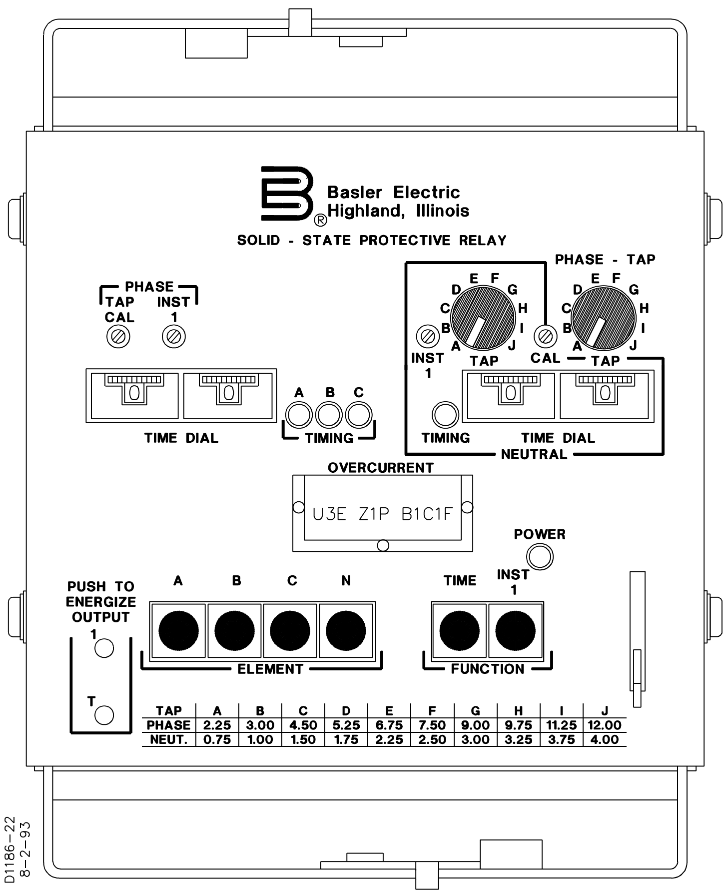
INSTRUCTION MANUAL

FOR

TIME OVERCURRENT RELAY WITH VOLTAGE RESTRAINT

MODEL BE1-51/27R



Basler Electric

Publication: 9 1372 00 999
Revision: B 09/99

INTRODUCTION

This Instruction Manual provides information concerning the operation and installation of BE1-51/27R Time Overcurrent (with voltage restraint) 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.

First Printing: September 1993

Printed in USA

September 1999

It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Should further information be required, contact Basler Electric Company, Highland, Illinois.

BASLER ELECTRIC
ROUTE 143, BOX 269
HIGHLAND, IL 62249 USA
http://www.basler.com, info@basler.com
PHONE 618-654-2341 **FAX 618-654-2351**

CONTENTS

CONTENTS - Continued

SECTION 4 INSTALLATION - Continued 4-1

SECTION 5 TESTS AND ADJUSTMENTS 5-1

SECTION 6 MAINTENANCE 6-1

SECTION 1 • GENERAL INFORMATION

DESCRIPTION

BE1-51/27R Time Overcurrent Relays with voltage restraint are microprocessor-based devices that provide voltage restraint of the phase time overcurrent function. With voltage restraint, the current pickup decreases proportionately with decreasing voltage over the rated voltage range. Instantaneous overcurrent element(s), when supplied, operate independently of the voltage restraint function. Relays are available with one, three, or four time overcurrent elements. The neutral time overcurrent element, when supplied, operates independently of the voltage restraint function.

APPLICATION

Voltage restraint provides an added means of discriminating between load and fault conditions. This allows the time overcurrent pickup to be set below the maximum load (or swing) current. This feature permits the relay to provide dual protection on a generator. For example, either backing up the differential protection for generator faults and/or backing up other relays external to the generator zone. As a back-up function, it must be set with a relatively long delay. Prior to relay time-out, the synchronous impedance of the generator may be limiting fault current to a level comparable to rated. If the regulator is not in service to boost excitation, the steady-state fault current, even for a fault on the machine terminals, will usually be less than rated. The relay pickup must be below generator rated current to insure dependable operation.

Backup Protection

This relay is useful for generator time overcurrent back-up protection for other relaying external to the system. It also provides primary (first line) phase fault protection for small generators not equipped with differential protection.

Phase overcurrent units should be supplied on all three phases. Either three single-phase relays or one three-phase relay when the objective is to protect for phase-phase faults on the other side of a delta-wye power transformer. Currents at the relay for a three-phase fault are in the proportions of 2:1:1 in the three phases, so only one phase sees the higher current level. For this application, each phase time-overcurrent element should be restrained by the phase-to-ground voltage on its phase, rather than by the phase-phase voltage.

Following fault inception, current varies continuously as the field current decays. In addition, for other than a bolted fault on the terminals of a generator, the voltage will not be zero and will vary with time as the fault current decays. If the restraint voltage is between 25 and 100 percent, the time overcurrent element pickup will also vary with the time because of the changing voltage. Because the pickup varies with time, the multiples of pickup, and therefore the timing, will also change. These factors must be considered when coordinating with external protective devices. Section 4 of this manual provides additional coordination information in the paragraphs on setting the relay.

Instantaneous overcurrent elements would not ordinarily be used for a generator back-up function. They would not have acceptable operation for faults external to the generator zone.

Because the phase time-overcurrent pickup will be less than the maximum non-fault current, the relay can misoperate if the voltage signal is interrupted (e.g., a blown voltage transformer fuse). Where two sources of signal voltage are available, the BE1-60 Voltage Balance relay can prevent such a misoperation. 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.

Residually Connected

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 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.

Operating Characteristics At Reduced Voltages

BE1-51/27R relays adjust the operating parameters based on system voltage. The sensitivity of the relay is increased as the system voltage drops. This provides a means of discriminating between load and fault conditions.

A decrease of the sensed voltage to a point between 100 percent and 25 percent of nominal results in a proportional decrease in the time overcurrent pickup point. Thus, at 50 percent nominal voltage, the time overcurrent relay will pickup at 50 percent of the setting (TAP + Calibration). At voltages above 100 percent nominal, the pickup will be the same as the setting. At voltages below 25 percent of nominal, the pickup will be 25 percent of the setting. Note that the BE1-51/27R is designed to trip at currents less than the setting if the voltage is depressed.

The timing characteristics of the BE1-51/27R continue to operate on a multiples of pickup basis. Pickup refers not to the setting, but to the operating point as adjusted for voltage. Thus, with a setting of 5.0 amperes, and system voltage of 50 percent, a current of 5.0 amperes represents 2 times pickup. For a given fault current magnitude, the relay will trip faster at reduced voltage, because the multiples of pickup increases.

Table 1-1 shows the timing characteristics at normal and reduced voltages. The curve is B4 and the time dial is five. The pickup is five amperes. Table 1-2 shows the timing characteristics for multiples of setting as it relates to multiples of pickup with the BE1-51/27R at 25 percent voltage.

Table 1-1. Timing, Characteristic Curve B4, With BE1-51/27R At 100% and 50% Voltages,

Fault Current	System voltage	Effective Pickup	Multiples of Pickup	Approximate Trip Time
4.25 Amps	100%	5.0 Amps	<1.0	NO TRIP
4.25 Amps	50%	2.5 Amps	1.7	1.499 Sec.
4.25 Amps	0%	1.25 Amps	3.4	.507 Sec.
7.50 Amps	100%	5.0 Amps	1.5	1.873 Sec.
7.50 Amps	50%	2.5 Amps	3.0	.772 Sec.
7.50 Amps	0%	1.25 Amps	6.0	.474 Sec.
15.00 Amps	100%	5.0 Amps	3.0	.772 Sec.
15.00 Amps	50%	2.5 Amps	6.0	.474 Sec.
15.00 Amps	0%	1.25 Amps	12.0	.355 Sec.

Table 1-2. Timing, Curve B4, BE1-51/27R At 25% Voltage (00 to 10 Time Dial Settings)

Multiple of Setting	Multiple of Pickup	Time Dial Setting (Seconds)						
		00	**01**	**02**	**03**	**05**	**07**	**10**
0.38	1.50	0.604	0.856	1.111	1.370	1.873	2.384	3.142
0.43	1.70	0.480	0.688	0.899	1.104	1.499	1.930	2.504
0.50	2.00	0.382	0.539	0.705	0.866	1.194	1.517	1.994
0.55	2.20	0.344	0.484	0.633	0.775	1.063	1.349	1.780
0.63	2.50	0.300	0.419	0.548	0.663	0.918	1.168	1.542
0.68	2.70	0.278	0.387	0.508	0.620	0.850	1.073	1.420
0.75	3.00	0.250	0.354	0.461	0.561	0.772	0.977	1.284
0.88	3.50	0.218	0.308	0.403	0.494	0.672	0.855	1.127
1.00	4.00	0.202	0.281	0.360	0.445	0.602	0.772	1.016
1.13	4.50	0.186	0.261	0.334	0.410	0.557	0.709	0.936
1.25	5.00	0.176	0.243	0.308	0.377	0.506	0.649	0.831
1.50	6.00	0.159	0.220	0.285	0.347	0.474	0.599	0.790
1.75	7.00	0.151	0.204	0.263	0.320	0.435	0.553	0.727
2.00	8.00	0.142	0.191	0.246	0.300	0.412	0.520	0.683
2.25	9.00	0.136	0.185	0.240	0.290	0.393	0.499	0.654
2.50	10.00	0.130	0.180	0.227	0.277	0.372	0.477	0.622
3.00	12.00	0.123	0.170	0.215	0.262	0.355	0.453	0.593
3.50	14.00	0.118	0.163	0.208	0.250	0.341	0.433	0.566
4.00	16.00	0.117	0.159	0.201	0.243	0.329	0.420	0.548
4.50	18.00	0.112	0.153	0.195	0.237	0.322	0.406	0.537
5.00	20.00	0.111	0.154	0.188	0.231	0.316	0.400	0.526

Table 1-2. Timing, Curve B4, BE1-51/27R At 25% Voltage (20 to 99 Time Dial Settings) - Continued

Multiple of Setting	Multiple of Pickup	Time Dial Setting (Seconds)						
		20	**30**	**40**	**50**	**60**	**80**	**99**
0.38	1.50	5.671	8.222	10.788	13.344	15.919	20.918	25.707
0.43	1.70	4.533	6.556	8.527	10.662	12.694	16.698	20.464
0.50	2.00	3.593	5.207	6.808	8.407	9.986	13.164	16.276
0.55	2.20	3.198	4.636	6.041	7.482	8.906	11.694	14.486

Table 1-2. Timing, Curve B4, BE1-51/27R At 25% Voltage (20 to 99 Time Dial Settings) - Continued

Multiple of Setting	Multiple of Pickup	Time Dial Setting (Seconds)						
		20	30	40	50	60	80	99
0.63	2.50	2.766	4.003	5.218	6.454	7.682	10.146	12.453
0.68	2.70	2.569	3.720	4.848	5.986	7.130	9.381	11.557
0.75	3.00	2.322	3.358	4.372	5.409	6.434	8.489	10.454
0.88	3.50	2.026	2.931	3.829	4.726	5.627	7.406	9.120
1.00	4.00	1.833	2.647	3.450	4.258	5.076	6.688	8.214
1.13	4.50	1.691	2.438	3.188	3.932	4.673	6.166	7.597
1.25	5.00	1.464	2.117	2.749	3.380	4.022	5.303	6.513
1.50	6.00	1.424	2.060	2.688	3.314	3.949	5.200	6.396
1.75	7.00	1.318	1.897	2.479	3.060	3.644	4.802	5.899
2.00	8.00	1.234	1.792	2.329	2.884	3.430	4.518	5.561
2.25	9.00	1.184	1.704	2.229	2.748	3.273	4.298	5.290
2.50	10.00	1.120	1.604	2.093	2.589	3.070	4.053	4.977
3.00	12.00	1.073	1.551	2.018	2.498	2.971	3.917	4.817
3.50	14.00	1.028	1.481	1.928	2.390	2.841	3.741	4.603
4.00	16.00	0.989	1.430	1.866	2.304	2.741	3.610	4.443
4.50	18.00	0.958	1.392	1.818	2.243	2.667	3.514	4.328
5.00	20.00	0.944	1.372	1.786	2.200	2.619	3.454	4.252

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 adjustable from 00 to 99 on the front panel **Time DIAL** thumbwheel switch. Curve type is either selected as an option or, in some models, selected by a switch that is located behind the front panel.

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

Characteristic curves: - continued

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

Timing option Z1 (16 position switch selects B & C curves (curves B1 - B8 and C1 - C8)):

- Seven inverse time
- Nine **I**^{2}T

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

- Seven inverse time with extended timing range
- Nine **I**^{2}T with extended timing range

Timing option Z2 (16 position switch selects B and E (BS142) curves):

- Seven inverse time
- One **I**^{2}T
- Five British Standard 142 (E curves)

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

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

Timing option Z3 (16 position switch selects B and C curves):

- Seven integrating inverse time
- Nine integrating **I**^{2}T

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

- Seven integrating inverse time with extended timing range
- Nine integrating **I**^{2}T with extended timing range

Characteristic curves are shown by the graphs in Figures 1-2 through 1-70. Note that each graph (i.e. function) consists of a set of representative curves. Each curve (as well as any between-curve interpolation) is selected 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 in conjunction with the procedures provided in Service Manual, publication 9 1372 00 620.

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 1-2 is timing type B1 and Figure 1-3 is the timing type B1 with extended timing range.

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 provide a voltage restraint circuit that varies the selected time overcurrent pickup point proportional to the monitored voltage. As the monitored voltage varies between 100 percent and 25 percent of nominal, the pickup point for each phase varies between 100 percent and 25 percent. Nominal voltage is 100 Vac for 50 hertz systems and 120 Vac for 60 hertz systems. Neutral time overcurrent elements are not restrained. Three-phase voltages are measured phase-to-phase for three wire connections and phase-to-neutral for four wire connections.

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

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). Relays with a serial number that consists of one alpha character followed by eight numerical characters also have the new wide range power supplies. A benefit of this new design increases the power supply operating ranges such that the 48/125 volt selector is no longer necessary. Five power supply options are available. They are:

- O (mid range) 48 Vdc
- P (mid range) 125 Vdc and 100/125 Vac
- R (low range) 24 Vdc
- S (mid range) 48 Vdc or 125 Vdc and 100/125 Vac
- T (high range) 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 timed 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 **PUSH-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 restrained.

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.

MODEL AND STYLE NUMBER DESCRIPTION

BE1-51/27R 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 BE1-51/27R relays. For example, if the style number were **U3E Z1P B1C1F**, the device would have the following:

- **(U)** - 3-phase-and-neutral current; 3-phase, 4-wire voltage restraint
- **(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)** - Sixteen position switch selects B and C (curves B1 - B8 and C1 - C8) 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.

SPECIFICATIONS

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

Repeatability All functions, ±2%.

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.

Sensing Input Burden Less than 0.1 ohms per phase or neutral.

Sensing Input Rating Maximum 1 second current rating is 50 X (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 a calculated as follows:

$$I = \frac{(50\ X\ tap\ value\ or\ 500\,A,\ whichever\ is\ less)}{\sqrt{T}}$$

Where: I = Maximum Current, and T = Current Flow in Seconds

Time Overcurrent Pickup Selection Range Continuously adjustable over the current sensing input ranges specified in the Style Chart (Figure 1-1).

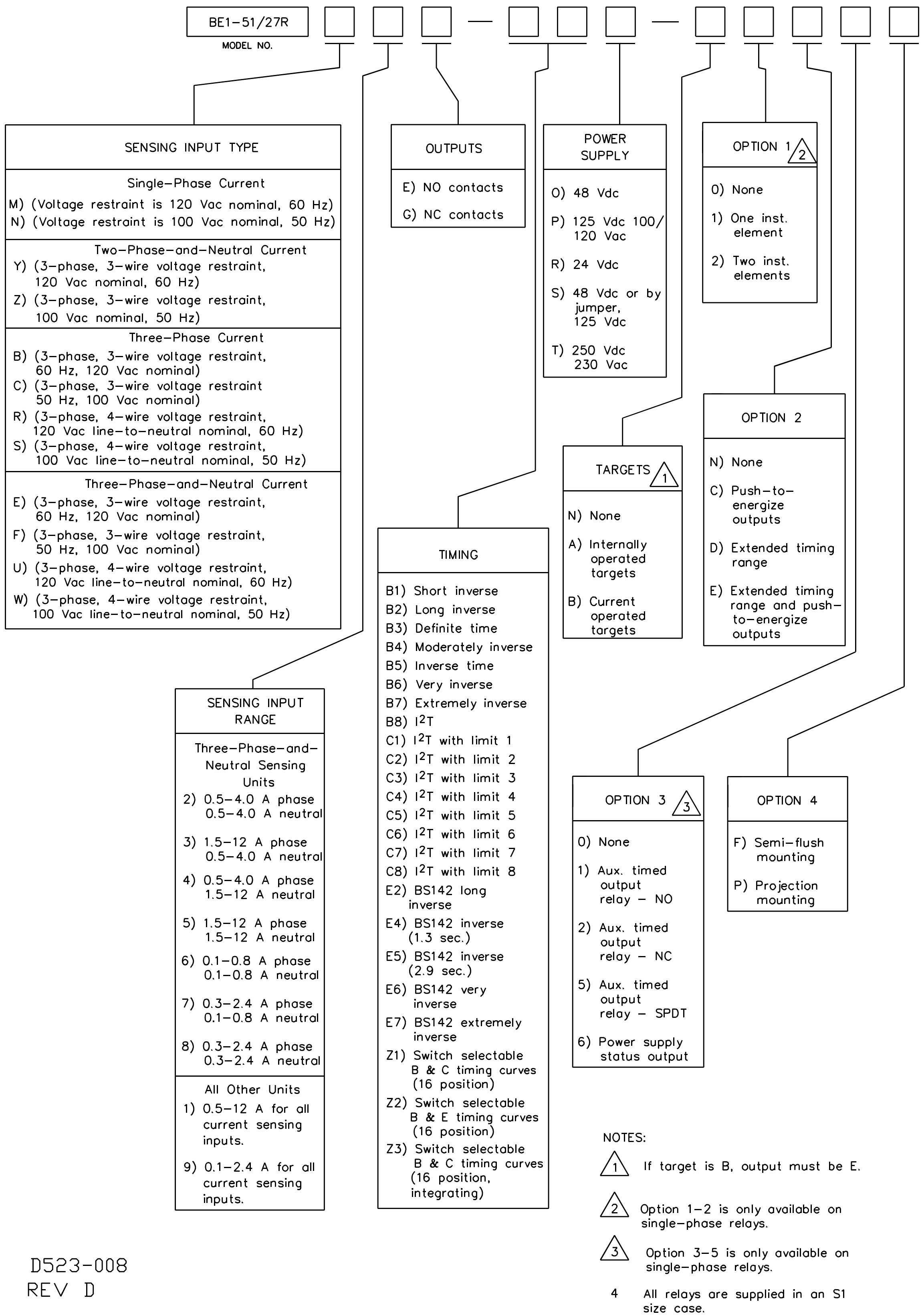


Figure 1-1. Style Number Identification Chart

Time Overcurrent Pickup Accuracy

At voltages ≥ nominal: ±5% of front panel tap selector setting with TAP CAL control fully CW or ±7% of minimum tap whichever is greater.

At voltages < nominal: ±10% of calculated pickup value or ±7% of the minimum tap whichever is greater.

To find the effective multiple of pickup current use the formula:

$$M = \frac{I}{I_t} \times \frac{V_N}{V}$$

Where:

M	=	Multiple of tap value current
I	=	Applied current level
I_T	=	Tap value
V_N	=	Nominal voltage
V	=	Applied voltage level

Time Overcurrent Dropout Ratio: Better than 92% of pickup level.

Instantaneous Overcurrent Pickup Range: Continuously adjustable over the range of 1 to 40 times the time overcurrent pickup setting.

Instantaneous Overcurrent Measuring Accuracy: ±2% of pickup setting.

Instantaneous Overcurrent Dropout Ratio: Better than 98% of pickup level.

Instantaneous Response: Chart 1-1 shows the typical response for the instantaneous pickup element.

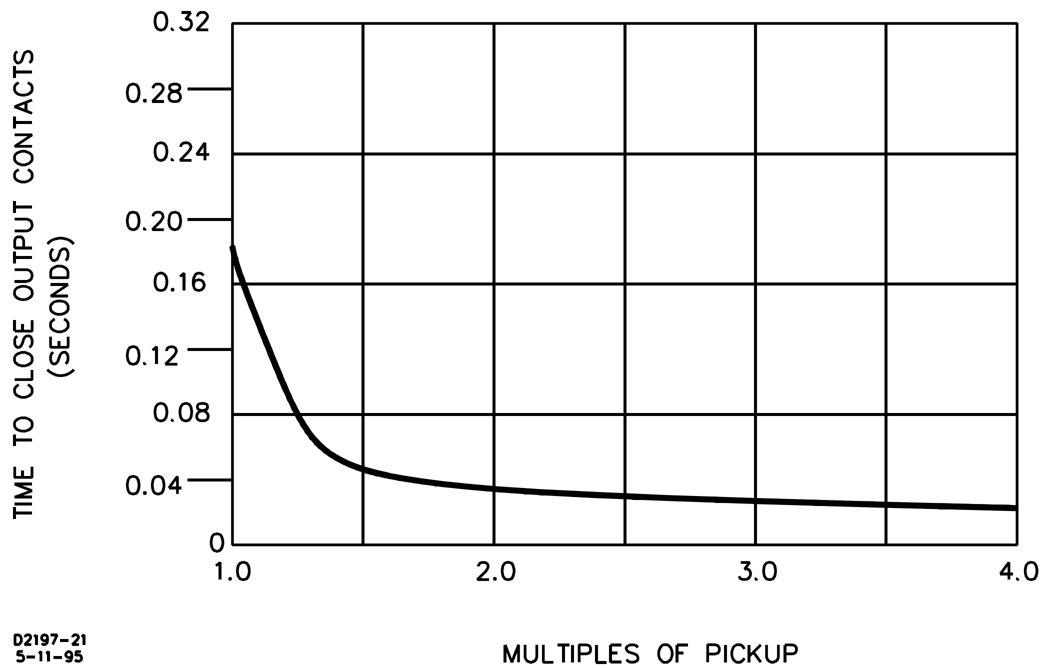


Chart 1-1. Instantaneous Response Time

Time Delay Accuracy: ±5% of the characteristic curve (Figures 1-2 through 1-70) for any combination of the front panel **TIME DIAL** setting and the front panel **TAP/TAP CAL** overcurrent pickup setting.

Power Supply

Power for the internal circuitry may be derived from ac or dc external power sources. Power supply voltages, ranges, and burden are provided in Table 1-3.

Table 1-3. Power Supply Types And Specifications

Type	Nominal Input Voltage	Input Voltage Range	Burden at Nominal
O (Mid Range)	48 Vdc	24 to 150 Vdc	5.0 W
P (Mid Range)	125 Vdc 120 Vac	24 to 150 Vdc 90 to 132 Vac	5.0 W 12.0 VA
R (Low Range)	24 Vdc	12 † to 32 Vdc	5.0 W
S (Mid Range)	48 Vdc 125 Vdc	24 to 150 Vdc 24 to 150 Vdc	5.0 W 5.0 W
T (High Range)	250 Vdc 240 Vac	62 to 280 Vdc 90 to 270 Vac	5.2 W 15.0 VA

NOTES: † Type L power supply initially requires 14 Vdc to begin operating. Once operating, the voltage may be reduced to 12 Vdc and operation will continue.
All references are at 50/60 Hz.

Output Circuits

Output contacts are rated as follows:

Resistive:

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.

Inductive:

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).

Target Indicators

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.

Isolation

Meets IEC 255-5 and exceeds ANSI/IEEE C37.90-1989, one minute dielectric (high potential) tests as follows:

Between each independent circuit and the ground circuit: 2828 Vdc.
Between independent circuit groups: 2000 Vac or 2828 Vdc.

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.

TIME OVERCURRENT CHARACTERISTIC CURVES

Graphs on the following pages illustrate sample characteristic curves for all of the time overcurrent functions individually as options, or selected by switch (if the Z1, Z2, or Z3 timing option is specified). Z1 option can select any of the timing types designated as B1 through B8, and C1 through C8. Z2 option can select any of the timing types designated as B1 through B8, and the British Standard timing types: E2, E4, E5, E6, and E7. 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. Both types are located on the same page. 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 provided with each characteristic curve chart. Use this number to order the full-size (11" X 17") characteristic curve chart on transparent paper (vellum). Publication 9 1372 00 897 contains 36 full size characteristic curve charts (timing options Z1 and Z2). To order any of these characteristic curve charts, contact *Customer Service Department* of the *Power Systems Group, Basler Electric*.

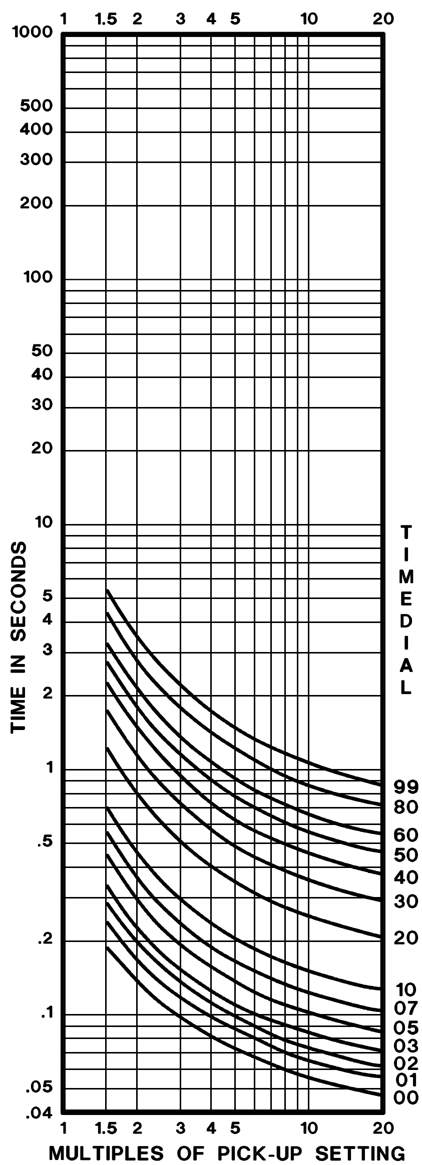


Figure 1-2. Timing Type B1: Short Inverse (Drawing No. 99-0932)

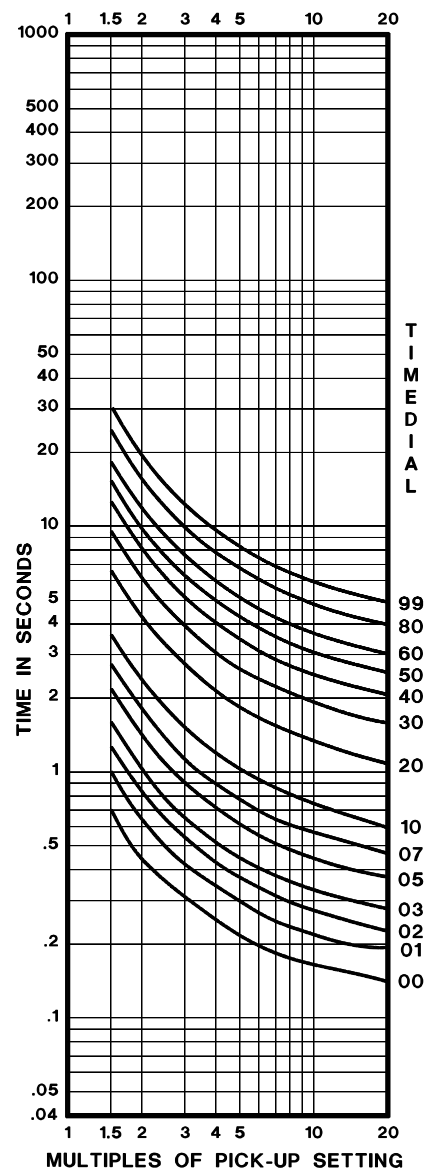


Figure 1-3. Timing Type B1: Short Inverse With Extended Timing Range (Drawing No. 99-0944)

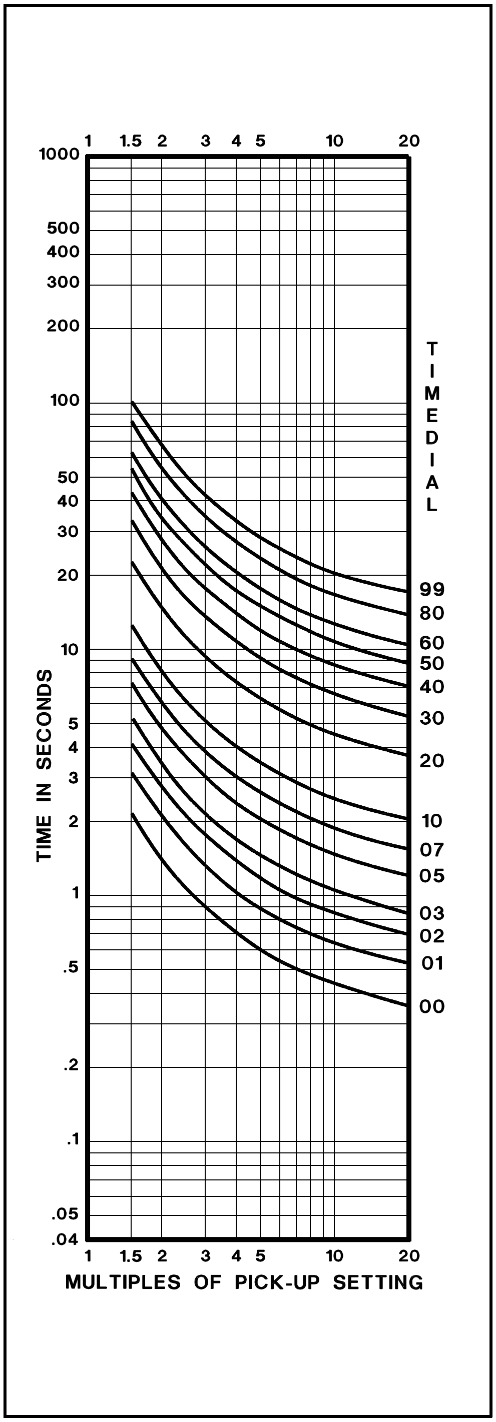


Figure 1-4. Timing Type B2: Long Inverse
(Drawing No. 99-0931)

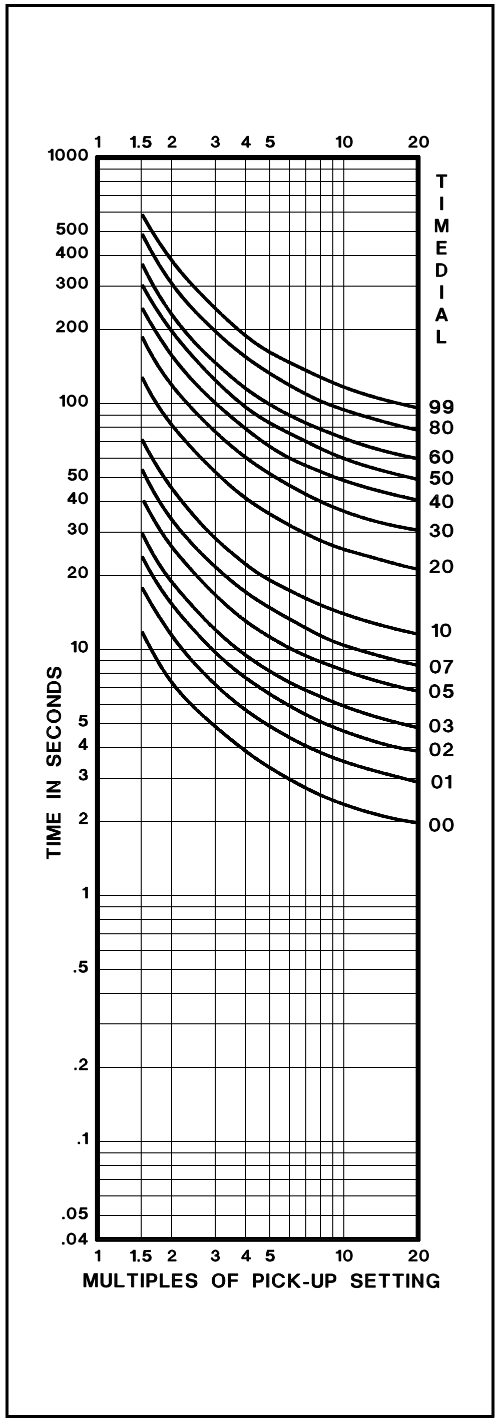


Figure 1-5. Timing Type B2: Long Inverse
With Extended Timing Range.
(Drawing No. 99-0946)

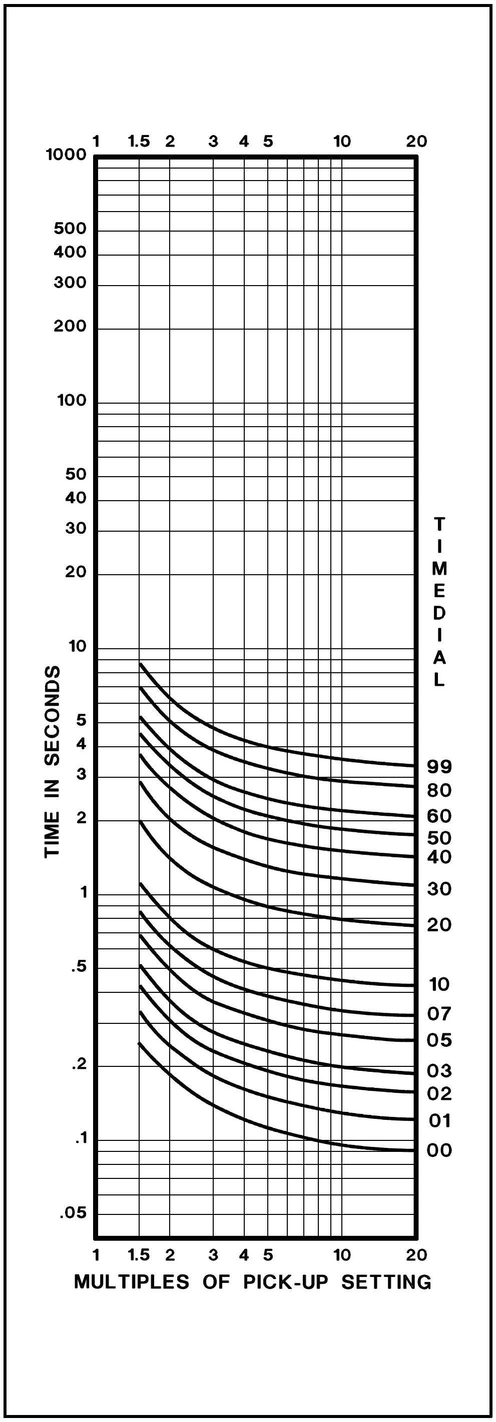


Figure 1-6. Timing Type B3: Definite Time (Drawing No. 99-0933)

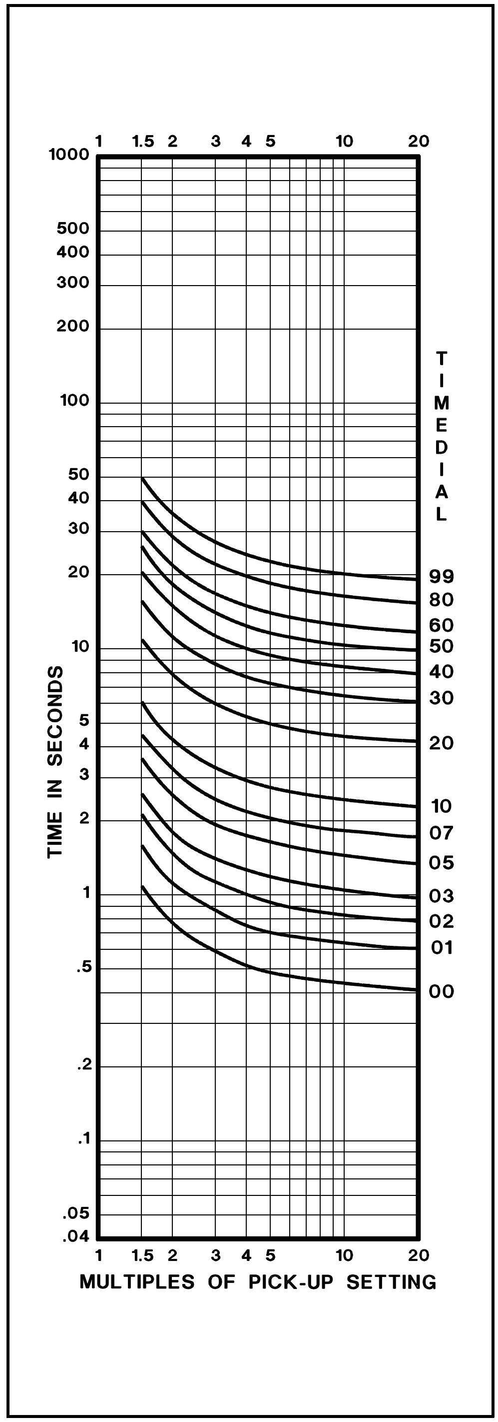


Figure 1-7. Timing Type B3: Definite Time With Extended Timing Range (Drawing No. 99-0942)

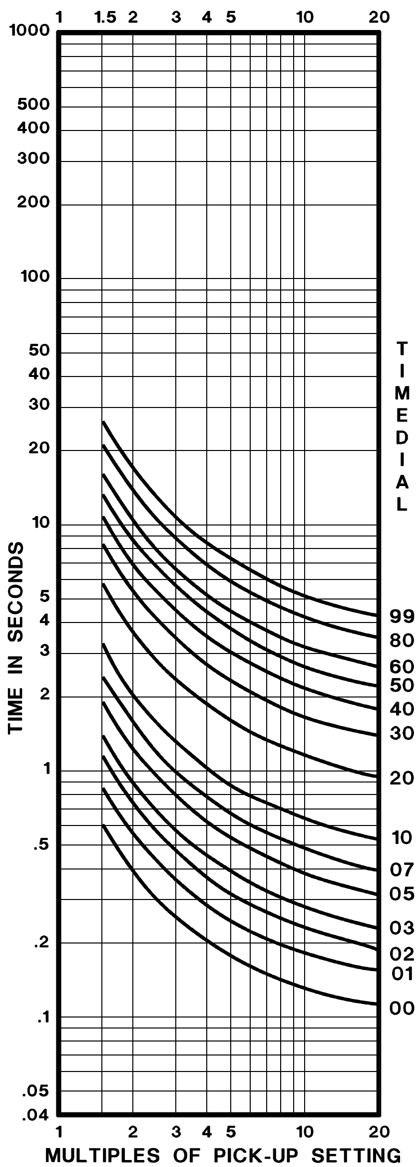


Figure 1-8. Timing Type B4: Moderately Inverse (Drawing No. 99-0930)

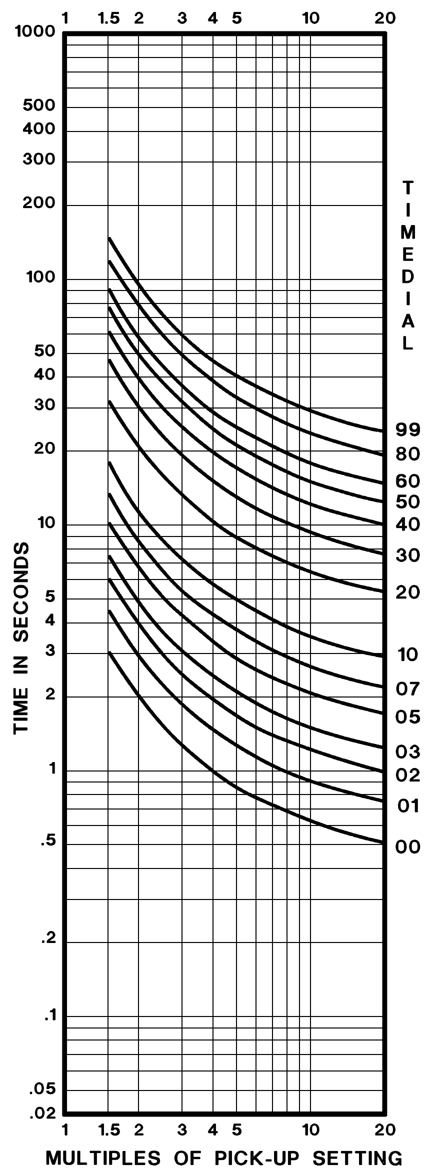


Figure 1-9. Timing Type B4: Moderately Inverse With Extended Timing Range (Drawing No. 99-0945)

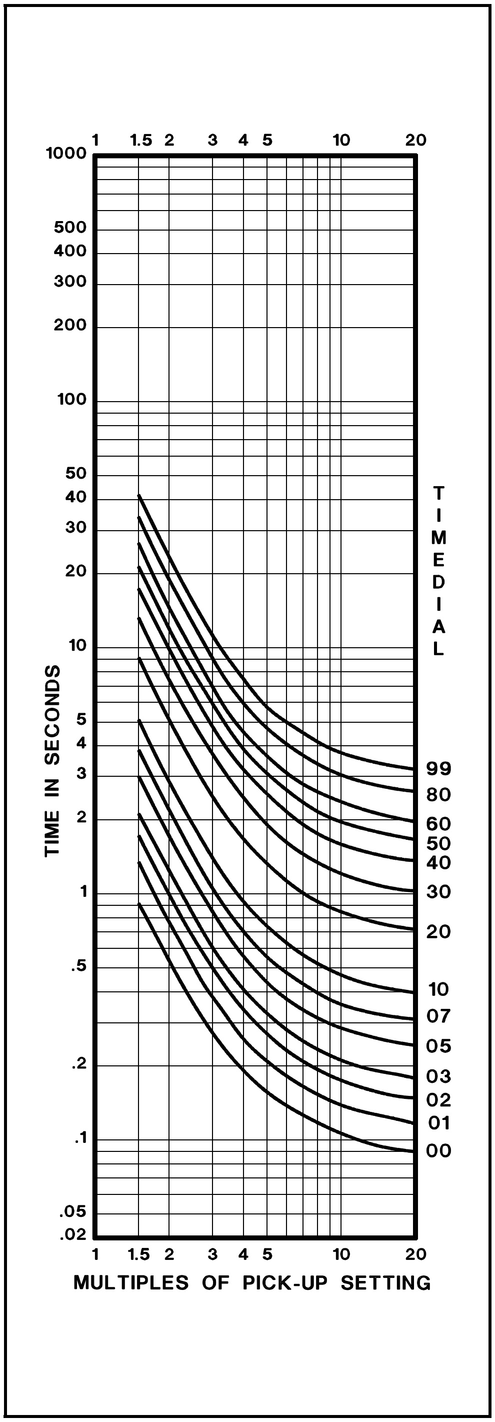


Figure 1-10. Timing Type B5: Inverse (Drawing No. 99-0929)

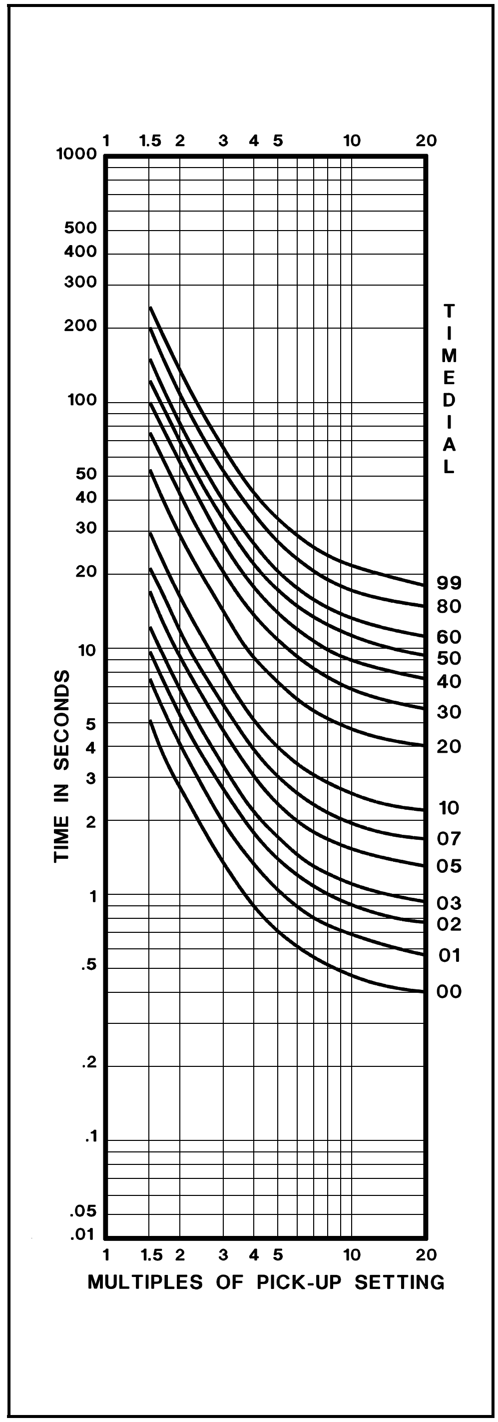


Figure 1-11. Timing Type B5: Inverse With Extended Timing Range (Drawing No. 99-0943)

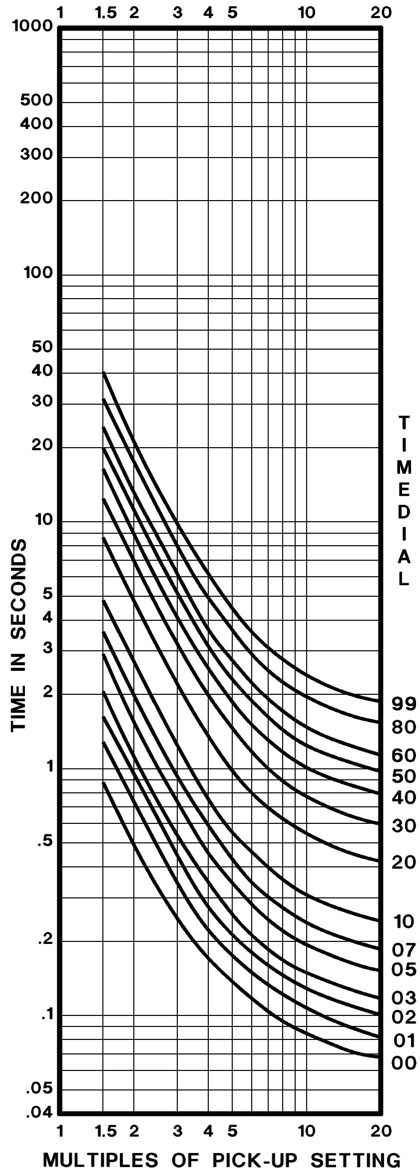


Figure 1-12. Timing Type B6: Very Inverse
(Drawing No. 99-0928)

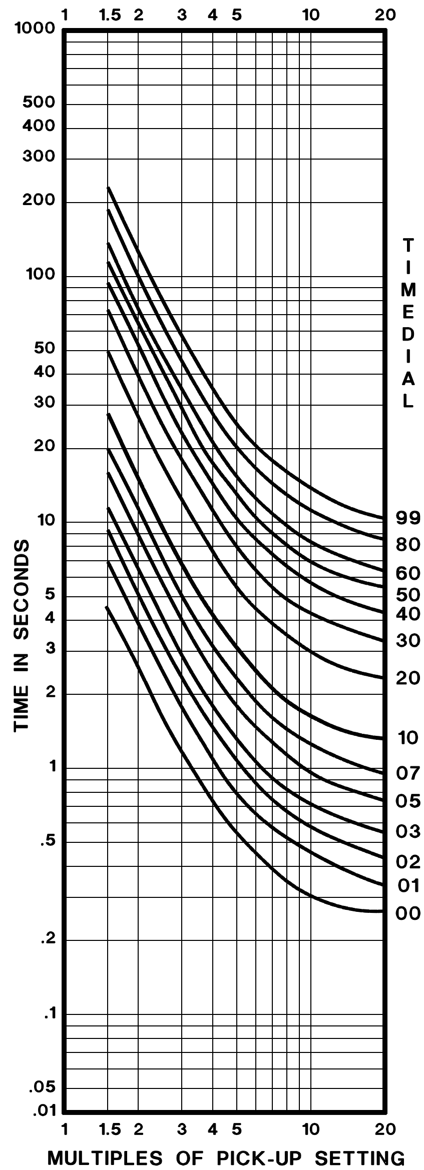


Figure 1-13. Timing Type B6: Very Inverse
With Extended Timing Range
(Drawing No. 99-0941)

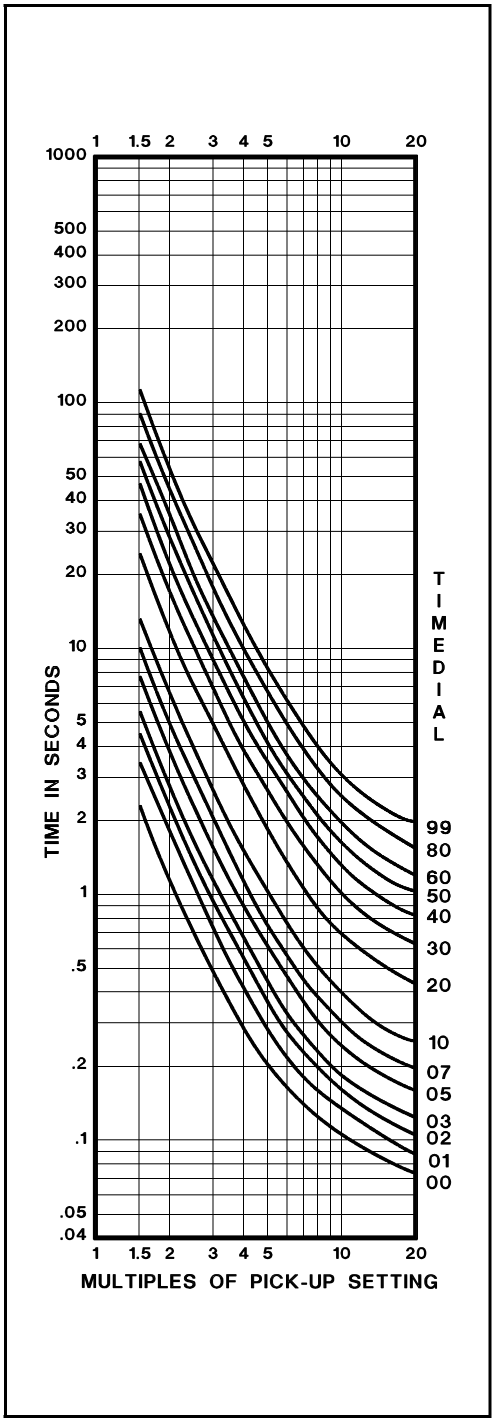


Figure 1-14. Timing Type B7: Extremely Inverse
(Drawing No. 99-0927)

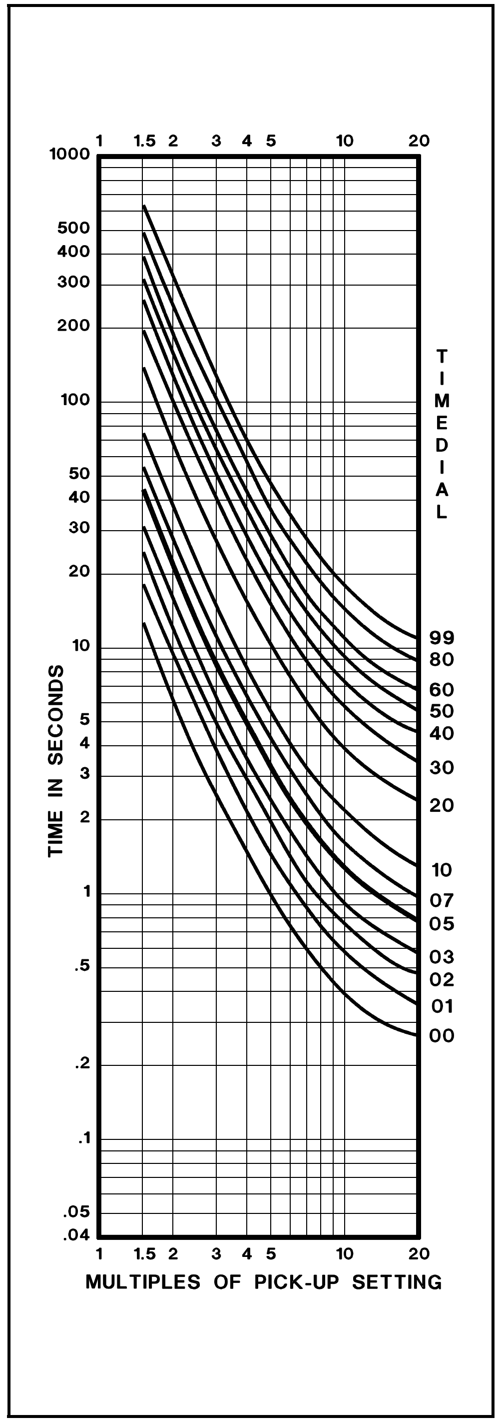


Figure 1-15. Timing Type B7: Extremely Inverse With Extended Timing Range
(Drawing No. 99-0940)

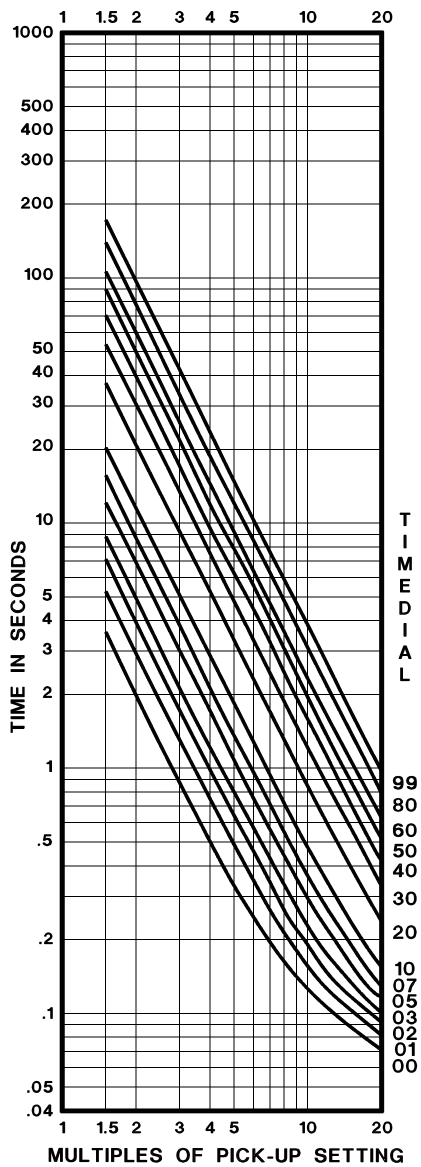


Figure 1-16. Timing Type B8: I^2T
(Drawing No. 99-0926)

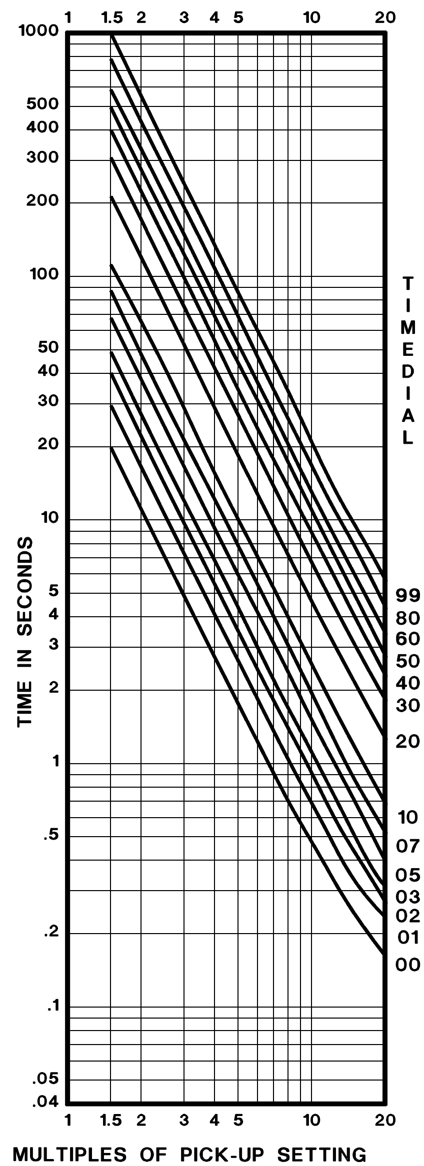


Figure 1-17. Timing Type B8: I^2T
With Extended Timing Range
(Drawing No. 99-0947)

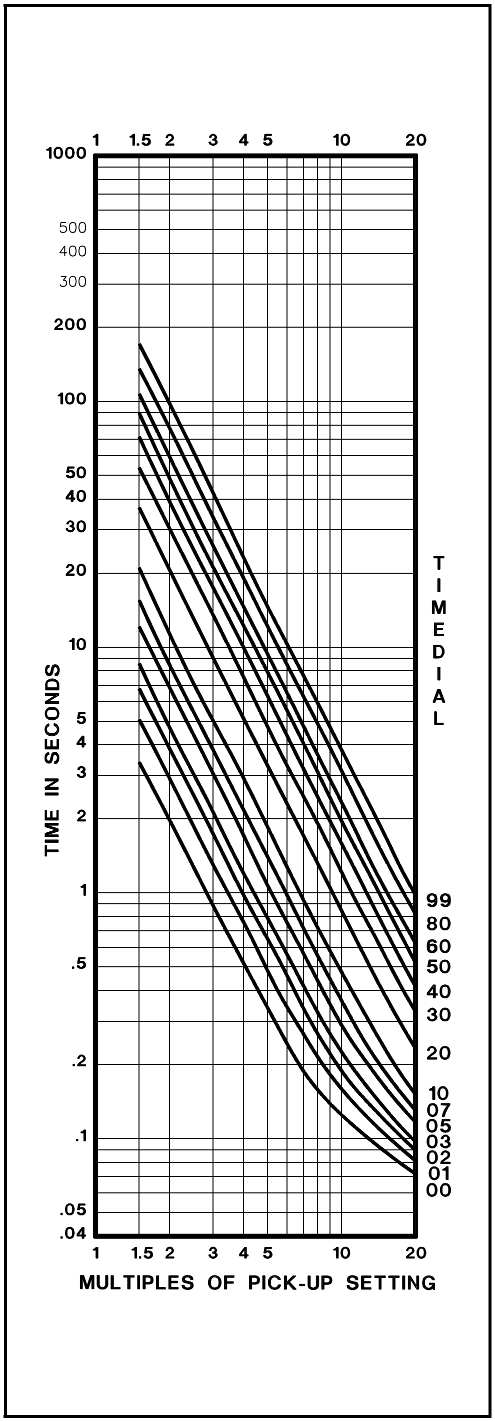


Figure 1-18. Timing Type C1: I^2T With Limit #1 (Drawing No. 99-0956)

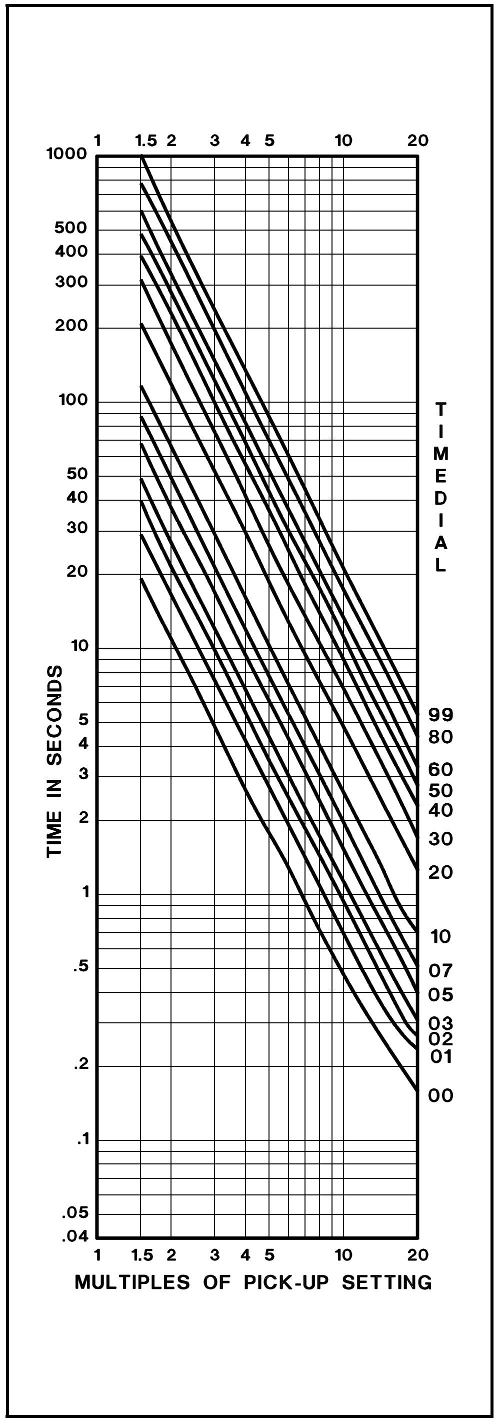


Figure 1-19. Timing Type C1: I^2T With Limit #1 and Extended Timing Range (Drawing No. 99-0948)

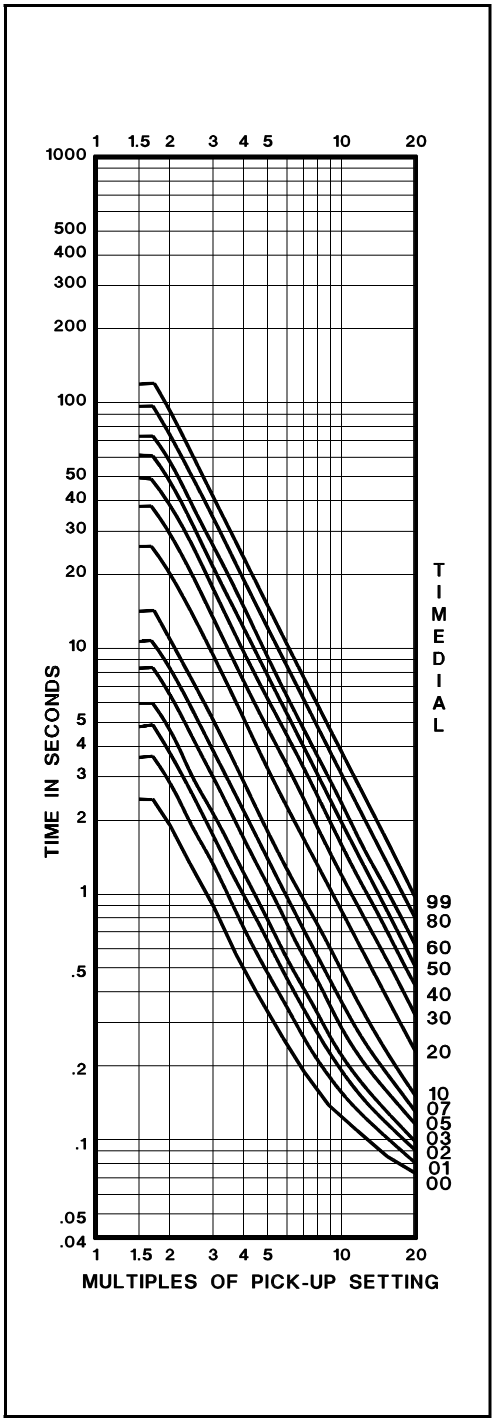


Figure 1-20. Timing Type C2: I^2T With Limit #2 (Drawing No. 99-0957)

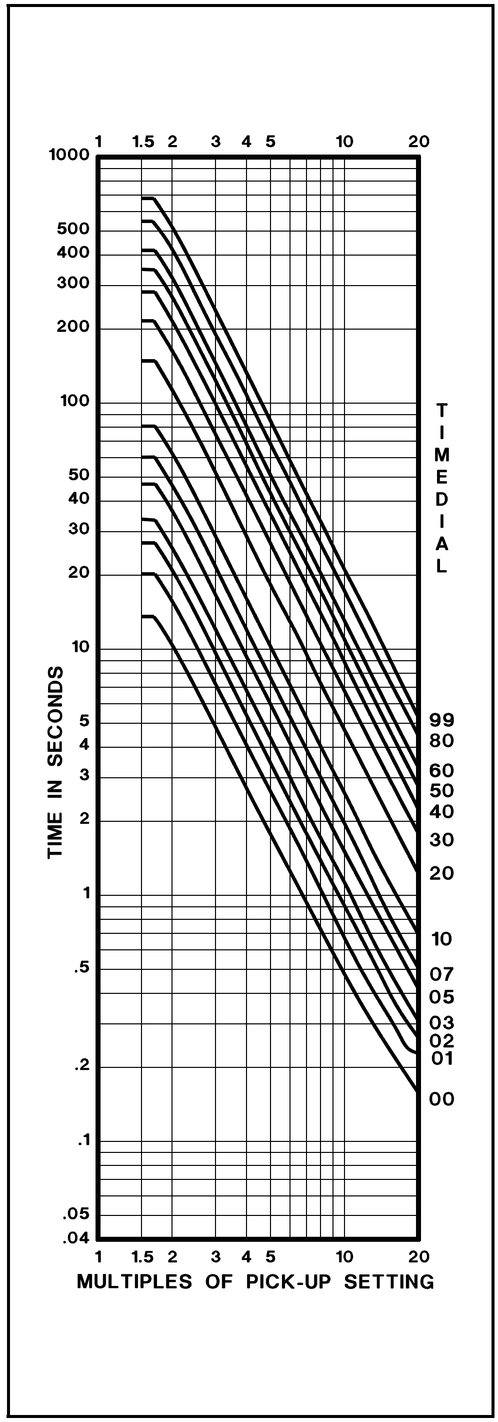


Figure 1-21. Timing Type C2: I^2T With Limit #2 and Extended Timing Range (Drawing No. 99-0949)

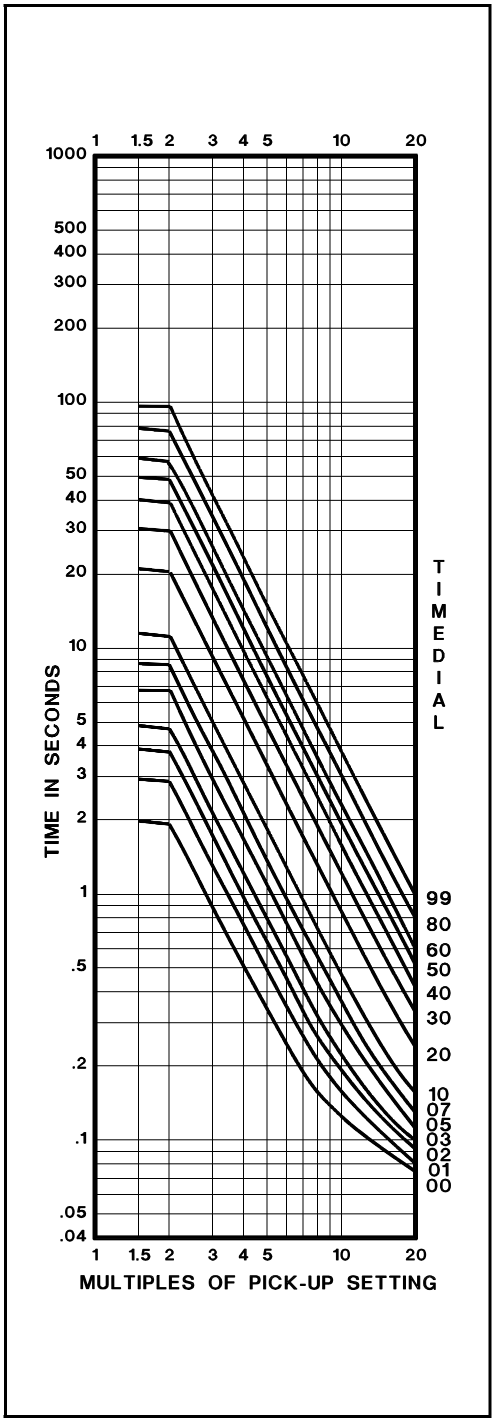


Figure 1-22. Timing Type C3: I^2T With Limit #3 (Drawing No. 99-0958)

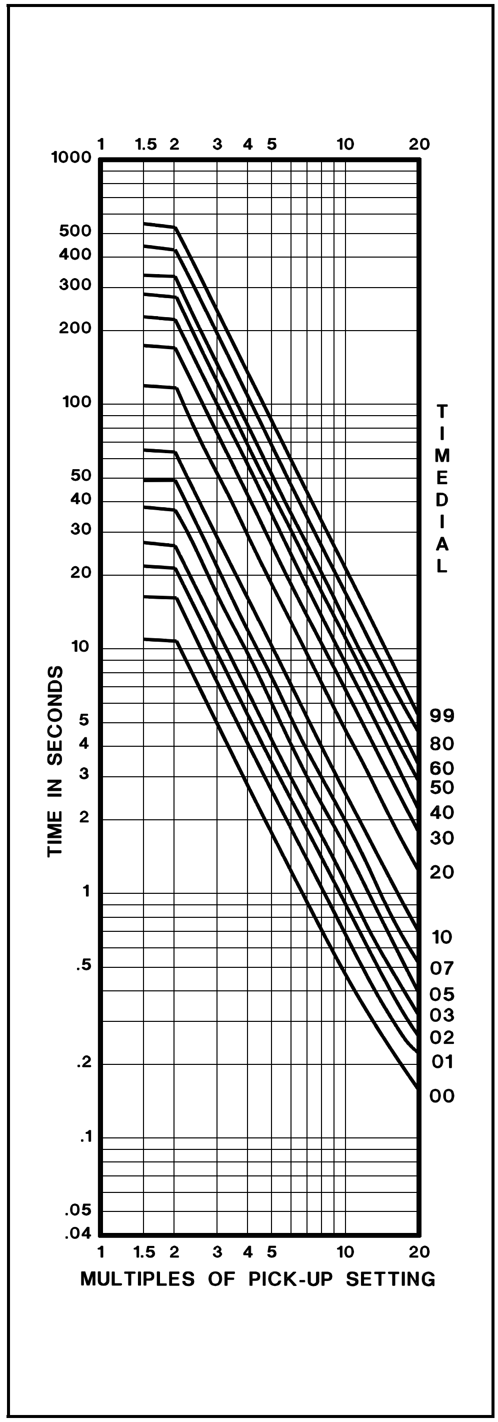


Figure 1-23. Timing Type C3: I^2T With Limit #3 and Extended Timing Range (Drawing No. 99-0950)

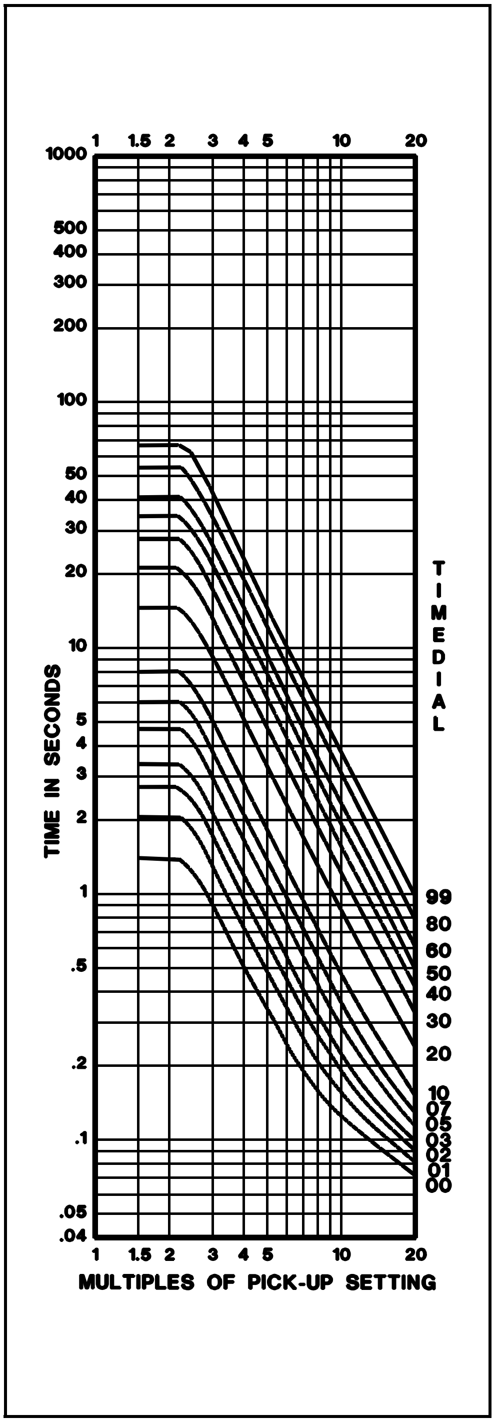


Figure 1-24. Timing Type C4: I^2T With Limit #4 (Drawing No. 99-0959)

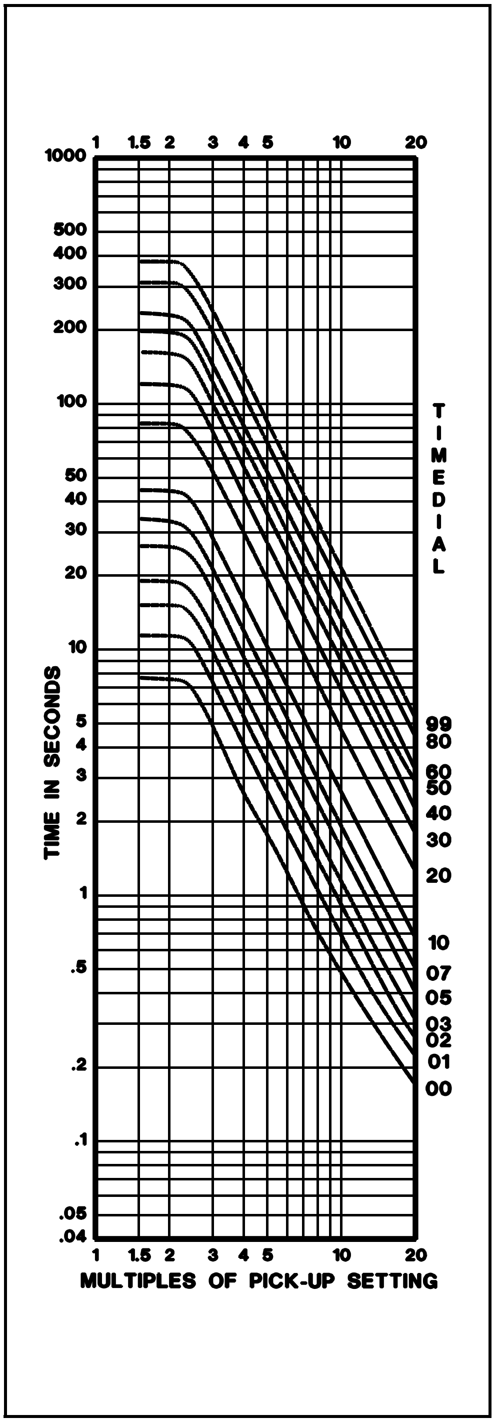


Figure 1-25. Timing Type C4: I^2T With Limit #4 and Extended Timing Range (Drawing No. 99-0951)

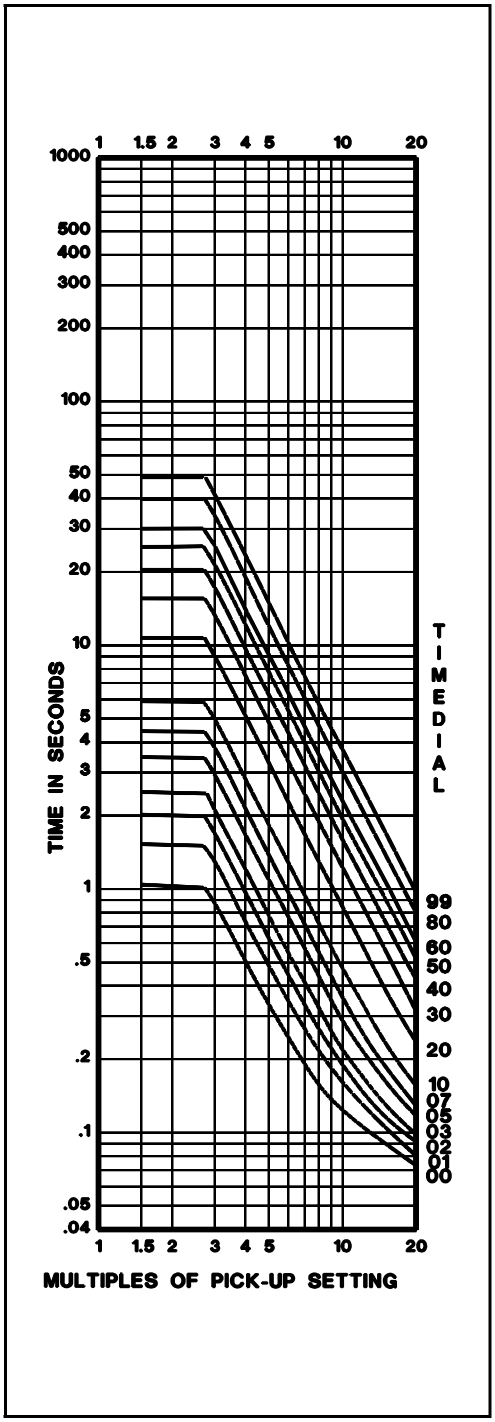


Figure 1-26. Timing Type C5: I^2T With Limit #5 (Drawing No. 99-0960)

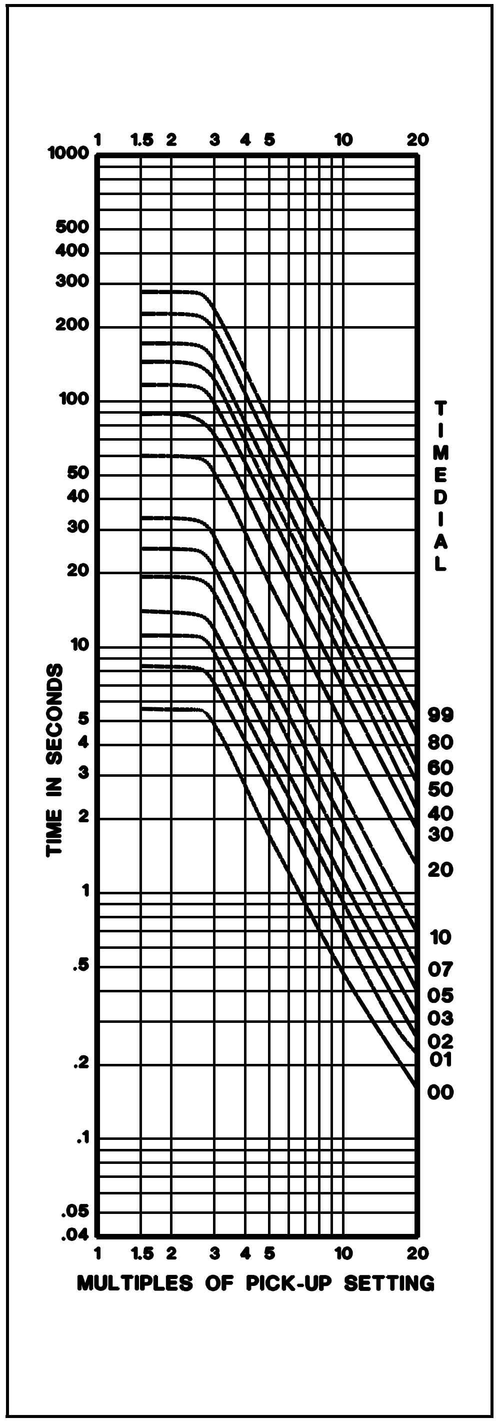


Figure 1-27. Timing Type C5: I^2T With Limit #5 and Extended Timing Range (Drawing No. 99-0952)

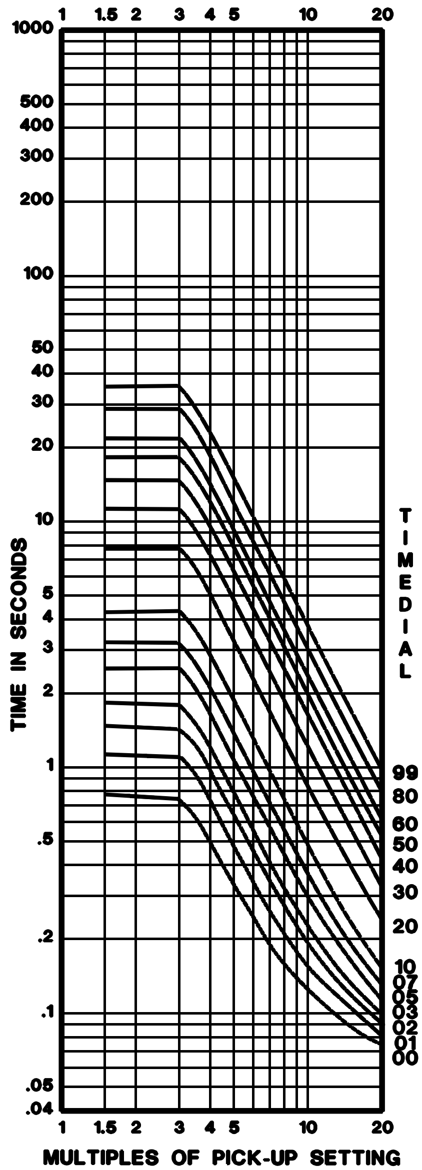


Figure 1-28. Timing Type C6: I^2T With Limit #6 (Drawing No. 99-0961)

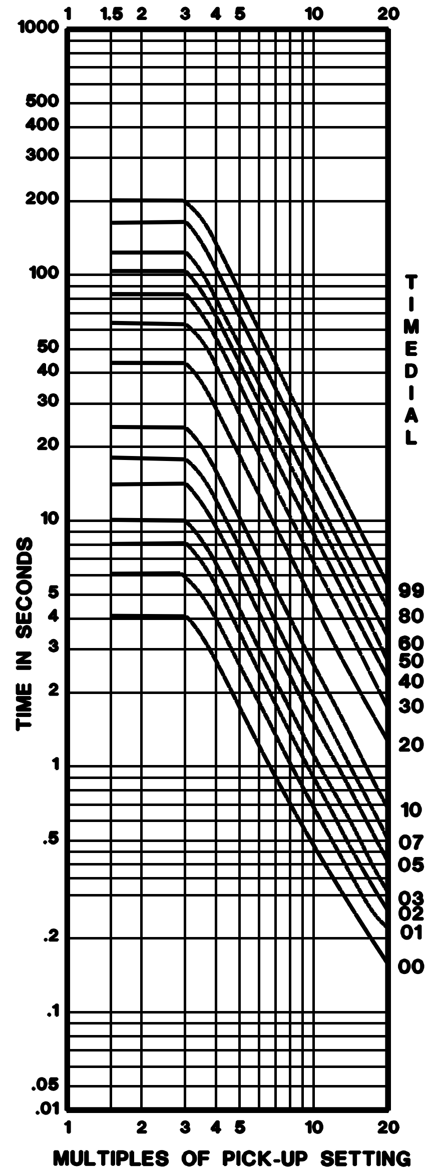


Figure 1-29. Timing Type C6E: I^2T With Limit #6 and Extended Timing Range (Drawing No. 99-0953)

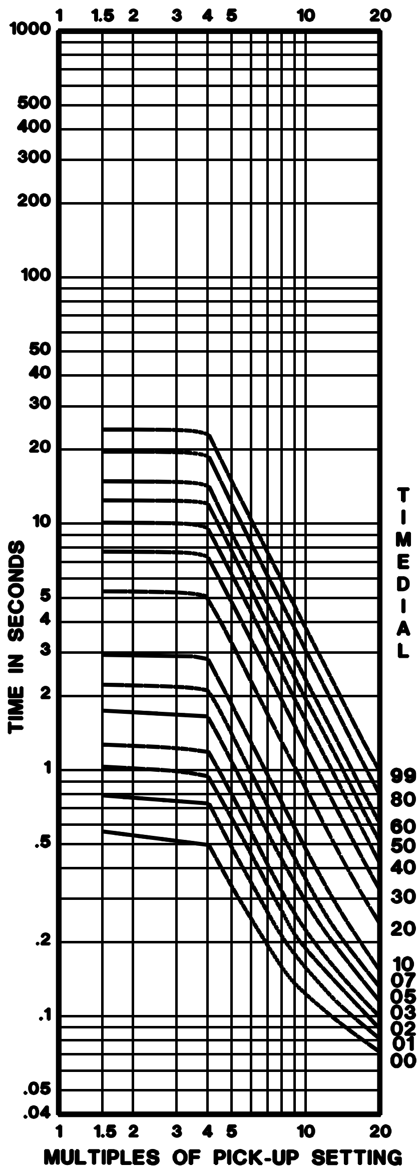


Figure 1-30. Timing Type C7: I^2T With Limit #7 (Drawing No. 99-0962)

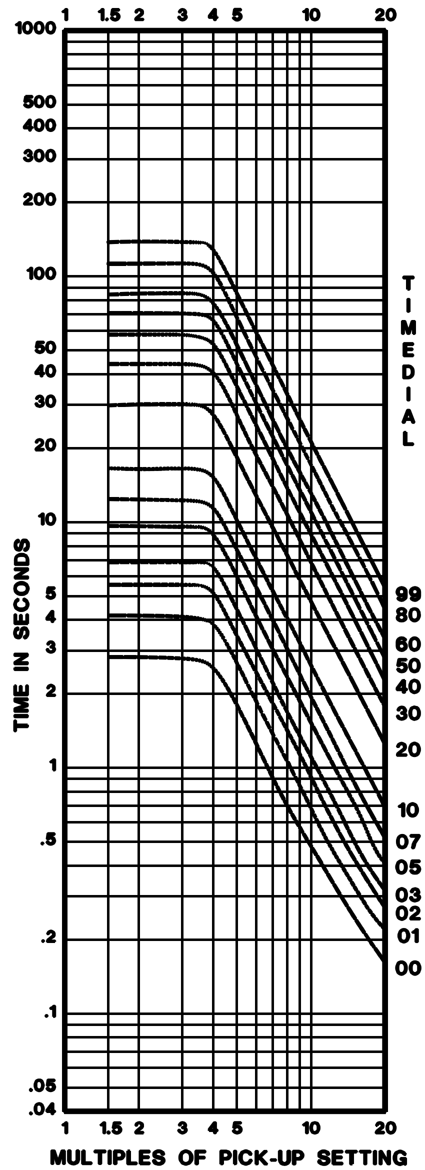


Figure 1-31. Timing Type C7E: I^2T With Limit #7 and Extended Timing Range (Drawing No. 99-0954)

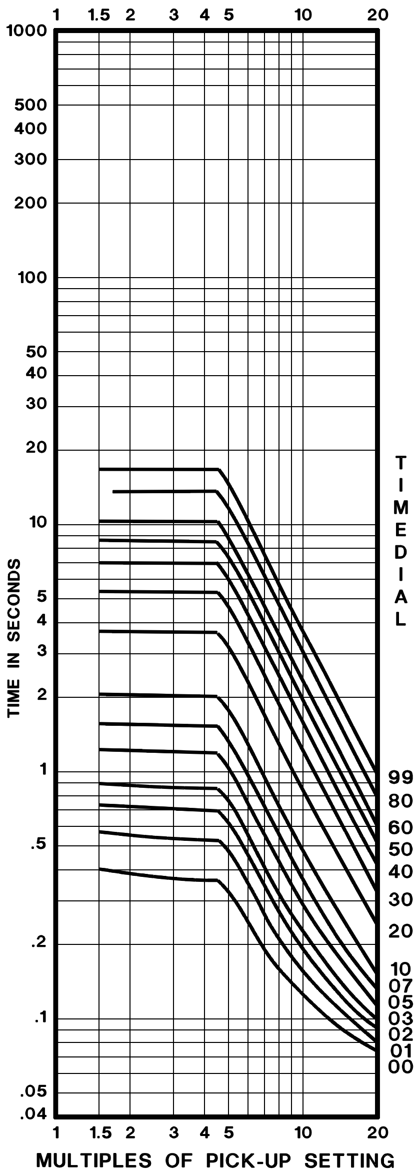


Figure 1-32. Timing Type C8:
I^2T With Limit #8
(Drawing No. 99-0963)

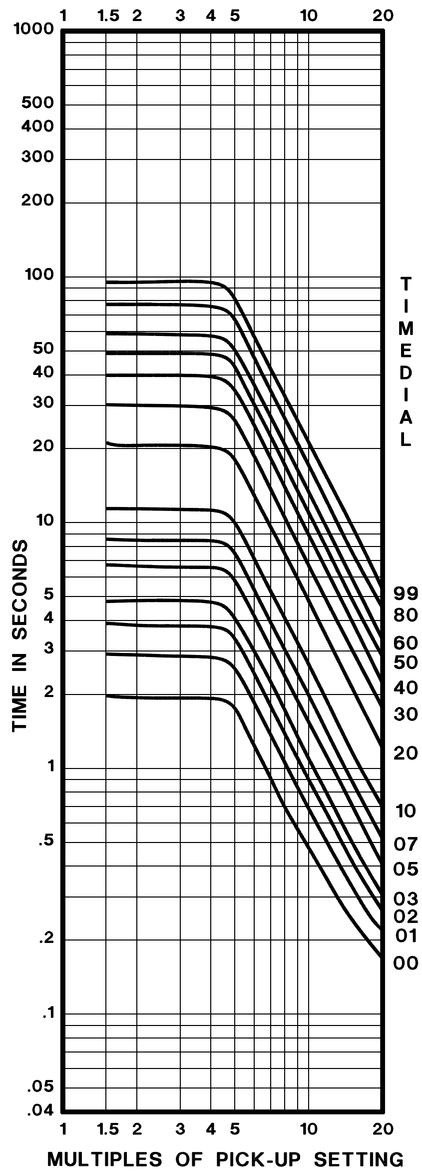


Figure 1-33. Timing Type C8E:
I^2T With Limit #8 and
Extended Timing Range
(Drawing No. 99-0955)

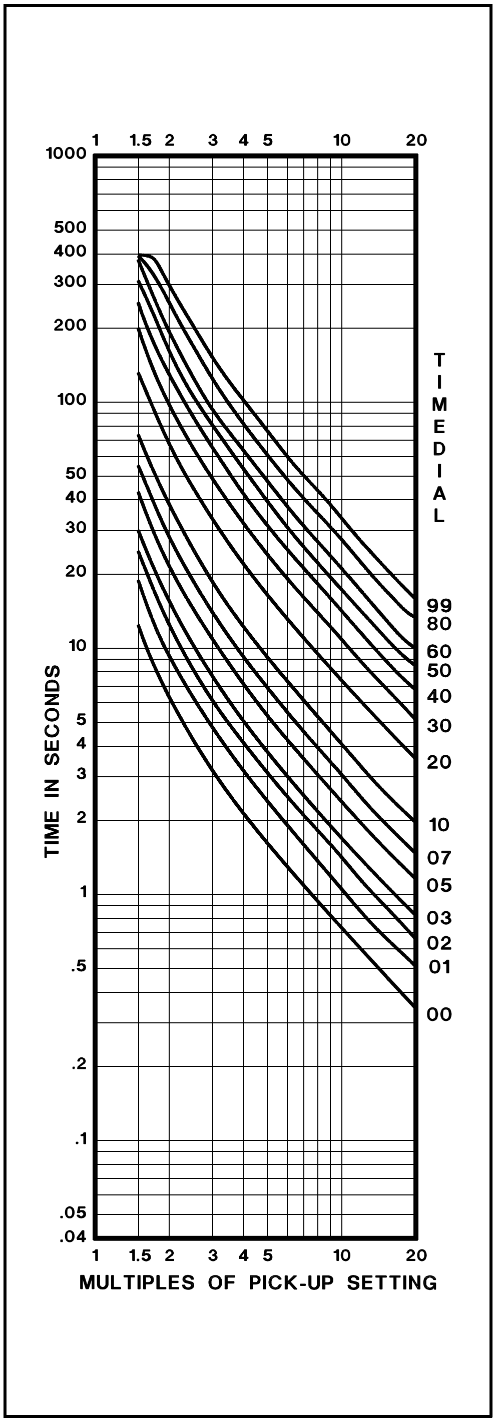


Figure 1-34. Timing Type E2: BS 142 Long Inverse (Drawing No. 99-1093)

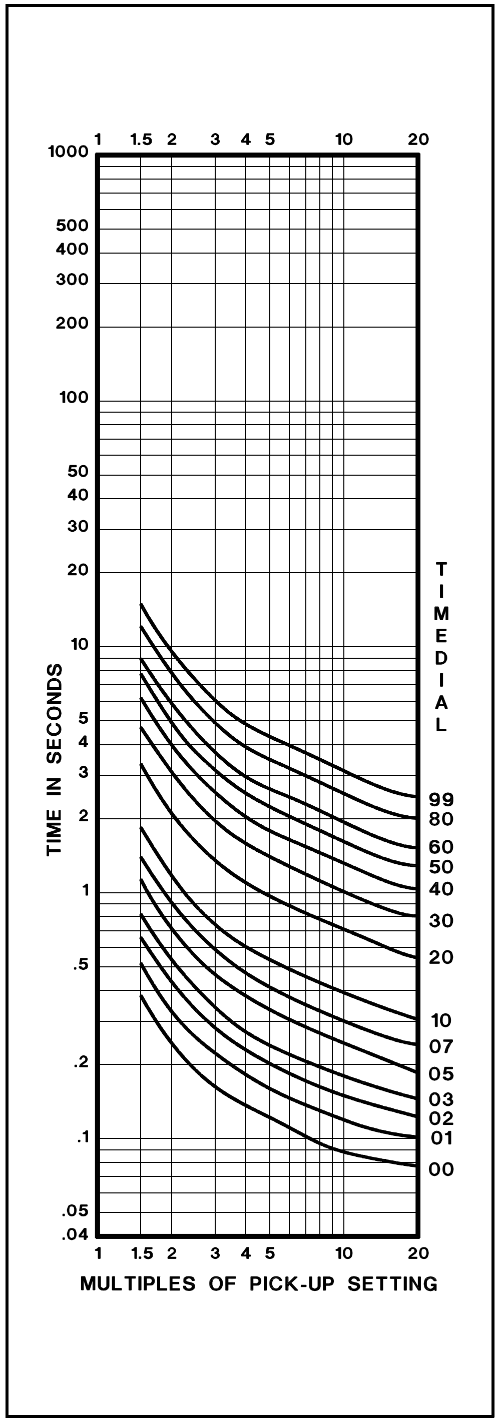


Figure 1-35. Timing Type E4: BS 142 Inverse (1.3 Sec) (Drawing No. 99-1094)

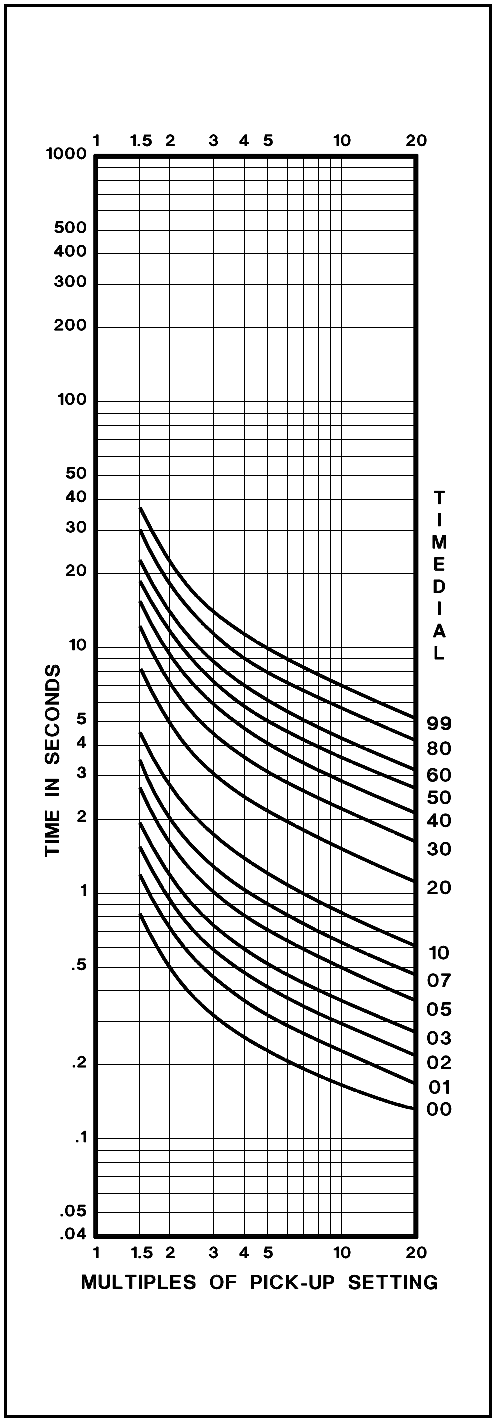


Figure 1-36. Timing Type E5:
BS 142 Inverse (2.9 Sec)
(Drawing No. 99-1095)

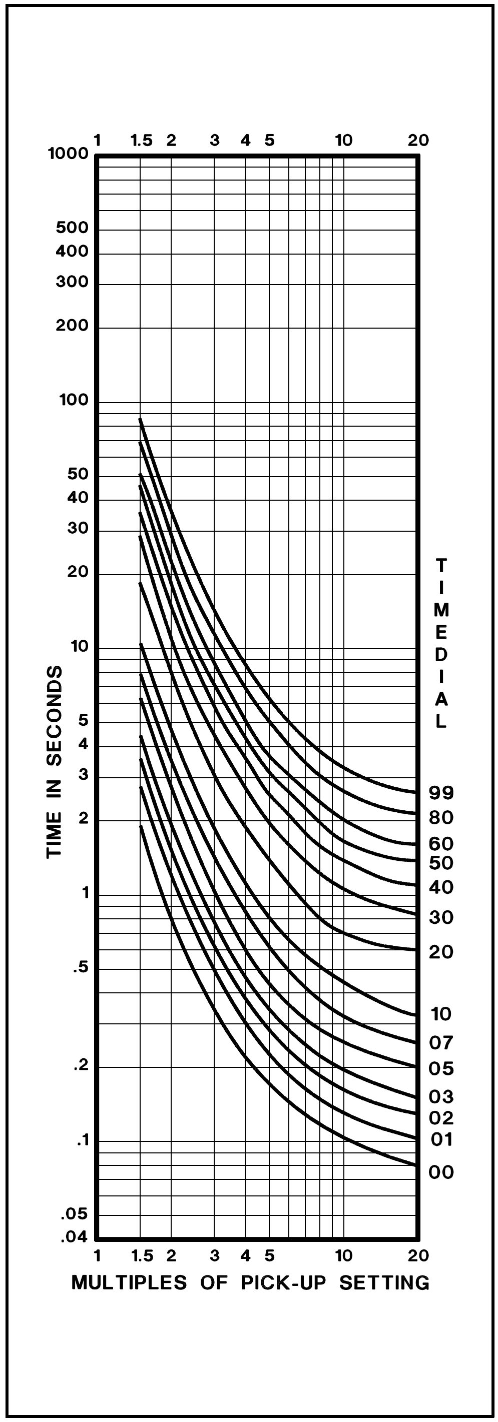


Figure 1-37. Timing Type E6:
BS 142 Very Inverse
(Drawing No. 99-1096)

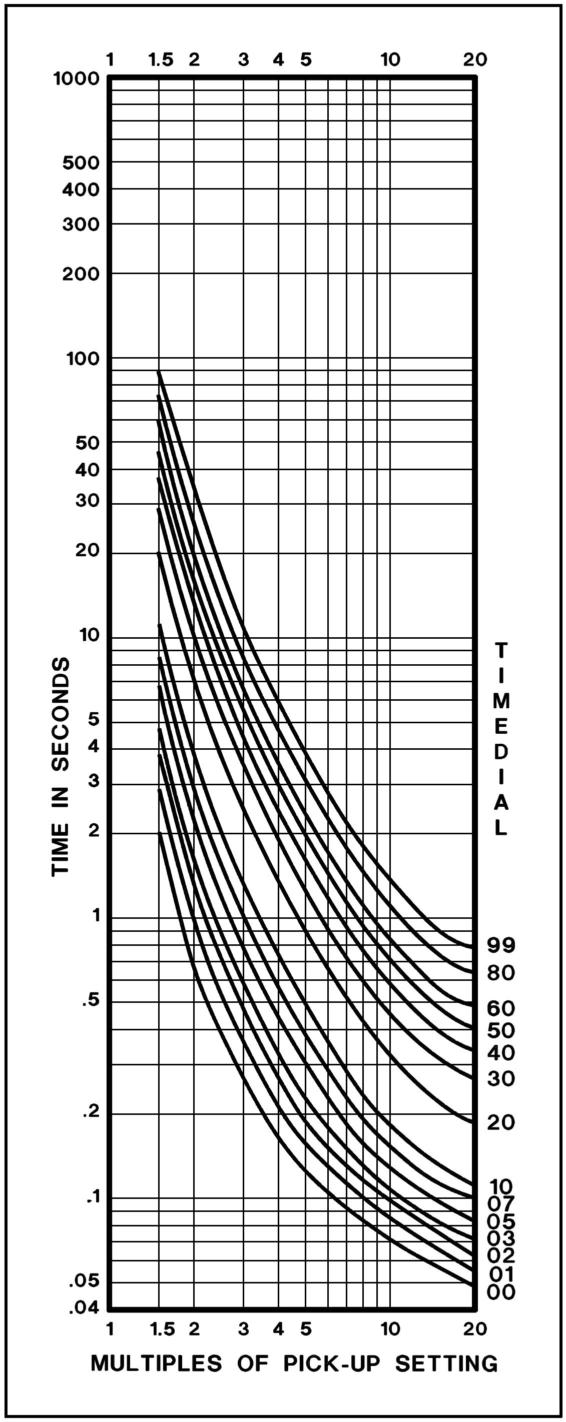


Figure 1-38. Timing Type E7:
BS 142 Extremely Inverse
(Drawing No. 99-1097)

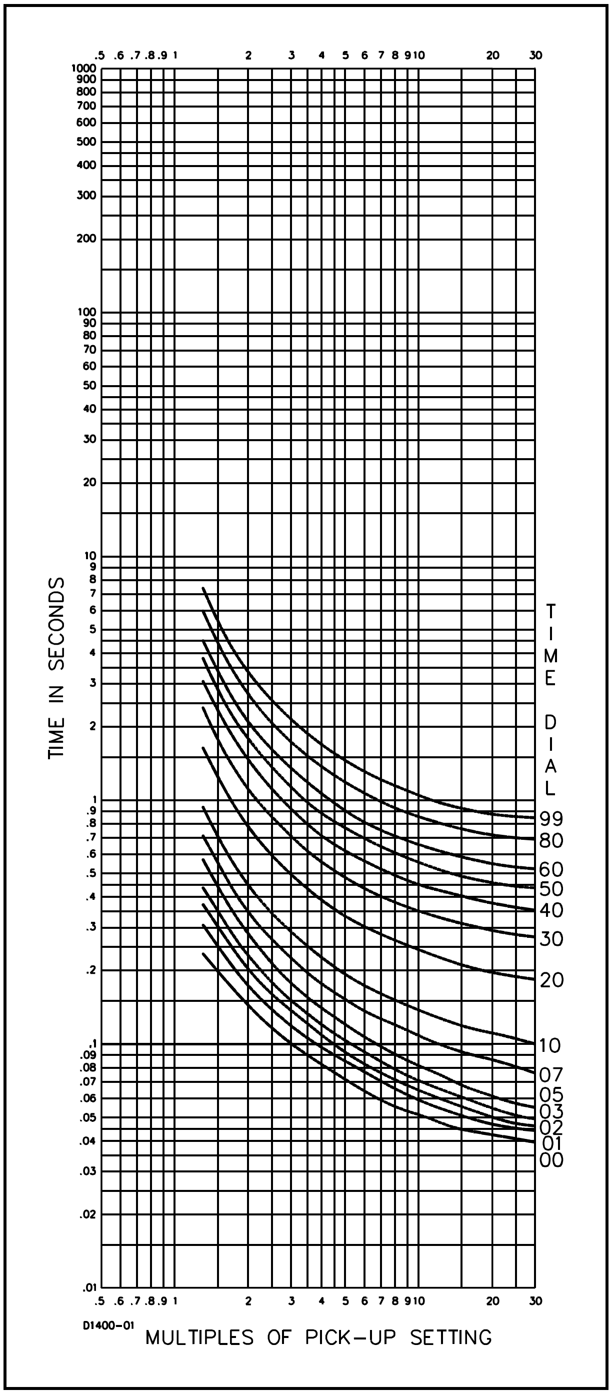


Figure 1-39 . Timing Type B1: Short Inverse
With Integrated Algorithm
(Drawing No. 99-1397)

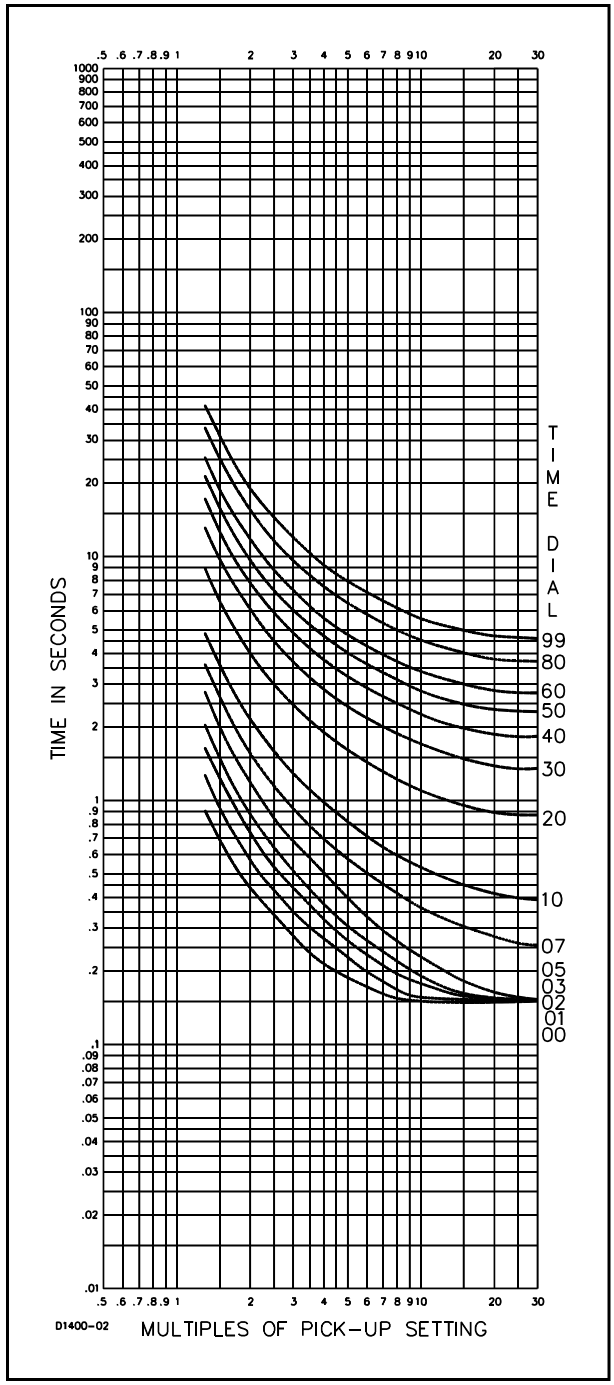


Figure 1-40. Timing Type B1: Short Inverse
With Integrated Algorithm and
Extended Timing
(Drawing No. 99-1398)

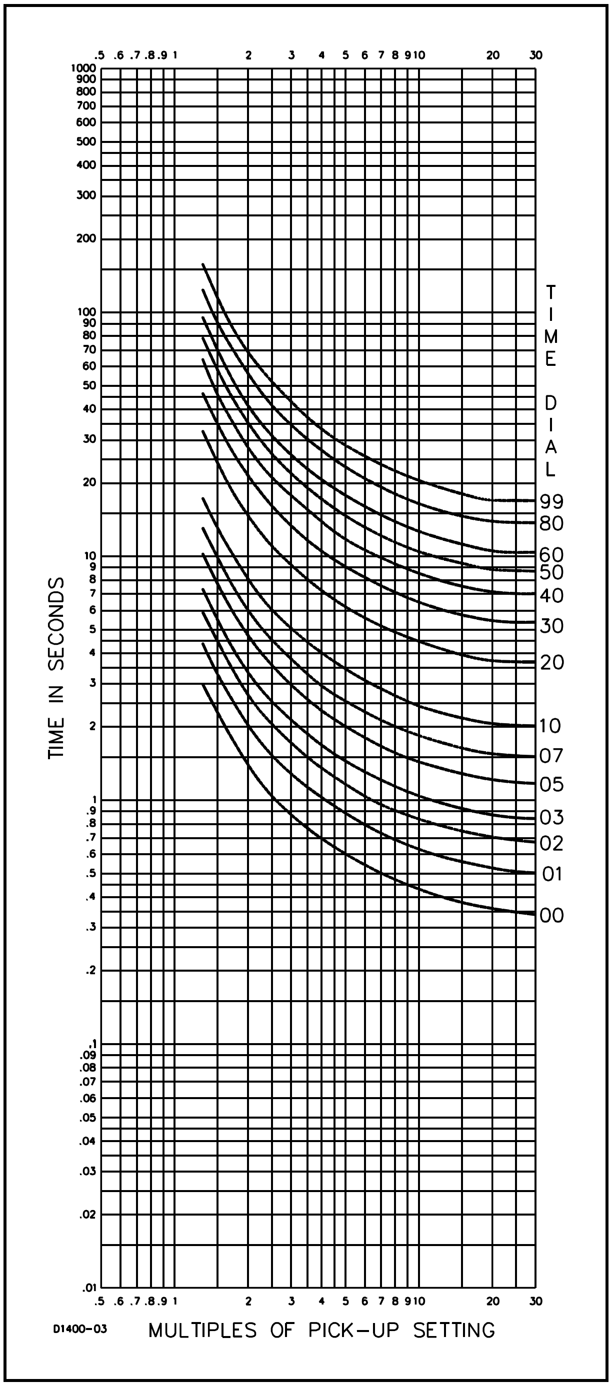


Figure 1-41. Timing Type B2: Long Inverse With Integrated Algorithm (Drawing No. 99-1399)

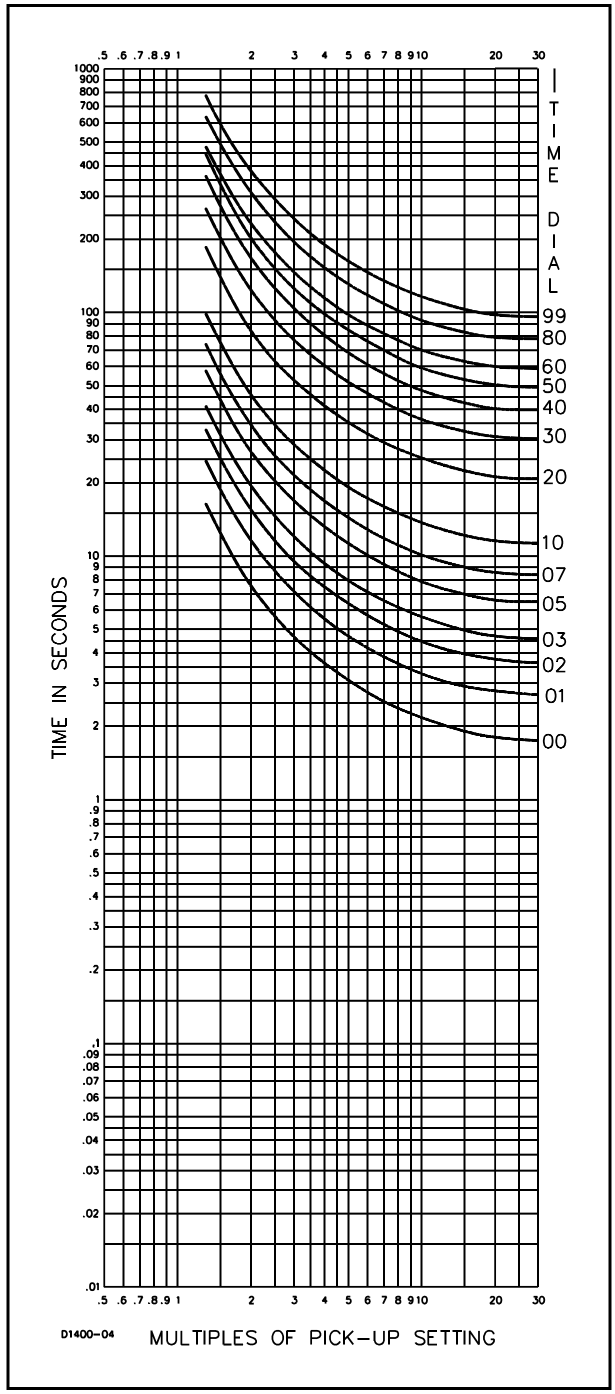
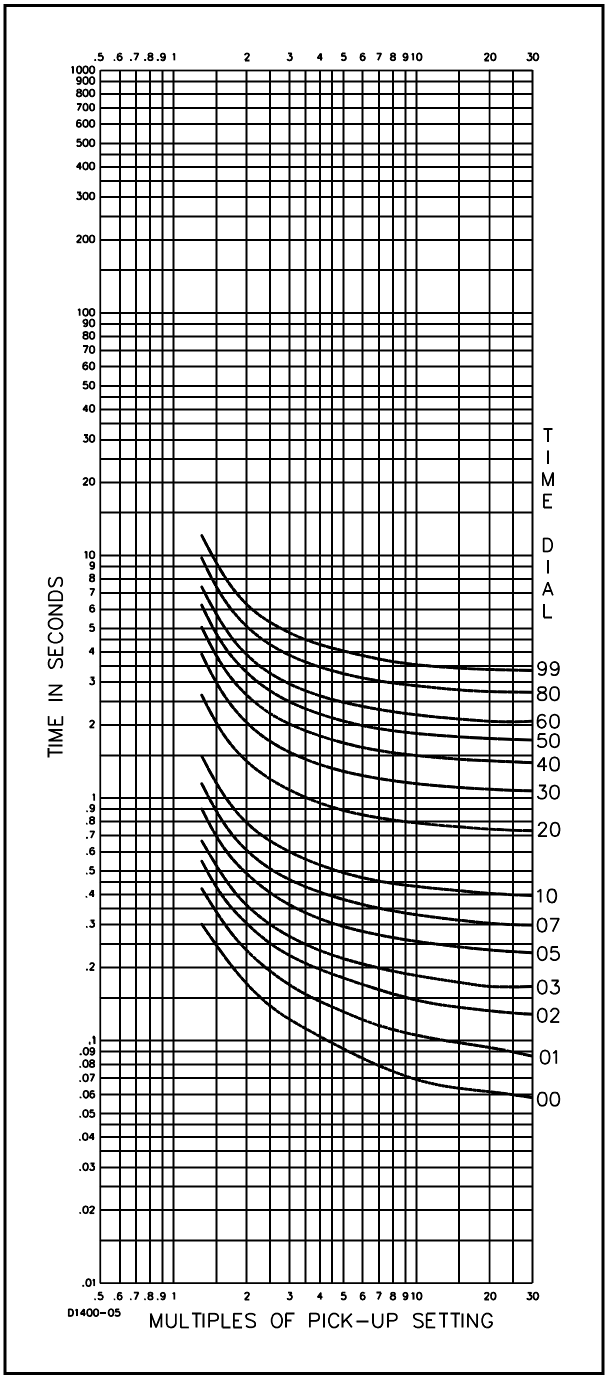


Figure 1-42. Timing Type B2: Long Inverse With Integrated Algorithm and Extended Timing (Drawing No. 99-1400)



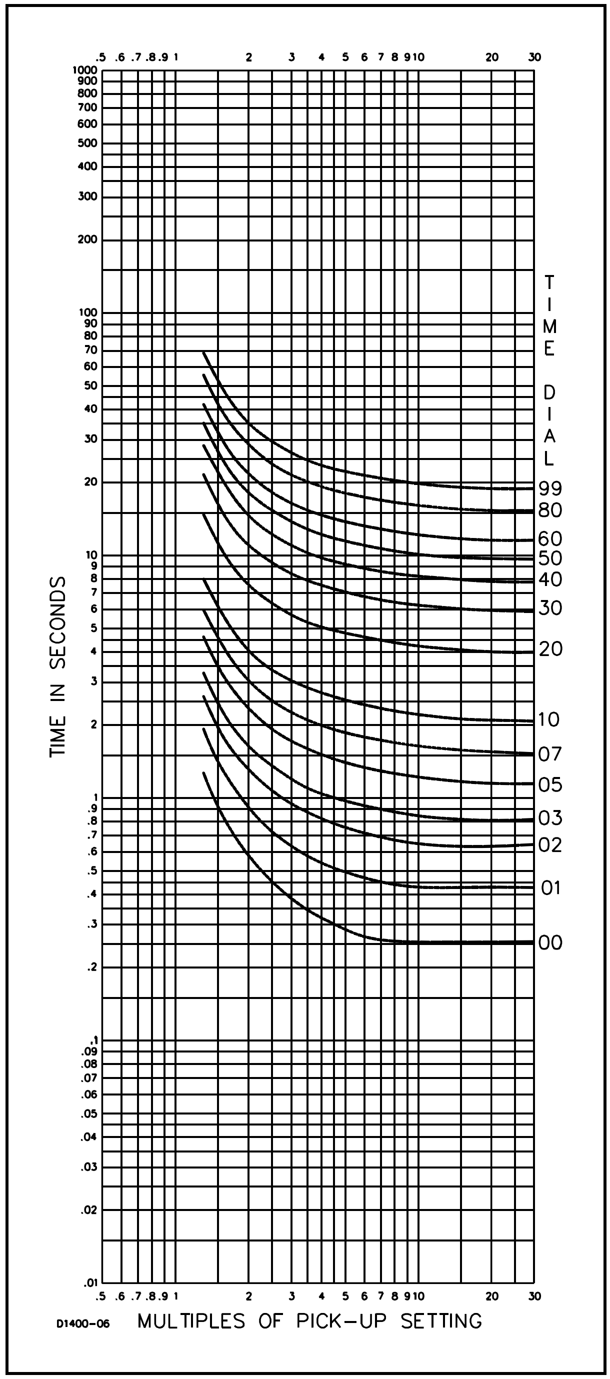


Figure 1-43. Timing Type B3: Definite Time With Integrated Algorithm (Drawing No. 99-1401)

Figure 1-44. Timing Type B3: Definite Time With Integrated Algorithm and Extended Timing (Drawing No. 99-1402)

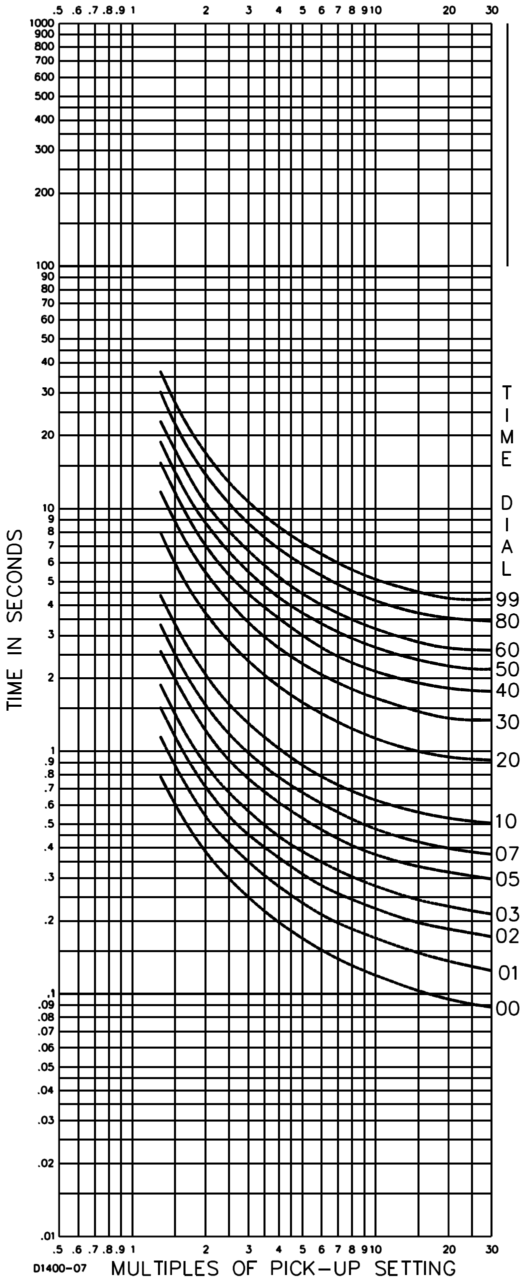


Figure 1-45. Timing Type B4: Moderately Inverse With Integrated Algorithm (Drawing No. 99-1403)

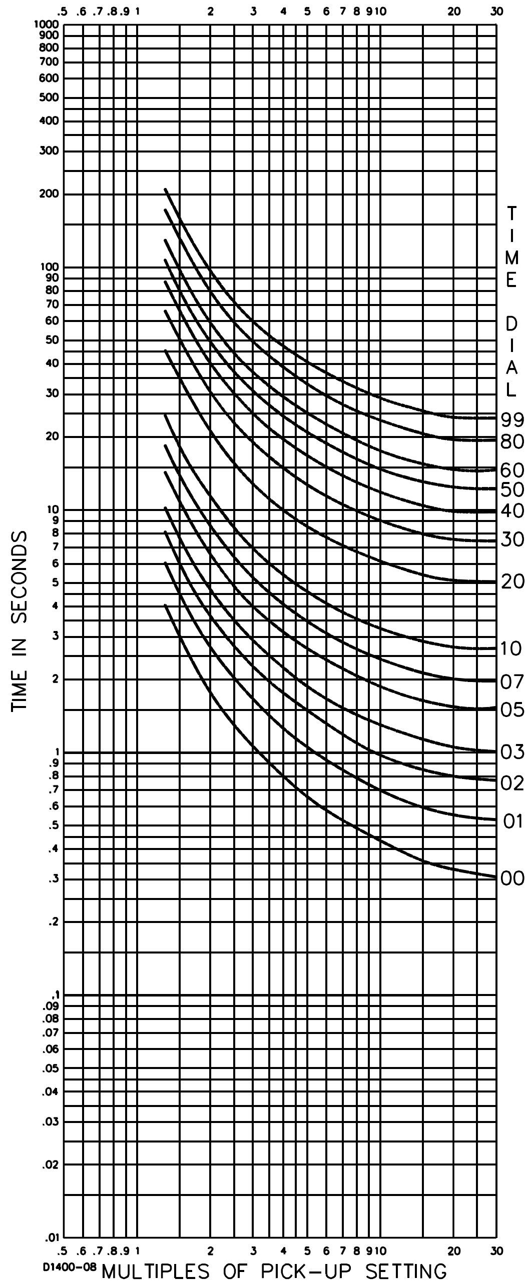


Figure 1-46. Timing Type B4: Moderately Inverse With Integrated Algorithm and Extended Timing (Drawing No. 99-1404)

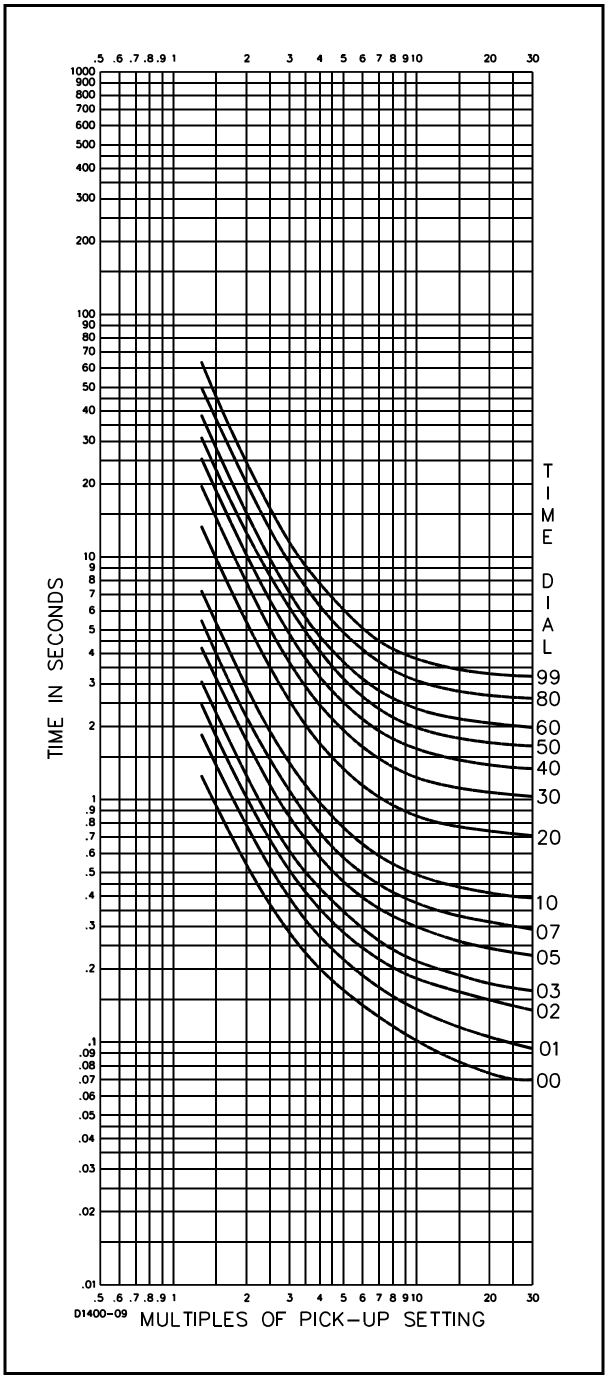


Figure 1-47 . Timing Type B5: Inverse With Integrated Algorithm (Drawing No. 99-1405)

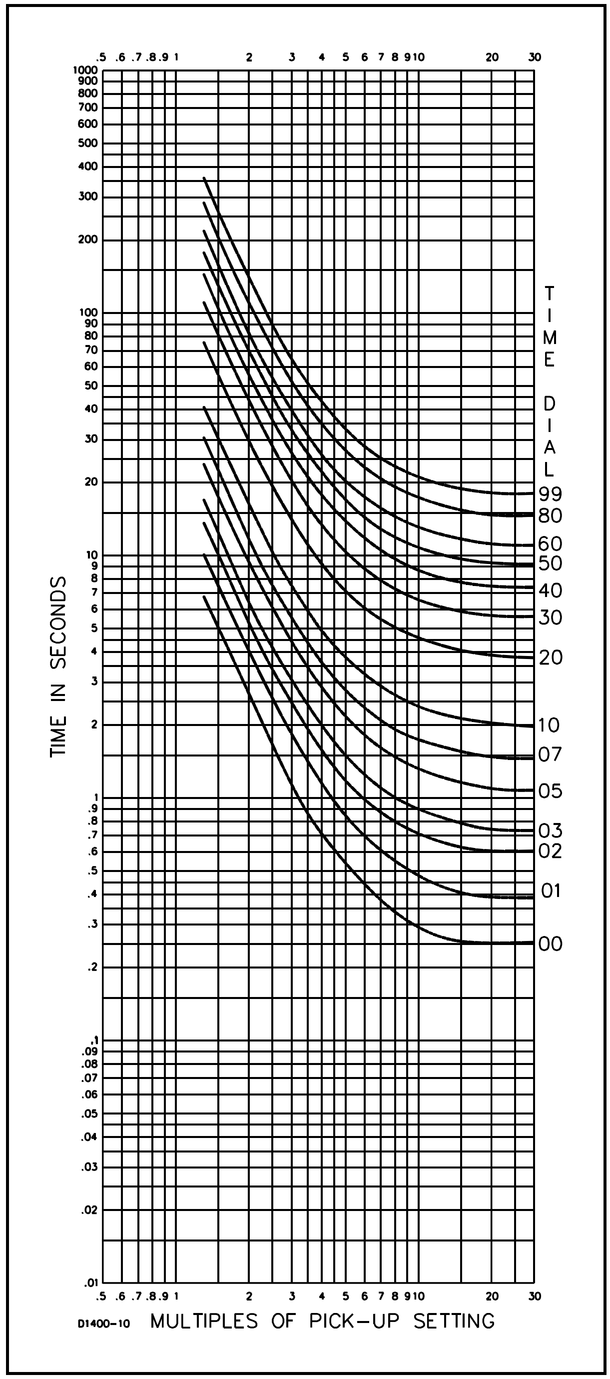


Figure 1-48. Timing Type B5: Inverse With Integrated Algorithm and Extended Timing (Drawing No. 99-1406)

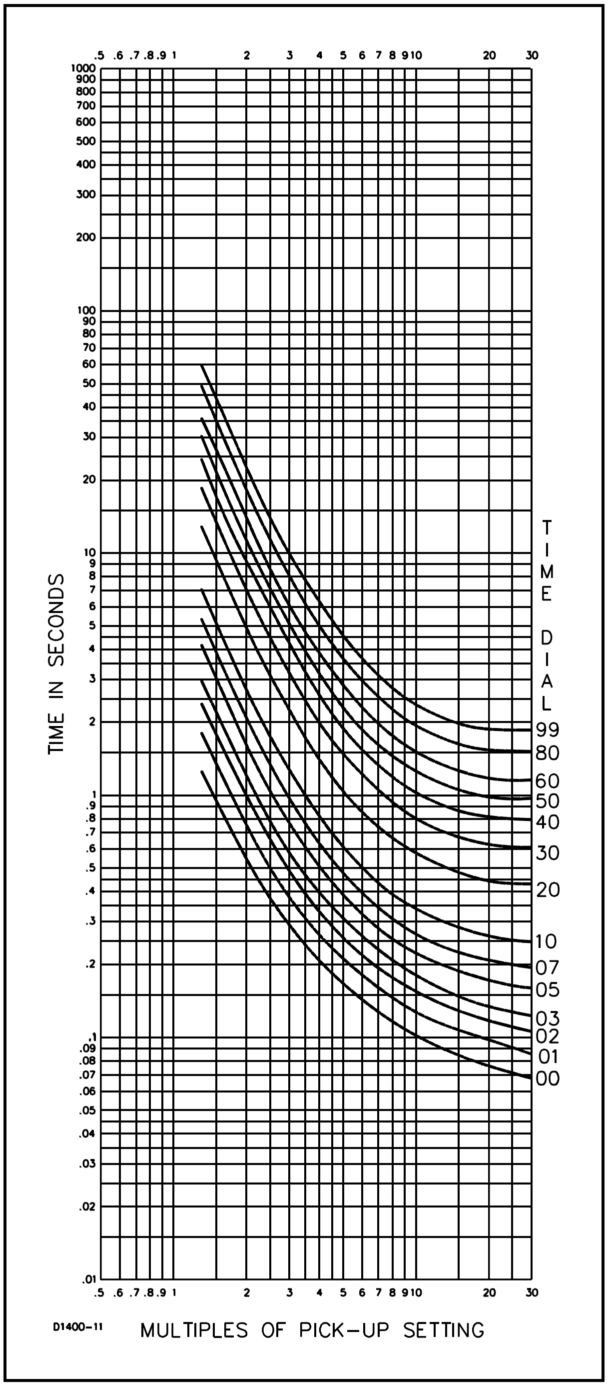


Figure 1-49. Timing Type B6: Very Inverse With Integrated Algorithm (Drawing No. 99-1407)

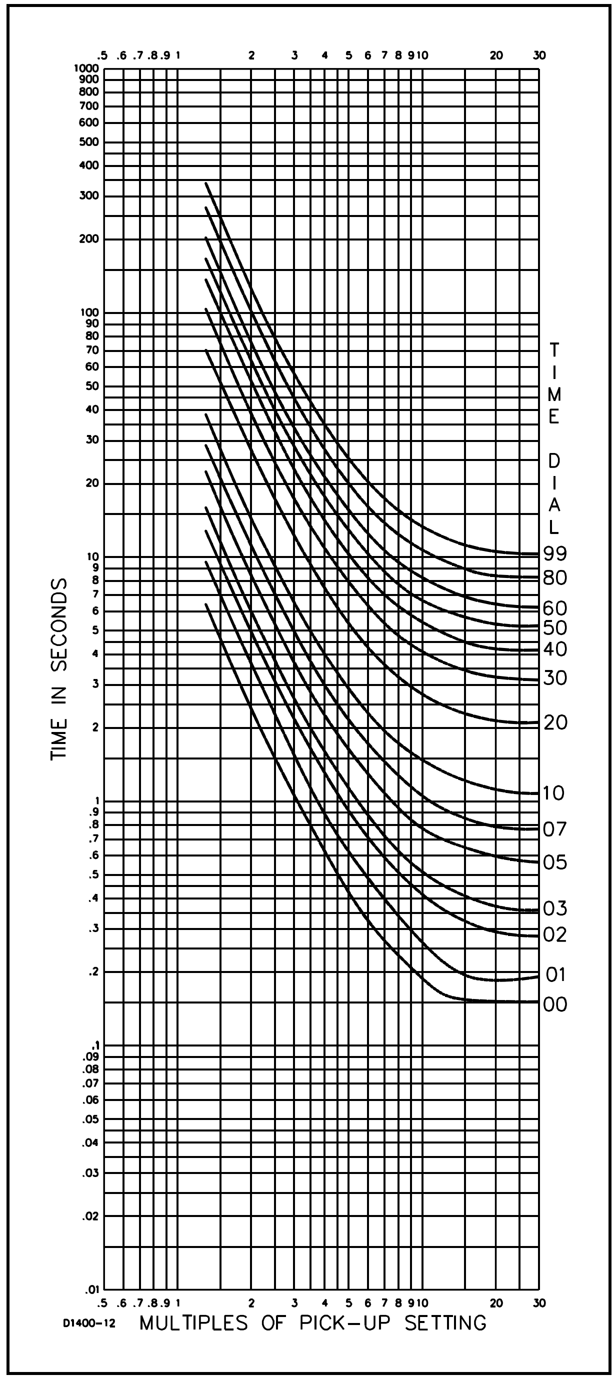


Figure 1-50. Timing Type B6: Very Inverse With Integrated Algorithm and Extended Timing (Drawing No. 99-1408)

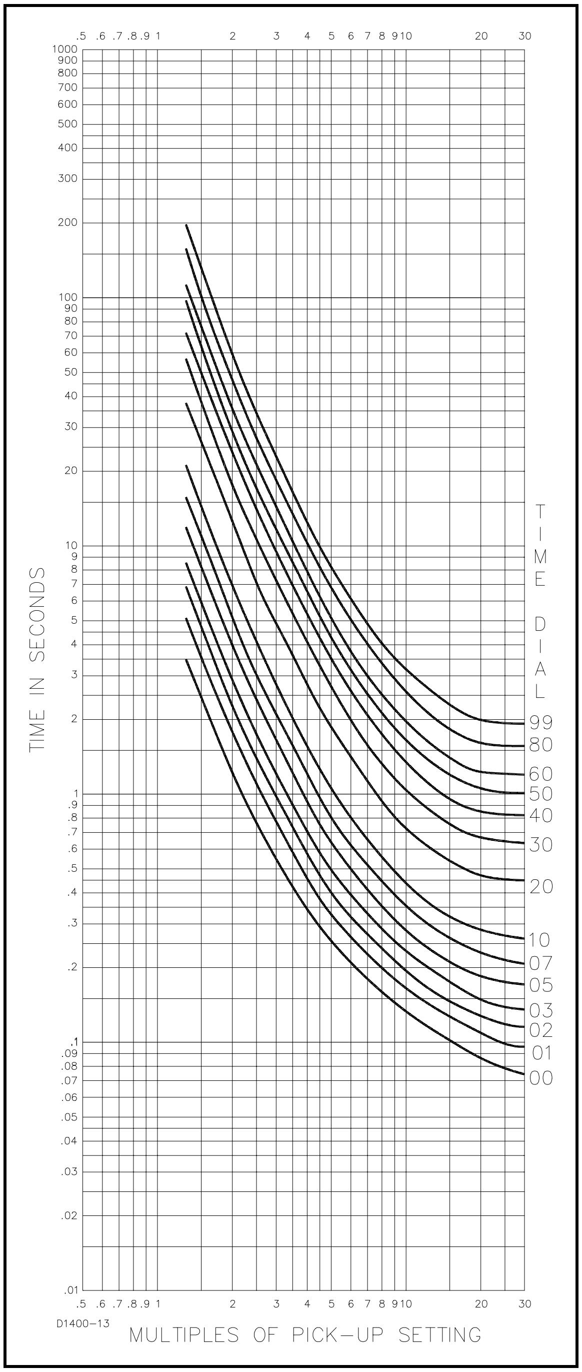


Figure 1-51. Timing Type B7: Extremely Inverse With Integrated Algorithm (Drawing No. 99-1409)

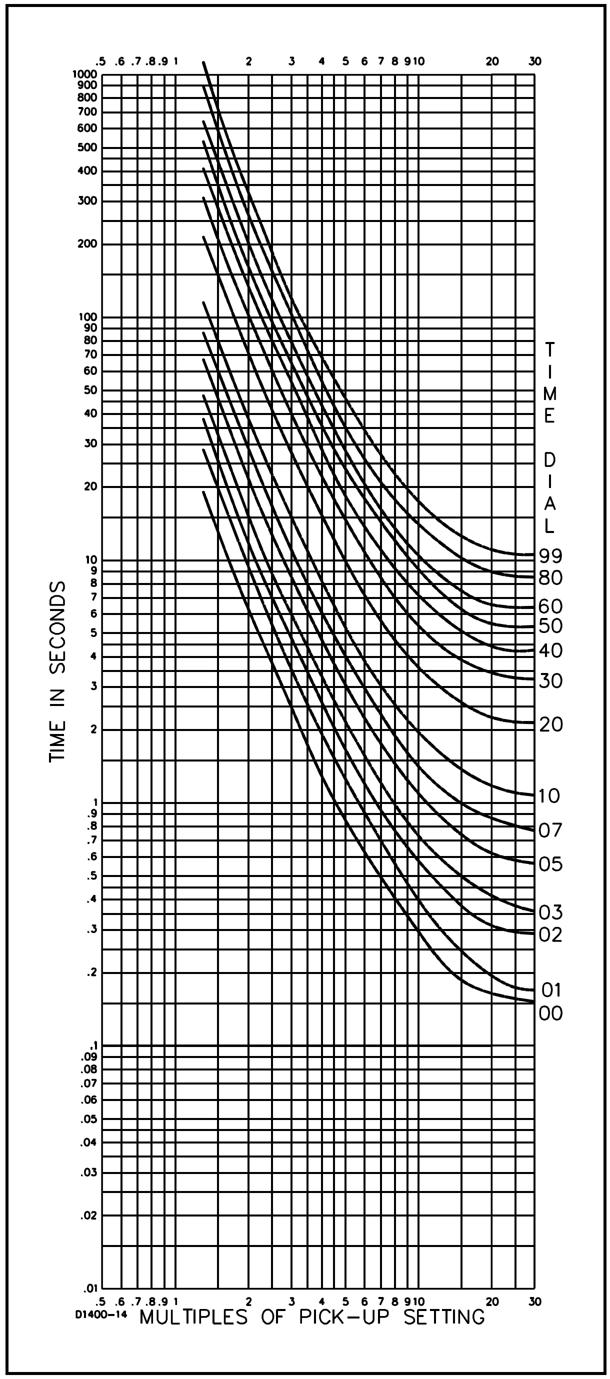


Figure 1-52. Timing Type B7E: Extremely Inverse With Integrated Algorithm and Extended Timing (Drawing No. 99-1410)

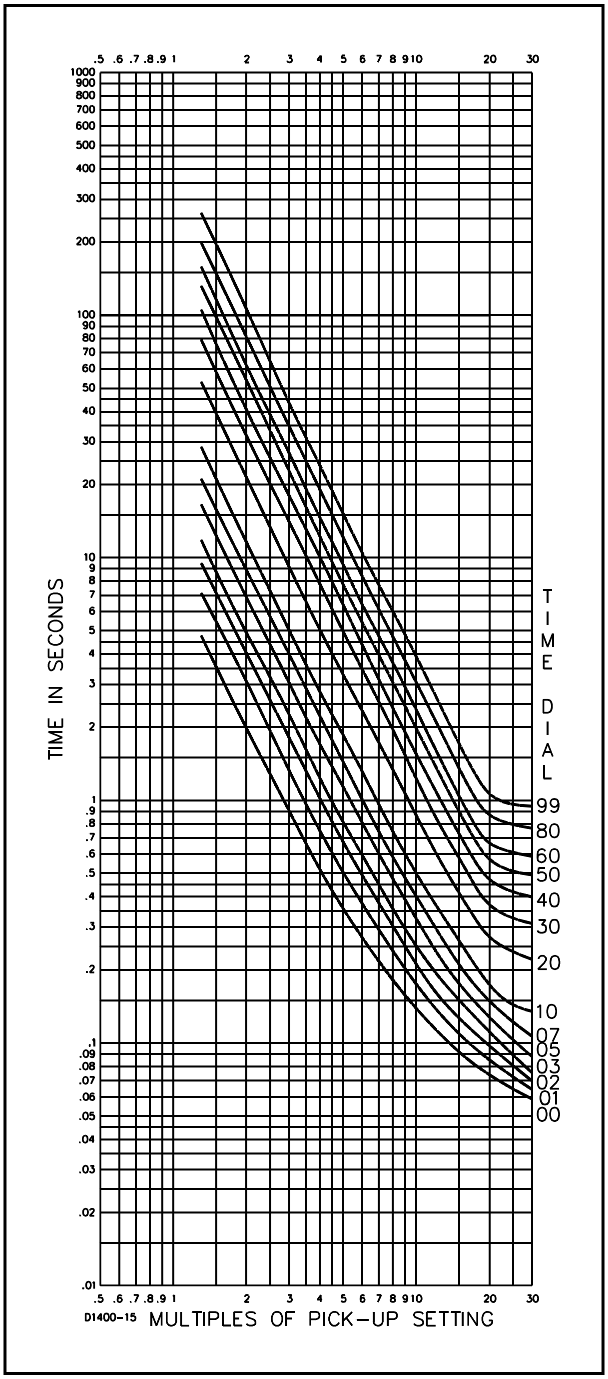


Figure 1-53. Timing Type B8: I^2T With Integrated Algorithm (Drawing No. 99-1411)

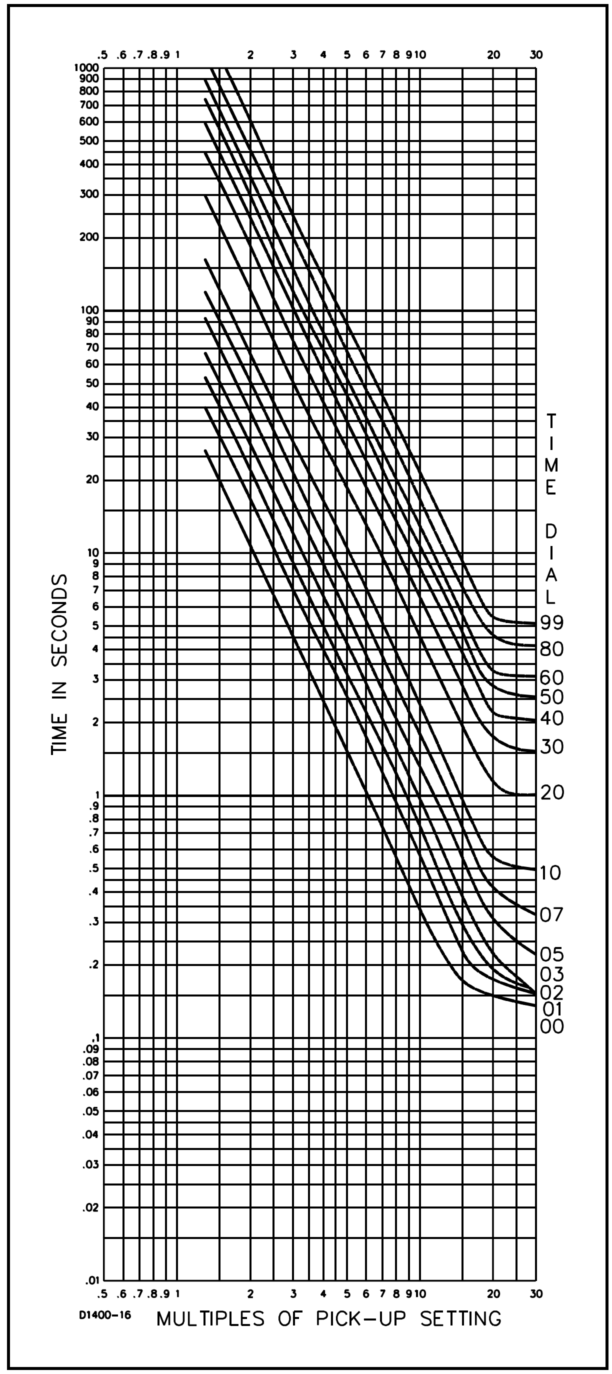


Figure 1-54. Timing Type B8E: I^2T With Integrated Algorithm and Extended Timing (Drawing No. 99-1412)

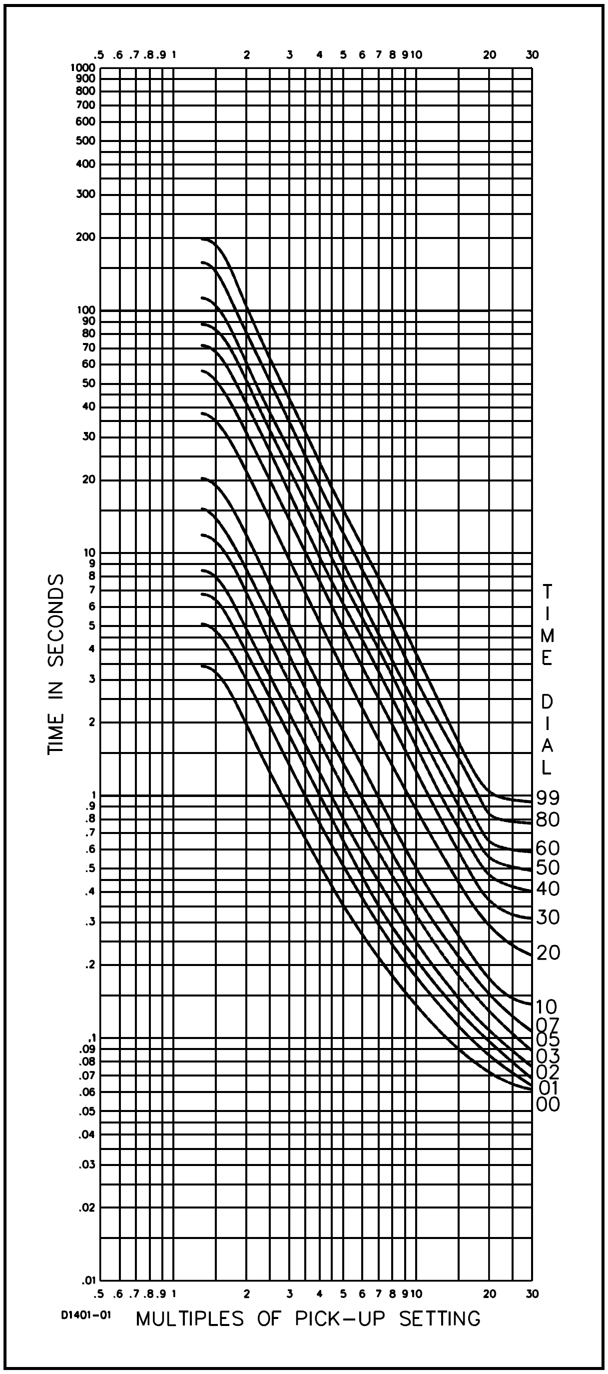


Figure 1-55. Timing Type C1: I^2T, Limit # 1 With Integrated Algorithm (Drawing No. 99-1413)

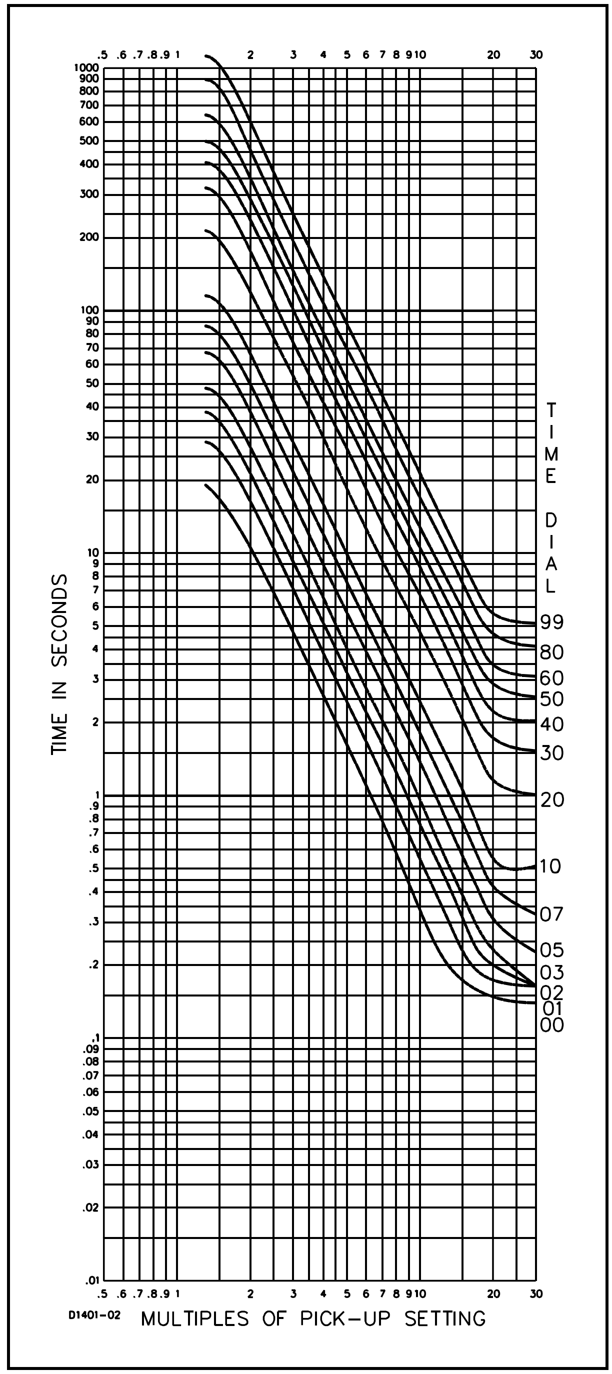


Figure 1-56. Timing Type C1E: I^2T, Limit # 1 With Integrated Algorithm and Extended Timing (Drawing No. 99-1414)

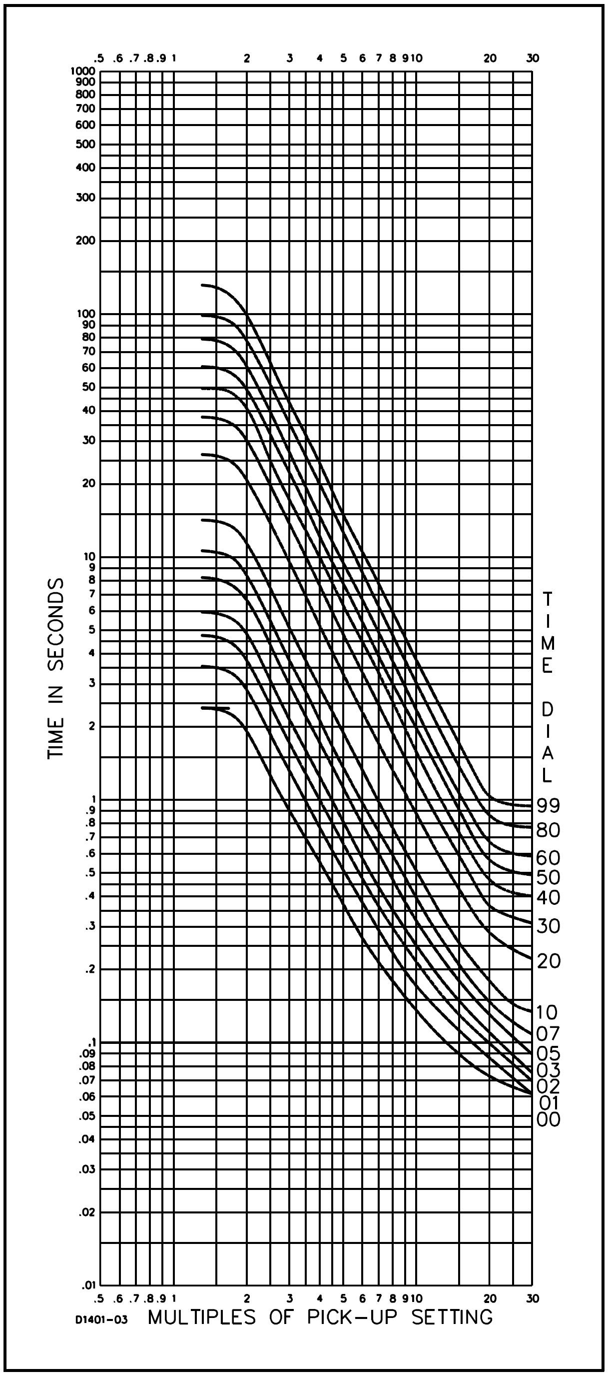


Figure 1-57. Timing Type C2: I^2T, Limit # 2 With Integrated Algorithm (Drawing No. 99-1415)

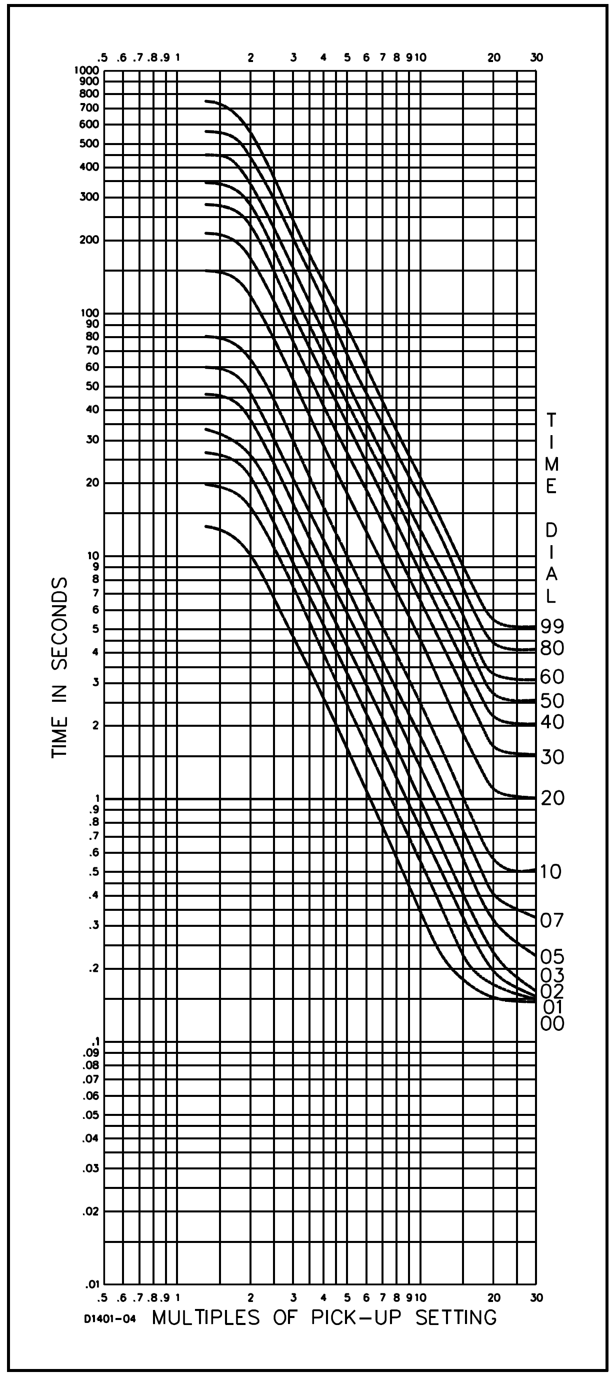


Figure 1-58. Timing Type C2E: I^2T, Limit # 2 With Integrated Algorithm and Extended Timing (Drawing No. 99-1416)

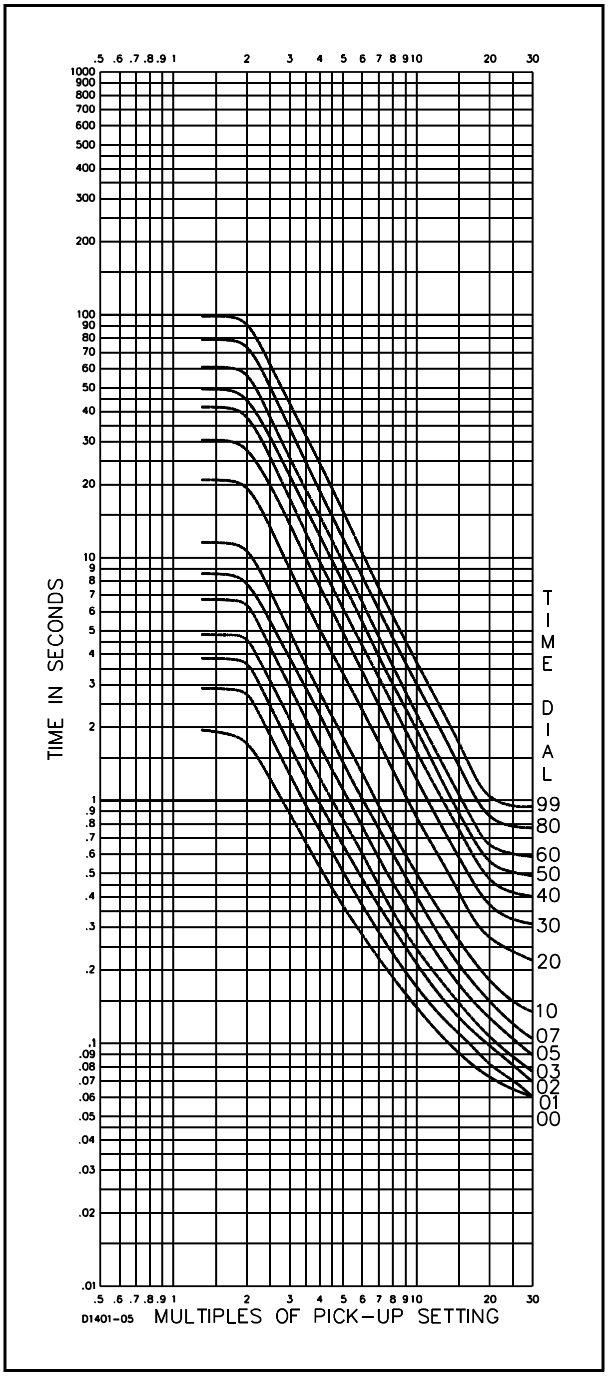


Figure 1-59. Timing Type C3: I^2T, Limit # 3 With Integrated Algorithm (Drawing No. 99-1417)

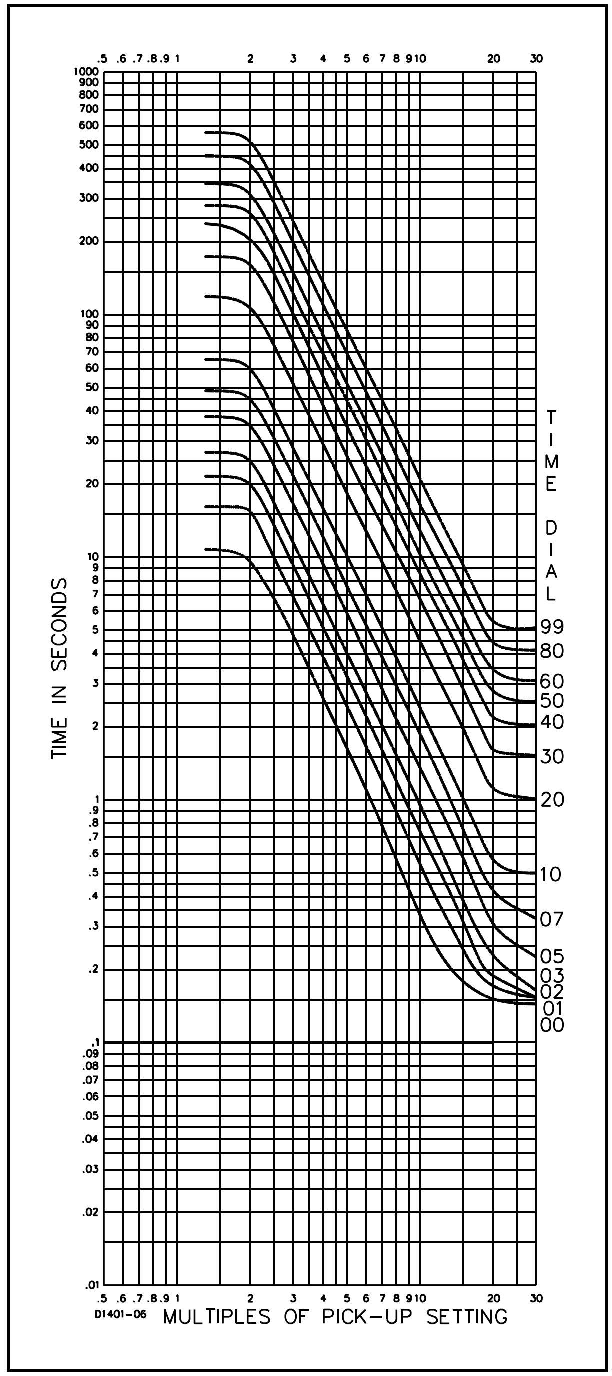


Figure 1-60. Timing Type C3E: I^2T, Limit # 3 With Integrated Algorithm and Extended Timing (Drawing No. 99-1418)

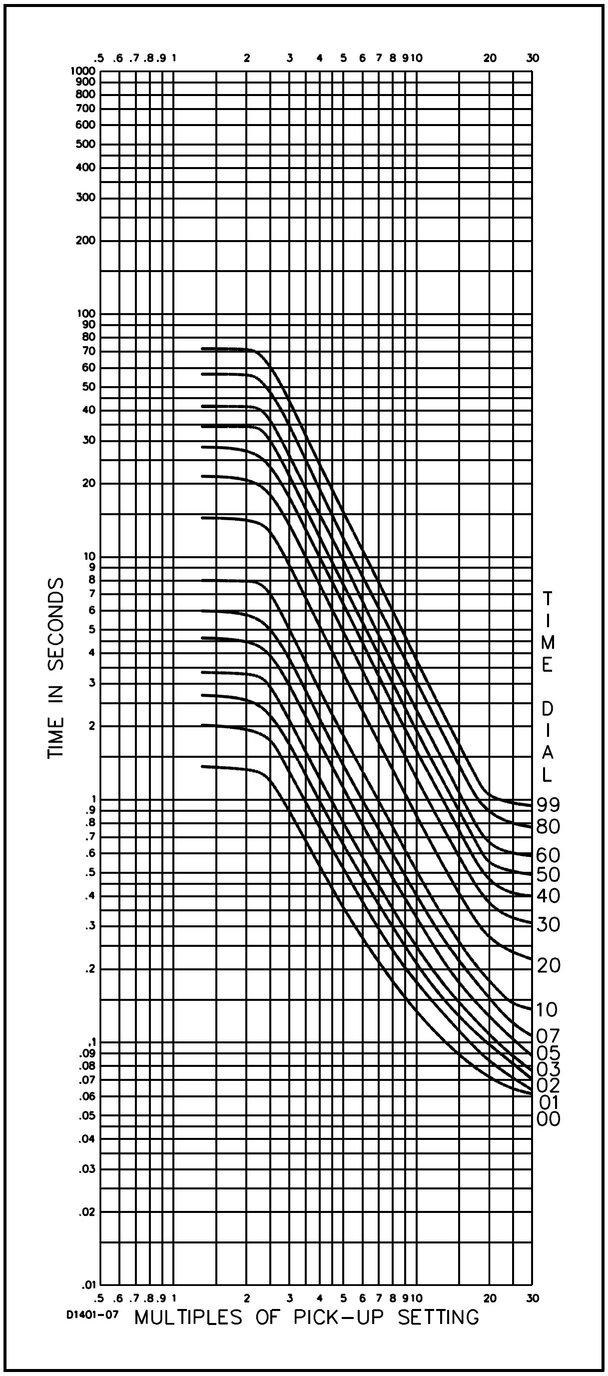


Figure 1-61. Timing Type C4: I^2T, Limit # 4 With Integrated Algorithm (Drawing No. 99-1419)

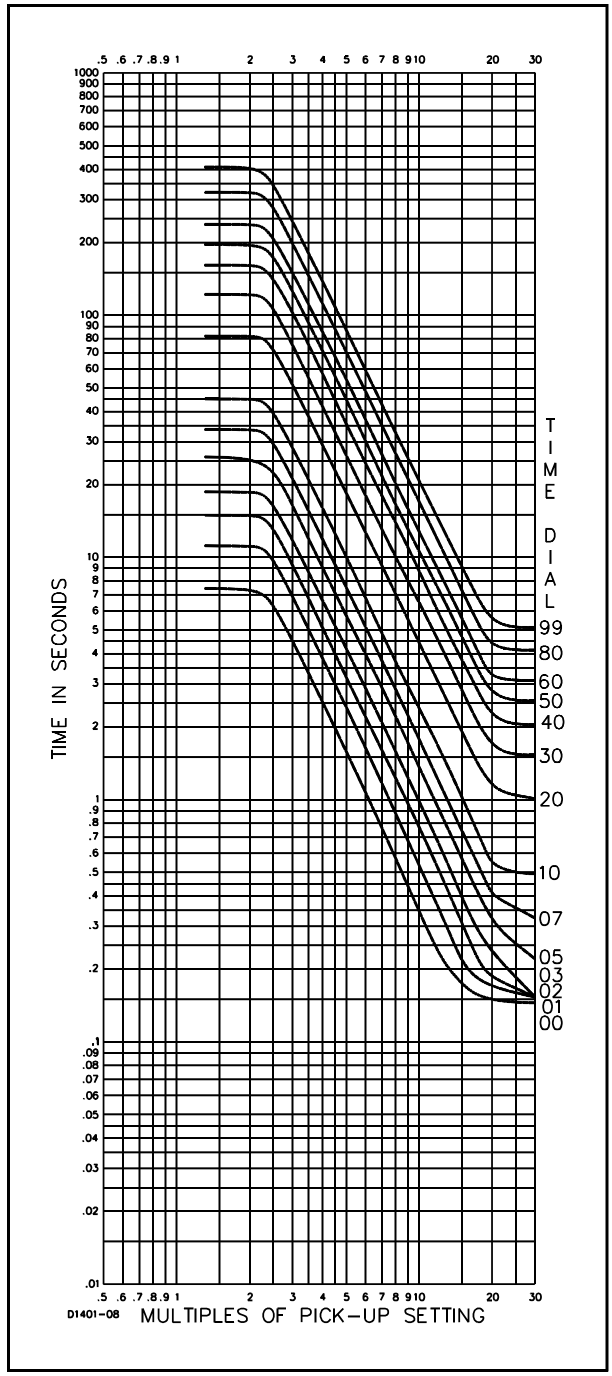


Figure 1-62. Timing Type C4E: I^2T, Limit # 4 With Integrated Algorithm and Extended Timing (Drawing No. 99-1420)

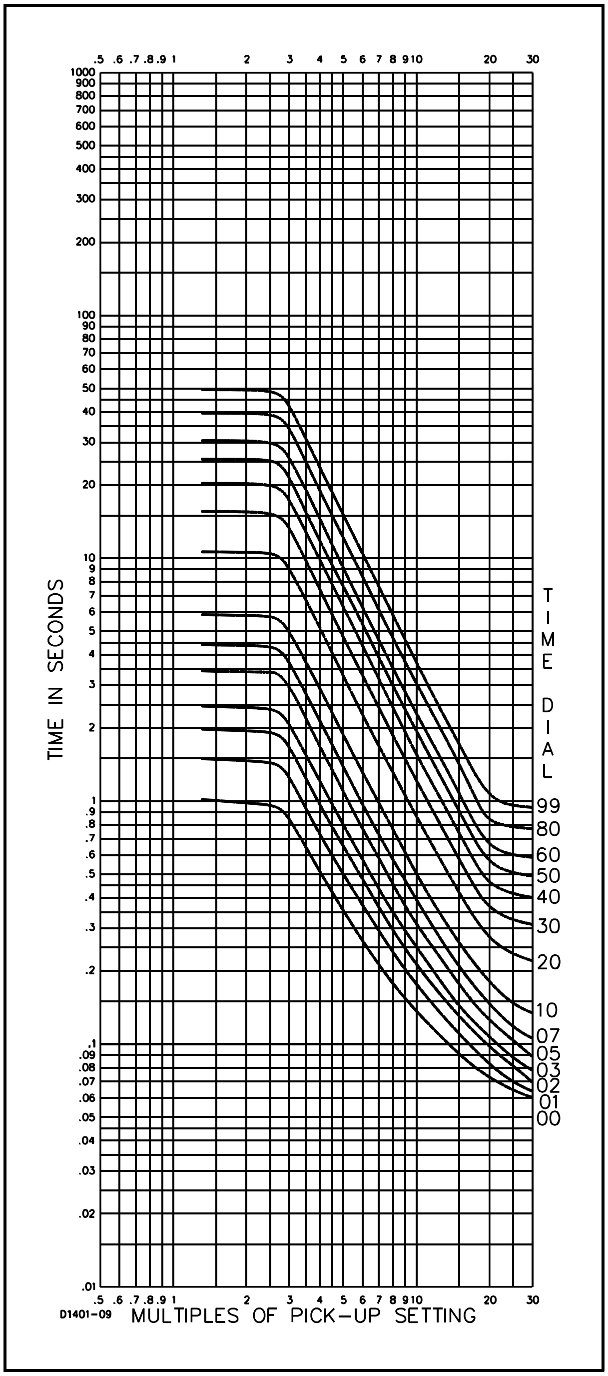


Figure 1-63 . Timing Type C5: I^2T, Limit # 5 With Integrated Algorithm (Drawing No. 99-1421)

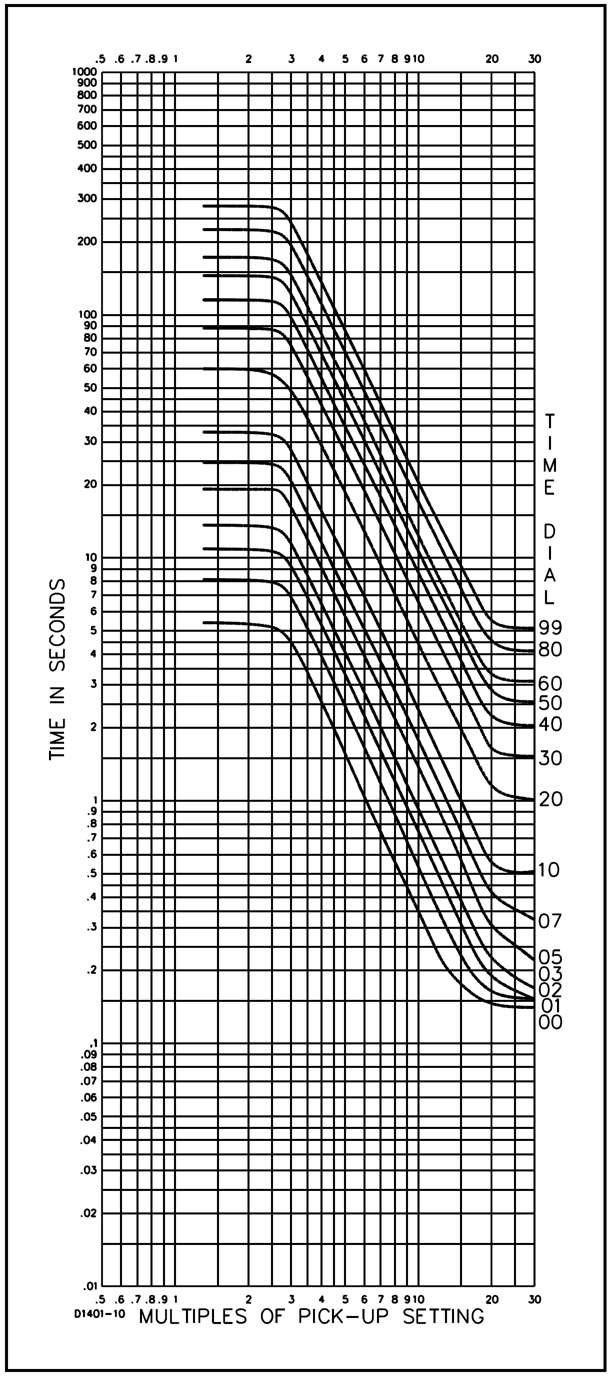


Figure 1-64. Timing Type C5E: I^2T, Limit # 5 With Integrated Algorithm and Extended Timing (Drawing No. 99-1422)

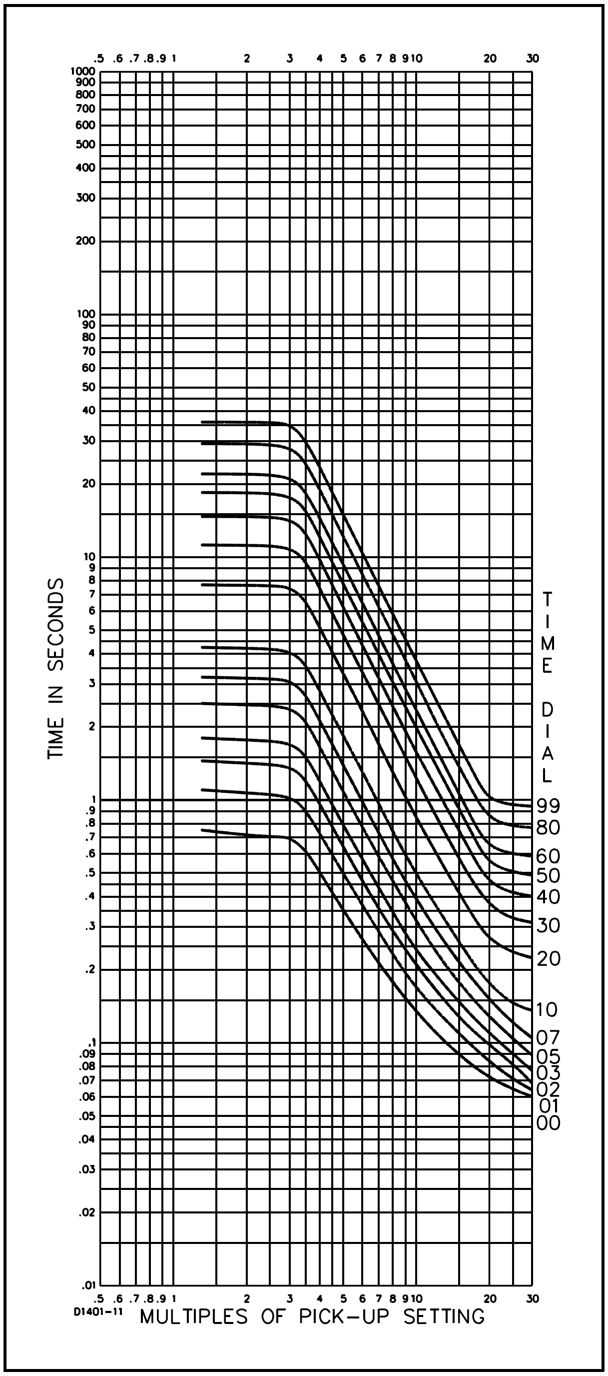


Figure 1-65. Timing Type C6: I^2T, Limit # 6
With Integrated Algorithm
(Drawing No. 99-1423)

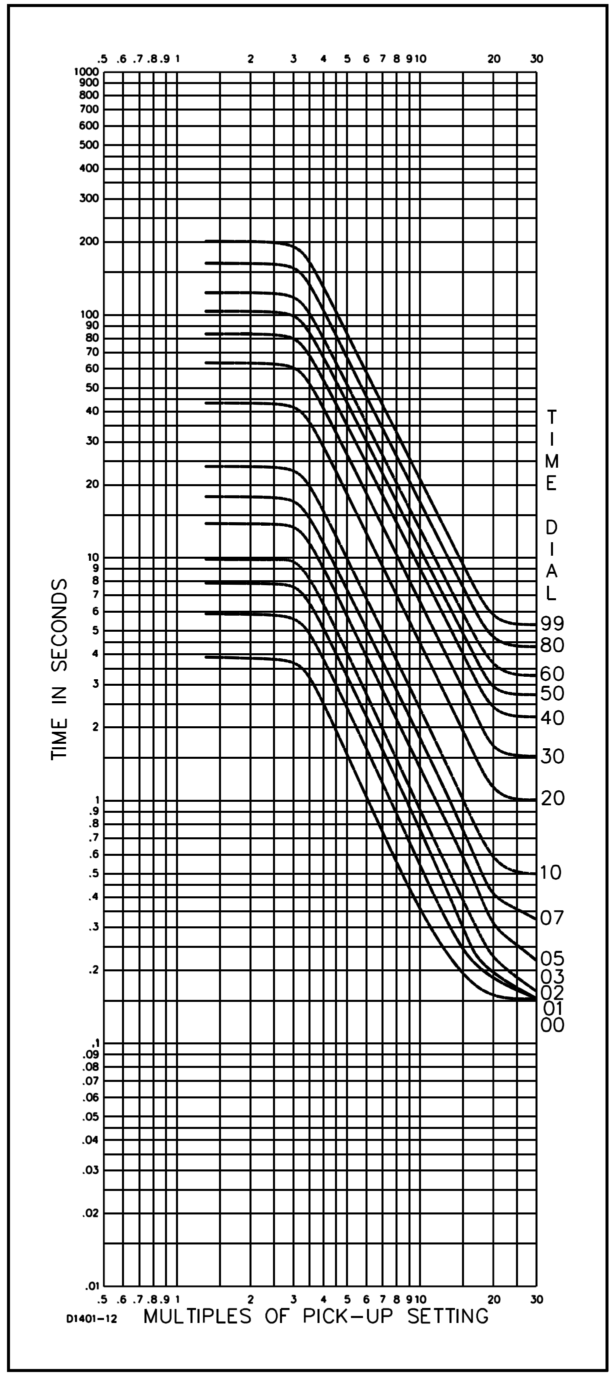


Figure 1-66. Timing Type C6E: I^2T, Limit # 6
With Integrated Algorithm and
Extended Timing
(Drawing No. 99-1424)

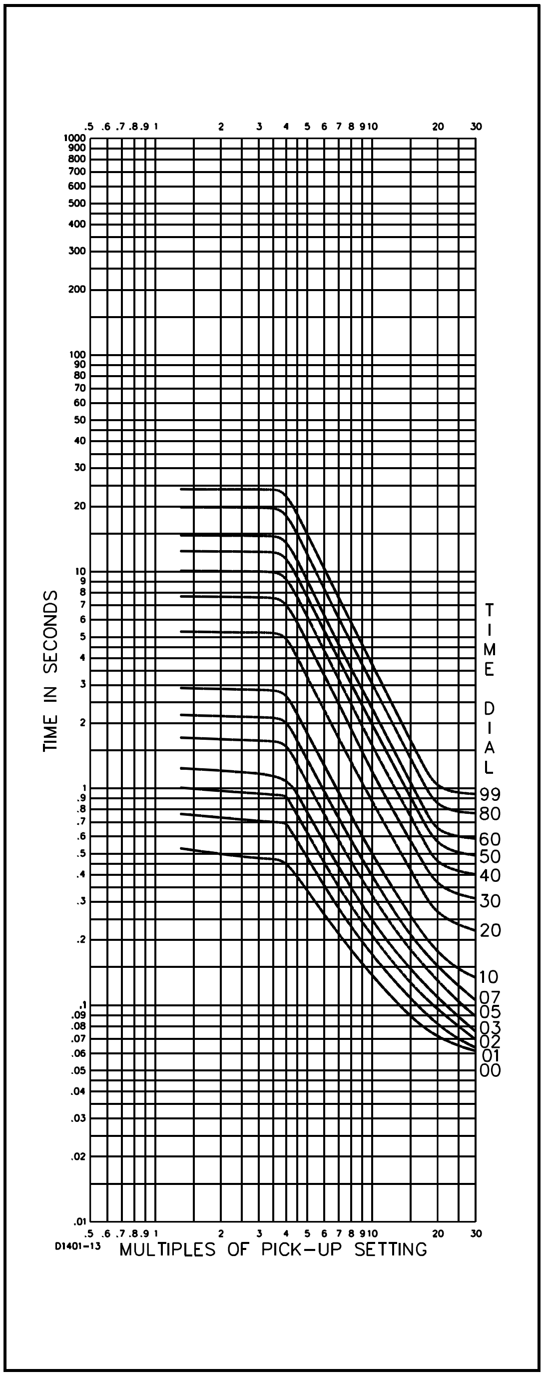


Figure 1-67. Timing Type C7: I^2T, Limit # 7 With Integrated Algorithm (Drawing No. 99-1425)

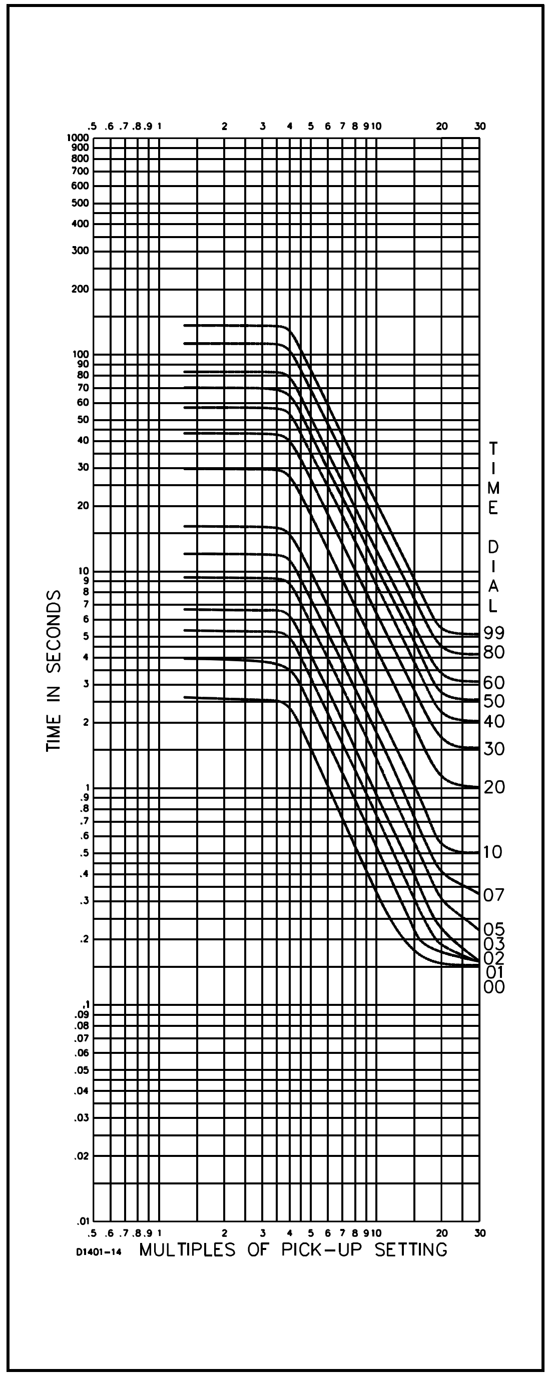


Figure 1-68. Timing Type C7E: I^2T, Limit # 7 With Integrated Algorithm and Extended Timing (Drawing No. 99-1426)

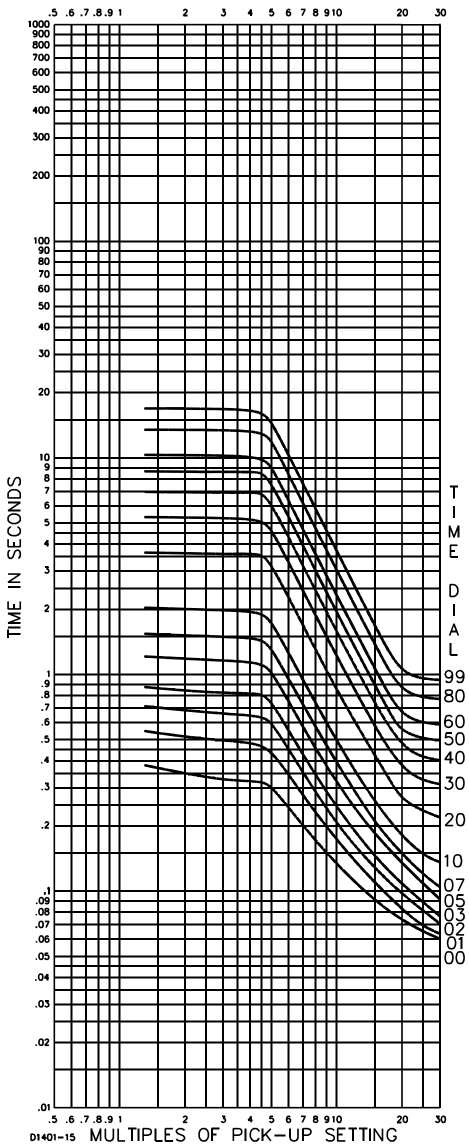


Figure 1-69. Timing Type C8: I^2T, Limit # 8
With Integrated Algorithm
(Drawing No. 99-1427)

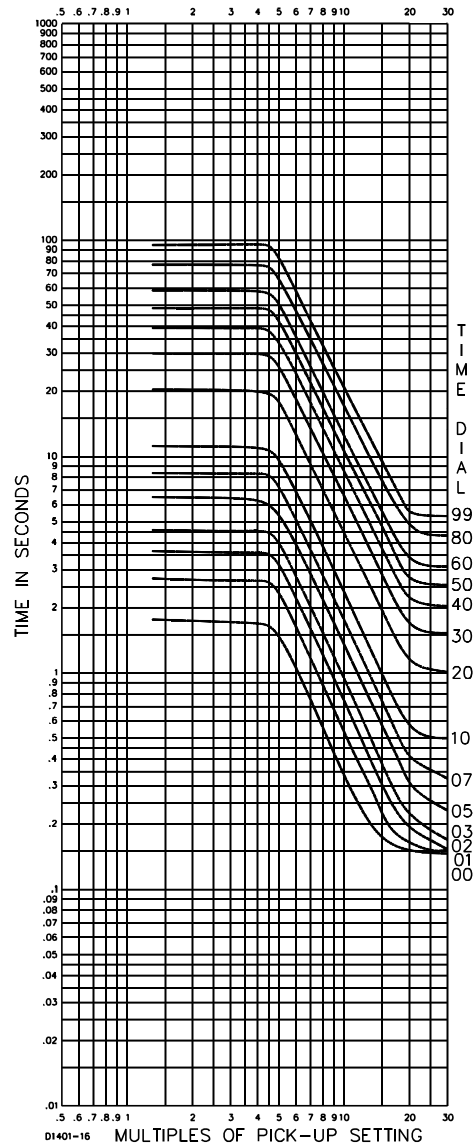


Figure 1-70. Timing Type C8E: I^2T, Limit # 8
With Integrated Algorithm
and Extended Timing
(Drawing No. 99-1428)

SECTION 2 • HUMAN MACHINE INTERFACE

(Controls And Indicators)

GENERAL

Table 2-1 lists and briefly describes the human machine interface (HMI) of the BE1-51/27R Time Overcurrent Relay with voltage restraint. Reference the call-out letters to Figure 2-1.

Table 2-1. Controls and Indicators

Letter	Control or Indicator	Function or Indicator
A	**TAP NEUTRAL** Selector	Provides selection of the neutral overcurrent pickup point in conjunction with the front panel **NEUTRAL CAL** control.
B	**PHASE - TAP** Selector	Provides the selection of the overcurrent pickup point in conjunction with the front panel **TAP CAL** control.
C	**CAL NEUTRAL** 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	**TAP RANGE** 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	**TIME DIAL NEUTRAL** (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	**TIMING NEUTRAL** (If pres-ent)	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	**POWER** 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	**FUNCTION** Targets **TIME INST1, INST2***	Front panel **FUNCTION** targets trip when the corresponding output relay is energized by an overcurrent condition.
J	**ELEMENT** Targets	Front panel **ELEMENT** targets trip when an output relay is energized by an overcurrent condition.

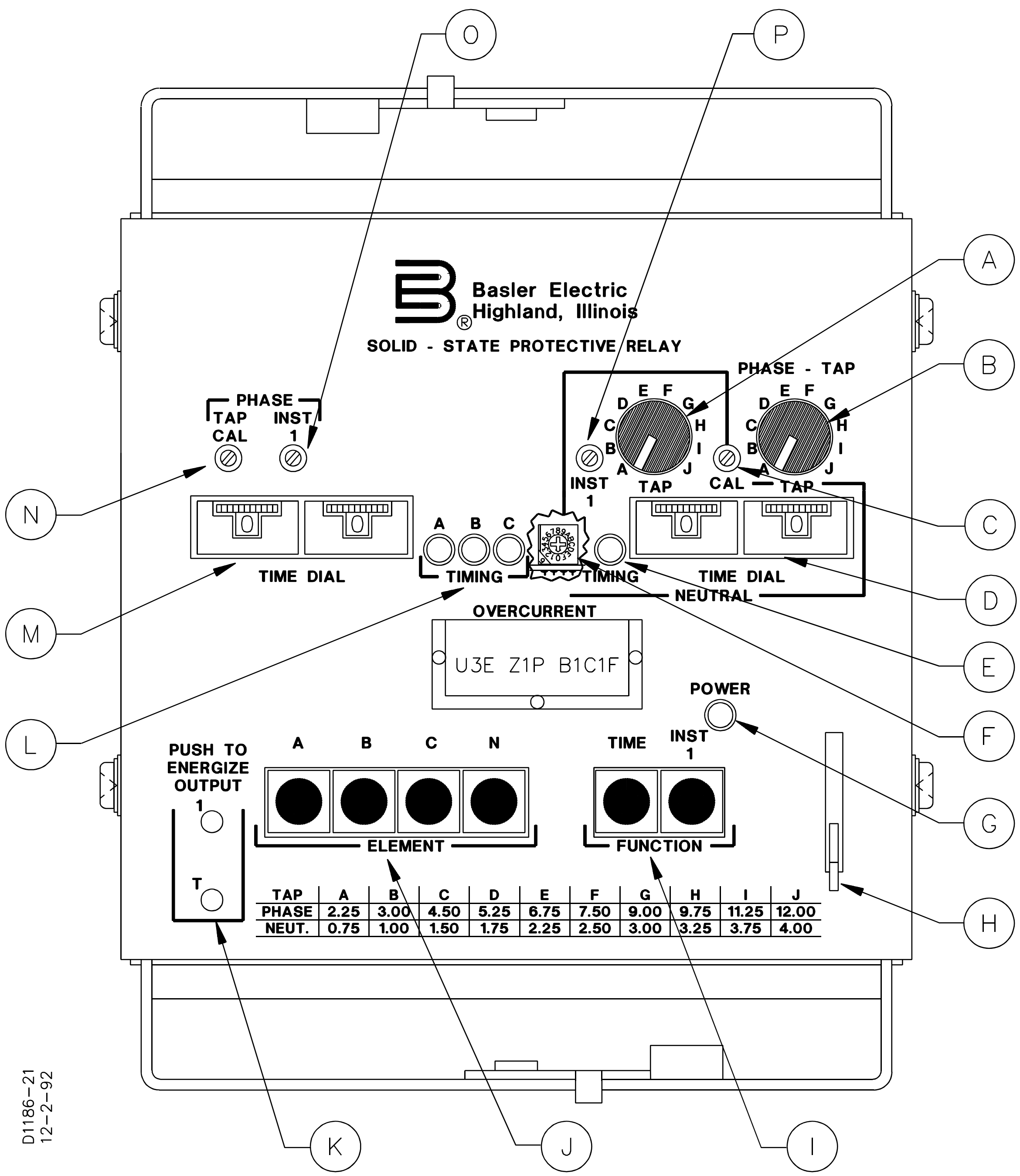


Figure 2-1. Location of Controls and Indicators

Table 2-1. Controls and Indicators - Continued

Letter	Control or Indicator	Function or Indicator
K	**PUSH-TO-ENERGIZE OUTPUT** Pushbutton	Actuation of this function is by a thin non-conducting rod (*do not use a screwdriver*) through a hole in the front panel. This allows the output relays to be manually energized for testing of the external trip circuit(s). **ELEMENT** targets, where supplied, are not operated by this control.
L	**TIMING** Indicator	LEDs illuminate when the preset overcurrent pickup point is reached and exceeded.
M	**TIME DIAL** 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	**TAP CAL** 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	**INST 1** Control (Options 1-1 and 1-2 Only) **	A four turn potentiometer provides adjustment of the front panel **INST 1** trip setting over the range of 1 to 40 times the selected phase time overcurrent pickup (TAP) value.
P	**INST 1 NEUTRAL** Control (Options 1-1 and 1-2 Only)**	A four turn potentiometer provides adjustment of the front panel **INST 1 NEUTRAL** trip setting over the range of 1 to 40 times the selected neutral time overcurrent pickup (TAP) value.
Not Shown	**INST 2** Control (Option 1-2 Only) **	A four turn potentiometer provides adjustment of the front panel **INST 2** trip setting over 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
Range 1, Single-Phase †														
HIGH	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	8,7	-----	-----	-----
LOW	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	9,7	-----	-----	-----
Range 1, Three-Phase †														
HIGH	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	8,7	14,15	17,18	-----
LOW	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	-----
Range 1, Two-Phase-and-Neutral †														
HIGH	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	8,7	-----	14,15	17,18
LOW	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
Range 2, Three-Phase-and-Neutral														
Phase or Neutral	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
Range 3, Three-Phase-and-Neutral														
Phase	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	8,9	13,14	15,16	-----
Neutral	0.75	1.00	1.50	1.75	2.25	2.50	3.00	3.25	3.75	4.00	-----	-----	-----	17,18
Range 4, Three-Phase-and-Neutral														
Phase	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	-----
Neutral	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	-----	-----	-----	17,18
Range 5, Three-Phase-and-Neutral														
Phase or Neutral	2.25	3.00	4.50	5.25	6.75	7.50	9.00	9.75	11.25	12.00	8,9	13,14	15,16	17,18
Range 6, Three-Phase-and-Neutral														
Phase or Neutral	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
Range 7, Three-Phase-and-Neutral														
Phase	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	-----
Neutral	0.15	0.20	0.30	0.35	0.45	0.50	0.60	0.65	0.75	0.80	-----	-----	-----	17,18
Range 8, Three-Phase-and-Neutral														
Phase or Neutral	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
Range 9 (All Other Sensing Types)														
HIGH	0.45	0.60	0.90	1.05	1.35	1.50	1.80	1.95	2.25	2.40	8,7	-----	-----	-----
LOW	0.15	0.20	0.30	0.35	0.45	0.50	0.60	0.65	0.75	0.80	9,7	-----	-----	-----

NOTE:

† For relays with sensing input range 1, 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^2T	0	0	1-16	1-17	1-53	1-54
C1 - I^2T with Limit #1	8	---	1-18	1-19	1-55	1-56
C2 - I^2T with Limit #2	9	---	1-20	1-21	1-57	1-58
C3 - I^2T with Limit #3	A	---	1-22	1-23	1-59	1-60
C4 - I^2T with Limit #4	B	---	1-24	1-25	1-61	1-62
C5 - I^2T with Limit #5	C	---	1-26	1-27	1-63	1-64
C6 - I^2T with Limit #6	D	---	1-28	1-29	1-65	1-66
C7 - I^2T with Limit #7	E	---	1-30	1-31	1-67	1-68
C8 - I^2T 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)						
				Element				Function		
	None	One	Two	A	B	C	N	TIME	INST 1	INST 2
M, N	X							X		
		X						X	X	
			X					X	X	X
R, S	X			X	X	X				
		X		X	X	X		X	X	
U, W	X			X	X	X	X			
		X		X	X	X	X	X	X	
B, C		X		X	X	X		X	X	
			X	X	X	X		X		X
E, F		X		X	X	X	X	X	X	
			X	X	X	X	X	X		X
Y, Z	X			X		X	X	X		
		X		X		X	X	X	X	

SECTION 3 • FUNCTIONAL DESCRIPTION

GENERAL

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

BLOCK DIAGRAM ANALYSIS

The following block diagram analysis is referenced to Figure 3-1. A microprocessor (not illustrated in Figure 3-2) 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). Relays with a serial number that consists of one alpha character followed by eight numerical characters also have the new wide range power supplies. 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 the following table.

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, 120 Vac	24 to 150 Vdc 90 to 132 Vac
High Range	T	125, 250 Vdc, 120, 240 Vac	62 to 280 Vdc 90 to 270 Vac

† 14 Vdc required to start the power supply.

Relay operating power is developed by the wide range, isolated, low burden, flyback switching, solid state power supply. Nominal $\pm$12 Vdc is delivered to the relay 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).

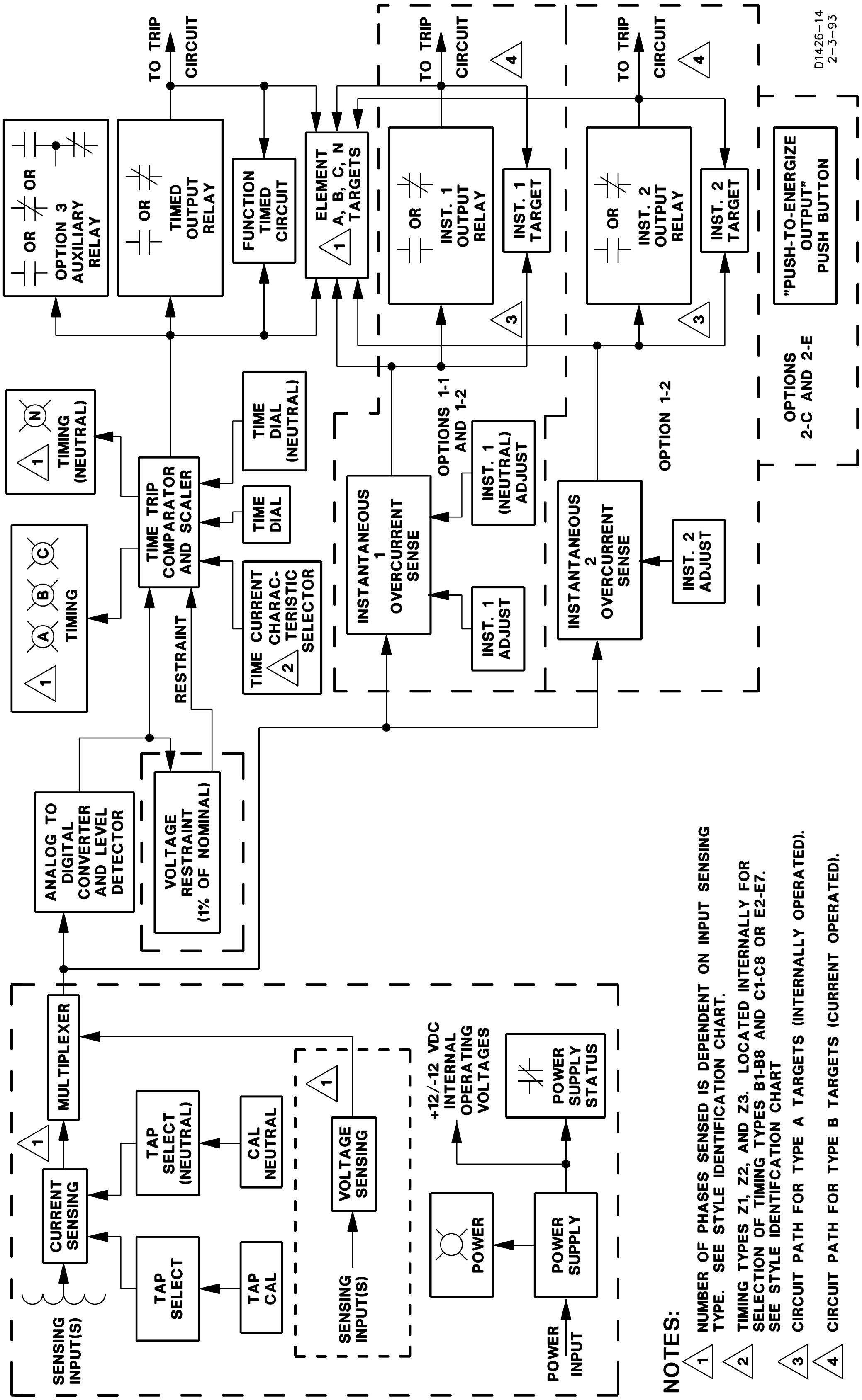


Figure 3-1. Functional Block Diagram

Current Sensing - Continued

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.

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.

Analog-To-Digital Converter and Level Detector

Analog dc voltages representing the sensed currents or sensed voltages from the multiplexor are converted to binary numbers (successive approximation) and applied to the voltage restraint circuits and the time trip comparator and scaler circuits.

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. Time delay characteristics are shown in the curves located in Section 1. 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 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.

Voltage Restraint

Voltage restraint compares the binary number representing the monitored voltage with the fixed nominal voltage limit (100 Vac for 50 hertz systems and 120 Vac for 60 hertz systems). When the voltage is between 100 percent and 25 percent of the nominal voltage, the circuit automatically lowers the selected time overcurrent pickup point proportionally. Instantaneous overcurrent operation, if present, is not affected. Neutral is not monitored for voltage, nor is the neutral time overcurrent pickup point restrained. When the voltage is above the 100 percent limit, the pickup point is restrained to 100 percent. When the voltage is below the 25 percent limit, the pickup point remains at the 25 percent point.

For a given level of current above pickup, a lowering of the pickup point, via voltage restraint effectively increases the multiples of current. This shifts the time delay characteristic to the right on the multiples-of-pickup-current axis (characteristic curves) as voltage drops from 100 percent to 25 percent. To find the effective multiple-of-pickup-current point on the axis, use Formula 1.

$$M = \frac{I}{I_t} \times \frac{V_N}{V}$$ **Formula 1**

Where: M = Multiple of tap value current
I = Applied current level
I_T = Tap value
V_N = Nominal voltage, and V = applied voltage level

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.

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 3 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 it 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:

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.

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) 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. The relay is a solid-state device. If a wiring insulation test is required, remove the connection plugs and withdraw the cradle from its case.

3. When the connection 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.

4. 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 2,000 Vac (45-65 hertz). This device employs decoupling capacitors to ground from the following terminals: power supply, voltage sensing input, and output contacts. At 2,000 Vac, a leakage current up to 55 milliamperes per terminal is to be expected. Because of the high leakage current, it is re-commended that dielectric tests be performed using dc voltages equivalent to the peak ac value (2,828 Vdc).

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.

CONNECTIONS

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 4-7. Internal connections are shown in Figures 4-8 through 4-13.

NOTE

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.

To prevent an inductive overload of the relay contacts, it is necessary to break the trip circuit externally through the 52a contacts.

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.

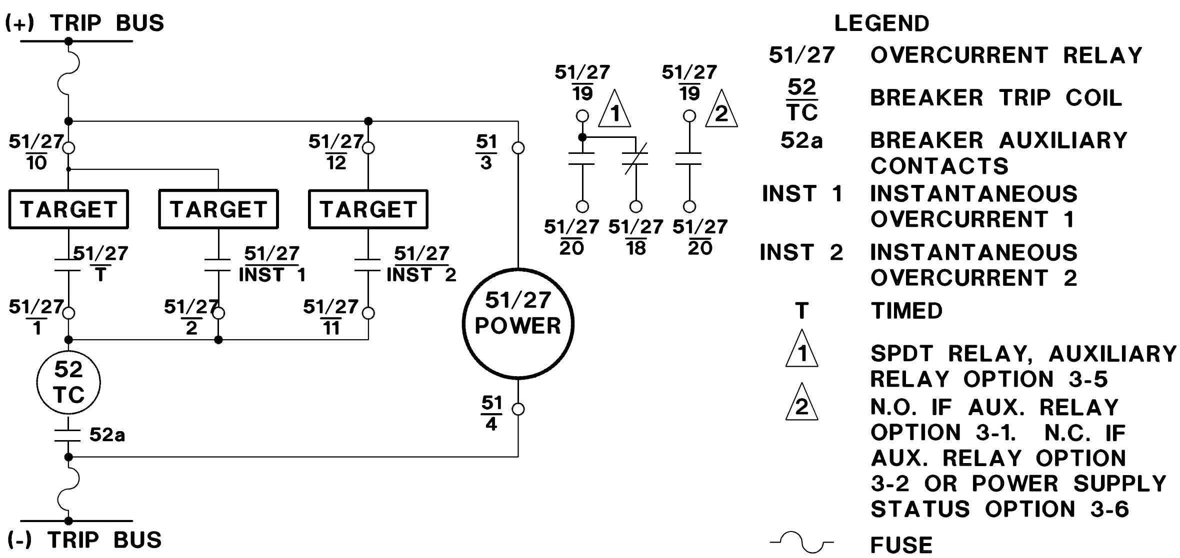


Figure 4-1. Typical External Connections, Current Operated Targets, DC Powered

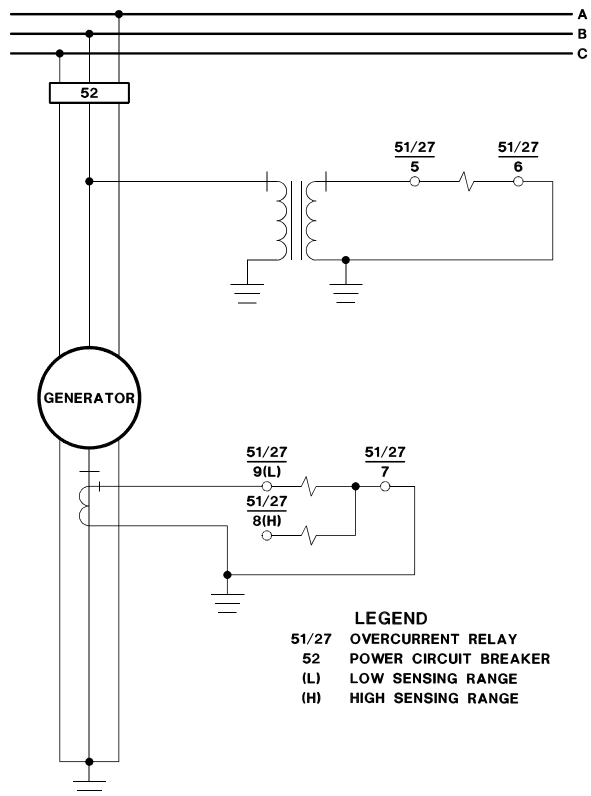


Figure 4-2. Typical Sensing External Connections, Sensing Input Type M or N

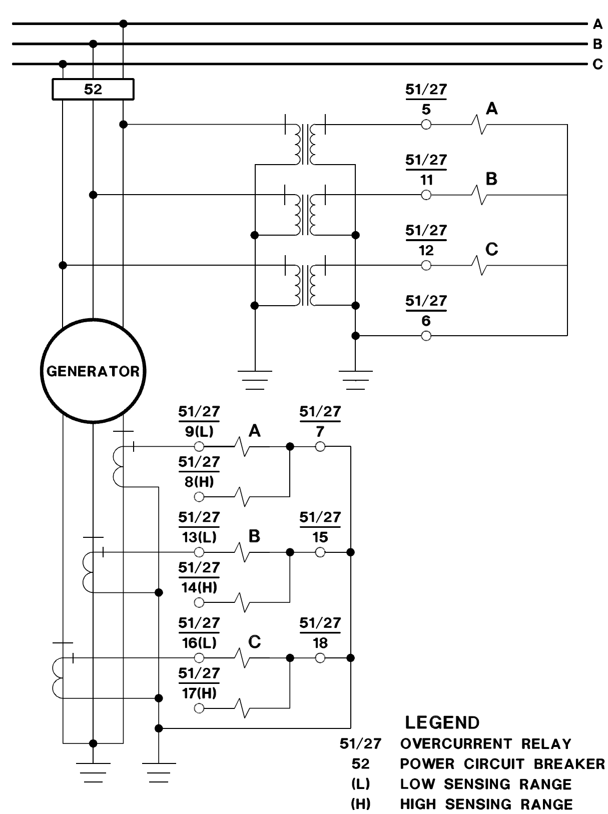


Figure 4-3. Typical Sensing External Connections, Sensing Input Type R or S

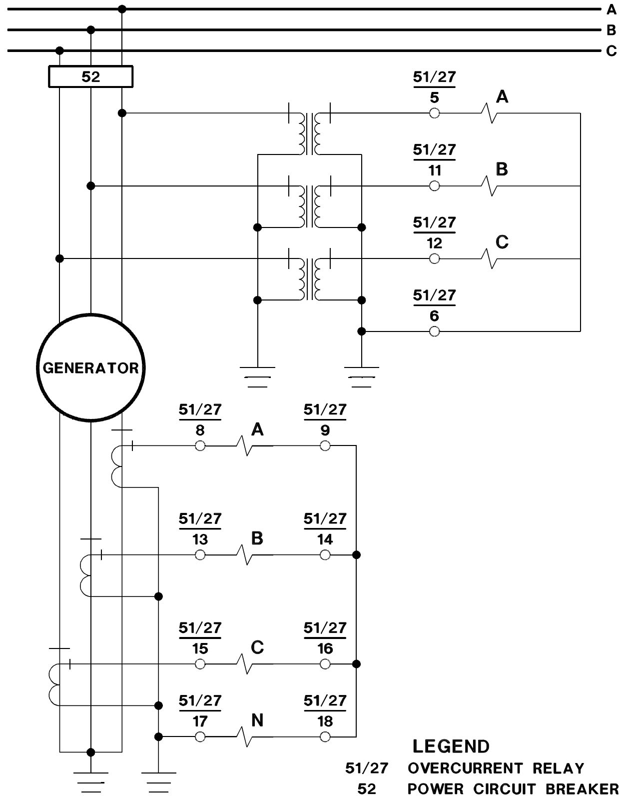


Figure 4-4. Typical Sensing External Connections, Sensing Input Type U or W

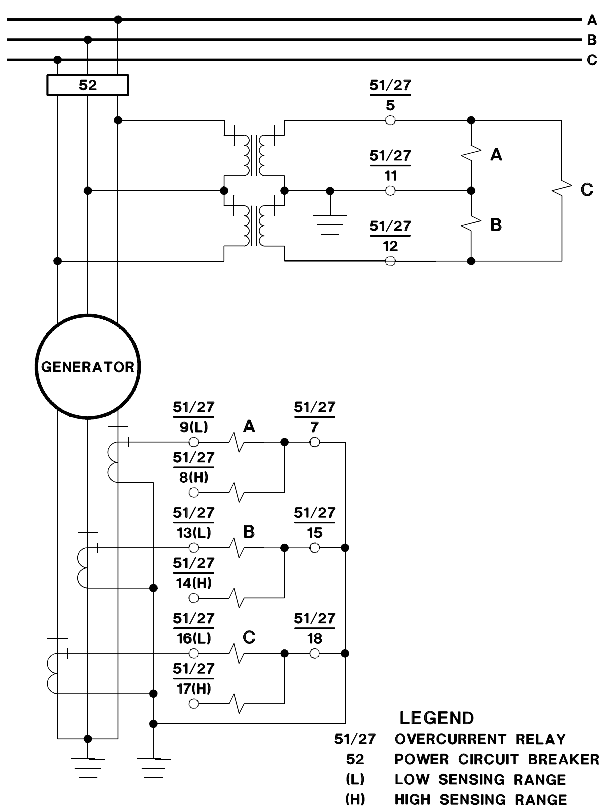


Figure 4-5. Typical Sensing External Connections, Sensing Input Type B or C

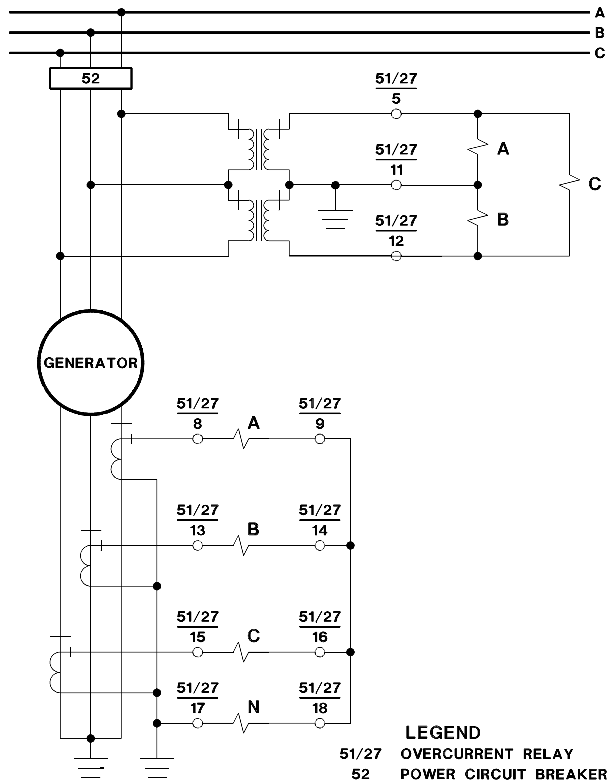


Figure 4-6. Typical Sensing External Connections, Sensing Input Type E or F

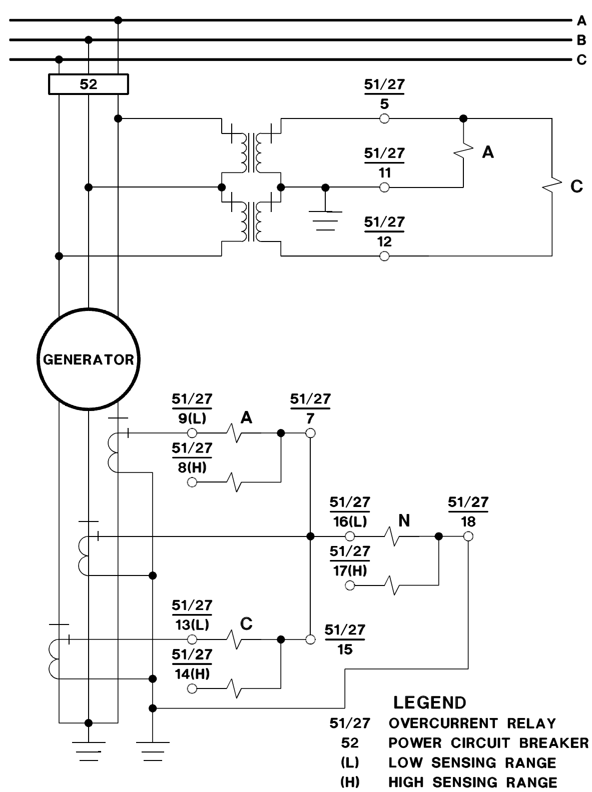


Figure 4-7. Typical Sensing External Connections, Sensing Input Type Y or Z

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). Relays with a serial number that consists of one alpha character followed by eight numerical characters also have the new wide range power supplies. 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 the following table.

Table 4-1. 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, 120 Vac	24 to 150 Vdc 90 to 132 Vac
High Range	T	125, 250 Vdc, 120, 240 Vac	62 to 280 Vdc 90 to 270 Vac

† 14 Vdc required to start the power supply.

Relay operating power is developed by the wide range, isolated, low burden, flyback switching, solid state power supply. Nominal ±12 Vdc is delivered to the relay 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.

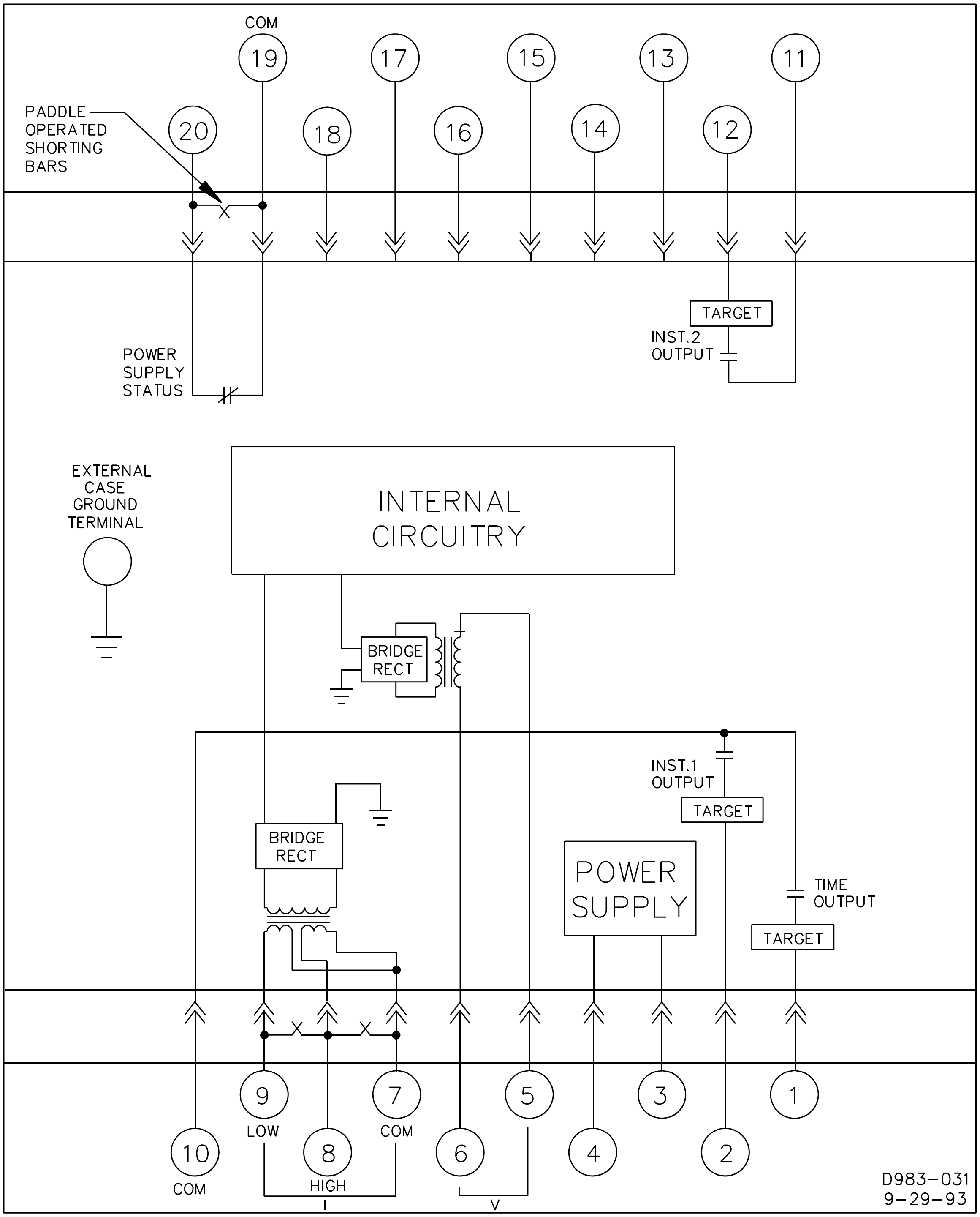


Figure 4-8. Typical Internal Diagram, Sensing Input Type M or N

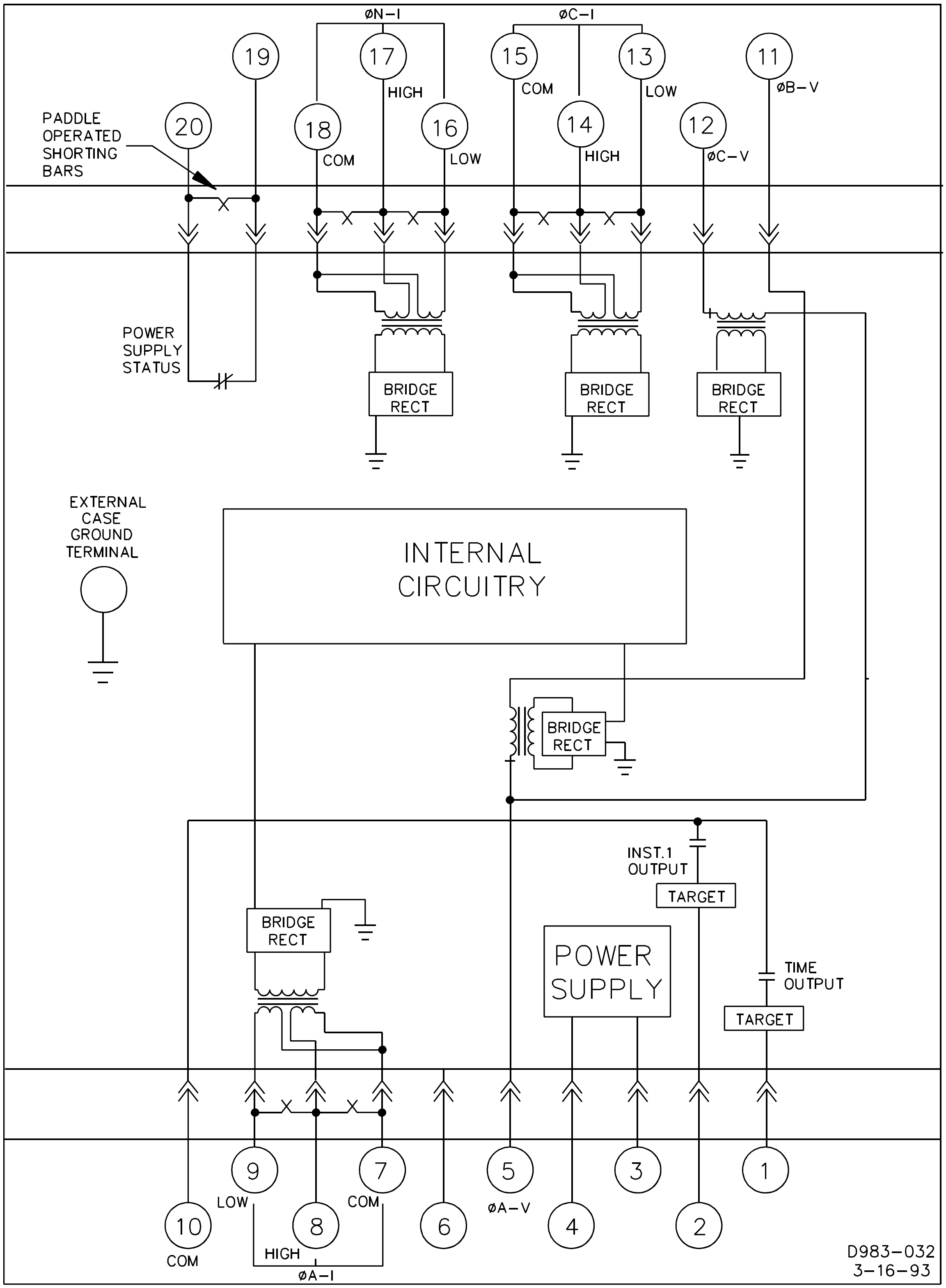


Figure 4-9. Typical Internal Diagram, Sensing Input Type Y or Z With Power Supply Status

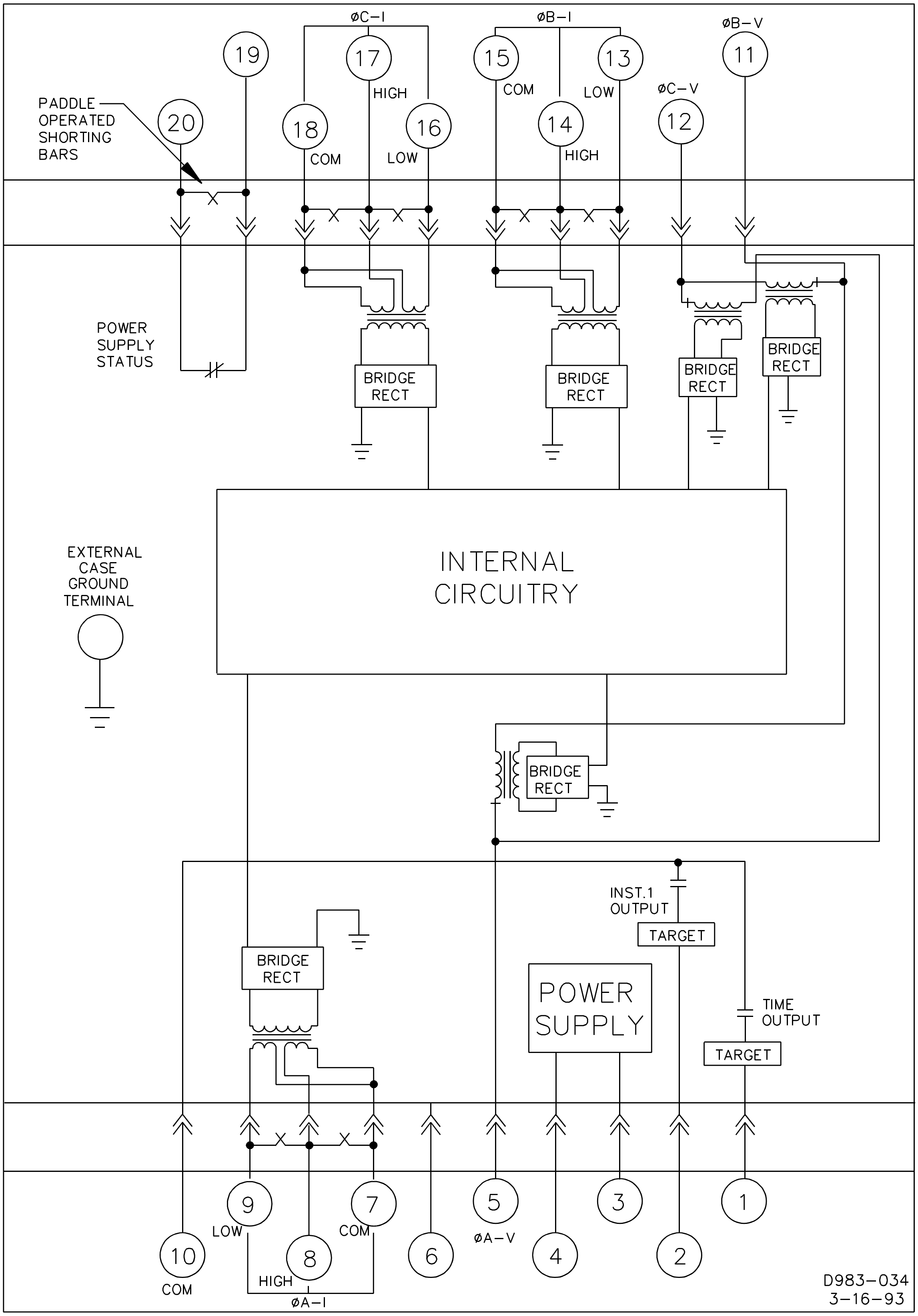


Figure 4-10. Typical Internal Diagram, Sensing Input Type B or C With Power Supply Status

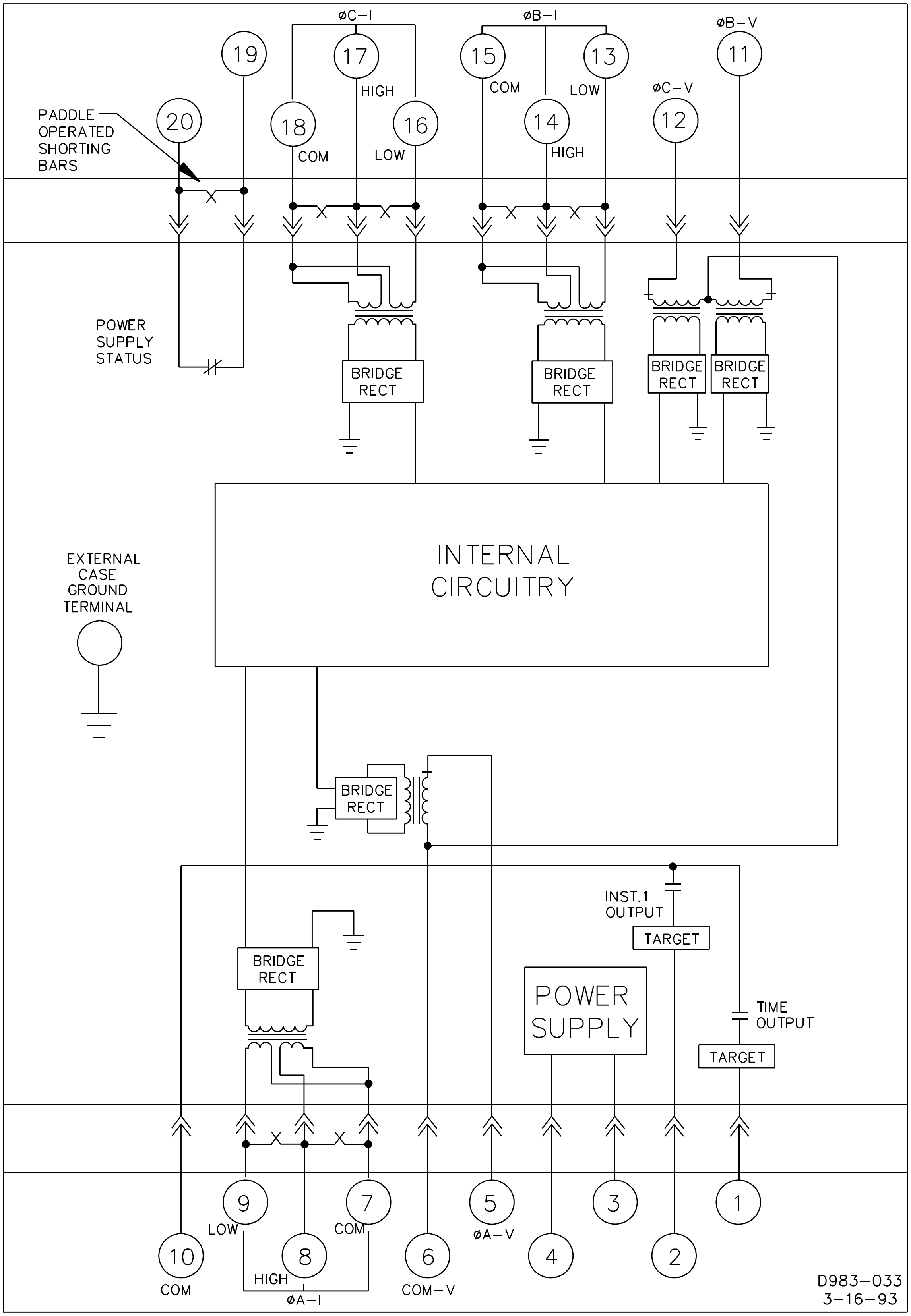


Figure 4-11. Typical Internal Diagram, Sensing Input Type R or S With Power Supply Status

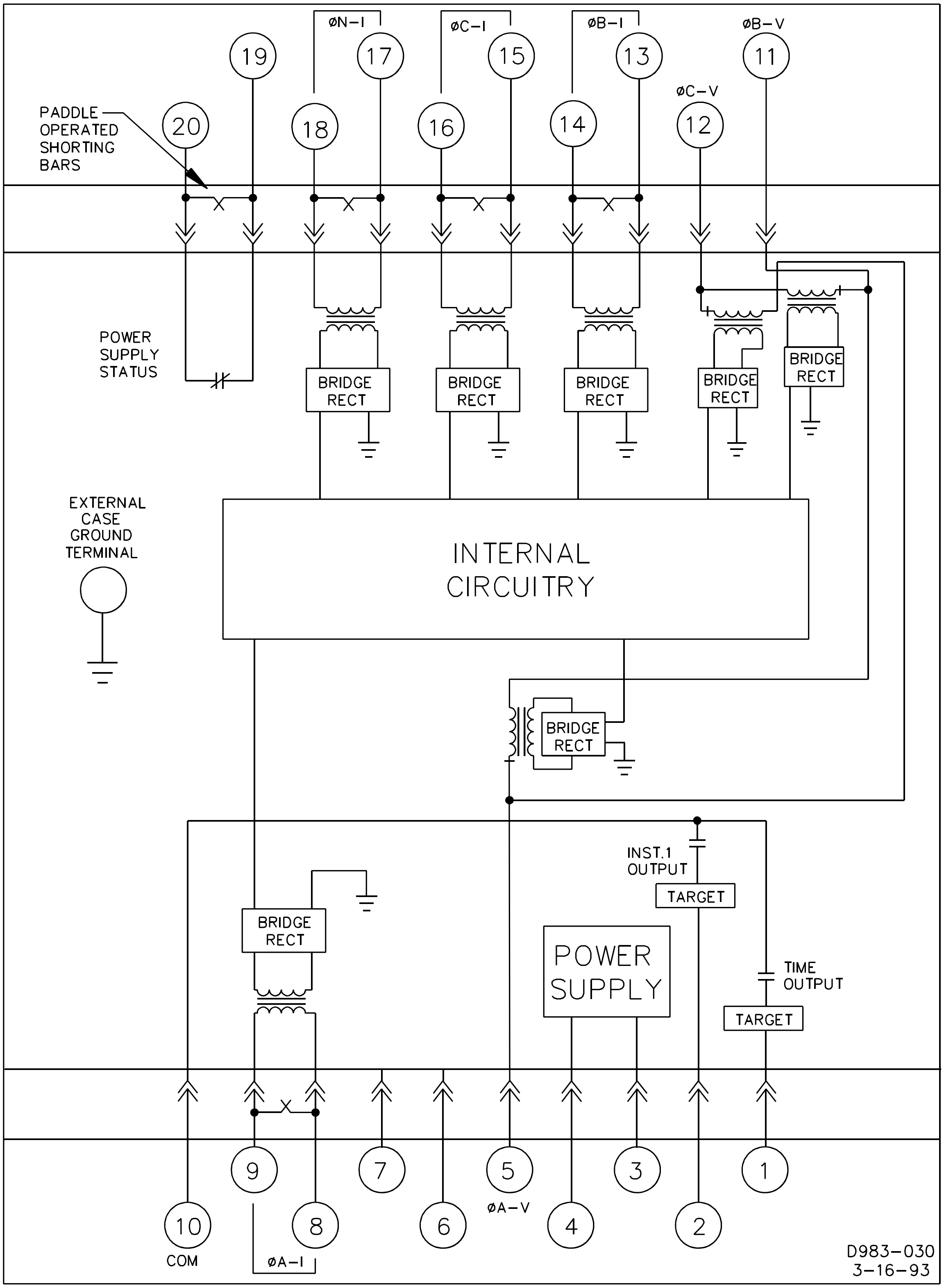


Figure 4-12. Typical Internal Diagram, Sensing Input Type E or F With Power Supply Status

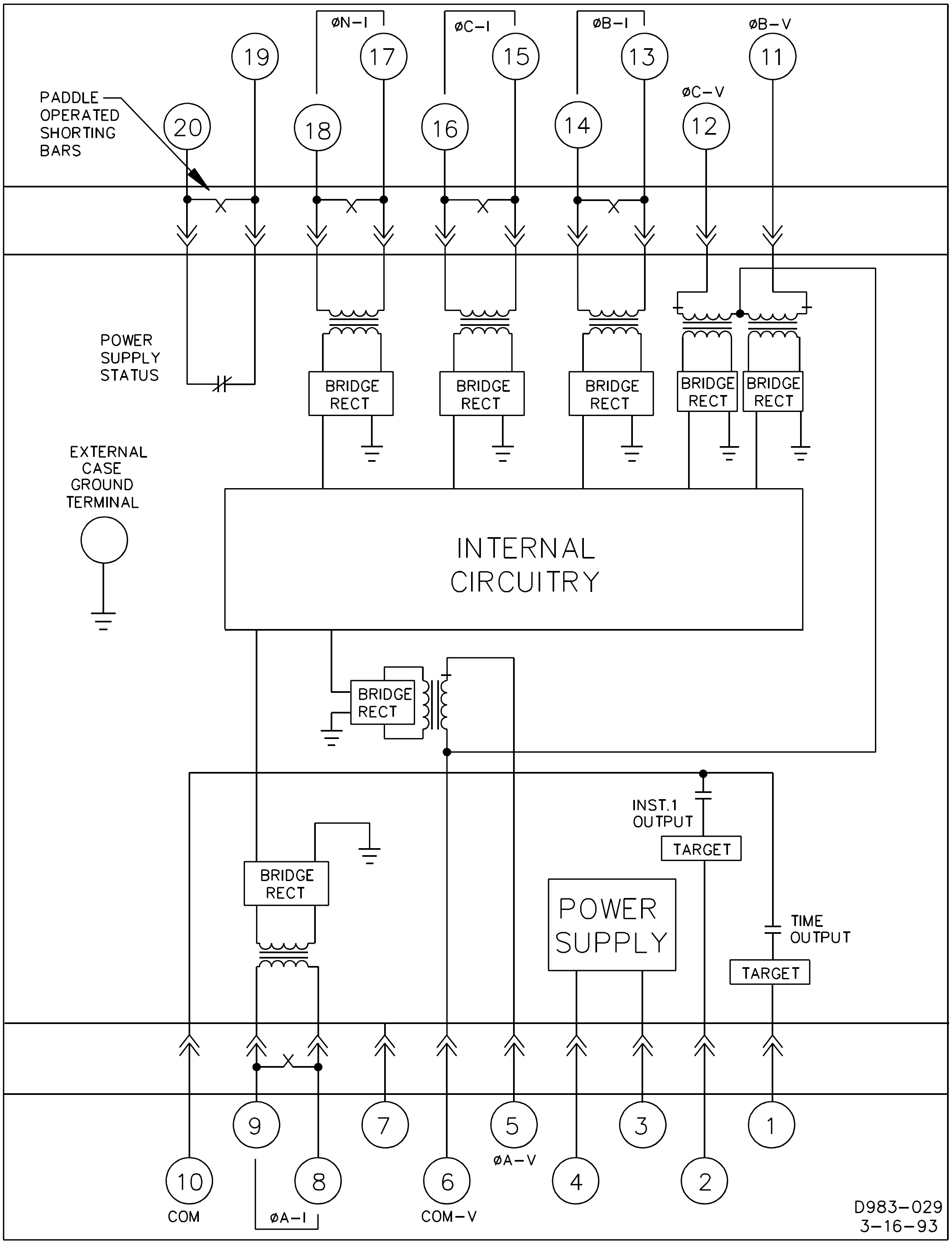


Figure 4-13. Typical Internal Diagram, Sensing Input Type U or W With Power Supply Status

SETTING THE RELAY

General

Phase time overcurrent elements (BE1-51/27R relays) can be coordinated with external protection in a conventional manner by assuming that the pickup current is 25 percent of nominal. This is the case when the restraint voltage is 25 percent or less. When the restraint voltage exceeds 25 percent, pickup current exceeds 25 percent of nominal and the relay is slower than if pickup current was fixed at 25 percent. Assuming a fixed 25 percent pickup simplifies calculations and provides an added safety margin because the BE1-51/27R relay is the last step in the coordination for an external fault.

Neutral (ground) time overcurrent and all instantaneous overcurrent functions operate independently of the voltage control circuits. Therefore, these elements (overcurrent functions) can be set in the normal manner. They are set independently of each other except that the instantaneous setting is 1 to 40 times the associated time overcurrent element pickup. The instantaneous element pickup should be set for at least 120 percent of the maximum current that can be seen by the relay for an external fault where operation is not desired.

Neutral time overcurrent pickup must be set above the maximum expected normal unbalance. Also, for residually connected elements, added relay current can result from dissimilar errors in the three current transformers. These errors are greater for the lower accuracy class current transformers. A neutral element pickup of ten percent of the circuit rating will ordinarily be above non-fault unbalances for a solidly grounded system. Lower settings are appropriate and safe for impedance grounded systems or for ungrounded protected equipment connections.

When choosing the time delay setting in a generator back-up application, for a motor starting application, or during acceleration after a fault is cleared, the limiting condition may be the percentage of generator rating that is motor load and not coordination for an external fault. The percentage of generator rating that is motor load needs to be considered when setting the relay.

A nominal phase time overcurrent pickup (with rated restraint voltage) of 200 percent of generator rating can prevent undesirable tripping during a severe recoverable swing. This pickup is still low enough to provide sufficient sensitivity for faults.

Relay Setting Concepts

Figure 4-14 plots fault current in multiples of generator rating (assuming no voltage regulator boosting) and relay pickup as a percent of nominal. The relay tap must be selected so that pickup in multiples of generator rating is less than the fault current shown in the Figure 4-14 example.

Restraint voltage (V) is proportional to the drop across external reactance (X_E), and decays along with the fault current (I) that is developed by the generator. Initial voltage is 40 percent of rated, so the phase time overcurrent pickup is also 40 percent of nominal. At about 0.04 seconds after fault inception, restraint voltage drops below 25 percent and the pickup current flattens to 25 percent. During the shaded portion of the graph, the relay operates slower than it would if the pickup current was constant at 25 percent of nominal. This occurs for a very small time interval compared to the total relay operating time, so the increased pickup has a negligible effect on operating time.

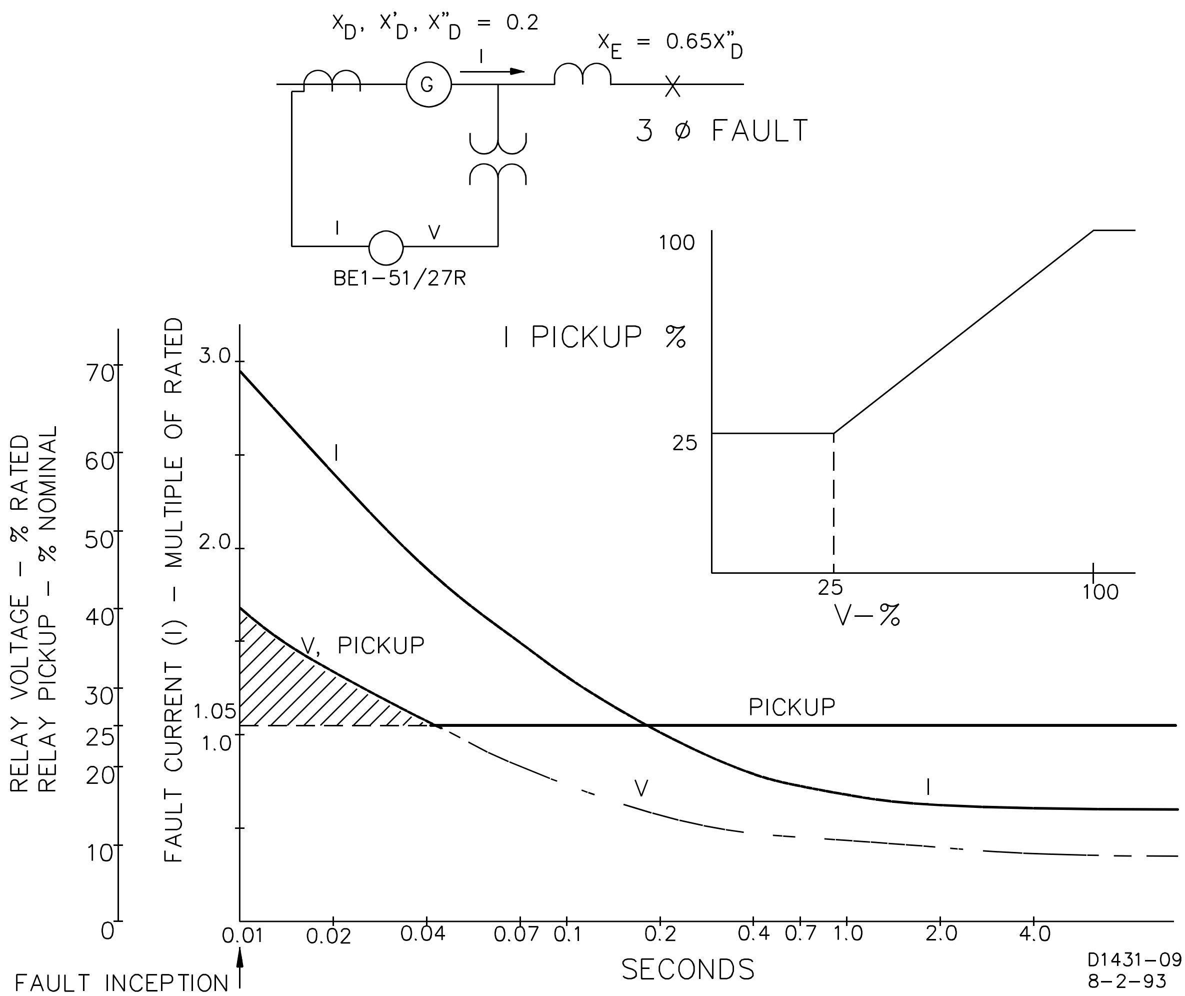


Figure 4-14. Relay Signals and Current Pickup Example For 3-Phase Fault (X_E = 0.65 X"$_D$)

Figure 4-15 shows an example similar to Figure 4-14, but the higher external reactance ($X_E = 2X''_D$) to the fault develops a higher restraint voltage. In Figure 4-15, the shaded area of the graph where pickup exceeds 25 percent of nominal is much larger than the shaded area in Figure 4-14. (This is the area where the relay operates slower.) If we assume a fixed 25 percent of nominal pickup current, a significant margin in the time coordination with external protection is added, although the log scale tends to exaggerate this effect.

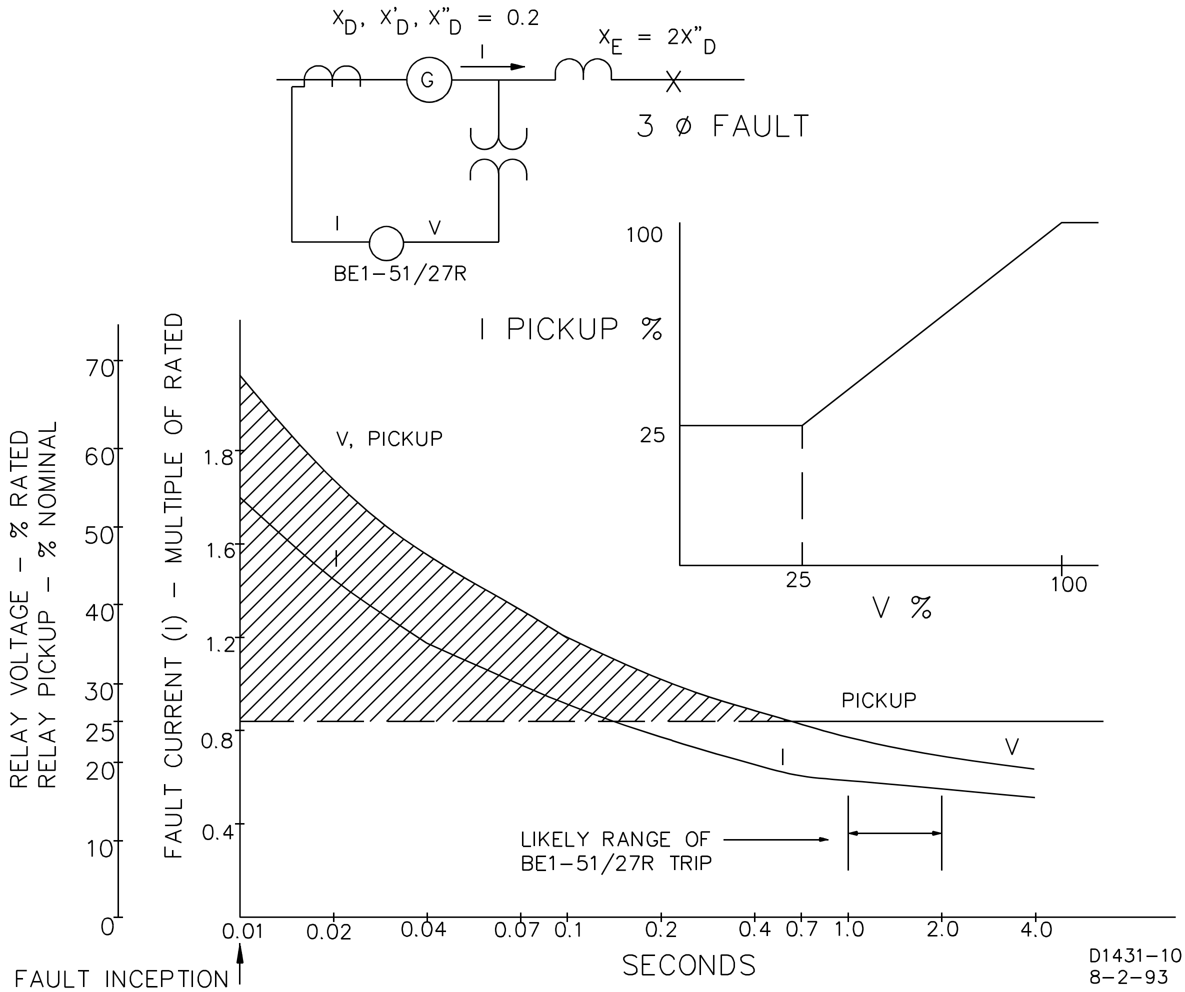


Figure 4-15. Relay Signals and Current Pickup Example For 3-Phase Fault ($X_E = 2 X''_D$)

Setting Example

Figure 4-16 illustrates generator relay elements that are to be set in this example. Plant 11 kV feeders are supplied by a 115 kV system that is supplemented by two local 3700 kVA generators. Line 1 is illustrated completely; line 2 is the same as line 1 and only shows major components. Settings are provided for the BE1-51/27R Time Overcurrent Relay with voltage restraint, BE1-51 Time Overcurrent Relay, and BE1-67 Phase Directional Overcurrent Relay.

<u>*Generator Backup*</u>	BE1-51/27R (51/27), relay style number, U3E B6S B2C0F
(Breaker A)	3-phase and neutral overcurrent
	1.5 to 12A phase (instantaneous trip is out of service)
	0.5 to 4A neutral (instantaneous is in service)
	Very inverse timing
	300/5 CTs

Feeder	BE1-51 (51)	
(Breaker F)	0.5 to 12 A	
	Very inverse timing	
	800/5 CTs	
	No instantaneous	
	Pickup set to 6 A	
	Time Dial set to 08	
Phase Directional	BE1-67, (67)	
Breaker L)	Definite timing (B3)	
	0.5 to 12 A	
	3000/5 CTs	
	Pickup set to 0.5 A	
	Time Dial set to 02	
Generator Reactance	Subtransient	0.18
(Per Unit)	Transient	0.25
	Steady state	1.5

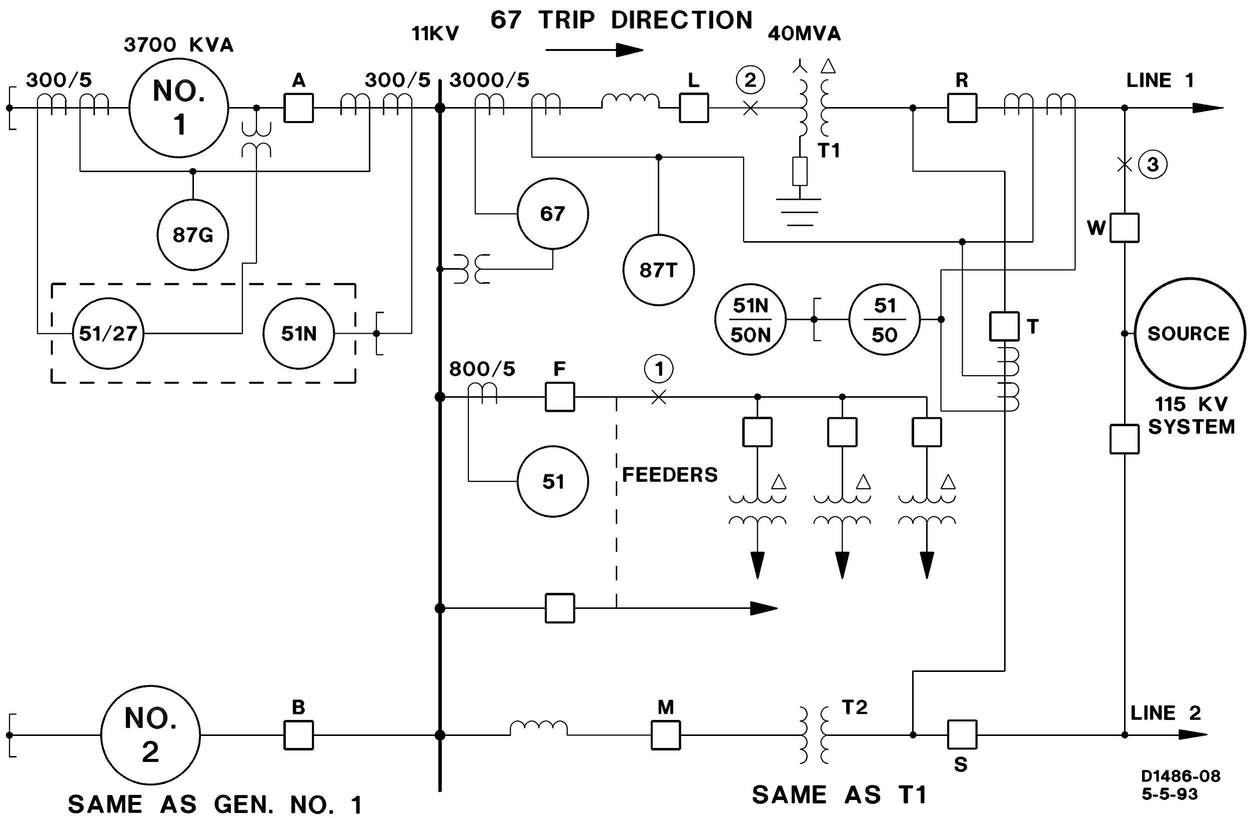


Figure 4-16. Setting Example

Downstream current in Table 4-1 is the current in the downstream relay with which the BE1-51/27R elements must coordinate. The currents are the changes resulting from the fault assuming a driving point voltage of 11 kV. Actual currents will be the sum of the table values plus the pre-fault load currents. Transient level currents are based on use of the generator transient reactance. Steady-state level currents are based on use of generator steady-state reactance and assuming no generator regulator boost. Note that the table values apply for 3-phase faults. Transient level currents in generators for a phase-to-phase fault will be about equal to the 3-phase current values. Steady-state level currents in the generators will be higher for a phase-to-phase fault.

Table 4-1. Three-Phase Fault Currents, -A @ 11 kV

Current Type	Out of Service	Fault Location	Downstream	Generator
Transient	T2	1	7256	776
Steady-State	T2	1	5961	129
Transient	-	2	7256	776
Transient	T2	2	1552	776
Steady-State	T2	2	258	129
Transient	-	3	713	713
Steady-State	-	3	127	127

Coordination With Feeder Relay 51 for Fault 1

Multiples of pickup in the 51 relay at transient level are: $\frac{7256}{\frac{800}{5}\times 6} = \frac{7256}{960} = 7.6$

Relay 51 time at 7.6 multiples (from B6 curves) @ 08 time dial: **0.31 seconds**.

Set 51/27 relay pickup: $\frac{1.75\times 3700}{11\times 1.73} = 340\ A\ Primary = \frac{340}{(\frac{300}{5})} = 5.7\ A\ Secondary$

Set 51/27 relay time to provide 0.3 seconds coordinating interval: $0.31\ plus\ 0.3 = 0.61\ seconds\ at\ 776\ A$

51/27 relay voltage = 0, so pickup = $0.25 \times 5.7 = 1.4\ A\ \ (84\ A\ Primary)$

51/27 multiples: $\frac{776}{1.4 \times \frac{300}{5}} = 9.2$

51/27 time dial (from B6 curve @ 9.2 multiple and 0.61 seconds): **23**.

Multiples of pickup in the 51 relay at steady state level are: $\frac{5961}{\frac{800}{5}\times 6} = 6.2$

51/27 time at 6.2 multiples: **0.36 seconds**.

51/27 multiples at 129 A: $\frac{129}{1.4 \times \frac{300}{5}} = 1.5$

51/27 time at 1.5 multiples: **9.0 seconds**.

Relay 51/27 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 times calculated here. If the fault is not interrupted by the feeder breaker, the generators will be tripped at a time falling between 0.61 seconds and 9.0 seconds.

Checking Coordination With Relay 67 for Fault 2

67 multiples at transient level with T2 in service: $\dfrac{7256}{0.5 \times \dfrac{3000}{5}} = 24$

67 time at 24 multiples (B3 curve, 02 time dial): **0.15 seconds**.

67 multiples at transient level with T2 out of service: $\dfrac{1552}{300} = 5.2$

67 time at 5.2 multiples: **0.19 seconds**.

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 versus 0.19 seconds). However, as the current decays, the times converge and cross because the 67 relays pickup is 300 amperes versus 84 amperes for the 51/27 relays. (See calculation that follows for the steady state multiple of just 0.86 for the 67 relay.) 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 and any pre-fault load current will add to the fault current values. For a phase-to-phase fault, the decay will be less.

Steady state level calculation: 67 multiples at steady state level with T2 out of service: $\dfrac{258}{300} = 0.86$

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

Checking Coordination With Relay 67 for Fault 3

67 multiples at transient level with T2 in service: $\dfrac{713}{300} = 2.4$

67 time at 2.4 multiples (B3 curve, 02 time dial): **0.26 seconds**.

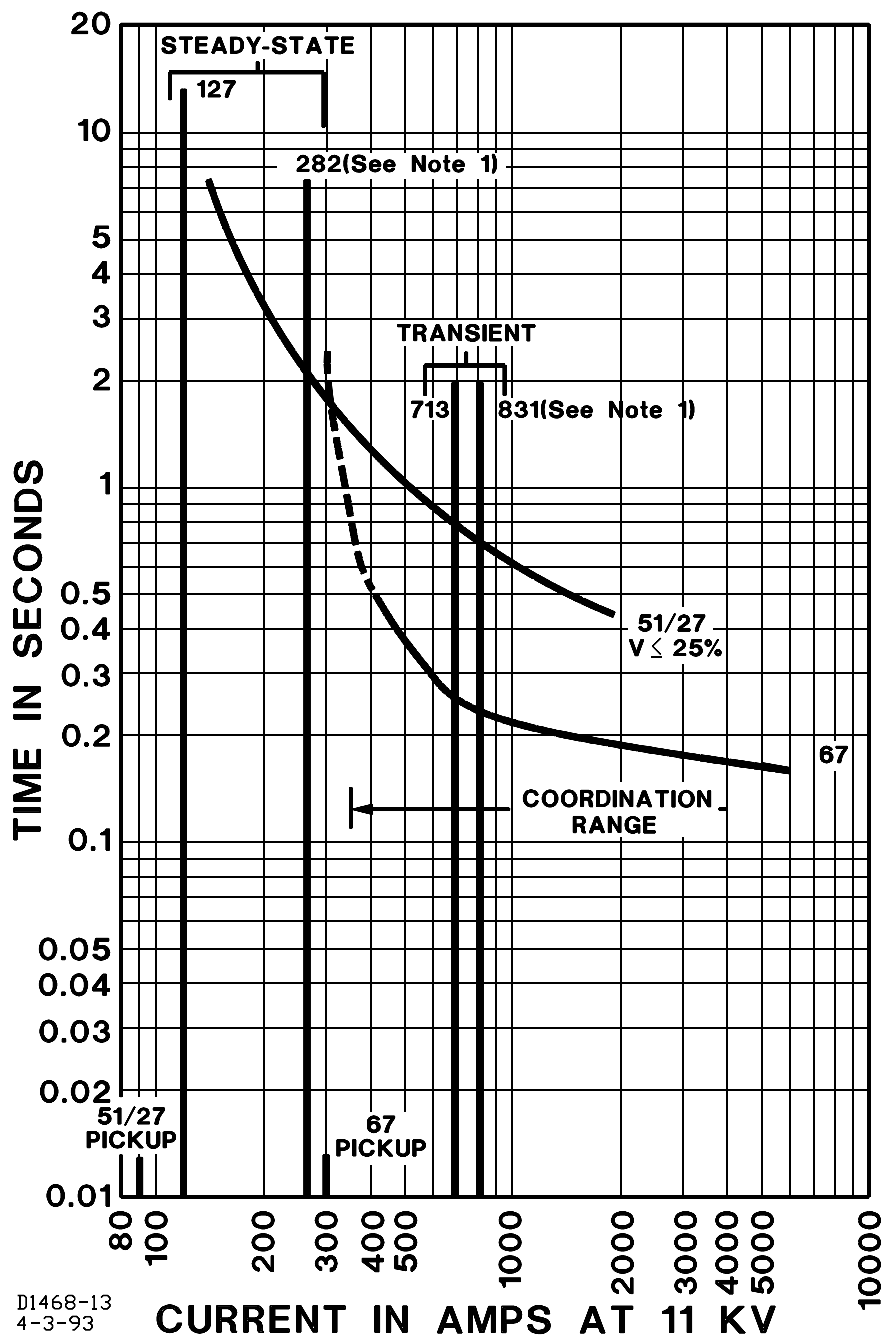
51/27 transient level voltage (reactor and transformer T1 drop): **8 %**.

51/27 multiples at transient level: $\dfrac{713}{5.7 \times 0.25 \times 60} = 8.3$

51/27 transient level time at 8.3 multiples: **0.7 seconds**.

51/27 relays coordinate with 67 relays for a high-side fault at the transient level. However, the current may drop below the 67 relays pickup (300 amperes) before this relay can operate. If the 67 relays fail to operate, the 51/27 relays will trip the generators. Figure 4-17 plots these characteristics. If the generator is fully loaded at 194 amperes with a 0.85 power factor, the superposition of this current and the fault current at minus 90 degrees 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.

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 at 0.25 seconds would avoid generator tripping for failure of breaker R to interrupt.



NOTE 1:

194 a @ -31.8°
(3700 kVA @
0.87 Power Factor)
Pre-Fault Load
Superimposed

Figure 4-17. Relay 51/27R Coordination With 67 Relay for Fault 3 In Figure 4-16

Neutral Element Back-up Settings

Because the generators are ungrounded, the 51N element of the BE1-51/27R relay has no relays to coordinate with. An instantaneous element, if used, must be set above the maximum false residual current that can be developed due to dissimilar CT saturation during an external three-phase fault. In a like manner, the time setting of the time overcurrent element must ride through this transient resulting from CT saturation.

Ground current contribution from each transformer is 485 amperes. Normal level is $2 \times 485 = 970A$.

Set neutral time element (51/27) for **0.8** amperes pickup.

Set time element (51N) at **0.2 seconds** for 970 ampere primary: $\frac{970}{60 \times 0.8} = 20\ \mathit{Multiples}:\ 08\ \mathit{timedial}$.

Set instantaneous (50N) pickup at 5 amperes $\frac{970}{300} = 3.2 \times (\mathit{relay\ pickup})$.

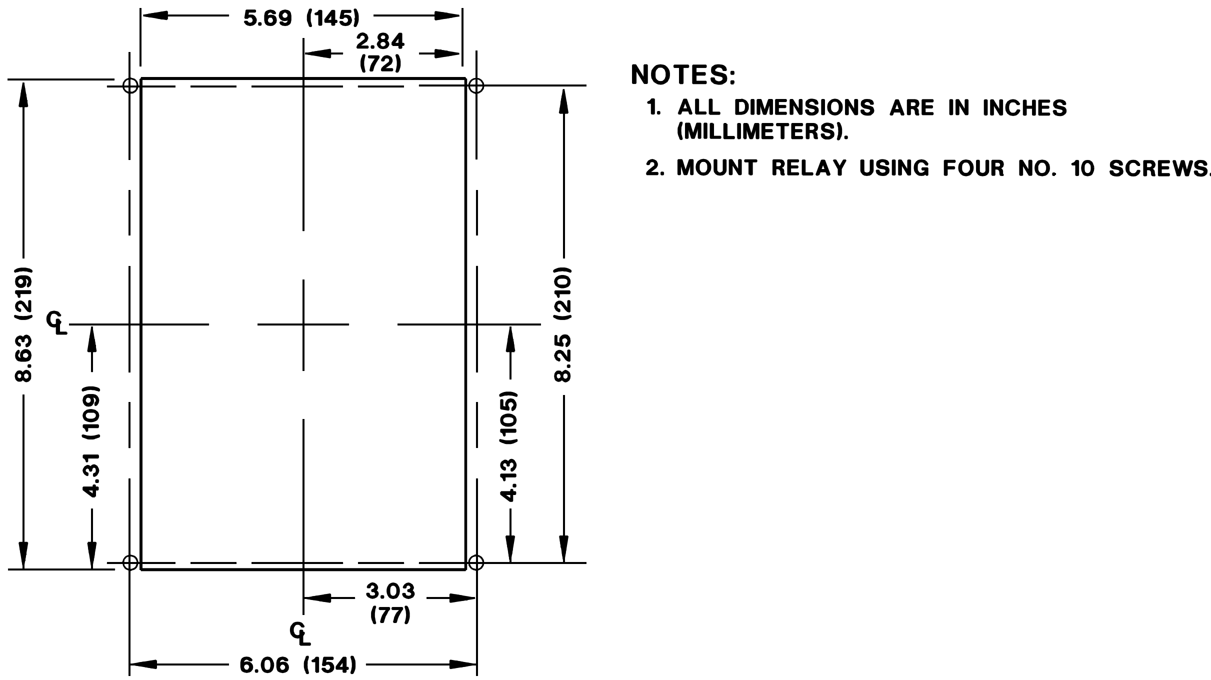


Figure 4-18. Panel Drilling Diagram, Semi-Flush Mounting

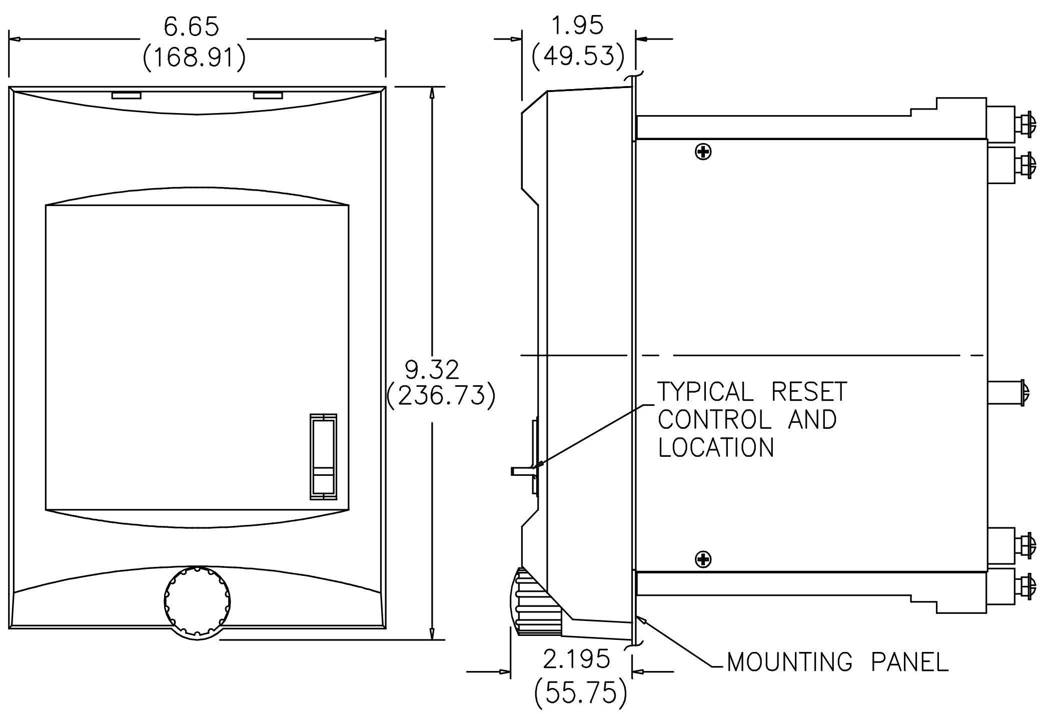


Figure 4-19. Outline Dimensions, Semi-Flush Mounting

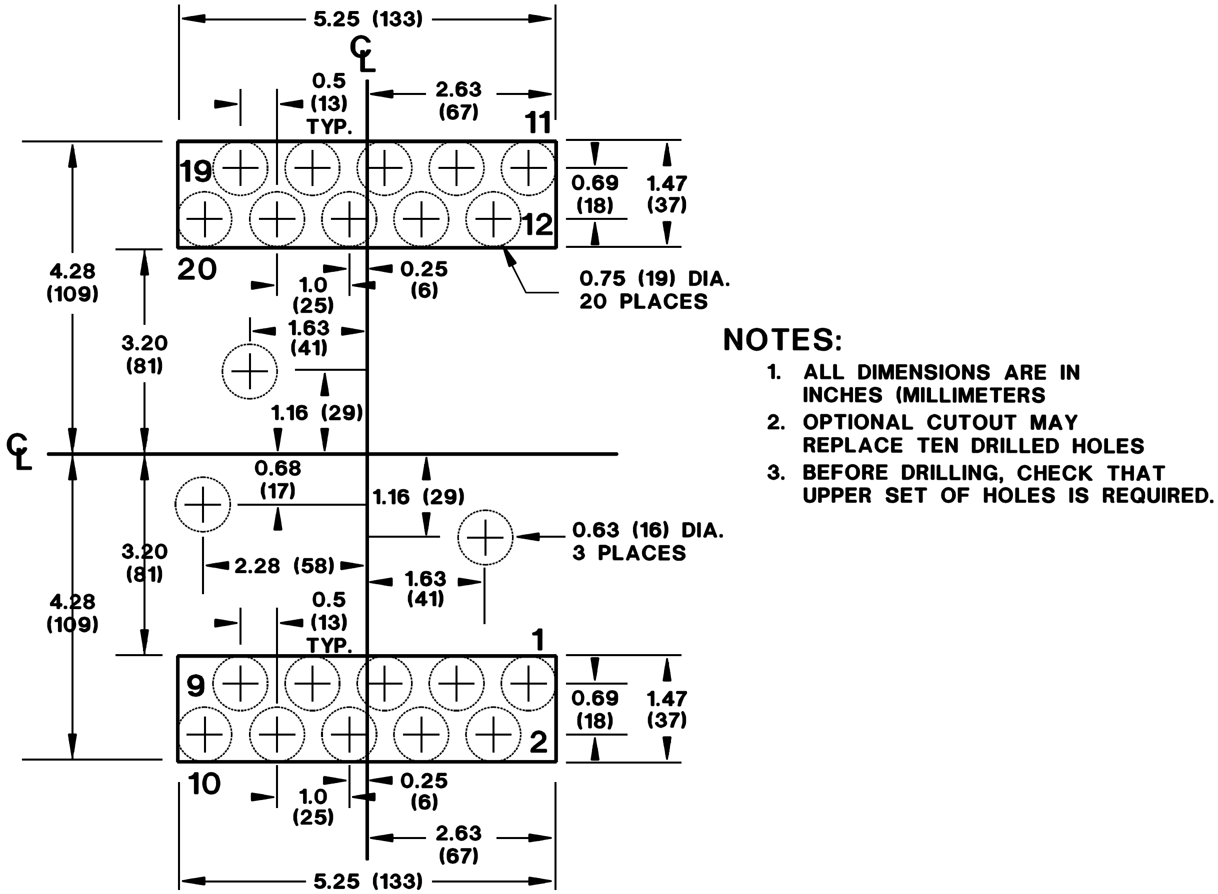


Figure 4-20. Panel Drilling Diagram, Projection Mounting, Rear View

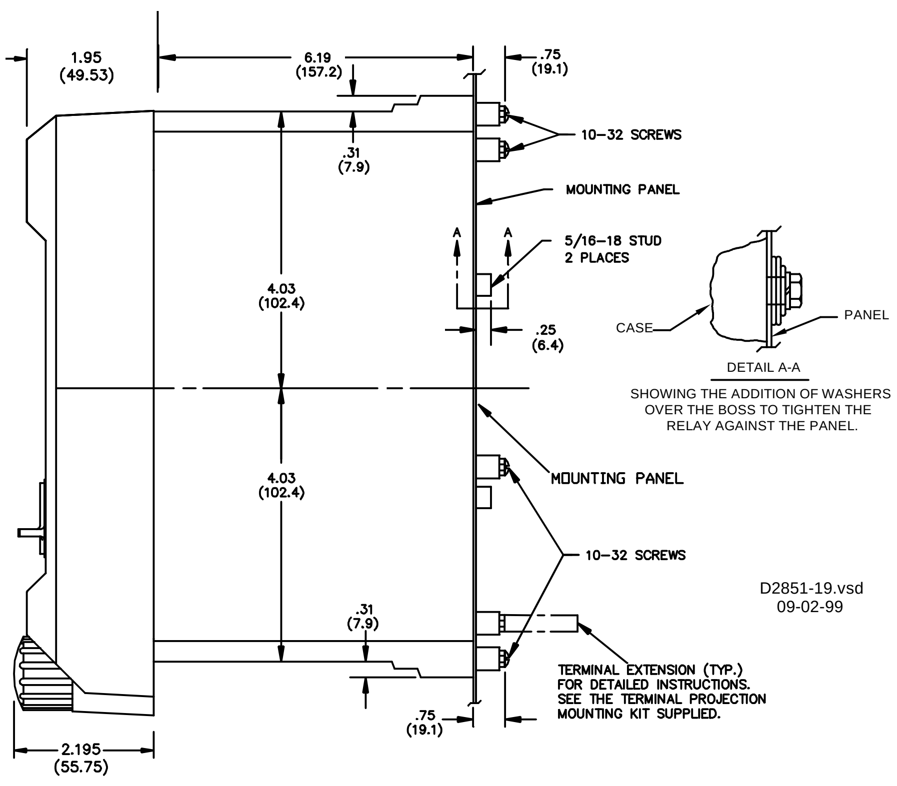


Figure 4-21. Outline Dimensions, Projection Mounting

SECTION 5 • TESTS AND ADJUSTMENTS

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.

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.

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 for your relay (See Figure 1-1, Style Number Identification Chart).

(a) *Sensing Input Type M or N (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 R or S (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 U or W (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 B or C (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 E or F (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 Y or Z (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 the front panel **TAP CAL** control, and if present, the front panel **TAP (NEUTRAL)** control fully CW.

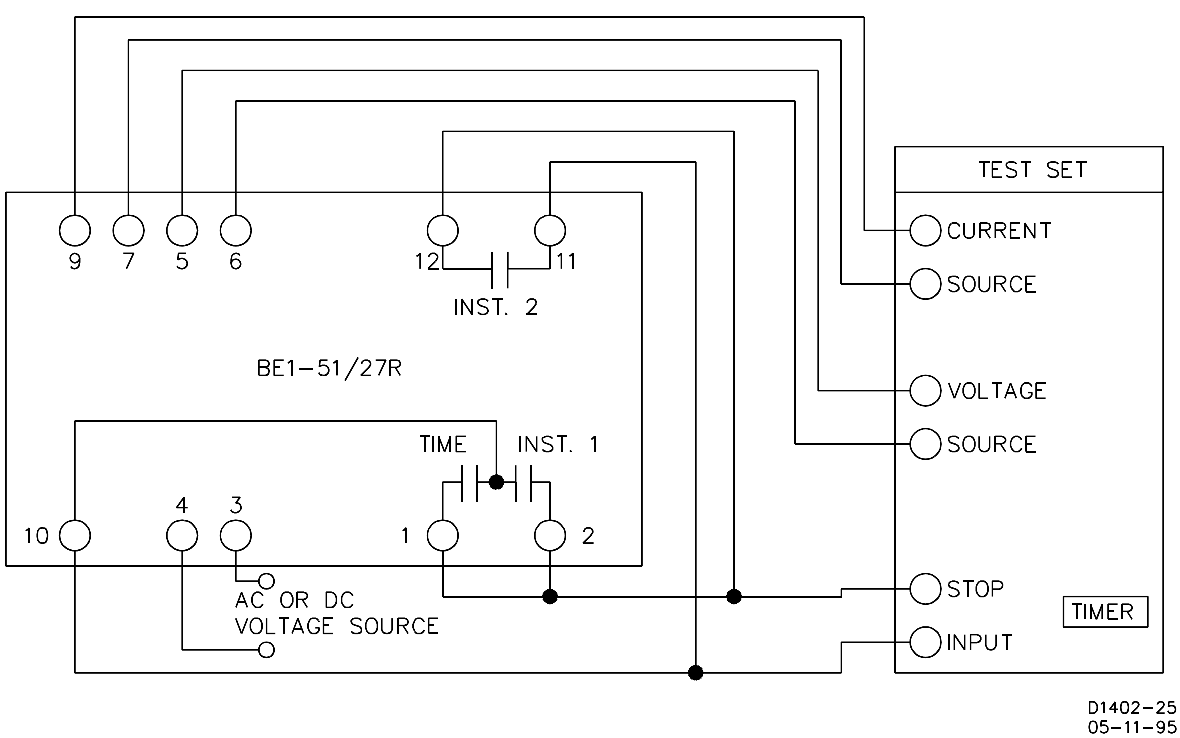


Figure 5-1. Test Setup for Sensing Input Type M or N (Single-Phase Sensing)

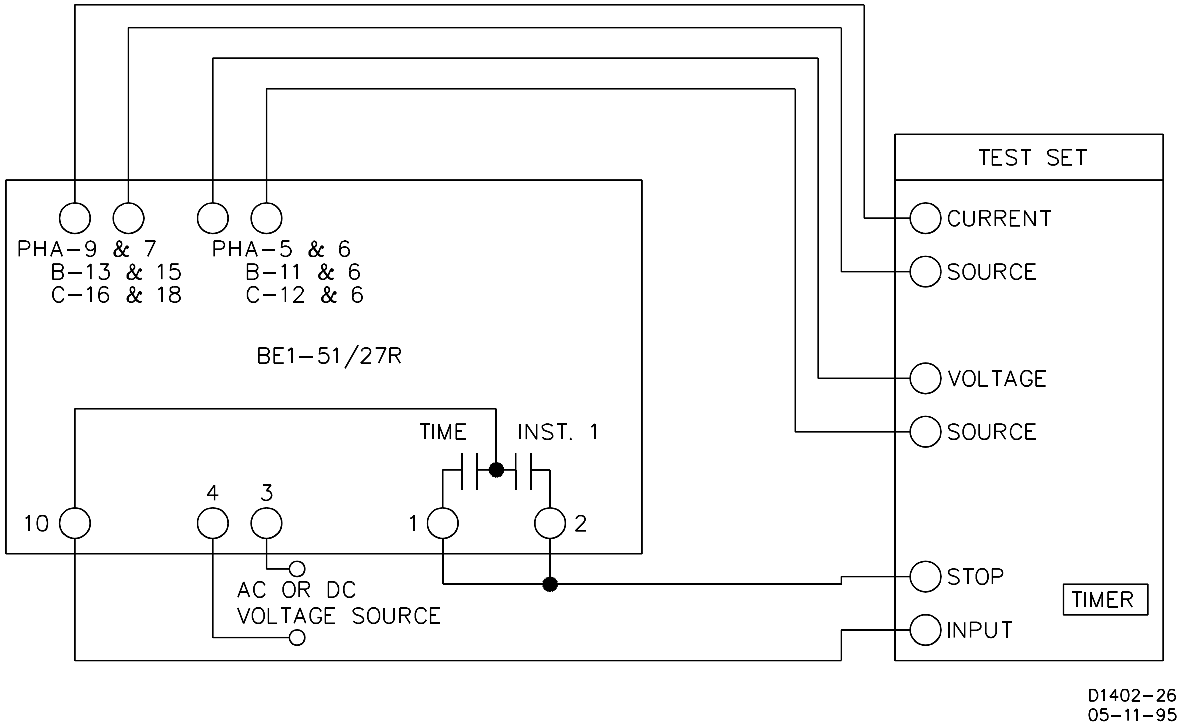


Figure 5-2. Test Setup for Sensing Input Type R or S (Three-Phase Sensing)

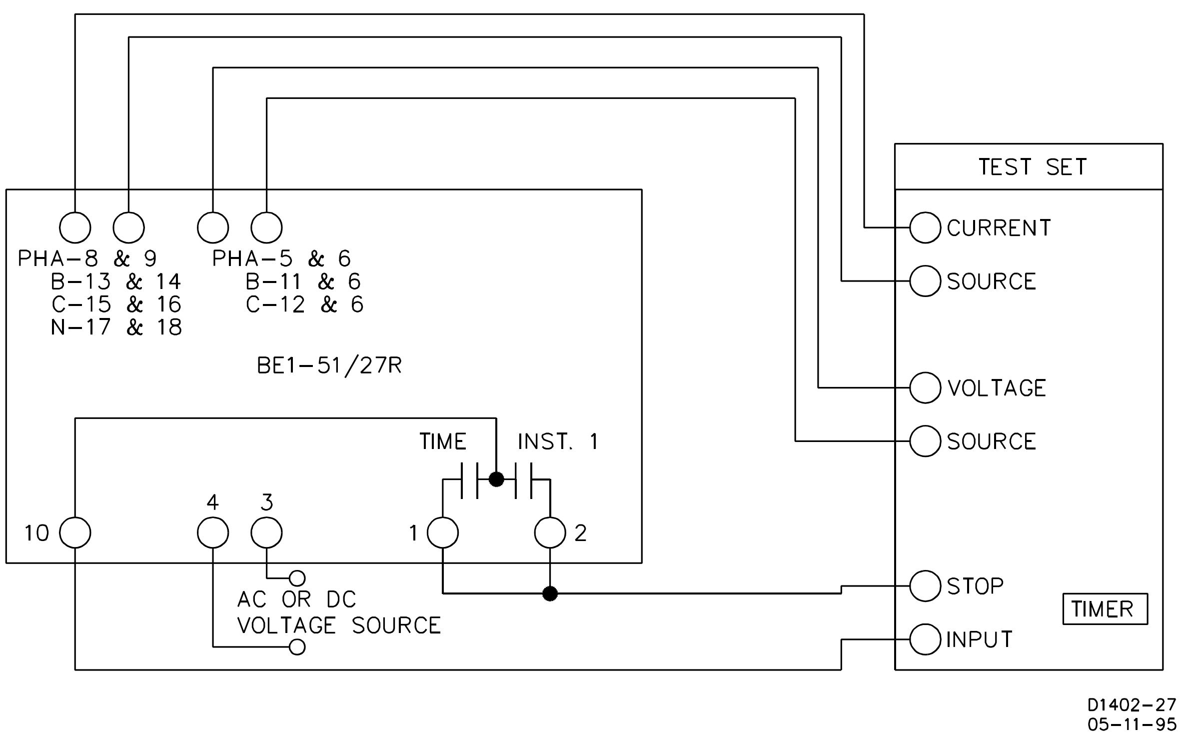


Figure 5-3. Test Setup for Sensing Input Type U or W (Three-Phase with Neutral Sensing)

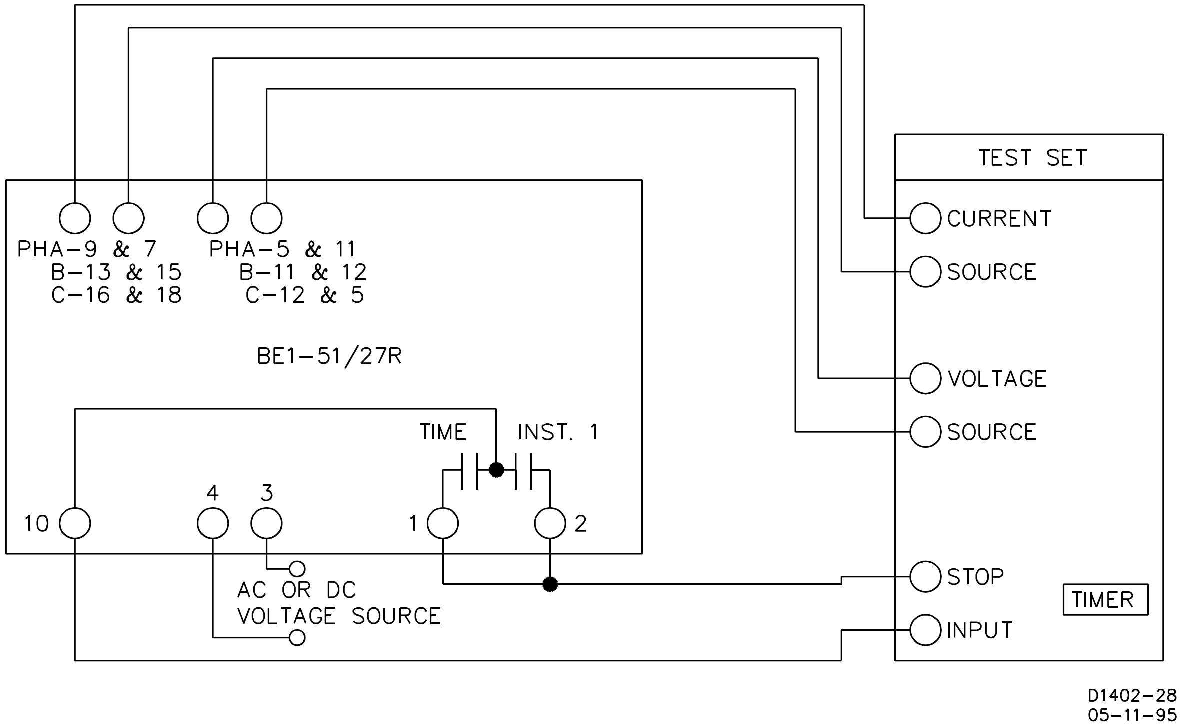


Figure 5-4. Test Setup for Sensing Input Type B or C (Three-Phase, Delta Configuration)

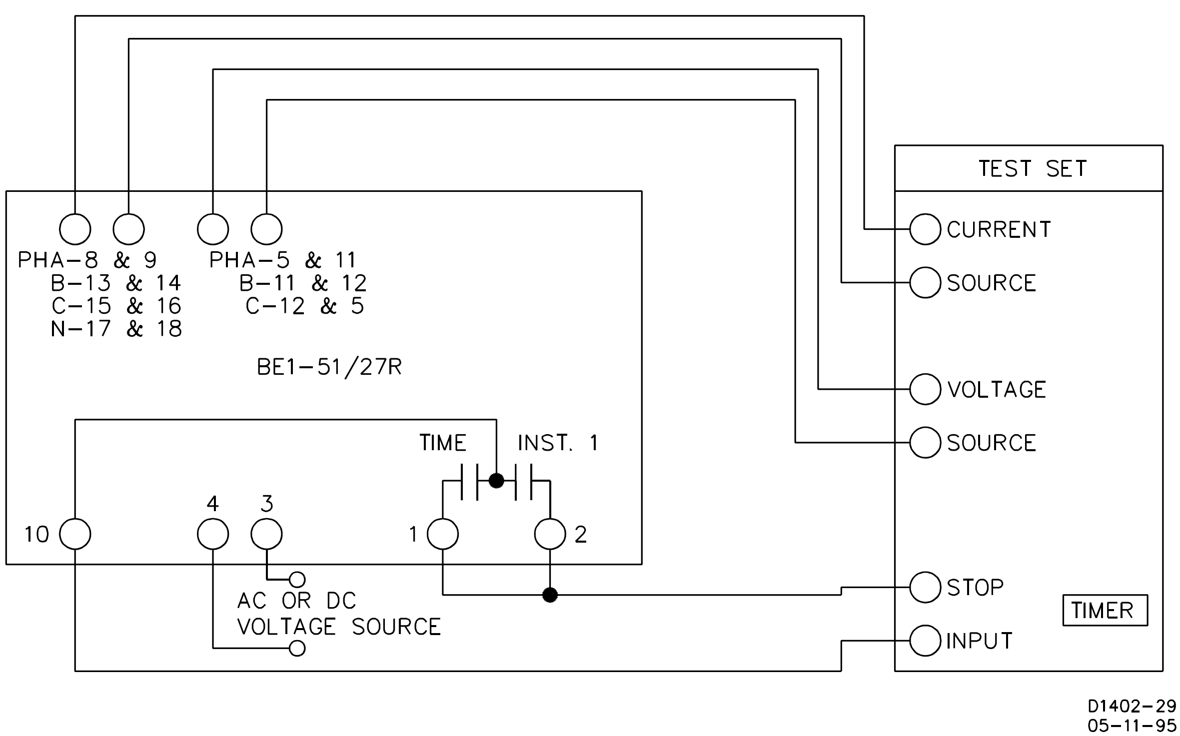


Figure 5-5. Test Setup for Sensing Input Type E or F (Three-Phase with Neutral Sensing)

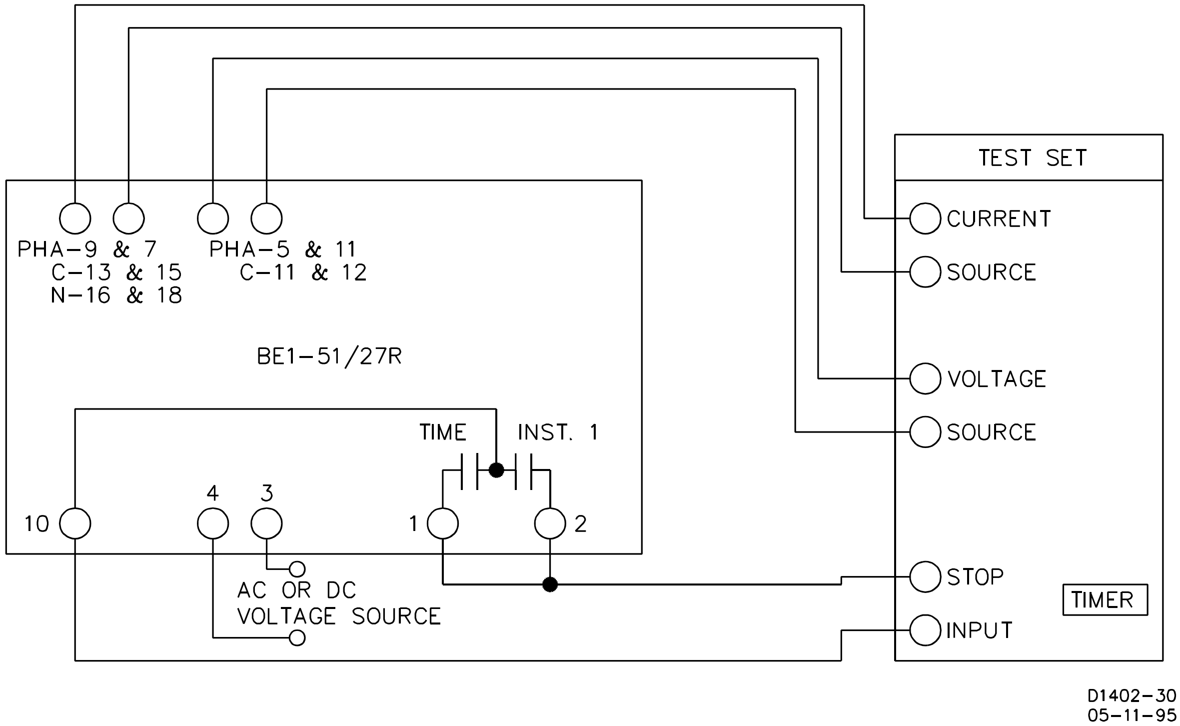


Figure 5-6. Test Setup for Sensing Input Type Y or Z (Two-Phase with Neutral Sensing)

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.

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 ±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 ±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 M or N (Single-Phase Sensing).* This concludes the time overcurrent test. Proceed to the timed output test.

(b) *Sensing Input Type Y or Z (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 B, C, R, or S (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 E, F, U, or W (Three-Phase with Neutral Sensing).* Remove the power and reconnect the input sensing to 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 ±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 ±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 B, C, R, or S) 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 E, F, U, N, Y, or Z), 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 ±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 B, C, E, F, R, S, U, W, Y, or Z) 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 types E, F, U, W, Y, or Z) perform Steps 11 through 20.
>
> For relays having single-phase or three-phase sensing (sensing input types B, C, M, N, R, or S) with instantaneous overcurrent option 1-1 or 1-2: Proceed to the instantaneous overcurrent test. All other relays proceed to the voltage restraint 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 1-70), locate the line representing 5 times the tap value (from Step 5) where it intersects the particular curve representing the front panel **TIME DIAL (NEUTRAL)** setting of 20 (from Step 14). The resulting time delay value in seconds should be within ±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 the voltage restraint 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 B, C, R, or S) 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 E, F, U, W, Y, or Z), 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 E, F, U, W, Y, or Z) perform Step 12. For relays with option 1-2 (inst 2 elements), perform Step 13. Otherwise, the test ends here.

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).

Step 13. Reconnect the test setup to the inst 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 Restraint Test

This test checks the overcurrent pickup points at 50 and 100 percent of nominal voltage levels.

Step 1. Perform the preliminary instructions.

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

Step 3. Verify that test voltage is 100% of nominal voltage based on the sensing input type for your relay.

Step 4. Slowly increase the input current from 0 until the appropriate phase timing indicator just illuminates.

RESULT: The overcurrent pickup point should be 100 ±5% of the front panel setting.

Step 5. Apply 50% of nominal voltage based on the sensing input type for your relay.

Step 6. Slowly increase the input current from 0 until the appropriate phase timing indicator just illuminates.

RESULT: The overcurrent pickup point should be whichever is greater: 50 ±10% of the front panel setting or 50 mA (Sensing Input Ranges 1, 2, 3, 4, and 5) or 10 mA (Sensing Input Ranges 6, 7, 8, and 9).

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 ±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 M or N:* 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 Y or Z:* 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 B, C, R, or S:* 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 E and F, or U and W:* Refer to Figures 5-5 or 5-3. 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 B, C, M, N, R, or S.* 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 100 percent of nominal voltage for your relay and the test 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 E, F, U, W, Y, or Z), 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**
> 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 sides 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:

(Selected Pickup Point) - (Anticipated Input Overcurrent) = Overcurrent Difference from Pickup

Step 2. Set the front panel **TIME DIAL** 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 **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.

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 paragraph **TAP AND TAP (NEUTRAL) Selector Setting** (page 5-11).

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 E, F, U, W, Y, or Z), 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

GENERAL

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

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.

Replacement parts may be purchased locally. The quality of replacement parts must be at least equal to that of the original components. Where special components are involved, order these parts 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.

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.

TEST PLUG

Test plugs (Basler 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.

SECTION 7 • MANUAL CHANGE INFORMATION

SUMMARY AND CROSS REFERENCE GUIDE

This section contains information concerning the previous editions of the manual. Substantive changes in this manual to date are summarized in Table 7-1.

Table 7-1. Changes

Revision	Summary of Changes	ECA/ECO	Date
-	Separated the BE1-51/27C/27R Instruction Manual 9 1372 00 990 into individual instruction manuals. Those manuals are: BE1-51, 9 1372 00 997; BE1-51/27C, 9 1372 00 998; and BE1-51/27R, 9 1372 00 999.	13659	09-22-93
A	Enhanced the description of the B and C curves in Section 1. Changed *Specifications*: *Time Overcurrent Pickup Accuracy; Time Overcurrent Dropout Ratio*, and *Isolation*. Added formula for pickup current and Chart 1-1, *Instantaneous Response Time*. Corrected Table 1-3 and Figure 1-49. Corrected Table 2-2 and 2-4. Corrected Figures 5-1 through 5-6 and Test Procedures to reflect changes in the specifications. Added Section 7, *Changes*.	15096	05-12-95
B	Changed the manual to the current manual style. Added the new information on wide range power supplies and case covers. Changed *Specifications,* Accuracy, Page 1-10 and Isolation, Page 1-11. Corrected Figure 1-51 and Table 2-4. Deleted Figures 4-8 and 4-9, and references to the Service Manual (obsolete) in the Introduction and Section 6.	5870	09-03-99