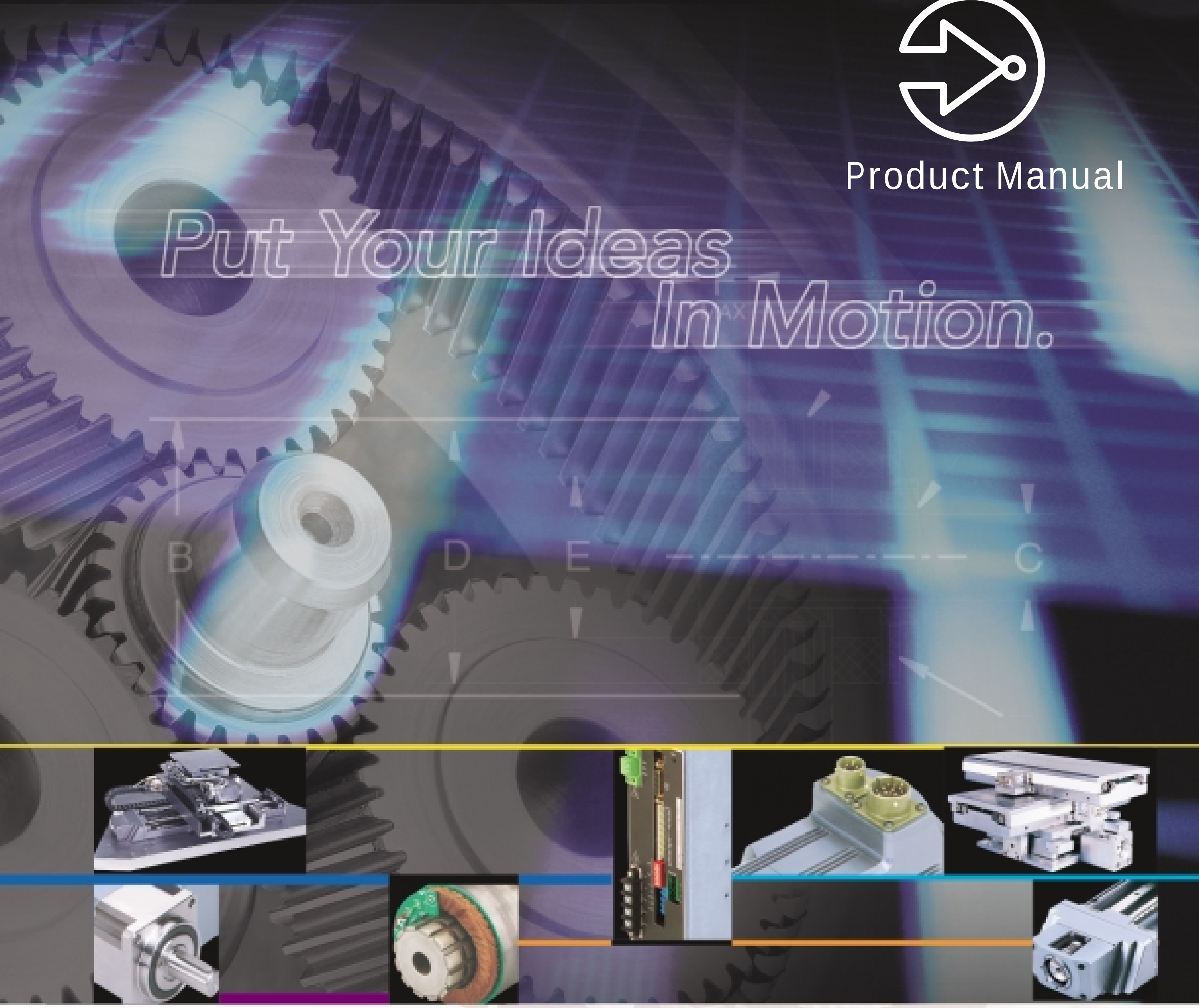
Product Manual



BAYSIDE®
Motion Group

Brushless Analog Servo Amplifier Product Manual

BAC/BDC Series
Brushless Servo Amplifiers

Product Manual

Rev: 1.2 / 0901
P/N: 12197007

Please check www.baysidemotion.com for latest revisions.

Product Manual

Brushless Servo Amplifiers

Table Of Contents

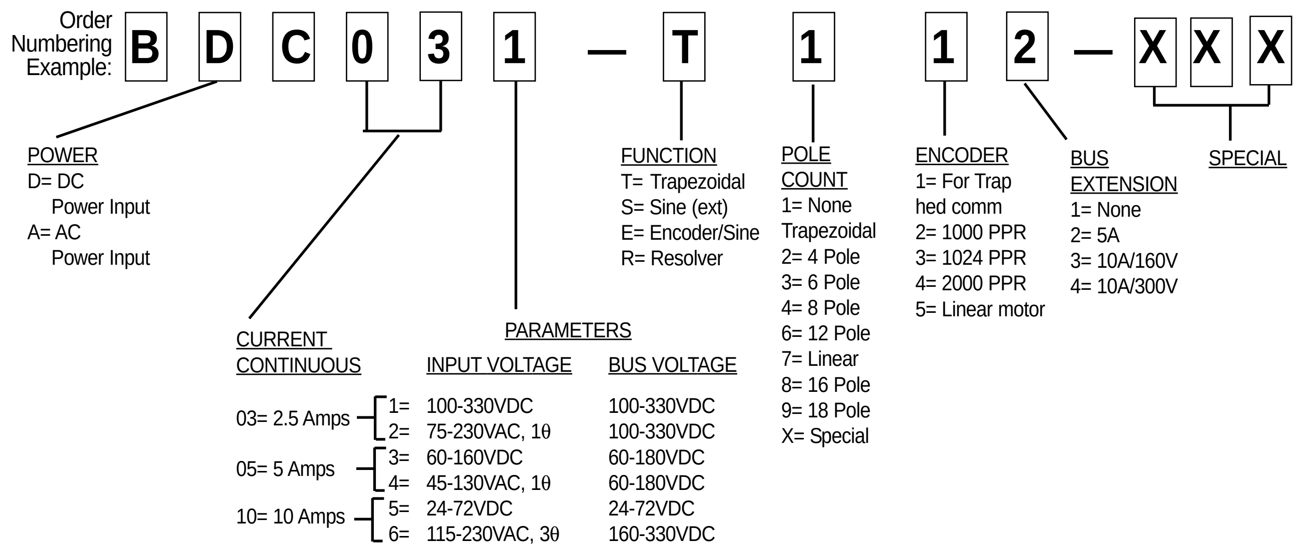
BAYSIDE® Motion Group

27 Seaview Boulevard * Port Washington, NY 11050 * ☎ 516-484-5353 * Fax: 516-484-5496
baysidemotion.com

I. Introduction

Thank you for purchasing a BAC/BDC Series Brushless Servo Amplifier. This manual provides installation, application, specification and maintenance information for the following models:

BAC03
BAC05
BAC10
BDC03
BDC05
BDC10



These amplifiers provide power for brushless DC motors, with Hall, encoder or resolver feedback. Either six step (trapezoidal), or sine wave operation is available.

Since the BAC/BDC amplifiers are the analog type, neither a computer nor software is required to configure the amplifier for any particular application.

Models are available for operation from 24 to 322 volts DC or 45 to 230 volts AC (RMS) with continuous/peak output current ratings of 2.5/5 amp, 5/10 amp and 10/20 amp, as shown in the following table:

Model	Power	Output Current (A) Cont.	Peak
BAC03	75 to 230 VAC 1 ph	2.5	5
BAC05	45 to 130VAC 1 ph	5	10
BAC10	115 to 230 VAC 3 ph (1ph)	10 (7.5)	20 (15)
BDC03	100 to 330 VDC	2.5	5
BDC05	60 to 180 VDC	5	10
BDC10	24 to 72 VDC	10	20

The sine waves can be generated either by an “on-board” circuit operating in conjunction with encoder or resolver feedback or by two of the three sine waves supplied by the system controller.

The design has been optimized by the use of surface mount technology, providing a full complement of brushless DC motor control features while minimizing volume. Torque mode and velocity mode operation is standard. Torque mode is implemented with three independent current loops for precise control. Velocity mode control is provided by either Hall sensor, encoder, resolver or tachometer feedback.

In the torque mode, the BAC/BCD amplifiers are typically used with motion controllers or modules that output a -10 to +10 volt analog command to control motor torque.
Velocity operation is available for a wide speed range, with Hall feedback providing acceptable performance at high speeds and encoder or tachometer feedback required for low speed applications.

Buffered encoder outputs or emulated encoder outputs from resolver feedback are provided for transmission to the system controller.

Continuous and peak current are independently adjustable via binary encoded switches. Peak current operation includes an inverse time-out feature to allow for optimum acceleration performance combined with protection for both the amplifier and the motor.

The power output stage consists of three MOSFET or IGBT half bridges, operating in a 50/50 PWM mode at 20 KHz, eliminating dead-band while providing full, four quadrant control.

A regen. circuit is provided in all BAC models to prevent an over-bus condition. The built-in regen. resistor may be paralleled, if needed, by an external resistor via a connector. This connector also provides access to the bus voltage, which can be used to power additional amplifiers in a multiple axis application. Power is available for either encoders or resolvers.

Protection against output-to-output and output-to-ground shorts are provided. Thermal protection is provided for both the output power stage and the motor. Fault protection is also provided for the on-board low voltage power supplies and an over bus condition. Fault indicators are provided by three LEDs. A fault condition is latched and can be reset by way of the interface connector or by a power off/on cycle. Limit switch inputs provide for both CW and CCW protection in limited motion applications.

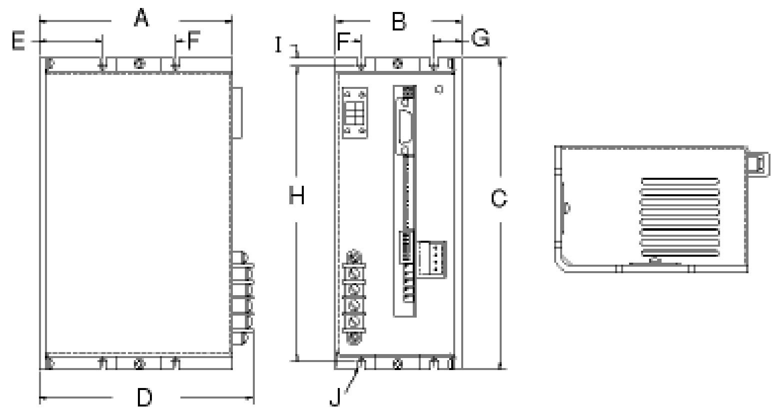
If you have any questions regarding the installation of your amplifier, please contact Bayside Motion Group, Technical Services at (516)484-5353 for additional support.

II. Packaging

The amplifier is shipped in a carton using high density foam padding.

The carton also contains mating connectors and connector pins. Be certain not to accidentally discard the connectors package during unpacking.

III. Outline & Mounting Dimensions

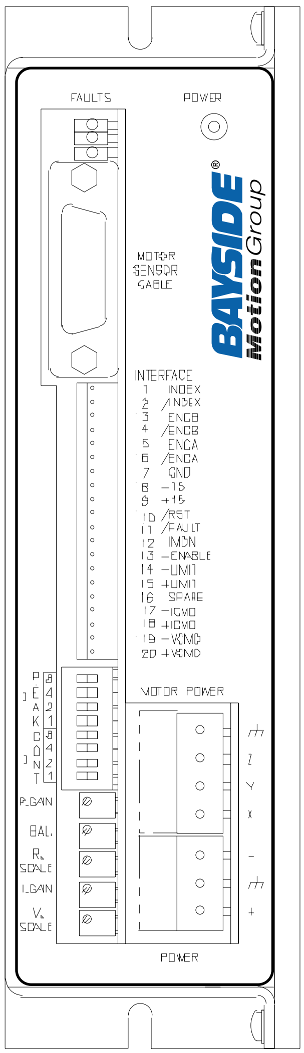


Model	A Depth mm	A Depth (in)	B Width mm	B Width (in)	C Height mm	C Height (in)	D Depth with Terminal Block mm	D Depth with Terminal Block (in)
BAC03 BAC05	134.9	(5.31)	88.1	(3.47)	217.4	(8.56)	149.6	(5.89)
BAC10	158.7	(6.25)	88.1	(3.47)	217.4	(8.56)	173.5	(6.83)
BDC03 BDC05 BDC10	104.6	(4.12)	53.8	(2.12)	190.5	(7.50)	N/A	N/A

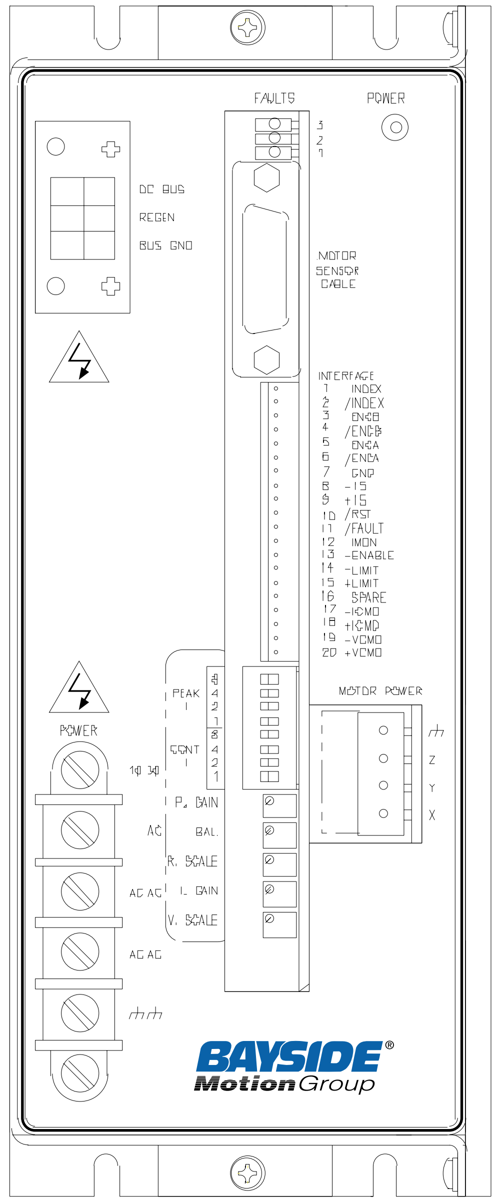
Model	E Mtg Slot Location mm	E Mtg Slot Location (in)	F Mtg Slot Spacing mm	F Mtg Slot Spacing (in)	G Front Mtg Slot Location mm	G Front Mtg Slot Location (in)	H Mtg Slot Spacing mm	H Mtg Slot Spacing (in)	I Mtg Slot Dept mm	I Mtg Slot Dept (in)
BAC03 BAC05	44.5	(1.75)	50.8	(2.00)	19.6	(0.77)	205.7	(8.10)	5.84	(0.23)
BAC10	56.4	(2.22)	50.8	(2.00)	19.6	(0.77)	205.7	(8.10)	5.84	(0.23)
BDC03 BDC05 BDC10	29.2	(1.15)	50.8	(2.00)	29.2	(1.15)	178.8	(7.04)	5.84	(0.23)

Note J Dimension:
AC Frame - Mtg Slots accept #8 Hardware 8 PL
DC Frame - Mtg Slots accept #8 Hardware 6 PL

IV. Front Panel - Connector Locations



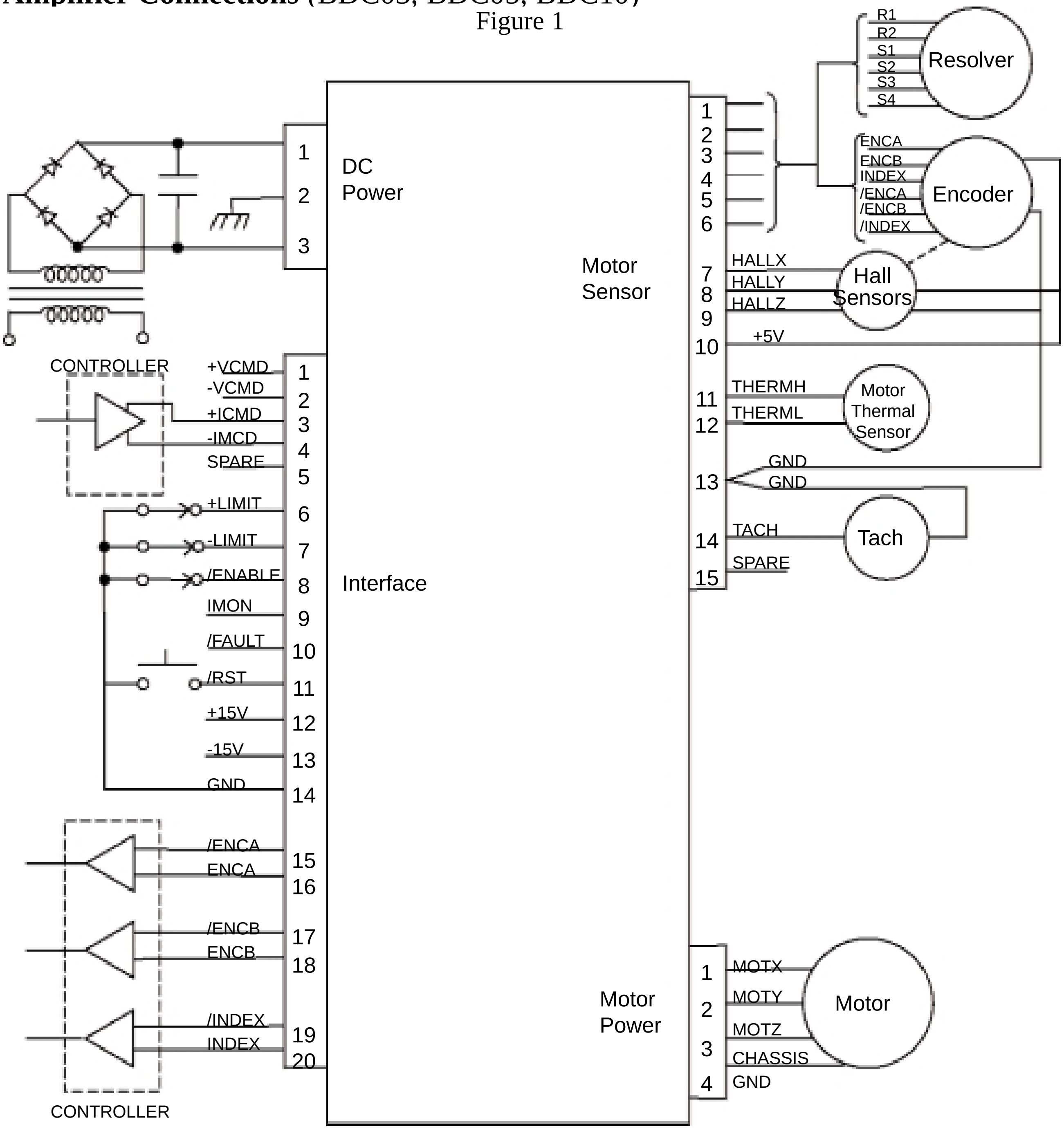
BDC03
BDC05
BDC10



BAC03
BAC05
BAC10

V. Amplifier Connections (BDC03, BDC05, BDC10)

Figure 1

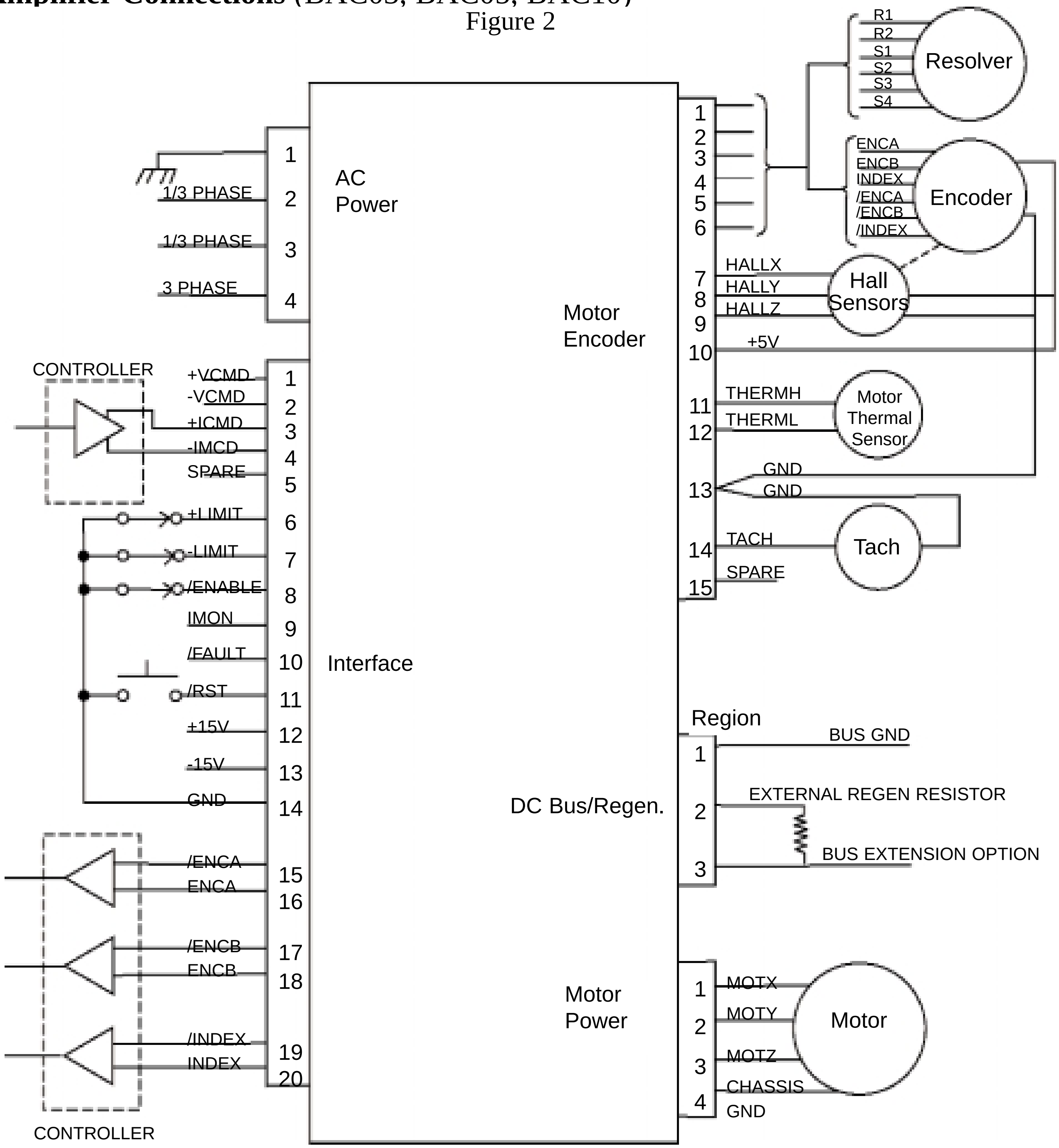


Notes

1. All grounds on BDC10 are common. Power ground on the BDC03 and BDC05 are isolated from circuit ground.
2. The case and the heatsink base are isolated from amplifier ground.
3. /Enable signal is active low (switch closed).
4. Limit switches are active high (+5V). When open, motion at that limit will be inhibited.
5. To minimize noise immunity and radiation emissions, it is recommended that the reference input, motor and input power leads should be twisted and shielded.
6. Voltage per model & system requirements.
7. In resolver based systems, emulated encoder signals are provided at pins 15 thru 20.
8. Typical feedback configurations: Encoder + Hall Sensors, Encoder with commutation tracks Resolver, Hall Sensors with Tachometer.
9. Limit, /ENABLE and reset inputs can be switches or open collector drives.

V. Amplifier Connections (BAC03, BAC05, BAC10)

Figure 2



Notes
1. Power ground is isolated from circuit ground.
2. The case and the heatsink base are isolated from amplifier ground.
3. /Enable signal is active low (switch closed).
4. Limit switches are active high (+5V). When open, motion at that limit will be inhibited.
5. To minimize noise immunity and radiation emissions, it is recommended that the reference input, motor and input power leads should be twisted and shielded.
6. Voltage and phases per model & system requirements.
7. In resolver based systems, emulated encoder signals are provided at pins 15 thru 20.
8. Typical feedback configurations: Encoder + Hall Sensors, Encoder with commutation tracks Resolver, Hall Sensors with Tachometer.
9. Limit, /ENABLE and reset inputs can be switches or open collector drives.

Mating Connectors

Interface	- Molex #22-01-2207 (or equivalent), Pins Molex #08-50-0114
Motor Sensor	- DB15P
Motor Power	- Phoenix #227-1002
DC Power	- Phoenix #227-1001
Regen	- Phoenix #227-1001

VI. Amplifier Interface Signals

Table 1

Connector	Pin	Signal	Description	Level
1 Interface	20	+VCMD *	+Velocity Command	0 to +/- 10 V
	19	-VCMD *	-Velocity Command	0 to +/- 10 V
	18	+ICMD *	+Current Command	0 to +/- 10 V
	17	-ICMD *	-Current Command	0 to +/- 10 V
	16	SPARE		
	15	+LIMIT	Will inhibit motion for a negative ICMD	Active State is +5V
	14	-LIMIT	Will inhibit motion for a positive ICMD	Active State is +5V
	13	/ENABLE	Motor drive enable	Active State is 0V
	12	IMON	Motor current monitor	0 to 10 V
	11	/FAULT	Fault indication	Active state 0 V
	10	/RST	Reset fault condition	Pulse +5V to 0V
	9	+15 V	+ 15V Output	+15V +/- 5% @ 10 ma.
	8	-15 V	- 15V Output	+15V +/- 5% @ 10 ma.
	7	GND	Circuit ground	
	6	/ENCA *	-Encoder A output	RS-422
	5	ENCA *	+Encoder A output	RS-422
	4	/ENCB *	-Encoder B output	RS-422
	3	ENCB *	+Encoder B output	RS-422
	2	/INDEX *	-Index output	RS-422
	1	INDEX *	+Index output	RS-422

* Differential Signals

Connector	Pin	Signal	Description	Color	Level
2 Motor Sensor	1	ENCA *	Motor encoder A+	Orange	RS-422
		(R1)	(Resolver Ref 1)		
	2	ENCB *	Motor encoder B+	Yellow	RS-422
		(R2)	(Resolver Ref 2)		
	3	INDEX *	Motor Index+	Blue	RS-422
		(S1)	(Resolver S1)		
	4	/ENCA *	Motor encoder A-	White/Orange	RS-422
		(S2)	(Resolver S2)		
	5	/ENCB *	Motor encoder B-	White/Yellow	RS-422
		(S3)	(Resolver S3)		
	6	/INDEX *	Motor Index	White/Brown	RS-422
		(S4)	(Resolver S4)		
	7	HALLX	Motor Hall X	White	TTL
	8	HALLY	Motor Hall Y	Green	TTL
	9	HALLZ	Motor Hall Z	Grown	TTL
	10	VCC	5V power for motor sensors	Red&Violet	5V +/-5% @ 200 ma max.
	11	THERMH	Motor therm sensor High	White/Red	Switch Closure OR 1K ohms @ Temp
	12	THERML	Motor therm sensor Low	White/Black	Switch Closure OR 1K ohms @ Temp
	13	GND	Circuit Ground	Black & Gray	0V
	14	TACH	Motor tach output		0 to +/- 10V
	15	SPARE			
3 Motor Power	1	PHASE X	Motor Phase X	Red	
	2	PHASE Y	Motor Phase Y	Black	
	3	PHASE Z	Motor Phase Z	White	
	4	GND	Chassis Ground	Green	
4 Input Power (BDC Models)	1	+V	DC input power V+		BDC10 24-72VDC BDC05 60-180 VDC BDC03 100-330 VDC
	2	GND	Chassis ground		
	3	-V	DC input power V-		Power Return

* Differential Signals

Connector	Pin	Signal	Description	Level
Input Power (BAC Models)	1	GND	Chassis ground	
	2	AC	AC input - 1/3 phase	BAC03 1 PH 75-230 VAC BAC05 1 PH 45-130 VAC BAC10 1 PH 115-230 VAC 3PH 208-230 VAC
	3	AC	AC input - 1/3 phase	
	4	AC	AC input - 3 phase	
DC Bus/ Regen (BAC Models ONLY)	1	PGND	BUS Ground	
	2	REGEN	External Regen Resistor	External Regen Resistor to be Connected between REGEN and DC BUS
	3	DC BUS	DC Bus Output	105 to 322 VDC Depending on Model

VII. Application Information

Input Power

BAC Models

BAC models are designed to operate from 45 - 130VAC 1 phase, 75 - 230VAC 1 phase, 208/230VAC 3 phase and 115/230VAC 1 phase. Each BAC model is internally protected by fuses, transient suppressors and in-rush current limiters. In compliance with safety regulations, a ground pin has been provided to connect the chassis of the amplifier to mains ground. Refer to section I for model input voltage range.

BDC Models

The BDC models are designed to operate with a transformer isolated power supply providing outputs in the range of 24 - 72VDC, 60 - 180VDC and 100 - 330VDC. The choice of supply voltage should consider the variation in the mains voltage and power supply regulation. The goal is to select a voltage that is adequate to power the motor at full load at low line conditions and that will not cause an over-voltage condition at high line. In compliance with safety regulations, a ground pin has been provided to connect the chassis of the amplifier to mains ground.

Regen Circuit

All BAC models have a Regen circuit to control bus pump-up due to regenerative power transfer during deceleration of large inertial loads. Internally, there is a 30 ohm, 50 watt resistor which is switched across the bus when the bus rises to 229VDC for a 115VAC model or 352VDC for a 230VAC model. Depending on the application, additional Regen resistors can be added externally by way of the Regen connector on the front panel.

Wiring & Cabling

The wire gauge used for input power and motor power connections should be adequate to support the amplifiers' continuous current rating. AWG 16 should support the high current models, AWG 18 the mid current models and AWG 20 the low current models. To minimize radiated noise, the motor and power cabling should be twisted and shielded.

To minimize coupling of PWM noise, Hall and Encoder wiring should utilize multi-conductor-shielded cable. Grounding the motor case will reduce coupling between motor winding and Hall and/or encoder signals.

Motor Phase Connections

Refer to the chart in Section VI. Connect the motor phase windings as indicated. Standard Bayside color code is shown and will provide correct motor phasing. In the case of Kit motors, correct phasing will depend in which direction the Hall sensor assembly is facing, forward or rearward.

Sensor Signals

The Motor Sensor Signals are those required for motor commutation, thermal protection, velocity and position sensing and sensor power. Refer to Section VI.

Hall Signals

Standard Bayside color code is shown and will provide correct Hall phasing. In the case of Kit motors, correct phasing may depend on which way the Hall sensor assembly is facing, forward or rearward.

Encoder Signals

Standard Bayside color code is shown and will provide correct encoder phasing. If an alternate encoder is used, check the manufacturers data sheet for the proper connection. The amplifier provides buffers for encoder signals. It is recommended that the buffered encoder signals be utilized by the controller instead of direct connection.

Hall/Encoder Power

The amplifier provides +5VDC for the Halls and the Encoders. The sensor power is limited to 200 ma. Exceeding this limit may affect amplifier operation.

Thermal Sensor

The thermal sensor could be either a switch closure or a NTC thermistor. If a thermistor is used, the amplifier will trip when the thermistor's resistance reaches 1K ohms.

Tach Feedback

The amplifiers have been designed to operate with an analog tachometer whose output is limited to +/-10V at maximum speed. Tachometer feedback requires a small modification to the amplifier for proper operation. Remove the cover from the amplifier and locate resistor R55 (10K). It is located on the far-left side of the upper PCB about 2/3 down from the top. Remove resistor R55 and verify that the amplifier is configured for velocity operation, refer to the Option Jumper Table. The tachometer may have to be reversed for proper operation.

Resolver Signals

The amplifier will provide power at 5 khz for the resolver reference winding and process signals from the sine and cosine windings, providing simulated encoder A, B, I signals at the interface connector. Resolvers with a 0.5 transfer ratio should be used.

Interface Signals

The interface signals are those signals required to command the amplifier and send status information to the controller.

Current Command (+ICMD & -ICMD)

The current command section of the amplifier is used for torque mode operation. It consists of a differential stage with inputs of +ICMD and -ICMD. The input command is typically a controller generated analog signal, ranging from 0 to +/- 10V and referenced to controller ground. For single ended input the command signal can be applied to either the +ICMD input or the -ICMD input with the other input connected to the controller’s ground reference.

Velocity Command (+VCMD & -VCMD)

The velocity command section of the amplifier is used for velocity mode operation. It consists of a differential stage with inputs of +VCMD and -VCMD. The input command is typically a controller generated analog signal, ranging from 0 to +/- 10V and referenced to controller ground. For single ended input the command signal can be applied to either the +VCMD input or the -VCMD input, with the other input connected to the controller’s ground reference.

Limit Switches

Limit switch inputs are provided to prevent accidental over travel. The active state of the limit switch is a logic high (+5V). When open, the command input will be disabled thus preventing commanded motion. the convention is a +LIMIT will prevent motion for a negative input at the +ICMD terminal and a -LIMIT will prevent motion for a positive input at the +ICMD terminal. Proper operation requires knowledge of command polarity and direction of motion.

/Enable Input

The /ENABLE signal functions as a run/stop input to the amplifier. The active state of the /ENABLE signal is logic low (0V). When active, the amplifier will respond to the input commands. This signal (when open) inhibits the input to the current section (Commands 0 Current) but does not disable the output power stage drivers.

/RST Input

The /RST signal is used to clear a Fault condition. The active state of the /RST signal is logic low (0V). All Faults detected are latched. Faults are reset by momentarily bringing the /RST to ground. Performing a power off-on cycle will also clear faults. Holding /RST low on an unfaulted amplifier will disable the output power stage drivers.

/FAULT Output

The /FAULT output provides indication to a controller that a fault has been detected. All faults are latched and the specific fault is displayed by three status LEDs. Faults are cleared by the /RST input or by performing a power off-on cycle. A persistent fault may signify a component failure. If this is the case, the amplifier should be returned for repair. When /FAULT is indicated the output power stage drivers are disabled.

IMON Output

The IMON output provides indication of motor current. The IMON is a DC level, which varies from 0 to +10V. This output will contain some ripple content that will be a function of motor inductance, operating mode and operating voltage. The calibration of IMON is a function of the amplifier current gain (Amps/Volt). For example, the BDC10/BAC10 constant is 2 amps/volt so an IMON output of 5V would indicate a motor current of 10 amps.

+/- 15VDC Output

The +/- 15Vdc output has been provided to power external devices for input command generation. The supply output is limited to 10ma.

Encoder Outputs (ENCA, /ENCA, ENCB, /ENCB, INDEX, /INDEX)

Buffered encoder signals are provided at the amplifier interface connector. These signals are RS422 compatible. It is recommended that these signals be utilized instead of a direct connection to the encoder.

Current Limits/Current Gain

If the continuous and peak current values are set at their rated maximum values, then the 0 to 10 volt command input voltage will result in the gains as shown in the following table:

Model	I_{cont}(amp) @ 5V input	I_{peak} (amp) @ 10V input	Gain (amp/volt)
BAC03 BDC03	2.5	5	0.5
BAC05 BDC05	5	10	1.0
BAC10 BDC10	10	20	2.0

If the peak current value is set to less than the maximum value, then the gain is equal to the peak current setting divided by 10.

This gain will then determine the command voltage value required to create a particular current.

Example: A BAC05 or BDC05 has the continuous current set for 5 amps.and the peak current set for 10 amps.

Therefore: Gain = 1 amp./volt
Input voltage for 5 amps = 5 volts
Input voltage for 10 amps = 10 volts

Next, the peak current setting is changed to 8 amps.

Therefore: Gain = 0.8 amp./volt
Input voltage for 5 amps = 6.25 volts
Input voltage for 8 amps = 10 volts

When the commanded current exceeds the continuous current, a shutdown timer is started, in which the time-out is inversely proportional to the magnitude of the commanded current. For a peak current which is twice the continuous current, the timer will time out in approximately 2.2 seconds. If the commanded current is reduced to the continuous current (or less) before the timer terminates, the timer is reset and the time out will start again the next time the continuous current is exceeded. Upon reaching “Time-Out”, the amplifier will disable the output power stage drivers and the fault indicator display will show the code for “Over Current”.

Continuous Current Setting

The continuous current setting provides a way of customizing the amplifier to match the requirements of a large range of motors and loads. It allows matching the amplifier's current to the specific continuous current rating of the motor, preventing over-driving of the motor. Refer to Section IV Front Panel - Connector Locations. The group of four dip switches labeled "I CONT" is used to adjust the continuous current setting of the amplifier in 15 steps, as shown in the following table:

SW1	SW2	SW4	SW8	Continuous Current Setting		
ON	ON	ON	ON	2.5 *	5.0 *	10.0 *
OFF	ON	ON	ON	2.3	4.7	9.3
ON	OFF	ON	ON	2.2	4.3	8.7
OFF	OFF	ON	ON	2.0	4.0	8.0
ON	ON	OFF	ON	1.8	3.7	7.3
OFF	ON	OFF	ON	1.7	3.3	6.7
ON	OFF	OFF	ON	1.5	3.0	6.0
OFF	OFF	OFF	ON	1.3	2.7	5.3
ON	ON	ON	OFF	1.2	2.3	4.7
OFF	ON	ON	OFF	1.0	2.0	4.0
ON	OFF	ON	OFF	0.8	1.7	3.3
OFF	OFF	ON	OFF	0.7	1.3	2.7
ON	ON	OFF	OFF	0.5	1.0	2.0
OFF	ON	OFF	OFF	0.3	0.7	1.3
ON	OFF	OFF	OFF	0.2	0.3	0.7

*Default setting

Peak Current Setting

The peak current setting provides a means for creating peak torque from the motor for a limited time or at a level to limit load acceleration to a specific value. In this way, both motor and amplifier can be protected.

SW1	SW2	SW4	SW8	Peak Current Setting		
ON	ON	ON	ON	5	10	20
OFF	ON	ON	ON	4.7	9.3	18.7
ON	OFF	ON	ON	4.3	8.7	17.3
OFF	OFF	ON	ON	4.0	8.0	16.0
ON	ON	OFF	ON	3.7	7.3	14.7
OFF	ON	OFF	ON	3.3	6.7	13.3
ON	OFF	OFF	ON	3.0	6.0	12.0
OFF	OFF	OFF	ON	2.7	5.3	10.7
ON	ON	ON	OFF	2.3	4.7	9.3
OFF	ON	ON	OFF	2.0	4.0	8.0
ON	OFF	ON	OFF	1.7	3.3	6.7
OFF	OFF	ON	OFF	1.3	2.7	5.3
ON	ON	OFF	OFF	1.0	2.0	4.0
OFF	ON	OFF	OFF	0.7	1.3	2.7
ON	OFF	OFF	OFF	0.3	0.7	1.3

*Default setting

Peak Current Duration

The following chart (page 19) can be used to determine the nominal time-out of the shutdown timer, as a function of the continuous and peak current settings.

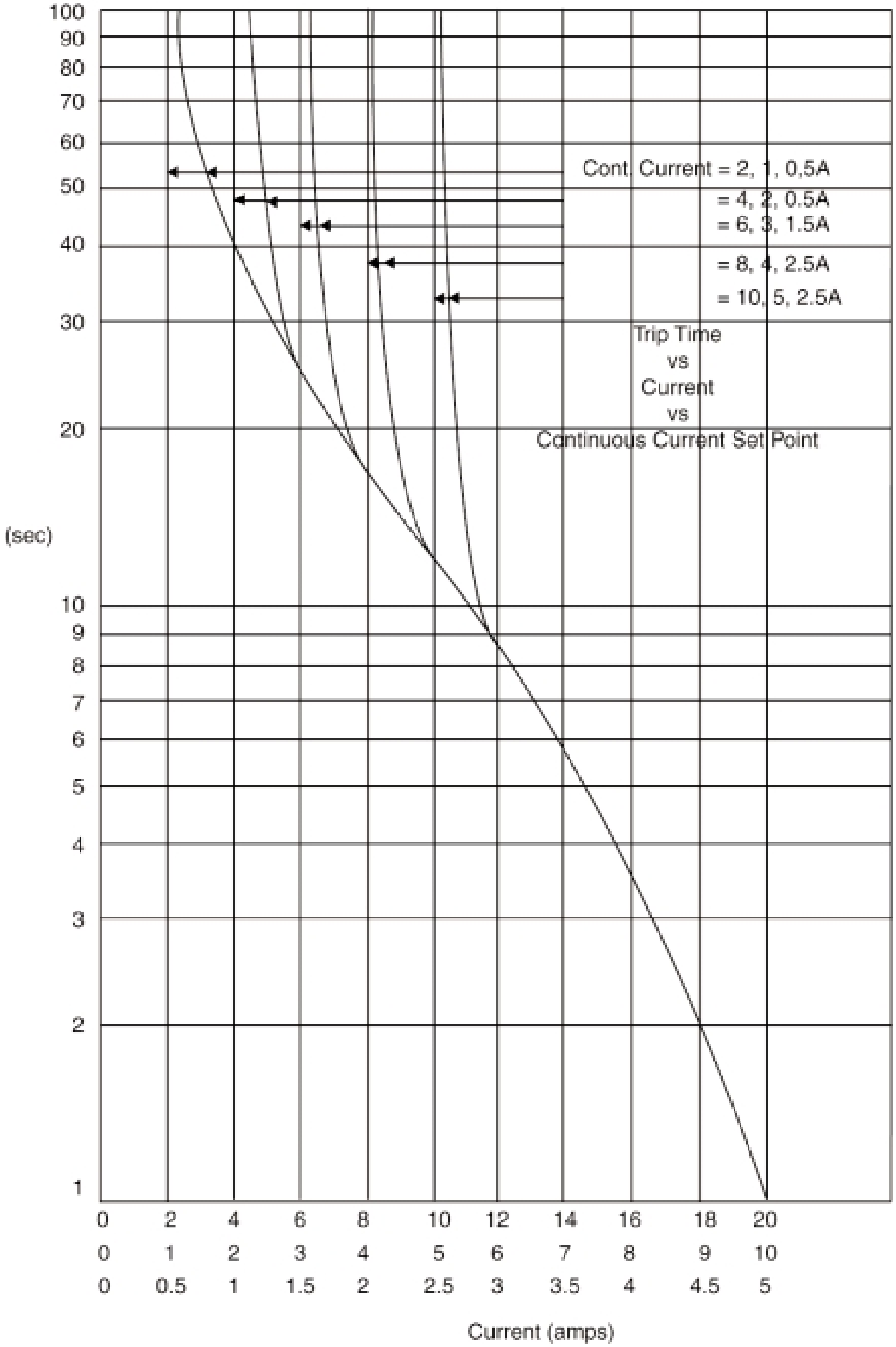
Example: A BAC10 & BDC10 has the continuous current set for 6 amps.
Therefore: A peak current of 7 amps will time out in 25 seconds
A peak current of 10 amps will time-out in 12 seconds.
A peak current of 20 amps will time-out in 1 seconds.

Fault Indication

Three fault indicators are located on the top of the amplifier as shown in Section IV. They are encoded to show seven possible faults, as follows:

- Power Supply - indicates that a low voltage power supply is out-of-tolerance.
- Over Bus - indicates that an over bus condition was detected.
- Over Current - indicates that an over current condition was detected in the motor.
- Over Temp. - indicates that an amplifier heatsink over temperature condition was detected.
- Inrush Current - indicates that a bus over current condition was detected. This fault may be an indication of a motor or motor driver short.
- Motor Temp. - indicates that a motor over-temperature condition was detected.
- Illegal Halls - indicates malfunctioning or disconnected Hall effect devices.

Fault	LED1	LED2	LED3
Power Supply	1	1	0
Over Bus	0	1	0
Over Current	1	1	1
Inrush Current	0	0	1
Motor Temp.	1	0	1
Over Temp	1	0	0
Illegal Halls	0	1	1


100
90
80
70
60
50
40
30
20
(sec)
10
9
8
7
6
5
4
3
2
1
Cont. Current = 2, 1, 0,5A
= 4, 2, 0.5A
= 6, 3, 1.5A
= 8, 4, 2.5A
= 10, 5, 2.5A
Trip Time
vs
Current
vs
Continuous Current Set Point
0 2 4 6 8 10 12 14 16 18 20
0 1 2 3 4 5 6 7 8 9 10
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Current (amps)

Velocity Mode Adjustments

The velocity mode configuration contains a frequency to voltage converter which converts either the Hall sensor signal or the encoder signal into an analog voltage whose magnitude is proportional to velocity and whose polarity is proportional to direction.

The scaling of this feedback signal is adjustable to allow the maximum velocity command (10 volts) to create the maximum required motor velocity.

The usual, factory default, setting is for this scaling to be 1 V/1,000 RPM, resulting in a maximum motor speed of 10,000 RPM.

Note: Regardless of the scaling adjustments, the maximum motor velocity is limited by the bus voltage and the motor voltage constant

$$\text{i.e. Maximum velocity} = \frac{\text{Ebus (volts)}}{K_e \left(\frac{\text{volt}}{\text{1000RPM}} \right)} \text{ KRPM}$$

The following adjustments refer to the potentiometers accessible on the front panel and test points on the top PCB assembly as shown in Figure 3.

V. Scale and R. Scale

These two adjustments, together, allow the scaling of the feedback and the maximum commandable speed to be accomplished.

1. Adjust the R. Scale potentiomenter to it’s maximum CW position.
2. Apply an input velocity command to create a motor speed of 1,000RPM.
3. With a voltmeter or oscilloscope, observe the voltage at TP6 (TP7 is GND).
   (nominal factory setting is 1volt at 1,000RPM).
4. Adjust the V. Scale potentiometer to change the voltage at TP6 (either up or down) as required.
   Making this adjustment will change the speed, requiring the input command to be re-adjusted to bring the speed back to 10,000RPM.
5. Alternately adjust V. Scale and the input voltage until the required calibration is achieved.

R. Scale

The maximum commandable speed can be achieved by adjusting the R. Scale potentiometer. With R. Scale adjusted to its’ maximum CW position, apply a 10volt velocity command and measure the motor velocity.

If the motor velocity exceeds the maximum required value, turn R. Scale CCW until the required speed is achieved. The final value of the attenuated command voltage can be measured at TP8.

If the motor velocity is less than the maximum required value, the feedback scaling is too high and must be adjusted to a lower value (see previous section).

BAL.

This is used to balance circuit and component offsets such that with a 0 volt command (input velocity command connected to circuit ground) the motor velocity is zero.

However, once connected to external command and feedback sources and impedances, the motor might turn slowly even though a zero velocity input command is being applied.

To re-balance the amplifier:

1. Adjust BAL either CW or CCW (as required) to achieve zero velocity.
2. Continue turning BAL until motor starts turning in the opposite direction. Count the number of turns to achieve this.
3. Turn BAL BACK by one-half this number of turns.

P. Gain and I. Gain

These two adjustments allow for setting the response of the motor to input velocity commands.

1. Adjust P. Gain fully CCW and I. Gain fully CW.

   This creates the lowest velocity loop gain and zero integral.

2. Apply a square wave input velocity command signal of approximately 1/10 of the maximum expected command and of low enough frequency to allow steady velocity to be achieved for each excursion of the command.

3. Slowly adjust P. Gain CW until instability is achieved or until maximum adjustment is reached. Adjust P. Gain back CCW from this position (or until stability is achieved).

4. Many systems will operate satisfactorily with the I. Gain at the zero setting. If variable loads cause unacceptable velocity variations, I Gain can be used to compensate for this. Adjust I. Gain CCW until instability is reached and then back CW one or two turns.

   Note: Adjusting I. Gain may require re-adjusting P. Gain to obtain optimum performance.

Jumpers

Various jumpers are used to configure the amplifier for different modes of operation.

The following jumpers can be adjusted by the user to accommodate various configurations. All other jumpers have been factory adjusted and should not be disturbed.

JP1 - When using the Hall sensors as the velocity feedback signal, the actual direction of the motor shaft must be determined by monitoring two of the three Hall signals.

When using the amplifier with kit motors, the Hall sensors can be either forward or rearward facing. This jumper adjusts the amplifier for this condition.

JP1 is in place for rearward facing Hall sensors.
JP1 is omitted for forward facing Hall sensors.

JP2 & JP4 - These jumpers determine whether the Hall sensors or an encoder are being used as the velocity feedback signal.

JP2 & JP4 are in place if the Hall sensors are being used.
JP2 & JP4 are omitted if the Hall sensors are being used.

JP3 - This jumper is used when configuring the amplifier for either transconductance or velocity mode.

JP3 is in place for velocity mode.
JP3 is omitted for transconductance mode.

Bus Extension Option (BDC60xx-x1,2,3)

A bus extension option is available for multi-axis systems. This option is available on AC models and can provide power for 1 or 2 additional DC power amplifiers. The Bus connection is located in the upper left corner, labeled “DC Bus” and “Bus Gnd”.

Option 2	Bus Extension	Voltage
0	none	
1	5 amps	160V
2	10 amps	160V
3	10 amps	160/300V

Figure 3