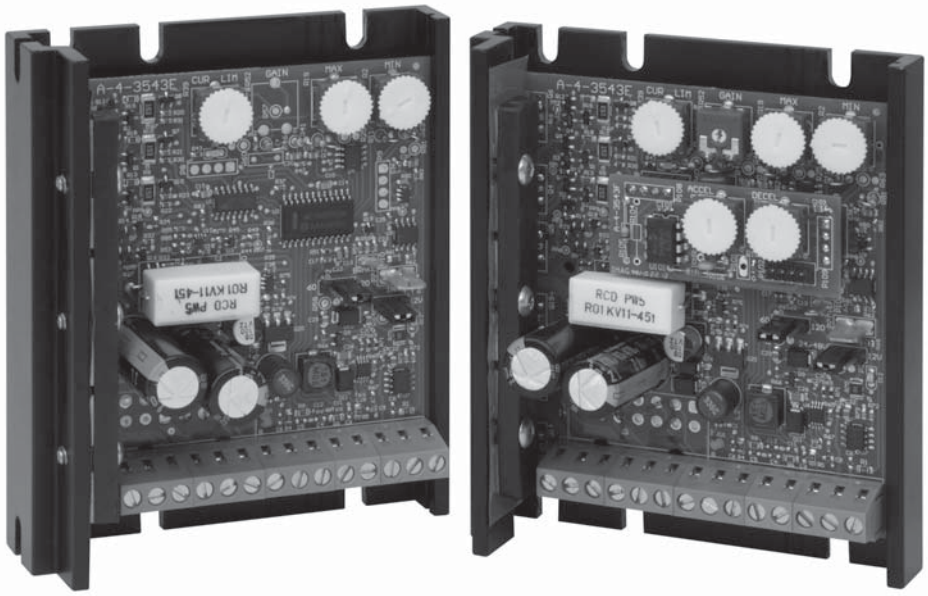
730 CONTROL SERIES

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 730 Series is a family of general purpose brushless motor controls. These controls commutate power into standard 3 phase sensored brushless (BLDC) motors.

The 730 Series uses DC power sources of 11 to 15VDC or 18 to 54VDC, including batteries of 12, 24, 36, and 48 volts. The 730 Series will supply up to 7.5 amperes of continuous current to the motor without an additional heat sink. With the -HS2 optional heat sink, the 730 series will supply up to 9 amperes of continuous current to the motor. It is available in either a basic open loop (730BDC), a basic closed loop (731BDC), and a full featured closed loop (733BDC), and all can drive motors with sensor spacings of 60 or 120 degrees.

A 14 position terminal strip connects the control to the DC power source, the motor, the speedpot, and the forward/reverse control switch. A pluggable terminal strip (-P option) is also available. There is a ¼" spade pin that can be used for inhibiting the control. There is a 1/8" spade pin that can be used to brake the control. The control's PC board carries the minimum speed, maximum speed and current limit trimpots for the 730BDC, an additional gain trimpot for the 731BDC, as well as Accel and Decel trimpots for the 733BDC.

Standard Features

- *AVAILABLE IN OPEN LOOP (730BDC), CLOSED LOOP (731BDC) AND FULL FEATURED (733BDC) VERSIONS*
- *POWER MOSFET TRANSISTORS*
- *QUIET 17KHz "PULSE WIDTH MODULATED" SWITCHED FREQUENCY*
- *FORWARD/REVERSE DIRECTIONAL CONTROL*
- *5KΩ SPEED POTENTIOMETER W/ DIAL, LEADS & KNOB FOR REMOTE MOUNTING*
- *ANODIZED CHASSIS*
- *INHIBIT INPUT PIN FOR START/STOP OPERATION*
- *BRAKE INPUT PIN FOR QUICK STOP OPERATION*
- *INTERNAL +6.2 VOLT DC SUPPLY FOR MOTOR HALL EFFECT SENSORS*

Model Selection

MODEL #	CONTROL TYPE	INPUT VOLTAGE	PHASE
730BDC	OPEN LOOP	12VDC or 18-54VDC SELECTABLE VIA JUMPER	60° or 120° SELECTABLE VIA JUMPER
731BDC	CLOSED LOOP	12VDC or 18-54VDC SELECTABLE VIA JUMPER	60° or 120° SELECTABLE VIA JUMPER
733BDC	CLOSED LOOP	12VDC or 18-54VDC SELECTABLE VIA JUMPER	60° or 120° SELECTABLE VIA JUMPER
733BDC-CL	CLOSED LOOP W/ CUR LIM LATCH	12VDC or 18-54VDC SELECTABLE VIA JUMPER	60° or 120° SELECTABLE VIA JUMPER

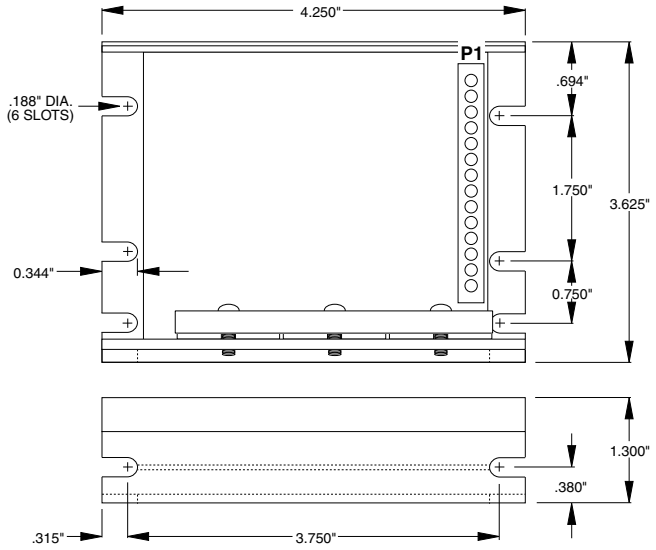
Unpacking

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 DC power source, hook-up wires, and appropriate tools for installation are needed. If the motor does not have a timing diagram, an ammeter of at least a rating of 200% of the full load motor current and a small hand-held DC volt-ohmmeter are required.

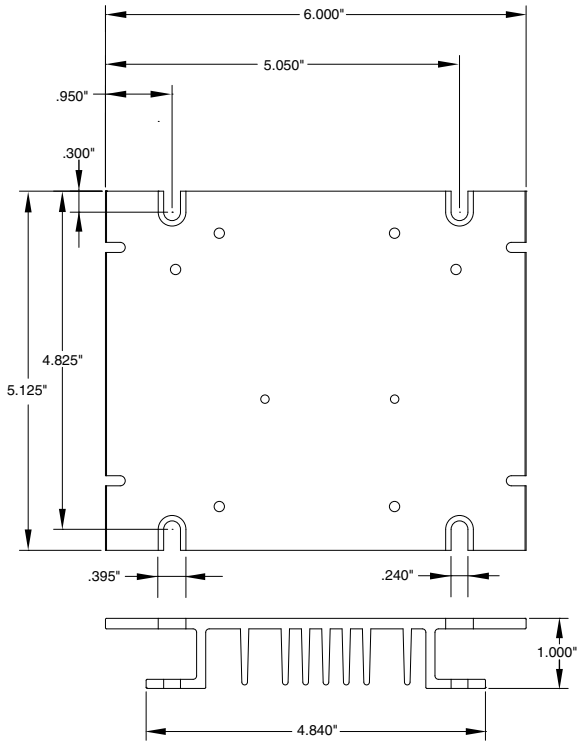
Mounting Instructions and Dimensions

1. Six 3/16" wide slots are provided for control mounting (see dimension diagram below).
2. Control chassis can be used as a template.
3. Use standard hardware to mount.

Caution:
Do not mount where ambient temperature is outside range of -10° C (15° F) to 45° C (115° F).



STANDARD 730 SERIES



-HS2

Brushless Motor Control Hook-up & Fusing

Brushless DC motors have eight (8) wires: three (3) phase lines to the motor, three (3) Hall sensor lines, and sensor power and common. Also BLDC motors come in two sensor configurations, 60 and 120 degrees.

Many BLDC motor manufacturers are familiar with the 730 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 discussed later. All BLDC motors, no matter what the hook-up status, are connected to the 730 Series control as shown in figure 1 of the Hook-Up Diagram section.

Notice how the power is connected to terminals P1-4 and P1-5 through an appropriate switch and fuse. Dart recommends the use of a Littlefuse 314 Series or Bussman ABC Series type fuse rated at 150% of the full load motor current. The power should be off until the hook-up procedure is complete and the motor is ready to run.

Hook-up Diagram

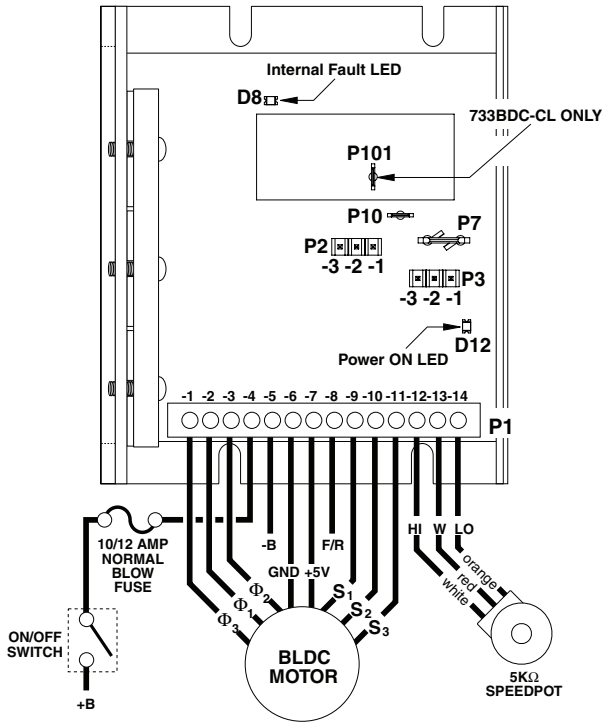


Figure 1

Hook-up Procedure for Motors with Timing Diagrams

It is prudent that when first testing the motor a DC ammeter be placed in series with the DC source. Zero to twenty 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 9 & 10. 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, make sure the control is set correctly. Return to the correct wiring diagram and connect the sensors to terminals S3, S2 and S1 of P1. 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 P1.

After the sensors are connected, attach the sensor power line to terminal 6.25V of P1. The sensor common line is connected to terminal COM of P1. Now attach the three motor armature wires and test for proper hook-up.
It is recommended arbitrarily attaching the phase lines to terminals P1, P2, and P3 of connector P1. Choose a configuration, test it, and then keep track of the results on paper.

Now apply power to the control. Slowly increase the speed by adjusting the Speed Pot clockwise. Watch for erratic rotation or excessive source current. If either occurs, immediately turn the Speed Pot counterclockwise to reduce speed, 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 DC 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 730 Series control. Find a voltmeter that will read a 6.25 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 P1. 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.

Features

Sensor Spacing & Input Voltage Selection

Normally the 730 Series control is shipped ready for 120 degree sensor spacing (P2-2 and P2-3 connected). However, if connecting to a motor that has 60 degree sensor spacing, connect the supplied jumper to P2-2 to P2-1. Note figure 1 of the Hook-Up Diagram section, which shows the location of the selectable sensor spacing connector and attached jumper connector. Using this selectable jumper connector enables the control to drive motors with 60 or 120 degree sensor spacings.

The input voltage is also jumper selectable and is shipped with the standard setting of 24/48VDC input (P3-2 and P3-3 connected). If 12 volt input is desired, move the supplied jumper to connect P3-2 to P3-1. See figure 1 of the Hook-Up Diagram section for location of the selectable input voltage connector and attached jumper connector.

Speed Command Selection and Hook-up

The 730 series controls can be operated with a 5K potentiometer (supplied with control) or a 0 to 5VDC power source. The 5K ohm speedpot is connected to terminals P1-12, P1-13, and P1-14. Connect the speedpot "LO" lead (orange wire) to terminal P1-14, the speedpot "WIPER" lead (red wire) to P1-13, and the speedpot "HI" lead (white wire) to P1-12. A 0 to 5V DC signal can also be used to regulate the speed. This is accomplished by connecting the DC source signal lead to terminal P1-13 (WIPER) and the common lead to terminal P1-14 (LO).

Note: A 5K ohm resistor must be connected from the Pot Hi terminal (P1-12) to the Pot Lo terminal (P1-14) for proper operation of the Min trimpot.

Inhibiting the Control

The 730 series control has a ¼" spade pin (P7) on the control that can be used to inhibit the control. Tying this pin to the control common terminal (P1-6) will stop the control and override any other speed command. Starting and stoping the control with the Inhibit input will not override Accel and Decel settings on the 733 models.

Braking the Control

The 730B series control has a 1/8" spade pin (P10) on the control that can be used to brake the control. Tying this pin to the control common terminal (P1-6) will quickly stop the control and override any other speed command. Using brake to start and stop the control will override the Accel and Decel settings of the 733BDC model. For a start and stop function with Accel and Decel, it is recommended to start and stop the control via inhibit or disconnecting the pot wiper or signal wire, via a switch.

Current Limit / Fault Condition Latch

733BDC-CL Only

The 733BDC-CL has a 1/8" spade pin (P101) on the control's top board. If the motor is stalled for any reason, this feature will not allow the motor to restart until the Current Limit Latch feature is reset. Momentarily tying pin (P101) to the control common terminal (P1-6) will reset the Current Limit Latch and override any other speed command. A Fault Condition Latch such as incorrect motor phase or drive over-temperature will also activate this shutdown / latch feature and may be cleared the same way (after fault condition is corrected).

Motor Direction Selection and Reversing

Terminal P1-8 on the 730 Series is the forward/reverse control. Allowing terminal P1-8 to remain unconnected will let the motor turn in a particular direction. Connecting terminal P1-8 to P1-6 will reverse the rotation direction. Either a jumper wire, switch, relay, or an open collector NPN transistor can be used to make this connection. **MAKE SURE WHEN THE MOTOR DIRECTION IS REVERSED THAT THE MOTOR IS STOPPED. THE CONTROL ISN'T DESIGNED FOR PLUG REVERSING.**

Sometimes it may be necessary to reverse the motor without using terminal P1-8. This is done by stopping the motor and exchanging terminals P1-1 with P1-2 and terminals P1-10 with P1-11. This will work with either a 60 or 120 degree motor.

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

This completes a general hook-up for the 730 Series. The next task is to connect the motor to the control.

Power ON LED

The internal 12V supply has a green LED attached to it for an indication that the internal power supply is operating and power is applied to the control.

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°/120° phasing jumper in wrong direction, over current condition (i.e. Current Limit set too low), undervoltage lockout (i.e. +12V supply is less than 10.0V) or thermal shutdown (i.e. U2 is too hot). Typical fault conditions are: invalid sensor attachment, 60°/120° phasing jumper is in the wrong position, or Current Limit is set too low.

Adjustments

Current Limit

Dart has factory set the Current Limit to 125% of 7.5 Amps DC. This 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 DC input current with an analog DC current meter placed in series with the Positive DC input lead.
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: Remember, keep the average current at 7.5 Amps or under, and make sure the motor is rotating. A stalled motor, after about 30 seconds, may overheat and cause extensive damage to the control and/or motor.

Minimum Speed

Turn the speedpot to zero (fully CCW). Next turn the minimum 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 zero deadband. If a nonzero minimum speed is desired, rotate the trimpot CW to the desired setting.

Maximum Speed

Turn the speedpot fully clockwise. Adjust the maximum trimpot (MAX) counterclockwise to the desired maximum output.

Closed Loop (731BDC and 733BDC) Gain

1. Adjust the Maximum speed trimpot (MAX) to 50% CW rotation.
2. Set Closed Loop Gain trimpot to the fully CW position.
3. Advance speedpot to the fully CW position. The motor should now be rotating at its maximum speed*.
4. Slowly rotate the Closed Loop Gain trimpot CCW until the motor speed decreases slightly**, then rotate the trimpot back CW just enough to return the motor to full speed.
5. Refer to the above Minimum Speed (MIN) and Current Limit (CUR LIM) trimpot adjustments.

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

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

Accel and Decel (733BDC)

Accel - The Accel trimpot is adjustable from 0-10 second of maximum output speed setting. The setting of the accel time is approximately proportional to the rotation of the Accel trimpot. As an example, a 50% setting of the Accel trimpot will result in approximately a 5 second linear accel ramp from zero to maximum speed. To test a setting, turn the speedpot to zero (fully CCW). Next turn the Accel trimpot CW to the estimated accel setting. Quickly rotate the speedpot full CW and time the motor accel ramp from zero to maximum speed. If necessary, adjust the Accel trimpot setting as needed and test again.

Decel - The Decel trimpot is adjustable from 0-10 second of maximum output speed setting. The setting of the decel time is approximately proportional to the rotation of the Decel trimpot. As an example, a 50% setting of the Decel trimpot will result in approximately a 5 second linear decel ramp from maximum to zero speed. To test a setting, turn the speedpot to maximum (fully CW). Next turn the Decel trimpot CW to the estimated decel setting. Quickly rotate the speedpot full CCW and time the motor decel ramp from maximum to zero speed. If necessary, adjust the Decel trimpot setting as needed and test again.

Note: Minumum, Maximum and Gain trimpot settings must already be completed to properly set and test Accel and Decel. Refer to the Open Loop and Closed Loop Trimpot sections above for Minimum Speed (MIN), Maximum speed (MAX), Current Limit (CUR LIM) and Gain trimpot adjustments.

Heatsink & Cooling

Dart recommends not letting the heatsink temperature rise above 75° C. (167° F.). The control, as shipped from the factory, will normally handle up to 7.5 Amps continuous current. With the use of the -HS2 optional heat sink, 9.0 Amps continuous current is achievable. If the ambient temperature increases above 25° C. (77° F.), adding more heatsink or decreasing the current to keep the heatsink temperature from exceeding 75° C is a must. Finally, no matter what the heatsink temperature, never exceed the rated current.

Specifications

INPUT VOLTAGE (JUMPER SELECTABLE) ..... 11 to 15VDC OR 18 to 54VDC
OUTPUT VOLTAGE ..... 0 to INPUT VOLTAGE
MOTOR HALL SPACING - ELECTRICAL (JUMPER SELECTABLE) ..... 60° OR 120°
LOAD CURRENT (CONTINUOUS) ..... 7.5 AMPS
LOAD CURRENT USING -HS2 (CONTINUOUS) ..... 9.0 AMPS
SPEED RANGE ..... 50 : 1
MINIMUM SPEED TRIMPOT ..... ADJUSTABLE 0-30% OF MAX.
CURRENT LIMIT TRIMPOT ..... ADJUSTABLE
OPEN LOOP SPEED REGULATION ..... (MODEL 730BDC) NONE
INPUT / OUTPUT CONNECTIONS ..... 14 POSITION TERMINAL BLOCK
INPUT / OUTPUT CONNECTIONS USING -P OPTION..... 14 POSITION PLUGGABLE
SPEED COMMAND SIGNAL ..... 5K Ohm SPEED POTENTIOMETER or 0 to +5V DC SIGNAL
OPERATING TEMPERATURE ..... 0° C. to 45° C. (32° F. to 113° F.)
CLOSED LOOP SPEED REGULATION ..... (MODEL 731BDC and 733BDC) ± 1/2% OF BASE SPEED
MAXIMUM SPEED TRIMPOT ..... ADJUSTABLE 60 to 100% OF INPUT VOLTAGE
ACCELERATION / DECELERATION ..... (MODEL 730BDC and 731BDC) FAST START
..... (733BDC) ADJUSTABLE 0 – 10 SECONDS
INTERNAL VOLTAGE SUPPLY (FOR MOTOR HALL SPACINGS) ..... +6.2 VDC

Timing Diagram for 60° Motor

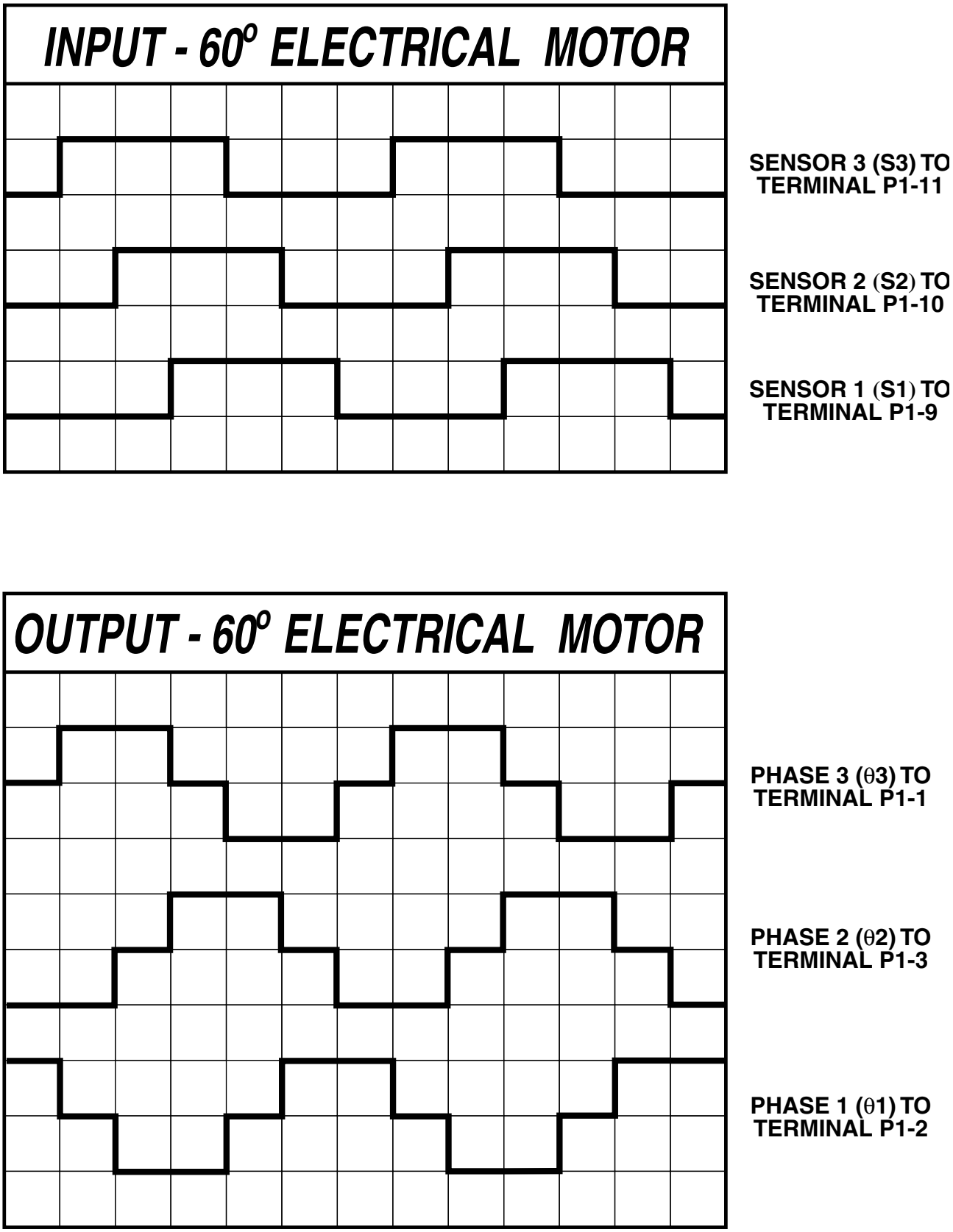


Figure 3

Timing Diagram for 120° Motor

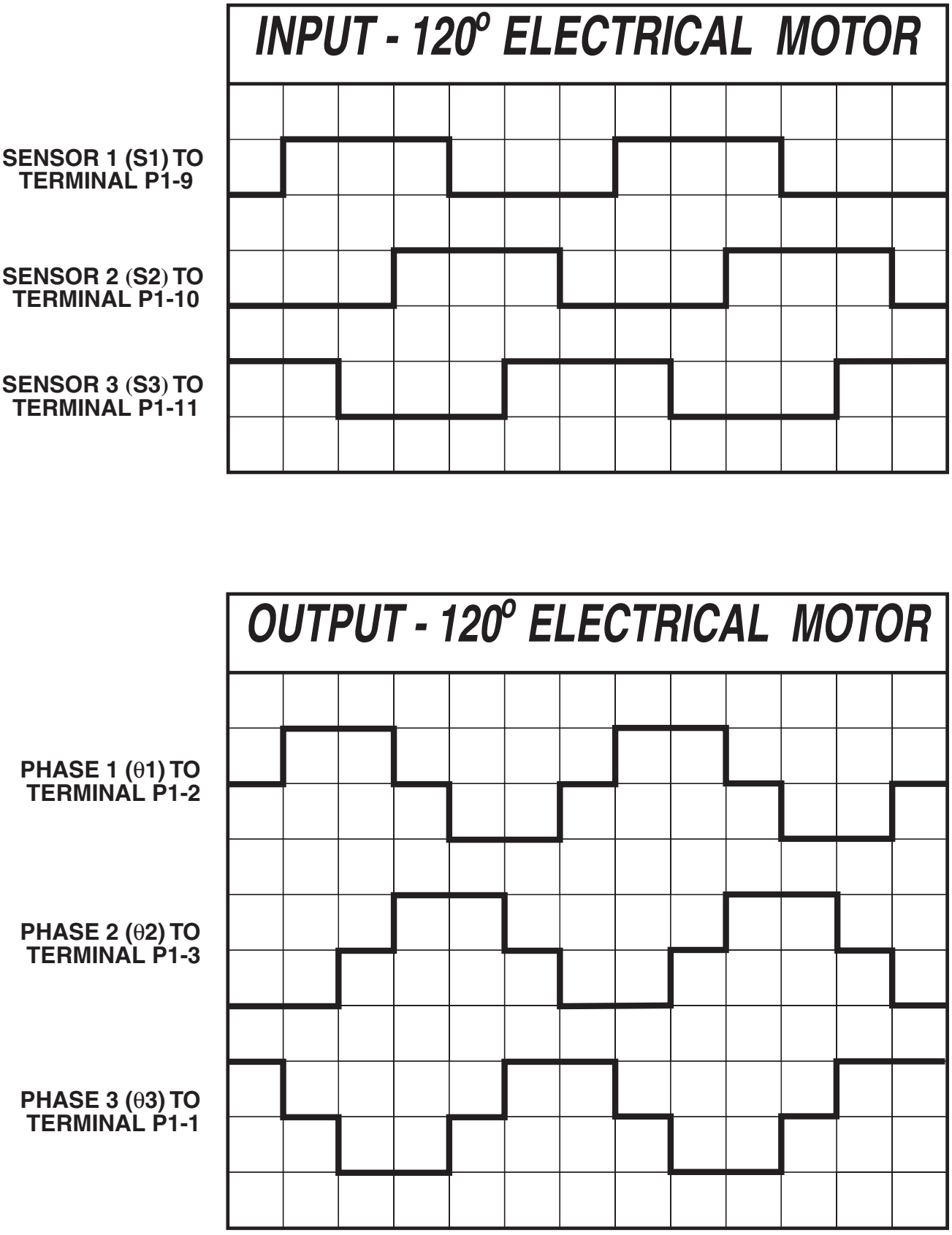


Figure 4

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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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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