BE1-40Q LOSS OF EXCITATION RELAY

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Reference
Publication Number
9 1715 00 990

INSTALLATION
Case dimensions and
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The BE1-40Q Loss of Excitation Relay can protect synchronous generators from extensive damage by detecting loss of field.

FEATURES

- Relay characteristics are defined on the complex power plane for ease of application.
- Provides economical protection for small, medium, and large machines.
- Features solid state reliability, repeatability, sensitivity, and accuracy.
- Convenient, readily testable.
- Qualified to the requirements of
  - ANSI/IEEE C37.90-1978, C37/90a-1974, and IEC 255 for surge withstand capability;
  - ANSI/IEEE C37.90.1-198X for fast transient;
  - IEC 255-5 for impulse.
- Two-year warranty.

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APPLICATION

PURPOSE

The BE1-40Q Loss of Excitation Relay is used in conjunction with synchronous generators to detect loss of field excitation which, if undetected, could result in serious damage to the machine.

Loss of excitation protection is applied on nearly all synchronous generators. Severely reduced or lost excitation can cause generator heating and unstable operation, or even loss of synchronism. Many modern excitation systems include minimum-excitation limiters to prevent under-excitation; however, protective relays are still applied as backup protection for these automatic controls.

CAPABILITY CURVES

Generators have characteristic limitations called capability curves. There are actually three curves which define the general region within which the generator can operate without damage. The curves are derived from three individual heating effects that occur as a function of time: specifically, the temperature-over-time characteristics of the stator end iron, the stator winding, and the rotor winding. These curves are depicted on the complex power plane with real power on the horizontal axis and reactive power on the vertical axis (Figure 1). Capability curves like these are routinely supplied by the generator manufacturer.

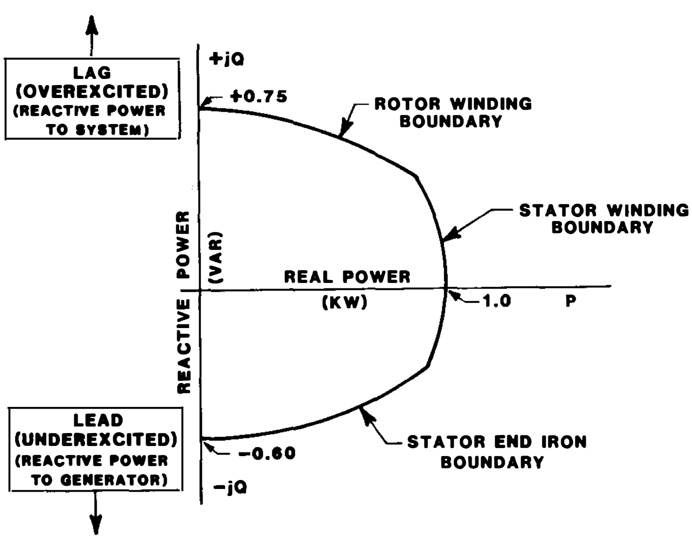


FIGURE 1. TYPICAL GENERATOR CAPABILITY CURVES

An additional limit is often included with the capability curves. Figure 2 shows the addition of the steady state stability limit (SSSL). A generator may pull out of step if the SSSL is exceeded. Figure 3 illustrates the proper operation of a generator within all four limits.

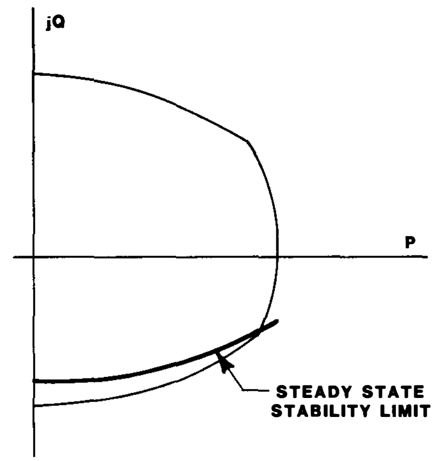


FIGURE 2. STEADY STATE STABILITY

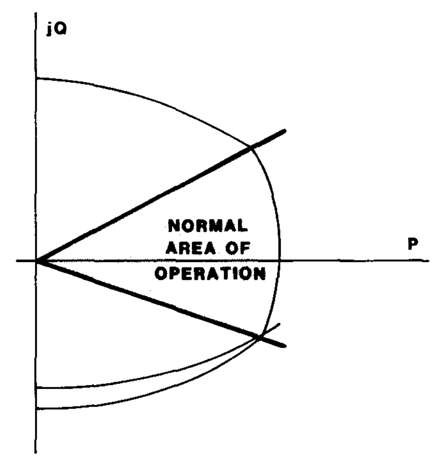


FIGURE 3. NORMAL AREA OF GENERATOR OPERATION

RELAY OPERATING CHARACTERISTIC

Application of the BE1-40Q Loss of Excitation Relay is made easy by remaining on the complex power plane where the generator's capabilities are defined. The relay's response characteristic is represented by a line 8° from horizontal as shown in Figure 4a. Note that this characteristic is placed above the most restrictive limit, and the attendant intercept on the Q axis (at 0.4 per-unit vars) is used to establish the pickup of the relay.

Mho-type loss-of-excitation relays require the conversion of the generator curves to the complex impedance plane, or require calculations employing transient and synchronous reactances. This approach may also be used with the BE1-40Q relay, as illustrated by Figure 4b. Note that the relay will trip *inside* the mho circle of Figure 4b, and *below* the characteristic line of Figure 4a.

APPLICATION (Continued)

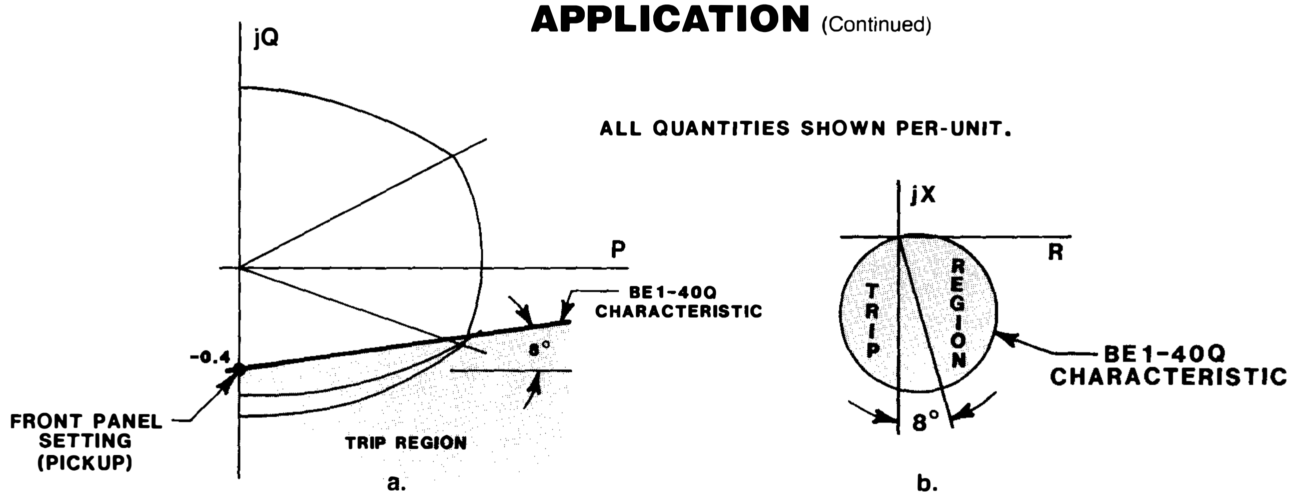


FIGURE 4. BE1-40Q OPERATING CHARACTERISTIC

TIME DELAYS

A time delay is included in the BE1-40Q to prevent misoperation for transient conditions such as power swings due to synchronizing or external fault clearing. A time delay setting of 02 is recommended for most tripping applications. Shorter times may be desired for alarming, longer times for unusual system conditions.

On large or especially critical machines it may be advantageous to use two BE1-40Q relays: one for the alarm and one for tripping.

ADDITIONAL CONSIDERATIONS

Synchronous generators operating in parallel are normally operated in the overexcited (lagging) region, which allows the generation of reactive power (vars). Although the field may safely be adjusted to cause the generator to absorb vars (leading), operation in this region is not reliably stable and therefore usually avoided. When field excitation is not sufficient to maintain the terminal voltage of a generator that is connected to a power system, the system will attempt to supply reactive power to excite the generator. This condition is considered a loss of excitation and is detectable by a protective relay.

When the system cannot supply the required vars, the weakened field may allow the rotor to slip poles during disturbances (such as a load change or a fault), causing loss of synchronism.

However, if the system can supply the necessary vars, the protected generator will act as an induction generator, drawing its excitation from the system. Under these conditions, the machine voltage will remain above the setting of the undervoltage protection for the machine. When a synchronous generator operates as an induction generator, the current induced by rotor slip flows in the damper (amortisseur) windings. Such current results in excessive heating within the generator — a condition which reduces machine life exponentially. This underscores the value of early detection.

SPECIFICATIONS

FUNCTIONAL DESCRIPTION

The specifications on these pages define the features and options that can be combined to exactly satisfy an application requirement. The block diagram (Figure 5) illustrates how the various standard features, as well as the options, function together.

VOLTAGE SENSING

The voltage sensing is derived from a system potential transformer connected phase-to-phase (not shown in block diagram but see Figure 9). An internal potential transformer (PT) provides isolation and reduces the voltage sensing input nominal value (120, 208, or 240 Vac) to internal circuitry requirements.

PHASE SHIFT

The relay is configured to monitor a phase-to-phase voltage input, V_{AB}, which leads the sensed current, I_B, by an angle of 150° for a unity power factor condition. To achieve the desired relay operating response characteristics, the voltage phasor is shifted 52° in a lagging direction to yield a resultant, I_{trip}, which lags the polarizing voltage, V_{POL} by 8°. (Figure 6.)

SPECIFICATIONS (Continued)

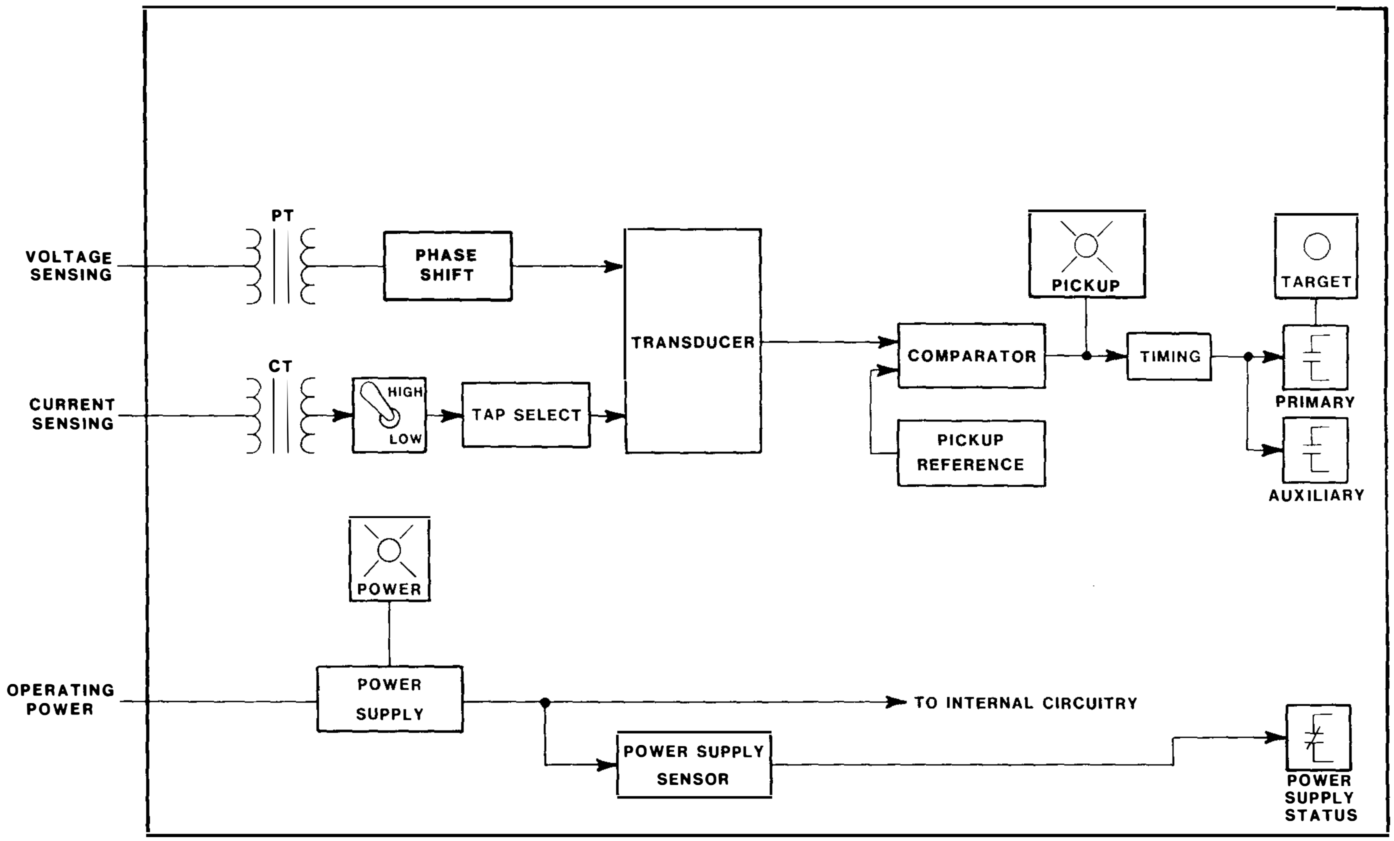


FIGURE 5. FUNCTIONAL BLOCK DIAGRAM

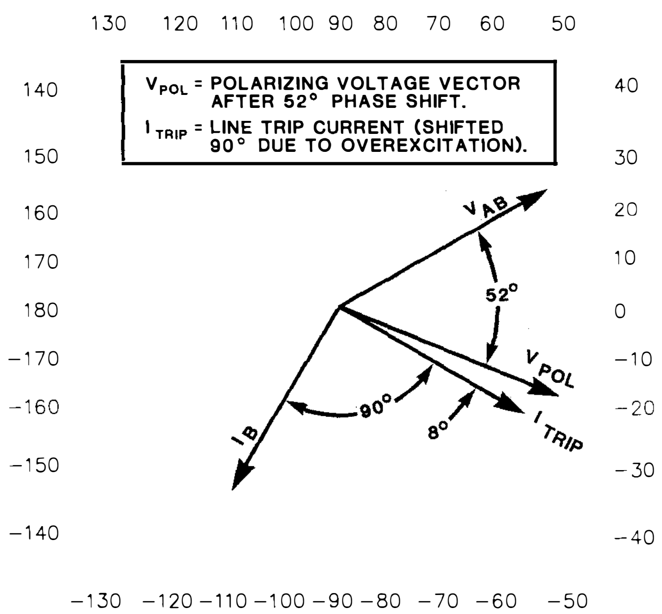


FIGURE 6. PHASE SHIFT EXAMPLE

CURRENT SENSING

The current sensing is supplied via a standard current transformer (not shown in block diagram) with a nominal 5 A secondary. An internal current transformer (CT) provides the necessary isolation and scaling for proper relay operation. The internal CT contains a tapped secondary which allows range selection (HIGH/LOW) for increased pickup settability.

RANGE SWITCH

The HIGH/LOW RANGE switch selects which secondary winding of the internal current transformer is connected to the TAP select and measurement circuitry. This switch may be changed while sensing current is present.

TAP SELECT

The TAP select switch is a 10-position rotary switch which, in conjunction with the HIGH/LOW RANGE switch, sets the pickup value (single-phase, vars) of the relay. The TAP switch selects the resistive burden value which is placed across the output of the (internal) sensing current transformer, thus scaling the internal signal to the input current value.

TRANSDUCER

The transducer consists of two major circuit functions: a multiplier and an integrator. The multiplier and its associated control circuits produce an output which is representative of the product of the two scaled inputs (i.e., the scaled current times the scaled phase-shifted-voltage). The

SPECIFICATIONS (Continued)

multiplier output waveform is an instantaneous value; therefore, the output must be integrated to develop a signal which represents the average var value. (Figure 7.)

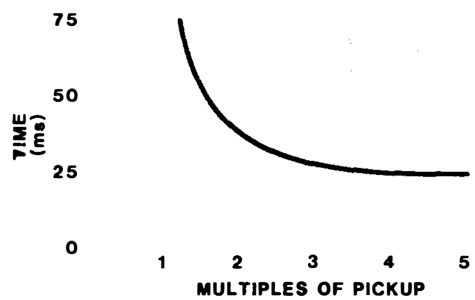


FIGURE 7. INTEGRATOR STEP RESPONSE OF TRANSDUCER

COMPARATOR

The signal representative of the monitored single-phase var level is applied to a comparator circuit where it is compared to the pickup reference. When the reference value is exceeded, the PICKUP indicator is illuminated and timing is initiated.

TIMING

A definite time delay is initiated when the monitored condition exceeds the pickup reference. A calibrated frequency generating circuit, in conjunction with counter circuits and thumbwheel switches, establishes the definite time delay interval. Definite time is adjustable by means of the front panel thumbwheel switches over the range of 0.1 to 9.9 seconds in 0.1-second intervals. A setting of 00 enables instantaneous (no intentional delay) operation. Timing is instantaneously reset if the input sensing level is reduced to less than the pickup value.

Note that total response time consists of (transducer) integration time (Figure 7) plus the deliberate delay introduced by the timer circuit.

POWER SUPPLY

One of five power supply types may be selected to provide internal operating power. They are described in Table 1.

TABLE 1. POWER SUPPLY OPTIONS

Parameter	OPTION				
	O	P	R	S*	T
Voltage (Nominal)	48 Vdc	125 Vdc 120 Vac	24 Vdc	48 Vdc 125 Vdc	250 Vdc 230 Vac
Burden	6.5 W	6.0 W 15.5 VA	7.5 W	6.5 W 6.2 VA	9.5 W 27.0 VA

*The type S power supply is field selectable for use with either 48 or 125 Vdc. Selection must be accomplished at the time of installation and prior to application of power.

OUTPUTS

A contact is provided as a tripping output. If desired, an auxiliary contact can be provided if ordered. Principle and auxiliary contacts may be configured for normally open (NO) or normally closed (NC) operation. (For redundancy, a second electro-mechanical relay is supplied to actuate the auxiliary contact if selected.)

For output contact ratings, see Bulletin UBY.

Power Supply Status Output (Option 2-S)
The power supply status output relay is energized and its NC output contact is opened when power is applied to the relay. Normal internal relay operating voltage maintains the power supply status output relay continuously energized with its output contact open. If the power supply output voltage falls below the requirements of proper operation, the power supply output relay is de-energized, closing the NC output contact.

Push-to-Energize-Output Pushbutton (Option 1-1)
Accessible by means of a thin non-conducting rod through the front panel, the push-to-energize pushbutton is available to energize the output relay for testing the external system wiring.

TARGET

A magnetically latched, manually reset target indicator is optionally available to indicate that the trip output has energized. Either an internally operated or current operated target may be specified. A current operated target requires a minimum of 0.2 A in the output trip circuit to actuate, and trip current must not exceed 30 A for 0.2 seconds, 7 A for 2 minutes, and 3 A continuous. A current operated target may be selected only when a normally open (NO) output contact has been specified.

SURGE WITHSTAND CAPABILITY

Qualified to ANSI/IEEE C37.90-1978 and C37.90a-1974 Surge Withstand Capability Test; IEC 255-5 Impulse Test and Dielectric Test; and ANSI/IEEE C37.90-198X Fast Transient Test.

MECHANICAL

Operating Temperature

−40° C (−40°F) to +70°C (+158°F).

Storage Temperature

−65° C (−85°F) to +100°C (+212°F).

SPECIFICATIONS (Continued)

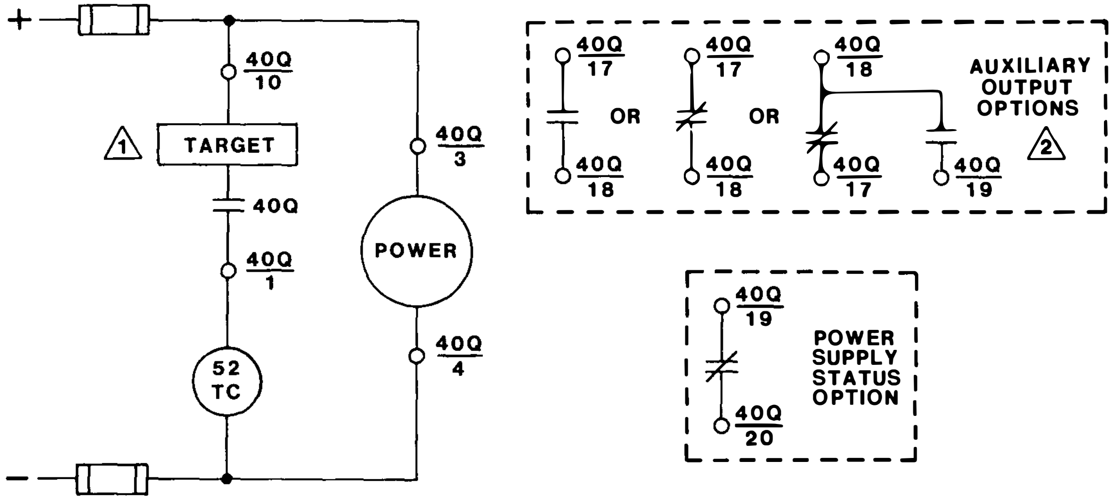
Weight
13.5 pounds net.

Case Size
S1. (Case and mounting dimensions are defined in Bulletin SDA)

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.

CONNECTIONS



1. OPTIONAL, INTERNALLY OPERATED OR CURRENT OPERATED. CURRENT OPERATED SHOWN.
2. SEE STYLE CHART FOR COMPLETE OUTPUT AND AUXILIARY DESCRIPTION.

FIGURE 8. OUTPUT CONNECTIONS

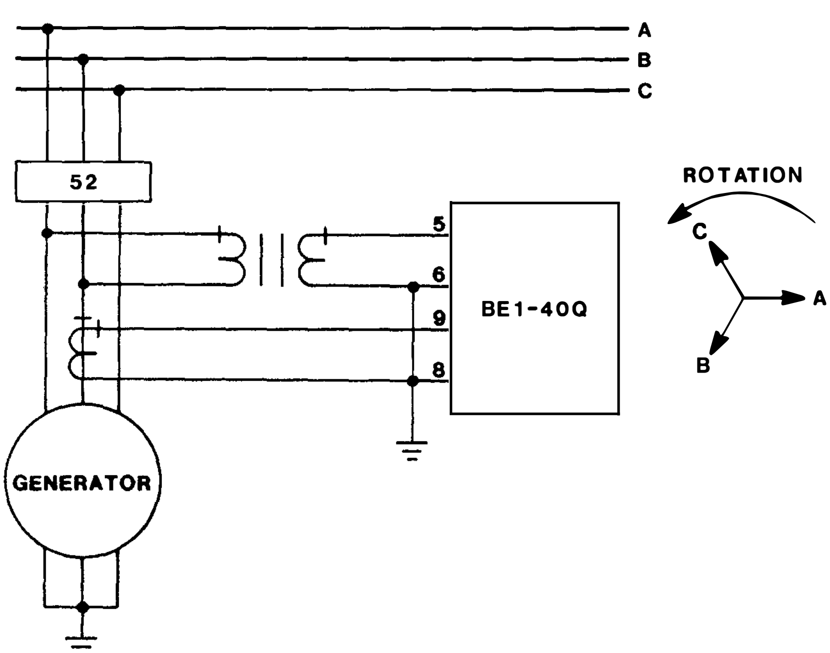


FIGURE 9. RECOMMENDED SENSING CONNECTIONS

ORDERING

MODEL NUMBER

When ordering, the model number, BE1-40Q, should be stated as a prefix to the style number (as illustrated in the diagram below).

STYLE NUMBER

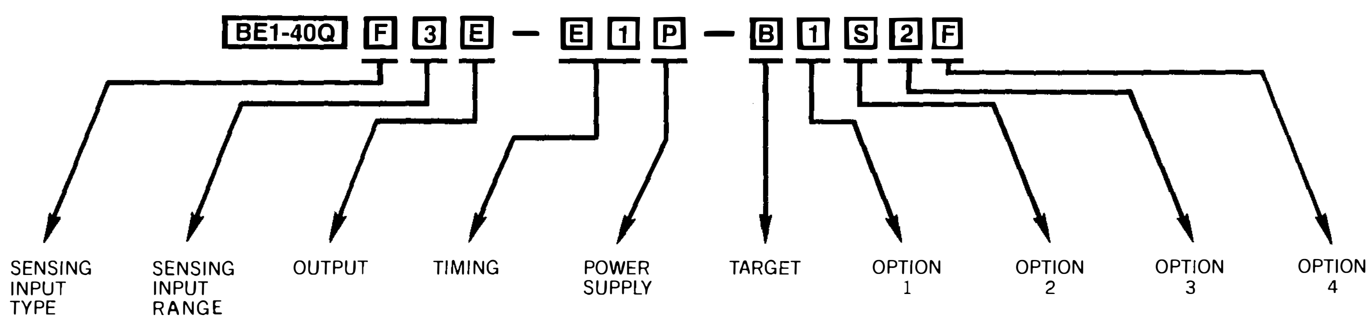
The style number appears on the front panel, drawout cradle, and inside the case assembly. This style number is an alphanumeric combination of characters identifying the features included in a particular unit. The sample style number below illustrates the manner in which the various features are designated. The Style Number Identification Chart (page 8) defines each of the options and characteristics available for this device.

SAMPLE STYLE NUMBER: F3E E1P A1S2F

The style number above describes a BE1-40Q Loss of Excitation Relay having the following features.

Sensing Input type	(F)	Single-phase, 60 Hz power sensing.
Sensing Input Range	(3)	120 Vac (nominal), 25 - 1000 VAR.
Output	(E)	The principle output contact is normally open.
Timing	(E1)	Timing is definite.
Power Supply	(P)	Internal operating power is obtained from an external source nominally rated at 125 Vdc or 120 Vac.
Target	(B)	The target requires current flow in the output circuit to indicate a trip.
Option 1	(1)	Equipped with a pushbutton that actuates both the principle and the auxiliary output relays for system testing.
Option 2	(S)	Equipped with an output contact which closes when the internal power supply voltage is below a specified level.
Option 3	(2)	Equipped with an auxiliary relay that has an NC contact.
Option 4	(F)	The relay is configured for semi-flush mounting.

Note: The description of a complete relay must include both the model number and the style number.



SAMPLE STYLE NUMBER ILLUSTRATED

HOW TO ORDER:

Designate the model number, followed by the complete stye number:

BE1-40Q, Style No. ☐☐☐ – ☐☐☐ – ☐☐☐☐☐

Complete the style number by selecting one feature from each column of the Style Number Identification Chart and entering its designation letter or number in the appropriate square. (Two squares are used to indicate time delay characteristics.) All squares must be completed.

STANDARD ACCESSORIES:

The following standard accessories are available for the BE1-40Q Loss of Excitation Relay.

Test Plug

Order test plug, Basler Electric part number 10095. (Two plugs may be required for complete testing capabilities).

Extender Board

The extender board will permit troubleshooting of the P.C. boards outside the relay cradle. Order Basler part number 9 1655 00 100.

STYLE NUMBER IDENTIFICATION CHART

BE1-40Q — ☐ ☐ ☐ E 1 ☐ ☐ ☐ ☐ ☐ ☐

Current Sensing Input Type

F) Single-phase, 60Hz
W) Single-phase, 50Hz

Current Sensing Input Range

3) 120 Vac line-to-line, 25-1000 VARs
6) 208 Vac line-to-line, 50-2000 VARs
9) 240 Vac line-to-line, 50-2000 VARs

Output

E) NO contact
G) NC contact

Timing

E1) Definite time (0.1 - 9.9 sec)

Power Supply

O) 48 Vdc
P) 125 Vdc/120 Vac
R) 24 Vdc
S) Selectable by jumper: 48 or 125 Vdc
T) 250 Vdc/230 Vac

1 Target

N) None
A) Internally operated
B) Current operated

Option 1

0) None
1) Push-to-energize output(s)

Option 2

N) None
S) Power supply status output

2 Option 3

0) None
1) Auxiliary relay, NO
2) Auxiliary relay, NC
5) Auxiliary relay, SPDT

Option 4

F) Semi-flush mounting
P) Projection mounting

NOTES:

1 If Target is B, output must be E.

2 If Option 3 is 5, Option 2 must be N.

3 All relays supplied in S1 case.

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