2.1 INPUTS

The secondary current from the protected line current transformers is connected to the relay and immediately reduced via the internal current transformers. The MDP CT secondaries are connected across input resistors, yielding a voltage proportional to the relay input current. This voltage is rectified and filtered before being applied to the multiplexer and analog-to-digital converter, which are internal to the microprocessor.

2.2 EXTERNAL INPUTS

Three external inputs (CP4, CP6, and CP7) are provided.

- CP4 – Block IOC Trip: when energized, blocks tripping by the ground units.
- CP6 – Block Ground Trip: blocks the phase and ground instantaneous trip elements when it is energized.
- CP7 – Breaker Status Input: when energized, indicates that the Breaker Status is "closed".

Since diode bridges are provided on all inputs, they can all be actuated by either switched-to-positive or switched-to-negative, depending on the polarity connected to the stud. These inputs can be energized by either AC or DC.

NOTE

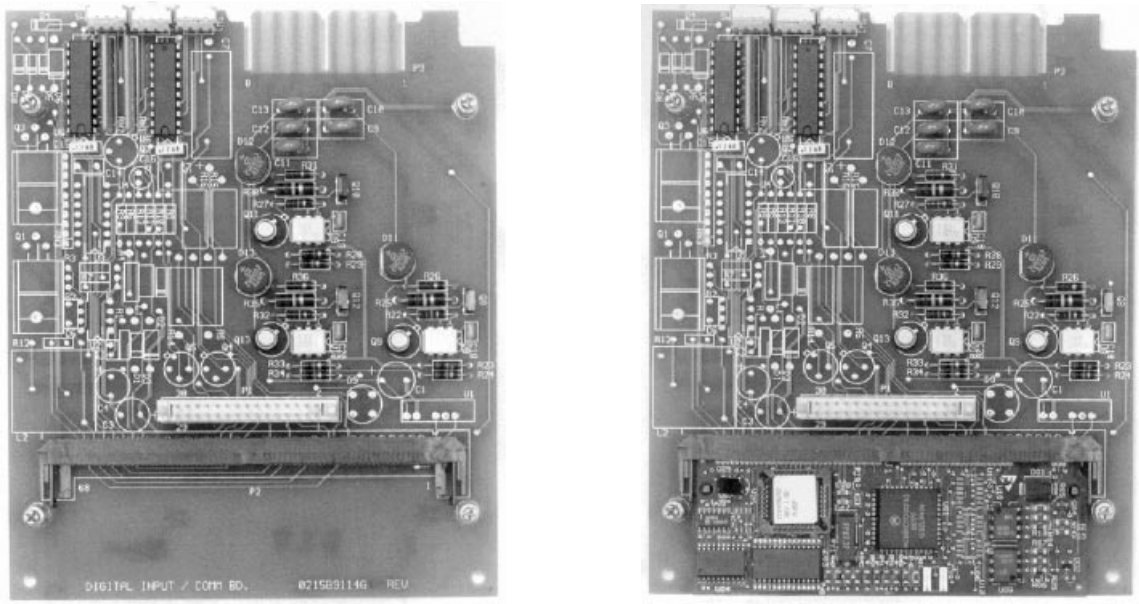
The Breaker Status and Block Ground inputs, CP7 and CP6 respectively, must be switched by the same polarity, since they share a common ground (CP8).

2.3 COMMUNICATIONS PORT

The MDP relay has a communications feature that permits easy installation of various communications interface modules. The procedure for installation/replacement of a communications upgrade card is provided below:

1. To install or replace a communications upgrade card, begin by removing the relay from the case.
2. Before continuing, connect an approved wrist grounding strap to ground. This discharges any static electricity in your body that could damage the electronics of the MDP relay. A wrist strap is provided with the communications card kit. The wrist strap must provide a "safe" high resistance to ground.
3. Remove four screws attaching the nameplate settings board and the NOMEX insulation paper to the relay cradle (see the cover photograph). Note that there are four metal spacers between the nameplate and the settings board. Be careful not to lose them or let them fall into the relay assembly. Carefully place the settings board on top of the cradle to expose the communication card SIMM socket located on the lowest board (digital input/communications board).
4. To expose the SIMM socket located on the lowest board, carefully push down on the board to disengage the board spacers. Do not try to remove the board from the cradle
5. This step is for replacement only – skip to step 6 if you are installing the card for the first time. If you are replacing an existing SIMM card, the old one must be removed! Start by simultaneously pushing the catches on either side of the SIMM board outwards while lifting the board to a 45° angle. This will release the board.

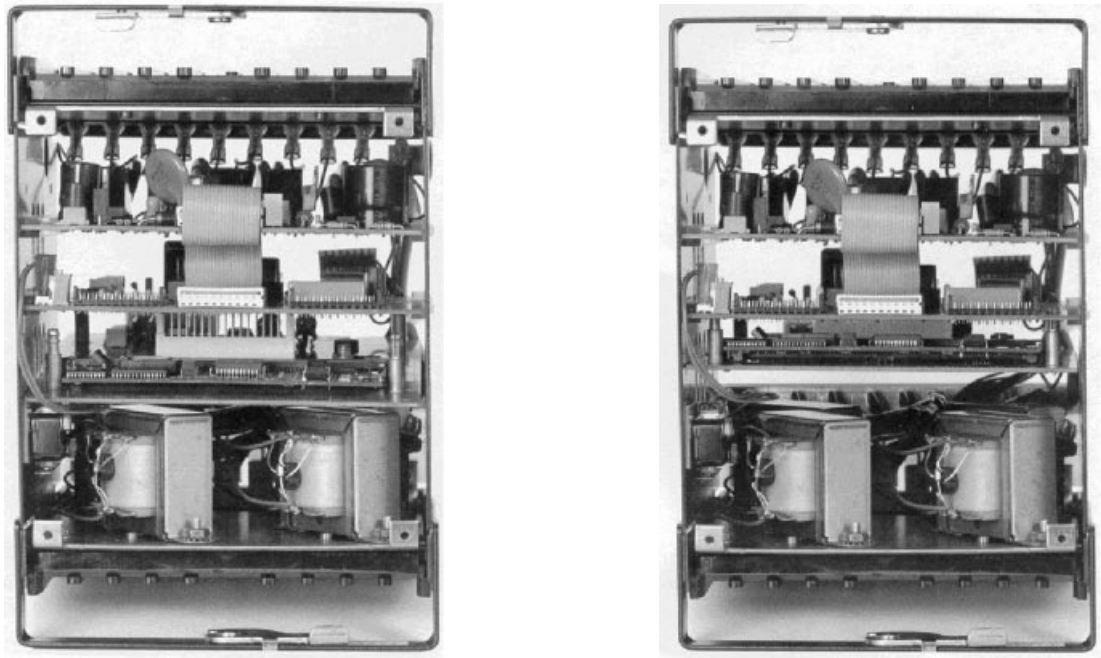
6. Remove the communications card from its protective packaging. Insert the card into the SIMM socket at a 45° angle to the socket with the integrated circuits facing up. Push the card down until it snaps into the socket and the latches on either side of the board catch above the new board



Without Communications Upgrade Card | Communications Upgrade Card Installed

Figure 2–1: DIGITAL INPUT/COMMUNICATIONS BOARD

7. Reassemble the MDP relay by engaging the board spacers of the lowest board (digital input/communications board) into the processor board above it. Align the NOMEX shield on the solder side of the settings board. Take one screw and spacer at a time and push the screw through the nameplate, spacer, settings board and NOMEX. The NOMEX protects the ribbon cable from the leads on the settings board.



Before DI/Comm Board is Raised Back into Position | With DI/Comm Board in Position

Figure 2–2: COMMUNICATIONS CARD INSTALLED

8. Tighten the screw just enough to hold the assembly in place until all four screws are aligned. When all the screws are aligned, tighten them with gentle pressure so that the board is mounted evenly.
9. **SET THE COMMUNICATIONS ADDRESS** before restoring the cradle to the case.

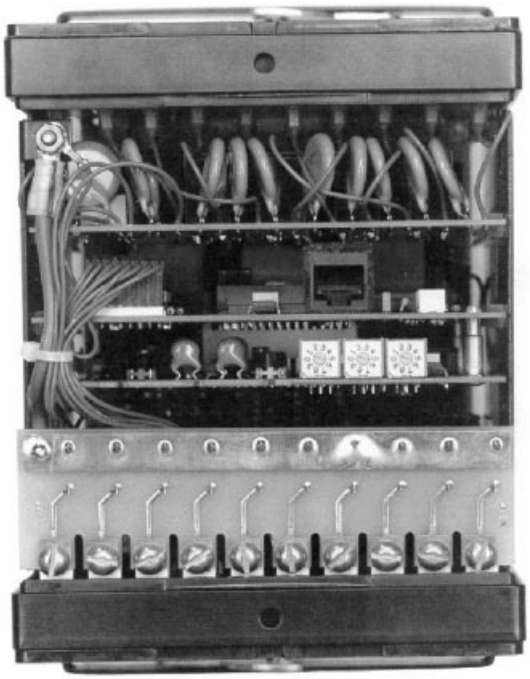


Figure 2–3: REAR VIEW SHOWING COMMUNICATION ADDRESS SWITCHES

2.4 MEASUREMENT

A timer internal to the microprocessor generates an interrupt every millisecond. Phase and ground measurements are made at each of these interrupts. These measurements are grouped, separately for each phase and ground, in groups of ten, and the average of the maximum value of these groups is taken.

This average is converted to a multiple of pickup TOC, the format used by the relay. This value is displayed in 5 second intervals.

2.5 INVERSE TIME UNIT

The multiple of pickup TOC measurement obtained is compared, independently for each phase and ground, with a value, the pickup setting, that corresponds to one times (1×) pickup TOC. If the measurement exceeds the fixed setting, a Pickup LED lights on the front of the relay.

The minimum current necessary to operate the Inverse Time measuring elements is never less than the set value (I_s), nor greater than 10% more than (110% of) the set value.

$$1.0 I_s < I_{min} < 1.1 I_s$$

The dropout to pickup ratio is not less than 95%, based on the actual operating value.

The MDP relay incorporates five inverse time curves and four definite times. The curve within a family is selected by the time dial. The characteristic curves for the MDP relay correspond approximately as follows.

a) 51 INVERSE (5 A RATED RELAYS)

For 1.1 to 4 times the pickup TOC: $T = \left(\frac{0.0059}{P^{0.001} - 1} + 0.419\right) \times \text{Time Dial} + 0.018$

For 4 to 31 times the pickup TOC: $T = \left(\frac{0.0069}{P^{0.001} - 1} - 0.252\right) \times \text{Time Dial} + 0.018$

See Figure 2–4: INVERSE TIME CURVE on page 2–5.

b) BS142 INVERSE (1 A RATED RELAYS)

For 1 to 31 times the pickup TOC: $T = \left(\frac{0.14}{P^{0.02} - 1}\right) \times \text{Time Dial} + 0.018$

See Figure 2–8: BS142 INVERSE TIME CURVE (1 A MODELS ONLY) on page 2–9.

c) 53 VERY INVERSE

For 1.1 to 4 times the pickup TOC: $T = \left(\frac{52.954}{P^{2.11} - 1} + 0.923\right) \times \text{Time Dial} + 0.018$

For 4 to 31 times the pickup TOC: $T = \left(\frac{28.447}{P^{1.702} - 1} + 1.007\right) \times \text{Time Dial} + 0.018$

See Figure 2–6: VERY INVERSE TIME CURVE on page 2–7

d) 77 EXTREMELY INVERSE

For 1.1 to 20 times the pickup TOC: $T = \left(\frac{58.132}{P^{2.135} - 1} + 0.166\right) \times \text{Time Dial} + 0.020$

See Figure 2–7: EXTREMELY INVERSE TIME CURVE on page 2–8.

e) 66 INVERSE LONG TIME

For 1.1 to 3 times the pickup TOC: $T = \left(\frac{0.0006}{P^{0.00001} - 1} + 5.644\right) \times \text{Time Dial}$

For 3 to 5 times the pickup TOC: $T = \left(\frac{0.746}{P^{0.01} - 1} - 5.630\right) \times \text{Time Dial}$

For 5 to 20 times the pickup TOC: $T = \left(\frac{0.00085}{P^{0.00001} - 1} - 12.530\right) \times \text{Time Dial}$

For 20 to 31 times the pickup TOC: $T = \left(\frac{250 - 4.5 \times P}{10}\right) \times \text{Time Dial}$

See Figure 2–5: LONG INVERSE TIME CURVE on page 2–6.

For all the above equations:

T = time in seconds
P = multiple of pickup TOC
$\text{Time Dial} = \frac{\text{Time Dial Setting}}{10}$ for 5 A rated unit
= Time Dial Setting for 1 A rated unit

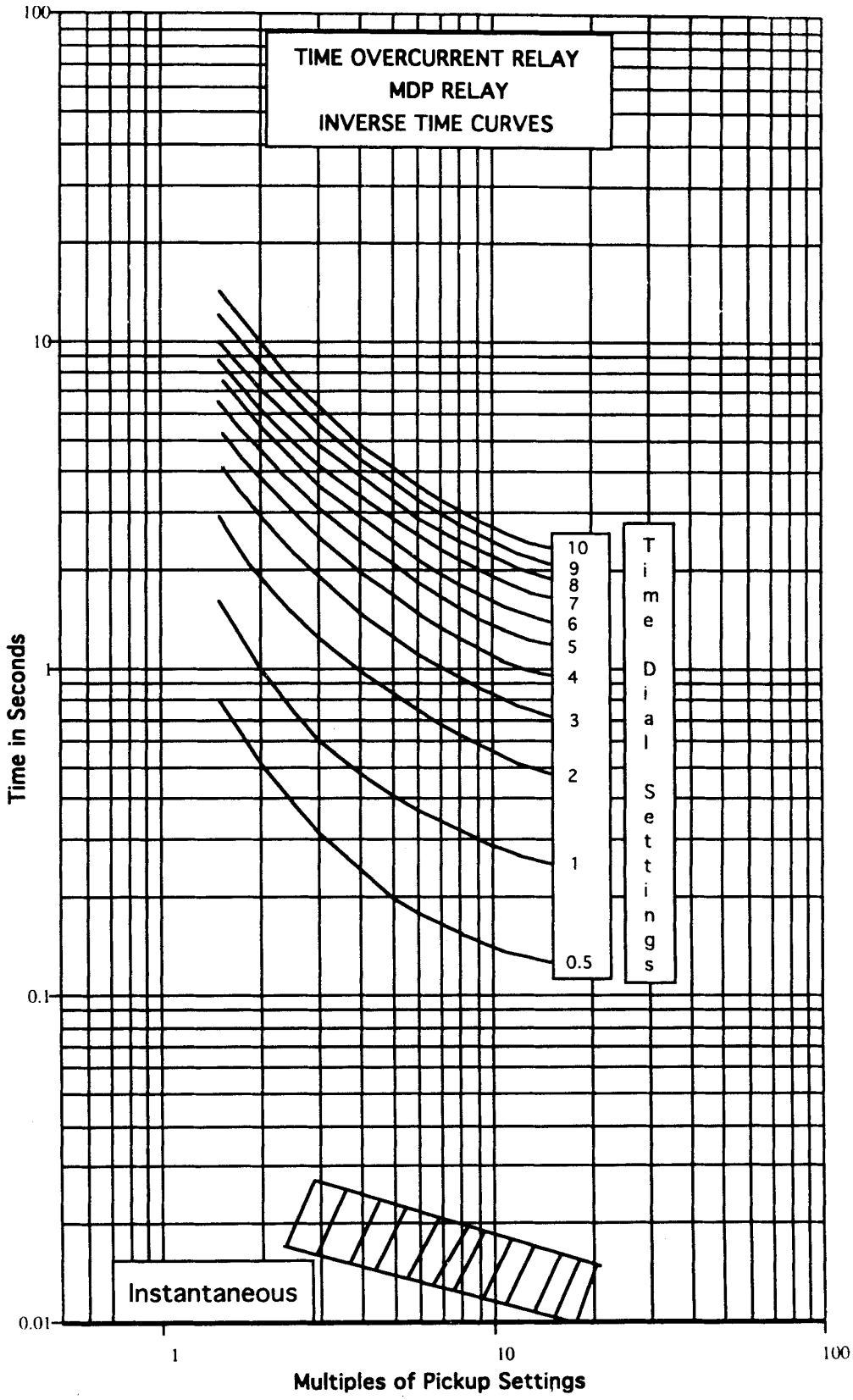


Figure 2–4: INVERSE TIME CURVE

2

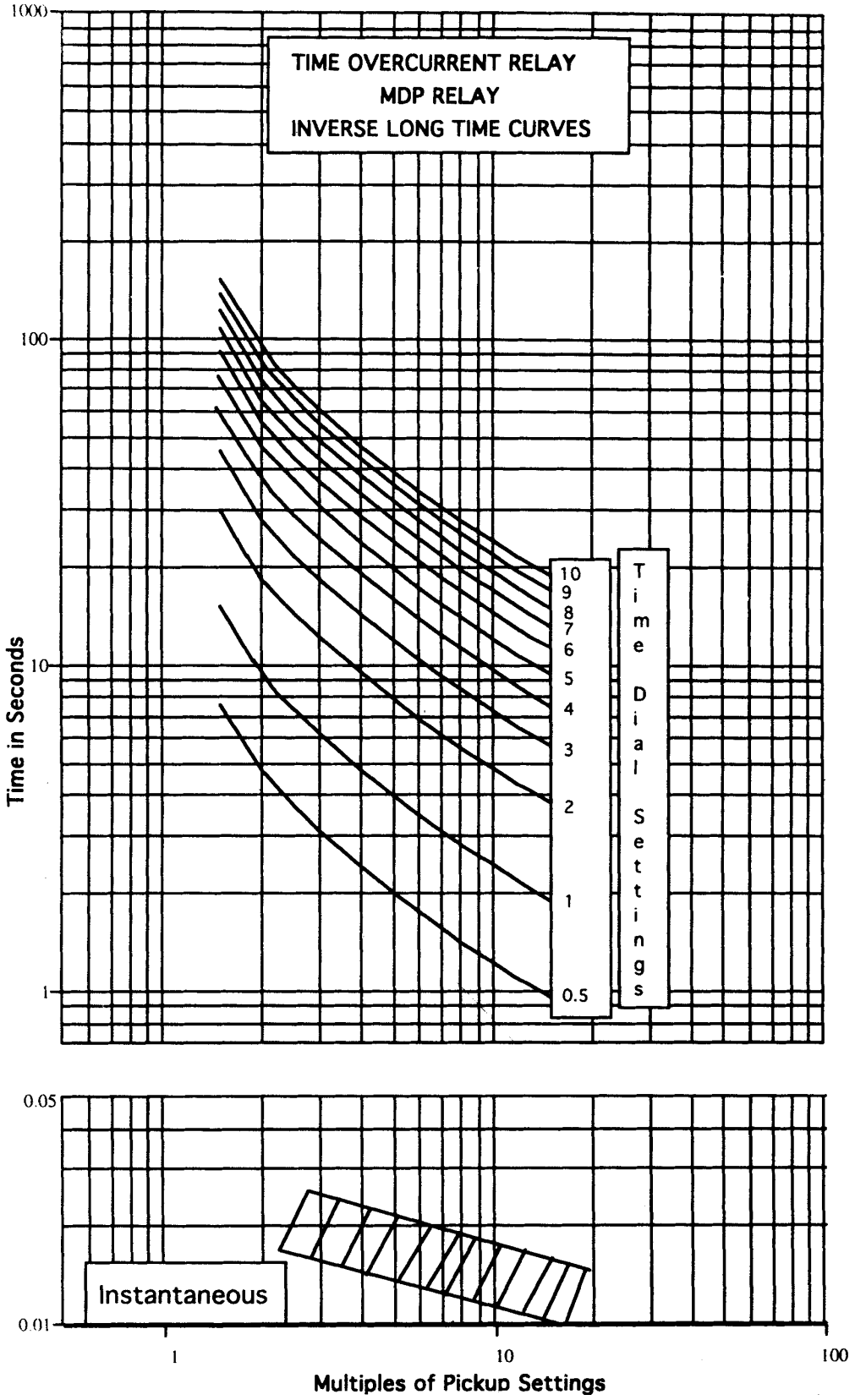


Figure 2–5: LONG INVERSE TIME CURVE

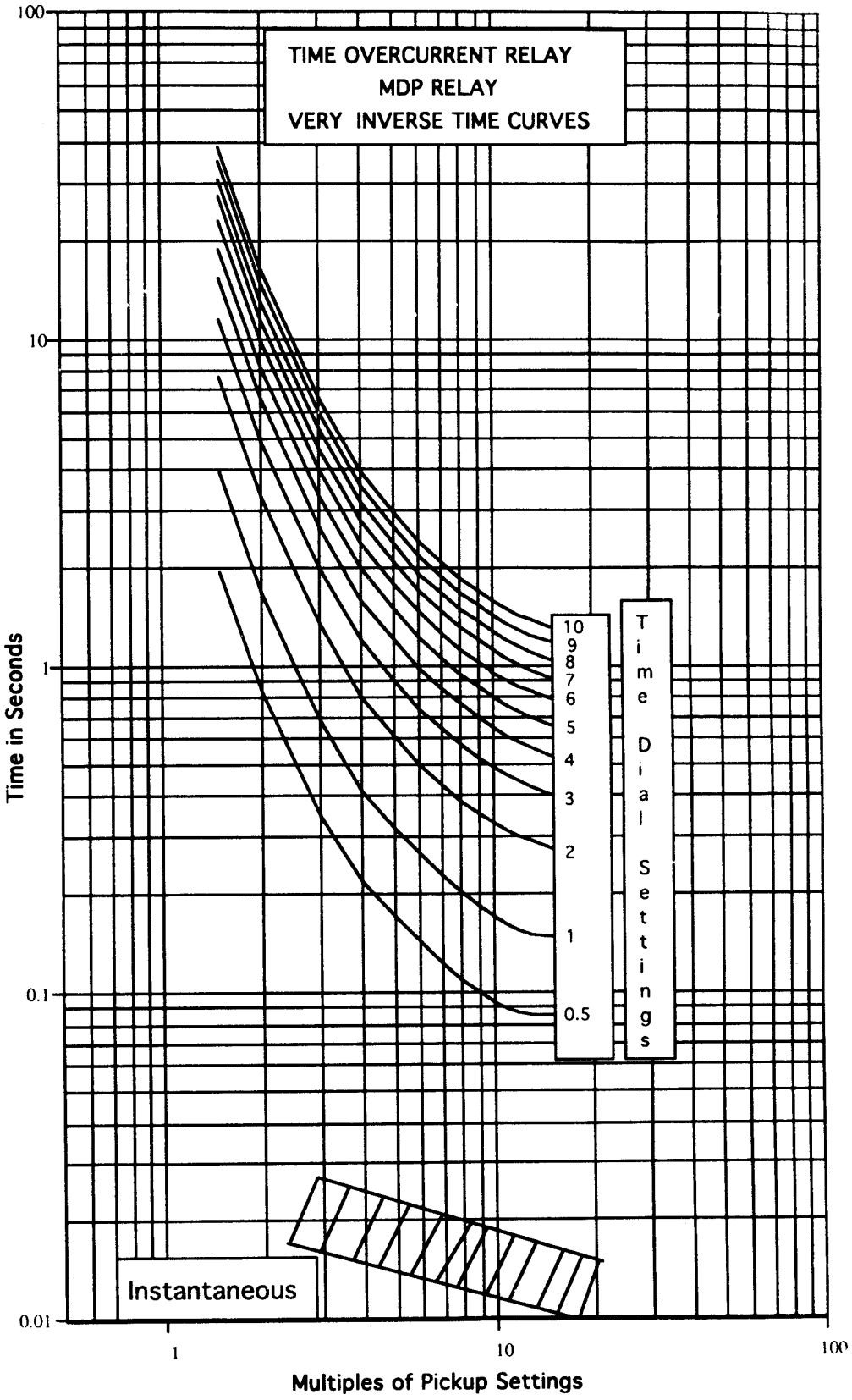


Figure 2–6: VERY INVERSE TIME CURVE

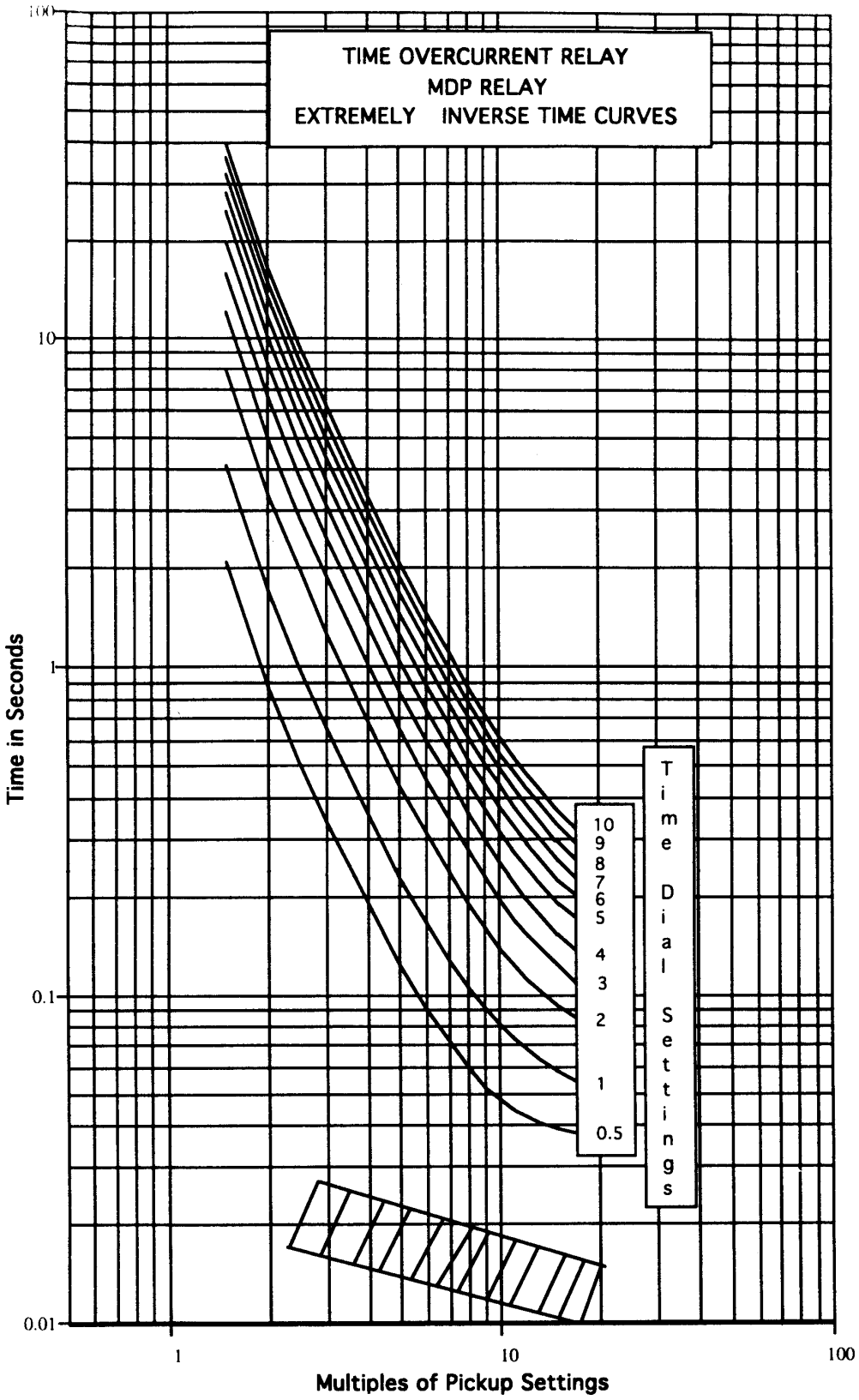


Figure 2–7: EXTREMELY INVERSE TIME CURVE

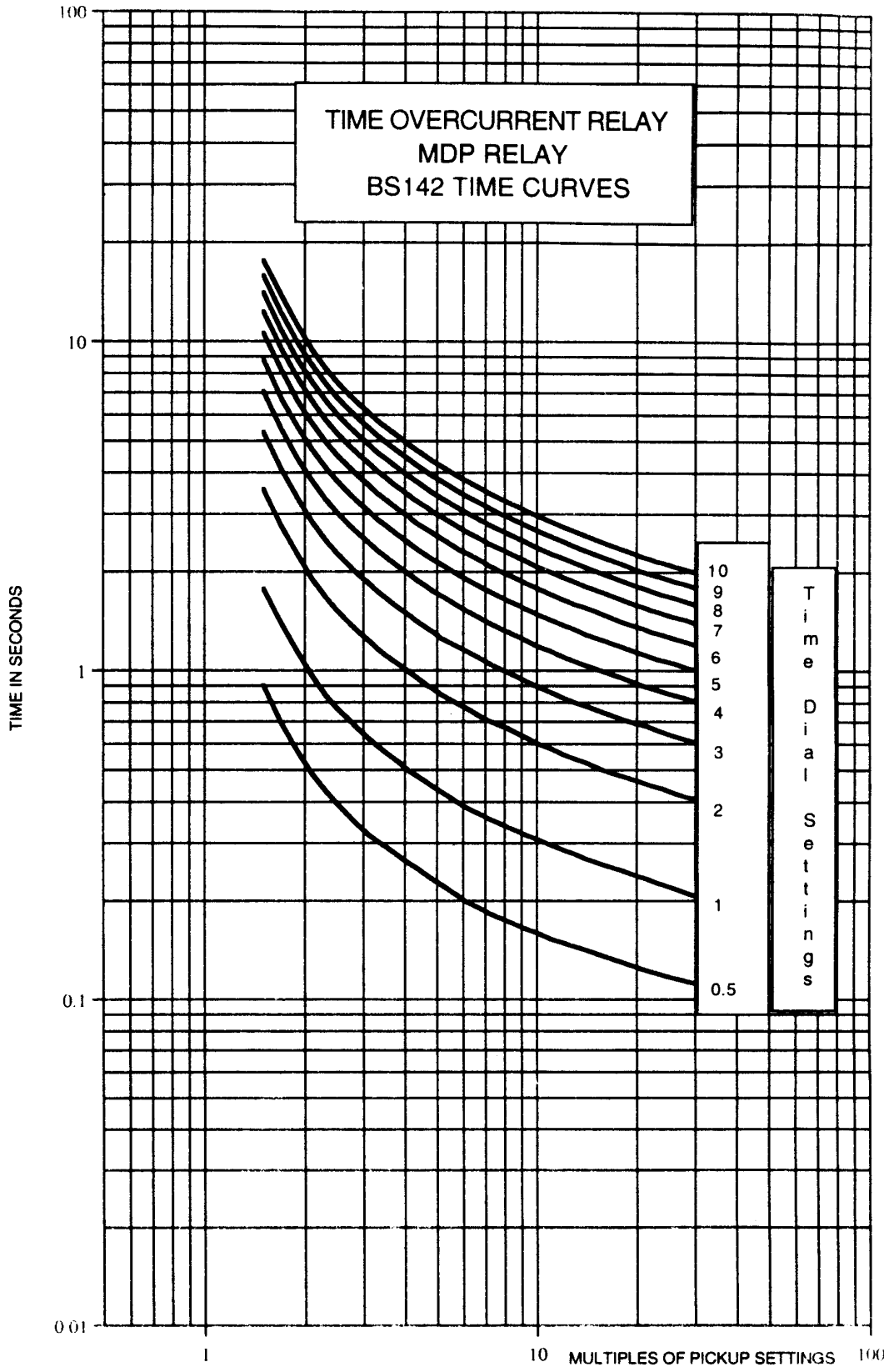


Figure 2–8: BS142 INVERSE TIME CURVE (1 A MODELS ONLY)

2.6 INSTANTANEOUS UNIT

The multiple of pickup TOC measurement is compared, independently for each phase and ground, with a user set value. If the set value is exceeded, a Pickup LED is turned on and a user programmable timer is started. When the timer times out, the relay trips and a Trip LED is turned on. The trip level is user adjustable independently for phase and ground. Likewise, the timer can be programmed, independently for phase and ground, between 0.0 and 1.55 seconds, in steps of 50 ms steps. The instantaneous unit can be disabled by setting the trip value multiplier to zero.

2.7 CHANGING SETTINGS

DO NOT CHANGE SETTINGS WHILE THE MDP IS IN OPERATION AND ITS PROTECTIVE ELEMENTS IN USE. TAKE THE RELAY OUT OF SERVICE BEFORE MAKING ANY SETTING CHANGES.

Settings can be changed by DIP switches on the front of the relay. Once the desired changes are made, the relay has to be initialized. Initialization is accomplished by depressing the reset lever for three seconds until the Ready LED goes out.

Any time a dip switch is changed, the Ready LED begins to flash twice per second. If the settings are returned to their previous positions, or if the relay is initialized by holding the reset lever for three seconds, the Ready LED will stop flashing but remain lit. If the relay settings are changed and the relay is not reset, it will continue to flash for three minutes, then it will accept the new settings and self-initialize.

Pickup current setting changes take effect immediately, altering the TOC and IOC elements, and could cause the relay to trip; this is unlike other types of changes, where the flashing of the Ready LED indicates that a change has been made but not yet finalized. Initializing the relay by pressing the reset lever will return the Ready LED to an ON condition.

2

a) PICKUP TOC

The pickup is the sum of the switches in the right-hand position, plus the base pickup. For example, if the second, third, and fifth phase TOC switches are in the right-hand position, the pickup current on a 5 A rated relay would be:

base of 1.5 + 0.75 + 1.5 + 6 A = 9.75 A

b) PICKUP IOC

The IOC pickup is the sum of the switches in the right-hand position *times the TOC pickup*. For example, if the second and third switches are in the right-hand position, the IOC pickup would be 2 + 4 = 6 times the TOC setting. Using the 9.75 A set above, this would result in an IOC pickup of 58.5 A.

c) TIME DIAL

The time dial is the sum of the switches in the right hand position plus the base 0.05 or 0.5. The time dial calibration is 0.05 for 1 A rated relays and 0.5 for 5 A rated relays.

d) CURVE SELECTION

Eight curves can be selected by means of the three curve selection switches. The settings are as follows:

CURVE	FIRST (TOP)	SECOND (MIDDLE)	THIRD (BOTTOM)
Inverse / (BS142) Inverse [1]	right	right	right
Very Inverse	right	right	left
Long Time Inverse	right	left	left
Extremely Inverse	right	left	right
2 Second Definite	left	right	right
4 Second Definite	left	right	left
6 Second Definite	left	left	right
8 Second Definite	left	left	left

1. For 1 A models, the inverse curve is defined by BS142

The time delay of the definite time curve is the range times the time dial for 1 A relays and the range times the time dial divided by 10 for 5 A relays. For example, to obtain a 3 second operating time, the time dial would be set first, third, and fourth switches to the right and second and fifth switches to the left, that is:

Time Dial = base of 0.05 + 0.05 + 0.2 + 0.2 A = 0.5 A [1 A]

or

Time Dial = base of 0.5 + 0.5 + 2 + 2 A = 5 A [5 A]

The 6 second curve would be chosen with the curve switches left, left, and right. The time delay is 6 (curve) times 0.5 (time dial) = 3 seconds for 1 A relays. For 5 A relays, the time dial (5) is divided by 10, also resulting in a 3 second delay.

e) IOC DELAY

The Instantaneous unit can be delayed from 0.05 to 1.55 seconds. The time delay is the sum of the switches in the right-hand position. For example, if only the third and fifth switches are in the right-hand position, the delay would be 0.2 + 0.8 = 1 second.

f) COMMUNICATIONS ADDRESS

The address for the communications port is set via three rotary switches on the rear of the cradle unit. A setting of 000 indicates no communications card is installed and disables the breaker status display. If breaker status is desired and there is no communications card installed, any address other than 000 or 999 may be set. See Figure 2–3: REAR VIEW SHOWING COMMUNICATION ADDRESS SWITCHES on page 2–3 for the location of the communication address switches.

NOTE

All MDP relays with the RS232 or RS485 protocol will respond to address 001.

g) OUTPUT CONTACT CONFIGURATION

The MDP relay has two output contacts that can be configured, by means of the output selection switch, allowing the user to distinguish either between phase and ground, or between time delay and instantaneous.

In the A position on the nameplate, IOC phase and ground trips are output on studs 11/12 and 14/15, and TOC phase and ground trips are output on studs 11/13 and 14/16.

In the B position on the nameplate, IOC or TOC ground trips are output on studs 11/13, and 14/16, and IOC or TOC phase trips are output on studs 11/12 and 14/15.

CONTACT	STUDS	A	B
K1a	11-12	IOC	IOC or TOC Phase
K2a	11-13	TOC	IOC or TOC Ground
K1b	14-15	IOC	IOC or TOC Phase
K2b	14-16	TOC	IOC or TOC Ground

2.9 DISPLAY AND RESET

The MDP relays are provided with a seven segment display, which can be scrolled without removing the cover, by pushing the reset lever.

Upon energizing the relay, a value appears on the display that indicates the relay state. In order to differentiate this from the rest of the information, it appears with the two decimal points illuminated. The values displayed indicate:

- **.0.0** Equipment in Service
- **.0.1** Internal settings are different from the external settings
- **80** Fatal flaw
- **CL** Breaker closed
- **OP** Breaker open

Pushing the reset lever for less than two (2) seconds advances through a sequence of data. This sequence is:

- **F0** Current Breaker status (open, closed)
- **F1** Phase A current, in multiples of pickup
- **F2** Phase B current, in multiples of pickup
- **F3** Phase C current, in multiples of pickup
- **F4** Ground current, in multiples of pickup
- **F5** Phase A current multiples for the last trip
- **F6** Phase B current multiples for the last trip
- **F7** Phase C current multiples for the last trip
- **F8** Ground current multiples at the last trip
- **F9** Operating time for the last trip

Last trip data, F5 to F9, is retained, provided auxiliary power is maintained.

The two-digit display can show a maximum operating time of 99 seconds. When the time exceeds 99 seconds, the MDP begins again from zero (0) with both decimal points lit to indicate the initial 100 units. If the time exceeds 199 seconds, the display shows 99 with both decimal points lit.

When the reset lever is pressed for less than 2 seconds, the next function appears on the display. If, for example, the phase A current is showing on the display and the lever is pushed, F2 appears, which indicates the next function, and the moment the lever is released, the display will show the value of this function, which is the B phase current multiples.

If the lever is held for more than 3 seconds, the In Service LED goes out and the relay initializes itself. The display shows the status function.

The relay can only be initialized if the input current is below pickup. If it has picked up, or has tripped and the fault persists, the display will show the actual function when the lever is released, and it will not initialize.

If the reset lever has not been pressed for more than two (2) minutes, phase A current appears on the display.

2.10 SELF-TEST AND ERROR ROUTINES

When the MDP relay detects a critical failure of one of its components, it immediately gives a fatal error order and disables the trip outputs. In this case, the relay program is put in a DO loop, from which it cannot exit until power is removed and the relay reenergized. Locally, the Ready LED goes out and the state of the relay is indicated by an "80" on the display, flashing once per second.

The first thing the MDP relay does when powered is to perform a complete check of the EPROM. If any error is detected, a Fatal Error output is given.

Once in operation, partial EPROM checks are made. If any one of these checks gives an error signal, the relay goes to Fatal Error status.

The MDP relay incorporates a WATCHDOG TIMER monitoring system for the program.