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Issue E

Instructions

March 1997

Integrated Microprocessor–Based Protective Relay System

# IMPRS™ Protective Relay System

## Catalog Series 470A


**ABB Power T&D Company, Inc.**

# Precautions

Take the following precautions when using the Integrated Microprocessor-based Protective Relay System (IMPRS™):

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-voltage insulation tests are not recommended. If a control wiring insulation test is required, bond all terminals together before applying the test voltage or fully withdraw the relay from its case.

4. Follow test procedures to verify proper operation. To avoid personal shock, exercise caution when troubleshooting entails working with energized equipment. Only competent technicians familiar with good safety practices should service this device.

5. If the self-checking function detects a system failure, the STATUS light-emitting diode (LED) flashes red-green, the protective functions are disabled, and the alarm contacts are actuated. Replace the unit as soon as possible.

## *Password*

6. A correct password is required to make changes to the relay settings and to test the output contacts. **The preset factory password is 48**. 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.

This instruction booklet contains the information to properly install, operate and test the IMPRS™, 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 Asea, Brown, Boveri.

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# Introduction

The Integrated Microprocessor-based Protective Relay System (IMPRS) is a multi-purpose microprocessor-based protective relay system used for full phase and ground overcurrent protection in electrical power distribution systems. Models are available for operation from standard 5-ampere or 1-ampere current transformers (CT). Various current-monitoring and event-recording features present an operating history of the feeder that is unavailable with conventional protective relays. Because of its powerful microprocessor, the unit allows substantial flexibility in configuring the unit for particular applications. The IMPRS provides in one integrated package the following protection and monitoring functions:

Multiple settings groups

Three-phase overcurrent protection (time and instantaneous)

Ground overcurrent protection (time and instantaneous)

Current monitoring (phases A, B, C and Neutral)

Demand and peak demand current monitoring

Event recording

Accumulation of breaker fault interrupting current

Continuous self-checking

Front 25-pin RS-232C communications port

Optional rear 9-pin RS-232C or 2-terminal RS-485 communications port

The IMPRS is packaged in a metal case suitable for semi-flush mounting on a panel. An automatic CT shorting feature and sequenced disconnects allow the relay to be totally withdrawn from its case. A unique rear circuit board accepts direct test connections and eliminates the need for a separate test accessory. All connections to the unit are made at terminals located on the rear of the unit and are clearly identified. A 25-pin connector for RS-232C serial communications is provided on the front panel. Optional IMPRS models come with an additional RS-232C or RS-485 communications port in the rear of the unit. The communications ports are used to gain access to the relay settings and other advanced functions of the relay.

These instructions contain the information required to properly install, operate and test the IMPRS.

# Protective Functions

The IMPRS contains many relay protection functions. The operation of these protective functions is controlled by using the IMPRS communications software.

### Four Programmable Settings Groups (Version 2.7 software and higher)

The IMPRS has four programmable setting groups. Select one of the four programmable settings groups as the main protection settings. Having multiple settings groups allows rapid changes of settings to accommodate changing system conditions. Normal loads, seasonal loads, system re-configuration, and load increases are examples of system conditions requiring different settings for full protection. Switching to a particular group is fast and easy through the relay communications and operations software. A ten second "select-before-operate" protocol secures against any unwarranted or interrupted settings changes. The details of switching, setting, and activating the four groups are discussed in the "IMPRS Communications Software" section.

### *Phase Overcurrent Protection (51/50)*

When a phase current exceeds the programmed pickup setting, the relay starts timing out to trip the breaker. Eight time overcurrent characteristic curves afford great flexibility for relay coordination:

Inverse
Very Inverse
Extremely Inverse
Short Time Inverse
Definite Time
Long Time Extremely Inverse
Long Time Very Inverse
Long Time Inverse

For a quick determination of a trip time, see Figures 17 to 23. Note that these plots have been reduced by 10% for placement in this instruction book and, therefore, cannot be copied and placed over log-log paper. Full-size transparencies for coordination studies are available upon request by writing or calling ABB at the address and phone number provided on the back cover. With the curve type, time dial, and specific per-unit fault current, you can determine the nominal time from the curve equations given in Figure 1. Time dial selection for the definite time curve is 0.05 to 10 seconds in 0.05 second increments. Time dial selection for the remaining curves is 1 to 10 in 0.1 increments. Models are offered with pickup current ranges selectable from 1 to 15 A in 0.5 A steps and 0.2 to 3.0 A in 0.1 A steps for 5-ampere CT and 1-ampere CT applications, respectively.

Three instantaneous characteristics are available: Standard, Inverse, and Delayed. The Standard curve trips instantaneously with no intentional delay. The Inverse instantaneous gives somewhat longer tripping times for low and moderate fault levels. This characteristic is useful for avoiding nuisance operations where current inrush is present on breaker closing. Some schemes needing coordination with downstream fuses or other devices may require the Delayed instantaneous, which is adjustable from 0 to 1 seconds in steps of .01 seconds. The Instantaneous pickup setting is a multiple of the time pickup with a range of 0.5X to 20X in steps of 0.1.

A Cold Load Pickup function is available to block instantaneous operation upon breaker closing. See the "Cold Load Pickup" section for details

## Ground Overcurrent Protection (51N/50N)

The ground input accepts a 5-ampere or 1-ampere CT input, depending on the model ordered. The same curve selections, instantaneous elements, and pickup setting ranges for phase overcurrent protection are available for the ground overcurrent function.

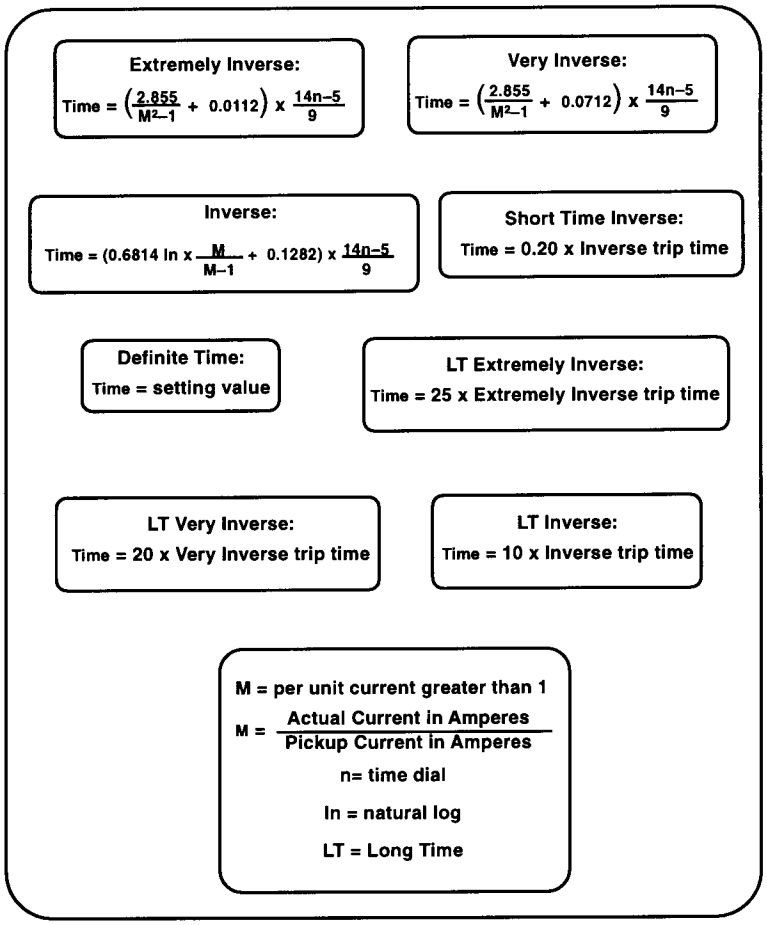



**Figure 1. Time Overcurrent Curve Trip Equations**

## Time Overcurrent Element Reset Time

Reset begins when the current falls below the time pickup setting whether or not a tripping output was activated by the relay. The reset time of the time overcurrent elements is adjustable from instantaneous (less than 0.1 seconds) to slow electromechanical-like response. Slow reset is useful to maintain coordination with upstream electromechanical relays in reclosing schemes or other applications with intermittent faults or overloads. Use the equations in Figure 2 to determine the curve slow reset time for relay coordination studies involving intermittent faults.

Select the mode of time overcurrrent reset in the Status and Control screen of the relay communications and operations software.

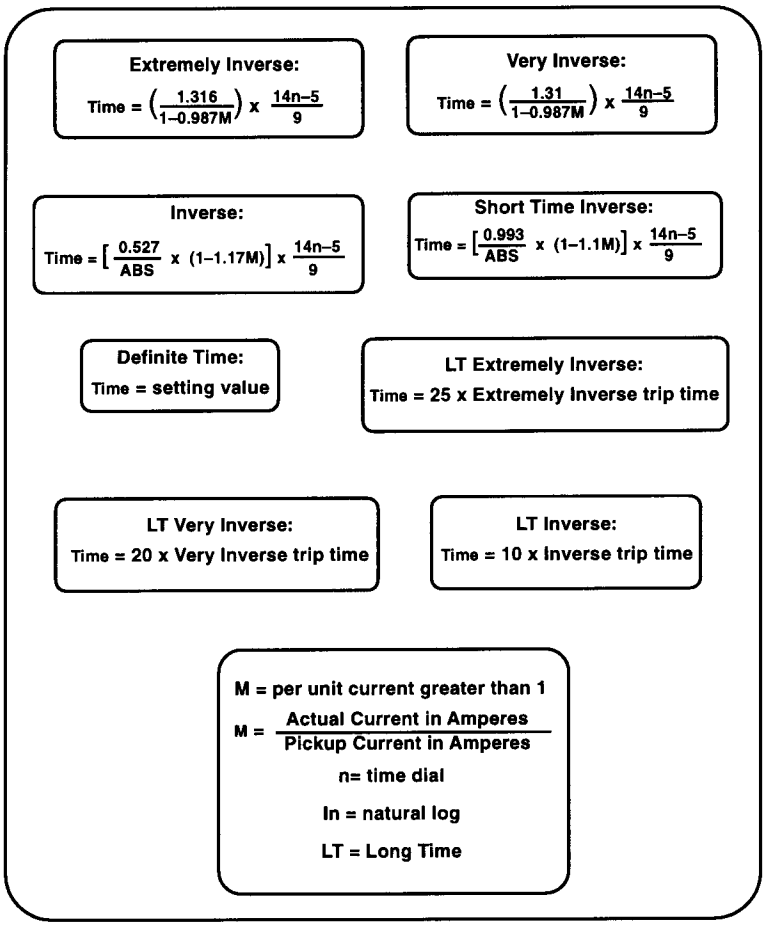



**Figure 2. Time Overcurrent Curve Reset Equations**

## *Current Monitoring Function*

The phase and neutral currents are metered in terms of primary amperes with the correct phase and neutral CT ratios programmed into the relay settings. For example, a 400:5 CT has a CT ratio setting of 80. Set the ratio in the Relay Settings screen of the relay communications and operations software. In the unusual event that your CT ratios are not selectable by the operations software, use the Terminal screen of the communications software to directly program the CT ratios (see "Terminal Mode" in the "IMPRS Communications Software" section). The acceptable range is from 1 to 1000 in steps of 1.

**NOTE: If the CT ratio is not entered into the relay, a default value of 100 is used.**

## Demand Current Monitoring Function

The relay employs a thermal demand current metering function for the three phase currents and neutral current, profiling line or bus usage. Program this function for either a 15- or 30-minute time constant using the Status and Control screen of the communications software. IMPRS retains the peak phase and neutral demand currents in primary amperes and the date and time they occurred. Use the Status and Control screen to view or record the peak demand currents and times, and then reset them back to zero for the next profile interval.

NOTE: **Demand and peak demand currents are cleared when the CT ratio or pickup setting is changed.**

## Breaker Maintenance

Monitoring the interrupted fault currents assists the user in deciding the best time to service the breaker. For the breaker it controls, the IMPRS retains the summation of interrupted fault currents by phase. This current value is saved as accumulated symmetrical RMS kiloamperes. The current flowing in each phase and neutral after an overcurrent trip is added to the previous totals, and the new values are permanently stored.

After the breaker has been serviced or replaced, use the Status and Control screen of the communications software to reset the sums to zero.

## Event Recording and Reporting

Fast and accurate fault location improves system availability and reduces outage time. IMPRS stores in memory the 20 most recent overcurrent trips. Use the Fault Record screen of the communications software to review the fault count, fault type, current magnitudes, and date and time. The current magnitudes retained for the three phases and neutral represent the largest current magnitude seen by the relay from the point of pickup to the time where the current falls below 90% of the lowest time pickup, or 40% of the lowest time pickup when the instantaneous multiple is set below one (1X). Once the fault current magnitudes and the line impedances are known, the location of the fault can be closely approximated.

When the commissioning tests are completed and the IMPRS is placed into service, reset the fault counter to "1" in the Status and Control screen to distinguish the test fault records from the system fault records.

## Trip Test Feature

Press the recessed TRIP pushbutton located on the front panel to test the relay's two isolated trip output contacts and the switchgear trip circuit connections. Use the Status and Control menu of the communications software to disable the trip pushbutton after trip verification tests are completed.

CAUTION: Operation of the Trip Test pushbutton trips the breaker if the Trip Test is enabled in the Status and Control screen. Take the necessary precautions.

NOTE: **Both trip output contacts remain closed until the TRIP pushbutton is released.**

## Battery Backed-Up Memory

Battery backed-up memory retains vital information upon loss of control power. This information includes the relay settings, fault event records, password, demand and peak demand currents, peak demand times, and the summation of interrupted fault currents. The battery is encapsulated in the memory device labeled U12 on the CPU board and has an average shelf life of ten years with no control power applied to the relay.

## Battery Backed-Up Clock

A battery backed-up clock provides times for event recording and peak and demand occurrences. Time is maintained in this device when control power is lost. The clock device is in a socket in location U12 of the CPU board. This battery should last the life of the relay because it has an average lifetime of 10 years with no control power applied to the relay.

## Breaker Failure to Operate

Knowing when the breaker has failed to operate in a timely manner is essential for power system reliability and safety. Program the Breaker Fail to Operate (BFO) setting in seconds, and the IMPRS will verify that the breaker has operated in that time after the trip output relay(s) have been energized. Enable "Alarming on BFO," and the IMPRS energizes the alarm relay for a sluggish breaker or a BFO condition. If both tripping contacts have been activated and the fault current has not been interrupted within the user-specified breaker operate time, the status light turns red and the relay displays a BFO event in the event record. The record number of the BFO event is set to the same number as the fault.

Use the Status and Control screen of the communications software for setting the BFO time and enabling the alarm relay for a BFO condition.

NOTE: **IMPRS assumes breaker operation has occurred when the current drops below 90% of the lower value of the phase and neutral 51 pickup values. When the instantaneous pickup is set below the phase or neutral pickup value, a breaker operation is recognized when the current falls below 40% of the lower value of the phase and neutral pickups.**

## Cold Load Pickup

The manual blocking of nuisance instantaneous trips during transformer or feeder inrush is no longer required when the Cold Load Pickup feature is used. The relay blocks the operation of the phase or neutral instantaneous function for the programmed time period when phase or neutral current goes from below 10% to above 10 % of its 51 pickup setting, respectively. When either the phase or neutral current has been above 10% of its respective pickup setting for at least the Cold Load time period, the phase and neutral instantaneous functions operate per the programmed instantaneous curve and pickup settings.

Use the Relay Settings screen of communications software to set the Cold Load Pickup time from 0 to 200 seconds in one-second increments.

CAUTION: If the breaker is closed-in on a fault, the Cold Load function delays instantaneous tripping, so carefully consider the use of this function for each application.

## Self-Checking Function/Status Indicator

With control voltage applied, a green STATUS light indicates a normal state. The status indicator displays a steady orange color when the input current exceeds a pickup tap setting. When the processor detects a system failure, the status indicator flashes red and green, the alarm contact changes its state, and **all overcurrent protective functions are disabled**. Loss of control power changes the alarm contact output state.

Configure the alarm contact (terminals 9 and 10) as normally closed or normally open using the link VSP1 located on the backplane board. The backplane board is mounted opposite the front panel with the relay withdrawn from its case. With an ohmmeter connected to terminals 9 and 10, verify the alarm contact's configuration by pushing and holding the front panel RESET pushbutton for more than two seconds and releasing it.

- IMPRS continuously runs system diagnostic checks on the following elements:
- **Power Supply**—The power supply transforms the control voltage input to three output voltages of +15, –15, and 5 volts. These voltages power the analog and digital integrated circuit (IC) chips and also serve as reference voltages for measuring circuits. The diagnostic check verifies that the power supply voltage outputs of +15 V, –15 V, and 5 V are within tolerance.
- **Memory**—The Electrically Programmable Read Only Memory (EPROM) contains the software program instructions executed by the microprocessor. The Random Access Memory (RAM) stores and provides data used by the processor in mathematical calculations. Diagnostics tests check the integrity of each memory location of the EPROM and RAM.
- **Analog-to-Digital Conversion**—The analog-to-digital (A/D) converter provides a digital or binary representation of the analog current input signal for the microprocessor to evaluate. It is imperative that the A/D converter converts the analog signal accurately and timely for proper operation. An internally generated signal serves as a known signal sent to the A/D converter to verify the conversion is within acceptable limits for accuracy and speed.
- **Analog-to-Digital Gain**—A digital-to-analog (D/A) converter and a feedback operational amplifier circuit amplify the analog input signals, increasing the resolution of the A/D converter. This circuit enables the relay to provide highly accurate metering.
- **Relay Settings**—The normal RAM diagnostics described above test the memory location integrity of the four groups of relay settings—one active and three alternate groups. To verify that the settings have not been corrupted, a checksum test is performed on each group of settings. The software calculates a one-byte checksum of the overcurrent settings of the group edited at the end of each saved editing session and stores the checksum permanently. The diagnostic test calculates the present checksum of each settings group and compares it to the stored value calculated after each group's latest saved editing session. If the active group checksums are unequal, the settings have been corrupted, the relay enters the failed mode, and **all overcurrent protective functions are disabled**. If any one of the alternate groups checksums are unequal, the relay flashes the STATUS light-emitting diode (LED) red on and off, blocks any transfer to that settings group, and continues to provide overcurrent protection per the **active** group settings. Clear the flashing red STATUS indicator by performing an edit session on the three alternate settings groups.

Note: **Entering a "9" at the settings group prompt reveals the active settings group (0-3) in the top of the Relay Settings screen. The remaining three groups are the alternates.**

With the exception of a "processor stalled" condition, the self-check failure code is retrievable in hexadecimal form using the command STS in the Terminal screen of the communications software. Translate the hex number to binary representation. Then see Table 1 below for the explanations of the self-check failure codes.

**Table 1. Failure Codes for "STS"**

| Bit Set | Failure |
|---|---|
| 7 | Default settings invoked |
| 6 | Settings group corrupted |
| 5 | VIA failure |
| 4 | P/S failure |
| 3 | A/D Gain failure |
| 2 | A/D failure |
| 1 | RAM failure |
| 0 | ROM failure |

(Bit 0 is the least significant bit.)

## *Target Indicators*

Phase and ground target LEDs indicate which phase or ground caused the trip. All phase and ground currents that are above their pickup setting while the relay times out to trip have their targets lit when the trip occurs. A steady red target indicates a time overcurrent trip, and a flashing red target indicates an instantaneous trip. The phase targets are read as Phase A, Phase B, and Phase C from top to bottom with the bottommost LED representing the ground target.

The targets displayed are for the last tripping event that occurred. Targets of the previous events are cleared when the next event targets are displayed.

View previous events via the serial port by using the Fault Records menu of the communications software. Clear the targets by pressing and releasing the front panel reset button or selecting Reset Targets in the Status and Control menu of the communications software. Targets are lost on a loss of control power. However, the stored event record is retained. Depressing the RESET button momentarily lights all target indicators.

**Table 2. STATUS LED Indication**

| STATUS Light | Description | Action Required |
|---|---|---|
| Steady green | DC control power; relay OK | None |
| Steady red | Breaker failure | View Event Record |
| Flashing red | Settings group checksum error | Edit settings groups |
| Flashing red-green | Self-diagnostics failure | Determine problem with STS command. Replace unit. |

| TARGET Light | Description |
|---|---|
| Steady red | Time-overcurrent Trip |
| Flashing red | Instantaneous Trip |

## Switch #1 Settings

Switch #1 (S1) configures the relay as follows (refer to Figure 6 for location):

**Table 3. Switch #1 Functions**

| Switch | Function | Comments | | |
|---|---|---|---|---|
| S1-1, S1-2 | Baud Rate | See Table 7. | | |
| S1-3, S1-4 | Relay Configuration | See Table 5. | | |
| S1-5 | Edit Enable | Off enables setting changes. | | |
| S1-6 | Frequency | On=50HZ, Off=60HZ | | |
| S1-7, S1-8 | Tap Ranges (Amps) | **S1-8** | **S1-7** | **Code** |
| | ø = 1-15; G = 1-15 | Off | Off | 0 |
| | ø = 1-15; G = .2 - 3 | Off | On | 1 |
| | ø = .2 - 3; G = .2 - 3 | On | Off | 2 |
| | ø = 1-15; G = 1-15 | On | On | 0 |

**ø= Phase; G = Ground**

**CAUTION: S1-7 and S1-8 set the software to comply with the model type of the hardware. To obtain proper relay operation, these switches must be set to the position dictated by the code number that follows the letter "A" in the catalog number, which is stamped on the relay nameplate. For example, 470A[*code number*]400.**

# Ratings and Tolerances

The ratings and tolerances for the IMPRS are listed below:

## Current Input Circuits

- 16 A continuous and 450 A for 1 second
- Input burden less than 0.05 VA at 5 A
- Frequency 50 or 60 Hz

## Control Power Requirements

- 48 Vdc model at 0.35 A maximum, range = 38 to 56 Vdc
- 125 Vdc model at 0.16 A maximum, range = 100 to 150 Vdc
- 250 Vdc model at 0.10 A maximum, range = 200 to 300 Vdc
- 120 Vac model at 0.16 A maximum, range = 100 to 140 Vac
- 220 Vac model at 0.10 A maximum, range = 176 to 240 Vac

## Operating Temperature

- –20º to +70º C

## Humidity

- Per ANSI 37.90, up to 95% without condensation

## Tolerances (within operating temperature range)

- Pickup — Time-overcurrent elements ± 2%, instantaneous elements ± 5%
- Timing — Time-overcurrent elements ± 7% or ± 10% msec., whichever is greater.*
- Metering — ±2% of Time-Overcurrent Pickup setting
- Dropout neous — 90% of lowest time pickup setting or 40% of lowest time pickup setting when instantaneous multiple is set below one (1X)

## Output Contacts Ratings

**125 Vdc**

- 30 A tripping
- 5 A continuous
- 0.3 A break inductive

**120 Vac**

- 30 A tripping
- 5 A continuous
- 2 A break inductive

**250 Vdc**

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

## Transient Immunity

- More than 2500 V/M, 1-mHz burst at 60 Hz repetition rate; Fast Transient Test (ANSI C37.90.1 and IEC 255)

## Electromagnetic Environment

- 10 V/M, 27 mHz to 1000 mHz (ANSI C37.90.2)

## Dielectric

- 2500 Vdc, 60-second test, all circuit to ground

* Where time curve flattens out, Extremely Inverse and Short Time Inverse time dial #1 curves, timing tolerance is +15/–5 ms.

# Installation

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

## *Receiving, Handling, Storage*

Upon receipt of the IMPRS, examine it for shipping damage. If damage or loss is evident, file a claim at once and promptly notify the nearest ABB sales office.

## *Installing the IMPRS*

Installing the IMPRS is a matter of cutting out a space in your panel, mounting the IMPRS case with the hardware supplied, and then inserting the unit itself into the case. Figure 3 shows the panel cutout. Figure 4 shows the dimensions of the IMPRS.

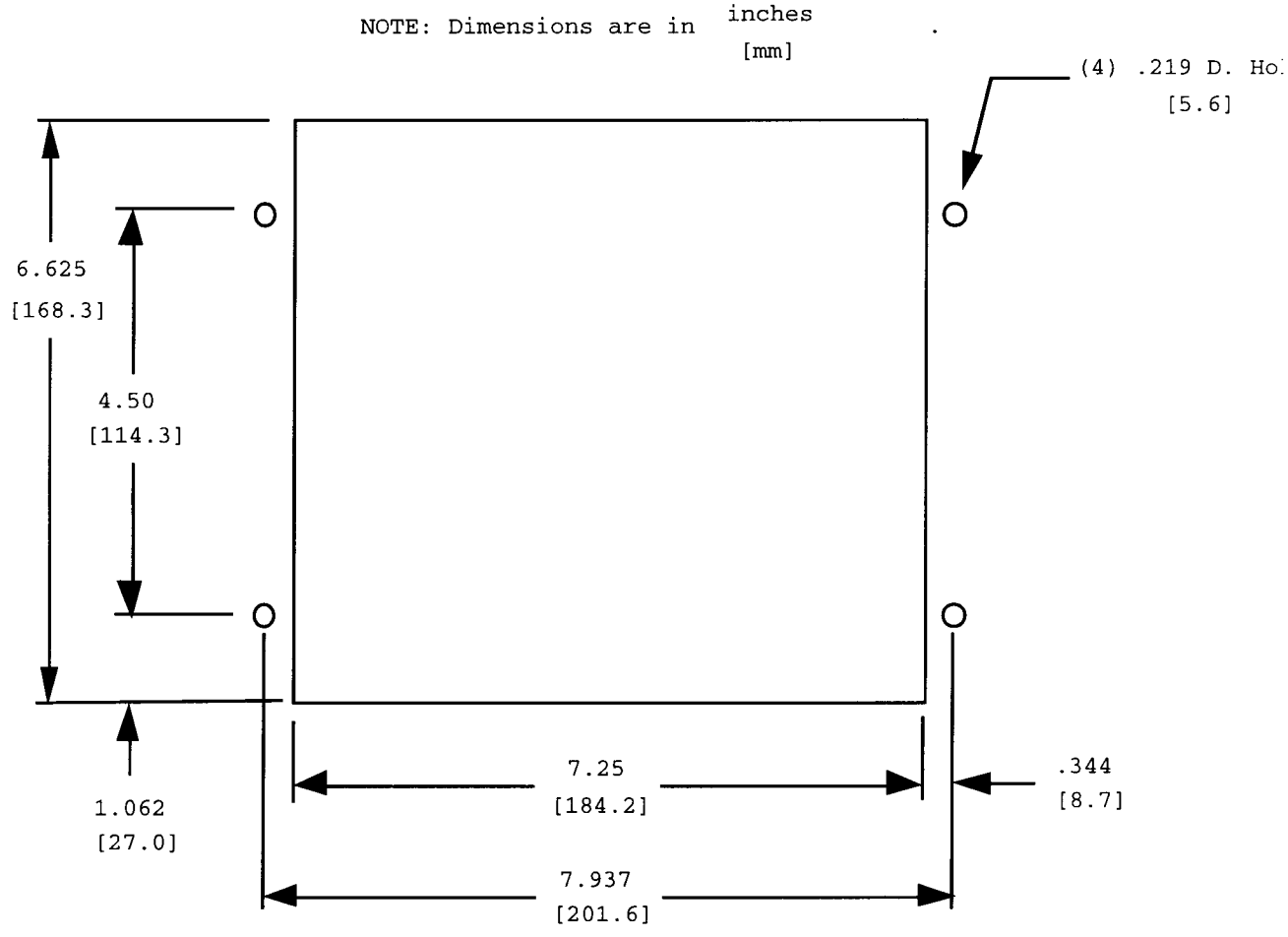



**Figure 3. Panel Cutout**

NOTE: Dimensions are in inches [mm]

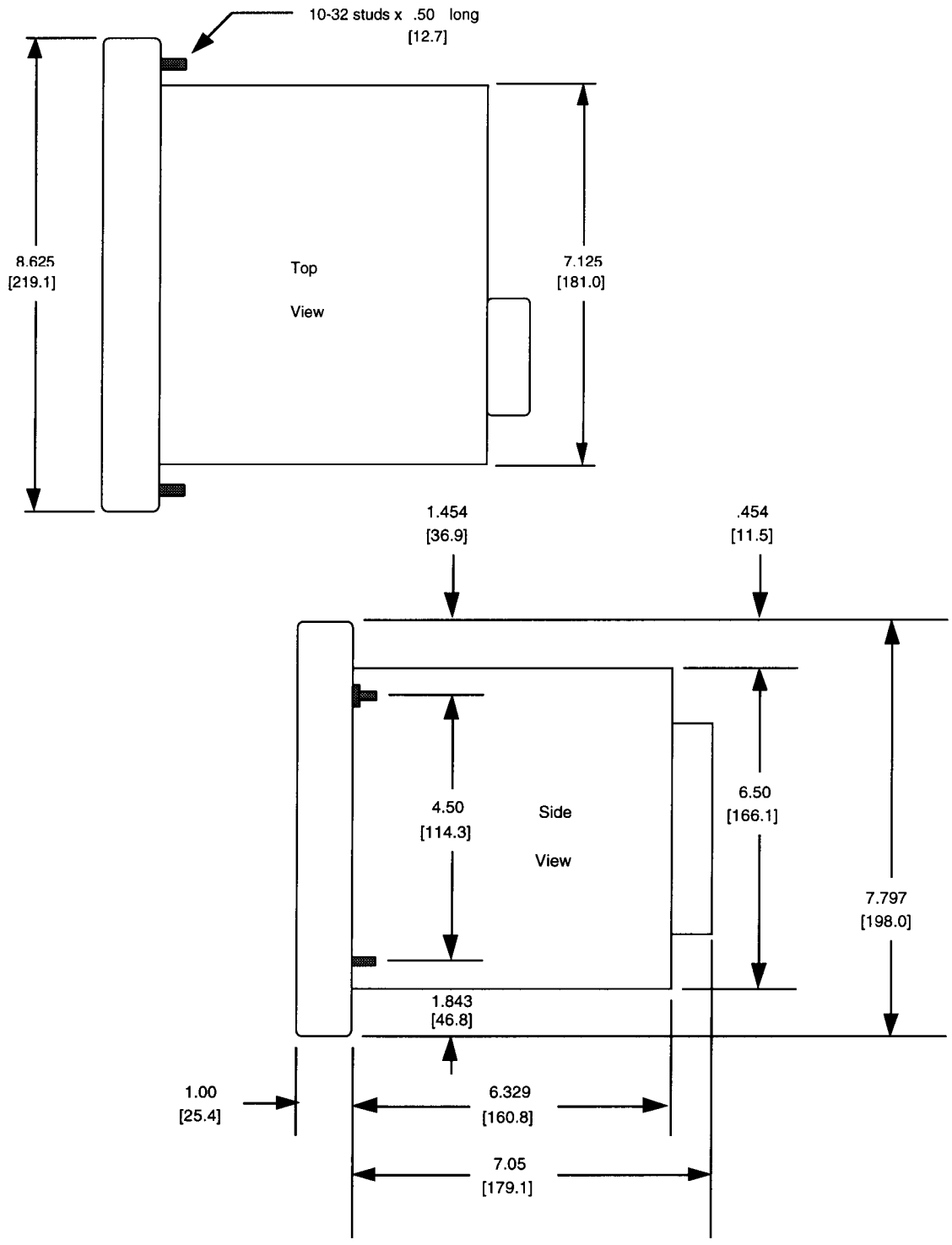



**Figure 4. Case Dimensions**

## Connecting the IMPRS

Apply only rated control voltage marked on the front panel of the unit to the positive terminal #15 and the negative terminal #16.

The system is enclosed in a metal case with a ground stud on the rear of the case. Wire the ground stud to the equipment ground bus with at least #10 AWG wire.

The protective relay system can be totally withdrawn from its case. Current transformer shorting is accomplished by a patented direct-acting blade and spring mechanism. Sequenced disconnects eliminate the possibility of nuisance tripping while withdrawing or inserting the relay.

Table 4 shows the current transformer input designations, while Figure 5 illustrates typical relay connections.

**Table 4. Current Transformer Input Connections**

| Input | Input |
|---|---|
| Phase | |
| IA | Terminals 1 and 2 |
| IB | Terminals 3 and 4 |
| IC | Terminals 5 and 6 |
| Ground Current Input | |
| IN | Terminals 7 and 8 |

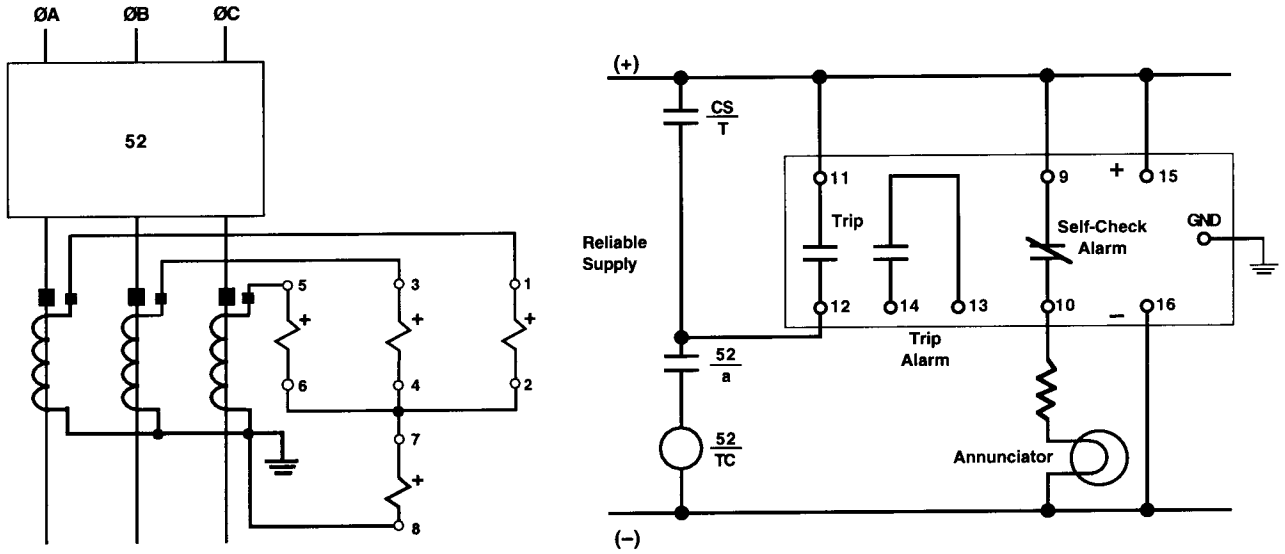



**Figure 5. Typical Relay Connections**

## Trip Output Contacts

IMPRS units with serial numbers below 1500 have only two normally open contacts from one output relay. With the units under 1500 there can be no separation of tripping functions.

In the IMPRS units with serial numbers above 1500, two normally open contacts from two independent output relays allow separation of the tripping functions. Figure 6 shows where Switch 1 (S1) is located on the CPU board, and Table 5 describes the switch positions to separate the tripping functions.

The user may select the length of time the output contacts hold in, or may select latching operation. This is done throughthe SEAL IN TIME parameter in the Status and Control screen. The setting range is 3 to 11. 3 to 10 represents a contact close time of 300-1000 milliseconds and then self reset if the fault has been interrupted. A setting of 11 causes latch-in. Reset is accomplished with the target reset button.

| Software | Switch 1-4 | Switch 1-3 | Trip Relay 1 (11-12) | Trip Relay 1 (13-14) |
|---|---|---|---|---|
| Standard | OFF | OFF | 51/51N | 50/50N |
| Example | OFF | ON | All faults | All faults |
| V2.0X or V2.0D | ON | OFF | 51P/50P | 51N/50N |
| | ON | ON | 51P | 50P,51N, 50N |
| Manual Close Special Software | OFF | OFF | 51/51N | 50/50N |
| Example | OFF | ON | All faults | All faults |
| V2.0R | ON | OFF | 51/50 | 51N/50N |
| | ON | ON | All faults | Close |
| #2 Special Software | OFF | OFF | 51/51N | 50/50N |
| Example | OFF | ON | All faults | All faults |
| V2.0C | ON | OFF | 51/50 | 51N/50N |
| | ON | ON | 51/50, 51N | 50N |

**Table 5. Switch Positions for Separate Tripping**

## Self-Check Alarm Contact

A configurable alarm contact is provided that can be set normally open (NO) or normally closed (NC) is provided. Configure the output relay's de-energized failure state by repositioning the jumper plug VSP1 located on the backplane board. The alarm contact is factory set for normally open.

This output contact changes state on loss of DC control power or on a specific self-test failure (see Self-Checking Function/Status Indicator). Connect the contact to a local annunciator light or for remote indication to a remote terminal unit (RTU). The alarm contacts may also be actuated by pushing and holding the RESET pushbutton for more than two seconds.

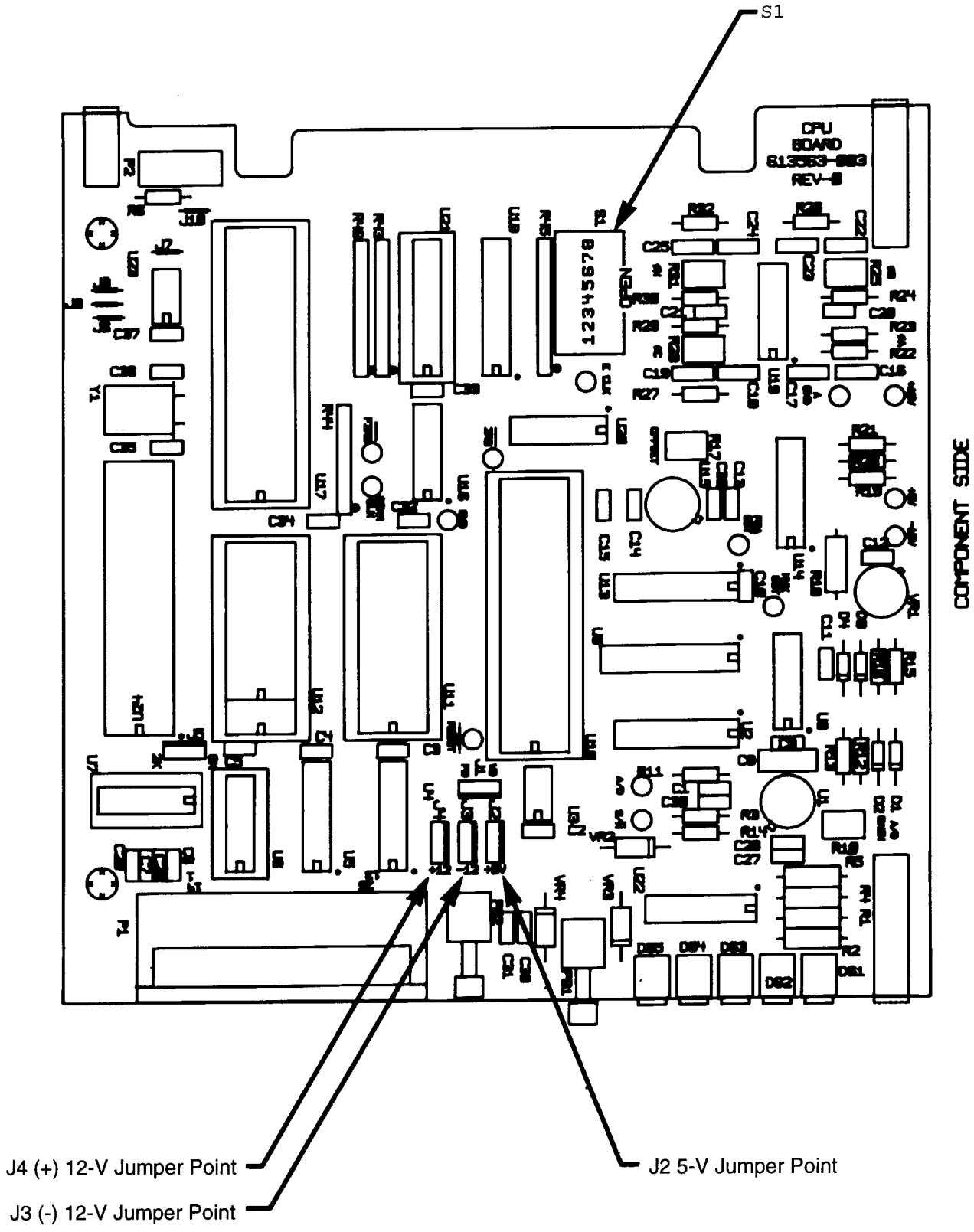



**Figure 6. CPU Board**

## Communications Link

IMPRS provides a male 25-pin industry standard RS-232C serial port on the front panel for local relay communications with a personal computer (PC). Connect to an optional RS-232C or RS-485 rear port (see "Ordering Information") for communications involving remote breaker control or switching to alternate settings. The rear port is located approximately one inch up and in from the lower right-hand corner of the back of the relay.

The RS-485 port is a two-terminal differential ("+" and "–") connection enabling communications with multiple devices wired in parallel. Use a shielded twisted-pair cable for connecting up to 30 IMPRS relays. Each relay must have a different unit ID, so only one IMPRS will respond to a RS-485 command. Convert the RS-485 signal to RS-232C with the ABB converter box catalog #245X2000 for remote communication via modem. See Figure 7 for typical communications link for multiple IMPRS relays.

All ports can interface with a computer, CRT terminal, printer or other devices having RS-232C or RS-485 communications capability. Multiple device connections for RS-232C are possible with a Code Operated Switch (COS) multiplexing device.

The serial ports are configured as data terminal equipment. The designations and descriptions of the serial port pins/signals are listed in Table 6. Figure 8 shows the different cable pin connections.

**NOTE:** The relay software is factory-set for the optional rear port ordered. Should the relay go to default settings, the rear port configuration defaults to a RS-485 type. To reconfigure the relay for a rear RS-232C port, use the Terminal screen of the IMPRS communications software and perform the following steps:

Type DCM and press <Enter>. Relay should respond with a "1" followed by the prompt ">"

Type DLC and press enter. Relay responds with prompt ">".

Type DCM and press enter. Relay should respond with a "0" followed by the prompt ">".

The relay's rear port is now configured as an RS-232C port.

**Table 6. DB-25 [DB-9] RS-232C Pin Connections**

| P in # | Function | Comments |
|---|---|---|
| 1 (N/A) | Frameground (GND) | This pin is internally tied to the relay chassis. |
| 2 (#2) | Transmit data (TxD) | The relay transmits data through this output. |
| 3 (#3) | Receive data (TxD) | The relay receives data through this port. |
| 4 (#8) | Request to send (RTS) | The relay permanently asserts this output signal. |
| 5 (#7) | Clear to send (CTS) | The relay monitors this input and transmits data to the serial port device only if this input pin is asserted. |
| 7 (#5) | Signal ground (SG) | This pin is also internally tied to the chassis. |
| 9 (#7*) | +12 Vdc | J4 on the CPU Board must be jumpered toward the front panel to provide this voltage. |
| 10 (#8*) | –12 Vdc | J3 on the Cpu board must be jumpered toward the front panel to provide this voltage. |
| 11 (#6*) | +5 Vdc | J2 on the CPU Board must be jumpered toward the front panel to provide this voltage. |

* These voltages are present at the pins designated only for the IMPRS PONI model (see "Ordering Information").

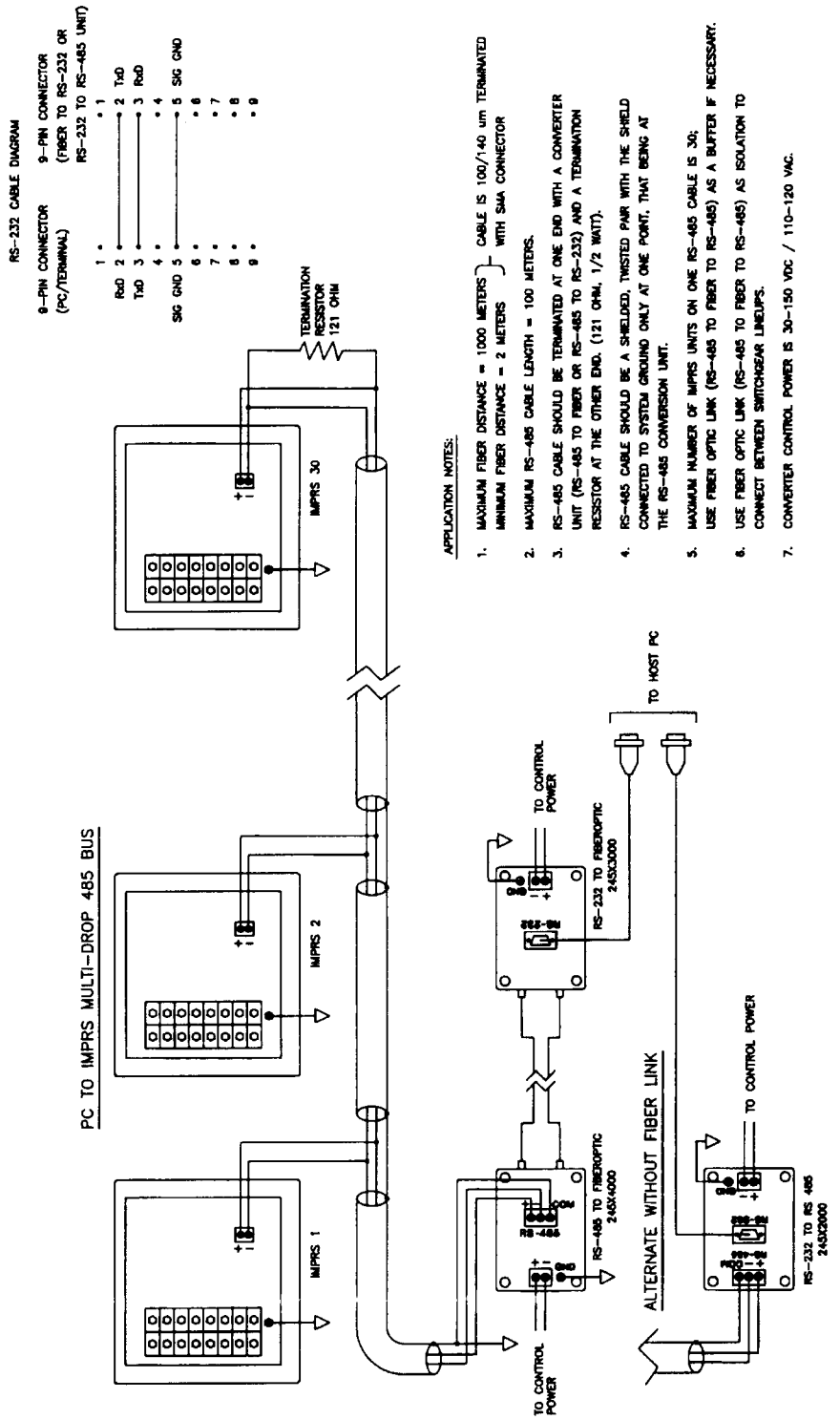
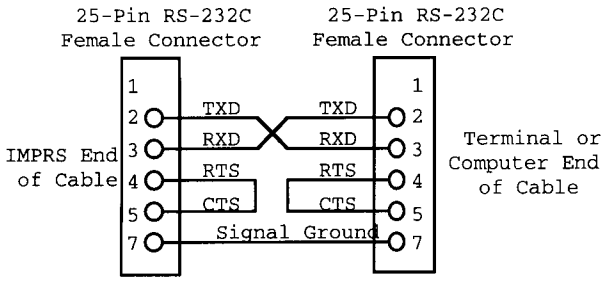
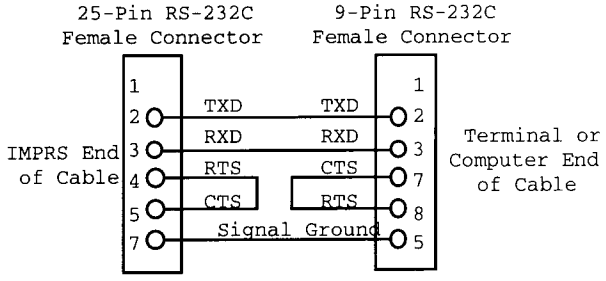


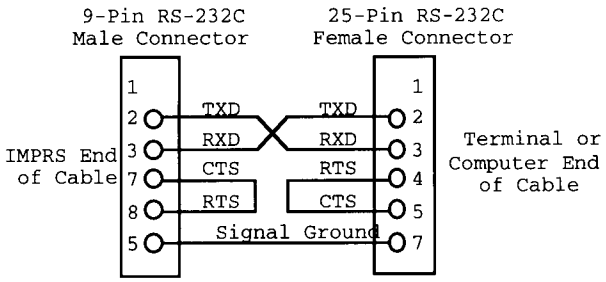

**Figure 7. Multiple IMPRS Connection**



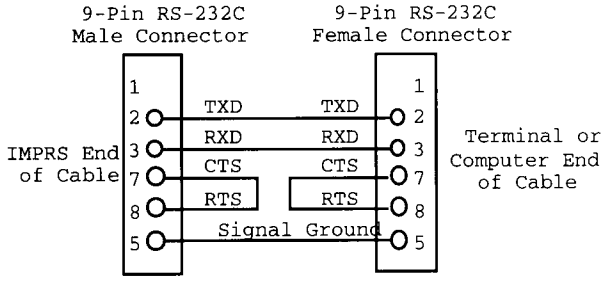

Serial port cable connection from a terminal (data terminal equipment) or computer to the IMPRS front RS-232 port.




Serial port cable connection from a terminal (data terminal equipment) or computer to the IMPRS front RS-232 port.




Serial port cable connection from a terminal (data terminal equipment) or computer to the IMPRS rear RS-232 port.




Serial port cable connection from a terminal (data terminal equipment) or computer to the IMPRS rear RS-232 port.

**Figure 8. RS-232 Cable Pin Connections**

To establish communication between the relay and the serial port device, set the transmit and receive speeds (or baud rates) and data format the same. Consult the user's manual of the external serial port device for configuration of its RS-232C port.

## *Baud Rate Selection*

The baud rate is internally selectable for 300, 1200, 2400, or 9600. Most serial port devices allow different baud rate selections. Choose a baud rate and then set the baud rate on the external serial port device and the IMPRS. Select the baud rate on the relay by the changing the appropriate dip switch positions of the dip switch labeled S1 on the CPU board (see Figure 6). Cycle the power to the relay, or press and release the RESET button to initialize the baud rate in the relay. The internal switch positions are listed in Table 7. A baud rate of 2400 is recommended when a large number of IMPRS relays are connected in an RS-485 network.

**Table 7. Baud Rate Switch Positions**

| Baud Rate | Switch S1 Positions | |
|---|---|---|
| | S1-1 | S1-2 |
| 300 | OFF/OPEN | OFF/OPEN |
| 1200 | ON/CLOSED | OFF/OPEN |
| 2400 | OFF/OPEN | ON/CLOSED |
| 9600 | ON/CLOSED | ON/CLOSED |

## Data Format

The relay uses a data format consisting of eight data bits, no parity, and two stop bits. The same data format must be selected for the external serial port device connected to the relay.

## Data Transmit/Receive Protocol

The protocol for the transmission and reception of data involves using commands from the serial port to the relay and from the relay to the serial port.

**Serial Port to Relay.** All commands from the serial port device to the relay must be terminated by pressing <Enter>. The relay responds by transmitting the requested data to the terminal. The transmitted data consists of a series of ASCII characters in the data format of the relay.

**Relay to Serial Port.** All data transmission from the relay to the serial port is terminated by pressing <Enter>, <LF> (LINE FEED), and a prompt ">". Note that the data format is strictly followed while transmitting each of the above characters. The valid command sequences and details of the protocol are described in the *IMPRS Protocol Document*, which is available from the factory upon request.

## Serial Port Cable Connection

The serial port is configured as data terminal equipment. This means that the port can be connected to a modem (data communications equipment that can transmit data through telephone and voice circuits) by a straight-through cable. If a modem is used, the baud rate of the relay and data terminal must be compatible with the modem's capabilities. If the relay is to be connected to other data terminal equipment, like a computer or a CRT terminal, the cable must follow the connections shown in Figure 8.

## Current Display

An optional current display, ABB catalog number 470X5000, is available for the IMPRS relay. The device displays one value at a time for the three phases' or neutral's load, demand, and peak demand current values. The display mounts on the relay front panel communications port. To power the display with +5 volts, place jumper J2 of the CPU Board on the two pins closest to the front panel (see Figure 6).

NOTE: **On older units with no pins on J2, a jumper wire must be soldered into the holes labeled J2.**

# IMPRS Communications Software

(Version 2.2 and higher)

The IMPRS/IMPRS PLUS© operations and communications software is supplied with each IMPRS unit on a 3.5" floppy disk. The program consists of several menu-driven screens. The up/down arrow keys select the particular menu screen or item and the left/right arrow keys select the desired value.

To run the IMPRS program, type the following at the DOS command prompt.

A:IMPRS-OC (Where "A:" is the drive in which the diskette is inserted.)

The program first asks if you want to change the foreground and background colors on your color monitor. The default colors are for a monochrome monitor—white foreground and black background. Follow the instructions to obtain a desirable color scheme. The next screen asks if the program is to be used with a single IMPRS, Communications Cluster Unit (CCU), or Code Operated Switch. Select "S" if the communications is direct to an IMPRS. When using the CCU, enter the channel (0 thru 7) of the IMPRS you wish to access. The Communications Configuration screen next appears, requesting the communications baud rate and RS-232C port (see Figure 9). Communication with the IMPRS is verified when the top screen displays relay information. If the top screen fills with asterisk(*), then communications has not been achieved. In this case, check the IMPRS baud rate, computer communications port, and communications cable connections.

With communications verified, exit the Communication Configuration screen and the Main Menu is displayed.

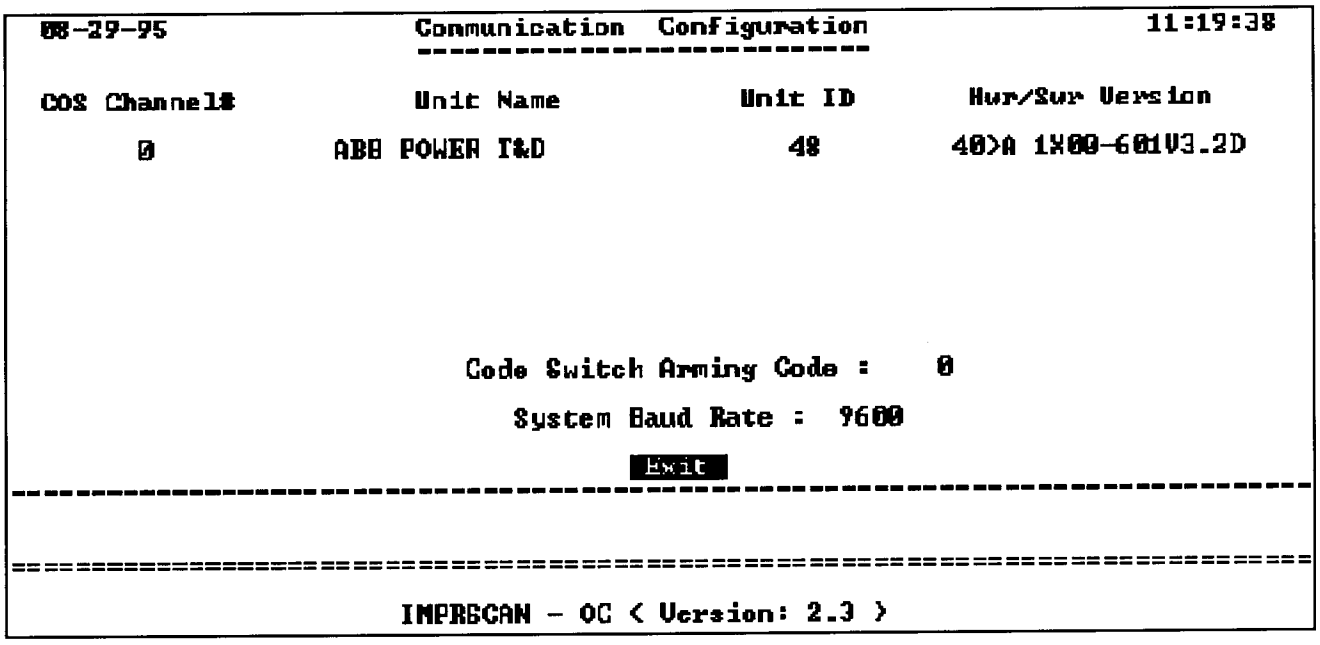



**Figure 9. Communications Configuration Screen (Initial Screen)**

## Main Menu

The Main Menu displays all the specific selections available for communicating with the IMPRS (see Figure 10). Use the up or down arrow keys to choose your selection. The selected menu item is highlighted as you move up and down the screen. Press RETURN to make your menu selection.

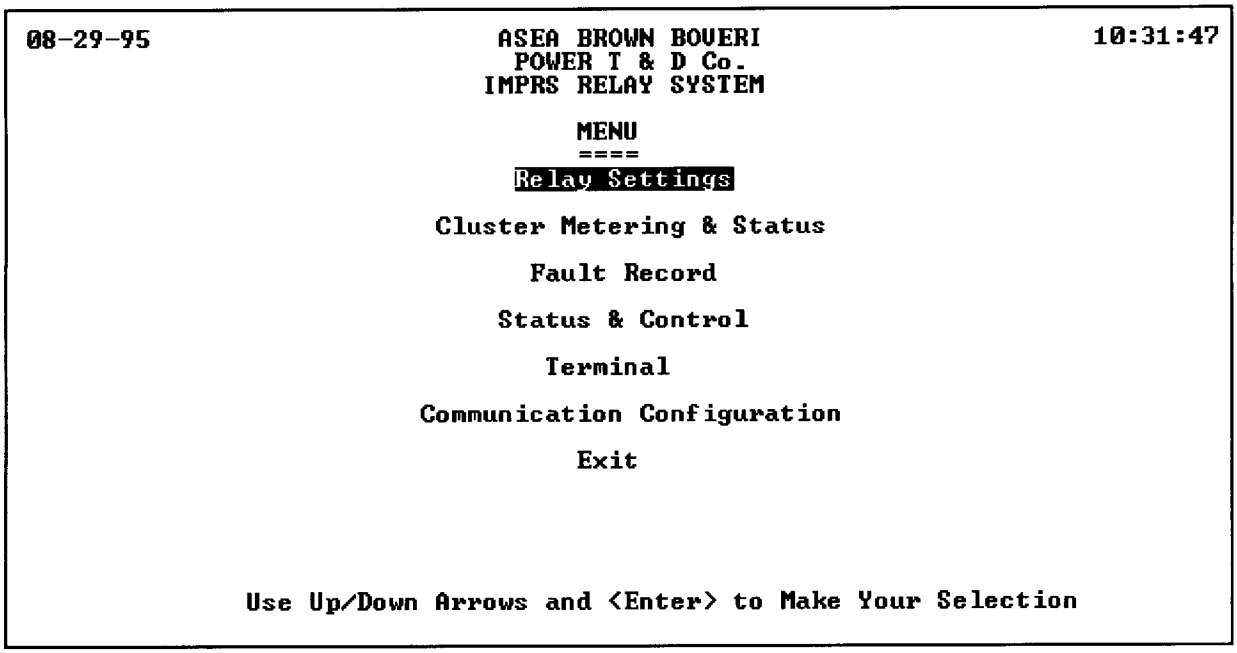



**Figure 10. Main Menu Screen**

## Relay Settings

When you select Relay Settings from the Main Menu, a screen first appears asking if you desire to switch to alternate settings or edit/display one of the four groups of settings. If you want to switch the operation of the relay to an alternate settings group, enter "0" followed by the settings group number (0–3) at the next prompt. The program displays the verification of the switch and then returns to the Main Menu. If you want to edit or display a particular settings group, enter a "1" followed by the settings group to be edited or viewed. The program then displays the alternate group settings. (See Figure 11.)

NOTE: **For IMPRS relays with software versions below V2.7, the alternate settings groups are not available. In this case, enter a "1" to edit a group; then enter "9" for editing or displaying the active group. Any attempt to switch to nonexisting settings groups will cause an error, and communications may be lost.**

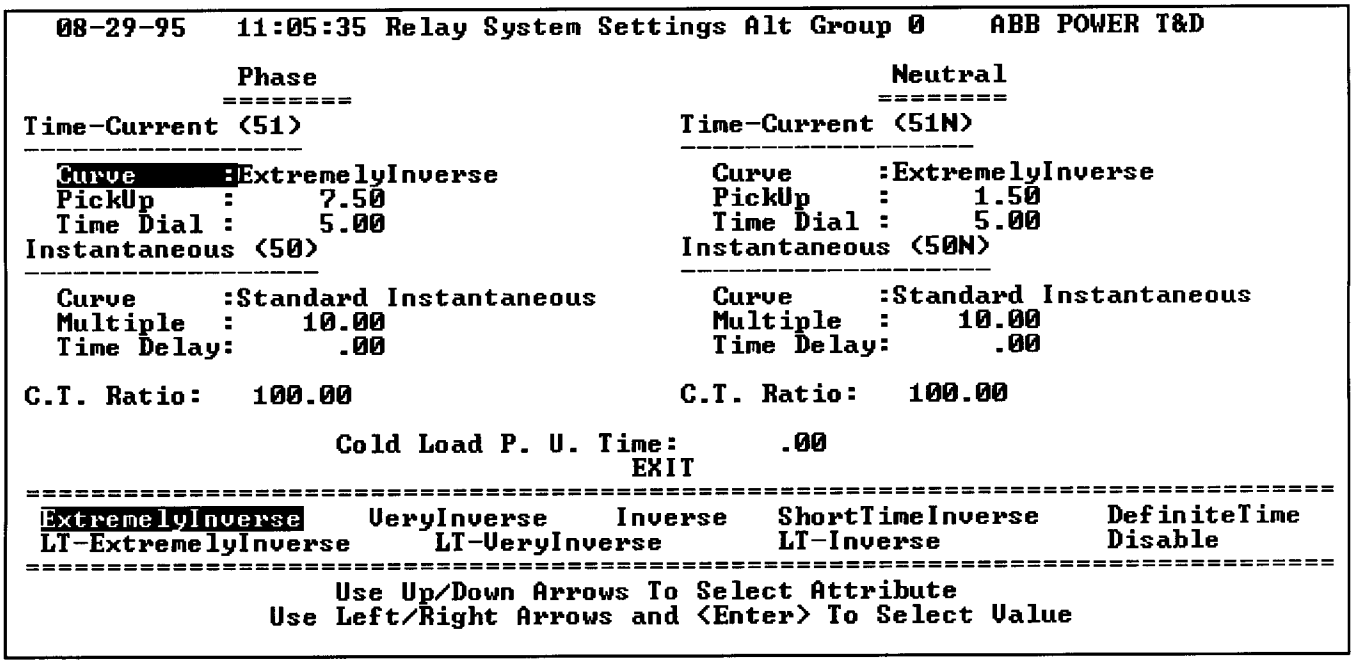



**Figure 11. Relay Settings Screen**

The Relay Settings screen displays the active group settings including the curves, pickups, and time dial settings for phase and ground time and instantaneous overcurrent protection; current transformer (CT) ratio; and Cold Load Pickup time. To view the settings without making changes, hit the enter key to quit and exit. Begin an edit session by pressing the up or down arrow key. The edit session starts with a prompt for the password (default is 48). Entering an incorrect password results in "INVALID PASSWORD" being displayed on the bottom of the screen. With a valid password, the program places the cursor into the settings portion of the screen.

Use the UP and DOWN arrows to step through the settings on the screen. Change the setting value, highlighted between the lines on the bottom of the screen, by using the left and right arrow keys. Choose the setting value by pressing the RETURN or ENTER. The screen updates the setting to the new value.

After completing the necessary relay setting changes, select the EXIT option. There are two EXIT selections: "Save and Exit" and "Quit without saving". Choosing the "Save and Exit" option changes the group settings in the relay. All changes performed are lost when choosing the "Quit without saving" option. After exiting the Relay Settings screen, the program returns to the Main Menu screen.

NOTE: **The revised settings displayed on the screen are not permanently stored in the relay until the edit session has been saved and exited.**

## Metering

The Metering screen displays the phase or neutral load, demand, and peak demand currents (see Figure 12). The program first prompts you for displaying phase or neutral current values. The neutral metering screen includes the summation of fault current interrupted (SFC) values. After selecting a metering screen, the program scans the IMPRS periodically, at approximately one-second intervals, and updates the meter values. This screen displays the meter values for up to eight IMPRS relays connected to a Communications Cluster Unit (CCU) or Code Operated Switch (COS). Those channels with no device or a device other than the IMPRS display asterisk (*) across the screen. Pressing <Enter> returns you to the Main Menu.

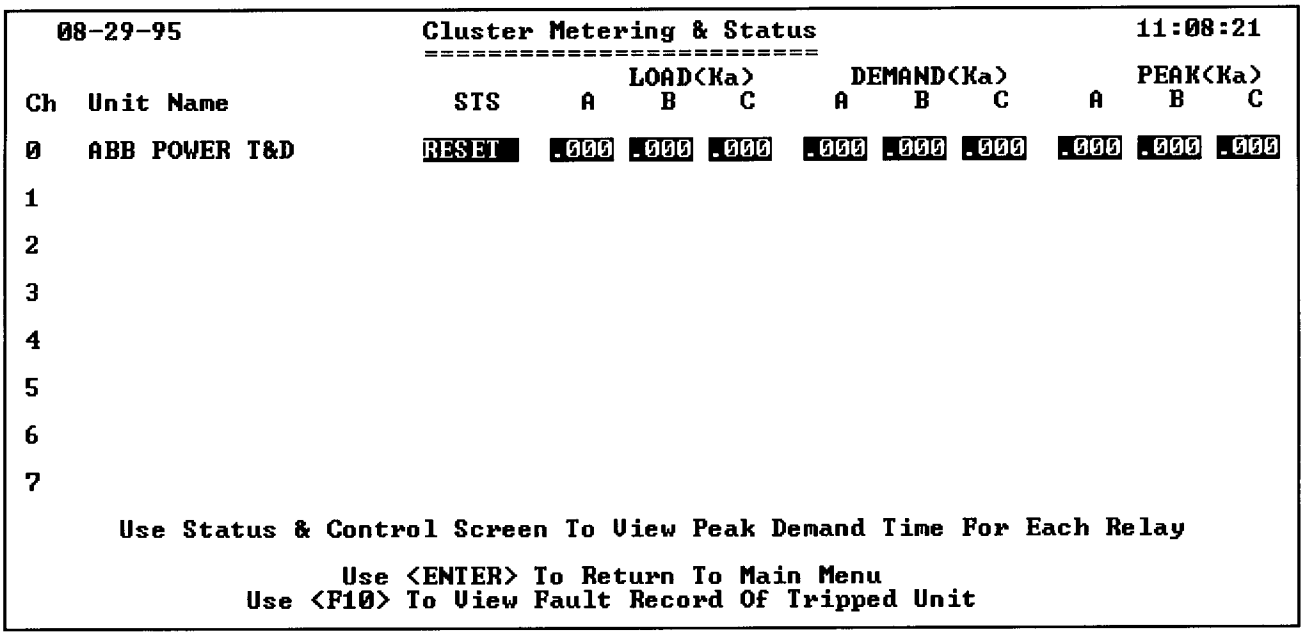



**Figure 12. Metering Screen**

## Fault Record

The latest 20 faults are displayed when "Fault Record" is selected from the Main Menu (see Figure 13). The record includes the fault number, fault type, maximum phase and neutral currents, relay trip time, and the date and time the fault occurred. Separate test records from in-service records when commissioning tests are complete by resetting the fault counter in the Status and Control screen. The phase and neutral current values are the maximum values the IMPRS measured from the initiation of pickup to the point where the current falls below 90% of the lowest time pickup, or below 40% of the lowest pickup when the instantaneous multiple is set below one (1X). The trip time is measured for the same interval as previously defined for the current magnitudes and thus includes breaker clearing time. Press <F6> to save the record as shown to a floppy or hard drive. The record is saved in the format shown on the screen, allowing it to be imported into an engineer's operations report. The program updates the screen periodically on a first in, first out (FIFO) basis. The newest fault is displayed on the bottom of the screen with the oldest displayed on the top line. To exit this screen, press <Enter>.

08-29-95 11:21:20 IMPRS Relay System Fault Record ABB POWER T&D

| Flt # | Trip Dev | Phase A | Phase B | Phase C | Neutral | Trip Time | Date/Time <DD-MMM-YY:HH:MM:SS> |
|---|---|---|---|---|---|---|---|
| 1 | 51n | 2252 | 0 | 0 | 454 | .208 | 05-NOV-02;02:55:00 |
| 2 | 51n | 2061 | 0 | 0 | 414 | 3.500 | 05-NOV-02;02:55:0 |
| 3 | 51n | 0 | 2066 | 0 | 2414 | 3.513 | 05-NOV-02;02:55:1 |
| 4 | 51n | 0 | 1747 | 0 | 351 | 5.163 | 05-NOV-02;02:55:28 |
| 5 | 51n | 0 | 1426 | 0 | 287 | 8.500 | 05-NOV-0:n02:55:41 |
| 6 | 51n | 0 | 0 | 0 | 1549 | 1.292 | 05-NOV-02;02:56:00 |
| 7 | 51p | 1760 | 0 | 1755 | 0 | 3.976 | 05-NOV-02;02:56:08 |
| 8 | 51p | 2066 | 0 | 2066 | 0 | 3.554 | 05-NOV-02;02:56:15 |
| 9 | 51p | 2199 | 0 | 2191 | 0 | 3.029 | 05-NOV-02;02:56:51 |
| 10 | 51p | 2273 | 0 | 2247 | 0 | 3.146 | 05-NOV-02;02:56:56 |
| 11 | 51p | 0 | 2061 | 2053 | 0 | 3.546 | 05-NOV-02;02:57:05 |
| 12 | 51p | 0 | 1147 | 1144 | 0 | 16.922 | 05-NOV-02;02:57:50 |

Use <F6> To Save Record To Disk Or Use <Enter> To Return To The Main Menu

**Figure 13. Fault Record Screen**

## Status and Control

In the Status and Control screen, you can access relay settings and functions not covered in the Relay Settings screen for review or change (see Figure 14). As with the Relay Settings screen, many of these parameters require the IMPRS password, factory default value of 48, before editing. Use this screen to determine the relay's trip output configuration without withdrawing the relay from its case to examine the switch S1 configuration. Exit this screen by choosing the EXIT selection, and the program returns to the Main Menu.

NOTE: **The cursor will highlight the Reclose option only for the special "R" suffix software version, e.g., V2.0R.**

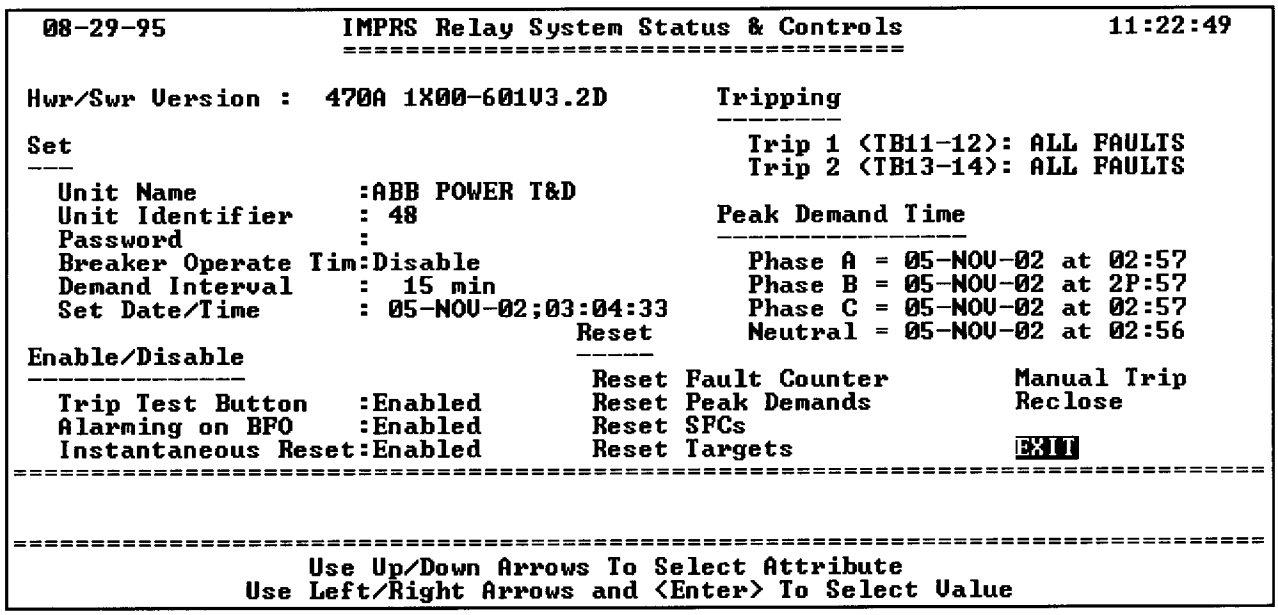



**Figure 14. Status and Control Screen**

## Terminal

Direct communication is possible with the Terminal screen. In this terminal emulation mode, type **in upper case only** the command for the desired function and press <Enter> (see Table 8). Since the Main Menu screens provide the bulk of the relay information, only a partial list of IMPRS serial commands are provided. If the IMPRS does not recognize a particular command, it returns the following message: "?1". If you wish to write your own interface program or program the commands into Supervisory control and Data Acquisition (SCADA) terminal equipment, contact the ABB factory and request the *IMPRS Protocol* document. Pressing <F10> returns you to

**Table 8. Terminal Command Codes**

| Command Function | Code |
|---|---|
| Metering | |
| Display Load Currents | D 14 |
| Display Demands Currents | D D 4 |
| Display Peak Demands | D P 4 |
| Display All Currents | D A L |
| Reset All Peak Demands | R P 4 |
| Display Fault Currents Interrupted | S F C |
| Display Demand Interval Time | D I T |
| Set Demand Interval to 15 min. | D 15 |
| Set Demand Interval to 30 min. | D 30 |
| Display CT Ratio | D CT |
| Event Recording | |
| Display Event Table | E V T |
| Faults Since Last Event | NEW |
| Operations Status | |
| Reset Targets | RTG |
| Display Maximum Expected Breaker Operating Time | DBT |
| Enable Alarm on Breaker Failure | ABM |
| Enable Alarm on Breaker Failure | DBM |
| Disable Self-Test Status | STS |
| Relay Settings | |
| Display Actural Relay Settings | DRS |

## Communication Configuration

Use the Communication Configuration screen to revise the communications configuration during the execution of the program. The relay name, identifier, system baud rate, and hardware and software versions are available from this screen. Select the "Exit" option to return to the Main Menu. This screen also appears prior to the Main Menu when the program is first executed.

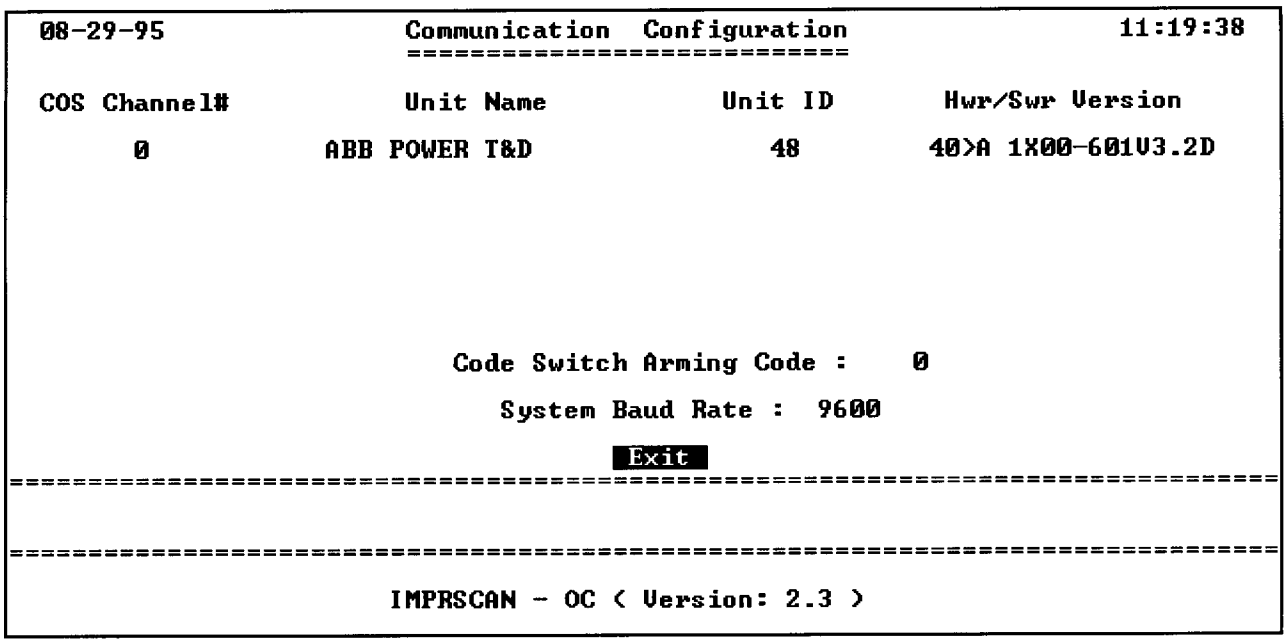



**Figure 15. Communication Configuration Screen**

## Hardware/Software Number Designations

The digits in the hardware/software number of the unit have specific meanings (see Figure 16):

Current range

1 = phase current 1.0–15 A, ground current 1.0–15 A

2 = phase current 1.0–15 A, ground current 0.2–3 A

3 = phase current 0.2–3 A, ground current 0.2–3 A

Frequency

5 = 50 Hertz, 6 = 60 Hertz

Software Type

0 = standard

1 = manual close

# = special (Special types of software are numbered individually.)

Relay Configuration (see Table 9)

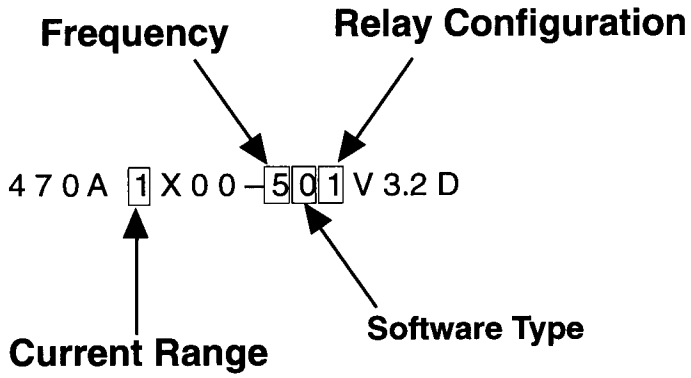



**Figure 16. Unit Number Designations**

| Digit | Switch | | |
|---|---|---|---|
| | S1-5 | S1-4 | S1-5 |
| 0 | Off | Off | Off |
| 1 | Off | Off | On |
| 2 | Off | On | Off |
| 3 | Off | On | On |
| @ | On | Off | Off |
| A | On | Off | On |
| B | On | On | Off |
| C | On | On | On |

**Table 9. Digit Designation for Relay Configuration**

# Maintenance and Testing

No routine maintenance is required on this system. Continuous self-testing ensures maximum availability of the unit. Follow the test procedures below to verify proper relay operation. Return an inoperative unit to the factory for repair.

The battery backed-up memory is labeled U12 on the electronics board and should last the life of the relay since it has an average lifetime of 10 years with no control power applied to the relay. The 32K EPROM containing software is labeled U11. Disconnect control power from the unit when replacing components on the electronics board. Match polarity "notch" markings with the silk screen outline of the component to be changed.

NOTE: **When replacing electronic components, take proper Electrostatic Discharge (ESD) precautions.**

## *High-Potential Tests*

High-potential tests are not recommended. If a control wiring insulation test is required, bond all terminals together before applying test voltage or fully withdraw the relay from its case.

## *Testing*

Fully withdraw the unit from its case. Make test connections directly to the rear circuit board with standard banana plugs. Use protective relay test sets that can be accurately preset without actually applying current until activated. See Figure 5 for input current and output contact connections. Follow these steps to properly test the IMPRS:

1. Apply proper control power to the unit, and enter or confirm the correct settings on the unit by using a computer.

2. Check pickup currents.

a. Verify the pickup accuracy of each phase by applying the test current to the desired phase input (Ph A = 1-2, Ph B = 3-4, Ph C = 5-6). Inject test current into terminals 7 and 8 to verify the ground pickup accuracy.

b. Time overcurrent pickup—Increase the test current until the STATUS LED on the front panel is steady orange. A green light indicates normal status with the current below pickup. Pickup should be within +/- 2% of the set value.

c. Instantaneous pickup (assuming instantaneous element is enabled)—Starting at about 85 percent of the expected tripping current, increase the current in small steps until an instantaneous trip is indicated by a flashing target LED. Instantaneous pickup should be within +/- 10% of the set value.

3. Check time-overcurrent timing—Use test currents of 3X, 5X and 10X the pickup current setting. Locate the expected relay operating time from the curves shown in Appendix A, or calculate it from the curve equations given in Figure 1. Apply test currents to each phase and neutral input, and measure the operating time. The times should be within +/- 7% of the expected values. If a specific operating time is desired, adjust the time dial setting (via the communications port) and retest until the desired time is obtained. For each type of curve, there are 100 selectable time dials.

4. Check the Loss of Control Power and Self-Check Alarm contacts—Record the position, open or closed, of the self-check alarm contact (9 and 10) with control power applied to the relay operating normally (green STATUS LED). Interrupt the DC or AC control power to the system. The self-check contacts change state. Reapply control power and verify via the communications port that all settings and records were properly retained.

5. Calibrate the A/D converter gain and individual phase current adjustment— Power up the IMPRS relay and wait 15 minutes for the electronic components to stabilize. Use the IMPRS communications software, the current display to monitor the phase currents during calibration. Pass an accurate current through Phase A terminals 1 and 2 of the relay. Adjust the A/D Gain trimpot (R10), located in the upper right hand corner of the CPU board, until the metered value equals the injected current value times the CT ratio. Allow a few seconds after each adjustment for the IMPRS to update its metering values. After the A/D gain has been properly adjusted for Phase A, pass a known current through Phase B terminals 3 and 4, Phase C terminals 5 and 6, and Neutral terminals 7 and 8. Adjust R25, R28, and R31, located in the upper left-hand corner of the CPU board, for each Phases B and C and the Neutral, respectively, in the same manner as for Phase A.

CAUTION: Since this test requires testing energized equipment, take caution to avoid personal shock. Only competent technicians familiar with good safety practices should perform this test. All IMPRS relays are factory calibrated and, therefore, recalibration of the A/D or individual phase current metering generally should not be necessary.

## *Disassembling The Unit*

Although field repair of a unit is not generally recommended, the IMPRS Protective Relay can be disassembled for replacement of the power supply, the CPU board, backplane board, and the CT board. Follow these steps to disassemble the unit:

Disconnect all control power to the unit.

Loosen the front panel screw, and pull the front handle up and out, withdrawing the relay from its case.

Separate the backplane board by removing the two screws attaching the backplane board to the CPU board and the three screws boxed in dotted squares on the right-hand side of CT board. Slide the connector J1 in the upper left-hand corner off the CT board. Pull the 36-pin connector away from the CPU board. Finally, remove the flexible power supply cable from the inside bottom of the backplane board.

Removal of the CT board is accomplished by removing the three screws vertically aligned on the right-hand side of the relay front panel. Next remove the screw located at the bottom left-hand corner of the CT board.

Remove the CPU board by removing the top and bottom screws on the front left-hand side of the front panel and the two screws across the bottom of the board.

Reassembly is accomplished by following the above sequence in reverse.

# Appendix A
# Timing Curves

**Notes:**

The time in seconds for the Long Time Extremely Inverse Curve is 25 times that of the Extremely Inverse Curve.

The time in seconds for the Long Time Very Inverse Curve is 20 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.

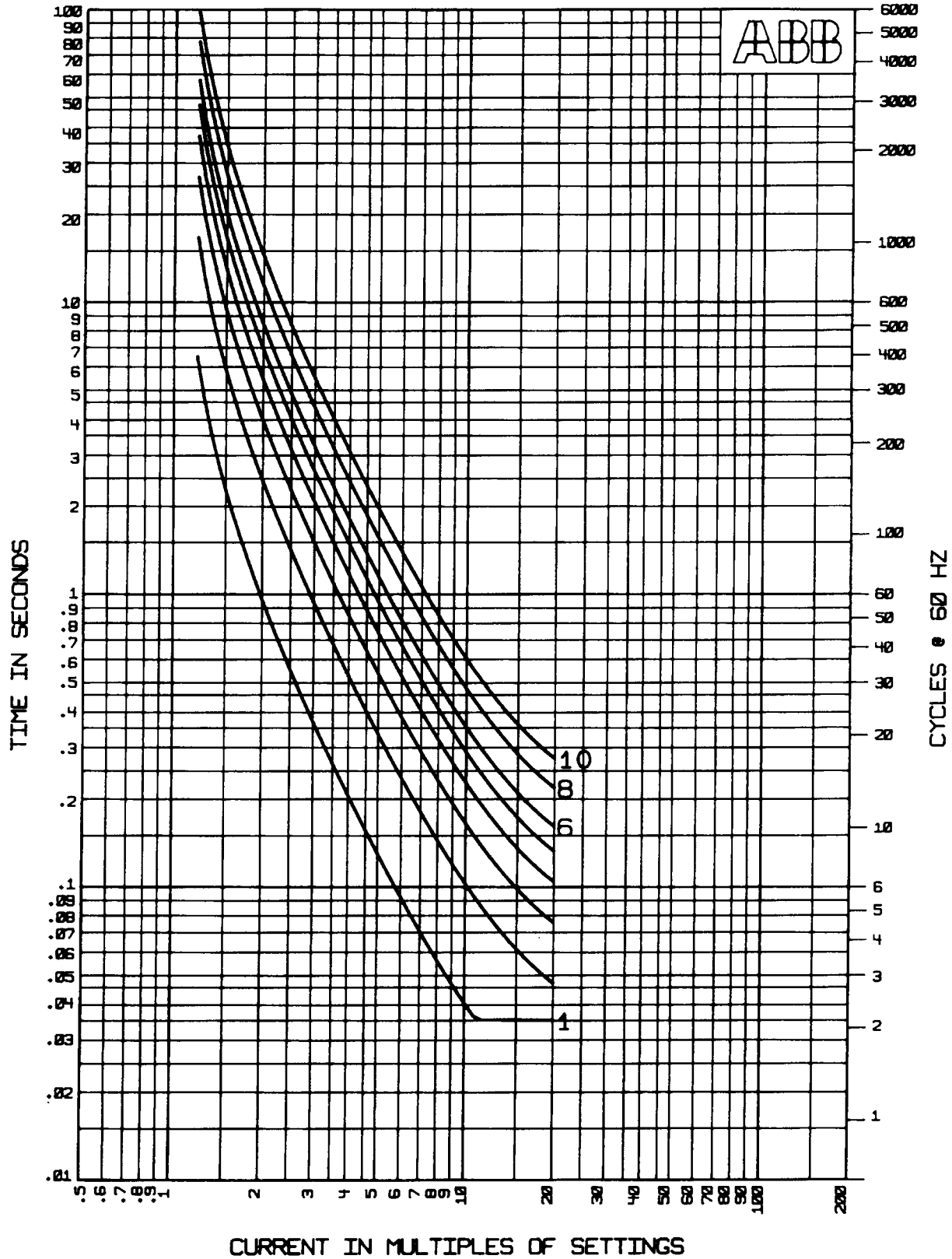



**Figure 17. Extremely Inverse Curve** **605850 Rev 2**

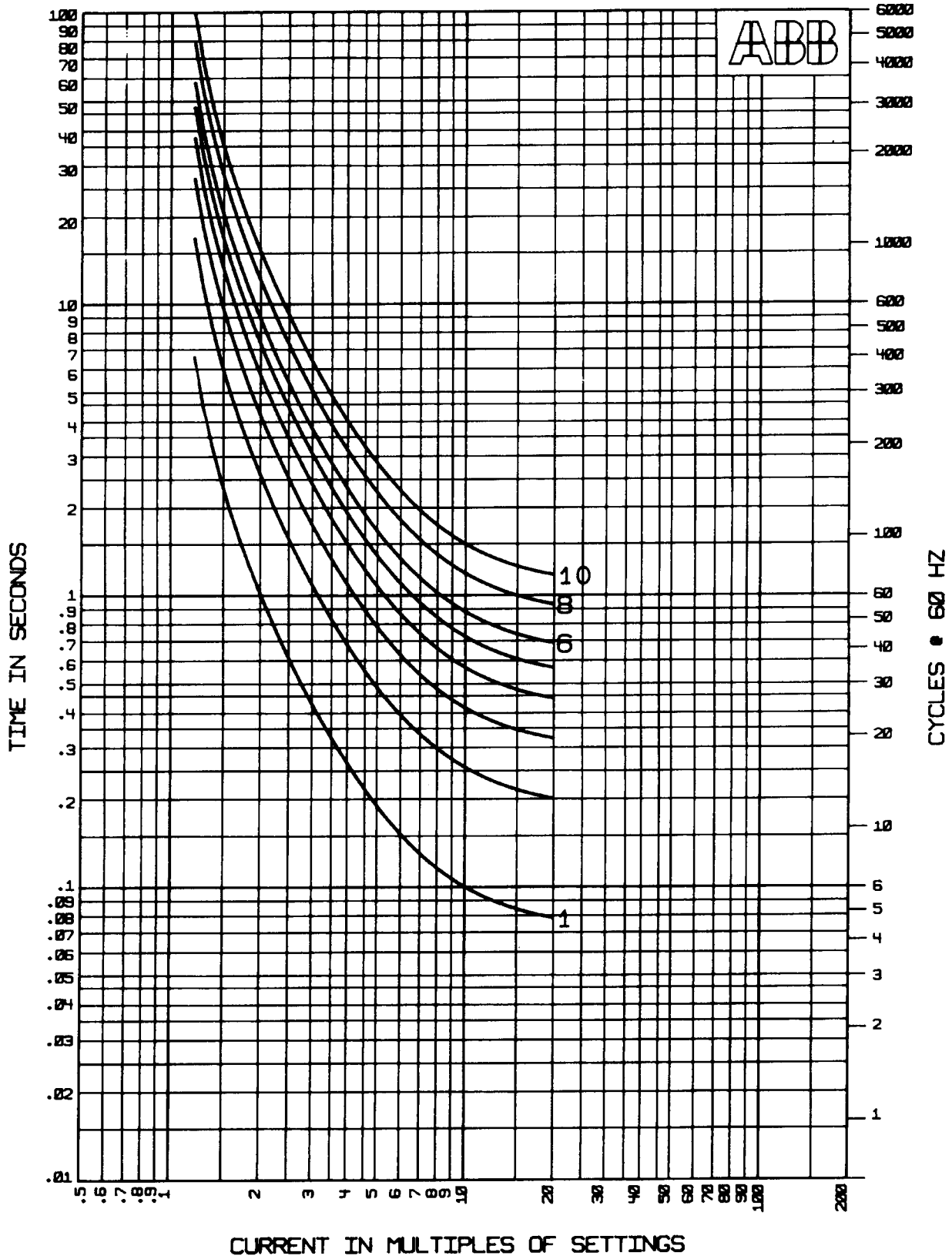



**Figure 18. Very Inverse Curve** **605851 Rev 2**

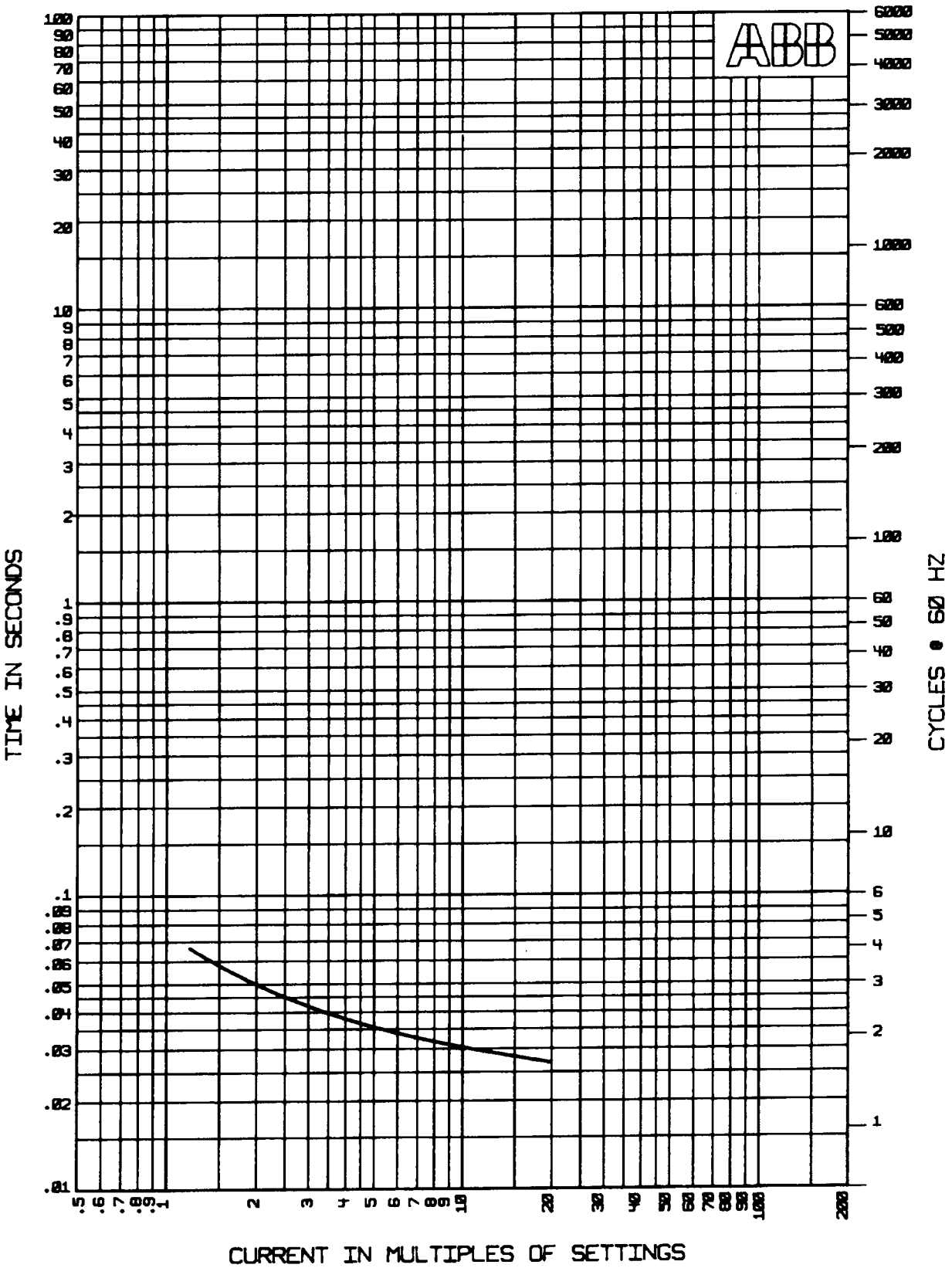



**Figure 19. Inverse Instantaneous Curve** **605860 Rev 2**

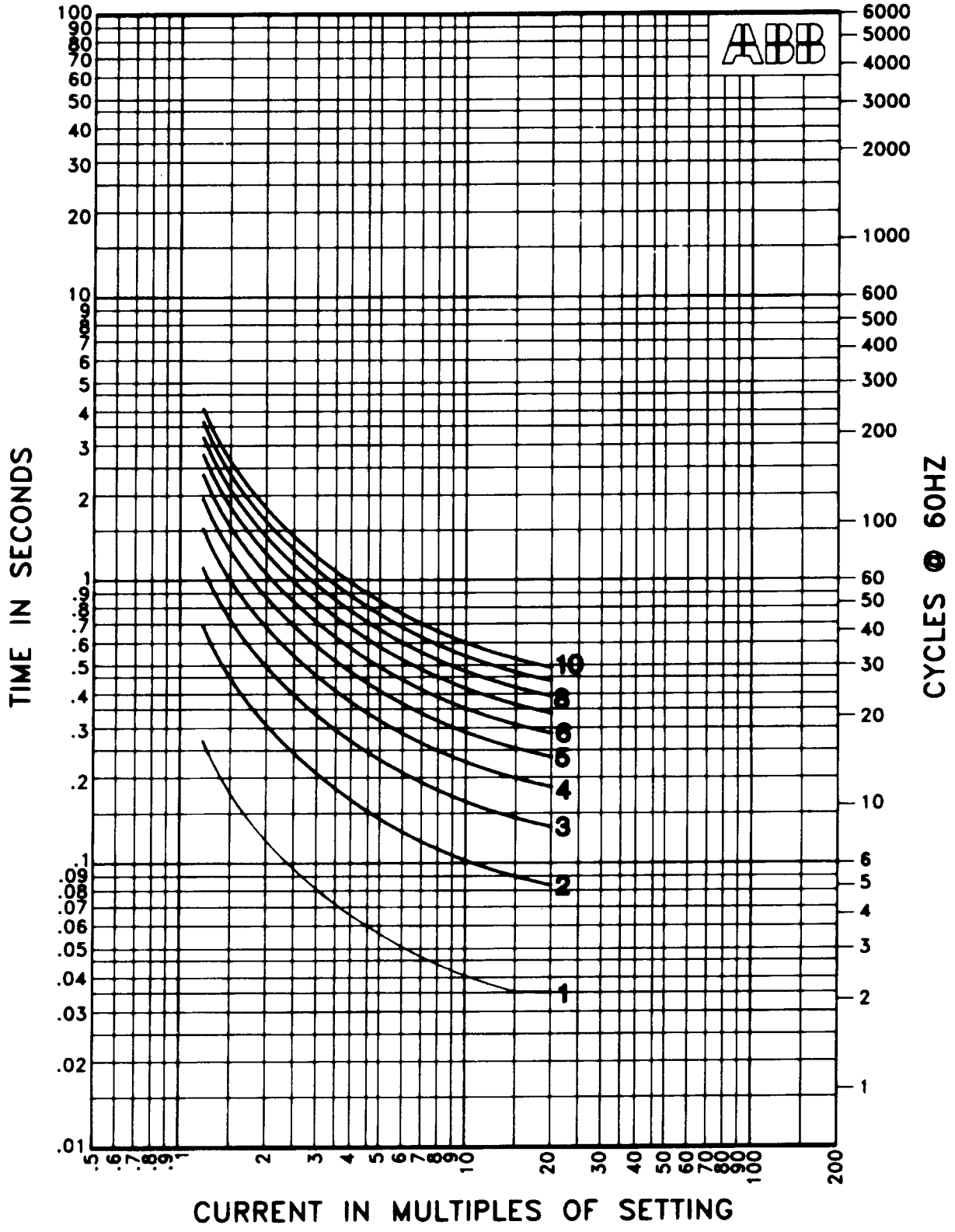



**Figure 20. Short Time Inverse Curve** 605853 Rev 3

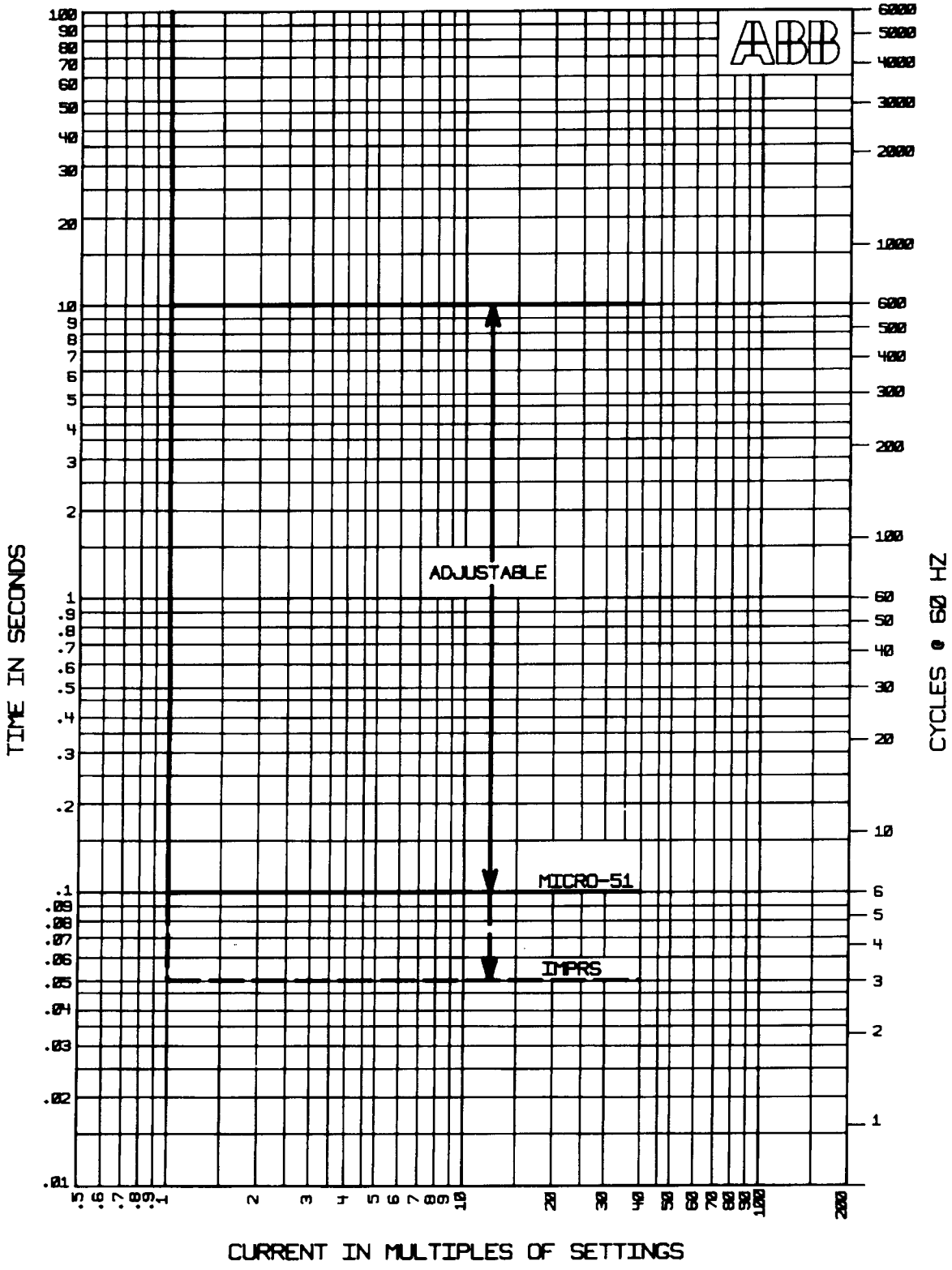



**Figure 21. Definite Time Curve** **605874 Rev 2**

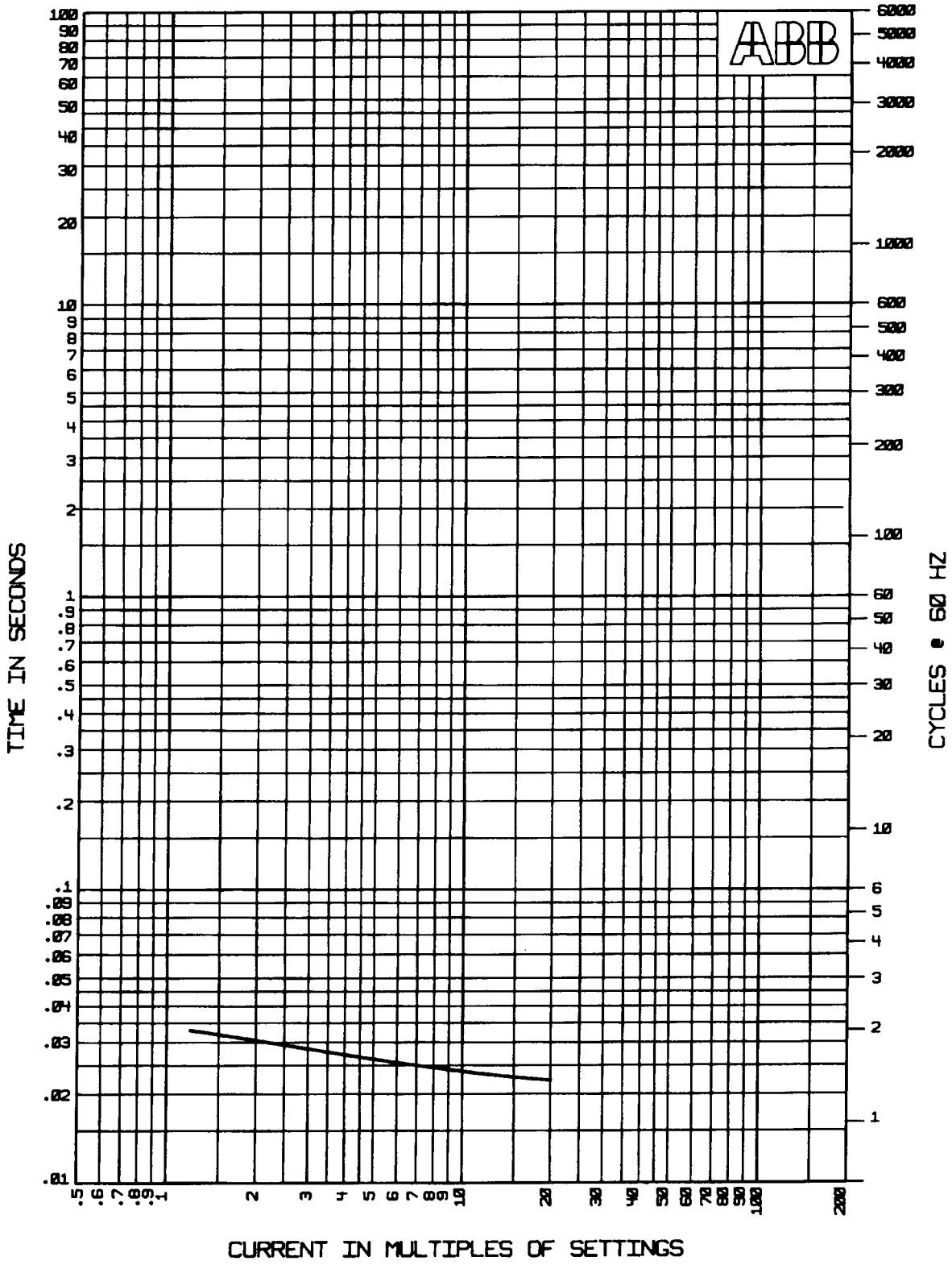



**Figure 22. Standard Instantaneous Curve**

**605861 Rev 2**

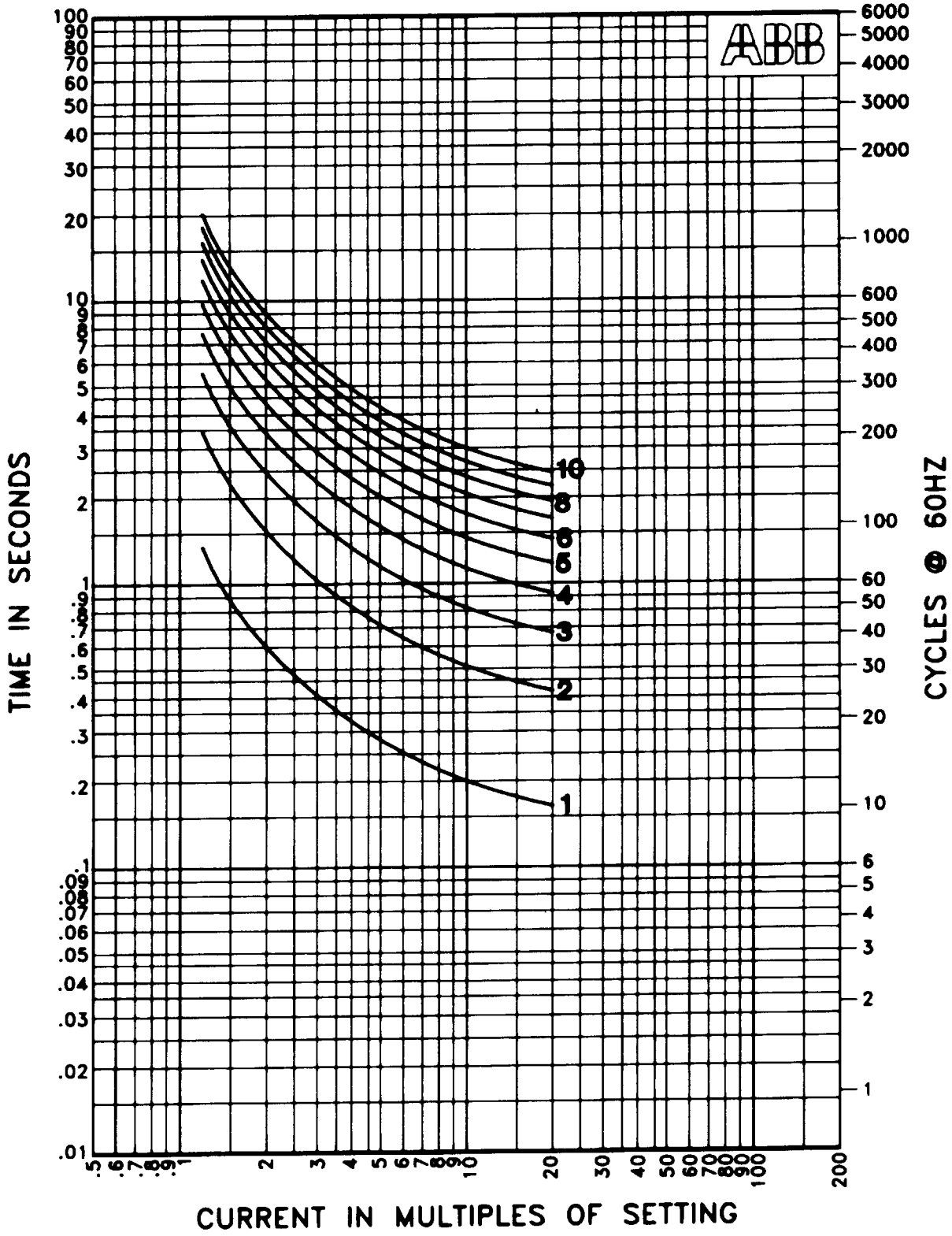
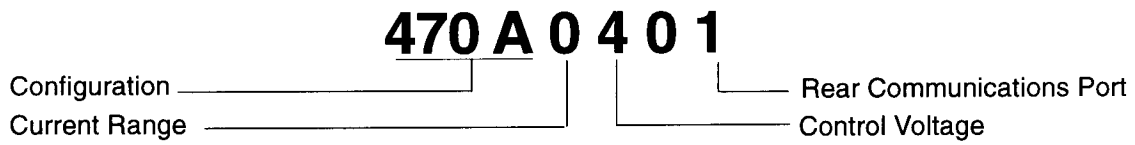



**Figure 23. Inverse Curve** 605852 Rev 2

# Ordering Instructions

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

**Sample Catalog Number**



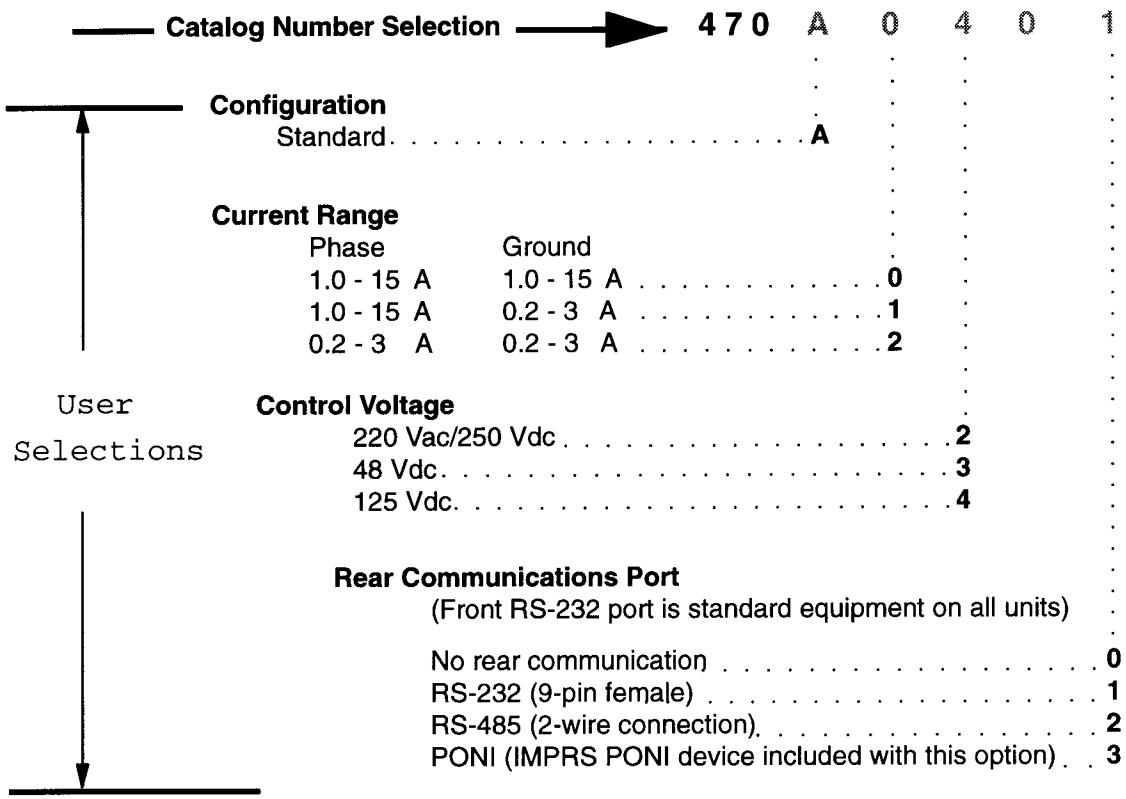

## *How To Order*

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

### Communication Port Configurations

The IMPRS relay platform provides a front panel 25-pin RS-232 which is standard on all units. Optional configurations include a rear 9-pin RS-232 plug, 2-wire RS-485 connector or an IMPRS PONI device that is supplied when this option is selected.

## Ordering Selections



Instruction Booklet

Issue E March 97 (IB–7.12.1.7–1)
Supersedes Issue D

These instructions do 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 covered sufficiently for the purchaser's purposes, the matter should be referred to your local ABB Power T&D Company, Inc. sales representative.

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