715B CONTROL SERIES

DART CONTROLS

Instruction Manual

Line Voltage DC Brushless Motor Control

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WARNING

IMPROPER INSTALLATION OR OPERATION OF THIS CONTROL MAY CAUSE INJURY TO PERSONNEL OR CONTROL FAILURE. THE CONTROL MUST BE INSTALLED AND GROUNDED IN ACCORDANCE WITH LOCAL, STATE, AND NATIONAL SAFETY CODES.

WARRANTY

Dart Controls, Inc. (DCI) warrants its products to be free from defects in material or workmanship. The exclusive remedy for this warranty is DCI factory replacement of any part or parts of such product which shall within 12 months after delivery to the purchaser be returned to DCI factory with all transportation charges prepaid and which DCI determines to its satisfaction to be defective. This warranty shall not extend to defects in assembly by other than DCI or to any article which has been repaired or altered by other than DCI or to any article which DCI determines has been subjected to improper use. DCI assumes no responsibility for the design characteristics of any unit or its operation in any circuit or assembly. This warranty is in lieu of all other warranties, express or implied; all other liabilities or obligations on the part of DCI, including consequential damages, are hereby expressly excluded.

CAREFULLY CHECK THE CONTROL FOR SHIPPING DAMAGE. REPORT ANY DAMAGE TO THE CARRIER IMMEDIATELY. **DO NOT ATTEMPT TO OPERATE THE DRIVE IF VISIBLE DAMAGE IS EVIDENT TO EITHER THE CIRCUIT OR TO THE ELECTRONIC COMPONENTS.**

ALL INFORMATION CONTAINED IN THIS MANUAL IS INTENDED TO BE CORRECT, HOWEVER INFORMATION AND DATA IN THIS MANUAL ARE SUBJECT TO CHANGE WITHOUT NOTICE. DCI MAKES NO WARRANTY OF ANY KIND WITH REGARD TO THIS INFORMATION OR DATA. FURTHER, DCI IS NOT RESPONSIBLE FOR ANY OMISSIONS OR ERRORS OR CONSEQUENTIAL DAMAGE CAUSED BY THE USER OF THE PRODUCT. DCI RESERVES THE RIGHT TO MAKE MANUFACTURING CHANGES WHICH MAY NOT BE INCLUDED IN THIS MANUAL.

WARNING

MAKE CERTAIN THAT THE POWER SUPPLY IS DISCONNECTED BEFORE ATTEMPTING TO SERVICE OR REMOVE ANY COMPONENTS !!! IF THE POWER DISCONNECT POINT IS OUT OF SIGHT, LOCK IT IN DISCONNECTED POSITION AND TAG TO PREVENT UNEXPECTED APPLICATION OF POWER.

ONLY A QUALIFIED ELECTRICIAN OR SERVICEMAN SHOULD PERFORM ANY ELECTRICAL TROUBLESHOOTING OR MAINTENANCE.

AT NO TIME SHOULD CIRCUIT CONTINUITY BE CHECKED BY SHORTING TERMINALS WITH A SCREWDRIVER OR OTHER METAL DEVICE.

INTRODUCTION

Dart Controls' 715BDC series is a family of general purpose brushless motor controls. These controls commutate power into standard 3-phase brushless (BLDC) motors.

The series uses input line voltage of 120 VAC ± 10%. These controls will supply up to 7 amperes of continuous current to the motor. They come in both open and closed loop versions, and can drive motors with sensor spacings of 60 and 120 degrees.

The 715BDC is composed of two PC boards—an upper and a lower, connected by ribbon cable. A 10-position terminal strip on the upper board connects the control to the motor sensors, the speedpot, and the forward/reverse control switch (optional). The control's upper board also carries the trimpots for minimum speed, maximum speed, and current limit, as well as a means for selecting the sensor spacing. In addition, the closed loop version (716BDC) has an extra trimpot for adjusting to motors of different speeds. The line voltage input and the three motor armature wires attach to a 5-position connector on the lower board.

STANDARD FEATURES

OPEN LOOP or INTEGRATED CLOSED LOOP MODELS

QUIET 15KHz PWM SWITCHING FREQUENCY

MOSFET POWER DEVICES

FORWARD/REVERSE DIRECTION CONTROL

5Ký SPEEDPOT with LEADS, KNOB and DIAL for REMOTE MOUNTING

INTERNAL +6.25 VOLT DC SUPPLY for MOTOR HALL-EFFECT SENSORS

ANODIZED CHASSIS MOUNT HEATSINK

UNPACKING

Unpack the control and check for shipping damage. Locate the motor and its timing diagram. In addition, you will need the 5Ký speedpot supplied with the control, a 120 VAC power source, hook-up wires, and appropriate tools for installation. If you have a motor without a timing diagram, you will also need a 10 ampere ammeter and a small hand-held dc volt-ohmmeter.

FUSING

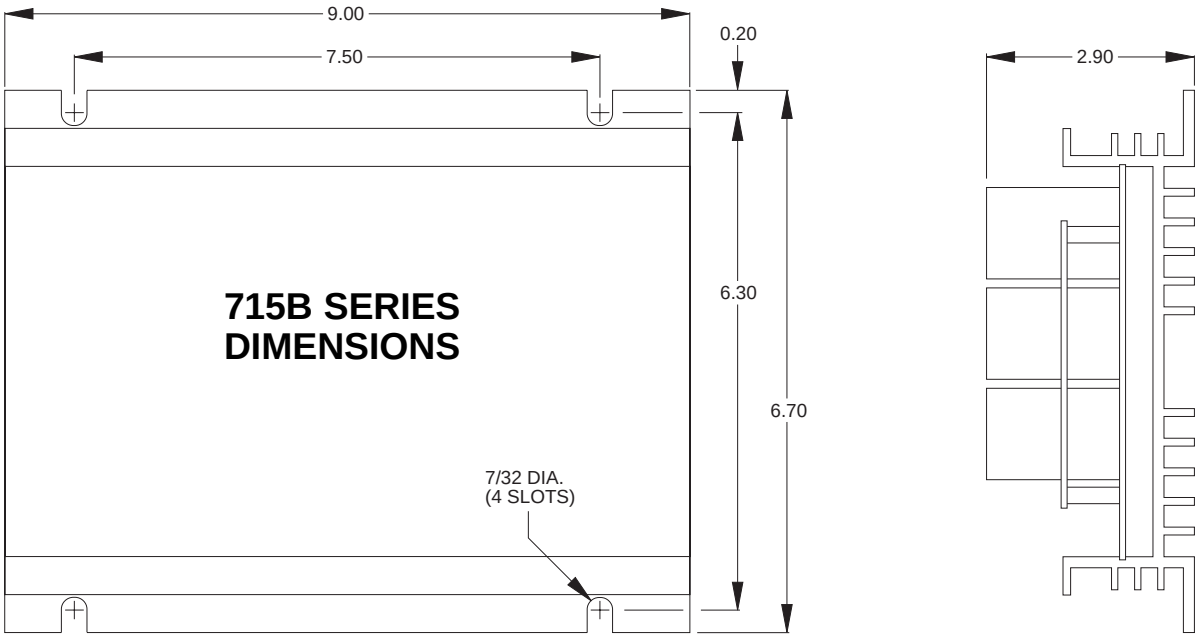
Fusing is accomplished by inserting a 12 amp fuse in one of the incoming AC lines. If using a one horsepower motor, a 15 amp fuse may be necessary.

MOUNTING INSTRUCTIONS & DIMENSIONS

1. Four 7/32" wide slots are provided for control mounting (see dimensional diagram on next page)
2. Control chassis can be used as a template.
3. Caution: Do not mount where ambient temperature is outside range of 0°C - 45°C (32°F - 113°F)

(continued)

(mounting dimensions continued)



TOP VIEW *END VIEW*

HOOK-UP OVERVIEW

Brushless DC motors have eight (8) wires: three (3) armature wires, three (3) motor sensor wires, and two (2) wires for sensor power and sensor common. BLDC motors come with one of two sensor configurations, 60 or 120 degrees.

Many BLDC motor manufacturers are familiar with the 715BDC series, and supply specific hook-up information for the Dart control. Other manufacturers only supply timing diagrams, leaving it up to the installer to generate a hook-up procedure. Finally, some manufacturers may supply motors with no accompanying information. The last two situations will be addressed later.

All BLDC motors, no matter what the hook-up status, are connected to the 715BDC control as shown in Figure 1 (page 5).

Power is connected to terminals P1-4 and P1-5 on the lower board. The power should be off until the hook-up procedure is complete.

60°/120° Sensor Spacing

There is a jumper on the **upper board** to switch between 60° and 120° hall sensor spacings. This jumper is shown in the upper portion of Figure 1 (page 5). Place this jumper in the left-most (dashed) position for 60° operation, or in the right-most (solid) position for 120° operation.

Speedpot

The 5Ký speedpot is connected to terminals P4-8, P4-9, and P4-10. If you don't have the furnished speedpot with orange, red, and white wires attached to it, any 5Ký pot may be used. Simply rotate the shaft of the speedpot fully CCW (counterclockwise), and measure the resistance between the wiper and each terminal. The terminal that measures about 5Ký is referred to as pot "HI", and the terminal that measures about 0ý is referred to as pot "LO". Connect pot "HI" to terminal P4-8, pot "LO" to terminal P4-10, and the wiper to P4-9.

NOTE: ***Until the motor is known to be correctly wired to the control, it is important that the speedpot is set fully CCW upon application of power***.

WIRING DIAGRAM

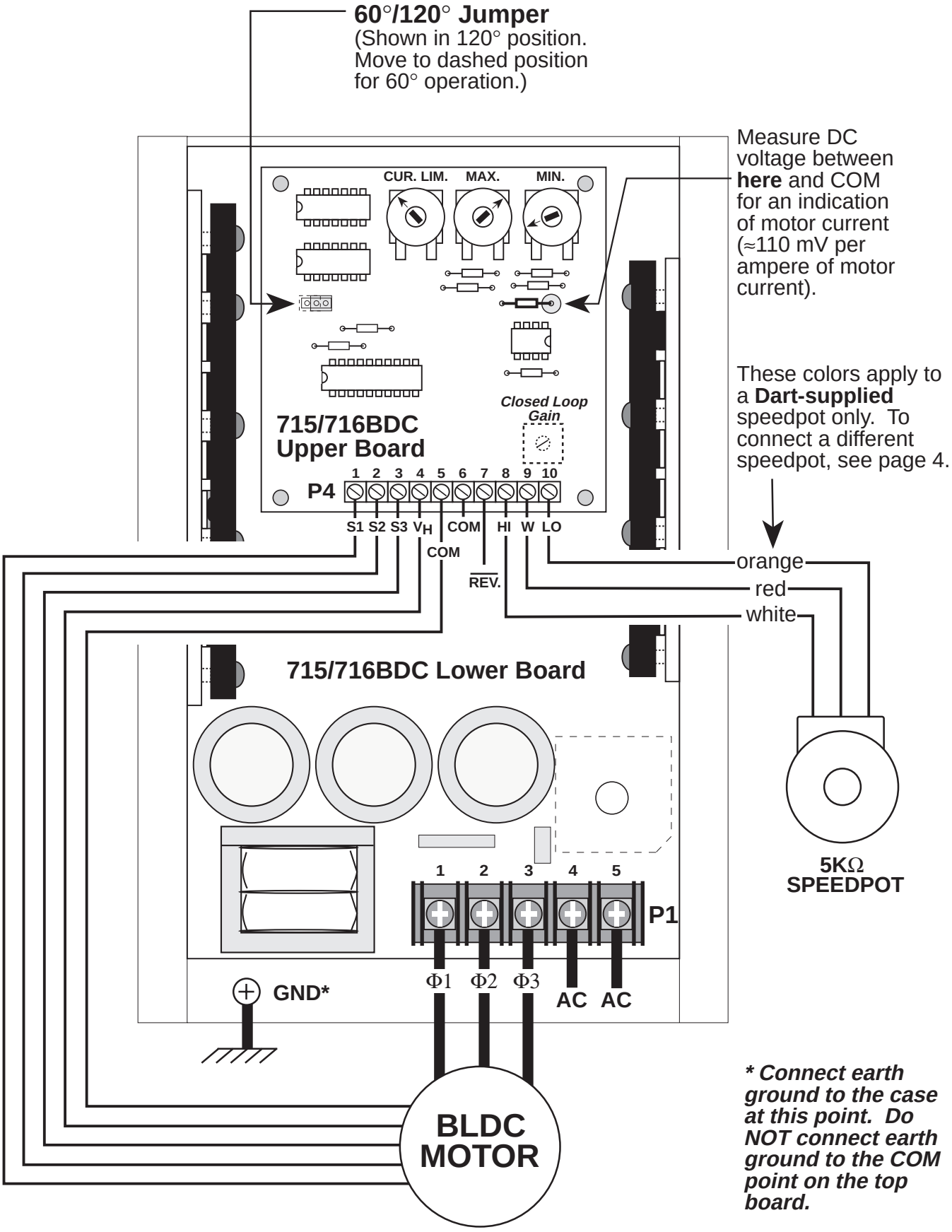


Figure 1

HOOK-UP PROCEDURE FOR MOTORS WITH TIMING DIAGRAMS

We think it's prudent that when first testing your motor an AC ammeter be placed in series with the AC source. Zero to ten amperes is fine (an analog movement is preferable).

Most manufacturers of BLDC motors send timing diagrams with their product. These diagrams show the sequencing of the Hall sensor outputs as related to the three motor phases. The Hall sensor sequencing is very useful, but since everyone has a slightly different way of notating the same information, deciphering the motor phases is typically quite confusing. Our procedure is to hook up the sensors according to their diagrams, then test for the proper motor phases. The current limit circuitry will protect the control from miswired phases.

First determine the spacing of the motor Hall sensors. They will either be 60 or 120 degrees. Usually the motor manufacturer will tell you the spacing. If they don't, compare the sensor diagram sent with the motor with those in Figure 2 or 3 at the end of this manual. Observe that a 60 degree spacing will at some position have all sensor lines at a logic high. With 120 degree spacing, all three sensors are never at the same logic level at the same time.

Once the spacing is determined, return to the section "60°/120° Sensor Spacing" (page 4) and make sure the control is set correctly. Return to Figure 1 and connect the sensors to terminals P4-1 through P4-3. Notice that for the 60 degree spacing there is a specific sensor line that leads the sequence, followed by a line lagging by 60 degrees, and a third line lagging the second by 60 degrees. It is important that the middle line in the train be connected to terminal P4-2.

After the sensors are connected, attach the sensor power line (notated by V_H in Figure 1) to terminal P4-4. The sensor common line (notated by COM in Figure 1) is connected to terminal P4-5. Now attach the three motor armature wires and test for proper hook-up.

We recommend arbitrarily attaching the phase lines to terminals P1-1, P1-2, and P1-3. Choose a configuration, test it, then keep track on paper of what you did.

Now apply power to the control. Slowly turn the speedpot CW. Watch for erratic rotation or excessive source current. If either occurs, immediately return the speedpot fully CCW, and turn off the power. Try a new phase line configuration, apply power and test again. There are six (6) different combinations for connecting the three phase lines to the control. One of them will work. The correct combination will allow smooth rotation of the motor, and the lowest current draw from the AC source.

HOOK-UP PROCEDURE FOR MOTORS WITHOUT TIMING DIAGRAMS

If you have a BLDC motor with no timing diagram, it is possible, with a little patience, to sort out the various leads and operate it with the 715BDC control. Find a voltmeter that will read a 6.25 volt logic level.

First sort out the three motor armature wires from the sensor wires. Armature wires are usually a heavier gauge wire. Once you find the armature wires, check them by measuring the resistance between any two. The resistance should be low, under 100 ohms, and be the same across any two of the three wires. The remaining five wires are the three sensors, sensor power, and sensor common. To find the power and common, look for color and gauge differences. If all else fails, call the motor manufacturer. Once the sensor power leads have been located, the remaining three leads will be the Hall sensors.

Now construct a timing diagram using the sensor lines. First, connect the motor to the control, but leave off the three motor armature wires. Don't worry about sensor spacing at this time. Next connect your voltmeter to any sensor lead. Reference the meter to terminal P4-6. Apply power and slowly rotate the motor shaft by hand. You should see the meter move from 0 to 6.25 volts as the Hall sensor switches. Check the other two sensors for switching.

Next compare each sensor against the others and draw a timing diagram. You can now hook up the motor with this new information using the procedure for motors with timing diagrams.

ADJUSTING CURRENT LIMIT

Dart has factory set the Current Limit to 10 amps. You should not have to increase this setting. If you wish to set the current limit to a lower value, do so by adjusting the Current Limit trimpot CCW until the desired setting is achieved.

Determining Motor Current

There are several ways to determine motor current, the most convenient of which is listed below.

Refer to figure 1 of this manual. Measure the DC voltage from Common (P4-6) to the point indicated on the R29 resistor located on the upper board. Divide that voltage by 110 mV to obtain the actual motor current in amperes.

Example: If you measure 770 mVdc, then the motor current is: 770 ÷ 110 = 7 amperes.

This method of determining motor current will always work, regardless of motor speed, speedpot position, current limit setting, etc.

Setting Current Limit

Current Limit should normally be set to approximately 125% of the FLA rating of the motor you are running. To set current limit for you specific motor or application, follow these steps while monitoring motor current: 1) preset Current Limit trimpot fully CW, 2) run motor at full or normal running speed, 3) load motor to 125% of its FLA rating or the desired maximum load, 4) decrease the Current Limit trimpot setting until the motor current begins to drop, then slowly increase the setting until just reaching the desired maximum current as obtained in step 3.

Note: Do not use the Current Limit trimpot as a torque control or to reduce the speed of a motor.

CAUTION:

Keep the average continuous DC current draw under 7 amperes, and make sure the motor is rotating. A stalled brushless DC motor can quickly overheat the control and/or the motor resulting in damage to either or both devices.

ADJUSTING MINIMUM SPEED

Turn the speedpot to zero (fully CCW). Next turn the minimum speed trimpot CW until the motor begins to rotate. Slowly rotate the trimpot CCW until the motor stops. The control will now run with a near-zero deadband. If a non-zero minimum speed is desired, rotate the minimum speed trimpot CW to the desired setting.

ADJUSTING MAXIMUM SPEED

Turn the speedpot fully CW and adjust the Maximum adjust trimpot to the desired maximum output. If you have a 716BDC (closed loop version), see the section titled "Closed Loop" on page 8.

HEATSINK COOLING

We recommend keeping the heatsink temperature below 75°C (167°F). The control, as shipped from the factory, will normally handle 7 amperes of continuous current. If the ambient temperature increases above 25°C (77°F), you may need to add more heatsink or decrease the current to keep the sink temperature from exceeding 75°C. No matter what the heatsink temperature is, never exceed 7 amperes of continuous motor current.

ADJUSTING CLOSED LOOP GAIN

Controls designated 716BDC are closed loop devices. These controls use additional circuits to transform the sensor signals into tachometer information, and accurately control the speed of the motor. Hook-up procedures are identical to the open loop series, however, there is an extra trimpot labeled **Closed Loop Gain** (Shown in Figure 1 on page 5)**.** This allows the flexibility to properly control motors in a wide spectrum of speeds.

To adjust the control to your motor:

1) Set the Maximum Speed (MAX.) trimpot to the position shown in Figure 1 on page 5.
2) Set the Minimum Speed (MIN.) and Closed Loop Gain trimpots to their fully counterclockwise (CCW) positions.
3) Advance your speedpot to the fully clockwise (CW) position. Your motor should now be spinning at its maximum speed.*
4) Slowly rotate the Closed Loop Gain trimpot clockwise until the motor speed decreases slightly**, then rotate the trimpot back counterclockwise just enough to return the motor to full speed.

* If your motor doesn't reach its maximum speed with the speedpot fully clockwise, rotate the MAX. trimpot clockwise until it does. Proceed with step 4.

** If you rotate the Closed Loop Gain trimpot fully clockwise and the motor speed doesn't decrease, rotate the MAX. trimpot counterclockwise just enough to make the speed decrease slightly. Then rotate the Closed Loop Gain trimpot counterclockwise just enough to return the motor to full speed.

REVERSING

Terminal P4-7 on the 715BDC is the forward/reverse control. You can reverse motor direction by connecting P4-7 to P4-6. Use a jumper wire, switch, relay, or an open collector NPN transistor. ***Before reversing directions, make sure the motor is stopped. The control isn't designed for plug reversing.***

Sometimes it may be necessary to reverse motor direction without using terminal P4-7. This is done by stopping the motor and exchanging terminals P1-1 with P1-2 on the lower board, and terminals P4-1 with P4-3 on the upper board. This will work with either a 60 or 120 degree motor.

If your motor draws an excessive amount of current in reverse, you may have a motor designed for only one direction. Consult with the motor manufacturer about this problem.

SPECIFICATIONS

INPUT VOLTAGE ..... 120 VAC±10%
OUTPUT VOLTAGE (FILTERED OUTPUT)..... 0 to 140 VDC
LOAD CURRENT (CONTINUOUS) ..... 7 AMPERES
OVERLOAD CURRENT .....150% FOR 30 SECONDS
SPEED RANGE 50:1
MAXIMUM SPEED TRIMPOT ..... 70 TO 100% OF INPUT VOLTAGE
MINIMUM SPEED TRIMPOT ..... ADJUSTABLE 0-30% OF MAX.
CURRENT LIMIT TRIMPOT ..... ADJUSTABLE
ACCELERATION..... FIXED, FAST START
MOTOR HALL SPACING (ELECTRICAL) ..... FIELD SELECTABLE 60° OR 120°
OPEN LOOP SPEED REGULATION ..... MOTOR DEPENDENT
CLOSED LOOP SPEED REGULATION ..... ± 1/2% OF BASE SPEED
INPUT / OUTPUT CONNECTION..... 10-POSITION TERMINAL BLOCK (upper board)
.....5-POSITION TERMINAL BLOCK (lower board)
SPEED CONTROL ..... 5Ký POTENTIOMETER OR 0-6.2 VDC ISOLATED SIGNAL
OPERATING TEMPERATURE..... 0°C – 45°C (32°F – 113°F)

DIMENSIONS

WIDTH ..... 6.75 in.
LENGTH ..... 9.00 in.
DEPTH ..... 2.90 in.
WEIGHT ..... 41 oz.

TIMING DIAGRAMS

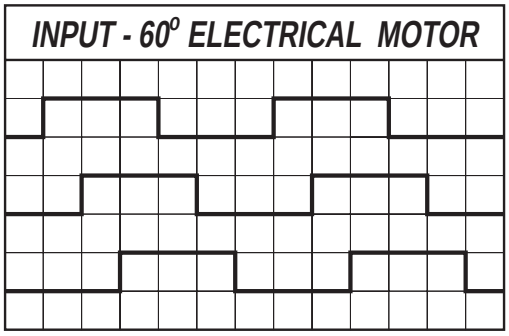


Figure 2

Notes on 60° Hall signals:

ÑAll three Hall signals are at the same logic level one-third of the time.

ÑThe middle Hall signal (S2) must be attached to P4-2. The other two may be attached in either order, and there will be a configuration of armature leads to make it work.

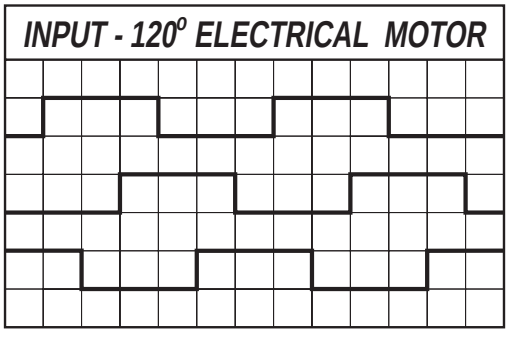


Figure 3

Notes on 120° Hall signals:

ÑThe three Hall signals are never all at the same logic level at the same time.

ÑThey may be attached to the control in any order, and there will be a configuration of armature leads to make it work.