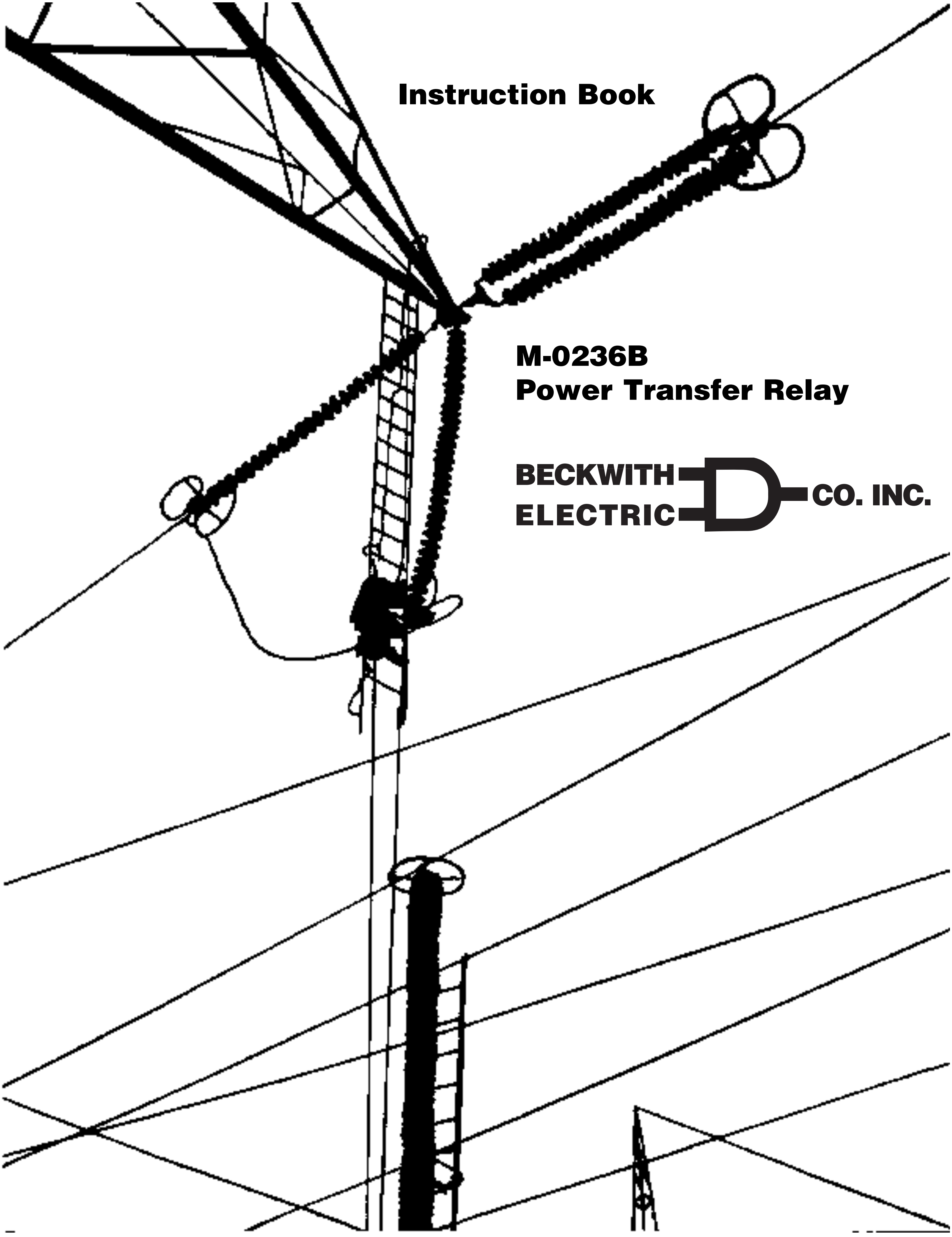
Instruction Book

M-0236B
Power Transfer Relay

BECKWITH ELECTRIC CO. INC.



SYNCROCLOSER® LINE

Power Transfer Relay M-0236B

Ultra High–Speed Automatic Synchronizer

- **For Electric Generating Plants**
- **For Industrial Plants**
- **Synchronously transfers a motor bus between alternate sources.**
- **Accurately closes a high-speed breaker at the first available zero phase condition.**
- **Closes only if the alternate source voltage is within preset limits.**

Synchronous 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. However, 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-0236B Power Transfer Relay provides a high-speed means to synchronously close a transfer breaker onto the disconnected but still spinning motor load, thereby avoiding damage to the machines. The maximum phase error at the instant of breaker closing is determined by slip rate and the breaker closing time.

Inputs

Motor Load Bus: 120 V ac nominal, 0.15 VA burden maximum.

Auxiliary Source: 120 V ac nominal, 0.15 VA burden maximum.

M-0236 Supply: 120 V ac ±10%, 12 VA burden, 50 to 400 Hz.

Optional 50 Hz operation is available.

Transfer Enable Contact: An external dry contact closure to enable the transfer sequence. This may be an auxiliary "b" contact of the main bus breaker.

Breaker Closing Time: Programmable from 2 to 12 cycles.

■ **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.

Breaker Closing Time

May be programmed by internal switches over a range of 2 to 12 cycles. The minimum time between opening the main breaker and closing the transfer breaker is 12 cycles, assuming a 5 cycle breaker closing time and proper phase coincidence at the end of this period.

Controls

UPPER VOLTAGE LIMIT for auxiliary voltage: 110 to 140 V ac.

LOWER VOLTAGE LIMIT for auxiliary voltage: 90 to 120 V ac.

∆ FREQUENCY LIMIT: 0.5 to 5 Hz.

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

LED Indicators

UPPER VOLTAGE LIMIT OK: The auxiliary voltage is less than the setting of the **UPPER VOLTAGE LIMIT**.

LOWER VOLTAGE LIMIT OK: The auxiliary voltage is greater than the setting of the **LOWER VOLTAGE LIMIT**.

∆ FREQUENCY LIMIT OK: The frequency difference is within the setting of the **∆ FREQUENCY LIMIT**.

READY: The unit is reset and ready. Breaker will close if the voltages and frequencies are within the preset limits and if the Transfer Enable Contact is closed.

OUTPUT CLOSED: The solid-state output contact between TB2-A to TB2-B is closed.

TRANSFER ENABLED: The external Transfer Enable Contact is closed.

Outputs

The solid-state Breaker Close Circuit is capable of controlling an inductive current of 15 A at 300 V dc. The closing signal will remain for 0.3 seconds. Reset time is 10 seconds. Operation of the Breaker Close Circuit is inhibited if the frequency of the auxiliary source is unstable.

The following analog outputs are provided:

Δ Frequency: 0 to +10 V dc corresponding to 0 to 5 Hz.

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

Auxiliary Source Voltage: 0 to 7 V dc corresponding to 0 to 140 V ac input .

Bus Voltage: 0 to 7 V dc corresponding to 0 to 140 V dc input .

■ **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.

Status Contacts

Auxiliary Source Voltage: Contact is closed when the voltage is within the **UPPER** and **LOWER VOLTAGE LIMIT** settings.

Δ Frequency: Contact is closed when the frequency difference between the auxiliary source and motor bus is within the **Δ FREQUENCY LIMIT** settings.

■ **NOTE**: These contacts are 20 VA dry type capable of carrying 1 A maximum, switching a 100 V dc resistive load and withstanding 250 V dc open circuit.

Response Time

Delay after power turn on: Approx. 2 seconds. 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 unit is enabled regardless of other inputs.

Delay to change in voltages in and out of band will generally range from 0 to .08 seconds.

Transient Protection

Input and output circuits are protected against system transients. The M-0236 will pass all requirements of ANSI/IEEE C37.90.1-1989 defining oscillatory surge withstand capability. All inputs and outputs will withstand 1500 V ac to chassis or instrument ground for one minute. Voltage inputs are electrically isolated from each other, from other circuits, and from ground. 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.

Reliability

The M-0236 Power Transfer 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.

Harmonic Filters

Many applications for the Power Transfer 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-0236 includes active filters on the bus and line voltage inputs to permit proper operation in these applications.

Variable Speed Motor Application

The M-0236B Power Transfer Relay includes a Variable Speed Motor Application circuit to facilitate proper operation on Motor Buses utilizing commutating speed control techniques.

Environmental

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

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

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

Seismic: Unit is 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)

Syncrocloser® Cover Kit

The M-0217 Cover Kit includes a transparent cover and mounting bracket to cover the knobs and prevent accidental resetting.

Patents

The M-0236B Power Transfer Relay is covered by U.S. Patents 4,256,972 and 4,310,771.

Warranty

The M-0236B Power Transfer Relay is covered by a two year warranty from date of shipment.

ISO 9001:1994 Registered

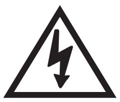
BECKWITH ELECTRIC CO., INC.
6190 - 118th Avenue North • Largo, Florida 33773-3724 U.S.A.
PHONE (727) 544-2326 • FAX (727) 546-0121
E-MAIL marketing@beckwithelectric.com
WEB PAGE www.beckwithelectric.com

800-0236B-SP-00 07/01

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

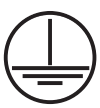


– This sign warns that the area is connected to a dangerous high voltage, and you must never touch it.

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.

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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. 4/93

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INTRODUCTION

Please refer to the M–0236 Application Guide in conjunction with this Instruction Book since information contained in one is usually not repeated in the other.

The Beckwith M–0236 utilizes advanced state-of-the-art semiconductors and circuits to achieve an overall stability and resolution unattainable with other techniques. Modern hybrid and monolithic semiconductors utilizing ion implantation and laser trimming are used throughout the Syncrocloser® Line to gain temperature stability without critical compensation or trimming.

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

THEORY OF OPERATION

Refer to Figure 1 Block Diagram.

Each input (Motor Load, Auxiliary Source) is passed through a transformer and scaled down from 120 V ac to 6 V ac. If variable speed motor control is utilized 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 voltage from the Auxiliary Source is converted into dc voltages by the Ac to Dc Converters. These converters are active full-wave rectifiers and filters which eliminate the usual highly temperature-dependent diode drop of conventional full-wave rectifiers. Full-wave rectification was chosen over half-wave rectification because the filter time response is much faster for a given ripple voltage. This is due to the fact that full-wave rectification contains no fundamental frequency components, only harmonics. The Upper and Lower Voltage Comparitor compares the output of the Ac to Dc Converter of the Auxiliary Source to a portion of a highly stable hybrid 10 V reference. LEDs located on the front panel indicate the condition of the Auxiliary Source with reference to upper and lower voltage limits.

Two Zero-Crossing Detectors generate rectangular waveforms at the zero crossings of each input. A logic gate provides a pulse width proportional to the phase difference between each input. The pulse width proportional to phase difference is integrated and sampled each half cycle of the highest frequency input; usually the Line. This sampled voltage is an accurate measure of the phase difference and is updated about once every 8.3 ms. The sampled voltage varies from 0 to +10 V for a phase difference change of 0 to 180°. TB1–5 allows external monitoring of the phase difference sampled voltage referenced as "Phase Difference Analog Output."

A four-pole Butterworth Active Filter removes any unwanted frequency components from the phase difference sampled voltage. These frequency components arise from the sampling process and are harmonically related to the sampling period. Phase slope is measured by the First Derivative Amplifier and the bipolar nature of the derivative is removed by the Absolute Value Amplifier. Thus the output of the Absolute Value Amplifier is a voltage proportional in magnitude to the phase slope or $\partial\Phi/\partial t$, where Φ is the phase difference voltage. In polarity transitions of the First Derivative Amplifier, small voltage spikes appear on the output of the Absolute Value Amplifier. The Phase Angle Controlled Filter removes these spikes without introducing time delay because the filter only "reacts" when the phase difference is near 0° or 180°; i.e., when the First Derivative Amplifier is in polarity transition, which causes the spikes. Circuit decisions are made before the phase difference is 0° and after the phase difference is 180°, thus the Phase Angle Controlled Filter has no time effect in circuit decisions.

The Phase Angle Controlled Filter output voltage is proportional to $\partial\Phi/\partial t$, or the difference in frequency between inputs. This voltage is available for external monitoring through TB1–6 and is internally monitored by the Δ Frequency comparitor as set by the front panel control Δ **FREQUENCY LIMIT**.

The derivative $\partial\Phi/\partial t$ and second derivative $\partial^2\Phi/\partial t^2$ are added with constants in the Summation Amplifier. The voltage from the Summation Amplifier is scaled in magnitude by the Breaker Closing Time Network and compared to phase difference voltage Φ. When these voltages are equal, the Comparitor and Pulse Generator send a "close" pulse to the logic section. The Breaker Closing Time Network allows various breaker closing times to be programmed.

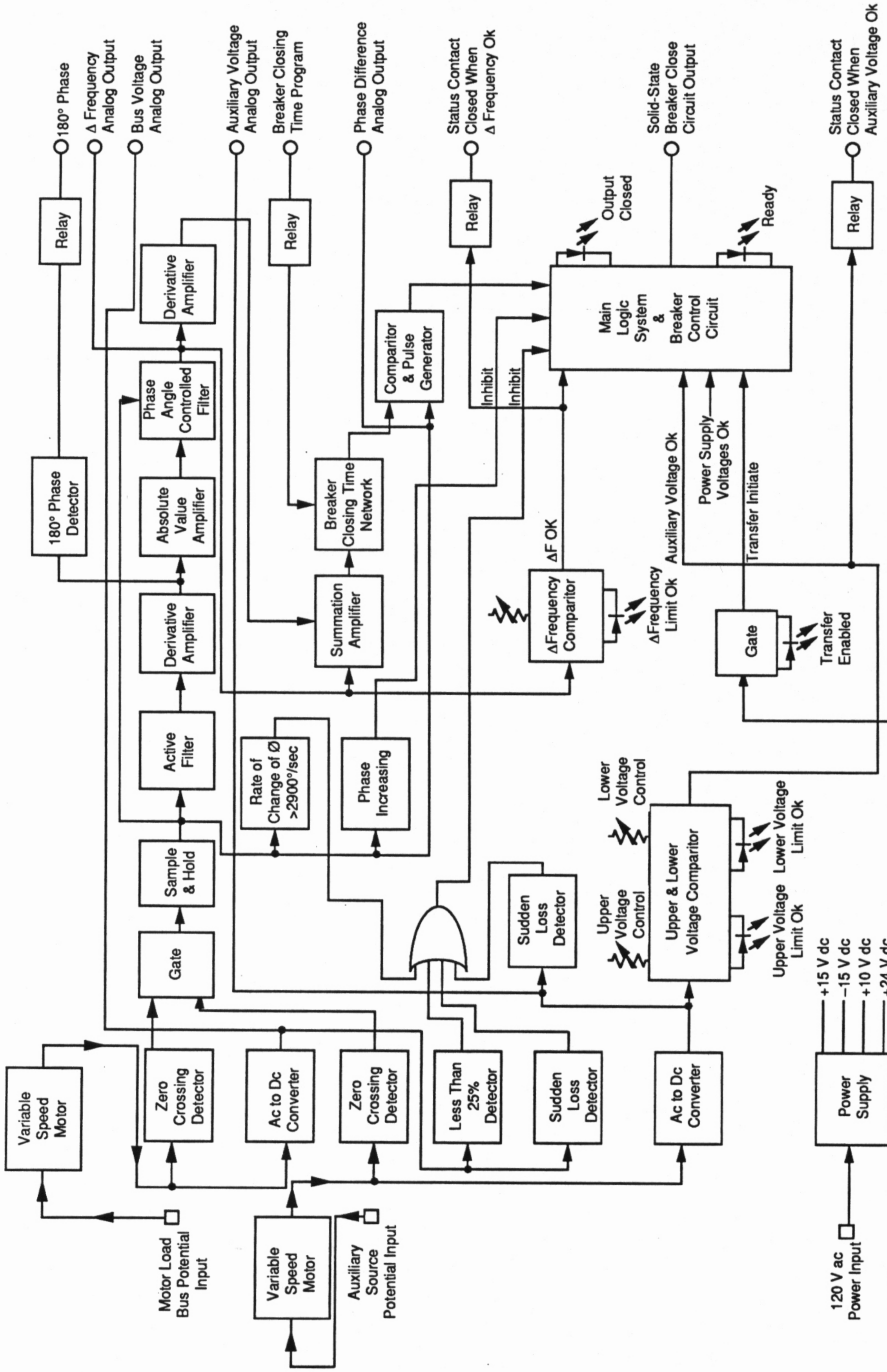


FIGURE 1 Block Diagram

At this point, the system has solved the following second order, partial differential equation:

$$0 = KT_B\, \partial^2\Phi/\partial t^2 + T_B\, \partial\Phi/\partial t + C\Phi$$

where K, C and T_B are not functions of time or phase difference Φ, but functions of circuitry and breaker close time.[1]

The Main Logic System and Breaker Control Circuit monitor all functions including power supply voltages. Upon receiving a logic "1" from the Initiate Transfer Gate and the appropriate logic conditions from the Frequency Comparitor, Upper and Lower Voltage Comparitor, Comparitor and Pulse Generator; a breaker close signal is generated. This signal causes the Breaker Control Circuit to electrically short TB2–A and TB2–B for 0.3 seconds. For the next 10 seconds, the Breaker Control Circuit generates an interrupt command which holds the complete M–0236 in a dormant state. A front panel LED indicates when the M–0236 is in a Ready or "non-dormant" state. If, at the end of 10 seconds, the Initiate Transfer Input is still programmed to transfer, the M–0236 will again electrically short TB2–A and TB2–B providing the previously mentioned logic conditions remain acceptable. Keep in mind that TB2–A and TB2–B will electrically short only when the time before zero-degrees phase difference is equal to the programmed breaker time.

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 M–0236 has been designed with an Input Loss Protection circuit to minimize the possibility of the output contacts closing due to the sudden loss of the vt input sources. The circuitry provides the following protection features.

1. The M–0236 output contact is forced to the normally open state for any of the following conditions:
   a. Rate of change of phase, as detected by the M–0236 circuitry, is greater than 2900°/sec (8 Hz frequency difference).
   b. Sudden drop in the Auxiliary vt voltage magnitude.
   c. Sudden drop in the Bus vt voltage magnitude.
   d. Bus vt voltage less than 0.25 p.u.

2. The M–0236 output is inhibited from closing (if not already closed) when the internal circuitry detects the phase angle is increasing, i.e., phase going away from 0°.

■ **NOTE:** 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 "Enable Transfer" contact from TB1–20 to TB1–21 should be closed only during the time required for the transfer sequence to be completed.

[1] M. A. Wyatt, "Synchronous Power Transfer, The Analysis Leading to the Development of the Beckwith Electric M-0236 Power Transfer Relay," a Beckwith Electric Publication January 1979.

TEST PROCEDURE

Please refer back to the **WARNING** page at the beginning of this manual and the **MAINTENANCE** page in the Application Guide before proceeding.

Refer to Figure 2 External Connections, and Figure 9 Component Location in conjunction with this Test Procedure section.

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

EQUIPMENT REQUIRED

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

A 60 [50] Hz variable frequency source capable of providing 120 V ac. Maximum phase jitter of 1° .

A 60 [50] Hz fixed frequency source capable of providing 120 V ac. Maximum phase jitter of 1° .

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

Two (2) Digital multimeters with ac and dc accuracy of ±0.2 of full scale; Hewlett-Packard 3465A or equivalent.

One (1) Solder sucking syringe or solder wick.

One (1) Soldering iron - Weller Controlled Output Soldering Station, model MTCPL, 60 W, 120 V, 50/60 Hz or equivalent.

PROCEDURE

1. If a component needs to be changed, carefully scrape away the coating surrounding the component using a small, sharp knife.
2. Clip out old component and discard.
3. 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.**

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.

UPPER VOLTAGE LIMIT

1. Supply a 120 V ac, 60.000 [50.000] Hz Auxiliary Source to TB1–4 (HOT) and TB1–3 (NEUTRAL); supply a variable phase, variable frequency source to the Motor Load Bus input TB1–1 (HOT) and TB1–2 (NEUTRAL).

2. Adjust the Auxiliary Source voltage of TB1–4 to TB1–3(N) to 120.0 V ac.

3. Adjust the **UPPER VOLTAGE LIMIT** front panel control to the 125 V setting.

4. Slowly increase the Auxiliary Source voltage toward the 125 V reading.

5. The **UPPER VOLTAGE OK** LED should go out as the input passes 125 V ± 0.75 V.

6. Slowly decrease the Auxiliary Source voltage to 124 V. The **UPPER VOLTAGE LIMIT OK LED** should light as the voltage drops below 125 V ± 0.75 V.

LOWER VOLTAGE LIMIT

1. Adjust the **LOWER VOLTAGE LIMIT** control to the 105 V setting.

2. Slowly decrease the Auxiliary Source voltage toward the 105 V reading.

3. The **LOWER VOLTAGE OK** LED should go out as the input passes 105 V ± 0.75 V.

4. Slowly increase the Auxiliary Source voltage to 106 V. The **LOWER VOLTAGE LIMIT OK LED** should light as the voltage goes above 105 V ± 0.75 V.

AUXILIARY SOURCE AND BUS VOLTAGE ANALOG OUTPUT

1. Readjust the Auxiliary Source voltage to 120.0 V ac.

2. Adjust the Bus voltage to 120.0 V ac at 60 [50] Hz.

3. Attach the negative lead of a dc voltmeter to TB1–7 and the positive lead to TB1–28.

4. The voltmeter should indicate 6.0 V ±0.1 V.

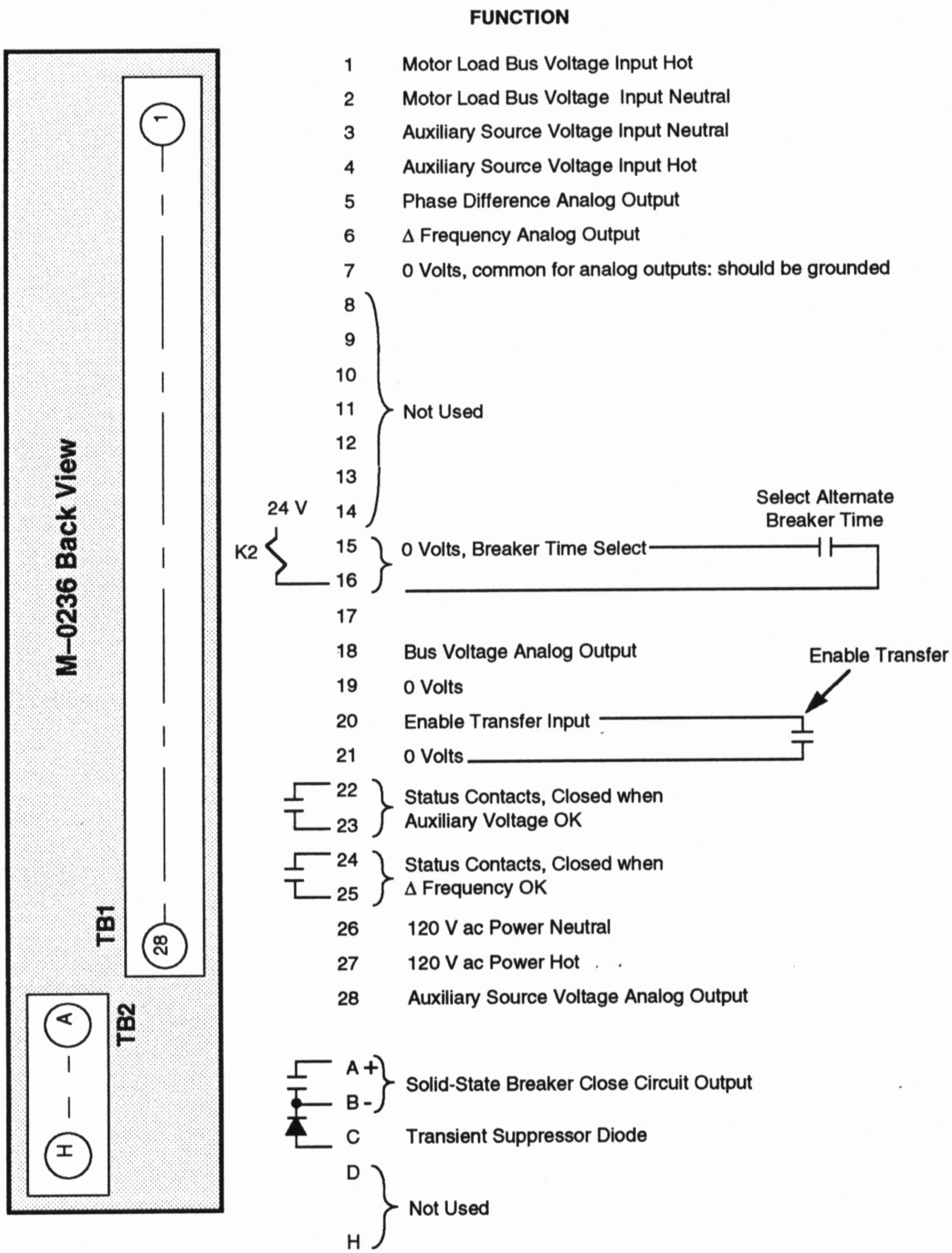
5. Remove the positive lead and attach to TB1–18.

6. The voltmeter should read 6.0 V ±0.1 V.

Δ FREQUENCY LIMIT

1. Adjust the Δ **FREQUENCY LIMIT** front panel control to 2.0 Hz.

2. Adjust the Motor Load Bus frequency TB1–1 and TB1–2 to 120 V ac, 60.000 [50.000] Hz.



■ **NOTE:** The contacts used to program the breaker closing time should be gold-plated, dry circuit contacts. The use of high voltage, high current contacts in this circuit may cause intermittent operation. The wiring between the M–0193 terminal block and these contacts should be kept as short as possible (less than 2 feet) and twisted/shielded wires are recommended.

FIGURE 2 External Connections

3. Adjust the Auxiliary Source frequency to 120 V ac, 60.000 [50.000] Hz.

4. Slowly decrease the Motor Load Bus frequency towards the 58.000 [48.000] Hz reading.

5. The Δ **FREQUENCY LIMIT OK** LED should go off as the frequency passes the 58.000 [48.000] Hz reading.

Δ FREQUENCY ANALOG OUTPUT

1. Adjust the Motor Load Bus frequency to 59.000 [49.000] Hz while maintaining Auxiliary Source frequency at 60.000 [50.000] Hz.

2. Attach the negative lead of a dc voltmeter to TB1–7, the positive lead to TB1–6.

3. The voltmeter should indicate 2.0 V ±0.2 V. Note that this reading may fluctuate slightly.

PHASE DIFFERENCE ANALOG OUTPUT

1. Supply a 120 V ac, 60 [50] Hz source to Motor Load Bus TB1–1 and TB1–2.

2. Place an accurate phase meter between TB1–1/TB1–4 and between TB1–2/TB1–3.

3. Adjust the phase angle between the Auxiliary and Bus sources to +90° (Auxiliary Source as a reference).

4. Attach the negative lead of a dc voltmeter to TB1–7 and the positive lead to TB1–5.

5. The voltmeter should indicate 5.00 V ±0.03 V. Note that this reading may fluctuate slightly.

6. Repeat steps 3 through 5 for –90° phase angle.

7. Remove the source between TB1–3 and TB1–4.

8. Place a clip lead between TB1–1 and TB1–3; another clip lead between TB1–2 and TB1–4 (180° phase angle).

9. The dc voltmeter should read 10.000 V dc ±0.05 V.

10. Remove the clip lead between TB1–1/TB1–3 and TB1–2/TB1–4.

11. Place the clip lead between TB1–1 and TB1–4; place another clip lead between TB1–2 and TB1–3.

12. The dc voltmeter should read 0.00 V dc ±0.05 V.

BREAKER CLOSE CIRCUIT

1. Remove all clip leads.

2. Reattach the source between TB1–3 and TB1–4.

3. Adjust the Auxiliary Source frequency to 120 V ac, 60 [50] Hz.

4. Supply a 120 V ac, 59 [49] Hz source to the Motor Load Bus inputs TB1–1 and TB1–2.

5. Set S3 to position 3 for a 5-cycle breaker closing time.

6. Wire an active load, such as a 100 W incandescent bulb in series with a 125 V dc power source. Attach the most positive end of the series-connected active load to TB2–A and the most negative end to TB2–B (see Figure 3).

7. Adjust the front panel control as follows:

UPPER VOLTAGE LIMIT	=	130 V
LOWER VOLTAGE LIMIT	=	100 V
Δ FREQUENCY LIMIT	=	2.5 Hz

8. All LEDs except the **INITIATE TRANSFER** LED should be on.

9. Attach a clip lead between TB1–20 and TB1–21.

10. The incandescent bulb should light for 0.3 seconds and remain off for the next 10 seconds. The bulb should light as the phase angle approaches zero phase.

11. Notice that the **READY** LED is off during the 10 seconds, comes on until the incandescent bulb lights, and remains off for the next 10 seconds.

12. The procedure in steps 10 and 11 will repeat as long as Enable Transfer Input is programmed.

13. Remove the clip lead between TB1–20 and TB1–21; wait one minute. The incandescent bulb should not light during this period.

14. Replace the clip lead; the incandescent bulb should repeat the sequence in steps 10 and 11.

15 Reduce the Auxiliary Source voltage to below 100 V ac. The incandescent bulb should remain off as long as the Auxiliary Source voltage is less than the **LOWER VOLTAGE LIMIT**, which in this case is 100 V ac.

16. Increase the Auxiliary Source voltage to greater than 130 V ac. The incandescent bulb should remain off as long as the Auxiliary Source voltage is greater than the **UPPER VOLTAGE LIMIT**, which in this case is 130 V ac.

17. Leave the Auxiliary Source Frequency at 60 [50] Hz and reduce the Motor Load Bus frequency to 57 [47] Hz. The incandescent bulb should not light because the frequency difference is greater than the Δ **FREQUENCY LIMIT**; which in this case is 2.5 Hz.

PHASE ANGLE DETECTION CIRCUIT

Rate of Change of Phase Angle

1. Supply 120 V ac, 60 [50] Hz to Motor Load Bus Terminals TB1–1 and TB1–2.

2. Attach the scope ground at C78(-); the probe to the anode of CR8.

3. Begin to slowly adjust the frequency of the Auxiliary Source to approximately 120 V ac, 69 [59] Hz.

4. Verify that the pulse rate is approximately one pulse per cycle as the Auxiliary Frequency approaches 68 [58] Hz.

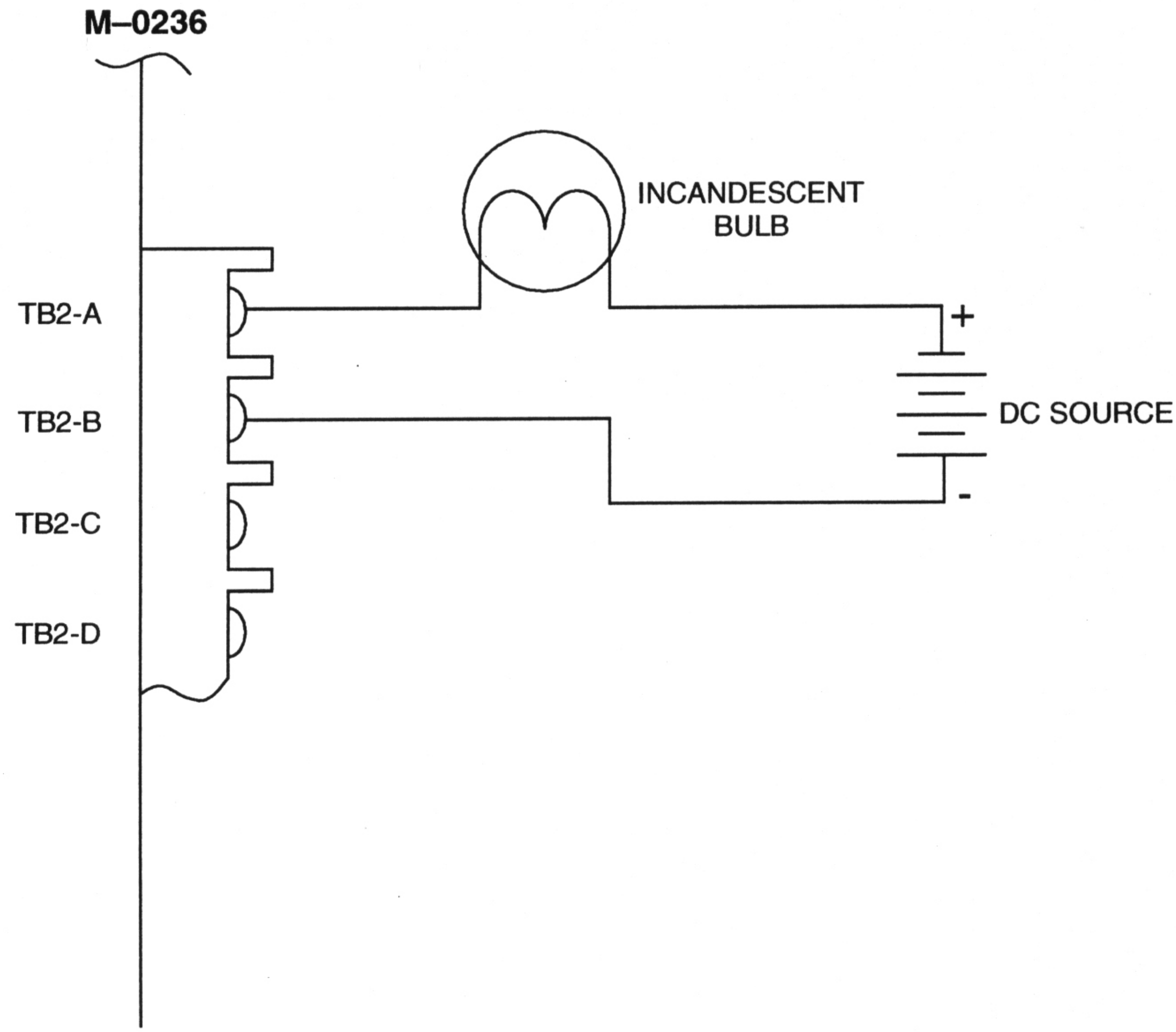


FIGURE 3 Breaker Close Circuit Test Setup

5. Reduce the Auxiliary Frequency slowly. The pulses should stop as the frequency drops below 68 [58] Hz.

Phase Increase

1. Adjust the Auxiliary Frequency to 120 V ac, 59.5 [49.5] Hz at TB1–3 and TB1–4.
2. Attach the scope probe to Test Point 5 (TP5).
3. The signal should be at the +15 V level as the phase angle travels away from 0° and should switch to -15 V after passing 180° and moving toward 0° phase.

LOSS OF VOLTAGE INPUT DETECTION CIRCUIT

Auxiliary Source Voltage Loss

1. Supply 120 V ac, 60 [50] Hz to TB1–1 and TB1–2, the Motor Load Bus input.
2. Supply 120 V ac, 60 [50] Hz to Auxiliary Source inputs TB1–3 and TB1–4.
3. Place the channel 1 probe on the anode of CR19.
4. Place the channel 2 probe on the end of R136 toward the rear terminal block.
5. Trigger scope on channel 1. Set the horizontal sweep time at 5 ms/div.
6. Remove the Auxiliary Source voltage completely.
7. The signal on channel 1 should immediately go high from -15 V to +15 V, and channel 2 should go high after 20 ms. See Figure 4.

Motor Load Bus Voltage Loss

1. Apply 120 V ac, 60 [50] Hz to Motor Load Bus voltage input TB1–1 and TB1–2.
2. Apply 120 V ac, 60 [50] Hz, to Auxiliary Source voltage input TB1–3 and TB1–4.
3. Place the channel 1 probe to Test Point 10 (TPIO) and channel 2 to Test Point 9 (TP9).
4. Trigger scope on channel 1. Set the horizontal sweep time at 10 ms/div.
5. Remove the Motor Load Bus voltage completely.
6. The signal on channel 1 should immediately go high from -15 V to +15 V, and channel 2 should go high after approximately 50 ms. See Figure 5.
7. Reapply the Motor Load Bus voltage with 120 V ac, 60 [50] Hz.
8. Remove the channel 1 probe.
9. Reduce the bus voltage slowly.
10. The signal on channel 2 should go high as the voltage level drops below 25%.

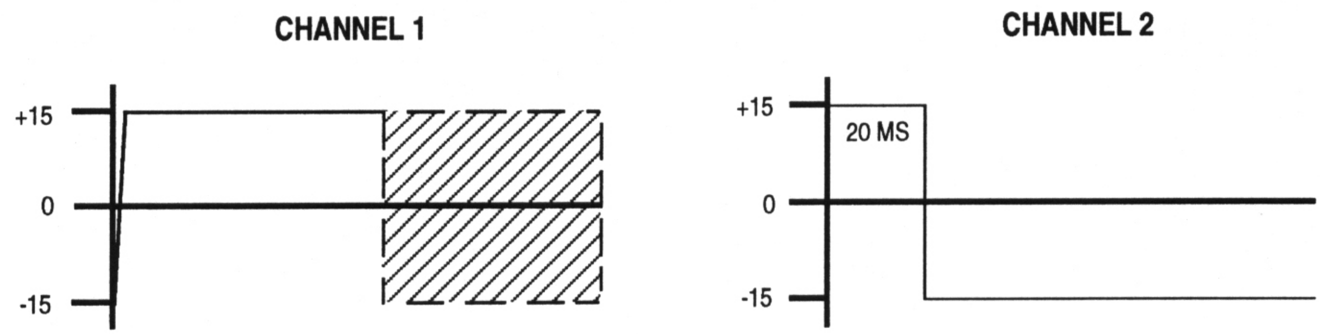


FIGURE 4 Auxiliary Source Voltage Loss

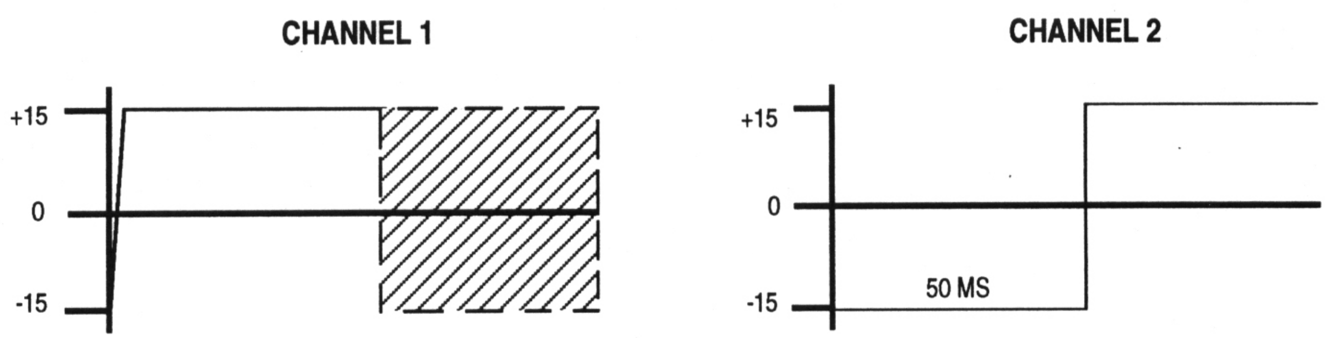


FIGURE 5 Motor Load Bus Voltage Loss

TYPICAL VOLTAGES

CONDITIONS

1. Motor Load Bus, Auxiliary Source and Power Supply are 120 V ac, 60 [50] Hz.
2. Measurements are made with a true rms type digital voltmeter (Data Precision 258 or equivalent).
3. Readings are made with a negative lead of the digital voltmeter tied to TB1–7, except as noted.

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

LOCATION OF TEST POINT	READING	TYPE OF WAVEFORM
Bottom End of R50	6.04 V dc	dc
Top End of R57	5.47 V dc	dc
Bottom End of R55	6.99 V dc	dc
Top End of R45	6.03 V ac	Sine Wave
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 R111	6.03 V ac	Sine Wave
Bottom End of R100	10.00 V dc	dc
Top End of R100	8.68 V dc	dc
Bottom of R133	6.00 V dc	dc
Top of R133	4.47 V dc	dc
Top of R163	1.02 V dc	dc
Bottom of R163	10.00 V dc	dc
Top of R187	14.87 V dc	dc
Test Point 8 (TP8)	-14.88 V dc	dc
Test Point 11 (TP11)	10.00 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 ac	Sine Wave

■ **NOTE:** The following readings are made with the negative lead of the digital voltmeter tied to TB2–B.

LOCATION OF TEST POINT	READING	TYPE OF WAVEFORM
+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

TYPICAL RESISTANCES

CONDITIONS

1. All rear terminals are open circuited.
2. Measurements are made with a true rms type digital volt meter (Data Precision 258 or equivalent).

LOCATION OF NEGATIVE DVM LEAD	LOCATION OF POSITIVE DVM LEAD	SCALE	READING
Rear TB1–1	Rear TB1–2	10 K	2.183 K
Rear TB1–1	Rear TB1–3	100 K	∞
Rear TB1–1	Rear TB1–7	100 K	∞
Rear TB1–3	Rear TB1–7	100 K	∞
Rear TB1–3	Rear TB1–4	10 K	2.211 K
Rear TB1–26	Rear TB1–27	1 K	0.0272 K
Rear TB2–B	Rear TB2–A	100 K	∞
Lead #4 of T1	Lead #3 of T1	10 K	0.151 K
Lead #4 of T2	Lead #3 of T1	10 K	0.148 K
Rear TB1–7	Lead #3 of T3	1 K	0.0037 K
Rear TB1–7	Lead #5 of T3	1 K	0.0039 K

▲ CAUTION: Any attempt to measure resistances between points on the printed circuit board other than those given in the Instruction Book is likely to cause damage to the unit.

CALIBRATION

■ **NOTE:** The M–0236 has been fully calibrated at the factory using highly sophisticated computer controlled test equipment. There is no need to re-calibrate the unit before initial installation. Further calibration is only necessary if a component was changed during a repair procedure. Access to the calibration points is only possible with the cover removed, therefore, after field repair, do not install the unit in a rack or panel before following the calibration or test procedure.

For component and Test Point location, refer to Figure 2 External Connections and Figure 9 Component Location.

PHASE ANGLE CALIBRATION

1. Supply 120 V ac, 57.500 [47.500] Hz to TB1–1 and TB1–2, noting TB1–1 is the HOT terminal.
2. Place a clip lead between TB1–1 and TB1–3.
3. Place a second clip lead between TB1–2 and TB1–4.
4. Attach the positive lead of the dc voltmeter to Test Point 1 (TP1).
5. Attach the negative lead to the negative end of C78 or to TB1–7.
6. Supply 120 V ac, 60 [50] to power input TBl–26 and TB1–27, noting that TB1–27 is the HOT terminal.
7. Adjust R89 until the voltmeter reads +10.000 V.
8. Remove the positive lead of the dc voltmeter and attach to Test Point 2 (TP2).
9. Adjust R6 until the voltmeter reads –10.014 V.
10. Remove the positive lead of the dc voltmeter and attach to Test Point 3 (TP3).
11. Adjust R65 until the voltmeter reads –10.014 V.
12. Remove the positive lead of the dc voltmeter and attach to bottom end of R105.
13. The voltmeter should read +10.00 V ±0.03 V.
14. Remove the positive lead of the dc voltmeter and attach to TB1–6.
15. Adjust R98 until the voltmeter reads 0.00 V, +0.02, –0.01.
16. Remove the positive lead of the dc voltmeter and attach to Test Point 7 (TP7).
17. Adjust R151 until the voltmeter reads 0.00 V, +0.02/–0.01.

18. Remove the clip leads to TB1–3 and TB1–4, and supply 60 [50] Hz at +90°, 120 V ac to TB1–3 and TB1–4 (HOT).

19. Remove the positive lead of the dc voltmeter and attach to the bottom end of R105. Record the voltmeter reading.

20. Change the phase of the source to TB1–3 and TB1–4 to –90°.

21. Adjust R32 until the voltmeter reads as close to the recorded voltage as possible.

22. Remove the positive lead of the dc voltmeter and attach to Test Point 7 (TP7).

23. Readjust the source to TB1–1 and TB1–2 to 120 V ac, 59.000 [49.000] Hz.

24. Adjust R148 until the voltmeter reads 2.0 V. This reading may fluctuate slightly but try to calibrate to the best average of the fluctuation.

LOW PASS FILTER FOR VARIABLE SPEED MOTOR APPLICATION

For Test Point and Component Locations, refer to Figure 5, External Connection; Figure 9, Component Location; and Figure 10, Schematic.

PHASE ANGLE CALIBRATION

1. Supply 120 V ac, 60 Hz to TB1-1 and TB1-2, noting TB1-1 is HOT terminal.

2. Place a clip lead between TB1-1 and TB1-4.

3. Place a second clip lead between TB1-2 and TB1-3.

4. Using a dual oscilloscope or phase meter, attach one channel to P2-3 of the low pass filter board.

5. Attach the second channel to P2-4.

6. Attach the common lead of the scope or phase meter to P1-3.

7. Adjust R7 of the filter board (B-0264) for a measured phase angle of 0.00 degrees.

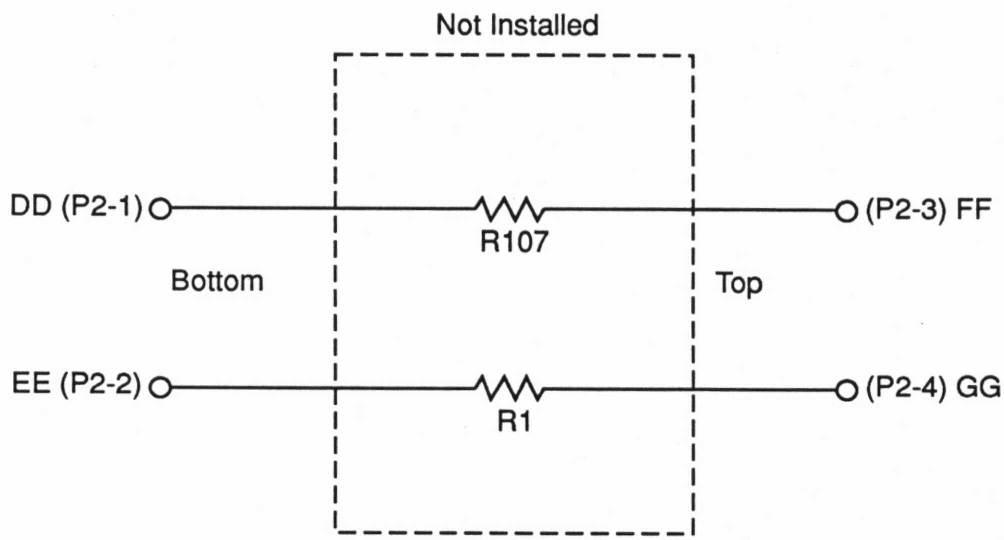
8. Remove the clip leads from TB1-1 to TB1-4 and TB1-2 and TB1-3.

VARIABLE SPEED MOTOR APPLICATION

Two matched low pass filters mount on a printed circuit board and are connected to the M-0236 zero crossing detector circuit.

This network eliminates false zero crossing detection due to the commutated voltage waveforms found on variable speed controlled buses.

The B-0264 assembly is connected to the M-0236 in the following manner:



AA (P1-1) ⟶ R210 top (+15 V dc) or TP6

BB (P1-3) ⟶ CR1 cathode (ground)

CC (P1-5) ⟶ TP8 (-15 V dc)

FIGURE 6 Connection Diagram for Variable Speed Motor Application

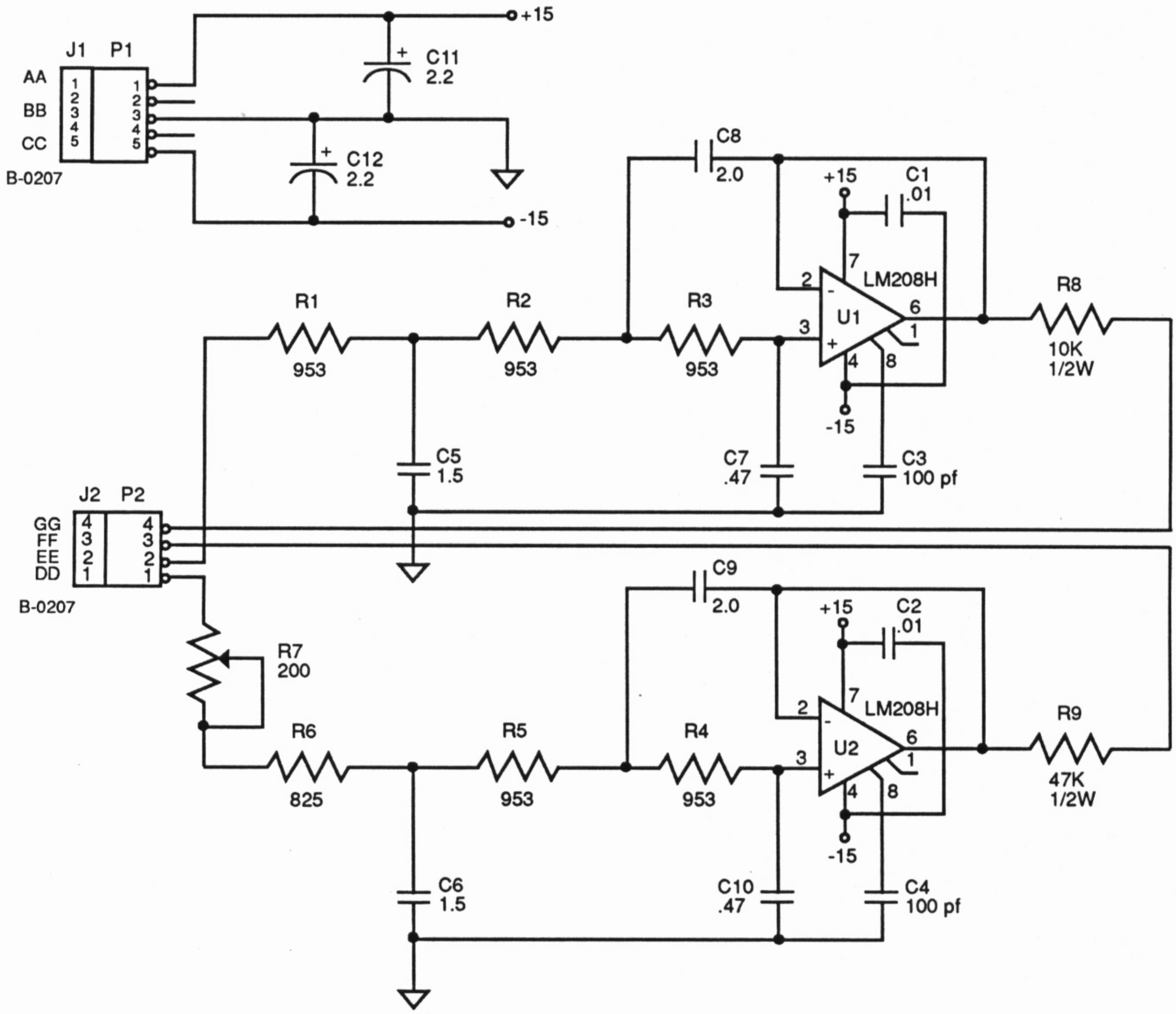


FIGURE 7 Low Pass Filter Schematic for Variable Speed Motor Application, Y-0264

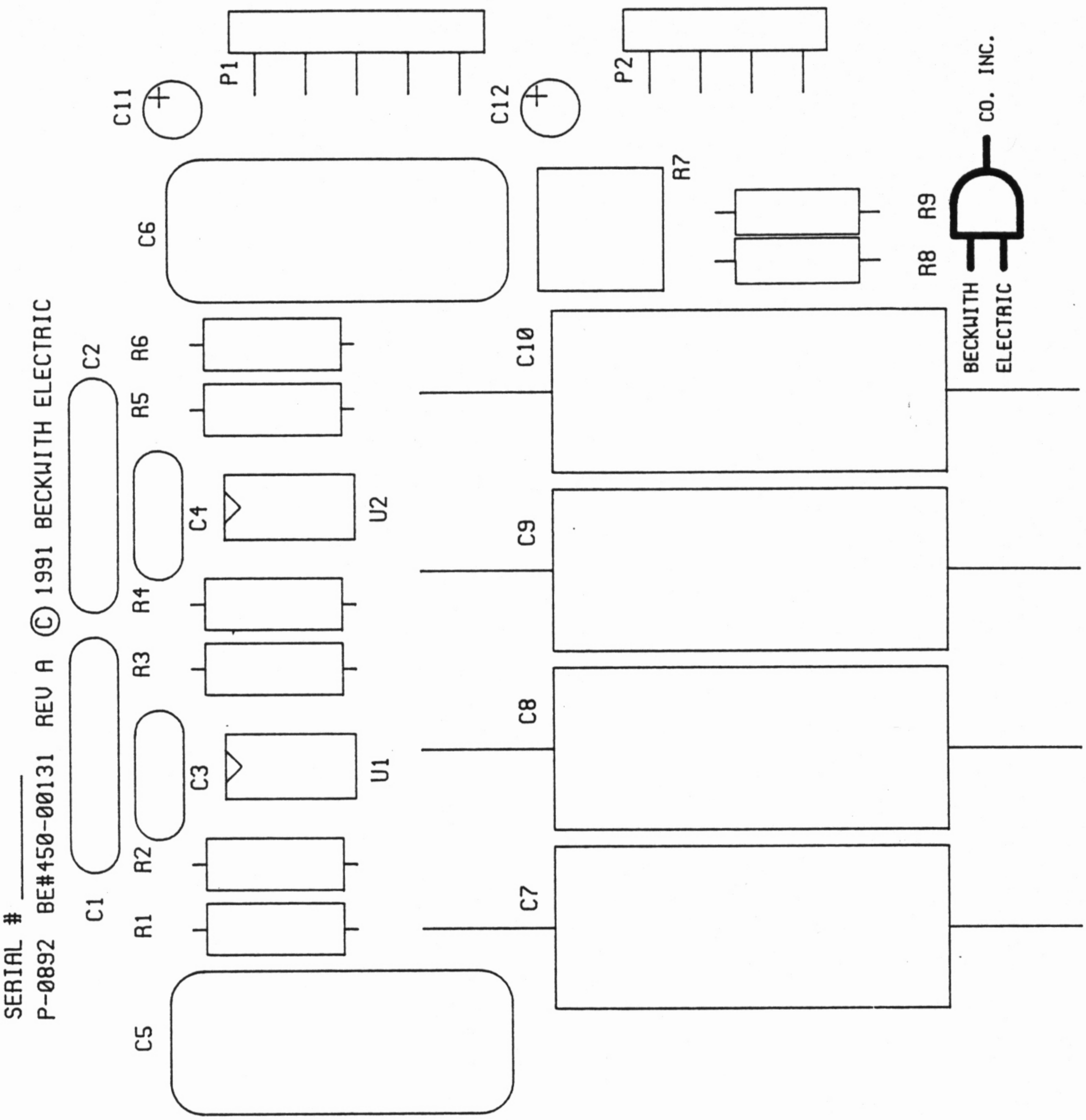


FIGURE 8 Component Location for Variable Speed Motor Application, B–0264

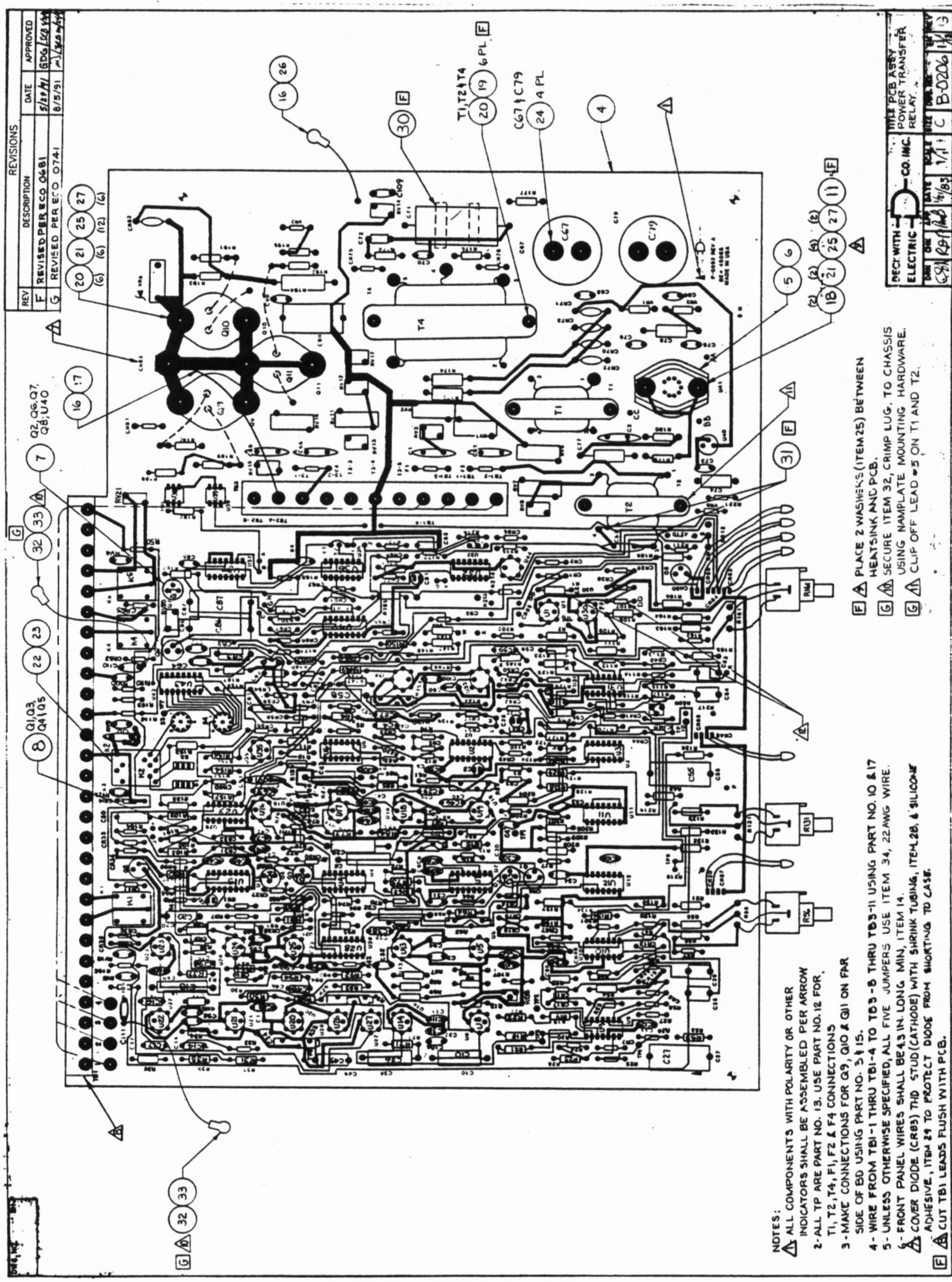
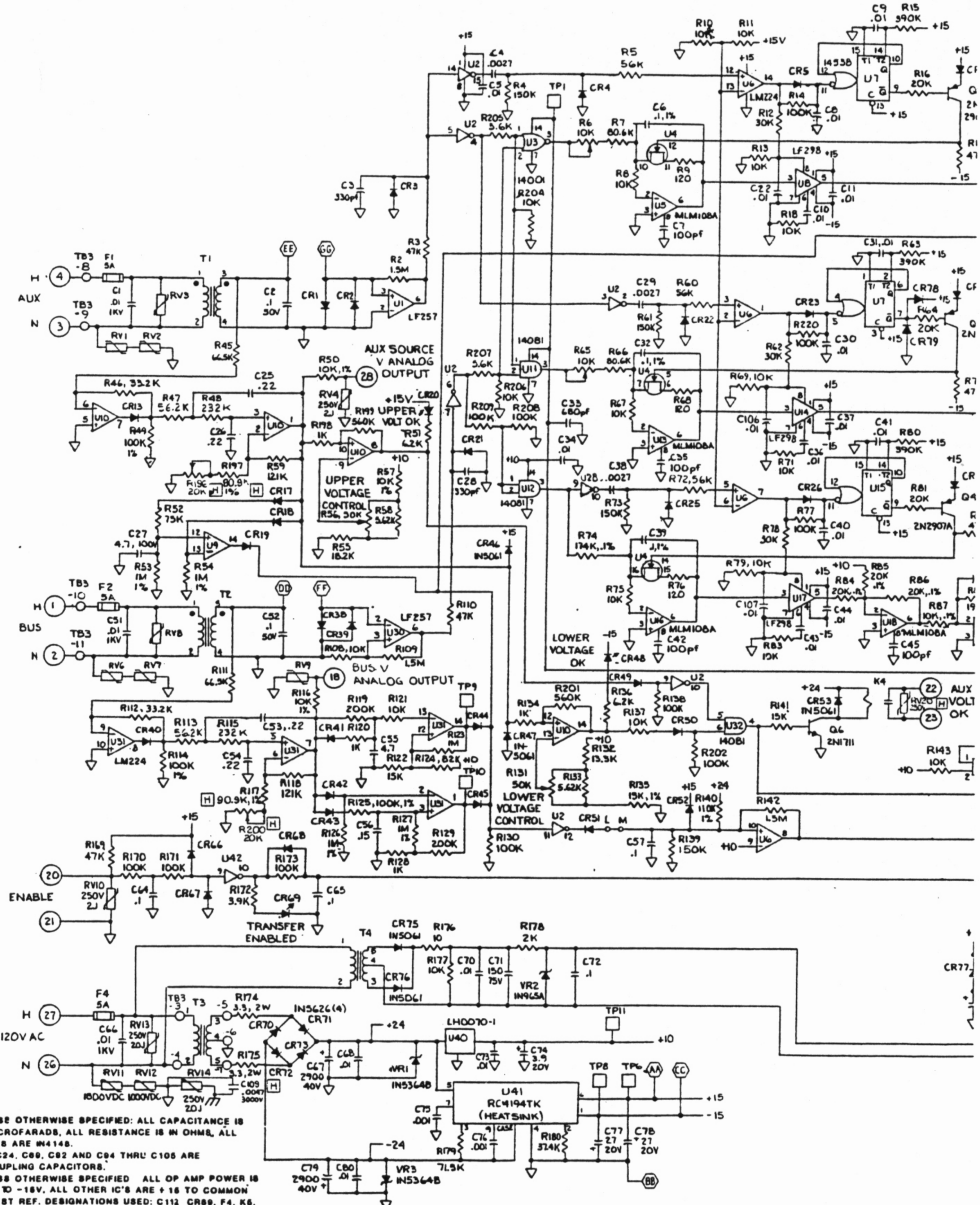


FIGURE 9 Component Location, B–0206



NOTES

1 UNLESS OTHERWISE SPECIFIED: ALL CAPACITANCE IS IN MICROFARADS, ALL RESISTANCE IS IN OHMS, ALL DIODES ARE IN4148.
2 C23 C24, C89, C92 AND C94 THRU C105 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: C112 CR89, F4, K6, Q11, R221, RV22 S4, U44, T4, TB3, VR6
5 UNUSED INPUTS ON U28 & U42 ARE TIED TO COMMON
[H] 6 ⬡ REPRESENT CONNECTION POINTS TO THE VARIABLE SPEED MOTOR APPLICATION

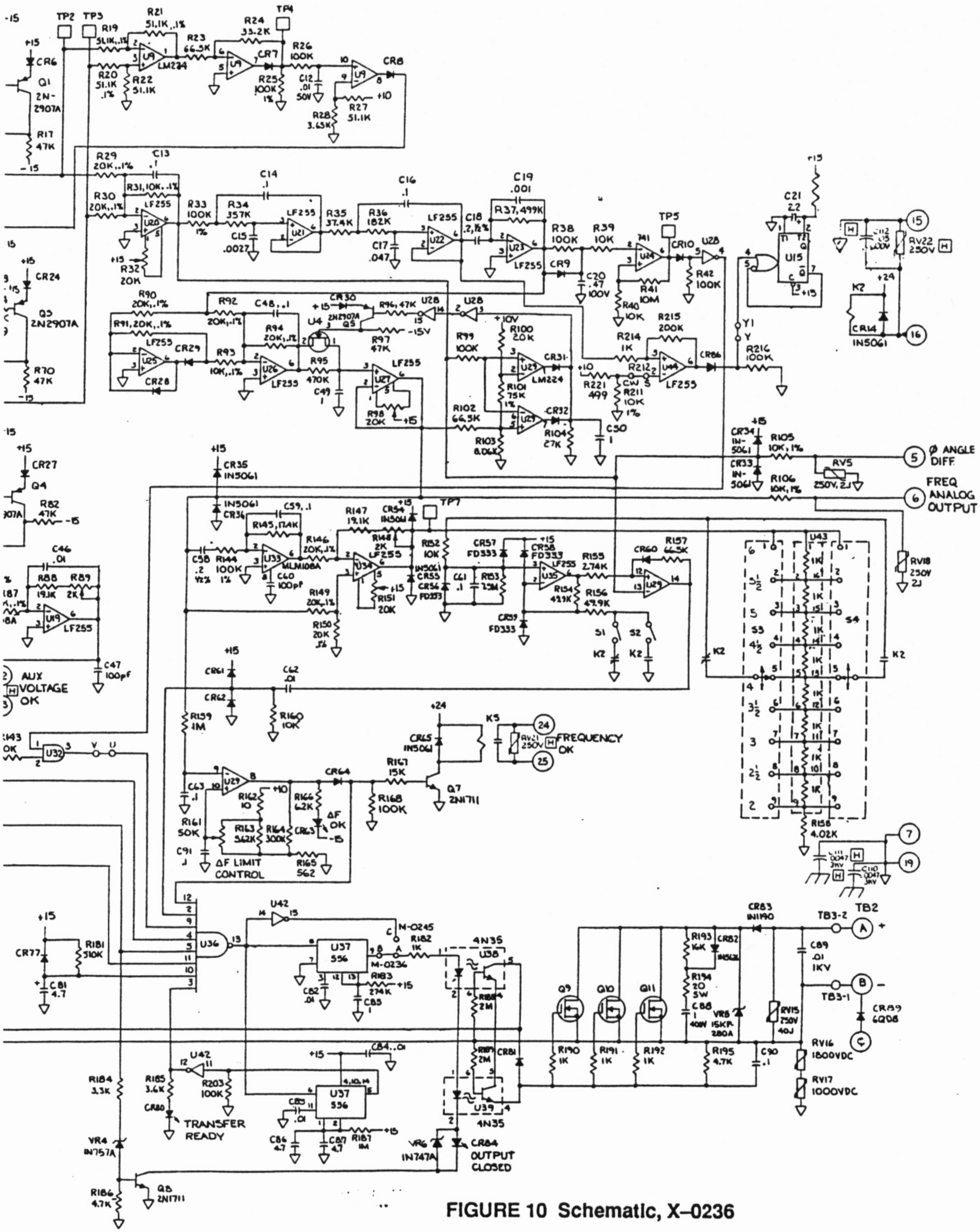


FIGURE 10 Schematic, X–0236

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PARTS LIST

M–0236 Power Transfer 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
C4,C15,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,C82,C84,C85, C92,C94-C99,C101, C103-C108	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,C60	000-00903	Capacitor, Ceramic Disc, 100 pF ±10%, 1 kV

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
C10,C36,C43	010-00432	Capacitor, Polystyrene, 0.01 µF ±10%, 63 V
C13,C14,C16,C48, C57,C59,C61, C63-C65,C72	000-00811	Capacitor, Polyester, 0.1 µF ±10%, 100 V
C17	000-00809	Capacitor, Polyester, 0.047 µF ±10%, 100 V
C18,C58	010-00801	Capacitor, Polysulfone, 0.2 µF ±0.5%, 50 V
C19	000-00812	Capacitor, Polyester, 0.001 µF ±10%, 100 V
C20	000-00814	Capacitor, Polyester, 0.47 µF ±10%, 100 V
C21	000-00553	Capacitor, Tantalum, 2.2 µF ±10%, 25 V
C23,C90,C100,C102	000-00909	Capacitor, Ceramic Disc, 0.1 µF +80%/-20%, 25 V
C25,C26,C53,C54,C83	000-00829	Capacitor, Polyester, 0.22 µF ±10%, 100 V
C27,C55, C86, C87	000-00813	Capacitor, Polyester, 4.7 µF ±10%, 100 V
C33	000-00902	Capacitor, Ceramic Disc, 680 pF ±10%, 1 kV
C46,C62	000-00808	Capacitor, Polyester, 0.01 µF ±10%, 400 V
C49,C50	000-00815	Capacitor, Polyester, 1.0 µF ±10%, 100 V
C56	000-00825	Capacitor, Polyester, 0.15 µF ±10%, 100 V
C67,C79	000-00637	Capacitor, Electrolytic, 2900 µF +100%/-10%, 40 V
C71	000-00626	Capacitor, Electrolytic, 150 µF +75%/-10%, 75 V
C74	000-00501	Capacitor, Tantalum, 3.9 uF ±10%, 35 V
C75,C76	000-00913	Capacitor, Ceramic Disc, 0.001 µF ±10%, 1 kV
C77,C78	000-00504	Capacitor, Tantalum, 27 µF ±10%, 20 V
C81	000-00555	Capacitor, Tantalum, 4.7 µF ±20%, 25 V
C88	000-00817	Capacitor, Polyester, 1 µF ±10%, 400 V
C93		Not Used
C109,C110,C111	000-00939	Capacitor, Ceramic Disc, 0.0047 µF ±20%, 3 kV

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
CR1-CR10,CR13,CR17-CR19,CR21-CR32,CR38-CR45,CR49-CR52,CR60-CR62,CR64,CR66-CR68,CR77-CR79,CR81,CR86	400-00224	Diode, 1N4148
CR11,CR14,CR33-CR36,CR46,CR47,CR53-CR55,CR65,CR75,CR76	400-00211	Diode, 1N5061
CR12,CR15,CR16		Not Used
CR20,CR48,CR63,CR69,CR80,CR84	400-00722	Diode, Light Emitting, Hewlet-Packard 5082-4658
CR37		Not Used
CR56-CR59	400-00225	Diode, FD333
CR70-CR73,CR82	400-00213	Diode, 1N5626
CR74		Not Used
CR83	400-00229	Diode, 1N1190
CR85,CR87-CR89		Not Used
F1,F2	420-00850	Fuse, 1A, Littelfuse 275.001
F3		Not Used
F4	420-00849	Fuse, 2A, Littelfuse 275.002
K4,K5	430-00151	Relay, 24 V dc, SPDT, American Zettler AZ4UP-V50-40L
K2	430-00143	Relay, 120 V ac, DPDT, American Zettler AZ420-V50-40L
K3		Not Used
Q1,Q3-Q5	400-00305	Transistor, PNP, 2N2907A
Q6-Q8	400-00300	Transistor, NPN, 2N1711
Q9-Q11	400-00422	Transistor, Power FET, Silconix VN45JA

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R2,R109,R142	200-00155	Resistor, Carbon Film, 1.5 M ±5%
R3,R17,R70,R82,R96, R97,R110, R169	180-00473	Resistor, Carbon, 47 K ±5%, 1/4 W
R4,R61,R73	200-00154	Resistor, Carbon Film, 150 K ±5%
R5,R60,R72	180-00563	Resistor, Carbon, 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
R8,R10,R11,R13, R18,R39,R40,R67,R69, R71,R75,R79,R83,R108, R121,R137,R143,R152, R160,R177,R204,R206	200-00103	Resistor, Carbon Film, 10 K ±5%
R9,R68,R76	200-00121	Resistor, Carbon Film, 120Ω ±5%
R12,R62,R78	180-00303	Resistor, Carbon, 30 K ±5%, 1/4 W
R14,R26,R38,R42,R43, R77,R99,R130,R138, R168,R170,R171,R173, R202,R203,R209,R216, R220	180-00104	Resistor, Carbon, 100 K ±5%, 1/4 W
R15,R63,R80	200-00394	Resistor, Carbon Film, 390 K ±5%
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,R102,R111, R157	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,R33,R49,R114, R125,R144	390-00601	Resistor, Metal Film, 100 K ±1%, 1/8 W, RN55C
R27	390-00569	Resistor, Metal Film, 51.1 K ±1%, 1/8 W, RN55C

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R28	390-00455	Resistor, Metal Film, 3.65 K ±1%, 1/8 W, RN55C
R29,R30,R84-R86, R90-R92,R94,R100, R146,R149,R150	340-00002	Resistor, Metal Film, 20 K ±0.1%, 1/4 W, RN60E
R31,R87,R93	340-00001	Resistor, Metal Film, 10 K ±0.1%, 1/4 W, RN60E
R32,R98,R151	360-00068	Potentiometer, 20 K, Bourns 3009P-1-203
R34	340-00654	Resistor, Metal Film, 357 K ±1%, 1/4 W, RN60C
R35,R180	340-00556	Resistor, Metal Film, 37.4 K ±1%, 1/4 W, RN60C
R36	340-00626	Resistor, Metal Film, 182 K ±1%, 1/4 W, RN60C
R37	330-00668	Resistor, Metal Film, 499 K ±1%, 1/4 W, RN60E
R41	200-00106	Resistor, Carbon Film, 10 M ±5%
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%, 1/8 W, RN55C
R50,R57,R105,R106, 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,R101	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, Allen Bradley 73B1G040S503W
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,R147	330-00528	Resistor, Metal Film, 19.1 K ±1%, 1/4 W, RN60E
R89,R148	360-00069	Potentiometer, 2 K, Bourns 3009P-1-202
R95	200-00474	Resistor, Carbon Film, 470 K ±5%, 1/4 W

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R103	340-00488	Resistor, Metal Film, 8.06 K ±1%, 1/4 W, RN60C
R104	180-00273	Resistor, Carbon Comp., 27 K ±5%, 1/4 W
R117,R197	390-00593	Resistor, Metal Film, 90.9 K ±17%, 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,R159,R187	200-00105	Resistor, Carbon Film, 1 M ±5%
R124	200-00823	Resistor, Carbon Film, 82 K ±5%
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
R139	180-00154	Resistor, Carbon, 150 K ±5%, 1/4 W
R140	390-00605	Resistor, Metal Film, 110 K ±1%, 1/8 W, RN55C
R145	340-00524	Resistor, Metal Film, 17.4 K ±1%, 1/4 W, RN60C
R153	200-00755	Resistor, Carbon Film, 7.5 M ±5%
R154,R156	330-00568	Resistor, Metal Film, 49.9 K ±1%, 1/4 W, RN60E
R155	340-00443	Resistor, Metal Film, 2.74 K ±1%, 1/4 W, RN60C
R158	330-00459	Resistor, Metal Film, 4.02 K ±1%, 1/4 W, RN60E
R162	180-00100	Resistor, Metal Film, 10 Ω ±5%, 1/4 W
R164	200-00304	Resistor, Carbon Film, 300 K ±5%
R165	330-00373	Resistor, Metal Film, 562 Ω ±1%, 1/4 W, RN60E
R172	180-00392	Resistor, Carbon Film, 3.9 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	340-00583	Resistor, Carbon Film, 71.5 K ±1%, 1/4 W, RN60C

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R181	200-00514	Resistor, Carbon Film, 510 K ±5%
R183	340-00643	Resistor, Metal Film, 274 K ±1%, 1/4 W, RN60C
R184	200-00332	Resistor, Carbon Film, 3.3 K ±5%
R185	200-00362	Resistor, Carbon Film, 3.6 K ±5%
R186,R195	200-00472	Resistor, Carbon Film, 4.7 K ±5%
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%, 5W
R196,R200	360-00141	Potentiometer, 20 K, ±10% Bourns 3266W-1-203
R199,R201	180-00564	Resistor, Carbon, 560 K ±5%, 1/4 W
R205,R207	180-00562	Resistor, Carbon, 5.6 K ±5%, 1/4 W
R208	200-00104	Resistor, Carbon Film, 100 K ±5%
R210		Not Used
R211	390-00401	Resistor, Metal Film, 10 K ±1%, 1/8 W
R212,R213		Not Used
R214	180-00102	Resistor, Carbon, 1 K ±5%, 1/4 W
R215	180-00204	Resistor, Carbon, 200 K ±5%, 1/4 W
R217-R219		Not Used
R221	390-00368	Resistor, Metal Film, 499 Ω ±1%, 1/8 W
RV1,RV3,RV6,RV8 RV13,RV14	400-00724	Varistor, 250 V, 20J, G.E. V250LA20
RV2,RV7,RV11,RV16	400-00718	Varistor, 1800 V dc, 80J, Panasonic ERZ-C-14DK182
RV4,RV5,RV9,RV10, RV18	400-00709	Varistor, 250 V, 2J, G.E. V250LA2
RV12,RV17	400-00734	Varistor, 1000 V dc, 40J, Panasonic ERZ-C-14DK102

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
RV15	400-00727	Varistor, 250 V, 40J, G.E. V250LA40B
S1,S2	430-00066	Switch, SPDT, Alcoswitch TT11DG-WW-2T
S3,S4	430-00075	Switch, Rotary, 10-position, Centralab, 2ASA-110AAB
T1,T2	410–00031*	Transformer Set B-0210, Two U–0086 transformers matched to maxium phase difference of ±0.05
T3	410-00030*	Transformer, U-0085
T4	410-00017*	Transformer, Power, U-0029
TB1	420-00052	Terminal Strip, 28-Position, RDI 6 PCR-28
TB2		Not Used
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	Verafet, Intersil IT401A
U5,U13,U16,U18,U33	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-U23,U25-U27,U34, U35,U44	400-00620	Op Amp, National LF255H
U24	400-00600	Op Amp, Fairchild µA741HQB
U36	400-00683	8-Input NAND-gate, Motorola MC14068BAL
U37	400-00626	Dual Timer, Signetics SE556A

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
U38,U39	400-00716	Photon Coupled Isolator, G.E. 4N35
U40	400-00644	Voltage Reference, National LH0070-1H
U41	400-00647	Voltage Regulator, Ratheon RC4194TK
U43	530-00003	Resistor Network, Beckman 698-3-R1KF
VR1, VR3	400-00057	Diode, Zener, 33 V ±5%, 5 W, 1N5364B
VR2	400-00030	Diode, Zener, 15 V ±10%, 400 mW, IN965B
VR4	400-00056	Diode, Zener, 1N757A
VR5	400-00074	Transient Supressor, Gen. Semi. Ind. 15KP280A
VR6	400-00017	Diode, Zener, 3.6 V, 1N747A

OPTIONAL COMPONENTS

60 HZ OPERATION

R7,R66	330-00588	Resistor, Metal Film, 80.6 K ±1%, 1/4W, RN60E
R74	330-00011	Resistor, Metal Film, 174 K ±1%, 1/4W, RN60E

REV G

50 HZ OPERATION OPTION

R7,R66	330-00601	Resistor, Metal Film, 100 K ±1%, 1/4W, RN60E
R74	330-00632	Resistor, Metal Film, 210 K ±1%, 1/4W, RN60E

PARTS MOUNTED TO THE ENCLOSURE

CR89	400-00230	Diode, Sarkes-Tarzian 6Q D8
TB2	420-00051	Terminal Block, Cinch-Jones 8-142Y

REV E

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	010-00800	Capacitor, 2.0 µF, ±5%, 50KV, 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, 953Ω, ±1%. 1/4 W RN60C
R6	330-00389	Resistor, Metal Film, 825Ω, ±1%. 1/4 W RN60E
R7	360-00034	Potentiometer, 200Ω, ±20%. Bourns 3386P-1-201
R8	200-00473	Resistor, Carbon Film, 10KΩ, ±5%
R9	200-00473	Resistor, Carbon Film, 47KΩ, ±5%
U1,U2	560-00011	OP AMP, LM108AJ-8

REV A-1

DESIGN CHANGES

Some simple changes are recorded by serial number: examples are changes in the detailed rating or manufacturer of a component where either the new or old part will perform properly.

More complex changes are made by adding a suffix letter. The rule is that it must be possible to use any later version as a replacement for an earlier version. The opposite may not be true because of features that were added.

If later units are not interchangeable for older units, a change in Model Number is made.

S.N. 0001 to 0024

Early models did not include protection circuitry to prevent the possibility of false closures occurring due to the sudden loss of the M–0236 V.T. input sources.

S.N. 0025 to 0050: M–0236A

An Input Loss Protection printed circuit board was added to block closure on sudden loss of the V.T. inputs.

S.N. 0051 to 0227: M–0236B

Input Loss Protection circuitry and additional transient protection was incorporated into a new printed circuit board design. The breaker closing time circuits were redesigned to use internal switches to allow two separate time settings to be selected by a relay on the printed circuit board.

S.N. 0228 to 0293: M–0236B

50 Hz operation was added as an option.

S.N. 0294 to 0305: M–0236B

Variable Speed Motor Application was added as an option.

S.N. 0306 and above: M–0236B

Variable Speed Motor Application was added as a standard feature.

Legal Information

Patent

The units described in this manual are covered by U.S. Patents 4,256,972 and 4,310,771.

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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BECKWITH ELECTRIC CO., INC.

6190 - 118th Avenue North • Largo, Florida 33773-3724 U.S.A.

PHONE (727) 544-2326 • FAX (727) 546-0121

E-MAIL marketing@beckwithelectric.com

WEB PAGE www.beckwithelectric.com

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