



Instruction Booklet
1MRA589765–MIB

Issue B November 2002 (IB 7.11.1.7-10)

Revision History

11/02 Changed Issue Date to November 2002. Test Procedures added in Section 10.

Introduction

This book contains instructions on the installation, operation, and testing of the Generator Protection Unit, Type GPU2000R, catalog series 589T, 589V, and 589W. (For series 589R refer to Instruction Book IMRA589764–MIB, IB 7.11.1.7-7)

Be sure to observe Precautions listed on page ii.

Quick Start information follows on page iv.



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Precautions

1. Incorrect wiring may result in damage. Be sure wiring agrees with connection diagram before energizing.
2. Apply only the rated control voltage marked on the unit.
3. High-potential tests are not recommended. If a control wire insulation test is required, fully withdraw the GPU-2000R from its case and perform only a DC high-potential test. **Surge capacitors installed in the unit do not allow AC high-potential testing.**
4. Follow test procedures to verify proper operation. To avoid personal shock, use caution when working with energized equipment. Only competent technicians familiar with good safety practices should service these devices.
5. When the self-checking function detects a system failure, the protective functions are disabled and the alarm contacts are actuated. Replace the unit as soon as possible.
6. During generator start-up, protective functions dependent 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) functions are disabled during startup. When a successful startup is complete, re-enable these functions.
7. Default settings are not "recommended settings." The user must review select, and apply appropriate settings based on the particular application.
8. In your application, it may be necessary to reposition certain links that set particular contacts to normally-open or normally-closed (see Section 5), or for communications (see Section 12).

Password

9. 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.

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 Inc., at 1-800-634-6005, or fax 610-395-1055.



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Quick Start

The following notes give some hints as to how to get started with the GPU2000R

1. Be sure to read the Precautions on page (ii).
2. Note the Menu structures shown on page 4-3 (MMI) and page 4-5 (ECP).
Instructions on using the front panel MMI or the ECP communications program are given in Section 4.
3. The programmable inputs and outputs are not pre-programmed. The Master Trip Output is the contact at terminals 29-30.
To make these settings you must communicate with the unit by running the GPUECP software in your PC and connect via the serial port to the front port of the GPU2000R.
Connect your pc to the unit using a null modem cable, or use a straight-through cable and a separate null-modem adaptor. (The null modem device swaps over pins 2 and 3).
Information on Communications ports is given in Section 12.
4. Any protection function that does not have a programmable input assigned to “torque-control” that function will be automatically enabled if that protection function is enabled in the protection settings menu.
5. Configuration Settings which are based on instrument transformer ratios, generator nameplate ratings, and other system parameters, should be determined first (see Section 2), followed by the protection and alarm settings (see Section 1).

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Protective Functions

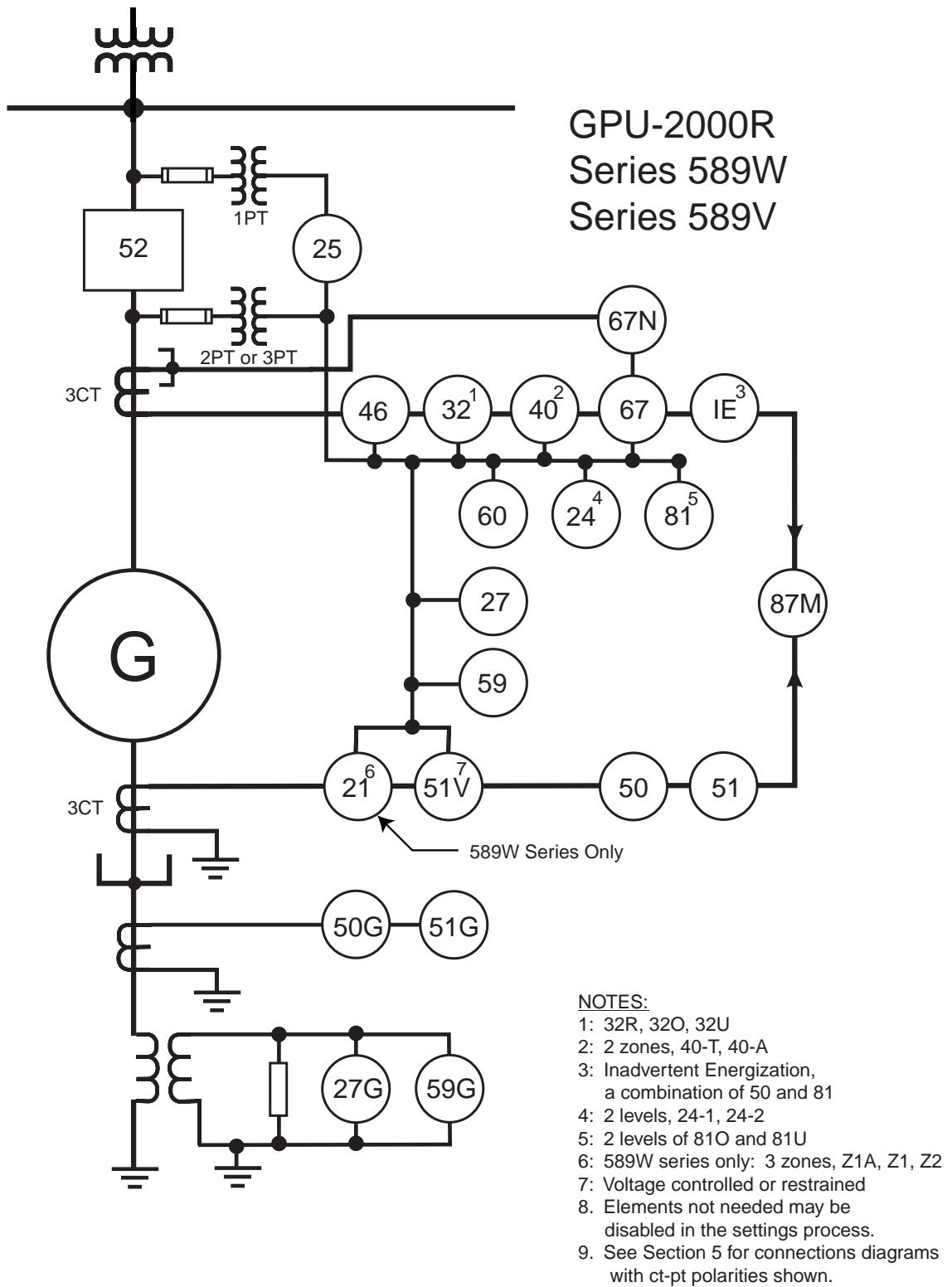


Figure 1-1: Protective Elements Included in Series 589W, 589V Units

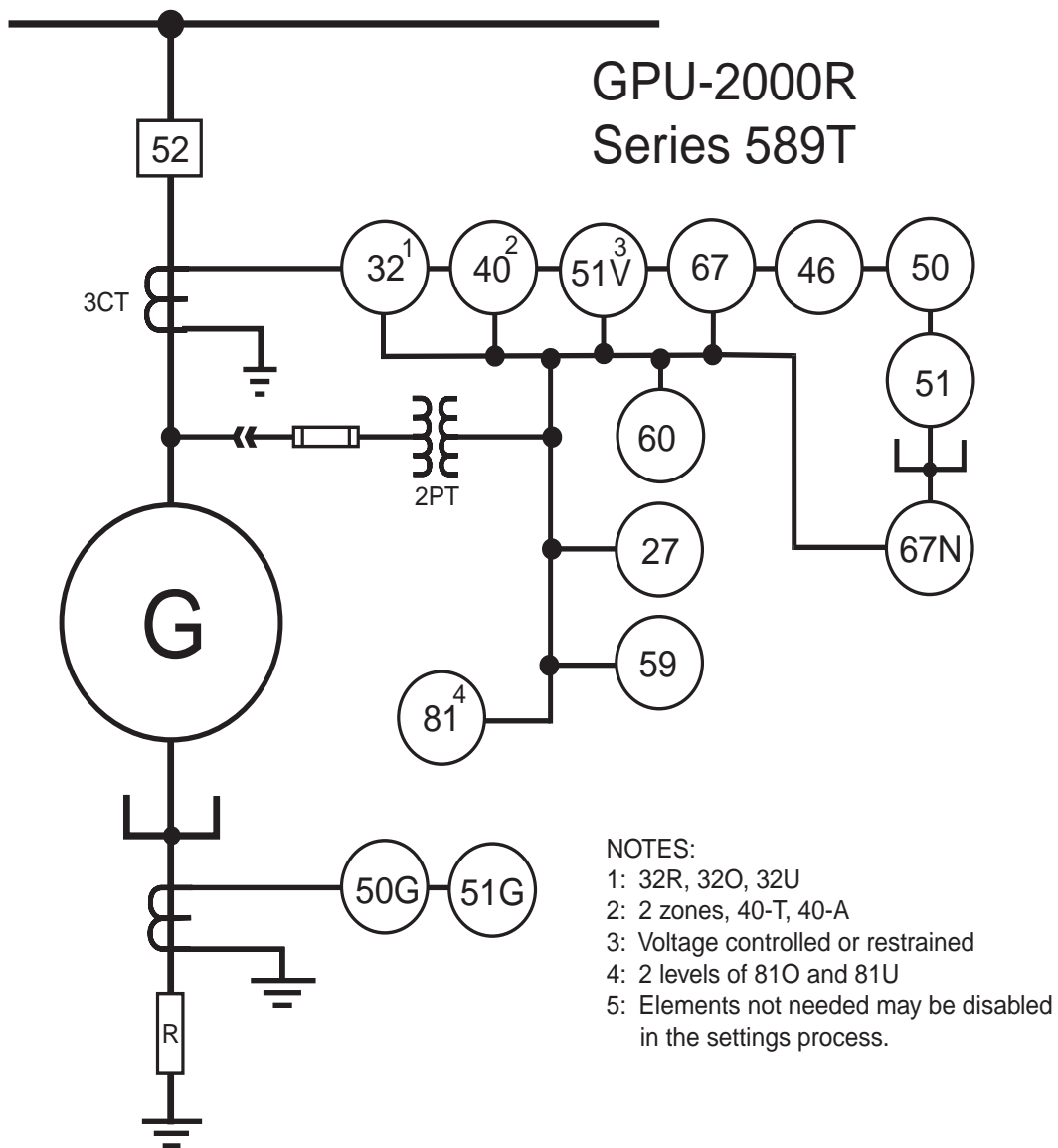


Figure 1-2: Protective Elements Included in Series 589T Units

Function 87: Machine Differential Protection

The differential element compares on a phase-by-phase basis, the secondary currents from the load-side ct's to the current from the neutral-side ct's, and provides fast, sensitive detection of phase-to-phase faults within this zone of protection. It will also detect ground faults in those cases, such as solidly grounded low voltage machines, where sufficient ground fault current is available for detection by the relay.

In machine differential schemes, due to the high sensitivity of the differential element, it is considered good practice that both sets of ct's be of identical construction.

A constant percentage differential characteristic is provided as shown in Figure1-3. The percentage characteristic, by requiring higher levels of operate current as the through current increases, gives security against misoperation on significant faults external to the zone of protection.

The 87 function has an adjustable minimum operate current setting for the high sensitivity region of the characteristic (low restraint current). This is shown expanded in the Figure 1-4. In general you should choose a setting in the lower portion of its range, which can be raised if required, based on experience during the process of commissioning the machine.

The 87 function operates over the frequency range of 20-87 Hz and is active during the start-up and shut-down of the machine.

A selectable definite-time is used with this function. The total operating time will be approximately 2 cycles of measurement time, plus the set definite-time.

Table 1-1. 87 Machine Differential Protection

Unit's Phase Current Range	87 Minimum Operate Current Range	Increment	Timer Range	Increment
2 - 8 A	0.1 - 1.0 A	0.1 A	0.00 - 0.10 sec	0.01 sec
0.4 - 1.6 A	0.02 - 0.2 A	0.02 A		

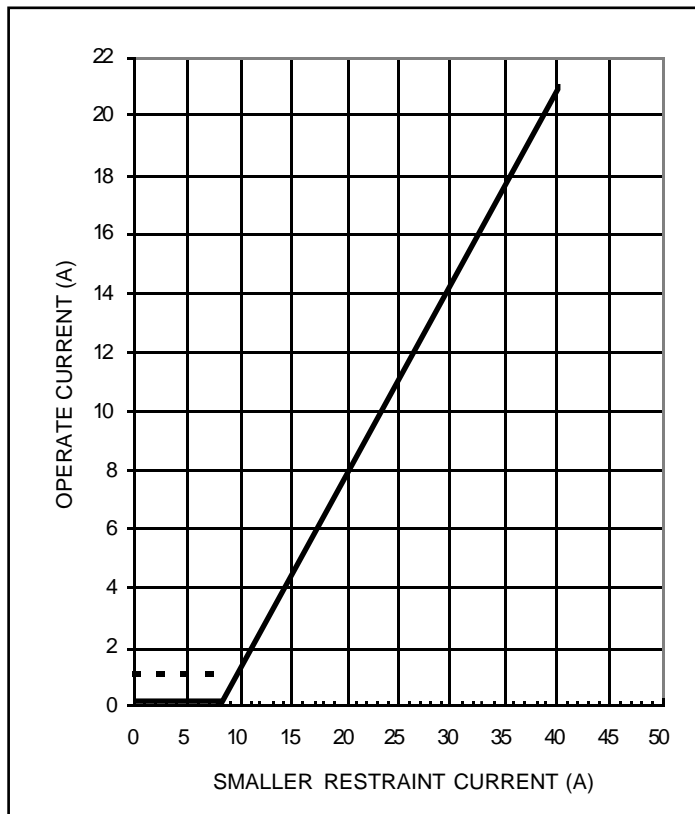


Figure 1-3: Operating Characteristics

Note:
Scales shown are for units with 2-8A range. Divide by 5 for 0.4 - 1.6A units

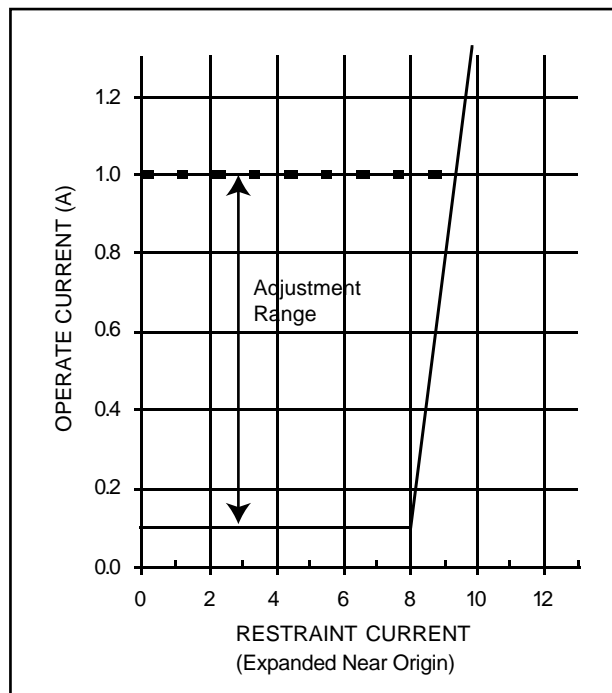


Figure 1-4. Characteristic Shown Expanded Near Origin

Function 21: Phase Distance Protection

The distance elements included in the 489W series units are used to provide phase-fault protection for faults within the zone of protection of the 87 element up through a portion of the unit transformer windings (using the 21-1a element); and backup protection for faults out on the connected system that are not cleared by their associated primary relaying (using the 21-1 and 21-2 elements).

The 21-1a impedance element would typically be set to see through 50-70% of the step-up transformer impedance in a unit-connected system.

The impedance, offset, characteristic angle and time delay are independently set for each zone of protection used. A negative or positive offset can be set if desired, but typically would be set for zero. The time delays would be set to coordinate with the primary protection of the zones overreached by the 21-1 and 21-2 elements; and also to coordinate with any breaker failure schemes that might be applied to those zones.

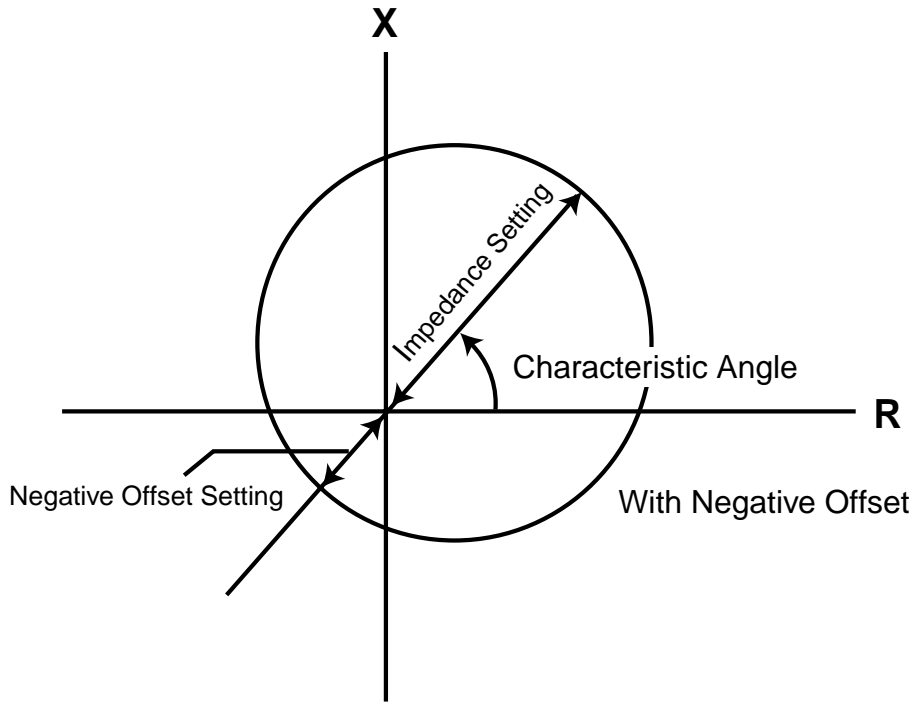
For applications where the generator is connected to the system through a delta-wye transformer, voltages and currents equivalent to the connected-system side of the transformer must be used in order for the relay to calculate the correct impedances for system faults. The delta-wye transform feature is enabled in the Configuration Settings (see Section 2) by selecting "Unit Transformer - Yes".

All primary side impedances must be reflected to the secondary side of the vt's and ct's to obtain the relay quantities, by using the following formula:

$$\text{Secondary Ohms} = \text{Primary Ohms} * \text{CT Ratio} / \text{VT Ratio}$$

Table 1-2. Phase Distance Backup Protection

21 Parameters	Range	Increment
Zone 21a - 1 Impedance 2.0 - 8.0 amp models 0.4 - 1.6 amp models	0.2 - 2.0 ohms 1.0 - 10.0 ohms	0.1 ohm
Characteristic Angle	70 - 90 degrees	0.1 degree
Offset 2.0 - 8.0 amp models 0.4 - 1.6 amp models	-1.0 to +1.0 ohm -5.0 to +5.0 ohm	0.1 ohm
Time Delay (Definite Time)	0.0 to 10 sec	0.1 sec
Zone 21 - 1 Impedance 2.0 - 8.0 amp models 0.4 - 1.6 amp models	0.1 - 100.0 ohms 0.5 - 500.0 ohms	0.1 ohm 0.1 ohm
Characteristic Angle	0.0 - 360.0 degrees	0.1 degree
Offset 2.0 - 8.0 amp models 0.4 - 1.6 amp models	-100 to +100 ohm -500 to +500 ohm	0.1 ohm
Time Delay (Definite Time)	0.0 to 10 sec	0.1 sec
Zone 21 - 2 Settings for this zone are identical to, and independent of the settings for Zone 21 - 1.		



Diameter of Circle =
Impedance Setting \ominus Offset Setting

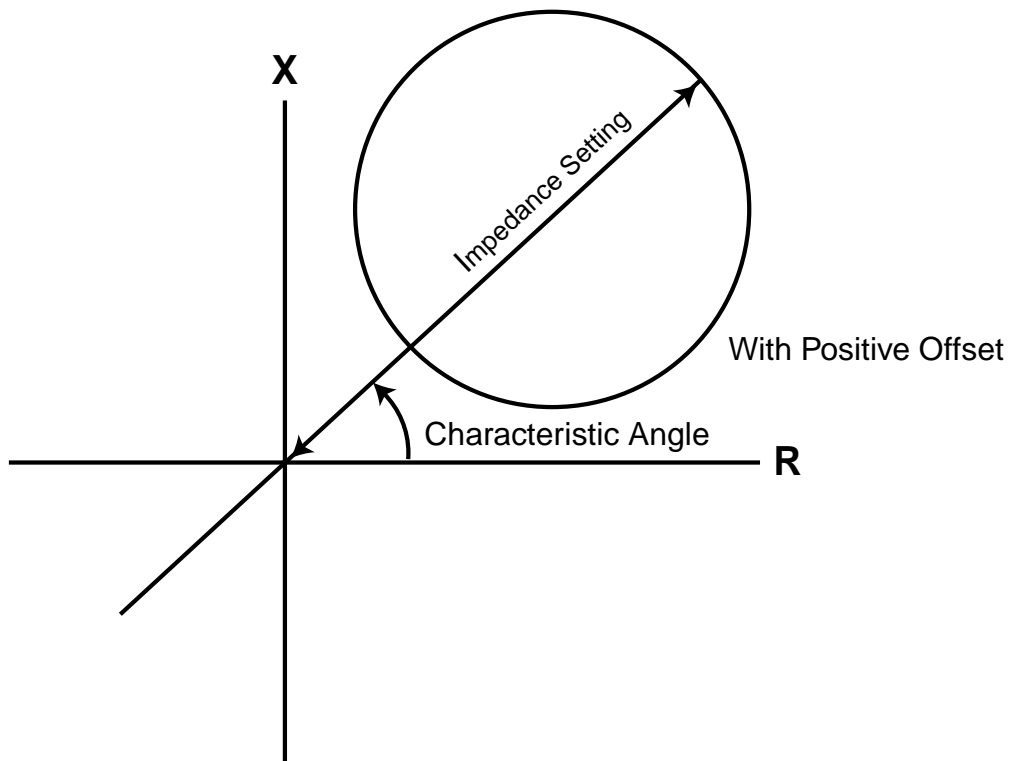


Figure 1-5. Phase Distance Function Characteristic

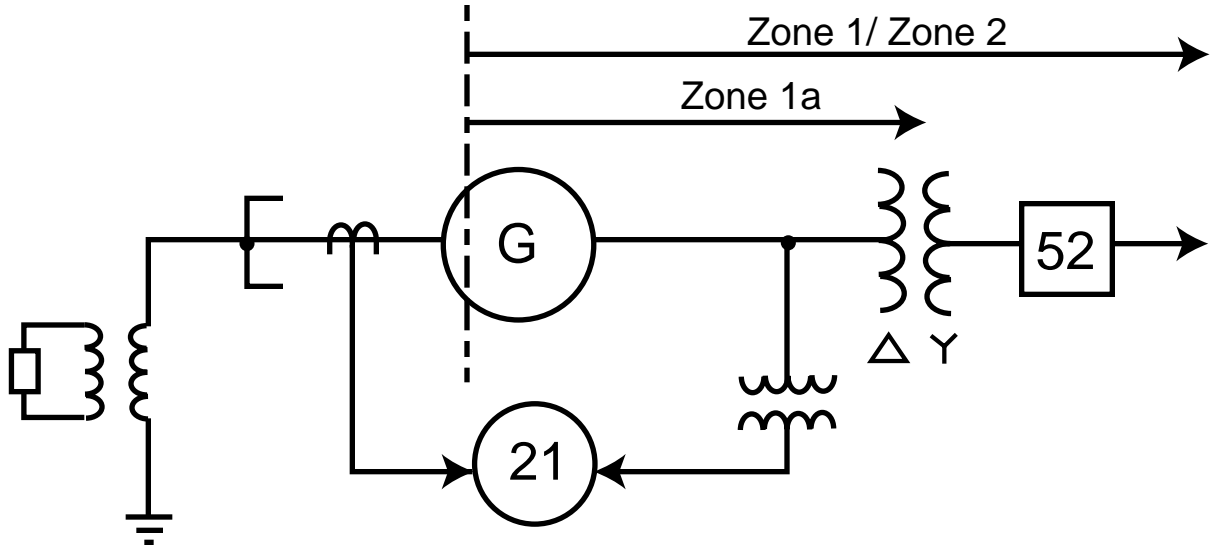


Figure 1-6. Phase Distance (21) Zones

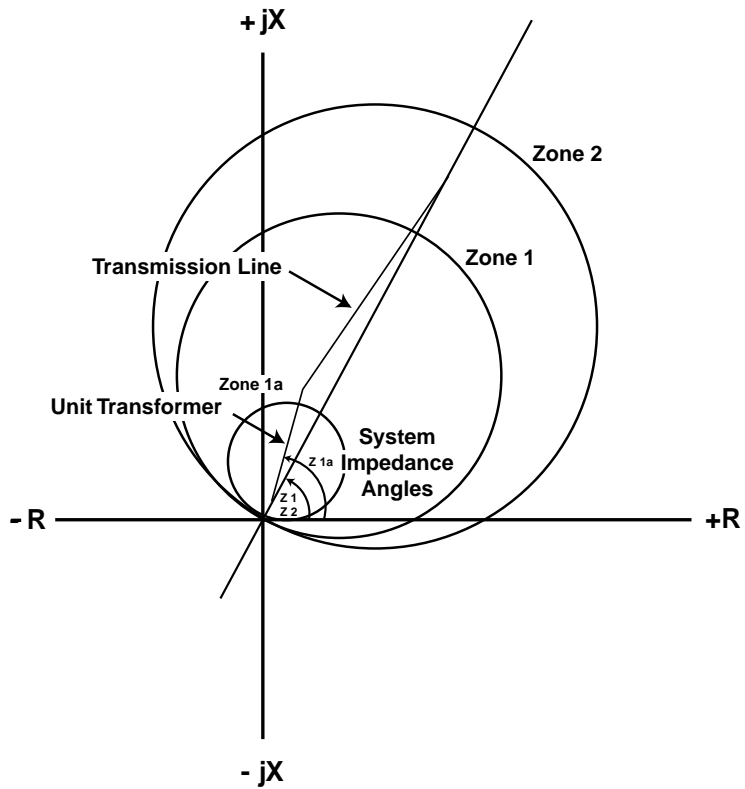


Figure 1-7. Phase Distance Function Applied for System Backup

Table 1-3. Function 21 - CT / VT Scaling

	Direct-Connected		Delta/Wye Transformer	
	VT Connection		VT Connection	
	Line-to-Line	Line-to-Ground	Line-to-Line	Line-to-Ground
AB Fault	$\frac{V_{AB}}{I_A - I_B}$	$\frac{V_A - V_B}{I_A - I_B}$	$\frac{V_{BC} - V_{AB}}{I_B}$	$\frac{V_B - V_O}{I_B}$
BC Fault	$\frac{V_{BC}}{I_B - I_C}$	$\frac{V_B - V_C}{I_B - I_C}$	$\frac{V_{CA} - V_{CB}}{I_C}$	$\frac{V_C - V_O}{I_C}$
CA Fault	$\frac{V_{CA}}{I_C - I_A}$	$\frac{V_C - V_A}{I_C - I_A}$	$\frac{V_{AB} - V_{CA}}{I_A}$	$\frac{V_A - V_O}{I_A}$
$Z_{sec} =$	$Z_{PRI} \left[\frac{R_C}{R_V} \right]$	$Z_{PRI} \left[\frac{R_C}{R_V} \right]$	$Z_{PRI} \left[\frac{R_C}{R_V} \right] 3$	$Z_{PRI} \left[\frac{R_C}{R_V} \right]$

Overcurrent Protection Functions

The following tables, 1-4, 1-5 are referenced throughout this instruction booklet as the available curve selections for overcurrent protective functions.

Table 1-4. Time Overcurrent Curves (51)

Curve	Time Dial
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 (Delay)	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 1-5. Instantaneous Overcurrent Curves (51)

Curve	Time Dial
Standard	Instantaneous
Inverse Instantaneous	#1.0 to #10
Definite Time (Delay)	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 optional feature - see section 11.

The Time-Current Curves and their equations are shown toward the end of this section. Transparent full-size curves are available on request, contact factory at 1-800-634-6005.

Function 51V Voltage Dependent Phase Time-Overcurrent Protection

*** Selectable for Voltage-Controlled or Voltage-Restrained Operation**

This protective element provides backup for the differential unit (87) and also will operate for downstream faults that have not been cleared by other relays. Voltage dependence provides security against improper operation during overload conditions, but allows the improved sensitivity required by the limited capability of the generator to supply sustained short circuit current. This element must be coordinated with downstream overcurrent relays.

The user may select either Voltage-Controlled or Voltage-Restrained operation. When voltage-controlled, the overcurrent element is not active until the voltage drops below the voltage set point. You then have a fixed set pickup current, and a fixed set time-dial selection. In general, this arrangement is easiest to coordinate with downstream relays.

In voltage-restrained operation, the pickup current of the overcurrent element is active at all times, and varies continually with voltage, becoming more sensitive as the voltage falls. Refer to Table 1-8. Because of this varying characteristic, coordination with downstream devices is more difficult.

Some users of traditional voltage-restrained overcurrent relays preferred the method because a degree of overload protection was provided since the overcurrent element was always active. The GPU2000R provides a separate overcurrent element, Device 51P, that can be set for overload protection, and thus allow such users to consider the use of the voltage-controlled method in those cases where coordination would be easier.

In setting the pickup current of the voltage-controlled element, the fundamental concern is that the relay will operate for the sustained short circuit current provided by the generator, which would be calculated from $1/X_d$, where X_d is synchronous reactance of the generator. The pickup current would typically be set at 80% of this value.

The typical pickup setting for the voltage-restrained element would be 125% of full load current at normal voltage.

The characteristic curve and time-dial selection would be based on coordination with downstream devices, and with a maximum time value that is under the short-time capability curves of the generator and associated devices such as a step-up transformer.

Table 1-6. 51V - Voltage Controlled Selection

Parameter	Range	Increment
Operating Voltage Wye PT's, line-to-neutral voltage Delta PT's, line-to-line voltage	20 - 170 volts 20 - 270 volts	10 volts 10 volts
Overcurrent Pickup Current Percent of Rated Current	25 - 100%	5
Time Curve: See Table 1-4. Time Dial (Inverse curves) Time Delay (Definite Time Curve Only)	1.0 - 10.0 0.1 - 10.0 sec	0.1 0.1 sec

Table 1-7. 51V - Voltage Restrained Selection

Parameter	Range	Increment
Overcurrent Pickup Current Percent of Rated Current	80 - 200%	5
Voltage Dependence	See Table 1-8	
Time Curve : See Table 1-4. Time Dial (Inverse Curves) Time Delay (Definite Time Curve Only)	1.0 - 10.0 0.1 - 10.0 sec	0.1 0.1 sec

Note: "Rated Current" is a Configuration Setting - see Section 2.

Table 1-8. Voltage Restraint Voltage and Current Characteristic

% Rated Volts	Pickup current Percent of Pickup Setting
100	100
75	75
50	50
25	25
0	25

Function 51P Phase Time-Overcurrent Protection

This time-overcurrent element is supplementary to the 51V function, and is useful primarily when the 51V is selected to be voltage-controlled. The 51P would be set above the rated load current to provide protection or alarm of an overload condition. It would be likely that one of the long-time curves would be selected for this function.

Table 1-9. 51P Phase Time-Overcurrent Protection

51P Parameter	Range	Increment
Overcurrent Pickup Current Percent of Rated Current	50 - 200%	5%
Time Curve - See Table 1-4. Time Dial (Inverse Curve) Time Delay (Definite Time Curve Only)	#1.0 - #10.0 0.1 - 10.0 sec	0.1 0.1 sec

Note: Rated Current is a Configuration Setting. See Section 2.

Function 50P Phase Instantaneous Overcurrent Protection

The ability to select one of the short-time inverse or the definite-delayed instantaneous curves allows the user to consider employing this element to provide faster clearing time on high faults, while maintaining coordination with downstream protective devices.

Table 1-10. 50P Phase Instantaneous Overcurrent Protection

50P Parameter	Range	Increment
Overcurrent Pickup Current Percent of 51P Pickup Setting	50 - 2000%	10%
Instantaneous Curve - See Table 1-5 Time Dial Inverse Curves Time Delay (Definite Delay)	#1.0 - #10.0 0.0 - 9.99 sec	0.1 0.01 sec

Note: Rated Current is a Configuration Setting. See Section 2.

Function 51G/50G Ground Time and Instantaneous Overcurrent Protection

In applications employing medium or low resistance grounding, or for solidly grounded machines, this element will operate from the current seen in the ct that is installed on the neutral to ground connection. It provides backup protection for ground faults and must be coordinated with any downstream ground overcurrent protection.

The ability to select one of the short-time inverse or the definite-delayed instantaneous curves allows the user to consider employing the instantaneous element in solidly grounded systems to provide faster clearing time on high faults, while maintaining coordination with downstream protective devices.

When significant third-harmonic currents are expected to be seen by this element, the “fundamental mode” configuration setting should be used to obtain a high degree of rejection of the third harmonic. See Configuration Settings in Section 2.

Table 1-11. 51G Ground Time– Overcurrent Protection

51G Parameter	Range	Increment
Overcurrent Pickup Current Percent of Rated Gound Current	50 - 200%	5%
Time Curve - See Table 1-4 Time Dial (Inverse Curves) Time Delay (Definite Time Curve Only)	#1.0 - #10.0 0.1 - 10.0 sec	0.1 0.1 sec

Note: Rated Ground Current is a Configuration Setting, see Section 2.

Table 1-12. 50G Ground Instantaneous Overcurrent Protection

50G Parameter	Range	Increment
Overcurrent Pickup Current Percent of Rated Ground Current	50 - 2000%	10%
Instantaneous Curves - See Table 1-5 Time Dial (Inverse Curves) Time Delay (Definite Delay)	#1.0 - #10.0 0.0 - 9.99 sec	0.1 0.01 sec

Note: Rated Ground Current is a Configuration Setting, see Section 2.

Function 50IE Inadvertent Machine Energization

Should an offline generator be suddenly connected to the system, large currents flow in order to try to accelerate the machine, similar to starting an induction motor. These currents will rapidly cause thermal damage to the machine. The reverse power function of the relay, device 32R, generally must be set with a time delay that is much too long to provide adequate protection against inadvertent energization, therefore, this separate 50IE function is required.

The inadvertent energization protection is “armed” when the frequency and current are below the setpoints. Then, if current above the frequency setpoint and above the magnitude setpoint is seen, the inadvertent energization element will send an immediate trip signal. The function is “disarmed” when the operating frequency is above the setpoint for greater than 1 second, with current below the setpoint, as would be normal during the startup and synchronization process.

Users must carefully consider what system devices must be tripped to isolate a machine that is in an inadvertent energization state.

Table 1-13. 50IE Inadvertent Machine Energization

50IE Parameter	Range	Increment
Overcurrent Pickup Percent of Rated Current	50 - 300%	10%
Arming Frequency Hertz Below Nominal System Frequency	4 - 15 Hz	1 Hz

Note: “Rated Current” is a Configuration Setting, see Section 2.

Function 32R Reverse Power Protection

In the event of the loss of mechanical input power to the generator, the machine will motor, drawing power from the connected system. Detection of this reverse power flow allows the machine to be removed from service to protect against mechanical damage and other hazards, such as those related to fuel supply. The reverse power function is also applied in sequential tripping schemes used for bringing steam turbine generators off line.

The reverse power function of the GPU2000R has been improved to increase its sensitivity compared to earlier models, so that it can be applied to most types of machines.

Typical settings for this function would be: pickup at 50% of the power level required to motor the system (get data from machine manufacturer), and time delay at 15 seconds.

Table 1-14. 32R Reverse Power Protection

32R Parameter	Range	Increment
Reverse Power Pickup Percent of Rated Power	0.2 - 15%	0.1%
Time Curve Long Time Inverse Definite Time	Time Dial #1 - #10 0.1 - 60 sec	0.1 0.1 sec

Note: "Rated Power" is calculated from the Rated Current and Rated Power Factor in the Configuration Settings, see Section 2.

System Voltage Correction Factor

An adjustment for the Reverse Power Pickup Setting will be required if your rated nominal primary system voltage and the VT ratios result in a secondary voltage value other than the choices given in the configuration setting "VT Conn" (see Section 2).

This is because the 32R pickup setting is in terms of percent of rated power which is computed by the relay based on the three configuration settings: Rated Current, Machine PF, and VT Conn.

The correction factor is computed as follows:

$$\text{For Y connected vt's: } CF = \frac{\text{System Line-Line Primary Rated Voltage}}{1.732 * \text{VT ratio} * \text{VT Conn Setting}}$$

$$\text{For Open-Delta connected vt's } CF = \frac{\text{System Line-Line Rated Voltage}}{\text{VT ratio} * \text{VT Conn Setting}}$$

Then to apply the correction factor:

$$\text{Actual Setting to be made on relay} = \text{Desired Setting as Percent of Machine Rated Power} * \text{Correction Factor}$$

Functions 32O and 32U Over and Underpower Protection

These functions can be used to trip or alarm if the generated power level is out of the set boundaries. For example, they might be used to detect improper load sharing where multiple generators are operated in parallel.

Table 1-15. 32O and 32U Over and Underpower Protection

32O Parameter	Range	Increment
Overpower Pickup Percent of Rated Power	100 - 200%	10%
Time Delay	0.1 - 60 sec	0.1 sec

32U Parameter	Range	Increment
Underpower Pickup Percent of Rated Power	10 - 100%	10%
Time Delay	0.1 - 60 sec	0.1 sec

Note: "Rated Power" is calculated from the Rated Current and Rated Power Factor in the Configuration Settings, see Section 2.

System Voltage Correction Factor

An adjustment for the Reverse Power Pickup Setting will be required if your rated nominal primary system voltage and the VT ratios result in a secondary voltage value other than the choices given in the configuration setting "VT Conn" (see Section 2).

This is because the 32O and 32U pickup settings are in terms of percent of rated power which is computed by the relay based on the three configuration settings: Rated Current, Machine PF, and VT Conn.

The correction factor is determined as follows:

$$\text{For Y connected vt's: } CF = \frac{\text{System Line-Line Primary Rated Voltage}}{1.732 * \text{VT ratio} * \text{VT Conn Setting}}$$

$$\text{For Open-Delta connected vt's } CF = \frac{\text{System Line-Line Rated Voltage}}{\text{VT ratio} * \text{VT Conn Setting}}$$

Then to apply the correction factor:

$$\text{Actual Setting to be made on relay} = \text{Desired Setting as Percent of Machine Rated Power} * \text{Correction Factor}$$

Function 40 Loss of Excitation Protection

Loss of excitation can occur for various reasons such as accidental tripping of the field breaker, short circuits, poor brush contact, or other failures in the excitation system.

With constant input power from the prime mover, the machine will accelerate and operate above synchronous speed as an induction generator. Excitation will be drawn from the system (leading Vars as seen by the machine). Under this condition, overheating of the machine will occur. Also, the terminal voltage will likely be depressed and system stability threatened.

The GPU2000R provides two mho circle characteristics (40T and 40A) for use in loss of excitation protection. This allows the user the possibility of employing various types of schemes, depending on personal preference for the size of the machine being protected. Each element has independent impedance settings and timer settings. A 13 degree fixed directional characteristic is also included in the 40T and 40A units.

Only the 40T element is mappable to the Master Trip Output at this time. The 40A element must be mapped to a separate physical output contact, and depending on your scheme, may be used to trip or to alarm.

Table 1-16. Loss of Excitation Protection

40 Parameters	Range	Increment
40T – Trip		
Offset 2.0 - 8.0 amp models 0.4 - 1.6 amp models	-100 to +100 ohms -500 to +500 ohms	0.5 ohms 2.5 ohms
Diameter & Offset 2.0 - 8.0 amp models 0.4 - 1.6 amp models	5 to 100 ohms 25 to 500 ohms	1.0 ohms 2.5 ohms
Time Delay (Definite Time)	0.1 to 10 sec	0.1 sec
40A–Alarm		
The 40A settings are identical to, and independent of those provided for 40T.		

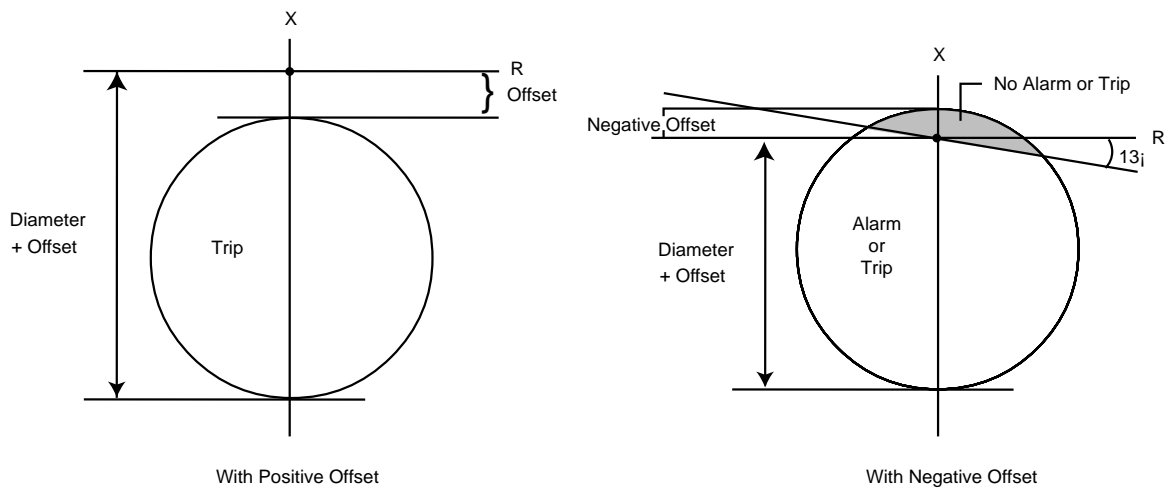


Figure 1-8. Function 40 Characteristics

Single Zone Scheme

The most common scheme uses a single element to measure the impedance as viewed at the generator's terminals. The mho circle is selected to encompass the final operating point of the machine, and must be sized to include impedance trajectories where the machine was lightly loaded and heavily loaded at the time excitation was lost. The size and placement of the circle on the R-X plane is based on the transient reactance (X_d^1) and synchronous reactance (X_d) of the machine, and is shown in Figure 1-9.

The timer is set to avoid tripping for stable swings due to faults on the system that are properly cleared by downstream protection. Typical setting values would be in the range 0.2 – 0.5 seconds.

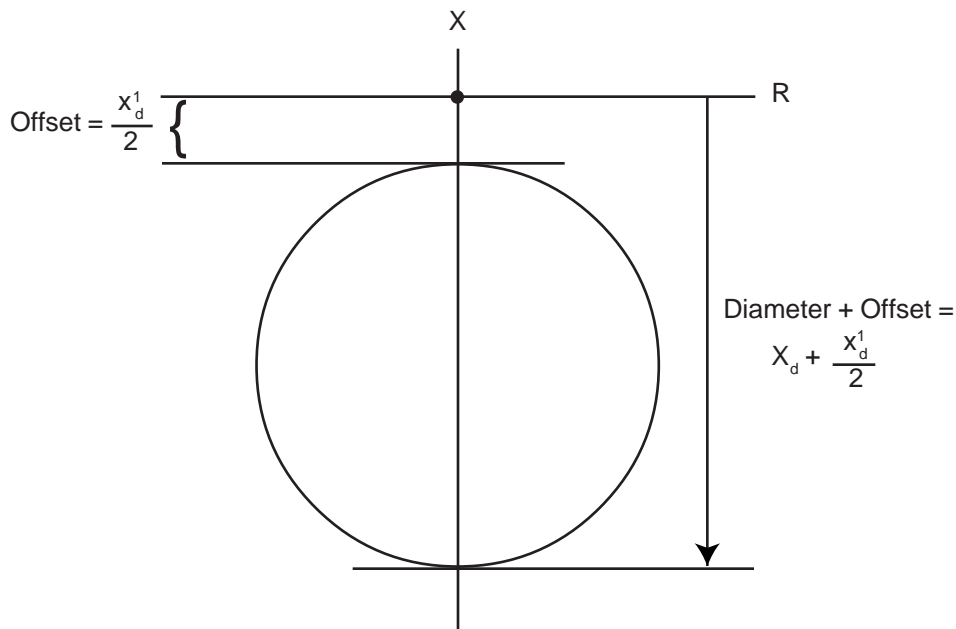


Figure 1-9. Single Zone Scheme

See sample calculation on next page.

Sample Settings Calculation for the Single-Zone Scheme

Primary impedances must be converted to secondary values to determine the relay settings using the relationship:
 Secondary Ohms = Primary Ohms * CT Ratio / VT Ratio

<u>Information Required</u>	<u>Assumed Values for the Example</u>
Transient Reactance X'_d (percent)	20 %
Synchronous Reactance X_d (percent)	120 %
Generator Rating (3 phase MVA) (base rating for percent reactances)	50 MVA
Generator Rating (kV) (base rating for percent reactances)	13.8 kV
CT Ratio	3000 : 5 = 600 : 1
VT Ratio	13200 : 120 = 110 : 1

<u>Calculation Method</u>	<u>Results Using Assumed Data</u>
1. $T = \text{CT Ratio} / \text{VT Ratio}$	1. $T = 600 / 110 = 5.45$
2. Base Ohms (primary) = $(\text{kV})^2 / \text{MVA}$	2. $(13.8)^2 / 50 = 3.81$ ohms
3. Base Ohms (sec) = $T * \text{Base Ohms (pri)}$	3. $5.45 \times 3.81 = 20.8$ ohms
4. X'_d (per unit) = X'_d (pct) / 100	4. $20 / 100 = 0.20$ pu
5. X_d (per unit) = X_d (pct) / 100	5. $120 / 100 = 1.20$ pu
6. X'_d (sec) = X'_d (pu) * Base Ohms (sec)	6. $0.20 \times 20.8 = 4.16$ ohms
7. Desired Offset = $1/2 X'_d$	7. $0.5 \times 4.16 = 2.08$ ohms
8. X_d (sec) = X_d (pu) * Base Ohms (sec)	8. $1.20 \times 20.8 = 24.96$ ohms
9. Determine Settings for Function 40T (refer to Figure1-9)	9. Set Offset = 2.0 ohms Set Diameter + Offset = 27 ohms

Function 46Q Negative–Sequence Overcurrent (Phase–Unbalance) Protection

This function provides back-up protection for certain downstream faults that have not been cleared by other devices; and also for unbalanced loading due to blown fuses, open conductors, or similar conditions. Negative-sequence currents cause heating of the machine’s rotor which is proportional to I_2^2 . The continuous operating limit is usually in the range of 5-10% of rated current, depending on the particular machine construction.

The GPU-2000R provides a thermal negative-sequence overcurrent tripping function with an I_2^2 characteristic, so that the full thermal capability of the machine can be used prior to removing the machine from service.

Upper and lower timing boundaries are applied to the I_2^2 curve: a fixed minimum operate time of 0.04 seconds, and a maximum operating time adjustable from 100 to 500 seconds.

The time-current characteristic curves are shown in Figure 1- 23.

A separate alarm function is provided to alert the operator of an existing unbalance condition. The pickup of this alarm function would normally be set below the tripping function pickup. The timing for the alarm is definite time, and should be set to allow downstream devices sufficient time for fault clearing.

Table 1-17. 46Q Parameters

46Q Parameters	Range	Increment
Tripping Function I_2 Pickup Current Percent of Rated Current	5 - 40%	1%
I_2^2 Withstand K (Time Dial)	1 - 99 seconds	1 sec
Maximum Time Delay	100 - 500 seconds	5 sec
Alarm Function I_2 Pickup Current Percent of Rated Current	5 - 40%	1%
Definite Time Delay	0.1 - 10 sec	0.1 sec

Typical settings for the 46Q function: Set 46Q Trip pickup equal to machine's continuous I_2 rating in percent. Set 46Q Trip timing equal to machine's "k" value, where $k = I_2^2 t$. Set 46Q maximum time at 300 seconds. Set 46Q alarm pickup less than or equal to 46Q Trip pickup, alarm delay at 10 seconds.

Function 24 Overexcitation Protection (Volts per Hertz)

Over-excitation is the condition where the flux density levels are above design values in the magnetic core of the generator, or in the core of the associated step-up transformer. In this condition stray flux can cause severe heating of core structures and insulation, and lead to failure.

Flux density is proportional to the ratio of Voltage/Frequency. At rated frequency, the continuous maximum voltage limit for a generator is usually 105%; therefore, this value is normally applied to obtain a Volts/Hz limit of 105%. Transformers usually are rated for a maximum continuous primary voltage of 110%; however, a transformer specifically designed for generator step-up unit service may have a higher voltage rating assigned to the winding connected to the generator, this being related to the impedance of the transformer.

Overexcitation damage most typically occurs during periods of off-frequency operation; i.e., start-up and shut-down of the generator, due to the excitation system being set in such a way as to attempt to hold rated voltage output. During periods that the generator is connected to the system, failure of the voltage regulator could cause overexcitation.

The short-time limits on overexcitation are inverse-time related and must be obtained from the manufacturer of the equipment being protected in order to determine the timing characteristic that should be set. The GPU2000R provides three inverse-time curves, and a definite-time curve for the Volts/Hertz function. These curves are shown at the end of this section. Since there is substantial time delay before tripping occurs at low levels of overexcitation, a separate alarm function is provided with a definite-time characteristic which can be used to alert an operator to take action to reduce the excitation level.

In order to provide a thermal characteristic in the event that repetitive overexcitation conditions occur, the timing element of the tripping function has slow-reset. The time-constant is selectable from 3 to 30 minutes. The alarm function uses instantaneous reset.

In order to provide security against tripping on momentary system conditions, the inverse curves are provided with a minimum operating time setting.

The Volts/Hz function uses Phase A–B voltage for its measurement.

Table 1-18. Volts per Hertz Protection

24 Parameters	Range	Increment
Tripping Function V/Hz Pickup Percent of Rated V/Hz	100 - 150%	1%
Time Curve Inverse Curves Definite Delay	#1, #2, #3 Def	
Time Dial Inverse Curves #1, #2 Inverse Curve # 3 Time Delay (Definite Curve Only)	#1 - #9 #1 - #8 1 - 100 seconds	0.1 0.1 1 sec
Minimum Operating Time (For Inverse Curves Only)	3 - 6 seconds	1 sec
Reset Characteristics Time - Constant (For Inverse Curves Only)	3 - 30 minutes	1 min
Alarm Function V/Hz Pickup Percent of Rated V/Hz	100 - 150%	1%
Time Delay (Definite Time)	1 - 100 seconds	1 sec

Note: "Rated Volts/Hz" is a configuration setting, see Configuration Settings, Section 2.

Functions 59G and 27G Stator Ground Fault Protection for High Impedance Grounded Generators

High impedance grounding is commonly used with unit connected generators; i.e., a generator connected to the delta winding of a step-up transformer. The value of impedance inserted between the generator neutral and ground is selected based on the stray capacitance to ground of the generator and transformer windings in order to limit transient overvoltages during ground fault conditions. The ground current is typically limited to value in the range of 2 to 30 amperes (primary).

The 59G ground overvoltage element is employed to sensitively detect ground faults within the stator winding of the generator and up through the delta winding of the unit transformer. The 59G element operates from the voltage obtained from the potential transformer connected across the grounding resistor, which is then filtered by the algorithms of the GPU2000R to obtain only the fundamental frequency content. The 59G unit is active over the frequency range of 10 to 87 Hz, thus it is also monitoring the generator during start-up and shut-down process. The 59G element has sufficient sensitivity to detect faults in more than 95% of the stator winding. A definite-time delay is provided in order to allow coordination with the fuses of the voltage transformers.

Table 1-19. 59G Stator Ground Fault Protection

59G Parameters	Range	Increment
Pickup Voltage	1 - 25 volts	1 volt
Time Delay (Definite Time)	1 - 100 seconds	1 sec

The 27G third-harmonic undervoltage element offers the possibility of obtaining 100% stator ground fault protection if the machine characteristics are such that a minimum level of third harmonic voltage is normally present across the grounding resistor. This is a function of the construction of the machine. By detecting the loss of the third-harmonic voltage which would occur on a ground fault, the 27G element provides protection for the last few percent of the stator winding not covered by the 59G element. The 27G is supervised by the measurement of the terminal voltage of the generator so that it is enabled only when the machine has been brought close to normal operating conditions.

A problem in applying third-harmonic undervoltage relaying in the past has been the need to connect external measuring equipment to study the amount of third-harmonic voltage present at the neutral of the machine over various operating conditions. This is necessary in order to determine a secure setting for the relay. The GPU2000R “solves” this problem by including a MIN and MAX third-harmonic metering function that can be used to “learn” the characteristics of the generator prior to placing the 27G element into service. The Min and Max records capture the 3rd harmonic voltage, the date and time, and the generator loading for each.

Table 1-20. 27G Third–Harmonic Undervoltage Element

27G Parameters	Range	Increment
Dropout Voltage (3rd Harmonic)	0.2 - 25 volts	0.1 volts
Time Delay (Definite Time)	1 - 100 seconds	1 sec
Supervising Voltage Percent of Rated Voltage	75 - 95%	1%

Note: 3rd Harmonic Voltage measurement is based on the input voltage at terminals 35 and 36, and supervising voltage is based on input voltage at terminals 31–32–33.

Alternate Use of the 59G Ground Overvoltage Function

When the generator is solidly grounded or low resistance grounded, the 59G element would not be used at the neutral of the machine, and the 51G overcurrent unit would usually be set up to provide the backup ground protection

In this case, there might be a need for ground voltage detection elsewhere in the system; for example, between the generator breaker and the delta winding of a transformer, used when the generator breaker is open and that portion of the system becomes ungrounded.

Terminals 35-36 could then be wired to a wye-broken delta set of auxiliary vt's. Note that the maximum continuous withstand of this input is 160vac; therefore, should the wye-broken delta arrangement provide 208v under a solid ground-fault, an auxiliary vt will be required to reduce the voltage. ABB offers a small auxiliary vt rated for 240vac with a 2:1 ratio suitable for this use, catalog 200T0201.

Functions 81O and 81U Over and Underfrequency Protection

Operation at frequencies other than nominal is usually caused by conditions on the connected power system.

Underfrequency operation would result from a deficiency of system generation capacity and would normally be corrected by load shedding. For applications of an isolated generator, underfrequency operation could be caused by a failure of the governor of the prime mover.

Overfrequency operation would typically be caused by a sudden loss of connected load.

The GPU2000R provides two independent underfrequency elements and two independent overfrequency elements. One each OF/UF elements would typically be assigned to trip the machine if its operating frequency limit has been reached for the period of time allowed by the design of the machine or its prime mover.

Consideration must be made of whether to supervise the frequency elements with a circuit breaker auxiliary contact input [52a] in the programmable logic, or to use these elements separately to indicate to the control system that the machine is up to nominal frequency.

In industrial or commercial cogeneration applications, the second set of elements could set with narrower limits and a fast time delay and be used to sever the tie to the utility on system disturbances. Alternately, the second set could be used in a high speed load shedding scheme to attempt to preserve critical in-plant loads upon opening of the tie to the utility.

A voltage block setting is provided to inhibit operation of any of the frequency elements when the system voltage drops below the set point.

Table 1-21. Functions 81O and 81U Over and Underfrequency Elements

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

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

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

Undervoltage Protection: 27

Close-in faults, or loss of a generator, or an increase in system demand reduces the generated output voltage. The exciter increases the field to compensate for this 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 conditions that will be cleared by other devices. The output contact programming and logic must be carefully considered for this function due to the likelihood of operation during generator startup and shutdown.

Table 1-22. Function 27 Undervoltage Protection

27 Parameter	Range	Increment
Pickup Setting	20 to 200 Volts	1 Volt
Time Delay	0 to 60.0 Seconds	1 Second

Overvoltage Protection: 59

Operation with voltage levels greater than rated output voltage may lead 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 to allow for momentary system conditions.

Table 1-23. Function 59 Overvoltage Protection

59 Parameter	Range	Increment
Pickup Setting	70 to 250 Volts	1 Volt
Time Delay	0 to 60.0 Seconds	1 Second

The voltage setting of each of these two functions 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.

Function 25 Synchronism Check

The Synchronism Check element is provided for those who want to back up the operator in cases where a manual synchronization process is used to place the machine in operation; or, perhaps to back up an automatic synchronizer.

The user may assign a physical output contact to the Logical Function 25, and a contact closure will be obtained when the phase angle difference, voltage difference, and slip frequency are within the set limits.

The settings process also allows the user to choose closure for a dead bus (live generator) condition.

The bus voltage is measured by connecting the secondary of a VT on the bus side of the generator circuit breaker to terminals 37 and 38 of catalog series 589V or 589W units. The settings for Function 25 ask you to designate which phase or phases the bus VT is connected to, so that the proper comparison can be made with the generator voltage. The VT on the bus side of the breaker must have the equivalent ratio to the generator side VT's so that the voltage at terminals 37-38 will match the particular voltage you have designated at terminals 31-32-33-34.

A red led is provided on the front of the unit to indicate an out-of-sync condition.

Assuming both sources are "live", the following conditions must be met in order to issue the Function 25 logical output:

- 1) The phase angle difference between the two sources must be less than the Angle Diff setting.
- 2) The magnitude difference between the two voltages must be less than the Volt Diff setting.
- 3) Conditions 1 and 2 must be met continuously for a time equal to or greater than the T Delay setting.
- 4) The measured slip frequency must be less than the slip frequency setting F_s .

Note that steps 3 and 4 are somewhat redundant. Figure 1-7 shows the relationship between the maximum slip frequency to obtain closing versus the T Delay setting and Angle Diff setting.

Should the machine be in service and the breaker be opened, the DeadTime timer prevents the synchronism measurement from being made again until its delay has expired.

If the Dead Bus setting is selected, then Function 25 will be obtained if the measured bus voltage is below the V_{dead}

Table 1-24. 25 Synchronism Check Function

25 Parameter	Range	Increment
Sync Check	Enable, Disable	
Voltage Difference (Volt Diff)	5 to 80 volts	5 Volt
Angle Difference (Angle Diff)	1 - 90 Degrees	1 Degree
Time Delay (T Delay)	0 to 60 Second	0.1 Second
Slip Cutoff Frequency (Slip Freq)	.005 to 1.000 Hz	.005 Hz
Breaker Close Time (Bkr Cl Time)	Disable, 0 to 20 Cycles	1 Cycle
Bus VT Phase (V Phase Sel)	Van, Vbn, Vcn Vab, Vbv, Vca	
Dead Bus Select	Dead Bus Select	
Line/Bus Voltage Dead (Dead Volt)	Line/Bus Voltage Dead (Dead Volt)	1
Dead Time (Dead Time)	Dead Time (Dead Time)	0.1

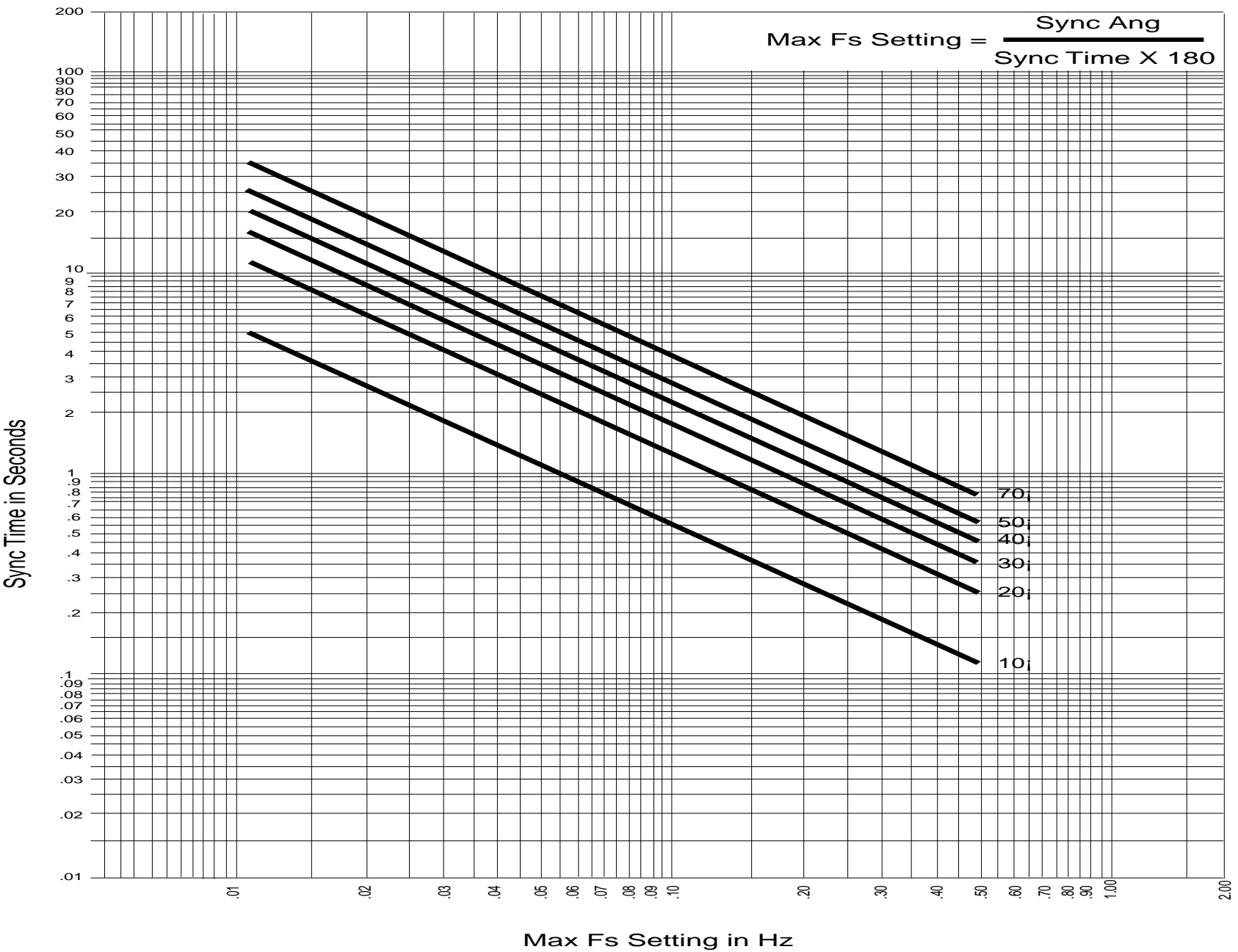


Figure 1-10. Sync Check Maximum Slip Frequency Characteristic to Obtain Closing

Function 67 Phase Directional Time-Overcurrent Protection

This function has limited applicability to protection of the generator, but is included to add to the flexibility of the relay. For example, it might be used in protection of the tie between a cogenerator and a utility source to obtain separation upon occurrence of a fault on the utility system.

This element uses positive-sequence voltage to polarize the directional unit, and the maximum torque angle is defined as the angle the positive-sequence current (I_1) leads the positive-sequence voltage (V_1).

The directional element, through internal logic, controls the operation of the phase-time overcurrent unit. The 67P overcurrent element is completely independent of the other phase overcurrent elements, 51P, 51V.

Function 32P Phase Directional Element (Contact factory for availability of this function.)

Programmable output function 32P instantaneously follows the operation of the directional unit, and has a current sensitivity of approximately 3% of the Configuration Setting "Rated Current at Machine rated PF".

Table 1-25. 67P Phase Directional Time-Overcurrent Protection

67 Parameter	Range	Increment
Overcurrent Pickup Current Percent of Rated Current	50 - 200%	5%
Time Curve: See Table 1-2 Time Dial (Inverse Curves) Time Delay (Definite Curve Only)	#1.0 - #10.0 0.1 - 10.0 Second	0.1 0.1 Second
Maximum Torque Angle I_1 Leads V_1	0 - 355	5

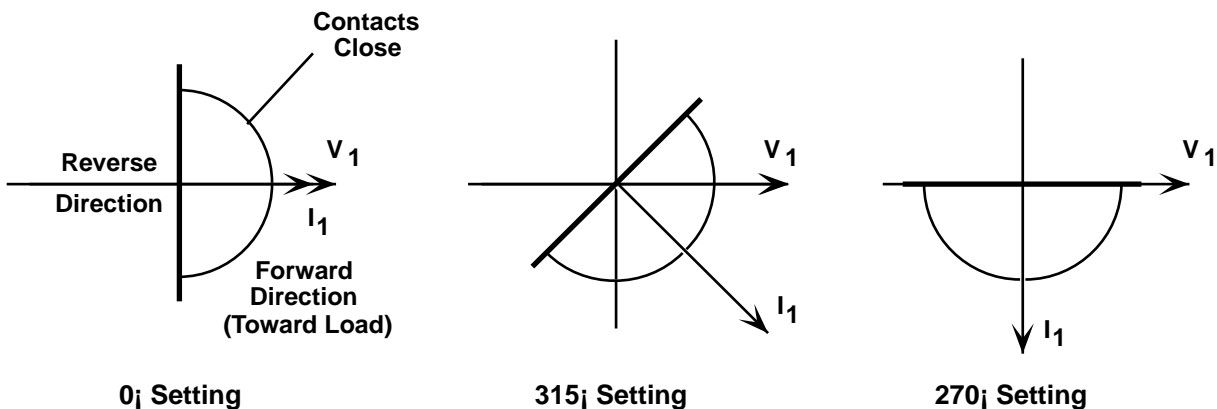


Figure 1-11. 67P Maximum Torque Angles, Example settings

Function 67N Ground Directional Time-Overcurrent Protection

This function has limited applicability to protection of the generator, but is included to add to the flexibility of the relay. For example, it might be used in protection of the tie between a cogenerator and a utility source to obtain separation upon occurrence of a fault on the utility system.

This element uses negative-sequence voltage to polarize the directional unit, and the maximum torque angle is defined as the angle the negative-sequence current (I_2) leads the negative-sequence voltage (V_2).

The directional element, through internal logic, controls the operation of the ground-time overcurrent unit. The 67N overcurrent element is completely independent of the other ground overcurrent element, 51N.

This protective element receives its current input from terminals 47 and 48 of the relay. For relays of catalog series 589V and 589W, the current range of this element is fixed at 0.4-1.6 amperes.

Function 32N Ground Directional Element (Contact factory for availability of this function)

Programmable output function 32N instantaneously follows the operation of the ground directional unit, and has a current sensitivity of approximately 3% of the pickup setting.

Table 1-26. 67N Ground Directional Time-Overcurrent Protection

67N Parameter	Range	Increment
Overcurrent Pickup Current	0.2 - 0.8A	0.01A
Time Curve: See Table 1-1 Time Dial (Inverse Curves) Time Delay (Definite Curve Only)	#1.0 - #10.0 0.1 - 10.0 Second	0.1 0.1 Second
Maximum Torque Angle I_2 Leads V_2	0 - 355	5

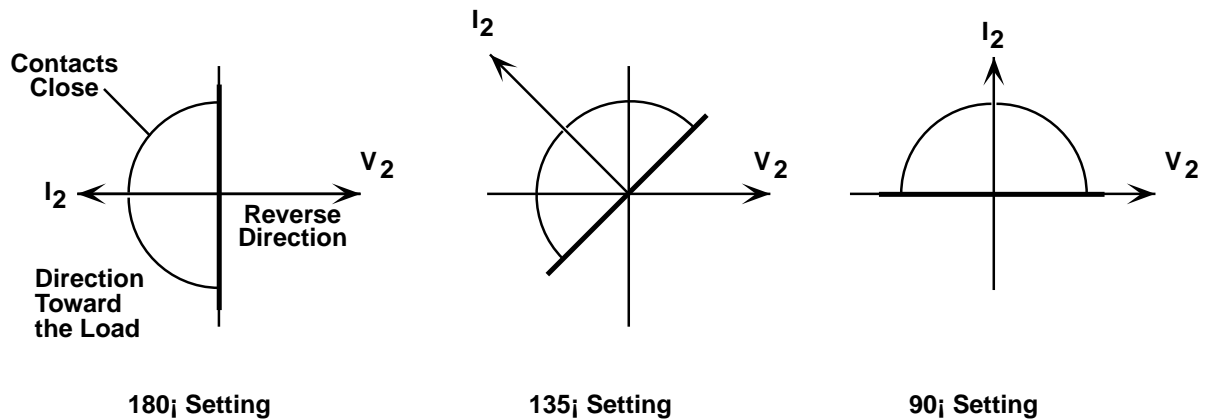


Figure 1-12. 67N Maximum Torque Angles, Negative Sequence Polarization and Operate Quantities, Example Settings.

Function 60 Blown Fuse Detection

Various protection elements available in the GPU2000R are dependent on the voltage inputs for their measurement of system conditions. Should the fuse protecting the primary winding of one of the potential transformers blow, then an undesired master trip operation could occur due to the undervoltage condition seen by the relay. In order to provide some security against this situation, the GPU2000R includes a blown fuse detection function. When a sudden loss of potential occurs in the absence of fault current, then a blown fuse condition is assumed, and voltage dependent protection elements are blocked, and the blown fuse logical output is asserted. We recommend that this output be mapped to a physical output and used to annunciate a blown fuse condition.

For important machines we recommend that a set of redundant potential transformers and an ABB Circuit-Shield™ Type 60 relay (catalog series 412A) be employed. The contact of the Type 60 that indicates failure of one of the pt's to which the GPU2000R is connected should be wired to a physical input on the GPU2000R. This physical input should be assigned to the Blown Fuse input function 60BFUA. When this is done, the internal blown fuse detection logic is disabled, and the GPU2000R will depend on the external signal. The total time required for the for the Type 60 to operate and the GPU2000R to recognize the contact closure and block the voltage dependent functions will be about 3 cycles.

Refer to Instruction Book IB 7.4.1.7–4 for details on the Type 60 relay.

The following functions are blocked upon assertion of the blown fuse detection: 21, 27, 32U, 40 and 51V.

Supplementary Protection Device 64F Field Ground Protection

The GPU2000R does not include a field ground protection function; however, it includes provisions to accept a contact closure from an external field ground relay such as the ABB Circuit-Shield Type 64F relay.

By assigning logical input function 64F (Field Ground Fault function) to a programmable input you can obtain an Operations Record of the event upon receipt of the contact closure. You may also assign an output of the GPU2000R to the 64F logical function and use this output for tripping or alarming.

Refer to instruction book IB 7.1.1.7-8 for details on the Type 64F relay.

Supplementary Protection for Catalog Series 589T - Machine Differential Function

Units of Catalog Series 589T do not include built-in machine differential protection; however, provisions are included for the use of an external relay such as the ABB Circuit-Shield Type 87M.

Refer to Application Note AN-28 for details on the use of the external relay.

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/I_{pu})

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

Table 1-27. Constants for ANSI Time Overcurrent Characteristics

Curve	A	B	C	P	D	E
Extremely Inverse	6.407	0.025	1	2	3	0.998
Very Inverse	2.855	0.0712	1	2	1.346	0.998
Inverse	0.0086	0.0185	1	0.02	0.46	0.998
Short Time Inverse	0.00172	0.0037	1	0.02	0.092	0.998
Short Time Ext. Inverse	1.281	0.005	1	2	0.6	0.998
Long Time Ext. Inverse	64.07	0.250	1	2	30	0.998
Long Time Very Inverse	28.55	0.712	1	2	13.46	0.998
Long Time Inverse	0.086	0.185	1	0.02	4.6	0.998
Recloser Curve #8	4.211	0.013	0.35	1.8	3.29	1.5

Notes:

- The time in seconds for the **Long Time Extremely Inverse** Curve is 10 times that of the Extremely Inverse Curve.
- The time in seconds for the **Long Time Very Inverse** Curve is 10 times that of the Very Inverse Curve.
- The time in seconds for the **Long Time Inverse** Curve is 10 times that of the Inverse Curve.
- The time in seconds for the **Short Time Inverse** Curve is 1/5 times that of the Inverse Curve.
- The time in seconds for the **Short Time Extremely Inverse** Curve is 1/5 times that of the Extremely Inverse Curve.
- These curves comply with ANSI C37.112.

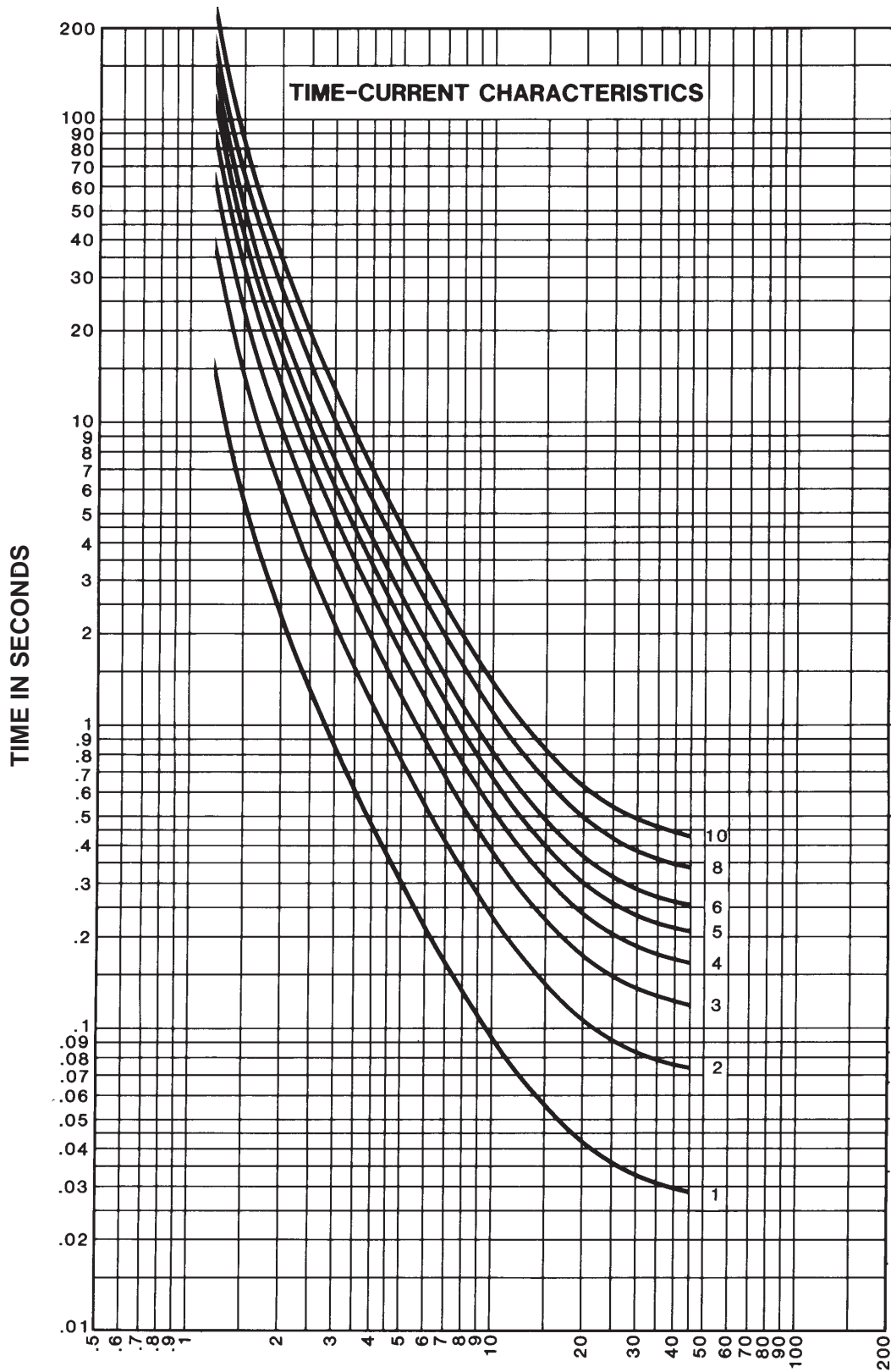


Figure 1-13. Extremely Inverse Curve

DWG. NO. 605842 Rev. 2

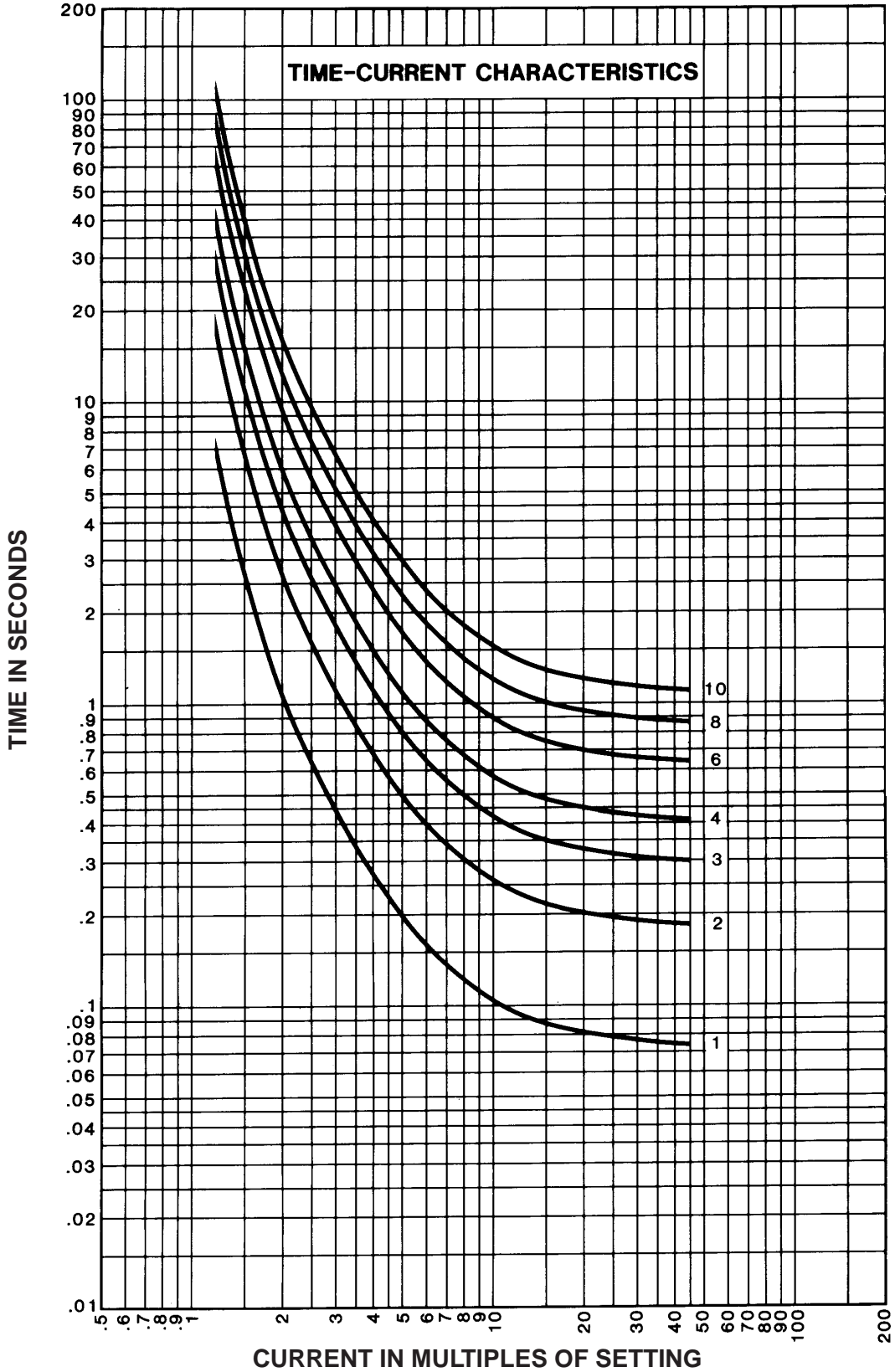


Figure 1-14. Very Inverse Curve

DWG. NO. 605841 Rev. 2

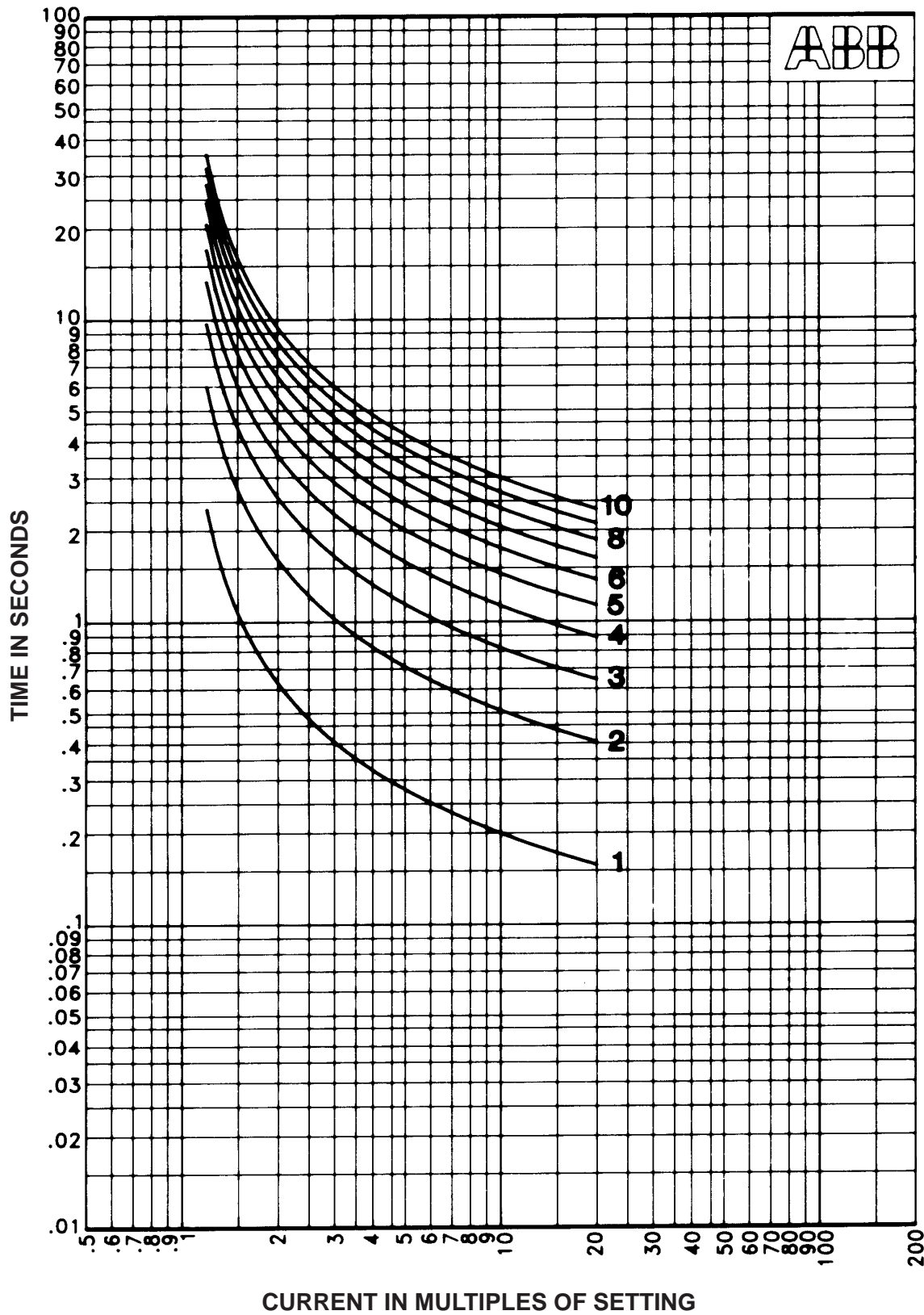


Figure 1-15. Inverse Curve

DWG. NO. 605854 Rev. 0

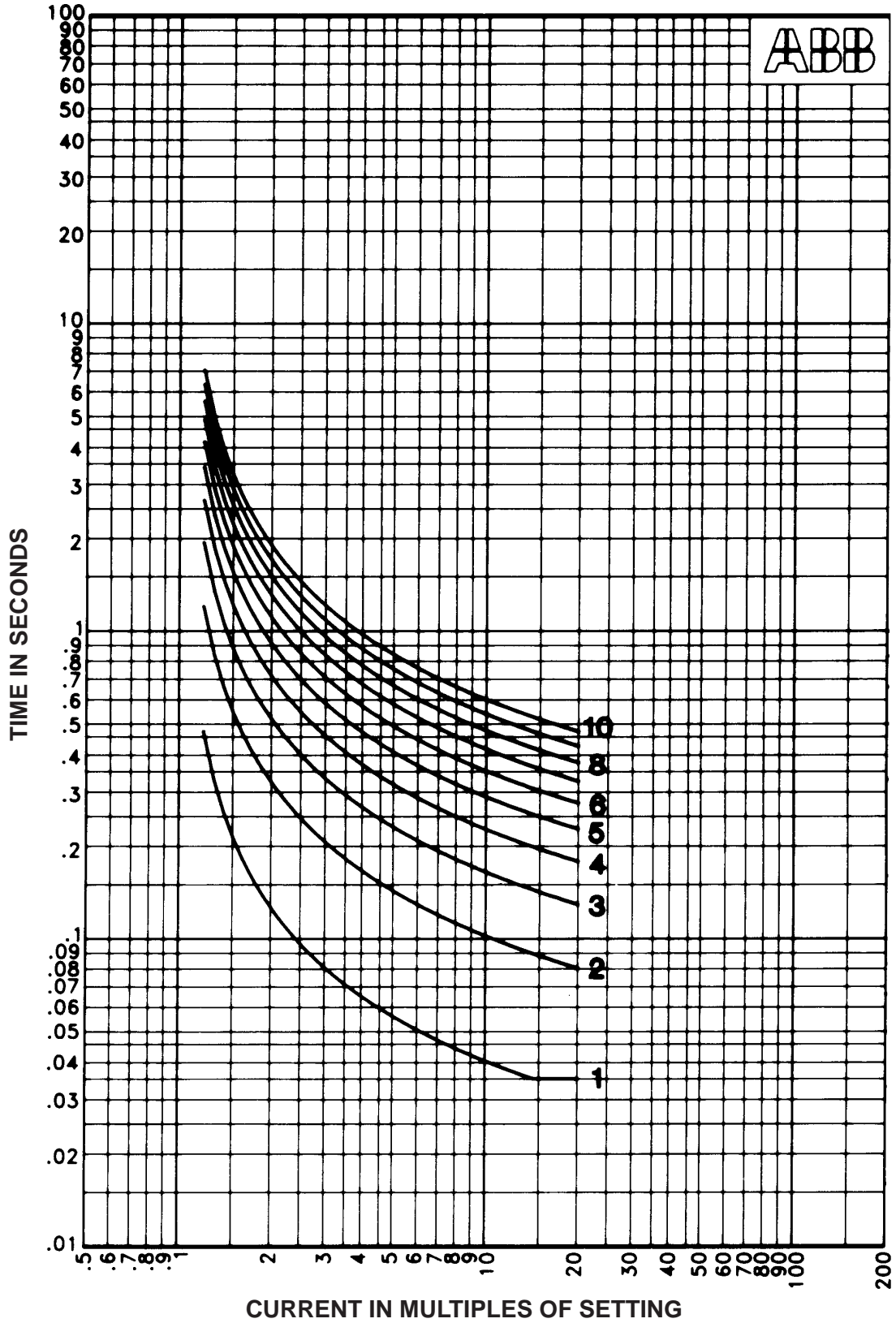


Figure 1-16. Short Time Inverse Curve

DWG. NO. 605855 Rev. 0

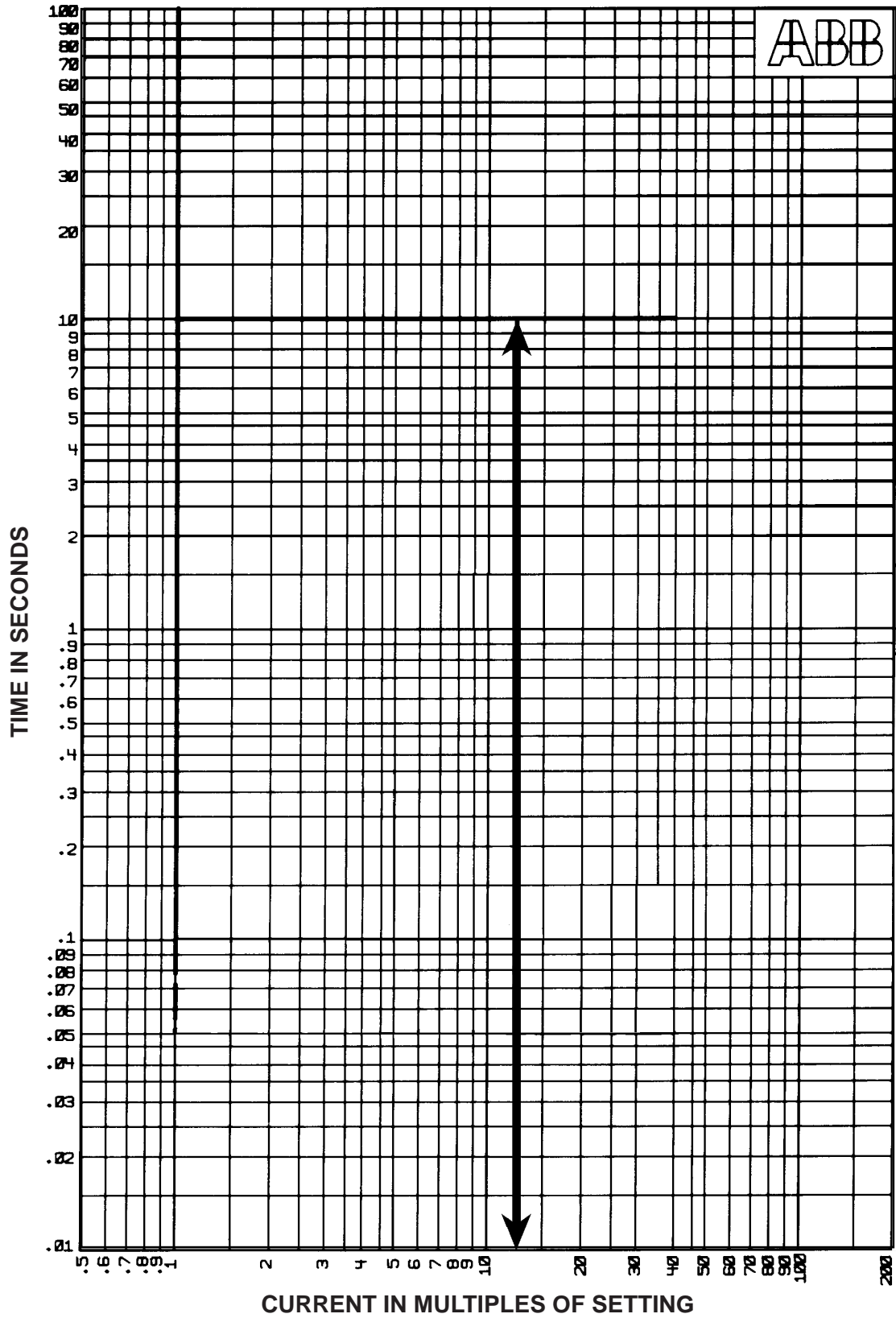


Figure 1-17. Definite Time Curve

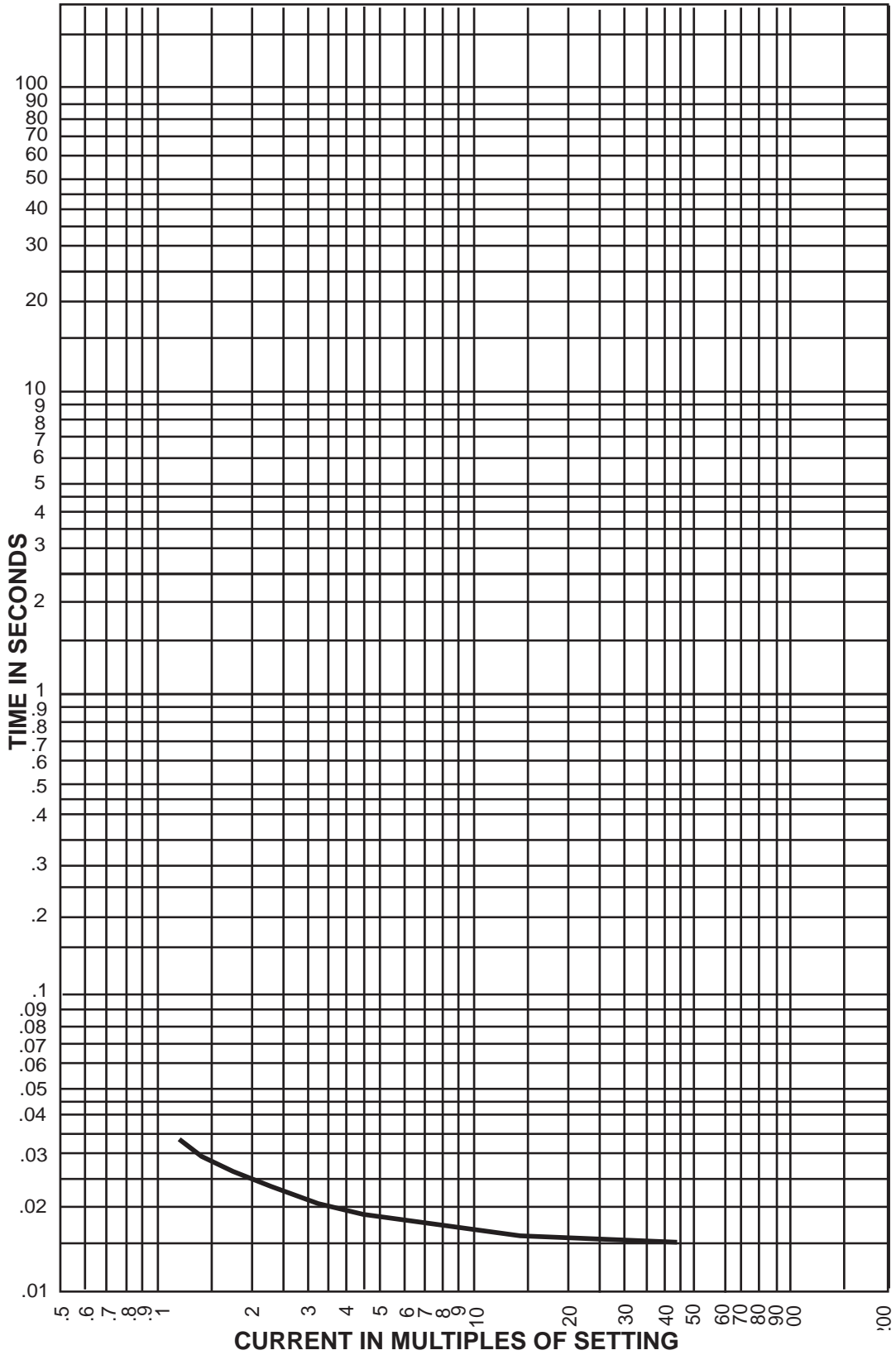


Figure 1-18. Standard Instantaneous Curve

DWG. NO. 605845 Rev. 2

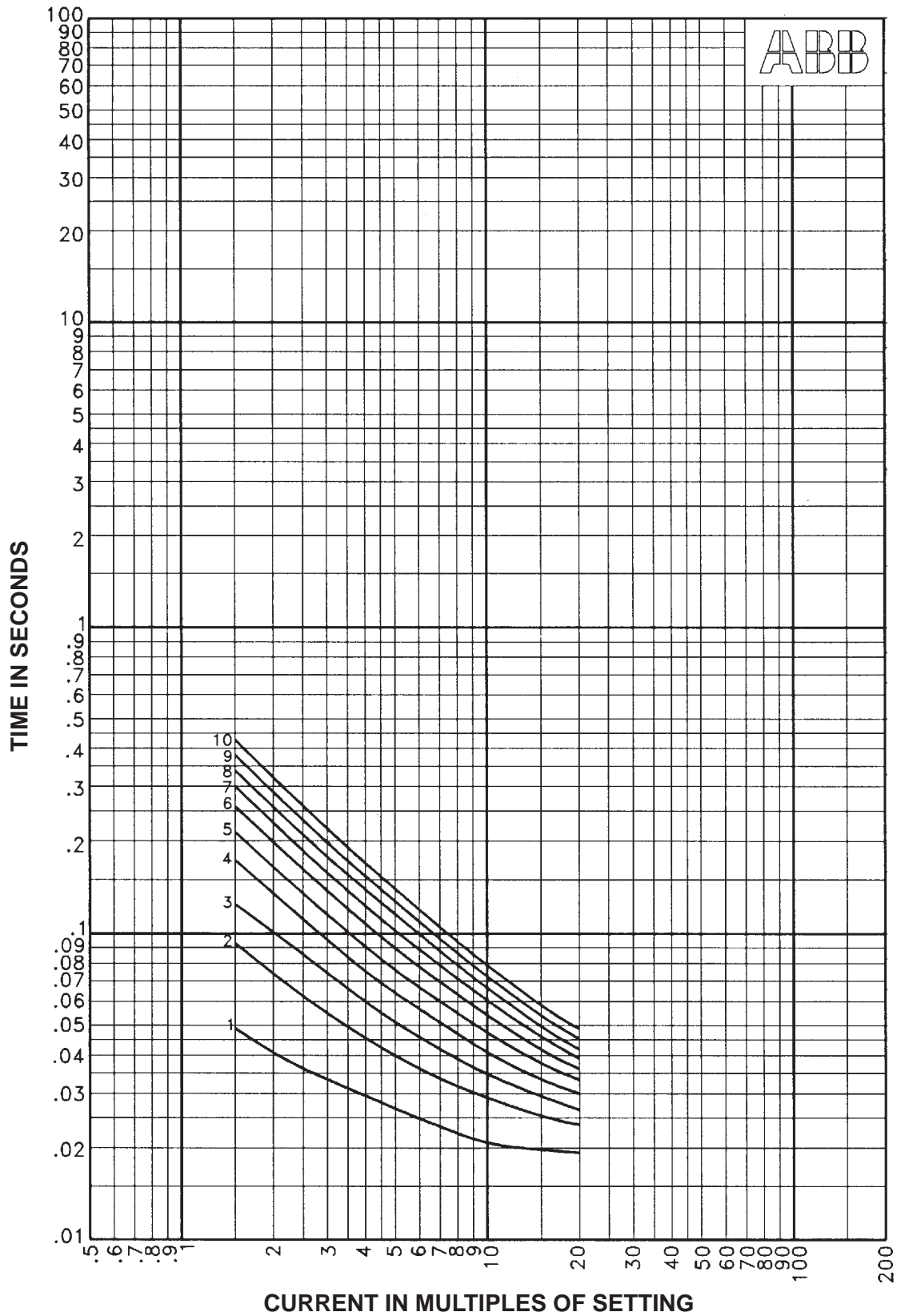


Figure 1-19. Inverse Instantaneous Curve

DWG. NO. 604916 Rev. 0

Volts per Hertz Timing Curves

Equation:

$$t = e^{\left(\frac{Ak + B - x}{C}\right)}$$

where:

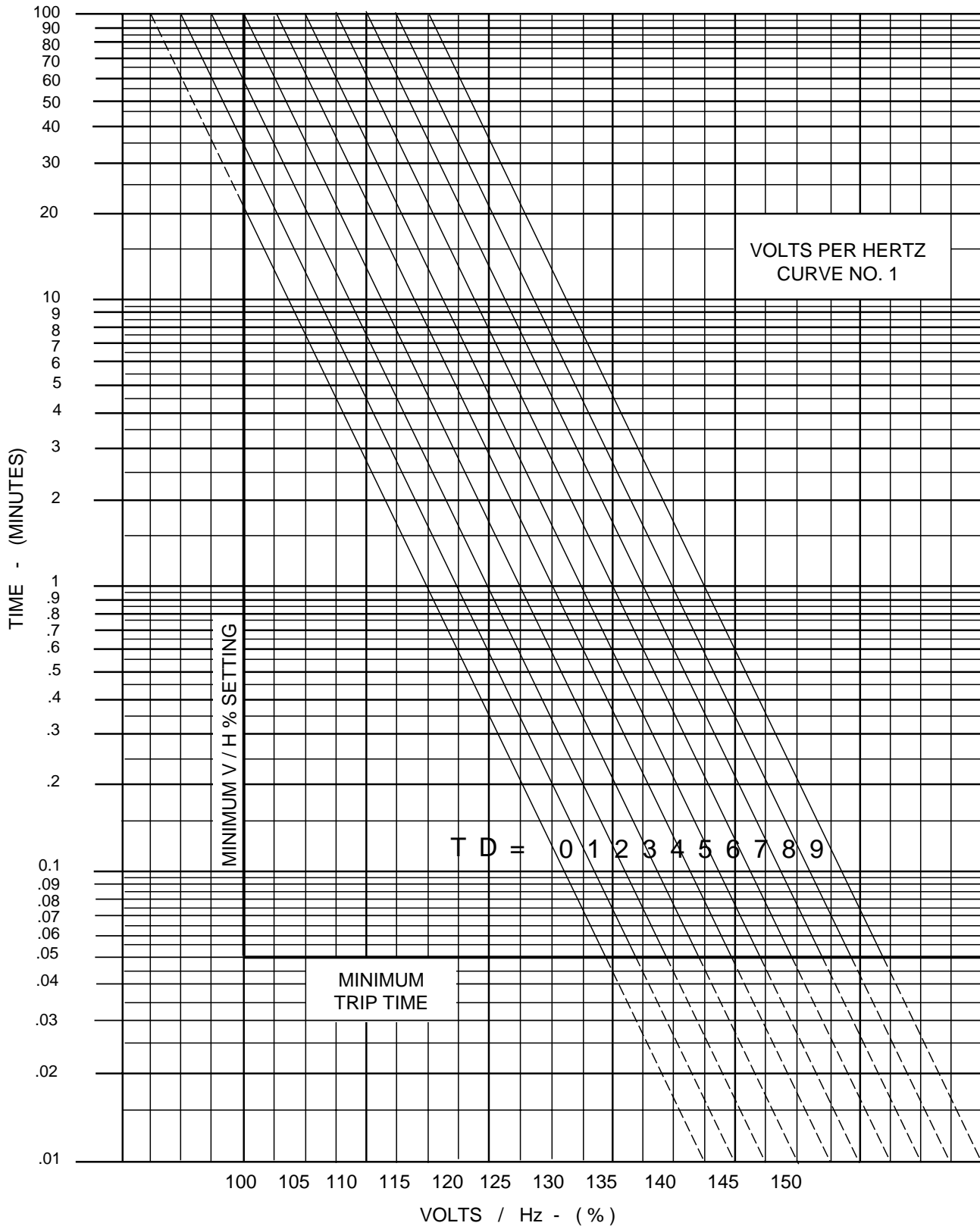
t = Trip Time in minutes

k = Time Dial Setting

x = Applied V/Hz value in percent of rated V/Hz

Table 1-28. Curve Parameters for Volts per Hertz Characteristics

V/Curve Parameters			
	A	B	C
Curve #1	2.5	115	4.886
Curve #2	2.5	113.5	3.040
Curve #3	2.5	108.75	2.443

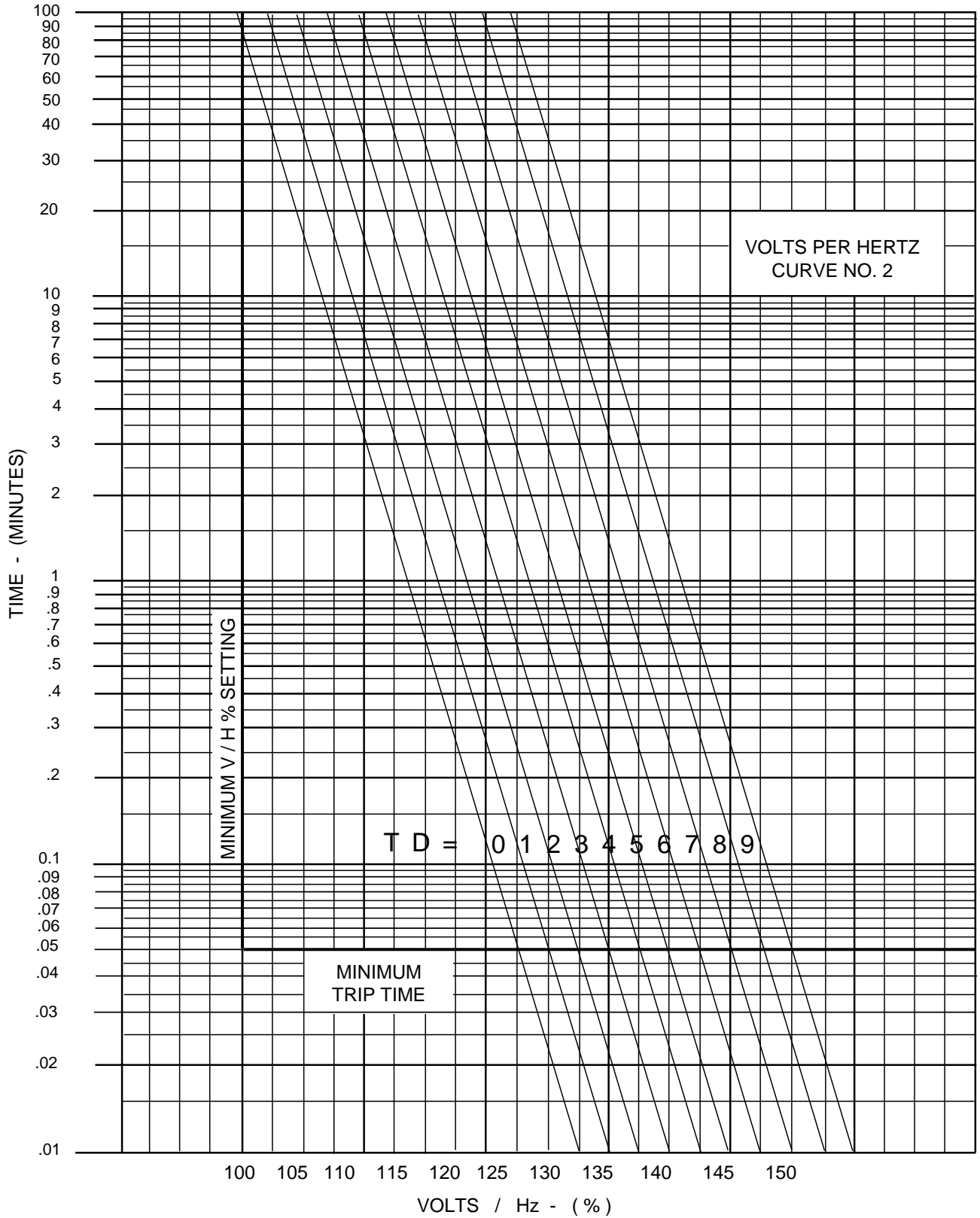


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Figure 1-20. Volts per Hertz Curve #1

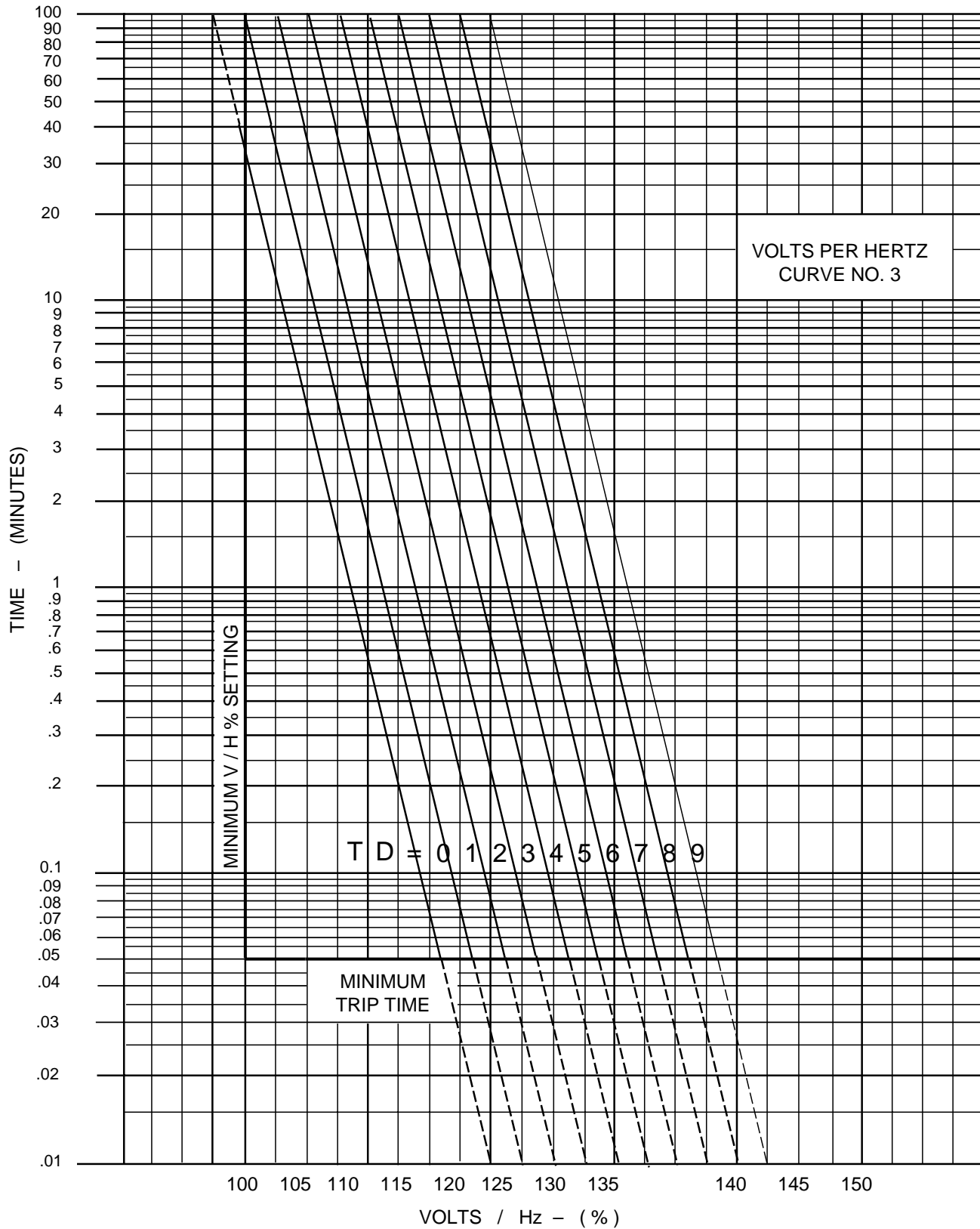


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Figure 1-21. Volts per Hertz Curve #2



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Figure 1-22. Volts per Hertz Curve #3

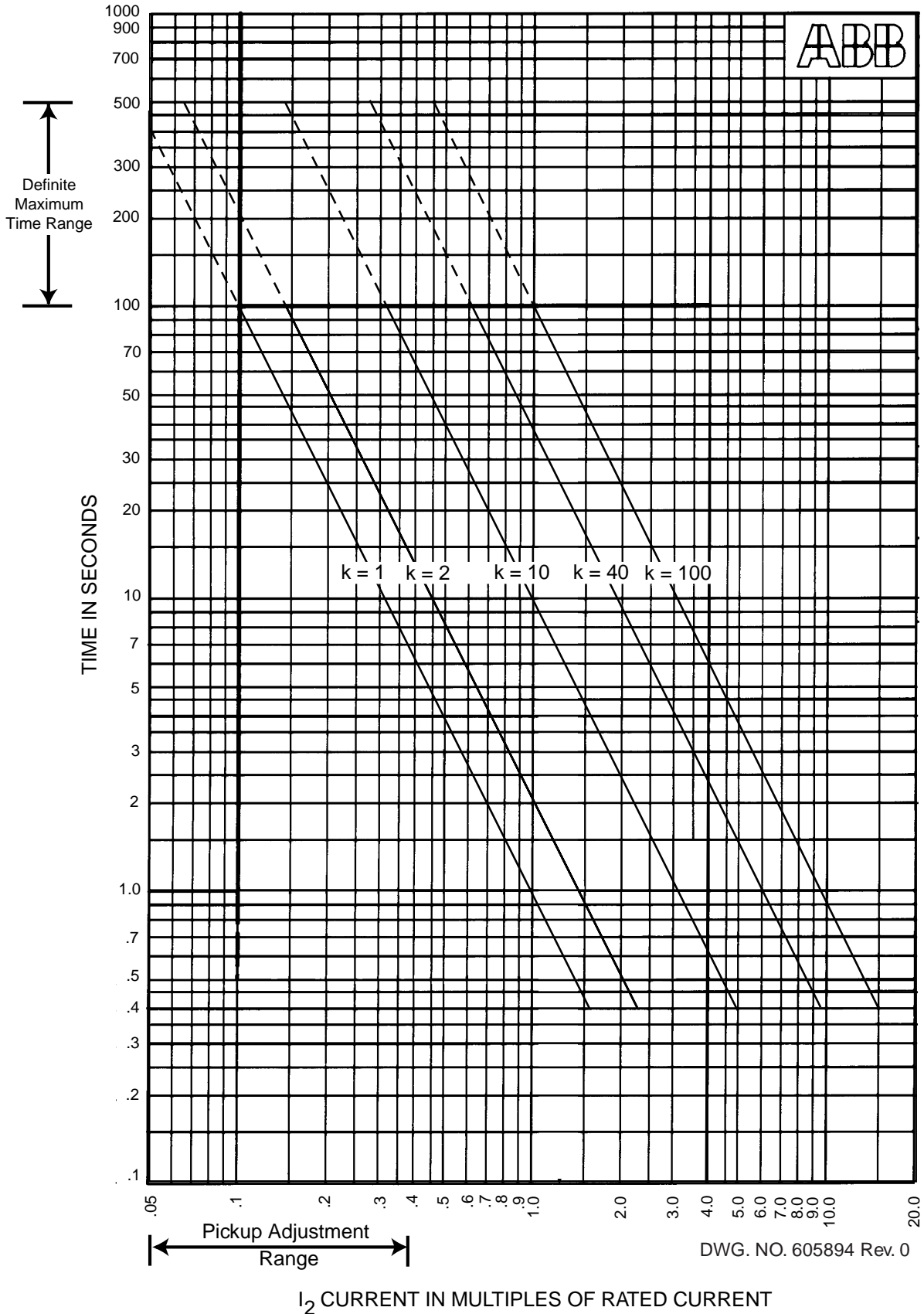


Figure 1-23. Negative-Sequence Time Curve

Changing Settings

Use ECP to change the following settings:

- Primary
- Alternate 1
- Alternate 2
- Configuration (See Section 2)
- Programmable Inputs (See Section 6)
- Programmable Outputs (See Section 6)
- Counter
- Alarm
- Clock
- Communication (See Section 12)

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 category 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 category contains a drop-down list used to enable or disable all settings in that category. 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 categories 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 are the factory default password) 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 you exit before settings are sent to the relay as described in step 4, all setting changes will be lost.

Configuration Settings

Phase CT Ratio

Used for metering purposes only. The range is from 1 - 9999.

Neutral CT Ratio

Used for metering purposes only. This refers to the CT in the connection from the neutral of the machine to ground. The range is from 1 -9999.

VT Range

Sets the range for the VT Ratio setting. Low range is used for low voltage systems. High range for medium voltage systems.

VT Ratio

Used for metering purposes only. The high range is from 1 - 3000, low range is 1.00 - 99.99.

VO VT Ratio

Used for metering purposes only. The ratio of the VT connected to relay terminals 35-36, when used.

Nominal Volts per Hertz

This is the reference value for the V/Hz protection element device 24. This value would be calculated as the nominal line-to-line voltage V_{ac} applied to terminals 31-33, divided by rated system frequency. For example, for 110v/50Hz, the entry would be 2.20.

VT Conn

Must be entered for proper GPU-2000R metering and protection.

Options are: 69V Wye
 120V Wye
 120V Delta
 208V Delta

These selections do not prevent the use of the relay with VTs that have other nominal secondary voltages such as 110v or 100v. Pick the selection closest to your arrangement. The only relay elements affected by this approximation are the settings for functions 32R, 32U, and 32O. The "correction factor" to be used is shown in Section 1 under the description of each element.

Rated Current

This is the machine's rated nameplate current divided by the phase CT ratio (see Power Factor setting below). This sets the reference current for various protective elements that use phase current measurements.

Ground Rating

This setting (in CT secondary amperes into the terminals of the relay) determines the base sensitivity of the 50G/51G ground overcurrent functions. The minimum pickup current of these elements will be 50% of this ground rating setting.

Machine Power Factor

This is the nameplate power factor value corresponding to the machine rated nameplate current in the Rated Current setting.

Breaker Trip Fail Timer

The GPU-2000R determines a successful trip by the state of the 52a breaker contact and the level of input current. The 52a contact must indicate an open breaker and the current must have dropped to below 5 percent of the 51P pickup setting. At the time that the GPU-2000R issues a trip, it also starts a "Trip Fail Timer." This timer is used to determine a failed or slow breaker. It is set in the Configuration Setting and is selectable for 5 to 60 cycles in 1 cycle steps. If the timer expires before the GPU-2000R determines an open breaker (either or both conditions stated above are met), a Breaker Failure Alarm (BFA) logical output is asserted. If the GPU-2000R determines an open breaker within the Trip Fail Time setting, it will reset and re-enable when the breaker is reclosed. The Trip Fail Timer is set by factory default to 18 cycles.

Trip Failure Percent Pickup

Sets the pickup/dropout level for the current detection element of the Trip Fail Timer.

Phase Rotation

Must be selected for proper sequence calculations for the metering. Options are ABC or ACB. This setting directly affects all negative-sequence and directional elements in the relay.

Protection Mode

Select "Fund" if the desired operating quantity for overcurrent protection is the 50 or 60 Hz fundamental current.

Select "RMS" if the desired operating quantity is the unfiltered RMS current which includes the fundamental and all harmonics up to and including 11th harmonic.

Unless the harmonic content of the load current is above 5%, the fundamental mode is recommended for most applications,

Reset Mode

Select "Instant" if the desired overcurrent reset mode is instantaneous.

Select "Delayed" if the desired overcurrent reset mode is delayed to emulate the action of induction-disk electromechanical relays. The reset characteristic equations are given in Section 1.

In most applications, Instantaneous reset would be the appropriate choice.

ALT1, ALT2 Setting

The Alternate 1 or Alternate 2 settings tables can be enabled or disabled with this setting. If enabled, the ALT settings will only be active if the logical input ALT1 or ALT2 is mapped via programmable inputs and the logic is "true." See section 6 for programmable inputs.

Target Display Mode

Select "Last" if the only target desired on the front panel of the relay is the most recent target. If "All" is selected, then all targets will accumulate and remain displayed since the last target reset.

Local Edit

"Enable" allows settings to be changed via the MMI

"Disable" disallows setting changes via the MMI

This setting can only be edited remotely via communications

Remote Edit

"Enable" allows settings to be changed via the communication ports

"Disable" disallows setting changes via the communication ports

This setting can only be changed locally through the MMI

WHR Display

Select KWHr or MWHr for kilowatt/kilovar or Megawatt/Megavar metering.

Voltage Units

Choose Volts for low voltage systems, KV for medium voltage systems. Used for metering displays only.

Voltage Display Mode

Select "Vll" for voltages to be displayed Line to Line.

Select "Vln" for voltages to be displayed Line to Neutral.

LCD Light

Select "ON" for continuous display.

Select "TIME OUT" to enable the LCD Screen saver. This setting will significantly extend the life of the LCD display. After the Screen saver times out, the user can press any button to activate the LCD display.

Unit ID

You can enter up to a 15 character description to identify the relay or circuit.

Demand Meter Constant

Select 5, 15, 30 or 60 minute time constant. Demand current metering replicates the operation of thermal demand meters. The demand kilowatts and kiloVARs are averaged values that are calculated by using the kilowatt-hours, kiloVARs-hours and the selected time constant.

LCD Contrast

This setting adjusts the brightness of the LCD Display. Adjustable from 0-63. Lower numbers give darker contrast.

Change Relay Password

The relay password can be changed via the MMI in the configuration settings menu. Or when using ECP, the user can change the relay password when exiting out of the configuration settings menu, select "send settings to unit", and select "Yes" to change relay password.

Change Test Password

The test password allows access to the actions in the Test Menu and the Operations Menu. See section 9. The user **cannot** make setting changes with the test password.

Unit Transformer

Select YES if the generator is used with a transformer in a unit connected arrangement. This provides information to the Device 21 impedance function to properly compensate for phase shifts through the unit transformer.

ABB Generator Protection Unit 2000R

Table 2-1. Configuration Settings—Password Protected

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

Setting	Range	Step Size	Default
Phase CT Ratio	1 – 9999	1	100
Neutral CT Ratio (GRD CT Ratio)	1 – 9999	1	100
VT Range	Low or High	—	Low
VT Ratio	1 – 99.99 for VT Range =LOW	0.01	1
	1 – 3000 for VT Range = HIGH	1	100
Vo VT Ratio	1 – 3000	1	100
Nominal V/hz	1.00 – 5.00 V/hz	0.01	3.46
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 machine power factor	2 to 8 Amps (5A CT)	0.1	5
	0.4 to 1.6 Amps (1A CT)	0.02	1
Ground (Rating)	2 to 8 Amps (5A CT)	0.1	5
	0.4 to 1.6 Amps (1A CT)	0.02	1
Machine PF	0.5 – 1.0	0.01	0.8
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
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
Unit Transformer	Yes or No	—	Yes

Table 2-2. 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
Master Trip Counter (Bkr Oper)	0 to 9999	1	0
Machine Run Time Hours 1	0 to 32000	1	0
Machine Run Time Hours 2	0 to 32000	1	0

Table 2-3. 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 Demand [3-phase kiloVAr alarm] (Pos kVAR)	10 to 99,990 (kVAr)	10	Disable
Negative kVAr Demand [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 32000	1	Disable
Machine Run Alarm 2 (hours)	1 to 32000	1	Disable

Table 2-4. Communications Settings—Password Protected

The following table lists all of the GPU-2000R's communications settings and their specific 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.

Internal Design

The heart of the GPU-2000R is the digital signal processor (DSP) which is a microprocessor optimized for fast calculations based on the sampled data and the central processing unit (CPU). The CPU, a 32 bit processor, performs all the protection algorithms and logical functions. Figure 3-1 shows a block diagram of the unit.

Processor Specifications

The processing power of the GPU-2000R provides a true multi-tasking 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

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.

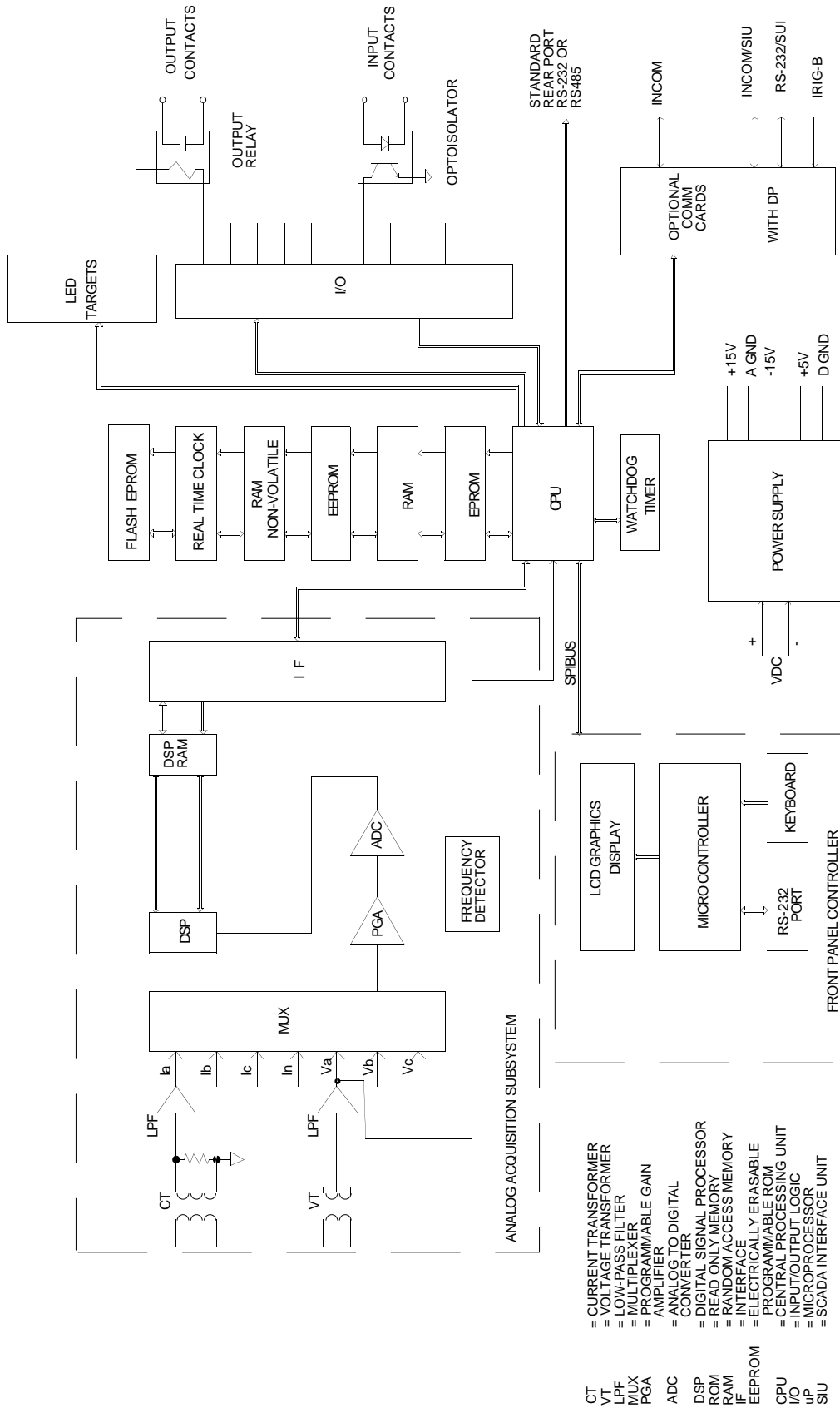


Figure 3-1 GPU-2000R Block Diagram

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

- 24 vdc model: 12 V to 140 Vdc
- Other models: 24 V to 280 Vdc

Voltage Input Circuits

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
- **Open-Delta** Connection: 260 V continuous and 480 V for 10 seconds
- **Vo** Input (termininals 35-36) 160 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 = 14 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

- 30 A tripping
- 6 A continuous
- 0.25 A break inductive

250 Vdc

- 30 A tripping
- 6 A continuous
- 0.1 A break inductive

ABB Generator Protection Unit 2000R

Operating Temperature

- -40° to $+70^{\circ}$ 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 $+55^{\circ}$ C

Function	Pickup	Dropout	Timing (whichever is greater)
51P/51V	$\pm 3\%$ of rated current	98% of setting	$\pm 7\%$ or ± 16 milliseconds
50P	$\pm 7\%$ of rated current	98% of setting	$\pm 7\%$ or ± 16 milliseconds
46/67P	$\pm 3\%$ of rated current	98% of setting	$\pm 7\%$ or ± 16 milliseconds
51G	$\pm 3\%$ of ground rating	98% of setting	$\pm 7\%$ or ± 16 milliseconds
50G	$\pm 7\%$ of ground rating	98% of setting	$\pm 7\%$ or ± 16 milliseconds
27/59/81V	$\pm 2\%$ of rated voltage	99.5% of setting	$\pm 7\%$ or ± 16 milliseconds
32R	$\pm 5\%$ of setting or $+ 0.2\%$ of rated power, whichever is greater	95% of setting	$\pm 7\%$ or ± 16 milliseconds
81	± 0.01 Hz	± 0.01 Hz	± 1 cycle
320/32U	$\pm 2\%$ of rated power	98% of setting	$\pm 7\%$ or ± 16 milliseconds
87M	$\pm 10\%$ of operate current	95% of setting	
27G/59G	$\pm 5\%$ of setting	98% of setting	$\pm 7\%$ or ± 16 milliseconds
24	$\pm 5\%$ of setting	98% of setting	$\pm 7\%$ or ± 16 milliseconds
21/40	$\pm 5\%$ of setting or 0.1 ohms, whichever is greater	98% of setting	$\pm 7\%$ or ± 16 milliseconds
Ammeter	$\pm 1\%$ of Phase: rated current. Gnd: ground rating		
Voltmeter	$\pm 1\%$ of VT Connection setting		
Power Meter	$\pm 2\%$ 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 (11.80 lbs)
- Boxed 5.67 kg (12.51 lbs)

Interfacing with the Relay

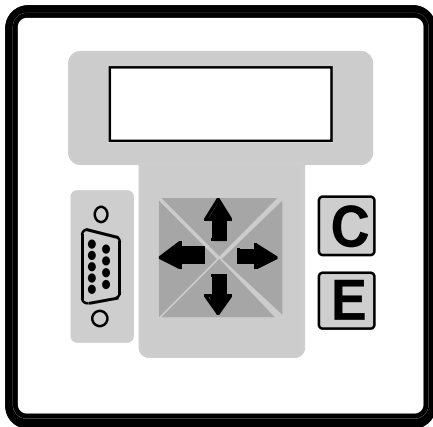


Figure 4-1. MMI Access Panel

Man-Machine Interface (MMI)

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 \leftarrow and \rightarrow 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 \blacklozenge and \oslash 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.

From the default screen, you can use the <C> key to:

If there are no targets

- Hit <C> once within a 5-second window:
Prompts the user to reset alarms. Hit <C> within 5 seconds to reset alarms. The user will then be prompted to reset seal-ins. Hit <C> within 5 seconds to reset seal-ins.
- Hit <C> two times within a 5-second window:
Automatically scrolls through demand values.
- Hit <C> three times within a 5-second window:
Prompts the user to reset Min/Max Demands. Hit <C> within 5 seconds to reset Min/Max Demands.

If there are targets

- Hitting <C> once will prompt the user to clear fault data.
- If <C> is hit again within 5 seconds, fault data will be cleared from the MMI and the user will be prompted to clear target data.
- If <C> is hit again within 5 seconds, targets are cleared and the user will be prompted to clear sealed-in outputs.
- If <C> is hit again, sealed-in outputs will be cleared.

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 Displays -- shows currents, voltages and which settings table is enabled
- Generator Off-Line/Startup Display -- shows voltage, frequency, and Volts per Hertz

Figure 4-2. MMI Displays

Metering Display (Continuous)

Ia: 500 KVan: 7.62
Ib: 500 KVbn: 7.62
Ic: 500 KVcn: 7.62
Primary Set Active

Main Menu

MAIN MENU
Meter
Settings
Records

Display After a Fault Interruption

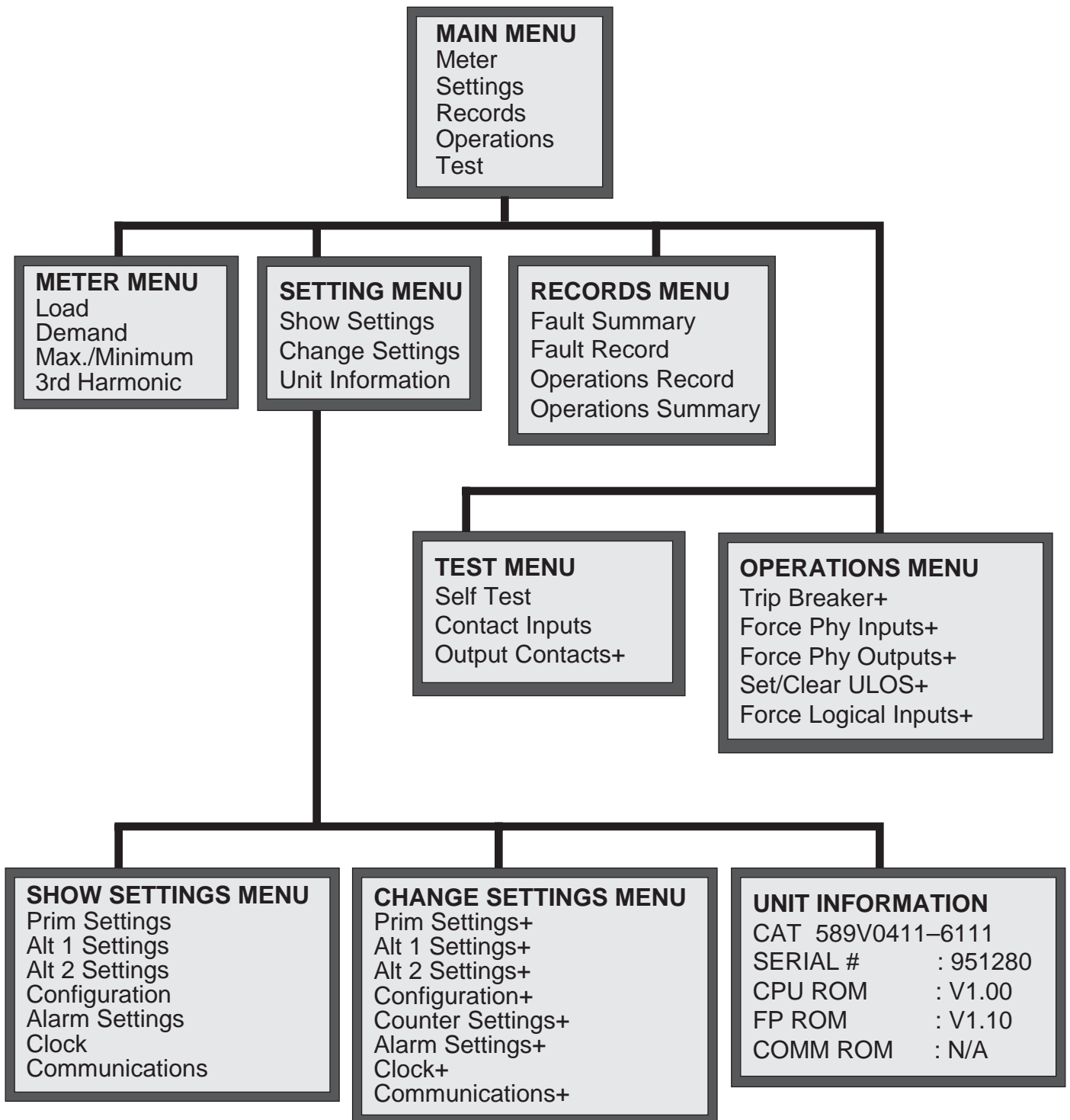
Ia: 3320 Ib: 430
Ic: 420 In: 3310
Primary Set Active

Display for Off-Line Operation

kVab: 13.20
kVbc: 13.20
kVca: 13.20
FREQ: 60.03 V/Hz: 2.0

Man-Machine Interface Menus

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



+password protected
Factory Default Password
is four blank spaces

Figure 4-3. 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.

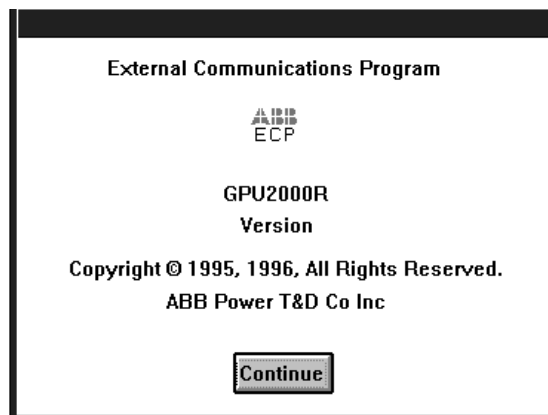
When changing the Configuration Settings through ECP, **you must type in four spaces (the factory default password)** followed by a carriage return. After entering the password, all other settings can be changed with a carriage return.

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.

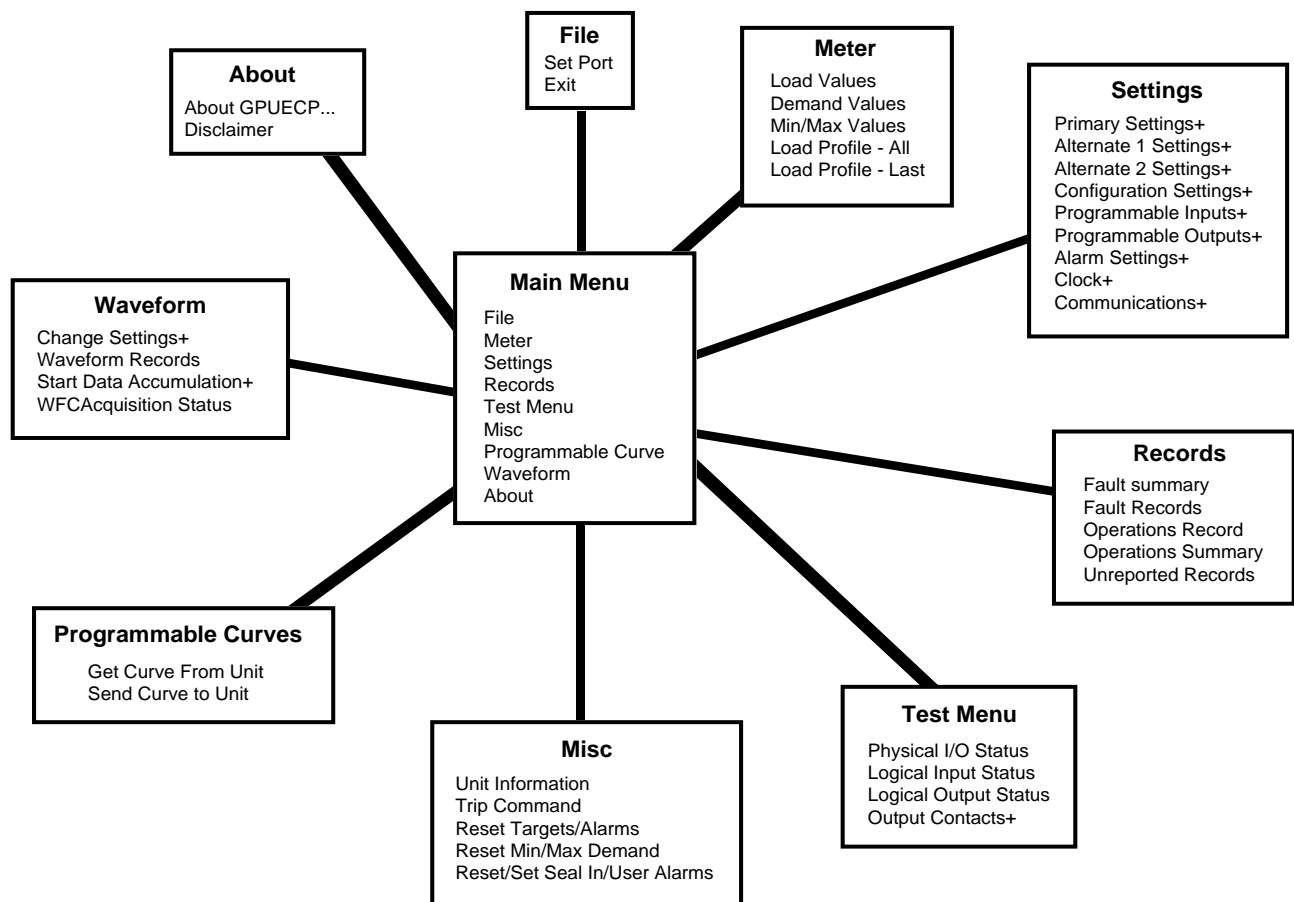
The application program on this disk has been carefully tested and performs accurately with most IBM-compatible personal computers. If you experience difficulty in using the External Communications Program, contact ABB at (610)395-7333 or toll free at 1-800-634-5005.



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.

Figure 9. External Communications Program Menus



+ Password protected

Mounting and Connections

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. Use normal care in handling to avoid mechanical damage. Keep unit clean and dry.

Short Acceptance Test

Before installing the unit, the following Short Acceptance Test could be performed:

On units equipped with an MMI:

- Power up the relay by applying rated DC control voltage to terminals 1 and 2 (observe polarity).
- Using the arrow keys, go to the Main Menu, scroll to Settings, press <E>, scroll to Unit Information, press <E>. Verify unit information against nameplate, sticker and the bill of material for your project.
- After checking the unit information, 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.

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 rack units), 19 x 5-inch metal case designed for rack mounting. Figure 5-2 shows the dimensions of the GPU-2000R.

The cover and bezel accessory shown in *Panel Mounting Kit* of this section (horizontal mounting and vertical mounting) is recommended for panel mounting of the unit, particularly when dust tightness of the control compartment must be maintained.

Drawout Feature

The electronic circuit board assembly including the power supply and communications card (if equipped), can be withdrawn from the case. The input transformers and their associated burdens remain in the case, so that all ct circuits remain continuous even with the main assembly removed from the case.

Rear Terminal Block Connections

The rear panel arrangement of terminal blocks and communications ports is shown in Figure 5-1.

Apply only rated dc control voltage as marked on the identification label to the control voltage input terminals 1 and 2, and to the programmable input terminals. Observe polarity. Note that programmable inputs #IN 1 through IN6 (terminals 4-10) have terminal #3 as the common.

Wire the ground stud on the rear panel to the equipment ground bus with at least #10 AWG wire to insure proper grounding and maximum effectiveness of the internal surge protection.

The GPU-2000R provides much flexibility to the user in programming input functions and output tripping and alarming functions. Refer to Section 6 for information on these functions.

Figure 5-5 shows typical basic control connections for the relay. Device 86, hand-reset lockout relay, is employed to require operator intervention on faults detected by the GPU2000R on functions such as 87, 59G, 27G, 51G, and 50G, before the machine can be returned to service. The GPU2000R also includes programmable “seal-in” outputs that could replace the separate 86 if desired. Refer to Section 6.

Trip Coil Monitoring

Consider the use of one of the double-ended inputs, IN7 or IN8, for the Trip Coil Monitor feature. Assign the input to programmable logical input TCM. Connect the positive side of the input to positive control voltage, and the negative side to the Trip bus. A trace current of approximately 6 milliamperes will pass through the input and through the trip circuit when the circuit breaker is closed. Should the trip circuit be interrupted, the input will be de-activated and the relay will issue the TCFA alarm and a message will appear on the MMI.

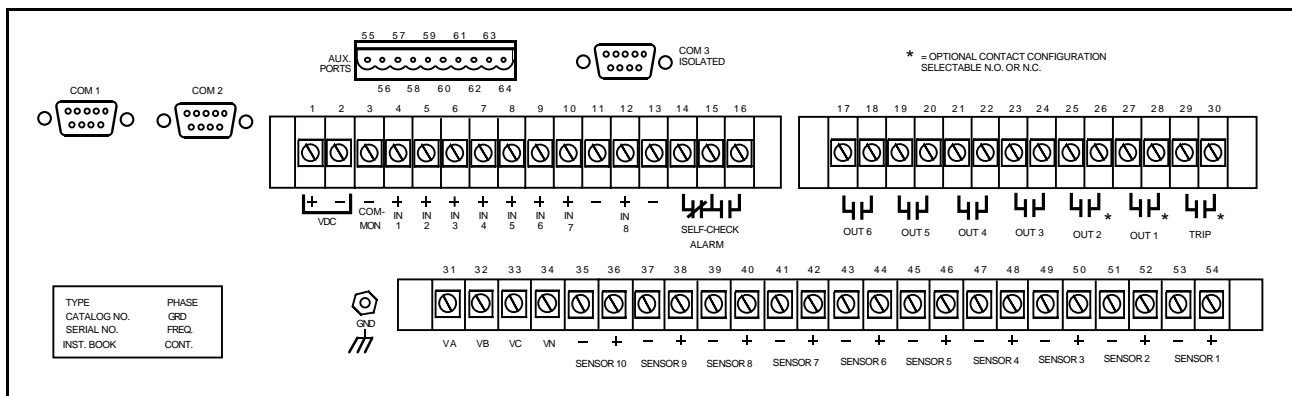
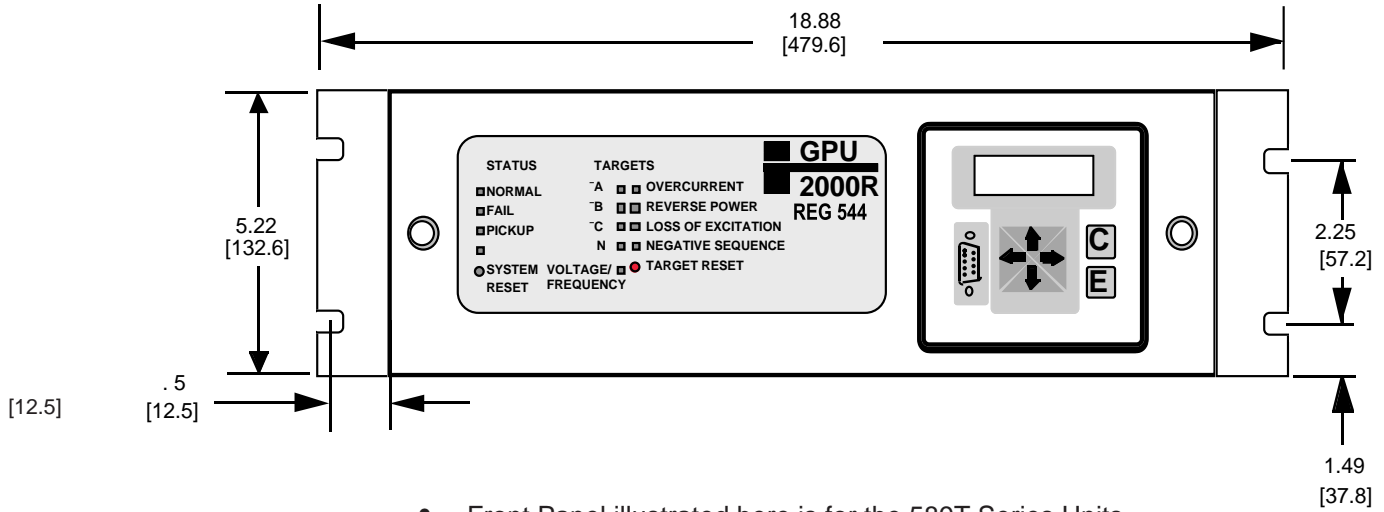


Figure 5-1. Panel Arrangement

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

Dimensions are in: inches
[millimeters]



- Front Panel illustrated here is for the 589T Series Units.
- See front cover picture for 589V/589T Series.
- Dimensions are the same for all 589 Series

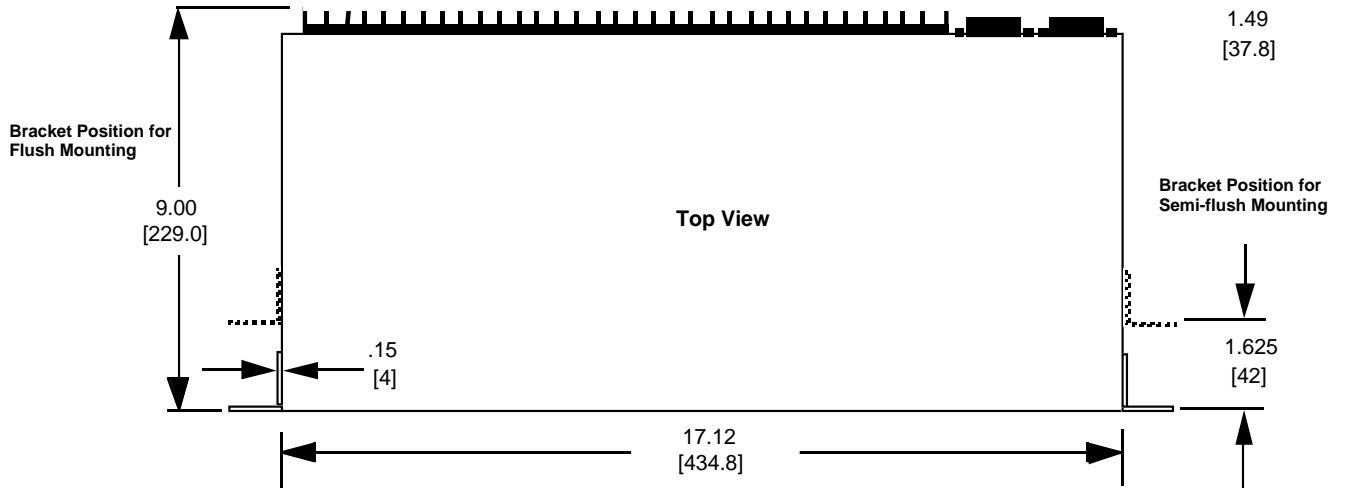


Figure 5-2. Dimensions

Panel Mounting Kit

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

Ordering Information:

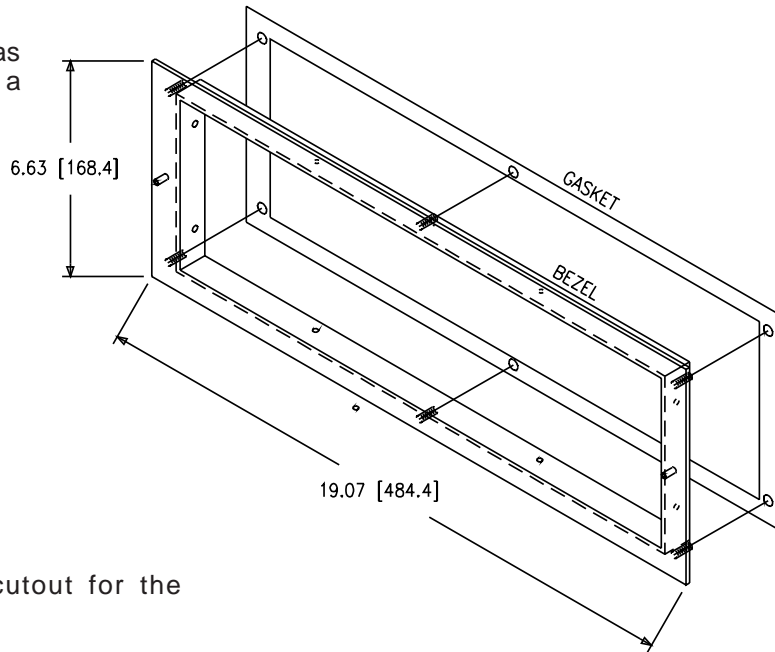
Horizontal Panel Mounting Kit	604513-K1
Vertical Panel Mounting Kit	604513-K2

Spare Parts List:

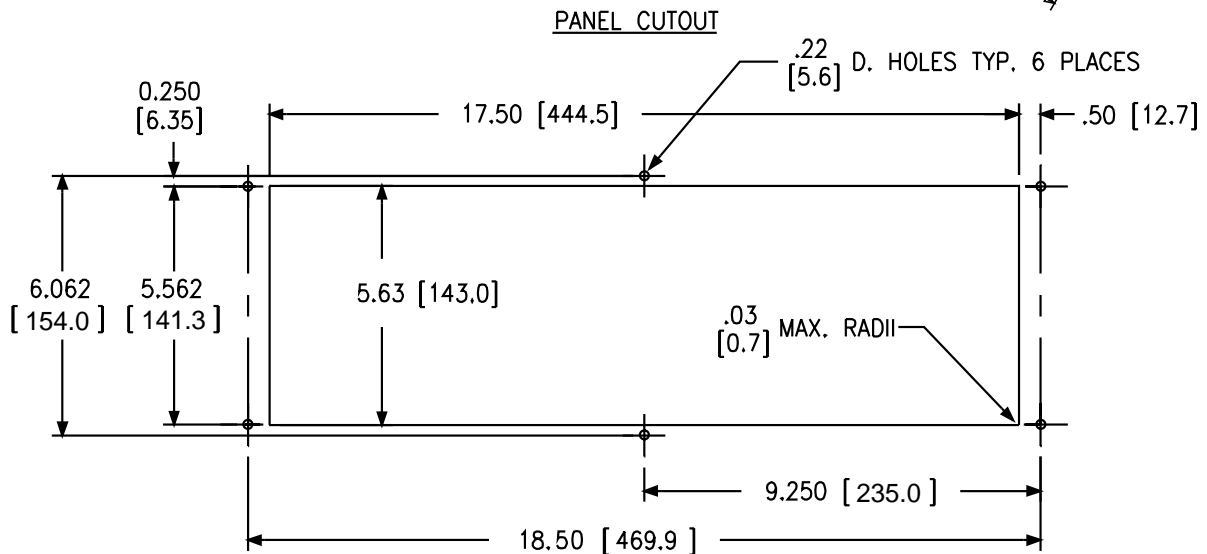
Bezel/gasket assembly only	604513-K3
Horizontal lens cover assembly	613724-K1
Vertical lens cover assembly	613724-K2

Horizontal Mounting

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

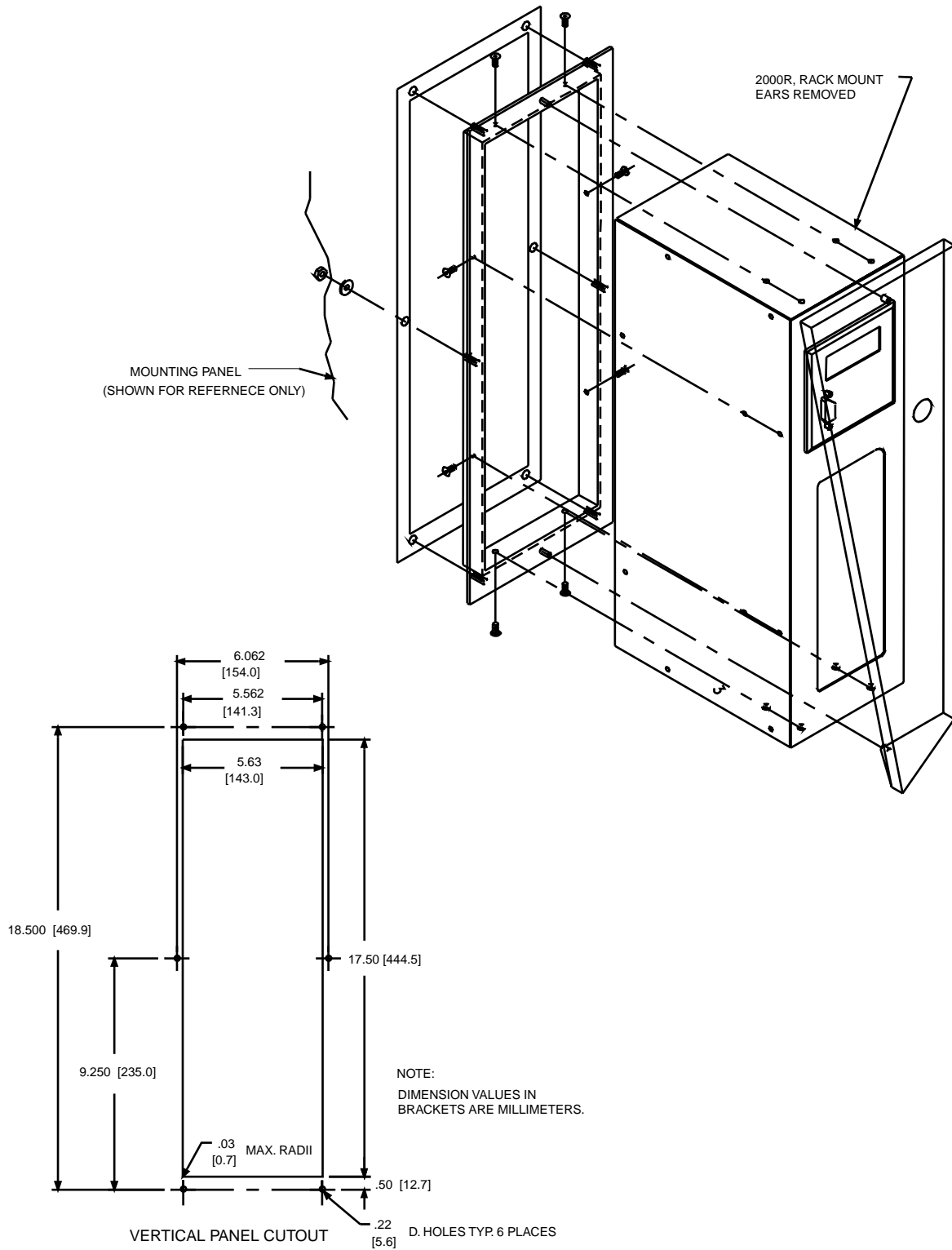


Note: Below is the panel drilling cutout for the DPU-2000R unit and the bezel assembly.

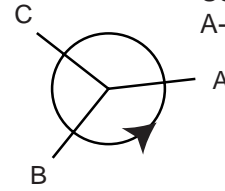


NOTE: DIMENSIONS ARE INCHES [MILLIMETERS]

Vertical Mounting

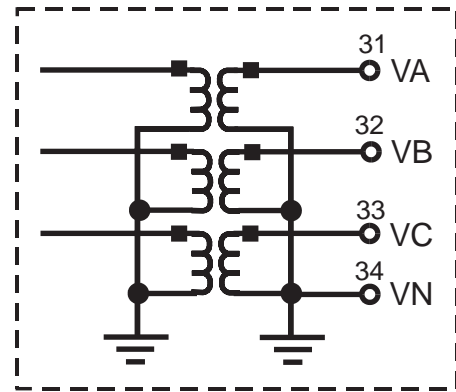
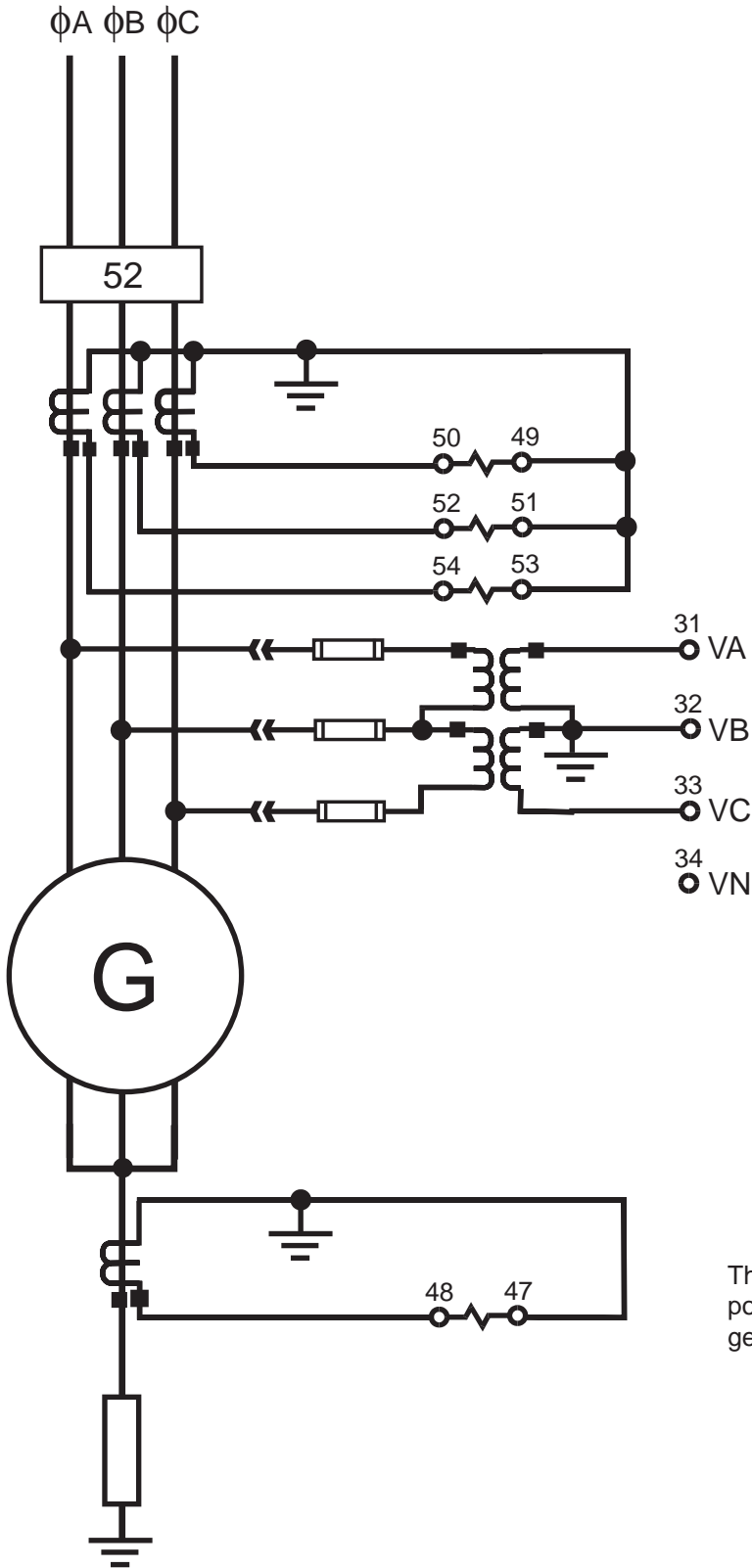


Phase Rotation is
User Selectable
A-B-C or A-C-B



GPU-2000R Series 589T

(Contact factory for availability
of 589T Series)



Wye Connected PTs

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

Figure 5-3. Typical Connections, 589T Series Units

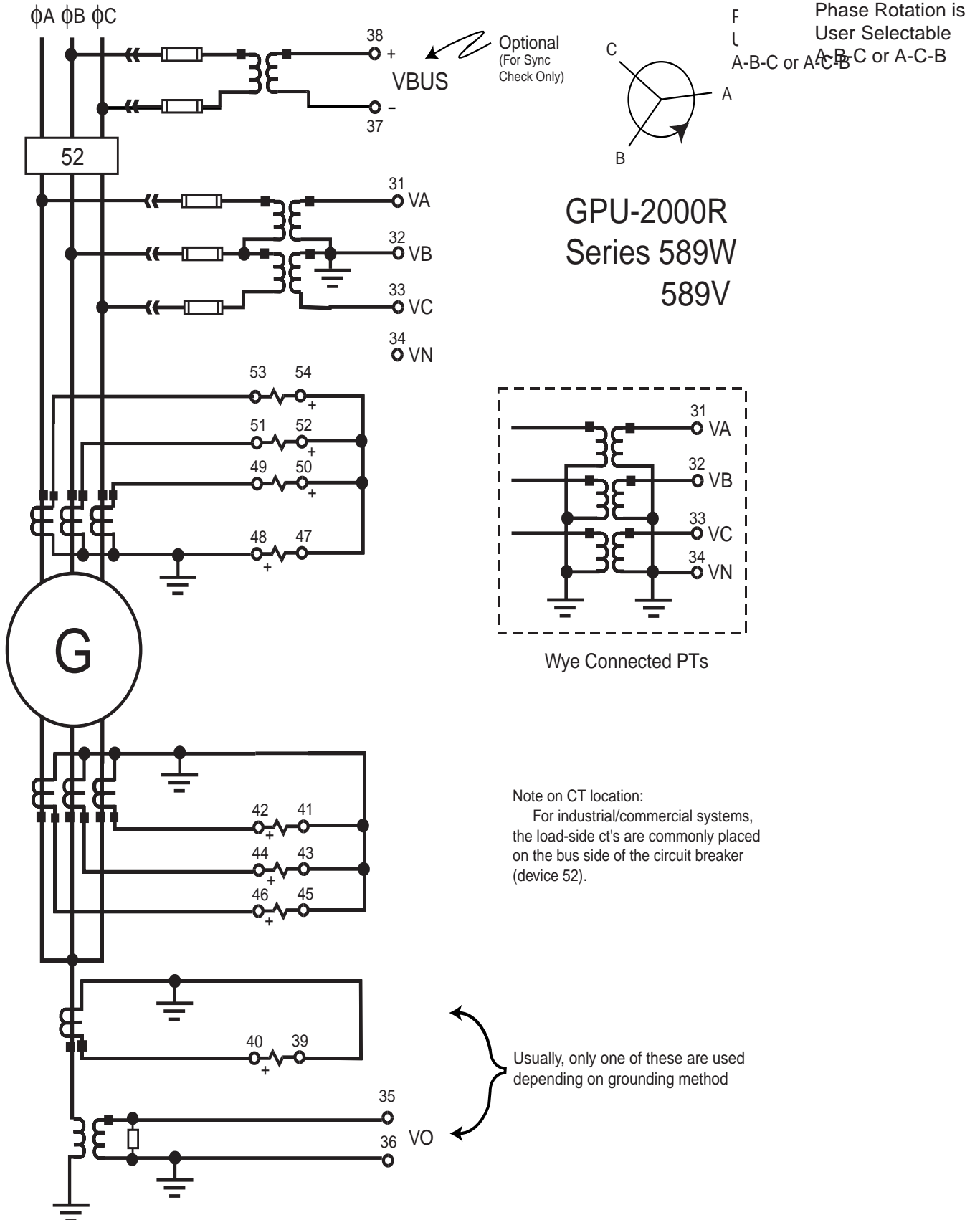


Figure 5-4. Typical Connections, 589W/589V Series Units

GPU2000R 589W/589V SERIES
TYPICAL CONTROL CONNECTIONS FOR BASIC OPERABILITY

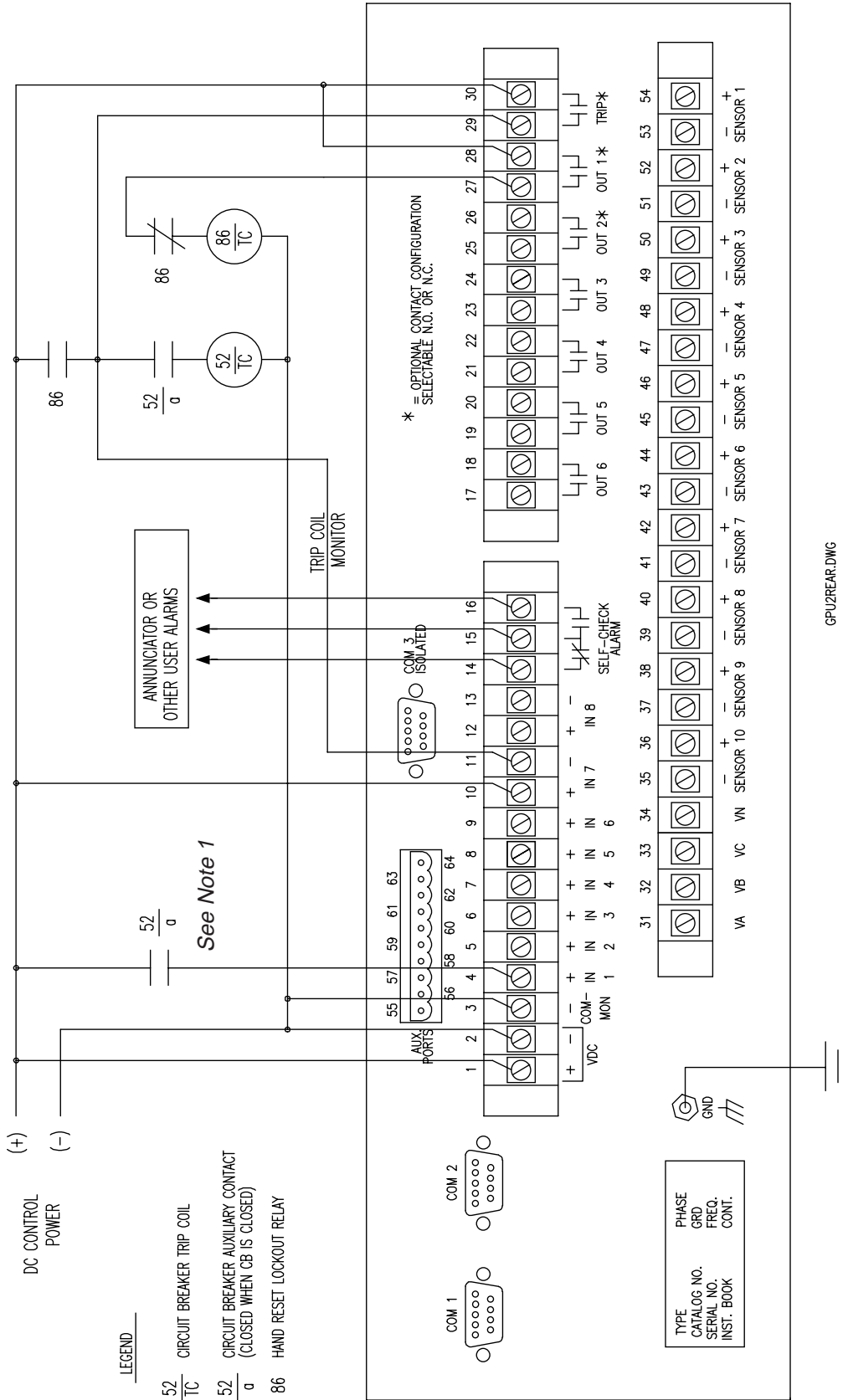


Figure 5-5. GPU-2000R Typical Basic Control Connection

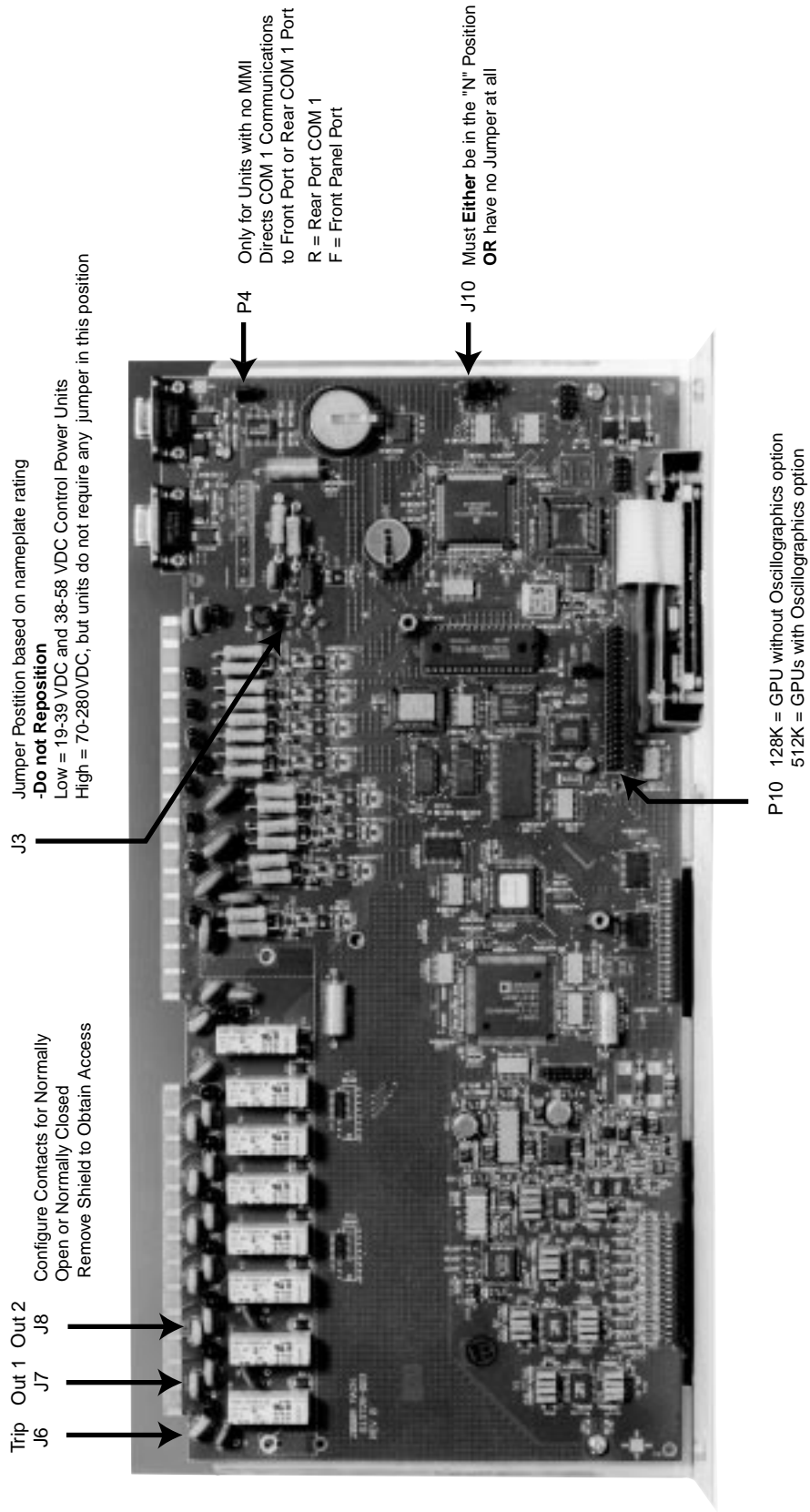


Figure 5-6. Main Circuit Board Jumpers

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 Figure 5-1 and described in Section 12.

RS-232 ports are available in two different configurations, Isolated and Non-Isolated. Isolated ports are preferred and provide electrical 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," Section 12 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.

Pin Connections

The pin connections for the various communications ports are shown in Tables 5-1 and 5-2.

Table 5-1. RS-232 Pin Connections

Pin Number	Pin Number
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 5-2. RS-485, INCOM, SIU and IRIG-B Pin Connections

Pin Number	Pin Number
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 and Communications Card Internal Jumper Positioning

For all communications hardware options with a single RS-485 port, that port is provided at terminals 55(+), 56 (-), and 57 (com). See Table 5-2.

For communications hardware option #8, dual RS485 ports, terminals 55, 56, and 57 are designated RS485 Rear Port #2, and pins 1(+), 2 (-), and 7(com) of the COM3 DB-9 connector represent RS485 Rear Port #1.

The RS485 port on the GPU-2000R has three associated resistors and jumper links that allow insertion or removal of these resistors, depending on the location of the relay in the network. Jumper link J6 on the communications card is for the termination resistor. A termination resistor should be inserted at the first and last devices on the network. Typically J6 would be set for “IN” for the last relay on the RS485 network; and, J6 would be set in the “OUT” position for all other relays in the loop. The first unit on the network, typically an ABB 245X series convertor, has the terminating resistor built-in. For communication hardware option “8,” dual RS485 ports, J6 is for Port #2 and a similar jumper, J16 is provided for RS485 Port #1.

Jumper links J7 and J8 insert or remove “pull-up” resistors. These resistors establish a known voltage level on the RS485 bus when no units are transmitting, in order to reduce noise. These jumpers should be set to the “IN” position on only one relay at either end of the RS485 loop. If an ABB communications convertor, catalog series 245X, is used on the network, it has these resistors built-in, and all relays can have J7 and J8 in the out position. For communications hardware option “8,” dual RS485 ports, J7 and J8 are for Port #2, and J17 and J18 are for Port #1.

The RS485 cable should be shielded 3 conductor twisted cable. The shield should be grounded at one end of the communications circuit, preferably where the RS485 circuit begins; eg: at the convertor unit. A typical RS485 connection diagram, drawing 604765, is available on request from the factory.

Recommended cables are Alpha #58902, Belden #9729, #9842, #9829 and Carol #58902.

Notes:

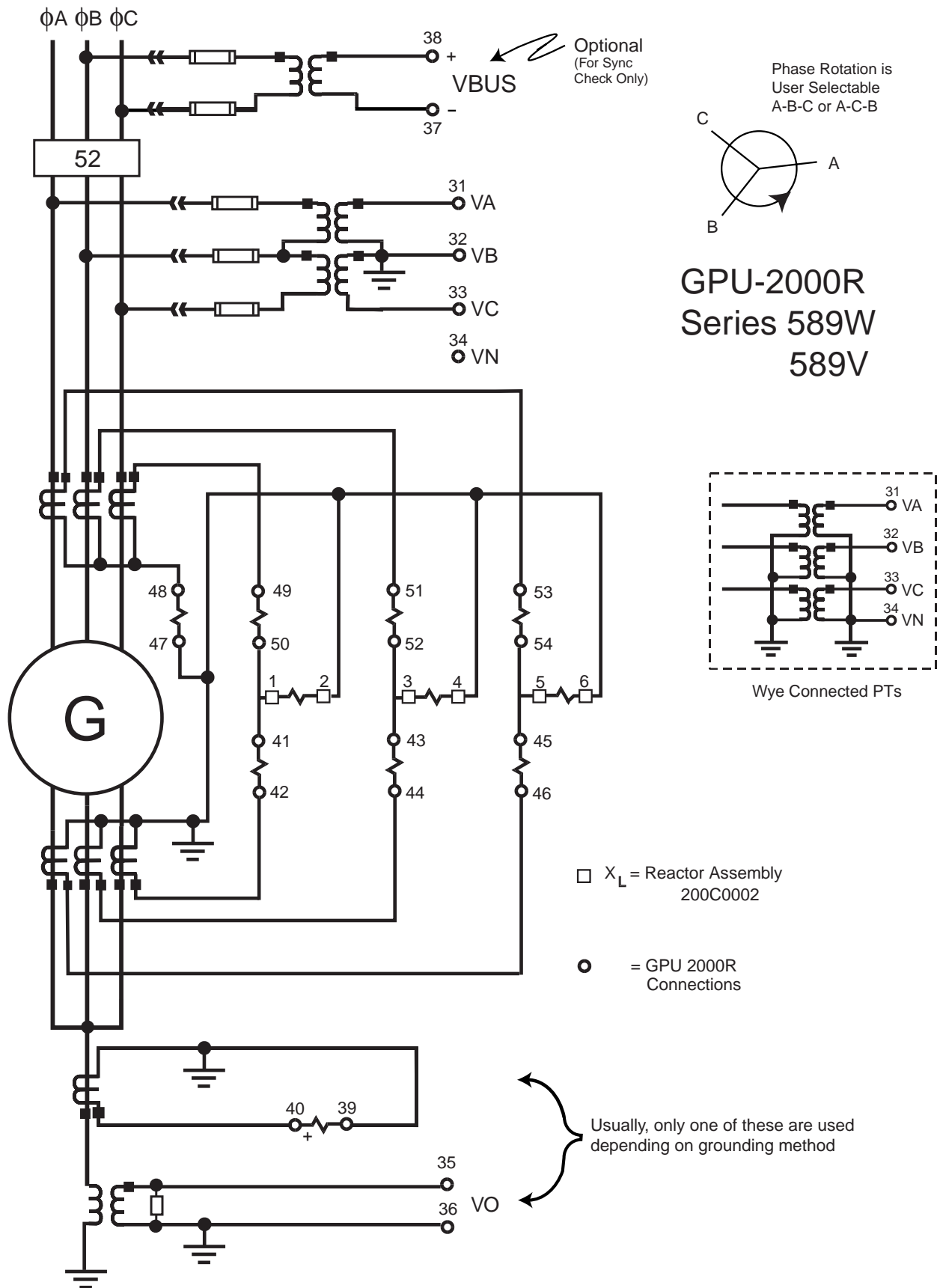


Figure 5-8. Typical Connections, 589W/589V Series Units with Stabilizing Reactor Figure 5-5. GPU-2000R Typical Basic Control Connection

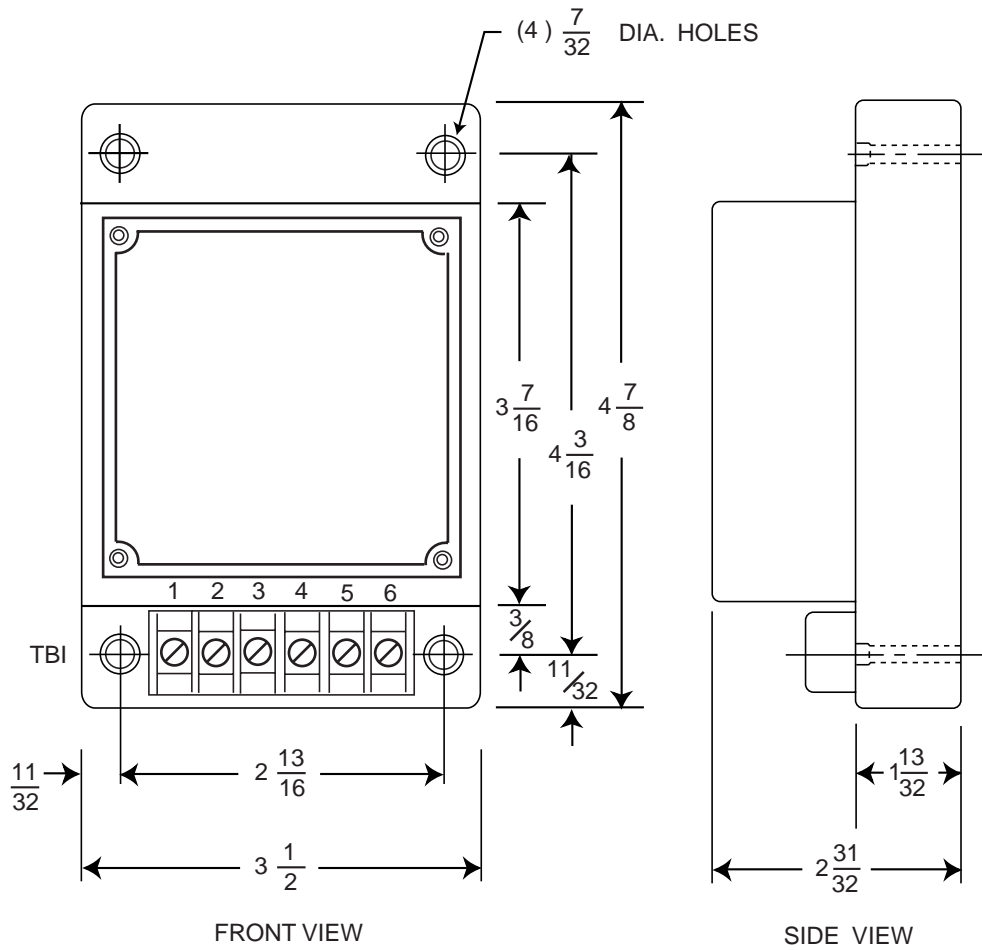


Figure 5-8. Outline for Reactor Catalog 200C0002 (Dimensions in Inches)

Programmable Inputs and Outputs

Programming of the Inputs and Outputs can only be done by using the GPUECP (External Communications Program).

Output Contacts

The relay output contacts are divided into these categories: Master Trip Contact, Self-Check Alarm Contact and User-Programmable Contacts. Jumpers on the CPU board allow you to choose whether the programmable output contacts are normally open or normally closed for certain output contacts (see connections diagrams).

A Fault Record is created only when a protective element causes a trip through the Master Trip Output. Operation of elements not programmed to the MTO, but to other output contacts will be logged in the Operations Record.

Master Trip Output Contact

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.

Master Trip Output							
Set/Exit	Get Data	Send Data					
Unit Name: Unknown Unit							
21-1	<input type="checkbox"/>	32R	<input checked="" type="checkbox"/>	51VR	<input checked="" type="checkbox"/>	81U1	<input type="checkbox"/>
21-2	<input type="checkbox"/>	40	<input checked="" type="checkbox"/>	59	<input type="checkbox"/>	81U2	<input type="checkbox"/>
21-3	<input type="checkbox"/>	46Q	<input checked="" type="checkbox"/>	59F	<input type="checkbox"/>	81O1	<input type="checkbox"/>
23	<input type="checkbox"/>	50P	<input checked="" type="checkbox"/>	59G	<input type="checkbox"/>	81O2	<input type="checkbox"/>
27-1P	<input type="checkbox"/>	50N	<input checked="" type="checkbox"/>	67P	<input checked="" type="checkbox"/>	87M	<input type="checkbox"/>
27-3P	<input type="checkbox"/>	51P	<input checked="" type="checkbox"/>	67N	<input checked="" type="checkbox"/>	87C	<input type="checkbox"/>
27G	<input type="checkbox"/>	51N	<input checked="" type="checkbox"/>				
32S	<input type="checkbox"/>	51VC	<input checked="" type="checkbox"/>				

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.

Self-Check Alarm Contacts

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 6-1 lists the relay conditions available for programming to an output contact for external indication.

In a manner similar to the Programmable Inputs, up to 32 output functions may be programmed into the left hand column. To change a function in the left column, click on the box and the library of output functions will appear.

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.

Set/Exit Get Data Send Data					
TIMERS:	0.00 ← [] [] [] →	0.00 ← [] [] [] →	0.00 ← [] [] [] →	0.00 ← [] [] [] →	1.50 ← [] [] [] →
	OUT-1	OUT-2	OUT-3	OUT-4	OUT-5
NAME:	TRIP	Alarm	Volt Air	O/C Air	U/O Freq
LOGIC:	OR ↓	OR ↓	OR ↓	OR ↓	OR ↓
TRIP	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Alarm	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27-1P	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27-3P	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
59	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
81U-1D	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
81O-1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
50P	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Table 6-1. 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	Duplicates Master Trip Output
ALARM	Self Check Alarm(Duplicates diagnostic alarm output)
21-1a	Zone 1a Impedance Trip
21-1	Zone 1 Impedance Trip
21-2	Zone 2 Impedance Trip
25	Synchronism Check Output
27-1P	Single Phase Undervoltage Trip (Trips on any one phase low)
27-3P	Three-Phase Undervoltage Trip (All phases must be below setpoint)
32R	Reverse Powre Trip
32FO	Forward Overpower Trip
32FU	Forward Underpower Trip
46Q:	Negative-Sequence Overcurrent Trip
50P	Phase Instantaneous Overcurrent Trip
50G	Ground Instantaneous Overcurrent Trip
51P	Phase Time-Overcurrent Trip
51G	Ground Time-Overcurrent Trip
51VC	Voltage-controlled Time-OC Trip
51VR	Voltage Restrained Time-OC Trip
59	Overvoltage Trip (Trips on any phase high)
24	Volts per Hertz Trip
59G	Stator Ground Overvoltage Trip
67P	Phase Directional Time-Overcurrent Trip
67N	Ground Directional Time-Overcurrent Trip
81U1	Underfrequency (first stage) Trip
81O1	Overfrequency (first stage) Trip
81U2	Underfrequency (second stage) Trip
81O2	Overfrequency (second stage) Trip
87M	Machine Differential Trip

Table 6-1 con't. Programmable Output Logical Functions

Programmable Output Logic	Function Description
27G	Third Harmonic Undervoltage Trip (stator ground)
50IE	Inadvertent Energization Trip
40-T	Loss of Excitation Trip (Zone 1)
40-A	Loss of Excitation Trip (Zone 2)
64F	Field Ground Trip (requires external field ground relay)
PATA	Phase A Target Alarm
PBTA	Phase B Target Alarm
PCTA	Phase C Target Alarm
46QA	Negative-Sequence Overcurrent Alarm
24A	Volts per Hertz Alarm
21-1a-D	Zone 1a Impedance Disabled Alarm
21-1-D	Zone 1 Impedance Disabled Alarm
21-2-D	Zone 2 Impedance Disabled Alarm
25-D	Sync Check Disabled Alarm
27-1P-D	Single-Phase Undervoltage Disabled Alarm
27-3P-D	Three-Phase Undervoltage Disabled Alarm
32FO-D	Forward Overpower Disabled Alarm
32FU-D	Forward Underpower Disabled Alarm
32R-D	Reverse Power Disabled Alarm
40T-D	Loss of Excitation Zone 1 Disabled Alarm
40A-D	Loss of Excitation Zone 2 Disabled Alarm
46Q-D	Negative-Sequence OC Disabled Alarm
50P-D	Phase Instantaneous OC Disabled Alarm
50G-D	Ground Instantaneous OC Disabled Alarm
51P-D	Phase Time-Overcurrent Disabled Alarm
51G-D	Ground Time-Overcurrent Disabled Alarm

Table 6-1 con't. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
51V-D	Voltage Dependent Time-Overcurrent Disabled Alarm
59-D	Overvoltage Disabled Alarm
24-D	Volts per Hertz Disabled Alarm
67P-D	Phase Directional Time OC Disabled Alarm
67N-D	Ground Directional Time OC Disabled Alarm
81U1-D	First Step Underfrequency Disabled Alarm
81O1-D	First Step Overfrequency Disabled Alarm
81U2-D	Second Step Underfrequency Disabled Alarm
81O2-D	Second Step Overfrequency Disabled Alarm
87M-D	Machine Differential Disabled Alarm
27G-D	Third Harmonic Undervoltage Disabled Alarm
50IE-D	Inadvertent Energization Disabled Alarm
51G-D	Ground Time-Overcurrent Disabled Alarm
PUA	Pickup Alarm (Operates when front panel Pickup light is lit)
32PA	Phase Directional Element Pickup
32NA	Ground Directional Element Pickup
PPDA	Phase Current Demand Alarm. Activates when the demand current for any phase has exceeded the Phase Demand Alarm setting. This alarm is based on the incremental demand values and not the instantaneous values as in the load alarms. When the demand value rises above the Phase Demand Alarm setting, a 60 second timer is started. When the timer expires, PDA becomes a logical 1.
NPDA	Neutral Current Demand Alarm. Operates when the demand current for the neutral input has exceeded the Neutral Demand Alarm setting. This alarm is based on the incremental demand value and not the instantaneous value as in the load alarms. When the demand value rises above the Neutral Demand Alarm setting, a 60 second timer is started. when the timer expires, NDA becomes a logical 1.

Table 6-1 con't. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
BFUA	Blown Fuse Alarm
KSI	Accumulated Breaker Contact Duty Alarm
HPFA	High Power Factor Alarm. Operates 60 seconds after the power factor rises above the Power Factor Alarm setting. If the value drops below the Alarm setting before the 60 second timer expires, the timer will reset. Operates for lagging power factor above the set point.
LPFA	Low Power Factor Alarm. Operates 60 seconds after the load power factor drops below the Powr Factor Alarm setting. If the value drops below the Alarm setting before the 60 second timer expires, the timer will reset. Operates only on lagging power factor.
OCTC	Overcurrent Trip Counter Alarm
STCA	Settings Table Changed Alarm. Activates when ever the "Change Settings" menu is entered via front panel MMI or remote ECP Program.
VarDA	Var Demand Alarm. Three Phase kiloVAr Demand Alarm. Operates when the value of the three phase demand VArS exceed the Three Phase Demand Alarm setting. This alarm is based on the incremental demand values and not the instantaneous values as in the load alarms. When the incremental value rises above the VArDA alarm setting, a 60 second timer is started. When the timer expires, VArDA becomes a logical 1.
PVArA	Positive 3 Phase kiloVAr Alarm. Operates 60 seconds after the positive 3 phase kiloVArS exceed the Positive KiloVAr Alarm setting. When the Positive KiloVAr value rises above the Positive KiloVAr Alarm setting, a 60 second timer is started. When the timer expires, PVArA becomes a logical 1. If the value drops below the Alarm setting before the 60 second timer expires, the timer will reset.
NVArA	Negative 3 Phase kiloVAr Alarm. Operates 60 seconds after the negative 3 phase kiloVArS exceed the Negative KiloVAr Alarm setting. When the Negative KiloVAr value rises above the Negative KiloVAr Alarm setting, a 60 second timer is started. When the timer expires, NVArA becomes a logical 1. If the value drops below the Alarm setting before the 60 second timer expires, the timer will reset.
LOADA	Load Current Alarm. Operates 60 seconds after any single phase of load current rises above the Load Alarm setting. If the value drops below the Alarm setting before the 60 second timer expires, the timer will reset.

*Seal In Alarm

Table 6-1 con't. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
Watt1	Positive 3 Phase Watt Alarm #1
Watt2	Positive 3 Phase Watt Alarm #2
BFA	Breaker Fail Alarm
TCFA	Trip Circuit Failure Alarm
MRTA1	Machine Run Time Alarm #1
MRTA2	Machine Run Time Alarm #2
21-1a*	Zone 1a Impedance Seal-in
21-1*	Zone 1 Impedance Seal-in
21-2*	Zone 2 Impedance Seal-in
25*	Sync Check Seal-in
27-1P*	Single-Phase Undervoltage Seal-in
27-3P*	Three-Phase Undervoltage Seal-in
32R*	Reverse Power Seal-in
32FO*	Forward Overpower Seal-in
32FU*	Forward Underpower Seal-in
40T*	Loss of Excitation (Zone 1 Trip) Seal-in
40A*	Loss of Excitation (Zone 2 Alarm) Seal-in
46Q*	Negative-Sequence Time OC Seal-in
50P*	Phase Instantaneous OC Seal-in
51P*	Phase Time Overcurrent Seal-in
51G*	Ground Time Overcurrent Seal-in
51VC*	Voltage-Controlled TOC Seal-in
51VR*	Voltage-Restrained TOC Seal-in
59*	Single Phase Overvoltage Seal-in
24*	Volts per Hertz Seal-in
59G*	Ground Overvoltage Seal-in

Table 6-1 con't. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
67P*	Phase Directional Time–OC Seal-in
67N*	Ground Directional Time–OC Seal-in
81U1*	Underfrequency (first stage) Seal-in
81O1*	Overfrequency (first stage) Seal-in
81U2*	Underfrequency (second stage) Seal-in
81O2*	Overfrequency (second stage) Seal-in
87M*	Machine Differential Seal-in
27G*	Third Harmonic Stator Ground UV Seal-in
50IE*	Inadvertent Energization Seal-in
51G*	Ground Time–Overcurrent Seal-in
PATA*	Phase A Target Alarm Seal-in
PBTA*	Phase B Target Alarm Seal-in
PCTA*	Phase C Target Alarm Seal-in
46QA*	Negative Sequence Alarm Seal-in
24A*	Volts per Hertz Alarm Seal-in
ULO1	<p>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 a SCADA communications command.</p> <p>For example, User Logical Output 8 is asserted by User Logical Input 8; it cannot be asserted by any other User Logical Input.</p>
ULO2	
ULO3	
ULO4	
ULO5	
ULO6	
ULO7	
ULO8	
ULO9	
64F*		Field Ground Function Seal-in

*Seal In Alarm

Table 6-1 con't. Programmable Output Logical Functions (Continued)

Programmable Output Logic	Function Description
FBO-1	Internal Logical Feedback 1
FBO-2	Internal Logical Feedback 2
FBO-3	Internal Logical Feedback 3
FBO-4	Internal Logical Feedback 4
FBO-5	Internal Logical Feedback 5
FBO-6	Internal Logical Feedback 6
FBO-7	Internal Logical Feedback 7
FBO-8	Internal Logical Feedback 8

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 function.
 - 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.

Important: If this is done before changes are sent to the relay as described in step 8, all changes will be lost.

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 nameplate.

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.

Programmable Inputs										
Set/Exit		Get Data		Send Data						
NAME:		IN1	IN2	IN3	IN4	IN5	IN6	IN7	IN8	
LOGIC:		IN-1	IN-2	IN-3	IN-4	IN-5	IN-6	IN-7	IN-8	
27-1P	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	↑
27-3P	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
32R	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
40	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
46Q	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
50P	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
50N	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
51P	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
51N	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
51V	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
59	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
67P	AND	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	↓

=  Enable=Closed,Disable=Opened
 =  Enable=Opened,Disable=Closed
 = Input Not Mapped

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.

Up to 32 programmable input functions may be set up in the left hand column, from a library of over 60 possibilities. To change a function in the left column, click on that box and make a selection from the Logical Select Menu library that appears. Refer to Table 6-2 for this library.

Table 6-2. Programmable Input Functions

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

Programmable Input Logic	Function Description
21-1a	Impedance Zone 1a Torque Control
21-1	Impedance Zone 1 Torque Control
21-2	Impedance Zone 2 Torque Control
25	Synchronous Check Torque Control
27-1P	Single Phase Undervoltage Torque Control
27-3P	Three Phase Undervoltage Torque Control
32FO	Overpower Torque Control
32FU	Underpower Torque Control
32R	Reverse Power Torque Control
46Q	Negative Sequence Overcurrent Torque Control
50P	Phase Instantaneous Overcurrent Torque Control
50G	Ground Instantaneous Overcurrent Torque Control
51P	Phase Time-Overcurrent Torque Control
51G	Ground Time-Overcurrent Torque Control
51V	Voltage Dependent Phase Time-Overcurrent Torque Control
59	Overvoltage Torque Control
24	Volts/Hz Torque Control
59G	59G Stator Ground Overvoltage Torque Control
67P	Phase Directional OC Torque Control
67N	Ground Directional OC 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
87M	Machine Differential Torque Control
27G	Stator Ground Third-Harmonic Undervoltage Torque Control

Table 6-2 con't. Programmable Input Functions

Programmable Input Logic	Function Description
24R	Volts per Hertz Instantaneous Thermal memory Reset
46QR	Negative Seq. OC Instantaneous Thermal Memory Reset
40T	Loss of Excitation Torque Control - Zone 1 (Trip)
40A	Loss of Excitation Torque Control - Zone 2 (Alarm)
52A	Breaker Position (follows 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	Initiate a Waveform Capture
OPEN	Initiate an External Trip
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
ULI1	<p>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 included in the Programmable Input Logical library above.</p>
ULI2	
ULI3	
ULI4	
ULI5	
ULI6	
ULI7	
ULI8	
ULI9	

Table 6-2 con't. Programmable Input Functions

Programmable Input Logic	Function Description
CLTRGT	Resets Front Panel Targets
CLSEAL	Resets All Seal-ins
64F	Field Ground Fault Function Input from External Relay
60BFUA	Blown Fuse Input from External Relay
FB-1	Internal Logical Feedback 1
FB-2	Internal Logical Feedback 2
FB-3	Internal Logical Feedback 3
FB-4	Internal Logical Feedback 4
FB-5	Internal Logical Feedback 5
FB-6	Internal Logical Feedback 6
FB-7	Internal Logical Feedback 7
FB-8	Internal Logical Feedback 8
IETC	Inadvertent Energization Torque Control
USER	Display the User Defined Message

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 (4 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.

Important: If this is done before settings are sent to the relay as described in step 7, all setting changes will be lost.

User Logical Inputs/Outputs

In addition to the factory assigned logic functions above, there are nine additional "User Logic Input" functions that can be mapped to any input/output contact (See Table 6-2). 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.

Application Notes on Programmable Logic

Refer to Application Notes AN-30 and AN-31 for additional information on the use of the programmable logic features of the GPI2000R.

Metering

The man-machine interface (MMI) continuously displays rms current magnitudes for I_a , I_b , I_c and I_n and rms voltage magnitudes for V_{an} , V_{bn} and V_{cn} (Wye-connected VTs) or for V_{ab} , V_{bc} and V_{ca} (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 V_{an} (V_{ab}) 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.

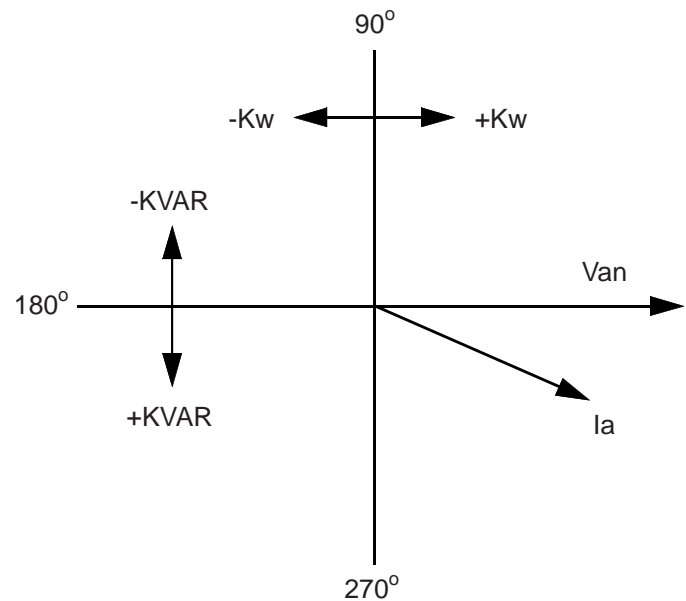
The metered sequence voltage components of the GPU-2000R (V_1 and V_2) are derived from the line-to-neutral voltages, regardless if the unit is wired in a Wye or Delta configuration. If a balanced condition is assumed:

- In a Delta configuration the angle of the positive sequence voltage (V_1) leads V_{ab} by 330° .
- In a Wye configuration the angle of the positive sequence voltage (V_1) equals V_{an} ($V_1 = V_{an} = 0^\circ$).

Figure 1. GPU-2000R Metering and Protective Conventions

Load Values

- Phase currents I_a , I_b and I_c
 - Amperes
 - Degrees
- Ground current I_n
 - Amperes
 - Degrees
- Phase voltage V_{an} , V_{bn} and V_{cn} for Wye VTs
 - Kilovolts
 - Degrees
- Phase voltage V_{ab} , V_{bc} and V_{ca} for Delta VTs
 - Kilovolts
 - Degrees
- Kilowatts per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- KiloVARs per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- Kilowatt-hours per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- KiloVAR-hours per phase and 3-phase for Wye VTs and 3-phase for Delta VTs
- Zero (I_0), positive (I_1) and negative (I_2) sequence currents
 - Amperes
 - Degrees
- Positive (V_1) and negative (V_2) sequence voltages
 - Kilovolts
 - Degrees
- Power factor
- Frequency



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.

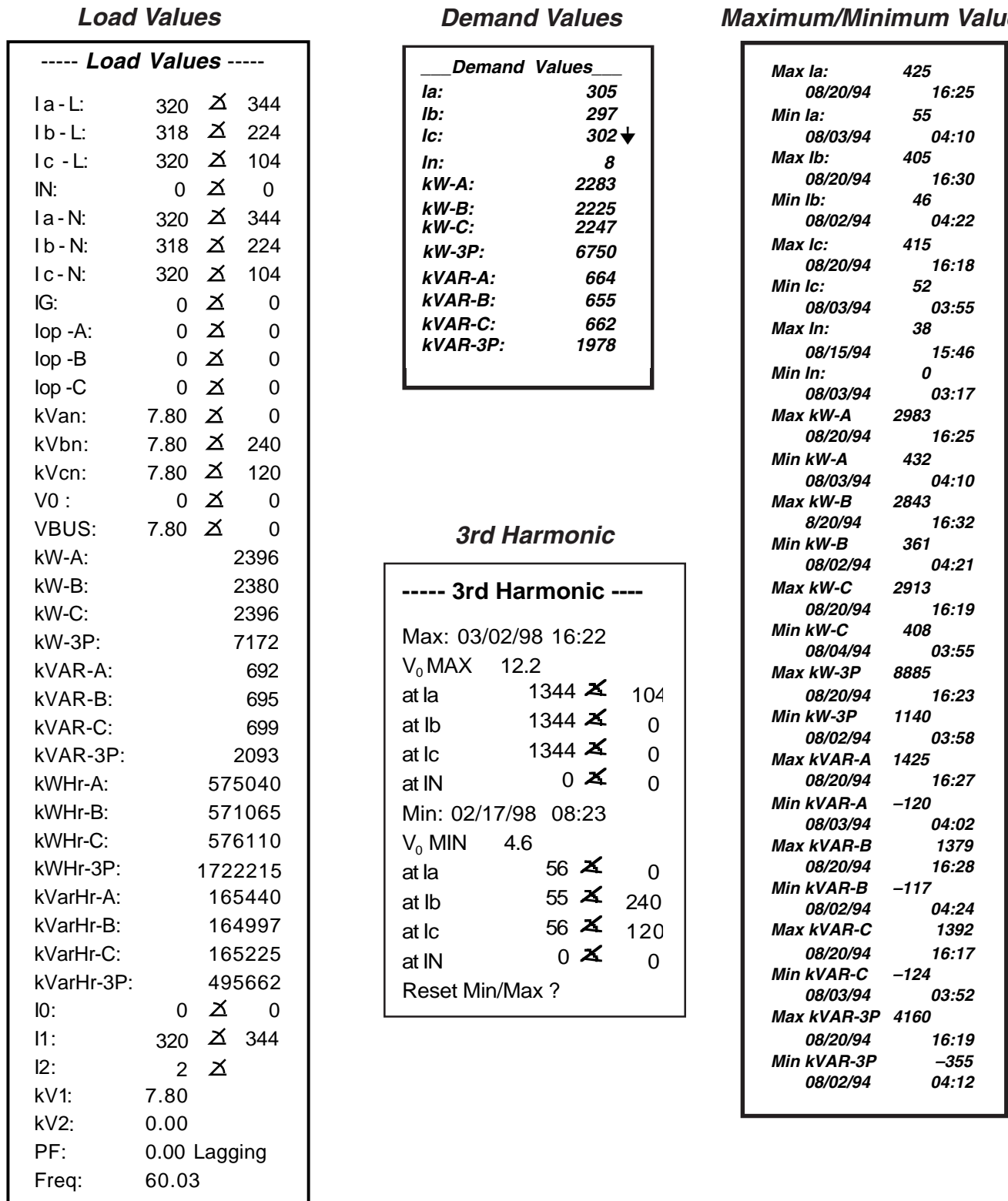
3rd Harmonic Metering Function

- Provided as an aid to the application of the 27G Third-Harmonic Undervoltage protection element.

The measurement is made for the voltage applied at terminals 35-36. The 27G operating voltage must be set below the minimum value of third-harmonic seen under any loading condition during the normal operation of the machine. The third-harmonic metering function includes retention of the min and max values and the load current conditions at those times.

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



Records Menu

The GPU-2000R provides detailed fault and operations records for analyzing your systems operations. The optional Waveform Capture/Oscillography feature is described in Section 10.

A FAULT-RECORD is created only when a protection element causes a trip through the Master Trip Output. Operation of elements not programmed to the MTO, but to other output contacts will be logged in the Operations Record.

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 Summary Record									
Set/Exit Get Data Send Data									
Rec	No	Active Set	Fault Type	Date	Time	IA1	IB1	IC1	IN1
184	1	Primary	50P	04/17/96	09:14:06.29	505	1	1	1
183	2	Primary	51P	04/17/96	09:10:03.15	505	1	0	1
182	3	Alt 1	51VC	04/16/96	09:37:13.75	7267	7	7	0
181	4	Alt 1	51VC	04/16/96	09:30:15.08	7267	7	7	0

0	Unit I.D. ABB Sample	Status Use Scroll Bar to Access Additional Records
---	-------------------------	---

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

The screenshot shows the 'Fault Records' interface with the following fields and sections:

- Buttons:** Set/Exit, Get Data, Send Data
- Header:** Fault No.: #, Fault Type: [], Date: [], Time: []
- Phase 1:** A table with columns for Magnitude and Angle for phases IA, IB, IC, and IG.
- Breaker Operate Time:** [] ms
- Relay Operate Time:** [] ms
- Machine Run Time:** IA [] hrs, IB [] hrs
- Active Set:** []
- Record Type:** []
- Connection Type:** []
- Unit ID:** Unknown Unit
- Status:** Communications Error!
- Navigation:** NEXT, LATEST, LAST

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 Log Listing

Listed in Table 8-1 are all of the possible operations records and their descriptions.

Table 8-1. Operations Record Log

Operations Record Log	Definition
21-1a Trip	Indicates that the Zone 1a impedance element has operated.
21-1 Trip	Indicates that the Zone 1 impedance element has operated.
21-2 Trip	Indicates that the Zone 2 impedance element has operated.
25 Alarm	Indicates that a condition of synchronism has been obtained and the programmed contact asserted.
27-1P Alarm	Indicates that the single phase undervoltage element, 27-1P, has timed out and operated.
27-3P Alarm	Indicates that the three phase voltage element, 27-3P, has timed out and operated.
27G Trip	Indicates that the third-harmonic undervoltage element has timed out and operated.
32FO Trip	Indicates that the forward overpower element has timed out and operated.
32FU Trip	Indicates that the forward underpower element has timed out and operated.
32R Trip	Indicates that the reverse power element has timed out and operated.
40 Trip	Indicates that the loss of excitation element (Zone 1) has timed out and operated.
40 Alarm	Indicates that the loss of excitation alarm unit (Zone 2) has timed out and operated.
46Q Trip	Indicates that the negative-sequence time-overcurrent element has timed out and operated.
46Q Alarm	Indicates that the negative-sequence overcurrent alarm unit has operated.
50P Trip	Indicates that the phase instantaneous overcurrent element has operated.
50G Trip	Indicates that the ground instantaneous overcurrent element has operated.

Table 8-1. Operations Record Log

Operations Record Log	Definition
51P Trip	Indicates that the phase time-overcurrent element has timed out and operated.
51G Trip	Indicates that the ground time-overcurrent element has timed out and operated.
51V Trip	Indicates that the voltage dependent time-overcurrent element has timed out and operated.
59G Trip	Indicates that the ground voltage element has timed out and operated.
67P Trip	Indicates that the phase-directional time-overcurrent element has timed out and operated.
67N Trip	Indicates that the ground-directional time-overcurrent element has timed out and operated.
81O-1 Over-frequency	Indicates that the overfrequency module 1 element has timed out and operated.
81O-2 Over-frequency	Indicates that the overfrequency module 2 element has timed out and operated.
81U-1 Under-frequency	Indicates that the underfrequency module 1 element has timed out and operated.
81O-2 Under-frequency	Indicates that the underfrequency module 2 element has timed out and operated.
81V Block	Indicates that one or more phases of voltage fell below the 81V threshold setting.
87M Trip	Indicates that the machine differential element has timed out and operated.
24 Trip	Indicates that the Volts per Hertz Tripping element has timed out and operated.
24 Alarm	Indicates that the Volts per Hertz alarm element has timed out and operated.

Table 8-1. Operations Record Log

Operations Record Log	Definition
50IE Trip	Indicates that the inadvertent energization element has timed out and operated.
64F Alarm	Indicates that a field ground failure signal has been received from the external 64F relay.
BackUp 50 Prot.	Indicates that a trip occurred due to the detection of current flow before the system was brought on line.
59 Trip	Indicates that the overvoltage element has timed out and operated.
59 Alarm	Indicates that the overvoltage element, 59, has operated.
25 Lines Synced.	Indicates conditions were met to obtain operation of the synchronism check output.
25 Sync Lost	Indicates that synchronism was lost and the sync check output was de-asserted.
21-1 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
21-1 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
21-1A Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
21-1A Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
21-2 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
21-2 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
25 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
25 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
27-1 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
27-1 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.

Table 8-1. Operations Record Log

Operations Record Log	Definition
27-3 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
27-3 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
32FO Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
32FO Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
32FU Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
32FU Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
32R Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
32R Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
46Q Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
46Q Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
50P Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
50P Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
50G Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
50G Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
51P Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
51P Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.

Table 8-1. Operations Record Log

Operations Record Log	Definition
51G Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
51G Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
51V Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
51V Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
59 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
59 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
24 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
24 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
59G unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
59 G Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
67P Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
67P Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
67N Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
67N Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
81U1 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
81U1 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.

Table 8-1. Operations Record Log

Operations Record Log	Definition
81O1 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
81O1 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
81U2 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
81U2 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
81O2 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
81O2 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
87M Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
87M Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
27G Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
27G unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
46QR Memory Reset	Indicates that the programmable input was asserted in order to reset the thermal memory of the negative-sequence time-overcurrent element 46Q
46QR Memory Enabled	Indicates that the programmable input was de-asserted to allow accumulation of time in the thermal memory of the 46Q element.

Table 8-1. Operations Record Log

Operations Record Log	Definition
40 Z1 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
40 Z1 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
40 Z2 Unit Enabled	Indicates that the programmed torque-control input for this element was asserted to enable operation of the element.
40 Z2 Unit Disabled	Indicates that the programmed torque-control input for this element was de-asserted to block operation of this element.
Ext 87M Fault, PHA	Indicates that the programmed input has been asserted from an external phase A machine differential relay.
Ext 87M Fault, PHB	Indicates that the programmed input has been asserted from an external phase B machine differential relay.
Ext 87M Fault, PHC	Indicates that the programmed input has been asserted from an external phase C machine differential relay.
Ext 87M Clear, PHA	Indicates that the programmed input from an external phase A machine differential relay has been de-asserted.
Ext 87m Clear, PHB	Indicates that the programmed input from an external phase B machine differential relay has been de-asserted.
Ext 87M Clear, PHC	Indicates that the programmed input from an external phase C machine differential relay has been de-asserted.
Primary Set Active	Indicates that a transition from an Alternate settings group took place and that the Primary settings are active at this point in the record.
Alt1 Set Active	Indicates that a transition from an Alternate 2 or Primary settings group took place and that the Alternate 1 settings are active at this point in the record.
Alt2 Set Active	Indicates that a transition from an Alternate 1 or Primary settings group took place and that the Alternate 2 settings are active at this point in the record.

Table 8-1. Operations Record Log

Operations Record Log	Definition
Blown Fuse Alarm	Indicates that "BFUA" programmable logical output has operated. See the Programmable Outputs section specifically the "BFUA" output, for more details.
Trip Coil Failure	Indicates that the logical input "TCM" indicated a trip coil failure. See Section 6, specifically the "TCM" input.
Accumulated KSI	Indicates that the KSI summation has exceeded the KSI Alarm setting. See Section 6, specifically the "KSI" output, for more details.
OC Trip Counter	Indicates that the Overcurrent Trip Counter has exceeded the Overcurrent Trip Counter Alarm setting. See Section 6, specifically the "OCTC" output, for more details.
Phase Demand Alarm	Indicates that the phase demand current has exceeded the Phase Demand Current Alarm setting. See Section 6, specifically the "PDA" output, for more details.
Neutral Demand Alm	Indicates that the neutral demand current has exceeded the Neutral Demand Current Alarm setting. See Section 6, specifically the "NDA" output, for more details.
kVAR Demand Alarm	Indicates that the demand KiloVARs have exceeded the Demand KiloVAr Alarm setting. See Section 6, specifically the "VARDA" output, for more details.
Low PF Alarm	Indicates that the power factor has gone below the Low Power Factor Alarm setting. See the Section 6, specifically the "LPFA" output, for more details.
High PF Alarm	Indicates that the power factor has risen above the High Power Factor Alarm setting. See Section 6, specifically the "HPFA" output, for more details.
Load Alarm	Indicates that the load current has exceeded the Load Current Alarm setting. See Section 6, specifically the "LOADA" output, for more details.
Pos. kVAR Alarm	Indicates that the positive KiloVARs have exceeded the Positive KiloVAr Alarm setting. Setting 6, specifically the "PVARA" output, for more details.
Neg. kVAR Alarm	Indicates that the negative KiloVARs have exceeded the negative KiloVAr Alarm setting. See Section 6, specifically the "NVARA" output, for more details.
Pos. Watt Alarm 1"	Indicates that the positive kilowatts have exceeded the Positive Kilowatt Alarm 1 setting. See Section 6, specifically the "Pwatt1" output, for more details.
Pos. Watt Alarm 2"	Indicates that the positive kilowatts have exceeded the Positive Kilowatt Alarm 2 setting. See Section 6, specifically the "Pwatt2" output, for more details.

Table 8-1. Operations Record Log

Operations Record Log	Definition
Waveform Capture	Indicates a waveform capture was triggered by the set trigger mechanisms.
CRI Input Closed	Indicates that the programmable input Clear Reclose and Overcurrent Counters, "CRI," transitioned from a logical 0 to a logical 1. See Section 6, specifically the "CRI" input, for more details.
CRI Input Opened	Indicates that the programmable input Clear Reclose and Overcurrent Counters, "CRI," transitioned from a logical 1 to a logical 0. See Section 6, specifically the "CRI" input, for more details.
ROM Failure	Indicates a failure of the GPU-2000R Read Only Memory. Contact ABB Technical Support at this time, 1-800-634-6005
RAM Failure	Indicates a failure of the GPU-2000R Random Access Memory. Contact ABB Technical Support at this time, 1-800-634-6005
Self Test Failed	Indicates a failure of the GPU-2000R during the self check procedure. See the Maintenance section for more details.
EEPROM Failure	Indicates a failure of the GPU-2000R Non-Volatile Memory. Contact ABB Technical Support at this time, 1-800-634-6005
BATRAM Failure	Indicates a failure of the GPU-2000R Battery Backed-up Random Access Memory. Contact ABB Technical Support at this time, 1-800-634-6005
DSP Failure	Indicates a failure of the GPU-2000R Digital Signal Processor. Contact ABB Technical Support at this time, 1-800-634-6005
Control Power Fail	Indicates that the control power has dropped below the control power operating threshold as outlined in the Specifications section.
Editor Access	Indicates that a settings change has been made.
Manual Trip	Indicates that the breaker has been opened by means external to the GPU2000R unit.
Fault Cleared	Indicates that a fault for which the Master Trip operated has been cleared (current below Trip Failure Pickup Setting)

Table 8-1. Operations Record Log

Operations Record Log	Definition
Direct Trip	Indicates that the master trip output was commanded to close via the MMI, or ECP, or SCADA communications.
CB Failed to Trip	Indicates the circuit breaker failed to trip within the period allowed by the trip fail timer after master trip was asserted.
CB Pops Open	Indicates circuit breaker opened after the CB failed to trip state occurred. (e.g. A sluggish breaker, or a backup trip)
_52A_Opened	Indicates the change of state of the programmable logical input "52A" to the open state. (Circuit breaker opens)
_52A_Closed	Indicates the change of state of the programmable logical input "52A" to the closed state. (Circuit breaker closes)
TCM Input Opened	Indicates that the programmable input assigned to the trip circuit monitor function was de-asserted (open path)
TCM Input Closed	Indicates that the programmable input assigned to the trip circuit monitor function was asserted (circuit path continuous)
ALT1 Input Enabled	Indicates that the programmable input assigned to Alternate 1 settings was asserted. Note that this input will be effective only if ALT1 settings are enabled in the configuration settings.
ALT1 Input Disabled	Indicates that the programmable input assigned to Alternate 1 settings was de-asserted.
ALT2 Input Enabled	Indicates that the programmable input assigned to Alternate 2 settings was asserted. Note that this input will be effective only if ALT2 settings are enabled in the configuration settings.
ALT2 Input Disabled	Indicates that the programmable input assigned to Alternate 2 settings was de-asserted.
Ext Trip Enabled	Indicates that the programmable input "Open" was asserted. This record indicates that the state of the programmable input "Open" only. It does not imply an actual breaker trip.
Ext Trip Disabled	Indicates that the programmable input "open" was de-asserted.

Table 8-1. Operations Record Log

Operations Record Log	Definition
Event Cap1 Init	Indicates that the programmable input "ECI1" was asserted and an event capture taken. The data from the event is stored in the Fault Records.
Event Cap1 Reset	Indicates that the programmable input "ECI1" was de-asserted.
Event Cap2 Init	Indicates that the programmable input "ECI2" was asserted and an event capture taken. The data from the event is stored in the Fault Records.
Event Cap2 Reset	Indicates that the programmable input "ECI2" was de-asserted.
Wave Cap Init	Indicates that the programmable input "WCI" was asserted and an oscillographic capture taken. The data from the event is stored in the Waveform Capture Records.
Wave Cap Reset	Indicates that the programmable input "WCI" was de-asserted.
ULI1 Input Closed	Indicates that the User Logical Input, ULI1, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI1 Input Opened	Indicates that the User Logical Input, ULI1, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI2 Input Closed	Indicates that the User Logical Input, ULI2, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI2 Input Opened	Indicates that the User Logical Input, ULI2, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI3 Input Closed	Indicates that the User Logical Input, ULI3, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI3 Input Opened	Indicates that the User Logical Input, ULI3, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI4 Input Closed	Indicates that the User Logical Input, ULI4, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI4 Input Opened	Indicates that the User Logical Input, ULI4, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.

Table 8-2. Operations Record Log

Operations Record Log	Definition
ULI5 Input Closed	Indicates that the User Logical Input, ULI5, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI5 Input Opened	Indicates that the User Logical Input, ULI5, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI6 Input Closed	Indicates that the User Logical Input, ULI6, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI6 Input Opened	Indicates that the User Logical Input, ULI6, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI7 Input Closed	Indicates that the User Logical Input, ULI7, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI8 Input Opened	Indicates that the User Logical Input, ULI7, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI8 Input Closed	Indicates that the User Logical Input, ULI8, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
ULI9 Input Opened	Indicates that the User Logical Input, ULI9, transitioned from a logical 1 to a logical 0. See Section 6 for more details on User Logical Inputs.
ULI9 Input Closed	Indicates that the User Logical Input, ULI9, transitioned from a logical 0 to a logical 1. See Section 6 for more details on User Logical Inputs.
Target Clear On	Indicates that the programmable input CLTRGT was asserted to reset the front panel targets.
Target Clear Off	Indicates that the programmable input CLTRGT was de-asserted.
Sealin Clear On	Indicates that the programmable input CLSEAL was asserted to reset the sealed-in outputs.
Sealin Clear Off	Indicates that the programmable input CLSEAL was de-asserted.
Internal SW Error	Indicates unit detected an internal software error. Contact ABB Technical Support at 1-800-634-6005.

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.

Operations Summary		
Set/Exit	Get Data	Send Data
Though Fault Sum kAmps A	0	
Though Fault Sum kAmps B	0	
Though Fault Sum kAmps C	0	
Overcurrent Trip	0	
Breaker Operations	0	
Machine Differential Trip (87)	0	
Machine Run Time Hrs #1	0	
Machine Run Time Hrs #2	0	

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.

☰
Physical I/O Contacts

Exit

Unit Name:

Inputs

IN 1	<input type="checkbox"/>
IN 2	<input type="checkbox"/>
IN 3	<input type="checkbox"/>
IN 4	<input type="checkbox"/>
IN 5	<input type="checkbox"/>
IN 6	<input type="checkbox"/>
IN 7	<input type="checkbox"/>
IN 8	<input type="checkbox"/>

= Open
 = Closed

Outputs

TRIP	<input type="checkbox"/>
OUT 1	<input type="checkbox"/>
OUT 2	<input type="checkbox"/>
OUT 3	<input type="checkbox"/>
OUT 4	<input type="checkbox"/>
OUT 5	<input type="checkbox"/>
OUT 6	<input type="checkbox"/>

= De-Energized
 = Energized

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 Input Status							
Exit							
21-1TC	<input type="checkbox"/>	59 TC	<input type="checkbox"/>	52A	<input type="checkbox"/>	ULI1	<input type="checkbox"/>
21-2 TC	<input type="checkbox"/>	59F TC	<input type="checkbox"/>	52B	<input type="checkbox"/>	ULI2	<input type="checkbox"/>
21-3 TC	<input type="checkbox"/>	59G TC	<input type="checkbox"/>	TCM	<input type="checkbox"/>	ULI3	<input type="checkbox"/>
25 TC	<input type="checkbox"/>	67P TC	<input type="checkbox"/>	ALT1	<input type="checkbox"/>	ULI4	<input type="checkbox"/>
27-1P	<input type="checkbox"/>	67N TC	<input type="checkbox"/>	ALT2	<input type="checkbox"/>	ULI5	<input type="checkbox"/>
27-3P	<input type="checkbox"/>	81U1 TC	<input type="checkbox"/>	ECI1	<input type="checkbox"/>	ULI6	<input type="checkbox"/>
32F0 TC	<input type="checkbox"/>	81O1 TC	<input type="checkbox"/>	ECI2	<input type="checkbox"/>	ULI7	<input type="checkbox"/>
32F4 TC	<input type="checkbox"/>	81U2 TC	<input type="checkbox"/>	WCI	<input type="checkbox"/>	ULI8	<input type="checkbox"/>
32R TC	<input type="checkbox"/>	81O2 TC	<input type="checkbox"/>	OPEN	<input type="checkbox"/>	ULI9	<input type="checkbox"/>
40 TC	<input type="checkbox"/>	87C TC	<input type="checkbox"/>	CLOSE	<input type="checkbox"/>	Unused	<input type="checkbox"/>
46Q TC	<input type="checkbox"/>	87M TC	<input type="checkbox"/>	CRI	<input type="checkbox"/>	Unused	<input type="checkbox"/>
50P TC	<input type="checkbox"/>	Unused	<input type="checkbox"/>	87A	<input type="checkbox"/>	Unused	<input type="checkbox"/>
50N TC	<input type="checkbox"/>	Unused	<input type="checkbox"/>	87B	<input type="checkbox"/>	Unused	<input type="checkbox"/>
51P TC	<input type="checkbox"/>	Unused	<input type="checkbox"/>	87C	<input type="checkbox"/>	Unused	<input type="checkbox"/>
51N TC	<input type="checkbox"/>	Unused	<input type="checkbox"/>	BFI	<input type="checkbox"/>	Unused	<input type="checkbox"/>
51V TC	<input type="checkbox"/>	Unused	<input type="checkbox"/>	SYNC	<input type="checkbox"/>	Unused	<input type="checkbox"/>

=Energized =Not Energized

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".

Logical Outputs Status													
Exit													
TRIP	<input type="checkbox"/>	51VR	<input type="checkbox"/>	24-4-D	<input type="checkbox"/>	59G-D	<input type="checkbox"/>	OCTC	<input type="checkbox"/>	32R*	<input type="checkbox"/>	81U2*	<input type="checkbox"/>
ALARM	<input type="checkbox"/>	59	<input type="checkbox"/>	24-2-D	<input type="checkbox"/>	67P-D	<input type="checkbox"/>	STCA	<input type="checkbox"/>	32FO*	<input type="checkbox"/>	81O2*	<input type="checkbox"/>
24-1	<input type="checkbox"/>	39F	<input type="checkbox"/>	24-3-D	<input type="checkbox"/>	67N-D	<input type="checkbox"/>	VarDA	<input type="checkbox"/>	32FU*	<input type="checkbox"/>	87G*	<input type="checkbox"/>
24-2	<input type="checkbox"/>	39C	<input type="checkbox"/>	25-B	<input type="checkbox"/>	81U1-D	<input type="checkbox"/>	PVARA	<input type="checkbox"/>	40*	<input type="checkbox"/>	87M*	<input type="checkbox"/>
24-3	<input type="checkbox"/>	67P	<input type="checkbox"/>	27-1P-D	<input type="checkbox"/>	81O1-D	<input type="checkbox"/>	NVARA	<input type="checkbox"/>	46Q*	<input type="checkbox"/>	PATA*	<input type="checkbox"/>
25	<input type="checkbox"/>	67N	<input type="checkbox"/>	27-3P-D	<input type="checkbox"/>	81U2-D	<input type="checkbox"/>	LOADA	<input type="checkbox"/>	50P*	<input type="checkbox"/>	PBTA*	<input type="checkbox"/>
27-1P	<input type="checkbox"/>	81U1	<input type="checkbox"/>	32FO-D	<input type="checkbox"/>	81O2-D	<input type="checkbox"/>	Watt1	<input type="checkbox"/>	50N*	<input type="checkbox"/>	PCTA*	<input type="checkbox"/>
27-3P	<input type="checkbox"/>	81O1	<input type="checkbox"/>	32FU-D	<input type="checkbox"/>	87G-D	<input type="checkbox"/>	Watt2	<input type="checkbox"/>	51P*	<input type="checkbox"/>	40A*	<input type="checkbox"/>
32FO	<input type="checkbox"/>	81U2	<input type="checkbox"/>	32R-D	<input type="checkbox"/>	87M-D	<input type="checkbox"/>	BFA	<input type="checkbox"/>	51N*	<input type="checkbox"/>	46QA*	<input type="checkbox"/>
32FU	<input type="checkbox"/>	81O2	<input type="checkbox"/>	40-D	<input type="checkbox"/>	PUA	<input type="checkbox"/>	TCFA	<input type="checkbox"/>	51VC*	<input type="checkbox"/>	39FA*	<input type="checkbox"/>
32R	<input type="checkbox"/>	87G	<input type="checkbox"/>	46Q-D	<input type="checkbox"/>	32PA	<input type="checkbox"/>	MRTA1	<input type="checkbox"/>	51VR*	<input type="checkbox"/>	UL01	<input type="checkbox"/>
40	<input type="checkbox"/>	87M	<input type="checkbox"/>	50P-D	<input type="checkbox"/>	32NA	<input type="checkbox"/>	MRTA2	<input type="checkbox"/>	59*	<input type="checkbox"/>	UL02	<input type="checkbox"/>
46Q	<input type="checkbox"/>	PATA	<input type="checkbox"/>	50N-D	<input type="checkbox"/>	PDA	<input type="checkbox"/>	24-1*	<input type="checkbox"/>	39F*	<input type="checkbox"/>	UL03	<input type="checkbox"/>
50P	<input type="checkbox"/>	PBTA	<input type="checkbox"/>	51P-D	<input type="checkbox"/>	NDA	<input type="checkbox"/>	24-2*	<input type="checkbox"/>	39C*	<input type="checkbox"/>	UL04	<input type="checkbox"/>
50N	<input type="checkbox"/>	PCTA	<input type="checkbox"/>	51N-D	<input type="checkbox"/>	BFUA	<input type="checkbox"/>	24-3*	<input type="checkbox"/>	67P*	<input type="checkbox"/>	UL05	<input type="checkbox"/>
51P	<input type="checkbox"/>	40A	<input type="checkbox"/>	51V-D	<input type="checkbox"/>	KSI	<input type="checkbox"/>	25*	<input type="checkbox"/>	67N*	<input type="checkbox"/>	UL06	<input type="checkbox"/>
51N	<input type="checkbox"/>	46QA	<input type="checkbox"/>	59-D	<input type="checkbox"/>	HPFA	<input type="checkbox"/>	27-1P*	<input type="checkbox"/>	81U1*	<input type="checkbox"/>	UL07	<input type="checkbox"/>
51VC	<input type="checkbox"/>	39FA	<input type="checkbox"/>	59F-D	<input type="checkbox"/>	LPFA	<input type="checkbox"/>	27-3P*	<input type="checkbox"/>	81O1*	<input type="checkbox"/>	UL08	<input type="checkbox"/>
												UL09	<input type="checkbox"/>

*=Sealed in Alarms =Energized =Not Energized

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.

Output Contacts

Set/Exit Send Data

Unit Name:

CLOSE TRIP

OUT 1

OUT 2

OUT 3

OUT 4

OUT 5

OUT 6

= Don't Energize
 = Energize

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 nonvolatile memory and is not lost during loss of control power.

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 impossible 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 main system 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 withdraw 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. Instructions on downloading firmware follows later in this section.

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.

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Testing the GPU-2000R

All tests described below require the use of 3-phase voltage and 3-phase current for most tests. The 27G and 59G elements also need an additional single-phase of voltage to test these functions. The tests are based on using the factory default settings. See Table 10-1 and Figure 10-1 for these settings.

Test 1 - Verify Self-Checking Test Via MMI

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

- Connect the proper control power to the unit. Wait for initialization of the relay. The green STATUS LED should light.
- From the MMI, press <E> to get to the Main Menu.
- Scroll down to "TEST" and press <E>
- The first choice is "Self TEST": press <E>. All elements should read "pass".
- Press "C" 3 times to return to the meter display.

Table 10-1. GPU2000R Factory Default Settings-Primary Settings

50P	=	Disable	50IE	=	Disable
50G	=	Disable	27G	=	Disable
51P	=	Disable	59G	=	Disable
51G	=	Disable	27	=	Disable
51V	=	Disable	59	=	Disable
46Q	=	Disable	32R	=	Disable
67P	=	Disable	32O	=	Disable
67N	=	Disable	32U	=	Disable
87M	=	Disable	81	=	Disable
40T	=	Disable	81U-1	=	56.00Hz 0.10 sec.
40A	=	Disable	81O-1	=	Disable 0.10 sec.
24	=	Disable	81U-2	=	56.00Hz 0.10 sec.
24A	=	Disable	81O-2	=	Disable 0.10 sec.
25	=	Disable	81V	=	40V

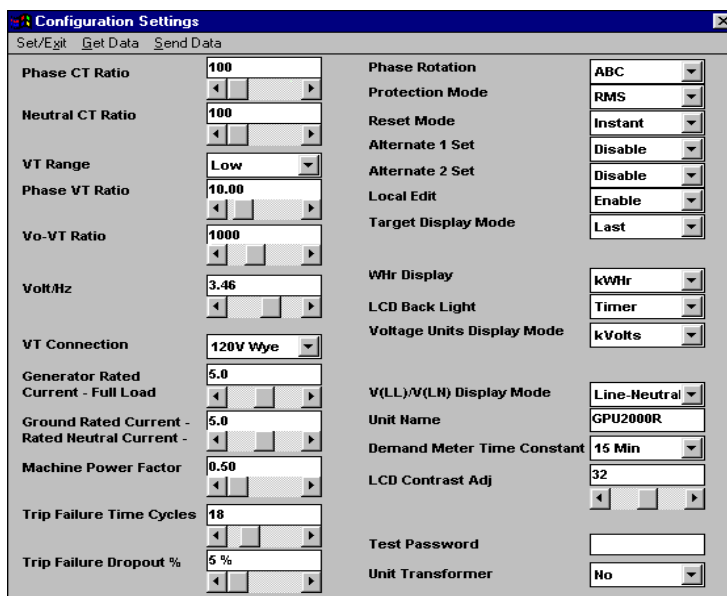


Figure 10-1. GPU2000R Factory Default Settings-Configuration Settings

Test 2 - Metering Tests

Change the following Configuration settings:

Phase VT Ratio	=	1.00
VT Connection	=	69V Wye
Voltage Units	=	V (Volts)

- Make the test connections as shown in Figure 10-2, page 10-17.
- Apply a balanced 3-phase voltage of 69.0 volts RMS phase to neutral and a balanced 3-phase current of 3.0 amperes RMS in phase with the voltage to the relay.
- From the MMI main menu, press <E> twice to gain access to the metering menu.
- Press <E> on the load choice. The following should be within the ranges listed:

Test 3 - 40 Loss of Excitation Function: 40T Trip

Verify or change the following PRIMARY settings for this test:

40T	=	Enable
40A	=	Disable
40T Dia +Off	=	100 Ohms
40T Offset	=	50 Ohms
40T Time Delay	=	1.0 Second

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced voltage of 69.0 volts RMS phase to neutral and a balanced 3-phase current of 0.10 amperes RMS with a phase angle of 270° lagging or 90° leading.

Slowly **increase** the current until the relay trips. The “Pickup” LED on the relay should light and the contact should indicate a closed contact. The “Loss of Excitation” LED should also light. This should occur when the current magnitude reaches 0.69 amperes RMS for one side of the MHO circle, and 1.38 amperes RMS for the other side of the circle.

Test 3A - 40 Loss of Excitation Function: 40A-Alarm

Verify or change the following PRIMARY setting for this test:

40T	=	Disable
40A	=	Enable
40A Dia + Off	=	100 Ohms
40A Offset	=	50 Ohms
40A Time Delay	=	1.0 Second

Ia-L = 300.0	0°	(±6 A)	kVAR-A = 0	(+8 kW)
Ib-L = 300.0	240°	(±6 A)	kVAR-B = 0	(+8 kW)
Ic-L = 300.0	120°	(±6 A)	kVAR-C = 0	(+8 kW)
In = 0.0		(±6 A)	kVAR-3P = 0	(+25 kW)
Ia-N = 0.00			kWhr-A = 0	
Ib-N = 0.00			kWhr-B = 0	
Ic-N = 0.00			kWhr-C = 0	
IG = 0			kVarHr-A = 0	
IOP-A = 300			kVarHr-B = 0	
IOP-B = 300			kVarHr-C = 0	
IOP-C = 300			Kvarhr-3P = 0	
Van = 69	0°	(±7 V)	I ₀ = 0.0	(±6 A)

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Vbn = 69	240°	(±7 V)	I ₁ = 300.0	0°	(±6 A)
Vcn = 69	120°	(±7 V)	I ₂ = 0.0		(±6 A)
Vo = 0			kV ₁ = 6.90	0°	(+7 V)
Vbus = 0.00			kV ₂ = 0	0°	(+7 V)
kW-A = 20		(+8 kW)	PF = 1.00		Lagging or Leading
kW-B = 20		(+8kW)	Freq = 60.00		(+0.01 Hz)
kW-C = 20		(+8 kW)			
KW-3P = 60		(+25 kW)			

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

Test the 40A function of the relay identical to the 40T function. However, the 40A function must be mapped to a separate physical output contact for indication purposes as it will not close the master trip contact. Disable the 40T function, and enable the 40A function. The “Loss of Excitation” LED and the “Pickup” LED should light for this test when the same current levels are reached as for the 40T test described above.

Test 4 - 46 Phase Unbalance (Negative Sequence) Test

Verify or change the following PRIMARY setting for this test.

46Q Select	=	Enable
46Q Trip % PU	=	5% Rated Current
46Q Time Dial	=	1
46Q Max. Time	=	100 seconds
46Q Alarm % PU	=	5% Rated Current
46Q Alarm Delay	=	1.0 sec.

Make the connections as shown in Figure 10-3, page 10-18, for the phase to be tested. Apply a balance voltage of 69 volts RMS phase to neutral. Set a single phase current to 0.50 (0.10) amperes RMS. One third of the single-phase current applied to the relay will produce the negative sequence current, I₂. It is therefore necessary to apply a current of three times pickup setting for I₂, which is 5% of rated current or 3*0.05*5.0 = 0.75 (0.15) amperes.

Apply a single phase current of 0.50 (0.10) amperes RMS to the relay. Slowly **increase** current until the “Pickup” LED lights and the “Phase Unbalance” LED flashes. This should occur when the test current reaches 0.75 (0.15) ±3% amperes RMS and I₂ reaches 0.25 (0.05) ± 3% amperes RMS.

To perform a timing test, apply 1.0 amperes RMS as the tested current. The Trip contacts should close in 100 seconds and the “Phase Unbalance” LED should be lit.

The 46Q Alarm function can be tested similar to the 46 Trip function, however the 46QA contact must be programmed (mapped) for contact monitoring to an output contact as it does not operate the “Master Trip Contact”.

Test 5 - 50P Phase Instantaneous Overcurrent Function

Verify or change the following PRIMARY settings for this test:

50P Select	=	Enable
50P Curve Selection	=	Definite Time
50P % Pickup	=	50% Rated Current
50P Time Delay	=	1.0 Second

Make the connections as shown in Figure 10-4, page 10-18, for the phase to be tested. Apply a balance voltage of 69 volts RMS phase to neutral. Set a single phase of current to 5.0 (1.0) 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 “Pickup” LED should be lit and the unit should trip in 1.00 seconds \pm 7%. The “Overcurrent/Impedance” LED should be lit.

Repeat the test for the remaining phases listed, as shown in Figure 10-4, page 10-18.

Apply three phase current to the relay at a level of 5.0 amperes RMS (2 X pickup). Observe that the unit produces an output within the same time parameters as the single-phase test. Test connections to the relay will be as illustrated Figure 10-5, page 10-19 for a three-phase test.

Test 6 - 50G Ground Instantaneous Overcurrent Function

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

Verify or change the following PRIMARY settings for this test:

50G Select	=	Enable
50G Curve	=	Definite Time
50G Pickup	=	50% Rated Current
50G Time Delay	=	1.0 Second

Make the connections as shown in Figure 10-8, page 10-20. Apply a balance voltage of 69 volts RMS phase to neutral. Set a single phase of current to 2.0 (0.4) amperes RMS. Slowly increase the current until the “Pickup” LED lights. This should occur at 2.5 (0.5) \pm 3% amperes RMS.

Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact. Apply a current of 5.0 (1.0) amperes RMS (2X pickup) to the relay. The unit should trip in 1.00 seconds \pm 7%. The “Overcurrent” LED should be lit.

Test 7 - 51P Phase Time Overcurrent Function

Verify or change the following PRIMARY settings for this test

50P Select	=	Disable
51P Select	=	Enable
51P Curve Selection	=	Ext. Inverse
51P Pickup	=	50% Rated Current
51P Time Dial	=	1.0

Make the connections as shown in Figure 10-4, page 10-18, for the phase to be tested. Apply a balance voltage of 69 volts RMS phase to neutral. Set a single phase of current to 5.0 (1.0) 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 “Pickup” LED should be lit and the unit should trip in 1.00 seconds \pm 7%. The “Overcurrent/Impedance” LED should be lit.

Repeat the test for the remaining phases listed, as shown in Figure 10-4, page 10-18.

Apply three phase current to the relay at a level of 5.0 amperes RMS (2 X pickup). Observe that the unit produces an output within the same time parameters as the single-phase test. Test connections to the relay will be as illustrated Figure 10-5, page 10-19, for a three-phase test.

Test 8 - 51G Ground Time Overcurrent Function

Verify or change the following PRIMARY settings for this test:

51G Select	=	Enable
51G Curve	=	Extremely Inverse
51G Pickup	=	50% Rated Current
51G Time Dial	=	1.0

Make the connections as shown in Figure 10-8, page 10-20. Apply a balanced voltage of 69 volts RMS phase to neutral. Set a single phase of current to 2.0 (0.4) amperes RMS. Slowly increase the current until the “Pickup” LED lights. This should occur at 2.5 (0.5) \pm 3% amperes RMS.

Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact. Apply 5.0 (1.0) amperes RMR (2x pickup) to the relay. The “Pickup” LED should be lit and the “overcurrent” LED should be flashing. The unit should trip in seconds 2.10 \pm 7% and the “Overcurrent/Impedance” LED should be lit.

Test 9 - 67P Phase Directional Overcurrent Function

Verify or change the following PRIMARY settings for this test:

67P Select	=	Enable
67P Curve Selection	=	Very Inverse
67P % Pickup	=	50% Rated Power
67P Time Dial	=	1.0
67P Max Torque Angle	=	0°
67P Sector Width	=	180°

Make the connections as shown in Figure 10-3, page 10-18, for the voltage phase to be tested. Apply a balanced 3-phase voltage of 69 phase to neutral volts RMS and set a single phase of current to 5.00 (1.00) ampere RMS (2x 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 “Pickup” LED should be lit and the “Overcurrent” LED should be flashing. The unit should trip in 1.00 seconds \pm 7%. The “Overcurrent” LED should be lit.

Change the angle of the tested phase current by 180°. Again apply the current to the relay. Verify that the relay does **not** trip.

Repeat the test for the remaining phases listed, as shown in Figure 10-3, page 10-18.

Test 10 - 67N Ground Directional Overcurrent Function

Verify or change the following PRIMARY settings for this test:

67N Select	=	Enable
67N Curve Selection	=	Very Inverse
67N Pickup	=	0.20 amps
67N Time Dial	=	1.0
67N Max Torque Angle	=	0°
67N Sector Width	=	180°

Make the connections as shown in Figure 10-6, page 10-19, 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 2.00 (0.40) ampere RMS (10-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 “Pickup” LED should be lit and the “Overcurrent” LED should be flashing. The unit should trip in $0.100 \pm 7\%$ seconds. The “Overcurrent” LED should be lit.

Change the angle of the tested phase current by 180° . Again apply the current to the relay. Verify that the relay does **not** trip.

Repeat the test for the remaining phases listed, as shown in Figure 10-6, page 10-19. Restore original voltage phase rotation when completed.

Test 11 - 51VC Voltage Controlled Time Overcurrent Function

Verify or change the following PRIMARY settings for this test:

51V Select	=	V Cont (VC)
51V Curve	=	Definite
51V % Pickup	=	25% Rated Current
51V Time Delay	=	1.0 Second
51V Operating Volt.	=	90 volts.

Make the connections as shown in Figure 10-4, page 10-18 for the voltage phase to be tested. Apply a balanced 3-phase voltage of 50 volts RMS and set a single phase of current to 1.25 (0.25) ampere RMS. 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 “Pickup” LED should be lit and the “Overcurrent” LED flashing. The unit should trip in $1.0 \pm 7\%$ seconds. The “Overcurrent” LED should be lit. Remove the current.

Increase the balanced 3-phase voltage to 100.0 volts RMS.

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

Repeat the test for the remaining phases listed, as shown in Figure 10-4, page 10-18.

Test 12 - 51VR Voltage Restraint Time Overcurrent Function

Verify or change the following PRIMARY settings for this test:

51V Select	=	V Rest (VR)
51V Curve Selection	=	Definite
51V % Pickup	=	100 % Rated Current
51V Time delay	=	1.0 second

Make the connections as shown in Figure 10-4, page 10-18, for the phase to be tested. Apply a balanced 3-phase voltage of 120.0 volts RMS phase to neutral to the relay. For each of the voltages listed in Table 10-2, reduce the magnitude of the phases under test to the listed values. Apply a single phase of current and slowly raise it to 5.0 amperes. The relay should pick-up as indicated by the “Pickup” status LED on the front panel. The relay will trip in $1.0 \pm 7\%$ seconds and the “overcurrent” LED should be lit.

Repeat the test for all the phase voltage and % Pickup settings listed in Table 10-2.

Table 10-2. 51VR Pickup Current

Voltage	% Pickup	Picks up @
120V	100%	5.0A \pm 3%
120V	80%	4.0A \pm 3%
60V	80%	2.0A \pm 3%
60V	100%	2.5A \pm 3%

Test 13 - 27 Under Voltage Function

Verify or change the following PRIMARY settings for this test:

27 Select	=	Enable
27 Pickup V	=	20.0 Volts
27 Time Delay	=	1.00 seconds

Make the connections as shown in Figure 10-3, page 10-18, or the phase to be tested. Apply a balanced 3-phase voltage of 30 volts RMS to the relay.

Slowly lower only one phase of voltage from 30 volts RMS until the “Pickup” LED lights. This should occur when the voltage reaches $20.0 \pm 3\%$ Volts RMS. The relay should trip in $1.00 \pm 7\%$ seconds and the “Voltage-Volts/Hertz” LED should light. The contact monitor should indicate a closed contact. Repeat the test for all the phase voltage values, shown in Figure 10-3, page 10-18, if tested single phase.

Repeat the test but slowly lower all three-voltage phases from 30 volts RMS until the “Pickup” LED lights. This should occur when the voltage reaches $20.0 \pm 3\%$ Volts RMS. The relay should trip in $1.00 \pm 7\%$ seconds and the “Voltage-Volts/Hertz” LED should light. The contact monitor should indicate a closed contact.

Examine the Operation Records and verify that the first three tests report a single-phase undervoltage, 27-1P Trip, and the latter test reports a three phase under voltage, 27-3P Trip.

Test 14 - 27G Third Harmonic Under Voltage Function

NOTE: This test requires a 3-phase voltage source and a single-phase voltage source.

Verify or change the following PRIMARY settings for this test:

27G Select	=	Enable
27G Dropout	=	25.0 Volts
27G Time Delay	=	1.0 seconds
27G% Min Op. V	=	95% (Percent of Rated Volt.)

Make the connections as shown in Figure 10-7, page 10-20, for the zero sequence voltage. Apply a voltage of 35 volts RMS at a frequency at 180 Hertz (third harmonic voltage). It is necessary to apply a balanced three-phase voltage of 69.0 volts RMS 60 Hz as the supervising voltage.

Slowly decrease only the tested voltage from 35 volts RMS until the relay dropouts. The contact monitor should indicate a closed contact. The “Stator ground” LED should light. This should occur when the third harmonic voltage reaches $25.0 \pm 3\%$ Volts RMS.

If a frequency synthesizer is unavailable, this function may be tested as follows: Repeat the above test with the same settings, but a 60 Hz source. Lower the voltage to 20 volts, and the relay should **not** have tripped.

Test 15 - 59G Stator Ground Fault Function

NOTE: This test requires a 3-phase voltage source and a single-phase voltage source.

Verify or change the following PRIMARY settings for this test:

59G Select	=	Enable
59G Pickup	=	25.0 Volts
59G Time Delay	=	1.0 seconds

Make the connections as shown in Figure 10-7, page 10-20, applying a balanced three-phase voltage of 69.0 volts RMS. Apply a voltage of 20 volts RMS at 60 Hertz representing the V_0 . Slowly increase the voltage V_0 until the "Pickup" LED is lit. This should be 25 volts RMS.

The relay will trip $1.0 \pm 7\%$ seconds later and the "Stator Ground" LED should be lit.

Test 16 - 59 Over Voltage Function

Verify or change the following PRIMARY settings for this test:

59 Select	=	Enable
59 Pickup	=	75.0 Volts
59 Time Delay	=	1.0 seconds

Make the connections as shown in Figure 10-3, page 10-18, for the phase to be tested. Apply a single-phase voltage of 69.0 volts RMS to the relay.

Slowly increase only the tested phase's voltage from 69 volts RMS until the "Pickup" LED is lit. This should occur when the voltage reaches $75.0 \pm 3\%$ Volts RMS.

The relay should trip in $1.00 \pm 7\%$ seconds later. The contact monitor should indicate a closed contact and the "Voltage-Volts/Hertz" LED should be lit.

Repeat the above test with a balanced 3-phase voltage.

Examine the Operation Records. All of the tests are indicated by a "59 Trip" event.

Test 17 - 81 Under and Over Frequency Functions

Verify or change the following PRIMARY settings for this test:

81 Select	=	81-1
81-1U Pickup	=	56.00 Hz
81-1U Time Delay	=	1.0 Second
81-1O Pickup	=	62.00 Hz
81-1O Time Delay	=	1.0 Second
81V Voltage Block	=	40 Volts

Apply a balanced 3-phase voltage of 69 volts RMS phase to neutral to the relay as shown in Figure 10-3, page 10-18, at frequency of 60.0 Hz. Increasing the frequency will cause the output contact to close, and decreasing the frequency will also cause the same contact to close. This should occur within 0.01 Hz of the listed frequency settings. The "Frequency" and the "Pickup" LED should light on the relay.

Repeat the test for 81-2 unit by changing the 81 Select to 81-2.

The 81 Voltage Block may be tested by lowering the test voltage below the setting of the 81V and verifying that the frequency outputs are blocked, and therefore will not close the contact.

Test 18 - 87M Current Differential Function

Verify or change the following PRIMARY settings for this test:

87M Select	=	Enable
87M Pickup	=	0.04 amperes (0.4 – 1.6A. model) 0.2 amperes (2.0 – 8.0A. model)
87M Definite Time Delay	=	0.0 seconds

Make the connections as shown in Figure 10-4, page 10-18, for the Neutral Phase A current transformer. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact. Apply the minimum current selected above. The “Pickup” LED on the relay should light and the contact should indicate a closed contact. The “Differential” LED should also light. With no time delay setting on the relay, the time for a differential trip should be approximately two (2) cycles. If time delay is set on the relay, that time must be added to the inherent time delay of two (2) cycles.

Repeat the above tests for the Neutral Phase B and the Neutral Phase C current transformers.

To test the load side of the differential circuit, repeat the above tests for the Load Phase A current transformer using the connections as shown in Figure 10-3, page 10-18.

Repeat the tests using the Load Phase B and the Load Phase C current transformers.

Test 19 - 21a-1 Distance/Impedance Function

Verify or change the following PRIMARY and CONFIGURATION settings for this test:

21a-1 Select	=	Enable
21-1 Select	=	Disable
21-2 Select	=	Disable
21 Impedance	=	2.0 Ohms (2.0 – 8.0 amp models) 10.0 Ohms (0.4 – 1.6 amp models)
21a-1 Characteristic angle	=	70°
21a-1 Offset	=	1 Ohm
21a-1 time Delay	=	1.0 second

Configuration setting:

Unit Transformer = YES (Note: this must be set to YES or the function will not operate)

Make the connections as shown in Figure 10-5, page 10-19, for the neutral side current transformers, and the voltage connections as shown on the load side potential transformer. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact (optional). Apply a balanced voltage of 12.0 volts, and 3.00 amperes balanced current at a phase angle of 70° lagging. Increase the current to 3.5 amps RMS and lower the voltage until the unit produces an output, which should occur at a voltage level of 7.0 volts RMS. The “Pickup” LED on the relay should light and the contact should indicate a closed contact. The “Overcurrent/Impedance” LED should light. With time delay setting on the relay, the time for a distance trip should be approximately two (2) cycles plus the time delay of one second set on the relay.

For the relay model having a lower current range and an impedance setting of 10.0 ohms, the unit should produce an output at 1.00 amperes RMS and a voltage level of 10.0 volts.

Test 19A - 21-1 Distance/Impedance Function

Verify or change the following PRIMARY and CONFIGURATION settings for this test:

21-1 Select	=	Enable
21a-1 Select	=	Disable
21-2 Select	=	Disable
21-1 Impedance	=	100 Ohms (2.0 – 8.0 amp models) 10.0 Ohms (0.4 – 1.6 amp models)
21-1 Characteristic angle	=	45°
21-1 Offset	=	50 Ohms
21-1 Time Delay	=	1.0 second

Configuration setting:		
Unit Transformer	=	NO

Make the connections as shown in Figure 10-5, page 10-19, new for the neutral side current transformers, and the voltage connections as shown on the load side potential transformer. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact (optional). Apply a balanced voltage of 69.0 volts, and 0.5 amp balanced current at a phase angle of 45° lagging. Increase the current until the unit produces an output, which should occur at a current level of .69 amperes. The “pickup” LED on the relay should light and the contact should indicate a closed contact. The “Overcurrent/Impedance” LED should also light. With time delay setting on the relay, the time for a distance trip should be approximately two (2) cycles plus the time set for delay on the relay. That time must be added to the inherent time delay of two (2) cycles.

For the relay model having a lower current range and an impedance setting of 10.0 ohms, the unit should produce an output at 1.0 amperes and 10 volts.

Test 19B - 21-2 Distance/Impedance Function

Verify or change the following PRIMARY and CONFIGURATION settings for this test:

21a-1 Select	=	Disable
21-1 Select	=	Enable
21-2 Select	=	Enable
21-2 Impedance	=	50 Ohms (2.0 – 8.0 amp models) 5 Ohms (0.4 – 1.6 amp models)
21-2 Characteristic angle	=	45°
21-2 Offset	=	25 Ohms
21-2 Time Delay	=	1.0 seconds

NOTE: The 21-1 Select must be Enabled in order for the 21-2 function to operate.

The test for the function 21-2 are identical to that for the 21-1. The settings are completely independent.

Make the connections as shown in Figure 10-5, page 10-19, new for the neutral side current transformers, and the voltage connections as shown on the load side potential transformer. Set the timer to start upon application of current and to stop when the contact monitor senses a closed contact (optional). Apply a balanced voltage of 69.0 volts, and 1.0 amperes balanced current at a phase angle of 45° lagging. Increase the current until the unit produces an output, which should occur at a current level of 1.38 amperes. The “pickup” LED on the relay should light and the contact should indicate a closed contact. The “Overcurrent/Impedance” LED should also light. With time delay setting on the relay, the time for a distance trip should be approximately two (2) cycles plus the time set for delay on the relay. That time must be added to the inherent time delay of two (2) cycles.

For the relay model having a lower current range and an impedance setting of 10.0 ohms, the unit should produce an output at 1.0 amperes and 10 volts.

Test 20 - 24T Volts Per Hertz

Verify or change the following PRIMARY and CONFIGURATION settings for this test:

24A	=	Disable
24	=	Enable
24 Curve	=	Definite Time
24 Pickup	=	100%
24 Time Delay	=	1.0 seconds
24 Time Reset/Decay	=	3 seconds
24 Min Trip Time	=	3 seconds

Configuration setting:		
Volt/Hz	=	2.20

Make the test connections as shown in Figure 10-3, page 10-18. Apply a balanced three-phase voltage of 69.0 volts RMS phase to neutral. Slowly **increase** the voltage until the relay's "Pickup" LED is lit. The relay will trip in $1.0 \pm 7\%$ seconds, the "Voltage-Volts/Hertz" LED should be lit and the contact should indicate a closed contact. This should occur when the voltage reaches $60 * 2.20 \div \sqrt{3}$ volts, or 76.2 volts.

Test 20A - 24A Volts Per Hertz

Verify or change the following PRIMARY and CONFIGURATION settings for this test:

24	=	Disable
24A	=	Enable
24A Pickup	=	100%
24A Time Delay	=	1.0 second

Configuration setting:		
Volt/Hz	=	2.20

The 24A output must be mapped to a programmable output (OUT1-OUT6) in order to monitor contact closure.

Make the test connections as shown in Figure 10-3, page 10-18. Apply a balanced three-phase voltage of 69.0 volts RMS phase to neutral. Slowly **increase** the voltage until the relay's "Pickup" LED is lit. The relay will trip in $1.0 \pm 7\%$ seconds, the "Voltage-Volts/Hertz" LED should be lit and the contact should indicate a closed contact. This should occur when the voltage reaches $60 * 2.20 \div \sqrt{3}$ volts, or 76.2 volts.

Test 21 - 32R Reverse Power Protection

Verify or change the following PRIMARY setting for this test:

32R Select	=	Enable
32O Select	=	Disable
32U Select	=	Disable
32R Curve	=	Definite
32R % Pickup	=	3% of rated Power (.03*120V*5A*3=54 Watts)
32R Time Delay	=	1.0 Second

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced voltage of 69 volts RMS and a balanced 3-phase current of 1.00 (.2) amperes at unity power factor.

Slowly **increase** the angle that all the currents lag their respective voltages from 0 degrees until the “Pickup” LED lights. The contact should close after $1.0 \pm 7\%$ seconds and the “Reverse Power” LED should be lit. This should occur when the angle reaches 100 ± 5 degrees, and the current is 1.00 (0.20) amps RMS.

Increase the angle until the “Pickup” LED drops out. This should occur when the angle reaches 280 ± 5 degrees.

Test 22 - 32O Over Power Protection

Verify or change the following PRIMARY settings for this test:

32R Select	=	Disable
32O Select	=	Enable
32U Select	=	Disable
32O % Pickup	=	100%
32O Time Delay	=	1.0 Second

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced voltage of 69.0 volts RMS and a balanced 3-phase current of 2.0 (.40) amperes at unity power factor.

Slowly increase the currents until the relay trips. The “Pickup” LED on the relay should light and the contact should indicate a closed contact. The “Overload/Overpower Power” LED should light. This should occur when the current level reaches 2.50 (0.50) amperes.

Note: The GPU Unit will produce a trip output and the respective LED’s will illuminate whenever the power from the generator is greater than the overpower (32O) setting, and the function is enabled with the master trip output programmed To terminate this condition, the 32O function must be disabled, and the master trip output 32FO function must be unmapped.

Test 22A - 32U Under Power Protection

Verify or change the following PRIMARY settings for this test:

32R Select	=	Disable
32O Select	=	Disable
32U Select	=	Enable
32U % Pickup	=	10.0%
32U Time Delay	=	1.0 Second

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced voltage of 69.0 volts RMS and a balanced 3-phase current of .50 (.10) amperes at unity power factor.

Slowly decrease the currents until the relay trips. The “Pickup” LED on the relay should light and the contact should indicate a closed contact. The “Overload/Overpower Power” LED should light. This should occur when the current is 0.25 (0.05) amperes.

Note: The GPU Unit will produce a trip output and the respective LED’s will illuminate whenever the power from the generator is less than the underpower (32U) setting, and the function is enabled with the master trip output programmed To terminate this condition, the 32U function must be disabled, and the master trip output 32FU function must be unmapped.

Test 23 - 25 Synchronism Check Function

Verify or change the following PRIMARY setting for this test:

25 Select	=	Enable
Volt. Diff.	=	60.0 volts
Angle Diff.	=	60.0 degrees
Time Delay	=	0.10 Second
Slip Freq.	=	1.0 Hz
V phase select	=	V _{an}
Dead Bus select	=	Selected
Dead Bus voltage	=	65 volts
Dead Bus time	=	120 seconds

Two voltage sources are required for this test.

Make the test connections as shown in Figure 10-2, page 10-17 but only use a single phase of voltage to Van. In addition connect a single-phase test source to unit terminal block connections no’s. 37 & 38. Map the function 25 to a programmable output (OUT1-OUT6).

To test for Voltage Difference pickup: Apply 65 volts RMS to V_{an} and 5 volts RMS to the V_{bus}. Verify that the unit is not in synch as the target LED “Out of Sync” will be on. Slowly increase the voltage until the relay indicates a synchronism condition as the target LED will be reset. The threshold voltage will be approximately 10 volts. Change of state of the contact will also verify the synch and out of synch conditions.

To test for Angle Difference: Apply a single phase of voltage, 65 volts RMS, 0 degrees to Van and another single phase of voltage, 65 volts RMS, 0 degrees to Vbus. Increase the phase angle of either Van or Vbus from 0 degrees until the “Out of Sync” LED lights. This should be at 60 degrees.

Test 24 - 60 Fuse Failure Detection Function

NOTE: This function will not operate from the Neutral side CTs.

Map the BFUA (Blown Fuse Alarm) to a programmable output contact (OUT1 – OUT6).

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced three phase voltage of 69 volts RMS phase to neutral to the relay. Also apply a balanced three phase current of 0.5 amps RMS. Remove the voltage of phase A and the relay contacts should closed. The time increment for the relay to react to a voltage phase failure is approximately 3 seconds. There will be no target indication for the operation of this function.

Verification can be made by reviewing the Operation Records for a “Blown Fuse Alarm” event.

Test 25 - 50IE Inadvertent Energization Detection Function

Verify or change the following PRIMARY settings for this test:

50IE Select	=	Enable
50IE Phase Pickup	=	50%
50IE Hz below Nominal	=	10 Hz.

Program the Master Trip Contact for monitoring

The Inadvertent Breaker Energization function is tricky to test. In order to test this function you need to be able to shift the potentials' frequency and the currents' magnitude simultaneously.

The relay must first be "armed" by applying a potential frequency below the arming frequency and a current below the pickup point. The arming frequency is set to 10 Hz (Hz below Nominal setting) so the frequency would need to be less than 50 Hz (60Hz – 10Hz). The current would also need to be set below the pickup setting (5.0A rated current x 50% = 2.5A)

Apply a three-phase balanced voltage of 69 volts RMS, 40 Hz and a three-phase balanced current of 2.0A of 60Hz. Shift the voltage frequency to above 50 Hz and the current to above 2.5A. The relay should trip with no delay. The "Reverse Power" and "Overcurrent/Impedance" LED's will be lit.

Verification can also be made by reviewing the Operations Record and Fault Summary for a "50IE Trip"

Make the test connections as shown in Figure 10-2, page 10-17. Apply a balanced three-phase voltage of 69 volts RMS and a three-phase balanced current of 3.0 amperes RMS at 60 Hz to the relay. Verify that the relay does not produce a trip. Repeat the same test, but change the frequency setting to 49 Hz to the voltage and the relay contacts should closed Also the "Reverse Power", and the "Overcurrent/Impedance" LED's may light depending on their respective settings. The "Pickup" LED will light.

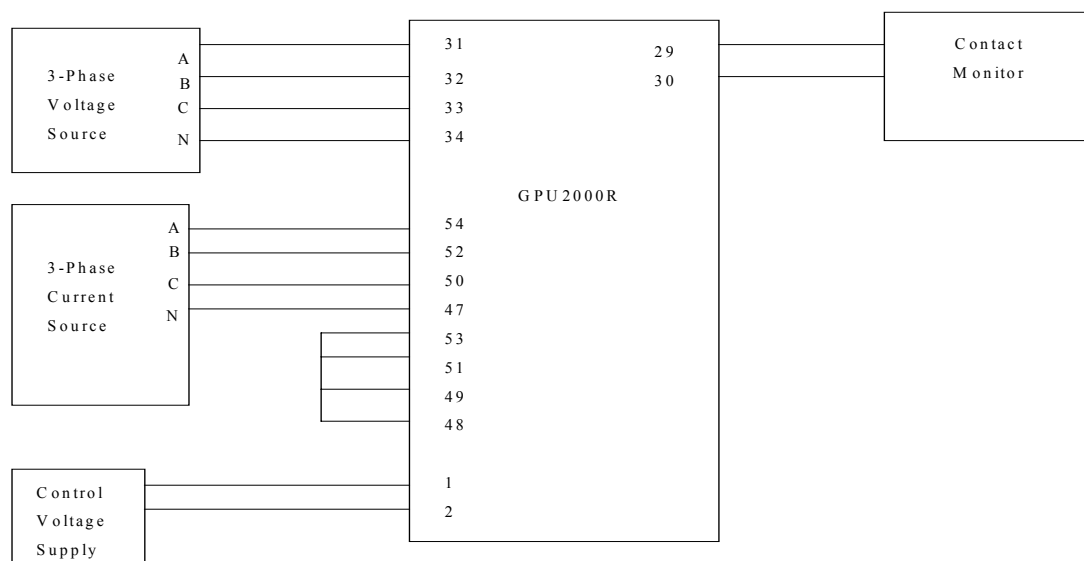


Figure 10-2. Connection for Tests 2, 3, 3A, 21, 22, 22A, 23, 24 and 25

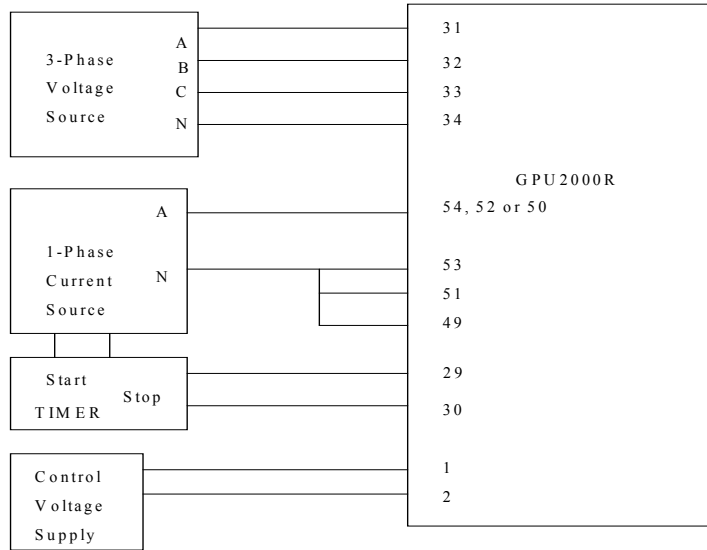


Figure 10-3. Connection for Tests 4, 9, 13, 16, 17, 20 and 20A

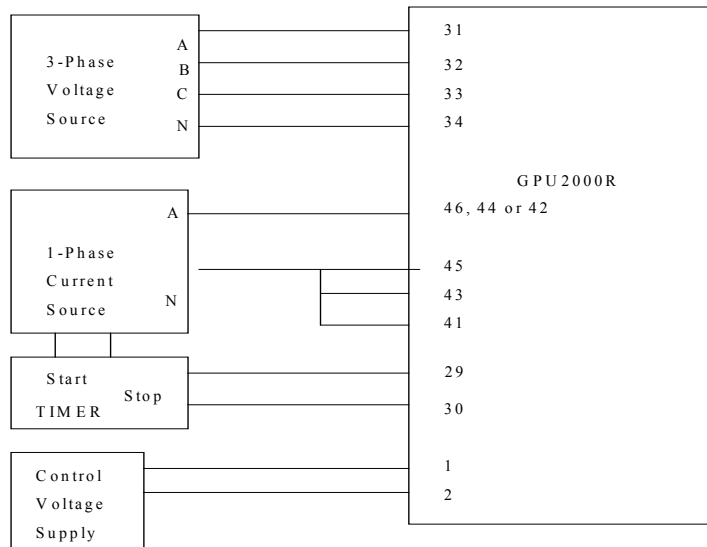


Figure 10-4. Connection for Tests 5, 7, 11, 12 and 18

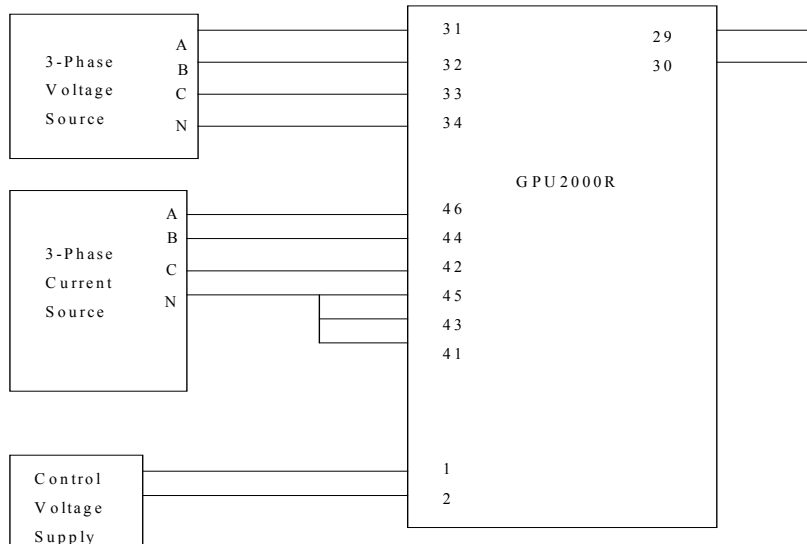


Figure 10-5. Connection for Tests 5, 7, 19, 19A and 19B

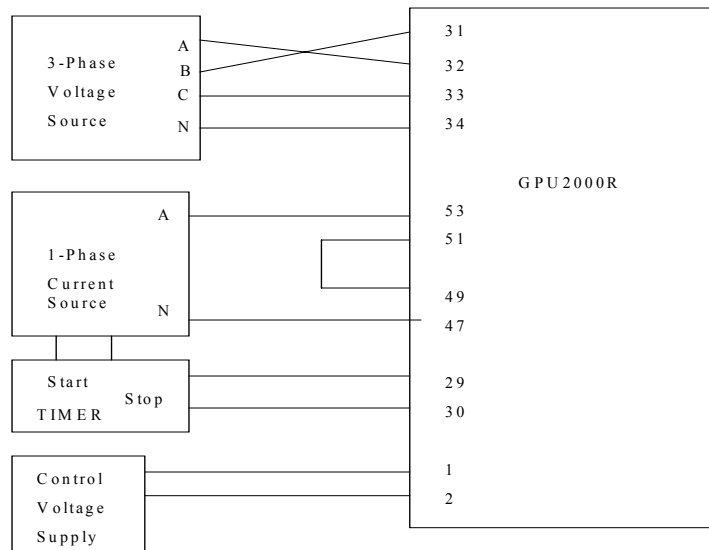


Figure 10-6. Connection for Test 10

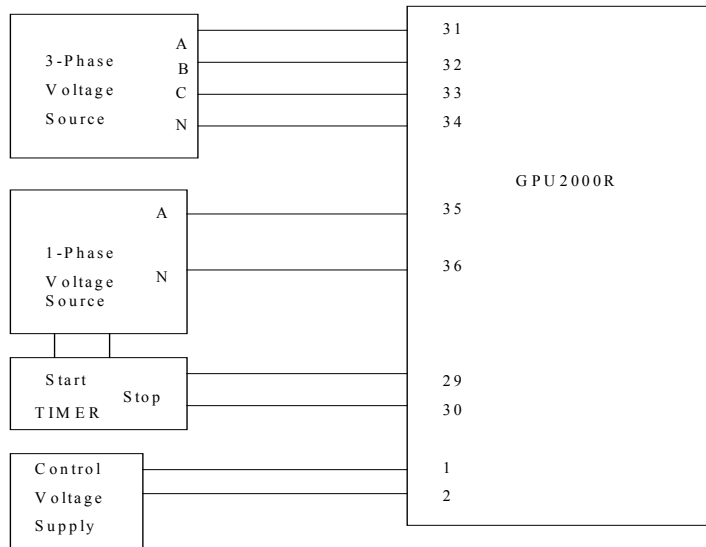


Figure 10-7. Connection for Tests 14 and 15

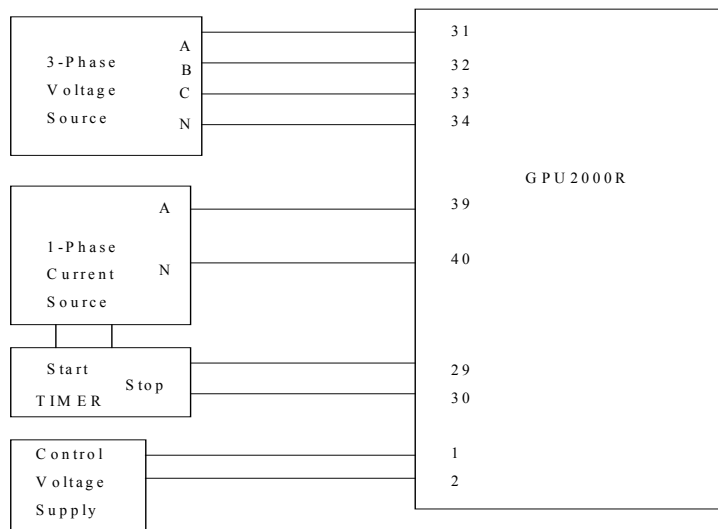


Figure 10-8. Connection for Tests 6 and 8

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 10-3 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 10-3 to reveal the device failure or editor access status reported. See the examples to follow for further explanation.

Table 10-3. Operations Record Value Information

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

New Firmware 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, contact the factory.

To download new software to the GPU-2000R:

- If desired, save all settings to a disk as described in Section 12.
- On your computer's hard drive, create a directory called C:\FPI.
- Copy files from the FPI diskette (FPI.exe) and the SAF diskette (*filename.abs*) to the C:\FPI drive. Remember the filename from the SAF diskette as it will be needed later.
- Connect the GPU-2000R to the computer via the serial port on the front panel of the unit with a null modem cable.
- 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.
- At the C:\FPI prompt, type FPI
- At the Monitor Type ? prompt, select the appropriate monitor (color or black and white) and press <CR>.
- After the ABB description screen, the Communication Options screen appears. Use the spacebar to change the com settings or accept the default settings by scrolling through the screen with the <CR> key.
- If all com settings are correct, the Successful Connection To... screen appears. Press <CR> to continue. The next screen to appear will be the Main Menu. If com settings are not compatible or some other problem exists, the Communication Status screen appears. Reset the com settings and recheck connections and press <CR>.
- 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 press <CR>.
- At the warning message screen, select continue with unit software update.
- At the Load New Firmware Data screen, type *filename.abs* (*filename* is the name of the file) copied from the SAF disk) and press <CR>. This will highlight the default action, [READ FROM DISK]. Press <CR> again. Downloading should take about 20 minutes to complete.

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- During download, the TARGET LEDs on the front panel will blink intermittently and in sequence starting with ØA with the following notes:

<u>Computer display</u>	<u>LED</u>	<u>MMI (If present)</u>
Monitor Has Been Entered	ØA blinks	GPU-2000R Monitor
Flash Erase	ØB blinks	Flash Memory Erase in Progress
Flash Programming	ØC 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>.
- Restore settings to the relay.

Optional Features

- Load Profile
- Waveform Capture
- Customer Defined Curves

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 11-2 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

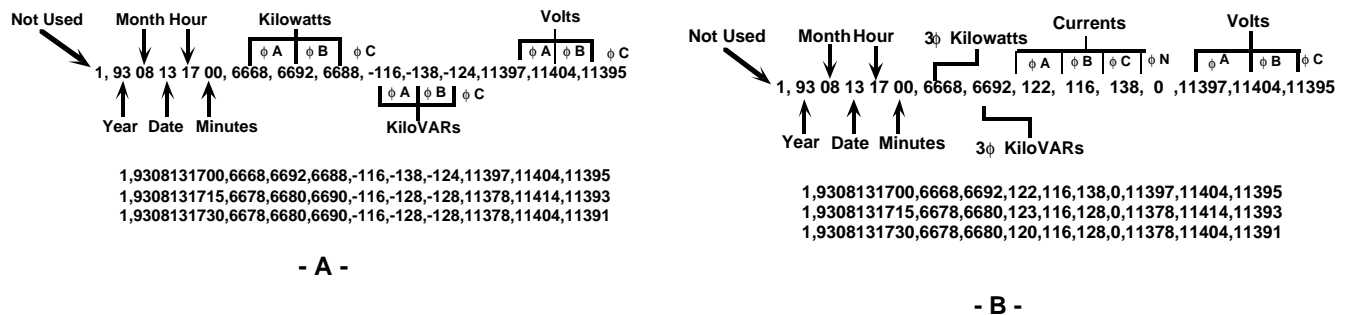
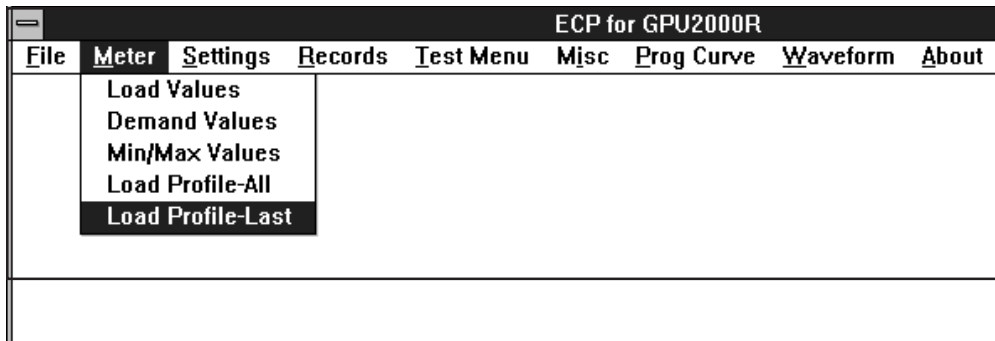


Figure 11-1. Sample Load Profile

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."



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.

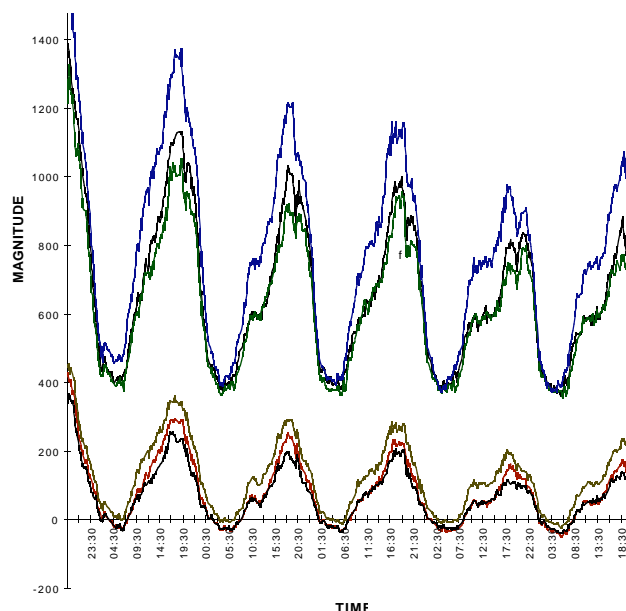


Figure 11-2. Load Profile Analysis

Customer-Programmable Curves

An external PC-based program, CurveGen, is used to create and program special user-defined time-current curves for the GPU-2000R. With CurveGen you can program curves other than the ones currently provided in the GPU-2000R (see Table 1-2). 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.

CurveGen Software Release 1.0

PC Requirements

386 processor or higher

Disk Space:

200K in specified Directory

6 MB in Windows/System Directory

Memory:

480K RAM in the lower 640K for setup

Installation

Step 1: Exit Windows™

Step 2: Type WIN at the c:\ prompt

Step 3: After you hit return, hold down the <SHIFT> key until Windows™ has completely booted up. This will ensure that nothing in your startup file will interfere with the CurveGen installation.

Step 4: While in the windows desktop, insert disk 1 of 2 into drive a:

Step 5: Click on **File**

Step 6: Click on **Run**

Step 7: Type **a:\setup** and press enter

Step 8: Follow the installation instructions

Step 9: If you encounter errors during the installation, go into your windows/system directory and delete the following files:

0C25.DLL

COMDLG16.DLL

TABCTL.OCX

THREED.OCX

VCFI16.OCX

Repeat installation from **Step 1**.

When the installation is complete, Windows will reboot (no need to hold down the "SHIFT" key and CurveGen can be run.

Using CurveGen

Click on the CurveGen 1.0 icon to run CurveGen. At this point, the user has two options. Curve coefficients can be calculated by the software by manually entering data points.

The standard equations for timing curves are shown below:

Trip Time (ANSI) = $(A/(M^P-C)+B) \times ((14n-5)/9)$

Trip Time (IEC) = $(A/(M^P-C)+B) \times n$

Where A, B, C and P are the coefficients to be computed and/or entered

n = time dial

M = Relay current in multiples of tap setting

Computing Coefficients

- Step 1:** If desired, the user may enter a description in the **Description** field.
- Step 2:** Under **Standard**, the user should select either **ANSI** curves or **IEC** curves.
- Step 3:** Under the **data entry method**, the user should select **Compute Coefficients**. At this point, the **Compute Coefficients Tab** towards the top of the screen should appear. Click this tab.
- Step 4:** Using the mouse, place the cursor on Row 1, Column 1 (Current M)
- Step 5:** Type the desired multiple of tap, M, and press the TAB key. Now type the corresponding time. Press the TAB key again to enter a second point. Continue until at least 5 data points are keyed in (100 points max). Please note that whether you are using ANSI or IEC type curves, the points you enter are equivalent to a time dial of 1.
- Step 6:** After all points are entered, click on **solve**. The computed coefficients will appear on the screen. In order to see these points on a graph, hit the **Apply** button.
- Step 7:** Click on the **Relay Data** tab. At this point, you'll see that the coefficients previously calculated appear under **Coefficients**. Under **Curve Series**, select default. Time dial 1 through 10 should appear on the screen for **ANSI** or 0.05 to 1 for **IEC**. Any combination of valid time dials can be used.
- Step 8:** Select **Apply**. At this point, a graph will appear on the screen. The graph format can be changed by selecting different options under the **Graph** menu at the top of the screen. The Curves can also be printed for a clearer view.
- Step 9:** If you are satisfied with the results, select **Save As** under **File** and Type in a filename with a .crv extension. This is the file to be used when downloading curves to your 2000R relay.
- Step 10:** The user also has the ability to save the worksheet. To do this, select **Save Worksheet As** under **File** and type in a filename with a .wrk extension.

Manually Entering Coefficients

- Step 1:** If desired, the user may enter a description in the **Description** field.
- Step 2:** Under **Standard**, select **ANSI** or **IEC**.
- Step 3:** Under **Data Entry Method** select **Manually Enter Coefficients**.
- Step 4:** The user can now enter the known coefficients **A, B, C** and **P**.
- Step 5:** Under **Curve Series**, select **Default**. Time dial 1 through 10 should appear on the screen for **ANSI** or 0.05 to 1 for **IEC**. Any combination of valid time dials can be used.
- Step 6:** Select **Apply**. At this point, a graph will appear on the screen. The graph format can be changed by selecting different options under the **Graph** menu at the top of the screen. The Curves can also be printed for a clearer view.
- Step 7:** If you are satisfied with the results, select **Save As** under **File** and type in a filename with a .crv extension. This is the file to be used when downloading curves to your 2000R relay.
- Step 8:** the user also has the ability to save the worksheet. To do this select **Save Worksheet As** under **File** and type in a filename with a .wrk extension.

Oscillographic Data Storage (Waveform Capture)

To enhance the ability to analyze fault and disturbance conditions, the GPU2000R can be furnished with the waveform capture oscillographic data storage feature.

The user can select to record any of the analog waveforms available at the analog inputs to the relay from the connected current and voltage transformers. The user selects the triggering sources and also specifies the number of cycles of pre-trigger and post-trigger data to be captured. Digital signals associated with the operation of the protective functions of the relay are also recorded. The data collected is held within the memory elements of the relay until downloaded to a file on your pc. Then a separate Oscillographics Analysis Program is used to display the waveforms. This analysis program is supplied when the relay is ordered with the waveform capture feature.

Figure 11 - 3 shows the screen display when you access the Waveform Capture Settings menu item from the GPUECP program.

Place an "X" in each box of protective elements that you wish to serve as triggering sources for a waveform capture. The operation of any one of these elements will cause a capture. You may also trigger a capture from an external contact closure by assigning a contact input to programmable input function WCI (See Section 6).

Place an "X" in each box representing the analog input waveforms that you wish to capture.

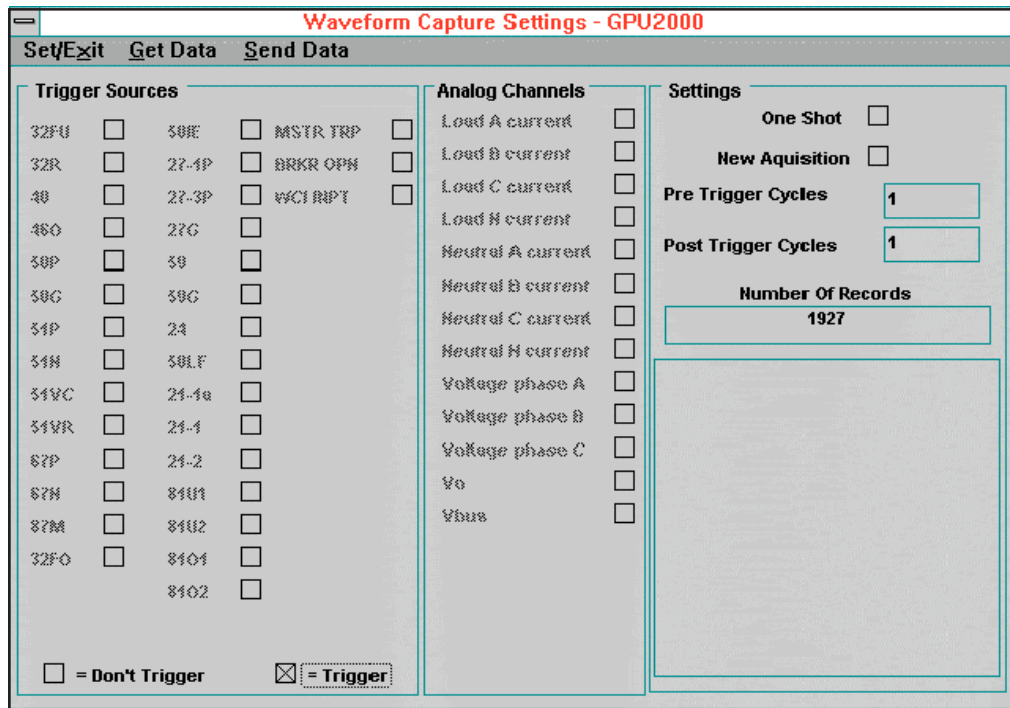


Figure 11 - 3. Waveform Capture Settings

Record Length and Number of Analog Channels

When the waveform capture feature is installed, there is a specific amount of memory within the GPU2000R that is available for data storage. The following equation defines the relationship between the number of analog channels that can be recorded, the number of power system cycles that can be recorded per record, and the number of records that can be stored.

$$\text{Record Size} = (1 + \text{CH}) * (1 + \text{CY}) \quad \text{Where: CH} = \text{number of analog channels selected}$$
$$\text{CY} = \text{number of cycles per record}$$

$$\text{Maximum Number of Records that can be Stored} = 6081 / (\text{Record Size})$$

Record size is allocated equally to each event. As an example, if we choose 9 analog channels, and a record length of 60 cycles, then record size is $(10*61) = 610$, and we have space for $6081/610 = 9$ events. A slightly better allocation would be 66 cycles, $(10*67) = 670$, $6081/670 =$ still 9 events, but we gain an additional 6 cycles of record length.

Also in this example, in the waveform capture settings we must allocate the 66 cycles to pre-trigger and post-trigger portions. So we might select 4 cycles pre-trigger, and 62 cycles post-trigger. You must allocate at least one cycle to the pre-trigger storage.

Modes of Operation: Single-Shot and Continuous

You must also select the Mode of Operation of the waveform capture. In the One-Shot mode, new events will be captured until the available memory is used up, then no more events will be captured even though a selected trigger source is seen. So it is not truly a one-shot mode, but rather a "several-shot" mode depending on how you have allocated the available memory.

When in the single-shot mode the relay automatically stops data accumulation when the space available has been filled. Important: After the records are transferred to your pc, you must re-initialize the waveform capture function by going into the waveform capture settings and re-sending the settings to the unit again.

In the New-Acquisition or Continuous mode, new events are recorded as triggering events occur, and when the memory is filled, the oldest event will be lost as the new event is recorded. In the Continuous mode, the storage capability is one less than in the single-shot mode, due to the need to record pre-trigger data which is being stored continuously for the "next" event.

Digital Data Capture and Triggering Details

The digital data being stored along with the analog data is stored every quarter cycle. The pickup status of each of the protective functions is stored. The operation of any of the protective functions is stored. And the operation of the Master Trip output, the 52a input, and the Blown Fuse alarm output are recorded.

Once a trigger is received, further triggers are ignored until the complete record has been stored.

Triggers occurring before the pre-trigger buffer is filled are ignored. Triggers are "edge-triggered"; therefore, any event that causes a trigger must be de-asserted and then re-asserted to obtain a second trigger.

Waveform Capture Settings Changes

In order to make a settings change you must go to the Stop/Start Data Accumulation menu item and issue the stop command.

When a new set of waveform capture settings are chosen, the unit takes several seconds to reconfigure, and no events can be captured during this period. Also, no additional change in the waveform capture settings can be

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made until the reconfiguration has been completed for the initial change. All previous waveform records retained in the memory are lost when the waveform capture settings are changed, therefore they should be downloaded to files on your pc prior to making any changes.

After the new settings are accepted by the unit you must go to the Stop/Start Data Accumulation menu item and issue a start command.

Stop/Start Data Accumulation

The Waveform menu item Start/Stop Data Accum allows the user to enable or disable the waveform capture function. When Stop Data Accumulation is selected, the records already in the memory are retained and no additional records will be taken until the Start Data Accumulation command is initiated.

Important: after making a settings change, or after re-loading your single-shot settings to re-initialize the capture memory, you must re-start the data accumulation.

Transferring a Captured Waveform Record

First, under the Waveform menu item, select the Stop/Start Data Accumulation menu item , and press the Stop Waveform Capture button. Then, select the menu item Waveform Records. Select the desired record in the listing shown and then press the Save-Data-Points-to-File button. You will be prompted to enter the desired filename and path.

Comtrade Format

The captured data is in the COMTRADE standard format, therefore the data files that are downloaded to your pc can be displayed by any analysis program that will accept files in this format.

ABB Analysis Program

Details on this program are not available at time of publication. Please contact factory, 1-800-634-6005.

Communications Ports

The GPU-2000R has a standard 9-pin RS-232C interface on the front for serial port communications. Connect a 9-pin RS-232C cable and 9-pin null modem adaptor from this port to your personal computer to have direct point-to-point communications through the ECP. Refer to the External Communications section of this manual, for the proper communications parameters.

As an option, a serial port termination can be provided at the rear of the GPU-2000R. This rear port, called the Auxiliary Communications port, can be a 9-pin RS-232C, 3-wire RS-485, 2-wire INCOM, IRIG-B or SCADA Interface Unit (SIU) connection. Because the hardware termination for all these options is on every GPU-2000R, you must refer to the catalog number on the front of the unit or to the software communications menu to know which rear port option is implemented. The front or rear RS-232C ports can interface with a modem using a straight through cable and a remotely connected computer. The RS-232C ports can also interface directly to a PC with the use of a null modem cable. The RS-232C ports are configured as data terminal equipment.

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). The following protocols are available in the GPU-2000R relay:

- STANDARD—ABB 2000 series-specific ASCII oriented 10 byte communication protocol available through all ports
- INCOM®—a two-wire communications system and protocol
- Modbus®—a protocol available through the Auxiliary Communications port
- Modbus Plus™—a token ring network capable of high speed communication (1 Mb/sec)

Pin Connections

The pin connections for the various communications ports are shown in Tables 12-1, 12-2 and 12-3.

Table 12-1. RS-232 Pin Connections

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

Table 12-2. RS-485, INCOM, SIU and IRIG-B Pin Connections

Pin Number	Pin Number
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

For all communications hardware options with a single RS-485 port, that port is provided at terminals 55(+), 56 (-), and 57 (com). See Table 13-3.

For communications hardware option #8, dual RS485 ports, terminals 55, 56, and 57 are designated RS485 Rear Port #2, and pins 1(+), 2 (-), and 7(com) of the COM3 DB-9 connector represent RS485 Rear Port #1.

Jumper Links

The RS485 port on the GPU-2000R has three associated resistors and jumper links that allow insertion or removal of these resistors, depending on the location of the relay in the network. Jumper link J6 on the communications card is for the termination resistor. A termination resistor should be inserted at the first and last devices on the network. Typically J6 would be set for "IN" for the last relay on the RS485 network; and, J6 would be set in the "OUT" position for all other relays in the loop. The first unit on the network, typically an ABB 245X series convertor, has the terminating resistor built-in. For communication hardware option "8," dual RS485 ports, J6 is for Port #2 and a similar jumper, J16 is provided for RS485 Port #1.

Cable

Jumper links J7 and J8 insert or remove "pull-up" resistors. These resistors establish a known voltage level on the RS485 bus when no units are transmitting, in order to reduce noise. These jumpers should be set to the "IN" position on only one relay at either end of the RS485 loop. If an ABB communications convertor, catalog series 245X, is used on the network, it has these resistors built-in, and all relays can have J7 and J8 in the out position. For communications hardware option "8", dual RS485 ports, J7 and J8 are for Port #2, and J17 and J18 are for Port #1.

The RS485 cable should be shielded 3 conductor twisted cable. The shield should be grounded at one end of the communications circuit, preferably where the RS485 circuit begins; eg: at the convertor unit. A typical RS485 connection diagram, drawing 604765, is available on request from the factory.

Recommended cables are Alpha #58902, Belden #9729, #9842, #9829 and Carol #58902.

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].

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).

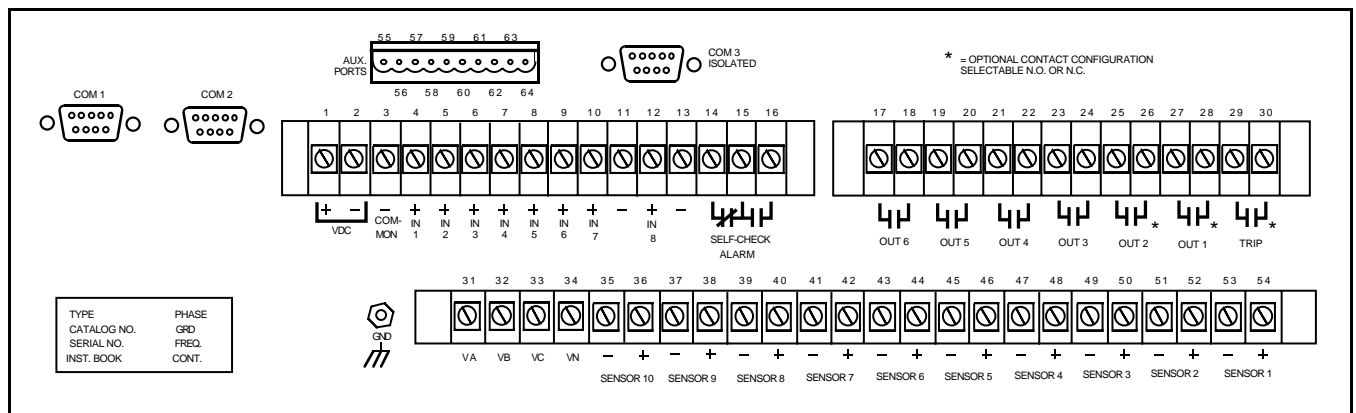


Figure 12-1: Rear Terminal Blocks and Communication Ports

ABB Generator Protection Unit 2000R

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 (DB-9) and Aux Com ports.

The pinout for the DB9 port for option 8 is as follows:

Pin	Signal
1	RS485 (+)
2	RS485 (-)
3	Direction (+) RTSA
4	Direction (-) RTSB
7	RS485 COMMON
8	+5VDC at 100ma

Table 12-3

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) is provided at no charge with the relay.

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

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.

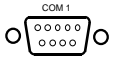
The auxiliary port labelled IRIG-B receives a demodulated IRIG-B signal for 2000R clock synchronization purposes.

Select other characteristics of the relay from the following pages.

**Catalog Number
Select Option**

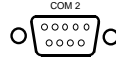
↓ ↓

REAR PORT ASSIGNMENTS



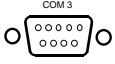
COM 1

NON ISOLATED RS-232



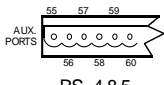
COM 2

NON ISOLATED RS-232




COM 3

ISOLATED RS-232 unless noted




AUX. PORTS

RS-485 ISOLATED



61
62

INCOM ISOLATED



63
64

IRIG-B

589V041[] - 6101[]		With Display	Without Display*					
0	0		Standard	Standard				
1	0		Standard		Standard			
2	0		Standard		Standard	Standard		IRIG-B
2	4		Standard		Modbus® or Standard See Note #	Modbus® or Standard See Note #		IRIG-B
3	0		Standard				INCOM	IRIG-B
4	0		Standard			Standard	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	4		Standard		Modbus® or Standard (RS-485) See Note #	Modbus® or Standard See Note #		IRIG-B

Select Communication Options Table

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

Consult factory for availability.

* Main board jumper selectable front or rear.
Protocol selectable in settings process, all 4 combinations possible.

Ordering Selections

Catalog Number Selection →		5 8 9	V	0	4	1	1	—	6	1	0	1	0
Configuration			.	.	.	.	.	.	.	.	.	.	.
	Standard	T	.	.	.	.	.	.	.	.	.	.	.
	With Differential Function	V	.	.	.	.	.	.	.	.	.	.	.
	With Differential and Distance Functions	W	.	.	.	.	.	.	.	.	.	.	.
Current Range			.	.	.	.	.	.	.	.	.	.	.
	Phase	Ground	.	.	.	.	.	.	.	.	.	.	.
	2.0 - 8 A	2.0 - 8 A	0	.	.	.	.	.	.	.	.	.	.
	2.0 - 8 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			.	.	.	.	.	.	.	.	.	.	.
	Horizontal/No Man Machine Interface	0	.	.	.	.	.	.	.	.	.	.	.
	Horizontal/Man Machine Interface	1	.	.	.	.	.	.	.	.	.	.	.
	Vertical/No Man Machine Interface	5	.	.	.	.	.	.	.	.	.	.	.
	Vertical/Man Machine Interface	6	.	.	.	.	.	.	.	.	.	.	.
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	.	.	.	.	.	.	.	.	.	.	.
	Std. ANSI Curves/No User Programmable Curves	0	.	.	.	.	.	.	.	.	.	.	.
	Std. ANSI Curves and User Programmable Curves	1	.	.	.	.	.	.	.	.	.	.	.
	No Load Profile	0	.	.	.	.	.	.	.	.	.	.	.
	Load Profile	1	.	.	.	.	.	.	.	.	.	.	.
Communications Protocol			.	.	.	.	.	.	.	.	.	.	.
	Standard (10-Byte protocol)	0	.	.	.	.	.	.	.	.	.	.	.
	Modbus®/Modbus Plus™	4	.	.	.	.	.	.	.	.	.	.	.

User
Selections