INSTRUCTION MANUAL

FOR

EXCITATION SUPPORT SYSTEM
Models: SBO 181 through SBO 186
Part Number: 9 0371 00 100 through 9 0371 00 105

Basler Electric
Highland, Illinois

Publication Number: 9 0371 00 99X
Date: December, 1974
Revision A: March, 1990

WARNING

To prevent personal injury or equipment damage, only qualified technicians/operators should install, operate, or service this device.

CAUTION

Meggers and high potential test equipment should be used with extreme care. Incorrect use of such equipment could damage components contained in the device.

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

NOTE

The title of this device has been changed from Series Boost Option to Excitation Support System to eliminate confusion with titles of other Basler products. References in this manual to the Excitation Support System, Series Boost Option and SBO all apply to the same device.

SECTION 1
GENERAL INFORMATION

1-1. DESCRIPTION

The Excitation Support System consists of a reservoir assembly (designated Model SBO---) and a power current transformer (CT) selected to match the generator rating. The reservoir assembly is a static type unit consisting of transformers, resistors, surge suppressors and capacitors mounted on a pan type sheet metal chassis. The CT is mounted externally and interconnected with the reservoir assembly. Section 5 explains the procedure used to select the appropriate CT.

1-2. PURPOSE

The purpose of the Excitation Support System is to provide motor starting and fault clearing capabilities for generators having brushless exciters. This system makes the use of brushless generators practicable in applications which would normally require conventional generators with brush type rotary or series boost exciters. These SBO's are specifically designed for use with Basler Electric Voltage Regulators SR8A and SR8F. Although the Excitation Support System is normally used on three-phase systems, it can be used on single-phase systems, when the appropriate current transformer is used. Contact the nearest Basler Electric Company sales representative or factory office for details.

Table 1-1. Excitation Support System Models.

Basler Regulator Model (or a regulator with these power input requirements	Nominal System Voltage* (Vac)	Reservoir Assembly Model Number	Basler Part Number
SR8A SR8F (240 Vac @ 7 A input)	208 - 240 @ 60 Hz	SBO 181	9 0371 00 100
	416 - 480 @ 60 Hz	SBO 182	9 0371 00 101
	575 - 600 @ 60 Hz	SBO 185	9 0371 00 102
	208 - 240 @ 50 Hz	SBO 183	9 0371 00 103
	416 - 480 @ 50 Hz	SBO 184	9 0371 00 104
	575 - 600 @ 50 Hz	SBO 186	9 0371 00 105

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

1-4. SPECIFICATIONS

Refer to Table 1-2 for the unit's operating parameters.

Table 1-2. Specifications.

Operating Temperature Range:	-40° C to +70° C (-40° F to +158° F).
Shock:	Withstands up to 15 G's in each of three perpendicular axes.
Vibration:	Withstands up to 5 G's at 260 Hz.
Power Dissipation:	Approximately 300 W.

SECTION 2
PRINCIPLES OF OPERATION

2-1. GENERAL

The Excitation Support System (series boost option) utilizes the principle of ferro-resonance to provide a source of regulated voltage for the voltage regulator. The basic circuit is shown below.

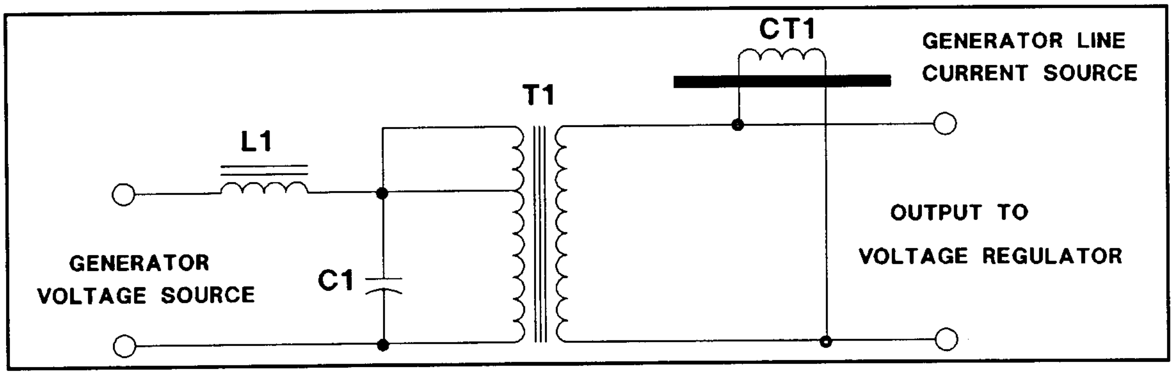


Figure 2-1. Excitation Support System Basic Circuit Diagram.

The excitation for the circuit is provided from two sources, a voltage source and a current source. The voltage source is taken from the generator output voltage and the current source is supplied from generator line current through the current transformer. Components T1, L1 and C1 (Figure 2-1) comprise a basic transformer regulating circuit (reservoir assembly) driven only by a voltage source. The reservoir assembly supplies the power requirements of the generator field through the voltage regulator when the generator system has no load. During no load conditions, the reservoir assembly should not be required to supply more than one-half of the total output capability of the voltage regulator.

The additional current necessary for the voltage regulator to provide the full load requirements of the generator is supplied by the current transformer. Current transformer CT1 (Figure 2-1) receives excitation from two of the generator load lines and provides a current which is added vectorially to the current from the voltage source in the reservoir assembly. Then the Excitation Support System can supply the current necessary to maintain the maximum output of the voltage regulator. The exciter current necessary for motor starting and fault clearing is supplied entirely from generator line current.

During short circuit or motor starting conditions, the CT must supply the current required by the exciter field, plus 5 amps required by the SBO to maintain ferro-resonance. To obtain the required output, the ratio of the secondary to primary turns of the CT must be correct for the amount of generator line current flowing in the primary. A wide range of turns-ratios is available by various combinations of primary turns and secondary turns in the series of CT's designed for this application.

SECTION 3
INSTALLATION

3-1. GENERAL

To ensure maximum performance and compliance with electrical specifications this device should not be mounted such that the terminal strip is at the top of the unit. Refer to Figures 3-1 and 3-2 for the chassis outline and transformer outline dimensions.

3-2. INTERCONNECTION

The SBO must be interconnected as shown in Figure 3-3 or 3-4. Correct phase relationship between the SBO voltage and current input is very important and must be as shown in the interconnection drawings. Incorrect phasing will prevent the SBO from maintaining sufficient current to the voltage regulator and poor regulation will result. Generator phase rotation is not important.

If the voltage is within the limits specified in paragraph 1-2 the input to the Excitation Support System may be taken directly from the generator load lines. The unit provides isolation for the voltage regulator and exciter or generator field.

For generators rated above 600 VAC, a step-down power transformer can be used between the Excitation Support System and the generator. Basler Electric manufactures high voltage current transformers, on special request, for use in 5 kVac and 15 kVac applications. Some customers use low voltage CT's in high voltage applications. If this is done, two CT's are required, with one primary line per CT. The user is cautioned to add additional insulation to insulate the generator line passing through the low voltage CT's and he does this at his own risk. IN NO CASE should low voltage CT'S be used in applications exceeding 5 kVac.

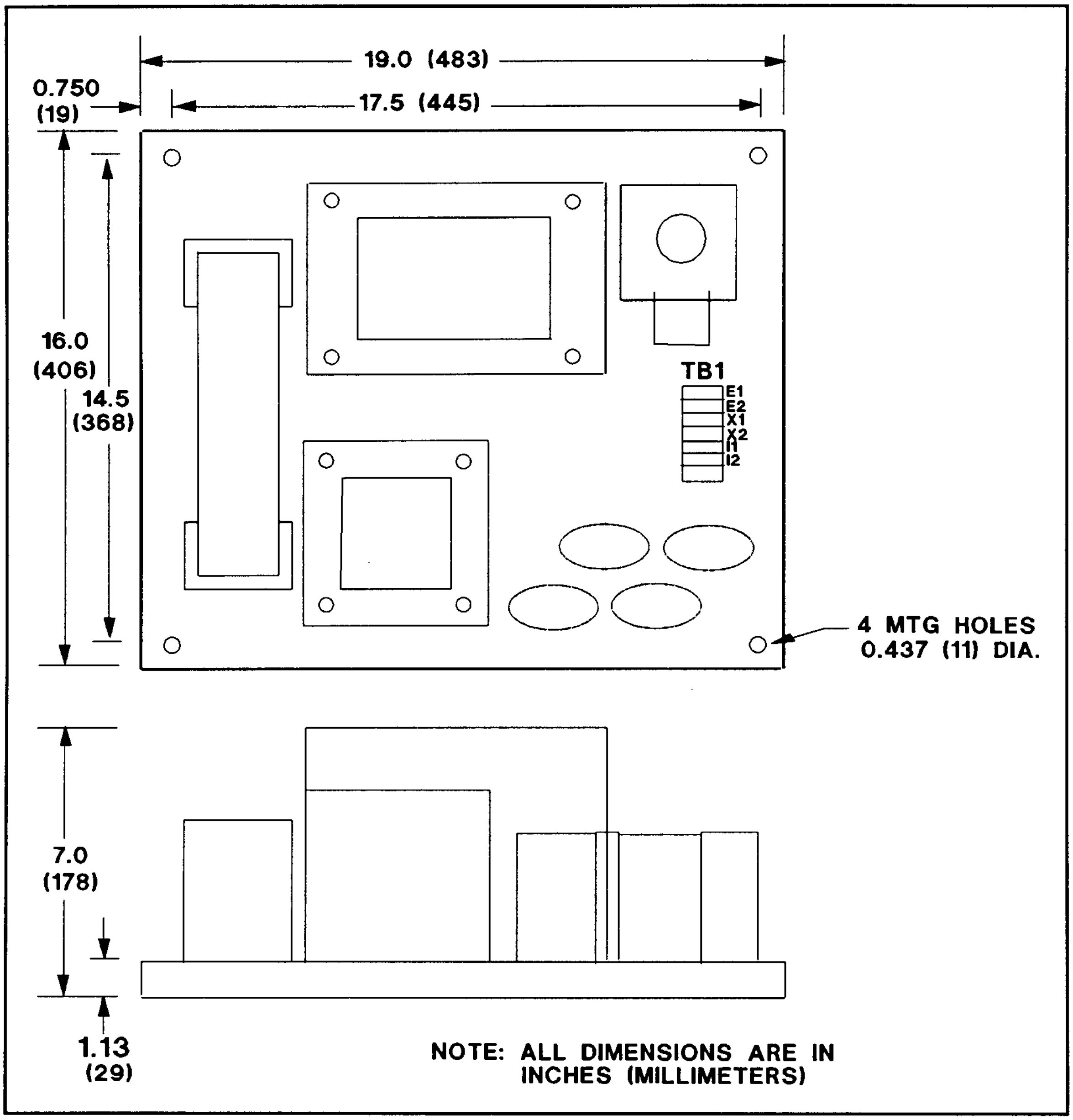
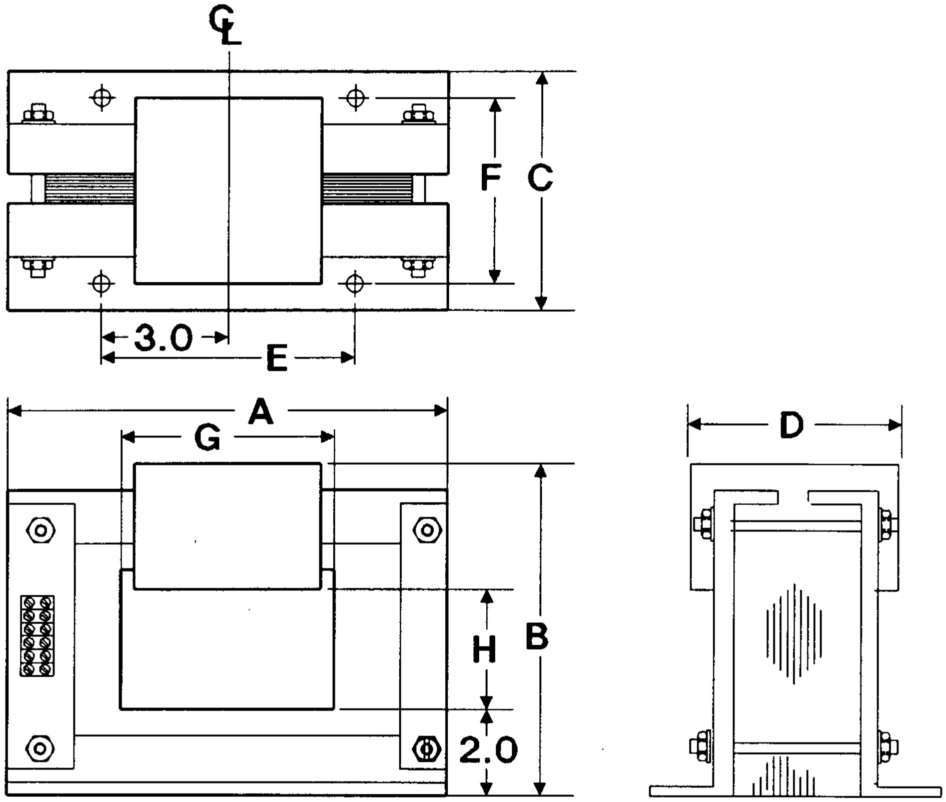


Figure 3-1. SBO Chassis Outline Drawing.



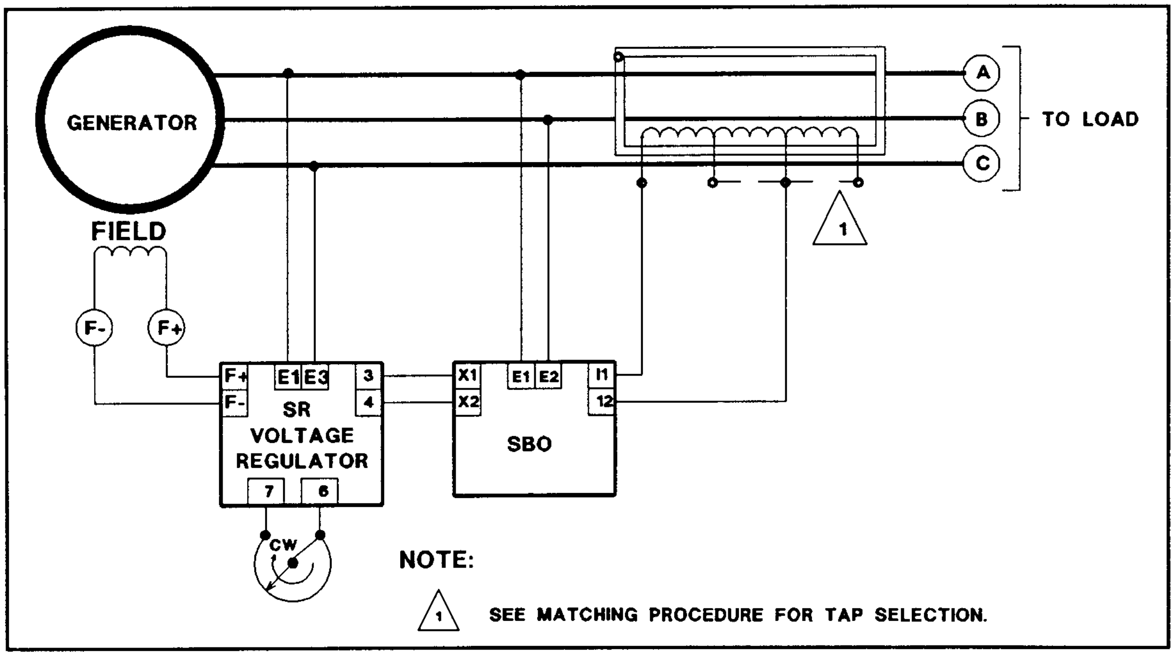
DIMENSIONS

TRANSFORMER	A	B	C	D	E	F	G	H
BE2462	10.5	9,25	7.75	7.38	6	6.75	5	3
BE2463	12.5	9.75	5.75	5.75	6	4.38	7	3
BE2464	11.5	10	4.63	5	6	5.63	7	3

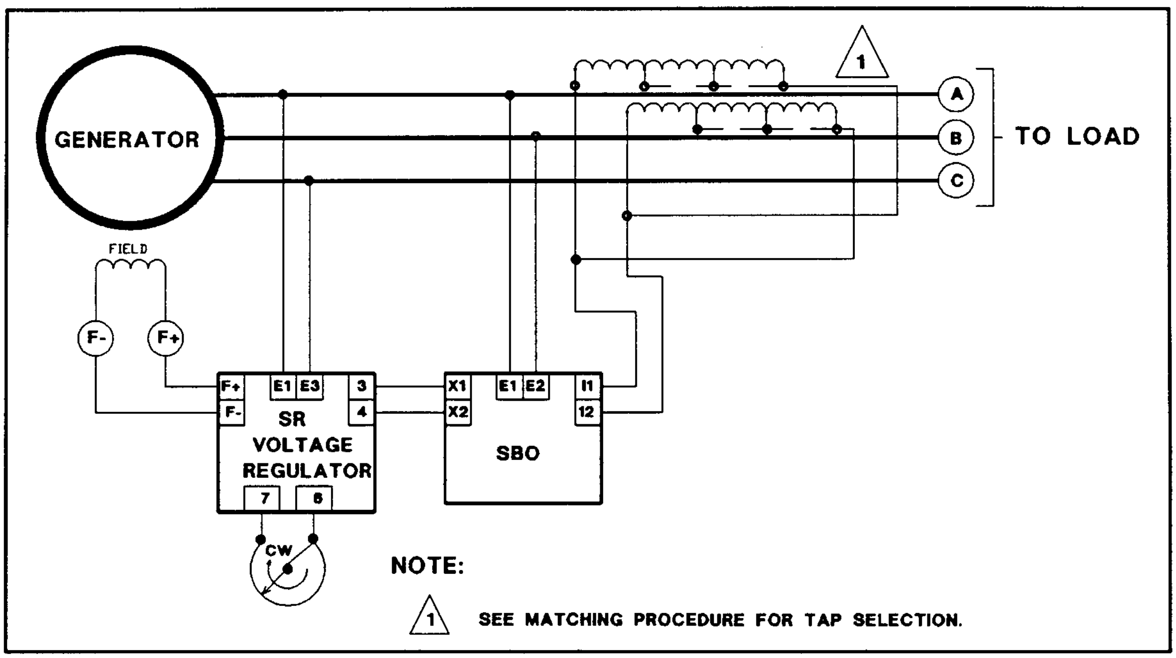
TURNS-RATIO

TRANSFORMER	C-1	C-2	C-3	C-4
BE2462	150	189	238	———
BE2463	300	378	476	———
BE2464	600	756	952	1200

Figure 3-2. CT Outline Drawing.



3-3. SBO and One CT Interconnection Diagram.



SBO and Two CT's Interconnection Diagram.

SECTION 4
MAINTENANCE

4-1. PREVENTIVE MAINTENANCE

Accumulations of dust and dirt should be removed from the SBO on a periodic basis, utilizing a soft brush or an air line that has a moisture trap.

4-2. CORRECTIVE MAINTENANCE

The SBO reservoir assembly is designed for easy removal and replacement of components in case field repairs are necessary. Figure 4-1 contains the reservoir chassis schematics to provide an aid in troubleshooting.

4-3. TROUBLESHOOTING

The following troubleshooting procedure allows testing of the unit without applying a full-rated load to the system. If it is suspected that the SBO is faulty due to excessive heat generation from the SBO or due to poor regulation as generator load is increased, proceed as follows:

a. Before testing, inspect the interconnection to ensure correctness (refer to Figures 3-1 and 3-2).

b. Place a clamp-on ammeter on the primary input to the SBO, terminal E1 or E2.

c. Vary the kW load of the generator between 20% and 100% of rated. If full load is not achievable, vary the kW load between 20% and the highest percentage of obtainable rated kW load. During the variation in kW load, monitor the input current (terminal E1 or E2).

d. Using the below formula, and the data taken in step c., calculate the change in current through E1 or E2 with respect to the kW loading:

$$M = \frac{(IH - IL)}{IL(\%kWH - kWL)} = \frac{\text{Percent Change of Current}}{\text{Percent Change of kW}}$$

where:

IH	=	Current through E1 (E2) at highest % of rated kW load rating.
IL	=	Current through E1 (E2) at the 20% point of rated kW rated load.
%kWH	=	Percent of rated kW load achieved for the high reading.
%kWL	=	20% of rated kW load.
M	=	Percent change in current (through E1 or E2) of the SBO for each percent change in kW.

e. The value of M should not exceed 0.375. If the value of M exceeds this figure, one of the following problems is likely:

(1) the phasing or the polarity of the current/voltage input into the SBO is incorrect,

(2) the selection of the CT ratio for the SBO is incorrect, or

(3) the SBO is faulty.

f. Reinspect the SBO interconnection for correctness.

g. Evaluate the current transformer selection by the use of current transformer selection chart and verify that the correct transformer was selected.

h. If steps f. and g. do not correct the problem, the SBO is defective.

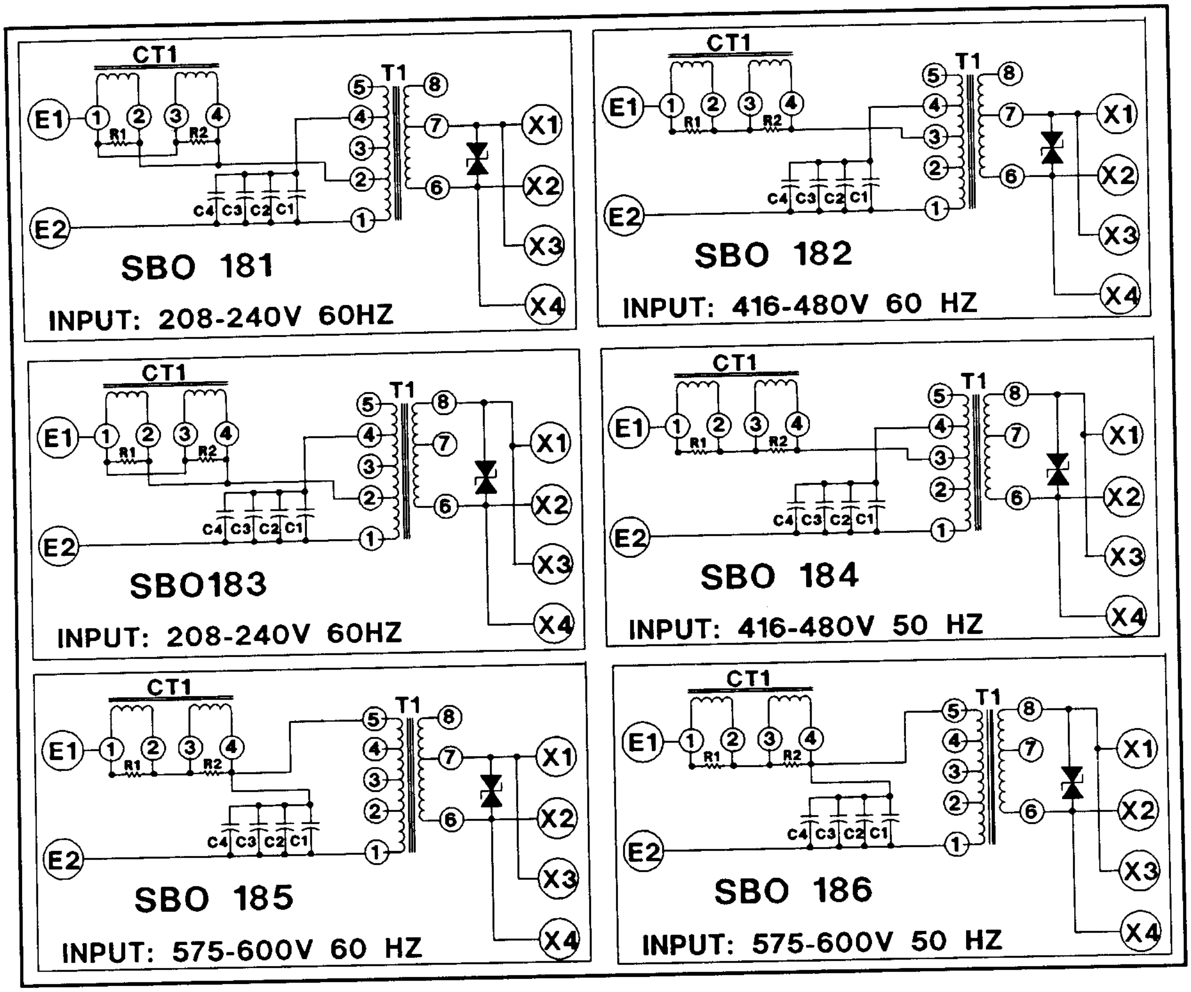


Figure 4-1. Reservoir Assembly Schematic Diagrams.

SECTION 5
CURRENT TRANSFORMER SELECTION

5-1. GENERAL

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_1 = he exciter field current,

R = the exciter R field resistance,

E = 180 volts.

(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, (180 volts). The amount of exciter field current that flows is a function of the exciter field resistance).

Step 2. From the 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 a greater field voltage forcing capability.

Step 3. (Refer to Table 5-1).

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 4.

b. In Column 2 locate the exciter field current calculated in Step 1 (or the closet value if the exact calculated value does not appear).

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

Table 5-1. Transformer Selection.

Column 1 3-Phase Short Circuit Line Current (A)	Column 2 When using Basler SR8A or SR8F Voltage Regulators supplying this maximum exciter field current during short circuit (Adc).							Column 3 Current Transformer Required
	2.5 A	3.4 A	4.4 A	5.6 A	6.9 A	8.4 A	10.0 A	
325	2:150		4:238		4:189		4:150	
366		2:150		4:238		4:189		
408	2:189		2:150		4:238		4:189	
459		2:189		2:150		4:238		
515	2:238		2:189		2:150		4:238	
577		2:238		2:189		2:150		
651	1:150		2:238		2:189		2:150	
731		1:150		2:238		2:189		
818	1:189		1:150		2:238		2:189	
919		1:189		1:150		2:238		BE 02462-001
1031	2:238		1:189		1:150		2:238	
1155		2:238		1:189		1:150		
1302	1:300		2:238		1:189		1:150	
1462		1:300		2:238		1:189		
1635	1:378		1:300		2:238		1:189	
1838		1:378		1:300		2:238		
2062	1:476		1:378		1:300		2:238	
2310		1:476		1:378		1:300		
2604	1:600		1:476		1:378		1:300	
2925		1:600		1:476		1:378		
3270	1:756		1:600		1:476		1:378	BE 02463-001
3675		1:756		1:600		1:476		
4125	1:952		1:756		1:600		1:476	
4620		1:952		1:756		1:600		
5205	1:1200		1:952		1:756		1:600	
5850		1:1200		1:952		1:756		
6540			1:1200		1:952		1:756	
7350				1:1200		1:952		BE 02454-001
8250					1:1200		1:952	
9240						1:1200		
10410							1:1200	
CT Output @ Short Circuit	7.5 A	8.4 A	9.4 A	10.5 A	11.9 A	13.4 A	15 A	

* If dual C.T.'s are used (in applications, for example, where primary bus connections would be difficult using a single C.T.) two identical C.T.'s are required and identical turns ratios are used.

d. 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 with 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 5-1). 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 4.

d. In Column 2, locate the exciter field current determined in step 4b (or the closest value if the exact value does not appear).

e. 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 "stepped" area to determine the correct CT, identified in Column 3.

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 on 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 capacity of dissipating this energy. Figure 3-2 identifies transformer secondary terminals.

NOTE - calculate the value of the series resistance using the following formula:

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

Where:

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

E = 180 volts

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

R_f = exciter field resistance.

The series resistance must not be so great as to restrict normal forcing.

EXAMPLE OF CT SELECTION

The following example summarizes the method used to select the appropriate CT.

Step 1. Calculate the actual exciter field current that will be provided by Basler SR8A voltage regulator during short circuit. Using the formula:

$$I_1 = \frac{E}{R}$$

$$I_1 = \frac{180\ V}{20.0\ \Omega}$$

$$I_1 = 9\ A$$

Step 2. From data supplied by the generator manufacturer, you determine that a generator line current of 2700 amperes would result using the 9 ampere output of the regulator. You consider this to be an excessive generator line current.

Step 3. You determine that 1800 amperes would constitute an acceptable generator line current at short circuit.

Step 4. From data supplied by the generator manufacturer, you determine that an exciter field current of 6 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).

Step 5. In Column 1 of Table 5-1, locate 1838 amperes (the value closest to 1800 amperes). Draw a horizontal line under 1838 and across the remaining columns.

Step 6. In Column 2, locate 5.6 amperes (the closest value to 6.0 amperes).

Step 7. Draw a vertical line through 5.6 amperes to intersect with the horizontal line drawn earlier.

Step 8. A turns ratio of 1:300 is intersected and will be used. Moving to the right within the "stepped" area from the selected turns-ratio you determine the appropriate CT to be a BE 02463 001.

Calculation of series resistance

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

$$R_S = \left(\frac{180}{6} - 10\right)$$

$$R_S = 10\ \Omega$$

The series resistance must not be so great as to restrict normal forcing.

SECTION 6
REPLACEMENT PARTS

6-1. GENERAL

The replacement parts list, Table 6-1, identifies the basic parts and assemblies of the SBO. Only those parts which are maintenance significant are included. When ordering parts, include the complete part number of the basic unit (such as 9 0371 00 100).

Table 6-1. Replacement Parts List.

Reference Designation	Basler Part Number	Qty	Description
T1	BE 02442-001	1	Transformer (prior to S/N 286)
	BE 02442-002	1	Transformer (S/N 286 and up)
L1	BE 02443-001	1	Reactor (prior to S/N 286)
	BE 02443-002	1	Reactor (S/N 286 and up)
C1 - C4	04874	4	Capacitor
R1 - R2	03717	2	Resistor, 150 Ω, 200 W
CR1	07145	1	Surge Arrestor