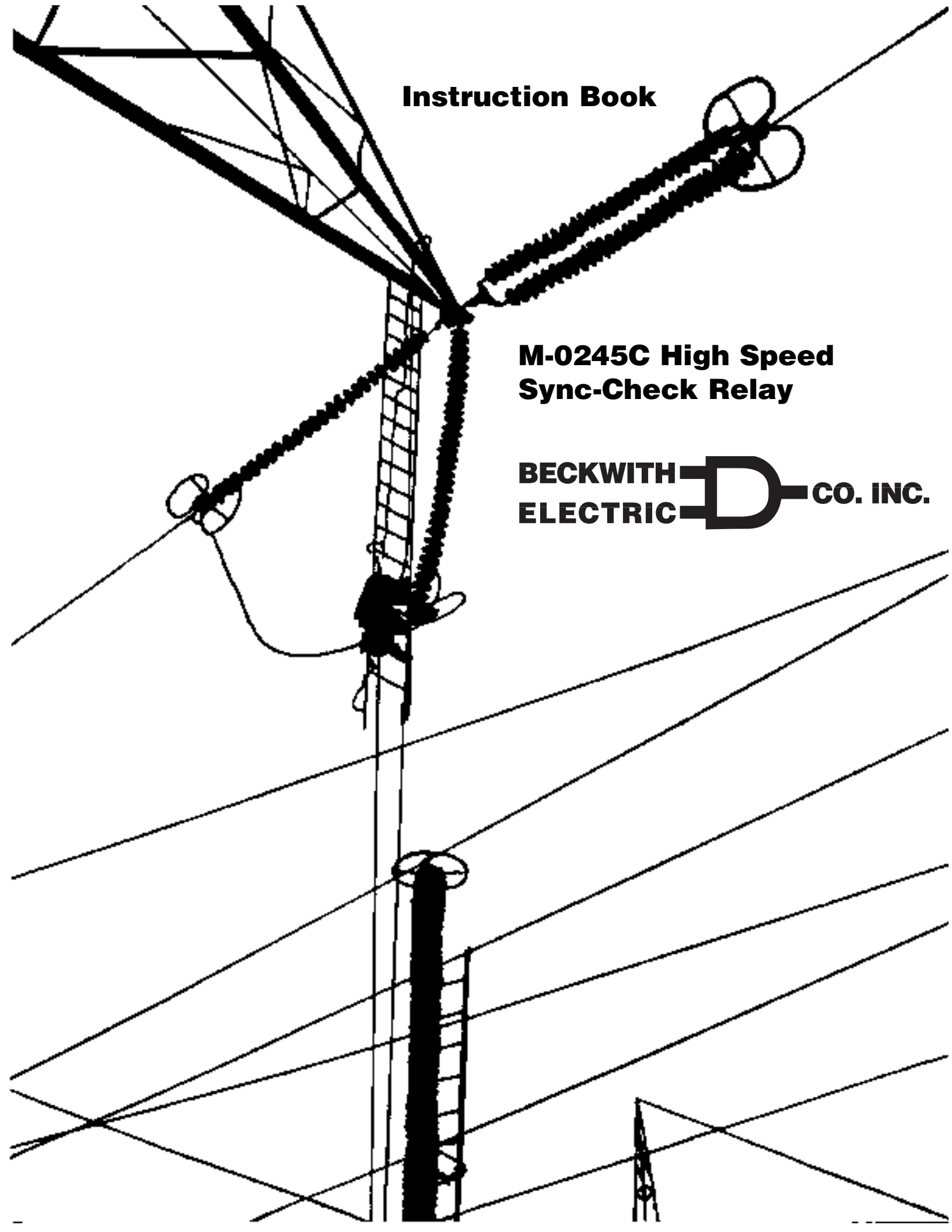
Instruction Book



M-0245C High Speed Sync-Check Relay

BECKWITH ELECTRIC CO. INC.

High Speed Sync-Check Relay M-0245C

Motor Bus Transfer Relay for Power Plant and Industrial Site Motor Bus Transfer

- **Verifies that the line voltage is within preset limits.**
- **Verifies within one cycle if the phase angle is within preset limits.**

High speed transfer of auxiliary services at a generating plant or the motor load in an industrial plant is highly desirable to prevent either damage to critical motors or an unplanned shutdown.

A significant induced voltage will remain at the terminals of a rotating machine for a period of time following removal of power. If, during the power transfer sequence, the phase angle of this voltage relative to the auxiliary source is ignored, severe damage to an expensive machine or process may result. The M-0245C High Speed Sync-Check Relay provides the means necessary to inhibit transfer if the phase angle is excessive or the line voltage is out of range.

Inputs

Motor Bus Voltage: 120 V ac nominal

Line Voltage: 120 V ac nominal

M-0245C Supply: 120 V ac ±10%, 60 to 400 Hz

External Dry Contact Closure: Enables the synchronizing verification. This contact should be designed for low voltage, low current signals.

■ **NOTE:** All voltage inputs are isolated. The supply input and auxiliary source may be connected together externally, provided the voltage transformer from this auxiliary supply has sufficient capacity.

Burden

Motor Bus Voltage: 0.15 VA burden

Line Voltage: 0.15 VA burden

M-0245C Supply: 12 VA burden

Controls

UPPER VOLTAGE LIMIT for Line Voltage: 110 to 140 V ac

LOWER VOLTAGE LIMIT for Line Voltage: 90 to 120 V ac

PHASE ANGLE LIMIT: Ranges are available from 0 to 180°, 0 to 120°, 0 to 60°, or 0 to 30°

■ **NOTE:** Accurately calibrated dials facilitate field adjustment without additional test equipment.

LED Indicators

UPPER VOLTAGE LIMIT - OK: Line voltage is less than the upper voltage limit setting.

LOWER VOLTAGE LIMIT - OK: Line voltage is greater than the lower voltage limit setting.

PHASE ANGLE LIMIT OK: Phase difference between the Line and Bus voltage inputs is less than the phase angle limit setting.

ENABLED: The external enable contact, rear terminal TB1-20 to TB1-21, is closed.

OUTPUT CLOSED: The solid-state output circuit, rear terminal TB2-A to TB2-B, is closed.

Breaker Close Relay

Solid-state Breaker Close Circuit is capable of making and breaking an inductive current of 15 A at 300 V dc. The closing signal will remain until the enable contact is opened, provided phase angle and voltage remain within preset limits.

Response Time

Delay after power turn on: Approximately 2 sec. Output will be open during this period, regardless of other inputs.

Delay after closing enable input: 1/4 cycle. Output will be open until the M-0245C is enabled, regardless of other inputs.

Delay after voltage change in or out of band: Generally ranges from 0 to 0.08 sec. Refer to the M-0245C Application Guide for further details.

Maximum delay after phase change in or out of band: 1 cycle

Status Relay Contacts

Line Source Voltage OK: Contact is closed when the voltage is within the upper and lower voltage limit settings.

Phase Angle OK: Contact is closed when the phase angle between the Line and Motor Bus voltage inputs is within the phase angle limit setting.

Analog Outputs

Phase Difference: 0 to 180° corresponding to 0 to 10 V dc (55.6 mV per degree)

Line Source Voltage: 0 to 140 V ac input corresponding to 0 to 7 V dc output

Motor Bus Source Voltage: 0 to 140 V ac input corresponding to 0 to 7 V dc output

■ **NOTE:** Each analog output has an output impedance of 10 K referenced to rear terminal TB1-7. These outputs are suitable for use with existing or future supervisory control systems.

Reliability

The M-0245C High Speed Sync-Check Relay 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 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.

Transient Protection

All inputs and outputs are fully transient protected and will pass the ANSI C37.90.1-1989 Surge Withstand Capability (SWC) Test. The Motor Bus and Line Input Voltages, Status Relay outputs, 120 V ac Power input and Breaker Close Circuit output will withstand 1500 V ac, 60 Hz to chassis or instrument ground for one minute. Voltage inputs are electrically isolated from each other, from other circuits and from ground.

■ **NOTE:** Use of varistor suppressors across contacts and from contacts to chassis ground is suggested if these contacts are to be tied to long wire runs.

Harmonic Filters

Many applications for the M-0245C High Speed Sync-Check Relay will involve power systems which incorporate loads such as variable speed drives, arc furnaces and converters which produce harmonics on the system. The M-0245C includes active filters on the bus and line voltage inputs to permit proper operation in these applications.

Environmental

Temperature Range: Units will operate properly over a temperature range of –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.

Seismic: Units are designed to meet extreme shock and vibration requirements.

Physical

Size: 19" wide x 3-1/2" high x 13" deep (48.3 cm x 8.9 cm x 33.0 cm). Requires two rack units space in a standard 19" rack. May also be panel-mounted horizontally or vertically.

Approximate Weight: 15 lbs (6.8 kg)

Approximate Shipping Weight: 20 lbs (9.1 kg)

The M-0245C includes a transparent cover to protect the knobs and prevent accidental resetting.

Patents

The M-0245C High Speed Sync-Check Relay is covered by U.S. Patents 4,218,625 and 4,256,972.

Warranty

The M-0245C High Speed Sync-Check Relay is covered by a two year warranty from date of shipment.

The Specification is subject to change without notice.

ISO 9001:1994 Registered

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800-0245C-00 04/01

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.

Table of Contents

M-0245C High Speed Sync-Check Relay Instruction Book

1.0 Introduction

The Beckwith Electric M-0245C is a solid-state device specifically designed to respond to changes in the phase angle between two input voltages. When the line voltage input is within the **UPPER** and **LOWER VOLTAGE LIMIT** dial settings, and the phase angle between the line voltage and the motor bus voltage is less than that set on the **PHASE ANGLE LIMIT** dial, the device will permit breaker closing. If the phase angle exceeds the control setting, the device will block closing within one cycle; i.e., if the limit is 30°, the unit will inhibit closing within one cycle of the time when the phase angle exceeds 30°. If the phase angle returns within the 30° limit, the unit will enable closing within one cycle.

Using advanced, state of the art semiconductors and circuits, the Beckwith Electric M-0245C achieves an overall stability and resolution unattainable with other techniques. Modern hybrid and monolithic semiconductors are used to gain temperature stability without critical compensation or trimming. Unique, patented circuitry allows precise phase measurement over a wide range of frequency, voltage and temperature; while operating within ±1% of the theoretical speed limit for phase measurement.

2.0 Theory of Operation

Refer to Figure 1, Block Diagram. Each input (Motor Bus, Line) is passed through a transformer and scaled down from 120 V ac to 6 V ac. If variable speed motor control is used on the motor bus, the variable speed motor application option should be specified, which places a dual channel low pass active filter after each input transformer. This eliminates false zero crossing triggering due to commutated bus voltage waveforms. The scaled down voltages are converted into dc voltages by the Ac to Dc Converters. These converters are active full-wave rectifiers and filters that eliminate the diode drop typical of conventional full-wave rectifiers, which are highly temperature-dependent. Full-wave rectification was chosen over half-wave rectification because the filter response time 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. The Upper and Lower Voltage Comparitors compare the output of the 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 the Line voltage with reference to the **UPPER** and **LOWER VOLTAGE LIMIT** settings.

Two Zero-Crossing Detectors generate rectangular waveforms at the zero crossing of each input. A logic gate provides a pulse width that is proportional to the phase difference between each input, which is then integrated and sampled each half cycle of the highest frequency input. This sampled voltage is an accurate measure of the phase difference and is updated once every 8.3 ms. The sampled voltage varies from 0 to +10 V for a phase difference change of 0 to ±180°. The sampled phase voltage is compared to the extremely stable hybrid voltage reference. The compared signal is an indication of the phase difference with reference to the front panel **PHASE ANGLE LIMIT** setting. Rear terminal TB1-5 allows external monitoring of the phase difference sampled voltage, referenced as “Phase Angle Analog Output.”

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 from 108 V ac to 132 V ac input and is electrically isolated from all other inputs and outputs. The Logic Network monitors all functions including power supply voltages. Upon receiving a logic “1” from the enable input and the appropriate logic conditions from the Phase Angle, Upper Voltage, and Lower Voltage Comparitors; the Logic Network outputs a breaker close signal to the Breaker Close Network. Terminals A and B are electrically shorted by the Breaker Close Network until one of the controlling logic conditions is false or logic “1.”

Motor Bus Undervoltage Monitor

The Motor Bus Undervoltage Detector will disable the relay if the voltage decays below 25% during a bus transfer sequence. This will ensure that the phase measurement circuitry does not misoperate during a low voltage condition.

Input Loss Protection

The M-0245C has been designed with an Input Loss Detector circuit to minimize the possibility of the output contacts closing due to sudden loss of the VT input sources. The M-0245C output contact is forced to the normally open state for any of the following conditions:

1. Sudden drop in the line V.T. voltage magnitude.
2. Sudden drop in the bus V.T. voltage magnitude.
3. Bus V.T. voltage less than 0.25%.
4. Rate of change of phase, as detected by the M-0245C circuitry, is greater than 2900°/sec. (8 Hz frequency difference).

The possibility still remains, however, that under certain conditions (i.e., loose wires causing an intermittent contact) the internal circuitry may not be able to detect the loss, and the output contact could close when the unit is initiated. Therefore, as a safeguard, the "Close to Enable Sync Check" contact from TB1-20 to TB1-21 should be closed only during the time required for the transfer sequence to be completed.

3.0 Maintenance

Due to the extremely sophisticated nature of the circuitry in the M-0245C, 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 determined, 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.

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.

To gain access to the circuit board, remove the top and bottom cover of the unit. Components can then be easily tested or changed. 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** and **CALIBRATION PROCEDURES** 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.

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

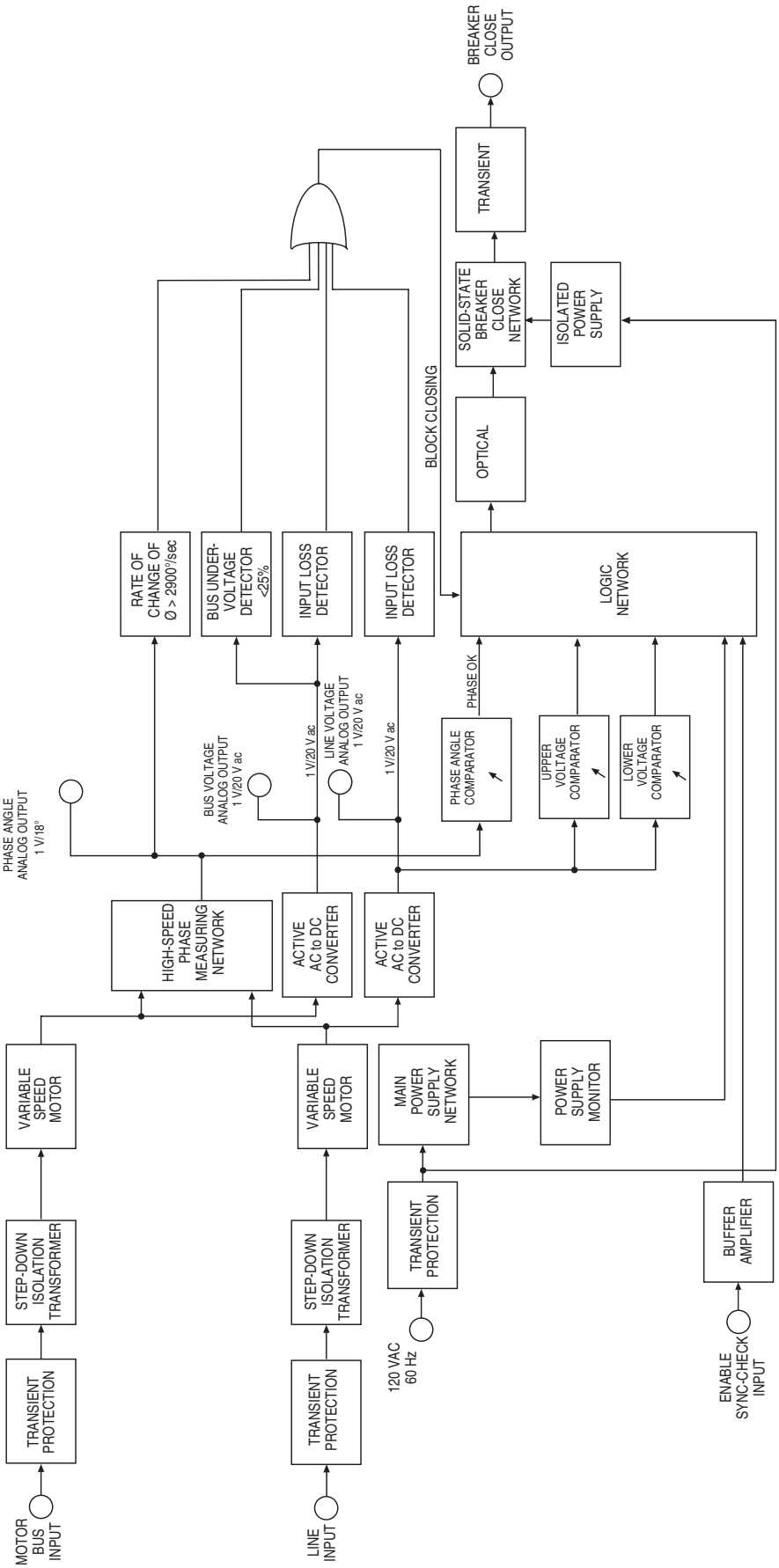


Figure 1 Block Diagram

4.0 Test Procedure

■ **NOTE:** Values that change for the 50 Hz Operation option are shown in brackets.

Refer to Figure 2, External Connections, and Figure 6, Component Location, in conjunction with this section.

Equipment Required

1. A variable frequency source with phase angle control capable of providing 140 V rms with a minimum phase setting resolution of 1°.
2. A fixed 60 [50] Hz frequency source capable of providing 140 V rms with a minimum phase setting resolution of 1° rms.
3. Two (2) digital multimeters (DMMs) with ac and dc accuracy of ±0.2% of full scale; Hewlett-Packard model 3465A or equivalent.
4. A dual trace oscilloscope; Tektronics, Inc. model 465 or equivalent.
5. A digital phase angle meter with an accuracy of ±0.5°.
6. A synchroscope, if available.
7. An incandescent bulb and dc battery source.

■ **NOTE:** The two ac sources above should be phase-locked to each other.

4.1 Component Replacement Procedure

1. The M-0245C printed circuit board has been coated with a moisture-resistant, conformal coating. 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 foil on the printed circuit board.
2. Clip out the old component and discard.

▲ **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.

3. Remove the clipped wires using a solder wick or syringe. Be sure to leave the holes clear to facilitate insertion of the new component.
4. When replacing integrated circuits, make 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.
5. Use a Weller Controlled Output Soldering Station, model MTCPL, 60 W, 120 V, 50/60 Hz with a grounded tip or equivalent equipment when soldering in new components.

4.2 Test Procedure

Upper Voltage Limit

1. Set the **UPPER VOLTAGE LIMIT** control to 125 V rms.
2. Apply the variable source at 120 V rms, 60 [50] Hz to TB1-1 and TB1-2. Note that TB1-1 is the Hot terminal. This source will later be referred to as the “Motor Bus voltage input.”
3. Apply the fixed source at 120 V rms, 60 [50] Hz to TB1-3 and TB1-4, and TB1-26 and TB1-27. Note that TB1-4 and TB1-27 are the Hot terminals. This source will later be referred to as the “Line voltage input.”
4. The **UPPER VOLTAGE LIMIT-LINE** LED should light.
5. Slowly raise the Line voltage input to approximately 125 V rms.
6. The **UPPER VOLTAGE LIMIT-LINE** LED should go out as the Line voltage passes 125 V rms.
7. Slowly reduce the Line voltage input; the **UPPER VOLTAGE LIMIT-LINE** LED should light as the voltage level drops below 125 V rms.
8. Return the Line voltage input to 120 V rms.
9. Repeat steps 3 through 7 with the **UPPER VOLTAGE LIMIT** dial set at 115 V rms, then at 135 V rms.

Lower Voltage Limit

1. Set the **LOWER VOLTAGE LIMIT** dial at 105 V rms.
2. Adjust the Line voltage input to approximately 106 V rms.
3. Adjust the Bus voltage input to 120 V rms.

■ **NOTE**: To prevent the voltage level detection circuit outputs from oscillating, there is approximately 0.5 V rms hysteresis between when the LEDs turn on and turn off, within a dial setting accuracy of ±2% of full scale.

4. The **LOWER VOLTAGE-LINE** LED should light.
5. Slowly reduce the Line voltage; the **LOWER VOLTAGE LIMIT-LINE** LED should go out as the Line voltage input drops below 105 V rms.
6. Slowly increase the Line voltage input; the **LOWER VOLTAGE LIMIT-LINE** LED should light as the voltage level passes 105 V rms.
7. Return the Line voltage input to 120 V rms.
8. Repeat steps 3 through 6 with the **LOWER VOLTAGE LIMIT** set at 95 V rms, then at 115 V rms.

Phase Angle Limit

■ **NOTE**: The following section is written for a 60° full scale unit. Multiply accordingly for other scale options.

1. Adjust the Line voltage input to 120 V rms, 60 [50] Hz.
2. Adjust the Motor Bus voltage input to 120 V rms, 60 [50] Hz.
3. The phase angle meter reading and synchroscope should show a stable phase angle.
4. Set the **PHASE ANGLE LIMIT** dial at midscale (30°).
5. Adjust the phase angle between the Line and Motor Bus voltage inputs to 29.5°.

■ **NOTE**: To prevent the voltage level detection circuit outputs from oscillating, there is approximately 0.5 V rms hysteresis between when the LEDs turn on and turn off, within a dial setting accuracy of ±2% of full scale.

6. The **PHASE ANGLE OK** LED should light.
7. Slowly increase the phase angle between the sources; the **PHASE ANGLE OK** LED should go out as the phase angle passes 30°.
8. Slowly reduce the phase angle; the **PHASE ANGLE OK** LED should come on as the phase angle drops below 30°.
9. Repeat steps 4 through 8 with the **PHASE ANGLE LIMIT** dial set at 10° and 50°.
10. Return both inputs to 120 V rms, 60 [50] Hz.

Voltage Analog Output

1. Connect the positive lead of the multimeter to TB1-28.
2. Connect the negative (common) lead of the multimeter to TB1-7.
3. The dc voltage reading should be proportional to the Line voltage input ac level, which should be 0 to 7 V dc as the Line voltage input varies from 0 to 140 V rms. The accuracy should be ±2% of full scale.
4. Move the DMM positive lead from TB1-28 to TB1-18. The negative lead remains on TB1-7.
5. The dc voltage reading should be 0 to 7 V dc as the Motor Bus voltage input varies from 0 to 140 V rms. The accuracy should be ±2% of full scale.

Phase Angle Analog Output

1. Connect the DMM positive lead to TB1-5.
2. Connect the DMM negative lead to TB1-7.
3. The dc voltage reading should be 0 to 10 V dc as the phase angle between the Line input and the Motor Bus input changes from 0° to 180°. The accuracy should be ±1% of full scale.

Voltage Status Output Contact

1. Place one ohmmeter across TB1-22 and TB1-23.
2. Set the **UPPER VOLTAGE LIMIT** dial at 125 V rms.
3. Set the **LOWER VOLTAGE LIMIT** dial at 105 V rms.
4. Adjust the Motor Bus voltage input level to 120 V rms, 60 [50] Hz.
5. Adjust the Line voltage input level to 120 V rms, 60 [50] Hz.
6. The **VOLTAGE LIMIT** LED should be lit.
7. The Voltage Status Contact from TB1-22 to TB1-23 should be closed.
8. Set the **UPPER VOLTAGE LIMIT** dial to 115 V rms.
9. The Voltage Status Contact from TB1-22 to TB1-23 should open when the **UPPER VOLTAGE LIMIT-LINE** LED is off.

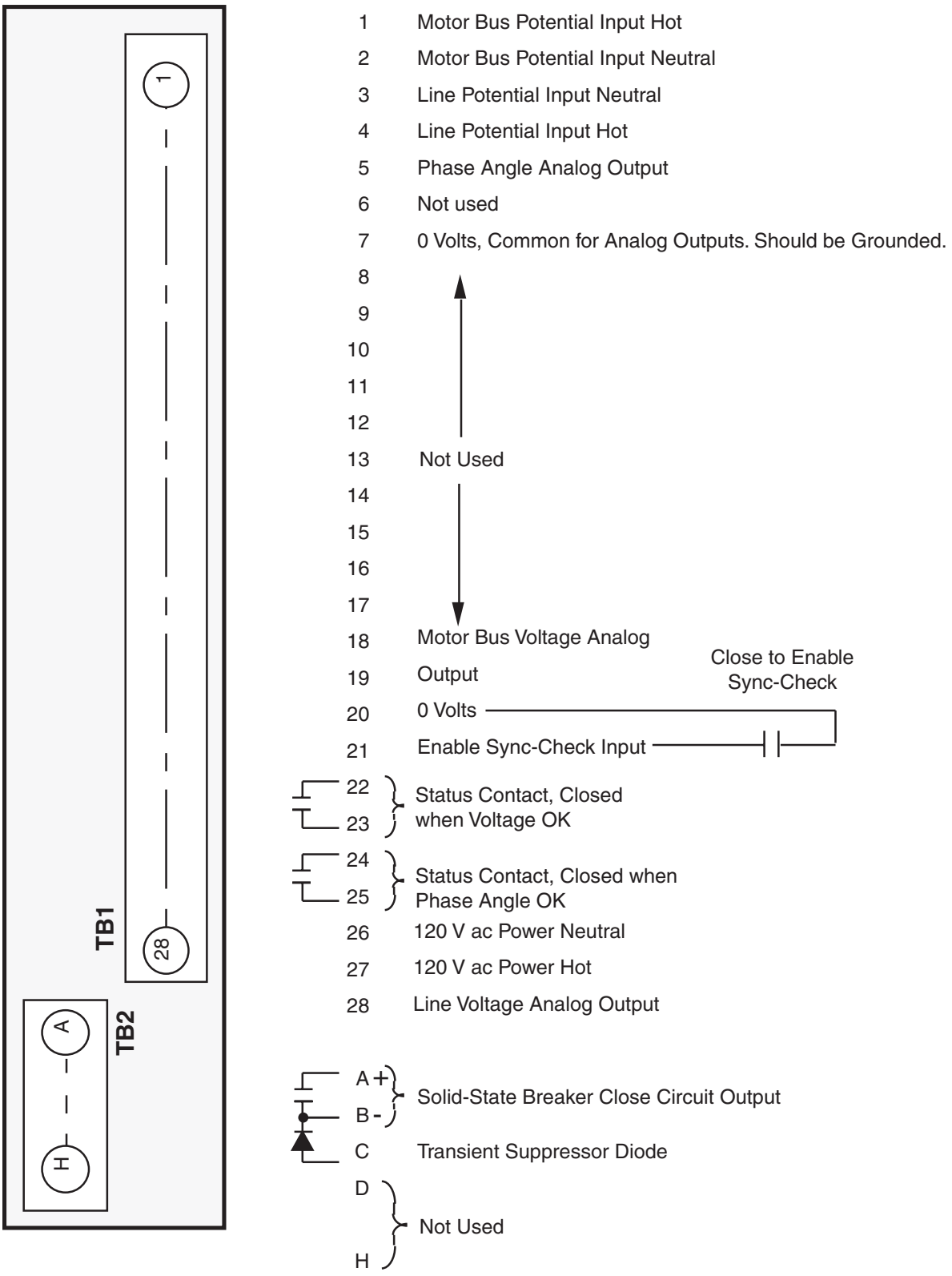


Figure 2 External Connections

10. Return the **UPPER VOLTAGE LIMIT** dial to 125 V rms.
11. The **UPPER VOLTAGE LIMIT-LINE** LED should be on, and the Voltage Status Contact from TB1-22 to TB1-23 should be closed.
12. Move the **LOWER VOLTAGE LIMIT** dial past 115 V rms to approximately 118 V rms.
13. The Voltage Status Contact from TB1-22 to TB1-23 should be open when the **LOWER VOLTAGE LIMIT-LINE** LED is off.
14. Return the **LOWER VOLTAGE LIMIT** dial to 105 V rms.
15. The **LOWER VOLTAGE LIMIT-LINE** LED should be on, and the Voltage Status Contact should be closed.

Phase Angle Status Output

1. Connect a 25 W incandescent bulb and a dc battery source across Phase Angle Status Contact TB1-24 and TB1-25 as shown in Figure 3, Test Setup.
2. Adjust the Line voltage input to 120 V rms, 60 [50] Hz.
3. Adjust the Motor Bus voltage input to 120 V rms, 60 [50] Hz at a 20° phase angle with respect to the Line voltage input.
4. Set the the **UPPER VOLTAGE LIMIT** dial to 125 V rms.
5. Set the **LOWER VOLTAGE LIMIT** dial to 105 V rms.
6. Set the **PHASE ANGLE LIMIT** dial to 30°.
7. Slowly increase the phase angle between the Line and Motor Bus voltage inputs.
8. The **PHASE ANGLE OK** LED and the light bulb should turn off as the phase angle passes 30°.
9. Slowly reduce the phase angle between the sources to below 30°; the light bulb and the LED should light as the phase angle passes 30°.

Breaker Close Circuit

1. Connect an incandescent bulb and a dc battery source to the Breaker Close Circuit Output TB2-A and TB2-B as shown in Figure 3. Note that TB2-A is the more positive terminal.
2. Adjust the Line voltage and Motor Bus voltage inputs to 120 V rms, 60 [50] Hz.
3. With the phase angle between the inputs at 20° and the **PHASE ANGLE LIMIT** dial set at midscale, the incandescent bulb and all front panel LEDs should light.
4. Slowly increase the phase angle above 30°, the light bulb and the **PHASE ANGLE OK** LED should turn off.
5. Return the phase angle between the sources to 20°.
6. The incandescent bulb should be lit.
7. Remove the jumper from the Enable Sync Check Input TB1-20 to TB1-21.
8. The output should drop out (the bulb should turn off) when the jumper is removed and should light when the jumper is reapplied.

Enable Response Time

1. Adjust the Line voltage input to 120 V rms, 60 [50] Hz.
2. Adjust the Motor Bus voltage input to 120 V rms at a 20° phase angle with respect to the Line input.
3. Place the Channel 1 scope probe on TB1-20 and the reference on TB1-21.
4. Place the Channel 2 scope probe on TB2-A and the reference on TB2-B.
5. Set the scope trigger mode on “Normal.”
6. Set the trigger slope level on (+).
7. Set the trigger source on Channel 1.
8. Set the horizontal sweep time at 2 ms/div.
9. Test the Enable Sync Check Input terminals TB1-20 and TB1-21 with a jumper to ensure proper trigger of the sweep. Adjust the stop level dial towards the (+) direction to observe better starting point of the sweep. Adjust the horizontal position, if necessary.
10. After proper triggering of the signal is observed when the unit is enabled, push the vertical mode to Channel 2 to monitor the signal on the Breaker Close Circuit Output.
11. Measure the delay time between when the Enable Sync Check Input closes and the Breaker Close Circuit Output TB2-A and TB2-B signal drops to minimum by counting the divisions on the horizontal screen.
12. The response time between when the Enable Sync Check Input closes and the Breaker Close Circuit Output closes should be approximately 5 ms ± 2 ms.

Phase Angle OK to Output Contact Response Time

1. Set the **PHASE ANGLE LIMIT** dial to 20°.
2. Apply 120 V rms, 60 [50] Hz to the Line voltage input.
3. Apply 120 V rms, 60 [50] Hz to the Motor Bus voltage input at a 40° phase angle with respect to the Line voltage input.
4. Attach the Channel 1 scope probe to CR64 cathode, with reference to TB1-7.
5. Change the scope trigger to trigger on a decrease in phase angle.
6. Channel 2 should remain attached to TB2-A and TB2-B.
7. Jump the phase angle to 0°.
8. Measure the time delay between the change in phase angle and the Channel 2 signal going high.
9. The time delay should be 7 ms (minimum) to 24 ms (maximum).
10. Change the scope trigger to trigger on an increase in phase angle.
11. Jump the phase angle from 0° to 40°.
12. Measure the time delay between the phase angle increasing and the output contact opening.
13. The time delay should be 7 ms (minimum) to 24 ms (maximum).

4.3 Phase Angle Detection Circuit

Rate of Change of Phase Angle

1. Apply 120 V ac, 60 [50] Hz to the Line voltage input.
2. Attach the scope ground to the negative end of C78; attach the probe to the anode of CR8.
3. Begin to slowly adjust the Motor Bus frequency to approximately 120 V ac, 51 Hz.
4. The pulse rate should be approximately one pulse per cycle as the Motor Bus frequency approaches 51 [41] Hz ±1 Hz.
5. Slowly increase the Motor Bus frequency. Pulses should stop as the frequency rises above approximately 51 [41] Hz.

4.4 Loss of Voltage Input Detection Circuits

Line Voltage Loss

Refer to Figure 4, Line Voltage Loss, for the following section:

1. Apply 120 V ac, 60 [50] Hz to the Bus voltage input.
2. Apply 120 V ac, 60 [50] Hz to the Line voltage input.
3. Place the Channel 1 probe on the anode of CR19.
4. Place the Channel 2 probe on the end of R136 nearest the rear terminal block.
5. Trigger the scope on Channel 1. Set the horizontal sweep time at 5 ms/div.
6. Completely remove the Line voltage inputs.
7. As shown in Figure 4, the Channel 1 signal should immediately go high from –15 V to +15 V, and Channel 2 should go low after 20 ms.

Motor Bus Voltage Loss

Refer to Figure 5 for the following section.

1. Apply 120 V ac, 60 [50] Hz to the Motor Bus voltage input.
2. Apply 120 V ac, 60 [50] Hz to the Line voltage input.
3. Place the Channel 1 probe on Test Point 10 (TP10); attach Channel 2 probe to TP9.
4. Trigger the scope on Channel 1. Set the horizontal sweep time at 10 ms/div.
5. Completely remove the Motor Bus voltage input.
6. As shown in Figure 5, the Channel 1 signal should immediately go high from –15 V to +15 V, and Channel 2 should go high after approximately 50 ms.

Motor Bus Undervoltage Detector <25%

1. Reapply 120 V ac, 60 [50] Hz to the Motor Bus voltage input.
2. Remove the Channel 1 probe.
3. Slowly reduce the Motor Bus voltage.
4. The signal on Channel 2 should go high as the voltage level drops below 25%.

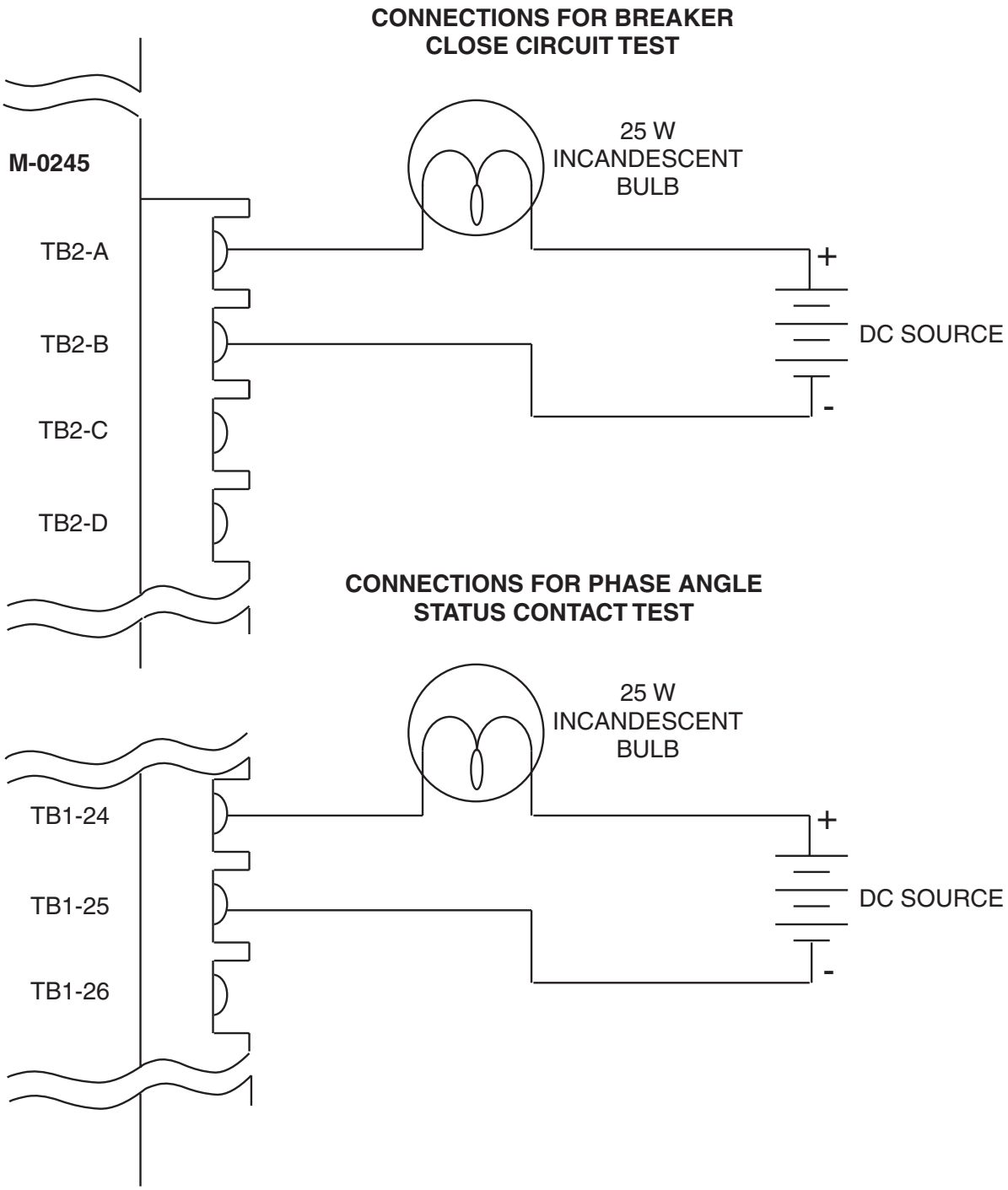


Figure 3 Test Setup

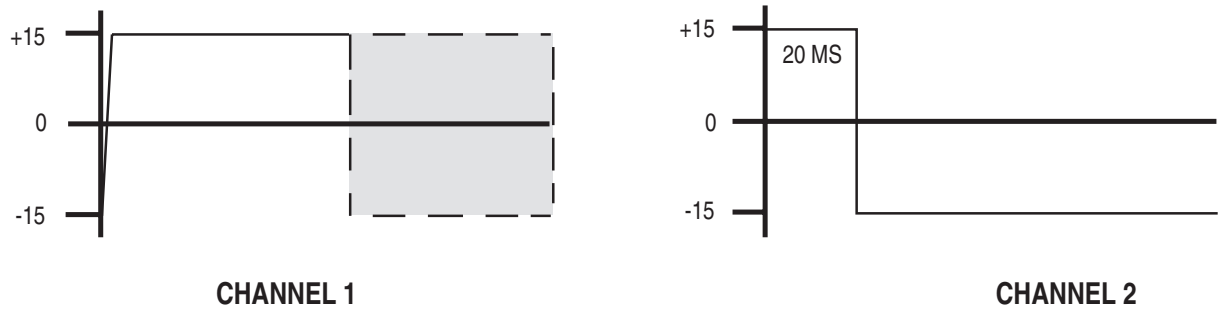


Figure 4 Line Voltage Loss

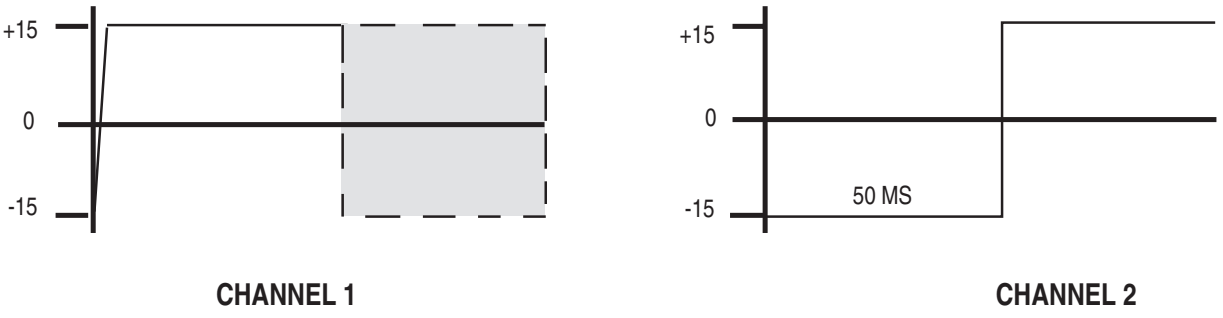


Figure 5 Motor Bus Voltage Loss

5.0 Typical Voltages

Conditions

1. Motor Bus, Line and Power Supply are 120 V, 60 [50] Hz.
2. Measurements are made with a true rms type digital multimeter as described in the **TEST PROCEDURE** section.
3. Readings are made with the negative lead of the multimeter tied to TB1-7, except where noted.

■ **NOTE:** The "bottom" of a component refers to the end nearest the front panel of the unit; the "top" refers to the end nearest the rear terminal block.

LOCATION OF TEST POINT	READING	TYPE OF WAVEFORM
TB1-28	6.04 V dc	dc
TB1-18	6.04 V dc	dc
Top End of R57	6.99 V dc	dc
Bottom End of R110	13.69 V ac	Square Wave
Bottom End of R3	13.67 V ac	Square Wave
Bottom End of R1	6.00 V ac	Sine Wave
Bottom End of R107	6.03 V ac	Sine Wave
Bottom End of R132	6.00 V dc	dc
Top of R135	4.47 V dc	dc
Test Point 11 (TP11)	10.00 V dc	dc
Test Point 8 (TP8)	-14.88 V dc	dc
Test Point 6 (TP6)	14.87 V dc	dc
Bottom of VR3	-22.92 V dc	dc
Top of VR1	20.65 V dc	dc
Top of CR70	17.74 V ac	Sine Wave
Top of CR72	17.65 V dc	Sine Wave

■ **NOTE:** The following readings are made with the negative lead of the multimeter tied to TB2-B and with the Enable jumper removed from TB1-20 to TB1-21.

LOCATION OF TEST POINT	READING	TYPE OF WAVEFORM
Positive End of C71	23.79 V dc	dc
Top End of VR2	13.95 V dc	dc
Top End of R192	0.00 V dc	dc

6.0 Typical Resistances

Conditions

1. All rear terminals are open-circuited.
2. Measurements are made with a true rms digital multimeter as described in the Section 4.0, **Test Procedure**.

LOCATION OF NEGATIVE DMM LEAD	LOCATION OF POSITIVE DMM LEAD	SCALE	READING
TB1-1	TB1-2	10 K	2.2 K
TB1-1	TB1-3	100 K	Open
TB1-1	TB1-7	100 K	Open
TB1-3	TB1-7	100 K	Open
TB1-3	TB1-4	10 K	2.2 K
TB1-7	TB1-19	1 K	0.0 Ω
TB1-7	TB1-25	100 K	Open
TB1-7	Lead #3 of T3	1 K	4 Ω
TB1-7	Lead #5 of T3	1 K	4 Ω
TB1-24	TB1-25	100 K	Open
TB1-26	TB1-27	1 K	27 Ω
TB2-B	TB2-A	100 K	Open
TB2-B	TB2-C	100 K	Open
TB2-C	TB2-B	1 K	Open
TB2-B	TB2-7	100 K	Open
Lead #4 of T1	Lead #3 of T1	10 K	150 Ω
Lead #4 of T2	Lead #3 of T1	10 K	150 Ω

▲ **CAUTION:** Any attempt to measure resistances between points on the printed circuit board other than those shown above is likely to cause damage to the unit.

7.0 Calibration

■ **NOTE:** The M-0245C has been fully calibrated at the factory using highly sophisticated, computer-controlled test equipment. There is no need to recalibrate the unit before initial installation. Further calibration is only necessary if a component is changed during a repair procedure.

Access to the calibration points is only possible with the top cover removed; therefore, after field repair, do not install the unit in a rack or panel before following these procedures.

Refer to Figure 2, External Connections, and Figure 6, Component Location.

Phase Angle Calibration

1. Supply 120 V ac, 60 Hz to TB1-1 and TB1-2, noting that TB1-1 is the HOT terminal.
2. Place a clip lead between TB1-1 and TB1-4.
3. Place a second between TB1-2 and TB1-3.
4. Using a dual trace oscilloscope or phase meter attach one channel to E3 of the low pass filter board.
5. Attach the second channel to E4.
6. Attach the common lead of the scope or phase meter to E6.
7. Adjust R1 of the filter board (B-0246) for a measured phase angle of 0.00 degrees.
8. Adjust R196 until the voltmeter reads 6.000 V dc at R50.
9. Adjust R200 until the voltmeter reads 6.000 V dc at R116.
10. Remove the clip leads from TB1-1 and TB1-4 and TB1-2 and TB1-3.
11. Place a clip lead between TB1-1 and TB1-3.
12. Place a second clip lead between TB1-2 and TB1-4
13. Attach the positive lead of the dc voltmeter to Test Point 1 (TP1).
14. Attach the negative lead to TB1-7 or C78 (–) end.
15. Supply 120 V ac, 60 Hz to power input TB1-26 and TB1-27, noting TB1-27 is the HOT terminal.
16. Adjust R89 until the voltmeter reads +10.000 volts.
17. Remove the positive lead of the dc voltmeter and attach to Test Point 2 (TP2).
18. Adjust R6 until the voltmeter reads –10.014 volts.
19. Remove the positive lead of the dc voltmeter and attach to Test Point 3 (TP3).
20. Adjust R65 until the voltmeter reads –10.014 volts.
21. Remove the positive lead of the dc voltmeter and attach to R105 or the jumper between points J and K.
22. The voltmeter should read +10.00 volts ±0.03 volts.
23. Adjust source supplying TB1-1 and TB1-2 to 60.000 Hz.
24. Remove clip leads to TB1-3 and TB1-4, supply 60 Hz at +90°, 120 V ac to TB1-3 and TB1-4, TB1-4 being HOT.
25. Record voltmeter reading.
26. Change phase angle of source to TB1-3 and TB1-4 to 90°.
27. The voltmeter reading should be about ±.05 V of the recorded voltage.

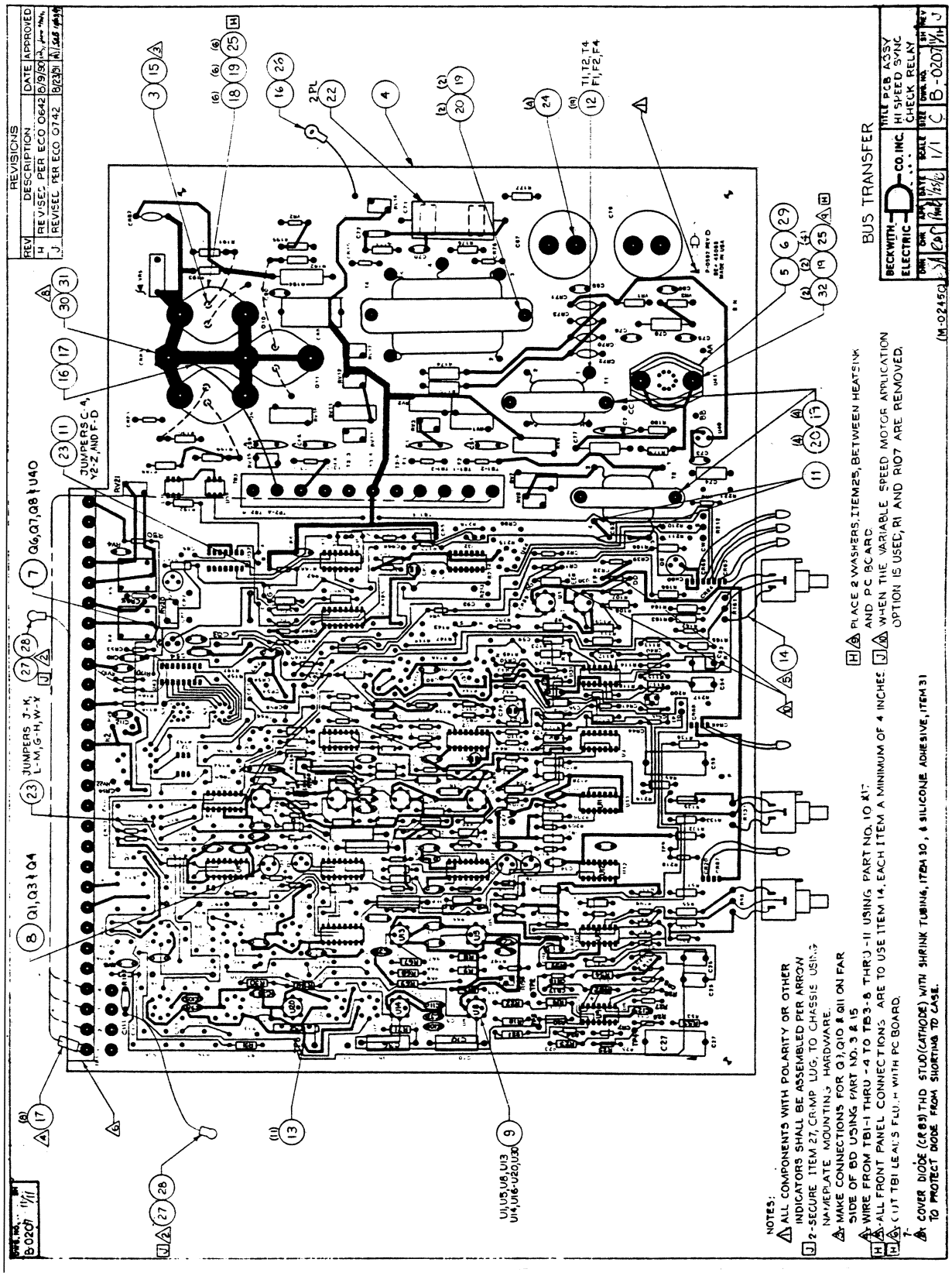


Figure 6 Component Location, B-0207

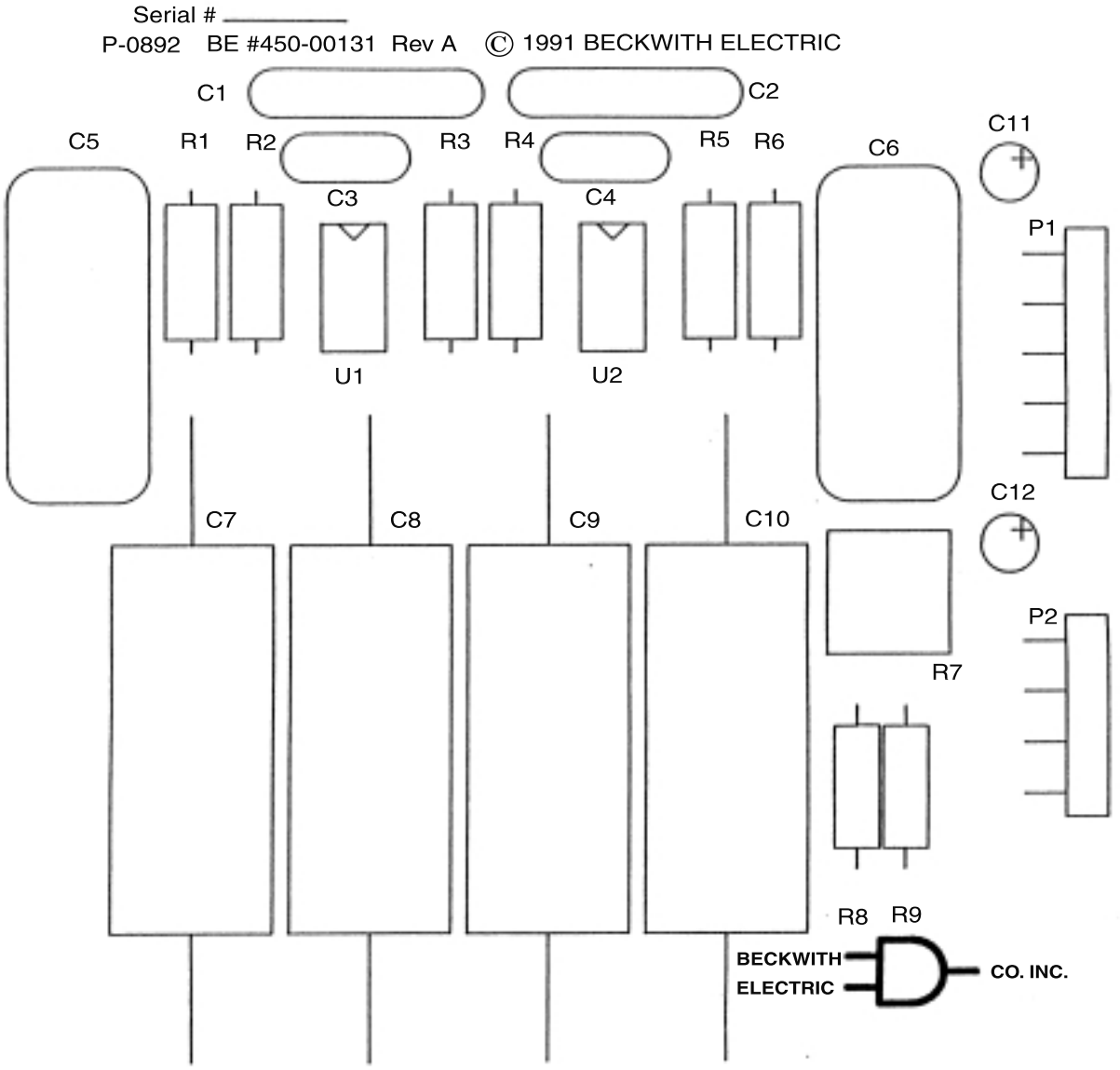
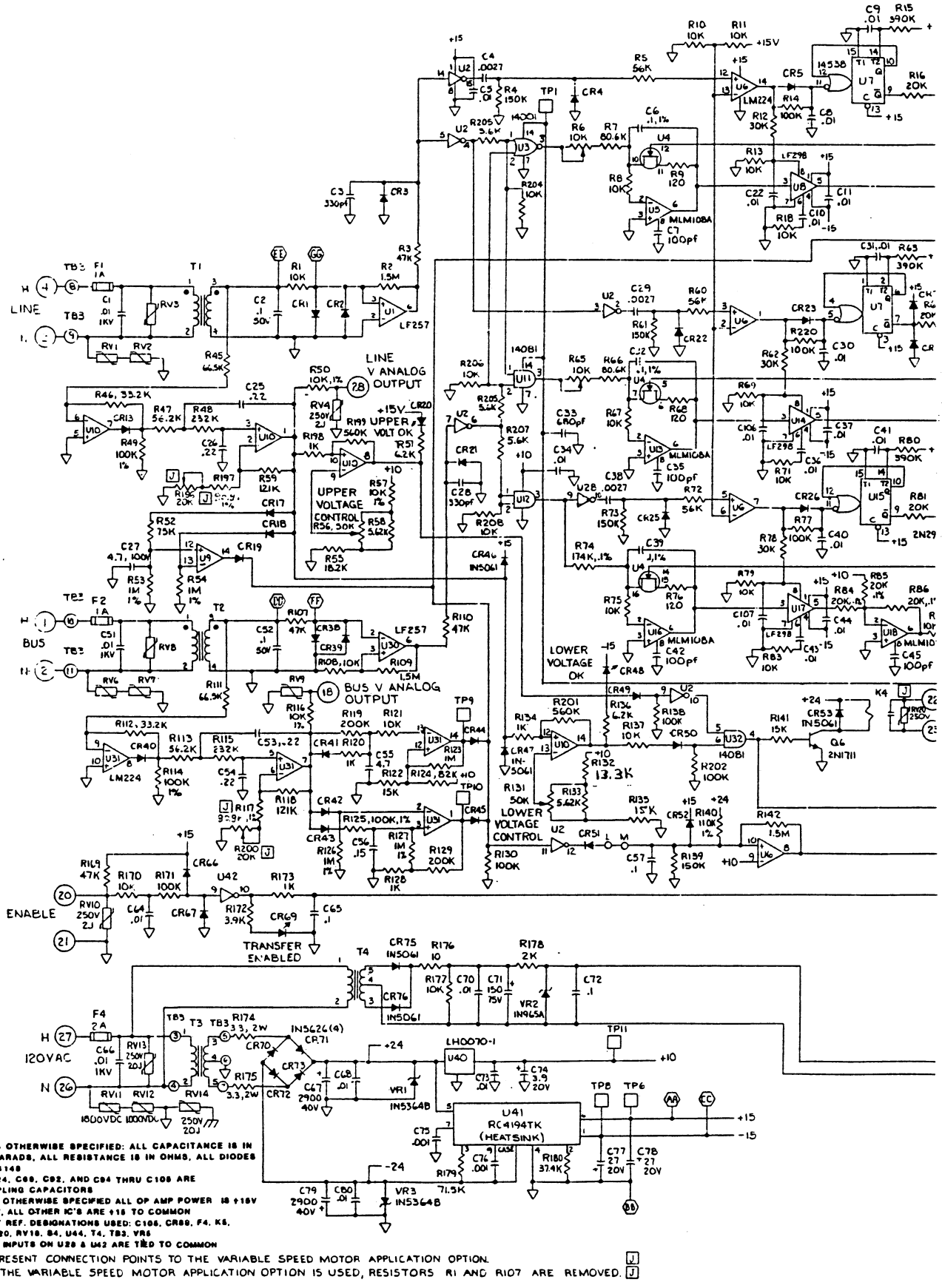


Figure 7 Variable Speed Motor Application Component Location, B-0264



NOTES
1. UNLESS OTHERWISE SPECIFIED: ALL CAPACITANCE IS IN MICROFARADS, ALL RESISTANCE IS IN OHMS, ALL DIODES ARE IN4148
2. C23, C24, C69, C82, AND C84 THRU C108 ARE DECOUPLING CAPACITORS
3. UNLESS OTHERWISE SPECIFIED ALL OP AMP POWER IS +15V TO -15V, ALL OTHER IC'S ARE +15 TO COMMON
4. HIGHEST REF. DESIGNATIONS USED: C108, CR88, F4, K5, Q11, R220, RV16, S4, U44, T4, TB3, VR6
5. UNUSED INPUTS ON U28 & U42 ARE TIED TO COMMON
6. ◯ REPRESENT CONNECTION POINTS TO THE VARIABLE SPEED MOTOR APPLICATION OPTION. [J]
7. WHEN THE VARIABLE SPEED MOTOR APPLICATION OPTION IS USED, RESISTORS R1 AND R107 ARE REMOVED. [J]

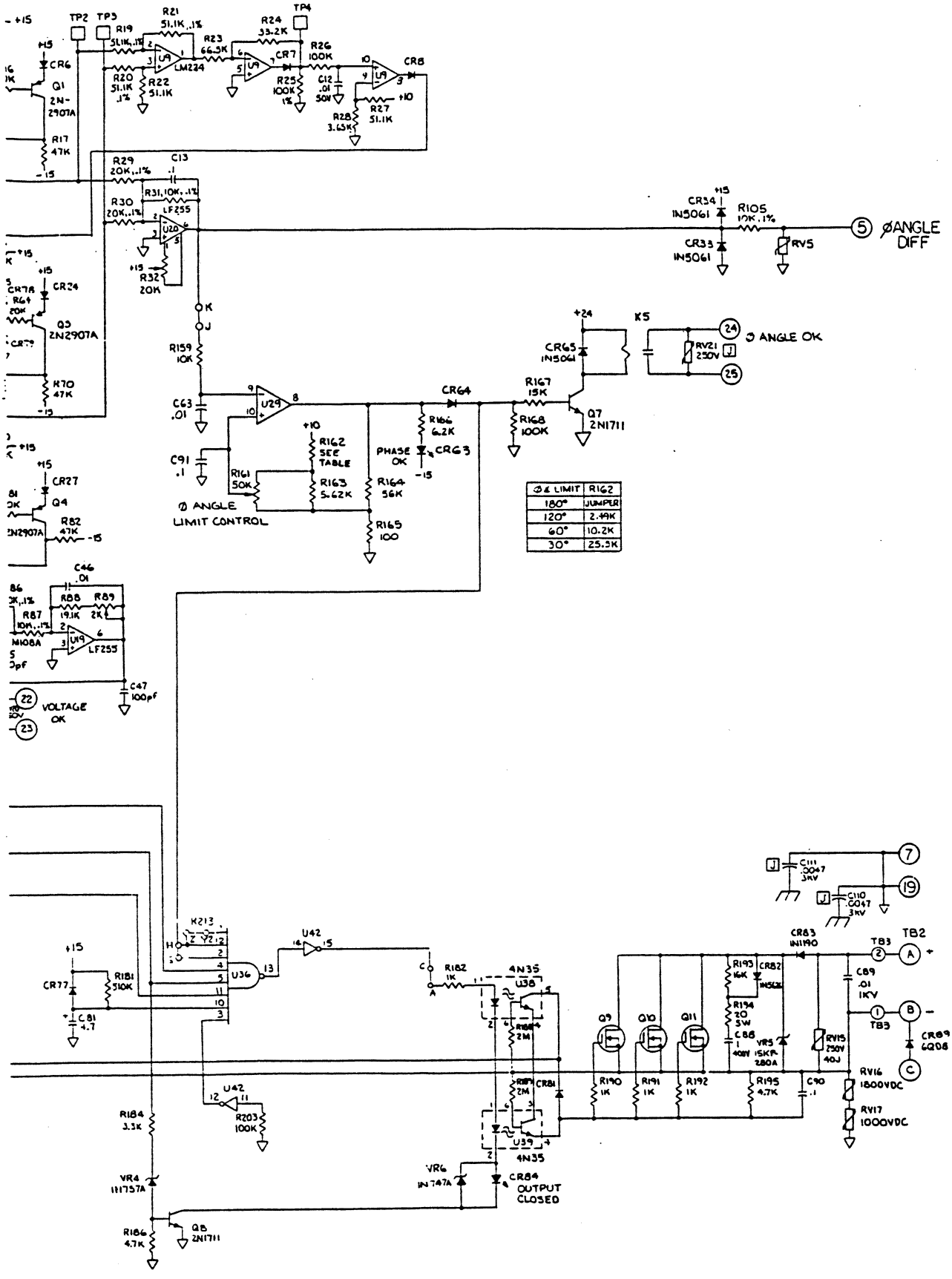


Figure 8 Schematic, X-0245C

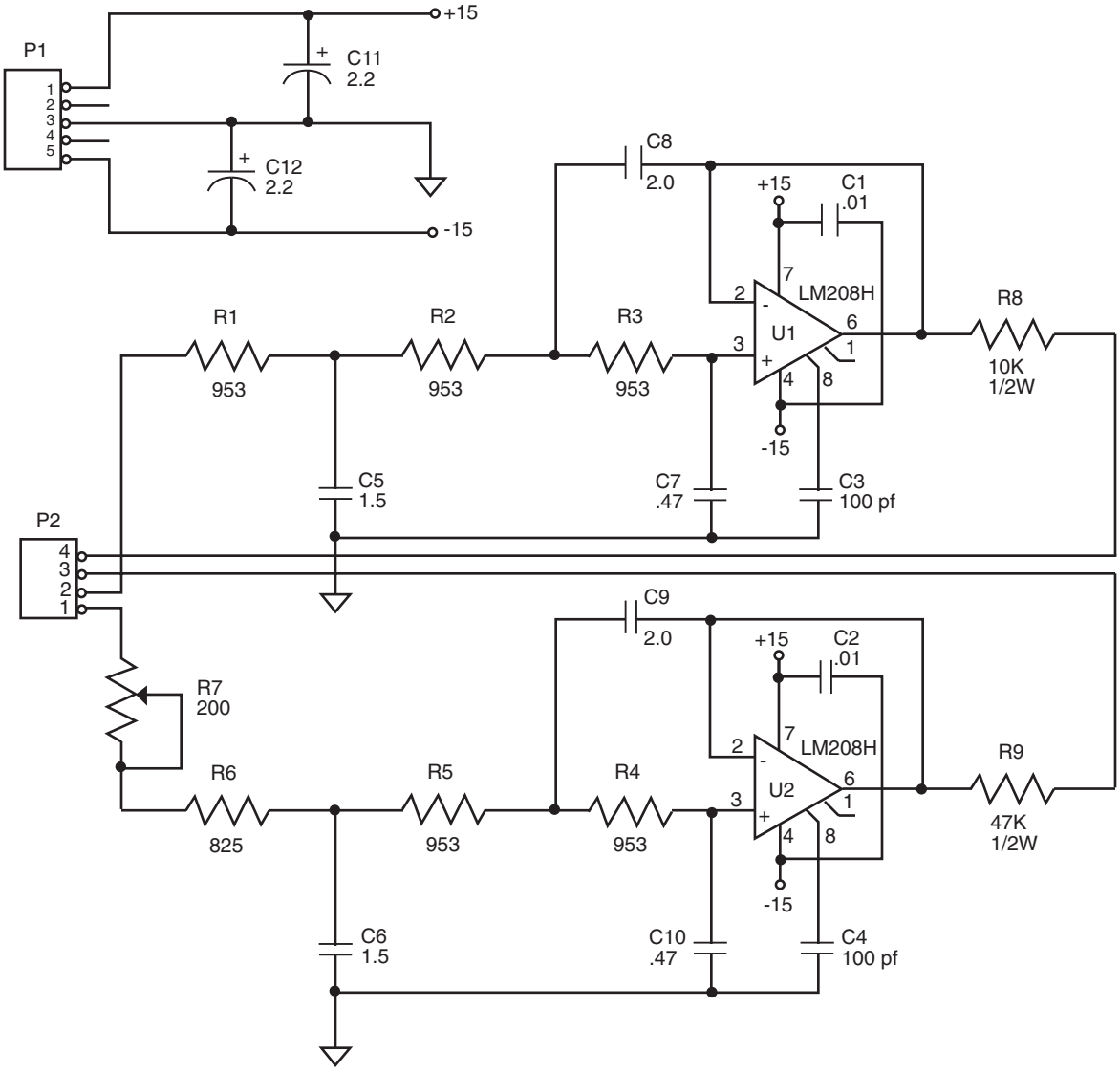


Figure 9 Variable Speed Motor Application Schematic, Y-0264

PARTS LIST

M-0245C High Speed Sync-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
	450-00065*	Printed Circuit Board, P-0592
C1,C51,C66,C89	000-00904	Capacitor, Ceramic Disc, 0.01 µF ±20%, 1 kV
C2,C52,C91	000-00914	Capacitor, Ceramic Disc, 0.1 µF ±20%, 50 V
C3,C28	010-00613	Capacitor, NPO Ceramic, 330 pF ±10%, 50 V
C4,C29,C38	000-00810	Capacitor, Polyester, 0.0027 µF ±10%, 400 V
C5,C8,C9,C11,C12,C22, C24,C30,C31,C34,C37, C40,C41,C44,C68–C70, C73,C80,C84,C92,C94–C99,C101,C103–C107	000-00917	Capacitor, Ceramic Disc, 0.01 µF ±20%, 50 V
C6,C32,C39	010-00802	Capacitor, Polysulfone, 0.1 µF ±1%, 50 V
C7,C35,C42,C45,C47	000-00903	Capacitor, Ceramic Disc, 100 pF ±10%, 1 kV
C10,C36,C43	010-00432	Capacitor, Polystyrene, 0.01 µF ±10%, 63 V

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
C13,C57,C65,C72	000-00811	Capacitor, Polyester, 0.1 µF ±10%, 100 V
C14–C21		Not Used
C23,C90,C100,C102	000-00909	Capacitor, Ceramic Disc, 0.1 µF +80/-20%, 25 V
C25,C26,C53,C54	000-00829	Capacitor, Polyester, 0.22 µF ±10%, 100 V
C27,C55	000-00813	Capacitor, Polyester, 4.7 µF ±10%, 100 V
C33	000-00902	Capacitor, Ceramic Disc, 680 pF ±10%, 1 kV
C46,C63,C64	000-00808	Capacitor, Polyester, 0.01 µF ±10%, 400 V
C48–C50		Not Used
C56	000-00825	Capacitor, Polyester, 0.15 µF ±10%, 100 V
C58–C62		Not Used
C67,C79	000-00637	Capacitor, Electrolytic, 3500 µF +100/-10%, 40 V
C71	000-00652	Capacitor, Electrolytic, 150 µF +75/-10%, 75 V
C74	000-00501	Capacitor, Tantalum, 3.9 µF ±10%, 35 V
C75,C76	000-00913	Capacitor, Ceramic Disc, 0.001 µF, ±10%, 100 V
C77,C78	000-00504	Capacitor, Tantalum, 27 µF ±10%, 20 V
C81	000-00555	Capacitor, Tantalum, 4.7 µF ±20%, 25 V
C82,C83,C85–C87		Not Used
C88	000-00817	Capacitor, Polyester, 1 µF ±10%, 400 V
C110,C111	000-00939	Capacitor, Ceramic Disc, 0.0047 µF ±20%, 3000 V
CR1–CR8,CR13,CR17–CR19,CR21–CR27, CR38–CR45,CR49–CR52,CR64,CR66,CR67, CR77–CR79, CR81	400-00224	Diode, 1N4148
CR9–CR12,CR14–CR16		Not Used
CR20,CR48,CR63, CR69,CR84	400-00722	Diode, Light Emitting, Hewlett–Packard 5082–4658
CR28–CR32		Not Used
CR33,CR34,CR46, CR47,CR53,CR65, CR75,CR76	400-00211	Diode, 1N5061
CR35–CR37,CR54–CR62,CR68		Not Used
CR70–CR73,CR82	400-00213	Diode, 1N5626

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
CR74,CR80		Not Used
CR83	400-00229	Diode, 1N1190
CR89		See **PARTS MOUNTED TO THE ENCLOSURE**
F1,F2	420-00850	Fuse, 1 A, 125 V, Littelfuse 275–001
F3		Not Used
F4	420-00849	Fuse, 2 A, 125 V, Littelfuse 275–002
K1–K3		Not Used
K4,K5	430-00151	Relay, 24 V dc, SPDT, American Zettler AZ4UP–E–1C–24D
Q1,Q3,Q4	400-00305	Transistor, PNP, 2N2907A
Q2,Q5		Not Used
Q6–Q8	400-00300	Transistor, NPN, 2N1711
Q9–Q11	400-00422	Transistor, Power FET, Silconix VN45JA
R8,R10,R11,R13,R18, R67,R69,R71,R75, R79,R83,R108,R121, R177,R204,R206	200-00103	Resistor, Carbon Film, 10 K ±5% ■ **NOTE**: If Variable Speed Motor Application Option is installed, see that option's parts list for R1 and R7 values.
R2,R109,R142	200-00155	Resistor, Carbon Film, 1.5 M ±5%
R3,R17,R70,R82, R107,R110,R169	180-00473	Resistor, Carbon Comp, 47 K ±5%, 1/4 W
R4,R61,R73	200-00154	Resistor, Carbon Film, 150 K ±5%
R5,R60,R72	180-00563	Resistor, Carbon Comp, 56 K ±5%, 1/4 W
R6,R65	360-00093	Potentiometer, 10 K, Bourns 3009P–1–103
R7,R66	330-00588	Resistor, Metal Film, 80.6 K ±1%, 1/4 W, RN60E NOTE: If Variable Speed Motor Application Option is installed, see that option's parts list for R1 and R7 values.
R9,R68,R76	200-00121	Resistor, Carbon Film, 120 Ω ±5%
R12,R62,R78	180-00303	Resistor, Carbon Comp, 30 K ±5%, 1/4 W
R14,R26,R77,R130,R138, R168,R171,R202,R203, R209,R220	180-00104	Resistor, Carbon Comp, 100 K ±5%, 1/4 W
R15,R63,R80	200-00394	Resistor, Carbon Film, 390 K ±5%

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R16,R64,R81	180-00203	Resistor, Carbon Film, 20 K ±5%, 1/4 W
R19–R22	340-00015	Resistor, Metal Film, 51.1 K ±0.1%, 1/4 W, RN60E5112B
R23,R45,R111	340-00580	Resistor, Metal Film, 66.5 K ±1%, 1/4 W, RN60C
R24,R46,R112	390-00551	Resistor, Metal Film, 33.2 K ±1%, 1/8 W, RN55C
R25,R49,R114,R125	390-00601	Resistor, Metal Film, 100 K ±1%, 1/8 W, RN60C
R27	390-00569	Resistor, Metal Film, 51.1 K ±1%, 1/8 W, RN55C
R28	390-00455	Resistor, Metal Film, 3.65 K ±1%, 1/8 W, RN55C
R29,R30,R84–R86	340-00002	Resistor, Metal Film, 20K ±0.1%, 1/4 W, RN60E
R31,R87	340-00001	Resistor, Metal Film, 10 K ±0.1%, 1/4 W, RN60E
R32	360-00068	Potentiometer, 20 K, Bourns 3009P–1–203
R33–R44		Not Used
R47,R113	390-00573	Resistor, Metal Film, 56.2 K ±1%, 1/8 W, RN55C
R48,R115	390-00636	Resistor, Metal Film, 232 K ±1%, 1/4 W, RN55C
R50,R57,R105,R116	340-00501	Resistor, Metal Film, 10 K ±1%, 1/4 W, RN60C
R51,R136,R166	200-00622	Resistor, Carbon Film, 6.2 K ±5%
R52	340-00585	Resistor, Metal Film, 75 K ±1%, 1/4 W, RN60C
R53,R54,R126,R127	340-00701	Resistor, Metal Film, 1 M ±1%, 1/4 W, RN60C
R55	330-00526	Resistor, Metal Film, 18.2 K ±1%, 1/4 W, RN60E
R56,R131,R161	360-00119	Potentiometer, 50 K ±10%, Allen Bradley 72B1G040S503W
R58,R133,R163	330-00473	Resistor, Metal Film, 5.62 K ±1%, 1/4 W, RN60E
R59,R118	330-00609	Resistor, Metal Film, 121 K ±1%, 1/4 W
R74	340-00011	Resistor, Metal Film, 174 K ±0.1%, 1/4 W, RN60E
R88	330-00528	Resistor, Metal Film, 19.1 K ±1%, 1/4 W, RN60E
R89	360-00069	Potentiometer, 2 K, Bourns 3009P–1–202
R90–R104,R106		Not Used
R117,R197	390-00593	Resistor, Metal Film, 90.9 K ±1%, 1/8 W, RN55C
R119,R129	200-00204	Resistor, Carbon Film, 200 K ±5%
R120,R128,R134,R182, R190–R192,R198	200-00102	Resistor, Carbon Film, 1 K ±5%
R122,R141,R167	200-00153	Resistor, Carbon Film, 15 K ±5%
R123	200-00105	Resistor, Carbon Film, 1 M ±5%
R124	200-00823	Resistor, Carbon Film, 82 K ±5%

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R132	330-00513	Resistor, Metal Film, 13.3 K ±1%, 1/4 W, RN60E
R135	330-00518	Resistor, Metal Film, 15 K ±1%, 1/4 W, RN60E
R137,R159,R170	180-00103	Resistor, Carbon Comp, 10 K ±5%, 1/4 W
R139	180-00154	Resistor, Carbon Comp, 150 K ±5%, 1/4 W
R140	390-00605	Resistor, Metal Film, 110 K ±1%, 1/8 W
R143–R158,R160		Not Used
R162		Select for 30°, 60°, 120°, or 180° phase angle limit - Refer to **OPTIONAL COMPONENTS**
R164	200-00563	Resistor, Carbon Film, 56 K ±5%
R165	330-00301	Resistor, Metal Film, 100 Ω ±1%, 1/4 W, RN60E
R172	180-00392	Resistor, Carbon Film, 3.9 K ±5%, 1/4 W
R173	180-00102	Resistor, Carbon Comp 1 K ±5%, 1/4 W
R174,R175	370-00006	Resistor, Wirewound, 3.3 Ω ±5%, 2 W
R176	200-00100	Resistor, Carbon Film, 10 Ω ±5%
R178	200-00202	Resistor, Carbon Film, 2 K ±5%
R179, R180	340-00443	Resistor, Metal Film, 2.74 K ±1%, 1/4 W
R181	200-00514	Resistor, Carbon Film, 510 K ±5%
R183		Not Used
R184	200-00332	Resistor, Carbon Film, 3.3 K ±5%
R185		Not Used
R186,R195	200-00472	Resistor, Carbon Film, 4.7 K ±5%
R187		Not Used
R188,R189	200-00205	Resistor, Carbon Film, 2 M ±5%
R193	340-00013	Resistor, Carbon Comp. 16 K ±5%
R194	350-00052	Resistor, Wirewound, 20 Ω ±5%, 5 W
R196,R200	360-00141	Potentiometer, 20 K, ±10%, Bourns 3266W-1-203
R199,R201	180-00564	Resistor, Carbon Comp, 560 K ±5%, 1/4 W
R205,R207,R209	180-00562	Resistor, Carbon Comp, 5.6 K ±5%, 1/4 W
R208	200-00104	Resistor, Carbon Film, 100 K ±5%
R222,R223	390-00339	Resistor, Metal Film, 249K, ±1%, 1/8W
R210–R219,R221		Not Used
RV1,RV3,RV6,RV8, RV13,RV14,RV20,RV21	400-00724	Varistor, 250 V, 20 J, G.E. V250LA20

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
RV2,RV7,RV11,RV16	400-00718	Varistor, 1800 V dc, 80 J, Panasonic ERZ–C–14DK182
RV4,RV5,RV9,RV10	400-00709	Varistor, 250 V, 2 J, G.E. V250LA2
RV12,RV17	400-00734	Varistor, 1000 V dc, 40 J, Panasonic ERZ–C–14DK102
RV15	400-00727	Varistor, 250 V, 40 J, G.E. V250LA40B
T1,T2	410-00031*	Transformer Set, B-0210, U-0086
T3	410-00030*	Transformer, U-0085
T4	410-00017*	Transformer, U-0029
TB1	420-00052	Terminal Strip, 28–Position, R.D.I. 6PCR-28-001
TB2		See **PARTS MOUNTED TO THE ENCLOSURE**
TB3	420-00067	Terminal Strip, 11–Position, Curtis GBPC-11
U1,U30	400-00655	Op Amp, National LF257H
U2,U28,U42	400-00638	Hex Inverter, Motorola MC14049BAL
U3	400-00625	Quad 2–Input NOR–Gate, Motorola MC14001BAL
U4	400-00658	Varafet, Intersil IT401A
U5,U13,U16,U18	400-00633	Op Amp, Motorola MLM108AG
U6,U9,U10,U29,U31	400-00665	Quad Op Amp, National LM224J
U7,U15	540-00010	Multivibrator, Motorola MC14538BAL
U8,U14,U17	400-00656	Sample and Hold, National LF298H
U11,U12,U32	400-00636	Quad 2–Input AND–Gate, Motorola MC14081BAL
U19,U20	400-00620	Op Amp, National LF255H
U21–U27,U33–U35		Not Used
U36	400-00683	8–Input NAND–Gate, Motorola MC14068BAL
U37		Not Used
U38,U39	400-00716	Photon Coupled Isolator, G.E. 4N35
U40	400-00644	Voltage Reference, National LH0070-1H
U41	560-00010	Voltage Regulator, Raytheon RC4194TK
VR1,VR3	400-00057	Diode, Zener, 33 V ±5%, 5 W, 1N5364B
VR2	400-00030	Diode, Zener, 15 V ±10%, 400 mW, 1N965B
VR4	400-00056	Diode, Zener, 9.1 V ±5%, 400 mW, 1N757A
VR5	400-00074	Transient Suppressor, General Semiconductor Ind. 15KP280A
VR6	400-00017	Diode, Zener, 3.6 V ±5%, 400 mW, 1N747A

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
PHASE ANGLE LIMIT CONTROL OPTION		
R162	370-00020	Jumper = 180^0
	190-00439	Resistor, Metal Film, 2.49 K ±1%, 1/8 W = 120^0
	190-00502	Resistor, Metal Film, 10.2 K ±1%, 1/8 W = 60^0
	190-00540	Resistor, Metal Film, 25.5 K ±1%, 1/8 W = 30^0
PARTS MOUNTED TO THE ENCLOSURE		
CR89	400-00230	Diode, 6QD8
TB2	420-00051	Terminal Block, Barrier Strip, Cinch-Jones 8-142Y
50 HZ OPTION		
B-0207-D1		
R7, R66	330-00601	Resistor, 100KΩ, ±1%, 1/4W
R74	330-00632	Resistor, 210KΩ, ±1%, 1/4W

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
B-0264 VARIABLE SPEED MOTOR APPLICATION		
C1,C2	000-00904	Capacitor, 0.01 µF, ±20%, 1KV, Centralab DD-1032
C3,C4	000-00903	Capacitor, 100 pf, ±20%, 1KV, Centralab DD-101
C5,C6	010-00549	Capacitor, 1.5 µF, 100 V, Polyester Seacor MMKK
C7,C10	010-00441	Capacitor, 0.47 µF, ±1%, 50V, Polystyrene, F-dyne PC12.47-50-1
C8,C9	010-00800	Capacitor, 2.0 µF, ±5%, 50V Component Research H14B205DXW
C11,C12	000-00553	Capacitor, 2.2 µF, 25V, Tantalum Panasonic F25E2R2
R1-R5	340-00395	Resistor, Metal Film, 953 Ω, ±1%. 1/4 W RN60C
R6	330-00389	Resistor, Metal Film, 825 Ω, ±1%. 1/4 W RN60E
R7	360-00034	Potentiometer, 200ý, ±20%. Bourns 3386P-1-201
R8	200-00103	Resistor, Carbon Film, 10KΩ, ±5%
R9	200-00473	Resistor, Carbon Film, 47KΩ, ±5%
U1,U2	560-00011	OP AMP, LM108AJ-8

Legal Information

Patent

The units described in this manual are covered by U.S. Patents 4,218,625 and 4,256,972.

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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