

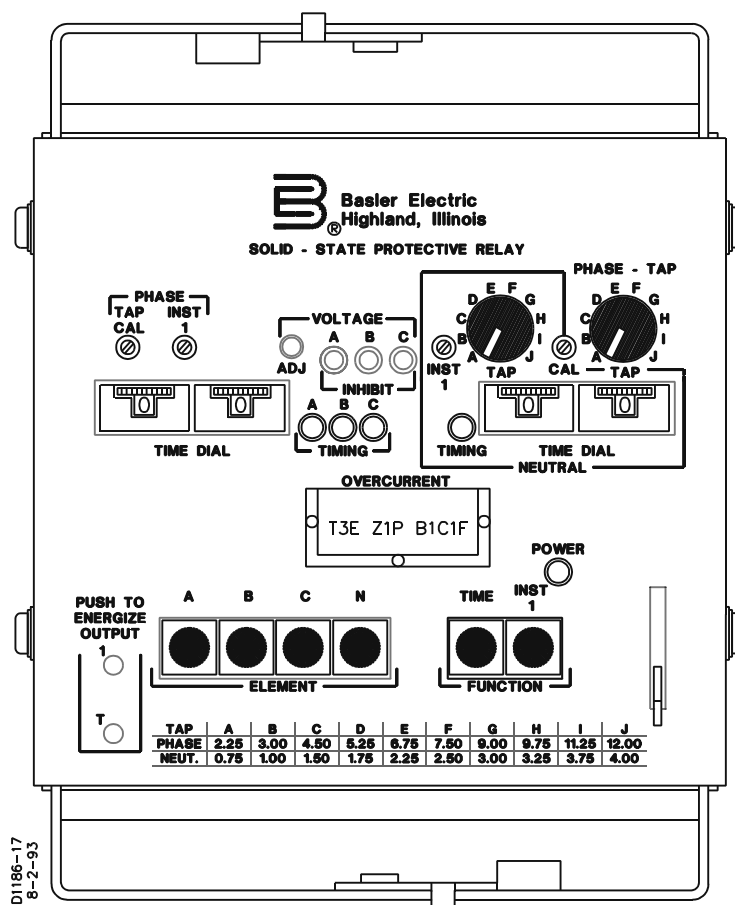
# INSTRUCTION MANUAL

## FOR

### TIME OVERCURRENT RELAY

### WITH VOLTAGE CONTROL

### MODEL BE1-51/27C



**Basler Electric**

# INTRODUCTION

The purpose of this Instruction Manual is to furnish information concerning the operation and installation of BE1-51/27C Time Overcurrent (with voltage control) Relays. To accomplish this, the following is provided:

- Specifications
- Functional characteristics
- Installation
- Operational Tests
- Setting Examples

## **W A R N I N G !**

To avoid personal injury or equipment damage, only qualified personnel should perform the procedures presented in this manual.

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# SECTION 1 • GENERAL INFORMATION

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## DESCRIPTION

BE1-51/27C Time Overcurrent Relays are microprocessor-based devices that monitor the magnitude of line current to provide accurate time-overcurrent protection with undervoltage control (when the voltage drops below the set point, the timing circuit is enabled). Instantaneous overcurrent element(s) and the neutral time overcurrent element, when supplied, operate independently of the undervoltage function. Each relay is available with one, three or four time overcurrent elements.

Basler BE1-51/27C relays provide backup protection for generators or transformers. Voltage control provides discrimination between load and fault conditions by allowing the time overcurrent pickup to be set below the maximum load (or swing) current. For sustained fault conditions, the synchronous reactance,  $X_{d(unsat)}$ , is typically larger than for normal load,  $X_{d(sat)}$ . As a result, if the regulator is not in service, the three-phase fault current will be less than the normal maximum load current. The relay pickup should be set below rated maximum load current (e.g., 50 percent of rated) to ensure dependable backup. The BE1-51/27C relay may also be used to provide primary phase fault protection for small generators or backup protection for transformers.

When the BE1-51/27C is used to protect for faults on either side of a delta-wye power transformer, phase overcurrent units should be supplied on all three phases (either three single-phase relays or one three-phase relay). For this application, each phase time overcurrent element should be controlled by the phase-to-ground voltage on its phase rather than by the phase-phase voltage.

Because the time overcurrent pickup of the phase element(s) does not vary with voltage level (the element is either enabled or not depending upon voltage level), conventional time coordination techniques apply.

A neutral (ground) overcurrent element can be applied and connected residually to a set of three current transformers on solidly grounded applications or on impedance grounded systems that provide ground fault current approximating the generator rated current level. The neutral element can also be connected to a 10:1 ampere, zero-sequence window current transformer to provide protection on systems producing a minimum of about 20 amperes primary current. Still another alternative would be connecting this device to a current transformer in the neutral of a generator or power transformer.

Instantaneous elements can be used for transformer back-up applications when connected on the source side of the power transformer. Because the pickup of these elements can be set above the relay current flowing in the low-side fault, coordination can be achieved. Instantaneous overcurrent elements would not ordinarily be used for a generator back-up function because they would not operate correctly for faults external to the generator zone.

Under normal operating conditions, the phase time overcurrent pickup will be less than the maximum load or non-fault current. As long as the rated voltage is applied to the relay, no operation will occur. However, if a fuse opens on the voltage transformer and interrupts the signal, the relay will see this as a fault condition (i.e., current level above pickup and voltage level below minimum set point) and operate accordingly. The Basler Electric BE1-60 Voltage Balance Relay can prevent such a misoperation where two sources of signal voltage are available. This relay compares the output of two signal sources, to detect an anomaly in one of these sources and block the operation of those devices connected to that signal source. Therefore, for generator applications, the Basler BE1-60 Voltage Balance relay should be used in conjunction with the BE1-51/27C to prevent misoperations due to loss of the voltage source.

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## STANDARD FEATURES

### Time Overcurrent

Time overcurrent elements pick up over a range of 0.1 to 0.8 amperes, 0.3 to 2.4 amperes, 0.5 to 4.0 amperes, 1.5 to 12.0 amperes, 0.1 to 2.4 amperes or 0.5 to 12.0 amperes and provide an adjustable time delay that is proportional to the overcurrent. Time delay is initiated when the sensed current exceeds the pickup point. When the current drops below the pickup point, the timing circuit is reset immediately. At reset, the output contacts, if operated, are restored to normal.

Adjustment of the overcurrent pickup point is provided by controls on the relay front panel. Time delay is a function of the characteristic curve that has been selected. Time delay is settable from 00 to 99 on the front panel **Time DIAL** thumbwheel switch. Curve type is either selected as an option or, in some models, is switch selectable.

Sixty-nine characteristic curves and three timing options are available. They are:

Characteristic curves:

- Seven inverse time
- Nine  $I^2T$
- Seven inverse time with extended timing range
- Nine  $I^2T$  with extended timing range
- Five British Standard 142 (E curves)
- Seven integrating inverse time
- Nine integrating  $I^2T$
- Seven integrating inverse time with extended timing range
- Nine integrating  $I^2T$  with extended timing range

Timing Option Z1 (switch selectable - 16 position) B & C curves:

- Seven inverse time
- Nine  $I^2T$

Timing option Z1 with option 2-D or 2-E, (switch selectable - 16 position) B and C curves:

- Seven inverse time with extended timing range
- Nine  $I^2T$  with extended timing range

Timing Option Z2 (switch selectable - 16 position) B and E (British Standard 142) curves:

- Seven inverse time
- One  $I^2T$
- Five British Standard (BS) 142 (E curves)

Timing Option Z2 with option 2-D or 2-E, (switch selectable - 16 position) B and E (BS142) curves:

- Seven inverse time with extended timing range
- One  $I^2T$  with extended timing range
- Five British Standard 142 (E curves)

Timing Option Z3 (switch selectable - 16 position) integrating B & C curves:

- Seven integrating inverse time
- Nine integrating  $I^2T$

Timing Option Z3 with option 2-D or 2-E, (switch selectable - 16 position) integrating extended B & C curves:

- Seven integrating inverse time with extended timing range
- Nine integrating  $I^2T$  with extended timing range

Characteristic curves are shown by the graphs in Figures A-1 through A-69. Note that each graph (i.e., function) consists of a set of representative curves. Each curve (as well as any between-curve interpolation) is selectable by the front panel **TIME DIAL** using a two-digit designation from 00 to 99. Because of space limitations, each graph shows only 14 of the 100 possible selections.

### Non-Integrating Timing

Timing options Z1 and Z2 and the characteristic curves available with those options use non-integrating timing. Non-integrating timing is accomplished by timing at a gate that is not solely dependent on the magnitude of the applied multiple of pickup current. The time-out value is calculated based on the type of time curve characteristic selected, time dial setting and the magnitude of the applied multiple of pickup current. The time-out value is continuously updated during the timing cycle. When pickup is exceeded, a timer is initiated. When the timer elapsed time exceeds the calculated time-out value, a time trip output signal is generated.

This type of non-integrating time delay characteristic exhibits a dynamic characteristic that is immediately responsive to changes of the applied multiple of pickup current.

## Integrating Timing

Timing option Z3 and the characteristic curves available for that option uses integrating timing. Integrating timing is accomplished by summing time increments that are based on the magnitude of the applied multiple of pickup current, the time curve characteristic selected and the time dial value. These time increments are summed until a predetermined value is exceeded, then a time trip output signal is generated.

This type of integrating time delay characteristic simulates the operating characteristics of an electromechanical overcurrent relay.

## Built-In Test

A built-in test (BIT) switch mounted on the Logic Board provides diagnostic troubleshooting and calibration.

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## OPTIONS

### Timing

An extended timing option multiplies by approximately 5.7, the standard time delays. The resulting curves are shown following the standard curves, e.g., Figure A-1 is timing type B1 and Figure A-2 is the timing type B1 with extended timing range. (Refer to Appendix A, *Time Overcurrent Curves*.)

When timing option Z1, Z2 or Z3 is specified, a printed circuit board mounted selector switch allows a choice of up to sixteen different time overcurrent functions. Timing Option Z1 or Z3 may be further specified as standard or extended time, depending upon Option 2 selection.

### Sensing Input Type

When single-phase, two-phase-and-neutral, three-phase or three-phase-and-neutral sensing has been specified, the front panel **TAP** selector and the front panel **TAP CAL** control set the pickup point for all phases. An independent front panel **TAP (NEUTRAL)** selector and front panel **CAL (NEUTRAL)** control set the neutral pickup point. Also, for three-phase-and-neutral sensing units, one of the seven sensing input range combinations must be specified.

Relay circuits inhibit the phase-element time overcurrent operation for a specific phase if the monitored ac voltage exceeds a preselected level. The voltage level is established by a front panel **VOLTS ADJ** control and all phases are inhibited at the same voltage level. *Neutral overcurrent elements are not inhibited.* When the voltage inhibit level is exceeded, front panel **INHIBIT** LED is lit for the affected phase and the front panel **TIMING** LED for that particular phase extinguishes.

### Sensing Input Range

For three-phase-and-neutral sensing units, input ranges are:

- 0.5 to 4.0 amperes (phase and neutral)
- 1.5 to 12 amperes (phase) and 0.5 to 4.0 amperes (neutral)
- 0.5 to 4 amperes (phase) and 1.5 to 12 amperes (neutral)
- 1.5 to 12 amperes (phase and neutral)
- 0.1 to 0.8 amperes (phase and neutral)
- 0.3 to 2.4 amperes (phase) and 0.1 to 0.8 amperes (neutral)
- 0.3 to 2.4 amperes (phase and neutral)

For all other units, two ranges are available. They are 0.5 to 12 amperes and 0.1 to 2.4 amperes.

### Power Supply

Five power supply options are available. They are:

- 48 Vdc
- 125 Vdc and 100/125 Vac



- 24 Vdc
- 48 Vdc or 125 Vdc and 100/125 Vac (jumper selectable)
- 250 Vdc and 230 Vac

## Targets

Single-phase relays have two function targets that indicate when the time delay or instantaneous elements(s) have operated. On multiple phase relays, additional targets indicate which phase or neutral elements(s) operated.

Function targets may be specified as either internally operated or current operated by a minimum of 0.2 amperes through the output trip circuit. When current operated, the output circuit must be limited to 30 amperes for 0.2 seconds, 7 amperes for 2 minutes and 3 amperes continuously. Element targets are internally operated.

## Outputs

Optional normally opened, normally closed or SPDT auxiliary output contacts may be selected. Contacts actuate when the output relay is energized. Internally operated front panel mounted targets and front panel targets operated by the dc current in the output circuit are available for the time overcurrent and instantaneous overcurrent functions. Optional front panel mounted **BUSH-TO-ENERGIZE-OUTPUT** pushbuttons allow direct actuation of each output relay for external circuit testing.

## Instantaneous Outputs

One or two instantaneous overcurrent outputs are optionally available. Each is adjustable up to 40 times the time overcurrent pickup point. When the sensed current exceeds the instantaneous overcurrent pickup point, an output relay is energized. An independent front panel control (**INST 1** or **INST 2**) adjusts the pickup point for each optional output. If more than one phase is applied to the relay, the instantaneous pickup point will be the same for all phases. If neutral current is sensed, a front panel **INST 1 (NEUTRAL)** provides adjustment of the neutral pickup point. Instantaneous overcurrent elements are not voltage controlled.

## Packaging

Each relay is mounted in a drawout cradle and enclosed in a standard utility style case with either semi-flush or projection mounting (depending upon case style selected). Circuit components are accessed by removing the individual printed circuit boards from the relay cradle. Use an extender card (Basler Electric part number: 9 1655 00 100) to test and troubleshoot the relay. An available test plug (Basler Electric part number: 10095 or G.E. part number 12XLA12A1) allows the relay to be tested in place without disturbing external control circuit wiring.

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## MODEL AND STYLE NUMBER DESCRIPTION

BE1-51/27C Time Overcurrent Relays electrical characteristics and operational features are defined by a combination of letters and numbers that make up its style number. The model number, together with the style number, describe the options included in a specific device and appear on the front panel, drawout cradle and inside the case assembly. Upon receipt of a relay, be sure to check the style number against the requisition and the packing list to ensure that they agree.

Style number identification chart (Figure 1-1) defines the electrical characteristics and operational features included in BE1-51/27C relays. For example, if the style number were **T3E Z1P B1C1F**, the device would have the following:

- (T)** - 3-Phase-and-neutral sensing, 60 Hz
- (3)** - Sensing input range of 1.5 to 12.0 A for phase, 0.5 to 4.0 A for neutral
- (E)** - N.O. outputs
- (Z1)** - Switch selectable B and C time overcurrent characteristic curves
- (P)** - Operating power derived from 125 Vdc or 100/120 Vac

- (B) - Current operated targets
- (1) - One instantaneous element
- (C) - Push-to-energize outputs
- (1) - N.O. auxiliary timed output relay
- (F) - Semi-flush mounting

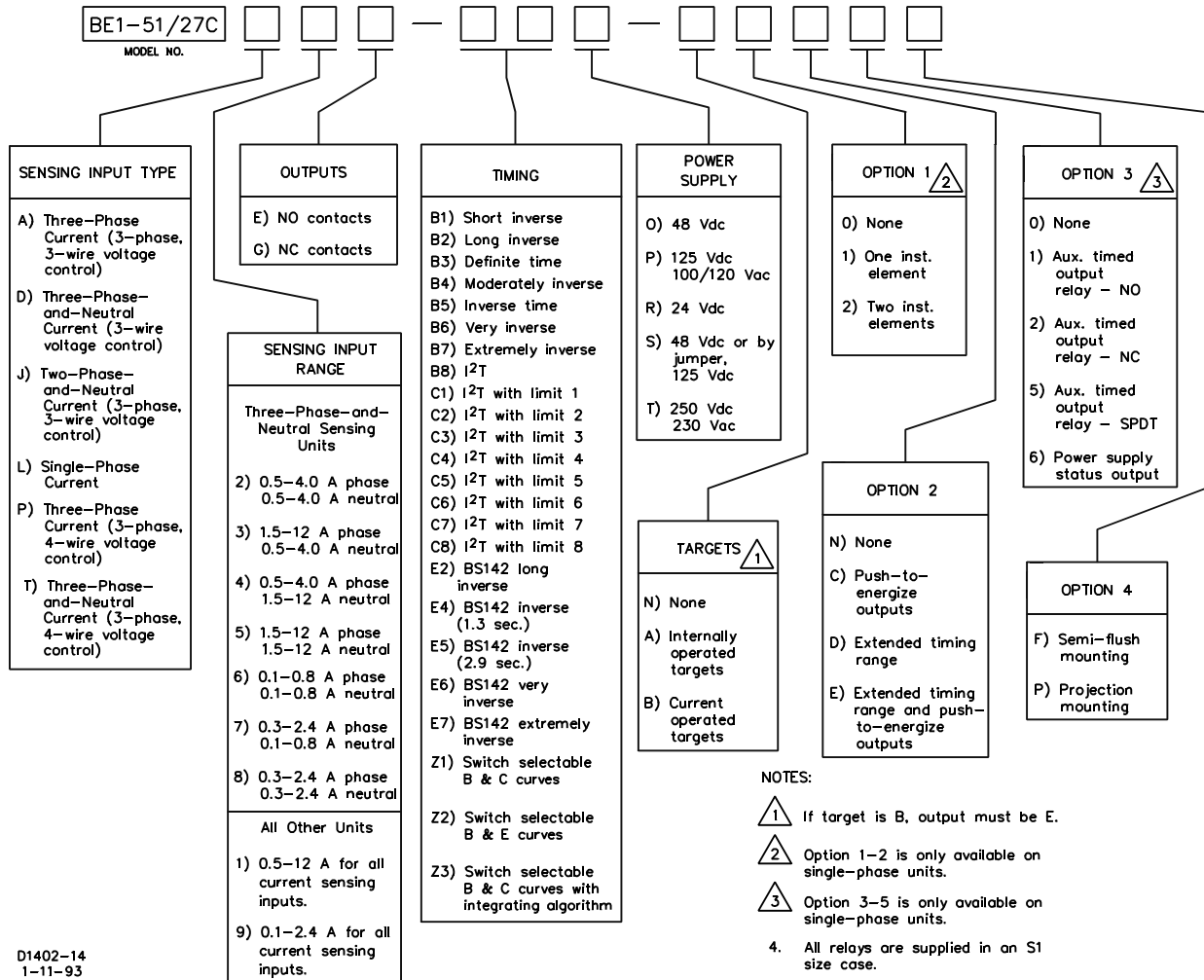


Figure 1-1. Style Number Identification Chart

## SPECIFICATIONS

BE1-51/27C Time Overcurrent Relays electrical and physical specifications are as follows:

### Voltage Sensing Inputs

Rated for 160 Vac continuous at 40 to 70 Hz (nominal frequency 50 or 60 Hz) with a maximum burden of 1 VA.

### Voltage Sensing Selection Range

Continuously adjustable over the range of 40 to 120 Vac.

<b>Voltage Sensing Accuracy</b>	±2% of pickup setting.
<b>Sensing Input Burden</b>	Less than 0.1 ohms per phase or neutral.
<b>Sensing Input Rating</b>	The maximum 1 second current rating is 50X (times) maximum tap current selected or 500 A, whichever is less. Maximum continuous current is 20 A. For ratings other than those specified by the time curves, rating is calculated as follows:  $I = \frac{(50 \times \text{tap value or } 500\text{A, whichever is less})}{\sqrt{T}}$ <p>where: I = maximum current and T = current flow in seconds</p>
<b>Time Overcurrent Pickup Selection Range</b>	Continuously adjustable over the current sensing input ranges specified in the Style Chart (Figure 1-1).
<b>Time Overcurrent Measuring Accuracy</b>	±2% of the pickup setting.
<b>Time Overcurrent Dropout Ratio</b>	Better than 92% of pickup level.
<b>Instantaneous Overcurrent Pickup Range</b>	Continuously adjustable over the range of 1 to 40 times the time overcurrent pickup setting.
<b>Instantaneous Overcurrent Measuring Accuracy</b>	±2% of pickup setting.
<b>Instantaneous Overcurrent Dropout Ratio</b>	Better than 98% of pickup level.
<b>Time Delay Accuracy</b>	±5% of the characteristic curve (Figures 1-2 through 1-70) for any combination of the front panel <b>TIME DIAL</b> setting and the front panel <b>TAP/TAP CAL</b> overcurrent pickup setting.  Repeatability is within ±2% of setting at 25°C.
<b>Output Circuits</b>	Output contacts are rated as follows:
<u>Resistive:</u>	
120/240 Vac	Make 30 A for 0.2 seconds, carry 7 A continuously and break 7 A.
250 Vdc	Make and carry 30 A for 0.2 seconds, carry 7 A continuously and break 0.3 A.
500 Vdc	Make and carry 15 A for 0.2 seconds, carry 7 A continuously and break 0.1 A.
<u>Inductive:</u>	
120/240 Vac, 125/250 Vdc	Make and carry 30 A for 0.2 seconds, carry 7 A continuously and break 0.3 A. (L/R = 0.04).
<b>Target Indicators</b>	Function targets may be specified as either internally operated or current operated by a minimum of 0.2 A through the output trip circuit. When current

operated, the output circuit must be limited to 30 A for 0.2 seconds, 7 A for 2 minutes and 3 A continuously.

## Power Supply

Input power may be obtained from a variety of ac or dc external power sources. Refer to Table 1-1 for available power supply options

*Table 1-1. Power Supply Specifications*

Type	Nominal Input Voltage	Input Voltage Range	Burden at Nominal
O	48 Vdc	24 to 60 Vdc	6.6 W
P	125 Vdc 120 Vac	62 to 150 Vdc 90 to 132 Vac	6.7 W 12.8 VA
R	24 Vdc	12 to 32 Vdc	7.2 W
S *	48 Vdc 125 Vdc	24 to 60 Vdc 62 to 150 Vdc	5.0 W 5.3 W
T	250 Vdc 230 Vac	140 to 280 Vdc 190 to 270 Vac	7.8 W 19.8 VA

### NOTES:

All references are at 50/60 Hz.

\* Type S Power Supply is field selectable for 48 or 125 Vdc. Selection must be implemented at time of installation. This power supply option is factory set for 125 Vdc.

## Isolation

1500 Vac at 60 hertz for one minute in accordance with IEC 255-5 and ANSI/IEEE C37.90-1989 (Dielectric Test).

## Radio Frequency Interference (RFI)

Field tested using a five watt, hand-held transceiver operating at random frequencies centered around 144 MHz and 440 MHz with the antenna located six inches from the relay in both horizontal and vertical planes.

## Surge Withstand Capability

Qualified to ANSI/IEEE C37.90.1-1989 Standard Surge Withstand Capability (SWC) Tests for Protective Relays and Relay Systems.

## UL Recognized

UL Recognized per Standard 508, UL File No. E97033. Note: Relay is not UL Recognized for output contact voltages greater than 250 volts and input power supply voltages greater than 150 volts.

## Operating Temperature

-40° C (-40° F) to +70° C (+158° F).

## Storage Temperature

-65° C (-85° F) to +100° C (+212° F).

## Shock

In standard tests, the relay has withstood 15 g in each of three mutually perpendicular planes without structural damage or degradation of performance.

## Vibration:

In standard tests, the relay has withstood 2 g in each of three mutually perpendicular planes, swept over the range of 10 to 500 Hz for a total of six

sweeps, 15 minutes each sweep without structural damage or degradation of performance.

**Weight**

Single-Phase: 13.0 lbs. (5.9 kg)

Three-Phase: 14.0 lbs. (6.4 kg)

Three-Phase -and Neutral: 14.4 lbs. (7.2 kg)

**Case Size**

S1

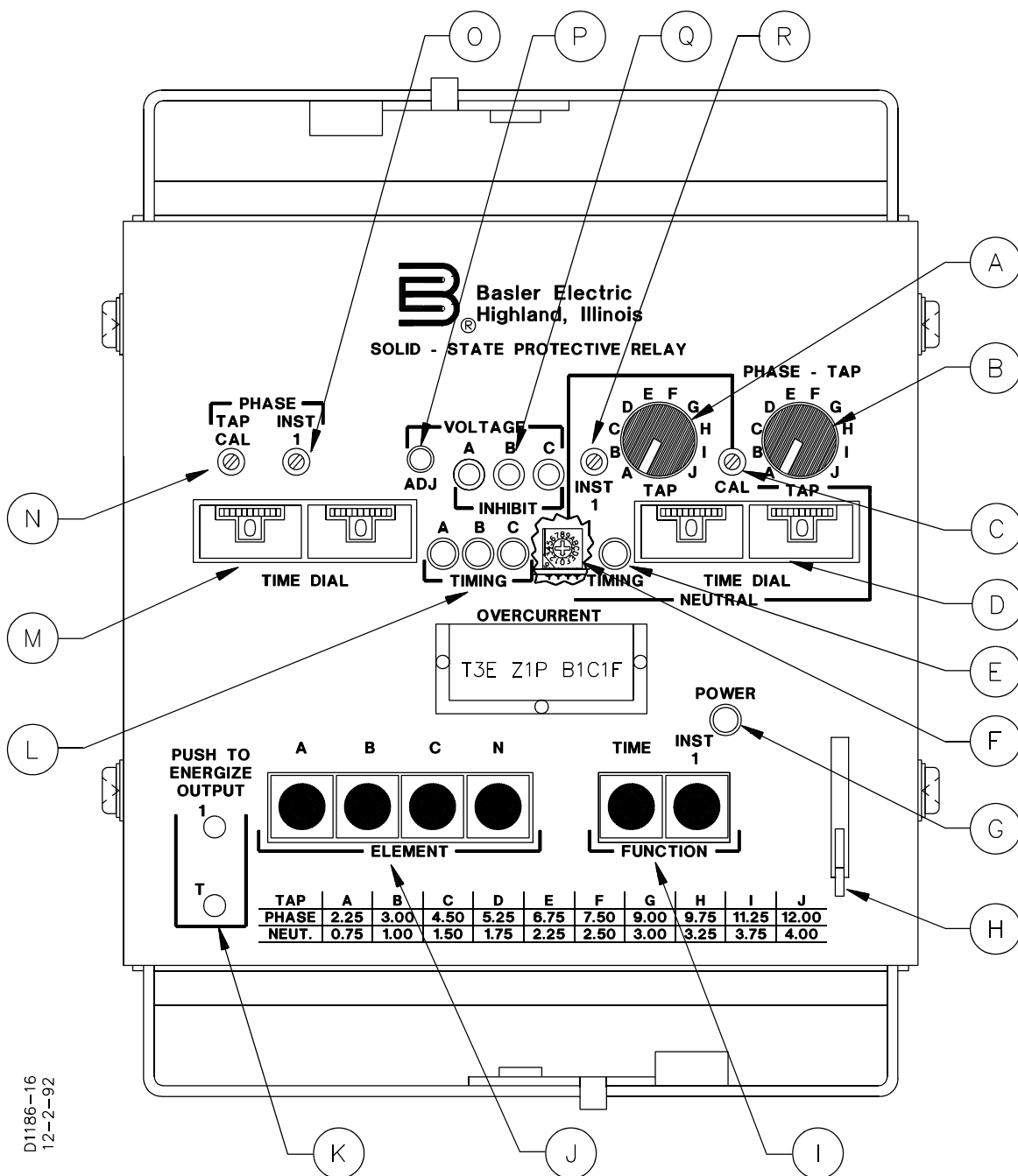
# SECTION 2 • HUMAN-MACHINE INTERFACE

## GENERAL

Table 2-1 lists and briefly describes the operator controls and indicators (that is, the human-machine interface [HMI]) of the BE1-51/27C Time Overcurrent Relay with voltage control. Reference the call-out letters to Figure 2-1.

*Table 2-1. Controls and Indicators*

Letter	Control or Indicator	Function or Indicator
A	<b>TAP NEUTRAL</b> Selector	Provides selection of the neutral overcurrent pickup point in conjunction with the front panel <b>NEUTRAL CAL</b> control.
B	<b>PHASE - TAP</b> Selector	Provides the selection of the overcurrent pickup point in conjunction with the front panel <b>TAP CAL</b> control.
C	<b>CAL NEUTRAL</b> Control (On Relays with Phase and Neutral Sensing, only)	A single turn potentiometer provides adjustment of the neutral overcurrent pickup point between the selected tap setting and the next lower tap setting.
Not shown	<b>TAP RANGE</b> Plate High/Low	Plate position indicates the terminal connections (high or low) used to select the current sensing input range. Refer to Table 2-2 for sensing input ranges.
D	<b>TIME DIAL NEUTRAL</b> (if present)	Determines the time delay between sensing of the overcurrent condition and the closing of the output relay. Refer to Section 1 and Table 2-3 for curve selection information.
E	<b>TIMING NEUTRAL</b> (if present)	LED illuminates when the neutral pre-set overcurrent pickup point is reached and exceeded.
F	Time Current Characteristic Curve Selector (Z1, Z2 and Z3 Timing Options only)	Provides selection of the time current characteristic curves. Refer to Section 1 and Table 2-3 for curve selection information. Cutaway view shows switch behind the front panel.
G	<b>POWER</b> Indicator	LED illuminates to indicate that the relay power supply is functioning.
H	Target Reset Lever	Manually resets all targets (both element and function type).
I	<b>FUNCTION</b> Targets <b>TIME INST1, INST2</b> *	Front panel <b>FUNCTION</b> targets trip when the corresponding output relay is energized by an overcurrent condition.
J	<b>ELEMENT</b> Targets	Front panel <b>ELEMENT</b> targets trip when an output relay is energized by an overcurrent condition.



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Figure 2-1. Location of Controls and Indicators

Table 2-1. Controls and Indicators - continued

Letter	Control or Indicator	Function or Indicator
K	<b>PUSH-TO-ENERGIZE OUTPUT</b> Pushbutton	Actuation of this function is by a thin non-conducting rod ( <i>do not use a screwdriver</i> ) through a hole in the front panel. This allows the output relays to be manually energized for testing of the external trip circuit(s).  <b>ELEMENT</b> targets, where supplied, are not operated by this control.
L	<b>TIMING</b> Indicator	LEDs illuminate when the preset overcurrent pickup point is reached and exceeded.
M	<b>TIME DIAL</b> Selector	Determines the time delay between sensing of the overcurrent condition and the closing of the output relay. Refer to Section 1 and Table 2-3 for curve selection information.
N	<b>TAP CAL</b> Control	A single turn potentiometer provides adjustment of the phase overcurrent pickup point between the selected tap setting and the next lower tap setting.
O	<b>INST 1</b> Control (Options 1-1 and 1-2 Only) †	A four turn potentiometer provides adjustment of the front panel <b>INST 1</b> trip setting over the range of 1 to 40 times the selected phase time overcurrent pickup (TAP) value.
P	<b>VOLTAGE INHIBIT A, B, C * ADJ</b>	A four turn potentiometer provides continuous adjustment over a range of 40 to 120 Vac of the sensed input front panel <b>VOLTAGE INHIBIT</b> level.
Q	<b>VOLTAGE INHIBIT A, B, C *</b> Indicator(s)	LEDs illuminate when the sensed input voltage level exceeds the front panel pre-set <b>VOLTAGE INHIBIT</b> level.
R	<b>INST 1 NEUTRAL</b> Control (Options 1-1 and 1-2 Only) †	A four turn potentiometer provides adjustment of the front panel <b>INST 1 NEUTRAL</b> trip setting over the range of 1 to 40 times the selected neutral time overcurrent pickup (TAP) value.
Not shown	<b>INST 2</b> Control (Option 1-2 Only) †	A four turn potentiometer provides adjustment of the front panel <b>INST 2</b> trip setting of the range of 1 to 40 times the selected phase time overcurrent pickup (TAP) value.
Not shown	N/T (Normal/Test) Switch S1	This switch is mounted internally on the logic board. Switch S1 provides stored built-in-test (BIT) programs used during troubleshooting, repair and calibration. This switch is not used during normal relay setting or operational testing.

#### LEGEND

- \* The number of phases and neutral sensed by the relay is defined by the sensing input type (see the Style Identification Chart, Figure 1-1).
- † This instantaneous overcurrent sensing circuit detects levels that are multiples of the level selected for the time overcurrent sensing circuit. Any change of the tap selector or calibration (CAL) controls will cause a directly proportional change of the instantaneous overcurrent levels.



Table 2-2. Sensing Input Ranges

TAP Range Plate or Pickup	TAP Selector										Current Sensing Terminals			
	A	B	C	D	E	F	G	H	I	J	φA	φB	φC	N
<b>Sensing Input Range 1, Single-Phase *</b>														
<b>HIGH</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	8,7	-----	-----	-----
<b>LOW</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	9,7	-----	-----	-----
<b>Sensing Input Range 1, Three-Phase *</b>														
<b>HIGH</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	8,7	14,15	17,18	-----
<b>LOW</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	9,7	13,15	16,18	-----
<b>Sensing Input Range 1, Two-Phase and Neutral *</b>														
<b>HIGH</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	8,7	-----	14,15	17,18
<b>LOW</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	9,7	-----	13,15	16,18
<b>Sensing Input Range 2, Three-Phase and Neutral</b>														
<b>Phase or Neutral</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	8,9	13,14	15,16	17,18
<b>Sensing Input Range 3, Three-Phase and Neutral</b>														
<b>Phase</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	8,9	13,14	15,16	-----
<b>Neutral</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	-----	-----	-----	17,18
<b>Sensing Input Range 4, Three-Phase and Neutral</b>														
<b>Phase</b>	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	8,9	13,14	15,16	-----
<b>Neutral</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	-----	-----	-----	17,18
<b>Sensing Input Range 5, Three-Phase and Neutral</b>														
<b>Phase or Neutral</b>	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.2 5	12.0 0	8,9	13,14	15,16	17,18
<b>Range 6, Three-Phase-and-Neutral</b>														
<b>Phase or Neutral</b>	0.15	0.20	0.30	0.35	0.45	0.50	0.60	0.65	0.75	0.80	8,9	13,14	15,16	17,18
<b>Sensing Input Range 7, Three-Phase and Neutral</b>														
<b>Phase</b>	0.45	0.60	0.90	1.05	1.35	1.50	1.80	1.95	2.25	2.40	8,9	13,14	15,16	-----
<b>Neutral</b>	0.15	0.20	0.30	0.35	0.45	0.50	0.60	0.65	0.75	0.80	-----	-----	-----	17,18
<b>Sensing Input Range 8, Three-Phase and Neutral</b>														
<b>Phase or Neutral</b>	0.45	0.60	0.90	1.05	1.35	1.50	1.80	1.95	2.25	2.40	8,9	13,14	15,16	17,18
<b>Sensing Input Range 9 (All Other Sensing Types) *</b>														
<b>HIGH</b>	0.45	0.60	0.90	1.05	1.35	1.50	1.80	1.95	2.25	2.40	Same a Range 1			
<b>LOW</b>	0.15	0.20	0.30	0.35	0.45	0.50	0.60	0.65	0.75	0.80	Same a Range 1			

NOTE: \* For relays with sensing input range 1 or 9, connect the system wiring to the current sensing terminals for the desired range (HIGH or LOW).

Table 2-3. Timing Curve Selection Table

Timing Type	Selector Position *	Selector Position †	Standard Curves Z1, Z2 Fig. No.	Extended Curves Z1, Z2 Fig. No.	Standard Curves Z3 Fig. No.	Extended Curves Z3 Fig. No.
B1 - Short Inverse	3	3	1-2	1-3	1-39	1-40
B2 - Long Inverse	1	1	1-4	1-5	1-41	1-42
B3 - Definite Time	5	5	1-6	1-7	1-43	1-44
B4 - Moderately Inverse	2	2	1-8	1-9	1-45	1-46
B5 - Inverse	4	4	1-10	1-11	1-47	1-48
B6 - Very Inverse	6	6	1-12	1-13	1-49	1-50
B7 - Extremely Inverse	7	7	1-14	1-15	1-51	1-52
B8 - I <sup>2</sup> T	0	0	1-16	1-17	1-53	1-54
C1 - I <sup>2</sup> T with Limit #1	8	---	1-18	1-19	1-55	1-56
C2 - I <sup>2</sup> T with Limit #2	9	---	1-20	1-21	1-57	1-58
C3 - I <sup>2</sup> T with Limit #3	A	---	1-22	1-23	1-59	1-60
C4 - I <sup>2</sup> T with Limit #4	B	---	1-24	1-25	1-61	1-62
C5 - I <sup>2</sup> T with Limit #5	C	---	1-26	1-27	1-63	1-64
C6 - I <sup>2</sup> T with Limit #6	D	---	1-28	1-29	1-65	1-66
C7 - I <sup>2</sup> T with Limit #7	E	---	1-30	1-31	1-67	1-68
C8 - I <sup>2</sup> T with Limit #8	F	---	1-32	1-33	1-69	1-70
E2 - Long Inverse	---	8	1-34	---	---	---
E4 - Inverse (1.3 Sec)	---	9	1-35	---	---	---
E5 - Inverse (3.0 Sec)	---	A	1-36	---	---	---
E6 - Very Inverse	---	B	1-37	---	---	---
E7 - Extremely Inverse	---	C,D,E,F	1-38	---	---	---

NOTES:

\* Timing Option Z1 and Z3.

† Timing Option Z2 only.

Table 2-4. Target Installation Configurations

Sensing Input Type	Number of Instantaneous Elements			Targets Installed (Types A and B)						
	None	One	Two	Element				Function		
				A	B	C	D	TIME	INST 1	INST 2
L	X							X		
		X						X	X	
			X					X	X	X
P	X			X	X	X				
		X		X	X	X		X	X	
T	X			X	X	X	X			
		X		X	X	X	X	X	X	
A		X		X	X	X		X	X	
			X	X	X	X		X		X
D		X		X	X	X	X	X	X	
			X	X	X	X	X	X		X
J	X			X		X	X	X		
		X		X		X	X	X	X	

# SECTION 3 • FUNCTIONAL DESCRIPTION

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## GENERAL

BE1-51/27C Time Overcurrent Relays are microprocessor-based devices that provide voltage control of the phase time overcurrent function.

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## BLOCK DIAGRAM ANALYSIS

The following block diagram analysis is referenced to Figure 3-1. A microprocessor (not illustrated in Figure 3-1) processes signals, performs logic functions and all of the time overcurrent computations.

### Power Supply

Basler Electric enhanced the power supply design for unit case relays. This new design created three, wide range power supplies that replace the five previous power supplies. Style number identifiers for these power supplies have not been changed so that customers may order the same style numbers that they ordered previously. The first newly designed power supplies were installed in unit case relays with EIA date codes 9638 (third week of September 1996). A benefit of this new design increases the power supply operating ranges such that the 48/125 volt selector is no longer necessary. Specific voltage ranges for the three new power supplies and a cross reference to the style number identifiers are shown in Table 3-1.

*Table 3-1. Wide Range Power Supply Voltage Ranges*

Power Supply	Style Chart Identifier	Nominal Voltage	Voltage Range
Low Range	R	24 Vdc	12 to 32 Vdc
Mid Range	O, P, S	48 , 125 Vdc, 125 Vac	24 to 150 Vdc, 90 to 132 Vac
High Range	T	250 Vdc, 230 Vac	62 to 280 Vdc, 90 to 270 Vac

Relay operating power is developed by the wide range, isolated, low burden, flyback switching design, solid-state power supply. A nominal positive and negative twelve volts dc is delivered to the internal circuitry. Input (source voltage) for the power supply is not polarity sensitive. A red LED turns ON to indicate that the power supply is functioning properly.

### Current Sensing

All relay models (except three-phase-and-neutral units) have two sensing ranges for each phase. Each high/low sensing range has its own set of input terminal connections.

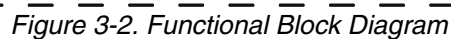
Five ampere CTs have: LOW (0.5 A to 4.0 A) and HIGH (1.5 A to 12.0 A).

One ampere CTs have: LOW (0.1 A to 0.8 A) and HIGH (0.3 A to 2.4 A).

Three-phase-and-neutral sensing units, however, have one of four possible combinations of input sensing ranges with one range for neutral and one range for the phases.

Five ampere CTs have: 0.5 A to 4.0 A and 1.5 A to 12.0 A.

One ampere CTs have: 0.1 A to 0.8 A and 0.3 A to 2.4 A.



- 1 NUMBER OF PHASES SENSED IS DEPENDENT ON INPUT SENSING TYPE. SEE STYLE IDENTIFICATION CHART.
- 2 TIMING TYPES Z1, Z2, AND Z3. LOCATED INTERNALLY FOR SELECTION OF TIMING TYPES B1-B8 AND C1-C8 OR E2-E7. SEE STYLE IDENTIFICATION CHART
- 3 CIRCUIT PATH FOR TYPE A TARGETS (INTERNALLY OPERATED).
- 4 CIRCUIT PATH FOR TYPE B TARGETS (CURRENT OPERATED).

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8-10-93

A front panel **TAP** selector and **TAP CAL** control are provided for selection and precise adjustment of the time overcurrent pickup point. The front panel **TAP** selector, a ten-position BCD weighted rotary switch, selects the desired current sensing pickup point while the front panel **TAP CAL** control provides precise adjustment between the selected setting and the next lower setting.

### Voltage Sensing

Input voltages for each phase to be monitored are applied to the voltage sensing circuits. Each voltage sensing circuit consists of an input transformer, rectifier and filter. Analog voltages from the voltage sensing circuits are applied to the multiplexor. Note that neutral is not monitored for voltage.

### Multiplexor

The multiplexor sequentially switches a voltage representing each of the sensed inputs (sensed currents or sensed voltages) to the analog-to-digital converter and level detector circuits and to the voltage inhibit circuits.

### Analog-to-Digital Converter and Level Detector

When the voltage representing the actual sensed inputs meets or exceeds the selected pickup point, this circuit converts the level to a corresponding binary number and applies it to a time trip comparator and scaler circuit and to a counter for calculation of the required time delay.

### Time Trip Comparator and Scaler

This circuit accepts both the binary number representing the detected current level and the desired time delay characteristic selected by the front panel **TIME DIAL**, then computes the required time delay before the timed output relay will be energized. The time delay characteristics are shown in the curves located in Section 1, *General Information*. If extended timing range options 2-D or 2-E is present, the time delay characteristic curves are modified so that the time delay is approximately 5.7 times the derived value.

Time delay computations are updated continuously so that changes in the overcurrent condition are monitored and thus, result in a corresponding change in the time delay. A software counter begins counting when the initial binary number is received from the analog-to-digital converter and level detector. The counter measures the elapsed time of the overcurrent condition and resets if the current decreases below the pickup point. This continuously increasing binary number is then passed to the comparator.

### Microprocessor (not shown)

Some of the circuitry already discussed is part of the microprocessor and no definite lines are drawn to separate the functions. The microprocessor compares the desired time delay (from the time trip comparator and scaler) with the actual elapsed time from the counter. When the elapsed time reaches the intended delay, the timed output relay is energized. During the time delay period, the front panel **TIMING** indicator (i.e., pickup) associated with the detected phase is illuminated.

If targets are present, the front panel **TIME FUNCTION** target will be tripped and the **A, B, C** or **N ELEMENT** target associated with the detected phase will be tripped. See table 2-4 for the types of targets that are present (depending upon relay configuration).

If option 3 is present, an auxiliary output relay (with either N.O., N.C. or SPDT contacts) is also actuated when the timed output relay energizes.

### Voltage Inhibit

The output of the multiplexor is applied to the voltage inhibit circuit for comparison with a voltage limit set by the front panel **VOLTAGE INHIBIT ADJ** control. If the (phase) input voltage exceeds this level, the appropriate front panel **VOLTAGE INHIBIT** indicator will be illuminated and a voltage inhibit signal will prevent the timed output relay and (if present) the auxiliary output relay from energizing. Instantaneous overcurrent operation, if present, will not be affected.

### Instantaneous Overcurrent (Options 1-1 and 1-2)

Input current levels applied to the time overcurrent circuitry are also passed to the instantaneous overcurrent circuitry. These levels are compared to the setting of the front panel **INST 1** adjust and the front panel **INST 1 (NEUTRAL)** adjust (if present). If the input current level is above the setting, the output driver energizes the instantaneous 1 Output Relay. If the instantaneous 2 option is present, the input level is also compared with the setting of the front panel **INST 2** adjust to energize the instantaneous 2 output relay. Note that the current level settings for the instantaneous overcurrent element will always be from 1 to 40 times above the front panel **TAP** and **TAP (NEUTRAL)** settings of the time overcurrent element.

If target type A or B is present, the front panel **INST 1** target and the front panel **INST 2** targets are tripped when their respective output relay is energized along with the front panel **A, B, C** or **N ELEMENT** targets (if present) associated with the detected phases. (See Section 2, *Human-Machine Interface*, for the types of targets that can be present depending upon the relay configuration.)

### Timed and Instantaneous Outputs

Each output signal (representing either time overcurrent or instantaneous overcurrent) from each monitored phase (or neutral) is applied to the respective output driver. Each output driver supplies operating current to energize its associated output relay. Either normally open (output type E) or normally closed (output type G) contacts may be specified. (The contact configurations of all output relays for a given model will be the same.)

### Auxiliary Outputs

In addition to the output relays, an auxiliary relay, having the same or a different contact configuration, may be specified. Both the output and the auxiliary relays will remain energized for the duration of the overcurrent condition.

### Push-to-Energize Pushbuttons

If either Option 2-C or 2-E is present, each individual output relay can be directly energized for test purposes by the actuation of a front panel **PUSH-TO-ENERGIZE OUTPUT** pushbutton. The pushbutton is actuated by the insertion of a thin, non-conducting rod through an access hole in the front panel.

### Power Supply Status Output (Option 3-6)

Power supply status output relays have a set of normally closed contacts that are energized open during power-up. If either or both power supply output legs (+12 Vdc or -12 Vdc) fails, the power supply status output relay is de-energized and the output contacts close. Shorting bars across the output contacts are held open by the installed connection plug. When the relay is removed from service by removing the connection plug, the shorting bars are closed.

### Target Indicator Circuits

When specified, a front panel target indicator for each type of monitoring (i.e., time overcurrent or instantaneous) will be supplied. Two types of target drive circuits are available, as follows.

#### Internally Operated Targets

Outputs from the overcurrent elements are directly applied to drive the appropriate target indicator. Each indicator is tripped regardless of the current level of the trip circuit.

#### Current Operated Targets

This target will operate only when a minimum of 0.2 A flows in the output circuit. A special reed relay in series with the output contact provides the signal to the target indicator.

Note that the front panel function targets (**TIMED, INST 1**, etc.) may be of either type. Phase and neutral indicators are current operated only if the instantaneous options are not included and if current operated targets are specified.

Each target, when operated, is magnetically latched and must be reset manually. Target configurations for the various models are provided in Section 2, *Human-Machine Interface*.

# SECTION 4 • INSTALLATION

---

## GENERAL

When not shipped as part of a control or switchgear panel, the relays are shipped in sturdy cartons to prevent damage during transit. Immediately upon receipt of a relay, check the model and style number against the requisition and packing list to see that they agree. Visually inspect the relay for damage that may have occurred during shipment. If there is evidence of damage, immediately file a claim with the carrier and notify the Regional Sales Office or contact the Sales Representative at Basler Electric, Highland, Illinois.

In the event the relay is not to be installed immediately, store the relay in its original shipping carton in a moisture and dust free environment. When relay is to be placed in service, it is recommended that the operational test procedure (Section 5, *Tests and Adjustments*) be performed prior to installation.

---

## RELAY OPERATING PRECAUTIONS

Before installation or operation of the relay, note the following precautions:

1. A minimum of 0.2 A in the output circuit is required to ensure operation of current operated targets.
2. Do not touch target indicator vanes. Always reset targets by use of the target reset lever.
3. The relay is a solid-state device. If a wiring insulation test is required, remove the connecting plugs and withdraw the cradle from its case.
4. When the connecting plugs are removed the relay is disconnected from the operating circuit and will not provide system protection. Always be sure that external operating (monitored) conditions are stable before removing a relay for inspection, test or service.
5. Be sure the relay case is hard wired to earth ground using the ground terminal on the rear of the unit. It is recommended to use a separate ground lead to the ground bus for each relay.

---

## DIELECTRIC TEST

In accordance with IEC 255-5 and ANSI/IEEE C37.90-1978, one-minute dielectric (high potential) tests may be performed using up to 1500 Vac (45-65 hertz). This device employs decoupling capacitors to ground from the following terminals: power supply, voltage sensing input and output contacts. At 1500 Vac, a leakage current of up to 40 milliamperes per terminal is to be expected. Because of the high leakage current, it is recommended that dielectric tests be performed using dc voltages equivalent to the peak ac value (2,120 Vdc).

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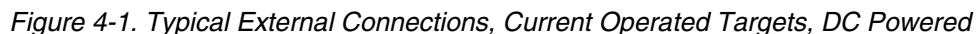
## MOUNTING

Because the relay is of solid state design, it does not have to be mounted vertically. Any convenient mounting angle may be chosen. Relay outline dimensions and panel drilling diagrams are supplied at the end of this section.

Incorrect wiring may result in damage to the relay. Except for the ground wire (see following note), connections should be made with minimum wire size of 14 AWG. Typical external connections are shown in Figures 4-1 through 4-8. Internal connections are shown in Figures 4-9 through 4-14.

Be sure the relay case is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the ground terminal on the rear of the relay case. When the relay is configured in a system with other protective devices, it is recommended to use a separate lead to the ground bus from each relay.

Relay circuitry is connected to the case terminals by removable connection plugs (1 plug for 10-terminal cases and 2 plugs for 20-terminal cases). Removal of the connection plug(s) opens the N.O. trip contact circuits and shorts the N.C. trip contact circuits before opening the power and Sensing Circuits.





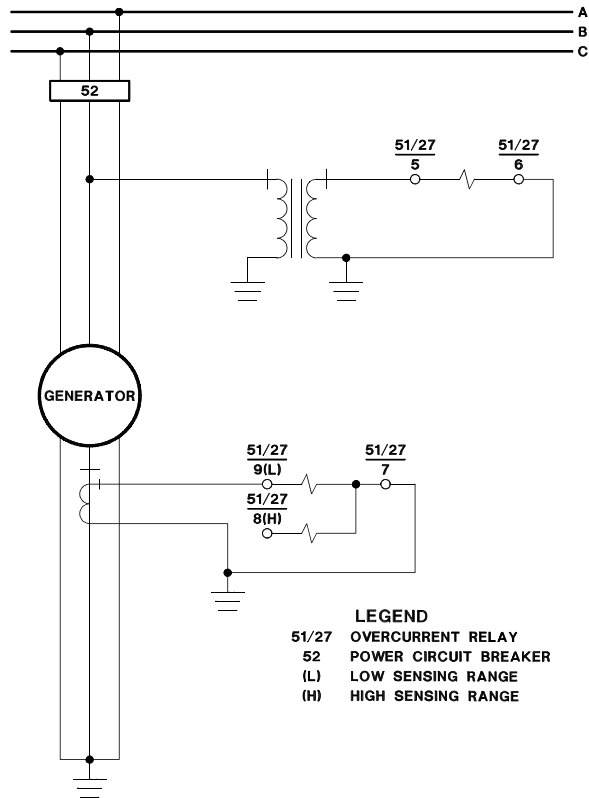


Figure 4-2. Typical Sensing External Connections, Sensing Input Type L

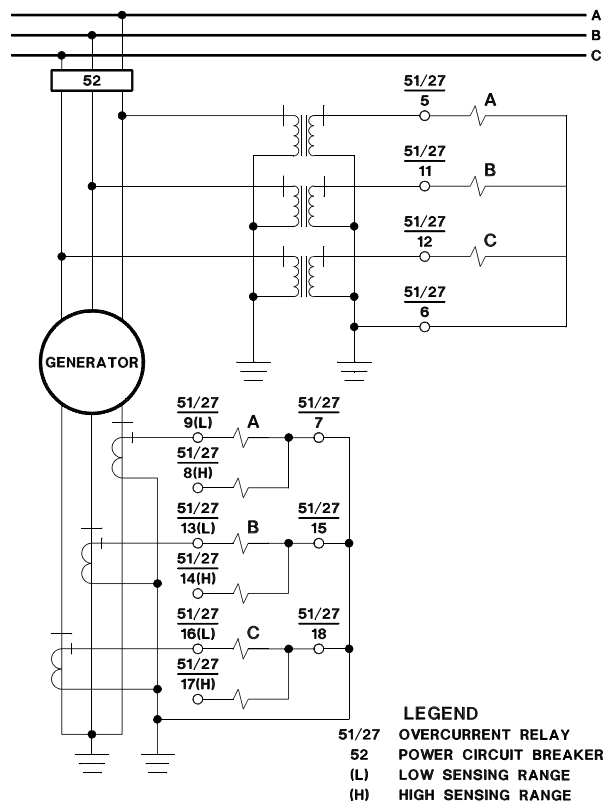


Figure 4-3. Typical Sensing External Connections, Sensing Input Type P

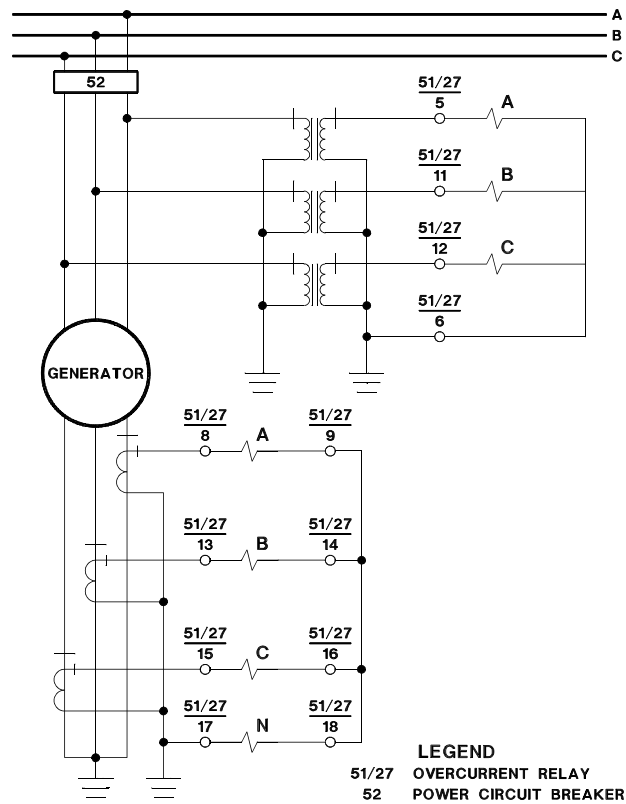


Figure 4-4. Typical Sensing External Connections, Sensing Input Type T

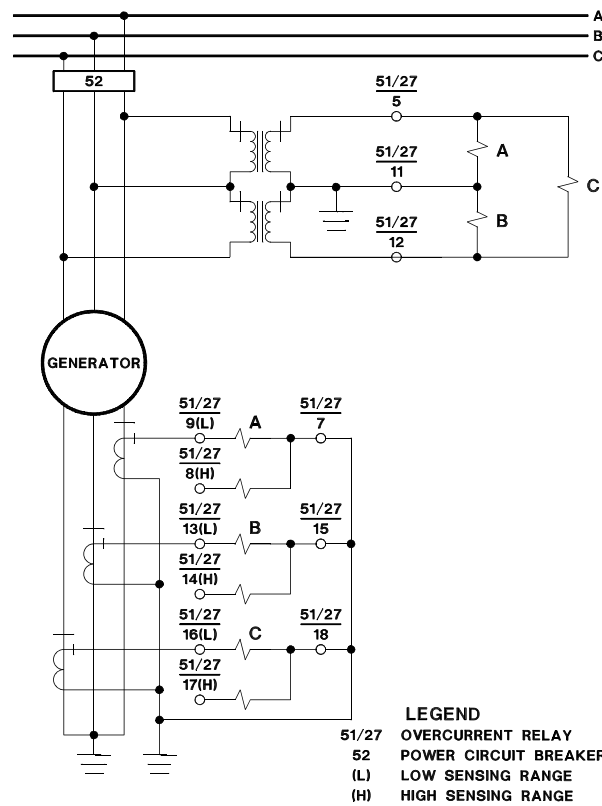


Figure 4-5. Typical Sensing External Connections, Sensing Input Type A, Open Delta Configuration

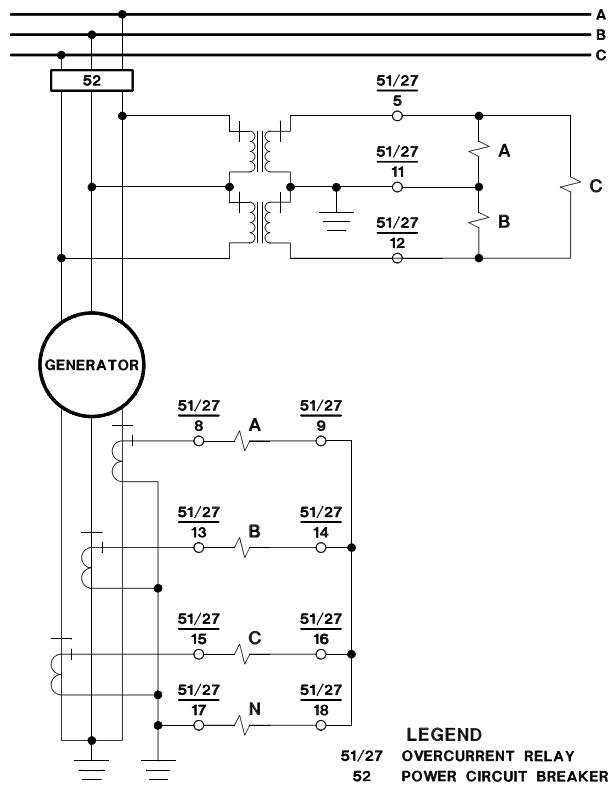


Figure 4-6. Typical Sensing External Connections, Sensing Input Type D, Open Delta Configuration

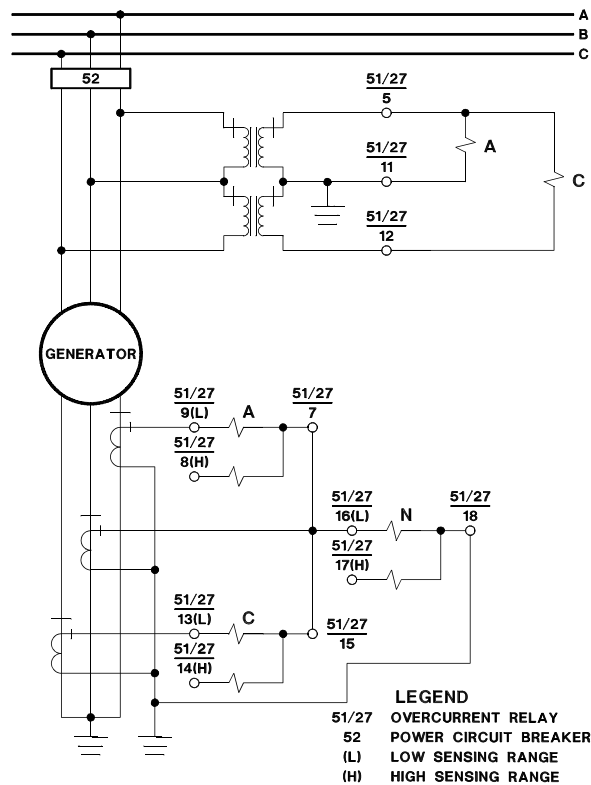


Figure 4-7. Typical Sensing External Connections, Sensing Input Type J

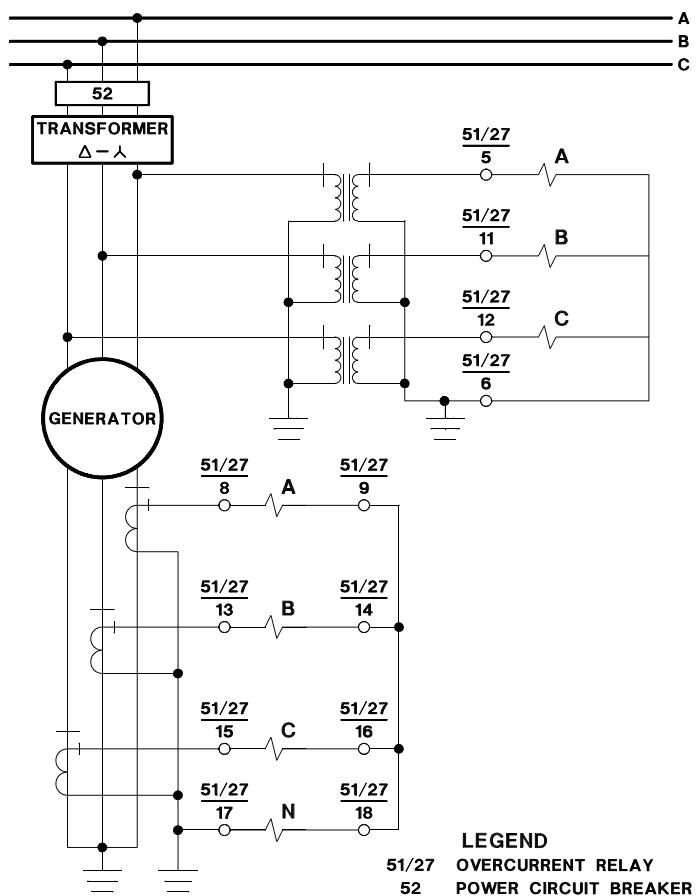


Figure 4-8. Unit-Connected Generator, Typical Sensing External Connections, Sensing Input Type P

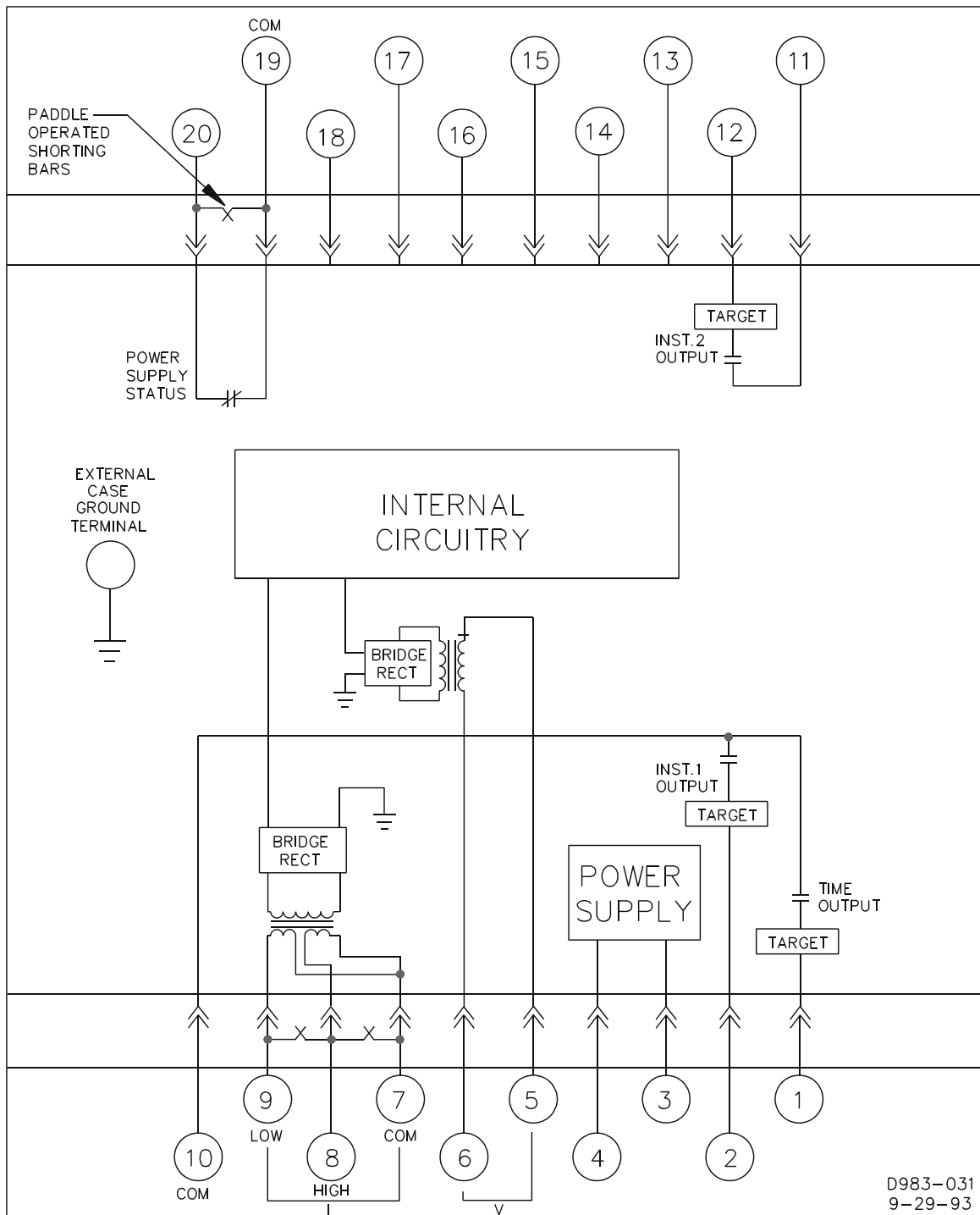


Figure 4-9. Typical Internal Diagram, Sensing Input Type L

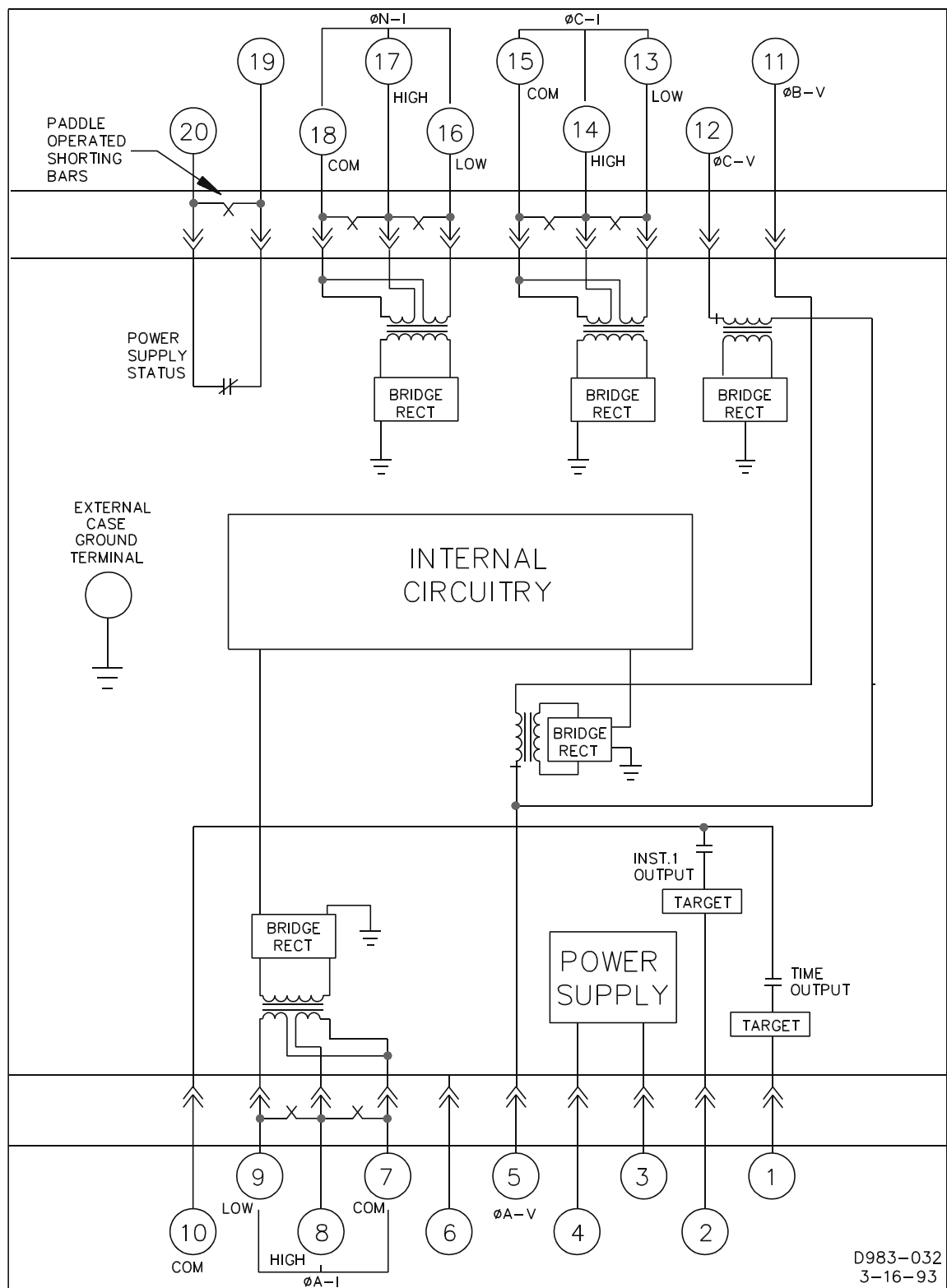


Figure 4-10. Typical Internal Diagram, Sensing Input Type J with Power Supply Status

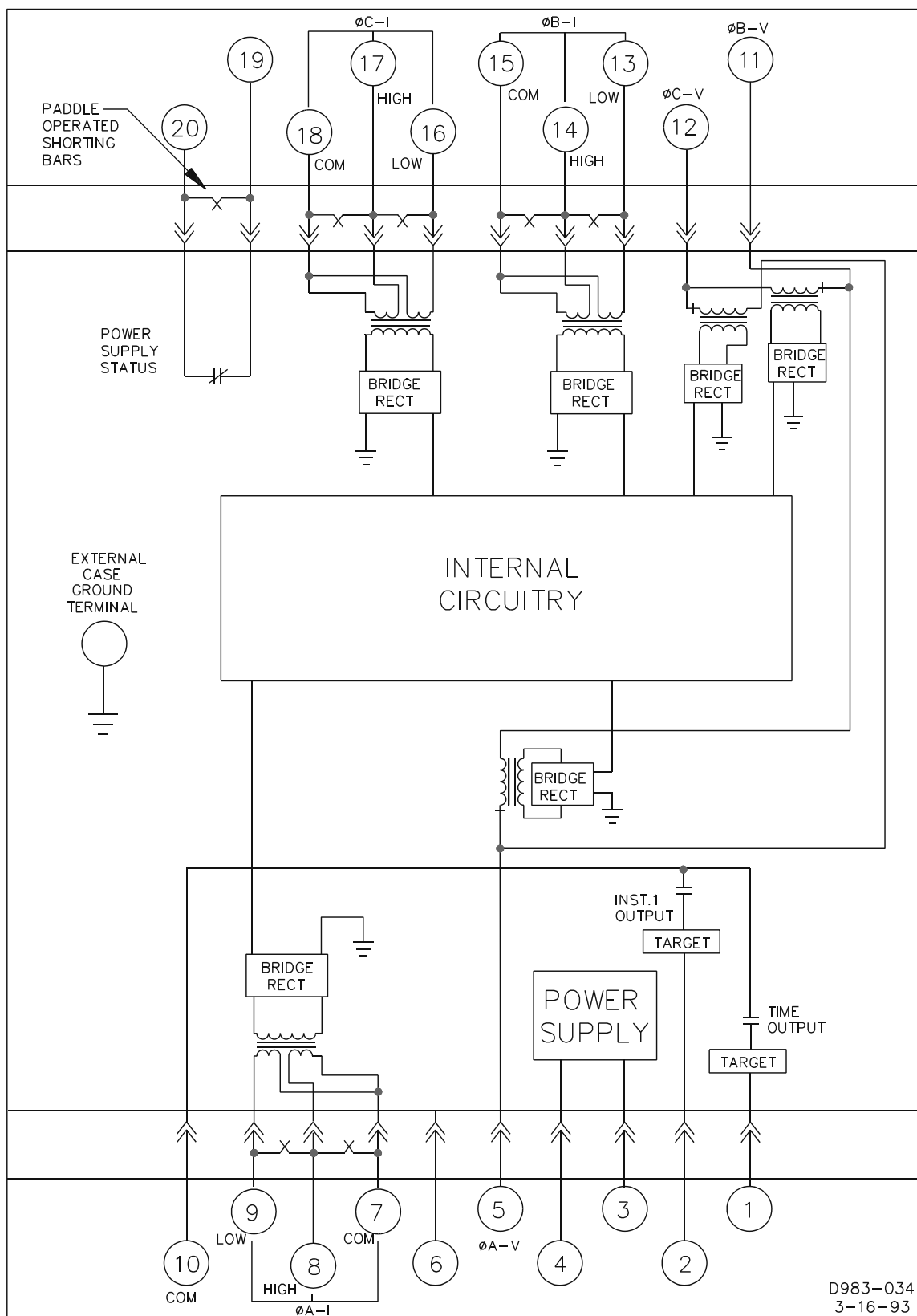


Figure 4-11. Typical Internal Diagram, Sensing Input Type A with Power Supply Status

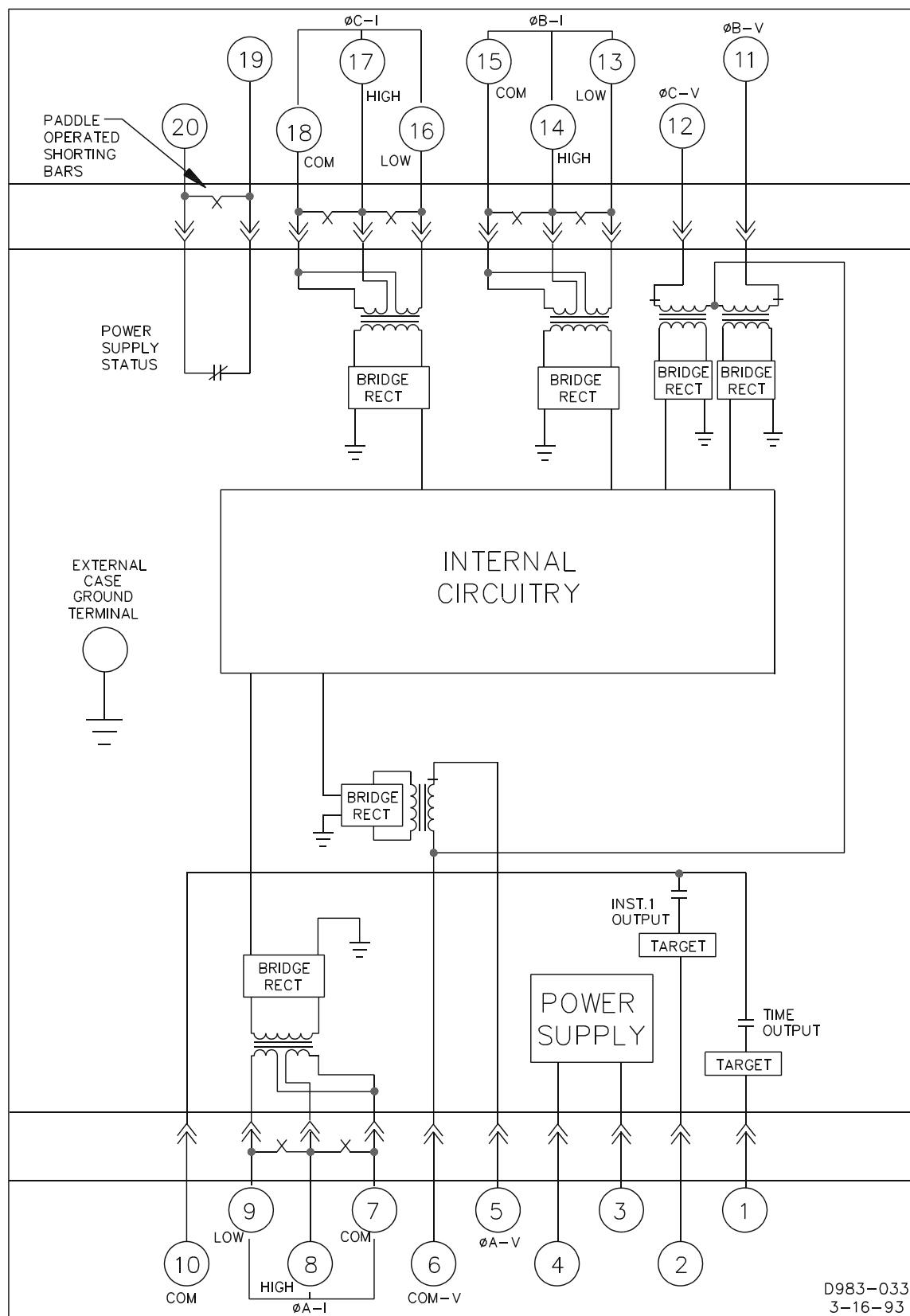
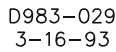


Figure 4-12. Typical Internal Diagram, Sensing Input Type P with Power Supply Status







**BE1-51/27C**

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## SETTING THE RELAY

### General

Neutral (ground) time overcurrent and all instantaneous overcurrent functions operate independently of the voltage control circuits so that these elements can be set conventionally. These optional functions are set independently of each other except that the instantaneous setting is 1 to 40 times the associated time-overcurrent element pickup.

Set the instantaneous elements pickup at least at 120 percent of the maximum current that can be seen by the relay for an external fault where operation is not desired. Time settings for the time overcurrent elements can be chosen as if the relay had no voltage sensing elements. This makes it easier to coordinate with other external protection. Set the phase-element pickup for about 50 percent of rated current for a generator back-up function. Neutral time overcurrent pickup must be set above the maximum expected normal unbalance. Also, in the case of residually-connected elements, added relay current can result from dissimilar errors in the three current transformers. This error will be greater for the lower accuracy-class voltages. A neutral-element pickup of 10 percent of the circuit rating is normally enough to be above any non-fault unbalance for a solidly grounded system. Lower settings are appropriate and safe for impedance-grounded systems or for ungrounded, protected-equipment connections.

Undervoltage settings should be as high as possible without allowing operation under the worst no-fault conditions. An 85 percent of rated voltage setting meets these requirements. If motor starting or motor accelerating following a fault can severely depress the relay voltage, a setting of 75 percent or 80 percent may be advisable.

### Setting Example

For our example, generator relay elements shown in Figure 4-16 are to be set for operation. Plant 11 kV feeders are supplied by a 115 kV system and supplemented by two local 3700 kVA generators. Particulars are as follows.

#### Generator Back-up Relay

BE1-51/27C-T3EB6, (Breaker A). This is a three-phase-and-neutral overcurrent type. Sensing is for 1.5 to 12 amperes (phase) with instantaneous elements (out of service sensing) and 0.5 to 4 amperes (neutral) instantaneous elements (in service sensing). It uses the very inverse (B6) timing curves and is connected to the system through 300/5 ratio current transformers.

#### Feeder Relay

BE1-51 using the very inverse (B6) timing curves, the sensing range is 0.5 to 12 amperes with no instantaneous elements. Sensing is through 800/5 ratio current transformers. The following front panel settings apply: **Pickup** - 6 A, **TIME DIAL** - 08.

#### BE1-67

Uses the definite time (B3) timing curves with sensing set for 0.5 to 12 amperes. Sensing is through 3000/5 ratio current transformers. The following front panel settings apply: **Pickup** - 0.5 ampere (C), **TIME DIAL** - 02.

#### Generator Reactance (per unit)

Sub-transient: 0.18; Transient: 0.25; Steady-State: 1.5.



### Coordination with Feeder 51 Relay for Fault 1

- (1) Multiples of pickup in 51 Relay at transient level:

$$\frac{7256}{(800/5) 6} = \frac{7256}{960} = 7.6$$

- (2) 51 Relay time at 7.6 multiples (from B6 curves) @ 08 time dial: 0.31 s.

- (3) Set 51/27 Relay pickup:

$$\frac{0.5 (3700)}{11 (1.73)} = 97A \text{ Primary}$$
$$\frac{97}{(300/5)} = 1.6A$$

- (4) Set the 51/27 Relay Time to provide 0.3s coordinating interval:

$$0.31 + 0.3 = 0.61s @ 776A$$

- (5) 51/27 Relay voltage equals 0, so the time element is operative.

- (6) 51/27 Relay multiples:

$$\frac{776}{97} = 8.0$$

- (7) 51/27 Relay **TIME DIAL** (from B6 curve, Figure 1-12, @ 8.0 multiple): 22

- (8) Multiples of pickup in 51 Relay at steady-state level:

$$\frac{5961}{(800/5) 6} = 6.2$$

- (9) 51 Relay time at 6.2 multiples: 0.37s.

- (10) 51/27 Relay multiples at 129 A:

$$\frac{129}{97} = 1.3$$

- (11) 51/27 Relay time at 1.3 multiples: 13.0 s (approx.).

- (12) 51/27 Relay coordinates with Relay 51 over the full range of fault currents with transformer T2 out of service. With both T1 and T2 in service, Relay 51 sees more current and operates faster than the above times. If the fault is not interrupted by the feeder breaker, the generators will be tripped at time falling between 0.61 s and 13.0 s.

### Checking Coordination with 67 Relay for Fault 2

- (1) Relay 67 multiples at transient level with T2 in service:

$$\frac{7256}{0.5 (3000/5)} = 24$$

- (2) 67 Relay Time at 24 multiples (B3 curve, Figure 1-6, **TIME DIAL 02**): 0.15s.

- (3) 67 Relay multiples at transient level with T2 out of service:

$$\frac{1552}{300} = 3$$

- (4) 67 Relay Time at 3 multiples: 0.23 s.

(5) Note that a failure of the differential protection (87T) for fault 2 with T2 out of service is a double contingency. Coordination of 51/27 Relays with 67 Relays does occur at the transient level (0.61 vs. 0.35 s). As the current decays, the times converge and cross because the 67 Relay pickup is 300 amperes vs 97 amperes for 51/27 Relays (see calculation below for steady-state multiple of 0.86 for the 67 Relays). So coordination may not be achieved for this double contingency with the generator regulators out of service. Boosting by the regulators will partially arrest the decay of current. Also, the decay will be less for a phase-phase fault.

(6) 67 Relay multiples at steady-state level with T2 out:  $\frac{258}{300} = 0.86$

(7) For a failure of Breaker L to open, the 51 Relays on transformer T2 will operate as well as the generator relays to clear fault 2. For a failure of the T1 differential relays (87T), the T2 51 Relays should coordinate with the 67 Relays so T2 and the generators will remain in service.

### Checking Coordination with Relays 67 for Fault 3

(1) 67 Relay multiples at transient level with T2 in service (Refer to Figure 4-16):  $\frac{713}{300} = 2.4$

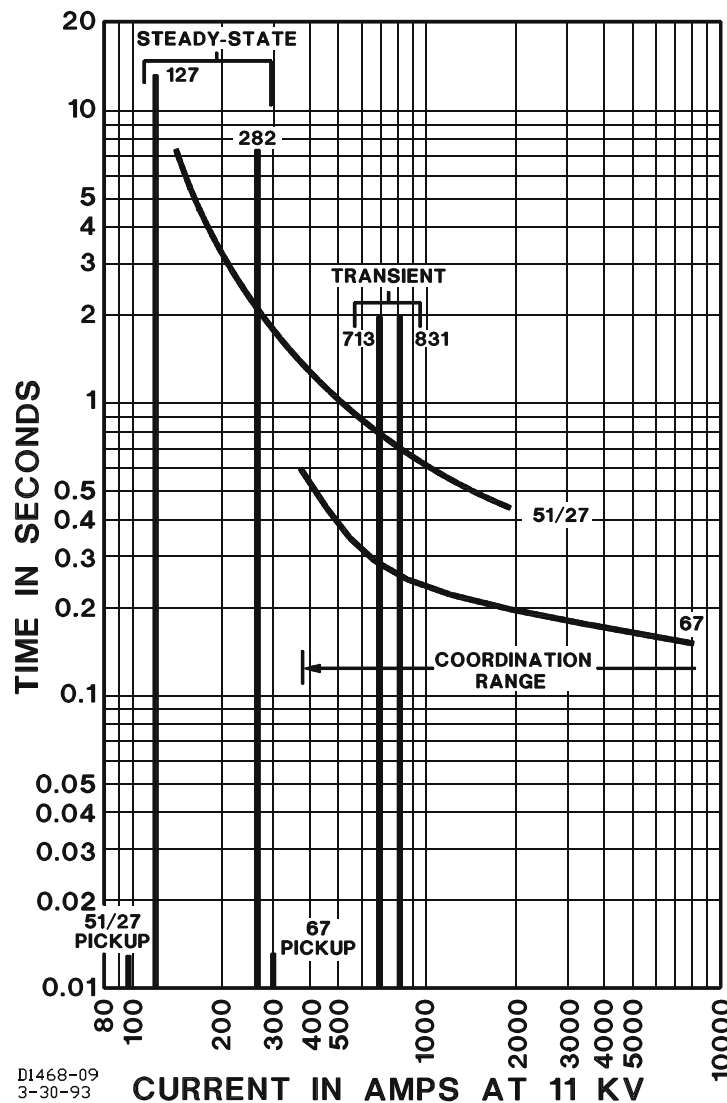


Figure 4-17. Relay 51/27 Coordination with Relay 67 for Fault 3 Example

- (2) 67 Relay time at 2.4 multiples: 0.26 s.
- (3) 51/27 Relay transient level voltage (reactor and transformer T1 drop): 8% so the time element is operative.
- (4) 51/27 Relay multiples at transient level:  $\frac{713}{97} = 7.4$
- (5) 51/27 Relay transient level time at 7.4 multiples and **TIME DIAL** setting of 22: 0.72 s.
- (6) 51/27 Relays coordinate with 67 Relays for a high-side fault at the transient level. However, it appears that the current may drop below the 67 Relay pickup (300 amperes) before this relay can operate. Should the 67 Relays fail to operate, the 51/27 Relays will trip the generators. Figure 4-17 plots these two relay characteristics. If the generator is fully loaded at 194 amperes with a 0.85 PF, the superposition of this current and the fault current at -90° yields a total current of 831 amperes at the transient level and 282 amperes at the steady-state level with no regulator boosting. The relays are selective down to about 350 amperes.
- (7) Assuming that the 67 Relays will not operate for fault 3, the generators will be unnecessarily tripped if the line relaying fails to operate or if breaker R fails to interrupt the fault. Redundant line relaying will minimize the need for generator tripping. Use of a breaker-failure timer set to about 0.25 seconds would avoid generator tripping for a failure of breaker R to interrupt.

### Neutral Element Backup Settings

- (1) The 51N element has no relays to coordinate with because the generators are ungrounded. An instantaneous element, if used, must be set above the maximum false residual current that can be developed due to dissimilar current transformer saturation during an external three-phase fault. Similarly, the time setting of the time-overcurrent element must ride through this transient resulting from current transformer saturation.

- (2) Ground current contribution from each transformer is 485 amperes. Normal total current level is:

$$2 \times 485 = 970\text{A}$$

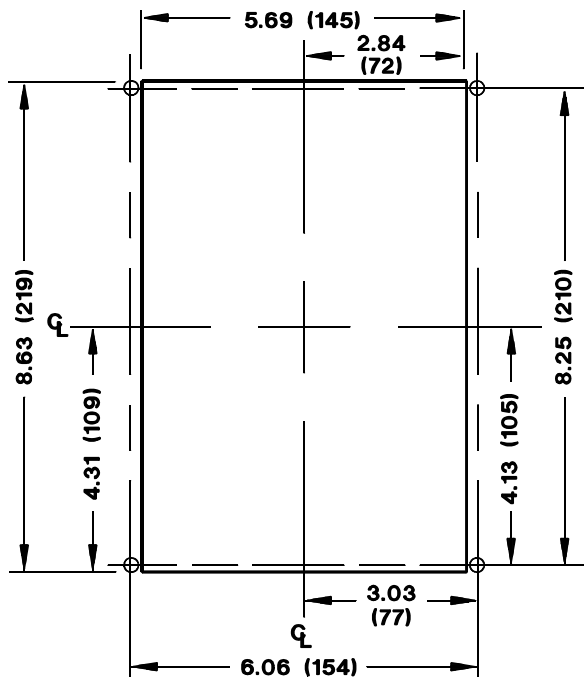
- (3) Set the time element for 0.8 ampere pickup.
- (4) Set the time element (51N) at 0.2 s for 970 amperes primary (see B3 curves, Figure 1-12):

$$\frac{970}{60 \times 0.8} = 20 \text{ multiples and } 08 \text{ timedial}$$

- (5) Set the instantaneous (50N) pickup at 5 amperes:  $\frac{5}{0.8} = 6.7$

The maximum ground fault current is:

$$\frac{970}{300} = 3.2 \text{ times the Relay pickup}$$



**NOTES:**

1. ALL DIMENSIONS ARE IN INCHES (MILLIMETERS).
2. MOUNT RELAY USING FOUR NO. 10 SCREWS.

Figure 4-18. Panel Drilling Diagram, Semi-Flush Mounting

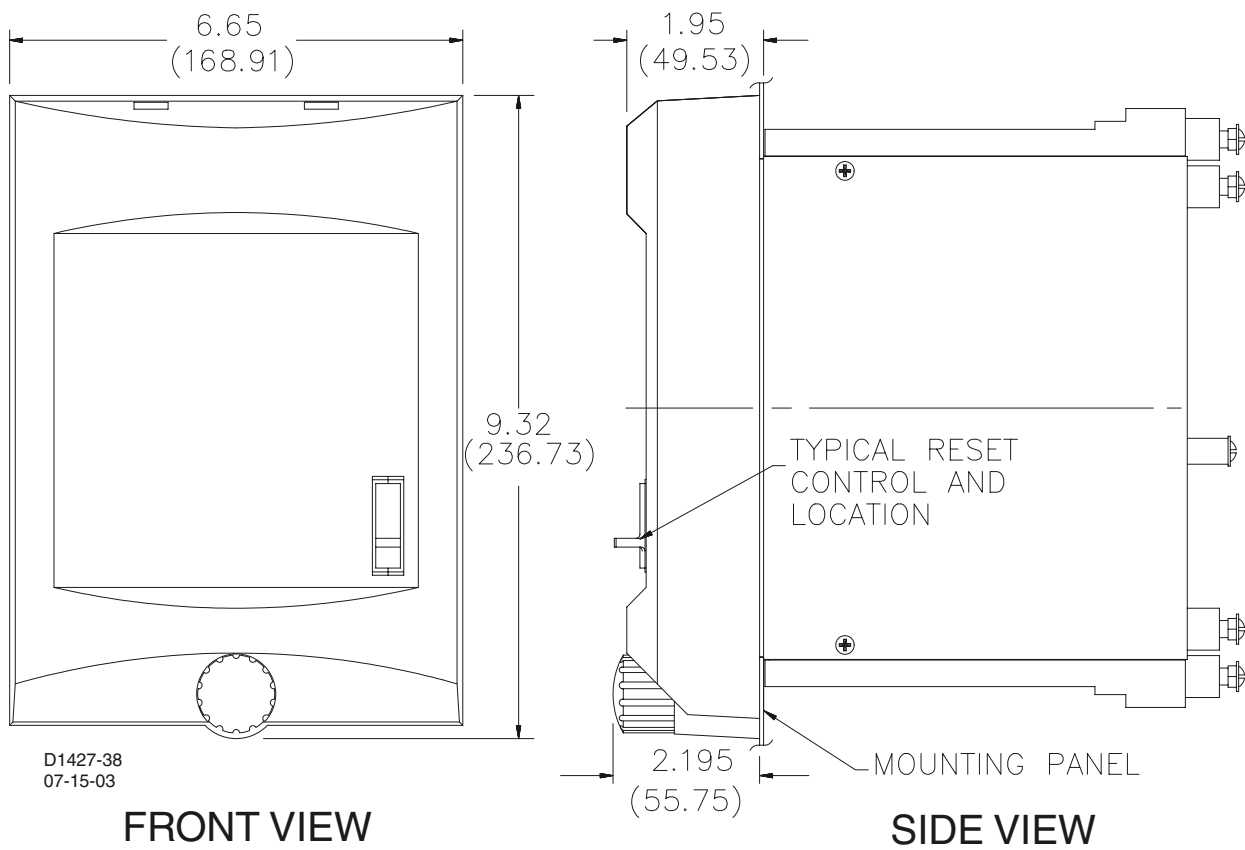


Figure 4-19. Outline Dimensions, Semi-Flush Mounting



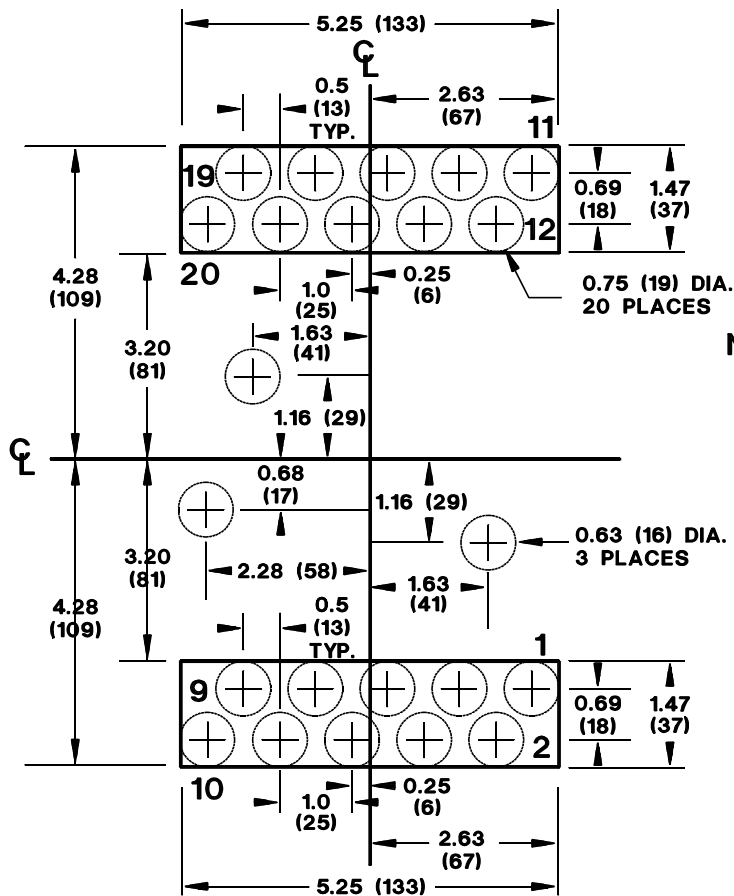


Figure 4-20. Panel Drilling Diagram, Projection Mounting, Rear View

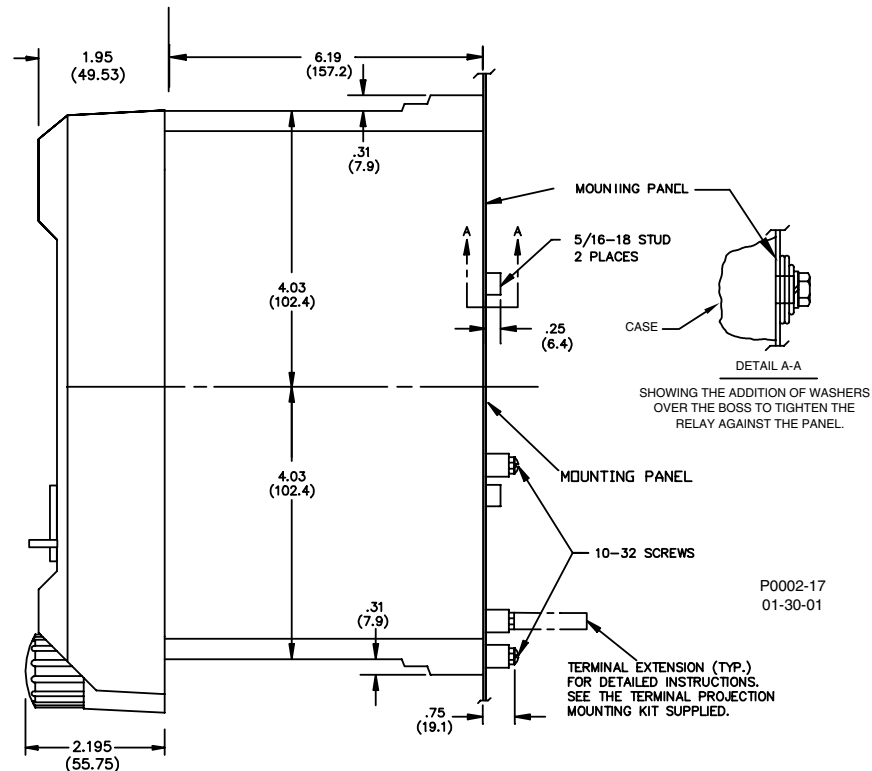


Figure 4-21. S1 Case, Single-ended, Outline Dimensions, Projection Mounting, Side View

# SECTION 5 • TESTS AND ADJUSTMENTS

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## GENERAL

Procedures in this section are for use in testing and adjusting a relay for the desired operation in a protective scheme. If a relay fails an operational test, or if an adjustment discloses a faulty relay, refer to Section 6, *Maintenance*.

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## REQUIRED TEST EQUIPMENT

Minimum test equipment required for relay testing and adjustment is listed below. Refer to Figures 5-1 through 5-6 for test setups.

- a. Appropriate ac or dc power source for relay operation.
- b. Appropriate ac source (50 or 60 Hz as appropriate) for voltage and current testing.
- c. Dc external power source for output relay(s) test setup and timer input.
- d. Relay test set capable of delivering 40 A. A higher capability is needed for instantaneous settings above 40 A.
- e. Timer.
- f. One shunt resistor for providing minimum target load.

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## OPERATIONAL TEST

### Preliminary Instructions

Perform the following steps before going on to any testing:

Step 1. Connect the relay test setup in accordance with Figures 5-1 through 5-6, depending upon the sensing input type (see Figure 1-1, *Style Number Identification Chart*).

(a) Sensing Input Type L (Single-Phase Sensing). Refer to Figure 5-1.

#### NOTE

For relays having the above sensing, only the front panel **LOW** range current sense terminal(s) should be connected for a complete check of the relay.

Ensure that the timed Output Terminals 1 and 10 are connected.

(b) Sensing Input Type P (Three-Phase Sensing). Refer to Figure 5-2.

#### NOTE

For relays having the above sensing, only the front panel **LOW** range current sense terminal(s) should be connected for a complete check of the relay.

For all three-phase relays, the test signals must connect to both the current and voltage terminals for the same phase.

Ensure that the timed Output Terminals 1 and 10 are connected.

- (c) Sensing Input Type T (Three-Phase with Neutral Sensing). Refer to Figure 5-3. Ensure that the timed Output Terminals 1 and 10 are connected. Also, verify that either A, B or C Current Sense Terminals are connected initially (N terminals will be connected later in the test).
- (d) Sensing Input Type A (Three-Phase Sensing). Refer to Figure 5-4. Ensure that the timed Output Terminals 1 and 10 are connected. Also, verify that either A, B or C Current Sense Terminals are connected initially (N terminals will be connected later in the test). Ensure that the voltage sense terminals and the current sense terminals are connected to the same phase.
- (e) Sensing Input Type D (Three-Phase with Neutral Sensing). Refer to Figure 5-5. Ensure that the timed Output Terminals 1 and 10 are connected. Also, verify that either A, B or current sense terminals are connected initially (N terminals will be connected later in the test).
- (f) Sensing Input Type J (Two-Phase with Neutral Sensing). Refer to Figure 5-6. Ensure that the timed Output Terminals 1 and 10 are connected. Also, verify that either A, B or C Current Sense Terminals are connected initially (N terminals will be connected later in the test).

- Step 2. Remove the relay front cover.
- Step 3. Set the front panel **TIME DIAL** selector and, if present, the front panel **TIME DIAL (NEUTRAL)** selector to 99.
- Step 4. Adjust the front panel **INST 1** and **INST 2** controls, if present, fully clockwise (CW).
- Step 5. Adjust front panel **TAP CAL** control and, if present, front panel **TAP (NEUTRAL)** control fully CW.
- Step 6. Ensure that the relay front panel **TARGETS**, if present, are reset.
- Step 7. Apply 100% of nominal voltage based on the sensing input type for your relay.

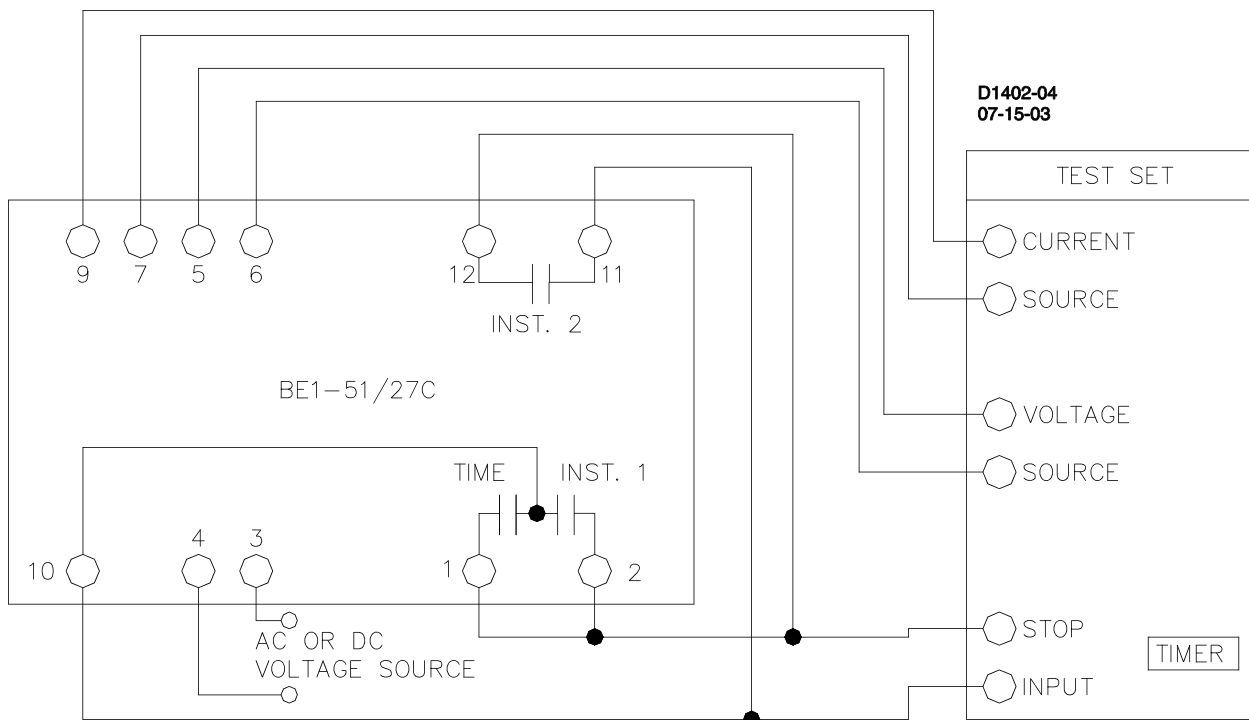


Figure 5-1. Test Setup for Sensing Input Type L (Single-Phase Sensing)

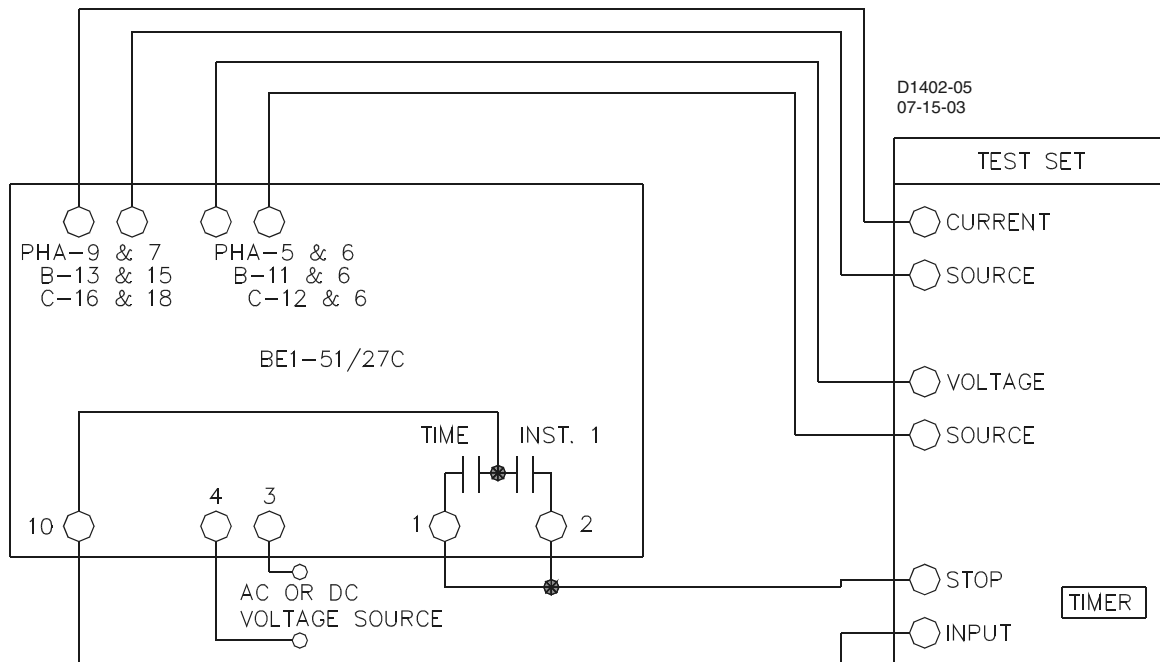


Figure 5-2. Setup for Sensing Input Type P (Three-Phase Sensing)

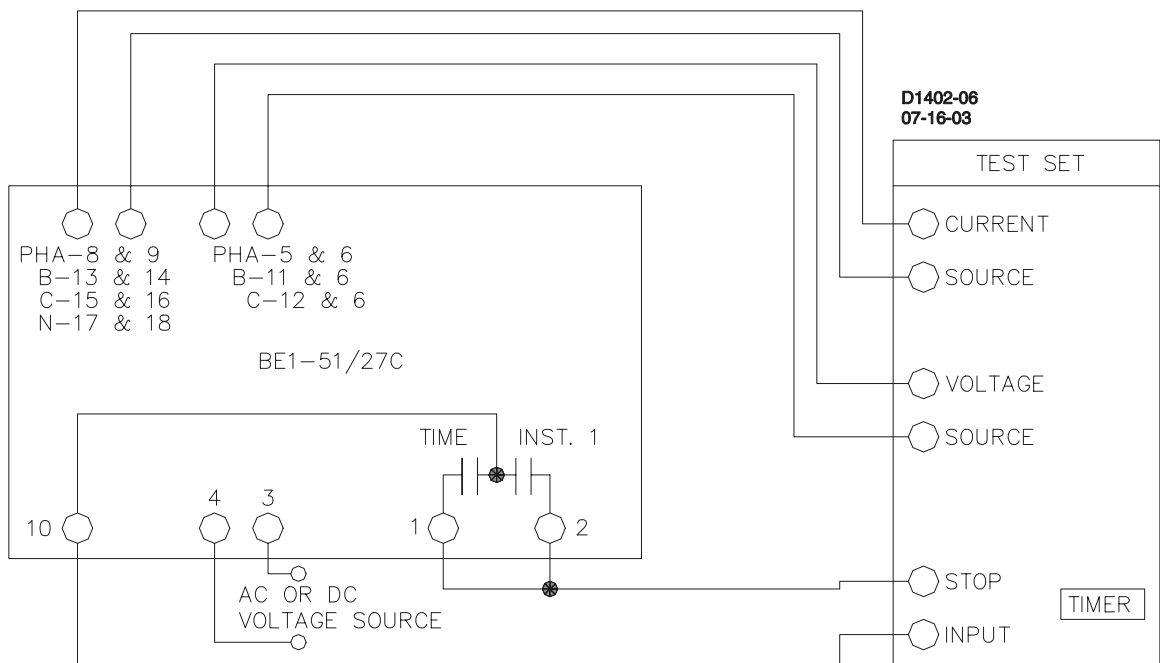


Figure 5-3. Setup for Sensing Input Type T (Three-Phase with Neutral Sensing)

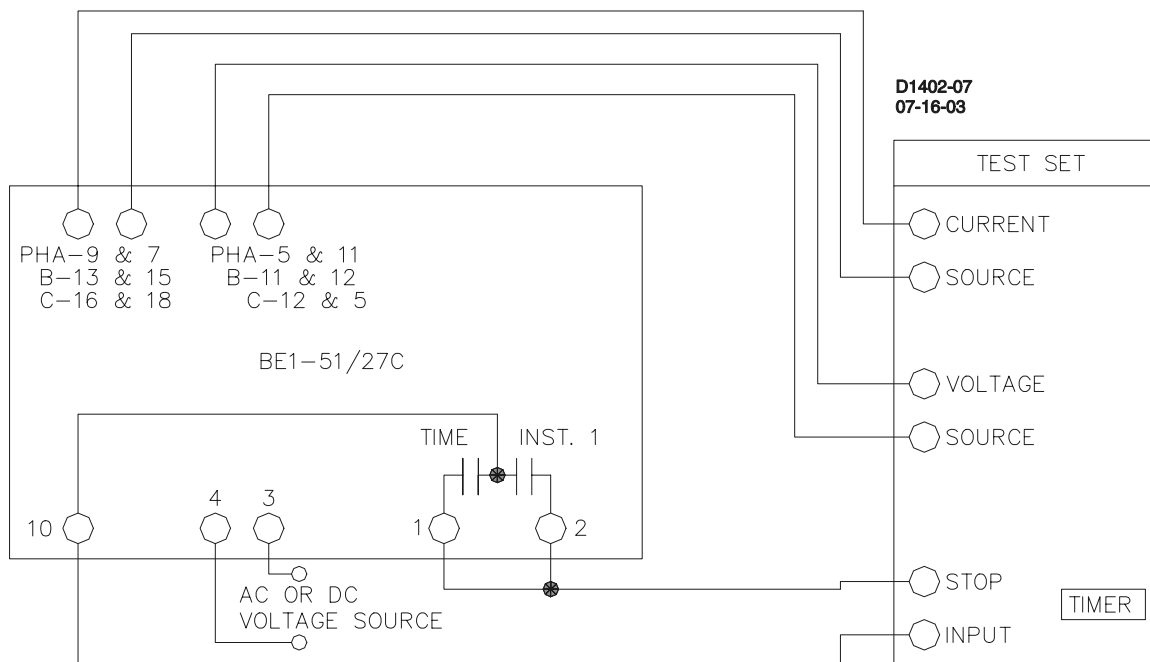


Figure 5-4. Test Setup for Sensing Input Type A (Three-Phase, Delta Configuration)

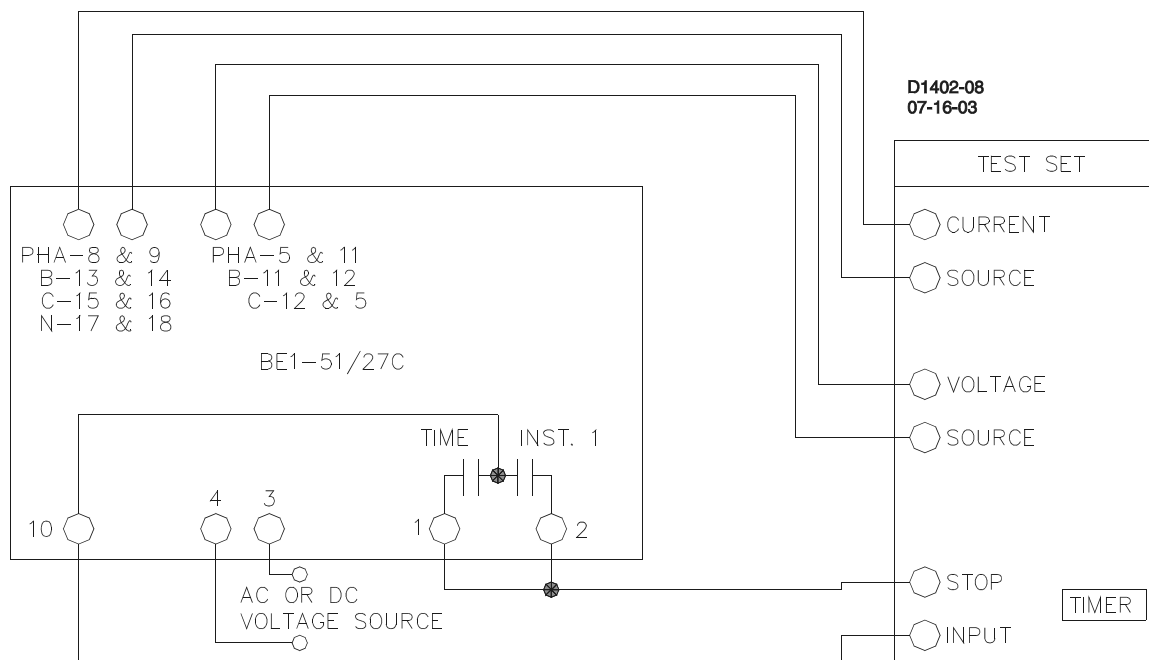


Figure 5-5. Setup for Sensing Input Type D (Three-Phase with Neutral Sensing)

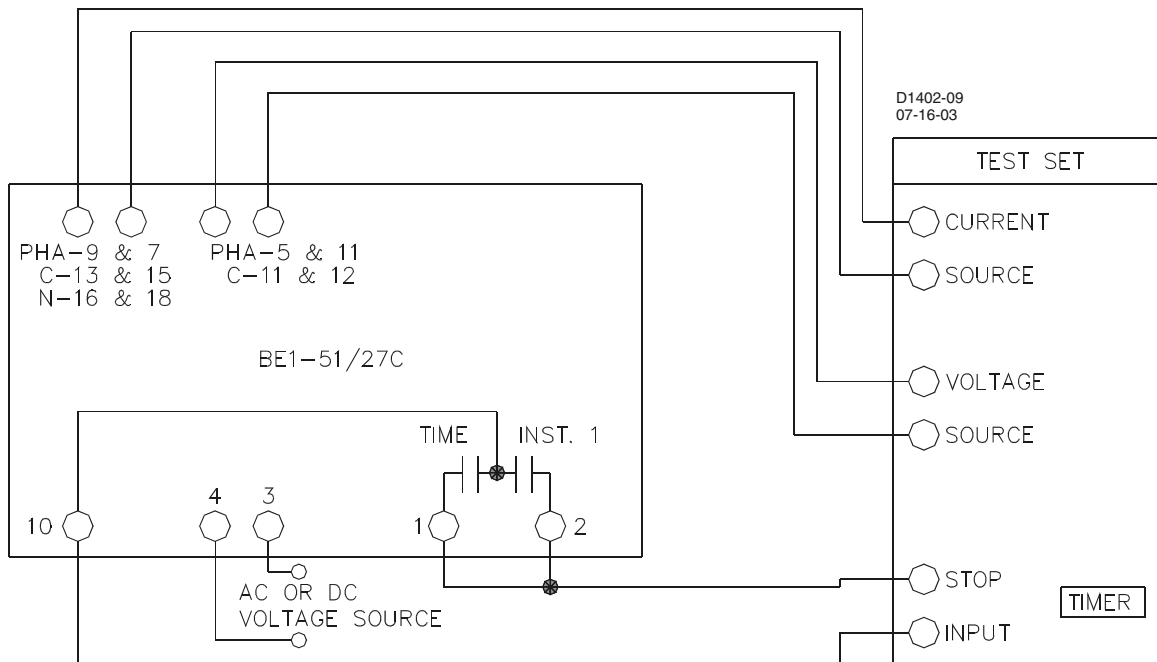


Figure 5-6. Test Setup for Sensing Input Type J (Two-Phase with Neutral Sensing)

#### Time Overcurrent Pickup Test

This test will check the minimum and maximum overcurrent pickup points of the time overcurrent element.

#### NOTE

During this test, disregard any indication on the test setup timer.

- Step 1. Perform the Preliminary Instructions.
- Step 2. Set the front panel **TAP** selector to **A**.
- Step 3. Adjust the test set for an overcurrent threshold having one of the following values:
  - a) 0.5 A for relays with Sensing Input Range 1, 2 or 4.
  - b) 1.5 A for relays with Sensing Input Range 3 or 5.
- Step 4. Slowly adjust the front panel **TAP CAL** Control CCW until the front panel **TIMING** Indicator illuminates.
 

**RESULT:** For the phase minimum overcurrent pickup point of 0.5 A (Step 3a., above) or 1.5 A (Step 3b., above) the front panel **TAP CAL** control should be near its maximum CCW limit.
- Step 5. Adjust the front panel **TAP CAL** control fully CW to allow measurement of the actual overcurrent pickup point at the **A** setting of the front panel **TAP** selector. Note that the front panel **TIMING** Indicator will extinguish. Do not disturb this setting.
- Step 6. Slowly increase the current toward the value of the front panel **TAP** selector **A** setting until the front panel **TIMING** indicator illuminates. Do not disturb this setting.

Step 7. Record the current reading and remove input current.

**RESULT:** The recorded value should be within  $\pm 5\%$  of the front panel **TAP** selector **A** setting for the phase minimum overcurrent pickup point for the time overcurrent.

Step 8. Set the front panel **TAP** selector to **J**.

Step 9. Slowly adjust the test set, increasing the overcurrent threshold toward the value of the front panel **TAP** selector **J** setting until the front panel **TIMING** indicator just illuminates. Do not disturb this setting.

Step 10. Record the current reading and remove input current.

**RESULT:** The recorded value should be within  $\pm 5\%$  of the front panel **TAP** selector **J** setting for the phase maximum overcurrent pickup point for the time overcurrent element.

Step 11. Perform the following steps, as appropriate, for the correct sensing input types.

**NOTE**

Ensure that the voltage sense terminals and current sense terminals are connected to the same phase.

- (a) Sensing Input Type L (Single-Phase Sensing). This concludes the time overcurrent test. Proceed to the Timed Output Test.
- (b) Sensing Input Type J (Two-Phase and Neutral Sensing). Remove the power and reconnect the input sensing to the remaining phases as shown in Figure 5-6, each time repeating Steps 1 through 10. For neutral testing continue with Step 12.
- (c) Sensing Input Type A and P (Three-Phase Sensing). Remove the power and reconnect the input sensing to each of the remaining phases as shown in Figures 5-4 and 5-6, each time repeating Steps 1 through 10.
- (d) Sensing Input Types D or U (Three-Phase with Neutral Sensing). Remove the power and reconnect the input sensing each of the remaining phases as shown in Figures 5-3 and 5-5, each time repeating Steps 1 through 10. For neutral testing continue with Step 12.

Step 12. Perform the Preliminary Instructions.

For the neutral sensing (Terminals 17 and 18), connect the relay as shown in Figures 5-3 and 5-5, then perform the following steps (Steps 13 through 21).

Step 13. Set the front panel **TAP (NEUTRAL)** selector to **A**.

Step 14. Adjust the test set for an overcurrent threshold having one of the following values:

- a) 0.5 A for relays with Sensing Input Range 2 or 3.
- b) 1.5 A for relays with Sensing Input Range 4 or 5.

Step 15. Slowly adjust the front panel **CAL (NEUTRAL)** Control CCW until the front panel **TIMING** indicator illuminates.

**RESULT:** For the neutral minimum overcurrent pickup point of 0.5 A (Step 16a., above) or 1.5 A (Step 16b., above) the front panel **CAL (NEUTRAL)** control should be near its maximum CCW limit.

- Step 16. Adjust the front panel **CAL (NEUTRAL)** control fully CW to allow measurement of the actual overcurrent pickup point at the **A** setting of the front panel **TAP (NEUTRAL)** selector. Note that the front panel **TIMING (NEUTRAL)** indicator will extinguish. Do not disturb this setting.
- Step 17. Slowly increase the current toward the value of the front panel **TAP (NEUTRAL)** selector **A** setting until the front panel **TIMING (NEUTRAL)** indicator illuminates. Do not disturb this setting.
- Step 18. Record the current reading and remove input current.

**RESULT:** The recorded value should be within  $\pm 5\%$  of the front panel **TAP (NEUTRAL)** selector **A** setting for the neutral minimum overcurrent pickup point for the time overcurrent.

- Step 19. Set the front panel **TAP (NEUTRAL)** selector to **J**.
- Step 20. Slowly adjust the test set, increasing the overcurrent threshold toward the value of the front panel **TAP (NEUTRAL)** selector **J** setting until the front panel **TIMING (NEUTRAL)** indicator just illuminates. Do not disturb this setting.
- Step 21. Record the current reading and remove input current.

**RESULT:** The recorded value should be within  $\pm 5\%$  of the front panel **TAP (NEUTRAL)** selector **J** setting for the neutral maximum overcurrent pickup point for the time overcurrent element.

### Timed Output Test

This test checks the accuracy of the time overcurrent characteristic delay.

#### NOTE

For relays having three-phase sensing (sensing input type A or P) only a single input phase needs to be connected since this is sufficient for a complete test of the time delay. For relays that include neutral sensing (sensing input types D, T and J), this test includes reconnecting the test output to the neutral sensing terminals for testing the timed output during neutral sensing.

- Step 1. Verify that the preliminary instructions have been performed.
- Step 2. (Timing type Z1, Z2 or Z3 only.) Select the desired time current characteristic curve.
- Step 3. Set the front panel **TAP** selector to **B**.
- Step 4. Adjust the front panel **TIME DIAL** to **20**.
- Step 5. Adjust the test set for an overcurrent threshold of precisely 5 times the front panel **TAP** selector **B** setting, as measured on the ammeter.
- Step 6. Apply input current to the relay and initiate the test setup timer.
- Step 7. Observe that the appropriate front panel **TIMING** indicator illuminates and when the time delay ends that the timed output relay is energized.

**RESULTS:**

- (1) The appropriate front panel **TIMING** indicator extinguishes.
- (2) The test setup timer stops. (Record count for use in Step 9.)
- (3) If target type A or B is present:
  - (a) The front panel **FUNCTION-TIME** target (if present) trips.
  - (b) The appropriate front panel **ELEMENT** target **A**, **B** or **C** (if present) trips.



Step 8. Remove input current and (if present) reset the relay front panel targets.

**NOTE**

Due to delays inherent in the test equipment, the time delay for the following test may appear to exceed these limits.

Step 9. On the appropriate time overcurrent curve chart (Figures 1-2 through 1-70), locate the line representing 5 times the tap value (from Step 5) where it intersects the particular curve representing the front panel **TIME DIAL** setting of 20 (from Step 4). The resulting time delay value in seconds should be within  $\pm 5\%$  of the timer reading [from Step 7(2)].

Step 10. Adjust the front panel **TIME DIAL** to **40**, **60** and **99**, each time repeating Steps 6 through 9.

**NOTE**

For relays having two-phase and neutral, three-phase or three-phase-and-neutral sensing (sensing inputs types A, D, P, T and J) it is not necessary to repeat this test for the remaining phases.

For relays having two-phase-and-neutral or three-phase-and-neutral sensing (sensing input type D, T and J) perform Steps 11 through 20.

For relays having single-phase or three-phase sensing (sensing input types A and P) with instantaneous overcurrent Option 1-1 or 1-2, proceed to the instantaneous overcurrent test. All other relays proceed to the voltage control test.

Step 11. Remove the power and reconnect the test output to the neutral current sensing input of the relay as shown in Figures 5-3 and 5-5 (Terminals 17 and 18).

Step 12. Set the front panel **TAP (NEUTRAL)** selector to **B**.

Step 13. Rotate the front panel **CAL (NEUTRAL)** Control fully CW.

Step 14. Rotate the front panel **TIME DIAL (NEUTRAL)** to **20**.

Step 15. Ensure that all relay targets have been reset.

Step 16. Adjust the test set for an overcurrent threshold of precisely 5 times the front panel **TAP (NEUTRAL)** selector **B** setting as measured by the ammeter.

Step 17. Apply input current to the relay and initiate the test setup timer.

**RESULTS:** Observe that the appropriate front panel **TIMING (NEUTRAL)** indicator illuminates.

Step 18. When the time delay ends, the timed output relay is energized.

**RESULTS:**

- (1) The front panel **TIMING (NEUTRAL)** indicator extinguishes.
- (2) The test setup timer stops. (Record count for use in Step 20.)
- (3) If target Type A or B is present:
  - (a) Front panel **FUNCTION-TIME** target (if present) trips.
  - (b) Appropriate front panel **ELEMENT** target **A**, **B** or **C** (if present) trips.

Step 19. Remove input current and (if present) reset the relay front panel targets.

Step 20. On the appropriate time overcurrent curve chart (Figures 1-2 through 1-38), locate the line representing 5 times the tap value (from Step 5) where it intersects the particular curve representing

the front panel **TIME DIAL (NEUTRAL)** setting of 20 (from Step 14). The resulting time delay value in seconds should be within  $\pm 5\%$  of the timer reading [from Step 18(2)].

**NOTE**

Due to delays inherent in the test equipment, the time delay may appear to exceed these limits. This concludes the timed output test.

Relays having instantaneous overcurrent Option 1-1 or 1-2 **only** proceed to the Instantaneous Overcurrent Test. All other relays proceed to voltage control test.

**Instantaneous Overcurrent Pickup Test**

This test checks the minimum Overcurrent Pickup Points for Instantaneous 1 and (if present) Instantaneous 2 outputs.

**NOTE**

For relays having three-phase sensing (sensing input type A or P), only a single input phase is connected since this is sufficient for a complete test of the instantaneous overcurrent sensing and output.

For relays that include neutral sensing (sensing input types D, T and J), this test includes reconnecting the test output to the neutral sensing terminals for testing the Instantaneous 1 output during neutral sensing.

- Step 1. Perform the Preliminary Instructions.
- Step 2. Reconnect the test setup to the INST 1 Output Terminals 2 and 10 as shown in Figures 5-1 through 5-6. Note that the timer may be removed from the test setup at this time.
- Step 3. Set the **TAP** selector to **A**.
- Step 4. Turn the front panel **INST 1** control fully CCW to establish a pickup point of 1 times the **TAP** selector **A** setting.
- Step 5. Slowly adjust the test set, increasing the overcurrent threshold toward the value of the front panel **TAP** selector **A** setting until the Instantaneous 1 Output Relay energizes). Do not disturb this setting.

**RESULT:** If the target Type A or B is present:

- (a) The front panel **FUNCTION - INST 1** target (if present) will trip.
- (b) The appropriate front panel **ELEMENT** target **A**, **B** or **C** (if present) will trip.

- Step 6. Remove input current. Record the test set current setting.

**RESULT:** The recorded value should be equal to or less than the front panel **TAP** selector **A** setting for the minimum overcurrent pickup point for the instantaneous 1 overcurrent element.

- Step 7. Reset the relay front panel targets (if present).
- Step 8. Turn the front panel **INST 1** control fully CW to establish a pickup point of 40 times the front panel **TAP** selector **A** setting.
- Step 9. Adjust the test set to approximately 35 times the front panel **TAP** selector **A** setting.

Step 10. Slowly adjust the test set further toward an overcurrent threshold of 40 times the front panel **TAP** selector **A** setting until the Instantaneous 1 Output Relay energizes. Do not disturb this setting.

**RESULT:** If target Type A or B is present:

- (a) The front panel **FUNCTION - INST 1** target (if present) will trip.
- (b) The appropriate front panel **ELEMENT** target **A**, **B** or **C** (if present) will trip.

Step 11. Record the current reading. Remove input current (the front panel **TIMING** indicator should extinguish).

**RESULT:** The recorded value should be greater than 40 times the front panel **TAP** selector **A** setting for the maximum overcurrent pickup point for the Instantaneous 1 Overcurrent element.

**NOTE**

For relays having neutral sensing (sensing input types D, T and J) perform Step 12. Otherwise, proceed to Step 13.

Step 12. For the neutral sensing, connect the relay as shown in Figures 5-3 and 5-5, then repeat Steps 2 through 11 substituting the following:

- (a) The front panel **TAP (NEUTRAL)** selector instead of the front panel **TAP** selector (Step 3).
- (b) The front panel **INST 1 (NEUTRAL)** control instead of the front panel **INST 1** control (Step 4).

**NOTE**

For relays with Option 1-2 (Inst. 2 elements), perform Step 13. Otherwise, the test ends here.

Step 13. Reconnect the test setup to the Instantaneous 2 Output Terminals (11 and 12) as shown in Figure 5-1. Then repeat Steps 4 through 11 substituting the following:

- (a) Front panel **INST 2** Control instead of the front panel **INST 1** Control (Step 3).
- (b) Front panel **FUNCTION - INST 2** target instead of the front panel **INST 1** target (Step 4).
- (c) Instantaneous 2 Output Relay instead of the Instantaneous 1 Output Relay (Step 2).

**NOTE**

This concludes the instantaneous overcurrent sensing and output test.

## Voltage Control Test

This test checks the voltage control minimum and maximum limits for the voltage inhibit levels.

Step 1. Perform the Preliminary Instructions.

Step 2. Set the front panel **TAP** Selector to **B**.

Step 3. Adjust the front panel **TIME DIAL** to **20**.

Step 4. Adjust for an overcurrent threshold of 2 times the front panel **TAP** selector **B** setting.

Step 5. Rotate the front panel **VOLTS INHIBIT ADJ** or **VOLTAGE INHIBIT ADJ** fully CCW.

Step 6. Adjust the test voltage to its minimum voltage setting, then slowly increase the voltage until the appropriate front panel **VOLTS INHIBIT** or **VOLTAGE INHIBIT** indicator just illuminates. Do not disturb this setting.

**RESULT:** The voltage should be <40 Vac.

Step 7. Apply input current to the relay and initiate the test setup timer.

**RESULT:** The front panel **TIMING** Indicator does not illuminate which signifies that the relay timed output is inhibited.

Step 8. Remove input current and reset the test setup timer.

Step 9. Rotate the front panel **VOLTS INHIBIT ADJ** or **VOLTAGE INHIBIT ADJ** fully CW.

Step 10. Adjust the test voltage for a 110 Vac output, then slowly increase its output voltage until the appropriate front panel **VOLTS INHIBIT** or **VOLTAGE INHIBIT** Indicator just illuminates.

**RESULT:** The voltage should be >120 Vac.

#### NOTE

For relays having two-phase-and-neutral sensing, three-phase sensing or three-phase-with-neutral sensing (sensing input types A, D, P, T and J) remove power and reconnect the input sensing to each of the remaining phases (see Figures 5-2 through 5-6), each time repeating Steps 1 through 10. Ensure that the voltage sense terminals and the current sense terminals are connected to the same phase.

When all phases have been tested, the voltage control test is concluded. If the instantaneous overcurrent Option 1-1 or 1-2 is present, proceed to instantaneous overcurrent pickup.

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## ADJUSTMENT OF CONTROLS FOR RELAY OPERATION

The following procedures set up the relay for use in a protective scheme. The procedures are arranged in a logical sequence that prevents upsetting previous control settings. For relays not having certain options, skip the corresponding adjustment paragraph. These paragraphs are identified by their headings.

### TAP and TAP (NEUTRAL) Selector Setting

#### NOTE

Selection of one of the specific overcurrent pickup points provided by the front panel **TAP** Selector (and with the front panel **TAP CAL** control fully CW) will permit a pickup point within  $\pm 5\%$  of the selector value without having to connect the relay to a test setup to verify the setting. If present, the front panel **TAP (NEUTRAL)** selector and the front panel **CAL (NEUTRAL)** control provide this function for the neutral overcurrent pickup point.

However, if the desired pickup point falls between these front panel **TAP** selector settings, or if the Instantaneous Overcurrent Option 1-1 or 1-2 is present, the relay should be connected to a test setup for a precise setting, then the following steps should be performed.

Step 1. Connect the test setup to the relay according to the sensing input type present in the relay as follows:

- (a) Sensing Input Type L: Refer to Figure 5-1. Because the relay front panel **TIMING** indicator provides the needed pickup indication, do not connect the test setup to the output terminals. The current sense terminals for the desired range (HIGH or LOW), however, should be connected to the relay.
- (b) Sensing Input Types J: Refer to Figure 5-6. Because the relay front panel **TIMING** indicator provides the needed pickup indication, do not connect the test setup to the output terminals. The front panel **TAP** selector is ganged and the adjustment of one input phase automatically aligns the other. Thus, only one set of current sense terminals need be connected. For adjustment of the front panel **TAP (NEUTRAL)** selector, the relay is re-connected for neutral sensing by this procedure.
- (c) Sensing Input Types A and P: Refer to Figures 5-2 or 5-4. Because the relay front panel **TIMING** indicator provides the needed pickup indication, do not connect the test setup to the output terminals. The desired range terminals (HIGH or LOW), however, should be connected to the relay. The front panel **TAP** selector is ganged and the adjustment of one input phase automatically aligns the others. Thus, only one set of current sense terminals need be connected.
- (d) Sensing Input Types D or T: Refer to Figures 5-3 and 5-5. Because the relay front panel **TIMING** indicator provides the needed pickup indication, do not connect the test setup to the output terminals. The front panel **TAP** selector is ganged and the adjustment of one input phase automatically aligns the others. Thus, only one set of current sense terminals need be connected. For adjustment of the front panel **TAP (NEUTRAL)** selector, the relay is re-connected for neutral sensing by this procedure.

#### NOTE

For three-phase relays, ensure that the test signals are connected to both the current and voltage terminals for the same phase.

- Step 2. Remove the relay front cover.
- Step 3. Sensing Input Types L and P. Verify that the front panel **TAP RANGE** plate is installed so the correct range (HIGH or LOW) is visible.
- Step 4. Adjust the test voltage to 0 Vac and current to the desired time overcurrent pickup point for the relay.
- Step 5. Set the front panel **TAP** selector to the closest setting above the desired pickup point.
- Step 6. Adjust the front panel **TAP CAL** control fully CW.
- Step 7. Apply current to the relay.
- Step 8. Slowly adjust the front panel **TAP CAL** Control CCW until the front panel **TIMING** indicator just illuminates which indicates the desired time overcurrent pickup point for phase sensing. For relays with two-phase-and-neutral, three-phase or three-phase-and-neutral sensing, this pickup point will be the same for all the phases.
- Step 9. Remove input current.

#### NOTE

For relays with two-phase-and-neutral or three-phase-and-neutral sensing (sensing input types D, T and J), perform Steps 10 through 15. Otherwise, the time overcurrent pickup point calibration ends here (unless Instantaneous 1 or 2 overcurrent calibration is to be performed later in these procedures).

- Step 10. Reconnect the test set output to the neutral sense terminals. See Figures 5-3, 5-5 or 5-6.
- Step 11. Adjust the current to the desired time overcurrent pickup point for the relay.
- Step 12. Set the front panel **TAP (NEUTRAL)** selector to the closest setting above the desired pickup point.
- Step 13. Rotate the front panel **CAL (NEUTRAL)** control fully CW.
- Step 14. Slowly adjust the front panel **CAL (NEUTRAL)** Control CCW until the front panel **TIMING (NEUTRAL)** indicator just illuminates to establish the desired time overcurrent pickup point for neutral sensing.
- Step 15. Remove input current.

**NOTE**

The pickup point calibration ends here.

**Time Overcurrent Curve Selection (Timing Type Z1, Z2 and Z3 only)**

- Step 1. Remove the relay case front cover to gain access to the logic board time overcurrent characteristic curve selector.
- Step 2. Remove the phillips-head screws from both side of the unit and remove the front panel. See Figure 2-1 for the location of the logic board and curve selector.
- Step 3. Select the desired curve. See Table 2-3 for the desired curve and selector position.
- Step 4. Re-install the front panel and the front cover.

**Time Delay Selection**

**NOTE**

If Timing Type Z1, Z2 or Z3 is installed, refer to time overcurrent curve selection to obtain the desired set of time overcurrent curves (see Figures 1-2 through 1-70). Then proceed to Step 1, following.

If Timing Type Z1, Z2 or Z3 is not installed, determine the timing type from the model and style number for a specific relay. Then select the appropriate timing curve (see Figures 1-2 through 1-70). Proceed to the following, Step 1.

- Step 1. Referring to the appropriate time overcurrent characteristic curve, select the desired time delay on the front panel **TIME DIAL** for the anticipated input overcurrent difference (multiples-of-pickup current) from the selected time overcurrent pickup point as follows:

$$(\text{Selected Pickup Point}) - (\text{Anticipated Input Overcurrent}) = \text{Overcurrent Difference from Pickup}$$

- Step 2. Set the front panel **TIME DIAL** as follows:
- On the appropriate curve, plot upward from the ***multiples-of-pickup-current*** value until the horizontal line opposite the desired time delay (***time-in-seconds***) is reached. The setting curve nearest the plot point should then be entered on the front panel **TIME DIAL**.

- b. Using Figure 1-6 as an example, if the overcurrent is expected to be 4 times the pickup point value and time delay of 4 seconds is desired, plot upward from the point 4 on the **multiples-of-pickup-current** axis until the point 4 from the **time-in-seconds** axis is crossed. The curve for a setting of **52** crosses the plot point and should be entered on the front panel **TIME DIAL**.
- c. For a lesser overcurrent difference from the pickup point, the time delay will be greater, so that for a multiple of 3 times the pickup current, the time delay for the previous front panel setting of **52** will be 5.8 seconds.

### Neutral Time Delay Selection

- Step 1. Use the same characteristic curve used in the previous paragraph (Time Delay Selection). However, the **multiples-of-pickup current**, **time-in-seconds** and the resulting front panel **NEUTRAL TIME DIAL** setting can differ.
- Step 2. Set the front panel **NEUTRAL TIME DELAY** as follows:
  - a. On the appropriate curve, plot upward from the **multiples-of-pickup-current** value until the horizontal line opposite the desired time delay ( **time-in-seconds**) is reached. The setting curve nearest the plot point should then be entered on the front panel **NEUTRAL TIME DELAY**.
  - b. Using Figure 1-6 as an example, if the overcurrent is expected to be 4 times the pickup point value and time delay of 4 seconds is desired, plot upward from the point 4 on the **multiples-of-pickup-current** axis until the point 4 from the **time-in-seconds** axis is crossed. The curve for a setting of **52** crosses the plot point and should be entered on the front panel **NEUTRAL TIME DIAL**.
  - c. For a lesser overcurrent difference from the pickup point, the time delay will be greater, so that for a multiple of 3 times the pickup current, the time delay for the previous front panel setting of **52** will be 5.8 seconds.

### VOLTS INHIBIT ADJ or VOLTAGE INHIBIT ADJ Setting

- Step 1. Verify that the test setup is performed.
- Step 2. Adjust the test voltage to the desired inhibit level (between 40 and 120 Vac).
- Step 3. Starting at fully CCW, slowly adjust the front panel **VOLTS INHIBIT ADJ** or **VOLTAGE INHIBIT ADJ** (move CW) until the appropriate front panel **VOLTS INHIBIT** or **VOLTAGE INHIBIT** indicator just illuminates. The voltage inhibit level is now established. If multiple phases are sensed by the relay, all phases will have the same voltage inhibit level.

### INST 1 Control Setting

#### NOTE

Because the lower limit for this pickup is determined by the front panel **TAP** selector setting and the front panel **TAP (CAL)** control position, ensure that these adjustments have been performed as in the **TAP AND TAP (NEUTRAL) Selector Setting** paragraph.

- Step 1. Verify that the test setup is as described in *TAP and TAP (NEUTRAL) Selector Setting*, Steps 1 through 6.
- Step 2. Connect the test setup to the instantaneous 1 element Output Terminals (2 and 10) as shown in Figures 5-1 through 5-6. The timer should not be connected.

### CAUTION

Steps 3 through 8 provide the application of overcurrent for short periods of time to allow adjustment while avoiding overheating of the input sensing transformers. To avoid damaging the relay, do not attempt to apply a constant high level of input current for adjustment of the front panel **INST 1**, **INST 1 (NEUTRAL)** or **INST 2** controls.

- Step 3. Set the front panel **INST 1** control to a position approximating the desired instantaneous 1 overcurrent pickup point for the relay.
- Step 4. Apply current to the relay.
- Step 5. Rapidly increase the overcurrent input to the relay until the Instantaneous Output Relay just energizes. Note the overcurrent threshold reading on the ammeter.
- Step 6. Remove input current.
- Step 7. Reset the **INST TARGET** (if present).
- Step 8. If the overcurrent threshold reading from Step 5 was too high or low, adjust the front panel **INST 1** control CCW to lower (or CW to raise) the instantaneous 1 overcurrent pickup point. Repeat Steps 4 through 8. If the overcurrent threshold reading from Step 5 was **NOT** too high or low, proceed to Step 9.

### NOTE

For relays with two-phase-and-neutral or three-phase-and-neutral sensing (sensing input types D, T and J), perform Steps 9 through 14.

- Step 9. Reconnect the output to the Neutral Current Sense Terminals. See Figures 5-3, 5-5 or 5-6.
- Step 10. Set the front panel **INST 1 (NEUTRAL)** control to a position approximating the desired Neutral Instantaneous 1 overcurrent pickup point for the relay.
- Step 11. Apply current to the relay.
- Step 12. Rapidly increase the overcurrent input to the relay until the instantaneous output relay just energizes. Note the test set overcurrent threshold reading on the ammeter.
- Step 13. Remove the input current.
- Step 14. Reset the **INST TARGET** (if present).
- Step 15. If the overcurrent threshold reading from Step 13 was too high or low, adjust the front panel **INST 1 (NEUTRAL)** Control CCW to lower (or CW to raise) the Neutral Instantaneous 1 Overcurrent pickup point. Repeat Steps 9 through 14. If **NOT**, proceed to the next test.

### INST 2 Control Setting

For this adjustment, repeat INST 1 Control Setting but substitute Instantaneous 2 Output Terminals (11 and 12) and the front panel **INST 2** controls. Because neutral sensing does not apply to this pickup point, ignore Steps 9 through 15.



# SECTION 6 • MAINTENANCE

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## GENERAL

BE1-51/27C Time Overcurrent Relays require no preventive maintenance other than a periodic operational test (refer to Section 5, *Tests and Adjustments*, for operational test procedure). If the relay fails to function properly, contact the Customer Service Department of the Power Systems Group, Basler Electric, for a return authorization number prior to shipping.

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## IN-HOUSE REPAIR

In-house replacement of individual components may be difficult and should not be attempted unless appropriate equipment and qualified personnel are available.

### CAUTION

Substitution of printed circuit boards or individual components does not necessarily mean the relay will operate properly. Always test the relay before placing it in operation.

If in-house repair is to be attempted, the quality of replacement parts must be at least equal to that of the original components.

Where special components are involved, Basler Electric part numbers may be obtained from the number stamped on the component or assembly, the schematic or parts list. These parts may be ordered directly from Basler Electric. When complete boards or assemblies are needed, the following information is required.

1. Relay model and style number
2. Relay serial number
3. Board or assembly
  - a) Part number
  - b) Serial number
  - c) Revision letter
4. The name of the board or assembly

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## STORAGE

This protective relay contains aluminum electrolytic capacitors which generally have a life expectancy in excess of 10 years at storage temperatures less than 40° C. Typically, the life expectancy of the capacitor is cut in half for every 10° C rise in temperature. Storage life can be extended if, at one-year intervals, power is applied to the relay for a period of thirty minutes.

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## TEST PLUG

Test plugs (Basler Electric part number 10095 or G.E. part number XLA12A1) provide a quick, easy method of testing relays without removing them from their case. Test plugs are simply substituted for the connection plugs. This provides access to the external stud connections as well as to the internal circuitry.

Test plugs consist of black and red phenolic moldings with twenty electrically separated contact fingers connected to ten coaxial binding posts. Fingers on the black side are connected to the inner binding posts (black thumb nuts) and tap into the relay internal circuitry. Fingers on the red side of the test plug are connected to the outer binding posts (red thumb nuts) and also connect to the relay case terminals.

When testing circuits connected to the bottom set of case terminals, the test plug is inserted with the numbers 1 through 10 facing up. Similarly, when using the test plug in the upper part of the relay, the numbers 11 through 20 are faceup. It is impossible, due to the construction of the test plug, to insert it with the wrong orientation.

# APPENDIX A • TIME OVERCURRENT CURVES

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## CHARACTERISTIC CURVES

Graphs on the following pages illustrate sample characteristic curves for all of the time overcurrent functions individually as options, or selectable by switch (if the Z1, Z2, or Z3 timing option is specified). The Z1 option can select any of the timing types designated as B1 through B8, and British Standard timing types E2, E4, E5, E6, and E7. The Z3 option can select the integrating algorithm for any of the timing types designated as B1 through B8, and C1 through C8.

Note that there are two versions of each timing type: standard and extended timing. The exception to this is the British Standard curves, which do not have an extended timing version. For any given relay, either the standard or the extended range version will apply, never both.

A drawing number is listed in the caption for each characteristic curve. Use this number to request the full-size (11 inches by 17 inches) characteristic curve chart on transparent paper. Publication 9 1372 00 897 contains 36 full-size characteristic curve charts (timing options Z1 and Z2). To order any of these charts, contact the Customer Service Department of the Power Systems Group at Basler Electric.

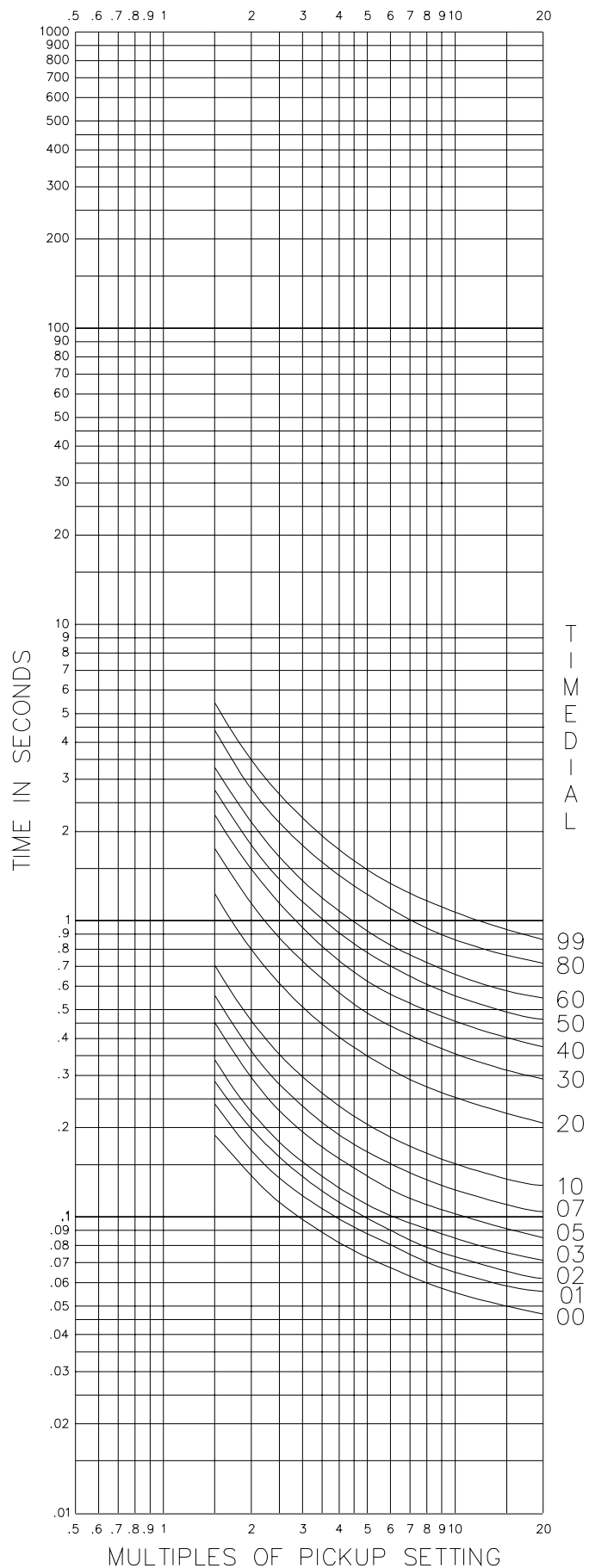


Figure A-1. Timing Type B1: Short Inverse (99-0932)

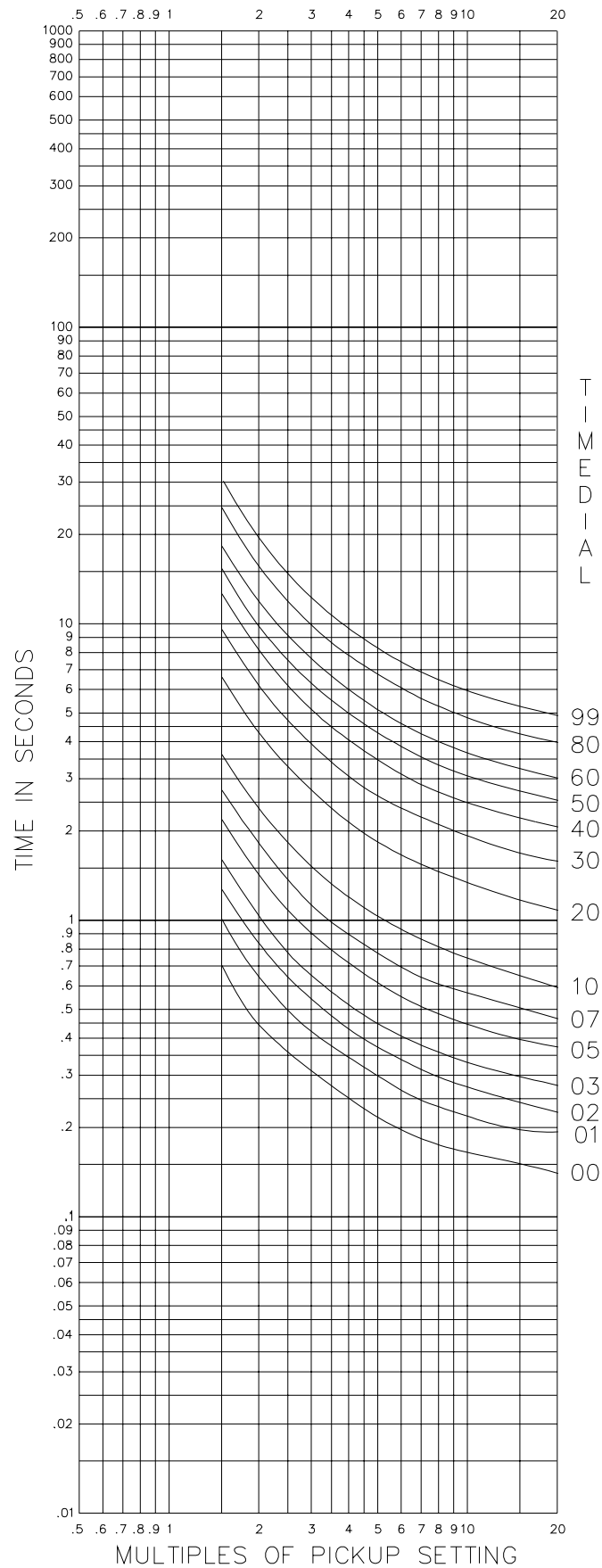


Figure A-2. Timing Type B1: Short Inverse with  
Extended Timing Range (99-0944)

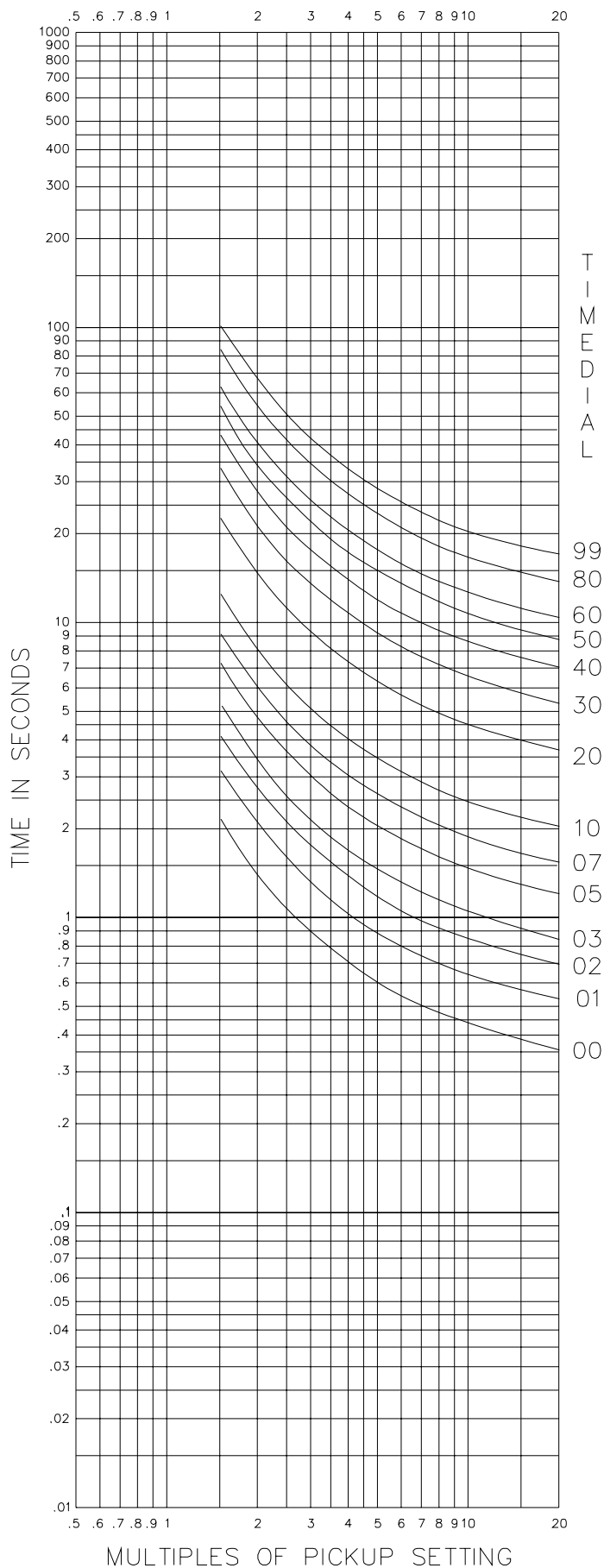
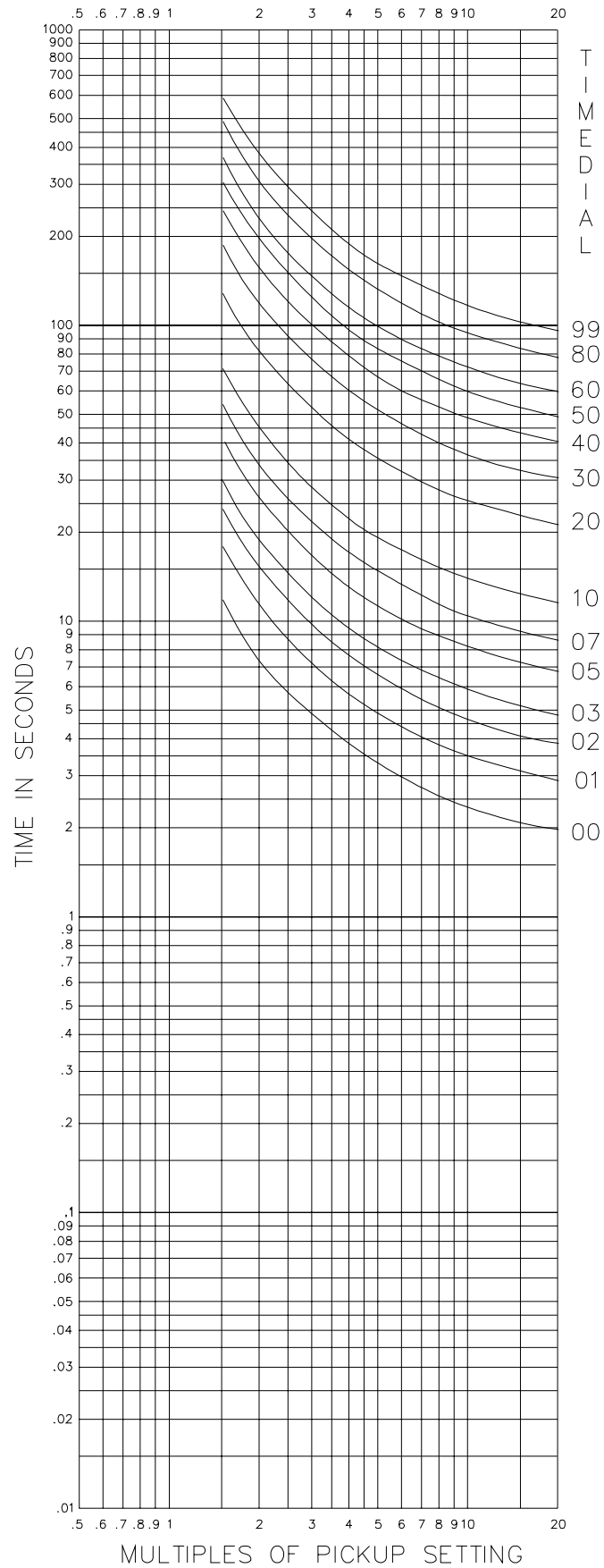


Figure A-3. Timing Type B2: Long Inverse (99-0931)



*Figure A-4. Timing Type B2: Long Inverse with Extended Timing Range (99-0946)*

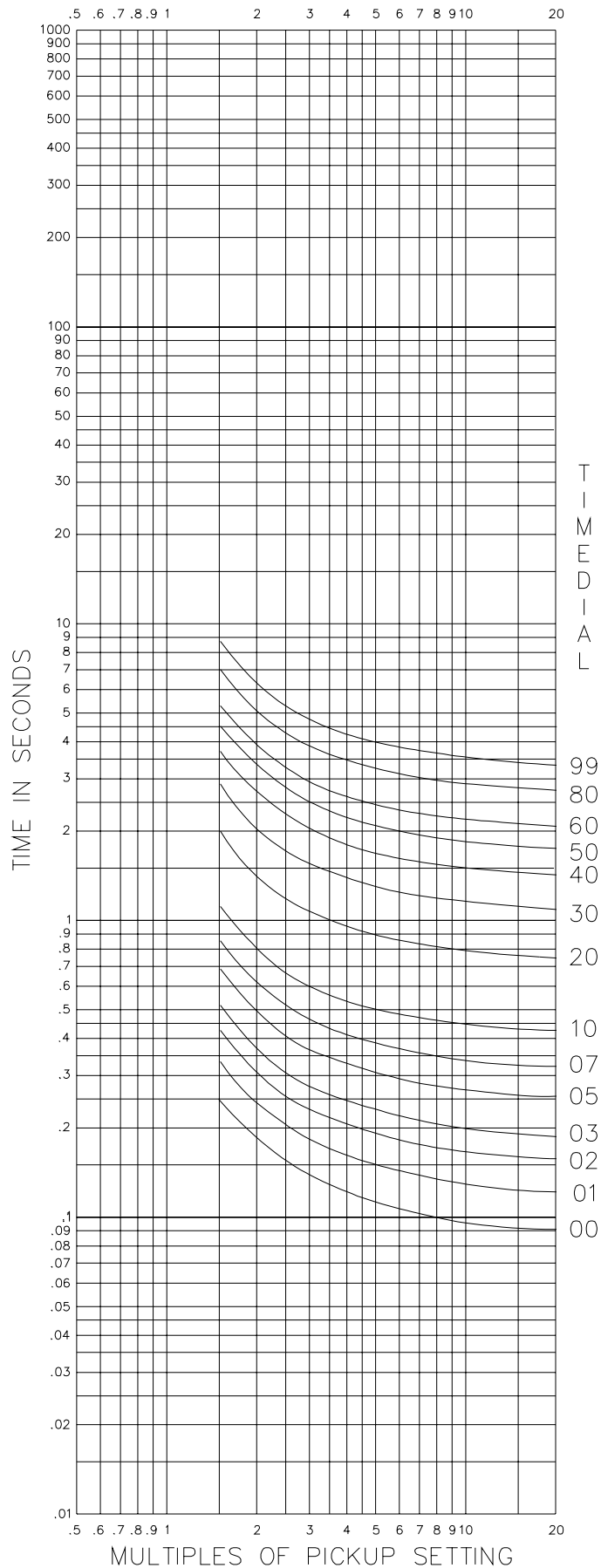


Figure A-5. Timing Type B3: Definite Time (99-0933)



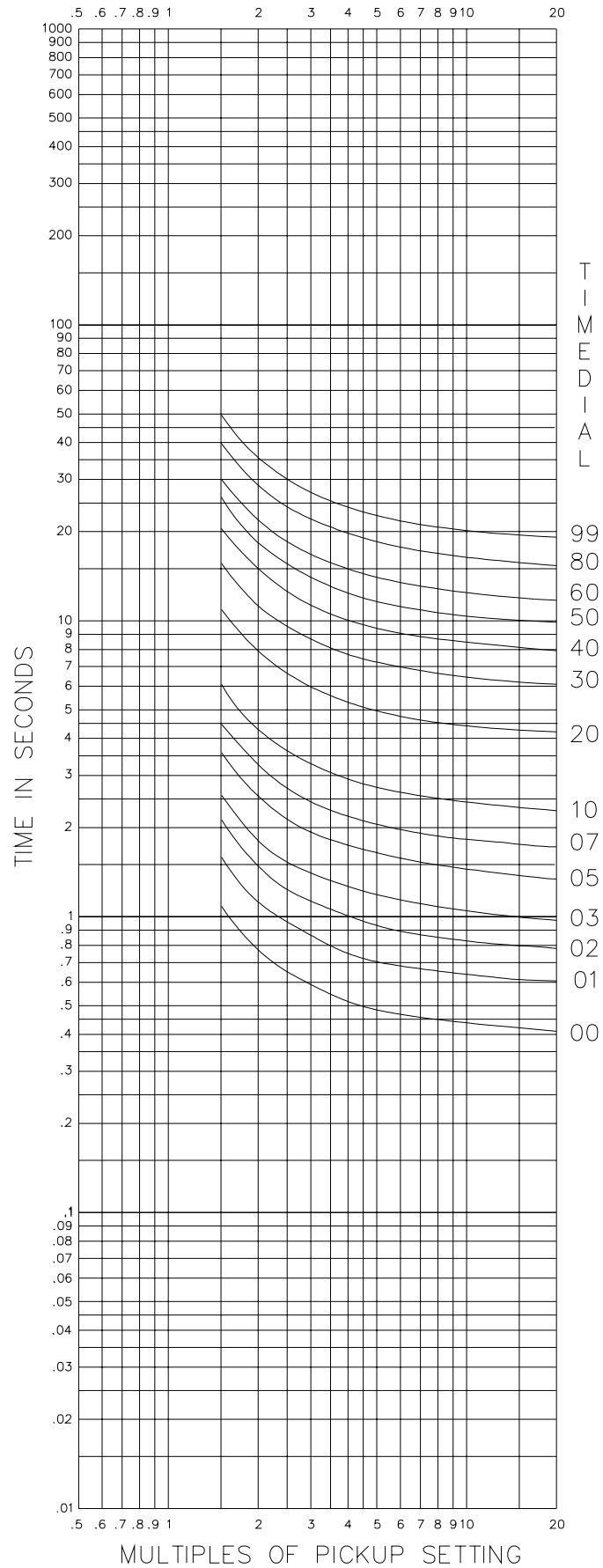


Figure A-6. Timing Type B3: Definite Time with Extended Timing Range (99-0942)

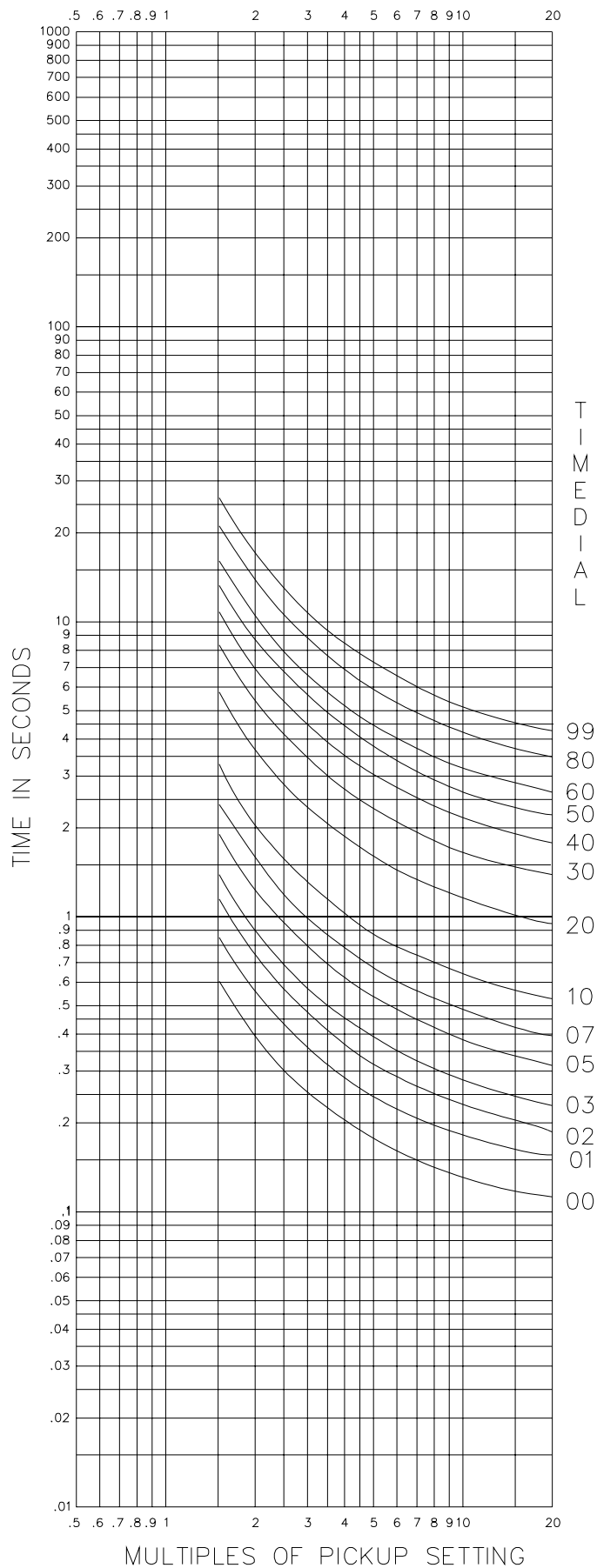


Figure A-7. Timing Type B4: Moderately Inverse (99-0930)

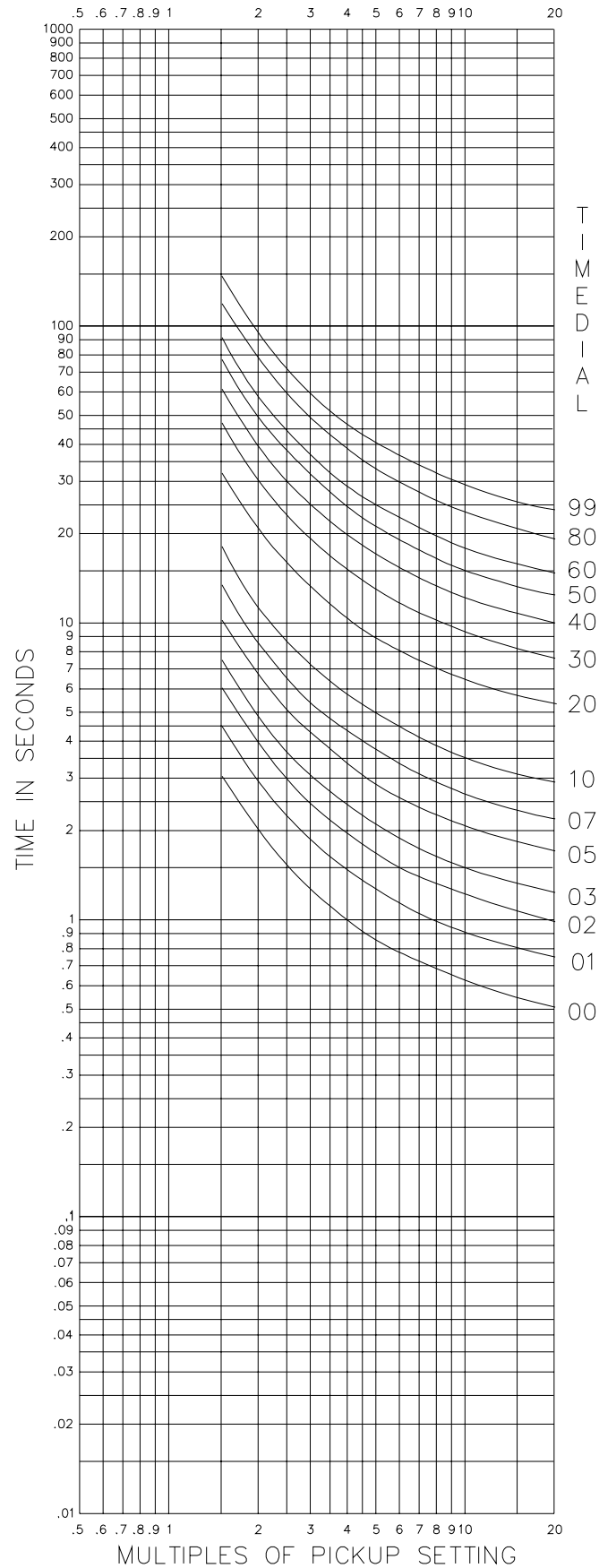


Figure A-8. Timing Type B4: Moderately Inverse with Extended Timing Range (99-0945)

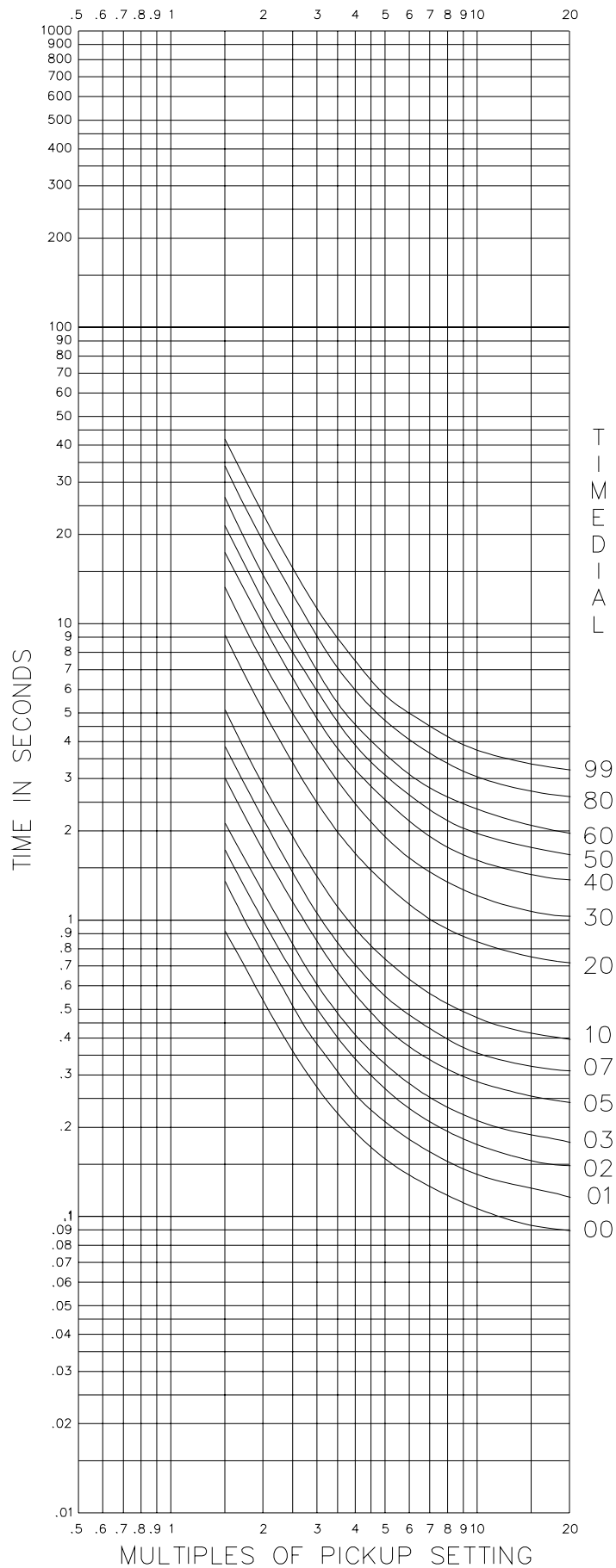


Figure A-9. Timing Type B5: Inverse (99-0929)

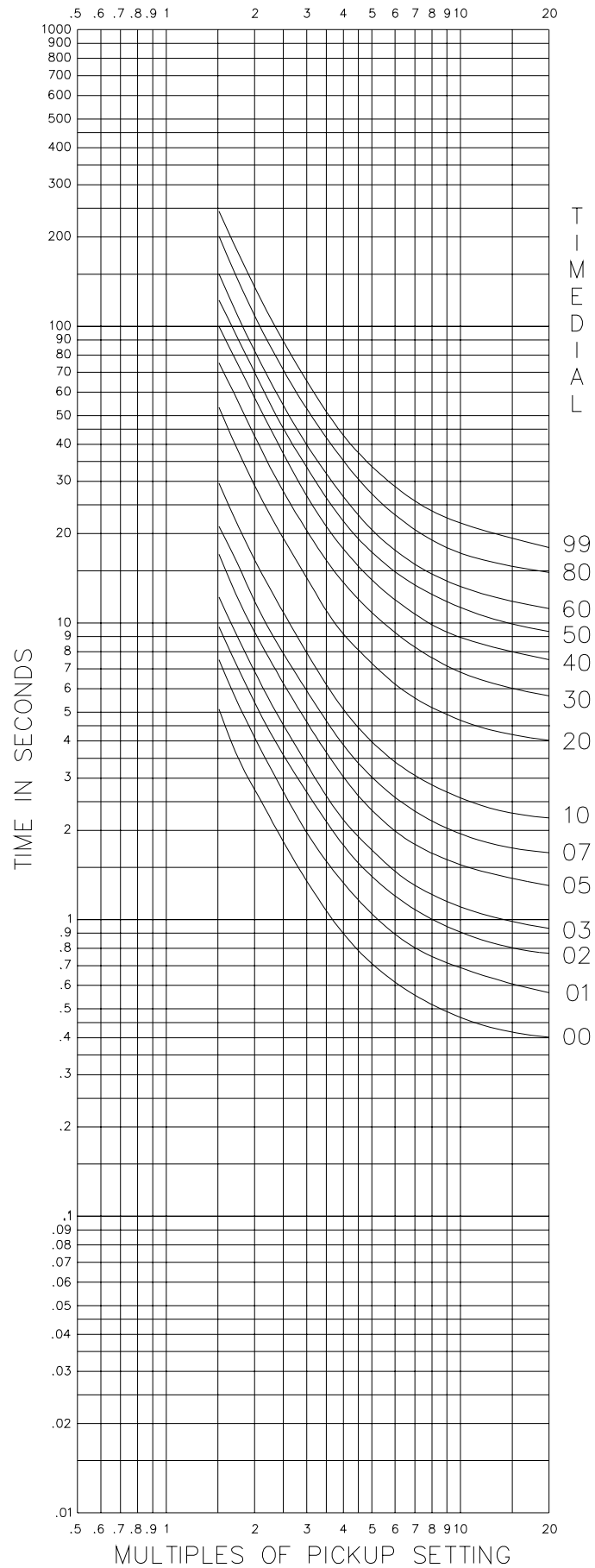


Figure A-10. Timing Type B5: Inverse  
with Extended Timing Range (99-0943)

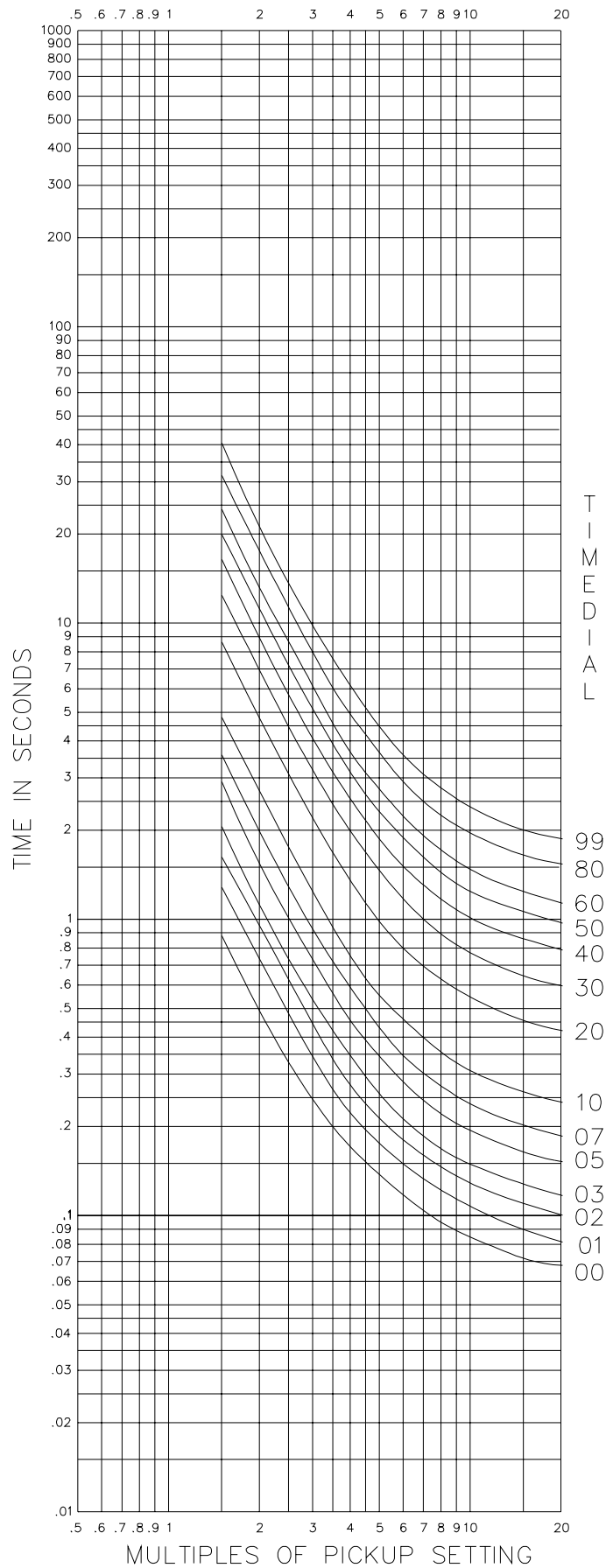


Figure A-11. Timing Type B6: Very Inverse (99-0928)

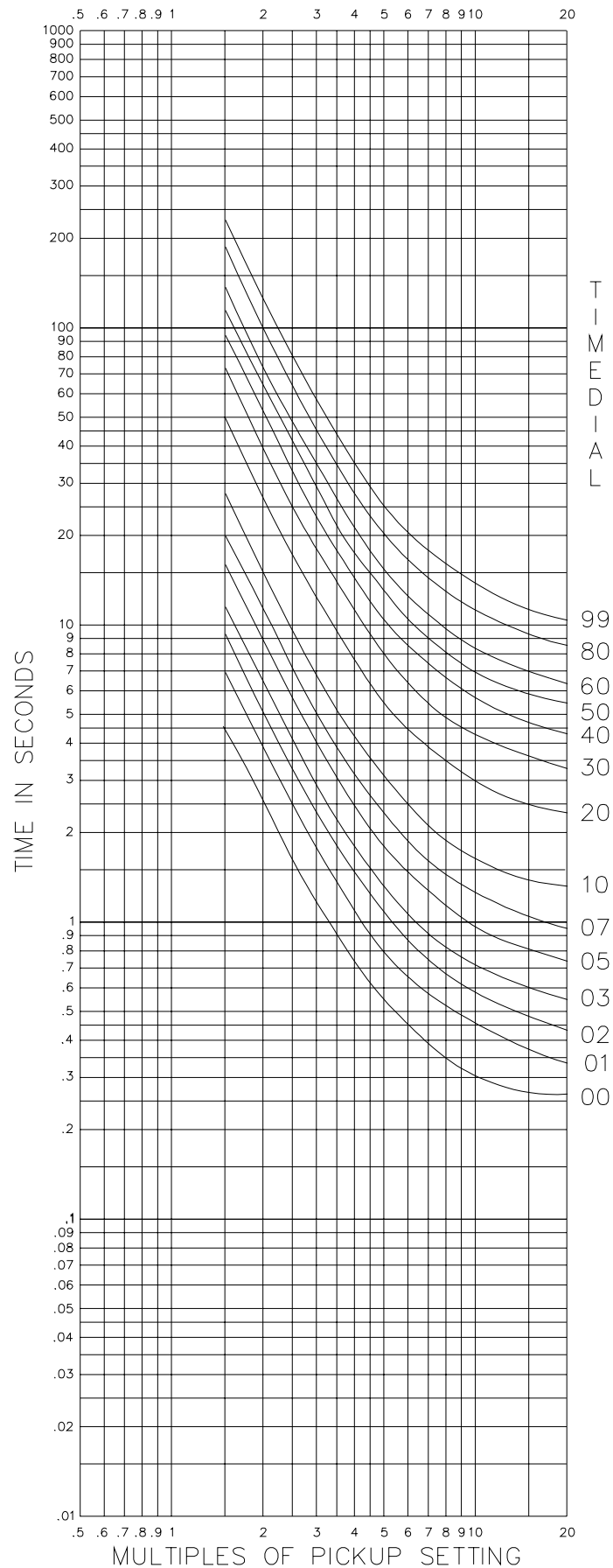


Figure A-12. Timing Type B6: Very Inverse  
with Extended Timing Range (99-0941)

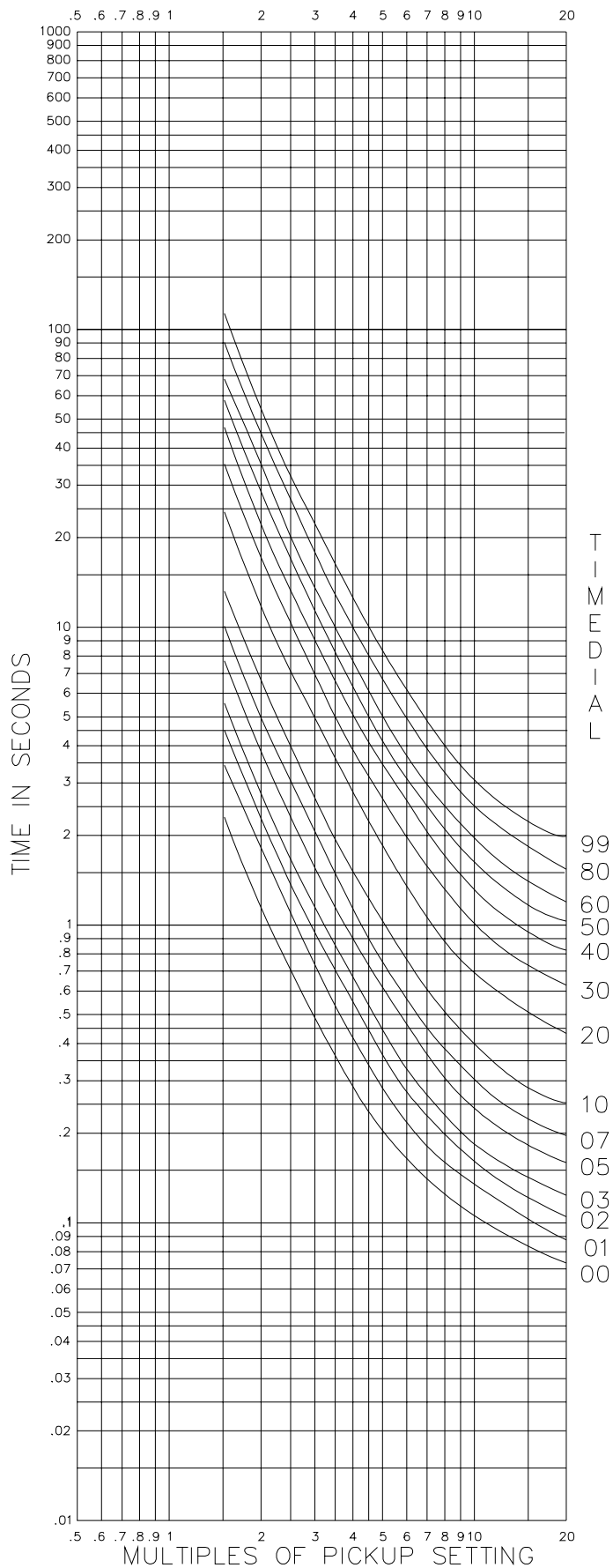
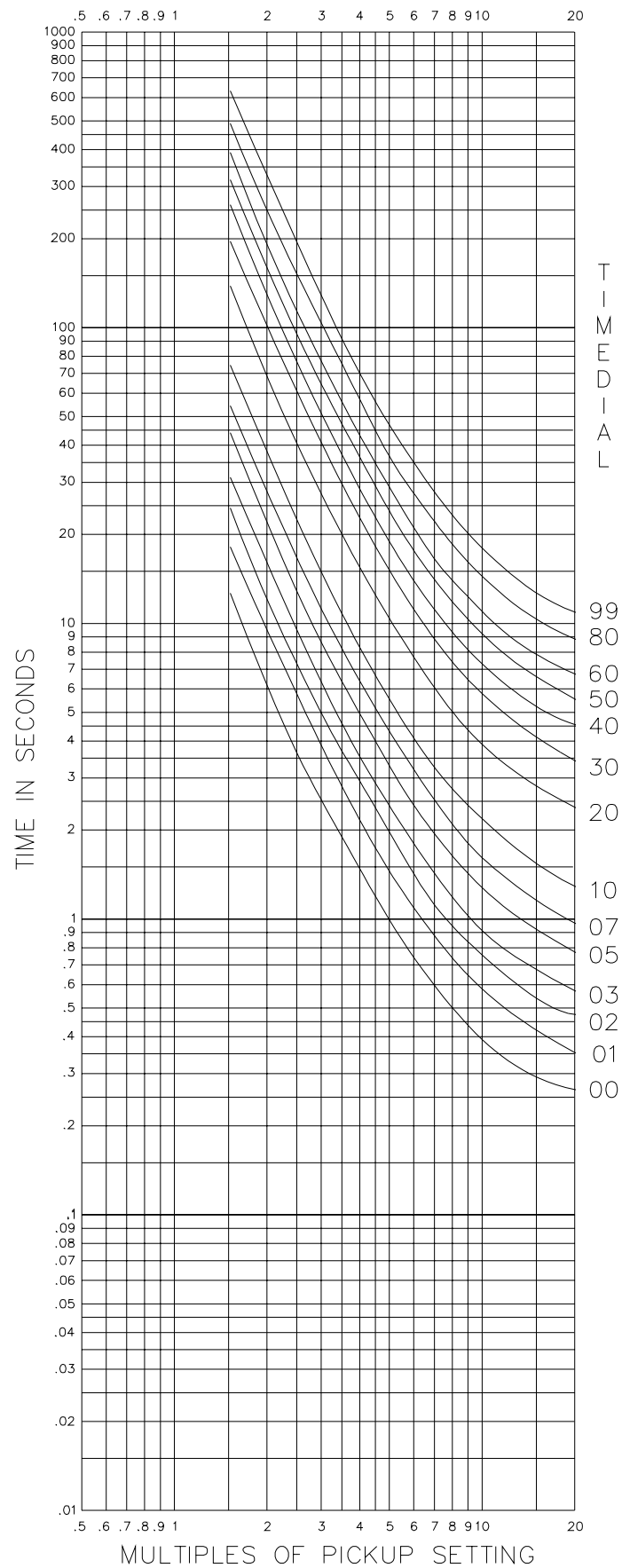


Figure A-13. Timing Type B7: Extremely Inverse (99-0927)





*Figure A-14. Timing Type B7: Extremely Inverse with Extended Timing Range (99-0940)*

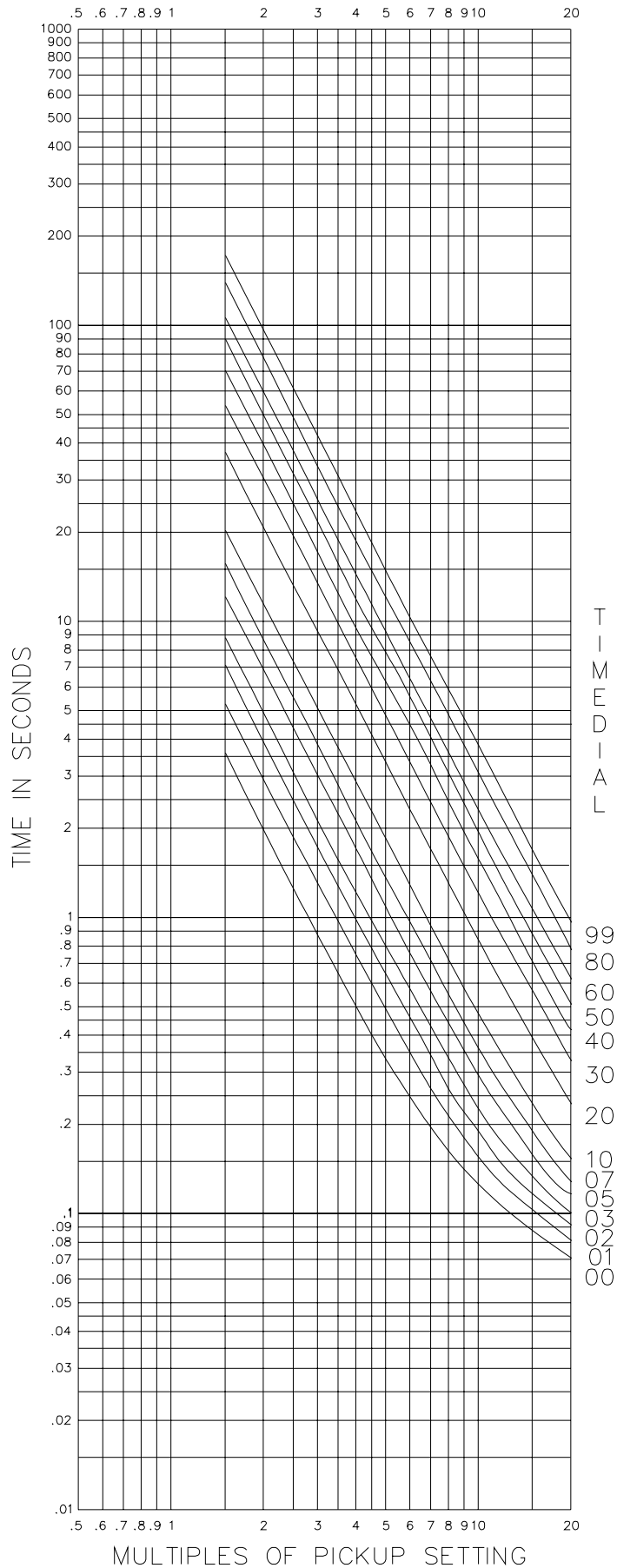


Figure A-15. Timing Type B8: PT (99-0926)

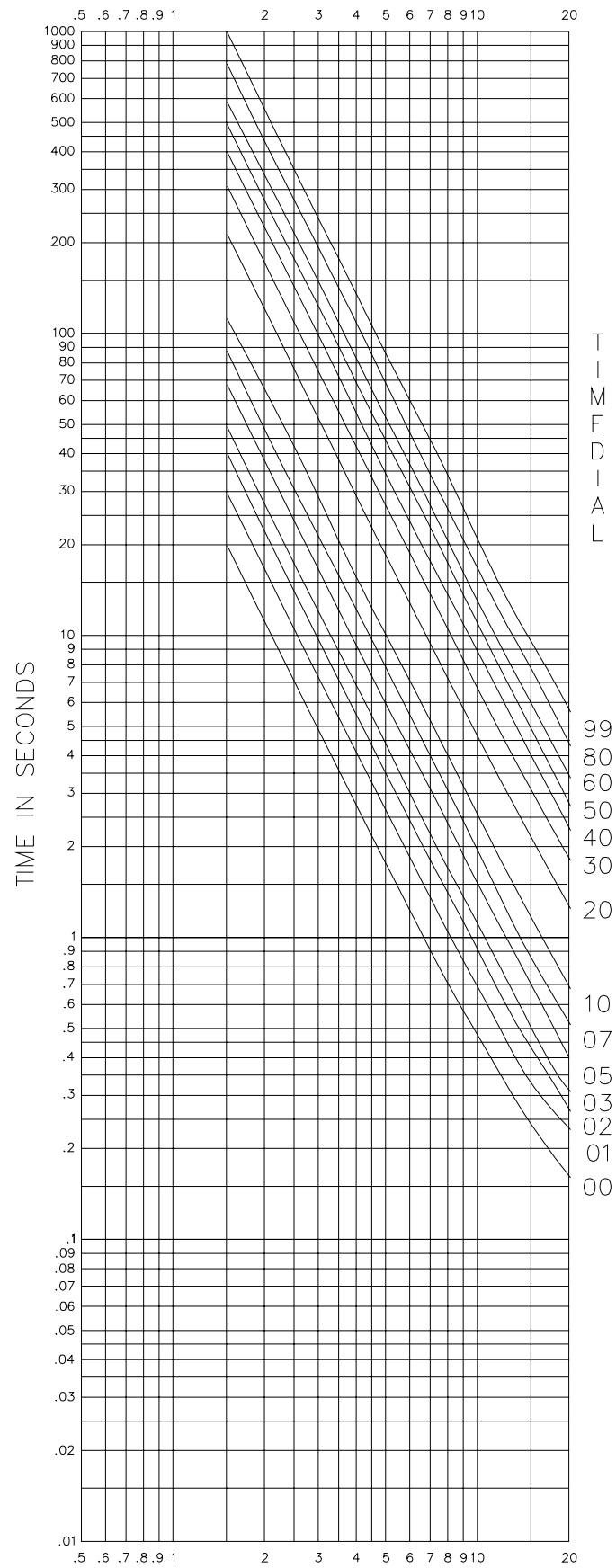


Figure A-16. Timing Type B8:  $I^2T$   
with Extended Timing Range (99-0947)

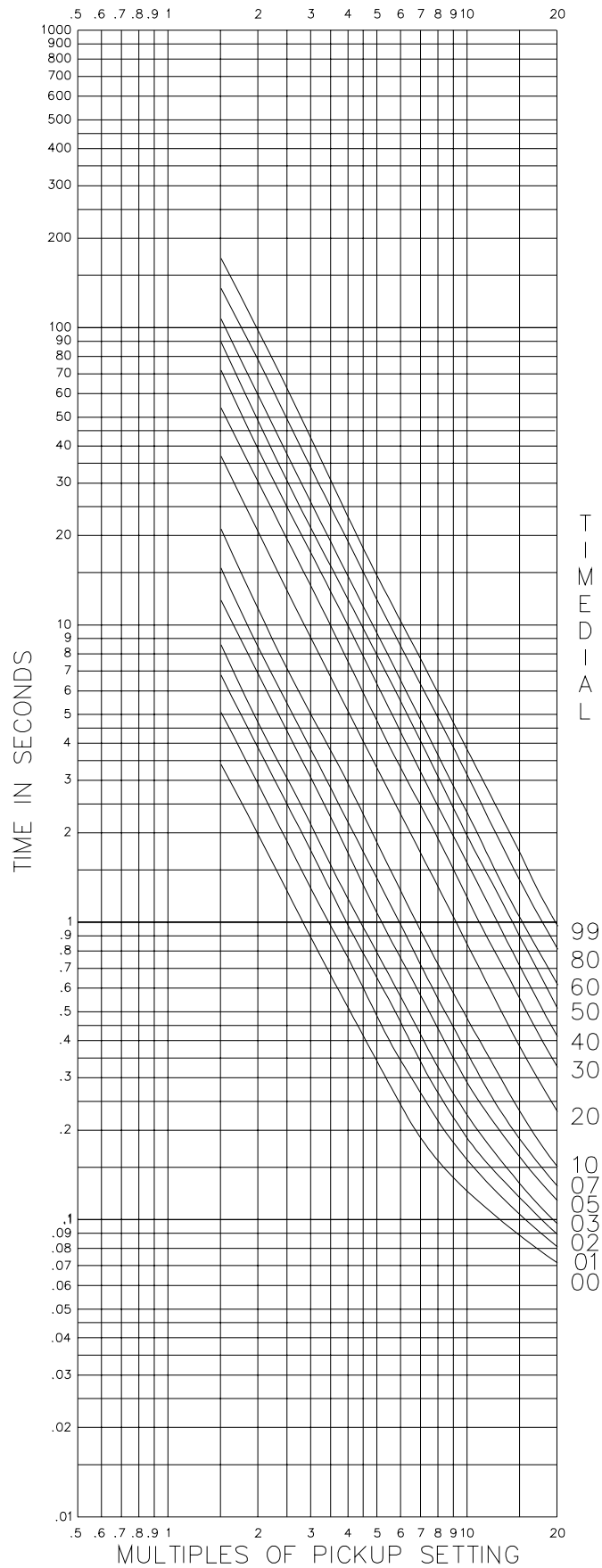


Figure A-17. Timing Type C1: P.T. with Limit #1 (99-0956)

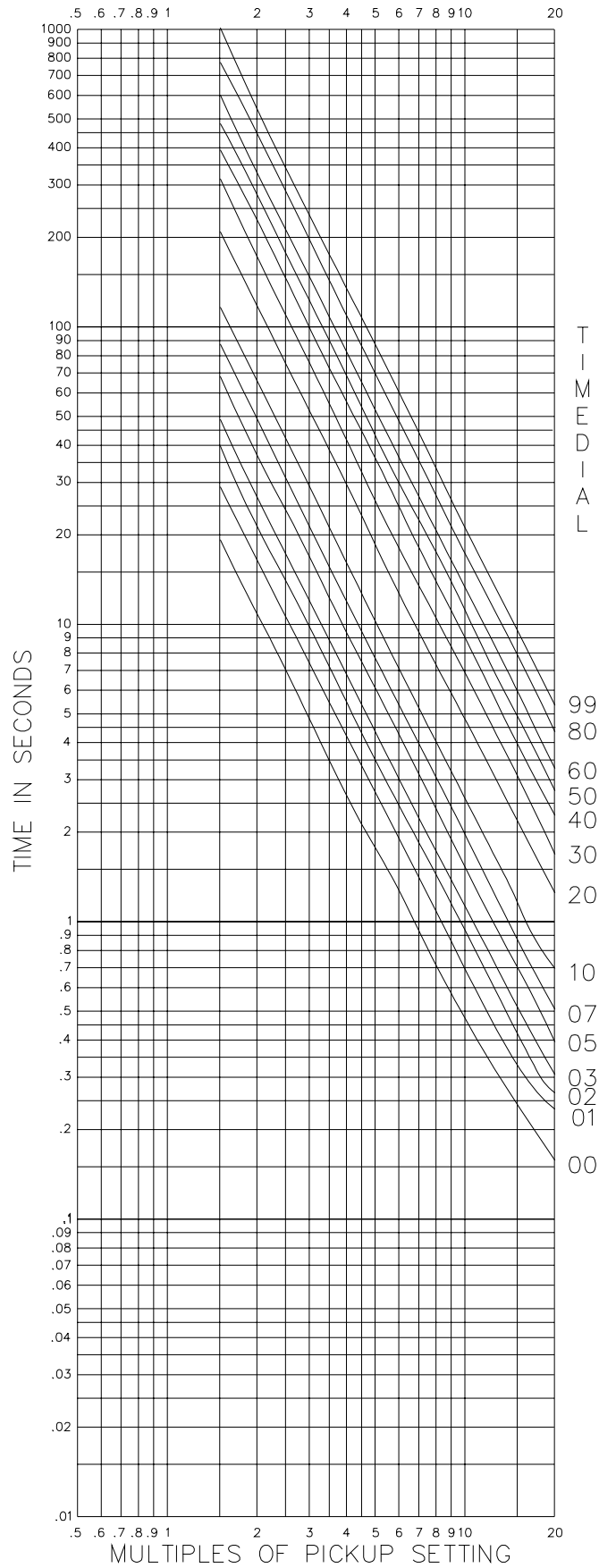


Figure A-18. Timing Type C1:  $P^2T$  with Limit #1 and Extended Timing Range (99-0948)

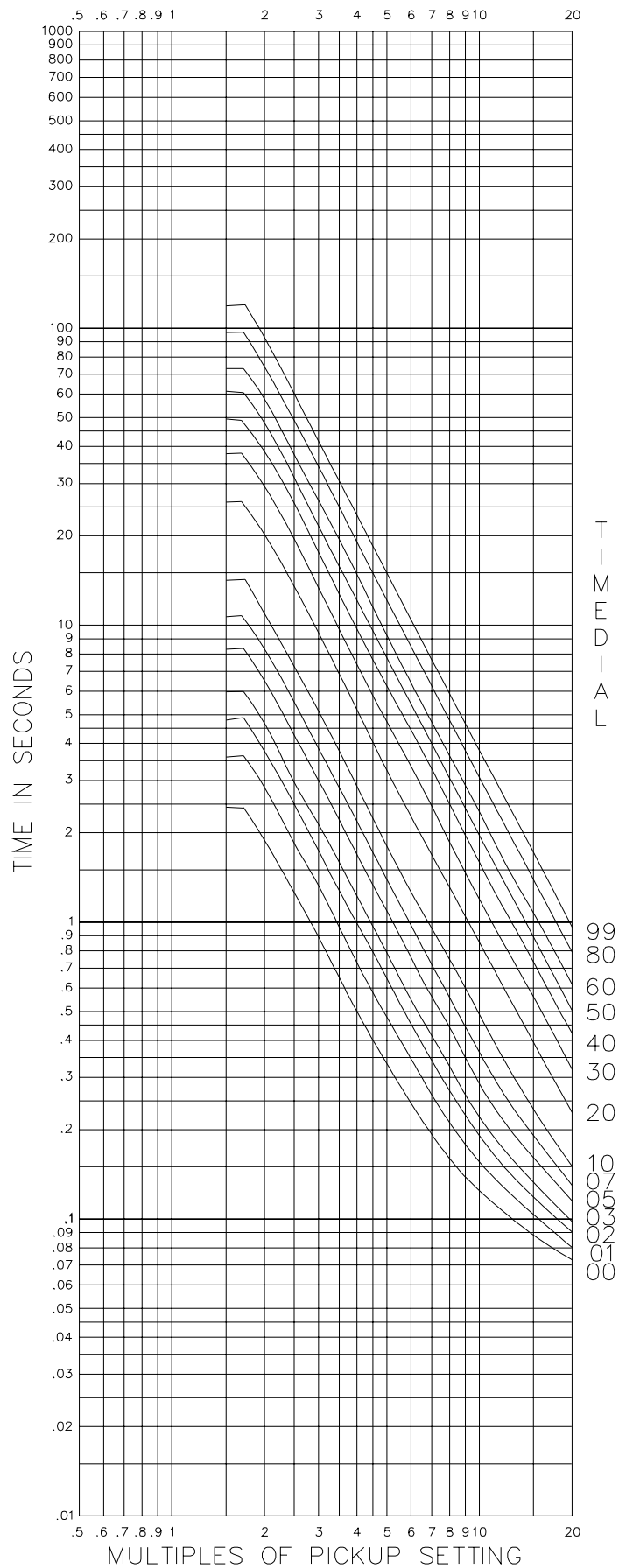


Figure A-19. Timing Type C2:  $P^T$  with Limit #2 (99-0957)

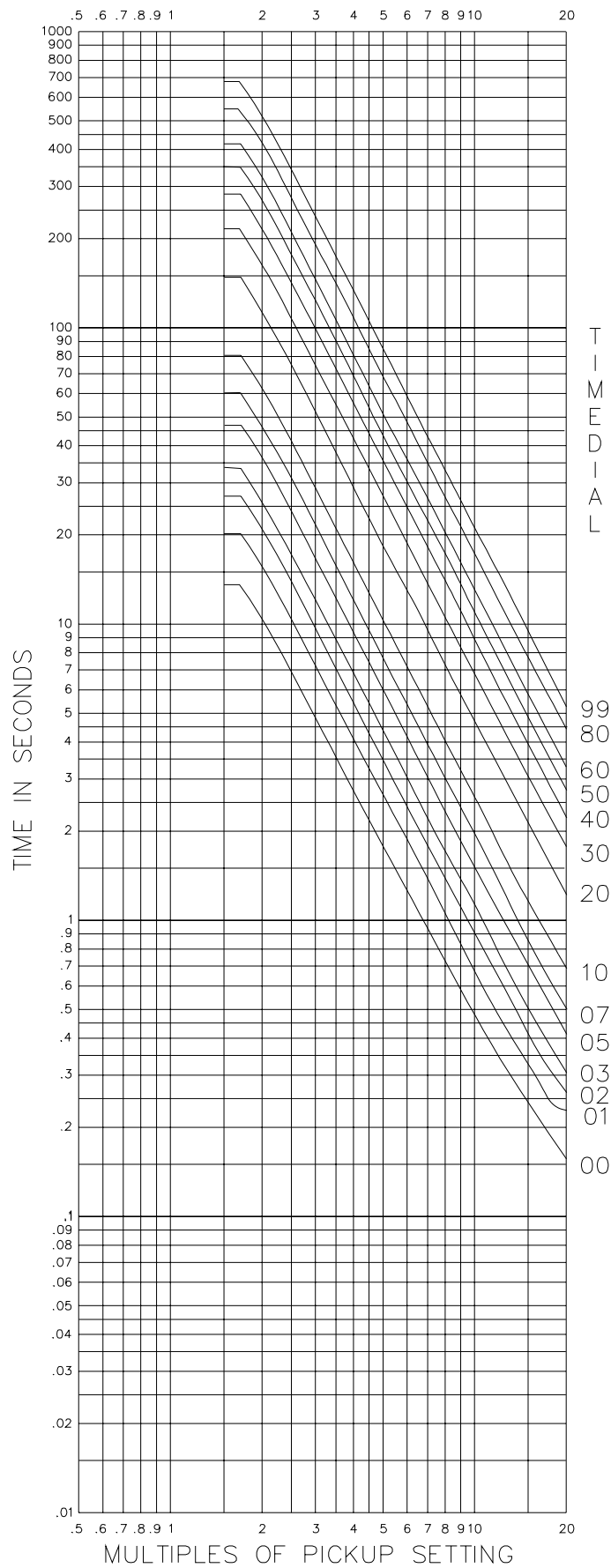


Figure A-20. Timing Type C2: I2T with Limit #2 and Extended Timing Range (99-0949)

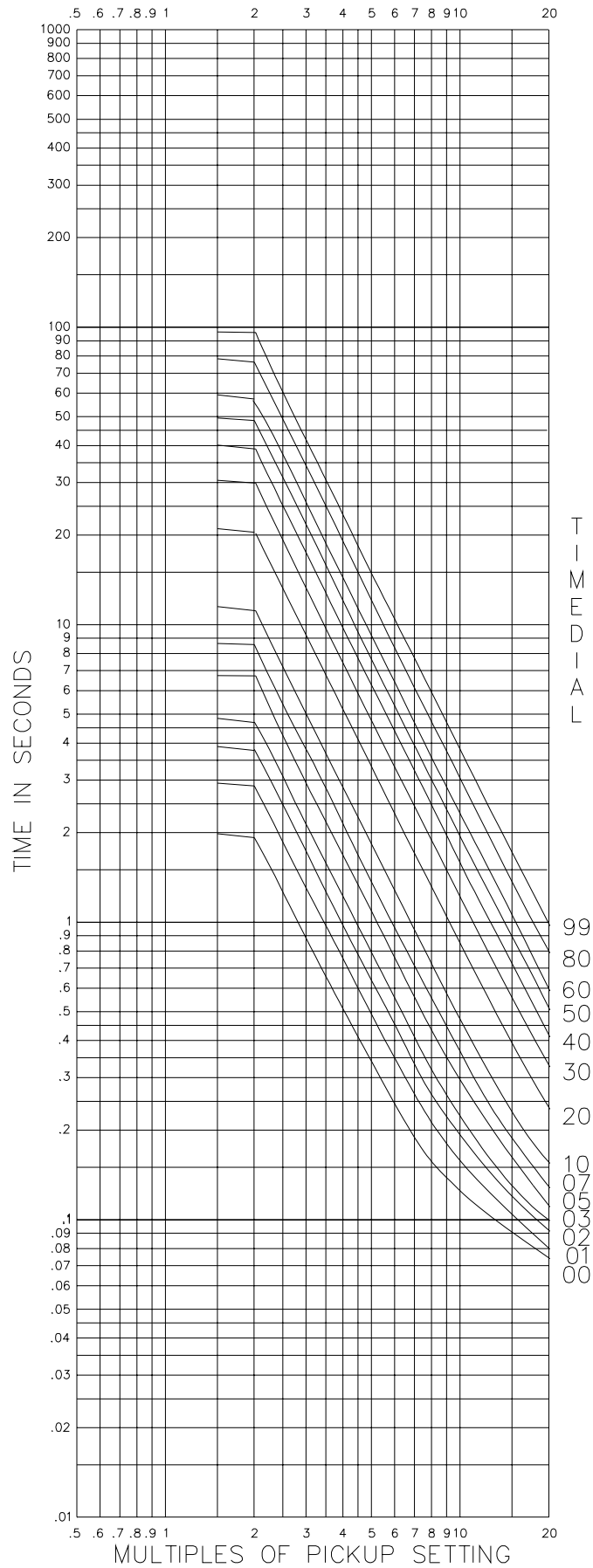


Figure A-21. Timing Type C2:  $I^2T$  with Limit #3 (99-0958)



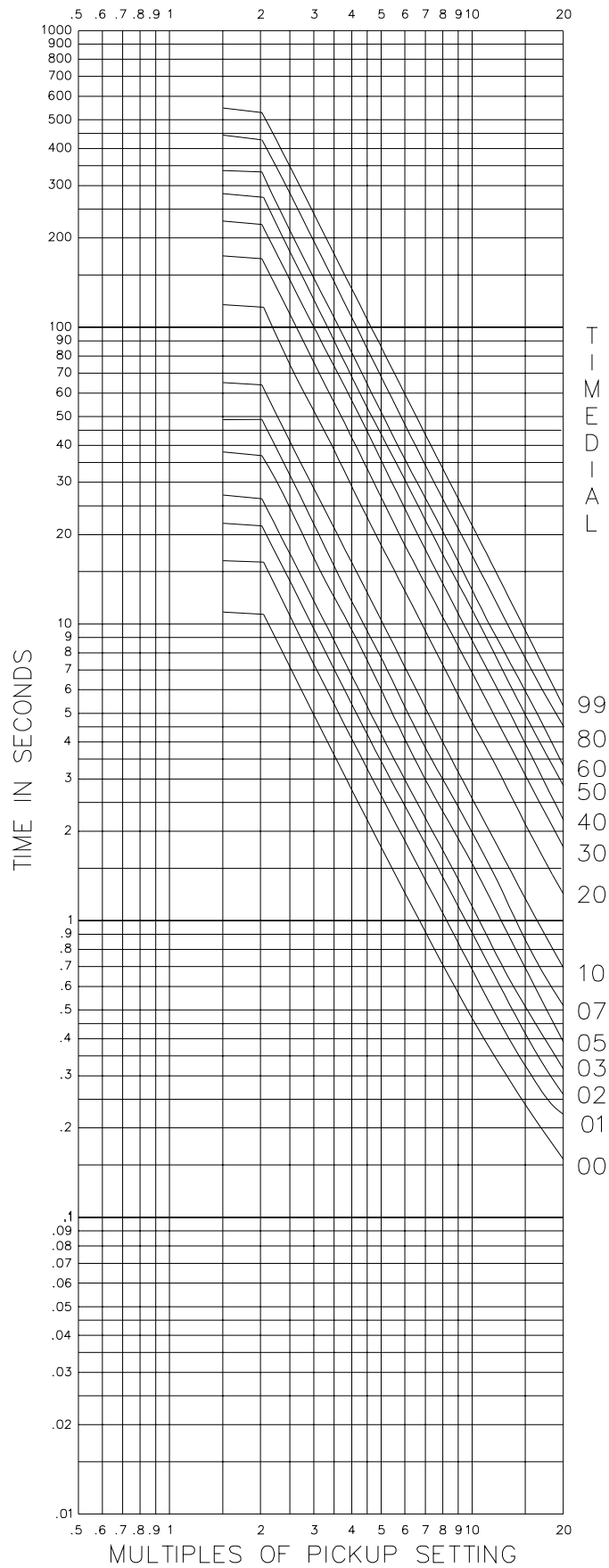


Figure A-22. Timing Type C3:  $P^T$  with Limit #3 and Extended Timing Range (99-0950)

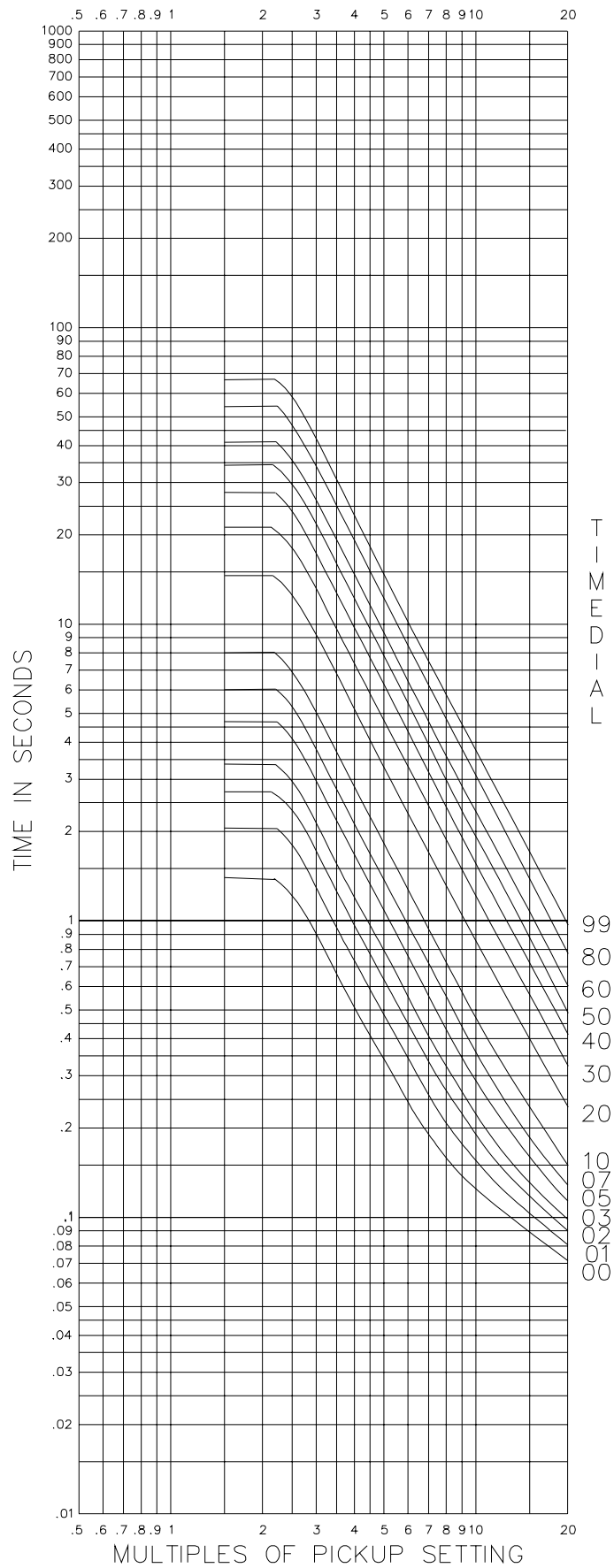


Figure A-23. Timing Type C4:  $I^2T$  with Limit #4 (99-0959)

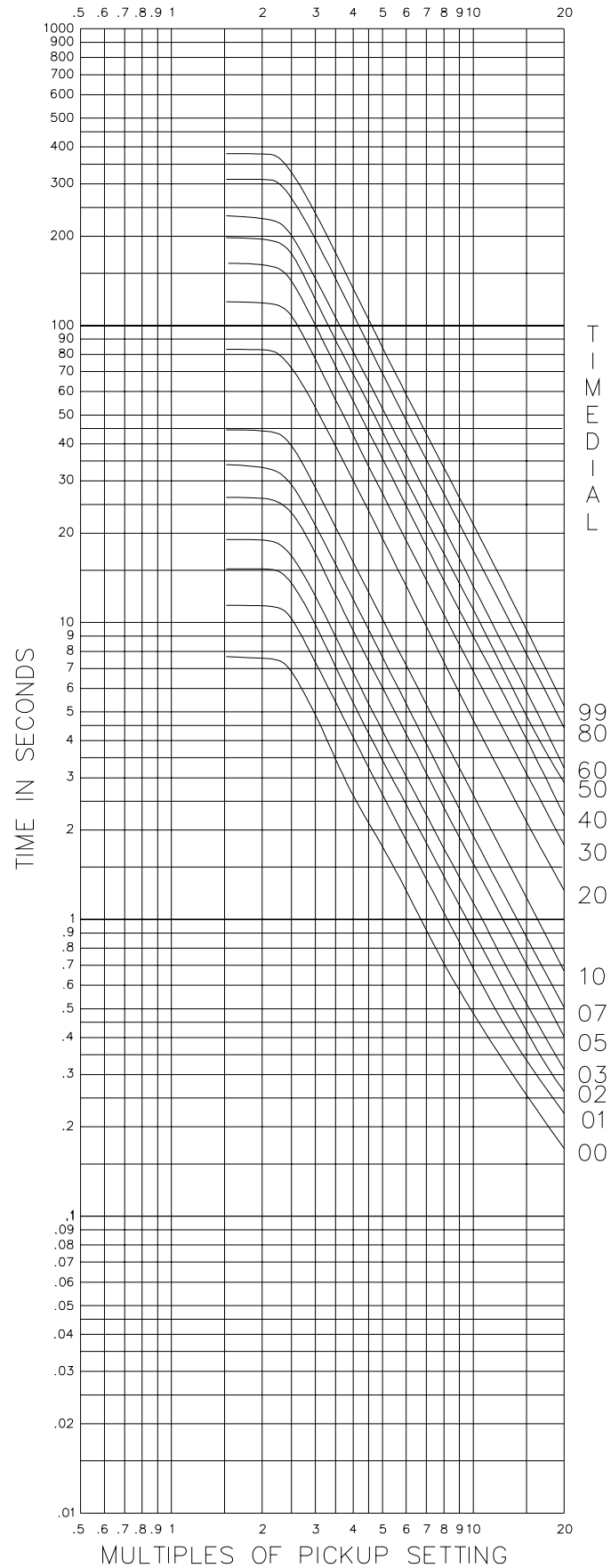


Figure A-24. Timing Type C4:  $P_T$  with Limit #4 and Extended Timing Range (99-0951)

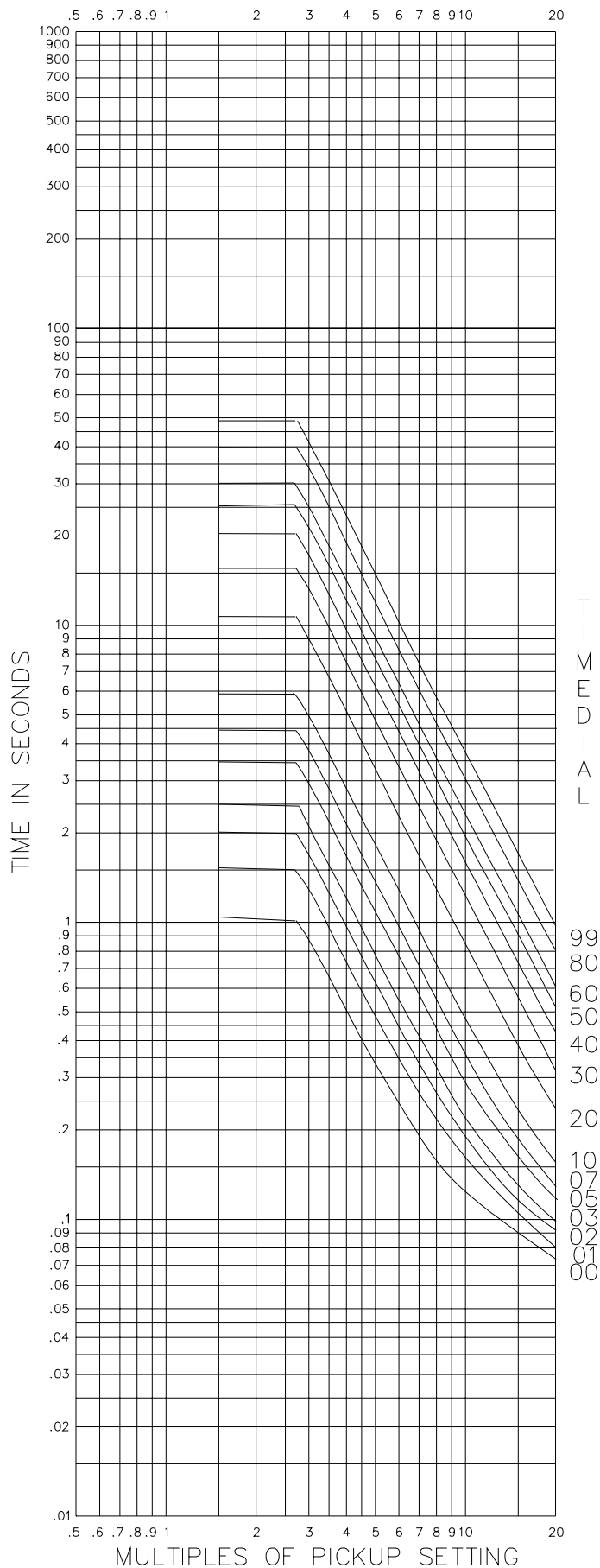


Figure A-25. Timing Type C5: P.T with Limit #5 (99-0960)

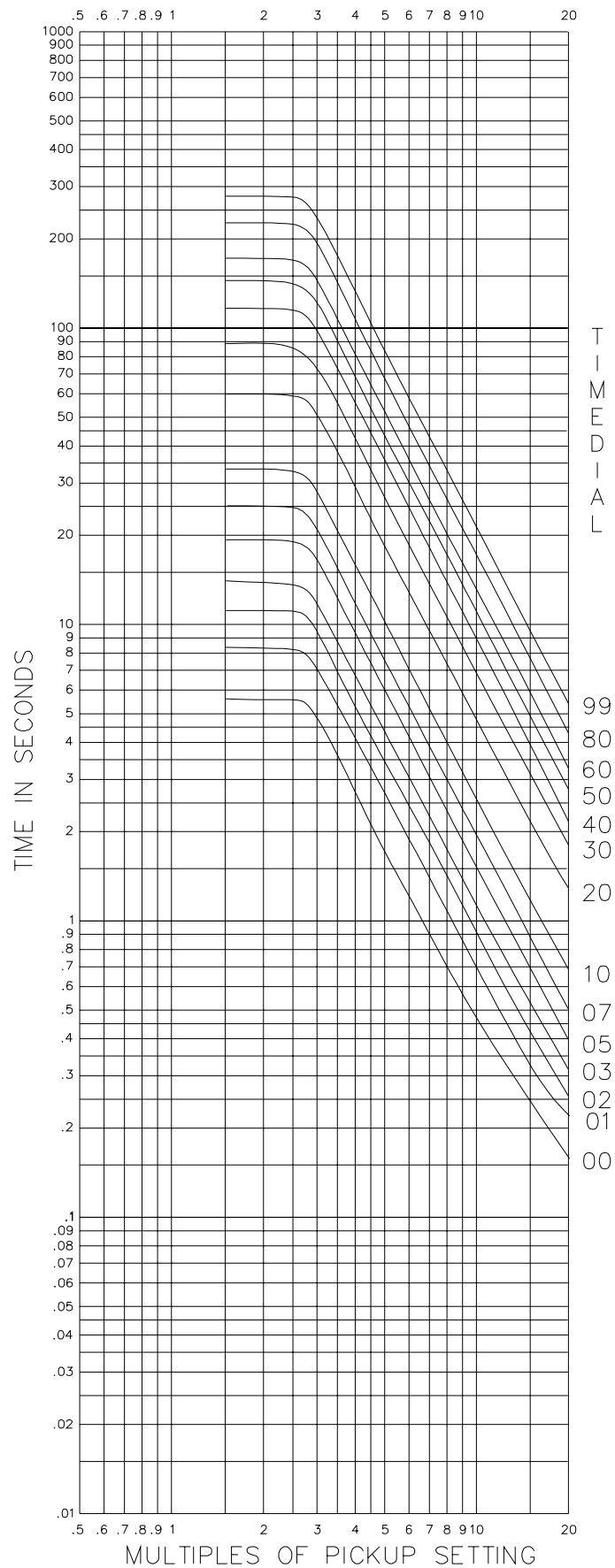


Figure A-26. Timing Type C5: PT with Limit #5 and Extended Timing Range (99-0952)

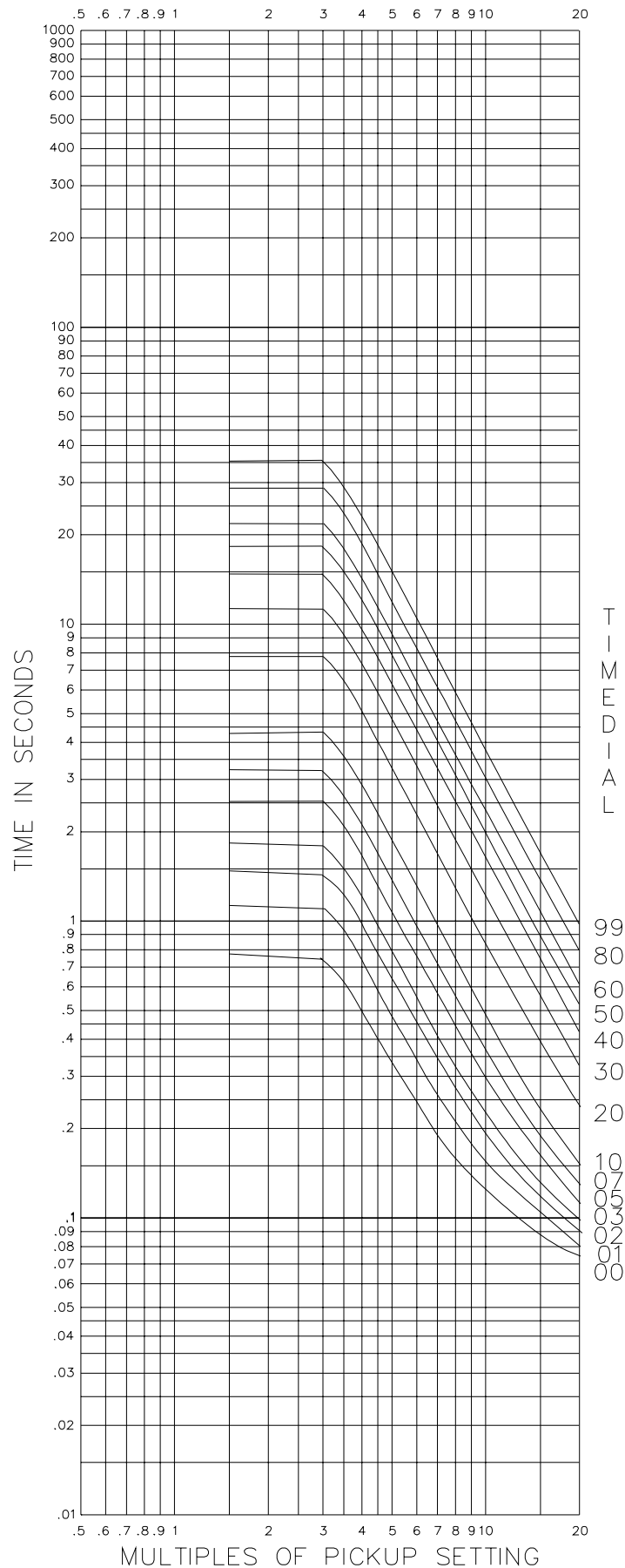


Figure A-27. Timing Type C6:  $I^2T$  with Limit #6 (99-0961)

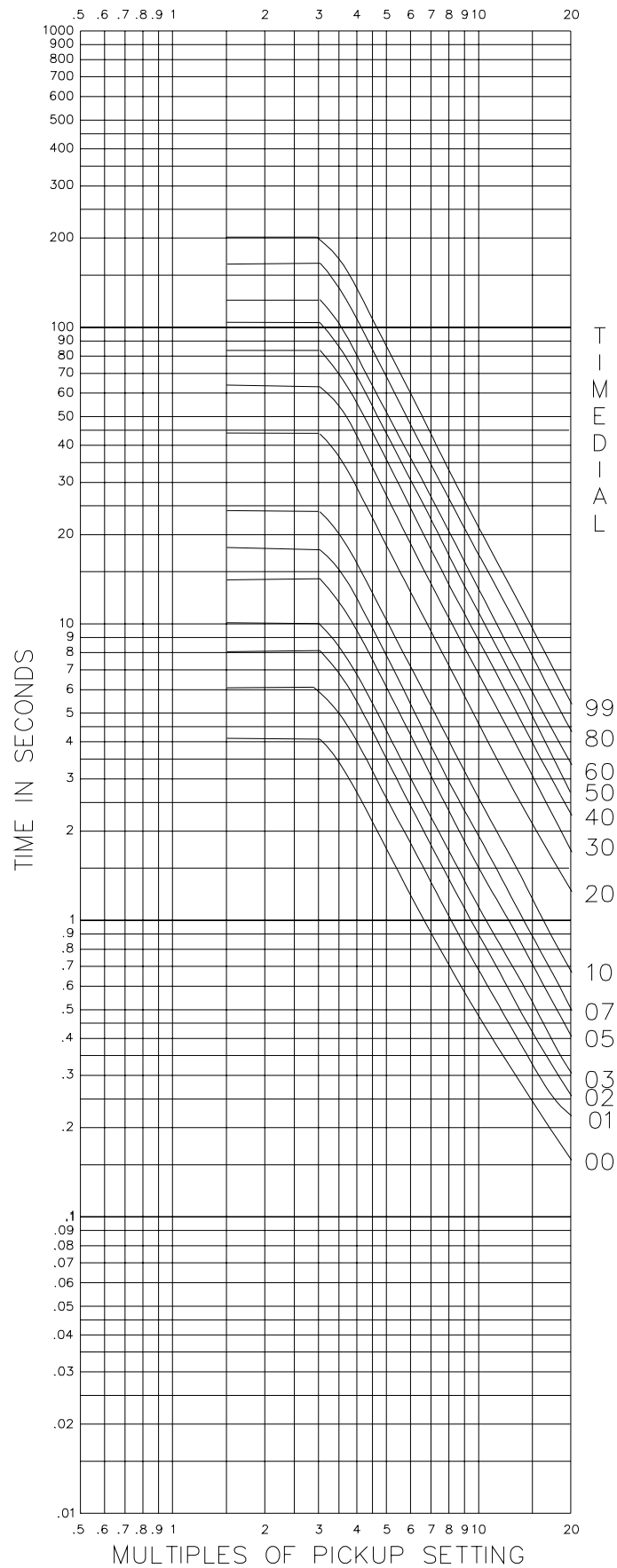


Figure A-28. Timing Type C6E: P.T with Limit #6 and Extended Timing Range (99-0953)

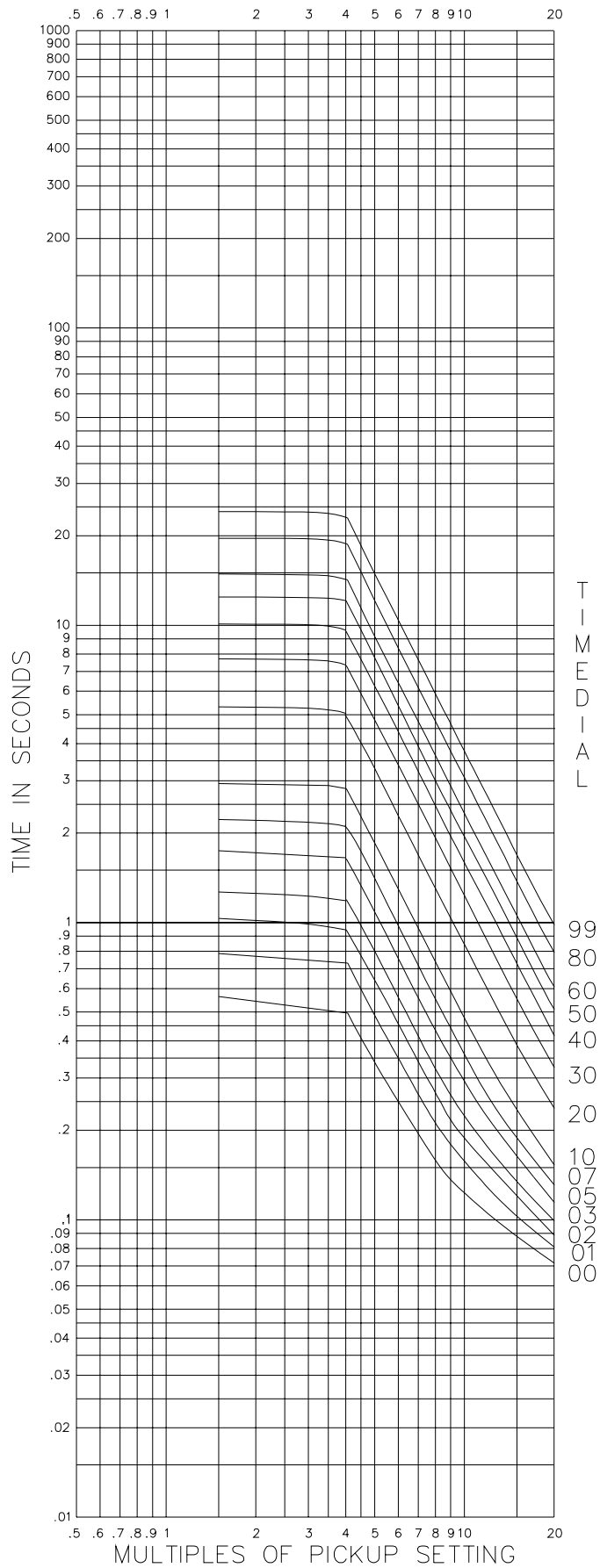


Figure A-29. Timing Type C7:  $P^T$  with Limit #7 (99-0962)



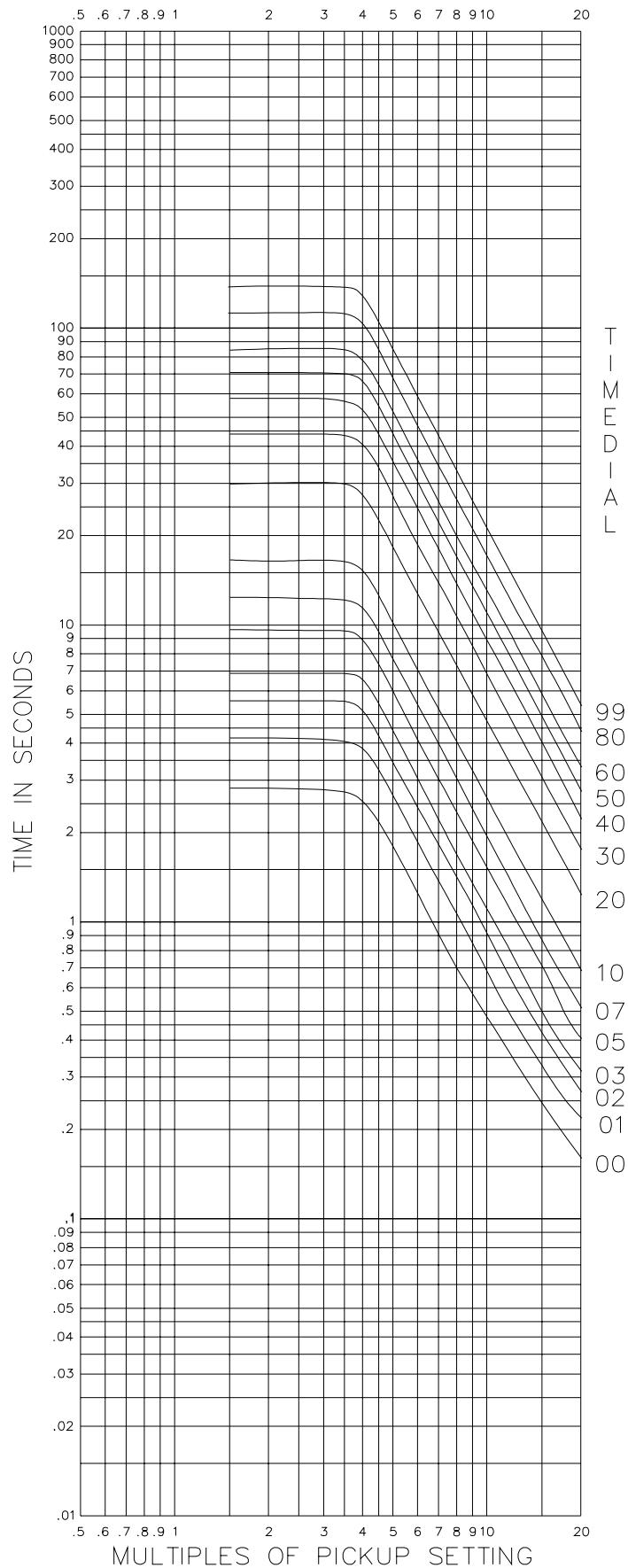


Figure A-30. Timing Type C7E: P T with Limit #7 and Extended Timing Range (99-0954)

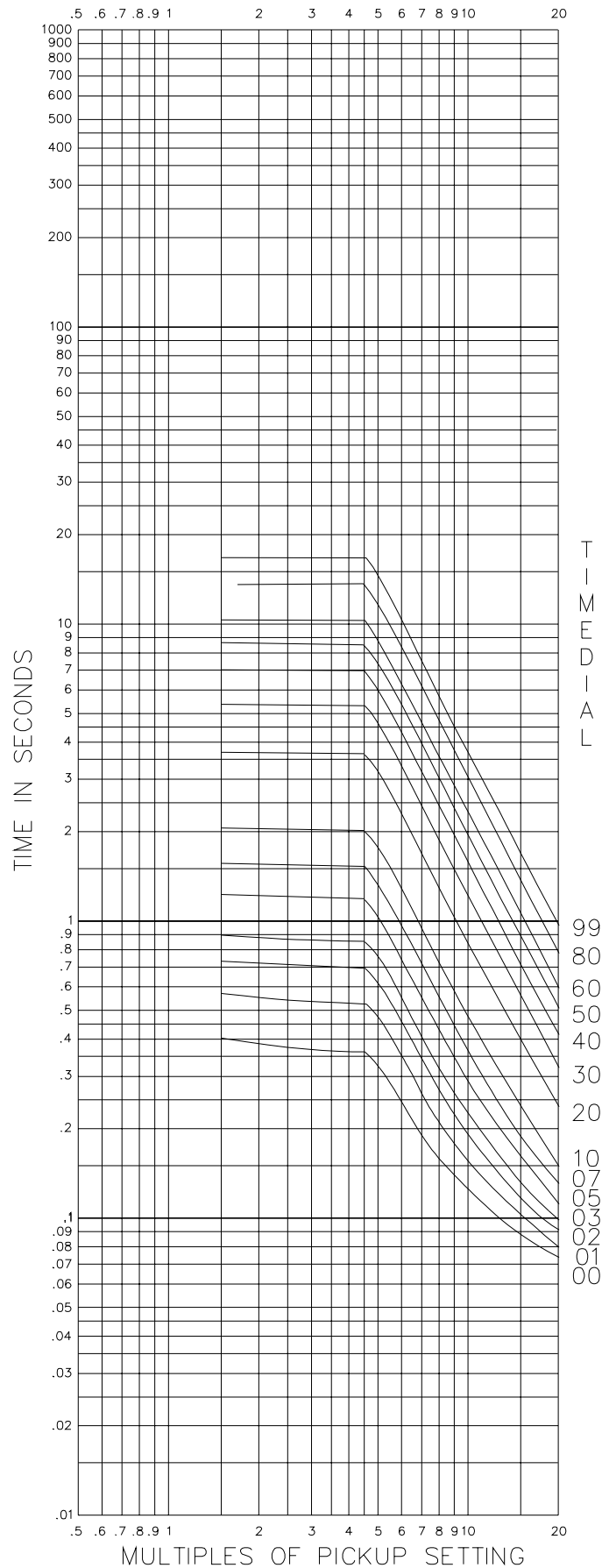


Figure A-31. Timing Type C8: P<sup>T</sup> with Limit #8 (99-0963)

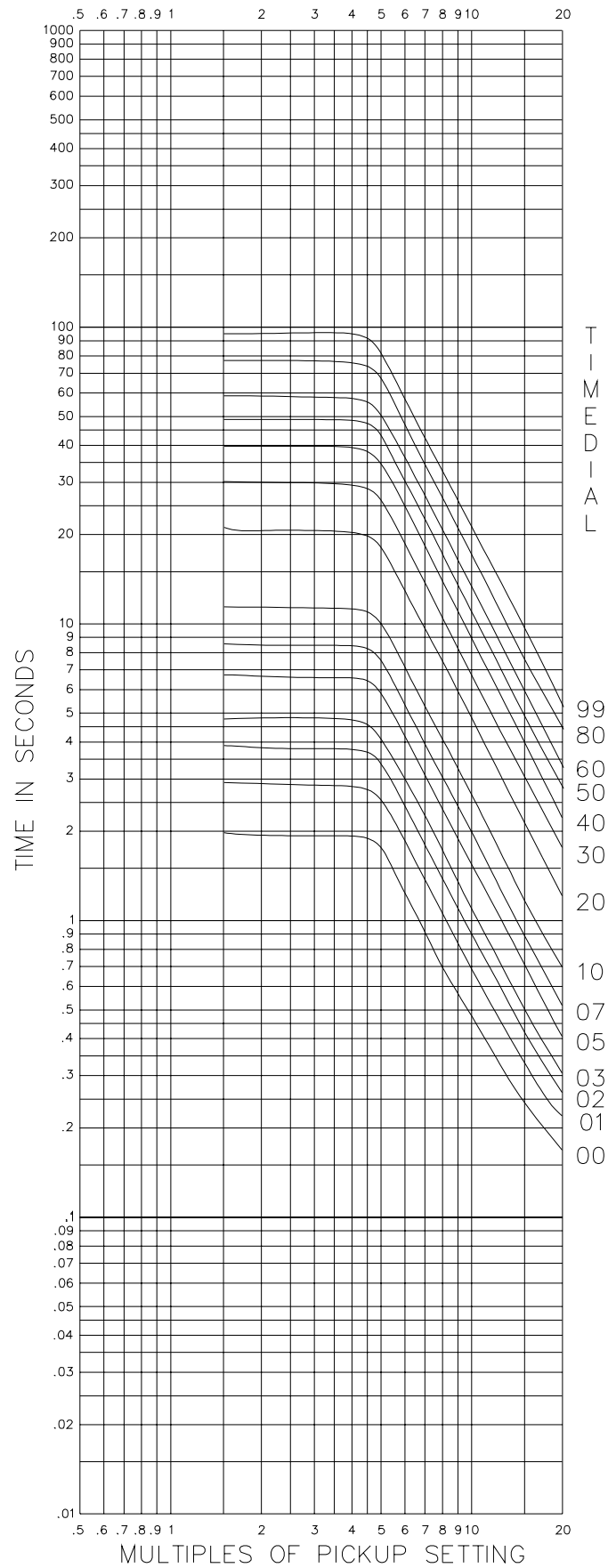


Figure A-32. Timing Type C8E:  $P T$  with Limit #8 and Extended Timing Range (99-0955)

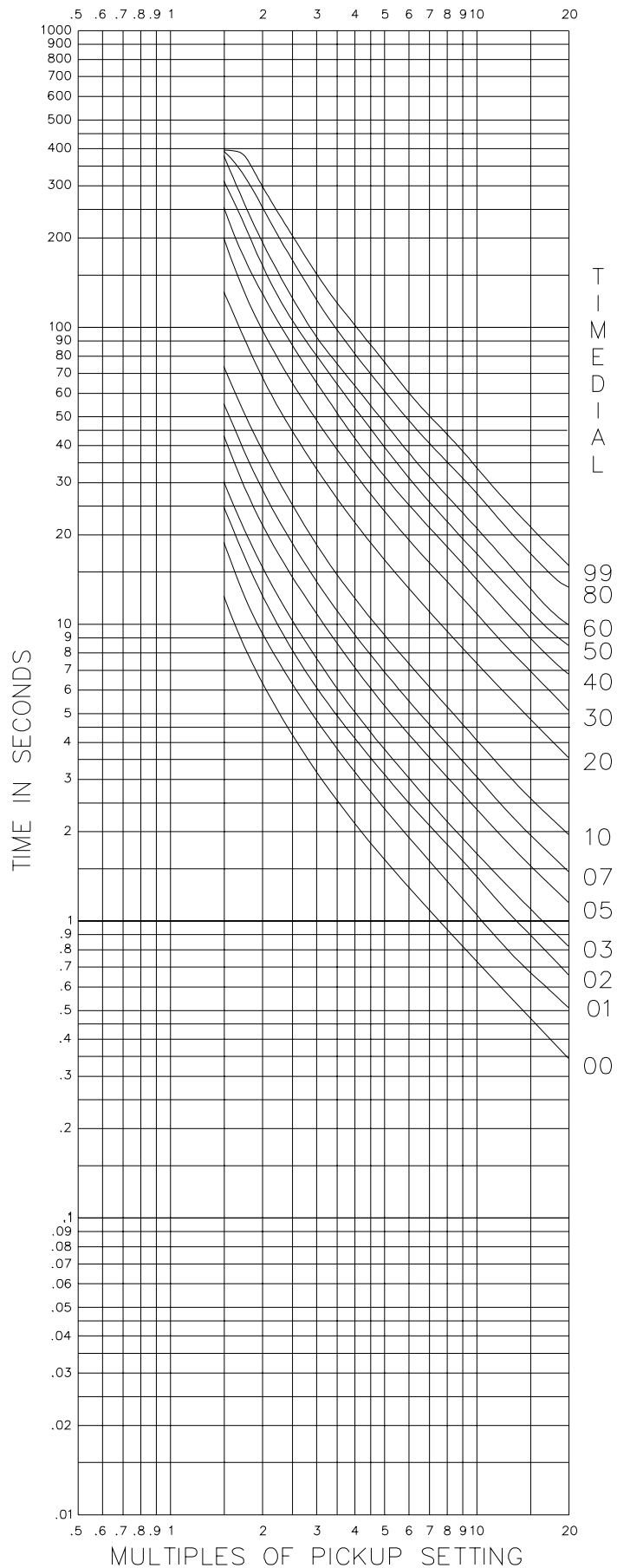


Figure A-33. Timing Type E2: BS 142 Long Inverse (99-1093)

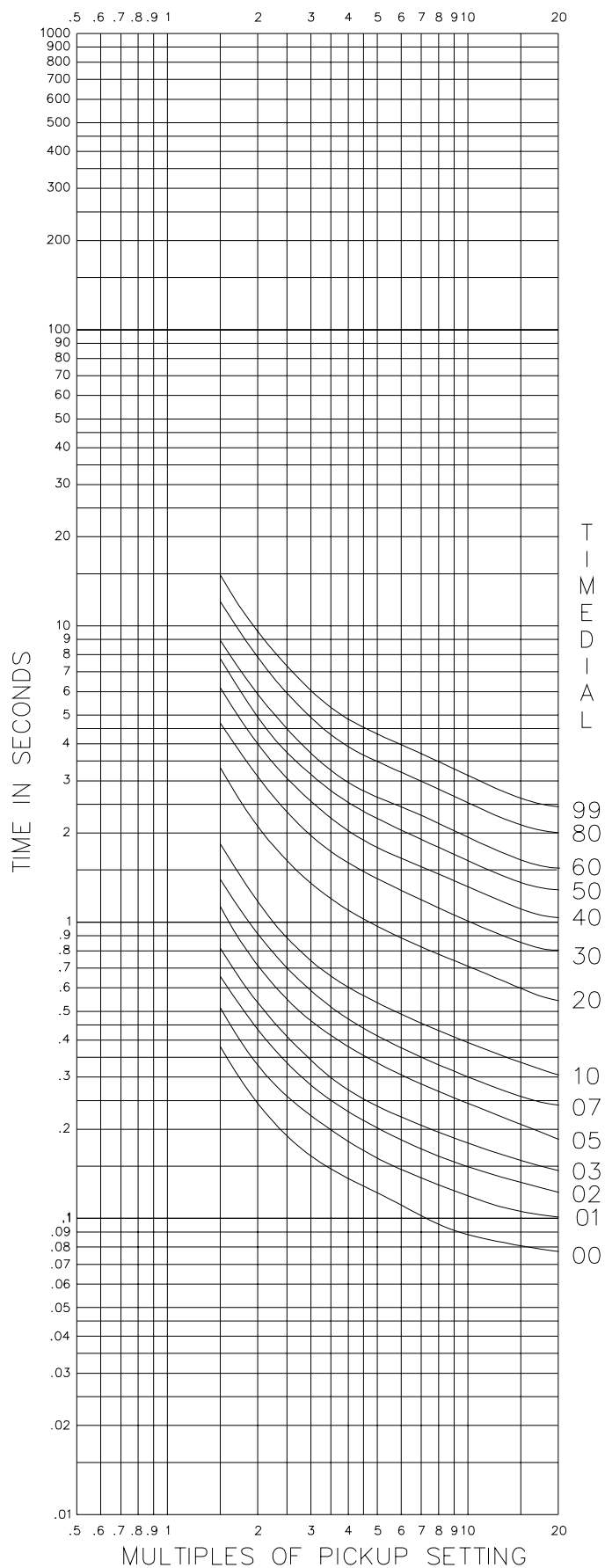


Figure A-34. Timing Type E4: BS 142 Inverse (1.3 s)  
(99-1094)

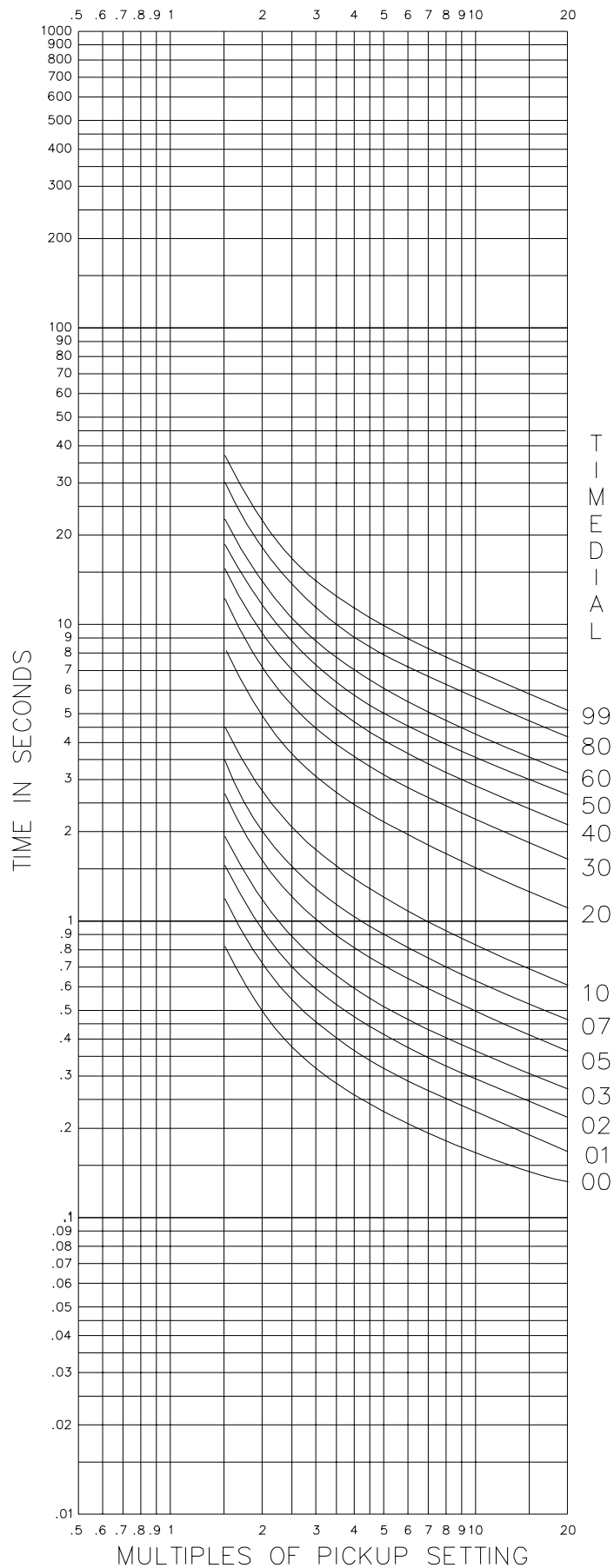


Figure A-35. Timing Type E5: BS 142 Inverse (2.9 s)  
(99-1095)

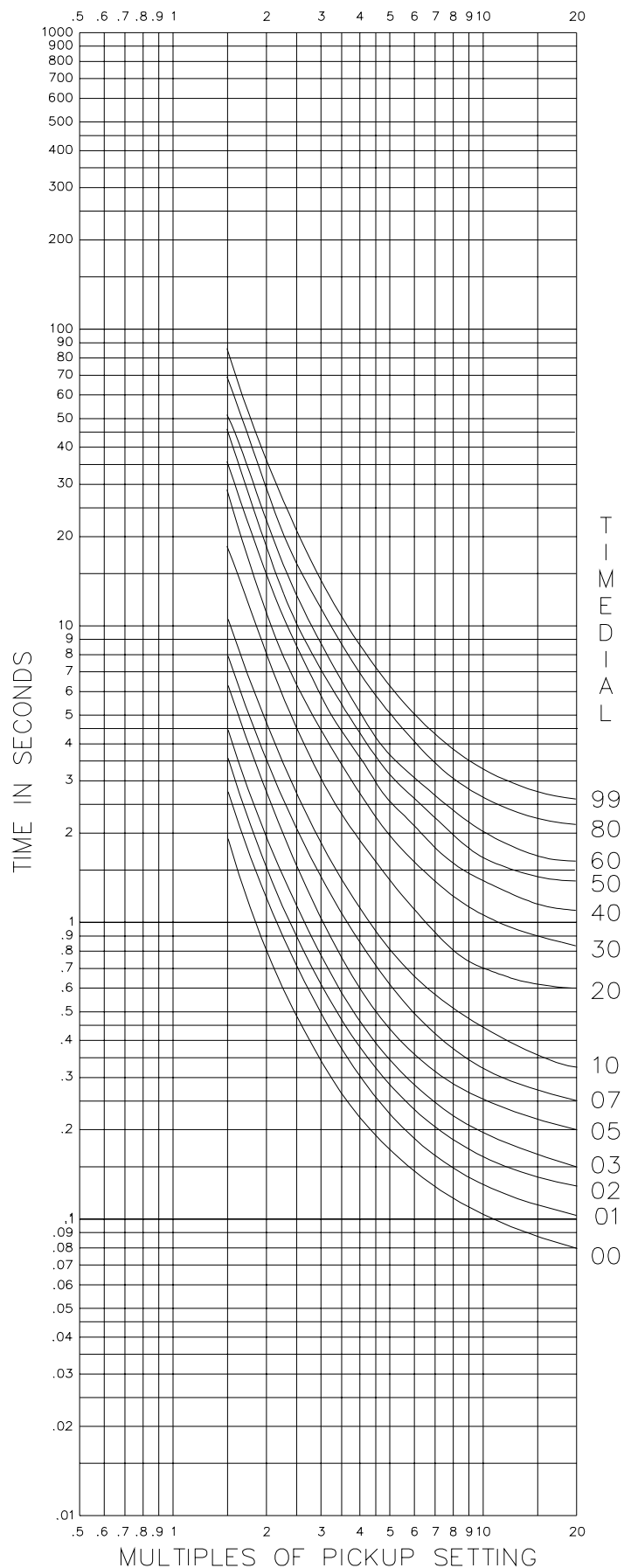


Figure A-36. Timing Type E6: BS 142 Very Inverse (99-1096)

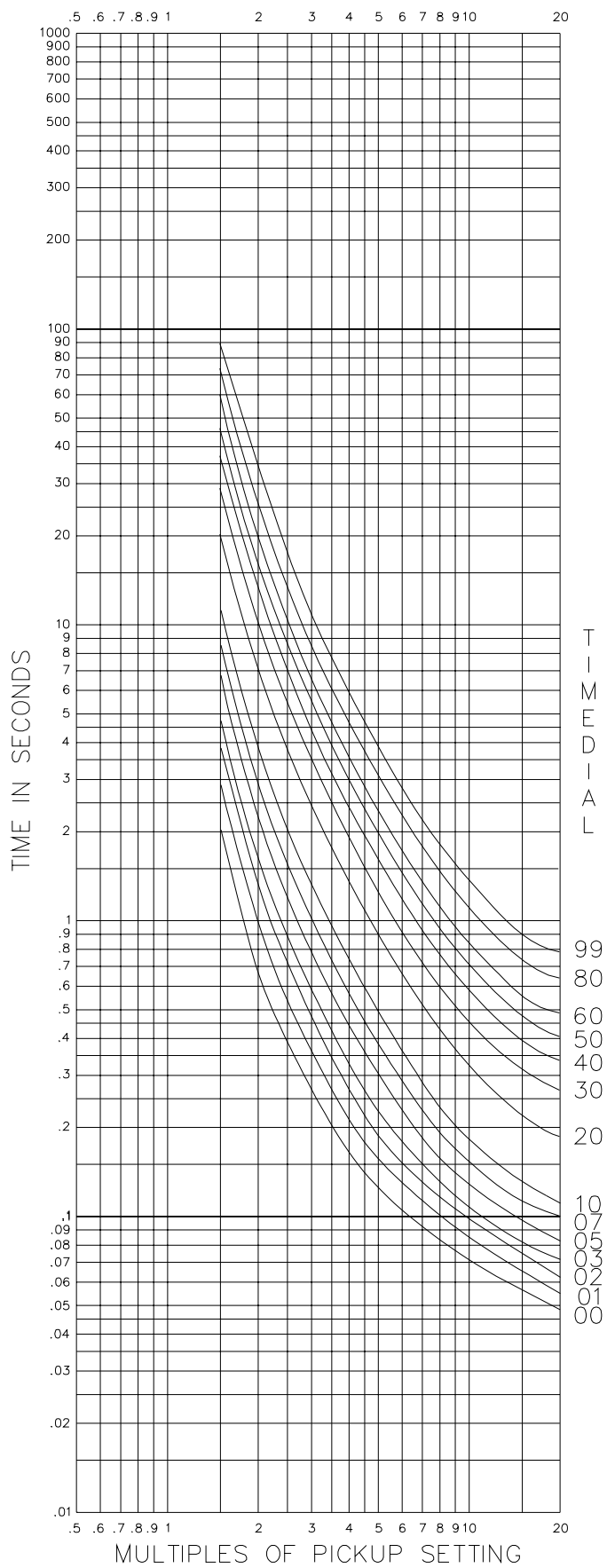


Figure A-37. Timing Type E7: BS 142 Extremely Inverse (99-1097)



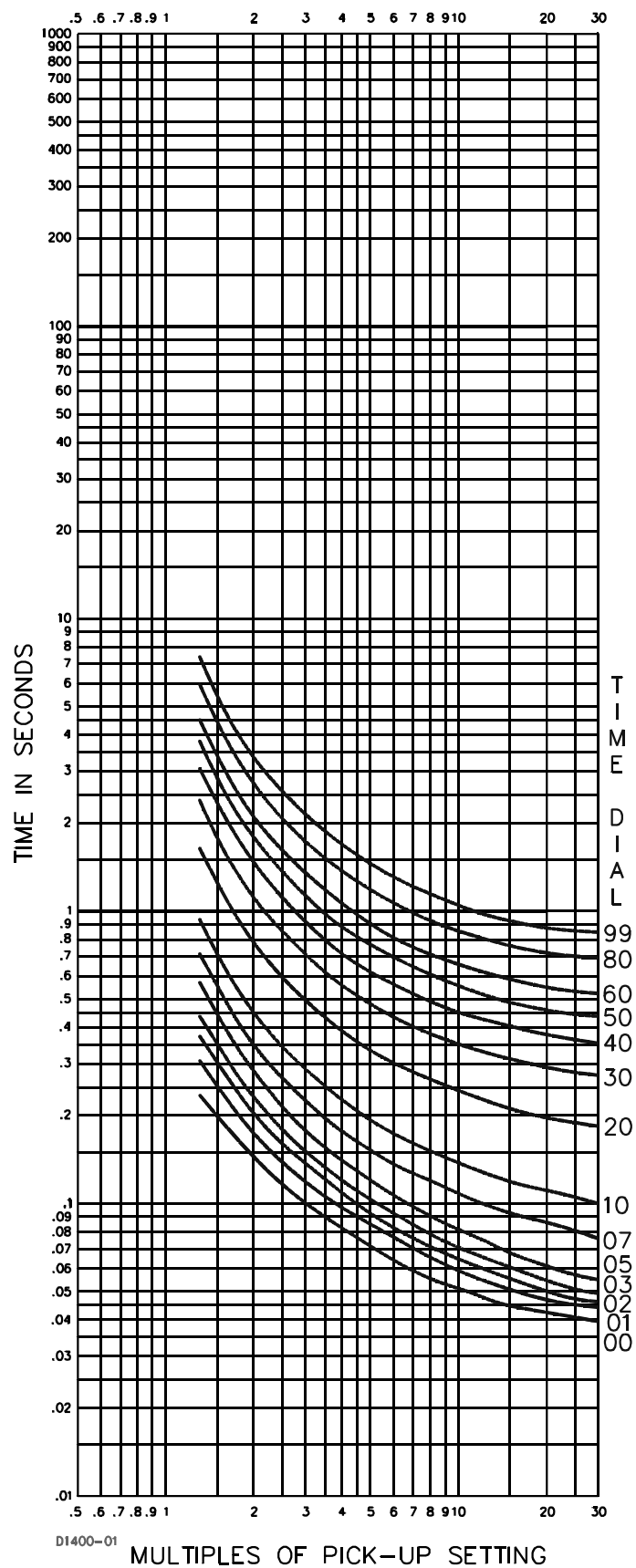


Figure A-38. Timing Type B1: Short Inverse with Integrated Algorithm (99-1397)

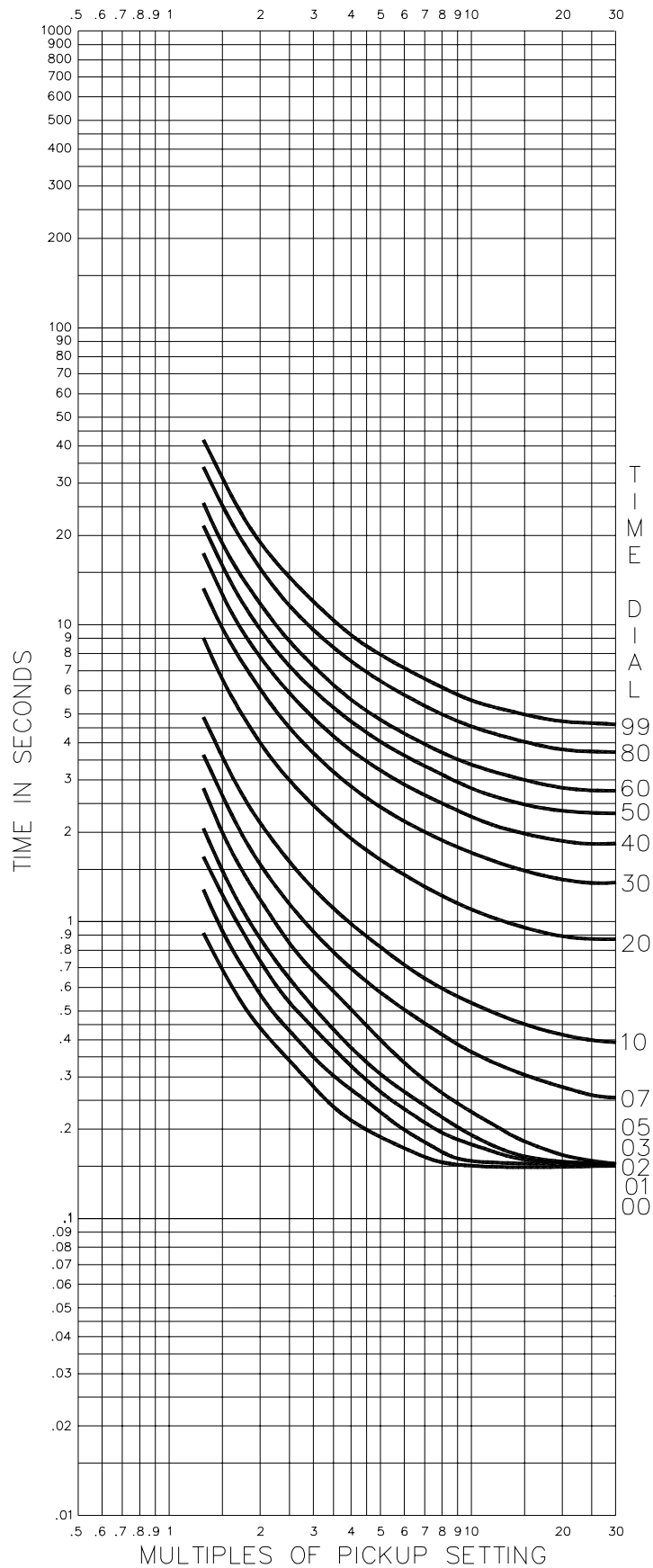


Figure A-39. Timing Type B1: Short Inverse with Integrated Algorithm and Extended Timing (99-1398)

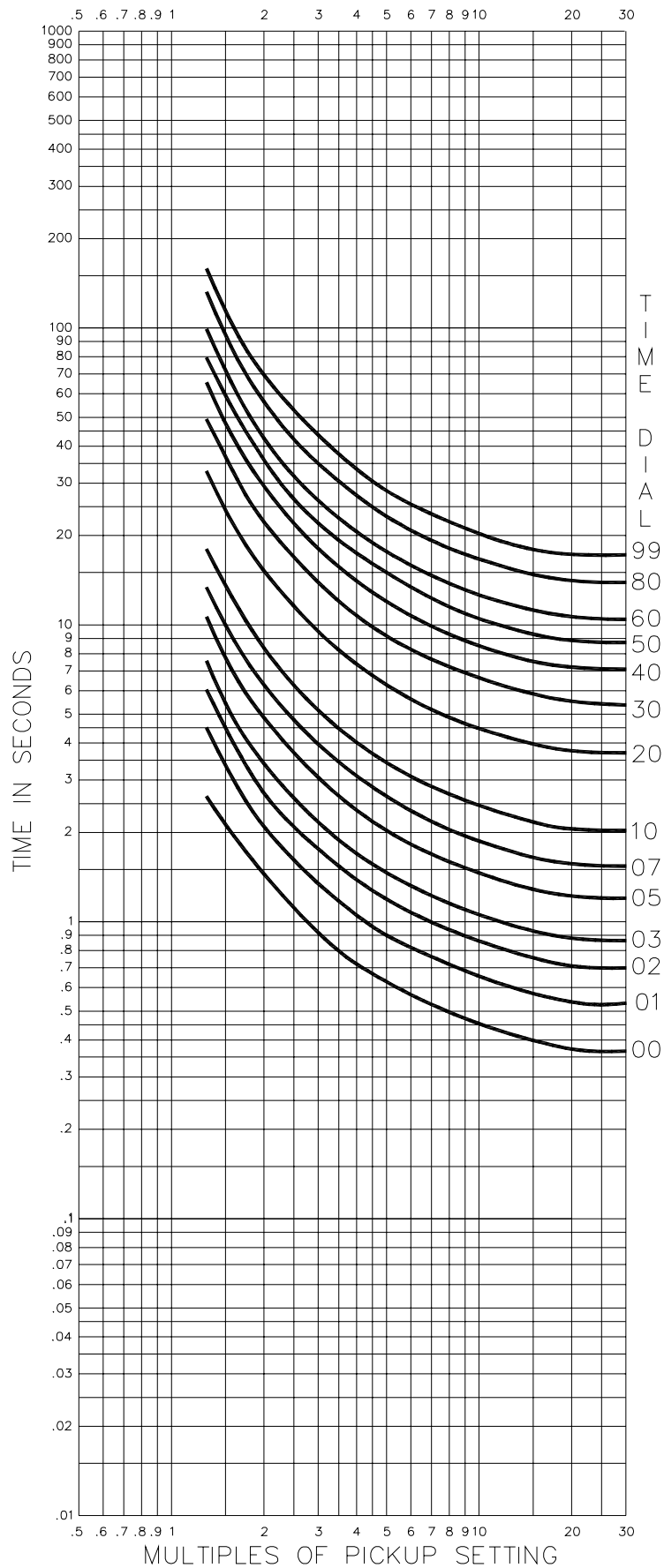


Figure A-40. Timing Type B2: Long Inverse  
with Integrated Algorithm (99-1399)

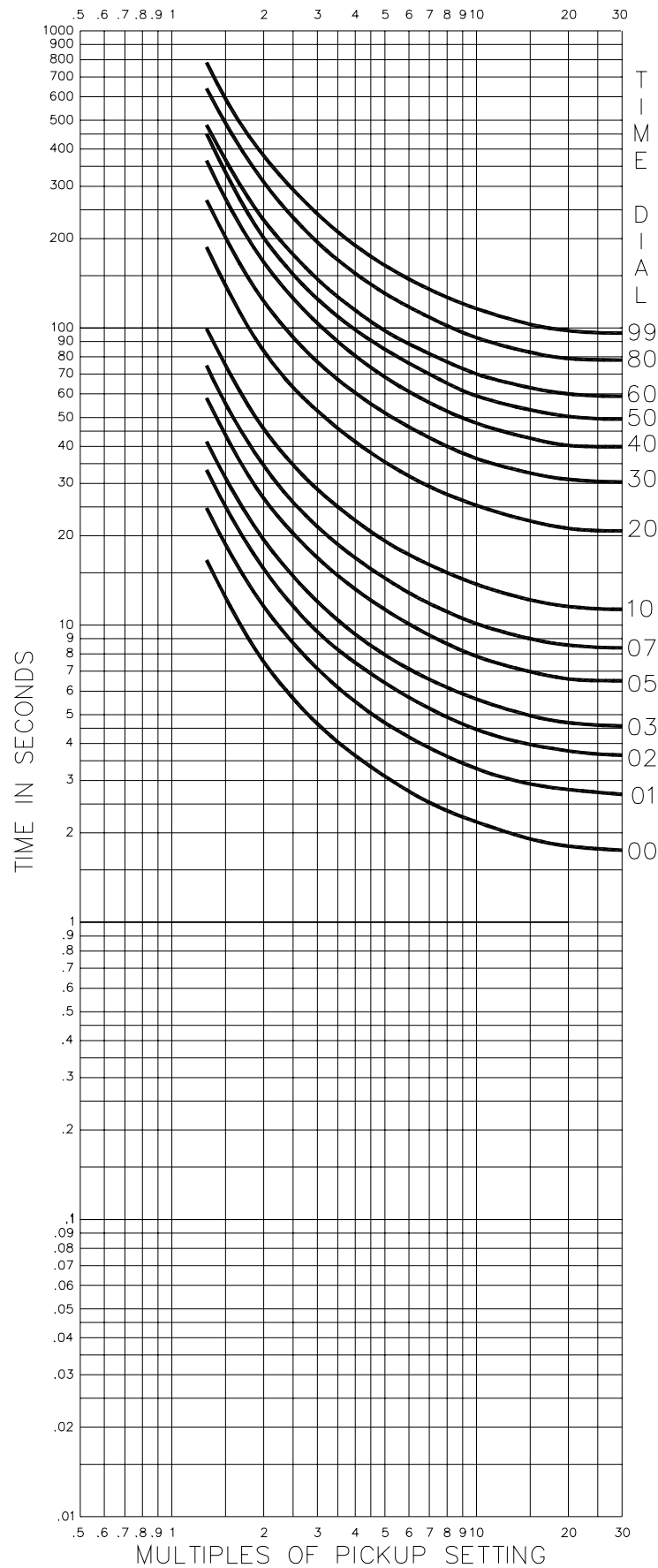


Figure A-41. Timing Type B2: Long Inverse with Integrated Algorithm and Extended Timing (99-1400)

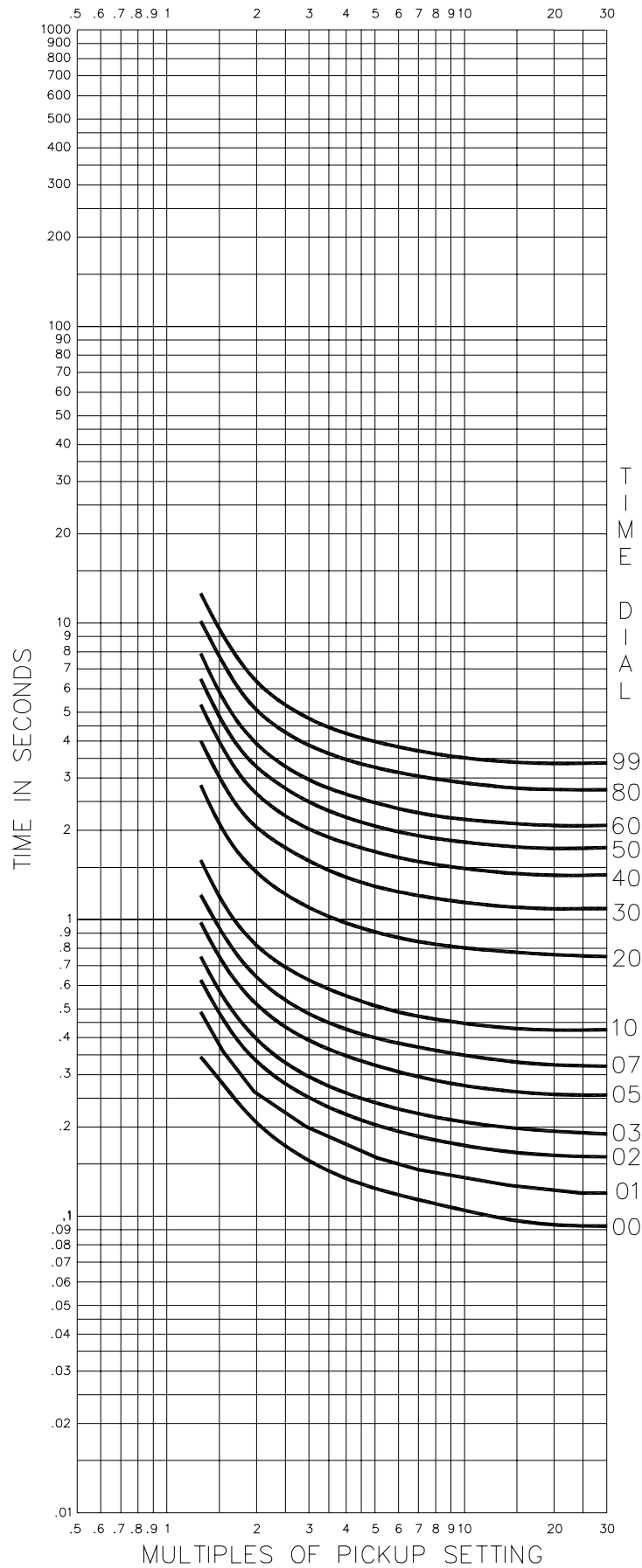


Figure A-42. Timing Type B3: Definite Time  
with Integrated Algorithm (99-1401)

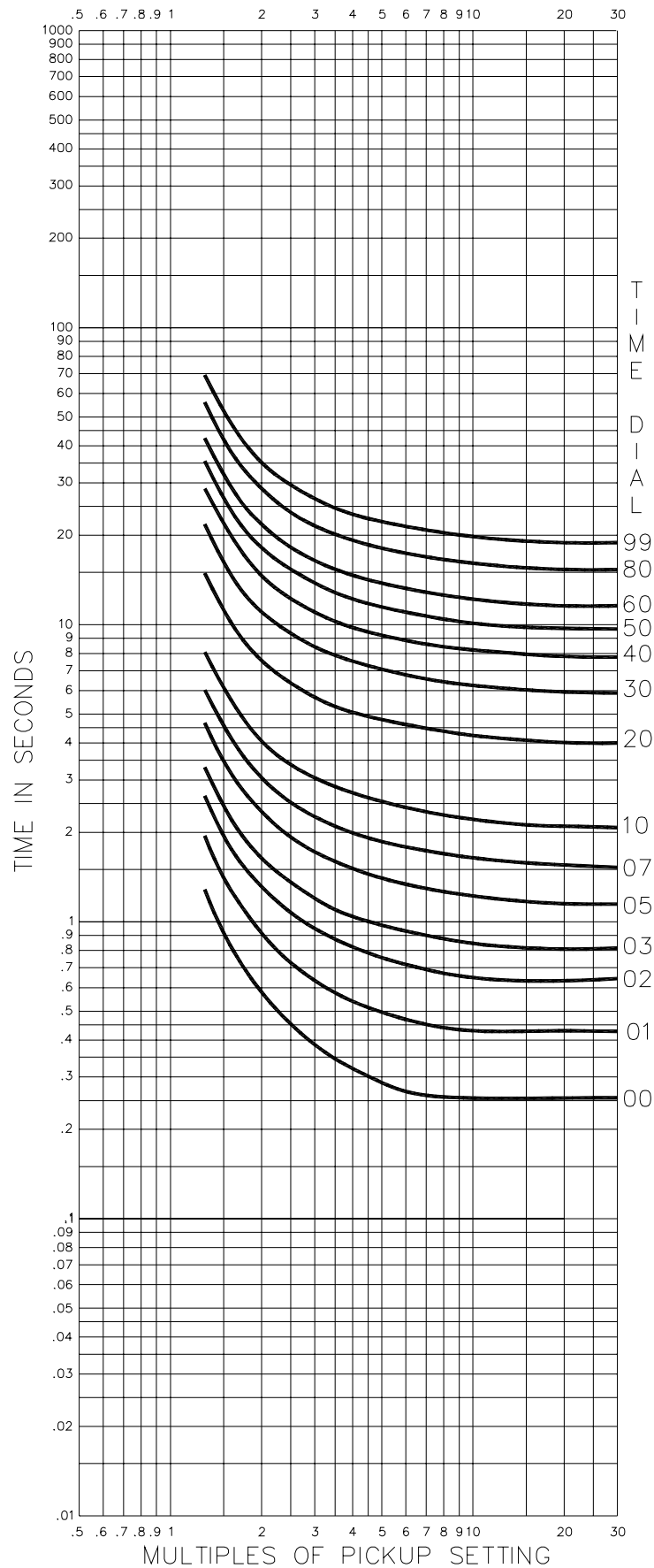


Figure A-43. Timing Type B3: Definite Time with Integrated Algorithm and Extended Timing (99-1402)

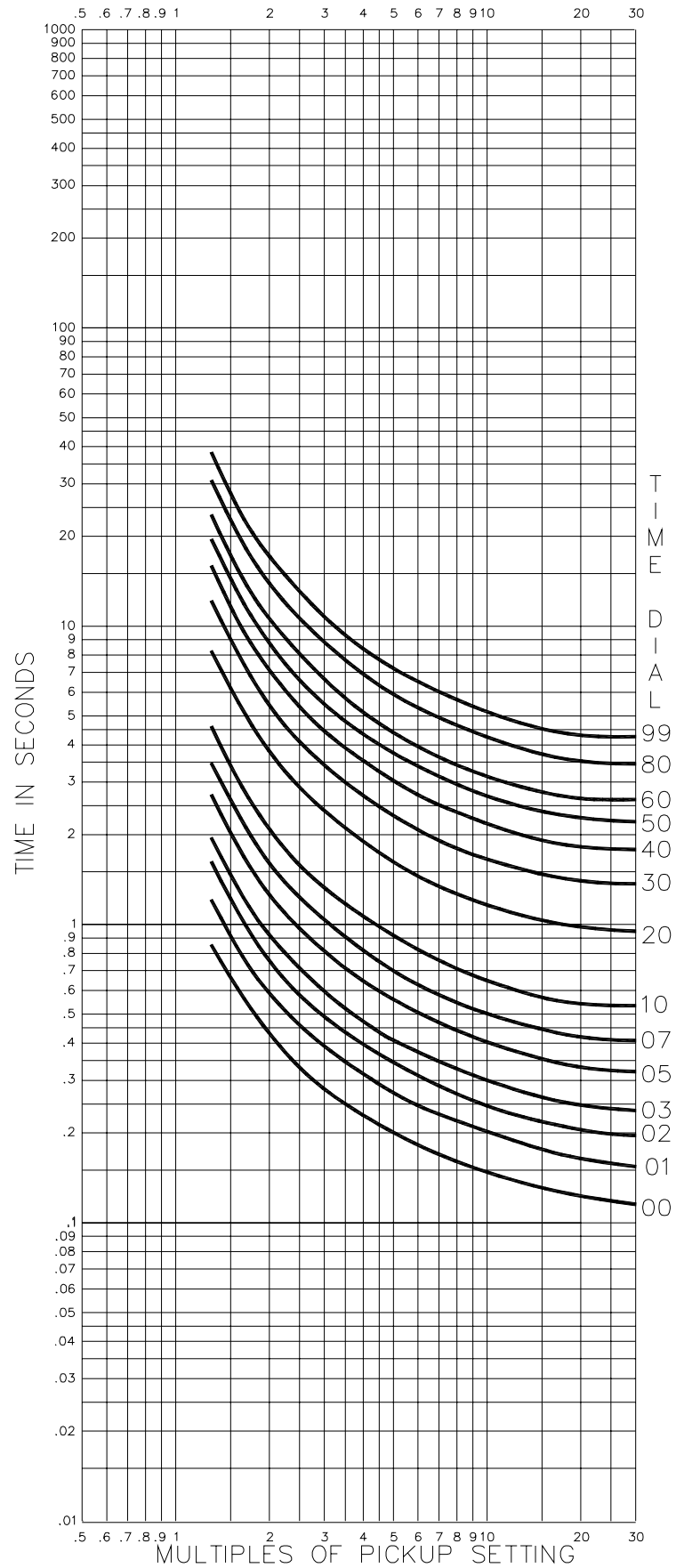


Figure A-44. Timing Type B4: Moderately Inverse  
with Integrated Algorithm (99-1403)

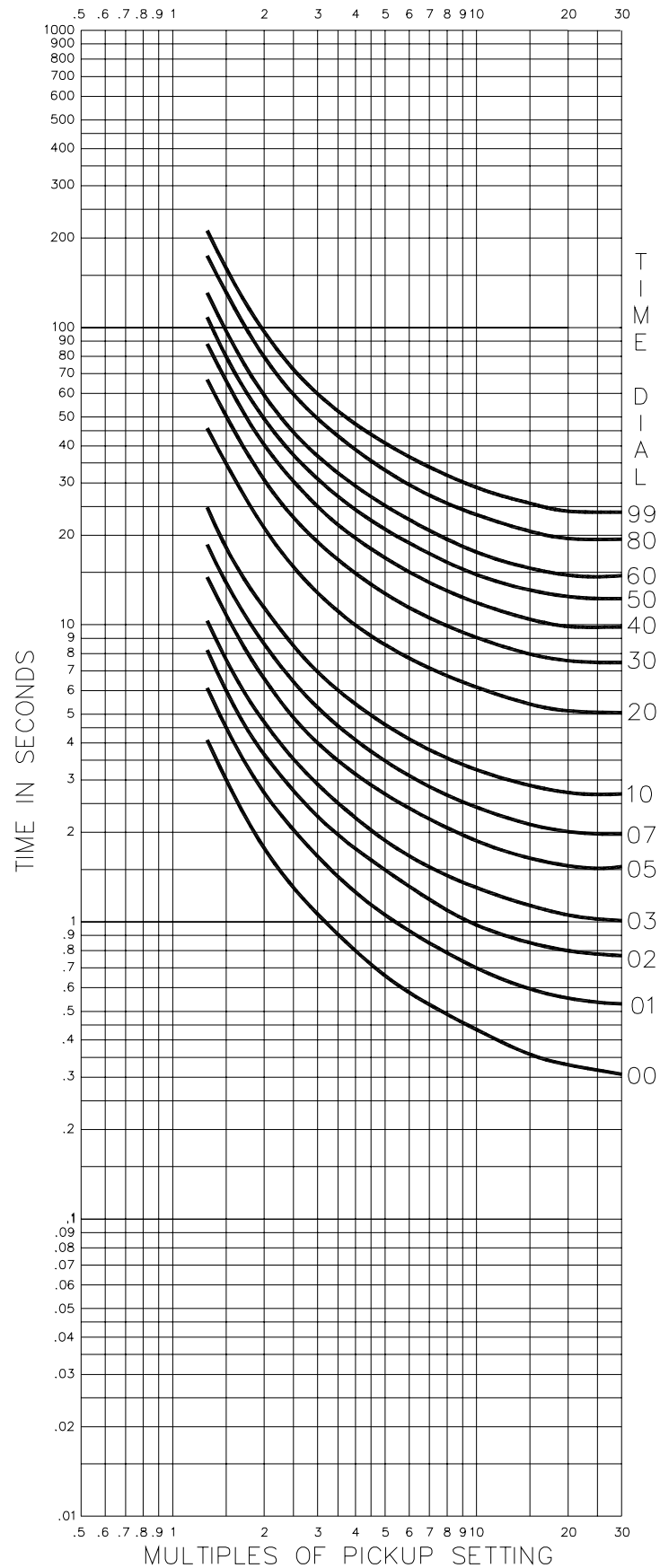


Figure A-45. Timing Type B4: Moderately Inverse with Integrated Algorithm and Extended Timing (99-1404)



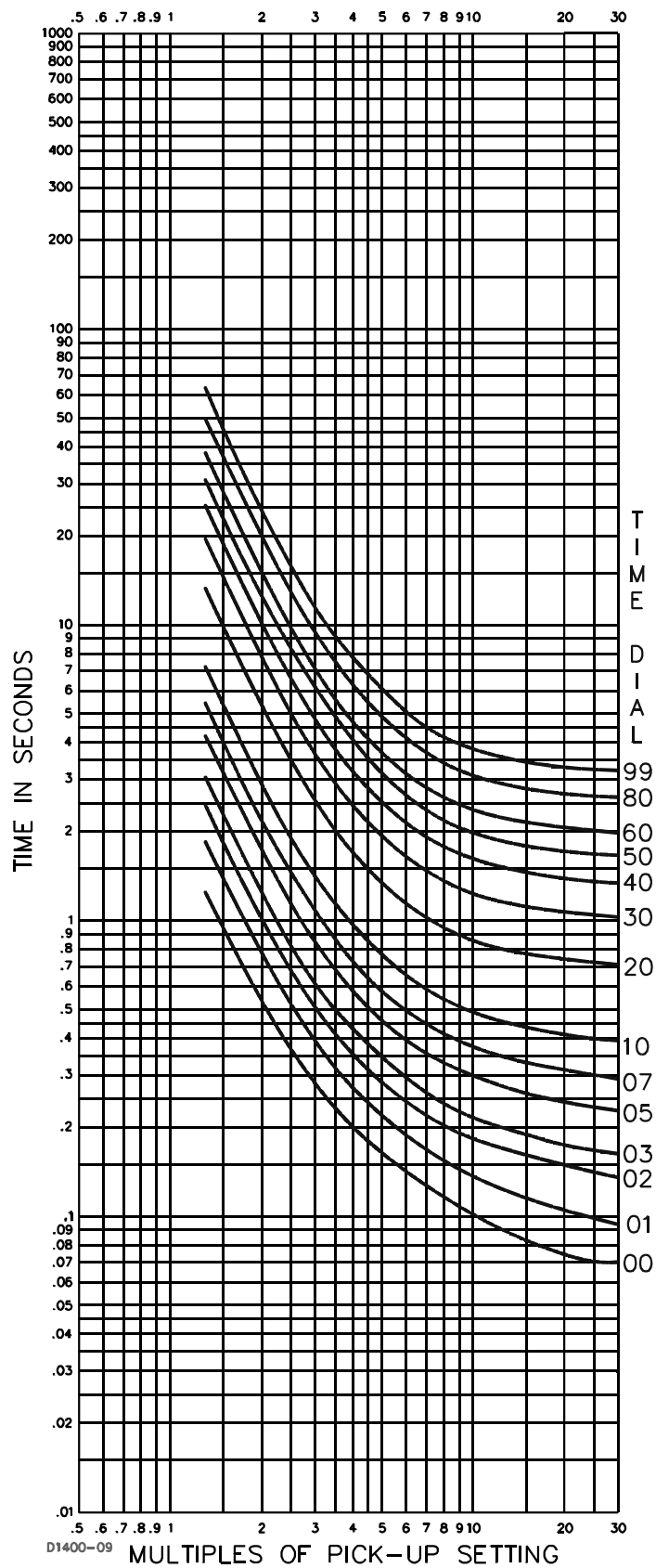


Figure A-46. Timing Type B5: Inverse with Integrated Algorithm (99-1405)

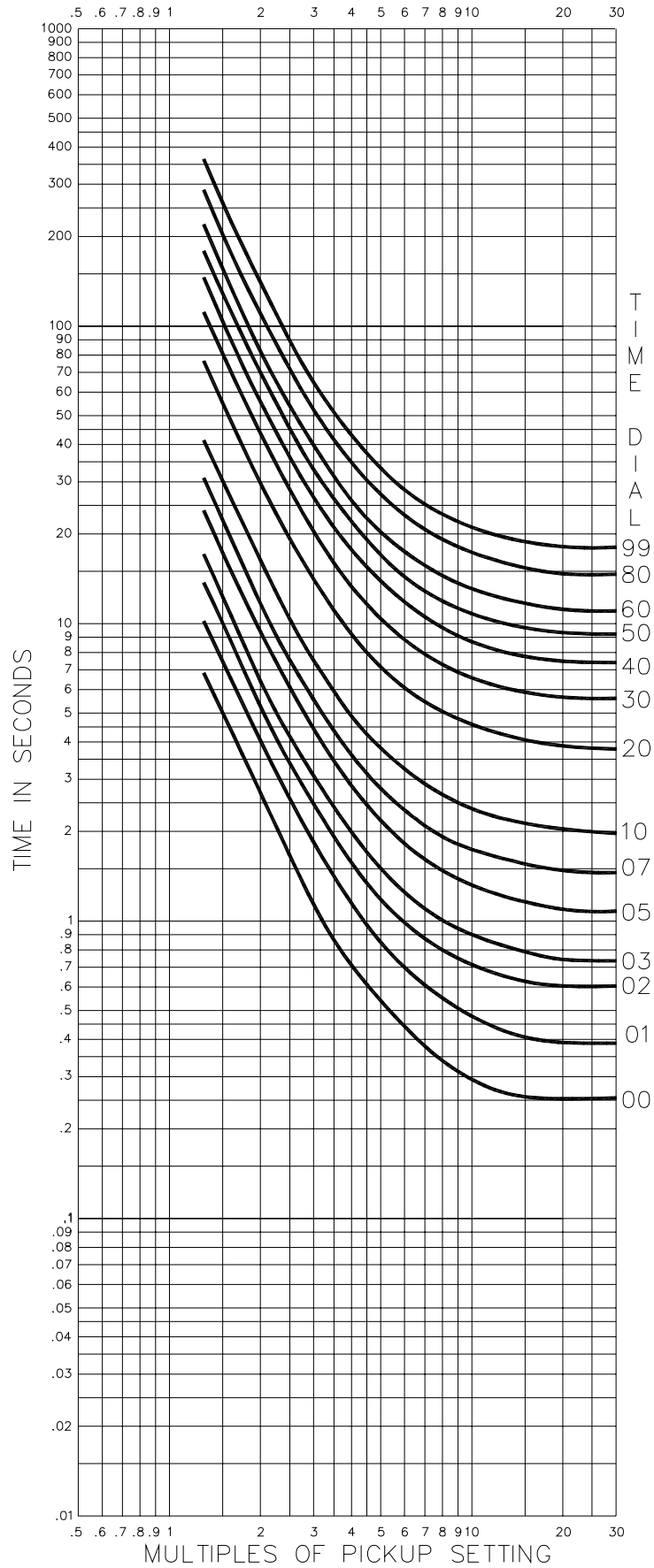


Figure A-47. Timing Type B5: Inverse with Integrated Algorithm and Extended Timing (99-1406)

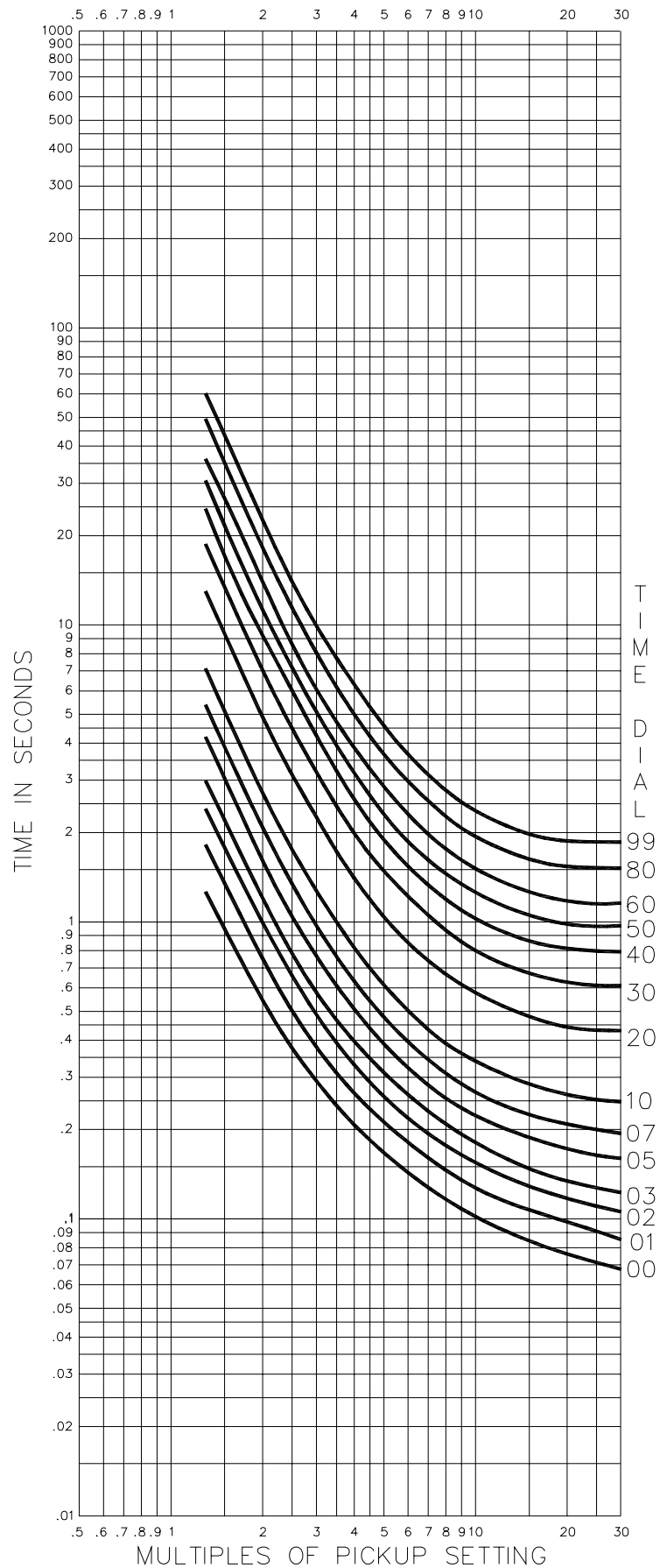


Figure A-48. Timing Type B6: Very Inverse  
with Integrated Algorithm (99-1407)

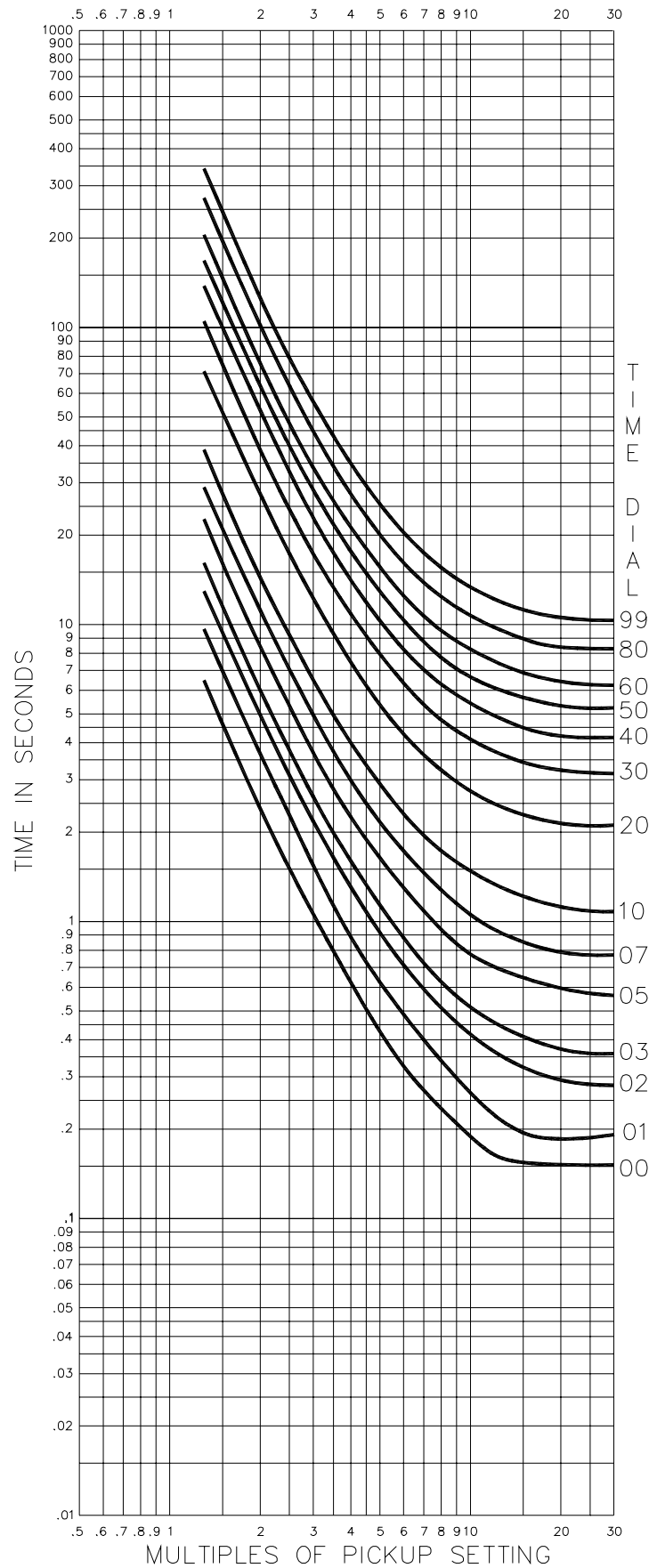


Figure A-49. Timing Type B6: Very Inverse  
with Integrated Algorithm and Extended Timing (99-1408)

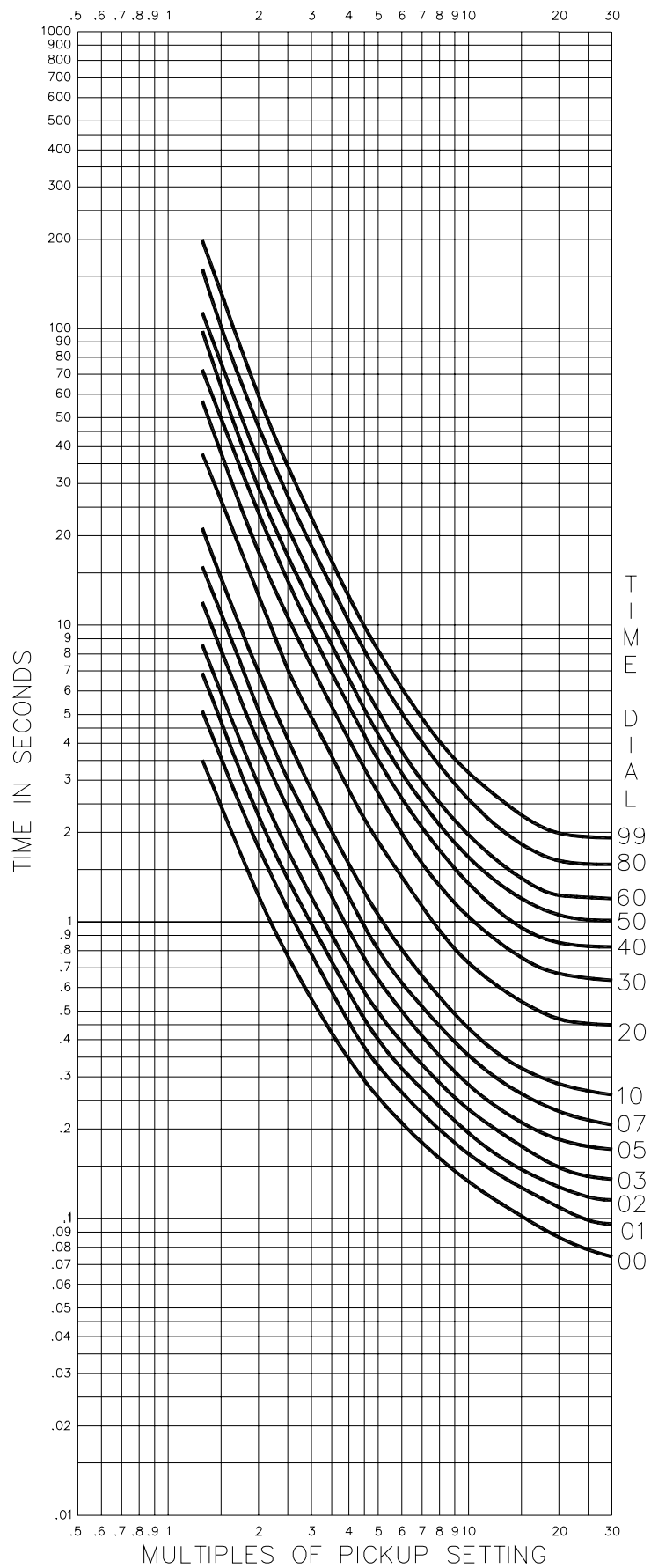


Figure A-50. Timing Type B7: Extremely Inverse with Integrated Algorithm (99-1409)

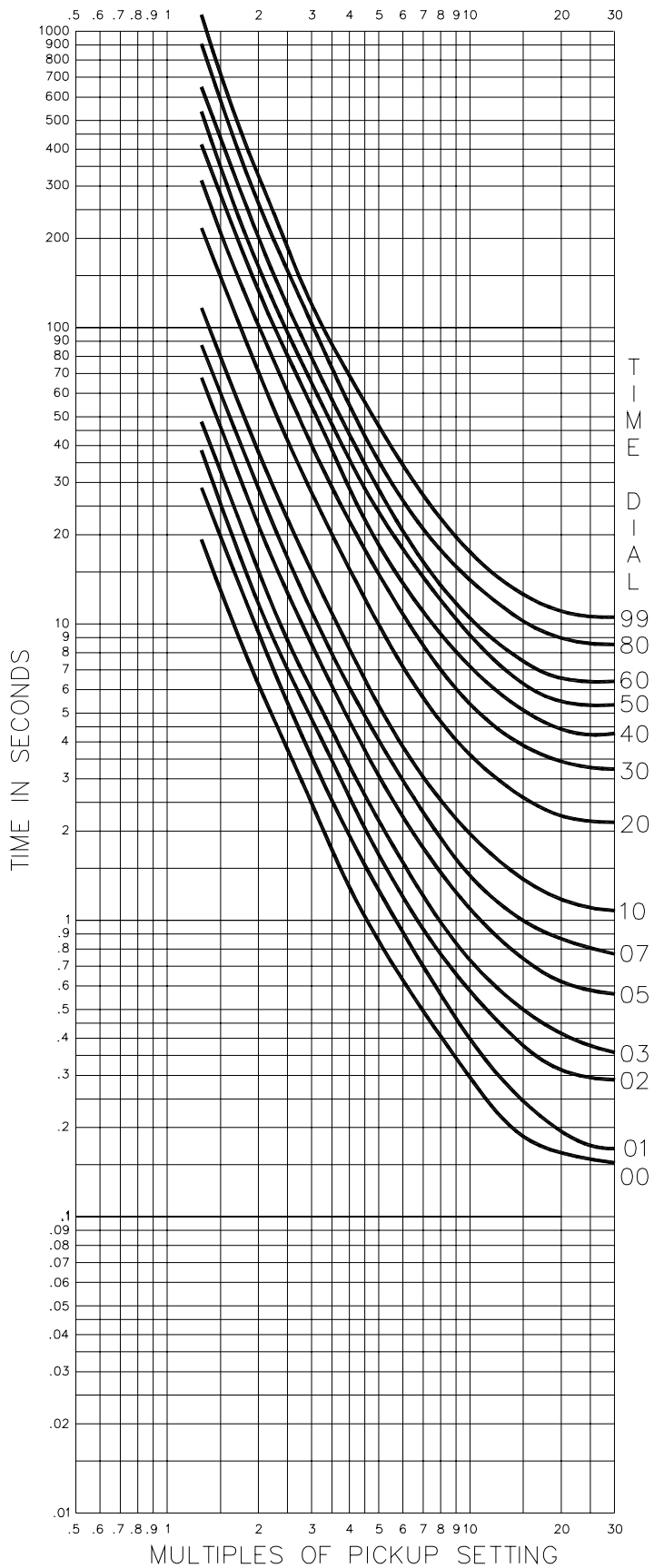


Figure A-51. Timing Type B7E: Extremely Inverse with Integrated Algorithm and Extended Timing (99-1410)

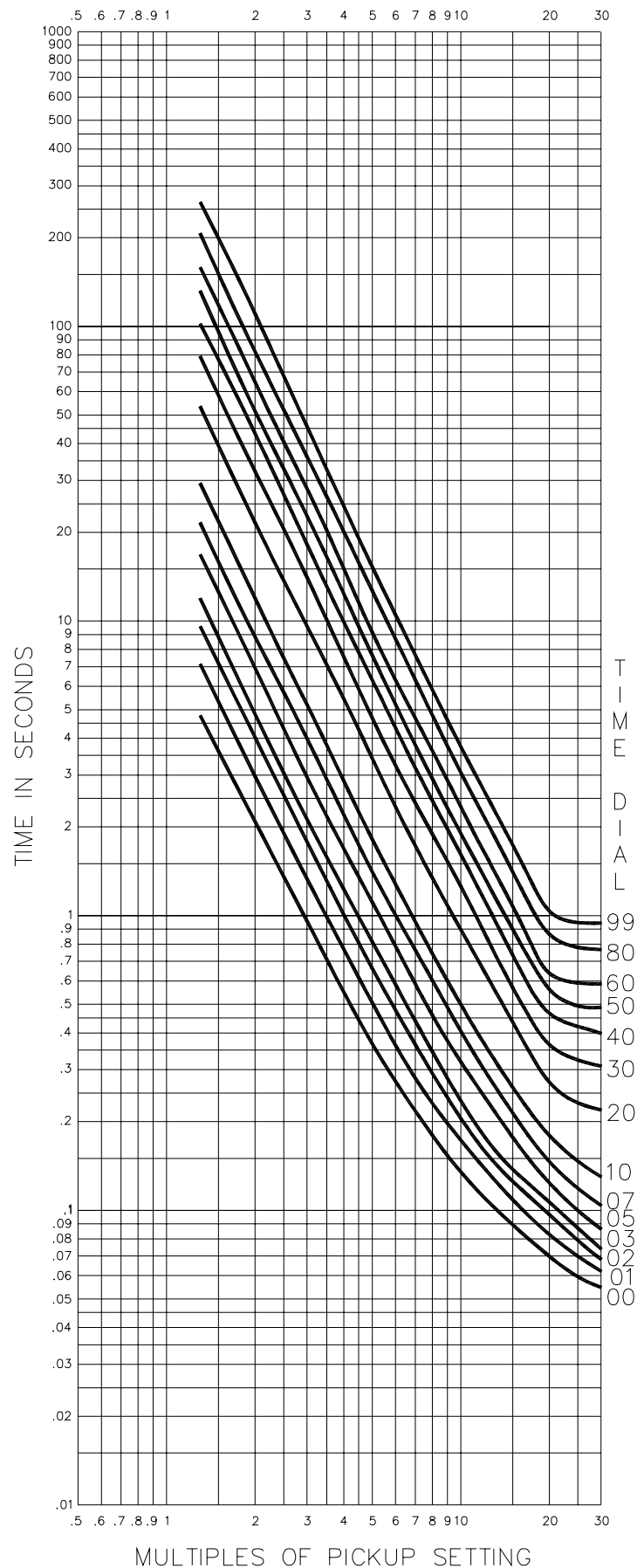


Figure A-52. Timing Type B8:  $P^2T$  with Integrated Algorithm (99-1411)

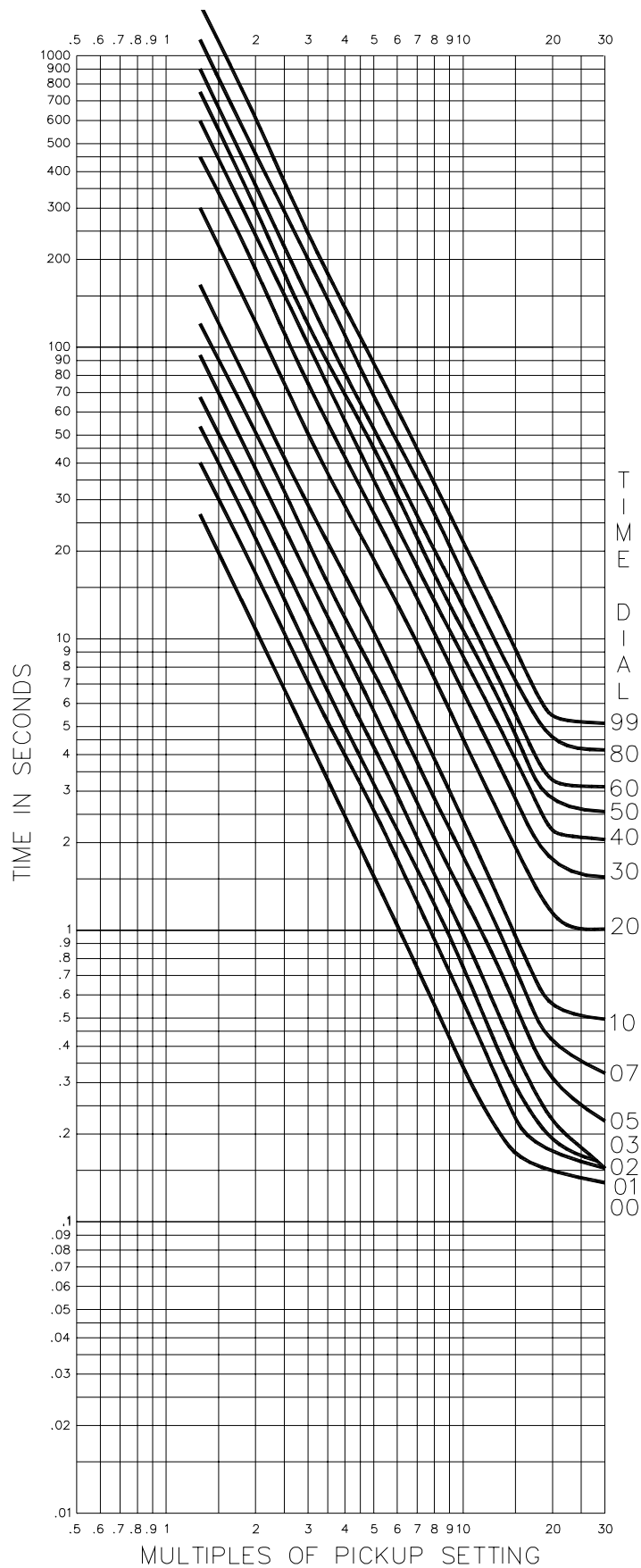


Figure A-53. Timing Type B8E:  $P^2T$  with Integrated Algorithm and Extended Timing (99-1412)



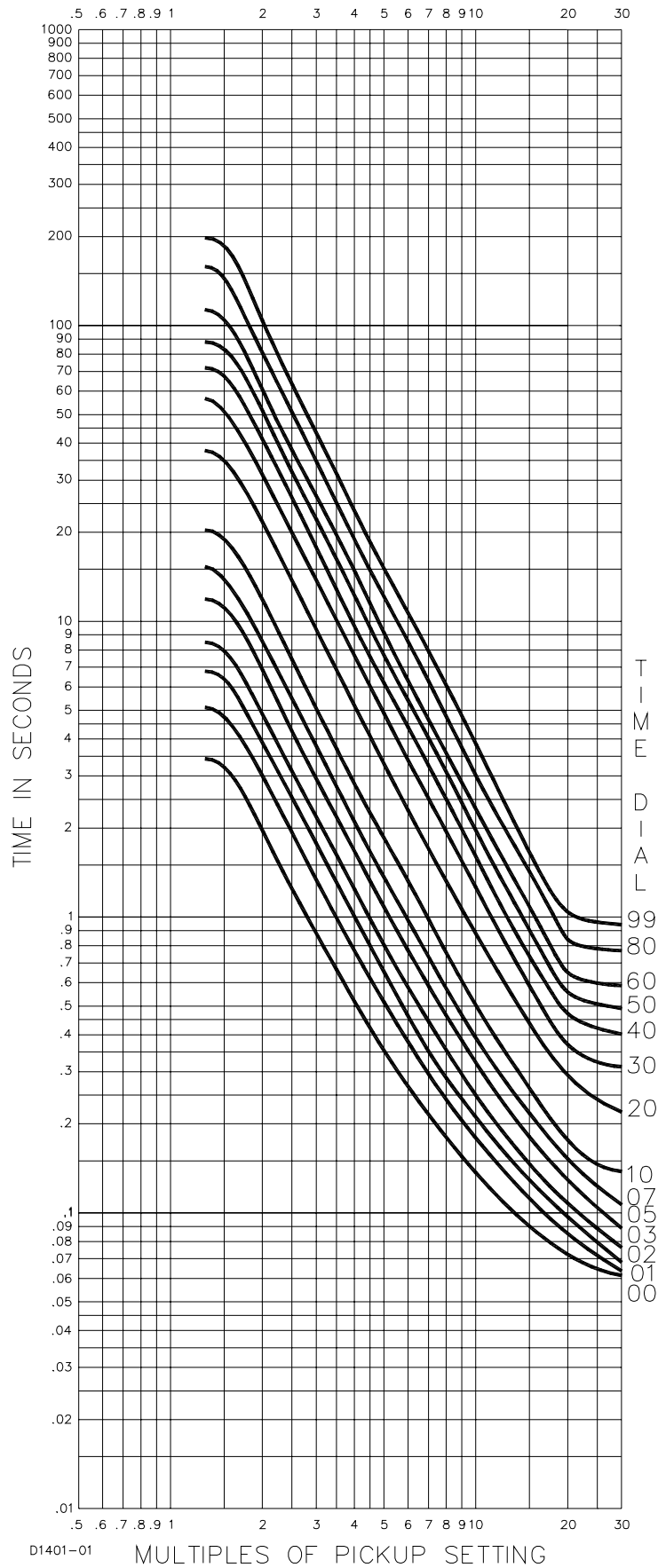
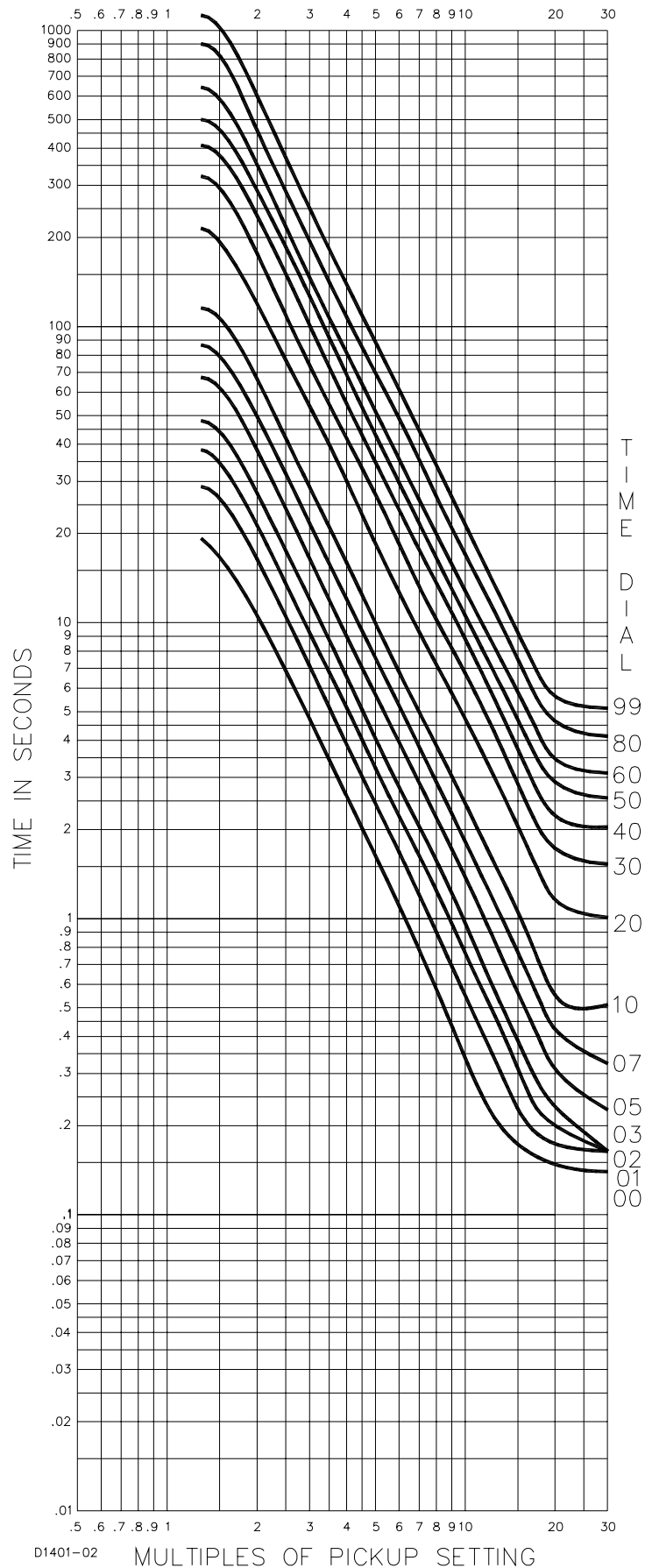


Figure A-54. Timing Type C1:  $P^2T$ , Limit #1  
with Integrated Algorithm (99-1413)



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Figure A-55. Timing Type C1E:  $P^T$ , Limit #1  
with Integrated Algorithm and Extended Timing (99-1414)

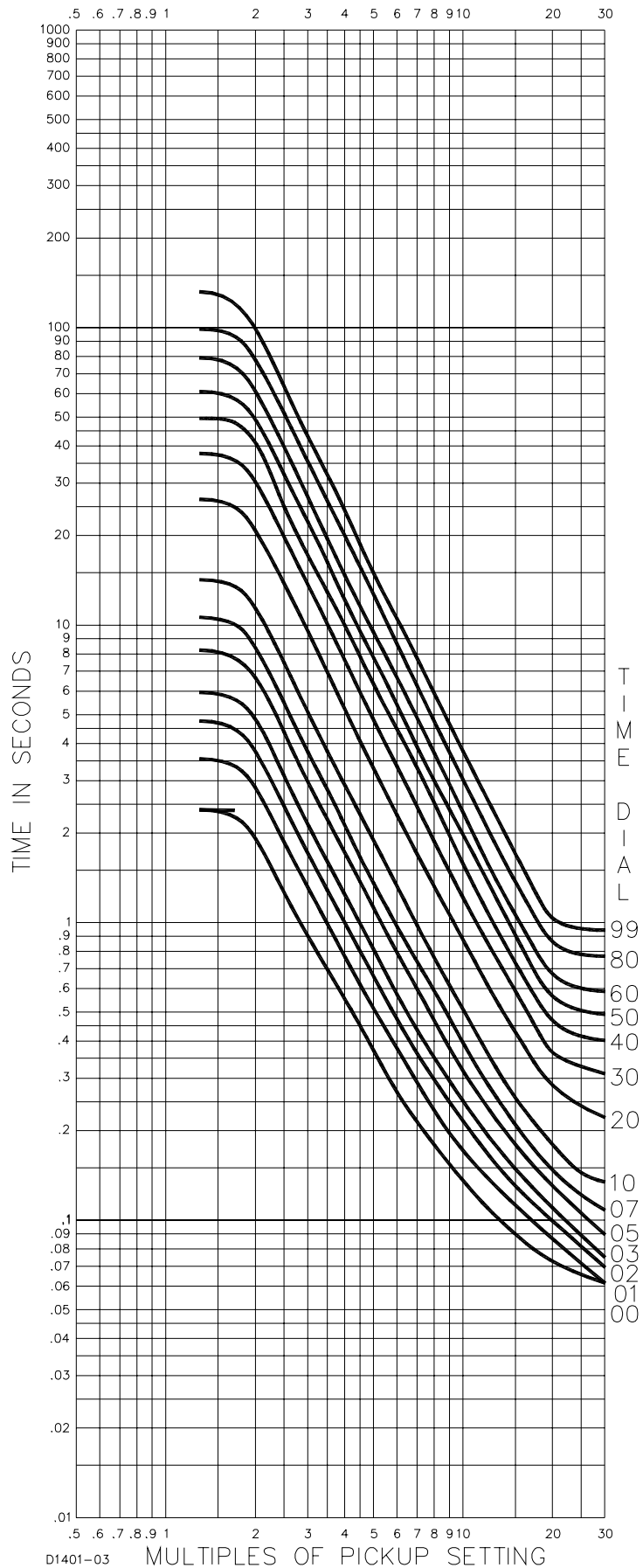


Figure A-56. Timing Type C2:  $P^2T$ , Limit #2  
with Integrated Algorithm (99-1415)

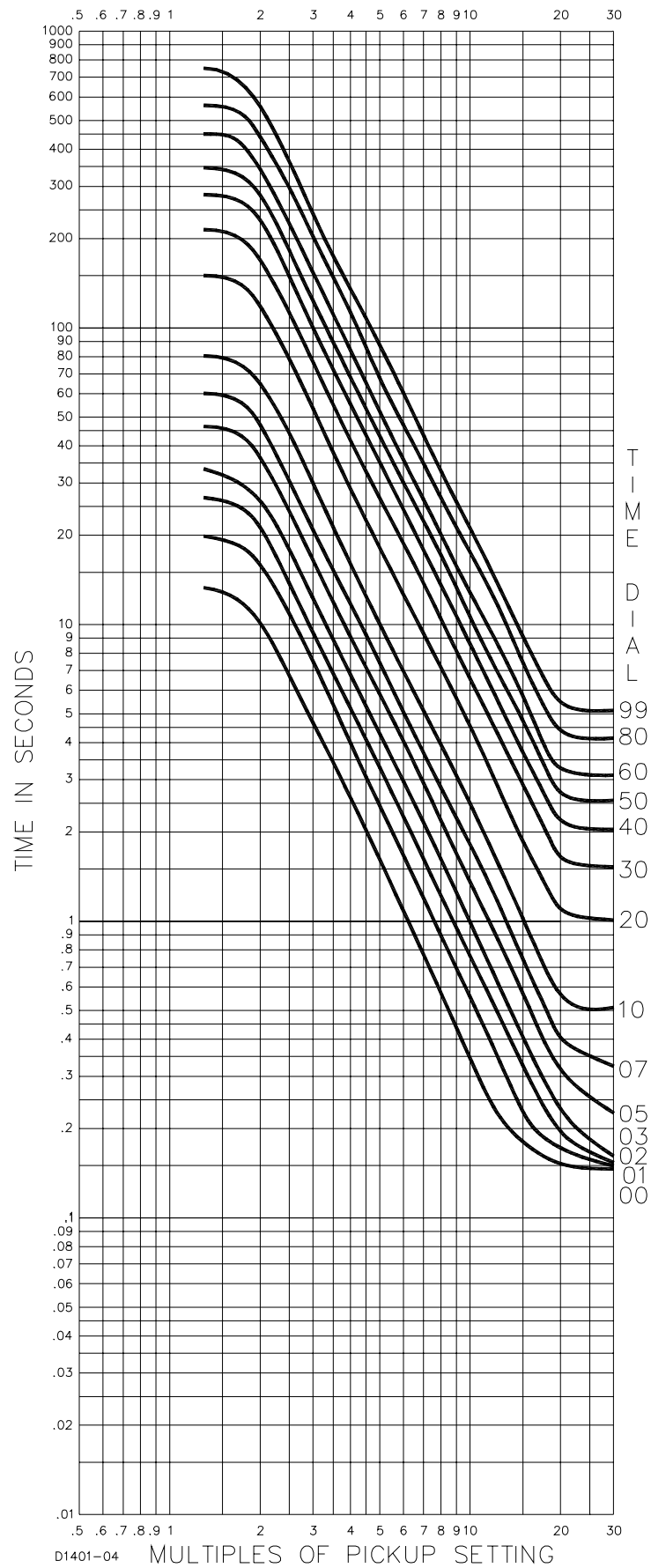


Figure A-57. Timing Type C2E:  $P^T$ , Limit #2 with Integrated Algorithm and Extended Timing (99-1416)

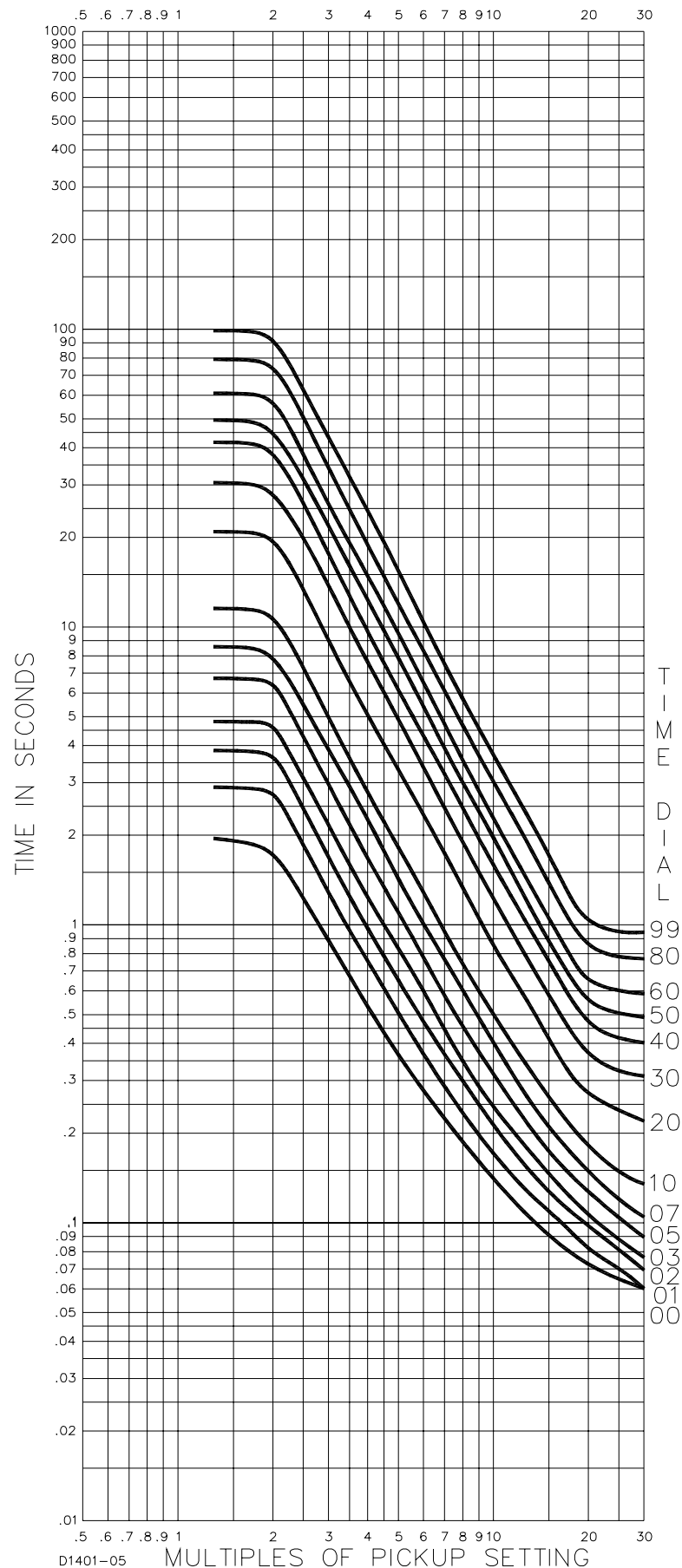


Figure A-58. Timing Type C3:  $I^2T$ , Limit #3 with Integrated Algorithm (99-1417)

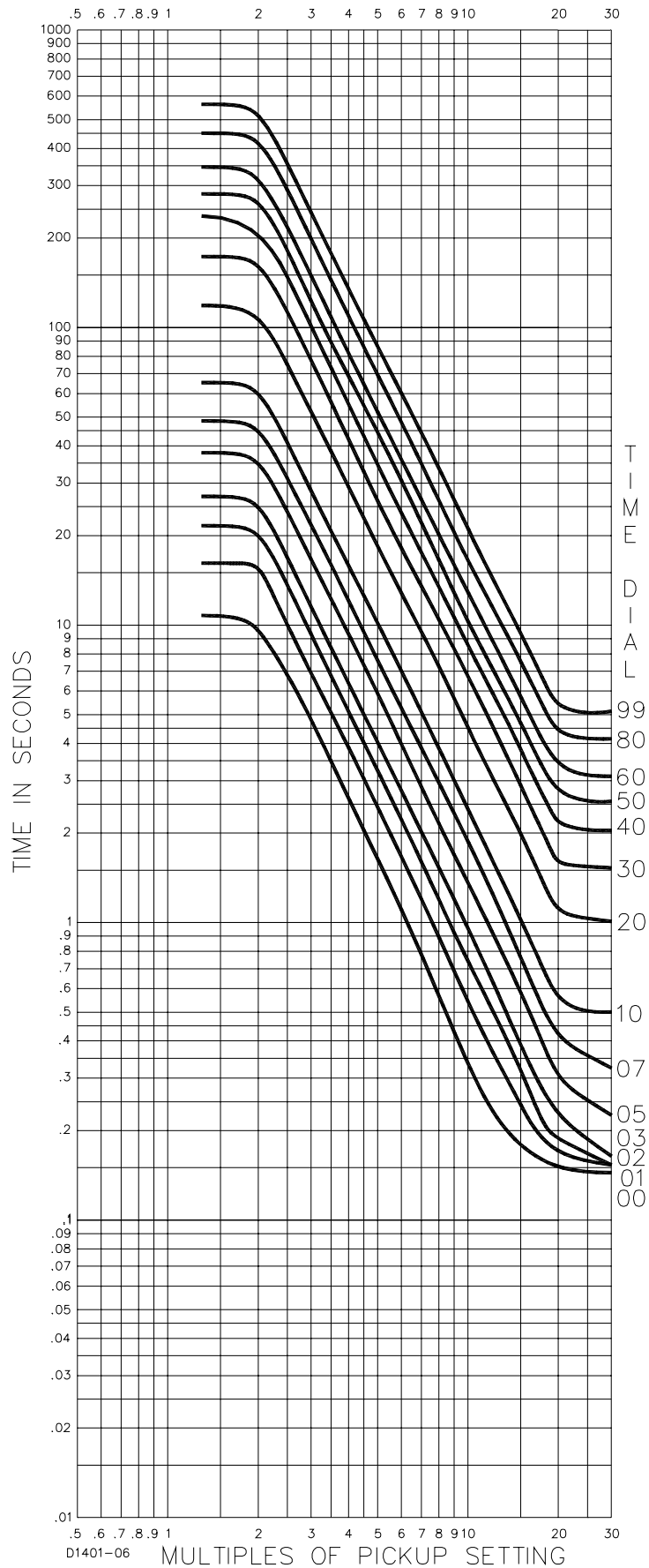


Figure A-59. Timing Type C3E:  $I^2T$ , Limit #3 with Integrated Algorithm and Extended Timing (99-1418)

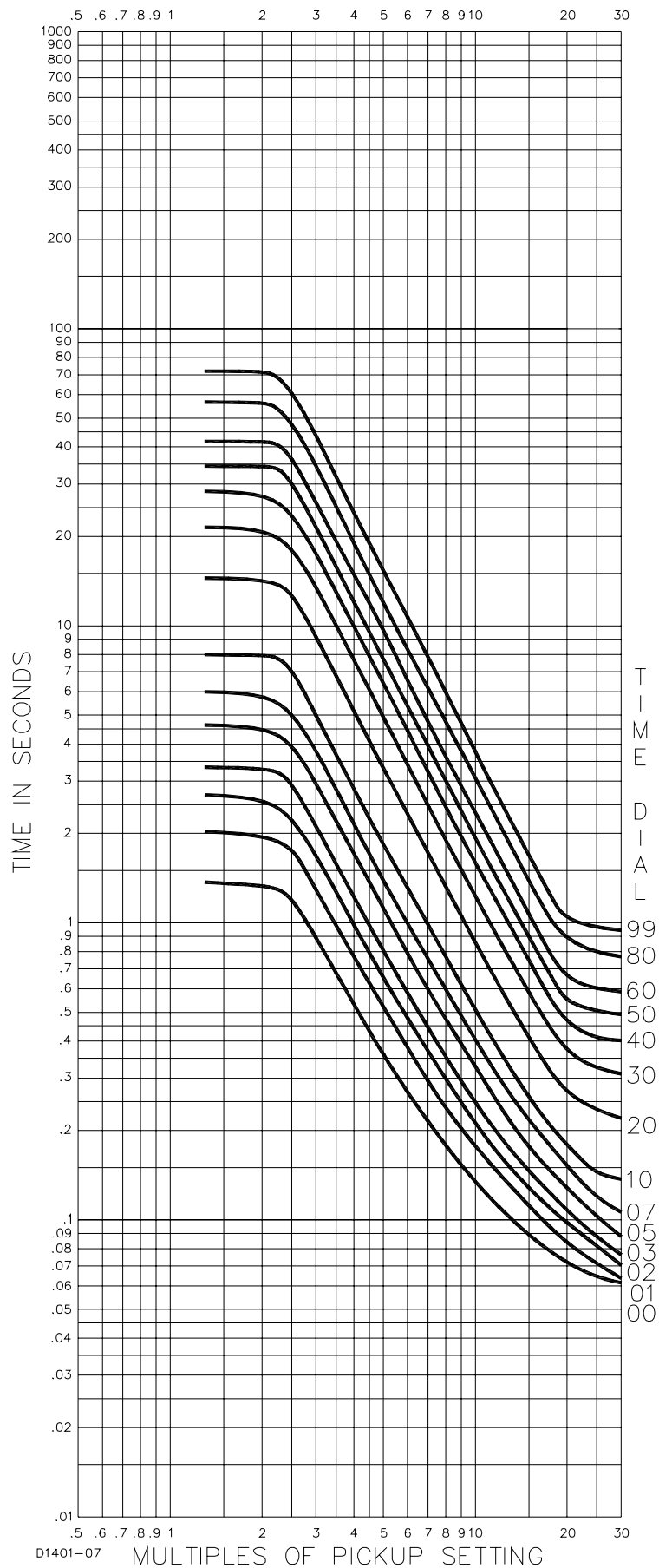


Figure A-60. Timing Type C4:  $I^2T$ , Limit #4  
with Integrated Algorithm (99-1419)

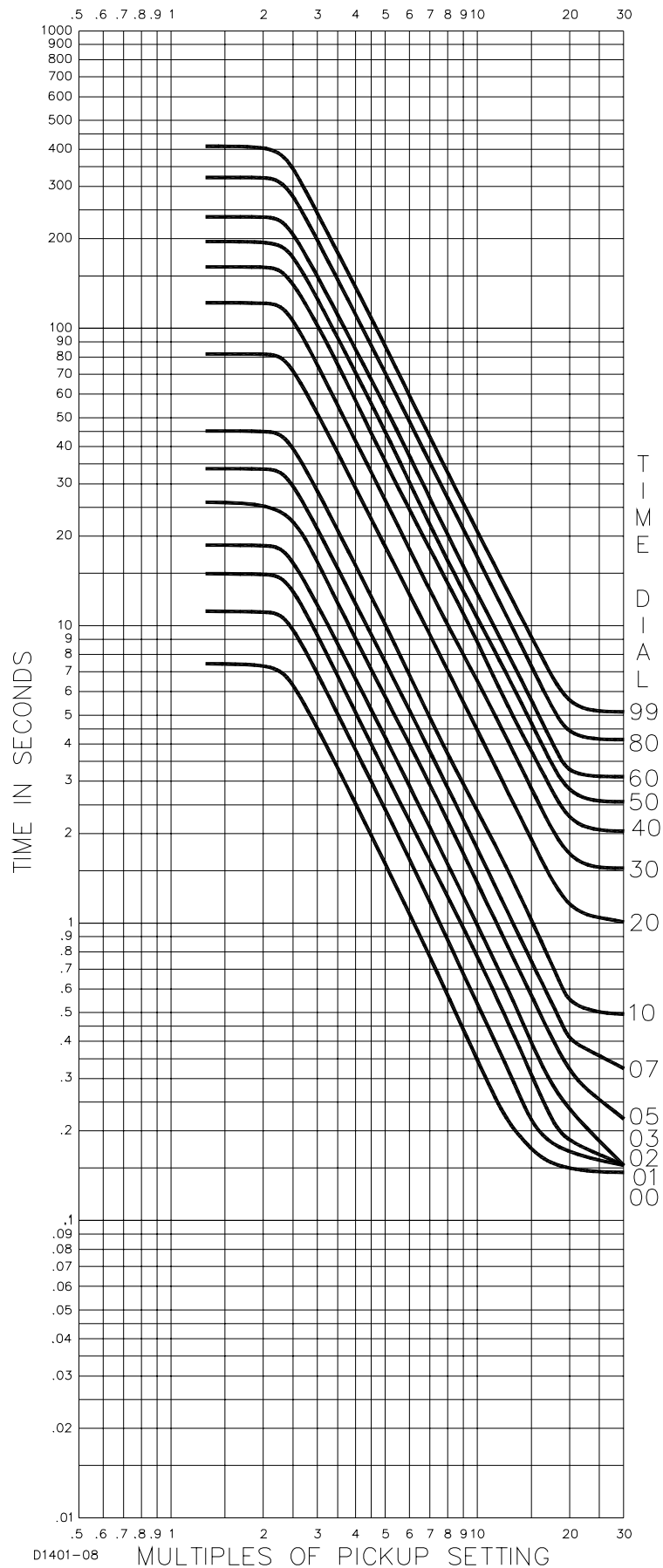


Figure A-61. Timing Type C4E:  $P^T$ , Limit #4 with Integrated Algorithm and Extended Timing (99-1420)



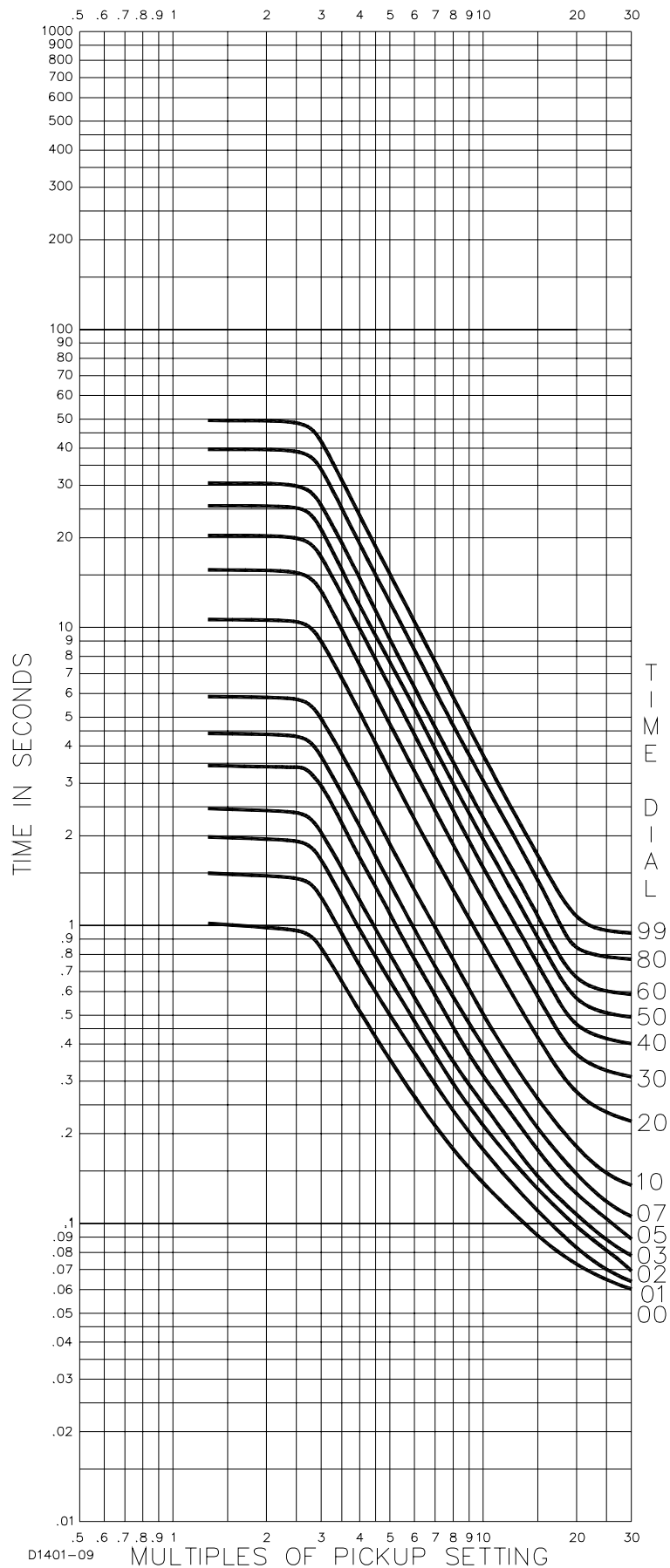


Figure A-62. Timing Type C5:  $P T$ , Limit #5  
with Integrated Algorithm (99-1421)

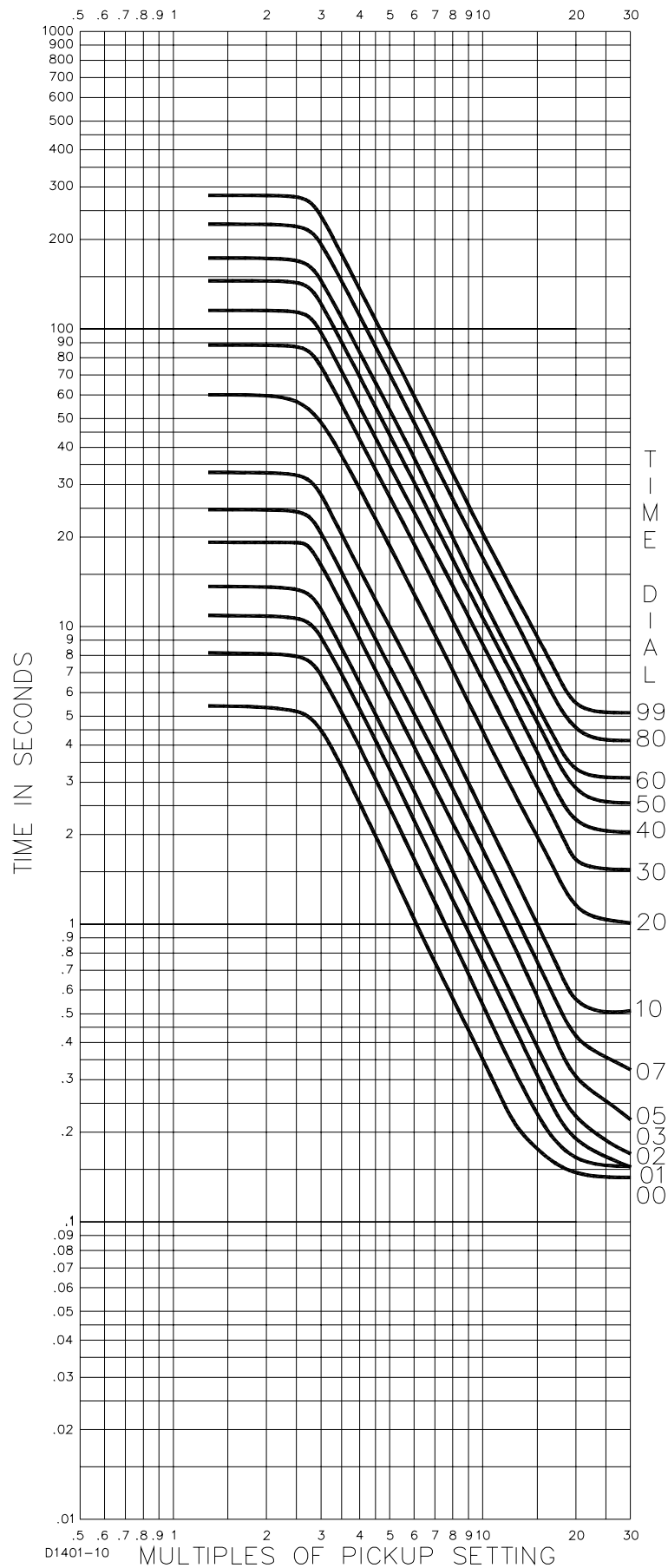


Figure A-63. Timing Type C5E:  $P^T$ , Limit #5  
with Integrated Algorithm and Extended Timing (99-1422)

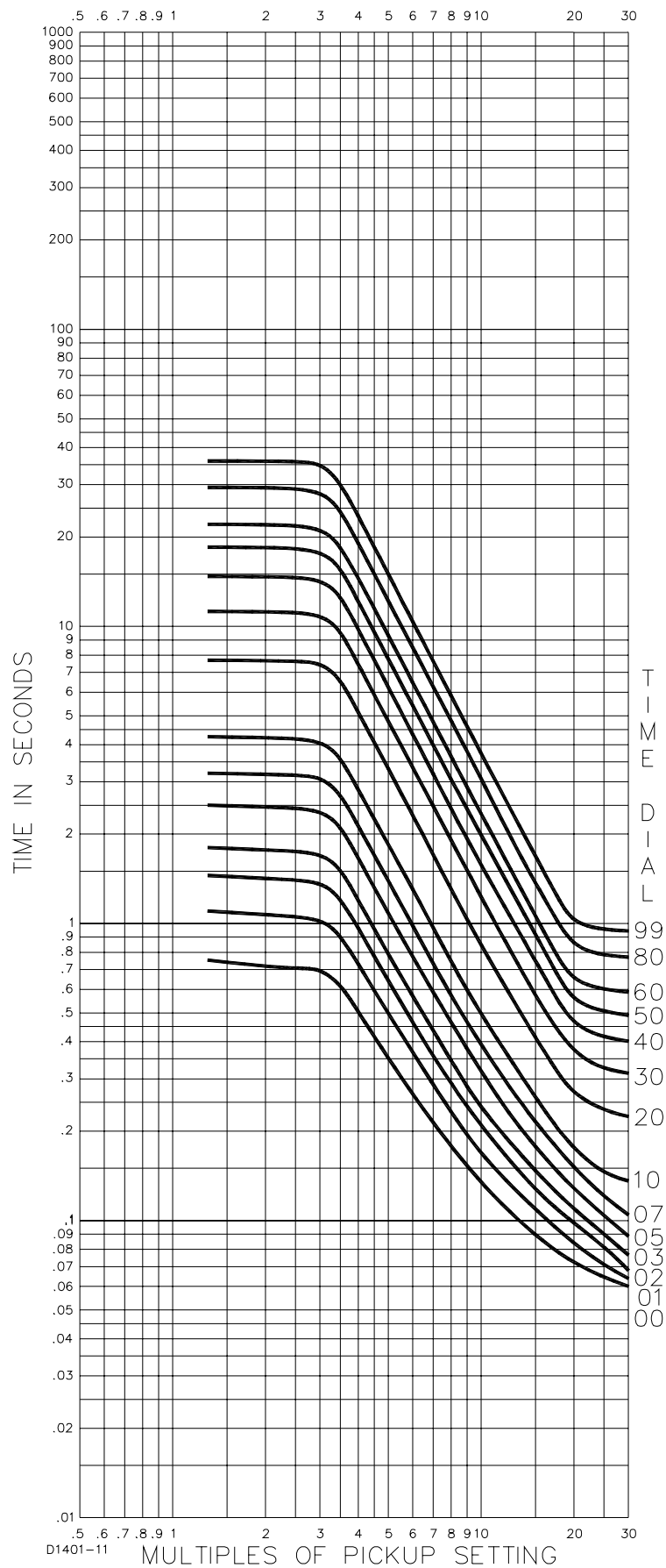


Figure A-64. Timing Type C6: P T, Limit #6  
with Integrated Algorithm (99-1423)

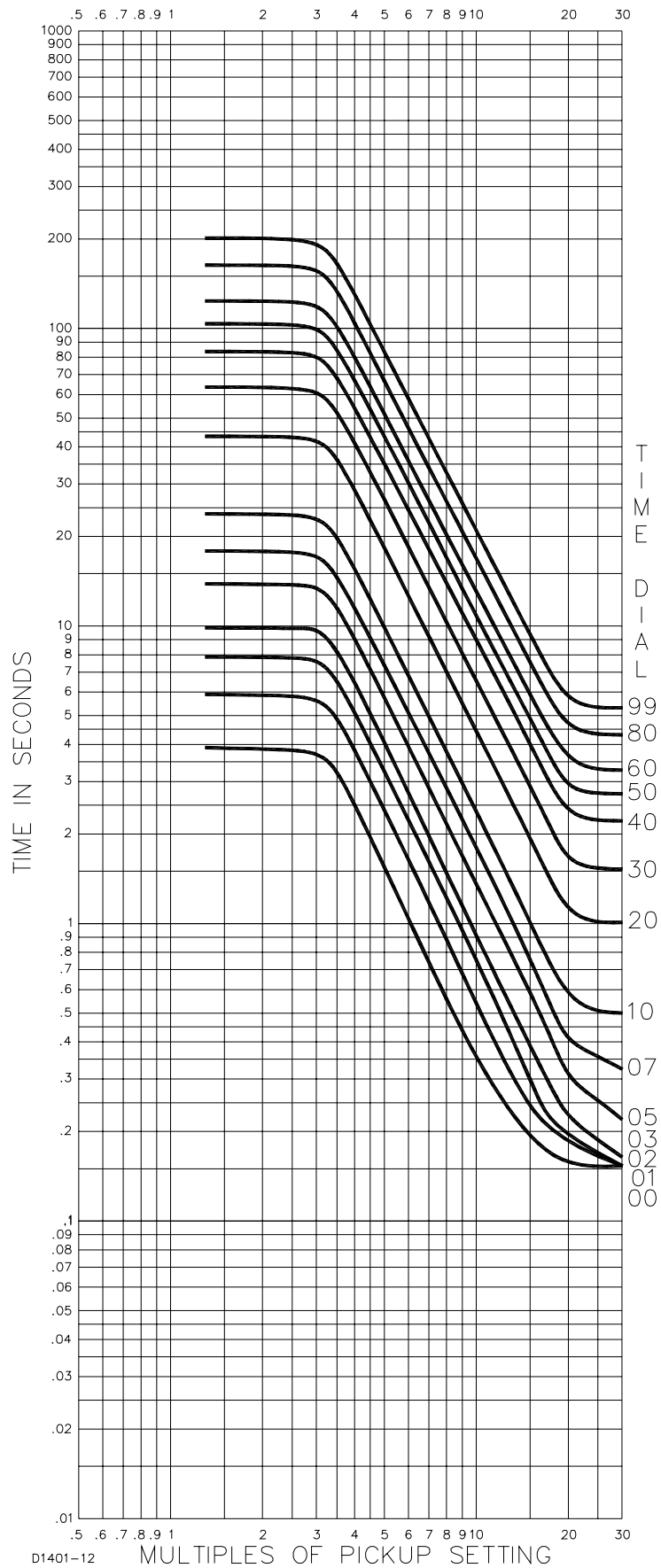


Figure A-65. Timing Type C6E:  $P^T$ , Limit #6 with Integrated Algorithm and Extended Timing (99-1424)

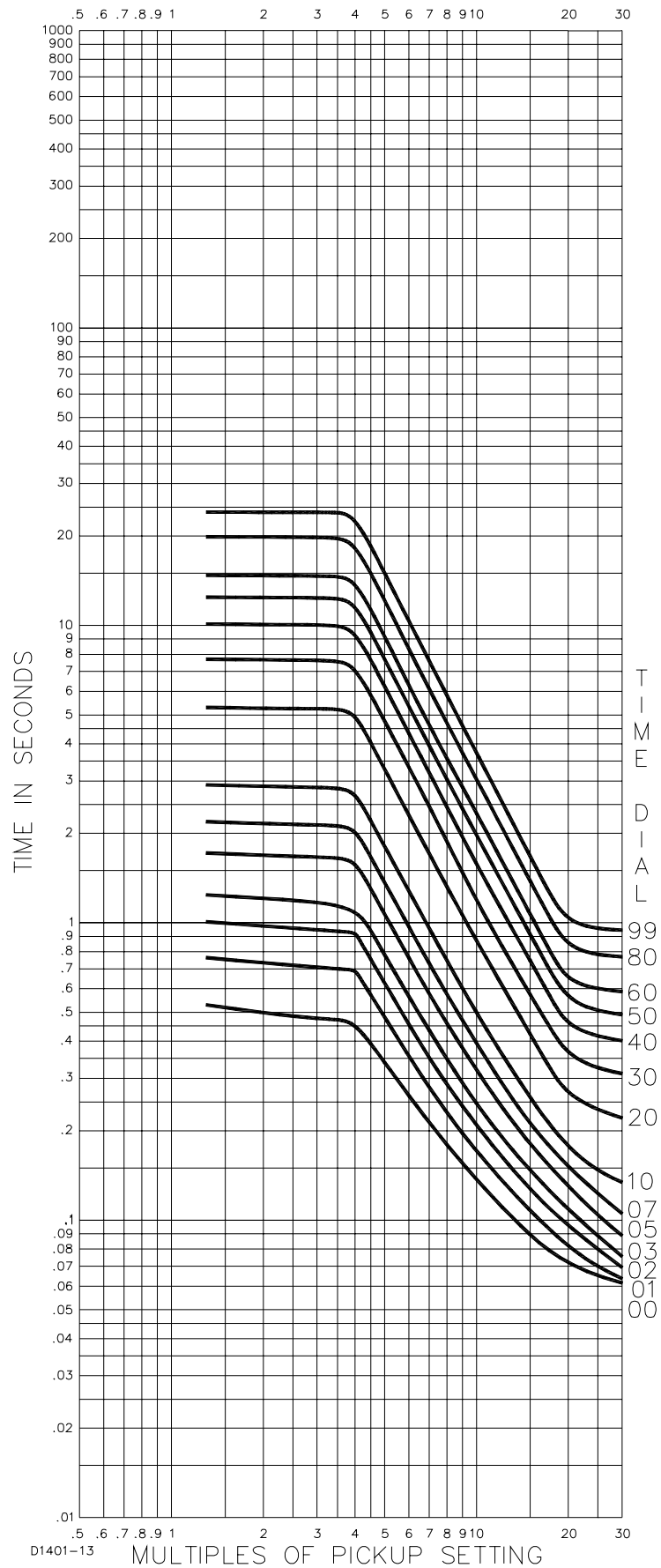


Figure A-66. Timing Type C7:  $P^T$ , Limit #7  
with Integrated Algorithm (99-1425)

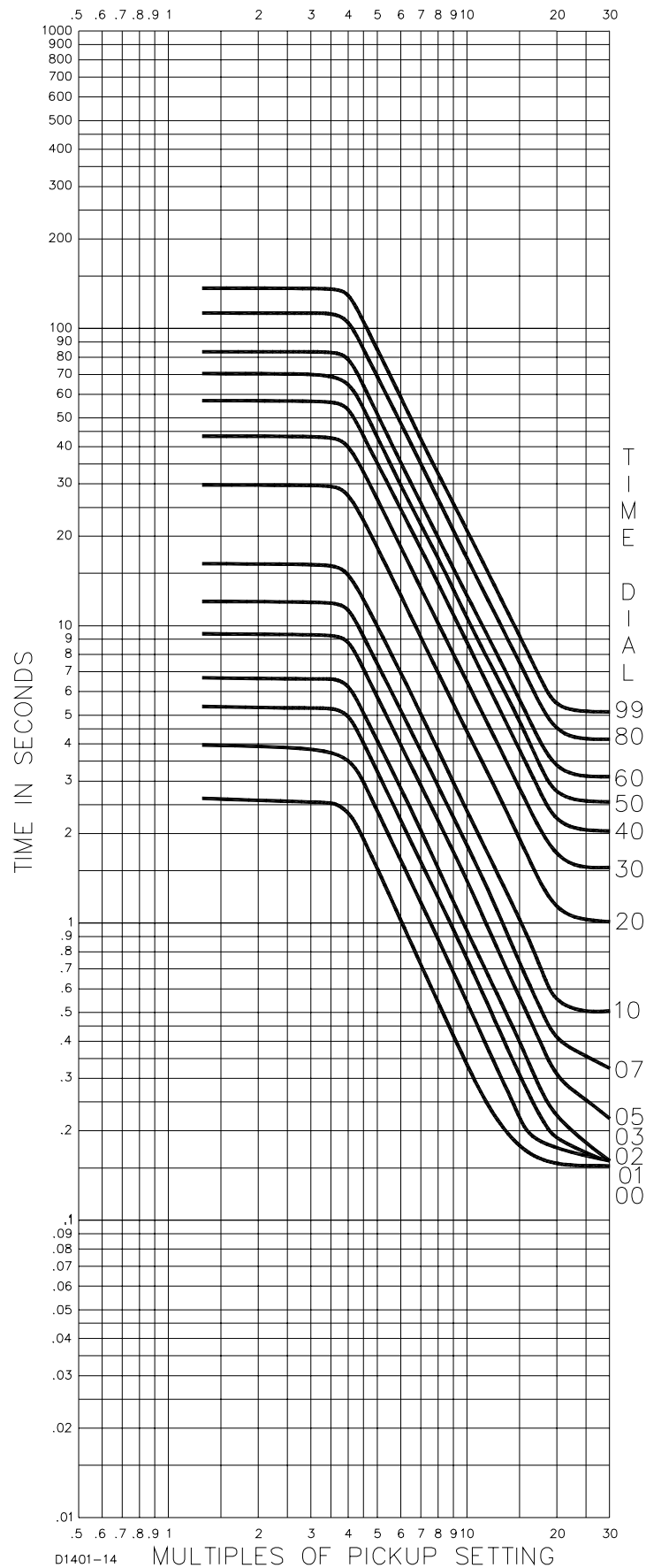


Figure A-67. Timing Type C7E: PT, Limit #7  
with Integrated Algorithm and Extended Timing (99-1426)

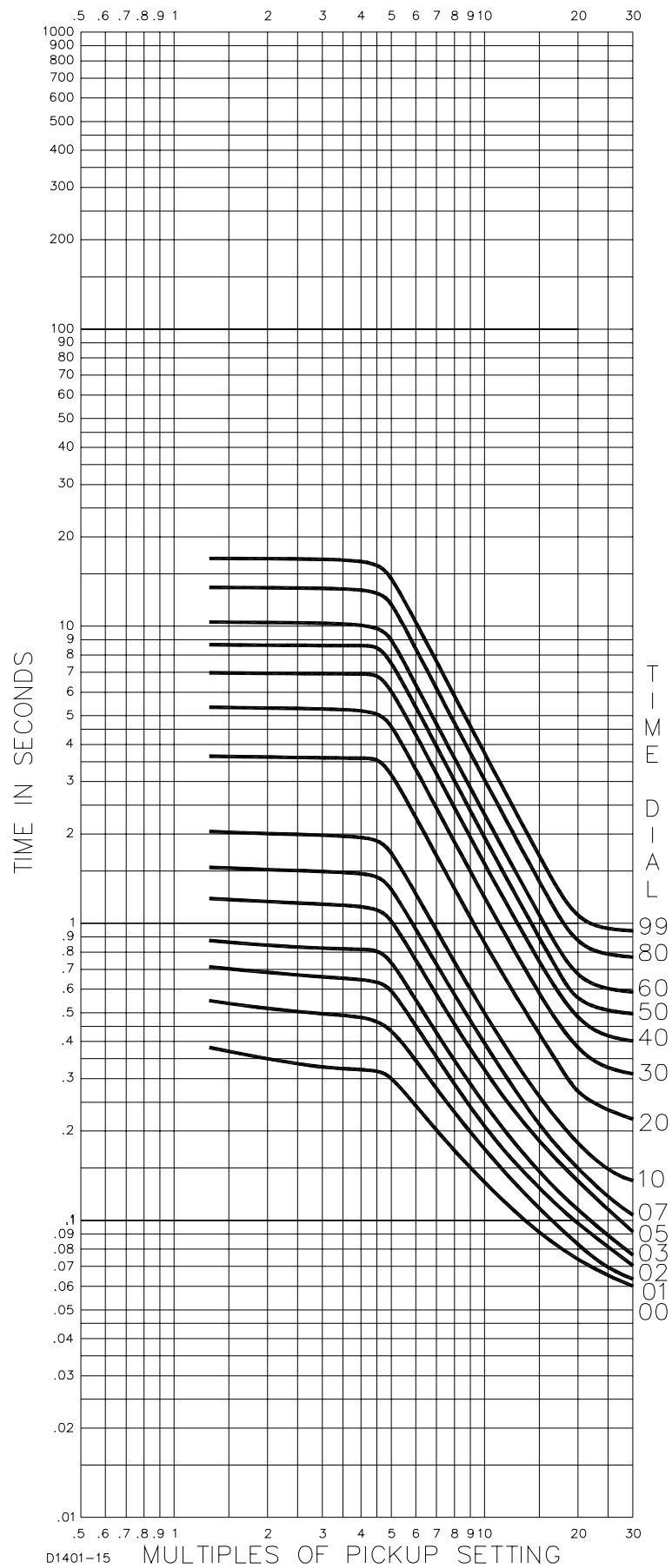


Figure A-68. Timing Type C8:  $P T$ , Limit #8  
with Integrated Algorithm (99-1427)

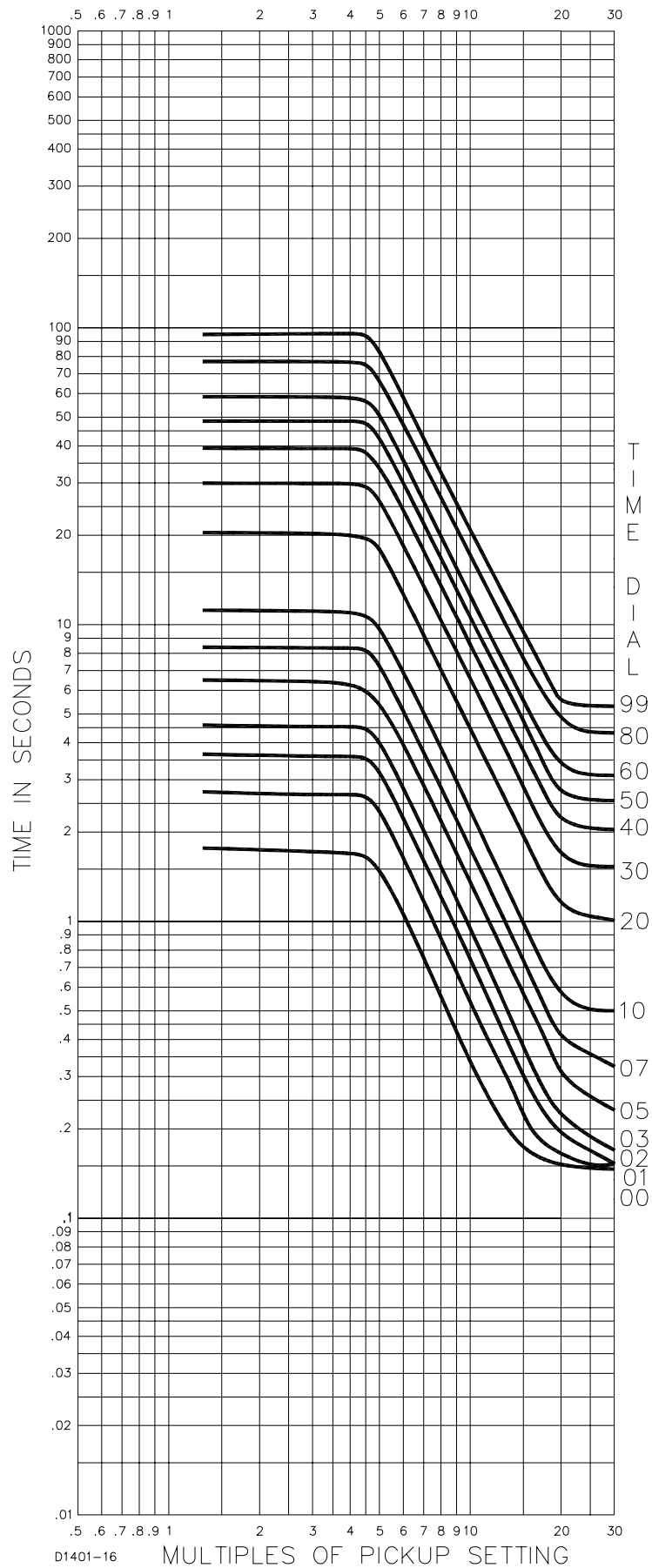


Figure A-69. Timing Type C8E:  $P^T$ , Limit #8  
with Integrated Algorithm and Extended Timing (99-1428)