DRAFT ** Prodelin 3.8 Meter Dual Axis Tracking Antenna (Model 1387) Motorization Kit

Installation and Operation Manual

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1. Introduction

This document describes an installation kit which allows an RC2000X ACU (antenna control unit) to interface with a Prodelin 3.8 meter antenna (Model 1381).

Here are the characteristics of the Prodelin 3.8m antenna motorization package …

- 90 VDC azimuth and elevation motors, ¾ horsepower.
- Position sense via a hall effect incremental pulse encoder on the motor mounting flange. The pulse encoder produces one pulse per revolution of the motor shaft.
- The az/el axis are equipped with Gemco rotary input limit switches.
- The Prodelin 3.8 meter antenna polarization axis is not motorized.

The interface kit consists of the following …

- An RC2K90INT-1 Interface box housed in a 12” x 12” x 6” NEMA enclosure that houses a 90 VDC motor drive, a circuit board, and an optional heater.
- Conduit and cabling to connect the RC2K90INT-1 to the antenna azimuth and elevation motors, position sensors, and limit switches.

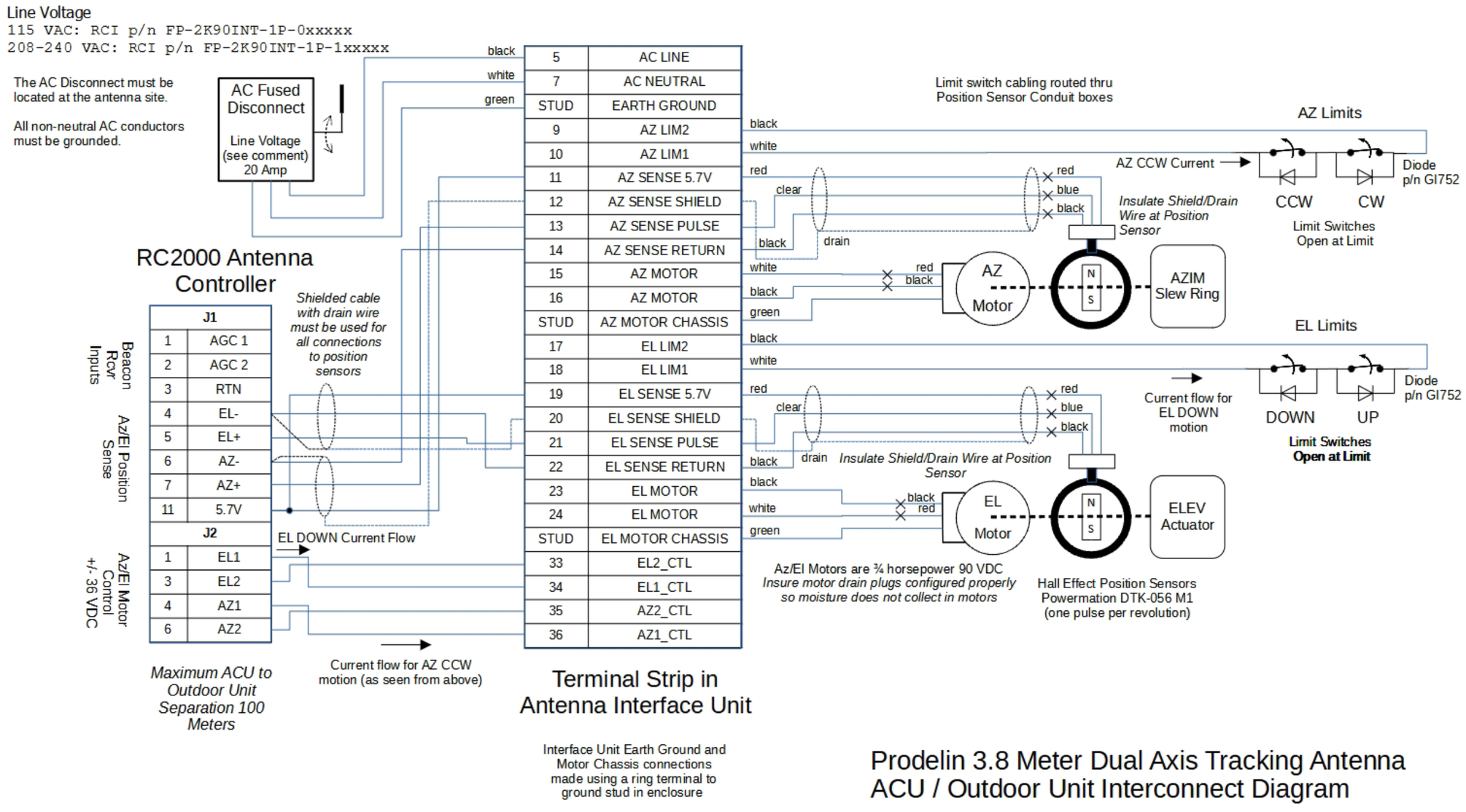
Here are the features of the RC2000X ACU relevant to the Prodelin 3.8 meter motorization system …

- Support for inclined orbit tracking via step track and memory track algorithms.
- The ACU keeps track of antenna position via position counts, each motor rotation produces two position counts.
- The ACU maintains logical az/el limits. The hardware limit switches are routed to the interface box where they inhibit motion of the drive.

2. Installation

The actuators are shipped with the motors, sensors, limit switches, and interconnect cables attached. Connections have to be made to the ACU and actuator assemblies. Take special care when connecting the sensor interface cables to the ACU and the interface box. A shielded 3 wire cable, 22 AWG or larger, with a bare drain wire is required for the sensor connection. Be sure to connect the drain wire as shown at the ACU and at the interface box terminal strip. Don’t allow the bare drain wire or cable shielding material to come in contact with earth grounded objects.

Refer to Figure 1, ‘Prodelin 3.8 Meter Dual Axis Tracking Antenna ACU/Outdoor Unit Interconnect Diagram’ for connection details. Figure 2 shows the conduit connections on the interface box. Figure 3 details the Limit Switch connections.



Prodelin 3.8 Meter Dual Axis Tracking Antenna ACU / Outdoor Unit Interconnect Diagram

Date: November 1, 2022
Drawn By: S Mikinski, Research Concepts, Inc.
File: RC2000_ACU_Prodelin_38_Interconnects.odg

Figure 1 – System Interconnect Diagram

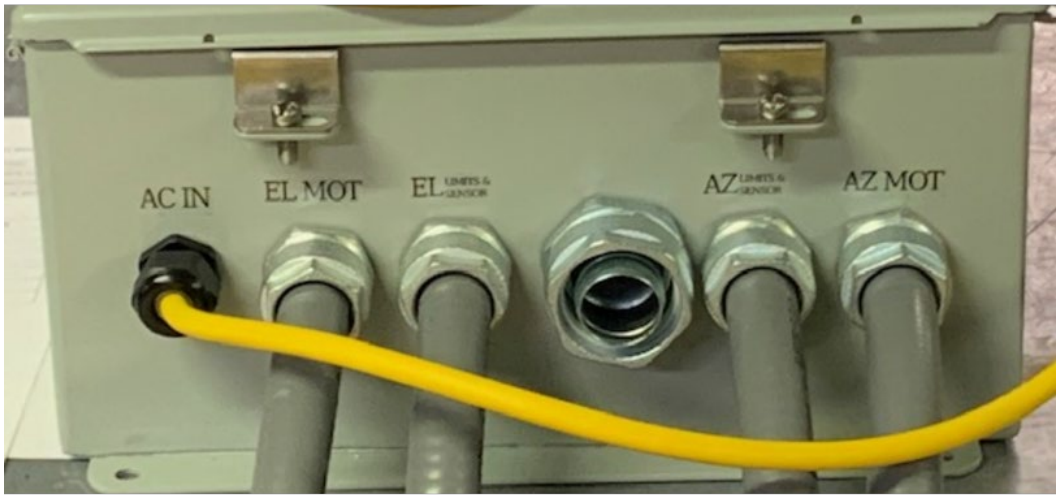


Figure 2 – Interface Box Conduit Connections

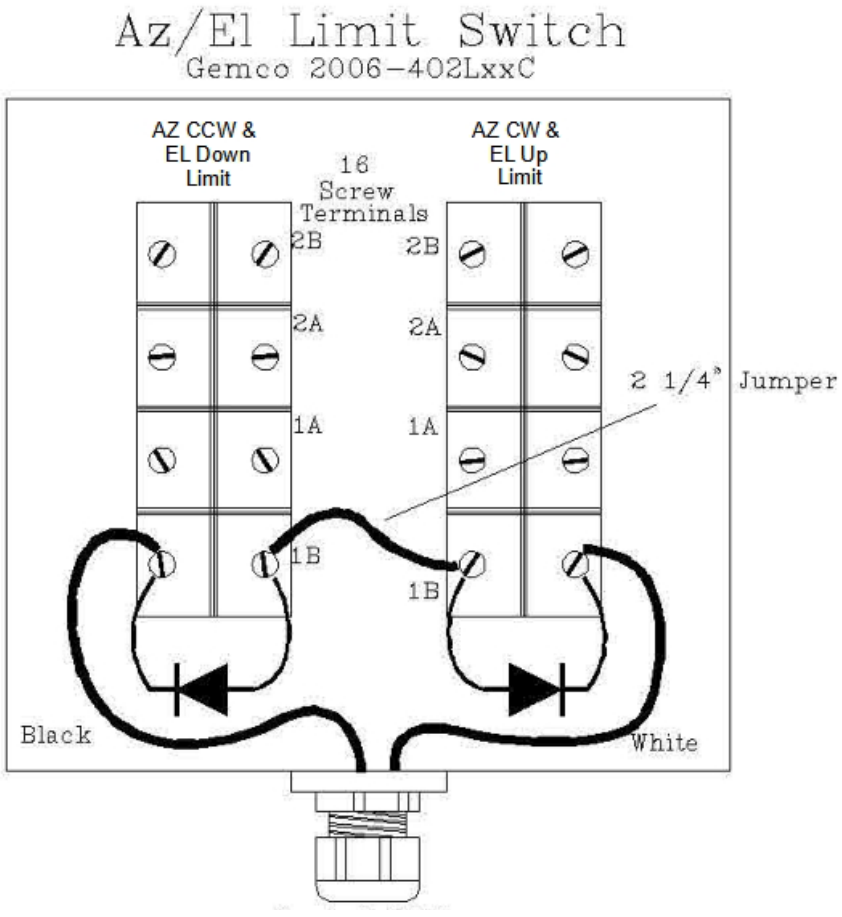


Figure 3 – AZ/EL Limit Switch and Diode Wiring

3. System Setup and Testing

3.1 ACU Configuration Items

Configure the ACU configuration items as described in the following table.

CONFIG Item	Factory Values Nov 2022
Simultaneous AZ/EL Enable	
Azim Slow Speed Elev Slow Speed	254 254
Pol Control Equipment Code	0
AZ/EL/POL Drive Options	1
AZ/EL Fast Deadband	1244
AZ/EL Slow Deadband	1244
AZ/EL Auto Retry Attempts	3
Azim Coast Threshold	6
Azim Max Position Error	1
Elev Coast Threshold	6
Elev Max Position Error	1
Azim Constant	1986
Elev Constant	11574
Max Track Error:	5
Ant Size	380

3.2 System Checkout

After the electrical connections have been made verify the operation of the antenna. When the controller is in LIMITS mode the user can manually jog the antenna in azimuth and elevation. See the ACU manual for information on how to enter LIMITS mode.

In LIMITS mode, if the AZ CCW key is depressed the antenna should move counter-clockwise in azimuth as seen by an observer located above the antenna. Similarly, if the AZ CW key is depressed the antenna should move in a clockwise direction. Elevation up and down movement is self explanatory.

The installer should also verify that the antenna limit switches function properly for each direction of movement about both the azimuth and elevation axis. For example, to verify the operation of the azimuth counter-clockwise limit, motor the antenna counter-clockwise until the limit is reached. Once the limit is reached check to make sure that the antenna can be motored clockwise in azimuth out of the limit.

In LIMITS mode, as the antenna is moved about a given axis the position count associated with that axis should change unless the displayed position has reached 0 or 65535. As the antenna moves counter-clockwise in azimuth or down in elevation the antenna position count will decrease until 0 is reached. As the antenna moves clockwise in azimuth or up in elevation the position count will increase up to a maximum value of 65535 - the display will not wrap back to 0 when 65535 is reached.

To verify the integrity of the pulse sensors and cabling, it is recommended that the installer perform the following check.

First, use SETUP mode to program a pair of satellites into the ACU's non volatile memory. Peakup carefully on each satellite. Choose the satellites to maximize the amount of elevation separation between the satellites. Note the az/el position of each satellite.

Use AUTO mode to repeatedly reposition the antenna from the first satellite to the second satellite and vice versa. The antenna should move to the position count values associated with each satellite. If the antenna does not move to the correct position values, review the section of the ACU manual titled Azimuth and Elevation Drive Options, some of the CONFIG mode items may need to be adjusted.

After each movement, use manual mode verify that the antenna did indeed land on the az/el position where the received power is a maximum. If the antenna az/el position sensors are installed and cabled properly the az/el position of peak received power will not change over repeated automatic moves from one satellite to the next.

If the peak az/el position appears to migrate this is an indication that the sensor cable shielding needs to be checked, the magnet wheel is not installed properly, or the gap between the magnet wheel and sensor pickup is not correct. Sensor cabling issues are usually the culprit.

4. Theory of Operation

The antenna az/el motors are 90 VDC. The interface box employs a single KBPB SCR type DC motor drive module. Units designed for operation from from 220 VAC employ a KBPB-225 module. Units designed for 115 VAC operation employ a KBPB-125 motor drive module. The motor drive modules are controlled via relays on the circuit board in the interface box. The relays on the circuit board are activated via +/- 36 VDC outputs from the ACU. A latching relay on the circuit board routes the output of the motor drive module to either the azimuth or elevation motor depending on which ACU motor control outputs are active. Simultaneous az/el motion is not supported by the interface box. The antenna limit switches inhibit operation of the relays that activate the motor drives. The limit switches are configured such that an antenna that has been driven into a limit can be driven in the opposite direction out of the limit.

A schematic of the Interface Box is included (Figure 4).

4.1 ACU Motor Drive Outputs

The RC2000 motor drive outputs are available on connector J2. The azimuth motor outputs are labeled AZ1 and AZ2. The elevation motor outputs are EL1 and EL2. The output voltage is nominally 36 VDC. The polarity of the output voltage determines the direction of antenna movement.

For the azimuth axis, azimuth CCW movement (as seen from an observer above the antenna) corresponds to a higher voltage on the AZ1 output relative to the AZ2 output. To put it another way, for azimuth CCW movement current flow is from AZ1 to AZ2. For azimuth CW movement, current flow is from AZ2 to AZ1.

For the elevation axis, elevation down motion corresponds to current flow out EL1 into EL2. Elevation up motion corresponds to current flow out EL2 into EL1.

The ACU is capable of producing a pulse width modulated (PWM) output when either azimuth or elevation slow speed operation is commanded to occur. To disable PWM output, set the Azim Slow Speed Code and Elev Slow Speed Code CONFIG items to 254.

The ACU does support simultaneous azimuth and elevation motor operation. To disable simultaneous azimuth and elevation movement, set the Simultaneous Az/El Enable CONFIG mode item to 0.

4.2 Antenna Limit Switches and Interface Box Printed Circuit Board

There is a limit switch associated with each axis/direction. The limit switches are shown in Figure 1. The limit switches open when the associated limit is reached and each limit switch has a diode in parallel with the switch contacts.

The direction of current flow thru the limit switches is associated with direction of movement that will occur if that limit switch is closed. Take the azimuth axis for example. In Figure 1 the direction of current flow associated with AZ CCW movement is shown. The AZ CW limit switch parallel diode allows AZ CCW current to flow around an open AZ CW limit switch. In this way the ACU can move AZ CCW away from the AZ CW limit.

The printed circuit board in the interface box performs two functions:

- Translates motor drive outputs from the ACU into control signals for the motor control module.
- Provides an interface to the limit switches.
- Routes the output of the motor drive module to the azimuth or elevation motor.

A schematic of the printed circuit board (PCB) is included as Figure 5. Not all relays shown in the schematic are present on the PCB. The relays present are noted on the schematic.

The motor drive module is controlled via contact closures provided by relays. There is a single contact closure associated with motion about each each axis/direction. These contact closures are provided by relays K2, K3, K5, and K6 (for control of AZ CCW, AZ CW, EL DOWN, and EL UP , respectively. Routing of the motor drive output to the az and el axis is accomplished by latching relay K4.

For azimuth CCW motion, the current flows out of the ACU AZ1 output into the PCB AZ1_CTL input. From the AZ1_CTL1 input current is routed out of the AZLIM1 PCB terminal to the azimuth limit switches and back to the PCB via the AZLIM2 terminal. If current flows in the AZ CCW direction, diode D2 will conduct and relay K2 is energized. When relay K2 activates the J9-1 (S1_KBPB1) and J9-2 (S2_KBPB1) terminals are shorted together.

For azimuth CW motion, the current flow in the azimuth limit switch circuit is reversed, diode D3 conducts, and relay K3 is energized. When relay K3 activates the J9-3 (S3_KBPB1) and J9-2 (S2_KBPB1) terminals are shorted together. J9 it the interface to the motor drive. When J9-2 is shorted to J9-1, the motor drive is activated. When J9-2 is shorted to the J9-3, the motor drive is activated with the opposite polarity.

Control of the elevation axis occurs in an analogous manner. The elevation motor control outputs are on terminals J9-4, J9-5, and J9-6.

A 'double pole - double throw' latching relay (K4) routes the motor drive's output to either the azimuth or elevation axis. The latching relay has two coils. Only one coil is energized at a time. One coil is energized to connect the motor drive to the azimuth axis, the other coil is energized to the motor drive to the elevation axis. If a given coil is energized to drive the relay to a given state, the relay will remain in that state until the other relay coil is energized to drive the relay to the opposite state.

To configure the latching relay to route motor drive current to the azimuth motor, the relay coil associated with terminals K4-A and K4-B is energized. Diodes D4, D5, D6, and D7 form a full wave rectifier. When current flows in either direction in the azimuth limit switch circuit, the coil associated with latching relay K4's A-B terminals is energized. This configures latching relay to connect the motor drive module output to the azimuth motor.

The latching relay is configured to route motor drive current to the elevation axis in a similar manner. Current in the elevation axis limit switch circuit is rectified by D8, D9, D10, and D11 and is routed thru the K4-5 and K4-8 terminals of the latching relay.

The diodes in parallel with the relay coils are 'buck diodes' to suppress the noise created by back emf when the coil is de-energized.

4.3 KBPB Motor Drive Module

Caution – All connections to the KBPB module are at or near AC line voltage potential. All components and traces on the KBPB circuit boards should be assumed to be at AC line voltage potential.

The KBPB motor drive modules are manufactured by KB Electronics, Inc. The KBPB motor drive modules use SCRs to rectify the AC line voltage and control the voltage DC delivered to the armature of the motor being controlled. The KBPB-125 is designed for use with 120 VAC line voltage. The KBPB-225 is designed for use with 240 VAC line voltage. These motor drive modules provide user adjustments for motor speed (JOG), electronic current limiting (CL), and IR compensation (IR). The drive supports dynamic braking. A resistor which is installed in the KBPB (Plug-In Horsepower Resistor) matches the KBPB's IR compensation and current limit characteristics to the DC motors used on the antenna. The Prodelin 3.8 meter motorization kit employs 90 VDC, ¾ horsepower motors. The correct Horsepower Set Resistor is KB Electronics p/n 9842. When the KBPB-225 is used with 90 volt DC motors place the KBPB-225 J2 jumper on the 90 position. Figures 6 and 7 are photos of the printed circuit boards of the KBPB motor drive.

The KBPB drives have two cartridge style fuses (1/4" x 1 ¼"). The fuses are 12 amp SloBlo type. BUSSMAN MDL-12 or LITTLEFUSE 326012. See Figure 6. The fuse on the right is the Line fuse. The fuse on the left is the Armature fuse.

The line voltage is applied to the L1 and L2 terminals. The polarity of the voltage applied to the motor and the operation of the dynamic brake are controlled by the S1, S2, and S3 connections. When the S2 terminal is not connected to either the S1 or S3 terminals the motor drive is in the brake mode. When S2 is connected to S1 voltage is applied to the armature of the motor (via the A1 and A2 terminals). When S2 is connected to the S3 terminal a voltage of the opposite polarity is applied to the motor.

The motor speed is adjusted via the JOG potentiometer, R25.

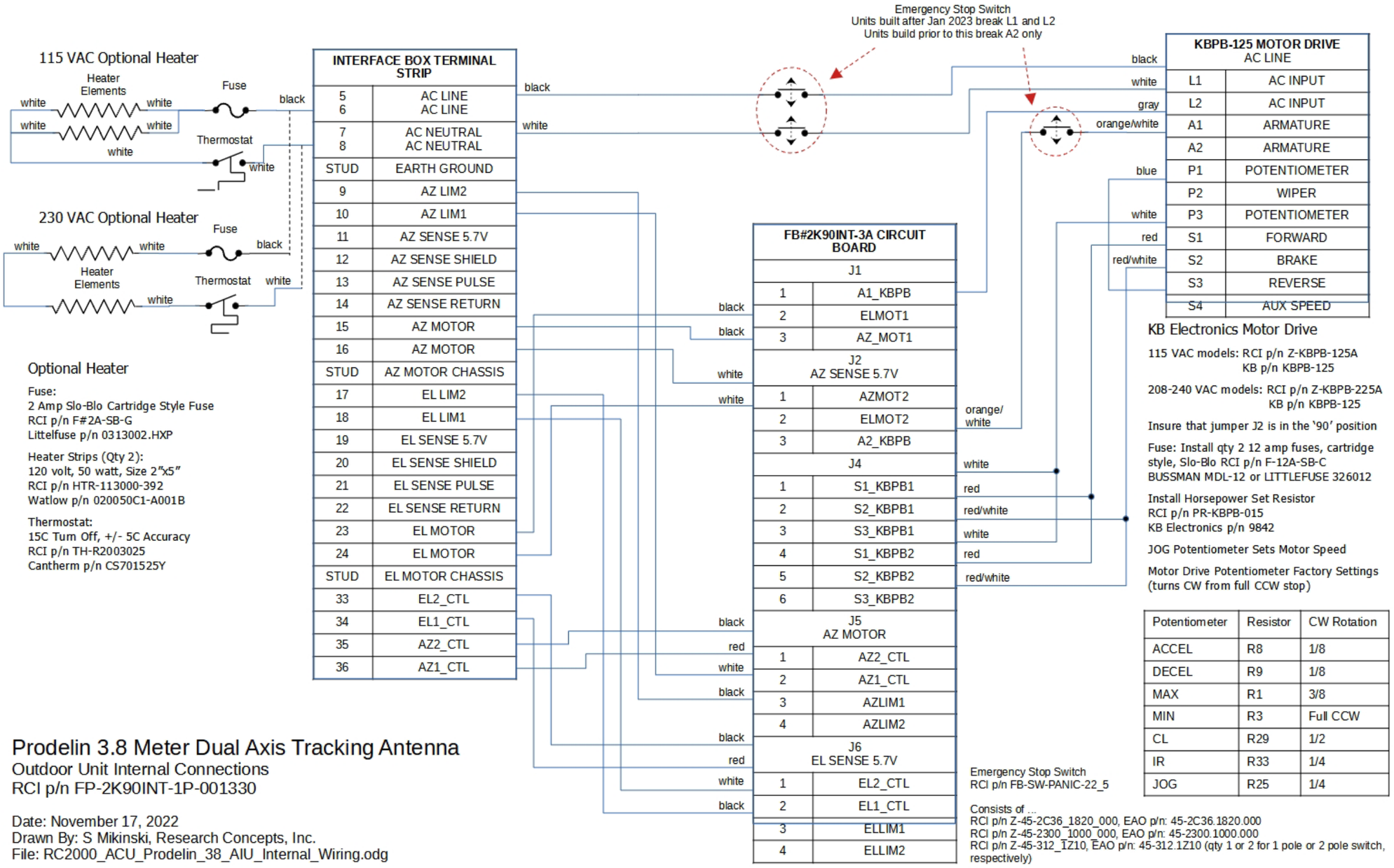


Figure 4 – Interface Box Schematic

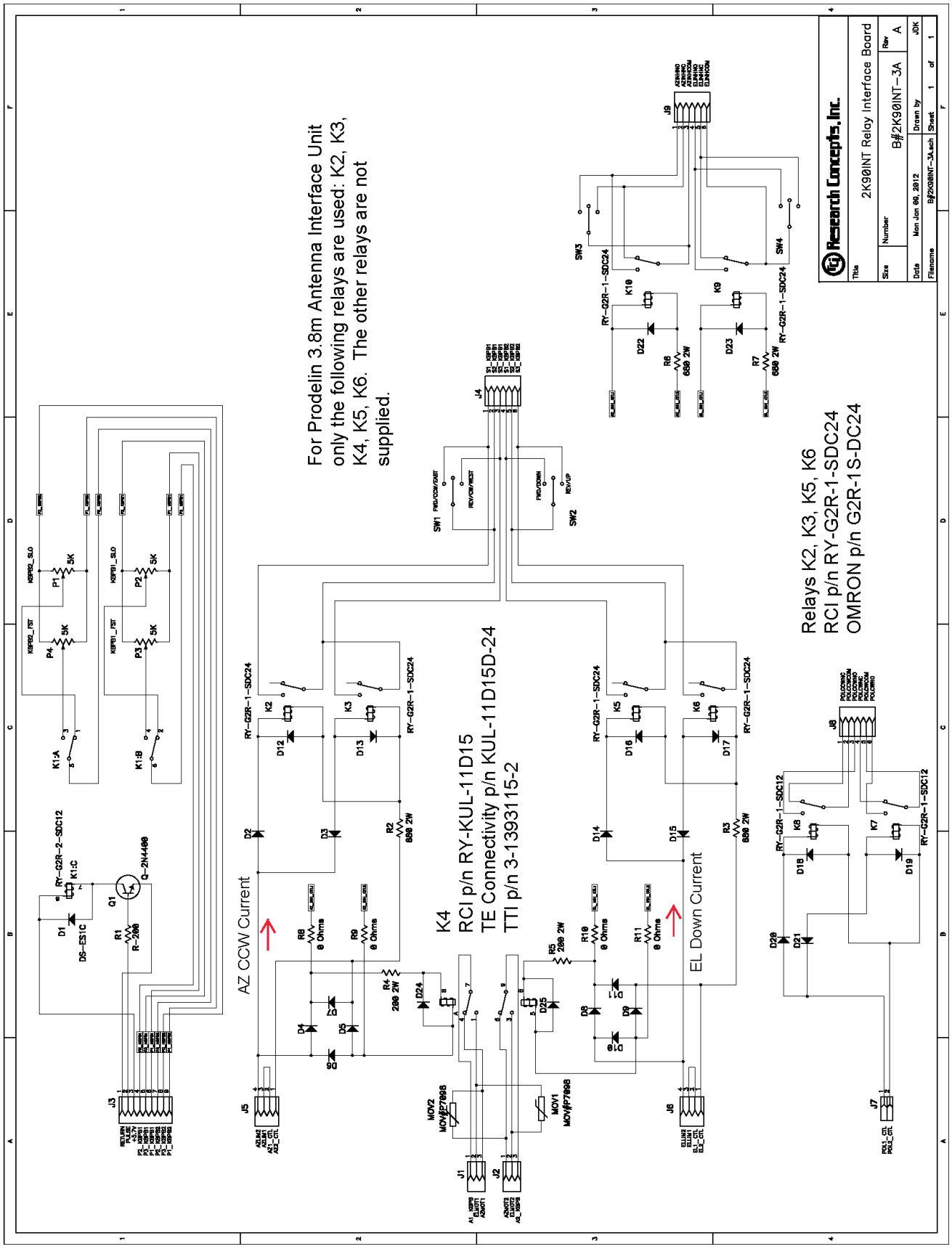


Figure 5 – Printed Circuit Board Schematic

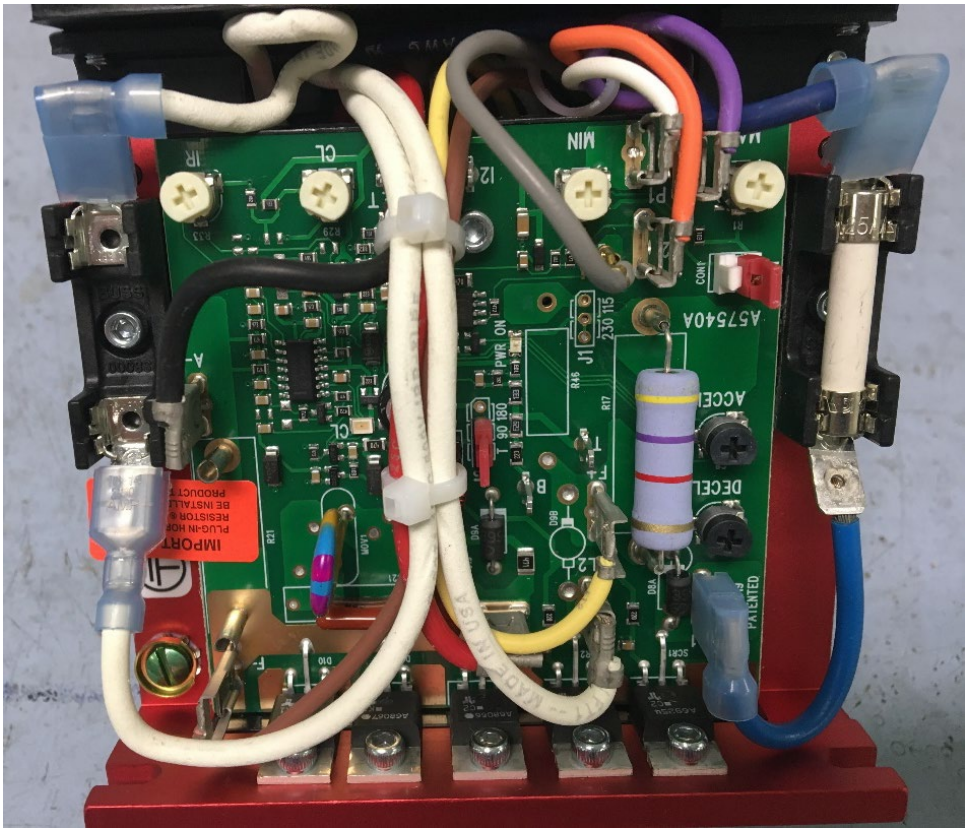


Figure 6

KBPB Printed Circuit Board (Fuse Side)

MAX Adjustment Pot in upper right hand corner of PCB.

IR, CL, MIN, ACCEL, DECEL Pots are labeled on the board.

LINE fuse on the right.

ARMATURE fuse on the left.

J2 jumper near the middle of the board (jumper positions are labeled T, 90, 180)

Horsepower Set Resistor (R21) plugs into a pair of PCB sockets on lower left near green ground screw and orange label.

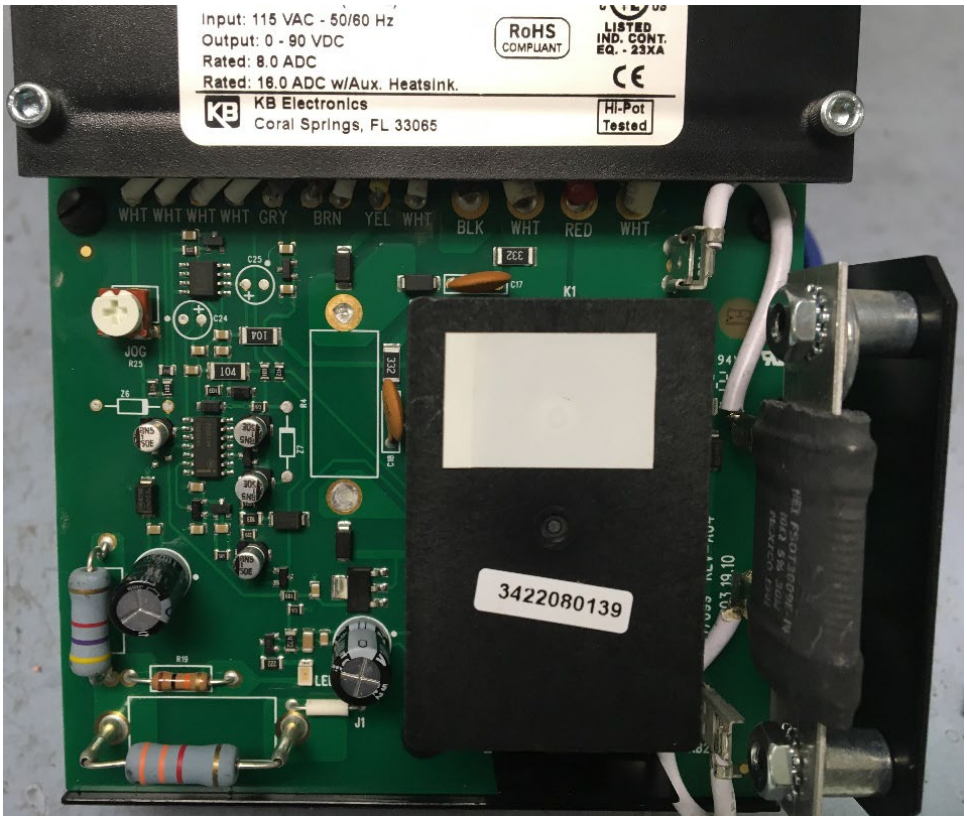


Figure 7

KBPB Printed Circuit Board (Speed Adjust)

JOG Speed Adjustment pot on the left, R25.

Brake Resistor on the right.

5. Specifications

Electrical

AC Input Requirements	115 VAC models: RCI p/n FP-2K90INT-1P-0xxxxx 208-240 VAC models: RCI p/n FP-2K90INT-1P-1xxxxx AC Disconnect at antenna with 20 amp breakers for each non-neutral input conductor.
Az/El Motor Rating	¾ HP, 90 VDC
Internal Fuses	Motor Drive: Qty 2, 12 amp Slow Blow Ceramic (Bussmann p/n MDL-12 or Littelfuse p/n 326012) Optional Heater: 2 amp Slow Blow, Littelfuse P/N 0313002.HXP
Optional Heater	100 watts

Physical / Environmental

Temp Range	Without Optional Heater: 0 – 45C With Optional Heater: -40 – 45C
Dimensions	12 x 12 x 6 inches
Mounting Hole Paterns	12.75 x 10 inches
Weight	21.4 lbs

6. Data Sheets

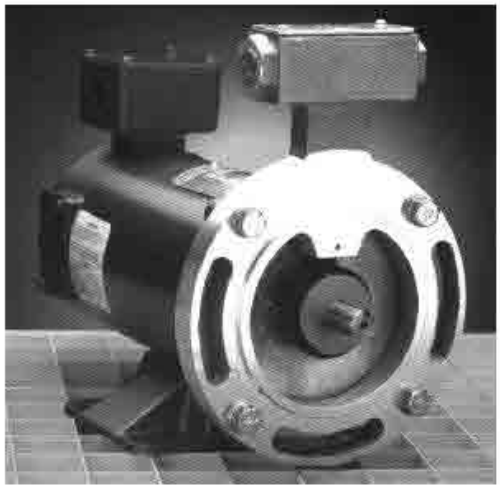
Data Sheets for the position sensor and motor drive follow.

Spares

Description	Research Concepts p/n	Mfg p/n
Az/El Position Sensor One Pulse per Revolution	Z-DTK-056M1	Powermation DTK-056 M1
Replacement Hall Effect Sensor Element	Z-84009-001	Powermation 84009-001
Replacement Magnet Wheel	Z-RM2-1-_625	Powermation RM2-1-.625
KBPB Motor Drive	115 VAC Input: Z-KBPB-125A 208 – 240 VAC Input: Z-KBPB-225A	KB Electronics 115 VAC: KBPB-125 208 – 240 VAC: KBPB-225

DIGITAL TACHOMETER SENSOR KITS

POWER/MATION
W238 N1690 Rockwood Drive
Waukesha, WI 53188
Phone: (414) 523-0600
800-242-2060
Fax: (414) 523-0611

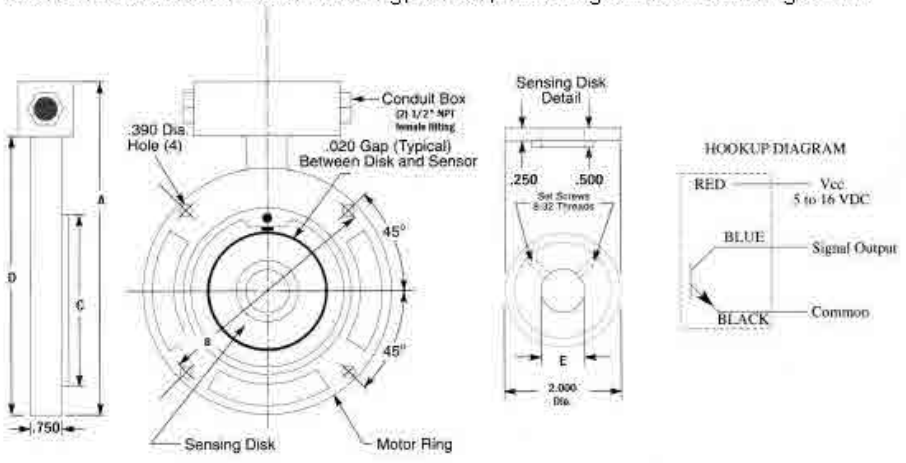


SPECIFICATIONS
INPUT: 5-16 VDC
OUTPUT: NPN, 20ma
TEMPERATURE: Minus 40^{0}F to plus 225^{0}F
OUTPUT CONNECTION: Three Wire
PULSES PER REVOLUTION (ppr): 1 *
WAVE FORM: Square Wave
ENVIRONMENT: Impervious to dust, oil & water
* 2, 15 & 60 ppr models are available

ORDERING CHART

MOTOR FRAME SIZE	KIT MODEL NUMBER	DIMENSIONS				
		A	B	C	D	E
56C	DTK-056 M1	9.375	5.875	4.500	7.875	5/8"
143TC, 145TC, 182C & 184C	DTK-184 M1	9.375	5.875	4.500	7.875	7/8"
182TC, 184TC, 213C, 215C & 254C	DTK-215 M1	12.312	7.250	8.500	10.000	1-1/8"
213TC, 215TC, 254UC & 256UC	DTK-254 M1	12.312	7.250	8.500	10.000	1-3/8"
254TC & 256TC	DTK-256 M1	12.312	7.250	8.500	10.000	1-5/8"

NOTE: Kits consist of motor face ring, sensor, mounting bolts and sensing wheel.



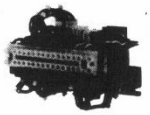
NOTE: Shielded cable must be used to interface sensor to ACU, see shielding guidelines in ACU Manual.

KBPB™ "Cycler" Solid State DC Motor Speed Controls

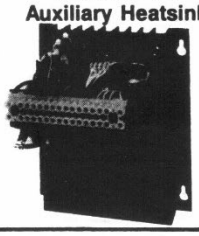
CE* *Improved*—Contains c UL us KBMM* Speed Control and APRM*-2C for Faster Switching

Installation and Operating Instructions

KBPB™

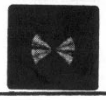


KBPB™ mounted on Auxiliary Heatsink



5K Remote Potentiometer

Knob and Dial Plate (Accessory Item Not Included)



- Ratings up to 1½ HP-120V & 3HP-240V
- Multiple Horsepower Capability with Plug-in Horsepower Resistor® (supplied separately)
- Voltage Following
- Contains the KB APRM (PATENTED) which provides Instant Anti-Plug Reversing and Solid State Dynamic Braking.
- Adjustable ACCEL and DECEL.
- Provision for AC Line and Armature fusing (fuses supplied separatley) *Patented

See SAFETY WARNING on page 18.

PENTA KB POWER™ ®

A COMPLETE LINE OF SCR DRIVES

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

IMPORTANT

Read these simplified instructions before operating control. (SEE WARNING ON PAGE 18.)

1. Be sure input AC line voltage corresponds to control voltage. (See electrical rating chart page 4)
2. Install the correct Plug-in Horsepower Resistor® (supplied separately) according to input voltage and motor horsepower (see chart, page 5).
3. Recheck connections: AC line to L1 and L2; armature to A1 and A2 and Field (Shunt motors only) to F+ and F−. Connect ground via ground screw. (Note: If motor runs in improper direction, interchange armature leads)
4. Connect S1 to S2 or S2 to S3 to activate control. LED brake light will be "on" if no connection is made.
5. AC Line Fuse and Armature Fuse must be installed in this product. (supplied separately)—(see page 10, Table 6)
6. Nominal trimpot settings are as follows (expressed in % of full CW rotation):

TABLE 1: NOMINAL TRIMPOT SETTINGS—SPEED CONTROL MODULE

MIN (minimum speed):	15%	CL (current limit/torque):	65%	For detailed
MAX (maximum speed):	65%	ACCEL (acceleration start):	20%	instructions
IR (IR compensation):	25%	DECEL (deceleration):	20%	see Sec. III

FOR TECHNICAL ASSISTANCE CALL TOLL FREE (OUTSIDE NY STATE ONLY) 1-800-221-6570

PLUG-IN HORSEPOWER RESISTOR®

A Plug-in Horsepower Resistor® must be installed to match the control to the motor horsepower and voltage. See Table 4 for the correct value. Plug-in Horsepower Resistors® are stocked by your distributor (supplied separately).

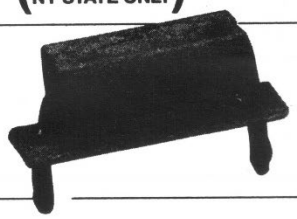


TABLE 2. ELECTRICAL RATINGS

MODEL NUMBER	AC LINE VOLTAGE (VAC)**	MOTOR VOLTAGE (VDC)	RATING WITHOUT AUXILIARY HEATSINK			RATING WITH AUXILIARY HEATSINK		
			AC LOAD CURRENT (RMS AMPS)	DC LOAD CURRENT (AVG. AMPS)	MAX. HP	AC LOAD CURRENT (RMS AMPS)	DC LOAD CURRENT (AVG. AMPS)	MAX. HP
KBPB-125	120	90–130	12.0	8.0	¾	24.0	16.0	1½
KBPB-225	240	180	12.0	8.0	1½	24.0	16.0	3

TABLE 3. GENERAL PERFORMANCE SPECIFICATIONS

Speed range (ratio)	50:1	CL/torque range (% full load)	0–200
Load regulation—armature feedback (0-full load, 50:1 speed range) (% base speed)	1*	Accel time range (0-full speed) (secs.)	.2–10
		Decel time range (full-0 speed) (secs.)	.2–10
Load regulation—tachometer feedback (0-full load, 50:1 speed range) (% set speed)	1*	Min. speed trimpot range (% full speed)	0–30*
		Max. speed trimpot range (% full speed)	50–110*
Line voltage regulation—armature feedback (at full load, ±10% line variation (% base speed)	½*	IR compensation trimpot range (at specified full load) (volts)	0–24
		Maximum allowable ambient temperature at full rating (°C/°F)	45/113
Line voltage regulation—tachometer feedback (at full load, ±10% line variation (% set speed)	½*	Tachometer feedback input volts (per 1000 RPM) (VDC)	7/50
Control linearity (% speed vs. dial rotation)	2	Maximum number of starts/stops or reversals (operations/min.)	10**

* Performance is for SCR rated PM motors only. Lower performance can be expected with other motor types. Factory setting is for 3% load regulation. To obtain superior regulation, see Sec. III F. Other factory trimpot settings are as follows: CL-150% FL, Accel-1 sec., Decel-1 sec., MIN-(0)-speed, MAX-full speed & IR-6 volts.

** Rating is based on a brake time of (1) second. For increased operations per minute or longer brake time, consult factory.

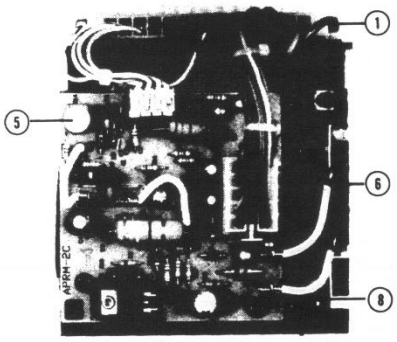
TABLE 4. PLUG-IN HORSEPOWER RESISTOR® CHART

MOTOR HORSEPOWER RANGE**		Plug-in Horsepower Resistor® Resistance Value (Ohms)	KB P/N
Armature Voltage 90–130V DC	Armature Voltage 180V DC		
1/100–1/50	1/50–1/25	1.0	9833
1/50–1/30	1/25–1/15	.51	9834
1/30–1/20	1/15–1/10	.35	9835
1/20–1/12	1/10–1/6	.25	9836
1/12–1/8	1/6–1/4	.18	9837
1/8–1/5	1/4–1/3	.1	9838
1/4	1/2	.05	9839
1/3	3/4	.035	9840
1/2	1	.025	9841
3/4	1–1/2	.015	9842
1***	2***	.01	9843
1–1/2***	3***	.006	9850

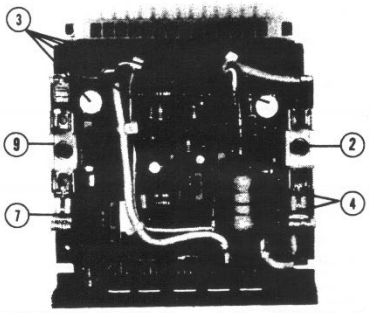
* Motor horsepower and armature voltage must be specified when ordering so that proper resistor will be supplied.
** For overlapping motor horsepower range use lower value Plug-in Horsepower Resistor.
*** Auxiliary heatsink must be used to achieve HP rating.

FIG. 1 FEATURES AND FUNCTIONS

(1) Barrier Terminal Block
(2) AC Line Fuse (supplied separately)
(3) Trimpots: Min, Max, CL, IR
(4) Trimpots: Accel, Decel
(5) Trimpot: Aux Speed
(6) Dynamic Brake Resistor
(7) Plug-in Horsepower Resistor® (supplied separately)
(8) "Brake" LED
(9) Armature Fuse (supplied separately)



TOP VIEW APRM® (patented)



BOTTOM VIEW Speed Control Module (patented)

5

INTRODUCTION

The KBPB™ Full Wave Solid State DC Motor Speed and Reversing Control represents the latest state-of-the-art design achievable through modern technology.

Features Include:

- ***Integrated Circuitry***
  Used to control and amplify command and reference levels with both closed and open loop feedback to provide superior motor regulation. (Speed changes due to load, line voltage, or temperature variations are held to mininum levels.)
- ***High Quality Components***
  Selected and tested for proven dependability.
- ***Transient Protection***
  Used to prevent failure of the power bridge circuit caused by voltage spikes on the AC line.
- ***High Reliability***
  When used in accordance with the instructions included in this manual, the KBPB™ will provide years of trouble-free operation.

SECTION I. APPLICATION INFORMATION

A. *Motor Type.* The KBPB™ is designed for Permanent Magnet (PM) and Shunt Wound D.C. motors. Controls operated on 120 volt AC inputs are designed for 90 volt SCR rated motors. Controls operated on 240 volt AC inputs are designed for 180 volt SCR rated motors. Use of higher voltage motors will result in degradation of full speed performance. Also, if motor is not an SCR rated type, the actual AC line amperage at full load should not exceed the motor's DC nameplate rating.

B. *Torque Requirements.* When replacing an AC induction motor with a DC motor and speed control, consideration must be given to the maximum torque requirements. The full load torque rating of the DC motor must be equal to, or greater than, that of the AC motor.

C. *Acceleration Start.* The KBPB™ contains an adjustable acceleration start feature which allows the motor to smoothly accelerate from 0-full speed over a time period of .2–10 seconds. The "ACCEL" is factory set at 1 second.

D. *Limitations in Use.* The KBPB™ controls are designed for use on machine applications.

E. *Switching Applications:* KBPB™ contains the KB APRM® which is designed to provide anti-plug instant reverse, solid state dynamic brake and rapid cycling. The maximum recommended number of run-brake cycles is 10 per minute. If higher rates are required, contact our sales dept.

CAUTION: Consult factory before using on constant horsepower applications such as saws or drill presses. Do not use in explosive atmosphere.

CAUTION: Be sure the KBPB™ is used within its max. ratings. Follow all installation instructions carefully. (Refer to Section II.)

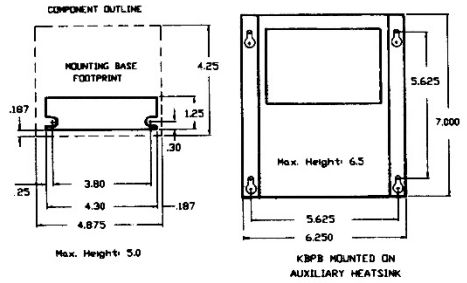
SECTION II. INSTALLATION INSTRUCTIONS

A. *Location and Mounting.* The KBPB control should be mounted on a flat surface and located in an area where it will not be exposed to contaminants such as water, metal chips, solvents or excessive vibration.

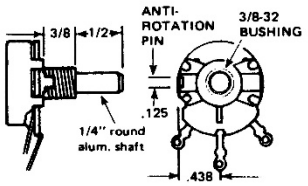
When mounting in an enclosure the air space should be large enough to provide adequate heat dissipation. The maximum allowable ambient temperature at full rating is 45°C/113°F. Consult factory if more information is required.

* Warning: Do not mount control with terminal block legend facing down. (Relay Plunger down.)

FIG. 2 MECHANICAL SPECIFICATIONS (inches)



REMOTE POTENTIOMETER



B. *Initial Setup and Wiring*

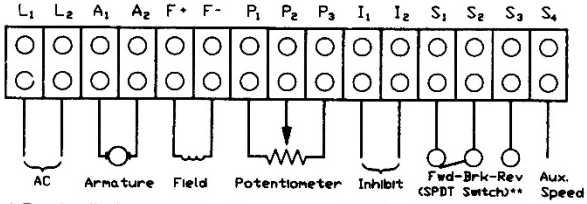
1. Install proper size Plug-in Horsepower Resistor® . (See chart page 5—table 4)
2. The KBPB™ can be connected to a standard 120V or 240V 50/60 Hz AC line [Be sure the AC input voltage corresponds to the control voltage rating and the motor rating (e.g. 90–130VDC motor on 120VAC and 180VDC motor on 240VAC)].
3. Follow the recommended supply wire sizes as per Table 5.
4. Follow the NEC and other electrical codes that apply. CAUTION: Separate branch protection must be provided on 240V circuits. (Do not fuse neutral or grounded conductors.)
5. Connect control according to connection diagram—See Fig. 3.

TABLE 5. MINIMUM SUPPLY WIRE SIZE REQUIREMENTS

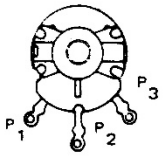
MAX. MOTOR AMPS (DC AMPS)	MAX. MOTOR HP 90V	MAX. MOTOR HP 180V	MINIMUM WIRE SIZE (AWG) Cu Only	
			MAX. 50 FOOT RUN	MAX. 100 FOOT RUN
6.0	1/2	1	16	14
12.0	1	2	14	12*
16.0	1/1/2	3	12	12

* Maximum recommended wire size.

FIG. 3 CONNECTION DIAGRAM



REMOTE POTENTIOMETER



* For detailed connection diagrams see KBPB connection diagrams. ** Since only 10 ma of current is switched, any switch or relay can be used except a solid state type or relays with capacitors or R-C networks (snubbers) across their contracts.

CAUTION: If control is wired to a transformer, it is advisable to switch the secondary to disconnect power. If the primary is switched, additional snubber capacitors may have to be added across the transformer output to prevent damage to the power bridge.

CAUTION: Do not bundle control wires P_1, P_2, P_3, I_1, I_2, S_1–S_4 with line or motor leads. If wires are over 18", use shielded cables.

C. Voltage Following. All models can be controlled with an **isolated** analog reference voltage (0–9VDC) in lieu of the main speed potentiometer. The voltage is connected to P_2(+) and F–. The control output voltage will linearily follow the input voltage. The source impedance of the input should be 10K ohms or less. The Min trimpot can be used to provide an offset speed. If an offset is not required adjust the Min to 0+ or 0– speed as desired. The Max trimpot is rendered inoperative in the voltage following mode. Use auxiliary trimpot to limit the control range. If the input signal is not isolated, or is a current signal (4–20ma), the KBSI-240D Signal Isolator must be used. It will allow direct connection to process controllers and microprocessors.

CAUTION: 1. The voltage feeding P_2 and F– must be isolated from the AC line. Do not ground P_2 or F– to set up a zero or ground reference.
2. Do not bundle signal wires to P_2 and F– with AC line or motor connections. If signal wires are over 18", use shielded cables.

D. Fusing. The KBPB™ has provision for a built-in AC line fuse and armature fuse. The AC line fuse protects the control against catastrophic failure. If the fuse blows, the control is miswired, the motor is shorted or grounded, or the KBPB™ control is defective. The armature fuse provides overload protection for the motor and control. Choose the proper size armature fuse by multiplying the maximum **dc motor amps by 1.7. NOTE: Be sure to fuse each ungrounded AC line supply conductor. Do not fuse neutral or grounded conductors. All fuses should be normal blow** ceramic **3AG, ABC or equivalent.** (See Table 6 on page 10)

TABLE 6. ARMATURE FUSE CHART

90VDC MOTOR	180VDC MOTOR	APPROX. DC MOTOR CURRENT (AMPS)	FUSE RATING (AC AMPS)
HORSEPOWER			
1/30	1/15	.33	1/2
1/20	1/10	.5	3/4
1/15	1/8	.65	1
1/12	1/6	.85	1-1/4
1/8	1/4	1.3	2
1/6	1/3	1.7	2-1/2
1/4	1/2	2.5	4
1/3	3/4	3.3	5
1/2	1	5.0	8
3/4	1-1/2	7.5	12*
1	2	10.0	15
1-1/2	3	15.0	25*

* Also used as AC Line Fuse.

NOTES:

1. AC Line Fuse is chosen according to the maximum rating of the control: *12 Amp* fuse for all motors up to ¾ HP-90V and 1½ HP-180VDC. *25 Amp* fuse for all motors 1 and 1½ HP-90V and 2 and 3 HP-180VDC. (Use Buss ABC, Litt. 326 ceramic fuse or equivalent.)
2. *Armature Fuse* can be chosen in accordance with the fuse chart. Note: The armature fuse is calculated based on the approximate full load DC current rating of the motor times a form factor of 1.5. If motor has characteristics not consistent with these approximations, a different fuse value may have to be used. Fuses are available from your distributor. Also available is a Fuse Kit (KB Part #9870) containing 700 assorted fuses.

SECTION III—ADJUSTMENTS AND CONTROL FUNCTIONS—See Safety Warning Page 18

The KBPB has been factory adjusted to provide 0-full speed using the speed control knob. Minimum and Maximum speed trimpots are provided to change the speed from other than 0-full speed. The Acceleration (ACCEL) trimpot is provided to allow for a smooth start over an adjustable time period each time the AC power is applied or the speed pot is rotated. The DECEL trimpot controls the amount of ramp-down time when the speed pot is adjusted to a lower speed. **Note:** If P_2 is connected to P_1, or the enable lead, P_3, is opened, the control will ramp down to the MIN speed trimpot, setting. If I_1 is shorted to I_2, the control will coast down to zero speed. The Current Limit (CL, or torque output) adjustment is factory set to approximately 1½ times the motor rating. The IR Compensation (IR) is factory adjusted to provide excellent motor regulation under normal operation. The KBPB contains the KB APRM® which provides anti-plug "instant" reverse and solid state dynamic braking. The APRM® contains a trimpot which is used to preset a fixed speed for either the forward or reverse direction (see KBPB connection diagrams for additional information).

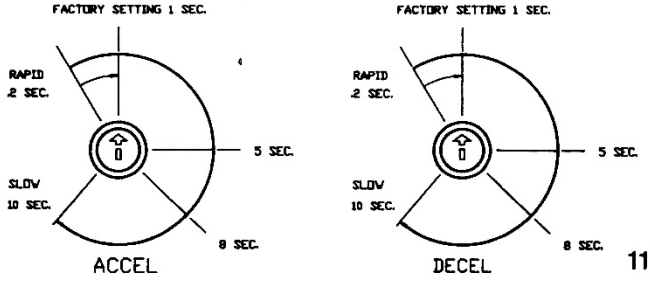
NOTE: In order for the IR comp and CL trimpot settings to be correct, the proper Plug-in Horsepower Resistor® must be installed for the particular motor and input voltage being used. Do not attempt to change the settings of the trimpots unless absolutely necessary since they are factory adjusted to near optimum settings.

The following procedure, presented in order of adjustment sequence, should be used when readjusting all trimpot functions:

Fig. 4 ACCEL/DECEL TRIMPOT ADJUSTMENT

CAUTION!

[PM motors only]. Adjusting the accel time below .5 seconds increases inrush current. It may be necessary to measure the peak inrush current and consult with motor manufacturer since field magnet demagnetization may occur.



A. *Acceleration Start.* The ACCEL is factory set at approx. 1 second. To readjust to different times, set the knob to the desired position as indicated in Fig. 4.

B. *Deceleration.* The DECEL is factory set to provide minimum ramp-down time. To increase the ramp-down time adjust the DECEL trimpot as indicated in Fig. 4.

C. *Maximum Speed Adjustment.* Turn Speed Control Knob to full speed (maximum CW position). Adjust max. speed trimpot to new desired setting.

NOTE: Do not attempt to adjust the max. speed above the rated motor RPM since unstable motor operation may occur. For moderate changes in the max. speed, there will be a slight effect on the min. speed setting when the min. speed is set at zero. There may be a significant variation in the min. speed setting if the min. speed is at a higher than zero setting.

D. *Minimum Speed Adjustment.* If a higher than zero minimum speed is desired, readjust the minimum speed by turning the speed control knob to zero setting (full CCW position). Then adjust the min. speed trimpot to the desired setting.

NOTE: The min. speed adjustment will affect the max. speed setting. Therefore, it is necessary to readjust the max. speed after the min. speed, and it may be necessary to repeat the sequence until both the min. and max. speeds are set to desired levels.

E. *Current Limit (CL/Torque Adjustment).* CL circuitry is provided to protect the motor and control against overloads and demagnetization of PM motors. The CL also limits the inrush current to a safe level during startup. The CL is factory set to approximately 1.5 times the full load rating of the motor. (CL trimpot is nominally set to approx. 65% of full CW rotation.)

NOTE: The correct value Plug-in Horsepower Resistor® must be installed in order for the CL and IR comp. to operate properly.

To set the CL to factory specifications adjust as follows:

1. Set speed control knob at approximately 30–50% CW rotation. Set CL trimpot to full CCW position.
2. Connect a DC ammeter in series with the armature lead.

3. Lock shaft of motor (be sure CL pot is in full CCW position). Apply power and rotate CL pot CW slowly until DC ammeter reads 1.5 times motor rating (do not exceed 2 times motor rating).

NOTE: If only an AC ammeter is available, it can be installed in series with AC input line. Follow above instructions; however, set AC amperage at .75 times motor rating.

F. *IR Compensation Adjustment.* IR compensation is provided to substantially improve load regulation. If the load presented to the motor does not vary substantially, the IR adjustment may be set at a minimum level (approximately ¼ of full setting). The control is factory adjusted to approximately 3% regulation. If superior performance is desired (less than 1% speed change of base speed from 0 to full load), then the IR comp. should be adjusted as follows:

NOTE: Excessive IR comp. will cause control to become unstable, which causes motor cogging.

1. Set IR comp. trimpot at approximately 25% of CW roation. Run motor unloaded at approximately ⅓ speed and record RPM.
2. Run motor with maximum load and adjust IR comp. trimpot so that the motor speed under load equals the unloaded speed per step 1.
3. Remove load and recheck unloaded RPM. If unloaded RPM has shifted, repeat procedure for more exact regulation.

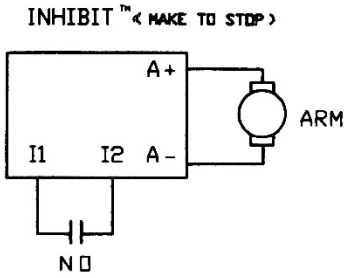
The KBPB is now compensated to provide minimal speed change under large variations of applied load.

SECTION IV. KBPB APPLICATION INFORMATION

The KBPB is designed to offer a variety of switching functions. The APRM® module is the interface between command signals and the KBMM speed control module. By using terminals S_1, S_2 and S_3 the KBPB can be made to perform the following functions: Run-Brake, Forward-Brake-Reverse and Forward-Reverse (instant anti-plug reverse). Terminal S_4 is used to supply a control voltage which is adjustable with the APRM® trimpot R11. This voltage is used to preset a

Jog or Run speed, either in Forward or Reverse direction. (DECEL Trimpot does not affect the brake time.)

In order for the KBPB control to drive a motor, S_1 and S_2 must be connected together for Forward and S_2 and S_3 must be connected together for Reverse. If no connection is made to S_2, the control will be in a "Brake" mode. The brake circuit consists of an SCR and dynamic brake resistor (RB). An LED indicator on the APRM® shows that power is applied to the SCR gate. If braking is not required, the wire to RB may be disconnected. (Note that the LED will still light with RB disconnected.)

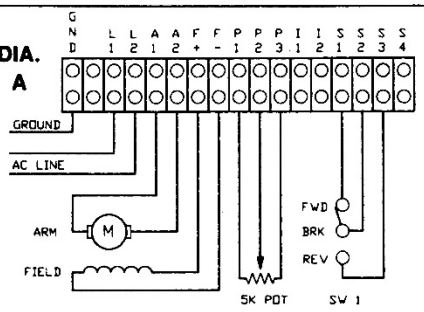


INHIBIT™: Terminals I_1 and I_2 provide an Inhibit™ function which electronically extinguishes the output of the control. This circuit is activated by connecting the I_1 and I_2 terminals together. When installing the KBPB be sure to follow the mounting and wiring instructions found in Sec. II.

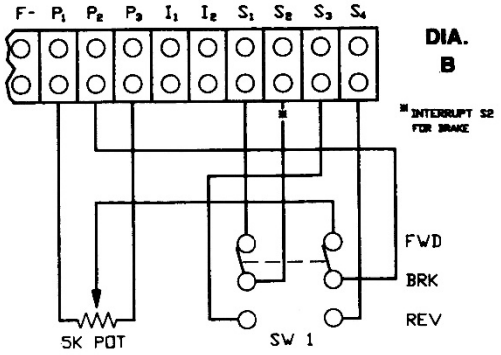
NOTE: When switching terminals S_1, S_2, S_3, approximately 10ma of current with full motor voltage may be present. Other terminals (I_1, I_2, P_1, P_2, P_3 and S_4) are low voltage to each other, but line voltage to ground. Any switch or relay can be used for switching **except** solid state relays or contacts with R-C networks (snubbers). S_1 and S_2 must be opened before S_2 and S_3 are closed and vice versa.

The following wiring diagrams are presented to demonstrate the capabilities of the KBPB.

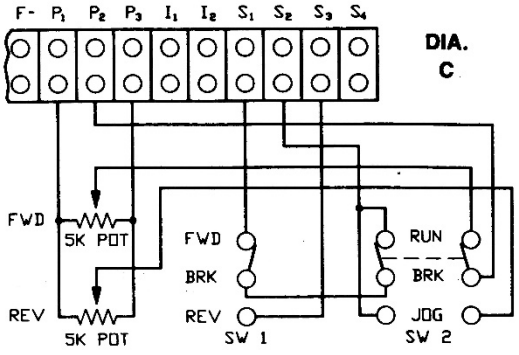
A. **Forward-Brake-Reverse with Single Potentiometer.** Use an SPDT ON-OFF-ON switch. Close S_1 and S_2 for motor to run in FWD direction. Open S_2 for Brake. Close S_2 and S_3 for motor to run in Reverse direction. If Brake position is not required, an SPDT (non-center OFF) may be used. This provides instant Anti-plug Reversing.



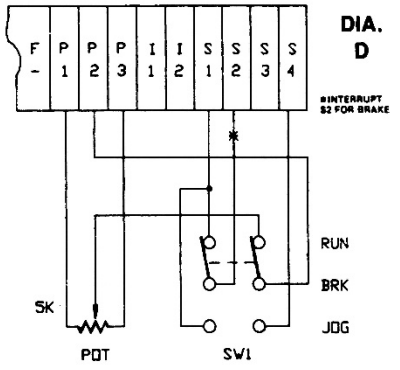
B. **Forward-Brake-Reverse with Adjustable Reverse Speed.** Reverse speed is adjustable with the trimpot on the APRM® board. Use a DPDT ON-OFF-ON switch. In the Forward direction, the remote speed pot is used. In the Reverse direction, P_2 is connected to S_4 for speed adjustment. If Brake position is not required, a DPDT switch (non-center OFF) may be used. If, while in Forward or Reverse position, a separate Brake function is required, S_2 may be interrupted using a limit switch or relay. (For remote reverse speed pot adjustment, see Wiring Diagram C.)



C. **Forward-Brake-Reverse with Run-Brake-Jog.** Jog speed is adjusted with remote speed pot. For SW1 use an SPDT ON-OFF-ON switch. For SW2 use DPDT ON-OFF-ON with momentary return from Jog position. (For non-remote Jog speed use trimpot on APRM® , see Wiring Diagram B).



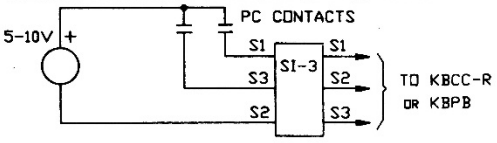
D. **Run-Brake-Jog with Adjustable Jog Speed.** The Jog speed is adjustable with the trimpot on the APRM® board. Use a DPDT ON-OFF-ON switch. In the Run mode, the external 5K speed pot is used. In the Jog mode P_2 is connected to S_4 and the Jog pot, located on the APRM® , is used for speed adjustment. If Brake position is not required, a DPDT switch (non-center OFF) may be used. If, while in Forward or Jog position, a separate Brake function is required, S_2 may be interrupted using a limit switch or relay. (For remote reverse speed pot adjustment, see Wiring Diagram C.)



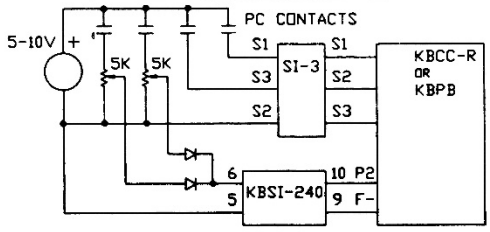
E. **Isolated Input for S_1, S_2, S_3.** An isolator board SI-3 is available as an accessory. It allows the KBPB forward-brake-reverse function to be activated by an analog signal. The SI-3 installs by removing the 4-pin connector on the APRM. Install the SI-3 on the 4-pin header and plug the mating connector into the SI-3.

The SI-3 is activated by applying an analog voltage of 5–10VDC to terminals S_1, S_2 for forward, or S_3, S_2 for reverse. The KBPB with the SI-3 option is suitable for operation with programmable controllers. For complete isolation of the voltage following input Model KBSI-240 Signal Isolator should also be used.

FWD-BRK-REV CONTROL USING PROGRAMMABLE CONTROLLER



FWD-BRK-REV AND DUAL SPEED CONTROL



F. **Tachometer feedback** (DC tachs only). The load regulation of the control can be improved to 1% of set speed over a 50:1 speed range by use of tachometer feedback. Since no provision is made for the tach input on the terminal block, the tach positive connection must be made directly to the B or T terminal on the speed control module. NOTE: If control is used on a reversing application, the tach wires must also be reversed so that positive (+) is always connected to B or T. To set control for tachometer feedback:

(1) For tach feedback, cut jumper J1 on Printed Circuit Board.
(Note: On Model KBPB-225, J1 is an 82K resistor)

(2) Connect tach as follows:

(a) 7 volts/1000 RPM Connect (+) lead to Terminal "T"
Connect (−) lead to Terminal I_2 or F−

(b) 50 volts/1000 RPM Connect (+) lead to Terminal "B"
Connect (−) lead to Terminal I_2 or F−

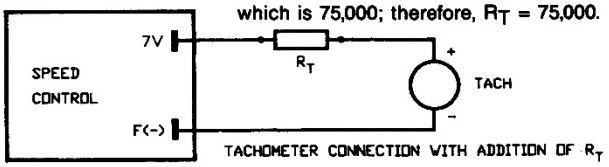
Note: Set IR Comp to minimum for tach feedback.

Note: The tachometer voltage input is based on 1,800 RPM motors. For motors other than 1,800 RPM, or for tachometer voltages other than what is specified, an external tachometer resistor must be used. Install the resistor (R_T) in series with positive (+) tachometer lead and the 7V input on the control. The value of R_T may be calculated using the following formula.

$R_T = [1.26 \times V_T \times S - 15{,}900]$
V_T = Tachometer voltage in volts/1,000 RPM
S = Base speed of motor in RPM

Example: Suppose you have a 3,600 RPM motor with a 20 volt/1,000 RPM tachometer:

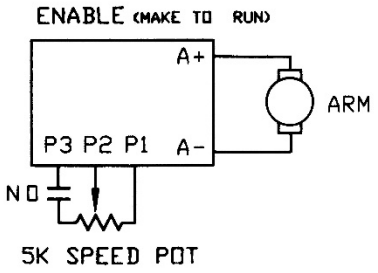
$R_T = 1.26 \times 20 \times 3{,}600 - 15{,}900 = 74{,}820$
Choose the closest ½ watt resistor value, which is 75,000; therefore, $R_T = 75{,}000$.



TACHOMETER CONNECTION WITH ADDITION OF R_T

G. **Enable.** Control can be made to start and stop electronically with Enable. This circuit is "make to run" which is opposite of Inhibit™.

Stop time is adjustable with DECEL trimpot. To obtain 0 speed when Enable is open MIN speed trimpot must be set to 0 speed. Two-speed operation can be obtained by setting the MIN speed to the desired level.

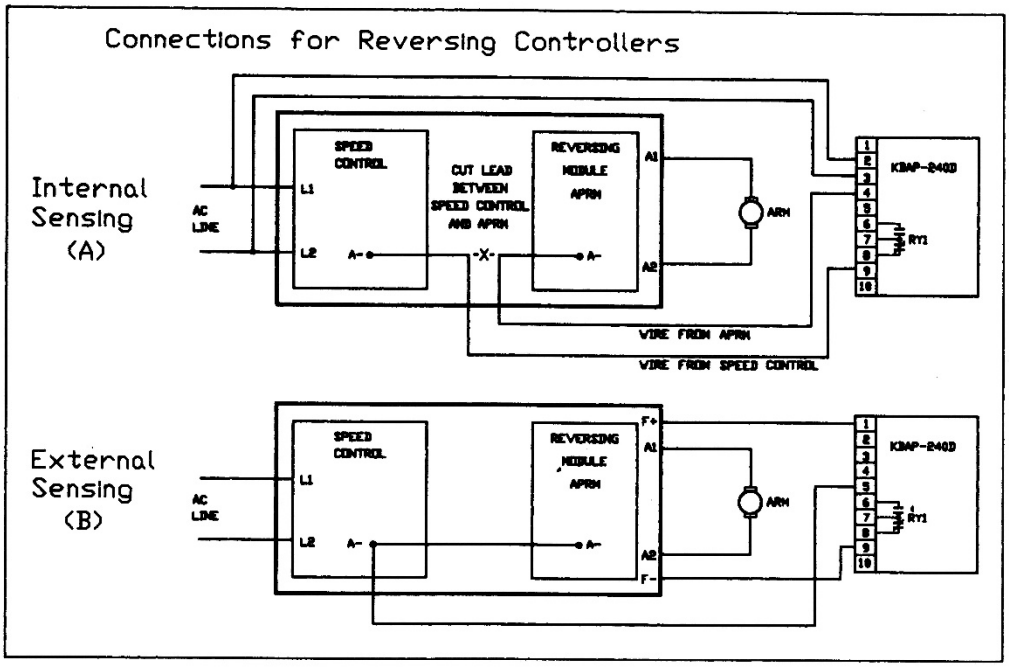


SAFETY WARNING—PLEASE READ CAREFULLY

This product should be serviced by a qualified technician, electrician or electrical maintenance personnel familiar with its operation and the hazards involved. Proper installation (see instruction information which accompanies product), which includes wiring, mounting in proper enclosure, fusing or other overcurrent protection and grounding, can reduce the chance of electric shocks, fires or explosion in this product or products used with this product, such as electric motors, switches, coils, solenoids and/or relays. Eye protection must be worn when working with control under power. This product is constructed of materials (plastics, metals, carbon, silicon, etc.) which may be a potential hazard. Individual material safety data sheets (MSDS) are available upon request. Proper shielding, grounding and filtering of this product can reduce the emission of radio frequency interference (RFI) which may adversely affect sensitive electronic equipment. If information is required on this product, contact our factory. It is the responsibility of the equipment manufacturer and individual installer to supply this safety warning to the ultimate user of this product. (SW effective 3/88).

H. **Overload Protection** The KBAP-240D is a multipurpose DC Current Sensing Relay and Overload Protector. It is specifically designed for use with DC motors and speed controls from 1/8–3 HP. The unit can be used with larger or smaller motors by utilizing the external method of connection. KBAP–240D operates by sensing current in the armature circuit. When the preset level is reached, an output relay trips. An adjustable time delay (.2–15 secs.) is incorporated, which eliminates nuisance tripping. Manual or automatic reset is provided at the user's option along with an LED, which indicates when the preset current level has been reached. In addition, a Hysteresis trimpot is provided which can be used to increase the differential between the pull-in and drop-out points of the output relay. When an overload occurs, the KBAP–240D can be used to shut the system down, sound an alarm, or initiate corrective action before damage occurs. The unit can be operated on either 120 or 240 VAC line voltage, and has five preset current trip points (2.5/5/10/15/20), which can be further adjusted with a built-in trimpot. See page 20 for connection diagram.

REVERSING APPLICATIONS. The KBAP set for Internal Sensing is suitable for unidirectional current only. Therefore, reversing controllers utilizing relays or reversing modules *cannot* be connected directly to the KBAP. For these applications the KBAP must be connected between the speed control and reversing module. For external Sensing the KBAP can be connected directly to the reversing control. See Fig. for correct connection diagrams (used for KB Models KBPB and KBCC-R suffix). See page 20 for connection diagram.

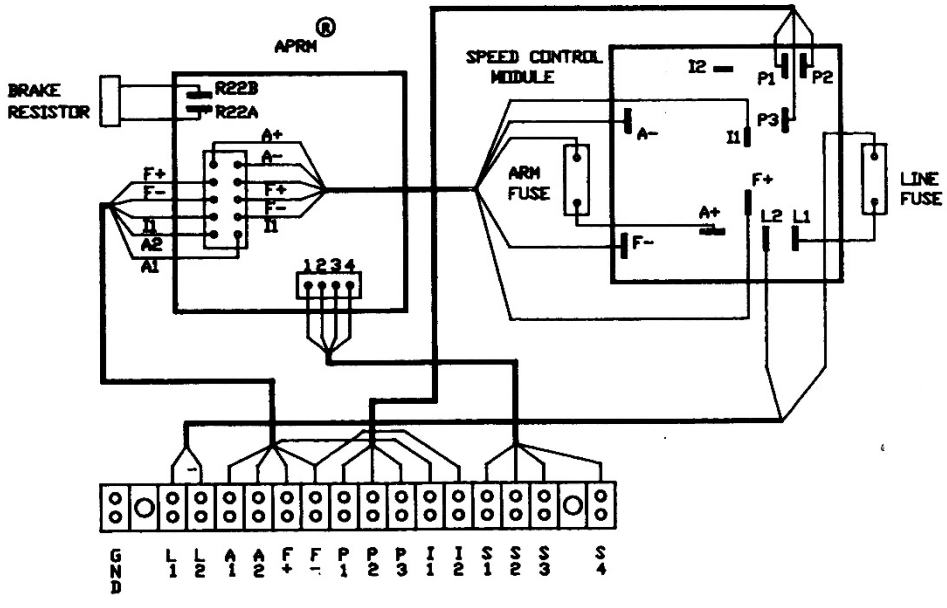


SECTION V. TROUBLESHOOTING GUIDE

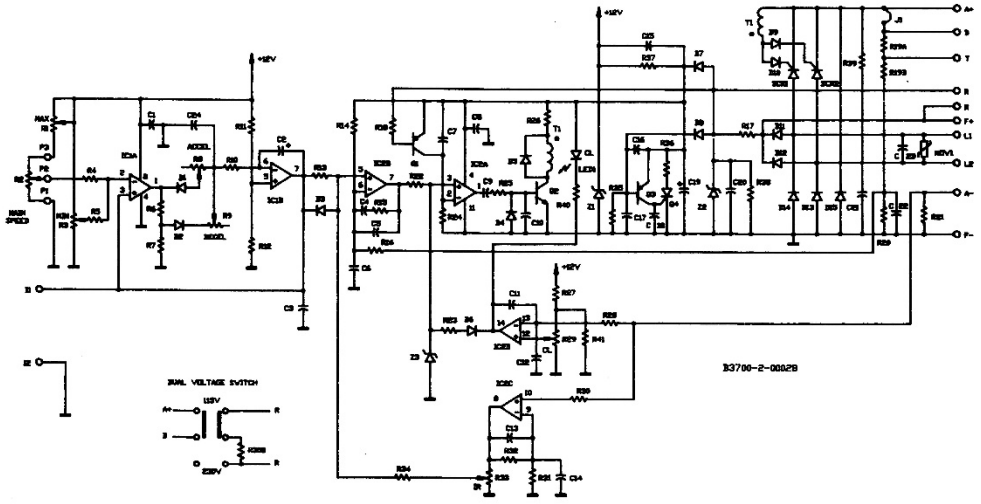
The following Troubleshooting Guide is intended for use by a qualified technician. The Guide is designed to isolate common malfunctions of the KBPB and/or motor. It should be used with the parts lists and schematics contained in this manual.

SYMPTOM	POSSIBLE CAUSE	CORRECTIVE ACTION
1. Motor does not run.	1. AC voltage not brought to L1, L2 terminals	1. Correct wiring to control.
	2. Blown line or armature fuse.	2. Replace blown fuse with properly rated 3AB-type. If fuse blew due to miswiring, speed control module may be defective.
	3. Speed control knob set to 0.	3. Turn knob CW to start motor.
	4. Defective motor.	4. Check for defective motor, worn brushes, etc. Replace motor.
	5. Plug-In Horsepower Resistor not installed.	5. Install proper size Plug-In Horsepower Resistor
2. Motor hums, or runs at very low speed (with control knob set at high number) or motor slows down substantially when load is applied.	1. Low voltage.	1. Check line voltage at control and rewire as required.
	2. Overload condition: control in current limit mode (CL) (trimpot not set correctly).	2. Reduce loading; CL trimpot setting may have to be increased. See Section IV.
	3. Plug-in Horsepower Resistor not correct size.	3. Install proper size resistor.
	4. Incorrect wiring. Armature and shunt connections interchanged (shunt motor only)	4. Correct wiring (armature has lower resistance than field).
3. Erratic motor performance.	1. Defective motor, worn brushes etc.	1. Repair motor.
	2. Overload condition.	2. Remove overload.
	3. Plug-in Horsepower Resistor wrong size.	3. Replace with proper size.
	4. IR comp and/or CL trimpots not set properly.	4. Readjust trimpots as per Section IV.
	5. Defective speed control module.	5. Replace module.
4. Motor continues to run when speed control knob is set to 0.	1. Min speed trimpot not set to full CCW position.	1. Readjust min. trimpot.
	2. IR comp trimpot set too high.	2. Lower IR comp trimpot setting.
5. Motor will not run in either forward or reverse direction.	1. Incorrect wiring or faulty reversing switch	1. Correct wiring. See KBPB connection diagrams.
	2. Defective APRM®	2. Replace APRM®
6. No Braking action in brake mode.	1. Incorrect wiring.	1. Correct wiring.
	2. Defective brake resistor.	2. Replace resistor.
	3. Defective APRM®	3. Replace APRM®
7. Motor runs in wrong direction.	1. Armature leads reversed.	1. Reconnect armature leads.

FIG. 5 INTERNAL CONNECTION DIAGRAM

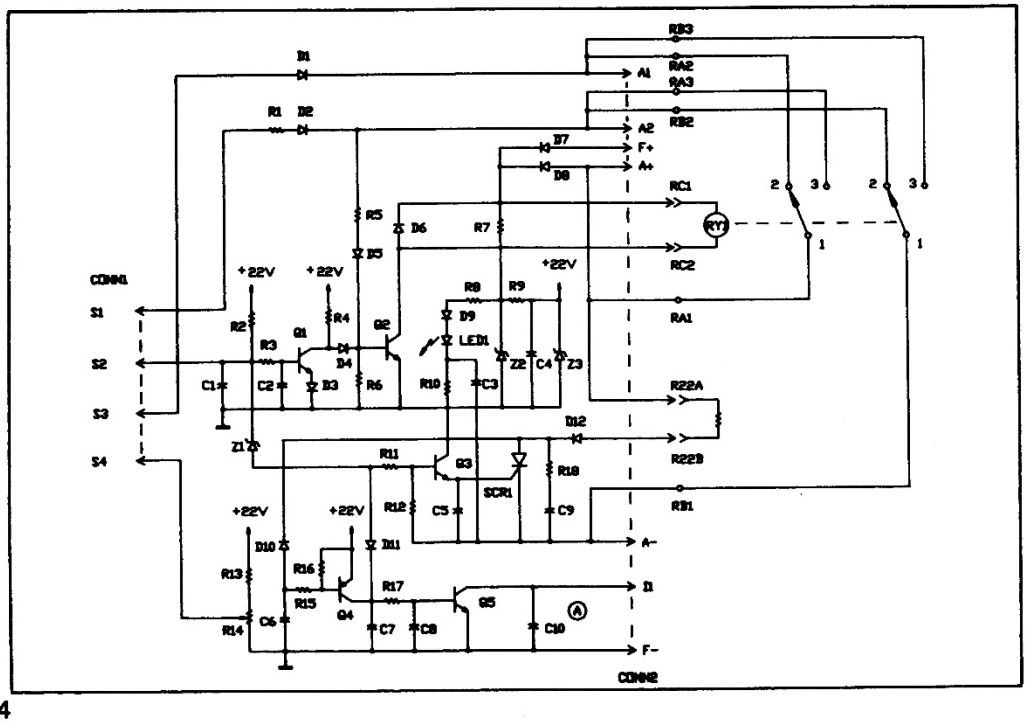


SECTION VI. (B) SPEED CONTROL MODULE SCHEMATIC*



* Patented.

SECTION IV. (C) APRM® SCHEMATIC—(patented)



SEC. VI. (D) 120V SPEED CONTROL MODULE PARTS LIST

CKT. REF.	VALUE/RATING	MFG. TYPE	FUNCTION
C1	0.01ufd-25V	Ceramic Tubular	Capacitor
C14-16,18	0.01ufd-25V	Ceramic Tubular	Capacitor
C2	1.5ufd-50V	Electrolytic	Capacitor
C3	0.47ufd-50V	Film/lytic	Capacitor
C4	0.33ufd-50V	Metal Film	Capacitor
C5	0.033ufd-50V	Metal Film	Capacitor
C6,8,10,12,24	0.022ufd-25V	Ceramic Tubular	Capacitor
C7	0.1ufd-50V	Metal Film	Capacitor
C9,11,13	0.01ufd-50V	Metal Film	Capacitor
C17	4.7ufd-35V	Electrolytic	Capacitor
C19	100-0ufd-35V	Electrolytic	Capacitor
C20	0.047ufd-50V	Metal Film	Capacitor
C21,23	.1ufd-250VDC	Metal Film	Capacitor
C22	0.022ufd-50V	Metal Film	Capacitor
D1-D10	1A-600V	1N4005GP	Diode
D11,12	1.5A-600V	1N5397GP	Diode
D13, D14	25A-600V	D6025L	Power Diode
D15	15A-600V	D6015L	Power Diode
IC1		LM358P	Dual Op-Amp
IC2		LM324	Quad Op-Amp
J1	22 AWG		Jumper
LED1	35MA-30mcd	MV5753	CL Indicator
MOV1	150V	V150LA10A	Transient Suppressor
Q1,3	0.6A-40V	2N4403	Small Signal Transistor
Q2	0.6A-40V	2N4401	Small Signal Transistor
Q4	0.8A-50V	S347S101E	Small Signal SCR
R1*	10K-0.33W-10%	PTC-10YV	Max Trimpot
R2	5K-5W-20%		Main Speed Pot
R3	25K-0.33W-10%	PTC-10YV	Min Trimpot
R4	33K-0.25W-5%	Carbon Film	Resistor
R5,16,18,27	47K-0.25W-5%	Carbon Film	Resistor
R28,30,31	47K-0.25W-5%	Carbon Film	Resistor
R6	24K-0.25W-5%	Carbon Film	Resistor
R7,12	3.3K-0.25W-5%	Carbon Film	Resistor
R8	500K-0.33W-10%	PTC-10YV	Accel Trimpot
R9	500K-0.33W-10%	PTC-10YV	Decel Trimpot
R10,41	1K-0.25W-5%	Carbon Film	Resistor

SEC. VI.(D) 120V SPEED CONTROL MODULE PARTS LIST

CKT. REF.	VALUE/RATING	MFG. TYPE	FUNCTION
R11	56K-0.25W-5%	Carbon Film	Resistor
R13,23,35	22K-0.25W-5%	Carbon Film	Resistor
R14,32	2.2M-0.25W-5%	Carbon Film	Resistor
R15	1M-0.25W-5%	Carbon Film	Resistor
R17	4.7K-3W-5%	MO-3	Resistor
R19A	62K-0.25W-5%	Carbon Film	Resistor
R19B	12K-0.25W-5%	Carbon Film	Resistor
R20	3.9K-0.25W-5%	Carbon Film	Resistor
R21*	0.006 ohm-1.0 ohm-5W-5%	Wire Wound	Plug-in-Horsepower Res.
R22,24,34	100K-0.25W-5%	Carbon Film	Resistor
R25	3.3K-0.25W-5%	Carbon Film	Resistor
R26	47 ohm-0.25W-5%	Carbon Film	Resistor
R29	25K-0.33W-10%	PTC-10YV	CL Trimpot
R33	10K-0.33W-10%	PTC-10YV	IR Trimpot
R36	1.0 ohm-0.25W-5%	Carbon Comp.	Resistor
R37	1.8K-0.25W-5%	Carbon Film	Resistor
R38	6.8K-0.25W-5%	Carbon Film	Resistor
R39	1K-0.25W-5%	Flameproof	Resistor
R40	4.7K-0.25W-5%	Carbon Film	Resistor
SCR1,2	25A-600V	S6025L	Power SCR
T1	1:1	KB Standard	Pulse Transformer
Z1	12V-1W-5%	1N4724A	Zener Diode
Z2	22V-1W-5%	IN4748A	Zener Diode
Z3	18V-1W-5%	1N4746A	Zener Diode
CHANGES FOR 240V SPEED CONTROL MODULE			
C21	.047ufd-400VDC	Metal Film	Capacitor
C23	.047ufd-250VAC/630VDC	Rita or Wima	Capacitor
J1	82K-0.25W-5%	Carbon Film	Resistor
MOV1	275V	V275LA20A	Transient Suppressor
R17	12K-7W-5%	CW-7	Resistor
R19A	62K-0.25W-5%	Carbon Film	Resistor

* Components whose value/rating may vary with application.

SEC. VII. APRM-2C–120V PARTS LIST

CKT. REF.	VALUE/RATING	MFG. TYPE	FUNCTION
C1, 11	0.01MF-50V-20%	Ceramic Disc	Capacitor
C2, 5, 6	0.01MF-50V-20%	Ceramic Axial	Capacitor
C3	10.0MF-100V-20%	Electrolytic	Capacitor
C4	15.0MF-35V-20%	Electrolytic	Capacitor
C8, 10	0.47MF-50V-20%	Electrolytic	Capacitor
C9	0.1MF-250V-20%	Mylar	Capacitor
D1-11	1A-600PIV	1N4005GP	Diode
D12	5A-500PIV	A15E	Diode
LED1	35mA-30mcd	MV5753	Brake Indicator
Q1, 5	600mADC-40VDC	2N4401	Bipolar Transistor
Q2, 3	300mADC-350VDC	MPSA45	Bipolar Transistor
Q4	600mADC-40VDC	2N4403	Bipolar Transistor
R1	1.5K-0.25W-5%	Carbon Film	Resistor
R2	5.6K-0.25W-5%	Carbon Film	Resistor
R3, 8	15K-0.25W-5%	Carbon Film	Resistor
R4, 11	10K-0.25W-5%	Carbon Film	Resistor
R5	15K-5W-5%	Wire Wound	Resistor
R6	39K-0.25W-5%	Carbon Film	Resistor
R7	3.3K-2W-5%	MO-2	Resistor
R9	4.7K-1W-5%	MO-1	Resistor
R10, 18	470 ohm-0.25W-5%	Flameproof	Resistor
R12, 15, 19	22K-0.25W-5%	Carbon Film	Resistor
R13, 16	.7K-0.25W-5%	Carbon Film	Resistor
R14	10K-0.33W-20%	Piher-PTC10YV	Jog Trimpot
R17	33K-0.25W-5%	Carbon Film	Resistor
R22	10 ohm-30W	Wire Wound	Brake Resistor
RY1	20A-110VDC	PBS87R11D2B1D1	DPDT Relay
SCR1	15A-600V	S6015L	Power SCR
Z1	7.5V-0.5W-5%	1N5236B	Zener Diode
Z2	75V-1W-5%	1N4761A	Zener Diode
Z3	22V-1W-5%	1N4748A	Zener Diode
CHANGES REQUIRED FOR APRM-2C—240V			
R7	10K-3W-5%	MO3	Resistor
RY1	20A-220VDC	PBS87R11D2B1D1	DPDT Relay
R22	20 ohm-60W	Wire Wound	Brake Resistor

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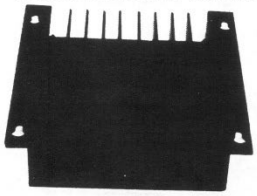
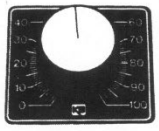
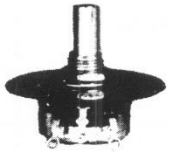
ACCESSORY ITEMS FOR KBPB AVAILABLE FROM YOUR DISTRIBUTOR



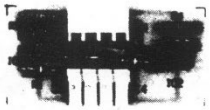
Auxiliary Heatsink Part No. 9861



Knob/Dial Kit Part No. 9832



Potentiometer Kit Part No. 9831



SI-3 Isolator for S_1, S_2, S_3 Part No. 9447

LIMITED WARRANTY

For a period of 18 months from date of original purchase KB will repair or replace without charge devices which our examination proves to be defective in material or workmanship. This warranty is valid if the unit has not been tampered with by unauthorized persons, misused, abused, or improperly installed and has been used in accordance with the instructions and/or ratings supplied. The aforegoing is in lieu of any other warranty or guarantee expressed or implied, and we are not responsible for any expense (including installation and removal), inconvenience, or consequential damage, including injury to any person, caused by items of our manufacture or sale. Some states do not allow certain exclusions or limitations found in this warranty so that they may not apply to you. In any event, KB's total liability, under all circumstances, shall not exceed the full purchase price of this unit. (Rev. 10/84)

The information contained in this brochure is intended to be accurate. However, the manufacturer retains the right to make changes in design which may not be included herein.

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Revision History

Draft, Nov 21, 2022 ** Draft

Draft, Jan 25, 2023 ** Draft, addition to section 4.3 and corrections to Fig 6 and Fig 7.

Sec 4.3 – add p/n for Horsepower Set Resistor
Figure 6 – add description of Horsepower Set Resistor
Figure 7 – correct text, the large power resistor is the Brake Resistor, not the Horsepower Set Resistor