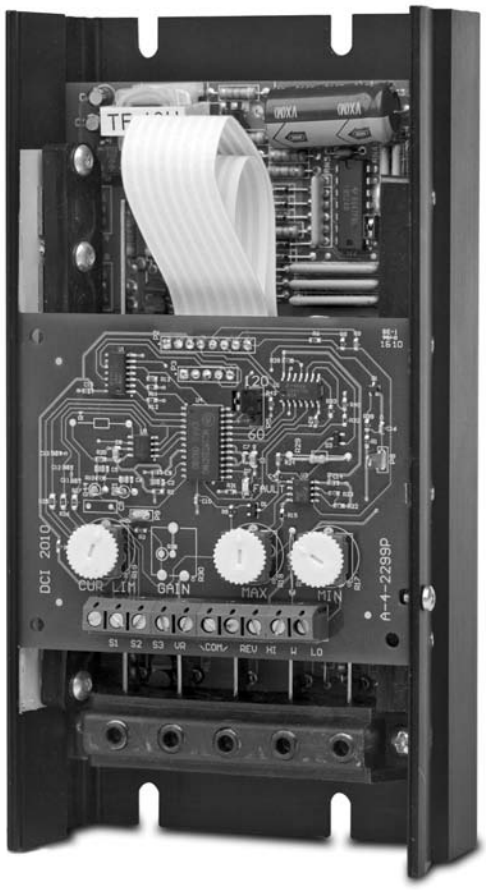
710A CONTROL SERIES

DART CONTROLS

Instruction Manual

Low Voltage DC Brushless Control



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WARRANTY

Dart Controls, Inc. (DCI) warrants its products to be free from defects in material and 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.

NOTE: 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

Improper installation or operation of this control may cause injury to personnel or control failure. The control must be installed in accordance with local, state, and national safety codes. 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 service personnel 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' 710A Series is a family of general purpose brushless motor controls. These controls commutate power into standard 3-phase brushless (BLDC) motors.

The series uses DC power sources from 10 to 54 volts. A 710A Series control will supply up to 20 amps of continuous current to the motor. They come in both open loop (model 710ADC) and closed loop (model 711ADC) versions, and can drive motors with sensor spacings of 60 and 120 degrees.

The 710A Series is composed of two PC boards—an upper and a lower, connected by two small ribbon cables. 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. The DC power source and the three motor armature wires attach to a 5-position connector on the lower board.

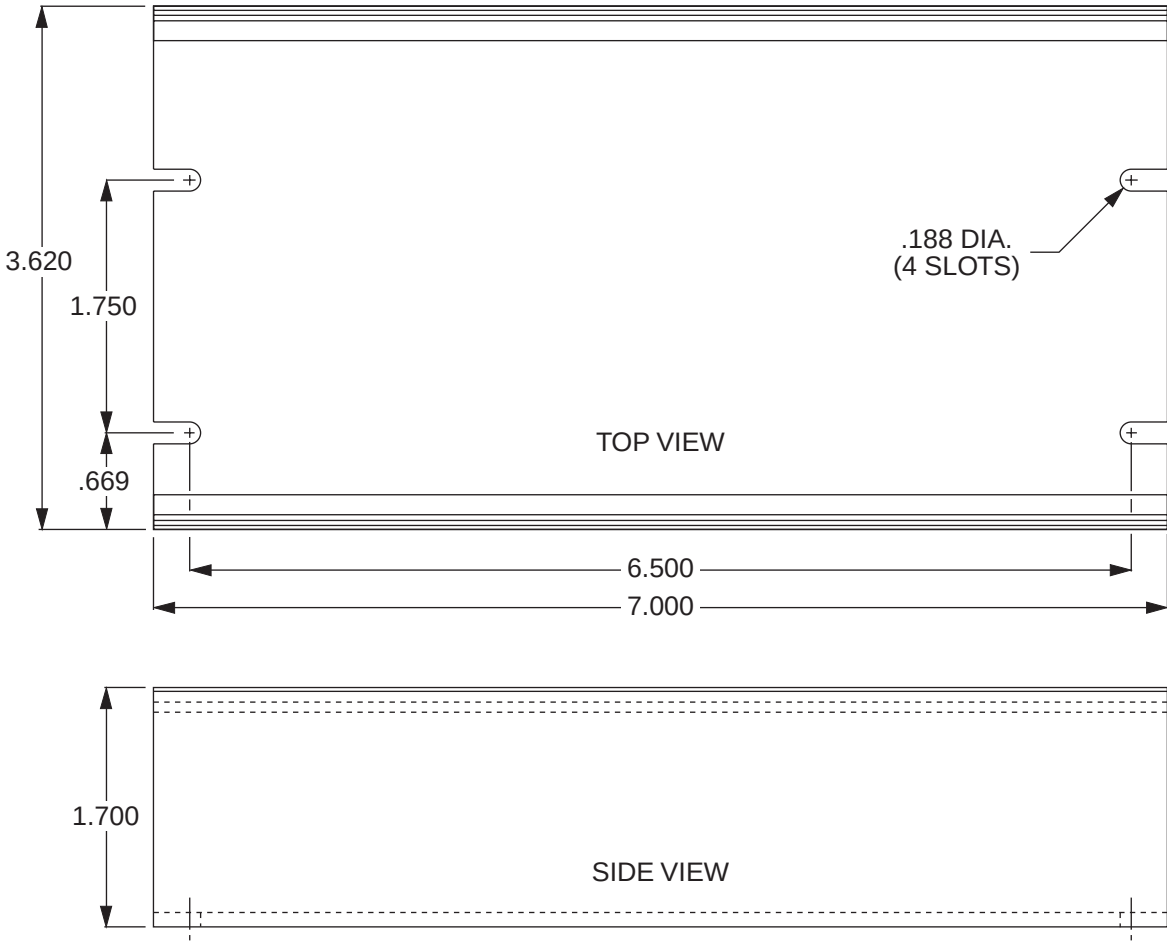
UNPACKING

Unpack the control and check for shipping damage. Locate the motor and its timing diagram. In addition, you will need the 5K Ohm speedpot supplied with the control, a DC 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. If you plan to readjust the current limit you will need an oscilloscope.

STANDARD FEATURES

- ***ALL SOLID-STATE DESIGN***
- ***QUIET 15KHz PWM SWITCHING FREQUENCY***
- ***MOSFET POWER DEVICES***
- ***FORWARD / REVERSE DIRECTION CONTROL***
- ***5K* Ohm *SPEED POTENTIOMETER WITH LEADS, KNOB AND DIAL INCLUDED***
- ***INTERNAL 6.25 VOLT DC SUPPLY FOR MOTOR HALL EFFECT SENSORS***
- ***ANODIZED CHASSIS MOUNT HEATSINK***

HEATSINK MOUNTING DIMENSIONS



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 710A 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 710A Series control as shown in figure 1 (page 4). Power is connected to terminals P1-1 and P1-5 on the lower board. The power should be off until the hook-up procedure is complete.

12/24-48 Volt Operation

There is a jumper on the **lower board** to accomodate two ranges of dc source voltage. This jumper is shown near the bottom of Figure 1 (page 4). If you have a 12 volt DC source, the jumper must be placed in the left-most (dashed) position, as illustrated in Figure 1. With DC sources from 24 to 48 volts, the jumper must be placed in the right-most (solid) position, which is also illustrated in Figure 1.

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710A SERIES HOOK-UP DIAGRAM

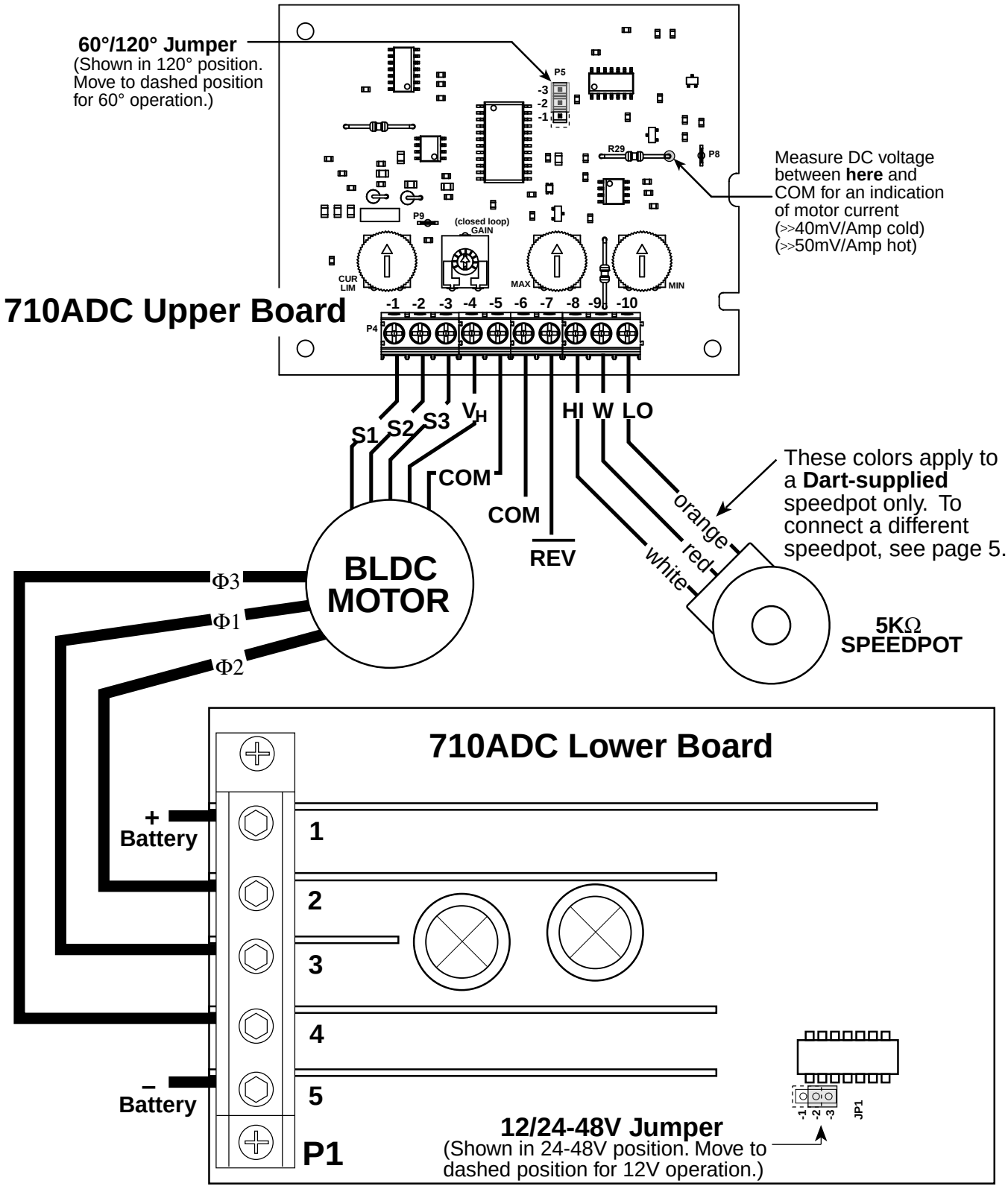

Figure 1

(continued)

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 left portion of Figure 1 (page 4). Place this jumper in the left-most (dashed) position for 60° operation, or in the right-most (solid) position for 120° operation.

Speedpot and Signal Input

The 5Kohm 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 5Kohm 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 5Kohm is referred to as pot "HI", and the terminal that measures about 0 ohm 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: IT IS IMPORTANT THAT WHEN POWER IS FIRST APPLIED TO THE SYSTEM, THE SPEEDPOT IS SET TO FULL CCW.

HOOK-UP PROCEDURE FOR MOTORS WITH TIMING DIAGRAMS

We think it's prudent that when first testing your motor a DC ammeter be placed in the DC power line. Zero to ten amps 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 5 above) 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 P1-2, P1-3, and P1-4. 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 current over 2 amps. If any of these conditions occur, 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)

(continued)

(continued)

different combinations for hooking the three phase lines to the control. One of them will work. Rotation will be smooth and the DC current will be less than 2 amps. You have now found the correct hook-up for your motor.

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 710A Series 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, a few 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 20 amps. You should not have to change this setting. You can set the current limit to a lower value by turning the Current Limit trimpot CCW.

Determining Motor Current

There are several ways to determine motor current. Two convenient methods are listed below.

1) Refer to figure 1 on page 4. Measure the DC voltage (with reference towards COM) at the point indicated on the upper board, then divide by 40mV to obtain the motor current in amperes.

   Example: If you measure 0.35V, the motor current is 0.35/0.040=8.75 amperes.

   This method will always work, regardless of motor speed, speedpot position, current limit, etc. The next method will work only within strict constraints, but within those constraints, it may be more easily done than method 1.

2) Monitor current by placing an ammeter in series with the DC source.
   NOTE: The current measured with the ammeter in series with the DC source will be equal to the motor current *only when the speedpot is at or near the fully clockwise (CW) position, the max. speed trimpot is fully clockwise (CW), and the control is* not *in current limit.* Otherwise, the DC source current will be *less* than actual motor current.
   Don't let the current exceed 20 amperes. Limit the average current with prudent use of torque and speed settings, *not* with the Current Limit trimpot.

CAUTION: KEEP THE AVERAGE CURRENT UNDER 20 AMPS, AND MAKE SURE THE MOTOR IS ROTATING. A STALLED MOTOR WILL QUICKLY OVERHEAT.

(continued)

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 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

HEATSINK COOLING

We recommend keeping the heatsink temperature below 75°C (167°F). The control, as shipped from the factory, will normally handle 20 amps continuous current. If the ambient temperature increases above 25°C (77°F), you must add more heatsink or decrease the current to keep the sink temperature from exceeding 75°C. Finally, no matter what the heatsink temperature, never exceed 20 amps of motor current.

ADJUSTING CLOSED LOOP GAIN

Controls designated 711ADC 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 4)**.** 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 4.
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 710A Series 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. WHEN YOU REVERSE 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 P1-3 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° 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.

INTERNAL FAULT LED

The internal fault LED (Red) indicates that there is a fault condition present with the control. One or several of the following fault conditions can be present: invalid sensor input code, $60^{o}/120^{o}$ phasing jumper in wrong position, undervoltage lockout (i.e. +12V supply is less than 10.0V) or thermal shutdown (i.e. U4 is too hot). Typical fault conditions are: invalid sensor attachment or $60^{o}/120^{o}$ phasing jumper is in the wrong position.

SPECIFICATIONS

INPUT VOLTAGE ..... (jumper selectable) 10-13.5 VDC *or* 18-54 VDC
LOAD CURRENT (CONTINUOUS) ..... 20 AMPS
OVERLOAD CURRENT ..... 200% FOR 30 SECONDS
SPEED RANGE ..... CLOSED LOOP = 50 : 1 / OPEN LOOP = 20:1
MINIMUM SPEED ..... ADJUSTABLE 0-30% OF MAX.
CURRENT LIMIT ..... ADJUSTABLE 0-200%
MOTOR HALL SPACING (ELECTRICAL) ..... (jumper selectable) 60° *or* 120°
OPEN LOOP SPEED REGULATION ..... MOTOR DEPENDENT
INPUT / OUTPUT CONNECTION .....10-POSITION TERMINAL BLOCK (upper board)
5-POSITION TERMINAL BLOCK (lower board)
SPEED CONTROL ..... 5K Ohm SPEED POTENTIOMETER *or*
0 TO +6.25V SIGNAL (GROUNDED OR UNGROUNDED SIGNAL)
OPERATING TEMPERATURE ..... 0°C - 45°C (32°F - 113°F)
CLOSED LOOP SPEED REGULATION ..... ± 1/2% OF BASE SPEED
MAXIMUM SPEED ..... 60 TO 100% OF INPUT VOLTAGE
TOTAL CONTROL HEIGHT ..... 2.00 INCHES
TOTAL CONTROL LENGTH ..... 7.00 INCHES
TOTAL CONTROL WIDTH ..... 3.62 INCHES
TOTAL CONTROL WEIGHT ..... 16 OUNCES

TIMING DIAGRAM FOR 60° MOTORS

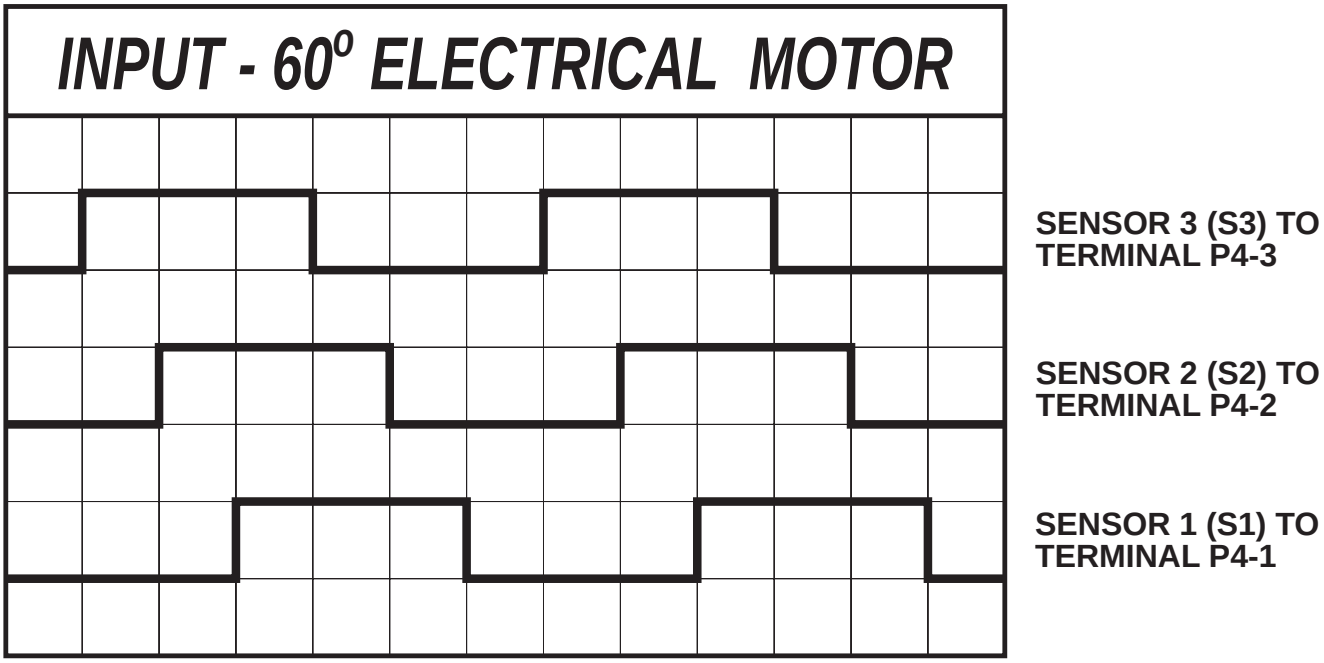

figure 2

NOTES ON 60° HALL SIGNALS:

- All three Hall signals are at the same logic level one-third of the time.
- The middle Hall signal (S2) must be attached to 4-2. The other two must be attached in either order, and there will be a configuration of armature leads to make it work.

TIMING DIAGRAM FOR 120° MOTORS

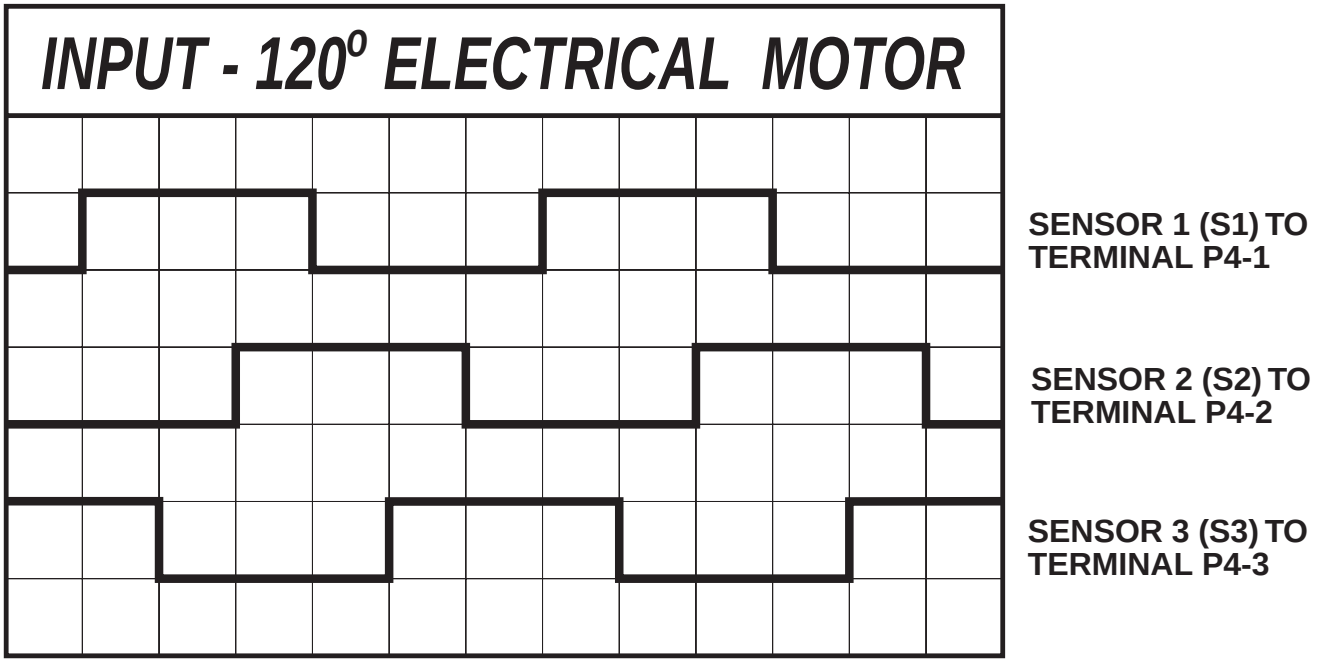

figure 3

NOTES ON 120° HALL SIGNALS:

- All three Hall signals are never all at the same logic level at the same time.
- They may be attached to the control in any order, and there will be a configuration of armature leads to make it work.

REPAIR PROCEDURE

In the event that a Product manufactured by Dart Controls Incorporated (DCI) is in need of repair service, it should be shipped, freight paid, to: Dart Controls, Inc., 5000 W. 106th Street, Zionsville, IN. 46077, ATTN: Repair Department. Please include Name, Shipping Address (no P.O. Box), Phone Number and if possible, e-mail address.

Those orders received from anyone without an existing account with DCI must specify if they will be paying COD or Credit Card (Master Card/Visa/American Express). This information is required before work will begin. If you have an account with Dart your order will be processed according to the terms listed on your account. Products with Serial Number date codes over 5 years old will automatically be deemed Beyond Economical Repair (BER). A new, equivalent device will be offered at a substantial discount.

Completed repairs are returned with a Repair Report that states the problem with the control and the possible cause. Repair orders are returned via UPS Ground unless other arrangements are made. If you have further questions regarding repair procedures, contact Dart Controls, Inc. at 317-873-5211.

YOUR MOTOR SPEED CONTROL SOLUTIONS PROVIDER

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1/50 HP through 1.0 HP

250G SERIES
AC INPUT - VARIABLE DC OUTPUT
1/50 HP through 2.0 HP

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CURRENT RATINGS OF 20, 40, AND 60 AMPS

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DC BRUSHLESS
5 & 20 Amp for
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MDP SERIES
PROGRAMMABLE
CLOSED LOOP DC
SPEED CONTROL

DM SERIES
FIELD PROGRAMMABLE
DIGITAL TACHOMETER

Dart Controls, Inc. is a designer, manufacturer, and marketer of analog and digital electronic variable speed drives, controls, and accessories for AC, DC, and DC brushless motor applications.

Shown above is just a sampling of the expanded line of Dart controls that feature the latest in electronic technology and engineering. Products are manufactured in the U.S.A. at our Zionsville (Indianapolis, Indiana) production and headquarters facility - with over 2,000,000 variable speed units in the field.

In addition to the standard off-the-shelf products, you can select from a wide variety of options to customize controls for your specific application. For further information and application assistance, contact your local Dart sales representative, stocking distributor, or Dart Controls, Inc.

Dart Controls, Inc.

Manufacturer of high quality DC and AC motor speed controls and accessories since 1963.

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