Addendum to IB 7.11.1.7-7 Issue B

Type GPU-2000R Generator Protection System
for Units of Catalog Series 589 R

Purpose and Cautionary Note:
It has been determined that there is an error in the firmware of the 589R Series GPU2000R unit, related to the operation of the AND logic function available for the Programmable Outputs. (in Firmware versions 1.60 and below)

The error in the firmware results in the AND logic operating as though the setting was for OR logic. Therefore, a closure of a physical output contact will be obtained on the assertion of only one logical output function, when it was desired to have the output only on the coincidence of two or more logical functions.

References in the Main Instruction Book:
See page 38 in Issue B of the main instruction book IB 7.11.1.7-7. The pc screen that is used to program the output logic is shown. The screen indicates that all outputs are set for OR logic. The alternate choice of AND logic must not be used due to the firmware error.

Commentary:
It has been observed that the use of this AND logic function by customers is quite rare in the actual application of the 589R series units. Therefore, prior to the availability of updated firmware, the following "workaround" method is suggested and has been used for field expediency.

Workaround
If the application requires the logical AND of two or more logical output functions, the workaround is to program each function to a separate output contact, and then physically wire those output contacts in series. Thus to obtain a continuous path through the outputs, all must be individually asserted, giving the desired AND logic.

Customer Support
Questions on this addendum can be directed to our customer support group at telephone 800-634-6005, or 610-395-7333, or e-mail to: powerful.ideas@us.abb.com.

ABB Inc.
Substation Automation and Protection Division
7036 Snowdrift Rd.
Allentown, PA 18106 USA

Rev 0: Feb 2002

Instruction Booklet
1MRA589764-MIB

Issue B (IB 7.11.1.7-7)

GPU-2000R™

Generator Protection Unit

REG 544

This instruction book version is current up to and including CPU firmware version 1.1 of the GPU-2000R.

Precautions

Take the following precautions when using the Generator Protection Unit 2000R (GPU-2000R):

1. Incorrect connections of 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 GPU-2000R from its case and only perform a DC high-potential test.

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. During generator startup, protective funcitons dependant on frequency and voltage should be disabled because of the ramping-up of the voltage and frequency. It is recommended that the undervoltage (27) and under frequency (81U) function are disabled during startup. When a successful startup is complete, re-enable these functions.

WARNING: Removal of the relay from the case exposes the user to dangerous voltages. Use extreme care. Do not insert hands or other foreign objects into the case.

This instruction booklet contains the information to properly install, operate and test the GPU-2000R, but does not purport to cover all details or variations in equipment, nor to provide for every possible contingency to be met in conjunction with installation, operation or maintenance. Should particular problems arise which are not sufficiently covered for the purchaser's purposes, please contact ABB Power T&D Company Inc.

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Contents

Tables

Figures

Introduction

The GPU-2000R™ is a Generator Protection Unit in the proven line of 2000R series relays. The GPU-2000R is an advanced microprocessor-based relay system providing primary and backup protection for small to medium-size synchronous generators. Utilizing three advanced microprocessors common to the 2000R Series relays, the GPU-2000R provides multiple generator protective functions, expansive fault and operations records, multiple settings groups, mappable inputs and outputs, detailed metering and much more. The flexible programmable inputs and outputs simplify the integration of this relay into new or existing systems.

The GPU-2000R is packaged in a metal case suitable for conventional flush mounting or a rack panel. The GPU-2000R microprocessor-based logic can be totally withdrawn from its case. All connections to the GPU-2000R are made at clearly identified terminals on the rear of the unit.

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

Features

- Password protected settings and controls
- 32 samples per cycle for all functions including Protection, Metering and Oscillographics
- Continuous metering of per phase: Currents, voltages, watts, VARs, watthours and VAR hours, powerfactor and frequency
- Protection based on RMS or fundamental values
- Alarms and counters on the following Values: Machine Running Times, through-fault kiloamperes and Overcurrent Trip, Breaker Operation counters. Neutral and Phase Demand Currents, Power Factor, Load Current and Watts
- Test Mode allows logic monitoring of relay functions
- Three selectable settings tables: Primary, Alternate 1 and Alternate 2
- Optional load profile capability: watts, VARs and Voltage for 40, 80 or 160 days
- Optional user-programmable time overcurrent curves
- Optional oscillographic data storage for last eight (8) faults

Hardware

- Simultaneous communication through front and rear ports via dedicated microprocessors
- Flash memory technology provides for quick and easy updating to latest software enhancements
- A 4-line by 20-character graphical liquid crystal display provides easy access to metering, records, testing and settings
- Isolated communication ports for superior noise-free communications
- Expanded operating temperature range, from -40° C to +70° C
- Available in panel mount or rack mount, vertical or horizontal case
- Programmable logic inputs (8) and outputs (6)
- Battery backed-up clock maintains date and time during control power interruptions
- Front RS-232 port and a variety of rear communication port options such as RS-485, INCOM and Modbus®
- Multiple communications protocols support 10 byte ASCII, SPACOM, MODBUS® and PG&E
- Continuous self-diagnostics on power supply, memory elements and microprocessors

Protection Functions

Undervoltage Protection: 27

Close-in faults or an increase in system demand reduces the generated output voltage. The exciter increases the field to compensate for the reduced voltage leading to generator stator and rotor overheating.

This function provides a voltage setting for pickup on any one of the phase voltage inputs. A definite time characteristic prevents nuisance operation due to transient conditions. This function should be disabled during generator startup (See precaution 7).

27 Parameter	Range	Increment
Pickup setting	10 to 200 volts	1 volt
Time Delay	0 to 60.0 seconds	1 second

Reverse Power: 32R

With the loss of the prime mover, the generator would begin to motor, drawing power from the connected system. The amount of power that flows into the generator is dependent upon the prime mover type. A prolonged reverse power flow condition could lead to severe mechanical and thermal damage to the prime mover. This function provides backup protection for steam turbine, diesel engine or gas turbine prime movers via a wide range of settings, which are specified in percent of generator full load rated three phase power. The relay calculates generator full load power rating by using the rated current and voltage transformer (VT) connection settings, which are defined in the Configurations Settings menu shown in Table 6.

32 R Parameter	Range	Increment
Pick up setting	3 to 50%	1%
Curves: Long Time Inverse	—	—
Time Dial	1 to 10.0	0.1
Curves: Definite Time Curve	—	—
Time Delay	0.1 to 60.0 seconds	0.1 seconds

Loss of Excitation: 40

Reduction or loss of the excitation system can lead to unstable machine operation and loss of synchronism threatening the system integrity and causing rotor overheating. The machine will take VARs from the system in the case of a loss of excitation. Detecting this reverse reactive power flow can be used to alarm and trip. This function provides alarm and trip settings for detection of underexcitation and exciter failure.

The trip and alarm pickup settings are defined in percent of generator full load rated three phase power. Long Time Inverse and Definite Time curves are selectable for tripping and a Definite Time curve is available for alarming.

40 Parameter	Range	Increment
Trip Pickup setting	10 to 100%	1%
Curves: Long Term Inverse	—	—
Time Dial	1 to 10.0	0.1
Curves: Definite Time Curve	—	—
Time Delay	0.1 to 60.0 seconds	0.1 seconds
Alarm Pickup setting	10 to 100%	1%
Curves: Definite Time curve		
Time Delay	0.1 to 60.0 seconds	0.1 seconds

Phase Unbalance (Negative Sequence): 46Q

Unbalanced loads or faults in the system create unbalanced currents in the generator. This unbalanced condition yields negative sequence currents which induce twice frequency currents on the rotor surface. Prolonged existence of these induced currents causes severe rotor thermal damage requiring extensive repairs. Phase unbalance protection provides primary protection for the generator rotor and backup protection for uncleared system faults.

46Q Parameter	Range	Increment
Trip Pickup Setting	5 to 40%	1%
Curves: $(I_2)^2t$	—	—
Time Dial (K)	1 to 10.0	0.1
Max Time	100 to 500 seconds	5 seconds
Alarm Pickup setting	5 to 40%	1%
Curves: Definite Time curve	—	—
Time Delay	0.1 to 10 seconds	0.1 seconds

Phase Unbalance (Negative Sequence): 46Q (continued)

This function provides sensitive pickup so the machine can be protected for any amount of negative sequence current above its continuous capability, typically 10%. The inverse characteristic provides fast clearing on severe faults and an alarm function may allow time for operator intervention on low levels. The curve relationship for tripping is based on the equation $(I_2)^2t = K$, where I_2 is the negative sequence current in percent of the generator rated current defined in the Configuration Settings menu in Table 6, t is the trip time in seconds and K is the generator negative sequence withstand factor. A maximum definite time function places an upper limit on clearing times for low level negative sequence currents. The alarm function is also set in percent of the generator rated current with a Definite Time curve operation.

The following tables, 1, 2 & 3 are referenced throughout this instruction booklet as the available curve selections for overcurrent protective functions.

Table 1. Time Overcurrent Curves (51)

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
Recloser Curve	1.0 to 10
User 1 *	Optional
User 2 *	Optional
User 3 *	Optional

Table 2. Instantaneous Overcurrent Curves (50)

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 *	Optional
User 2 *	Optional
User 3 *	Optional

* Only available with user-programmable curve option

Table 3. Voltage Restraint Voltage and Current Characteristic

% Rated Volts	Pickup Current, % Tap Setting
100	100
75	75
50	50
25	25
0	25

Instantaneous Overcurrent: 50 (Phase and Ground)

Faults located within the generator or at the generator terminals produce large values of current. This function provides additional rapid tripping for severe internal generator or external system faults.

The pickup setting below is in percent of the rated generator current

50-P Phase & 50-N Ground Parameters	Range	Increment
Trip Pickup setting	50 to 2000 %	10 %
Curves: See table 2	——	——
Time Dial	1 to 10.0	0.1
Time Delay	0.1 to 10.0 seconds	0.1 seconds

Use of the standard instantaneous timing characteristics is not possible if coordination with downstream relays is required. Consider using one of the other characteristic curves shown in Table 2.

Time Overcurrent Protection: 51 (Phase and Ground)

Time-Overcurrent backup protection prevents generator damage or deterioration. Overcurrent situations may occur due to overload conditions or system faults not cleared by downstream devices.

This phase overcurrent element is mainly used to provide overload protection when the 51V element is set up as a voltage controlled unit

51-P Phase & 51-N Ground Parameter	Range	Increment
Trip Pickup setting	50 to 200 %	5 %
Curves: See table 1	——	——
Time Dial	1 to 10.0	0.1
Time Delay	0.1 to 10.0 seconds	0.1 seconds

Voltage Dependent Phase Time Overcurrent: 51V

Failure of primary relaying to clear system faults could lead to generator overheating or power distribution equipment damage. A time overcurrent function whose operation is dependent upon the system voltage accomplishes the necessary backup protection for uncleared system faults. The voltage dependence assures security against nuisance overcurrent trips during generator overload situations and the sensitivity required by the limited capability of the generator to supply short circuit current.

The pickup setting below is in percent of the rated generator current

51V Control Parameter	Range	Increment
Trip Pickup setting	25 to 100 %	5 %
Curves: See table 1	——	——
Time Dial	1 to 10.0	0.01
Time Delay	0.1 to 10.0 seconds	0.1 seconds
Vop:	——	——
Wye PT's, line-to-neutral voltage	10 to 170 volts	10 volts
Delta PT's, line-to-line voltage	10 to 270 volts	10 volts

This function offers either voltage control or voltage restraint overcurrent protection as backup to bus and feeder faults not interrupted by their primary protection. The voltage control selection allows time overcurrent operation only when the system voltage falls below the operate voltage (Vop). With the voltage restraint selection, the overcurrent pickup sensitivity increases as the system voltage decreases. (See Table 3).

The pickup setting below is in percent of the rated generator current

51V Restraint Parameter	Range	Increment
Trip Pickup setting	80 to 100 %	5 %
Curves: See table 1	——	——
Time Dial	1 to 10.0	0.01
Time Delay	0.1 to 10.0 seconds	0.01 seconds
Voltage: See table 3	——	——

Overvoltage Protection: 59

Operation with voltage levels greater than rated output voltage leads to extensive generator damage. Increase in voltage results from abnormal system conditions such as loss of load.

This function provides a voltage setting that only one phase voltage input must exceed for a pickup condition. A definite time delay provides a delay for transient system conditions.

The pickup setting below is based on line-to-neutral voltage when the PT's are in a Wye configuration, or line-to-line voltage when the PT's in a Delta configuration

59 Parameter	Range	Increment
Pickup setting	70 to 250 volts	1 volt
Time Delay	0 to 60.0 seconds	1 second

Directional Overcurrent: 67 (Phase and Ground)

The phase directional overcurrent function uses positive sequence polarization with the maximum torque angle defined as the angle the positive sequence current (I_1) leads the positive sequence reference voltage (V_1). The ground directional overcurrent function uses negative sequence polarization with the maximum torque angle defined as the angle the negative sequence current (I_2) leads the negative sequence reference voltage (V_2).

The pickup setting below is in percent of the rated generator current

67 Phase & Ground Parameter	Range	Increment
Trip Pickup setting	50 to 200 %	5 %
Curves: See table 1	——	——
Time Dial	1 to 10.0	0.1
Time Delay	0.1 to 10.0 seconds	0.1 seconds
Max. Torque Angle:	——	——
67 Phase where I_1 lead V_1	0 to 355º	5º
67 Neutral where I_2 lead V_2	0 to 355º	5º
Sector Width:	180º	——

Under/Over Frequency: 81U/81O

Off frequency generator operation resulting from changes in system load demand may cause machine damage due to stator and rotor overheating and in the case of underfrequency operation, prime mover mechanical damage. The under frequency function (81U) should be disabled during generator startup (See precaution 8).

81U-1,2 Parameter	Range	Increment
Trip Pickup setting	——	——
60 Hz	56 to 64 Hz	.01 Hz
50 Hz	45 to 54 Hz	.01 Hz
Time Delay	0.08 to 9.98 seconds	0.02 seconds

This function allows two independent frequency settings, steps, for each underfrequency and overfrequency protection. Shed partial or all load or shut down the machine with the two underfrequency settings and alarm or trip with the two overfrequency settings. Each setting provides a definite time delay to prevent nuisance tripping due to transient off frequency conditions.

A separate voltage block setting prevents any frequency trip from occurring when the voltage from which the frequency is measured drops below a specified value.

81O-1,2 Parameter	Range	Increment
Trip Pickup setting	——	——
60 Hz	56 to 64 Hz	.01 Hz
50 Hz	45 to 54 Hz	.01 Hz
Time Delay	0.08 to 9.98 seconds	0.02 seconds

A separate voltage block setting prevents any frequency trip from occurring when the voltage from which the frequency is measured drops below a specified value.

81 Voltage Block Parameter	Range	Increment
Voltage	40 to 200 volts	1 volt

Breaker Failure Alarm

The Breaker Failure Alarm occurs after the GPU-2000R has asserted the TRIP output for the period of the Breaker Fail Time interval without the phase currents dropping below the Trip Failure Dropout Threshold.

The drop in the fault current must occur before the Trip Failure Time expires or the Breaker Failure Alarm will activate.

During the Breaker Failure Alarm, the GPU-2000R continues to send a TRIP signal until the breaker is tripped, either through SCADA or manual tripping. When the breaker is tripped, the Breaker Failure Alarm is removed.

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 GPU-2000R. When the GPU-2000R 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.

Self Diagnostics

The GPU-2000R continuously checks itself for proper functioning. If the self-test fails, the GPU-2000R is no longer providing protection. Replace the unit as soon as possible.

Self-Test Status

The GPU-2000R provides continuous self-diagnostic 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 GPU STATUS light (LED) and system failure is indicated by a red GPU STATUS light (or by the green GPU STATUS light not being lit in the case of a loss of control power).

The extensive self diagnostics and Operations monitoring that is performed by the unit provides detail detection of multiple combinations of Self-Test failures or Editor Access conditions to be detected within a record capture. The Self-Test Failures and Editor Access Status records are recorded as a decimal number in the Operations Record. After converting this number to binary, the binary bit pattern indicates the Self-Test Failure(s) or Editor Access Status involved. The 1's in the bit pattern reference Table 4 below to indicate the failure type or editor access information. Count from the right of the bit pattern (starting with zero) to the position where a "1" occurs. Compare that bit position with Table 4 to reveal the device failure or editor access status reported. See the examples to follow for further explanation.

Table 4. 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 in this example).
Bit 4 : Front communications port initiated the editor access and change.
Bit 7 : Real-time clock settings were changed.

GPU-2000R Settings Tables Diagnostics

Three copies of each settings table are stored in a nonvolatile memory device, 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 the nonvolatile memory device.

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.

Should the GPU-2000R ever detect 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.

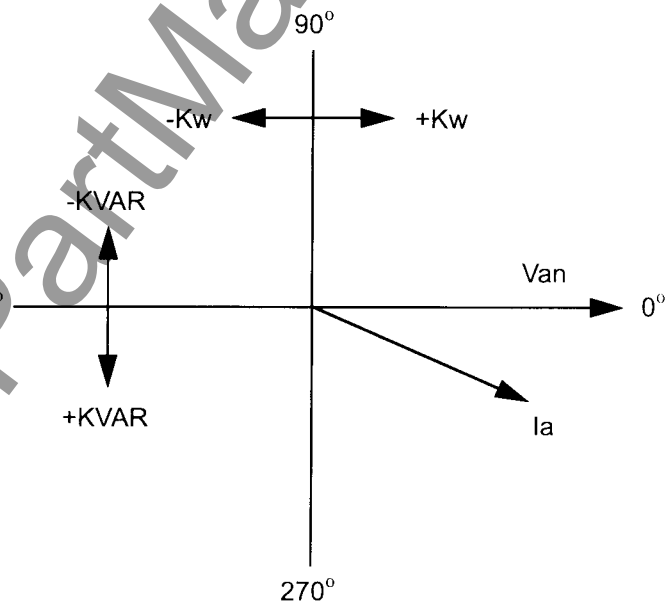
Metering

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 0° phase angle and is used as a reference for the other voltage and current phase angles. The MMI also allows you to scroll through the numerous system parameters listed below.

The metered sequence voltage components of the GPU-2000R (V_1 and V_2) are derived from the line-to-neutral voltages, regardless if the unit is wired in a Wye or Delta configuration. If a balanced condition is assumed:

- In a Delta configuration the angle of the positive sequence voltage (V_1) leads Vab by 330°.
- In a Wye configuration the angle of the positive sequence voltage (V_1) equals Van (V_1 = Van = 0°).

Figure 1. GPU-2000R Metering and Protective Conventions



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 only when VTs are Wye-connected
- Frequency

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 Values

- Maximum and minimum (phase and ground) currents in amperes
- Date and time stamp for maximum and minimum (phase and ground) currents
- Maximum and minimum kilowatts
  - Per phase and 3-phase for Wye VTs
  - 3-phase for Delta VTs
- Date and time stamp for maximum and minimum kilowatts
- Maximum and minimum kiloVARs per phase and 3-phase for Wye VTs; 3-phase for Delta VTs
- Date and time stamp for maximum and minimum 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 6).

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

Figure 2. Man-Machine Interface Metering Display

Below are man-machine interface (MMI) sample screens of the metered load values, demand values and maximum/minimum values captured by the relay

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-B:    165440


I0:       0 ∠ :    0
I1:     320 ∠ :    0
I2:       0 ∠ :    0
kV1: 7.80 ∠ :    0
kV2:      0 ∠ :    0
PF:  0.96      LAGGING
FREQ:          60.00
```

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 protection functions, the GPU-2000R has load profile, oscillographic waveform capture and user-programmable curve, optional features.

Load Profile

An optional load profile feature records per-phase demand kilowatts, demand kiloVARs and line-to-ground voltages. 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". The graph in Figure 4 is a sample of the type of load profile data analysis that can be performed.

On units having the load profile option the Load profile feature is always activated. The sampling time intervals may be changed between 5-, 15-, 30- or 60- minutes in the configuration settings screen of the External Communication Program (ECP).

To download the collected load profile data from the GPU-2000R to your computer: click the "Meter" menu option on the ECP program, From this menu you can select to download all historic load profile records available in the relays buffer "Load Profile-All" or download only the most current load profile record "Load Profile-Last" .

Name and specify the directory and filename for the load profile data file being downloaded and click on the "OK" button to execute this request. It is recommended that the load profile filename have an extension of .dla

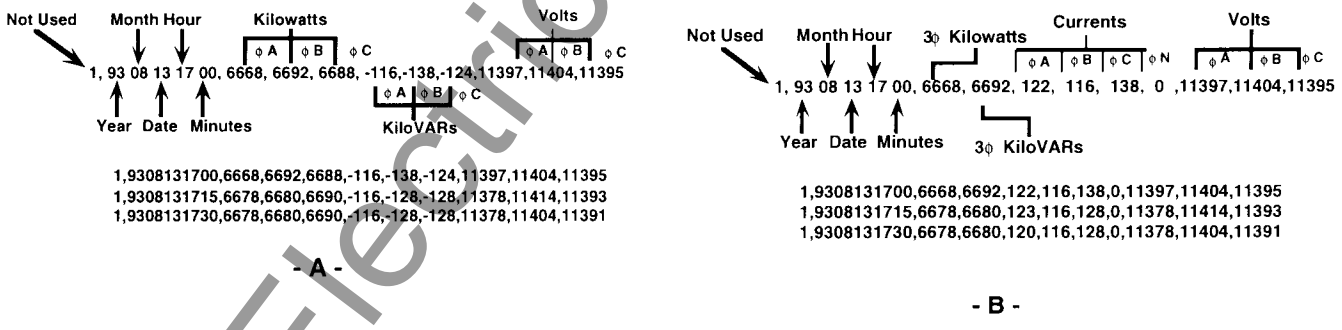


Figure 3. Sample Load Profile

NOTE:
The figure on the right is a sample of a load profile capture that has been generated with Microsoft® Excel to Show magnitudes of per-phase currents and Kwatts.

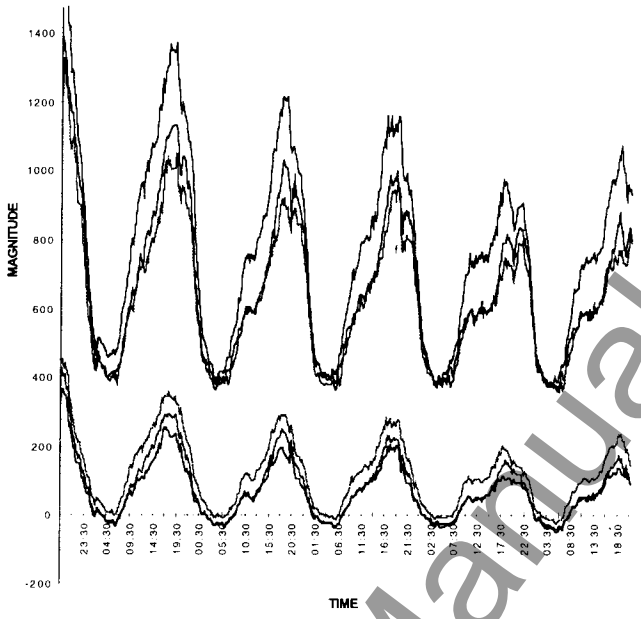


Figure 4. Load Profile Analysis

Oscillographic Data Storage (Waveform Capture)

To enhance disturbance analysis, the GPU-2000R can be furnished with optional 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 GPU-2000R by using the Waveform Capture Menu in the External Communications Program. Fault analysis is enhanced by an Oscillographic Display and Analysis Program that uses a Microsoft® Windows-based Graphical User Interface.

You can program the GPU-2000R 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 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. You can also program the GPU-2000R to trigger the capturing of waveform data on trip of the following functions: 27, 32R, 40, 46Q, 50P, 50N, 51P, 51N, 59, 67P, 67N, 81U1, 81U2, 81O1 and 81O2. 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.

NOTE: Download the captured waveform records to a file before changing any Waveform Capture settings. Changing settings reset the storage buffers. Previous waveform data will be lost.

When Single-Shot Mode is selected, the captured waveform record(s) is not overwritten by additional triggered wave forms. Enabling the single-shot mode stops the waveform capture program when the records are full.

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 GPU-2000R 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.

Retrieving a waveform record functions like the Start Data Accumulation command in single-shot mode. If you have a record already stored and you retrieve two more waveform records, the second retrieved record overwrites the record previously stored.

Saving a Captured Waveform Record

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 GPU-2000R. With CurveGen you can program curves other than the ones currently provided in the GPU-2000R (see Tables 1 and 3). You can manipulate the curves in the time and current domains just like any other curve currently programmed into the GPU-2000R. CurveGen generates all of the necessary variables for the user-defined curves to be stored in the GPU-2000R (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 GPU-2000R 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 GPU-2000R. 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 GPU-2000R. 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 GPU-2000R.

Internal Design

The heart of the GPU-2000R is the digital signal processor (DSP) which is microprocessor optimized for fast calculations based on the sampled data and the central processing unit (CPU). The CPU, a 32 bit processor, performes all the protection algorithms and logical functions. Figure 5 shows a block diagram of the unit.

Processor Specifications

The processing power of the GPU-2000R 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.
- 16-bit analog-to-digital (A/D) converter
- FLASH EPROM stores the CPU's programming.
- DSP RAM—16 K of memory provide temporary storage of DSP's arithmetic values.
- Real-time battery backed-up clock

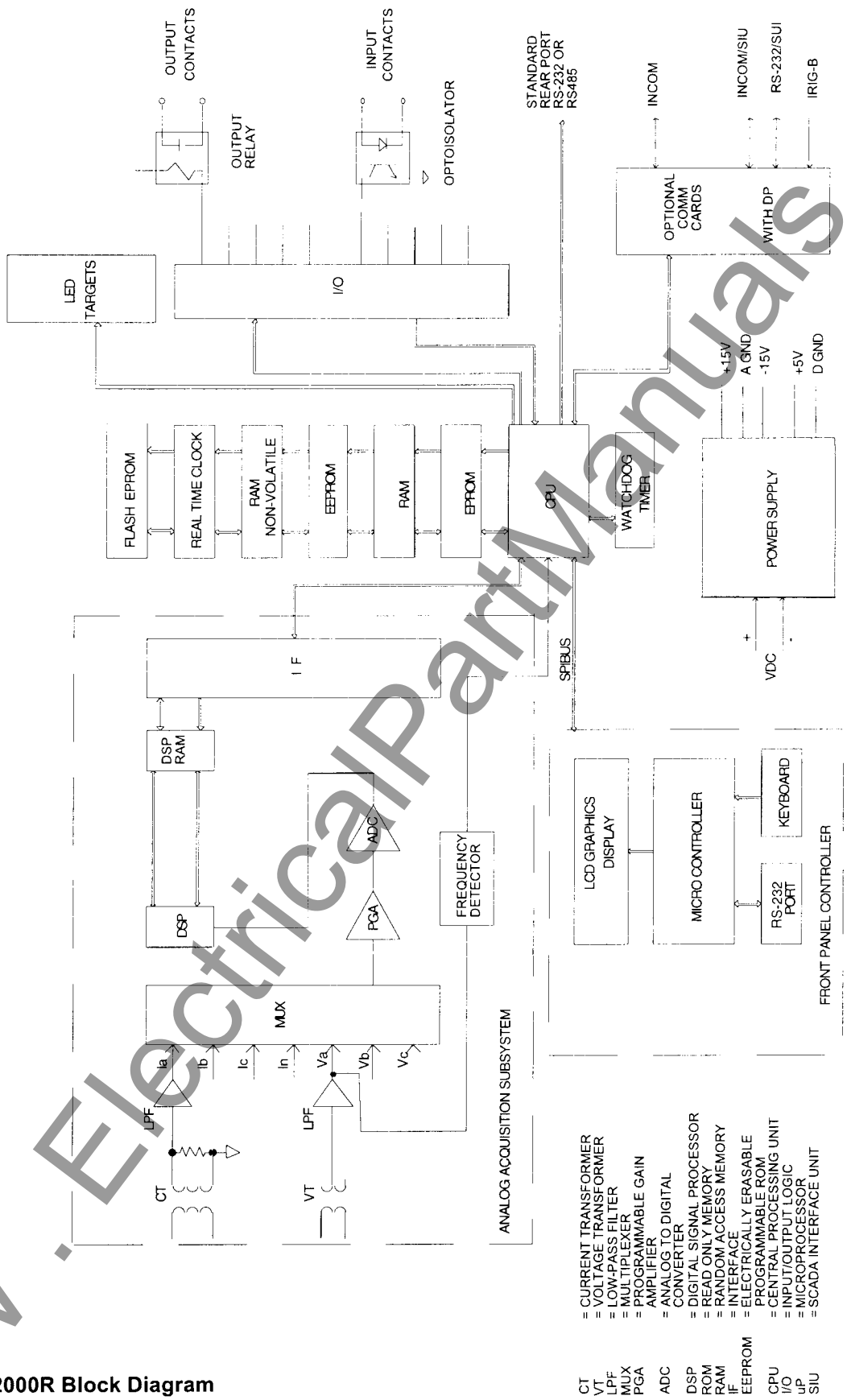


Figure 5. GPU-2000R Block Diagram

Man-Machine Interface (MMI)

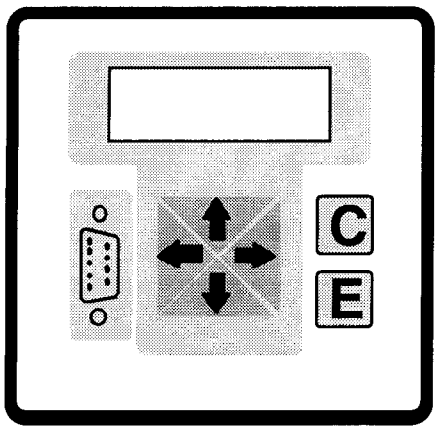


Figure 6. MMI Access Panel

The man-machine interface (MMI) on the front panel consists of a graphics LCD, six push-buttons (keys) and twelve 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. If you hold down the right or left arrow key, the setting value slowly changes. If you press the arrow keys repeatedly, the value changes more rapidly.

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 Demand, Min/Max and Load 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 stored information or settings are lost.

The following displays and menus are available through the MMI:

- Continuous Display—shows currents, voltages and which settings table is enabled
- Post-Fault Display—shows fault currents for last fault until targets are reset

Figure 7. 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
Meter
Settings
Records
```

Display After a Fault Interruption

```
Ia:  3320      Ib:  430
Ic:  420       In:  3310
```

Man-Machine Interface Menus

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

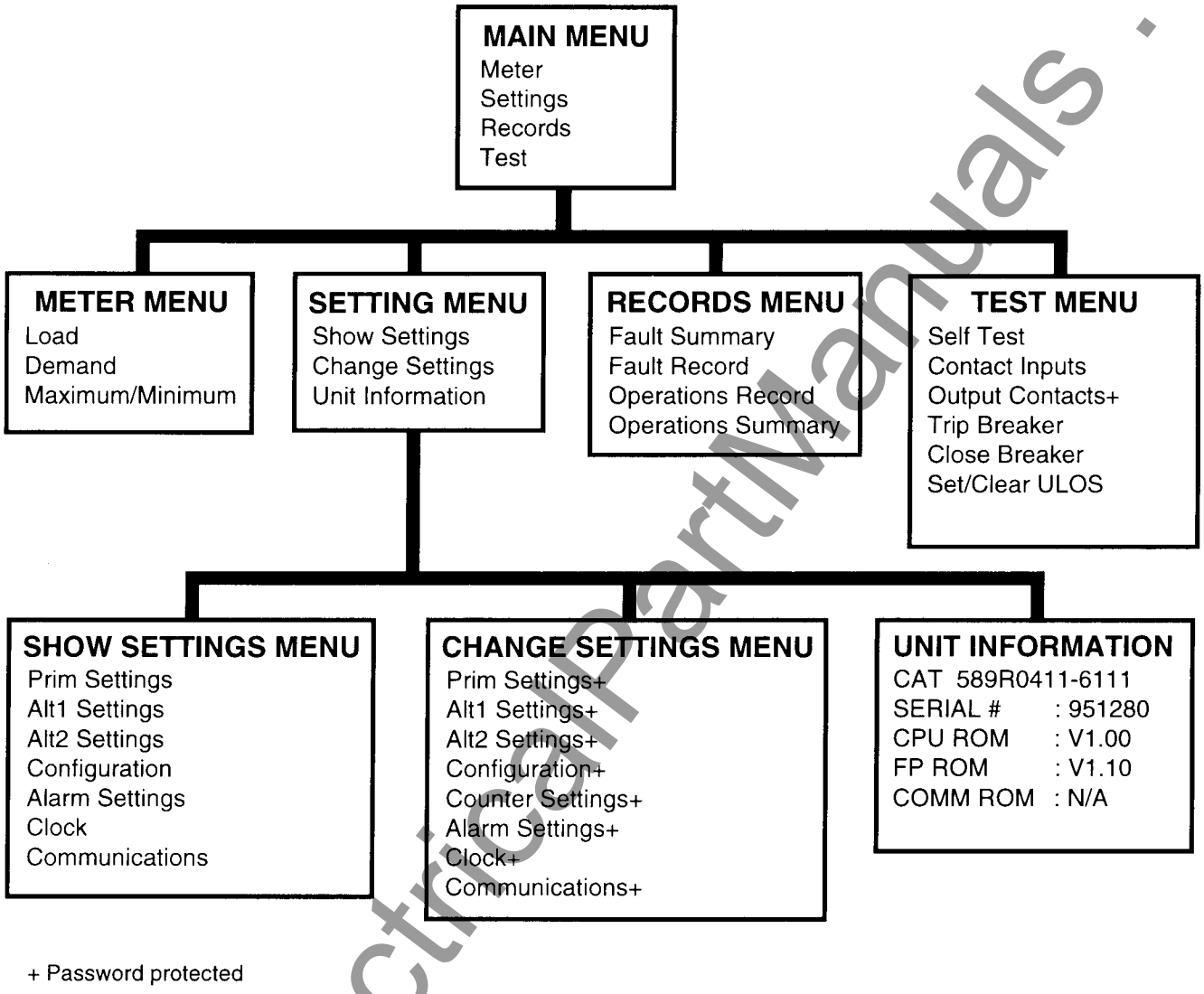


Figure 8. Man-Machine Interface Menus

External Communications Program

The External Communications Program (ECP) provides point-to-point communications with the GPU-2000R relay. By using ECP, you can program the settings for the GPU-2000R's various functions, map logical inputs and outputs and monitor the relay's activity. ECP is a Microsoft™ Windows®-based program and can be copied to your computer's hard drive. To invoke the program, click on the "ecp" icon.

The software can be used without the GPU-2000R relay to explore the capabilities and functionality of the relay. When your PC is not connected to a GPU-2000R 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 transfer to a GPU-2000R. When the PC is connected to a GPU-2000R, the records can be viewed (Get Data From GPU-2000R), saved to a file (Save Data To Disk) and viewed later (Get Data From Disk).

NOTE: 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.

The GPU-2000R has password protection for selected menu items of the unit (Relay Password) in addition to a lower level password protection for the Test Menu and Test SCADA commands. Relay Password allows complete access to a systems administrator. Test Password permits access only to the Test Menu and Test SCADA commands. The Test Password can only be set or changed by a system administrator with Relay Password access.

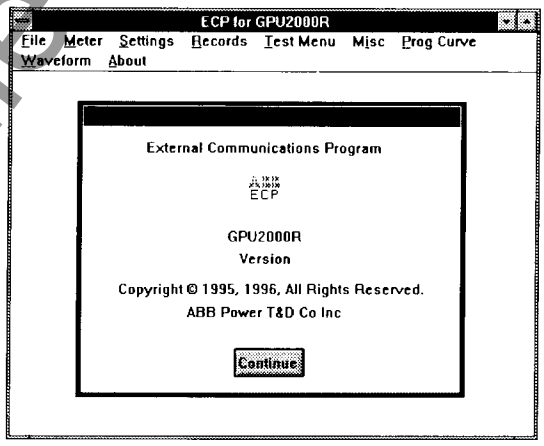
When changing the Configuration Settings through ECP, you must type in four spaces (the factory default password) followed by a carriage return. After entering the password, all other settings can be changed with a carriage return.

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 9-pin null modem adaptor when you connect a PC, via a 9-pin RS-232 cable, directly to the GPU-2000R (not via modems).

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.

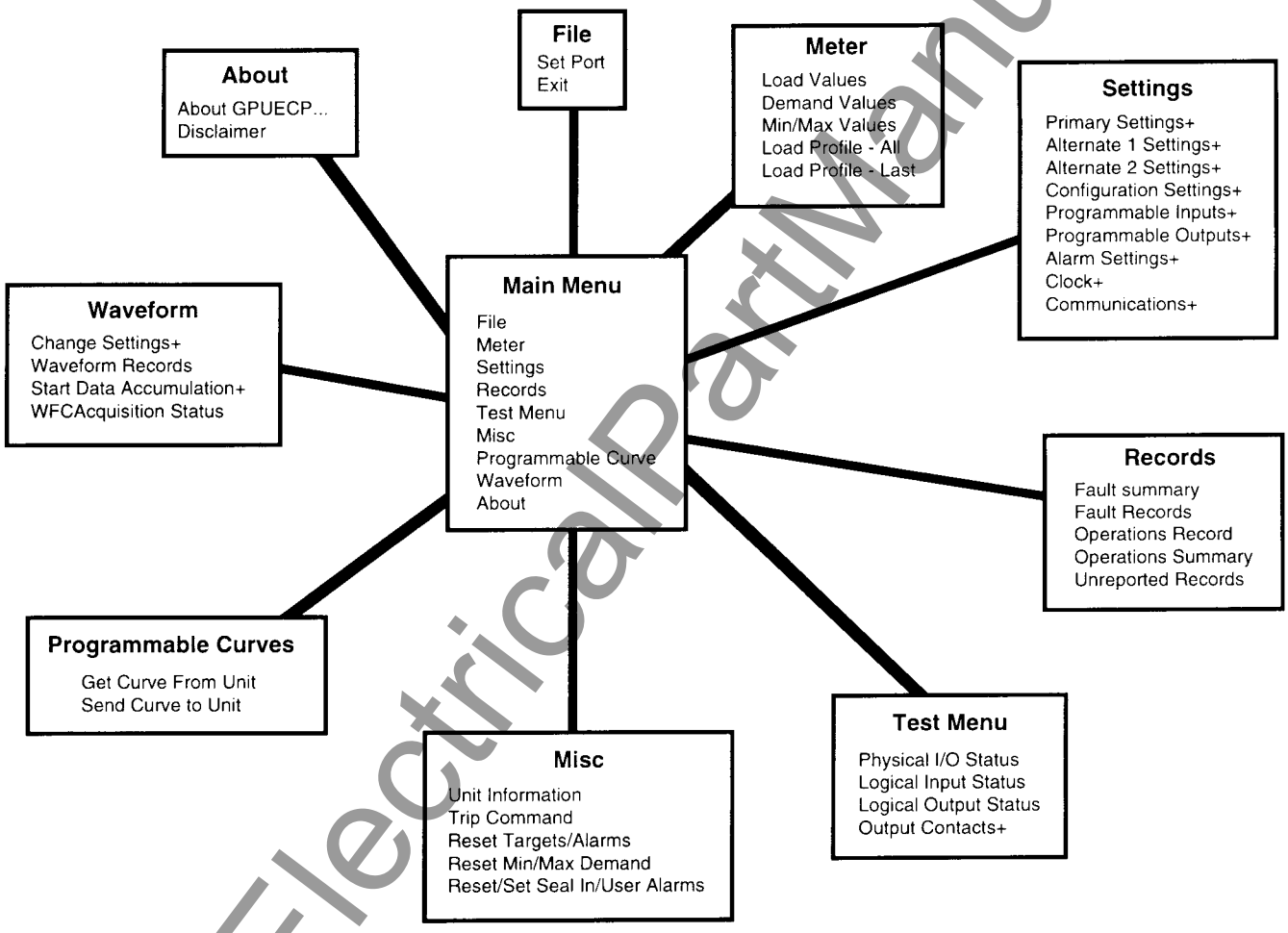
The application program on this disk has been carefully tested and performs accurately with most IBM-compatible personal computers. If you experience difficulty in using the External Communications Program, contact ABB at (610)395-7333.



External Communications Program Menus

Below is an outline of all the menus available through the Windows®-based GPU-2000R 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 5–9 show the specific settings for the GPU-2000R.

Figure 9. External Communications Program Menus



+ Password protected

Table 5. Primary, Alternate 1 and Alternate 2 Settings—*Password Protected*

The following table lists all of the GPU-2000R's protective functions and their specific settings range and step size.

Function	Setting	Range	Step Size	Default
27	Curve selection	Disable or Enable	—	Disable
	Pickup volts	10 to 200 volts	1 volt	10
	Time delay	0 to 60.0 seconds	1 second	0
32R	Curve selection	Disable, Long Time Inverse, Definite Time	—	Disable
	Pickup setting	3% to 50% generator rated power	1%	3%
	Time Dial	1.0 to 10.0	0.1	1.0
	Time Delay	0.1 to 60.0 seconds	0.1 second	0.1 second
40	Curve selection	Disable, Long Time Inverse, Definite Time	—	Disable
	Pickup setting	10% to 200% generator rated power	1%	10%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0.1 to 60.0 seconds	0.1	1.0
	Alarm pickup setting	10% to 100%	1%	10%
	Alarm time delay	0.1 to 60.0 seconds	0.1 second	1.0
46Q	Curve Selection	Disable or Enable	—	Disable
	Pickup setting	5% to 40% generator rated current	1%	5%
	Time Delay Seconds	2 to 40 seconds	0.1 second	2 seconds
	Max. Time	100 to 500 seconds	5 seconds	100 seconds
	Alarm pickup setting	5% to 40% generator rated current	1%	5%
	Alarm time delay	0.1 to 10.0 seconds	0.1 second	10 seconds
50P	Curve Selection	See Table 2	—	Disable
	Pickup setting	50% to 2000% generator rated current	10%	50%
	Time Dial	1 to 10.0	0.1	1.0
	Time Delay	0.00 to 99.9 seconds	.01 second	0.00
50N	Curve Selection	See Table 2	—	Disable
	Pickup setting	50% to 2000% generator rated current	10%	50%
	Time Dial	1 to 10.0	0.1	1.0
	Time Delay	0.00 to 99.9 seconds	.01 second	0.00

Table 5. Primary, Alternate 1 and Alternate 2 Settings — *Password Protected [Continued]*

Function	Setting	Range	Step Size	Default
51P	Curve selection	See Table 1	—	Disable
	Pickup setting	50% to 200% generator rated current	10%	50%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0 to 60.0 seconds	1 second	0
51N	Curve selection	See Table 1	—	Disable
	Pickup setting	50% to 200% generator rated current	10%	50%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0 to 60.0 seconds	1 second	0
51V Voltage control	Curve selection	See Table 1	—	Disable
	Pickup setting	25% to 100% generator rated current	1%	25%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0.1 to 10.0 seconds	0.1	0.1
	Operating voltage	10 to 200 volts	1 volt	10
51V Voltage restraint	Curve selection	See Table 1	—	Disable
	Pickup setting	80% to 200% generator rated current	1%	80%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay seconds	0.1 to 10.0 seconds	0.1 second	0.1 seconds
59	Curve selection	Disable or Enable	—	Disable
	Pickup volts	70 to 250 volts	1 volt	70 volts
	Time delay	0 to 60.0 seconds	1 second	0
67P	Curve selection	See Table 1	—	Disable
	Pickup setting	50% to 200% generator rated current	1%	50%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0.1 to 10.0 seconds	0.1 second	0.1
	Max. torque angle	0 to 355°	5°	0
67N	Curve selection	See Table 1	—	Disable
	Pickup setting	50% to 200% generator rated current	1%	50%
	Time dial	1.0 to 10.0	0.1	1.0
	Time delay	0.1 to 10.0 seconds	0.1 second	0.1
	Max. torque angle	0 to 355º	5º	0

Table 5. Primary, Alternate 1 and Alternate 2 Settings— *Password Protected [Continued]*

Function	Setting	Range	Step Size	Default
81 Select	Selection	Disable, 81-1, 81-2	—	Disable
81U-1/2	Pickup Hz	56.00 to 64.00 Hz, Disable (60 Hz) 46.00 to 54.00 Hz, Disable (50 Hz)	0.01	Disable
	Time Delay	0.08 to 9.98 seconds	0.01	0.08
81O-1/2	Pickup Hz	56.00 to 64.00 Hz, Disable (60 Hz) 46.00 to 54.00 Hz, Disable (50 Hz)	0.01	Disable
	Time Delay	0 to 999 seconds	1	1
81V	Voltage Block	40 to 200 volts	1	40

Table 6. Configuration Settings—*Password Protected*

The following table lists all of the GPU-2000R's Configuration setings and their specific settings range and step size.

Setting	Range	Step Size	Default
Phase CT Ratio	1 – 2000	1	100
Neutral CT Ratio (GRD CT Ratio)	1 – 2000	1	100
VT Ratio	1 – 99.99 for VT Range =LOW	0.01	1
VT Ratio	1 – 2000 for VT Range = HIGH	1	100
VT Connection (VT Conn:)	69 V or 120 V Wye (phase to ground); 120 V or 208 V Delta (phase to phase)	—	120V Wye
Rated Current at 1.0 power factor	2 to 8 Amps (5A CT)	0.1	5
	0.4 to 1.6 Amps (1A CT)	0.02	1
Ground Current	2 to 8 Amps (5A CT)	0.1	5
	0.4 to 1.6 Amps (1A CT)	0.02	1
Trip Failure Time	5 to 60 cycles	1	18
Trip Failure dropout	5 to 90% rated current	1	18
Phase Rotation	ABC or ACB	—	ABC
Protection Mode	Fund(amental) or RMS	—	RMS
Reset Mode (51/67)	Instant (2 cycles) or Delayed	—	Instant
Alternate 1 Settings (Alt1 Set)	Enable or Disable	—	Enable
Alternate 2 Settings (Alt2 Set)	Enable or Disable	—	Enable
Target Display Mode	Last or All (faults)	—	Last
Remote Edit = (Remot Edit)	Enable or Disable	—	Enable
Local Edit (Comm Ports Only)	Enable or Disable	—	Enable
Meter Mode (WHr Display)	kWHr or MWHr (6 Digits)	—	kWHr
Voltage Units	KiloVolts or Volts	—	Kilovolts
Voltage Display Mode	Line-Neutral or Line-Line	—	Line-Neutral
VT Range	Low or High	—	Low
LCD Light	On or Time Out (5 Minutes)	—	On
Unit Identification (ID)	(15 alphanumeric characters)	—	GPU2000R
Demand Meter Constant (Demand Minutes)	5, 15, 30, or 60 minutes	—	15
LCD Contrast	0 to 63	1	32
Change Relay Password	4 Alphanumeric characters	—	4 blank spaces
Change Test Password	4 Alphanumeric characters	—	4 blank spaces

Table 7. Counter Settings —*Password Protected*

The following table lists all of the GPU-2000R's Counter and Alarm settings specific range and step size

Setting	Range	Step Size	Default
KSI Summation A Phase Setting (KSI Sum A)	0 to 9999 (kA)	1	0
KSI Summation B Phase Setting (KSI Sum B)	0 to 9999 (kA)	1	0
KSI Summation C Phase Setting (KSI SumC)	0 to 9999 (kA)	1	0
Overcurrent Trip Counter (OC Trip)	0 to 9999	1	0
Breaker Operations Counter (Bkr Oper)	0 to 9999	1	0
87 Differential Trip	0 to 9999	1	0
Machine Run Time Hours 1	0 to 9999	1	0
Machine Run Time Hours 1	0 to 9999	1	0

Table 8. Alarm Settings —*Password Protected*

Setting	Range	Step Size	Default
KSI Summation [alarm] (KSI Sum)	1 to 9999 (kA)	1	Disable
Over Current Trip Counter [alarm] (OC Trip)	1 to 9999	1	Disable
Phase Demand current alarm	1 to 9999 (A)	1	Disable
Neutral Demand [current alarm] (Neutral Dmnd)	1 to 9999 (A)	1	Disable
Demand 3P-kVar [3-phase kiloVAr alarm] (Dmnd 3P-kVAr)	10 to 99,990 (kVAr)	10	Disable
Low PF [power factor alarm]	0.5 to 1.0 (lagging)	0.01	Disable
High PF [power factor alarm]	0.5 to 1.0 (lagging)	0.01	Disable
Load Current [alarm]	1 to 9999 (A)	1	Disable
Positive kVAr [3-phase kiloVAr alarm] (Pos kVAR)	10 to 99,990 (kVAr)	10	Disable
Negative kVar [3-phase KiloVAr alarm] (Neg kVAR)	10 to 99,990 (kVAr)	10	Disable
Positive KWatt Alarm 1	1 to 9999	1	Disable
Positive KWatt Alarm 2	1 to 9999	1	Disable
Machine Run Alarm 1 (hours)	1 to 9999	1	Disable
Machine Run Alarm 2 (hours)	1 to 9999	1	Disable

Table 9. Communications Settings—*Password Protected*

The following table lists all of the GPU-2000R's communications settings and their spicific range and step size.

Setting	Range	Default
Unit Address	3 hexadecimal characters (0-9 & A-F)	001
Front RS232 Port:		
Baud Rate	300, 1200, 2400, 4800, 9600	9600
Frame	N,8,1 or N,8,2	N,8,1
Rear Port RS232 :		
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 Port RS485 :		
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 Port INCOM Baud Rate*	1200, 9600	9600
Rear Port IRIG-B Enable*	Disable or Enable	Disable
Network Parameters*	0 to 250	0
Network Modes*	Disable or Enable	Disable

* Check catalog number for available communications port options.

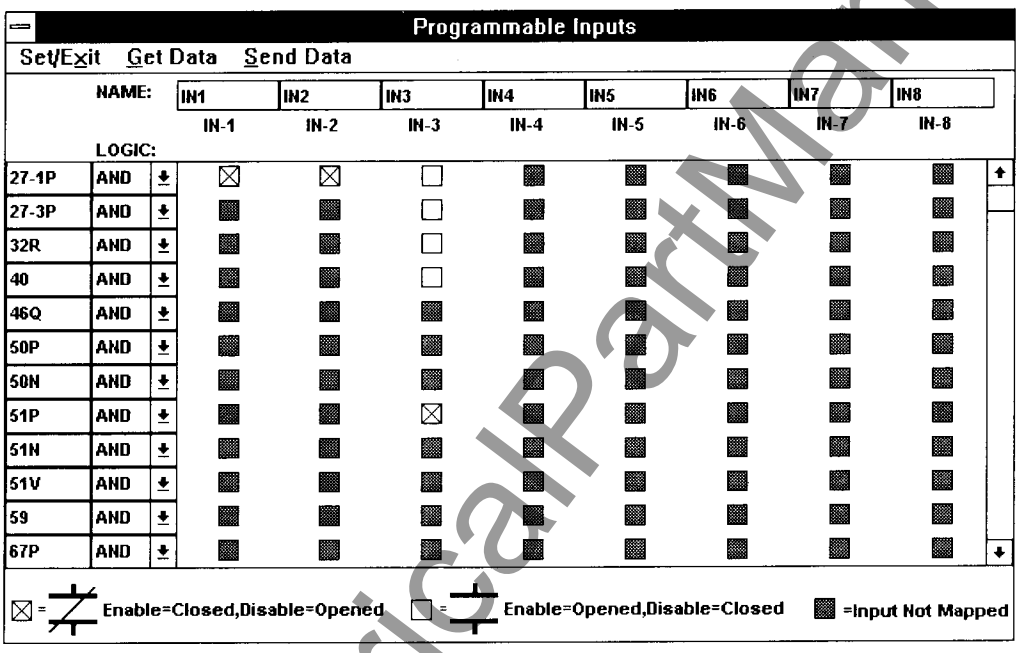
Programmable Input and Output Contacts

By using the External Communications Program, you can individually program certain input and output contacts to a list of available library logic functions (See Table 10) for alarming, protection or control purposes.

Binary (Contact) Inputs

Programmable contact inputs are either single-ended, or double-ended. Single-ended inputs have one terminal connection marked "+" and share a common terminal (# 3) marked "–". Double-ended inputs have two terminal connections, marked "+" and "–". The recognition time for the change in state of an input is two (2) cycles.

These inputs have a continuous dc rating as stamped on the relay's nameplace.



Up to eight user-programmable contact inputs are available. The inputs are programmed via the External Communications Program only.

A box with an "X", refers to a logical input that is enabled (asserted) when control voltage is applied (contact closed) to the physical input and disabled (deasserted) when control voltage is not applied (contact open) to the physical input.

An empty box refers to a logical input that is enabled (asserted) when control voltage is not applied (contact open) to the physical input and disabled (deasserted) when control voltage is applied (contact closed) to the physical input.

Table 10. Programmable Input Functions

This table lists all available library logic functions that can be mapped to the programmable inputs.

Programmable Input Logic	Function Description
27-1P	Single phase undervoltage torque control
27-3P	Three phase undervoltage torque control
32R	Reverse power torque control
40	Loss of excitation torque control
46Q	Negative sequence overcurrent torque control
50P	Phase instantaneous overcurrent torque control
50N	Neutral instantaneous overcurrent torque control
51P	Phase time overcurrent torque control
51N	Neutral time overcurrent torque control
51V	Voltage dependent phase time overcurrent torque control
59	Overvoltage torque control
67P	Positive sequence polarized directional overcurrent torque control
67N	Negative sequence polarized directional overcurrent torque control
81U-1	Step 1 underfrequency torque control
81O-1	Step 1 overfrequency torque control
81U-2	Step 2 underfrequency torque control
81O-2	Step 2 overfrequency torque control
52A	Breaker position (follows breaker's contact)
52B	Breaker position (opposite breaker's contact)
TCM	Trip coil monitoring
ALT1	Enables alternate 1 settings table
ALT2	Enables alternate 2 settings table
ECI1	Event #1 capture initiated data in fault record
ECI2	Event #2 capture initiated data in fault record
WCI	Waveform capture initiate
OPEN	External trip initiate
CLOSE	External close initiate
CRI	Resets overcurrent and differential trip counters
87A	External differential trip phase A
87B	External differential trip phase B
87C	External differential trip phase C
BFI	Breaker fail algorithm external indicate
SYNC	External Synchronous check input
ULI1	*ULI1 - ULI9 allows 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 the user to define user specific functions for the contact inputs that are not specific to the Programmable Input Logic library above.*
ULI2	
ULI3	
ULI4	
ULI5	
ULI6	
ULI7	
ULI8	
ULI9	
CLTRGT	Resets front panel targets
CLSEAL	Resets all sealins logic functions

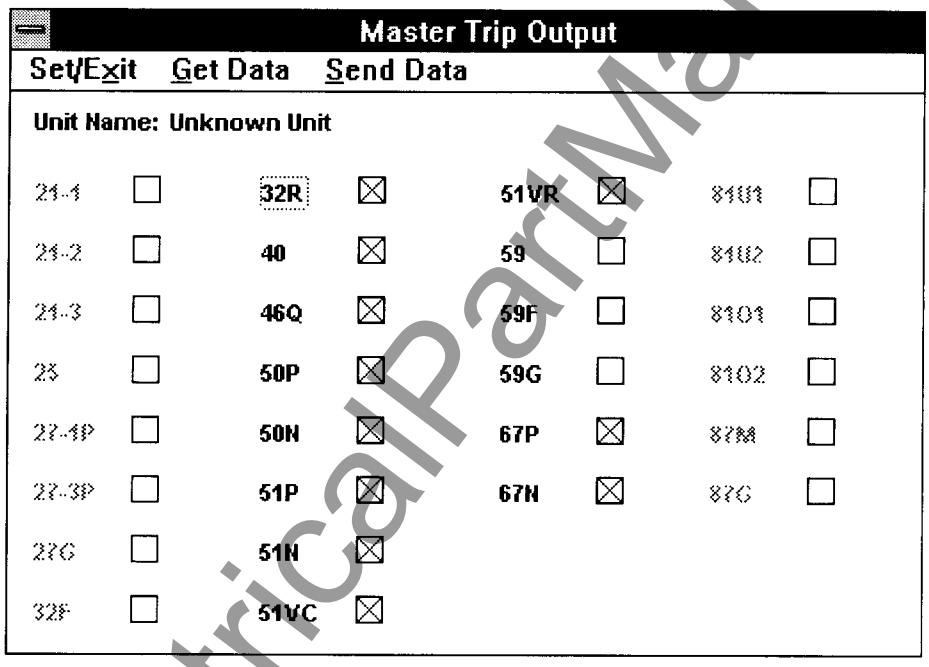
Output Contacts

The relay output contacts are divided into two categories: permanently programmed and user-programmable. Jumpers on the CPU board allow you to choose whether the programmable output contacts are normally open or normally closed.

Permanently Programmed Output Contacts

Permanently programmed output contacts include the following:

- TRIP—The main trip output contact of the GPU-2000R relay (terminal 29 & 30) is programmable for energization on the trip of any of the protective functions available. Those protective functions whose box has an "X" will energize the TRIP contact when that function trips.



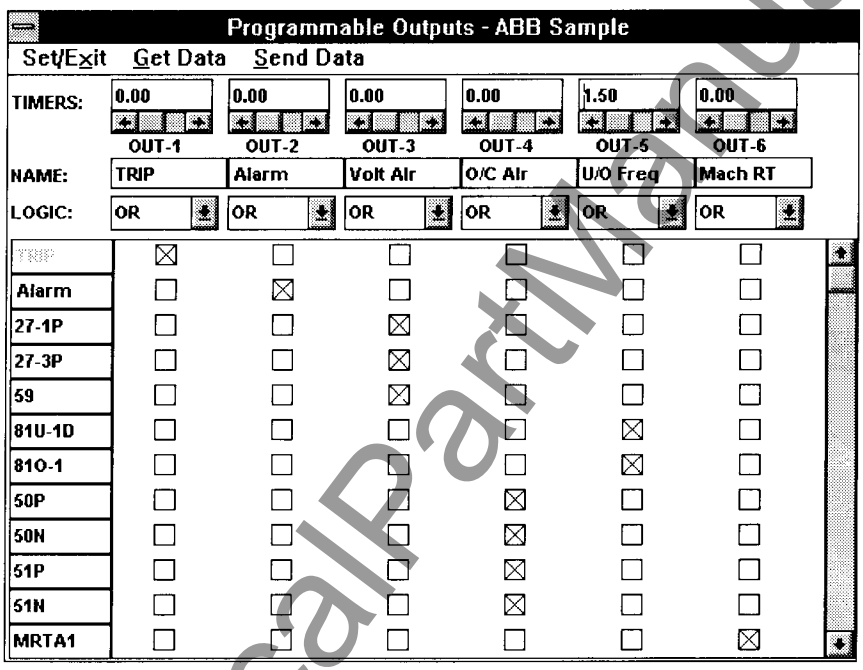
***Bold* Protective Functions** *indicate that these functions are selectable and have been enabled in primary or alternate settings. Greyed functions above are not available in the relay, or have been disabled in primary/alternate functions and are not selectable.*

- 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-diagnostic, the contacts return to their normal state. It is strongly recommended that a contact be connected to a local annunciator light or, if available, to a remote terminal unit.

User-Programmable Output Contacts

Up to six (6) user-programmable output contacts are available. Each of these contacts can be individually programmed for time delay on pickup via the ECP. The time delay interval is adjustable from 0 to 60 seconds in 0.01 steps. You can program the user programmable output to indicate a specific condition by placing an "X" in the box under the output contact(s). Table 11 lists the relay conditions available for programming to an output contact for external indication.

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 the output contacts, the User Logical Outputs can also be wired to the contact inputs. The contact inputs can then be controlled by the INCOM/SCADA communications commands.



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

User Logical Inputs/Outputs

In addition to the factory assigned logic functions above, there are nine aditional "User Logic Input" functions that can be mapped to any input/output contact (See Table 11). The user logical inputs (ULI1 - ULI9) are internally tied to the same numbered user logical outputs (ULO1- ULO9). When the user logical outputs are mapped to an output contact, that contact is controlled by the state of the corresponding user logical input. The state of the user logical input is controlled through either a mapped input contact or SCADA communications commands. When a user logical input is mapped to a contact input, SCADA commands have no effect on that user logical input.

Table 11. Programmable Output Logical Functions

This table lists all available library logic functions that can be mapped to the programmable output contacts.

Programmable Output Logic	Function Description
TRIP	Fixed Trip Output Function
Alarm	Self check alarm
27-1P	Single phase undervoltage trip
27-3P	Three phase undervoltage trip
32R	Reverse power trip
40	Loss of excitation trip
46Q	Negative sequence overcurrent trip
50P	Phase instantaneous overcurrent trip
50N	Neutral instantaneous overcurrent trip
51P	Phase time overcurrent trip
51N	Neutral time overcurrent trip
51VC	Voltage control overcurrent trip
51VR	Voltage restraint overcurrent trip
59	Overvoltage trip
67P	Directional overcurrent (positive sequence) trip
67N	Directional overcurrent (negative sequence) trip
81U-1	Under frequency (first stage) trip
81O-1	Over frequency (first stage) trip
81U-2	Under frequency (second stage) trip
81O-2	Over frequency (second stage) trip
PATA	Phase A target alarm
PBTA	Phase B target alarm
PCTA	Phase C target alarm
40A	Loss of excitation alarm
46QA	Negative sequence overcurrent alarm

Table 11. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
27-1P-D	Single phase undervoltage disable alarm
27-3P-D	Three phase undervoltage disable alarm
32R-D	Reverse power disable alarm
40-D	Loss of excitation disable alarm
46Q-D	Negative sequence overcurrent disable alarm
50P-D	Phase inst overcurrent disable alarm
50N-D	Neutral inst overcurrent disable alarm
51P-D	Phase time overcurrent disable alarm
51N-D	Neutral time overcurrent disable alarm
51V-D	Voltage dependent phase time oc disable alarm
59-D	Overvoltage disable alarm
67P-D	Positive sequence polarized directional overcurrent disable alarm
67N-D	Negative sequence polarized directional overcurrent disable alarm
81U-1-D	Step 1 underfrequency disable alarm
81O-1-D	Step 1 overfrequency disable alarm
81U-2-D	Step 2 underfrequency disable alarm
81O-2-D	Step 2 overfrequency disable alarm
87G-D	Ground differential current disable alarm
87M-D	Machine differential current disable alarm
PUA	Overcurrent pickup alarm
32PA	Directional overcurrent (positive sequence) pickup alarm
32NA	Directional overcurrent (negative sequence) pickup alarm
PDA	Phase peak demand current alarm
NDA	Neutral peak demand current alarm

Table 11. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
BFUA	Blown fuse alarm
KSI	Intterupted kiloampere summation alarm
HPFA	High power factor alarm
LPFA	Low power factor alarm
OCTC	Overcurrent trip counter alarm
STCA	Settings table changed alarm
VarDA	Three phase kVAR demand alarm
PVARA	Positive three phase kVAR demand alarm
NVARA	Negative three phase kVAR demand alarm
LOADA	Load current alarm
Watt1	Three phase kilowatt alarm #1
Watt2	Three phase kilowatt alarm #2
BFA	Breaker fail alarm
TCFA	Trip circuit fail alarm
MRTA1	Machine run-time alarm #1
MRTA2	Machine run-time alarm #2
27-1P*	Single phase undervoltage seal-in alarm
27-3P*	3 Phase undervoltage seal-in alarm
32R*	Reverse power seal-in alarm
40*	Loss of excitiation seal-in alarm
46Q*	Negative sequence overcurrent seal-in alarm
50P*	Phase instantaneous overcurrent seal-in alarm
50N*	Neutral instantaneous overcurrent seal-in alarm
51P*	Phase time overcurrent seal-in alarm

* Seal In Alarm

Table 11. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
51N*	Neutral time overcurrent seal-in alarm
51VC*	Voltage control overcurrent seal-in alarm
51VR*	Voltage restraint overcurrent seal-in alarm
59*	Overvoltage seal-in alarm
67P*	Directional overcurrent (positive sequence) seal-in alarm
67N*	Directional overcurrent (negative sequence) seal-in alarm
81U-1*	Under frequency (first stage) seal-in alarm
81O-1*	Over frequency (first stage) seal-in alarm
81U-2*	Under frequency (second stage) seal-in alarm
81O-2*	Over frequency (second stage) seal-in alarm
PATA*	Phase A target seal-in alarm
PBTA*	Phase B target seal-in alarm
PCTA*	Phase C target seal-in alarm
40A*	Loss of excitation seal-in alarm
46QA*	Negative Sequence overcurrent seal-in alarm
59FA*	Volts/hertz seal-in alarm
ULO1	The User Logical Outputs (ULOs) allow you to operate any of the nine user-programmable OUT-contacts for a function other than those listed. 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.
ULO2	
ULO3	
ULO4	
ULO5	
ULO6	
ULO7	
ULO8	
ULO9	

* Seal In Alarm

Records Menu

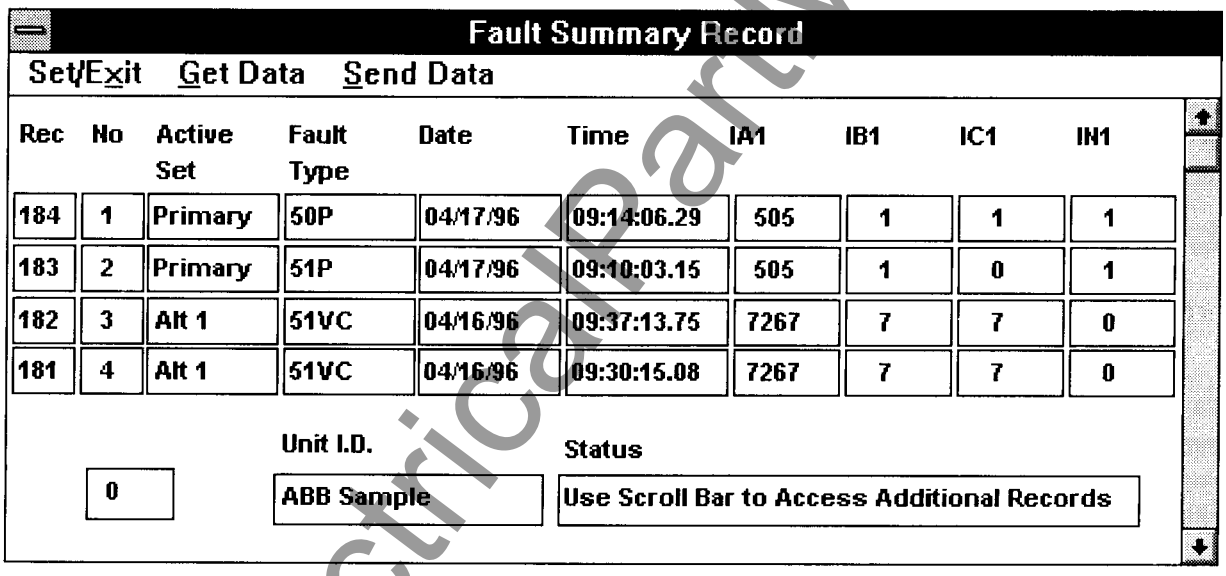
The GPU-2000R provides detailed fault and operations records for analyzing your systems operations.

Fault Summary

The GPU-2000R 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)
- Active settings table
- Fault type
- Date and time
- Phase and neutral currents (magnitude only)

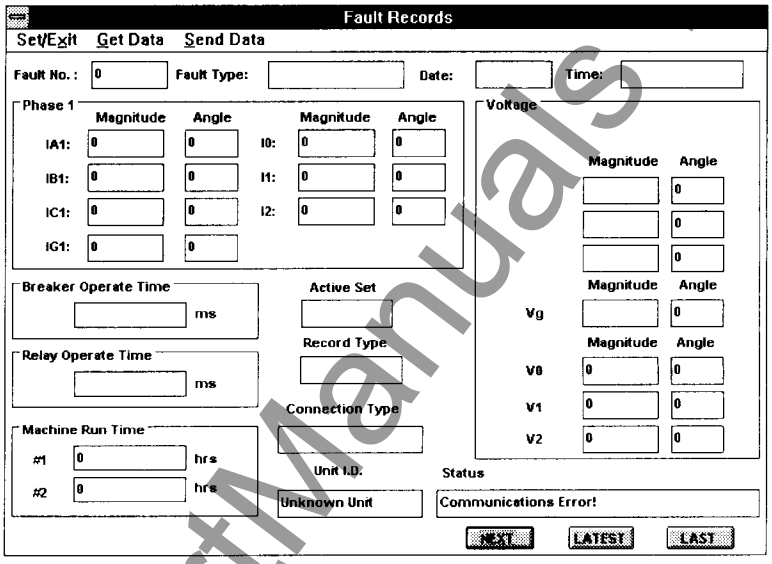
After a fault, the MMI continuously displays the fault currents (magnitude only) until the targets are reset. Save the Fault Summary as a file via the ECP.



Fault Record

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

- Fault number
- Fault Type
- Date and time
- Tripping element
- Relay operate time
- Breaker operate 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)
- Machine run time
- Active settings table
- Record type
- Connection type



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

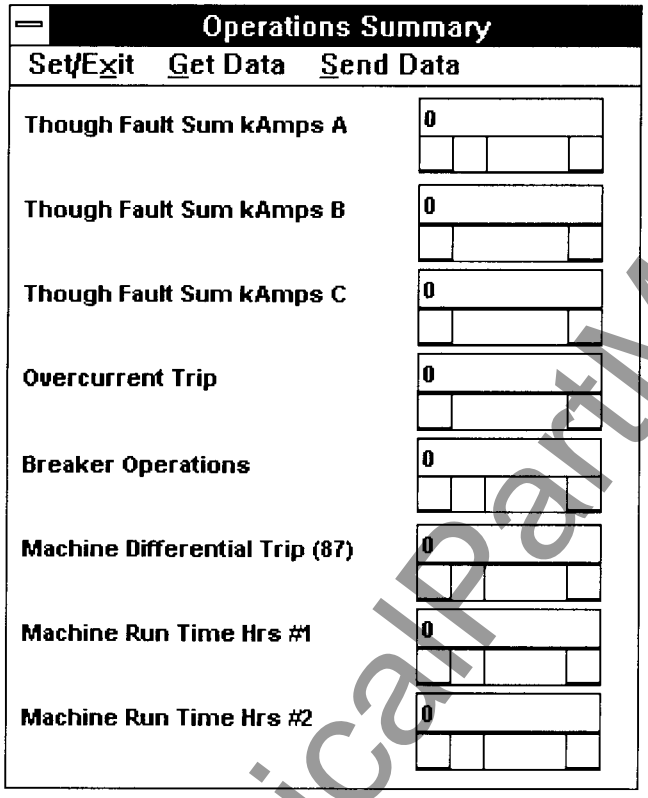
When the operation number reaches 999, the screen resets to 1.

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)

Save the Operations Summary as a file via the ECP.



Unreported Records

When a SCADA application 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 manually view the Unreported Records screen. When either you manually download 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.

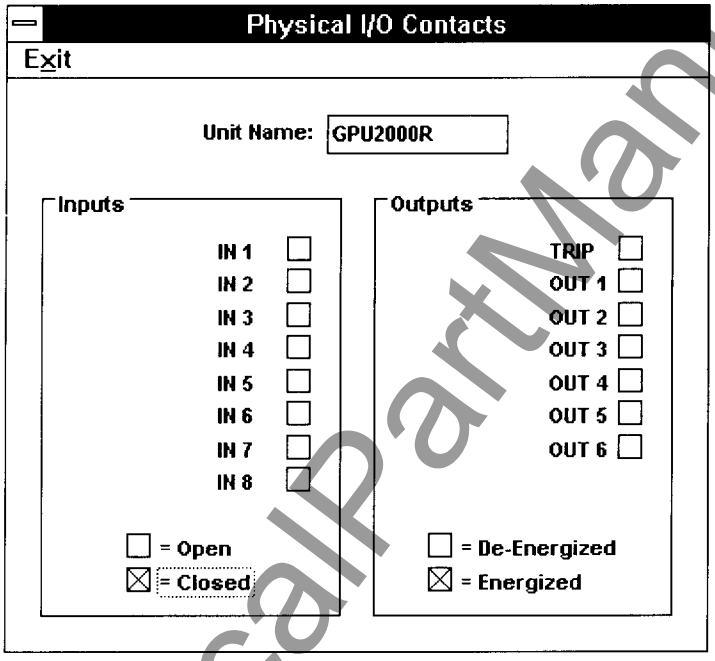
In this manner, the Unreported Records help by showing the faults and operations records that have occurred since the last time SCADA downloaded or you viewed the Unreported Records. The Fault Summary, Fault Record, Operations Summary and Operations Record do not identify which records have been reported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

Test Menu

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

Physical I/O 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 (no voltage applied) and closed (voltage applied) states and to confirm the status of each output relay.

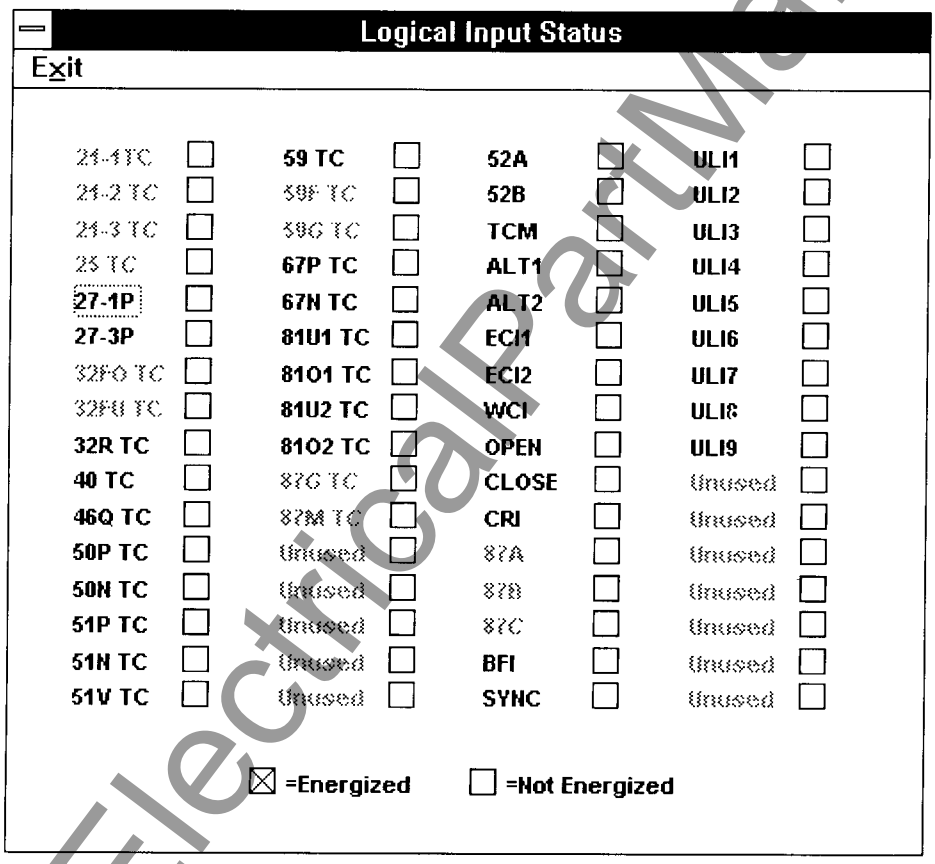


Logical Input/Output Status

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.

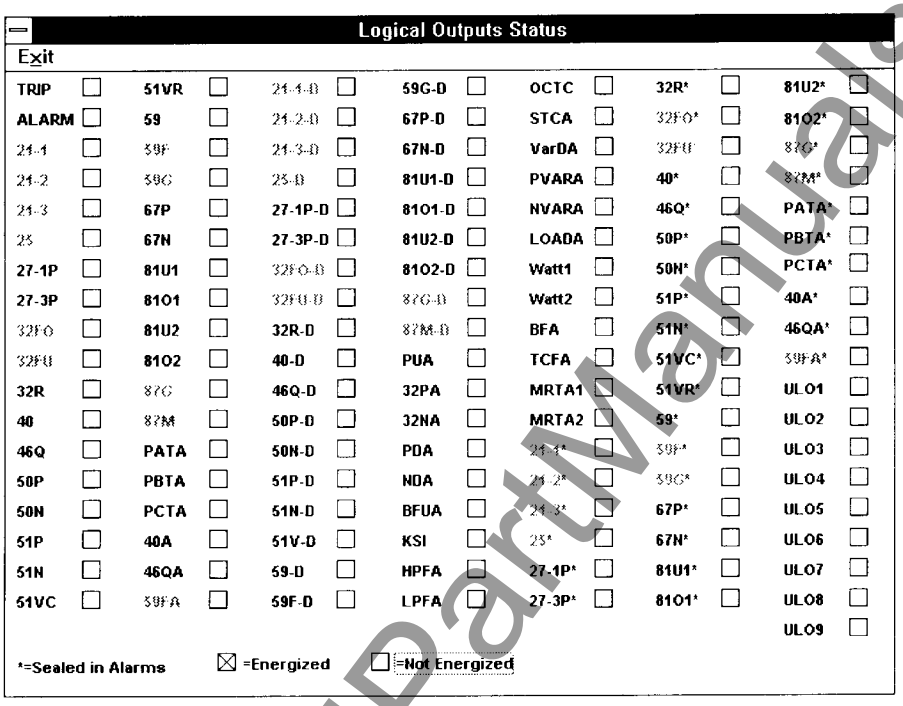
Logical Input Status

The logical input status screen displays which functions are enabled (energized) and disabled (not energized) based on the contact input logic. Use this display to confirm whether or not the input logic is correct and provides the desired results. Assign the desired input functions to contact inputs for the functions to be enabled (asserted).



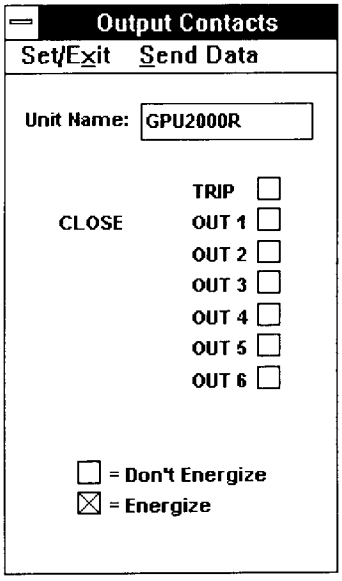
Logical Output Status

The logical output status displays 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. A logical output is energized or set if its box has an "X".



Output Contacts (Password Protected)

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. Place an "X" in the box for the output contact(s) you wish to energize.



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 GPU-2000R. You can also download (receive) curve data from the GPU-2000R 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.

NOTE: Contact factory for availability of the CurveGen program prior to ordering.

Miscellaneous Commands Menu

The Miscellaneous Commands menu lets you:

- View information about the GPU-2000R unit.
- 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. The state of the User logical outputs "ULO" status can only be reset using the Reset alarms menu in the Miscellaneous Commands Menu. The state of the ULO logic is stored in nonvalatile memory and is not lost during loss of control power.

Ratings and Tolerances

The following are the ratings and tolerances of the GPU-2000R.

Current Input Circuits

- 5-A input rating, 16 A continuous and 450 A for 1 second
- 1-A input rating, 3 A continuous and 100 A for 1 second
- Input burden at 0.245 VA at 5 A (1 - 12A range)
- Input burden at 0.014 VA at 1 A (0.2 - 2.4A range)
- Frequency 50 or 60 Hz

Contact Input Circuits Voltage Range

- 19 to 280 Vdc

Voltage Input Circuit

Voltage ratings based on the VT connection configuration setting.

BURDEN

- 0.04 VA for V(A-N) at 120 Vac

VOLTAGE

- **Wye** Connection: 160 V continuous and 480 V for 10 seconds
- **Delta** Connection: 260 V continuous and 480 V for 10 seconds

Contact Input Circuits (Input Burden)

- 2.10 VA at 220 Vdc and 250 Vdc
- 0.52 VA at 125 Vdc and 110 Vdc
- 0.08 VA at 48 Vdc
- 0.02 VA at 24 Vdc

Control Power Requirements

- 48 Vdc model, range = 38 to 58 Vdc
- 110/125/220/250 Vdc models, range = 70 to 280 Vdc
- 24 Vdc model, range = 19 to 29 Vdc

Control Power Burden

24 Vdc = 0.7A max @ 19 V

48 Vdc = 0.35A max @ 38 V

110/125 Vdc = 0.25A max @ 70 V

220/250 Vdc = 0.10A max @ 250 V

Output Contacts Ratings

125 Vdc	250 Vdc
• 30 A tripping	• 30 A tripping
• 6 A continuous	• 6 A continuous
• 0.25 A break inductive	• 0.1 A break inductive

Operating Temperature

- –40° to +70° C

  —*Operating temperatures below –20° C may impede the LCD display contrast.*

  —*Operating temperatures below 0° C may impede Modbus Plus™ communications on units equipped with the Modbus Plus™ communications card (rear port options 6 and 7).*

Humidity

- Per ANSI 37.90, up to 95% without condensation

Transient Immunity

- Surge withstand capability
  - SWC and fast transient tests per ANSI C37.90.1 and IEC 255-22-1 class III and 255-22-4 class IV for all connections except comm or AUX ports
  - Isolated comm ports and AUX ports per ANSI 37.90.1 using oscillatory SWC Test Wave only and per IEC 255-22-1 class III and 255-22-4 class III
  - Impulse voltage withstand test per IEC 255-5
  - EMI test per trial use standard ANSI C37.90.2 - 1995

Tolerances Over Temperature Range of -20° C to +55° C

Function	Pickup	Dropout	Timing (whichever is greater)
51P/51N	±3% of rated current	98% of setting	± 7% or +/-- 16 milliseconds
50P/50N	±7% of rated current	98% of setting	± 7% or +/-- 16 milliseconds
46P/67N	±3% of rated current	98% of setting	± 7% or +/-- 16 milliseconds
67N	±3% of ground rating	98% of setting	± 7% or +/-- 16 milliseconds
27/59/81V	±3% of rated current	99.5% of setting	± 7% or +/-- 16 milliseconds
81	± 0.01 Hz	± 0.01 Hz	± 1 cycle
Ammeter	± 1% of Phase: rated current. Gnd: ground rating		
Voltmeter	± 1% of VT Connection setting		
Power Meter	± 2% of I xV, rated current X rated voltage		
Frequency	± 0.01 Hz		

Dielectric

- All circuits to ground except INCOM™, Modbus Plus™, and non-isolated RS232 ports

  2828 VDC for 60 seconds. (Equivalent to 2000VAC)
- INCOM™ Circuit to ground

  2121VDC for 60 sec (Equivalent to 1500VAC)
- Modbus Plus™ Circuit to ground

  1414 VDC for 60 sec (Equivalent to 1000VAC)

Weight *(GPU-2000R unit)*

- Unboxed 5.36 kg (11.80lbs)
- Boxed 5.67 kg (12.51 lbs)

Installation

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

Receipt of the GPU-2000R

When you receive the GPU-2000R, 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.

Before installing the unit, it is suggested that the following procedures be performed:

On units equipped with an MMI

- Power up the relay. The LEDs should light and a slight clicking sound will be heard.
- Using the arrow keys, go to the Main Menu, scroll to Settings, press <E>, scroll to Unit Information, press <E>. Verify unit information against rear panel nameplate.
- Press <C> to return to the Settings menu, scroll to Show Settings, press <E>. Check default settings against the tables supplied in this manual.
- After checking the default settings, press <C> twice to return to the Main menu. Scroll to Test and press <E>, at the Self Test selection, press <E>. The unit will self test.
- After performing the self test, press <C> twice to return to the Main menu. Scroll to Settings and press <E>, in the Settings menu, scroll to Change Settings and press <E>. In the Change Settings menu, scroll to Clock and set the unit clock.
- Press <E> to enter the correct time and return to the Change Settings menu.
- Set the PASSWORD by scrolling to Configuration and press <E>. At the Password prompt, press <E> again. Once in the Change Confi Sett menu, scroll to Relay Password and enter a password. This will be the main password for entry to the unit. Press <E> to enter the password and return to the Change Confi Sett menu. Scroll to Test Password and enter a different password. This password allows low level entry to the Test options of the unit.

WARNING: If the password entered in the Relay Password section is lost or forgotten, the unit cannot be accessed. If this situation occurs, contact ABB Allentown immediately.

On units not equipped with an MMI, connect a PC to the RS-232 port on the front of the unit and use the ECP (External Communication Program) and follow the same process as outlined above.

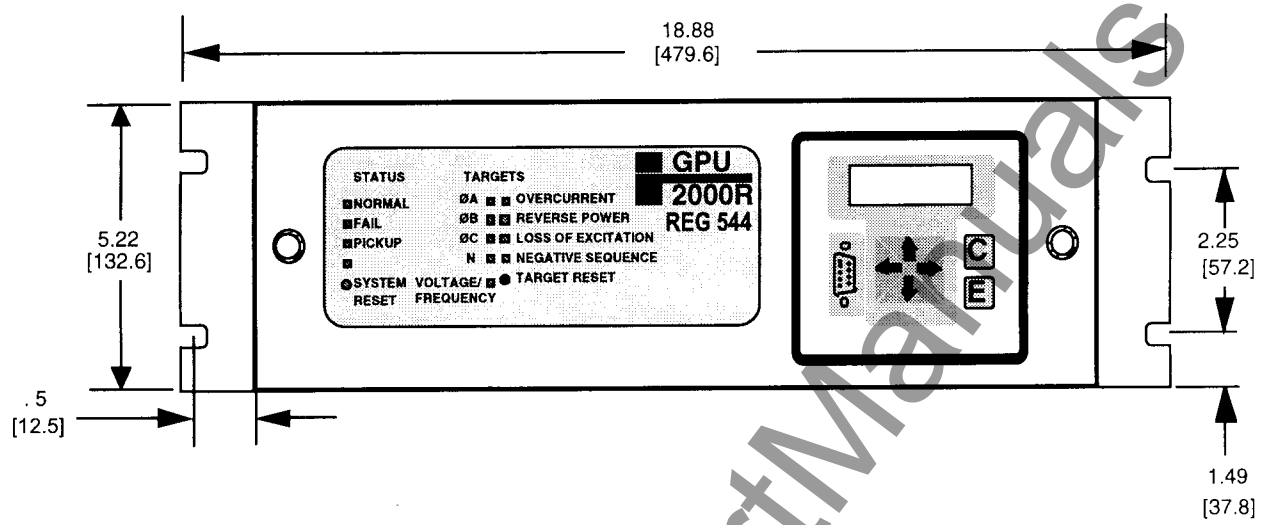
Installing the GPU-2000R

The GPU-2000R is enclosed in a standard 3U (3 unit high rack), 19 x 5-inch case designed for rack mounting or panel mounting. Figure 10 shows the dimensions of the GPU-2000R and Appendix I shows the dimensions of the Bezel assembly

For panel mounting applications, it is recommended that the Bezel assembly be used. See Appendix I.

Case Dimensions (Standard 19" Rack mount 3 units high)

Dimensions are in: inches
[millimeters]



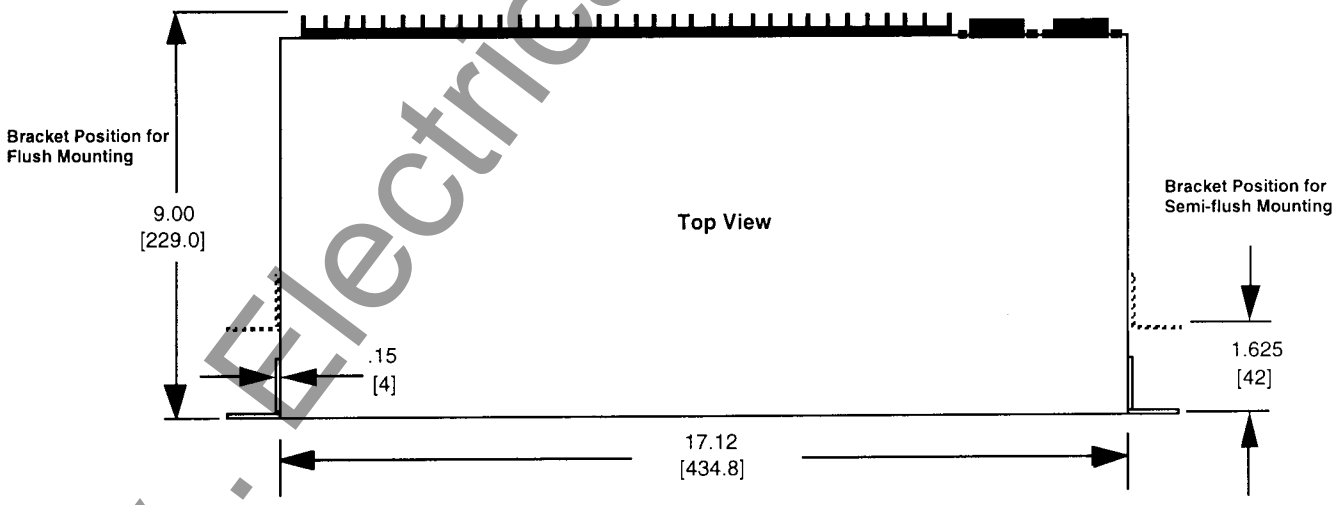


Figure 10. Dimensions

Rear Terminal Block Connections

Wire the current and voltage transformers to the corresponding phase terminals located on the rear of the relay. Phase rotations of "ABC" or "ACB" are internally compensated for with software. If your system is configured as "ACB", set the "Phase Rotation" setting to "ACB" in the configuration setting menu.

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.

With exception of the CTs and burden board, you can totally withdraw the GPU-2000R from its case even while the unit is energized.

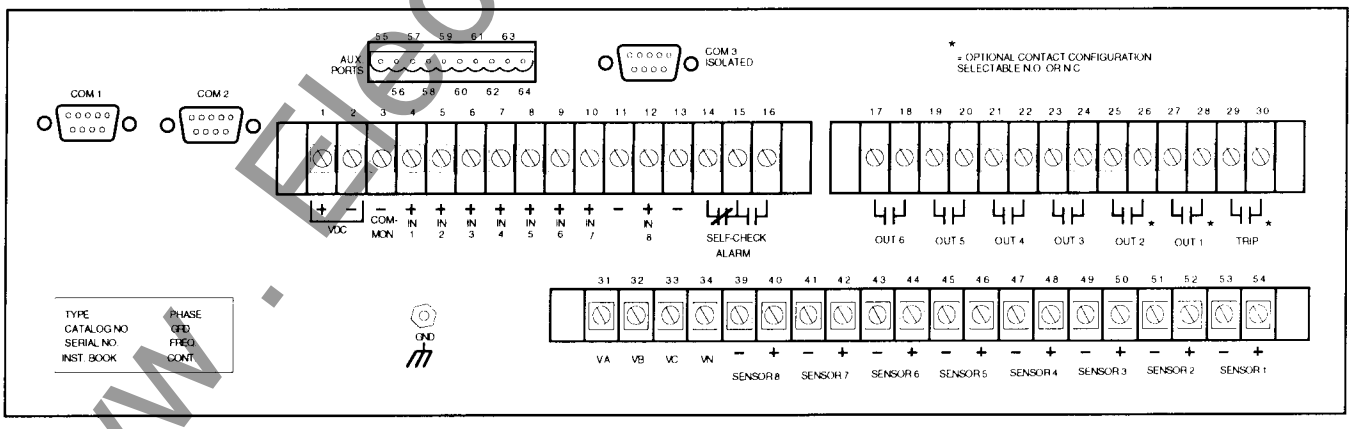
Table 12 lists the minimum required connections for a functioning system. Optional connections are shown on the bottom of the table. Jumper #6 located on the main processor board near the output contacts sheild is used to set the TRIP Output Contact to Normally Open or Normally Close. Use jumper J7 to convert Out 1 and J8 to convert Out2 to normaly open or closed.

You can use inputs IN7 or IN8 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.

Table 12. Minimum Connections

Required Connections	Terminals
Control Voltage Input	Positive: 1, Negative: 2, Common Negative: 3
Current Inputs	Sensor 1 (Ia): 54 & 53; Sensor 2 (Ib): 52 & 51; Sensor 3 (Ic): 50 & 49; Sensor 4 (In): 48 & 47
TRIP Output Contact	29 & 30 configurable for N.O./N.C. Jumper # J6
SELF-CHECK ALARM Output Contacts	15 & 16 N.O.; 14 & 15 N.C. (GPU-2000R powered down)
Optional Connections	**Terminals**
Voltage Inputs	VA: 31; VB: 32; VC: 33; VN: 34

Figure 11. Rear Terminal Block



NOTE:

See the terminal connection figure 11 for additional output contacts

The Current Transformers may also be positioned in the return leads of the generator

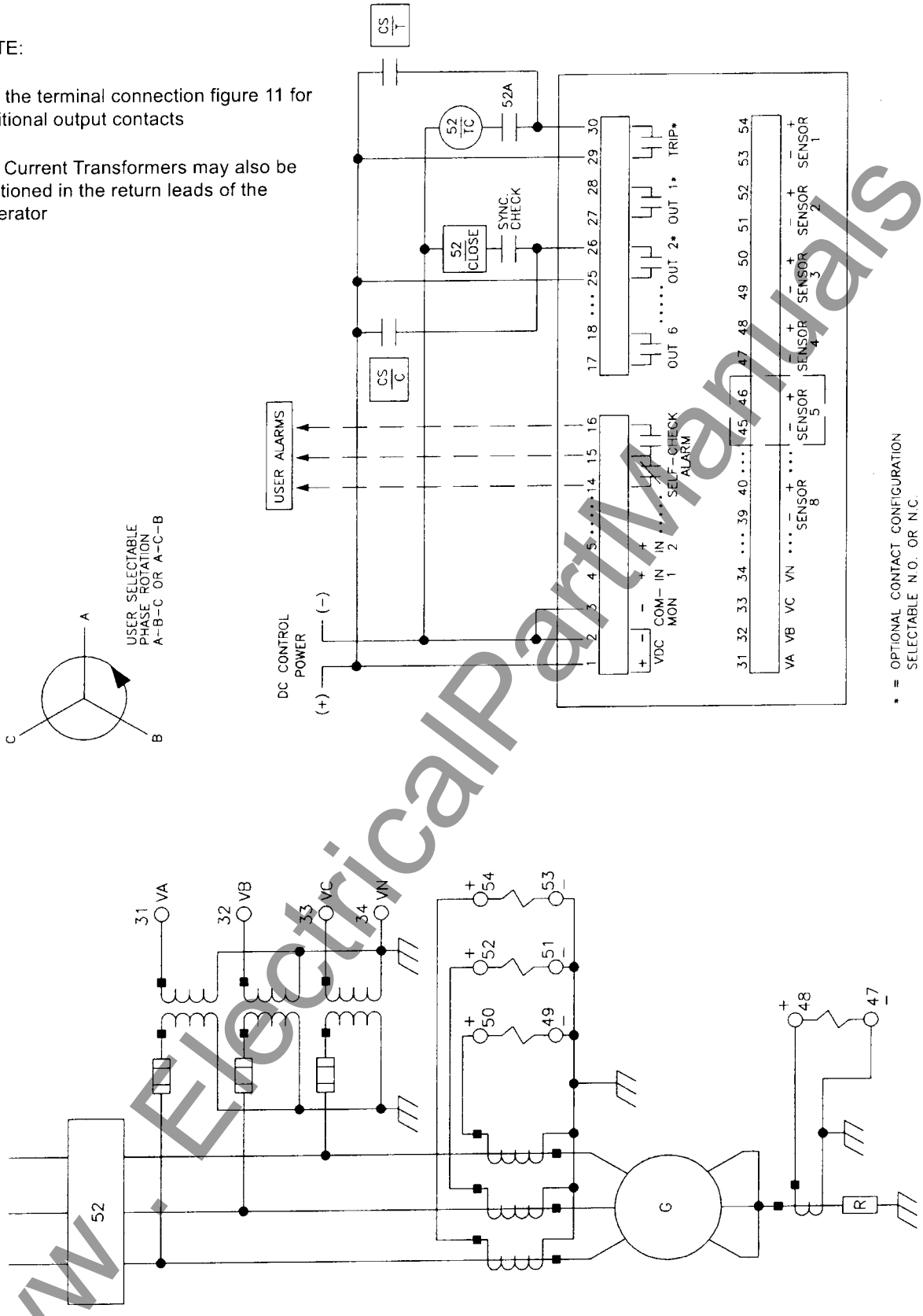


Figure 12. Connection Diagram Using Wye Connected Potential Transformers

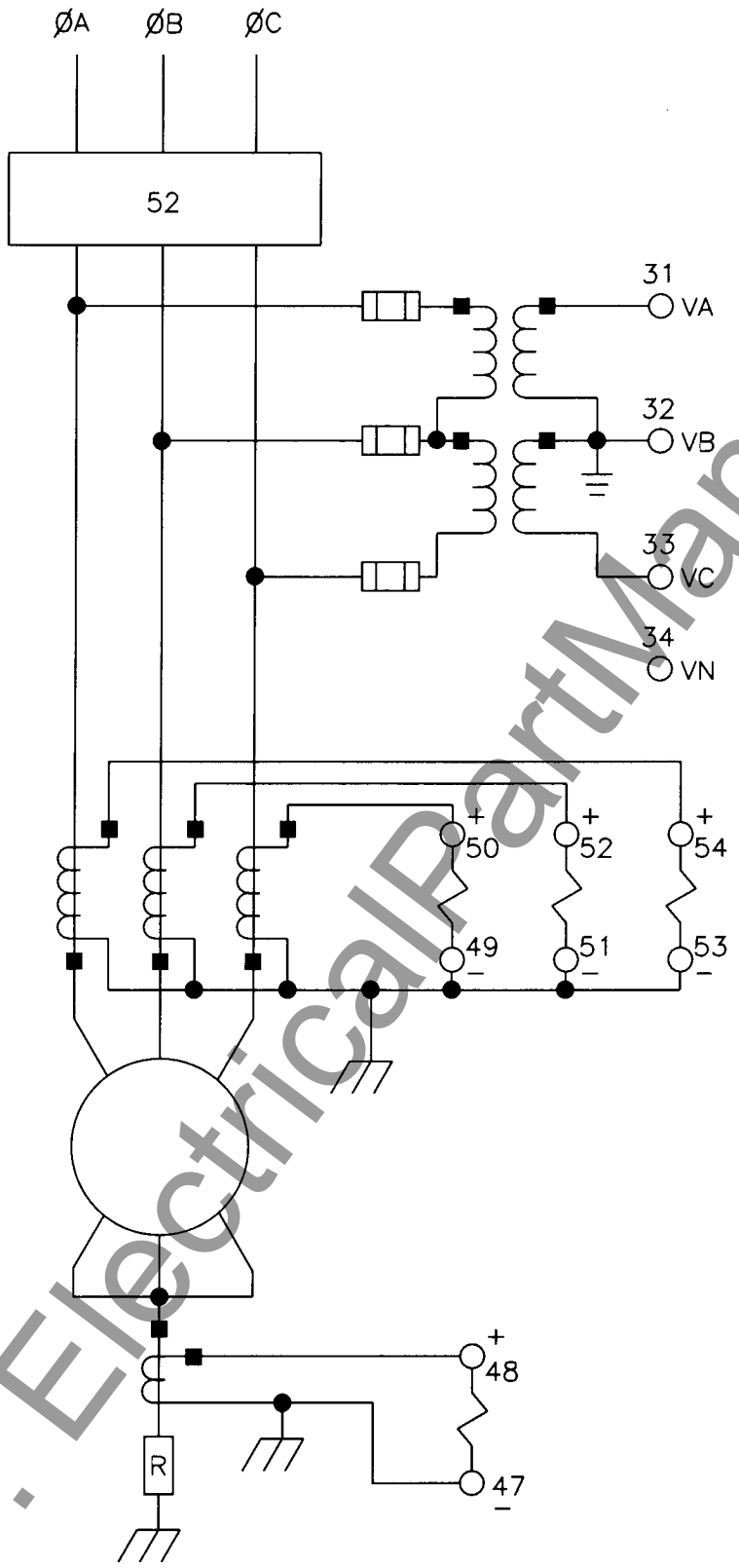


Figure 14.: Connection Diagram Using Open-Delta Potential Transformer Configuration

Communications Ports

The GPU-2000R has a standard 9-pin RS-232C interface on the front for serial port communications. You can connect a computer to this port. There is also at least one serial port on the rear of the unit. Additional ports are optional. Rear Port arrangements are shown on Page 101.

RS-232 ports are available in two different configurations, Isolated and Non-Isolated. Isolated ports provide isolation between the communication port and the rest of the relay.

These rear port options, called Auxiliary Communications ports, can be isolated 9-pin RS-232C, 3-wire RS-485, 2-wire INCOM, IRIG-B, or SCADA Interface Unit (SIU) connections. Because the hardware termination for all these options is on every GPU-2000R, you must refer to the catalog number on the rear 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 2000R series also features ABB's innovative RS-485 isolated communications capability available when the optional Auxiliary Communication board is installed. This isolated RS-485 configuration provides superior communication quality recommended for applications in areas of high electrical noise or that require connecting cables longer than 10 feet (3m).

The GPU-2000R 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 GPU-2000R via the following protocols:

- ASCII—a protocol available through the front RS-232 and rear RS-232/RS-485 ports
- SPACOM—a protocol available through the Auxiliary Communications port
- INCOM®—a two-wire communications system and protocol
- IEC870-5 (DNP3.0)—a protocol available through the Auxiliary Communications port
- Modbus Plus™—a token ring network capable of high speed communication (1 Mb/sec)
- Modbus™—a master slave address structure used in communicating with intelligent devices

Pin Connections

The pin connections for the various communications ports are shown in Tables 13 and 14.

Table 13. 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 and standard rear ports have signal ground tied to the chassis. There is an optional RS-232 rear port where both data and signal ground are fully isolated.

Table 14. RS-485, INCOM, SIU and IRIG-B Pin Connections

Pin Number	Pin Definition
64	IRIG-B Minus
63	IRIG-B Positive
62	INCOM
61	INCOM
60	+5 VDC at 100 milliamperes
59	Direction minus
58	Direction positive
57	RS-485 common/VDC return
56	RS-485 minus or SIU minus (aux. comm. port)
55	RS-485 positive or SIU positive (aux. comm. port)

RS-485 Port

The RS-485 port on the GPU-2000R 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 terminating resistor, the RS-485 printed circuit board in the GPU-2000R has jumper J6. Use an ABB RS-232 to RS-485 Converter Unit (catalog no. 245X2000) to connect a network of GPU-2000R'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 GPU-2000Rs to a central communications center upto several miles away. If the converter unit is not at the end of the network, you must remove its terminating resistors.

The RS-485 cable should be a shielded twisted pair cable with the shield grounded at one end of the communications circuit, preferably where the RS-485 circuit begins, i.e., at the converter unit.

To reduce noise on the bus when no units are transmitting, one set of pull-up and pull-down resistors (jumpers J7 and J8 on the Communications Board) must be set to the "in" position on one end of the network. If the ABB converter, without its terminating resistors removed, is used at the end of the network, all GPU-2000Rs on that network must have J7 and J8 set to the "out" position. If an alternative to the ABB converter unit is used a pull up and pull down resistor may be needed (Jumper J7 and J8 (in)) at one end of the network.

Communications Settings

Change communications settings via the man-machine interface (MMI) on the front of the GPU-2000R or through the ECP. 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 all communications settings, such as baud rate, data bits, parity and stop bits. You can change settings locally or remotely. If you use a computer or modem to change the settings, be certain that the communications settings on your equipment match those of the GPU-2000R.

Set the communications settings (baud rate, [parity, data bits, stop bits]) for the front and rear ports as follows:

- Front port: 300, 1200, 2400, 4800, or 9600 [n, 8, 1 or n, 8, 2]
- Rear port: 300, 1200, 2400, 4800, 9600, or 19,200 [n, 8, 1, or n, 8, 2 or e, 8, 1 or odd, 8, 1 or e, 7, 1 or n, 7, 2 or odd, 7, 1].

Maintenance and Testing

Because of its continuous self-testing, the GPU-2000R 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 number.

High-Potential Tests

High-potential tests are not recommended. If a control wire insulation test is required, completely withdraw the GPU-2000R from its case and perform only a DC high-potential test. (Surge suppression capacitors make it imposible to do AC testing with the unit connected to the external wiring)

Withdrawing the GPU-2000R Electronics from the Case

The GPU-2000R can be disassembled to install optional equipment or to change jumper settings of the selectable output contacts between normally open (NO) and normally closed (NC).

With exception of the internal CTs and burden board, you can totally withdraw the GPU-2000R from its case. The CT's are not open circuited when this is done.

Follow these steps to disassemble the unit:

WARNING: Removal of the relay from the case exposes the user to dangerous voltages. Use extreme care. Do not insert hands or other foreign objects into the case.

1. Loosen the knurled screws on the face of the GPU-2000R and gently remove the face and attached circuit board by grasping the knurled screws and pulling the unit straight forward. Pulling the board out at an angle or otherwise stressing the board on extraction may damage the unit. Once removed from the case, position the unit face down on a static secured mat.

2. Install the desired options according to the instructions provided with those options. The output relays are on the top-left-rear section of the board (when viewed from the front) under the metal shield. Movable jumper links alongside the output relays set the selectable output contacts to normally open (NO) or normally closed (NC). To access the jumper links it is necessary to remove the shield, which is secured by a screw and 1/4" PCB mounting stud. If an AUX COM board is installed, it is necessary to rwithdraw the unit from its case completely to allow access to the shield.

3. To reinstall the unit into the case, carefully align and insert the lips on both sides of the board into the guide rails on the inside walls of the case and gently push the unit straight inward until it fully seats in the case. Secure the knurled screws.

Installing Software Revisions

You can install new software by connecting a PC to the GPU-2000R and downloading the software from the PC to the GPU-2000R. It is not necessary to open the unit to update software. Refer to Appendix G for instructions on downloading software.

System Verification Tests

In addition to the continuous internal self-diagnostics, you can perform routine hardware tests to verify that the GPU-2000R 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.

GPU-2000R Acceptance Tests

Required Equipment

- Active 3 phase AC voltage with variable frequency and 3 phase current source with timer.
- IBM or compatible computer with available serial port and null modem communications cable.

Three phases of current are required for accurate measurement of Watts, VARs, and power factor during the Metering, Reverse Power, and Loss of Excitation tests. All other tests can be performed with a single phase of current that is moved to test all current inputs in the relay.

Settings

The following tests were written to verify proper relay operation after it is received from the factory. They are assumed to be performed on the factory default settings. TABLE 15 lists the factory default PRIMARY and TABLE 16 the default CONFIGURATION settings to be tested. Some settings in the GPU-2000R will not be listed in the tables and do not affect the test. To down load factory settings to an in-service unit for testing see "Saving and Downloading Settings Section".

Refer to Figures 13-15 in this section for test connections.

Table 15. Primary Settings

Factory Default Settings

FUNCTION	SETTING	DEFAULT
27	Curve Selection	Disable
	Pickup Volts	10
	Time Delay	0
32R	Curve Selection	Disable
	Pickup VA	3%
	Time Dial	1.0
40	Curve Selection	Disable
	Pickup VA	10%
	Time Dial	1.0
46Q	Curve Selection	Disable
	Pickup A	5%
	Time Delay	2 sec
	Max. Time	100 sec
50P	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
50N	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
51P	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
51N	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
51VC	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
51VR	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
59	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
67P	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
67N	Curve Selection	Disable
	Pickup A	50%
	Time Dial	1.0
81	Curve Selection	Disable
81U-1	Pickup Hz	Disable
81O-1	Pickup Hz	Disable

Table 16. Configuration Settings

SETTING	DEFAULT
Phase CT Ratio	100
Neutral CT Ratio	100
VT Ratio	1.00
VT Connection	120V Wye
Rated Current	5
Ground Current	5
Phase Rotation	ABC
Remote Edit	Enable
V Display Mode	Line-Neutral
VT Range	Low

Saving and Downloading Settings

Saving Factory Settings to a File:

1. With an IBM PC or compatible computer, load and execute the GPU-2000R External Communication Program (ECP). Do not connect the PC to the GPU-2000R at this time.
2. Press "Continue" after reading header.
3. The "Communications Options" menu should appear. It should read:

Serial Communications Port:	COM1 (or whichever will be used on your PC)
Baud Rate:	9600
Frame	N-8-1
GPU Address	001

4. Select "No Connect".
5. Enter the relay catalog number and select "OK".
6. Select "Settings".
7. Select "Primary Settings".
8. Select "All Functions". The default settings should appear.
9. Select "Send Data".
10. Select "To File"
11. Enter the desired file name for the factory default settings such as DEFAULT.CFG.
12. Select "OK".
13. Select "Exit" to return to the main window.

Saving Existing (in-service) Settings to a File:

1. Connect the GPU-2000R to the PC. Load and execute the GPU-2000R External Communication Program (ECP).
2. Press "Continue" after reading header.
3. The "Communications Options" menu should appear. It should read:

Serial Communications Port:	COM1 (or whichever will be used on your PC)
Baud Rate:	9600
Frame	N-8-1
GPU Address	001

4. Select "Connect".
5. Select "Settings".
6. Select "Primary Settings".
7. Select "All Functions". The GPU-2000R settings should appear.
8. Select "Send Data".
9. Select "To File".
10. Enter the desired file name for the actual settings such as ACTUAL.CFG.
11. Select "OK" and press Enter.
12. Select "Exit" to return to the main window.

Sending Settings to the Relay From a File:

1. Connect the GPU-2000R tc the PC. Load and execute the GPU-2000R External Communication Program (ECP).
2. Press "Continue" after reading header.
3. The "Communications Options" menu should appear. It should read:
   Serial Communications Port: COM1 (or whichever will be used on your PC)
   Baud Rate: 9600
   Frame N-8-1
   GPU Address 001
4. Select "Connect".
5. Select "Settings".
6. Select "Primary Settings".
7. Select "All Functions". The GPU-2000R settings should appear.
8. Select "Get Data".
9. Select "From File". The file settings should appear.
10. Select "Send Data".
11. Select "To Unit".
12. Enter the relay password (factory password = four spaces) and select "OK".
13. The cursor will turn into an hour glass while ECP is communicating with GPU-2000R.
14. Select "Exit" to return to the main window.

Notes Before Testing

1. The connections required for each test are shown in Figures 13, 14 and 15 and listed in tables 18 and 19. It is not necessary to remove existing connections that are not needed for a particular test.

2. The GPU-2000R comes from the factory with all outputs disabled, including trip outputs. Before testing begins, ECP must be used to map the protective functions to the Master Trip Output or to any of the other Programmable Outputs. These tests will assume that all protective units, with the exception of the 27 and 81U functions, have been mapped to the Master Trip Output. The 27 and 81U functions cannot be assigned to the Master Trip and should be assigned to Programmable Output 1. Refer to Appendix D for instructions.

3. A balanced 3-phase voltage is defined as three voltages at nominal frequency equal in magnitude with phase A at 0^{O}, phase B at -120^{O} (lagging A), and phase C at 120^{O} (leading A). The voltage magnitude will be specified within each test.

4. Timing tests can be verified using the timing curves and equations in Appendix A.

5. The values shown in parentheses (x.xx) are the values for 1 ampere rated units.

TESTING THE GPU-2000R

Self Check Test

Test 1: Verify Self-Checking Test Via MMI:

Follow these steps to verify the pass/fail status of each self-check element on the GPU2000R:

a. Connect the proper control power to the unit. Wait for initialization to be complete. The green STATUS LED should be lit.
b. From the MMI, press <E> to get to the Main Menu.
c. Scroll down to "TEST" and press <E>.
d. The first choice is "Self Test", so press <E>. All elements should read "pass".
e Press "C" to return to the meter display.

Test 2. Metering Tests:

a. Make the test connections as shown in Figure 15.
b. Apply a balanced 3-phase voltage of 69.0 volts RMS and a balanced 3-phase current of 3.0 amperes RMS in phase with the voltage to the relay.
c. From the MMI main menu, press<E> twice to gain access to the metering menu.
d. Press <E> on the load choice. The following should be within the ranges listed:

Ia = 300.0	**0°**	(±6 A)	**kVAR-A = 0**		(± 8 kW)
Ib = 300.0	**240°**	(±6 A)	**kVAR-B = 0**		(± 8 kW)
Ic = 300.0	**120°**	(±6 A)	**kVAR-C = 0**		(± 8 kW)
In = 0.0		(±6 A)	**kVAR-3P = 0**		(± 25 kW)
kVan = 0.07	**0°**	(±7 V)	**I_0 = 0.0**		(±6 A)
kVbn = 0.07	**240°**	(±7 V)	**I_1 = 300.0**	**0°**	(±6 A)
kVcn = 0.07	**120°**	(±7 V)	**I_2 = 0.0**	**0°**	(±6 A)
kW-A = 2070		(± 8 kW)	**kV_1 = 6.90**	**0°**	(± 7 V)
kW-B = 2070		(± 8 kW)	**kV_2 = 0**	**0°**	(± 7 V)
kW-C = 2070		(± 8 kW)	**PF = 1.00**		Lagging or Leading
kW-3P = 6210		(± 25 kW)	**Freq = 60.00**		(+ 0.01 Hz)

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

REVERSE POWER TEST

Test 3: Testing the 32R Reverse Power Function:

Verify or change the following PRIMARY settings for this test:

40 Curve Selection	=	Disable
32R Curve Selection	=	Long Time Inverse
32R Pickup Setting	=	3% Rated Power (= 0.03*120V*5A*3Ph = 54 W)
32R Time Dial	=	1.0

Make the test connections as shown in Figure 15. Apply a balanced 3-phase voltage of 69.00 volts RMS and a balanced 3-phase current of 1.00 (0.2) Amperes RMS in phase with the voltage to the relay.

Slowly **increase** the angle that all the currents lead their respective voltages from 0 degrees until the relay trips. The "Pickup" status on the relay should light and the contact monitor should indicate a closed contact. The "Reverse Power" target should light. This should occur when the angle reaches 105 ± 5 Degrees.

LOSS OF EXCITATION TEST

Test 4: Testing the 40 Loss of Excitation Function:

Verify or change the following PRIMARY settings for this test:

32R Curve Selection	=	Disable
40 Curve Selection	=	Long Time Inverse
40 Pickup Setting	=	10% Rated (= 0.1*120V*5A*3Ph = 180 VAR)
40 Time Dial	=	1.0

Make the test connections as shown in Figure 15. Apply a balanced 3-phase voltage of 69.00 volts RMS and a balanced 3-phase current of 1.00 (0.2) Amperes RMS in phase with the voltage to the relay.

Slowly **increase** the angle that all the currents lag their respective voltages from 0 degrees until the relay trips. The "Pickup" status on the relay should light and the contact monitor should indicate a closed contact. The "Loss of Excitation" target should light. This should occur when the angle reaches 60 ± 5 Degrees.

PHASE UNBALANCE (NEGATIVE SEQUENCE) TEST

Test 5: Testing the 46Q Phase Unbalance (Negative Sequence) Function:

Verify or change the following PRIMARY settings for this test:

46Q Curve Selection	=	Enable
46Q Pickup Setting	=	20% Rated Current

Make the test connections as shown in Figure 16 for the phase to be tested. Set a single phase of current to 2.0 (0.4) amperes RMS. One third of the single phase of current applied to the relay will produce the negative sequence current, I_2. It is therefore necessary to apply a current at three times pickup setting for I_2 which is 20% of rated current or 0.2*5.0 = 1.0 (0.2) Amperes.

Apply the current to the relay. Slowly **increase** the current from 2.0 (0.40) amperes RMS until the relay trips. The contact monitor should indicate a closed contact. The "Negative Sequence" target along with the phase target should light. This should occur when the test current reaches 3.00 (0.60) $\pm$ 3% amperes RMS and I_2 reaches 1.00 (0.2) $\pm$ 3% amperes RMS.

OVERCURRENT TESTS

Teat 6: Testing the 50P Phase Instantaneous Overcurrent Function:

CAUTION: Do not allow high currents to persist.

Verify or change the following PRIMARY settings for this test:

50P Curve Selection	=	Definite Time
50P Pickup Setting	=	50% Rated Current
50P Time Delay	=	1.0 second

Make the test connections as shown in Figure 16 for the phase to be tested. Set a single phase of current to 5.0 (0.10) amperes RMS (2 x pickup). Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact.

Apply the current to the relay. The unit should trip in 1.00 seconds $\pm$ 7%. The "Overcurrent" and Phase targets should light.

Repeat the test for the remaining phases listed in Table 19.

Test 7: Testing the 50N Ground Instantaneous Overcurrent Function:

CAUTION: Do not allow high currents to persist. If tripping is not obtained instantaneously, shut off the current and review your set up.

Verify or change the following PRIMARY settings for this test:

50N Curve Selection	=	Definite Time
50N Pickup Setting	=	50% Rated Current
50N Time Delay	=	1.0 second

Make the test connections as shown in Figure 16 for the N phase. Set a single phase of current to 5.00 (1.00) amperes RMS (2 x pickup). Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact..

Apply the current to the relay. The unit should trip in 1.00 seconds ± 7%. The "Overcurrent" and N targets should light.

Test 8. Testing the 51P Phase Time Overcurrent Function:

Verify or change the following PRIMARY settings for this test:

50P Curve Selection	=	Disable
51P Curve Selection	=	Extremely Inverse
51P Pickup	=	50% Rated Current
51P Time Dial	=	1.0

Make the test connections as shown in Figure 16 for the phase to be tested. Set a single phase of current to 5.00 (1.00) amperes RMS (2 x pickup). Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact..

Apply the current to the relay. The unit should trip in 2.10 seconds ± 7%. The "Overcurrent" and Phase targets should light.

Repeat the test for the remaining phases listed in Table 19.

Test 9: Testing the 51N Ground Time Overcurrent Unit:

Verify or change the following PRIMARY settings for this test:

50N Curve Selection	=	Disable
51N Curve Selection	=	Extremely Inverse
51N Pickup	=	50% Rated Current
51N Time Dial	=	1.0

Make the test connections as shown in Figure 16 for the N phase. Set a single phase of current to 5.00 (1.00) amperes RMS (2 x pickup). Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact.

Apply the current to the relay. The unit should trip in 2.10 seconds ± 7%. The "Overcurrent" and N targets should light.

Test 10: Testing 67P Phase Directional Overcurrent Unit:

Verify or change the following PRIMARY settings for this test:

67P Curve Selection	=	Very Inverse
67P Pickup	=	50% Rated power
67P Time Dial	=	1.0
67P Max. Torque Angle	=	0^{O}

Make the test connections as shown in Figure 16 for the voltage phase to be tested. Apply a balanced 3-phase voltage of 69 volts RMS and set a single phase of current to 5.00 (1.00) amperes RMS (2 x pickup) in phase with its voltage. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact.

Apply the current to the relay. The unit should trip in 1.00 seconds $\pm$ 7%. The "Overcurrent" and Phase targets should light. Remove the current.

Change the angle of the tested phase current by 180^{O}. Again apply the current to the relay. Verify that the relay does not trip.

Repeat the test for the remaining phases listed in Table 19.

Test 11. Testing 67N Ground Directional Overcurrent Unit:

Verify or change the following PRIMARY settings for this test:

67P Curve Selection	=	Disable
67N Curve Selection	=	Very Inverse
67N Pickup	=	50% Rated power
67N Time Dial	=	1.0
67N Max. Torque Angle	=	0^{O}

Make the test connections as shown in Figure 17 for the N phase. The current is also applied through phase A to create negative sequence current in the relay. Apply a balanced 3-phase voltage of 69 volts RMS with phases B and C interchanged to create a negative sequence voltage. Set the current to 5.00 (1.00) amperes RMS (2 x pickup) in phase with its voltage. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact.

Apply the current to the relay. The unit should trip in 1.00 seconds $\pm$ 7%. The "Overcurrent" and N targets should light.

Change the angle of the tested phase by 180^{O}. Again apply the current to the relay. Verify that the relay does not trip.

Remember to restore the original voltage phase rotation.

Test 12.: Testing the 51VC Voltage Control Time Overcurrent Unit:

Verify or change the following PRIMARY settings for this test:

51P Curve Selection	=	Disable
51V Selection	=	Volt. Control
51V Curve Selection	=	Extremely Inverse
51V Pickup	=	25% Rated Current
51V Time Dial	=	1.0
51V Operating Voltage	=	10 volts

Make the test connections as shown in Figure 16 for the phase to be tested. Apply a balanced 3-phase voltage of 8.00 volts RMS and set a single phase of current to 5.00 (1.00) amperes RMS (4 x pickup). Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact.

Apply the current to the relay. The unit should trip in 0.45 seconds ± 7%. The "Overcurrent" and Phase targets should light. Remove the current.

Increase the balanced 3-phase voltage to 12.0 volt RMS.

Re-apply the current to the relay. The unit should not trip.

Repeat the test for the remaining phases listed in Table 19.

Test 13: Testing the 51VR Voltage Restraint Time Overcurrent Unit:

Verify or change the following PRIMARY settings for this test:

VT Connection	=	120V Wye
51P Curve Selection	=	Disable
51V Selection	=	Volt. Restraint
51V Curve Selection	=	Extremely Inverse
51V Pickup	=	80% Rated Current = 0.80 * 5.0(1.0) = 4(0.8)A
51V Time Dial	=	1.0

Make the test connections as shown in Figure 16 for the phase to be tested. Apply a balanced 3-phase voltage of 69.30 volts RMS to the relay. For each of the voltages listed in Table 17, reduce the magnitude of the phase under test to the listed value. Apply a single phase of current for the same phase and slowly raise it from 0 Amp until the relay picks-up as indicated by the "Pickup" status LED on the front panel.

Phase Voltage	% 120 V	Pickup Current (Amps RMS ± 3%)	% Pickup (% 4A)
69.3	57.7	2.30	57.5
60.0	50.0	2.00	50.0
30.0	25.0	1.00	25.0
0.0	0.0	1.00	25.0

Table 17: 51VR Pickup Current

Repeat the test for all the phase voltage values in Table 17.
Repeat the test for the remaining phases listed in Table 19.

Voltage/Frequency Tests

Test 14: Testing the 27 Under Voltage Unit:

Verify or change the following PRIMARY settings for this test:

27 Curve Selection	=	Enable
27 Pickup Volts	=	10.0 V
27 Time Delay	=	0.0 seconds

27-1P and 27-3P functions are mapped to Programmable Output 1.

Make the test connections as shown in Figure 14 for the phase to be tested. Apply a balanced 3-phase voltage of 20 volts RMS to the relay.

Slowly **lower** only the tested phase's voltage from 20 Volts RMS until the relay trips. The contact monitor should indicate a closed contact. The "Voltage/Frequency" target should light. This should occur when the voltage reaches 10.0 ± 3% Volts RMS.

Repeat the test for the remaining voltage phases listed in Table 19.

Repeat the test but slowly **lower** all three voltage phases from 20 Volts RMS until the relay trips. The contact monitor should indicate a closed contact. The "Voltage/Frequency" target should light. This should occur when the voltage reaches 10.0 ± 3% Volts RMS.

Examine the fault records and verify that the first three tests report a single phase undervoltage, 27-1P, and the most recent test reports a three phase under voltage, 27-3P.

Test 15: Testing the 59 Overvoltage Protection Unit:

Verify or change the following PRIMARY settings for this test:

27 Curve Selection	=	Disable
59 Curve Selection	=	Enabled
59 Pickup	=	70 Volt
59 Time Delay	=	0 seconds

Make the test connections as shown in Figure 14 for the phase to be tested. Apply a balanced 3-phase voltage of 67 volts RMS.

Slowly **increase** one phase of the voltage from 67 volts RMS until the relay trips. The contact monitor should indicate a closed contact. The "Voltage/Frequency" target along with the phase target should light. This should occur when the voltage reaches 70.00 ± 3% Volts RMS.

Repeat the test for the remaining phases listed in Table 19.

Test 16: Testing the 81U-1 Under Frequency Unit:

Verify or change the following PRIMARY settings for this test:

81 Select	=	Enabled
81U-1 Pickup	=	56 Hz
81U-1 Time Delay	=	0.08 seconds

81U functions are all mapped to Programmable Output 1.

Make the test connections as shown in Figure 16. Apply a balanced 3-phase voltage of 69 volts RMS to the relay.

Slowly **decrease** voltage frequency from 60.0 Hz until the relay trips. The contact monitor should indicate a closed contact and the "Voltage/Frequency" target should light. This should occur when the frequency reaches 56 ± 0.01 Hz.

Repeat this test for the 81U-2 unit.

Test 17: Testing the 81O-1 Over Frequency Unit:

Verify or change the following PRIMARY settings for this test:

81 Select	=	Enabled
81O-1 Pickup	=	64 Hz
81O-1 Time Delay	=	1.0 seconds

Make the test connections as shown in Figure 16. Apply a balanced 3-phase voltage of 69 volts RMS to the relay.

Slowly **increase** voltage frequency from 60.0 Hz until the relay trips. The contact monitor should indicate a closed contact and the "Voltage/Frequency" target should light. This should occur when the frequency reaches 64 ± 0.01 Hz.

Repeat this test for the 81O-2 unit.

Test 18: Testing the 81V Voltage Block Unit:

Verify or change the following PRIMARY settings for this test:

81 Select	=	Enabled
81O-1 Pickup	=	64 Hz
81V Voltage Block	=	40 Volt

Make the test connections as shown in Figure 16. Apply a balanced 3-phase voltage of 36.0 volts RMS to the relay.

Slowly **increase** voltage frequency from 60 Hz to 66 Hz. Verify that the relay does not trip.

Repeat the test using 44.0 volts RMS and verify that the relay does trip.

Restoration of Settings:

Verify or change the PRIMARY settings to return to the factory defaults listed in TABLES 15 and 16.

Change the CONFIGURATION settings to return to the factory default:

IMPORTANT: To return the unit to service, the settings must be restored to the in-service values. Follow the procedure outlined in the "Saving and Downloading Settings Section", Sending Settings to the Relay. If the unit is not to be placed into service, the factory default settings should be restored. This can be done by downloading a previously saved default file or by manually checking each setting.

GPU-2000R Test Connections

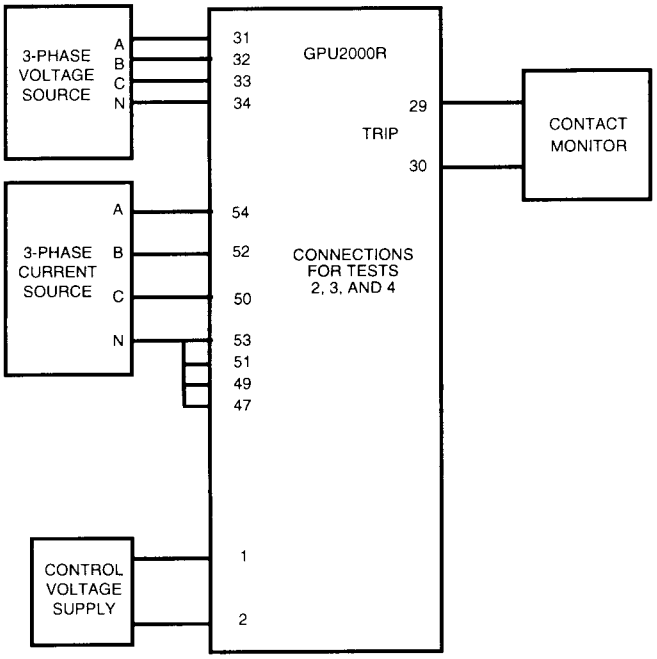


Figure 15.: Connections for Tests 2, 3 and 4

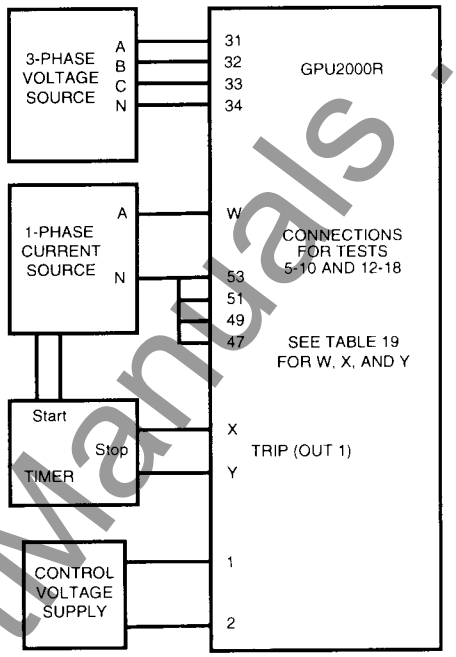


Figure 16.: Connections for Tests 5-10 and 12-18

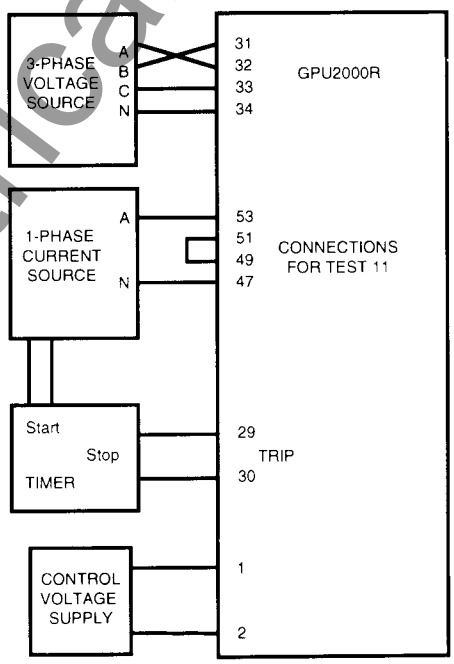


Figure 17.: Connections for Test 11

Table 18. Test Connections—Figure 15

Test No.	Figure No.	Function Under Test	Phase Under Test	CONNECTIONS							MNTR		Expected Value	Tested Value
				VA	VB	VC	VN	IA	IB	IC	X	Y		
2	15	Metering	A	31			34						0.69 kV ± 7 V	
			B		32		34						0.69 kV ± 7 V	
			C			33	34						0.69 kV ± 7 V	
			A					54					100 (20) ± 6 A	
			B						52				100 (20) ± 6 A	
			C							50			100 (20) ± 6 A	
			N					48					100 (20) ± 6 A	
3	15	32R Reverse Power	ALL	31	32	33	34	54	52	50	29	30	105 ± 5 deg.	
4	15	40 Loss of Excitation	ALL	31	32	33	34	54	52	50	29	30	60 ± 5 deg.	

Table 19. Test Connections—Figure 16 and 17

Test No.	Figure No.	Function Under Test	Phase Under Test	CONNECTIONS					MNTR		Expected Value	Tested Value
				VA	VB	VC	VN	W	X	Y		
5	16	46Q Phase Unbalance	A					54	29	30	3.0 (0.6) + 0.1 A	
			B					52	29	30	3.0 (0.6) + 0.1 A	
			C					50	29	30	3.0 (0.6) + 0.1 A	
6	16	50P Phase Inst. Overcurrent	A					54	29	30	1.00 + 0.07 sec	
			B					52	29	30	1.00 + 0.07 sec	
			C					50	29	30	1.00 + 0.07 sec	
7	16	50N Gnd. Inst. Overcurrent	N					48	29	30	1.00 + 0.07 sec	
8	16	51P Phase Time Overcurrent	A					54	29	30	2.10 + 0.15 sec	
			B					52	29	30	2.10 + 0.15 sec	
			C					50	29	30	2.10 + 0.15 sec	
9	16	50N Gnd. Time Overcurrent	N					48	29	30	2.10 + 0.15 sec	
10	16	67P Ph. Dir. Overcurrent	A	31	32	33	34	54	29	30	Trip 1.00 sec	
			A	31	32	33	34	54	29	30	No Trip	
			B	31	32	33	34	52	29	30	Trip 1.00 sec	
			B	31	32	33	34	52	29	30	No Trip	
			C	31	32	33	34	50	29	30	Trip 1.00 sec	
			C	31	32	33	34	50	29	30	No Trip	
11	17	67N Gnd. Dir. Overcurrent	N	31	33	32	34	54	29	30	Trip 1.00 sec	
				31	33	32	34	54	29	30	No Trip	

Table 19. Test Connections (continued)

Test No.	Figure No.	Function Under Test	Phase Under Test	CONNECTIONS					MNTR		Expected Value	Tested Value
				VA	VB	VC	VN	W	X	Y		
12	16	51VC Cntrl. Time Overcurrent	A	31	32	33	34	54	29	30	Trip 0.45 sec	
			A	31	32	33	34	54	29	30	No Trip	
			B	31	32	33	34	52	29	30	Trip 0.45 sec	
			B	31	32	33	34	52	29	30	No Trip	
			C	31	32	33	34	50	29	30	Trip 0.45 sec	
			C	31	32	33	34	50	29	30	No Trip	
13	16	51VR Rstrnt. Time Overcurrent	A	31	32	33	34	54			**SEE TABLE 17**	
			B	31	32	33	34	52				
			C	31	32	33	34	50				
14	16	27 Under Voltage	A	31			34		28	27	10.0 ± 0.3 V	
			B		32		34		28	27	10.0 ± 0.3 V	
			C			33	34		28	27	10.0 ± 0.3 V	
			ALL	31	32	33	34		28	27	10.0 ± 0.3 V	
15	16	59 Over Voltage	A	31			34		29	30	70.0 ± 2.1 V	
			B		32		34		29	30	70.0 ± 2.1 V	
			C			33	34		29	30	70.0 ± 2.1 V	
16	16	81U-1 Under Freq.	ALL	31	32	33	34		28	27	56.00 ± 0.01 Hz	
		81U-2 Under Freq.	ALL	31	32	33	34		28	27	56.00 ± 0.01 Hz	
17	16	81O-1 Over Freq.	ALL	31	32	33	34		29	30	64.00 ± 0.01 Hz	
		81O-2 Over Freq.	ALL	31	32	33	34		29	30	64.00 ± 0.01 Hz	
18	16	81V Volt. Block	ALL	31	32	33	34		29	30	No Trip	
			ALL	31	32	33	34		29	30	Trip	

Appendix A
Timing Curves

Time Overcurrent Curve Equation

ANSI

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

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

M = Multiples of pickup current (I/Ipu)

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

Table A1. Constants for Time Overcurrent Characteristics

Curve	A	B	C	P	D	E	K	α
Extremely Inverse	6.407	0.025	1	2.0	3	0.998	80.0	2.0
Very Inverse	2.855	0.0712	1	2.0	1.346	0.998	13.5	1.0
Inverse	0.0086	0.0185	1	0.02	0.46	0.998	0.14	0.02
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	120.0	1.0

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.

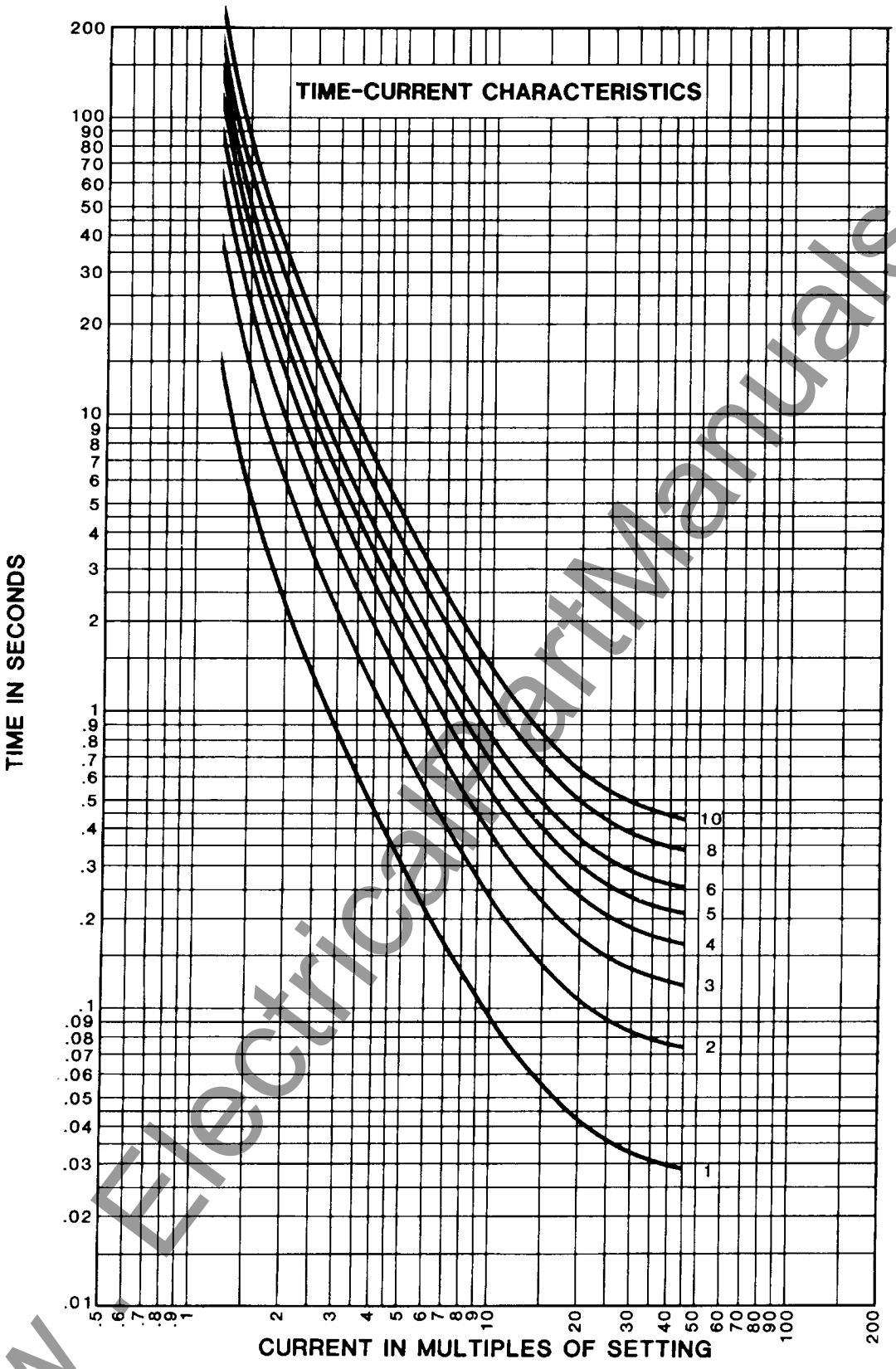


Figure A1. Extremely Inverse Curve

Drawing Number 605842

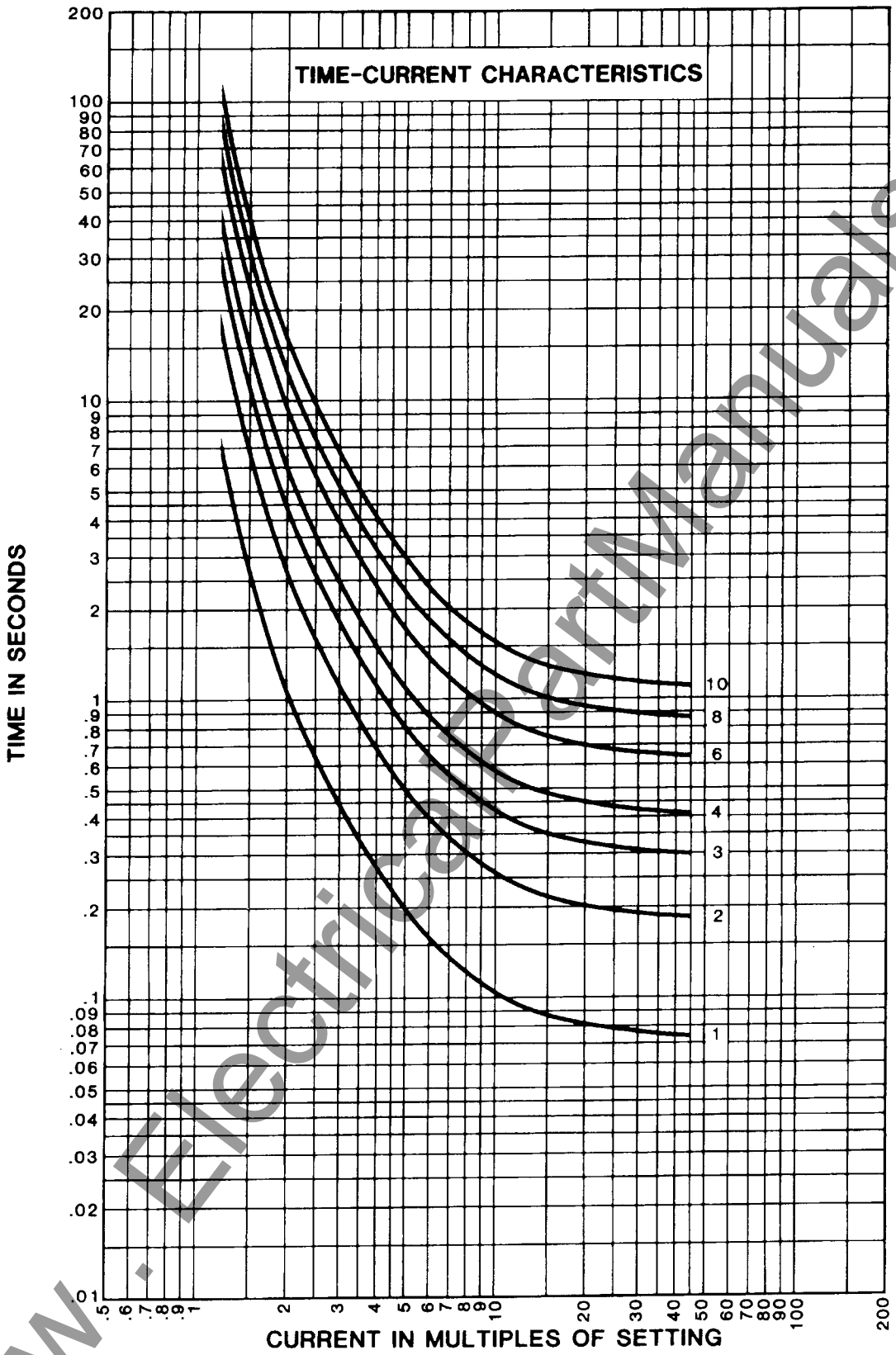


Figure A2. Very Inverse Curve
Drawing Number 605841

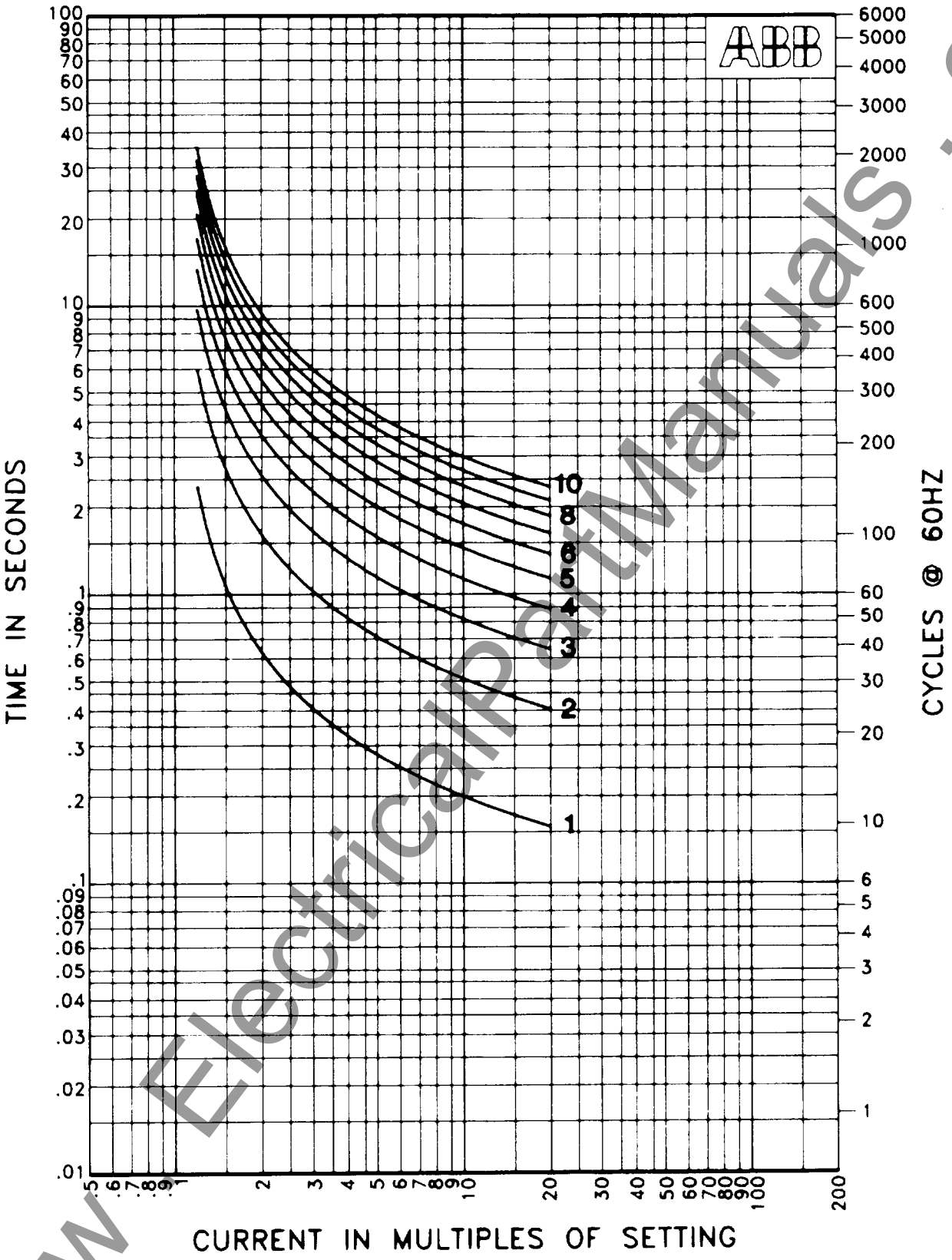


Figure A3. Inverse Curve

Drawing Number 605854

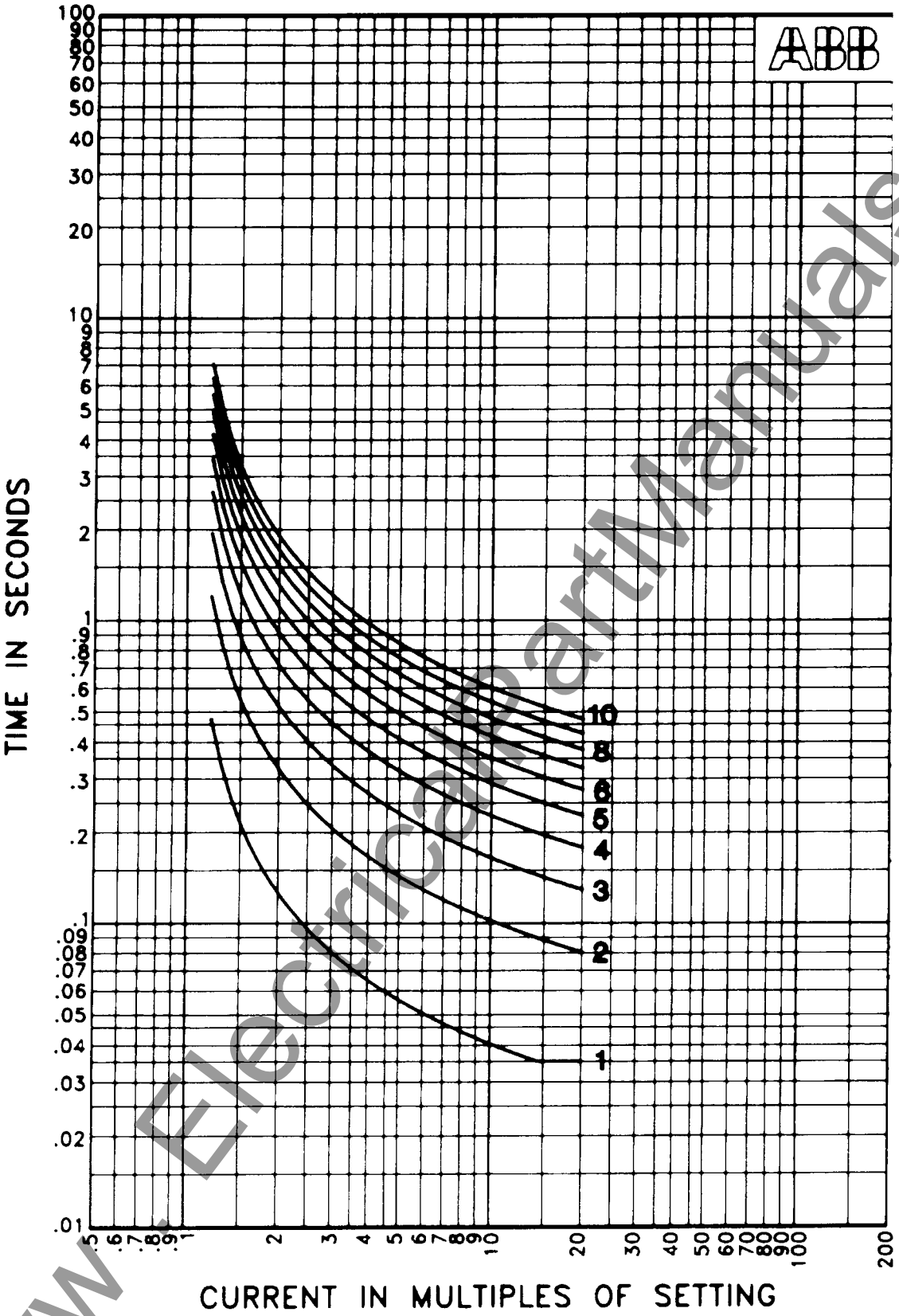


Figure A4. Short Time Inverse Curve

Drawing Number 605855

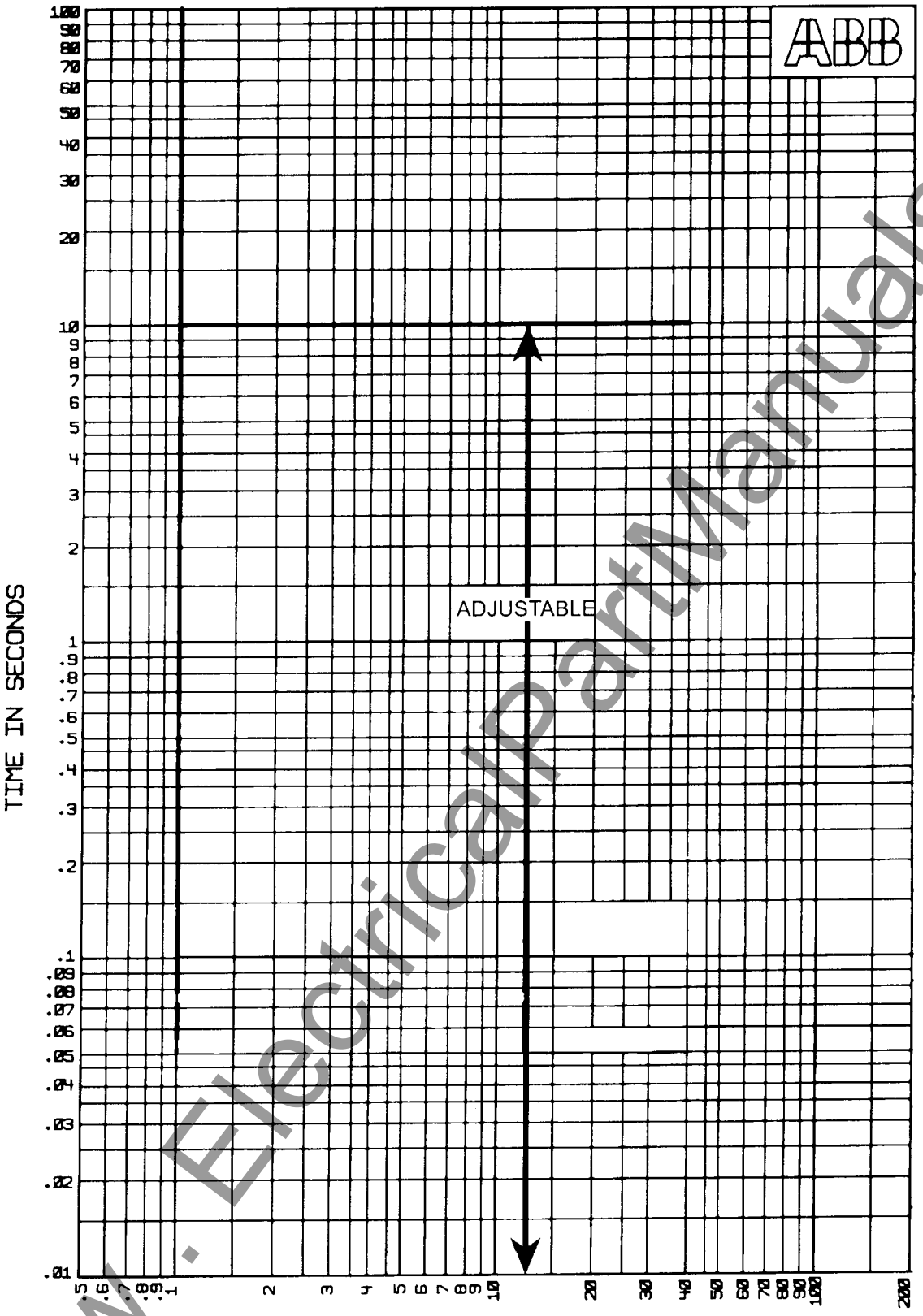


Figure A5. Definite Time Curve

Drawing Number 605874

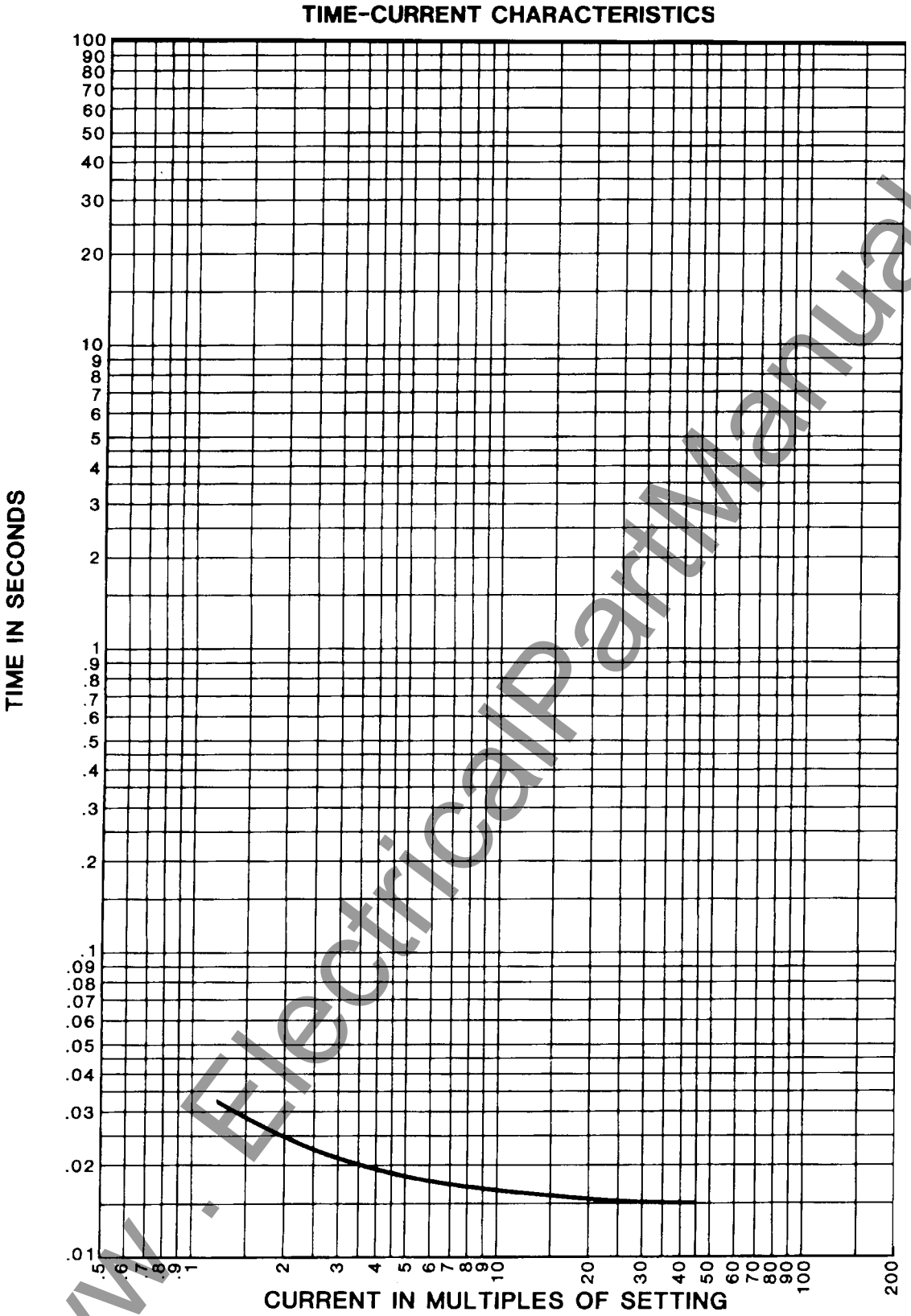


Figure A6. Standard Instantaneous Curve
Drawing Number 605845

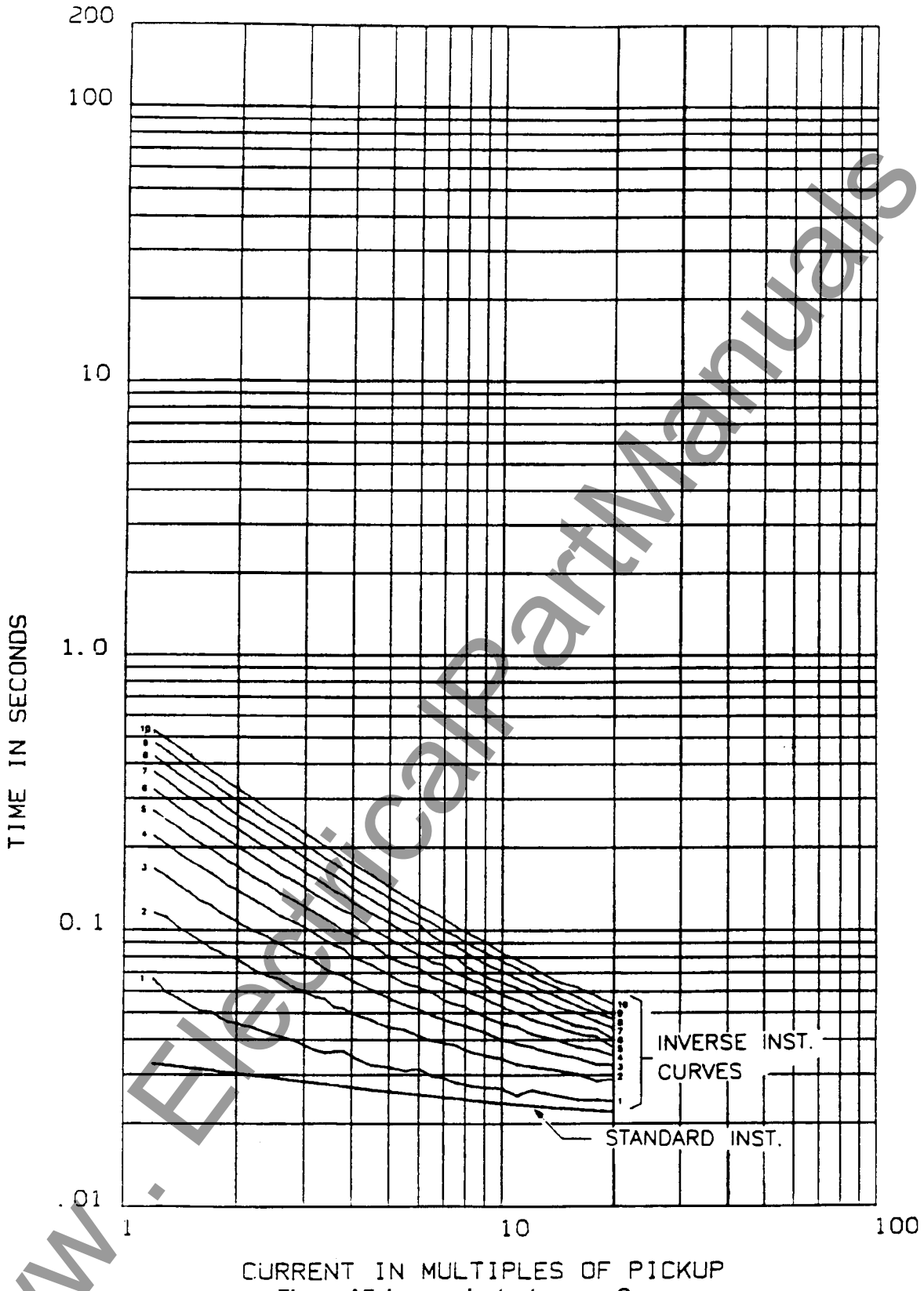


Figure A7. Inverse Instantaneous Curve

Appendix B
Changing Settings

Use ECP to change the following settings:

- Primary
- Alternate 1
- Alternate 2
- Configuration
- Programmable Inputs
- Programmable Outputs
- Counter
- Alarm
- Clock
- Communication

Tables 5–9 show the range, step size, and default 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 "Settings."
2. From the Settings menu, select the settings group you want to change (listed above). The Primary, Alternate1, Alternate 2, and Configurable Output groups will provide another sub-menu. Choose the desired setting catagory from the sub-menu.

   A Setting Screen appears and displays current settings retrieved from the relay or, if the program cannot communicate with the relay, displays default values.

   The first setting in each catagory contains a drop-down list used to enable or disable all settings in that catagory. If the first setting is disabled, the rest will be grayed out and cannot be selected or changed.

   The remaining settings have sliders which increase the value of the setting if you click on the right arrow or drag the button to the right and decrease the value if you click on the left arrow or drag the button to the left.
3. Make changes to the setting as described in step 2.

   Other settings catagories can be reached by using the horizontal and vertical scroll bars on the edge of the settings window.
4. After making all desired changes, save your changes as follows:

   a. Select "Send Data" from the menu. Select "To Unit" from the drop down menu.

      A dialog box prompting for a password will appear.

   b. Enter the password (4 blank spaces for default) and select OK.

      The new settings are sent to the relay.
5. Exit from the Settings menu by selecting "Set/Exit" from the top menu. Select "Exit" from the drop down menu. If this is done before settings are sent to the relay as described in step 4, all setting changes will be lost.

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 "Settings."
2. From the Settings menu, select "Programmable Inputs."
   The Programmable Input Map screen appears.
3. To change an item in the input contact listing:
   a. Use the mouse to select the desired position in the list of input functions.
      A Logical Inputs Menu dialog box appears with a list of all the possible contact input functions.
   b. Scroll through the list and select the desired function. Select OK.
      The name of the selected input function appears at the chosen position.
4. To map an input contact to a function:
   a. Use the mouse to select the block to the right of the function and under the desired input.
   b. Clicking on the box once creates an Enabled=Opened,Disabled =Closed contact.
   c. Clicking on the box again creates an Enabled=Closed,Disabled=Opened contact.
   d. Clicking a third time returns the box to its' original (unmapped) state.
5. To change the logic of a contact:
   a. Use the mouse to select the item in the logic column just to the right of the desired function.
   b. Click on the logic state required (AND or OR).
6. To assign a name to an input:
   a. Use the mouse to select the edit box in the NAME row over the desired input.
   b. Type in the new name (up to 8 characters).
   c. Select any other item on the screen to complete the edit
7. Save your changes.
   a. Select "Send Data" from the top menu. Select "To Unit" from the drop-down menu.
      A dialog box prompting for a password will appear.
   b. Enter the password (5 blank spaces for default) and select OK.
      The new settings are sent to the relay.
8. Exit from the Programmable Inputs menu by selecting "Set/Exit" from the top menu. Select "Exit" from the drop down menu. If this is done before settings are sent to the relay as described in step 4, all setting changes will be lost.

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 "Settings."
2. From the Settings menu, select "Programmable Outputs."
   The Programmable Output Map screen appears.
3. To change an item in the output contact listing:
   a. Use the mouse to select the desired position in the list of input functions.
      A Logical Inputs Menu dialog box appears with a list of all the possible contact output functions.
   NOTE: You cannot access the Trip and Close functions.
   b. Scroll through the list and select the desired function. Select OK.
   c. Scroll through the list until the contact you want is highlighted.
   The name of the selected input function appears at the chosen position.
4. To map an output contact to a function:
   a. Use the mouse to select the block to the right of the function and under the desired output.
   b. Clicking on the box once creates a link between the function and the output contact.
   c. Clicking a second time returns the box to its' original (unmapped) state.
5. To change the logic of a contact:
   a. Use the mouse to select the item in the logic row directly above the desired output.
   b. Click on the logic state required (AND or OR).
6. To assign a name to an output:
   a. Use the mouse to select the edit box in the NAME row over the desired output.
   b. Type in the new name (up to 8 alphanumeric characters).
   c. Select any other item on the screen to complete the edit.
7. To change a Timer value:
   a. Use the mouse to adjust the slider bar for the TIMERS edit box over the desired output.
   b. Increase the value of the setting by clicking on the right arrow or dragging the button to the right and decrease the value by clicking on the left arrow or dragging the button to the left.
      The time can range from 0.00 to 60.00 seconds.
8. Save your changes.
   a. Select "Send Data" from the top menu. Select "To Unit" from the drop-down menu.
      A dialog box prompting for a password will appear.
   b. Enter the password (5 blank spaces for default) and select OK.
9. Exit from the Programmable Outputs menu by selecting "Set/Exit" from the top menu. Select "Exit" from the drop-down menu.

If this is done before changes are sent to the relay as described in step 9, all changes will be lost.

Appendix E
Oscillographic Display and Analysis Tool

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

The analog waveforms 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 waveform. 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 waveform onto any other analog waveform. For example, you can overlay Va onto Ia to examine the phase relationship.

You can scale all current waveforms 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 waveforms with respect to the largest amplitude encountered for that waveform only; this is called the Normalized Scale. The Normalized Scale accentuates noise and other characteristics of the waveform.

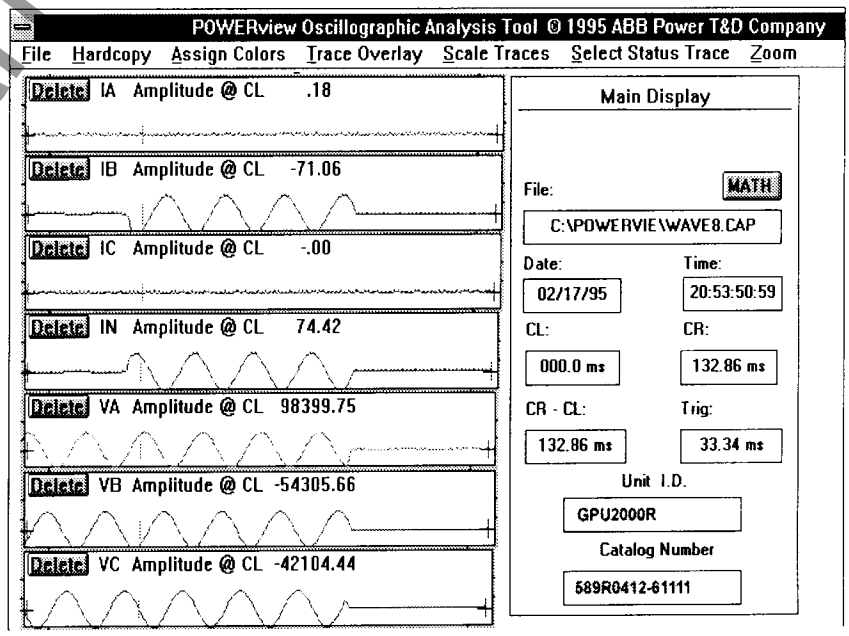
A zoom feature allows you to position the left and right cursors within the waveform and then "zoom in" to closely examine that section of the waveform.

System Requirements and Installation

The Oscillographics Program 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 Oscillographics Program Analysis Tool to be seen at one time.

To install the Oscillographics Program 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 OSCGRAPH.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. Create an icon for the program 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.

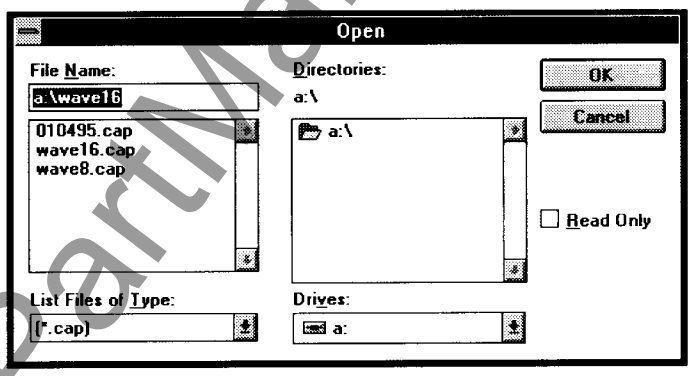
Using the Oscillographics Program Analysis Tool

Running on Windows, the Oscillographics Program Analysis Tool is a menu-driven program. A parent window contains windows for the analog waveforms 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. Oscillographics Program 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 Display window. The Main Display window appears to the right of the analog waveforms 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.

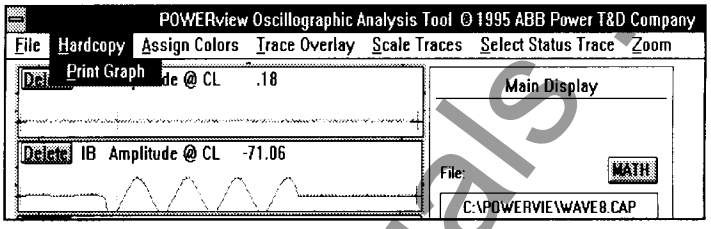
Each analog waveform window can be deleted. Simply click on the DELETE button in the window. That waveform window disappears and the other waveform windows shift to take up the empty space.

Menu Commands

Each menu on the Oscillographics Program 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.

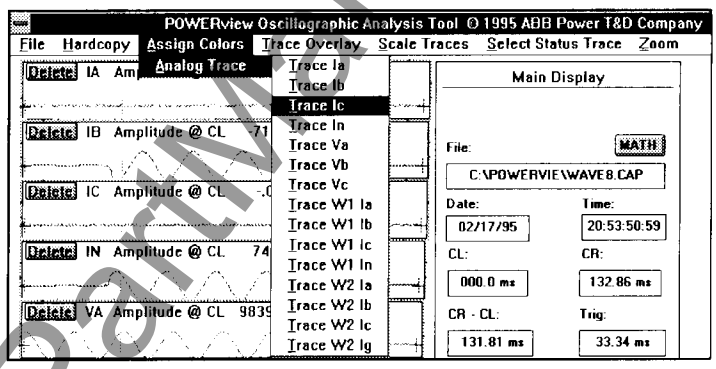


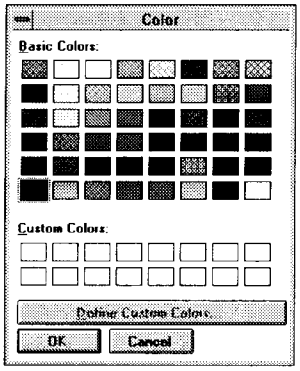
Assign Colors Menu

Use this menu to assign colors to the analog waveforms and the digital traces. This is especially helpful when you overlay two waveforms.

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

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

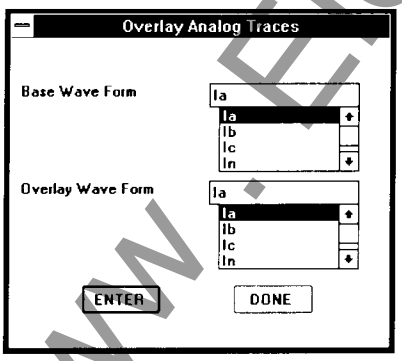




Trace Overlay Menu

Use the Trace Overlay menu to overlay any analog waveform on any other analog waveform. 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.

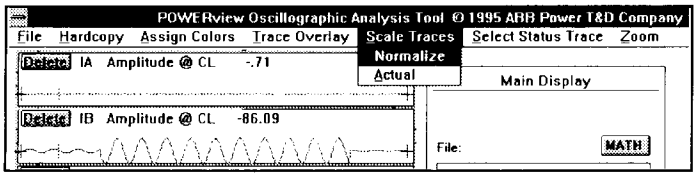
After selecting from the Trace Overlay menu, a window appears that requests you to enter a base trace and an overlay trace. Enter each trace and select "Enter." The overlay trace appears in the window of the base trace. Enter other traces as you desire and select "Done" when you are finished.



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

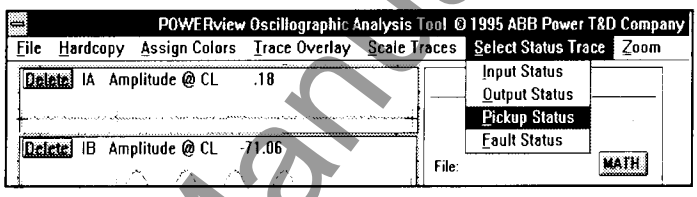
Scale Traces Menu

You can scale analog waveforms to an Actual Scale or a Normalized Scale. Actual Scale shows an analog waveform in relation to the other six waveforms. When you choose Normalized Scale, the waveform is scaled with respect to the largest amplitude for that waveform 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.

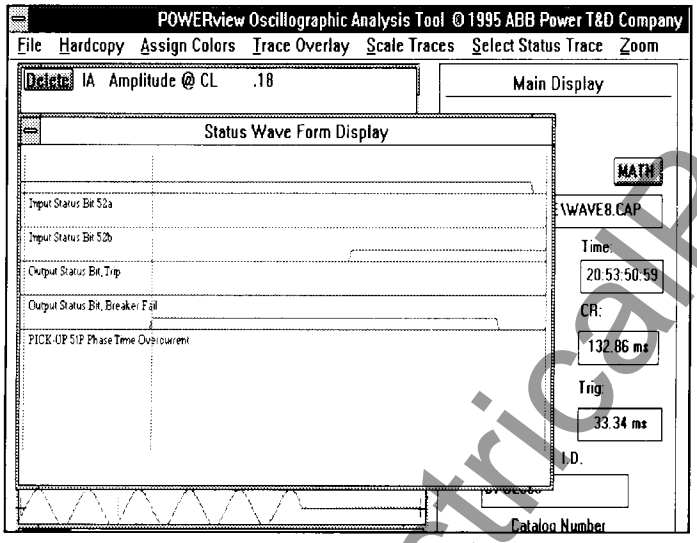


Select Status Trace Menu

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.

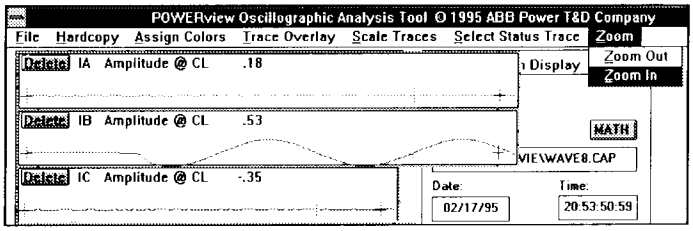


2. A window appears with a list of the different parameters measured. Click on the parameters you want. As you click on a parameter, a digital line appears in the graph window.

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 waveform. 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 waveforms.

FFT

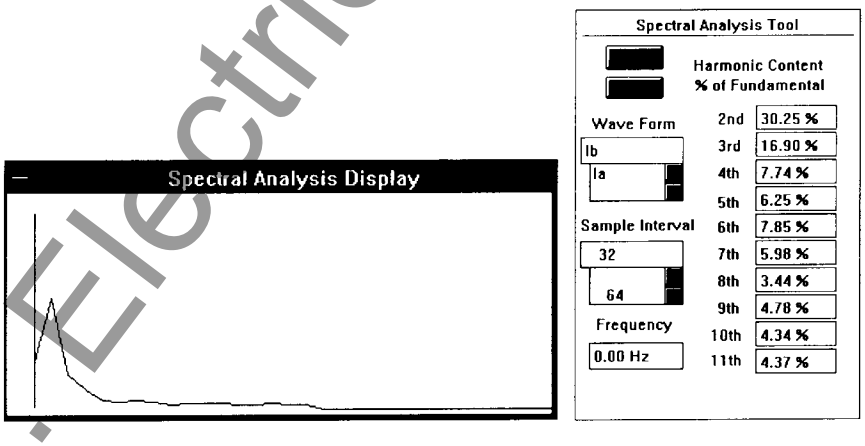
The Fast Fourier Transformer (FFT) button appears when you click on the Math button. By using this button, you can create a spectrum window for a selected region of waveform data.

Two types of spectra are possible: Cycle-Correlated and Full. The Cycle-Correlated spectrum is correlated to the cycle sampling used in the target 2000R protection unit (DPU, TPU, GPU, LPU,etc.). In this spectrum the left FFT cursor is the endpoint for the previous cycle of data and the FFT is performed on the 32 sample points prior to the left cursor. The movement of the left FFT cursor is constrained to quarter-cycle movements. When you drag and drop the cursor, it goes to the nearest quarter-cycle point. The resulting spectrum appears in a separate window labeled "Cycle-Correlated Spectra."

If you select Full Spectrum, the region to be analyzed is chosen by moving left and right cursors to the desired positions. The software adjusts the cursor positions internally to a power of 2. The FFT is performed on the data points between the cursors and the resulting spectrum appears in a separate window labeled "Full Spectra."

Follow these steps to perform an FFT:

1. Click on the Math button at the top of the parent window.
2. A new window appears. Click on the FFT button.
3. Another window appears. Select Cycle-Correlated Spectrum or Full Spectrum.
4. A list of the analog waveforms appears. Select the waveform you want.
5. FFT cursors appear in the window of the waveform you selected. Adjust the cursors as you desire and click on the OK button in the FFT window. The spectrum window appears.



Appendix F
Using the Load Profile Feature

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

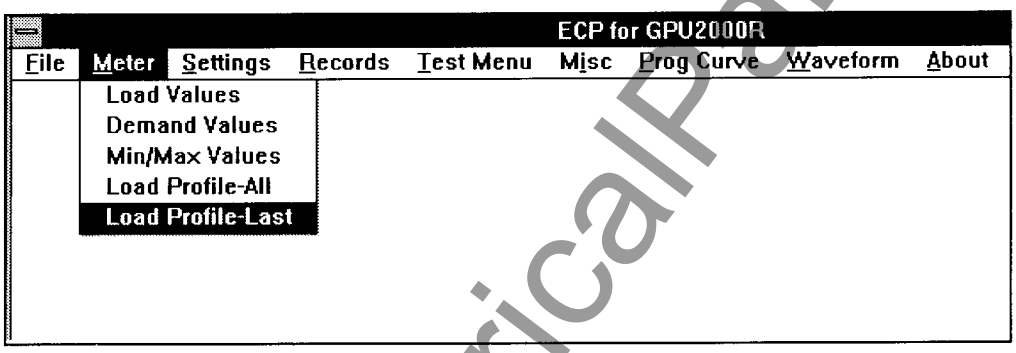
1. Under the Meter Menu, select Load Profile – All or Load Profile – Last. As the names suggest, choosing Load Profile – All downloads all the load profiles, while choosing Load Profile – Last downloads only the most recent load profile.

2. Type in a filename in the Specify Output File dialog box and select OK. A dialog box will appear with the status of the download.

3. When the download is completed successfully, select OK.

4. 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."



Appendix G
Software Installation

WARNING: Interrupting the download process before it is completed will result in lost EEPROM data. In the event that the download is prematurely terminated, replace the GPU-2000R and contact ABB Allentown immediately.

To download new software to the GPU-2000R:

- Connect the GPU-2000R to the computer via the serial port on the front panel of the unit.
- Ensure that the communications settings of the computer com port and the settings of the GPU-2000R are both set to 9600, 8, N, 1.
- Insert the disk provided by ABB into your computer and type: (A:) and press <CR>
- Type: (FPI) and press <CR>.
- At the Monitor Type ? prompt, select the appropriate monitor and press <CR>.
- After the ABB description screen, the Communication Options screen appears. Use the mouse to change the com settings or accept the default settings by scrolling through the screen by clicking on <OK>.
- If all com settings are correct, the Successful Connection To... screen appears. Click <OK> to continue. The next screen to appear will be the Main Menu. If com settings are not compatible or some other fault exists, the Communication Status screen appears. Reset the com settings and recheck connections and click <OK>.
- The only option necessary for downloading the software update is the Update Unit Software selection. Using the arrow keys, scroll to the Update Unit Software selection and click <OK>.
- At the Load New Firmware Data screen, the default selection is [A:\out.abs] press <CR>. This will highlight the default action, [READ FROM DISK]. Press <CR> again. Downloading should take about 20 minutes to complete.
- During download, the TARGETS LEDs on the front panel will blink intermittently and in sequence starting with ϕA with the following notes:

Computer display	LED	MMI (If present)
Monitor Has Been Entered	ϕ A blinks	GPU2000R Monitor
Flash Erase	ϕ B blinks	Flash Memory Erase in Progress
Flash Programming	ϕ C blinks	Flash Memory Download in Progress

- The message "Successfully Completed Downloading! Hit Any Key To Return To Main Menu" will appear. Hitting the <CR> key will cause the systems to reboot and the message "Please Wait While System Reboots" will appear.
- After the system has rebooted, the Main Menu will reappear. Scroll down to the Quit Program selection and press <CR>.

Appendix H
Operations Record Table

The following table lists all possible operation conditions that may be listed in the operations record.

	Operation Type		Operation Type		Operation Type		Operation Type
1	27-1P Alarm	42	50P Unit Disabled	83	Low PF Alarm	124	ALT2 Input Enabled
2	27-3P Alarm	43	50N Unit Enabled	84	High PF Alarm	125	ALT2 Input Disabled
3	27G Trip	44	50N Unit Disabled	85	Load Alarm	126	Ext Trip Enabled
4	32FO Trip	45	51P Unit Enabled	86	Pos. kVAR Alarm	127	Ext Trip Disabled
5	32FU Trip	46	51P Unit Disabled	87	Neg. kVAR Alarm	128	Ext Close Enabled
6	32R Trip	47	51N Unit Enabled	88	Pos. Watt Alarm 1	129	Ext Close Disabled
7	40 Trip	48	51N Unit Disabled	89	Pos. Watt Alarm 2	130	Event Cap1 Init
8	40 Alarm	49	51V Unit Enabled	90	Machine Run Alarm 1	131	Event Cap1 Reset
9	46Q Trip	50	51V Unit Disabled	91	Machine Run Alarm 2	132	Event Cap2 Init
10	46Q Alarm	51	59 Unit Enabled	92	Diff. Trip Alarm	133	Event Cap2 Reset
11	50P Trip	52	59 Unit Disabled	93	Event Capture #1	134	Wave Cap. Init
12	50N Trip	53	59F Unit Enabled	94	Event Capture #2	135	Wave Cap. Reset
13	51P Trip	54	59F Unit Disabled	95	Waveform Capture	136	ULI1 Input Closed
14	51N Trip	55	59G Unit Enabled	96	CRI Input Closed	137	ULI1 Input Opened
15	51VR Trip	56	59G Unit Disabled	97	CRI Input Opened	138	ULI2 Input Closed
16	51VC Trip	57	67P Unit Enabled	98	ROM Failure	139	ULI2 Input Opened
17	59 Alarm	58	67P Unit Disabled	99	RAM Failure	140	ULI3 Input Closed
18	59F Trip	59	67N Unit Enabled	100	Self Test Failed	141	ULI3 Input Opened
19	59G Trip	60	67N Unit Disabled	101	EEPROM Failure	142	ULI4 Input Closed
20	67P Trip	61	81U1 Unit Enabled	102	BATRAM Failure	143	ULI4 Input Opened
21	67N Trip	62	81U1 Unit Disabled	103	DSP Failure	144	ULI5 Input Closed
22	81O-1 Overfreq.	63	81O1 Unit Enabled	104	Control Power Fail	145	ULI5 Input Opened
23	81O-2 Overfreq.	64	81O1 Unit Disabled	105	Editor Access	146	ULI6 Input Closed
24	81U-1 Underfreq.	65	81U2 Unit Enabled	106	Manual Trip	147	ULI6 Input Opened
25	81U-2 Underfreq.	66	81U2 Unit Disabled	107	Manual Close	148	ULI7 Input Closed
26	81V Block	67	81O2 Unit Enabled	108	TOC Pickup-No Trip	149	ULI7 Input Opened
27	27-1 Unit Enabled	68	81O2 Unit Disabled	109	Breaker Opened	150	ULI8 Input Closed
28	27-1 Unit Disabled	69	Brkr Fail Enable	110	Breaker Closed	151	ULI8 Input Opened
29	27-3 Unit Enabled	70	Brkr Fail Disable	111	Open Trip Contact	152	ULI9 Input Closed
30	27-3 Unit Disabled	71	Ext Sync Enable	112	Direct Trip	153	ULI9 Input Opened
31	32FO Unit Enabled	72	Ext Sync Disable	113	Direct Close	154	Target Clear On
32	32FO Unit Disabled	73	Primary Set Active	114	CB Failed To Trip	155	Target Clear Off
33	32FU Unit Enabled	74	Alt1 Set Active	115	CB Pops Open	156	Sealin Clear On
34	32FU Unit Disabled	75	Alt2 Set Active	116	52A Opened	157	Sealin Clear Off
35	32R Unit Enabled	76	Blown Fuse Alarm	117	52A Closed		
36	32R Unit Disabled	77	Trip Coil Failure	118	52B Opened		
37	40 Unit Enabled	78	Accumulated KSI	119	52B Closed		
38	40 Unit Disabled	79	OC Trip Counter	120	TCM Input Opened		
39	46Q Unit Enabled	80	Phase Demand Alarm	121	TCM Input Closed		
40	46Q Unit Disabled	81	Neutral Demand Alm	122	ALT1 Input Enabled		
41	50P Unit Enabled	82	kVAR Demand Alarm	123	ALT1 Input Disabled		

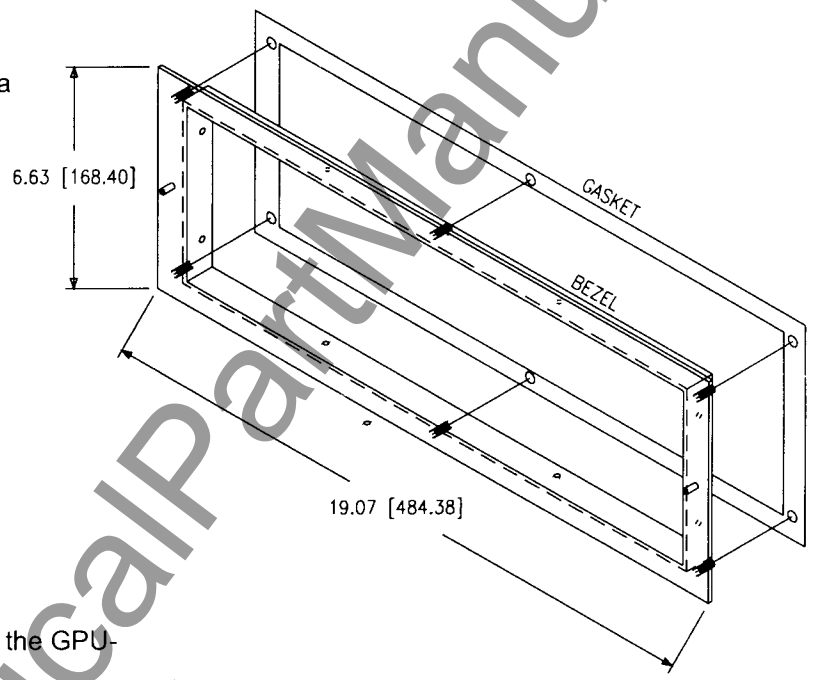
Appendix I
Bezel Assembly Option & Panel Cutout & Drilling

The complete kit will include a bezel, its associated hardware and gasket, as well as a plastic cover with its associated hardware. This kit will provide a means for panel mounting and dustproofing.

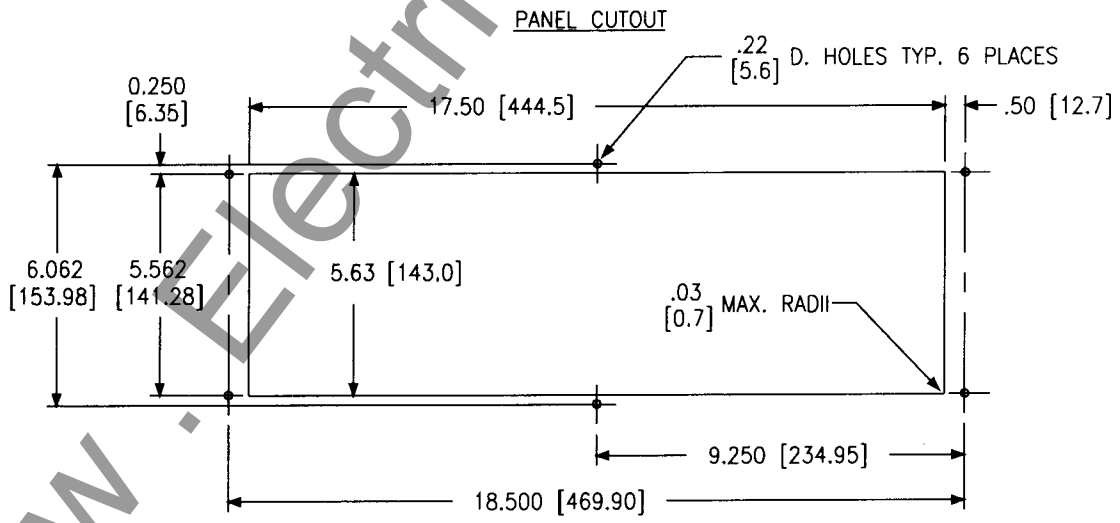
Ordering Information:	
Horizontal Panel Mounting Kit	604513-K1
Vertical Panel Mounting Kit	604513-K2

Spare Parts List:	
Bezel/gasket assembly only	604513-K3
Horizontal lens cover assembly	613724-K1
Vertical lens cover assembly	613724-K2

Note: The Bezel Assembly is available as an option for mounting the 2000R units in a panel application.



Note: Below is the panel drilling cutout for the GPU-2000R unit and the bezel assembly.



NOTE: DIMENSION VALUES IN BRACKETS ARE MILLIMETERS.

Parts and Assemblies

The following table lists the parts and assemblies involved in the GPU-2000R.

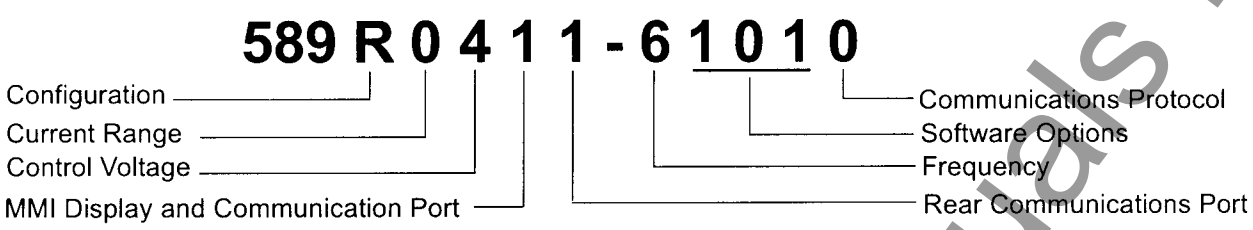
GPU-2000R Parts and Assemblies Table

Part and Assembly Description	Part Number
125-Vdc Power Supply Assembly	613806-K2
48-Vdc Power Supply Assembly	613806-K1
24-Vdc Power Supply Assembly	613806-K1
RS-232 Front Communication 1	613800-T2
RS-232 Card (non isolated Communication 2)	613811-T1
RS-232 Card (isolated Communication 3)	613630-T10
Aux Comm & RS-232 Card (isolated Communication 3)	613624-T8
INCOM (isolated)	613624-T6
Aux Comm & INCOM (isolated)	613624-T7
RS-485 (isolated)	613630-T6
Modbus Plus & RS-232 (non isolated Communication 2)	613628-T3
Modbus Plus & RS-485 (isolated)	613628-T4

Ordering Instructions

The 2000R series of relays have a structured catalog number ordering system. The unit's catalog number is built up from 13 customer-selectable characters. Each character identifies features or functions that can be incorporated into the relay.

Sample Catalog Number



How To Order

Using the Ordering Selection sheet, select those special features or options that are required to adapt the 2000R to your specific application. Create the catalog number, as shown above, by selecting the associated number or letter that refers to the desired feature or option from each category.

Communication Port Configurations

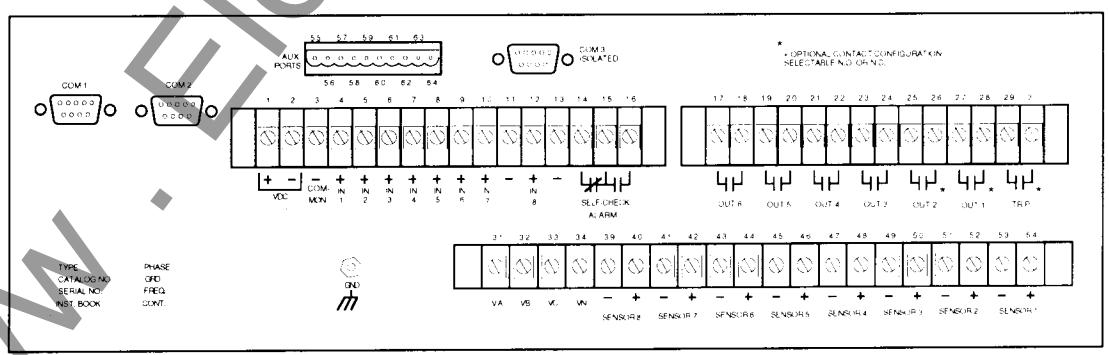
The 2000R platform provides several variations of communication ports, such as a 9-pin RS-232, RS-485, INCOM™ and Modbus Plus™. Also available is a list of factory supported common communication protocols for networking the unit.

RS-232 ports are available in two different configurations, Isolated and Non-Isolated. Isolated ports provide isolation between the communication port and the rest of the relay.

COM 1 port is configured as a non-isolated port only. Units having an MMI display use the RS-232 port on the front panel as COM 1, thereby permanently disabling the RS-232 port marked COM 1 on the rear of the unit. Units not having an MMI Display permit the user to select, via jumper setting, either the front or rear (labeled COM 1) RS-232 connectors to act as COM 1.

COM 2 port is a non-isolated configuration and COM 3 port is an isolated configuration. Refer to the following list of options to select the most suitable configuration.

The 2000R series also features ABB's innovative RS-485 isolated communications capability available when the optional Auxiliary Communication board is installed. This isolated RS-485 configuration provides superior communication quality recommended for applications in areas of high electrical noise or that require connecting cables longer than 10 feet (3m).



Rear Terminal Blocks and Communication Ports

NOTE: Non-isolated RS-232 ports are susceptible to electrical noise. For that reason it is recommended that connecting cables be no longer than 10 feet (3m) when connecting to a non-isolated port. Devices connected to non-isolated ports must have the same ground return as the 2000R unit.

Refer to the Select Communication Options Table when making option selections.

In addition to the standard front or rear non-isolated RS-232 port (COM 1), the following rear communication port options are available:

Option 0

This option provides RS-232 communication via the non-isolated COM 2 port and is suitable only in applications where communication to the unit is local through a direct connection to a PC or remote through an external isolating communication device , such as an RS-232 to fiber optic converter, which is connected to the relay using a short cable.

Options 1 through 8 are provided on an independent communication card installed in the unit.

Option 1

This option provides RS-232 communication via the isolated COM 3 port for transient immunity and isolation and must be used where communication cable lengths are greater than 10 feet (3m) or a common ground is not guaranteed. In general, RS-232 communication is limited to a maximum distance of 50 feet (15m). Aux Com and COM 2 ports are disabled in this configuration.

Option 2

This option provides RS-232 communication via isolated COM 3 port and RS-485 communication via the isolated Aux Com ports. The auxiliary port is an isolated RS-485 configuration that supports several communication protocols (*See Communication Protocol Category On Ordering Sheet*).

Option 3

This option provides INCOM™ availability, via the Aux Com port, in applications where either the Westinghouse INCOM™, or ABB WRELCOM™, network is used.

Option 4

This option provides RS-485 communication and INCOM™ availability, via the isolated Aux Com port. In this configuration, the INCOM™ port provides the same functionality as option 3.

Option 5

This option provides RS-485 communication via the isolated Aux Com port and is highly recommended for applications requiring communication over distances of up to 300 feet (100m). This option has an advantage over RS-232 by allowing networking of multiple relays via a simple 3 wire connection.

An RS-485 to RS-232 converter (Catalog Number 245X2000) is available to connect the network to an external device such as a modem or a personal computer.

Option 6

This option provides a Modbus Plus™ interface, via the COM 3 port, and RS-232 communication via the non-isolated COM 2 port.

Option 7

This option provides a Modbus Plus™ interface via the COM 3 and RS-485 communication via the isolated Aux Com port.

Option 8

This option provides RS-485 communication via the isolated COM 3 and Aux Com ports.

Communication Protocols

The Select Options Table shows the communication protocols and the respective hardware port assignments that are currently available.

The "Standard" Protocol

The "Standard" protocol referenced throughout this publication refers to an ABB 2000 series-specific 10 byte ASCII oriented communication protocol. This protocol is standard for COM 1 and is selectable for other rear ports as per the Select Options Table. The 2000 series External Communication Program (ECP) provided, at no charge, with the relay uses the standard protocol.

Product specific protocol documents are available from the factory upon request.

Special Software Options

The special software options available on the 2000R series include Load Profile, Customer Programmable Curves, Special Recloser Curves and Oscillographic Data. Any combination of these options may be selected.

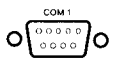
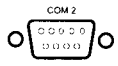
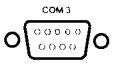
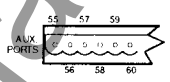
- 3 character locations in the catalog number define your selection of software options.
- Special recloser curve options duplicate popular recloser time current characteristic curves. Contact ABB Allentown for curve details.

The table below illustrates all possible hardware configurations for the communication ports and the supported protocols. The Catalog Number Select Option columns list every communication option for which the relays can be configured.

The different protocol variations are outlined under the corresponding communication ports that support them. Select the row containing the protocol combination that best suits your communications requirements and use the corresponding catalog number options to fill in the brackets [ ] of the catalog number.

The auxiliary port labelled IRIG-B receives a demodulated IRIG-B signal for 2000R clock synchronization purposes.

For example, if your system requires DNP 3.0 (IEC870-5) protocol, the ordering catalog number would be 589R041[**2**]-6101[**1**] (4th row), 589R041[**4**]-6101[**1**](10th row) or 589R041[**8**]-6101[**1**](18th row) based on your choice for the second port provided

Catalog Number Select Option		REAR PORT ASSIGNMENTS						
									
				NON ISOLATED RS-232	NON ISOLATED RS-232	ISOLATED RS-232 unless noted	RS-485 ISOLATED	INCOM ISOLATED	IRIG-B
589R041[ ] - 6101[ ]		With Display	Without Display*						
0	0		Standard	Standard					
1	0		Standard		Standard				
2	0		Standard		Standard	Standard			IRIG-B
2	1		Standard		Standard	Standard			IRIG-B
2	2		Standard		Standard	SPACOM			IRIG-B
2	3		Standard		Standard	PG&E			IRIG-B
2	4		Standard		Modbus® (RS-232)	Standard			IRIG-B
3	0		Standard					INCOM	IRIG-B
4	0		Standard			Standard		INCOM	IRIG-B
4	1		Standard					INCOM	IRIG-B
4	2		Standard			SPACOM		INCOM	IRIG-B
4	3		Standard			PG&E		INCOM	IRIG-B
4	4		Standard			Modbus®		INCOM	IRIG-B
5	0		Standard			Standard			
6	4		Standard	Standard	Modbus® (Modbus Plus™)				
7	4		Standard		Modbus® (Modbus Plus™)	Standard			
8	0		Standard		Standard (RS-485)	Standard			IRIG-B
8	1		Standard		Standard (RS-485)	Standard			IRIG-B
8	2		Standard		SPACOM (RS-485)	SPACOM			IRIG-B
8	3		Standard		Standard (RS-485)	PG&E			IRIG-B
8	4		Standard		Standard (RS-485)	Modbus®			IRIG-B

Select Communication Options Table

An empty selection box indicates communication port is either not provided or is disabled.

* Main board jumper selectable front or rear

Ordering Selections

Catalog Number Selection → **589** R 0 4 1 1 – 6 1 0 1 0

User Selections

Configuration
- Type A . . . . . R
- Type B . . . . . T
- Type C . . . . . W

Current Range

Phase	Ground	
2.0 - 8.0 A	2.0 - 8.0 A	0
2.0 - 8.0 A	0.4 - 1.6 A	1
0.4 - 1.6 A	0.4 - 1.6 A	2

Control Voltage
- 38 — 58 Vdc 3
- 70 — 280 Vdc 4
- 19 — 29 Vdc 9

Man-Machine Interface
- No Man Machine Interface 0
- Man Machine Interface 1

Rear Communications Port
(Front RS-232 port is standard equipment on all units)
- RS-232 (non-isolated) 0
- RS-232 (isolated) 1
- Auxiliary Port & RS-232 (isolated) 2
- INCOM™ (isolated) 3
- Auxiliary Port & INCOM™ (isolated) 4
- RS-485 (isolated) 5
- Modbus Plus™ & RS-232 (non-isolated) 6
- Modbus Plus™ & RS-485 (isolated) 7
- Dual RS-485 Ports (isolated) 8

Frequency
- 50 Hertz 5
- 60 Hertz 6

Software Options
- No Oscillographics 0
- Oscillographics 1
- Extended Oscillographics 2

Contact factory for availability
- No User Programmable Curves 0
- • • • • • • • • User Programmable Curves 1

- No Load Profile 0
- Load Profile 1

Communications Protocol
- Standard (10-Byte protocol) 0
- SPACOM 2
- PG&E 3
- Modbus® 4