

**DIGITAL SERVO DRIVE FOR BRUSH & BRUSHLESS MOTORS**

**CONTROL MODES**

- Cyclic Synchronous Position-Velocity-Torque (CSP, CSV, CST)
- Profile Position-Velocity-Torque, Interpolated Position, Homing
- Camming, Gearing
- Indexer

**COMMAND INTERFACE**

- CAN application protocol over EtherCAT (CoE)
- ASCII and discrete I/O
- Stepper commands
- ±10V position/velocity/torque
- PWM velocity/torque command
- Master encoder (Gearing/Camming)

**COMMUNICATIONS**

- EtherCAT
- RS-232

**FEEDBACK**

*Incremental Encoders*

- Digital quad A/B
- Analog Sin/Cos
- Panasonic Incremental A Format
- Aux. quad A/B encoder / encoder out

*Absolute Encoders*

- SSI, EnDat, Absolute A, Tamagawa & Panasonic Absolute A, Sanyo Denki Absolute A, BiSS (B & C)

*Resolver (-R option)*

- Brushless Resolver

*Other*

- Digital Halls

**I/O DIGITAL**

- 6 High-speed inputs
- 1 Motor over-temp input
- 4 Opto-Isolated inputs
- 3 Opto-Isolated outputs
- 1 Opto-Isolated brake output

**I/O ANALOG**

- 1 Reference Input, 12-bit

**SAFE TORQUE OFF (STO)**

- SIL 3, Category 3, PL d

**DIMENSIONS: IN [MM]**

- 5.08 x 3.41 x 1.99 [129 x 86.6 x 50.4]
- 5.08 x 3.41 x 3.39 [129 x 86.6 x 86.1] with heatsink

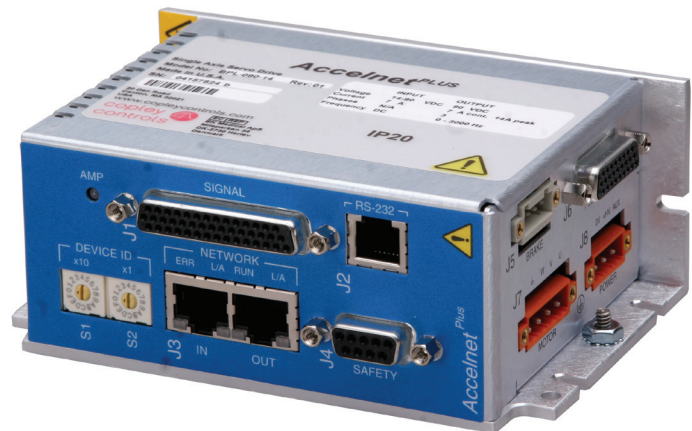
**DESCRIPTION**

The BEL is a high-performance, DC powered drive for position, velocity, and torque control of brushless and brush motors via EtherCAT, an Ethernet-based fieldbus. The BEL operates as an EtherCAT slave using the CANopen application protocol over EtherCAT (CoE). Supported modes include: Profile Position-Velocity-Torque, Cyclic Synchronous Position-Velocity-Torque, Interpolated Position Mode (PVT), Homing, and CSTCA (Cyclic-sync torque with commutation angle).

Feedback from both incremental and absolute encoders is supported. A multi-mode encoder port functions as an input or output depending on the drive's basic setup.

DIGITAL SERVO DRIVE FOR BRUSHLESS/BRUSH MOTORS

**EtherCAT**  
Conformance tested



Model	Ip	Ic	Vdc
BEL-090-06	6	3	90
BEL-090-14	14	7	90
BEL-090-30	30	15	90

Add -R for resolver feedback option

There are seven non-isolated inputs. All inputs have programmable active levels. Three opto-isolated outputs [OUT1~3] have individual +/- connections. An isolated MOSFET brake output [OUT4] is programmable to drive motor brakes or other functions and has a flyback diode to the Brake 24V input for driving inductive loads. Drive power is transformer-isolated DC from regulated or unregulated power supplies. An AuxHV input is provided for "keep-alive" operation permitting the drive power stage to be completely powered down without losing position information, or communications with the control system.

**GENERAL SPECIFICATIONS**

Test conditions: Load = Wye connected load: 2 mH + 2 Ω line-line. Ambient temperature = 25°C, +HV = HV<sub>max</sub>

MODEL	BEL-090-06	BEL-090-14	BEL-090-30	
<b>OUTPUT POWER</b>				
Peak Current	6 (4.24)	14 (9.9)	30 (21.2)	Adc (Arms-sine), ±5%
Peak time	1	1	1	Sec
Continuous current (Note 1)	3 (2.1)	7 (5)	15 (10.6)	Adc (Arms-sine) per phase
<b>INPUT POWER</b>				
HVmin~HVmax	+14 to +90	+14 to +90	+14 to +90	Vdc Transformer-isolated
Ipeak	6	14	30	Adc (1 sec) peak
Icont	3	7	15	Adc continuous
Aux HV	+14 to +90 Vdc, 3 W (Typ, no load on encoder +5V output), 6 W, (Max, encoder +5V @ 500 mA)			Optional, not required for operation
<b>DIGITAL CONTROL</b>				
Digital Control Loops	Current, velocity, position. 100% digital loop control			
Sampling rate (time)	Current loop: 16 kHz (62.5 μs), Velocity & position loops: 4 kHz (250 μs)			
Bus voltage compensation	Changes in bus or mains voltage do not affect bandwidth			
Minimum load inductance	200 μH line-line			
<b>COMMAND INPUTS (NOTE: DIGITAL INPUT FUNCTIONS ARE PROGRAMMABLE)</b>				
<i>Distributed Control Modes</i>				
CANopen application protocol over EtherCAT (CoE)	Cyclic Synchronous Position-Velocity-Torque, Profile Position-Velocity-Torque, Interpolated Position, Homing			
<i>Stand-alone mode</i>				
Analog torque, velocity, position reference	±10 Vdc, 12-bit resolution		Dedicated differential analog input	
Digital position reference	Pulse/Direction, CW/CCW		Stepper commands (2 MHz maximum rate)	
	Quad A/B Encoder		2 M line/sec, 8 Mcount/sec (after quadrature)	
Digital torque & velocity reference	PWM, Polarity		PWM = 0% - 100%, Polarity = 1/0	
	PWM 50%		PWM = 50% ±50%, no polarity signal required	
	PWM frequency range		1 kHz minimum, 100 kHz maximum	
	PWM minimum pulse width		220 ns	
Indexing	Up to 32 sequences can be launched from inputs or ASCII commands.			
Camming	Up to 10 CAM tables can be stored in flash memory			
ASCII	RS-232, DTE, 9600~115,200 Baud, 3-wire, RJ-11 connector			
<b>DIGITAL INPUTS</b>				
Number 11	Digital, non-isolated, Schmitt trigger, 1 μs RC filter, 24 Vdc compatible, programmable pull-up/down to +5 Vdc/ground, Vt+ = 2.5~3.5 Vdc, Vt- = 1.3~2.2 Vdc, VH = 0.7~1.5 Vdc			
[IN1,2]	Digital, non-isolated, programmable as single-ended or differential pairs, 100 ns RC filter, 12 Vdc max, 10 kΩ programmable pull-up/down per input to +5 Vdc/ground, SE: Vin-LO ≤ 2.3 Vdc, Vin-HI ≥ 2.7 Vdc, VH = 45 mV typ, DIFF: Vin-LO ≤ 200 mVdc, Vin-HI ≥ 200 mVdc, VH = 45 mV typ,			
[IN3,4,5,6]	Digital, opto-isolated, single-ended, ±15~30 Vdc compatible, bi-polar, with common return			
[IN7,8,9,10]	Rated impulse ≥ 800 V, Vin-LO ≤ 6.0 Vdc, Vin-HI ≥ 10.0 Vdc, Input current ±3.6 mA @ ±24 Vdc, typical			
[IN11]	Defaults as motor overtemp input on feedback connector, 12 Vdc max, programmable to other functions			
	Other digital inputs are also programmable for the Motemp function			
	330 μs RC filter, 4.99k pull-up to +5 Vdc, Vt+ = 2.5~3.5 Vdc, Vt- = 1.3~2.2 Vdc, VH = 0.7~1.5 Vdc			
Functions	All inputs are programmable, [IN1] defaults to the Enable function and is programmable for other functions.			
<b>ANALOG INPUTS</b>				
Number	1			
[AIN1]	Differential, ±10 Vdc, 5 kΩ input impedance, 12-bit resolution			
<b>SAFE TORQUE OFF (STO)</b>				
Function	PWM outputs are inactive and current to the motor will not be possible when the STO function is asserted			
Standard	Designed to IEC-61508-1, IEC-61508-2, IEC-61800-5-2, ISO-13849-1			
Safety Integrity Level	SIL 3, Category 3, Performance level d			
Inputs	2 two-terminal: STO-IN1+, STO-IN1-, STO-IN2+, STO-IN2-			
Type	Opto-isolators, 24V compatible, Vin-LO ≤ 6.0 Vdc or open, Vin-HI ≥ 15.0 Vdc,			
Input current (typical)	STO-IN1: 9.0 mA, STO-IN2: 4.5 mA			
Response time	2 ms (IN1, IN2) from Vin ≤ 6.0 Vdc to interruption of energy supplied to motor			
<b>Reference</b>	<b>Complete information and specifications are in the Accelnet &amp; Stepnet Plus Panels STO Manual</b>			
<b>DIGITAL OUTPUTS</b>				
Number	4			
[OUT1~3]	Opto-isolated SSR, two-terminal, 300 mA max, 24 V tolerant, Rated impulse ≥ 800 V, series 1 Ω resistor			
[OUT4]	Opto-isolated MOSFET, default as motor brake control, current-sinking, 1 Adc max, flyback diodes to +24 V external power supply for driving inductive loads			
	Programmable for other functions if not used for brake			
<b>RS-232 PORT</b>				
Signals	RxD, TxD, Gnd in 6-position, 4-contact RJ-11 style modular connector, non-isolated, common to Signal Ground			
Mode	Full-duplex, DTE serial communication port for drive setup and control, 9,600 to 115,200 Baud			
Protocol	Binary and ASCII formats			
<b>ETHERCAT PORTS</b>				
Format	Dual RJ-45 receptacles, 100BASE-TX			
Protocol	EtherCAT, CANopen application protocol over EtherCAT (CoE), CiA-402 for motion control devices			



**NOTES:**

1) Heatsink or forced-air is required for continuous current rating

**GENERAL SPECIFICATIONS**

**DC POWER OUTPUT**

Number	1
Ratings	+5 Vdc, 500 mA max, thermal and short-circuit protected
Connections	The combined current from Feedback J6-6,17 and Control J1-17,32 cannot exceed 500 mA

**INDICATORS**

AMP	Bicolor LED, drive state indicated by color, and blinking or non-blinking condition
RUN	Green LED, status of EtherCAT state-machine (ESM)
ERR	Red LED, shows errors due to time-outs, unsolicited state changes, or local errors
L/A	Green LED, Link/Act, shows the state of the physical link and activity on the link (EtherCAT connection)

RUN, ERR, and L/A LED colors and blink codes conform to ETG.1300 S(R) V1.1.0

**PROTECTIONS**

HV Overvoltage	+HV > 90 Vdc	Drive outputs turn off until +HV < 90 Vdc
HV Undervoltage	+HV < +14 Vdc	Drive outputs turn off until +HV > +14 Vdc
Drive over temperature	Heat plate > 70°C.	Drive outputs turn off
Short circuits	Output to output, output to ground, internal PWM bridge faults	
I <sup>2</sup> T Current limiting	Programmable: continuous current, peak current, peak time	
Motor over temperature	Digital input programmable to detect motor temperature switch	
Feedback Loss	Inadequate analog encoder or resolver signal amplitude or missing incremental encoder signals	

**MECHANICAL & ENVIRONMENTAL**

Size	5.08 x 3.41 x 1.99 [129 x 86.6 x 50.4] in[mm] without heatsink
	5.08 x 3.41 x 3.39 [129 x 86.6 x 86.1] in[mm] with heatsink
Weight	0.75 [0.34] lb[kg] without heatsink
	1.70 [0.77] lb[kg] with heatsink
Ambient temperature	0 to +45C operating, -40 to +85C storage, as per IEC 60068-2-1:2007 and IEC 60068-2-2:2007
Humidity	0 to 95%, non-condensing, as per IEC 60068-2-78:2001
Altitude	≤ 2000m (6560 ft), as per IEC 60068-2-13:1983
Vibration	2 g peak, 10~500 Hz (sine), as per IEC 60068-2-6:2007
Shock	110 g, 10 ms, half-sine pulse, as per IEC 60068-2-27:2008
Contaminants	Pollution degree 2, as per IEC 60664-1:2007
Environment	IEC68-2: 1990
Cooling	Heat sink and/or forced air cooling required for continuous power output

**AGENCY STANDARDS CONFORMANCE**

*standards and Directives*

*Functional Safety*

IEC 61508-1:2010, IEC 61508-2:2010, IEC 61508-3:2010, IEC 61508-4: 2010 (SIL 3)  
 Directive 2006/42/EC (Machinery)  
 ISO 13849-1/Cor. 1:2009 (Cat 3, PL d)  
 IEC 61800-5-2:2007 (SIL3)

**(see the Xenus Plus Dual Axis STO Manual for further details)**

*Product Safety*

Directive 2006/95/EC (Low Voltage)  
 IEC 61800-5-1:2007

*EMC*

Directive 2004/108/EC (EMC)  
 IEC 61800-3:2004/A1:2011

*Restriction of the Use of Certain Hazardous Substances (RoHS)*

Directive 2011/65/EU (RoHS II)

*Approvals*

*UL and cUL recognized component to:*  
 UL 61800-5-1, 1st Ed.

*TÜV SÜD Functional Safety to:*

IEC 61508-1:2010, IEC 61508-2:2010, IEC 61508-3:2010, IEC 61508-4: 2010 (SIL 3)  
 ISO 13849-1/Cor. 1:2009 (Cat 3, PL d)



**GENERAL SPECIFICATIONS**

**FEEDBACK**

*Incremental:*

Digital Incremental Encoder	Quadrature signals, (A, /A, B, /B, X, /X), differential (X, /X Index signals not required) 5 MHz maximum line frequency (20 M counts/sec) MAX3097 differential line receiver with 121 Ω terminating resistor between A & /A, B & /B inputs X & /X inputs have 130 Ω terminating resistor, S & /S inputs have 221 Ω terminating resistor X & S inputs have 1 kΩ pull-ups to +5V, /X & /X inputs have 1 kΩ pull-down to ground
Analog Incremental Encoder	Sin/cos format (sin+, sin-, cos+, cos-), differential, 1 V <sub>peak-peak</sub> , ServoTube motor compatible, BW > 300 kHz, 121 Ω terminating resistor between complementary inputs Digital Index (X, /X) input

*Absolute:*

SSI	Clock (X, /X), Data (S, /S) signals, 4-wire, clock output from BEL, data returned from encoder
EnDat	Clock (X, /X), Data (S, /S), sin/cos (sin+, sin-, cos+, cos-) signals
Absolute A	Tamagawa Absolute A, Panasonic Absolute A Format A, Sanyo Denki Absolute A SD+, SD- (S, /S) signals, 2.5 or 4 MHz, 2-wire half-duplex communication Status data for encoder operating conditions and errors
BiSS (B&C)	MA+, MA- (X, /X), SL+, SL- (S, /S) signals, 4-wire, clock output from BEL, data returned from encoder

**DIGITAL HALLS**

Type	Digital, single-ended, 120° electrical phase difference between U-V-W signals, Schmitt trigger, 1.5 μs RC filter, 24 Vdc compatible, 15k pull-up to +5 Vdc, V <sub>t+</sub> = 2.5~3.5 Vdc, V <sub>t-</sub> = 1.3~2.2 Vdc, V <sub>H</sub> = 0.7~1.5 Vdc
Inputs	15 kΩ pull-ups to +5 Vdc, 1.5 μs RC filter to Schmitt trigger inverters

**MULTI-MODE ENCODER PORT**

As Input	Digital quadrature encoder (A, /A, B, /B, X, /X), 5 MHz maximum line frequency (20 M counts/sec), MAX3097 line receiver, 1.5 kΩ pull-ups to +5V on X & S inputs, 1.5 kΩ pull-downs to S <sub>gnd</sub> on /X & /S inputs Digital absolute encoder (Clk, /Clk, Dat, /Dat) half or full-duplex operation, S & X inputs are used for absolute encoder interface
As Emulated Output	Quadrature encoder emulation with programmable resolution to 4096 lines (65,536 counts) per rev from analog sin/cos encoders or resolvers, or absolute encoders
As Buffered Output	A, /A, B, /B, from MAX3032 differential line driver, X, /X, S, /S from MAX3362 differential line driver Digital A/B/X encoder feedback signals from primary quad encoder are buffered (see line drivers above)

**RESOLVER (-R OPTION)**

Type	Brushless, single-speed, 1:1 to 2:1 programmable transformation ratio
Resolution	14 bits (equivalent to a 4096 line quadrature encoder)
Reference frequency	8.0 kHz
Reference voltage	2.8 Vrms max, auto-adjustable by the drive to adjust sin/cos signals to 2.0 Vrms
Reference maximum current	100 mA
Maximum RPM	10,000 typical
Sin/Cos inputs	Differential, 54 kΩ ±1% differential impedance, 2.0 Vrms, BW ≥ 300 kHz

**ETHERCAT COMMUNICATIONS**

EtherCAT is the open, real-time Ethernet network developed by Beckhoff based on the widely used 100BASE-TX cabling system. EtherCAT enables high-speed control of multiple axes while maintaining tight synchronization of clocks in the nodes.

Data protocol is CANopen application protocol over EtherCAT (CoE) based on DSP-402 for motion control devices. More information on EtherCAT can be found on this web-site: <http://ethercat.org/default.htm>

**ETHERCAT CONNECTIONS**

Dual RJ-45 sockets accept standard Ethernet cables. The IN port connects to a master, or to the OUT port of a device that is 'upstream', between the Accelnet and the master.

The OUT port connects to 'downstream' nodes. If Accelnet is the last node on a network, only the IN port is used. No terminator is required on the OUT port.

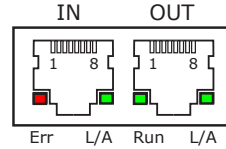
**ETHERCAT LEDES (ON RJ-45 CONNECTORS)**

**RUN** Green: Shows the state of the ESM (EtherCAT State Machine)  
 Off = Init  
 Blinking = Pre-operational  
 Single-flash = Safe-operational  
 On = Operational

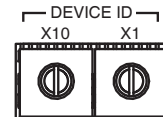
**ERR** Red: Shows errors such as watchdog timeouts and unsolicited state changes in the BEL due to local errors.  
 Off = EtherCAT communications are working correctly  
 Blinking = Invalid configuration, general configuration error  
 Single Flash = Local error, slave has changed EtherCAT state autonomously  
 Double Flash = PDO or EtherCAT watchdog timeout, or an application watchdog timeout has occurred

**L/A** Green: Shows the state of the physical link and activity on the link.  
 A green LED indicates the state of the EtherCAT network:  

LED	Link	Activity	Condition
ON	Yes	No	Port Open
Flickering	Yes	Yes	Port Open with activity
Off	No	(N/A)	Port Closed



**J3: EtherCAT PORTS**  
 RJ-45 receptacles, 8 position, 4 contact



**S1 S2**  
 EtherCAT Device ID Switch  
 Decimal values

**EtherCAT DEVICE ID (STATION ALIAS)**

In an EtherCAT network, slaves are automatically assigned consecutive addresses based on their position on the network. But when the device must have a positive identification that is independent of cabling, a Device ID is used. In the BEL, this is provided by two 16-position rotary switches with hexadecimal encoding. These can set the Device ID of the drive from 0x00~0xFF (0~255 decimal). The chart shows the decimal values of the hex settings of each switch.

Example 1: Find the switch settings for decimal Device ID 107:

- 1) Find the highest number in the x10 column that is less than 107 and set x10 to the hex value in the same row:  
 $96 < 107$  and  $112 > 107$ , so  $x10 = 96 = \text{Hex } 6$
- 2) Subtract 96 from the desired Device ID to get the decimal value for the switch x1 and set it to the Hex value in the same row:  
 $x1 = (107 - 96) = 11 = \text{Hex } B$
- 3) Result: X10 = 6, X1 = B, Alias = 0x6B (107)

Set	x10	x1	Set	x10	x1
Hex	Dec		Hex	Dec	
0	0	0	8	128	8
1	16	1	9	144	9
2	32	2	A	160	10
3	48	3	B	176	11
4	64	4	C	192	12
5	80	5	D	208	13
6	96	6	E	224	14
7	112	7	F	240	15

**INDICATORS: DRIVE STATE**

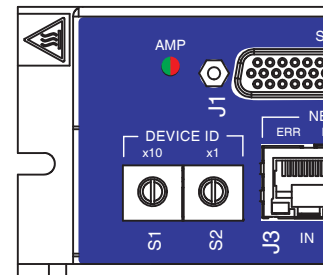
Two bi-color LEDs give the state of the BEL drive. Colors do not alternate, and can be solid ON or blinking. When multiple conditions occur, only the top-most condition will be displayed. When that condition is cleared the next one below will be shown.

- 1) Red/Blinking = Latching fault. Operation will not resume until drive is Reset.
- 2) Red/Solid = Transient fault condition. Drive will resume operation when the condition causing the fault is removed.
- 3) Green/Double-Blinking = STO circuit active, drive outputs are Safe-Torque-Off
- 4) Green/Slow-Blinking = Drive OK but NOT-enabled. Will run when enabled.
- 5) Green/Fast-Blinking = Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
- 7) Green/Solid = Drive OK and enabled. Will run in response to reference inputs or EtherCAT commands.

**Latching Faults**

- |   |   |
|---|---|
| Defaults  | Optional (programmable)   |
| <ul style="list-style-type: none"> <li>• Short circuit (Internal or external)</li> <li>• Drive over-temperature</li> <li>• Motor over-temperature</li> <li>• Feedback Error</li> <li>• Following Error</li> </ul> | <ul style="list-style-type: none"> <li>• Over-voltage</li> <li>• Under-voltage</li> <li>• Motor Phasing Error</li> <li>• Command Input Fault</li> </ul> |

**AMP LED & DEVICE ID SWITCHES**



COMMUNICATIONS: RS-232 SERIAL

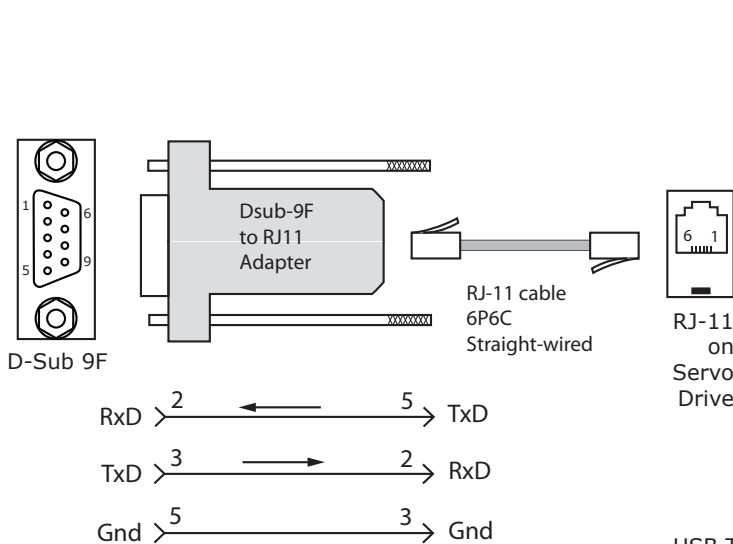
BEL is configured via a three-wire, full-duplex DTE RS-232 port that operates from 9600 to 115,200 Baud, 8 bits, no parity, and one stop bit. Signal format is full-duplex, 3-wire, DTE using RxD, TxD, and Gnd. Connections to the BEL RS-232 port are through J2, an RJ-11 connector. The BEL Serial Cable Kit (SER-CK) contains a modular cable, and an adapter that connects to a 9-pin, Sub-D serial port connector (COM1, COM2, etc.) on PC's and compatibles.

After power-on, reset, or transmission of a Break character, the Baud rate will be 9,600. Once communication has been established at this speed, the Baud rate can be changed to a higher rate (19,200, 57,600, 115,200).

SER-CK SERIAL CABLE KIT

The SER-CK provides connectivity between a D-Sub 9 male connector and the RJ-11 connector on the BEL. It includes an adapter that plugs into the COM1 (or other) port of a PC and uses common modular cable to connect to the BEL. The connections are shown in the diagram below.

J2: RS-232 PORT  
RJ-11 receptacle,  
6 position, 4 contact



Don't forget to order a Serial Cable Kit SER-CK when placing your order for a BEL!

USB TO RS-232 ADAPTERS

These may or may not have the speed to work at the 115,200 Baud rate which gives the best results with CME2. Users have reported that adapters using the FTDI chipset work well with CME2

ASCII COMMUNICATIONS

The Copley ASCII Interface is a set of ASCII format commands that can be used to operate and monitor Copley Controls Accelnet, Stepnet, and BEL series amplifiers over an RS-232 serial connection. For instance, after basic amplifier configuration values have been programmed using CME 2, a control program can use the ASCII Interface to:

- Enable the amplifier in Programmed Position mode.
- Home the axis.
- Issue a series of move commands while monitoring position, velocity, and other run-time variables.

The Baud rate defaults to 9,600 after power-on or reset and is programmable up to 115,200 thereafter.

After power-on, reset, or transmission of a Break character, the Baud rate will be 9,600. Once communication has been established at this speed, the Baud rate can be changed to a higher rate (19,200, 57,600, 115,200).

ASCII parameter 0x90 holds the Baud rate data. To set the rate to 115,200 enter this line from a terminal:

```
s r0x90 115200 <enter>
```

Then, change the Baud rate in the computer/controller to the new number and communicate at that rate.

Additional information can be found in the ASCII Programmers Guide on the Copley website:


[http://www.copleycontrols.com/Motion/pdf/ASCII\\_ProgrammersGuide.pdf](http://www.copleycontrols.com/Motion/pdf/ASCII_ProgrammersGuide.pdf)

**SAFE TORQUE OFF (STO)**

The Safe Torque Off (STO) function is defined in IEC 61800-5-2. Two channels are provided which, when de-energized, prevent the upper and lower devices in the PWM outputs from being operated by the digital control core.

This provides a positive OFF capability that cannot be overridden by the control firmware, or associated hardware components. When the opto-couplers are energized (current is flowing in the input diodes), the control core will be able to control the on/off state of the PWM outputs.

**INSTALLATION**

 <b>DANGER</b>	<b>Refer to the Accelnet &amp; Stepnet Plus Panels STO Manual</b>
	The information provided in the <i>Accelnet &amp; Stepnet Plus Panels STO Manual</i> must be considered for any application using the drive's STO feature. <b>FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.</b>



**STO BYPASS (MUTING)**

In order for the PWM outputs of the BEL to be activated, current must be flowing through all of the opto-couplers that are connected to the STO-IN1 and STO-IN2 terminals of J4, and the drive must be in an ENABLED state. When the opto-couplers are OFF, the drive is in a Safe Torque Off (STO) state and the PWM outputs cannot be activated by the control core to drive a motor.

This diagram shows connections that will energize all of the opto-couplers from an internal current-source. When this is done the STO feature is overridden and control of the output PWM stage is under control of the digital control core.

**If not using the STO feature, these connections must be made in order for the drive to be enabled.**

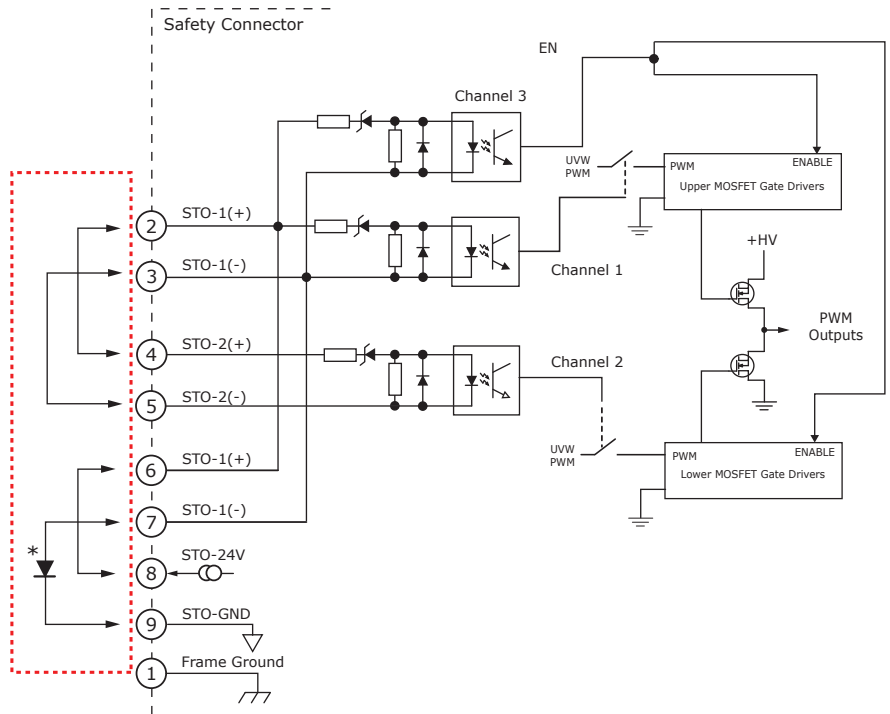
**FUNCTIONAL DIAGRAM**

**STO BYPASS CONNECTIONS**



**Current must flow through all of the opto-couplers before the drive can be enabled**

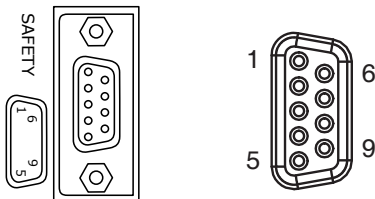
\* STO bypass connections on the BEL and Xenus XEL-XPL models are different. If both drives are installed in the same cabinet, the diode should be wired as shown to prevent damage that could occur if the STO bypass connectors are installed on the wrong drive. The diode is not required for STO bypass on the BEL and can be replaced by a wire between pins 7 and 9.



**CONNECTIONS**

PIN	SIGNAL	PIN	SIGNAL
1	Frame Gnd	6	STO-1(+)
2	STO-1(+)	7	STO-1(-)
3	STO-1(-)	8	STO-24V
4	STO-2(+)	9	STO-GND
5	STO-2(-)		

**SAFETY CONNECTOR J4**



**DIGITAL COMMAND INPUTS: POSITION**

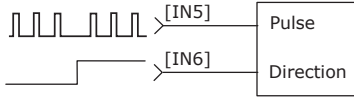
**POSITION COMMAND INPUTS**

Single-ended digital position commands must be sourced from devices with active pull-up and pull-down to take advantage of

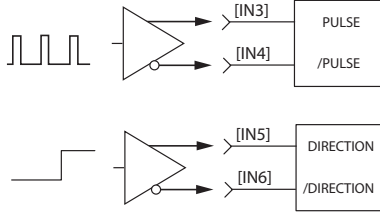
the high-speed inputs.

For differential commands, the A & B channels of the multi-mode encoder ports are used.

**SINGLE-ENDED PULSE & DIRECTION**



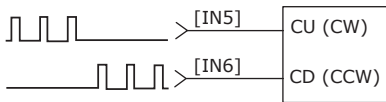
**DIFFERENTIAL PULSE & DIRECTION**



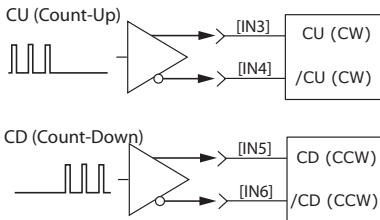
**SINGLE-ENDED: IN5, 6**

Signal	J1 Pins
[IN5] Pls, CU, Enc A	11
[IN6] Dir, CD, Enc B	12
Signal Ground	6,16,22,31,37,44
Frame Ground	1

**SINGLE-ENDED CU/CD**



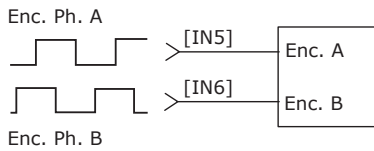
**DIFFERENTIAL CU/CD**



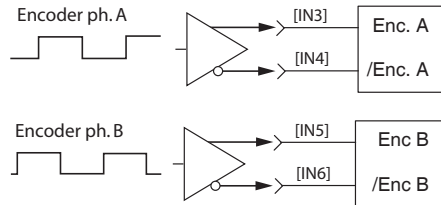
**DIFFERENTIAL: IN3,4,5,6**

Signal	J1 Pins
[IN3] Pls, CU, Enc A	9
[IN4] /Pls, /CU, Enc /A	10
[IN5] Dir, CD, Enc B	11
[IN6] /Dir, /CD, Enc /B	12
Signal Ground	6,16,22,31,37,44
Frame Ground	1

**QUAD A/B ENCODER SINGLE-ENDED**



**QUAD A/B ENCODER DIFFERENTIAL**

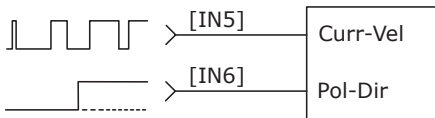


**DIGITAL COMMAND INPUTS: VELOCITY, TORQUE**

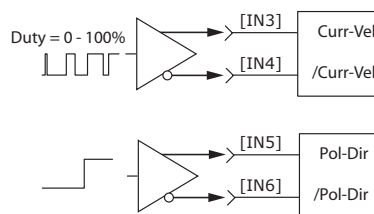
Single-ended digital torque or velocity commands must be sourced from devices with active pull-up and pull-down to take advantage of the high-speed inputs.

For differential commands, the A & B channels of the multi-mode encoder ports are used.

**SINGLE-ENDED PWM & DIRECTION**



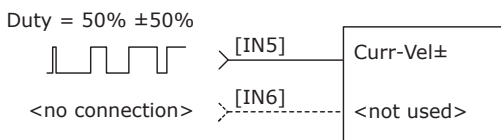
**DIFFERENTIAL PWM & DIRECTION**



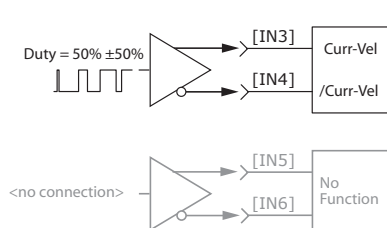
**SINGLE-ENDED: IN5,6**

Signal	J1 Pins
[IN5] Curr-Vel±	11
[IN6] Pol-Dir	12
Sgnd	6,16,22,31,37,44
Frame Ground	1

**SINGLE-ENDED 50% PWM**



**DIFFERENTIAL 50% PWM**



**DIFFERENTIAL: IN3,4,5,6**

Signal	J1 Pins
[IN3] Curr-Vel±	9
[IN4] / Curr-Vel±	10
[IN5] Pol-Dir	11
[IN6] /Pol-Dir	12
Signal Ground	6,16,22,31,37,44
Frame Ground	1

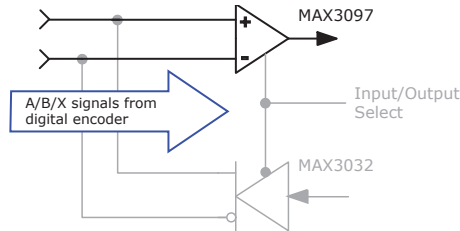


MULTI-MODE PORT AS AN INPUT

INPUT TYPES

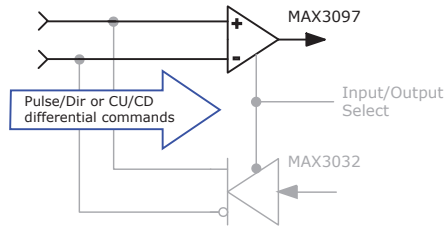
POSITION COMMAND INPUTS: DIFFERENTIAL

- Pulse & Direction
- CW & CCW (Clockwise & Counter-Clockwise)
- Encoder Quad A & B
- Camming Encoder A & B input



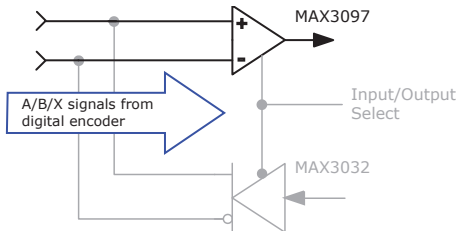
CURRENT or VELOCITY COMMAND INPUTS: DIFFERENTIAL

- Current or Velocity & Direction
- Current or Velocity (+) & Current or Velocity (-)



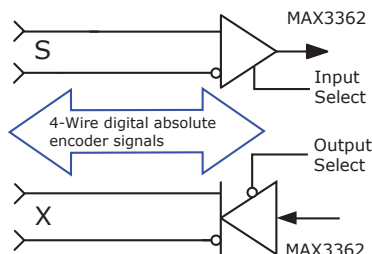
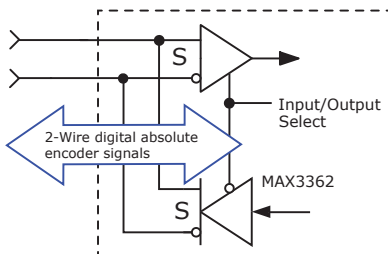
SECONDARY FEEDBACK: INCREMENTAL

- Quad A/B/X incremental encoder



SECONDARY FEEDBACK: ABSOLUTE

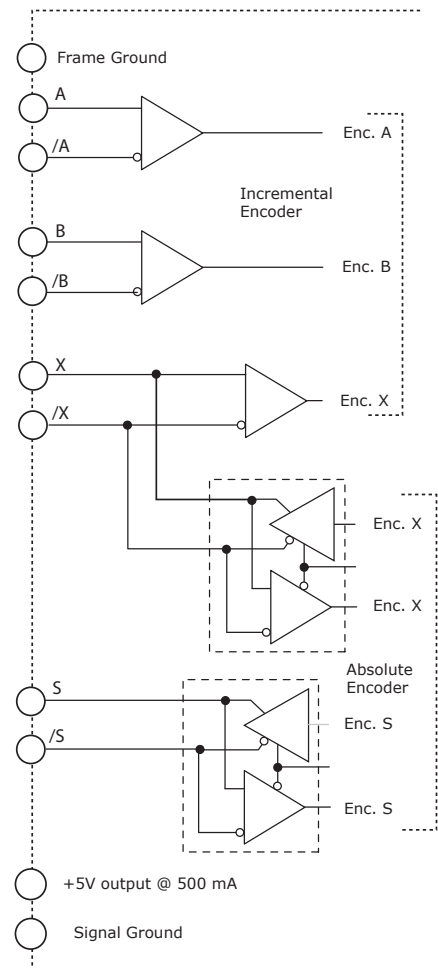
- S channel: Absolute A encoders (2-wire)  
The S channel first sends a Clock signal and then receives Data from the encoder in half-duplex mode.
- S & X channels: SSI, BiSS, EnDat encoders (4-wire)  
The X channel sends the Clock signal to the encoder, which initiates data transmission from the encoder on the S-channel in full-duplex mode



SIGNALS & PINS

Signal	J1
Pulse, CW, Encoder A	36
/Pulse, /CW, Encoder /A	21
Direction, CCW, Encoder B	35
/Direction, /CCW, Encoder /B	20
Quad Enc X, Absolute Clock	34
Quad Enc /X, /Absolute Clock	19
Enc S, Absolute (Clock) Data	33
Enc /S, / Absolute (Clock) Data	18
Signal Ground	6, 16, 22, 31, 37, 44
Frame Ground	1

J1 Multi-Port



MULTI-MODE PORT AS AN OUTPUT

OUTPUT TYPES

BUFFERED FEEDBACK OUTPUTS: DIFFERENTIAL

- Encoder Quad A, B, X channels
- Direct hardware connection between quad A/B/X encoder feedback and differential line drivers for A/B/X outputs

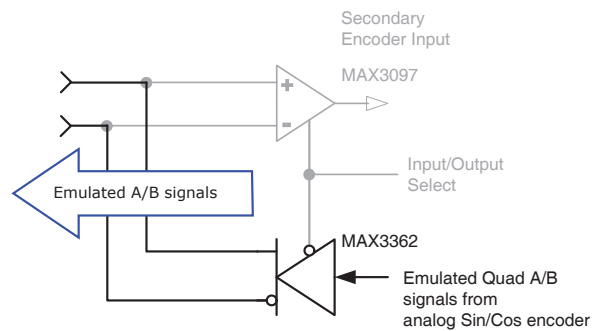
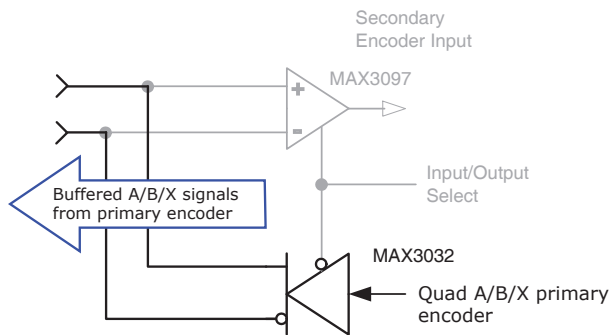
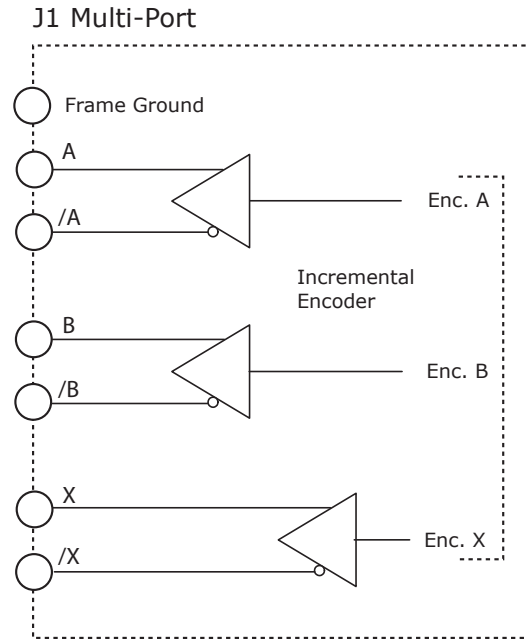
EMULATED FEEDBACK OUTPUTS: DIFFERENTIAL

Firmware produces emulated quad A/B signals from feedback data from the following devices:

- Absolute encoders
- Resolvers (-R option)
- Analog Sin/Cos incremental encoders

SIGNALS & PINS

Signal	J1
Encoder A	36
Encoder /A	21
Encoder B	35
Encoder /B	20
Encoder X	34
Encoder /X	19
Encoder S	33
Encoder /S	18
Signal Ground	6, 16, 22, 31, 37, 44
Frame Ground	1



**CME2 DEFAULTS**

These tables show the CME2 default settings. They are user-programmable and the settings can be saved to non-volatile flash memory.

**Input/Output**

Digital Inputs | Digital Outputs

Name	Configuration	PU/PD
IN1	Enable-LO, Clear Faults	+5V
IN2	Not Configured	
IN3		
IN4		
IN5		
IN6		
IN7	Opto Not Configured	
IN8		
IN9		
IN10		
IN11	Motemp	+5V PU

**Input/Output**

Digital Inputs | Digital Outputs

Name	Notes
OUT1	Fault Active-OFF
OUT2	Not Configured
OUT3	
OUT4	Brake Active-HI

**Filter Configuration**

Filter Settings | Analog | V Loop | I Loop | Input Shaping

Name	Notes
Analog: Reference Filter	Disabled
Vloop: Input Filter	Disabled
Vloop: Output Filter 1	Low Pass, Butterworth, 2-pole, 200 Hz
Vloop: Output Filter 2	Disabled
Vloop: Output Filter 3	Disabled
Iloop: Input Filter 1	Disabled
Iloop: Input Filter 2	Disabled
Input Shaping	Disabled

**Fault Configuration**

Latch Fault

Active	Notes
✓	Short Circuit
✓	Amp Over Temperature
✓	Motor Over Temp
	Over Voltage
	Under Voltage
✓	Feedback Error
	Motor Phasing Error
✓	Following Error
	Command Input Fault
	Motor Wiring Disconnected

OPTIONAL FAULTS

	Over Current (Latched)
--	------------------------

**Home**

Option	Notes
Method	Set Current Position as Home

**HIGH SPEED INPUTS: IN1, IN2**

- Digital, non-isolated, high-speed
- Programmable pull-up/pull-down
- 24V Compatible
- Programmable functions

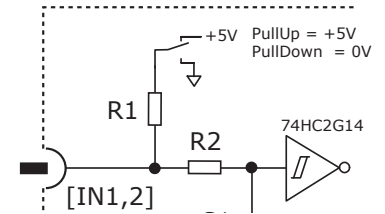
**SPECIFICATIONS**

Input	Data	Notes
Input Voltages	HI	$V_{T+} = 2.5 \sim 3.5$ Vdc
	LO	$V_{T-} = 1.3 \sim 2.2$ Vdc
	VH <sup>1</sup>	$V_H = \pm 0.7 \sim 1.5$ Vdc
	Max	+30 Vdc
	Min	0 Vdc
Pull-up/down	R1	15 k $\Omega$
Low pass filter	R2	15 k $\Omega$
	C1	100 pF
Input Current	24V	1.3 mA <sub>dc</sub>
	0V	-0.33 mA <sub>dc</sub>
Time constant	RC <sup>2</sup>	1.5 $\mu$ s

**CONNECTIONS**

Input	Pin
IN1	J1-7
IN2	J1-8
Sgnd	J1-6, 16, 22, 31, 37, 44

**FEEDBACK CONNECTOR**



- Notes:
- 1) VH is hysteresis voltage ( $V_{T+}$ ) - ( $V_{T-}$ )
  - 2) The  $R_2 \cdot C_2$  time constant applies when input is driven by active HI/LO devices

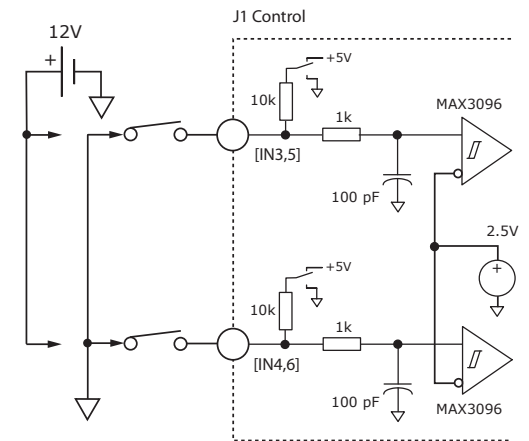
**SINGLE-ENDED/DIFFERENTIAL INPUTS: IN3, IN4, IN5, IN6**

- Digital, non-isolated, high-speed
- Programmable pull-up/pull-down
- 12V Compatible
- Single-ended or Differential
- Programmable functions

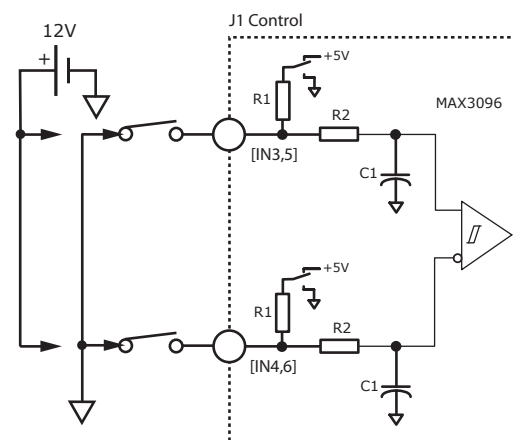
**SPECIFICATIONS**

Input	Data	Notes
Input Voltages Single-ended	HI	$V_{in} \geq 2.7$ Vdc
	LO	$V_{in} \leq 2.3$ Vdc
	VH <sup>1</sup>	45 mVdc typ
Input Voltages Differential <sup>3</sup>	HI	$V_{diff} \geq +200$ mVdc
	LO	$V_{diff} \leq -200$ mVdc
	VH	$\pm 45$ mVdc typ
Common mode	V <sub>cm</sub>	0 to +12 Vdc
Pull-up/down	R1	10 k $\Omega$
Low pass filter	R2	1 k $\Omega$
	C1	100 pF
Time constant	RC <sup>2</sup>	100 ns

**SINGLE-ENDED**



**DIFFERENTIAL**



**CONNECTIONS**

S.E.	DIFF	Pin
IN3	IN3+	J1-9
IN4	IN4-	J1-10
IN5	IN5+	J1-11
IN6	IN6-	J1-12
Sgnd		J1-6, 16, 22, 31, 37, 44

- Notes:
- 1) VH is hysteresis voltage  
IN2 - IN3 or IN12 - IN13
  - 2) The  $R_2 \cdot C_2$  time constant applies when input is driven by active HI/LO devices
  - 3)  $V_{diff} = AIN_n(+) - AIN_n(-)$   
n = 1 for Axis A, 2 for Axis B

**MOTOR OVERTEMP INPUT: IN11**

- Digital, non-isolated
- Motor overtemp input
- 12V Compatible
- Programmable functions

SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	$V_{in} \geq 3.5 \text{ Vdc}$
	LO	$V_{in} \leq 0.7 \text{ Vdc}$
	Max	+12 Vdc
	Min	0 Vdc
Pull-up/down	R1	4.99 kΩ
Input Current	12V	1.4 mA <sub>dc</sub>
	0V	-1.0 mA <sub>dc</sub>
Low pass filter	R2	10 kΩ
	C1	33 nF
Time constant	Te	330 μs *

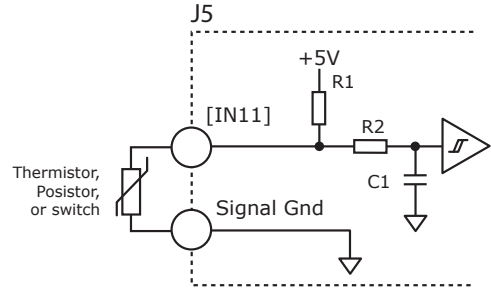
\* RC time constant applies when input is driven by active high/low device

CONNECTIONS

Input	Pin
IN11	J6-7
Sgnd	J6-5, 16, 25, 26

MOTOR OVER TEMP INPUT

The 4.99k pull-up resistor works with PTC (positive temperature coefficient) thermistors that conform to BS 4999:Part 111:1987, or switches that open/close indicating a motor over-temperature condition. The active level is programmable.



BS 4999:Part 111:1987

Property	Ohms
Resistance in the temperature range 20°C to +70°C	60~750
Resistance at 85°C	≤1650
Resistance at 95°C	≥3990
Resistance at 105°C	≥12000

**OPTO-ISOLATED INPUTS: IN7, IN8, IN9, IN10**

- Digital, opto-isolated
- A group of four, with a common terminal
- Works with current sourcing or sinking drivers
- 24V Compatible
- Programmable functions

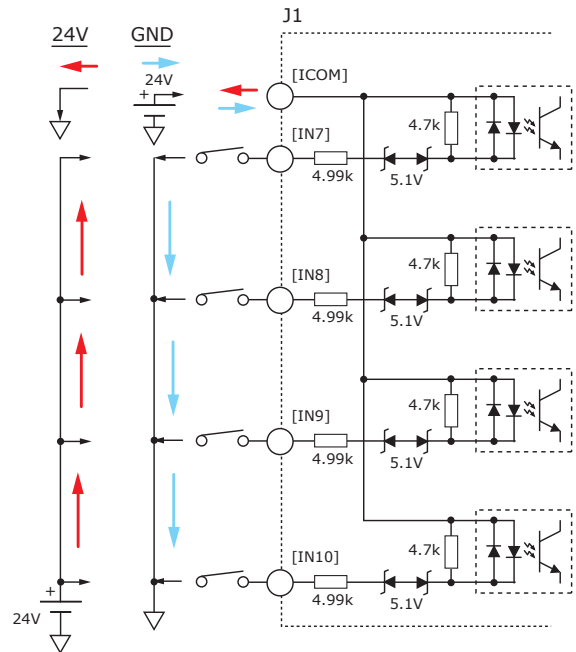
SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	$V_{in} \geq \pm 10.0 \text{ Vdc} *$
	LO	$V_{in} \leq \pm 6 \text{ Vdc} *$
	Max	±30 Vdc *
Input Current	±24V	±3.6 mA <sub>dc</sub>
	0V	0 mA <sub>dc</sub>

\* Vdc Referenced to ICOM terminals.

CONNECTIONS

Signal	J1 Pin
IN7	13
IN8	14
IN9	15
IN10	30
ICOM	28



**ANALOG INPUT: AIN1**

- ±10 Vdc, differential
- 12-bit resolution
- Programmable functions

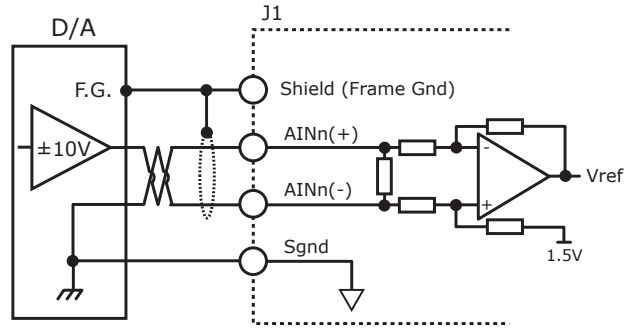
The analog input has a ±10 Vdc range at 12-bit resolution  
 As a reference input it take position/velocity/torque commands from a controller. If not used as a command input, it can be used as general-purpose analog input.

SPECIFICATIONS

Spec	Data	Notes
Input Voltage	Vref	±10 Vdc
Input Resistance	Rin	5.05 kΩ

CONNECTIONS

Signal	Pins
AIN(+)	J1-3
AIN(-)	J1-2
Sgnd	J1-6, 16, 22, 31, 37, 44



**OPTO-ISOLATED OUTPUTS: OUT1, OUT2, OUT3**

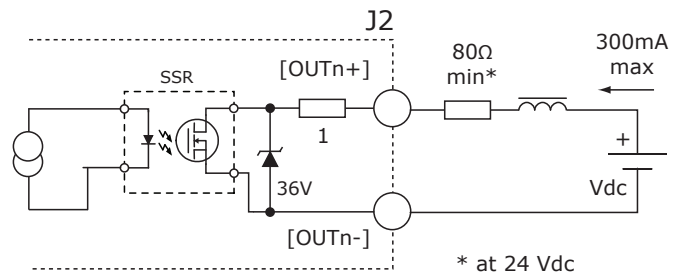
- Digital, opto-isolated
- MOSFET output SSR, 2-terminal
- Flyback diode for inductive loads
- 24V Compatible
- Programmable functions

SPECIFICATIONS

Output	Data	Notes
ON Voltage OUT(+) - OUT(-)	Vdc	0.85V @ 300 mAdc
Output Current	Iout	300 mAdc max

CONNECTIONS

Signal	(+)	(-)
OUT1	J1-42	J1-27
OUT2	J1-41	J1-26
OUT3	J1-40	J1-25



HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
OUT1~3	HI	Output SSR is ON, current flows
	LO	Output SSR is OFF, no current flows

OPTO-ISOLATED MOTOR BRAKE OUTPUT: OUT4

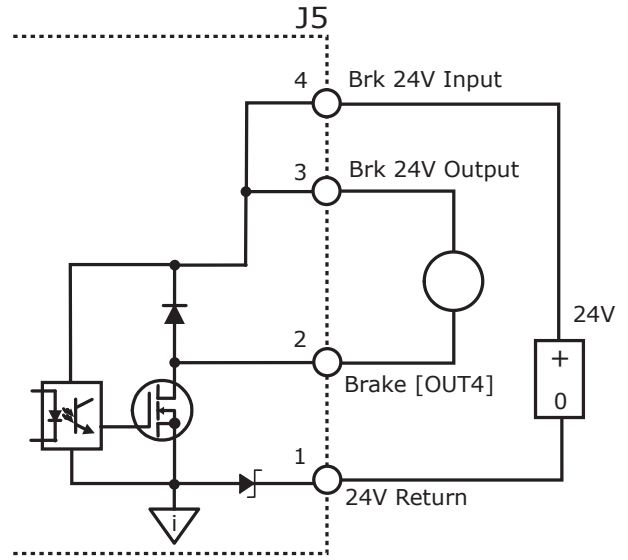
- Brake output
- Opto-isolated
- Flyback diode for inductive load
- 24V Compatible
- Connection for external 24V power supply
- Programmable functions

SPECIFICATIONS

Output	Data	Notes
Voltage Range	Max	+30 Vdc
Output Current	Ids	1.0 Adc

HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
BRAKE [OUT4]	HI	Output transistor is OFF Brake is un-powered and locks motor Motor cannot move Brake state is Active
	LO	Output transistor is ON Brake is powered, releasing motor Motor is free to move Brake state is NOT-Active



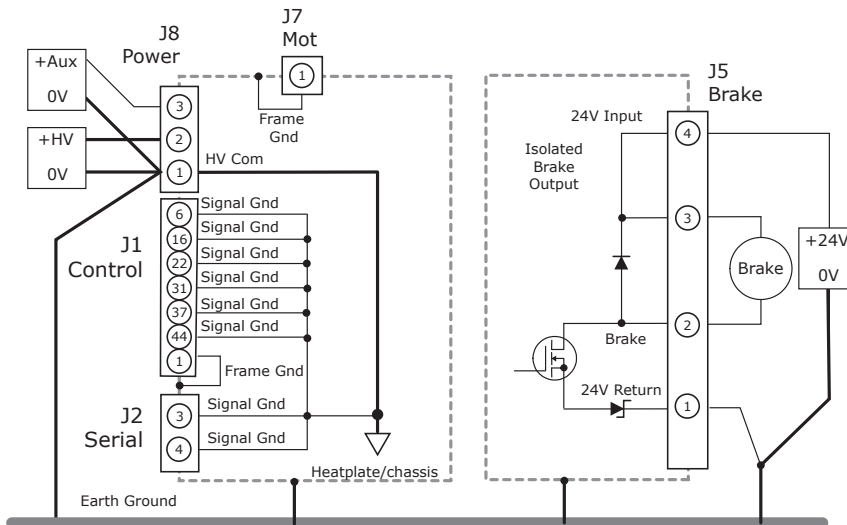
The brake circuits are optically isolated from all drive circuits and frame ground.

CME2 Default Setting for Brake Output [OUT4] is "Brake - Active HI"

- Active = Brake is holding motor shaft (i.e. the *Brake is Active*)  
 Motor cannot move  
 No current flows in coil of brake  
 CME2 I/O Line States shows Output 4 as HI  
 BRK Output voltage is HI (24V), MOSFET is OFF  
 Servo drive output current is zero  
 Servo drive is disabled, PWM outputs are off
- Inactive = Brake is not holding motor shaft (i.e. the *Brake is Inactive*)  
 Motor can move  
 Current flows in coil of brake  
 CME2 I/O Line States shows Output 4 as LO  
 BRK output voltage is LO (~0V), MOSFET is ON  
 Servo drive is enabled, PWM outputs are on  
 Servo drive output current is flowing

J5 CONNECTIONS

Pin	Signal
4	Brk 24V Input
3	Brk 24V Output
2	Brake [OUT4]
1	24V Return



Earthing connections for power supplies should be as close as possible to eliminate potential differences between power supply 0V terminals.

**This diagram shows the connections to the drive that share a common ground in the driver. If the brake 24V power supply is separate from the DC supply powering the drive, it is important that it connects to an earth or common grounding point with the HV power supply.**

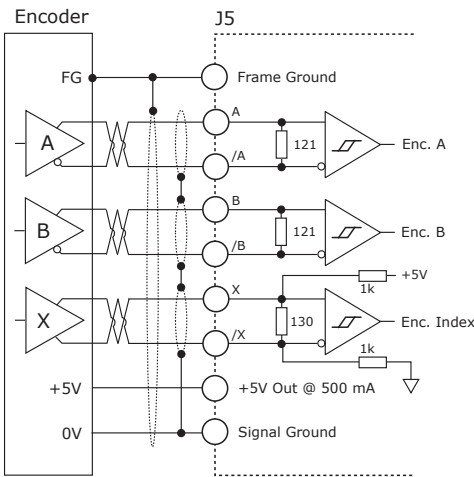
FEEDBACK CONNECTIONS

QUAD A/B/X ENCODER WITH SIGNAL LOSS DETECTION

Encoders with differential line-driver outputs are required (single-ended encoders are not supported) and provide incremental position feedback via the A/B signals and the optional index signal (X) gives a once per revolution position mark. The MAX3097 receiver has differential inputs with fault protections for the following conditions:

Condition	Example
Line-line shorts	A shorted to /A
Open-circuits:	A disconnected, /A connected. Terminator resistor pulls A & /A together for a short-circuit fault
Low-voltage	V <sub>a</sub> - V <sub>b</sub> ≤ 200 mV, or ≥ -200 mV Encoder power loss, cabling, etc.

QUAD ENCODER WITH INDEX

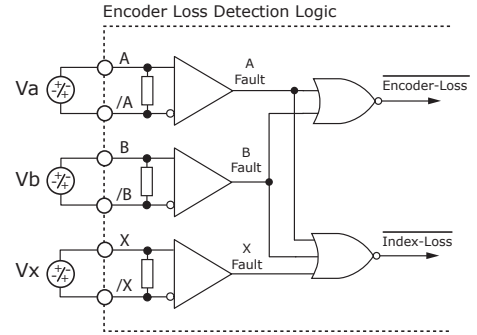


A/B/X SIGNALS

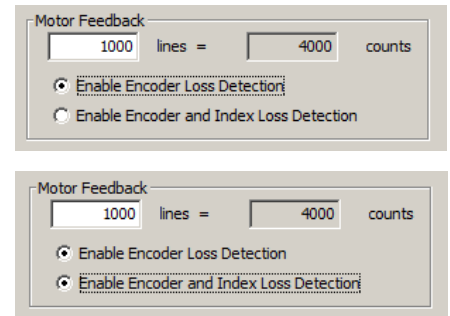
Signal	J6 Pins
Enc A	13
Enc /A	12
Enc B	11
Enc /B	10
Enc X	9
Enc /X	8
+5V	6, 17
Sgnd	5, 16, 25, 26
F.G.	1

Sgnd = Signal Ground  
F.G. = Frame Gnd

SIGNAL LOSS DETECTION LOGIC

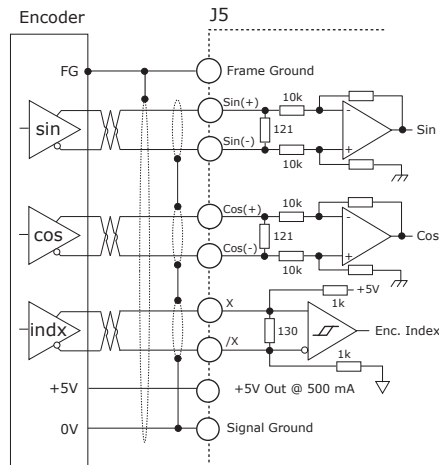


CME2 FEEDBACK OPTIONS



ANALOG SIN/COS INCREMENTAL ENCODER

The sin/cos inputs are analog differential with 121 Ω terminating resistors and accept 1 V<sub>p-p</sub> signals in the format used by incremental encoders with analog outputs, or with ServoTube motors. The index input is digital, differential.



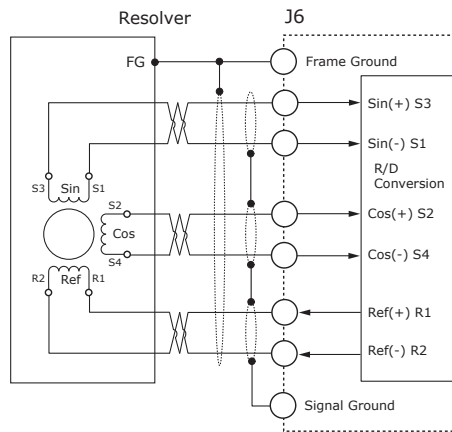
SIN/COS SIGNALS

Signal	J6 Pins
Sin(+)	19
Sin(-)	18
Cos(+)	21
Cos(-)	20
X	9
/X	8
+5V	6, 17
Sgnd	5, 16, 25, 26
F.G.	1

Sgnd = Signal Ground  
F.G. = Frame Gnd

RESOLVER (-R OPTION)

Connections to the resolver should be made with double-shielded cable that uses three twisted-pairs plus an outer shield. Once connected, resolver set up, motor phasing, and other commissioning adjustments are made with CME 2 software. There are no hardware adjustments.



RESOLVER SIGNALS

Signal	J6 Pins
Sin(+)	S3 19
Sin(-)	S1 18
Cos(+)	S2 21
Cos(-)	S4 20
Ref(+)	R1 23
Ref(-)	R2 22
F.G.	12

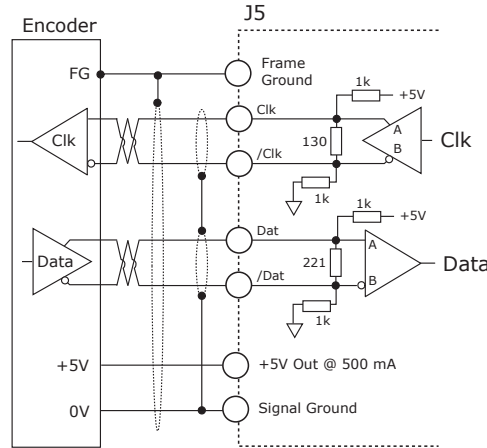
Sgnd = Signal Ground  
F.G. = Frame Gnd



FEEDBACK CONNECTIONS

SSI ABSOLUTE ENCODER

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The XEL drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock pulses. The polling of the encoder data occurs at the current loop frequency (16 kHz). The number of encoder data bits and counts per motor revolution are programmable. The hardware bus consists of two signals: SCLK and SDATA. Data is sent in 8 bit bytes, LSB first. The SCLK signal is only active during transfers. Data is clocked out on the falling edge and clock in on the rising edge of the Master.



SSI, BiSS SIGNALS

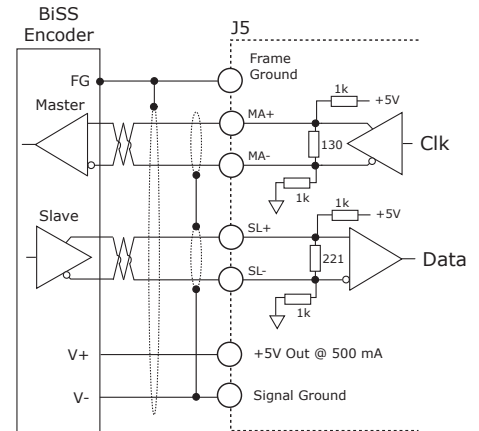
SSI	BiSS	J6 Pins
Clk	MA+	9
/Clk	MA-	8
Data	SL+	15
/Data	SL-	14
+5V		6, 17
Signal Ground		5, 16, 25, 26
Frame Gnd		1

Note: Single (outer) shields should be connected at both ends (motor and drive frame grounds). Inner shields should only be connected to Signal Ground on the drive.

BiSS ABSOLUTE ENCODER

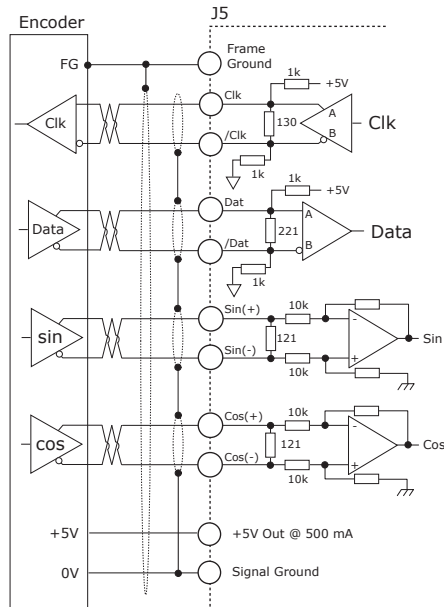
BiSS is an - Open Source - digital interface for sensors and actuators. BiSS refers to principles of well known industrial standards for Serial Synchronous Interfaces like SSI, AS-Interface® and Interbus® with additional options.

- Serial Synchronous Data Communication
- Cyclic at high speed
- 2 unidirectional lines Clock and Data
- Line delay compensation for high speed data transfer
- Request for data generation at slaves
- Safety capable: CRC, Errors, Warnings
- Bus capability incl. actuators
- Bidirectional
- BiSS B-protocol: Mode choice at each cycle start
- BiSS C-protocol: Continuous mode



ENDAT ABSOLUTE ENCODER

The EnDat interface is a Heidenhain interface that is similar to SSI in the use of clock and data signals, but which also supports analog sin/cos channels from the same encoder. The number of position data bits is programmable as is the use of sin/cos channels. Use of sin/cos incremental signals is optional in the EnDat specification.



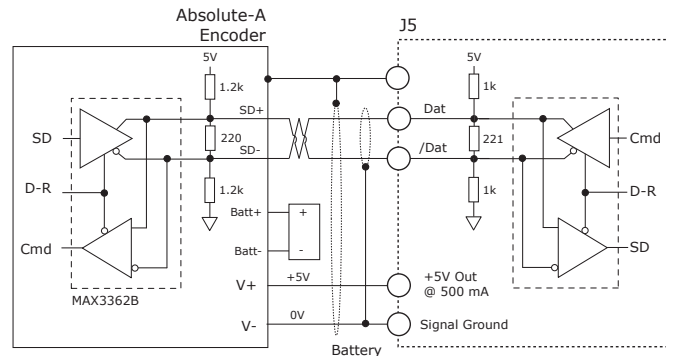
ENDAT SIGNALS

Signal	J6 Pins
Clk	9
/Clk	8
Data	15
/Data	14
Sin(+)	19
Sin(-)	18
Cos(+)	21
Cos(-)	20
+5V	6, 17
Sgnd	5, 16, 25, 26
F.G.	1

Sgnd = Signal Ground  
F.G. = Frame Gnd

ABSOLUTE-A ENCODER

The Absolute A interface is a serial, half-duplex type that is electrically the same as RS-485. Note the battery which must be connected. Without it, the encoder will produce a fault condition.



ABSOLUTE-A SIGNALS

Signal	J6 Pins
Data	15
/Data	14
+5V	6, 17
Sgnd	5, 16, 25, 26
F.G.	1

Sgnd = Signal Ground  
F.G. = Frame Gnd

**MOTOR CONNECTIONS**

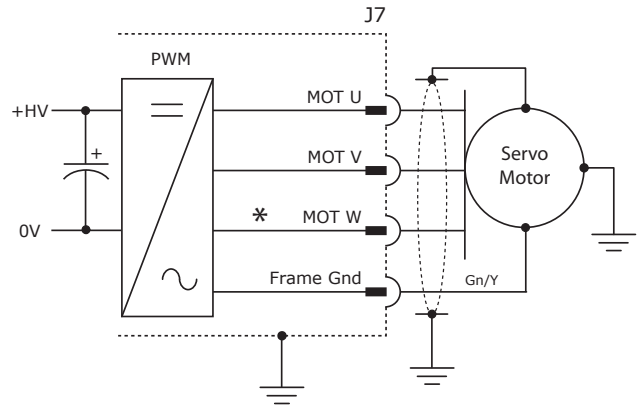
**MOTOR PHASE CONNECTIONS**

The drive output is a three-phase PWM inverter that converts the DC buss voltage (+HV) into three sinusoidal voltage waveforms that drive the motor phase-coils. Cable should be sized for the continuous current rating of the motor. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the drive frame ground terminal (J7-1) for best results.

**MOTOR SIGNALS**

Signal	J7 Pin
Mot U	4
Mot V	3
Mot W*	2
Frame Gnd	1

\* MOT W not used for DC brush motors

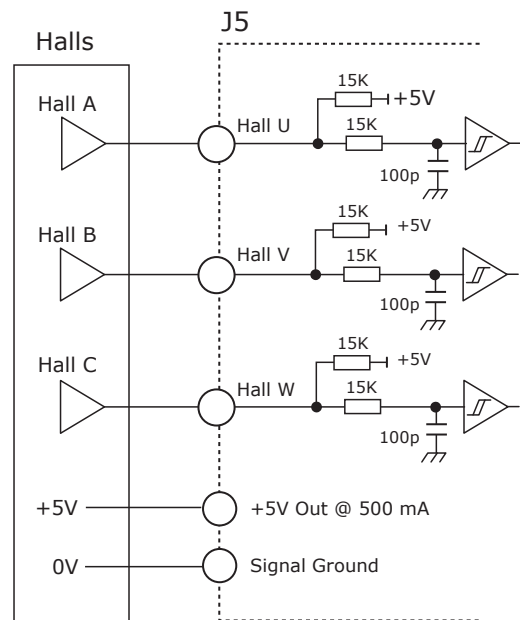


**DIGITAL HALL SIGNALS**

Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much lower frequencies than the motor encoder signals, and are used for commutation-initialization after startup, and for checking the motor phasing after the amplifier has switched to sinusoidal commutation.

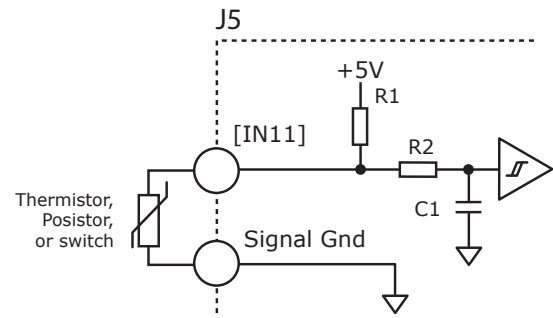
**HALL SIGNALS**

Signal	J6 Pins
Hall U	2
Hall V	3
Hall W	4
+5V	6, 17
Sgnd	5, 16, 25, 26
Frame Gnd	1



**MOTOR OVER TEMP INPUT**

The 4.99k pull-up resistor works with PTC (positive temperature coefficient) thermistors that conform to BS 4999:Part 111:1987 (table below), or switches that open/close indicating a motor over-temperature condition. The active level is programmable. These inputs are programmable for other functions if not used as Motemp inputs. And, other inputs are programmable for the Motemp function.



**MOTEMP SIGNALS**

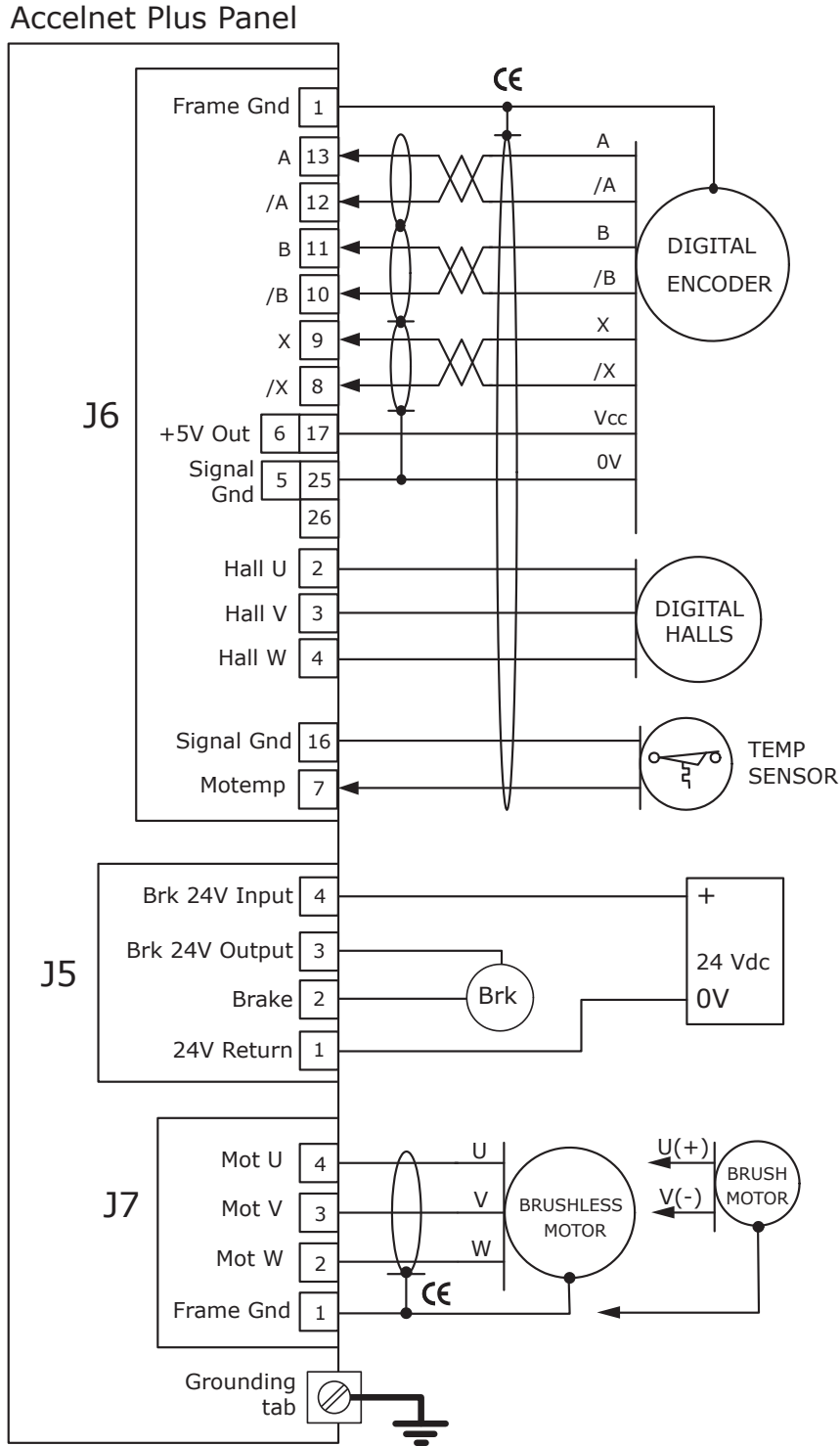
Signal	J6 Pins
Motemp	7
J6 Signal Ground	5,16,25,26
Frame Gnd	1

**BS 4999 SENSOR**

Property	Ohms
Resistance in the temperature range 20°C to +70°C	60~750
Resistance at 85°C	≤1650
Resistance at 95°C	≥3990
Resistance at 105°C	≥12000

**MOTOR CONNECTIONS: DIGITAL QUAD A/B ENCODERS**

The connections shown may not be used in all installations

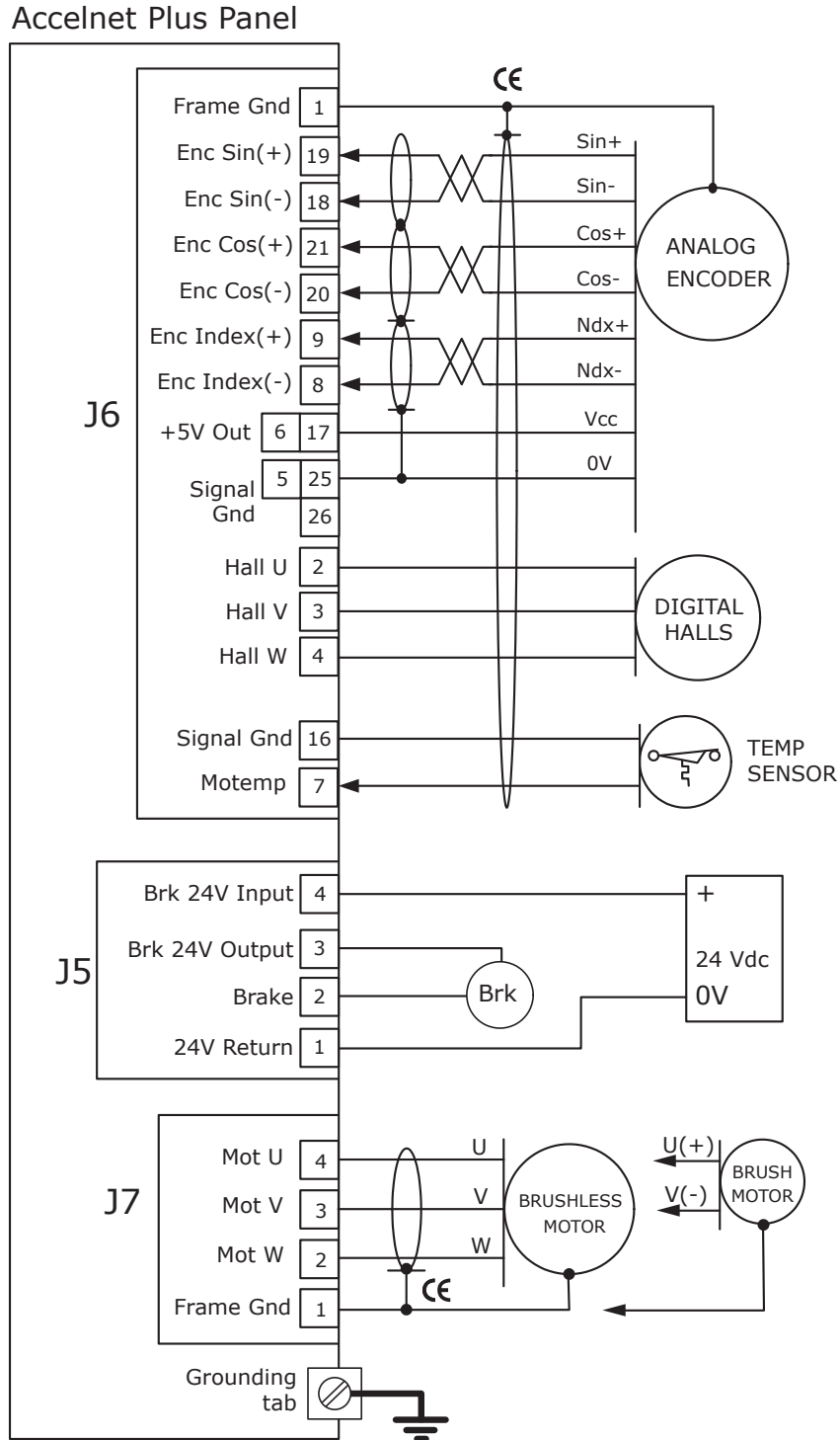


**NOTES:**

- 1) +5V Out on J1 & J6 connect to the same power supply. The sum of output currents is limited to 500 mA
- 2) CE symbols indicate connections required for CE compliance.

**MOTOR CONNECTIONS: ANALOG SIN/COS INCREMENTAL ENCODERS**

The connections shown may not be used in all installations

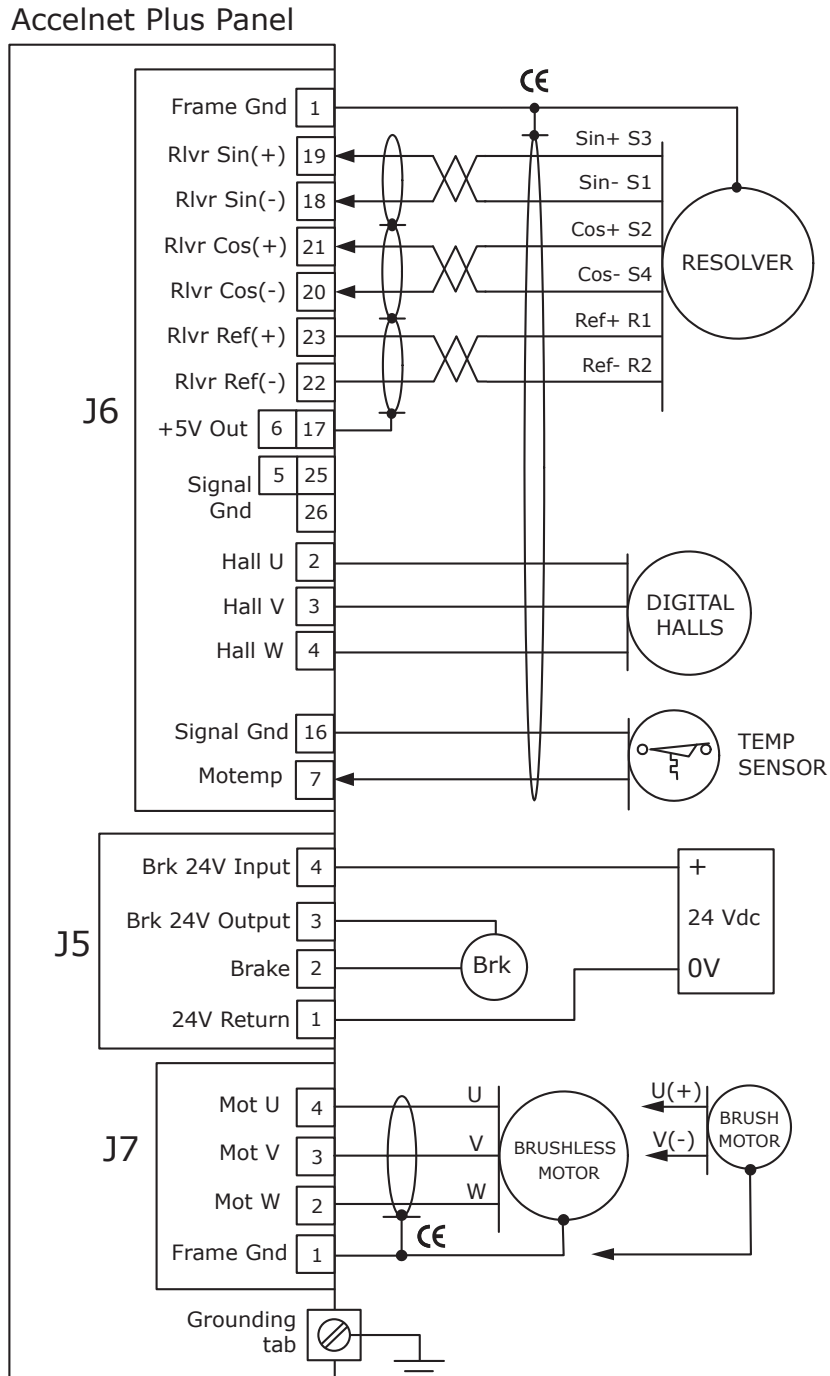


**NOTES:**

- 1) +5V Out on J1 & J6 connect to the same power supply. The sum of output currents is limited to 500 mA
- 2) CE symbols indicate connections required for CE compliance.

**MOTOR CONNECTIONS: RESOLVERS (-R OPTION)**

The connections shown may not be used in all installations.  
Hall signals are not generally used with resolver feedback but are shown here because they function if needed for resolver operation.

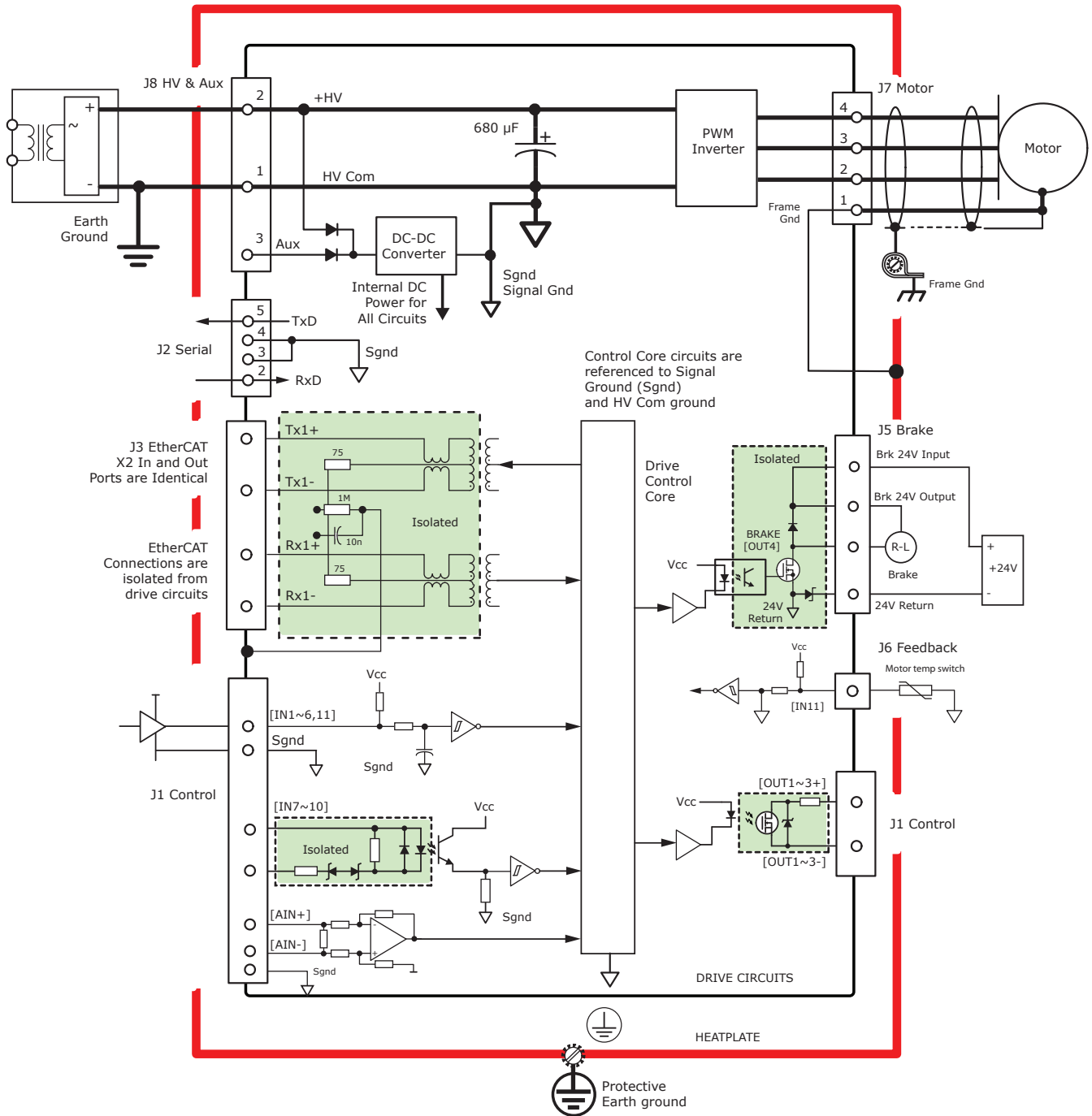


**NOTES:**

- 1) +5V Out on J1 & J6 connect to the same power supply. The sum of output currents is limited to 500 mA
- 2) CE symbols indicate connections required for CE compliance.

DEVICE STRUCTURE & ISOLATION

This graphic shows the electrical structure of the drive, detailing the elements that share a common circuit common (Signal Ground, HV Com) and circuits that are isolated and have no connection to internal circuits. Note that there is no connection between the heatplate (Chassis, Frame Ground) and any drive circuits.



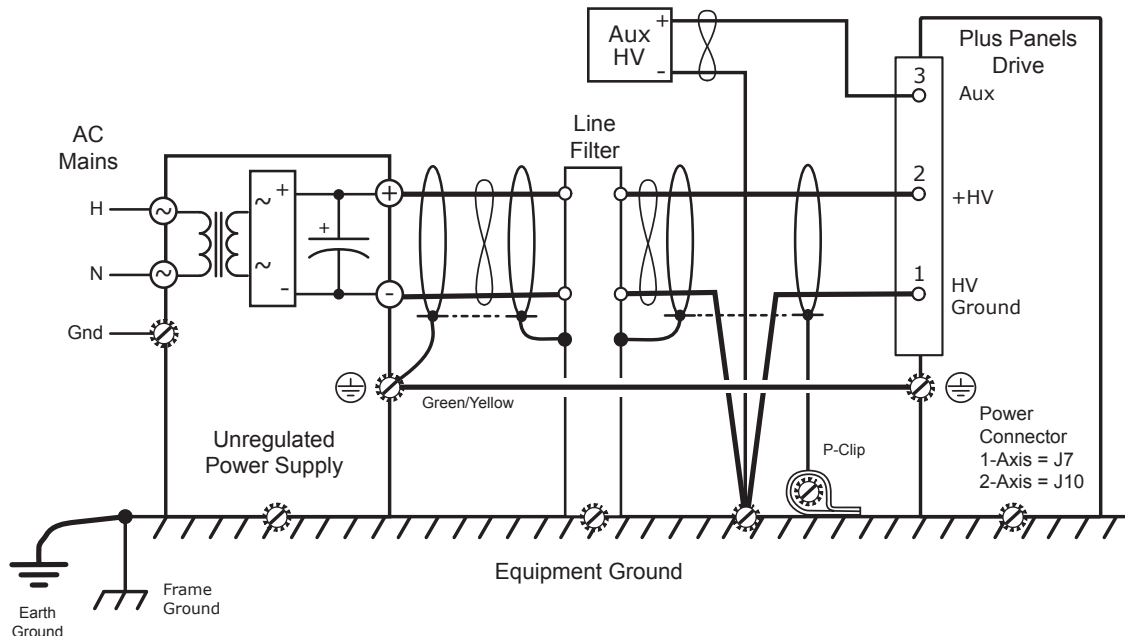
POWER & GROUNDING CONNECTIONS

DC POWER CONNECTIONS

- DC power must be provided by transformers that are galvanically isolated and provide reinforced insulation from the mains. *Auto-transformers cannot be used.*
- The (-) terminal of the power supply is not grounded at the power supply. It is grounded near each drive.
- Cabling to multiple drives for the +HV and 0V is best done in a "star" configuration, and not a "daisy-chain".
- The 0V, or return terminal of the DC power should be connected to frame ground near the drive power connector. From that point, a short wire can connect to the drive HV Ground.
- Cabling to the drive +HV and 0V terminals must be sized to carry the expected continuous current of the drive in the user's installation.
- DC power cabling should be shielded, twisted-pair for best EMI reduction. The shield should connect to the power supply frame ground on one end, and to the drive frame ground on the other. Adding a pigtail and ring-lug, as short as possible will provide a good connection of the shield at the drive.
- Motor cabling typically includes a green/yellow conductor for protective bonding of the motor frame. Connect as shown in the Motor Connections diagram on the following page.
- Motor cable conductors should be twisted and shielded for best EMI suppression.
- If a green/yellow grounding wire connects the motor to the drive's PE terminal, the shield pigtail and ring-lug may connect to one of the screws that mount the drive to the panel. A P-clip to ground the shield as near as possible to the drive will increase the EMI suppression of the shield. On the motor-end, the shield frequently connects to the connector shell. If the motor cable is a flying-lead from the motor, the shield may be connected to the motor frame internally.
- Braided cable shields are more effective for EMI reduction than foil shields. Double-shielded cables typically have a braided outer shield and foil shields for the internal twisted pairs. This combination is effective for both EMI reduction and signal quality of the feedback signals from analog encoders or resolvers.
- Motor cable shielding is not intended to be a protective bonding conductor unless otherwise specified by the motor manufacturer.
- For feedback cables, double-shielded cable with a single outer shield and individual shielded twisted pair internal shields gives the best results with resolvers, or analog sin/cos encoders.
- In double-shielded cables, the internal shielding should connect to the drive's Signal Ground on one end, and should be unconnected on the motor end.
- Single-shield feedback cables connect to the drive frame on one end, and to the motor frame on the other. Depending on the construction of the motor, leaving the feedback cable shield disconnected on the motor but connected on the drive end may give better results.
- The drive should be secured to the equipment frame or panels using the mounting slots. This ensures a good electrical connection for optimal EMI performance. The drive chassis is electrically conductive.

DC POWER WIRING

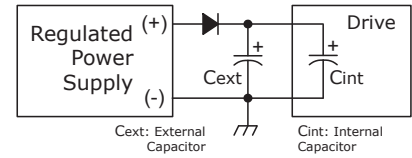
P-clips secure cables to a panel and provide full contact to the cable shields after the insulation has been stripped. This should be done as close to the drive as possible for best EMI attenuation.



**+HV POWER SUPPLY REQUIREMENTS**

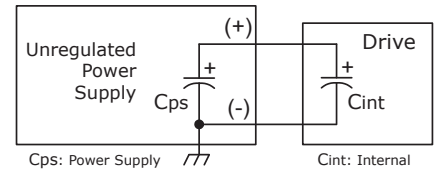
**Regulated Power Supplies**

- Must be over-voltage protected to 100 Vdc max when the STO (Safe Torque Off) feature of the drive is used.
- Require a diode and external capacitor to absorb regenerative energy.
- The VA rating should be greater than the actual continuous output power of the drives connected to the power supply, and adequate for the transient output power due to acceleration of motor loads.
- Must handle the internal capacitance of the drives on startup.



**Unregulated Power Supplies**

- No-load, high-line output voltage must not exceed 90 Vdc.
- Power supply internal capacitance adds to the drive's internal capacitance for absorption of regenerative energy.
- The VA (Volts & Amps) rating at the power supply's AC input is typically 30~40% greater than the total output power of the drives.



**AUXILIARY HV POWER**

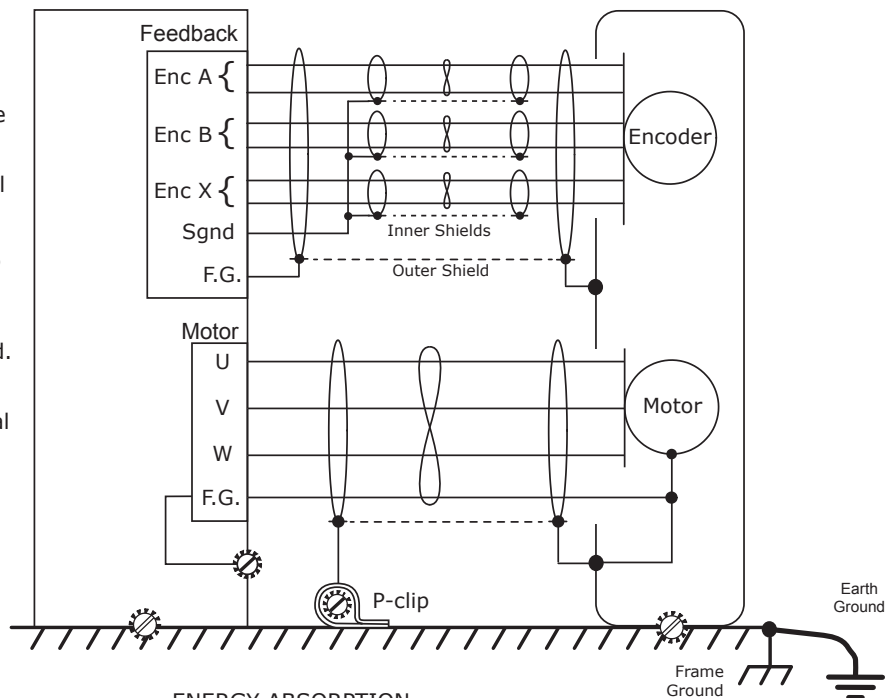
- Aux HV is power that can keep the drive communications and feedback circuits active when the PWM output stage has been disabled by removing the main +HV supply.
- Useful during EMO (Emergency Off) conditions where the +HV supply must be removed from the drive and powered-down to ensure operator safety.
- Voltage range is the same as +HV.
- Powers the DC/DC converter that supplies operating voltages to the drive DSP and control circuits.
- Aux HV draws no current when the +HV voltage is greater than the Aux HV voltage.

**MOTOR CONNECTIONS**

- Motor cable shield connects to motor frame, is grounded with a P-clip near the drive and terminates in a ring-lug that is screwed to the drive chassis by a mounting screw to the panel
- If provided, a green/yellow grounding wire from the motor connects to the F.G. terminal of the motor connector.

**FEEDBACK CONNECTIONS**

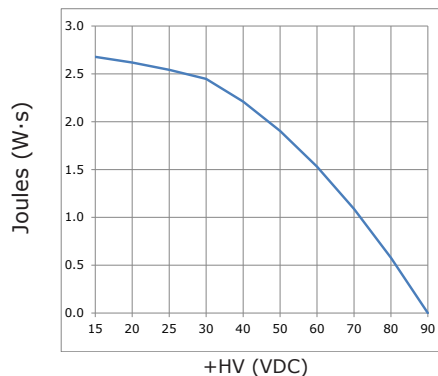
- Cable shield connects to motor frame and to the F.G. terminal of the feedback connector.
- When double-shielding is used, the inner shields connect to the Signal Ground at the drive, and is not connected at the motor end.
- If not provided by the motor manufacturer, feedback cables rated for RS-422 communications are recommended for digital encoders.



**REGENERATION**

This chart shows the energy absorption in W·s for the drive operating at some typical DC voltages. It is based on the internal 680 uF capacitor and would be increased by the capacitance of the external DC power supply. When the load mechanical energy is greater than these values an external regenerative energy dissipater is required, or the DC power supply capacitance can be increased to absorb the regen energy.

**ENERGY ABSORPTION**

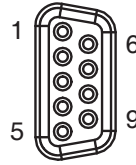




**CONNECTORS & SIGNALS: FRONT PANEL**

J4 SAFETY (SAFE TORQUE OFF)

PIN	SIGNAL	PIN	SIGNAL
1	Frame Gnd	6	STO-1(+)
2	STO-1(+)	7	STO-1(-)
3	STO-1(-)	8	STO-24V
4	STO-2(+)	9	STO-GND
5	STO-2(-)		



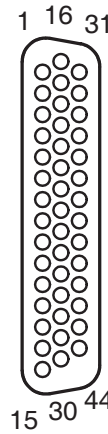
**J4 BEL CONNECTOR:**  
Dsub DB-09F, 9 position female receptacle

**J4 CABLE CONNECTOR:**  
Poke and crimp Dsub DB-09M, 9 position

Details on J1, J4, & J6 cable connectors can be found in the BEL-CK listing under the Accessories section of the last page

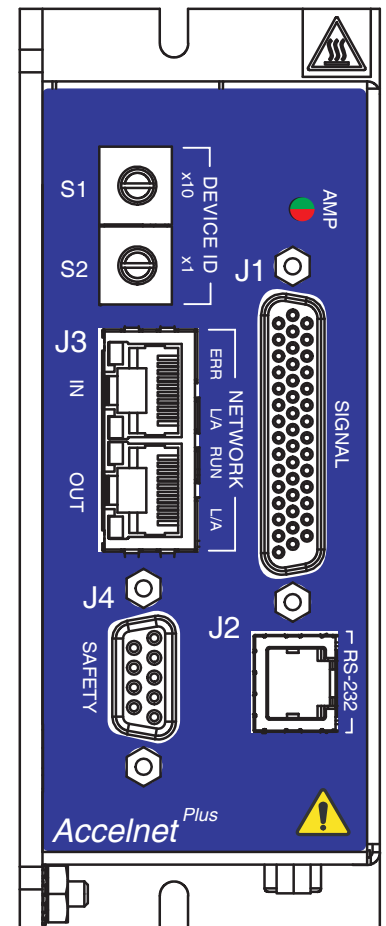
J1: CONTROL SIGNALS

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	Frame Gnd	16	Signal Gnd	31	Signal Gnd
2	[AIN1-]	17	+5Vout	32	+5Vout
3	[AIN1+]	18	MultiEnc /S	33	MultiEnc S
4	N/C	19	MultiEnc /X	34	MultiEnc X
5	N/C	20	MultiEnc /B	35	MultiEnc B
6	Signal Gnd	21	MultiEnc /A	36	MultiEnc A
7	[IN1]	22	Signal Gnd	37	Signal Gnd
8	[IN2]	23	N/C	38	N/C
9	[IN3] Diff1(+)	24	N/C	39	N/C
10	[IN4] Diff1(-)	25	[OUT3-]	40	[OUT3+]
11	[IN5] Diff2(+)	26	[OUT2-]	41	[OUT2+]
12	[IN6] Diff2(-)	27	[OUT1-]	42	[OUT1+]
13	[IN7]	28	[ICOM]	43	N/C
14	[IN8]	29	N/C	44	Signal Gnd
15	[IN9]	30	[IN10]		



**J1: DRIVE CONNECTOR**  
High-Density Dsub DB-44F, female receptacle, 44 Position

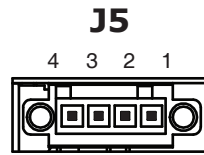
**J1: CABLE CONNECTOR**  
High-Density Dsub DB-44M, male plug, 44 Position



**CONNECTORS & SIGNALS: DIGITAL AND ANALOG ENCODERS**

**J5: BRAKE**

Pin	Signal
4	Brk 24V Input
3	Brk 24V Output
2	Brake A [OUT4]
1	24V Return



**J5: BEL CONNECTOR**

Euro-style 3.5 mm male receptacle, 4-position  
Wago: MCS-MINI, 734-164/108-000

**J5: CABLE CONNECTOR**

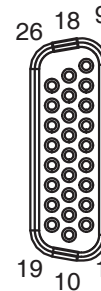
Wago MCS-MINI 734-104/107-000  
or 734-105/107-000

**WAGO CONNECTOR TOOL**

Contact opener: 734-231 operating tool

**J6: FEEDBACK**

PIN	SIGNAL	PIN	SIGNAL
26	Signal Gnd	9	Enc X
25	Signal Gnd	8	Enc /X
24	N/C	7	[IN11] Motemp
23	N/C	6	+5VOut
22	N/C	5	Signal Gnd
21	Cos(+)	4	Hall W
20	Cos(-)	3	Hall V
19	Sin(+)	2	Hall U
18	Sin(-)	1	Frame Gnd
17	+5VOut		
16	Signal Gnd		
15	Enc S		
14	Enc /S		
13	Enc A		
12	Enc /A		
11	Enc B		
10	Enc /B		

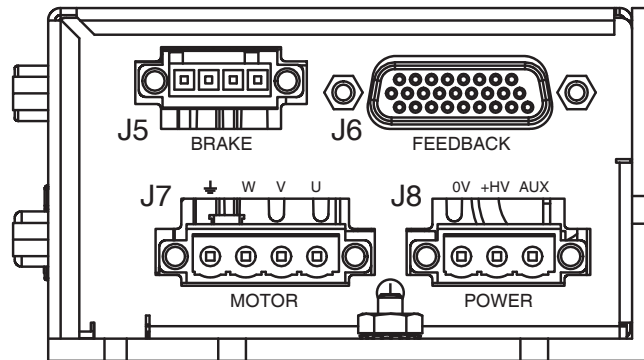


**J6**

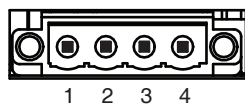
**J6: MOTOR FEEDBACK**

**J6: BEL CONNECTOR**  
High-Density Dsub DB-26F, female receptacle, 26 Position

**J6: CABLE CONNECTOR**  
High-Density Dsub DB-26M, male plug, 26 Position



**J7**



**J7: MOTOR OUTPUT**

Signal	Pin
Frame Ground	1
Motor Phase W	2
Motor Phase V	3
Motor Phase U	4

**J7: DRIVE CONNECTORS**

Euro-style 5.08 mm male receptacle, 4-position  
Wago: MCS-MIDI, 231-564/108-000

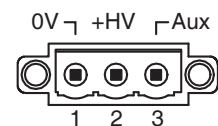
**J7 CABLE CONNECTORS**

Wago MCS-MIDI Classic 231-304/107-000

**WAGO CONNECTOR TOOL**

Contact opener: 231-159 operating tool

**J8**



**J8: +HV & AUX POWER**

Signal	Pin
HV Ground	1
HV	2
Aux HV	3

**J8: DRIVE CONNECTOR**

Euro-style 5.08 mm male receptacle, 3-position  
Wago: MCS-MIDI, 231-563/108-000

**J8: CABLE CONNECTOR**

Wago MCS-MIDI, 231-303/107-000

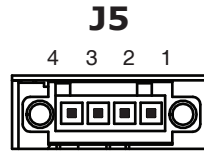
**WAGO CONNECTOR TOOL**

Contact opener: 231-159 operating tool

**CONNECTORS & SIGNALS: RESOLVER OPTION (-R)**

**J5: BRAKE**

Pin	Signal
4	Brk 24V Input
3	Brk 24V Output
2	Brake A [OUT4]
1	24V Return



**J5: BEL CONNECTOR**

Euro-style 3.5 mm male receptacle, 4-position  
Wago: MCS-MINI, 734-164/108-000

**J5: CABLE CONNECTOR**

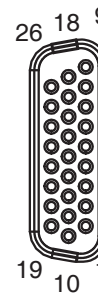
Wago MCS-MINI 734-104/107-000  
or 734-105/107-000

**WAGO CONNECTOR TOOL**

Contact opener: 734-231 operating tool

**J6: FEEDBACK**

PIN	SIGNAL	PIN	SIGNAL
26	Signal Gnd	9	Enc X
25	Signal Gnd	8	Enc /X
24	N/C	7	[IN11] Motemp
23	Ref(+) R1	6	+5VOut
22	Ref(-) R2	5	Signal Gnd
21	Cos(+) S2	4	Hall W
20	Cos(-) S4	3	Hall V
19	Sin(+) S3	2	Hall U
		1	Frame Gnd

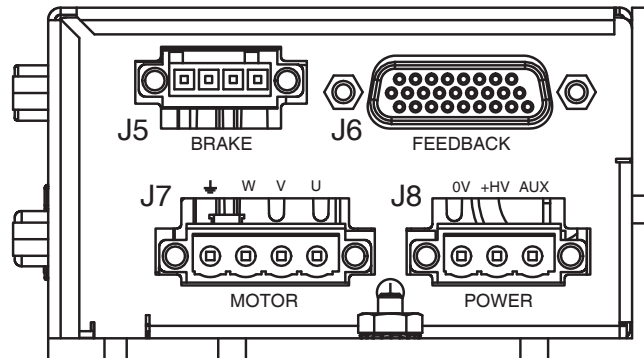


**J6**

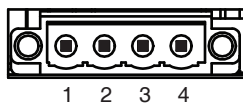
**J6: MOTOR FEEDBACK**

**J6: BEL CONNECTOR**  
High-Density Dsub DB-26F, female receptacle, 26 Position

**J6: CABLE CONNECTOR**  
High-Density Dsub DB-26M, male plug, 26 Position



**J7**



**J7: MOTOR OUTPUT**

Signal	Pin
Frame Ground	1
Motor Phase W	2
Motor Phase V	3
Motor Phase U	4

**J7: DRIVE CONNECTORS**

Euro-style 5.08 mm male receptacle, 4-position  
Wago: MCS-MIDI, 231-564/108-000

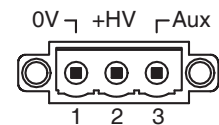
**J7 CABLE CONNECTORS**

Wago MCS-MIDI Classic 231-304/107-000

**WAGO CONNECTOR TOOL**

Contact opener: 231-159 operating tool

**J8**



**J8: +HV & AUX POWER**

Signal	Pin
HV Ground	1
HV	2
Aux HV	3

**J8: DRIVE CONNECTOR**

Euro-style 5.08 mm male receptacle, 3-position  
Wago: MCS-MIDI, 231-563/108-000

**J8: CABLE CONNECTOR**

Wago MCS-MIDI, 231-303/107-000

**WAGO CONNECTOR TOOL**

Contact opener: 231-159 operating tool

**WIRING**

**24V & BRAKE: J5**

Wago MCS-MINI: 734-104/107-000, female connector; with screw flange; 4-pole; pin spacing 3.5 mm / 0.138 in  
 Conductor capacity  
 Bare stranded: AWG 28~16 [0.08~1.5 mm<sup>2</sup>]  
 Insulated ferrule: AWG 24~16 [0.25~1.5 mm<sup>2</sup>]  
 Stripping length: 0.24~0.28 in [6~7 mm]  
 Operating tool: Wago MCS-MINI: 734-231



**FERRULE PART NUMBERS: SINGLE WIRE INSULATED**

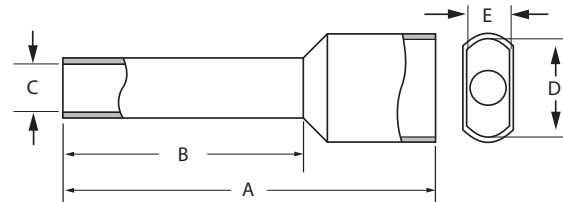
AWG	mm <sup>2</sup>	Color	Mfgr	PNUM	A	B	C	D	E	SL
18	1.0	Red	Wago	216-223	12.0 (.47)	6.0 (.24)	1.4 (.06)	3.0 (.12)	3.5 (.14)	8 (.31)
20	0.75	Gray	Wago	216-222	12.0 (.47)	6.0 (.24)	1.2 (.05)	2.8 (.11)	3.3 (.13)	8 (.31)
22	0.5	White	Wago	216-221	12.0 (.47)	6.0 (.24)	1.0 (.04)	2.6 (.10)	3.1 (.12)	7.5 (.30)

**FERRULE PART NUMBERS: DOUBLE WIRE INSULATED**

AWG	mm <sup>2</sup>	Color	Mfgr	PNUM	A	B	C	D	E	SL
2 x 18	2 x 1.0	Red	Altech	2776.0	15.4 (.61)	8.2 [.32]	2.4 (.09)	3.2 (.13)	5.8 (.23)	11.0 (.43)
2 x 18	2 x 1.0	Gray	Altech	2775.0	14.6 (.57)	8.2 (.32)	2.0 (.08)	3.0 (.12)	5.5 (.22)	11.0 (.43)
2 x 20	2 x 0.75	White	Altech	2794.0	14.6 (.57)	8.2 (.32)	1.7 (.07)	3.0 (.12)	5.0 (.20)	11.0 (.43)
2 x 20	2 x 0.75	Gray	TE	966144-2	15.0 (.59)	8.0 (.31)	1.70 (.07)	2.8 (.11)	5.0 (.20)	10 (.39)
2 x 22	2 x 0.50	White	TE	966144-1	15.0 (.59)	8.0 (.31)	1.40 (.06)	2.5 (.10)	4.7 (.19)	10 (.39)

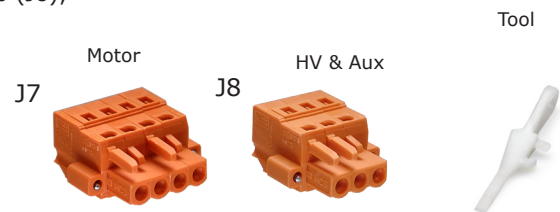
**NOTES**

PNUM = Part Number  
 SL = Stripping length  
 Dimensions: mm (in)



**HV/AUX POWER AND MOTOR OUTPUTS: J7 & J8**

Wago MCS-MIDI Classic: 231-304/107-000 (J7), 231-303/107-000 (J8); with screw flange; 3-pole; pin spacing 5.08 mm / 0.2 in  
 Conductor capacity  
 Bare stranded: AWG 28~14 [0.08~2.5 mm<sup>2</sup>]  
 Insulated ferrule: AWG 24~16 [0.25~1.5 mm<sup>2</sup>]  
 Stripping length: 8~9 mm  
 Operating Tool: Wago MCS-MIDI Classic: 231-159

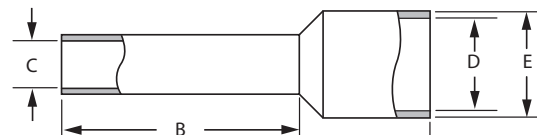


**FERRULE PART NUMBERS: SINGLE WIRE INSULATED**

AWG	mm <sup>2</sup>	Color	Mfgr	PNUM	A	B	C	D	E	SL
14	2.5	Blue	Wago	216-206	15.0 (0.59)	8.0 (0.31)	2.05 (.08)	4.2 (0.17)	4.8 (0.19)	10 (0.39)
16	1.5	Black	Wago	216-204	14.0 (0.59)	8.0 (0.31)	1.7 (.07)	3.5 (0.14)	4.0 (0.16)	10 (0.39)
18	1.0	Red	Wago	216-223	12.0 (.47)	6.0 (.24)	1.4 (.055)	3.0 (.12)	3.5 (.14)	8 (.31)
20	0.75	Gray	Wago	216-222	12.0 (.47)	6.0 (.24)	1.2 (.047)	2.8 (.11)	3.3 (.13)	8 (.31)
22	0.5	White	Wago	216-221	12.0 (.47)	6.0 (.24)	1.0 (.039)	2.6 (.10)	3.1 (.12)	7.5 (.30)

**NOTES**

PNUM = Part Number  
 SL = Stripping length  
 Dimensions: mm (in)



**HEATSINK KIT INSTALLATION**

- STANDARD HEATSINK FOR ACCELNET PLUS PANEL BEL
- COMPLETE KIT FOR USER INSTALLATION OF THE HEATSINK

**DESCRIPTION**

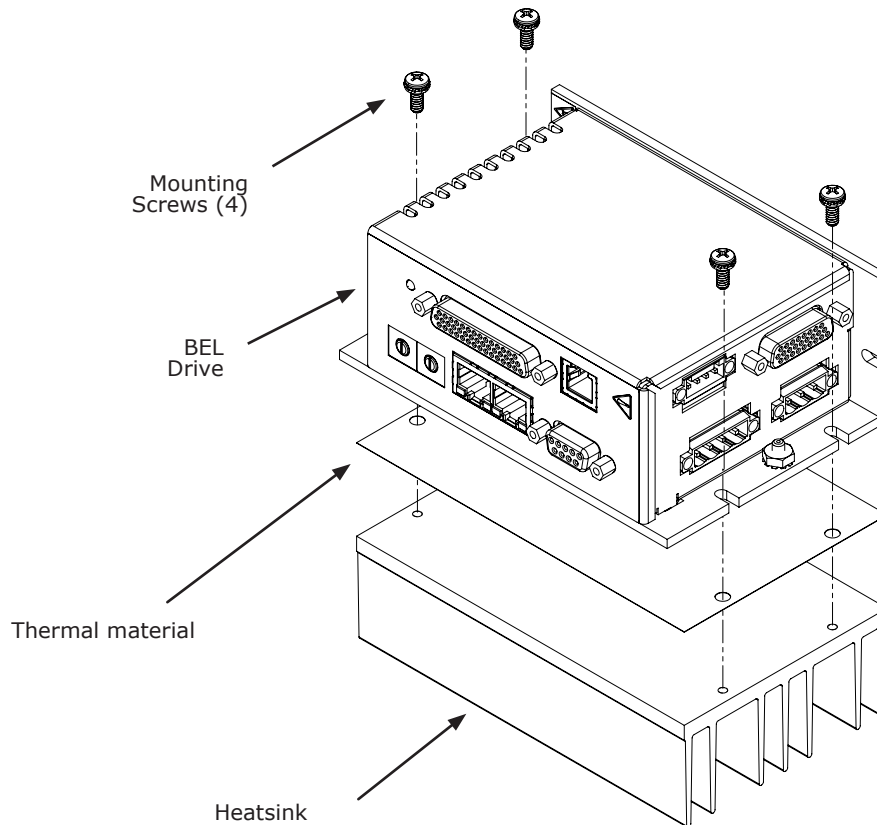
The BEL-HK is a kit containing a heatsink and mounting hardware for field installation of a standard heatsink onto a BEL model servo drive. To order an BEL drive with heatsink fitted at the factory, add "-H" to the model part number.

**HEATSINK KIT PART LIST**

Qty	Description	
1	Heatsink, standard, BEL-HS	
1	Thermal pad, 4x4 in.	
1	Kit, Heatsink Hardware, BEL	
	4	Washer, flat, #8
	4	Screw, PAN, SEMS, #8-32 x 1/2 in

**INSTALLATION**

- 1) Place the heatsink fins-down on a work surface. Orient the heatsink so that the edge with part number is away from you. The hole for the BEL grounding lug should be to your left.
- 2) Remove the clear protective film from the thermal material and discard it. Place the thermal material onto the heatsink in the placement area which is marked with four white "L". Apply light pressure to ensure that the thermal material is flat.
- 3) Peel the white protective layer away from the thermal material. Do this slowly from one corner so as not to lift the thermal material from the heatsink.
- 4) Align the BEL as shown and lower onto the heatsink. If needed to adjust the position, lift it away from the thermal material and lower onto the heatsink again.
- 5) Install the four mounting screws with flat washers and tighten evenly. Torque to 17.8 lb-in (2.0 Nm) maximum.



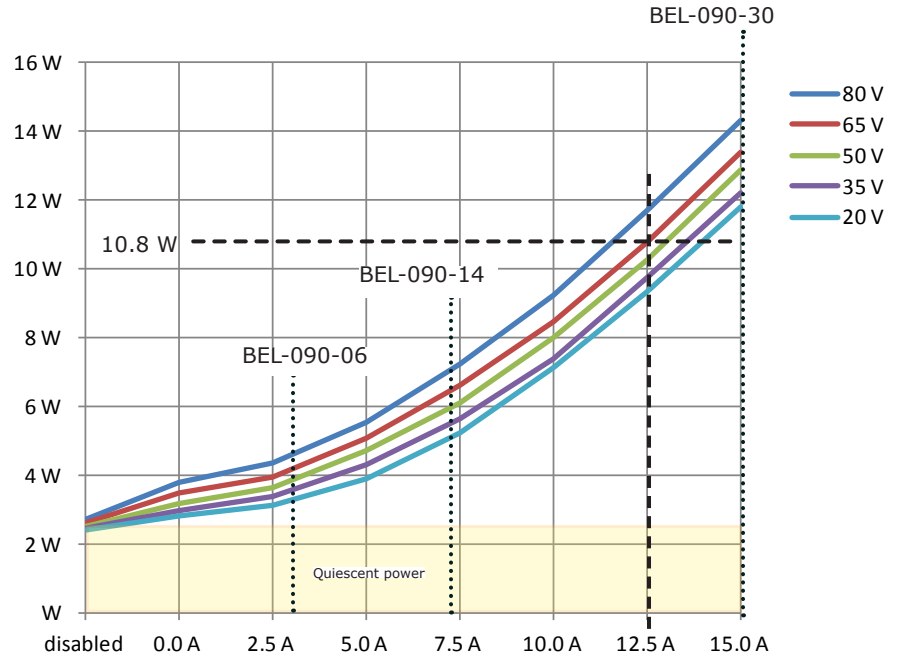
**THERMALS: POWER DISSIPATION**

The top chart on this page shows the internal power dissipation of the BEL under differing power supply and output current conditions. The +HV values are for the average DC voltage of the drive power supply. The lower chart shows the temperature rise vs. power dissipation under differing mounting and cooling conditions.

**POWER DISSIPATION**

Use this chart to find the Watts dissipation. The vertical dashed lines show the continuous currents for the three BEL models.

Example BEL-090-30:  
Power supply HV = 65 Vdc  
Current = 12.5A  
Power dissipation= 10.8 W

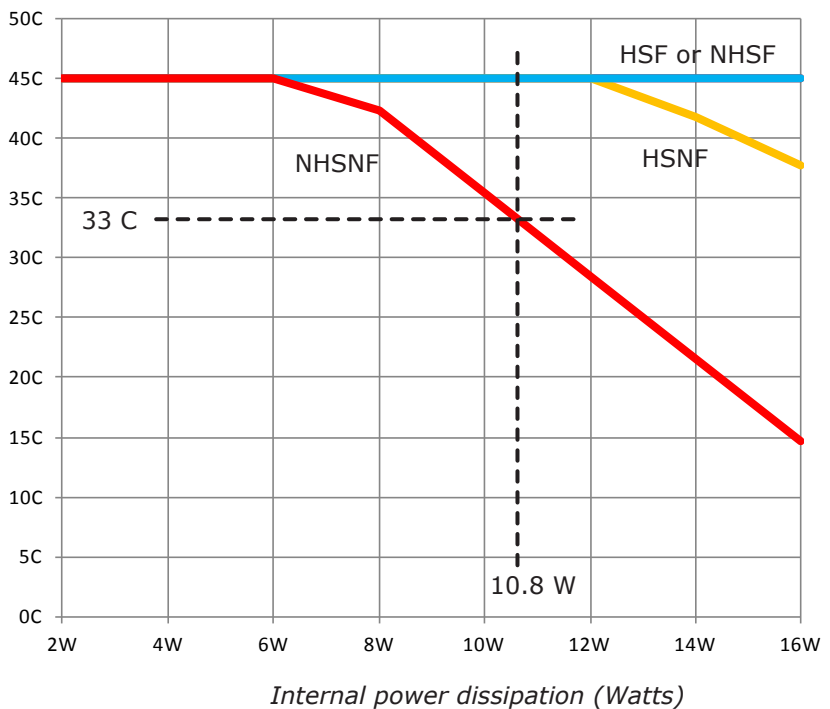


**THERMALS: MAXIMUM OPERATING TEMPERATURE VS. DISSIPATION**

Use this chart to find the maximum operating temperature of the drive under differing mounting and cooling conditions.

Example:  
Using the 10.8 W value from the calculations above, draw a vertical line. This shows that 33 C is the maximum operating temperature for NHSNF. But HSFNF, NHSF, or HSF mountings allow operation to 45 C maximum ambient.

- HSF = Heat Sink (with) Fan
- NHSF = No Heat Sink (with) Fan
- HSNF = Heat Sink No Fan
- NHSNF = No Heat Sink No Fan



**THERMALS: MOUNTING & THERMAL RESISTANCE**

**MOUNTING**

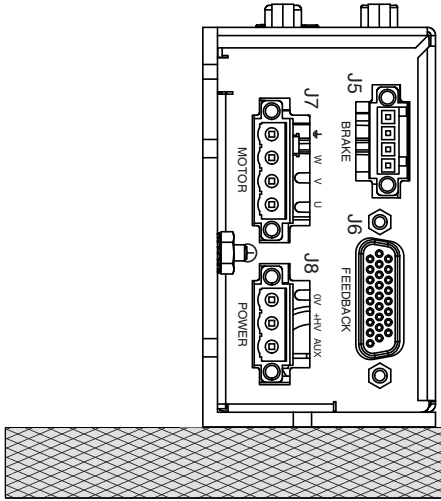
Thermal data for convection-cooling with a heatsink assumes a vertical mounting of the drive on a thermally non-conducting surface. Heatsink fins run parallel to the long axis of the drive. When fan-cooling is used vertical mounting is not necessary to guarantee thermal performance of the heatsink.

**THERMAL RESISTANCE**

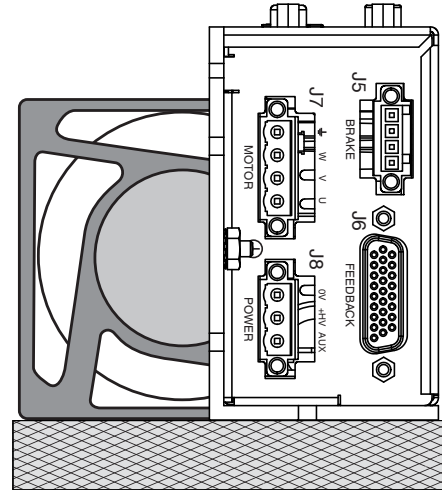
Thermal resistance is a measure of the temperature rise of the drive heatplate due to power dissipation in the drive. It is expressed in units of °C/W where the degrees are the temperature rise above ambient.

E.g., a drive dissipating 13 W mounted with no heatsink or fan would see a temperature rise of 45 °C above ambient based on the thermal resistance of 3.46 °C/W. Using the drive maximum heatplate temperature of 70 °C and subtracting 46 °C from that would give 24 °C as the maximum ambient temperature the drive in which the drive could operate before going into thermal shutdown. To operate at higher ambient temperatures a heatsink or forced-air would be required.

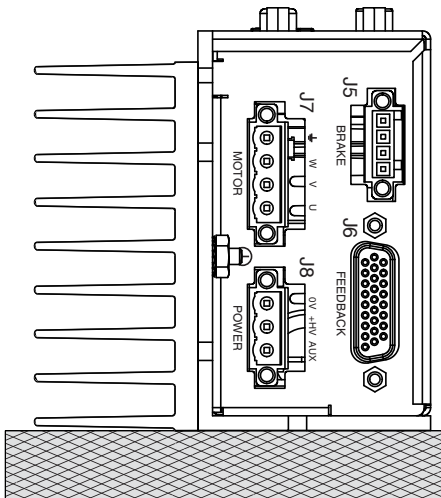
**END VIEWS  
VERTICAL MOUNTING**



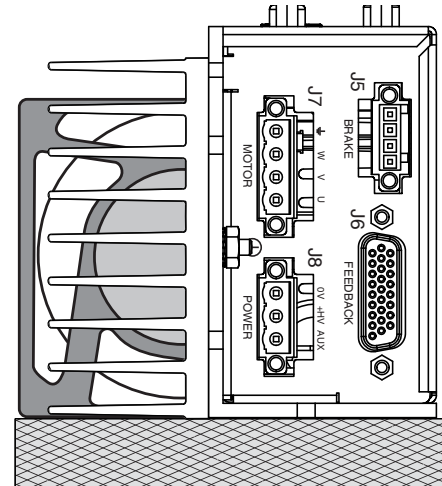
NO HEATSINK, NO FAN	°C/W
CONVECTION	3.46



NO HEATSINK + FAN	°C/W
FORCED-AIR, 300 LFM	1.32



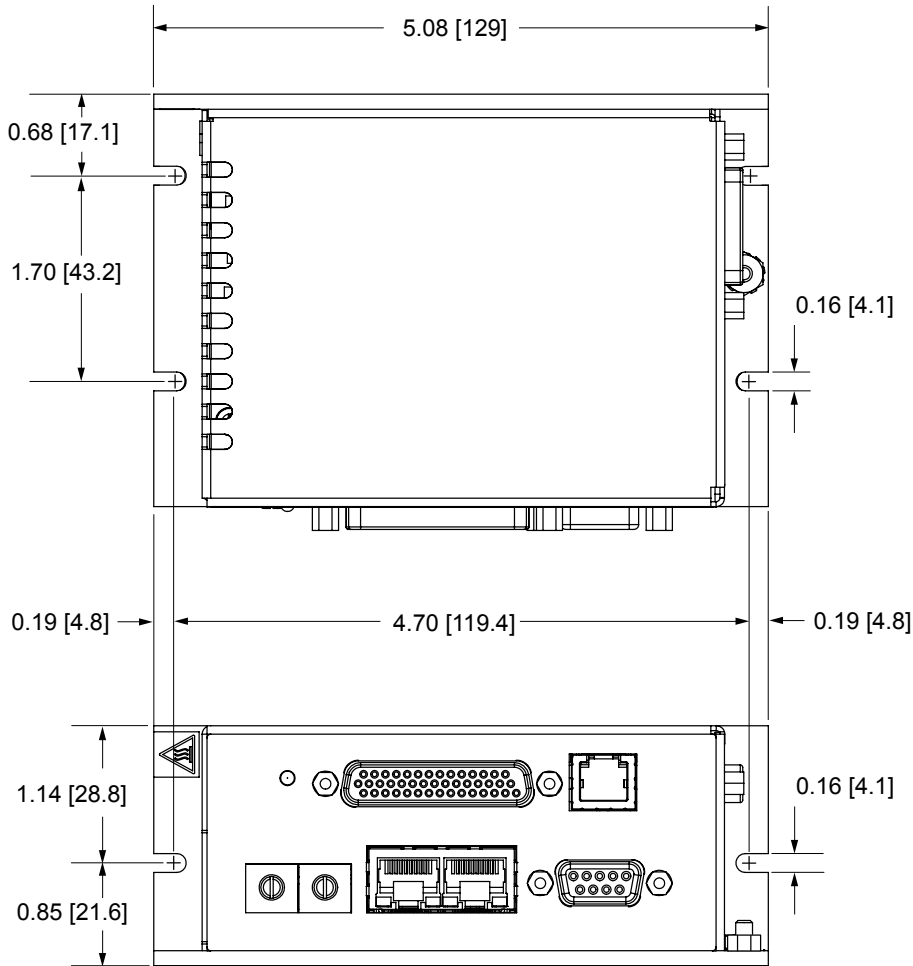
HEATSINK, NO FAN	°C/W
CONVECTION	2.02



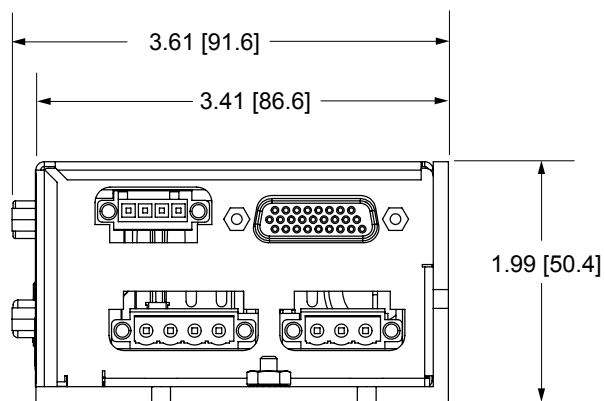
HEATSINK + FAN	°C/W
FORCED-AIR, 300 LFM	0.91

**DIMENSIONS: NO HEATSINK**

Units: IN[MM]



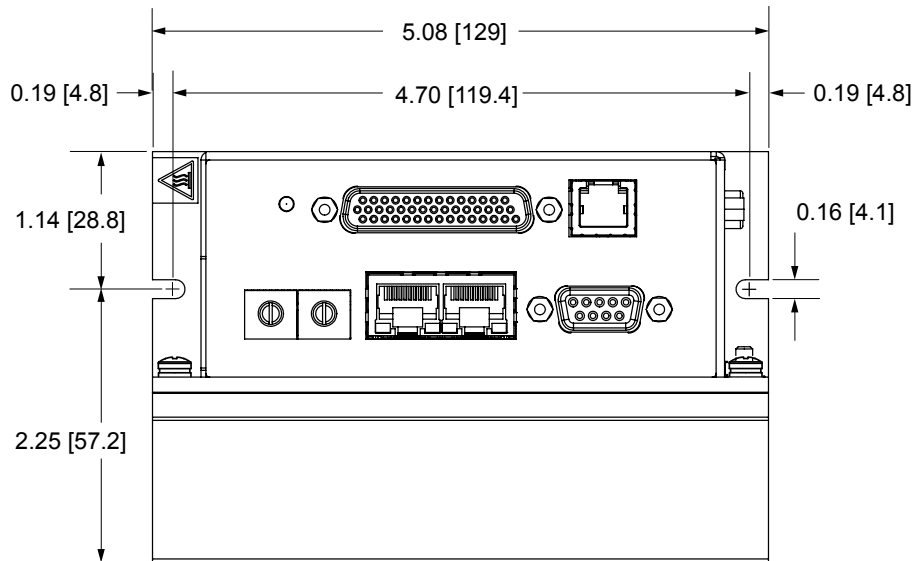
Mounting screws:  
#6-32, or 3.5 mm



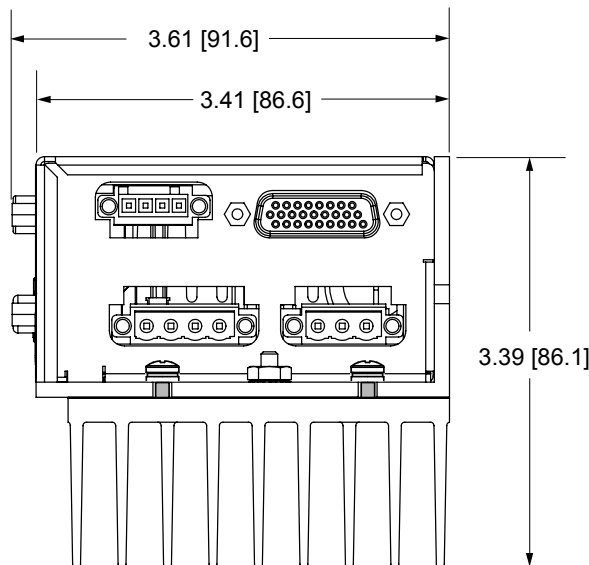


**DIMENSIONS: HEATSINK MOUNTED**

Units: IN[MM]



Mounting screws:  
#6-32, or 3.5 mm



**MASTER ORDERING GUIDE**

BEL-090-06	Accelnet Plus Panel EtherCAT servo drive, 3/6 A, 90 Vdc
BEL-090-14	Accelnet Plus Panel EtherCAT servo drive, 7/14 A, 90 Vdc
BEL-090-30	Accelnet Plus Panel EtherCAT servo drive, 15/30 A, 90 Vdc



Add -R to model number for resolver feedback option (Example: BEL-090-14-R)  
 Add -H to model number for heatsink installed at the factory (Example: BEL-090-06-H)

Example: Order one Accelnet Plus BEL drive, resolver version, 7/14 A, with connector Kit, serial cable kit and heatsink fitted at the factory:

Qty	Item	Remarks
1	BEL-090-14-R-H	Accelnet Plus BEL servo drive with resolver, and heatsink
1	BEL-CK	BEL Connector Kit
1	BEL-SK	Serial Cable Kit

**ACCESSORIES**

	Qty	Ref	Name	Description	Manufacturer P/N	
<b>BEL-CK</b> Connector Kit	1	J8	DC HV	Plug, 3 position, 5.08 mm, female	Wago: 231-303/107-000 (Note 1)	
	1			Strain relief, snap-on, 5.08 mm, 3 position, orange	Wago: 232-633	
	1	J7	Motor	Plug, 4 position, 5.08 mm, female	Wago: 231-304/107-000 (Note 1)	
	1			Strain relief, snap-on, 5.08 mm, 4 position, orange	Wago: 232-634	
	1	J7, J8	Tool	Tool, wire insertion & extraction, 231 series	Wago: 231-159	
	1	J5	Brake	Plug, 4 position, 3.5 mm, female	Wago: 734-104/107-000 (Note 1)	
	1			Strain relief, snap-on, 3.5 mm, 4 position, grey	Wago: 734-604	
	1			Tool, wire insertion & extraction, 734 series	Wago: 734-231	
	1	J4 Note 2	Safety	Connector, DB-9M, 9-position, standard, male	TE/AMP: 205204-4	
	9			AMPLIMITE HD-20 Crimp-Snap contacts, 24-20AWG, AU flash	TE/AMP: 66506-9	
	1			Metal Backshell, DB-9, RoHS	3M: 3357-9209	
	4			Jumper, with pins crimped on both ends	Copley: 10-75177-01	
	1	J1	Control	Connector, high-density DB-44M, 44 position, male, solder cup	Norcomp: 180-044-103L001	
	1			Metal Backshell, DB-25, RoHS	3M: 3357-9225	
	1	J6	Feed-back	Connector, high-density DB-26M, 26 position, male, solder cup	Norcomp: 180-026-103L001	
	1			Metal Backshell, DB-15, RoHS	3M: 3357-9215	
	SER-CK	1	J2	RS-232	Serial Cable Kit	
	BEL-NC-10	1	J3	Network	EtherCAT® network cable, 10 ft (3 m)	
BEL-NC-01	1	EtherCAT® network cable, 1 ft (0.3 m)				

Note 1: For RoHS compliance, append "/RN01-0000" to the Wago part numbers listed above

Note 2: Insertion/extraction tool for J4 contacts is AMP/Tyco 91067-2 (not included in BEL-CK)

16-01438 Document Revision History

Revision	Date	Remarks
A	October 21, 2015	Initial released version

EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

Note: Specifications subject to change without notice