indicating the head of a frame.

(2) Current data

12 bit data (incl. one sign bit) indicating the current value of sampling of each phase.

(3) SA flag and control data

Device data (CB, DS) and control data necessary for the protective function are transmitted by sub-commutation. Sub-commutation is used for signals that may be transmitted at low speed, and has the meaning that 1-bit information is different from frame to frame.

Frames are identified by the SA flag, which is also transmitted by sub-commutation. It detects the signal pattern of 00001 and identifies a frame number. One cycle of frame numbers covers 12 frames.

(4) SP flag and time data

The SP flag and time data for sampling time synchronization are transmitted by sub-commutation. Sub-commutation detects the signal pattern of 00001 and identifies a frame number.

The time data for sampling time synchronization has 16 bits.

(5) CRC (Cyclic Redundancy Check) data

CRC data is added to check transmitting data for transmission errors.

Data without the frame header is divided by a polynomial and the resultant remainder is transmitted as the CRC data.

On the receiving side, the CRC data is subtracted from the transmitted data, the result divided by the same polynomial, and the remainder checked for 0.

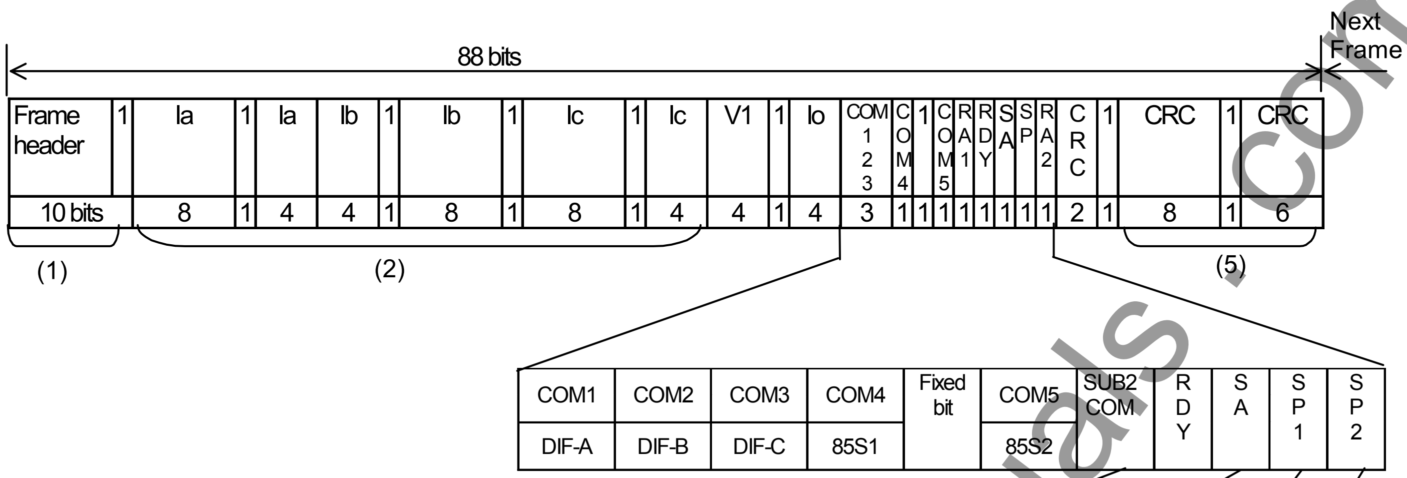
Polynomial: $X^{16} + X^{12} + X^5 + 1$

(6) User configurable data

Number of user configurable data depends on the communication mode and whether a function is used or not. The transmission data and user configurable data is shown in Table N-1 and Figures N-1 and N-2.

Table N-1 User Configurable data

Transmission data	Sending side	Receiving side	Remarks
Phase current	12 bits × (Ia, Ib, Ic)	12 bits × (Ia, Ib, Ic)	Fixed.
Positive-sequence Voltage	A-MODE: V1 fixed. 4 bits / 1 frame (sent it by 3 frame shared) B-/GPS-MODE: V1 for OST/FL. If the OST/FL are not used, the following are configurable. V.COM1-S (Signal No.: 2096) V.COM2-S (Signal No.: 2097) V.COM3-S (Signal No.: 2098) S.V.COM1-S (Signal No.: 2100) to S.V.COM12-S (Signal No.: 2111)	A-MODE: V1 fixed. 4 bits / 1 frame (sent it by 3 frame shared) B-/GPS-MODE: V1 for OST/FL. If the OST/FL are not used, the following are configurable. V.COM1-R1 (Signal No.: 960) / V.COM1-R2 (Signal No.: 976) V.COM2-R1 (Signal No.: 961) / V.COM2-R2 (Signal No.: 977) V.COM3-R2 (Signal No.: 962) / V.COM3-R2 (Signal No.: 978) S.V.COM1-R1 (Sig. No.: 964) to S.V.COM12-R1 (Sig. No.: 975) / S.V.COM1-R2 (Sig. No.: 980) to S.V.COM12-R2 (Sig. No.: 991)	
Zero-sequence current	A-MODE: I0 fixed. 4 bits / 1 frame (sent it by 3 frame shared) B-/GPS-MODE: I1 for DIFG is assigned. If the DIFG is not used, the following are configurable. I.COM1-S (Signal No.: 2112) I.COM2-S (Signal No.: 2113) I.COM3-S (Signal No.: 2114) S.I.COM1-S (Signal No.: 2116) to S.I.COM12-S (Signal No.: 2127)	A-MODE: I1 fixed. 4 bits / 1 frame (sent it by 3 frame shared) B-/GPS-MODE: I1 for DIFG. If the DIFG are not used, the following are configurable. I.COM1-R1 (Signal No.: 992) / I.COM1-R2 (Signal No.: 1008) I.COM2-R1 (Signal No.: 993) / I.COM2-R2 (Signal No.: 1009) I.COM3-R2 (Signal No.: 994) / I.COM3-R2 (Signal No.: 1010) S.I.COM1-R1 (Sig. No.: 996) to S.I.COM12-R1 (Sig. No.: 1007) / S.I.COM1-R2 (Sig. No.: 1012) to S.I.COM12-R2 (Sig. No.: 1023)	
COM1 – COM3	A-MODE: DIF-A, -B, -C for model 513 fixed. For other models, these are configurable. COM1-S (Signal No.: 2048) COM2-S (Signal No.: 2049) COM3-S (Signal No.: 2050)	COM1-R1 (Signal No.: 1088) / COM1-R2 (Signal No.: 1128) COM2-R1 (Signal No.: 1089) / COM2-R2 (Signal No.: 1129) COM3-R1 (Signal No.: 1090) / COM2-R2 (Signal No.: 1130) The following are signals without two-time verification: COM1-R1_UF (Sig. No.: 1096) / COM1-R2_UF (Sig. No.: 1136) COM2-R1_UF (Sig. No.: 1097) / COM2-R2_UF (Sig. No.: 1137) COM3-R1_UF (Sig. No.: 1098) / COM2-R2_UF (Sig. No.: 1138)	Available for only A-MODE except for model 513.
COM4, COM5 (85S1, 85S2)	Used for transfer signals. COM4-S (Signal No.: 2051) COM5-S (Signal No.: 2052)	COM4-R1 (Signal No.: 1091) / COM4-R2 (Signal No.: 1131) COM5-R1 (Signal No.: 1092) / COM5-R2 (Signal No.: 1132) The following are signals without two-time verification: COM4-R1_UF (Sig. No.: 1099) / COM4-R2_UF (Sig. No.: 1139) COM5-R1_UF (Sig. No.: 1100) / COM5-R2_UF (Sig. No.: 1140)	
SUB2-COM (CBDS/RA1) SP2/RA2	B-/GPS-MODE: RA∗ for RYIDSV is assigned. If RYIDSV is not used, the following are configurable. SUB2_COM1-S (Signal No.: 2064) to SUB2_COM12-S (Signal No.: 2075) SUB3_COM1-S (Signal No.: 2080) to SUB3_COM12-S (Signal No.: 2091)	SUB2_COM1-R1 (Sig. No.: 1112) to SUB2_COM12-R1 (Sig. No.: 1123) / SUB2_COM1-R2 (Sig. No.: 1152) to SUB2_COM12-R2 (Sig. No.: 1153) SUB3_COM1-R1 (Sig. No.: 1168) to SUB3_COM12-R1 (Sig. No.: 1179) / SUB3_COM1-R2 (Sig. No.: 1184) to SUB3_COM12-R2 (Sig. No.: 1195)	Sent by 12 SSP cycle.
SA	Configurable data. SUB_COM1-S (Signal No.: 2056) to SUB_COM5-S (Signal No.: 2060)	SUB_COM1-R1 (Sig. No.: 1104) to SUB_COM5-R1 (Sig. No.: 1108) / SUB_COM1-R2 (Sig. No.: 1144) to SUB_COM5-R2 (Sig. No.: 1148)	No. 2058, 2059 and 2060 in B-/GPS-MODE are not available.



Legend

Ia, Ib, Ic :	Phase current
V1 :	Positive-sequence voltage
Io :	Zero-sequence current
ON / OFF :	Control data
RDY :	Ready
SA :	Sampling address
SP :	Sampling synchronization
CRC :	Cyclic redundancy check
S.F.C.	Simultaneous fault control (synchronized test trigger signal)

Frame No.	SUB2_COM		SA SUB_COM		SP1	SP2
0	SUB2 COM1	CBDS-A	0		2^0	2^8
1	SUB2 COM2	-B	0		2^1	2^9
2	SUB2 COM3	-C	0		2^2	2^{10}
3	SUB2 COM4	CBDS-A	0		2^3	2^{11}
4	SUB2 COM5	-B	1		SP flag	-
5	SUB2 COM5	-C	SUB COM1	ARC BLOCK	2^4	2^{12}
6	SUB2 COM7	CBDS-A	SUB COM2	Local Test	2^5	2^{13}
7	SUB2 COM8	-B	SUB COM3	DIFG	2^6	2^{14}
8	SUB2 COM9	-C	1		2^7	2^{15}
9	SUB2 COM10	CBDS-A	SUB COM5	SPARE	-	-
10	SUB2 COM11	-B	SUB COM4	TFC	-	-
11	SUB2 COM12	-C	S.F.C.		-	-

Time data(*)

(3) (4)

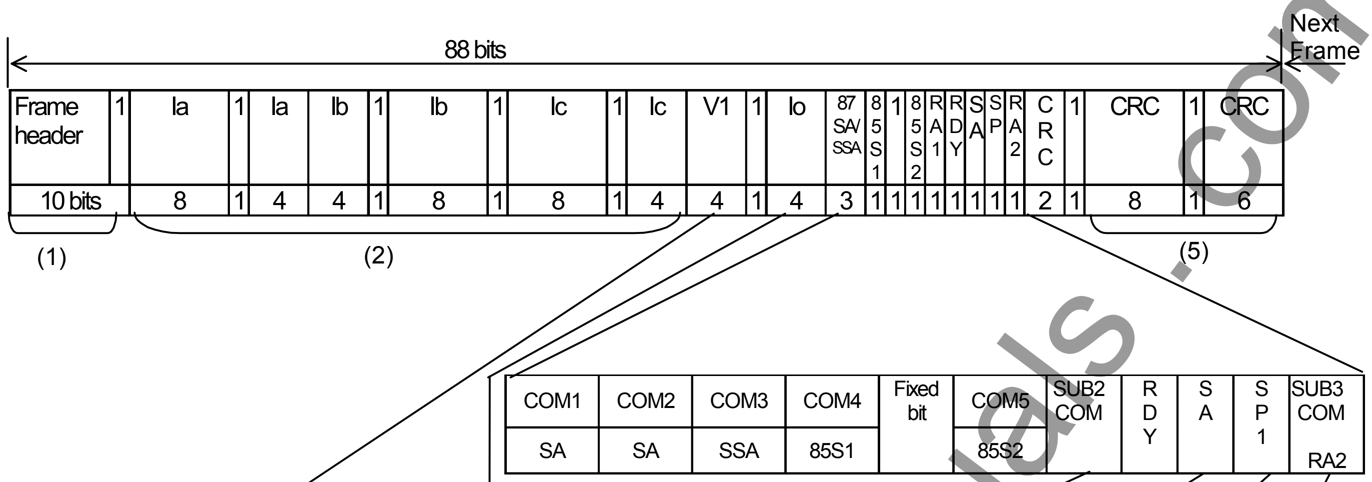
(*) Time data are transmitted once per two cycles.

Figure N-1 Data Transmission Format of A-MODE

User configurable commands are the followings:

COM1- to COM5-: These commands are sent every frame and used for high-speed signals such as a transfer trip and block signals. COM1, COM2 and COM3 are not available for Model 513 and assigned to DIF-A, DIF-B and DIF-C signals.

SUB_COM1 to SUB_COM5: These commands are sent every 12 frames. SUB_COM1, SUB_COM2, SUB_COM3 and SUB_COM4 are assigned to ARC_BLOCK, Local test, DIFG, and TFC signals as default setting. If these signals are changed, the related functions cannot be applied.



Frame No.	V1					Io					SUB2-COM* CBDS / RA		SA SUB-COM*		SP1	SUB3_COM* RA2	
	V.COM1	V.COM2	V.COM3	S.V.COM*		I.COM1	I.COM2	I.COM3	S.I.COM*		*		*			*	
0				1	V1 / SPARE				1	Io / SPARE	1	RA0 / CBDS-A		0	$2^0, 2^8$	1	RA3 / SPARE
1				2	V1 / SPARE				2	Io / SPARE	2	RA1 / CBDS-B		0	$2^1, 2^9$	2	RA4 / SPARE
2				3	V1 / SPARE				3	Io / SPARE	3	RA2 / CBDS-C		0	$2^2, 2^{10}$	3	RA5 / SPARE
3				4	V1 / SPARE				4	Io / SPARE	4	RA0 / CBDS-A		0	$2^3, 2^{11}$	4	RA3 / SPARE
4	V1 / SPARE	V1 / SPARE	V1 / SPARE	5	V1 / SPARE	Io / SPARE	Io / SPARE	Io / SPARE	5	Io / SPARE	5	RA1 / CBDS-B		1	SP flag	5	RA4 / SPARE
5				6	V1 / SPARE				6	Io / SPARE	6	RA2 / CBDS-C	1	ARC BLOCK	$2^4, 2^{12}$	6	RA5 / SPARE
6				7	V1 / SPARE				7	Io / SPARE	7	RA0 / CBDS-A	2	Local test	$2^5, 2^{13}$	7	RA3 / SPARE
7				8	V1 / SPARE				8	Io / SPARE	8	RA1 / CBDS-B	3	0	$2^6, 2^{14}$	8	RA4 / SPARE
8				9	V1 / SPARE				9	Io / SPARE	9	RA2 / CBDS-C		1	$2^7, 2^{15}$	9	RA5 / SPARE
9				10	V1 / SPARE				10	Io / SPARE	10	RA0 / CBDS-A	5		-	10	RA3 / SPARE
10				11	V1 / SPARE				11	Io / SPARE	11	RA1 / CBDS-B	4		-	11	RA1 / SPARE
11				12	V1 / SPARE				12	Io / SPARE	12	RA2 / CBDS-C		S.F.C.	-	12	RA2 / SPARE

(3)

Time data(*)

(4)

Legend

Ia, Ib, Ic : Phase current
V1 : Positive-sequence voltage
Io : Zero-sequence current
ON / OFF : Control data
RDY : Ready
SA : Sampling address for a cycle
SSA Sampling address for a second
SP : Sampling synchronization
CRC : Cyclic redundancy check
S.F.C. Simultaneous fault control (synchronized test trigger signal)

(*) Time data are transmitted once per two cycle.

Figure N-2 Data Transmission Format of B-MODE and GPS-MODE

User configurable commands are as:

COM1 to COM3: Used for sampling address.

COM4 and COM5: Used for transfer signals.

SUB_COM: These commands are sent every 12 frames. SUB_COM1 and SUB_COM2 are assigned to ARC_BLOCK and Local test signals as default setting. If these signals are changed, the related functions cannot be applied.

V.COM1 to V.COM3 and S.V.COM1 to S.V.COM12: If the OST and FL functions are not used, the user can use these commands. The V.COM1 to V.COM3 commands are sent every frame. The S.V.COM1 to S.V.COM12 are sent every 12 frames.

I.COM1 to I.COM3 and S.I.COM1 to S.I.COM12: If the DIFG function is not used, the user can use these commands. The I.COM1 to I.COM3 commands are sent every frame. The S.I.COM1 to S.I.COM12 are sent every 12 frames.

SUB2_COM1 to SUB2_COM12: These commands are assigned to bits (RA∗) for relay address monitoring RYIDSV as default setting. If the RYIDSV is not used, the user can use these commands. If multi-phase autoreclosing function is applied, for example, these commands are assigned to CBDS-A, -B and –C such as shown in Figure N-1.

SUB3_COM1 to SUB3_COM12: These commands are also assigned to bits (RA∗) for relay address monitoring RYIDSV as default setting. If the RYIDSV is not used, the user can use these commands.

Appendix O

Example of DIF and DIFG Setting

1. Segregated-phase Current Differential Element DIF

(1) Small current region DIFI1

The characteristic of the DIF for small current region is expressed by the following equation.

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

Where, DIFI1 defines the minimum operating current. Therefore, DIFI1 is determined to detect minimum fault current with margin of 1.5.

Examples: Minimum fault current = 3000A, CT ratio = 2000

DIFI1 = 3000A/1.5/2000 = 1 A

(2) Large current region DIFI2

The characteristic of the DIF for large current region is expressed by the following equation.

$I_d \geq I_r - 2 \times \mathrm{DIFI2}$

Where, DIFI2 defines the maximum out-flow current during an internal fault.

The characteristic has stronger restraint and prevents the element from operating falsely in response to the erroneous current caused by the CT saturation. The CT saturation occurs in smaller current than the current determined CT over current constant when the fault current includes transient DC. Therefore, DIFI2 is preferable as small as possible, but it must be larger than the maximum out-flowing current during an internal fault.

In case of two terminal network, the maximum out-flowing current is the maximum load current. In this case, DIFI2 is determined to the maximum load current with margin of 3 or 4.

Examples: Maximum load current = 2000A, CT ratio = 2000

DIFI2 = 2000A × 3/2000 = 3 A

2. Zero Sequence Current Differential Element DIFG

The minimum operating sensitivity of DIFGI is determined to detect high impedance earth fault. DIFGI is set to 30 to 50% of the minimum fault current DIFI1 setting.

DIFG must not operate in response to the erroneous current caused by transient errors of the CT during an external fault. Therefore, the time delay TDIFG setting is preferable larger than 0.1s.

Appendix P

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 or definite 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.

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 P-1 illustrates this theory.

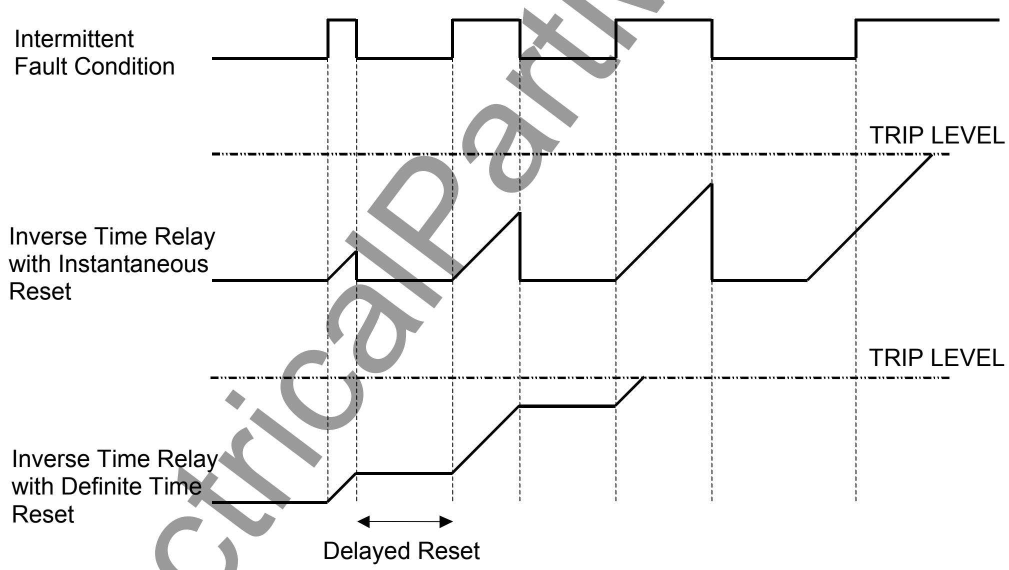


Figure P-1

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 P-2. If θ = 100%, then the allowable thermal capacity of the system has been reached.

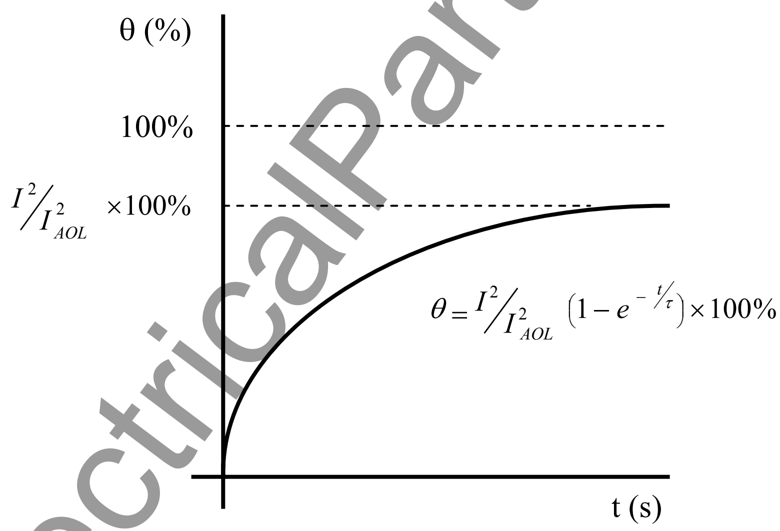


Figure P-2

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 P-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.

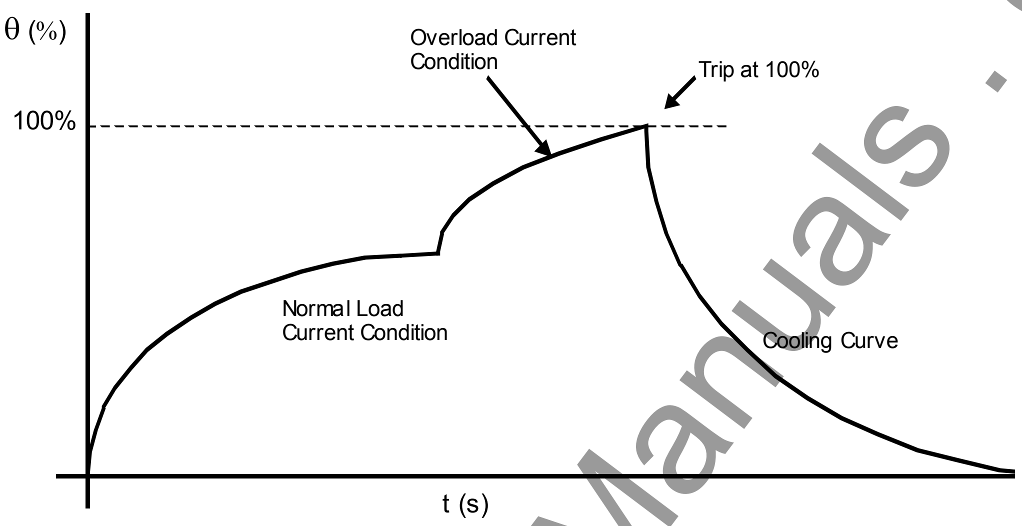


Figure P-3

Appendix Q

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.

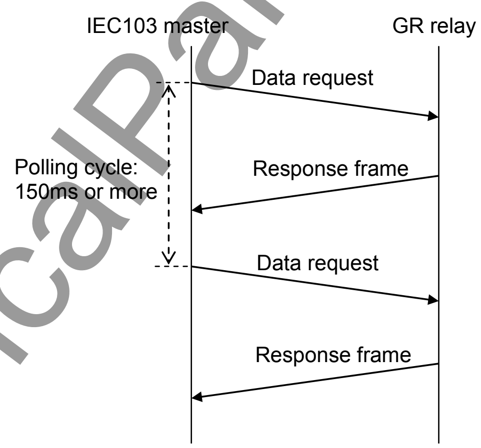
Starting IEC103 Configurator

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.

Requirements for IEC60870-5-103 master station

Polling cycle: 150ms or more
Timeout time (time till re-sending the request frame to relay): 100ms or more



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.	GI	1	1, 9, 11, 12	192	1411	1	2
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	1412	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	1413	1	2
19	LED reset	Reset of latched LEDs	--	1	1, 11, 12	192	1409	--	2
20	Monitor direction blocked	Block the 103 transmission from a relay to control system. IECBLK: "Blocked" settimg.	GI	1	9, 11	192	1241	1	2
21	Test mode	Transmission of testmode situation froma relay to control system. IECTST "ON" setting.	GI	1	9, 11	192	1242	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	1243	1	2
24	Characteristic2	Setting group 2 active	GI	1	1, 9, 11, 12	192	1244	1	2
25	Characteristic3	Setting group 3 active	GI	1	1, 9, 11, 12	192	1245	1	2
26	Characteristic4	Setting group 4 active	GI	1	1, 9, 11, 12	192	1246	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	1267	1	2
33	Measurand supervision V	Zero sequence voltage supervision	GI	1	1, 9	192	1268	1	2
35	Phase sequence supervision	Negative sequence voltage supevision	GI	1	1, 9	192	1269	1	2
36	Trip circuit supervision	Output circuit supervision	Not supported						
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	226	1	2
46	Group warning	Only alarming	GI	1	1, 9	192	1258	1	2
47	Group alarm	Trip blocking and alarming	GI	1	1, 9	192	1252	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	1280	--	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	No set						
73	Fault location X In ohms	Fault location	--	4	1	192	1048	--	--
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	92	--	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	--	2	1	192	114	--	2
91	Trip I>>	Definite time OC trip	--	2	1	192	113	--	2
92	Trip IN>	Inverse time earth fault OC trip	--	2	1	192	117	--	2
93	Trip IN>>	Definite time earth fault OC trip	--	2	1	192	115	--	2
Autoreclose indications									
128	CB 'ON' by Autoreclose	CB close command output	--	1	1	192	177	--	2
129	CB 'ON' by long-time Autoreclose		Not supported						
130	Autoreclose Blocked	Autoreclose block	GI	1	1, 9	192	121	2	1

Details of Fault location settings in IEC103 configurator

INF	Tbl	Offset	Data type	Coeff
73	5	26	short	0.1

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	1	36	short	0	4096	3.41333
	Ib	1	40	short	0	4096	3.41333
	Ic	1	44	short	0	4096	3.41333
	Va	1	0	short	0	4096	0.26877
	Vb	1	4	short	0	4096	0.26877
	Vc	1	8	short	0	4096	0.26877
	P	2	8	long	-4096	4096	0.00071661
	Q	2	12	long	-4096	4096	0.00071661
	f	2	16	short	0	4096	0.34133

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		ON/OFF	20	20	192
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
16	2684	2684	✓	0
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	GRL100 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	Configurable	
	Voltage L2-E	Vb	Configurable	
	Voltage L3-E	Vc	Configurable	
	Active power P	P	Configurable	
	Reactive power Q	Q	Configurable	
	Frequency f	f	Configurable	
	Voltage L1 - L2	Vab	Configurable	

Details of Common settings in IEC103 configurator

- Setting file's remark: GRL100_1.00
- 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: 1242
- Signal No. for Real time and Fault number: 1279

[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:

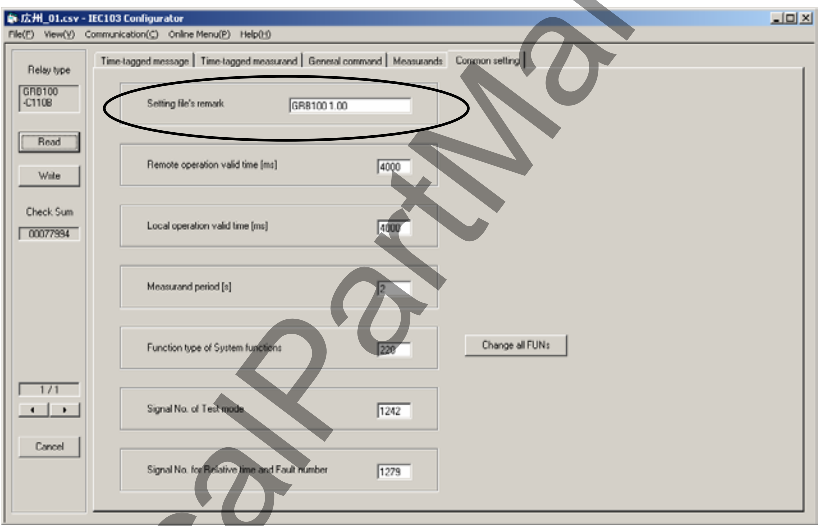
First draft: ******_01.csv

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><td>RS485 port at the back of the relay</td><td>PRTCL1 =HDLC</td><td>PRTCL1 =IEC</td></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

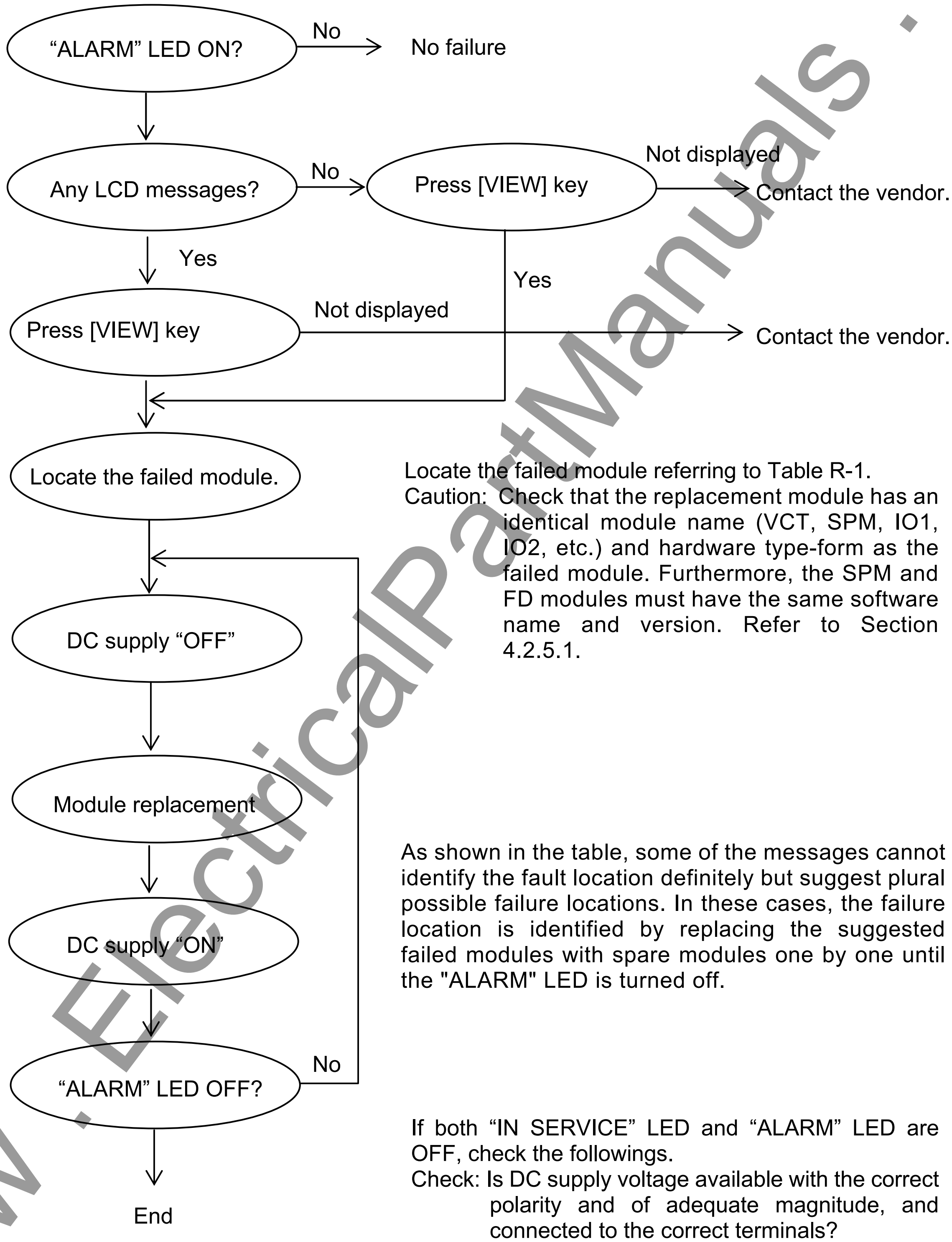
Appendix R

Failed Module Tracing and Replacement

1. Failed module tracing and its replacement

If the “ALARM” LED is ON, the following procedure is recommended. If not repaired, contact the vendor.

Procedure **Countermeasure**



Locate the failed module referring to Table R-1.
Caution: Check that the replacement module has an identical module name (VCT, SPM, IO1, IO2, etc.) and hardware type-form as the failed module. Furthermore, the SPM and FD modules must have the same software name and version. Refer to Section 4.2.5.1.

As shown in the table, some of the messages cannot identify the fault location definitely but suggest plural possible failure locations. In these cases, the failure location is identified by replacing the suggested failed modules with spare modules one by one until the "ALARM" LED is turned off.

If both “IN SERVICE” LED and “ALARM” LED are OFF, check the followings.
Check: Is DC supply voltage available with the correct polarity and of adequate magnitude, and connected to the correct terminals?

Table R-1 LCD Message and Failure Location

Message	Failure location										
	VCT	SPM (GCOM)	IO1 or IO8(*)	IO2	IO3, IO5, IO6	IO4	FD	HMI	Channel	Discon-nector	AC cable
Checksum err		×									
ROM-RAM err		×									
SRAM err		×									
BU-RAM err		×									
DPRAM err		×									
EEPROM err		×									
ROM data err		×									
A/D err		×									
V0 err	× (2)	× (1)									× (2)
V2 err	× (2)	× (1)									× (2)
I0 err	× (2)	× (1)									× (2)
Id err	× (2)	× (1)									× (2)
CT err	× (2)	× (2)									× (1)
Sampling err		×									
DIO err		× (2)	× (1)	× (1)	× (1)	× (1)					
RSM err		× (2)	× (1)								
COM_ ….err		×									
FD: … err		× (2)	× (1)				× (1)				
O/P circuit fail		× (2)	× (1)				× (1)				
DS fail		× (2)	× (2)							× (1)	
Com.1 fail, Com.2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
Sync.1 fail, Sync.2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
TX1 level err, TX2 level err		× (1)*	× (2)*	× (2)*					× (1)*		
RX1 level err, RX2 level err		× (2)*	× (2)*	× (2)*					× (1)*		
CLK 1 fail, CLK 2 fail		× (2)*	× (2)*	× (2)*					× (1)*		
Term1 rdy off, Term2 rdy off		× (2)*							× (1)*		
RYID1 err, RYID2 err		× (2)*							× (1)*		
CT fail	× (2)	× (2)									× (1)
No-working of LCD		× (2)						× (1)			

IO8 required for models 204, 206, 214 and 216.
The location marked with (1) has a higher probability than the location marked with (2).
The item of location marked with (*): also check the remote terminal relays and equipment.

2. Methods of Replacing the Modules

⚠ CAUTION When handling a module, take anti-static measures such as wearing an earthed wrist band and placing modules on an earthed conductive mat. Otherwise, many of the electronic components could suffer damage.

CAUTION After replacing the SPM and/or FD modules, check all of the settings including the data related the PLC and IEC103, etc. are restored the original settings.

The initial replacement procedure is as follows:

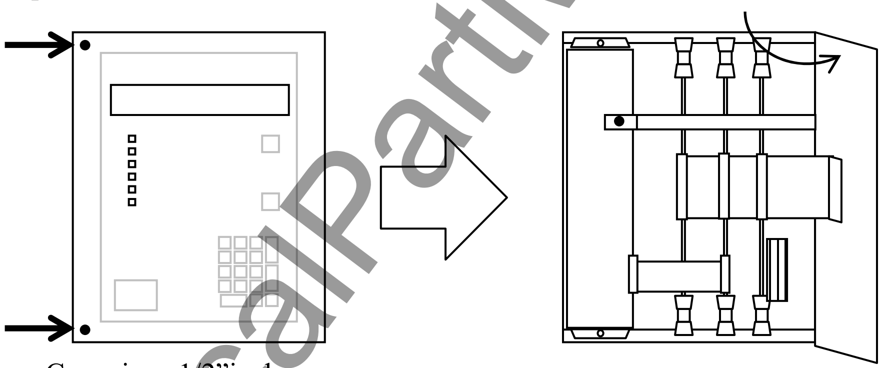
1). Switch off the DC power supply.

⚠ 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.

2). Remove the front panel cover.

3). Open the front panel.

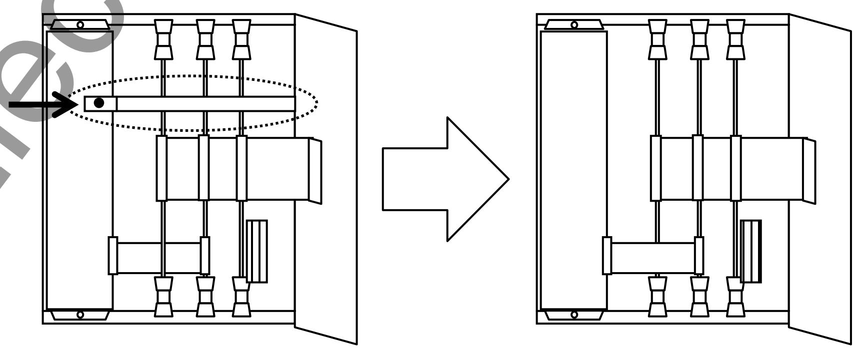
Open the front panel of the relay by unscrewing the binding screw located on the left side of the front panel.



Case size : 1/2"inchs

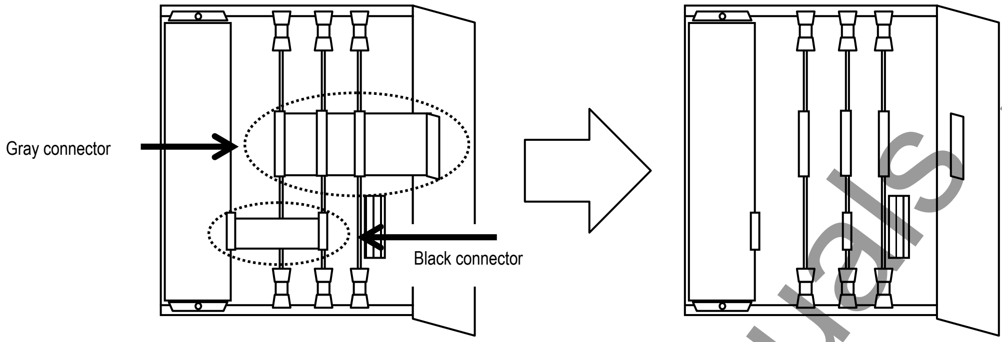
4). Detach the holding bar.

Detach the module holding bar by unscrewing the binding screw located on the left side of the bar.



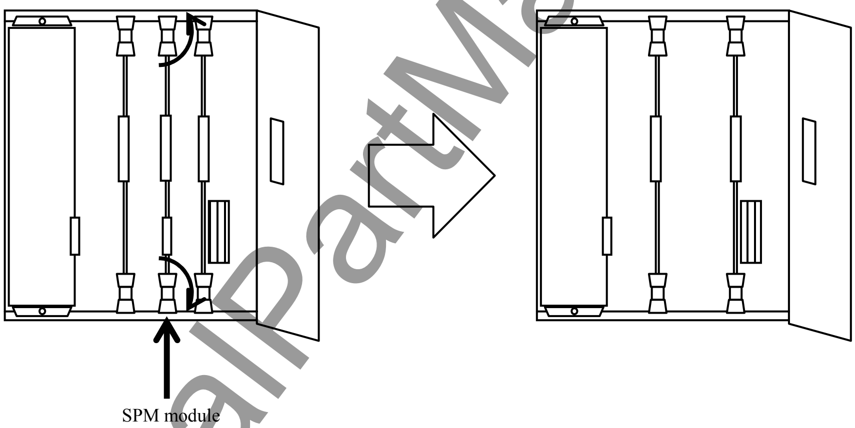
5). Unplug the cables.

Unplug the ribbon cable running among the modules by nipping the catch (in case of black connector) and by pushing the catch outside (in case of gray connector) on the connector.



6). Pull out the module.

Pull out the failure module by pulling up or down the top and bottom levers (white).



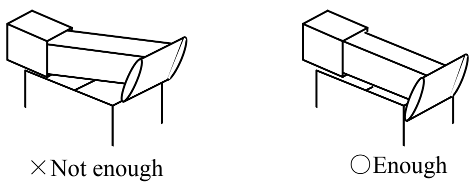
7). Insert the replacement module.

Insert the replacement module into the same slots where marked up.

8). Do the No.5 to No.1 steps in reverse order.

⚠ CAUTION Supply DC power after checking that all the modules are in their original positions and the ribbon cables are plugged in. If the ribbon cables are not plugged in enough (especially the gray connectors), the module could suffer damage.

Details of the gray connector on modules (top side)



9). Lamp Test

- RESET key is pushed 1 second or more by LCD display off.

- It checks that all LCDs and LEDs light on.

10). Check the automatic supervision functions.

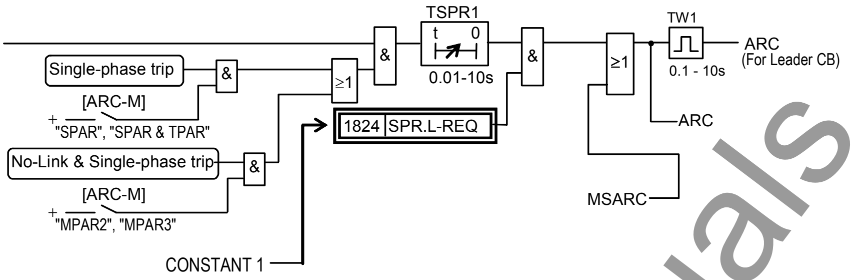
- LCD not display "Auto-supervision" screens in turn, and Event Records
- Checking the "IN SERVICE" LED light on and "ALARM LED" light off.

Appendix S

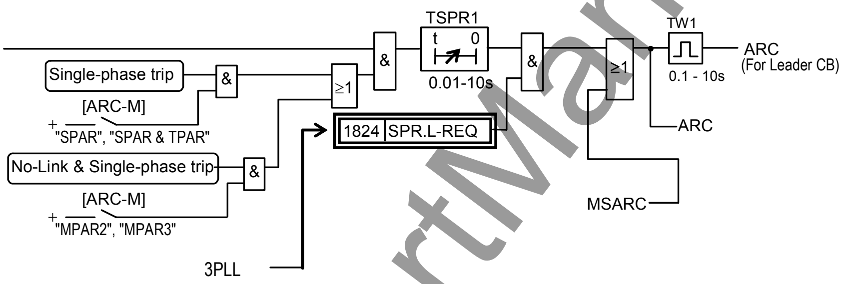
PLC Setting Sample

PLC setting sample for autoreclosing (UARCSW application)

If the follower Terminal is reclosed after checking the leader Terminal reclosed in the autoreclose mode “SPAR”, the leader Terminal is assigned to the signal number 1 with signal name “CONSTANT_1” and the follower Terminal assigned to the signal number 498 with signal name “3PLL” as shown in Figure S-1.



Leader Terminal



Follower Terminal

Figure S-1

In this case, the reclosing condition of [SPR.L-REQ] is the difference between the leader Terminal and the follower Terminal. If the same setting is required for the reclosing condition of [SPR.L-REQ], set the PLC using the [UARCSW] described in 2.10.2 as follows:

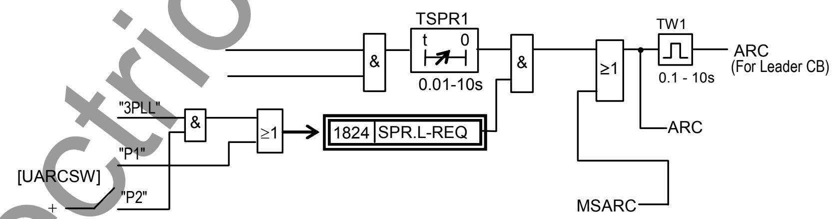


Figure S-2

The reclose condition can be changed by the position of [UARCSW].

[UARCSW] = P1: (No condition for reclosing)

[UARCSW] = P2: 3PLL (Three phase live line condition for reclosing)

The [UARCSW] is effective when the reclosing condition of PLC setting has the difference between the leader Terminal and the follower Terminal.

Appendix T

Ordering

Ordering

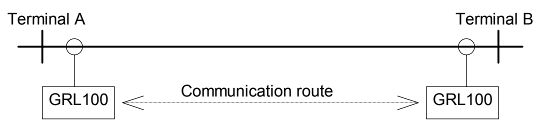
1. Line Differential Protection Relay

a. Two-terminal application

GRL100 – [ ] B– [ ] [ ] – [ ] [ ] – [ ]

Relay Type:	
Line differential protection relay	GRL100
Relay Model:	
-Model100: No autoreclose	
18 BIs, 13 BOs, 6 trip BOs	101
18 BIs, 23 BOs, 6 trip BOs	102
-Model200: With autoreclose for single breaker scheme	
25 BIs, 19 BOs, 6 trip BOs	201
28 BIs, 37 BOs, 6 trip BOs	202
22 BIs (12-independent), 19 BOs, 3 trip BOs	204
25 BIs (12-independent), 37 BOs, 3 trip BOs	206
-Model300: With autoreclose for one and a half breaker scheme	
25 BIs, 19 BOs, 6 trip BOs	301
28 BIs, 37 BOs, 6 trip BOs	302
-Model400: With autoreclose for single breaker scheme / with fault detector	
28 BIs, 31 BOs, 6 trip BOs	401
-Model500: With autoreclose for one and a half breaker scheme / with fault detector	
28 BIs, 31 BOs, 6 trip BOs	501
28 BIs, 31 BOs, 6 trip BOs	503
Ratings:	
1A, 50Hz, 110V/125Vdc	1
1A, 60Hz, 110V/125Vdc	2
5A, 50Hz, 110V/125Vdc	3
5A, 60Hz, 110V/125Vdc	4
1A, 50Hz, 220V/250Vdc	5
1A, 60Hz, 220V/250Vdc	6
5A, 50Hz, 220V/250Vdc	7
5A, 60Hz, 220V/250Vdc	8
1A, 50Hz, 48V/54V/60Vdc	A
1A, 60Hz, 48V/54V/60Vdc	B
5A, 50Hz, 48V/54V/60Vdc	C
5A, 60Hz, 48V/54V/60Vdc	D
1A, 50Hz, 24V/30Vdc	E
1A, 60Hz, 24V/30Vdc	F
5A, 50Hz, 24V/30Vdc	G
5A, 60Hz, 24V/30Vdc	H
Differential relay communication interface:	
Electrical interface (CCITT-G703-1.2.1)	1
Electrical interface (CCITT-G703-1.2.2 or 1.2.3)	2
Optical interface(Short wavelength light: GI: 2km class)	3
Optical interface(Long wavelength light: SM: 30km class)	6
Optical interface(Long wavelength light: DSF: 80km class)	7
Electrical interface (RS530, X.21)	9
Communications:	
RS485	1
Fibre optic	2
Dual RS485	3
Dual Fibre optic	4
RS485 + Fibre optic	9
(*Note) 10BASE-T is available for alternative communication port	
Miscellaneous:	
None	0
GPS opt.. input	1
LED label:	
Standard	None
Option: User configurable LED label	J

Note: Model 503 has countermeasure of CT saturation function.

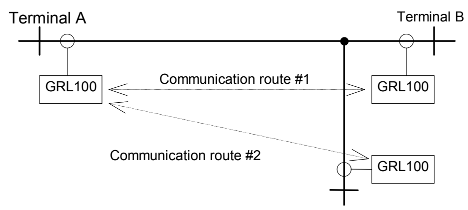


b. Three-terminal application

GRL100 – [ ] B– [ ] [ ] – [ ] [ ] – [ ]

Relay Type:	
Line differential protection relay	GRL100
Relay Model:	
-Model100: No autoreclose	
18 BIs, 13 BOs, 6 trip BOs	111
18 BIs, 23 BOs, 6 trip BOs	112
-Model200: With autoreclose for single breaker scheme	
25 BIs, 19 BOs, 6 trip BOs	211
28 BIs, 37 BOs, 6 trip BOs	212
22 BIs (12-independent), 19 BOs, 3 trip BOs	214
25 BIs (12-independent), 37 BOs, 3 trip BOs	216
-Model300: With autoreclose for one and a half breaker scheme	
25 BIs, 19 BOs, 6 trip BOs	311
28 BIs, 37 BOs, 6 trip BOs	312
-Model400: With autoreclose for single breaker scheme / with fault detector	
28 BIs, 31 BOs, 6 trip BOs	411
-Model500: With autoreclose for one and a half breaker scheme / with fault detector	
28 BIs, 31 BOs, 6 trip BOs	511
28 BIs, 31 BOs, 6 trip BOs	513
Ratings:	
1A, 50Hz, 110V/125Vdc	1
1A, 60Hz, 110V/125Vdc	2
5A, 50Hz, 110V/125Vdc	3
5A, 60Hz, 110V/125Vdc	4
1A, 50Hz, 220V/250Vdc	5
1A, 60Hz, 220V/250Vdc	6
5A, 50Hz, 220V/250Vdc	7
5A, 60Hz, 220V/250Vdc	8
1A, 50Hz, 48V/54V/60Vdc	A
1A, 60Hz, 48V/54V/60Vdc	B
5A, 50Hz, 48V/54V/60Vdc	C
5A, 60Hz, 48V/54V/60Vdc	D
1A, 50Hz, 24V/30Vdc	E
1A, 60Hz, 24V/30Vdc	F
5A, 50Hz, 24V/30Vdc	G
5A, 60Hz, 24V/30Vdc	H
Differential relay communication interface:	
Electrical interface (CCITT-G703-1.2.1)	1
Electrical interface (CCITT-G703-1.2.2 or 1.2.3)	2
Optical interface(Short wavelength light: GI: 2km class)	3
Optical interface(Long wavelength light: SM: 30km class)	6
Optical interface(Long wavelength light: DSF: 80km class)	7
Electrical interface (RS530, X.21)	9
Optical I/F (2km class) + Optical I/F (30km class)	G
Optical I/F (2km class) + Optical I/F (80km class)	H
Communications:	
RS485	1
Fibre optic	2
Dual RS485	3
Dual Fibre optic	4
RS485 + Fibre optic	9
(*Note) 10BASE-T is available for alternative communication port	
Miscellaneous:	
None	0
GPS opt.. input	1
LED label:	
Standard	None
Option: User configurable LED label	J

Note: Model 513 has countermeasure of CT saturation function.



2. Optical Interface Unit (Option)

G1IF1 – □ – □

Type:	
Communication interface box	G1IF1
Model:	
For X21 (∗)	01
For CCITT–G703–1.2.1	02
For CCITT–G703–1.2.2 or 1.2.3	03
For X21	04
DC auxiliary power supply:	
DC 48V/54V/60V	01
DC 110V/125V	02
DC 220V/250V	03

Note (∗): With Outer case. For details, see the G1IF1 instruction manual.

Version-up Records

Version No.	Date	Revised Section	Contents
0.0	May. 19, 2005		First issue.
0.1	Jul. 12, 2005	2.2.9	Added Section 2.2.9 'Blind Zone Protection'.
0.2	Jul. 25, 2005	2.6 3.3.4 3.3.10 6.7.2 Appendices	Added the description (Note). Added Section 3.3.4. Modified Table 3.3.10.1. Modified Table 6.7.2.1. Modified Appendix B, H, P and R.
0.3	Sep. 14, 2005	2.2.13 2.12.3 3.3.6 Appendices	Modified the setting range table and the Setting of TDSV, TCDT1 and TCDT2. Modified the description and Figure 2.12.3.1, and deleted Figure 2.12.3.4. Modified the description. Modified Appendix S.
0.4	Sep. 27, 2005	2. 2.13 3.2.1 Appendices	Modified the setting range table and the description, and added the 'Setting of T.SFT1, T.SFT2, B.SYN1 and B.SYN2'. Modified Tables 3.2.1.2 and 3.2.1.3. Corrected the terminal No. in Appendix G (206B).
1.4	Oct. 12, 2005	2.10.2 Appendices	Modified the description and Figures 2.10.2.1, 2.10.2.3 and 2.10.2.9, and added Figure 2.10.2.8. Modified Appendix B, H and M.
1.5	Feb. 10, 2006	2.10.2.1 2.10.2.2 2.10.2.3 3.1.5 4.2.6.7 Appendices	Modified the description and Figure 2.10.2.1. Modified the description and Figure 2.10.2.8. Modified the setting range table. Modified the description. Modified the LCD sample screen (Scheme switch). Modified the Appendix B and H, and added Appendix S. (Old Appendix S → T)
1.6	May 15, 2006	2.2.7.1 2.2.9 2.2.13 2.12.1 2.12.2 3.3.6 3.3.10.1 Appendices	Modified the description. Modified the description. Modified the description of setting range table and TDSV, TCDT1 and TCDT2 setting. Modified the description. Modified the description and Figure 2.12.2.1. Modified the description. Modified Table 3.3.10.1. Modified Appendix E, G, H, K and T.
1.7	May. 31, 2006	4.1.2 4.2.6.4 4.2.6.6 Appendices	Modified the description. Modified the description of <PRTCL1>. Modified the description. Modified Appendix G.
1.8	Jul. 19, 2006	2.2.13 Appendices	Modified the description of the 'CT Ratio matching'. Modified Appendix T.
1.9	Nov. 02, 2006	2.2.8 3.1.5 3.3.2 4.1.1 4.2.1 4.2.4.1 4.2.6.10 Appendices	Modified the description and added Figure 2.2.8.1. Modified the description of user configurable LED. Modified the description of 'DC supply monitoring'. Modified the description of LED. Modified the description of latch LED operation. Modified the description of 'Note'. Modified the description. Modified Appendix Q and R.
2.0	Apr. 03, 2007	4.2.4.6 4.4 5.5 6.7.2 Appendices	Modified the description. Modified the description. Modified the description. Modified the description and Table 6.7.2.1. Modified Appendix E, F, K, R, Q and T.

Version No.	Date	Revised Section	Contents
2.1	Sep. 27, 2007	2.10.2.2 2.12.2 4.2.3.1 4.2.7.5 6.7.3 Appendices	Modified the description and Figure 2.10.2.8. Modified the description. Added the description on the sample of fault record screen. Added the description of ‘Note’. Modified the description of ‘CAUTION’. Modified Appendix G, K, R and T.

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