INSTRUCTION MANUAL

FOR

EXCITATION SUPPORT SYSTEM

SBO 24X, SBO 27X

Model	Part Number
SBO 241	9032300100
SBO 242	9032300101
SBO 243	9032300102
SBO 244	9032300103
SBO 245	9032300108
SBO 246	9032300109
SBO 271	9032300104
SBO 272	9032300105
SBO 273	9032300106
SBO 274	9032300107
SBO 275	9032300110
SBO 276	9032300111

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Preface

This instruction manual provides information about the installation and operation of the Excitation Support System. To accomplish this, the following information is provided:

- Model information
- Functional description
- Installation and maintenance information

Conventions Used in this Manual

Important safety and procedural information is emphasized and presented in this manual through warning, caution, and note boxes. Each type is illustrated and defined as follows.

Warning!
Warning boxes call attention to conditions or actions that may cause personal injury or death.

Caution
Caution boxes call attention to operating conditions that may lead to equipment or property damage.

Note
Note boxes emphasize important information pertaining to installation or operation.

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Warning!

READ THIS MANUAL. Read this manual before installing, operating, or maintaining the SBO 24X, SBO 27X. Note all warnings, cautions, and notes in this manual as well as on the product. Keep this manual with the product for reference. Only qualified personnel should install, operate, or service this system. Failure to follow warning and cautionary labels may result in personal injury or property damage. Exercise caution at all times.

Basler Electric does not assume any responsibility to compliance or noncompliance with national code, local code, or any other applicable code. This manual serves as reference material that must be well understood prior to installation, operation, or maintenance.

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It is not the intention of this manual to cover all details and variations in equipment, nor does this manual provide data for every possible contingency regarding installation or operation. The availability and design of all features and options are subject to modification without notice. Over time, improvements and revisions may be made to this publication. Before performing any of the following procedures, contact Basler Electric for the latest revision of this manual.

The English-language version of this manual serves as the only approved manual version.

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Introduction

The Excitation Support System (Series Boost Option or SBO) provides motor starting and fault clearing capabilities for generators equipped with a brushless exciter. The Excitation Support System enables the use of a brushless generator in an application normally requiring a conventional generator with a brush-type rotary, PMG, or series-boost exciter.

Each Excitation Support System consists of a reservoir assembly (with a model designation of SBO XXX) and a power current transformer (CT) selected to match the generator rating. The CT is mounted separately and connected to the reservoir assembly by the user. Selection of the CT for your application is described in Section 3.

Each reservoir assembly (SBO) is specifically designed for use with Basler Electric voltage regulator models SR4A, SR4F, KR4F, KR4FF, SR8A, SR8F, KR7F, or KR7FF. The capabilities and voltage regulator compatibility of each SBO model are summarized in Table 1.

Table 1. Reservoir Assembly (SBO) Model Summary

When using Basler voltage regulator model:	Or a regulator with these power input requirements: *	And the nominal system line voltage is: †	Select this reservoir assembly model:
SR4A SR4F KR4F KR4FF	120 Vac @ 7 Aac	208 to 240 Vac at 60 Hz 416 to 480 Vac at 60 Hz 573 to 600 Vac at 60 Hz 208 to 240 Vac at 50 Hz 380 to 480 Vac at 50 Hz 575 to 600 Vac at 50 Hz	SBO 241 (9032300100) SBO 242 (9032300101) SBO 245 (9032300108) SBO 243 (9032300102) SBO 244 (9032300103) SBO 246 (9032300109)
SR8A ‡ SR8F ‡ KR7F KR7FF	240 Vac @ 3.5 Aac	208 to 240 Vac at 60 Hz 416 to 480 Vac at 60 Hz 575 to 600 Vac at 60 Hz 208 to 240 Vac at 50 Hz 380 to 480 Vac at 50 Hz 575 to 600 Vac at 50 Hz	SBO 271 (9032300104) SBO 272 (9032300105) SBO 275 (9032300110) SBO 273 (9032300106) SBO 274 (9032300107) SBO 276 (9032300111)

* Maximum continuous rating.

† The SBO reservoir assembly can also be used in high-voltage applications by using a power isolation transformer and special high-voltage, insulated, power CTs. For high-voltage applications (above 600 V), consult Basler Electric for transformer selection.

‡ At half power. If the exciter field current at short-circuit is 5 Adc or less and if the exciter field resistance is 36 Ω or greater.

Excitation Support Systems are normally used on three-phase systems but may be applied on a single-phase system when the appropriate current transformer is used. Contact Basler Electric for assistance with a single-phase application.

Functional Description

The Excitation Support System utilizes the principle of ferroresonance to provide a source of regulated voltage for the voltage regulator. Figure 1 illustrates the basic circuit.

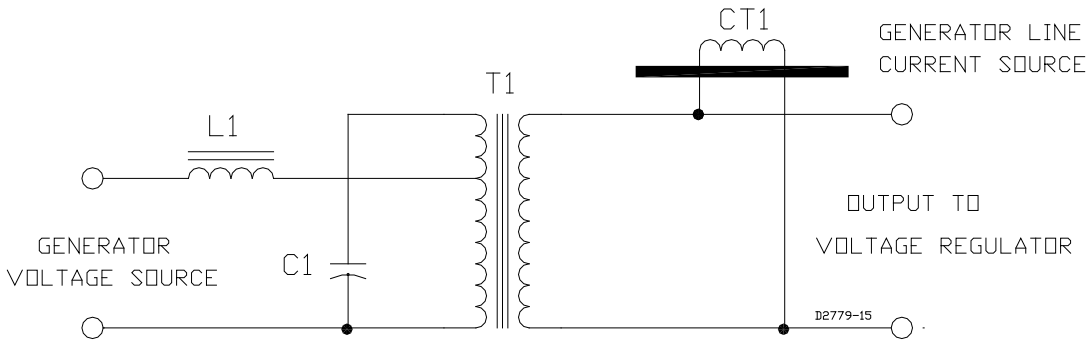


Figure 1. Excitation Support System Circuit Diagram

Excitation for the circuit is provided from two sources: voltage and current. 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 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 half 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 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 amperes required by the SBO to maintain ferroresonance. 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 winding. A wide range of turns ratios is available by various combinations of primary turns and secondary turns in the series of CTs designed for this application.

CT Selection

CT Selection Procedure

Selection of the appropriate current transformer is accomplished by performing the following procedure.

1. Calculate the exciter field current supplied by the voltage regulator during a generator short-circuit. Use the equation $I_1 = E \div R$ where I_1 is the exciter field current, R is the exciter field resistance, and E is a value of voltage selected from Table 2.

Table 2. Basler Voltage Regulator to E Cross-Reference

With this Basler regulator:	E =
SR4A	90
SR4F	
KR4F	
KR4FF	
SR8A	180
SR8F	
KR7F	
KR7FF	

NOTE: During a short-circuit, the generator output voltage is zero. Since the regulator power stage is receiving normal voltage from the SBO output, it will deliver the maximum output listed in Table 2. The amount of exciter field current that flows is a function of the exciter field resistance.

2. From the short-circuit saturation data (plot of exciter field current versus line current with the output of the generator shorted), 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 this results in acceptable generator line current, proceed to step 3.

   If this results in excessive generator line current, proceed to step 4.

   This this results in insufficient generator line current, us a Basler voltage regulator with greater field voltage forcing capability.

3. If step 2 results in acceptable generator line current, perform the following steps:

   a. In column 1 of Table 3, 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 is not shown). 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 of Table 3, locate the model of Basler voltage regulator being used.

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

   d. Draw a vertical line through the exciter field current value identified in step 3c so that it intersects with the horizontal line drawn in step 3a.

   e. Proceed to step 5.

4. If step 2 results in excessive generator line current, perform the following steps:

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

Table 3. CT Selection Table

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 CT listed below †	3-phase short-circuit line current in amperes
	SR4A SR4F	2.5	3.4	4.4	5.6	6.9	8.4	10		
	SR8A * SR8F * KR7F KR7FF	1.2	1.7	2.2	2.8	3.4	4.2	5		
	KR4F KR4FF	2.5	3.4	Consult Basler Electric for KR4F and KR4FF applications below 2.5 A.						
102		8:189		8:150		16:238		16:189		102
115			8:189		8:150		16:238			115
129		8:238		8:189		8:150		16:238		129
144			8:238		8:189		8:150			144
163		4:150		8:238		8:189		8:150		163
183			4:150		8:238		8:189			183
204		4:189		4:150		8:238		8:189		204
230			4:189		4:150		8:238			230
258		4:238		4:189		4:150		8:238		258
289			4:238		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		BE02461001 ‡	459
515		2:238		2:189		2:150		4:238		515
577			2:238		2:189		2:150			577
651		1:150		2:238		2:189		2:150		651
731			1:150		2:238		2:189			731
818		1:189		1:150		2:238		2:189		818
919			1:189		1:150		2:238			919
1031		1:238		1:189		1:150		2:238		1031
1155			1:238		1:189		1:150			1155
1302		1:300		1:238		1:189		1:150		1302
1462			1:300		1:238		1:189			1462
1635		1:378		1:300		1:238		1:189		1635
1838			1:378		1:300		1:238			1838
2062		1:476		1:378		1:300		1:238		2062
2310			1:476		1:378		1:300			2310
2604		1:600		1:476		1:378		1;300		2604
2925			1:600		1:476		1:378		BE02463001	2925
3270		1:756		1:600		1:476		1:378		3270
3675			1:756		1:600		1:476			3675
4125		1:952		1:756		1:600		1:476		4125
4620			1:952		1:756		1:600			4620
5205		1:1200		1:952		1:756		1:600		5205
5850			1:1200		1:952		1:756			5850
6540				1:1200		1:952		1:756	BE02464001	6540
7350					1:1200		1:952			7350
8250						1:1200		1:952		8250
9240							1:1200			9240
10410								1:1200		10410
CT output current at short-circuit		7.5 A	8.4 A	9.4 A	10.6 A	11.9 A	13.4 A	15 A		

* 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.

‡ BE02470001 can be substituted for BE0246101 in applications where it is desirable or necessary to reduce by half the number of primary turns specified in TABLE.

b. From the short-circuit saturation data (plot of exciter field current versus line current with the generator output 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 *Series Resistance Calculation*.)

c. In column 1 of Table 3, locate the value of acceptable generator line current at short-circuit (step 4a, or the closest value if the exact value is not shown). 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 of Table 3, locate the model of Basler voltage regulator being used.

e. In column 3 of Table 3, opposite the appropriate regulator model, locate the exciter field current determined in step 4b (or the closest value if the exact value is not shown).

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

5. The point of intersection (step 3d or step 4f) 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 4.

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 I 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 ferroresonant circuitry has the capability of dissipating this energy.

Series Resistance Calculation

The series resistance value is calculated using the following equation:

$$R_S = \frac{E}{I_2} - R_f$$

Where:
R_S is the value of series field resistance (in ohms) to be added.
E is the maximum regulator forcing voltage.
I_2 is the field current required to produce acceptable generator line current at short-circuit.
R_f is the 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.

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 = E ÷ R, 90 V (from chart) ÷ 11.1 Ω (generator data) = 8.1 A.
2. From data supplied by the generator manufacturer, you determine that a generator line current of 2,700 amperes would result using the 8.1 ampere output of the SR4A regulator. You consider this to be excessive line current.
3. You determine that 1,800 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 1,800 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 the calculation at the conclusion of this example).

5. In column 1 of Table 3-2, locate 1,838 amperes (the value closest to 1,800 amperes). Draw a horizontal line under 1838 to the same number in column 5.
6. In column 2 of Table 3-2, locate the SR4A voltage regulator.
7. In column 3 of Table 3-2, 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 in step 5.
9. 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 BE02463001.
10. Calculate the series resistance:

$$R_S = \frac{E}{I_2} - R_f$$

$$R_S = \frac{90}{5.4} - 11.1$$

$$R_S = 5.5\Omega$$

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

Mounting

The Excitation Support System reservoir assembly and the current transformer can be mounted in any position.

Reservoir Assembly

Mounting dimensions for the reservoir assembly are shown in Figure 2. Dimensions are expressed in inches with millimeters in parenthesis.

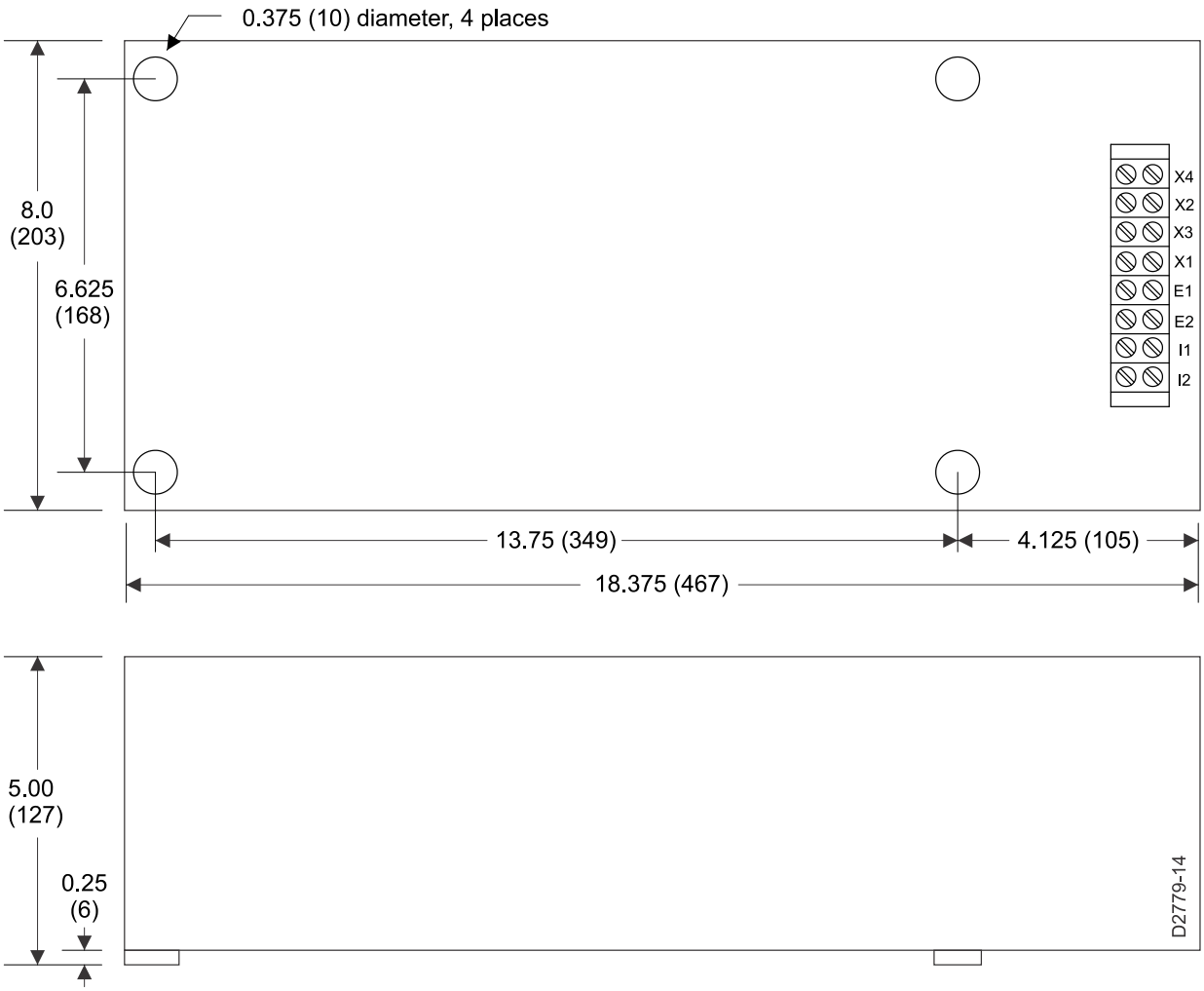


Figure 2. Reservoir Assembly Mounting Dimensions

CT

CT mounting dimensions are provided in Figure 3 and Table 4.

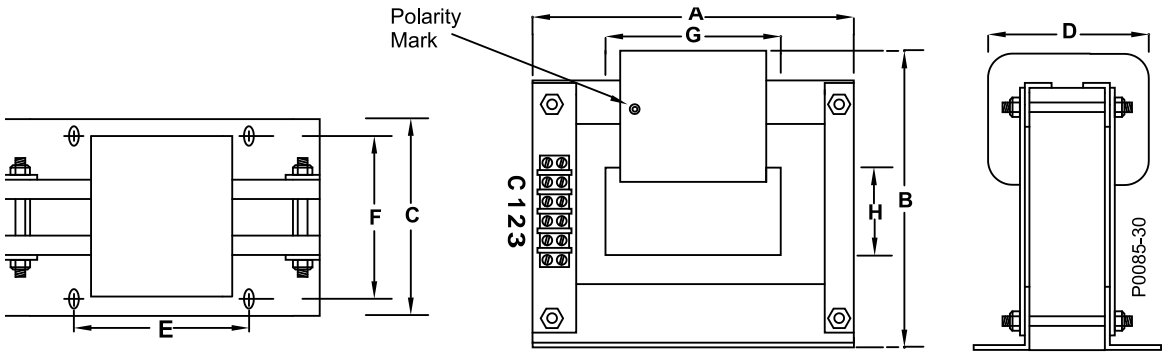


Figure 3. CT Dimensions

Table 4. CT Dimensions

CT P/N	Dimension							
	A	B	C	D	E	F	G	H
BE02461001	10.5 in. 267 mm	7.75 in. 197 mm	5.38 in. 137 mm	5.0 in. 127 mm	6.0 in. 152 mm	4.38 in. 111 mm	5.0 in. 127 mm	2.0 in. 51 mm
BE02463001	12.5 in. 318 mm	9.75 in. 248 mm	5.38 in. 137 mm	5.75 in. 146 mm	6.0 in. 152 mm	4.38 in. 111 mm	7.0 in. 178 mm	3.0 in. 76 mm
BE02464001	11.5 in. 292 mm	10.0 in. 254 mm	4.63 in. 118 mm	5.0 in. 127 mm	6.0 in. 152 mm	3.63 in. 92 mm	7.0 in. 178 mm	3.0 in. 76 mm
BE02470001	9.5 in. 241 mm	7.75 in. 197 mm	7.75 in. 197 mm	7.0 in. 178 mm	6.0 in. 152 mm	6.75 in. 171 mm	4.0 in. 102 mm	2.0 in. 51 mm

Connections

Connect the Excitation Support system as shown in Figure 4 or Figure 5. Reservoir assembly schematic diagrams for the six SBO models are provided in Figure 6 through Figure 17. The phase relationship between the SBO voltage and current inputs is critical. Incorrect phasing will prevent the Excitation Support System from maintaining sufficient current to the voltage regulator and poor regulation will result.

If the generator voltage is within the limits specified in Table 1, Excitation Support System power can be taken directly from the generator load lines. Isolation for the voltage regulator and exciter or generator field is provided by the Excitation Support System.

For generator s rated above 600 Vac, a step-down power transformer must be used between the generator and Excitation Support System.

Basler Electric manufactures high-voltage current transformers, on special request, for use in 5 kVac and 15 kVac applications.

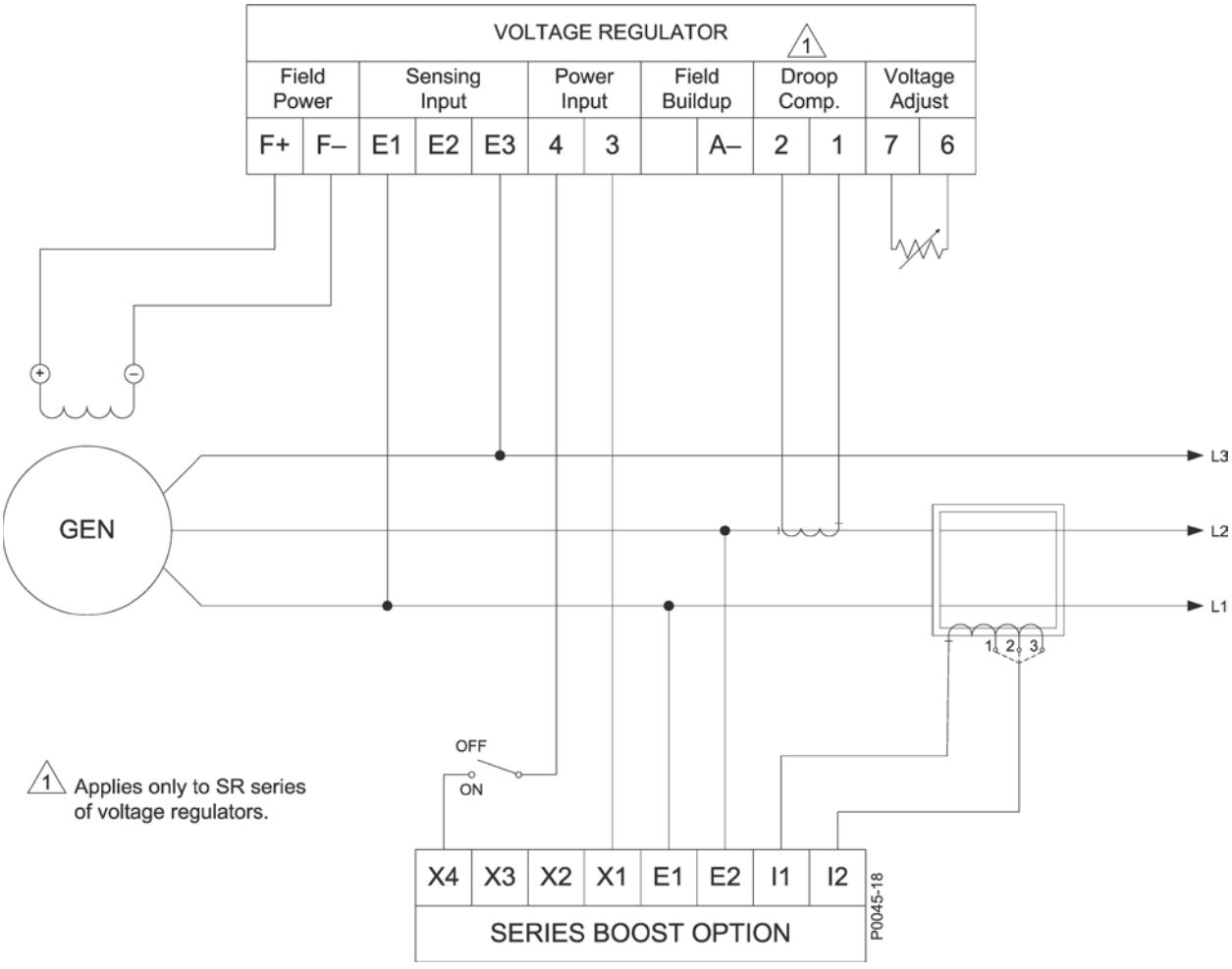


Figure 4. Interconnection Diagram, One CT

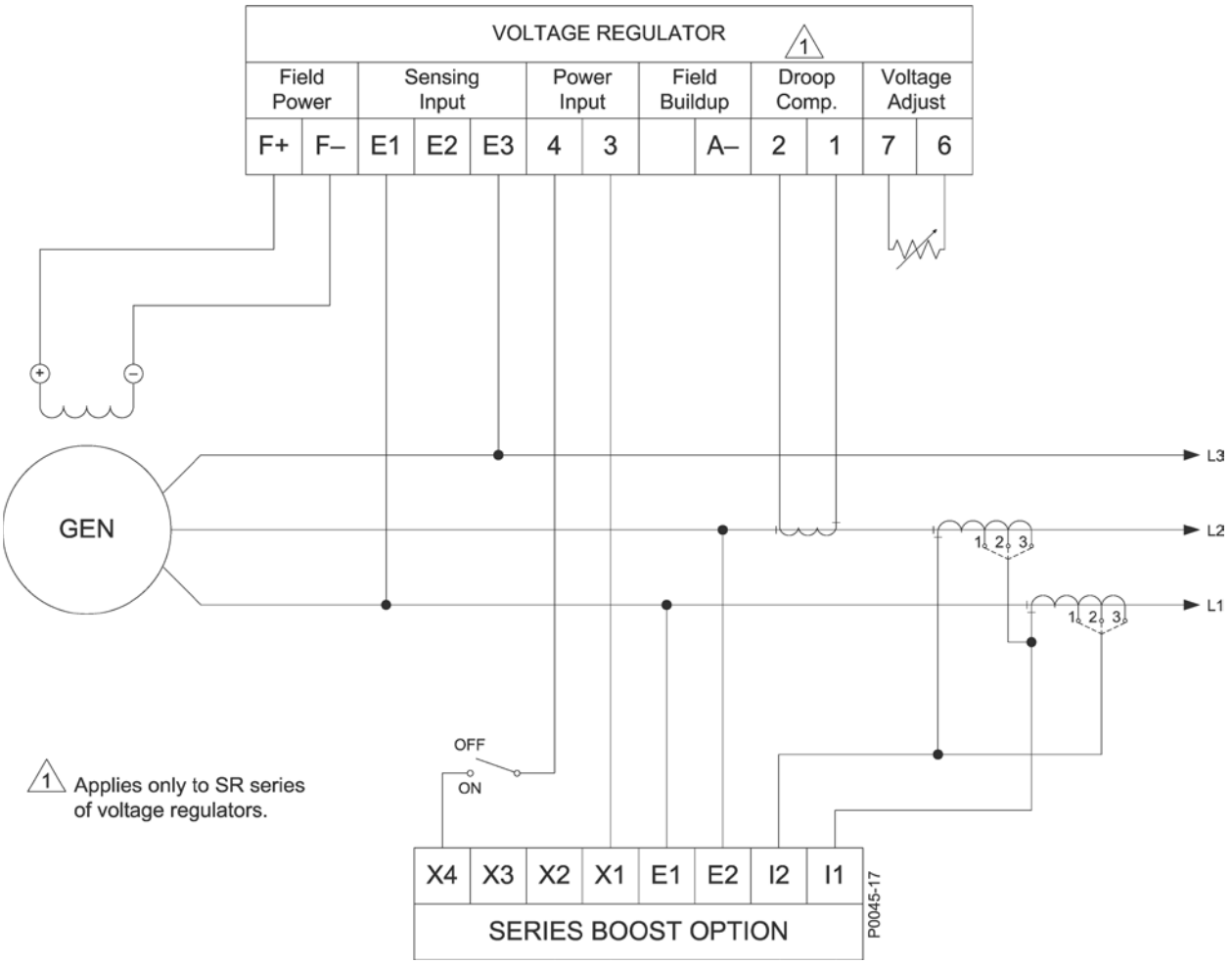


Figure 5. Interconnection Diagram, Two CTs

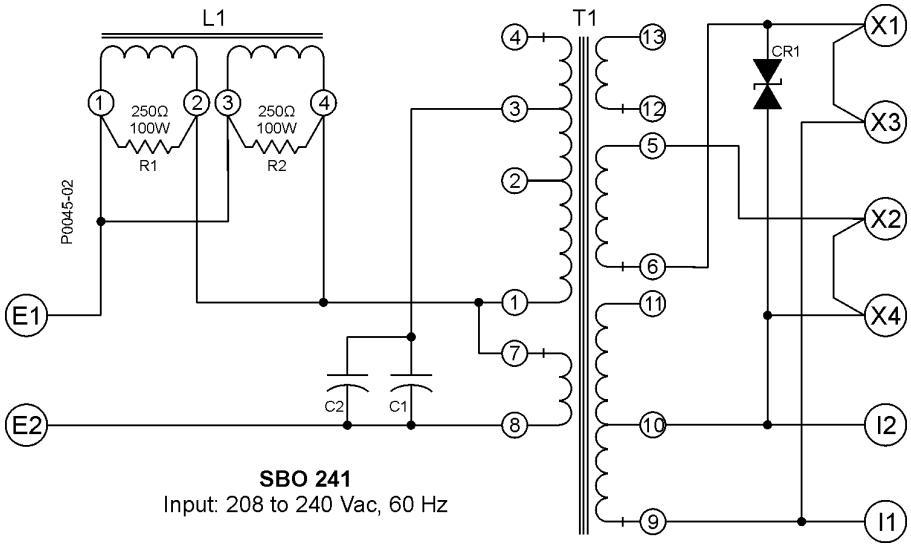


Figure 6. Internal Connections, SBO 241

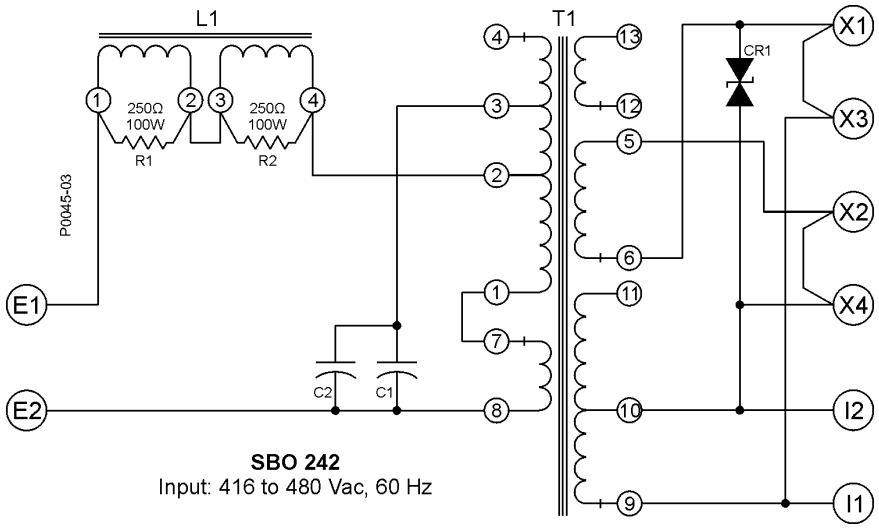


Figure 7. Internal Connections, SBO 242

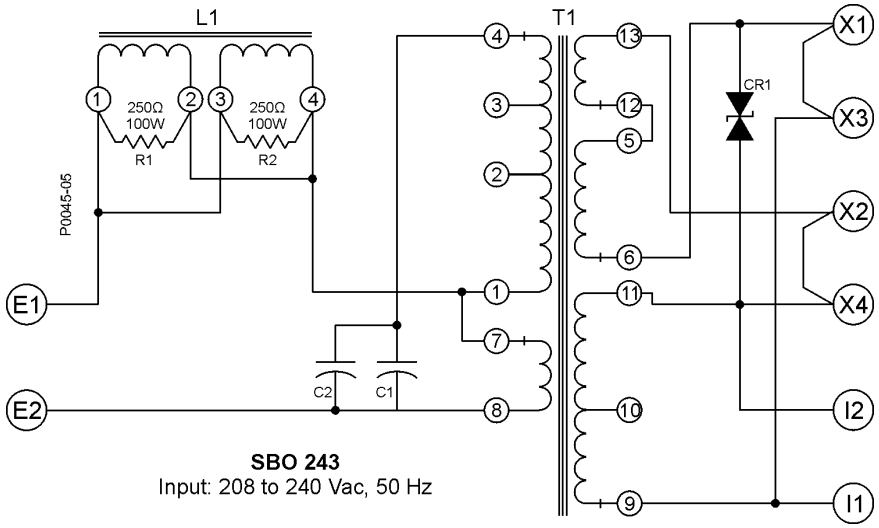


Figure 8. Internal Connections, SBO 243

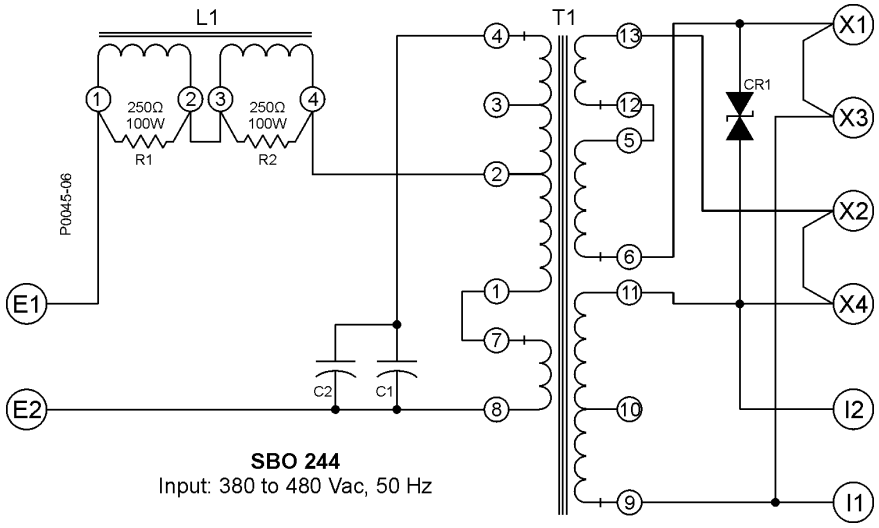


Figure 9. Internal Connections, SBO 244

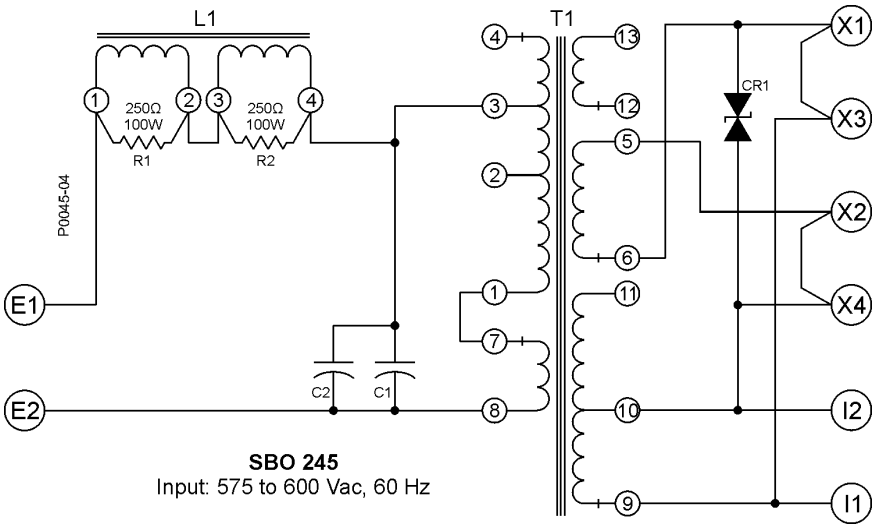


Figure 10. Internal Connections, SBO 245

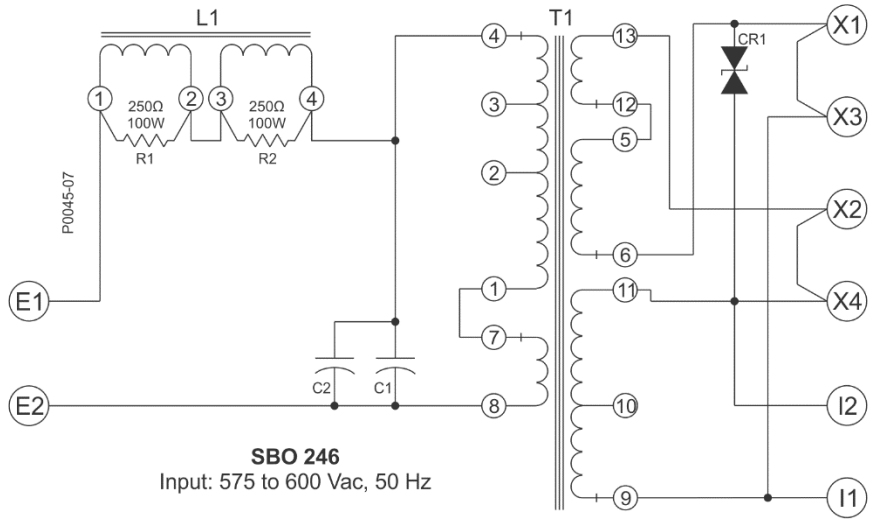


Figure 11. Internal Connections, SBO 246

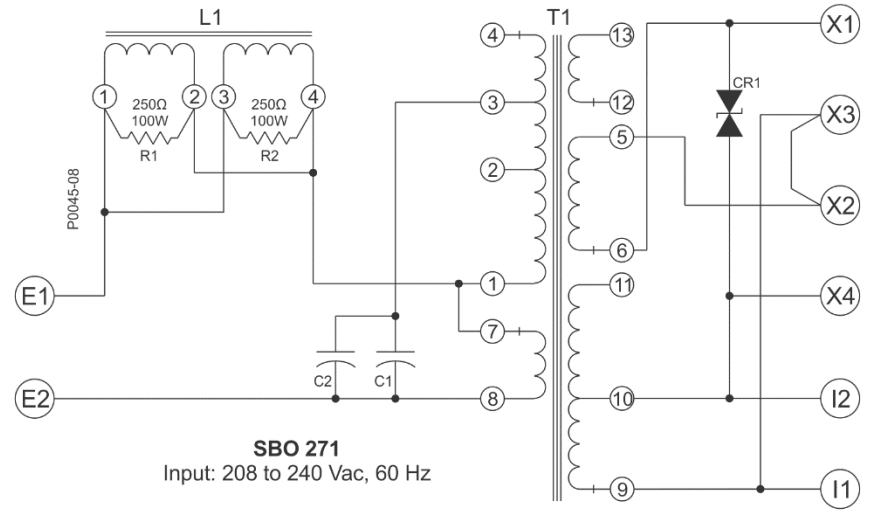


Figure 12. Internal Connections, SBO 271

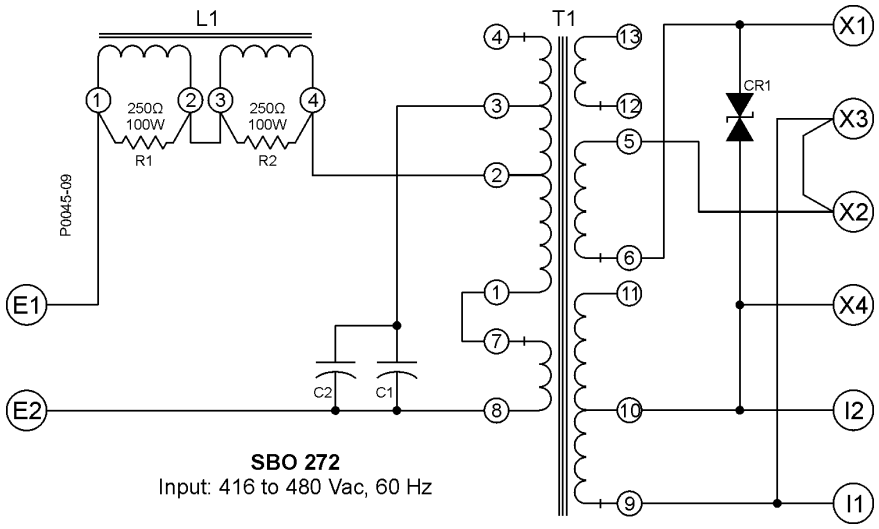


Figure 13. Internal Connections, SBO 272

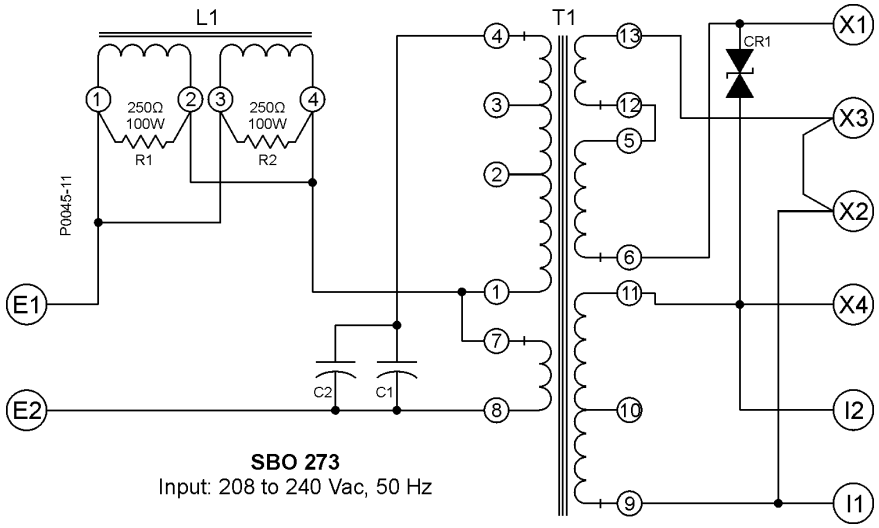


Figure 14. Internal Connections, SBO 273

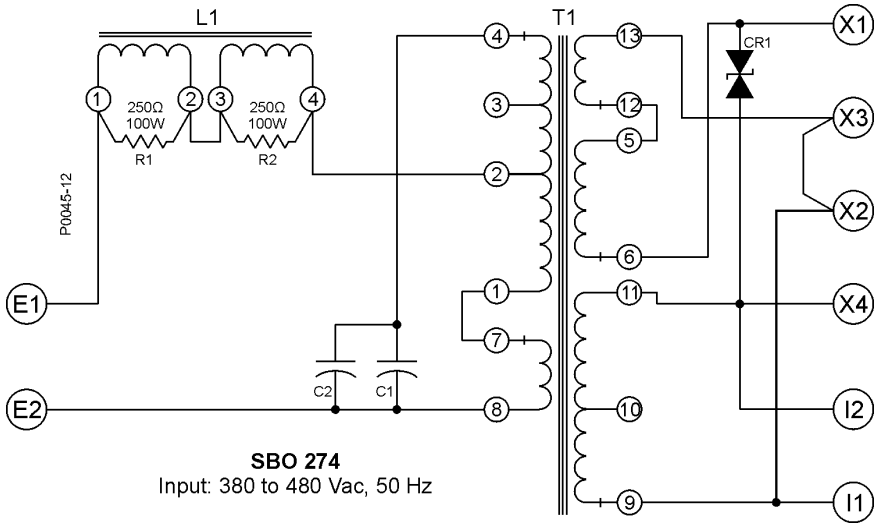


Figure 15. Internal Connections, SBO 274

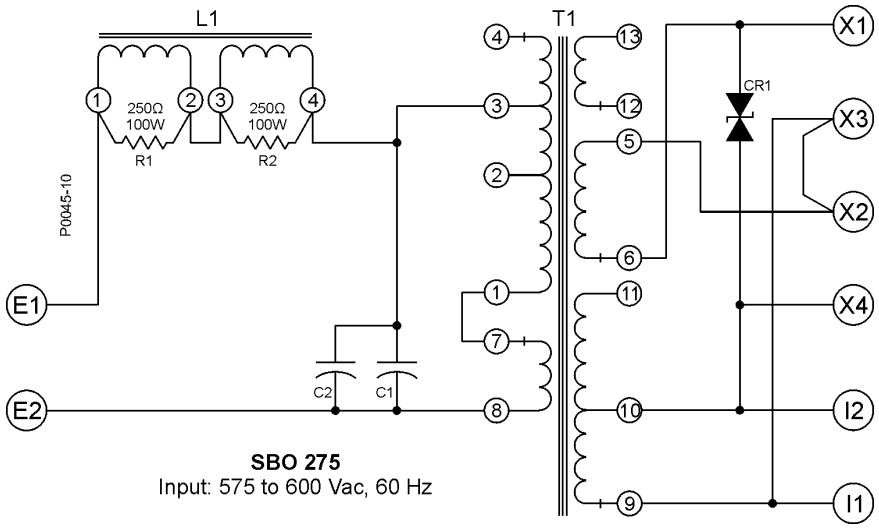


Figure 16. Internal Connections, SBO 275

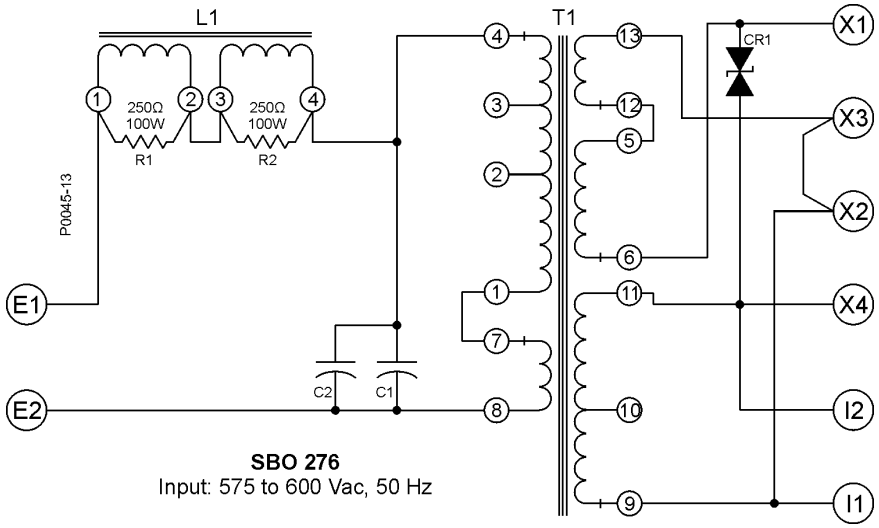


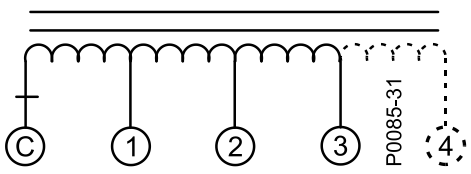
Figure 17. Internal Connections, SBO 276

CT Turns Ratios

CT connections and the corresponding turns ratios are provided in Table 5.

Table 5. CT Turns Ratios

CT P/N	Terminal C to 1	Terminal C to 2	Terminal C to 3	Terminal C to 4
BE02461001	150	188	238	N/A
BE02463001	300	378	476	N/A
BE02464001	600	756	952	1200
BE02470001	75	94	119	N/A



Maintenance

On a periodic basis, accumulations of dust and dirt should be removed from the Excitation Support System. All connections should be inspected to ensure that they are clean and tight.

Replacement Parts

Table 6 lists the Excitation Support System components that have maintenance significance. When ordering parts, always specify the SBO part number (found in Table 1).

Table 6. SBO Replacement Parts

Reference Designation	Description	Part Number	Quantity
T1	Transformer	BE01486001	1
L1	Reactor	BE01487001	1
C1, C2	Capacitor, 6 uF, 660 Vac	04874	2
R1, R2	Resistor, 250 Ω, 100 W	03350	2
CR1	Surge Arrestor, SBO 24X series	07040	1
CR1	Surge Arrestor, SBO 27X series	07145	1

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