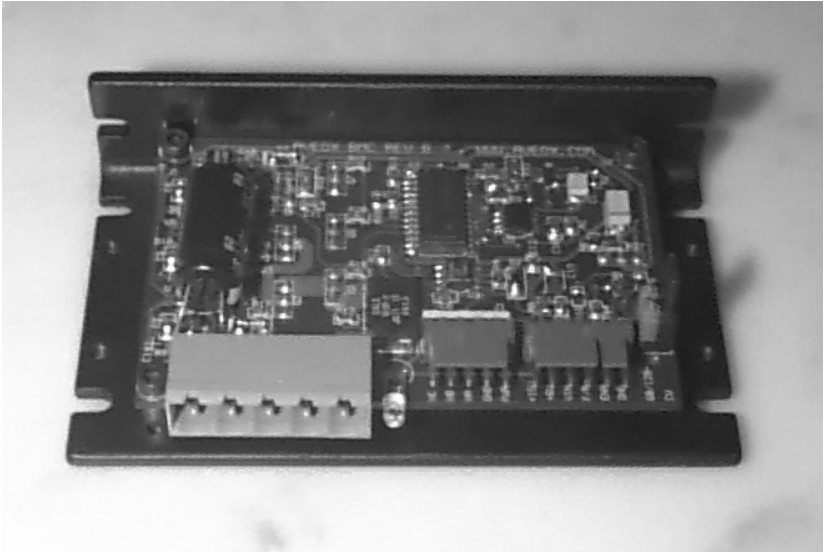




AVX-50BL10 50V, 10A Brush / Brushless Power Amplifier Data Sheet and Setup Guide



Introduction

The AVX-50BL10 amplifier is designed to drive brushless or brush motors at currents up to 10A and 50V. Using hall sensor feedback, a constant velocity mode can be selected for brushless motors. The amplifier is protected against over current (cycle-by-cycle

limited), hall sensor error and under voltage. A two quadrant drive technique results in a low-cost, and highly efficient drive.

Applications

The AVX-50BL10 amplifier is appropriate where any simple, low cost control of a brush or brushless DC motor is required. Since it is a two-quadrant amplifier, it should only be used in a open loop or velocity loop where controlled deceleration is not required. Some applications are:

- Conveyor belts
- Small electric vehicles
- Flywheels
- Pumps
- Simple actuators
- Air moving
- Centrifuges
- Compressors
- Mixers
- Material handling equipment
- Turn tables
- Robotics
- Machine Tools

Rev 3: 2/27/08



Specifications

Operating Voltage Range	12-50V
Max Continuous Motor Current	10A
PWM Frequency	6500Khz
Operating Modes	Voltage Mode, Constant Velocity ¹
Max Heatsink Temperature	80°C

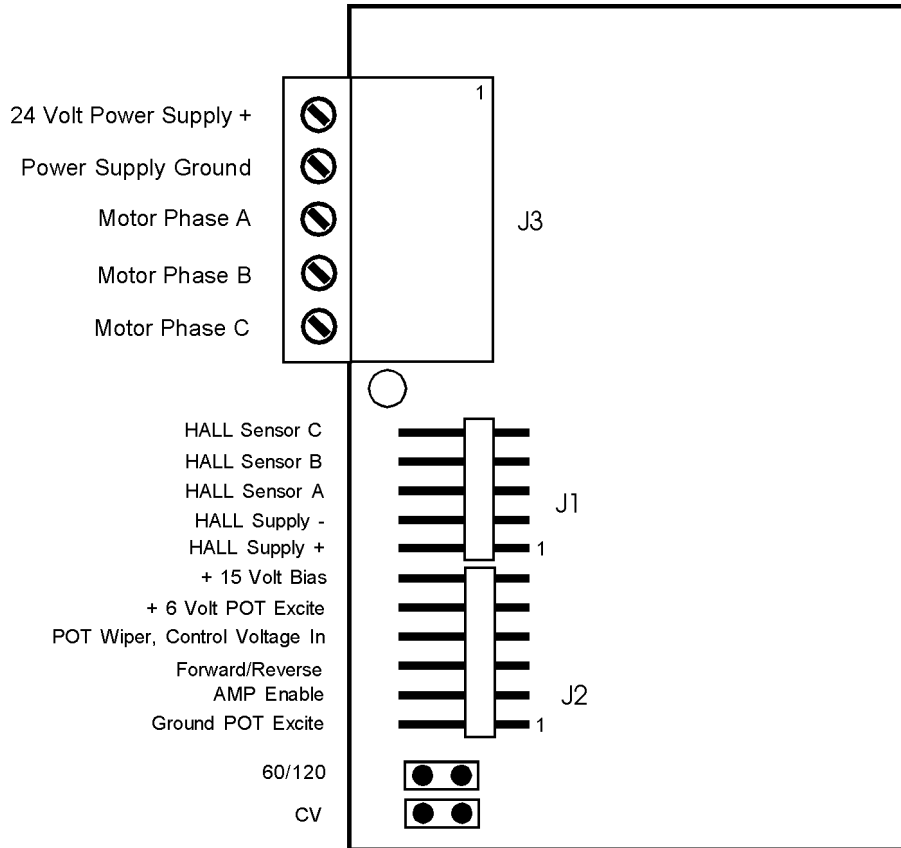
¹Brushless motor Only

Connector Specification:

Connector	Pin	Name	Description / Notes
J1	1	Hall sensor Power	Power for hall sensors, 30mA, short circuit protected, 6.25V
	2	Hall Sensor GND	GND For hall sensor power
	3	Hall A	Hall sensor inputs. There is a 20kΩ pull-up resistor to 6.25V. The minimum high state voltage is 3.0V. The maximum low state voltage is .8V.
	4	Hall B	
	5	Hall C	
J3	1	Positive Power Rail	DC Motor Power
	2	Ground Rail	Dc Motor GND
	3	Motor Phase A (Motor + for Brush Motors)	Motor Phase A Connection
	4	Motor Phase B (Motor- for Brush Motors)	Motor Phase B Connection
	5	Motor Phase C	Motor Phase C Connection
J2	1	Signal Ground	
	2	Enable	Enable Input. There is a 20kΩ pull-up resistor to 6.25V. The minimum high state voltage is 3.0V. The maximum low state voltage is .8V. Drive this input with an open-collector output only.
	3	Direction	Direction Input. There is a 20kΩ pull-up resistor to 6.25V. The minimum high state voltage is 3.0V. The maximum low state voltage is .8V.
	4	Analog Speed Input	Common mode input range is from 0 to 6.25V. Effective range in the open loop mode is 1.1V to 4.5V. Effective range in the Constant velocity mode is 0V- 4V.
	5	+6.25V	6.25V reference out. Total available current is 30mA including hall sensor power. 3 hall sensors typically draw 15-20mA.



AVEOX AVX-55BL10



	6	+15V	On lower voltage models, this can be used to drive external circuitry, up to 50mA. On higher voltage models(>55V) this is the bias supply input necessary for amplifier operation.
CV Jumper	1	Mode Select	Install a jumper here to disable the Constant Velocity mode
	2		
60/120-	1	Hall Sensor Spacing	Install a jumper here to select 120° Hall Sensor spacing
	2		



Amplifier Connections and Setup for a Brushless Motor

1. Determine from the motor manufacturer's data the connections for the hall sensors and phase wires. Connect the hall sensor wires to J1. Do not connect the phase wires at this time
2. Select the appropriate hall sensor spacing (120° or 60°) using the 60/120- pins. Placing a shorting jumper here will select 120° hall sensor spacing. Place a shorting jumper on the CV pins to remove the Constant Velocity mode.
3. Supply a 12-50V supply between pins 1 and 2 on connector J2.
4. Slowly rotate the motor by hand. If the error light comes on at all, try changing the 60/120- jumper. If the error light is still coming on, confirm that there are transitions on each hall sensor input using a Digital Volt Meter or oscilloscope. If the motor has 60° hall sensor spacing, the order in which the hall sensors are connected is important. Refer to the commutation sequence tables for more information.
5. Disconnect the power from the amplifier and connect the motor phases.
6. Connect the wiper of a 10K potentiometer to pin 4 of connector J3, and either end to GND (pin 1, J3) and +6.25V (Pin 5, J3) as shown in the schematic in Figure 1:

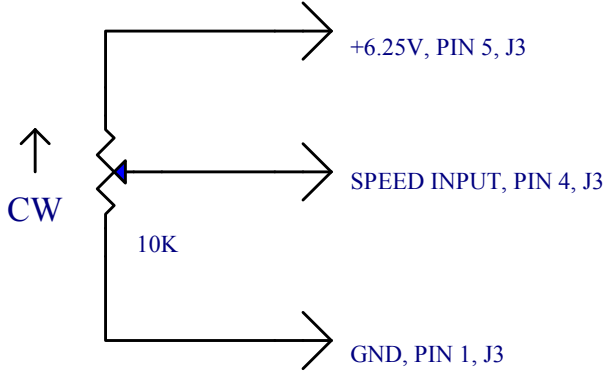


Figure 1

7. It is recommended that you use a current-limited power supply to do the initial motor setup. After applying power to the amplifier, turn the potentiometer so that a voltage appears on pin 4 of J3. If the motor runs rough or just vibrates, remove the power from the amplifier and connect the phase wires differently to the amplifier. There are only six different ways to connect the motor to the amplifier as shown in table 1.

	Controller Phase A	Controller Phase B	Controller Phase C
Motor	Phase A	Phase B	Phase C
	Phase A	Phase C	Phase B
	Phase B	Phase A	Phase C
	Phase B	Phase C	Phase A
	Phase C	Phase A	Phase B
	Phase C	Phase B	Phase A

Table 1

8. Usually two out of six possible combinations will make the motor rotate, but only one will be correct. Connect a wire or switch from pin 3 of J3 to pin 1 of J3 to reverse the motor. The no-load current of the motor should be almost equal and the motor should run smooth in both directions.
9. If desired, remove the jumper on JP2 to enable the constant velocity mode. Note that the velocity amplifier will saturate at about 10,000RPM for a 4 pole motor and 5000 RPM for an 8 pole motor.



Contact Aveox if you need higher speeds. Also note that the effective voltage range into the Vin input is about 4V. Any input voltage greater than 4V will make the motor run at the maximum speed.

10. To reverse the direction of the motor you can also swap Hall sensors A and C and Motor phases A and B.

Commutation Sequence

The commutation pattern is the following for 120° sequence forward:

	STEP							E	E
	1	2	3	4	5	6	7		
PHASE A	+	Z	-	-	Z	+	+	R	R
PHASE B	Z	+	+	Z	-	-	Z	O	O
PHASE C	-	-	Z	+	+	Z	-	R	R
HALL A	1	1	0	0	0	1	1	0	1
HALL B	0	1	1	1	0	0	0	0	1
HALL C	0	0	0	1	1	1	0	0	1

The commutation pattern is the following for 120° sequence reverse:

	STEP							E	E
	1	2	3	4	5	6	7		
PHASE A	-	Z	+	+	Z	-	-	R	R
PHASE B	Z	-	-	Z	+	+	Z	O	O
PHASE C	+	+	Z	-	-	Z	+	R	R
HALL A	1	1	0	0	0	1	1	0	1
HALL B	0	1	1	1	0	0	0	0	1
HALL C	0	0	0	1	1	1	0	0	1



The commutation pattern is the following for 60° sequence forward:

	STEP							E	E
	1	2	3	4	5	6	7		
PHASE A	+	Z	-	-	Z	+	+	R	R
PHASE B	Z	+	+	Z	-	-	Z	O	O
PHASE C	-	-	Z	+	+	Z	-	R	R
HALL A	1	1	1	0	0	0	1	1	0
HALL B	0	1	1	1	0	0	0	0	1
HALL C	0	0	1	1	1	0	0	1	0

The commutation pattern is the following for 60° sequence reverse:

	STEP							E	E
	1	2	3	4	5	6	7		
PHASE A	-	Z	+	+	Z	-	-	R	R
PHASE B	Z	-	-	Z	+	+	Z	O	O
PHASE C	+	+	Z	-	-	Z	+	R	R
HALL A	1	1	1	0	0	0	1	1	0
HALL B	0	1	1	1	0	0	0	0	1
HALL C	0	0	1	1	1	0	0	1	0

Z = High impedance
 + = Positive Current
 - = Negative Current

An error condition will make all outputs high-impedance and the LED will be on.

Amplifier Connections and Setup for a Brush Motor

1. Remove any jumpers on 60/120- pins to select 60° Hall sensor spacing and place a jumper on the CV pins to remove the constant velocity mode. (Note that Aveox can modify the amplifier to work with an incremental encoder to use the constant velocity mode with a brush motor. Contact Aveox for more information)
2. Supply a 12-50V supply between pins 1 and 2 on connector J2.
3. Connect the motor on pins 3 and 4 of connector J2
4. Connect a potentiometer as in figure 1 to connector J3 or connect another voltage source between J3 pin 4 and J3, pin 1.

Note: Aveox can modify the controller to accept an incremental encoder for velocity feedback when using a brush motor. This allows very precise velocity regulation even at low speed. Please contact Aveox for more information.

Motion Control Primer

By David Palombo



Sizing a Motor for the Job

Selecting the right motor for the job can sometimes be the most confusing aspect of a motion control problem. A priority list must be made as to what properties of the motor system are to be optimized. These properties may include, motor efficiency, motor torque, motor power, reliability, and of course, cost. Generally torque is the driving factor in a motor's weight, size and consequently cost, so knowing the torque requirements is paramount.

Any DC permanent magnet motor has a figure of merit called the motor Constant (Km). This rating is usually in units of $in - oz / \sqrt{W}$ which is a very useful measure because it describes a motor's ability to produce torque as a function of heat. As you can see, the heat dissipated goes up with the square of the torque. This power produced is solely from the I^2R loss in the copper winding and does not describe the heat produced by the iron loss. In most applications, the I^2R loss is the predominant loss except when the motor is moving at very high speed. Ultimately one must look at the thermal dynamics of the motor system because other than a maximum RPM limit, a motor usually has a maximum operating temperature. The total surface area of the motor must be able to dissipate the total power loss in the motor while keeping the temperature below the manufacturer's maximum rated temperature. A good rule of thumb is to keep the total loss in the motor less than .5 to 1W per square inch of motor area. It should be apparent that a motor's torque capability can be dramatically increased by keeping the motor cool.

The key is to try and reduce the torque requirements of the motor by increasing the RPM or the mechanical advantage (gearing). This can work to a certain point; At some point the iron loss due to higher RPM can cause a loss in the motor greater than the copper loss. The motor is at its peak efficiency when the iron loss equals the copper loss.

Which Type - Brush or Brushless?

Even though we manufacture only brushless motors, I find myself recommending to customers that they use a brush motor instead more often than not. A brushless permanent magnet motor is the highest performing motor in terms of torque / vs. weight or efficiency. Brushless motors are usually the most expensive type of motor relegating them to where their features make them absolutely necessary. Usually there must be a compelling need for a brushless motor. Some of its outstanding features are:

- Very high torque to inertia ratio (on interior rotors only)
- Zero out-gassing (no brush dust)
- Very high peak torque (on interior rotors)
- No arcing (use in explosive environments)
- Very high reliability (no commutator or brush to wear out)
- Potentially higher efficiency (due to no brush friction)

Of course there are good brushless motors and bad brushless motors just like there are good and bad brush motors. What is considered a "good" motor will be different for every user. Always look carefully at your application and try to figure out what motor is "good enough" to do the job.

Is not the size that counts, its how you use it

Bigger is not always better. As I have already said, the most important parameter to optimize in a motion system is torque. If you have an application that requires high torque at slow speed, a gear reduction of some sort can sometimes dramatically reduce the motor size or increase the motor's efficiency. If you need high speed at low torque, a large motor can have excessive iron loss. This will manifest itself as a high no-



load current. If you notice that the no-load current goes up dramatically with speed, then the motor probably has a lot of eddy current loss. If the no-load current remains the same over its RPM range, the iron loss is mostly attributable to hysteresis drag torque. Knowing what components make up the iron loss is important because it can point you in two directions: 1. reduce the frequency (RPM) of the motor to reduce the eddy current loss or 2. reduce the size of the motor to reduce the hysteresis drag.

Measuring Motor Parameters

With just a few motor parameters, the steady state performance can accurately be calculated. These parameters are the motor's torque constant (oz-in /A), terminal resistance, and no-load current.

The torque constant and terminal resistance is usually supplied by the motor manufacture, but should be measured to accurately predict motor performance.

Any DC, permanent magnet motor has a linear relationship to motor torque and current. This ratio is called the motor torque constant and is usually in units of oz-in/Amp or NM/Amp. The torque constant is directly proportional to the voltage constant which describes the voltage generated per RPM or per rad/sec. This is also called the back EMF constant. Since the torque constant is difficult to measure directly without sophisticated equipment, it is best to measure the voltage constant and calculate the torque constant.

The best way to measure the voltage constant is to drive the motor at a known constant speed and measure the voltage at the terminals. If you lack the means to back-drive the motor you can use the amplifier and measure the no-load RPM of the motor at a fixed voltage.

Most digital volt meters cannot accurately measure low resistance as is usually the case in the motor's terminal resistance. Connect a good current source (1A or less) while measuring the voltage drop across the motor terminals. The voltage divided by the current is the terminal resistance.

The no-load current is a combination of a motor's friction (bearing and or brush), hysteresis iron loss, eddy current loss and viscous fluid loss. The no-load current should really be thought as a no-load torque. Although the no-load current varies slightly with RPM, it is more or less a constant torque. Making this assumption greatly simplifies the mathematically model of the motor but may be inaccurate in some instances. The no-load current should be measured at the RPM in which the motor is intending to be run.

Calculating Motor Performance

Use these handy equations to calculate steady state motor performance. A spread sheet will help in visually graphing motor parameters. If the Torque constant is not supplied by the motor manufacturer, you can measure the motors no-load RPM / Volt and use the following equations to calculate the torque constant.

Torque constant: $Kt = Kb \times 1.345$

Current draw of motor: $I = \frac{V - (Kb \times kRPM)}{Rm}$

Torque output of motor: $J = (Kt \times I) - (Kt \times Inl)$

RPM of motor: $kRPM = \frac{V - RmI}{Kb}$



$$\text{Power output of motor: } P_o = \frac{J \times \text{RPM}}{1345}$$

$$\text{Power input: } P_i = V \times I$$

$$\text{Motor Efficiency: } \text{Eff} = \frac{P_o}{P_i} \times 100$$

$$\text{Current at peak motor efficiency: } I_{e \text{ max}} = \sqrt{\frac{V \times I_{nl}}{R_m}}$$

Symbol Definitions:

Eff = Efficiency

I = Current

I_{max} = Most efficient current

I_{nl} = No Load Current

J = Torque (oz-in/A)

K_b = Voltage Constant (Volt / 1000 RPM)

K_t = Torque Constant (oz-In / A)

P_i = Power Input (Watts)

P_o = Mechanical Power Output (Watts)

R_m = Terminal Resistance

RPM = Revolutions / Minute

V = Voltage