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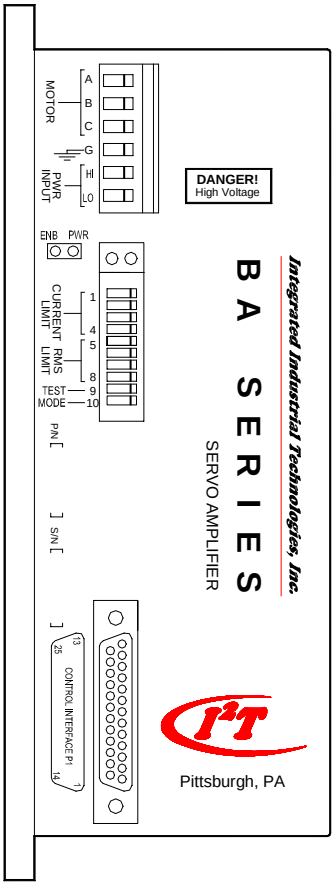
BA10, BA20 and BA30
BA Series Servo Drive
User's Guide



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In this Chapter you will learn about:

- Important User Information
- Product Warranty
- Return Policy
- Technical Support
- Assumptions
- Contents of This User's Guide

1.1. Important User Information

To ensure safe and satisfactory operation of the equipment described in this user's guide, as well as the equipment connected to and used with your BA Series Servo Drive, all applicable local and national codes that apply to installing and operating the equipment must be followed.

WARNING ☞ Failure to comply with applicable local and national codes and standards can result in damage to equipment and/or serious injury to personnel.

Personnel responsible for the installation and/or operation of the equipment should study this user's guide and all referenced documentation prior to installation or operation of the equipment.

In no event is the provider of the equipment liable for any incidental, consequential or special damages of any kind or nature whatsoever, including but not limited to lost profits arising from or in any way connected with the use of this user's guide or the equipment.

The BA Series Servo Drive provides solutions for a wide variety of servo applications. Therefore, it is the end user's responsibility to determine the acceptability of any products used in any application. The equipment provider assumes no responsibility for the User's misapplication of the BA Series Servo Drive.

Since I^2T constantly strives to improve its products, we reserve the right to change this user's guide and any equipment mentioned herein at any time without notice.

1.2. Warranty

I^2T warrants that all equipment they manufacture will be free from defects in materials and workman-ship for a period of one (1) year from the date of invoice. Within this warranty period, I^2T shall, at its option, repair or replace – free of charge, any equipment covered by this warranty. This warranty does not cover any equipment damaged by improper installation, accident, alteration or misuse. In no event shall I^2T be liable for incidental or consequential damages or for delay in performance of this warranty.

1.3. Return Policy

Any equipment returned as new must be in the original, unopened shipping carton and is subject to a 20% restocking fee. All equipment returned to I^2T for repair or replacement, regardless of warranty status, must have return authorization. To receive return authorization, call the I^2T technical assistance number with the following product information:

- Product Part Number
- Serial Number
- Description of Problem

I^2T issues a Return Material Authorization (RMA) number. You must ship the product to I^2T with shipping charges prepaid and the RMA clearly marked on the outside of the shipping container. Title and risk of loss or damage remains with the customer until shipment is received by I^2T. All equipment returned for warranty repair must be in the original shipping container or additional handling charges apply. In special cases, I^2T will provide emergency replacement of defective equipment. For special cases, the customer must provide a Purchase Order number in the amount of a product being shipped plus any applicable taxes and shipping charges. In the event that the defective equipment is not returned within seven (7) days, I^2T bills the customer for the replacement equipment.

1.4. Technical Support

All I^2T products are sold through authorized Schneider Electric high-tech distributors. The customer should attempt to resolve any problems through their local distributor before contacting I^2T directly. Should your local distributor be unavailable or unable to solve a problem, contact I^2T Technical Support at (412) 828-1200. Additional information and updates are available via our WEB site at http://www.i2t-inmotion.com.

1.5. Assumptions

To effectively use the BA Series User's Guide to install, develop and maintain your setup, you should have a fundamental understanding of the following:

- Electronic concepts such as voltage, current, switches, etc.
- Motion control concepts
- Contents of this User's Guide.

1.6. Manual Contents

Each chapter provides a different level of help to get your product set up and ready to go. Below is a summary of each chapter's purpose.

Chapter	Purpose
1 – Overview	Provides an introduction to product warranty and field support as well as an overview of the items to be covered in this User's Guide.
2 – Introduction	Describes the BA drive and provides a brief overview of applications, hardware, electrical specifications, dimensions and mounting.
3 – Getting Started	Provides instructions for inspecting your shipment, selecting operating modes, configuring typical systems, mounting and wiring the BA Series Servo Drive.
4 – Troubleshooting	Describes methods for isolating and resolving hardware problems.

In this Chapter you will learn about:

- Overview
- Applications
- Hardware
- Electrical Specifications
- Dimensions / Mounting

2.1. Overview

This section provides a user with an understanding of the capabilities of the BA Series Servo Drive. The BA drive is a stand-alone drive for three-phase AC brushless and single-phase DC brush motors. This versatile drive can run in velocity or torque mode using a self-commutating, low ripple, modified six-step algorithm.

The BA drive is based on a 20 kHz IGBT for reliable operation in a compact package. It is completely self-contained, requiring only AC line power, and the drive is fully protected. The DC-isolated power stage minimizes loop noise. The drive accepts a quadrature encoder input for velocity feedback. The encoder signal is converted to a voltage representing speed.

2.1.1. Features

The BA drive is available in six models up to 100A peak to match your application power requirements. For the purposes of this manual I^2T will only focus on three models: BA10, BA20 and BA30. These models and available voltage configurations are described in the table below. Other models available are discussed under separate cover.

Model	Std. Voltage Configuration	Peak Output Current	Continuous Output Current (Peak)	Continuous Output Current (Peak)
BA10	160V	10 A	5 A	80 to 100V, 80 to 160V, 80 to 320V
BA20	160V	20 A	10 A	80 to 100V, 80 to 160V, 80 to 320V
BA30	320V	30 A	15 A	160V, 160 to 320V

2.1.2. BA Drive Voltage Configurations

The BA Series Servo Drives feature self-commutation with Hall Effect feedback signals. Operation for 320V is also available. The drives even include a 5 Vdc, 250 mA supply to power Encoders and Hall Effect Devices (HEDs). Each model is jumper selectable to drive both brush and brushless motors. The heat sink can be mounted in one of two different orientations, but I²T recommends that the heat sink be mounted to a larger, thermally conductive surface for further heat dissipation. Complete electrical isolation is provided between the control and power stage for all drive configurations. This is accomplished with a transformer isolated control voltage power supply and opto-isolation of the drive signals, current feedback signals, and fault signal between the control and power stages. Each drive is fully protected against the following fault conditions:

- Control Power Supply Under Voltage
- RMS Current Limit Exceeded
- Power Stage Bias Supplies Under Voltage
- Over-temperature
- Over-current
- Output Short Circuits (Phase-to-phase and Phase-to-ground)
- DC Bus Over Voltage

Operating modes include Current Command, Velocity Command or Dual-Phase Command (for brushless modes of operation only). For brush modes of operation, the available operating modes are Current Command and Velocity Command. Differential inputs are used for better noise immunity. Velocity feedback occurs from either an encoder or tachometer. Logic inputs include directional current limits and shutdown. Fault, current and velocity outputs simplify the need to monitor drive status.

2.1.3. Standard Drive Package

The standard package includes the heat sink, cover, shunt regulator, and the bus power supply which operates from 56 to 230 Vac depending on the model. The power supply is included with the standard package for off-line operation without the need for an isolation transformer. *Figure 2-1* shows a functional diagram of the standard package configuration.

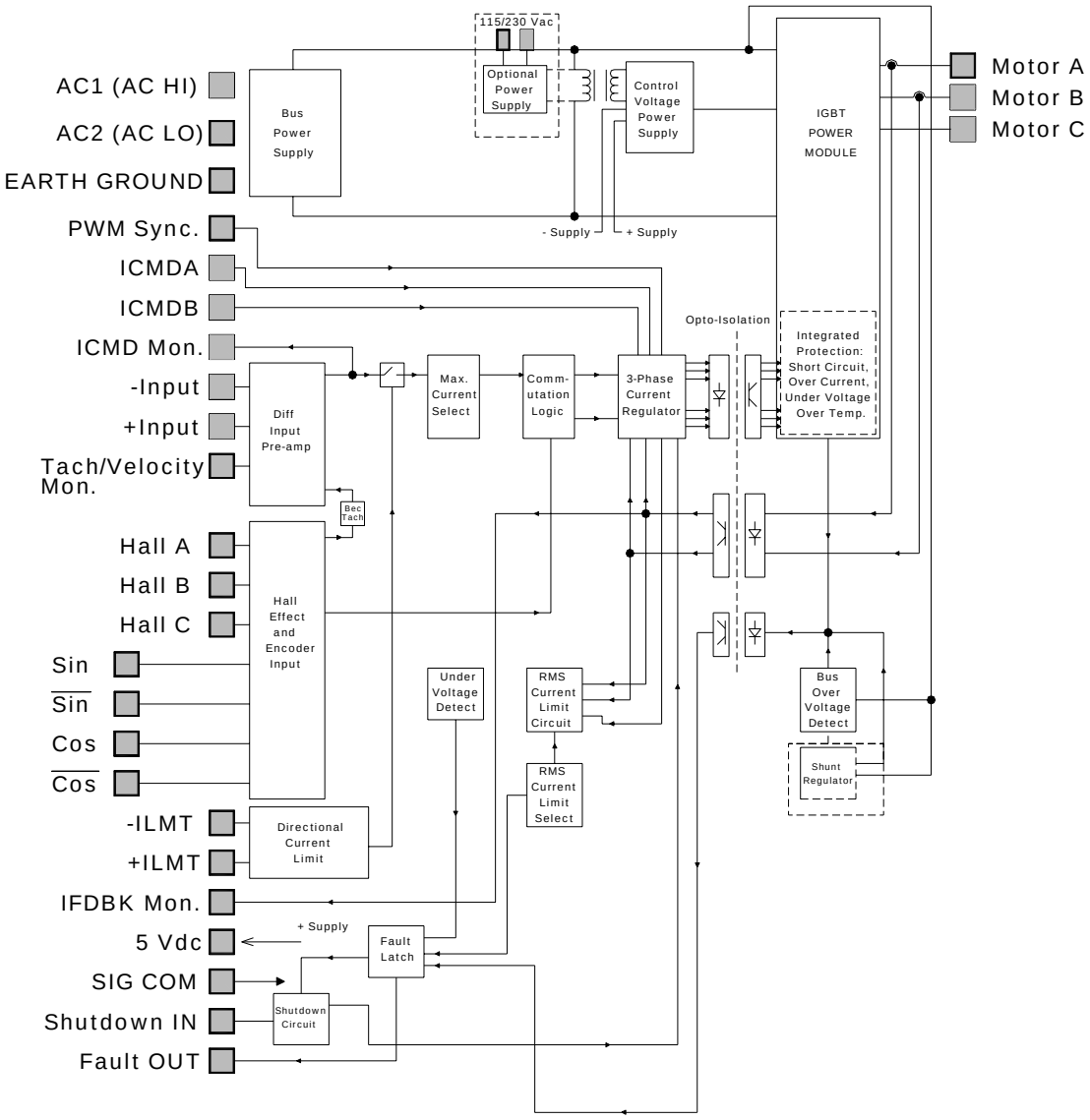


Figure 2-1: Functional Diagram

The shunt regulator is not included with the BA 10 or BA 20 drive. To order, request option "-S".

A secondary 115/230 Vac connection is necessary if the DC bus power is required to operate below 80 Vdc.

2.2. Applications

There are many applications that can use a BA Series Servo Drive. The following sections present a select few of these applications in detail.

- Machine Tools
- Packaging
- Labeling
- X-Y Stages
- Inspection
- Medical
- Winding
- Semiconductor Fabrication
- Food Processing.

2.3. Hardware

This section defines the hardware configuration of the drive using switches, jumpers, connectors and power hook-ups when using either a brush or brushless DC motor.

The BA Series Servo Drive consists of two power connections (motor and input), four potentiometers, a 10-position DIP switch, an Enable LED indicator lamp, and a 25-pin "D" style connector. See *Figure 2-2* for locations.

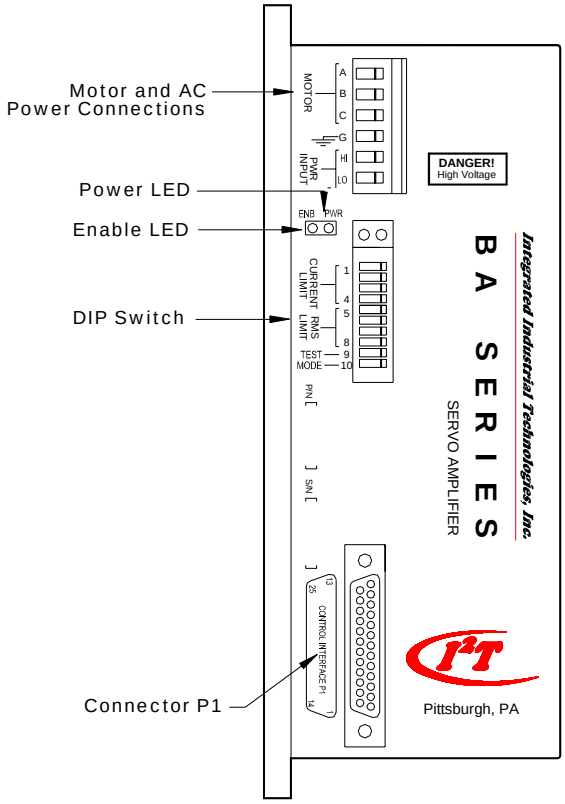
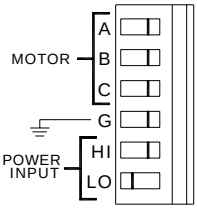


Figure 2-2: Hardware for BA 10, 20 and 30 Series Servo Drives

2.3.1. Motor and AC Power Connections

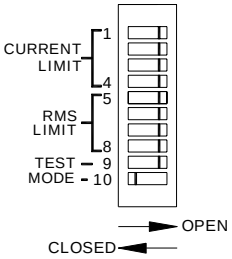
The three phase motor terminal connections are made at connections A, B and C. This area is designated on the drive.



Input power to the drive is made at the HI (line) and LO (neutral) terminals with earth ground connected to ground. Motor frame and shield connect to a grounding stud on the heat sink.

2.3.2. DIP Switch Settings

There is a 10-position DIP Switch (shown at right) on the BA Series Servo Drive that provides four discrete functions. The switch controls the maximum allowable current to the motor, RMS current limit level, velocity or current operational mode, and test mode. *Figure 2-2* shows the location of this switch on the drive. Refer to *Table 2-2* for exact switch functions.



	Switches	Position	Function
CURRENT LIMIT PEAK	1*	Closed	Peak is 6% of Ipeak
	2*	Closed	Peak is 13% of Ipeak
	3*	Closed	Peak is 27% of Ipeak
	4*	Closed	Peak is 54% of Ipeak
* Switches affect the GAIN adjustment of the velocity loop. Max. gain adjustment when 1 to 4 are closed.			
CONTINUOUS CURRENT PEAK *	5	Closed	Icont is 3% of Ipeak
	6	Closed	Icont is 7% of Ipeak
	7	Closed	Icont is 14% of Ipeak
	8	Closed	Icont is 27% of Ipeak
TEST	9	Closed	Close this position to allow the BALance pot to manually control motor velocity or torque without the need for an input signal (depending upon the setting of switch 10).
MODE	10	Open	Velocity/Current Mode – Close this position to enable the current mode.
* Continuous current peak is 54% of peak instead of 100%.			

Table 2-1: DIP Switch Functions

NOTE ☝ **Positions 1-4 and 5-8 can be combined for sixteen threshold combinations, evenly divided between zero and the maximum current of the drive.**

NOTE ☝ **If Current Limit = RMS Current, the Amp will fault after 30 seconds of running at maximum current.**

NOTE ☝ **If Current Limit = 2 times RMS Current, the Amp will fault after 2 seconds of running at maximum current.**

The following examples should be used as a guideline for setting the DIP switches.

2.3.2.1. Example: BA30 – Setting Continuous Current Limits

To set Continuous Current Limit to 5.5A:

- 5.5A Continuous RMS x 1.414 = 7.8A Continuous Peak
- (7.8A Continuous Peak / 30A Max. Peak) x 100 = 26%
- Open Switches 5, 6 and 7
- Close Switch 8

2.3.2.2. Example: BA20 – Setting Current and RMS Limits

To set RMS Limit to 5.0A (RMS) and Peak Current to 15A:

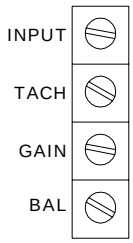
PEAK CURRENT

- (15A Peak / 20A Max. Peak) x 100 = 75%
- Close Switches 3 and 4
- Open Switches 1 and 2

RMS CURRENT

- 5.0A RMS x 1.414 = 7A Continuous Peak
- (7A Continuous Peak / 20A Max. Peak) = 35%
- Close Switches 6 and 8
- Open Switches 5 and 7

2.3.3. Factory Set Potentiometer (POTs)



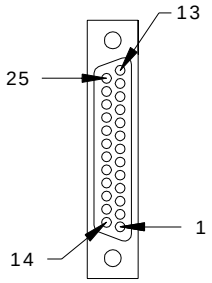
Potentiometers INPUT, TACH, GAIN and BALance are associated with the pre-amplifier circuit contained in the drive. These POTs are located under the cover and are factory set for the benefit of the user. I²T sets these potentiometers at the factory for the purpose of adjusting the pre-amplifier gain when the MODE switch is set for velocity control using an incremental encoder or external DC tachometer for velocity feedback. *Table 2-2* describes the functions of the pot, even or pot functions.

Potentiometer	CW	CCW	Function
INPUT	Increase	Decrease	Adjusts DC gain of the input command present at P1, pins 8 and 21.
TACH	Increase	Decrease	Adjusts DC gain of the encoder or tach derived velocity feedback input present at P1, Pin 3.
GAIN	Decrease	Increase	Adjusts AC gain of the pre-amplifier.
BALance			Permits a user to cancel small DC offsets present in the pre-amplifier circuit.

Table 2-2: Potentiometer Functions

2.3.4. Control Interface Connector (P1) Pinouts

Connector P1 (25-pin "D" type, female) provides the interface for input and output control connections. Refer to *Table 2-3* for these pinouts. The LED ENABLE indicator illuminates at all times until there is a fault or external shutdown, at which time the indicator is off and motor power removed. Refer to *Figure 2-2* for location of the interface connector and enable indicator.



Pin Numbers	Input or Output	Signal	Function
Pin 1	Shield	Ground	***Connection Point to Earth Ground***. Reduces electrical noise in control and feedback signals. Typically connected to foil shield of shielded cable.
Pin 2	Output	Power	***On-board 5V Power Supply.*** Pin 2 powers an encoder and supplies up to 250 mA of current.
Pin 3	Input/Output	+ Tach	***Tachometer Input for Velocity Feedback*** (encoder vs. tach velocity feedback is jumper selectable). Using a tachometer in the velocity loop configuration provides negative feedback to the drive. This allows the drive to close the servo loop and control the loop's stability. If using an encoder for velocity feedback, this pin serves as an output for monitoring velocity (0.2V/KRPM).
Pin 4	Input[A]	Hall A	***Hall Effect A.*** 1 of 3 commutation signals used with brushless motors. Used in conjunction with Hall Effect B and C to provide motor rotor position information to the drive.
Pin 5	Input[A]	Cosine	***Cosine Signal from Encoder.*** Used as an option in conjunction with Sine to derive an electronic tachometer signal. Line receiver input.
Pin 6	Input	Cosine –N	***Compliment of Cosine (P1-5).*** Line receiver input.
Pin 7	Input	Ground	***Signal Common.*** Electrical reference for all control circuitry.
Pin 8	Input	+ Input	***Non-inverting Input of Differential Input Circuit.*** A positive voltage on this input causes CCW motor rotation (torque or velocity mode). For single ended operation, connect command to the input and ground (Pin 21 of P1).
Pin 9	Input	Icmda	***Current Command A.*** Jumper selectable input that bypasses differential input, pre-amplifier and self-commutation circuit.
Pin 10	Input[A]	Shutdown	***Active High or Active Low Input.*** This jumper selectable input shuts off power stage and thus removes all power to the motor.
Pin 11	Input[A]	+ Ilmt	***Directional Current Limit Input.*** When pulled to its active state, positive motion (CW motor shaft rotation) is inhibited (jumper selectable).
Pin 12	Output	- Fdbk	***Current Feedback Monitor.*** If running a brushless motor, this signal represents the current in motor Phase A. For brush motors, this signal represents the entire motor current.
Pin 13	Input	PWM Sync	***PWM Sync.*** Input that allows for an external 20 kHz square wave input to control the PWM circuit to improve system stability. Use this input only if your BA drive is connected to the BB501 interface board. Contact factory for additional information.
Pin 14	Signal Common	Ground	***Electrical Reference for All Control Circuitry on Drive.*** Used as the connection point for the signal common of an encoder. Used with Pin 2 as the power supply connection to an encoder.

Table 2-3: P1 -- Control Interface Connector Pinouts

Pin Numbers	Input or Output	Signal	Function
Pin 15	Input	- Tach	***Recommended Reference Input for Tachometer.*** Identical to signal common.
Pin 16	Input[A]	Hall B	***Hall Effect B.*** 1 of 3 commutation signals used with brushless motors. Used with Hall Effect A and C.
Pin 17	Input[A]	Hall C	***Hall Effect C.*** 1 of 3 commutation signals used with brushless motors. Used with Hall Effect A and B.
Pin 18	Input[A]	Sine	***Sine Signal from Encoder.*** Used as an option with cosine to derive an electronic tachometer signal. Line receiver input.
Pin 19	Input	Sine – N	***Compliment of Sine (P1 – 18).*** Line receiver input.
Pin 20	Input	Power	***5V On- board 5V Power Supply.***
Pin 21	Input	- Input	***Inverting Input of Differential Input Circuit.*** A positive voltage on this input causes CW motor rotation (torque or velocity mode). For single ended command operation, ground this connection and connect signal to Pin 8 of P1.
Pin 22	Input	Icmdb	***Current Command B.*** Jumper selectable input that bypasses differential input, pre-amplifier and self-commutation.
Pin 23	Output	- Fault	***Active High or Active Low (open collector) Output***. Jumper Selectable. Indicates the status of the power stage (drive enabled or faulted).
Pin 24	Input[A]	- Ilimt	***Directional Current Limit Input.*** Jumper Selectable. When pulled to its active state, negative motion (CCW motor shaft rotation) is inhibited.
Pin 25	Output	-Icmd	***Current Command Monitor.*** Representative of the current command.
Note: A. Denotes input pull up to internal +5V through a 10K resistor.			

Table 2-3: P1 -- Control Interface Connector Pinouts (cont'd.)

2.4. Electrical Specifications

2.4.1. Output Voltage

BA10 and BA20	80 – 320 Vdc
BA30:	160 – 320 Vdc

2.4.2. Peak Output Current (2 sec)

Current rating based on BA drive mounted to NEMA panel (*Figure 2-3*)

BA10	10 A (peak)
BA20	20 A (peak)
BA30	30 A (peak)

2.4.3. Continuous Output Current

Current rating based on BA drive mounted to NEMA panel (*Figure 2-3*)

BA10	5 A (peak)
BA20	10 A (peak)
BA30	15 A (peak)

2.4.4. Peak Power Output (Includes AC Line Drop)

BA10	2720 Watts
BA20	5440 Watts
BA30	8160 Watts

2.4.5. Continuous Power Output (Includes AC Line Drop)

BA10	1360 Watts
BA20	2720 Watts
BA30	4080 Watts

2.4.6. Efficiency

BA10 / BA20 / BA30 97%

2.4.7. Pre-amplifier Gain (Max.) – Velocity Mode

BA10 / BA20 / BA30 100 dB

2.4.8. Power Amplifier Gain – Current Command Mode

BA10	1 A/V
BA20	2 A/V
BA30	3 A/V

2.4.9. Power Amplifier Bandwidth

BA10 / BA20 / BA30 2 kHz

2.4.10. PWM Switching Frequency

BA10 / BA20 / BA30 20 kHz

2.4.11. Minimum Load Inductance (at 160 Vdc Bus)

BA10 / BA20 / BA30 0.8 mH

2.4.12. Maximum Shunt Regulator Dissipation

BA10	Not Included
BA20 and BA30	40 Watts

2.4.13. Operating Temperature

BA10 / BA20 / BA30 0 to 50°C

2.4.14. Storage Temperature

BA10 / BA20 / BA30 -30 to 85°C

2.4.15. Weight

BA10 and BA20	2.5 lbs. (1 kg)
BA30	3.0 lbs. (1.4 kg)

2.4.16. Modes of Operation (Jumper Selectable)

BRUSHLESS:

- Single current command with On-board 6-step commutation from Hall Effect Device (HEDs) inputs.
- Dual phase commands with sinusoidal commutation provided by an external motion controller, third phase command is derived from the drive.
- Velocity command with 6-step commutation from Hall Effect Device inputs and velocity feedback from the encoder or tachometer.

BRUSH:

- Single current command.
- Velocity command with velocity feedback from the encoder or tachometer.

2.4.17. Command Inputs

+INPUT (Pin 8) and –INPUT (Pin 21): Differential inputs for current or velocity commands, 0 to ±10 Vdc input. +INPUT (non-inverting) can be used in a single-ended fashion. A positive voltage on this input causes CCW motor rotation. -INPUT (inverting) can also be used in a single ended fashion. A positive voltage on this input causes CW motor rotation.

ICMDA (Pin 9) and ICMDB (Pin 22): Dual phase, ±10V input. ICMDA (Current Command A) and ICMDB (Current Command B) are jumper selectable current command inputs. They bypass the differential input, pre-amplifier and self-commutation circuit. They are to be used with motion controllers that provide external velocity loop and commutation control.

2.4.18. Feedback Inputs

Hall A (Pin 4), Hall B (Pin 16) and Hall C (Pin 17): Hall effect device inputs for commutation, 0 to 5 Vdc, internal pull-up, 10K input. Commutation signals used with brushless motors to provide motor rotation position information to the drive. This allows the drive to steer the three phases of the motor currents in such a fashion that it provides rotation of the motor in the desired direction and at the desired speed. TTL level input.

SINE/SINE-N (Pin 18) and COSINE/COSINE-N (Pin 5 and 6): Encoder inputs for velocity feedback, single ended 0 to 5Vdc TTL, internal pull-up 10K input. Sine and Cosine are optionally used in conjunction with one another for deriving an electronic tachometer signal.

+TACHOMETER (Pin 3): Tachometer input for velocity feedback (encoder vs. tachometer velocity feedback is jumper selectable). A tachometer may be used in the velocity loop configuration to provide negative feedback to the drive. This allows the drive to close the servo loop and control the stability of the loop.

TACHOMETER (Pin 15): Reference input for tachometer (point is identical to signal common).

2.4.19. Logic Inputs

-ILMT (Pin 24) and +ILMT (Pin 11): Directional current limit inputs (jumper selectable polarity). When +ILMT is pulled to its active state, motion in the positive direction (CW motor shaft rotation) is inhibited. When –ILMT is pulled to its active state, motion in the negative direction (CCW motor shaft rotation) is inhibited. TTL level input 0 to 5 Vdc, internal pull-up, 10K input.

-SHUTDOWN (Pin 10): Jumper selectable active high or active low input. Used to shut off power stage and thus remove all power to the motor. TTL level input 0 to 5 Vdc, internal pull-up, 10K input.

PWM Sync (Pin 13): This input allows for an external 20 kHz square wave input to control the PWM circuit. This input can only be used in conjunction with the BB501 interface board (contact factory for additional information).

SIGNAL GROUND (Pin 7 and 14): Electrical reference for all control circuitry on drive.

SIGNAL SHIELD (Pin 1): Connected internally to earth ground. Reduces electrical noise in control and feedback signals.

FAULT (Pin 23): Jumper selectable active high or active low output. Indicates the status of the power stage (drive enabled or disabled). The fault output goes to its active state upon a power stage fault, thermal overload, RMS current limit, power supply under voltage condition and DC bus over-voltage condition. Open collector output. Requires pull-up resistor to external power supply ranging from +5 to +30V.

2.4.20. Monitor Outputs

FDBK (Pin 12): Current feedback monitor. When running a brushless motor, this signal represents the current in the Motor Phase A. When running a brush motor, this signal represents the entire motor current. ± 2.6V output.

PHASE A: Output is 3.75 A/V for BA10, 7.5 A/V for BA20 and 11.25 A/V for BA30.

ICMD (Pin 25): Current command monitor. Representative of the current command. ±3V output.

2.4.21. Power Inputs

AC Input: AC HI, AC LO, Earth Ground, 56 to 230 Vac, 50 to 60 Hz, single phase.

2.4.22. Motor Outputs

Motor: Phase A, B and C: 30A peak / 15A continuous, 320 Vdc maximum output.

2.4.23. Auxiliary Power Outputs

5V (Pin 20): On-board 5V power supply. 250 mA maximum output.

5V (Pin 2): On-board 5V power supply. Pin 2 is intended for powering an encoder. Can supply up to 250 mA of current.

2.4.24. Connectors

Control: 25-pin “D” style female.

Power: 6-pin unpluggable screw terminal for AC input and motor output; mate provided.

2.4.25. Potentiometers

Gain: Adjusts pre-amplifier AC gain.

BALance: Nulls command input DC offsets.

TACH: Adjusts gain of encoder or tachometer derived velocity feedback input.

INPUT: Adjusts gain of command input.

2.4.26. DIP Switches

Peak Current Limit: Four switches allow User to set the peak current from 6 to 100% of maximum value.

RMS Current Limit: Four switches allow User to set RMS current from 6 to 100% of maximum value.

Mode: This switch selects current or velocity mode.

Test: This switch selects test mode to allow the BALance pot to be used as velocity or current command.

2.4.27. Protective Features

- Output Short Circuit
- Peak Over Current
- RMS Over Current
- DC Bus Over-voltage
- Over-temperature
- Control Power Supply Under-voltage
- Power Stage Bias Supply Under-voltage

2.4.28. Isolation

Opto and transformer isolation between control and power stages.

2.4.29. Indicator

LED indicates drive enabled.

2.5. Dimensions

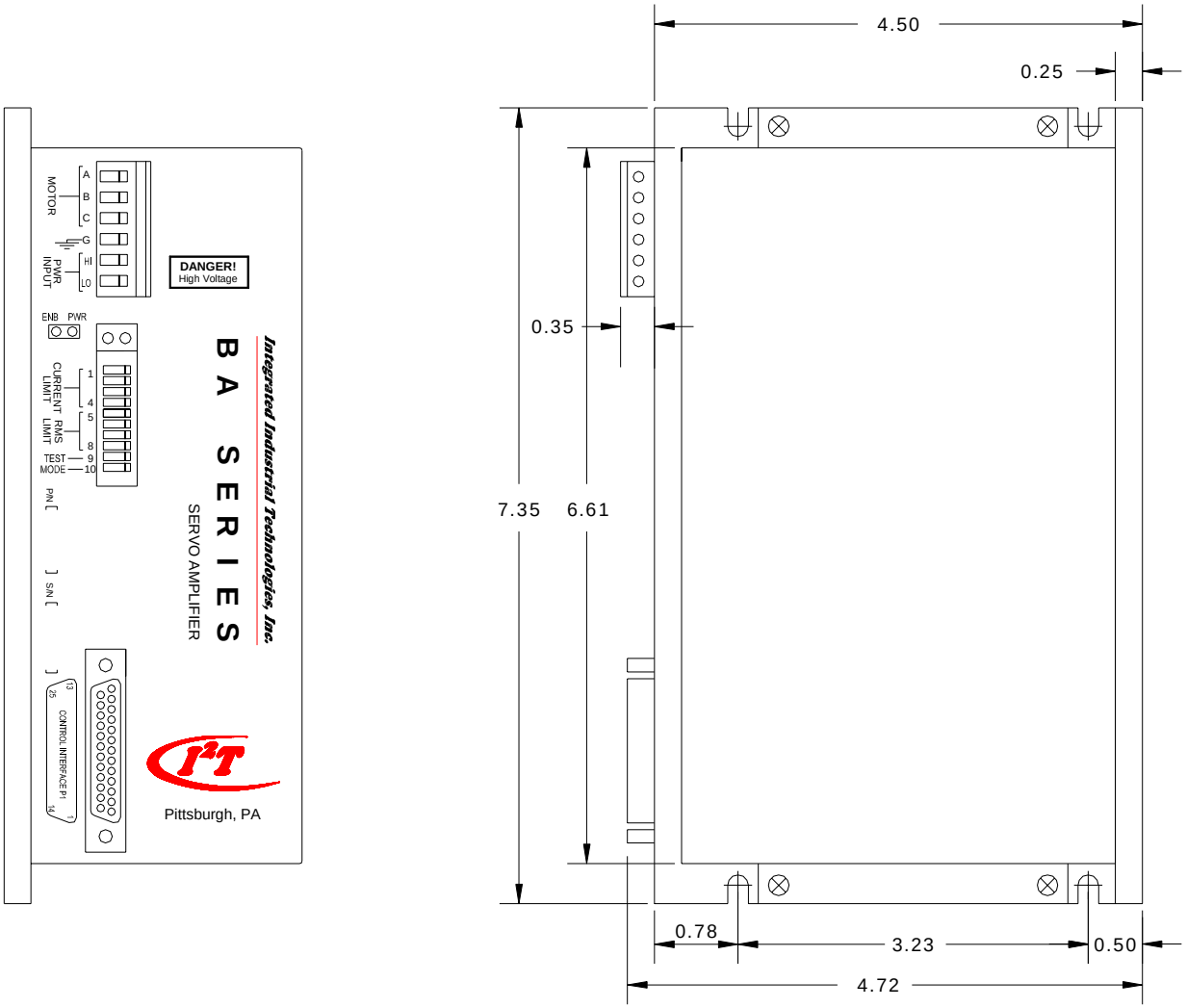


Figure 2-3: BA 10, BA20 and BA30 Series Drive Dimensions (inches)

2.6. Mounting

I^2T recommends using a heat sink and fan when mounting a BA series drive.

NOTE **It is advisable that the drive be mounted lying flat on a metal panel not less than two square feet for better heat dissipation (*Figure 2-4* and *Figure 2-5*).**

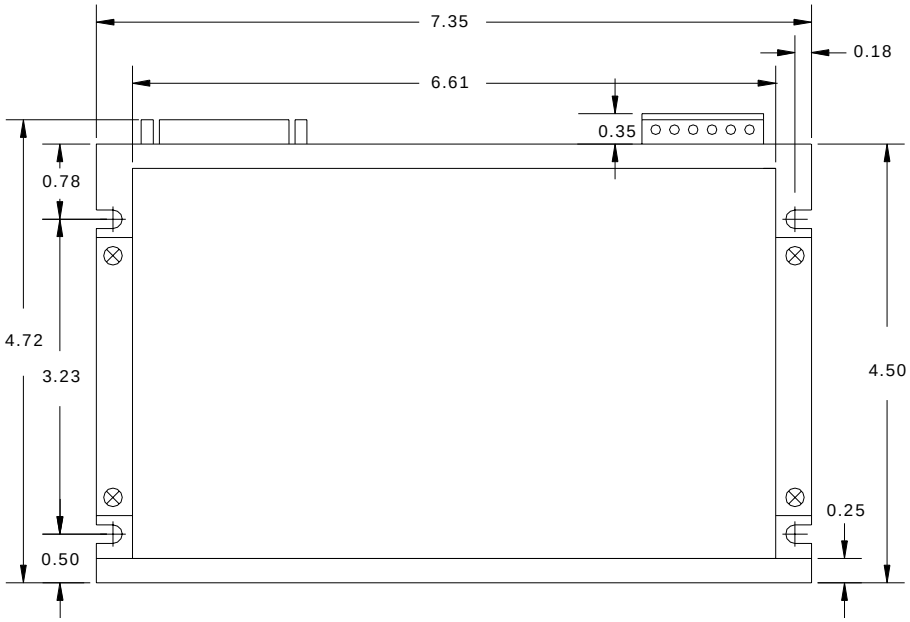


Figure 2-4: Preferred Mounting (Top View)

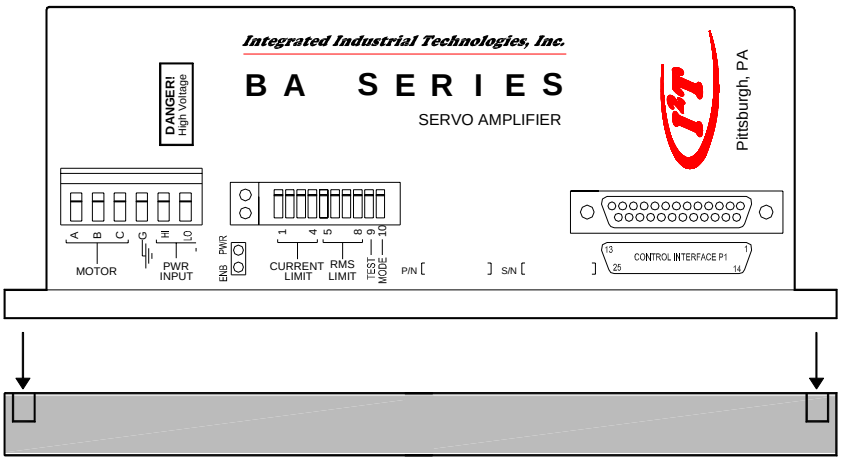


Figure 2-5: Preferred Mounting (Side View)

In this Chapter you will learn about:

- Inspecting the Shipment
- Configuring the Jumpers
- Installing/Integrating the Drive
- Wiring the Drive

3.1. Shipment Inspection

Check your BA Series package, upon receipt, for obvious damage that may have occurred during shipment. Report any damage to the shipping company immediately. I^2T cannot be held responsible for damage incurred during shipment. Along with your BA Series Drive, the following should be included:

- BA Series User's Manual (P/N 5001-01)
- Heat Sink
- Metal Cover
- Shunt Regulator (not included w/ BA10 drive)
- Bus Power Supply

Retain the shipping container in case you need to return the BA Series Servo Drive for any reason. Any damage incurred due to improper packing is the responsibility of the shipper and will further delay the repair or replacement of your parts.

3.2. Jumper Selection

The BA Series Servo Drives are jumper selectable providing the user with quick reconfiguration capability of operating modes. *Table 3-1* provides a list of the jumpers and the default configurations set in the drive.

Jumpers	Position	Function
JP2	1-2	Over-voltage Monitor. Shuts off drive if bus voltage exceeds a preset threshold. (Default on BA10)
	2-3	Shunt Option. Allows optional shunt regulator to activate and pull elevated bus voltage back into range. This shuts the drive off if the fuse in the shunt regulator opens. (Default on BA20 and BA30)
JP3	1-2	Selects brushless mode of operation. (Default)
	2-3	Selects brush mode operation.
JP4	1-2	Active High Shutdown Input. Logic high on P1-10 shuts off power stage. (Default)
	2-3	Active Low Shutdown Input. Logic low (5V) on P1-10 shuts off power stage.
JP5	1-2	Selects brushless mode operation. (Default)
	2-3	Selects brush mode operation.
JP6	1-2	Selects brushless mode of operation. (Default)
	2-3	Selects brush mode of operation.
JP7	1-2	On-board triangle wave generator performs pulse width modulation of current commands. (Default)
	2-3	External square wave used for pulse width modulating commands (external square wave signal can only be generated through BB501 interface board. Contact factory for additional information.)
JP8	1-2	Provides 120° commutation. (Default)
	2-3	Provides 60° commutation.
JP9	1-2	Active Low + ILMT. Logic low on P1-11 stops CW (+) motor movement. (Default)
	2-3	Active High + ILMT. Logic (5V) on P1-11 stops CW (+) motor movement.
JP10	1-2	Active Low – ILMT. Logic low on P1-24 stops CCW (-) motor movement. (Default)
	2-3	Active High – ILMT. Logic high (5V) on P1-24 stops CCW (-) motor movement.
JP11	1-2	Power stage drive signal (Phase A) derived from differential pre-amp input. BA drive performs self-commutation. (Default)
	2-3	Power stage drive signals derived from input signal at P1-9. Controller must perform commutation.
JP12	2-3	Active low fault output. Open collector output P1-23 pulls to a logic low to indicate a drive fault.
	1-2	Active high fault output. Open collector output P1-23 sets to a high impedance state (must be pulled to a logic high by an external resistor) to indicate a drive fault. (Default)
JP13	1-2	Power stage drive signal (Phase B) is derived from differential pre-amp input. Drive performs self-commutation. (Default)
	2-3	Power stage drive signals are derived from input signal at P1-22. Controller must perform commutation.
JP14	2-3	Current command configuration or tachometer feedback through pin 3 of P1 in the velocity loop configuration. (Default)
	1-2	Electronic tachometer signal derived from encoder signals in velocity loop configuration. Allows P1-3 to be used as a velocity monitor.
JP15	1-2	Selects brushless mode operation. (Default)
	2-3	Selects brush mode operation.
JP22	1-2	Signal common of control section connected to earth ground (Motor and AC Power Connector, Pin 4). (Default)
	2-3	Signal common, not referenced to earth ground.

Table 3-1: Jumper Selections

3.3. System Integration

BA Series Servo Drives can be integrated into a system using three basic configurations: Velocity, Current and Dual-phase Command. Each configuration has its own set of advantages and disadvantages, depending upon the user's specific needs.

3.3.1. Velocity Command Configuration

In the velocity command configuration (*Figure 3-2*) the drive controls the speed of the motor. A feedback signal from an incremental encoder or DC tachometer is monitored by the drive. From this signal, the drive adjusts the velocity of the motor accordingly, depending upon the velocity command set or sent from the external motion controller. In this configuration the drive closes and controls the velocity loop. This configuration can drive brush or brushless DC motors.

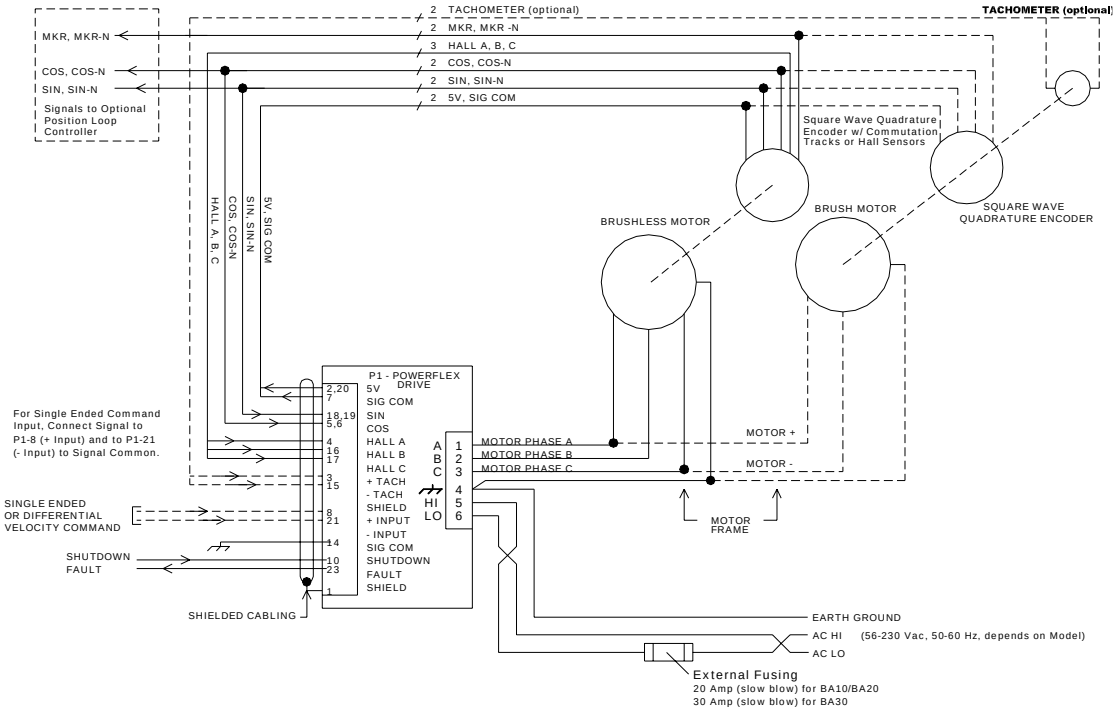


Figure 3-2: Velocity Command Configuration

3.3.2. Current Command Configuration

In this configuration (*Figure 3-3*) the output current to the motor is proportional to the current command input. The advantage to this configuration is the sine and cosine signals to the drive and a tachometer are not required. Like the Velocity Command Configuration, this setup drives both brush and brushless DC motors.

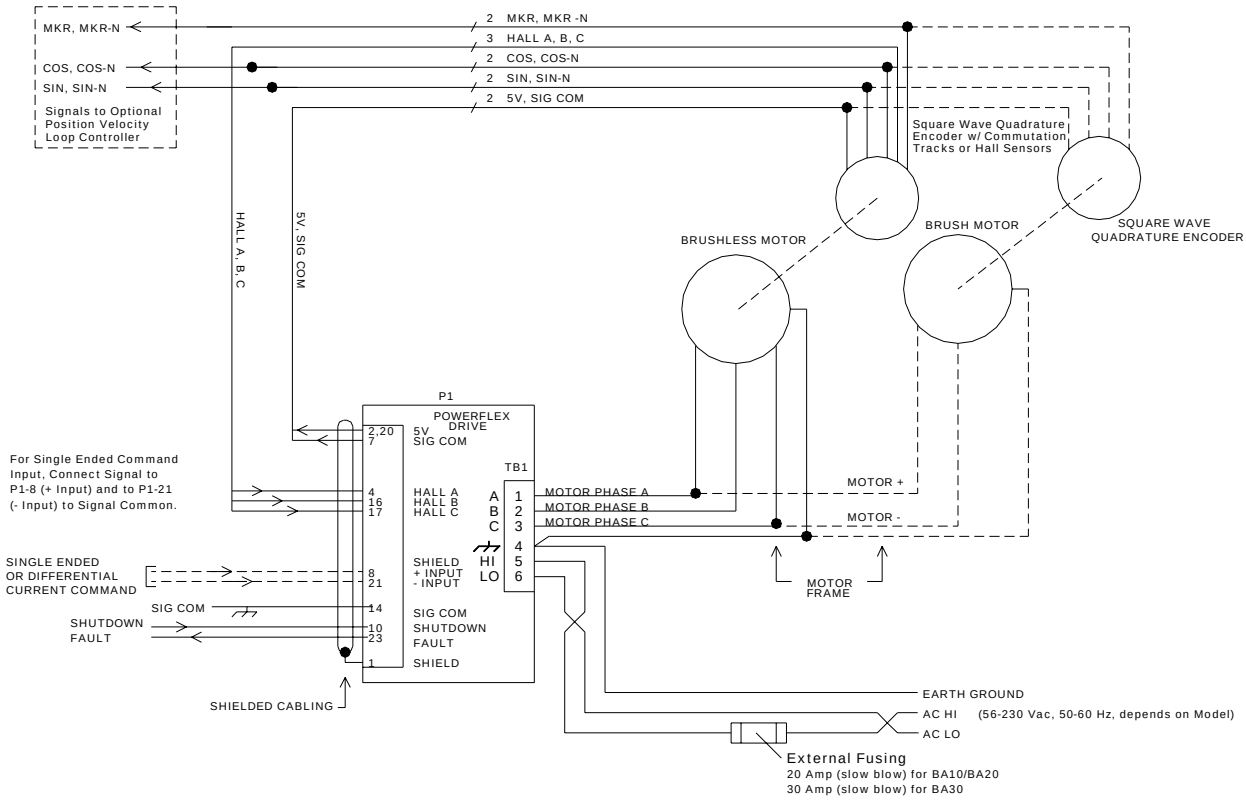


Figure 3-3: Current Command Configuration

3.3.3. Dual-phase Command Configuration

This mode is used with brushless motors only. The differential input, pre-amplifier, and self-commutation circuits are bypassed (*Figure 3-4*). The dual-phase inputs are sinusoidal and 20° out of phase from each other. The third phase is generated by the drive. The advantage to this configuration is that it provides the smoothest possible motion.

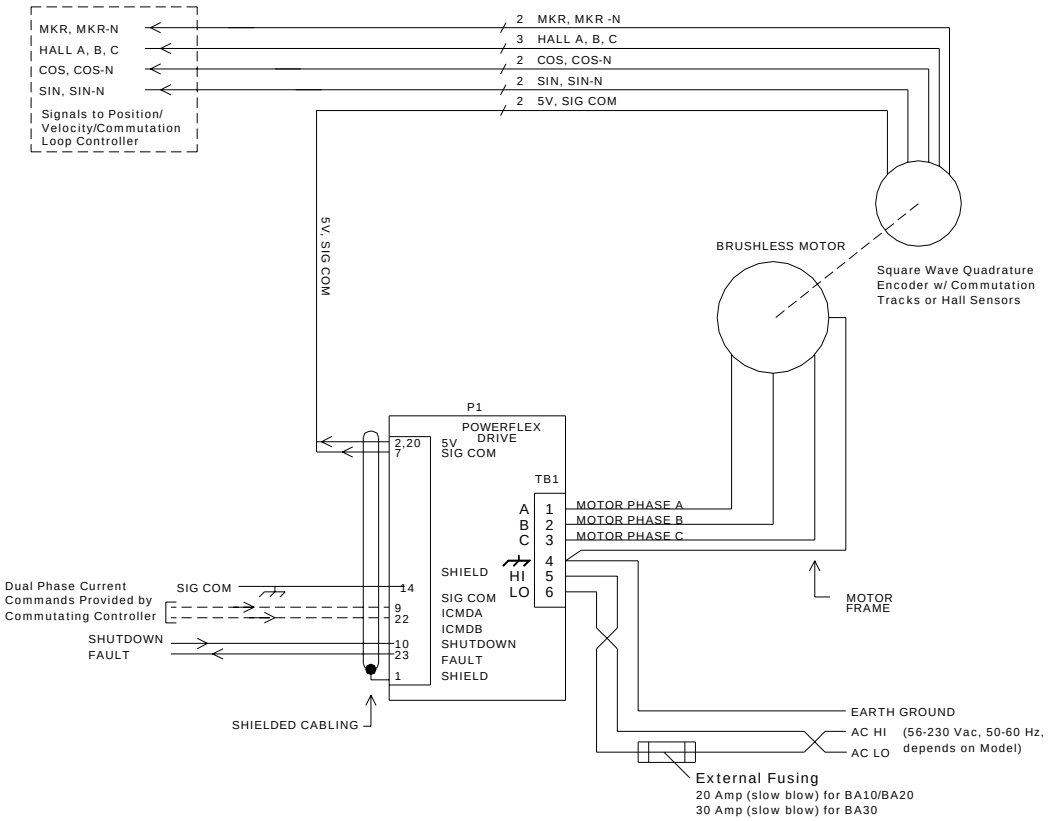


Figure 3-4: Dual-phase Command Configuration

3.4. Wiring and Grounding

To reduce electrical noise in the BA Series Servo Drive, observe the motor and input power wiring techniques explained in the following sections.

3.4.1. Minimizing EMI Interference

The BA10/20/30 are high efficiency PWM drives operating at a 20 kHz switching rate.

The switching time between positive and negative rails on each of the motor leads is less than 50 nano-seconds for a 320 Vdc bus. This switching rate generates Electromagnetic Interference (EMI) into the Mega Hz band. To minimize EMI, twist motor leads together with the motor cable grounding wire and surround it using a foil shield (*Figure 3-5*)

In addition to EMI effects, electro-static (capacitive) coupling to the motor frame is very high and thus requires grounding the frame to eliminate shock hazard. Additional electro-static coupling exists between the three twisted motor leads and the foil shield of the motor cable.

The coupling forces high frequency currents to flow through the returning earth ground of the motor cable. To minimize this problem and maintain low levels of EMI radiation, the motor should be wired according to *Figure 3-5.*

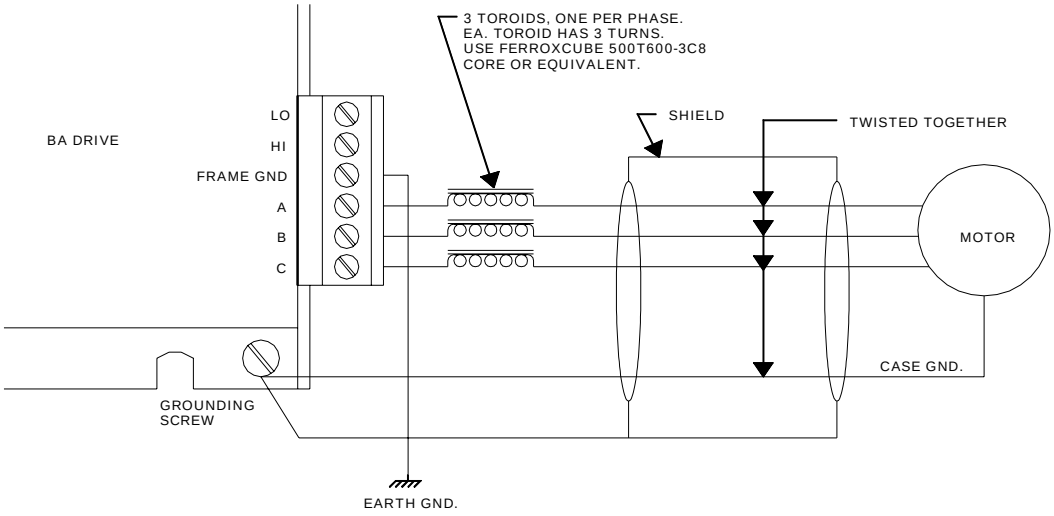


Figure 3-5: Wiring to Minimize EMI and Capacitive Coupling

NOTE **This configuration is important if the BA Drive is operating at DC bus voltages of 160 Vdc or 320 Vdc (i.e., 115 Vac or 230 Vac input power).**

3.4.2. Power and Control Connections

The BA drive can be wired into a system in one of two ways, depending upon the desired mode of operation. Command signals can be referenced to velocity or torque (current) control signals. The user has access to four potentiometers, three that adjust gain while the fourth (BALance) compensates for input signal offsets. *Figure 3-5* illustrates a portion of the pre-amplifier circuit that is accessible to the user for adjusting command signal gains.

NOTE **For adjustments in gain roll-off, "Personality Module" RCN1, pins 7-12 and 8-11 are provided for the selection of the appropriate resistor/capacitor pair (factory default values are shown in *Figure 3-6*).**

3.4.3. Setup – Torque Command Mode (Current)

To setup the pre-amplifier circuit for use in the torque (current) command mode, configure the BA drive as follows:

- Place SW1 position 10 (mode) to closed (***default***)
- Place SW1 position 9 (test) to open (***default***)
- SW1 positions 1 - 4 selects current limit, while 5 - 8 selects RMS limit
- Setting INPUT full CW and GAIN full CCW provides a transconductance gain of ±10V for full current output. BALance and TACH have no effect.
- Set JP14 to 2-3 (***default***)
- Set JP11 and JP13 to 1-2 (***default***)
- Set JP3, JP5, JP15 and JP6 to 1-2 (***default***) for brushless motor operation or 2-3 for brush motor operation
- Set JP8 to 1-2 (***default***) for 120° commutation or 2-3 for 60° commutation (brushless motor operation only).

With Torque Command Mode, an input signal of ±10V to pins +INPUT and –INPUT produces the maximum current output signal (viewed at P1 pin 25 ICMD) or ±3V. Use switch SW1 positions 1 - 4 to scale this ±3V signal from zero to maximum current. Refer to *Figure 3-3* for torque command configuration.

3.4.4. Setup – Velocity Command Mode

This mode (*Figure 3-3*) requires a velocity feedback signal. You can derive this signal from two sources: 1.) Incremental Encoder connected to the sine and cosine pins, or 2.) Analog DC Tachometer connected to the +TACH pin. To setup the pre-amplifier circuit for use in the velocity command mode, configure the BA Servo Drive as follows:

- Place SW1 position 10 (mode) to open
- Place SW1 position 9 (test) to open (***default***)
- Set SW1 positions 1 - 4 for current limit, and positions 5 - 8 for RMS limit
- INPUT, GAIN, BALance and TACH pots adjust pre-amplifier gain and offset.

For most applications under the velocity command mode, the preferred starting point for setting the three gain potentiometers is as follows

- INPUT – 1/3 CW from full CCW
- TACH – 2/3 CW from full CCW
- GAIN – full CW

NOTE **These initial settings usually generate a stable system assuming 1.) an encoder is used and the line resolution is between 1000 and 1500 per rev, or 2.)that the tach feedback gain is around 3V/Krpm.**

- Set JP14 to 1-2 for encoder or 2-3 (***default***) for tachometer velocity feedback
- Set JP11 and JP13 to 1-2 (***default***)
- Set JP3, JP5, JP15 and JP6 to 1-2 (***default***) for brushless motor operation or 2-3 for brush motor operation
- Set JP8 to 1-2 (***default***) for 120° commutation or 2-3 for 60° commutation (brushless motor operation only).

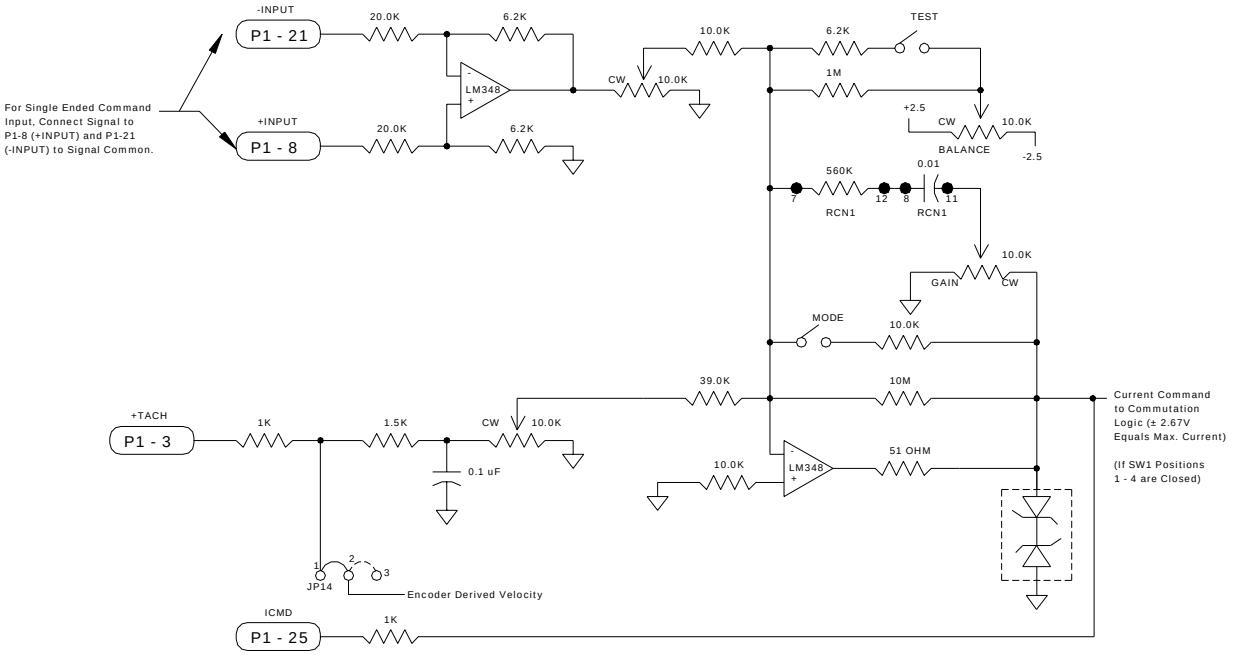


Figure 3-5: Command Signal Adjustment of the Pre-amplifier Circuit

WARNING ☝ **To minimize the possibility of electrical shock and bodily injury, verify the motor is decoupled from the mechanical system to avoid personal injury if the motor begins to spin.**

Starting with a zero input command signal, apply power to the drive. If the motor spins uncontrollably, remove power and switch the polarity of the TACH input signal. When using an encoder, switch the sine and cosine input signals. Verify compliment signals (SIN and Sin-N, COS and COS-N) are of correct phasing.

Again, apply power to the drive. If the motor begins to oscillate, turn the TACH pot CCW until oscillation stops. The GAIN and TACH potentiometer can be adjusted to provide maximum stiffness on the motor shaft.

NOTE ☝ **If the desired stiffness is unattainable, the components connected to personality module RCN1 pins 8-11 and 7-12 may need to be changed.**

The BALance pot cancels any bias in the internal or external control circuit that would cause the motor to rotate when the input command signal is zero.

If the TEST switch is closed, the effects of the BALance pot are greatly magnified. This is useful when a test bias signal is desired (for velocity or torque modes) to be applied to the drive without introducing an external command signal.

3.4.5. Setup – Dual-phase Command Mode

To setup the pre-amplifier circuit for use in the dual phase command mode, configure the BA drive as follows:

- Set JP11 and JP13 to 2-3
- Set JP3, JP5, JP15 and JP6 to 1-2 (***default***)

This mode is used with brushless motors only. Refer to *Figure 3-4* for the Dual-phase Command configuration.

3.5. Motor Phasing

When configuring the BA drive to run a brushless motor, the commutation signal input connections (Hall A, B, C on connector P1 – pins 4, 16 and 17) are necessary. Two sequences of 60° and 120° (***default***) signal separation can be used, depending on the setting of JP8. These sequences and the generated output motor phase voltages (motor output connections A, B and C) are shown in *Figure 3-7*. The voltages generated are made under the conditions of a positive signal placed at +INPUT with respect to –INPUT at control signal input/output connector P1. A "0" for the given HALL input indicates zero voltage or logic low, where "1" indicates five volts or logic high.

WARNING ☞ **When using a brushless motor with your BA drive, motor phase and Hall connections can be easily determined by referring to the system interconnection drawings in *Figure 3-2*, *Figure 3-3* and *Figure 3-4*.**

3.5.1. Determining Phase/Hall Sequence

For a motor with an unknown phase/hall sequence, a simple test can be performed on the motor to determine the proper connections to the BA drive.

WARNING ☞ **Before performing the following steps, verify the motor leads are completely disconnected from the drive.**

NOTE ☝ **The tests outlined below do not require that the drive be turned on since *Figure 3-7* illustrates the generated output voltage of the drive relative to the input Hall sequences.**

The equipment needed for this test is a two-channel oscilloscope and three resistors (typically 10K Ohm, ½ watt) wired in a Wye configuration.

Connect the ends of the three resistors to motor terminals A, B and C. Use one channel of the oscilloscope to monitor motor terminal A with respect to the Wye neutral (i.e., point where all 3 resistors are connected). Turn the shaft of the motor CCW and note the generated voltage. This voltage represents the Phase A to neutral CEMF. With the second oscilloscope probe, determine the Hall switch that is "in phase" with this voltage. Similarly, Phase B and C should be aligned with the other two Hall switches.

Refer to *Figure 3-7* and note the generated output voltages of the drive relative to the Hall sequences applied to Hall A, B and C connections at connector P1. For proper operation, the CEMF generated motor phase voltages should be aligned to the drive's output generated voltage with the given Hall effect sequence shown in *Figure 3-7*.

If the sequence of Hall signals relative to the generated motor voltage (i.e., motor CEMF) is adhered to as shown in *Figure 3-7*; a positive (+) voltage signal applied to pin 8 (+INPUT) of connector P1 relative to pin 21 (-INPUT) of P1 or pin 19 (signal common) of P1 will produce a CCW (i.e., a negative rotation) rotation of the motor shaft as viewed from the front of the motor.

DEGREES	COMMUTATION SEQUENCE (HALL A, B, C)					
60	000	100	110	111	011	001
120	101	100	110	010	011	001

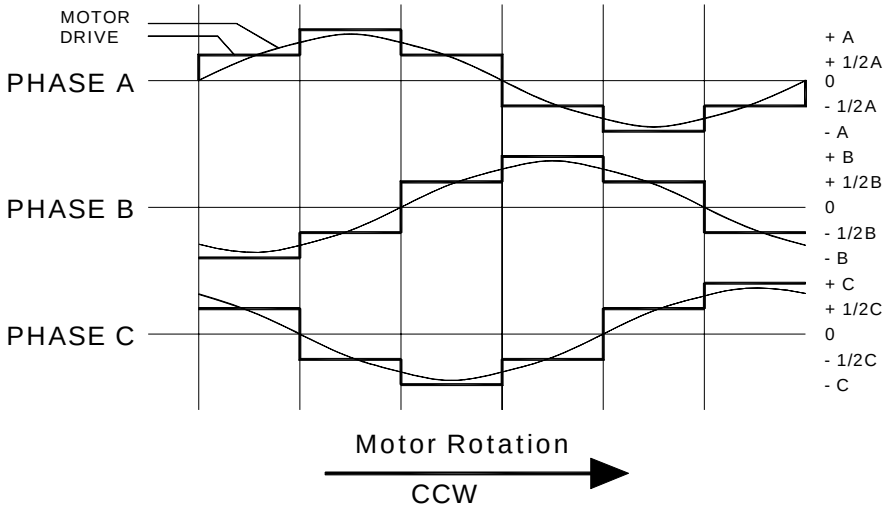


Figure 3-7: Motor Phasing

3.6. Current Regulator Adjustment

The three-phase current regulator circuit is illustrated in *Figure 3-8*. Details to this circuit, like the pre-amplifier circuit described earlier are provided so that the user may optimize gains.

The BA drive provides three independent current regulator circuits, one for each phase of the DC brushless motor (for DC brush motors, only Phase A regulator is used). Regulators A and B are provided with a current command from either the internal six-step commutation circuit or an external current command input (ICMDA and ICMDB), depending on the settings of JP11 and JP13.

Two internally isolated circuits, one for Phase A and one for Phase B, provide the motor current feedback signals.

The two current command signals and the two current feedback signals are each summed with the result providing the current command and current feedback signals for Phase C.

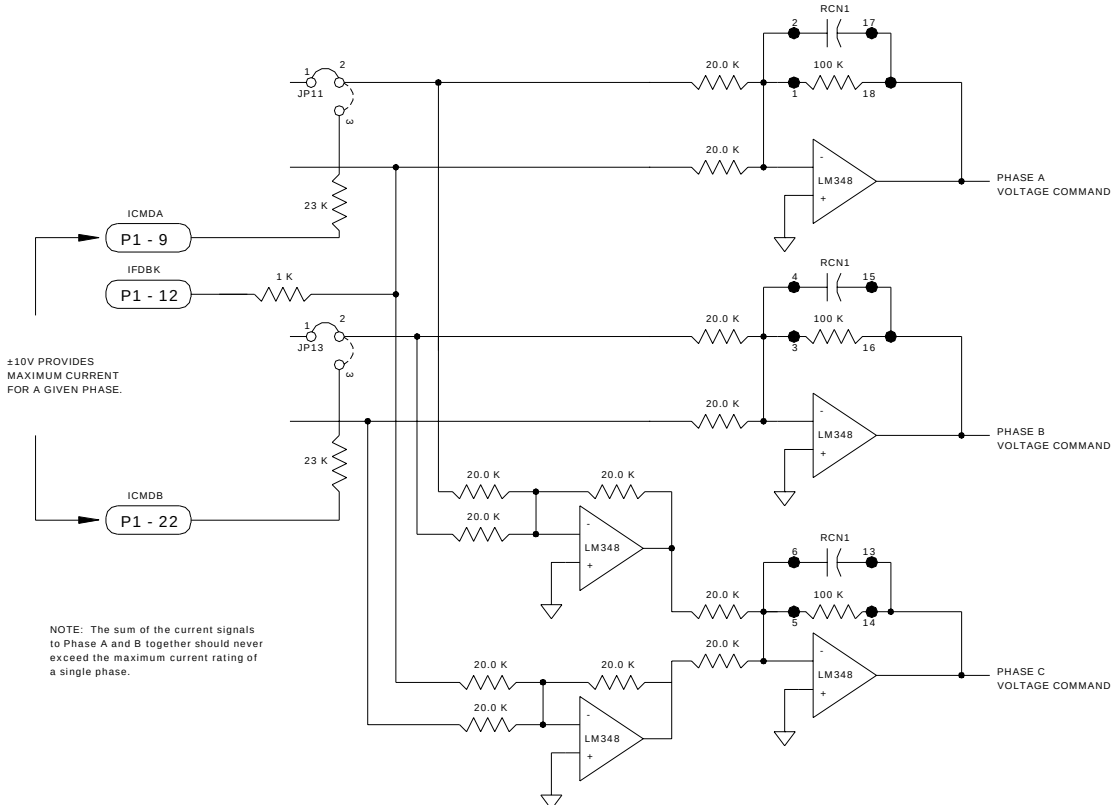


Figure 3-8: Three-phase Current Regulator Circuit

Pins 1-18 and 2-17 "personality module" RCN1 provide gain compensation for the Phase A regulator circuit. Similar compensation is provided for Phase B and C circuits (*Figure 3-8*). The default values for these selectable components (RCN1) are shown in *Figure 3-8*.

Connection IFDBK (Pin 12 of P1) monitors the Phase A current. For brushless motor operation, the signal at this pin represents motor Phase A current. For brush motor operation, this signal represents the current flowing in the motor armature.

In this Chapter you will learn about:

Troubleshooting Procedures

Amplifier Related Problems

4.1. Troubleshooting Procedures

The information in this chapter will help you isolate and resolve hardware problems.

When your system does not function properly (or as you expect it to operate), the first thing that you must do is identify and isolate the problem. When you have accomplished this, you can effectively begin to resolve the problem.

The first step is to isolate each system component and ensure that each component functions properly when it runs independently. You may have to dismantle your system and put it back together piece-by-piece to detect the problem. If you have additional components available, you may want to try replacing them with existing components or components that are working in another system. You should also try removing features until the component is running in its most basic mode.

Determine if the problem is mechanical, hardware, or software-related. Try to recreate or repeat the problem. Do not attempt to make quick rationalizations about the problem. Random events may appear to be related, but they are not necessarily contributing factors to the problem. You must carefully investigate and decipher the events that occur leading up to the problem at hand.

You could be experiencing more than one problem. Try to isolate and solve one problem at a time. Document all testing and problem isolation procedures for review with a technician at a later time. When you feel that you have exhausted all possibilities and the problem still exists, call your local distributor or I^2T Technical Support at (412) 828-1200. Please have the following information available when you call.

- Product Part Number
- Product Serial Number
- Detailed Description of Problem
- Description of Application

4.2. Amplifier Related Problems

This section defines probable causes and solutions related to the BA amplifier operation. The following problem/cause and solution guide will help you to correct the most common cases of irregular operation.

4.2.1.1. Amplifier Problems, Causes and Solutions

PROBLEM/CAUSE	SOLUTION
ENABLE LED fails to energize when AC input power is applied. ***Cause*** may be insufficient input voltage.	Use volt meter to check voltages at "HI" and "LO" AC input terminals.
PROBLEM/CAUSE	**SOLUTION**
ENABLE LED fails to energize when AC input power is applied. ***Cause*** may be short circuit condition at motor connections A, B and C.	Disconnect motor connections from BA amplifier and check resistance at each terminal relative to the other terminal. Resistance should read the same for all terminals (between 0.5 and 2 omega, depending on motor).
PROBLEM/CAUSE	**SOLUTION**
ENABLE LED fails to energize when AC input power is applied. ***Cause*** may be a short condition between motor connections and case of motor.	Use ohm meter to check resistance between all motor leads and motor frame (ensure motor is disconnected from drive). Resistance should read "infinity".
PROBLEM/CAUSE	**SOLUTION**
ENABLE LED fails to energize when AC input power is applied.	Shutdown, P1-10 is not in active state for running amplifier.
PROBLEM/CAUSE	**SOLUTION**
Brushless motor will not spin in open loop current mode. ***Cause*** may be motor phases A, B and C connected incorrectly relative to HA, HB and HC hall inputs.	See section on motor phasing.
PROBLEM/CAUSE	**SOLUTION**
Motor spins uncontrollably in velocity mode configuration. ***Cause*** may be encoder (sine and cosine) signals or tachometer (±) signals are improperly connected.	Swap connections to change polarity of feedback.

PROBLEM/CAUSE	SOLUTION
Drive faults (ENABLE LED de-energizes) when motor decelerates. ***Cause*** may be shunt fuse is open (BA20) or bus over-voltage detected (BA10)	Both conditions indicate an excessive regeneration condition. In the case of the BA20, disconnect the drive and replace the shunt fuse. The BA10 requires that a shunt regulator be mounted in the unit.
PROBLEM/CAUSE	**SOLUTION**
Motor runs erratic in velocity mode using encoder for velocity feedback. ***Cause*** may be the phase of the sine/cosine signal of the encoder is not separated by 90 degrees.	The encoder must be adjusted on the motor.
PROBLEM/CAUSE	**SOLUTION**
Motor runs erratic in velocity mode using encoder for velocity feedback. ***Cause*** may noise on the sine/cosine signals of the encoder.	Use a shield or twisted pair (signal common wrapped around sine/cosine wires) cable between the motor and the drive.
PROBLEM/CAUSE	**SOLUTION**
Drive faults ENABLE LED de-energizes. ***Cause*** may be RMS current is exceeded.	Turn off and then back on, run at lower current.
PROBLEM/CAUSE	**SOLUTION**
Drive faults ENABLE LED de-energizes. ***Cause*** may be over-temperature condition.	Turn off and let drive cool. Provide better ventilation.
PROBLEM/CAUSE	**SOLUTION**
Drive faults ENABLE LED de-energizes. ***Cause*** may be defective on board power supply.	Return for repair.
PROBLEM/CAUSE	**SOLUTION**
Drive faults ENABLE LED de-energizes. ***Cause*** may be over-loaded logic power supply.	Remove device(s) being powered from drives 5V supply.