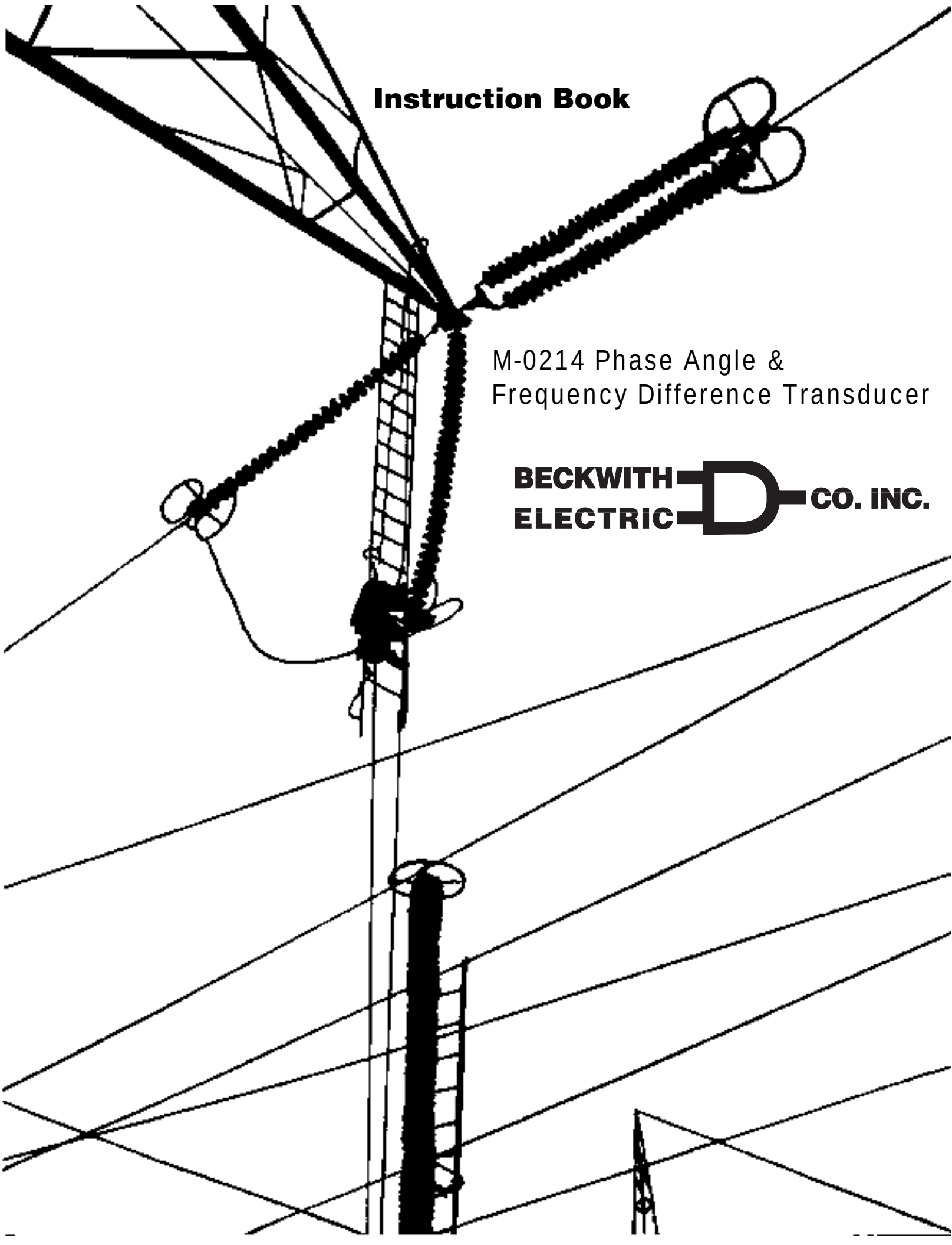
Instruction Book

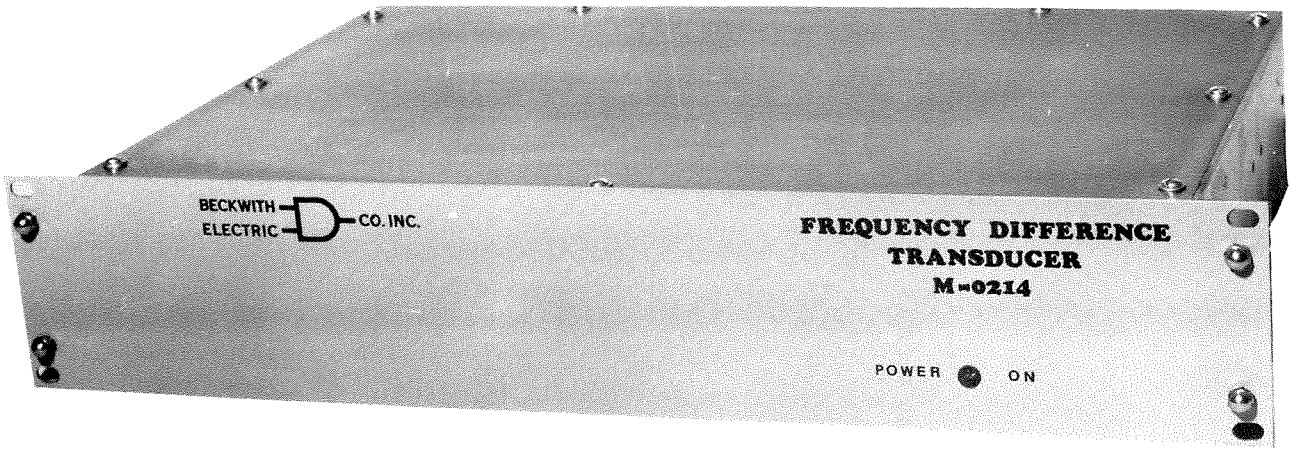
M-0214 Phase Angle &
Frequency Difference Transducer

BECKWITH ELECTRIC CO. INC.



BECKWITH ELECTRIC CO. INC.

Phase Angle & Frequency Difference Transducer M-0214 Frequency Deviation Transducer M-0215



- Modern Solid-State Circuitry Provides Fast, Accurate Performance.
- Fully Transient Protected.
- Current or Voltage Input Options Available.
- Provides Analog Outputs, Either Current or Voltage.

The M–0214 Phase Angle & Frequency Difference Transducer provides outputs, either current or voltage, proportional to both the difference in frequency and the phase angle between inputs A and B. When ordering the M–0214, a choice must be made for each input.

The M–0215 Frequency Deviation Transducer provides an analog output, either current or voltage, proportional to the difference in frequency from a true 60 Hz. An internal crystal oscillator is provided as one input; a choice must be made for the second input when ordering the M–0215.

INPUTS

1) 120 V ac nominal, 150 V ac max. continuous.
2) 5 A nominal (Current withstand: 3 X continuous, 20 X for 2 sec.)
3) 0.2 A nominal (Current withstand: 3 X continuous, 20 X for 2 sec.)
4) Logic voltage from FSK receiver.

INPUT BURDEN

0.1 VA each, current or voltage.

OUTPUTS

The output can optionally be selected as either a 0 to ±1 mA current loop or a 0 to ±10 V dc output. Polarity is positive when A lags B. Other current and voltage ranges are available on special order.

OUTPUT BURDEN

Voltage output will drive 1 K or greater; current output will feed up to 10 K total loop resistance.

POWER SUPPLY

Isolated 120 V ac ±10%, 5 VA. May be common to a voltage input.

SCALE RANGES

Phase Angle Range (M–0214 only)	
±60°	Full Scale
±90°	Full Scale
±180°	Full Scale

ΔF (M–0214) or Deviation from 60 Hz (M–0215)	
±.05 Hz	Full Scale
±0.1 Hz	Full Scale
±0.25 Hz	Full Scale
±0.5 Hz	Full Scale
±1.0 Hz	Full Scale

■ NOTE: All ranges are bipolar.

ACCURACY AS PERCENT OF FULL SCALE

±0.5% from 45 Hz to 500 Hz; deviation from 60 Hz ±0.0001 Hz. ±0.1% due to output ripple, depending on instant of sample. ±0.05% with load resistance, either voltage or current.

OUTPUT RESPONSE TIME

99% response to step change in phase angle or frequency is adjustable from 0.1 to 40 sec.

TRANSIENT PROTECTION

All inputs are fully transient protected and will pass the ANSI C37.90.1-1974 Surge Withstand Capability (SWC) Test. All inputs and outputs 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.

RELIABILITY

The units are assembled on a single glass-epoxy printed circuit board, thereby eliminating the need for plug-in connectors. All semiconductors 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.

ENVIRONMENTAL

Temperature Range: Stated accuracies are maintained from -20° to +70° C.
Humidity: Stated accuracies are maintained under 95% relative humidity (non-condensing).
Fungus Resistance: A conformal printed circuit board coating inhibits fungus growth.

PHYSICAL

Size: 19" wide x 3-1/2" high x 13" deep (48.26 cm x 8.89 cm x 33.02 cm). Requires two rack units in a standard 19" rack. May also be panel mounted horizontally or vertically.
Approximate Weight: 15 lb (6.8 kg).
Approximate Shipping Weight: 20 lb (9.1 kg).

Printed in U.S.A. 9/89

WARNING

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

DANGER! HIGH VOLTAGE

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

PERSONNEL SAFETY PRECAUTIONS

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

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

Always Ground the Equipment

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

Do NOT operate in an explosive environment

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

Keep away from live circuits

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

Exercise care during installation, operation, & maintenance procedures

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

Do not modify equipment

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

PRODUCT CAUTIONS

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

Avoid static charge

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

Use caution when measuring resistances

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

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M-0214 FREQUENCY DIFFERENCE TRANSDUCER
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.

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INTRODUCTION

The M-0214 Frequency Difference Transducer provides an analog output, either current or voltage, proportional to the difference in frequency between inputs A and B; and an analog output, either current or voltage, proportional to the phase angle between inputs A and B.

The instrument is designed to fit in a standard 19 inch rack, is 2 rack units high, and is capable of meeting extreme shock, vibration, and seismic requirements. All inputs are protected against transient voltages and have passed a surge withstand capability (SWC) test.

All circuitry is on a single printed circuit board using no plug-in connectors. The most advanced and stable solid-state components available have been used to achieve an accuracy and reliability of service not previously available in this class of instruments.

Inputs may be selected as a voltage input of 120 V ac nominal, a current input of either 0.2 A nominal or 5 A nominal, or a logic input which interfaces with standard frequency shift keying (FSK) equipment.

Outputs may be selected as a 0 to ±1 mA current loop or a voltage output by connecting to the appropriate terminal on the barrier-type terminal block mounted on the rear of the unit. This choice of outputs is available with either voltage or current output options.

The operating temperature range is from –20° C to +70° C. Power is supplied to the rear terminal and is 120 V ac nominal with a maximum burden of 5 VA. Input burden is typically 0.1 VA for either current or voltage inputs. The Frequency Difference Range may be selected by jumpers on the printed circuit board and is available as ±1.0 Hz, ±0.5 Hz, ±0.25 Hz, ±0.1 Hz, or ±0.05 Hz maximum full scale. The Phase Angle Range may be selected by changing resistors on the printed circuit board and is available as ±60°, ±90°, and ±180° maximum full scale.

GENERAL DESCRIPTION

DESCRIPTION OF OUTPUT OPTIONS

The M-0214 can provide either a voltage or a current output. The output type is determined by the connection made to the rear terminal block (See Figure 2). The purchaser must specify either the voltage option or the current option for both phase angle and frequency when the M-0214 is ordered. This is necessary because the load driving capability of the output circuit and the scale factor may depend on the option specified. The option page in the front of this manual is provided for this purpose. Table 1 below refers to the possible voltage and current outputs available with either the voltage or the current option.

When the M-0214 is ordered with the Voltage Option, typically the unit is intended to be used as a 0 to ±10 V output that will drive a load resistance of 1 K or greater. When the M-0214 is ordered with the Current Option, a 0 to ±1 mA current output that can drive up to 10 K loop resistance is a typical customer require-

ment. However, as shown in Table 1, both a voltage and current output are available with either the voltage or current option.

If conversion is later desired from voltage option to current option, or from current option to voltage option, please return the unit to the factory. Unauthorized conversions will void the warranty.

Customer Specification	Voltage Output*	Current Output*
Voltage Option 0 to ±10.0 V dc	Scale Factor: 0 to ±10.0 V dc Load: 1.0 K or greater load resistance	Scale Factor: 0 to ±1.0 mA with RX = RY = 10.0 K Load: 1.0 K or less loop resistance
Current Option 0 to ±1.0 mA dc	Scale Factor: 0 to ±1.0 V dc Load: 200 Ω or greater load resistance	Scale Factor: 0 to ±1.0 mA with RX = RY = 1.00 K Load: 10.0 K or less loop resistance

* **NOTE:** See Figure 2 for External Connections.

TABLE 1 Output Scale Factor and Loading

THEORY OF OPERATION

Please refer to SK-0152, Block Diagram. Input A, which may be a voltage, current, or logic signal, depending on the input circuitry chosen, is either passed through the transformer or through an optical coupler for the logic input. The output of the zero-crossing detector is a logic output whose zero-crossing corresponds to that of the input signal. This is shifted 180° in phase by the phase shift network. Input B, which has the same options as Input A, is passed through a zero-crossing detector and to the bi-stable latch. The bi-stable latch provides a pulse that is proportional to the difference in phase angle between the two inputs. The integrator produces a voltage level output that is proportional to the duty cycle output of the bi-stable latch. The precision derivative amplifier measures the slope of the output of the integrator. Since this slope is directly proportional to the frequency difference between Input A and Input B, the output of the precision derivative amplifier is in direct proportion to the frequency difference between the inputs. The analog switch selects between the precision derivative amplifiers whose outputs are 180° out of phase. This is necessary because, as the phase angle rotates through 0°, there is a discontinuity in the output of the precision derivative amplifiers. The decision when to switch between one derivative amplifier and the other is made by the dual comparator. The dual comparator senses when the phase angle information of the output of the active filter is between ±5 V. This ensures that the derivative amplifiers will not go through a discontinuity.

The output of the analog switch is passed through an active filter which removes any ripple components on the signal. The output of the active filter goes to the frequency difference damping control. This provides a variable integration period which will remove any phase jitter which may occur on Input A or Input B.

Since the damping control is variable, the customer may optimize the performance to his particular needs. The output of the damping control goes to the voltage-to-current converter and buffer amplifier. This circuit buffers the output of the damping control and also provides a voltage or current output.

Phase angle information is taken from the output of the active filter and applied to the variable phase angle damping control. The scaling amplifier provides the means for selecting phase angle ranges, and is driven by the output of the phase angle damping control. The output of the scaling amplifier goes to the voltage-to-current converter and buffer amplifier. This circuit buffers the output of the scaling amplifier and also provides voltage or current outputs.

The power supply provides ±15 V for the various blocks, and ±10 V which is used for the precision reference voltages. The power supply is run from a nominal 120 V ac input which is available on the rear terminal block.

CALIBRATION PROCEDURE

EQUIPMENT REQUIRED

1. Two distortion-free 60 [50] Hz voltage sources, capable of providing the correct input, either voltage, current, or logic, depending on the input circuitry selected:

   a. A 60 [50] Hz variable-phase source with a minimum phase accuracy of ±0.1%.

   b. A 60 [50] Hz variable-frequency source with frequency accuracy of ±0.0015% minimum.

2. A digital voltmeter, Hewlett-Packard Model 3465A or equivalent.

PROCEDURES

Make sure that the inputs provided to the M-0214 agree with the input circuitry selected by referring to the **OPTIONAL COMPONENTS** section of the Parts List and to Figure 3, Component Location.

1. Carefully remove the nine screws on the top panel.

2. Supply 120 V ac to pins 26 and 27 on the rear terminal block, noting pin 26 is the NEUTRAL terminal and pin 27 is the HOT terminal.

3. Connect the negative lead of the DC voltmeter to the negative end of capacitor C34, the large electrolytic capacitor located in the front right-hand corner of the printed circuit board. Next connect the positive lead of the DC voltmeter to the left side of R38 located on the right-hand side of the printed circuit board.

4. Adjust R37, located in the lower right-hand corner, to read –10.000 V on the DC voltmeter.

5. Next adjust R33, the frequency damping control located in the middle rear portion of the board, to midrange.

6. Place a jumper between pins 16 and 17 on the rear terminal block.

7. Attach the positive lead of the DC voltmeter to pin 16 on the rear terminal block.

8. The Frequency Difference Range selection resistors are located in the front left-hand corner of the printed circuit board. Use Table 2 to assure that the jumpers from C12 and C24 are correct for the Frequency Difference Range specified.

9. Supply the fixed 60 Hz source to rear terminal pins 5 and 6, noting that pin 5 is the HOT terminal and pin 6 is the NEUTRAL terminal.

10. Supply the variable frequency source to rear terminal pins 1 and 2, noting that pin 1 is the HOT terminal and pin 2 is the NEUTRAL terminal. (Refer to Table 1 for full scale voltage and current ranges.)

11. Adjust the variable frequency source to 60 Hz plus the Frequency Difference Range of the unit (e.g., if the Frequency Difference Range is 0.25 Hz, then the variable frequency source should be adjusted to a frequency of 60.250 Hz). The DC voltmeter should indicate negative full scale.

12. Adjust the variable frequency source to 60.000 Hz; the DC voltmeter should indicate 0 V dc.

13. Adjust R65 to come as close as possible to 0.00 V dc.

14. Next adjust the variable frequency source to 60 Hz minus the Frequency Difference Range; the DC voltmeter should read positive full scale.

15. Remove the variable frequency source and attach the variable phase source, noting that pin 1 is the HOT terminal and pin 2 is the NEUTRAL terminal.

16. Adjust the variable phase source to 0°. Attach the positive lead of the DC voltmeter to the left end of R9, located in the front left-hand corner of the printed circuit board.

17. Adjust R59 located in the lower left-hand corner of the main printed circuit board, and R7 on the B-0562 board, until the DC voltmeter indicates 0 V dc.

18. Place a jumper between rear terminal pins 21 and 22 and attach the positive lead of the DC voltmeter to pin 22. Adjust R53, located in the middle rear of the board, until the DC voltmeter reads 0 V dc.

19. Remove the positive lead of the DC voltmeter and re-attach it to the left end of R9. Adjust the variable phase source to +90°; the DC voltmeter should indicate +5 V dc full scale. Adjust the variable phase source for –90°; the DC voltmeter should read –5 V dc full scale.

M-0214 OPERATION

Refer to Figure 2.

> ■ **NOTE:** The inputs provided to the M-0214 must agree with the input circuitry selected; either voltage, current or logic inputs.

Attach the HOT lead for Input A to pin 5 on the rear terminal block and the NEUTRAL or cold input lead for Input A to pin 6 on the rear terminal block. Attach the HOT lead for Input B to pin 1 and the NEUTRAL lead for Input B to pin 2 on the rear terminal block. Supply 120 V ac power to pins 26 and 27 on the rear terminal block, pin 26 being the NEUTRAL terminal and pin 27 being the HOT terminal.

If the frequency difference output is to be a voltage, place a jumper between pin 16 and pin 17 on the rear terminal block. The voltage out will be between pin 15 and pin 16, pin 15 being the GROUND lead and pin 16 being the HOT lead.

If the frequency output is to be a current, install (as per Table 1) a ±0.1% RN60E resistor between pin 15 and pin 16. See Table 1 for details of voltage and current output specifications. This resistor is included with your unit in a separate plastic bag.

If the phase angle output is to be a voltage, place a jumper between pin 21 and pin 22 on the rear terminal block. The voltage output will be between pin 21 and pin 24; pin 21 being the HOT lead and pin 24 being the GROUND lead.

If the phase angle output is to be a current, install (as per Table 1) a ±0.1% RN60E resistor, between pin 21 and pin 24. See Table 1 for details of scale factor and loading. This resistor is included with your unit in a separate plastic bag.

FREQUENCY DIFFERENCE RANGE

To select the Frequency Difference Range, refer to Table 2 and to Figure 3, Component Location. Install a jumper between the components indicated, which are located in the front left-hand corner of the printed circuit board.

Full-Scale Range	±1.0 Hz	±0.5 Hz	±0.25 Hz	±0.1 Hz	±.05 Hz
Jumper	C12 & R71	C12 & R10	C12 & R11	C12 & R12	C12 & R13
	C24 & R72	C24 & R25	C24 & R26	C24 & R27	C24 & R28

TABLE 2 Frequency Difference Ranges

DAMPING ADJUSTMENT

The frequency damping control R33 is located in the rear middle portion of the printed circuit board. By rotating the control clockwise, damping is increased. By rotating the control counter-clockwise, damping is decreased. The integration period can be varied from a minimum of 0.1 second to a maximum of 40 seconds. Minimum transient response time occurs with minimum damping.

The purpose of the damping control is to reduce the effects of phase jitter which are normally caused by load transients. This control should be set by each customer to meet the requirements of a particular system.

MAINTENANCE

The M-0214 Frequency Difference Transducer is designed to be both accurate and reliable, which is made possible by the use of modern, solid state technology. The printed circuit board uses broad, two ounce copper foil runs. Holes are plated through and the holes filled with solder to assure reliable, long-life connections from one side to the other. All solder joints are carefully made and visually inspected to assure no voids, cold solder joints, or other potential failure points. After final test, the boards are coated with an insulated coating to avoid any possibility of conducting dust creating undesired circuits between foils.

Many of the high quality semi-conductors, resistors and capacitors used in the equipment are not readily available but are carried in stock by Beckwith Electric Company, Inc. Because of this and due to the sophistication of the circuit and the test procedures involved, field repair is not suggested.

SUGGESTED PROCEDURE IN THE EVENT OF TROUBLE

In the event that a unit does not operate properly, it should be established that the problem is caused by malfunction of a Beckwith unit and not caused by an external fault, misoperation or wiring error. Once this is assured, the entire unit should be returned to the Beckwith factory for repair.

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 the fault is due to abuse or misuse, a modest charge will be made. Repair can normally be expected to take one week. If faster service is required, it should be requested at the time of return.

Any equipment returned for repair must be sent with transportation charges paid. 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.

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 specific circuitry involved and have an adequate understanding of field effect devices.

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

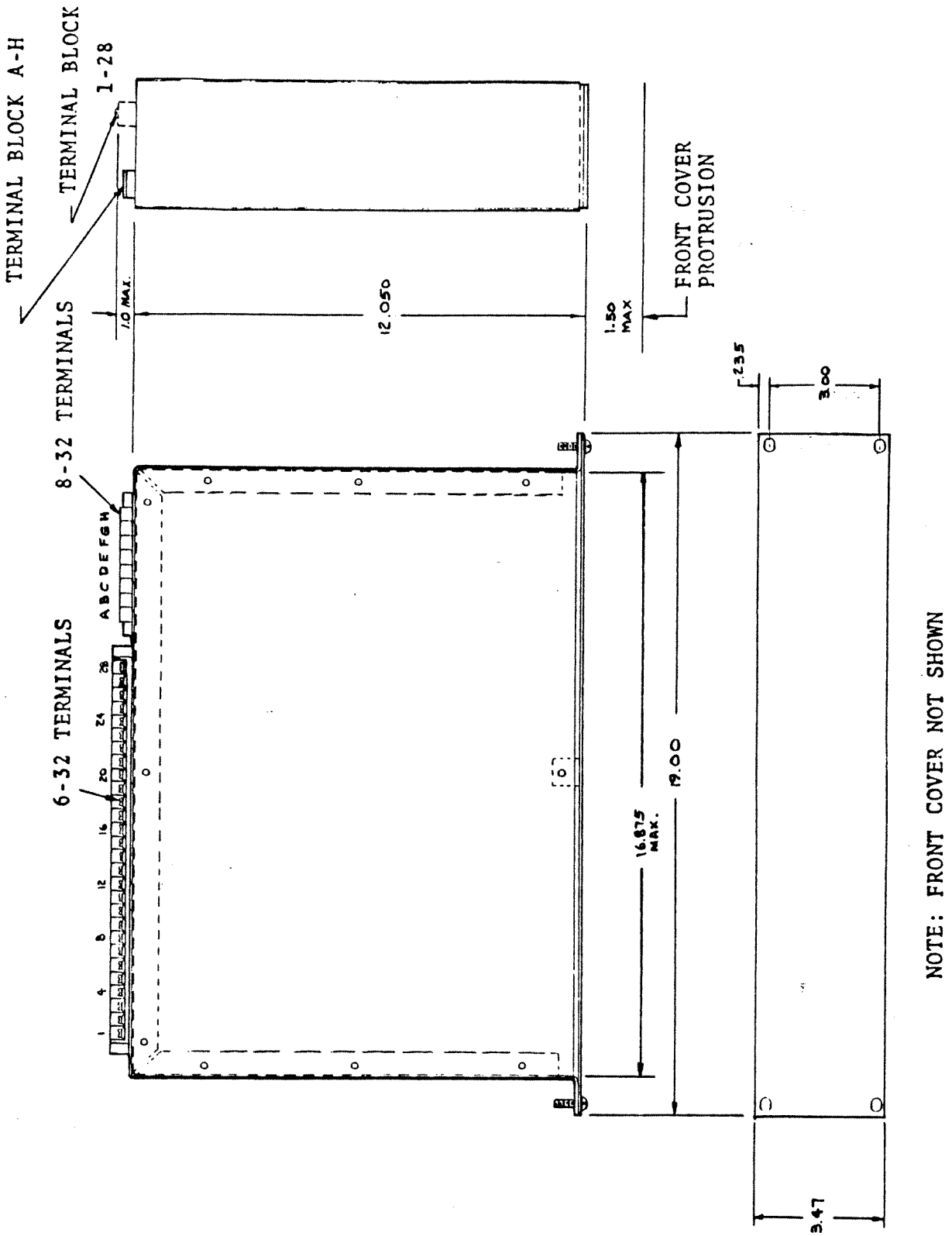
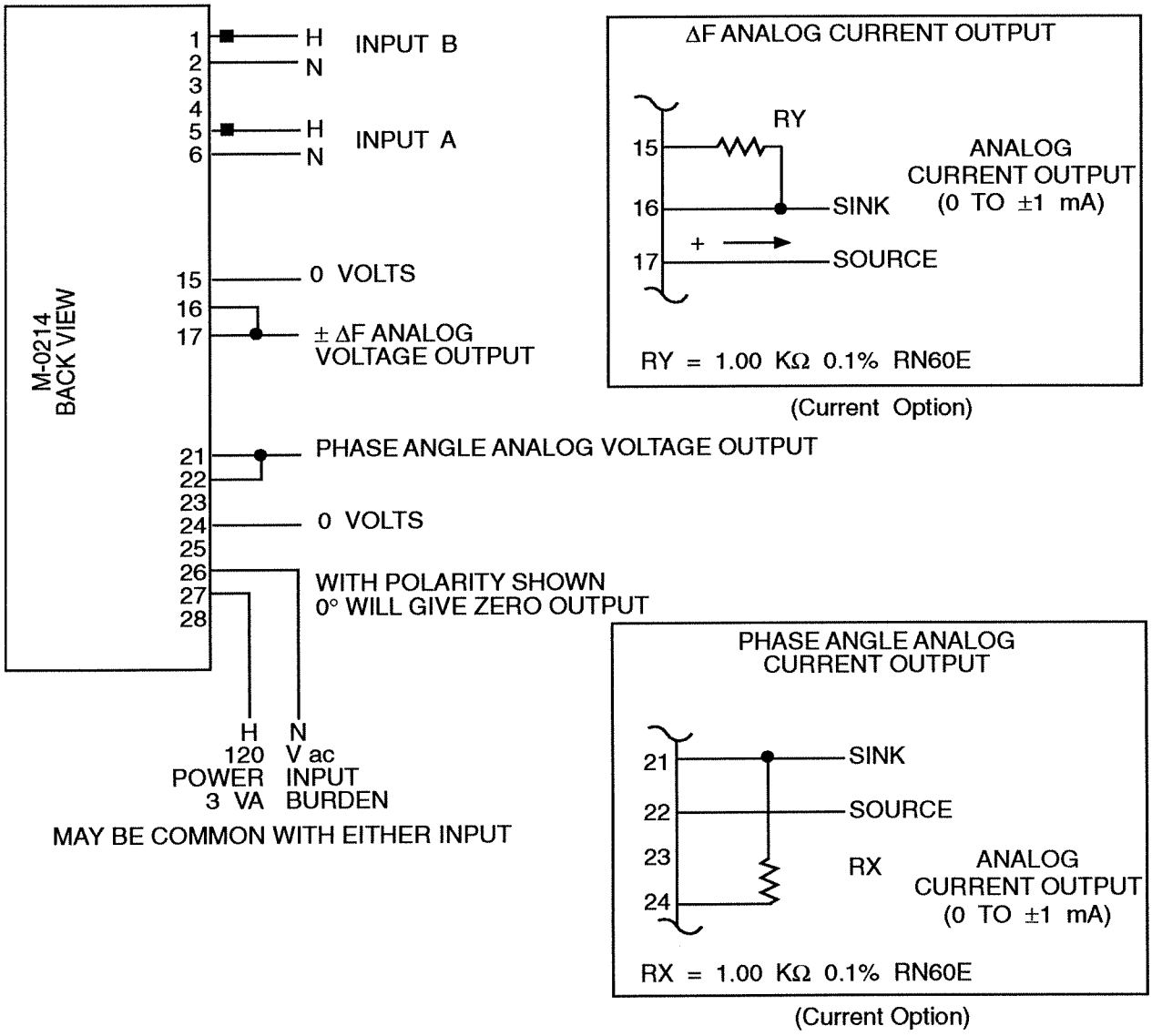


FIGURE 1 Outline Dimensions



NOTE: INPUT A OR B MAY BE SPECIFIED AS,

1. 120 V ac VOLTAGE INPUT
2. 5 AMPS AC CURRENT INPUT
3. 0.2 AMPS AC CURRENT INPUT
4. 5 TO 24 V LOGIC VOLTAGE INPUT; BIPOLAR OR MONOPOLAR
5. RESISTOR AND MOUNTING HARDWARE FOR ANALOG CURRENT OUTPUT ARE INCLUDED SEPARATELY WITH THE UNIT.

FIGURE 2 External Connections

PARTS LIST

M-0214 FREQUENCY DIFFERENCE TRANSDUCER

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
		MAIN PRINTED CIRCUIT BOARD
	450-00024*	Printed Circuit Board, Main
C1,C2		Refer to **OPTIONAL COMPONENTS**
C3,C15,C16	000-00715	Capacitor, Polyester, 0.001 µF ±10%, 100 V
C4	Not Used	
C5,C17	000-00703	Capacitor, Polyester, 0.047 µF ±10%, 50 V
C6,C18	010-00423	Capacitor, Polycarbonate, 0.1 µF ±10%, 63 V
C7,C8,C19,C20	010-00421	Capacitor, Polycarbonate, 0.15 µF ±1%, 50 V
C9,C21	010-00422	Capacitor, Polycarbonate, 0.30 µF ±1%, 50 V
C10,C22	010-00800	Capacitor, Polysulfone, 2 µF ±0.5%, 50 V (C10 & C22 to be matched pair)

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
C11,C23,C47,C62	000-00903	Capacitor, Ceramic Disc, 100 pF ±10%, 1 kV
C12,C24	010-00424	Capacitor, Polycarbonate, 0.01 µF ±10%, 600 V
C13,C14	Not Used	
C25,C56	000-00857	Capacitor, Polyester, 10 µF ±10%, 50 V
C26,C40	000-00708	Capacitor, Polyester, 1 µF ±10%, 50 V
C27	010-00430	Capacitor, Polycarbonate, 0.30 µF ±10%, 50 V
C28,C29	000-00904	Capacitor, Ceramic Disc, 0.01 mF ±10%, 1 kV
C30,C34	000-00413	Capacitor, Electrolytic, 1500 µF, 50 V
C31,C32,C41–C46, C48–C51,C59–C61	000-00917	Capacitor, Ceramic Disc, 0.01 µF ±20%, 50 V
C33,C37,C38	000-00543	Capacitor, Tantalum, 27 µF ±10%, 20 V
C39,C52–C55	Not Used	
C57		Refer to **OPTIONAL COMPONENTS**
C58	Not Used	
D1,D2	Not Used	
D3,D4		Refer to **OPTIONAL COMPONENTS**
D5,D6,D14,D15,D34, D35,D42	400-00224	Diode, 1N4148
D7,D8,D16,D17	400-00225	Diode, FDH333
D9	400-00004	Diode, Zener, 10 V, 1N758A
D10–D13	Not Used	
D18–D21,D30–D33	400-00211	Diode, 600 V, 1N5061
D22,D23	Not Used	
D24-D27	400-00213	Diode, 1N5626, G.E. A15M
D28,D29	400-00057	Diode, Zener, 33 V, 1N5364B
D36	Not Used	
D37–D39		Refer to **OPTIONAL COMPONENTS**
D40,D41	Not Used	
D43	400-00722	Diode, Light Emitting, H.P. 5082-4658
D44	Not Used	
F1		Refer to **OPTIONAL COMPONENTS**
F2	Not Used	
F3,F4,F6,F7	420-00844	Fuse, Picofuse, 1/8 A, 125 V, Littelfuse 275.125

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
F5	420-00843	Fuse, Picofuse, 1/2 A, 125 V, Littelfuse 275.500
Q1,Q4	400-00649	Op Amp, T. I. LF357L
Q2,Q3	400-00614	NAND-Gate, Quad 2 Input, RCA CD14011BD
Q5,Q6,Q10,Q13,Q16	400-00620	Op Amp, National LF255H
Q7,Q8,Q21,Q22	400-00633	Op Amp, Motorola MLM108AG
Q9	400-00648	Analog Switch, Siliconix DG191BP
Q11	400-00644	Voltage Reference, National LH0070-1
Q12	560-00010	Voltage Regulator, Negative, LM337T, Linear Technology
Q14,Q15	Not Used	
Q17	400-00639	Quad Op Amp, Fairchild 4136DC
Q18	Not Used	
Q19	400-00636	Logic NAND-Gate, Motorola MC14081BAL
Q20,Q23,Q24		Refer to **OPTIONAL COMPONENTS**
Q25,Q26	Not Used	
Q27–Q29	400-00709	Varistor, 250 V, 21 J, G.E. V250LA2
Q30		Refer to **OPTIONAL COMPONENTS**
Q31	560-00008	Voltage Regulator, LM317T, Linear Technology
R1		Refer to **OPTIONAL COMPONENTS**
R2,R16,R41,R42, R44–R46,R48,R49	200-00104	Resistor, Carbon Film, 100 K, ±5%
R3,R17,R18	340-00547	Resistor, Metal Film, 30.1 K, ±1%, 1/4 W, RN60C
R4,R5,R19,R20	340-00647	Resistor, Metal Film, 301 K, ±1%, 1/4 W, RN60C
R6,R7,R21,R22	340-00525	Resistor, Metal Film, 17.8 K, ±1%, 1/4 W, RN60C
R8,R23	340-00492	Resistor, Metal Film, 8.87 K, ±1%, 1/4 W, RN60C
R9,R14,R24,R29	200-00103	Resistor, Carbon Film, 10 K, ±5%
R10,R25	340-00003	Resistor, Metal Film, 499 K, ±0.1%, 1/4 W, RN65E4993B
R11,R26	340-00004	Resistor, Metal Film, 1.0 M, ±0.1%, 1/4 W, RN65E1004B
R12,R27	340-00005	Resistor, Metal Film, 2.49 M, ±0.1%, RN65E2494B
R13,R28	340-00006	Resistor, Metal Film, 4.99 M, ±0.1%, 1/4 W, RN65E4994B
R15	Not Used	
R30	340-00556	Resistor, Metal Film, 37.4 K, ±1%, 1/4 W, RN60C
R31	340-00568	Resistor, Metal Film, 49.9 K, ±1%, 1/4 W, RN60C
R32,R66	340-00001	Resistor, Metal Film, 10.0 K, ±0.1%, 1/4 W, RN60E

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
R33,R61	360-00081	Potentiometer, 1 M, 10%, Bourns 3009P-1-105
R34,R35	370-00006	Resistor, Wirewound, 3.3 Ω, ±5%, 2 W, IRC BWH 3.3Ω
R36,R38	330-00568	Resistor, Metal Film, 49.9 K, ±1%, 1/4 W, RN60E
R37	360-00082	Potentiometer, 1 K, Bourns 3009P-1-102
R39,R77	390-00339	Resistor, Metal Film, 249 Ω, ±1%, 1/8 W, RN60C
R40,R78	340-00443	Resistor, Metal Film, 2.74 K, ±1%, 1/4 W, RN65C
R43	200-00335	Resistor, Carbon Film, 3.3 M, ±5%
R47,R50	Not Used	
R51,R60,R73,R76	200-00102	Resistor, Carbon Film, 1 K, ±5%
R52	200-00274	Resistor, Carbon Film, 270 K, ±5%
R53,R59,R65	360-00068	Potentiometer, 20 K, Bourns 3009P-1-203
R54,R55		Refer to **OPTIONAL COMPONENTS**
R56–R58	Not Used	
R62,R63		Resistor, Select, ±0.1%, RN60E
R64	200-00332	Resistor, Carbon Film, 3.3 K, ±5%
R67,R69	340-00018	Resistor, Metal Film, 1.10 K, ±1%, 1/4 W, RN60E
R68,R70	340-00205	Resistor, Metal Film, 11.0 Ω, ±1%, 1/4 W, RN60C
R71,R72	340-00019	Resistor, Metal Film, 249 K, ±1%, 1/4 W, RN60E
R74	200-00392	Resistor, Carbon Film, 3.9 K, ±5%
R75	200-00473	Resistor, Carbon Film, 47 K, ±5%
T1,T2,T3		Refer to **OPTIONAL COMPONENTS**
T4	410-00030*	Transformer, Power, U-0085

REV H

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
OPTIONAL COMPONENTS		
120 V AC NOMINAL INPUT		
C1,C2	000-00904	Capacitor, Ceramic Disc, 0.01 µF, ±10%, 1 kV
C57	Not Used	
D3,D4	400-00224	Diode, 1N4148
D37–D39	Not Used	
F1	420-00845	Fuse, Picofuse, 1/4 A, 125 V, Littelfuse 275.250
Q20,Q30	Not Used	
Q23,Q24	400-00709	Varistor, 250 V, 21 J, G.E. V250LA2
R1	200-00473	Resistor, Carbon Film, 47 K, ±5%
R54,R55	Not Used	
T1	410-00031*	Transformer, U-0086-B
T2,T3	Not Used	
REV A		
LOW PASS FILTER BOARD		
	450-00157*	Printed Circuit Board, Low Pass Filter Board
C1,C4	010-00443	Capacitor, Polyester, 0.1 µF ±5%, 63 V
C2,C3	010-00442	Capacitor, Polyester, 0.022 µF ±5%, 100 V
P1	030-00085	Connector, 5-position
R1	390-00518	Resistor, Metal Film, 15 K ±1%, 1/8 W
R2,R5	390-00469	Resistor, Metal Film, 5.11 K ±1%, 1/8 W
R3,R4	200-00203	Resistor, Carbon Film, 20 K ±5%, 1/2 W
R6	340-00516	Resistor, Metal Film, 14.3 K ±1%, 1/4 W
R7	360-00069	Potentiometer, 2 K ±10%
REV A		

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
5 AMPS NOMINAL INPUT		
C1	Not Used	
C2,C57	000-00904	Capacitor, Ceramic Disc, 0.01 µF ±10%, 1 kV
D3,D4,D39	Not Used	
D37,D38	400-00211	Diode, 1N5061
F1	Not Used	
Q20,Q23	Not Used	
Q24,Q30	400-00709	Varistor, 250 V, G. E. V250LA2
R1	370-00020	Resistor, Jumper, 0 Ω
R54,R55	Not Used	
T1,T3	Not Used	
T2	410-00025*	Transformer, U-0036
REV A		
0.2 AMPS NOMINAL INPUT		
C1	Not Used	
C2,C57	000-00904	Capacitor, Ceramic Disc, 0.01 µF ±10%, 1 kV
D3,D4,D39	Not Used	
D37,D38	400-00211	Diode, 1N5061
F1	Not Used	
Q20,Q23	Not Used	
Q24,Q30	400-00709	Varistor, 250 V, G. E. V250LA2
R1	370-00020	Resistor, Jumper, 0 Ω
R54,R55	Not Used	
T1,T2	Not Used	
T3	410-00065*	Transformer, U-0111
REV A		

COMPONENT DESIGNATION	BECO NUMBER	DESCRIPTION
LOGIC VOLTAGE FROM FSK RECEIVERS		
C1,C2,C57	Not Used	
D3,D4,D37,D38	Not Used	
D39	400-00224	Diode, 1N4148
F1	Not Used	
Q20	400-00716	Optical Coupler, G.E. 4N35
Q23,Q24,Q30	Not Used	
R1	Not Used	
R54	200-00152*	Resistor, Carbon Film, 1.5 K, ±5%, U-0090
R55	200-00104*	Resistor, Carbon Film, 100 K, ±5%, U-0090
T1-T3	Not Used	
REV A		
EXTERNAL RESISTORS FOR ANALOG CURRENT OUTPUT		
	340-00027	Resistor, Metal Film, 1 K, 1/4 W, ±0.1%

Legal Information

Patent

The units described in this manual are covered by U.S. Patents, with other patents pending.

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.

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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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