



- Accurate, independent controls require no additional instrumentation for field setting.
- Various ΔV and ΔF limits available.
- Breaker closing times are field programmable.
- Operator Window and Anti-Motoring features available.
- 50 Hz operation available.

INPUTS

Gen/Line voltage, nominal 120 V ac, 145 V ac maximum continuous. Will withstand 200 V ac for 1 sec.

Bus voltage, nominal 120 V ac, 145 V ac maximum continuous. Will withstand 200 V ac for 1 sec.

Supply voltage, minimum 100 V ac, maximum 140 V ac.

Enable Auto-Sync close.

Breaker closing time; field programmable from 20 to 800 ms.

NOTE: Gen/Line, Bus and Supply voltages are transformer-isolated to allow complete freedom in applications.

BURDEN

Gen/Line or Bus: 0.5 VA maximum at 120 V ac.

Supply: 7 VA maximum at 120 V ac.

CONTROLS

UPPER VOLTAGE LIMIT (either input): 110 to 140 V ac, accuracy ±1-1/2% of full scale.

LOWER VOLTAGE LIMIT (either input): 90 to 120 V ac, accuracy $\pm 1-1/2\%$ of full scale.

 ΔV LIMIT (Maximum Voltage Difference Limit): 1 to 5 V ac, accuracy $\pm 5\%$ of full scale. Multiples of this range are available. A ΔV LIMIT of 4 to 20 V ac or lower must be specified if the M-0193B is to be used in conjunction with the M-0194 Generator Control Unit.

 Δ **F LIMIT** (Maximum Frequency Difference Limit): 0.05 to 0.5 Hz, accuracy $\pm 3\%$ of full scale. An additional range of 0.005 to 0.05 Hz is available.

LED INDICATORS

These LEDs are lit when conditions are met to close the breaker: BUS UPPER VOLTAGE LIMIT OK.
GEN/LINE UPPER VOLTAGE LIMIT OK.
BUS LOWER VOLTAGE LIMIT OK.
GEN/LINE LOWER VOLTAGE LIMIT OK.
ΔV LIMIT OK.
ΔF LIMIT OK.
M-0193B READY.

BREAKER CLOSE RELAYS

Dry output contacts rated to make and carry 20 A up to 250 V dc, interrupt 0.9 A, 120 V dc inductive load; 0.4 A, 250 V dc inductive load. Open contacts or contacts to ground will withstand 1500 V ac for one minute.

STATUS CONTACTS

Relay contacts; closed indicates ΔF conditions OK.

Relay contacts; closed indicates ΔV conditions OK.

These are light duty contacts intended primarily for status interrogation by supervisory control. They can be used to light local lights with the following maximum restrictions:

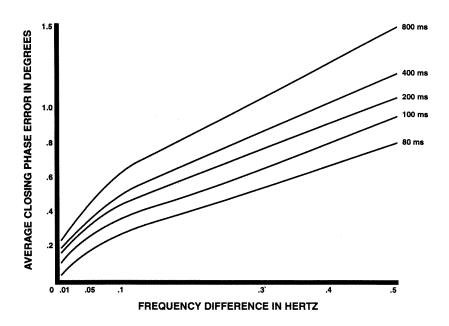
1/2 A at 125 V dc resistive, 1 A 120 V ac, 250 V dc across open contacts.

MINIMUM FREQUENCY DIFFERENCE

The guaranteed Zminimum frequency difference for operation is 0.0005 Hz; however, typical units consistently operate with frequency differences of 0.0001 Hz.

ZERO PHASE PREDICTION

The figure below illustrates the average closing phase error as a function of frequency difference for 80 ms, 100 ms, 200 ms, 400 ms and 800 ms breaker closing times. This data was taken under lab conditions with a constant frequency difference.



ANTI-MOTORING

The Anti-Motoring feature prevents closing of the breaker when the generator frequency is slower than the line frequency, thus preventing motoring power from flowing into the generator.

OPERATOR WINDOW OPTION

The Operator Window Option allows an operator to work in conjunction with the M-0193B. The operator's contact must be closed within a variable time and phase angle "window," otherwise the M-0193B will block closing of the breaker. The unit will then automatically reset for the next attempt to close.

ANTI-PUMP OPTION

The breaker close contacts will close for approximately 0.5 sec. Power must be removed for approximately 10 sec. before another closure is possible, regardless of other inputs. A front panel LED (M-0193B READY) indicates that the M-0193B is active and ready to operate, provided input conditions meet their respective limits. The M-0193B can be ordered without the Anti-Pump Option. In this case, the M-0193B will close once on each slip cycle when all input conditions are within their limits and the unit is enabled.

GENERATOR CONTROL UNIT COMPATIBILITY OPTION

This option must be ordered if the M-0193B is to be used in conjunction with the M-0194 Generator Control Unit. Please refer to the M-0193B Application Guide for further information.

50 HZ OPTION

This option allows the M-0193B to operate with Gen/Line and Bus frequency at nominal 50 Hz.

MOUNTING OPTIONS

Horizontal mounting is standard; vertical mounting or vertical General Electric GES21A Retrofit Panel mounting are available as options.

SYNCROCLOSER® UNIT COVER KIT

The M-0193B Syncrocloser Unit includes a transparent cover with associated mounting bracket to cover the dials and prevent accidental resetting.

RELIABILITY

The M-0193B Syncrocloser Unit is assembled on a single glass-epoxy printed circuit board, thereby eliminating the need for plug-in connectors. All semiconductor components are hermetically sealed and are of the highest and most reliable quality available. Highly stable, instrument grade capacitors and resistors are used in critical measurement circuits to minimize the possibility of error.

The output relay is picked up for approximately 0.5 sec. by a capacitor which also forms the time delay. No seal-in is required, because once the capacitor discharge into the relay is started, it cannot be stopped by input conditions.

TRANSIENT PROTECTION

Input and output circuits are protected against system transients. The M-0193B will pass all requirements of ANSI/IEEE C37.90.1-1989, which defines oscillatory and fast transient surge withstand capability. All inputs and outputs will withstand 1500 V ac to chassis or instrument ground for one minute. Voltage inputs are electrically isolated from each other, from other circuits, and from ground.

ENVIRONMENTAL

Temperature Range: Stated accuracies are maintained from -40° to +80° C.

Humidity: Stated accuracies are maintained under 95% relative humidity (non-condensing).

Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

PHYSICAL

Size: 19" wide x 3-1/2" high x 13" deep (48.26 cm x 8.89 cm x 33.02 cm). Horizontal mounting requires two rack units space in a standard 19" rack.

Approximate Weight: 15 lb (6.8 kg).

Approximate Shipping Weight: 20 lb (9.1 kg).

PATENT

U.S. Patent 3,491,248.

WARRANTY

The M-0193B Syncrocloser Unit is covered by a two year warranty from date of shipment.



BECKWITH ELECTRIC CO., INC.

Printed in U.S.A.

WARNING

DANGEROUS VOLTAGES, capable of causing death or serious injury, are present on the external terminals and inside the equipment. Use extreme caution and follow all safety rules when handling, testing or adjusting the equipment. However, these internal voltage levels are no greater than the voltages applied to the external terminals.

DANGER! HIGH VOLTAGE



This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

PERSONNEL SAFETY PRECAUTIONS

The following general rules and other specific warnings throughout the manual must be followed during application, test or repair of this equipment. Failure to do so will violate standards for safety in the design, manufacture, and intended use of the product. Qualified personnel should be the only ones who operate and maintain this equipment. Beckwith Electric Co., Inc. assumes no liability for the customer's failure to comply with these requirements.



 This sign means that you should refer to the corresponding section of the operation manual for important information before proceeding.



Always Ground the Equipment

To avoid possible shock hazard, the chassis must be connected to an electrical ground. When servicing equipment in a test area, the Protective Earth Terminal must be attached to a separate ground securely by use of a tool, since it is not grounded by external connectors.

Do NOT operate in an explosive environment

Do not operate this equipment in the presence of flammable or explosive gases or fumes. To do so would risk a possible fire or explosion.

Keep away from live circuits

Operating personnel must not remove the cover or expose the printed circuit board while power is applied. In no case may components be replaced with power applied. In some instances, dangerous voltages may exist even when power is disconnected. To avoid electrical shock, always disconnect power and discharge circuits before working on the unit.

Exercise care during installation, operation, & maintenance procedures

The equipment described in this manual contains voltages high enough to cause serious injury or death. Only qualified personnel should install, operate, test, and maintain this equipment. Be sure that all personnel safety procedures are carefully followed. Exercise due care when operating or servicing alone.

Do not modify equipment

Do not perform any unauthorized modifications on this instrument. Return of the unit to a Beckwith Electric repair facility is preferred. If authorized modifications are to be attempted, be sure to follow replacement procedures carefully to assure that safety features are maintained.

PRODUCT CAUTIONS

Before attempting any test, calibration, or maintenance procedure, personnel must be completely familiar with the particular circuitry of this unit, and have an adequate understanding of field effect devices. If a component is found to be defective, always follow replacement procedures carefully to that assure safety features are maintained. Always replace components with those of equal or better quality as shown in the Parts List of the Instruction Book.

Avoid static charge

This unit contains MOS circuitry, which can be damaged by improper test or rework procedures. Care should be taken to avoid static charge on work surfaces and service personnel.

Use caution when measuring resistances

Any attempt to measure resistances between points on the printed circuit board, unless otherwise noted in the Instruction Book, is likely to cause damage to the unit.

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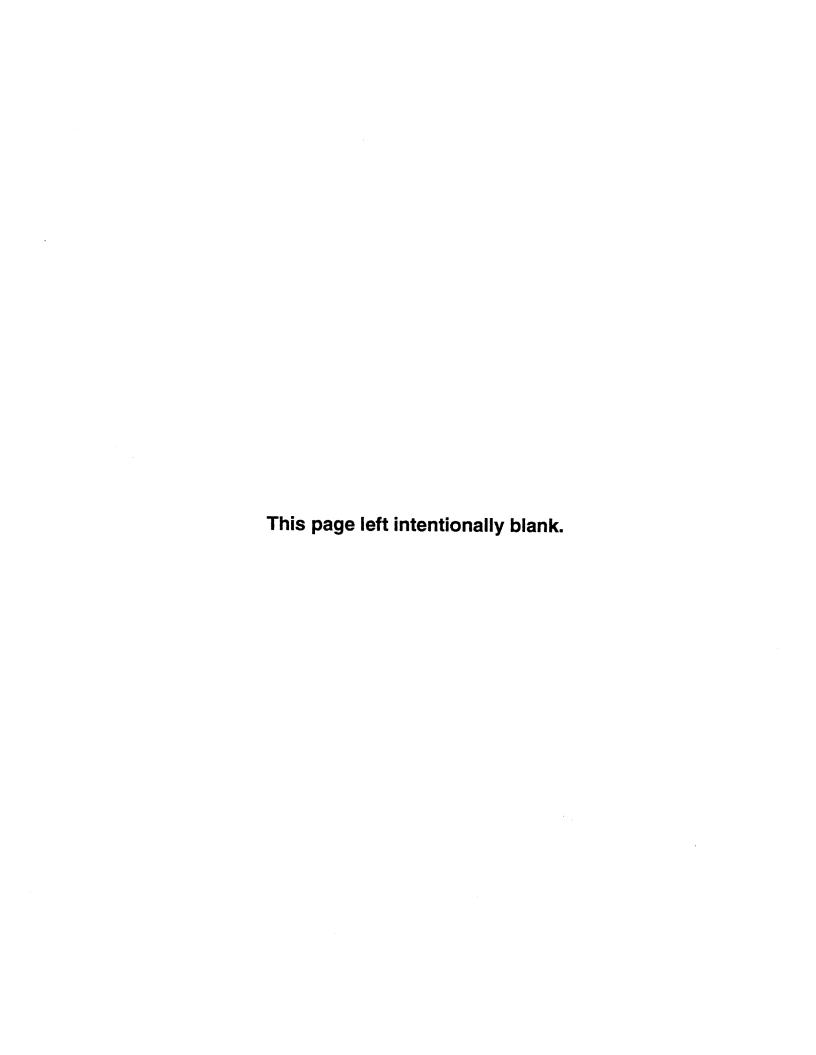
M-0193B SYNCROCLOSER® UNIT Instruction Book

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Patent, Warranty & Indemnification

In our efforts to provide accurate and informative technical literature, suggestions to improve the clarity or to correct errors will receive immediate attention. Please contact the Marketing Services Department, specifying the publication and page number.

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INTRODUCTION

Please refer to the M-0193B Application Guide in conjunction with this Instruction Book since the information contained in one is not always repeated in the other.

The Beckwith M-0193B uses advanced state of the art semiconductors and circuits to achieve an overall stability and resolution unattainable with current electromechanical automatic synchronizers. Modern hybrid and monolithic semiconductors using ion implantation and laser trimming are incorporated throughout the Syncrocloser[®] Line to gain temperature stability without critical compensation or trimming.

All components except the power transformer are mounted on a single double-sided circuit board for reliability and ease of servicing.

This instruction book is prepared for use with the M-0193B Syncrocloser Unit which may be configured for 60 Hz or 50 Hz systems. Where instructions differ because of the operating frequency, a value will be shown as applies to 60 Hz operation, followed immediately, in brackets, by the appropriate 50 Hz value.

THEORY OF OPERATION

Refer to Figure 1 Block Diagram.

Each input (Gen/Line, Bus) is passed through a transformer and scaled down from 120 V ac to 6 V ac. The scaled down voltage is converted into a dc voltage by the ac to dc converter. This converter is an active full-wave rectifier and filter which eliminates the usual highly temperature-dependent diode drop of conventional full-wave rectifiers. Full-wave rectification was chosen over half-wave rectification because the filter time response is much faster for a given ripple voltage. This is due to the fact that full-wave rectification contains no fundamental frequency components, only harmonics.

Upper and lower voltage comparators compare the output of each ac to dc converter to a portion of a highly stable hybrid 10 V reference. LEDs located on the front panel indicate the condition of each input (Gen/Line, Bus) with reference to upper and lower voltage limits.

A special circuit developed by Beckwith Electric provides a voltage which is directly proportional to the absolute value of the difference between two or more voltages. This circuit, the absolute value difference amplifier, is used to precisely evaluate the difference voltage ΔV between the two inputs. A comparator compares this difference voltage to a portion of the highly stable 10 V reference. Again, a front panel LED indicates the status of ΔV .

Two zero-crossing detectors generate rectangular waveforms at zero-crossings of each input. The AND-gate provides a pulse width proportional to the phase angle between each input. A seven-pole active filter provides the required averaging without the excessive time delay of conventional RC filters. Phase angle voltage \varnothing varies from 0 to 10.0 V for a 0 to 180° phase change, and back to 0 V for an additional 180° phase change. The phase angle voltage slope $d\varnothing/dt$ is directly proportional to the difference frequency ΔF . This derivative is bipolar, depending upon the direction of phase change. By taking the absolute value of $d\varnothing/dt$, continuous monitoring of ΔF is achieved without the usual "dead band". Absolute value and time derivative $d\varnothing/dt$ are functions of the absolute value amplifier and the precision derivative amplifier. This is followed by a comparator with a front panel LED indicator, which indicates in or out of band conditions.

Breaker closing time is generated by selecting one of a series of programmable times, ranging from 20 to 200 ms. The times are a function of the breaker closing time network. A multiplier, which is programmable from X1 to X4, allows a full range of times to 800 ms. The operation of breaker closing time is accomplished by dividing and scaling the magnitude of $d\emptyset/dt$ and comparing this to \emptyset . When the comparator of \emptyset and $|d\emptyset/dt|$ senses that they are equal, a breaker-close pulse is provided. The comparator is arranged to provide a pulse only when \emptyset is approaching zero degrees, which eliminates the possibility of closing "going away from zero". The following explanation may provide more insight into the breaker closing time operation.

Assume $d^2 \emptyset / dt^2 = 0$, or the difference in frequency between the two inputs, is constant:

$$d^2 \mathcal{O}/dt^2 = 0 \tag{1}$$

Integrating equation (1):

$$d\emptyset/dt = C (2)$$

Integrating equation (2) to obtain \emptyset :

$$\emptyset = Ct + D \tag{3}$$

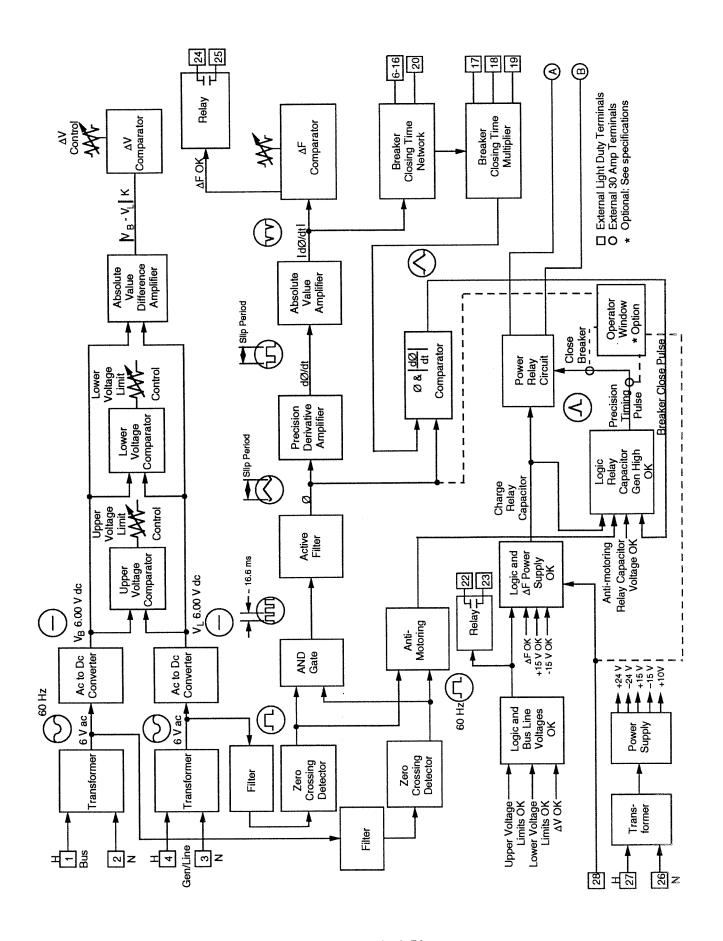


FIGURE 1 Block Diagram

Introduce B, which is a function of the breaker closing time selection; B scales the output of dØ/dt:

$$B(d\emptyset/dt) = BC (4)$$

Equating (3) and (4), the function of the \emptyset , $d\emptyset/dt$ comparator:

$$Ct + D = BC (5)$$

Solving equation (5) for t:

$$t = B - D/C \tag{6}$$

Applying boundary conditions to equation (6); let B = 0 which is the breaker closing time selection:

$$t = 0 - D/C \tag{7}$$

Since equation (7) must apply for all t, let t = 0:

$$0 = 0 - D/C \tag{8}$$

Since C cannot equal infinity, then D must equal 0:

$$t = B \tag{9}$$

Since B is a constant independent of \emptyset and $d\emptyset/dt$; then t, which is the breaker closing time, is only a function of B, the breaker closing time selection.

All circuit parameters are continuously monitored by the logic circuits. This includes the power supply voltages, all input voltages and frequency conditions, and power relay charging capacitor voltage. The output power relay can only be closed when sufficient charge is available in the capacitor. Charge is allowed to "flow in" when all input voltages and frequency conditions are met. This scheme virtually eliminates any possibility of false closing under any conditions.

Power is provided by the power supply which supplies ± 24 V dc, ± 15 V dc, and the precision 10 V reference used for comparison. The supply is designed to operate between 100 and 140 V ac input.

RECOMMENDED WIRING TO BREAKER CLOSING TIME AND MULTIPLIER CONNECTIONS (TB1-7 TO TB1-19)

When making the connections to the M-0193B for Breaker Closing Time selection, connect wires only to the terminals required. When only one breaker speed is needed, place short jumper(s) directly onto the M-0193B terminal block from TB1-20 to TB1-(7-16) and TB1-5 to TB1-(17, 18, 19), if required. Avoid using long wires to external disconnect devices. When more than one breaker time is needed, mount small auxiliary relays adjacent to the M-0193B to make the necessary selections. See Figure 3 for typical wiring. Do not connect wires to the unused terminals. The auxiliary relay(s) can then be energized by control wiring from the appropriate breaker select switches.

The auxiliary relays, used to program the breaker closing time, should have gold-plated, dry circuit contacts. The use of high voltage/high current contacts in this circuit may cause intermittent operation. The wiring between the M-0193B terminal block and these auxiliary relay contacts should be kept as short as possible (less than 2 feet). Twisted/shielded wire is recommended.

MAINTENANCE

Due to the extremely sophisticated nature of the circuitry in the M-0193B circuitry, field repair is not recommended. All units are fully calibrated at the factory prior to shipment; there is no need to re-calibrate a unit prior to initial installation. Calibration is only required after a component is replaced. In the event that a unit does not operate properly, it should be established that the problem is caused by malfunction of a Beckwith Electric unit and not caused by an external fault or wiring error. Once this is assured, the entire unit should be returned to Beckwith Electric. Pack the unit carefully (in the original carton if possible), assuring that there is adequate packing material to protect the contents.

■ NOTE: Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the user. The warranty is void if the value of the unit is invoiced to Beckwith Electric at the time of return or if the unit is returned with transportation charges collect.

If under warranty, units will be repaired rapidly and returned at no cost and with return transportation paid if the fault is found to be due to workmanship or failure of material. If a unit is under warranty and express shipment for return of the repaired unit is requested, shipping charges will be billed at the current rate. If the fault is due to abuse or misuse, or if the unit is out of warranty, a modest charge will be made. Repair can normally be expected to take two weeks, plus shipping time. If faster service is required, it should be requested at the time of return.

■ NOTE: Units returned with only a blown fuse are not covered by warranty and a nominal repair charge will be made for replacement of the fuse. Please check the fuses before returning the M-0193B for repair in order to avoid unnecessary repair charges.

To help in analyzing the problem, a complete description of the malfunction and conditions leading to the failure should be included with the unit.

However, if you choose to repair the unit, it is necessary to be completely familiar with the circuitry involved, and have an adequate understanding of field effect devices. Be sure to carefully read the **WARNING** page at the beginning of this manual.

▲ CAUTION: This unit contains sensitive MOS circuitry that can be damaged by improper repair procedures. Work stations used for repair should be static-free and procedures for handling MOS circuitry should be followed. In addition, any attempt to measure resistances between points on the printed circuit board may cause damage to the unit.

It is suggested that first a visual inspection be made for any component that does not appear normal or appears to have overheated. Analysis of the circuit will then often lead to the cause of the failure and components that need to be replaced.

If no obvious problems exist, it is suggested that the **TEST PROCEDURE** and **CALIBRATION PROCEDURE** be followed until a portion of a circuit is detected which does not perform as expected or until a calibration point is found which will not meet requirements. These procedures should lead to a determination of the defective component.

TEST SOURCES

Two highly stable test sources must be used to test the M-0193B. The power system is suitable as one input for a "general" test but is not sufficiently stable in phase or frequency to determine the accuracy limits of the M-0193B.

To properly test the M-0193B, each input must have a short-term frequency stability of ± 0.001 Hz and phase jitter at no more than 0.1° peak to peak.

EQUIPMENT REQUIRED

(2) Distortion free 60 [50] Hz variable voltage sources, as follows:

A variable frequency source nominal 60 [50] Hz capable of providing 120 V ac. Maximum phase jitter of 0.1°.

A fixed frequency source of 60 [50] Hz capable of providing 120 V ac. Maximum phase jitter of 0.1°.

- (2) Digital multimeters with ac and dc accuracy of 0.05% of full scale ± 1 least significant digit; Hewlett-Packard 3465A or equivalent.
- (1) Solder sucking syringe or solder wick.
- (1) Soldering iron Weller Controlled Output Soldering Station, model MTCPL, 60 W, 120 V, 50/60 Hz or equivalent.

COMPONENT REPLACEMENT PROCEDURE

- To gain access to the circuit board, remove the top and bottom covers of the unit. Components can now be
 easily tested or changed. Analysis of the circuit will then often lead to the cause of the failure and
 components to be replaced.
- 2. If a component needs to be changed, carefully scrape away the coating surrounding the component using a small sharp knife, being careful not to damage the printed circuit path.
- 3. Clip out the old component and discard.
- Remove the clipped wires using the solder wick or syringe. Be sure to leave the holes clear to facilitate insertion of the new component.
 - ▲ CAUTION: Do not attempt to melt the solder and push the new component through the hole as the leads are likely to catch the edge of the foil and lift it off the board.
- 5. When replacing integrated circuits, be sure to insert the unit into the transipad so that the tab fits into the slot. Once this is done, there is only one way to insert the combination into the printed circuit board.

TEST PROCEDURE

Refer to Figure 2 External Connections.

UPPER VOLTAGE LIMIT

- 1. Adjust Gen/Line and Bus voltages to 125.0 V ac.
- Slowly rotate the UPPER VOLTAGE LIMIT control clockwise toward 125 V reading.
- BUS and GENLINE LEDs should light as control passes 125 V.

LOWER VOLTAGE LIMIT

- 1. Adjust Gen/Line and Bus voltages to 105.0 V ac.
- 2. Slowly rotate LOWER VOLTAGE LIMIT control counter-clockwise toward 105 V reading.
- BUS and GEN/LINE LEDs should light as control passes 105 V.

AV LIMIT

- 1. Adjust Gen/Line and Bus voltages to provide ΔV midscale difference in voltage with a median value of 120 V ac.
- 2. Rotate the ΔV LIMIT control clockwise toward the midscale value.
- 3. The ΔV OK LED should light as control passes the midscale value.

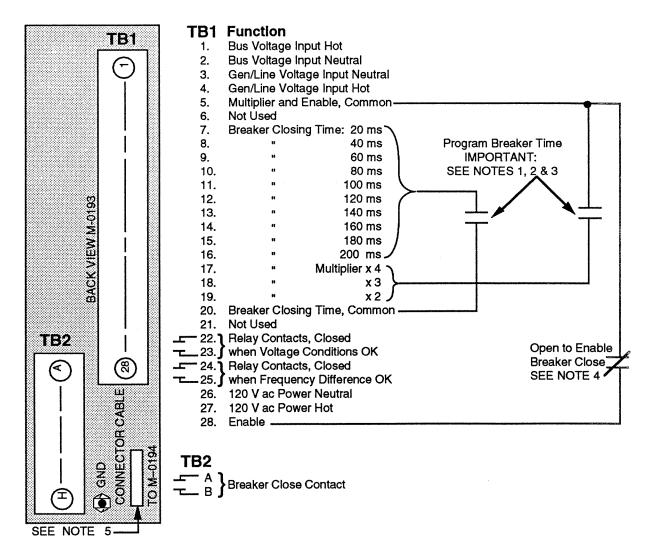
Example: With a ΔV full scale range of 10 V, midscale value would be 5 V. Adjust Gen/Line voltage to 117.5 V ac and Bus voltage to 122.5 V ac. Slowly rotate the ΔV LIMIT control clockwise toward midscale value of 5 V. The ΔV OK LED should light as 5 V is passed.

△F LIMIT FOR 0.005 TO 0.05 HZ RANGE

- Adjust Bus frequency to 60 [50] Hz.
- 2. Adjust Gen/Line frequency to 60.040 [50.040] Hz.
- Slowly adjust ΔF LIMIT control clockwise; ΔF OK LED should light as control passes 0.040 Hz.

AF LIMIT FOR 0.05 TO 0.5 HZ RANGE

Repeat above steps 2 and 3 with Gen/Line frequency set at 60.400 [50.400] Hz; Δ F **OK** LED should light as control passes 0.40 Hz.

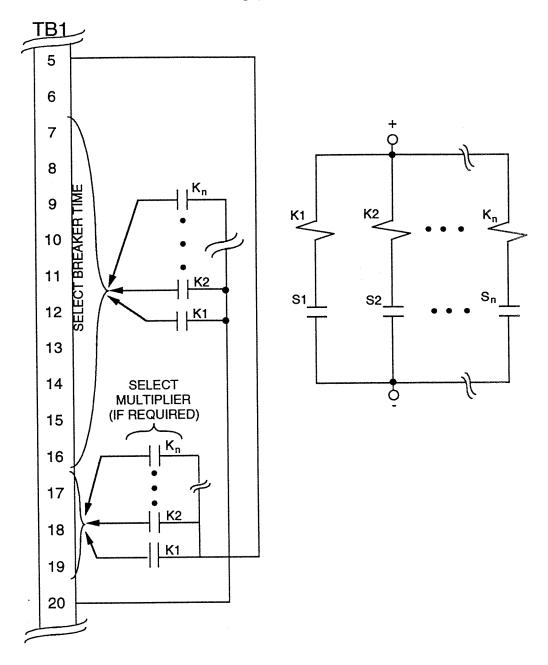


NOTES:

- When making connections to the rear of the unit to program the breaker closing time, 20 ms must be added
 to the actual breaker closing time. This additional time is the average pickup time of the M-0193B output
 relay. For example, if the average closing time for the circuit breaker is 100 ms, the M-0193B should be
 programmed for 120 ms. If only one breaker closing time would ever be required, a permanent jumper
 should be added here. DO NOT MAKE CONNECTIONS TO UNUSED BREAKER CLOSING TIME
 TERMINALS.
- 2. Use multiplier only for breaker times greater than 200 ms.
- 3. The contacts used to program the breaker closing time should be gold-plated, dry circuit contacts. The use of high voltage, high current contacts in this circuit may cause intermittent operation. The wiring between the M-0193B terminal block and these contacts should be kept as short as possible (less than 2 feet) and twisted/shielded wires are recommended. Refer to Figure 3 for wiring multiple breaker times. If only one breaker closing time is required, then place a short jumper on the rear of the M-0193B between the proper terminals.
- 4. Terminal 28 is used for the Operator Window Option, in which case a closed contact enables breaker close.
- 5. Refer to the M-0194 Generator Control Unit Application Guide for further details.

FIGURE 2 External Connections

Breaker Time Select Contact Wiring (Two or More Breaker Closing Times)



Where:

 $S1, S2,, S_n$ are the contacts from the breaker select control switches. Only one contact should be closed at any one time. If several breakers have identical closing times the "S" contacts can be paralleled to energize one relay.

 $K1,K2,....,K_n$ are auxiliary relays mounted close to the rear of the M-0193B. A separate relay is required for each different breaker closing time. One relay for each breaker is unnecessary, unless all breakers have different closing times. A multiplier contact is required for each breaker with a closing time greater than 200 ms.

FIGURE 3 External Connections for Multiple Breaker Time Programming

BREAKER CLOSE CIRCUIT

- Supply 120.00 V ac, 60 [50] Hz to Bus terminals TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal and TB1-2 is the NEUTRAL terminal.
- 2. Supply 120.00 V ac, 60.010 [50.010] Hz to Gen/Line terminals TB1-3 and TB1-4, noting that TB1-3 is the **NEUTRAL** terminal and TB1-4 is the **HOT** terminal.
- 3. Adjust the UPPER VOLTAGE LIMIT control fully clockwise.
- 4. Adjust the LOWER VOLTAGE LIMIT control fully counter-clockwise.
- 5. Adjust the ΔV LIMIT control and ΔF LIMIT control fully clockwise.
- 6. Monitor the phase difference between the Bus and the Gen/Line inputs with an accurate phase meter.
- 7. Place a jumper between TB1-12 and TB1-20 to program a breaker time of 120 ms. This connection is for an actual circuit breaker closing time of 100 ms. As described in Note 1 of Figure 2, this time allows for the 20 ms average closing time of the M-0193B output relay.
- 8. Apply power (120 V ac) to TB1-26 and TB1-27, noting that TB1-26 is the **NEUTRAL** terminal and TB1-27 is the **HOT** terminal.
- 9. Skip to step 13 if the Operator Window Option is not used.
- 10. If the Operator Window Option is used, locate potentiometers R148 and R160 as shown in Figure 4. Adjust R148 fully counter-clockwise for maximum time and adjust R160 fully clockwise for maximum angle.
- 11. If the Operator Window Option is used, place a normally open switch between TB1-5 and TB1-28.
- 12. The phase meter will indicate when the phase angle between the Bus and Gen/Line is approaching 0°. Close the switch when the phase meter indicates an angle of 5° before 0° is reached.
- 13. As the phase reading of the phase meter approaches 0°, the output relay will pick up.
- 14. The relay should pick up about 1° before 0° is reached.
- 15. Reset the M-0193B by removing power from TB1-26 and TB1-27 for 10 sec. and then reconnecting.
- 16. The M-0193B READY LED will light.
- 17. To repeat the above sequence if the Operator Window Option is used, go to step 12.
- 18. Readjust R148 and R160 according to the instructions in the M-0193B Application Guide.

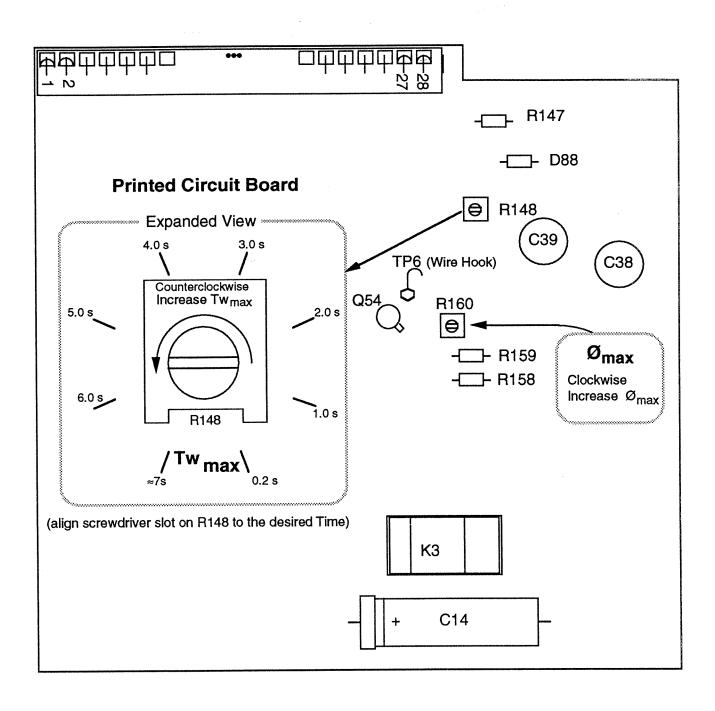


FIGURE 4 Component Location for Operator Window Adjustment

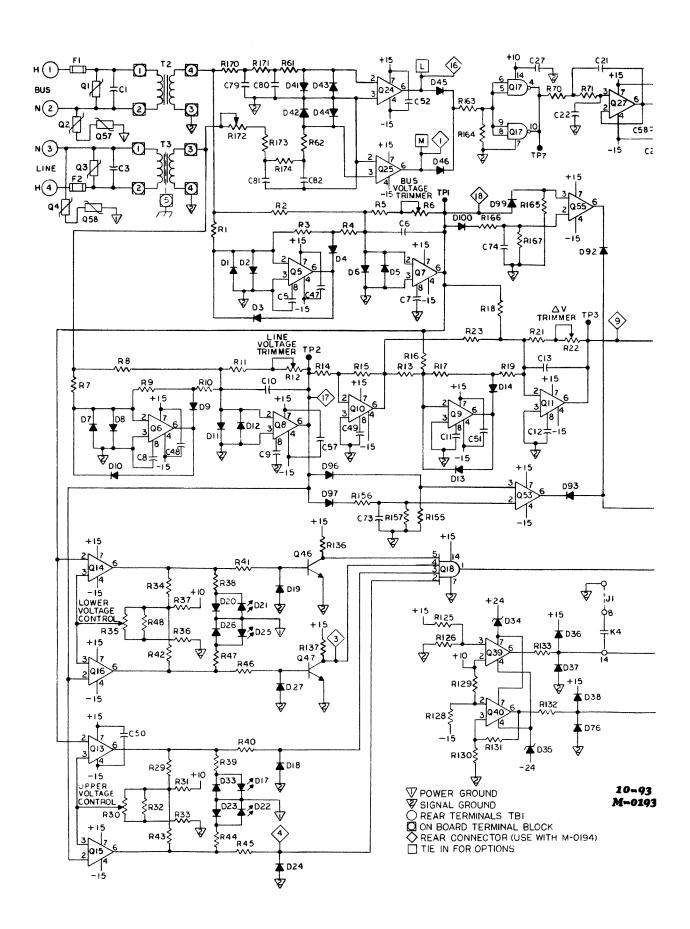
TYPICAL VOLTAGES

FROM	то	CONDITIONS	VOLTAGE
0 V	T2-4	120 V ac Input to Bus	6 V ac
0 V	T3-3	120 V ac Input to Gen/Line	6 V ac
0 V	Q5 pin 6	120 V ac Input to Bus	–2.7 V dc approx.
0 V	Q6 pin 6	120 V ac Input to Gen/Line	–2.7 V dc approx.
0 V	TP1	120 V ac Input to Bus	+6 V dc
0 V	TP2	120 V ac Input to Gen/Line	+6 V dc
0 V	Q13 pin 2	120 V ac Input to Bus	+6 V dc
0 V	Q13 pin 3	120 V ac Input to Bus	+6.23 V dc ±12.5%
0 V	Q13 pin 6	120 V ac Input to Bus	+14 V dc, -12 V dc
0 V	Q14 pin 2	120 V ac Input to Bus	+6 V dc
0 V	Q14 pin 3	120 V ac Input to Bus	+5.25 V dc ±14.3%
0 V	Q14 pin 6	120 V ac Input to Bus	+14 V dc, -12 V dc
0 V	Q15 pin 2	120 V ac Input to Gen/Line	+6 V dc
0 V	Q15 pin 3	120 V ac Input to Gen/Line	+6.23 V dc ±12.5%
0 V	Q15 pin 6	120 V ac Input to Gen/Line	+14 V dc, -12 V dc
0 V	Q16 pin 2	120 V ac Input to Gen/Line	+6 V dc
0 V	Q16 pin 3	120 V ac Input to Gen/Line	+5.25 V dc ±14.3%
0 V	Q16 pin 6	120 V ac Input to Gen/Line	+14 V dc, -12 V dc
0 V	Q53 pin 6	120 V ac Input to Gen/Line	$\pm 15 \pm 0.5 \text{ V dc}$
0 V	Q53 pin 6	0 V ac Input to Gen/Line	–12 V dc
0 V	Q55 pin 6	120 V ac Input to Bus	±15 ±0.5 V dc
0 V	Q55 pin 6	0 V ac Input to Bus	–12 V dc
0 V	Q54 pin 2	120 V ac Input to Gen/Line and Bus,	+10 V dc
	or TP4	180° out of phase	
0 V	TP6	30° Phase Angle, Operator Window	0 to +1.66 V dc
		Option, ΔF Scale 0.005 to 0.05 Hz	
0 V	TP6	180° Phase Angle, Operator Window	0 to +10 V dc
		Option, ΔF Scale 0.05 to 0.5 Hz.	
0 V	Q54 pin 6	120 V ac Input to Gen/Line and Bus	+14 V dc, -12 V dc
0 V	Q9 pin 6	120 V ac Input to Gen/Line and Bus	+0.7 V dc to -0.5 V dc
0 V	TP3	120 V ac Input to Bus +2.50 V dc	
		125 V ac Input to Gen/Line	
		ΔV Range 1–5 V x 1	
0 V	Q12 pin 6	120 V ac Input to Gen/Line and Bus	+14 V dc, -12 V dc

FROM	то	CONDITIONS	VOLTAGE
0 V	Q12 pin 3	ΔV Range 1–5 V x 1	+1.5 V dc ±67.2%
0 V	Q19 pin 1	120 V ac Input to Gen/Line and Bus	+14 V dc
0 V	Q19 pin 2	120 V ac Input to Gen/Line and Bus Upper	+15 V dc
	-	and Lower Voltage Controls Centered.	
0 V	Q18 pin 12	120 V ac, 60 Hz Input to Gen/Line and	+14 ±0.5 V dc
		Bus. ΔF Control Centered.	
0 V	Q19 pin 12	All LEDs lit on Front Panel	+12 V dc approx.
0 V	Q18 pin 13	All LEDs lit on Front Panel	+15 V dc
0 V	Q19 pin 6	120 V ac Input to Gen/Line and Bus	+15 V dc
		Gen. High Option	
0 V	Q24 pin 2	120 V ac Input to Bus	0.5 V ac
0 V	Q24 pin 6	120 V ac Input to Bus	15 V ac
0 V	Q25 pin 3	120 V ac Input to Gen/Line	0.5 V ac
0 V	Q25 pin 6	120 V ac Input to Gen/Line	15 V ac
0 V	TP7	120 V ac Input to Bus and Gen/Line	0-5 V dc*
0 V	TP8	120 V ac Input to Bus and Gen/Line	0-5 V dc*
0 V	Q17 pin 3	120 V ac Input to Bus and Gen/Line	0-10 V dc*
0 V	Q28 pin 6	120 V ac Input to Bus and Gen/Line	0–10 V dc*
0 V	Q30 pin 6	120 V ac Input to Bus and Gen/Line	±0.7 V dc
0 V	TP10	120 V ac Input to Bus and Gen/Line	+14 V dc, -12 V dc
0 V	TP5	120 V ac Input to Bus and Gen/Line	0-10 V dc
0 V	Q37 pin 3	120 V ac Input to Bus and Gen/Line	+5.5 V dc ±82%
0 V	Q37 pin 6	120 V ac Input to Bus and Gen/Line	+14 V dc, -12 V dc
0 V	Base of Q50	All LEDs Lit on Front Panel	+2.4 V dc approx.
0 V	Base of Q20	All LEDs Lit on Front Panel	+2 V dc approx.
0 V	Q39 pin 6	120 V ac Power Input	+19 V dc approx.
0 V	Q40 pin 6	120 V ac Power Input	+19 V dc approx.
T1-3	T1-5	120 V ac Power Input	40 V ac
0 V	TP4	120 V ac Input to Bus and Gen/Line	0–10 V dc*
0 V	Q34 pin 6	120 V ac Input to Bus and Gen/Line	0–10 V dc**
0 V	TP9	120 V ac Input to Bus and Gen/Line	0-10 V dc*

▲ CAUTION: Any attempt to measure resistances between points on the circuit board is likely to cause damage to the unit.

- * With Phase Angle between Bus and Gen/Line inputs varied from 0 to 180° .
- ** ΔF from minimum to maximum scale



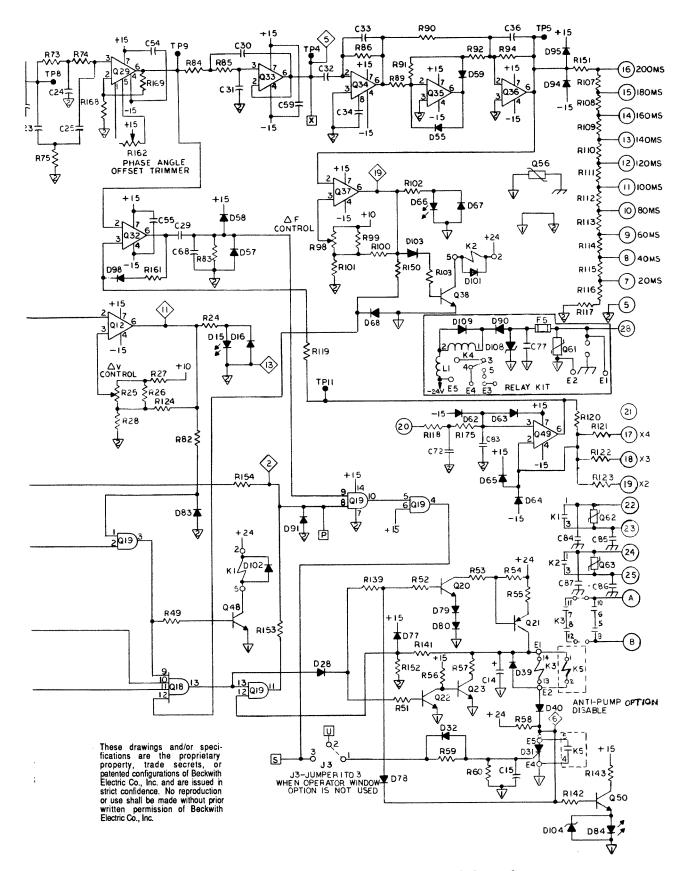


FIGURE 5 Schematic

CALIBRATION

Refer to Figure 2 External Connections, Figure 6 Component Location and Figure 7 Component Location for Calibration and Range Resistors.

■ NOTE: The M-0193B has been fully calibrated at the factory using highly sophisticated, computer-controlled test equipment. There is no need to re-calibrate the unit before initial installation. Further calibration is only necessary if a component was changed during a repair procedure. Access to the calibration points is only possible with the cover removed; therefore, after field repair do not install the units in a rack or panel before following the calibration procedure.

AC TO DC CONVERTER CALIBRATION

The ac to dc converter consists of operational amplifiers Q5, Q6, Q7 and Q8 with potentiometers R6 and R12 providing calibration for Bus and Gen/Line inputs.

- 1. Supply 120 V ac, 60 [50] Hz to Bus input terminals TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
- 2. Continuously monitor the Bus input to assure that the voltage remains steady.
- 3. Supply 120 V ac, 60 [50] Hz to power input terminals TB1-26 and TB1-27, noting that TB1-26 is the **NEUTRAL** terminal and TB1-27 is the **HOT** terminal.
- 4. Place the positive lead of the dc voltmeter on Test Point 1 (near C6).
- 5. Place the negative lead on Test Point 0 (located between Q43 and C42).
- Adjust potentiometer R6 (Bus Voltage Trimmer, near C6) to read 6 V dc.
- 7. Supply 120 V ac, 60 [50] Hz to Gen/Line input terminals TB1-3 and TB1-4, noting that TB1-3 is the **NEUTRAL** terminal and TB1-4 is the **HOT** terminal.
- Monitor the Gen/Line voltage as in step 2.
- 9. Place the positive lead of the dc voltmeter to Test Point 2 (near C10).
- 10. Adjust potentiometer R12 (Gen/Line Voltage Trimmer, near C6) to read 6 V dc.

ABSOLUTE VALUE DIFFERENCE AMPLIFIER CALIBRATOR

Components Q9, Q10 and Q11 form this circuit.

- 1. Supply voltage to Bus and Gen/Line input terminals according to the values in Table 1.
- Continuously monitor the voltages to assure that they remain steady.

- Place the positive lead of the dc voltmeter on Test Point 3 (C13 end near C35).
- 4. Place the negative lead to Test Point 0 (located between Q43 and C42).
- 5. Adjust R22 (Δ V Trimmer, near Q10) to read the voltage indicated in Table 1.

For ∆V Range	Set Bus Voltage TB1-1 (H) & TB1-2 (N)	Set Line Voltage TB1-3 (N) & TB1-4 (H)	Adjust R22 to achieve Voltmeter Reading
1–5	115.00 V ac	120.00 V ac	2.50 V dc
2–10	110.00 V ac	120.00 V ac	5.00 V dc
3–15	110.00 V ac	125.00 V ac	7.50 V dc
4–20	110,00 V ac	130.00 V ac	10.00 V dc
5–25	105.00 V ac	130.00 V ac	2.50 V dc
10–50	90.00 V ac	140.00 V ac	10.00 V dc

TABLE 1 Test Point 3 Calibration

PHASE ANGLE CALIBRATION

Components Q17, Q24, Q25, Q27, Q29 and Q33 form this circuit.

- 1. Supply 120 V ac, 60 [50] Hz to Bus terminals TB1-1 and TB1-2, noting that TB1-1 is the **HOT** terminal and TB1-2 is the **NEUTRAL** terminal.
- 2. Place a clip lead between TB1-1 and TB1-4.
- 3. Place a second clip lead between TB1-2 and TB1-3.
- 4. Attach the positive lead of the dc voltmeter to Test Point 4 (C32 end near R72).
- 5. Attach the negative lead to Test Point 0 (located between C38 and C39).
- 6. Adjust R162 (Phase Angle Offset Trimmer, near C24) until the voltmeter reads between 0 V and -0.003 V.

OPERATOR WINDOW ADJUSTMENT

Components Q51, Q52 and Q54 form this circuit. Refer to the M-0193B Application Guide, ADJUSTMENT chapter, for the adjustment procedures.

■ NOTE: This is an internal adjustment on the printed circuit board and needs to be set prior to installation since the top cover must be removed.

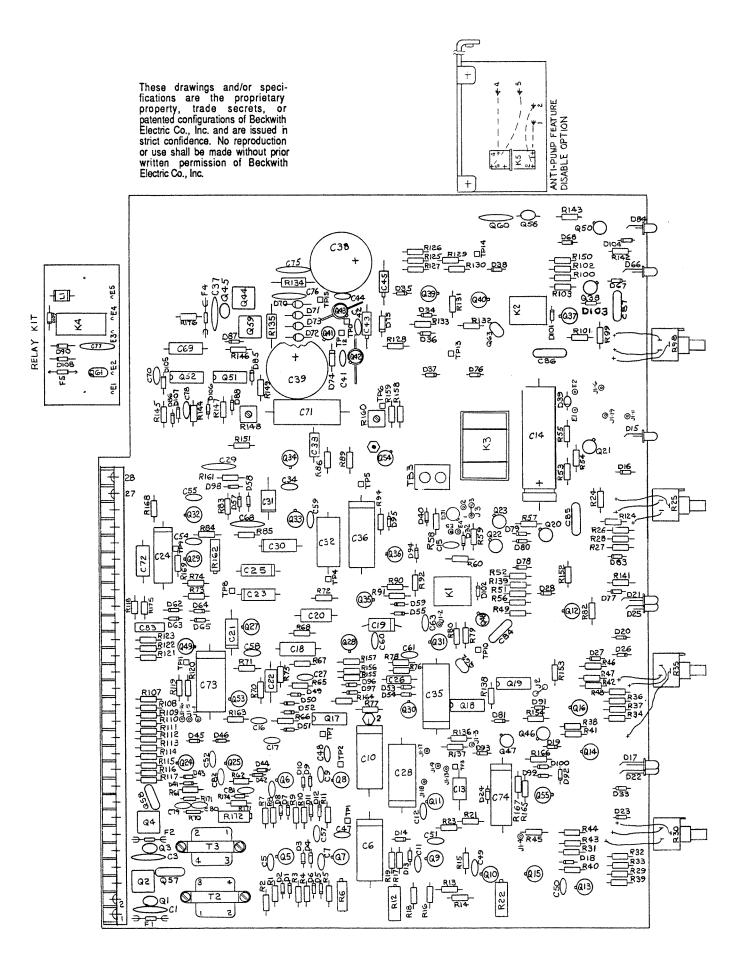


FIGURE 6 Component Location

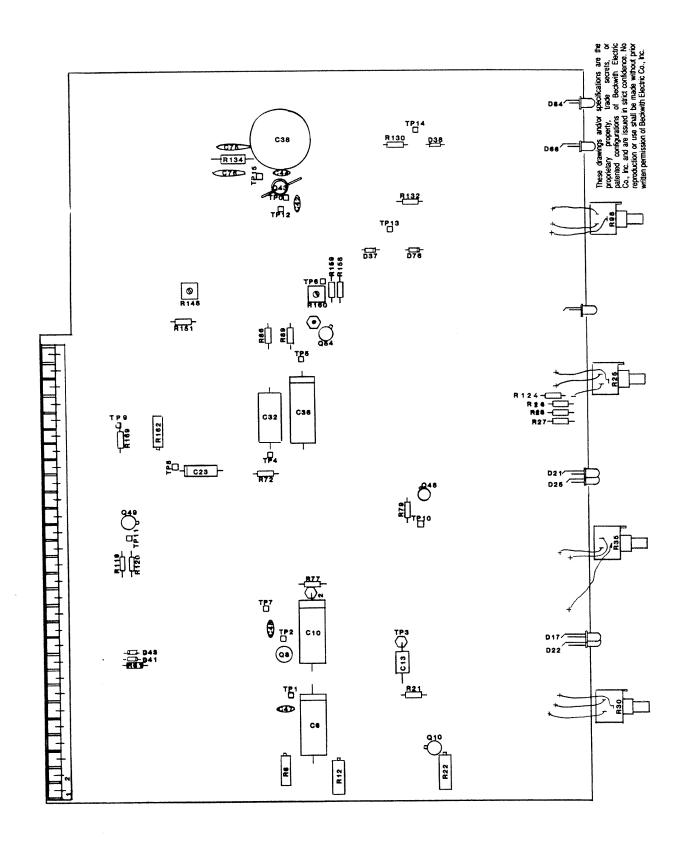


FIGURE 7 Component Location for Calibration and Range Resistors

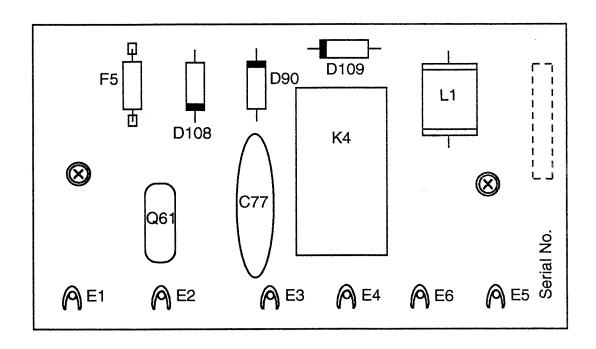


FIGURE 8 Relay Kit Component Location, B-0307

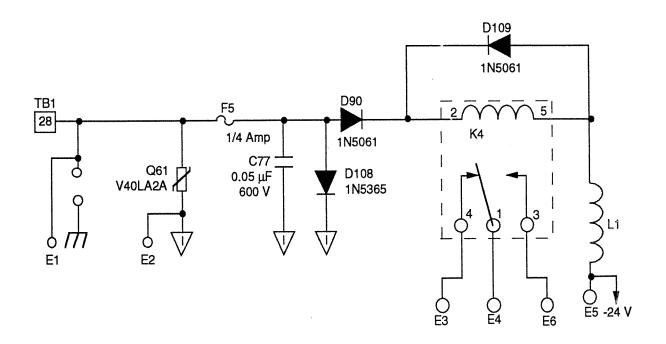
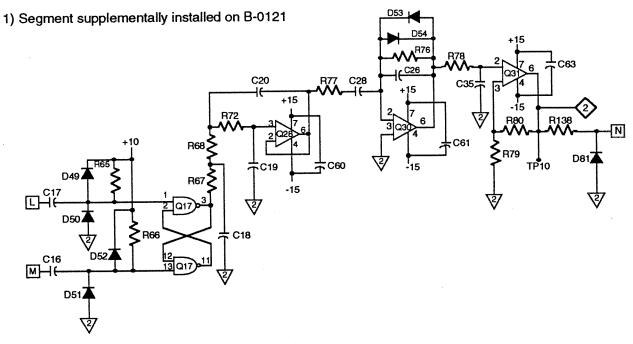


FIGURE 9 Relay Kit Schematic



2) Segment mounted on PCB B-0331 in place of Q37.

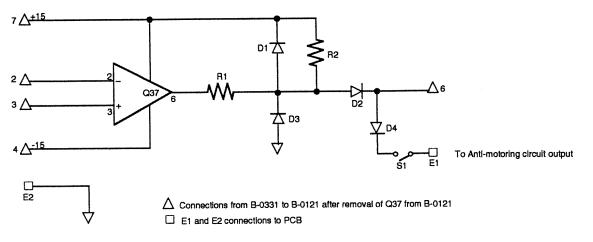


FIGURE 10 Anti-Motoring Schematic

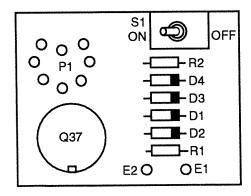


FIGURE 11 Anti-Motoring Component Location, B-0331

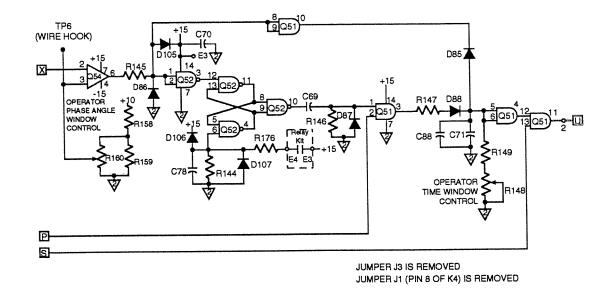


FIGURE 12 Operator Window Option Schematic

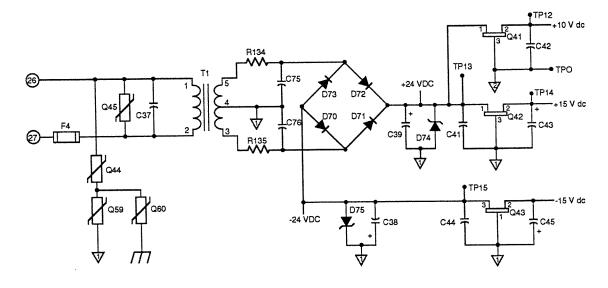


FIGURE 13 Power Supply Schematic

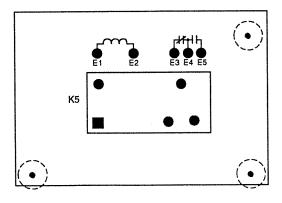


FIGURE 14 Anti-Pump Option (Disabled) Component Location, B-0258

HOW TO CHANGE RANGES

- WARNING: It is a violation of Beckwith Electric patents to add any options without written permission from Beckwith Electric. Permission is granted to make the range changes included in this section.
- 1. Follow steps 1 through 5 in the **COMPONENT REPLACEMENT PROCEDURE** section of the **MAINTE** NANCE chapter, using the equipment specified.
- 2. Referring to the tables below and to the **SELECTED RESISTORS** section of the **PARTS LIST**, choose the correct resistor value or jumper wire. Use 20 gauge insulated wire for all jumpers. Refer to Figure 7 Component Location for Calibration & Range Resistors.
- 3. Refer to the **CALIBRATION** chapter after replacing any components.

AV LIMIT

RANGE	R21	R22	R27
1–5	182 K	50 K	11 K
2–10	182 K	50 K	3.74 K
3–15	182 K	50 K	1.24 K
420	182 K	50 K	Jumper
5–25	35.7 K	10 K	11 K
6–30	24.9 K	10 K	11 K
10–50	71.5 K	20 K	Jumper

AF LIMIT

RANGE	R151	R86
0.005 to 0.05 Hz	487 K	4.99 MΩ
0.05 to 0.5 Hz	40.2 K	499 K

OPERATOR WINDOW OPTION

RANGE	R158	R159
0.005 to 0.05 Hz	15 K	3.16 K
0.05 to 0.5 Hz	Jumper	Open

DESIGN CHANGES

Beckwith Electric maintains a system whereby our customers can be aware of design changes in any of our units. Full documentation on any unit is kept on file by Model Number and Serial Number.

All units have a Model Number, consisting of a letter and four numbers. Complex changes are recorded by adding a suffix letter. The rule is that it must be possible to use any later version as a replacement for an earlier version. The opposite may not be true because of features added. If later units are <u>not</u> interchangeable with older units, a change in the Model Number is made.

Some simple changes are recorded by Serial Numbers; for example, changes in the detailed rating or manufacturer of a component where either the new or old part will perform properly.

The following describes the changes that have taken place on the M-0193 Syncrocloser® Unit.

I. M-0193

This first version did not provide the Operator Window Option.

II. M-0193A

This version included the Operator Window Option. Also, additional circuitry was added to reduce "worst case" phase angle error.

III. M-0193B

This version added a noise filter on each input, modified the Generator Control Compatibility Feature to provide an indication when the generator voltage is excessively high or low, increased the contact rating of the status relays and modified the mounting of the front panel control potentiometers.

PARTS LIST

M-0193B Syncrocloser® Unit

This list includes all electrical and mechanical parts which could conceivably either require replacement or be lost. The **COMPONENT DESIGNATION** is the same as that appearing on schematics or referred to in Instruction Books.

The **BECO NUMBER** refers to an index maintained by the company. This lists the currently available device which may be substituted even though the device originally supplied is obsolete and no longer available. Parts marked by an asterisk* are not available from other sources. Either the original component or a current substitute will be carried in stock by Beckwith Electric.

Parts not marked with an asterisk are normally available from an electronics components house. Those parts or a current substitute will normally be available from Beckwith Electric stock.

In either case, when parts are ordered from Beckwith Electric, we will be responsible for supplying the current replacement in the shortest possible time.

Sufficient detailed description is also given to permit purchasing from an electronics parts house, providing the part is of equal or better quality to insure reliable operation. This may require some interpretation of specifications which may be avoided by direct purchase from Beckwith Electric using the **BECO NUMBER**.

Note that in a few instances, components are selected in final test. Procedures described in the **TEST PROCEDURE** chapter must be followed in replacing these components.

All resistors are 1/2 W unless noted.

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
	450-00002*	Printed Circuit Board, P-0409
C1,C3,C37,C75,C76	000-00904	Capacitor, Ceramic Disc, 0.01 μF ±20%, 1 kV
C2,C4		Not Used
C5,C7-C9,C11,C12, C34,C49	000-00903	Capacitor, Ceramic Disc, 100 pF ±10%, 1 kV
C6,C10,C36,C73,C74	000-00857	Capacitor, Polyester, $10\mu\text{F}\pm10\%$, $50 ext{V}$
C13,C22,C31	010-00423	Capacitor, Polycarbonate, 0.1 μ F $\pm 10\%$, 50 V
C14	000-00410	Capacitor, Electrolytic, 1900 μF -10/+75%, 40 V
C15,C27,C41,C42,C44, C47,C48,C50-C52,C54, C55,C57-C59,C61,C63	000-00917	Capacitor, Ceramic Disc, 0.01 μF ±20%, 50 V
C16-C20,C26,C28,C35, C60		Refer to ANTI-MOTORING FEATURE

COMPONENT DESIGNATION		DESCRIPTION
C21,C30	010-00418	Capacitor, Polycarbonate, 0.47 μF ±10%, 50 V
C23,C25	010-00421	Capacitor, Polycarbonate, $0.15\mu\text{F}\pm1\%$, 50V
C24	010-00422	Capacitor, Polycarbonate, 0.3 μF ±1%, 50 V
C29,C68	000-00923	Capacitor, Ceramic Disc, 0.2 μF ±20%, 25 V
C32	010-00800	Capacitor, Polysulfone, 2 μ F $\pm 0.5\%$, 50 V
C33	010-00424	Capacitor, Polycarbonate, $0.01\mu\text{F}\pm10\%$, 50V
C38,C39	000-00637	Capacitor, Electrolytic, 3500 μF -10%/+100%, 40 V
C40,C46,C53,C56,C60 C62,C64-C67		Not Used
C43,C45	000-00543	Capacitor, Tantalum, 27 μF ±10%, 20 V
C69-C71,C78,C88		Refer to OPERATOR WINDOW OPTION
C72	010-00415	Capacitor, Polyester, 3 μ F $\pm 10\%$, 50 V
C77		Refer to RELAY KIT ASSEMBLY
C79,C81	010-00443	Capacitor, Polyester, 0.1 μ F ±5%, 63 V
C80,C82	010-00442	Capacitor, Polyester, 0.022 μ F ±5%, 100 V
C83	000-00821	Capacitor, Polyester, 0.33 μ F $\pm 10\%$, 100 V
C84-C87	000-00939	Capacitor, Ceramic Disc, 0.0047 μF ±20%, 3 kV
D1-D14,D55,D59	400-00225	Diode, FD333
D15,D17,D21,D22, D25,D66,D84	400-00722	Diode, Light Emitting, Red, Hewlett-Packard HLMP-3316
D16,D19,D20,D23,D26- D28,D32,D33,D41-D46,	400-00224	Diode, Fairchild, 1N4148
D62-D65,D67,D77-D80, D92-D103		D96 and D97 are matched pair. D99 and D100 are matched pair.
D18,D24,D36-D38,D57, D58,D68,D76,D83,D91	400-00237	Diode, Motorola, 1N5819
D29,D30		Not Used
D31	400-00723	Thyrister, 1.6 A, 100 V, 2N2324
D34	400-00038	Diode, Zener, 5.6 V ±5%, 1N752A
D35	400-00044	Diode, Zener, 12 V ±5%, 1N759A
D39,D40	400-00211	Diode, Rectifier, 50 V, G.E., 1N5061
D47,D48,D56,D60,D61, D69,D81,D82,D89		Not Used
D49-D54,D81		Refer to ANTI-MOTORING FEATURE
D70-D73	400-00213	Diode, Rectifier, 5 A, 600 V, G.E., 1N5626

COMPONENT DESIGNATION	<i></i>	DESCRIPTION
D74,D75 D85-D88,D105-D107 D90,D108,D109 D104	400-00057	Diode, Zener, 33V ±5%, 5 W, Motorola, 1N5364B Refer to OPERATOR WINDOW OPTION Refer to RELAY KIT ASSEMBLY Diode, Zener, 3.6 V ±5%, 1N747A
F1,F2,F4 F3 F5	420-00847	Fuse, 5 A, Littelfuse 275.005 Not Used Refer to RELAY KIT ASSEMBLY
K1,K2 K3 K4 K5	430-00151 430-00145	Relay, 24 V dc, American Zettler AZ4UP-E-1C-24D Relay, 12 V dc, American Zettler AZ6E-4CH-12D Refer to RELAY KIT ASSEMBLY Refer to ANTI-PUMP OPTION
L1		Refer to RELAY KIT ASSEMBLY
Q1,Q3,Q45,Q56-Q58, Q60	400-00724	Varistor, 250 V ac, G.E. V250LA20A
Q2,Q4,Q44,Q59 Q5-Q11,Q34 Q12-Q16,Q32,Q39,	400-00718 400-00633 560-00021	Varistor, 1000 V ac, G.E. V1000LB80A Op Amp, Motorola LM108AH Op Amp, Raytheon RM741T/883B
Q40,Q53,Q55 Q17 Q18 Q19	400-00634 400-00635 400-00636	Quad 2-Input NAND-Gate, RCA CD4011BD/BF Dual 4-Input AND-Gate, RCA CD4082BF/883 Quad 2-Input AND-Gate, RCA CD4081BD/BF
Q20,Q22,Q23,Q38, Q46-Q48,Q50 Q21 Q24,Q25 Q26	400-00300 400-00305 400-00655	Transistor, Motorola, 2N1711 Transistor, Motorola, 2N2907A Op Amp, LF257H Not Used
Q27,Q29,Q33,Q35,Q36, Q49 Q28,Q30,Q31	400-00620	Op Amp, National LF155H/LF255H Refer to ANTI-MOTORING FEATURE
Q41 Q42 Q43	400-00644 400-00627 400-00637	Voltage Reference, National LH0070-1H Voltage Regulator, +15 V, Fairchild µA78M15HM Voltage Regulator, -15 V, Fairchild µA79M15HM
Q51,Q52,Q54		Refer to OPERATOR WINDOW OPTION

COMPONENT DESIGNATION		DESCRIPTION
Q61		Refer to RELAY KIT ASSEMBLY
Q62,Q63	400-00709	Varistor, 250 V, G.E. V250LA2A
R1-R3,R5,R7-R9, R11,R122	330-00568	Resistor, Metal Film, 49.9 K±1%, 1/4 W, RN60E
R4,R10	330-00539	Resistor, 24.9 K ±1%, 1/4 W, RN60E
R6,R12	360-00093	Potentiometer, 10 K, Bourns 3009P-1-103
R13-R18,R23,R89-R91 R94,R168,R169	340-00002	Resistor, 20 K ±0.1%, 1/4 W, RN60E
R19,R92	340-00001	Resistor, $10 \text{ K} \pm 0.1\%$, $1/4 \text{ W}$, RN60E
R20		Not Used
R21,R22,R27		Refer to SELECTED RESISTORS
R24,R38,R39,R44, R47,R102,R143	200-00472	Resistor, Carbon Film, 4.7 K $\pm 5\%$
R25,R30,R35,R98	360-00119	Potentiometer, Cermet, 50 K $\pm 10\%$, Allen Bradley 73B1G040S503W
R26,R32,R48,R99	330-00449	Resistor, Metal Film, $3.16\mathrm{K}\pm1\%$, $1/4\mathrm{W}$, RN60E
R28	330-00385	Resistor, Metal Film, 750 Ω ±1%, 1/4 W, RN60E
R29,R43	200-00275	Resistor, Carbon Film, 2.7 M Ω $\pm 5\%$
R31	330-00475	Resistor, 5.9 K ±1%, 1/4 W, RN60E
R33	330-00504	Resistor, 10.7 K ±1%, 1/4 W, RN60E
R34,R42	200-00335	Resistor, Carbon Film, 3.3 M Ω $\pm 5\%$
R36	330-00492	Resistor, Metal Film, $8.87~\mathrm{K}\pm1\%$, $1/4~\mathrm{W}$, RN60E
R37	330-00487	Resistor, Metal Film, 7.87 K $\pm 1\%$, $1/4$ W, RN60E
R40,R41,R46,R65,R66, R82,R136,R137,R153, R164	200-00104	Resistor, Carbon Film, 100 K ±5%
R45,R58	200-00222	Resistor, Carbon Film, 2.2 K $\pm 5\%$
R49,R52,R59,R103, R139,R154	200-00103	Resistor, Carbon Film $10~\mathrm{K}\pm5\%$
R50		Not Used
R51,R61,R62	200-00203	Resistor, Carbon Film, 20 K ±5%
R53,R56	200-00333	Resistor, Carbon Film, 33 K ±5%
R54	200-00564	Resistor, Carbon Film, 560 K ±5%
R55	200-00331	Resistor, Carbon Film, 330 Ω ±5%
R57	200-00101	Resistor, Carbon Film, $100~\Omega~\pm5\%$
	•	-

OMPONENT ESIGNATION		DESCRIPTION
R60	200-00152	Resistor, Carbon Film, 1.5 K ±5%
R63,R64,R69		Not Used
R67,R68,R72,R76-R80, R138		Refer to ANTI-MOTORING FEATURE
R70,R71,R84,R85	340-00562	Resistor, 43.2 K ±1%, 1/4 W, RN60C
R73,R74	340-00525	Resistor, 17.8 K ±1%, 1/4 W, RN60C
R75	340-00492	Resistor, 8.87 K ±1%, 1/4 W, RN60C
R81		Not Used
R83	200-00753	Resistor, Carbon Film, 75 K ±5%
R86		Refer to SELECTED RESISTORS
R87,R88,R93,R95-R97		Not Used
R100	200-00304	Resistor, Carbon Film, 300 K ±5%
R101	340-00351	Resistor, 332 Ω ±1%, 1/4 W, RN60C
R104-R106		Not Used
R107-R116	340-00401	Resistor, 1 K ±1%, 1/4 W, RN60C
R117	200-00470	Resistor, Carbon Film, 47 Ω $\pm5\%$
R118	330-00522	Resistor, Metal Film, 16.5 K ±1%, 1/4 W, RN60E
R119	200-00102	Resistor, Carbon Film, 1 K ±5%
R120,R123	330-00601	Resistor, Metal Film, $100~\mathrm{K}\pm1\%$, $1/4~\mathrm{W}$
R121	330-00551	Resistor, Metal Film, 33.2 K ±1%, 1/4 W, RN60E
R124	200-00185	Resistor, Carbon Film, 1.8 M Ω ±5%
R125	340-00488	Resistor, 8.06 K ±1%, 1/4 W, RN60C
R126,R128	340-00530	Resistor, 20 K ±1%, 1/4 W, RN60C
R127,R131	200-00515	Resistor, 5.1 M ±5%
R129	340-00516	Resistor, 14.3 K ±1%, 1/4 W, RN60C
R130	200-00622	Resistor, Carbon Film, 6.2 K ±5%
R132,R133,R163	200-00473	Resistor, Carbon Film, 47 K ±5%
R134,R135	370-00006	Resistor, Wirewound, 3.3 Ω ±5%, 2 W
R140		Not Used
R141	340-00003	Resistor, Metal Film, 499 K \pm 0.1%, $1/4$ W
R155,R157, R165,R167	340-00701	Resistor, Metal Film, 1 M Ω ±1%, 1/4 W, RN60C
R142	200-00154	Resistor, Carbon Film, 150 K ±5%
R144-R149,R160,R176		Refer to OPERATOR WINDOW OPTION

COMPONENT DESIGNATION		DESCRIPTION
R150	200-00393	Resistor, Carbon Film, 39 K ±5%
R151,R158,R159		Refer to SELECTED RESISTORS
R152	340-00672	Resistor, 549 K ±1%, 1/4 W, RN60C
R156,R166	340-00518	Resistor, Metal Film, 10 K \pm 1%, 1/4 W, RN60C
R161	200-00623	Resistor, Carbon Film, 62 K ±5%
R162	360-00083	Potentiometer, Cermet, 100 K, Bourns 3009P-1-104
R170	390-00518	Resistor, Metal Film, 15 K $\pm 1\%$, 1/8 W
R171,R174	390-00469	Resistor, Metal Film, $5.11~\mathrm{K}\pm1\%$, $1/8~\mathrm{W}$
R172	360-00084	Potentiometer, 5 K Ω ±10%, Bourns 3009P-1-502
R173	340-00510	Resistor, Metal Film, 12.4 K ±1%, 1/4 W, RN60C
R175	330-00618	Resistor, Metal Film, 150 K ±1%, 1/4 W, RN60E
T1	410-00030*	Transformer, U-0085
T2,T3	410-00031*	Transformer, U-0086
TB1	420-00052	Terminal Block, 28-position, Reed Devices, Inc., 6PCR-28
TB2	420-00051	Terminal Block, Cinch 8-142 Y
TB3	420-00066	Terminal Block, 2-position, Curtis EPR-2
REV AD		

RELAY KIT ASSEMBLY, B-0307

C77 D90,D109 D108 F5 K4	000-00905 400-00211 400-00061 420-00845 430-00151	Capacitor, Ceramic Disc, 0.05 μF -20/+80%, 600 V Diode, Rectifier, G.E., 1N5061 Diode, Zener, 36 V ±5%, 5 W, 1N5365B Fuse, 1/4 A, 125 V, Littelfuse 275.250 Relay, SPDT, 24 V dc Coil, American Zettler AZ4-IC-24DE
L1 Q61 REV B	410-00521 400-00713	Choke, Feroxcube VK20020/4B Varistor, 40 V, G.E. V40LA2A

	DESCRIPTION				
OPERATOR WINDOW OPTION					
010-00423	Capacitor, Polycarbonate, 0.1 μF ±10%, 50 V				
000-00917	Capacitor, Ceramic Disc, 0.01 μF ±20%, 50 V				
000-00857	Capacitor, Polyester, 10 μF ±10%, 50 V				
000-00909	Capacitor, Ceramic Disc, 0.1 μF +80/-20%, 25 V				
000-00850	Capacitor, Polyester, 1.0 μ F $\pm 10\%$, 50 V				
400-00224	Diode, Fairchild, 1N4148				
400-00237	Diode, Fairchild, 1N5819				
400-00636	Quad 2-input, AND-Gate, Motorola MC14081BAL				
400-00634	Quad 2-input, NAND-Gate, Motorola MC14011BAL				
560-00021	Op Amp, Raytheon RM741T/883B				
200-00473	Resistor, Carbon Film, 47 K ±5%				
200-00104	Resistor, Carbon Film, 100 K ±5%				
200-00624	Resistor, Carbon Film, 620 K ±5%				
200-00471	Resistor, Carbon Film, 470 Ω ±5%				
360-00037	Potentiometer, 1 M, Single Turn				
200-00303	Resistor, Carbon Film, 30 K ±5%				
	Refer to SELECTED RESISTORS				
360-00038	Potentiometer, 1 turn, 50 K ±20%, Bourns 3386				
180-00512	Resistor, Carbon Comp., 5.1 K ±5%, 1/4 W				
ANTI-N	NOTORING FEATURE				
B-0121 PF	RINTED CIRCUIT BOARD				
000-00917	Capacitor, Ceramic Disc, 0.01 ±20%, 50 V				
	Capacitor, Polyester, 0.18 μF ±10%, 50 V				
	Capacitor, Polyester, 0.027 μF ±10%, 50 V				
	010-00423 000-00917 000-00857 000-00909 000-00850 400-00224 400-00237 400-00636 400-00634 560-00021 200-00473 200-00104 200-00624 200-00471 360-00037 200-00303 360-00038 180-00512				

COMPONENT DESIGNATION		DESCRIPTION
	SELE	CTED RESISTORS
R21	330-00626	Resistor, Metal Film, 182 K ±1%, 1/4 W, RN60E
1.4.1	330-00554	Resistor, Metal Film, 35.7 K ±1%, 1/4 W, RN60E
	330-00539	Resistor, Metal Film, 24.9 K ±1%, 1/4 W, RN60E
	330-00583	Resistor, Metal Film, 71.5 K \pm 1%, 1/4 W, RN60E
R22	360-00070	Potentiometer, 50 K, Bourns 3009P-1-503
	360-00093	Potentiometer, 10 K, Bourns 3009P-1-103
	360-00068	Potentiometer, 20 K, Bourns 3009P-1-203
R27	330-00505	Resistor, Metal Film 11 K ±1%, 1/4 W, RN60E
	330-00456	Resistor, Metal Film, 3.74 K ±1%, 1/4 W, RN60E
	330-00410	Resistor, Metal Film, 1.24 K ±1%, 1/4 W, RN60E
R86	340-00003	Resistor, 499 K ±0.1%, 1/4 W, RN60E
	340-00006	Resistor, Metal Film, 4.99 M $\pm 0.1\%$, 1/4 W, RN60E
R151	330-00559	Resistor, Metal Film, 40.2 K ±1%, 1/4 W, RN60E
	330-00667	Resistor, Metal Film, 487 K ±1%, 1/4 W, RN60E
R158	340-00518	Resistor, Metal Film, 15 K $\pm 1\%$ if .005 to .05 ΔF range is used, Jumper if .05 to .5 ΔF range is used
R159	330-00449	Resistor, Metal Film, 3.16 K $\pm 1\%$, if .005 to .05 ΔF range is used, Open if .05 to .5 ΔF range is used
	50 HZ OP	PERATING FREQUENCY
D70 D74	330-00531	Resistor, Metal Film, 20.5 K ±1%, 1/4 W RN60E
R73,R74	330-00504	Resistor, Metal Film, 10.7 K ±1%, 1/4 W RN60E
R75 R78	200-00304	Resistor, Carbon Film, 300 K ±5%
N/O	200-000-0-1	(Added only if anti-motoring is also selected)
R100,R142	200-00154	Resistor, Carbon Film, 150 K ±5%
R124	200-00514	Resistor, Carbon Film, 510 K ±5%
REV A		

Legal Information

Patent

The units described in this manual are covered by U.S. Patent 3,491,248.

Buyer shall hold harmless and indemnify the Seller, its directors, officers, agents, and employees from any and all costs and expense, damage or loss, resulting from any alleged infringementof United States Letters Patent or rights accruing thereform or trademarks, whether federal, state, or common law, arising from the Seller's compliance with Buyer's designs, specifications, or instructions.

Warranty

Seller hereby warrants that the goods which are the subject matter of this contract will be manufactured in a good workmanlike manner and all materials used herein will be new and reasonably suitable for the equipment. Seller warrants that if, during a period of two years from date of shipment of the equipment, the equipment rendered shall be found by the Buyer to be faulty or shall fail to peform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided, however, that Buyers shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to replacement value of the equipment furnished under this contract.

Seller makes no warranties expressed or implied other than those set out above. Seller specifically excludes the implied warranties of merchantibility and fitness for a particular purpose. There are no warranties which extend beyond the description contained herein. In no event shall Seller be liable for consequential, exemplary, or punitive damages of whatever nature.

Any equipment returned for repair must be sent with transportation charges prepaid. The equipment must remain the property of the Buyer. The aforementioned warranties are void if the value of the unit is invoiced to the Seller at the time of return.

Indemnification

The Seller shall not be liable for any property damages whatsoever or for any loss or damage arising out of, connected with, or resulting from this contract, or from the performance or breach thereof, or from all services covered by or furnished under this contract.

In no event shall the Seller be liable for special, incidental, exemplary, or consequential damages, including but not limited to, loss of profits or revenue, loss of use of the equipment or any associated equipment, cost of capital, cost of purchased power, cost of substitute equipment, facilities or services, downtime costs, or claims or damages of customers or employees of the Buyer for such damages, regardless of whether said claim or damages is based on contract, warranty, tort including negligence, or otherwise.

Under no circumstances shall the Seller be liable for any personal injury whatsoever.

It is agreed that when the equipment furnished hereunder are to be used or performed in connection with any nuclear installation, facility, or activity, Seller shall have no liability for any nuclear damage, personal injury, property damage, or nuclear contamination to any property located at or near the site of the nuclear facility. Buyer agrees to indemnify and hold harmless the Seller against any and all liability associated therewith whatsoever whether based on contract, tort, or otherwise. Nuclear installation or facility means any nuclear reactor and includes the site on which any of the foregoing is located, all operations conducted on such site, and all premises used for such operations.

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