Line Distance Relays

iTP-100 Line Distance Relay

Figure 1: Edison Idea Relay

The iTP-100 is a member of Cooper Power Systems' Edison® Idea™ line of protective relays. The iTP-100 is a full-featured relay ideally suited for transmission line applications including distance protection, out of step tripping/blocking and communication-aided tripping schemes. The iTP-100 also provides advanced power quality, metering, control, communication and PLC functions.

The iTP-100 uses the Cooper Power Systems' ProView™ software package for PCs running the Microsoft® Windows® operating system. The *IDEA Workbench™* feature of ProView permits the user to add additional functionality to the iTP-100 by means of downloadable custom modules. These modules can be obtained from Cooper Power Systems or created by the user. This ability provides a continuous upgrade path that not only protects the initial investment in the relay, but also provides a means to increase the relay's functionality in response to regulatory, power quality and reliability concerns.

APPLICATIONS

The iTP-100 is an extremely versatile relay that is well-suited for any number of applications that require the use of any or all of its many functions. Typical applications include: transmission line distance protection and/or backup protection, communication-aided fault protection, power swing protection, bus backup protection, reclosing with or without synchronism check, and over/undervoltage protection.

HIGHLIGHTS

- Viewable Factory Logic Programming
- IDEA Workbench™ programming environment for adding new functions and features
- Trip coil monitoring (and close coil monitoring on the IdeaPLUS hardware version)
- Front panel access to view/modify all relay settings
- Virtual Test Set™ event record simulator including Power Swing and Load Encroachment simulators
- Relay Replay™: The "what-if" analysis tool
- Interactive oscillography and Sequence of Events Recording
- Amps, Volts, Watts and VAR metering
- Demand and Energy Metering
- Eight setting groups
- Programmable front panel pushbuttons and targets.

PROTECTIVE FUNCTIONS

- Five Zones of Phase Distance (21P)
- Five Zones of Ground Distance, Mho or Selective Reactance (21G)
- Four Shots of Programmable Reclosing (79)
- High Speed Communication Aided Trip Schemes (POTT, DCB, DCUB, PUTT, DTT, etc.)
- Synchronism Check (25)
- Out of Step Tripping and Blocking
- Load Encroachment Supervision
- Five Levels of Definite Time Directional Overcurrent (67)
- One Level of Inverse Time Directional Overcurrent (67)
- Phase, Negative Sequence and Ground Overcurrent available at each level
- Breaker fail-to-trip and fail-to close
- Fuse Failure Protection
- Two Levels of Overvoltage Protection (59)
- Two Levels of Undervoltage Protection (27)

Advanced power quality, metering, control and communications capabilities address the needs of automation, EMS and SCADA systems.

TWO HARDWARE PLATFORMS

The iTP-100 is available both in the Idea and IdeaPLUS relay platforms. The IdeaPLUS platform is the same as the Idea platform shown in Figure 1 with the addition of a breaker control panel. See Figure 2. These features eliminate the need for separately mounted breaker controls. This control panel provides:

■ Large green and red, self-illuminated breaker TRIP and CLOSE pushbuttons that operate even if the relay is not powered.

■ Close Inhibit switch which, when enabled, blocks the ability of the relay to issue a close command to the circuit breaker[1].

■ Close Circuit disable link. When removed, this link places a physical open in the breaker's close circuit making it impossible to close the breaker via the relay or its CLOSE button under any condition. This is provided in addition to the Close Inhibit control for those situations when extra security is required.

Figure 2: IdeaPLUS Relay Hardware with Integral Breaker Control Panel

■ Nine additional programmable feature pushbuttons with integral indicating LEDs.

CUSTOMIZE THE iTP-100 WITH THE *IDEA WORKBENCH*™

The iTP-100 is a fully functional relay, ready to use right out of the box. However, there are applications where custom control logic, or custom functions need to be added to the relay. The *IDEA Workbench* is a revolutionary graphical software-programming environment that permits the user to customize the iTP-100.

■ Add new features or protective functions by means of *IDEA Workbench* custom modules. Your investment in the relay is protected as future needs and developments may be addressed through new custom modules.

■ Create custom control and protection logic using over 400 programming signals and tools, all selectable from drag-off Toolboxes. Logic created using these tools can then be saved as custom modules to be reused or shared with associates.

■ Reassign targets and front panel pushbutton functionality.

■ Create and display custom text messages.

■ Monitor and control practically every aspect of the relay's operation.

■ Create custom metering and measurement quantities.

■ Create custom sequence of event records.

■ Configure communication protocols to match existing SCADA system mappings.

The *IDEA Workbench* offers the user the ability to rapidly and accurately create customizations by working the way the engineer thinks, using logic diagram and flowchart construction methods. No equation-based or commands-based logic programming is required. See Figure 3.

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[1] The Close Inhibit switch may be cleared remotely by communications unless Supervisory control is disabled from the relay's front panel.
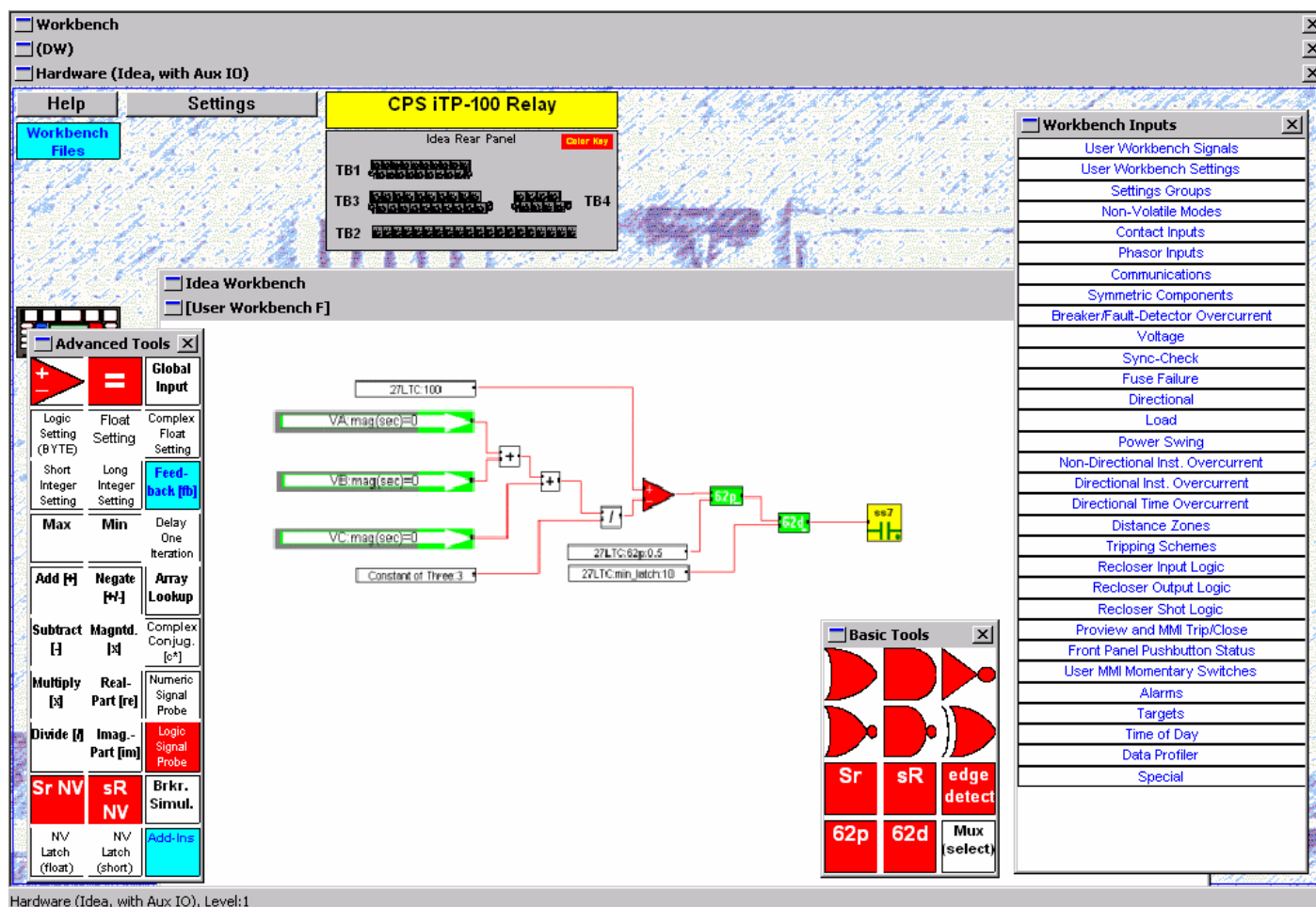
Figure 3: The *IDEA Workbench* Graphical Customization Environment

The *IDEA Workbench* also addresses some of the more difficult questions associated with custom relay programming, namely:

Clarity: Graphical programming results in customization, whose operation is intuitive compared to equation- and command-based programming techniques.

Testing: ProView provides a Virtual Test Set™ (VTS™) that can be used to test the developed logic with realistic fault signals. During test, the logic diagrams become "live" showing the state of all variables, logic gates, contacts, counters, etc. To avoid any question of how the custom logic interacts with the relay itself, the VTS environment models the entire relay in addition to the custom programming. Unlike other programming environments, the VTS does not require the user to have an actual relay or relay test set on hand to verify the proper operation of the programmed logic.

Documentation: Notes regarding how the custom logic operates may be embedded within the *IDEA Workbench*. This improves the ability of others to quickly understand how the logic is designed to work. Links to external files may also be embedded in the *IDEA Workbench* providing fast access to larger documents stored on company's network servers.

Portability: If the original data files are lost, the entire *IDEA Workbench* may be uploaded from the relay, complete with logic diagrams, embedded notes and external reference links.

DISTANCE PROTECTION

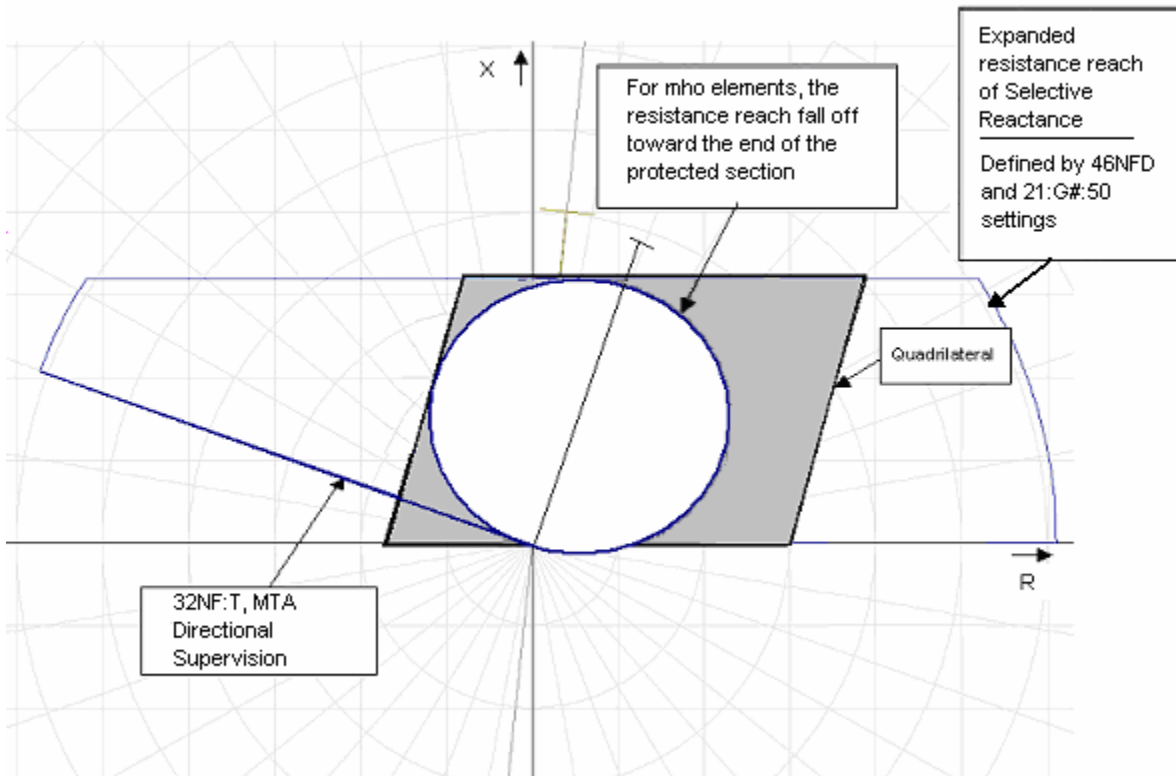The iTP-100 offers five levels of phase and ground distance protection.

Figure 4:   Selective Reactance Characteristic of the iTP-100 Compared to Mho and Quadrilateral Characteristics

Phase Distance Elements

Pick-up range of phase elements (21P1)   0.01 to 20 Per Unit
Pick-up range of phase elements (21P2-5)   0.05 to 20 Per Unit
Time delay   0 to 3600 seconds

Ground Distance Elements
The ground distance elements may be selected to follow a traditional mho characteristic or a ground reactance characteristic.

Pick-up range of ground elements (21G1)   0.01 to 20 Per Unit
Pick-up range of ground elements (21G2-5)   0.05 to 20 Per Unit

Time delay   0 to 3600 seconds

In the iTP-100 scheme, the reactance ground elements – one per zone, five per phase – are supervised by internal selective functions that ensure they do not operate except when a ground fault of the selected type is applied. Thus, for example, the selective A-phase-ground reactance element is permitted to trip only when an unbalanced fault – specifically an A-phase-ground fault – is already detected. Consequently, the selective reactance elements are made generally unresponsive to load.

The practical benefits of this design are two-fold. First, the actual resistive reach of the line protection need no longer be artificially limited to accommodate possible encroachment of load. Accordingly, the effective resistance coverage for

ground faults is expanded – often greatly. Second, versus quadrilateral distance, the required settings for the resistance blinders are no longer needed and are eliminated, simplifying the setting determination, entry, and management process. The result is ground distance protection having the desirable section-end characteristics of the quadrilateral element (no fall-off of resistance reach at the section ends), but with greater resistance reach for the entire protected line than conventional quadrilateral schemes can supply.

POWER SWING PROTECTION

The iTP-100 employs a double blinder characteristic of power swing protection allowing for tripping on the way in and on the way out of the blinder zone. Power Swing logic allows the user to block distance and overcurrent elements for swing conditions.
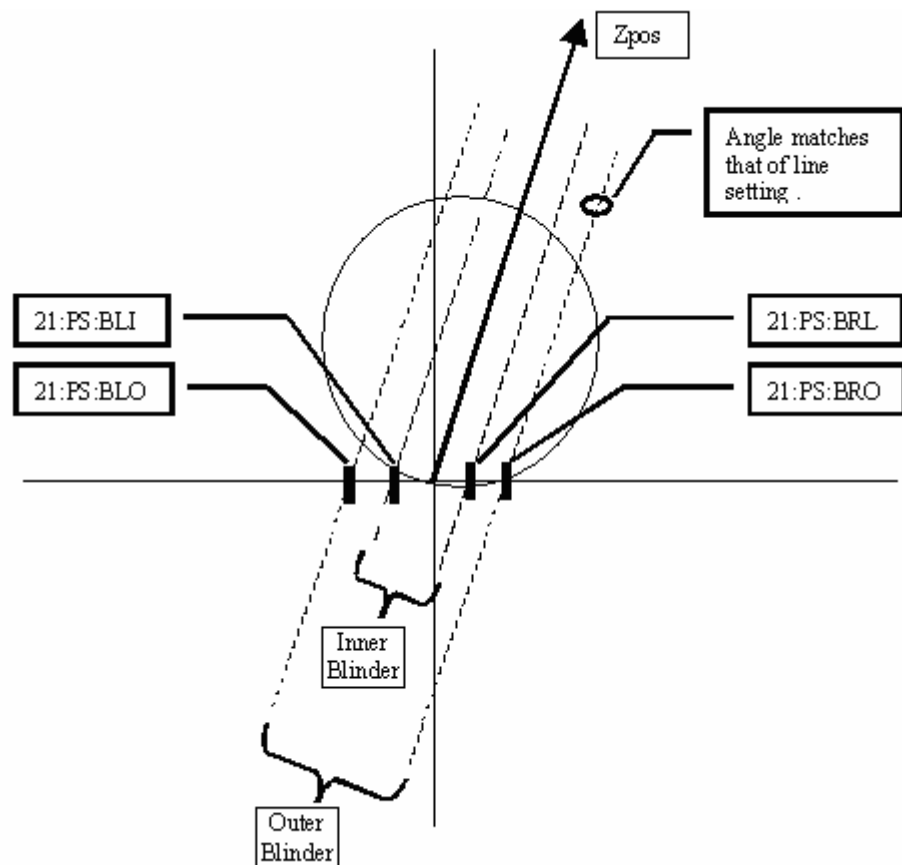
Figure 5:   Power Swing Blinder Characteristics

Blinder Range

Inner Left Power Swing Blinder	-1 to –100 ohms sec
Outer Left Power Swing Blinder	-1 to –100 ohms sec
Inner Right Power Swing Blinder	1 to 100 ohms sec
Outer Right Power Swing Blinder	1 to 100 ohms sec

OVERCURRENT PROTECTION
The iTP-100 offers inverse and instantaneous elements for phase, residual and negative sequence overcurrent protection.

Definite Time
Five directional phase (67P), negative sequence (67Q) and residual (67N) elements are provided.

Pick-up range of definite time elements	0.1 to 90 amps secondary
Time delay	0 to 3600 seconds

Inverse Time
One phase (67P), negative (67Q) and residual (67R) element is provided.

Selectable curve shapes	Moderately inverse, very inverse, extremely inverse, IEC A, IEC B, IEC C, IEC D, IEC E, SEL-U1, SEL-U2, SEL-U3, SEL-U4, SEL-U5, User-defined
Pick-up range	0.025 to 90 amps secondary
Time Dial Setting range	0.1 to 10
Reset characteristic	Instantaneous or disk-like

LOAD ENCROACHMENT LOGIC
The iTP-100 provides load encroachment logic to prevent heavily loaded lines in steady state conditions from tripping far-reaching distance and overcurrent elements.

Examples include:

■ Lines where load growth has made previous settings inappropriate. The load encroachment logic anticipate the line's expected maximum future load with protection set for the present load, reducing the likelihood of false tripping until such time that the line's settings may be revisited.

■ Lines which may experience very heavy load increases due to contingency situations.

The iTP-100 will block the operation of balanced three-phase overcurrent and impedance elements as long as the load is balanced and is within permissible feeder watt and VAR import/export limits. See Figure 6. This logic will not affect the operation of the relay for any unbalanced fault condition.
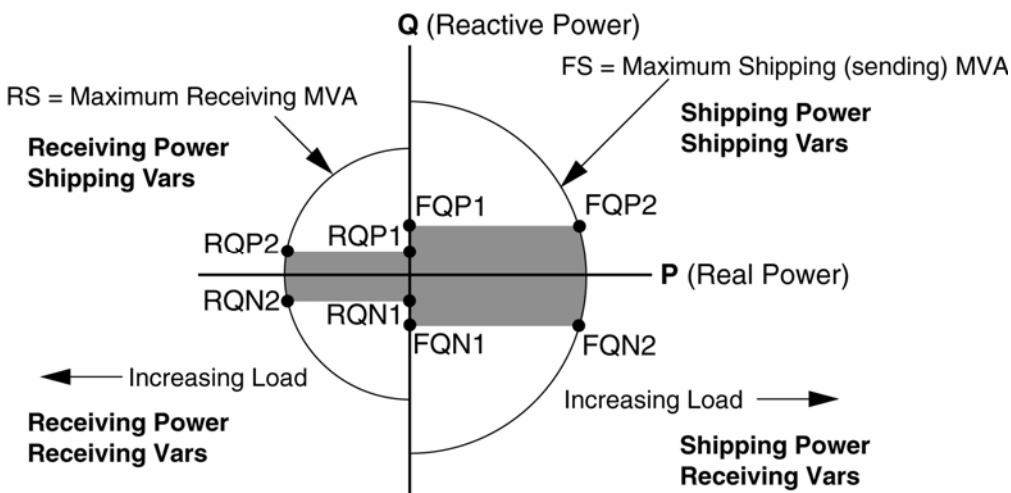

Figure 6:   Load Encroachment Logic Blocks Phase Overcurrent and Impedance Elements When Load Falls within the Shaded Area of the Power Plane

RECLOSING AND SYNCH-CHECK
A four-shot reclose element, complete with sequence coordination and synch-check supervision, is provided. External relays may also be connected to the iTP-100 reclosing logic. The iTP-100 can be used as a stand-alone reclosing and/or synch-check relay. The Synch-Check function provides the following features:

- Anticipatory Close accounts for the time it takes the circuit breaker mechanism to actually close once sent a CLOSE command.

- Anti-motoring control assures that synch-check will be declared only when the resulting power flow will be in the specified direction.

- Synch against voltages of different PT ratios and different nominal phase angle displacements (delta vs. wye)

- Anti-pump logic

- Programmable Hot Bus, Cold Bus, Hot Line and Dead Line operation

VOLTAGE ELEMENTS
Two levels of phase overvoltage and undervoltage elements are provided. One level is for tripping and the other is for alarming purposes.

Overvoltage Elements (59P:Trip, 59P:Alarm)
Two levels overvoltage protection are provided.
Pickup range   1 – 300 volts secondary
Time delay   0 – 3600 seconds

Undervoltage Elements (27P:Trip, 27P:Alarm)
Two levels of undervoltage protection are provided.
Pickup range   1 – 300 volts secondary
Time delay   0 – 3600 seconds

METERING
The iTP-100 offers extensive metering capabilities, including:

- Instantaneous Volt, Amp, Watt, var, PF in both primary and secondary scaled values.

- Demand metering

- Energy metering

EVENT RECORDS AND ANALYSIS TOOLS
The iTP-100 shares the same event record and analysis tools as all Edison Idea relays. The Edison Idea relay allows for the display of event records in a variety of formats including waveforms (oscillography), magnitude plots, phasor diagrams, symmetrical component diagrams and more. ProView, the software for the Edison Idea relay, also provides a unique Application Diagram View that provides a one-screen view of everything that is going on in the relay. Many of these event views are also available in On-Line View mode, where it is possible to monitor the status of the relay in real-time.
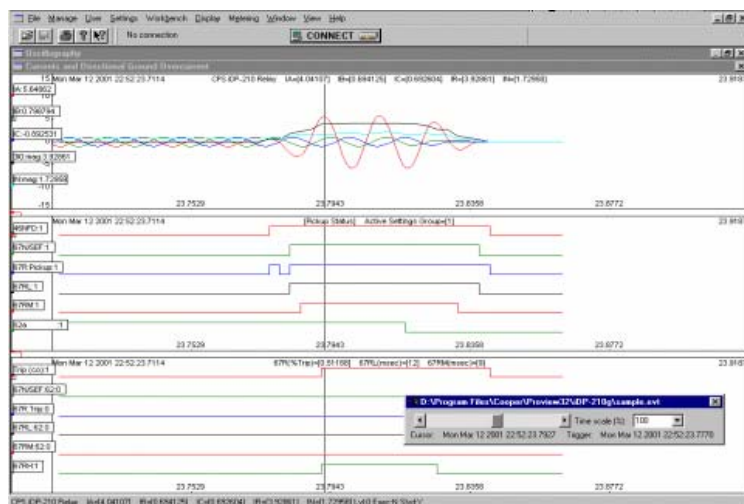

Figure 7:   Oscillographic Events

Relay Replay™[2]

To evaluate the effect different settings would have on the relay, the Relay-Replay feature of the Edison Idea software allows the user to make any number of setting changes and replay an existing event using these new settings without the need for an actual relay or expensive test equipment. The operation of every aspect of the relay's performance, from which elements pick-up to the response time of those elements that do, can be observed. This tool provides unprecedented "what-if" analysis capabilities.

Virtual Test Set™ (VTS™)

To evaluate settings against any arbitrary fault, the Edison Idea software permits the user to create a virtual event record through use of the software's VTS feature. The VTS allows complete control over:

- Pre-fault and post-fault voltage and current levels
- Selection of phase-ground, phase-phase, phase-phase-ground and three-phase fault types
- Fault duration
- Secondary fault impedance
- Fault location
- Selection of DC time constant
- Frequency change, rate of change and acceleration during faults
- Breaker open and close times
- Power Swing and Load Encroachment simulation

BREAKER HEALTH MONITORING

To assist in preventative maintenance programs, the iTP-100 monitors a number of critical breaker statistics. These include the circuit breaker's average, maximum and most recent closing and opening times, the accumulated interrupted current and breaker fail-to-trip, slow-to-trip, fail-to-close and slow-to-close conditions.

COMMUNICATIONS

Both Modbus RTU and DNP 3.0 communication protocols are included with the iTP-100. The Communications Workbench™ provides the user the ability to customize communication maps, add or delete information, add control points, and even create new signals to be brought out through communications. The iTP-100 features three auto-baud (57,600 kbps max) communication ports: two RS-232 and one RS-485. DNP TCP/IP is available with Ethernet ordering options including copper, multimode fiber, single mode fiber or some combinations of each.
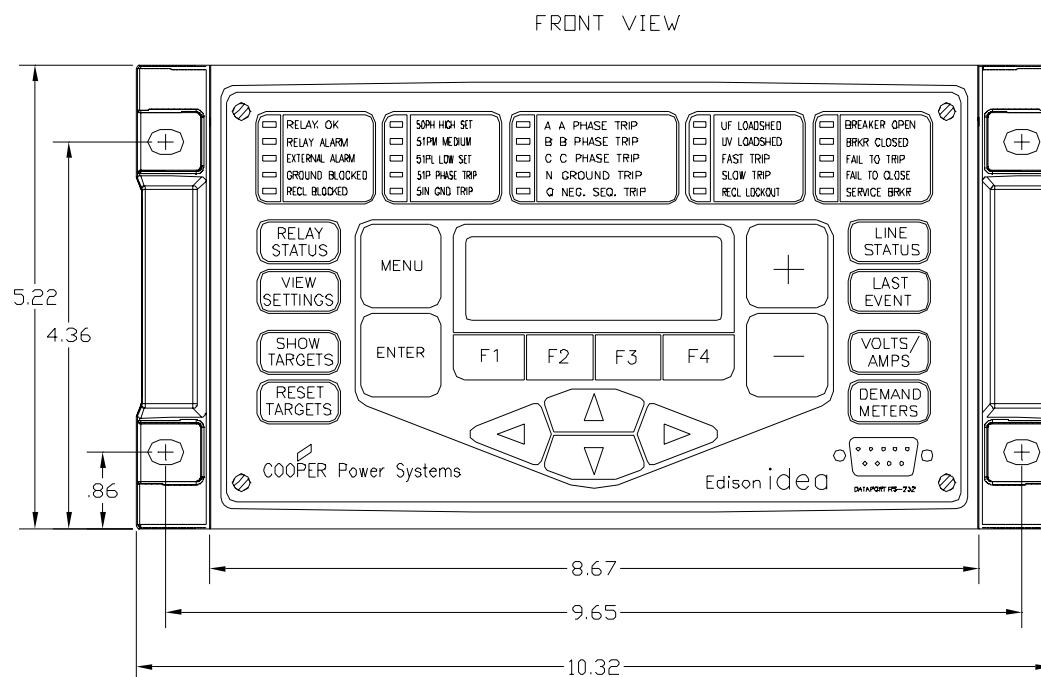
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[2] United States Patent Number 5,878,375

FRONT VIEW

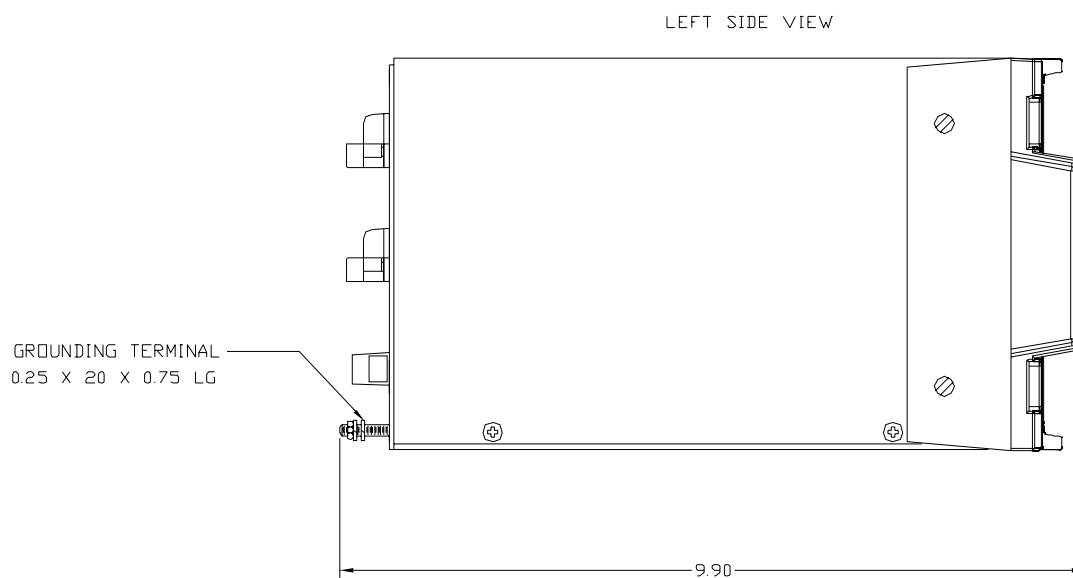**Figure 8:** Idea Relay, Front View (inches)

LEFT SIDE VIEW

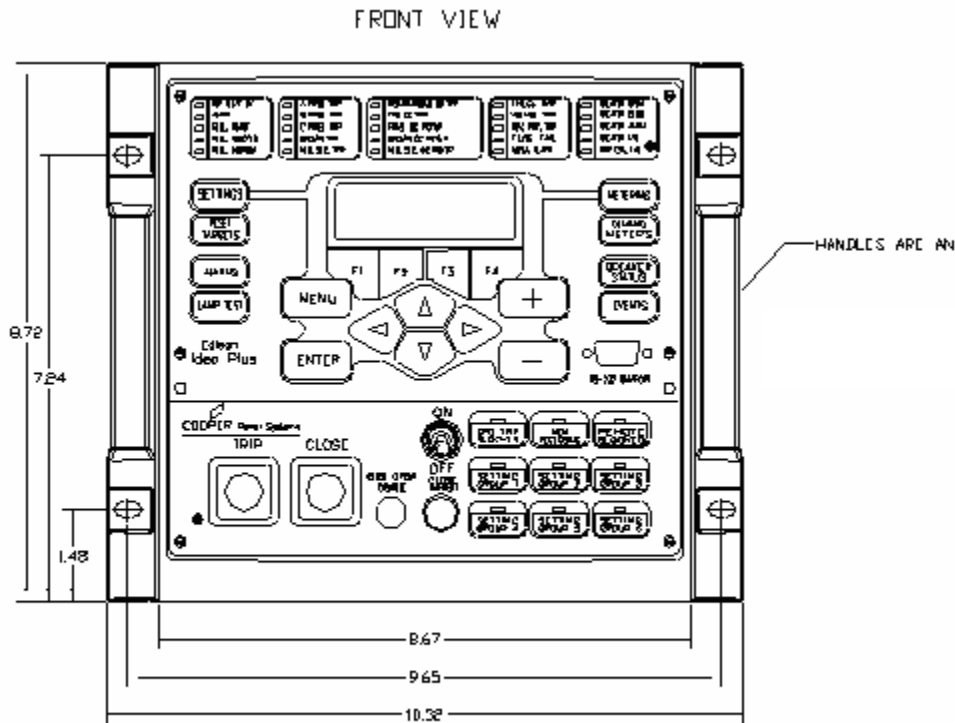**Figure 9:** Idea Relay, Side View (inches)

Figure 10: IdeaPLUS Relay, Front View (inches)

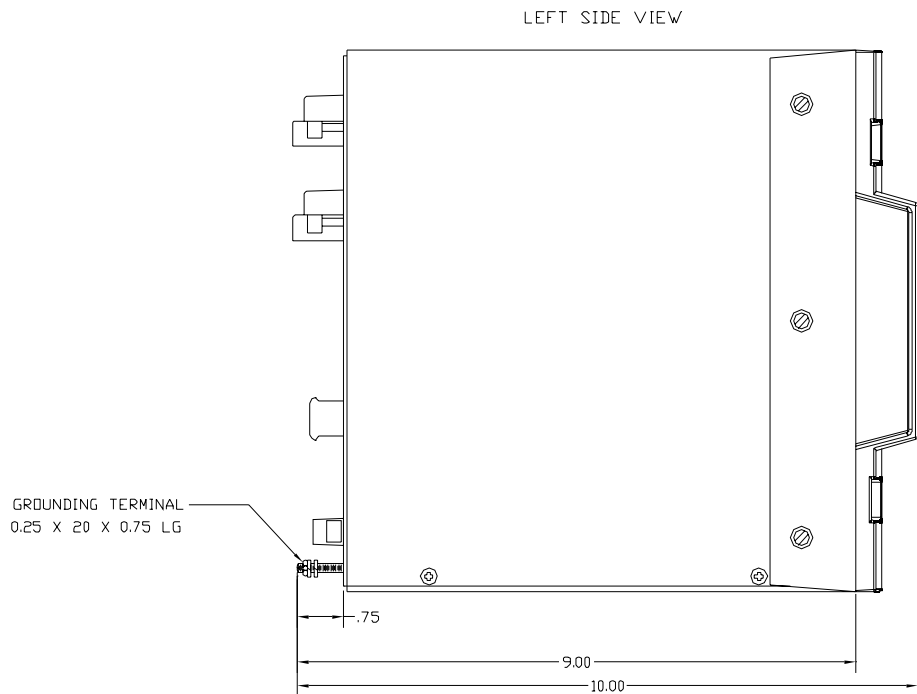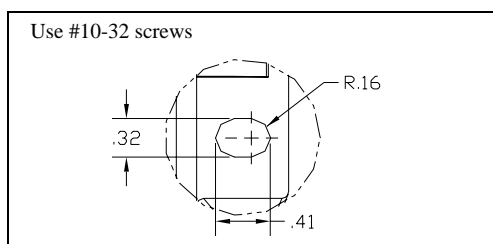**Figure 11:** IdeaPLUS Relay, Side View (inches)

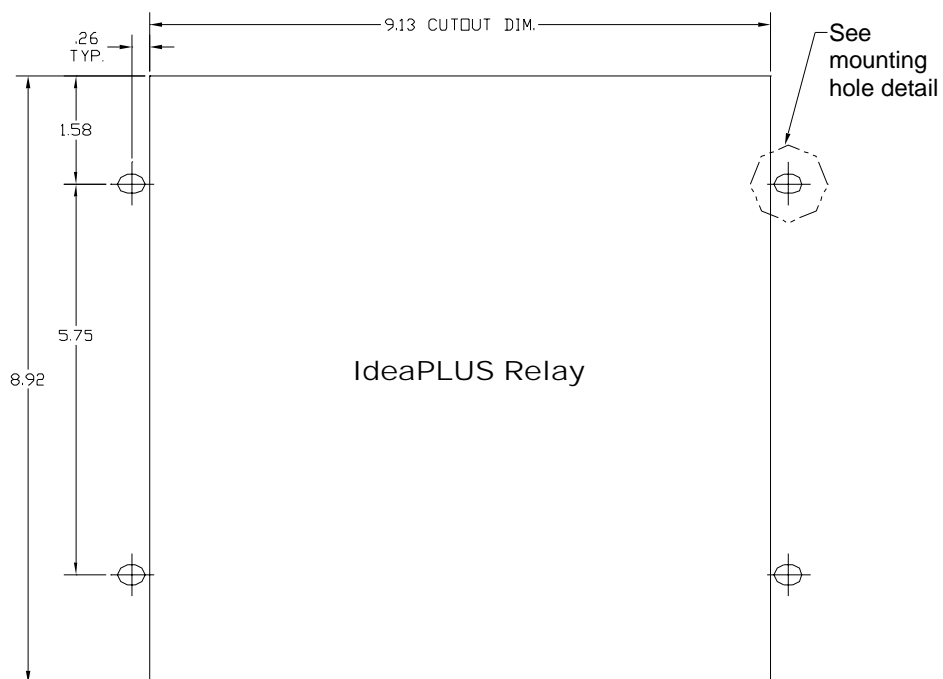**Figure 12:**   Idea Relay, Mounting Hole Detail (inches)

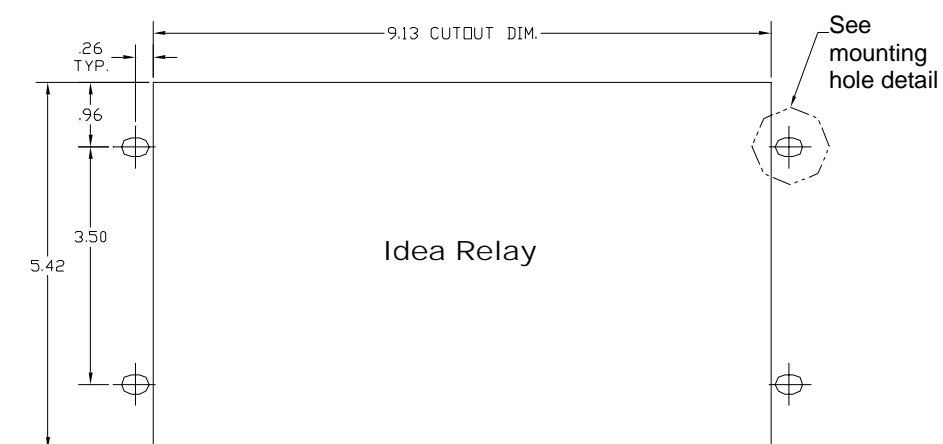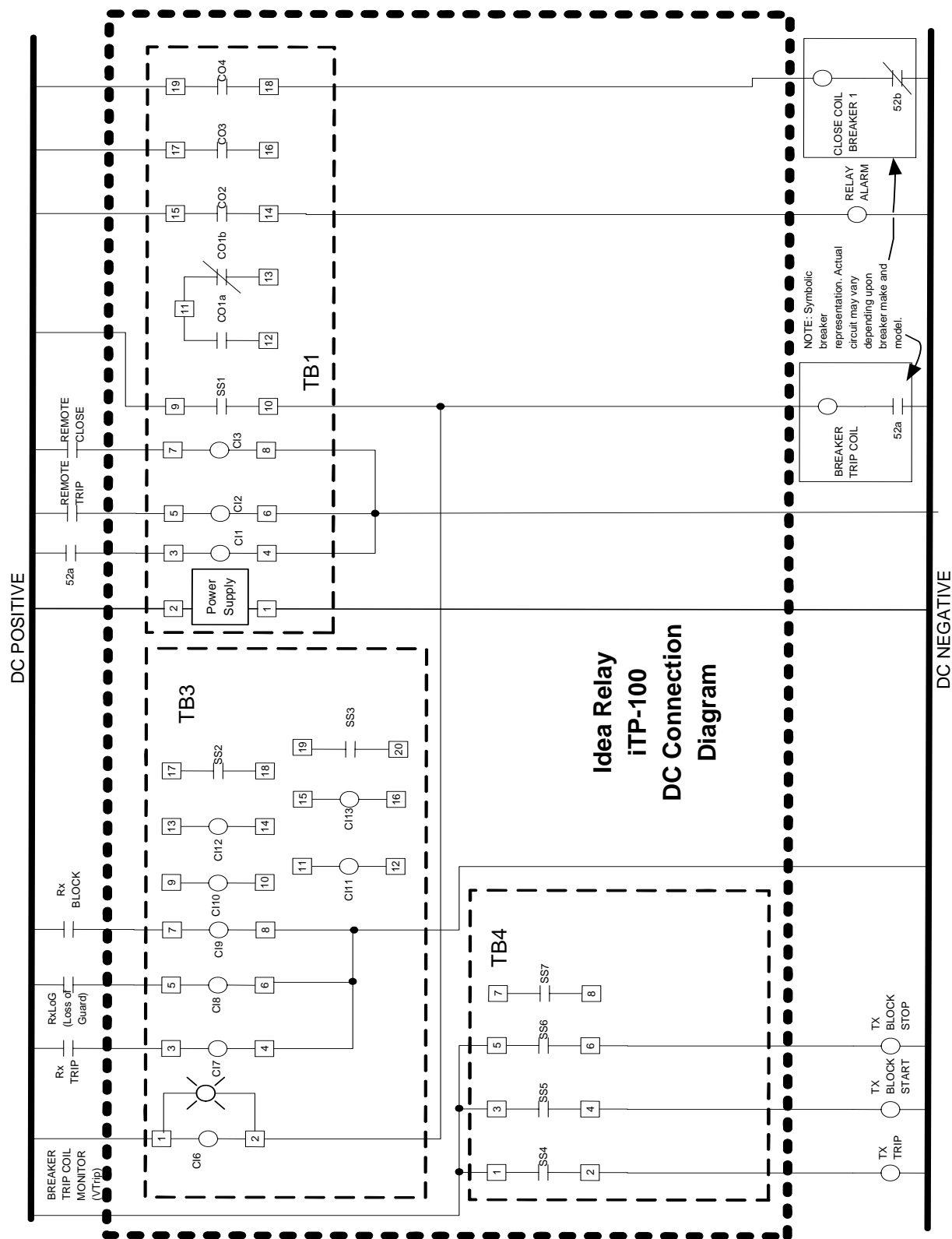**Figure 13:**   Panel Cutout Dimensions (inches)

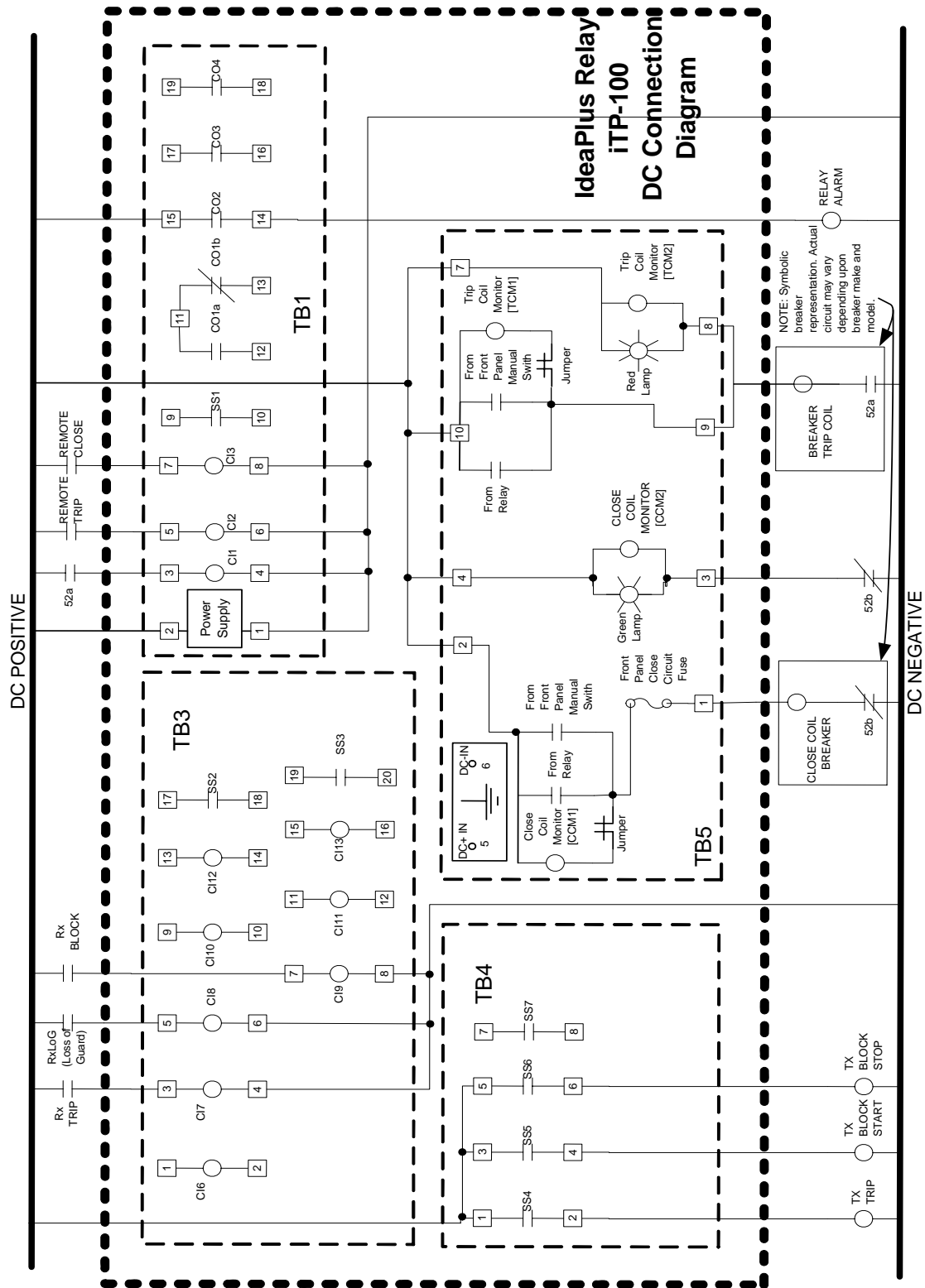**Figure 14:**   Typical iTP-100 DC Wiring Diagram for Idea Hardware

Figure 15: Typical iTP-100 DC Wiring Diagram for IdeaPLUS Hardware
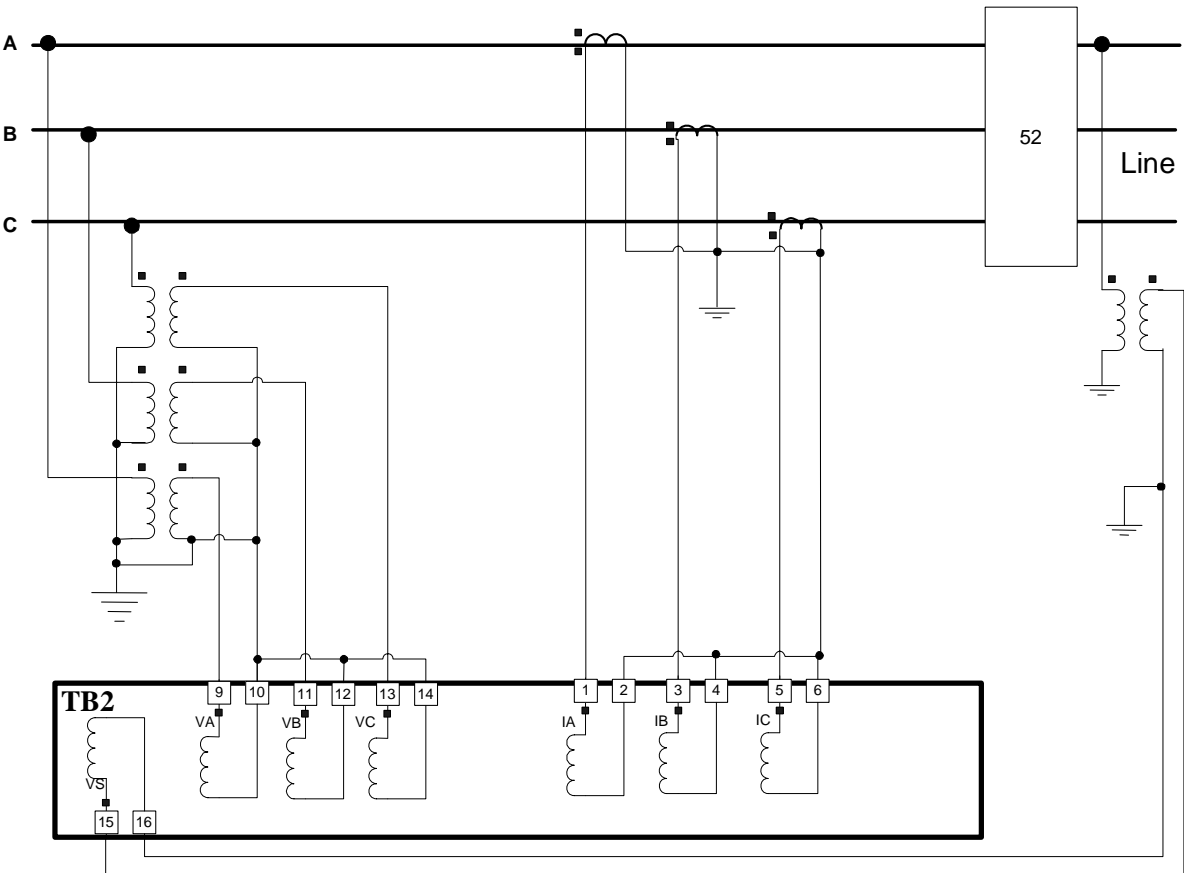
Figure 16: iTP-100 AC Wiring Diagram

Table 1 – Ordering Options

NOTE: Tagging and Lamp Style options (columns J and K) apply only to IdeaPLUS part numbers.

Construct Catalog Number from this table.

		A	B	C	D	E	F	G	H	I	J	K
		Idea and IdeaPLUS →									IdeaPLUS →	
		Product	Enclosure	Scheme	Language	Power	Input Range	Protocol	Aux I/O	TermBlk	Tagging	Lamp Style.
		PR6										
Sample Catalog Number:		PR6	P2	T30	E	1	5	1	4	S	C	3
TYPE	Edison Idea/IdeaPlus Relay	PR6										
	Edison Idea Chassis		D2									
	Edison IdeaPlus Chassis		P2									
Scheme	iTP-100 Protective Relay			T30								
Inserts Language	English				E							
	Portuguese				P							
	Spanish				S							
	Other				O							
Power	48VDC Power Supply					4						
	125VDC/120VAC Power Supply					1						
	250VDC/240VAC Power Supply					2						
	Other					X						
Input Ranges	5 Amp CT Inputs, 67/120V PT Inputs						5					
	1 Amp CT Inputs, 67/120V PT Inputs						1					
Comm. Protocol	RS 485							1				
	Fiber Serial							3				
	Ethernet: Multimode Fiber MTRJ/MTRJ							4				
	Ethernet: Multimode Fiber MTRJ/ Wire RJ 45							5				
	Ethernet: Wire RJ45/RJ45							6				
	Standard: None							7				
	Ethernet: Single Mode Fiber LC/LC							8				
Aux I/O	Select 8 Contact Inputs and 6 solid state outputs								4			
Term.	All Barrier									S		
	All Compression									C		
Tag Type	Software based Close-inhibit, CLOSE inhibited on relay fail										C	
	Software based Close-inhibit, CLOSE enabled on relay fail										R	
Trip/Close Lamp Type	24 VDC LED Lamps for Trip and Close Status											1
	24 VDC Incandescent Lamps for Trip and Close Status											6
	48 VDC LED Lamps for Trip and Close Status											2
	48 VDC Incandescent Lamps for Trip and Close Status											7
	125VDC/120VAC LED Lamps for Trip and Close Status											3
	Other											X
	No Bulbs											0

Accessories: **Description**	**Catalog Number**
19″ rack mount panel adapter for Idea relay	PR6DRP
19″ rack mount panel adapter for IdeaPLUS relay	PR6PRP
19″ 2-relay side-by-side 19″ rack mount adapter for Idea relay	PR6ADRPDR
19″ 2-relay side-by-side 19″ rack mount adapter for IdeaPLUS relay	PR6APRPDR
6 foot (2m) front panel RS232 cable	*KM5-665*

Specifications

Frequency	**50/60 Hz**
Voltage Inputs	**Four voltage input channels** **50 – 250 VAC continuous (phase-to-neutral)** **Burden < 0.1VA at 120V** **Primary DC Resistance 1,454**Ω **Error % < 0.3% over operating temperature**
Current Inputs	**Three current input channels** **I**$_{Nominal}$ **= 5A, I**$_{continuous}$ **= 15A, I**$_{3sec}$ **= 150A, I**$_{1sec}$ **= 300A** **Range of overcurrent settings 0.1 A to 90 A** **Step size 0.01 A** **Burden < 0.2VA at 5A** **Primary DC Resistance 3.4 m**Ω **Error % < 0.3% over operating temperature** **I**$_{Nominal}$ **= 1A, I**$_{continuous}$ **= 3.2A, I**$_{3sec}$ **= 30 A, I**$_{1sec}$ **= 100A** **Range of overcurrent settings 0.02 A to 18 A** **Step size 0.002 A** **Burden < 0.2VA at 1A** **Primary DC Resistance 52.1 m**Ω **Error % < 0.3% over operating temperature**
Digital Inputs (Optically Isolated)	**9 – 150 VDC [24 VDC power supply]** **36 – 150 VDC [48 VDC power supply]** **90 – 300 VDC [120 VAC / 125 VDC power supply]** **165 – 300 VDC [240 VAC / 250 VDC power supply]** **Nominal current draw of 2.5 mA, minimum operating time of 15 msec**
Relay Outputs	**240 Vac / 250 Vdc. Make: 30A for 0.2 seconds; Carry: 6A continuous. Break: 0.2A (L/R = 40 ms)** **Pickup time: <8ms; Dropout time: <5ms**
Solid-State Outputs	**240 Vac / 250 Vdc; Make: 30A for 0.2 seconds; Carry: 8A continuous. Break: 10A (L/R = 40 ms)** **Pickup time: <1ms; Dropout time: <15ms**
Power Supply	**24 VDC $\pm$ 20%** **48 VDC $\pm$ 20%** **120 VAC / 125 VDC $\pm$ 30%** **240 VAC / 250 VDC $\pm$ 20%** **Burden: 14W**
Local/Remote communications	**EIA-RS-232C: 1 ea. located on front and rear panel** **Baud Rates: Auto baud rate up to 115,200 bps** **IRIG-B: 1 located on rear panel** Optional Comm. Daughterboards (available with ProView 4.0.1): **RS-485 (DC isolated)** **Modbus 57,600 bps; DNP 38,400 bps** **Serial Fiber Optic (ST)** **Ethernet, Multi-Mode, Fiber Optic (MTRJ/MTRJ)** **Ethernet, Multi-Mode, Fiber Optic / Wire (MTRJ/RJ45)** **Ethernet, Multi-Mode, Wire (RJ45/RJ45)** **Ethernet, Single-Mode, Fiber Optic (LC/LC)**

Front Panel Targets	**23 Programmable LEDs**
Front Panel Display	**20 x 4 character LCD**
Front Panel Keypad	**8 fixed-function keys, 4 multi-function "soft" keys** **8 programmable "Hot-Keys"**
Dimensions	**Idea relay: 3 U high by 8.5" wide; 19" rack mount adapter plates and side by side mounting kits available**
Relay Weight	**10 lbs (4.5 kg) – Idea; 15 lbs (6.8 kg) – IdeaPlus;**
Mounting	**Horizontal**
Operating Temperature	**-40 °F to 158 °F (-40°C to 70 °C) continuous**
Bump & Shock Test	**IEC 60255-21-2 (1988) Class 1**
Cold Temperature Test	**IEC 60068-2-1 (1993) 16 hours at –40C**
Electrostatic Discharge	**EN 61000-4-2 (2001) Levels 1, 2, 3, and 4.**
High temperature Test	**IEC 60068-2-2 (1993) 16 hours at 70C**
Humidity Test	**IEC 60068-2-30 (1999) 25C to 55C, 95% Humidity, 2 cycles**
Impulse/Dielectric Withstand	**IEC 60255-5 (2000)** **Impulse Test: 5kV, 1.2 μs rise time, half wave 50 μs. Applied 3 impulses at each polarity.** **Dielectric: 3150 VDC for 1 minute.** **Insulation Resistance: Greater than 10 Gigaohms.**
Radio Frequency Interference	Radiated: **EN 61000-4-3 (2001)** **20 MHz – 1 Ghz, Idea 35 V/m and IdeaPlus 20 V/m.** **ANSI/IEEE C37.90.2 (1995)** **35V/m from 20 MHz to 1 GHz** Conducted: **IEC 61000-4-6 (2001)** **150 kHz – 80 MHz, 10 Vrms** **IEC 61000-4-16 (2001)** **15 Hz – 150 kHz, 10 Vrms**
Surge Withstand	**ANSI/IEEE C37.90.1 (2002) 2.5 kV oscillatory, $\pm$ 4 kV fast transient**
Vibration Test	**IEC 60255-21-1 (1988) Class 1**
Contact Rating	**ANSI/IEEE C37.90, Section 6.7 (1989) 30A for 0.2 seconds, 2000 operations, at 125 VDC, 250 VDC, and 240 VAC.**
Object Penetration	**IEC 60529 (2001-02) IP3X rating**
Emissions	**EN 55022, Class A, Radiated and Conducted**
Conducted Disturbances	**IEC 6100-4-6 (150kHz – 80 MHz)**

Specifications subject to change without notice.

COOPER Power Systems