720 CONTROL SERIES

DART CONTROLS

Instruction Manual

Line Voltage Brushless DC Control

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LT83 (0810)

A-5-3533B

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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' 720 Series is a comprehensive offering of line voltage source power brushless DC (BLDC) variable speed motor controls. The 720 Series commutate power into standard 3-phase brushless DC motors.

The 720 Series use single phase 120 VAC for source power, providing up to 3.1 amperes of continuous current to the motor. They come in both open and closed loop versions for BLDC motors with sensor spacings of 60 and 120 degrees.

STANDARD FEATURES

- LINE VOLTAGE SOURCE POWER
- OPEN LOOP or INTEGRATED CLOSED LOOP MODELS
- QUIET 17 kHz PWM SWITCHING FREQUENCY
- IGBT POWER DEVICES
- FORWARD/REVERSE DIRECTION CONTROL
- BRAKE CONTROL
- INHIBIT CONTROL
- RUN/STOP OUTPUT INDICATOR
- INTERNAL POWER ON LED
- INTERNAL FAULT LED
- VOLTAGE FOLLOWER INPUT (0-5 TO 0-20VDC), V_{IN}
- 5KΩ SPEEDPOT with LEADS, KNOB and DIAL for REMOTE MOUNTING
- INTERNAL +5 VOLT DC SUPPLY for MOTOR HALL-EFFECT SENSORS
- ANODIZED CHASSIS MOUNT HEATSINK

MODEL SELECTION

CONTROL TYPE	CHASSIS MODEL	ENCLOSED MODEL	ISOLATED CHASSIS MODEL	ISOLATED ENCLOSED MODEL
Open Loop	720AC-C	720AC-E	720AC-IC	720AC-IE
Closed Loop	721AC-C	721AC-E	721AC-IC	721AC-IE

UNPACKING

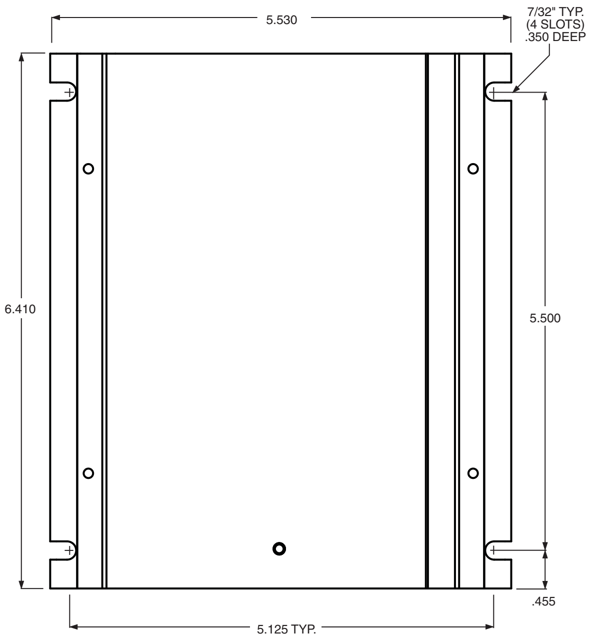
Unpack the control and check for shipping damage. Locate the motor and its timing diagram. In addition, the 5KΩ speedpot supplied with the chassis control, a 120 VAC power source, hook-up wires, and appropriate tools for installation are needed. If the motor does not have a timing diagram, a 10 ampere ammeter and a small hand-held DC volt-ohmmeter are required.

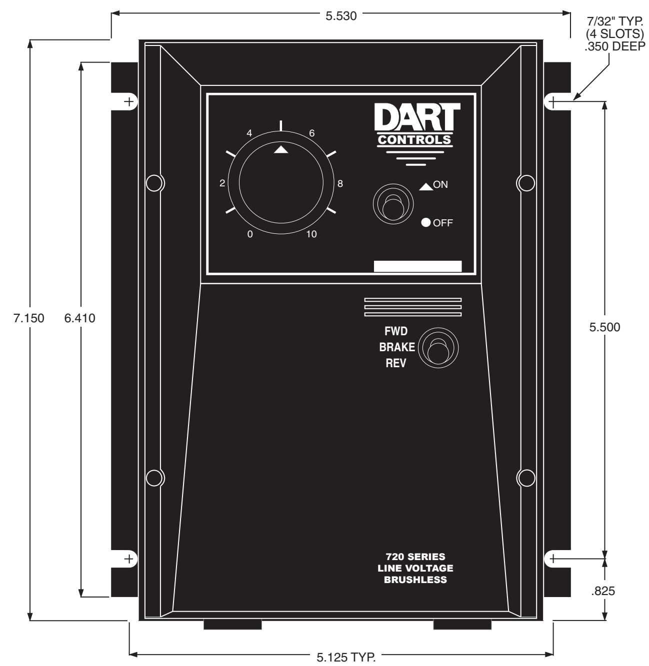
FUSING

Use a 10 amp fuse in one of the two AC source power lines.

MOUNTING INSTRUCTIONS & DIMENSIONS

1. Four 7/32" wide slots are provided for control mounting
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)





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.

All BLDC motors, regardless of the sensor spacing, are connected to the 720 control as shown in the Chassis wiring or Enclosed wiring diagrams.

Power is connected to terminals L and N of P1. The power should be off until the hook-up procedure is complete.

60°/120° Sensor Spacing

There is a jumper on the control to switch between 60° and 120° hall sensor spacings. This jumper is used with a 3 pin header, JP1. Place this jumper in the 2 pins of JP1 that are close to "60" position for 60° operation, or in the 2 pins of JP1 that are close to "120" position for 120° operation.

Speedpot

The 5KΩ speedpot is connected to terminals LO, WP, and HI of P1. If the furnished speedpot with orange, red, and white wires attached to it is not available, any 5KΩ 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 5KΩ is referred to as pot "HI", and the terminal that measures about 0Ω is referred to as pot "LO". Connect pot "HI" to terminal HI of P1, pot "LO" to terminal LO of P1, and the wiper to WP of P1.

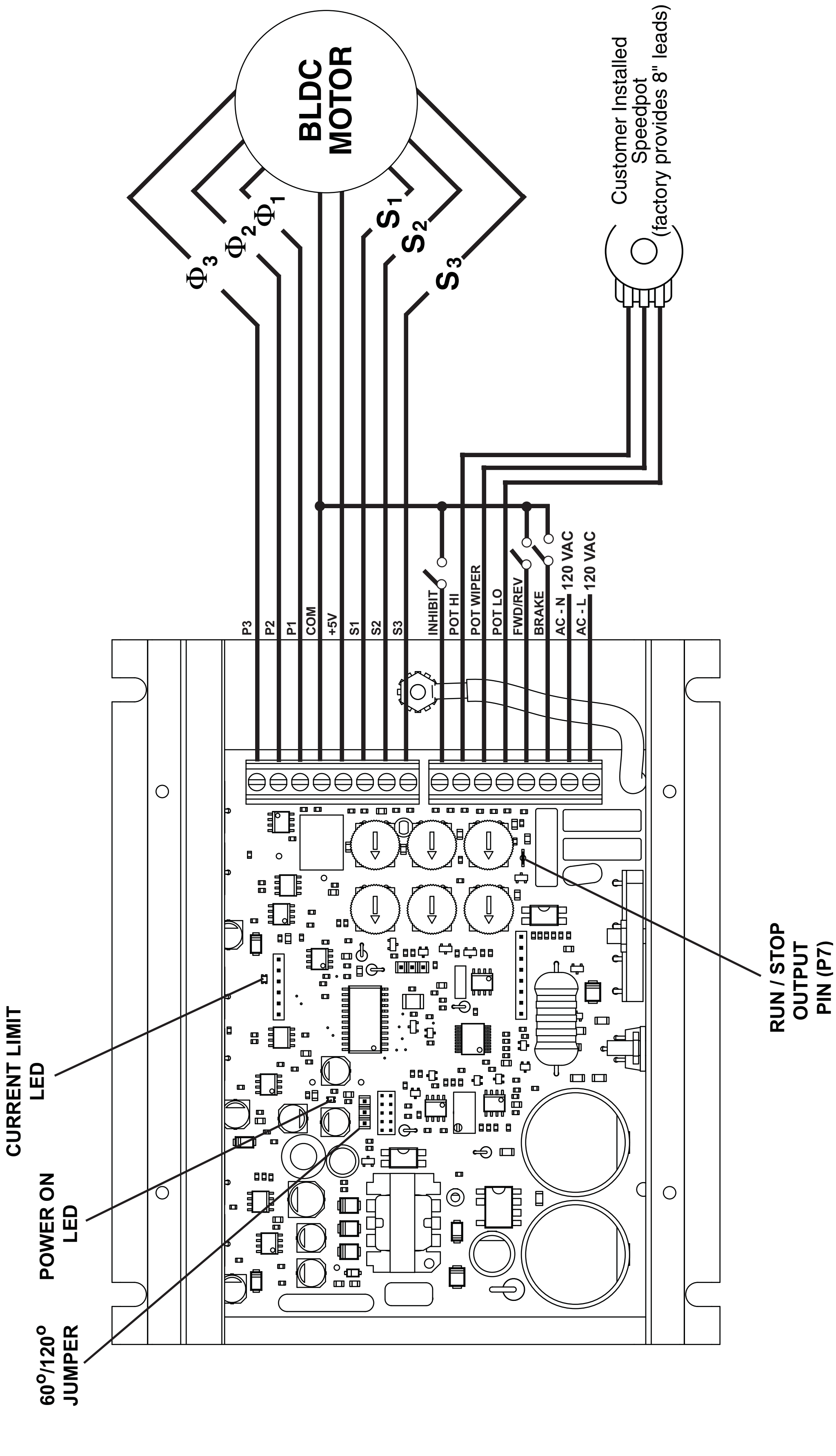
NOTE: Until the motor is known to be correctly wired to the control, it is important that the speedpot is set fully CCW upon application of power.

Analog Input

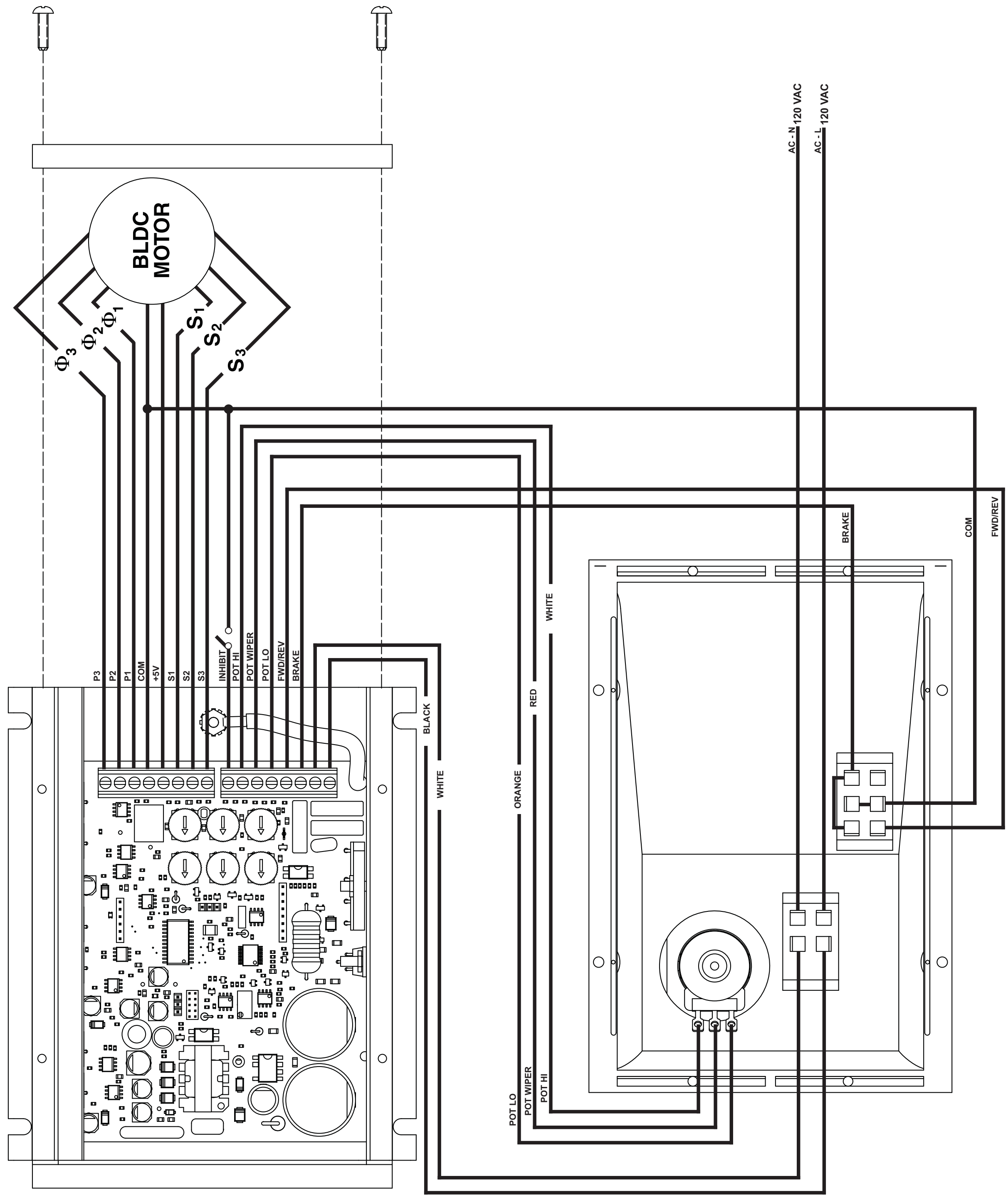
If an analog signal to control the speed of the motor is used, the +V goes to terminal WP of P1 and the -V goes to LO of P1.

WIRING DIAGRAM

CHASSIS WIRING



ENCLOSED WIRING



WARNING

It is good practice to separate the High Current, High Voltage AC power inputs from the High Current, High Voltage motor phase outputs. Also, keep the High Current, High Voltage connections separated from the Low Voltage motor sensor signals and sensor power supply lines to reduce crosstalk and possible noise/interference issues. The Enclosed models have 3 endplate conduit holes for this purpose.

HOOK-UP PROCEDURE FOR MOTORS WITH TIMING DIAGRAMS

It is prudent that when first testing the 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 (See pages 15 & 16). 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. The recommended 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 supply the spacing. If they don't, compare the sensor diagram sent with the motor with those at the end of this manual. Observe that 60 degree spacing will, at some position, have all sensor lines at 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 the correct wiring diagram and connect the sensors to terminals S3, S2 and S1 of P2. 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 S2 of P2.

After the sensors are connected, attach the sensor power line to terminal 5V of P2. The sensor common line is connected to terminal COM of P2. Now attach the three motor armature wires and test for proper hook-up.

We recommend arbitrarily attaching the phase lines to terminals P1, P2, and P3 of connector P2. Choose a configuration, test it, and then keep track of the results on paper.

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 the BLDC motor has with no timing diagram, it is possible, with a little patience, to sort out the various leads and operate it with the 720 control. Find a voltmeter that will read a 5 volt logic level.

First, separate the three motor armature wires from the sensor wires. Armature wires are usually a heavier gauge wire. Once the armature wires are found, 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 the voltmeter to any sensor lead. Reference the meter to terminal COM of P2. Apply power and slowly rotate the motor shaft by hand. The meter should move from 0 to ≈ 5 volts as the Hall sensor switches. Check the other two sensors for switching.

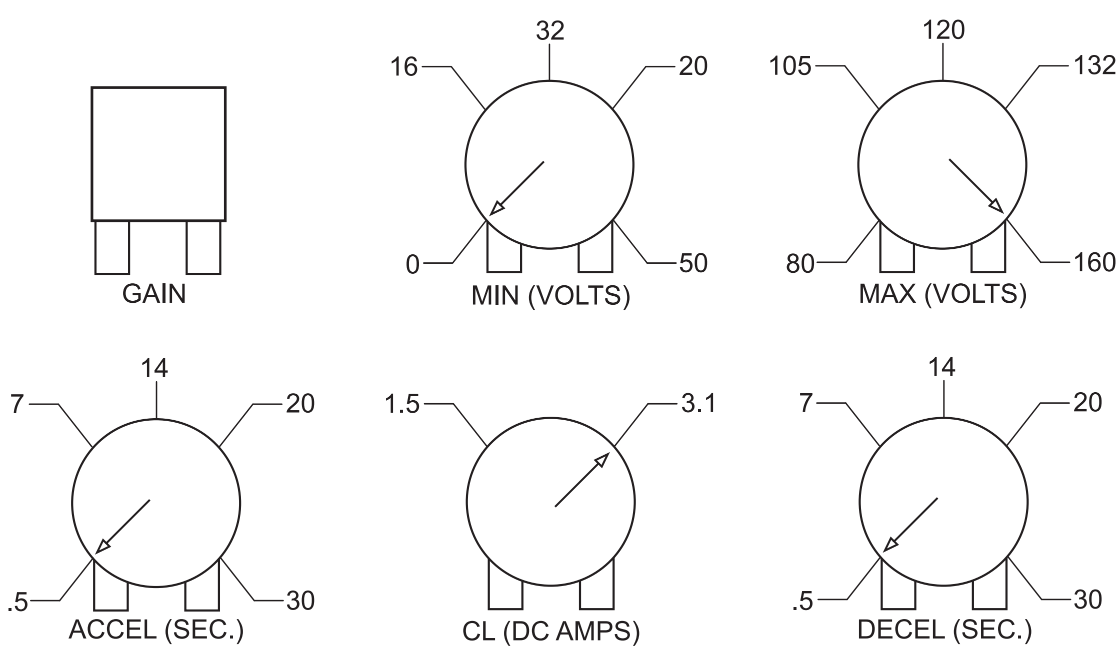
Now, compare each sensor against the others and draw a timing diagram. The motor can now be hooked up with this new information using the procedure for motors with timing diagrams.

ADJUSTMENTS

V_{IN}

Dart has factory set the speed pot adjustment range for a 0 to12 VDC input. The setting does not need to be adjusted if the speed pot uses the internal 'Pot Hi' voltage (HI of P1). If the desired input voltage range is different from 0 to 12V then this Vin Adj. needs to be adjusted. To make this adjustment, apply the maximum DC input level (+20VDC or less) expected to the 'WIPER' input, WP of P1. Then adjust 'Vin Adj.' (R108) so that the DC voltage on U4-7 (or the same side of R116 as U4-7) to less than or equal to 5 VDC.

TRIMPOT SETTING CHART



CURRENT LIMIT

Dart has factory set the Current Limit to 125% of 3.1 Amps DC. The setting should not need to be increased. If the current limit needs to be set to a lower value, do so by adjusting the Current Limit trimpot (CL) CCW until the desired setting is achieved.

Setting Current Limit

Current Limit should normally be set to approximately 125% of the FLA rating of the motor that is running. To set current limit for the specific motor or application, follow these steps while monitoring motor current:

1) Preset Current Limit trimpot (CL) 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) Measure the AC input current with an analog AC current meter placed in series with one of the AC input leads (L or N). 3.1 Amps DC at the motor is approximately 6.4A of AC input current.
5) Decrease the Current Limit trimpot setting until the motor current begins to drop, and 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 3.1 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.

MINIMUM SPEED

Turn the speedpot to zero (fully CCW). Next turn the minimum speed trimpot (MIN) clockwise 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.

MAXIMUM SPEED

Turn the speedpot fully clockwise. Adjust the maximum speed trimpot (MAX) clockwise to the desired maximum output. If using a 721 model (closed loop version) see the section titled "Adjusting Closed Loop Gain" below.

ACCELERATION

Clockwise rotation of the (ACCEL) trimpot increases length of acceleration time needed for the control to reach full speed.

DECELERATION

Clockwise rotation of the (DECEL) trimpot increases length of deceleration time needed for the control to reach minimum speed or stop.

CLOSED LOOP GAIN

Controls designated 721 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 (GAIN) in the Trimpot Setting Chart. This allows the flexibility to properly control motors in a wide spectrum of speeds.

To adjust the control to the motor:

1. Set the Maximum Speed (MAX) trimpot to 50% rotation or ≈ 12 0'clock.
2. Set the Minimum Speed (MIN) trimpot to its fully counterclockwise (CCW) position.
3. Set the Closed Loop Gain trimpot to its fully clockwise (CW) position.
4. Advance the speedpot to the fully clockwise (CW) position. The motor should now be spinning at its maximum speed.*
5. Slowly rotate the Closed Loop Gain trimpot (GAIN) counterclockwise until the motor speed decreases slightly**, then rotate the trimpot back clockwise just enough to return the motor to full speed.

* If the motor doesn't reach its maximum speed with the speedpot fully clockwise, rotate the MAX trimpot clockwise until it does. Proceed with step 5.

** If the Closed Loop Gain trimpot (GAIN) is rotated fully counterclockwise 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 clockwise just enough to return the motor to full speed.

FEATURES

FORWARD / REVERSE

Terminal F/R of P1 on the 720 is the forward/reverse terminal and is internally pulled to 5V. The motor direction can be reversed by connecting F/R of P1 to common via a jumper wire to either LO of P1 or COM of P2 or by using a switch, relay or an open collector NPN transistor.

Utilizing the forward/reverse feature will activate dynamic braking within the control and provide for a fast stoppage of the motor and then a ramp up to the previous speed at the rate that was set by the acceleration trimpot.

NOTE: If the motor draws an excessive amount of current in reverse, the motor may be designed for only one direction. Consult with the motor manufacturer about this problem.

BRAKE

Terminal BRK of P1 on the 720 is the brake terminal and is internally pulled to 5V. The control is shipped so that the motor is enabled to run. Connecting the BRK terminal of P1 to common via a switch, relay, or an open collector NPN transistor will cause the motor to brake. If an enclosed model, the FWD/BRAKE/REV switch controls the motor condition.

Utilizing the brake feature will activate dynamic braking within the control and provide for a fast stoppage of the motor. On releasing the brake, the control will ramp up to the previous speed at the rate that was set by the acceleration trimpot.

INHIBIT

Terminal INH of P1 on the 720 is the inhibit terminal and is internally pulled to 5V. The motor can be inhibited by connecting INH terminal to common via a jumper wire to either LO of P1 or COM of P2 or by using a switch, relay or an open collector NPN transistor.

Utilizing the inhibit feature will slow the motor to a stop by the rate previously set by the deceleration trimpot. On releasing the inhibit, the control will ramp up to the previous speed at the rate that was set by the acceleration trimpot.

RUN/STOP OUTPUT INDICATOR

This is an OPEN COLECTOR NPN output that can be used to drive a relay. There is a 0.110" spade pin located at P7 between the ACCEL trimpot and C2. When the motor is not running, the output is off (High). When the motor is running, the output (P7) is connected to the COM of P2. This output can withstand voltages to 50VDC and drive 0.10 Amp loads.

NOTE: This is not an isolated output. If using a non-isolated control and Earth Ground is applied to this or any input/output of this control, the control could be damaged.

NOTE: If P7 is controlling a relay, a flyback diode is required across the relay coil and its supply voltage source to prevent over voltage being applied to the control transistor.

INTERNAL POWER ON LED

The internal power LED (Green) indicates that the +5V power supply is operating correctly when AC power is supplied to the control. When the +5V supply is operating, then the +12V and +15V power supplies are also operating correctly. When AC power is removed from the control, the internal power LED remains lit until the internal high voltage is dissipated.

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 (i.e. Hall effect sensors attached in the wrong order or 60°/120° phasing jumper in wrong position), over current condition (i.e. Current Limit set too low), undervoltage lockout (i.e. +12V supply is less than 10.5V) or thermal shutdown (i.e. U13 is too hot). Typical fault conditions are invalid sensor attachment or current limit set too low.

APPLICATION EXAMPLE

Conveyor Belt In A Medical Device Production Line

Description:

In this example, a moving conveyor belt is part of a medical device production line. The following specifications are given for the belt.

- An HMI touch-screen must provide an operator with start/stop, belt speed, and forward/reverse control. The HMI must interface with a networked PLC.

- The belt motor drive must be controlled by a 0-10 VDC signal from the PLC.

- Precise speed regulation of the belt is critical.

- The HMI must display the actual belt speed.

- Acceleration and Deceleration times must be set to 5 seconds to keep product in correct position during a normal start or stop of the belt.

- If the product is out of position the belt must abruptly stop, and an alarm light must activate.

- The environment is sensitive to noise and must be clean.

- Low equipment maintenance is required.

Since the production environment is sensitive to noise, must be clean, and low equipment maintenance is required, a BLDC motor drives the belt. BLDC motors are quiet, do not have brushes that put dust into the environment, and require little maintenance.

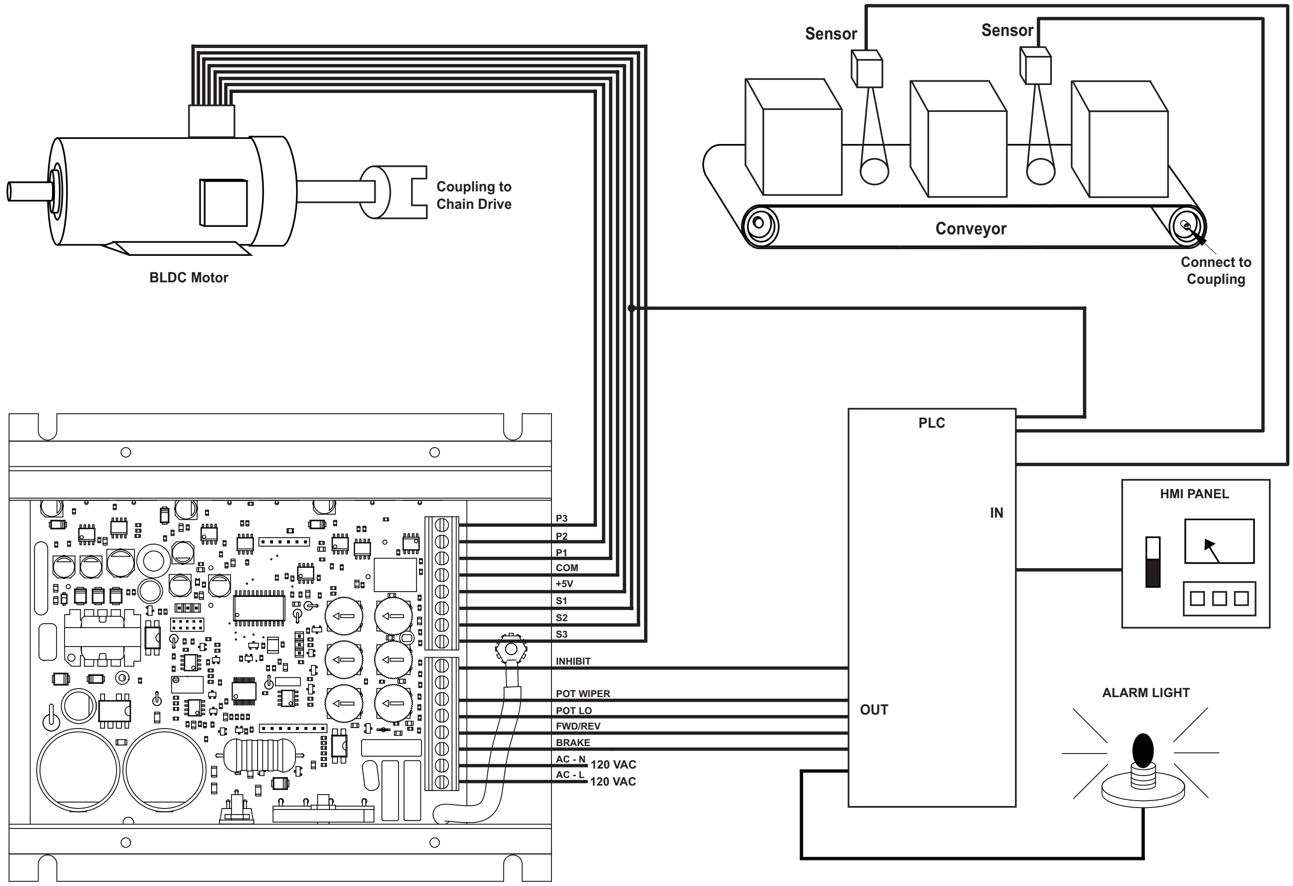
A DART Controls 721AC-IC drives the BLDC motor. The 721AC-IC accepts a 0-10 VDC signal from the PLC to vary the belt speed. The drive's closed loop feature provides speed regulation to within +/- ½ % of base speed. One of the built-in BLDC motor sensors is connected to the PLC to display belt speed at the HMI panel.

The adjustable acceleration and deceleration trim pots on the 721AC-IC are set to 5 seconds. The drive's inhibit input is signaled by the PLC during controlled stop/start operations. The 721AC-IC also provides the PLC with a forward/reverse input.

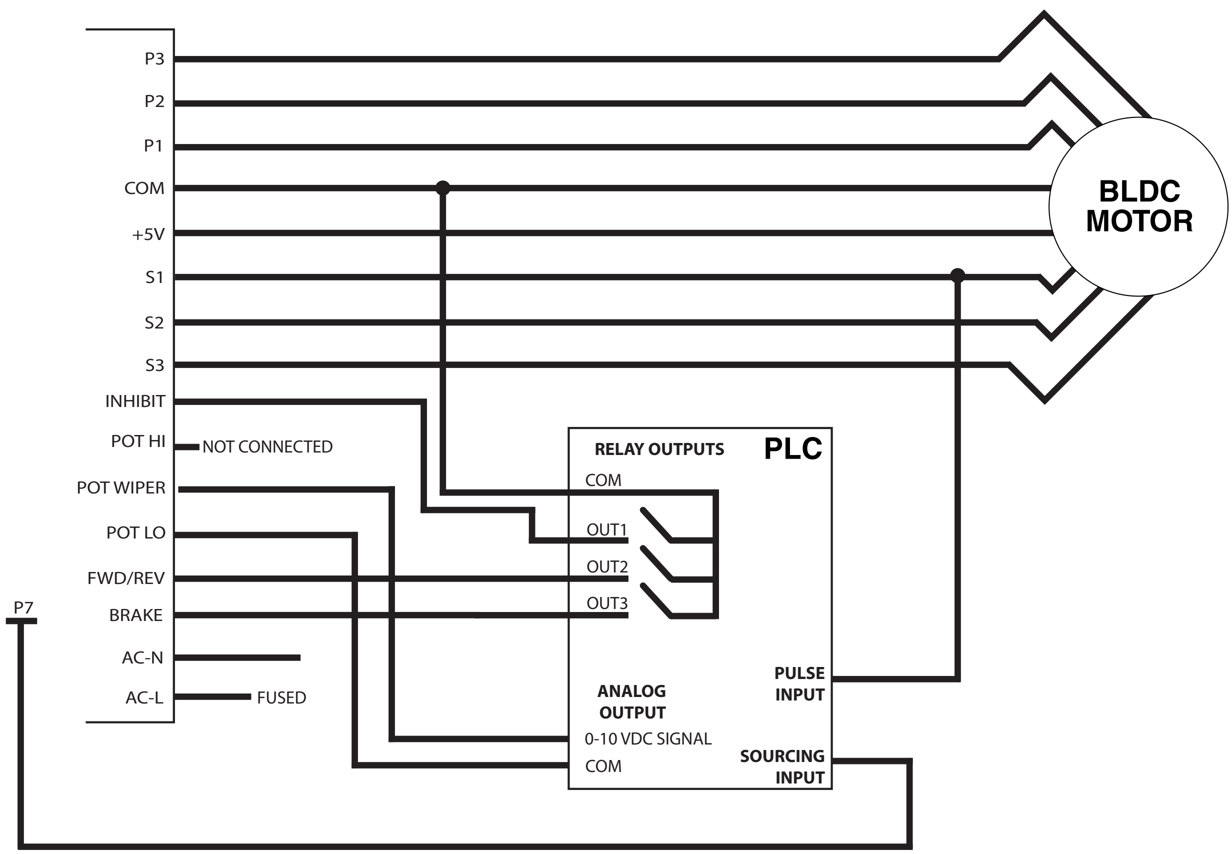
Optical sensors are strategically placed near the belt to sense the product position. If the sensors are triggered by a product out of position, the PLC signals the brake input of the 721AC-IC to make the belt stop abruptly without deceleration.

The RUN/STOP output from the 721AC-IC is monitored by the PLC. If this output indicates STOP when the motor is commanded to run, the alarm light is activated to indicate the failure.

Application Diagram:



Wiring Diagram:



SPECIFICATIONS

INPUT VOLTAGE... 120 VAC±10%
OUTPUT VOLTAGE (FILTERED OUTPUT)...0 to 160 VDC
LOAD CURRENT (CONTINUOUS)..3.1 AMPERES DC
OVERLOAD CURRENT...150% FOR 30 SECONDS
SPEED RANGE..50:1
MAXIMUM SPEED TRIMPOT..60 TO 100% OF INPUT VOLTAGE
MINIMUM SPEED TRIMPOT..ADJUSTABLE 0-30% OF MAX.
CURRENT LIMIT TRIMPOT...ADJUSTABLE
ACCELERATION...ADJUSTABLE .5 TO 30 SECONDS
DECELERATION...ADJUSTABLE .5 TO 30 SECONDS
MOTOR HALL SPACING (ELECTRICAL)...............................FIELD SELECTABLE 60° OR 120°
OPEN LOOP SPEED REGULATION..MOTOR DEPENDENT
CLOSED LOOP SPEED REGULATION...± 1/2% OF BASE SPEED
SPEED CONTROL....................5KΩ POTENTIOMETER OR 0-20 VDC V_{IN} ISOLATED SIGNAL
RUN/STOP OUTPUT INDICATOR..0-50VDC @ 0.10 AMPERES
OPERATING TEMPERATURE... -10°C TO 45°C (14°F – 113°F)

DIMENSIONS

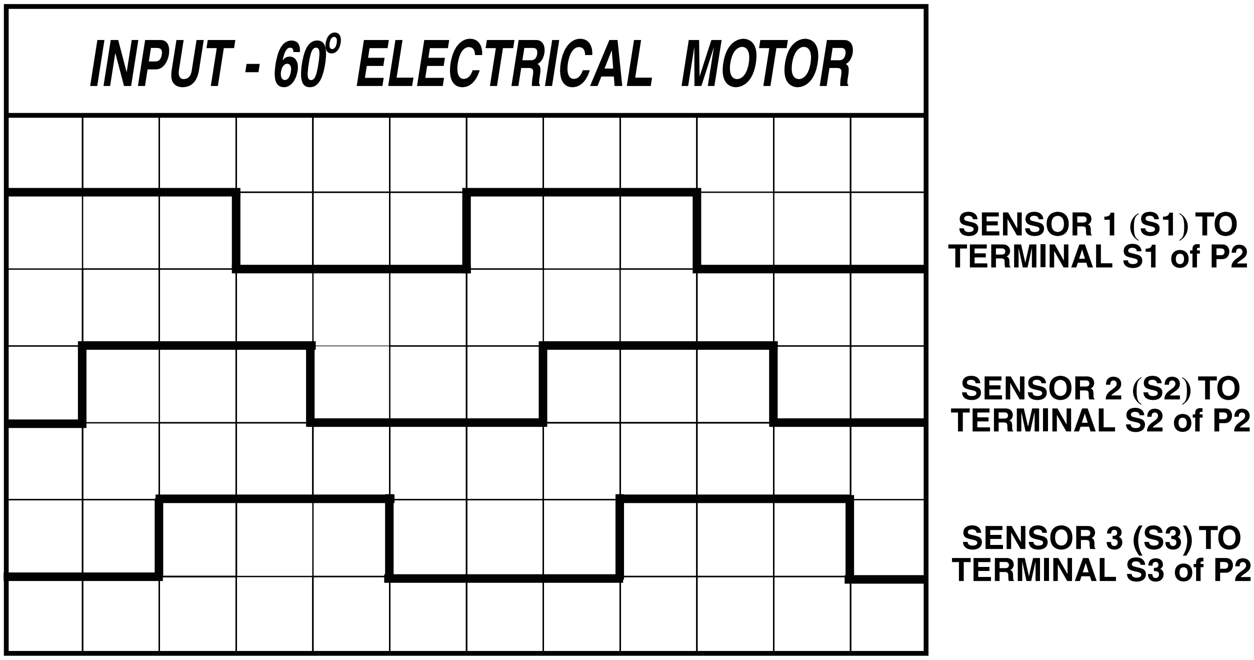
	WIDTH	LENGTH	HEIGHT	WEIGHT
CHASSIS	5.53 in.	6.41 in.	2.60 in.	27 oz.
ENCLOSED	5.53 in.	7.15 in.	4.33 in.	38 oz.

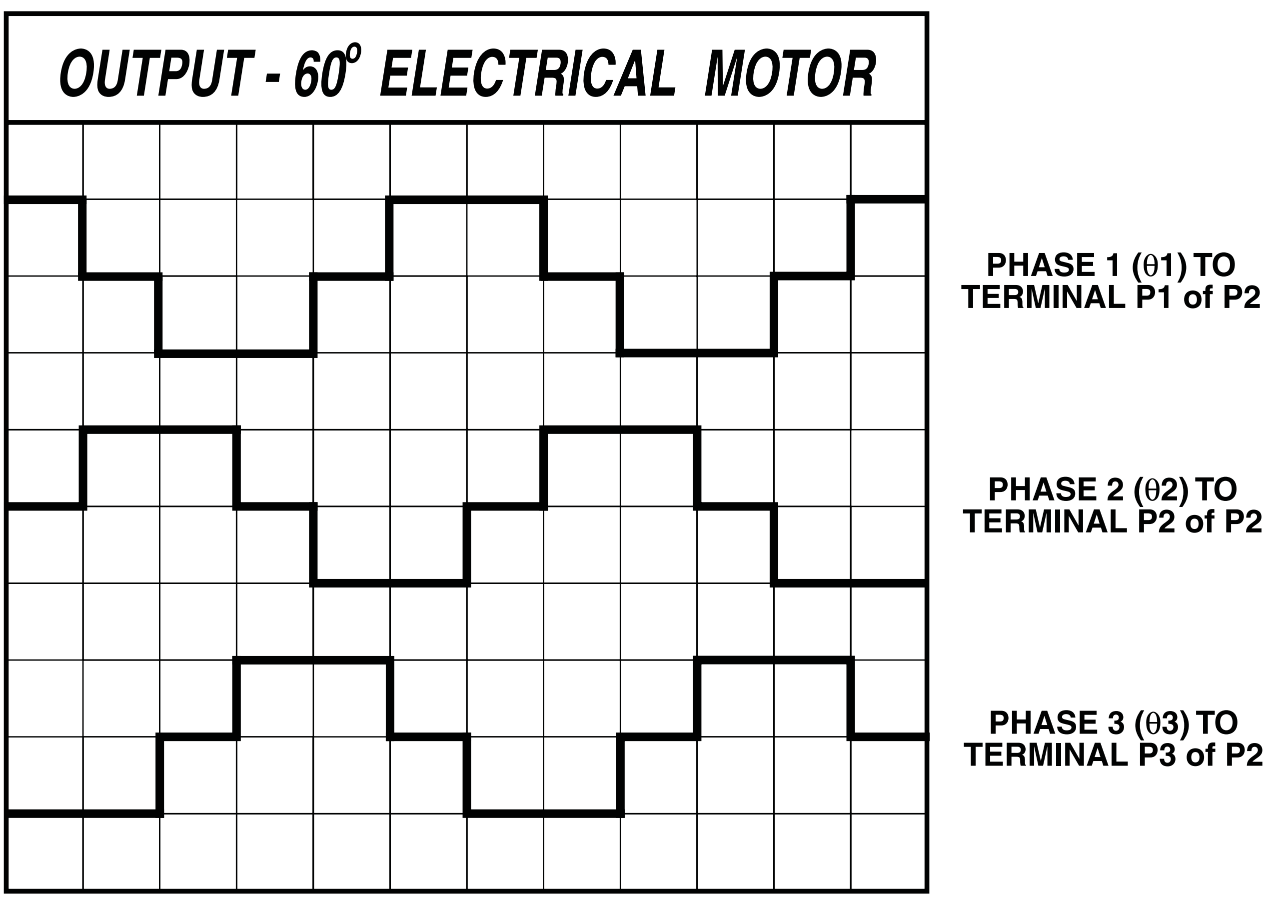
HEATSINK COOLING

The heatsink temperature is recommended to be kept below 75ºC (167ºF). The control, as shipped from the factory, will normally handle 3.1 amperes of continuous current. If the ambient temperature increases above 45ºC (113ºF), more heatsink may be needed or decrease the current to keep the sink temperature from exceeding 75ºC. No matter what the heatsink temperature is, never exceed 3.1 amperes of continuous motor current.

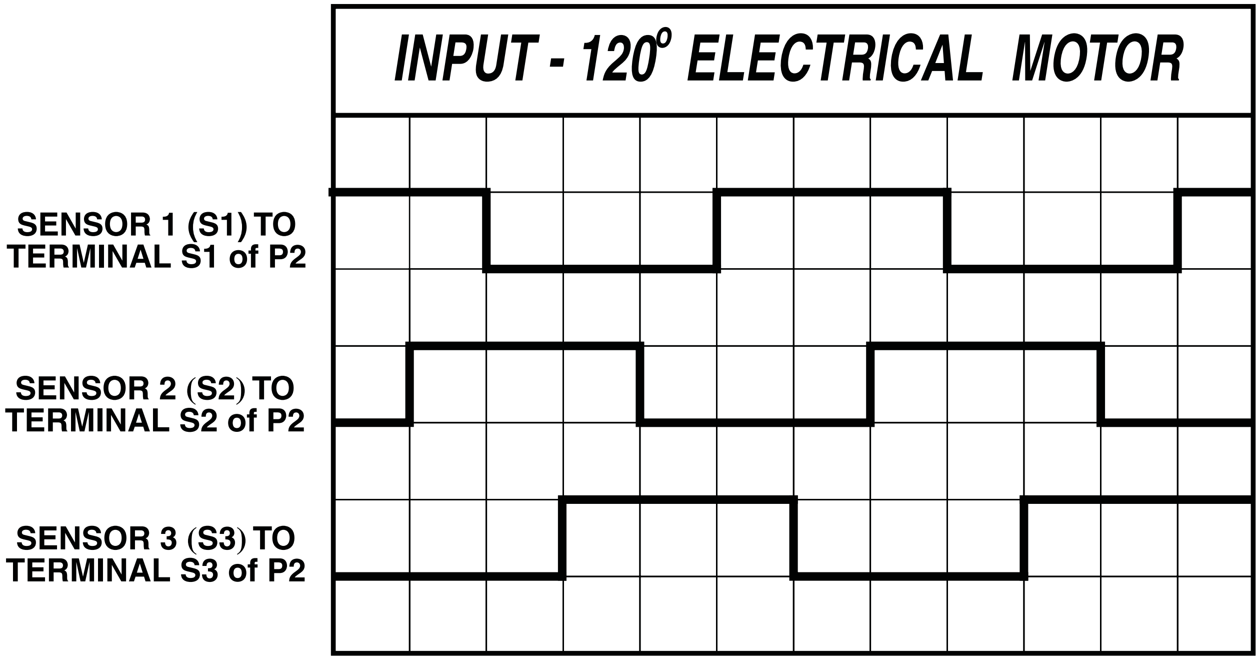
TIMING DIAGRAMS

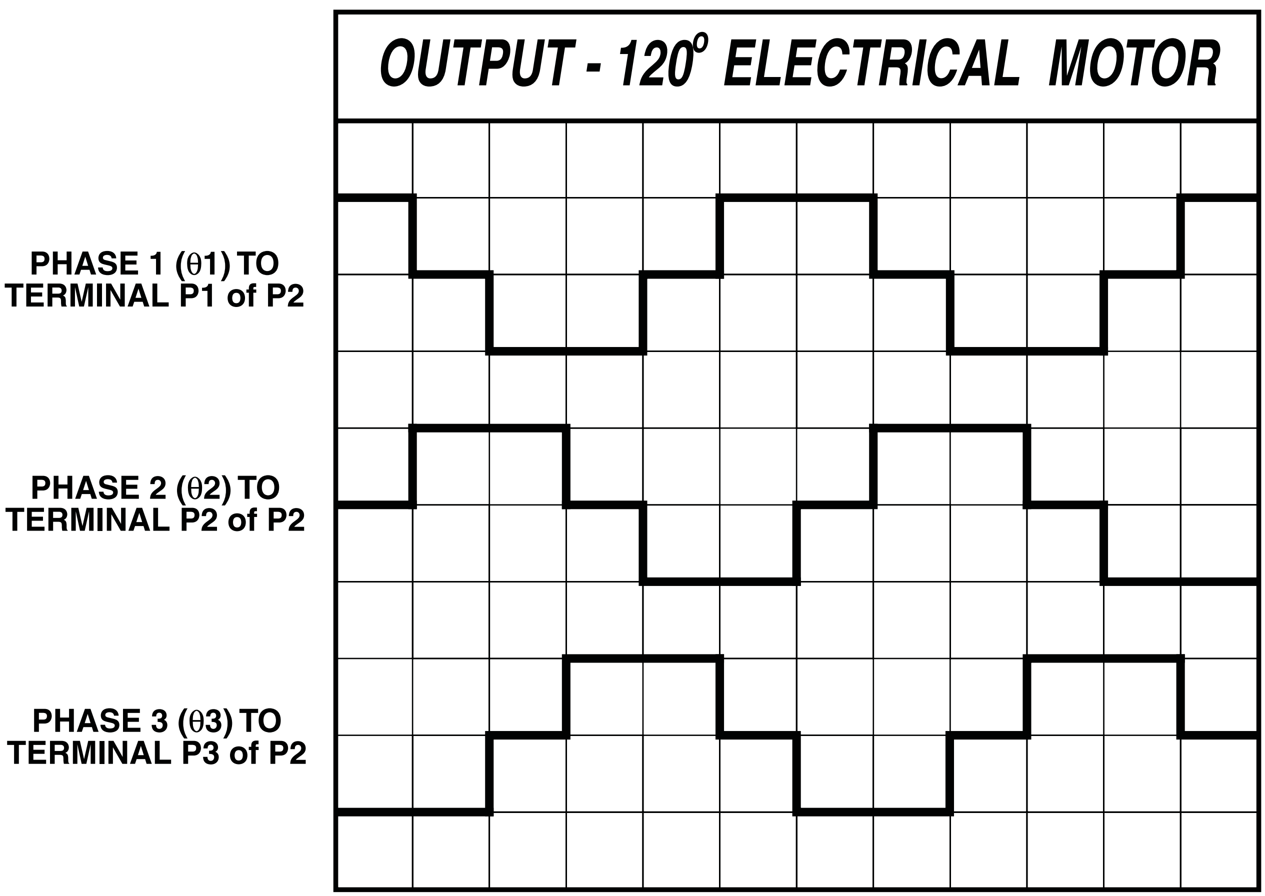
TIMING FOR 60° MOTOR





TIMING FOR 120º MOTOR





NOTES:

NOTES:

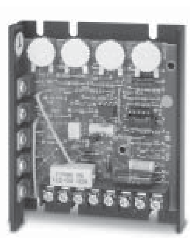
REPAIR PROCEDURE

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



125D SERIES
AC INPUT - VARIABLE DC OUTPUT
1/50 HP through 1.0 HP

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

65 SERIES
DC INPUT - VARIABLE DC OUTPUT
CURRENT RATINGS OF 20, 40, AND 60 AMPS

700/COMMUTROL SERIES
DC BRUSHLESS
5 & 20 Amp for
12,24,& 36VDC Inputs

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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