MODELS 7226AC, 7426AC
LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS
FOR LINEAR MOTORS WITH ANALOG HALL SENSORS

FEATURES

- **Drives linear AC brushless motors in sinusoidal commutation with feedback from analog Hall sensors**
- **Works with control cards that output a single ±10V torque command**
- **Independent settings for peak and continuous current**
- **Operates directly from AC mains with full optical isolation between signal and power stages**
- **Separate motor and signal Sub-D type connectors for simpler cabling**
- **+5V power for Halls adjustable from 1.25V to 10V**
- **FAIL-SAFE ENABLE INPUT**
  Ground or +5V level select
  Pull-up or pull-down select
- **FAULT PROTECTIONS**
  Short-circuits
  output to output
  output to gnd
  Over / under voltage
  Over temperature
  Self-reset or latch-off
- **3kHz max bandwidth.**
  Wide load inductance range

THE OEM ADVANTAGE

- **Internal header configures amplifier for plug and play operation**
- **No power supply required**

MODEL	POWER	I-CONT (A)	I-PEAK (A)
7226AC	32~132VAC	10	20
7426AC	32~264VAC	10	20

FEATURES

The 7xx6AC models are PWM servoamplifiers for linear AC brushless motors operating in force (current) mode. These amplifiers use Hall sensors with analog, sinusoidal outputs to produce sinusoidal commutation in the motor, and accept a single +/-10V reference input to control motor current, which produces linear force in the motor.

Models operate directly from 115VAC or 230VAC single-phase AC mains. Signal, logic, Halls, encoder, and monitor signals are all optically isolated from the mains.

Analog Hall sensors output sinusoidal signals, unlike the digital Halls on six-step (trapezoidal) commutated DC brushless motors. There are two of these sensors on a linear motor, aligned so that their outputs correspond to the U and V phase currents. These signals are typically 1~2V peak to peak, and offset from ground. Gain and offset adjustments are provided in the amplifier to normalize these signals to +/-10V. Thereafter, these signals control analog multipliers that process the single analog +/-10V force (current) command to produce phase current demand signals for the U and V motor phases. The amplifier then synthesizes the W phase current for full sinusoidal commutation.

The quality of sinusoidal commutation with this method depends on the outputs of the Hall sensors and the construction of the motor. If the back emf is a mirror image of the Hall signals, a high-quality sinusoidal force vector will be produced in the motor. For applications where the Hall outputs are less than perfectly sinusoidal, a force will be produced that is smoother than simple six-step commutation.

Quieter because there is no step-discontinuity when one winding is switched off, and the next is turned-on. The quality of this force will be intermediate between pure sinusoidal, and six-step commutation.

An internal solderless sockets permits users to configure the various gain and current limit settings to customize the amplifiers for a wide range of loads and applications. Header components permit compensation over a wide range of load inductances to maximize bandwidth with different motors.

The /Enable input active logic-level is switch-selectable to ground or +5V to interface with all types of control cards. Fail-safe operation in either polarity results from an internal jumper that selects the default input level and input resistor pull-up or pull-down connections so that the amplifier shuts down with no input.

Current limits on the +/-10V force command control peak, continuous, and peak-time to tailor the amplifier output to the thermal limits of the motors.

A digital input for N.C. (normally closed) thermal switches in the motor forcer will shutdown the amplifier to protect the motor from thermal overloads.

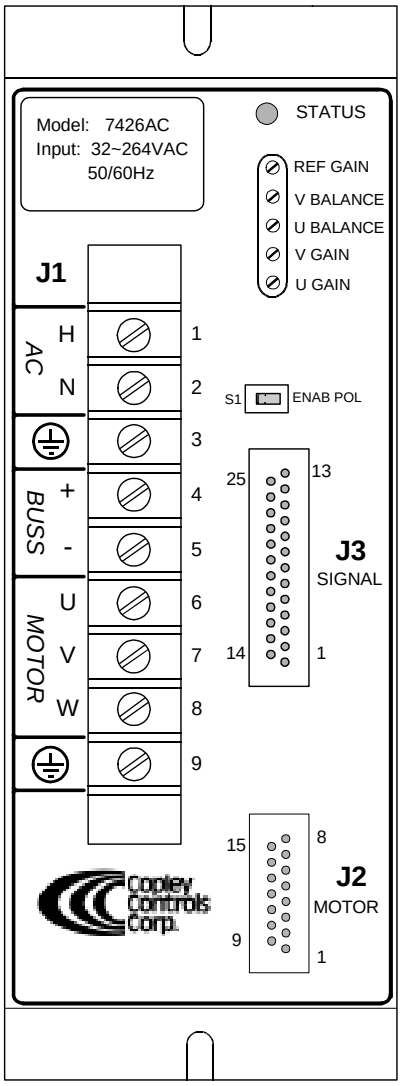
All models are protected against output short circuits (output to output and output to ground) and heatplate overtemperature. With the /Reset input open the amplifier will latch off until powered-down or the /Reset input is toggled the amplifier will reset itself automatically from faults if the /Reset input is wired to GND.

TECHNICAL SPECIFICATIONS

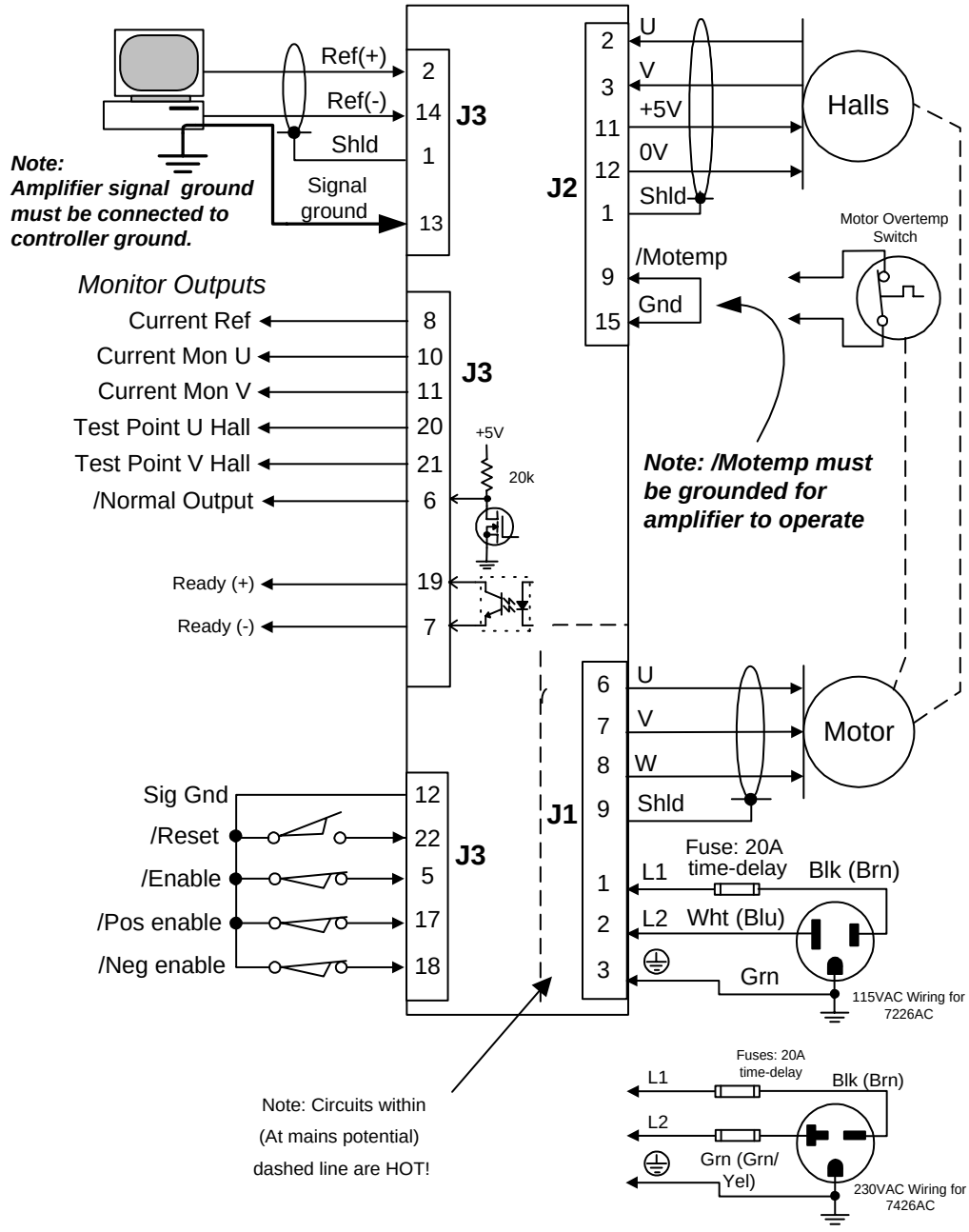
MODEL		7226AC	7426AC
OUTPUT POWER			
	Peak power	20A @ 110V	20A @ 205V
	Peak time	1 sec at peak power or 2 secs. after polarity reversal	
	Continuous power	10A @ 130V	10A @ 250V
OUTPUT VOLTAGE			
	On-resistance (Ro, ohms)	0.2	0.15
	Max PWM Peak Output Voltage	±Vout = (VAC X 1.41 -2)×(0.97) - (Ro)×(Io)	
	Maximum effective output voltage at continuous power	130V @ 10A	250V @ 10A
	Maximum effective output voltage at peak rated current	110V @ 20A	205V @ 20A
INPUT POWER			
	Voltage	32~132VAC, 47~63Hz	32~264VAC, 47~63Hz
	Current	16A	16A
	Inrush current on startup	37A max	37A max
	External mains fuse rating	20A/125V	20A/250V
LOAD INDUCTANCE			
	Minimum inductance	400 µH.	800 µH.
	Maximum inductance	No maximum. See chart of load inductance values. Bandwidth varies with inductance and header parts.	
BANDWIDTH	Small signal	-3dB @ 3kHz with minimum load at nominal supply voltage. Varies with load inductance and header values	
PWM OUTPUTS			
	PWM frequency	25 kHz	
	Modulation	Center-weighted, 50% duty cycle at 0V input	
REFERENCE INPUT		Differential, 94kΩ between inputs, ±20V maximum	
POTENTIOMETERS			
	Ref Gain	Default = CW	CCW attenuates Reference input from x1 to 0
	Hall V Offset	Default = center	Adjusts Hall signals to 0V average value
	Hall U Offset	Default = center	Adjusts Hall signals to 0V average value
	Hall V Gain	Default = CW	Adjusts Hall signal amplitude to +/-10V
	Hall U Gain	Default = CW	Adjusts Hall signal amplitude to +/-10V
DIPSWITCH	S1:	/Enable input active polarity. OFF (default): Gnd enables amplifier, open or +5V inhibits. ON: Gnd inhibits, open enables	
LOGIC INPUTS			
	/Enable	Default = GND	GND enables amplifier, open or >2.5V inhibits with S1 OFF. If S1 ON then GND inhibits See following section on Fail-Safe operation for JP1 settings. Response time: 1 ms. From enable active to amplifier output ON
	/POS enable, /NEG enable	Default = GND	GND enables, open or >2.5V inhibits positive/negative output currents (S1 has no effect)
	/Reset	Default = Open	GND resets latching fault condition, ground for self-reset every 50 ms.
	/Motemp	Default = GND	Motor temperature sensor. Typically normally closed bimetal sensor. Open = overtemp
	Input resistance		10kΩ (Jumper JP1 selects connection to +5V or ground), R-C filters on inputs
	Logic threshold voltage		2.5V (Schmitt trigger inputs with hysteresis, 74HC14)
	Input voltage range		0V to +32VDC
FAIL-SAFE ENABLE INPUT			
	Internal jumper JP1 selects +5V or GND connection for input pull-up resistors to /Enable input only so that amplifier will default to *disabled* condition if inputs are open-circuit, or wires are broken. (See Applications section for details)		
LOGIC OUTPUTS			
	/Normal		LO (current sinking) when Normal LED is ON; HI when LED is OFF
	HI output voltage		+5V (no load). Output is N-channel mosfet drain terminal with10kΩ pullup resistor to +5V
	LO output voltage		On resistance Ro = 5Ω. Max sink current of 250mA. max off-voltage = 50VDC
	Amp OK		N-channel opto-isolator is ON when amp is OK: Buss volts OK AND NOT (output short OR overtemp)
	ON current		4 mA.
	Max voltage		32 VDC
STATUS LED			
	Bicolor LED changes color and flashes to indicate amplifier operating status		
	Green = Normal	*Amplifier enabled* AND Amp OK (see above)	
	Flashing green = Ready	Amplifier OK, will *run* when enabled	
	Red = Buss Fault, non-latching	Over or under-voltage condition. Amplifier recovers when voltage is in normal range	
	Flashing red = Latching Fault	Output overcurrent (short circuit) or overtemp condition. Ground /Reset or power amp off/on to clear condition	
MONITOR OUTPUTS			
	Current Ref	Current demand signal to PWM stage: ±10V = ±Ipeak	
	Current Monitor U	Motor winding current: ±10V @ ±Ipeak (10kΩ, 2.2nF R-C filter)	
	Current Monitor V	Motor winding current: ±10V @ ±Ipeak (10kΩ, 2.2nF R-C filter)	
DC POWER OUTPUTS			
		Adjustable +1.25V to +10V @ 250mA max (J2-11) power for halls and/or encoder +5V @ 250 mA max (J3-23) +10VDC @ 5 mA (J3-24) -10VDC @ 5mA (J3-25) Note: maximum power from all dc outputs not to exceed 1.4W	

PROTECTIVE FEATURES		
	Short circuit (output to output, output to ground)	Latches unit OFF (Power off/on, or ground at /Reset input resets)
	OverTemperature	Latches unit OFF at 70°C on heatplate (Power off/on, or ground at /Reset input resets) *Wire /Reset input to ground for automatic reset after latching fault*
	Undervoltage	Shutdown at DC buss < 45VDC
	Overvoltage	Shutdown at DC buss > 195VDC (Model 7226AC), or DC buss > 390VDC (Model 7426AC) (Amplifier operation resumes when power is NOT undervoltage or NOT overvoltage)
	Current-limiting (foldback)	Output current set by header components (peak, continuous, & peak-time)
THERMAL REQUIREMENTS		
		Storage temperature range -30°C to +85°C Operating temperature range 0° to 70°C baseplate temperature Thermal resistance (heatplate to ambient): No heatsink or fan: 0.92 deg C/W, no heatsink with fan: 0.51 deg C/W With heatsink, no fan:0.6 deg C/W; with heatsink and fan: 0.23 deg C/W
MECHANICAL		
	Size	7.50 x 7.0 x 2.72 in. (190 x 178 x 69 mm) without optional heatsink 7.5 x 7.0 x 4.72 in. (190 x 178 x 120mm) with optional heatsink
	Weight	2.71 lbs. (1.69 kg) without optional heatsink. Add 3.2 lb (1.47 kg) for heatsink.
CONNECTORS		
	J1: Power & motor	9-position terminal strip
	J2: Halls / Options	15-position female Sub-D type. #4-40 standoffs for cable shell lock screws
	J3: Signal	25-position female Sub-D type. #4-40 standoffs for cable shell lock screws Connector shells are connected to amplifier chassis for grounding/shielding

PANEL LAYOUT



AMPLIFIER CONNECTIONS



CONNECTORS

J1 POWER AND MOTOR WINDING CONNECTIONS

Connector type: Barrier-block. Screw-terminal connections. #6-32 locking screws with cable clamps.

PIN	SIGNAL	FUNCTION
1	L1	AC Power Input Hot (black or brown wire from AC mains)
2	L2	AC Power Input Neutral (white or blue wire from AC mains)
3	GND	Chassis safety ground (green or green/yel wire from AC mains)
4	Buss (+)	Positive terminal of internal DC power supply
5	Buss (-)	Negative terminal of internal DC power supply
6	Motor U	Amplifier output to “U” winding of motor
7	Motor V	Amplifier output to “V” winding of motor
8	Motor W	Amplifier output to “W” winding of motor
9	GND	Chassis safety ground. Also for cable shield of motor cable.

J2 MOTOR HALL AND ENCODER CONNECTIONS

Connector type: Female Sub-D, 25 position, #4-40 locking standoffs

PIN	SIGNAL	FUNCTION
1	Safety GND	Chassis ground. Use to ground cable shield. Not connected to internal signal ground.
2	Hall U	Analog Hall signal from “U” phase sensor
3	Hall V	Analog Hall signal from “V” phase sensor
4	N.C.	No Connection
5	N.C.	No Connection
6	N.C.	No Connection
7	N.C.	No Connection
8	N.C.	No Connection
9	Motemp	Motor temperature sensor ***Must be grounded for amplifier to operate***
10	0V.	Signal ground for Hall Vcc
11	Hall Vcc(+5V)	DC power for Halls (Note 1)
12	0V.	Signal ground for Halls.
13	N.C.	No Connection
14	0V.	Signal ground for Halls.
15	0V.	Signal ground for Halls.

J3 SIGNAL CONNECTIONS

Connector type: Female Sub-D, 9-position, #4-40 locking standoffs

PIN	SIGNAL	FUNCTION	PIN	SIGNAL	FUNCTION
1	Safety GND	Chassis ground. Use to ground cable shield. Not connected to internal signal ground (J3-12, 13,15,16).			
2	Ref (+)	Positive terminal of differential +/-10V analog command input	14	Ref (-)	Negative terminal of differential +/-10V analog command input
3	N.C.	No connection	15	N.C.	No Connection
4	N.C.	No connection	16	0V.	Signal ground.
5	/Enable input	Amplifier enable	17	/Pos Enable input	Enable positive current
6	/Normal output	Mosfet output amp status	18	/Neg Enable input	Enable negative current
7	Ready (-) output	Opto-isolator emitter (NPN)	19	Ready (+) output	Opto-isolator collector (NPN)
8	Current Ref output	Torque demand ±10V @ ±20A	20	TP-U	Hall U signal test point
9	N.C.	No Connection	21	TP-V	Hall V signal test point
10	Current Monitor U	±10V @ ±20A output	22	/Reset input	Ground to reset latching fault
11	Current Monitor V	±10V @ ±20A output	23	+5V @ 250 mA.	+5V, 250mA max.
12	0V.	Signal ground.	24	+10V @ 5 mA	Auxiliary DC power
13	0V.	Signal ground.	25	-10V @ 5 mA	Auxiliary DC power

Notes:

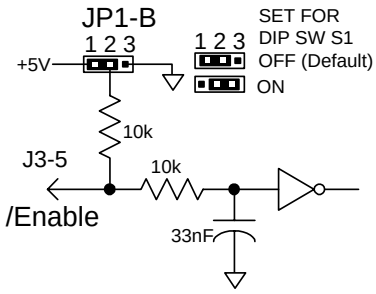
1. Hall Vcc can be adjusted to 10V max. @ 250mA. See application section

/ENABLE INPUT ACTIVE LEVEL CONTROL

DIP switch S1, ENAB POL, controls active level of the amplifier enable input at J3-5. The *default* position is S1 OFF, this will make the */Enable input ground-active, >2.5V will disable the amplifier.* With S1 ON, this will make the /Enable input disable amplifier if grounded, >2.5V will enable.

ENABLE INPUT FAIL SAFE CONTROL

Jumper JP1-B, on the signal board, controls the /Enable input level control resistor. The figure below shows the function, with S1 OFF and JP1-B on pins 1-2 as the default condition. The /Enable input must be pulled LO to enable the amplifier, and if the input is open (disconnected or wire broken) the amplifier turns off as the input is pulled-up to +5V. This is called *fail-safe* because the amplifier must be connected, and the input actively driven to ground to turn the amplifier ON, otherwise it's OFF.



If an active HI fail-safe operation is desired, then turn S1 ON and move JP1-B to pin 2-3. Now the input is *pulled-down* to ground if it is disconnected, and must be actively pulled-up to >2.5V by the control system to enable the amplifier.

POTENTIOMETER FUNCTIONS

POT	DFLT	DESCRIPTION
REF GAIN	CW	Input signal attenuation. Controls gain (Amps/Volts) Full CCW attenuates signal to zero.
V BAL	CNTR	Adjusts U Hall signal to 0V average at Test Point U
U BAL	CNTR	Adjusts V Hall signal to 0V average at Test Point V
V GAIN	CW	Adjusts U Hall signal to ±10V amplitude at Test Point U
U GAIN	CW	Adjusts V Hall signal to ±10V amplitude at Test Point V

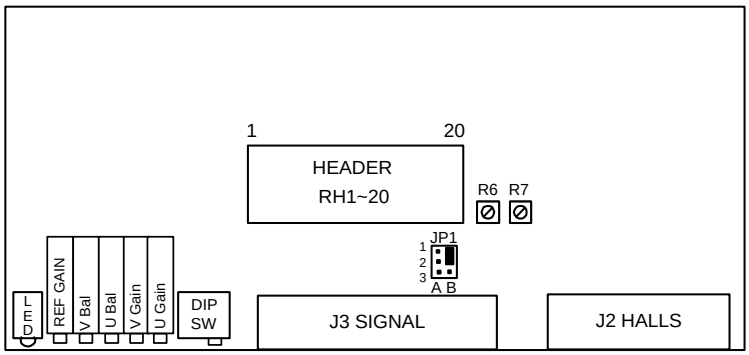
LED INDICATOR FUNCTIONS

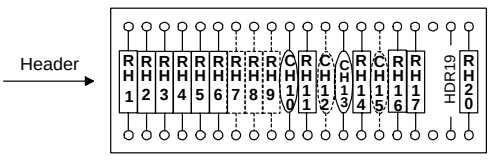
Color and state of LED indicates amplifier operating conditions

LED COLOR	CONDITION	ACTION to ENABLE
Flashing Green	Ready (AMP OK)	Activate /ENABLE
Green	Normal	None
Red	Fault	Power, /MOTEMP (J2-9)
Flashing Red	Latching Fault	/Reset, Power OFF/ON

Ready	=	Amp OK AND NOT enabled
Normal	=	Amp OK AND enabled
Amp OK	=	Internal buss voltage is within AND NOT fault
Fault	=	Over voltage, under voltage, or motor overtemp
Latching Fault	=	Output short circuit or heatplate overtemperature. Amplifier "latches" off and stays off until reset

SIGNAL BOARD AND HEADER SOCKET LAYOUT

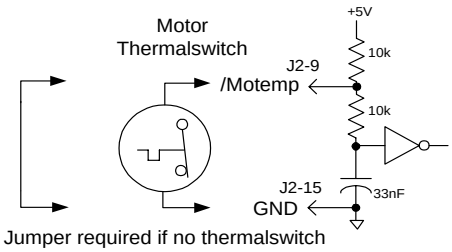




The header socket holds the components that determine the amplifiers performance such as, current limits. Components are named **RH**n, **CH**n as **R**esistor **H**eader n, **C**apacitor **H**eader n, etc. Detailed instructions for the selection of these components follows.

MOTOR TEMPERATURE SENSOR

The /MOTEMP (J2-9) line must be pulled to GND (J2-15) in order to enable the amplifier. A normally closed thermal switch can be connected to protect the motor from over temperature. When the switch opens the /MOTEMP line is pulled to +5V through a 10k resistor, disabling the amplifier.



Jumper required if no thermalswitch

MOTOR INDUCTANCE COMPENSATION

Header components control the amplifier compensation for different motors. These set the gain in the current error amplifier to give the best response for different winding *inductances*. There are two current-control loops in this series of amplifiers, both must have the same values in the header. The tables below give values for the header parts for the two models. The default values for RH11 and RH14 are indicated below in bold & italic. If the inductance of your motor is less than ½ of the value shown in the table, use the values from the next *lower* inductance range.

For all tables: CH12 & CH15 are <out>

Model 7226AC @ 115VAC; CH10 & CH13 = 15nF

L (mH)	R11& RH14 (Ω)
0.3	18k
1	***39k***
3	75k
10	180k
30	300k

Model 7426AC @ 230VAC; CH10 & CH13 = 10nF

L (mH)	R11& RH14 (Ω)
0.3	12.5k
1	***24.9k***
3	51k
10	120k
30	200k

Model 7426AC @ 115VAC CH10 & CH13 = 10nF

L (mH)	R11& RH14 (Ω)
0.3	18k
1	39k
3	75k
10	180k
30	300k

If the default values do not give sufficient bandwidth, contact factory for a detailed tuning procedure.

PEAK CURRENT LIMIT (RH7)

Ipeak Amps	RH7 (Ω)
20	**<out>**
18	39k
16	19.5k
14	11.7k
12	7.5k
10	5.1k
8	3.4k
6	2.2k
4	1.3k
2	560

CONTINUOUS CURRENT LIMIT (RH8)

Icont Amps	RH8 (Ω)
10	**<out>**
9	30k
8	15k
7	7.5k
6	4.7k
5	2.7k
4	1.5k
3	560
2.1	0

Notes on Current Limits:

1. Values in ***Bold & Italics*** are factory default values.
2. Peak current limit should always be set greater than or equal to continuous current limit.

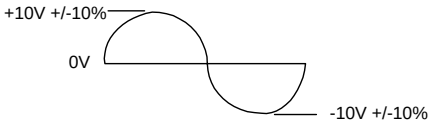
HALL SUPPLY VOLTAGE SETTING

The Hall supply voltage HALLVCC (J2-11) with respect to GND (J2-12) is set to +5V (default). The Hall supply voltage may be adjusted from 1.25V to 10V by adjusting the value of RH20. The Default value of RH20 is 604Ω. The formula for calculating RH20 is:

$$RH20 = 200 \left(\frac{Vcc}{1.25} - 1 \right)$$

If the Hall Vcc is changed then the values of RH1 and RH4 may need to be changed. These establish the center voltage for the Hall reference (default is 2.5V) The formula is: RH1 = RH4 = (5V*10K) / (center voltage)

ANALOG HALL U AND V ADJUSTMENTS



After connecting Hall U (J2-2), Hall V (J2-3), Hall Vcc (J2-11) and Gnd (J2-12). Use an oscilloscope and monitor TP-U (J3-20) with respect to Gnd available at (J3-13). While moving the motor, first adjust the U Balance potentiometer to center the sinusoid, second adjust the U Gain potentiometer for an amplitude of +/-10V +/-10%. Repeat the process with TP-V (J3-21) adjusting V Balance and V Gain

AMPLIFIER WIRING & CABLING

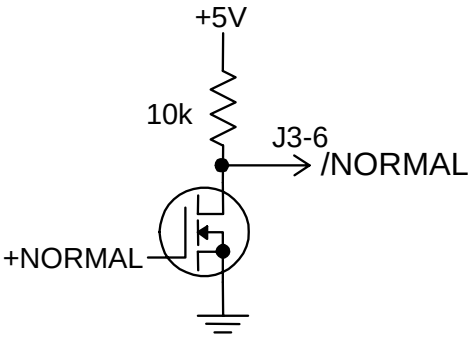
Power supply and motor connections should be made with wire that has a rating to support the amplifiers continuous current. AWG 14 wire will support all amplifiers in this series. To minimize noise radiation from the motor and power cabling, wires should be twisted and shielded. Motor sensor signals are often routed near the motor phase winding cables. To minimize coupling of PWM noise, sensor signal wiring should be multiple-conductor-shielded cable.

GROUNDING AND ISOLATION

The signal board is fully isolated from the power section in this series of amplifiers. For proper operation, ***connect the signal ground J3-13 to the controller ground.***

For safety, it is important that J1-3 be connected to earth ground, typically through the power cable.
The connections on the power board, such as the motor phase, are at line potential.

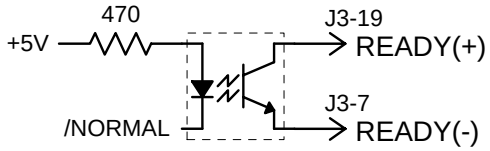
/NORMAL OUTPUT SIGNAL



N-channel mosfet with 10k-ohm resistor connected to +5V.
Maximum voltage: 50VDC. Maximum current 250 mA.
On-resistance = 5 ohms.
Output is LO (mosfet ON) whenever amplifier is enabled and NORMAL (LED Green)
Output is HI (mosfet OFF) whenever amplifier is NOT enabled, or FAULT occurs.

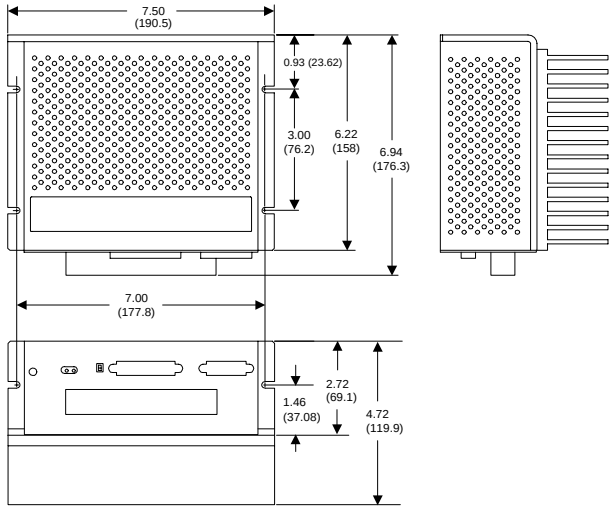
OPTO-ISOLATED NORMAL OUTPUT SIGNAL

This AMP OK signal indicates that the amplifier ready to run. It is completely optically isolated from the amplifier. The input of the optocoupler is driven by the amplifier logic circuits, and the output is a floating NPN transistor with both terminals brought to signal connector J3 as shown below.



Maximum voltage = 32VDC. ON current = 4mA. minimum
Output transistor ON voltage: 0.4 at 4mA

OUTLINE DIMENSIONS



Dimensions in inches (mm)

WEIGHT

2.71 lbs. (1.69 kg) without optional heatsink. Add 3.2 lb. (1.47 kg) for heatsink.

CONNECTORS

J1: Power & motor 9-position barrier strip; #6-32 screws have wire protector
J2: Motor signal 15 position female sub-D type; with #4-40 standoffs for cable
J3: Control Signal 25 position female sub-D type; with #4-40 standoffs for cable

ORDERING GUIDE

Model 7226AC	20A peak, 10A continuous, 32~132VAC Sinusoidal brushless amplifier for Analog Halls
Model 7426AC	20A peak, 10A continuous, 32~264VAC Sinusoidal brushless amplifier for Analog Halls

Notes: 1. Add "H" to model number to specify heatsink option.
Example: Model 7426AC with heatsink would b e ordered as a 7426ACH

Copley Controls Corp.

Corporate Office, USA
20 Dan Road
Canton, MA 02021
Tel: 781-828-8090
Fax: 781-828-6547