User Manual
PAC-E150
(Multi-functional Integrated Digital Current and Voltage Relay)

PNC Technologies

Safety Precautions

The following safety precautions are provided to prevent personal injuries and property damages.
Please read them carefully and follow them to use the product safely.
Keep this User Manual in a place that is easily accessible by users.

Warning

If the instruction is not followed, it may cause death or serious injuries.

Caution

If the instruction is not followed, it may cause injuries to people or damages to property.

Signs

This sign indicates prohibition.

This symbol indicates that the instruction must be followed.

Warnings

Never perform wiring work while power is supplied or the product is running.
There is a danger of electric shock.

Never perform wiring work while power is supplied or the product is running.
There is a danger of electric shock.

Never touch the product with wet hands.
There is a danger of electric shock.

Do not use the cable if the covering is damaged.
There is a danger of electric shock.

Never perform wiring work if the main power line is active.
There is a danger of electric shock, damages or fire by the charged voltage of the current transformer.

Do not disassemble the product even if power is not supplied except for wiring work or regular inspections.
There is a danger of electric shock by the charged current inside the product.

Do not disassemble the product even if power is not supplied except for wiring work or regular inspections.
There is a danger of electric shock by the charged current inside the product.

Use the terminal block when connecting the cables.
There is a danger of electric shock by the exposed wires of the cable.

Cover the terminal at the rear terminal block after wiring work.
There is a danger of electric shock.

Cautions

Apply the rated power to the power terminal of the product.
There is a danger of product damage and fire if the rated power is not used.

Adhere to the rated loads of the input and output contacts.
There is a danger of product damage and fire if the rated load is not used.

Keep the product free of foreign substances such as screws, metals, water, oil, etc.
There is a danger of product damage and fire.

Do not expose the product to direct sunlight.
There is a danger of product damage.

Insert or remove the product into/from the case on a level place.
There is a danger of product damage if it is handled on an uneven place.

Make sure that the product is normal before installing it.
The product may become abnormal due to excessive shock during distribution.

Check the use environment of the product before installing it.
Check the use environment and conditions of the product in this User Manual before installing it.

Perform regular and daily inspections.
- Check any damages of the product.
- Check the installation and terminal connections.
- Check the product operation status and indications.
- Check any problems such as abnormal sound and discoloration.

Always keep the product clean.
Do not wipe the surface of the product cover too strongly.
Stay clear of volatile chemicals (e.g., benzene, thinner).

Adhere to the specified location and test voltage when performing an insulation test.
Always observe the test conditions in this User Manual because the test conditions may differ by model or terminal.

If you do not use the product for a long time, turn off the power, disconnect the cable, and pack the product. Then keep the product under the following conditions:
- Ambient temperature: -30 ~ +75℃
- Daily average temperature: +35℃ or lower
- Relative humidity: 90% or lower
- No dusts, corrosive gases, salts, or harmful smokes
- No vibration or shock
- No moisture or direct sunlight

If the product breaks down or works abnormally, disconnect the power supply and call our after-sales service department.

When you disuse the product, discard the product as a general industrial waste.

REVISIONS

REV	Date	Description/Reason
V1.0	2005.12.07	Draft of the PAC-E150 Manual
V2.0	2010.03.17	Cold Load, Inrush, TCP/IP, Data logger Updated

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1 Overview

PAC-E150 is a multi-functional integrated digital current and voltage relay that satisfies the standards of KEMC-1120 (2008.06.26), IEC-60255, and CE.

The protective relay elements of PAC-E150 include Instantaneous/Time-delayed Overcurrent, Selective Ground Overcurrent, Thermal Overload, Undercurrent, Negative Sequence Overcurrent, Phase Unbalance Protection, Start-up Monitoring/Stall Protection for Motor, Ground Overvoltage, Cold Load Pickup, and Inrush. The time-current behavior characteristic curves consist of 4 IEC standard curves, 7 ANSI standard curves, and 2 voltage inverse time characteristic curves for the Ground Overvoltage protection element.

PAC-E150 can measure the phase current, ZCT current, ground voltage, sequence current, 2nd harmonic phase current, thermal, and frequency, and control the circuit breaker.

PAC-E150 provides Programmable EasyLogic to allow the simple implementation of a hardware sequence logic, which used to be made up by receiving the relay output as input, inside the PAC-E150. Furthermore, for user convenience, four programmable LEDs that can be easily made up by user are provided.

There is one RS-232 port for communication with E3RSet™ which is an integrated PC application on the front of PAC-E150, and there are one RS-485 port and one RS-232 port for linking with remote monitoring systems on the back. Communication protocols for remote systems include ModBus RTU, Modbus TCP/IP (optional), DNP3.0, and IEC 60870-5-103.

1.1 Features

- Protection of isolateding wiring lines and motor control
- 10 protective relay elements: OCR, SGR, Thermal Overload, UCR, NSOCR, UBOCR, STALL, OVGR, Cold Load, Inrush
- Various behavior characteristic curves: IEC standard, ANSI standard, KEPCO induction type, voltage inverse time characteristic curve
- Control of circuit breaker open/close, on-site/remote, etc.
- Digital display of settings and measurements on a LCD screen (2 × 16 LCD screen)
- Recording of 128 events and up to 20 fault waveforms (16 samples/cycle)
- Data Logger recording (analog input, digital channel 16 points, up to 10000 min)
- Self-diagnosis function: Memory, range of setting values, AD converter, calibration
- Trip circuit (TCS) monitoring function
- Four user-definable LEDs
- Easy to design a switchboard through the composition of a sequence logic using the Programmable EasyLogic
- Test function: Output contact and front display
- Free selection of control voltage (client selection: AC 110~240V, DC80~300V).
- Improved security function through the requirement of password input when changing setting values or controlling circuit breaker
- Electrical quantity measurement functions: Size and phase of each phase current, size and phase of ZCT current, size and phase of ground voltage, size and phase of symmetrical current, size of the 2nd harmonic of the current in each phase, thermal, frequency, etc.
- Engineering tools: Change of setting values, event view, accident wave form analysis, and Data Logger analysis
- Communication ports: One RS232 port on the front (Modbus Protocol: change of setting values, event/fault waveforms/Data Logger transmission, measurement monitoring); one RS485 port and one RS232 port on the back (SCADA communication, DNP3.0/Modbus RTU/IEC60870-5-103/Modbus TCP/IP protocol).
- Improved EMC/EMI performance

1.2 Application

■ Protection of isolateding wiring lines and motor control

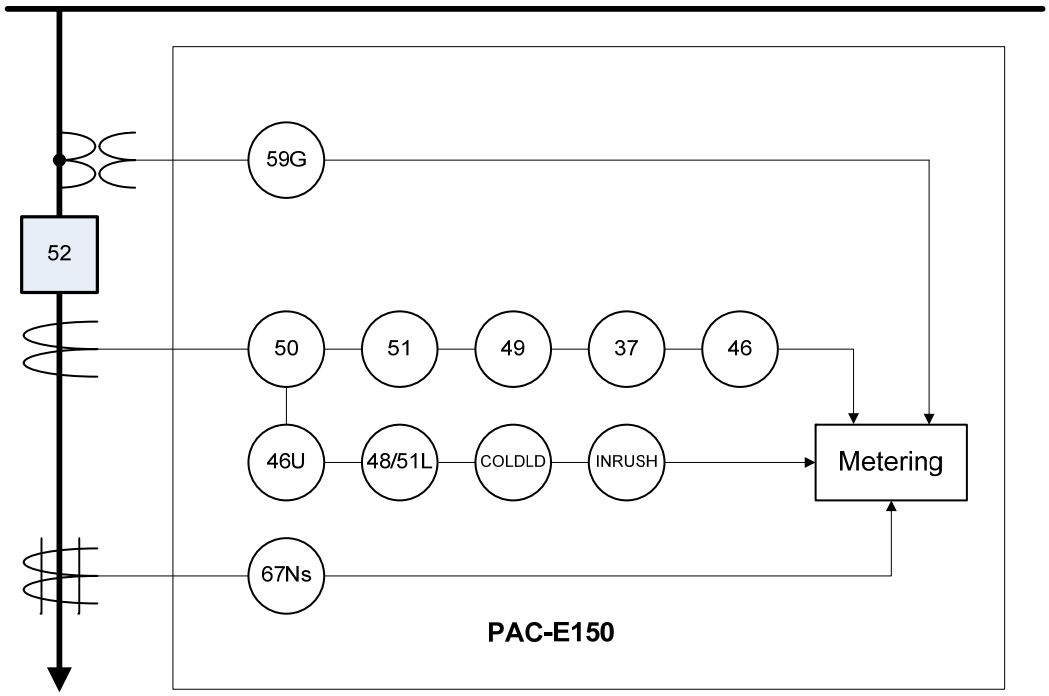

Figure 1-1 Function Diagram

Table 1-1 Device/Functions

Device	Functions
52	Circuit Breaker
50	Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection
51	Time-delayed Short-circuit Overcurrent Protection
49	Thermal Overload Protection
37	Undercurrent Protection
46	Instantaneous/Definite Time-delayed Negative Sequence Overcurrent Protection
46U	Phase Unbalance (Loss of Phase) Protection
48/51L	Start-up Monitoring/Stall Protection for Motor
COLD LD	Cold Load Pickup
INRUSH	Inrush Current Detection
59G	Ground Overvoltage Protection
67Ns	Selective Ground Overcurrent Protection

1.3 General Specifications

1.3.1 Control Power Supply

Input	AC 110~240 V±20%(50/60 Hz), DC 80~300V
Power Consumption	10VA or lower

1.3.2 Current/Voltage

Current	
Rated Current	AC 5/1A (50/60Hz)
Input Range	0.1 ~ 250A (5A rating), 0.02 ~ 50A (1A rating)
Overload Capability (Maximum permissible current)	1 sec (100 times of rating) 4 sec (20 times of rating) Continuous (3 times of rating)
Load	0.5VA or lower / phase
ZCT Current	
Rated Current	AC 1.5mA(50/60Hz)
Input Range	0.5 ~ 380mA
Load	0.5VA or lower / phase
Voltage	
Rated Voltage	AC 220V(50/60Hz)
Input Range	1 ~ 220V
Load	0.5VA or lower / phase

1.3.3 Contact Output

For Trip (4 Points(2A, 2C), Configurable)	
Closed Circuit Capacity	16A / Continuous / AC 250V 30A / 0.5sec / DC 125V / Resistance Load
Open Circuit Capacity	0.5A / 25ms (L/R Time Constant) / DC 125V

1.3.4 Contact Input

Count	4, Configurable
Input Voltage	Maximum DC 250V
On/Off Recognition Voltage	Von≥80V, Voff ≤60V
Contact Application Time	10ms or less

1.3.5 Communication

Front RS-232C	1 (For maintenance/E3RSet) 38400bps (fixed), 8bit/No parity/1 stop Modbus protocol
Rear RS-232	1, 38400bps (fixed), 8bit/No parity/1 stop, Modbus protocol
Rear RS-485	1 (For SCADA communication) 300 ~ 38400bps, 8bit/No parity/1 stop Modbus/DNP3.0/IEC60870-5-103 protocol

1.3.6 Case

Structure	Draw-out type
Material	Fe
Weight	2.8kg
Terminal Block	U(spade)/Rring Rug
	Inner diameter: 5mm, Maximum outer diameter: 12mm

1.4 Tests

1.4.1 Insulation Test

Insulation Resistance	
Standards	IEC60255-5, ANSI/IEEE 37.90.0
Details	Measurements with 500 Vdc insulation resistance meter
	Electric Circuit Batch-Case 10 MΩ
	Between Electric Circuits 5 MΩ
	Between Contact Circuit Terminals 5 MΩ
	Communication Circuit Batch-Case 10 MΩ
Commercial Frequency Withstand Voltage	
Standards	IEC60255-5, ANSI/IEEE 37.90.0
Details	Applied Time: 1 min (50/60 Hz)
	Electric Circuit Batch-Case 2 kV
	Between Electric Circuits 2 kV
	Between Contact Circuit Terminals 1 kV
	Communication Circuit Batch-Case 500 V
Lightning Impulse Withstand Voltage	
Standards	IEC60255-5, ANSI/IEEE 37.90.0
Details	Applied waveform: 1.2×50 μs
	Application count: 3 times for each of positive/negative polarities
	Electric Circuit Batch-Case 5 kV
	Transformer Circuit-Control Circuit 5 kV
	Between Control Circuits 3 kV
	Between Transformer Circuit Terminals 3 kV
	Between Control Power Circuit Terminals 3 kV
	Communication Circuit Batch-Case 500 V

1.4.2 Noise Resistance Test

1MHz burst disturbance	
Standards	IEC60255-22-1, ANSI/IEEE C37.90.1
Details	Vibration frequency: 1 MHz
	Voltage rising time: 75 ns
	Repetition frequency: 400 Hz
	Output impedance: 200 Ω
	Application method: Asynchronous
	Polarity: positive, negative
	Applied time: 2 sec
	Control Power Circuit: Common Mode 2.5 kV
	Differential Mode 1.0 kV
	Transformer Circuit: Common Mode 2.5 kV
	Differential Mode 1.0 kV
	Contact Circuit Common Mode 2.5 kV
	Differential Mode 1.0 kV
Fast transients / burst	
Standards	IEC60255-22-4 class Ⅳ, ANSI/IEEE C37.90.1
Details	Voltage rising time: 5 ns
	50% peak voltage holding time: 50 ns
	Repetition frequency: 5.0 kHz
	Burst holding time: 15 ms
	Burst cycle: 300 ms
	Application method: Asynchronous, Common- Mode
	Polarity: positive, negative
	Applied time: 1 min
	Idle time: 1 min
	Control Power Circuit: 4 kV
	Transformer Circuit: 4 kV
	Contact Input/Output Circuit: 4 kV
	Ground Circuit: 4 kV
	Communication Circuit: 2 kV
Electrostatic discharge	
Standards	IEC60255-21-2 class Ⅱ
Details	Voltage polarity: positive, negative
	Application count: 10
	Application interval: 1 sec
	Applied part: Case
	Air discharge: 8 kV
	Contact discharge: 6 kV

Composite Surge

Standards	IEC60255-22-5 class Ⅳ
Details	Voltage waveform: 1.2×50 μs Current waveform: 8×20 μs Output impedance: 2 Ω (Control Power Circuit) 12 Ω (Current Circuit) 42 Ω (Contact Circuit) Application method: Asynchronous Polarity: positive, negative Application count: 5 Application interval: 60 sec Control Power Circuit: Common Mode 4.0 kV Differential Mode 2.0 kV Transformer Circuit: Common Mode 4.0 kV Differential Mode 2.0 kV Contact Circuit: Common Mode 4.0 kV Differential Mode 2.0 kV Communication Circuit: Common Mode 1.0 kV Differential Mode 0.5 kV

Radiated Susceptibility

Standards	IEC60255-22-3 class Ⅲ, ANSI/IEEE C37.90.2
Details	**Frequency sweep test** Electric field strength: 10 V/m Applied frequency: 80 MHz~1 GHz, 1.4 GHz~2.7 GHz Frequency modulation: 1 kHz sine wave 80 % AM Applied direction: Front, rear, left and right Antenna direction: vertical, horizontal Dwell time: 1 sec **Spot frequency sweep test** Electric field strength: 10 V/m Applied frequency: (80, 160, 380, 450, 900, 1850, 2150) MHz, Frequency modulation: 1 kHz sine wave 80 % AM Applied direction: Front, rear, left and right Antenna direction: vertical, horizontal Dwell time: 10 sec

Line Conducted HF

Standards	IEC 61000-4-6 class Ⅲ
Details	**Frequency sweep test** Applied frequency: 150 kHz ~ 80 MHz Electric field strength: 10 V Frequency modulation: 1 kHz sine wave 80 % AM Dwell time: 1 sec **Spot frequency sweep test** Electric field strength: 10 V Applied frequency: (27, 68) MHz, Frequency modulation: 1 kHz sine wave 80 % AM Dwell time: 1 sec

1.4.3 Mechanical Test

Vibration

Standards	IEC60255-21-1 class II
Details	**Vibration response** Frequency range: 10 Hz~150 Hz Crossover frequency: 60 Hz Vibratory force - 60 Hz or lower: Displacement amplitude 0.075 mm (peak amplitude) Higher than 60 Hz: Acceleration 1.0 G(4.9 ㎨) Sweep cycle: 1 (about 8 min) Vibration direction: Front, rear, left, right, top, and bottom **Vibration endurance** Frequency range: 10 Hz~150 Hz Acceleration: 2.0 G(9.8 ㎨) Sweep cycle: 20 (about 160 min) Vibration direction: Front, rear, left, right, top, and bottom

Impact

Standards	IEC60255-21-2 class I
Details	**Impact response** Pulse waveform: Half sine wave Maximum acceleration: 10 G(49 ㎨) Pulse duration: 11 ㎳ Application direction: Front, rear, left, right, top, and bottom Application count: 3 times in positive and negative polarities for each direction **Impact endurance** Pulse waveform: Half sine wave Maximum acceleration: 30 G(147 ㎨) Pulse duration: 11 ㎳ Application direction: Front, rear, left, right, top, and bottom Application count: 3 times in positive and negative polarities for each direction

Collision

Standards	IEC60255-21-2 class I
Details	Pulse waveform: Half sine wave Maximum acceleration: 20 G(98 ㎨) Pulse duration: 16 ㎳ Application direction: Front, rear, left, right, top, and bottom Application count: 1000 times in positive and negative polarities for each direction (1 sec interval)

Earthquake

Standards	IEC60255-21-3 class I
Details	Frequency range: 1 Hz~35 Hz Crossover frequency: 8.5 Hz Horizontal vibratory force - 8.5 Hz or lower: Displacement amplitude 3.5 mm (peak amplitude) Higher than 8.5 Hz: Acceleration 1 G(9.8 ㎨) Sweep cycle: 1 (about 1 min) Vibration direction: Front, rear, left, right, top, and bottom

1.4.4 Temperature and Humidity Test

Standards	IEC 60068-2-1/2
Operation temp.	-25 ~ 70°C
Storage temp.	-30~75°C
Humidity	RH 30~ 95%

1.5 Use Environment

Elevation	1000m or lower
Others	Free of abnormal vibration, impact, slope, electric field effect, explosive powder, inflammable dust, inflammable/corrosive gas, and salt

1.6 Protection/Detection Elements

1.6.1 Short Circuit Overcurrent Protection (50/51)

Operation Current	0.50~100.00A, 0.05A step
Definite time-delayed operation time	0.00~60.00sec, 0.01sec step
Inverse time-delayed magnification (TM)	0.01~10.00, 0.01 step
Inverse time-delayed operation characteristics	See Appendix. Inverse Time-delayed Operation Characteristics
	IEC
	Normal Inverse(IEC_NI)
	Very Inverse(IEC_VI)
	Extremely Inverse(IEC_EI)
	Long Inverse(IEC_LI)
	ANSI/IEEE
	Inverse(ANSI_I)
	Short Inverse(ANSI_SI)
	Long Inverse(ANSI_LI)
	Moderately Inverse(ANSI_MI)
	Very Inverse(ANSI_VI)
	Extremely Inverse(ANSI_EI)
	Definite Inverse(ANSI_DI)
	KEPCO
	Normal Inverse(KNI)
	Very Inverse(KVI)

1.6.2 Selective Ground Overcurrent Protection (67Ns)

Direction	NONE/FORWARD.REVERSE
Operation Voltage	5~110V, 1V step
Operation Current	0.9~300.0mA, 0.1mA step
MTA	-90~+90°, 1° step
Definite time-delayed operation time	0.00~60.00sec, 0.01sec step

1.6.3 Thermal Overload Protection (49)

K-Factor	0.10~4.00, 0.01 step
Time Constant (τ)	1.0~999.9min, 0.1min step
Cool Factor	1.0~10.0, 0.1 step
Alarm Level	50~100% of the trip level, 1% step

1.6.4 Undercurrent Protection (37)

Operation Current	0.10~ 5.00A, 0.05A step
Operation Time	0.00~180.00sec, 0.01sec step

1.6.5 Negative Sequence Overcurrent Protection (46)

Operation Current (I2)	0.50~ 100.00A, 0.05A step
Definite time-delayed operation time	0.00~180.00sec, 0.01sec step

1.6.6 Phase Unbalance (Loss of Phase) Protection (46U)

Operation Ratio (I2/I1)	2~80%, 1% step
Minimum Normal Current (I1)	0.50~5.00A, 0.05A step
Operation Time	0.00~180.00sec, 0.01sec step

1.6.7 Start-up Monitoring/Stall Protection for Motor (48/51L)

Start-up Current	5.00~90.00A, 0.05A step
Start-up Time	1.0~180.0sec, 0.1sec step
Rotor Locked Time	0.5~180.0sec, 0.1sec step
Speed Switch	None, DI1~DI4

1.6.8 Ground Overvoltage Protection (59G)

Mode	DT/INVERSE TRIP/INVERSE ALARM
Operation Voltage	5~170V, 1V step
Definite time-delayed operation time	0.00~60.00sec, 0.01sec step
Inverse time-delayed magnification (TM)	0.01~10.00, 0.01 step

1.6.9 Cold Load Pickup(COLDLD)

Operation Current	0.50~2.50A, 0.05A step
Operation Time	0~1000sec, 1sec step
Recovery Time	0~1000sec, 1sec step

1.6.10 Inrush Current Detection (INRUSH)

Operation Ratio (I2f/I1f)	10~ 100%, 1% step
Minimum Operation Current (I1f)	0.50~2.50A, 0.05A step
Definite time-delayed operation time	0.00~60.00sec, 0.01sec step

1.6.11 Protection Element Accuracy

Operation Value	Within ± 3% of the setting
Operation Time	±40msec (≤ 1.2sec operation time)
	±3% (> 1.2sec operation time)
Recovery Value	96~98% of operation value
Recovery Time	≤40msec

1.7 Supplementary Features

1.7.1 Measurement

Current	RMS Current / Phase, 0.05~250 A ±2%(0.05~1.00A), ±0.5%(1.0~6.0A), ±1.0%(>6.0A) Is(ZCT) RMS Current / Phase, 0.5~380.0mA ±2%(0.5~8.0mA), ±0.5%(8.0~380.0mA)
Voltage	N-phase Effective Voltage / Phase, 1~220 V ±1%(1~220V)
Sequence Current	Effective Value of Positive Sequence, Negative Sequence, and Zero Sequence Current / Phase
2nd harmonic Current	2nd harmonic current effective value by phase
Thermal	A size calculated with RMS current, 0.0~250.0%
Frequency	Based on A-phase current, 40.00~70.00 Hz (0.002Hz)

1.7.2 Recording

Event Recording	
Maximum Recordings	128
Resolution	1msec
Event Items	Status of protection elements (including RMS current), contact input/output status, setting change, circuit breaker control, Power On, record deletion, etc.
Characteristics	When a protection relay element event occurs, the electrical quantity (RMS current, effective ZCT, effective voltage) are recorded together. The data remain even if the control power is lost.
Waveform Recording	
Maximum Recordings	Up to 20 depending on the setting
Samples per cycle	16 samples/cycle
Recording type (Block × Cycle)	10×12, 20×6
Trigger position	0 ~ 99% (1% step)
Trigger condition	Set by EasyLogic operand
Sample data	Current Status of protection element (pickup/motion) Status of contact input/output
Characteristics	COMTRADE (IEEE C37.111) file format The data remain even if the control power is lost.
Data Logger (Data logger Recording)	
Type	CONTINUOUS/ONE TIME
Recording Cycle	4~10000 min
Sample data	Current (average current per sample) Digital 16 points (select between protection element sate and contact input/output status)
Characteristics	The data remain even if the control power is lost.

1.7.3 EasyLogic

Operand	Circuit breaker open/close control
	Operation status of protective relay elements
	Self-diagnosis status
	Contact input status
Operator	OR8 (8 positive inputs logical sum)
	HALF_OR8 (4 positive inputs, 4 negative inputs logical sum)
	AND8 (8 positive inputs logical multiplication)
	HALF_AND8 (4 positive inputs, 4 negative inputs logical multiplication)
Reset Type	SELF (Recovery after Reset Delay)
	/ MANUAL (Recovery when RESET is inputted)
Reset Delay	0.00~60.00sec(0.01 sec step)
Characteristics	Contact output and LED control through EasyLogic

1.7.4 Control

Circuit Breaker	
Count	1 CB
Interlocking	Freely configurable through EasyLogic
Local Control	Control through the control keypad
	Operation errors are prevented by password input
Remote Control	Control through the RS-485 communication port at the rear or through contact input

2 Operational Description

2.1 Configuration of Front Display and Control Panel

The front Display and Control Panel of PAC-E150 consists of an LCD (16 chars × 2 lines), 13 LEDs, 11 keypad buttons, and an RS232C communication port.

Operation errors are prevented by requiring password input before the values are changed or the control keypad is operated. The protection functions are carried out even while the operation information is handled through the LCD. When an event of a higher priority occurs, the latest information is updated and displayed on the LCD.

In addition to operation through the display, you can also connect E3RSet™ to the front RS232C port to use your notebook for convenient modification of the values and transmission of events and fault waveforms.

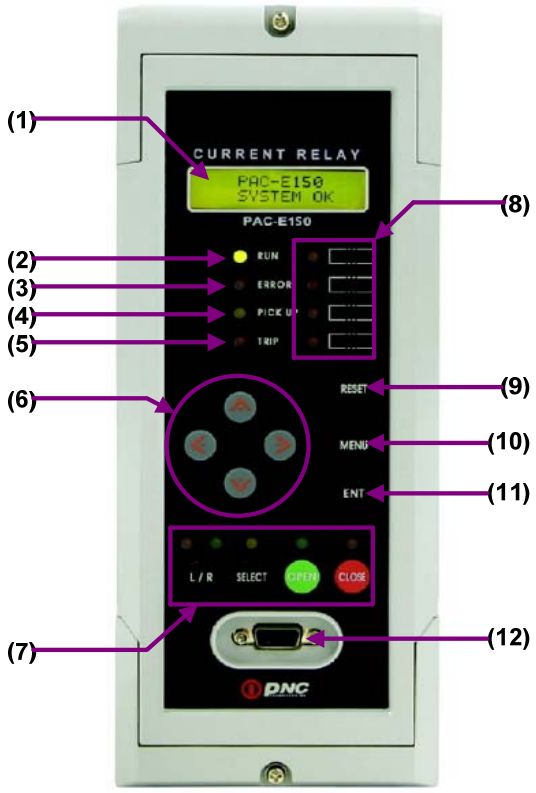

Figure 2-1 Function Diagram

Table 2-1 LED/LCD Functions

LED/LCD		Functions
(1) LCD		Display of settings, measurements, and operation screen
(2) "RUN/TEST"		Green; LED is lighted when the control power is supplied LED flashes when the contact output or front display is tested
(3) "ERROR"		Red; LED is lighted when the system or TCS monitoring function is in error. LED can be restored by manual reset using the RESET key.
(4) "PICKUP"		Yellow; LED is lighted when a protection element is picked up.
(5) "TRIP"		Red; LED is lighted when a protection element LED can be restored by manual reset using the RESET key.
(7) Control	"L/R" LED	Red (Local)/Green (Remote) Displays Local/Remote control status.
	"SELECT"LED	Yellow LED flashes in Local control mode
	"OPEN" LED	Green Lights when the circuit breaker is open.
	"CLOSE"LED	Red Lights when the circuit breaker is closed
(8) Programmable LED		4 Red LEDs; Functions can be assigned via EasyLogic.

Table 2-2 Key Functions

KEY		Functions
(6) Direction keys	∧	Change of items on the initial measurement screen Movement on the menu and change of value range
	∨	
	>	Movement on the menu and selection of a menu item
	<	Movement on the menu, ESC (move to top menu, cancellation of item)
(7) Control	L/R	Change of Local/Remote control position
	SELECT	Select a circuit breaker to control
	OPEN	Open the selected circuit breaker
	CLOSE	Close the selected circuit breaker
(9) RESET		Manual reset of the "ERROR" and "TRIP" LEDs Operation of EasyLogic 'ANN_RESET' Operand'
(10) MENU		Display of Menu on the top window
(11) ENTER		Enter values or confirm Yes/No on the Command Menu

(12) RS-232 communication port for connection of E3RSet™

The LCD screen of PAC-E150 is largely divided into top window and menu configuration window.
On the top window, the current size in each phase is automatically displayed in turn.

2.2 Top Window

On the top window, the current and voltage sizes in each phase are automatically displayed for 2 sec in turn

If there is no key operation for 3 min, the backlight of the LCD window goes off and the top window is displayed.

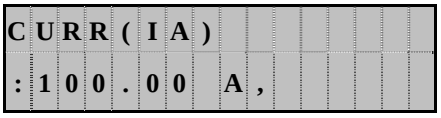

Figure 2-2 LCD Top Window

2.2.1 Measurement Display

On the top window of PAC-E150, the current and voltage sizes in each phase are automatically displayed for 2 sec in turn. The following table shows the components of the top window.

Table 2-3 LCD Initial Measurements Display Items

LCD Display Items	Description
CURR(IA)	Primary A-phase current
CURR(IB)	Primary B-phase current
CURR(IC)	Primary C-phase current
CURR(Is)	ZCT current
VOLT(VN)	Primary N-phase current

2.2.2 Status Display and Control of Circuit Breaker

How to change circuit breaker control authority

At least one contact input must be CB OPENED or CB CLOSED for the control authority and current status of the circuit breaker is displayed as LED. If the LEDs of all circuit breaker control parts are turned off, you must check the setting of the input contact and set the input contact to be used for status input of the circuit breaker as you intend it to be.

If the control authority of the circuit breaker is local or remote, and you want to change it, press the L/R key.

When you are prompted for password, use the left and right keys for each digit to enter the password, and then press the ENT key.

When you press the L/R key after entering the password, the control authority is changed to local or remote and the LED showing the control authority is changed as well.

How to control circuit breaker

At least one contact input must be CB OPENED or CB CLOSED for the control authority and current status of the circuit breaker is displayed as LED. If the LEDs of all circuit breaker control parts are turned off, you must check the setting of the input contact and set the input contact to be used for status input of the circuit breaker as you intend it to be.

If the control authority of the circuit breaker belongs to Remote, the control authority must be changed to Local using the circuit breaker control authority changing method described above (Red LED).

If the control authority of the circuit breaker belongs to Local, press the SELECT key.

When you are prompted for password, use the left and right keys for each digit to enter the password, and then press the ENT key.

After entering the password, press OPEN or CLOSE keys to control the circuit breaker.

If the command for the same status as the present is issued, the message that it is already the status appears on the LCD. If the command for the status that is different from the present is issued, the command appears on the LCD.
The password input is always required when the circuit breaker is controlled.
If you want to control the circuit breaker from Remote, you can change the control authority of the circuit breaker to Remote and control it from the upper-level communication or SCADA through RS485 communication.

2.2.3 Other Displays

"**Tx**" on the first line and "**Rx**" on the second line of the LCD indicate the transmission or receipt status of the RS485 terminal. "Tx" refers to the tx data of COM, and "Rx" refers to the rx data of COM.

2.2.4 Screen Switching

If there is no key operation for 3 min, the backlight of the LCD window goes off and the top window is displayed.

2.2.5 LED Latched Status Clear

"TRIP" LED Clear

The "TRIP" LED is the representative LED of the protection element operation and turns on when one or more protection elements are activated. The "TRIP" LED is cleared when you press the RESET key after all the protection elements have been restored.

"ERROR" LED Clear

The "ERROR" LED is the representative LED of the self-diagnosis status display and turns on when one or more self-diagnosis elements are activated. The "ERROR" LED is cleared when you press the RESET key after all the self-diagnosis elements have been restored.

2.3 Menu Configuration Window

The Menu Configuration Window consists of the DISPLAY block for displaying status, measurements, and records, the SETTING block for setting and displaying the values of the system and protection elements, and the COMMAND block for initializing records and data or testing the contact status and front display.

Menu Tree Key Operation

When you press the MENU key on the top window, it changes to the DISPLAY, SETTING, or COMMAND screens while the texts flash. When you press the ENT key, you will enter the Menu Configuration Window. On the Menu Configuration Window, you can move on the menu or change values using the direction keys. After changing the values, you must press the ENT key to input them. For menu items and settings that are not displayed on one screen, you can select them using the ∧ and ∨ keys. When you press the > key on the lowest-level menu, the details screen appears.
If there is no key operation for 3 min or if you keep pressing the < key, the top window appears again.

Example 1) When moving from the top window to the event screen:

MENU(DISPLAY) ENT(STATUS) ∨(MEASURE) ∨(RECORD) >(EVENT)

Example 2) When moving from the event screen to the RTC setting screen:

<(RECORD) <(TOP WINDOW)
MENU(DISPLAY) MENU(SETTING) ENT(SYSTEM)
>(POWER SYSTEM) ∨(WAVEFORM) ∨(DATA LOGGER) ∨(RTC)

For details of the menu configuration items, see the Menu Configuration Window.

Table 2-4 Menu Configuration Window

TOP WINDOW	DISPLAY	STATUS	CONTACT INPUT	Contact input status
			CONTACT OUTPUT	Contact output status
			SELF_DIAGNOSIS	Self-diagnosis status
			PROTECTION	Protection active status
		MEASURE		Electrical quantity measurement
		RECORD	EVENT	Event details
			WAVEFORM	Waveform details
			DATA LOGGER	Data Logger status
		SYSTEM INFO		Software version
	SETTING	SYSTEM	POWER SYSTEM	Power system setting
			WAVEFORM	Waveform setting
			DATA LOGGER	Data Logger setting
			DCMA OUTPUT	Analog output setting
			RTC	System time setting
			CB CONTROL	Circuit breaker pulse time setting
			COM	RS485 communication setting
			TCP/IP	TCP/IP communication setting
			DNP 3.0	DNP 3.0 setting
			CONTACT INPUT	Contact input setting
			CONTACT OUTPUT	Contact output setting
			LED	Programmable LED setting
			PASSWORD	Password setting
		PROTECTION	IOC1(50_1)	Setting of the instantaneous overcurrent protection 1
			IOC2(50_2)	Setting of the instantaneous overcurrent protection 2
			TOC(51)	Setting of the time-delayed overcurrent protection
			SG(67Ns)	Selective ground overcurrent protection setting
			THERMAL(49)	Thermal overload protection setting
			UC(37)	Undercurrent protection setting
			NSOC(46)	Negative sequence overcurrent protection setting
			UBOC(46U)	Phase unbalance (loss of phase) protection setting
			STALL(48/51L)	Start-up monitoring/Stall protection for motor
			OVG1(59G_1)	Setting of the ground overcurrent protection

			OVG2(59G_2)	Setting of the ground overcurrent protection 2
			OVG3(59G_3)	Setting of the ground overcurrent protection 3
			COLD LD	Cold Load Pickup setting
			INRUSH	Inrush current detection setting
	COMMAND	CONT OUT TEST		Contact output test
		EVENT CLEAR		Delete event record data
		WAVE CLEAR		Delete waveform data
		DATA LOG CLEAR		Delete/start data logger recording
		THERMAL CLEAR		Delete thermal accumulation
		PANEL TEST		Front LCD/LED test
		DATA LOG STOP		Stop/complete Data Logger recording

2.4 DISPLAY

DISPLAY shows the contact input/output status, self-diagnosis status, operation status of protection elements, and firmware version.

2.4.1 STATUS

DISPLAY/STATUS shows the operation status of input/output contacts, self-diagnosis status, and the operation status of protection elements. The information that is not displayed on one screen can be seen using the ∧ and ∨ keys.

CONTACT INPUT

DISPLAY/STATUS/CONTACT INPUT shows the current status of four contact inputs. The contact input whose function is set to a use mode (other than NOT_CONNECTED) is displayed as 'ON' if the logic is 1 and 'OFF' if the logic is 0. The contact input whose function is set to NOT_CONNECTED is displayed as 'OFF' regardless of the input status.

CONTACT OUTPUT

DISPLAY/STATUS/CONTACT OUTPUT shows the current status of four contact outputs. 'ENERGIZED' is displayed if there is output; otherwise, 'DEENERGIZED' is displayed.

SELF_DIAGNOSIS

DISPLAY/STATUS/SELF DIAGNOSIS shows the self-diagnosis status. The normal items are displayed as 'OK'. If there is an error, 'FAIL' is displayed and the SYSTEM ERROR LED turns on.
Self-diagnosis items include MEMORY, SETTING, ADCONVERTER, CALIBRATION, and TRIP CIRCUIT.

PROTECTION

DISPLAY/STATUS/PROTECTION shows only the pickup and operation status of the protection elements. For the operation status, the phase is displayed for 3-phase protection elements. For example, 'A' is displayed if the A phase is activated. For single-phase protection elements, 'OP' is displayed.

2.4.2 MEASURE

DISPLAY/MEASURE shows various measurement values. The phase display is based on A-phase current. See the following table for details of measurement display.

Table 2-5 Measurement Display

LCD Title		Description
CURR(IA)	1/13	A-phase primary current size and phase **(reference phase)**
CURR(IB)	2/13	B-phase primary current size and phase
CURR(IC)	3/13	C-phase primary current size and phase
CURR(Is)	4/13	ZCT current size and phase
VOLT(VN)	5/13	N-phase primary voltage size and phase
SEQ(I0)	6/13	Primary zero sequence current size and phase
SEQ(I1)	7/13	Primary positive sequence current size and phase
SEQ(I2)	8/13	Primary negative sequence current size and phase
2nd(IA)	9/13	A-phase 2-harmonic primary current size
2nd(IB)	10/13	B-phase 2-harmonic primary current size
2nd(IC)	11/13	C-phase 2-harmonic primary current size
THERMAL	12/13	Thermal accumulation
FREQUENCY	13/13	Frequency

2.4.3 RECORD

DISPLAY/RECORD shows the event details, waveform information and Data Logger information.

DISPLAY/RECORD/EVENT shows up to 128 fault records that are saved in the memory of PAC-E150. All the fault records are saved together with the occurrence time at the resolution of 1 msec and managed in FIFO. The fault record fields include power ON, protection element operation status, input/output contact status, device control, setting change, monitoring/diagnosis status, fault clear, fault waveform clear, Data Logger record clear, thermal clear, and Data Logger recording stop/complete.
The protection element operation status event recording also records the fault information (frequency, RMS current). The event records can be seen locally through the LCD window, and can be checked locally or remotely through E3RSet™.

Table 2-6 Event Display

Item 1	Item 2	Description
System Reset	-POWER ON	Power ON
	-PowerOn WDG	Watchdog reset
System Error	-Memory	Memory error
	-Setting	Setting error
	-AD	AD Converter error
	-Calibration	Calibration error
	-TCS	TCS operation (release)
Annuc. Reset	-ProtOP (Loc/Rem)	Protection annunciator reset (Local/Remote)
	-SysErr (Loc/Rem)	System error annunciator reset (Local/Remote)
Setting Chg	-System (Loc/Rem)	Power System setting change (Local/Remote)
	-Wave (Loc/Rem)	Waveform setting change (Local/Remote)
	-Data (Loc/Rem)	Data Logger setting change (Local/Remote)
	-RTC (Loc/Rem)	RTC setting change (Local/Remote)

	-CB (Loc/Rem)	CB Control setting change (Local/Remote)
	-COM (Loc/Rem)	COM setting change (Local/Remote)
	-TCP/IP (Loc/Rem)	TCP/IP setting change (Local/Remote)
	-DNP3.0 (Loc/Rem)	DNP3.0 setting change (Local/Remote)
	-CI (Loc/Rem)	Contact Input setting change (Local/Remote)
	-CO (Loc/Rem)	Contact output setting change (Local/Remote)
	-LED (Loc/Rem)	LED setting change (Local/Remote)
	-PASS (Loc/Rem)	Password setting change (Local/Remote)
	-50_1 (Loc/Rem)	IOC1(50_1) setting change (Local/Remote)
	-50_2 (Loc/Rem)	IOC2(50_2) setting change (Local/Remote)
	-51 (Loc/Rem)	TOC(51) setting change (Local/Remote)
	-67Ns (Loc/Rem)	SG(67Ns) setting change (Local/Remote)
	-49 (Loc/Rem)	THERMAL(49) setting change (Local/Remote)
	-37 (Loc/Rem)	UC(37) setting change (Local/Remote)
	-46 (Loc/Rem)	NSOC(46) setting change (Local/Remote)
	-46U (Loc/Rem)	UBOC(46U) setting change (Local/Remote)
	-48/51L (Loc/Rem)	STALL(48/51L) setting change (Local/Remote)
	-59G_1 (Loc/Rem)	OVG1(59G_1) setting change (Local/Remote)
	-59G_2 (Loc/Rem)	OVG2(59G_2) setting change (Local/Remote)
	-59G_3 (Loc/Rem)	OVG3(59G_3) setting change (Local/Remote)
	-COLDLD(Loc/Rem)	COLD LD setting change (Local/Remote)
	-INRUSH(Loc/Rem)	INRUSH setting change (Local/Remote)
Event Clear		Delete event records
Wave Clear		Delete waveform records
Wav Capture		Capture waveform record
Therm Clear		Delete thermal accumulation
Data Clear		Delete Data Logger records
Data Capture		Capture Data Logger records
CB Cls Ctrl (Loc/Rem)		CB close control (Local/Remote)
CB Opn Ctrl (Loc/Rem)		CB open control (Local/Remote)
Prot Alarm	-49	Operation of thermal overload alarm
Prot Op/Relese		Operation/release of thermal overload protection
Prot Lock	-48/51L	Rotor lock operation
Prot Pkp/Op/Relse	-50_1 (A,B,C)	Pickup/Operation/Release of instantaneous/definite time-delayed overcurrent protection 1
	-50_2 (A,B,C)	Pickup/Operation/Release of instantaneous/definite time-delayed overcurrent protection 2
	-51 (A,B,C)	Pickup/Operation/Release of time-delayed overcurrent protection
	-67Ns	Pickup/Operation/Release of selective ground overcurrent protection
	-37 (A,B,C)	Pickup/Operation/Release of undercurrent protection
	-46	Pickup/Operation/Release of Negative sequence overcurrent protection
	-46U	Pickup/Operation/Release of phase unbalance (loss of phase) protection
	-48/51L	Pickup/Operation/Release of start-up monitoring/stall protection for motor
	-59G_1	Pickup/Operation/Release of ground overvoltage protection 1

	-59G_2	Pickup/Operation/Release of ground overvoltage protection 2
	-59G_3	Pickup/Operation/Release of ground overvoltage protection 3
	-COLDLD	Pickup/Operation/Release of Cold Load Pickup
	-INRUSH	Operation/Release of inrush current detection
CONT IN#x	-On/Off	Operation/Release of Contact Input#x
CONT OUT#x	-On/Off	Operation/Release of Contact Output#x
Event ID Err		Event ID Error

DISPLAY/RECORD/WAVEFORM shows the data count, trigger time, and content of the fault waveform records saved in the memory. The accident details include the trigger source, block elements and a short description. Up to 20 blocks can be recorded depending on the fault waveform record setting. The resolution is 16 amples per cycle, and the maximum recording time per block is 0.24 sec (based on 50Hz, 10 blocks). The waveform record includes the sample data for current, contact input/output status, and protection element operation status, which can be uploaded locally or remotely through E3RSet™. As the waveform records are recorded in the COMTRADE file format, they can be used for fault analysis reproduction through a protective relay tester.

DISPLAY/RECORD/DATA LOGGER shows the saving mode, data count, and capture time of Data Logger data saved in the memory. The Data Logger records include the 16 points that were set among current (average current size), protection element operation status, and contact input/output status, which can be uploaded locally or remotely through E3RSet™.
Data Logger can save only one data. COMMAND/DATA LOG CLEAR starts the recording of Data Logger and COMMAND/DATA LOG STOP stops the recording of Data Logger.
In One Stop Mode, Data Logger automatically stops saving after the Record Time.

2.4.4 SYS INFO

DISPLAY/SYS INFO shows the firmware version.

2.5 COMMAND

The COMMAND menu of PAC-E150 has commands for contact output test, event clear, fault waveform clear, Data Logger records clear, thermal accumulation clear, front panel test, and Data Logger recording stop/complete.

2.5.1 CONT OUT TEST

This menu item is for testing four output contacts of PAC-E150. When the test screen appears, all the energized output contacts are de-energized, and once the test starts, the "RUN" LED flashes.

Contact Out Test Procedure

(1) Select CONT OUT TEST on the COMMAND menu screen and press >. The output contact test screen appears.
(2) Select the output contact to test using the ∧ and ∨ keys. Then press the > key.
(3) When prompted for password, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.
(4) When you press the > after entering the correct password, the status text of the 'DEENERGIZED' output contact flashes.
(5) Each time the ∧ or ∨ Keys are pressed, the contact status toggles between 'ENERGIZED' and 'DEENERGIZED', and the RELAY activating sound is heard. Furthermore, the "RUN" LED flashes.
(6) When you press the < key, the selected output contact test stops.
To test another output contact, repeat steps (2)-(6). The system does not ask password for re-testing. If you don't want further tests of output contacts, press the < key to exit the test screen.

2.5.2 EVENT CLEAR

This menu item clears event data saved in PAC-E150. Performing Event Clear initializes event count and data.

Event Clear Procedure

(1) Select EVENT CLEAR on the COMMAND menu screen and press the > key.
(2) When prompted for password in the last line of the screen, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.
(3) When you press the > key after entering the correct password, the deleted data appear and the word 'NO' flashes. If you don't want to delete the data, press the < key to exit the menu or press the ENTER key while the 'NO' flashes.
(4) If you want to delete the data, make 'YES' flash using the ∧ or ∨ keys.
Then press the ENTER key.
'ALL CLEARED' appears on the screen and the EVENT CLEAR screen returns.

2.5.3 WAVE CLEAR

This menu item clears fault waveform data saved in PAC-E150. Performing Wave Clear deletes the waveform count and data.

Wave Clear Procedure

(1) Select WAVE CLEAR on the COMMAND menu screen and press the > key.
(2) When prompted for password in the last line of the screen, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.

(3) When you press the > key after entering the correct password, the deleted data appear and the word 'NO' flashes. If you don't want to delete the data, press the < key to exit the menu or press the ENTER key while the 'NO' flashes.
(4) If you want to delete the data, make 'YES' flash using the ∧ or ∨ keys.
Then press the ENTER key.
'ALL CLEARED' appears on the screen and the WAVE CLEAR screen returns.

2.5.4 DATA LOG CLEAR

This menu item deletes Data Logger records saved in PAC-E150 and starts Data Logger recording. Performing DATA LOG CLEAR deletes Data Logger records and starts new Data Logger.

Data Log Clear Procedure

(1) Select DATA LOG CLEAR on the COMMAND menu screen and press the > key.
(2) When prompted for password in the last line of the screen, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.
(3) When you press the > key after entering the correct password, the deleted data appear and the word 'NO' flashes. If you don't want to delete the data, press the < key to exit the menu or press the ENTER key while the 'NO' flashes.
(4) If you want to delete the data, make 'YES' flash using the ∧ or ∨ keys.
Press the ENTER key.
'Data Logger Clear' appears on the screen and the DATA LOG CLEAR screen returns.

2.5.5 THERMAL CLEAR

This menu item clears thermal accumulation saved in PAC-E150. Performing the THERMAL CLEAR command clears the THERMAL accumulation.

Thermal Clear Procedure

(1) Select THERMAL CLEAR on the COMMAND menu screen and press the > key.
(2) When prompted for password in the last line of the screen, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.
(3) When you press the > key after entering the correct password, the deleted data appear and the word 'NO' flashes. If you don't want to delete the data, press the < key to exit the menu or press the ENTER key while the 'NO' flashes.
(4) If you want to delete the data, make 'YES' flash using the ∧ or ∨ keys.
Then press the ENTER key.
'ALL CLEARED' appears on the screen and the THERMAL CLEAR screen returns.

2.5.6 PANEL TEST

This menu item tests 13 LEDs and LCDs on the front panel of PAC-E150. During the panel test, all LEDs are turned on for 1 sec and 'TEST' appears on the LCD screen and then all LEDs and LCD are turned off for 1 sec. This process is repeated three times.

Panel Test Procedure

(1) Select PANEL TEST on the COMMAND menu screen and press the > key.
(2) When prompted for password, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.
(3) When you press the > key after entering the correct password, all LEDs are turned on and 'TEST' appears on the LCD screen. Then all LEDs and LCD are turned off for 1 sec.
This test process is performed 3 times before the PANEL TEST screen returns.

2.5.7 DATA LOG STOP

This menu item stops and saves Data Logger records in PAC-E150.

Performing DATA LOG STOP stops Data Logger recording and saves the Data Logger. In One Time Mode, this command has no effect after the Record Time (One Time Mode: Automatically saved after Record Time).

Data Log Stop Procedure

(1) Select DATA LOG STOP on the COMMAND menu screen and press the > key.

(2) When prompted for password in the last line of the screen, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.

(3) When you press the > key after entering the correct password, you are asked whether or not to stop Data Logger and the word 'NO' flashes. If you don't want to stop Data Logger, press the < key to exit the menu or press the ENTER key while the 'NO' flashes.

(4) If you want to save Data Logger, make 'YES' flash using the ∧ or ∨ keys. Then press the ENTER key.

'DATA LOG STOPED' appears on the screen and the DATA LOG STOP screen returns.

3 Functions

3.1 General

The ***SETTING*** menu is used to display and change settings for the performance of the functions of PAC-E150. The current settings can be seen by front key operation, but you must enter the password in order to change the settings.

Setting through the front display panel

(1) To change settings, select the item to change with the ∧ and ∨ keys in the submenu and press the > key. (There is a page number on the bottommost menu except for PASSWORD.)

(2) When prompted for password, enter the password using the ∧ and ∨ keys while moving between digits using the < and > keys. Then press the ENTER key.

(The initial password is '0000')

(3) When you press the > key after entering the correct password, the setting value flashes. If you enter a wrong password, you are asked to enter the password again.

(4) Select a desired value using the ∧ and ∨ keys and press the ENTER key.

(5) If you press the < key before pressing the ENTER key, the setting returns to the previous setting. (6) When returning to the top window using the < key, if you are asked whether or not to save the setting, select 'YES' using the ∧ and ∨ keys and press the ENTER key to save the changed setting.

(7) If you select 'NO', the changed setting is cancelled. When changing multiple items simultaneously, you will not be prompted for password if you don't leave the ***SETTING*** block.

You can conveniently change the settings through E3RSet™.

3.1.1 SYSTEM

System setting items include POWER SYSTEM, WAVEFORM, DATA LOGGER, DCMA OUTPUT, RTC, CB CONTROL, COM, TCP/IP, DNP 3.0, CONTACT INPUT, CONTACT OUTPUT, LED, and PASSWORD.

3.1.2 POWER SYSTEM

SETTING/SYSTEM/POWER SYSTEM includes setting items for analog circuit composition, motor start-up and stop detection current setting items.

Rated Frequency

Rated Frequency is an important element used for the measurement and protection operations of PAC-E150 and must be set in line with the system frequency. If the set frequency differs from the system frequency, the measurement values can fluctuate severely or cause errors in the operation characteristics of the protection elements. The rated frequency can be set through the local keypad or E3RSet™. The changed rated frequency is applied only after the control power of PAC-E150 is turned off and on.

Phase CT Ratio

PAC-E150 has three current inputs. They are the current source of all protection elements that use current. The phase current ratio can be set through the local keypad or E3RSet™.

Current on the measurement display screen = ***PHS CT RATIO****Input Current (A)

Ground PT Ratio
PAC-E150 has one ground voltage input. This is the voltage source of all protection elements that use voltage. The ground voltage ratio can be set through the local keypad or E3RSet™.

Ground voltage on the measurement display screen = (***GND PT PRI / GND PT SEC)****Input Current (A)

START CURR
START CURR is the motor start detection current and is used for Start-up Monitoring/Stall Protection for Motor (48/51L).
The motor start detection current can be set through the local keypad or E3RSet™.
STOP CURR
STOP CURR is the motor stop detection current and is used for Thermal Overload Protection (49) and Start-up Monitoring/Stall Protection for Motor (48/51L). The motor stop detection current can be set through the local keypad or E3RSet™.

SETTING/ SYSTEM/ POWER SYSTEM

Setting Item		Range (Step)	Unit	Description
FREQUENCY	1/7	60Hz, 50Hz		Rated Frequency
PHS CT RATIO	2/7	5 ~ 6000 : 5		Phase CT Ratio
GND PT PRI	3/7	0 ~ 1000		Ground PT Primary in 1000V unit
GND PT PRI	4/7	0.0 ~ 999.9	V	Ground PT Primary in 0.1V unit
GND PT SEC	5/7	0.0 ~ 999.9	V	Ground PT Secondary
START CURRENT	6/7	1.00~50.00(0.01)	A	Motor Start Detection Current
STOP CURRENT	7/7	0.10~1.00(0.01)	A	Motor Stop Detection Current

3.1.3 PASSWORD
Password in PAC-E150 is used when changing settings or the circuit breaker is controlled through the keypad. The password is a 4-digit number consisting of '0' to '9'. The initial value at shipment is '0000'.

If you change the password and forget it, you cannot change the settings or control through key operation.

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3.2 Protection
The protection elements of PAC-E150 are set through ***SETTING/PROTECTION***.
The protection elements of PAC-E150 are Short Circuit Overcurrent (50/51), Selective Ground Overcurrent (67Ns), Thermal Overload (49), Undercurrent (37), Negative Sequence Overcurrent (46), Phase Unbalance (Loss of Phase) (46U), Start-up Monitoring/Stall Protection for Motor (48/51L), Ground Overvoltage (59G), Cold Load Pickup, and Inrush Current Detection (INRUSH).

Function Selection (FUNCTION) and Protection Element Blocking (BLOCK)
Every protection element commonly has the Function Selection (FUNCTION) and Protection Element Blocking (BLOCK) items which can be linked with EasyLogic to perform protection only in special conditions. If FUNCTION is ENABLED, the corresponding protection element stops functioning while the BLOCK input is the logic '1'. If FUNCTION is DISABLED, the corresponding protection function does not work and no event is recorded.

3.2.1 Short Circuit Overcurrent Protection (50/51)

Short Circuit Overcurrent Protection consists of 2 Instantaneous/Definite Time-delayed Negative Sequence Overcurrent Protections (50) and 1 Inverse Time-delayed Short-circuit Overcurrent Protection (51). Three-step protection characteristics can be implemented by combining three independent short-circuit elements. The minimum operation time of Instantaneous / Time-delayed Overcurrent element is 40 msec or less, and the characteristic curves of the Inverse Time-delayed element consist of 4 types of IEC, 7 types of IEEE/ANSI, and 2 types of KEPCO.
For the detection current of the Short-circuit/Ground Overcurrent Protection, the CT 2nd current that is inputted to PAC-E150 is used.

For more information on characteristic curves, see Appendix A, Inverse Time-delayed Operation Characteristics.

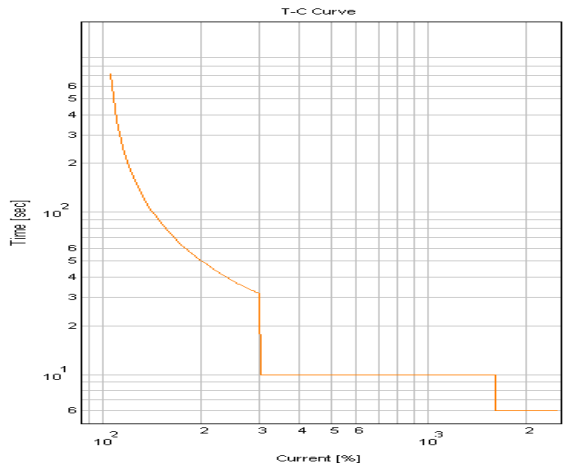


Figure 3-1 Operation Characteristics of Short Circuit Overcurrent Protection

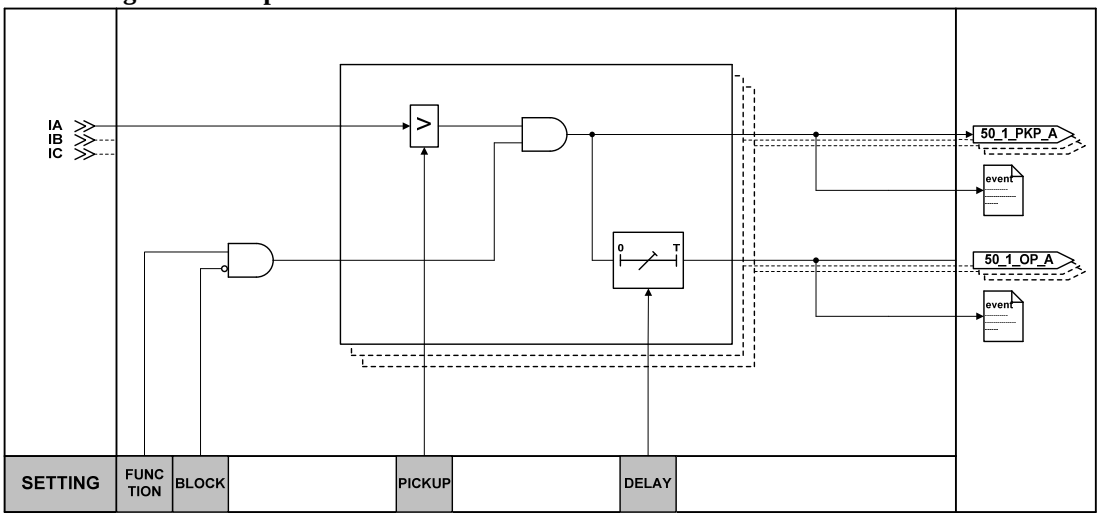


Figure 3-2 Operation Characteristics of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection

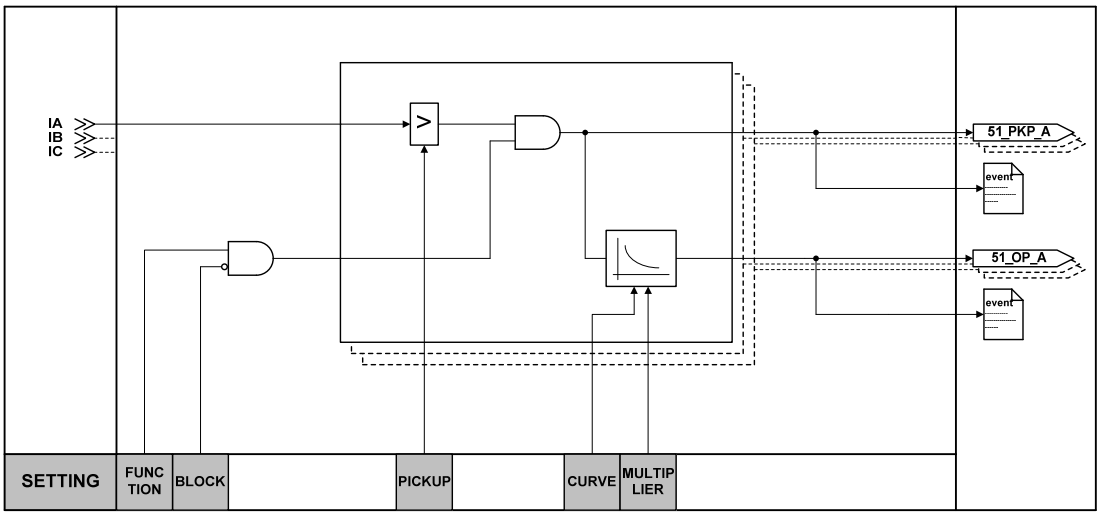


Figure 3-3 Operation Characteristics of Time-delayed Short-Circuit Overcurrent Protection

SETTING/PROTECTION/IOC1(50_1), IOC2(50_2)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/4	ENABLED, DISABLED		Use or no use of function
PICKUP	2/4	0.50 ~ 100.00 (0.05)	A	Pickup current
DELAY	3/4	0.00 ~ 60.00 (0.01)	sec	Operation delay
BLOCK	4/4	EasyLogic operand		Protection element blocking condition

SETTING/PROTECTION/TOC(51)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/5	ENABLED, DISABLED		Use or no use of function
CURVE	2/5	IEC_NI, …, KVI		Inverse time-delayed characteristic curve setting IEC_NI : IEC Normal Inverse IEC_VI : IEC Very Inverse IEC_EI : IEC Extremely Inverse IEC_LI : IEC Long Inverse ANSI_I : ANSI Inverse ANSI_SI: ANSI Short Inverse ANSI_LI: ANSI Long Inverse ANSI_MI: ANSI Moderately Inverse ANSI_VI: ANSI Very Inverse ANSI_EI :ANSI Extremely Inverse ANSI_DI : ANSI Definite Inverse KNI : KEPCO Normal Inverse KVI : KEPCO Very Inverse
PICKUP	3/5	0.50 ~ 100.00 (0.05)	A	Pickup current
MULTIPLIER	4/5	0.01 ~ 10.00 (0.01)		Time Multiplier
BLOCK	5/5	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
IA, IB, IC	Size and phase of secondary phase current
50_1_PKP_OR	Pickup OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
50_1_PKP_A, B, C	A, B, and C phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
50_1_OP_OR	Operation OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
50_1_OP_A, B, C	A, B and C phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
50_2_PKP_OR	Pickup OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
50_2_PKP_A, B, C	A, B, and C phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
50_2_OP_OR	Operation OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
50_2_OP_A, B, C	A, B and C phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
51_PKP_OR	Pickup OR of Time-delayed Short-Circuit Overcurrent Protection
51_PKP_A, B, C	A, B, and C phase pickup of Time-delayed Short-Circuit Overcurrent Protection
51_OP_OR	Operation OR of Time-delayed Short-Circuit Overcurrent Protection
51_OP_A, B, C	A, B, and C phase operation of Time-delayed Short-Circuit Overcurrent Protection

3.2.2 Selective Ground Overcurrent Protection (67Ns)

Selective Ground Overcurrent Protection is used for detection of ground accidents of isolated systems. This is a directional protection element that operates with definite time limit by the size/phase of the input voltage and zero sequence current (Is) depending on the type of voltage input.

Due to the nature of directional element, special care must be taken to the wiring direction of the zero sequence current/voltage sensor.

If the directional element is 'NONE', the system only operates by the zero sequence current size.

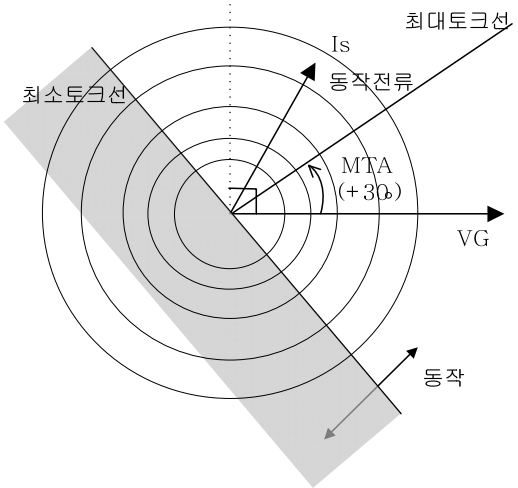


Figure 3-4 Operation Angle of the Selective Ground Overcurrent Protection

The operation phase of the selective ground overcurrent protection element is as follows:

FORWARD : $Co\sin e(\angle(VG)+MTA-\angle Is)\geq 0$

REVERSE : $Co\sin e(\angle(VG)+MTA-\angle Is)<0$

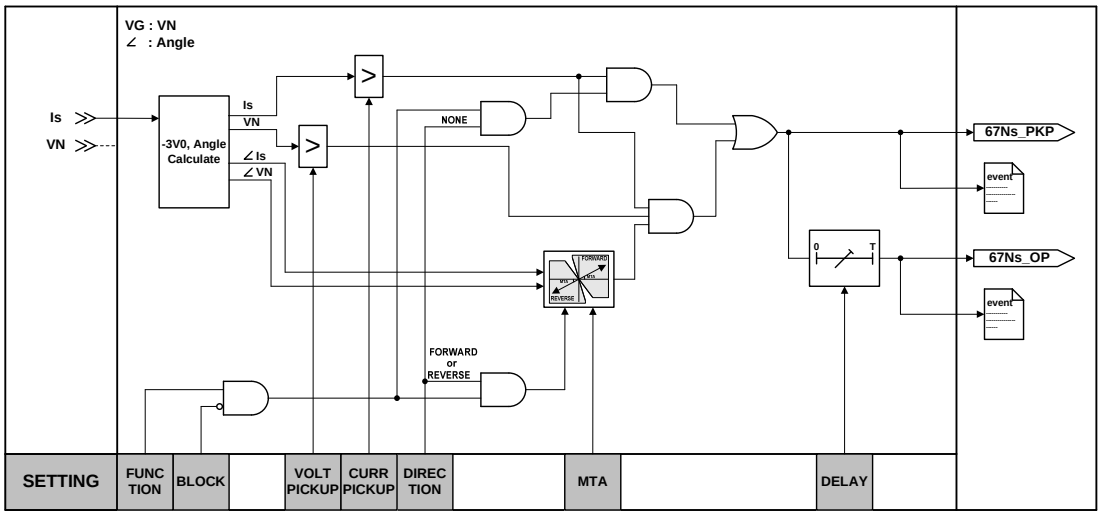


Figure 3-5 Operation Characteristics of the Selective Ground Overcurrent Protection

SETTING/PROTECTION/SG(67Ns)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/7	ENABLED, DISABLED		Use or no use of function
DIRECTION	2/7	NONE,…,REVERSE		Direction setting NONE: No direction FORWARD: Forward direction REVERSE : Reverse direction
VOLT PICKUP	3/7	5 ~ 110 (1)	V	Pickup voltage
CURR PICKUP	4/7	0.9 ~ 300.0 (0.1)	mA	Pickup current
MTA	5/7	-90 ~ 90 (1)	°	MTA setting
DELAY	6/7	0.00 ~ 60.00 (0.01)	sec	Operation delay
BLOCK	7/7	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
Is	Size and phase of zero sequence current (Is)
VG	Size and phase of secondary N-phase voltage
67Ns_PKP	Pickup of Selective Ground Overcurrent Protection
67Ns_OP	Operation of Selective Ground Overcurrent Protection

3.2.3 Thermal Overload Protection (49)

Thermal Overload Protection operates based on the maximum value of the 3 phase currents and can set alarm level. If the maximum of the 3 phase currents is greater than the rated current*K-Factor, Thermal accumulates by TIME CONST(τ); otherwise, Thermal decreases by TIME CONST(τ). If the maximum of the 3 phase currents is greater than ***POWER SYSTEM/STOP CURRENT***, Thermal decreases by TIME CONST(τ)*COOL FACTOR. If Thermal is greater than alarm level, ALARM is activated; if it is 100% or greater, OP is generated.

Thermal status can be checked in DISPLAY/MEASURE, and can be compulsorily initialized from the COMMAND/THERMAL CLEAR menu. For more information on operation time, see Appendix A, Inverse Time-delayed Operation Characteristics.

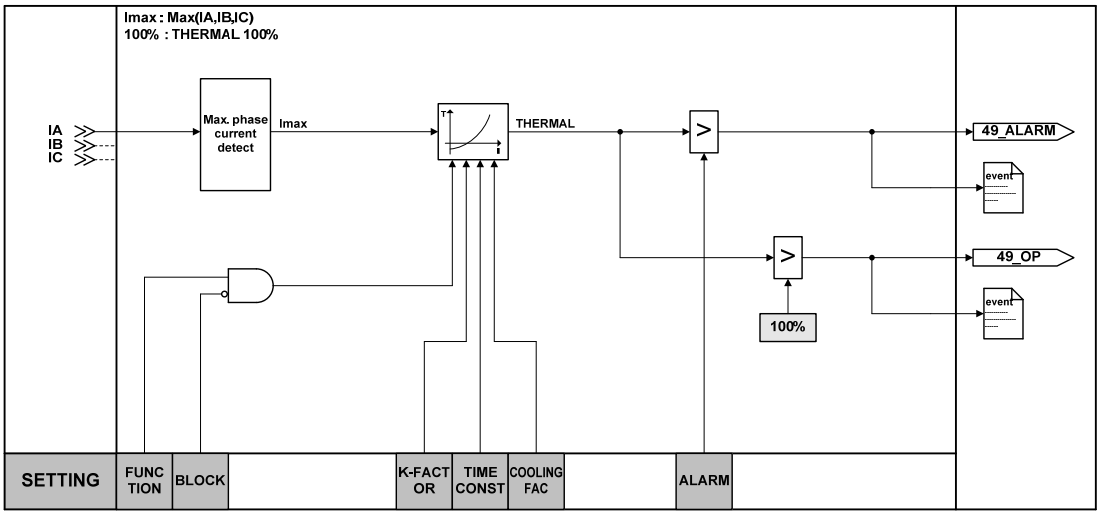


Figure 3-6 Operation Characteristics of Thermal Overload Protection

SETTING/PROTECTION/THERMAL(49)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/6	ENABLED, DISABLED		Use or no use of function
K-FACTOR	2/6	0.10 ~ 4.00 (0.01)		k-Factor setting
TIME CONST	3/6	1.0 ~ 999.9 (0.1)	min	Time Constant (τ) setting
ALARM	4/6	50 ~ 100 (1)	%	Alarm level setting
COOL FACTOR	5/6	1.0 ~ 10.0 (0.1)		Cool factor setting
BLOCK	6/6	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
THERMAL	Thermal %
IA, IB, IC	Size and phase of secondary phase current
49_ALARM	Alarm of Thermal Overload Protection
49_OP	Operation of Thermal Overload Protection

3.2.4 Undercurrent Protection (37)

Undercurrent Protection is a definite time-delayed protection element that can be used for loss of load and open line detection.
It activates when the phase current size is lower than the preset pickup.

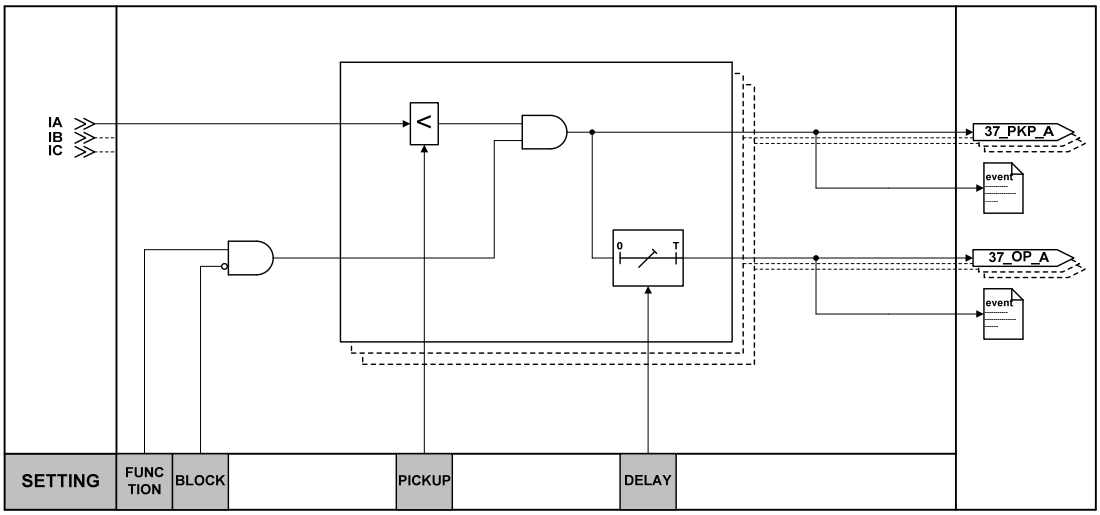


Figure 3-7 Operation Characteristics of Undercurrent Protection

SETTING/PROTECTION/UC(37)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/4	ENABLED, DISABLED		Use or no use of function
PICKUP	2/4	0.10 ~ 5.00 (0.05)	A	Pickup current
DELAY	3/4	0.00 ~ 180.00 (0.01)	sec	Operation delay
BLOCK	4/4	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
IA, IB, IC	Size and phase of secondary phase current
37_PKP_OR	Pickup OR of Undercurrent Protection
37_PKP_A, B, C	A, B, and C phase pickup of Undercurrent Protection
37_OP_OR	Operation OR of Instantaneous/Definite Time-delayed Undercurrent Protection
37_OP_A, B, C	A, B and C phase operation of Instantaneous/Definite Undercurrent Protection

3.2.5 Negative Sequence Overcurrent Protection (46)

Negative Sequence Overcurrent Protection can be applied to the detection of unbalance faults that cannot be detected by Ground Overvoltage Protection. It is a definite time-delayed element that is activated by the negative sequence current.

The pickup current (I2) of the Negative Sequence Overcurrent Protection is:

$I2 = \frac{1}{3}(\dot{I}_A + a^2\dot{I}_B + a\dot{I}_C)$, ABC phase rotation.

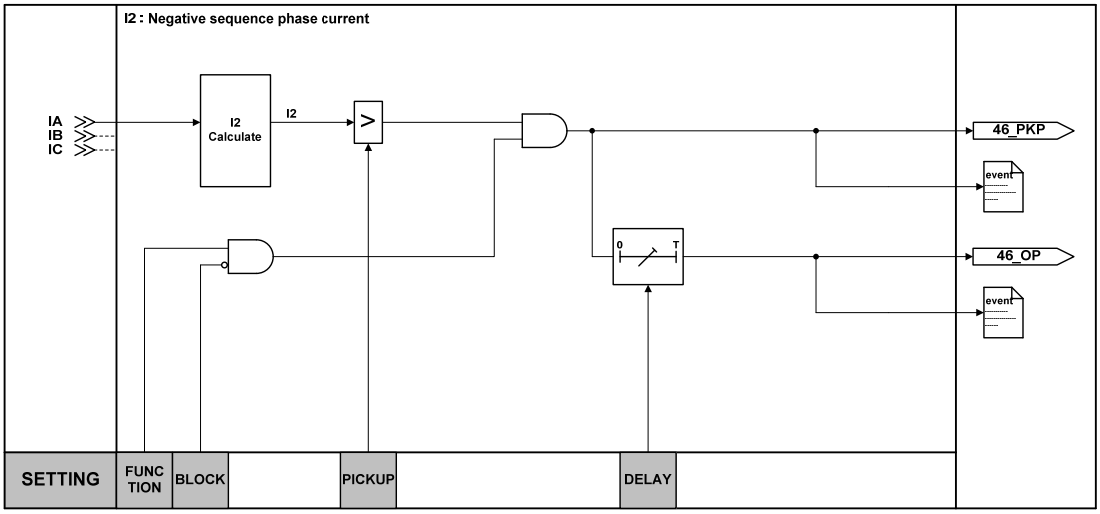


Figure 3-8 Operation Characteristics of Instantaneous/Definite Time-delayed Negative Sequence Overcurrent Protection

SETTING/PROTECTION/NSOC(46)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/4	ENABLED, DISABLED		Use or no use of function
PICKUP	2/4	0.50 ~ 100.00 (0.05)	A	Pickup of negative sequence current
DELAY	3/4	0.00 ~ 180.00 (0.01)	sec	Operation delay
BLOCK	4/4	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
I2	Size and phase of the negative sequence secondary current
46_PKP	Pickup of Negative Sequence Overcurrent Protection
46_OP	Operation of Negative Sequence Overcurrent Protection

3.2.6 Phase Unbalance (Loss of Phase) Protection (46U)

Phase Unbalance (Loss of Phase) Protection can be used in places that require unbalance detection with a sensitivity that is higher than that of Negative Sequence Overcurrent Protection. Loss of phase can be caused by the breaking of the line or the loss of single-phase fuse. Phase Unbalance (Loss of Phase) Protection is a definite time-delayed protection element that operates by the ratio of negative sequence current (I2) to the positive sequence current (I1).

The positive sequence current used for Phase Unbalance (Loss of Phase) Protection is:

$I1 = \frac{1}{3}(\dot{I}_A + a\dot{I}_B + a^2\dot{I}_C)$, ABC phase rotation.

The negative sequence current (I2) is:

$I2 = \frac{1}{3}(\dot{I}_A + a^2\dot{I}_B + a\dot{I}_C)$, ABC phase rotation.

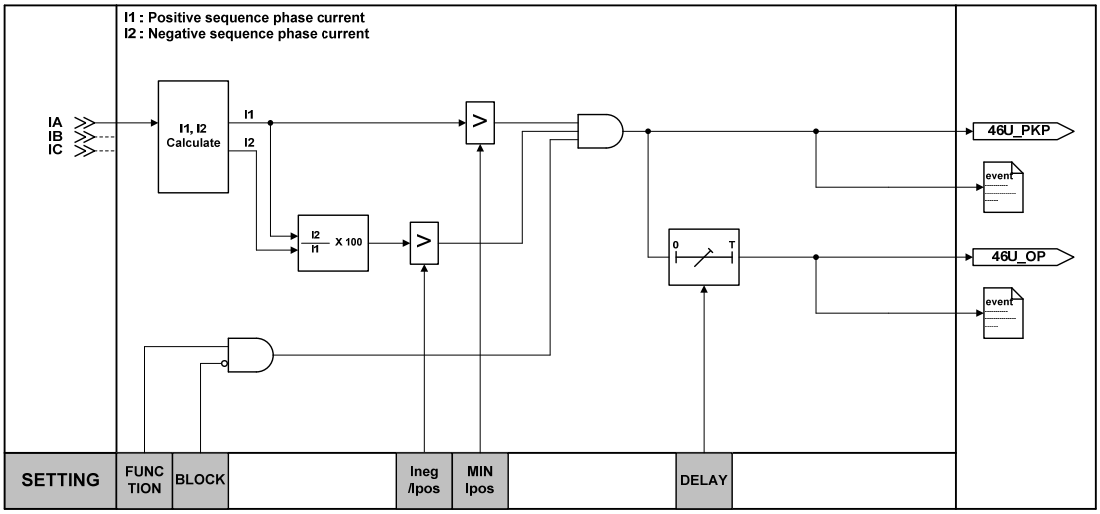


Figure 3-9 Operation Characteristics of Phase Unbalance (Loss of Phase) Protection

SETTING/PROTECTION/UBOC(46U)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/5	ENABLED, DISABLED		Use or no use of function
MIN I1	2/5	0.50 ~ 5.00 (0.05)	A	Normal phase minimum operation current
I2/I1 PICKUP	3/5	2 ~ 80 (1)	%	Ratio of negative sequence/positive sequence
DELAY	4/5	0.00 ~ 180.00 (0.01)	sec	Operation delay
BLOCK	5/5	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
I1	Size and phase of the positive sequence secondary current
I2	Size and phase of the negative sequence secondary current
46U_PKP	Pickup of Phase Unbalance (Loss of Phase) Protection
46U_OP	Operation of Phase Unbalance (Loss of Phase) Protection

3.2.7 Start-up Monitoring/Stall Protection for Motor (48/51L)

The motor start-up current is much greater than that in normal operation. The motor can be damaged if the start-up current flows for the start-up time specified by the manufacturer. Start-up Monitoring/Stall Protection for Motor is an inverse time-delayed protection element of the start-up current and start-up time that is activated only when the motor starts. We also have the definite time-delayed overcurrent element that protects the locked rotor of the motor that has a safe stall time shorter than the start-up time and has a speed switch contact.

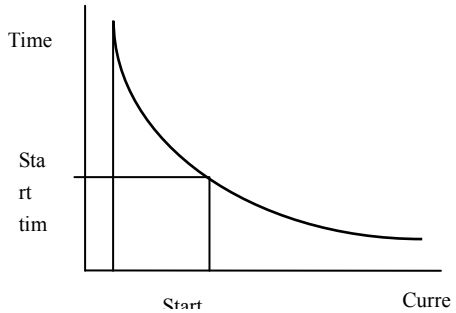


Figure 3-10 Operation Characteristics of Start-up Monitoring/Stall Protection for Motor

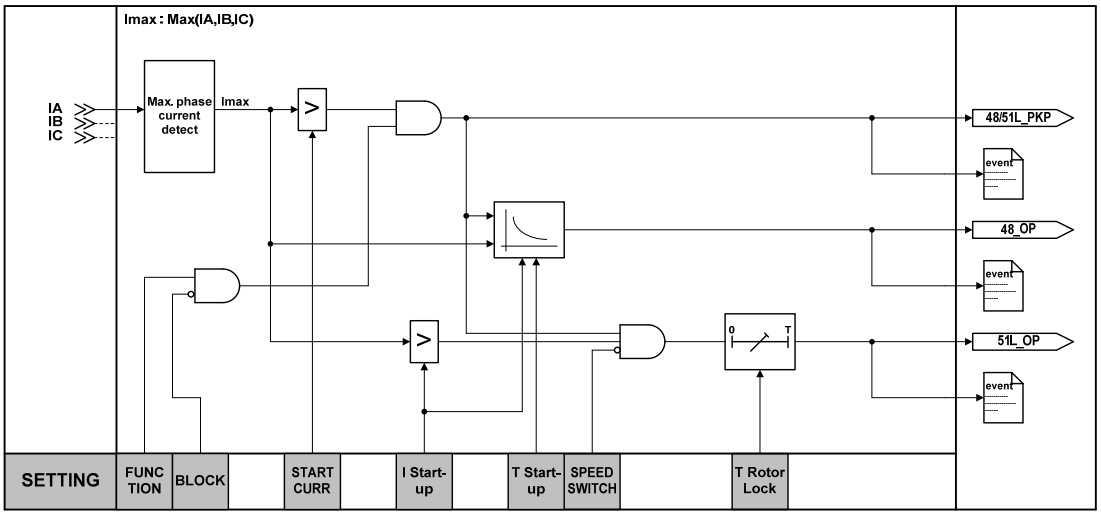


Figure 3-11 Operation Characteristics of Start-up Monitoring/Stall Protection for Motor

SETTING/PROTECTION/STALL(48/51L)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/6	ENABLED, DISABLED		Use or no use of function
I START-UP	2/6	5.00 ~ 90.00 (0.05)	A	Current Pickup
T START-UP	3/6	1.0 ~ 180.0 (0.1)	Sec	Start-up time delay
T ROTOR LOCK	4/6	0.5 ~ 180.0 (0.1)	Sec	Rotor lock time delay
SPEED SWITCH	5/6	None, DI#1~DI#4		Speed switch
BLOCK	6/6	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
IA, IB, IC	Size of secondary phase currents
START CURR	Size of motor start detection current
48/51L_PKP	Pickup of Start-up Monitoring/Stall Protection for Motor
48_OP	Operation of Start-up Monitoring/Stall Protection for Motor
51L_OP	Operation of motor rotor lock

3.2.8 Ground Overvoltage Protection (59G)

Ground Overvoltage Protection is a single-phase protection element that operates as a definite time-delayed/inverse time-delayed element. The inverse time-delayed operation characteristics are identical to those of the induction-type Ground Overvoltage Protection, and it is activated when the image voltage size is greater than the preset value. The image voltage is an open delta wiring (GPT) voltage of 3-phase PT. For more information on characteristic curves, see Appendix A, Inverse Time-delayed Operation Characteristics.

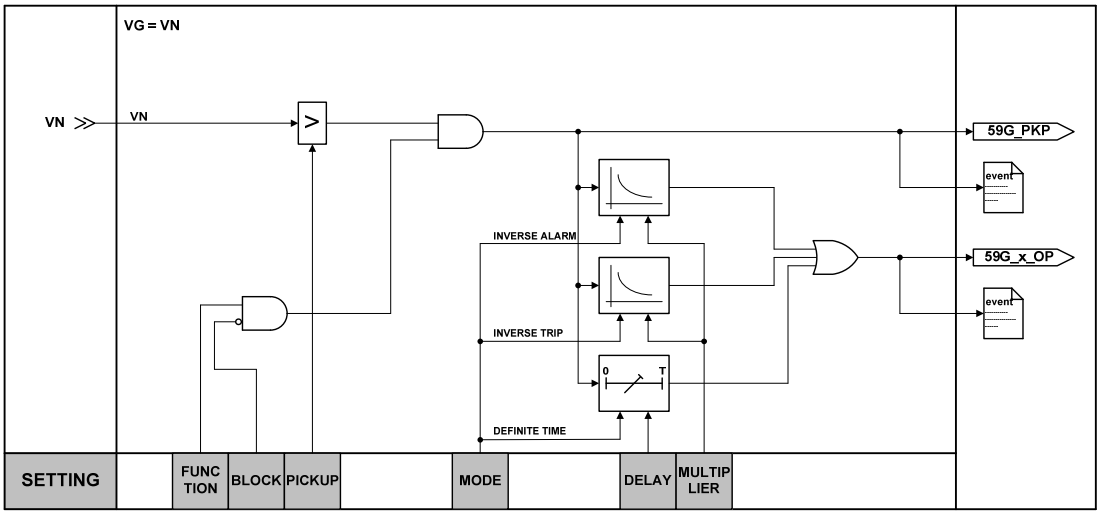


Figure 3-12 Operation Characteristics of Ground Overvoltage Protection

SETTING/PROTECTION/ OVG1(59G_1), OVG2(59G_2), OVG3(59G_3)

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/5	ENABLED, DISABLED		Use or no use of function
MODE	2/5	DEFINITE TIME ,..,INVERSE ALARM		Operation mode DT : Definite time-delayed INVERSE TRIP : Inverse time-delayed trip INVERSE ALARM : Inverse time-delayed alarm
PICKUP	3/5	5 ~ 170 (1)	V	Voltage Pickup
DELAY	4/5	0.00 ~ 60.00	sec	Operation delay
MULTIPLIER	4/5	0.01 ~ 10.00(0.01)		Time Multiplier
BLOCK	5/5	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
VN	Size and phase of secondary N-phase voltage
59G_1_PKP	Pickup of Ground Overvoltage Protection 1
59G_1_OP	Operation of Ground Overvoltage Protection 1
59G_2_PKP	Pickup of Ground Overvoltage Protection 2
59G_2_OP	Operation of Ground Overvoltage Protection 2
59G_3_PKP	Pickup of Ground Overvoltage Protection 3
59G_3_OP	Operation of Ground Overvoltage Protection 3

3.2.9 Cold Load Pickup (COLD LD)

Inrush current that occurs when lines, transformers and reactors are applied can cause malfunctions by exceeding the preset values during the normal operation of protection elements. Cold Load Pick-up detects the application time to apply higher settings of protection elements for the preset time from the application point and apply the rated settings in normal state for optimum protection. The system operates with operation delay when all the phase currents (IA, IB, IC) are under the preset values, and recovers with the recovery delay if one or more of the phase currents are over the preset values.

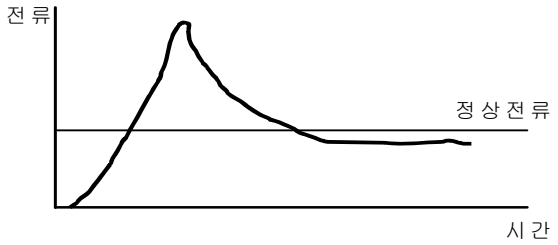


Figure 3-13 Current type of Cold Load Pickup

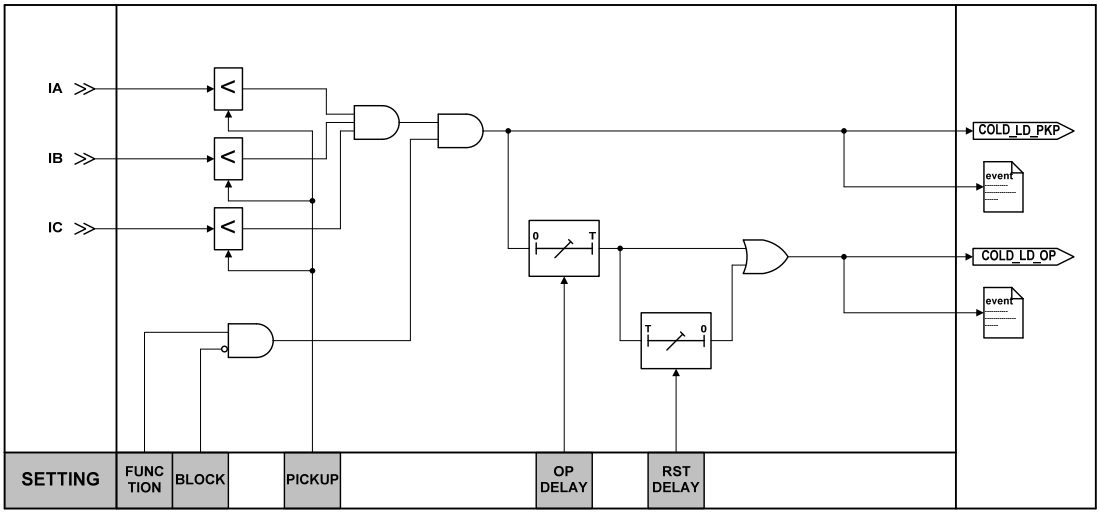


Figure 3-14 Operation Characteristics of Cold Load Pickup

SETTING/PROTECTION/ COLD LD

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/5	ENABLED, DISABLED		Use or no use of function
PICKUP	2/5	0.50 ~ 2.50 (0.05)	A	Cold Load Pickup current
OP DELAY	3/5	0~1000(1)	sec	Operation delay
RST DELAY	4/5	0~1000(1)	sec	Recovery delay
BLOCK	5/5	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
COLD_LD_PKP	Pickup of Cold Load Pickup detection
COLD_LD_OP	Operation of Cold Load Pickup detection

3.2.10 Inrush Current Detection (INRUSH)

Inrush Current Detection is used to protect the protection elements from inrush current that occurs when pressurizing long-distance lines, transformers, and reactors. Inrush Current Detection is an instantaneous/definite time-delayed element that is activated when the fundamental wave current (I1f) is greater than the preset value (MIN I1f) and the ratio of the 2-harmonic current (I2f) to the fundamental wave current (I1f) is greater than the preset value. PAC-E150 can suppress the operation of protection elements during the inrush current detection through the Block setting of each protection element.

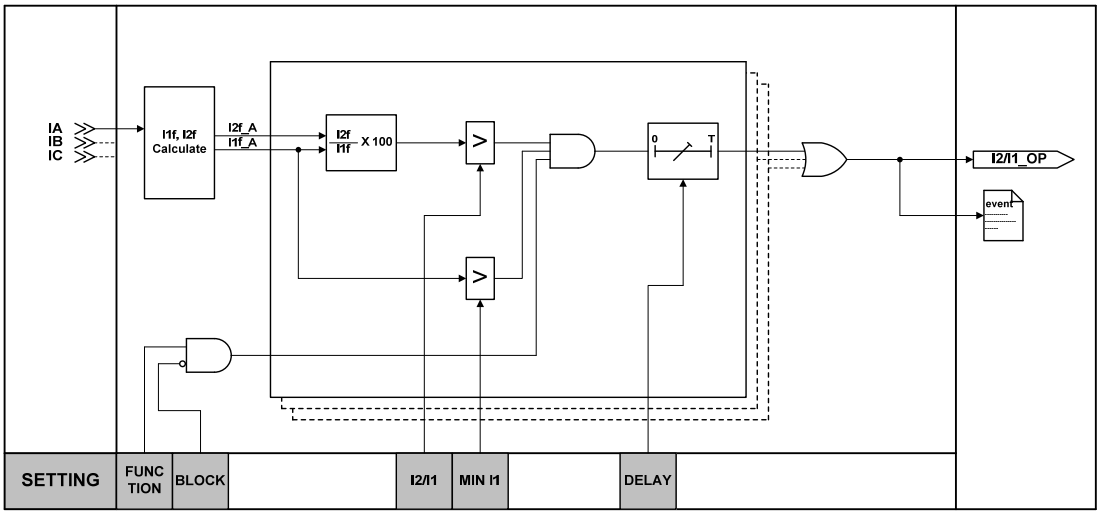


Figure 3-15 Operation Characteristics of Inrush Current Detection

SETTING/ PROTECTION/ INRUSH

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/5	ENABLED, DISABLED		Use or no use of function
I2/I1	2/5	10 ~ 100% (1)	%	(2-harmonic current/fundamental wave current)*100
MIN I1	3/5	0.50 ~ 2.50(0.05)	A	Minimum operation current of fundamental wave
DELAY	4/5	0.00 ~ 60.00(0.01)	sec	Operation delay
BLOCK	5/5	EasyLogic operand		Protection element blocking condition

Metering and EasyLogic Operand

LCD Display Items	Description
I1	Phase current of secondary fundamental wave
I2	Phase current of secondary 2-harmonic wave
I2/I1_OP	Operation of inrush current detection

3.3 Supplementary Features

3.3.1 Recording

Event/Fault Recording

Up to 128 events/faults can be recorded. All the events/faults are recorded together with the occurrence time at the resolution of 1 msec.

The event/fault record fields include power on, protection element operation status, contact input/output status, device control, setting change, monitoring/diagnosis status, event data clear, waveform data clear, Data Logger data clear/start, thermal clear, and Data Logger stop/completion. When the protection element operation status is changed, the fault information is recorded as well.

- Sizes of A, B, and C-phase secondary currents
  Size of Is phase current, size of N-phase secondary voltage

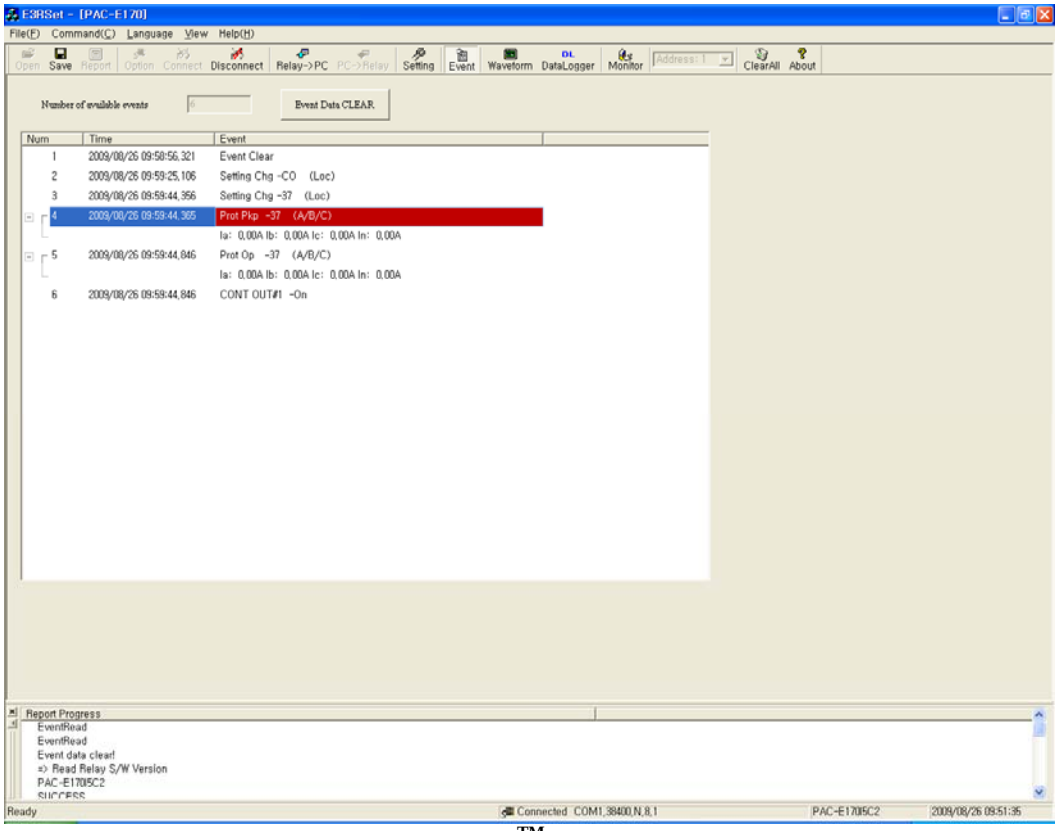


Figure 3-16 E3RSet™ Event/Fault Records

The event/fault records can be seen locally through the LCD window, and can be checked locally or remotely through E3RSet™. The event/fault recording continues even if the PAC-E150 loses power supply.

Waveform Recording

Waveform Recording can record up to 20 blocks. The resolution is 16 amples per cycle, and the maximum recording time per block is 0.24 sec (based on 50Hz, 10 blocks). The waveform records include the sample data for current, voltage, contact input/output status, and protection elements operation status.

The trigger condition for waveform recording can be composed through EasyLogic of the internal status of PAC-E150 such as the contact input/output status change and protection element operation. The trigger position of waveform recording can be set between 0 and 99% of the total block size.

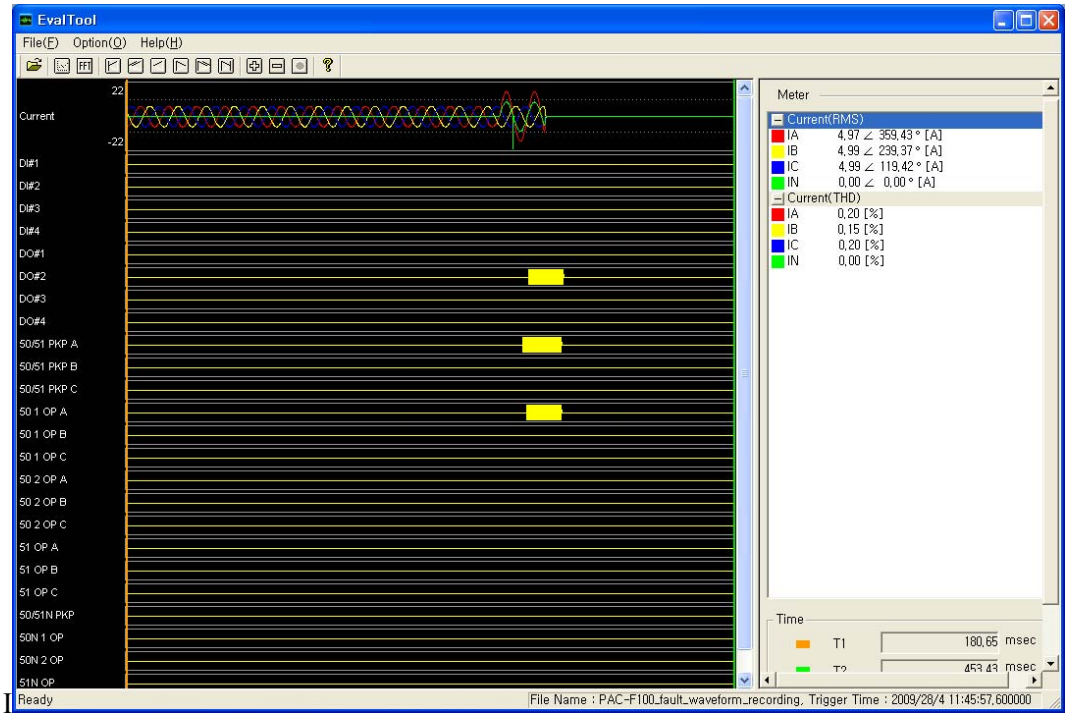


Figure 3-17 Waveform Analysis of E3RSet™

Waveform records can be uploaded locally or remotely through E3RSet™, and data are maintained even if PAC-E150 loses power supply. As the waveform records are recorded in the COMTRADE file format, they can be used for fault analysis reproduction through a protective relay tester.

SETTING/SYSTEM/WAVEFORM

Setting Item		Range (Step)	Unit	Description
TYPE	1/3	10*12, 20*6	Cycle	Waveform storing count and capacity 10*12 : 10 units, 12cycle
TRIGGER SRC	2/3	EasyLogic operand		Trigger source
TIRGGER POS	3/3	0 ~ 99% (1)	%	Trigger position 40% : Waveform before trigger (40%) + Waveform after trigger (60%)

Data Logger Recording

Data Logger can record only once. When DATA LOG CLEAR is performed, the existing data are deleted and new data are recorded automatically. The recording time is set in Record Time and the maximum Record Time is 10000 min. The Data Logger records include the size of phase currents, size of Is current, size of N-phase voltage, and the statuses of 16 digital channels. The current size recorded in Data Logger use the average current size per sample cycle.

In ONE TIME mode, the records are automatically saved after Record Time from the start of recording. In CONTINUOUS mode, the records are saved when the DATA LOG STOP Command is issued. Even if the Record Time has not been reached, when the DATA LOG STOP Command is issued, the records for the commanded time are recorded regardless of the mode.

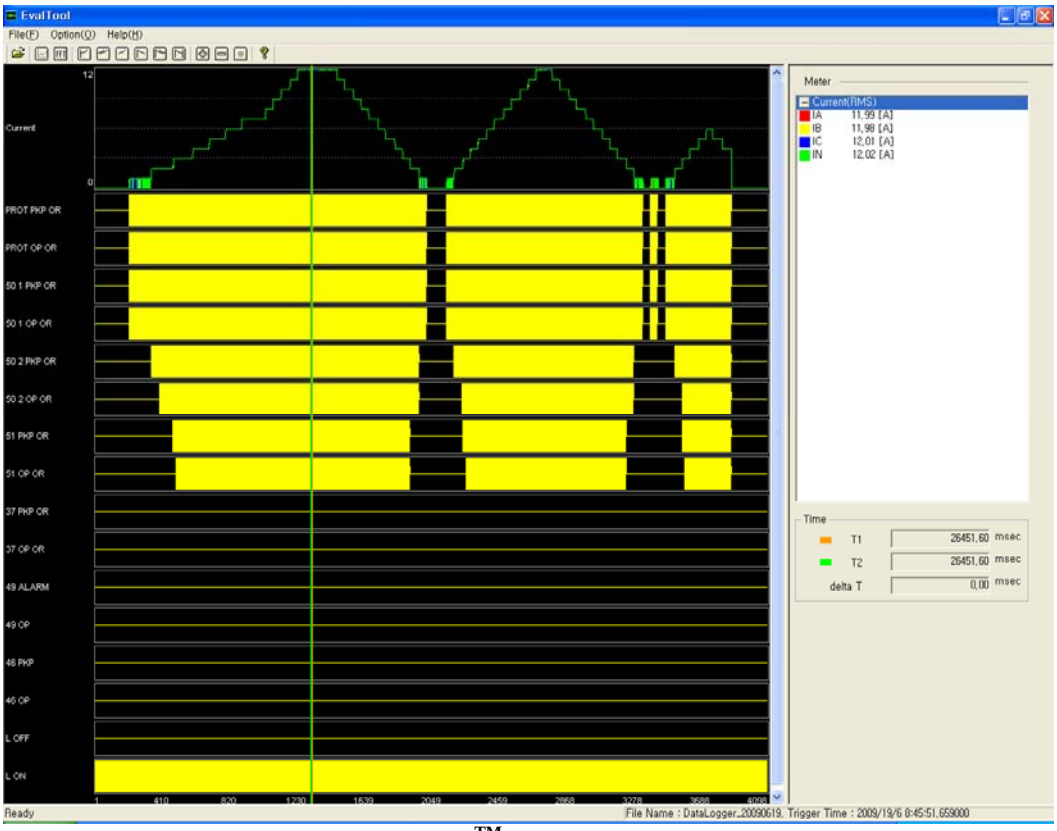


Figure 3-18 E3RSet™ Data Logger Record Analysis

Data Logger records can be uploaded locally or remotely through E3RSet™, and data are maintained even if PAC-E150 loses power supply.

SETTING/SYSTEM/DATA LOGGER

Setting Item	Range (Step)	Unit	Description
MODE 1/18	ONE TIME / CONTINEOUS		Record saving mode
RECORD TIME 2/18	4~10000	min	Recording time
DIGIT CH01 3/18 ~ DIGIT CH16 18/18	EasyLogic operand		Digital source

3.3.2 Circuit Breaker Control

PAC-E150 can control one circuit breaker.

The control functions of PAC-E150 allow users to locally operate the circuit breaker for opening or closing or remotely control from the control center. For remote control, the circuit breaker is controlled through communication with a upper-level system, and the RS485 communication port at the rear is used for communication.

To control the circuit breaker, one of the contact input must be set as CB_OPENED or CB_CLOSED. If one or more circuit breaker status inputs are received, the fastest contact status input is used for circuit breaker control (Contact Input #1 is the fastest).

If no contact input is set as circuit breaker status input, all the LEDs of the circuit breaker control part turn off. If one ore more contact inputs are set as circuit breaker status input, the LEDs of the circuit breaker control part turn on in accordance with the control authority status and circuit breaker status.

The open/close pulse time for circuit breaker control can be set from SETTING/SYSTEM/CB CONTROL.

SETTING/SYSTEM/CB CONTROL

Setting Item	Range (Step)	Unit	Description
TRIP PULSE 1/2	0.1 ~ 5.0(0.1)	sec	Minimum pulse width for circuit breaker trip control output
CLOSE PULSE 2/2	0.1 ~ 5.0(0.1)	sec	Minimum pulse width for circuit breaker close control output

3.3.3 Contact Input Settings

PAC-E150 has four contact inputs.
Each input setting can be selected among 6 setting items.
Setting to NOT_CONNECTED always displays OFF regardless of input status.
The following table describes each setting item.

Table 3-1 Contact Input Setting

Item	Description
NOT_CONNECTED	No effect of contact input
CB_OPENED	If the input is logic '1', it is regarded that the circuit breaker is open.
CB_CLOSED	If the input is logic '1', it is regarded that the circuit breaker is closed.
ANN_RESET	If the input logic status is changed, Annunciator Reset is activated.
TCS_INPUT	Used as TCS input. TCS is activated if the input is logic '0' for over 5 min.
GENEREAL_INPUT	Used as a general input.

3.3.4 MONITORING

PAC-E150 provides the Trip Circuit Supervision (TCS) function. For TCS, one of the contact inputs must be set to TCS_INPUT. For TCS, the trip contact output is fed back to the contact input, and a system error is generated if the contact input s '0' for over 5 min. If two or more contact inputs are set to TCS_INPUT, the fastest contact input is recognized as TCS_INPUT (Contact Input#1 is the fastest). That is, if all four contact inputs are set to TCS_INPUT, the contact input #1 is recognized as TCS_INPUT.
For supervision regardless of circuit breaker open/close status, the circuit breaker subsidiary contacts 52a and 52b, and resistance are needed.

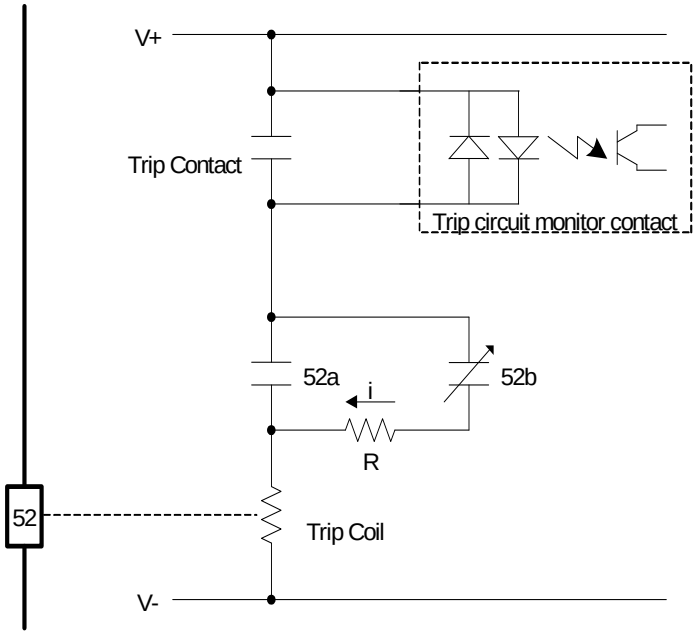


Figure 3-19 TCS Circuit

- Refer to the following for the resistances used for Trip Circuit Supervision and the power consumption.

$$R = \frac{R_{MAX} + R_{MIN}}{2}$$

$$R_{MAX} = \left(\frac{V_{DC} - V_{MIN}}{I_{MIN}} \right) - R_{TC}$$

$$R_{MIN} = \left(\frac{V_{DC} - V_{TC\_MAX}}{V_{TC\_MAX}} \right) \times R_{TC}$$

$$P_R = I^2 R = \left(\frac{V_{DC}}{R + R_{TC}} \right)^2 \times R$$

I_{MIN} : Minimum current of contact input ON
V_{MIN} : Minimum voltage of contact input ON
V_{DC} : Control Voltage of Circuit Breaker Trip Coil
R_{TC} : DC Resistance of Circuit Breaker Trip Coil
V_{TC_MAX} : Maximum voltage on the Circuit Breaker Trip Coil that does not lead to Tripping
P_R : Power consumption of the resistance

Example)

V_{DC} : 24V (from System)
V_{MIN} : 16V (from PAC-E150)
I_{MIN} : 0.0025A (from PAC-E150)
R_{TC} : 300Ω (from System)
V_{TC_MAX} : 10V (from System)

$$R_{MAX} = \left(\frac{24V - 16V}{2.5mA} \right) - 300\Omega = 2.9K\Omega$$

$$R_{MIN} = \left(\frac{24V - 10V}{10V} \right) \times 300\Omega = 420\Omega$$

$$R = \frac{2.9K\Omega - 420\Omega}{2} = 1.24K\Omega$$

The closest standard value of 1.3kΩ is selected; the power is:

$$P_R = \left(\frac{24V}{1.3K\Omega + 0.3K\Omega} \right)^2 \times 1.3K\Omega$$

$$P_R \geq 0.2925$$

3.3.5 EasyLogic

EasyLogic allows the implementation of various logic functions such as independence sequence, Inter-Lock, Lock-out(86), and programmable LED with an operator consisting of logic gates (OR8, HALF_OR8, AND8, HALF_AND8) and an operand consisting of contact input status, protection element operation status, control command, and self-diagnosis status. EasyLogic can be edited locally or through E3RSet™.

SETTING/SYSTEM/CONTACT OUTPUT, LED

Setting Item		Range (Step)	Unit	Description
LOGIC	1/11	OR8, HALF_OR8, AND8, HALF_AND8		Logic setting
INPUT#1 ~INPUT#8	2/11 9/11	EasyLogic operand		Logic input
RESET TYPE	10/10	SELF, MANUAL		Logic Reset Type SELF : Recovery after reset delay MANUAL: Recovery after reset input
RESET DELAY	11/11	0.00~60.00 (0.01)	sec	Reset Delay

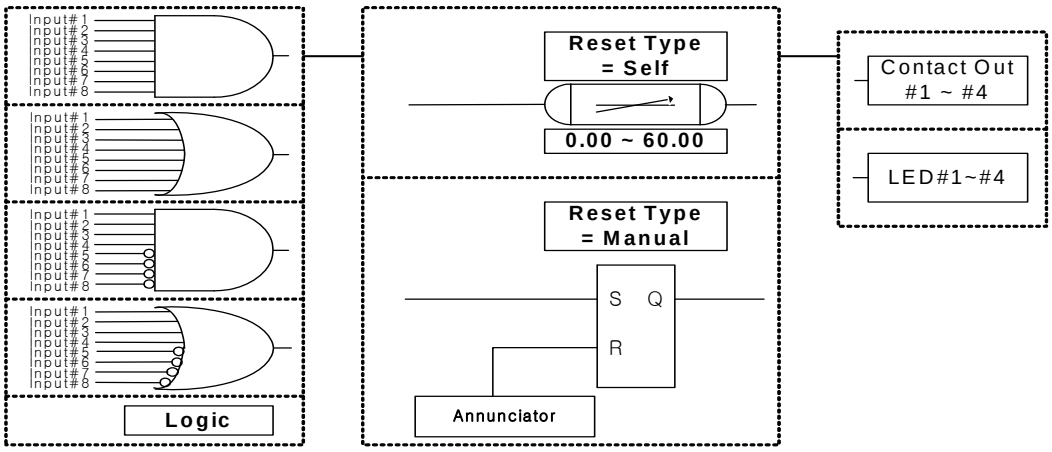


Figure 3-20 EasyLogic Operation

Table 3-2 EasyLogic Operator

Operator	Description
OR8	Logical sum of 8 logical inputs (Non inverting input 8)
HALF_OR8	Logical sum of 8 logical inputs (Non inverting input 4 & Inverting input 4)
AND8	Logical sum of 8 logical inputs (Non inverting input 4 & Inverting input 4)
HALF_AND8	Logical multiplication of 8 logical inputs (Non inverting input 4 & Inverting input 4)

Table 3-3 EasyLogic Operand

Operand Group	Operand	Description
Logic Constant	L_OFF	EasyLogic '0'
	L_ON	EasyLogic '1'
CB Control	CB_OPEN_CTL	Circuit breaker open control (Local or Remote)
	CB_CLOSE_CTL	Circuit breaker close control (Local or Remote)
Contact Input	CONT_IN#1	Operation of contact input #1

	…	…
	CONT_IN#4	Operation of contact input #4
System	SYS_ERR	Self-diagnosis result
Protection Elements	PROT_PKP_OR	Pickup OR of all protection elements
	PROT_OP_OR	Operation OR of all protection elements
	50_1_PKP_OR	Pickup OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_PKP_A	A phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_PKP_B	B phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_PKP_C	C phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_OP_OR	Operation OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_OP_A	A phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_OP_B	B phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_1_OP_C	C phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 1
	50_2_PKP_OR	Pickup OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_PKP_A	A phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_PKP_B	B phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_PKP_C	C phase pickup of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_OP	Operation OR of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_OP_A	A phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_OP_B	B phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	50_2_OP_C	C phase operation of Instantaneous/Definite Time-delayed Short-Circuit Overcurrent Protection 2
	51_PKP_OR	Pickup OR of Time-delayed Short-Circuit Overcurrent Protection
	51_PKP_A	A-phase pickup of Time-delayed Short-Circuit Overcurrent Protection
	51_PKP_B	B-phase pickup of Time-delayed Short-Circuit Overcurrent Protection
	51_PKP_C	C-phase pickup of Time-delayed Short-Circuit Overcurrent Protection
	51_OP	Operation OR of Time-delayed Short-Circuit Overcurrent Protection
	51_OP_A	A-phase operation of Time-delayed Short-Circuit Overcurrent Protection

	51_OP_B	B-phase operation of Time-delayed Short-Circuit Overcurrent Protection
	51_OP_C	C-phase operation of Time-delayed Short-Circuit Overcurrent Protection
	67Ns_PKP	Pickup of Selective Ground Overcurrent Protection
	67Ns_OP	Operation of Selective Ground Overcurrent Protection
	37_PKP_OR	Pickup OR of Undercurrent Protection
	37_PKP_A	A-phase pickup of Undercurrent Protection
	37_PKP_B	B-phase pickup of Undercurrent Protection
	37_PKP_C	C-phase pickup of Undercurrent Protection
	37_OP_OR	Operation OR of Undercurrent Protection 1
	37_OP_A	A-phase operation of Undercurrent Protection 1
	37_OP_B	B-phase operation of Undercurrent Protection 1
	37_OP_C	C-phase operation of Undercurrent Protection 1
	49_ALARM	Alarm of Thermal Overload Protection
	49_OP	Operation of Alarm of Thermal Overload
	46_PKP	Pickup of Negative Sequence Overcurrent Protection
	46_OP	Operation of Negative Sequence Overcurrent Protection
	46U_PKP	Pickup of Phase Unbalance (Loss of Phase) Protection
	46U_OP	Operation of Phase Unbalance (Loss of Phase) Protection
	48_51L_PKP	Pickup of Start-up Monitoring/Stall Protection for Motor
	48_OP	Operation of Start-up Monitoring/Stall Protection for Motor
	51L_OP	Operation of Motor Rotor Lock
	59G_1_PKP	Pickup of Ground Overvoltage Protection 1
	59G_1_OP	Operation of Ground Overvoltage Protection 1
	59G_2_PKP	Pickup of Ground Overvoltage Protection 2
	59G_2_OP	Operation of Ground Overvoltage Protection 2
	59G_3_PKP	Pickup of Ground Overvoltage Protection 3
	59G_3_OP	Operation of Ground Overvoltage Protection 3
	COLD_LD_PKP	Pickup of Cold Load Pickup
	COLD_LD_OP	Operation of Cold Load Pickup
	I2/I1_OP	Operation of Inrush Current Detection

3.3.6 Communication

The settings required for RS485 communication at the rear of the relay are defined in ***SETTING/SYSTEM/COM.***
The settings required for communication with the relay via Modbus TCP/IP when the COM protocol is MODBUS are defined in ***SETTING/SYSTEM/TCP/IP.***
The settings required for communication with the relay via DNP3.0 Protocol when the COM protocol is DNP3.0 are defined in ***SETTING/SYSTEM/DNP3.0.***

When changing the protocol of COM#1, the power must be turned off and on after saving the setting. (The changed protocol is not applied unless the power is turned off and on.)

SETTING/SYSTEM/COM

Setting Item		Range (Step)	Unit	Description
FUNCTION	1/4	ENABLED, DISABLED		Use or no use of communication port
BPS	2/4	300, 1200, 2400, 4800, 9600, 19200, 38400		Bit/sec This must be set to 9600 or higher when TCP/IP is used.
SLAVE ADDR	3/4	1~65534(1)	sec	Slave address
PROTOCOL	4/4	ModBus, DNP3.0 or Modbus, IEC60870-5-103	sec	Communication protocol Varies depending on Ordering Option.

SETTING/SYSTEM/TCP/IP

Setting Item		Range (Step)	Unit	Description
IP	1/3	0.0.0.0~255.255.255.255		IP setting
NMASK	2/3	0.0.0.0~255.255.255.255		Network Mask setting
GATEWAY	3/3	0.0.0.0~255.255.255.255		Gateway setting

SETTING/SYSTEM/DNP3.0

Setting Item		Range (Step)	Unit	Description
TX DELAY	1/7	0 ~ 65000(1)	msec	Tx delay time
LINK CONFIRM	2/7	NEVER, ALWAYS, SOMETIMES		Link layer confirm
LINK RETRY	3/7	0~5(1)		Link layer retry count
LINK TIMEOUT	4/7	1 ~ 65000(1)	msec	Link layer timeout
SBO TIMEOUT	5/7	1 ~ 65000(1)	msec	SBO timeout
WR TIME INT	6/7	1 ~ 65000(1)	min	Write time interval; Time synchronization request cycle
COLD RESTART	7/7	ENABLED, DISABLED	sec	Cold restart. Start of the slave in response to the cold start request of DNP Master (only the ENABLED:DNP Process is initialized)

3.3.7 System Time

The system time can be set locally or remotely through communication.

SETTING/SYSTEM/RTC is used to change the system time set inside the protection relay. The setting sequence is year, month, day, hour, minute, and second.
Select an item with < and > Keys and change the value with ∧ and ∨ keys. Time is set when you press the ENTER key.

SETTING/SYSTEM/RTC

Setting Item	Range (Step)	Unit	Description
YYYY	2000 ~ 2100(1)		Year
MM	01~12(1)		Month
DD	01~31(1)		Day
HH	00~23(1)		Hour
MM	00~59(1)		Minute
SS	00~59(1)		Second

4 Application Examples

4.1 Connections and Settings

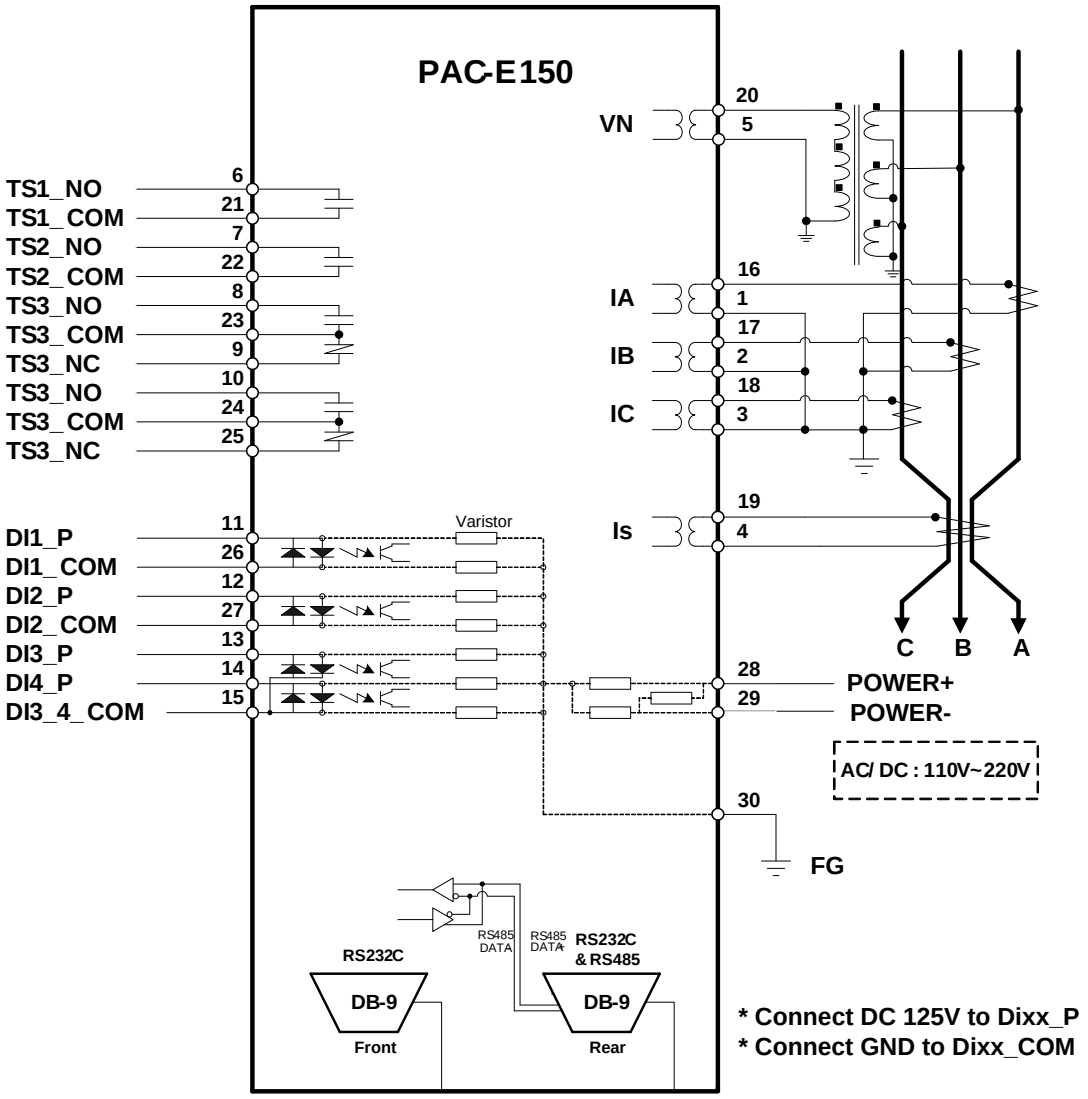


Figure 4-1 Example Connection Diagram

4.2 Measurement

Table 4-1 Example Power System Settings

Power System		Setting	Unit
FREQUENCY	1/1	60Hz	
PHS CT RATIO	2/7	300:5	
GND PT PRI	3,4/7	22900.0	V
GND PT SEC	5/7	110.0	V

Select settings in SETTING/SYSTEM/POWER SYSTEM with the Example Power System in Table 4-1 and enter the current values.

Current Input

Terminal	Input Value
FREQUENCY	60Hz
IA	1.00 A, 0.0 º
IB	2.00 A, 240.0 º
IC	3.00 A, 120.0 º
Is	1.5 mA, 1.1 º
VN	110.0V, 0.8 º
Applied time	24Hours

Primary Current/Frequency/Sequence Current

Current size is displayed as primary current by applying the CT Ratio setting. Phase is measured based on the phase of the IA terminal current.

- A-phase current : (300/5)*1 = **60[A], 0.0 º**
- B-phase current : (300/5)*2 = **120[A], 240.0 º**
- C-phase current : (300/5)*3 = **180[A], 120.0 º**
- Is current : 1.50 = **1.5[mA], 1.1 º**
- N-phase voltage : (22900/110)*110 = **22.9[kV], 0.8 º**

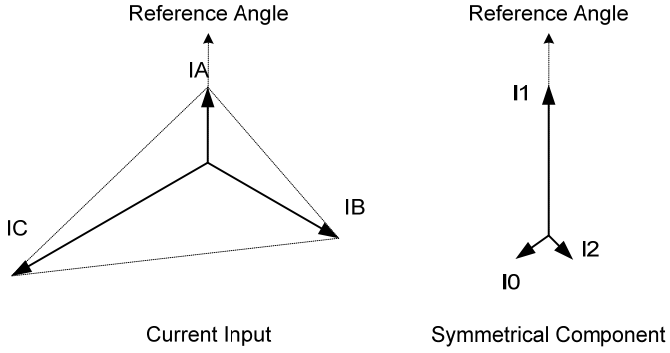


Figure 4-2 Sequence Current

Refer to the Sequence Current Vector Diagram of the above ABC Rotation:

- Zero Sequence Current, $I0 = \frac{1}{3}(\dot{I}_A + \dot{I}_B + \dot{I}_C)$:(300/5)*0.57 = **34.2[A], 150.0 º**
- Positive Sequence Current, $I1 = \frac{1}{3}(\dot{I}_A + a\dot{I}_B + a^2\dot{I}c)$:(300/5)*2 = 120[A], 331.5 º
- Negative Sequence Current, $I2 = \frac{1}{3}(\dot{I}_A + a^2\dot{I}_B + a\dot{I}c)$:(300/5)*0.57= 34.2[A], 210.0 º

5 Installation and Connections

5.1 Dimensioned Drawings

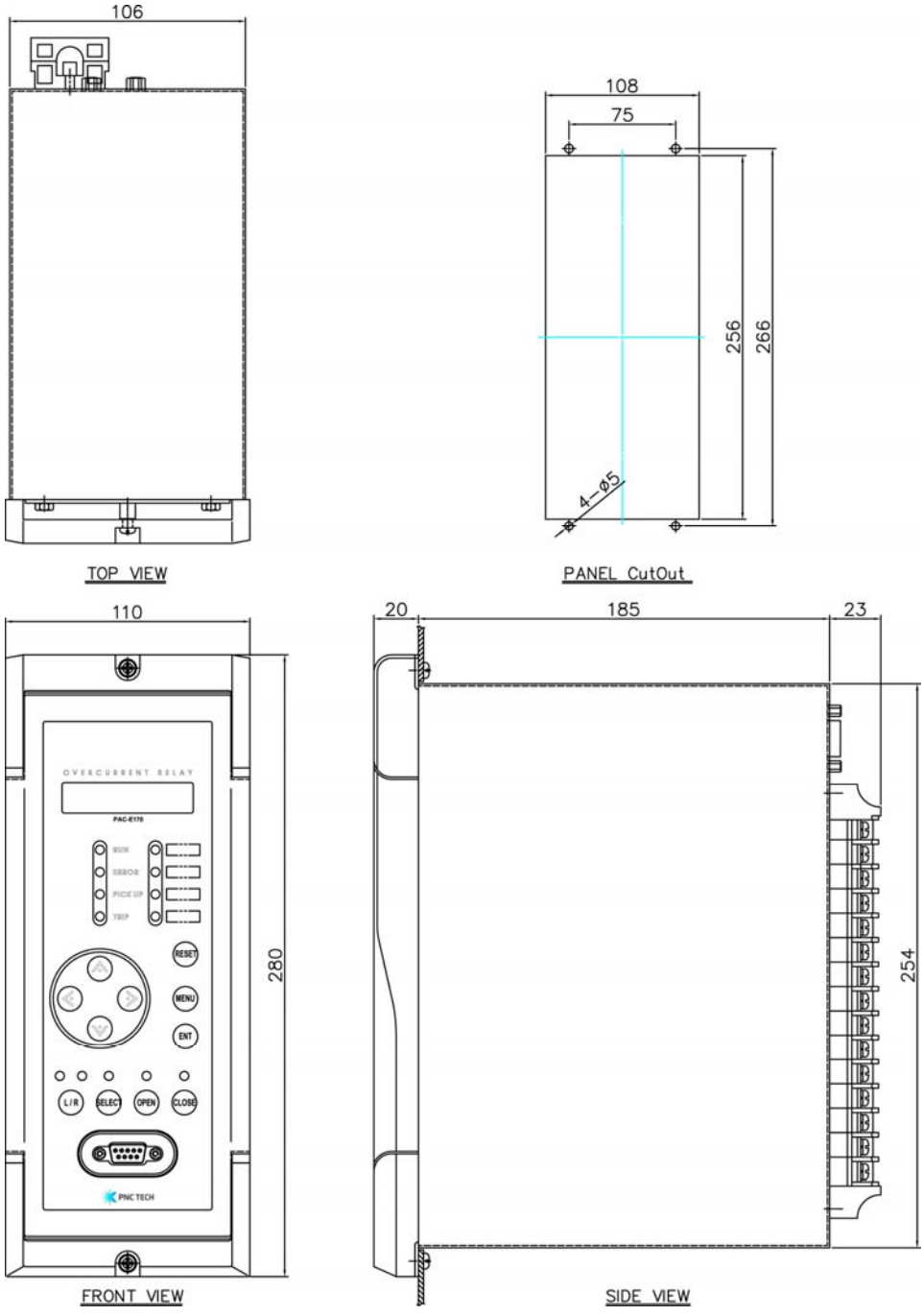


Figure 5-1 PAC-E150 Dimensioned Drawing

5.2 Rear Terminal Layout

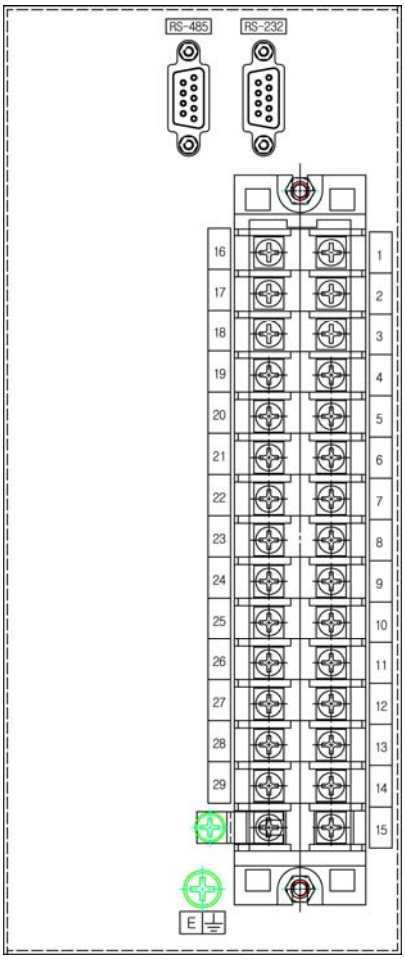


Table 5-1 Terminal Layout

16	IA+	1	IA-
17	IB+	2	IB-
18	IC+	3	IC-
19	Is+	4	Is-
20	VN+	5	VN-
21	TS1_COM	6	TS1_NO
22	TS2_COM	7	TS2_NO
23	TS3_COM	8	TS3_NO
24	TS4_COM	9	TS3_NC
25	TS4_NC	10	TS4_NO
26	DI1_COM	11	DI1_P
27	DI2_COM	12	DI2_P
28	PWR+	13	DI3_P
29	PWR-	14	DI4_P
30	FG	15	DI3_4_COM

5.3 External Connections

5.3.1 PAC-E150 CT Connection

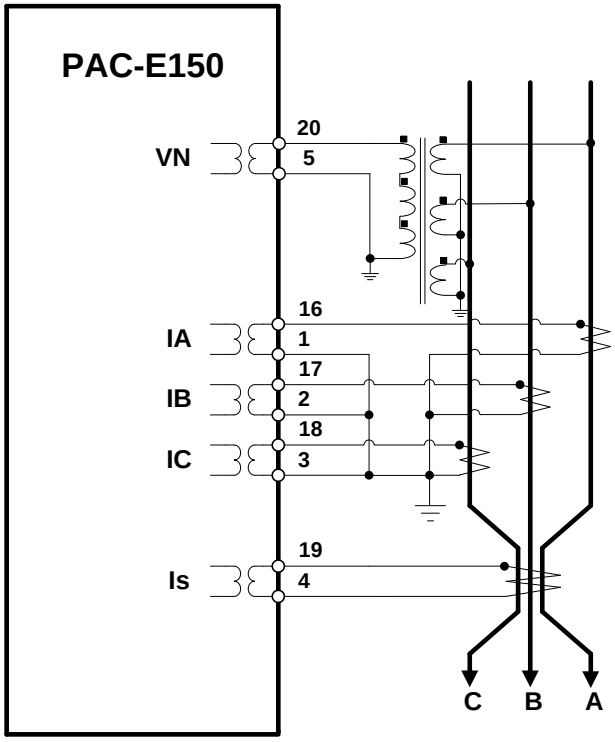


Figure 5-2 PAC-E150 CT Connection

5.3.2 Input/Output Contact Connections

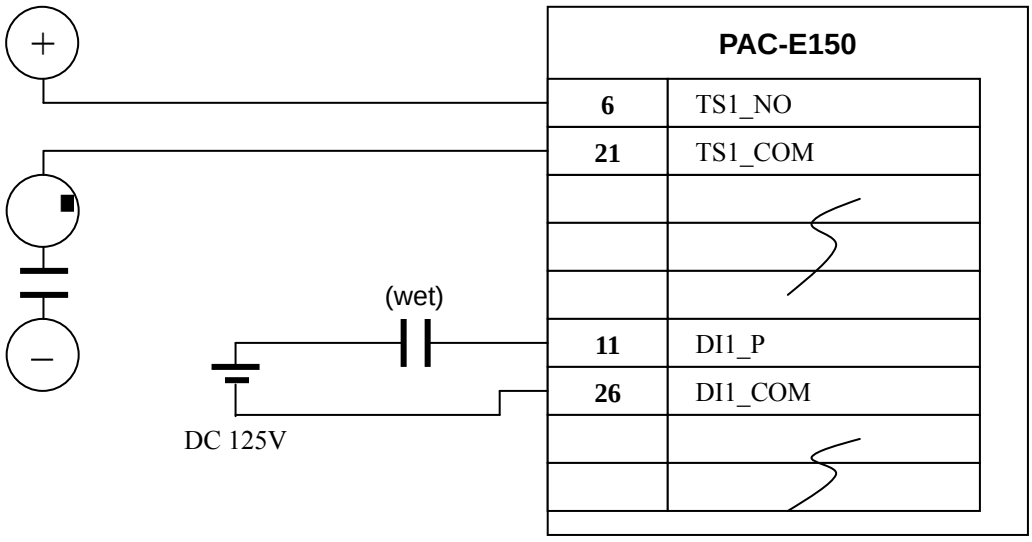


Figure 5-3 Input/Output Contact Connections

5.3.3 RS232 Port Connection

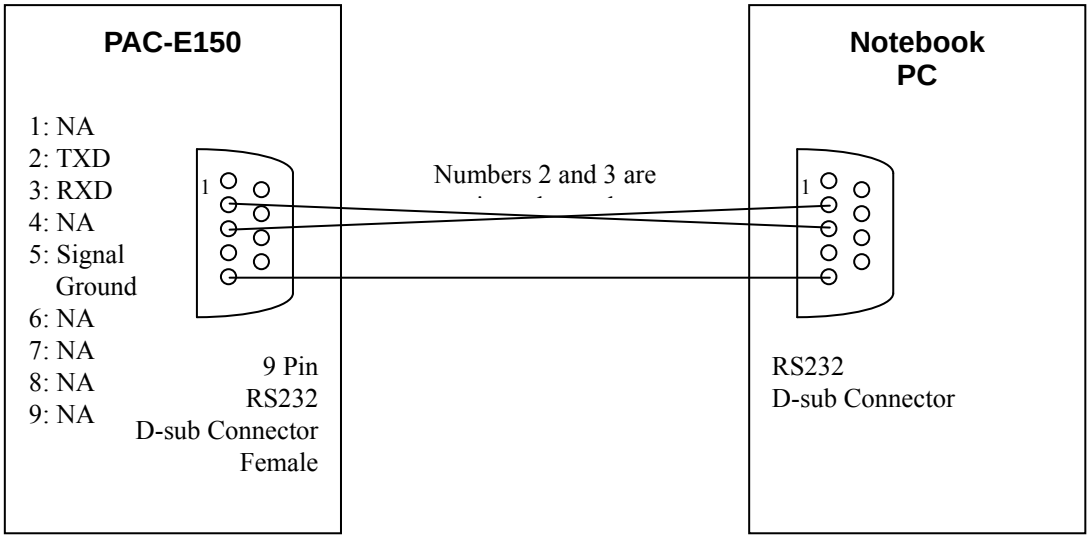


Figure 5-4 RS232 Port Connections

5.3.4 RS485 Port Connection

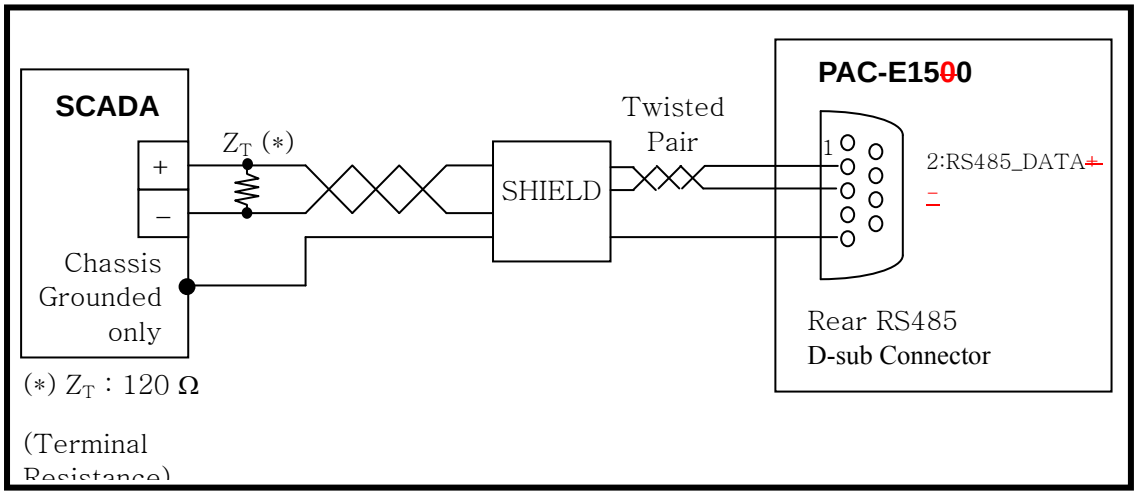


Figure 5-5 RS485 Port Connection

5.3.5 TCP/IP Port Connection

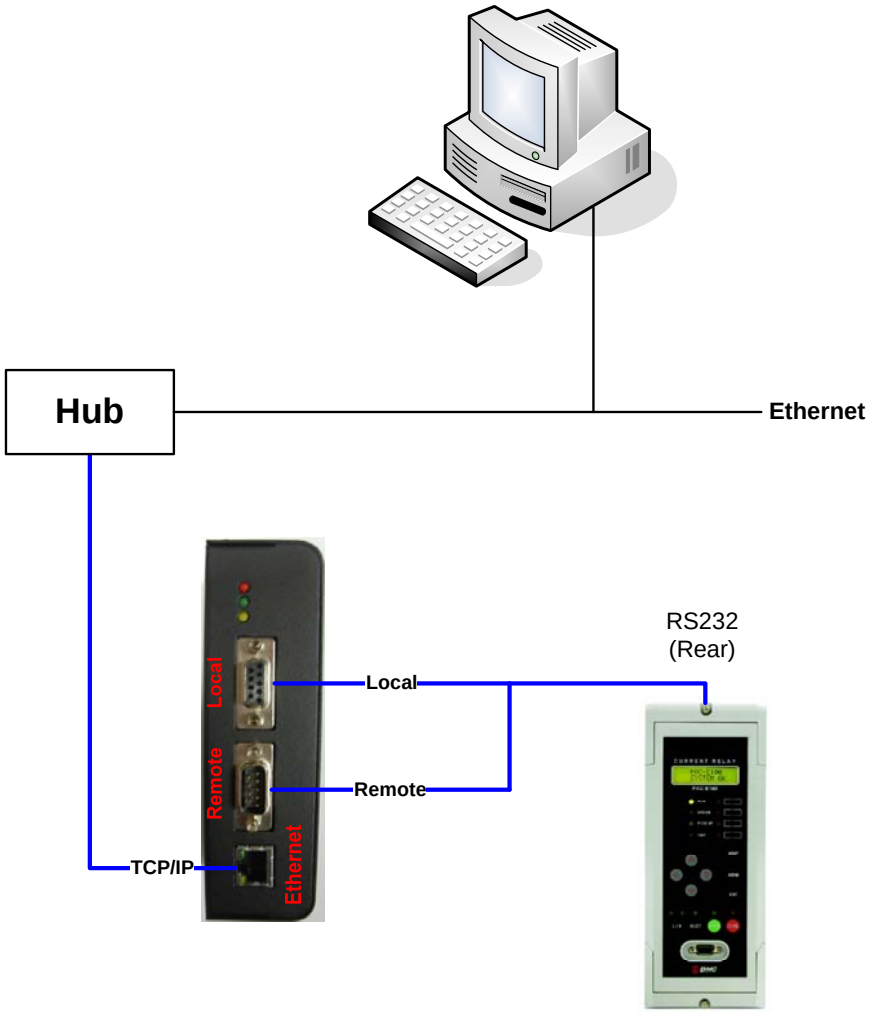


Figure 5-6 TCP/IP Port Connections

5.4 Removal and Replacement of Modules

Caution

The module must be installed or removed with the control power supply turned off. Installing or removing the module with the control power supply turned on may injure the workers, damage the module, or cause malfunctions of the protection control part.

5.4.1 Removal of Modules

Unfasten the screws in the middle of the top and bottom of the front display unit, and pull out the handle at the top and bottom. The relay will be removed excluding the case and the connection terminals at the back. When you unfasten the set screws after pulling out the relay, the DSP and DISPLAY modules will be removed.

5.4.2 Replacement of Modules

Each removed module can be replaced in board unit. Make sure that the connectors are completed connected for the DSP and DISPLAY boards and then fasten the set screws. After assembling the modules, put the DSP module inside along the rail inside the case while vertically erecting the handles at the top and bottom of the front display unit. Once the module is completely pushed inside, the handles at both sides return to their original positions. If the handles are not returned to their original positions, check if the module assembly is normal. If there is no error, you can directly push it in. Once the module assembly finishes, fasten the screws in the middle of the top and bottom to fix the module.

Engineering Tools (E3RSet™ PC Software)

For details on E3RSet™, refer to the user manual for E3RSet™.

Appendix A. Inverse Time-delayed Operation Characteristics

- Overcurrent/Overvoltage Characteristic Equation

$$t = \left(\frac{K}{\left(\frac{G}{G_S} \right)^L - 1} + C \right) \times TM(\text{sec})$$

t	: Operation time
K, C, L	: Constants of characteristic curve
G	: Current (voltage) input
Gs	: Current (voltage) operation value
TM	: Magnification (0.01~10.00)

Protection Elements	Inverse Time-delayed Operation Characteristic Curve	K	L	C
Short-Circuit Overcurrent Protection (51)	IEC Normal Inverse	0.14	0.02	0.00
	IEC Very Inverse	13.50	1.00	0.00
	IEC Extremely Inverse	80.00	2.00	0.00
	IEC Long Inverse	120.00	1.00	0.00
	ANSI Inverse	8.9341	2.0938	0.17966
	ANSI Short Inverse	0.2663	1.2969	0.03393
	ANSI Long Inverse	5.6143	1	2.18592
	ANSI Moderately Inverse	0.0103	0.02	0.0228
	ANSI Very Inverse	3.922	2	0.0982
	ANSI Extremely Inverse	5.64	2	0.02434
	ANSI Definite Inverse	0.4797	1.5625	0.21359
	KEPCO Normal Inverse	0.11	0.02	0.42
	KEPCO Very Inverse	39.85	1.95	1.08
Ground Overvoltage Protection (59G)	Inverse Trip	12.5	2	0.35
	Inverse Alarm	24.75	2.23	4.15

However, the operation time of current that is greater than 2000% of the set current is equal to the operation time of 2000%.

- Characteristic Equation of Thermal Overload Protection

Hot Condition

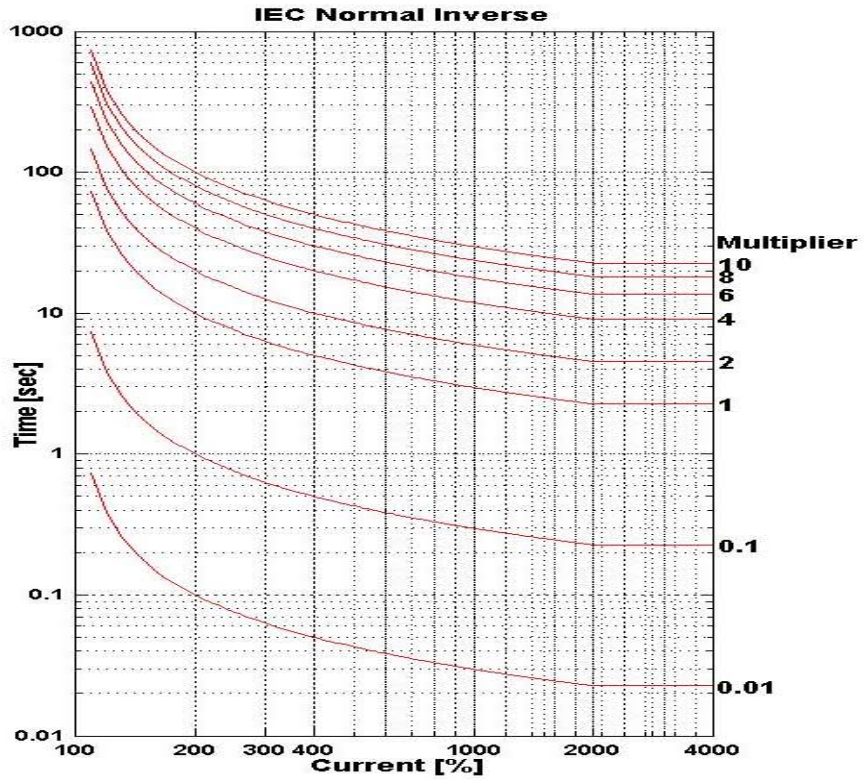
$$t = \tau \cdot \ln \left(\frac{\left(\frac{I}{k \cdot I_N} \right)^2 - \left(\frac{I_P}{k \cdot I_N} \right)^2}{\left(\frac{I}{k \cdot I_N} \right)^2 - 1} \right) [\text{min}]$$

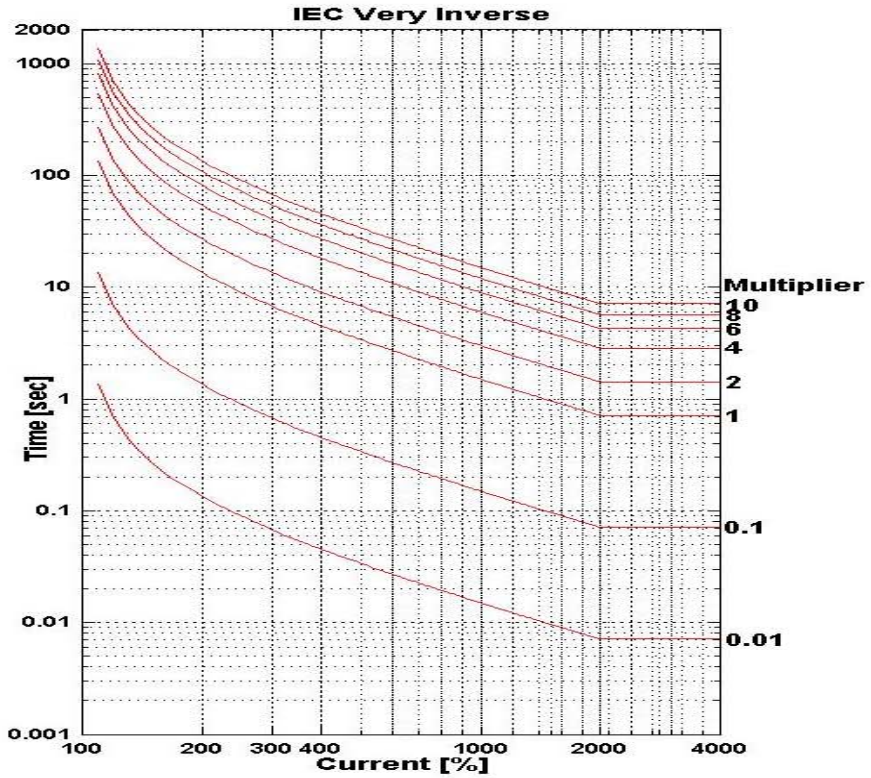
Cold Condition

$$t = \tau \cdot \ln \left(\frac{\left(\frac{I}{k \cdot I_N} \right)^2}{\left(\frac{I}{k \cdot I_N} \right)^2 - 1} \right) [\text{min}]$$

t	: Operation time
τ	: Time constant (min)
I	: Current input
I_N	: Rated current
Ip	: Previous current
K	: Overload ratio

However, the operation time of current that is greater than 800% of the set current is equal to the operation time of 800%.


IEC Normal Inverse
Time [sec]
1000
100
10
1
0.1
0.01
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01


IEC Very Inverse
Time [sec]
2000
1000
100
10
1
0.1
0.01
0.001
100
200
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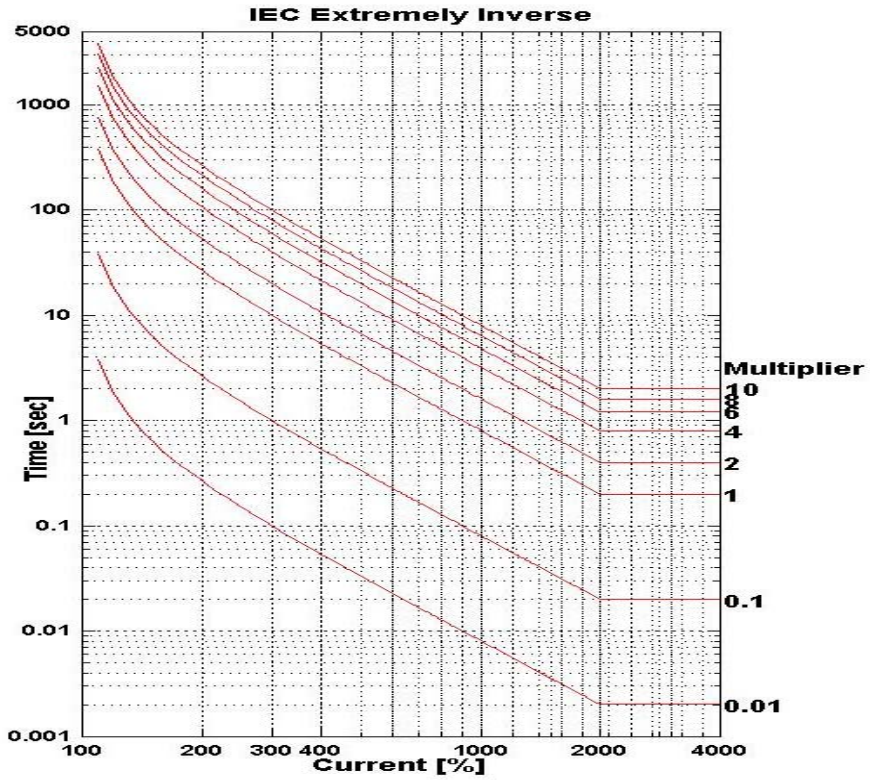
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01


IEC Extremely Inverse
5000
1000
100
10
1
0.1
0.01
0.001
Time [sec]
100
200
300 400
1000
2000
4000
Current [%]
Multiplier
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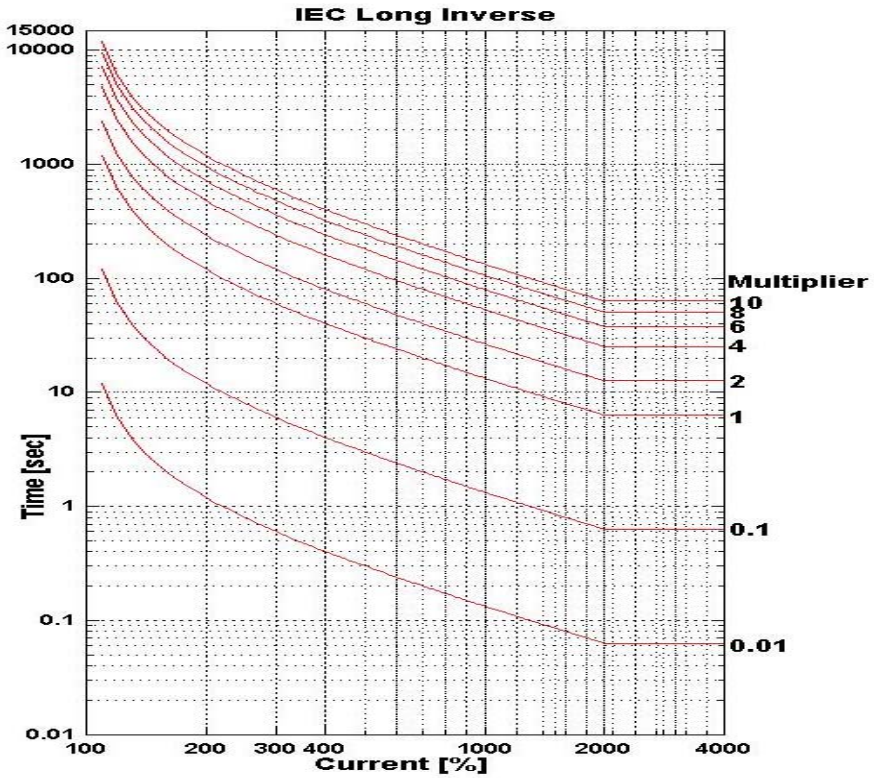
8
6
4
2
1
0.1
0.01


IEC Long Inverse
15000
10000
1000
100
10
1
0.1
0.01
Time [sec]
100
200
300 400
1000
2000
4000
Current [%]
Multiplier
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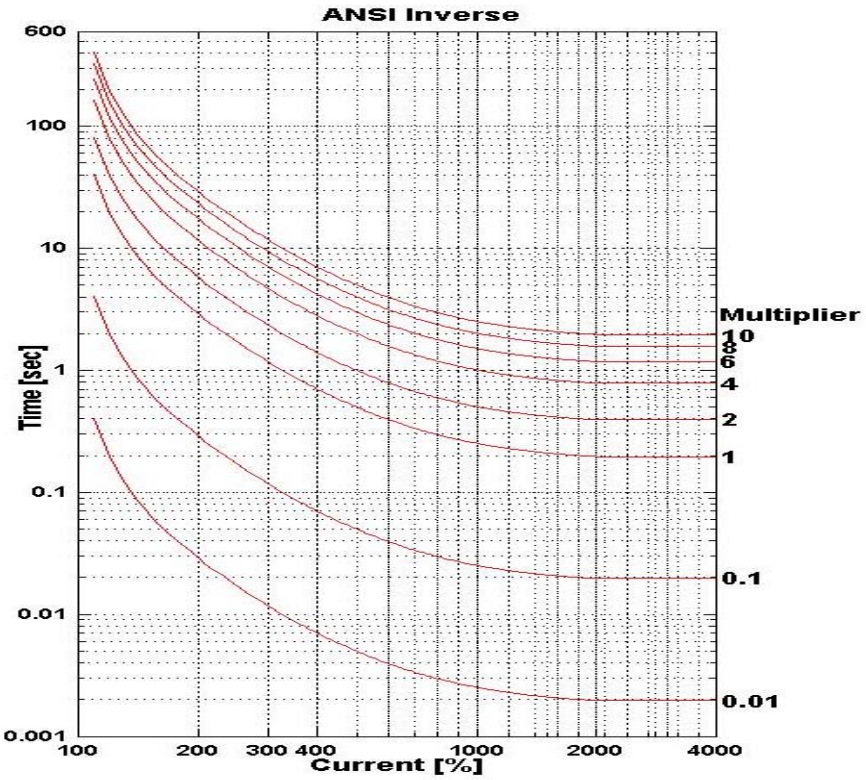
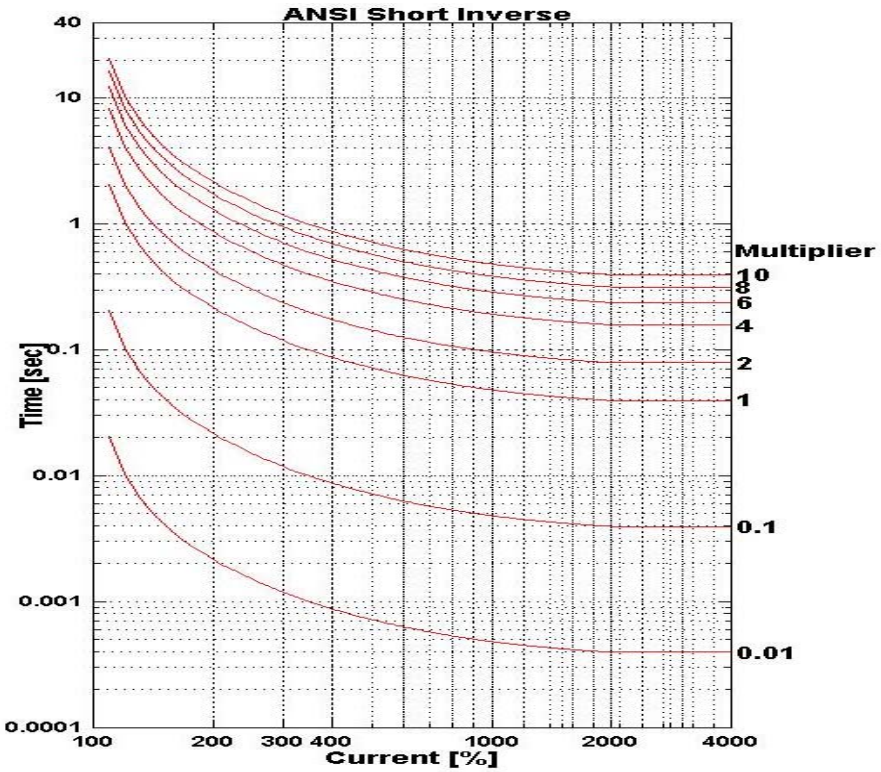
8
6
4
2
1
0.1
0.01


ANSI Inverse
600
100
10
1
0.1
0.01
0.001
Time [sec]
100
200
300 400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01


ANSI Short Inverse
40
10
1
0.1
0.01
0.001
0.0001
Time [sec]
100
200
300 400
1000
2000
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Current [%]
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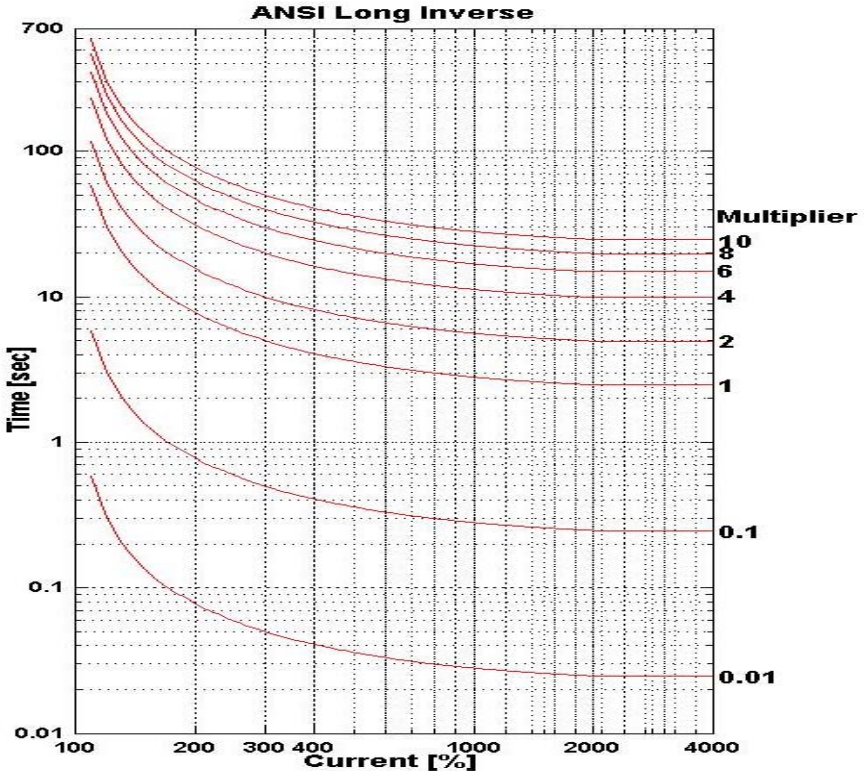
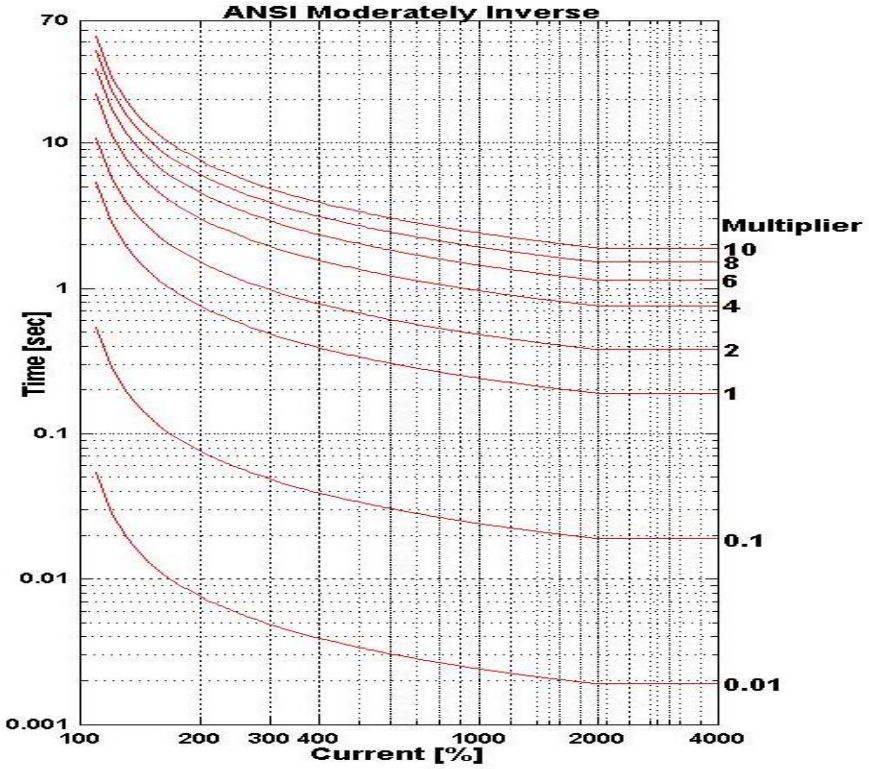
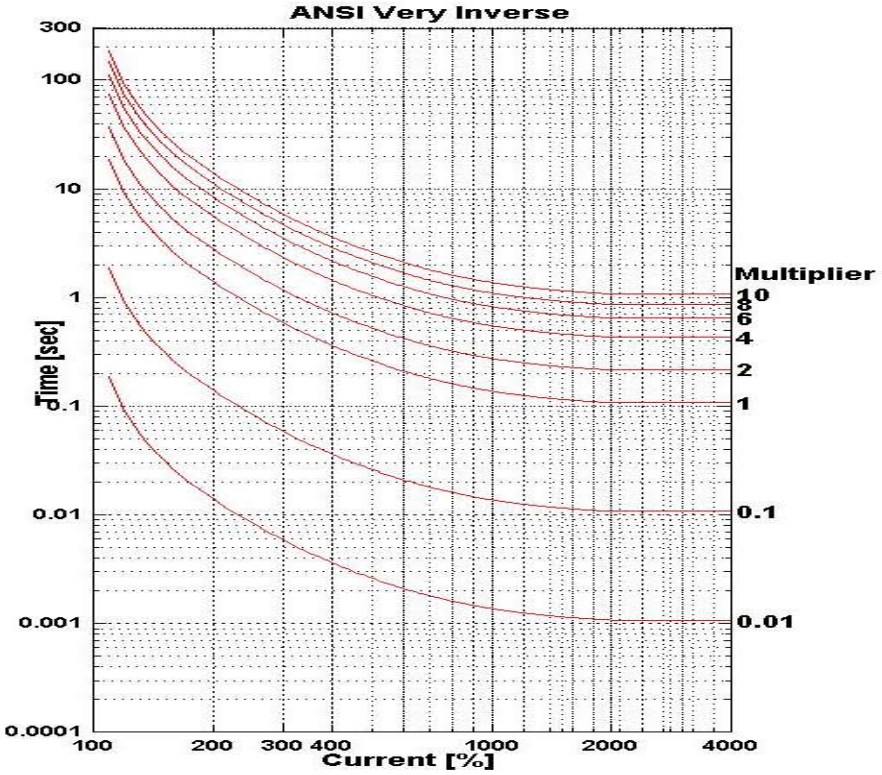
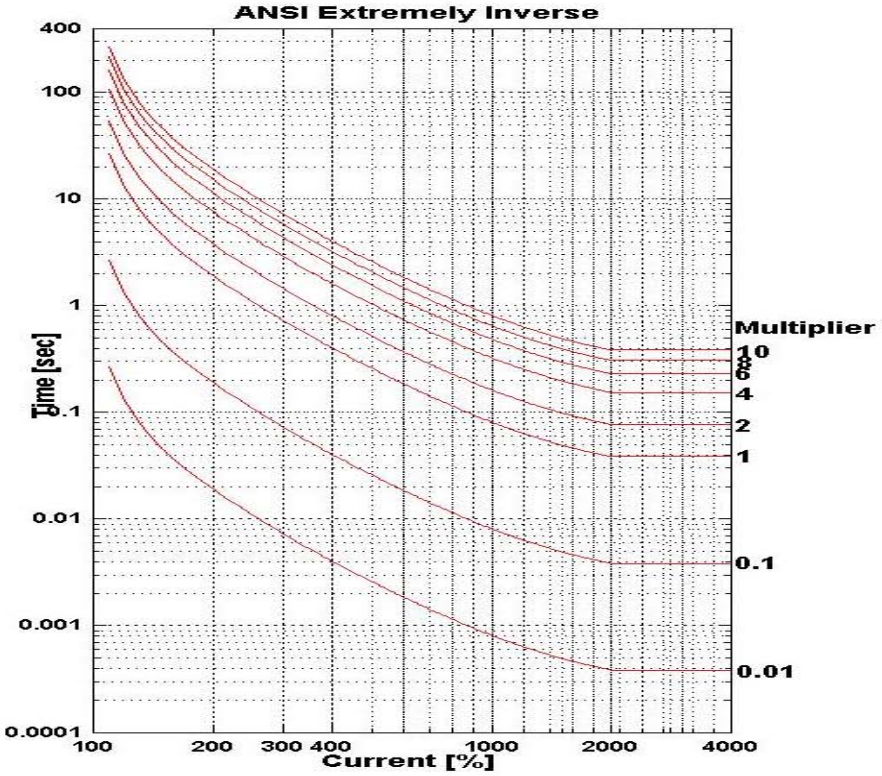
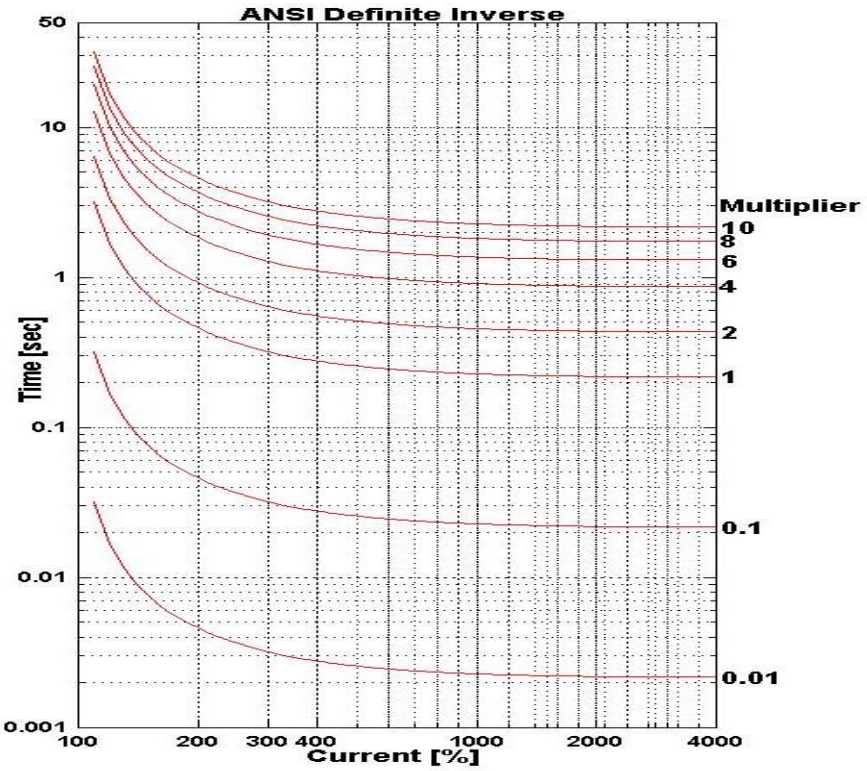
10
8
6
4
2
1
0.1
0.01

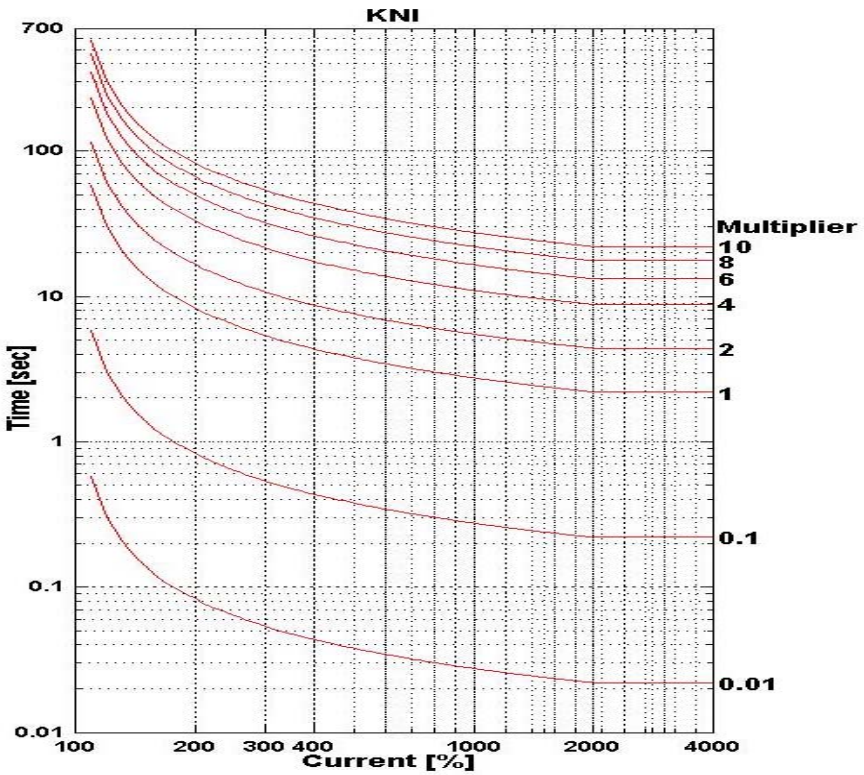

ANSI Long Inverse
700
100
10
1
0.1
0.01
Time [sec]
100
200
300 400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01

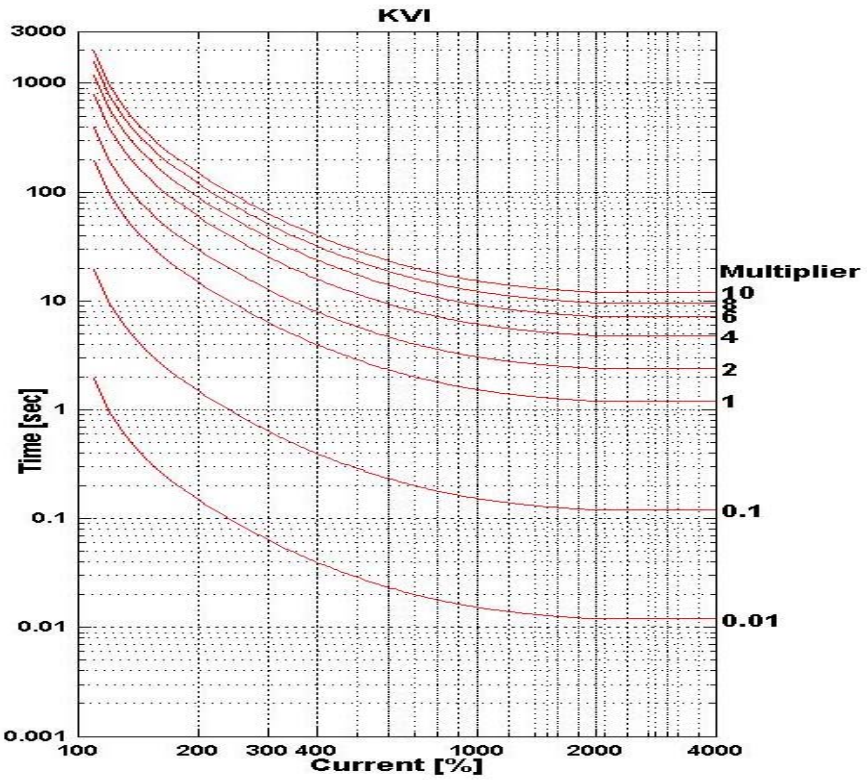

ANSI Moderately Inverse
70
10
1
0.1
0.01
0.001
Time [sec]
100
200
300 400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01

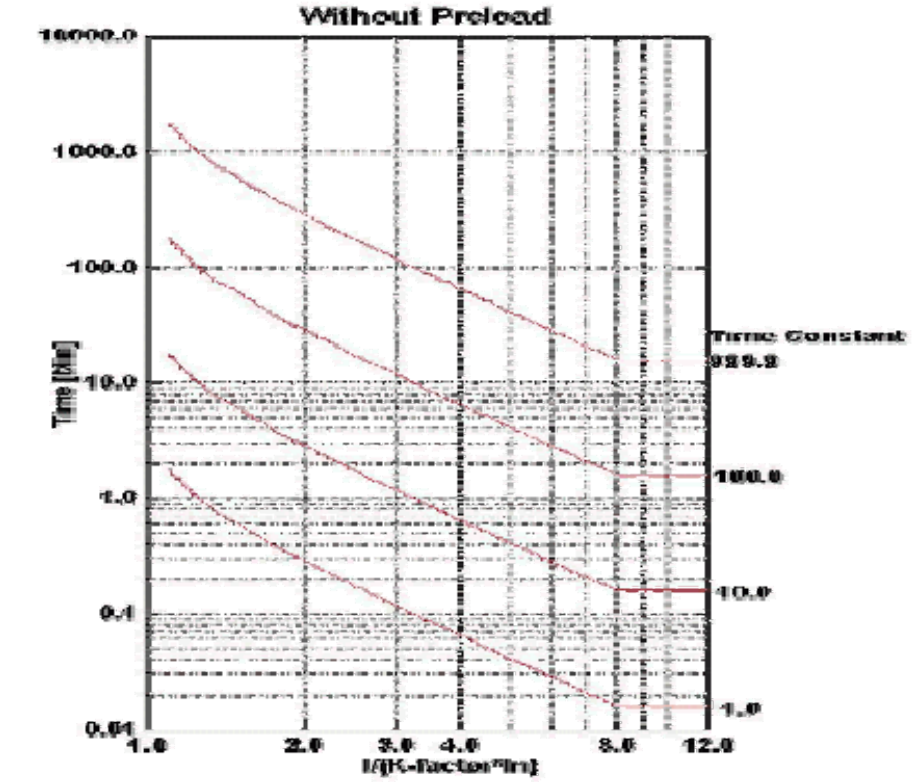

ANSI Very Inverse
Time [sec]
300
100
10
1
0.1
0.01
0.001
0.0001
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01

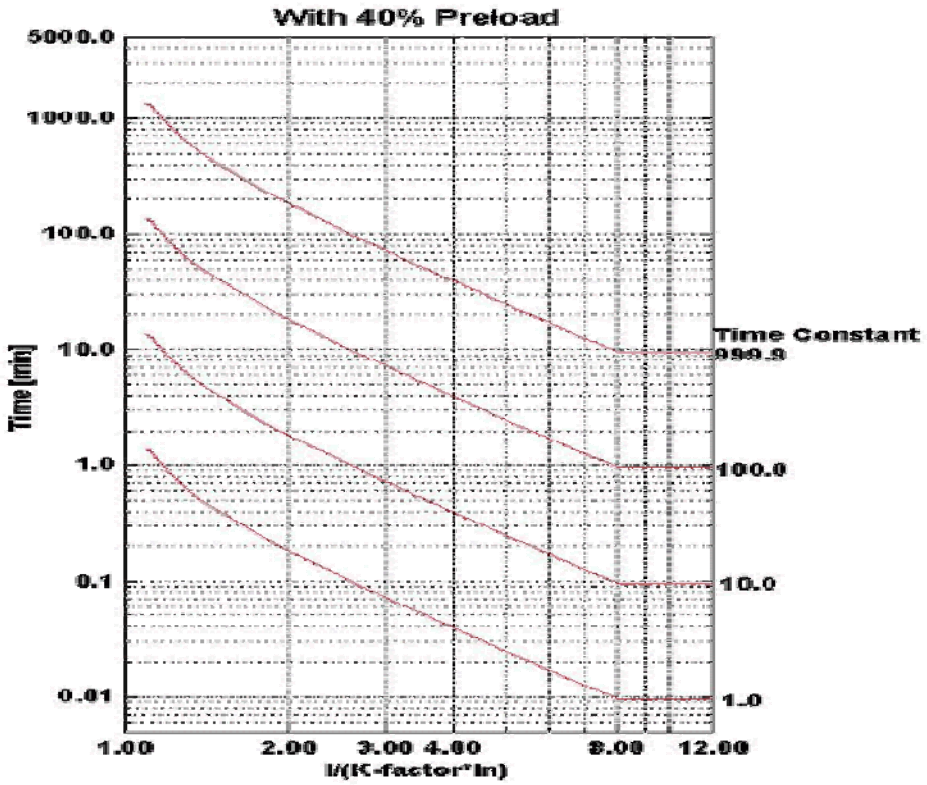

ANSI Extremely Inverse
Time [sec]
400
100
10
1
0.1
0.01
0.001
0.0001
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01

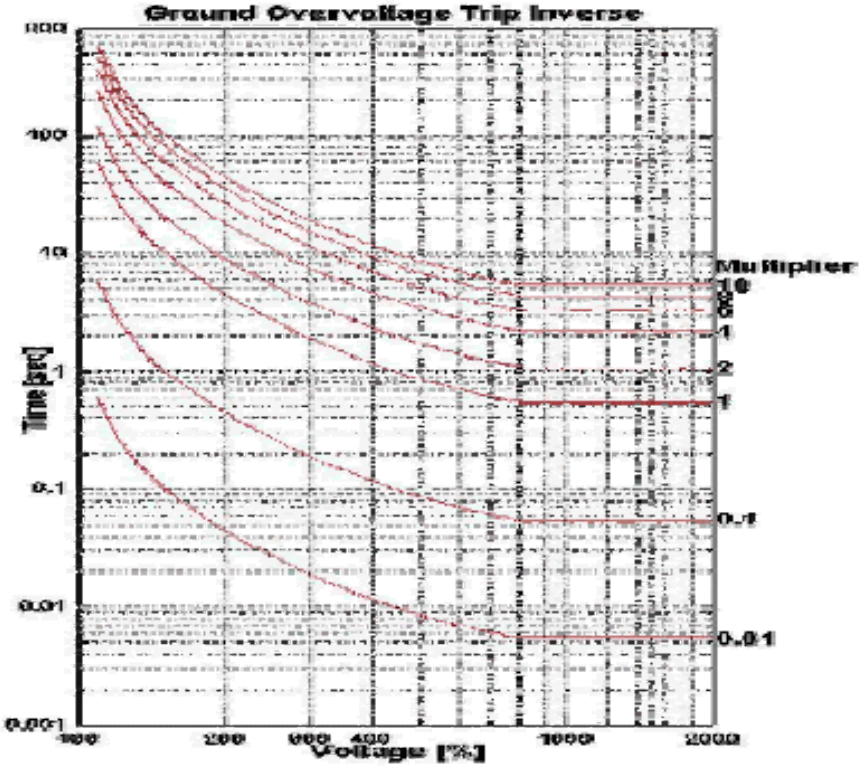

ANSI Definite Inverse
Time [sec]
50
10
1
0.1
0.01
0.001
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01

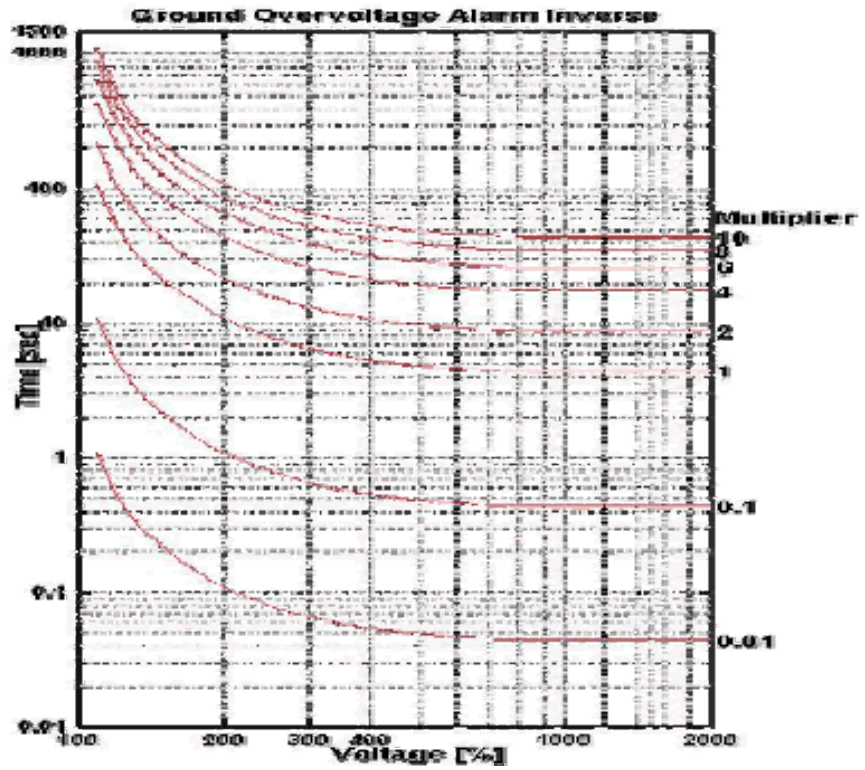

KNI
Time [sec]
700
100
10
1
0.1
0.01
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01


KVI
3000
1000
100
10
1
0.1
0.01
0.001
Time [sec]
100
200
300
400
1000
2000
4000
Current [%]
Multiplier
10
8
6
4
2
1
0.1
0.01


Without Preload
10000.0
1000.0
100.0
10.0
1.0
0.1
0.01
Time [Min]
Time Constant
999.9
100.0
10.0
1.0
1.0
2.0
3.0
4.0
8.0
12.0
I/(K-factor*In)


With 40% Preload
5000.0
1000.0
100.0
10.0
1.0
0.1
0.01
Time [min]
Time Constant
999.9
100.0
10.0
1.0
1.00
2.00
3.00
4.00
8.00
12.00
I/(K-factor*In)


Ground Overvoltage Trip Inverse
Time [sec]
Voltage [%]
Multiplier
10
5
4
2
1
0.4
0.1
0.01


Ground Overvoltage Alarm Inverse
Time [sec]
Voltage [%]
Multiplier
10
5
4
2
1
0.4
0.1
0.01

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