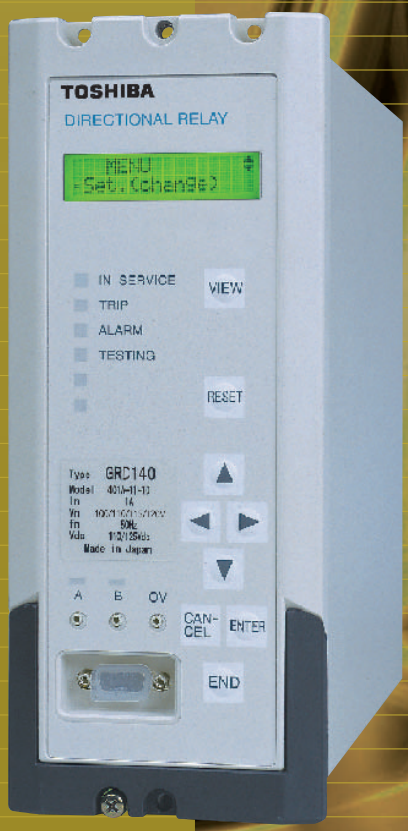
TOSHIBA

GR Series Relay

Numerical Relay

GRD140

DIRECTIONAL OVERCURRENT PROTECTION



FEATURES

- Four stage non-directional and directional overcurrent protection for phase and earth faults with IDMTL or DTL.
- Polarising voltage memory.
- Directional earth fault command protection.
- Five shot, three phase auto-reclose (six trips to lockout).
- Sequence co-ordination with in-series auto-reclosing devices.
- Programmable reset characteristics.
- Directional sensitive earth fault protection.
- Restricted earth fault protection.
- Undercurrent protection with DTL.
- Thermal overload protection.
- Directional negative phase sequence overcurrent protection.
- Phase under/overvoltage protection.
- Zero phase sequence overvoltage (neutral voltage displacement) protection.
- Negative phase sequence overvoltage protection.
- Under/overfrequency protection.
- Broken conductor detection.
- Circuit breaker fail protection.
- Cold load pick-up feature.
- Fault Locator.
- CT and VT supervision.
- Four settings groups.
- Configurable binary inputs and outputs.
- Circuit breaker condition monitoring.
- Trip circuit supervision.
- Automatic self-supervision.
- Menu-based HMI system.
- Configurable LED indication.
- Metering and recording functions.
- Communications for remote setting and data download is provided via the RSM (Remote Setting and Monitoring) system.
- Front mounted RS232 serial port for local PC communications.
- Rear mounted RS485 or fibre optic serial port for remote PC communications.
- The IEC60870-5-103 protocol is provided for communication with substation control and automation systems.

APPLICATION

The GRD140 is a range of fully numeric, multi-function, directional protection relays from TOSHIBA. GRD140 has three models which differ according to the number and type of inputs fitted, see Table 1.

Table 1 - GRD140 Models

Model	Configuration
GRD140-110	Directional Earth Fault and Directional Sensitive Earth Fault
GRD140-400	Directional Three Phase Fault and Earth Fault
GRD140-420	Directional Three Phase Fault, Earth Fault and Sensitive Earth Fault

All models include multiple, high accuracy, overcurrent protection elements (for phase and/or earth fault) with inverse time and definite time delay functions. All phase, earth and sensitive earth fault overcurrent elements can be independently subject to directional control.

In addition, GRD140 provides multi-shot, three phase auto-reclose, with independent sequences for phase fault, and earth fault and sensitive earth fault. Auto-reclosing can also be triggered by external protection devices.

Other protection functions are available according to model type, including thermal protection to IEC60255-8, negative sequence overcurrent protection, under/overvoltage and under/overfrequency protections. See Table 2 for details of the protection functions available in each model.

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

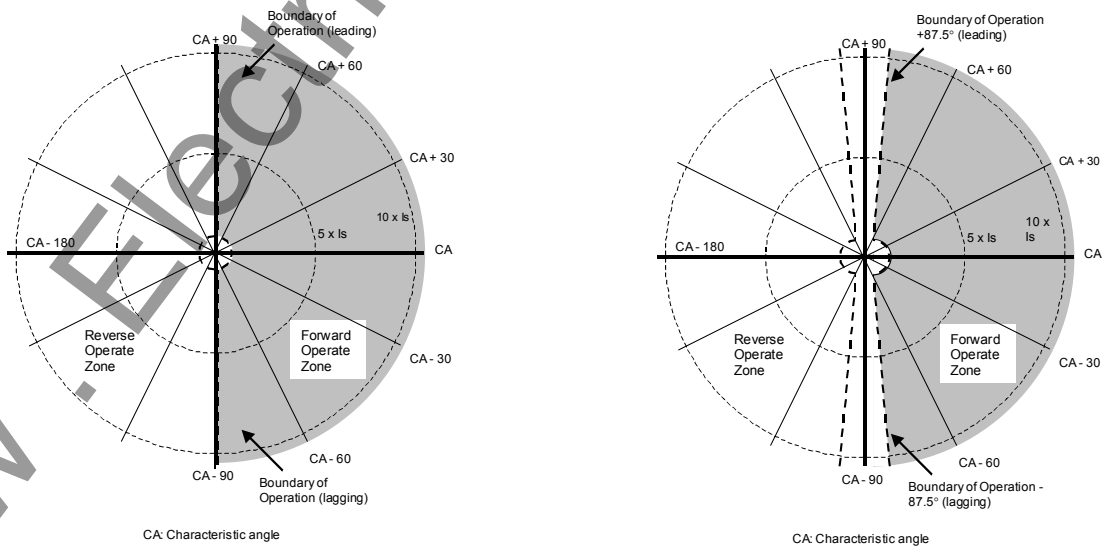
A user-friendly HMI is provided through a backlit LCD, programmable LEDs, keypad and menu-based operating system. PC access is also provided, either for local connection via a front-mounted RS232 port, or for remote connection via a rear-mounted RS485 or fibre optic port. The communication system allows the user to read and modify the relay settings, and to access data gathered by the relay's metering and recording functions.

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

- Metering
- Fault recording
- Event recording
- Disturbance recording

Table 2 - GRD140 Features

Model Number	GRD140 -		
	110	400	420
Directional Phase Fault O/C (67/50P, 67/51P)		✓	✓
Directional Earth Fault O/C (67/50N, 67/51N)	✓	✓	✓
Directional Sensitive Earth Fault O/C (67/50N, 67/51N)	✓		✓
Phase Undercurrent (37P)		✓	✓
Thermal Overload (49)		✓	✓
Directional Negative Phase Sequence Overcurrent (67/46)		✓	✓
Phase Overvoltage (59)		✓	✓
Phase Undervoltage (27)		✓	✓
Zero Phase Sequence Overvoltage (59N)	✓	✓	✓
Negative Phase Sequence Overvoltage (47)		✓	✓
Under/Overfrequency (81U/81O)		✓	✓
Broken Conductor		✓	✓
Circuit Breaker Fail (50BF)		✓	✓
Cold Load Protection		✓	✓
Auto-reclose (79)	✓	✓	✓
Fault Locator		✓	✓
CT Supervision		✓	✓
VT Supervision		✓	✓
Trip circuit supervision	✓	✓	✓
Self supervision	✓	✓	✓
CB State Monitoring	✓	✓	✓
Trip Counter Alarm	✓	✓	✓
$\sum I^y$ Alarm		✓	✓
CB Operate Time Alarm	✓	✓	✓
Four settings groups	✓	✓	✓
Metering	✓	✓	✓
Fault records	✓	✓	✓
Event records	✓	✓	✓
Disturbance records	✓	✓	✓
IEC60870-5-103 Communication	✓	✓	✓



(a) Characteristic for Phase Fault and Earth Fault (b) Characteristic for Sensitive Earth Fault

Figure 1 - Directional Operate Characteristic

PROTECTION FUNCTIONS

Directional Phase Fault Overcurrent Protection

Models GRD140-400 and GRD140-420 can provide two or three phase directional overcurrent protection. Each provides four independent overcurrent stages. Stage 1 may be set for inverse time or definite time operation. If inverse time is selected, then any one of nine curves may be chosen, including IEC and IEEE/ANSI standard characteristics, (see Figure 2). Alternatively, a user-configurable curve may be created.

Stage 1 has a programmable reset feature, selectable for instantaneous, definite time or dependent time operation. This feature can be used to protect against flashing fault conditions, or to grade correctly with electromechanical overcurrent relays.

Stages 2, 3 and 4 may be set for definite time, or instantaneous operation. These elements are immune to the effects of transformer magnetising inrush and dc offset transient over-reach.

All elements can be inhibited by binary input signals for operation in blocked overcurrent schemes and busbar zone blocking protection.

Figure 1 illustrates the directional characteristic, with the forward operate zone shaded. Polarisation is achieved by the 90° quadrature method, whereby each current's phase angle is compared with the phase to phase voltage between the other two phases. Since the voltage inputs to the relay are connected phase to neutral, the polarising phase to phase voltages are derived internally.

In the event of a close up three phase fault, all three polarising signals will collapse below the minimum threshold. Voltage memory provides a temporary polarising signal in these circumstances. GRD140 maintains the polarising signal for 500ms by reconstructing the pre-fault voltages.

To cover applications where a 2:1:1 current distribution may be experienced, it is possible to program the directional phase fault protection such that a trip output will only be given if two or more phases detect fault current in the same operate zone.

Directional Earth Fault Protection

The standard directional earth fault protection is available in all models, and provides four independent overcurrent stages. Protection functionality is the same as for the phase fault elements.

Each earth fault threshold can be independently configured for directional operation, in the same manner as the phase fault elements. The system residual voltage is used as the polarising signal. This may be obtained either by direct measurement, commonly using the open delta tertiary winding of a five limb VT, or it may be derived internally by calculating the zero sequence voltage from the three phase-to-neutral voltages.

The directional earth fault elements have a user selectable minimum voltage threshold.

GRD140 can provide the directional earth fault command protection by using two stage directional earth fault elements which one is for tripping and the other is for blocking or for current reverse detection.

Directional Sensitive Earth Fault (SEF) Protection

GRD140-110 and -420 provide directional earth fault protection with more sensitive settings for use in applications where the fault current magnitude may be very low.

The sensitive earth fault element includes a digital filter which rejects all harmonics other than the fundamental power system frequency.

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

This input can also be used in transformer restricted earth fault applications, by the use of external metrosils and setting resistors.

The sensitive earth fault elements can be configured for directional operation in the same way as the standard earth fault pole, by polarising against the residual voltage. An additional restraint on operation can be provided by a Residual Power element, for use in protection of power systems which utilise resonant (Petersen coil) earthing methods.

Phase Undercurrent Protection

Protection against loss of load is provided by the phase undercurrent protection. Two independent stages are provided, each with a programmable definite time delay.

Thermal Overload Protection

The thermal overload feature provides protection for cables and other plant against the effects of prolonged operation under excess load conditions. A thermal replica algorithm is applied to create a model for the thermal characteristics of the protected plant. Tripping

times depend not only on the level of overload current, but also on the level of prior load current, the thermal replica providing 'memory' of previous conditions.

The thermal characteristics of the system are defined by entering settings for full load current and thermal time constant. The GRD140 issues a trip according to the 'cold' and 'hot' curves specified in IEC60255-8 (see Figure 3), to prevent the protected system from exceeding its thermal capacity. The cold curve tripping times are applicable when the system is first energised, while the hot curves are relevant when the system has already been carrying some prior load for a period of time. An alarm output is also available to give early warning of high load current, set as a percentage of thermal capacity.

Directional Negative Phase Sequence Overcurrent Protection

Negative Phase Sequence (NPS) 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. Alternatively, NPS can be used to protect a three-phase motor against the severe overheating which results from operating with an unbalanced supply.

Two independent stages are provided, each with a programmable definite time delay. The negative phase sequence overcurrent elements can be directionalised by polarising against the negative phase sequence voltage.

Under/Overvoltage Protection

Two undervoltage and two overvoltage stages are provided. In each case, the two stages can be programmed with definite time delays, and one is also available with an inverse delay.

Zero Phase Sequence Overvoltage (Neutral Voltage Displacement) Protection

Two NVD stages are provided for detection of earth faults in high impedance earthed or isolated systems. The two stages can be programmed with definite time delays, and one is also available with an inverse delay. The zero sequence voltage may be derived from the phase voltages, or directly measured. Suppression of superimposed 3rd harmonic components of the supply voltage is included.

Negative Phase Sequence Overvoltage Protection

For detection of unbalanced supply voltages, two NPS overvoltage thresholds are available, both of which can be programmed with definite time delays, and one is also available with an inverse delay.

Under/Overfrequency Protection

Four independent frequency stages are provided. Each is programmable for either underfrequency or overfrequency operation, and each has an associated DTL timer.

Broken Conductor Protection

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

Circuit Breaker Fail Protection

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.

Cold Load Protection

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

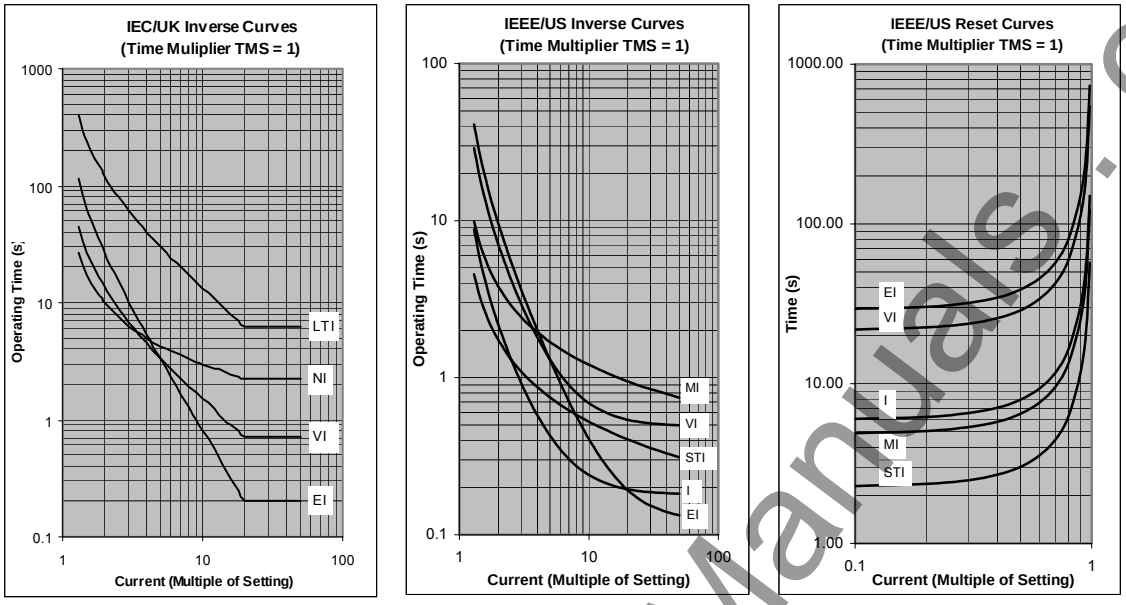
Auto-Reclose

Four independent sequences are provided, one for each of the following:

- Phase fault
- Earth fault
- Sensitive earth fault
- External trip (initiated by a binary input)

Each sequence is independently programmable for single shot, two shot, three shot, four shot or five shot (i.e. six trips to lock-out) auto-reclose. Each protection trip is programmable for instantaneous or delayed operation, and each ARC shot has a programmable dead time. Sequence co-ordination is maintained between the auto-reclose sequences of in-series relays on a feeder.

Inverse Time Operate and Reset Curves



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

Inverse time operate function

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

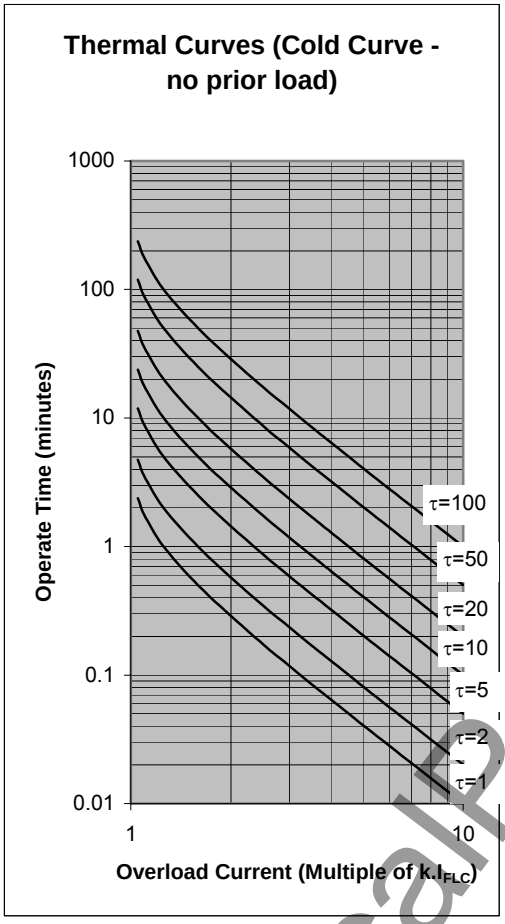
Dependent time reset function

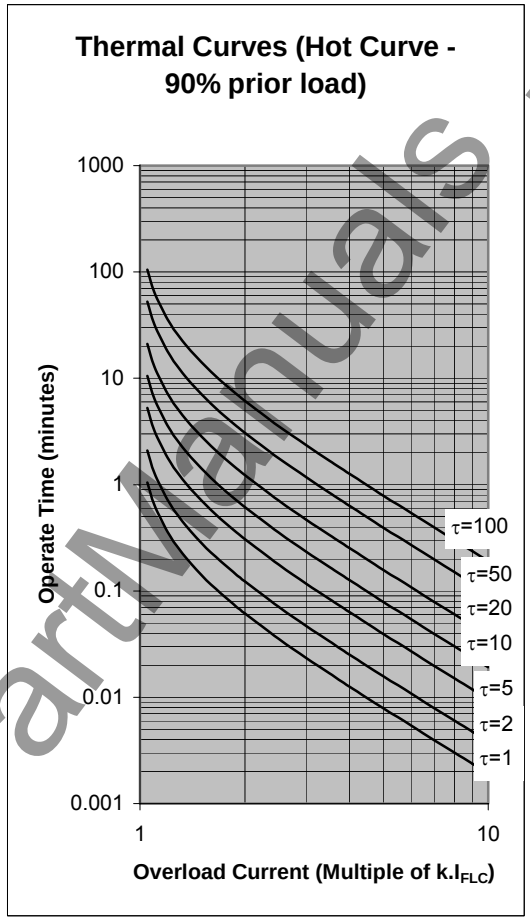
Constants for dependent time curves

Curve Description	k	α	C	t_r
IEC Normal Inverse (NI)	0.14	0.02	0	-
IEC Very Inverse (VI)	13.5	1	0	-
IEC Extremely Inverse (EI)	80	2	0	-
UK Long Time Inverse (LTI)	120	1	0	-
IEEE Moderately Inverse (MI)	0.0515	0.02	0.114	4.85
IEEE Very Inverse (VI)	19.61	2	0.491	21.6
IEEE Extremely Inverse (EI)	28.2	2	0.1217	29.1
US CO8 Inverse (I)	5.95	2	0.18	5.95
US CO2 Short Time Inverse (STI)	0.02394	0.02	0.01694	2.261
User configurable setting	0.00 – 30.000	0.00 – 5.00	0.000 – 5.000	0.000 – 30.000

Figure 2 - Operate and Reset Characteristics

IEC60255-8 Thermal Characteristics





$$t = \tau.Ln\left[\frac{I^2}{I^2 - (k.I_{FLC})^2}\right];$$

IEC60255-8 'Cold' Curve

$$t = \tau.Ln\left[\frac{I^2 - I_P^2}{I^2 - (k.I_{FLC})^2}\right]$$

IEC60255-8 'Hot' Curve

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

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

I_P = previous load current (pu)

$k.I_{FLC}$ (or I_θ) = thermal overload current setting (pu)

τ = thermal time constant (seconds)

Ln = natural logarithm

Figure 3 - IEC60255-8 Thermal Characteristics

MONITORING FUNCTIONS

Trip Circuit Supervision

The circuit breaker tripping control circuit can be monitored by a binary input. Figure 4 shows a typical scheme. When the trip circuit is complete, a small current flows through the binary input, the circuit breaker auxiliary contacts and the trip coil. This current flows for both the breaker open and closed conditions.

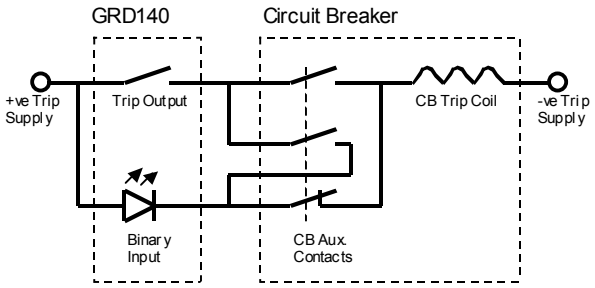


Figure 4 - Trip Circuit Supervision Scheme

If the trip supply is lost or if a connection becomes open circuit then the binary input resets and a Trip Circuit Fail alarm is given in the form of an output contact operation and LCD or 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 on the relay fascia 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. This feature is not available in GRD140-110.
- 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 fascia LCD and at a local or remote PC.

- Primary and secondary currents for each input.
- Positive and negative phase sequence currents (only available in 3 phase models).
- Ratio of negative phase sequence to positive phase sequence currents.
- Primary and secondary voltages for each input.
- Positive and negative phase sequence voltages (only available in 3 phase models).
- System residual voltage.
- Power frequency.
- Active and reactive power.
- Power factor.
- Peak phase power demand.
- Peak phase current demand.
- Thermal condition of system.
- Relay element output status.
- Binary input and output status.

Event Record

Records are stored for the 480 most recent events, time-tagged to 1ms resolution. The event record is available on the relay fascia LCD and at a local or remote PC. 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 8 most recent faults, time-tagged to 1ms resolution. The fault record is available on the relay fascia LCD and at a local or remote PC. Fault records include the following data:

- Date and time of trip operation
- Operating phase
- Protection element responsible for trip
- Measured current and voltage data
- Auto-reclose operation
- Fault location

Disturbance Record

The relay can record 9 analog and 32 binary signals, initiated by relay tripping and initiating relay elements. Post-trigger recording time can be set, and the maximum number of records which can be stored is dependent on the recording times chosen.

Date and Time

GRD140 provides a date and time feature for tagging of records.

Fault Location

Fault location is initiated by a tripping operation and is indicated in km and % of line length. The result of fault location is stored as fault record data.

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, 2-line LCD with back light.
- 6 LEDs.
- Keypad.
- RS232C serial port for connection of local PC
- Monitoring jacks

Local PC Connection

The user can communicate with the GRD140 from a local PC via the RS232C port on the front panel. Using RSM100 software, the user can view and modify settings, monitor real-time metering and analyse recorded data.

Relay Setting and Monitoring (RSM)

GRD140 can be connected to the RSM system via the rear mounted serial communications port, using either RS485 or fibre optic connections (specified at time of order). Using RSM100 software, the user can view and modify settings, monitor real-time metering and analyse recorded data.

A maximum of 32 x 8 relays can be connected to the remote PC in multi-drop mode, by connection via a protocol converter G1PR2, with a maximum data transmission rate of 64kbps. The G1PR2 can be provided with maximum 8 ports and each port supports maximum 32 relays addressing.

Figure 5 and 6 show the configuration of the RSM system and typical displays from the RSM100 software.

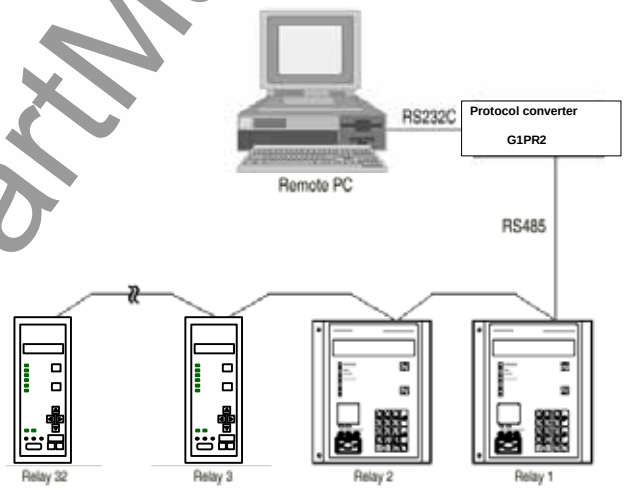


Figure 5 - Relay setting and monitoring system

IEC60870-5-103 Communications

GRD140 supports the IEC60870-5-103 communication protocol. This protocol is used for communication with a substation control and monitoring system and is used to transfer measurand data, status data and general commands between the relay and the control system.

Relay Setting

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

Four settings groups are provided, allowing the user to set one group for normal conditions, while the other groups 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

GRD140 provides eight binary output contacts for tripping and alarm, of which seven are user programmable. 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 (200ms) drop-off, dwell timer or for latching operation. If latching operation is selected then an operated relay must be reset by the user, either by pressing the RESET button, by energising a binary input which has been programmed for 'Remote Reset' operation, or by a communications command.

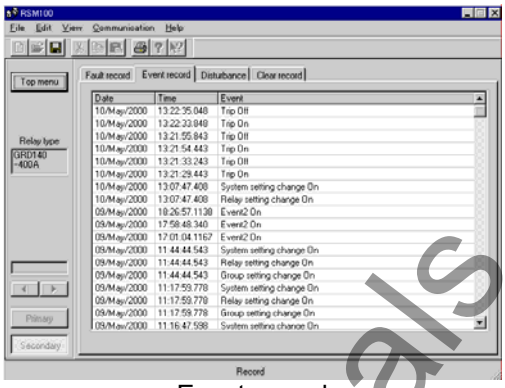
Binary Inputs

GRD140 provides five programmable binary inputs. 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.

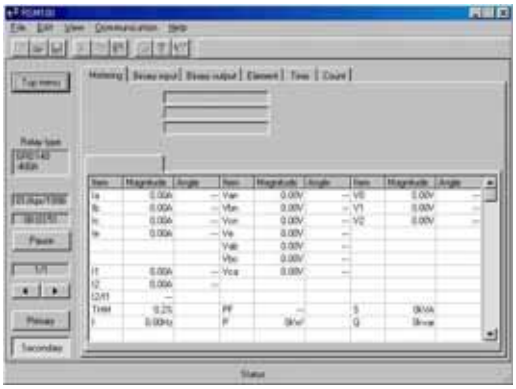
General purpose alarm functions are also included. The user can define a text message for each alarm. Then when inputs associated with that alarm are raised, the defined text is displayed on the LCD.

PC DISPLAY

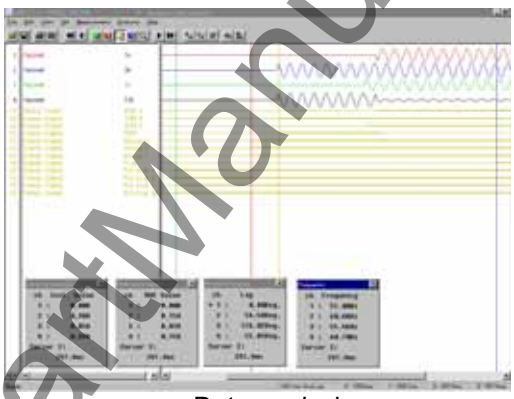
Setting



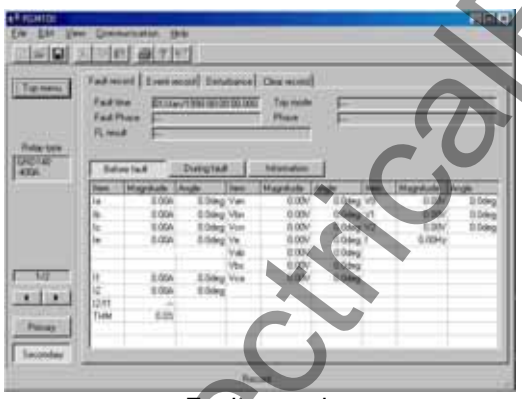
Event record



Metering



Data analysis



Fault record

Figure 6 - Relay Setting and Monitoring System - PC Displays

TECHNICAL DATA

Ratings	
AC current In:	1A or 5A
AC voltage Vn:	100V to 120 V
Frequency:	50Hz or 60Hz
DC auxiliary supply:	110/125Vdc (Operative range: 88 - 150Vdc) 220/250Vdc (Operative range: 176 - 300Vdc) 48/54/60Vdc (Operative range: 38.4 - 72Vdc)
Superimposed AC ripple on DC supply:	maximum 12%
DC supply interruption:	maximum 50ms at 110V
Binary input circuit DC voltage:	110/125Vdc (Operative range: 88 - 150Vdc) 220/250Vdc (Operative range: 176 - 300Vdc) 48/54/60Vdc (Operative range: 38.4 - 72Vdc)
Overload Ratings	
AC current inputs:	3 times rated current continuous 100 times rated current for 1 second
AC voltage inputs:	2 times rated voltage continuous
Burden	
AC phase current inputs:	≤ 0.1VA (1A rating) ≤ 0.2VA (5A rating)
AC earth current inputs:	≤ 0.3VA (1A rating) ≤ 0.4VA (5A rating)
AC sensitive earth inputs:	≤ 0.3VA (1A rating) ≤ 0.4VA (5A rating)
AC voltage inputs:	≤ 0.1VA (at rated voltage)
DC power supply:	≤ 10W (quiescent) ≤ 15W (maximum)
Binary input circuit:	≤ 0.5W per input at 110Vdc
Current Transformer Requirements	
Phase Inputs	Typically 5P20 with rated burden according to load.
Standard Earth Inputs:	Core balance CT or residual connection of phase CTs.
Sensitive Earth Inputs:	Core balance CT.
Directional Phase Overcurrent Protection	
P/F 1st Overcurrent threshold:	OFF, 0.02 – 5.00A in 0.01A steps (1A rating) OFF, 0.1 – 25.0A in 0.1A steps (5A rating)
Delay type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
IDMTL Time Multiplier Setting TMS:	0.010 – 1.500 in 0.001 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Type:	Definite Time or Dependent Time
Reset Definite Delay:	0.0 – 300.0s in 0.1s steps
Reset Time Multiplier Setting RTMS:	0.010 – 1.500 in 0.001 steps
P/F 2nd Overcurrent threshold:	OFF, 0.02 – 5.00A in 0.01A steps (1A rating) OFF, 0.1 – 25.0A in 0.1A steps (5A rating)
P/F 3rd, 4th Overcurrent thresholds:	OFF, 0.02 – 50.00A in 0.01A steps (1A rating) OFF, 0.1 – 250.0A in 0.1A steps (5A rating)
DTL delay:	0.00 – 300.00s in 0.01s steps
P/F Characteristic Angle:	–95° to +95° in 1° steps

Directional Earth Fault Protection	
E/F 1st Overcurrent threshold:	OFF, 0.02 – 5.00A in 0.01A steps (1A rating) OFF, 0.1 – 25.0A in 0.1A steps (5A rating)
Delay type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
IDMTL Time Multiplier Setting TMS:	0.010 – 1.500 in 0.001 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Type:	Definite Time or Dependent Time
Reset Definite Delay:	0.0 – 300.0s in 0.1s steps
Reset Time Multiplier Setting RTMS:	0.010 – 1.500 in 0.001 steps
E/F 2nd threshold:	OFF, 0.02 – 5.00A in 0.01A steps (1A rating) OFF, 0.1 – 25.0A in 0.1A steps (5A rating)
E/F 3rd, 4th thresholds:	OFF, 0.02 – 50.00A in 0.01A steps (1A rating) OFF, 0.1 – 250.0A in 0.1A steps (5A rating)
DTL delay:	0.00 – 300.00s in 0.01s steps
E/F Characteristic angle:	–95° to +95° in 1° steps
E/F directional voltage threshold:	0.5 – 100.0V in 0.1V steps
Directional Sensitive Earth Fault Protection	
SEF 1st Overcurrent threshold:	OFF, 0.002 – 0.200A in 0.001A steps (1A rating) OFF, 0.01 – 1.00A in 0.01A steps (5A rating)
Delay Type:	DTL, IEC NI, IEC VI, IEC EI, UK LTI, IEEE MI, IEEE VI, IEEE EI, US CO8 I, US CO2 STI
IDMTL Time Multiplier Setting TMS:	0.010 – 1.500 in 0.001 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Type:	Definite Time or Dependent Time
Reset Definite Delay:	0.0 – 300.0s in 0.1s steps
Reset Time Multiplier Setting RTMS:	0.010 – 1.500 in 0.001 steps
DTL delay (back-up timer):	0.00 – 300.00s in 0.01s steps
SEF 2nd, 3rd, 4th threshold:	OFF, 0.002 – 0.200A in 0.001A steps (1A rating) OFF, 0.01 – 1.00A in 0.01A steps (5A rating)
DTL delay:	0.00 – 300.00s in 0.01s steps
SEF Characteristic angle:	–95° to +95° in 1° steps
SEF Boundary of operation:	±87.5°, ±90°
SEF directional voltage threshold:	0.5 – 100.0V in 0.1V steps
Residual power threshold:	OFF, 0.00 – 20.00W in 0.01W steps (1A primary) OFF, 0.0 – 100.0W in 0.1W steps (5A primary)
Phase Undercurrent Protection	
Undercurrent 1st, 2nd threshold:	OFF, 0.10 – 2.00A in 0.01A steps (1A rating) OFF, 0.5 – 10.0A in 0.1A steps (5A rating)
DTL Delay:	0.00 – 300.00s in 0.01s steps
Thermal Overload Protection	
$I_\theta = k.I_{FLC}$ (Thermal setting):	OFF, 0.40 – 2.00A in 0.01A steps (1A rating) OFF, 2.0 – 10.0A in 0.1A steps (5A rating)
Previous load current (I_P)	0.00 – 1.00A in 0.01A steps (1A rating) 0.0 – 5.0A in 0.1A steps (5A rating)
Time constant (τ):	0.5 – 500.0mins in 0.1min steps
Thermal alarm:	OFF, 50% to 99% in 1% steps

Directional Negative Phase Sequence Overcurrent Protection (NOC)	
NOC 1st, 2nd threshold:	OFF, 0.10 – 2.00A in 0.01A steps (1A rating) OFF, 0.5 – 10.0A in 0.1A steps (5A rating)
DTL delay:	0.00 – 300.00s in 0.01s steps
NOC Characteristic angle:	−95° to +95° in 1° steps
NOC Directional voltage threshold	0.5 – 25.0V in 0.1V steps
Overvoltage Protection	
1st, 2nd Overvoltage thresholds:	OFF, 10.0 – 200.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL
IDMTL Time Multiplier Setting TMS:	0.05 – 100.00 in 0.01 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
DO/PU ratio	10 – 98% in 1% steps
Reset Delay (1st threshold only):	0.0 – 300.0s in 0.1s steps
Undervoltage Protection	
1st, 2nd Undervoltage thresholds:	OFF, 5.0 – 130.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL
IDMTL Time Multiplier Setting TMS:	0.05 – 100.00 in 0.01 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Delay (1st threshold only):	0.0 – 300.0s in 0.1s steps
Undervoltage Block	5.0 – 20.0Vin 0.1V steps
Zero Phase Sequence Overvoltage Protection (ZOV)	
1st, 2nd ZOV Overvoltage thresholds:	OFF, 1.0 – 130.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL
IDMTL Time Multiplier Setting TMS:	0.05 – 100.00 in 0.01 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Delay (1st threshold only):	0.0 – 300.0s in 0.1s steps
Negative Phase Sequence Overvoltage Protection (NOV)	
1st, 2nd NOV Overvoltage thresholds:	OFF, 1.0 – 130.0V in 0.1V steps
Delay type (1st threshold only):	DTL, IDMTL
IDMTL Time Multiplier Setting TMS:	0.05 – 100.00 in 0.01 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
Reset Delay (1st threshold only):	0.0 – 300.0s in 0.1s steps
Under/Over Frequency Protection	
1st - 4th under/overfrequency threshold	(F_{nom} − 10.00Hz) – (F_{nom} + 10.00Hz) in 0.01Hz steps F_{nom}: nominal frequency
DTL delay:	0.00 – 300.00s in 0.01s steps
Frequency UV Block	40.0 – 100.0V in 0.1V steps
Broken Conductor Protection	
Broken conductor threshold (I_2/I_1):	OFF, 0.10 – 1.00 in 0.01 steps
DTL delay:	0.00 – 300.00s in 0.01s steps
CBF Protection	
CBF threshold:	OFF, 0.10 – 2.00A in 0.01A steps (1A rating) OFF, 0.5 – 10.0A in 0.1A steps (5A rating)
CBF stage 1 (Backup trip) DTL:	0.00 – 300.00s in 0.01s steps
CBF stage 2 (Re-trip) DTL:	0.00 – 300.00s in 0.01s steps

Autoreclose	
ARC Reclaim Time	0.0– 600.0s in 0.1s steps
Close Pulse Width	0.01 – 10.00s in 0.01s steps
Lock-out Recovery Time	OFF, 0.1 – 600.0s in 0.1s steps
Sequences	1 – 5 Shots to Lock-out, each trip programmable for inst or Delayed operation
Dead Times(programmable for each shot)	0.01 – 300.00s in 0.01s steps
Accuracy	
Overcurrent Pick-ups:	100% of setting ± 5%
Overcurrent PU/DO ratio:	≥100%
Undercurrent Pick-up:	100% of setting ± 5%
Undercurrent PU/DO ratio:	≤100%
Overvoltage Pick-ups:	100% of setting ± 5%
Undervoltage Pick-ups:	100% of setting ± 5%
Inverse Time Delays:	± 5% or 30ms (1.5 to 30 times setting)
Definite Time Delays:	± 1% or 10ms
Transient Overreach for instantaneous elements:	<–5% for X/R = 100.
Front Communication port - local PC (RS232)	
Connection:	Point to point
Cable type:	Multi-core (straight)
Cable length:	15m (max.)
Connector:	RS232C 9-way D-type female
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:	64kpbs for RSM system 9.6, 19.2kbps for IEC60870-5-103
Rear Communication port - remote PC (Fibre Optic for IEC60870-5-103: option)	
Cable type:	50/125 or 62.5/125μm fibre
Cable length:	1000m (max.)
Connector:	ST
Transmission rate:	9.6, 19.2kbps for IEC60870-5-103
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
Binary Outputs	
Number	8
Ratings:	Make and carry: 4A continuously Make and carry: 20A, 290Vdc for 0.5s (L/R≥5ms) Break: 0.1A, 290Vdc (L/R=40ms)
Durability:	Loaded contact: 10000 operations Unloaded contact: 100000 operations
Mechanical design	
Weight	4.5kg
Case colour	Munsell No. 10YR8/0.5
Installation	Flush mounting

ENVIRONMENTAL PERFORMANCE

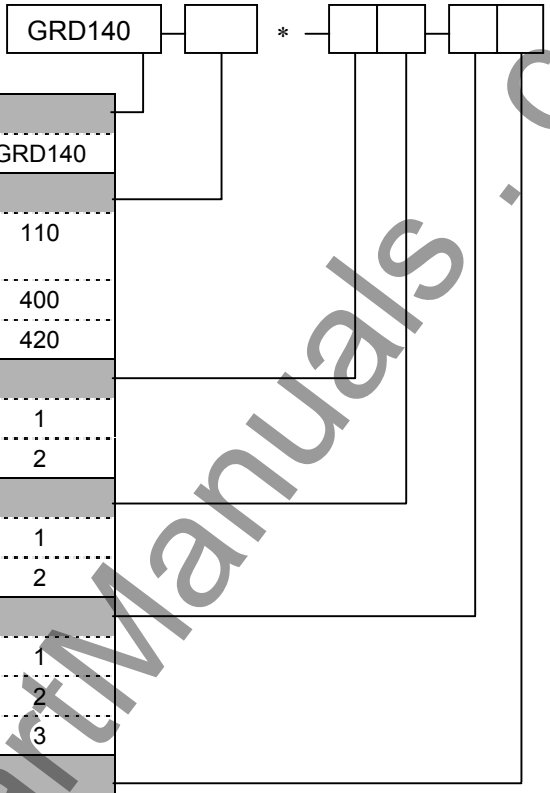
Test	Standards	Details
Atmospheric Environment		
Temperature	IEC60068-2-1/2	Operating range: -10°C to +55°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC60068-2-3	56 days at 40°C and 93% relative humidity.
Enclosure Protection	IEC60529	IP51
Mechanical Environment		
Vibration	IEC60255-21-1	Response - 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: 4kV/2kV (peak) PSU and I/O ports: 2kV/1kV (peak) RS485 port: 1kV/0.5kV (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		
CE	89/336/EEC	Compliance with the European Commission Electromagnetic Compatibility Directive is demonstrated according to EN 61000-6-2 and EN 61000-6-4.
	73/23/EEC	Compliance with the European Commission Low Voltage Directive is demonstrated according to EN 50178 and EN 60255-5.

PROTOCOL CONVERTER G1PR2 (OPTION)

Ratings		
Power supply:	110Vdc/100Vac	Operative range: 88 - 150Vdc of 110Vdc rated voltage 80 - 120Vac of 100Vac rated voltage
	220Vdc/200Vac	Operative range: 170 - 300Vdc of 220Vdc rated voltage 200 - 240Vac of 200Vac rated voltage
	48Vdc	Operative range: 38.4 - 72Vdc
Burden:	less than 20W	
Communication port		
RS232C interface		
Connector type	RS232C 9-pin D-subminiature connector female	
Cable type	Multi-core (straight)	
RS485 interface		
Connector	Screw terminals (Phoenix Contact, FRONT type)	
Cable type	Twisted pair cable	
Optical interface		
Operative Range:	less than 1.2km with 62.5/125μm GI fibre (3dB/km)	
Wavelength:	820nm	
Connector type:	ST	
Fibre type:	62.5/125μm glass fibre	
IRIG-B		
Connector	Screw terminals (Phoenix Contact, FRONT-MSTB type)	
Mechanical design		
Enclosure Protection	IEC60529, IP20 (excluding terminal parts)	
Weight	5 kg	
Installation	Flush mounting	
Atmospheric Environment		
Temperature	IEC60068-2-1/2	Operating range: -10°C to +55°C. Storage / Transit: -25°C to +70°C.
Humidity	IEC60068-2-3	56 days at 40°C and 93% relative humidity.

ORDERING

1. Directional Overcurrent Relay



Type:	
Directional Overcurrent Relay	GRD140
Model:	
-Model 110: Directional earth fault and directional sensitive earth fault	110
-Model 400: Directional 3 phase + earth fault	400
-Model 420: Directional 3 phase + earth + sensitive earth	420
CT Rating:	
1A	1
5A	2
Frequency:	
50Hz	1
60Hz	2
DC auxiliary supply rating:	
110V/125V	1
220V/250V	2
48V/54V/60V	3
Rear communication port:	
RS485	1
Fibre optic	2
Dual RS485	3
RS485 + Fibre optic	9

2. Protocol Converter (Option)

Type:	
Protocol converter	G1PR2
Model:	
1 port, Electrical signal (RS485)	101
4 ports, Electrical signal (RS485)	104
8 ports, Electrical signal (RS485)	108
8 ports, Electrical signal (RS485): Max. 8, Optical signal: Max. 1	118
8 ports, Electrical signal (RS485): Max. 8, Optical signal: Max. 4	148
8 ports, Electrical signal (RS485): Max. 4, Optical signal: Max. 8	184
1 port, Electrical signal (RS485) or Optical signal	111
1 port, Optical signal	110
4 ports, Optical signal	140
8 ports, Optical signal	180
AC power supply rating:	
AC 100/DC 110V	10
AC 200/DC 220V	50
DC 48V	A0
External time synchronisation:	
None.	00
Provided. (IRIG-B)	10

RELAY OUTLINE

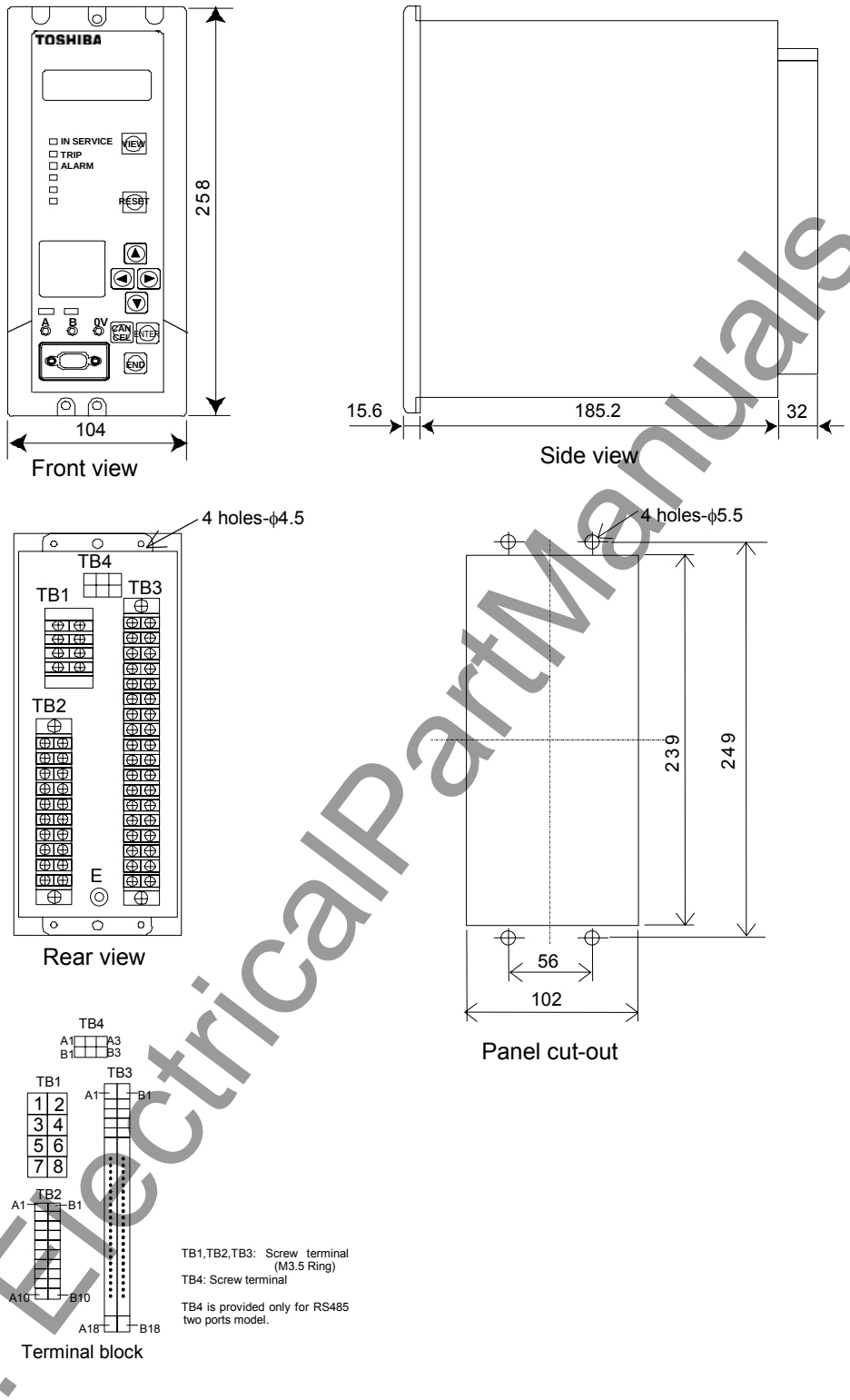
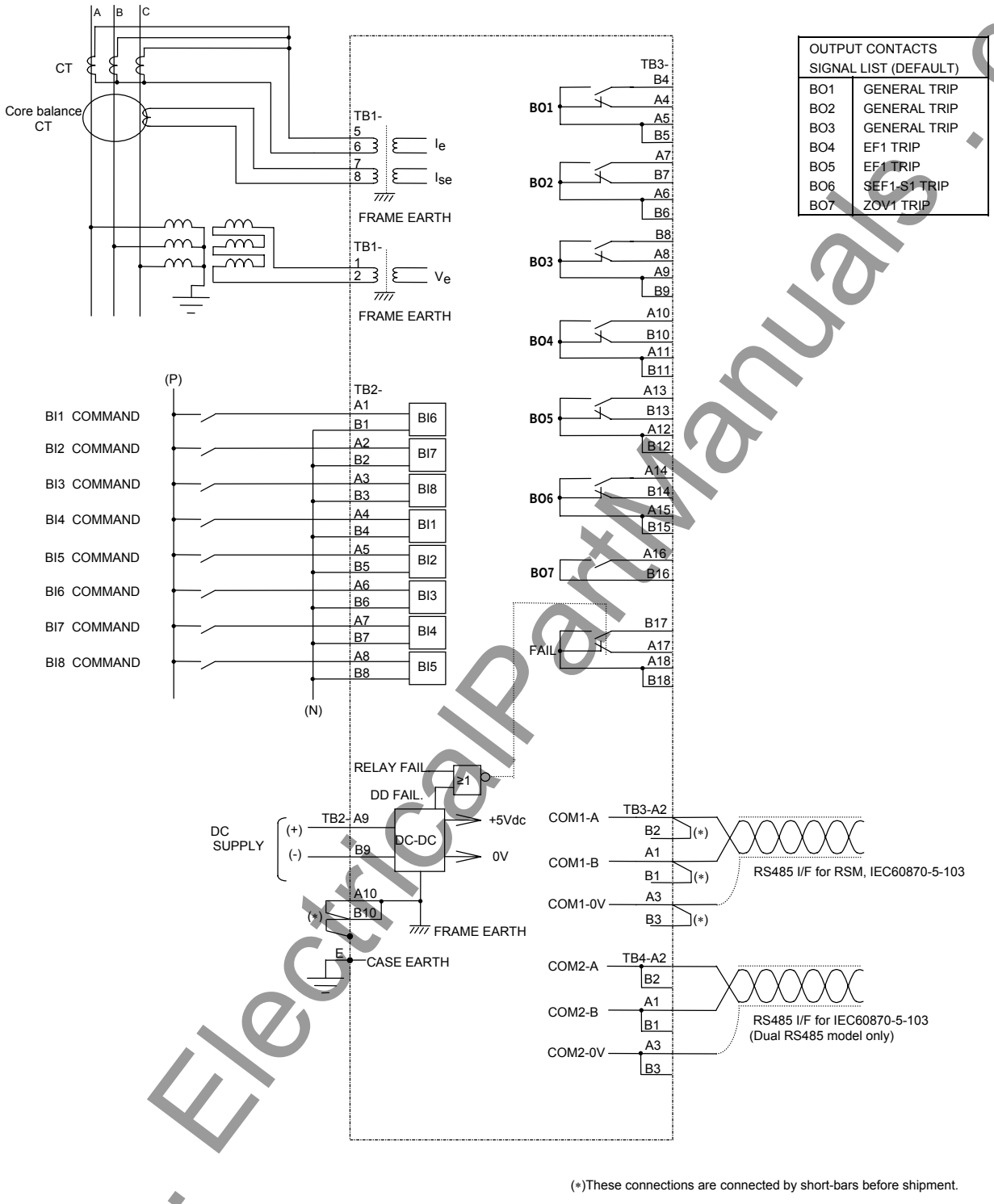


Figure 7 - GRD140 Outline Diagram

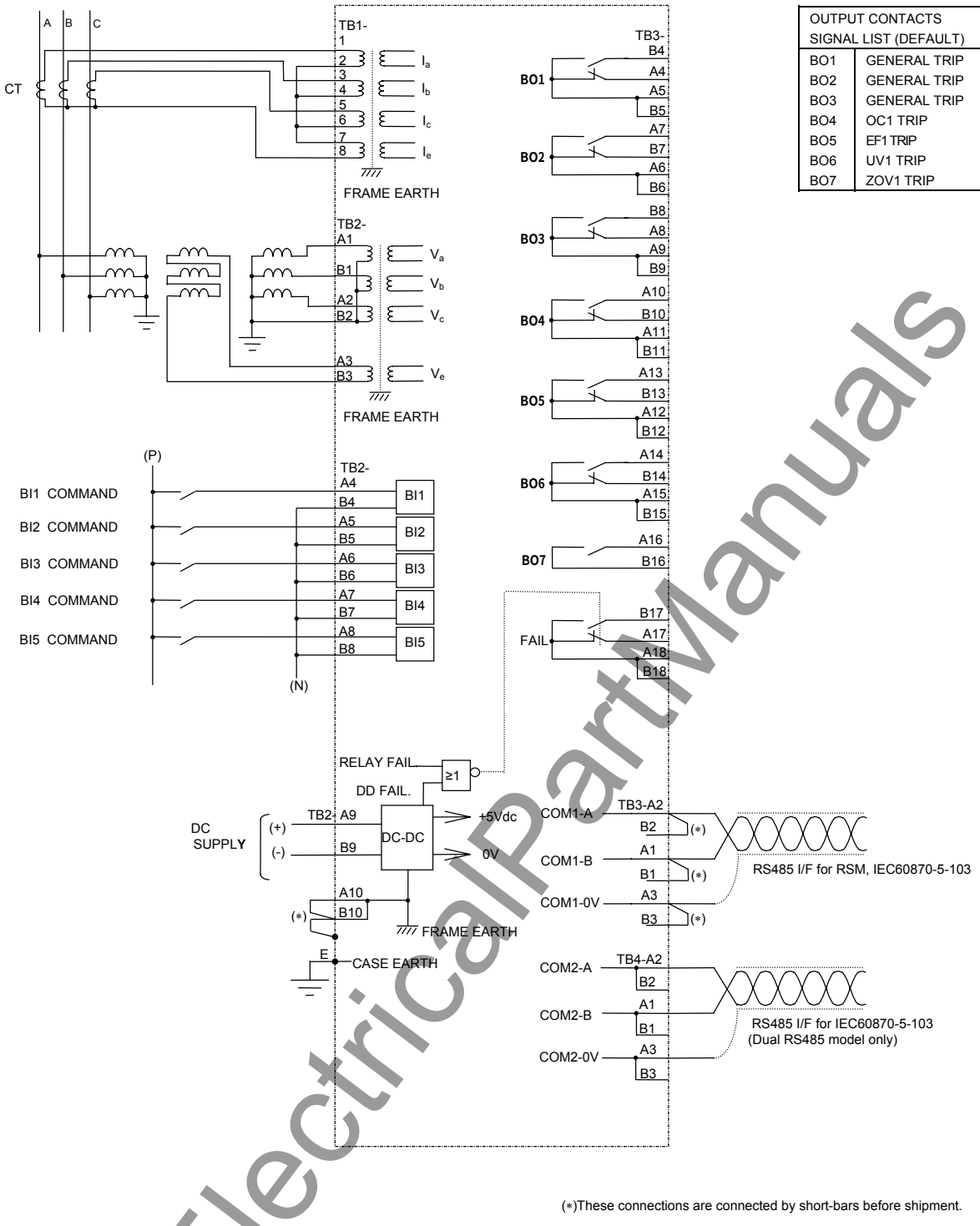
EXTERNAL CONNECTION DIAGRAM



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	GENERAL TRIP
BO4	EF1 TRIP
BO5	EF1 TRIP
BO6	SEF1-S1 TRIP
BO7	ZOV1 TRIP

(*)These connections are connected by short-bars before shipment.

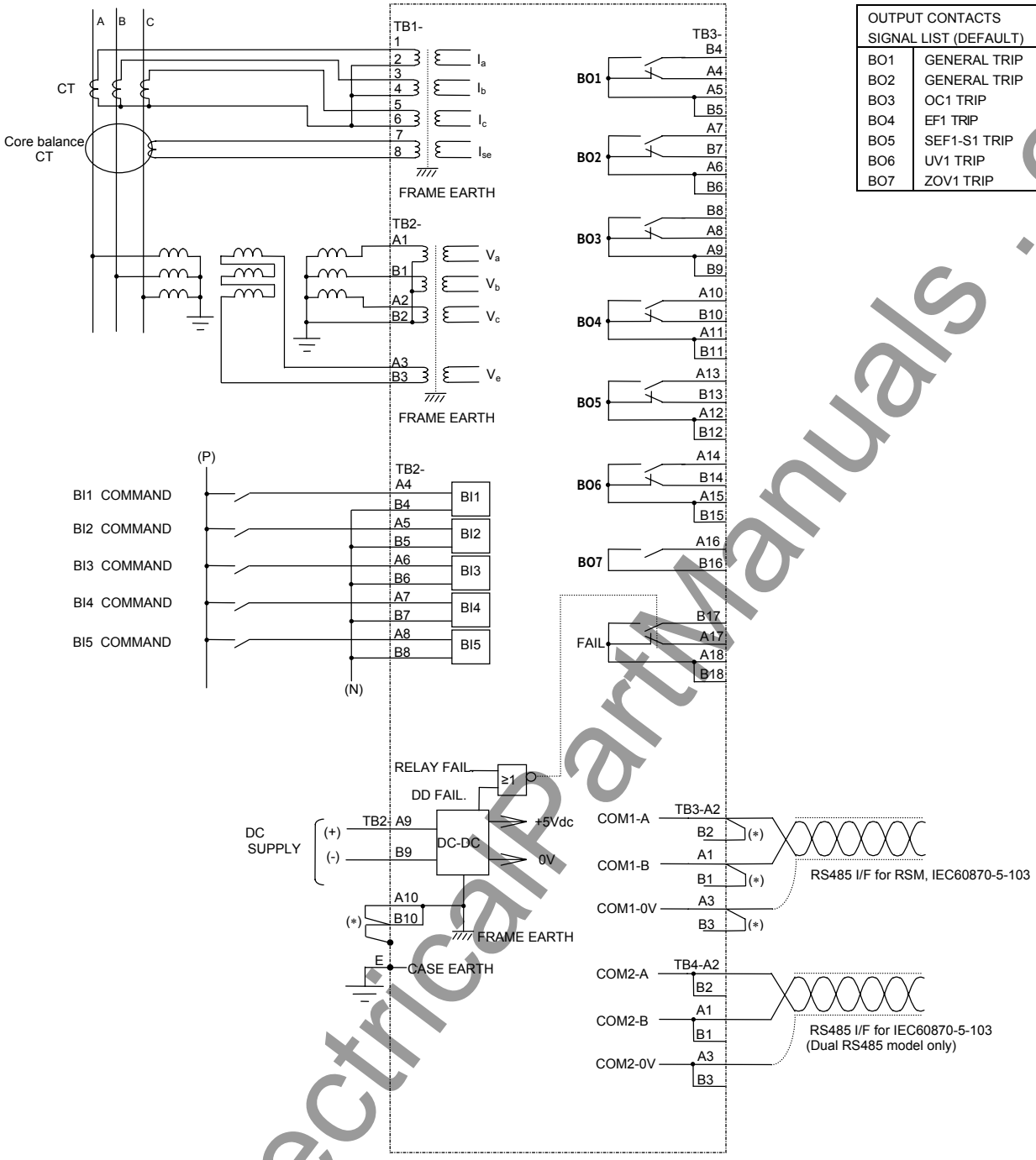
Figure 8 - GRD140-110 Typical External Connection Diagram



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	GENERAL TRIP
BO4	OC1 TRIP
BO5	EF1 TRIP
BO6	UV1 TRIP
BO7	ZOV1 TRIP

(*)These connections are connected by short-bars before shipment.

Figure 9 - GRD140-400 Typical External Connection Diagram



OUTPUT CONTACTS SIGNAL LIST (DEFAULT)	
BO1	GENERAL TRIP
BO2	GENERAL TRIP
BO3	OC1 TRIP
BO4	EF1 TRIP
BO5	SEF1-S1 TRIP
BO6	UV1 TRIP
BO7	ZOV1 TRIP

(*)These connections are connected by short-bars before shipment.

Figure 10 - GRD140-420 Typical External Connection Diagram

Numerical Relay

GRD140

DIRECTION OVERCURRENT PROTECTION

TOSHIBA

TOSHIBA CORPORATION
Industrial and Power Systems & Services Company
1-1,SHIBAURA 1-CHOME,MINATO-KU, TOKYO 105-8001,JAPAN
PHONE;+81-3-3457-3644 FAX;+81-3-5444-9168
http://www.toshiba.co.jp/f-ene/tands/english/protect/f_pc_top.htm

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