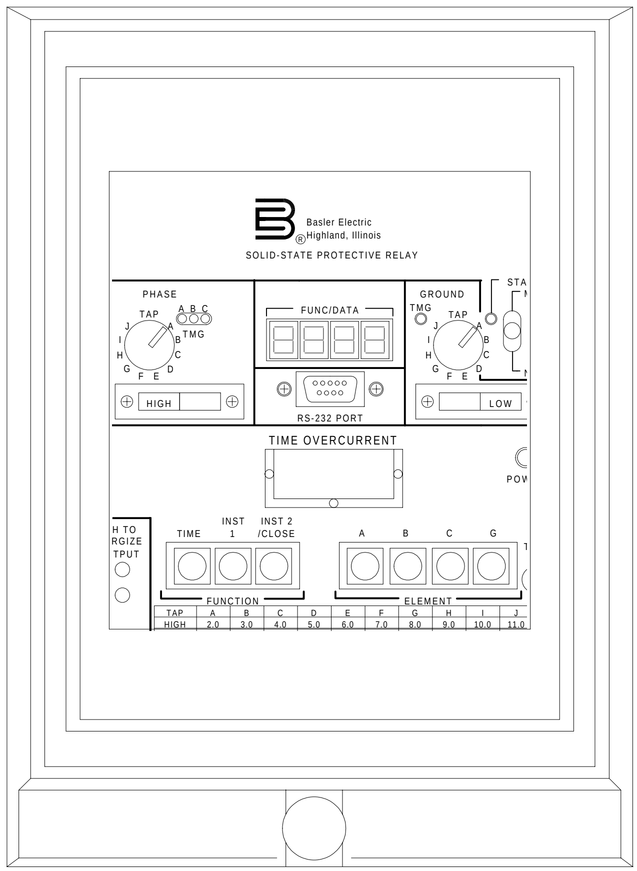
INSTRUCTION MANUAL

FOR

COMMUNICATIONS OVERCURRENT RELAY

MODEL BE1-51C



Basler Electric
Highland, Illinois

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INTRODUCTION

This manual provides information concerning the operation and installation of:

BE1-51C Communications Overcurrent Relay

Version 1.6

Software Revision 3.46

To accomplish this, the following is provided.

- Specifications
- Functional description
- Mounting information
- Operational Test Procedure

A Service Manual, publication 9 2330 00 620, is available on special order as an aid in troubleshooting and repair.

WARNING!
TO AVOID PERSONAL INJURY OR EQUIPMENT DAMAGE, ONLY QUALIFIED PERSONNEL SHOULD PERFORM THE PROCEDURES PRESENTED IN THIS MANUAL.

THIS MANUAL MAY BE USED IN PLACE OF ALL EARLIER EDITIONS. FOR CHANGE INFORMATION SEE SECTION 8.

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SECTION 1

GENERAL INFORMATION

DESCRIPTION

The BE1-51C Communications Overcurrent Relay is a microprocessor based time overcurrent relay designed for easy incorporation into a computer managed power system. It is available in a number of styles to supply single-phase, two-phase-with-neutral, three-phase, and three-phase-with-neutral protection for power systems.

The relay provides for the incorporation of an optional communications board to interface with external devices via (typically) a systems-managing computer. The communications interface, when fully implemented, allows remote monitoring of circuit and breaker information in real time, the transmission of historical data, and remote control of operating parameters.

APPLICATION

The BE1-51C relay is utility grade, and may be used for the protection of medium voltage electrical power systems. It is designed to monitor the outputs of standard (5 A secondary) current transformers and, when tripped, to close an output contact that may be used to trip a breaker.

The relay requires power for its internal circuits. A number of ac and dc supply voltage options are available for this purpose that match the usual ac or dc power used for tripping the circuit breaker.

TIME OVERCURRENT FUNCTION

Pickup

A coarse incremental adjustment of overcurrent pickup is provided by front panel rotary switches. One switch simultaneously sets the pickup point for all the monitored phases. If neutral is also monitored, a second rotary switch independently sets the neutral overcurrent pickup point.

A fine incremental adjustment that provides 99 intermediate pickup points between adjacent positions of the rotary switches is provided by entering data into the memory of the internal microcomputer.

Timing

A time delay is initiated when a pickup point is exceeded. When the current drops below pickup, the timing circuit is reset immediately. The amount of delay required before trip is a function of the overcurrent magnitude, the selected time curve, and the time dial setting.

One of eight time overcurrent characteristics may be selected for the monitored phases. These characteristics are graphically illustrated in Figures 1-2 through 1-9. If neutral current is monitored, its timing characteristic is independently selected. Selection of the timing characteristics is made at the front panel or via one of the two communications links.

After a characteristic is selected, it is adjusted to specific requirements by determining the appropriate TIME DIAL number. (These are the numbers in a vertical row along the righthand margins of Figures 1-2 through 1-9.) The TIME DIAL number (0 to 99) selects one of the 100 characteristic curves available for each characteristic type. (Only 14 of the 100 curves in the computer memory are shown on each graph because of space limitations.)

The selected TIME DIAL number is entered into the relay memory, again using either the front-panel data entry controls, or one of the two communications links. The available timing characteristics include one set of definite time curves, and seven different types of inverse time curves.

Trip and Reset

When the monitored current exceeds the overcurrent pickup point, the TMG LED illuminates and timing begins. The timing process continues until the interval calculated by the selected time overcurrent characteristic is completed (thereby tripping the associated output and target indicators), or until the sensed overcurrent drops below the pickup setting (which causes the timer to reset). In either case (trip or reset), the timing process is terminated. The TMG LED remains on after trip as an indication of contact closure, or extinguishes at reset.

Although a tripped BE1-51C relay resets immediately when the monitored current drops below the pickup setting, the target indicators remain tripped until manually reset at the front panel. (Power is required to reset the targets.)

INSTANTANEOUS OVERCURRENT OPTIONS

Two instantaneous overcurrent outputs can be incorporated. The pickup point of each is adjustable from 0.5 times to 20 times the time overcurrent TAP setting. When the sensed input current exceeds an instantaneous overcurrent pickup setting, the associated instantaneous output relay is energized. Also a target indicator is set to show that an instantaneous output was tripped. (On multi-phase relays, additional indicators denote the phase or neutral element which initiated the timing.)

The desired instantaneous overcurrent pickup values for phase and for neutral are entered via the data entry controls at the front panel. (This can also be done remotely by the data link if the communications option is present.)

COMMAND ACTUATED CLOSE (OUTPUTS)

Command actuated close is available on all outputs at version 1.6 and subsequent.

When two independent instantaneous outputs are incorporated, the INST2 can be programmed to serve instead as an output under the control of the (remote) system computer. An enabling requirement for computer authorized closure is that the breaker be open (i.e., the 52b contact is detected closed). After a closure is effected by the computer, the output contact stays closed until the breaker recloses (52b opens) or one second has elapsed.

Additionally, the timed and INST1 can be closed from computer control. This close time is limited to one second.

Note that a computer actuated output cannot be employed unless the Communications Board has been INSTalled in the relay (Option 2-C). Also, if a contact is programmed to serve the Command Close application, it cannot simultaneously serve as the INST2 trip output.

NEUTRAL TRIP SELECTIVITY

This standard feature of the BE1-51C allows the neutral element to be enabled or disabled on the timed and INST1 output. Alternatively, their functions can be shifted to the INST 2 output relay (functions are shifted when the affected output bit is set to a 1). This information is in register 65.

```
neutral flag    xxxx xxxx
                |||| ||||--neutral function active
                |||| |||----50g function active
                |||| ||-----51g function active
                |||| |-------affected output (0 = normal = TIMED and INST1, 1 = INST2)
```

Following are examples of the internal flags. When the setting is handled from the front panel, these flags are not available to the user. When the setting is from the computer, these flags are needed.

Partial list of examples (function 07 is identical to units version 1.5 and previous).

FLAG	DESCRIPTION
0000 xxx0	Neutral function selectivity completely disabled (same functionality as 07h)
0000 0011=03h	Neutral function enabled for 50 element Neutral function disabled for 51 element Functions incorporated into existing output relays (51, INST1)
0000 0101=05h	Neutral function enabled for 51 element Neutral function disabled for 50 element Functions incorporated into existing output relays (51, INST1)
0000 0111=07h	50g and 51g both enabled Neutral functions incorporated with phase functions (51, INST1) This is how BE1-51C/SCOR version 1.5 and previous functioned.
0000 1011=0bh	Neutral function disabled for 51 element Neutral function enabled for 50 element Functions removed from existing output relays and grouped into INST2 output relay
0000 1101=0dh	Neutral function enabled for 51 element Neutral function disabled for 50 element Functions removed from existing output relays and grouped into INST2 output relay
0000 1111=0fh	Neutral function enabled for 51 element Neutral function enabled for 50 element Functions removed from existing output relays and grouped into INST2 output relay

BREAKER FAILURE

This standard feature invokes a breaker failure function within the relay. If enabled (reg 68=01) the function occurs as follows.

The breaker failure function involves a 1 second timer. When a trip occurs, the timer starts. At timeout, two checks are made: one, that the breaker properly changed state, and two, that the current is below approx 10% of the tap value. If the results of either check is not correct, then a breaker failure has occurred.

The result of a breaker failure is an event in the event log. The event contains the timestamp and the breaker status (register 68). A sample of the breaker status in register 68 follows.

Reg 68 Breaker Status (This is a read/write register.)

```
xxxx xxxx
|||| ||||--spare
|||| |||---spare
|||| ||----spare
|||| |-----timeout without breaker change of state

||||-------phase a > 0.1 x tap
|||--------phase b > 0.1 x tap
||---------phase c > 0.1 x tap
|----------phase n > 0.1 x tap
```

COMMUNICATIONS OPTION

Ports

The communications interface (a plug-in board, Option 2-C) supports an RS-232 port on the front panel and an RS-485 port on the back of the relay case. (These are also known by the designations EIA-232 and EIA-485.) Both ports have equal access to the relay registers. When connection is made to the RS-232 port, the RS-485 port is disabled.

The RS-232 port is for relatively short range communication (under 50 feet). Its intended purposes are local testing and maintenance. (For RS-232 wiring connections, see Section 5.)

The RS-485 provides for intercommunication between the relay and a system-control computer over a shielded twisted pair at distances of up to 4000 feet. (For RS-485 wiring connections, see Section 5.)

System Considerations

The data and settings capability of the communications link includes:

Real-time data for amperes (each phase and neutral), and amperes demand (each phase). The monitored line current is expressed in primary quantities:

$$I_{MONITORED} = (I_{RELAY})(\text{system CT ratio}).$$

Relay status (normal/timing/tripped), and breaker position (open/closed).

Event record, with amperes prior to trip, timestamp, element which caused trip, and targets. The last 20 events are stored in the relay non-volatile memory.

MIN/MAX log, which contains the minimum and maximum values for polyphase current and polyphase demand current which have occurred since last cleared.

Selected setting data for phase and neutral, including time overcurrent function and curve selected, pickup settings, and primary current transformer ratio.

Whichever port is used, all communications must be initiated by the computer. When the computer addresses the relay, all of the relay storage registers may be read by the computer.

STYLE NUMBER

The style number of the relay determines the features to be included (or ordered) for a particular application. Each available option is represented by a character as shown in the Style Number Identification Chart (Figure 1-1).

Suppose, for example, it was decided that three-phase-with-neutral monitoring would be best for an application. Then the first character of the style number would be H.

The second character of the style number depends upon the range required for overcurrent pickup. For example, Sensing Input Range 1 would have a range of 2.0 to 11.0 A for each phase, and a range of 0.5 to 5.0 A for the neutral current.

Normally open (NO) output contacts for tripping the breaker are standard, so output Option E is the third character.

The fourth and fifth characters are Z5, representing switch selectable timing - standard on the BE1-51C relay. This feature allows the timing to be selected from any of the eight overcurrent timing functions illustrated in Figures 1-2 through 1-9.

The sixth character represents the most convenient source of operating power for the relay. If it is J, the internal power for the relay is derived from an external source of 125 Vdc or 120 Vac (nominal).

Since only one target configuration is offered, the seventh character is B. Note that all of the FUNCTION targets are current operated. Current operated targets are advantageous because they confirm that current did flow in the output circuit as the result of a trip. (Since the ELEMENT targets are not associated with any output contacts, they are internally operated.)

If one instantaneous overcurrent element is needed, the eighth character of the style number is 1; if two, the eighth character is 2. Alternatively, if the eighth character is 2 the second instantaneous overcurrent output contact can be programmed to function as an output that is externally controlled by computer.

The ninth character must be C to specify the communications board option. This allows communication with a remote computer or a local terminal.

The tenth character of the style number is always 0, and the last character always F. (These relays are always supplied in a draw out case for semi-flush mounting.)

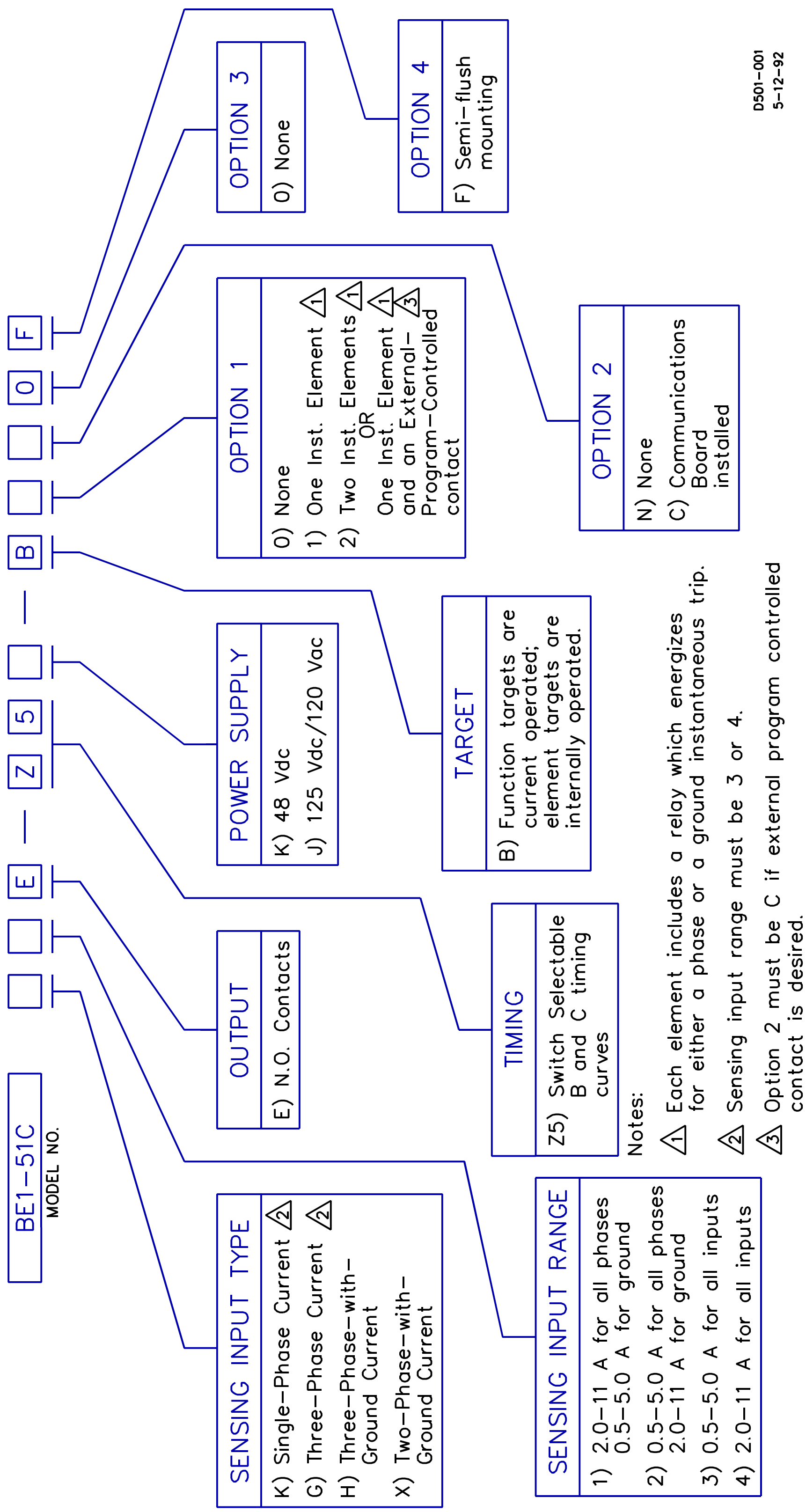


Figure 1-1. Style Number Identification Chart

BE1-51C SPECIFICATIONS

The BE1-51C relay is available in single-phase, three-phase, two-phase-with-neutral, and three-phase-with-neutral configurations, and with the following features and capabilities.

Current Sensing Inputs

The unit is designed to operate from the secondary of a standard current transformer rated at 5 A. The maximum continuous current rating for each input is five times tap or 20 A, whichever is less.

The one-second current rating for each input is 50 times tap or 500 A, whichever is less. Ratings at less than one second are calculated as:

$$I = \sqrt{\frac{K}{T}}$$

where
K = (500 A or 50 times TAP)^2
T = Time that current flows (in seconds)

Current Sensing Burden

Less than 0.1 ohm.

Frequency (nominal)

60 Hz.

Time Overcurrent

Pickup Ranges

Two ranges are available: HIGH (2-11 A), and LOW (0.5-5 A). Range is independently specified for phase and neutral by the second digit of the Style Number. The TAP range plate(s) on the front panel indicate which range (HIGH or LOW) is specified.

Pickup Adjustment

Incrementally adjustable over the selected range by a front-panel (TAP) selector switch (coarse), and by numerical data entered into the Tap Cal register (fine).

Pickup Setting Accuracy

The accuracy of the pickup setting is ±2% of the programmed setting over the full specified range of the relay at 60 Hz.

Pickup Repeatability

Within 2%.

Dropout Ratio

Better than 80% of the established pickup level within 50 milliseconds.

Instantaneous Overcurrent

Pickup Range

0.5 to 20 times the value of the time overcurrent pickup setting.

Pickup Setting Accuracy

The accuracy of the instantaneous pickup setting is ±2% of the programmed setting over the full specified range of the relay at 60 Hz.

Pickup Repeatability

Within 2%.

Dropout Ratio

Better than 80% of the established pickup level within 50 milliseconds.

Overcurrent Timing Characteristics

The relay incorporates all of the time overcurrent characteristics shown in Figures 1-2 through 1-9. Selection of a specific timing characteristic is accomplished by programmed INSTructions. Separate selections can be made for phase current and for neutral current.

Time Delay Accuracy

The time overcurrent delay will be within 5% or 40 milliseconds (whichever is greater) of the characteristic curves shown in Figures 1-2 through 1-9 for any combination of TIME DIAL and pickup setting at 25°C. The time delay will not vary more than ±5% over the temperature range of -40° to 70°C (-40° to 158°F).

Instrumentation Feature

Provision is made to monitor various input parameters (e.g., primary current) on a real time basis. Accuracy is within ±2%. Range is from 0.1 X TAP (at the low end) to 1.5 X pickup (at the high end).

Communications Option

Includes an RS-232 port on the front panel for testing and local programming, and an RS-485 port at rear of unit for operation by a systems computer at distances up to 4000 feet using baud rates up to 19,200.

Power Supply

Power for the internal circuitry may be derived from ac or dc external power sources as indicated in Table 1-1.

Table 1-1. Power Supplies

Type	Nominal Input Range	Input Voltage Range	Burden At Nominal (Maximum)
K	48 Vdc	24 to 60 Vdc	7.0 W
J	125 Vdc 120 Vac	62 to 150 Vdc 90 to 132 Vac	8.0 W 19.0 VA

Target Indicators

For Single-Phase Units

Current-operated targets are furnished for each of the tripping outputs included within the relay (e.g., TIME and instantaneous overcurrent functions). To trip, a current-operated target requires a minimum of 0.2 A in the output circuit of its associated output contact. This confirms that current has flowed through the relay output contacts and the external trip circuit.

For Multi-Phase Units

Includes the above plus an internally-operated target for each phase element (A, B, C, and/or neutral) which may initiate a trip.

Outputs

Output contacts are rated as follows:

Resistive

120/240 Vac — Make 30 A for 0.2 seconds, carry 7 A continuously, break 7 A.

250 Vdc — Make and carry 30 A for 0.2 seconds, carry 7 A continuously, break 0.3 A.

Outputs - Continued

500 Vdc — Make and carry 15 A for 0.2 seconds, carry 7 A continuously, break 0.1 A.

	<u>inductive</u> 120/240 Vac, Make and break 0.3 A (L/R=0.04). 125/250 Vdc
Shock	In standard tests the relay has withstood 15 g in each of three mutually perpendicular axes without structural damage or degradation of performance.
Vibration	In standard tests the relay has withstood 2 g in each of three mutually perpendicular axes, 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.
Isolation	1000 Vac at 60 hertz for one minute may be applied across output terminal pairs in accordance with IEC 255-5 and ANSI/IEEE C37.90-1989 (Dielectric Test). Maximum applied voltage must be no greater than 300 volts where MOV suppressors are used. Terminals 11 and 12 have MOV suppressors installed between terminals and ground. Terminals 3 and 4 have one MOV suppressor installed between the terminals. All terminals have decoupling capacitors installed between terminals and ground. According, a leakage current of approximately 2.0 milliamperes per terminal is to be expected when high potting at 1000 Vac, 60 hertz. 1500 Vac at 60 hertz for one minute may be applied across current sensing input terminals, between circuit groups, and between circuit groups and chassis ground in accordance with IEC 255-5 and ANSI/IEEE C37.90-1989 (Dielectric Test).
Surge Withstand Capability	Qualified to ANSI/IEEE C37.90.1-1989 *Standard Surge Withstand Capability Tests for Protective Relays and Relay Systems.*
Impulse Test	Qualified to IEC 255.
Radio Frequency Interference with **(RFI)**	Maintains proper operation when tested for interference in accordance IEEE C37.90.2-1989, *Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interference.*
Temperature	
<u>Operating</u>	-40° to 70°C (-40° to 158°F).
<u>Storage</u>	-65° to 100°C (-85° to 212°F).
Weight	14.8 pounds net.
Case Size	S1. (Dimensions are given in Figure 6-1.)
Certification	UL pending.

TIME OVERCURRENT CHARACTERISTIC CURVES

Figures 1-2 through 1-9 illustrate the characteristic curves that are programmed into the nonvolatile memory of this relay. A drawing number is given under each caption. Use this number to order a full-size (10 inch x 12 inch) Characteristic Curve graph.

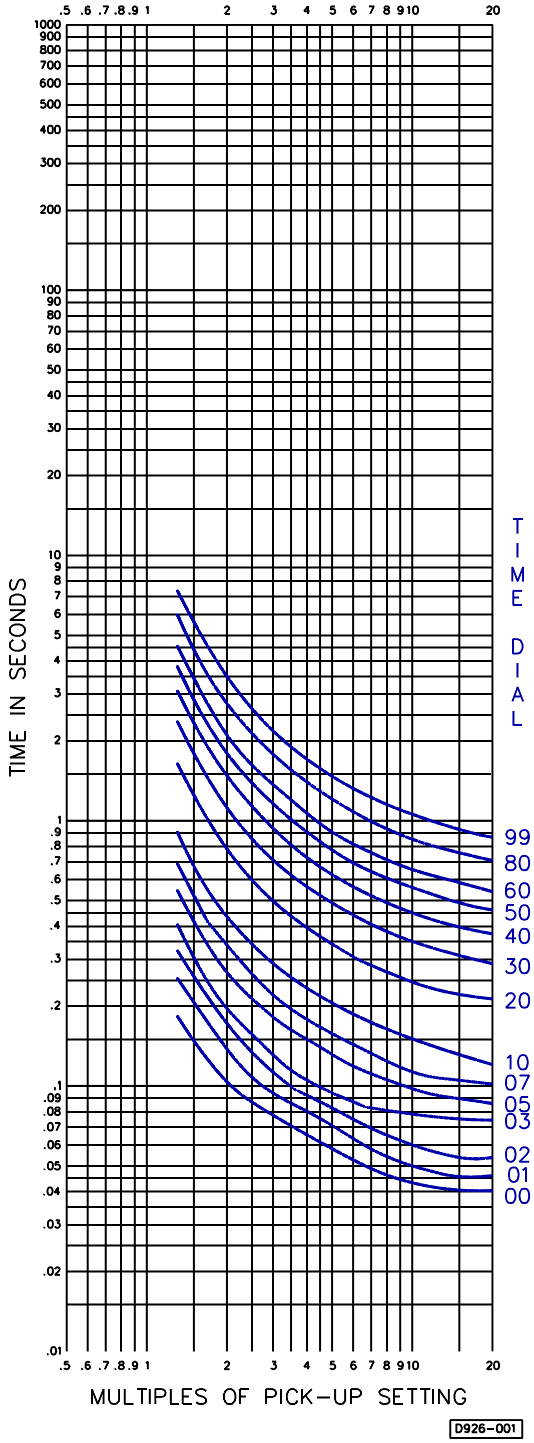


Figure 1-2. Timing Option B1, Short Inverse (99-1250)

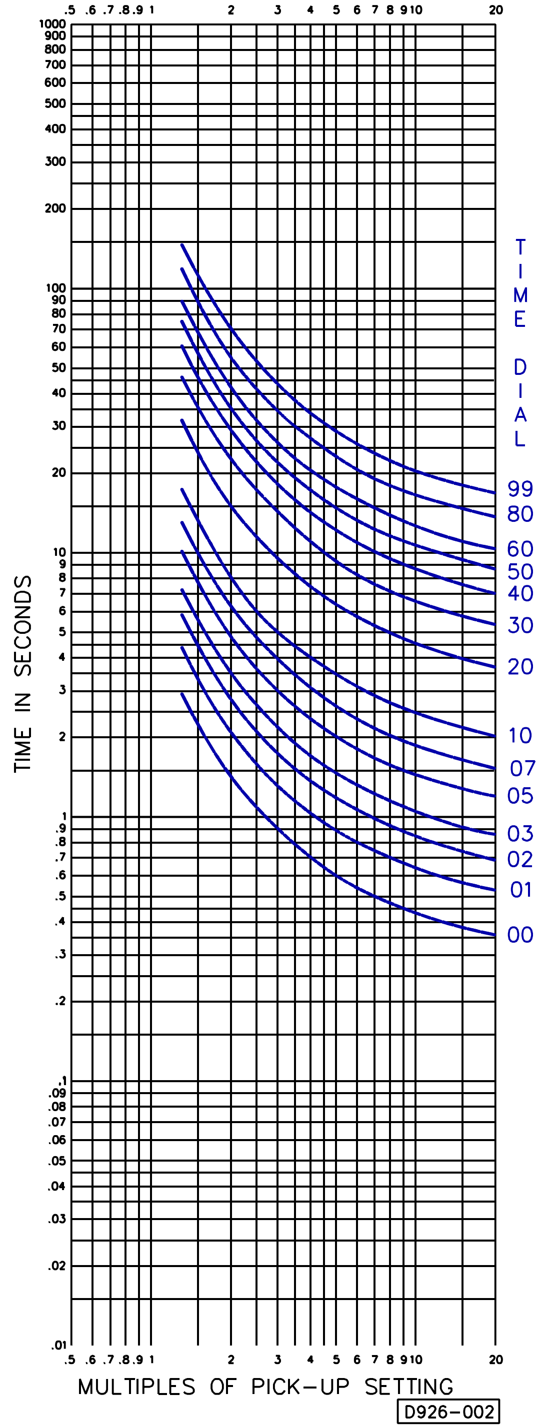


Figure 1-3. Timing Option B2, Long Inverse (99-1251)

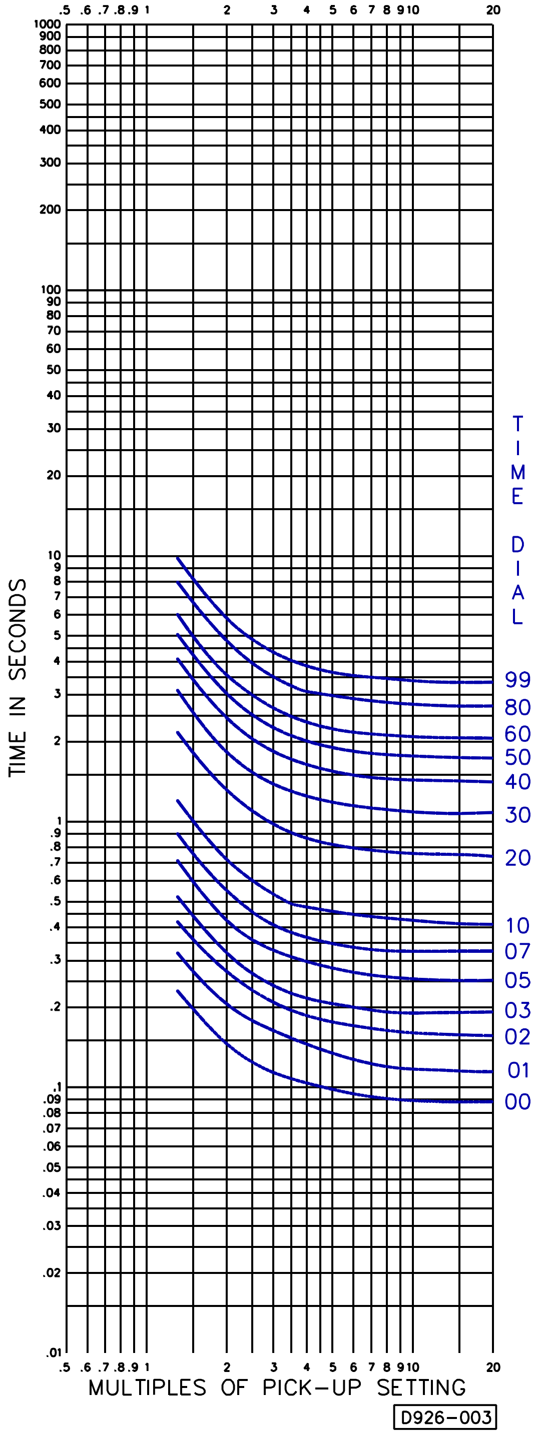


Figure 1-4. Timing Option B3, Definite Time (99-1252)

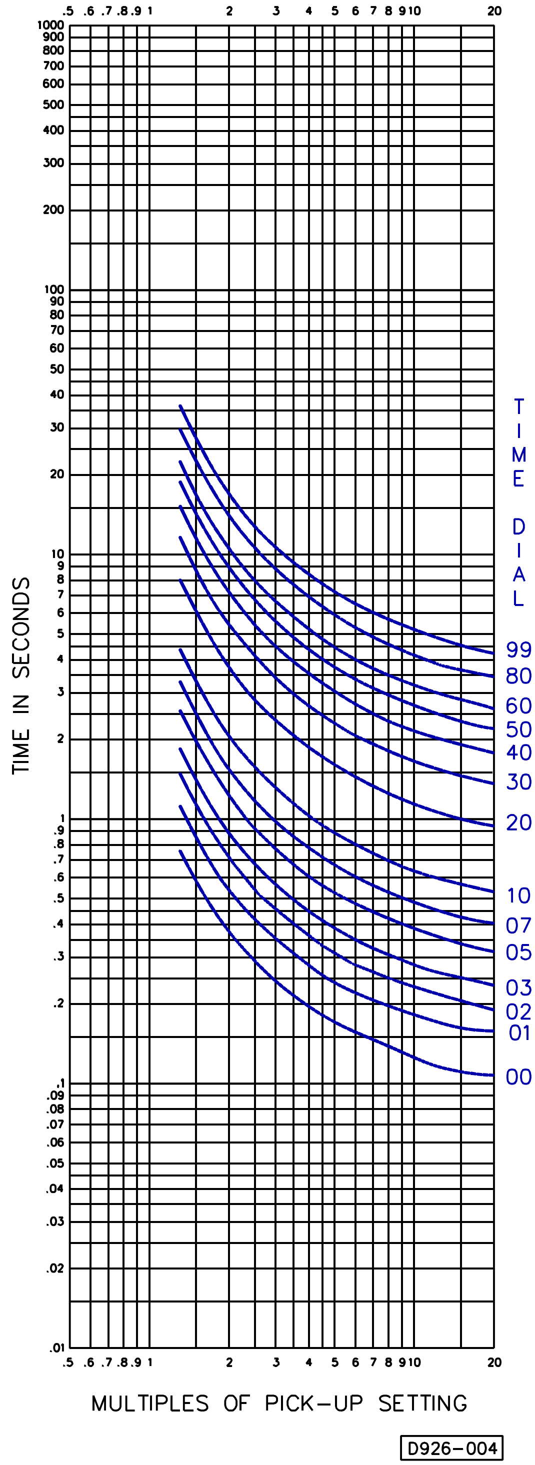


Figure 1-5. Timing Option B4, Moderate Inverse (99-1253)

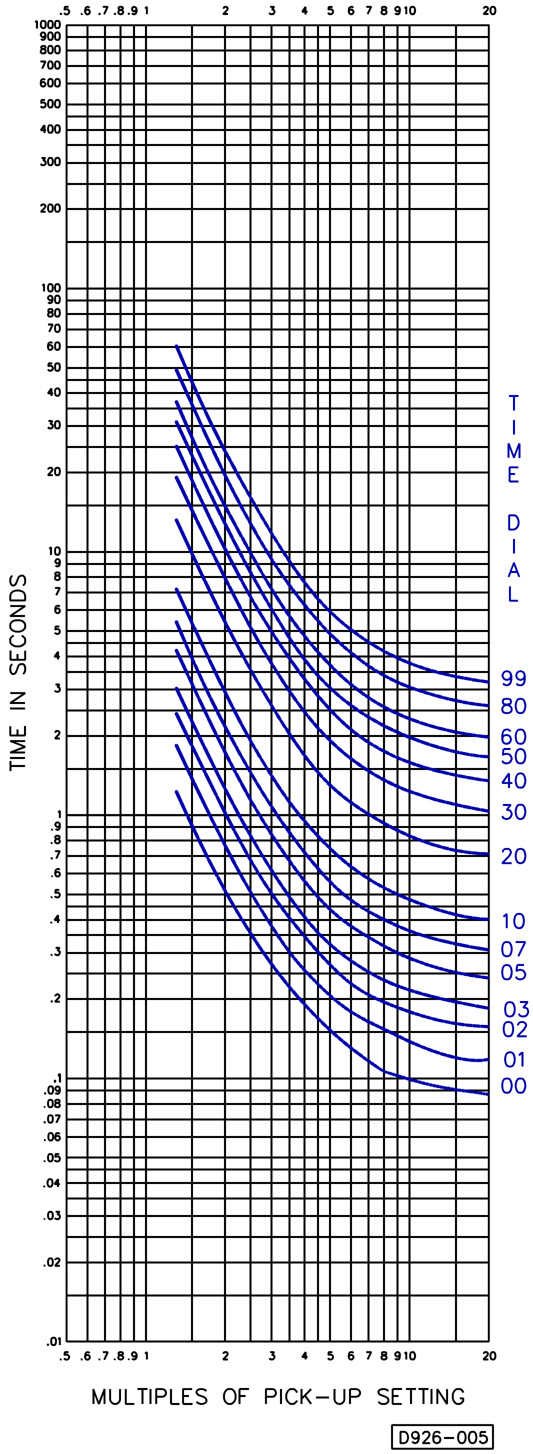


Figure 1-6. Timing Option B5,
Inverse (99-1254)

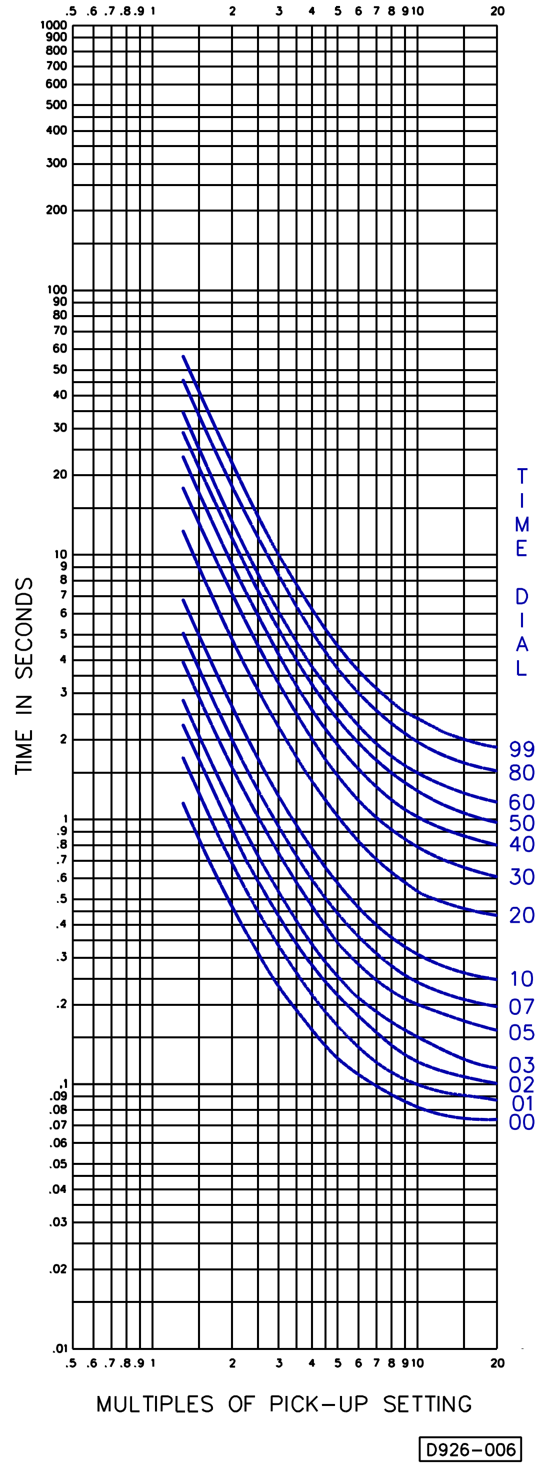


Figure 1-7. Timing Option B6,
Very Inverse (99-1255)

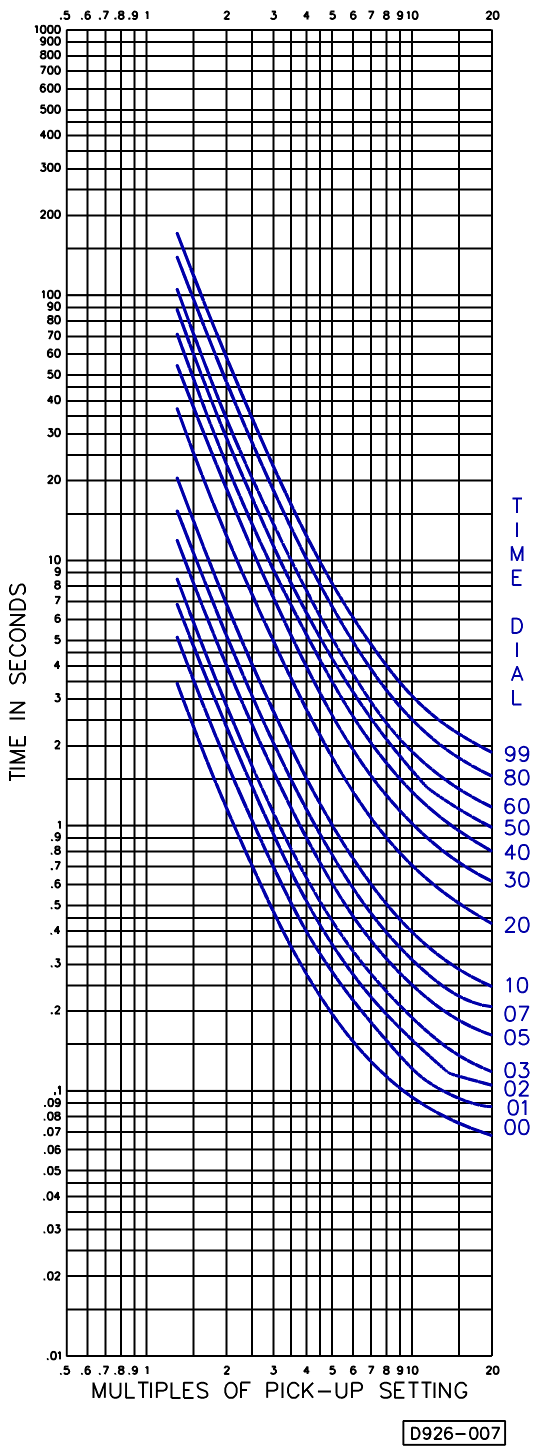


Figure 1-8. Timing Option B7, Extremely Inverse (99-1256)

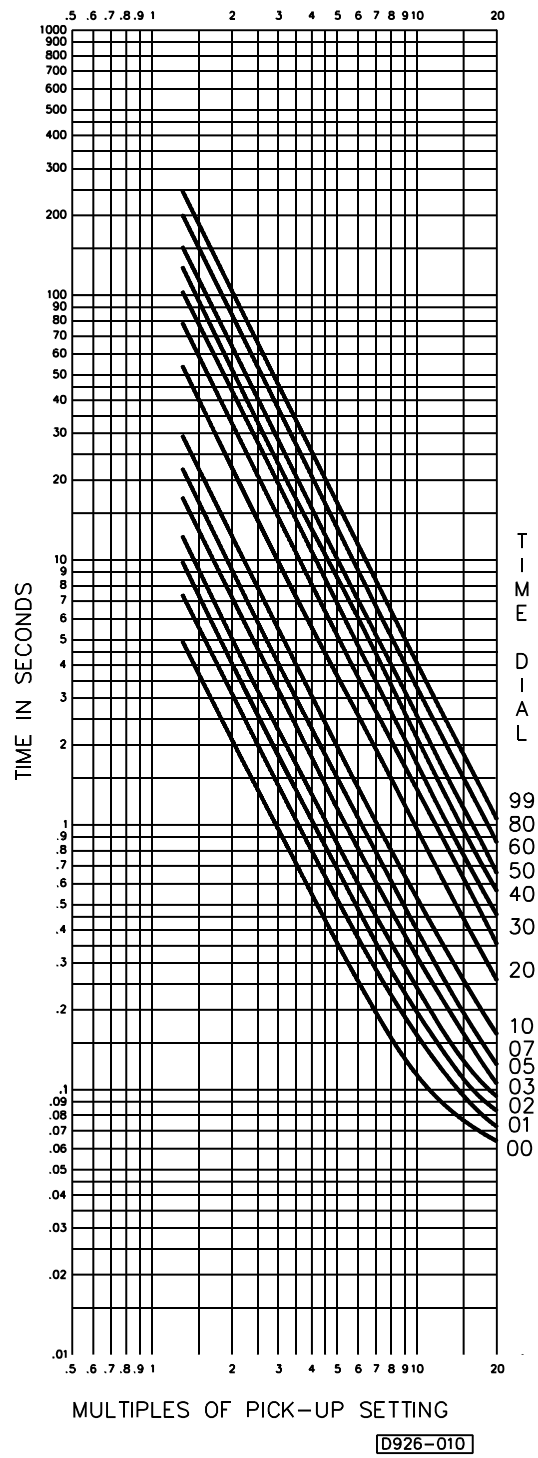


Figure 1-9. Timing Option B8, I^2T (99-1257)

SECTION 2

CONTROLS AND INDICATORS

Figure 2-1 shows the front panel of the BE1-51C relay with all the options installed. Each control and indicator is assigned a locator letter which is described in Table 2-1.

Table 2-1. BE1-51C Controls and Indicators

Locator	Control or Indicator	Function
A	**PHASE TAP**	A ten-position switch that provides an incremental adjustment of the current pickup point for all of the phases (simultaneously). The switch positions are defined for both HIGH and LOW range in a table printed on the front panel (locator O of Figure 2-1). (Intermediate settings between the switch positions may be established by the Tap Cal register.)
B	**PHASE TMG (A, B, C)** Indicators	LEDs that lite when the preset overcurrent pickup phase point for the corresponding phase is exceeded.
C	**PHASE** Range Plate	Indicates the range of the phase current inputs of the phase relay. The range is either HIGH or LOW. (Reference the TAP value table, locator O.) Note that the range is actually determined when the relay is ordered; the setting of this plate is simply for guidance in interpreting the TAP value table.)
D	**FUNC/DATA**	This four-character, seven-segment LED display (with display right-hand decimal point for each digit) has two modes of operation: (1) the DATA mode which permits reading the instrumentation registers, and (2) the CONFiguration mode that permits reading and writing into the registers that control operation of the relay. The instrumentation registers monitor the input current and the demand current in kiloamperes. A row of dashes indicates an out-of-range condition. (Dashes along the bottom of the display indicate that the current is somewhere below 0.1 X TAP. Dashes along the top indicate a current above 1-1/2 X pickup.) A front-panel switch (locator I) can cause the display to exhibit a particular register of interest in either mode. If - while in the CONFiguration mode - neither the UP/DWN nor the MODE/NEXT switches have been actuated for one minute, the display will revert to the DATA mode. (This protects the settings by requiring the deliberate action of loading to effect a change. In the DATA mode, however, a specifically selected register can be displayed indefinitely.) Note that when in the CONFiguration mode, the relay output are inoperative.

BE1-51C Controls and Indicators

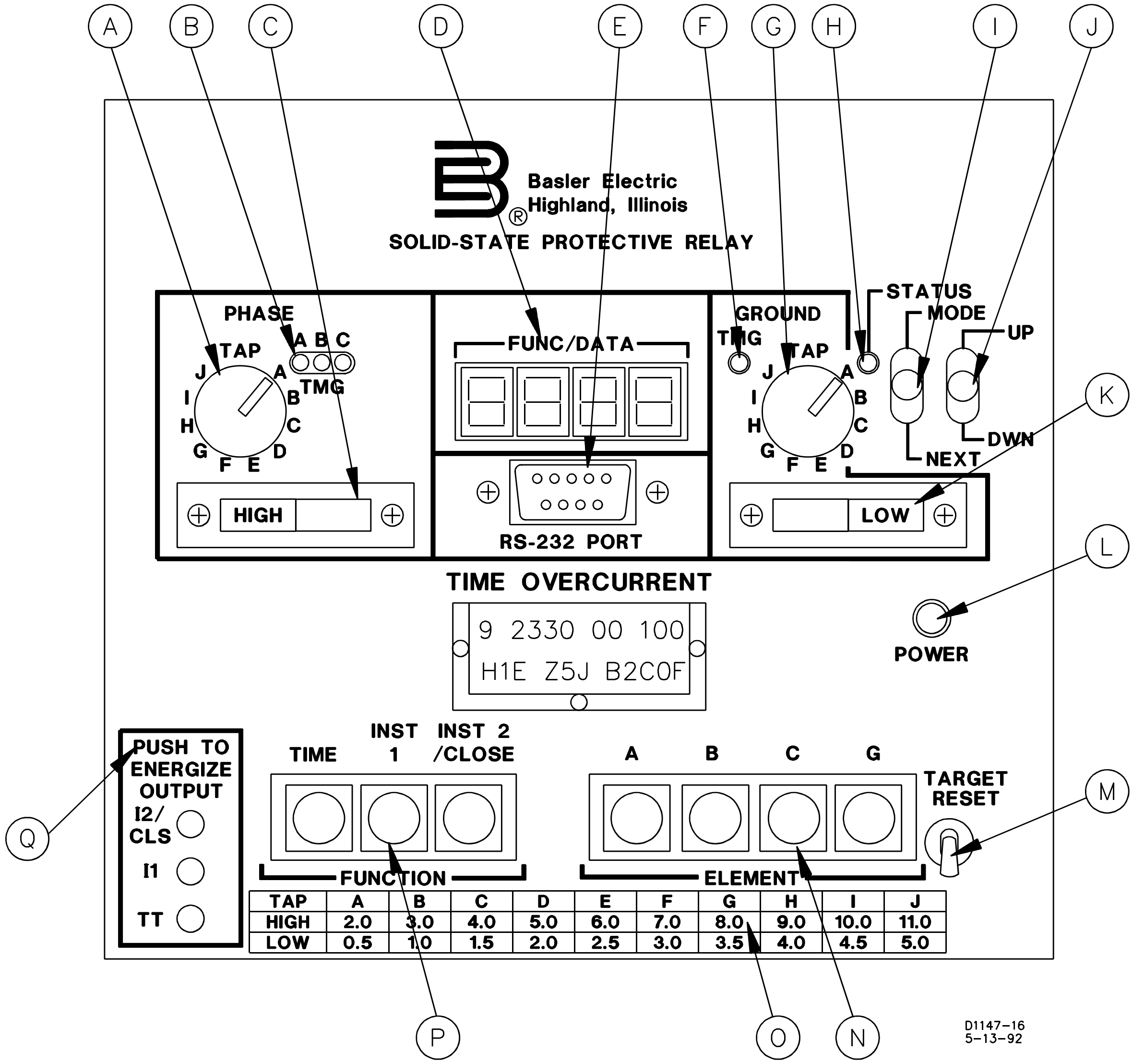


Figure 2-1. Location of Controls and Indicators

Table 2-1. BE1-51C Controls and Indicators - Continued

Locator	Control or Indicator	Function
D	**FUNC/DATA** - Continued	When the relay is powered up, the display will default to the DATA mode. Crossing from one mode to the other, and entering/modifying the data is described briefly below (locators I, J), and in detail in Section 4. When the display exhibits the word dAtA for 60 seconds, the display will automatically begin scrolling through the instrumentation registers in a fixed sequence. After stepping through all of the DATA registers, the display wraps around to repeat the sequence until instructed otherwise. (This process is covered in detail beginning on page 4-4.)
E	**RS-232 PORT** (Supplied with the communications option.)	Provides connection for any RS-232 device that is to be used for reading or loading the relay registers. (Reference the interconnection diagram of Figure 5-1.)
F	**GROUND TMG** Indicator	An LED that illuminates when the preset ground over-current pickup point is exceeded.
G	**GROUND TAP** Selector	A ten-position switch that provides an incremental adjustment of the ground current pickup point. The switch positions are defined for both HIGH and LOW range in a table printed on the front panel (locator O). (Intermediate settings between the switch positions may be established by the Tap Cal register.)
H	**STATUS** Indicator	An LED that illuminates whenever the relay is in the CONFiguration mode.
I	**MODE/NEXT** Switch	Holding this switch in the MODE position (up) for approximately 5 seconds when the word DATA is exhibited on the FUNCT/DATA display (locator D) selects the CONFiguration mode. Holding the switch in the MODE position for 5 seconds when CONF is displayed selects the DATA mode, and also loads data changes (if any) into memory. (The loading process is explained in further detail on page 4-3.) When neither DATA nor CONF is on display, holding the switch up in the MODE position identifies the register whose contents were on display immediately before the switch was operated. Each time the switch is toggled to the NEXT position (down), the display advances to the next function in the sequence (if the DATA mode was selected) or to the next operating parameter (if CONF was selected).
J	**UP/DWN** Switch	Active in the CONFiguration mode only: Increments (if raised) or decrements (if depressed) the value of the displayed register.

Table 2-1. BE1-51C Controls and Indicators - Continued

Locator	Control or Indicator	Function
K	**GROUND** Range Plate	Indicates the range (HIGH or LOW) of the relay ground current input. (Reference the front-panel TAP value table, locator O.) Note that the range is determined (during manufacture) by the style number of the relay. The position of this plate serves only a documentary purpose.
L	**POWER** Indicator	Red LED that illuminates when relay power supply is functioning.
M	**TARGET RESET** Switch	Raising this switch simultaneously resets all of the targets (locators N and P) if relay is powered up.
N	**ELEMENT** Targets	Magnetically latched indicators that change from black to orange when tripping occurs to indicate the phase (A, B, or C) or ground (G) that caused the trip. Depending on the relay style number, some of these targets may not be present. (Reset by M.)
O	**TAP** scaling chart	Defines the settings of the TAP switches (locators A and G).
P	**FUNCTION** targets	Magnetically latched indicators that change from black to orange when a relay output has tripped. Note that the current through the associated output contact must exceed 0.2 A to actuate the target. (For reset see M. Depending upon the style number, some of the illustrated targets may not be present.)
	TIME	Indicates that trip was caused by a TIME overcurrent function.
	INST 1	Indicates that trip was caused by the INSTantaneous-1 function.
	INST 2/CLOSE	Indicates a trip initiated by the INSTantaneous-2 function, or that a Command Actuated Close output was initiated by an external computer.
Q	**PUSH-TO-ENERGIZE OUTPUT**	Momentary pushbuttons that provide the means to test the functioning of the output contacts without having to apply current to the sensing inputs. The buttons are depressed by inserting a 1/8 diameter non-conducting rod through holes in the front panel.
	I2/CLS	Closes the Instantaneous-2 or the CLoSe output contact (depending upon the option present).
	I1	Closes the (optional) Instantaneous-1 output contact.
	TT	Closes the (optional) Timed Trip output contact.

SECTION 3

FUNCTIONAL DESCRIPTION

GENERAL

The BE1-51C relay is a microprocessor based overcurrent relay that can communicate with a remote computer. The following text is referenced to Figure 3-1, which is a functional block diagram that illustrates the overall operation of a fully implemented version of the relay.

CURRENT SENSING

The BE1-51C relay can be configured for single-phase, two-phase-with-neutral, three-phase, or three-phase-with-neutral current monitoring. The illustrated relay is of the three-phase-with-neutral type.

The internal current sensing transformers are designed to receive their input from the 5 A nominal secondaries of standard current transformers (CTs). Note the dual primaries of the internal transformers. One or the other is connected during manufacturing to obtain a LOW or a HIGH current sensing range (0.5 to 5.0 A, or 2.00 to 11.00 A) in accordance with the specified Style Number of the relay.

The outputs of the internal transformers are applied to scaling circuits (one for each of the phases, one for neutral) that convert each of the input currents to a voltage level that can be utilized within the relay.

A coarse incremental adjustment for the current pickup setting is provided by the TAP switches. These are front-panel rotary switches - one for the phases, and another for neutral if neutral current is monitored. The current setting represented by each of the 10 switch positions is given for each range (HIGH and LOW) in the table printed on the front panel. (Reference Figure 2-1.)

The fine adjustment of the current pickup point is determined by the value (00 to 99) stored in the relay Tap Cal registers (again, one setting for the phases, one for neutral). When the Tap Cal register contains the value 00, the pickup setting of the relay is the indicated TAP setting.

The Tap Cal registers provide a means of adjusting the timed trip pickup between the selected position of the TAP switch and its next higher position. For example, when the TAP switch is set to position A, the Tap Cal register provides an adjustment from 0.5 to 1.0 A for the LOW range, and from 2.00 to 3.00 A for the HIGH range. EXCEPTION: At the highest TAP position (i.e., J), the setting of the Tap Cal register is ignored. Therefore the J values of 5.00 and 11.00 represent the upper limits of the LOW and HIGH ranges, respectively.

POWER SUPPLY

General

The solid state power supply is a low burden, flyback switching design which delivers a nominal +5 and ±12 Vdc to the relay internal circuits. The power supply also delivers an isolated +5 Vdc for the communications circuits.

The input terminals of the power supply are not polarity sensitive. A red POWER LED illuminates to indicate that the power supply is functioning.

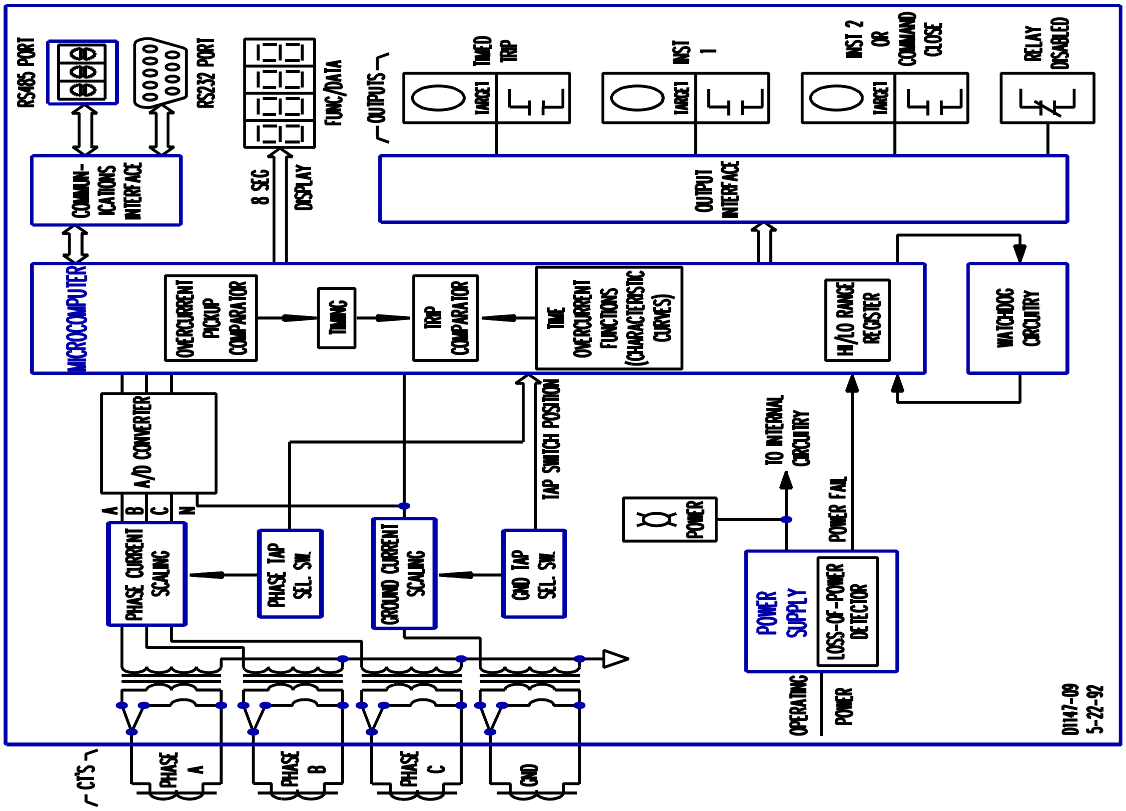


Figure 3-1. Functional Block Diagram

Loss-of-Power Sensing

A loss-of-power circuit monitors the power supply. If power is interrupted, the Relay Disabled output contact closes as explained later in this section (under Outputs).

ANALOG-TO-DIGITAL (A/D) CONVERTER

The voltage representing the sensed current is applied to the A/D converter. The A/D converter supplies the equivalent binary value of the sensed current to the trip comparator. The trip comparator stores a number of these samples, and calculates the true RMS value of the current at each input.

INTERNAL MICROCOMPUTER

The onboard computer fulfills many of the logic and signal processing functions described in the following paragraphs, and performs the time delay computations.

Time Overcurrent Calculations

If the magnitude of the current exceeds the pickup setting, the microprocessor calculates the required time delay by evaluating the magnitude of the overcurrent in the context of the selected time overcurrent response curve. (All of the time overcurrent functions that are graphically illustrated in Figures 1-2 through 1-8 are in the computer memory.) The data inputs are continuously polled and the calculations updated once for every 60 Hz (line) cycle.

As long as the sensed current is above the pickup point, the elapsed time is accumulated toward trip. Once the sensed current falls below pickup, the relay is reset and all accumulated time is cancelled.

When the value of a sensed current exceeds the pickup setting, the TIMING LED for that phase lites and indicates timing has started. The LED stays lit after the output relay has tripped for as long as the sensed current exceeds the selected pickup level.

High/Low Range Register

It was noted earlier in this section that the input transformers must be wired for one of two sensing ranges: HIGH or LOW. This information is recorded (at the factory) into the HI/LO Range Registers - one register for the phases, one for neutral. All current sensing and pickup data is weighted by the computer accordingly.

Watchdog Circuitry

The watchdog circuit checks that the microcomputer is operational. If some transient condition has disrupted its normal pattern of operation, the watchdog will momentarily close the Relay Disabled output contact, reset the computer, and initialize the program. The microcomputer is then automatically restarted, and the relay resumes its monitoring function (without human input). A SCADA program can be devised to record the date and time of the event.

OUTPUTS

General

Although the output relays are controlled by the microcomputer, the output interface contains the transistors that energize them. With the exception of the Relay Disabled contact (described below), all of the output contacts are of the normally open type and have targets associated with them.

Relay Disabled Output

The Relay Disabled output contact is of the normally closed (NC) type. It is held open (by the output relay energized coil) at all times after power-up unless a malfunction is detected. (This arrangement provides for a fail-safe output signal, since the contact is able to close an external alarm circuit even in the absence of power.)

The Relay Disabled output contact will close if the:

- Power supply voltage falls below requirements.
- Upper connection plug (paddle) is removed.
- Relay is removed from the case.

Additionally, the Relay Disabled output contact will <u>momentarily</u> close if the watchdog circuit detects abnormal operation of the computer. (More specifically, the detection of abnormal operation leads to the resetting of the microcomputer in an effort to correct the problem. It is the reset operation that actually causes the momentary contact closure.)

Instantaneous and Command Close Options

One or two instantaneous outputs are available as options. The trip points for these options are selected by a programming method described in Section 4.

When two instantaneous outputs are selected, one of them can be programmed to operate directly from the system computer (assuming that the Communications Option is also present). The programming information is supplied on page 6-6. (The second output relay, when controlled by the computer, cannot simultaneously serve as an instantaneous output.)

TARGET INDICATORS

Targets are provided for each function - TIME, INST 1, and INST 2 (or CLOSE). Targets are also provided for each phase and neutral that is current monitored on multiphase relays. Each target indicator is visible on the front panel of the relay with the cover in place. When operated, the disk in the target changes from black to orange and is magnetically latched in this position.

The FUNCTION targets only operate when a minimum of 0.2 A flows through the associated relay output circuit. This is to provide confirmation that the contact actually did close and that a signal was delivered. The ELEMENT targets - i.e., phase and neutral - are internally operated.

To detect the output current, the coil of a special reed relay is placed in series with the output contacts. Actuation of the reed relay trips the target. (The series impedance of the reed relay coil is less than 0.1 ohm.)

To reset the target(s) after an abnormal system condition has been cleared, manually raise the target reset switch on the front of the relay, or its extension bar that protrudes through the bottom of the cover. (The relay must be under power to reset a target.)

COMMUNICATIONS OPTION

Option 2-C provides for access by a remote computer via an RS-485 communication port on the rear of the case, and an RS-232 port on the front panel. For further information concerning the operation of the communications option, see Section 5.

SECTION 4

OPERATION BY FRONT PANEL

GENERAL

Once installed, and with its operating parameters established in internal memory, the relay functions automatically to protect the system from overcurrent conditions. Front panel operation of the relay consists of programming the registers that define the relay automatic operation. These parameters are entered into the relay memory by using the controls and indicators that were introduced in Section 2, and are further explained below.

The memory registers accessible from the front panel fall into two basic categories: read-only registers which are accessible when the relay is in the DATA mode (the normal or working mode - these registers contain real time data), and the read/write registers which may be accessed only when the relay is in the configuration mode.

Note that all the registers accessible at the front panel (plus many others that aren't) are also accessible by remote computer and by local terminal. This aspect of relay control is covered in Section 5.

CONFIGURATION MODE

Defined

Configuring the relay means loading the operating parameters into the relay internal registers and setting the PHASE TAP and Neutral TAP switches. The configuration registers are accessible (and changeable) whenever the relay is in the configuration mode - i.e., when the letters ConF appear in the front-panel display and the STATUS LED is lit. (These registers may also be read or changed remotely by computer. This is documented in Section 5.) During this mode, all output relays are disabled.

> **NOTE**
>
> If the relay is in the configuration mode, and neither the UP/DOWN nor the MODE/NEXT switches have been actuated for one minute, the display will automatically revert to the DATA mode. When this occurs, any data entries not loaded (by raising the MODE switch) are lost, and the previous settings are displayed.
>
> This is a safety feature to preserve protective settings, and to ensure that the relay will default to an active, system-monitoring status.

Entering the Configuration Mode

To leave the data mode and enter the configuration mode, depress the MODE/NEXT switch repeatedly until the word dAtA is in view on the front-panel display. Then hold the switch up for approximately five seconds, during which time the display will be blank. Release the switch when ConF appears in the display. (Releasing the MODE switch before 5 seconds has expired will return the display to the data mode.)

Stepping Through the Read/Write Registers

Starting with the display reading ConF, step through the configuration registers by depressing and releasing the NEXT switch. The registers will appear in the sequence given in Table 4-1.

After the 21st register is reached, one more depression of the NEXT switch brings the display back (full circle) to the ConF position. At this point, one has the option of stepping through the configuration registers

Table 4-1. Configuration Mode Display Sequence

Display Sequence	Register Abbreviation	Register Function	Register Range
	ConF	Mode selection window.	-
1	Addr	Indicates the present address of the relay.	0001 to 0254.
2	bAUd	Selected bAUd rate.	See text.
3	P_td	Phase time dial setting.	0000 to 0099
4	n_td	Neutral time dial setting.	0000 to 0099
5	PtAP	Phase tAP calibrate.	0000 to 0099
6	ntAP	Neutral tAP calibrate.	0000 to 0099
7	Pin1	Phase Instantaneous #1 (X TAP).	0.50 to 020.0
8	Pin2	Phase Instantaneous #2 (X TAP).	0.50 to 020.0
9	nin1	Neutral Instantaneous #1 (X TAP).	0.50 to 020.0
10	nin2	Neutral Instantaneous #2 (X TAP).	0.50 to 020.0
11	Pcur	Phase time overcurrent curve type.	b1 thru b8
12	ncur	Neutral time overcurrent curve type	b1 thru b8
13	PPri	Phase CT ratio, numerator.	5 thru 5000
14	PSEc	Phase CT ratio, denominator.	5 always
15	nPri	Neutral (neutral) CT ratio, numerator.	5 thru 5000
16	nSEc	Neutral (neutral) CT ratio, denominator.	5 always
17	PrAn	Phase rAnge.*	HI or LO
18	nrAn	Neutral rAnge.*	HI or LO
19	dPrd	Demand period (in minutes).	1-30
20	gEn	Neutral enable	YES or NO
20A	50g	Instantaneous trip	YES or NO
20B	51g	Time trip	YES or NO
21	BF	Breaker failure	YES or NO
22	ConF	Wraps to the top (i.e., to the Mode selection window).	_

* Factory programmed registers. For field access see the Service Manual.

again, or returning to the data mode. To effect the latter, raise the MODE switch up and hold it there until the word dAtA appears in the display. (This requires about 5 seconds.)

Loading the Read/Write Registers

As the MODE switch is held raised (in the procedure just described for returning to the data mode), the display should blank and then - after about 5 seconds - the message P EE should appear. This indicates that the data changes made while in the configuration mode have now replaced the former contents of the registers in the nonvolatile memory. After a brief interval, the display changes again to read dAtA. The relay is now returned to its normal operating mode.

Setting the Baud Rate

Using the procedures described above for entering the configuration mode, display bAUd by advancing to the second register. (Reference Table 4-1.) The baud rate may now be adjusted by raising or depressing the UP/DOWN switch as required.

The baud rates available and their sequence are listed below. Note that the displayed value requires a multiplier of 1000 to arrive at the actual rate.

Baud Rate	Displayed Value
19,200	19.20
9,600	9.600
4,800	4.800 (default value)
2,400	2.400
1,200	1.200
600	0.600
300	0.300 (The next advance wraps to 19.20.)

The selected baud rate is loaded into the relay nonvolatile memory with the return to the data mode. The message P EE will appear briefly on the display to indicate that the new data has been stored in a nonvolatile fashion.

Setting the Time Dial

There are two Time Dial registers, one for the phases, one for neutral (the 2nd and 3rd registers, respectively, in the stepping sequence shown in Table 4-1). (Some relays do not monitor the neutral current. Check the style number.)

The Time Dial registers may contain any integer from 00 to 99. Each integer designates one of the hundred timing variations of the characteristic curves available for each overcurrent function (as illustrated in Figures 1-1 through 1-7).

Setting Tap Calibration

The Tap Cal registers (5th and 6th of the sequence listed in Table 4-1) may hold any integer from 00 to 99. Each integer represents a one-percent increment between adjacent taps.

Setting Instantaneous Overcurrent Pickup

The Pin1 and Pin2 registers (7th and 8th of the configuration sequence, Table 4-1) hold the phase trip values for the INST 1 and the INST 2 output contacts. These instantaneous overcurrent registers may contain any number in the range 0.5 to 20, representing 0.5 to 20 times the phase TAP setting.

Neutral current instantaneous trip values are similarly entered (as multiples of the Neutral TAP setting) into registers nin1 and nin2 for the INST 1 and INST 2 contacts.

Selecting the Time Overcurrent Characteristic

The timing curve registers (11th and 12th in the sequence of Table 4-1) may contain any of 8 codes, b1 through b8, representing the curve types listed in Table 4-2. Refer to Figures 1-2 through 1-9 for graphic representations of these curves.

Table 4-2. Available Characteristics

Number	Time Overcurrent Characteristic	Figure
b1	Short Inverse	1-2
b2	Long Inverse Time	1-3
b3	Definite Time	1-4
b4	Moderately Inverse Time	1-5
b5	Inverse Time	1-6
b6	Very Inverse Time	1-7
b7	Extremely Inverse Time	1-8
b8	I^2T	1-9

Selecting the CT Ratios

Registers 13 through 16 (Table 4-1) provide a multiplier that allows the microprocessor to match the relay response to the turns ratio of the system CTs. The relative turns ratio of the CTs is expressed as a fraction whose numerator is 5.

Current Sensing Range

The 17th and 18th registers in the sequence (of Table 4-1) display the current sensing range to which the relay is configured (either HI or LO) in accordance with the style chart. This is a factory setting.

Demand Period

Register 19 (Table 4-1) indicates the number of minutes in a demand period. This figure is used to calculate the demand current. For further information, look under Instrumentation Display, page 4-5.

DATA MODE

Defined

The data mode provides the normal display of real time data for an operating relay. When in this mode, all the read-only registers which are accessible from the front panel (Table 4-3) may be viewed by stepping the MODE switch, or by automatic scrolling (described below).

Table 4-3. Data Mode Display Sequence

Display Sequence	Display Abbreviation	Display Range	Register Function
	dAtA	Mode selection window.	-
1	Ph. A	Phase A current times 1000.	0-50 kA
2	Ph. b	Phase B current times 1000.	0-50 kA
3	Ph. c	Phase C current times 1000.	0-50 kA
4	Gnd	Neutral current times 1000.	0-50 kA
5	Ph.Ad	Phase A demand current.	0-50 kA
6	Ph.bd	Phase B demand current.	0-50 kA
7	Ph.cd	Phase C demand current.	0-50 kA
8	Err	Error code. (See above text.)	-
9	dAtA	Wraps to the top (i.e., to the Mode selection window.)	-

Entering the DATA Mode

To leave the configuration mode and enter the data mode, depress the MODE/NEXT switch repeatedly until ConF is displayed on the front-panel display. Then hold the switch up for approximately five seconds until the word dAtA appears. At this time the STATUS LED will extinguish. (Releasing the MODE switch before five seconds has expired will return the display to the configuration mode.)

Automatic Scrolling

When the display is left at dAtA for 60 seconds, the display will automatically step through all of the read-only registers (i.e., it will scroll) in the sequence of Table 4-3, then wrap around and repeat. This scrolling process first presents the name of the next register of the sequence (for 0.4 seconds), then presents the data of that register (for 0.4 seconds). This process will repeat endlessly while the relay remains in the data mode unless deliberately halted.

To halt the display at a particular register, step the display to the desired read-only register using the NEXT switch. (The registers will appear in the sequence of Table 4-3). Raising the MODE/NEXT switch (above center) displays the name of the register arrived at (except when dAtA is displayed).

Holding the MODE switch up for five seconds or more when the word dAtA is displayed puts the relay into the configuration mode. Leaving the display at dAtA for 60 seconds will cause it to scroll again.

Instrumentation Display

The first seven registers of the data mode display sequence (Table 4-3) comprise the real time data instrumentation display. The first four registers indicate the current at the CT primarys of each phase in kiloamperes. Registers 5, 6, and 7 of the sequence indicate the demand current (at the primaries in kiloamperes).

The Demand Current registers show the average demand of each monitored phase over a time period that is entered into the Demand Period register (register 19, Table 4-1). The displayed average is recalculated each minute for each phase by adding the Demand Period samplings which have accumulated for a given phase, then dividing this sum by the Demand Period number to obtain the average demand value. The latter is then displayed in the Demand Current register for the appropriate phase. (The demand current values may also be read over the data link.)

All of the instrumentation registers (registers 1 through 7) display their data in real time. Note that under certain conditions the microprocessor may not be able to handle its high priority real-time tasks and also supply the instrumentation registers with timely data that is within the specified accuracy (±5%). In such cases the display will show a row of four dashes. The position of these dashes (high or low) indicate which way the parameter is out-of-range:

If current is below the 0.1 X TAP level, the row of dashes are along the bottom of the display.

If current is above 1-1/2 X pickup, the row of dashes are along the top of the display.

Error Code Display

The error code display is the last register of the sequence described in Table 4-3. In the event of a malfunction, the Error Code register can narrow the search for possible causes. When this register is at 0000, there is no error message. If not at 0000, consult the Service Manual for interpretation and procedural suggestions, or contact a Basler representative.

SETTING THE RELAY (EXAMPLE)

Example Defined

The service environment of this hypothetical example is given as follows:

Parameter	For Phase	For Neutral
Time overcurrent pickup	4.7 A	1.6 A
Pickup Range	High	Low
Curve shape	Very Inverse	Inverse
Time delay setting	5.2 sec. @ 28.5 A	To be determined.
Instantaneous overcurrent pickup	16.0 A	6.0 A

The following model and style number describes an appropriate relay for this hypothetical application. (The second style digit indicates that HIGH range was chosen for phase monitoring, and LOW range for neutral current monitoring.)

Model: BE1-51C **Style: H1E Z5J B1NOF**

Calculating the Settings

1. The time overcurrent characteristic must be selected such that it will coordinate with the other relays in the scheme to meet the protective needs of the application. Assume that a Very Inverse function is suitable for phase protection, and Inverse for neutral protection. From Table 4-2 we see that these two characteristics are designated b6 and b5 respectively. The table also provides the figure numbers that illustrate the desired curve sets.

2. Note that the phase time overcurrent pickup, 4.7 A, falls between tap C and tap D of the HIGH range (as shown on the front-panel chart illustrated in Figure 2-1). The phase Tap Cal value (which interpolates between TAP switch positions) is then calculated as follows.

   Given:

Pickup value	= 4.7 A
Tap C (HIGH)	= 4.0 A
Tap D (HIGH)	= 5.0 A

   Then:

Span	= Tap D - Tap C = 1.0
Difference	= Pickup value - Tap C = 0.70
Tap Cal value (phase)	= Difference/Span = 70

3. The given neutral time overcurrent pickup, 1.6 A, falls between tap F and tap G of the LOW range (Figure 2-1). The neutral Tap Cal value is:

Pickup value	= 1.6 A
Tap C (LOW)	= 1.5 A
Tap D (LOW)	= 2.0 A

   Then:

Span	= Tap D - Tap C = 0.50
Difference	= Pickup value - Tap C = 0.10
Cal value (phase)	= Difference/Span = 0.10/0.50 = 20

4. The ratio of the phase Instantaneous Overcurrent pickup to the phase Time Overcurrent pickup setting is calculated as follows.

Phase Instantaneous Overcurrent	= 16.0 A
Phase Time Overcurrent	= 4.0 A
Ratio	= 4.0

5. The ratio of the neutral Instantaneous Overcurrent pickup to the neutral Time Overcurrent pickup setting is calculated as follows.

Neutral Instantaneous Overcurrent	= 6.0 A
Neutral Time Overcurrent	= 1.5 A
Ratio	= 4.0

6. From Figure 1-7, find the phase TIME DIAL setting that corresponds to a delay of 5.2 seconds at 6 times pickup.

   Ans: A TIME DIAL setting of 08.

7. From Figure 1-6, find the neutral TIME DIAL setting that corresponds to a delay of 12.0 seconds at 3.1 times pickup.

   Ans: A TIME DIAL setting of 05.

Entering the Settings

BE1-51C Operation By Front Panel

1. Set PHASE TAP to C, and Neutral TAP to C.

2. Load b6 into the Phase Curve Type register, and b5 into the Neutral Curve Type register.

3. Enter 0070 into the Phase Tap Cal register, and 0020 into the Neutral Tap Cal register.

4. Enter 4.0 into the Phase Instantaneous #1 Overcurrent register, and also into the Neutral Instantaneous #1 Setting register.

5. Enter 08 into the Phase TIME DIAL register, and 05 into the Neutral TIME DIAL register.

SECTION 5

OPERATION BY COMPUTER

EQUIPMENT AND PROCEDURES

General

The equipment and procedures for communicating with the BE1-51C relay are defined in the following document.

BEBUS User's Manual, Basler Publication 9 2330 00 993.

Port Converter

When the system's managing computer is not equipped with an RS-485 port, the following device will allow an RS-232 port to provide the electrical signals required by the RS-485 standard. The unit is capable of operating up to 4000 meters at the maximum permissible baud rate of the system (19,200).

Name of device: RS-232 to RS-485 Converter

Make and Model: MetraByte™ M1100/115.

Input power: 115 Vac.

Order from: MetraByte Corporation
440 Myles Standish Blvd.
Taunton, MA 02780

BAUD RATE

Communication with the remote computer must be accomplished at the baud rate selected for the system environment. The baud rate may be changed via the RS-485 or RS-232 channels (in which case, the command to change the baud rate must be received at the existing rate). Alternatively, the baud rate may be changed using the front-panel setting method. The baud rate default value is 9600.

THE REGISTERS

General

When the remote computer is set up to communicate with the relay (and assuming that they are operating on the same baud rate), many of the relay's internal registers which are not accessible from the front panel may be read by the computer. Those registers that have a read/write capability may also be written into by the computer.

Table 5-1 lists all of the registers in the relay that may be read or written to by a remote computer connected to the RS-485 port, or by a local computer connected to the RS-232 port.

The Secure Registers

Some of the read/write registers in the relay are provided with a "secure" feature. This protects the register from accidental overwriting by requiring a timer to be non-zero before writing to that register is accepted. When the timer times out, access is refused until the timer is again initialized.

To enter a secured register:

<u>METHOD 1</u> - Enter a number ≤9000 into the Secured Timer register (register 16) that represents a convenient and appropriate access time in milliseconds. (The relay will immediately begin decrement this counter at a once-per-millisecond rate.) Then write into the secured register.

<u>METHOD 2</u> - To avoid racing the timer during an entry operation, a procedure illustrated by the following example is recommended.

WRITE 16=10; 64=5,10,5,10; 66=01,01 **[ENTER]**

Using this method, the timer countdown doesn't begin until the ENTER key is depressed. Note that two or more secured registers (64 and 66 in the example) can be changed with one timer entry (register 16).

Register Overview

There are 256 possible registers, assigned as follows:

Register Number	Function
0 thru 16	Common System Registers
17 thru 49	Instrumentation Registers (See below.)
50 thru 59	General Status Registers
60 thru 79	Settings
80 thru 89	Input Connections
90 thru 99	Product Specific Registers
100 thru 149	History Registers
150 thru 255	Reserved.

Instrumentation Registers

The instrumentation registers (numbers 17 through 49, as assigned) provide quantitative information on a real-time basis for the various parameters monitored by the relay. The numbers are accurate within 5% except as follows.

0000 indicates a number under the instrumentation range of the relay (i.e., below 0.75 X TAP).

FFFF indicates a number over the instrumentation range of the relay (i.e., above 1-1/2 X pickup).

PORT WIRING

Figures 5-1 and 5-2 are wiring diagrams for the RS-232 and RS-485 ports.

Table 5-1 Registers Accessible Via The RS-232 And RS-485 Ports
All registers are read/write except as noted.

Register Number	Register Name	Description
0	**ZERO**	This register is provided as a register to read or write as a diagnostic aid. Writes to this register are ignored, and the response status is always zero. This register always reads a value of zero.

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
1	**AVAILABLE REGISTER LIST** [READ ONLY]	The 256 bits in this register are a map of the registers which are accessible on this relay. A master can read this register and tell which registers are supported by this slave. A one-bit indicates that the register is supported. A zero-bit tells the master that the register is not supported. Bit 0 of the least significant byte of this register corresponds to register 0. Bit 7 of the least significant byte of this register corresponds to register 7. Bit 7 of the most significant byte of this register corresponds to register 255.
2	**RELAY TYPE & REVISION LEVEL** [READ ONLY]	This 2-byte register contains information about the type of relay and the level of revision. The format of this register is: <u>Byte Number</u> / <u>Name</u> / <u>Value</u> 1 / Hardware Product Type / 0 to 255 2 / Hardware Version Number / 0 to 255 This register is a factory setting and is read-only during normal operating conditions.
3	**SOFTWARE INFORMATION** [READ ONLY]	This register holds information about the release date and version of the software inside the unit. The format of this register is: <u>Byte Number</u> / <u>Name</u> / <u>Value</u> 1 / Version Number / 0 to 99 2 / Release Number / 0 to 9 3 / Month / 1 to 12 4 / Day / 1 to 31 5 / Year / 0 to 99
4	**RELAY SERIAL NUMBER** [READ ONLY]	A unique 16 bit serial number is stored into this register at the factory.
5	**TIME and DATE**	The register format is: <u>Byte Number</u> / <u>Name</u> / <u>Value</u> 1 / year / 0 - 99 2 / month / 1 - 12 3 / day / 1 - 31 4 / hour / 0 - 23 5 / minute / 0 - 59 6 / second / 0 - 59

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
		7 second/100 0 - 9
7	**BAUD RATE** [SECURED]	Baud rate times 1000. Rate may be .3 (for 300 baud), .6, 1.2, 2.4, 4.8, 9.6, or 19.2 (19,200 baud).
8	**REMOTE ADDRESS** [SECURED]	The address assigned (1-254) to the relay for identification within the system.
9	**RELAY STYLE NUMBER** [READ ONLY]	The style number of the relay is stored as a string of ASCII characters into this register at the factory. (See Style Number Identification Chart in Section 1.)
10	**COMMAND** [SECURED]	Code to command relay action. The acceptable codes and the commanded actions are: 00 = No operation. 01 = Initialize registers to factory (default) settings. 02 = Reset relay. 03 = Restart main CPU. 04 = Not used. 05 = Set history log (registers 100 - 120) to zero. 06 = Reset register 30 (max/min polyphase current). 07 = Not used. 08 = Reset register 36 (max/min demand current). 09 = Not used. 10 = Not used. 11 = Not used. 12 = Actuate the CLOSE contact if breaker is open (and if 01 has been entered in register 93). 13 = Update the settings in nov-ram. 14 = Update the factory settings in nov-ram. (Hardware identification and relay serial number.) 15 = Close timed trip output for one second. 16 = Close INST 1 output for one second. 17 = Reset breaker failure status.
11	**COMMAND STATUS** [READ ONLY]	This one-byte register indicates the execution status of the command held in register number 10. Some of the valid codes are: <u>Status</u> <u>Name</u> 00 Command execution was successful. 01 Execution of command is in progress. 02 Slave unit does not support this command. 0 3

Slave was unable to execute the command.

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
16	**SECURED TIMER**	This register counts down from a user entered value to 0. The register will accept any number from 0 to 9000, which is the count-down time in milliseconds. Any data sent to the secured registers must be accomplished during this countdown. Otherwise, the write operation will have no effect on the secured registers.
20	**POLYPHASE CURRENT** [READ ONLY]	Holds the CT-primary RMS current (in kA*) for each phase and ground.
21	**AVERAGE POLYPHASE CURRENT** [READ ONLY]	Holds the average value of CT-primary current (in kA*) for phases A, B, C, and ground, averaged collectively and calculated every other metering interval (i.e., approximately every 3 seconds).
25	**DEMAND PERIOD**	Number of minutes (1 to 30) in demand period. (Thirty minutes is the default value.) * 0000 indicates a number under the instrumentation range of the relay; FFFF indicates a number over the instrumentation range of the relay.
26	**DEMAND CURRENT** [READ ONLY]	This 40-byte register holds the values of RMS current for the last 4 demand periods. This demand current is computed as follows. Once each minute the relay computes the average of each of the three phase currents, and uses these averages to compute the demand for the demand period (which may be one to 30 minutes as defined by register 25). These averages are used to compute the demand for a given demand period. For example: If n is the demand period as stored in register 25, then the new demand is the average per phase current for the past n minutes. Since a new demand is computed each minute, this sliding method of reporting demand shows maximum and minimum values that other methods of computing demand might not observe. The format of this register is:

Byte Number	Value (in kA)§
1-2	#1 Phase A Current*
3-4	#1 Phase B Current*
5-6	#1 Phase C Current*
7-10	#1 Time Stamp**

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description	
26	**DEMAND CURRENT** [READ ONLY]	- Continued	
		11-12	#2 Phase A Current
		13-14	#2 Phase B Current
		15-16	#2 Phase C Current
		17-20	#2 Time Stamp**
		21-22	#3 Phase A Current
		23-24	#3 Phase B Current
		25-26	#3 Phase C Current
		27-30	#3 Time Stamp**
		31-32	#4 Phase A Current
		33-34	#4 Phase B Current
		35-36	#4 Phase C Current
		37-40	#4 Time Stamp**
		The #l entry is for the most recent demand period. The #4 entry is for the least recent demand period.	

* This information may be read at the front panel display.
** The time stamp indicates the time of the event in a packed binary format that is decoded by BEBUS.
§ 0000 indicates a number under the instrumentation range of the relay; FFFF indicates a number over the instrumentation range of the relay.

Register Number	Register Name	Description	
30	**MAX/MIN POLYPHASE CURRENT** [READ ONLY]	Maximum and minimum metered (i.e., averaged) primary currents for phases A, B, C, and ground, including the time that each maximum and minimum occurred. (This register can be read or written into at any time.)	
		The format of this register is:	
		<u>Byte Number</u>	<u>Value (in kA)§</u>
		1-2	Max Phase A Current
		3-4	Max Phase B Current
		5-6	Max Phase C Current
		7-8	Max Neutral Current
		<u>Byte Number</u>	<u>Value (in kA)§</u>
		9-10	Min Phase A Current
		11-12	Min Phase B Current
		13-14	Min Phase C Current
		15-16	Min Neutral Current

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name		Description
30	**MAX/MIN POLYPHASE CURRENT** [READ ONLY]	- Continued	
		17-20	Time Stamp, Max Ph A Cur*
		21-24	Time Stamp, Max Ph B Cur*
		25-28	Time Stamp, Max Ph C Cur*
		29-32	Time Stamp, Max Neut Cur*
		33-36	Time Stamp, Min Ph A Cur*
		37-40	Time Stamp, Min Ph B Cur*
		41-44	Time Stamp, Min Ph C Cur*
		45-48	Time Stamp, Min Neut Cur*
31	**MAX/MIN POLYPHASE CURRENT with RESET** [READ ONLY]	Same as register 30 except that reading this register will reset the contents.	
36	**MAX/MIN DEMAND CURRENT** [READ ONLY]	Maximum and minimum demand currents (primary) for phases A, B, C, and ground, and the time that each maximum and minimum occurred.	
		Byte Number	Value (in kA)§
		1-2	Max Phase A Current
		3-4	Min Phase A Current
		5-6	Max Phase B Current
		7-8	Min Phase B Current
		9-10	Max Phase C Current
		11-12	Min Phase C Current
		13-16	Time Stamp, Max Ph A Cur*
		17-20	Time Stamp, Min Ph A Cur*
		21-24	Time Stamp, Max Ph B Cur*
		25-28	Time Stamp, Min Ph B Cur*
		29-32	Time Stamp, Max Ph C Cur*
		33-36	Time Stamp, Min Ph C Cur*

* The time stamp indicates the time of the event in a packed binary format that is decoded by BEBUS.

§ 0000 indicates a number under the instrumentation range of the relay; FFFF indicates a number over the instrumentation range of the relay.

Register Number	Register Name	Description
40	**MAX/MIN DEMAND CURRENT**	Same as register 36 except that reading this register will reset the contents.

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
	[READ ONLY]	
50	**BREAKER FAILURE STATUS**	This eight-bit register is used to convey information about the last breaker failure event. The register is bit mapped as follows. bit 0 - spare bit 1 - spare bit 2 - spare bit 3 - Time out with no breaker change of state bit 4 - phase A > 0.1 X TAP bit 5 - phase B > 0.1 X TAP bit 6 - phase C > 0.1 X TAP bit 7 - phase N > 0.1 X TAP
51	**CPU DIAGNOSTICS** [READ ONLY]	Sixteen bits that are reserved for internal CPU diagnostics. The following bits have been assigned. bit 1 - hard EE write failure bit 2 - hard EE read failure bit 3 - soft EE failure bit 4 - EPROM failure bit 5 - RAM bit 6 - A/D bit 7 - RMS calculation overflow bit 8 - calibrate calculation overflow bit 9 - burden resistor calculation overflow bit 10 - floating point calibration constant conversion overflow
	During normal operation, this register should read 00. Any other indication is an error. For details of application, consult the Service Manual.	
52	**DISPLAY TARGET STATUS** [READ ONLY]	Each of the eight low-order bits represent the status of an associated target. A one-bit indicates that the target is set (orange); a zero indicates that the target is reset (black). The register is bit mapped as follows. bit 1 - spare / bit 5 - phase A target bit 2 - Inst 2 target / bit 6 - phase B target bit 3 - Inst 1 target / bit 7 - phase C target bit 4 - Timed Trip target / bit 8 - Ground target
53	**DISPLAY LED STATUS** [READ ONLY]	Each of the eight low-order bits represent the status of an associated LED. A one-bit indicates that the LED is on; a zero indicates that the LED is off. The register is bit mapped as follows. bit 1 - phase A timing / bit 5 - phase B inhibit

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
		bit 2 - phase B timing bit 3 - phase C timing bit 4 - phase A inhibit bit 6 - phase C inhibit bit 7 - Ground timing bit 8 - spare
54	**CALIBRATION CONSTANTS** [READ ONLY]	Contains calibration information that relates to the internal CT burden resistance (as calculated at the last calibration procedure on the selected range). (The register value is 100 times the calculated burden resistance value.)
55	**OUTPUT STATUS** [READ ONLY]	This 8-bit register is bit mapped to represent the state of the output relays. A one-bit indicates that the associated relay is energized; a zero-bit that it is de-energized. (Note that the contacts of all output relays are of the normally open type, with the sole exception of the Relay Disabled output which is always of the normally closed type.) This register is bit mapped to represent the outputcontacts as follows. bit 0 - unused bit 1 - Inst 2, or Command Close bit 2 - Inst 1 bit 3 - Timed Trip bit 4 - spare bit 5 - spare bit 6 - spare bit 7 - spare
56 & 57	**POLLING STATUS** [READ ONLY]	These two registers are identical in function; the only difference is that 57 is automatically cleared each time it is read. Each register represents the status of the relay with regard to polling initiated by the managing computer. A one-bit indicates that new information has been acquired since the byte was last reset. This byte should be cleared after each interrogation. (The clearing is automatic after each reading for register 57. The registers are bit mapped as follows. <u>Byte 1 - Global</u> Bit 1 = Anything changed? Bit 2 = New minimum Bit 3 = New maximum Bit 4 = New event record Bit 5 = Trip Bit 6 = New timing LED Bit 7 = Spare Bit 8 = Spare <u>Byte 2 - New Minimums</u> Bit 1 = Current Bit 2 = Voltage Bit 3 = Demand Bit 4 = Watts Bit 5 = Vars Bit 6 = Power factor Bit 7 = Spare Bit 8 = Spare <u>Byte 3 - New Maximums</u>

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description

Bit 1 = Current
Bit 2 = Voltage
Bit 3 = Demand
Bit 4 = Watts
Bit 5 = Vars
Bit 6 = Power factor
Bit 7 = Spare
Bit 8 = Spare

Byte 4 = Spare

Register Number	Register Name	Description
58	**PICKUP STATUS** [READ ONLY]	This register indicates all of the phases that are timing at the instant that a given phase (bytes 1-4) begins timing toward trip (i.e., its LED comes on).

Additionally, this register records the level of input current above the timed-trip setpoint. This information is provided on a per phase basis, and timestamps are taken for each excursion above pickup for each phase (bytes 5 through 28).

In order for this register to be updated, the input current of at least one phase must exceed the timed trip pickup setting.

Byte	Name	Range (in kA)
1	Phase Timing Status	

This register is bit-mapped as follows.

Bit 0 = Phase A timing
Bit 1 = Phase B timing
Bit 2 = Phase C timing
Bit 3 = spare
Bit 4 = spare
Bit 5 = spare
Bit 6 = Neutral timing
Bit 7 = spare

Byte	Name	Range (in kA)
2	Spare	
3-4	Phase A Current	0-50
5-6	Phase B Current	0-50
7-8	Phase C Current	0-50
9-10	Neutral Current	0-50
11-14	Neutral Timestamp**	

**The time stamp indicates the time of the event in a packed binary format that is decoded by BEBUS.

Register Number	Register Name	Description
59	**PICKUP STATUS**	This register functions in an identical manner to register 58 except that the reading of this register will

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
	with RESET	reset the contents. Bit 1 = Phase A Bit 5 = Spare Bit 2 = Phase B Bit 6 = Spare Bit 3 = Phase C Bit 7 = Neutral Bit 4 = Spare Bit 8 = Spare
61	**TAPS SETTING** [READ ONLY]	This register holds the TAP switch selections for the phase and neutral pickups. Its format is: <u>Byte Number</u> <u>Name</u> <u>Range §</u> 1 Phase Selection A-J 2 Neutral Selection A-J § Taps A through J: A = 00, B = 01, etc.
62	**TIME DIAL SETTING**	Stores time dial selection for phases and ground. Range is 0 to 99 for each dial.
63	**TAP CAL SETTING** [SECURED]	Stores TAP CAL setting for phases and ground. Range is 0 to 99 for each setting.
64	**INSTANTAN-EOUS SETTING** [SECURED]	Holds the instantaneous overcurrent trip settings. The setting range is 0.75 to 20 times TAP, representing actual current values that are 100 times the setting. All 8 bytes of the following format must be written into the register (for standardization across product lines). <u>Byte</u> <u>Name</u> <u>Times TAP</u> 1, 2 Inst. #1 (phase) 50 to 2000 A 3, 4 Inst. #2 (phase) 50 to 2000 A 5, 6 Inst. #1 (neutral) 50 to 2000 A 7, 8 Inst. #2 (neutral) 50 to 2000 A
65	**NEUTRAL TRIP SELECTIVITY** [SECURED]	This eight-bit register is used to hold the flags to enable/disable neutral trips. The register is bit mapped as follows. bit 0 - neutral selectivity enabled bit 1 - 50g bit 2 - 51g bit 3 - affected output (0 = timed, INST1) (1 = INST2) bit 4 - spare bit 5 - spare bit 6 - spare

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
		bit 7 - spare
66	**CURVE TYPE** [SECURED]	Holds the two codes that determine the characteristic timing curves being used for the phases and ground.

The format of this register is:

Byte	Name	Value
1	Phase time overcurrent characteristic	0 to 255
2	Ground time overcurrent characteristic	0 to 255

The following characteristic curves are supported at this writing.

Code	Type	Description	Figure Reference
01	b1	Short inverse	1-1
02	b2	Long inverse	1-2
03	b3	Definite time	1-3
04	b4	Moderately inverse	1-4
05	b5	Inverse	1-5
06	b6	Very inverse	1-6
07	b7	Extremely inverse	1-7

Register Number	Register Name	Description
67	**TAP RANGE** [READ ONLY]	Indicates the current sensing input range - HIGH or LOW - of the relay. The range is determined by the style number at the time of the order. (This is a factory setting.)
68	**BREAKER FAILURE ENABLE** [SECURED]	This register controls the breaker failure function. 1 = enabled, 0 = disabled
81	**CT RATIO** [SECURED]	Holds the primary pickup ratio(s) for phase and ground CTs. The format of this register is:

Byte Number	Name
1-2	Phase CT Primary Relative Turns
3-4	Phase CT Secondary Relative Turns
5-6	Neutral CT Primary Relative Turns
7-8	Neutral CT Secondary Relative Turns

Register Number	Register Name	Description
91	**BREAKER**	0 = breaker open; 1 = breaker closed.

Table 5-1. Registers Accessible Via The RS-232 And RS-435 Ports - Continued

Register Number	Register Name	Description
	STATUS [READ ONLY]	
92	**FAULT ACCUMULATION** [SECURED]	Provides a cumulative total of the RMS current passing through the breaker during the last cycle of every fault. Since this is one of the factors in breaker contact wear, it can be used as an aid in the scheduling of breaker maintenance time. <u>Byte Number</u> / <u>Name</u> / <u>Value</u> 1-4 / Total A Phase / 0 to 99999 5-8 / Total B Phase / 0 to 99999 9-12 / Total C Phase / 0 to 99999 13-16 / Total Neutral / 0 to 99999
93	**OUTPUT CONFIGURA-TION** [SECURED]	Indicates the output configuration of the relay when Option 1-2 is incorporated. Possible assigned values for this register are: 00 = No optional output provided. 01 = Program-controlled output contact. 02 = INST 2 function incorporated.
100	**EVENT RECORD** [READ ONLY]	Returns number, size, and format of the relay's history registers. The format of the register is: <u>Byte Number</u> / <u>Name</u> / <u>Value</u> 1 / Number / 20 2 / Size in bytes. / 14
101 to 120	**EVENT HISTORY** [READ ONLY	Returns history of last 20 trips (most recent is in register 101, 2nd most recent in register 102, etc.). The format of each register is as follows. <u>Byte Number</u> / <u>Name</u> / <u>Range</u>* 1-4 / Phase A Current / 0 to 50,000 A

* In Primary Amperes.

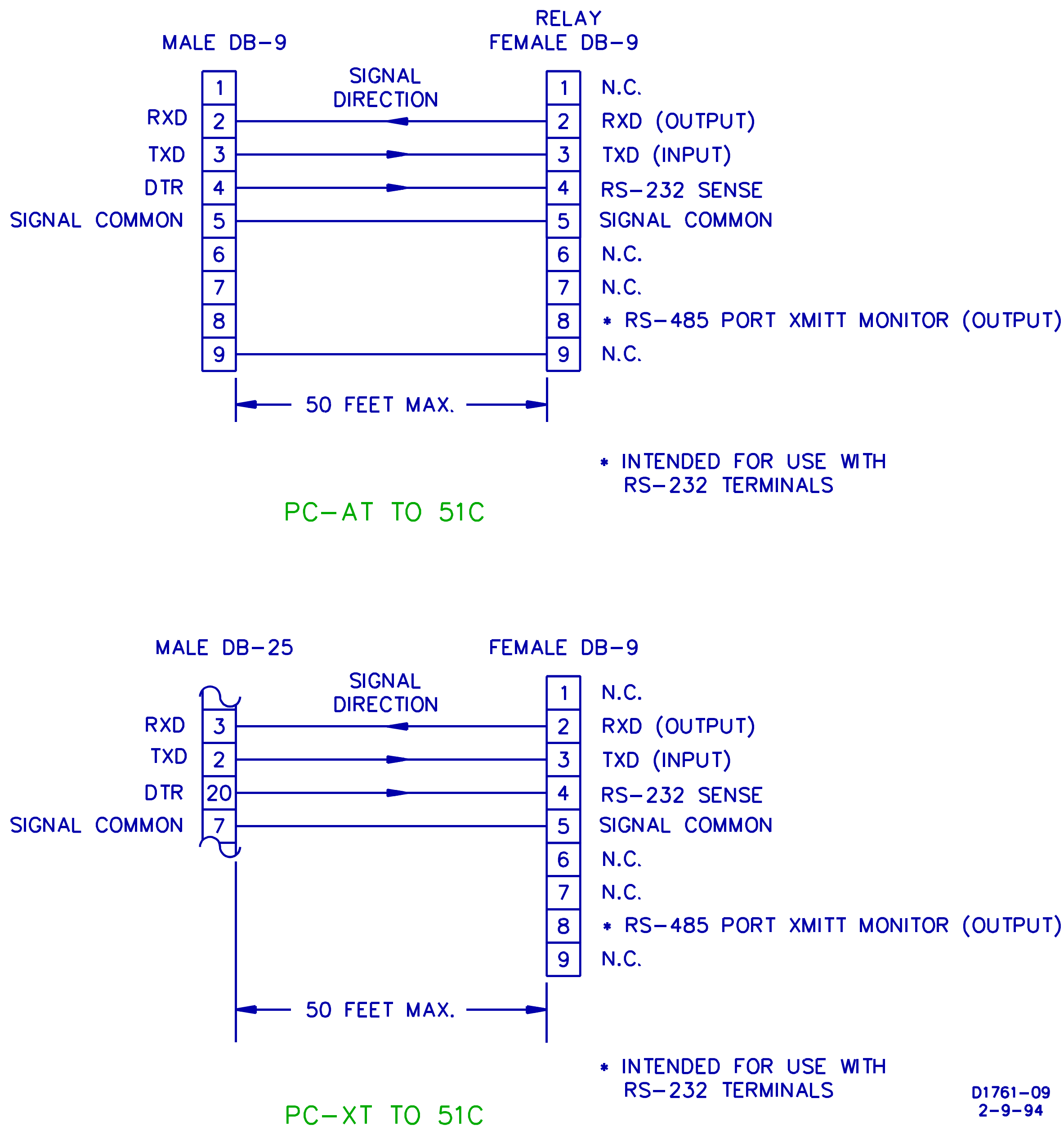


Figure 5-1. RS-232 Port Connector Wiring

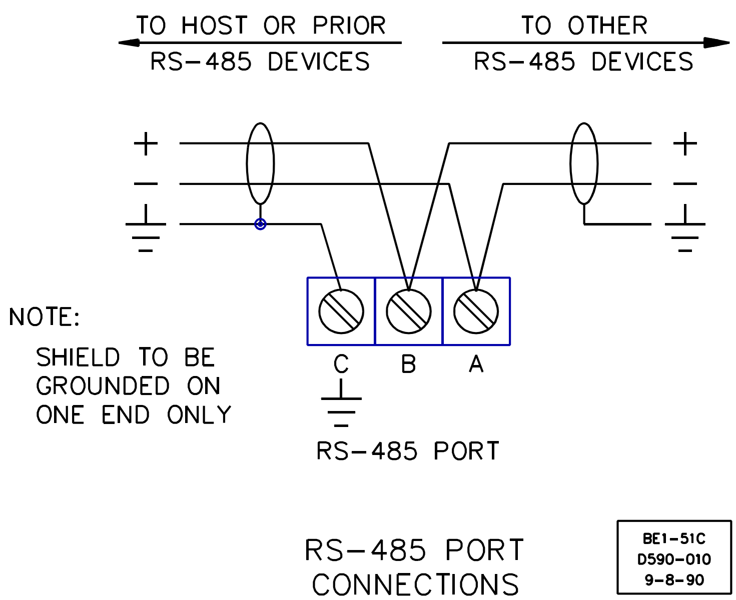


Figure 5-2. RS-485 Port Connector Wiring

SECTION 6

INSTALLATION AND TESTING

GENERAL

When not shipped as part of a control or switchgear panel, the relay is shipped in a sturdy carton 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 evident damage, immediately file a claim with the carrier and notify the Regional Sales Office, or contact a 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 the relay is to be placed in service, it is recommended that the verification tests (given later in this section) 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 the FUNCTION targets.

2. Always reset targets by means of the target reset switch.

3. The relay is a solid state device and has been type tested in accordance with the requirements defined below under DIELECTRIC TEST. If a wiring insulation test is required on the panel assembly in which this relay is to be installed, it is suggested that the connecting plugs (or paddles) of the relay be removed and the cradle withdrawn from the case so as not to produce false readings during the wiring insulation test.

4. When the connecting plugs are removed, the relay is disconnected from the operating circuit and will not provide system protection. Always be sure that external operating (monitored) conditions are stable before removing a relay for inspection, test, or service. Be sure that connecting plugs are in place before replacing the front cover.

DIELECTRIC TEST

1000 Vac at 60 hertz for one minute may be applied across output terminal pairs in accordance with IEC 255-5 and ANSI/IEEE C37.90-1989 (Dielectric Test). Maximum applied voltage must be no greater than 300 volts where MOV suppressors are used. Terminals 11 and 12 have MOV suppressors installed between terminals and ground. Terminals 3 and 4 have one MOV suppressor installed between the terminals. All terminals have decoupling capacitors installed between terminals and ground. According, a leakage current of approximately 2.0 milliamperes per terminal is to be expected when high potting at 1000 Vac, 60 hertz. 1500 Vac at 60 hertz for one minute may be applied across current sensing input terminals, between circuit groups, and between circuit groups and chassis ground in accordance with IEC 255-5 and ANSI/IEEE C37.90-1989 (Dielectric Test).

MOUNTING

The BE1-51C relay is supplied in a standard S1 size drawout case. Figure 6-1 provides the outline dimensions for this case. The panel drilling and cutout dimensions for this case are provided in Figure 6-2.

The relay does not have to be mounted vertically. Any convenient mounting angle may be chosen.

CONNECTIONS

Incorrect wiring may result in damage to the relay. Be sure to check the model and style number of the relay with the STYLE NUMBER IDENTIFICATION CHART before connecting and energizing the relay. A connection diagram is provided in Figure 6-8.

The terminals along the top and bottom of the back of the case are suitable for use with wiring terminals and wire sizes of 14 AWG or larger. The RS-485 port terminals A, B, and C (back of case, center) require a shielded twisted pair.

Be sure that the relay case is hard wired to earth ground using no smaller than 12 AWG copper wire to the ground terminal on the rear of the unit. A ground terminal on the rear of the case is provided for this purpose. Ideally, each relay should have a separate ground wire to the ground bus. If this is not practical, the number of relays sharing a ground wire should be kept to a minimum.

VERIFICATION TESTING

General

The test procedures which follow are intended to verify correct operation of the relay, and to set the controls for a specific application. Each phase of a two- or three-phase relay may be tested as a single-phase device using the procedures given. Check the Style Number Identification Chart with the style number of the relay to identify the options included within the specific relay to be tested.

All LED and target indicators should be checked in the course of carrying out these test procedures. Reminder: The FUNCTION targets require at least 0.2 A in the output circuit to operate.

When test results do not fall within the specified tolerances, the following should be evaluated.

1. The tolerances of the test equipment;
2. Cycle-to-cycle phase stability of the test equipment;
3. The tolerances of any external components used in the test setup.

Detailed calibration and troubleshooting procedures are in the Service Manual, Basler publication 9 2330 00 620.

Scope

A complete checkout of the relay (or verification test) confirms that the following are within the published specifications.

1. Time overcurrent pickup;
2. Instantaneous pickup;
3. Time overcurrent timing;
4. Communications option. (The testing procedure for this software option is covered in the BEBUS Users Manual, Publication 9 2330 00 993.)

While every comprehensive test program should cover all of the above items, the amount of testing within any category can vary over a great range. The operational test defined below illustrates an appropriate lower limit for this range.

Operational Test

Confirmation of every parameter within the capability of this relay is usually not practical nor necessary except as an acceptance procedure for a newly delivered relay. Succeeding tests can be reduced in scope to conserve time (and thereby permit more frequent tests). Such an operational test may be accomplished by scaling down the verification tests of this subsection as follows.

1. By concentrating on the parameters actually required in the assigned application;
2. By using spot tests that check (for example) only one or two multiples of applied TAP current at only one or two TAP positions.

Accordingly, the procedures described below can serve as the basis for both verification and operational testing.

Equipment Required

1. A current source with the following capabilities.

   a. Current output should be switchable so that the test current can be adjusted before it is applied to the relay's sensing inputs.

   b. The current source needs to be capable of delivering at least 20 A. This is necessary to test the full capability of the instantaneous overcurrent element.

   c. Because the current levels used to verify operation of the instantaneous overcurrent element(s) may exceed the continuous current rating of the relay, it is suggested that the current source include a provision for automatic removal of the test current following a trip.

2. A timer accurate to within 0.001 seconds.

3. Two test plugs, Basler p/n 10095 or GE p/n XLA12A. (Replaces the paddles when testing an installed relay.)

4. For bench testing: An appropriate AC or DC power source for relay operation.

NOTE
Several proprietary test sets are marketed which combine the current source and timer, and include other features to simplify setup.

Preliminary Steps

1. With the connecting plugs removed, connect the unit per Figure 6-8. Connect the proper power supply voltage to terminals 3 and 4. (See the Style Chart for the correct power source for each supply.)

2. Insert the relay connecting plugs if bench testing. If relay is installed, insert test plugs instead. Before applying power, check that the Relay Fail contact is closed (terminals 11 and 12).

3. Apply operating power at terminals 3 and 4. Verify that the POWER LED is lit, and that the relay fail contact is open.

4. Load 00 into the Phase Tap Cal register. (The procedure for loading the registers is described in Section 4.)

Time Overcurrent Pickup Test

The phase current pickup of the relay will be set at the factory to operate on one of the two available ranges: HIGH or LOW. If ground current is monitored, it will also be set for one of the two ranges. Determine which range applies by noting the placement of the range plate(s) on the front panel. (There are two plates if ground current is monitored.)

Verify time overcurrent pickup as follows.

1. After performing the Preliminary Steps given above, connect the input current source to terminals 7 and 8 (on the relay case) to test Phase A.

2. Set the PHASE TAP switch to position A.

3. Adjust the input current source to the value shown on the front panel table for TAP A (HIGH or LOW range as indicated by the second digit of the style number). Observe that the PHASE A TMG LED illuminates within 2 cycles.

4. Adjust the current source so that the PHASE A TMG LED goes dark. The current applied when the LED extinguishes should be between the pickup point (from the table) and .90 times the pickup point.

5. Repeat steps 3 and 4 with the PHASE TAP switch set to B, C, D, E, F, G, H, I, and J successively.

NOTE

If this is a single-phase relay, this completes the Time Overcurrent Pickup Test. If this is a three-phase relay, perform steps 6, 7, 8, and 9 below. If two-phase-with-ground relay, perform steps 6, 7, 10, and 11 below. If three-phase-with-ground, perform all of the following steps.

6. Disconnect the input current source from terminals 7 and 8 (Phase A) and connect it to terminals 14 and 15 (Phase B).

7. Repeat steps 2 through 5 above for phase B.

8. Disconnect the input current source from terminals 14 and 15 (Phase B) and connect it to terminals 17 and 18 (Phase C).

9. Repeat steps 2 through 5 above for phase C.

10. Disconnect the input current source from terminals 17 and 18 (Phase C) and connect it to terminals 13 and 16 (Ground).

11. Repeat steps 2 through 5 above for ground current.

Timing Test

The timing characteristics available by programming the relay are illustrated in Figures 1-1 through 1-7. Output trip should occur at the timing shown on these graphs, for any given TIME DIAL setting, to within 10% or 20 milliseconds (whichever is greater). Verification of timing accuracy can be limited to low current levels for convenience.

Verify timing accuracy as follows.

1. After performing the Preliminary Steps (page 6-3), connect the input current source to terminals 7 and 8 on the relay case (Phase A).

2. Select the time overcurrent characteristic of choice by entering its identifying code number into the Phase curve (Pcur) register. (Reference Tables 4-1 and 4-2.) Similarly load the Ground curve register with the characteristic of choice (if ground current monitoring is a relay option).

3. Set the PHASE TAP switch to position A. Load 99 into the Time Dial register. (The CALibrate register is still at the 00 setting given in Preliminary Steps.)

4. Measure the timing from the application of input current to output contact closure for currents that are adjusted to the following multiples of TAP:

   (a) 2.0 X TAP, and (b) 5.0 X TAP.

   Check the results against the graphed values.

5. Adjust the TIME DIAL to 20 and repeat step 4.

NOTE

If this is a single-phase relay, this concludes a minimal Timing Test. Other TAP switch positions may be tried within the limitations of the current source. If this is a three-phase relay, perform steps 6, 7, 8, and 9 below. If two-phase-with-ground relay, perform steps 6, 7, 10, and 11. If three-phase-with-ground, perform all of the following steps.

6. Disconnect the input current source from terminals 7 and 8 (Phase A) and connect it to terminals 14 and 15 (Phase B).

7. Repeat steps 2 through 5 above for phase B.

8. Disconnect the input current source from terminals 14 and 15 (Phase B) and connect it to terminals 17 and 18 (Phase C).

9. Repeat steps 2 through 5 above for phase C.

10. Disconnect the input current source from terminals 17 and 18 (Phase C) and connect it to terminals 13 and 16 (Ground).

11. Repeat steps 2 through 5 above for ground current.

Instantaneous Overcurrent Pickup Test

The phase current pickup of the relay is set at the factory to operate on one of the two available ranges: HIGH or LOW. If ground current is monitored, it will also be set for one of the two ranges. Determine which range your relay is set for by the placement of the range plate on the front panel. (There are two plates if ground current is monitored.)

> **CAUTION**
> When testing the instantaneous element, the thermal rating of the relay must not be exceeded. The maximum continuous current rating for each input is five times tap or 20 A, whichever is less.
>
> The one-second current rating for each input is 50 times tap or 500 A, whichever is less. For ratings at less than one second, refer to formula on page 1-5.

Verify instantaneous overcurrent pickup as follows.

1. After performing the Preliminary Steps (page 6-3), connect the input current source to terminals 7 and 8 on the relay case (Phase A).

2. Load .75 into the Phase Instantaneous #1 register. (Appears as Pin1 in the display, and in Table 4-1.)

3. Set the PHASE TAP switch to position A.

4. Starting from 0 A, slowly increase the input current source until the INST 1 output contact closes. This should occur at 3/4 the value shown on the front panel table for TAP A.

5. Adjust the current source so that the INST 1 relay just opens. The current applied should be above 71.25% of the TAP value (reference the front panel table).

6. Repeat steps 3 through 5 above with the PHASE TAP switch set to B, C, D, E, F, G, H, I, and J successively.

7. If Option 1-2 is present, follow the procedures of steps 2 through 6 for testing the INSTantaneous 2 pickup and output.

> **NOTE**
> If this is a single-phase relay, this completes the Instantaneous Overcurrent Pickup Test. If this is a three-phase relay, perform steps 8, 9, 10 and 11 below. If a two-phase-with-ground relay, perform steps 8, 9, 12 and 13 below. If three-phase-with-ground, perform all of the following steps.

8. Disconnect the input current source from terminals 7 and 8 (Phase A) and connect it to terminals 14 and 15 (Phase B).

9. Repeat steps 2 through 7 above for Phase B.

10. Disconnect the input current source from terminals 14 and 15 (Phase B) and connect it to terminals 17 and 18 (Phase C).

11. Repeat steps 2 through 7 above for phase C.

12. Disconnect the input current source from terminals 17 and 18 (Phase C) and connect it to terminals 13 and 16 (Ground).

13. Repeat steps 2 through 7 above for ground current.

COMMUNICATIONS TESTS

General Verification

1. Perform the Preliminary Steps on page 5-3.

> **NOTE**
> The page and table references given below apply to the BEBUS User's Manual, publication 9 2330 00 993.

2. Follow the setup instructions given in Sections 2 and 3 of the BEBUS User's Manual. Establish that communications are established by performing (as a minimum) the following steps.

3. Use the BAUD command to establish the desired common baud rate for the relay and host computer.

4. To confirm that communications are established:

   a) Read the serial number of the relay.

   b) Read the style number of the relay.

   c) Write into the Time & Date register; read same to verify.

Command Actuated Close

Verify operation of the Option 1-3 Command output (at terminals 5 and 6) as follows.

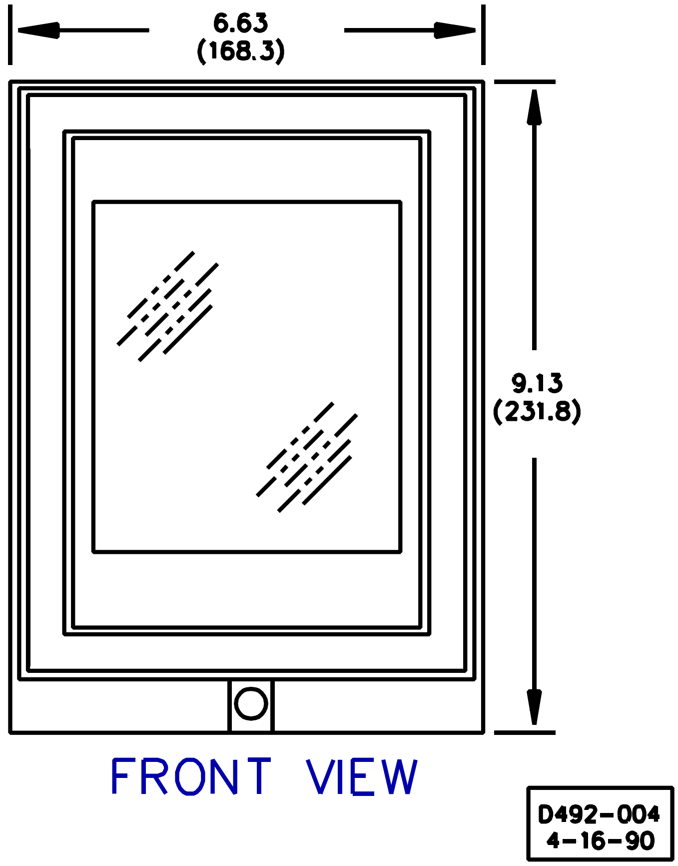
1. With the relay set up for communication with a computer (see above article), jumper input terminals 3 and 9 to represent an open breaker (52b closed).

2. Actuate the Close contact by typing:

   WRITE 16=10; 10=12 **[ENTER]**

   The first instruction sets up the Secured Timer; the second instruction calls up the Command register (register 10), and enters the Close command (12).

3. Verify that the Command contact at terminals 5 and 6 closes.



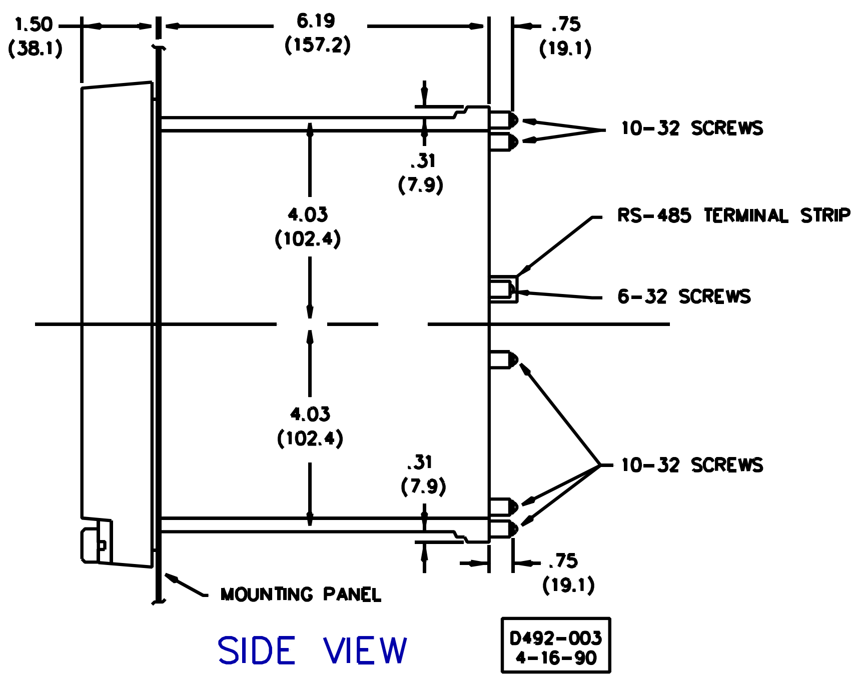


Figure 6-1. Outline Dimensions

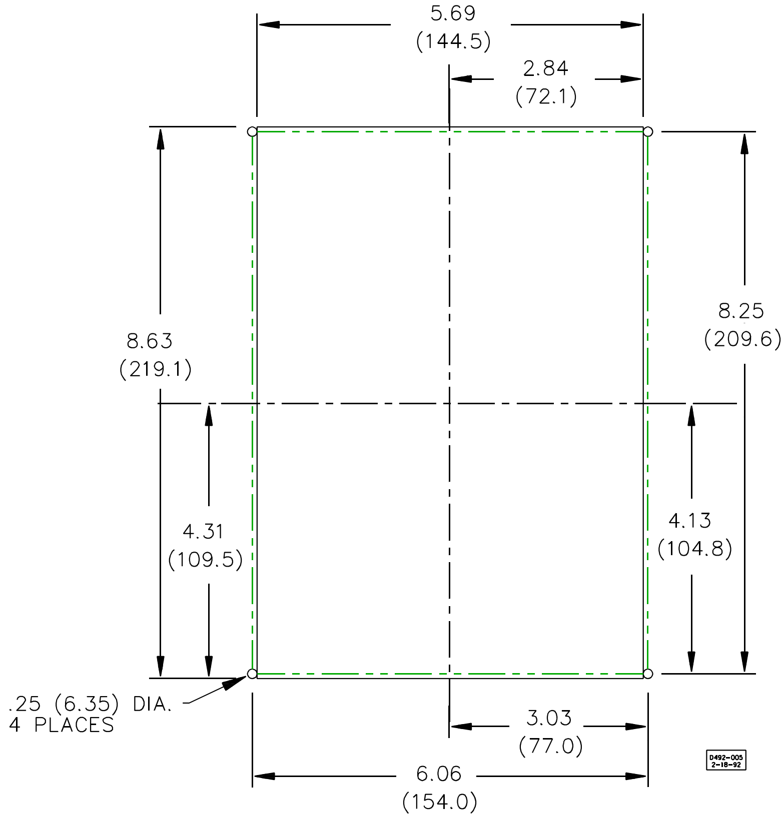


Figure 6-2. Panel Drilling and Cutout Dimensions (Semi-Flush Mounting)

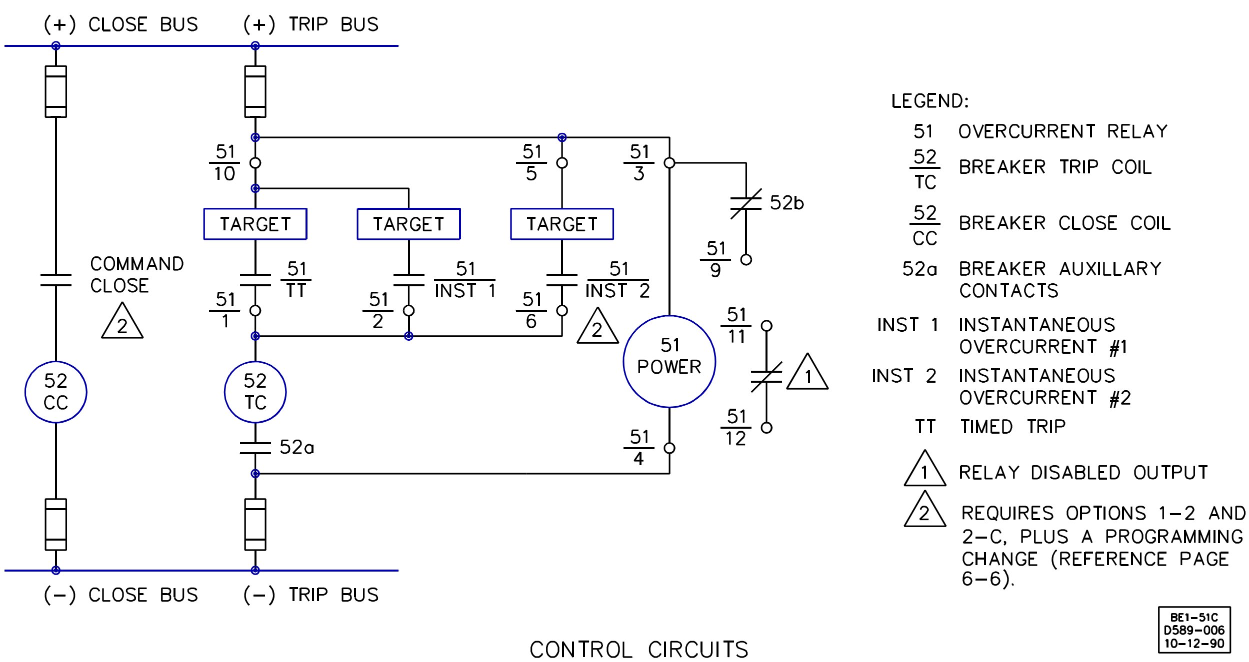


Figure 6-3. Control Circuits

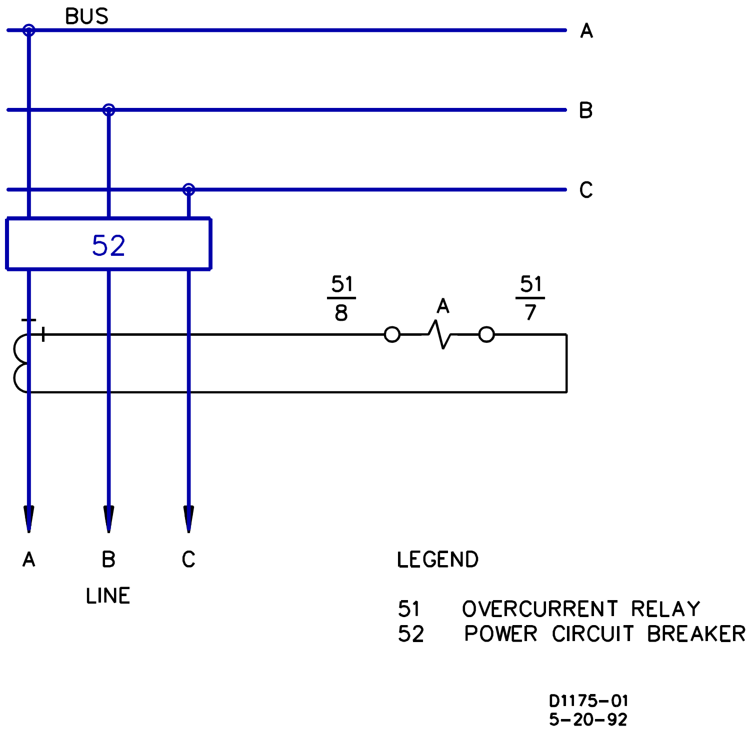


Figure 6-4. Single-Phase Current Sensing Connections

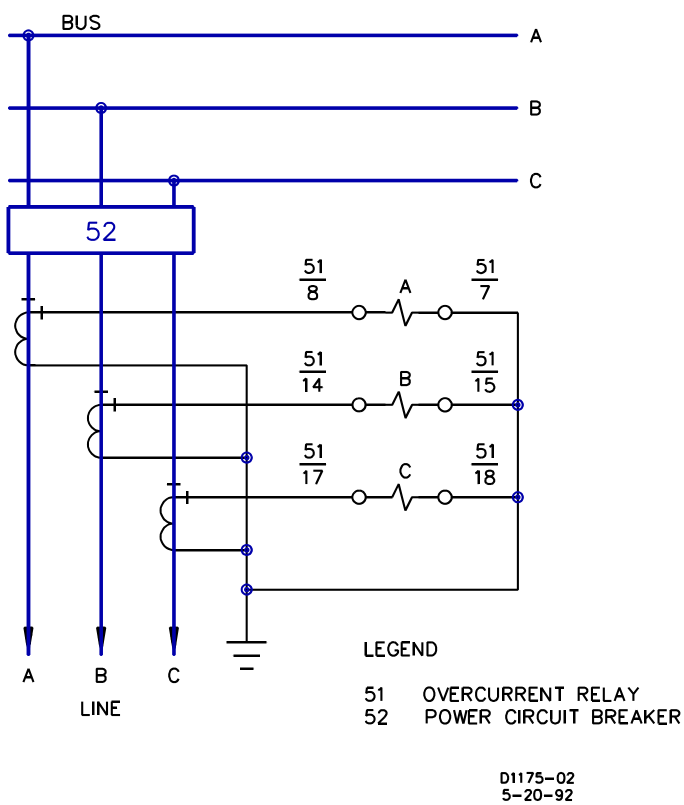


Figure 6-5. Three-Phase Current Sensing Connections

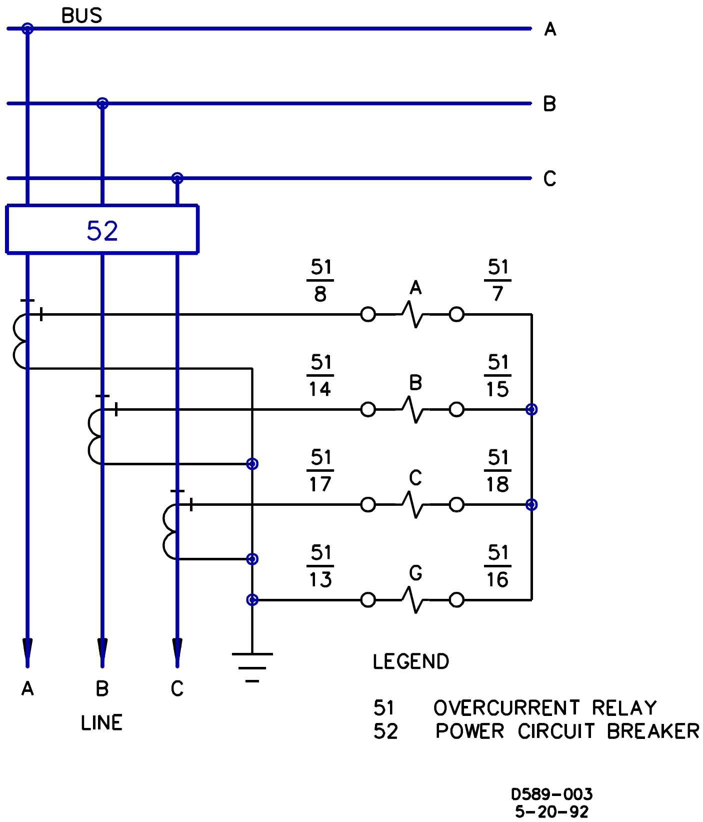


Figure 6-6. Three-Phase-with-Neutral Current Sensing Connections

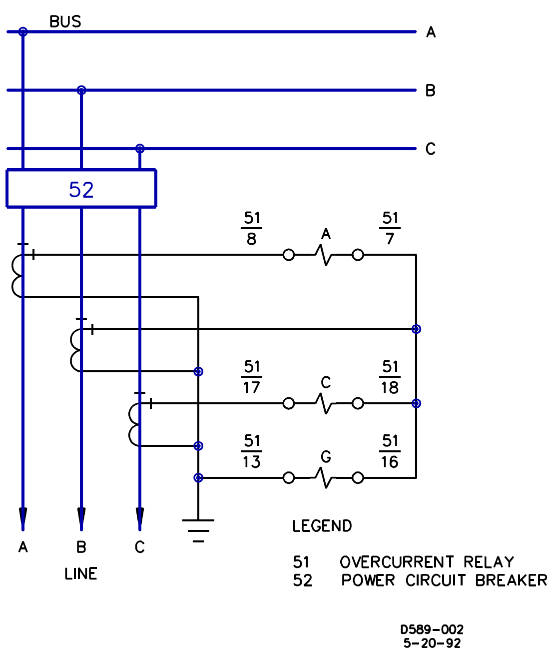


Figure 6-7. Two-Phase-with-Neutral Current Sensing Connections

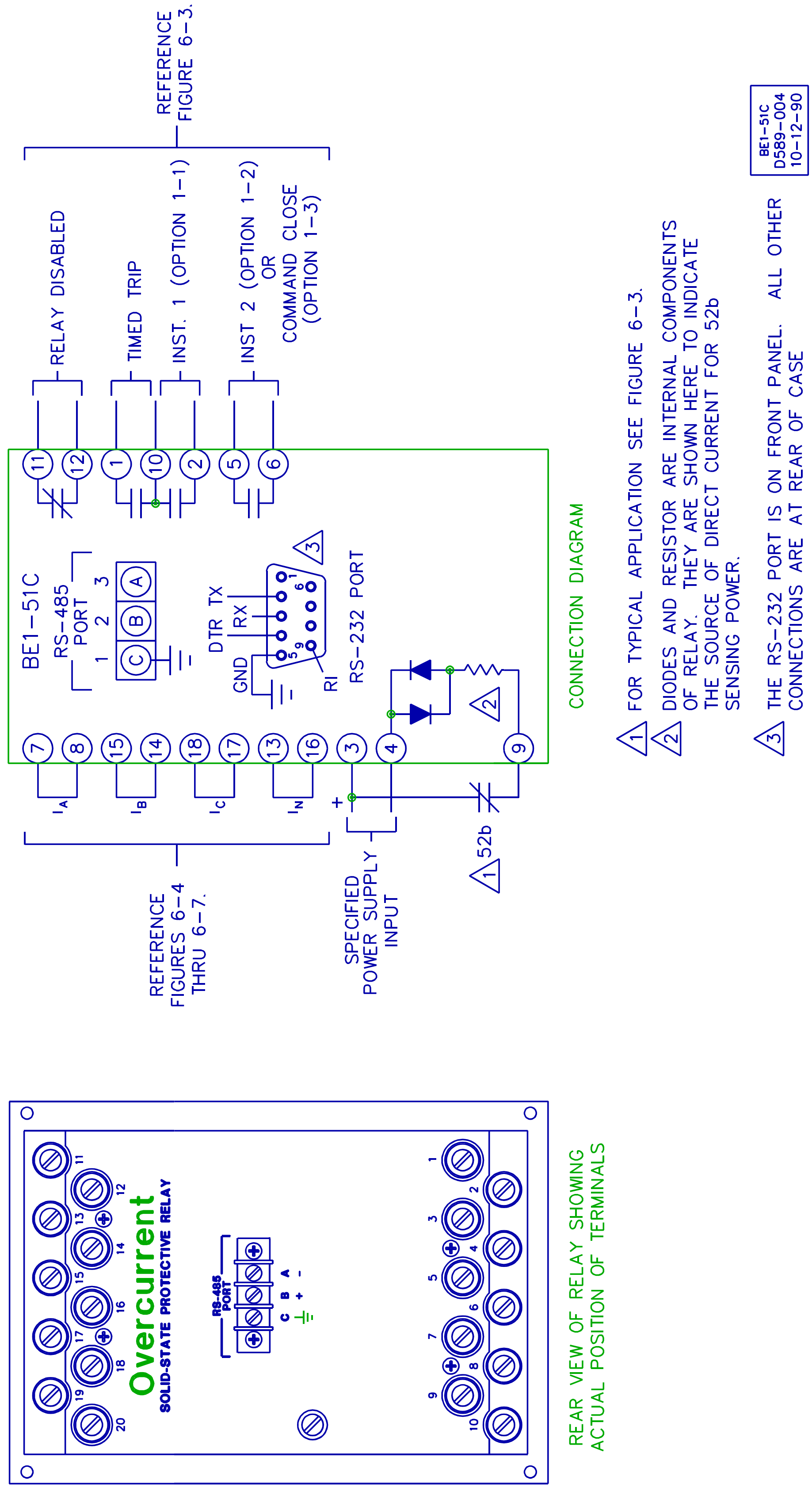


Figure 6-8. Relay Connections

SECTION 7

MAINTENANCE

GENERAL

BE1-51C Communications Overcurrent Relay requires no preventive maintenance other than a periodic operational test (refer to Section 6 for operational test procedure). If the relay fails to function properly and is to be repaired in-house, consult the Service Manual (publication number 9 2330 00 620). If 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.

If in-house repair is to be attempted, component values may be obtained from the schematics or the parts list of the Service Manual. 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, Basler Electric part numbers may be obtained from the number stamped on the component or assembly, the schematic, or parts list. These parts may be ordered directly from Basler Electric. When complete boards or assemblies are needed, the following information is required.

1. Relay model and style number

2. Relay serial number

3. Board or assembly

   a) Part number
   b) Serial number
   c) Revision letter

4. The name of the board or assembly.

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.

TROUBLESHOOTING

The following resources are available to aid in troubleshooting.

Built-In-Test

The Built-In-Test feature (BIT) is a quick-test routine that is programmed into the firmware of the relay. When initiated, the relay will automatically perform (at one-second intervals) a series of tests that may be monitored by the outputs and indicator lamps of the relay. By observing that the sequence ran as specified, the proper operation of all indicators and outputs, as well as much of the internal digital and analog circuitry, is verified. (It does not check the input circuitry, however.)

BIT requires isolation of the relay (all outputs disconnected), and withdrawal of the logic circuit board (to move the TEST/NORMAL switch to the test position). Therefore it is intended as a service bench resource for troubleshooting, rather than as part of - for example - a scheduled, periodic operational test program. For implementation instructions, see the Service Manual.

Batch Programs

To assist in troubleshooting, the relay may be exercised by a programmed sequence of changing parameters using a batch program. For instructions and a sample diagnostic program, see Section 4 of the BEBUS User's Manual (publication 9 2330 00 993).

TIMEKEEPING

The real-time clock within the relay, once set after power up, maintains time to a resolution of 0.01 second; however, drift within the clock can be as much as 0.5 seconds per day. In order to keep all of the clocks in the system in proper synchronization, it is suggested that the master station broadcast the correct time at least once per day.

Note that changing the time within a relay by seconds or minutes can upset instrumentation functions such as demand calculations.

SECTION 8

MANUAL CHANGE INFORMATION

SUMMARY AND CROSS REFERENCE GUIDE

This section contains information concerning the previous editions of the manual. The substantive changes to date are summarized in the Table 8-1.

REV	ECA	Summary of Changes
A	10/90	Subsection added on page 3-4 entitled Instantaneous and Command Close Options. Tables in Section 4 and 5 revised. Added Register Overview, page 6-2; Troubleshooting and Timekeeping, page 7-2. General Editorial revisions.
B	06/92	All Sections of the manual have been revised to upgrade the relay to Version 1.6.
C	11/94	Changed Software Revision from 3.40 to 3.46. Page 1-7, *Specifications*, corrected K = (500 A or 5 times TAP)^2 to K = (500 A or 50 times TAP)^2. Deleted old Table 1-1 *Current Sensing Burden* and replaced with Burden is less than 0.1 ohm. Changed Table 1-2 to Table 1-1. Changed *Isolation* specifications to current standards. Corrected Figure Titles 1-2 and 1-3. Section 3, changed paragraph *Loss-of-Power Sensing* to reflect changes in the relay software. Section 4, corrected Table 4-1, *Display Sequence* 11 and 12. Section 5, deleted references to Register Number 6. Corrected Register Number 58, *Description*. Corrected Figure 5-1 to show communication port wiring. Section 6, changed *Dielectric Test* to current standards.

R E F E R E N C E S

1) EIA Standard: EIA 485. (Also known as the RS-485 Standard.) Published by Electronic Industries Association (April 1983).

2) Remote Access Protocol for Serial Data Link Networks, Basler Publication 9 2330 00 683.

3) BEBUS User's Manual, Basler Publication 9 2330 00 993.