Synchrocloser® Check Relay
M-0388

- Panel-Mounted G.E. IJS and SLJ or Westinghouse CVE Replacement
- Accurate, Independent Phase, Time and Voltage Functions Transducer and Status Outputs are Standard Features
- Modular construction allows cards to be removed while unit is installed.
- Optional unit with voltage checking and dead line and dead bus closure capabilities can be installed at any time.
- Does not require a separate power source.
- Complete test and checkout from front panel.
- 20 A output relay contacts open 0.9 A inductive at 125 V dc.
- Temperature range of -40° to +80° C.

INPUTS

(M-0388)
Functional in either 50 or 60 Hz applications.
Line voltage, nominal 120 V ac, 150 V ac maximum continuous. Will withstand 200 V ac for 1 sec.
Bus voltage, nominal 120 V ac, 150 V ac maximum continuous. Will withstand 200 V ac for 1 sec.
Enable Sync-Check (by closing contact*).
Open circuit voltage = 10 to 15 V dc; closed circuit current = 0.02 to 0.04 mA dc.

NOTE: One input must be greater than 100 V ac to ensure the Output Relay will close.

(M-0389)
Enable Dead Bus Closing (by closing contact*).
Enable Dead Line Closing (by closing contact*).

* **NOTE:** Requires use of gold-plated contacts located close to the unit or a permanent jumper on the back of the unit.

BURDEN

Whichever input voltage is high, 4 VA; other input, 1 VA.

CONTROLS

(M-0388)
PHASE LIMIT: 0 to ±45° or 0 to ±90° (switch selectable), dial accuracy ±5% of full scale.
TIME LIMIT to close after **PHASE LIMIT OK:** 0 to 1.5 sec. or 0 to 15 sec. (switch selectable), dial accuracy ±10% of full scale.

(M-0389)
UPPER VOLTAGE LIMIT, either input: 110 to 140 V ac, dial accuracy ±5% of full scale.
LOWER VOLTAGE LIMIT, either input: 90 to 120 V ac, dial accuracy ±5% of full scale.
DEAD LINE/BUS LIMIT: 0 to 60 V ac, dial accuracy ±10% of full scale.

PROGRAMMABLE SETPOINTS

Switches are provided on the Phase Verifier printed circuit board to modify the range of the **PHASE LIMIT** and **TIME LIMIT** controls. The **PHASE** range may be set in the **X1** or **X2** position. In the **X2** position, the front panel **PHASE LIMIT** control setpoint will be multiplied by 2, and the **X2** LED on the M-0388 front panel will light to indicate a 0 to ±90° **PHASE LIMIT** control range. The **TIME** range may be set in the **X1** or **X10** position. In the X10 position, the front panel **TIME LIMIT** control setpoint will be multiplied by 10, and the **X10** LED on the front panel will light indicating a 0 to 15 sec. **TIME LIMIT** range.

LED INDICATORS

(M-0388)
PHASE LIMIT OK: Phase angle is within limit setting.
PHASE X2: PHASE setting is multiplied by 2.
TIME X10: TIME setting is multiplied by 10.
OUTPUT CLOSED: Output Relay Contacts have closed in the **OPERATE** mode.
TEST CLOSE: Conditions are correct to close the Output Relay Contacts in the **TEST** mode (although the Output Relay Contacts are disabled).

(M-0389)
UPPER VOLTAGE LIMIT - L OK: Line voltage is below the **UPPER VOLTAGE LIMIT** setting.
UPPER VOLTAGE LIMIT - B OK: Bus voltage is below the **UPPER VOLTAGE LIMIT** setting.
DEAD LINE/BUS LIMIT - L HOT: Line voltage is above the **DEAD LINE/BUS LIMIT** setting.
DEAD LINE/BUS LIMIT - B HOT: Bus voltage is above the **DEAD LINE/BUS LIMIT** setting.
LOWER VOLTAGE LIMIT - L OK: Line voltage is above the **LOWER VOLTAGE LIMIT** setting.
LOWER VOLTAGE LIMIT - B OK: Bus voltage is above the **LOWER VOLTAGE LIMIT** setting.

BREAKER CLOSE RELAY

1) Two form A output contacts rated to make 10 A at up to 250 V dc; interrupt 0.9 A, 125 V dc or 0.4 A at up to 250 V dc inductive load. Open contacts will withstand 1500 V ac for 1 minute. Contacts to ground will withstand 1500 V ac for 1 minute. Contacts may be paralleled to make 20 A at up to 250 V dc.

2) One normally open output contact rated to make 10 A at up to 250 V dc; interrupt 0.9 A, 125 V dc or 0.4 A at up to 250 V dc inductive load. Open contacts will withstand 1500 V ac for 1 minute. Contacts to ground will withstand 1500 V ac for 1 minute. A normally closed light duty contact is provided that opens when either the line or bus is above 80 V ac ±10 V. The contact closes when both the line and bus voltage drop below 50 V ac ±10 V. The light duty contact is rated at 3 A at up to 240 V ac.

RESPONSE TIME

The M-0388 will close the breaker with proper phase angle only after the time set by the **TIME LIMIT** control. After the timer has timed out, the M-0389 will respond to correct voltage conditions in approximately 0.2 sec. In closing on dead line or dead bus, the phase condition is ignored so that the unit will close upon a voltage below set threshold in approximately 0.5 sec.

STATUS RELAY CONTACTS

These are light duty, form C contacts rated for 3 A at 120 V ac noninductive load. They are intended primarily for status interrogation by supervisory and may be used to light local lights.

Phase Status: Phase angle is within the limit setting.
Voltage Status: Line and Bus voltages are within the limit settings.

ANALOG OUTPUT OPTIONS

SCADA compatible analog outputs are provided that can be connected for either voltage or current outputs, and may be used as transducer outputs or for interrogation of the unit while in operation.

Phase (M-0388)

1) 0 to 10 V dc = 0 to 180°, accuracy ±1°. Load: 5 K or greater.
2) 0 to 1.0 mA dc = 0 to 180°, accuracy ±3°. Load: 10 K or less.

Other voltage/current ranges can be set by external precision resistors.

Line/Bus Voltage (M-0389)

1) 0 to 7.5 V dc = 0 to 150 V rms, accuracy ±5% of full scale including ±2% of full scale variation over stated temperature range. Load: 3 K or greater.
2) 0 to 1.0 mA dc = 0 to 150 V rms, accuracy ±5% of full scale including ±2% of full scale variation over stated temperature range. Load: 10 K or less.

Other voltage/current ranges can be set by external precision resistors.

NOTE: The Analog Outputs are not isolated from each other. A common zero volt reference (Analog Common) is used for all analog outputs.

SYNC-CHECK ENABLE TIMER LOGIC OPTION (M-0388)

1) Enable circuit has no effect on the operation of the timer.
2) Timer is blocked if the M-0388 is not enabled.

VOLTAGE VERIFIER TIMER LOGIC OPTION (M-0389)

1) Voltage Verifier has no effect on the operation of the timer.
2) Timer is blocked if either input voltage is not within the **UPPER** and **LOWER VOLTAGE** limits.

M-0292 TEST CABLE SET OPTION

The M-0292 Test Cable Set allows the Power Supply and Phase Verifier boards of the M-0388 and the Voltage Verifier Board of the M-0389 to be tested either in the field or in the laboratory. The cable set allows the boards to be physically removed from the case while remaining electrically connected for testing.

FIELD TESTING

Two **OPERATE/TEST** switches, located on the M-0388 front panel, internally disable the Output Relay and disconnect the Bus and Line V.T. inputs when in the **TEST** position. This isolates the V.T. inputs of the M-0388 from the external wiring and ensures that the Output Relay Contact will not close while the unit is being tested. The M-0388/M-0389 can then be checked by applying 120 V ac nominal Line and Bus inputs at the respective jacks on the M-0388 front panel.

CALIBRATION

No circuit calibration is required; complete, solid-state design has no circuit calibration controls.

RELIABILITY

The most advanced and stable solid-state components are used to achieve an accuracy and reliability of service not usually available for this class of relay. The reliability is enhanced by the basic stability of the circuits; no temperature compensation is used.

TRANSIENT PROTECTION

Input and output circuits are protected against system transients. The M-0388 will exhibit no component failure or false commands when subjected to the requirements of ANSI/IEEE C37.90.1-1989 defining oscillatory and fast transient surge withstand capability.

All faces of the relay, with the chassis solidly grounded, have been exposed to Radio Frequency Immunity testing and have successfully passed with a field intensity of 20 volts per meter at typical utility frequencies of 144 MHz, 148 MHz, 438 MHz, and at 450 MHz.

ENVIRONMENTAL

Temperature Range:. Stated accuracies are maintained from –40° to +80° C; analog output signals to +60° C.
Humidity: Stated accuracies are maintained under 85% relative humidity (non-condensing).
Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

PHYSICAL

Size and Mounting: The unit is designed for semiflush panel mounting, compatible with G.E. type S1 and Westinghouse type FT-21 drawout relay cases. Refer to the Application Guide for specific dimensions. A transparent cover is supplied with the unit.
Approximate Weight: Including M-0389, 9 lb (4.1 kg).
Approximate Shipping Weight: Including M-0389, 12 lb (5.4 kg).

PATENT

U.S. Patent 4,218,625

WARRANTY

The M-0388 Syncrocloser® Check Relay is covered by a two year warranty from date of shipment.

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● WARNING

DANGEROUS VOLTAGES, CAPABLE OF CAUSING DEATH OR SERIOUS INJURY, ARE PRESENT ON THE EXTERNAL TERMINALS AND INSIDE THIS 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.

● 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.

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 chassis must be attached to a separate ground since it is not grounded by external connections.

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 metal 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 AND 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 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

If this unit contains MOS circuitry, it 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.

TABLE OF CONTENTS

M–0388/M–0389 SYNCROCLOSER® CHECK RELAY
Instruction Book

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.

INTRODUCTION

Please refer to the M–0388 Application Guide in conjunction with this Instruction Book since the information contained in one is usually not repeated in the other. The Beckwith Electric M–0388 Syncrocloser® Check Relay uses advanced state of the art semiconductors and circuits to achieve an overall stability and resolution unattainable with current electromechanical sync-check relays. Modern hybrid and monolithic semiconductors are used throughout the Syncrocloser Line to gain temperature stability without critical compensation or trimming. Figure 1 shows the Logic Diagram, Figure 2 shows the Functional Block Diagram, and Figure 3 shows the Mother Board and Overall Schematic.

DESCRIPTION

Use of modern precision solid-state technology yields the following features.

PHASE ANGLE FUNCTIONS

1. Precise adjustment of phase angle for acceptable breaker closing is via a calibrated, front panel **PHASE LIMIT** dial.
2. Phase angle adjustment range is switch selectable as either 0 to ±45° (X1 range) or 0 to ±90° (X2 range). The X2 range is indicated by a front panel LED.
3. Phase Angle Analog transducer output is programmable as a voltage or current source as an external indication of angle.
4. Phase Status Relay indicates whether or not the measured angle is within the **PHASE LIMIT** setting, and is indicated by the **PHASE LIMIT OK** LED.

TIME DELAY

1. Adjustable time delay ensures that the phase angle remains within the **PHASE LIMIT** setting for a minimum time period.
2. Time delay is adjustable via a calibrated, front panel **TIME LIMIT** control over a range of 0 to 1.5 sec. (X1 range) or 0 to 15 sec. (X10 range).
3. Time delay range is switch selectable, with a front panel LED indicating the X10 range.
4. Timer is blocked if either input voltage is less than 60 V ac. Timer can also be blocked if:
   a) M–0388 is not enabled.
   b) M–0389 senses a voltage outside of the setting range.

ADDITIONAL M-0388 FEATURES

1. Standard Output Relay Contacts are two form A output contacts. These contacts are rated to make 10 A at up to 250 V dc; interrupt 0.9 A, 125 V dc or 0.4 A at up to 250 V inductive load. The contacts may be paralleled to make 20 A at up to 250 V dc. With the Output Relay Contacts Option for dead line and dead bus, one normally open output contact and one normally closed light duty contact is provided. The normally open contact is rated to make 10 A at up to 250 V dc; interrupt 0.9 A, 125 V dc or 0.4 A at up to 250 V inductive load. The normally closed light duty contact opens when either the line or bus voltage is above 80 V ac ±10 V. The contact closes when both the line and bus voltage drop below 50 V ac ±10 V. The light duty contact is rated at 3 A at up to 240 V ac.

2. Front panel test inputs can be used without removing the unit.
3. An **OUTPUT CLOSED** LED indicates the Output Relay status.
4. Operating power is drawn from the higher of the input voltages, and no dc power source is required. Burden is 4 VA on higher input.
5. All inputs and outputs, including the control and analog interfaces, are transient protected.

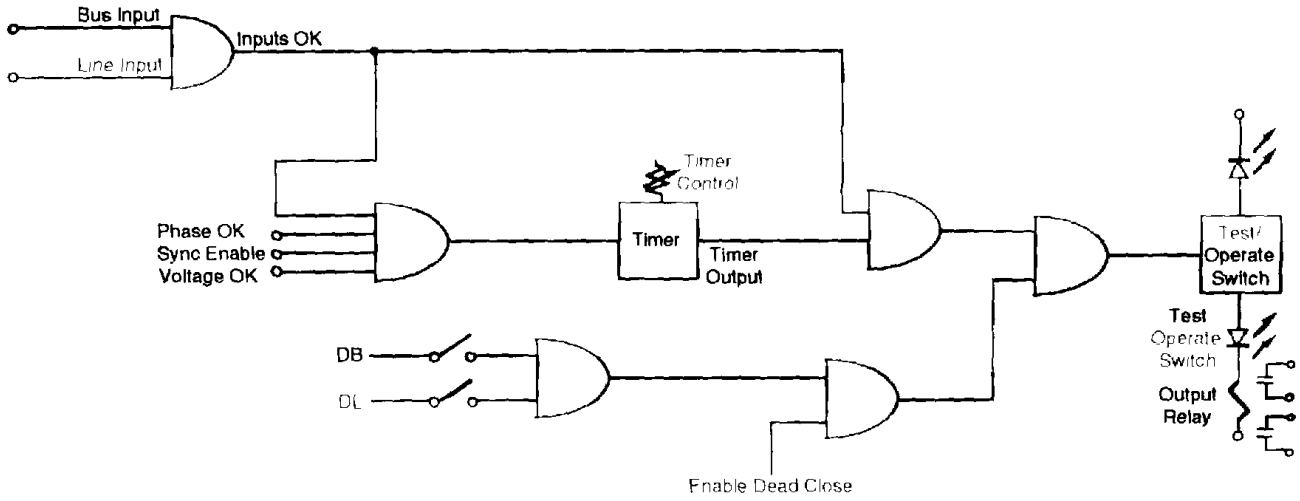


FIGURE 1 Logic Diagram

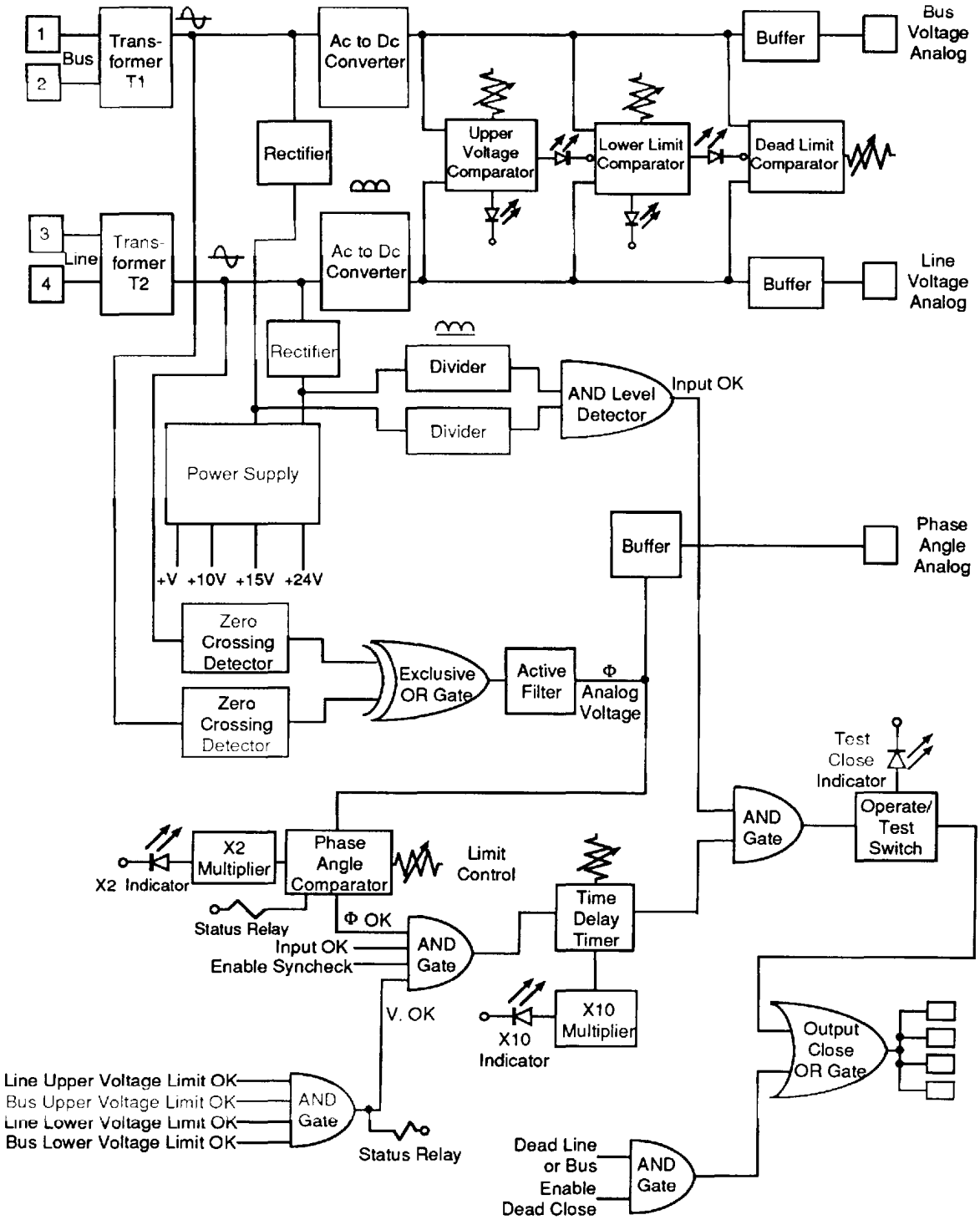


FIGURE 2 Functional Block Diagram

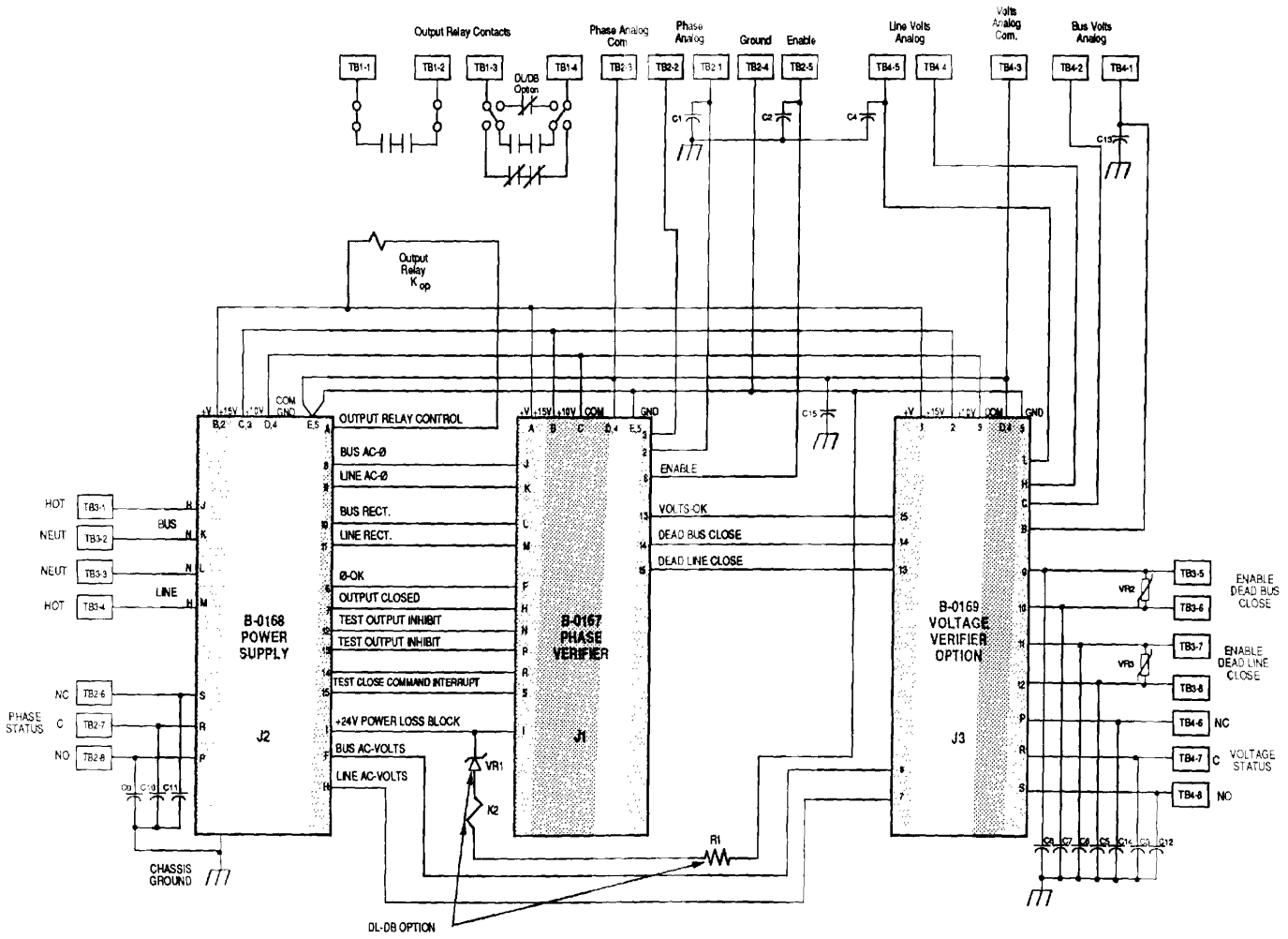


FIGURE 3 Mother Board and Overall Schematic

THEORY OF OPERATION

M–0388 SYNCROCLOSER® CHECK RELAY

MOTHER BOARD

Refer to Figure 4. The Mother Board assembly provides the interconnection of the three plug-in boards, the external signals from TB1 through TB4, and the Output Relay. All external connections to the M–0388 Syncrocloser Check Relay are made to the rear terminal blocks TB1 through TB4, as shown in Figures 5 and 6. These signals are connected to the internal circuit boards by connectors J1 through J3 via the Mother Board. The Output Relay (K_{op}) is mounted in a plug-in socket on the Mother Board. The output contact circuits for this relay are wired directly to TB1. The optional dead line and dead bus relay (K2) is also mounted on the Mother Board. The output contact circuits for this relay are wired to TB1.

POWER SUPPLY BOARD

Refer to Figures 7, 8, and 9. The Power Supply Board assembly conditions the two voltage inputs to provide signals for the Phase and Voltage Verifier Boards and provides the dc power supply voltages required by the unit.

The Bus and Line input voltages are reduced in magnitude by transformers T1 and T2, respectively. The **OPERATE/TEST** switches S1 and S2 are used to disconnect the primaries of T1 and T2 from the input voltage sources and connect them to the red and black test jacks on the front panel. Either or both inputs can be switched to apply an external voltage and test the unit. Other S1 and S2 contacts are used to disable the Output Relay drive, so that the Output Relay cannot close if either of the switches is in the **TEST** position. If either switch is in the **TEST** position, the **TEST CLOSE** LED (D12) will light when all conditions are correct for closing the Output Relay.

F1 and F2 are fuses mounted on the Power Supply Board that will open if excessive current is drawn from either input source. Components C1, C2, Q1 through Q4 and Q8 are used to protect the unit from external transients, allowing the unit to pass the Surge Withstand Capability Test.

The ac secondary voltages from T1 and T2 are rectified by diodes D1, D2 and D3, D4, respectively. These two dc voltages are diode "ORed" by diodes D5 and D6 to provide an unregulated +24 V dc for internal circuit power. Capacitors C3 through C5, C7 and C8 provide smoothing of the rectified dc voltages with C4 being the primary filtering capacitor. Resistor R1 and zener diode D7 are used to limit the voltage on the +24 V signal, thus protecting the internal circuitry from high voltage spikes that might enter the unit.

A precision +10 V dc reference voltage is produced by the Q5 regulator. This reference is used as the basis for all voltage and phase angle limit comparisons within the unit. Transistors Q6 and Q7-Pin 14, along with resistors R2 through R5, make up a +15 V regulated supply that is used as the power source for all internal circuitry, except the relays.

The three other transistors labeled Q7, which are not a part of the +15 V regulator, are used to drive the Phase Status Relay (K1) and the Output Relay (mounted on the Mother Board). The drive signals to the transistors come from the Phase Verifier Board via the Mother Board.

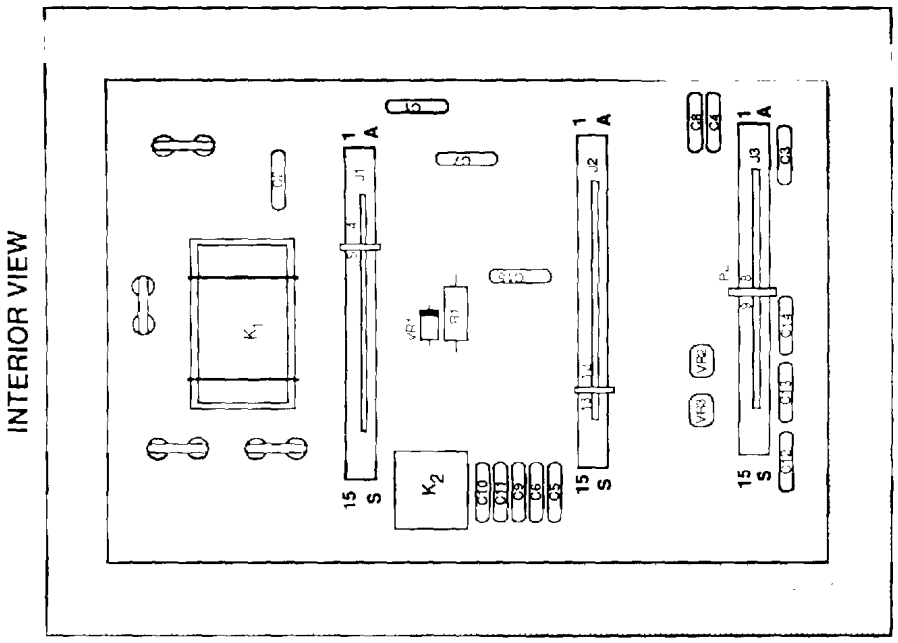
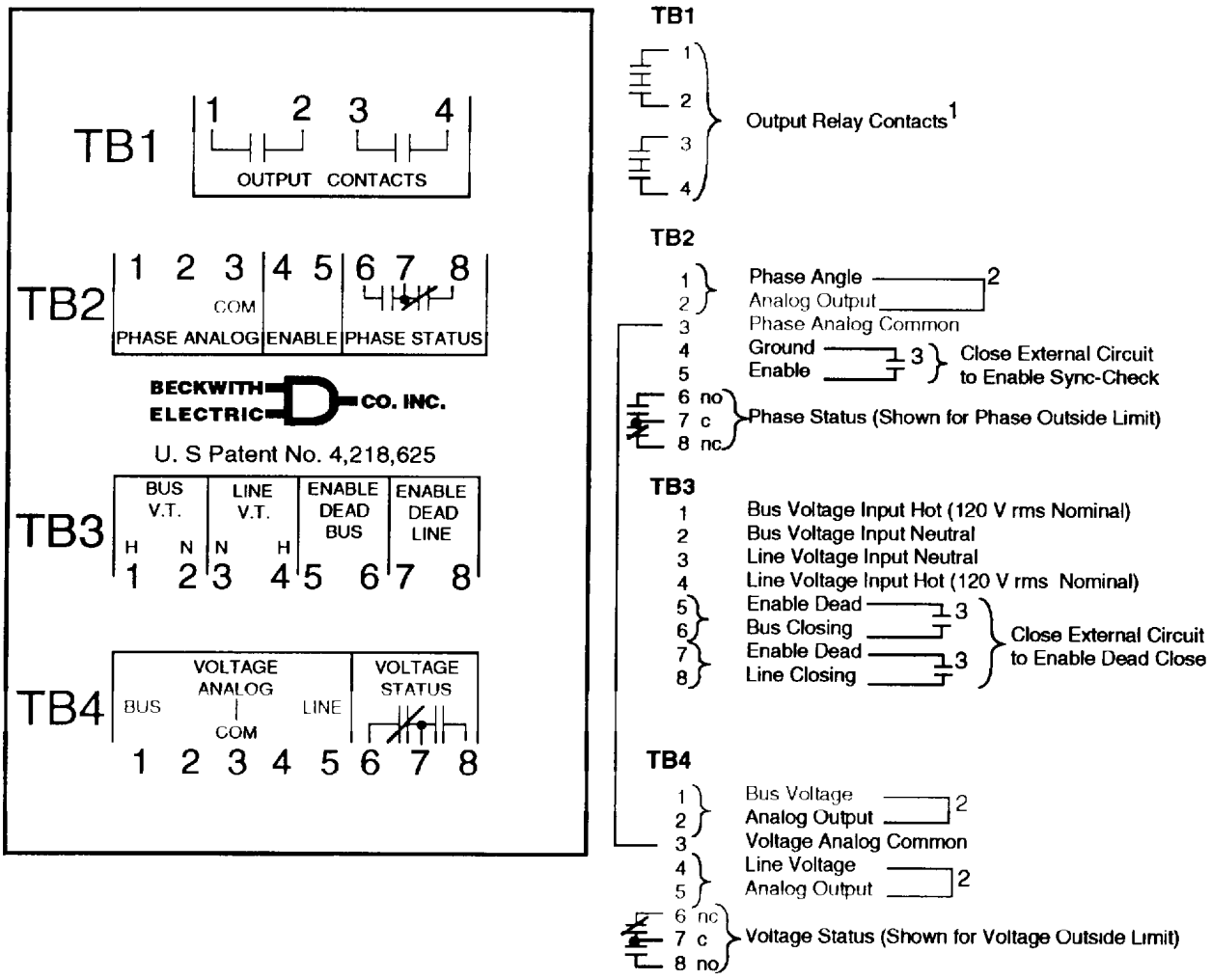


FIGURE 4 Mother Board Assembly and Component Location



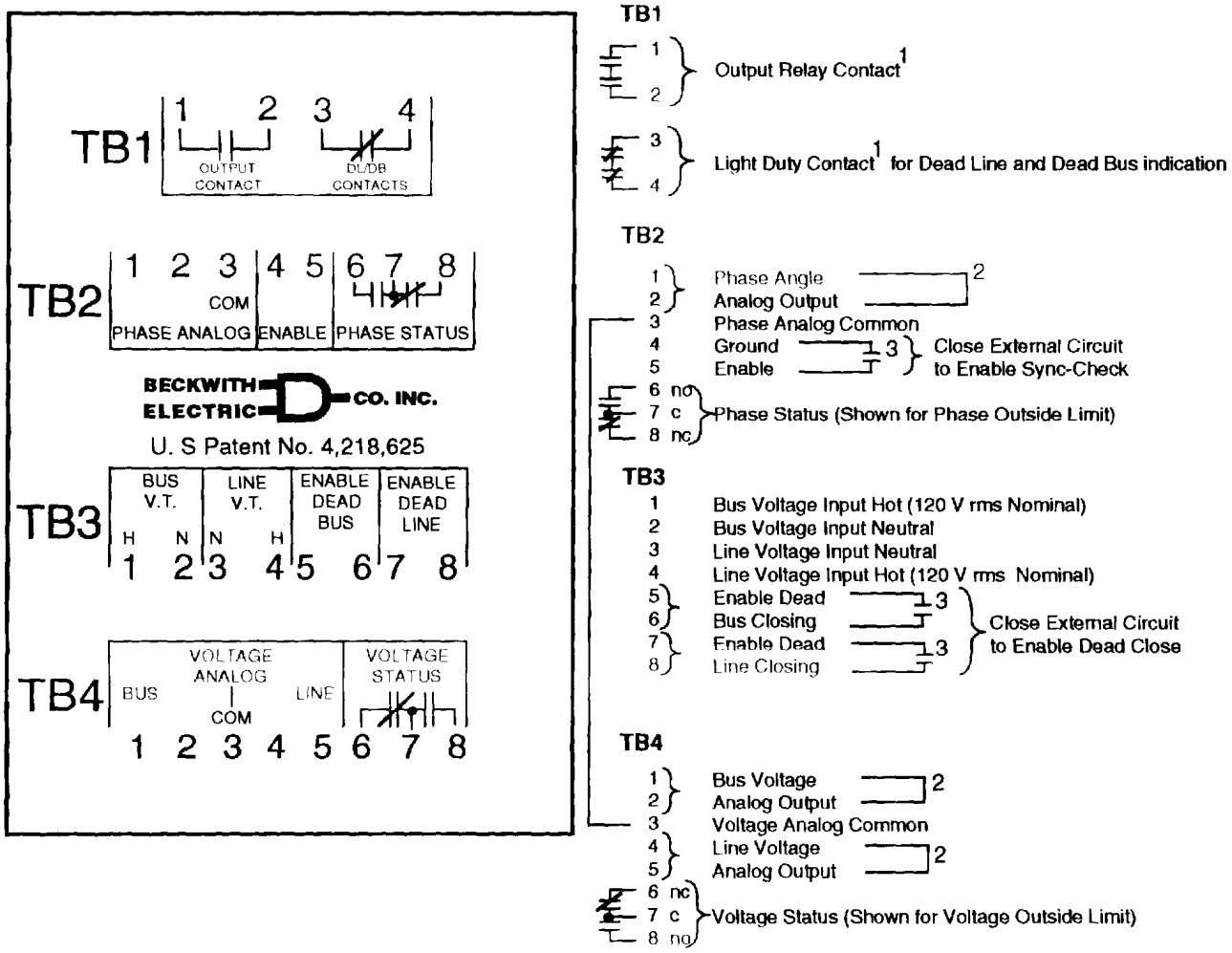
■ NOTES:

1. Shown for standard Output Relay Contacts. See Figure 6 for Output Relay Contacts—Dead Line and Dead Bus Option.

2. External Connections are shown in Figure 14 and Figure 15.

3. Requires the use of gold-plated contacts mounted close to the M–0388 or permanent jumpers on the M–0388 terminal blocks.

FIGURE 5 Standard External Connections



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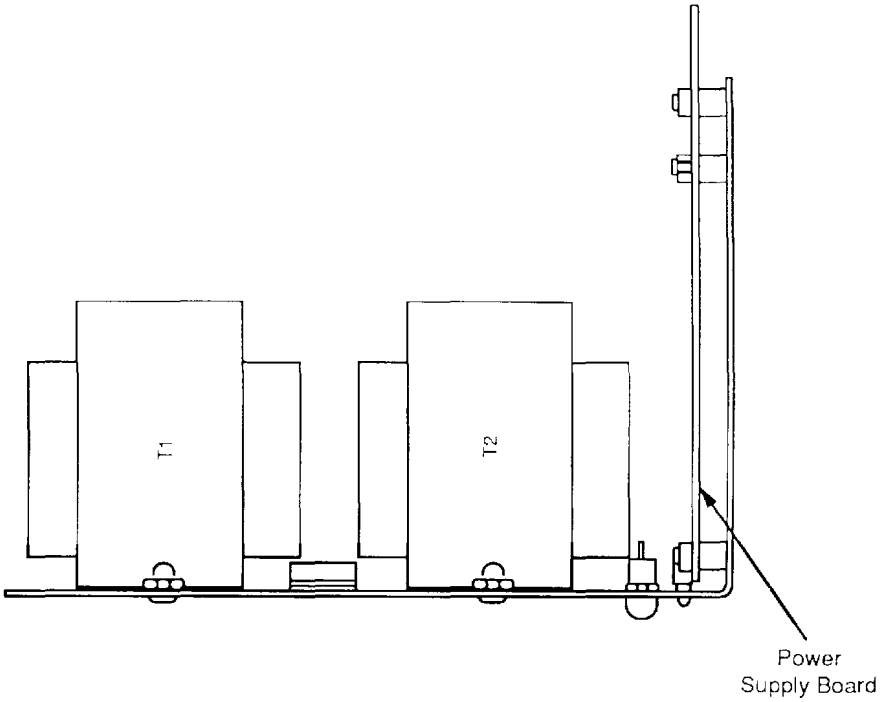
2. External Connections are shown in Figure 14 and Figure 15.

3. Requires the use of gold-plated contacts mounted close to the M-0388 or permanent jumpers on the M-0388 terminal blocks.

FIGURE 6 Dead Line and Dead Bus Option External Connections



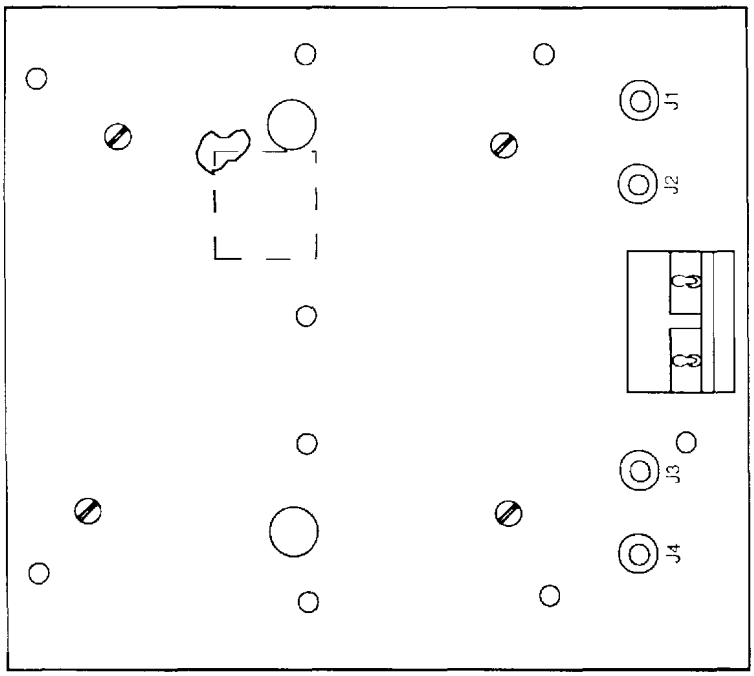


FIGURE 7 Panel Assembly and Power Supply Board

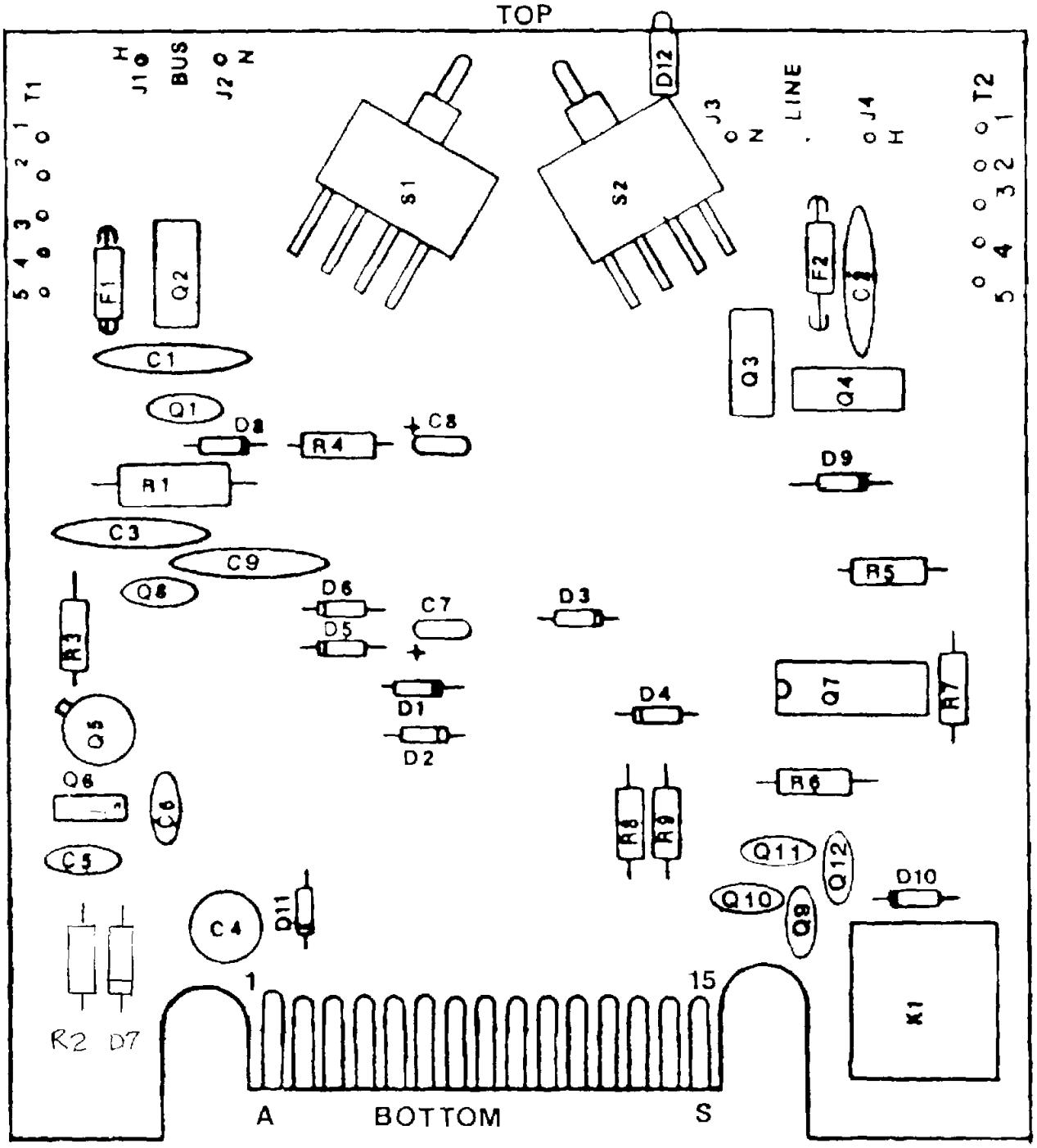


FIGURE 8 Power Supply Board Component Location

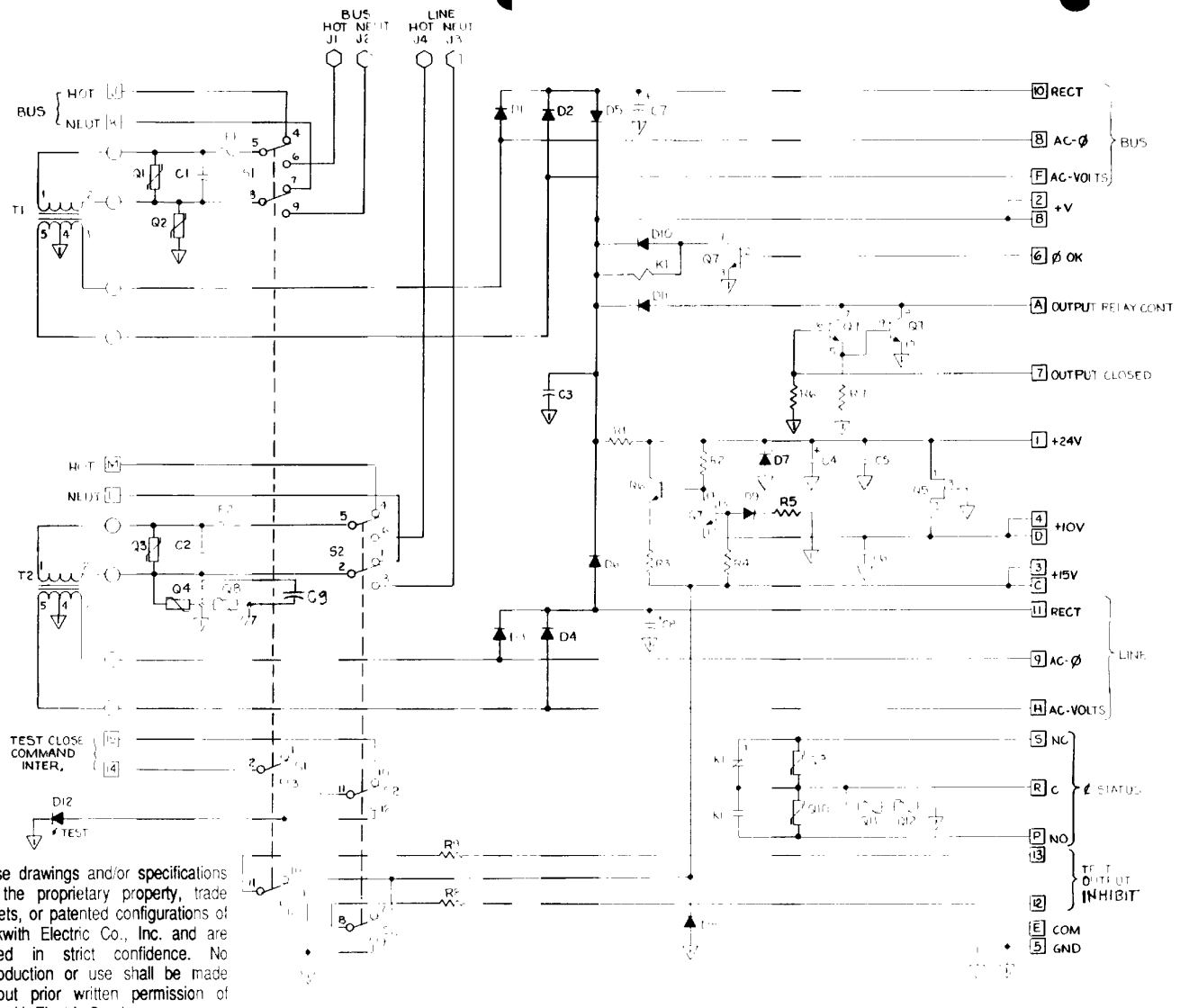


FIGURE 9 Power Supply Board Schematic

PHASE VERIFIER BOARD

Refer to Figures 10, 11 and 12. The Phase Verifier Board measures the phase angle between the Bus and Line input voltages and compares this angle to the **PHASE LIMIT** control setting. If the measured angle is less than the angle setting, a timer is started. If the angle has remained less than the angle setting for a time duration that exceeds the setting on the **TIME LIMIT** control, a "close" command is generated to indicate that the breaker can be closed. Control logic on this board will decide if all conditions are correct for closing the Output Relay.

PHASE VERIFIER BOARD FUNCTIONS

Phase Angle Detector

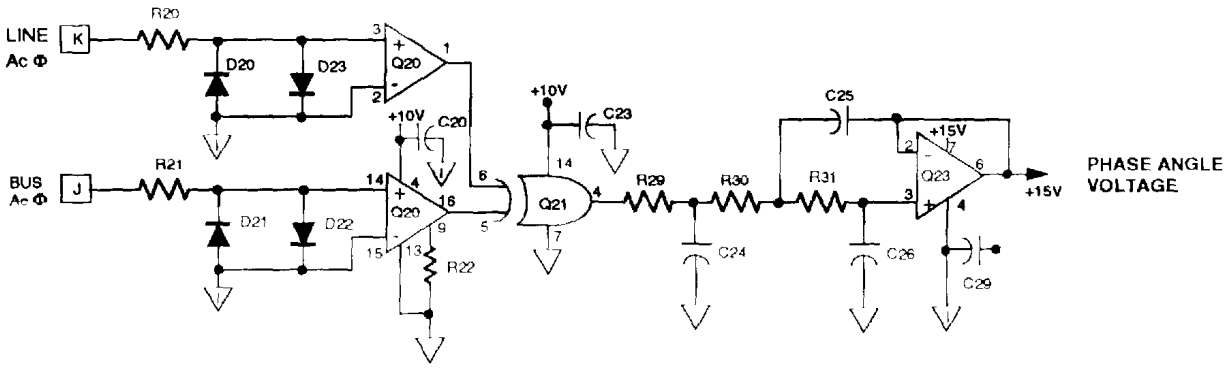


FIGURE 10 Phase Angle Detector Schematic

■ **NOTE:** The symbols [K], [J], etc., refer to the terminal numbers of the connectors of the plug-in boards on the M–0388/M–0389.

The inputs to circuits [K] and [J] are 18 V rms voltages from the secondaries of the Bus and Line input transformers. The signal Line Ac Φ [K] is from the Line voltage and Bus Ac Φ [J] is from the Bus voltage. These signals are in phase with the input voltages. The two amplifiers labeled Q20 are used to square up the sinusoidal inputs. The outputs at Q20–Pin 1 and Q20–Pin 16 are square wave voltages from 0 to 10 V and in phase with the Line and Bus Ac Φ signals, respectively. Logic gate Q21 generates a 120 Hz square wave output, with a duty cycle proportional to the phase angle between the Line and Bus voltages. The amplitude of this signal is equal to the +10 V reference level, ensuring accuracy of the phase angle measurement. Amplifier Q23 is a third order low-pass filter that extracts the dc or average value from the output of Q21. This dc voltage, (Phase Angle Voltage), varies from 0 to +10.00 V dc as the phase difference varies from 0 to ±180°. The Phase Angle Voltage is thus proportional to the absolute value of the phase angle (nondirectional).

Phase Angle Transducer Amplifier

The Phase Angle Transducer Amplifier (see Figure 13) is a buffer between the internal Phase Angle Analog Voltage and the external signal connections to the M–0388. Components D26 through D29, Q26, Q27, R32 and R33 are used for protection of Q24 from any external transient voltages that might be coupled to the external connections.

R70 and R71 form a 1:10 voltage divider that is only used when a current output is specified for the Phase Analog Output. If a voltage analog output is specified, R71 is not installed in the unit. Connections for each are shown in Figures 14 and 15.

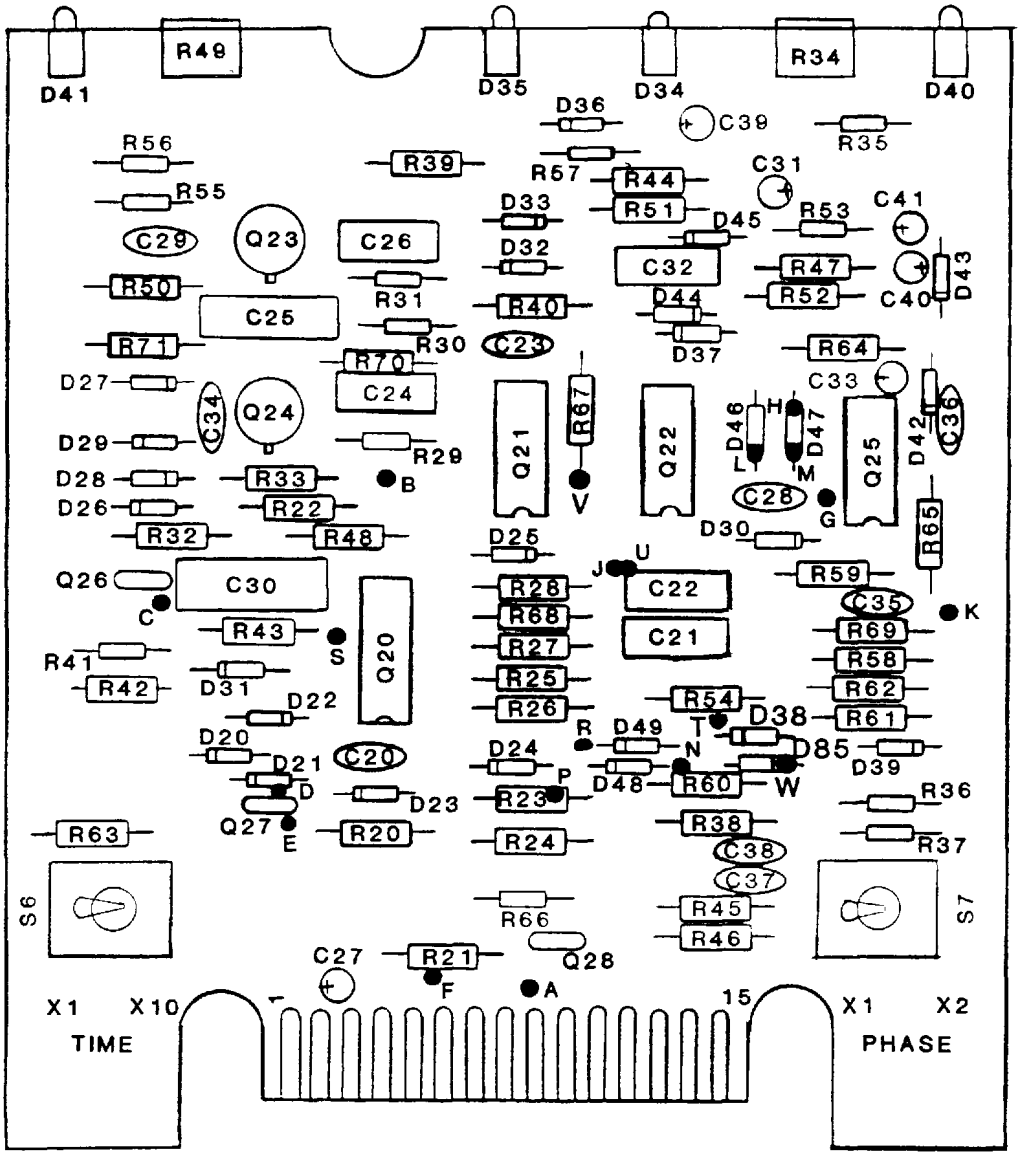


FIGURE 11 Phase Verifier Board Component Location

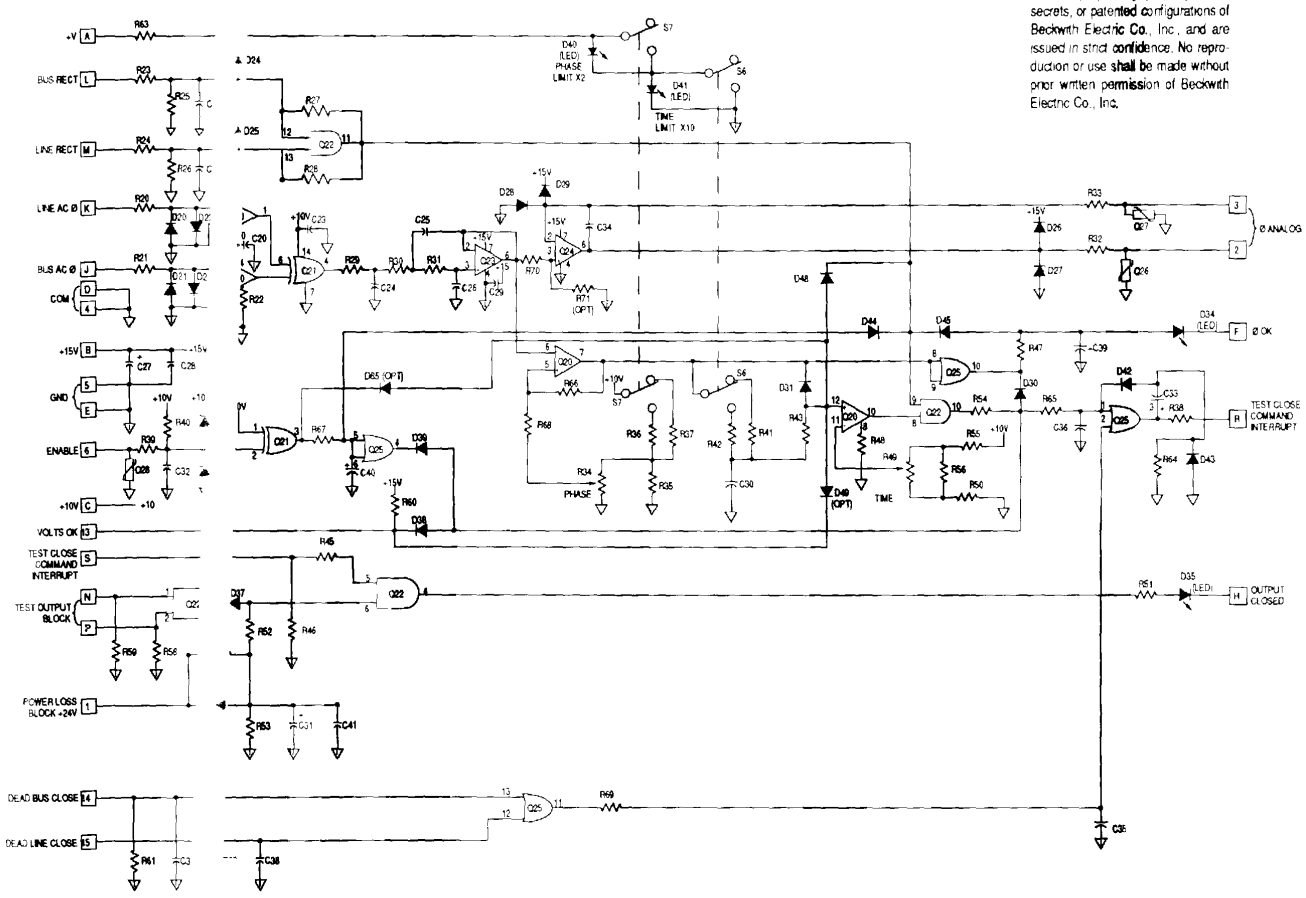


FIGURE 12 Phase Verifier Board Schematic

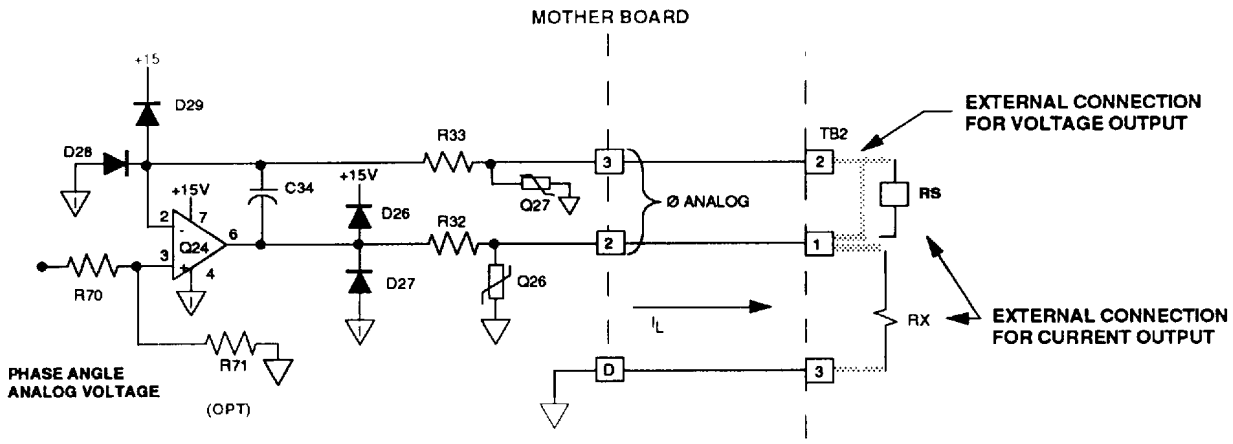


FIGURE 13 Phase Angle Transducer Amplifier Schematic

1. Voltage Analog Output

When a voltage output is specified (i.e., R71 is not installed), and the unit is connected for a voltage output, the transducer output at TB2–1 will be equal to the Phase Angle Analog Voltage. Any current burden on the output must flow through R32. Therefore, the voltage output at Q24–Pin 6 will be higher than the output by I_L X R32 volts. The maximum current that can be supplied to the external load is limited by R32 and the maximum output voltage of Q24, or approximately 12 V dc.

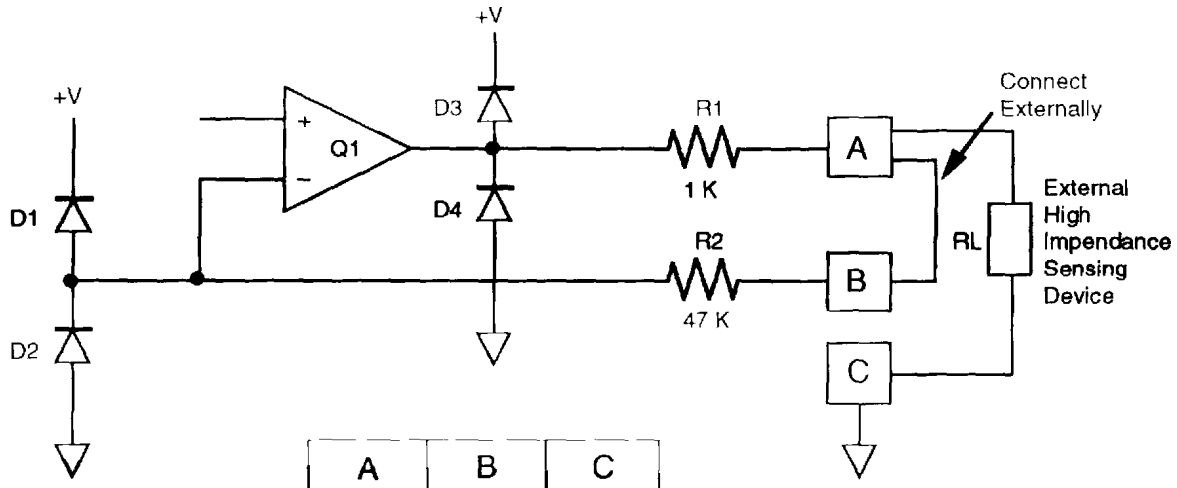
2. Current Output

When a current output is specified for the transducer, the optional R71 is installed so that the voltage at Q24–Pin 3 is 1/10 of the Phase Angle Analog Voltage. By using the external connections for a current output, the output current flows out of TB2–1, through the external load, and returns to TB2–2. An externally mounted RX resistor provides the return path for the output current to the Phase Analog Common TB2–3 as shown in Figure 13. A voltage is produced across the external resistor that exactly matches the voltage at Q24–Pin 3. The circuit from TB2–2 to Q24–Pin 2 is a very high impedance, and the voltage at Q24–Pin 2 exactly matches the voltage at Q24–Pin 3. The voltage at Q24–Pin 6 will automatically be adjusted by Q24 so that the voltages at Q24–Pin 3 and Q24–Pin 2 are equal. The current through the external load is equal to the voltage at Q24–Pin 3 (+ Input) divided by the value of RX (1 K for 0 to 1 mA output level).

■ NOTE: Refer to the **ANALOG OUTPUTS** section in the M–0388 Application Guide for scaling information for the analog outputs.

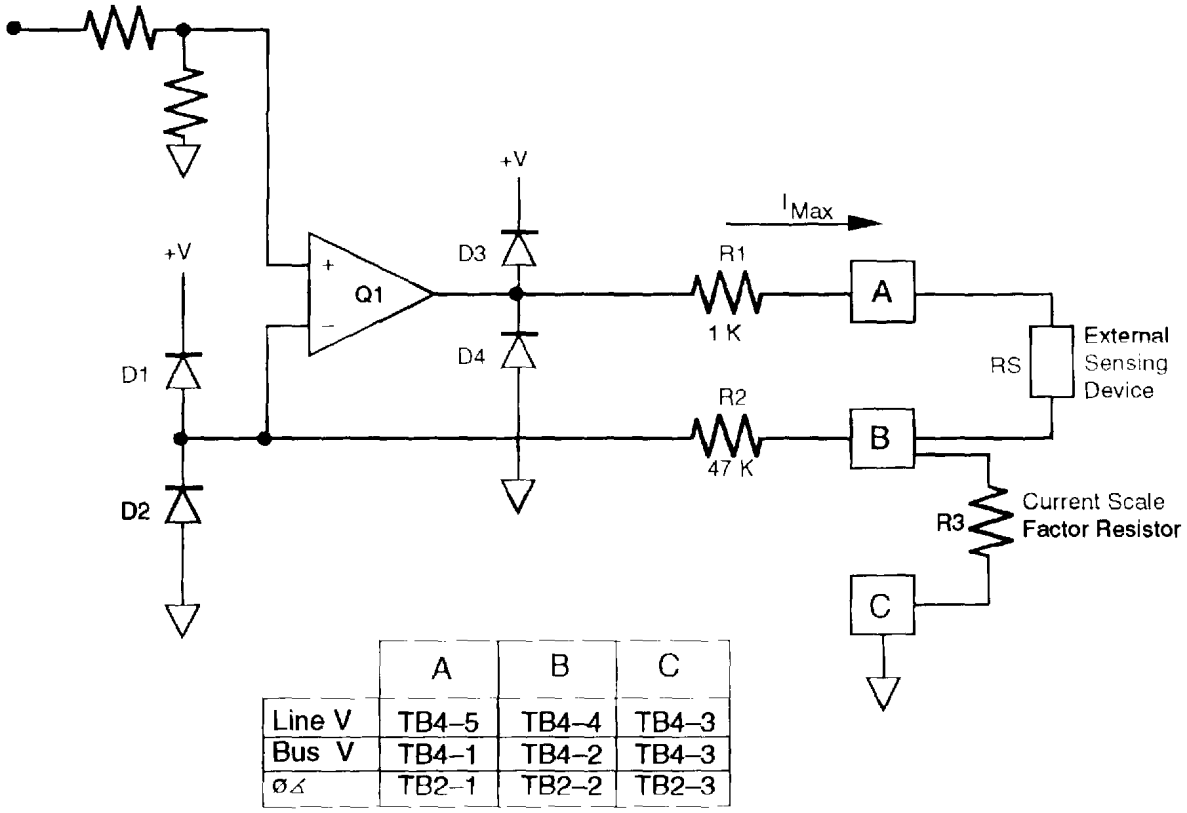
Phase Angle Comparator

The Phase Angle Comparator (see Figure 16) compares the Phase Angle Analog Voltage to a voltage determined by the R34 setting, the **PHASE LIMIT** control. If the phase angle voltage is less than the R34 voltage, then the Angle OK output at Q20–Pin 7 is equal to 10.0 V dc. If the phase angle voltage is greater than the R34 voltage, Q20–Pin 7 is approximately 0 V dc.



	A	B	C
Line V	TB4–5	TB4–4	TB4–3
Bus V	TB4–1	TB4–2	TB4–3
ø∠	TB2–1	TB2–2	TB2–3

FIGURE 14 Voltage Analog Output Connections



	A	B	C
Line V	TB4–5	TB4–4	TB4–3
Bus V	TB4–1	TB4–2	TB4–3
ø∠	TB2–1	TB2–2	TB2–3

FIGURE 15 Current Analog Output Connections

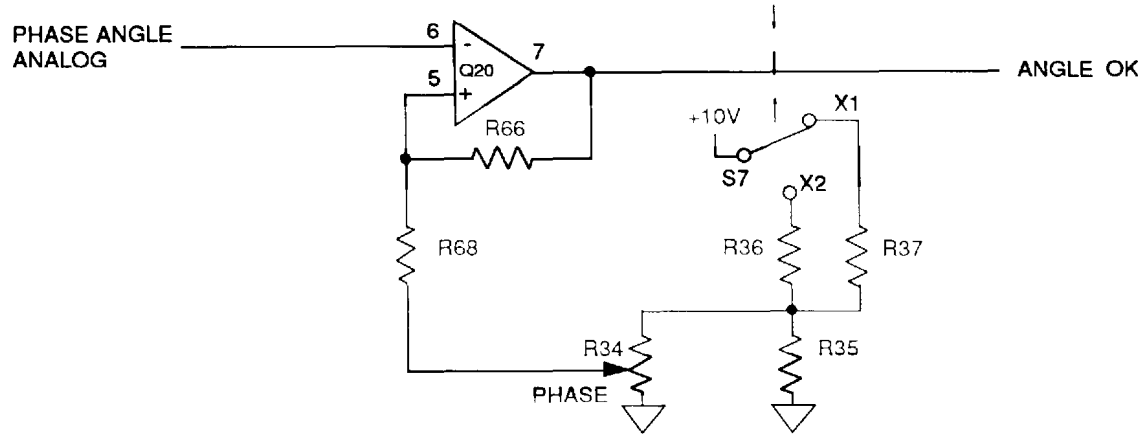


FIGURE 16 Phase Angle Comparator Schematic

The voltage on the wiper of R34 is determined by the setting of S7 (the **PHASE** range switch), the resistor divider R36/R37 and R35, and by the angular adjustment of R34. With S7 in the **X1** position, the M–0388 **PHASE LIMIT** adjustment range is 0 to 45°, via R34. The voltage at the junction of R37, R35 and R34 is established at 2.5 V dc by these resistors and the +10 V reference. With S7 in the **X2** position, the M–0388 **PHASE LIMIT** adjustment range is 0 to 90°, via R34. The voltage at the junction of R36, R35 and R34 is +5.0 V dc. When S7 is in the **X2** position, D40 (labeled **X2** on the front panel) will light, indicating the setting is multiplied by 2.

Time Delay

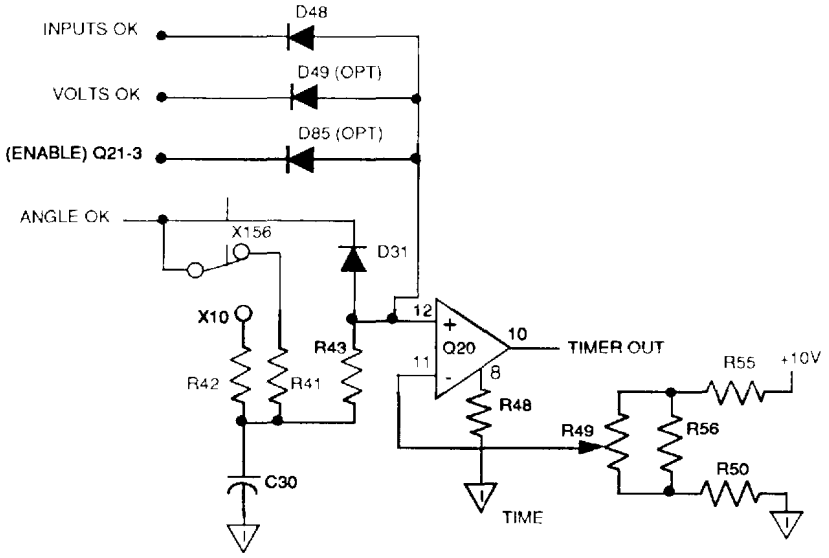


FIGURE 17 Time Delay Schematic

The Time Delay circuit, shown in Figure 17, provides an adjustable time delay using an RC timer and high impedance comparator. Potentiometer R49, the front panel **TIME LIMIT** control, and the associated resistors form a precision voltage divider. The angular setting of R49 determines the time delay by setting the voltage at Q20–Pin 11. When the Angle OK signal is at 0 V, the output at Q20–Pin 10 is also 0 V.

When the Angle OK signal goes to +10.0 V, the voltage at Q20–Pin 11 rises as C30 is charged from R42 or R41. When the voltage on C30 exceeds the voltage at Q20–Pin 11, the output at Q20–Pin 10 goes to +10 V, indicating that the angle has been OK for the prescribed time period. When the Angle OK signal goes to 0 V, the voltage on C30 is quickly discharged through R43 and D31, resetting the timer. The X1 or X10 time delay range is determined by the setting of S6, the **TIME** range switch. In the **X1** setting, the R41 X C30 time constant is 1 sec., and the range of the R49 (**TIME LIMIT** dial) adjustment is from 0 to 1.5 sec. In the **X10** position, the R42 X C30 time constant is 10 sec., and the R49 adjustment range is from 0 to 15 sec. Also in this position, D41 will light to indicate that the setting of S6 is in the **X10** position. The charging of C30 will be blocked if any one of the following three possible conditions is present.

1. In all cases, D48 will stop the timer from timing if the Inputs OK signal is not high. This prevents the timer from timing if one input voltage is below approximately 60 V rms.

If the Sync-Check Enable Timer Logic Option (timer is blocked if M-0388 is not enabled) or the Voltage Verifier Timer Logic Option (timer is blocked if M-0389 voltages are out of range) is selected, D85 and D49 are added, respectively. D85 and D49 are diodes that will block the timer under the following conditions:

2. D85 - The M–0388 is not Enabled, i.e., TB2–4 to TB2–5 is not shorted.

3. D49 - The voltage conditions, as sensed by the M–0389, are not within the settings of the relay.

If the voltage is within the setpoints and the M–0388 is enabled, the timer will time out.

Control Logic

Refer to Figure 18. The Control Logic ensures that all conditions are correct before closing the Output Relay. The following are the major parameters checked.

1. Bus and Line inputs are applied.
2. M–0388 is enabled.
3. Phase angle is within limits.
4. Voltage is within limits (if M–0389 is installed).
5. Time delay is completed.
6. Unit is in **OPERATE**, not in the **TEST** mode.
7. +24 V dc supply is within specifications.

Additionally, if the M–0389 Voltage Verifier is installed, and the Dead Closing is enabled, the Output Relay will be closed for Dead Line/Hot Bus or Dead Bus/Hot Line without checking parameters 1 through 6, above.

The Inputs OK signal (1) at Q22–Pin 11 will be high (approximately +15 V dc) when both the Bus Rect [L] and Line Rect [M] voltages from the Power Supply Board are greater than approximately 20 V dc. This will be the condition when the Bus and Line V.T. inputs are applied and are greater than 90 V ac. When one of the V.T. inputs drops below approximately 60 V ac (the Bus Rect [L] or Line Rect [M] drops below approximately 16 V dc), the Inputs OK signal will go low (0 V). Therefore, if one of the inputs is disconnected or is less than 60 V ac, the Output Relay will be disabled. When the Inputs OK signal is low (approximately 0 V), the Φ OK [F] signal is pulled low by D45 so that the **PHASE LIMIT OK** LED on the front panel will be off, and the Phase Status Relay on the Power Supply Board will be de-energized.

The Enabled signal (2) will go high after approximately 0.15 sec. if an external Enable (short circuit) is applied between TB2–5 and TB2–4, and the Inputs OK signal (1) is high. R67 and C40 are used to delay this signal after the above conditions are satisfied. D44 holds the timer (R67,C40) reset if the Inputs OK signal is low. When Enabled signal (Q25–Pin 4) is low, the Close signal (R54, R65 junction) is held low via D39.

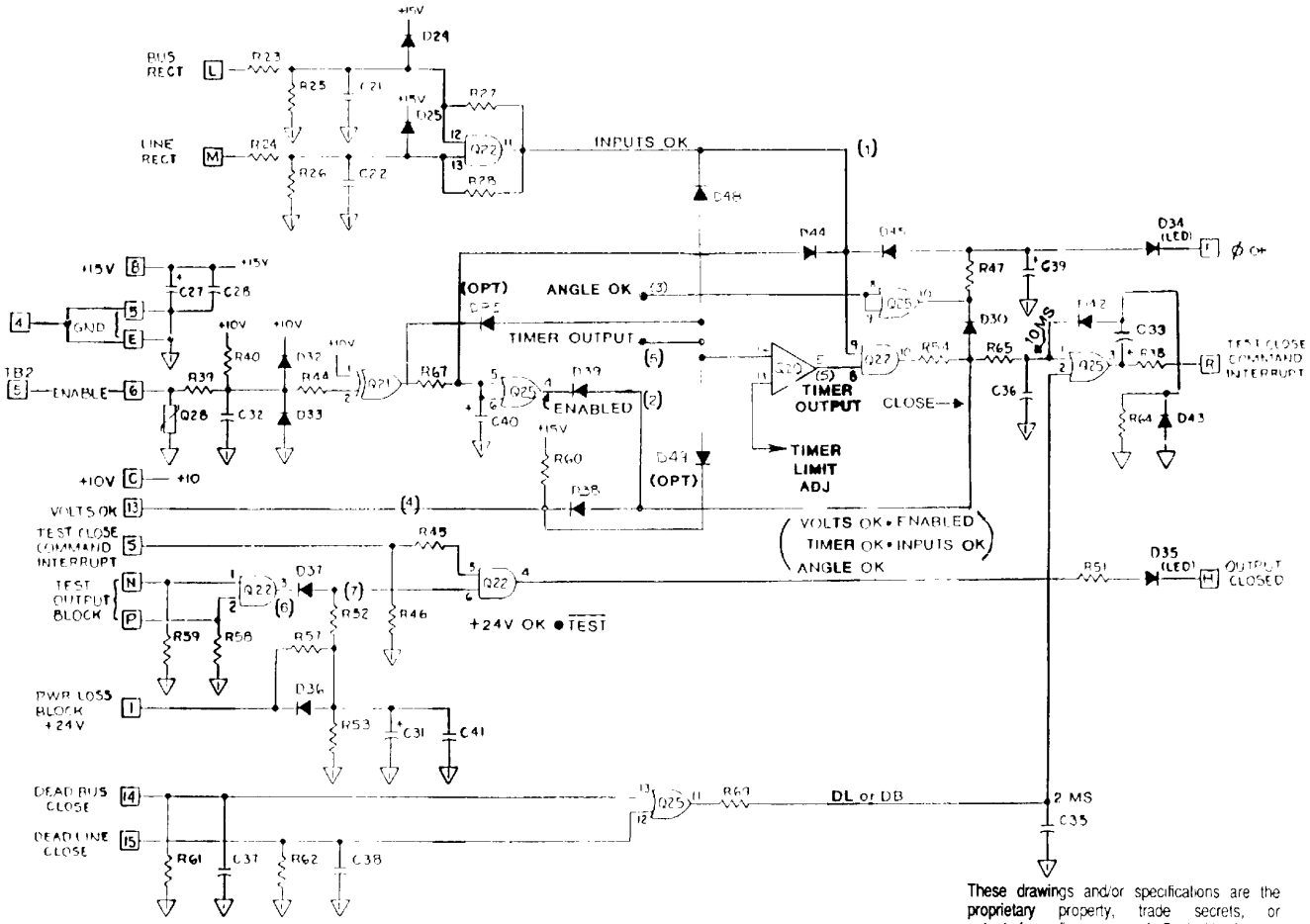


FIGURE 18 Control Logic Schematic

The Close signal is also kept low by the action of the Angle OK (3) signal and the Timer Output (5). When the Angle OK is high, the voltage at D30-Cathode goes high, lighting the **PHASE LIMIT OK** LED (D34) by the current flowing through R47 from Q25–Pin 10. This current also turns on the Phase Status Relay drive transistor on the Power Supply Board via terminal [F] (Φ OK). With the voltage at Q25–Pin 10 high, D30 is reverse–biased, allowing the Close signal to go high.

With the Timer Output (5) high and the Inputs OK (1) high, the voltage at Q22–Pin 10 will go high. This forces the Close signal to go high via current through R54, assuming D30, D38 and D39 are reverse-biased. As the Close signal goes high, the voltage at Q25–Pin 1 goes high after a 10 ms time delay provided by R65 and C36. The time delay is provided to ensure that no noise voltages can force Q25–Pin 1 high. Q25–Pin 2 will go high if the M–0389 is installed and if the Dead Line and Dead Bus conditions are satisfied.

When either input (Q25–Pin 1 or Q25–Pin 2) goes high, the output at Q25–Pin 3 will go high. Components R64, D43, D42 and C33 are used to keep this signal high for at least 100 ms before it can go low, even if the input goes low. The voltage at [R] goes high when Q25–Pin 3 goes high. This voltage goes to the Power Supply Board. If both **OPERATE/TEST** switches are in the **OPERATE** position, this voltage returns to terminal [S], forcing the voltage at Q22–Pin 5 high.

The voltage at Q22–Pin 6 will be high if the +24 V supply voltage is greater than approximately 20 V dc, a the two signals on the [N] and [P] terminals from the Power Supply Board are high. With Q22– Pin 5 and Q22–Pin 6 high, the output at Q22–Pin 4 goes high. This output then forces a current through R51 and D35 (**OUTPUT CLOSED** LED). This current flows from [H] to the Power Supply Board and turns on the Output Relay drive circuit, closing the Output Relay Contacts at TB1–1 to TB1–2 and TB1–3 to TB1–4.

The Volts OK signal (4) is forced high by the +15 V supply through R60, unless the M–0389 is installe unit. If the M–0389 is installed, the signal at [13] is forced high or low by the output of the M–0389 circuitry.

PARTS LIST

M–0388 Syncrocloser® Check Relay

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 PROCEDURES** Section must be followed in replacing these components.

All resistors are 1/2 W unless noted.

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
		MOTHER BOARD, B-0173
	450-00047*	Printed Circuit Board, P-0517
C1-C15	000-00939	Capacitor, Ceramic Disc, 0.0047 µF ±20%, 3 kV
C16,C17	000-00905	Capacitor, Ceramic Disc, 0.05 µF ±80-20%, 600 V
J1-J3	420-00074	Connector, 30-Pin, AMP 583660-2
K1	430-00153	Relay, 24 V dc, IDEC RH-4BU-24VDC
TB1	420-00018	Terminal Block, 4-position, Cinch Jones 4-142-Y
TB2-TB4	420-00075	Terminal Block, 30 pin, 8-position, Curtis 38210-8
VR2-VR3	400-00709	Varistor, 250 V, GE V250LA2

REV 1

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
DEAD LINE AND DEAD BUS RELAY OPTION		
K2	430-00199	Relay, DPDT, 12 V dc, American Zettler AZ-420-C07-4WLVS
R1	200-00301	Resistor, Carbon Film, 300 Ω ±5%
VR1	400-00001	Diode, Zener, 6.2 V ±5%, 400 mW, 1N753A
REV F		
PANEL ASSEMBLY, B-0179		
J1,J4	420-00207	Banana Jack - Red, Johnson 108-0902-001
J2,J3	420-00208	Banana Jack - Black, Johnson 108-0903-001
T1,T2	410-00030*	Input Transformer, U-0085
POWER SUPPLY BOARD, B-0168		
	450-00050*	Printed Circuit Board, P-0519
C1-C3	000-00904	Capacitor, Ceramic Disc, 0.01 µF ±20%, 1 kV
C4	000-00643	Capacitor, Electrolytic, 470 µF ±20%, 50 V
C5,C6	000-00917	Capacitor, Ceramic Disc, 0.01 µF ±20%, 50 V
C7,C8	000-00018	Capacitor, Electrolytic, 1.5 µF ±20%, 50 V
C9	000-00939	Capacitor, Ceramic Disc, 0.0047 µF ±20%, 3 kV
D1-D6,D10,D11	400-00232	Diode, Fairchild, 1N4004
D7	400-00061	Diode, Zener, 36 V ±5%, 5 W, 1N5365B
D8	400-00083	Diode, Zener, 18 V ±5%, 400 mW, 1N5248B
D9	400-00224	Diode, Signal, 1N4148

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
D12	400-00729	Diode, Light Emitting, IDI 4305H1
F1,F2	420-00719	Fuse, 125 V, 1 A, Littelfuse 273001
K1	430-00151	Relay, 24 V dc, American Zettler AZ4UP-E-1C-24D
Q1,Q3,Q8	400-00724	Varistor, 250 V ac, Panasonic ERZ-C14DK391
Q2,Q4	400-00718	Varistor, 1 kV ac, G.E. V1000LA80A
Q5	400-00667	Voltage Regulator, National LH0070-OH
Q6	400-00426	Power Transistor, Motorola MJE181
Q7	400-00673	Transistor Array, Motorola MPQ3904
Q9-Q12	400-00709	Varistor, 250 V ac, G.E. V250LA2
R1	220-00100	Resistor, Carbon Comp., 10 Ω ±10%, 1 W
R2	200-00472	Resistor, Carbon Film, 4.7 K ±5%
R3	200-00100	Resistor, Carbon Film, 10 Ω ±5%
R4	370-00580	Resistor, Molded Metal Film, 66.5 K ±1%, 1/8 W, RN55D
R5	370-00630	Resistor, Molded Metal Film, 200 K ±1%, 1/8 W, RN55D
R6,R7	200-00473	Resistor, Carbon Film, 47 K ±5%
R8,R9	200-00104	Resistor, Carbon Film, 100 K ±5%
S1,S2	430-00063	Switch, 4PDT, C & K 7401-AV2G
REV G		

PHASE VERIFIER BOARD, B-0167

	450-00049*	Printed Circuit Board, P-0514
C19		Not Used
C20,C28,C29,C34, C37,C38	000-00917	Capacitor, Ceramic Disc, 0.01 µF, 50 V

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
C21,C22,C32	000-00811	Capacitor, Polyester, 0.1 ±10%, 100 V
C23,C35,C36	000-00909	Capacitor, Ceramic Disc, 0.1 µF +80%/-20%, 25 V
C24	000-00839	Capacitor, Polyester, 0.33 µF ±10%, 63 V
C25	000-00823	Capacitor, Polyester, 0.39 µF ±10%, 250 V
C26	000-00840	Capacitor, Polyester, 0.068 µF ±10%, 250 V
C27,C31,C33,C39-C41	000-00553	Capacitor, Tantalum, 2.2 µF ±10%, 25 V
C30	000-00826	Capacitor, Mylar, 1 µF ±5%, 100 V
D20-D30,D32,D33, D36-D39,D42-D45	400-00224	Diode, Fairchild, 1N4148
D31,D48	400-00225	Diode, Fairchild FD333
D34,D35,D40,D41	400-00729	Diode, Light Emitting, IDI 4305H1
D46,D47		Not Used
Q20	400-00669	Quad Programmable Comparator, Motorola MC14574CL
Q21	400-00670	Quad Exclusive OR-Gate, 14-Pin, Motorola MC14070BCL/BAL
Q22	540-00035	Quad 2-Input AND-Gate, 14-Pin, Motorola MC14081BAL
Q23,Q24	400-00672	Op Amp, 8-pin, RCA CA316OT
Q25	540-00045	Quad 2-Input OR-Gate, 14-pin, RCA CD4071BF
Q26-Q28	400-00709	Varistor, 250 V, G.E. V250LA2
R20,R21,R64,R65	200-00104	Resistor, Carbon Film, 100 K ±5%
R22,R48	200-00105	Resistor, Carbon Film, 1 M ±5%
R23,R24,R68	200-00303	Resistor, Carbon Film, 30 K ±5%
R25,R26	200-00243	Resistor, Carbon Film, 24 K ±5%
R27,R28	200-00154	Resistor, Carbon Film, 150 K ±5%

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R29-R31	390-00609	Resistor, Molded Metal Film, 121 K ±1%, 1/8 W, RN55D
R32,R52	200-00102	Resistor, Carbon Film, 1 K ±5%
R33,R39,R44-R46, R54	200-00473	Resistor, Carbon Film, 47 K ±5%
R34,R49	360-00107	Potentiometer, 50 K ±5%, Bourns 3345W-1-503
R35,R56	390-00473	Resistor, Molded Metal Film, 5.62 K ±1%, 1/8 W, RN55C
R36	390-00468	Resistor, Molded Metal Film, 4.99 K ±1%, 1/8 W, RN55C
R37	390-00518	Resistor, Molded Metal Film, 15.0 K ±1%, 1/8 W, RN55C
R38,R47,R51,R63	200-00682	Resistor, Carbon Film, 6.8 K ±5%
R40	200-00204	Resistor, Carbon Film, 200 K ±5%
R41	370-00701	Resistor, Molded Metal Film, 1 M ±1%, RN55D
R42	340-00023	Resistor, Metal Film, 10 M ±2%
R43	200-00472	Resistor, Carbon Film, 4.7 K ±5%
R50	200-00151	Resistor, Carbon Film, 150 Ω ±5%
R53	370-00630	Resistor, Molded Metal Film, 200 K ±1%, 1/8 W RN55D
R55	390-00416	Resistor, Molded Metal Film, 1.43 K ±1%, 1/8 W, RN55C
R57	370-00647	Resistor, Molded Metal Film, 301 K ±1%, 1/8 W, RN55D
R58-R62	200-00474	Resistor, Carbon Film, 470 K ±5%
R66	200-00106	Resistor, Carbon Film, 10 M ±5%
R67	200-00683	Resistor, Carbon Film, 68 K ±5%
R69	200-00203	Resistor, Carbon Film, 20 K ±5%
S6,S7	430-00074	Switch, DPDT, 0.4 VA Gold Contacts Toggle

REV U

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
		PHASE ANALOG OUTPUT
		VOLTAGE OPTION
R70	200-00682	Resistor, Carbon Film, 6.8 K ±5% (Same as R38)
R71		Not Used
		CURRENT OPTION
R70	340-00020	Resistor, Metal Film, 10.2 K ±0.1%, 1/4 W, RN60E
R71	340-00021	Resistor, Metal Film, 1.13 K ±1%, 1/4 W, RN60E
		SYNC-CHECK ENABLE TIMER LOGIC OPTION
	■ NOTE: Timer is blocked if M-0388 is not enabled.	
D85	400-00225	Diode, Fairchild FDH333
		VOLTAGE VERIFIER TIMER LOGIC OPTION
	■ NOTE: Timer is blocked if M-0389 voltages are out of range.	
D49	400-00225	Diode, Fairchild FDH333

M–0389 VOLTAGE VERIFIER

Refer to Figures 19, 20 and 21. The M–0389 Voltage Verifier is an optional voltage monitor board that can be used with the M–0388 Syncrocloser® Check Relay. The M–0389 adds precise Overvoltage, Undervoltage and Dead Line and Dead Bus functions to the M–0388.

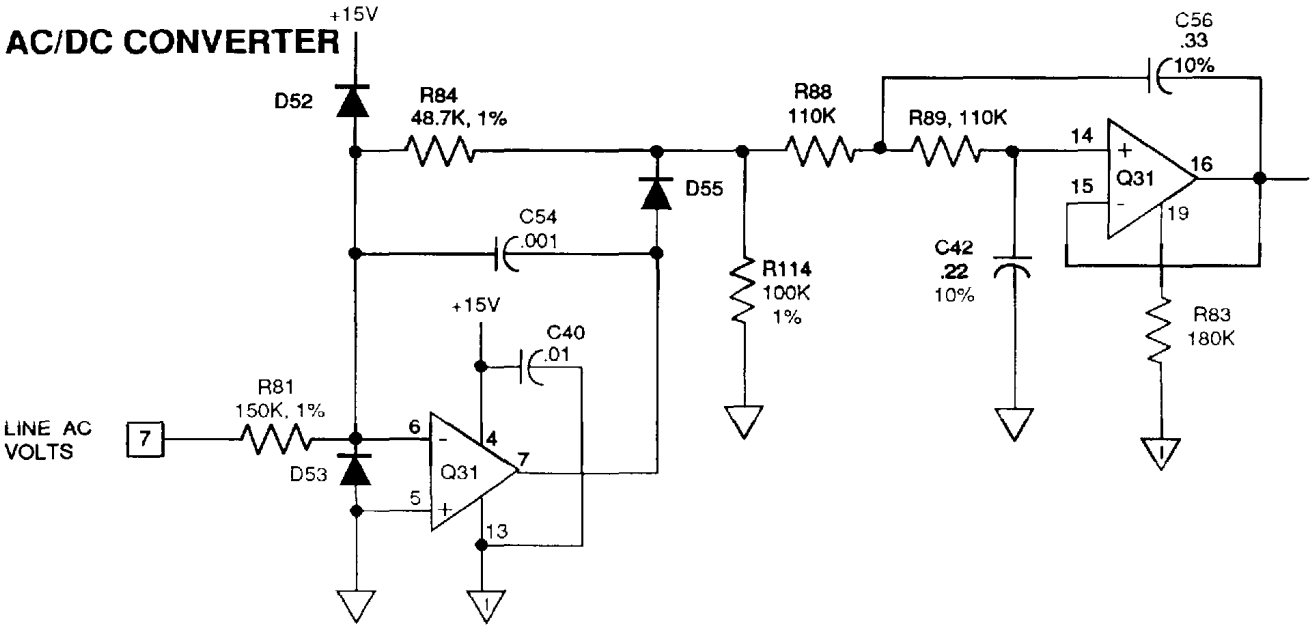


FIGURE 19 Ac/Dc Converter Schematic

Refer to Figure 19. There are two identical Ac/Dc Converter circuits on the M–0389. The Line Voltage circuit is shown above. The Bus Voltage circuit is identical except for the components used.

The Ac/Dc Converter consists of a full-wave rectifier and a low-pass filter. The Line Ac Volts inputs at [7] and Bus Ac Volts at [6] are sinusoidal voltages from the secondaries of T1 and T2 on the Power Supply Board. The Line V dc and Bus V dc outputs are scaled for 0.05 V dc/V rms, such that when the voltage input is equal to 150 V rms, the output equals 7.5 V dc.

Components R81, R84, R114, D55 and C54 work with 1/4 of the quad Q31 amplifier (pin 7 output) to make up a full-wave rectifier circuit. With the input [7] positive, D55 becomes reverse-biased, and the Q31 amplifier is not active in the circuit. The voltage at D55-Cathode (band end) is determined by the voltage divider formed by the three resistors. With the Line input negative, the output at Q31–Pin 7 goes positive, such that the cathode voltage of D55 equals R84/R81 times Line Ac Volts [7]. Diodes D52 and D53 protect Q31 from any voltage transients on the Line Ac voltage, clamping the voltage at Q31–Pin 6 to +15.7 V or -0.7 V maximum.

The second Q31 amplifier section (output Q31–Pin 16) and the components R88, R89, C42 and C56 are a low-pass filter that convert the D55-Cathode voltage to a dc voltage equal to the average value of the voltage at D55-Cathode.

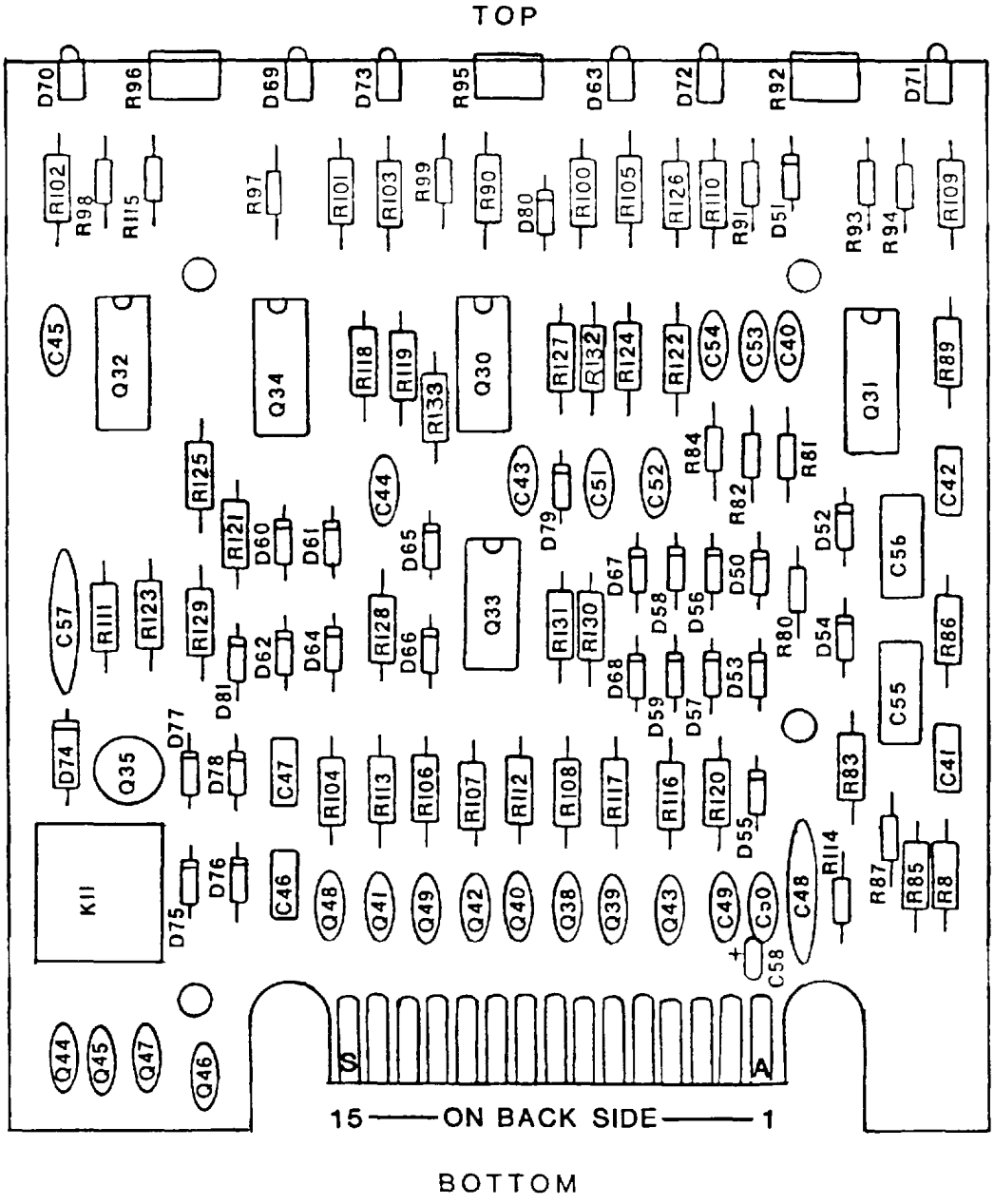


FIGURE 20 Voltage Verifier Board Component Location

TRANSDUCER AMPLIFIERS

Refer to Figures 20 and 21. Two of the amplifiers labeled Q33 are buffers used to provide analog transducer outputs. These are the outputs of Q33–Pin 14 and Q33–Pin 8. These circuits are identical to the Phase Angle Transducer Amplifier, discussed previously, except for the scaling.

UPPER AND LOWER VOLTAGE LEVEL DETECTION

The four amplifiers labeled Q30 and the two labeled Q33 with outputs on Q33–Pin 1 and Q33–Pin 7 are level detectors that compare the front panel **UPPER** and **LOWER VOLTAGE LIMIT** settings to the dc voltage that represents the Bus and Line input levels.

The **UPPER VOLTAGE LIMIT** control potentiometer R96, and the associated bias resistors R98, R115 and R97 form a voltage divider from the +10 V reference, such that the R96 wiper voltage varies from 7.0 V dc to 5.5 V dc as R96 is adjusted from 140 V to 110 V ac, respectively. When the Bus voltage is less than the R96 setting, the output at Q33–Pin 1 is low (0 V), forcing the output of Q34–Pin 4 high (approximately 14 V) and lighting the D69 **UPPER VOLTAGE LIMIT B OK** LED. When the Line voltage is less than the R96 setting, the **UPPER VOLTAGE LIMIT L OK** LED D70 will light.

The **LOWER VOLTAGE LIMIT** control potentiometer R92, and the associated resistors form a bias network for low voltage detection. An R92 adjustment from 90 V ac to 120 V ac charges the R92-wiper voltage from 4.5 V dc to 6.0 V dc, respectively. When the Bus and Line inputs are higher than the R92 setting, amplifier outputs Q30–Pin 14 and Q30–Pin 8 are forced high, lighting the **LOWER VOLTAGE LIMIT L OK** and **B OK** LEDs. If either or both inputs are less than the R92 setting, the appropriate amplifier output is at 0 V, extinguishing the LED.

When the two Upper and two Lower Voltage conditions are within limits (i.e., D69 through D72 LEDs will be on), the logic gate output at Q32–Pin 13 will go high. This forces current through R111, turning on Q35. When Q35 turns on, the Voltage Status Relay (K11) will energize, indicating all voltage conditions are correct. After approximately 10 ms, the voltage on C57 will charge up to a level to force Q32–Pin 1 high. This forces the Volts OK [13] signal on the Phase Verifier Board high, allowing the Output Relay to close.

DEAD LINE/DEAD BUS DETECTORS

The Dead Line/Dead Bus detectors are used to detect the Dead Line/Hot Bus condition or the Dead Bus/Hot Line condition of the inputs.

A dc voltage level from 0 to 3 V dc is established by the setting of R95, the **DEAD LINE/BUS LIMIT** control on the ΔF detector board. This dc level corresponds to an input level of from 0 to 60 V rms. When the Bus or Line input(s) exceed this setting, the outputs of Q30–Pin 1 (Bus) and Q30–Pin 7 (Line) go high. The **L HOT** (Line) or **B HOT** (Bus) LEDs will light to indicate an input level that exceeds the control setting. Logic gate Q34 is used to invert the signal, and the outputs at Q34–Pin 10 and Q34–Pin 11 are low when the appropriate input is high.

If either voltage input drops below the R95 setting, the respective Q30 output will go low, extinguishing the appropriate LED, and the logic gate output will go high.

In order for the output relay to close, an external enable circuit must be made from terminals:

Dead Bus Closing - TB3–5 to TB3–6
Dead Line Closing - TB3–7 to TB3–8

If the external enable circuits are closed, the voltage at [12] will appear on [11], and the voltage on [10] will appear on [9], respectively.

The diodes D60 through D62, D64, D75 through D78, resistors R104, R106, R112, R113 and surge suppressors Q40, Q41, Q48 and Q49 are used to protect the M–0388/M–0389 circuitry from transients that could be coupled into the external enable circuit. Capacitors C46 and C47 provide noise filtering to reduce the effect of high frequency noise pickup on the external enable circuit.

The voltages on [9] and [11] pass through the printed circuit board to [13] and [14] and then go to the Phase Verifier Board via the Mother Board.

A high voltage (greater than 11 V dc) on [9] or [10] will force the M–0388 Output Relay to close if all conditions on the Phase Verifier Board are correct, as described previously under **Control Logic** in the **Phase Verifier Board Functions** section.

PARTS LIST

M–0389 Voltage Verifier

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 PROCEDURES** Section must be followed in replacing these components.

All resistors are 1/2 W unless noted.

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
	450-00053*	Printed Circuit Board, P-0532
C40,C43-C45,C49, C50	000-00917	Capacitor, Ceramic Disc, 0.01 µF ±20%, 50 V
C41,C42	000-00829	Capacitor, Polyester, 0.22 µF ±10%, 100 V
C46,C47	000-00811	Capacitor, Polyester, 0.1 µF ±10%, 100 V
C48,C57	000-00914	Capacitor, Ceramic Disc, 0.1 µF ±20%, 50 V
C51-C54	000-00913	Capacitor, Ceramic Disc, 0.001 µF ±10%, 1 kV
C55,C56	000-00821	Capacitor, Polyester, 0.33 µF ±10%, 100 V
C58	000-00553	Capacitor, Tantalum, 2.2 µF ±10%, 25 V
D50-D62,D64-D68, D75-D81	400-00224	Diode, Fairchild, 1N4148

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
D63,D69-D73	400-00729	Diode, Light Emitting, IDI 4305H1
D74	400-00232	Diode, Fairchild, 1N4004
K11	430-00151	Relay, 24 V, American Zettler AZ4-UP-E-1C-240
Q30,Q33	400-00665	Quad Op Amp, National LM224J
Q31	400-00689	Quad Programmable Op Amp, Motorola MC14573-1AL
Q32	400-00635	Dual 4-Input AND-Gate, Motorola MC14082BAL
Q34	400-00634	Quad NAND-Gate, Motorola MC14011BAL
Q35	400-00300	Transistor, NPN 2N1711
Q36,Q37		Not Used
Q38-Q49	400-00709	Varistor, 250 V, G.E. V250LA2
R80,R81	390-00618	Resistor, Molded Metal Film, 150 K ±1%, 1/8 W, RN55C
R82,R84	390-00567	Resistor, Molded Metal Film, 48.7 K ±1%, 1/8 W, RN55C
R83	200-00184	Resistor, Carbon Film, 180 K ±5%
R85,R86,R88,R89	200-00114	Resistor, Carbon Film, 110 K ±5%
R87,R114	390-00601	Resistor, Molded Metal Film, 100 K ±1%, 1/8 W, RN55C
R90,R118,R121, R122,R124,R129	200-00242	Resistor, Carbon Film, 2.4 K ±5%
R91	390-00442	Resistor, Molded Metal Film, 2.67 K ±1%, 1/8 W, RN55C
R92,R95,R96	360-00111	Potentiometer, 10 K ±5%, Bourns 3345
R93,R115	390-00406	Resistor, Molded Metal Film, 1.13 K ±1%, 1/8 W, RN55C
R94	390-00447	Resistor, Molded Metal Film, 3.01 K ±1%, 1/8 W, RN55C
R97	390-00455	Resistor, Molded Metal Film, 3.65 K ±1%, 1/8 W, RN55C
R98	390-00430	Resistor, Molded Metal Film, 2.00 K ±1%, 1/8 W, RN55C
R99	390-00536	Resistor, Molded Metal Film, 23.2 K ±1%, 1/8 W, RN55C

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R100,R119,R125-R128	200-00244	Resistor, Carbon Film, 240 K ±5%
R101-R103,R105, R109,R110	200-00472	Resistor, Carbon Film, 4.7 K ±5%
R104,R106,R108, R112,R113,R117	200-00473	Resistor, Carbon Film, 47 K ±5%
R107,R116	200-00102	Resistor, Carbon Film, 1 K ±5%
R111	200-00103	Resistor, Carbon Film, 10 K ±5%
R120	200-00753	Resistor, Carbon Film, 75 K ±5%
R123	200-00104	Resistor, Carbon Film, 100 K ±5%
LINE/BUS VOLTAGE ANALOG OUTPUT		
VOLTAGE OPTION		
R130,R131	200-00473	Resistor, Carbon Film, 47 K ±5%
R132,R133		Not Used
CURRENT OPTION		
R130,R131	340-00022	Resistor, Metal Film, 64.9 K ±0.1%, 1/4 W, RN60E
R132,R133	340-00001	Resistor, Metal Film, 10 K ±0.1%, 1/4 W, RN60E

REV H

MAINTENANCE

Due to the extremely sophisticated nature of the circuitry in the relays, field repair is not recommended. All units are fully calibrated at the factory prior to shipment; there are no user calibration points on the unit. 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. If a printed circuit board is being returned, place it in an anti-static bag and pack it carefully to avoid damage.

■ 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–0388 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.

M–0292 TEST CABLE SET

The M–0292 Test Cable Set was developed to allow the technician to perform a full series of tests on the M–0388, either in the field or lab. Such testing requires voltage readings and switch settings on the slide-out circuit boards, which are either inaccessible when the unit is assembled, or inoperational when the boards are removed. The cables are long enough to allow the technician to place the boards on a convenient working surface, no matter where the unit is located on the relay panel.

REPLACEMENT SUBASSEMBLIES AND PRINTED CIRCUIT BOARDS

The following subassemblies are easily replaced. All but the Back Panel Assembly may be exchanged with power applied.

1. M–0388 Panel Assembly, which includes the Power Supply Board.
2. Phase Verifier Board.
3. M–0389 Panel Assembly, which includes the Voltage Verifier Board.
4. Back Panel Assembly, which includes the terminal blocks, Mother Board, board sockets and Output Relay socket.
5. Output Relay.

SUGGESTED PROCEDURE IN THE EVENT OF TROUBLE

First, check all external connections, then perform the procedures described in the **SIMPLE FIELD TEST** section of the **TEST PROCEDURES**. If the unit does not operate correctly, either return the entire unit to Beckwith Electric, or carefully inspect the printed circuit boards 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 the component or subassembly that needs to be replaced.

■ **NOTE:** If you choose to repair the unit, it is necessary to be completely familiar with the specific circuitry involved and have an adequate understanding of field effect devices.

If no obvious problem exists, the **DETAILED TEST PROCEDURES** may be followed until a portion of a circuit is detected which does not perform as expected. This procedure should lead to a determination of the defective component.

▲ **CAUTION: Do not reverse polarity of V.T. leads to the rear terminal block if the unit is taken out for maintenance.**

EQUIPMENT REQUIRED

1. Two (2) distortion-free 60 Hz variable voltage sources, as follows:

   a. A variable phase, variable voltage source (60 Hz) capable of providing 120 V ac. Maximum phase jitter of 1°.
   b. A fixed phase, variable voltage source (60 Hz) capable of providing 120 V ac. Maximum phase jitter of 1°.

   The output voltage of both sources should be variable from 0 to 150 V ac. The variable phase source should be phase-locked to the fixed phase source, with the phase difference between the two variable from 0 to ±180°.

■ **NOTE:** A Beckwith Electric GRAM–II is ideal for these sources, providing perfect isolation and voltage regulation.

2. Two (2) digital multimeters with ac and dc accuracy of 0.2% of full scale ±1 least significant digit; Hewlett-Packard 3465A or equivalent.

3. Solder sucking syringe or solder wick.

4. Soldering iron - Weller Controlled Output Soldering Station, model MTCPL, 60 W, 120 V, 50/60 Hz or equivalent.

5. A stopwatch or any accurate timing device.

> ▲ **CAUTION: Any attempt to measure resistances on the printed circuit board may cause damage to the unit.**

COMPONENT REPLACEMENT PROCEDURE

If the **TEST PROCEDURES** described below reveal that you must replace a faulty component, please follow the replacement procedures exactly.

1. To gain access to the circuit board, remove the clear plastic dust cover from the unit. Modular cards can now be easily removed, 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 conformal 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.

4. 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 that are mounted with a transipad, make sure to insert the new 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.

> ■ **NOTE:** Components have been chosen whose normal drift will be negligible in their effect on calibration. Therefore, no calibration adjustments are provided. A change in a specified reading should be interpreted as an indication of an abnormal component change. The proper procedure is to replace or repair the defective subassembly or printed circuit board.

TEST PROCEDURES

SETUP PROCEDURE

▲ CAUTION: This unit contains sensitive MOS circuitry which can be damaged by improper handling and rework procedures. Care should be taken to avoid static charge on work surfaces. Both OPERATE/TEST switches must be in the lower or TEST position before removing or installing the M–0388 or M–0389 subassemblies.

1. Disconnect all external connections. (Not required in the SIMPLE FIELD TEST procedure.)
2. Supply 120 V ac, 60 Hz to Bus input terminal TB3–1 and TB3–2, noting that TB3–1 is polarity (Hot). (For the SIMPLE FIELD TEST, use the front panel BUS jacks.)
3. Supply 120 V ac, 60 Hz to Line input terminal TB3–3 and TB3–4, noting that TB3–4 is polarity (Hot). (For the SIMPLE FIELD TEST, use the front panel LINE jacks.)
4. Connect the Enable Jumper from TB2–4 to TB2–5 (required in both procedures).

SIMPLE FIELD TEST

When field testing an installed unit which has voltage applied, set the two OPERATE/TEST switches to the TEST or lower position. These switches, located on the M–0388 front panel, internally disable the M–0388 Output Relay and disconnect the Bus and Line V.T. inputs. This isolates the V.T. inputs of the M–0388 from the external wiring and ensures that the Output Relay Contact will not close while the unit is being tested. With both switches in the TEST position, the unit may be checked by applying 120 V ac nominal Bus and Line V.T. inputs at the respective jacks on the M–0388 front panel. If all conditions are met for closing the Output Relay, the TEST CLOSE LED, adjacent to the OPERATE/TEST switches, should light.

If during field testing, the TEST CLOSE LED does not light, check the resistances across the rear terminals, as shown in the TYPICAL RESISTANCES section. If a resistance measurement is out of specification, the DETAILED TEST PROCEDURES should be followed, or the unit should be returned to the factory.

■ NOTE: After simple field testing is completed, be sure to return both switches to the OPERATE position to allow the Output Relay Contact to close.

DETAILED TEST PROCEDURES

M–0292 TEST CABLE SET

In the event the SIMPLE FIELD TEST described above does not identify the problem, the optional M–0292 Test Cable Set allows the technician to perform a full series of tests on the M–0388 and M–0389, either in the field or lab. Such testing requires voltage readings and switch settings on the slide-out circuit boards, which are either inaccessible when the unit is assembled, or inoperational when the boards are removed. The cables are long enough to allow the technician to place the boards on a convenient working surface, no matter where the unit is located on the relay panel.

RESISTANCE CHECK

Before disassembling the units, perform a resistance check across the rear terminals as listed below in the **TYPICAL RESISTANCES** section.

INSTALLING THE M–0292 TEST CABLE SET

1. Refer to Figure 22.
2. The cables and test boards are all labeled. There must be one test board and cable each for the Power Supply, Phase Verifier, and Voltage Verifier boards.

> ● **WARNING: Turn off V.T. supplies before inserting the test boards. 120 V ac may be present when the test boards are plugged in, posing risk of physical injury.**

3. Remove the clear cover from the relay case by loosening the thumbscrews.

> ▲ **CAUTION: Using the wrong board/cable combination can result in damage to the** components.

4. Loosen the thumbscrews on the front panel of the M–0388 and slide out the panel assembly. The Power Supply Board will slide out with the assembly. Place it on a static-free surface.
5. Remove the Phase Verifier Board from the case, placing it on a static-free surface.
6. Remove the M–0389 Panel Assembly (if applicable). The Voltage Verifier Board will slide out at the same time. Place the assembly on a static-free surface.
7. Slide in the Power Supply test board, making sure the alignment slot in the board mates with the alignment peg in the internal connector of the case. The board should seat securely.
8. Repeat step 6 for the Phase Verifier test board.
9. Repeat step 6 for the Voltage Verifier test board (if applicable).

M–0388 SYNCROCLOSER® CHECK RELAY

> ■ NOTE: Both **TEST/OPERATE** switches must be in the **OPERATE** position.

POWER SUPPLY

The power supply is checked by confirming the voltage readings as listed in the **TYPICAL VOLTAGES** section.

FIGURE 22 M–0292 Test Cable Set Installed in M–0388/M–0389

PHASE

1. Set the **PHASE X1/X2** switch on the Phase Verifier Board to the **X1** (0 to 45°) position.
2. Set the **PHASE LIMIT** control to 15°.
3. Slowly increase the phase difference between the Line and Bus inputs toward 15°. The **PHASE LIMIT OK** LED should light as the angle approaches 15° ±2.25°.
4. Repeat steps 2 and 3 for 40°.
5. Set the **PHASE X1/X2** switch to the **X2** position (0 to 90°). The **PHASE LIMIT X2** LED should light.
6. Repeat steps 2 and 3 for 30° and 80°. Accuracy should be ±4.5° of the dial setting.

TIME

1. Set the **TIME** switch to **X1** (0 to 1.5 sec.).
2. Set the **PHASE LIMIT** control to 5°.
3. Adjust the phase difference between the Line and Bus inputs to 10°.
4. Adjust the **TIME LIMIT** control to full scale (1.5 sec.).
5. Decrease the phase difference between the Line and Bus inputs towards 0°, and start timing when the **PHASE LIMIT OK** LED lights.
6. End timing when the **OUTPUT CLOSED** LED lights. Accuracy should be ±0.15 sec.
7. Set the **TIME** switch to **X10** (0 to 15 sec.). The **TIME LIMIT X10** LED should light.
8. Repeat steps 3 through 6 for 15 sec. Accuracy should be ±1.5 sec.

TIMER LOGIC

Input OK

1. Return the **TIME** switch to the **X1** position (0 to 1.5 sec.). The **TIME LIMIT X10** LED should extinguish.
2. Adjust the phase difference between the Line and Bus inputs to 0°.
3. The Output Relay should close approximately 1.5 sec. ±0.15 sec. after the **PHASE LIMIT OK** LED lights.
4. Slowly decrease the Bus voltage to approximately 60 V rms until the Output Relay drops out.
5. Adjust the Bus voltage back to 120 V rms; the Output Relay should close after a time delay of about 1.5 sec. ±0.15 sec.
6. Return the Bus voltage to 120 V rms.
7. Repeat steps 4 and 5 while decreasing the Line voltage.

Voltage OK

■ **NOTE:** Only complete this section if the M–0389 is installed.

1. Return the Bus and Line voltage to 120 V rms.
2. All of the LEDs on M–0389 should light, and the Output Relay should close.
3. Slowly decrease the Bus voltage until the **LOWER VOLTAGE LIMIT B OK** LED goes off; the Output Relay should drop out.
4. Increase the Bus voltage until the **B OK** LED lights.
5. If the Voltage Verifier Timer Logic Option is used (M-0389 has no effect on the timer operation), the Output Relay should close <u>without</u> a time delay (i.e., closes after approximately 0.3 sec.) after the Bus voltage increases above the **LOWER VOLTAGE LIMIT** setting and the **B OK** LED lights.
6. If the Voltage Verifier Timer Logic Option is used (timer is blocked if M-0389 voltages are out of range), the Output Relay should close <u>after</u> the time delay of about 1.5 sec.

7. Repeat steps 3 through 5 or 6 while decreasing the Line voltage.
8. Repeat steps 3 through 5 or 6 while increasing the Bus and Line voltage above **UPPER VOLTAGE LIMIT** setting.

Sync-Check Enable

1. Return the Bus and Line voltages to 120 V rms and 0° phase. The Output Relay should close.
2. Remove the jumper from TB2–4 to TB2–5 (Enable input); the Output Relay should drop out.
3. Place a jumper between TB2–4 and TB2–5.
4. If the Sync-Check Enable Timer Logic Option is used (enable circuit has no effect on timer operation), the Output Relay should close without a time delay (i.e., closes after approximately 0.3 sec.).
5. If the Sync-Check Enable Timer Logic Option is used (timer is blocked if M-0388 is not enabled), the Output Relay should close after a time delay of about 1.5 sec.

PHASE STATUS RELAY

1. With the **PHASE LIMIT OK** LED lit, check the Phase Status Relay normally-open contact, TB2–6 to [illegible]. The contact should be closed.
2. Check the Phase Status Relay normally-closed contact, TB2–7 to TB2–8. The contact should be open.
3. With the **PHASE LIMIT OK** LED off, check the Phase Status Relay normally-open contact. The contact should be open.
4. Check the Phase Status Relay normally-closed contact. The contact should be closed.

PHASE ANALOG OUTPUT

■ NOTE: The Analog Outputs may be used as either a voltage or current output. Select the test procedure below for the option selected. Refer to Figures 14 and 15 for the Voltage or Current Analog Output Connections.

Voltage Option

1. Place a jumper between TB2–1 and TB2–2.
2. Attach the positive lead of a digital voltmeter to TB2–1 and TB2–2; attach the negative lead to TB2–3.
3. Apply the Line and Bus inputs with the following phase angles and verify the correct analog voltage outputs.

PHASE	OUTPUT VOLTAGE
0°	0.0 V dc ±0.056 V dc
±45°	2.5 V dc ±0.056 V dc
±90°	5.0 V dc ±0.056 V dc
180°	10.0 V dc ±0.056 V dc

Additional tests can be conducted at any angle using the following formula:

$$V_{out} = 0.0556 \times \text{Angle Magnitude; accuracy } \pm 1.0°$$

Current Option

1. Attach the positive lead of a current meter to TB2–1; attach the negative lead to TB2–2.
2. Attach an RN60E 1K ±0.1% resistor from TB2–2 to TB2–3.
3. Apply the Line and Bus inputs with the following phase angles and verify the correct analog current outputs.

PHASE	OUTPUT CURRENT
0°	0.0 mA ±0.017 mA
±45°	0.25 mA ±0.02 mA
±90°	0.5 mA ±0.022 mA
180°	1.0 mA ±0.027 mA

Additional tests can be conducted at any angle using the following formula:

I_{out} = 1/180 mA/degree; accuracy ±3° ±1% of angle

M–0389 VOLTAGE VERIFIER

UPPER VOLTAGE LIMIT

1. Adjust the Line and Bus inputs to 135 V ac.
2. Set the **UPPER VOLTAGE LIMIT** control to 125 V.
3. Slowly decrease the Line and Bus inputs together towards 125 V.
4. The **L OK** and **B OK** LEDs should light as the voltage approaches 125 V ac ±7 V ac.

LOWER VOLTAGE LIMIT

1. Adjust the Line and Bus inputs to 95 V ac.
2. Set the **LOWER VOLTAGE LIMIT** control to 105 V.
3. The **L OK** and **B OK** LEDs should light as the voltage approaches 105 V ±6 V ac.

DEAD BUS LIMIT

1. Place a jumper between TB3–5 and TB3–6 (Enable Dead Bus Close).
2. Set the **DEAD LINE/BUS LIMIT** control to 40 V ac.
3. Slowly reduce the Bus input. The Output Relay should pick up as the Bus input approaches 40 V ac ±6 V ac. The **B HOT** (Bus Hot) LED should go out at the same time.
4. Remove the TB3–5 jumper; the Output Relay should drop out. Replace the jumper; the Output Relay should pick up.
5. Return the Bus input to 120 V ac.

DEAD LINE LIMIT

1. Place a jumper between TB3–7 and TB3–8 (Enable Dead Line Close).
2. Set the **DEAD LINE/BUS LIMIT** control to 40 V ac.
3. Slowly reduce the Line input. The Output Relay should pick up as the Line input approaches 40 V ac ±6 V ac; the **L HOT** (Line Hot) LED should go out at the same time.
4. Remove the jumper from TB3–7; the Output Relay should drop out. Replace the jumper; the Output Relay should pick up.
5. Return the Line input to 120 V ac.

VOLTAGE STATUS RELAY

1. Adjust the unit as follows: **UPPER VOLTAGE LIMIT** control to 125 V ac, **LOWER VOLTAGE LIMIT** control to 90 V ac, Line and Bus inputs to 120 V ac.
2. With all M–0389 LEDs lit, check the Voltage Status Relay normally open contacts TB4–7 to TB4–8. The contacts should be closed.
3. Check the Voltage Status Relay normally closed contacts TB4–6 to TB4–7. The contacts should be open.
4. Adjust the **UPPER VOLTAGE LIMIT** control to 130 V ac.
5. With the **UPPER VOLTAGE LIMIT** LEDs off, check the Voltage Status Relay normally open contacts. The contacts should be open.
6. Check the Voltage Status Relay normally closed contacts. The contacts should be closed.

BUS VOLTAGE ANALOG OUTPUTS

■ **NOTE:** The Analog Outputs may be used either as voltage or current outputs. Select the test procedure below for the option selected. Refer to Figures 14 and 15 for Voltage or Current Analog Output Connections.

Voltage Option

1. Place a jumper between TB4–1 and TB4–2.
2. Attach the positive lead of a digital voltmeter to TB4–1 and TB4–2; attach the negative lead to TB4–3.
3. Apply 120 V ac to the Line input.
4. Apply the following Bus input voltage levels and verify the output voltage is correct.

BUS INPUT	OUTPUT
150 V ac	7.5 V dc ±0.35 V dc
120 V ac	6.0 V dc ±0.35 V dc
90 V ac	4.5 V dc ±0.35 V dc

Current Option

1. Attach the positive lead of a current meter to TB4–1; attach the negative lead to TB4–2.
2. Attach an RN60E 1 K ±0.1% resistor from TB4–2 to TB4–3.
3. Apply 120 V ac to the Line input.
4. Apply the following Bus input voltage levels and verify the output current is correct.

BUS INPUT	OUTPUT
150 V ac	1.0 mA dc ±0.05 mA
120 V ac	0.8 mA dc ±0.05 mA
90 V ac	0.6 mA dc ±0.05 mA

LINE VOLTAGE ANALOG OUTPUTS

Voltage Option

1. Place a jumper between TB4–4 and TB4–5.
2. Attach the positive lead of a digital voltmeter to TB4–4 and TB4–5; attach the negative lead to TB4–3.
3. Apply 120 V ac to the Bus input.
4. Apply the following Line input voltage levels and verify the output voltage is correct.

LINE INPUT	OUTPUT
150 V ac	7.5 V dc ±0.35 V dc
120 V ac	6.0 V dc ±0.35 V dc
90 V ac	4.5 V dc ±0.35 V dc

Current Option

1. Attach the positive lead of a current meter to TB4–5; attach the negative lead to TB4–4.
2. Attach an RN60E 1 K ±0.1% resistor from TB4–4 to TB4–3.
3. Apply 120 V ac to the Bus input.
4. Apply the following Line input voltage levels and verify the output voltage is correct.

LINE INPUT	OUTPUT
150 V ac	1.0 mA dc ±0.05 mA
120 V ac	0.8 mA dc ±0.05 mA
90 V ac	0.6 mA dc ±0.05 mA

TYPICAL VOLTAGES

CONDITIONS

1. Line and Bus voltages are 120 V ac, 60 Hz.
2. Measurements are made with a true rms type Digital Voltmeter (DVM); Hewlett Packard 3466A or equivalent.
3. Readings are made with reference at TB2-3 (common), except as noted.
4. Jumper TB2-4 to TB2-5.

■ **NOTE:** For component location and orientation, refer to Figures 8, 11, and 20.

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LOCATION OF TEST POINTS	ASSEMBLY	READING	TYPE OF WAVEFORM
D4 Cathode	Power Supply Board	25.2 V	dc
D2 Cathode	Power Supply Board	25.1 V	dc
D6 Cathode	Power Supply Board	24.5 V	dc
D3 Anode	Power Supply Board	19.7 V rms	Sine Wave
D1 Anode	Power Supply Board	19.8 V rms	Sine Wave
Left of R40	Phase Verifier	10.0 V	dc
D44 Anode	Phase Verifier	9.8 V	dc
D30 Cathode	Phase Verifier	14.5 V	dc (Φ OK)
D30 Cathode	Phase Verifier	0.0 V	dc (Φ not OK)
Right of R51	Phase Verifier	14.5 V	dc (Output Closed)
Right of R51	Phase Verifier	0.0 V	dc (Output Open)
Right of R20	Phase Verifier	19.7 V rms	Sine Wave
Right of R21	Phase Verifier	9.8 V rms	Sine Wave

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LOCATION OF TEST POINTS	ASSEMBLY	READING	TYPE OF WAVEFORM
R122 Bottom	Voltage Verifier	6.0 V	dc
R121 Top	Voltage Verifier	6.0 V	dc
R109 Top	Voltage Verifier	11.5 V	dc (Bus Lower Limit OK)
R110 Top	Voltage Verifier	11.5 V	dc (Line Lower Limit OK)
R102 Top	Voltage Verifier	11.5 V	dc (Line Upper Limit OK)
R101 Top	Voltage Verifier	11.5 V	dc (Bus Upper Limit OK)
D81 Cathode	Voltage Verifier	14.4 V	dc

TYPICAL RESISTANCES

CONDITIONS

1. All the rear terminals are open circuited.
2. Measurements are made with a true rms type Digital Voltmeter; Hewlett Packard 3466A or equivalent.

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LOCATION OF NEGATIVE DVM LEAD	LOCATION OF POSITIVE DVM LEAD	SCALE	READING
TB3-1	TB3-2	200 ohm	32.2
TB3-3	TB3-4	200 ohm	31.7
TB3-1	TB3-3	200 K	∞
TB3-1	TB2-3	200 K	∞
TB3-3	TB2-3	200 K	∞
TB1-1	TB1-2	200 K	∞
TB2-6	TB2-7	200 K	∞
TB2-7	TB2-8	2 K	0

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LOCATION OF NEGATIVE DVM LEAD	LOCATION OF POSITIVE DVM LEAD	SCALE	READING
TB4-6	**TB4-7**	**2 K**	**0**
TB4-7	TB4-8	200 K	∞
TB2-4	TB2-5	200 K	90 K

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

PATENT

The unit described in this manual is protected by U.S. Patent 4,218,625.

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 infringement of United States Letters Patent or rights accruing therefrom 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 therein 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 perform in accordance with Seller's specifications of the product, Seller shall at his expense correct the same, provided however that Buyer shall ship the equipment prepaid to Seller's facility. The Seller's responsibility hereunder shall be limited to the replacement value of the equipment furnished under this contract. The foregoing shall constitute the exclusive remedy of the Buyer and the sole liability of the seller and is in lieu of all other warranties, whether written, oral, implied or statutory, except as to the title of the Seller to the equipment furnished. No implied statutory warranty of merchantability or of fitness for a particular purpose shall apply. Seller does not warrant any product or services of others which Buyer has designated.

SELLER MAKES NO WARRANTIES EXPRESSED OR IMPLIED OTHER THAN THOSE SET OUT ABOVE. SELLER SPECIFICALLY EXCLUDES THE IMPLIED WARRANTIES OF MERCHANTABILITY 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 claims of any kind whether based on contract, warranty, tort including negligence or otherwise, 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 or any services 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. It is the intention of the parties that this is a complete indemnification and hold harmless agreement in regard to all claims arising from nuclear operations of Buyer.

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