ABB

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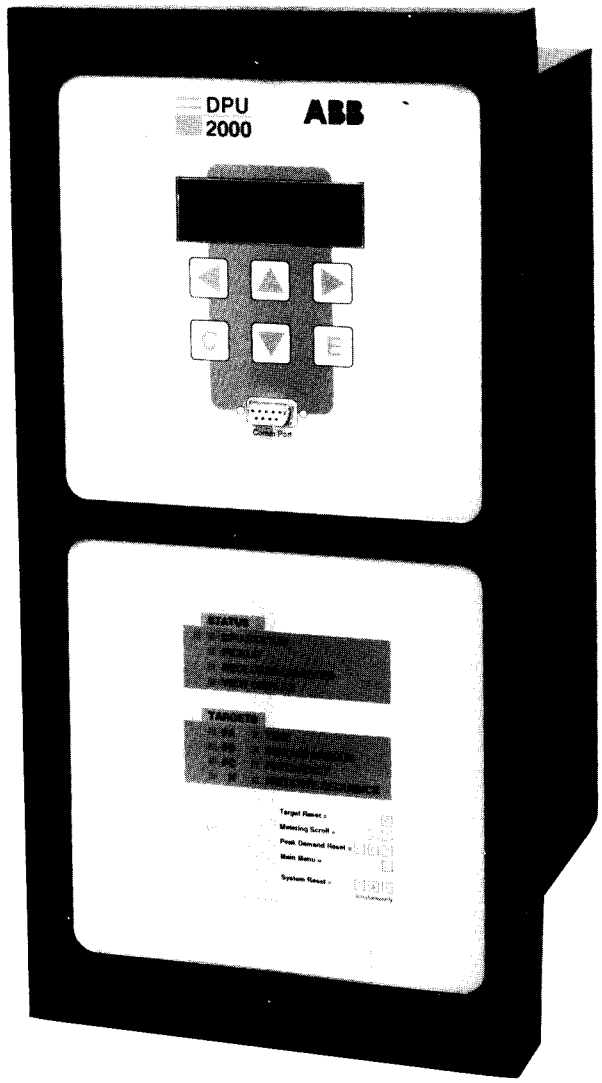
ISSUE F

INSTRUCTIONS

Microprocessor-Based Distribution Protection System

Distribution Protection Unit
TM
DPU-2000



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Precautions

Take the following precautions when using the Distribution Protection Unit 2000 (DPU-2000):

1. Incorrect wiring may result in damage. Be sure wiring agrees with connection diagram before energizing.

2. Apply only the rated control voltage marked on the unit.

3. High-potential tests are not recommended. If a control wire insulation test is required, fully withdraw the DPU-2000 from its case and only perform a DC high-potential test. **Surge capacitors on the backplane circuit board do not allow AC high-potential testing.**

4. Follow test procedures to verify proper operation. To avoid personal shock, use caution when working with energized equipment. Only competent technicians familiar with good safety practices should service these devices.

5. When the self-checking function detects a system failure, the protective functions are disabled and the alarm contacts are actuated. Replace the unit as soon as possible.

6. A correct password is required to make changes to the relay settings and to test the output contacts. **The preset factory password is four blank spaces**. Once you have chosen a new password and entered it into the system, access will be denied if the password is forgotten. If you forget the password, contact the factory.

7. Wire the current and voltage transformers for **proper** phase rotation, for **correct** measurement of kilowatts and kiloVARs, and for the proper operation of the 46, 67P, and 67N functions.

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Introduction

The Distribution Protection Unit 2000 (DPU-2000) is a microprocessor-based relay that protects electrical power subtransmission and distribution systems. Available for 5- or 1-ampere secondary current transformers (CTs), the DPU-2000 uses circuit breaker 52a and 52b auxiliary contacts for logic input signals. You can use the DPU-2000 with voltage transformers (VTs) connected for operation at 69 or 120 volts AC phase-to-ground (Wye), 120 volts AC phase-to-phase (Delta or Open Delta with B phase grounded), or 208 volts AC phase-to-phase (Delta).

The DPU-2000 is packaged in a metal case suitable for conventional semi-flush mounting on a relay panel. Because of a patented automatic CT shorting feature and sequenced disconnects, you can totally withdraw the DPU-2000 from its case. The specially designed levers allow you to insert it easily into the case. All connections to the DPU-2000 are made at clearly identified terminals on the rear of the unit.

Because of its microprocessor capability, the DPU-2000 provides the following protection, control, and monitoring functions in one integrated package:

- Phase time and instantaneous overcurrent protection: 51P, 50P-1, 50P-2, 50P-3
- Ground time and instantaneous overcurrent protection: 51N, 50N-1, 50N-2, 50N-3
- Negative sequence (I2) time overcurrent protection: 46
- Multishot reclosing: 79
- Positive sequence polarized phase directional time overcurrent protection: 67P
- Negative sequence polarized ground directional time overcurrent protection: 67N
- Two load shed, two restoration, and two overfrequency functions: 81S-1, 81S-2, 81R-1, 81R-2, 81O-1, 81O-2
- Single- and three-phase undervoltage and single-phase overvoltage functions: 27-1P, 27-3P, and 59
- Metering: currents, voltages, watts, VARs, watt hours and VAR hours, power factor, frequency
- Peak demand currents, watts and VARs with time stamp
- Fault locator with distance in miles and fault resistance
- Fault summary and detailed fault records for last 32 trips
- Operations (sequence of events) record for last 128 operations
- Sixteen (16) binary (contact) inputs: thirteen (13) user-programmable, three (3) permanently programmed
- Eleven (11) output contacts: eight (8) user-programmable, (3) permanently programmed
- Three selectable settings tables: Primary, Alternate 1, and Alternate 2
- Breaker failure detection and zone sequence coordination function
- Summation of breaker interrupting duty and breaker operations counter
- Continuous self-diagnostics on power supply, memory elements, and microprocessors
- Front RS-232 and rear RS-485, RS-232, or an Auxiliary communication port to support user specific protocols
- Optional load profile capability: watts, VARs, and voltage for 40, 80, or 160 days
- Optional user-programmable time overcurrent curves
- Optional oscillographic data storage analyzer captures 64 cycles of current and voltage waveform data.

This instruction booklet contains the information to properly install, operate, and test the DPU-2000.

Relay Functions

The DPU-2000 contains many relay protection functions. Three settings tables (Primary, Alternate 1, and Alternate 2) provide the flexibility to quickly change parameters. In addition, the DPU-2000 has programmable logic capabilities and expanded metering.

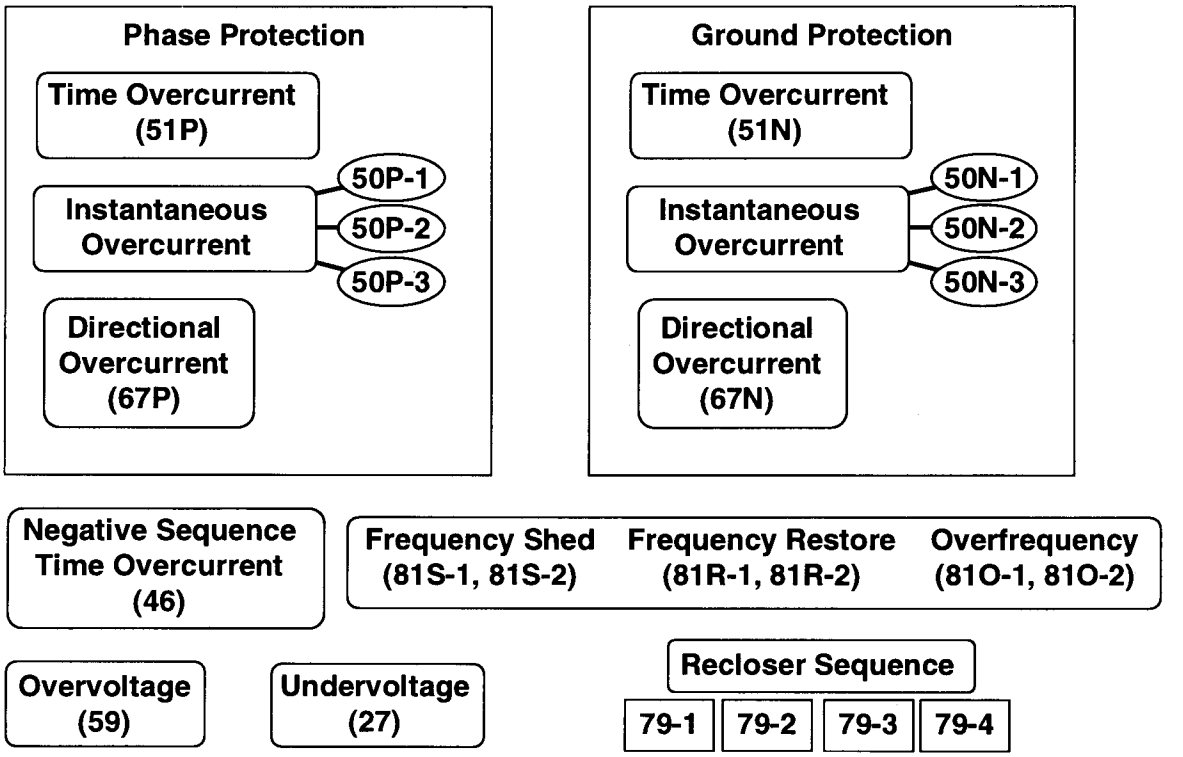


Figure 1. DPU-2000 Protective Functions

Phase Time Overcurrent Function 51P

When a phase current exceeds the programmed pickup setting, the 51P trip timer starts timing out to trip the breaker. The range of the pickup varies according to the model of the DPU-2000: 5-A CT or 1-A CT. Depending on your system's timing requirements, you can select any one of the nine 51P time overcurrent characteristic timing curves programmed into the DPU-2000 (see Table 1). You can control (enable/disable) the phase time overcurrent function by using the programmable Phase PH3 contact input.

51P Parameter	Range	Increment
Pickup setting, 5-A CT model	1 to 12 A	0.1 A
Pickup setting, 1-A CT model	0.2 to 2.4 A	0.02 A

You can program the 51P function to reset instantaneously or on a delayed basis to simulate an electromechanical induction disk relay. The reset mode for the 51P function follows the Reset Mode setting in the Configuration Settings. In the instantaneous reset mode, the 51P function resets immediately when the current drops below the pickup setting for one half of a cycle. In the delayed reset mode, the function follows a slow reset characteristic that depends on the duration of the overcurrent condition and the amount of load current present after the overcurrent condition. When Multiple Device Trip mode is enabled in the Configuration Settings, the reset mode is automatically switched to instantaneous and cannot be set for delayed reset (see the "Multiple Device Trip Mode" section).

Table 1. Time Overcurrent Curves (51/46/67)*

Curve	Time Dial/Delay
Extremely Inverse	1.0 to 10
Very Inverse	1.0 to 10
Inverse	1.0 to 10
Short Time Inverse	1.0 to 10
Definite Time	0.0 to 10.0 seconds
Long Time Extremely Inverse	1.0 to 10
Long Time Very Inverse	1.0 to 10
Long Time Inverse	1.0 to 10
(DPU) Recloser Curve #8	1.0 to 10
User 1 †	—
User 2 †	—
User 3 †	—

Table 2. Instantaneous Overcurrent Curves (50-1)

Curve	Time Dial/Delay
Standard	Instantaneous
Inverse Instantaneous	1.0 to 10
Definite Time	0 to 9.99 seconds
Short Time Inverse	1.0 to 10
Short Time Extremely Inverse	1.0 to 10
User 1 †	—
User 2 †	—
User 3 †	—

* Time overcurrent curves are also available as transparencies.
† Only available with the user-programmable curve option.

Phase Instantaneous Overcurrent Function 50P-1

50P-1 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Curves:		
Instantaneous curve	No delay	
Inverse instantaneous, short time inverse, and short time extremely inverse curves	1 to 10 time dial	0.1
Definite Time curve	0 to 9.99 seconds	0.01 seconds

The 50P-1 function trips when the phase current exceeds the 50P-1 trip setting. The response of this instantaneous tripping varies as a function of the changing current magnitude. The 50P-1 pickup setting is in MULTIPLES of the 51P time overcurrent pickup setting. Table 2 lists the five selectable 50P-1 overcurrent characteristic timing curves programmed into the DPU-2000. The standard instantaneous curve has no intentional delay.

Enable or disable the 50P-1 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 50P-1 function enabled, disabled, or lockout reclosing. The 50P-1 function can also be enabled or disabled by programming the phase torque control function (PH3) to a contact input. Upon manual closing of the breaker, you can block the 50P-1 function from tripping for the amount of time set in the Cold Load Time, found in the Primary, Alternate 1, and Alternate 2 settings (see "Cold Load Time" below). When the 2-Phase 50P Trip is enabled in the Primary, Alternate 1, or Alternate 2 settings, the 50P-1 function trips only when two or three phases exceed the 50P-1 pickup setting and does not trip for phase-to-ground faults.

Phase Instantaneous Overcurrent Function 50P-2

Like the 50P-1 function, the 50P-2 pickup setting is in MULTIPLES of the 51P time overcurrent pickup setting. The 50P-2 function has one definite time characteristic curve.

50P-2 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Definite Time curve	0 to 9.99 seconds	0.01 seconds

Enable or disable the 50P-2 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. (The External Communications Program is a PC-based software program used to monitor and program the DPU-2000.) At each step in the reclose sequence, you can program the 50P-2 to be enabled, disabled, or lockout reclosing. The 50P-2 function is also enabled or disabled by the programmable Phase PH3 contact input. The 50P-2 function is not affected by the Cold Load Time setting. When you enable the 2-Phase 50P Trip in the Primary, Alternate 1, or Alternate 2 settings, the 50P-2 function trips only when two or three phases exceed the 50P-2 pickup setting and does not trip for phase-to-ground faults when only one phase exceeds the pickup setting.

Phase Instantaneous Overcurrent Function 50P-3

50P-3 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Time Delay	No intentional delay	

The 50P-3 pickup setting also is in MULTIPLES of the 51P time overcurrent pickup setting. The 50P-3 function has no intentional delay.

Enable or disable the 50P-3 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 50P-3 to be enabled, disabled, or lockout reclosing. The PH3 contact input and Cold Load Time setting have no effect on the 50P-3 function. When the 2-Phase 50P Trip is enabled in the Primary, Alternate 1, or Alternate 2 settings, the 50P-3 function trips only when two or three phases exceed the 50P-3 pickup setting.

Negative Sequence Time Overcurrent Function 46

46 Parameter	Range	Increment
Pickup setting, 5-A CT model	1 to 12 A	0.1 A
Pickup setting, 1-A CT model	0.2 to 2.4 A	0.02 A

The negative sequence overcurrent function provides increased sensitivity for phase-to-phase faults. The 46 time overcurrent function has the same pickup settings range, curve selections, and time dial settings range as the 51P function. The negative sequence function can be set below load current because normal, balanced load currents do not generate negative sequence current. For a phase-to-phase fault where current in Phase A equals Phase B current and Phase C current equals 0, the negative sequence current equals 58% of Phase A current.

Enable or disable the 46 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program.

The reset mode for the 46 function is based on the Reset Mode setting in the Configuration Settings. In the instantaneous reset mode, the 46 function resets immediately when the current drops below the pickup setting for one half of a cycle. In the delayed reset mode, the function follows a slow reset characteristic that depends on the duration of the overcurrent condition and the amount of load current after the overcurrent condition. When you enable Multiple Device Trip Mode in the Configuration Settings, the reset mode is automatically switched to instantaneous (see the "Multiple Device Trip Mode" section).

Ground Time Overcurrent Function 51N

The DPU-2000 ground current input can be provided by the residual connection of the phase CT secondaries (see the CT connection in Figure 25) or can be connected to a zero sequence ground current transformer. The nine selectable 51N time overcurrent characteristic curves programmed into the DPU-2000 are listed in Table 1.

51N Parameter	Range	Increment
Pickup setting	1 to 12 A	0.1 A

Enable or disable the 51N function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to the Ground (GRD) logic function in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 51N to be enabled, disabled, or lockout reclosing.

The reset mode for the 51N function is based on the Reset Mode setting in the Configuration Settings. In the instantaneous reset mode, the 51N function resets immediately when the current drops below the pickup setting for one half of a cycle. In the delayed reset mode, the function follows a slow reset characteristic that depends on the duration of the overcurrent condition and the amount of load current after the overcurrent condition. When you enable Multiple Device Trip Mode in the Configuration Settings, the reset mode is automatically switched to instantaneous.

Ground Instantaneous Overcurrent Function 50N-1

The 50N-1 pickup setting is in MULTIPLES of the 51N time overcurrent pickup setting. Table 2 lists the five selectable 50N-1 overcurrent characteristic curves programmed into the DPU-2000.

50N-1 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Curves:		
Instantaneous curve	No delay	
Inverse instantaneous, short time inverse, and short time extremely inverse curves	1 to 10 time dial	0.1
Definite Time curve	0 to 9.99 seconds	0.01 seconds

Enable or disable the 50N-1 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 50N-1 to be enabled, disabled, or lockout reclosing. The 50N-1 function can also be enabled or disabled by the programmable Ground (GRD) contact input. Upon manual closing of the breaker, you can block the 50N-1 function from tripping for the amount of time set in the Cold Load Time setting, found in the Primary, Alternate 1, and Alternate 2 Settings (see "Cold Load Time" below).

Ground Instantaneous Overcurrent Function 50N-2

The 50N-2 pickup setting is in MULTIPLES of the 51N time overcurrent pickup setting. The 50N-2 function has one definite time characteristic.

50N-2 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Definite Time curve	0 to 9.99 seconds	0.01 seconds

Enable or disable the 50N-2 function in the Primary, Alternate 1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 50N-2 function to be enabled, disabled, or lockout reclosing. The 50N-2 function is also enabled or disabled by the programmable Ground (GRD) contact input. The Cold Load Time setting does not affect the 50N-2 function.

Ground Instantaneous Overcurrent Function 50N-3

Like the other 50N functions, the 50N-3 pickup setting is in MULTIPLES of the 51N pickup setting. The 50N-3 function has no intentional delay.

Enable or disable the 50N-3 function in the Primary, Alternate, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to a programmable contact input in the Programmable Inputs screen of the External Communications Program. At each step in the reclose sequence, you can program the 50N-3 function to be enabled, disabled, or lockout reclosing. The GRD contact input and Cold Load Time setting have no effect on the 50N-3 function.

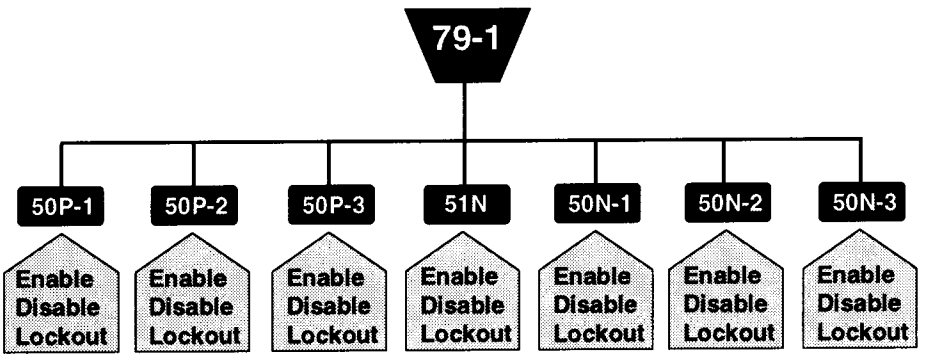
50N-3 Parameter	Range	Increment
Pickup setting	0.5 to 20 times	0.1 times
Time Delay	No intentional delay	

Reclosing Function 79

After a fault has occurred, the 79 Reclosing Function closes the circuit breaker when the programmed open time interval expires. Zero to four reclosures may be selected, and each reclosure has its own separate open interval timer. The multishot reclose sequence occurs only if the DPU-2000 initiates an overcurrent trip or a programmable 79M input is initiated.

The reset timer begins timing from the Reset Time setting down to 0 after each reclosure, provided the phase and ground currents are below the lowest pickup setting of all the functions. At each step in the reclose sequence, you can enable or disable the 50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, or 50N-3 functions or set the function to lockout reclosing as a result of tripping on any one of these functions. The 51P function is always enabled throughout each reclose sequence. Disable the reclosing function in the Primary, Alternate 1, and Alternate 2 Settings by selecting LOCKOUT for the first Reclose Open Interval Time or by opening the permanently programmed 43A contact input.

Function	Range	Increment
79 Reclosing Function Open Interval	0.1 to 200 seconds	0.1 seconds
79 Reset Time	3 to 200 seconds	1 second
79 Cutout Time	1 to 200 seconds	1 second
79 Voltage Block	10 to 200 volts AC	1 volt
79V Block Time Delay	4 to 200 seconds	1 second



Same selections are available for the 79-2, 79-3, and 79-4 recloser functions.

Figure 2. Recloser Sequence

A lockout state occurs under any of the following conditions:

- A fault persists for the entire programmed reclosing sequence.
- The breaker is manually closed and a fault occurs before the expiration of the reset time.
- A TRIP output occurs and the fault current is not removed or the breaker's 52a and 52b contacts do not indicate that the breaker opened. Both the removal of the fault current and the opening of the breaker must occur before the Trip Failure Time (5 to 60 cycles) expires, or the DPU-2000 will proceed to lockout.
- The reclose function is programmed to lock out after a 50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3, 67P, or 67N overcurrent trip.
- The 79V function is enabled, the bus voltage is below the voltage block setting, and the block time delay has expired.

In addition to a visual indication on the liquid crystal display (LCD) that the recloser is in the lockout state, a programmable lockout alarm (79LOA) contact is available. The lockout state is cleared when the 52a and 52b contact inputs indicate that the breaker has been manually closed **and** the reset time has expired. When Multiple Device Trip Mode is enabled, the lockout state is cleared when either of the following occurs:

- The 52b contact input is open **and** currents in all three phases are greater than 5% of the 51P pickup setting **and** the reset time has expired.
- The 52b contact input is open **and** the light-emitting diode (LED) targets are reset **and** the reset time has expired.

Breaker Failure Alarm

The Breaker Failure Alarm occurs when the DPU-2000 sends a TRIP signal and one or both of the following occur:

- The fault current fails to drop at least 5% below the lowest pickup setting.
- The breaker's 52a and 52b contacts do not indicate that the breaker opened.

Both the drop in the fault current and the opening of the breaker must occur before the Trip Failure Time expires or the Breaker Failure Alarm will activate.

During the Breaker Failure Alarm, the DPU-2000 continues to send a TRIP signal until the breaker opens, either through SCADA or manual tripping. When the breaker is tripped, the DPU-2000 goes into lockout and the Breaker Failure Alarm is removed.

79 Cutout Time Function

The 79 Cutout Time (79-CO) function allows for the detection of low-level or intermittent faults prior to the resetting of the reclose sequence. At the end of the selected cutout time period, all overcurrent functions are re-enabled based on the 79-1 settings. For example, if the 79-3 reclose sequence is set for ten seconds and the 79 Cutout Time is set for five seconds, the first five seconds of the reclose sequence follow the overcurrent function settings for the 79-3 reclose sequence, but the second five seconds (after the cutout time period) follow the 79-1 settings. The 79-CO setting is programmable from 1 to 200 seconds. When enabled, the 79-CO setting must be less than the 79 Reset Time.

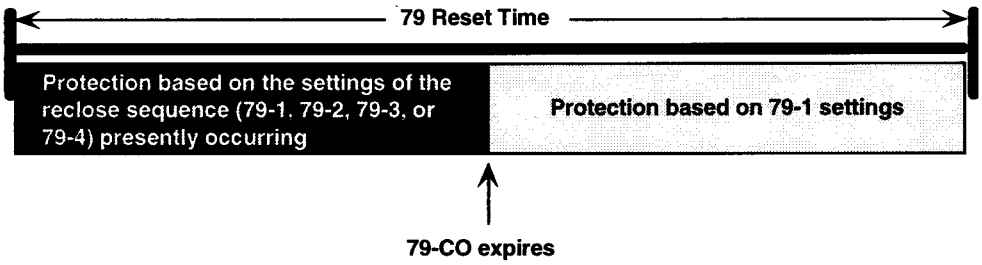


Figure 3. 79 Cutout Time

79S Single-Shot Reclosure

The programmable 79S input function initiates a single-shot reclosure when the 52a and 52b contact inputs indicate that the breaker has been externally tripped. The close signal is initiated after the 79-1 open interval time expires. If the breaker remains closed for the Reset Time setting, the reclose sequence resets. If the breaker reopens within the Reset Time setting, no other reclosures are issued.

When Multiple Device Trip (MDT) mode is enabled, the 52b contact input is required for the 79S contact input functions to initiate a reclosure.

79M Multishot Reclosure

Based on an external device tripping the breaker, the programmable 79M input function steps through the entire reclose sequence. When the 79M input is enabled, the multishot reclose sequence is initiated or continued when the 52a and 52b contact inputs indicate that the breaker has been tripped by an external device.

When Multiple Device Trip (MDT) mode is enabled, the 52b contact input is required for the 79M contact input functions to initiate a reclosure.

Cold Load Time

Cold Load Time disables the 50-1 and 50-2 instantaneous phase and ground protective functions for a programmable period of time. Use this function to block unintentional tripping due to cold load inrush for a selected time delay between 0 to 254 seconds or minutes. Select "seconds" or "minutes" in the Configuration Settings, and set the time delay in the Primary, Alternate 1, and Alternate 2 Settings.

During the Cold Load Time time delay, an output alarm, CLTA, is activated. For example, you can use this output alarm to change to an alternate settings table if you program the CLTA output contact to an ALT1 or ALT2 programmable input contact.

Two-Phase 50P Tripping

Enabling this functions disables the DPU-2000 from tripping in a single-phase fault condition. If the assumed fault is not a two-phase (∅AB, ∅AC, or ∅BC) or three-phase fault, tripping is blocked.

79V Voltage Block Function

The 79V voltage block function delays or blocks reclosing when one or more of the voltage inputs are below the 79V Voltage Block setting. When the input voltage is restored within the 79V Block Time Delay setting, the recloser open interval time is started. When the input voltage is not restored within the Block Time Delay setting, the recloser goes to lockout. You can enable or disable the 79V function in the Primary, Alternate1, and Alternate 2 setting tables.

79V Parameter	Range	Increment
Voltage	10 to 200 V	1 V
Time Delay	4 to 200 seconds	1 second

Directional Time Overcurrent Functions 67P and 67N

67P Parameter	Range	Increment
Pickup setting, 5-A CT model Pickup setting, 1-A CT model	1 to 12 A 0.2 to 2.4 A	0.1 A 0.02 A
Curves:		
Inverse curves	1 to 10 time dial	0.1
Definite Time curve	0 to 10 seconds	0.1 seconds

The 67P and 67N functions work on a set value of AC overcurrent flowing in a predetermined direction. These functions apply to parallel subtransmission lines or double-ended substations involving multiple sources. The 67P and 67N overcurrent functions have the same pickup range, curve selections, and time dial range as the 51P and 51N functions, respectively. The range of the 67P pickup varies according to the model of the DPU-2000: 5-A CT or 1-A CT. The 67P function is achieved by comparing the direction of the positive sequence current I_1 to the positive sequence voltage V_1. The 67N function is achieved by comparing the direction of the negative sequence current I_2 to the negative sequence voltage V_2.

For the 67P function to operate properly, the positive sequence polarizing voltage V_1 must be at least two (2) volts and a phase current must be greater than the 67P pickup setting. The negative sequence polarizing voltage V_2 must be at least two (2) volts, and the neutral current must be greater than the 67N pickup setting for the 67N function to operate properly.

67N Parameter	Range	Increment
Pickup setting	1 to 12 A	0.1 A

The Reset Mode setting also affects the 67P and 67N functions. Enable or disable the directional time overcurrent functions in the Primary, Alternate1, and Alternate 2 Settings or by mapping a programmable contact input to the 67P or 67N logic function in the Programmable Inputs screen of the External Communications Program. These inputs can also be programmed to lockout reclosing.

When the 51P and 51N functions are not used as backup to the 67P and 67N functions, set the 51P and 51N pickup settings equal to the 67P and 67N pickup settings, respectively, to provide the greatest metering resolution. Also, you must program the PH3 and GRD contact inputs to disable the 51P and 51N functions.

Angle	Range	Increment	Recommended Forward Setting	Recommended Reverse Setting
67P Torque Angle (angle at which I1 leads V1)	0º to 355º	5º	315º	135º
67N Torque Angle (angle at which I2 leads V2)	0º to 355º	5º	135º	315º

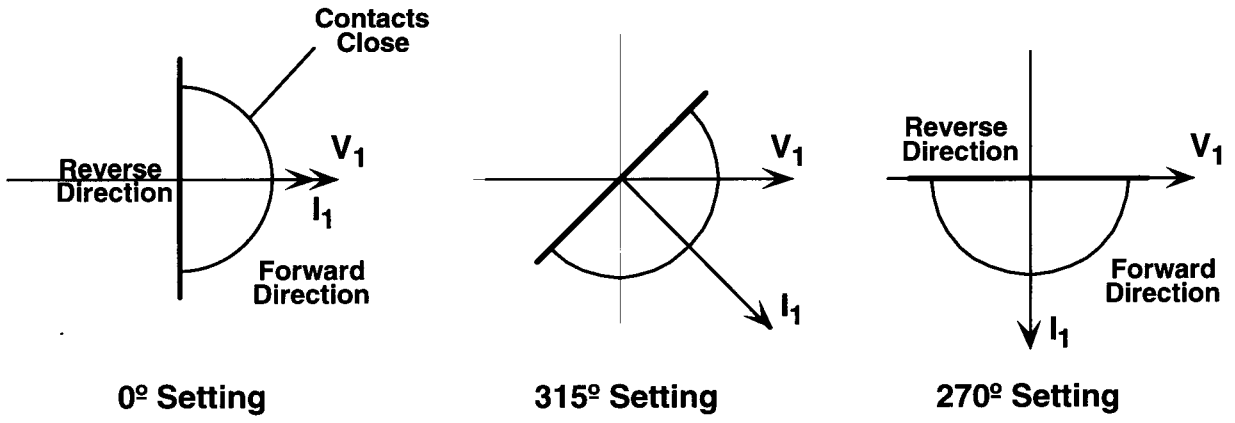


Figure 4. Positive Sequence Current I_1 Shown at Maximum Torque Angles

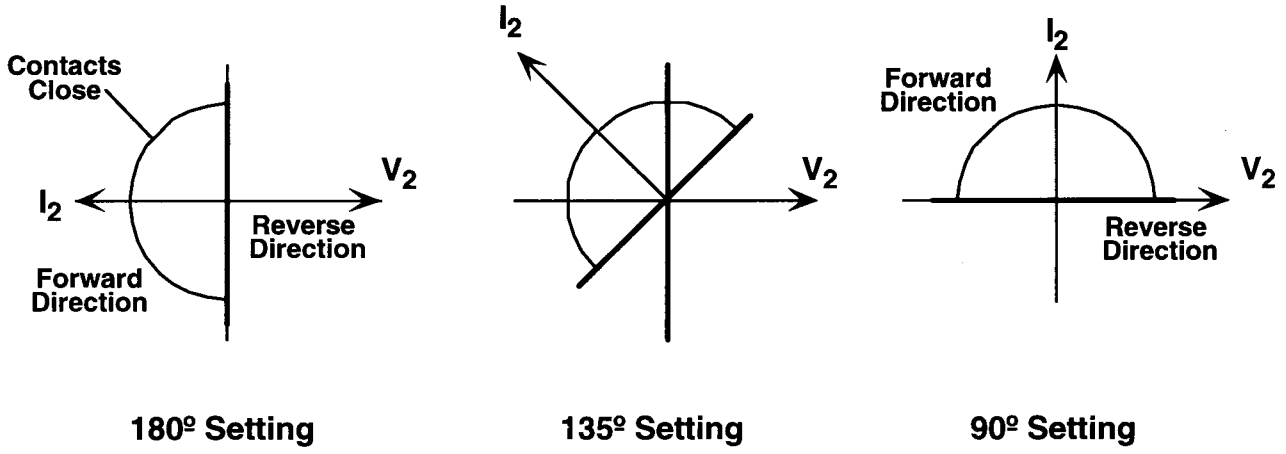


Figure 5. Negative Sequence Current I_2 Shown at Maximum Torque Angles

Frequency Load Shed and Restoration Functions 81S, 81R, and 81O

The 81S, 81R, and 81O functions provide protection and/or alarming for under- and overfrequency conditions. Two independent frequency modules can shed load on the underfrequency condition and restore the load when the system stabilizes. For frequency alarming applications, you can configure a module to alarm on under- and overfrequency thresholds.

The two independent modules allow for two separate load shed points: minor load shedding and restoring at small frequency deviations, and major load shedding when the unstable system mandates a heavy load shed to normalize the system. You can also configure the modules to provide load shed, restoration, and over/under frequency alarming together.

Module Number	Load Shed and Underfrequency	Load Restoration	Overfrequency
1	81S-1	81R-1	81O-1
2	81S-2	81R-2	81O-2

Function	Range	Increment
81S and 81R settings	56 to 64 Hz (60-Hz applications) 46 to 54 Hz (50-Hz applications)	0.01 Hz
Time Delay:		
81S	0.08 to 9.98 seconds	0.02 seconds
81R	0 to 999 seconds	1 second

The power system frequency is measured from the zero-crossing on the Vcn voltage input for Wye-connected power transformers (PTs) or on the Vbc voltage input for Delta-connected PTs.

Common to both modules is an undervoltage setting (81V) that blocks the frequency (81S) alarm outputs when the system voltage is below the setting's level (40–200V).

The load shed function or underfrequency alarm (81S-1, 81S-2) activates the programmed contact output when the frequency is below the selected threshold and the time delay has expired (see Figure 6). The output (81S-1, 81S-2) is maintained as long as the frequency is below the setting but is blocked in the event of the voltage dropping below the selected 81V setting.

The load restoration function (81R-1, 81R-2) activates the programmed contact output only after an associated load shed (81S) occurs, the frequency is above the selected threshold, and the time delay has expired. If the frequency drops below the restore threshold, the timer is reset. The output for this function is activated until the breaker closes or until the close failure time has elapsed. A successful breaker close operation is determined by the state of the 52a and 52b contacts. The restore function is not armed again until the next load shed operation.

The overfrequency alarm function (81O-1, 81O-2) can be implemented when the load restore function is not required. The programmed overfrequency output is activated when the frequency is above the selected 81R threshold and the 81R time delay has expired. The output remains activated until the frequency drops below the 81R threshold.

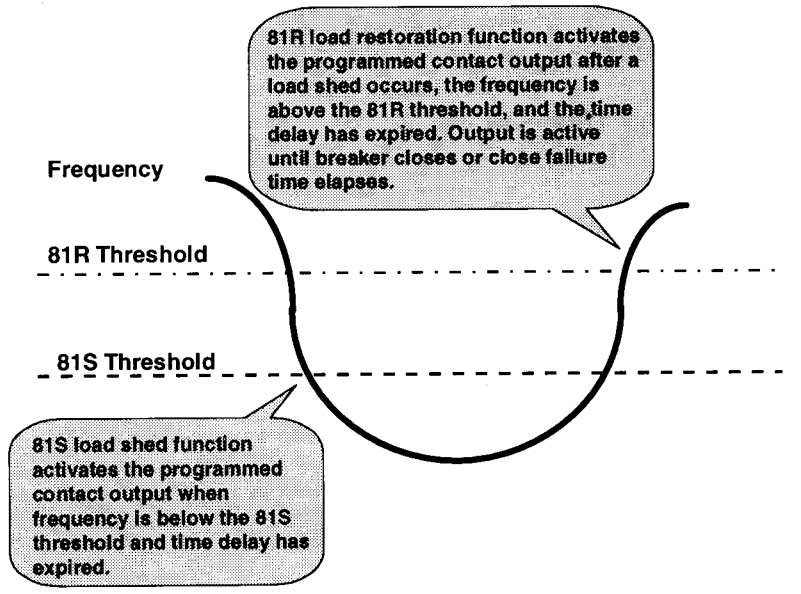


Figure 6. 81S and 81 R Functions

Program the settings for the 81S and 81R functions in the Primary, Alternate 1, and Alternate 2 settings. Map the 81O alarm function to an output contact in the Programmable Outputs screen in the External Communications Program (ECP).

The dropout point for the 81S-1 and 81S-2 functions is 0.02 Hz above the pickup setting, and the dropout time is equal to the Trip Failure Time setting. The dropout point for the 81R-1 and 81R-2 functions is 0.02 Hz below the corresponding pickup setting, and the dropout time is equal to the Close Failure Time setting. The dropout point for the 81O-1 and 81O-2 functions is 0.02 Hz below the corresponding 81R pickup setting, and the dropout time is equal to the Trip Failure Time setting. The Trip and Close output contacts are not activated by these functions.

Undervoltage Control/Alarm 27 and Overvoltage Alarm 59

An undervoltage function 27 and an overvoltage function 59 are available for alarm and control purposes. You can program output contacts to signal an undervoltage condition when any single phase (27-1P output) or all three phases (27-3P output) are below the 27 setting. You also can program the output contacts to signal an overvoltage condition when any phase is above the 59 setting.

Function	Range	Increment
27 Undervoltage	10 to 200 volts AC	1 volt
59 Overvoltage	70 to 250 volts AC	1 volt
27 and 59 Time Delay	1 to 60 seconds	1 second

Enable or disable the 27 and 59 functions in the Primary, Alternate1, and Alternate 2 settings. When the function is enabled in the settings table, you can remotely enable or disable that function by mapping it to the 27-1P, 27-3P, and 59 logic functions in the Programmable Inputs screen of the External Communications Program.

51V Function

Connecting the programmed 27-1P or 27-3P undervoltage mapped output contact to the PH3 mapped contact input controls the phase overcurrent function, creating a 51V function. Connecting the programmed 27-1P or 27-3P undervoltage output contact to the ALT 1 contact input activates the enabled overcurrent functions in the Alternate 1 settings (27 function must be set at the same values in the Primary and Alternate 1 settings). A separate time delay setting is associated with the 27 and 59 functions. The Trip and Close output contacts are not activated by these functions.

Zone Sequence Coordination (ZSC) Function

The zone sequence coordination function coordinates the instantaneous functions within the reclosing sequence of the upstream and downstream reclosing devices. Applications include fuse-saving schemes for faults that occur beyond the downstream reclosers.

When you select the ZSC function, the DPU-2000 increments through its reclose sequence after it senses that the fault current has been interrupted by a downstream device. The 50P-1/50N-1 or 50P-2/50N-2 instantaneous functions in the upstream DPU-2000 must be set for a time delay that is equal to or greater than the clearing time of the downstream device. The Reset Time setting of the upstream DPU-2000 must also be longer than the longest open interval time of the downstream device.

Turn on the ZSC function by (1) enabling it in the Configuration Settings **and** (2) mapping the ZSC function to a contact input in the Programmable Inputs screen of the External Communications Program. The zone sequence step occurs when the fault current exceeds the enabled instantaneous pickup setting and then decreases to less than 90% of the setting value before its time delay setting is exceeded. The recloser reset time is displayed when a zone sequence step occurs. All zone sequence coordination steps that occur are logged in the Fault Summary and Fault Record.

Multiple Device Trip Mode

The DPU-2000 has Multiple Device Trip (MDT) mode capability. When you enable its MDT mode, a DPU-2000 on a bus breaker can be programmed to provide primary protection to the bus breaker and backup protection to feeder breakers. If the relay protecting the feeder breaker fails, the bus breaker DPU-2000 provides isolated backup tripping to the faulted feeder breaker without tripping the bus breaker. Continuity of service will be maintained on all of the unfaulted feeders.

Component Requirements

The DPU-2000 includes the logic and timing elements and the programming flexibility that allow the implementation of such backup protection with minimal additional devices:

- DPU-2000 for bus breaker (DPU/B)
- DPU-2000 for each feeder breaker (DPU/Fn*)
- 1 Pickup Auxiliary Relay (PA)
- 1 Auxiliary Tripping Relay on the bus (Aux/B)
- Auxiliary Self-Check Failure relay (74/Fn*) for each feeder breaker

  * n = Number of feeder

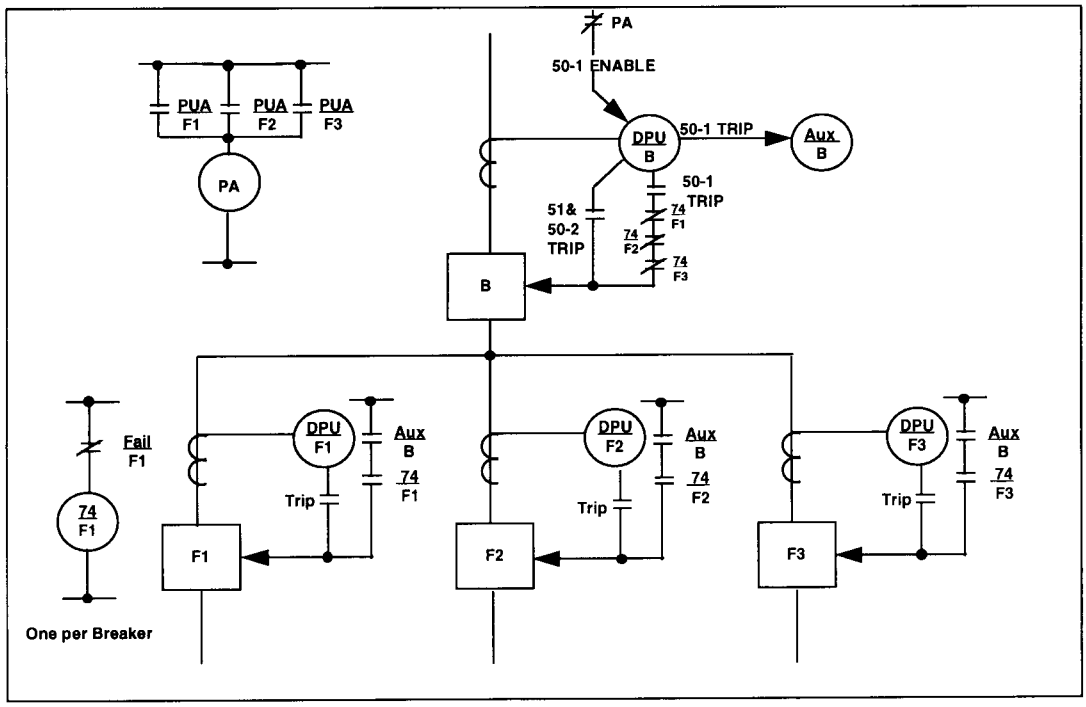


Figure 7. Multiple Device Trip Schematic

Pickup Auxiliary (PA) Relay

During faulted feeder conditions, the Pickup Auxiliary high-speed relay disables the 50P-1 and 50N-1 functions of the bus DPU-2000. This prevents the bus DPU-2000 from tripping the bus breaker before the feeder relay has a chance to clear the fault.

When a feeder DPU-2000 relay goes into pickup, its programmed pickup alarm (PUA) output contact closes. This opens the PA relay output contact, disabling the 50P-1 and 50N-1 functions of the bus relay.

The 50P-1 and 50N-1 functions of the bus relay are enabled when there is no pickup condition on any feeder relay or when the relay on the faulted feeder is in a failed state.

Using the External Commmunications Program (ECP), map the logical output condition PUA to your desired output contact for each feeder DPU-2000. Wire all these mapped output contacts to the PA relay, as shown in Figure 8.

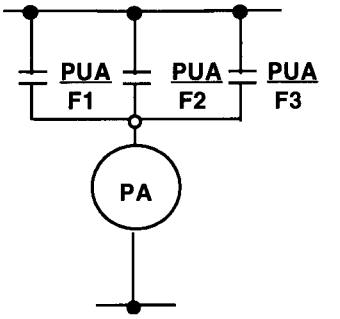


Figure 8. PA Relay

Auxiliary Tripping Relay (Aux/B)

The Aux/B relay allows for DC isolation among the feeder and bus breakers and provides the tripping output necessary to trip the feeder breakers when the feeder relay is in a failed state. If the Aux/B relay fails to trip the feeder breaker, the 51 function of the bus DPU-2000 trips the bus breaker.

Auxiliary Self-Check Failure Relay (74/Fn)

For each feeder DPU-2000, wire the normally open self-check alarm contact (terminals 55 and 56) to an auxiliary failure relay coil. In an energized and normal operating state, the alarming contact (terminals 55 and 56) is closed. This energizes the 74/Fn relay, opening its normally closed contacts and blocking the DPU-2000 on the bus breaker from tripping the feeder. If the feeder relay fails, the alarm contact opens, the 74/Fn relay becomes de-energized, and the 74/Fn output contact closes, which allows the bus DPU-2000 to trip the feeder breaker.

Setting the MTD Mode on the DPU-2000s

Use the following External Communications Program (ECP) screens to program the DPU-2000s for MTD mode:

- Configuration Settings
- Primary Settings
- Programmable I/O Screen

Programming the Bus DPU-2000

The bus DPU-2000 provides tripping for all faults on the bus and backup tripping for faults on the feeder. You normally do not need reclosing on the bus breaker; therefore, disabling the recloser allows tripping of the bus and feeder breakers only during a fault.

Follow these steps to program MDT mode on the DPU-2000 on the bus breaker:

1. Enable Multiple Device Trip mode (MDT Mode) in the Configuration Settings.

2. Set the 50P-1 and 50N-1 settings in the Primary Settings table as follows:

   a. Set the curve setting to "Definite Time."

   b. Select the desired pickup setting.

   c. Set the Time Delay setting to 0.05 sec.

   e. Disable the 79 reclosing function by setting the 79-1 open time to "Lockout."

3. Map the instantaneous functions (50P-1, 50N-1) with "OR" logic to one selected input contact. Set the control logic to "C."

Programming the Feeder DPU-2000

The feeder instantaneous overcurrent relay requires a faster trip response than the bus instantaneous overcurrent relay. When a feeder fault occurs, timing coordination is crucial in allowing the feeder relay to time out faster than the bus relay.

1. Set the 50P-1 and 50N-1 settings in the Primary Settings table as follows:

   a. Set the curve setting to "Standard Instantaneous."

   b. Select the desired pickup setting.

2. At the Programmmable Outputs screen, map the PUA condition to the desired output.

Sample Operation

Condition 1. Feeder and Bus DPU-2000 OK: Feeder Fault (see Figure 9)

The pickup alarm (PUA) picks up the pickup auxiliary relay (PA). The PA contact disables the 50-1 functions of the bus DPU-2000. The feeder relay trips and recloses for the fault.

All auxiliary self-check relays (74/Fn) are picked up, blocking the bus DPU-2000 from tripping the feeder breaker.

Condition 2: Feeder and Bus DPU-2000 OK: Bus Fault (see Figure 10)

The pickup auxiliary relay (PA) is not energized, and therefore the 50-1 function of the bus DPU-2000 is enabled. The 50-1 function trips the bus breaker after 0.05 seconds through the closed contacts of the energized (74/Fn) relays.

Condition 3: A Feeder DPU-2000 Fails or Is Withdrawn from Its Case: Feeder Fault (see Figure 11)

The self-check alarm contact de-energizes the (74/Fn) relay. The (74/Fn) contact in the feeder trip circuit closes. The PA relay is not energized, thereby enabling the 50-1 functions of the bus DPU-2000. The bus DPU-2000's 50-1 functions energize the Aux/B relay, which trips the feeder breaker with no reclosing.

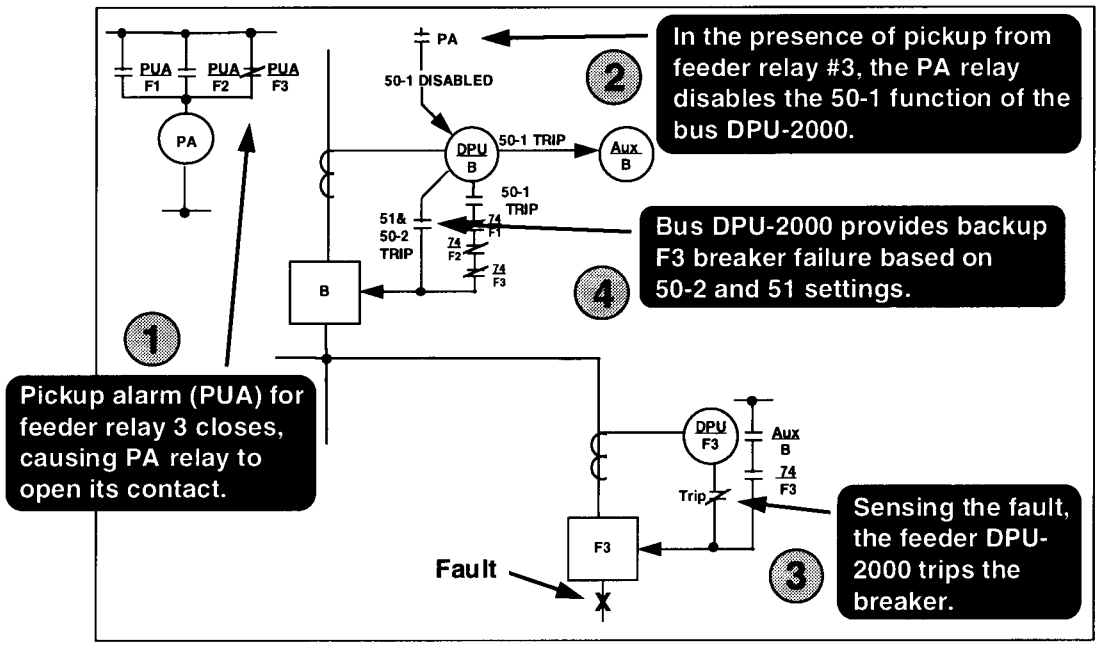


Figure 9. Feeder Fault: Bus and Feeder Relays OK

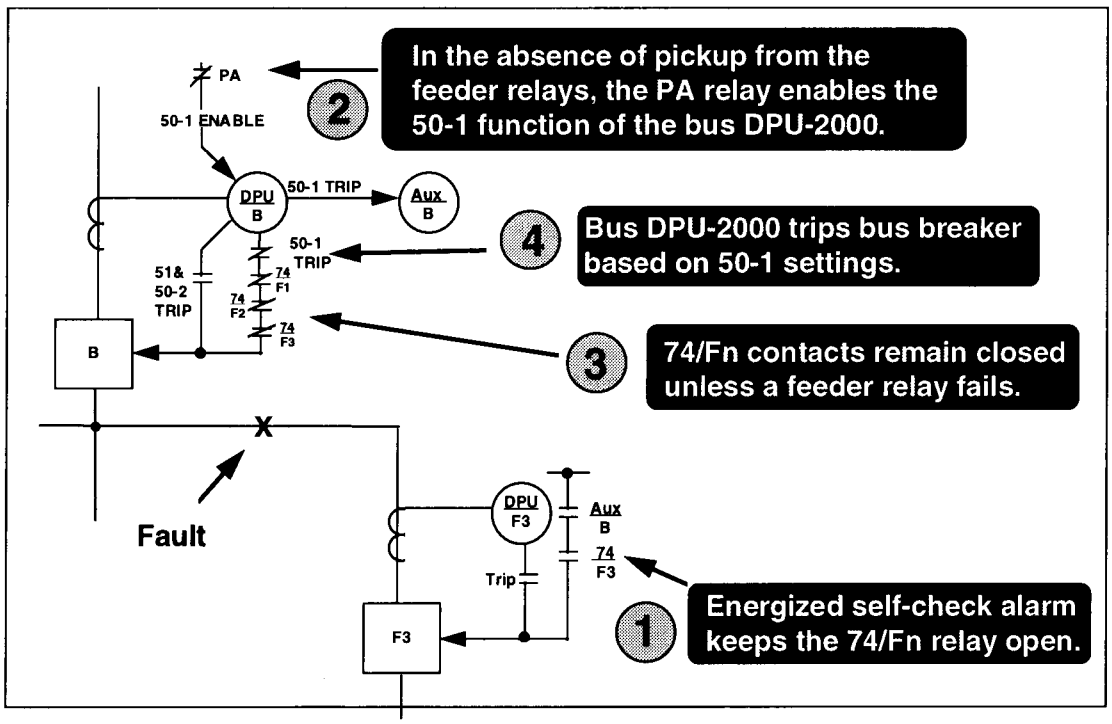


Figure 10. Bus Fault: Bus and Feeder Relays OK

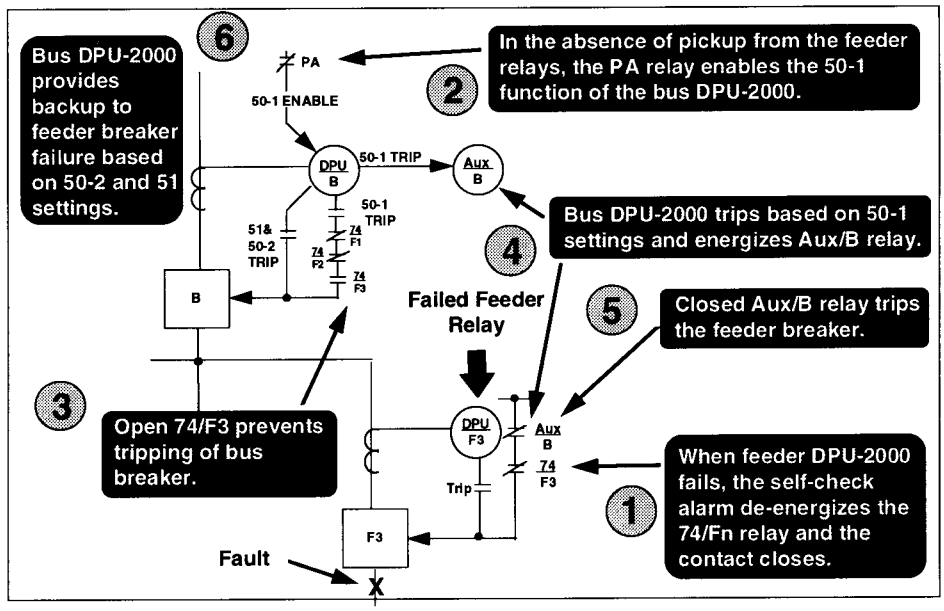


Figure 11. Feeder Fault: One Feeder DPU-2000 Fails

Fault Locator

The DPU-2000 uses a patented fault algorithm to compute an apparent distance to the fault and an estimated fault resistance for a homogeneous distribution line. An A/D converter and a digital signal processor digitally sample the four analog currents and three analog voltages at a rate of 32 times per cycle. Using a multitasking program, a 32-bit microprocessor captures the current and voltage waveform data and analyzes it in the background mode, so that the protective functions are not impeded. Then an analysis is performed on three cycles of prefault data and six cycles of fault data to learn the system parameters. The prefault and fault data is analyzed in the resistive and reactive plane by using iterative and statistical methods with the learned system parameters. An apparent fault impedance is calculated. The positive and zero sequence reactance of the line along with the line length is used to calculate the apparent distance to the fault. The estimated fault resistance is calculated by using the positive and zero sequence impedances of the line along with the line length.

The fault algorithm does not begin to calculate the distance to a fault until a successful trip of the breaker has occurred. The claculation is performed on the first fault in a reclose sequence and is reset after the 79 reset timer expires. This calculation may take up to 20 seconds after the successful trip occurs.

Fault data may not be accurate for a close-into-fault condition where there is no prefault power flow. In the case of closing into a fault during a reclose sequence, the apparent distance to the fault for the first fault appears on the first line of the LCD for the entire reclose sequence. The fault records also display the original fault distance in each record of that reclose sequence. The algorithm for the fault locator is most applicable to a radial feeder.

Battery Backed-Up Clock

An internal clock time-tags the faults in the Fault Record, events in the Operations Record, and values in the Load Profile record. In normal operation, this clock is powered by the DPU-2000. When the DPU-2000 is withdrawn from its case, a battery powers the clock. As long as you turn off the battery backed-up clock during prolonged storage, the battery should last the life of the unit. Turn off the battery backed-up clock through the front man-machine interface by entering a "0" for the day.

Built-In Testing

The DPU-2000 continuously checks itself for proper functioning. You can use the Functional Test Mode to run tests on the overcurrent functions and the reclose sequence without simulating operation of the 52a and 52b contact inputs.

Self-Test Status

The DPU-2000 provides continuous self-testing of its power supply voltages, its memory elements and digital signal processor, and its program execution. In the event of a system failure, the protective functions are disabled and the Self-Check Alarm contacts are actuated. Except for a "processor stalled" condition, review the PASS/FAIL status of these self-test elements by using the man-machine interface (MMI). Normal status is indicated by a green DPU STATUS light (LED), and system failure is indicated by a red DPU STATUS light (or by the green DPU STATUS light not being lit in the case of a loss of control power).

Self-Test Failures are recorded as a number in the Operations Record. The binary bit pattern of this number indicates the Self-Test Failure or Editor Access Status involved. The 1's in the bit pattern indicate where a failure has occurred. Count from the right of the bit pattern (starting with zero) to the position where a "1" occurs. Compare that bit position with Table 3 to reveal the failure. See the examples below for further explanation.

If the self-test fails, the DPU-2000 is no longer providing protection. Replace the unit as soon as possible.

Table 3. Operations Record Value Information

Bit Position	Self-Test Failure	Editor Access Status
0	CPU RAM	INTERRUPT LOGGING
1	CPU EPROM	REMOTE EDIT DISABLE = 1
2	CPU NVRAM	LOCAL EDIT DISABLED = 1
3	CPU EEPROM	FRONT MMI EDIT ACTIVE
4	NOT USED	FRONT COMM PORT EDIT ACTIVE
5	NOT USED	REAR COMM PORT EDIT ACTIVE
6	NOT USED	REAR AUX COMM PORT EDIT ACTIVE
7	NOT USED	REAL TIME CLOCK EDITED
8	DSP ROM	PROGRAMMABLE I/O EDITED
9	DSP INTERNAL RAM	PRIMARY SET EDITED
10	DSP EXTERNAL RAM	ALTERNATE1 SETTINGS EDITED
11	DSP ANALOG/DIGITAL CONVETER	ALTERNATE2 SETTINGS EDITED
12	DSP +/-5 V POWER SUPPLY	CONFIGURATION SETTINGS EDITED
13	DSP +/-15 V POWER SUPPLY	COUNTER SETTINGS EDITED
14	DSP STALL or +5 V POWER SUPPLY	ALARM SETTINGS EDITED
15	DSP TO CPU COMMUNICATIONS	COMMUNICATIONS SETTINGS EDITED

Example of a Self-Test Failure

Value : 256 has a binary bit pattern of 0000000100000000 (bit order 15.....0)

The 1 is in bit position 8 as you count from the right. This bit position correlates to DSP ROM failure.

Example of an Editor Access

Value : 145 has a binary bit pattern of 0000000010010001 (bit order 15.....0)

The 1's in this bit pattern have the following bit positions and corresponding Editor Access Status:

Bit 0 : Interrupt logging bit (Ignore this bit because it will always be set.)
Bit 4 : Front communications port initiated the editor access and change.
Bit 7 : Real-time clock settings were changed.

DPU-2000 Settings Tables Diagnostics

Three copies of each settings table are stored in non-volatile memory, preventing data loss during control power cycling. When you finish editing any settings table, the changed table's data is transferred from a temporary edit buffer into three separate locations in non-volatile memory.

A background diagnostics task continuously runs a checksum on each copy of the settings tables to verify data consistency. If an invalid copy is detected, the diagnostic task attempts self-correction by transferring a valid copy to the invalid copy location. If this is unsuccessful, the task marks the copy as unusable and switches to the next available copy.

When the DPU-2000 detects that all three copies of a settings table are not valid, the diagnostic task adds a self-diagnostic error in the Operations Record, drops the self-check alarm, and disables all protective functions. In addition, the Self Test display under the MMI Test Menu shows the current status (PASS or FAIL) for all memory devices.

Functional Test Mode (Password Protected)

Use the Functional Test Mode to test programmed overcurrent functions and the reclose sequence (upon removal of test current) without simulating operation of the 52a and 52b contact inputs. The DPU-2000 stays in Functional Test Mode for fifteen minutes or until you exit. Use the <C> key on the MMI to reset the recloser when it is in Lockout in the Test Mode. The MMI display shows the time remaining in the Functional Test Mode. The test sequences are written only into the Operations Record.

Metering

The man-machine interface (MMI) continuously displays rms current magnitudes for Ia, Ib, Ic, and In and rms voltage magnitudes for Van, Vbn, and Vcn (Wye-connected VTs) or for Vab, Vbc, and Vca (Delta-connected VTs). For the MMI to show correct primary values, you **must** enter the ratio of the CTs and VTs and the type of VT connection (Wye phase-to-ground or Delta phase-to-phase, nominal voltage) into the Configuration Settings. Use the meter menu to confirm continuity of current and voltage through each input sensor. Voltage Van (Vab) is shown at 0º phase angle and is used as a reference for the other voltage and current phase angles (see Figure 12). The MMI also allows you to scroll through the numerous system parameters listed below.

Load Values

- Phase currents Ia, Ib, and Ic
  - Amperes
  - Degrees
- Ground current In
  - Amperes
  - Degrees
- Phase voltage Van, Vbn, and Vcn for Wye VTs
  - Kilovolts
  - Degrees
- Phase voltage Vab, Vbc, and Vca for Delta VTs
  - Kilovolts
  - Degrees
- Kilowatts per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- KiloVARs per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- Kilowatt-hours per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- KiloVAR-hours per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- Zero (I_0), positive (I_1), and negative (I_2) sequence currents
  - Amperes
  - Degrees
- Positive (V_1) and negative (V_2) sequence voltages
  - Kilovolts
  - Degrees
- Power factor
- Frequency

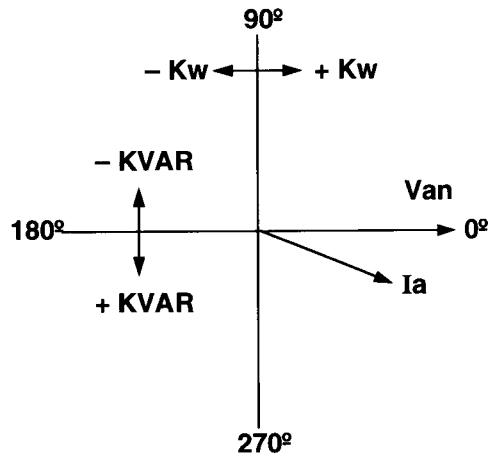


Figure 12. DPU-2000 Metering Conventions

Demand Values

- Demand (phase and ground) currents in amperes
- Demand kilowatts
  - Per phase and 3-phase for Wye VTs
  - 3-phase for Delta VTs
- Demand kiloVARs
  - Per phase and 3-phase for Wye VTs
  - 3-phase for Delta VTs

Maximum and Minimum Demand Values

- Maximum and minimum (phase and ground) demand currents in amperes
- Date and time stamp for maximum and minimum (phase and ground) demand currents
- Maximum and minimum demand kilowatts
  - Per phase and 3-phase for Wye VTs
  - 3-phase for Delta VTs
- Date and time stamp for maximum and minimum demand kilowatts
- Maximum and minimum demand kiloVARs per phase and 3-phase for Wye VTs; 3-phase for Delta VTs
- Date and time stamp for maximum and minimum demand kiloVARs

The demand currents are calculated by using a $\log_{10}$ function and replicate thermal demand ammeters. The demand kilowatts and kiloVARs are averaged values that are calculated by using the kilowatt-hours, kiloVAR-hours, and the selected Demand Meter Constant. The Demand Meter Constant is a time interval you can program for 5, 15, 30, or 60 minutes. It is found in the Configuration Settings (see Table 5).

Examples of the metering displays for Load, Demand, Maximum/Minimum Demand Values, and Fault Records are shown on the next page.

Meter Menu Displays

Load Values

Load Values			
Ia:	320	∠:	344
Ib:	318	∠:	224
Ic:	320	∠:	104
In:	2	∠:	2
kVan:	7.80	∠:	0
kVbn:	7.80	∠:	240
kVcn:	7.80	∠:	120
kW-A:			2396
kW-B:			2381
kW-C:			2396
kW-3P:			7173
kVAR-A:			699
kVAR-B:			695
kVAR-C:			699
kVAR-3P:			2093
kWHr-A:			575040
kWHr-B:			571065
kWHr-C:			576110
kWHr-3P:			1722215
kVARHr-A:			167760
kVARHr-B:			165440
kVARHr-C:			168225
kVARHr-3P:			501425
I0:	0	∠:	0
I1:	320	∠:	0
I2:	0	∠:	0
kV1:	7.80	∠:	0
kV2:	0	∠:	0
PF:	0.96		LAGGING
FREQ:			60.00

Fault Record

<-FAULT RECORD 1 ->			
Fault Number:			209
Reclose Seq :			Prim - 1
Date:			24Aug93
Time:			12:09:03.36
Element:			50P-2
Dist. (mi):			4.7
Fault res:			0.235
Relay Time:			0.800
Clear Time:			0.046
Ia:	1850	∠:	315
Ib:	1850	∠:	195
Ic:	1850	∠:	75
In:	0	∠:	0
I1:	1850	∠:	315
I2:	0	∠:	0
I0:	0	∠:	0
kVan:	7.02	∠:	0
kVbn:	7.02	∠:	240
kVcn:	7.01	∠:	120
kV1:	7.02	∠:	0
kV2:	0	∠:	0

Demand Values

Demand Values	
Ia:	305
Ib:	297
Ic:	302
In:	8
kW-A:	2283
kW-B:	2225
kW-C:	2247
kW-3P:	6750
kVAR-A:	664
kVAR-B:	655
kVAR-C:	662
kVAR-3P:	1978

Maximum/Minimum Values

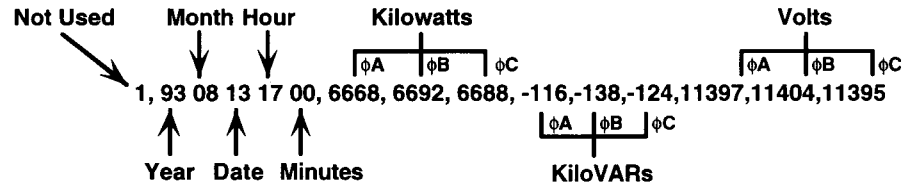
Max Ia:	425	
	08/20/94	16:25
Min Ia:	55	
	08/03/94	04:10
Max Ib:	405	
	08/20/94	16:30
Min Ib:	46	
	08/02/94	04:22
Max Ic:	415	
	08/20/94	16:18
Min Ic:	52	
	08/03/94	03:55
Max In:	38	
	08/15/94	15:46
Min In:	0	
	08/03/94	03:17
Max kW-A	2983	
	08/20/94	16:25
Min kW-A	432	
	08/03/94	04:10
Max kW-B	2843	
	8/20/94	16:32
Min kW-B	361	
	08/02/94	04:21
Max kW-C	2913	
	08/20/94	16:19
Min kW-C	408	
	08/04/94	03:55
Max kW-3P	8885	
	08/20/94	16:23
Min kW-3P	1140	
	08/02/94	03:58
Max kVAR-A	1425	
	08/20/94	16:27
Min kVAR-A	-120	
	08/03/94	04:02
Max kVAR-B	1379	
	08/20/94	16:28
Min kVAR-B	-117	
	08/02/94	04:24
Max kVAR-C	1392	
	08/20/94	16:17
Min kVAR-C	-124	
	08/03/94	03:52
Max kVAR-3P	4160	
	08/20/94	16:19
Min kVAR-3P	-355	
	08/02/94	04:12

Optional Features

In addition to the standard protection functions, the DPU-2000 has optional load profile, oscillographic waveform capture, and user-programmable curve features.

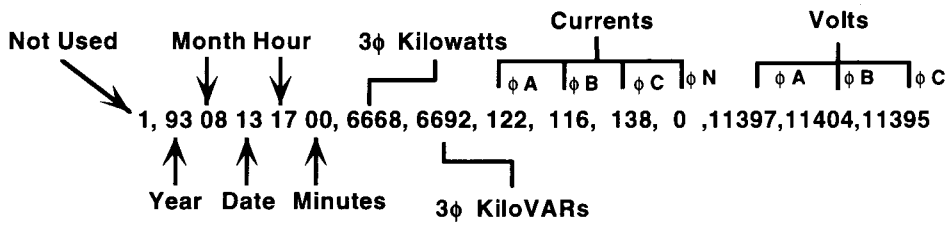
Load Profile

A load profile feature records per-phase demand kilowatts, demand kiloVARs, and line-to-ground voltages (see Appendix F). You can select a 5-, 15-, 30-, or 60-minute time interval (Demand Meter Constant) for which the load profile record then contains 13.3, 40, 80, or 160 days of information, respectively (default is 15 minutes and 40 days). The load profile feature requires Wye-connected VTs to accurately measure per-phase kilowatts and kiloVARs for unbalanced loads. For Delta-connected VTs, the load profile feature records three-phase kilowatts and kiloVARs, per-phase and ground demand currents, and line-to-line voltages. You can retrieve this load profile data only through the External Communications Program, which stores the load profile and its header in a comma-delimited ASCII file (default is ***filename.dla***). You can view this file by using any text editor program (word processor or spreadsheet) or by using the following DOS command: ***type [name of file].dla|more***. Use the pipe character (|) above the \ character between DLA and MORE.



1,9308131700,6668,6692,6688,-116,-138,-124,11397,11404,11395
1,9308131715,6678,6680,6690,-116,-128,-128,11378,11414,11393
1,9308131730,6678,6680,6690,-116,-128,-128,11378,11404,11391

- A -



1,9308131700,6668,6692,122,116,138,0,11397,11404,11395
1,9308131715,6678,6680,123,116,128,0,11378,11414,11393
1,9308131730,6678,6680,120,116,128,0,11378,11404,11391

- B -

Figure 13. Sample Load Profile for (-A-) Wye-Connected VTs and (-B-) Delta-Connection VTs

Oscillographic Data Storage (Waveform Capture)

```
Waveform Capture Menu
Show Settings
Change Settings
Waveform Records
Start Data Accumulation
Stop Data Accumulation
Acquisition Status
Return
Show Waveform Capture
```

To enhance disturbance analysis, the DPU-2000 can be furnished with oscillographic data storage that captures and stores up to 64 cycles of waveform data for each of the four input currents and three input voltages. Retrieve the waveform data from the DPU-2000 by using the Waveform Capture Menu in the External Communications Program. Fault analysis is enhanced by the POWERview Oscillographic Analysis Tool program, which uses a Microsoft® Windows™-based Graphical User Interface (see Figure 14 and Appendix E).

You can program the DPU-2000 to capture eight, four, two, or one record(s) containing 8, 16, 32, or 64 cycles of data. Thirty-two points per cycle for each of the seven analog inputs, the 52a and 52b contact inputs, and numerous protective and logic functions are stored in each waveform record. The capturing of waveform data can be triggered when the trip output is actuated, the breaker is opened, or the waveform capture input (WCI) is initiated (provided the WCI logic function has been mapped to an input contact). You can also program the DPU-2000 to trigger the capturing of waveform data on pickup of the following functions: 50N-1, 50P-1, 50N-2, 50P-2, 50N-3, 50P-3, 51N, 51P, 67N, 67P, 46, 27, 59, 81S, and 81R (see Figure 15). To provide as many cycles of prefault and fault data as possible, you can program the trigger position at any quarter-cycle within the fault record. The time stamp of a waveform record is captured at the time of trigger.

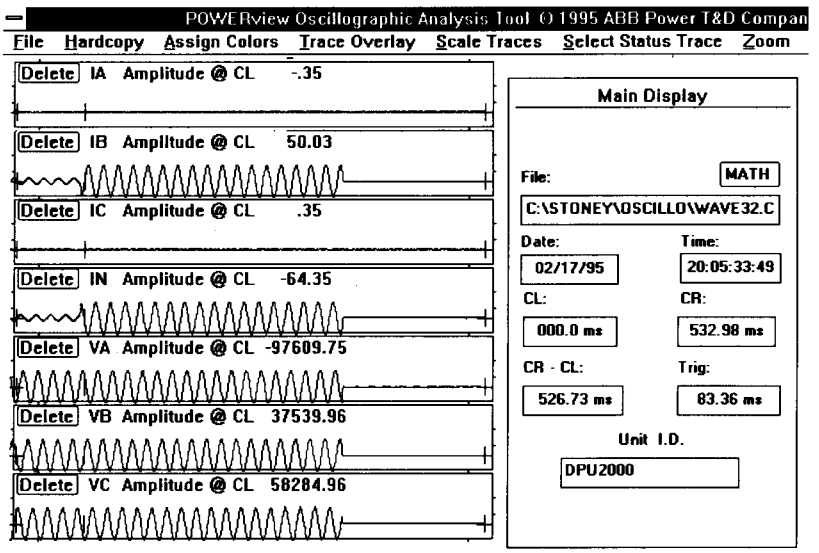


Figure 14. Oscillographic Wave Forms

NOTE: Download the captured waveform records to a file before changing any Waveform Capture settings. Changing settings may lose waveform records.

The waveform capture program includes an option called Single-Shot Mode. When you select Single-Shot Mode and the Record Type is 3, the accumulation of data stops when a record is captured (see Figure 15). In this way, you can ensure that a waveform record will not be overwritten by new captures. Select "Start Data Accumulation" from the Waveform Capture Menu to capture a new record and overwrite the old one.

NOTE: When Single-Shot Mode is off and the selected Record Type is 3, no waveform record is captured.

Selecting "On" for the Appended Record Mode enables the DPU-2000 to capture a new triggered record while it is still completing the capture of another record. If Appended Record Mode is "Off," the new record cannot be captured until the current record has been completed.

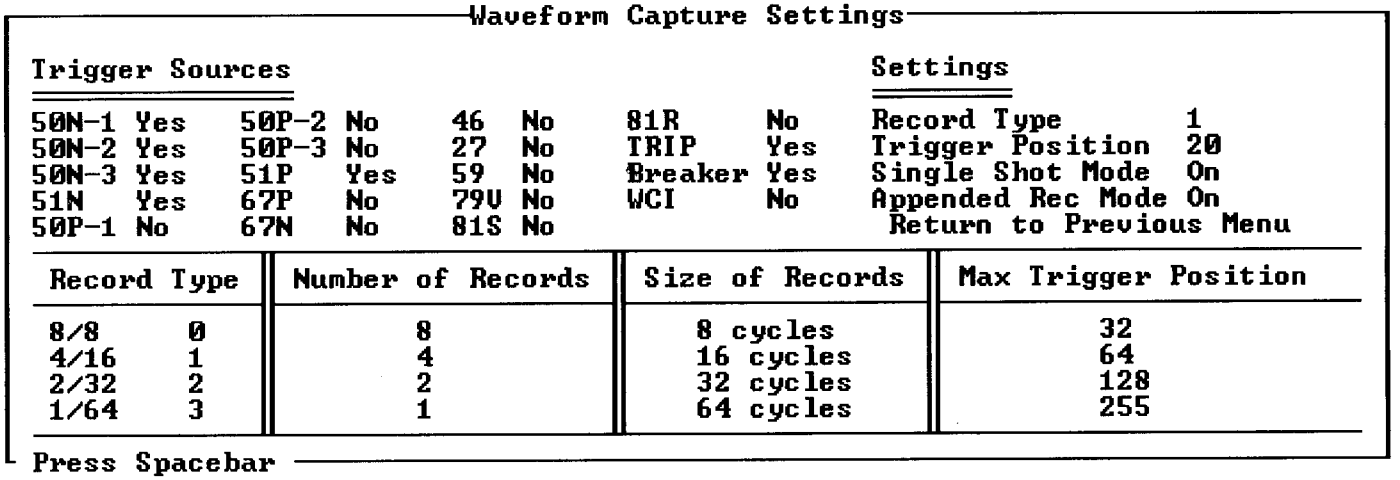


Figure 15. Waveform Capture Settings Screen

Saving a Waveform Capture Record

To save a waveform capture record, do the following:

1. Select "Waveform Records" from the Waveform Capture Menu.
2. Select the record you want to save and press Enter.
3. Type the path and filename you want for the record and press Enter.

Customer-Programmable Curves

An external PC-based program, CurveGen, is used to create and program time-current curves for the DPU-2000. With CurveGen you can program three time-overcurrent curves other than the ones currently provided in the DPU-2000 (see Tables 1 and 2). You can manipulate the curves in the time and current domains just like any other curve currently programmed into the DPU-2000. CurveGen generates all of the necessary variables for the user-defined curves to be stored in the DPU-2000 (i.e. the alpha's, beta's, and pointers to the curve table). The method of accomplishing this task is curve definition.

The standard curve entered into the DPU-2000 has the form of:

$$t = \left(\frac{A}{M^{p}-C}\right) + B$$

M is the per-unit current above the pickup value

t is total trip time at M

A, p, C, and B are variables to be defined.

To define the curve, you must define the variables in the equation. There are two ways to do this:

- Enter variables by hand: In the CurveGen program you can define all four variables by hand. This is designed for users who do not want curves based on already established functions but instead are ready to define curves through mathematical manipulation.
- Determine variables via curve fitting: Define a series of time versus current points and fit them to the standard equation listed above.

With the CurveGen program you can enter these series of time/current points from an already defined curve. CurveGen then fits the four variables to these points. There are two ways to enter these points into the CurveGen program:

- Enter all sampled points by hand. The ability to remove, sort, plot, edit, and view points gives you total power over the curve to be generated.
- File entry: CurveGen also can read files with points defined in them. The ability to remove, sort, plot, edit, and view points gives you total power over the curve to be generated.

Once all the points are entered, the CurveGen program is cued to fit a standard curve. After A, p, C, and B have been determined, you can plot the curve against the points given as well as determine the overall error of the curve versus the plotted points.

After all four variables have been determined, you can generate a linear approximation of the curve. A maximum error criteria must be satisfied before CurveGen can determine the coefficients needed for the DPU-2000. Errors and warnings indicate whether or not the error criteria can be met or if the number of entries in the curve table is above the maximum value allowed.

When the curve tables have been defined by CurveGen, you must download them into the DPU-2000. When you want to use a customer-defined curve, select "Receive Prog Curve Data" from the Programmable Curve Menu in the External Communications Program (see "Programmable Curve Menu" in this instruction book). After you have retrieved a curve file from a disk, you can download it into the DPU-2000.

Internal Design

The heart of the DPU-2000 is the microprocessor. The capabilities of the microprocessor allow the DPU-2000 to perform the many protective functions. Figure 16 shows a block diagram of the unit.

Processor Specifications

The processing power of the DPU-2000 provides a true multitasking environment that combines protection, metering, and control. The hardware components of the unit include:

- CPU—16-MHz, 32-bit 68332 Motorola microprocessor
- CPU RAM—64 K of temporary storage for CPU
- DSP—a 16-bit analog device digital signal processor handles all analog acquisition and measurement of input parameters. It also performs all arithmetic iterations of the converted digital input signals.
- EEPROM stores all protective function settings.
- 14-bit analog-to-digital (A/D) converter
- CPU EPROM stores the CPU's programming.
- DSP EPROM—3 K of memory store the DSP's operating algorithm.
- DSP RAM—16 K of memory provide temporary storage of DSP's arithmetic values.
- Real-time battery backed-up clock

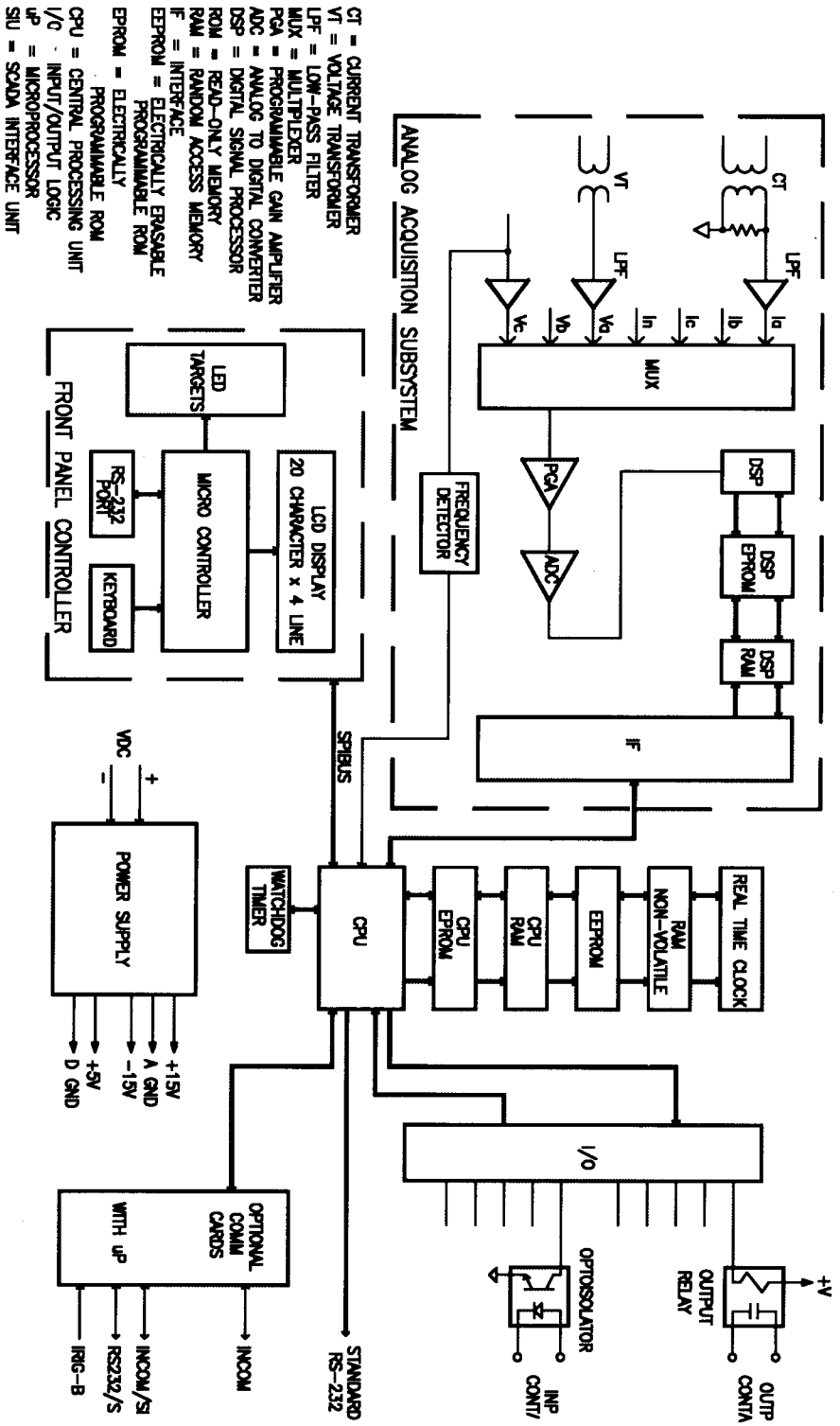
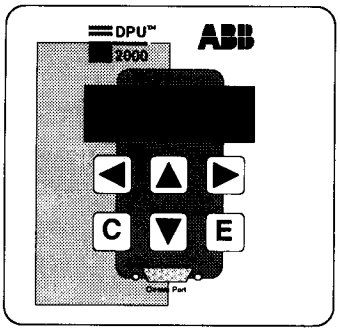


Figure 16. DPU-2000 Block Diagram

Man-Machine Interface (MMI)



The man-machine interface (MMI) on the front panel consists of a four-line LCD with twenty characters per line, six push-buttons (keys), and thirteen LED targets. Press the Enter <E> key to access the Main Menu. Use the up and down arrow keys to move through the various menus and to change the character value when you enter the alphanumeric password. Use the Enter <E> key to select the desired menu or desired value when you change settings.

Use the left and right arrow keys to decrease and increase, respectively, setting values or record numbers. Also use them to move from left to right within the password string. Hold down or repeatedly press the arrow keys to change the setting value.

Figure 17. MMI Access Panel

Use the clear <C> key to return to the previous menu. You can also use the <C> key to:

- reset LED targets and the LCD after a fault (push <C> once)
- scroll through all metered values (push <C> twice)
- reset the peak demand values (push <C> three times)

You can do a system reset by simultaneously pressing the <C>, <E>, and up arrow keys. A "System Reset" resets the microprocessor and re-initiates the software program. During a system reset, no information or settings are lost.

The following displays and menus are available through the MMI:

- Continuous Display—shows curents, voltages, and which settings table is enabled
- Post-Fault Display—shows distance to fault in miles and fault currents for last fault until targets are reset
- Reclosing Display—shows open interval or reset time counting down to zero

MMI Displays

Metering Display (Continuous)

```
Ia:  500 KVan:  13.00
Ib:  500 KVbn:  13.00
Ic:  500 KVcn:  13.00
In:    0 Primary Set ■
```

Main Menu

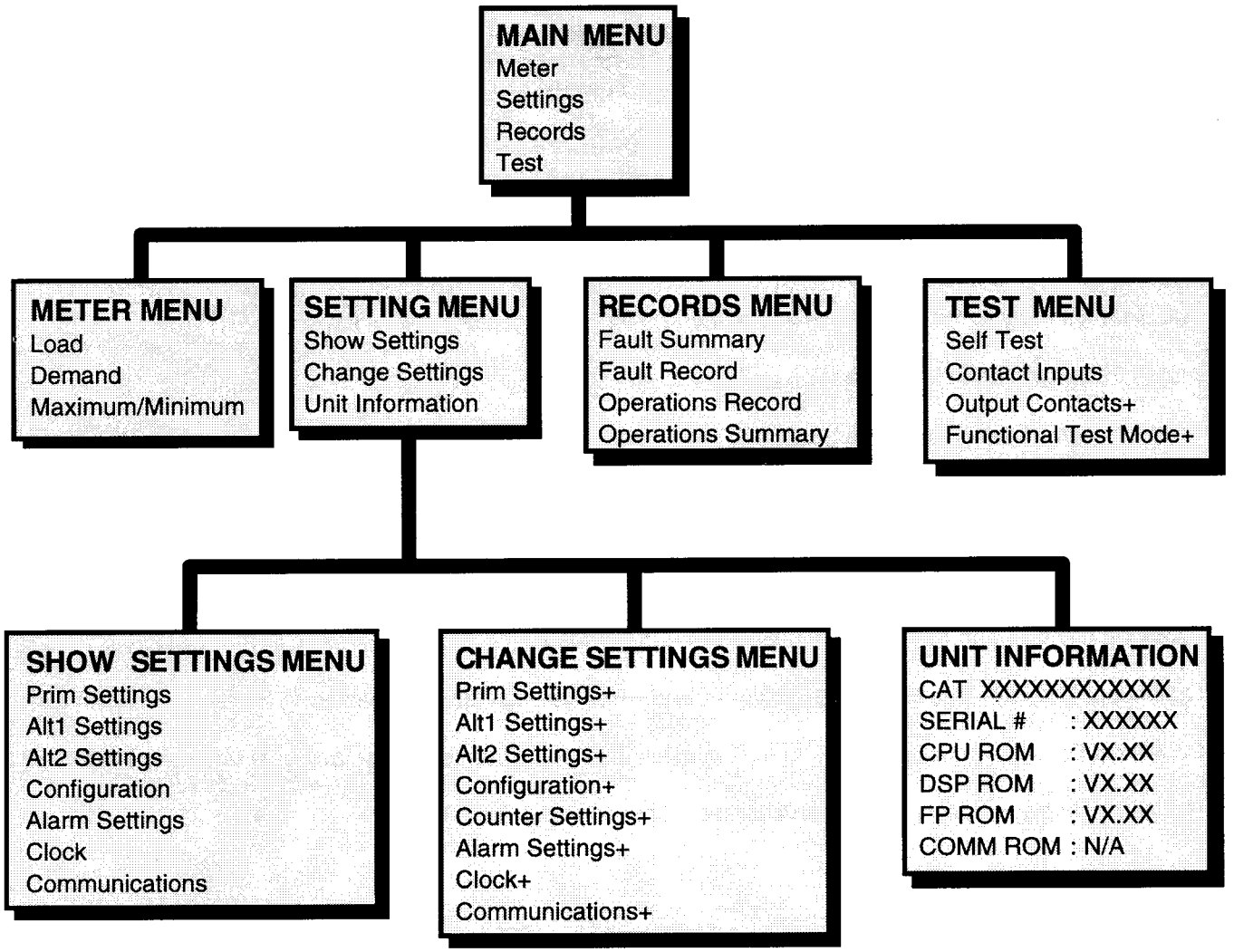
```
MAIN MENU
Metering
Show Settings
Change Settings  ↓
```

Display After a Fault Interruption

```
Distance - Miles:  10.1
Ia:  3320      Ib: 430
Ic:  420       In: 3310
     Reset Time:  14
```

Man-Machine Interface Menus

Below is an outline of all the menus available through the man-machine interface.



+ Password protected

External Communications Program

The External Communications Program (ECP) provides point-to-point communications with the DPU-2000 relay. By using ECP, you can program the settings for the DPU-2000's various functions, map logical inputs and outputs, and monitor the relay's activity. ECP is a DOS®-based program and can be copied to your computer's hard drive. To execute the program, type "ecp."

You also can use the software without the DPU-2000 relay to explore the capabilities and functionality of the relay. When your PC is not connected to a DPU-2000 and you have not retrieved a file from a disk, the settings and configurations displayed are the factory default values. You can then change the values and save them to a file for later retrieval to a DPU-2000. When the PC is connected to a DPU-2000, the records can be viewed (Get Data From DPU-2000), saved to a file (Save Data To Disk), and viewed later (Get Data From Disk).

For the Fault Summary and the Operations Record, only the screens you view are saved to a file. Therefore, to save all the data to a file, you must view all the screens before exiting the record display.

When changing the Configuration Settings through ECP, you must type in the four-digit password (the factory default password is four spaces) followed by a carriage return.

The ECP contains terminal emulation commands to dial through a modem to access the relay or other devices connected to a remote modem. If communication is not established, a communications error message appears. If this message appears frequently, the line may be too noisy. Hang up and redial; if possible, use another line.

Use a null modem when you connect a terminal directly to the DPU-2000 (not via modems).

To print ECP screens with a laser jet printer by using the Print Screen key, you must change the character set mode of the printer from an ASCII character set to a line character set. Each printer has its own specific code to accomplish this. What code to use and how to program the code into the printer are detailed in the printer manual.

For example, on the HP Laser Jet III printer the code is "PC8," and the printer can be programmed by using the menu system located on the front of the printer. Follow these steps to program an HP Laser Jet III printer:

1. Take the printer off line by pressing the On Line key. This enables you to scroll through the menu options.
2. Press the Menu button until you see "Sym Set."
3. Press the "+" key until you see "PC8."
4. Press the Enter key to put the printer in the line character set mode.
5. Press the On Line key and you are ready to print ECP screens.

Once you have printed the desired ECP screens, you should reprogram the printer to its original mode; otherwise the printer will remain in the line character mode.

The application program on this disk has been carefully tested and performs accurately with most IBM-compatible personal computers. If you experience difficulty in using the External Communications Program, contact ABB at (610)395-7333.

External Communications Program Menus

Below is an outline of all the menus available through the External Communications Program. Many of these menus are the same as those in the man-machine interface (MMI), but some are unique to the ECP. Tables 4–8 show the specific settings for the DPU-2000.

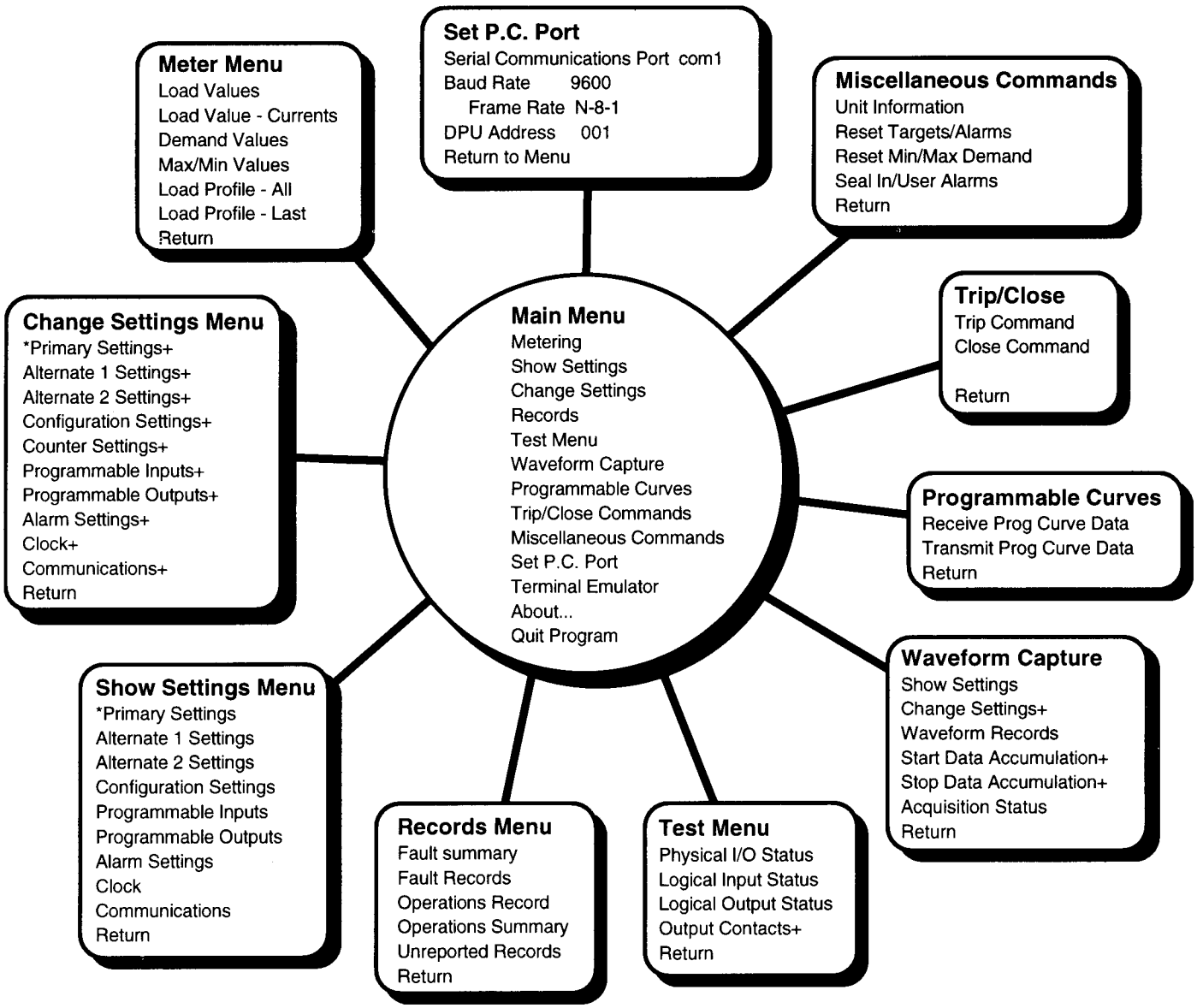


Table 4. Primary, Alternate 1, and Alternate 2 Settings (Password Protected)

Function	Setting	Range	Step Size	Default
51P	Curve Selection	See Table 1		Extremely Inverse
	Pickup Amps	1 to 12 A or 0.2 to 2.4 A	0.1 or 0.02	6.0 or 1.2
	Time Dial/Delay	See Table 1		5.00
50P-1	Curve Selection	See Table 2 or Disable		Standard
	Pickup X 51P	0.5 to 20 times 51P pickup setting	0.1	3.00
	Time Dial/Delay	See Table 2		—
50P-2	Selection	Disable or Enable		Disable
	Pickup X 51P	0.5 to 20 times 51P pickup setting	0.1	—
	Time Delay	0 to 9.99 seconds	0.01	—
50P-3	Selection	Disable or Enable		Disable
	Pickup X 51P	0.5 to 20 times 51P pickup setting	0.1	—
46	Curve Selection	See Table 1 or Disable		Disable
	Pickup Amps	1 to 12 A or 0.2 to 2.4 A	0.1 or 0.02	—
	Time Dial/Delay	See Table 1		—
51N	Curve Selection	See Table 1 or Disable		Extremely Inverse
	Pickup Amps	1 to 12 A or 0.2 to 2.4 A	0.1 or 0.02	6.0 or 1.2
	Time Dial/Delay	See Table 1		5.00
50N-1	Curve Selection	See Table 2 or Disable		Standard
	Pickup X 51N	0.5 to 20 times 51N pickup setting	0.1	3.00
	Time Dial/Delay	See Table 2		—
50N-2	Selection	Disable or Enable		Disable
	Pickup X 51N	0.5 to 20 times 51N pickup setting	0.1	—
	Time Delay	0 to 9.99 seconds	0.01	—
50N-3	Selection	Disable or Enable		Disable
	Pickup X 51N	0.5 to 20 times 51N pickup setting	0.1	—
79	Reset Time	3 to 200 seconds	1	10.00
79-1	Trip #1 Functions	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		—
	Open Time	0.1 to 200 seconds or Lockout		Lockout

Table 4. Primary, Alternate 1, and Alternate 2 Settings (Password Protected) (Continued)

Function	Setting	Range	Step Size	Default
79-2	Trip #2 Functions	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		—
	Open Time	0.1 to 200 seconds or Lockout		—
79-3	Trip #3 Functions	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		—
	Open Time	0.1 to 200 seconds or Lockout		—
79-4	Trip #4 Functions	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		—
	Open Time	0.1 to 200 seconds or Lockout		—
79-5	Trip #5 Functions	50P-1, 50P-2, 50P-3, 51N, 50N-1, 50N-2, 50N-3 (Enable, Disable, or Lockout for each)		—
	Lockout			—
79-CO	Cutout Time	1 to 200 seconds or Disable	1	Disable
Cold Load Time		0 to 254 seconds/minutes or Disable*	1	Disable
2-Phase 50P	2Phase 50P Trip	Disable or Enable		Disable
67P	Select	Disable, Enable or Lockout		Disable
	Curve Selection	See Table 1		—
	Pickup Amps	1 to 12 A or 0.2 to 2.4 A	0.1 or 0.02	—
	Time Dial/Delay	See Table 2		—
	Torque Angle	0 to 355º	5	—
67N	Select	Disable, Enable or Lockout		Disable
	Curve Selection	See Table 1		—
	Pickup Amps	1 to 12 A or 0.2 to 2.4 A	0.1 or 0.02	—
	Time Dial/Delay	See Table 2		—
	Torque Angle	0 to 355º	5	—
81	Select	Disable, Enable 81-1, Enable 81-2		Disable
81S-1	Load Shed Pickup	56 to 64 Hz or 46 to 54 Hz	0.01	—
	Shed Time Delay	0.08 to 9.98 seconds	0.02	—
81R-1	Load Restoration	Disable, 56 to 64 Hz, or 46 to 54 Hz	0.01	—
	Restoration T.D.	0 to 999 seconds	1	—

* Choose seconds or minutes in the Configuration Settings.

Table 4. Primary, Alternate 1, and Alternate 2 Settings (Password Protected) (Continued)

Function	Setting	Range	Step Size	Default
81S-2	Load Shed Pickup	56 to 64 Hz or 46 to 54 Hz	0.01	—
	Shed Time Delay	0.08 to 9.98 seconds	0.02	—
81R-2	Load Restoration	Disable, 56 to 64 Hz or 46 to 54 Hz	0.01	—
	Restoration T.D.	0 to 999 seconds	1	—
81V	Voltage Block	40 to 200 volts AC	1	—
27	Select	Disable or Enable		Disable
	Pickup Volts	10 to 200 volts AC	1	—
	Time Delay	0 to 60 seconds	1	—
79V	Voltage Select	Disable or Enable		Disable
	Pickup Volts	10 to 200 volts AC	1	—
	Block Time Delay	4 to 200 seconds	1	—
59	Select	Disable or Enable		Disable
	Pickup Volts	70 to 250 volts AC	1	—
	Time Delay	0 to 60 seconds	1	—

Table 5. Configuration Settings (Password Protected)

Setting	Range	Step Size	Factory Default Value
Phase CT Ratio	1 to 999	1	100
Neutral CT Ratio	1 to 999	1	100
VT Ratio	1 to 999	1	100
VT Connection	69 V or 120 V Wye (phase to ground); 120 V or 208 V Delta (phase to phase)	—	120 Wye
Positive Sequence Reactance/Mile	0.001 to 4 Ohms primary	0.001	0.001
Positive Sequence Resistance/Mile	0.001 to 4 Ohms primary	0.001	0.001
Zero Sequence Reactance/Mile	0.001 to 4 Ohms primary	0.001	0.001
Zero Sequence Resistance/Mile	0.001 to 4 Ohms primary	0.001	0.001
Line Length	0.1 to 50 miles	0.1	20
Trip Failure Time	5 to 60 cycles	1	18
Close Failure Time	18 to 999 cycles	1	18
Phase Rotation	ABC or ACB	—	ABC
Protection Mode	Fundamental or RMS	—	Fundamental
Reset Mode (51/46/67)	Inst. (2 cycles) or delayed	—	Instantaneous
Alternate 1 Settings	Enable or Disable	—	Enable
Alternate 2 Settings	Enable or Disable	—	Enable
Multiple Device Trip Mode*	Disable or Enable	—	Disable
Cold Load Time Mode	Seconds or minutes	—	Seconds
Zone Sequence Coordination	Disable or Enable	—	Disable
Target Display Mode	Last or All Faults	—	Last
Remote Edit (Local MMI Only)	Enable or Disable	—	Enable
Local Edit (Comm Ports Only)	Enable or Disable	—	Enable
Meter Mode	kWHr or MWHr (6 Digits)	—	kWHr
LCD Light	On or Time Out (5 Minutes)	—	On
Unit (Relay) Identification	15 alphanumeric characters	—	DPU2000
Demand Meter Constant	5, 15, 30, or 60 minutes	—	15
LCD Contrast	0 to 63	1	16
Change Relay Password	4 alphanumeric characters	—	4 blank spaces

* When the Multiple Device Trip Mode is enabled, the reset mode is automatically changed to instantaneous and cannot be changed.

Table 6. Counter Settings (Password Protected)

Setting	Range	Step Size	FactoryDefault Value
KSI Summation A Phase Setting	0 to 9999 kA	1	0
KSI Summation B Phase Setting	0 to 9999 kA	1	0
KSI Summation C Phase Setting	0 to 9999 kA	1	0
Overcurrent Trip Counter	0 to 9999	1	0
Breaker Operations Counter	0 to 9999	1	0
Recloser Operations Counter 1	0 to 9999	1	0
Recloser Operations Counter 2	0 to 9999	1	0
Successful 1st Reclosures	0 to 9999	1	0
Successful 2nd Reclosures	0 to 9999	1	0
Successful 3rd Reclosures	0 to 9999	1	0
Successful 4th Reclosures	0 to 9999	1	0

Table 7. Alarm Settings (Password Protected)

Setting	Range	Step Size	Factory Default Value
KSI Summation Alarm (KSI)	1 to 9999 kA	1	Disable
Overcurrent Trip Counter Alarm (OCTC)	1 to 9999	1	Disable
Recloser Operations Counter 1 Alarm (79CA1)	1 to 9999	1	Disable
Recloser Operations Counter 2 Alarm (79CA2)	1 to 9999	1	Disable
Phase Demand Current Alarm (PDA)	1 to 9999 A	1	Disable
Neutral Demand Current Alarm (NDA)	1 to 9999 A	1	Disable
Three-Phase KiloVAr Demand Alarm (VarDA)	0 to 99,990 kVAr	10	Disable
Positive Three-Phase KiloVAr Alarm (PVarA)	0 to 99,990 kVAr	10	Disable
Negative Three-Phase KiloVAr Alarm (NVarA)	0 to 99,990 kVAr	10	Disable
Low Power Factor Alarm (LPFA)	0.5 to 1.0 lagging	0.01	Disable
High Power Factor Alarm (HPFA)	0.5 to 1.0 lagging	0.01	Disable
Load Current Alarm (LOADA)	1 to 9999 A	1	Disable

Table 8. Communications Settings (Password Protected)

Setting	Range	Factory Default Value
Front RS-232 Port		
Baud Rate	300, 1200, 2400, 4800, 9600	9600
Frame	N,8,1 or N,8,2	N,8,1
Rear RS-232 Port		
Baud Rate*	300, 1200, 2400, 4800, 9600, 19200	9600
Frame	N,8,1; E,8,1; ODD,8,1; N,8,2; E,7,1; ODD,7,1; N,7,2	N,8,1
Rear RS-485 Port		
Baud Rate*	300, 1200, 2400, 4800, 9600, 19200	9600
Frame	N,8,1; E,8,1; ODD,8,1; N,8,2; E,7,1; ODD,7,1; N,7,2	N,8,1
Rear INCOM Port Baud Rate*	1200, 9600	9600
Unit Address	3 hexadecimal characters (0–9 & A–F)	001
IRIG-B Input	Disable or Enable	Disable

* Check catalog number for available communications port options.

Programmable Input and Output Contacts

By using the External Communications Program, you can individually program certain input and output contacts.

Binary (Contact) Inputs

Binary inputs are divided into two categories: permanently programmed single-ended and user-programmable single- or double-ended. Single-ended inputs have one terminal connection marked "+" and share a common terminal (# 52) marked "–". Double-ended inputs have two terminal connections, marked "+" and "–". Double-ended Inputs 3 and 4 are powered internally (wet). The recognition time (debounce time) for the change in state of an input is two (2) cycles.

Permanently programmed contact inputs include the following:

- 52a Breaker Position: Closed (input closed)/Opened (input opened)
- 52b Breaker Position: Opened (input closed)/Closed (input opened)
- 43a Reclose Function: Enabled (input closed)/Disabled (input opened)

Up to thirteen (13) user-programmable contact inputs are available. You can program these only by using the External Communications Program. Nine (9) input functions remain operational (enabled) when not assigned to contact inputs in the Programmable Input Map. These input functions are: GRD, PH3, 46, 50-1, 50-2, 50-3, 67P, 67N, and TCM. You must assign the remaining input functions to contact inputs for the functions to be operational (enabled). The user-programmable inputs can monitor, enable, initiate, or actuate the input functions shown in Table 9. The programmable inputs in the table are arranged in the order they appear on the default Programmable Inputs screen.

Figure 18 shows the factory default settings for mapping the programmable inputs. The "C" represents a closed contact to enable the function; to represent an open contact to enable the function, you place an "O" under the input in the desired contact line. For example, based on the factory default settings, you must apply control power to Input 1 to enable the trip coil monitoring (TCM).

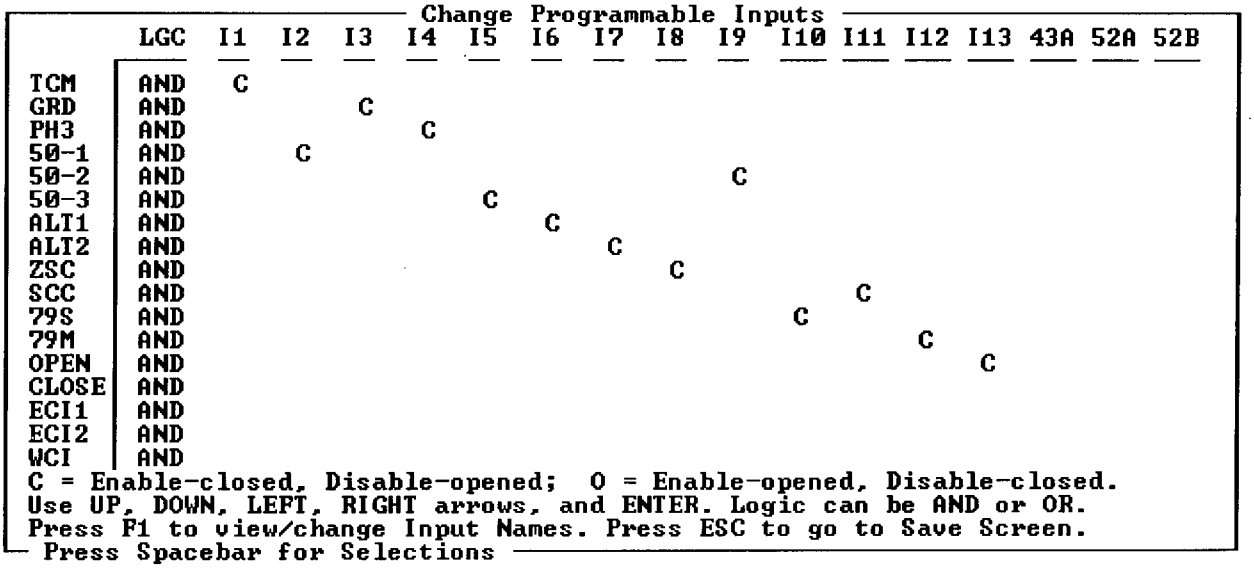


Figure 18. Programmable Inputs Screen

Table 9. Programmable Input Functions

Programmable Input	Function	Factory Default Input Contact
TCM (Trip Coil Monitoring)	Monitors continuity through the trip coil when the breaker is closed; outputs to TCFA	IN 1 (doubled-ended)
GRD (Ground Control)	Enables the 51N/50N-1/50N-2 functions	IN 3 (double-ended and wetted)
PH3 (Phase Control)	Enables the 51P/50P-1/50P-2 functions	IN 4 (double-ended and wetted)
50-1 (50-1 Instantaneous Control)	Enables the 50P-1 and 50N-1 functions	IN 2
50-2 (50-2 Instantaneous Control)	Enables the 50P-2 and 50N-2 functions	IN 9
50-3 (50-3 Instantaneous Control)	Enables the 50P-3 and 50N-3 functions	IN 5
46 (Negative Sequence Control)	Enables the 46 function	--
67P (Positive Sequence Phase Directional Control)	Enables the 67P function	--
67N (Negative Sequence Ground Directional Control)	Enables the 67N function	--
ALT1	Enables Alternate 1 Settings table	IN 6
ALT2	Enables Alternate 2 Settings table	IN 7
ZSC	Enables Zone Sequence Coordination scheme	IN 8
SCC	Monitors Spring Charging contact when breaker is opened	IN 11
79S	Initiates a single-shot reclosure when breaker is opened by another device	IN 10
79M	Initiates multishot reclosing per enabled settings table when breaker is opened by another device	IN 12
OPEN	Initiates Trip output contact; recommend ANDing 2 single-ended inputs	IN 13
CLOSE	Initiates Close output contact; recommend ANDing 2 single-ended inputs	--
ECI1 (Event Capture Initiated)	Initiates storage of data in Fault Summary and Fault Record	--
ECI2 (Event Capture Initiated)	Initiates storage of data in Fault Summary and Fault Record	--
WCI (Waveform Capture Initiated)	Initiates oscillographic data storage in the waveform capture record	--
CRI (Clear Reclose Initiated)	Resets Recloser Counters 1 and 2 and the Overcurrent Trip Counter to zero	--
ULI1–ULI9 (User Logical Inputs 1 through 9)	Allow you to logically AND or OR contact inputs together. User Logical Inputs (ULIs) 1 through 9 are mapped to the corresponding User Logical Outputs (ULOs) 1 through 9 in the Programmable Output screen. The User Logical Inputs allow you to define functions for the contact inputs that are not listed above.	--

Programming Examples:

1. If you do not want to use the TCM function, place an "O" under I1 on the TCM line or replace "TCM" with "– – –", indicating no logic function. The "O" enables the TCM function when the mapped input contact is open.

Change Programmable Inputs - unknown unit

	LGC	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	43A	52A	52B
TCM	AND	O															

2. If you want the 50-1 function enabled when reclosing is disabled or I2 is closed, place a "C" under I2 in the 50-1 line, an "O" under 43a, and an "OR" under LOGIC. This is logically 50-1 = I2 OR (not 43a).

Change Programmable Inputs - unknown unit

	LGC	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	43A	52A	52B
TCM	AND	O															
GRD	AND			C													
PH3	AND				C												
50-1	OR		C												O		

3. If you want I2 or I9 to enable the 50-2 function, place a "C" under I2 and I9 and an "OR" under LOGIC on the 50-2 line. This is logically 50-2 = I2 OR I9.

4. If you want I3 to enable both the GRD and 46 functions, assign the 46 Negative Sequence function to one of the lines and place a "C" under I3 on both the GRD and 46 lines.

5. If you do not want the PH3, 79M, or other functions, remove these entries from the table.

6. If the external contact controlling the 79S function is maintained closed, place a "C' under I10, a "C" under 52b, and an "AND" under LOGIC in the 79S line. This is logically 79S = I10 AND 52b.

See Appendix C, "Programming the Binary (Contact) Inputs," for the actual programming procedure.

Output Contacts

Like the binary inputs, the relay output contacts are divided into two categories: permanently programmed and user-programmable. Jumpers on the I/O boards allow you to choose whether certain programmable output contacts (1, 6, 7, 8, TRIP, and CLOSE) are normally open or normally closed.

Permanently Programmed Output Contacts

Permanently programmed output contacts include the following:

- TRIP—The trip output contact is actuated by the ENABLED OVERCURRENT protective functions. The trip output remains closed until the fault current is removed (less than 5% of the 51P and 51N pickup settings) and until the 52a and 52b contact inputs indicate that the breaker has opened.

  If Multiple Device Trip Mode is enabled, the trip output is removed 3 cycles after the fault current drops below 90% of the lowest pickup setting. Removal of the trip output is not dependent on the 52a and 52b contact inputs.

- CLOSE—The close output contact is actuated by the reclosing function. The close output is momentarily actuated for the programmable Close Failure Time setting of 18 to 999 cycles or until the 52a and 52b contact inputs indicate that the breaker has closed.

If Multiple Device Trip Mode is enabled, the open interval timer and subsequent close output are initiated only if an Overcurrent Trip Output has occurred and the current has dropped below 90% of the lowest pickup setting. Initiation of the open interval timer and the subsequent close output is not dependent on the 52a and 52b contact inputs.

- ALARM—Self-check alarm output contacts, one normally open and one normally closed, change state when control power is applied. Upon a loss of control power or a failure status of a specific self-test, the contacts return to their normal state. A contact should be connected to a local annunciator light or, if available, to a remote terminal unit.

User-Programmable Output Contacts

Up to eight (8) user-programmable output contacts are available. Only by using ECP can you program these contacts for time delay on pickup. The time delay interval is adjustable from 0 to 60 seconds in 0.01 steps. You can program the user-programmable output to indicate the conditions shown in Table 10. Table 10 lists the functions in the order they appear on the default Programmable Outputs screen.

When a User Logical Input function is mapped to a contact input, the SCADA command to control the corresponding User Logical Output has no effect; the corresponding User Logical Output can be controlled only by the contact input. If the User Logical Output function is **not** mapped to a contact input, only the SCADA command can control that User Logical Output.

Figure 19 shows the factory default settings for the output contact mapping. An "X" appears where the output is selected.

Programming Examples:

1. On the factory default settings, OUT-7 is programmed to mirror the TRIP because all of the (enabled) overcurrent protective functions are logically ORed together.

2. If you want a contact closure when the Recloser Operations Counter 1 (79CA1) or the Overcurrent Trip Counter (OCTC) alarm, you must program OUT-8 with an "OR" on the LOGIC line and an X on both the 79CA1 and OCTC lines.

See Appendix D, "Programming the Output Contacts," for the actual programming procedure.

Table 10. Programmable Output Functions

Programmable Output Functions	Description	Default Output Contact
TRIP	Same as permanently programmed contacts	---
CLOSE	Same as permanently programmed contacts	---
ALARM	Same as permanently programmed contacts	---
BFA (Breaker Failure Alarm)	Indicates that the breaker failed to trip within the programmable Trip Failure Time setting of 5 to 60 cycles. The BFA clears when the current is less than 5% of the 51P and 51N pickup settings and the 52a and 52b contact inputs indicate that the breaker has opened. If Multiple Device Trip mode is enabled, the BFA is initiated if the fault current does not drop below 90% of the lowest pickup setting within the Trip Failure Time. The BFA in MDT mode does not depend on the 52a and 52b contact inputs. (See "Breaker Failure Alarm Condition" in the Relay Functions section.)	OUT-1
TCFA	Trip Circuit Failure Alarm indicates that the trip circuit is open when the 52a and 52b contacts indicate the breaker is closed. This alarm remains until continuity is re-established. Gets input from TCM.	OUT-5
79LOA	Lockout Alarm indicates that the recloser is locked out until the breaker is manually closed	OUT-3
TCC	Tap Changer Cutout contact is activated at the first trip in the reclose sequence and returns to the normal state upon lockout or expiration of the reset time	OUT-2
PUA	Overcurrent (51/50/46/67) Pickup Alarm. This condition mirrors the Pickup LED and can be used as a fault detector OUT-alarm. The contact resets 500 milliseconds after the pickup indicator has dropped out	OUT-6
51P	Phase Time Overcurrent Trip Alarm	---
51N	Ground Time Overcurrent Trip Alarm	---
46	Negative Sequence Time Overcurrent Trip Alarm	---
50P-1	1st Phase Instantaneous Overcurrent Trip Alarm	---
50N-1	1st Ground Instantaneous Overcurrent Trip Alarm	---
50P-2	2nd Phase Instantaneous Overcurrent Trip Alarm	---
50N-2	2nd Ground Instantaneous Overcurrent Trip Alarm	---
50P-3	3rd Phase Instantaneous Overcurrent Trip Alarm	---
50N-3	3rd Ground Instantaneous Overcurrent Trip Alarm	---
67P	Positive Sequence Directional Time Overcurrent Trip Alarm	---
67N	Negative Sequence Directional Time Overcurrent Trip Alarm	---
PATA	Phase A LED Target Alarm: drops out when targets are reset.	---
PBTA	Phase B LED Target Alarm: drops out when targets are reset.	---

Table 10. Programmable Output Functions (Continued)

Programmable Output Functions	Description	Default Output Contact
PCTA	Phase C LED Target Alarm: drops out when targets are reset.	---
81S-1	1st Frequency Load Shed Trip: Dropout time is equal to the Trip Failure time.	---
81R-1	1st Freq. Load Restoration Closure: After the 81S-1 trips, dropout time is equal to the Close Failure time.	---
81O-1	1st Overfrequency Alarm: Based on 81R-1 settings, dropout time is equal to the Trip Failure time.	---
81S-2	2nd Frequency Load Shed Trip: Dropout time is equal to the Trip Failure time.	---
81R-2	2nd Freq. Load Restoration Closure: After the 81S-2 trips, dropout time is equal to the Close Failure time.	---
81O-2	2nd Overfrequency Alarm: Based on 81R-2 Settings, dropout time is equal to the Trip Failure time.	---
27-1P	Single-Phase Undervoltage Alarm: Dropout time is equal to the Trip Failure time.	---
27-3P	Three-Phase Undervoltage Alarm: Dropout time is equal to the Trip Failure time.	---
59	Single-Phase Overvoltage Alarm: Dropout time is equal to the Trip Failure time.	---
CLTA	Cold Load Timer Alarm picks up when the cold load timer has been initiated by a manual closure of the breaker and drops out when the cold load time has expired.	---
79DA	Recloser Disabled Alarm indicates that the 43a contact input is open or the Reclose Function Setting 79-1 is set to LOCKOUT. It mirrors the LED target.	---
79CA1	Recloser Operations Counter 1 Alarm	---
79CA2	Recloser Operations Counter 2 Alarm	---
OCTC	Overcurrent Trip Counter Alarm	---
KSI	KSI Summation Alarm	---
PDA	Phase Demand Current Alarm	---
NDA	Neutral Demand Current Alarm	---
VArDA	Three-Phase KiloVAr Demand Alarm	---
PVArA	Positive Three-Phase KiloVAr Alarm	---
NVArA	Negative Three-Phase KiloVAr Alarm	---
LOADA	Load Current Alarm	---

Table 10. Programmable Output Functions (Continued)

Programmable Output Functions	Description	Default Output Contact
LPFA	Low Power Factor (lagging) Alarm	—
HPFA	High Power Factor (lagging) Alarm	—
ZSC	Zone Sequence Coordination Enabled Indicator	—
50-1D	50-1 Input Disabled, 50-1 Instantaneous Function Disabled Alarm	—
50-2D	50-2 Input Disabled, 50-2 Instantaneous Function Disabled Alarm	—
PH3-D	PH3 Input Disabled, Phase Overcurrent Functions (51P/50P-1/50P-2) Disabled Alarm	—
GRD-D	GRD Input Disabled, Ground Overcurrent Functions (51N/50N-1/50N-2) Disabled Alarm	—
67P-D	67P Input Disabled, Positive Sequence Phase Directional Function Disabled Alarm	—
67N-D	67N Input Disabled, Negative Sequence Ground Directional Function Disabled Alarm	—
BFUA	Blown Fuse Alarm is given when voltage on any phase is less than seven (7) volts and no 51P or 51N overcurrent pickup condition exists. Pickup time delay is eight (8) milliseconds and dropout time delay is 500 milliseconds.	—
STCA	Settings Table Changed Alarm is activated whenever the Change Settings menu is accessed. This alarm is cleared when the targets are reset.	—
32PA	67P Pickup Alarm, Positive Sequence Directional Alarm instantaneously indicates direction of fault current with no intentional time delay on pickup and 3 cycles time delay on dropout.	—
32NA	67N Pickup Alarm, Negative Sequence Directional Alarm instantaneously indicates direction of fault current with no intentional time delay on pickup and 3 cycles time delay on dropout.	—
TRIPA	Phase A Trip with 3 cycles dropout time after the current drops below 90% of pickup	—
TRIPB	Phase B Trip with 3 cycles dropout time after the current drops below 90% of pickup	—
TRIPC	Phase C Trip with 3 cycles dropout time after the current drops below 90% of pickup	—

Table 10. Programmable Output Functions (Continued)

Programmable Output Functions	Description	Default Output Contact
51P*	Phase Time Overcurrent Seal In Alarm	---
51N*	Ground Time Overcurrent Seal In Alarm	---
46*	Negative Sequence Overcurrent Seal In Alarm	---
50P-1*	1st Phase Instantaneous Overcurrent Seal In Alarm	---
50N-1*	1st Ground Instantaneous Overcurrent Seal In Alarm	---
50P-2*	2nd Phase Instantaneous Overcurrent Seal In Alarm	---
50N-2*	2nd Ground Instantaneous Overcurrent Seal In Alarm	---
50P-3*	3rd Phase Instantaneous Overcurrent Seal In Alarm	---
50N-3*	3rd Ground Instantaneous Overcurrent Seal In Alarm	---
67P*	Positive Sequence Directional Time Overcurrent Seal In Alarm	---
67N*	Negative Sequence Directional Time Overcurrent Seal In Alarm	---
81S-1*	1st Frequency Load Shed Seal In Alarm	---
81R-1*	1st Frequency Load Restoration Seal In Alarm	---
81O-1*	1st Overfrequency Seal In Alarm	---
81S-2*	2nd Frequency Load Shed Seal In Alarm	---
81R-2*	2nd Frequency Load Restoration Seal In Alarm	---
81O-2*	2nd Overfrequency Seal In Alarm	---
27-1P*	Single-Phase Undervoltage Seal In Alarm	---
27-3P*	Three-Phase Undervoltage Seal In Alarm	---
59*	Single-Phase Overvoltage Seal In Alarm	---
TRIPA*	Phase A Seal In Alarm	---
TRIPB*	Phase B Seal In Alarm	---
TRIPC*	Phase C Seal In Alarm	---
ULO1–ULO9 (User Logical Outputs 1 through 9)	The User Logical Outputs (ULOs) allow you to operate any of the nine user-programmable OUT-contacts for a function other than those listed above. Each ULO is asserted by the corresponding User Logical Input or an INCOM/SCADA communications command. For example, User Logical Output 8 is asserted by User Logical Input 8; it cannot be asserted by any other User Logical Input. When a User Logical Input is mapped to contact inputs, the SCADA command has no effect on the corresponding User Logical Output. When assigned to an OUT contact, the ULO can also be wired to a contact input. The contact input can then be controlled by an INCOM/SCADA communications command.	---
PWatt 1	Positive Watt Alarm 1	---
PWatt 2	Positive Watt Alarm 2	---
79CA1	Recloser Counter Alarm I	---
79CA2	Recloser Counter Alarm 2	---

* Seal In Alarm

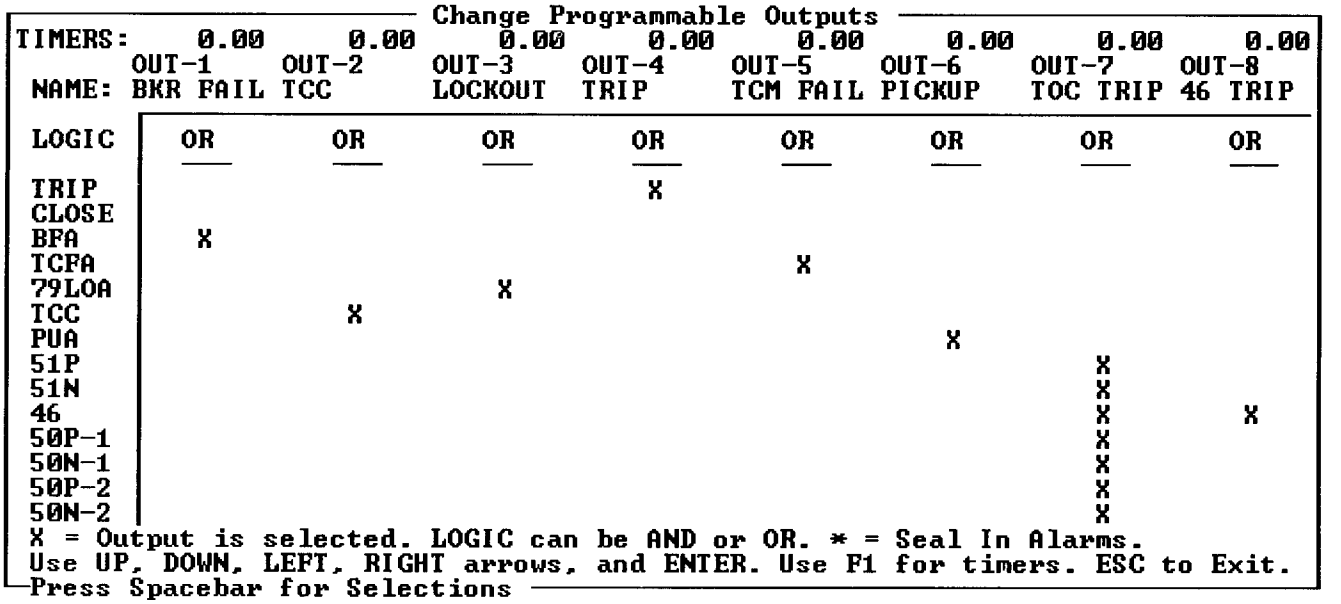
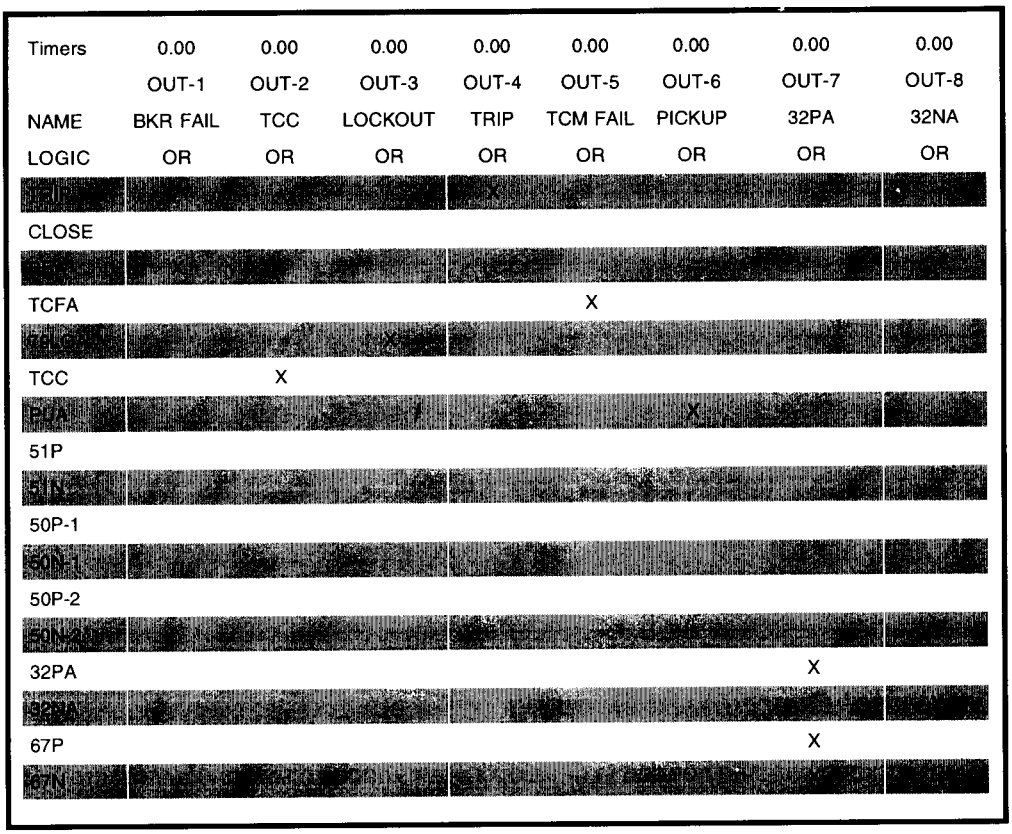


Figure 19. Programmable Outputs Default Settings

Instantaneous Directional Overcurrent Mapping

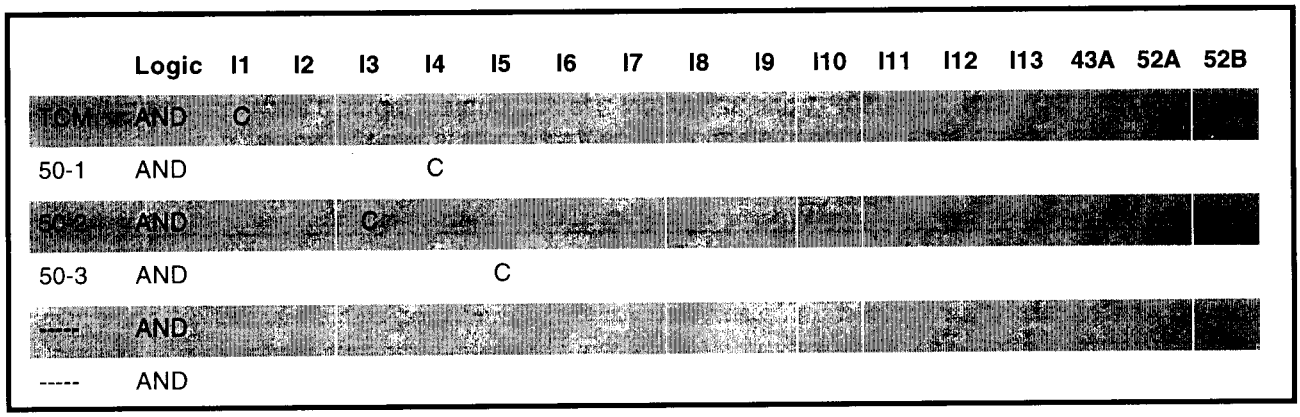
Figure 20 shows the output contact mapping needed to develop instantaneous directional overcurrent functions. Figure 21 shows the input contact mapping needed to develop instantaneous directional overcurrent functions.

To have the 32PA (phase directional pickup alarm, positive sequence) function control the 50P-1 function, wire OUT-7 to IN 4 (terminal 31 to 43 and terminal 32 to 44). To have the 32NA (phase directional pickup alarm, negative sequence) function control the 50N-2 function, wire OUT-8 to IN 3 (terminal 29 to 41 and terminal 30 to 42). For fault conditions where current reversal can occur, the 50P-1 and 50N-2 function can be set for definite time with 50 milliseconds delay. The 50P-2 and 50N-1 functions are disabled. You can use the 51P and 51N functions to back up the directional relays that are set to trip for faults in the other direction. The Trip Output Contact (terminals 17 and 18) is used to trip the breaker for 67P, 67N, 51P, 51N, 32PA/50P-1 and 32NA/50N-2 faults. Contact Inputs 3 and 4 are internally powered (wetted), and the recognition time for a change in state of the contact inputs is two (2) cycles.



Timers	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	OUT-1	OUT-2	OUT-3	OUT-4	OUT-5	OUT-6	OUT-7	OUT-8
NAME	BKR FAIL	TCC	LOCKOUT	TRIP	TCM FAIL	PICKUP	32PA	32NA
LOGIC	OR	OR	OR	OR	OR	OR	OR	OR
TRIP				X				
CLOSE								
TCFA					X			
50P-3			X					
TCC		X						
P0A						X		
51P								
51N								
50P-1								
50N-1								
50P-2								
50N-2								
32PA							X	
32NA								
67P							X	
67N								

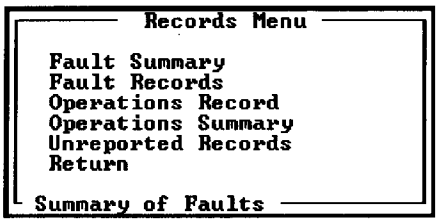
Figure 20. Instantaneous Direction Overcurrent Output Contact Mapping



	Logic	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13	43A	52A	52B
TCM FAIL	AND	C															
50-1	AND				C												
50-2	AND			C													
50-3	AND					C											
-----	AND																
-----	AND																

Figure 21. Instantaneous Direction Overcurrent Input Contact Mapping

Records Menu



The DPU-2000 provides fault and operations records. It also provides a list of records not yet reported.

Fault Summary

The DPU-2000 provides a summary of the last 32 faults. The Fault Summary includes the:

- Record number (most recent listed first as "1")
- Fault number (numbered in order occurred)
- Enabled settings table and recloser sequence number (1, 2, 3, 4, or L for lockout)
- Tripping element
- Date and time
- Phase and neutral currents (magnitude only)

Save the Fault Summary as a file by using ECP.

Fault Summary Record

Rec	No	Recl Seq	Element	Date	Time	Ia	Ib	Ic	In
1	20	Prim-L	67P	01-Nov-94	11:03:13.07	18	13	1	3
2	19	Prim-L	67P	01-Nov-94	11:03:11.76	13	18	1	1
3	18	Prim-L	67P	01-Nov-94	10:44:59.87	763	769	1	2
4	17	Prim-L	67P	01-Nov-94	10:43:59.39	1171	1182	3	2
5	16	Prim-1	46	01-Nov-94	10:42:51.92	1174	1180	1	2
6	15	Prim-1	46	01-Nov-94	10:42:20.37	1174	1182	0	1
7	14	Prim-L	46	01-Nov-94	10:41:38.72	1174	1180	3	2
8	13	Prim-L	46	01-Nov-94	10:32:30.09	1131	1138	1	1
9	12	Prim-L	51P	01-Nov-94	10:20:32.49	1094	1101	2	1
10	11	Prim-L	51P	01-Nov-94	10:18:16.95	3358	3367	1	1
11	10	Prim-L	51P	01-Nov-94	10:08:53.34	615	1324	504	771
12	9	Prim-L	51P	01-Nov-94	10:08:04.72	615	1323	504	768
13	8	Prim-L	51P	01-Nov-94	10:06:55.13	615	1275	1351	698
14	7	Prim-L	51P	01-Nov-94	10:02:41.18	1632	1656	1696	12
15	6	Prim-L	50P-2	01-Nov-94	10:01:17.32	1824	1839	1890	14
16	5	Prim-L	51P	01-Nov-94	10::48.06	1242	1285	1248	12
17	4	Prim-L	51P	01-Nov-94	09:57:14.28	808	1	207	726
18	3	Prim-L	51P	01-Nov-94	09:54:39.92	936	939	969	7

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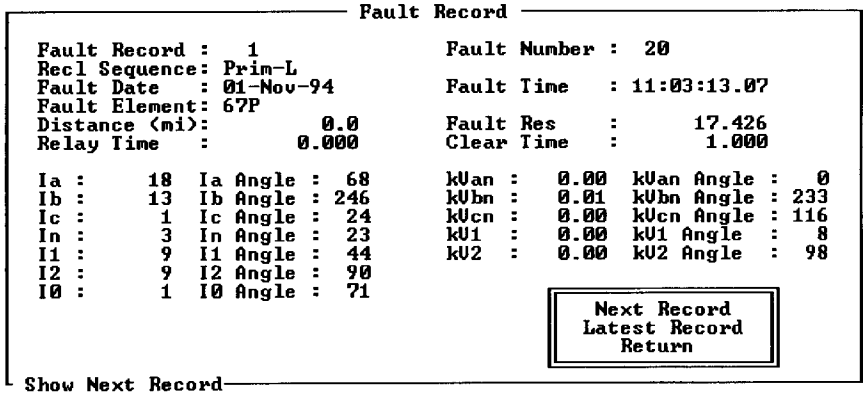
Fault Record

The Fault Record contains the last 32 faults. The Fault Record displays one fault at a time and includes the following information:

- Record number
- Fault number
- Reclose sequence number and enabled settings table
- Date and time
- Tripping element
- Apparent distance to the fault
- Fault resistance
- Relay operate time
- Breaker clearing time
- Phase and neutral currents (magnitude and angle)
- Positive, negative and zero sequence currents (magnitude and angle)
- Phase voltages (magnitude and angle)
- Positive and negative sequence voltages (magnitude and angle)



Save the Fault Record as a file by using ECP.

Operations Record

The Operations Record contains the last 128 operations. The Operations Record includes the:

- Record number (most recent listed as "1")
- Operation number (numbered sequentially in order of occurrence)
- Description of the operation
- Date and time of the operation

Operations include manual opening and closing of the breaker, overcurrent trips and reclose sequences, activation of binary inputs and output contacts, alarm conditions, editor accesses, and Functional Test Mode data. One fault can cause many operations to be logged. Save the Operations Record as a file by using ECP.

When the operation number reaches 999, the screen resets to 001.

Operations Records

Rec	No	Type	Date	Time	Value
1	286	52b Closed	01-Nov-94	11:06:17.62	0
2	285	52a Opened	01-Nov-94	11:06:17.60	0
3	284	Ext. Trip CB Stuck	01-Nov-94	11:06:17.60	0
4	283	Trip Coil Failure	01-Nov-94	11:06:07.32	0
5	282	52a Closed	01-Nov-94	11:06:07.00	0
6	281	External Close	01-Nov-94	11:06:06.99	0
7	280	52b Opened	01-Nov-94	11:06:06.98	0
8	279	46 Unit Disabled	01-Nov-94	11:05:41.74	0
9	278	TCM Input Opened	01-Nov-94	11:05:41.72	0
10	277	Wave Cap. Reset	01-Nov-94	11:05:41.72	0
11	276	46 Unit Enabled	01-Nov-94	11:05:33.54	0
12	275	Wave Cap. Init	01-Nov-94	11:05:33.53	0
13	274	TCM Input Closed	01-Nov-94	11:05:33.51	0
14	273	46 Unit Disabled	01-Nov-94	11:05:31.76	0
15	272	TCM Input Opened	01-Nov-94	11:05:31.75	0
16	271	Wave Cap. Reset	01-Nov-94	11:05:31.74	0
17	270	Editor Access	01-Nov-94	11:05:13.66	273
18	269	Editor Access	01-Nov-94	11:05:06.33	273

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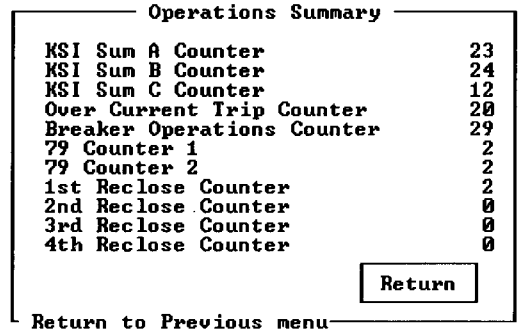
Operations Summary

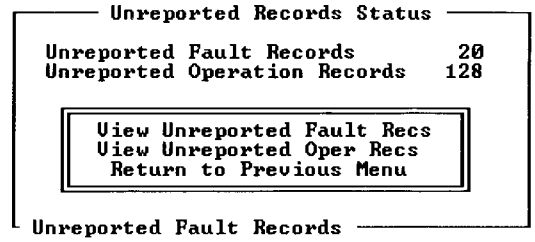


The Operations Summary includes:

- Summation of breaker interruption duty on a per-phase basis in KSI (thousand symmetrical amperes)
- Number of overcurrent trips
- Number of breaker operations (overcurrent, load current, and no load)
- Total number of reclosures (two independent counters)
- Number of successful reclosings by reclosure sequence number (1st, 2nd, 3rd, and 4th)

Save the Operations Summary as a file by using ECP.

Unreported Records



When a SCADA applications polls a relay, it sends the fault and operations information to the Unreported Fault and Operations Records. At the same time the information also appears in the Fault and Operations Records. Records remain in the Unreported Records until either SCADA downloads the information or you physically view the Unreported Records screen. When SCADA downloads the information, the entire Unreported Records is cleared, the record counter on the Unreported Records Status screen drops to 0, and access to the Unreported Records is denied until more information is reported. When you view a screen of Unreported Records, the record counter decreases by the number of records that can fit onto your screen. For example, if your computer screen can show 15 records, the record counter decreases by 15 when you exit the Unreported Records screen.

In this manner, the Unreported Records help by showing the faults and operations records that have occurred since the last time SCADA downloaded or you viewed the Unreported Records. The Fault Summary, Fault Record, Operations Summary, and Operations Record do not identify which records have been reported and which remain in the Unreported Records.

Unreported Fault Records

Rec	No	Recl Seq	Element	Date	Time	Ia	Ib	Ic	In
20	1	Prim-L	50P-1	01-Nov-94	09:51:22.90	1884	1902	1951	15
19	2	Prim-L	50P-1	01-Nov-94	09:52:22.77	1881	1903	1953	15
18	3	Prim-L	51P	01-Nov-94	09:54:39.92	936	939	969	7
17	4	Prim-L	51P	01-Nov-94	09:57:14.28	808	1	207	726
16	5	Prim-L	51P	01-Nov-94	10::48.06	1242	1285	1248	12
15	6	Prim-L	50P-2	01-Nov-94	10:01:17.32	1824	1839	1890	14
14	7	Prim-L	51P	01-Nov-94	10:02:41.18	1632	1656	1696	12
13	8	Prim-L	51P	01-Nov-94	10:06:55.13	615	1275	1351	698
12	9	Prim-L	51P	01-Nov-94	10:08:04.72	615	1323	504	768
11	10	Prim-L	51P	01-Nov-94	10:08:53.34	615	1324	504	771
10	11	Prim-L	51P	01-Nov-94	10:18:16.95	3358	3367	1	1
9	12	Prim-L	51P	01-Nov-94	10:20:32.49	1094	1101	2	1
8	13	Prim-L	46	01-Nov-94	10:32:30.09	1131	1138	1	1
7	14	Prim-L	46	01-Nov-94	10:41:38.72	1174	1180	3	2
6	15	Prim-1	46	01-Nov-94	10:42:20.37	1174	1182	0	1
5	16	Prim-1	46	01-Nov-94	10:42:51.92	1174	1180	1	2
4	17	Prim-L	67P	01-Nov-94	10:43:59.39	1171	1182	3	2
3	18	Prim-L	67P	01-Nov-94	10:44:59.87	763	769	1	2

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Unreported Operations Records

Rec	No	Type	Date	Time	Value
128	159	Phase TC Disabled	01-Nov-94	10:44:14.13	0
127	160	50P/N-1 Disabled	01-Nov-94	10:44:14.13	0
126	161	Ground TC Disabled	01-Nov-94	10:44:14.14	0
125	162	50P/N-2 Disabled	01-Nov-94	10:44:14.14	0
124	163	ALT2 Input Disabled	01-Nov-94	10:44:14.15	0
123	164	Zone Seq Disabled	01-Nov-94	10:44:14.16	0
122	165	Wave Cap. Reset	01-Nov-94	10:44:14.17	0
121	166	46 Unit Disabled	01-Nov-94	10:44:14.18	0
120	167	52b Opened	01-Nov-94	10:44:14.20	0
119	168	Recloser Disabled	01-Nov-94	10:44:14.21	0
118	169	CB State Unknown	01-Nov-94	10:44:14.46	0
117	170	Control Power Fail	01-Nov-94	10:44:14.56	0
116	171	Blown Fuse Alarm	01-Nov-94	10:44:55.95	0
115	172	67P Trip	01-Nov-94	10:44:58.87	0
114	173	52a Opened	01-Nov-94	10:44:58.93	0
113	174	52b Closed	01-Nov-94	10:44:58.95	0
112	175	CB Failed To Trip	01-Nov-94	10:44:59.87	0
111	176	81U Block	01-Nov-94	10:46:25.61	0

Next Latest Return

Show Next Page

Test Menu

```
Test I/O Menu
  Physical I/O Status
  Logical Input Status
  Logical Output Status
  Output Contacts
  Return
Show I/O Status
```

The Test menu displays options for viewing the status of input and output contacts.

Input/Output Status

The Physical I/O Status screen displays the physical, not logical, open/close status of all contact inputs and the energized/de-energized status of all output relays. Use this display to confirm continuity through each optically isolated contact input for both the opened and closed states and to confirm the status of each output relay.

I/O Contacts

52a		Open	TRIP		De-Energized
52b		Closed	CLOSE		De-Energized
43a		Closed	OUT 1	BKR FAIL	De-Energized
IN 1	TRIPCOIL	Open	OUT 2	TCC	De-Energized
IN 2	50P/N-1	Closed	OUT 3	LOCKOUT	De-Energized
IN 3	GRD TC	Closed	OUT 4	TRIP	De-Energized
IN 4	PH3 TC	Closed	OUT 5	TCM FAIL	Energized
IN 5	50P/N-3	Closed	OUT 6	PICKUP	De-Energized
IN 6	ALT1 SET	Closed	OUT 7	TOC TRIP	De-Energized
IN 7	ALT2 SET	Closed	OUT 8	46 TRIP	De-Energized
IN 8	ZSC	Closed			
IN 9	50P/N-2	Closed			
IN 10	79S	Open			
IN 11	SCC	Open			
IN 12	79M	Open			
IN 13	OPEN BKR	Open			

Hit Any Key to Return

Logical Input/Output Status

Both the logical input and output status displays are available only through the External Communications Program (ECP). The status of the logical inputs and outputs is shown in real time.

With these screens you can verify that the logic you entered in the mapping screens is working properly without physically looking at the contacts. For example, if the Trip Coil and the waveform capture input (WCI) are mapped to Input 1 as closed and with AND logic, both TCM and WCI in the logical input/output displays show as being disabled (1 turns to 0) when Input 1 closes.

Logical Input Status

The logical input status shows which functions are enabled (asserted) and disabled (not asserted) based on the contact input logic. Use this display to confirm whether or not the input logic is correct and provides the desired results. The GRD, PH3, 46, 50-1, 50-2, 50-3, 67P, 67N, and TCM input functions remain enabled (asserted) whether or not they are assigned to contact inputs in the Programmable Input Logic Map. You must assign the remaining input functions to contact inputs for the functions to be enabled (asserted).

Logical Input Status

52A	1	WCI	0	CRI	0
52B	0	ZSC	1		
43A	1	OPEN	0		
PH3	0	CLOSE	0		
GRD	0	46	1		
SCC	0	67P	1		
79S	0	67N	1		
79M	0	ULI1	0		
TCM	1	ULI2	0		
50-1	1	ULI3	0		
50-2	1	ULI4	0		
50-3	0	ULI5	0		
ALT1	1	ULI6	0		
ALT2	1	ULI7	0		
ECI1	0	ULI8	0		
ECI2	0	ULI9	0		

1 = Enabled/Asserted, 0 = Disabled/Not Asserted

Hit Any Key to Return

Logical Output Status

The logical output status shows which output functions are energized and de-energized. Use this display to confirm whether or not the functions are programmed correctly in the Primary, Alternate 1, Alternate 2, Programmable Inputs, and Alarm Settings tables. Also use it to check that the settings provide the desired results.

Logical Output Status

TRIP	0	81S-1	0	HPFA	0	TRIPC	0	81O-1*	0	LOADA	0
CLOSE	0	81R-1	0	LPFA	0	27-1P*	0	27-3P*	0	81O-1	0
ALARM	1	PATA	0	OCTC	0	46*	0	TRIPA*	0	81O-2	0
27-1P	0	PBTA	0	50-1D	0	50P-1*	0	TRIPB*	0	81S-2	0
46	0	PCTA	0	50-2D	0	50N-1*	0	TRIPC*	0	81R-2	0
50P-1	0	TCFA	0	STC	0	50P-2*	0	ULO1	0	81O-2*	0
50N-1	0	TCC	0	ZSC	1	50N-2*	0	ULO2	0	81S-2*	0
50P-2	0	79DA	1	PH3-D	1	50P-3*	0	ULO3	0	81R-2*	0
50N-2	0	PUA	0	GRD-D	1	50N-3*	0	ULO4	0	CLTA	0
50P-3	0	79LOA	0	32PA	0	51P*	0	ULO5	0		
50N-3	0	BFA	0	32NA	0	51N*	0	ULO6	0		
51P	0	PDA	0	27-3P	0	59*	0	ULO7	0		
51N	0	NDA	0	VarDA	0	67P*	0	ULO8	0		
59	0	BFUA	0	79CA2	0	67N*	0	ULO9	0		
67P	0	KSI	0	TRIPA	0	81S-1*	0	PUARA	0		
67N	0	79CA1	0	TRIPB	0	81R-1*	0	NUARA	0		

1 = Energized, 0 = Not Energized. * = Sealed in Alarms.

Hit Any Key to Return

Output Contacts (Password Protected)

Output Contacts

TRIP		No
CLOSE		No
OUT 1	BKR FAIL	No
OUT 2	TCC	No
OUT 3	LOCKOUT	No
OUT 4	TRIP	No
OUT 5	TCM FAIL	No
OUT 6	PICKUP	No
OUT 7	TOC TRIP	No
OUT 8	46 TRIP	No

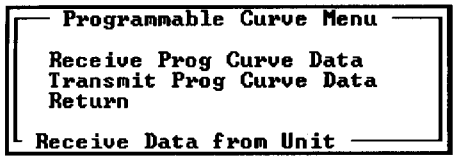
Press spacebar to toggle Yes/No.

Return

Energize Trip

By using the Output Contacts screen, you can activate all permanently programmed and user-programmed output contacts via the MMI or the ECP. The output contacts are activated for a period of time equal to the Trip Failure Time setting.

Programmable Curve Menu



By using the Programmable Curve Menu, you can send (transmit) curve data that you have created via the CurveGen program from your computer to the DPU-2000. You can also download (receive) curve data from the DPU-2000 into your computer for storage and for modification through the CurveGen program.

To transmit or receive curve data, highlight "Transmit Prog Curve Data" or "Receive Prog Curve Data" and press Enter. Type in the curve's filename (including all directories) and press Enter again. The curve data is sent or retrieved as you selected.

Miscellaneous Commands Menu

```
Miscellaneous Commands Menu

 Unit Information
 Reset Targets/Alarms
 Reset Min/Max Demand
 Seal In/User Alarms
 Return

Show Unit Information
```

The Miscellaneous Commands menu lets you:

- View information about the DPU-2000 unit (for example, catalog number, firmware version, etc.).
- Reset targets and alarms.
- Reset minimum and maximum demand values.
- Reset Seal In alarms.
- Set or reset alarms for user-programmable logic functions.

When you select Seal In/User Alarms from the Miscellaneous Commands Menu, a screen appears showing all the Seal In and user-programmed alarms. On this screen you can remotely set (user-programmed logic functions only) or reset the programmed output state of each alarm contact.

Set/Reset Output Contacts

27-1P*	0	No Change	27-3P*	0	No Change
46*	0	No Change	TRIPA*	0	No Change
50P-1*	0	No Change	TRIPB*	0	No Change
50N-1*	0	No Change	TRIPC*	0	No Change
50P-2*	0	No Change	UL01	0	No Change
50N-2*	0	No Change	UL02	0	Set
50P-3*	0	No Change	UL03	0	Set
50N-3*	0	Reset	UL04	0	No Change
51P*	0	No Change	UL05	0	No Change
51N*	0	No Change	UL06	0	No Change
59*	0	No Change	UL07	0	No Change
67P*	0	No Change	UL08	0	No Change
67N*	0	Reset	UL09	0	No Change
81S-1*	0	No Change	81O-2*	0	No Change
81R-1*	0	No Change	81S-2*	0	No Change
81O-1*	0	No Change	81R-2*	0	No Change

*=Sealed in Alarms 0=Energized 1=Not Energized

Reset All Seal Ins Set/Reset Outputs

Press Spacebar

Ratings and Tolerances

Table 11 lists the ratings and tolerances of the DPU-2000.

Table 11. Ratings and Tolerances

Parameter	Value		
Analog Input Circuits			
5 A Input Rating	16 Amps continuous and 450 Amps for 1 second		
1 A Input Rating	3 Amps continuous and 100 Amps for 1 second		
Input Burden	Less than 0.1 VA @ 5 Amps		
Voltage Rating Based on VT Connection Setting			
69/120 V Wye	160 V continuous and 480 V for 10 seconds		
120/208 V Delta	260 V continuous and 480 V for 10 seconds		
Frequency	Models available for 50 or 60 Hz		
Binary (Contact) Input Circuits			
Burden	0.44 VA for 125 VDC, 110 VDC, and 120 VAC models		
	0.16 VA for 48 VDC models		
	0.3 VA for 24 VDC models		
Control Power Requirements	125 VDC @ 0.16 Amps, range 70–150 VDC		
	120 VAC @ 0.17 Amps, range 100–140 VAC		
	110 VDC @ 0.17 Amps, range 70–140 VDC		
	48 VDC @ 0.35 Amps, range 28–58 VDC		
	24 VDC @ 0.70 Amps, range 18–30 VDC		
Output Contact Rating			
Each Contact At	120 VAC	125 VDC	250 VDC
Tripping	30 A	30 A	30 A
Continuous	5 A	5 A	5 A
Break (Inductive)	2 A	0.3 A	0.1 A

Table 11. Ratings and Tolerances (Continued)

Parameter	Value		
Operating Temperature Range	–40º C to +70º C (temperatures below –20º C may reduce LCD contrast)		
Tolerances Over Temperature Range of –30º C to +70º C			
Function	**Pickup**	**Dropout**	**Timing (Whichever is greater)**
51P/51N	± 3% of setting	98% of setting	± 7% or +/-16 milliseconds
50P/50N	± 7% of setting	98% of setting	± 7% or +/-10 milliseconds
46P/67P	± 3% of 51P setting	98% of setting	± 7% or +/-16 milliseconds
67N	± 3% of 51N setting	98% of setting	± 7% or +/-16 milliseconds
27/59/81V/79V	± 3% of setting	99.5% of setting	± 7% or +/-16 milliseconds
81	± 0.01 Hz	± 0.01 Hz	± 32 cycles
Ammeter	± 1% of 51P and 51N time overcurrent pickup setting		
Voltmeter	± 1% of the VT Connection setting		
Power Meter	± 2% of I x V, 51P pickup setting x VT Connection setting		
Frequency	± 0.01 Hertz		
Humidity	per ANSI 37.90, up to 95% without internal condensation		
Transient Immunity	3000 Volts, 1-MHz burst at 64-Hz repetition rate SWC and fast transient tests per ANSI C37.90.1 and IEC 255		
Electromagnetic Environment	10 V/m, 27 to 1000 MHz per ANSI C37.90.2		
Dielectric	2125 VDC for 1 second, all circuits to ground		

Installation

The DPU-2000 unit comes enclosed in a metal case. Follow the instructions and diagrams in this section to install the DPU-2000.

Receipt of the DPU-2000

When you receive the DPU-2000, examine it carefully for shipping damage. If any damage or loss is evident, file a claim at once with the shipping agent and promptly notify the nearest ABB sales office.

Installing the DPU-2000

Installing the DPU-2000 is a matter of cutting out a space in your panel and inserting first the case for the DPU-2000 and then the unit itself into the case. Figure 22 shows the panel cutout; Figure 23 shows the dimensions of the DPU-2000. The DPU-2000 comes in a vertical package and a horizontal package. For both orientations the dimensions are the same.

The DPU-2000 also is available in a rack-mountable design. In this case, install the case in the rack by using #10 screws.

NOTE: Dimensions are in inches [mm].

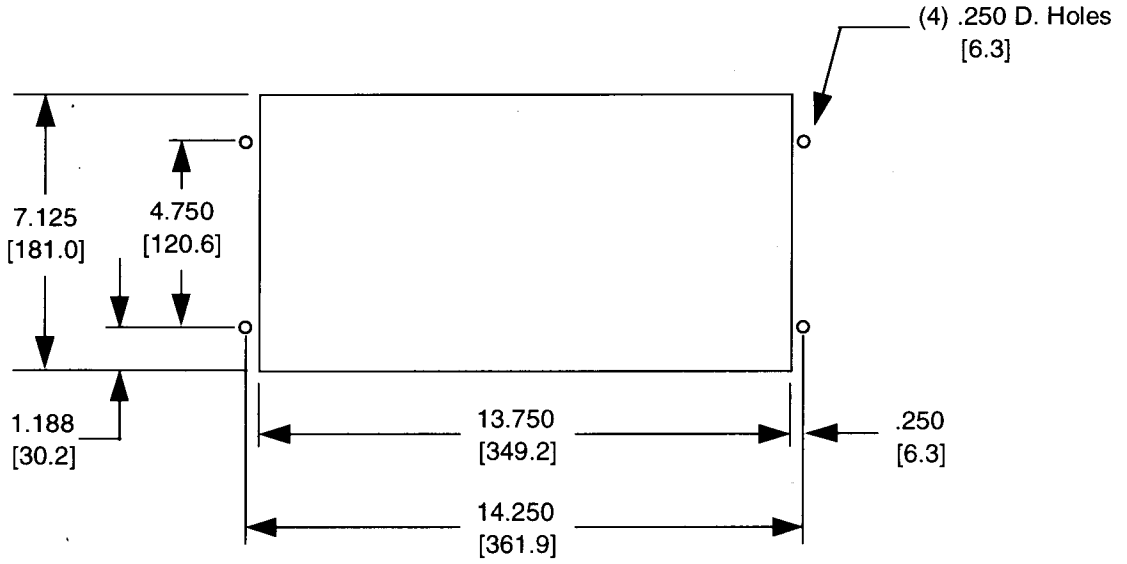


Figure 22. Panel Cutout

Rear Terminal Block Connections

Apply only rated control voltage marked on the front panel of the unit to the positive terminal and the negative terminal. Wire the ground stud on the rear of the case to the equipment ground bus with at least #10 gauge wire. Figure 24 shows the rear terminal block layout and numbers.

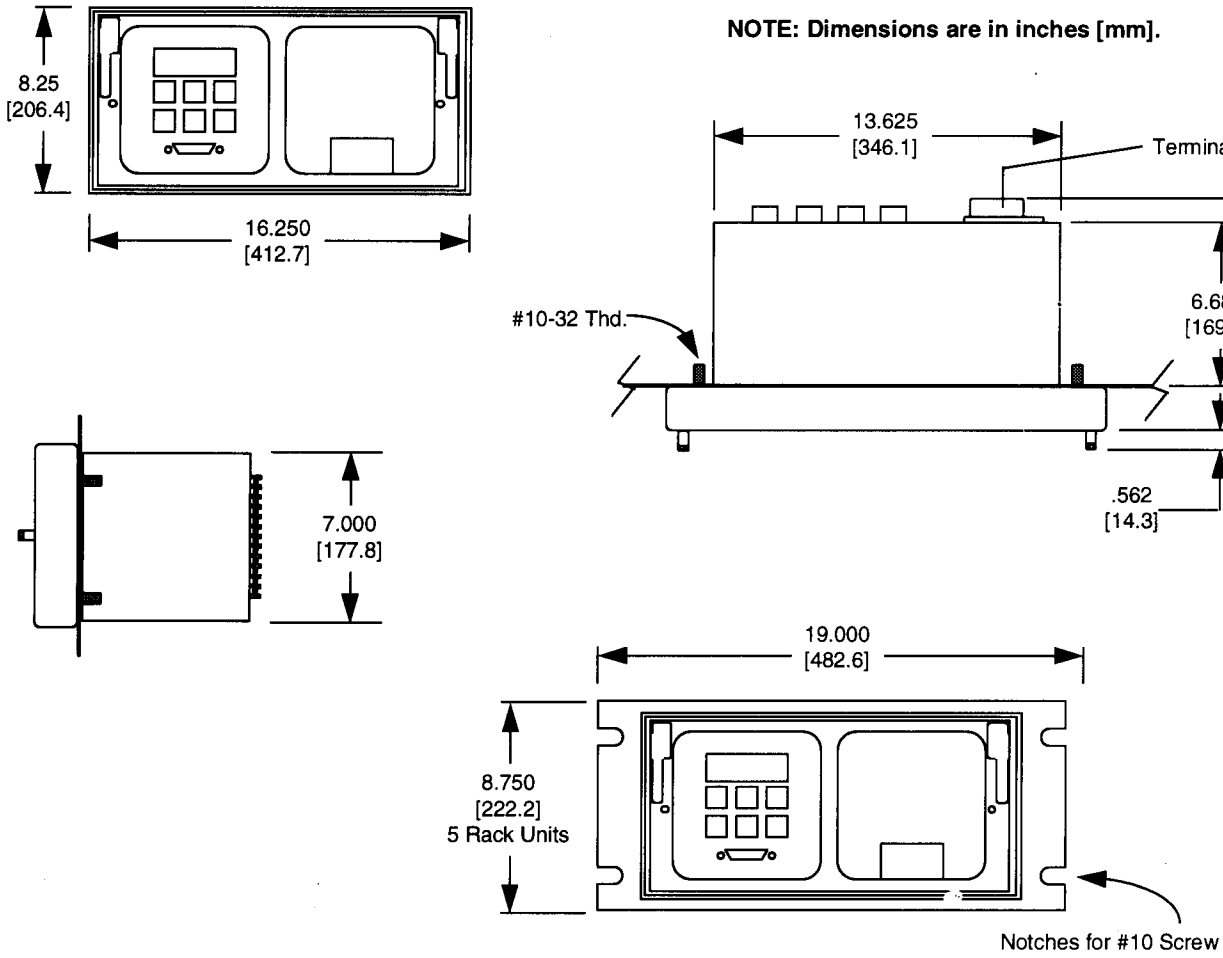


Figure 23. Dimensions

You can totally withdraw the DPU-2000 from its case. Current transformer shorting is accomplished by a direct-acting blade and spring. Sequenced disconnects eliminate the possibility of nuisance tripping during withdrawal or insertion of the unit.

Figure 25 shows typical connections for the DPU-2000. Table 12 lists the minimum required connections for a functioning system. Table 13 displays the optional connections with their default settings. The references to jumpers in Tables 12 and 13 indicate what jumper on which printed circuit board sets the connection to normally open or normally closed.

You can use inputs IN1, IN12, and IN13 as a Trip Coil Monitor (TCM) input. When the breaker is closed, a small trace current of 6 milliamperes is passed from the positive terminal through the negative terminal and the trip coil circuit. If an open circuit is detected while the breaker is closed, the Trip Circuit Failure Alarm (TCFA) contacts are actuated and a "Trip Coil Failed" message appears on the MMI display.

Inputs IN3 and IN4 are internally powered (wet) with 20 VDC and can be strapped to output contacts or control switches to enable or disable protective functions. Avoid long cable runs through substations when making connections to wetted inputs IN3 and IN4. If a long cable run is unavoidable, use other optically isolated contact inputs or interposing relays.

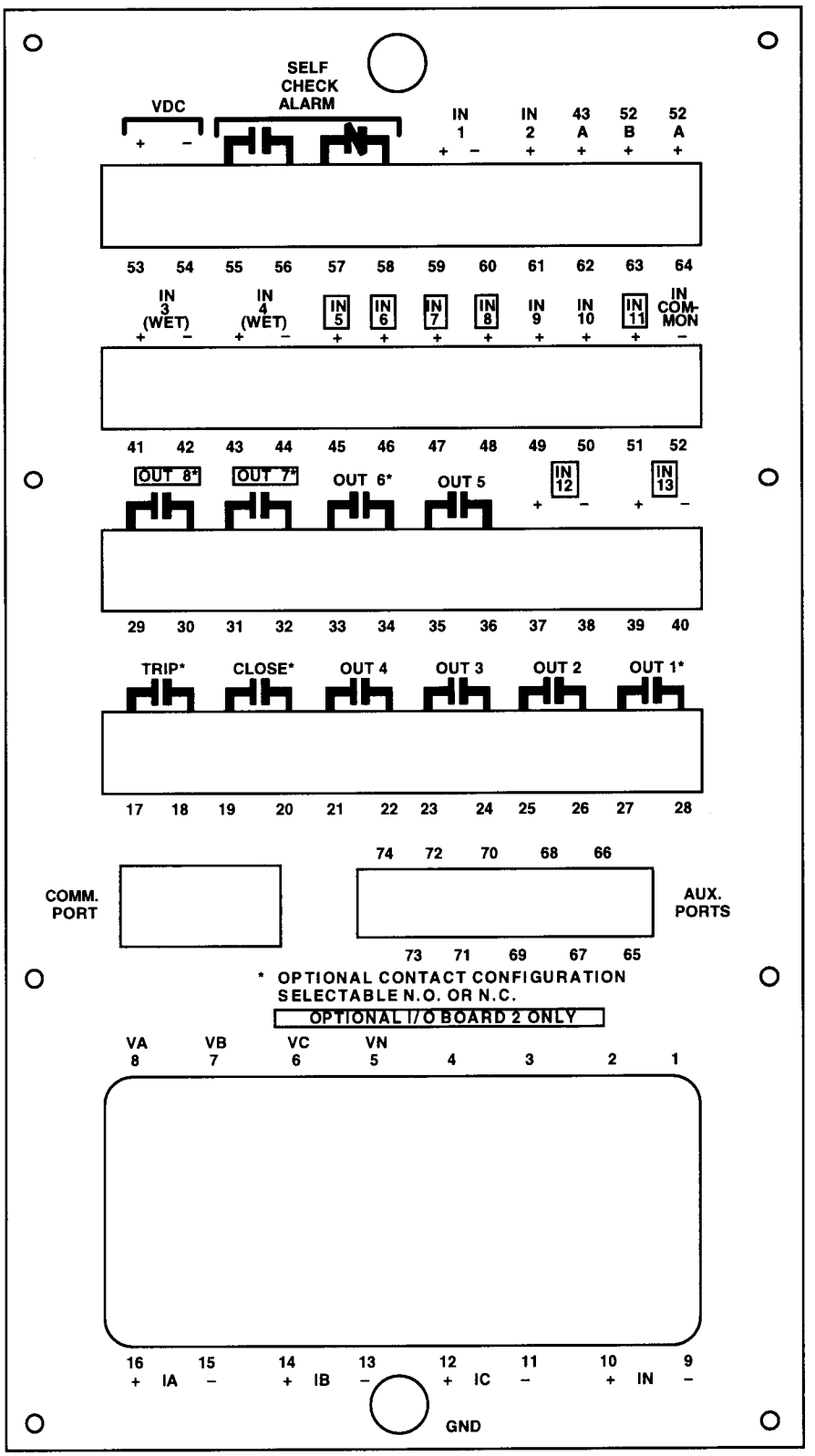


Figure 24. Rear Terminal Block (Vertical Mounting Shown)

NOTE: IN1 is shown programmed as a Trip Coil Monitoring input. Refer to the "Programmable Contacts" section for the use of additional programmable inputs and outputs.
See the "Rear Terminal Connection" figure for additional output contacts and for optional I/O Board #2 connections.

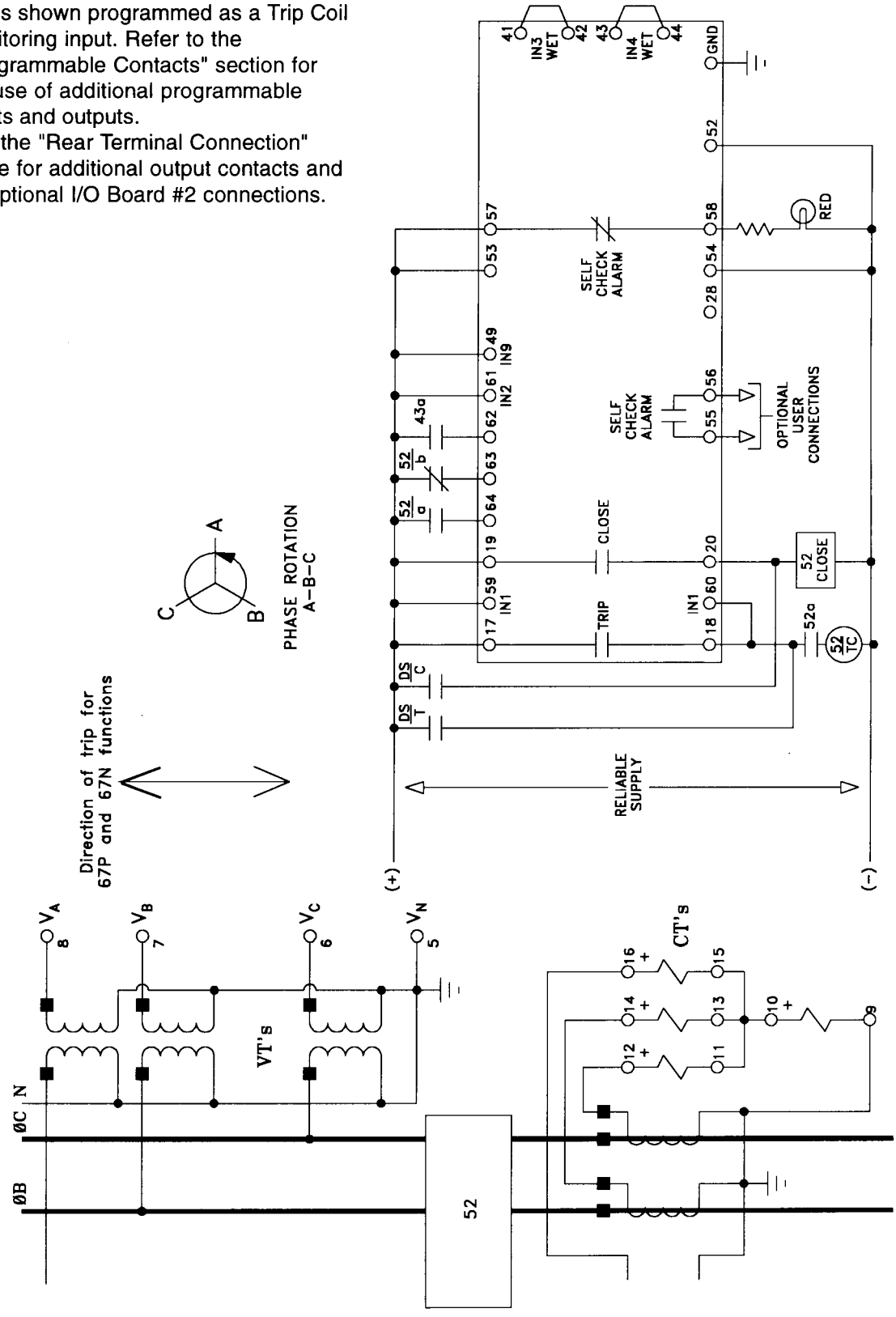


Figure 25. Typical External Connections

Table 12. Minimum Required Connections

Required Connections	Terminals
Control Voltage Input	Positive: 53; Negative: 54; Common Negative: 52
Current Inputs	IA: 16 & 15; IB: 14 & 13; IC: 12 & 11; IN: 10 & 9
52A Contact Input	64(+)
52B Contact Input	63(+)
43A Contact Input	62(+)
50P-1 and 50N-1 Contact Input	IN 2; 61(+)
GRD (51N/50N-1/50N-2) Contact Input	IN 3; (Wet); Jumper 41 to 42
PH3 (51P/50P-1/50P-2) Contact Input	IN 4; (Wet); Jumper 43 to 44
TRIP Output Contact	17 & 18 (I/O Board #3) N.O./N.C. Jumper # J1
CLOSE Output Contact	19 & 20 (I/O Board #3) N.O./N.C. Jumper # J2
SELF-CHECK ALARM Output Contacts	55 & 56 N.O.; 57 & 58 N.C. (DPU-2000 powered down)

Table 13. Optional Connections

Connection	Terminal
Voltage Inputs	VA: 8; VB: 7; VC: 6 & VN: 5
Programmable Inputs (Factory Default Assignments)	
TCM Trip Coil Monitoring	IN 1; 59(+) & 60(-)
50P-3 and 50N-3 Functions	IN 5; 45(+) (I/O Board #2)
ALT1 Alternate 1 Settings	IN 6; 46(+) (I/O Board #2)
ALT2 Alternate 2 Settings	IN 7; 47(+) (I/O Board #2)
ZSC Zone Sequence Coordination	IN 8; 48 (+) (I/O Board #2)
50P-2 and 50N-2 Functions	IN 9; 49(+)
79S Single-Shot Reclosing	IN 10; 50(+)
SCC Spring Charging Contact	IN 11; 51(+) (I/O Board #2)
79M Multishot Reclosing	IN 12; 37(+) & 38(-) (I/O Board #2)
OPEN Trip Initiated	IN 13; 39(+) & 40(-) (I/O Board #2)
Programmable Outputs (Factory Default Assignments)	
BFA Breaker Failure Alarm	OUT-1; 27 & 28 (I/O Board #3) N.O./N.C.; Jumper # J4
TCC Tap Changer Cutout	OUT-2; 25 & 26 (I/O Board #3)
79LOA Lockout Alarm	OUT-3; 23 & 24 (I/O Board #3)
TRIP	OUT-4; 21 & 22 (I/O Board #3)
TCFA Trip Circuit Failure Alarm	OUT-5; 35 & 36 (I/O Board #3)
PUA Overcurrent Pickup Alarm	OUT-6; 33 & 34 (I/O Board #3) N.O./N.C.; Jumper # J3
51P/51N/46/50-1/50-2/50-3/67P/67N	OUT-7; 31 & 32 (I/O Board #2) N.O./N.C.; Jumper # J2
46 Overcurrent Trip Alarm	OUT-8; 29 & 30 (I/O Board #2) N.O./N.C.; Jumper # J1

Serial Communications Ports

The DPU-2000 has a standard 9-pin RS-232C interface, marked "Comm. Port," on the front for serial port communications. Connect a 9-pin RS-232C cable from this port to your personal computer to have direct point-to-point communications through the ECP.

As an option, a serial port termination can be provided at the rear of the DPU-2000. This rear port, called the Auxiliary Communications port, can be a 9-pin RS-232C, 3-wire RS-485, 2-wire INCOM, IRIG-B, or SCADA Interface Unit (SIU) connection. Because the hardware termination for all these options is on every DPU-2000, you must refer to the catalog number on the front of the unit or to the software communications menu to know which rear port option is implemented. An IRIG-B input for precision real-time setting is furnished with the rear communications port catalog options 2, 3, or 4 (see "Ordering Selections" on the last page of this instruction book). The rear RS-232C port can interface with a modem and a remotely connected computer, or you can attach a computer directly to the rear RS-232C port. The RS-232C ports are configured as data terminal equipment.

The DPU-2000 supports various byte-oriented protocols. The command message structure and substructures for these protocols are available upon request. Contact the nearest ABB sales office or ABB at its Allentown, PA factory for information about the emulation of SCADA protocols via the rear Auxiliary Communications port (SIU). Use the External Communications Program (ECP) shipped with the relay to communicate with the DPU-2000 via the following protocols:

- ASCII—a protocol through the front RS-232 and rear RS-232/RS-485 ports
- SPACOM—a communications protocol interfacing to SPA-bus
- MODBUS—a byte-oriented communications protocol
- INCOM®—a two-wire, RF carrier-based communications system and protocol
- IEC870 (DNP3.0)—an RS-485-based protocol through the Auxiliary Communications port

Pin Connections

The pin connections for the various communications ports are shown in Tables 14 and 15.

Table 14. RS-232 Pin Connections

Pin Number	Pin Definition
2	Receive data—Relay receives data through this pin.
3	Transmit data—Relay transmits data through this pin.
5	Signal ground—Front port has signal ground tied to the chassis; rear port signal ground is fully isolated.

* INCOM is a registered trademark of the Westinghouse Electric Corporation.

Table 15. RS-485, INCOM, SIU, and IRIG-B Pin Connections

Pin Number	Pin Definition
65	IRIG-B Minus
66	IRIG-B Positive
67	INCOM
68	INCOM
69	+5 VDC at 100 milliamperes
70	Direction minus
71	Direction positive
72	RS-485 common/VDC return
73	RS-485 minus or SIU minus (aux. comm. port)
74	RS-485 positive or SIU positive (aux. comm. port)

RS-485 Port

The RS-485 port on the DPU-2000 has three terminating resistors inserted for point-to-point communications. For a multiple-drop RS-485 system, the devices connected between the two end devices of the network cannot have termination resistors. To allow the removal (out) or insertion (in) of the three terminating resistors, the RS-485 printed circuit board in the DPU-2000 has jumpers J6, J7, and J8.

Use an ABB RS-232 to RS-485 Converter Unit (catalog no. 245X2000) to connect a network of DPU-2000's with RS-485 ports to a modem or personal computer. An ABB RS-485 to fiber-optic converter (catalog no. 245X4000) can be used to network multiple DPU-2000s to a central communications center up to 1000 meters away. If the converter unit is not at the end of the network, you must remove its terminating resistors.

Communications Settings

Change communications settings by using the man-machine interface (MMI) on the front of the DPU-2000. When you use the MMI, the communications ports are blocked from downloading settings but can still retrieve data. Similarly, when a communications port is downloading new settings, the MMI and other communications ports are blocked from changing or downloading settings but not from retrieving data.

Use the MMI to change the baud rate. You can also use a communications port to change the baud rate for communications ports other than the one you are using. If you use a computer or modem to change the settings, the baud rate on your equipment must match that of the DPU-2000.

Set the baud rate for the front and rear ports as follows:

- Front port: 300, 1200, 2400, 4800, or 9600 (n81 or n82)
- Rear port: 300, 1200, 2400, 4800, 9600, or 19,200 (n81, n82, e81, odd81, e71, n72, or odd71).

Maintenance and Testing

Because of its continuous self-testing, the DPU-2000 requires no routine maintenance. However, you can conduct testing to verify proper operation. ABB recommends that an inoperative unit be returned to the factory for repair. If you need to return a unit, contact your local ABB sales office for a return authorization.

High-Potential Tests

High-potential tests are not recommended. If a control wire insulation test is required, completely withdraw the DPU-2000 from its case and perform only a DC high-potential test. Surge capacitors on the motherboard do not allow AC high-potential testing.

Disassembling the DPU-2000

Although field repair of a unit is not recommended, you can disassemble the DPU-2000 for replacement of any circuit board module. Follow these steps to disassemble the unit:

1. Remove the relay from its case and position it horizontally with the power supply to the left and the front panel facing you, as shown in Figure 26.

2. Remove the two screws that secure the top cover over the circuit boards in slots 1–7.

3. Remove the circuit board(s) you need to replace. The output relays are on circuit boards I/O3 and optional I/O2. Movable jumper links on these boards set the selectable output contacts to normally open or normally closed.

   CAUTION: The I/O circuit boards look identical, so be sure to return them to their proper positions.

4. Install the new circuit board(s), screw on the top cover, and place the relay back in its case.

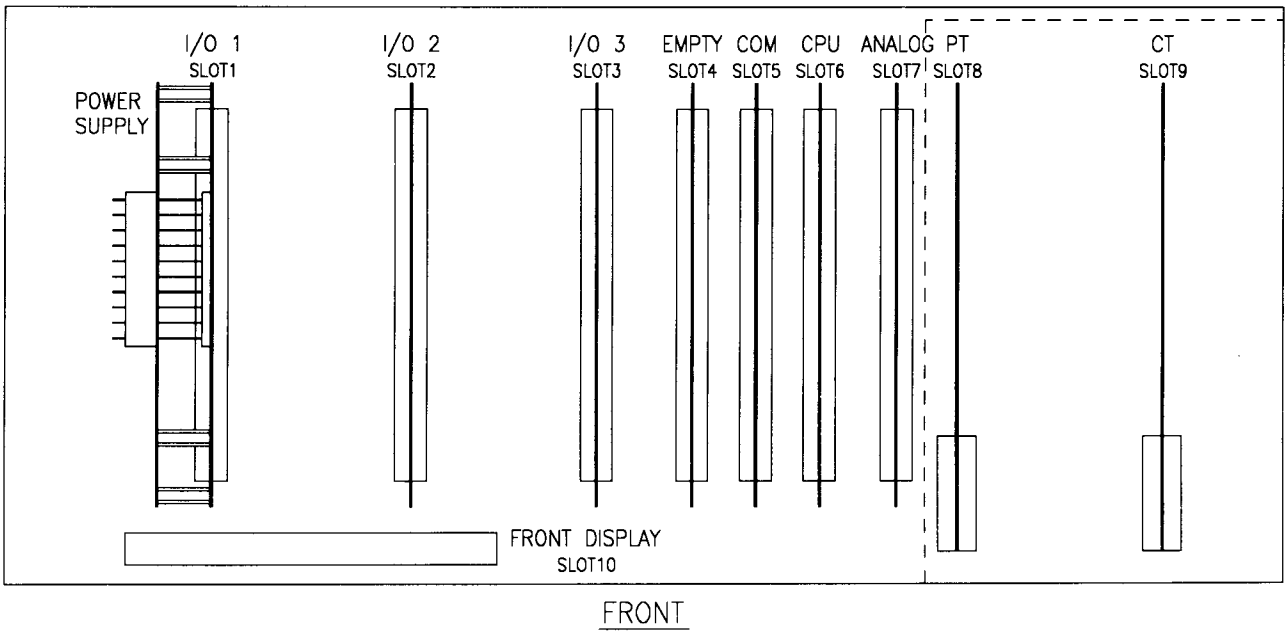


Figure 26. Circuit Card Arrangement

Installing New EPROMs

EPROMs can be replaced in the field if you take proper precautions against static discharge. The EPROMs are in sockets U8 and U10 on the CPU board of the DPU-2000. When you insert the new EPROMs, pay strict attention to the socket numbers and the EPROM key indicators (polarity markings).

Once the unit is reassembled, energize it. After three minutes, use the Self-Check Status on the man-machine interface (MMI) to check if the relay settings have changed. If they have, re-enter the correct values.

System Verification Tests

Besides continuously monitoring a Self-Check output contact, perform routine hardware tests to verify that the DPU-2000 is functioning properly. Run these tests via the MMI or via the communications port and the External Communications Program. The tests are:

1. Confirm pass/fail status of each Self-Check element by using the Test Menu.
2. Confirm continuity of current and voltage through each input sensor by using the Meter Menu.
3. Confirm continuity through each optically isolated contact input for both the opened and closed condition by using the Test Menu.
4. Verify operation of each output contact by using the Test Menu.
5. Confirm that all relay settings are correct by using the Show Settings Menu.
6. Check the Fault and Operation Records for proper sequential operation.

Testing the DPU-2000

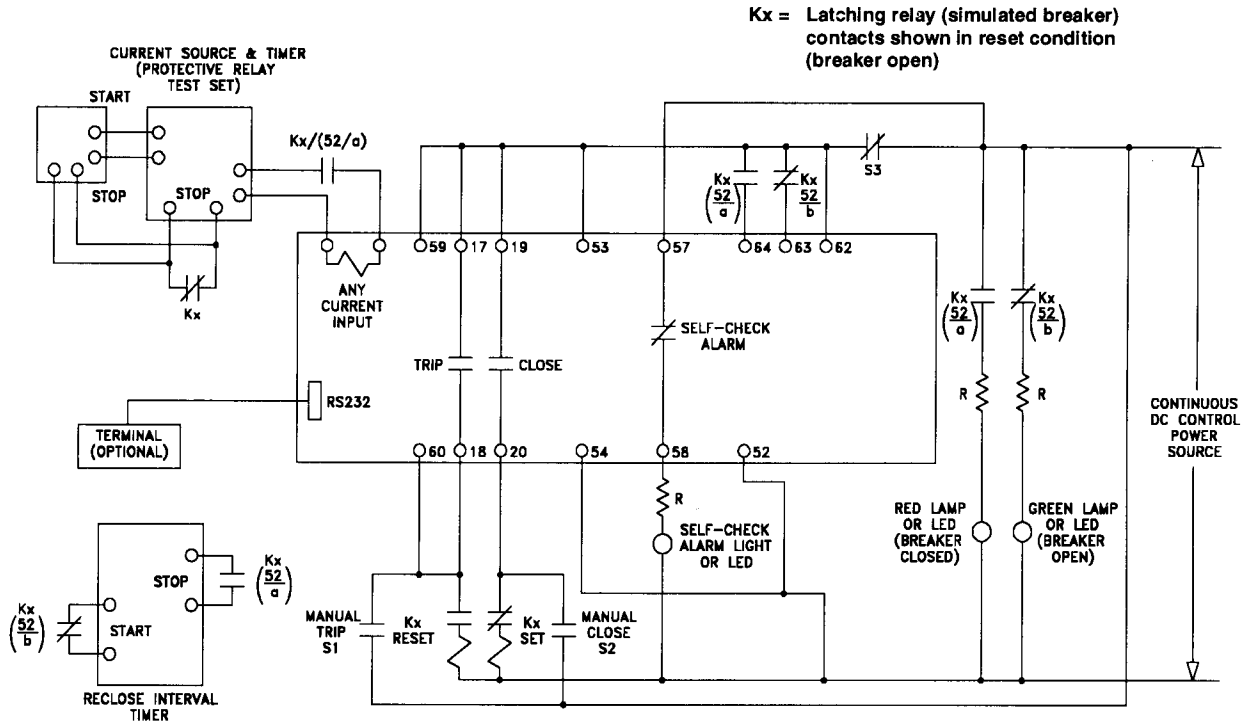
When the DPU-2000 is in service, its functions depend on the state of the breaker monitored through the 52a and 52b contacts. Therefore, to fully test the system, apply a test circuit that simulates circuit breaker operation. If this is not possible, place the DPU-2000 in the Functional Test Mode. This mode allows testing of the programmed overcurrent functions and reclose sequence (when the test current is removed) without simulating the operation of the 52a and 52b contacts.

If you do not place the unit in Functional Test Mode and do not connect the 52a and 52b contacts during testing, the DPU-2000 goes into the Breaker Failure state.

The DPU-2000 stays in the Functional Test Mode for fifteen minutes or until you exit. Use the "C" key on the MMI to reset the recloser when it is in Lockout in the Test Mode. In the Test Mode the fault sequence is written only to the Operations Record. Figure 27 shows a typical test circuit.

The tests described below confirm the relay's protective capabilities and metering accuracy. Test only those functions that will be enabled when the relay is placed into service. Testing the enabled functions ensures that the relay settings are correct for the desired application. Check the Fault and Operations Records after each test to confirm proper sequential operation of the relay logic.

NOTE: The following test procedures are written from the perspective of using the MMI. You can also use the ECP to change settings and run the test. See Appendix B, "Changing Settings," for basic instructions on using ECP.



Programmable inputs I3 (GRD), I2 (50-1), I9 (50-2) and I5 (50-3) must be wired to enable their respective functions or programmed in the Input Mapping screen such that these functions are enabled when the inputs are open (O = Enable-Opened).

Figure 27. Typical Test Circuit

Use a single-phase current test set to confirm continuity through the four current input sensors and the proper operation/settings of 51P, 51N, 50P-1, 50N-1, 50P-2, 50N-2, 50P-3, 50N-2, and 46 functions. Test the phase functions by injecting current into the Ia and Ib input sensors. Test the neutral (ground) functions by injecting current into the Ic and In input sensors. Test the 46 function by injecting current into one phase input sensor (since Ia = $3I_1$ = $3I_2$ = $3I_0$ when Ib = Ic = 0).

You must have a three-phase current and voltage test set to fully test the proper operation/settings of the 67P and 67N protective functions, the fault locator, and the accuracy of the watts, VARs, and power factor metering capabilities of the DPU-2000.

Use a single-phase voltage test set to confirm the proper operation/settings of the 27, 59, 79V, and 81 (Vcn) functions. You must have 3-phase current sources, 3-phase voltage sources, and a digital timer. Properly ground all equipment used in testing.

If the relay detects a system failure during testing, the MMI registers it, the red status light turns on, and a contact output alarms.

Tables 16 and 17 show the factory default settings on which the tests are based. These are the same default settings shown in Tables 4 and 5.

Table 16. Factory Defaults for Testing: Primary Settings

Function	Setting
51P	Ext Inv
51P Pickup A	6.0
51P Time Dial	5.0
50P-1	Standard
50P-1 PickupX	3.0
50P-2	Disable
50P-3	Disable
46	Disable
51N	Ext Inv
51N Pickup A	6.0
51N Time Dial	5.0
50N-1	Standard
50N-1 PickupX	3.0
50N-2	Disable
50N-3	Disable
79 Reset Time	10
79-1 Functions	<E>50P-1, 51N, and 50N-1 Enable
79-1 Open Time	LOCK
79 Cutout Time	Disable
Cold Load Time	Disable
2Phase 50P	Disable
67P	Disable
67N	Disable
81 Select	Disable
27 Select	Disable
79V	Disable
59 Select	Disable

Table 17. Factory Defaults for Testing: Configuration Settings

Function	Setting
Phase CT ratio	100
Neutral CT ratio	100
VT Ratio	100
VT Connection	120 wye
Positive Sequence X/mi	.001
Positive Sequence R/mi	.001
Zero Sequence X/mi	.001
Zero Sequence R/mi	.001
Line Length Miles	0.1
Trip Fail Time	18
Close Fail Time	18
Phase Rotation	ABC
Protection Mode	Fund
Reset Mode	Instant
ALT1	Enable
ALT2	Enable
MDT Mode	Disable
Zone Seq Coordination	Disable
Target Mode	Last
Local Edit	Enable
Meter Mode	kWHr
LCD Light	On
Unit Address	001
Unit ID	DPU-2000
Demand Meter Constant	15
Baud Front	9600-N81
Baud Rear	9600-N81
LCD Contrast	16
Password	[ ] 4 spaces

Verify Self-Checking Test Via MMI

Follow these steps to verify the pass/fail status of each self-check element on the DPU-2000:

1. Connect the proper control power to the unit. Wait for initialization to be complete. The green STATUS LED should be lit, and the red RECLOSER DISABLED LED should also be lit if the recloser is disabled by the 43A contact input or the enabled settings table.
2. From the MMI, press "E" to get the Main Menu.
3. Scroll down to "TEST" and press "E."
4. The first choice is "Self Test," so press "E." All elements under the "Self Test" should read "pass."
5. Press "C" to return to the meter display.

Metering Test

1. Apply 3-phase voltages and currents as shown in Figure 28. The values for these are:
   - Ia = 3.0 A ∠ 0º
   - Ib = 3.0 A ∠ 240º
   - Ic = 3.0 A ∠ 120º
   - Van = 120.0 V ∠ 0º
   - Vbn = 120.0 V ∠ 240º
   - Vcn = 120.0 V ∠ 120º

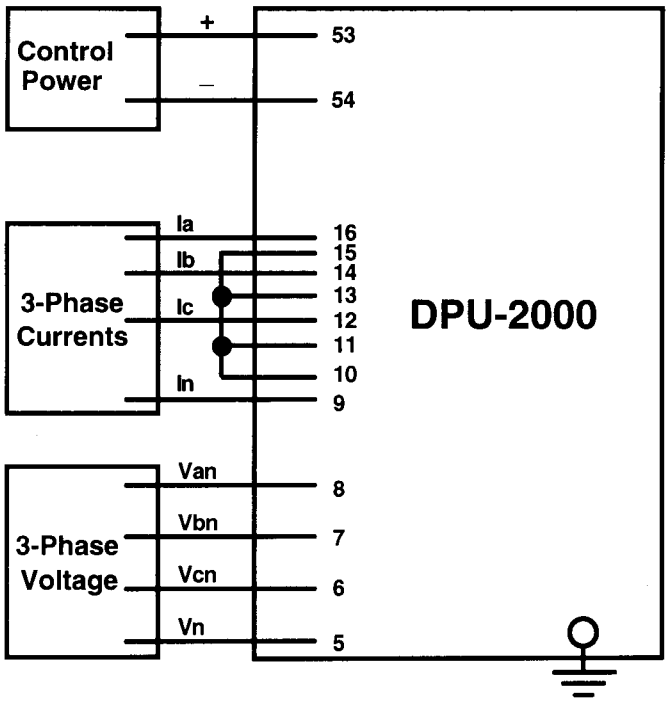


Figure 28. Metering Test

2. From the MMI main menu, press "E" twice to gain access to the metering menu.

3. Press "E" on the "Load" choice. The following should be within the ranges listed:

• Ia = 300.0	0º	(±6 A; the ±6A was calculated by taking 1% of the product of the pickup setting [6.0 A] x the Phase CT Ratio [100]: .01 x [6.0 x 100] = 6.)
• Ib = 300.0	240º	(±6 A)
• Ic = 300.0	120º	(±6 A)
• In = 0.0		(±6 A)
• kVan = 12.0	0º	(±0.12 kV)
• kVbn = 12.0	240º	(±0.12 kV)
• kVcn = 12.0	120º	(±0.12 kV)
• kW-A = 3600		(±144 kW)
• kW-B = 3600		(±144 kW)
• kW-C = 3600		(±144 kW)
• kW-3P = 10800		(±432 kW)
• kVAR-A = 0		(±144 kW)
• kVAR-B = 0		(±144 kW)
• kVAR-C = 0		(±144 kW)
• kVAR-3P = 0		(±432 kW)
• I_0 = 0		(±6 A)
• I_1 = 300	0º	(±6 A)
• I_2 = 0	0º	(±6 A)
• kV_1 = 12.00	0º	(±0.12 kV)
• kV_2 = 0	0º	(±0.12 kV)
• PF = 1.00		Lagging or Leading
• Freq = 60.00		(± 0.01 Hz)

NOTE: You may have to allow additional tolerance to account for any test source inaccuracy.

4. Apply 3.0 A to Neutral. Read the current from the metering menu as above. The current In should be 300.0 ±6 A.

Pickup Current—Time Overcurrent

Follow these steps to check the time overcurrent of the pickup current.

1. Connect the DPU-2000 as shown in Figure 29.

2. Apply 5.5 A, gradually increasing the current until the PICKUP LED just lights. This should be within ±3% (the tolerance range from Table 11) of the pickup (from Table 16), or ±0.18 A (±18.0 A primary). This confirms the continuity and accuracy of phases A and B.

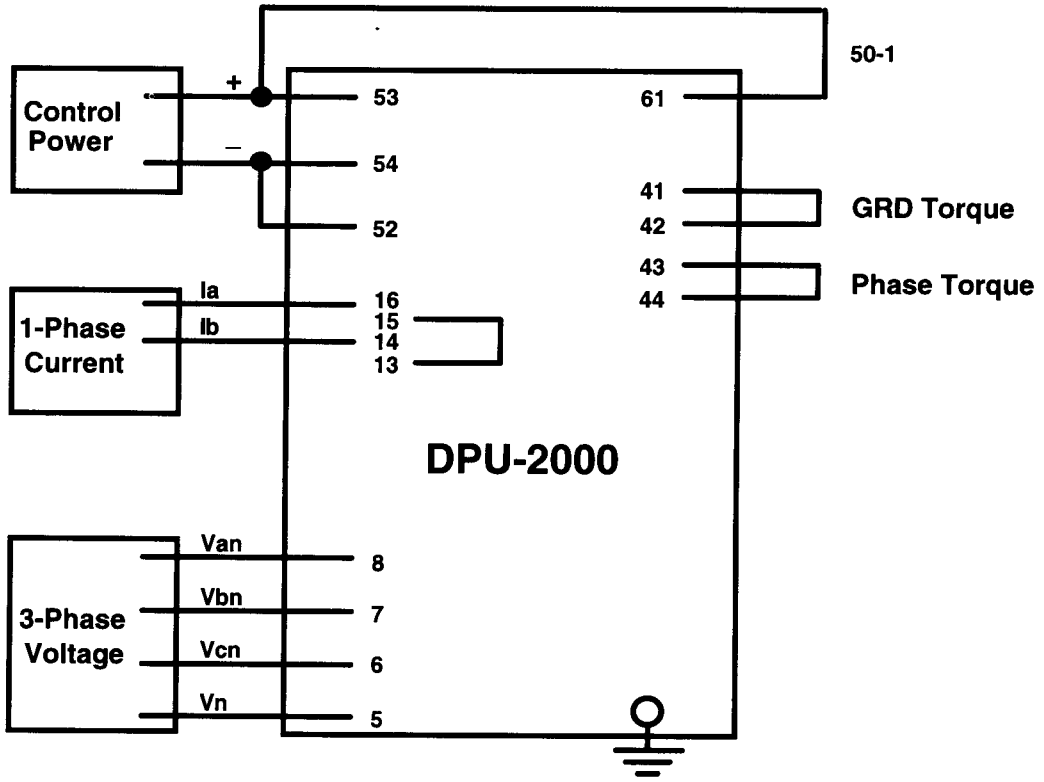


Figure 29. Test Circuit for Time Overcurrent, 50P-1, 2-Phase 50P, and 46 Functions

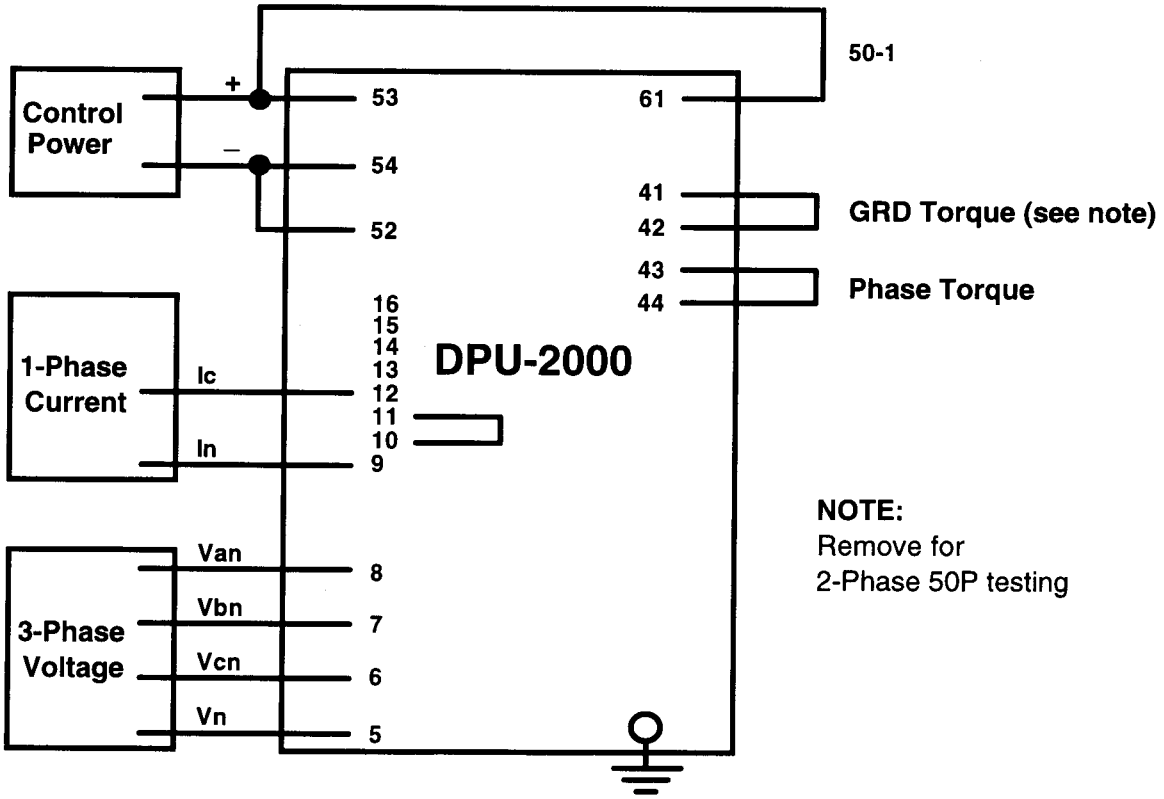


Figure 30. Test Circuit for 51N, 50N-1, and 2-Phase 50P Functions

4. Connect the DPU-2000 as shown in Figure 30. Repeat Step 2 to confirm the continuity and accuracy of phases C and N.

5. To confirm the ground pickup, lower the 51N setting to 5.0 A. To do this:

   a. Access the settings menu by pressing "E" on the MMI.

   b. Scroll to "Settings."

   c. Hit "E" and scroll to "Change Settings."

   d. Hit "E" twice to access "Prim Settings."

   e. Enter the password (four spaces for factory default) and press "E."

   f. Scroll to "51N Pickup A" and Press "E."

   g. Press the left arrow key until 5.0 is displayed; hit "E" to accept this value.

   h. Press "C" twice to get out of settings change.

   i. Press right or left arrow key to respond "YES" to the "Save Settings" prompt. Press "E."

   j. Press "C" until the present metering values are displayed.

6. Apply 4.5 A to the DPU-2000 as shown in Figure 30. Gradually increase the current until the PICKUP LED just lights. This should be within ±3%c of the pickup (5 A). This confirms the ground pickup.

7. Decrease the input current to 0 and reset targets, if necessary, by pressing "C."

Pickup Current—Instantaneous Overcurrent

Follow these steps to test the instantaneous overcurrent of the pickup current:

1. To test the 50P-1 phase instantaneous unit:

   a. Connect the DPU-2000 as shown in Figure 29.

   b. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

   c. Gradually increase the current until the LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). This confirms phases A & B. Targets that should be lit are A, B, and INSTANTANEOUS.

   d. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

2. To test the 50N-1 ground instantaneous unit:

   a. Disable the 50P-1 function via the Change Settings menu.

   b. Connect the DPU-2000 as shown in Figure 30.

   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). Targets N and INSTANTANEOUS should be lit.

e. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

3. To test the 50P-2 phase instantaneous unit:

a. Enable the 50P-2 function and disable the 50N-1 function via the Change Settings menu.

b. Connect the DPU-2000 as shown in Figure 31.

c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

d. Gradually increase the current until the instantaneous trip LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). Targets C and INSTANTANEOUS should be lit.

e. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

4. To test the 50N-2 ground instantaneous unit

a. Enable the 50N-2 function and disable the 50P-2 function via the Change Settings menu.

b. Connect the DPU-2000 as shown in Figure 31.

c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). Targets N and INSTANTANEOUS should be lit.

e. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

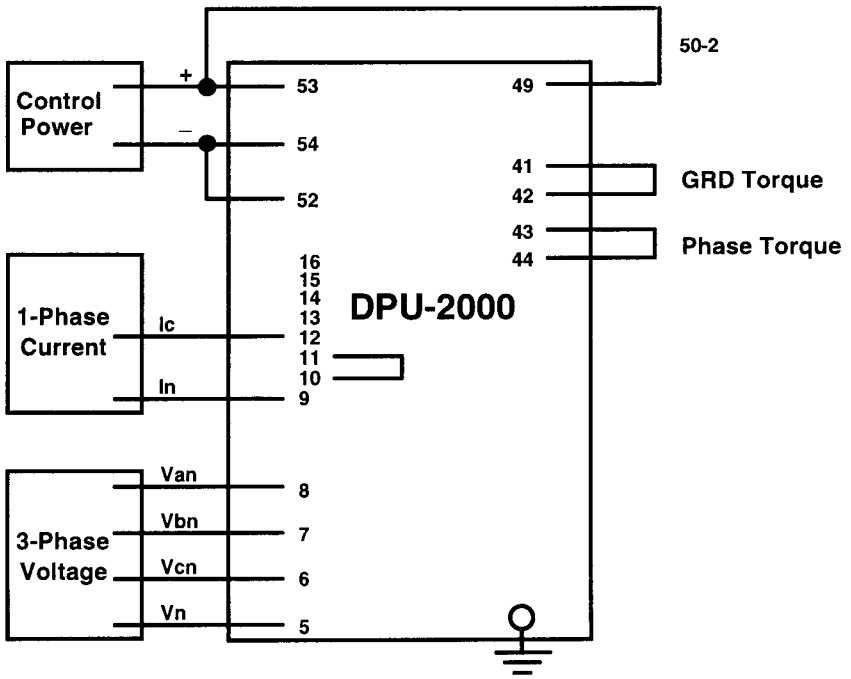


Figure 31. Test Circuit for 50P-2 and 50N-2 Functions

5. To test the 50P-3 phase instantaneous unit:

   a. Enable the 50P-3 function and disable the 50N-2 function via the Change Settings menu.

   b. Connect the DPU-2000 as shown in Figure 32.

   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). Targets C and INSTANTANEOUS should be lit.

   e. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

6. To test the 50N-3 ground instantaneous unit:

   a. Enable the 50N-3 function and disable the 50P-3 function via the Change Settings menu.

   b. Connect the DPU-2000 as shown in Figure 32.

   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

   d. Gradually increase the current until the INSTANTANEOUS LED lights. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). Targets N and INSTANTANEOUS should be lit.

   e. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

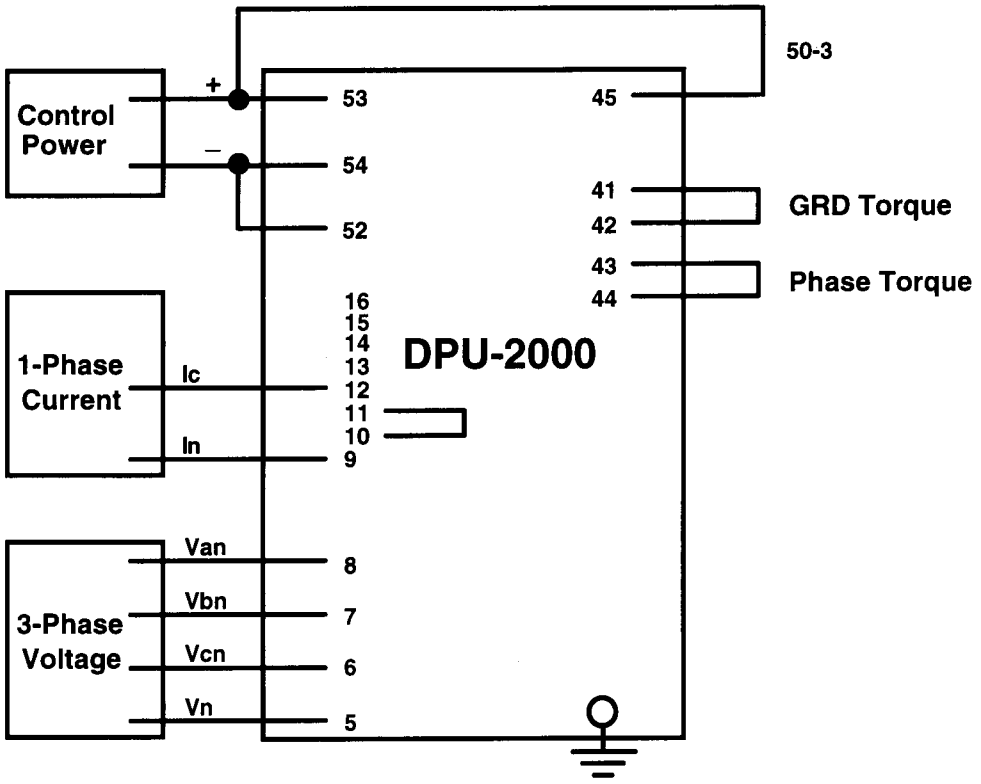


Figure 32. Test Circuit for 50P-3 and 50N-3 Functions

7. To test the 2-Phase 50P Trip function:

   a. Enable the 2-Phase 50P function via the Change Settings.

   b. Connect the test set as shown in Figure 29.

   c. Apply approximately 85% of the instantaneous pickup current (18 A from Table 16) to the relay, or 15.3 A.

   d. Gradually increase the current until the 50P-1 relay trips. This should be ±7% (from Table 11) of the setting, or ±1.26 A (±126 A primary). This confirms phases A & B. Targets A, B, and INSTANTANEOUS should be lit.

   d. Decrease the input current to 0 and reset targets by pressing "C" on the MMI.

8. Connect the DPU-2000 as shown in Figure 30, removing the ground contact input jumper from 41 and 42. Apply the fault as for C to N, and confirm that the relay does not trip on 50P-1.

Timing Tests

Follow these steps to test the timing of the DPU-2000:

1. Connect the DPU-2000 as shown in Figure 33.

2. Apply a fault current of 12 A to the relay. This current is 2x the default pickup current of 6.0 A. The relay should trip between 14.5 and 16.7 seconds (derived from the Extremely Inverse curve, Figure 34, by using the default values in Table 14).

3. Apply a fault current of 24 A to the relay (4x the default pickup current). The relay should trip between 3.0 and 3.5 seconds.

4. Apply a fault current of 36 A to the relay (6x the default pickup current). The relay should trip between 1.4 and 1.6 seconds.

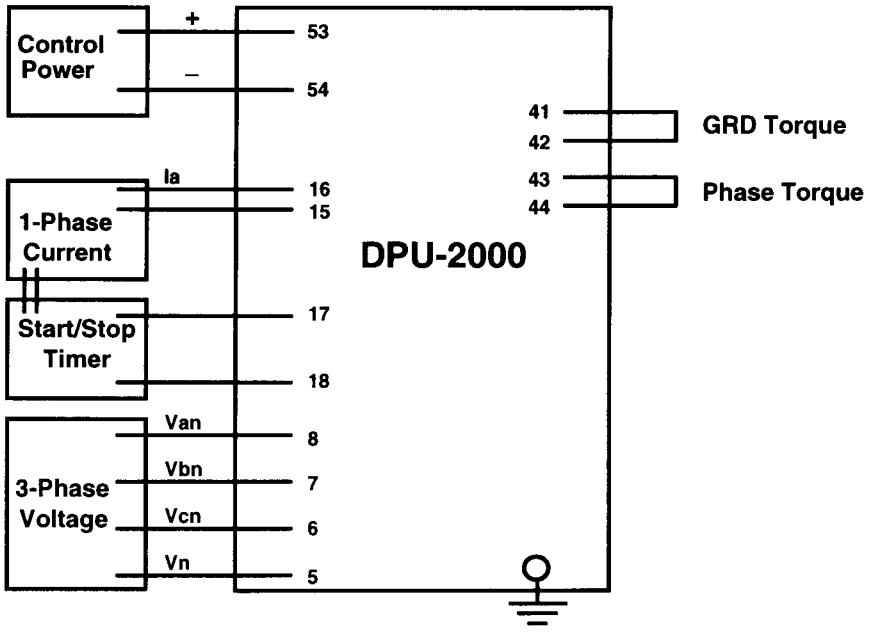


Figure 33. Test Circuit for Timing and Recloser Lockout

Directional Testing

Follow these steps to test the directional functions:

1. To test the 67P protective function, enable the directional functions:

   a. Press the "E" key.

   b. Scroll to "Settings" and press "E."

   c. Scroll to "Change Settings" and press "E."

   d. Scroll to "Prim Settings" and press "E."

   e. Enter password (four spaces for default) and press "E."

   f. Scroll down to "67P" and press "E."

   g. Hit right arrow key to change to "Enable" and press "E."

   h. Press "C" twice.

   i Press right arrow key to "Yes" and press "E" to save settings.

   j. The factory default settings are as follows:

   - 67P Curve Extremely inv
   - 67P Pickup 1.0
   - 67P Time Dial 5
   - Torque Angle 0

   k. Apply the following test values as shown in Figure 34:

   - Ia = 5 A ∠ 0º
   - Ib = 0 A
   - Ic = 0 A
   - In = 5 A ∠ 0º
   - Van = 10 V ∠ 0º
   - Vbn = 120 V ∠ 240º
   - Vcn = 120 V ∠ 120º

   l. The relay should trip on 67P directional overcurrent between 1.95 and 2.25 seconds (from the Extremely Inverse curve, Figure 35). This is indicated by a lit phase target (e.g., A) with no other targets lighting. Check the fault records to confirm the 67P trip.

   m. Reset the targets by pressing "C" on the MMI.

   n. Change the Ia and In angles to 180º.

   o. The relay should not trip on the 67P directional overcurrent.

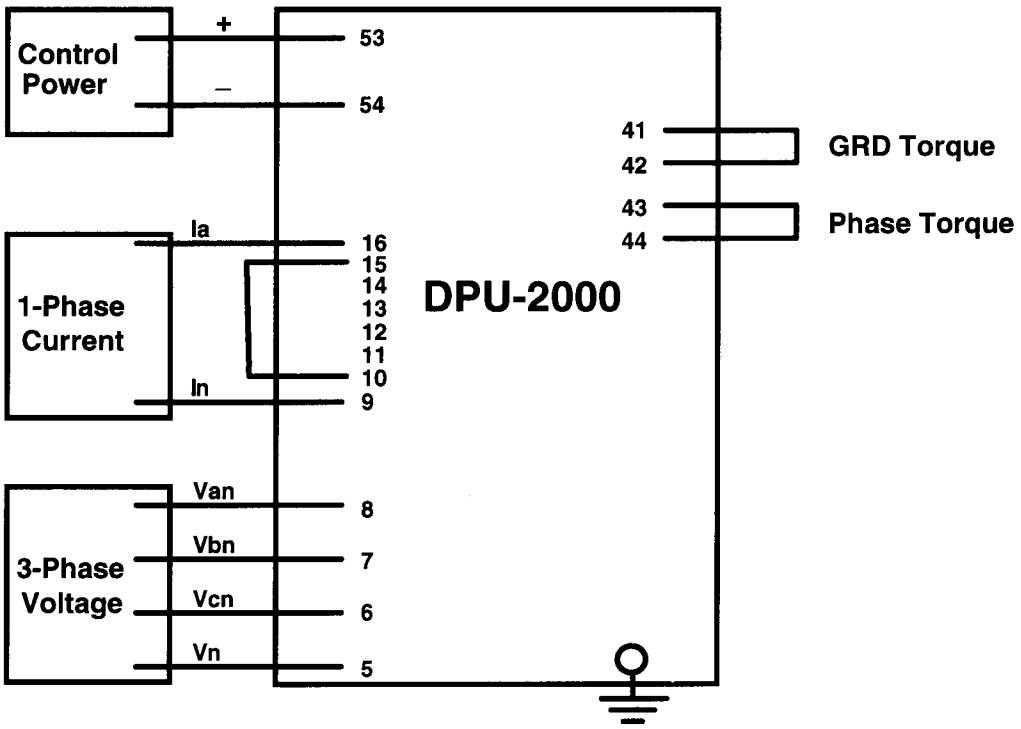


Figure 34. Test Circuit for 67P and 67N Functions

2. To test the 67N, disable the 67P function and enable the 67N function.
   a. Press the "E" key.
   b. Scroll to "Settings" and press "E."
   c. Scroll to "Change Settings" and press "E."
   d. Scroll to "Prim Settings" and press "E."
   e. Enter the password (four spaces for default) and press "E."
   f. Scroll down to "67N" and press "E."
   g. Hit right arrow key to change to "Enable" and press "E."
   h. Press "C" twice.
   i. Press right arrow key to "Yes" and press "E" to save settings.

j. The factory default settings are as follows:

- 67N Curve Extremely inv
- 67N Pickup 1.0
- 67N Time Dial 10
- Torque Angle 180

k. Apply the following test values as shown in Figure 33:

- Ia = 5 A ∠ 0º
- Ib = 0 A
- Ic = 0 A
- In = 5 A ∠ 0º
- Van = 10 V ∠ 0º
- Vbn = 120 V ∠ 240º
- Vcn = 120 V ∠ 120º

l. The relay should trip on 67N directional overcurrent between 0.28 and 0.32 seconds (from the Extremely Inverse curve, Figure 34). This is indicated by the ØA LED lighting with no other targets lit. Check the fault records to confirm the 67N trip.

m. Reset the targets by pressing "C" on the MMI.

n. Change the Ia and In angles to 180º.

o. The relay should not trip on 67N directional overcurrent.

Negative Sequence Testing

Follow these steps to test the 46 function:

1. Set the 46 function according to the following values, similar to how the 67P and 67N were enabled:

- Curve: Extremely Inverse
- Pickup: 3.4 (This is 58% of the 51P setting of 6 A)
- Time Dial: 5.0

2. Apply the following currents as shown in Figure 28:

- Ia = 12 A ∠ 0º
- Ib = 12 A ∠ 180º
- Ic = 0
- In = 0

3. The relay should trip between 14.3 and 16.3 seconds (from the Extremely Inverse curve, Figure 34), and only

the NEGATIVE SEQUENCE LED should light.

Reclosing Sequence Test

Follow these steps to test the reclosing sequence:

1. Change the Primary Settings.
   a. Press the "E" key.
   b. Scroll to "Settings" and press "E."
   c. Scroll to "Change Settings" and press "E."
   d. Scroll to "Prim Settings" and press "E."
   e. Enter the password (four spaces for default) and press "E."
   f. Scroll down to each of the following and change the value as necessary by using the right arrow key.
      - 79-1 Open T: 5
      - 79-2 Functions: <E>
      - 79-2 Open T: 10
      - 79-3 Functions <E>
      - 79-3 Open T: 15
      - 79-4 Functions: <E>
      - 79-4 Open T: LOCK
   g. Press "E" when the value you want is displayed.
   h. Press "C" twice.
   i. Press the right arrow key to "Yes" and press "E" to save settings.
2. Set the relay to Functional Test Mode. This eliminates the need for a breaker.
   a. Press the "E" key to access the main menu.
   b. Scroll to "Test" and press "E."
   c. Scroll to "Func. Test Mode" and press "E."
   d. Enter the password (four spaces for default) and press "E."
   e. Press right arrow key to "Yes" and press "E."
   f. The DPU-2000 will remain in the Functional Test Mode for 15 minutes, unless reset.
3. Test the Recloser Lockout function.
   a. Connect the DPU-2000 as shown in Figure 33.

b. Apply a fault current of 12 A to the relay. Once the relay has tripped, it remains open according to the settings in Step 1f; then the relay should reclose.

c. Before the reset time of the relay has expired, apply a subsequent fault current. The relay will trip and reclose.

d. Continue to apply the fault until Recloser Lockout occurs. This should be on the fourth trip.

Frequency Tests

1. Enable the 81 function through the menus:

   a. Press the "E" key.

   b. Scroll to "Settings" and press "E."

   c. Scroll to "Change Settings" and press "E."

   d. Scroll to "Prim Settings" and press "E."

   e. Enter the password (four spaces for default) and press "E."

   f. Scroll down to 81 Disable and press "E."

   g. Press the right arrow key until "81S Enable" appears and press "E."

   h. Press "C." Note that additional settings for 81 have been added.

   i. Scroll to the following values and press "E." Change the value as necessary by pressing the right arrow key. When the value you want is displayed, press "E."

      - 81 Select 81S Enable
      - 81S Pickup 60.02 Hz
      - 81S T. Delay 0.10 seconds
      - 81V Block 40 volts

   j. After changing the values for 81, press "C" again.

   k. Use the right arrow key to select "Yes" and press "E" to save the new settings.

2. Verify the underfrequency condition by monitoring the FREQUENCY target LED on the front panel of the DPU-2000.

3. Program an output contact by using the External Communications Program to detect the underfrequency trip conditions.

4. Apply the following voltages to the relay at 60 Hertz. The relay should trip for an underfrequency condition on phase Vcn.

   - Van = 120.0 ∠ 0º
   - Vbn = 120.0 ∠ 240º
   - Vcn = 120.0 ∠ 120º

5. Reset the frequency target by pressing "C" on the MMI.

6. Change the settings as follows:

   - 81 Select 81S Enable
   - 81S Pickup 59.95 Hz
   - 81S T. Delay 0.10 seconds

7. Apply the same voltages as in Step 4. The relay should not trip for an underfrequency condition.

Loss of Control Power and Self-Check Alarm Contact Test

Follow these steps to test the loss of control power and the self-check alarm contact:

1. With control power applied to the DPU-2000, check the self-check alarm contact and the STATUS LED. Normal status is indicated by a green LED.

2. Interrupt the control power to the DPU-2000. The self-check contacts should return to their normal state.

3. Reapply control power and check the DPU-2000 to see that all settings were properly retained.

Appendix A
Timing Curves

Time Overcurrent Curve Equation

$$\text{Trip Time} = \left(\frac{A}{M^P - C} + B\right) \times \frac{14n-5}{9}$$

$$\text{Reset Time} = \frac{D}{|1-EM|} \times \frac{14n-5}{9}$$

M = Multiples of pickup current (I/Ipu)

n = Time Dial setting (range 1 to 10 in steps of 0.1)

Table 18. Constants for Time Overcurrent Characteristics

Curve	A	B	C	P	D	E
Extremely Inverse	6.407	0.025	1	2.0	3	0.998
Very Inverse	2.855	0.0712	1	2.0	1.346	0.998
Inverse	0.0086	0.0185	1	0.02	0.46	0.998
Short Time Inverse	0.00172	0.0037	1	0.02	0.092	0.998
Short Time Ext. Inv.	1.281	0.005	1	2.0	0.6	0.998
Long Time Ext. Inv.	64.07	0.250	1	2.0	30	0.998
Long Time Very Inv.	28.55	0.712	1	2.0	13.46	0.998
Long Time Inverse	0.086	0.185	1	0.02	4.6	0.998
Recloser Curve #8	4.211	0.013	0.35	1.8	3.29	1.5

Notes:

- The time in seconds for the Long Time Extremely Inverse Curve is 10 times that of the Extremely Inverse Curve.
- The time in seconds for the Long Time Very Inverse Curve is 10 times that of the Very Inverse Curve.
- The time in seconds for the Long Time Inverse Curve is 10 times that of the Inverse Curve.
- The time in seconds for the Short Time Inverse Curve is 1/5 times that of the Inverse Curve.
- The time in seconds for the Short Time Extremely Inverse Curve is 1/5 times that of the Extremely Inverse Curve.

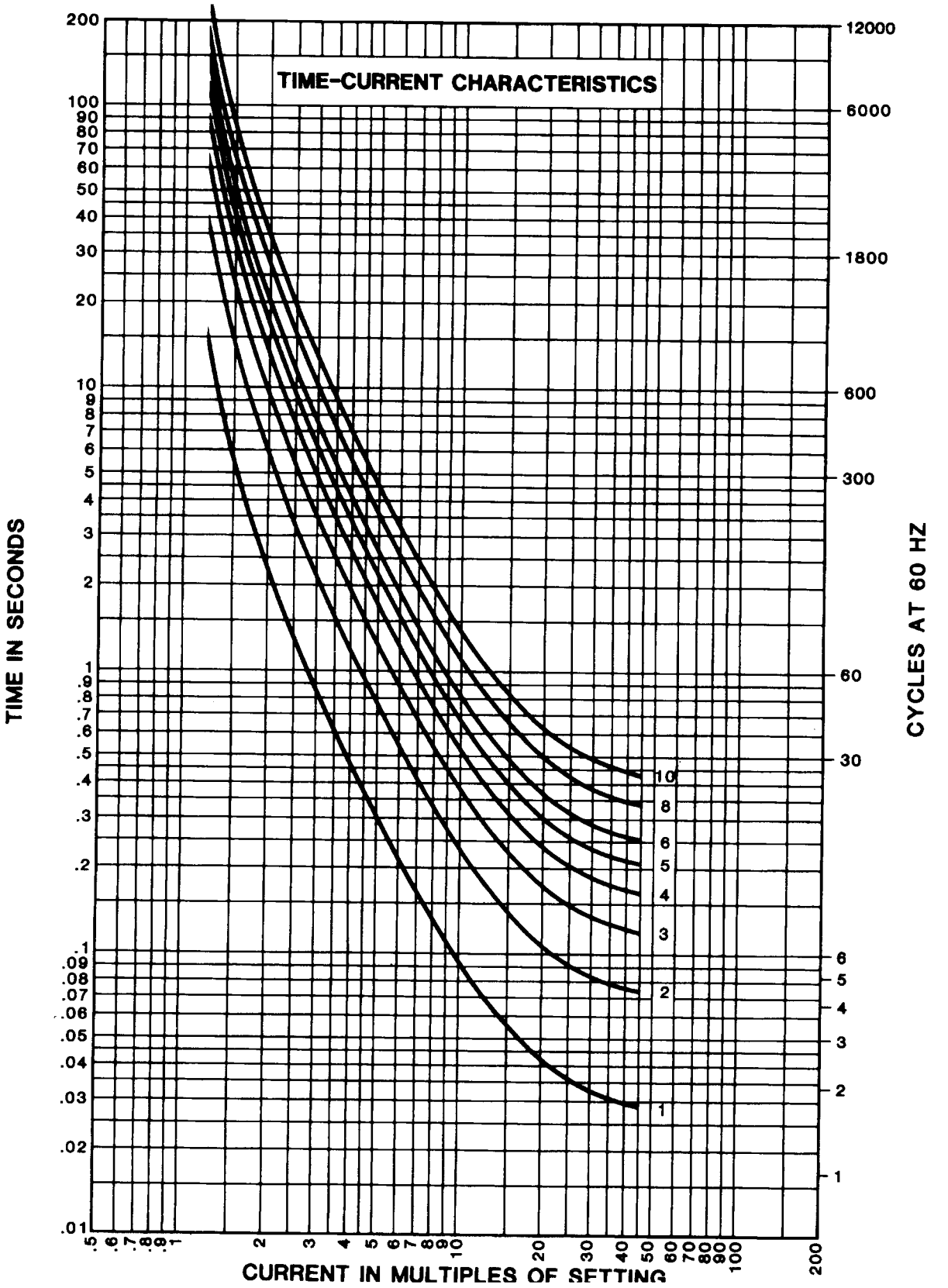


Figure 35. Extremely Inverse Curve

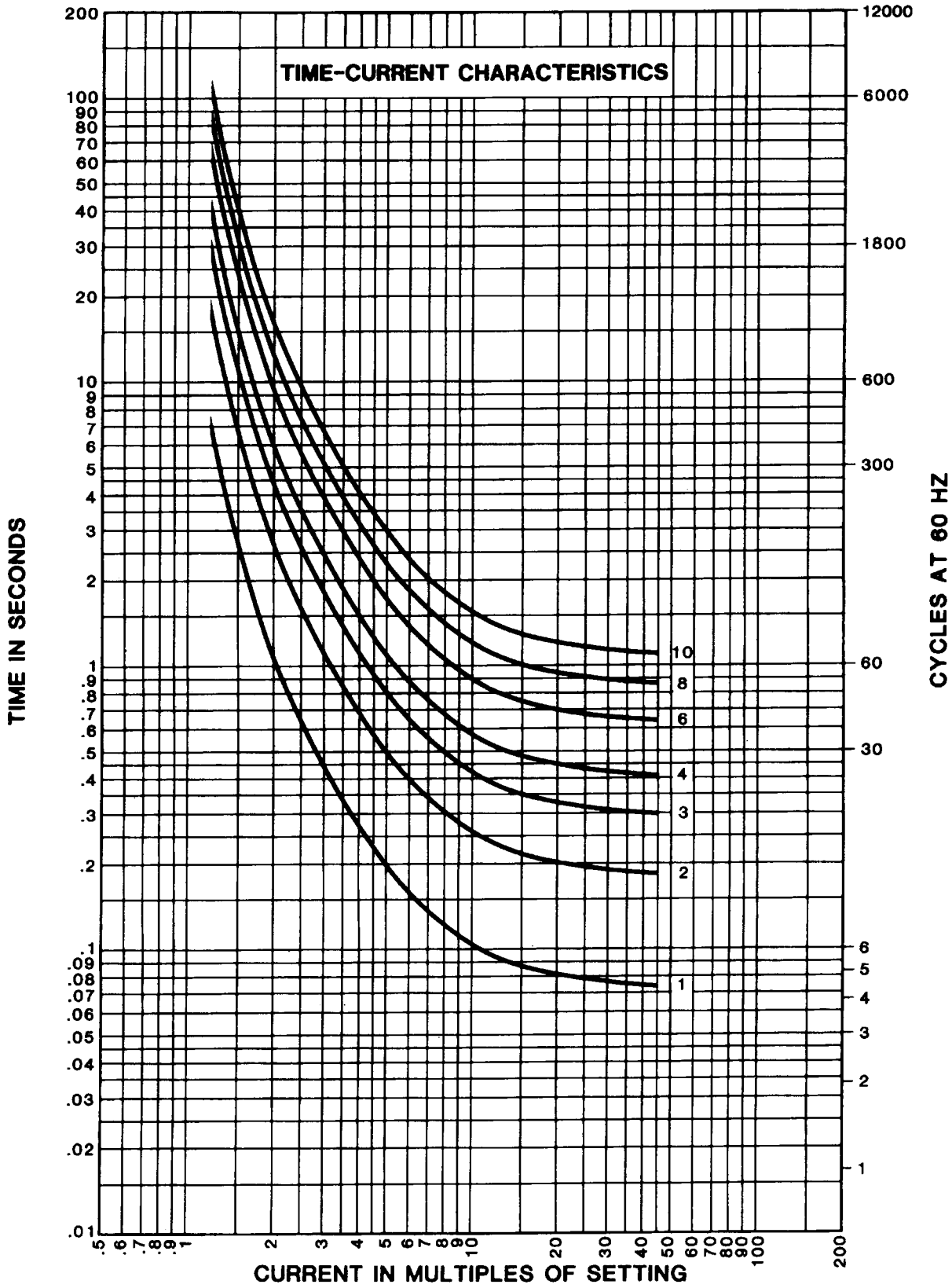


Figure 36. Very Inverse Curve

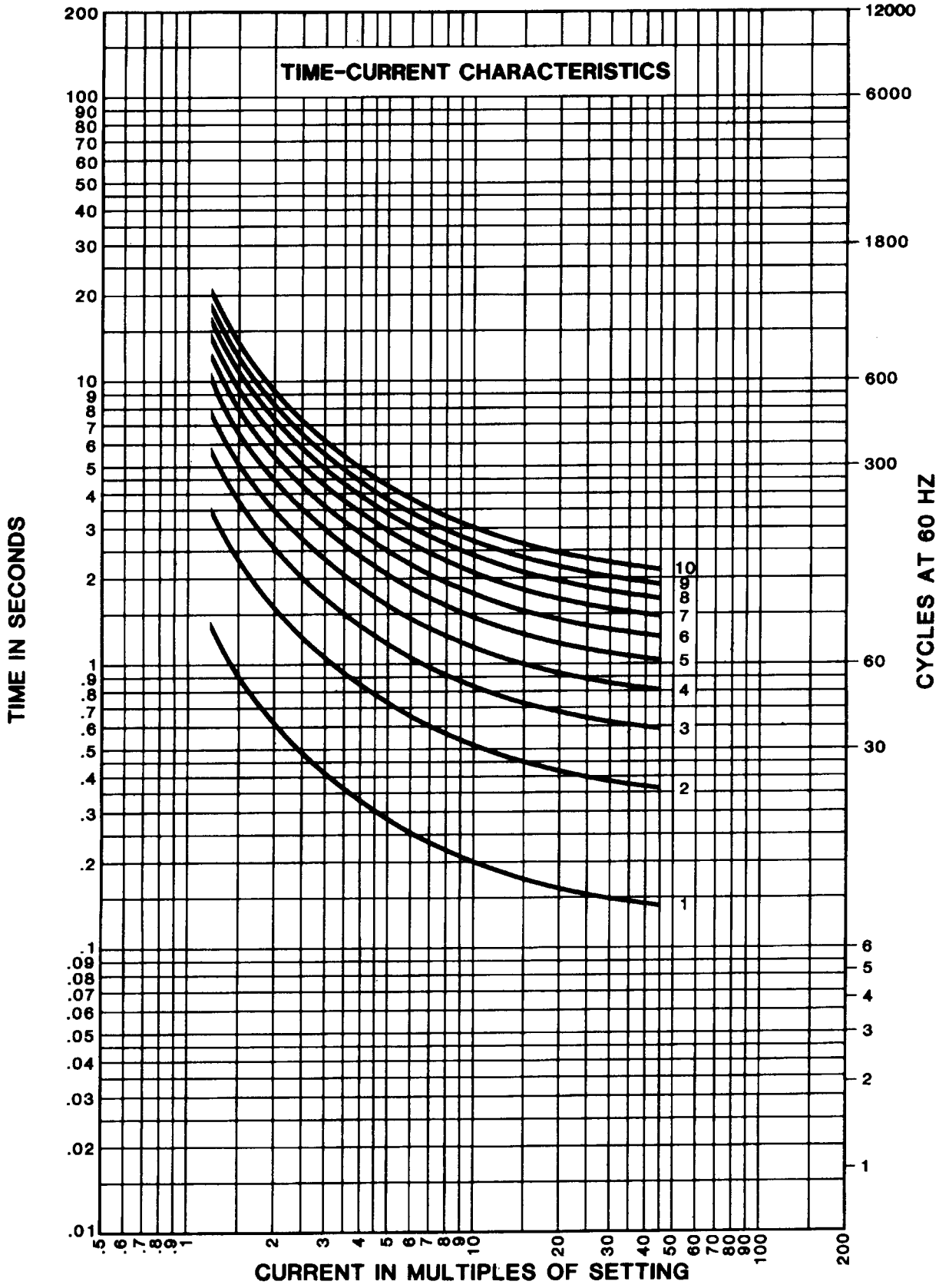


Figure 37. Inverse Curve

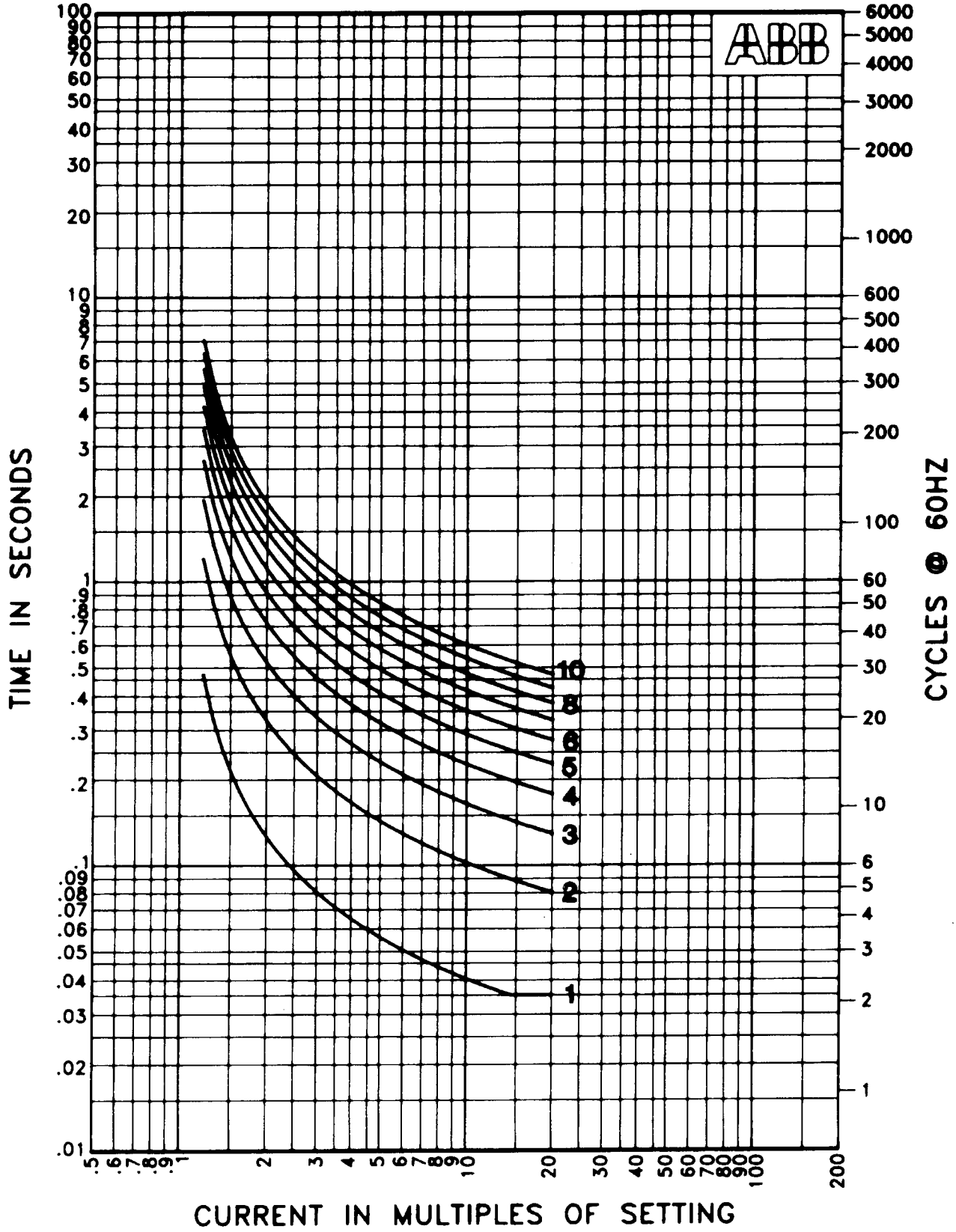


Figure 38. Short Time Inverse Curve

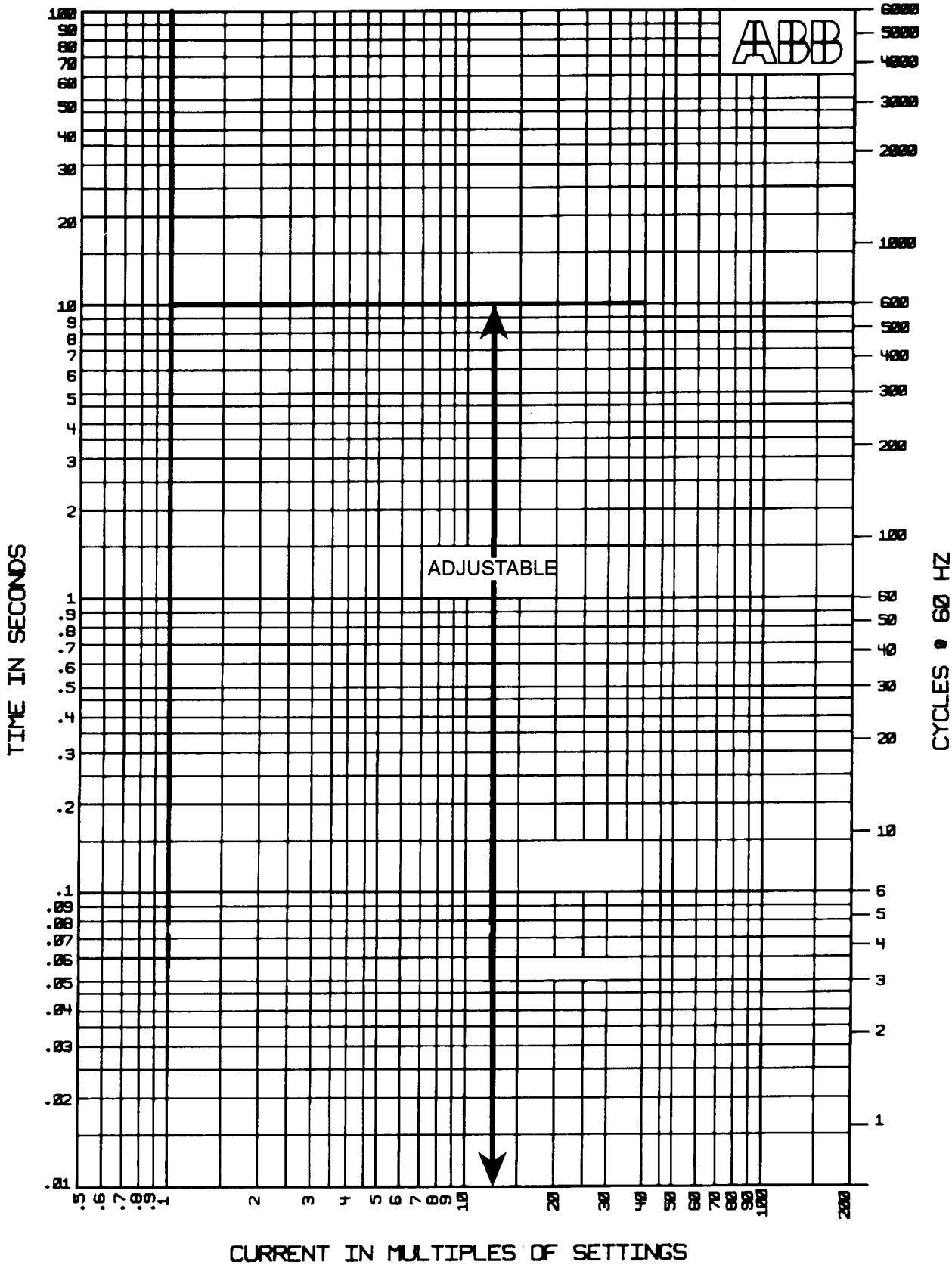


Figure 39. Definite Time Curve

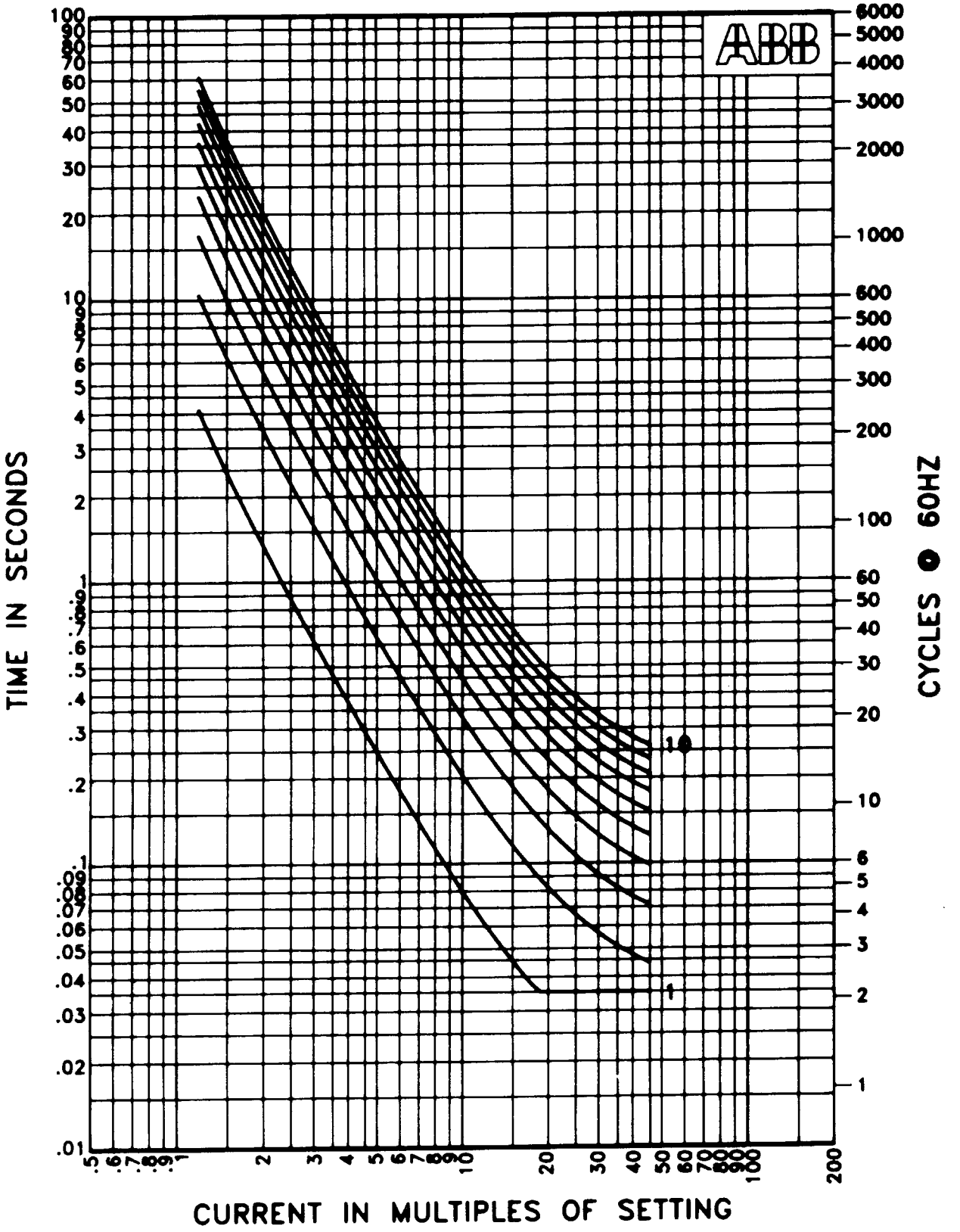


Figure 40. Recloser Curve #8

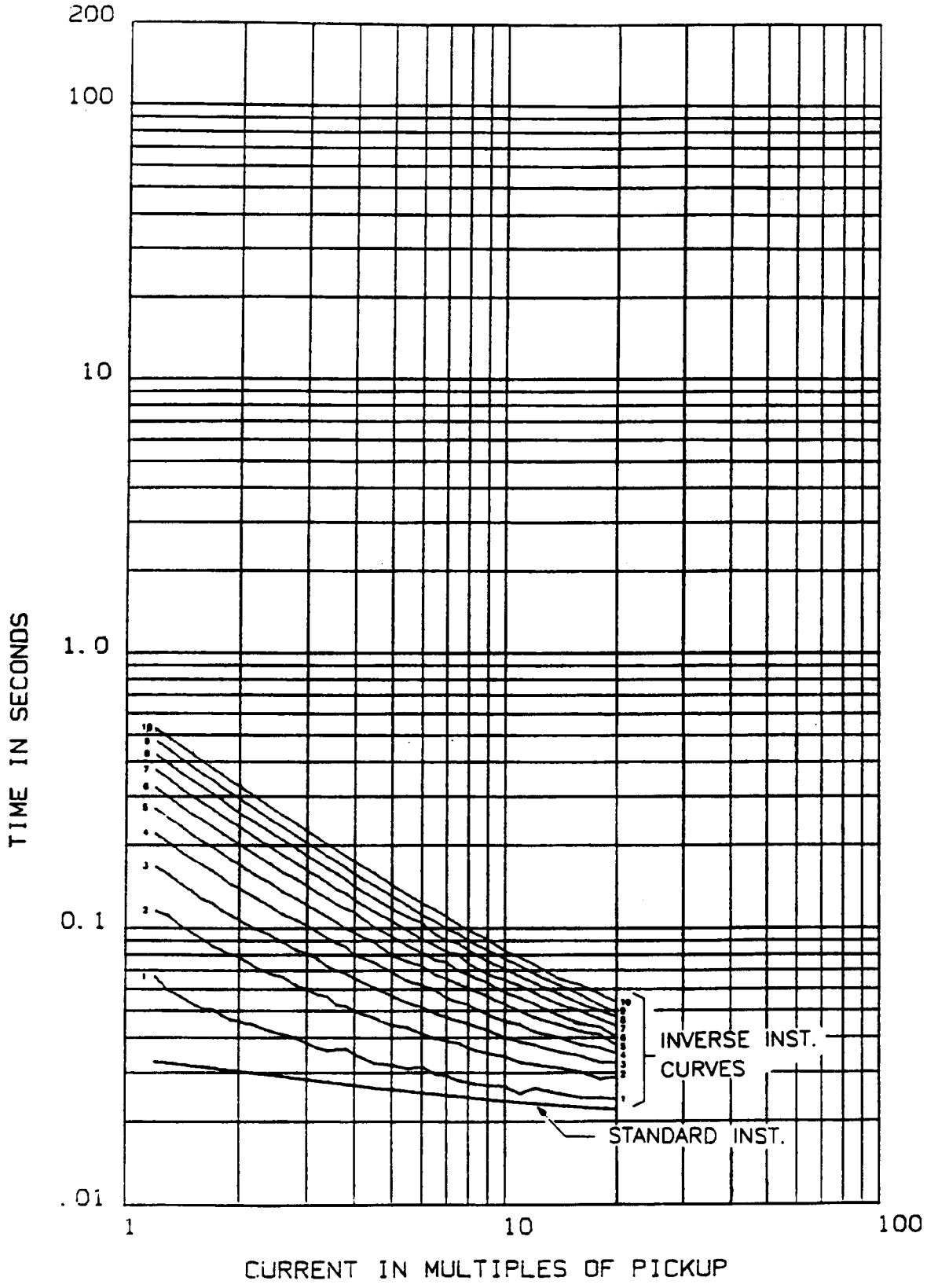


Figure 41. Standard Instantaneous Curve

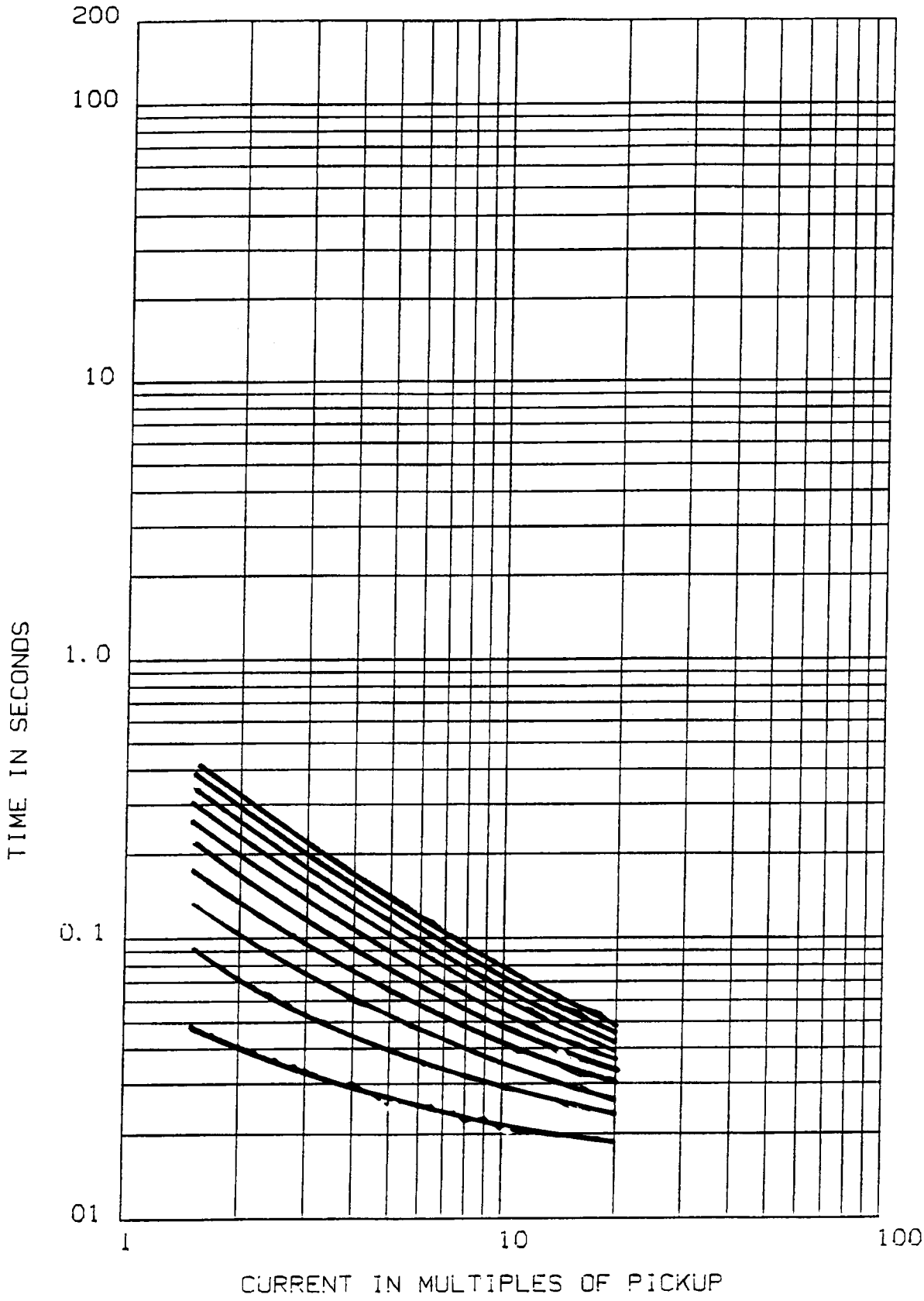


Figure 42. Inverse Instantaneous Curve

Appendix B
Changing Settings

Use ECP to change the following settings:

- Primary
- Alternate 1
- Alternate 2
- Configuration
- Counter
- Alarm
- Communication

Tables 3–7 show the values for the different settings.

Basic Procedure

The procedure for changing settings is basically the same for all the settings. Follow these steps to change settings:

1. From the ECP Main Menu, select "Change Settings."
2. From the Change Settings menu, select the settings you want to change.
3. A Load Screen appears, prompting you to load the data. Choose one of the following:
   - Get Data from DPU2000
   - Get Data from Disk
4. The screen for the selected settings appears. Scroll to the function you want and press ENTER.
5. A window appears with either the possible options or a prompt to change the settings by using the arrow keys.
6. Press Enter to accept the new setting, or press ESC to close the window without any changes.
7. Select "Return to Menu."
8. Save your changes.
   a. Press ESC.
   b. At the window prompting you to save, highlight the option by using the arrow keys and press ENTER.

Appendix C
Programming the Binary (Contact) Inputs

Use ECP and follow these steps to program the binary (contact) inputs on the Programmable Input Map screen:

1. From the ECP Main Menu, select "Change Settings."
2. From the Change Settings menu, select "Programmable Inputs."
3. The Programmable Input Map screen appears.
4. To change the contact listing:
   a. Use the arrow keys to highlight the contact.
   b. Press the spacebar to display a list of possible contacts.
   c. Scroll through the list until the contact you want is highlighted.
   d. Press ENTER to change the contact, or press ESC to close the contact list window without changing the current contact.
5. To change the logic of a contact:
   a. Use the arrow keys to highlight the logic value of a contact.
   b. Press the spacebar to display a window with AND and OR.
   c. Highlight AND or OR.
   d. Press ENTER to change the logic, or press ESC to close the logic window without any changes.
6. To change the status of a contact:
   a. Use the arrow keys to highlight the area across from the contact name and underneath the input you want.
   b. Press the spacebar to display a window with a blank, a "C," and an "O" (nothing, closed, and open).
   c. Highlight the status you want.
   d. Press ENTER to change the status, or press ESC to close the status window without any changes.
7. To assign a name to an input:
   a. Press F1.
   b. Use the right arrow key to highlight the input you want to change and press the spacebar.
   c. A window appears prompting you to enter the new name. Type in the new name (up to 8 characters).
   d. Press ENTER to change the name, or press ESC to close the input window without any changes.
8. Save your changes.
   a. Press ESC.
   b. At the window prompting you to save, highlight the option you want by using the arrow keys and press ENTER.

Appendix D
Programming the Output Contacts

Use ECP and follow these steps to program the output contacts on the Programmable Output Map screen. You can select up to 32 attributes to be displayed on the Programmable Output Map.

1. From the ECP Main Menu, select "Change Settings."
2. From the Change Settings menu, select "Programmable Outputs."
3. The Programmable Output Map screen appears.
4. To change the contact listing:
   a. Use the arrow keys to highlight the contact.
   b. Press the spacebar to display a list of possible contacts. **NOTE:** You cannot access the Trip and Close functions.
   c. Scroll through the list until the contact you want is highlighted.
   d. Press ENTER to change the contact, or press ESC to close the contact list window without changing the current contact.
5. To change the logic of a contact:
   a. Use the arrow keys to highlight the logic value of a contact.
   b. Press the spacebar to display a window with AND and OR.
   c. Highlight AND or OR.
   d. Press ENTER to change the logic, or press ESC to close the logic window without any changes.
6. To select an output:
   a. Use the arrow keys to highlight the area across from the contact name and underneath the output you want.
   b. Press the spacebar to display a window with a blank and an "X."
   c. Highlight the status you want.
   d. Press ENTER to change the status, or press ESC to close the status window without any changes.
7. To change the name:
   a. Use the arrow keys to highlight the output name you want to change.
   b. Type in the new name (up to 8 alphanumeric characters).
   c. Press ENTER to keep the new name, or press ESC.

Appendix D
Programming the Output Contacts (Continued)

8. To change a Timer value:

   a. Press F1.

   b. Use the right arrow key to highlight the timer you want to change and press ENTER.

   c. A window appears. Use the arrow keys to increase or decrease the timer's value.

   d. Press ENTER to keep the value, or press ESC to close the window without any changes.

9. Save your changes.

   a. Press ESC.

   b. At the window prompting you to save, highlight the option you want by using the arrow keys and press ENTER.

Appendix E
POWERview Oscillographic Analysis Tool

ABB's POWERview Oscillographic Analysis Tool software program enhances the fault analysis capabilities of the ABB Protection Units. The POWERview Oscillographic Analysis Tool displays the waveform data captured by these units. Besides all analog wave forms, this program shows digital input/output, pickup, and fault information.

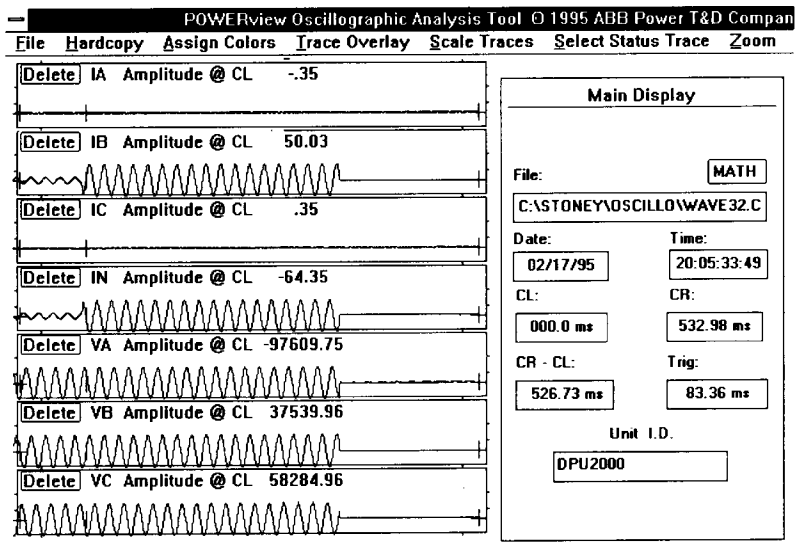
The analog wave forms are displayed simultaneously in individual windows. Each window contains a trigger indicator, a left cursor, and a right cursor. You can move either cursor to any position within the window for that wave form. When you move the cursor in one window, it moves in the other windows as well. Each waveform window can be resized to enhance viewing and can be deleted individually.

The time location of the left and right cursors and the difference in time between the cursors are provided in the Main Display window. Other information in the Main Display window includes the file name from which the waveform records were extracted; the date, time, and trigger position of the sample taken at the Protection Unit; the unit ID number; and the catalog number.

You can overlay an individual analog wave form onto any other analog wave form. For example, you can overlay Va onto Ia to examine the phase relationship.

You can scale all current wave forms with respect to the largest amplitude within that group. This is called the Actual Scale and is the default setting. But you can also scale wave forms with respect to the largest amplitude encountered for that wave form only; this is called the Normalized Scale. The Normalized Scale accentuates noise and other characteristics of the wave form.

A zoom feature allows you to position the left and right cursors within the wave form and then "zoom in" to closely examine that section of the wave form.



System Requirements and Installation

The POWERview Oscillographic Analysis Tool requires at least a 386-based PC running Microsoft® Windows™ 3.1. It is recommended that you set the screen resolution to 1024 x 768 to allow all the windows generated by the POWERview Oscillographic Analysis Tool to be seen at one time.

To install the POWERview Oscillographic Analysis Tool, follow these steps:

1. Start Windows and enter the File Manager program.
2. Create a directory where the program will reside on your hard drive. This may be any directory name you choose.
3. Place the 3.5" disk in your floppy drive and copy the files named PWRVIEW.EXE and TEST.CAP from the 3.5" disk to the directory you created. The test file is used to explain the operation of the Oscillographic Display and Analysis software.
4. Set up the executable application in the Program Manager window:
   a. Go to the Main window in the Program Manager window.
   b. Double-click on "Windows Setup."
   c. The Windows Setup window appears. Select "Set Up Application" under the Options menu.
   d. Another window appears. Select "Ask you to specify an application," and click on "OK."

e. Enter the application path and filename (e.g., C:\Yourdir\pwrview.exe), and click on "OK." The icon should appear in the Applications window of the Program Manager.

Using the POWERview Oscillographic Analysis Tool

The POWERview Oscillographic Analysis Tool is a menu-driven program. A parent window contains windows for the analog wave forms and for digital information.

Opening a File

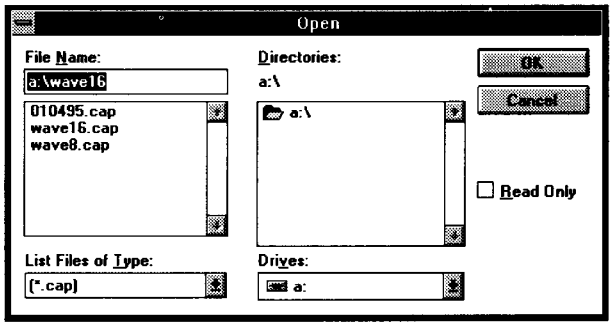
To open a file, do the following:

1. Double-click on the icon in the Applications window of the Program Manager.

2. Click on "Continue" at the prompt.

3. Under the File menu, select "Load Graph Data File."

4. The "Open" window appears. POWERview Oscillographic Analysis Tool files are listed as *.CAP files, including the TEST.CAP file. Click on the file you want and select "OK," or double-click on the filename.



The file loads and the individual analog waveform windows appear.

Analog Display Windows

The analog waveform windows appear within the Main Displaywindow. The Main Display window appears to the right of the analog wave forms and lists the file name, date and time the data was captured at the Protection Unit, and locations of the trigger point and the left and right cursors.

The left cursor is at the far left side of each analog waveform window, and the right cursor is at the far right side. You can "drag" the cursors by moving the mouse cursor close to the left or right cursors. Hold down the left mouse button while dragging the left or right cursor to the desired position. Release the mouse button.

After you move the left or right cursor, the time value for that cursor changes in the parent window. Also, the cursor position in all the other analog waveform windows mirrors your cursor movement. **The trigger cursor cannot be moved.**

To resize an analog waveform window, move the mouse to the border on that window. A double-headed arrow appears when the mouse is properly positioned. Hold down the left mouse button and drag the window border to the desired position. Release the mouse button.

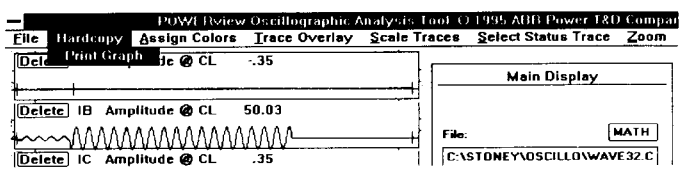
Each analog waveform window can be deleted. Simply click on the DELETE button in the window. That waveform window disappears, and the other waveform windows shift to take up the empty space.

Menu Commands

Each menu on the POWERview Oscillographic Analysis Tool parent window has specific features.

Hardcopy Menu

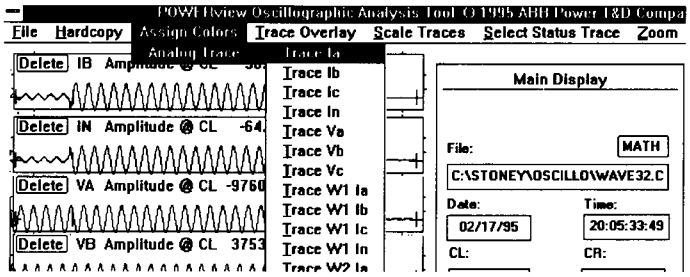
Under the Hardcopy menu is the command "Print Graph." When you want to print a copy of the window(s) you are viewing, select this command.



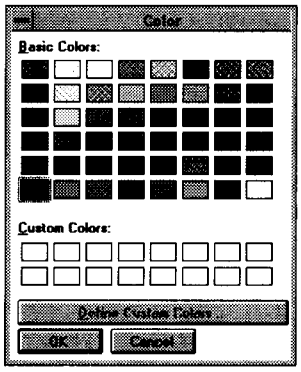
Assign Colors Menu

Use this menu to assign colors to the analog wave forms. This is especially helpful when you overlay two wave forms.

When you select Analog Trace, a list of the analog traces appears.

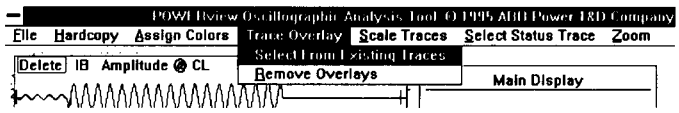


Click on the trace you want, and a window with color patterns appears. Click on a color and select "OK."

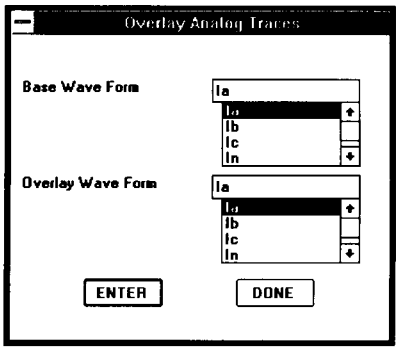


Trace Overlay Menu

Use the Trace Overlay menu to overlay any analog wave form on any other analog wave form. This way you can directly compare the two. From the Trace Overlay menu, choose "Select From Existing Traces." You can also use this menu to remove overlays.



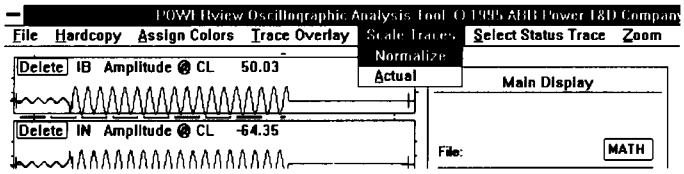
After selecting from the Trace Overlay menu, a window appears that requests you to enter a base trace and an overlay trace. Enter each trace and select "Enter." The overlay trace appears in the window of the base trace. Enter other traces as you desire, and select "Done" when you are finished.



NOTE: Only one wave form may be overlaid onto any base trace.

Scale Traces Menu

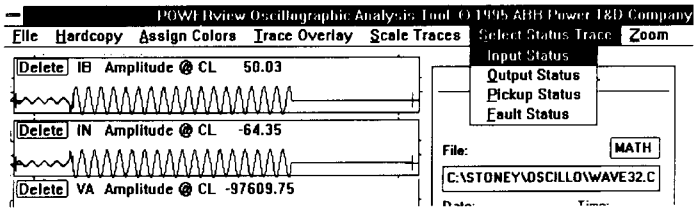
You can scale analog wave forms to an Actual Scale or a Normalized Scale. Actual Scale shows an analog wave form in relation to the other six wave forms. When you choose Normalized Scale, the wave form is scaled with respect to the largest amplitude for that wave form only. In other words, the peaks expand to fit that individual window. From the Scale Traces menu, select Actual Scale or Normalized Scale. The program launches in Actual Scale.



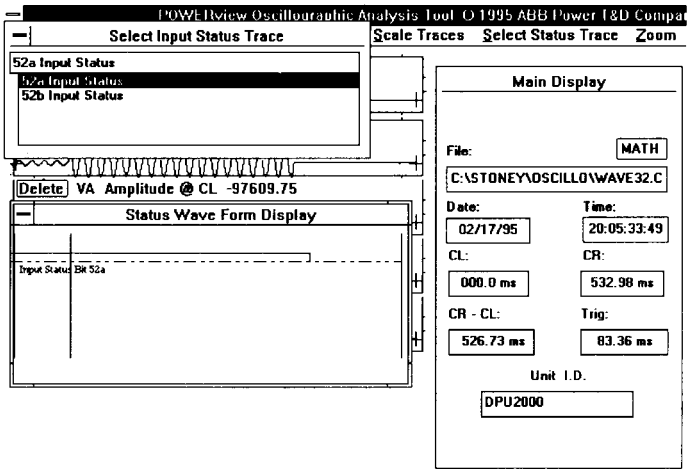
Select Status Trace Menu

You can present digital input/output, pickup and fault information in a window by using the Select Status Trace menu. Follow these steps to display digital information.

1. Select the digital information you want under the menu.



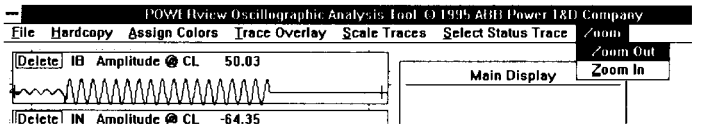
2. A window appears with a list of the different parameters measured. Double click on the parameters you want. As you double click on a parameter, a digital line appears in the graph window.



3. When you have selected all the parameters you want, click on Done.

Zoom Menu

Zooming in allows you to enlarge a selected portion of the analog wave form. To do this, set the left and right cursors to the desired range. Then select "Zoom In" from the "Zoom" menu. The portion you selected enlarges. Use "Zoom Out" to return to the original size.



Math Button

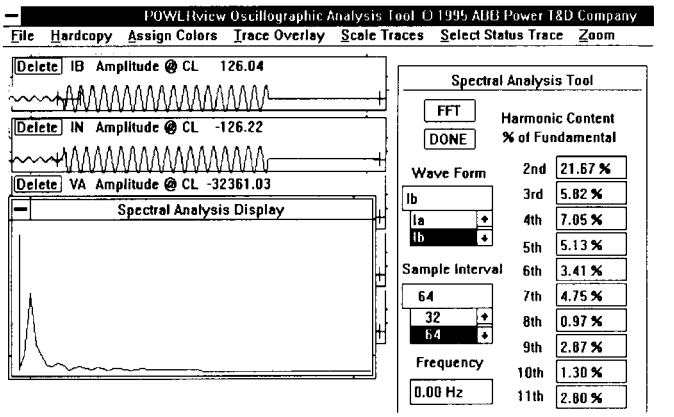
At the top of the Main Display window is a button marked "Math." Press this button to perform math functions associated with the analog wave forms.

Spectral Analysis

The Spectral Analysis Tool window appears when you click on the Math button. By using this tool, you can create a spectrum window for a selected region of waveform data.

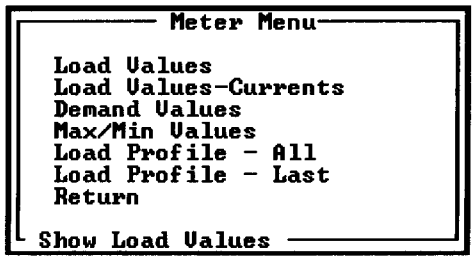
Follow these steps to perform a spectral analysis:

1. Click on the Math button at the top of the Main Display window.
2. The Spectral Analysis Tool window appears.
3. Select the wave form you want by scrolling up or down in the "Wave Form" box. Double-click on the desired wave form. An extended cursor appears in place of the left cursor in the window of the selected wave form. (The default is the uppermost wave form.)
4. Select the desired sample interval by scrolling up or down in the "Sample Interval" box. Double-click on the interval you want. The extended cursor in the waveform window changes size accordingly. (Default = 32 or one cycle for a 50-Hz or 60-Hz wave form.)
5. Move the extended cursor over the section of the wave form on which you want to perform the spectral analysis. Do this by clicking on the left vertical of the cursor and dragging in the waveform window.
6. Click on the FFT (Fast Fourier Transformer) button in the Spectral Analysis Tool window. The Spectral Analysis Display window appears with the generated spectrum. The harmonic content as a percentage of the fundamental (50 or 60 Hz) appears in the Spectral Analysis Tool window for the harmonics (2nd to the 11th).
7. As you wish, move the cursor within the Spectral Analysis Display window by clicking the left mouse button in the region you want. The cursor snaps to that position, and the frequency appears in the "Frequency" box of the Spectral Analysis Tool window.
8. Double-click on the upper left corner of the Spectral Analysis Display window to close it, or click on "Done" in the Spectral Analysis Tool window to remove the Spectral Analysis Display and Spectral Analysis Tool windows.



Appendix F
Using the Load Profile Feature

Use the ECP and follow these steps to retrieve the optional Load Profile feature information.



1. Under the Meter Menu, select Load Profile – All or Load Profile – Last. As the names suggest, choosing Load Profile – All downloads all the load profiles, while choosing Load Profile – Last downloads only the most recent load profile.

2. Type in the filename and select SAVE ON DISK.

3. View the load profile information by doing one of the following:

   - Open the file from your word processing or spreadsheet program.

   - Type the following DOS command and press Enter.

     type [name of file].dla|more

     Type the pipe character (|), found above the \ character on the keyboard, between "dla" and "more."

Parts and Assemblies

Table 19 lists the parts and assemblies involved in the DPU-2000.

Table 19. Parts and Assemblies

Part and Assembly Description	Part Number
Vertical Case Assembly with Backplane	613471-T1
Horizontal Case Assembly with Backplane	613471-T2
Backplane Assembly	613461-T1
Vertical Molded Front Cover	613364-001
Horizontal Molded Front Cover	613364-002
Vertical Front Membrane Panel	613470-T1
Horizontal Front Membrane Panel	613470-T2
125-VDC Power Supply Assembly	611934-T3
48-VDC Power Supply Assembly	611934-T5
24-VDC Power Supply Assembly	611934-T4
125-VDC Power Supply Assembly with I/O1 PCB (Slot 1)	613451-T1
48-VDC Power Supply Assembly with I/O1 PCB (Slot 1)	613451-T2
24-VDC Power Supply Assembly with I/O1 PCB (Slot 1)	613451-T3
125-VDC I/O 2 Printed Circuit Board Assembly (Slot 2)	613452-T3
48-VDC I/O 2 Printed Circuit Board Assembly (Slot 2)	613452-T4
24-VDC I/O 2 Printed Circuit Board Assembly (Slot 2)	613452-T6
I/O 3 Printed Circuit Board Assembly (Slot 3)	613453-T1
RS-232 Rear Communications Card (Slot 5)	613454-T1
Aux Comm Port and RS-232 Rear Comm. Card (Slot 5)	613478-T2
INCOM Rear Communications Card (Slot 5)	613479-T6
Aux Comm Port and INCOM Rear Comm. Card (Slot 5)	613479-T7
RS-485 Rear Communication Card (Slot 5)	613454-T2
CPU Printed Circuit Board Assembly (Slot 6)	613455-T1
A/D Converter and DSP PCB Assembly (Slot 7)	613456-T1
A/D Converter/DSP and CPU Assembly (Slots 6 and 7)	613467-T0
1 to 12 A CT and PT Cage Assembly (Slots 8 and 9)	613468-T1
1 to 12 A PH & 0.2 to 2.4 GRD CT & PT Cage Ass'y (Slots 8 and 9)	613468-T2
0.2 to 2.4 A CT and PT Cage Assembly (Slots 8 and 9)	613468-T3
Vertical Front Display Assembly (Slot 10)	613460-T3
Horizontal Front Display Assembly (Slot 10)	613460-T4
Optional 19-Inch Rack Mount Panel	613134-001

Ordering Selections

Catalog Number

48	A	M	R	X	D	C	–Z	SSS	S+

User Selections

Four Analog Inputs (currents only) 4
Seven Analog Inputs (currents and voltages) 7

Vertical Mounting V
Horizontal Mounting H

Current Range

Phase	Ground	
1.0-12 A	1.0-12 A	0
1.0-12 A	0.2-2.4 A	1
0.2-2.4 A	0.2-2.4 A	2

Control Voltage

110 Vdc	0
48 Vdc	3
125 Vdc	4
120 Vac	6
24 Vdc	9

Digital I/O

Inputs	Outputs	
9	9	0
16	11	1

Rear Communications Port

RS-232	1
Aux Comm Port & RS-232	2
INCOM	3
Aux Comm Port & INCOM	4
RS-485	5

Frequency

50 Hertz	5
60 Hertz	6

Special Software Options

Standard (No Options)	000
Load Profiles*	001
Customer Programmable Curves*	010
Oscillographic Data*	100
All Special Software Options*	111

* Optional Features

† Needed only when Rear Communications Port option 2 or 4 is selected

Communications Protocol

Standard (10-Byte protocol)	0
IEC 870-5 †	1
SPACOM †	2