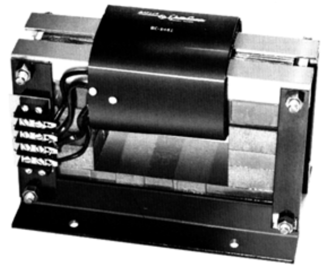
Reservoir Assembly



Current Transformer

CLASS 200 EQUIPMENT EXCITATION SUPPORT SYSTEM

APPLICATION:

Many brushless exciter-equipped generators are required to sustain the substantial current overloads associated with starting large motors. Typically, such overloads can be several times the normal running current. Some generating systems may also be required to maintain line current during brief periods of short circuit fault conditions. Brushless exciter-equipped generators and their associated voltage regulators are unable to meet these requirements because the generator output provides the voltage regulator power. As the generator output voltage decreases, the ability of the voltage regulator to provide exciter field power also decreases, and the result can be a total loss of excitation. The Basler Excitation Support System compensates for this inherent limitation by providing a constant voltage regulator power sauce. Application of this system is represented schematically in Figures 4, 7, and 8.

FEATURES:

- Allows full regulator forcing output during heavy motor starting and 3 phase symmetrical short circuit.
- Adaptable to a wide range of generator sizes.
- Reliably designed for long life and minimum maintenance.
- 50 and 60 Hertz units available.
- Static (no moving parts).
- Surge protection on output.
- Ruggedly constructed.
- CSA approved.

ADDITIONAL INFORMATION

INSTRUCTION MANUALS

Request Publication 93710099x (SBO 181-186)
Request Publication 93230099x (SBO 232-237, 241-246 and 271-276)

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DESCRIPTION:

The Basler Excitation Support System consists of a reservoir assembly (SBO) and a current transformer (CT) which function together to furnish a relatively constant voltage to the regulator power-stage during all operating conditions including severe generator overload and short circuit. The regulator, therefore, can delivery full forcing to the exciter field during such conditions.

The reservoir assembly consists of a transformer, reactor and associated components. It employs the ferroresonant principle to provide the regulator with a regulated power input during no-load conditions. The CT provides virtually all power input to the regulator during periods of overload (motor starting or short circuit). For this reason, the CT must be capable of producing many times the power rating of ordinary metering type current transformers. It is of larger size than CTs used in metering applications and is designed with ample window space to accommodate generator cables. As the load varies from no-load to full-load, the source of power to the regulator gradually shifts from the reservoir assembly to the CT.

The Excitation Support System will permit a 3-wire generator to support any sustained 3 phase line-to-line short circuit. Generators employing a fourth wire neutral may not, however, sustain short circuit current between the neutral and the line not being “sampled” by a current transformer.

SPECIFICATION:

- **OPERATING TEMPERATURE RANGE:** -40°C to +70°C (-40°F to + 158°F).
- **SHOCK:** Withstands up to 15 Gs in each of three perpendicular axes.
- **VIBRATION:** Withstands up to 5 Gs at 260 Hertz.
- **POWER DISSIPATION:** Reservoir Assembly
  - 180 series - approximately 300 watts.
  - 220 series - approximately 200 watts.
  - 230, 240 and 270 series - approximately 175 watts.
- DIMENSIONS: Reservoir Assemblies - See Figures 1 and 2. Current Transformers - See Figures 3 and 6, and Tables 4 and 5.
- WEIGHT: Reservoir Assembly - 180 series, 70 lbs. net
- 120 lbs. shipping
- Reservoir Assembly - 200 series, 45.5 lbs. net
- 50 lbs. shipping
- Current Transformers - See Tables 4 and 5.

SAMPLE SPECIFICATION:

Power for the voltage regulator shall be supplied by a device which will utilize both generator voltage and current to maintain generator field excitation under motor starting and short circuit conditions. This device shall utilize the current in two phases of the generator through use of power current transformers and shall be static throughout. The unit shall be a Basler Model SBO — with appropriate power current transformer.

HOW TO ORDER Reservoir Assembly

When using Basler Regulator model	OR	A regulator with these power input requirements (Max. Continuous)	Select this with a nominal system line voltage of*	Basler reservoir assembly
SR4A		120 Vac @7A	208-240 (60Hz)	SBO 241
SR4F			416-480 (60Hz)	SBO 242
KR4FF			575600 (60Hz)	SBO 245
			208-240 (50Hz)	SBO 243
			380-480 (50Hz)	SBO 244
			575-600 (50Hz)	SBO 246
SR8A at full power		240 Vac@ 7A	208-240 (60Hz)	SBO 181
SR8F			416-480 (60Hz)	SBO 182
			575-600 (60Hz)	SBO 185
			208-240 (50Hz)	SBO 183
			380-480 (50Hz)	SBO 184
			575-600 (50Hz)	SBO 186
SR8A at half** power		240 Vac@3.5A	208-240 (60Hz)	SBO 271
SR8F			416-480 (60Hz)	SBO 272
KR7FF			575-600 (60Hz)	SBO 275
			208-240 (50Hz)	SBO 273
			380-480 (50Hz)	SBO 274
			575-600 (50Hz)	SBO 276
KR2FF		120/138 Vac@8A	208-240 (60Hz)	SBO 221
			416-480 (60Hz)	SBO 222
			575-600 (60Hz)	SBO 223
			208-240 (50Hz)	SBO 224
			380-480 (50Hz)	SBO 225
			575-600 (50Hz)	SBO 226
SR32A		60 Vac@ 20A	208-240 (60Hz)	SBO 232
SR32H			416-480 (60Hz)	SBO 233
			575-600 (60Hz)	SBO 236
			208-240 (50Hz)	SBO 234
			380-480 (50Hz)	SBO 235
			575-600 (50Hz)	SBO 237

Table 1 - Selecting a Reservoir Assembly

* The SBO reservoir assembly can also be used in high voltage assembly applications by using a power isolation transformer and special high voltage insulated power current transformers. For high voltage applications (above 600V) consult factory for selection of transformers.

** If the exciter field current at short circuit is 5 Amperes or less and if the exciter field resistance is 36 Ohms or greater.

HOW TO ORDER - Current Transformer (CT)

Selection of the appropriate CT is accomplished in the following manner:

Step 1. Calculate the exciter field current supplied by the voltage regulator during generator short circuit. Use the formula $I_1 = \frac{E}{R}$

where I, equals the exciter field current, R is the exciter field resistance and E is a value selected from the following chart. (During short circuit, generator output voltage is zero. Since the regulator power stage is receiving normal voltage from the SBO output, it will be “full on” delivering maximum voltage output, listed below. The amount of exciter field current that flows is a function of the exciter field resistance.)

With this Basler regulator	E=
SR32A SR32H KR2FF	45 volts
SR4A SR4F KR4FF	90 volts
SR8A SR8F KR7FF	180 volts

HOW TO ORDER CT, continued

Step 2. From short circuit saturation data (plot of exciter field current versus line amps with the output of the generator short circuited), available from the generator manufacturer, determine the generator short circuit line current that would result from the exciter field current calculated in step 1.

IF	THEN
this results in acceptable generator line current,	proceed to step 3
this results in excessive generator line current,	proceed to step 4
this results in insufficient generator line current,	use a Basler regulator with greater field voltage forcing capability

Step 3. (Refer to Table 2)

a. In Column 1, locate the value determined in step 2 for generator line current to be sustained during a short circuit (or the closest value if the exact value does not appear). Using a straight edge, draw a horizontal line immediately under the selected number across the page to the corresponding number repeated in column 5.

b . In column 2, locate the model of Basler voltage regulator being used.

c. In column 3, opposite the appropriate regulator, locate the exciter field current calculated in step 1 (or the closest value if the exact calculated value does not appear).

d . Draw a vertical line through this value to intersect with the horizontal line drawn in step 3a.

e. Proceed to step 5.

Step 4.

a. Determine what constitutes acceptable generator line current at short circuit (typically 250-300% nominal).

b. From short circuit saturation data (plot of exciter field current versus line amps from the output of the generator short circuited), available from the generator manufacturer, determine the exciter field current required to generate the acceptable generator line current just determined. (To obtain this reduced current it will be necessary to place a current limiting resistor in series with the exciter field. See explanation in Note 1).

c . (Refer to Table 2) In Column 1, locate the value of acceptable generator line current at short circuit (step 4a) (or the closest value if the exact value does not appear). Using a straight edge, draw a horizontal line immediately under the selected number across the page to the corresponding number repeated in column 5.

d. In column 2, locate the model of Basler voltage regulator being used.

e. In column 3, opposite the appropriate regulator, locate the exciter field current determined in step 4b (or the closest value if the exact value does not appear).

f. Draw a vertical line through this value to intersect with the horizontal line drawn in step 4c.

Step 5. The point of intersection indicates the turns ratio for the transformer to be selected (turns ratio explained further in step 6). If the lines do not intersect a turns ratio, select the ratio indicated directly above the intersection. From the turns ratio selected, move to the right **within the same shaded area** to determine the correct CT, identified in column 4.

Step 6. The first numeral of the turns ratio indicates the number of turns of each generator feeder that must pass through the CT window (the same number of line A and Line B turns is necessary). The second numeral indicates the number of secondary turns to be used. An increase in CT primary turns or a decrease in CT secondary turns on any specific transformer results in increased CT power output. Selection of a smaller turns ratio may result in the CT delivering slightly more secondary current than required. However, the SBO ferro-resonant circuitry has the capability of dissipating this energy. Tables 4 and 5 identify transformer secondary terminals.

NOTE 1 - Calculate the value of the series resistance using the following formula: $R_S = \left(\frac{E}{I_2}\right) - R_f$

where R_S= value of series field resistance to be added (Ohms).

E = maximum regulator forcing voltage (from chart in step 1).

I_2 = field current required to produce acceptable generator line current at short circuit.

R_2 = exciter field resistance.

THE SERIES RESISTANCE MUST NOT BE SO GREAT AS TO RESTRICT NORMAL FORCING.

EXAMPLE

The following example, illustrated in table 2, summarizes the method used to select the appropriate CT.

1. Calculate the actual exciter field current that will be provided by a Basler SR4A voltage regulator during short circuit. Using the formula $I_1 = \frac{E}{R}$

   $$I_1 = \frac{90 \text{ volts (from chart)}}{11.1 \text{ Ohms (generator data)}} = 8.1 \text{ Amperes}$$

2. From data supplied by the generator manufacturer, you determine that a generator line current of 2700 Amperes would result using the 8.1 Ampere output of the SR4A regulator. You consider this to be an excessive generator line current.
3. You determine that 1800 Amperes would constitute an acceptable generator line current at short circuit.
4. From data supplied by the generator manufacturer, you determine that an exciter field current of 5.4 Amperes is required for the generator system to deliver 1800 Amperes during short circuit. To obtain this reduced current it will be necessary to place a current limiting resistor in series with the exciter field (See calculation at conclusion of this example).
5. In column 1 of table 2, locate 1838 Amperes (the value closest to 1800 Amperes). Draw a horizontal line under 1838 to the same number in column 5.
6. In column 2, locate the SR4A voltage regulator.
7. In column 3, opposite the SR4A, locate 5.6 Amperes (the closest value to 5.4 Amperes).
8. Draw a vertical line through 5.6 Amperes to intersect with the horizontal line drawn earlier.
9. A turns ratio of 1:300 is intersected and will be used. Moving to the right **within the non-shaded area** from the selected turns ratio, you determine the appropriate CT to be BE 02463 001.

Calculation of series resistance

$$R_S = \left(\frac{E}{I_2}\right) - R_f$$

$$= \left(\frac{90}{5.4}\right) - 11.1$$

$$= 16.6 - 11.1 = 5.5 \text{ Ohms}$$

THE SERIES RESISTANCE MUST NOT BE SO GREAT AS TO RESTRICT NORMAL FORCING.

COLUMN													
1	2	3										4	5
3 phase short circuit line current in amperes	When using this Basler Voltage Regulator	supplying this maximum exciter field current during short circuit (in amperes)										Select the Basler Current Transformer(s Shown below. **	3 phase short circuit line current in amperes
	SR4A SR4F SR8A SR8F	2.5	3.4	4.4	5.6	6.9	8.4	10	--	--	--		
	SR8A* SR8F* KR7FF	1.2	1.7	2.2	2.8	3.4	4.2	5	--	--	--		
	SR32A SR32H	5	6.8	8.8	11.2	13.8	16.8	20	21.2	25.1	28.2		
	KR2FF	5.3	6	6.7	7.6	8.5	9.6	10.8	12	--	--		
	KR4FF	2.5	3.4	Consult Basler Electric Company for KR4FF applications below 2.5 Amperes.									
102		8:189		8:150		16:238		16:189		16:150			102
115			8:189		8:150		16:238		16:189		16:150		115
129		8:238		8:189		8:150		16:238		16:189			129
144			8:238		8:189		8:150		16:238		16:189		144
163		4:150		8:238		8:189		8:150		16:238			163
183			4:150		8:238		8:189		8:150		16:238		183
204		4:189		4:150		8:238		8:189		8:150			204
230			4:189		4:150		8:238		8:189		8:150		230
258		4:238		4:189		4:150		8:238		8:189		BE02461 001*** (For use with any 200 Series of Reservoir Assemblies)	258
289			4:238		4:189		4:150		8:238		8:189		289
325		2:150		4:238		4:189		4:150		8:238			325
366			2:150		4:238		4:189		4:150		8:238		366
408		2:189		2:150		4:238		4:189		4:150			408
459			2:189		2:150		4:238		4:189		4:150		459
515		2:238		2:189		2:150		4:238		4:189			515
577			2:238		2:189		2:150		4:238		4:189		577
651		1:150		2:238		2:189		2:150		4:238			651
731			1:150		2:238		2:189		2:150		4:238	BE 02462 001 (For use with the 180 Series of Reservoir Assemblies)	731
818		1:189		1:150		2:238		2:189		2:150			818
919			1:189		1:150		2:238		2:189		2:150		919
1031		1:238		1:189		1:150		2:238		2:189			1031
1155			1:238		1:189		1:150		2:238		2:189		1155
1302		1:300		1:238		1:189		1:150		2:238			1302
1462			1:300		1:238		1:189		1:150		2:238		1462
1635		1:378		1:300		1:238		1:189		1:150			1635
1838			1:378		1:300		1:238		1:189		1:150		1838
2062		1:476		1:378		1:300		1:238		1:189			2062
2310			1:476		1:378		1:300		1:238		1:189		2310
2604		1:600		1:476		1:378		1:300		1:238			2604
2925			1:600		1:476		1:378		1:300		1:238		2925
3270		1:756		1:600		1:476		1:378		1:300			3270
3675			1:756		1:600		1:476		1:378		1:300		3675
4125		1:952		1:756		1:600		1:476		1:378		BE 02463 001	4125
4620			1:952		1:756		1:600		1:476		1:378		4620
5205		1:1200		1:952		1:756		1:600		1:476			5205
5850			1:1200		1:952		1:756		1:600		1:476		5850
6540				1:1200		1:952		1:756		1:600			6540
7350					1:1200		1:952		1:756		1:600		7350
8250						1:1200		1:952		1:756		BE 02464 001	8250
9240							1:1200		1:952		1:756		9240
10410								1:1200		1:952			10410

TABLE 2 - SELECTING A CT

* at half power

** if dual CTs are used (in applications, for example, where primary bus connections would be difficult using a single CT) two identical CTs are required and identical turns ratios are employed.

*** BE 02470 001 can be substituted for BE 02461 001 in applications where it is desirable or necessary to reduce by one-half the number of primary turns specified in Table 2.

HOW TO ORDER MEDIUM VOLTAGE CURRENT TRANSFORMERS:

This series of power current transformers is designed for use in systems having nominal line voltages of 2400 volts (60 Hz), 3300 volts (50 Hz) and 4160 volts (60 Hz). Two power CTs are required for each generating system. Selection of the appropriate CTs is accomplished in the same manner as described in the Excitation Support System Bulletin USING TABLE 3 below and Step 6A, following, that replaces step 6.

Step 6A.
The first numeral of the turns ratio indicates the number of primary turns wound on the CT. The second numeral indicates the number of secondary turns to be used. Note that the cable for each generator phase is connected to its respective CT. A decrease in CT secondary turns on any specific transformer results in increased CT power output. Selection of a smaller turns ratio may result in the CT delivering slightly more secondary current than required. However, the SBO ferroresonant circuitry is designed to dissipate this energy. Table 5 identifies transformer secondary terminals.

COLUMN										
1	2	3							4	5
	When using this Basler Voltage Regulator	supplying this maximum exciter field current during short circuit (in amperes)							Select the Basler Current Transformer Shown Below**	
	SR4A SR4F	2.5	3.4	4.4	5.6	6.9	8.5	10		
	SR8A at SR8F half power*	1.2	1.7	2.2	2.8	3.4	4.2	5.0		
	SR32A SR32H	5	6.8	8.8	11.2	13.8	16.8	20		
102		8:189		8:150						102
115					8:150					115
129		8:238			8:189			8:150		129
144					8:189		8:150			144
163		4:150		8:238		8:189		8:150		163
183					8:238		8:189			183
204		4:189		4:150		8:238		8:189	BE 15822 001	204
230					4:150		8:238			230
258		4:238		4:189		4:150		8:238		258
289					4:189		4:150			289
325		2:150		4:238		4:189		4:150		325
366			2:150		4:238		4:189			366
408		2:189		2:150		4:238		4:189		408
459			2:189		2:150		4:238			459
515		2:238		2:189		2:150		4:238		515
577			2:238		2:189		2:150			577
651				2:238		2:189		2:150	BE 15621 001	651
731					2:238		2:189			731
818						2:238		2:189		818
919							2:238			919
1031								2:238		1031
1155										1155
1302								1:150	BE 15620 001	1302
1462										1462
1635								1:189		1835
1838										1838
2062										2062

TABLE 3- SELECTING A MEDIUM VOLTAGE CT

* If the exciter field current at short circuit is 5 Amperes or less and if the exciter field resistance is 36 Ohms or greater.
** Two identical CTs are required. CT can be used with any SBO 230, 240, 270 series of excitation support.

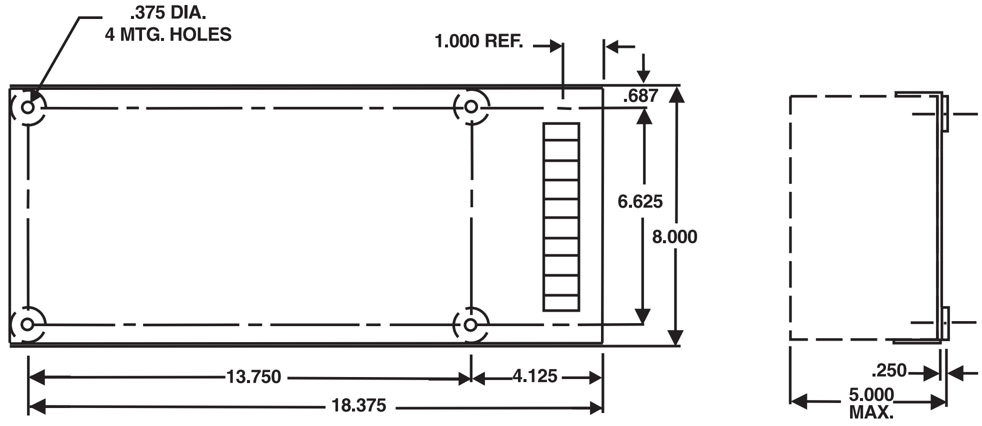


Figure 1 - Outline Drawing - Reservoir Assembly - SBO 200 Series

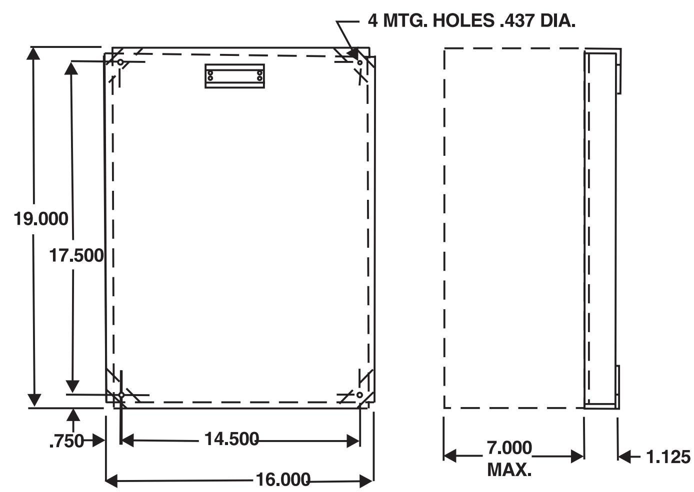
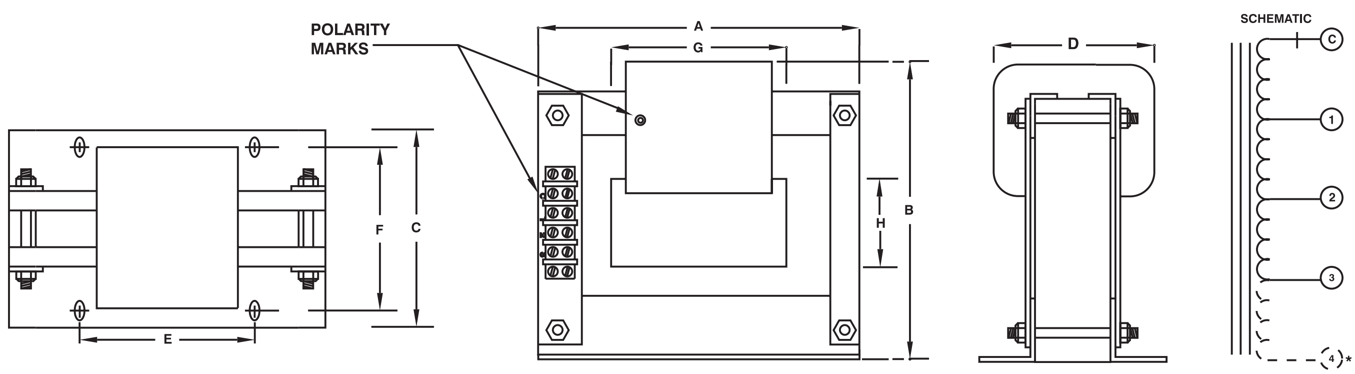


Figure 2 - Outline Drawing - Reservoir Assembly - SBO 180 Series



* BE 02464 001 only

Figure 3 - Outline Drawing - Current Transformer

C.T. Part No.	Dimensions in Inches								Secondary Turns				Weight
	A	B	C	D	E	F	G	H	C-1	C-2	C-3	C-4	Lbs. (Net)
BE 02461 001	10.5	7.75	5.37	5	6	4.37	5	2	150	189	238	---	44
BE 02462 001	10.5	9.25	7.75	7.37	6	6.75	5	3	150	189	238	---	85
BE 02463 001	12,5	9.75	5.37	5.75	6	4.37	7	3	300	378	476	---	63
BE 02464 001	11.5	10	4.62	5	6	3.62	7	3	600	756	952	1200	47
BE 02470 001	9.5	7.75	7.75	7	6	6.75	4	2	75	94	119	---	70

Table 4 - Dimensions and Weights

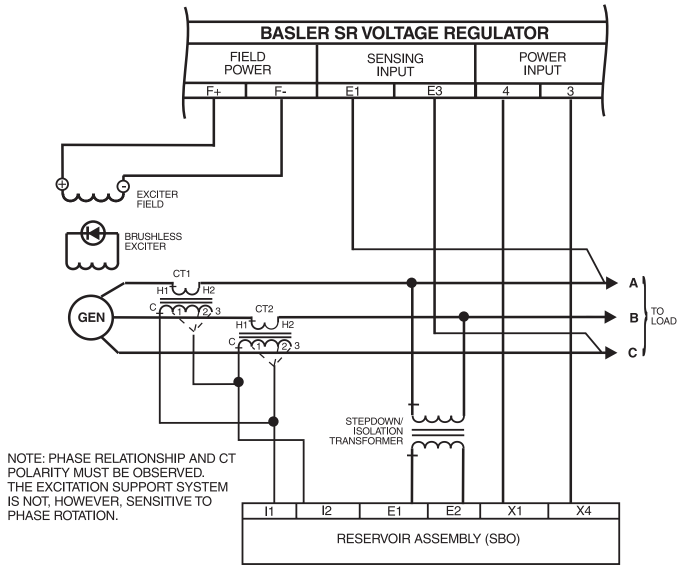


Figure 4 - Excitation Support System Interconnection Diagram

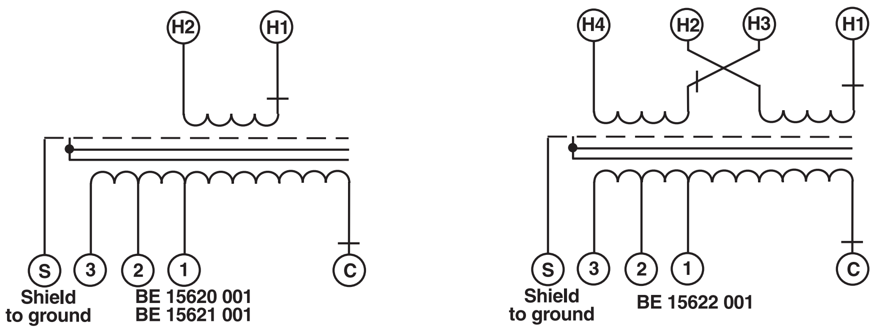


Figure 5 - Schematics

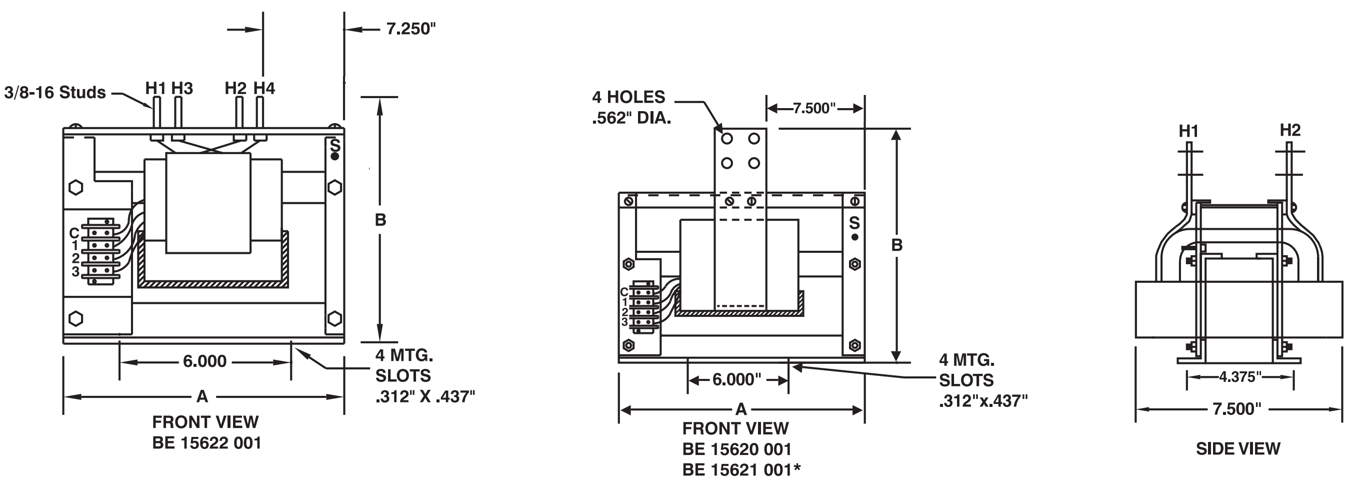


Figure 6 - Outline Drawings - Medium Voltage Current Transformers

Current Transformer Part Number	Dimensions		Primary		Secondary Turns			Net Weight
	A	B	Turns	Amps*	C-1	C-2	C-3	
BE 15620 001	18.00" (475.20mm)	12.75" (323.85mm)	1	700	150	189	238	65 Pounds (29.44 kg)
BE 15621 001	16.50" (419.10mm)	12.75" (323.85mm)	2	350	150	189	238	60 Pounds (27.18 kg)
BE 15622 001	16.50" (419.10mm)	11.12" (282.45mm)	4/8	175/88	150	189	238	60 Pounds (27.18 kg)

* Maximum Continuous

Table 5 - Dimensions and Weights

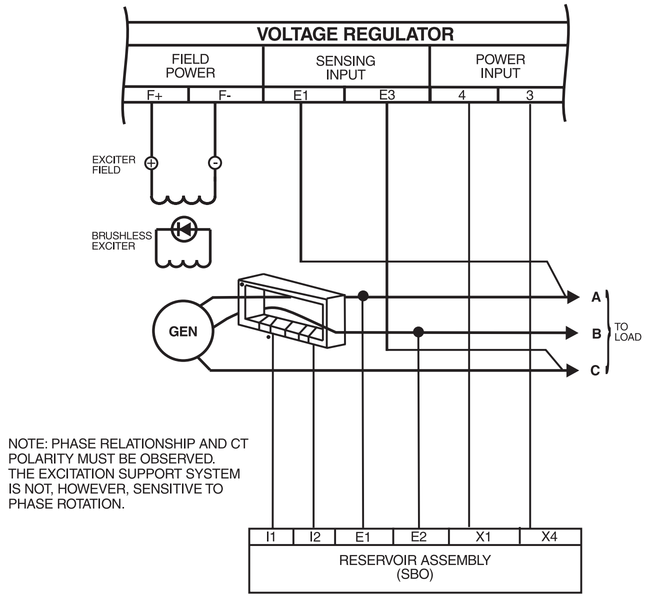


Figure 7 - Excitation Support System Interconnection Diagram One Current Transformer (Typical)

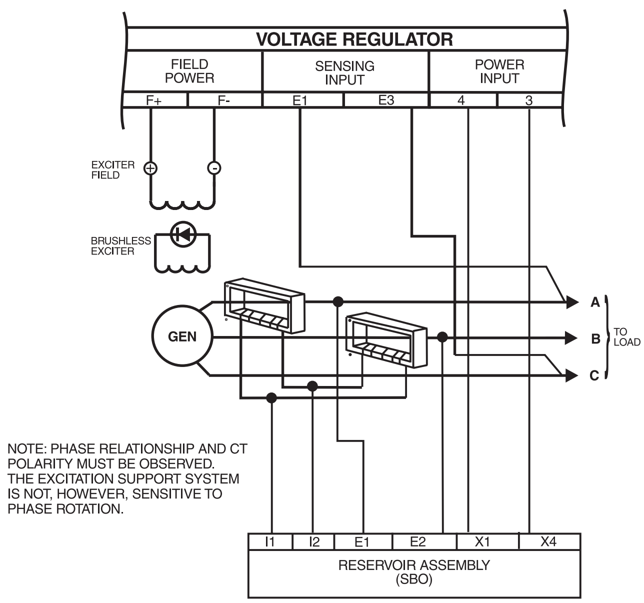


Figure 8 - Excitation Support System Interconnection Diagram Two Current Transformer (Typical)

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