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BE1-25A AUTOMATIC SYNCHRONIZER

The BE1-25A Automatic Synchronizer is a microprocessor based system including features to bring any generator on line in a minimum time, from small diesel units to large difficult hydros. It may be configured for simple manual control systems or equipped for complete automatic control of generators.

ADVANTAGES

- Anticipatory close signal provides smooth synchronizing with minimum system impact.
- Patented real-time adaptive proportional speed control algorithm provides fast, reliable frequency matching while eliminating overshoots and hunting. Includes smart target pulse to prevent hung scope condition. (Patent #5,761,073)
- Highly flexible design can be configured for optimum performance over a wide range of system characteristics from sensitive, asymmetrical low inertia to high inertia hydro systems.
- One unit can control multiple systems with up to six different sets of breaker closing parameters.
- Test module facilitates testing via front panel terminals.
- Standard 19 inch rack-mounted case with front cover.

ADDITIONAL INFORMATION

INSTRUCTION MANUAL

Request publication 9146600990

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Basler Electric

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INTRODUCTION

The BE1-25A automatic synchronizer initiates closure of the generator circuit breaker when voltage magnitude, slip frequency, and phase difference are within preset limits. This capability minimizes system transients that can result from differences in speed, voltage level, or phase angle at the instant of the breaker closure - transients that can damage the breaker and generating system.

The BE1-25A has the ability to operate over a wide range of slip frequencies. This allows it to be used on virtually any type of prime mover, from very slow-responding, high inertia, hydroturbines to fast-responding gas turbines and diesel engines.

To ensure that the circuit breaker closes when the proper phase relationship exists between the oncoming generator and the station bus, the BE1-25A calculates an advance angle based upon the preset circuit breaker closing time and the measured slip frequency (F_S) (See Figure 1). It delivers the breaker close signal ahead of system co-incidence so that actual closure of the breaker contacts occurs when the phase angle between the generator and the bus voltage is at, or very close to, zero.

Assurance of picking up load upon synchronizing can be achieved by closing a contact connected to the GF>BF (generator frequency greater than bus frequency) terminals at the rear of the unit.

Likewise, closing a contact connected to the GV>BV terminals will ensure that circuit breaker closing will only occur if the generator voltage is greater than the bus voltage. This feature is only available if Voltage Acceptance options are included.

Optional modules may be used to provide correction signals to the generator for automatic synchronizing.

The system dynamics of hydro-electric facilities require close control of the speed (frequency) correction signals. Optional control features are available to supply correction pulses whose duration is adjustable or vary in proportion to slip frequency.

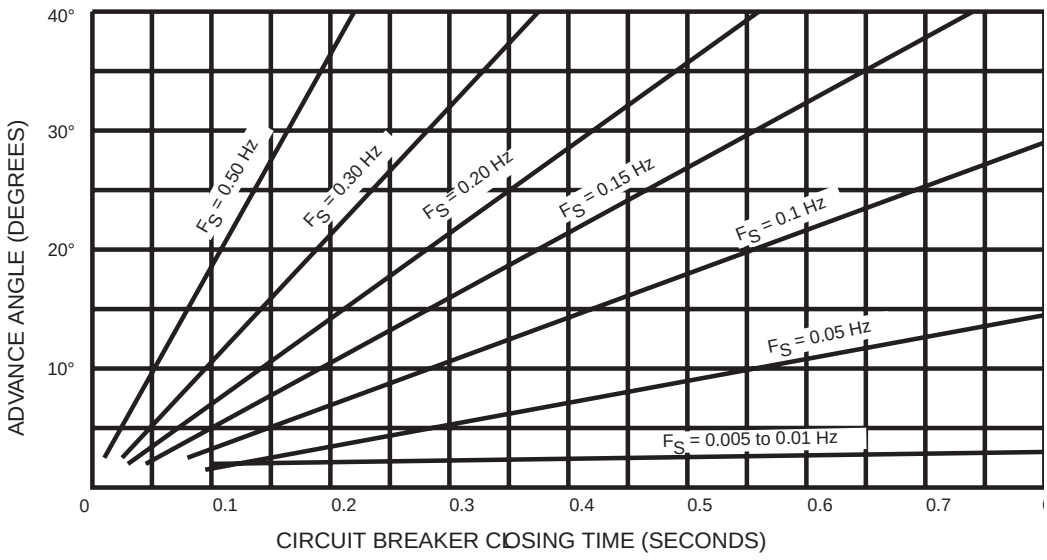


Figure 1 - Slip, advance angle, and breaker closing time

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APPLICATION

The basic BE1-25A synchronizer, without any options, may be used to close the breaker between a generator and bus when the generator frequency and phase angle are within prescribed limits.

A voltage acceptance option (A1 or A2) may be added to permit breaker closing only if the generator and bus voltages are within preset limits.

The frequency (F5) and voltage matching (V1, V2, V3) options provide outputs for automatically adjusting the prime mover governor and generator voltage controls as necessary to achieve automatic synchronization and closure of the breaker.

The Dead Bus option (D1) may be added to close the breaker when the bus voltage is less than the value set on the Dead Bus Module control regardless of generator speed. In practice, this function is controlled by the operator and is enabled by closing a switch across the terminals labeled Dead Bus Control Switch.

Emergency standby generating systems require the lead generator to automatically close into a dead bus without concern for synchronization. The BE1-25A has available an optional dead bus feature that allows immediate closure under this circumstance.

MULTI-GENERATOR OPERATION

The BE1-25A automatic synchronizer can be used on multiple-generator systems by switching the generator sensing voltage and the breaker closing circuit simultaneously to the desired generator. The closing parameters for each different generator/breaker are recalled from nonvolatile memory and used to calculate the closing conditions for the particular breaker. If all generators/breakers have the same parameters, the default set can be used and no selection is necessary.

BUS-TO-BUS APPLICATION

Some transmission circuits, when split apart, assume a phase angle difference that stabilizes as a steady state offset. When this occurs, it is possible to reclose by supervisory means (usually supervised by a sync-check relay) if the angle is small enough and the shock to the system can be tolerated. Other circuits, however, may exhibit a frequency slip with respect to each other when split apart.

The BE1-25A can be used in a bus-to-bus application if either of the following conditions is met:

1. The slip is within a prescribed limit (i.e., within the setting adjustment of the synchronizer); or,

2. The slip is essentially zero and the phase angle difference is less than 3 degrees. In this case, the phase angle between the two systems must have passed through 180 degrees to enable the synchronizer.

When 1 or 2 are met, the automatic synchronizer will operate in a bus-to-bus environment as it would in the case of an oncoming generator: it will provide a closure command at the appropriate advance angle so that the breaker contacts close when the phase difference is near zero.

DEFINING THE PARAMETERS

The relationship between slip, advance angle and breaker closing time is shown in Figure 1 and described by the formula:

$$A_A = 360 * (T_{CB} + T_R) * F_S$$

A_A = advance angle in degrees. (This is the time, measured in electrical degrees, between initiation of breaker closure and the actual closure of the breaker contacts.)

360 = degrees per slip cycle.

T_{CB} = the closing time of the selected circuit breaker in seconds. (This is the time required from the closure of the synchronizer's output contact to the actual closing of the circuit breaker's contacts. T_{CB} is preset in the synchronizer memory for each circuit breaker to be controlled by the synchronizer.)

T_R = response time in seconds of the synchronizer's Breaker Close output relay. This is a factory preset constant.

F_S = slip frequency. This is the magnitude difference in frequency between the oncoming generator and the system bus.

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FUNCTIONAL DESCRIPTION

The BE1-25A is contained in a standard, 19-inch, rack-mount case with all controls and indicators visible through the front cover and accessible by removing the front cover. The active circuits are contained within plug-in modules.

The primary control module (called the MCU Sync module) is essentially a dedicated computer that monitors the voltage on both sides of the breaker to be closed, calculates the slip frequency, and then (taking into consideration the defined operating speed of the breaker) calculates the angle at which to initiate “ideal” closing. The “ideal” closing is one that minimizes electrical and mechanical transients.

Since the “ideal” closing occurs when the voltages are in phase, the initiating signal must be delivered ahead of phase coincidence by a factor termed the advanced angle.

The closure will occur only if the slip frequency is less than the limit established by the maximum slip setting. After the breaker close contact has been closed (and if the lockout feature is enabled) the unit will go into lockout if the breaker reopens within 15 seconds. This is to prevent repeatedly closing the breaker into a fault.

If lockout occurs, the BE1-25A is inhibited from further operation until reset. Reset may be done via a front panel switch, an input contact, or will occur automatically if the breaker is closed by other means and remains closed for 15 seconds.

The test module (shown in Figure 2), when inserted into the case in the operate position, allows selected parameters to be monitored while the unit is in normal service. When moved to the test position, the unit is isolated from its operational environment for test or calibration purposes. In this position, test signals may be applied to the unit through the convenient pin jacks on the front panel.

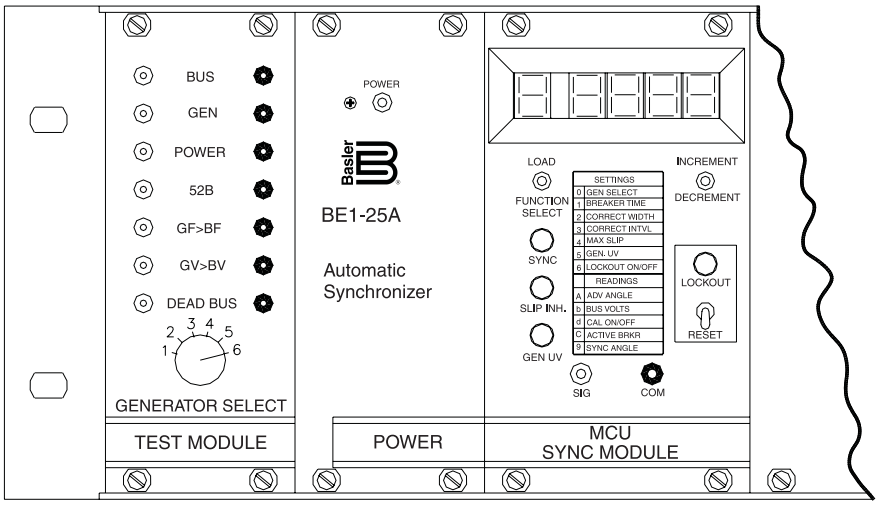


Figure 2 - Front Panel

FRONT PANEL INDICATORS

5-Digit LED Display

The variables that may be displayed are:

- Bus/generator phase angle difference
- Bus voltage
- Generator voltage
- Advance closing angle
- Identification number of the breaker selected

Settable parameters with F0 option:

- Up to six breaker closing times
- Maximum allowable slip rate
- Generator undervoltage
- Lockout ON/OFF

Settable parameters with F5 option:
Each generator/breaker selection (1 through 6) has a configurable menu of parameters as shown below:

- Breaker closing time
- Speed correction pulse width
- Speed correction pulse interval
- Maximum allowable slip rate
- Generator undervoltage
- Lockout ON/OFF

Lockout Indicator: Illuminates to indicate the synchronizer is locked out. The lockout condition is the result of a trip of the generator breaker within 15 seconds of closure by the synchronizer.

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FUNCTIONAL DESCRIPTION, continued

Generator Undervoltage Indicator (**GEN UV**): Illuminates when the generator voltage is less than the defined level for operation of the synchronizer.

Slip High Indicator: Illuminates when the Slip Frequency exceeds the max. slip setting.

Sync Indicator: Illuminates when the Auto-Sync output contact is closed.

RELAY FAIL OUTPUT

The relay fail output includes both a power supply fail function and a watchdog circuit function. The power supply fail function is achieved by using a normally closed (NC) output contact that is held in open state when the power supply is operating. If the power supply fails, the contact will drop out and provide a closed contact.

The watchdog circuit checks that the microprocessor is operational. If some transient condition has disrupted its normal pattern of operation, the watchdog will reset the microprocessor and reinitialize the program. The microprocessor is then restarted on its main sequence.

If this reset operation occurs 3 times within a 60-minute period (perhaps indicative of some hardware failure), the microprocessor is stopped, effectively shutting down the entire unit and activating the fail alarm. This condition will remain until operating power is disconnected, then reapplied.

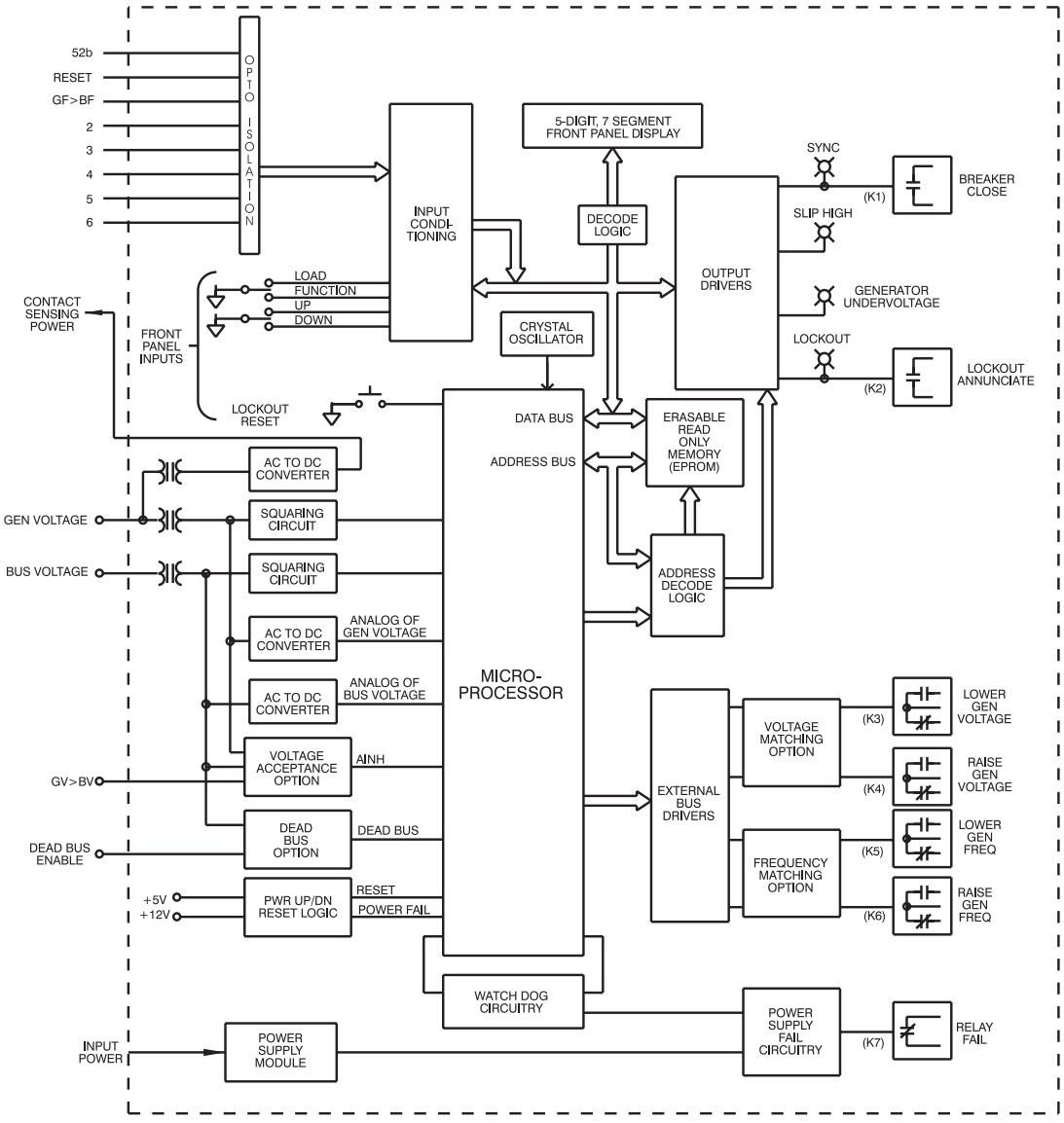


Figure 3 - Function Block Diagram

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FUNCTIONAL DESCRIPTION, continued

CONTACT SENSING INPUTS

The BE1-25A Auto-Synchronizer monitors the position of external user-supplied contacts. The sensing current is supplied by the Auto-Synchronizer.

User-supplied contacts perform the following functions.

Breaker (52b) - An auxiliary contact of the controlled breaker used to determine the position of the breaker.

Reset - An external switch or contact that may be used to reset a lockout condition. (There are two additional methods of reset: (1) By means of the front panel switch; (2) By removal and reapplication of power.)

GF>BF - When closed, the Auto-Synchronizer will not issue a breaker closure signal unless the generator frequency is equal to or greater than the bus frequency.

Generator Select 2 through 6 - These five inputs select any one of the five memory registers that are reserved for the breaker closing times. When any one (of the five) contacts are closed, a particular register (i.e., breaker time) is selected. When none of these contacts are closed, the system defaults to the breaker time held in a sixth register (1).

GV>BV (optional) - If one of the voltage acceptance options is selected, the closure of this contact input inhibits the breaker close output unless generator voltage equals or exceeds the bus voltage.

Dead Bus Enable (optional) - If the Dead Bus Enable option is installed, the closure of this contact input coupled with a dead bus condition will bring about an immediate breaker close output.

OPTION MODULES

The modular options available for the auto-synchronizer are grouped into four functional categories: Voltage Acceptance, Voltage Matching, Frequency Matching, and Dead Bus. These modules plug in to the right of the MCU.

Only one option from each category can be installed in the unit at any one time. For example, if Voltage Acceptance Option A1 is installed, the A2 Voltage Acceptance Option cannot be installed without first removing A1.

VOLTAGE ACCEPTANCE OPTIONS

Option A1 compares the generator voltage to the bus voltage. If the voltage difference is greater than the front panel preset limit (0.5% to 5.0% of the bus voltage), breaker closure is inhibited, and the voltage matching option (if installed) is enabled.

Option A2 verifies that the bus voltage is between an upper and lower limit (front panel preset values), and that the difference between the bus and generator voltages is less than the front panel preset value.

If the bus voltage is above the upper limit (adjustable 100 to 150V), or below the lower limit (80 to 120V), or if the bus-to-generator voltage difference is too large (1 to 50V), breaker closure is inhibited. The voltage matching option (if installed) is enabled only if the bus voltage is within the preset limits and voltage difference (generator to bus) is greater than the preset value.

NOTE

If the application requires the generator voltage to be greater than the bus voltage before closing the breaker, and if either option A1 or A2 are present, this requirement can be met by closing a contact connected to the GV>BV terminals on the rear of the unit.

VOLTAGE MATCHING OPTIONS

The voltage matching options provide contact outputs to control the voltage regulating equipment associated with the generator. The three options described below (V1, V2, and V3) require one of the Voltage Acceptance Options (A1 or A2) to be installed.

Option V1 provides a continuous contact closure to either raise or lower the generator output voltage until it is within the limits defined by the Voltage Acceptance Option.

Option V2 provides a pulsed contact closure to either raise or lower the generator output voltage within the limits defined by the Voltage Acceptance Option. The duration of the correction pulse is adjustable between 0.1 and 5.0 seconds. The interval between correction pulses is adjustable over a range of 0.2 to 10 seconds. These adjustments compensate for the response time of the voltage regulating system and governor.

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OPTION MODULES, continued

Option V3 provides a pulsed contact closure like the V2 Option except that when the voltage difference is within 20 volts, the correction pulse width is reduced linearly with voltage difference. This reduction in correction pulse duration reduces "hunting" and overshooting.

FREQUENCY MATCHING OPTION

The Frequency Matching Option described below includes a Bump Pulse Circuit to reduce the time required to move the phase angle when the generator frequency is matched to the bus but the phase difference is greater than permitted for synchronization. The Bump Pulse causes the governor to change speed slightly to decrease the phase difference.

Option F5 provides a pulsed contact closure like the F1 option except that when the frequency difference is less than four times the max slip setting, the correction pulse width is reduced linearly with slip frequency.

This option is particularly useful on units with unstable governors because the speed correction pulse width responds dynamically, adapting to instantaneous changes in slip frequency.

Note: The previously available F1 and F3 frequency matching options are no longer available. These functions can be achieved with the F5 option. Request Application Note PC-2501, or refer to the Instruction Manual for more information.

DEAD BUS OPTION

The Dead Bus Option, when installed, monitors the bus voltage and compares it with a front-panel-adjustable limit setting (10 to 40 Vdc). When this option has been enabled and the monitored bus voltage is less than the dead bus voltage setting, the breaker closure output relay is immediately energized. This function may be enabled by closing a contact across the terminals so labeled in Figure 4.

SPECIFICATIONS

VOLTAGE SENSING

The two sensing inputs–for the generator and the bus voltage–are designed to operate in the range of 70-150 Vac, 50/60 Hz. Burden is less than 6.0 VA for the generator input and less than 2.0 VA for the bus input.

POWER SUPPLY

Power for the internal circuitry requires an external source rated at 90-132 Vac, 50/60 Hz (single phase), or 70-150 Vdc. Burden: Less than 20.0 VA.

BREAKER CLOSING CONTACT:

Make and carry 30 A at 250 Vdc for 1 second, 7 A continuously, and break 0.3 A at 250 Vdc. L/R = 0.04.

VOLTAGE, FREQUENCY (SPEED) CORRECTION and LOCKOUT CONTACTS:

Make and break 5 A at 250 Vac (80% PF), 5 A at 28 Vdc (resistive) and 0.5 A at 120 Vdc (resistive).

RELAY FAIL CONTACT:

Make and break 5 A at 250 Vac (80% PF), 5 A at 28 Vdc (resistive) and 0.5 A at 120 Vdc (resistive).

SURGE WITHSTAND CAPABILITY:

The unit has been qualified to ANSI/IEEE C37.90.1-1989 Standard Surge Withstand Capability Tests; (Oscillatory and Fast Transient), IEC 255-5 Impulse Test and Dielectric Test.

RADIO FREQUENCY INTERFERENCE (RFI):

Maintains proper operation when tested for interference in accordance with IEC C37.90-1989, *Trial-Use Standard Withstand Capability of Relay Systems to Radiated Electromagnetic Interfence from Transceivers*.

AGENCY CERTIFICATIONS

- UL Listed per Standard 508, UL File Number E97033.
- CSA Certified per Standard CAN/C.S.A.-C22.2 No. 14
- CE Qualified
- GOST R Certified #POCC US.ME05.B03391.

TEMPERATURE

Operating Range -40°C (-40°F) to 70°C (158°F)
Storage Range -65°C (-85°F) to 100°C (212°F)

SIZE AND WEIGHT

19-inch rack mount per Figure 5.
16 pounds (7.26 kg) net for basic synchronizer.

WARRANTY

5 years

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SPECIFICATIONS, continued

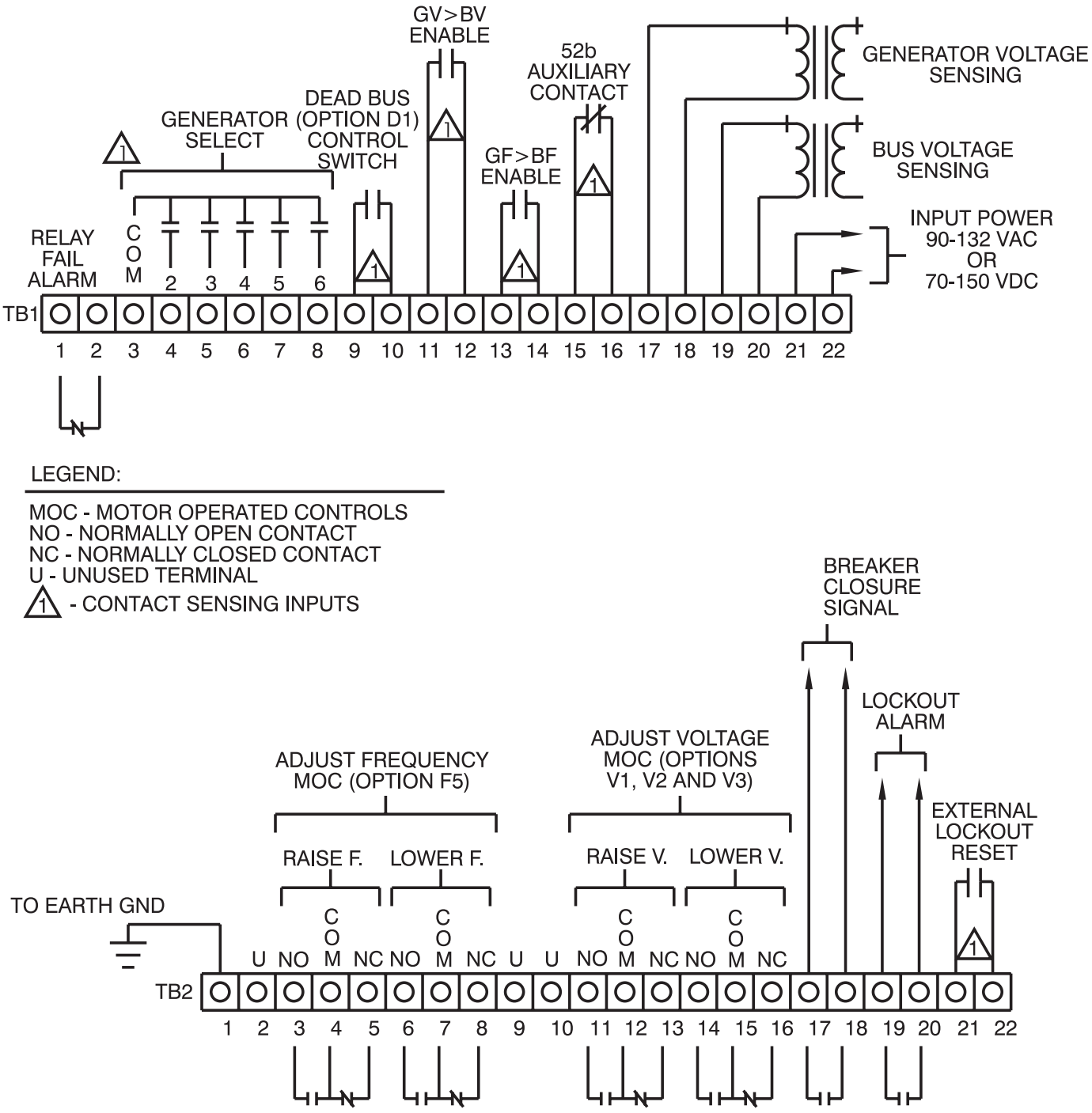


Figure 4 - External Connections

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SPECIFICATIONS, continued

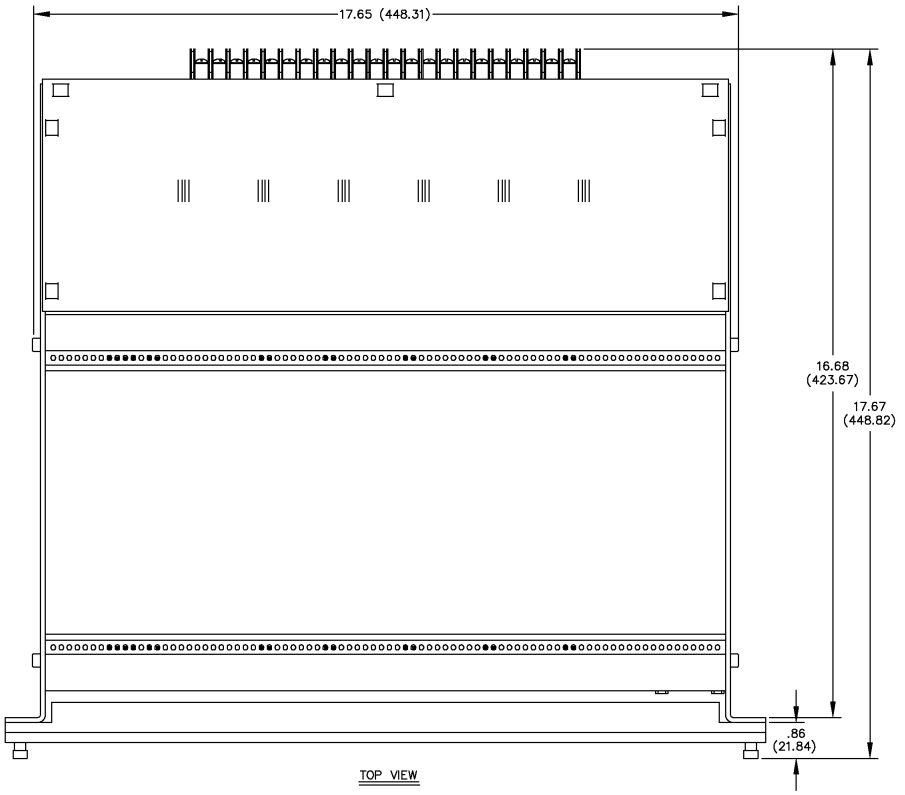


Figure 5 - Dimensions and Cutout

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ORDERING

HOW TO ORDER:

Designate the BE1-25A model and each of the required options as follows:

BE1-25A-A___ F___ V___ D___

If voltage matching (V1, V2 or V3) is required, be sure either option A1 or A2 has been included.

The BE1-25A basic synchronizer includes test plug, power supply and MCU Sync unit.

STANDARD ACCESSORY

The card extender permits troubleshooting of the modules when they must be outside the case (for service accessibility) but electrically engaged. Order Basler Electric part number 9146624100.

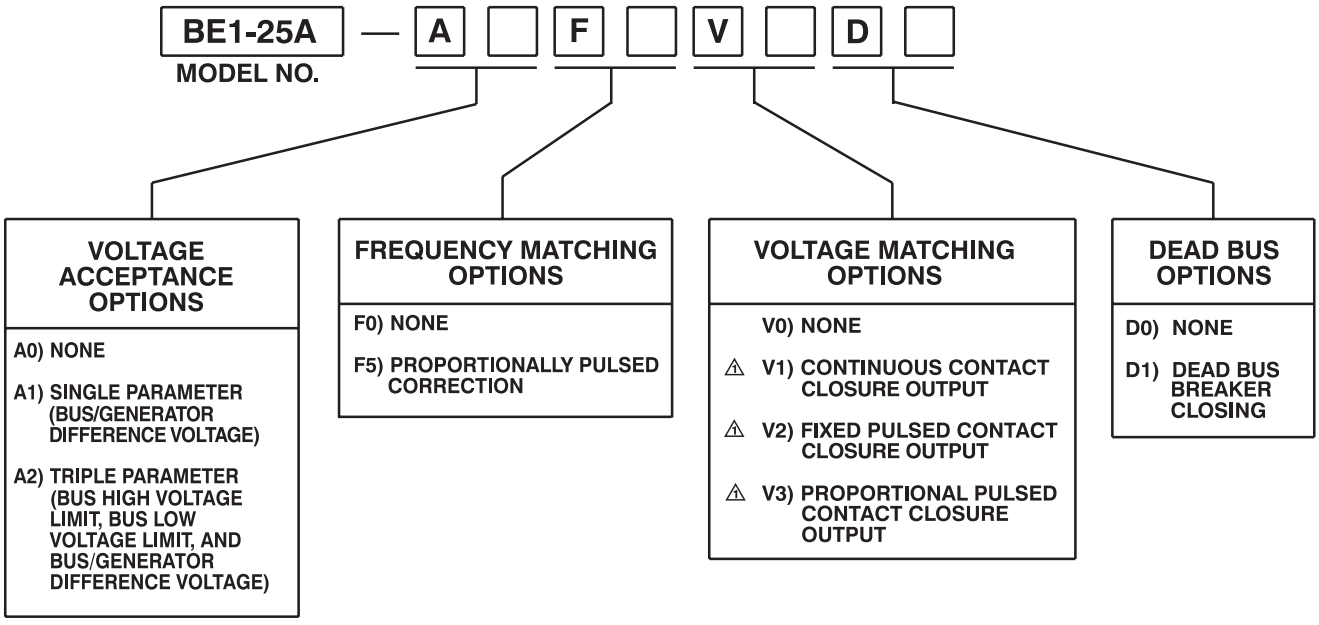
STYLE NUMBER

The style number is an alphanumeric designation that identifies the option modules included in a particular unit. The following sample style number illustrates the manner in which the various options are designated. The Style Number Identification Chart below defines each option available for this device.

SAMPLE STYLE NUMBER: BE1-25A-A2F5V1D1

The style number above describes a BE1-25A Automatic Synchronizer with the following options:

- Voltage Acceptance Option (A2): This option defines high and low bus voltage and voltage difference.
- Frequency Matching Option (F5): Proportional pulsed contact output for adjusting speed of generator.
- Voltage Matching Option (V1): Continuous closed contact for adjusting generator voltage.
- Dead Bus Option (D1): Immediate breaker closing when dead bus condition is sensed.



⚠ REQUIRES OPTION A1 OR A2 TO BE PRESENT IN UNIT.

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NOTES

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