TOSHIBA

Leading Innovation

GRE160

Transformer Protection

FEATURES

- Fully numerical transformer protection
- Current differential protection for two-winding transformers with inrush restraint (87T)
- High-set differential overcurrent protection
- No interposing CTs required
- CT ratio and vector group compensation
- Time-Overcurrent protection (50/51/50N/51N)
- Restricted earth fault protection (64/87G)
- Negative phase sequence overcurrent protection (46).
- Thermal overload protection (49)
- Circuit breaker fail (50BF)
- Overexcitation protection (24)
- Over/under voltage protection (59/27)
- Voltage controlled overcurrent protection (51V)
- Frequency protection (81U/O)
- Frequency rate of change (df/dt)
- Lockout relay (86/94)
- Configurable binary outputs
- Automatic self-supervision
- Trip circuit supervision scheme using two binary inputs for high integrity (74TC).
- Metering and recording functions
- Local/Remote control
- Two settings groups.
- Combined 1A / 5A current inputs
- Front mounted USB port for local PC communications.
- Rear mounted RS485 serial port and optional Ethernet port for remote communications.

APPLICATION

GRE160 is a numerical transformer protection relay, which can be applied for two-winding power transformers, auto-transformers and generator-transformer units.

GRE160 features the following protection schemes.

- The current differential protection provides fast and selective main protection. This protection requires no interposing CTs and provides stability against magnetizing inrush and overexcitation.
- The restricted earth fault protection will detect internal earth faults where the transformer star point is directly or low impedance earthed and can be applied on both the high-voltage and low-voltage sides respectively.
- The time-overcurrent protection is mainly used as backup protection and can be applied on both the high- and low-voltage sides respectively.
- The thermal overload feature provides protection for insulation against thermal stress and provides two independently set levels for alarm and tripping.
- The overexcitation protection provides alarm and tripping.
- The voltage protection includes both overvoltage and undervoltage protection. The number and types of voltage input vary depending upon the model of the relay.
- The voltage controlled/voltage restrained inverse overcurrent protection will respond to faults that may occur on the lower voltage side of the transformer when the fault current may be lower than the nominal value for certain types of fault.
- The underfrequency protection is provided for the purpose of load shedding in order to maintain frequency within the normal range. The The provision of a rate of change of frequency protection enables load shedding to be initiated quickly when the frequency change is more rapid. Overfrequency protection is also provided.

GRE160 provides the following metering and recording functions.

- Metering (current, voltage, frequency)
- Fault recording
- Event recording
- Disturbance recording

GRE160 provides the following user interfaces for relay setting or viewing of stored data.

- Relay front panel: LCD, LED display and operation keys
- Local PC
- Remote PC

The relay is equipped with communication ports providing access from either a local or remote PC.

A local PC can be connected to the relay via the USB port on the front fascia of the relay; a remote PC can be connected to the relay through the RS485 port or an optional Ethernet port (electrical or fiber) at the rear of the relay.

GRE160 has five models which differ according to the number of analogue inputs provided for backup protection functions for the 2-winding transformer protection.

Model 100	2 three-phase current inputs
Model 200	2 three-phase and 2 zero-phase current inputs for restricted earth fault protection
Model 300	2 three-phase current inputs and 1 single-phase voltage input for voltage, overexcitation, frequency, voltage controlled overcurrent protections

Model 400	2 three-phase and 2 zero-phase current inputs and 1 single-phase voltage input
Model 500	2 three-phase and 2 zero-phase current inputs and 1 set of three-phase and zero-phase voltage inputs.

For each model, there are three different types which differ depending on the number of binary inputs and outputs provided. Combined 1A/5A current inputs and wide auxiliary supply voltage ranges simplify type selection.

Type	Configuration
GRE160-*00	6 x BIs, 4 x BOs and Fail BO
GRE160-*01	12 x BIs, 10 x BOs and Fail BO
GRE160-*02	18 x BIs, 16 x BOs and Fail BO

where * represents the model number from 1 to 5

All models include the current differential protection element which has both 2nd/5th harmonic restraint features. The 2^{nd} harmonic restraint feature is provided to avoid unnecessary tripping due to inrush current during transformer energization and the 5^{th} harmonic restraint feature can be used to block the operation of the relay during transient power system disturbances. Multiple, high accuracy, overcurrent and earth fault protection elements with inverse time and definite time delay functions are provided in accordance with the IEC 60255-151 functional standard. A comprehensive range of additional protection functions are also supported, including thermal protection in accordance with functional standard IEC 60255-149 negative sequence overcurrent protection and circuit breaker failure protection.

When models equipped with the voltage input are chosen, overexcitation protection, over/under voltage protection, frequency protection and voltage controlled overcurrent protection are available. (See Table 1)

Control functions including the two-step operation of circuit breakers are also provided.

All models provide continuous monitoring of internal circuits and software. A trip circuit supervision function using two binary inputs provides high-integrity monitoring of the circuit breaker tripping circuit in both the circuit breaker open and closed conditions. Circuit breaker condition monitoring functions provide guidance in planning the optimum time for maintenance.

A user-friendly HMI is provided through a backlit LCD, programmable LEDs, keypad and menu-based operating system. PC access is also provided, either for local connection via a front-mounted USB port, or for remote connection via a rear-mounted RS485 port or an optional Ethernet port. The communication system allows the user to read and modify the relay settings, and to access data gathered by the metering and recording functions provided within the relay.

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

- Metering
- Fault recording
- Event recording
- Disturbance recording
- (available via communications ports)

Table 1 - GRE160 Features

Function	GRE160
Current Differential (87)	✓
Inrush Restraint (2f and 5f)	✓
Overexcitation (24)	(✓)
Under/overvoltage (27/59)	(✓)
NPS Overcurrent (46)	✓
Thermal Overload (49)	✓
Phase Fault O/C (50/51P)	✓
Earth Fault O/C (50/51N)	✓
Circuit Breaker Fail (50BF)	✓
Voltage Controlled/Restrained OCI (51V)	(✓)
Restricted Earth Fault (64&87G)	(✓)
Over/under Frequency (81U/O)	(✓)
Rate of Change of Frequency	(✓)
Local/Remote Control	✓
Trip Circuit Supervision (74TC)	✓
Self-supervision	✓
CB State Monitoring	✓
Trip Counter Alarm	✓
$\sum I^y$ Alarm	✓
CB Operate Time Alarm	✓
Two Settings Groups	✓
Metering	✓
Fault Records	✓
Event Records	✓
Disturbance Records	✓
Communication	✓

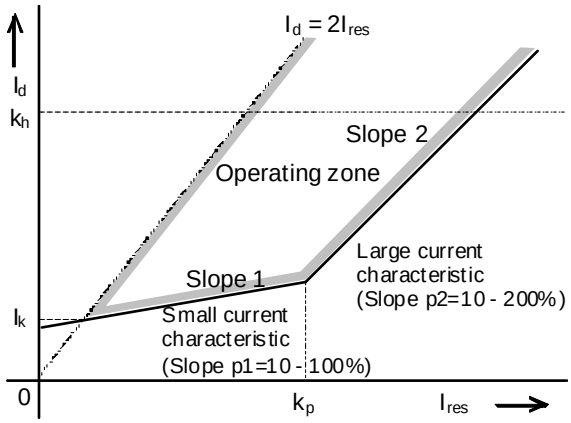
(✓) is an optional function when appropriate voltage input module type (-30*A, -40*A, -50*A) is selected.

FUNCTIONS

Current Differential Protection

GRE160 provides fast, selective protection for two-winding transformers. It has three phase- segregated differential elements, each with a dual- slope, percentage differential characteristic as shown in Figure 1.

Slope 1 provides sensitivity to low level faults. For higher level faults, slope 2 having an increased bias compensates for the effects of CT saturation. For the rapid clearance of severe internal faults, a high-set overcurrent protection element, independent of harmonic restraint is provided in this function.



I_d: Differential current ($|I_1 + I_2|$)
I_{res}: Restraining current ($(|I_1| + |I_2|)/2$)
I_k : Sensitivity setting of small current characteristic
K_p: Sensitivity setting of break point of dual characteristic
K_h: Sensitivity setting for high-set overcurrent

Figure 1. Percentage differential element

GRE160 provides internal vector group compensation and CT ratio correction, and hence there is no requirement for interposing CTs. CT polarity configuration is also provided so that the GRE160 can be matched to the primary CT arrangement.

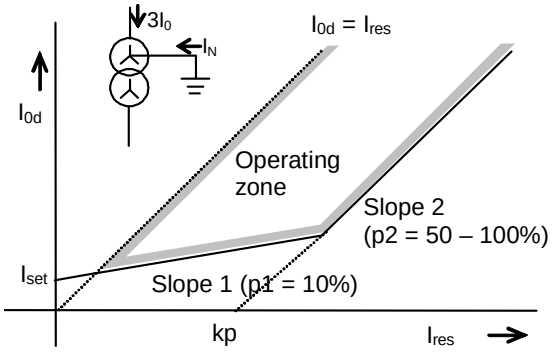
During periods of transformer energization, the use of a second harmonic restraint method blocks the relay operation.

When the transformer is overexcited due to a transient power system disturbance, the use of a fifth harmonic restraint method is available to block the operation of the relay.

Restricted Earth Fault Protection

Employing the residual current of each winding and the neutral point current, Restricted Earth Fault (REF) protection provides a highly sensitive differential protection for earth faults in transformers which have star points directly earthed or low impedance earthed.

The REF element has a dual slope, percentage characteristic as shown in Figure 2; independent elements can be applied for each transformer winding.



I_{od}: Residual differential current ($|3I_0 + I_N|$)
I_{res}: Restraining current (Max.(I_A, I_B, I_C, I_N))
I_{set}: Sensitivity setting of small current characteristic
K_p: Sensitivity setting of large current characteristic

Figure 2. REF Characteristic

Thermal Overload Protection (alarming and/or tripping)

The characteristics are exponential functions according to functional standard IEC 60255-149 and take into account the I^2R losses due to the specific operational current and the simultaneous cooling effect of the coolant. In this way the tripping time during an overload condition takes the prior level of load current into consideration. An alarm can be set to operate before the tripping condition is reached.

Thermal image:

$$t = \tau \ln \frac{I^2 - I_p^2}{I^2 - (k\, I_B)^2}$$

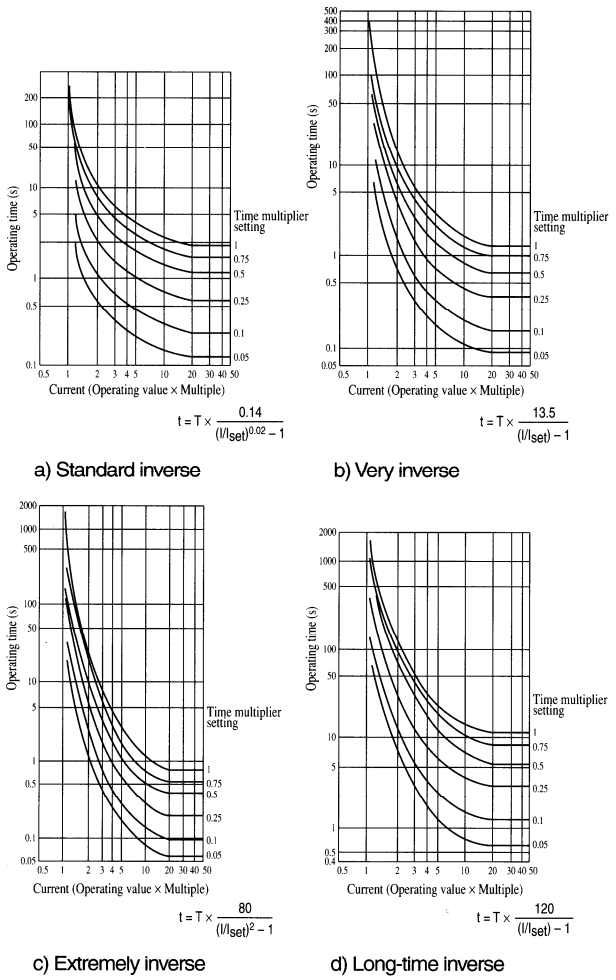
where

- t : Operating time
- τ : Thermal time constant
- I : Overload current
- I_B : Thermal overload current setting
- k : Constant
- I_p : Specified load current before the overload occurs

Time-Overcurrent Protection

The overcurrent protection can be applied for phase-to-phase faults, and neutral points of the transformer for phase-to-earth faults on the high- and low-voltage side to provide backup protection. The inverse time overcurrent elements conform to either of three IEC standard characteristics (Standard inverse, Very inverse, and Extremely inverse) or a Long-time inverse characteristic. The characteristics of each element are shown in Figure 3.

The high-set overcurrent element provides an instantaneous or definite time overcurrent protection.



I_{set}: Overcurrent element setting
T: Time multiplier setting
I: Input current
t: Operating time

Figure 3. Characteristics of inverse time delayed overcurrent element

Negative Phase Sequence Overcurrent Protection (NOC)

NOC protection can be used in applications where certain fault conditions may not be detected by the normal phase and earth overcurrent protections, for example, in the case of a relay applied on the delta side of a delta-star transformer, to detect an earth fault on the star side.

Two independent thresholds are provided, each with a programmable definite time delay.

Circuit Breaker Fail Protection (CBF)

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

Frequency Protection

GRE160 has two frequency elements, which provide the following schemes:

- Under frequency protection
- Over frequency protection
- Frequency rate of change protection

Two stages are provided for alarm and trip, and each stage can be configured either for under frequency or over frequency protection.

For detecting frequency fluctuation, a rate of change of frequency protection is provided to enable prompt intitiation of load shedding when the frequency change is rapid.

Under / Over Voltage Protection

GRE160 is equipped with definite time under/over voltage protection elements for backup protection in accordance with IEC 60255-127.

Overexcitation Protection

A single phase to phase connected voltage input is provided to detect overexcitation. Alarms and tripping, based on a measurement of the voltage/frequency ratio are provided. The voltage/frequency ratio is calculated using per unit quantities.

The alarm is definite time delayed whilst the characteristic may be selected as either having a definite time or an inverse time delay, as shown in Figure 4.

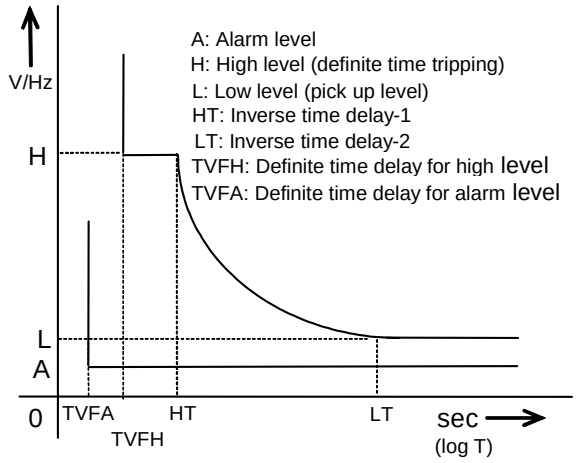


Figure 4. Characteristic of overexcitation element

Voltage controlled overcurrent Protection

Voltage controlled or voltage restrained inverse time overcurrent protection is provided so that the relay can issue a trip signal in response to certain fault types on the lower voltage side of a transformer when the fault current may be lower than the nominal value. The user can select either the voltage controlled OCI or the voltage restrained OCI function in addition to the normal OCI function. When voltage controlled OCI is used, the OCI element will only function when an input voltage is lower than a setting. When voltage restrained OCI is used, the sensitivity of OCI is

proportionally adjusted by the voltage input value between 20 and 100% of the voltage setting.

Trip and / or indication of External Protection Device

External signals such as overpressure devices and Buchholz relay operation, can be introduced via binary input circuits. Logic can be arranged for alarms, event recording and tripping. The binary input circuit is provided with a logic level inversion function.

For redundancy it is recommended to route tripping from the Buchholz or overpressure device in parallel to the relay.

Switchgear Control

GRE160 provides the facility for switchgear control on the relay front panel. Two-stepped operation (select-control) is applied for the control procedure of circuit breakers to ensure highly secure operation. An interlock check function is included for safe operation of the switchgear. Password protection is provided for the above functions.

A local/remote selector switch is also provided on the relay front panel so that remote control from station level or load dispatching center can be chosen.

Equipment status (Open or Closed) is indicated on the LEDs at the front of the relay and on the relay fascia LCD.

MONITORING FUNCTIONS

Trip Circuit Supervision

GRE160 provides a high-integrity trip circuit supervision scheme. Trip circuits can be monitored with the circuit breaker either closed or open using two binary inputs as shown in Figure 5.

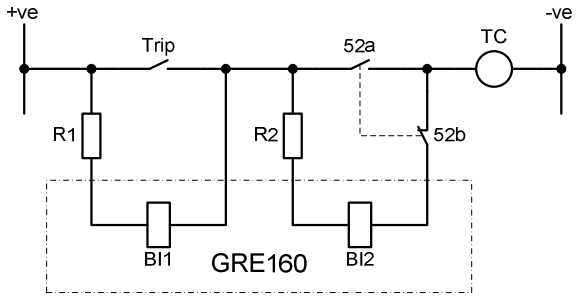


Figure 5 – Trip Circuit Supervision Scheme

CB Closed:

Under healthy conditions, binary input BI1 is energised via external resistor, R1.

If an open-ciruit occurs in the trip circuit, BI1 resets and a Trip Circuit Fail alarm is raised.

CB Open:

Under healthy conditions, binary inputs BI1 & BI2 are energised via external resistors, R1 & R2 respectively.

If an open-ciruit occurs in the trip circuit, both inputs reset and a Trip Circuit Fail alarm is raised.

The Trip Circuit Fail alarm incorporates a time delay of 400ms to prevent false alarms arising during normal tripping operations or voltage dips and is given in the form of an output contact operation and LCD/LED indication.

Automatic Self-supervision

Automatic monitoring of internal circuits and software is provided. In the event of a failure being detected, the ALARM LED or the RELAY FAIL LED on the relay front panel is illuminated, the 'RELAY FAILURE' binary output operates, and the date and time of the failure is recorded in the event record.

Circuit Breaker State Monitoring

If two binary inputs are programmed to the functions 'CB OPEN' and 'CB CLOSED' then the CB State Monitoring function becomes active. In normal circumstances these inputs are in opposite states. If both show the same state then a 'CB Defective' alarm is raised.

Circuit Breaker Condition Monitoring

The following CB condition monitoring functions are provided:

- The trip counter increments the number of tripping operations performed. An alarm is issued when the count exceeds a user-defined setting.
- The $\sum I^y$ counter increments the value of current to the power 'y', recorded at the time of issuing the tripping signal, on a phase by phase basis. An alarm is issued when the count for any phase exceeds a user-defined setting.
- The operating time monitor records the time between issuing the tripping signal and the phase currents falling to zero. An alarm is issued when the operate time for any phase exceeds a user-defined setting.

The CB condition monitoring functions are triggered each time a trip is issued, and they can also be triggered by an external device via a binary input.

METERING AND RECORDING

Metering

The following data is continuously available on the relay front panel LCD and can be viewed on a local or remote PC if connected.

- Primary and secondary currents and voltages for each input.
- Positive and negative phase sequence currents and voltages.
- Power, frequency and power factor
- Peak phase current and voltage demand.

- Thermal condition of the primary equipment or plant.
- Relay element output status.
- Binary input and output status.

Event Record

Records are stored for the 200 most recent events, time-tagged to 1ms resolution. The event record is available on the relay front panel LCD and can be viewed on a local or remote PC when connected. Events are recorded as follows:

- Tripping operations.
- Alarms.
- Operation of protection elements.
- Change of state of binary inputs / outputs.
- Change of relay setting.
- Failure detected by automatic supervision.

Fault Record

A relay trip initiates fault recording. Records are stored for the 5 most recent faults, time-tagged to 1ms resolution. The fault record is available on the relay front panel LCD and can be viewed on a local or remote PC if connected. Fault records include the following data:

- Date and time of trip operation.
- Operating phase.
- Protection scheme responsible for the trip.
- Measured current data.

Disturbance Record

The relay can record 8 analog and 32 binary signals, initiated by relay tripping. The post-trigger recording time can be set, and the maximum number of records which can be stored is dependent on the recording time chosen.

Date and Time

GRE160 provides a date and time feature for tagging of records.

USER INTERFACE

Relay Front Panel

A user friendly interface is provided on the relay front panel. A menu-based system provides for easy programming of relay functions and access to real-time and stored data. The front panel includes the following features.

- 16 character, 8-line LCD with backlight.
- 14 LEDs (8 fixed display and 6 configurable).
- Keypad.
- USB2.0 port for connection of local PC.

Local PC Connection

The user can communicate with the GRE160 from a local PC via the USB2.0 port on the front panel. Using RSM100 software, the user can view and modify settings, monitor real-time metering and analyze recorded data.

Figure 6 shows the configuration of typical displays from the RSM100 software.

Remote Communications

GRE160 is provided with an RS485 port, it can also be equipped with an optional Ethernet port, (electrical or fiber) for remote communication with a substation control and monitoring system or an automation system linked to a SCADA system or regional control center. The remote communications feature is used to transfer measurand data, status data and general commands between the relay and the control system. Modbus ® RTU, IEC 60870-5-103, DNP3 and IEC 61850 are all supported selection of which is defined when ordering.

Relay Setting

The user can modify relay settings by using either the front panel keypad or the RSM100 software from a local or remote PC. Password protection is available for added security.

Two settings groups are provided, allowing the user to set one group for normal conditions, while the other group may be set to cover alternative operating conditions.

Using the RSM software, the user can create a settings file on a PC (without being connected to a relay), and store the file ready for download to a relay at a later date.

Binary Outputs

GRE160 provides user programmable binary output contacts for tripping and alarm. Each of the programmable binary outputs is driven via a logic gate which can be programmed for OR gate or AND gate operation. Further, each output has a programmable reset characteristic, settable for instantaneous drop-off, delayed drop-off, or for latching operation. If latching operation is selected then a relay that has operated must be reset by the user, either by pressing the RESET button, by energizing a binary input which has been programmed for ‘Remote Reset’ operation, or by a communications command.

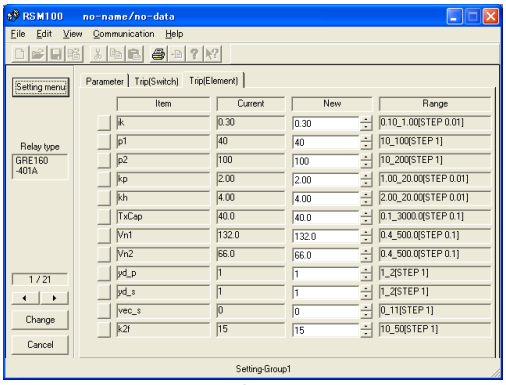
Binary Inputs

GRE160 provides programmable binary inputs as standard. Each binary input is individually user-programmable for normal or inverted operation and

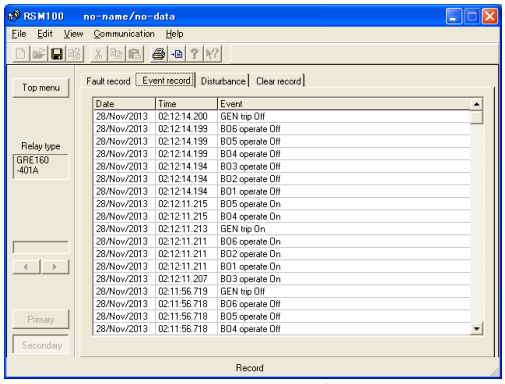
for delayed pick-up and/or drop-off. Each input can also be used to switch relay operation to a different settings group.

General purpose alarm functions are also included. The user can define a text message for each alarm. Thus when inputs associated with that alarm are raised, the defined text is displayed on the LCD.

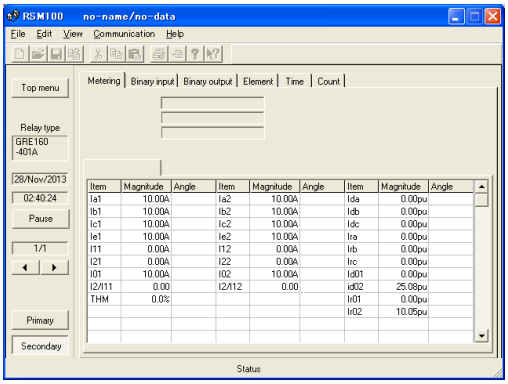
PC DISPLAY



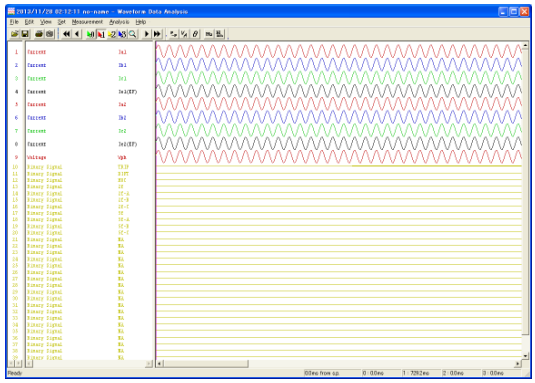
Setting



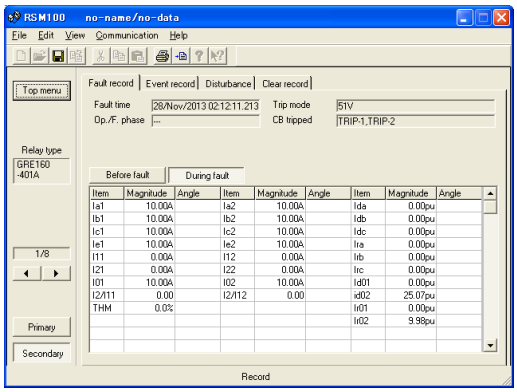
Event record



Metering



Data analysis



Fault record

Figure 6 - Relay Setting and Monitoring System - PC Displays

TECHNICAL DATA

Ratings	
AC current In (primary and secondary):	1A / 5A (combined)
AC voltage Vn:	100-240V
Frequency:	50/60Hz
Auxiliary supply:	110 – 250Vdc / 100-220Vac (Operative range: 88 – 300Vdc / 80 – 264Vac) 48－110Vdc (Operative range: 38.4 – 132Vdc) 24 – 48Vdc (Operative range: 19.2 – 60.0Vdc)
Superimposed AC ripple on DC supply:	maximum 12%
DC supply interruption:	maximum 50ms at 110V
Binary input circuit DC voltage:	For alarm indication 110-250Vdc (Operative range: 88 - 300Vdc) 48-110Vdc (Operative range: 38.4 – 132Vdc) 24-48Vdc (Operative range: 19.2 – 57.6Vdc) For trip circuit supervision Operative range: ≥38.4V (for 110Vdc rating) ≥88V (for 220/250Vdc rating) ≥19.2V (for 48Vdc rating) ≥9.6V (for 24Vdc rating)
Overload Ratings	
AC current inputs:	4 times rated current continuous 100 times rated current for 1 second 2 times rated continuous
AC voltage inputs:	2 times rated voltage continuous
Burden	
AC phase current inputs:	≤ 0.3VA
AC earth current inputs:	≤ 0.3VA
AC voltage inputs:	≤ 0.1VA (at rated voltage)
Power supply:	≤ 10W (quiescent) ≤ 15W (maximum)
Binary input circuit:	≤ 0.5W per input at 220Vdc
Current differential protection (87T)	
Minimum operate current (ik)	OFF, 0.10 - 1.00pu in 0.01pu steps
Slope 1 (p1) for DF1	10 - 100% in 1% steps
Slope 2 (p2) for DF2	10 - 200% in 1% steps
kp	1.00 - 20.00pu in 0.01pu steps
Vector group compensation (d1 – d2)	0 to 11 (0 to 330deg in 30deg steps)
CT ratio (primary)	1 – 30000A in 1A steps
CT ratio (secondary)	1 – 30000A in 1A steps
Transformer Capacity	0.1 – 3000.0MVA in 0.1MVA steps
Voltage rating (primary)	0.4 – 500.0kV in 0.1kV steps
Voltage rating (secondary)	0.4 – 500.0kV in 0.1kV steps
Inrush setting (2nd harmonic ratio) (k2f)	10 to 50% in 1% steps
Overexcitation setting (5th harmonic ratio) (k5f)	10 to 100% in 1% steps
Operating time	typical 35ms (including BO operation time)

High-set differential overcurrent protection	
Overcurrent (kh)	OFF, 2.00 - 20.00pu in 0.01pu steps
Operating time	typical 25ms (including BO operation time)
Restricted earth fault element (64/87G)	
Minimum operating current	OFF, 0.05 - 2.50pu in 0.01pu steps
Slope 1 (primary; 1p1, secondary; 2p1)	10 % (fixed)
Slope 2 (primary; 1p2, secondary; 2p2)	50 - 100% in 1% steps
1kp, 2kp (primary and secondary)	0.50 - 2.00pu in 0.01pu steps
CT ratio (primary;CT1, secondary;CT2)	1 – 30000A in 1A steps
CT ratio for neutral point (primary ;CTn1, secondary ;CTn2)	1 – 30000A in 1A steps
Phase Overcurrent Protection (50P/N, 51P/N)	
Definite time overcurrent element	
Pick up level (OC, EF)	OFF, 0.10 - 20.00pu in 0.10pu steps
Delay time (TOC, TEF)	0.00 - 300.00s in 0.01s steps
Reset time delay(TOCR,TEFR)	0.0 - 300.0s in 0.1s steps
Inverse time overcurrent element	
Pick up level (OCI, EFI)	OFF, 0.10 - 5.00pu in 0.01pu steps
Time multiplier (TOCM, TEFM)	0.010 – 15.000 in 0.001 steps
Reset Time multiplier (TOCRM, TEFRM)	0.010 – 15.000 in 0.001 steps
Delay type	IDMTL (IEC 60255-151): IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
Thermal Overload Protection (49)	
$I_\theta = k.I_{FLC}$ (Thermal setting):	OFF, 0.40 to 2.50pu in 0.01pu steps
Previous load current (IP) for testing	0.00 – 1.00pu in 0.01pu steps
Time constant (τ):	0.5 - 500.0mins in 0.1min steps
Thermal alarm:	OFF, 50% to 100% in 1% steps
Negative Phase Sequence Protection (46)	
Definite time overcurrent element	
Pick up level (NC)	OFF, 0.10 - 20.00pu in 0.10pu steps
Delay time (TNC)	0.00 - 300.00s in 0.01s steps
Reset time delay(TNCR)	0.0 - 300.0s in 0.1s steps
Inverse time overcurrent element	
Pick up level (NCI)	OFF, 0.10 - 5.00pu in 0.01pu steps
Time multiplier (TNCM)	0.010 - 1.500 in 0.001 steps
Reset Time multiplier (TNCRM)	0.010 - 1.500 in 0.001 steps
Delay type	IDMTL (IEC 60255-151): IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
CBF Protection (50BF)	
CBF threshold:	OFF, 0.10 - 2.00pu in 0.01pu steps
CBF stage 1 DTL:	0.00 - 300.00s in 0.01s steps
CBF stage 2 DTL:	0.00 - 300.00s in 0.01s steps

Undervoltage Protection (27)	
1st, 2nd Undervoltage thresholds	OFF, 5.0 - 130.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL(complied with IEC 60255-127)
DTL delay	0.00 - 300.00s in 0.01s steps
IDMTL Time Multiplier Setting TMS:	0.05 – 100.00 in 0.01 steps
Reset delay	0.0 – 300.0s in 0.1s steps
Undervoltage block	5.0 - 20.0V in 0.1V steps
Overvoltage Protection (59)	
1st, 2nd Overvoltage thresholds	OFF, 10.0 to 200.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL(complied with IEC 60255-127)
DTL delay	0.00 to 300.00s in 0.01s steps
DO/PU ratio	10 – 98% in 1% steps
Reset Delay:	0.0 – 300.0s in 0.1s steps
Overexcitation Protection (24)	
Pickup voltage	100.0 - 120.0V in 0.1V steps
Alarm level (A)	1.03 - 1.30pu in 0.01pu steps
High level (H)	1.10 - 1.40pu in 0.01pu steps
Low level (L)	1.05 - 1.30pu in 0.01pu steps
LT (Definite time)	1 - 600s in 1s steps
HT (Definite time)	1 - 600s in 1s steps
TVFH (Definite time)	1 - 600s in 1s steps
TVFA (Definite time)	1 - 600s in 1s steps
Start time	less than 130ms
RT (Definite time)	60 - 3600s in 1s steps
Voltage Restraint Protection (51V)	
Voltage threshold (OCV)	10.0 - 120.0V in 0.1V steps
Pick up level (OCVIS)	0.10 - 5.00pu in 0.01pu steps (available at OCVEN=Cont)
Time multiplier (TOCVM)	0.010 – 15.000 in 0.001 steps
Reset time(TOCVR)	0.0 – 300.0s in 0.1s steps
Reset Time multiplier (TOCVRM)	0.010 – 15.000 in 0.001 steps
Delay type	IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
Frequency Protection (81U/O)	
Overfrequency	50.00 to 60.00Hz in 0.01Hz steps (50Hz setting)
	60.00 to 70.00Hz in 0.01Hz steps (60Hz setting)
Underfrequency	40.00 to 50.00Hz in 0.01Hz steps (50Hz setting)
	50.00 to 60.00Hz in 0.01Hz steps (60Hz setting)
Delay time	0.00 to 300.00s in 0.01s steps
Frequency rate-of-change	+0.1 to +15.0Hz/s in 0.1Hz/s steps
	-0.1 to -15.0Hz/s in 0.1Hz/s steps
Operating time	less than 100ms
Undervoltage blocking	40.0 - 100.0V in 0.1V steps

Accuracy	
Current differential element: pick-up	100% of setting ±5%
Time-overcurrent protection: pick-up	100% of setting ± 5% (G_S>0.2A)
Inverse Time Delays:	IEC60255-151, ±5% or 50ms ($2 \leq G/G_S \leq 20$) $G_T = 1.1G_S$ $G_D = 20G_S$ ($G_S \leq 10A$), 200A ($G_S > 10A$)
Instantaneous Time Delays	≤50ms (DT, TMS=0s)
Voltage protection	±5%
Frequency protection: pick-up	±5%
Overexitation protection	±2% of pick-up voltage (frequency range 2%)
Front Communication port - local PC (USB2.0)	
Connector type:	Type B
Cable length:	5m (max.)
Rear Communication port - remote PC (RS485)	
Connection:	Multidrop (max. 32 relays)
Cable type:	Twisted pair
Cable length:	1200m (max.)
Connector:	Screw terminals
Isolation:	1kVac for 1 min.
Transmission rate:	19.2 kbps for Modbus RTU
Rear Communication port - remote PC (Ethernet)	
100BASE-TX	RJ-45 connector
100BASE-FX	SC connector
Rear Time synchronizationport (IRIG-B port)	
IRIG Time Code	IRIG-B122
Input impedance	4k-ohm
Input voltage range	4Vp-p to 10Vp-p
Connector type	Screw terminal
Cable type	50 ohm coaxial cable
Binary Inputs	
Number	6 (x00 model) / 12 (x01 model) / 18 (x02 model)
Operating Voltage	For alarm indication Typical 154Vdc (min. 110Vdc) for 220Vdc rating Typical 77Vdc (min. 70Vdc) for 110Vdc rating Typical 33.6Vdc (min. 24Vdc) for 48Vdc rating Typical 16.8Vdc(min. 12Vdc) for 24Vdc rating For trip circuit supervision ≥88V for 220/250Vdc rating ≥38.4Vdc for 110Vdc rating ≥19.2V for 48Vdc rating ≥9.6V for 24Vdc rating
Binary Outputs	
Number	4 (x00 model) / 10 (x01 model) / 16 (x02 model)
Ratings	Make and carry: 5A continuously
for BO1 and BO2 CB control:	Contact : 0.4A 250Vdc, 8A 380Vac, 3040VA, 150W
and for BO5 and BO6 (model x01)	Make and carry: 30A, 250Vdc for 0.5s (L/R≥40ms)
and for BO11 and BO12 (model x02)	Break: 0.1A, 250Vdc (L/R=40ms)

for other BOs	Make and carry: 4A continuously Contact: 0.2A 110Vdc, 8A 250Vac, 2000VA, 240W
Durability:	Loaded contact: ≥1,000 operations Unloaded contact: ≥10,000 operations
Pickup time:	Less than 15ms
Reset time:	Less than 10ms
Mechanical design	
Weight	3.4kg (minimum configuration), 4.0kg (maximum configuration)
Case color	Munsell No. 10YR8/0.5
Installation	Flush mounting with attachment kits

ENVIRONMENTAL PERFORMANCE

Test	Standards	Details
Atmospheric Environment		
Temperature	IEC 60068-2-1/2 IEC 60068-2-30	Operating range: -20°C to +60°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC 60068-2-78	56 days at 40°C and 93% relative humidity.
Enclosure Protection	IEC 60529	IP52 (front), IP20 (rear), IP40 (top)
Mechanical Environment		
Vibration	IEC 60255-21-1	Response - Class 1 Endurance - Class 1
Shock and Bump	IEC 60255-21-2	Shock Response Class 1 Shock Withstand Class 1 Bump Class 1
Seismic	IEC 60255-21-3	Class 1
Electrical Environment		
Dielectric Withstand	IEC 60255-5 IEEE C37.90.0	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	IEC 60255-5	Three positive and three negative impulses of 5kV(peak) for CT, Power Supply Unit (PSU), BI and BO circuits; between terminals and earth, and between independent circuits 3kV (peak) for RS485 circuit; between terminals and earth 3kV (peak) for BO circuit; across normally open contacts 1.2/50μs, 0.5J between all terminals and between all terminals and earth.
Electromagnetic Environment		
High Frequency Disturbance / Damped Oscillatory Wave	IEC 60255-22-1 Class 3, IEC 61000-4-12 IEEE C37.90.1	1MHz 2.5kV to 3kV (peak) applied to all ports in common mode. 1MHz 1.0kV applied to all ports in differential mode.
Electrostatic Discharge	IEC 60255-22-2 Class 3, IEC 61000-4-2	6kV contact discharge, 8kV air discharge.
Radiated RF Electromagnetic Disturbance	IEC 60255-22-3 Class 3, IEC 61000-4-3	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	IEC 60255-22-4 Class A, IEC 61000-4-4, IEEE C37.90.1	4kV, 2.5kHz, 5/50ns applied to all inputs.

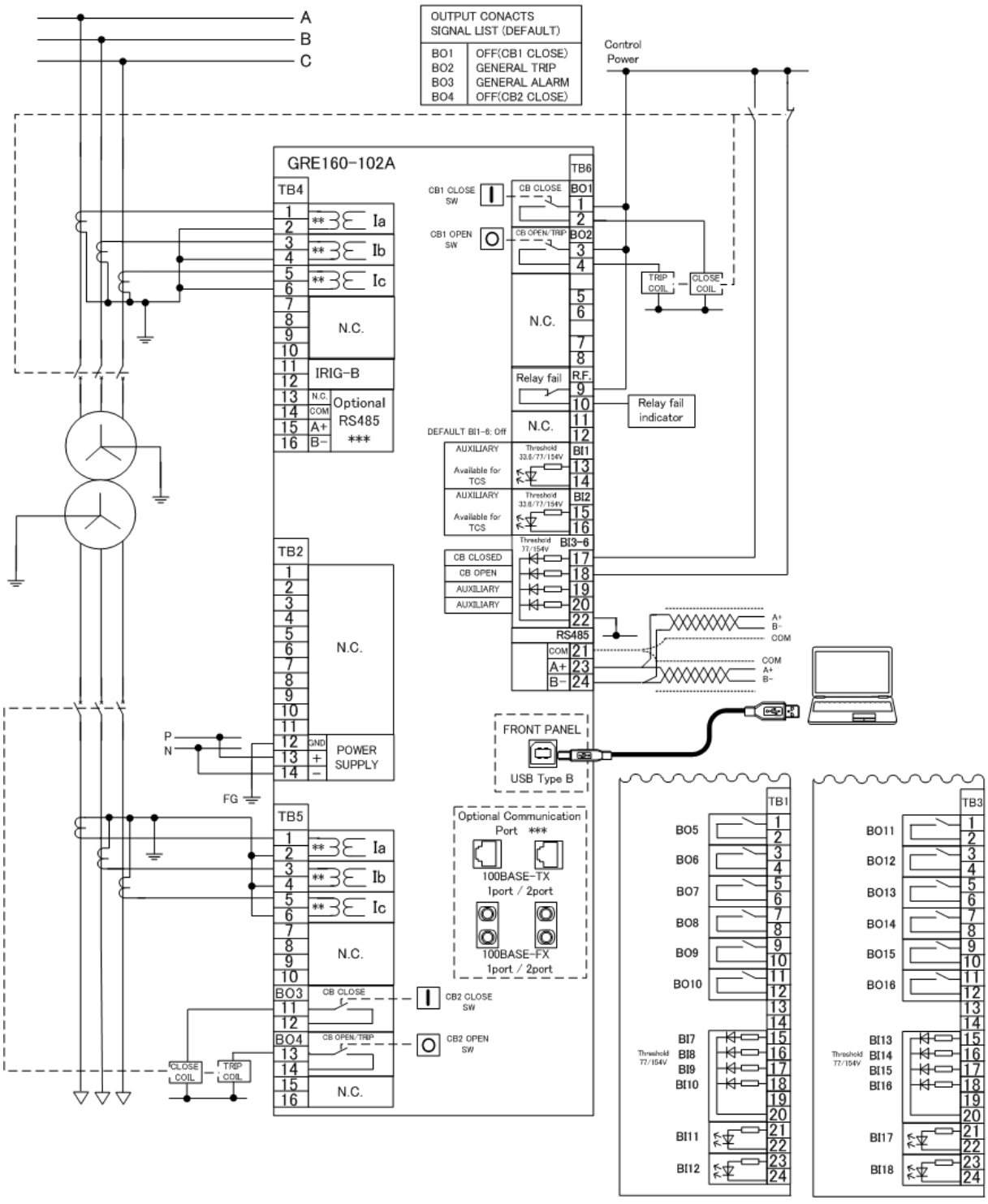
Test	Standards	Details
Surge Immunity	IEC 60255-22-5, IEC 61000-4-5	1.2/50μs surge in common/differential modes: HV, PSU and I/O ports: 2kV/1kV (peak) RS485 port: 1kV (peak)
Conducted RF Electromagnetic Disturbance	IEC 60255-22-6 Class 3, IEC 61000-4-6	10Vrms applied over frequency range 150kHz to 100MHz. Additional spot tests at 27 and 68MHz.
Power Frequency Disturbance	IEC 60255-22-7 Class A, IEC 61000-4-16	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	IEC 60255-25, EN 55022 Class A, IEC 61000-6-4	Conducted emissions: 0.15 to 0.50MHz: <79dB (peak) or <66dB (mean) 0.50 to 30MHz: <73dB (peak) or <60dB (mean) Radiated emissions (at 10m): 30 to 230MHz: <40dB 230 to 1000MHz: <47dB
European Commission Directives		
CE	89/336/EEC	Compliance with the European Commission Electromagnetic Compatibility Directive is demonstrated according to generic EMC standards EN 61000-6-2 and EN 61000-6-4.
	73/23/EEC	Compliance with the European Commission Low Voltage Directive is demonstrated according to product safety standard EN 60255-27.

ORDERING

Transformer Protection Relay

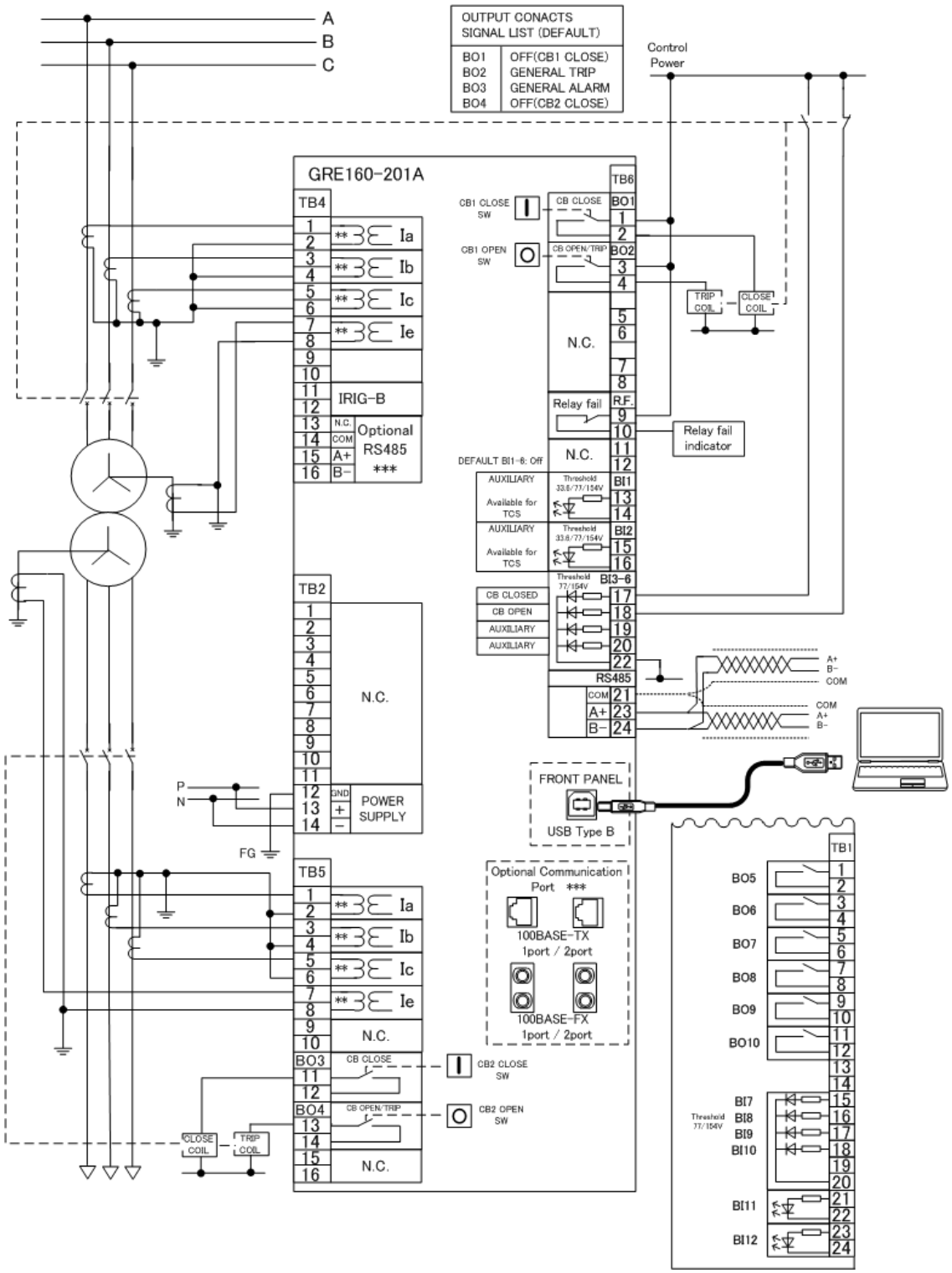
Type:	
Transformer Protection	GRE160
Model (analog input):	
2 x three-phase CT	1
2 x three-phase CT + 2 x zero-phase CT	2
2 x three-phase CT + 1 x single-phase VT	3
2 x three-phase CT + 2 x zero-phase CT + 1 x single-phase VT	4
2 x three-phase CT + 2 x zero-phase CT + 4 x single-phase VT	5
Model (binary input and output):	
6 x BIs, 4 x BOs, 1 x Relay fail	0
12 x BIs, 10 x BOs, 1 x Relay fail	1
18 x BIs, 16 x BOs, 1 x Relay fail	2
Rating:	
CT: 1/5A, f: 50/60Hz, 110-250Vdc / 100-220Vac	1
CT: 1/5A, f: 50/60Hz, 48-110Vdc	2
CT: 1/5A, f: 50/60Hz, 24-48Vdc	A
Standard and language:	
IEC (English)	0
Communication:	
RS485 1port (Modbus/IEC 60870-5-103)	10
RS485 1port (Modbus/DNP3)	11
100BASE-TX 1port (Modbus/IEC 61850) +RS485 1port (Modbus/IEC 60870-5-103)	A0
100BASE-TX 1port (Modbus/IEC 61850/DNP3) +RS485 1port (Modbus/DNP3)	A1
100BASE-FX 1port (Modbus/IEC 61850) +RS485 1port (Modbus/IEC 60870-5-103)	C0
100BASE-FX 1port (Modbus/IEC 61850/DNP3) +RS485 1port (Modbus/DNP3)	C1

TYPICAL APPLICATIONS / CONNECTIONS



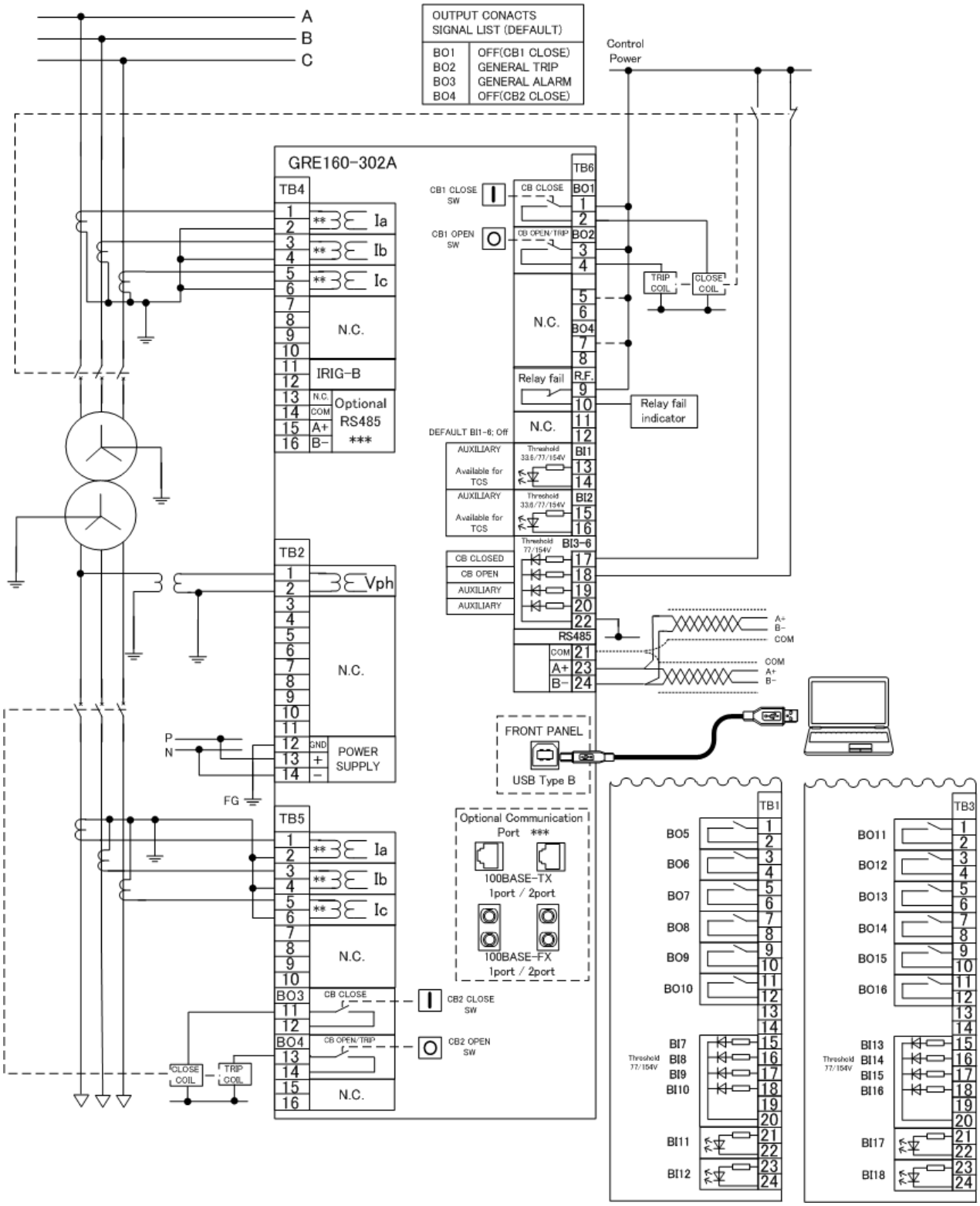
*BO7 to BO10 and BO13 to BO16 are NOT suitable for direct CB coil connection.
**Analogue current input ports are shorted when the terminal block is removed.
(1-2, 3-4, 5-6)

Figure 7 - GRE160-102A Typical Application Diagram



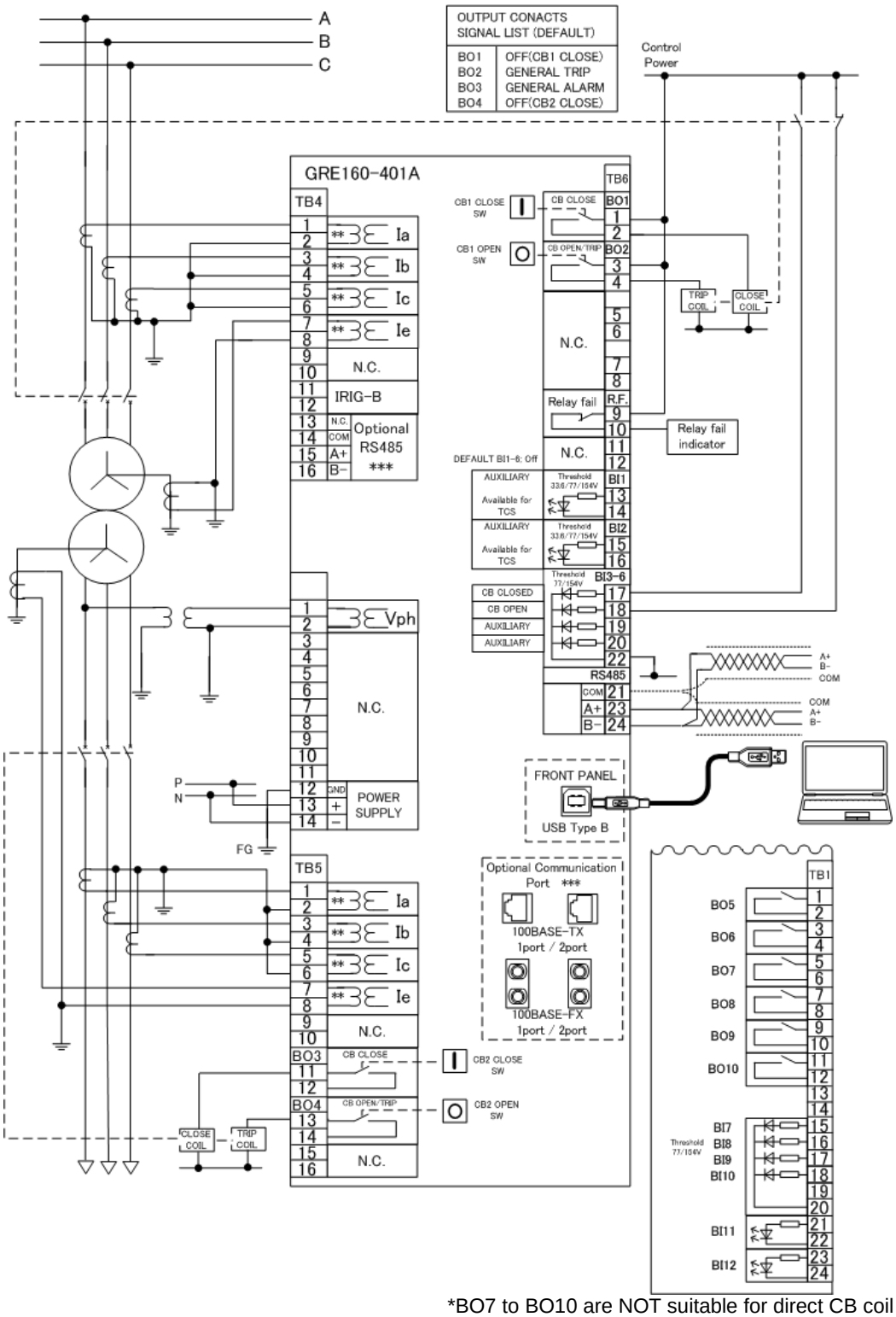
*BO7 to BO10 are NOT suitable for direct CB coil connection.
**Analogue current input ports are shorted when the terminal block is removed.
(1-2, 3-4, 5-6, 7-8)

Figure 8 - GRE160-201A Typical Application Diagram



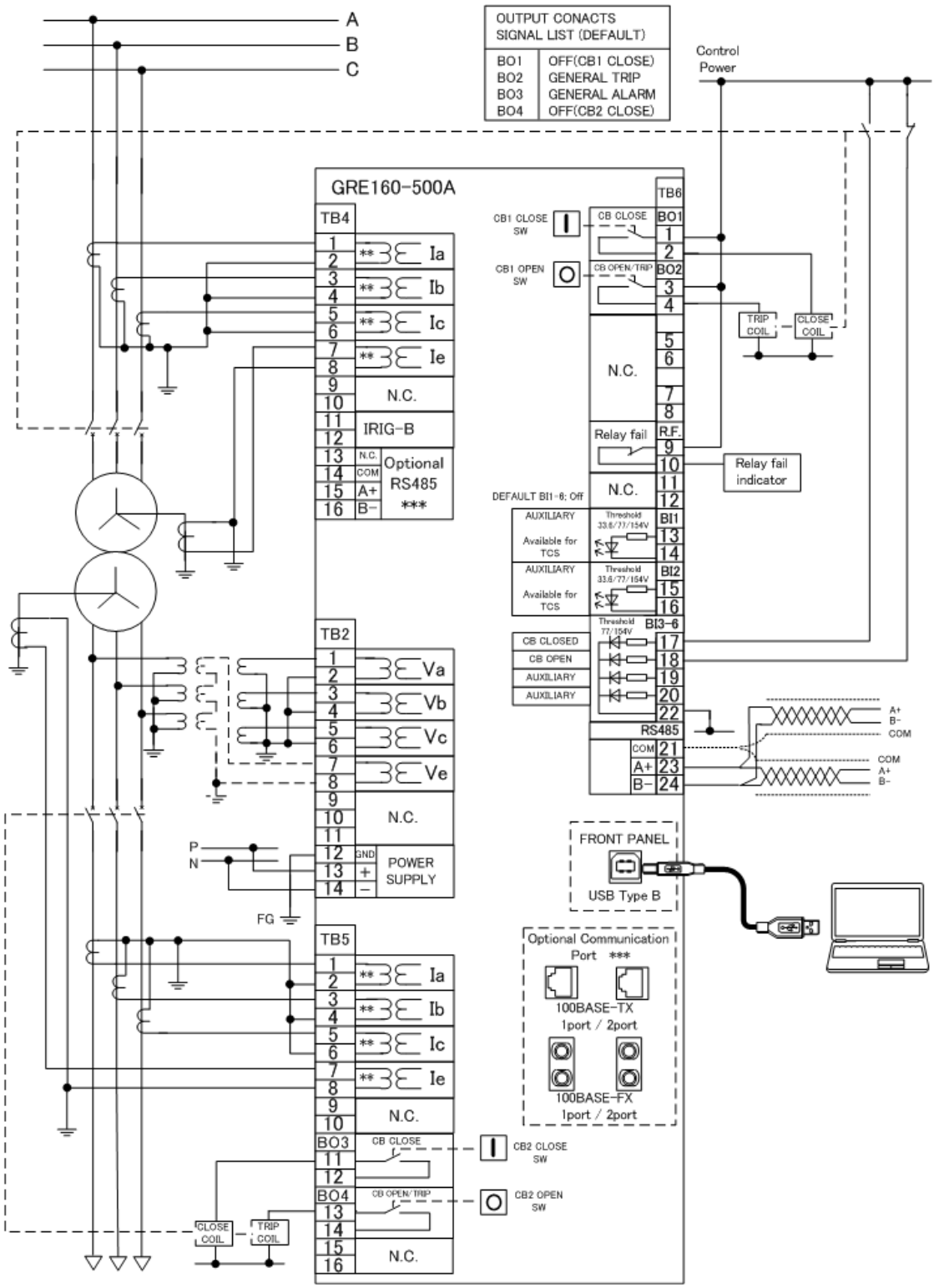
*BO7 to BO10 and BO13 to BO16 are NOT suitable for direct CB coil connection.
**Analogue current input ports are shorted when the terminal block is removed. (1-2, 3-4, 5-6)

Figure 9 - GRE160-302A Typical Application Diagram



*BO7 to BO10 are NOT suitable for direct CB coil connection.
**Analogue current input ports are shorted when the terminal block is removed. (1-2, 3-4, 5-6, 7-8)

Figure 10 - GRE160-401A Typical Application Diagram



**Analogue current input ports are shorted when the terminal block is removed. (1-2, 3-4, 5-6, 7-8)

Figure 11 - GRE160-500A Typical Application Diagram

RELAY OUTLINE

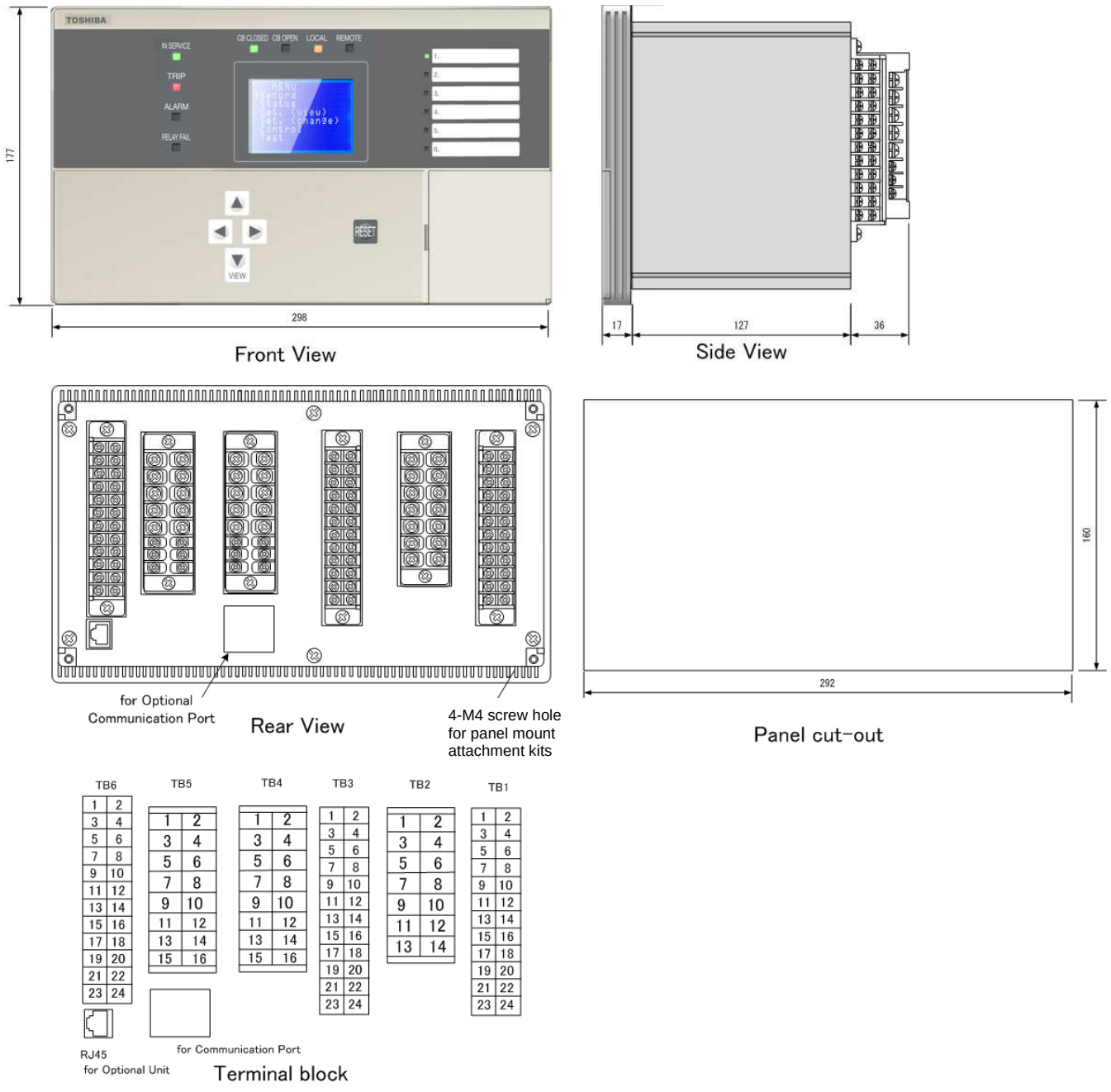


Figure 12 - GRE160 Outline Diagram

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