MODELS 7227AC, 7427AC

LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS FOR RESOLVER MOTORS

FEATURES

- **Drives AC brushless motors with resolver feedback with sinusoidal commutation in torque or velocity mode**
- **10, 12, 14, or 16 bit resolution**
- **Encoder outputs emulate 256, 1024, 4096, or 16,384 line encoders with *Burst* mode output of absolute position via encoder lines**
- ***DriveTorque* mode switching from torque to velocity for fastener-drive applications**
- **Overspeed limiting controls maximum rpm**
- **Independent settings for peak and continuous current, and peak-time settable via internal header**
- **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**
- **FAIL-SAFE ENABLE INPUT**
  Ground or +5V level select
  Pull-up or pull-down select
- **Dual Status outputs (amp NORMAL and amp READY)**
- **FAULT PROTECTIONS**
  Short-circuits
  output to output
  output to gnd
  Over / under voltage
  Over temperature
  Self-reset or latch-off

THE OEM ADVANTAGE

- **Production amplifiers can be pre-configured at the factory for volume production**
- **Built in power supply!**

MODEL	POWER	I-CONT (A)	I-PEAK (A)
7227AC	32~132VAC	10	20
7427AC	32~264VAC	10	20

FEATURES

The 7xx7AC models are PWM servoamplifiers for AC brushless motors using resolver feedback. The amplifiers use this feedback to drive motors with sinusoidal commutation in torque or velocity modes. The resolution of the resolver is settable for 10, 12, 14, or 16 bits. Quadrature encoder emulation signals for 256, 1024, 4096, and 16384 line encoders are generated for the control system.

Models operate from 115 or 230VAC single-phase AC mains. Signal logic, resolver, and monitor lines are all isolated from the mains.

Built with surface-mount technology, these amplifiers offer a full complement of features for AC brushless motor control. Torque-mode operation is standard, velocity mode is based on the analog velocity signal generated by the resolver interface.

In velocity mode maximum rpm can be limited via a settable overspeed limit feature.

Absolute position can be sent via the A/B encoder lines by grounding an input with the amplifier disabled.

The resolver interface can drive a wide range of resolver types. Selectable resolutions permit optimum setup for a wide range of motor speeds, and mechanical angular accuracy.

Torque mode is used typically with digital controllers that calculate position and velocity from the motor's encoder. Velocity mode works with these controllers as well as in stand-alone applications where the motor is to follow a setpoint speed command.

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.

Separate current-limits provide protection for motors while optimizing acceleration characteristics. Peak current, continuous current, and peak-time are individually settable via the internal header.

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.

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

AMPLIFIER FEATURES

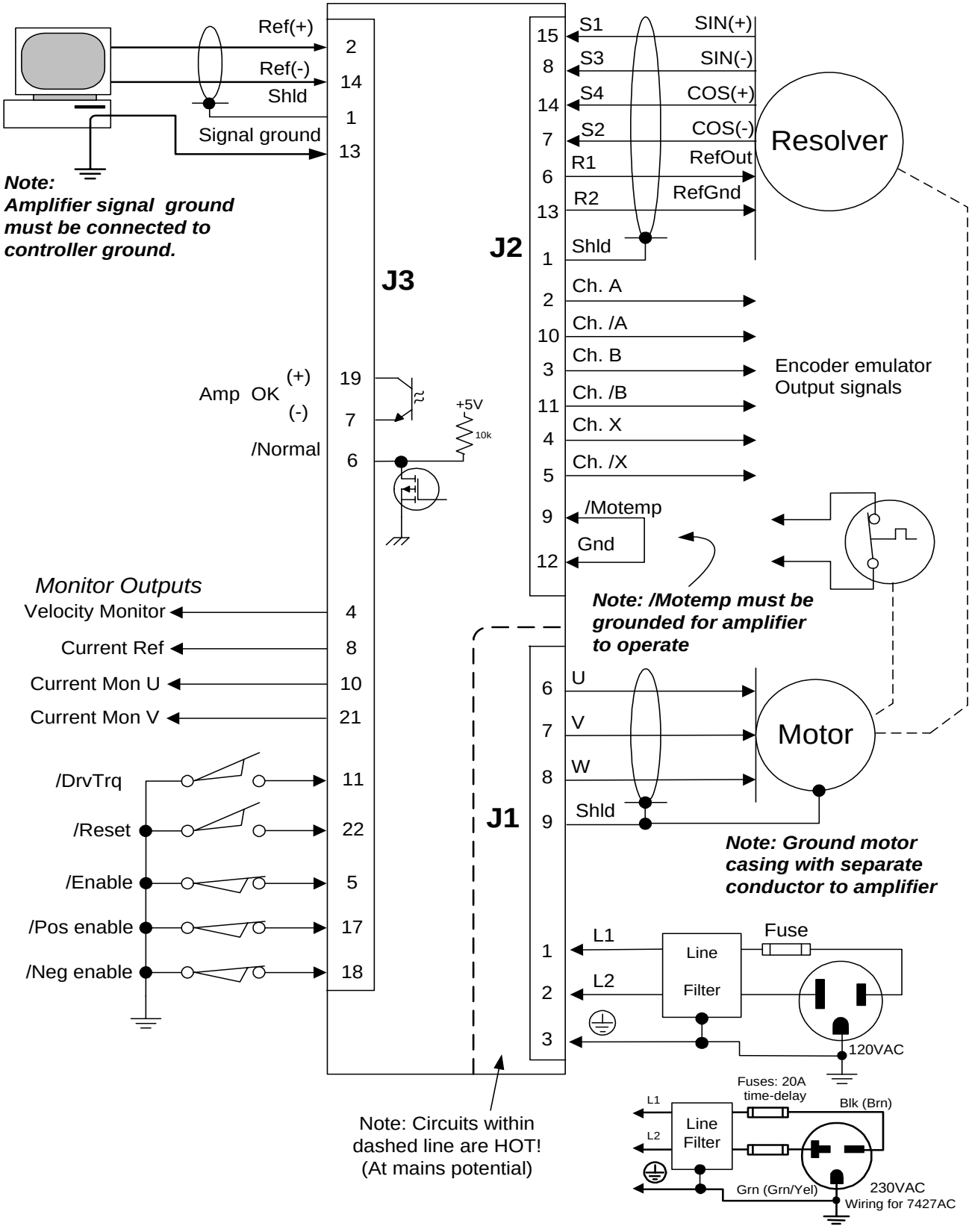
MODEL			7227AC	7427AC
OUTPUT POWER				
	Peak power		20A @ 110V	20A @ 205V
	Peak time		1 sec at peak power or 2 secs. after polarity reversal	
	Continuous power		10A @ 130V	10A @ 250V
OUTPUT VOLTAGE				
	On-resistance (Ro, ohms)		0.2	0.15
	Max PWM Peak Output Voltage		±Vout = (VAC X 1.41 -2)×(0.97) - (Ro)×(Io)	
	Maximum effective output voltage at continuous power		130V @ 10A	250V @ 10A
	Maximum effective output voltage at peak power		110V @ 20A	205V @ 20A
INPUT POWER				
	Mains voltage		32~132VAC, 47~63Hz	32~264VAC, 47~63Hz
	Mains current @ continuous output rating		16A	16A
	Inrush current on startup		37 A max	37 A max
	External mains fuse rating		20A/125V	20A/250V
LOAD INDUCTANCE				
	Minimum inductance		400 µH.	400 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		25kHz	
	Modulation		Center-weighted, 50% duty cycle at 0V output	
REFERENCE INPUT			Differential, 94KΩ between inputs, ±20V maximum	
POTENTIOMETERS (15 turn)	Ref Gain	Default = CW	CCW attenuates Reference input from x1 to 0	
	Tach Gain	Default = CCW	CW increases speed (decreases feedback from tachometer). Note: fully CW = 5% of max	
	Loop Gain	Default = CCW	CW increases loop gain in velocity mode, current gain in torque mode	
	Integ Freq	Default = CCW	Integrator zero-gain frequency in velocity mode. CW increases stiffness	
	Balance/Test	Default = center	Use to set output current or rpm to zero; or use as ±10V test input if RH9 set to 50kΩ	
DIP SWITCHES	S1:		Velocity loop integrator control. ON: Torque mode, integrator disabled. OFF: Velocity mode, integrator enabled.	
	S2:		/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 S4 ON then GND inhibits See following section on Fail-Safe operation for JP4 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 J4 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 JP4 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 pull-up 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)	
	Blinking green = Ready		Amplifier OK, will *run* when enabled	
	Red = Fault, non-latching		Over or under-voltage condition OR motor overtemp OR resolver referance line open circuit. Amplifier recovers when fault condition is corrected.	
	Blinking red = Latching Fault		Output overcurrent (short circuit) OR amp. 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 & V		Motor winding current: ±10V @ ±Ipeak (1kΩ, 33nF R-C filter) for U and V motor phases	
	Velocity monitor		Monitor signal for resolver tachometer signal, voltage feedback	
DC POWER OUTPUTS				
			+5V @ 250 mA max (J2-11, 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	<28VAC (40VDC buss voltage)
Overvoltage	>135VAC (191VDC buss voltage) for 7227AC, >275VAC (389VDC buss voltage) for 7427AC (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	3.71 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: Resolver	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

RESOLVER INTERFACE FEATURES

RESOLUTION						
Selectable: 10, 12, 14, or 16 bits per resolver electrical cycle						
REFERENCE WINDING DRIVE						
Frequency	2, 5, 10, or 20kHz jumper selectable; intermediate frequencies settable via component header resistor RH27					
Amplitude	2~4Vrms @ 150mA maximum					
Phase adjustment	Dynamic; automatically compensates for phase variation in resolver by phase-locking to SIN/COS signals					
SIN/COS FEEDBACK SIGNALS						
Amplitude	2.0Vrms +/-10%					
ENCODER EMULATION						
Resolution	Bits	10	12	14	16	
Encoder Emulation	Lines	256	1024	4096	16,384	
Counts	Lines X 4	1024	4096	16,384	65,536	
ACCURACY						
Resolution	Bits	10	12	14	16	
Accuracy (Arc-minutes + 1 LSB)	Arc mins	8	4	2	1	
VELOCITY SIGNAL						
Amplitude	+/-4V maximum from R/D converter at maximum tracking rate. Scaleable to +/-10V with header component RH17					
Scale factor tempco	100ppm typical, 200ppm maximum per degree C.					
Reversal error	0.75% typical, 1.3% maximum					
Linearity	0.25% typical, 0.5% maximum					
Zero offset	5mV typical, 10mV maximum, adjustable to zero with amplifier Balance potentiometer					
Zero offset tempco	15 typical, 30 maximum µV/degree C.					
OVERSPEED PROTECTION						
Adjustable via potentiometer R8 on signal board. 0~10V range disables motor torque when speed setpoint is exceeded to limit RPM.						
RESOLVER FEEDBACK LOSS PROTECTION						
Loss of SIN or COS signal will shut down amplifier						
DYNAMIC CHARACTERISTICS						
Resolution	Bits	10	12	14	16	
Tracking Rate (maximum)	Rev/s	1152	288	72	18	
Tracking Range (maximum)	RPM	69,120	17,280	4,320	1080	
Bandwidth (closed loop)	Hz	1080	1080	540	270	
Acceleration (1 LSB lag)	deg/s^2	2M	500k	30k	2k	
Settling time	msec	2	8	20	50	

AMPLIFIER CONNECTIONS



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 (N.C.)
5	Buss (-)	Negative terminal of internal DC power supply (N.C.)
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 RESOLVER CONNECTIONS

Connector type: Female Sub-D, 15-position, #4-40 standoffs for cable shell

PIN	SIGNAL	FUNCTION
1	Safety GND	Chassis ground. Use to ground cable shield. Not connected to internal signal ground.
2	Encoder Ch. A Out	Output for encoder emulator A channel
3	Encoder Ch. B Out	Output for encoder emulator B channel
4	Encoder Ch. X Out	Output for encoder emulator X (index) channel
5	Encoder Ch. /X Out	Output for encoder emulator /X (inverted index) channel
6	RefOut	Resolver Reference winding drive
7	S2	Resolver Cos (-)
8	S3	Resolver Sin (-)
9	Motemp	***Note: Must be grounded for amplifier to operate (Connect to J2-12)***
10	Encoder Ch. /A Out	Output for encoder emulator /A (inverted A) channel
11	Encoder Ch. /B Out	Output for encoder emulator /B (inverted B) channel
12	0V.	Signal ground
13	RefGnd (0V)	Resolver Reference winding return (0V, signal ground)
14	S4	Resolver Cos (+)
15	S1	Resolver Sin (+)

J3 SIGNAL CONNECTIONS

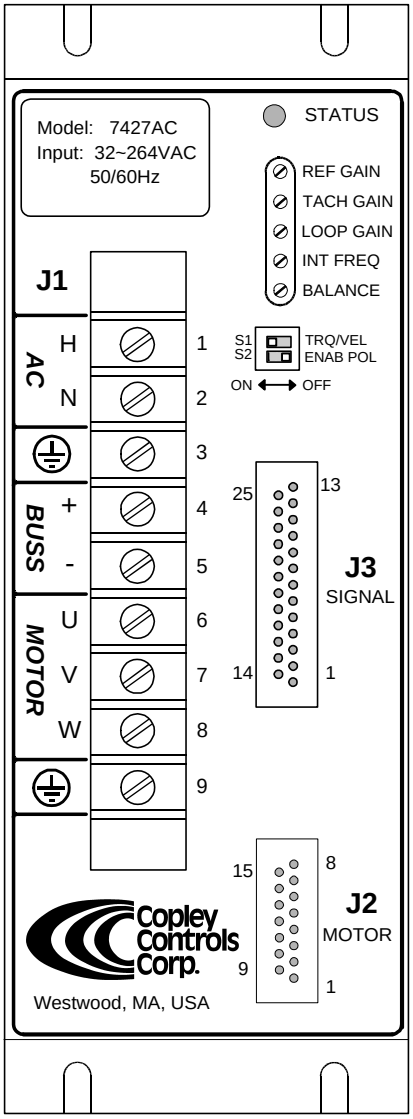
Connector type: Female Sub-D, 25-position, #4-40 standoffs for cable shells

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	Burst	Encoder burst to index	15	0V.	Signal ground.
4	Tacho	Scaled to +/-10V max.	16	0V.	Signal ground.
5	/Enable input	Amplifier enable	17	/Pos Enable input	
6	/Normal output	Mosfet output amp status	18	/Neg Enable input	
7	Amp OK (-) output	Opto-isolator emitter (NPN)	19	Amp OK (+) output	Opto-isolator collector (NPN)
8	Current Ref output	+/-10V @ +/-20 A command	20	N.C.	
9	Aux input		21	Current Monitor V	+/-10V @ +/-20 A
10	Current Monitor U	+/-10V @ +/-20 A	22	/Reset input	
11	/DRVTRQ	Switch to torque mode circuit	23	+5V @ 200 mA.	Auxiliary DC power for user devices (Note 1)
12	0V.	Signal ground.	24	+10V @ 5 mA	Auxiliary DC power
13	0V.	Signal ground.	25	-10V @ 5 mA	Auxiliary DC power

Notes:

1. +5V @ 200mA connects to *both* J3-23 *and* J2-11. Combined current from both pins must not exceed 200mA.

PANEL LAYOUT



DIP SWITCH FUNCTIONS

ON is toward PC board, OFF is away from PC board.
The default configuration for the amplifier is *torque mode*, and active low /Enable input (open or +5V inhibits).

S1 TRQ/VEL *ON* (Default) = Torque mode, velocity integrator disabled. *OFF* = Velocity integrator enabled

S2 EN POL ON = /Enable input disables amplifier if ground. Open or >2.5V enables. ***OFF* (Default)** /Enable input ground-active. Open or >2.5V disables amplifier.

LED INDICATOR FUNCTIONS

Color and state of LED indicates amplifier operating conditions:

Flashing Green = *Ready!*
Action required to enable**:** Ground /Enable input (J3-5)

Green = *Normal.* "RUN" condition.

Red = *Fault!*
Action required to enable**:** Bring AC voltage into range, ground /Motemp input, connect revolver SIN+COS cables

Flashing Red = *Latching Fault!*
Action required to enable**:** Ground /Reset input, or cycle AC power OFF/ON

POTENTIOMETER FUNCTIONS (EXTERNAL)

The potentiometers are 15 turns from full CW (Clockwise) to full CCW (Counter clockwise).

REF GAIN Input reference signal attenuation.
Controls amplifier velocity gain rpm/volt.
Full ***CW (Default*)** provides no reference signal attenuation
Full CCW attenuates reference signal to zero.

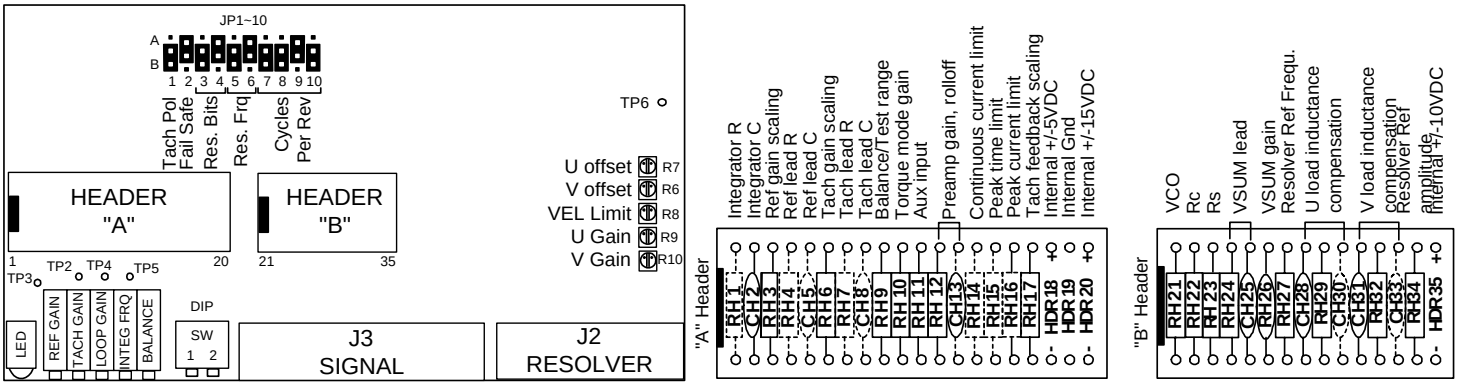
TACH GAIN Tachometer feedback control.
Full ***CCW (Default)*** = maximum feedback (lowest speed)
Full CW = minimum feedback (highest speed)
Range = 20:1 (maximum to minimum speed).

LOOP GAIN Response control for velocity loop
CW increases bandwidth
CCW (Default) decreases.
In torque mode: CW increases amps/volt

INTEG FREQ DIP switch S1 must be OFF for this pot to function. In velocity mode,
CW increases stiffness, makes loop less stable
CCW (Default)decreases stiffness, makes loop more stable.
Too much CW leads to violent oscillation.

BALANCE Sets velocity to zero, or output current to zero with zero input. ***Center (Default)***

SIGNAL BOARD LAYOUT



JUMPER FUNCTIONS JP1 ~ JP10

10 shorting jumpers can occupy two alternate positions: A or B on the three pins. The functions of these are summarized below.

JP1 Tach Pol: Controls motor rotation direction The default position is “B”. If the motor “runs away ” in velocity mode, move jumper to “A”.

JP2 Fail Safe: In “A” position (default), /Enable input “pull-up” resistor connects to +5V so that open input will go HI, and disable amplifier when dip switch S2 is OFF(default). In “B” position, resistor connects to ground for fail-safe function when S2 is ON so that a HI input enables amplifier, and ground disables.

JP3 & JP4 Resolver bits: Controls tracking resolution and encoder emulation line number. Default in Bold and italic.

JP3	JP4	Bits	Lines	Max RPS	Max. Fr (Hz)
B	B	10	1024	1152	20k
B	***A***	***12***	***4096***	***288***	***11k***
A	B	14	16384	72	7k
A	A	16	65536	18	5k

JP5 & JP6 Resolver frequency: drive signal (reference) frequency. Default in Bold and italic.

JP5	JP6	f(Hz)
B	B	2k
B	***A***	***5k***
A	B	10k
A	A	20k

JP7, JP8, JP9, & JP10 Cycles Per Rev: Motor electrical cycles per revolution of motor. Were, N = number of Pole pairs. Default in Bold and italic.

N	JP7	JP8	JP9	JP10
N/A	B	B	B	B
1	B	B	B	A
2	***B***	***B***	***A***	***B***
3	B	B	A	A
4	B	A	B	B
5	B	A	B	A
6	B	A	A	B
7	B	A	A	A

N	JP7	JP8	JP9	JP10
8	A	B	B	B
9	A	B	B	A
10	A	B	A	B
11	A	B	A	A
12	A	A	B	B
13	A	A	B	A
14	A	A	A	B
15	A	A	A	A

POTENTIOMETERS (INTERNAL)

R7 U offset: Fine offset control for U Phase drive. Default is center position.

R6 V offset: Fine offset control for V Phase drive. Default is center position.

R8 VEL Limit: Speed limiting

R9 U Gain: Fine gain control for U Phase drive. Default is center position.

R10 V Gain: Fine gain control for V Phase drive. Default is center position.

TEST POINTS

The test points TP2, TP3, TP4, and TP5 ar located on the signal board. These can be used to measure the resistance of the external potentiometer settings, with respect to ground on J3-13. This is helpful when cloning the settings of one amplifier with another. The table below can be sued to record the settings.

Pot	TP#	Measurement Ω
Tach Gain	TP2	
Ref Gain	TP3	
Loop Gain	TP4	
Integ. Frequ.	TP5	

APPLICATIONS

SETUP

Copley Controls will configure the amplifier for the customer's motor at no extra charge when this amplifier is ordered. Given the number of operations required to set up a resolver motor, we strongly recommend this.

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.

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 phases, are at line potential.

RESOLVER CONNECTION

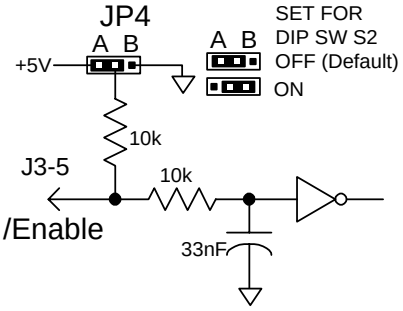
Noise immunity is critical for proper operation. Since resolver signals are often routed near the motor phase winding cables, to minimize coupling of PWM noise, resolver wirings should be multiple-conductor-shielded cable. Three sets of individually twisted-pairs are preferred.
Connect resolver Sin(+) to amplifier J2-15, Sin(-) to J2-8, Cos(+) to J2-14, Cos(-) to J2-7, Ref(+) to J2-6, Ref(-) to J2-13. Ground the resolver wiring shield at the amplifier connector J2-1 and leave it disconnected at the motor. Grounding the shield at the motor housing may give increased noise levels, and should be tested for best results with each installation. Ground the motor casing with a separate conductor to amplifier J1-9. This setup is important to prevent switching noise from being coupled from the motor housing to the resolver signals.

/ENABLE INPUT ACTIVE LEVEL CONTROL

DIP switch S2, ENAB POL, controls active level of the amplifier /ENABLE input at J3-5. The *defaul**t*** position is S1 OFF, this will make the */ENABLE input ground-active, >2.5V will disable the amplifier**.*** With S2 ON, this will make the /ENABLE input disable amplifier if grounded, >2.5V will enable.

ENABLE INPUT FAIL SAFE CONTROL

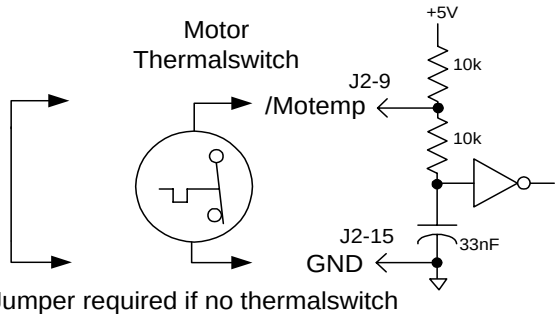
Jumper JP4, on the signal board, controls the /ENABLE input level control resistor. The figure below shows the function, with S2 OFF and JP4 in the "A" position, (default). The /Enable input must be pulled LO to enable the amplifier, and if the input is open (disconnected or wire broken) the amplifier 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 S2 ON and move JP4 to position B. 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.
Note: /POS ENABLE J3-17 and /NEG ENABLE J3-18 must be pulled low to allow drive in both directions

MOTOR TEMPERATURE SENSOR

The /MOTEMP (J2-9) line must be pulled to GND (J2-15) in order to enable the amplifier. The figure below shows the function. 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 10kΩ 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 RH29 and RH32 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. Ex., for a 4 mH motor, use the values from the 3 mH row (1/2 of 10mH is 5mH, which is greater than 4mH, so the value from the next *lower* row, 3mH, is used).

For all tables: CH30 & CH33 are <out>

Model 7227AC @ 115VAC; CH28 & CH31 = 15nF

L (mH)	R29 & RH32 (Ω)
0.3	18k
1	***39k***
3	75k
10	180k
30	300k

Model 7427AC @ 230VAC; CH28 & CH31 = 10nF

L (mH)	R29 & RH32 (Ω)
0.3	12.5k
1	***24.9k***
3	51k
10	120k
30	200k

Model 7427AC @ 115VAC CH28 & CH31 = 10nF

L (mH)	R29& RH32 (kΩ)
0.3	18
1	39
3	75
10	180
30	300

If the default values do not give sufficient bandwidth, contact factory.

CURRENT LIMITS

The Current Reference J3-8, with respect to signal gnd J3-13, provides a way to customize these settings, with the motor disconnected. It has the same scale factor as the current monitor were, ±10V, will command ±Peak current from the amplifier.
In terms of Amsp/Volt the ratio will be I-peak/10V. So, for a Model 7227AC with a rated Peak current of 20Amps the current reference scale factor would be 20A/10V or 2A/V.

CONTINUOUS CURRENT LIMIT

Control of the continuous current limit can be made internally via component RH14 in the header socket .Choose RH14 using manufacturers specification for your motor. This keeps the motor within its thermal limits. The Table values below give basic settings. Note that this limit measures average current and will not work on symmetrical waveforms such as might occur during system oscillation. Use an external thermal switch for protection from such overcurrent

Icont	**R14 Ω**
10	<out>
9	30k
8	15k
7	7.5k
6	4.7k
5	2.7k
4	1.5k
3	560
2.1	0

These values are within 10%, typically. For greater accuracy, measure current reference and select parts for exact limit value.

PEAK CURRENT LIMIT

Control of the peak current limit can be made internally via component RH16 in the header socket. Amplifiers are shipped with no part installed in RH16, which delivers the amplifier's peak rated current. For a lower setting use values from the table below. This setting is of importance since currents that are within the peak-current capability of the amplifier can demagnetize a motor. Note: In the current mode, if the system requires lower peak currents the transconductance should be set to provide a better use of the controllers output range, typically a ±10V DAC. (See the section on Transconductance adjustment.)

Ipeak	**R16 Ω**
20	<out>
18	44k
16	20k
14	12k
12	7.7k
10	5.2k
8	3.5k
6	2.2k
4	1.3k
2	580

These values are within 10%, typically. For greater accuracy, measure Current Ref and select parts for exact limit value.

PEAK CURRENT TIME-LIMIT

Header component RH15 controls the length of time for which the amplifier will output peak current. At currents that are less than the amplifier's peak rated current, peak time will increase, eventually becoming infinite as you reach the continuous current. After a polarity reversal, the peak time will be twice that of a unipolar current change.
Peak time settings are best made while monitoring the Current Ref J3-8, with the motor disconnected. Applying a ±10V square wave, at a frequency of about 0.25Hz, across the inputs Ref(+), J3-2 and Ref(-) J3-14.This will display the peak, continuous, and peak times (note that these double after polarity reversals). Peak time adjustment is non-linear and is best made by component selection based on oscilloscope measurements.

ELECTRICAL CYCLES PER REVOLUTION

The number of electrical cycles per revolution is jumper selectable by positioning JP7,JP8,JP9,JP10 as indicated in the table below. Where, N is the number of electrical cycles per resolver cycle. The default jumper position is indicated in Bold and Italic. Typically there is one resolver cycle per motor cycle. The number of electrical cycles is the number of Poles divided by 2. By connecting two of the motor wires to a low-voltgae DC supply, and driving a small current through the windings, the number of electrical cycles per revolution, can be identified since, each stable position represents one electrical cycle.

N	JP7	JP8	JP9	JP10
N/A	B	B	B	B
1	B	B	B	A
2	***B***	***B***	***A***	***B***
3	B	B	A	A
4	B	A	B	B
5	B	A	B	A
6	B	A	A	B
7	B	A	A	A

N	JP7	JP8	JP9	JP10
8	A	B	B	B
9	A	B	B	A
10	A	B	A	B
11	A	B	A	A
12	A	A	B	B
13	A	A	B	A
14	A	A	A	B
15	A	A	A	A

RESOLVER REFERENCE SIGNAL FREQUENCY

The Reference frequency, Fr is the drive for the static primary winding of the resolver. The Sin and Cos signals come from the two secondary rotor windings. The frequency is set to be within the range of the resolver. The range is 2~20kHz.
Set jumpers JP5 & JP6 to the frequency, that is closest to but not greater than, the required frequency. See chart below, 5kHz is the default value indicated in Bold and Italic.

JP5	JP6	Fr (Hz)
B	B	2k
B	***A***	***5k***
A	B	10k
A	A	20k

The jumper-selected frequencies can be further fine adjusted to 50% of the set value by changing header component RH27 from 0Ω (default) to 30kΩ. Typical values show below.

RH27 0Ω	20K (Hz)	10K (Hz)	5k (Hz)
3.01kΩ	18k	9k	4.5k
8.06kΩ	16k	8k	4k
13.2kΩ	14k	7k	3.5k
20kΩ	12k	6k	3k
30.1kΩ	10k	5k	2.5k

RESOLVER REFERENCE SIGNAL AMPLITUDE

The reference signal must be set so that the maximum peak to peak amplitude of the Sin and Cos signals are 2.0Vrms ±10%. The Ref amplitude is controlled by header component, RH34. The default value is 10k, which produces a reference signal of 4.0Vrms. As resolvers commonly have a ratio of 2:1 between the reference and the Sin/Cos windings, this produces the required 2.0Vrms at the Sin and Cos outputs.

The amplitude can be adjusted by connecting a scope probe to the SIN test point at TP6 on the signal board. Rotate the motor slowly, with the amplifier disabled, until the Sin signal is at a maximum amplitude, then adjust the value of RH34 to produce the 2.0Vrms (5.66V peak-peak) ±10%.

REFERENCE PHASE ADJUSTMENT

The adjustment of the phasing of the Sin and Cos signals to the Reference signal is not necessary since, the resolver circuitry auto-adjusts the phasing.

MOTOR CONNECTION

Copley uses U-V-W naming convention for motor phasing but other conventions such as R-S-T, A-B-C are also OK.
Connect the motor phase windings in the same U-V-W order to start the phasing process. Some motors are setup to work with this wiring scheme but, if it is not the correct one, then there are only five other possible combinations of wiring remaining, and one of these will be the correct one. We take the approach that wires the resolver first, and then changes the motor windings as needed simply because, the motor connections are screw terminals.

RESOLVER RESOLUTION BITS

Jumpers JP3 & JP4 select the number of resolution bits used for tracking. The default position is set for 12 Bits, as indicated in Bold and italic in the table below. The number of resolver bits will be dependant on the maximum resolver frequency Fr, and the maximum tracking speed in rotations per second. This will also effect the number of encoder emulation lines. See table below.

JP3	JP4	Bits	Lines	Max RPS	Max. Fr (Hz)
B	B	10	1024	1152	20k
B	***A***	***12***	***4096***	***288***	***11k***
A	B	14	16384	72	7k
A	A	16	65536	18	5k

The max. RPS and max. Fr will be dependent on the value of RH23, and RH22 set to 30.1k Ohms default. Consult factor before chaining these values.

RESOLVER TRACKING

Copley Controls has calculated header components for optimum tracking. Considering typical application speed, resolver frequency, and resolution bits. The table below indicates the default values.

Header	Value	Name
RH21	150kΩ	Rv
RH24	7.15MΩ	Rb
CH25	100pF	Cbw
CH26	10pF	Cbw/10

Contact Copley Controls before changing these components.

CURRENT MODE

For current (Torque) mode operation, The /TORQ J3-11 line must be pulled low to bypass the servo preamp and any velocity feedback.

TRANSCONDUCTANCE ADJUSTMENT

CURRENT MODE GAIN

The current gain or transconductance is the ratio of output current to input voltage. In the current mode transconductance should be set to provide a better use of the controllers output range, typically a +/10V DAC. The gain can be set via RH10.

In the current mode, It is recommended that the transconductance be set. This will limit the peak current delivered to the motor. Most applications require peak currents of two or three times the motors continuous current rating. Example: For a typical +/-10V DAC and a required 15 Amps peak, the transconductance should be set to 15 Amps / 10 Volt = 1.5 Amps / Volt.

The Gain (Amps / Volt) = 2*RH10 Ω / 10kΩ The default gain is 2A/V with RH10 = 10kΩ. (Indicated in bold & italic in the table below.)

Transconductance

Gain Amps/Volt	R10 (Ω)
2	***10k***
1.5	7.5k
1	5k
0.5	2.5k

VELOCITY MODE

Adjustments of the velocity loop are best done in a two step procedure. First establish the relationship between input Vref and the resolver tachometer voltage, These voltages will be determined by the controller and the gain factor of the resolver tachometer in V/Krpm. After this relationship is established, the next step is tune the closed loop response.

RESOLVER TACHOMETER SPEED CONSTANT

The speed constant Kr is calculated based on a nominal DDC 4v @ maximum established speed, determined in the resolution bits and resolver tracking selection. The default value of Kr is 0.66V/krpm as indicated in Bold and italic in the table below.

Kr (V/krpm)	Bits
	10
0.66	***12***
	14
	16

TACH OUTPUT SCALING

The resolver tachometer output can be scaled to 9V @ motor required top speed. The default value of RH17 is 10k Ohms. The value of RH17 can be calculated form:

$$RH17 < \text{or} = \frac{9V * 10k\Omega}{(\text{top speed in krpm} * Kr)} - 10k$$

VTACH/VREF

If the controller output is a +/-10V command signal and the tach output is scaled to be =10V @ top speed, then no further scaling is required, except for some small adjustments that may be made by adjusting the Tach potentiometer CCW to increase the top speed, if required.
For lower command levels the value of RH6 can be calculated from the ratio:

RH6 = RH3*Vtacho/Vref

Example: if RH3 = 100k Ohms (default) and if Vtach has been scaled for 10V @ top speed, and Vref = 5V then:
RH6 = 100kΩ ∗ 10V / 5V = 200kΩ

RESPONSE ADJUSTMENTS

One method for adjusting the closed loop response is to input a small signal square wave (Say +/- 0.25V at 5 Hz) across Ref(+) J3-2 and Ref(-) J3-14, While monitoring, with an oscilloscope, the tacho J3-4 (The velocity signal from the resolver chip.).
First turn the integration to a minimum by adjusting the INT FREQ potentiometer full CCW (counter clockwise), and adjust the LOOP GAIN potentiometer CW (clockwise) for best step response. After this is done adjust the INT FREQ potentiometer CW (Clockwise) for the fastest response with out oscillations.

SPEED LIMITING

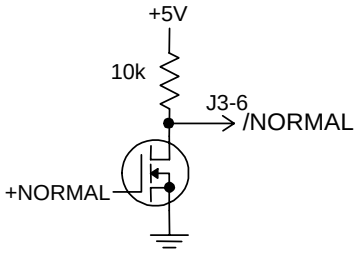
The speed limiting potentiometer R8 can be adjusted to limit the top speed. When the Tacho voltage exceeds the trip voltage set by R8 the current is cutting to the motor. The default position is full CW limiting the Tacho to +/-10V (The maximum Tacho voltage set by scaling for top speed.) By adjusting R8 CCW the top speed can be limited.

DRIVETORQUE MODE

This mode is most useful in fastener-drive applications where the amplifier is operated in a velocity mode to drive the fastener in at a constant speed until the controller senses that the current has reached a set value. Then the controller grounds the /DRVTRQ input switching the amplifier into torque mode that applies a set current to the fastener to drive it into position at a constant torque value.
With J3-11 open (default) amplifier operates in velocity mode using the signal from the R/D converter section.
When J3-11 is grounded, DriveTorque mode is enabled, and amplifier switches to torque mode with transconductance controlled by RH10. The REF GAIN, LOOP GAIN, INTEG FREQ, and BALANCE pots have no effect in this mode. The current gain is controlled by this simple equation:

$$\text{Gain} = \frac{RH10}{10} \text{ (kOhms)} \quad (A/V)$$

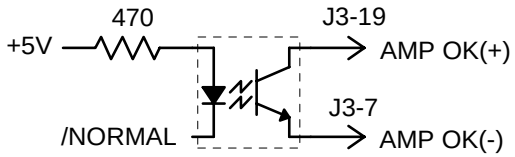
AMP-NORMAL OUTPUT



N-channel mosfet with 10k-ohm resistor connected to +5V. Maximum voltage: 50VDC. Maximum current 250mA. 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.

OPTOISOLATED AMP OK OUTPUT

The Amp OK signal indicates amplifier ready to run status. 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

ENCODER EMULATION

Quadrature encoder emulation signals are produced in differential format (A & /A, etc.). The equivalent line-count is shown in the specification section.
There are four quadrature counts for each line, and one count corresponds to $1/(2^N)$ of a revolution. An index signal is produced one per electrical cycle of the resolver (once per revolution for a 'one-speed' resolver). This is useful for 'homing' the motor when using an end of travel switch. This also is the reference for the motor absolute position that is used in *Burst* mode (see below).

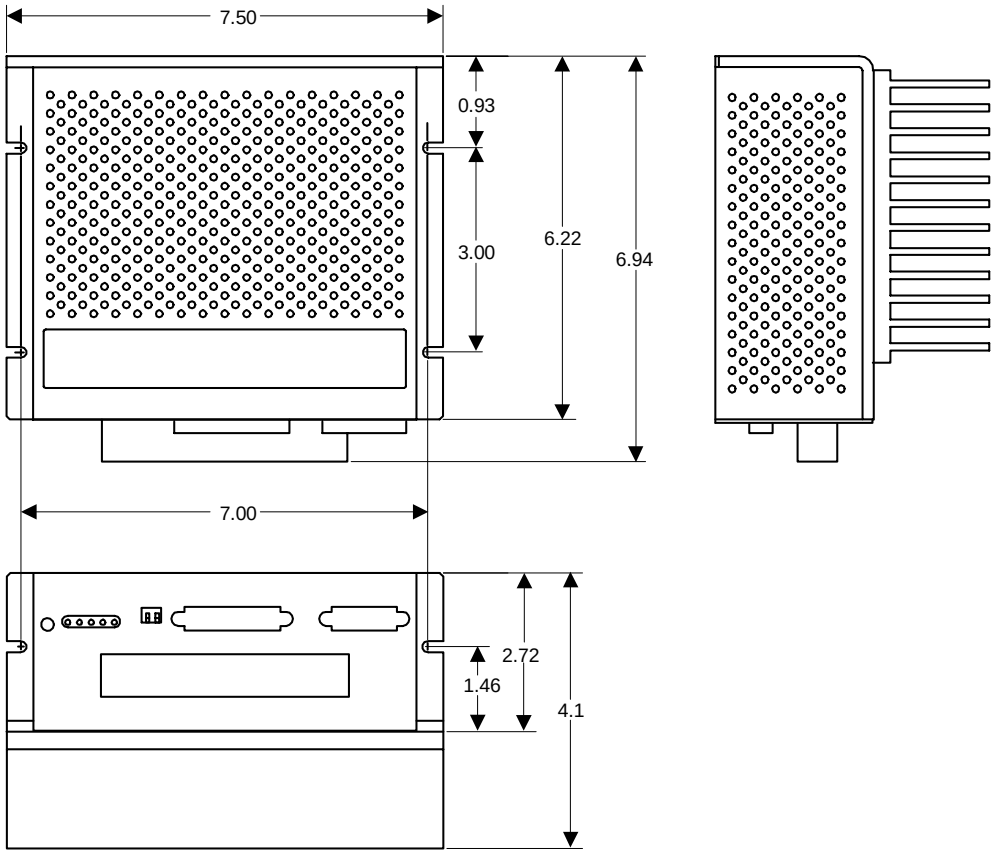
BURST MODE

This feature gives the motors absolute position in the form of a pulse-train from the encoder outputs. The number of lines is equal to the angular displacement between the resolver index position, and the motor/resolver current position.

Burst mode functions when the amplifier is disabled, and the /Burst input is momentarily grounded.
Disabling the amplifier is important because the burst signal might be interpreted by the control signal as a large position error, causing undesired motion.
To use the burst mode, use the following sequence of operations in the control system:

1. Disable amplifier
2. Zero the position-error counter in the control system.
3. Ground the /Burst input.
4. Delay <tbd> msec.
5. Read the position-error count in the control system. The contents will be the motor/resolver absolute position from the index position.

OUTLINE DIMENSIONS



Dimensions in inches

Weight 3.71 lbs. (1.69 kg) without optional heatsink. Add 3.2 lbs. (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

ORDERING GUIDE

Model 7227AC	20A peak, 10A continuous, from 32~132VAC, 50/60Hz AC mains
Model 7427AC	20A peak, 10A continuous, from 32~264VAC, 50/60Hz AC mains

Notes:
1. Add "H" to model number to specify heatsink option.

OTHER AC BRUSHLESS AMPLIFIERS

For AC Brushless Motors (Sinusoidal) Each type available in AC (Off-line) or DC powered variants

7xx5 Models For controllers that output +/-10V analog torque commands for U & V phases

7xx6 Models For linear motors that use analog Hall sensors for commutation

7xx8 Models For motors using incremental encoders as feedback

7xx9 Models To interface with Delta-Tau PMAC2 control cards using Direct-Drive digital bridge control

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