

INSTRUCTION MANUAL

FOR

CURRENT BOOST SYSTEM

Models: CBS 344
CBS 377

Part Numbers: 9 1096 00 102
9 1096 00 103



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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 must not be used. Incorrect use of such equipment could damage components contained in the device.

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SECTION 1

GENERAL INFORMATION

1.1 DESCRIPTION

The purpose of the Current Boost System is to assist KR4 and KR7 series voltage regulators during generator overload conditions such as motor starting and to independently supply the generator exciter field current during generator short circuits. The CBS will permit 3-wire and 4-wire generators to support sustained single phase and multiple phase line-to-line faults. In addition, the CBS permits 4-wire generators to support phase A and phase B line-to-neutral faults (excluding phase C line-to-neutral faults). The CBS consists of a current boost module and a current transformer. An operation point adjustment and LED indicator are mounted on the front of the current boost module.

A special power current transformer is connected to two phases of the generator to provide current for the CBS. This CT provides several turns-ratios for tailoring the CBS to a variety of 3-wire generator systems. Refer to paragraph 4.3 for a chart showing the range of (three phase) short circuit line current/short circuit field current available using the CT, and the appropriate turns-ratios.

The CBS is available in two models:

- a) CBS 344 - for KR4 series regulator
- b) CBS 377 - for KR7 series regulator

The CT is available in two sizes (both have identical electrical ratings and turns-ratios):

- a) P/N BE 15486-001 - standard size (see Figure 4-2A)
- b) P/N BE 16866-001 - larger "window" (see Figure 4-2B)

1.2 SPECIFICATIONS

DC Output Power:	(see Table 1-1)
AC Sensing Voltage:	(see Table 1-1)

Table 1-1

MODEL	DC OUTPUT POWER		AC SENSING VOLTAGE	
	DC Volts (Max.)	DC Amps (Max.)	Adjustment Range	Burden
CBS 344 (Used with KR4 Series Regulator)	90 Vdc	3.5A	70 - 131 Vac	10VA
CBS 377 (Used with KR7 Series Regulator)	180 Vdc	5.0A	140 - 262 Vac	15VA

Power Dissipation: Less than 50 watts at continuous rating.

Dropout Ratio - CBS 344: Dropout @ 5V above pickup point.
CBS 377: Dropout @ 10V above pickup point.

Storage Temperature Range: -85°F (-65°C) to +185°F (+85°C)

Operating Temperature Range: -40°F (-40°C) to +140°F (+60°C)

Shock: Withstand up to 15 G's in each of three mutually perpendicular planes.

Vibration: Withstand 5 to 26 Hz. @ 1.2 G's; 26 to 52 Hz. @ 0.036 double amplitude; 52 to 260 Hz @ 5.0 G's.

Dimensions: 7.12 in. (180.97 mm) by 7.10 in. (180.34 mm) by 3.93 in. (99.99 mm)

Weight:

CBS 344/CBS 377: 4.5 lbs. (2.03kg) net
5.0 lbs. (2.27 kg) shipping
(CT) BE 15486-001: 32.4 lbs. (14.69kg) net
35.0 lbs. (15.9 kg) shipping
(CT) BE 16866-001: 52.0 lbs. (23.59kg) net
53.0 lbs. (24.0 kg) shipping

SECTION 2

THEORY OF OPERATION

2.1 CURRENT TRANSFORMER (CT)

The current transformer(s) selected for use with the CBS 344 or CBS 377 system is placed in two phases of the generator output to provide a source of both operating power and current boost for the current boost module. See Figure 4-3A. Secondary coil taps are provided to select appropriate ampere turns. Two electrically identical transformers are available: P/N BE 15486-001 (standard, see Figure 4-2A) and P/N BE 16866-001 (larger cable "window", see Figure 4-2B).

Due to conductor size or location, some generator systems cannot provide more than one output line for one CT (window) - it then becomes necessary to use two identical CTs, one for each phase, and each having the same turns-ratio. See Figure 4-3B.

2.2 CURRENT BOOST MODULE

The current boost module rectifies the ac from the CT to provide dc current boost for the generator exciter field. During normal generator operation, power from the generator output provides sufficient exciter field power - the Current Boost System remains dormant and the OPERATION POINT indicator is illuminated. At this time, the input CT is effectively shorted by SCRs in the current boost module.

If the generator output voltage drops below the operation point selected on the OPERATION POINT adjustment (due to a short or during motor starting) the current boost module detects the voltage drop, extinguishing the OPERATION POINT indicator and removing the SCR "short" from the CT. The module then provides full current boost to the generator exciter until the voltage returns to a level just above the operation point, and illuminates the OPERATION POINT indicator. Refer to sections 3.0 and 4.0 for proper use of the OPERATION POINT adjustment.

A voltage limiting circuit prevents the output of the current boost module from exceeding the specified nominal output voltage of 90 Vdc (CBS 344) and 180 Vdc (CBS 377).

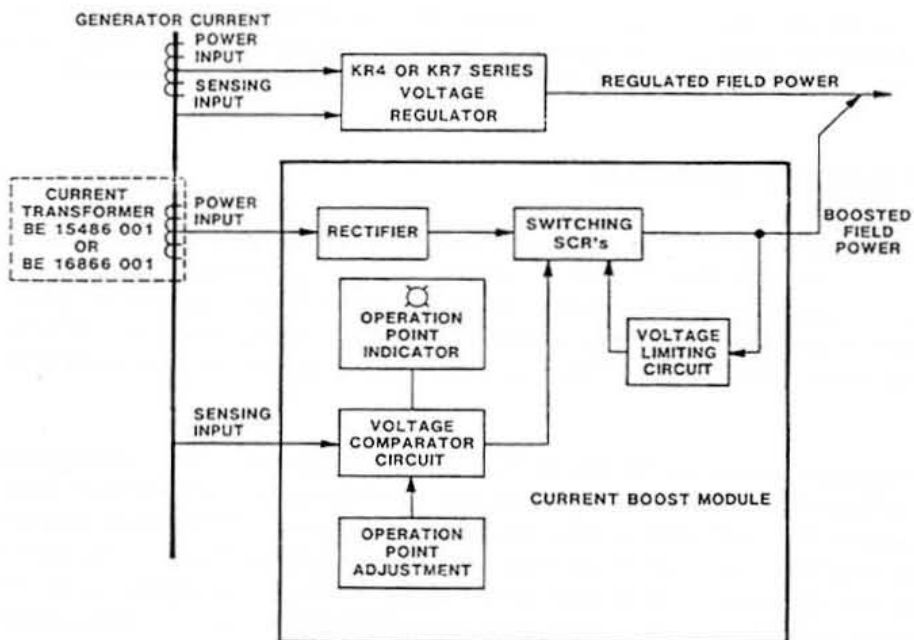


Figure 2-1. Current Boost System CBS 344 and CBS 377

SECTION 3

CONTROLS AND INDICATORS

3.1 GENERAL

Table 3-1 lists and describes the operator's controls and indicators of the Current Boost System.

Table 3-1 Controls and Indicators

Control or Indicator	Function or Indication
OPERATION POINT Adjustment	<p>This front panel-mounted screwdriver adjustment on the current boost module establishes the lower limit (pickup point) of generator output voltage if the sensed output voltage decreases below this limit, current boost will occur, continuing until the voltage increases to 5V (CBS 344) or 10V (CBS 377) above the limit (dropout point).</p> <p style="text-align: center;">NOTE</p> <p>Setting the OPERATION POINT adjustment too close to the nominal generator output voltage may cause oscillation of the output voltage. If this occurs, rotate the adjustment CCW until the oscillation stops.</p>
OPERATION POINT Indicator	<p>This front panel-mounted LED on the current boost module is normally illuminated, extinguishing during current boost, and illuminating again when generator output voltage exceeds the setting of the OPERATION POINT adjustment.</p>

SECTION 4

INSTALLATION

4.1 CONSTRUCTION

See Figure 4-1. The current boost module consists of a fabricated steel chassis containing electrical components and a printed circuit board.

A single control, indicator, and terminal board for generator system interconnection, are mounted on the front of the unit.

See Figure 4-2A and 4-2B for the configuration of the two available CTs. (Both CTs have identical electrical characteristics - however, the CT shown in figure 4-2B has a larger "window" for accepting the generator cables).

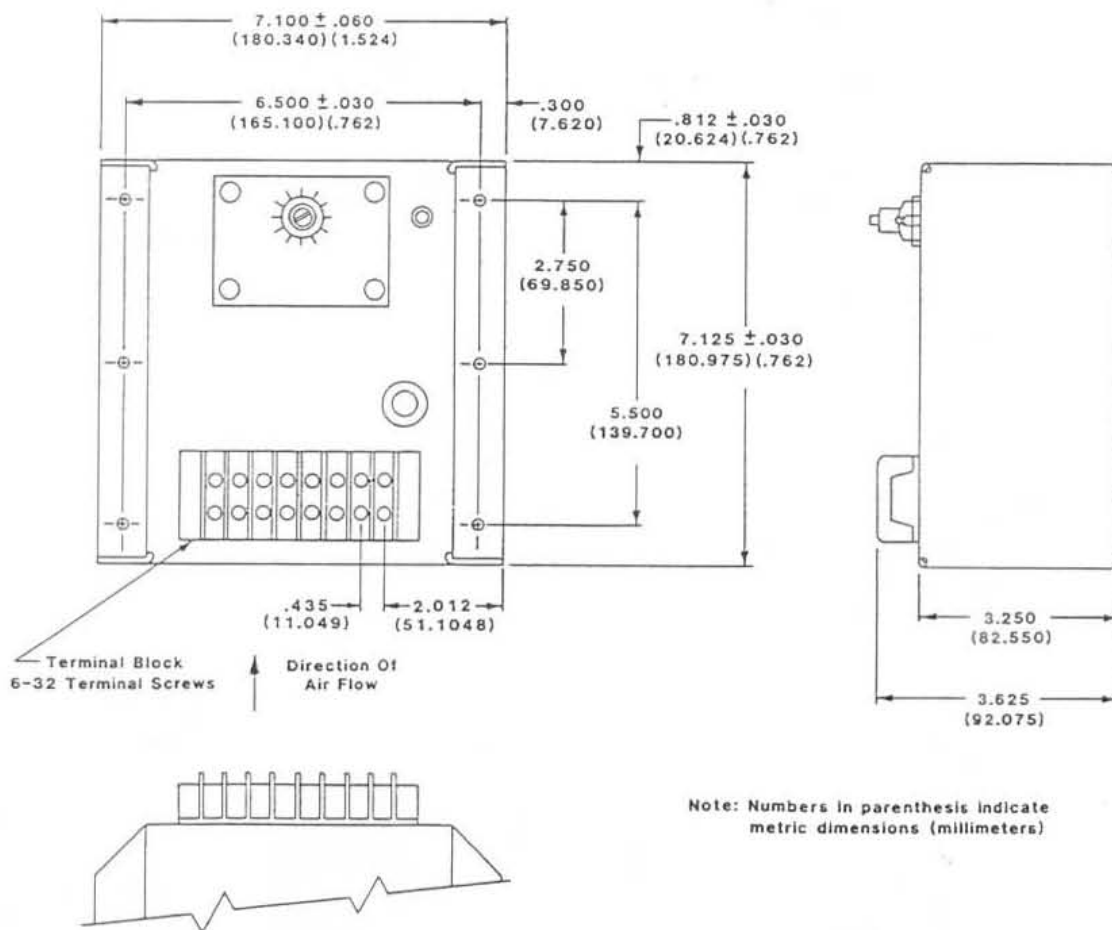


Figure 4-1. Outline Drawing - Current Boost Module

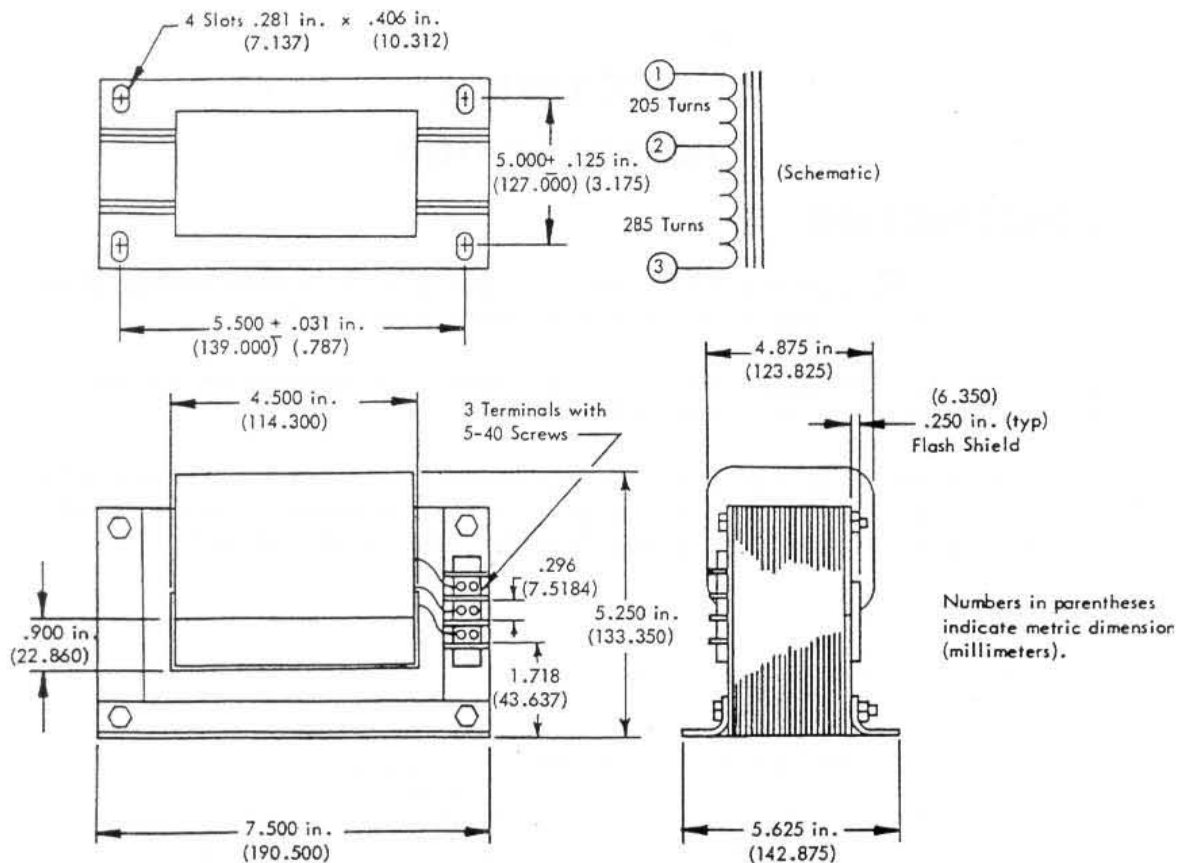


Figure 4-2A. Outline Drawing - Current Transformer Pt no. BE 15486-001

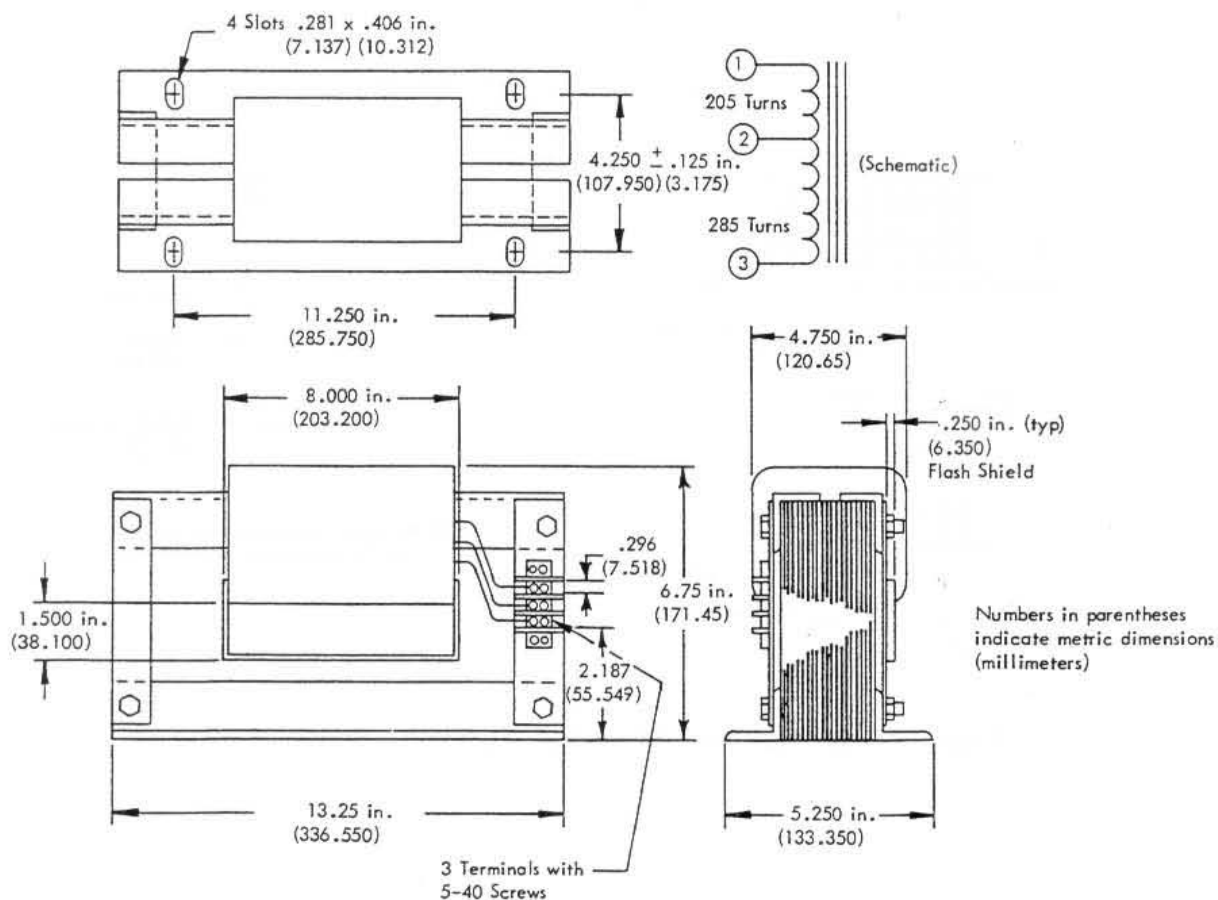


Figure 4-2B. Outline Drawing - Current Transformer Pt. no. BE 16866-001

4.2 INSTALLATION

4.2.1 Mounting

The current boost module is convection cooled and should not be mounted near heat generating equipment nor inside totally enclosed switchgear where the temperature rise could exceed its operating limit. Vertical mounting is recommended to obtain optimum convection cooling.

4.2.2 Interconnections

External connections to the current boost module are made at the front of the unit.

4.2.2.1 Current Transformer

A typical external connection utilizing a single CT is shown in Figure 4-3. A typical external connection to a zig-zag connected generator is shown in Figure 4-5.

Two current transformers are recommended for generators rated above 600 volts or when their use simplifies wrapping the primary turns. Figure 4-4 shows a typical external connection for those situations requiring two CTs.

NOTE

For selection of the CT turns
-ratio refer to paragraph 4.3.

Figures 4-3 through 4-5 show how the output leads of the generator pass through the window of the CT(s). NOTE THAT THE LEADS OF TWO PHASES PASS THROUGH THE WINDOW IN OPPOSITE DIRECTIONS.

With this configuration, energy is supplied to the CT to activate the module during the following fault conditions:

- a) Symmetrical Three Phase Short (Phase A to Phase B to Phase C)
- b) Phase A to Phase B Short
- c) Phase A to Phase C Short
- d) Phase B to Phase C Short
- e) Phase A to Neutral Short
- f) Phase B to Neutral Short

If the generator has a neutral terminal, energy will be supplied to the CT during conditions e and f, but not for a phase C to Neutral short. In this

case, if the voltage regulator is powered by phase A and phase B, the regulator may continue to supply power to the exciter field.

4.2.2.2 Exciter Field Current Boost Output Circuit (Terminals P and N)

Disconnect generator terminal F+ from the regulator F+ terminal. Reconnect generator terminal F+ to terminal P on the current boost module. Connect a new lead from terminal N on the current boost module to the F+ terminal on the voltage regulator.

4.2.2.3 Current Input Circuit (Terminals 1 and 2)

Connect terminals 1 and 2 to the CT secondary terminals. Refer to paragraph 4.3 for the correct turns-ratio for the CT.

4.2.2.4 Sensing Circuit (Terminals 3 and 4)

Generator voltage is applied between terminals 3 and 4 of the current boost module. The range of input voltage should not exceed 90 to 139 Vac for the CBS 344 Current Boost System or 180 to 277 Vac for the CBS 377 Current Boost System. If the appropriate input voltage is not available, a power isolation transformer should be installed as shown in Figures 4-3 through 4-5.

4.3 CT TURNS-RATIO SELECTION

4.3.1 Selection Procedure

Two phases of the generator output are applied to the CT. The following procedure is used to calculate the number of CT primary turns (generator output lines, wound through the CT window by the installer) for each phase, and secondary turns (Figure 4-2, terminals 1, 2, 3).

If dual CTs are used (for example, safety requirements will not allow generators with output voltage greater than 600V to pass two output cables through the "window" of the CT), two identical CTs are required, and identical turns-ratios applied.

- Step 1. Calculate the exciter field current during a generator short circuit:

$$I_{\text{Field}} = \frac{E}{R}$$

where,

I_{Field} = Exciter Field Current at Short Circuit

R = Exciter Field Resistance

E = CBS Field Forcing Voltage*

* 90 Vdc Forcing Voltage for CBS 344
180 Vdc Forcing Voltage for CBS 377

- 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 three phase line current or Line to Line line current for a zig-zag connected generator during a short circuit that would result from the exciter field current calculated in Step 1.

If (for your generator system)	Then
This results in <u>excessive</u> generator line current.	Proceed to step 3A
This results in <u>acceptable</u> generator line current.	Proceed to step 3B

Step 3A.

- Determine the desired acceptable generator three phase line current (or Line to Line line current for a zig-zag connected generator) at short circuit (typically 250 - 300% nominal). In Table 4-1 or 4-2, column 1, locate the value closest to this value.
- Using short circuit saturation data (plot of exciter field current versus line amps with the output of the generator short circuited) from the generator manufacturer, determine the exciter field current at short circuit required to generate the acceptable generator line current*. In table 4-1 or 4-2, column 3, locate the current value closest to this value.

* To obtain this reduced current, place a current limiting resistor in series with the exciter field - the value of this resistance is calculated as follows:

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

where, R_s = value of series field resistance to be added (ohms). (This resistance must not be so great as to restrict normal forcing).

Table 4-1 - Turns-Ratio Selection (1)

COLUMN 1	COLUMN 2	COLUMN 3				
3 Phase Line Current At Short Circuit (Amperes)	Maximum Continuous Line Current	Exciter Field Current at Short Circuit (Amperes) - KR4 and KR7 Series Voltage Regulators				
		2.8	3.54	4.0*	4.45*	5.0*
141	50			5:205		6:205
158		3:205	4:205		5:205	
178	65			4:205		5:205
200		3:205	3:205		4:205	
225	80			3:205		4:205
253		2:205	3:205		3:205	
283	100			3:205		3:205
318		2:285	2:205		3:205	
357				2:205		3:205
401		2:285	2:285		2:205	
450	150			2:285		2:205
505		1:205	2:285		2:285	
567	200			2:285		2:285
636		1:285	1:205		2:285	
714				1:205		2:285
801		1:285	1:285		1:205	
900	300			1:285		1:205
1010		1:285	1:285		1:285	
1134				1:285		1:285
1273	450	1:490	1:285		1:285	
1428				1:285		1:285
1603		1:490	1:490		1:490	
				1:490		1:490
2020		1:490	1:490		1:490	
				1:490		1:490
2547		1:490	1:490		1:490	
2857				1:490		1:490
3207	800		1:490		1:490	
3600				1:490		1:490
4040					1:490	
4536						1:490

NOTE:

- (1) First number - primary (generator cable) turns. Second number - secondary turns. If dual CTs are used, each CT receives the indicated primary turns from only one phase of the generator, and each CT is connected using the indicated secondary turns.

* KR7F only

- ** Only one phase connected to CT.
Example (Paragraph 4.3.2) Step 3A
Example (Paragraph 4.3.2) Step 3B

Table 4-2 - Turns-Ratio Selection (1) for Zig-Zag Connected Generators

COLUMN 1	COLUMN 2	COLUMN 3				
L1 - L2 Line Current At Short Circuit (Amperes)	Maximum Continuous Line Current	Exciter Field Current at Short Circuit (Amperes) - KR4 and KR7 Series Voltage Regulators				
		2.8	3.54	4.0*	4.45*	5.0*
120	60			5:205		6:205
137	70	3:205	4:205		5:205	
154				4:205		5:205
171	90	3:205	3:205		4:205	
192				3:205		4:205
219	120	2:205	3:205		3:205	
244				3:205		3:205
274		2:285	2:205		3:205	
308				2:205		3:205
347	180	2:285	2:285		2:205	
390				2:285		2:205
438	250	1:205	2:285		2:285	
491				2:285		2:285
551		1:285	1:205		2:285	
620				1:205		2:285
694	370	1:285	1:285		1:205	
765				1:285		1:205
850	520	1:285	1:285		1:285	
965				1:285		1:285
1050		1:490	1:285		1:285	
1200				1:285		1:285
1395	890	1:490	1:490		1:490	
1560				1:490		1:490
1745		1:490	1:490		1:490	
1960				1:490		1:490
2202		1:490	1:490		1:490	
2475				1:490		1:490
2780			1:490		1:490	
3124				1:490		1:490
3489					1:490	
3932						1:490

NOTE:

- (1) First number - primary (generator cable) turns. Second number - secondary turns. If dual CTs are used, each CT receives the indicated primary turns from only one phase of the generator, and each CT is connected using the indicated secondary turns.

* KR7F only

** Only one phase connected to CT.

Example (Paragraph 4.3.2) Step 3A

Example (Paragraph 4.3.2) Step 3B

E = exciter field forcing voltage (from step 1).
 I_2 = field current required to produce acceptable generator line current at short circuit.
 R_f = exciter field resistance.

- c. Check that the rated generator full load line current doesn't exceed the maximum continuous line current. If the generator full load line current does exceed the maximum continuous line current (Table 4-1 or 4-2, column 2) rating, consult the factory.
- d. Proceed to step 4.

Step 3B

- a. In Table 4-1 or 4-2, column 1, locate the value of generator line current at short circuit, closest to the value determined in step 2.
- b. In table 4-1 or 4-2, column 3, locate the value of exciter field current at short circuit, closest to the value determined in step 1.
- c. Check that the rated generator full load line current doesn't exceed the maximum continuous line current. If the generator full load line current does exceed the maximum continuous line current (Table 4-1 or 4-2, column 2) rating, consult the factory.
- d. Proceed to step 4.

- Step 4. Find the turns-ratio at the point of intersection of the values found in step 3A or 3B - if there is not a ratio at this point, use the ratio directly above the intersection.

The first numeral of the turns-ratio indicates the number of turns of each generator line that passes through the CT window. The second numeral indicates the number of secondary turns to be used. See Figure 4-2 for appropriate CT terminals for secondary turns.

NOTE

Increased CT power will result if a smaller turns-ratio is selected (CT primary turns are increased or CT secondary turns are decreased).

- Step 5. Verify that the CT "window" size is sufficient for the generator conductor, as follows. Multiply the first numeral of the turns-ratio by the number of conductors in each phase, then by the number of phases (2). Multiply this product by the diameter of the conductor to find the required minimum size of the CT window. The "window" of the CT specified for your CBS (Figure 4-2A or 4-1B) should exceed this minimum. Figures 4-2A and 4-2B also show the appropriate CT terminals for secondary turns.

NOTE

If dual CTs are used, each CT receives the indicated primary turns from only one phase of the generator and each CT is connected using the indicated secondary turns.

4.3.2 Example of CT Turns-Ratio Selection

This example shows the resulting turns-ratio of paragraph 4.3.1, Selection Procedure, for both excessive and acceptable generator short circuit current.

- (Step 1) Determine the exciter field current that will be provided by a Basler KR4F voltage regulator during short circuit:

$$I_F = \frac{E}{R} = \frac{90 \text{ Vdc}}{30 \text{ ohms}} = 3.0A$$

where, I_F = Field current
E = Table 1-1, CBS 344/KR4 max. dc volts
R = Exciter field resistance

- (Step 2) From generator manufacturer data, you determine that the exciter field current of 3.0A from the KR4F voltage regulator would result in a short circuit line current of 2258A.

If (for your generator system)	Then
This results in <u>excessive</u> generator line current.	Proceed to step 3A
This results in <u>acceptable</u> generator line current.	Proceed to step 3B

- (Step 3A) (You determine that 1800A would constitute an acceptable generator line current at short circuit).

From generator manufacturer data, you determine that an exciter field current of 2.5A is required for the generator system to deliver an acceptable 1800A at short circuit.

Determine the necessary resistance to be added to the exciter field to achieve the 2.5A exciter field current.

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

$$\frac{90 \text{ Vdc} - 30 \text{ ohms}}{2.5\text{A}}$$

$$36 - 30 \text{ ohms}$$

$$6 \text{ ohms}$$

NOTE

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

In table 4-1, column 1, the value of "1800A" corresponds with the required value of 1800A. Draw a horizontal line from this point across the chart.

In table 4-1, column 3, the value of 2.5A corresponds with the required value of 2.5A (from step 3A). Draw a vertical line from this point down the chart.

- (Step 4) From table 4-1, the intersection of the two lines from step 3A is the turns-ratio, 1:490:

1 turn on primary (done by installer)
490 turns on secondary (terminals 1 and 3, Figure 4-2)

- (Step 5) The first numeral of the turns-ratio (1), the number of conductors per phase (2) and the number of phases (2) multiplied together results in: 4 conductors (through the CT window). From generator manufacturer data, 0.7 in. is the conductor diameter; therefore, for 4 conductors the CT window must be at least 0.7 in. X 2.8 in. Basler CT P/N BE 15486-001 (Figure 4-2A)) is 0.9 in. X 4.5 in. and meets the requirement.

NOTE

This ends the EXAMPLE for excessive line current.

- (Step 3B) In table 4-1, column 1, the closest value to 2258A (from step 2) is "2267A". Draw a horizontal line from this point across the chart.

In table 4-1, column 3, the closest value to 3.0A (from step 1) is "3.15A". Draw a vertical line from this point down the chart.

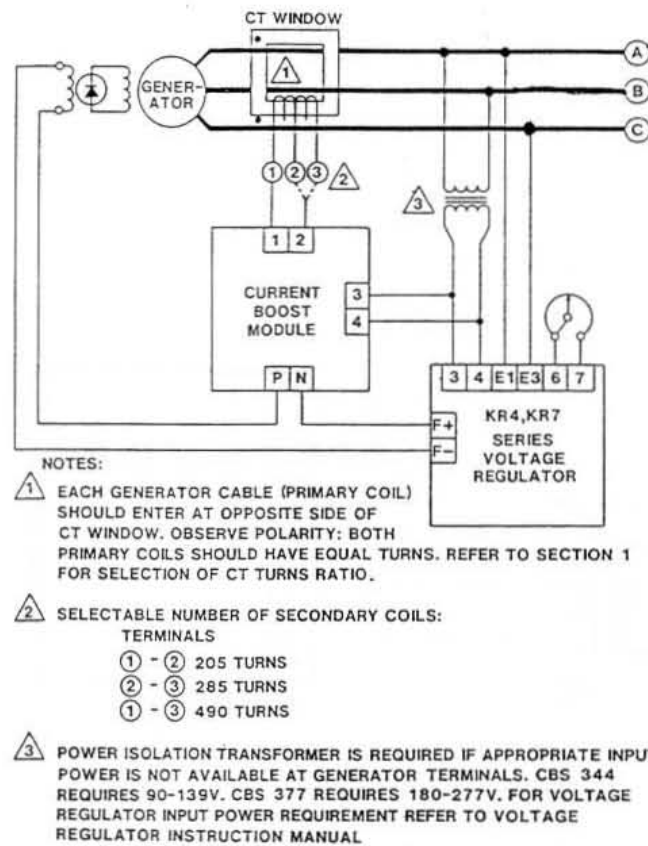


Figure 4-3. Interconnection Diagram - Single CT

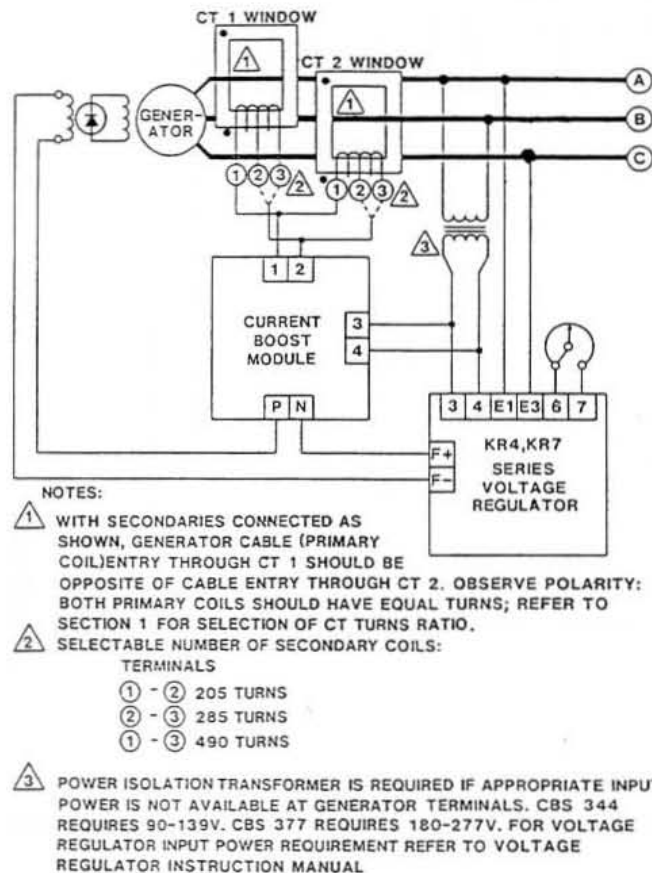
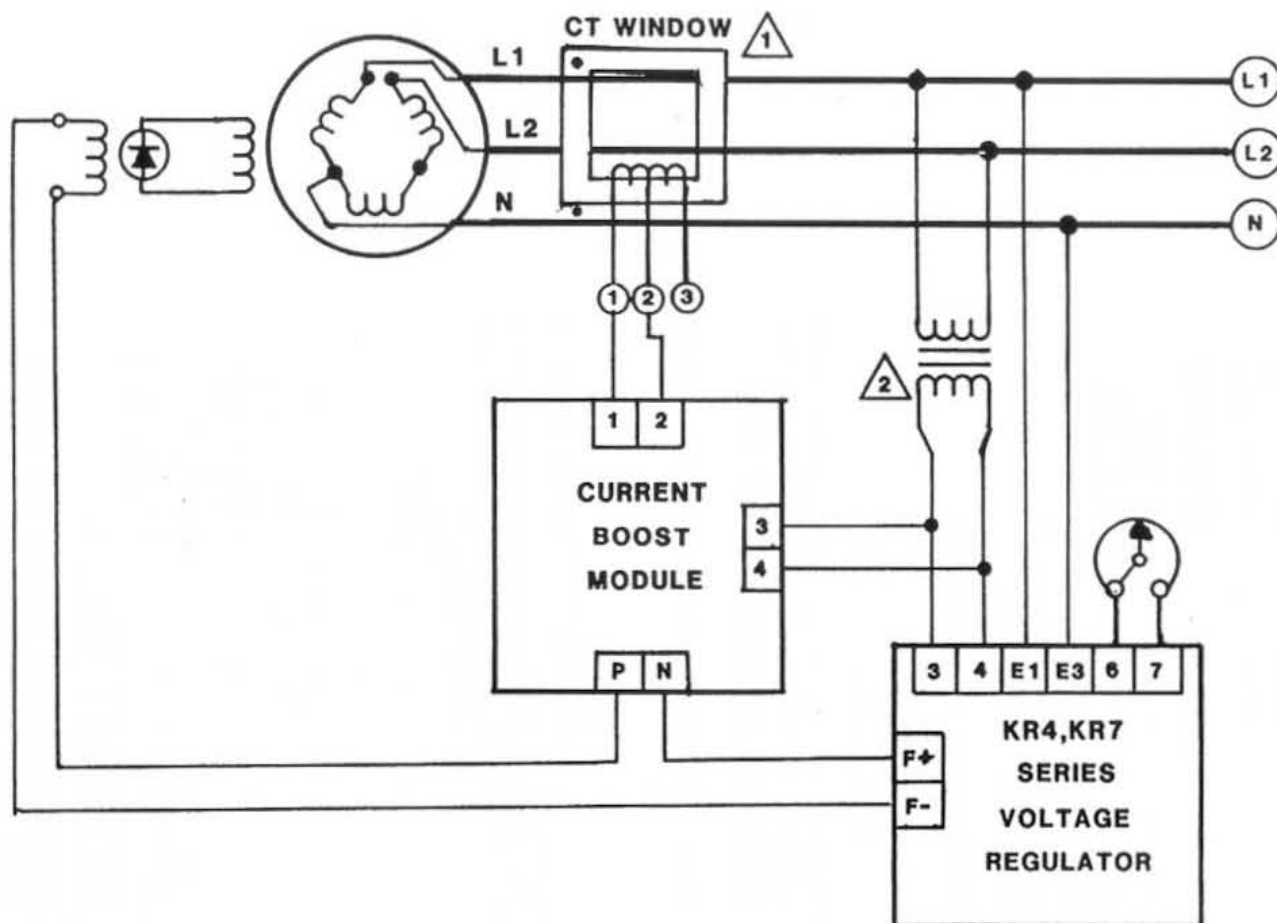


Figure 4-4. Interconnection Diagram - Dual CTs

Figure 4-5. Interconnection Diagram - Zig-Zag Connected Generator.



NOTES:

- 1 EACH GENERATOR CABLE (PRIMARY COIL) SHOULD ENTER AT OPPOSITE SIDE OF CT WINDOW. BOTH PRIMARY COILS SHOULD HAVE EQUAL TURNS. REFER TO SECTION 4 FOR SELECTION OF CT TURNS-RATIO.
- 2 POWER ISOLATION TRANSFORMER IS REQUIRED IF APPROPRIATE INPUT POWER IS NOT AVAILABLE AT GENERATOR TERMINALS.

(Step 4) From table 4-1, the intersection of the two lines from step 3B is the turns-ratio, 1:490:

1 turn on primary (done by installer)

490 turns on secondary (terminals 1 and 3, Figure 4-2)

(Step 5) The first numeral of the turns-ratio (1), the number of conductors per phase (2) and the number of phases (2) multiplied together, results in: 4 conductors (through the CT window). From generator manufacturer data, 0.7 in. is the conductor diameter; therefore, for 4 conductors the CT window must be at least 0.7 in. X 2.8 in. Basler CT P/N BE 15486-001 (Figure 4-2A) is 0.9 in. X 4.5 in. and meets the requirement.

SECTION 5

OPERATIONAL TEST

5.1 GENERAL

CAUTION

MEGGERs AND HIGH POTENTIAL TEST EQUIPMENT MUST NOT BE USED. INCORRECT USE OF SUCH EQUIPMENT COULD DAMAGE THE SEMICONDUCTORS CONTAINED IN THE UNIT.

The procedures in this section are suggested for verifying proper installation, for adjusting and testing the operation point of the current Boost System, and for verifying boost current power.

The following procedures are performed with the unit installed in the generator system per section 4.0.

5.2 INSTALLATION VERIFICATION

5.2.1 Preliminary

- a. Ensure the prime mover is off.
- b. Ensure Current Boost System CBS 344 or CBS 377 is connected per Section 4.0.
- c. Install a 10A ammeter in the line leading to terminal 1 of the current boost module.
- d. Set the OPERATION POINT adjustment CCW.

5.2.2 Test

- a. With the generator at no-load, start the prime mover and bring up to rated speed.

RESULT: The CBS 344 or 377 OPERATION POINT indicator is illuminated.

- b. Apply a load to the generator.

c. The measured input current (I_M) on the current boost module terminal 1 ammeter should be approximately equal to the calculated value of current at terminal 1 (I_C), which is based on a known value for generator line current and on the CT turns-ratio from table 4-1, as follows:

$$I_M = I_C$$

where, I_M = the measured input current at terminal 1
 I_{C*} = the calculated input current at terminal 1
 $* I_C = I_L \times 1.73 \times P:S$

where, I_L = generator line current
 $P:S$ = (primary:secondary) CT turns-ratio selected from table 1-2.

If $I_M = I_C$, check CT polarity, recheck generator data used for CT turns ratio selection, and check interconnection wiring.

5.3 TEST PROCEDURES

5.3.1 Preliminary

- a. Ensure the prime mover is off.
- b. Ensure Current Boost System CBS 344 or CBS 377 is connected per Section 4.0.
- c. Set the OPERATION POINT adjustment CCW.

5.3.2 Test

- a. With the generator at no-load, start the prime mover and bring up to rated speed.

RESULT: The CBS 344 or 377 OPERATION POINT indicator is illuminated.

- b. Reduce the generator voltage to the desired operation point for current boost.

NOTE

Setting the OPERATION POINT adjustment too close to the nominal generator output voltage may cause oscillation of the output voltage. If this occurs, rotate the adjustment CCW until the oscillation stops.

- c. To establish the pickup point for current boost operation, adjust the OPERATION POINT adjustment CW until the OPERATION POINT indicator extinguishes.

RESULT: Current boost operation occurs.

d. Return the generator voltage to nominal.

RESULT: The OPERATION POINT indicator illuminates and current boost ceases at a dropout point 5V (CBS-344) or 10V (CBS-377) above the pickup point.

NOTE

The CBS 344 or CBS 377 is now set to provide current boost at the selected operation point.

5.4 POWER VERIFICATION

To verify that the Current Boost System will provide the specified boost current during shorting of the generator output, refer to the generator manufacturer's recommended procedures for generator testing under short circuit conditions.

SECTION 6

REPLACEMENT PARTS

6.1 GENERAL

The following list describes the components that have maintenance significance. When ordering parts from Basler Electric, always specify the description of the item, part number and quantity.

Table 5-1. Replacement Parts

Reference Designation	Basler Part Number	Description
C1	04870	Capacitor
C2	10908	Capacitor
CR1, CR2	02677	Diode
CR3, CR4	06721	Diode
CR13	08590	LED
R13	11438	Resistor
SCR1, SCR2	06899	SCR
	9 1096 02 100*	Circuit Board Assembly
	9 1096 02 101**	Circuit Board Assembly
	BE 15486-001	Current Transformer
	BE 16866-001	Current Transformer

* Used with CBS 377

** Used with CBS 344