

Control Modes

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

Command Interface

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

Communications

- EtherCAT
- RS-232

Feedback

- Digital quad A/B encoder
- Analog sin/cos incremental
- Panasonic Incremental A Format
- SSI, EnDat, Absolute A, Tamagawa & Panasonic Absolute A, Sanyo Denki Absolute A, BiSS, BiSS
- Aux. encoder
- Digital Halls

I/O

- Digital: 20 inputs, 7 outputs
- Analog: 2, 12-bit inputs

Dimensions: mm [in]

- 114 x 73 x 20.6 [4.5 x 2.9 x 0.8]

DESCRIPTION

Accelnet AE2 is a dual-axis, high-performance, DC powered servo drive for position, velocity, and torque control of brushless and brush motors via EtherCAT, an Ethernet-based fieldbus. Using advanced FPGA technology, the AE2 provides a significant reduction in the cost per axis in multi-axis EtherCAT systems.

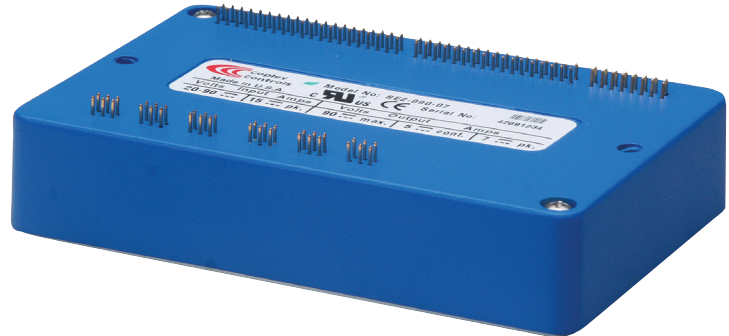
Each of the two axes in the AE2 operates as an EtherCAT slave using the CAN application layer over EtherCAT (CoE) protocol of DSP-402 for motion control devices. Supported modes include: Cyclic Synchronous Position-Velocity-Torque, Profile Position-Velocity-Torque, Interpolated Position Mode (PVT), and Homing.

Command sources also include ±10V analog torque/velocity/position, PWM velocity/torque, and stepper command pulses.

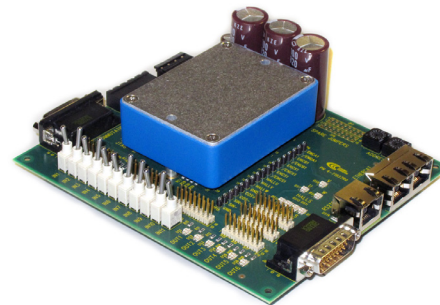
Feedback from a number of incremental and absolute encoders is supported.

2-AXIS DIGITAL SERVO DRIVE FOR BRUSHLESS/BRUSH MOTORS

EtherCAT[®] 
Conformance tested



Model	Ic	Ip	Vdc
AE2-090-06	3	6	14-90
AE2-090-14	7	14	14-90
AE2-090-30	15	30	14-90



DEVELOPMENT KIT

Seventeen high-speed digital inputs with programmable functions are provided, and two low-speed inputs for motor temperature switches.

An SLI (Switch & LED Interface) function is supported by combining a high-speed input with four high-speed digital outputs. If not used for SLI, the input and outputs are programmable for other functions. Three open-drain MOSFET outputs can drive loads powered up to 24 Vdc.

An RS-232 serial port provides a connection to Copley's CME2 software for commissioning, firmware upgrading, and saving configurations to flash memory.

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_{max}

MODEL	AE2-090-06	AE2-090-14	AE2-090-30	Units	
OUTPUT POWER (each axis)					
Peak Current	6	14	30	A	DC, sinusoidal
	4.2	10	21.2	A	RMS, sinusoidal
Peak time	1	1	1	s	Sec
Continuous current (Note 1)	3	7	15	A	DC, sinusoidal
	2.1	5	10.6	A	RMS, sinusoidal
Maximum Output Voltage	Vout = HV*0.97 - Rout*Iout				
INPUT POWER (module)					
HVmin~HVmax	+14 to +90	+14 to +90	+14 to +90	V	Transformer-isolated
Ipeak	12	28	30	A	For 1 sec
Icont	6	14	15	A	Continuous
Aux HV	+14 to +HV Vdc @ 500 mAdc maximum, 2.5 W				
PWM OUTPUTS					
Type	3-phase MOSFET inverter, 16 kHz center-weighted PWM, space-vector modulation				
PWM ripple frequency	32 kHz				
CONTROL MODES					
EtherCAT: CAN application layer over EtherCAT (CoE): Cyclic Synchronous Position/Velocity/Torque, Profile Position/Velocity/Torque, Interpolated Position (PVT), Homing					
Analog ±10 Vdc velocity/torque, 12-bit resolution					
Digital PWM velocity/torque and stepper position commands					
Discrete I/O: camming, internal indexer and function generator					
COMMAND INPUTS					
Type	EtherCAT, galvanically isolated from drive circuits				
Signals & format	TX+, TX-, RX+, RX-; 100BaseTX				
Data protocol	CAN application layer over EtherCAT (CoE)				
Device ID Selection	Programmable, or via digital inputs				
Analog	±10 Vdc, torque/velocity control				
Digital	High speed inputs for PWM velocity/torque and stepper/encoder position commands				
Camming	Quad A/B digital encoder				
DIGITAL CONTROL					
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)				
Commutation	Sinusoidal, field-oriented control for brushless motors				
Modulation	Center-weighted PWM with space-vector modulation				
Bandwidth	Current loop: 2.5 kHz typical, bandwidth will vary with tuning & load inductance				
HV Compensation	Changes in bus voltage do not affect bandwidth				
Minimum load inductance	200 μH line-line				
ANALOG INPUTS					
Number	2				
Type	±10 Vdc, 12-bit resolution, differential				
DIGITAL INPUTS					
Number, type	18, 74LVC14 Schmitt trigger, V _{T+} = 1.1~2 Vdc, V _{T-} = 0.8~1.5 Vdc, V _{H+} = 0.3~1.2 Vdc				
[IN1~17]	High-speed (HS) digital, 100 ns RC filter, 10 kΩ pull-up to +3.3 Vdc,				
[IN18]	SLI port MISO input, 47 ns RC filter, 10 kΩ pull-up to +3.3 Vdc				
[IN19~20]	2, 74LVC2G14, V _{T+} = 1.3~2.2 Vdc, V _{T-} = 0.6~1.5 Vdc, V _{H+} = 0.4~1.2 Vdc				
Functions	Motor temperature switch, 330 μs RC filter, 4.99 kΩ pull-up to +3.3 Vdc				
	Default functions are shown above, programmable to other functions				
DIGITAL OUTPUTS					
Number	7				
[OUT1~3]	Open-drain MOSFET with 1 kΩ pull-up with series diode to +5 Vdc				
	300 mAdc max, +30 Vdc max. Functions programmable				
[OUT4~7]	SLI port MOSI, SCLK, SS1, & SS2 signals, 74AHCT125 line drivers; +5 Vdc tolerant;				
	Output current: -8 mA source @ V _{OH} = 2.4V, 6 mA sink at V _{OL} = 0.5V				
Functions	Default functions are shown above, programmable to other functions				
DC POWER OUTPUTS					
Number	2				
Ratings	+5 Vdc, 400 mA max each output, thermal and short-circuit protected				
Connections	Axis A +5V Output: P3-17				
	Axis B +5V Output: P3-7				

NOTES:

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

FEEDBACK (each axis)

Incremental encoders:

Digital Incremental Encoder Quadrature signals, (A, /A, B, /B, X, /X), differential (X, /X Index signals not required)
 RS-422 differential line receivers, 5 MHz maximum line frequency (20 M counts/sec)
 Fault detection for open/shorted inputs, or low signal amplitude, external 121Ω terminators required
 Sin/Cos, differential, internal 121Ω terminators between ± inputs, 1.0 Vp-p typical, 1.45 Vp-p maximum,
 Common-mode voltage 0.25 to 3.75 Vdc, ±0.25 V, centered about 2.5 Vdc
 Signals: Sin(+), Sin(-), Cos(+), Cos(-),
 Frequency: 230 kHz maximum line (cycle) frequency, interpolation 12 bits/cycle (4096 counts/cycle)

Analog Incremental Encoder

Absolute encoders:

Heidenhain EnDat 2.2, SSI Serial Clock (X, /X), Data (S, /S) signals, differential 4-wire, external 121Ω terminator required for Data
 Heidenhain EnDat 2.2 Clock (X, /X), Data (S, /S), sin/cos (sin+, sin-, cos+, cos-) signals
 Internal 121Ω terminators between sin/cos inputs, external 121Ω terminator required for Data
 Absolute A, Tamagawa Absolute A, Panasonic Absolute A Format
 SD+, SD- (S, /S) signals, 2.5 or 4 MHz, 2-wire half-duplex, external 121Ω terminator required
 Position feedback: 13-bit resolution per rev, 16 bit revolution counter (29 bit absolute position data)
 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 drive, data returned from encoder
 External 121Ω terminator required for SL

Commutation:

Digital Hall signals, single-ended, 1.5 μs RC filter, 15 kΩ pull-up to +5 Vdc, 74LVC14 Schmitt trigger
 (See DC POWER OUTPUTS section)

Encoder power

RS-232 PORT

Signals RxD, TxD, Gnd for operation as a DTE device
 Mode Full-duplex, DTE serial port for drive setup and control, 9,600 to 115,200 Baud
 Baud rate defaults to 9,600 after power-on or reset. Programmable to 19,200, 57,600, 115,200
 Protocol ASCII or Binary format

MOTOR CONNECTIONS (each axis)

Phase U, V, W PWM outputs to 3-phase ungrounded Wye or delta connected brushless motors, or DC brush motors
 Encoders See FEEDBACK section above
 Hall & encoder power See DC POWER OUTPUTS section
 Motemp [IN19~20] Motor overtemperature switch input. Active level programmable, 4.99 kΩ pull-up to +3.3 Vdc
 Programmable to disable drive when motor over-temperature condition occurs

PROTECTIONS

HV Overvoltage +HV > HV_{max} Drive outputs turn off until +HV < HV_{max} (See Input Power for HV_{max})
 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
 I²T Current limiting Programmable: continuous current, peak current, peak time
 Motor over temperature Digital inputs programmable to detect motor temperature switch
 Feedback Loss Inadequate analog encoder amplitude or missing incremental encoder signals

MECHANICAL & ENVIRONMENTAL

Size mm [in] 114 x 73 x 20.6 [4.5 x 2.9 x 0.8]
 Weight 0.19 kg [0.42 lb] without heatsink, add 0.28 lb [.13 kg] for heatsink
 Ambient temperature 0 to +45°C operating, -40 to +85°C storage
 Humidity 0 to 95%, non-condensing
 Vibration 2 g peak, 10~500 Hz (sine), IEC60068-2-6
 Shock 10 g, 10 ms, half-sine pulse, IEC60068-2-27
 Contaminants Pollution degree 2
 Environment IEC68-2: 1990
 Cooling Heat sink and/or forced air cooling required for continuous power output

AGENCY STANDARDS CONFORMANCE

In accordance with EC Directive 2014/30/EU (EMC Directive)

EN 55011: 2009/A1:2010 CISPR 11:2009/A1:2010
 Industrial, Scientific, and Medical (ISM) Radio Frequency Equipment –
 Electromagnetic Disturbance Characteristics – Limits and Methods of Measurement
 Group 1, Class A
 EN 61000-6-1: 2007 Electromagnetic Compatibility (EMC) – Part 6-1: Generic Standards –
 Immunity for residential, Commercial and Light-industrial Environments

In accordance with EC Directive 2014/35/EU (Low Voltage Directive)

IEC 61010-1:2010 Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

Underwriters Laboratory Standards

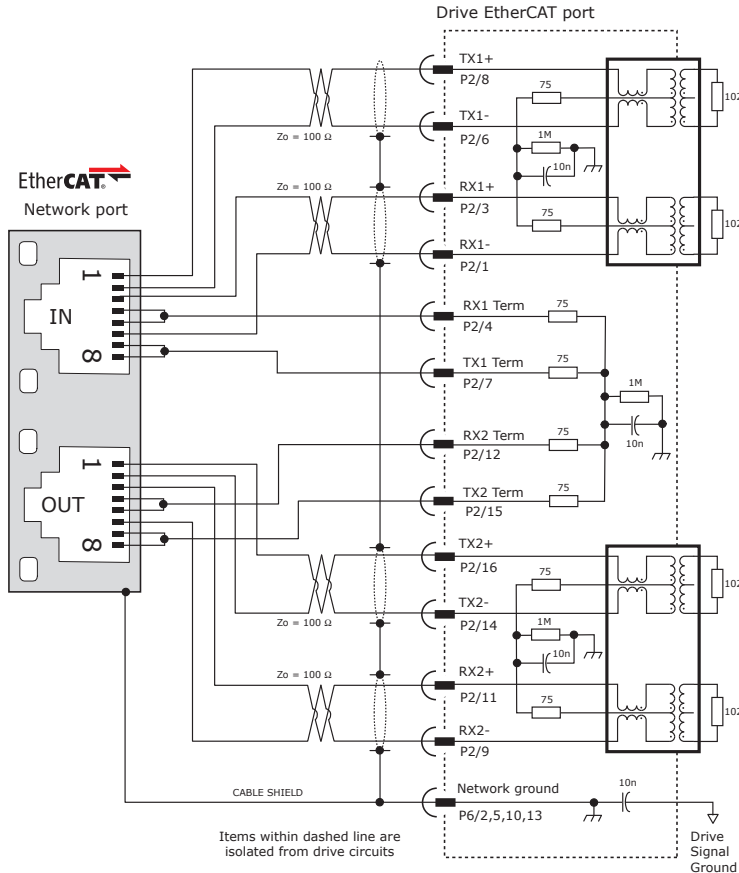
UL 61010-1, 3rd Ed.: 2012 Electrical Equipment for Measurement, Control and Laboratory Use;
 Part 1: General Requirements

UL File Number E249894

COMMAND INPUTS

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 CAN application layer 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>

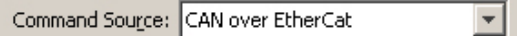


ETHERCAT CONNECTIONS

Page 11 shows guidelines for PC board layout and designing for EtherCAT signals.

Page 13 shows the dual EtherCAT cable connections on the Development Kit.

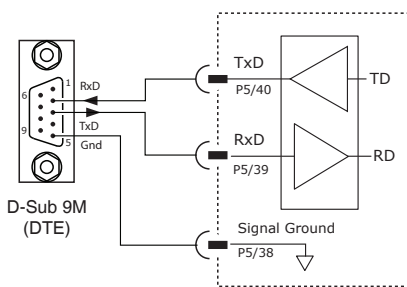
CME2 -> Basic Setup -> Operating Mode Options



RS-232 COMMUNICATIONS

AE2 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 AE2 RS-232 port are through P2. The graphic below shows the connections between an AE2 and a computer COM port which is a DTE device.

RS232 PORT



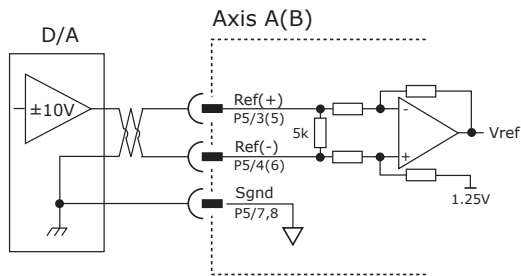
CME2 -> Tools -> Communications Wizard



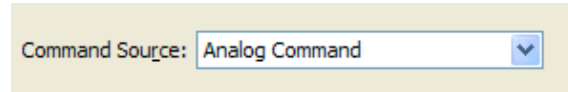
COMMAND INPUTS

ANALOG COMMAND INPUT

The analog inputs have a ±10 Vdc range. As a reference input it can take position/velocity/torque commands from a controller.



CME2 -> Basic Setup -> Operating Mode Options

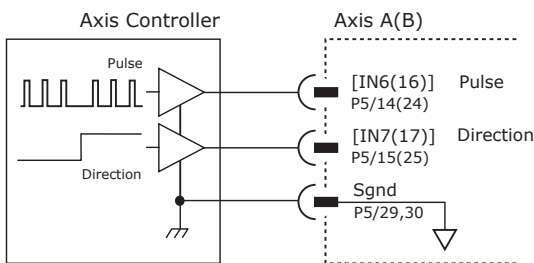


DIGITAL COMMAND INPUTS

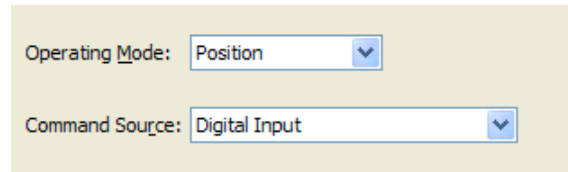
Digital commands are single-ended format and should be sourced from devices with active pull-up and pull-down to take advantage of the high-speed inputs. The active edge (rising or falling) is programmable for the Pulse/Dir and CU/CD formats.

DIGITAL POSITION

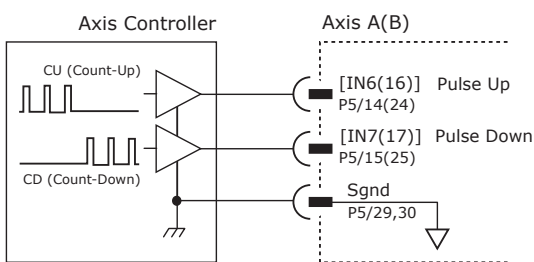
PULSE & DIRECTION



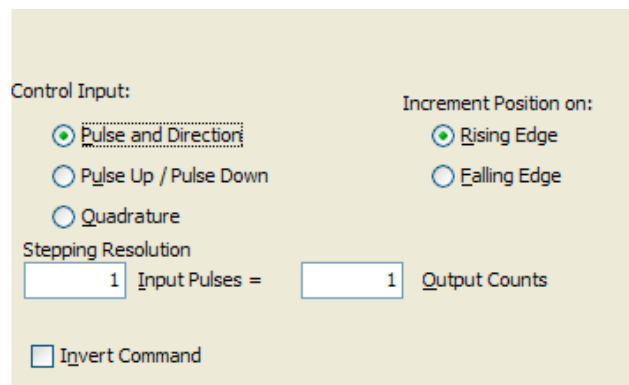
CME2 -> Basic Setup -> Operating Mode Options



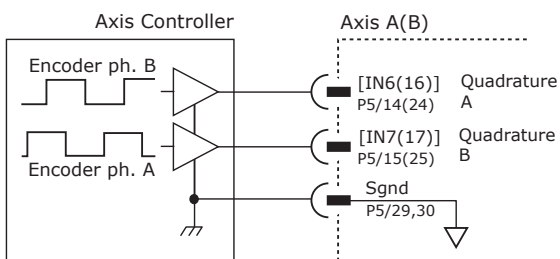
CU/CD



CME2 -> Main Page -> Digital Inputs -> Input Config



QUAD A/B ENCODER

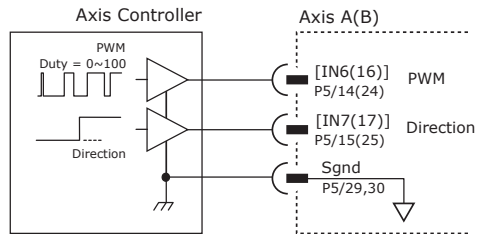


This screen shows the configuration screen for Pulse & Direction. CU/CD and Quad A/B encoder are selectable on this screen, too.

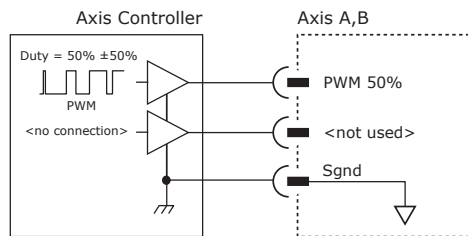
DIGITAL COMMAND INPUTS (CONT'D)

DIGITAL TORQUE, VELOCITY

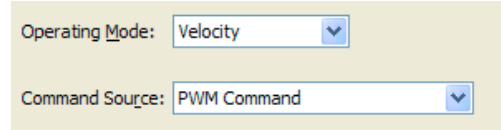
PWM COMMAND (100% DUTY CYCLE)



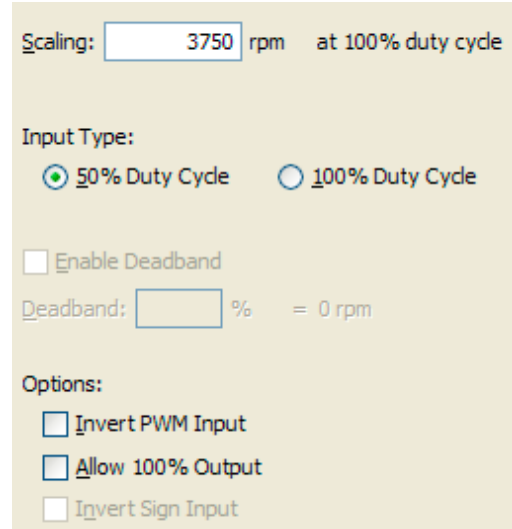
PWM COMMAND (50% DUTY CYCLE)



CME2 -> Basic Setup -> Operating Mode Options



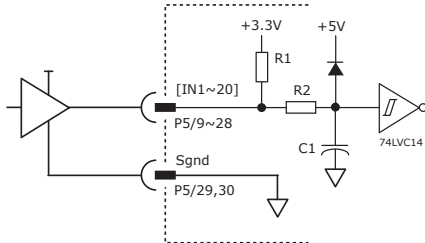
CME2 -> Main Page-> PWM Command



INPUT-OUTPUT

HIGH SPEED DIGITAL INPUTS

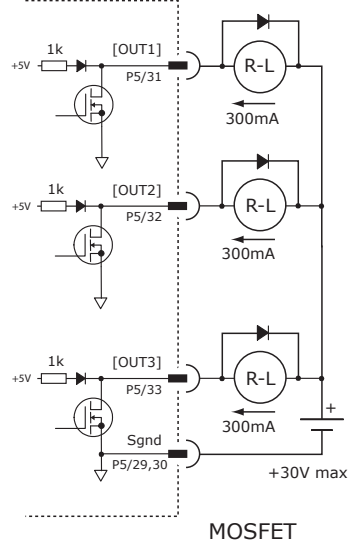
7V tolerant



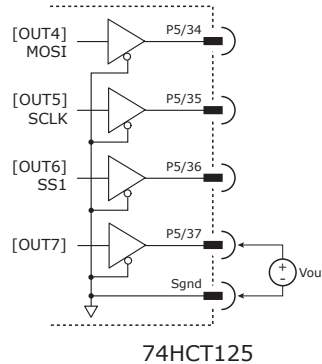
Input	P2 Pin	R1	R2	C1
IN1	9	10k	1k	100p
IN2	10			
IN3	11			
IN4	12			
IN5	13			
IN6	14			
IN7	15			
IN8	16			
IN9	17			
IN10	18			
IN11	19	10k	1k	100p
IN12	20			
IN13	21			
IN14	22			
IN15	23			
IN16	24			
IN17	25			
IN18	26			
IN19	27	4.99k	10k	33n
IN20	28			

DIGITAL OUTPUTS

30V max



5V max



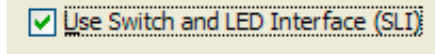
Output	P5 Pin
OUT1	31
OUT2	32
OUT3	33
OUT4	34
OUT5	35
OUT6	36
OUT7	37

Diodes shown on outputs must be supplied when driving inductive loads.

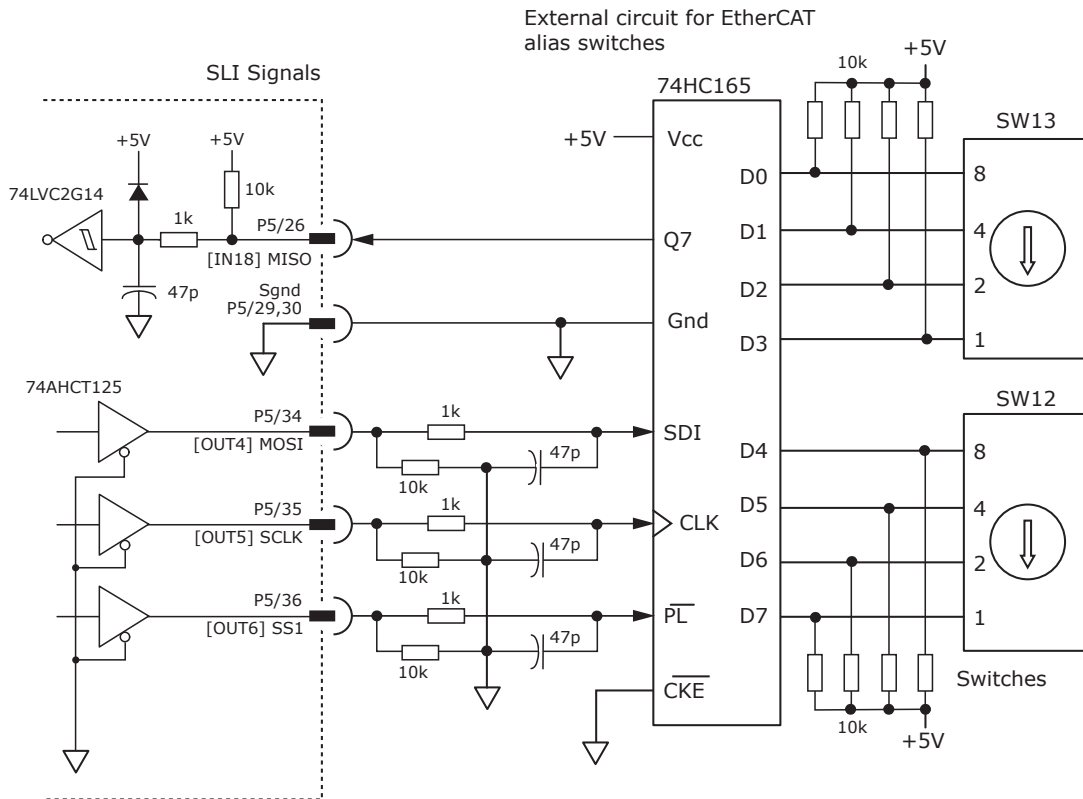
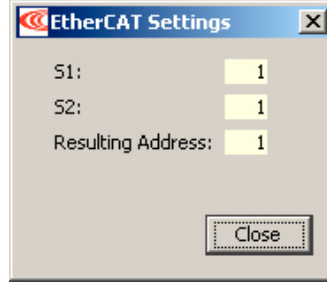
ETHERCAT DEVICE ID (STATION ALIAS) SWITCHES

The SLI (Switch & LED Interface) port takes in the 8 signals from the two BCD encoded switches that set the EtherCAT Device ID and controls the LEDs on the EtherCAT port connectors. The graphic below shows the circuit for reading the EtherCAT Device ID switches. The 74HC165 works as a parallel-in/serial-out device. The 10k pull-down resistors pull the shift register inputs to ground when the AE2 is initializing. In the graphics below, switch SW13 is "S2" and SW12 is "S1". The values of S1 are 16~255 and of S2 are 0~15. Together they provide Device ID range of 0~255.

CME2 -> Input/Output -> Digital Outputs



CME2 -> Amplifier -> Network Configuration



ETHERCAT 2-AXIS AND THE OBJECT DICTIONARY

Single-axis EtherCAT devices use objects in the range of 0x6000 to 0x67FF for standardized data that are read or written via the network as defined in CAN-CiA document CiA 301 *CANopen Application Layer and Communication Profile*. The AE2 appears as a single slave node on an EtherCAT network that contains two logical devices: Axis A, and Axis B. The standardized data objects for each is located in two sections of the object dictionary:
 Axis A = 0x6000 to 0x67FF (the same range as single-axis devices such as the AE2 and AEP models)
 Axis B = 0x6800 to 0x6FFF
 Axis B objects correspond exactly to the objects for Axis A and can be addressed easily by adding 0x800 to the address of an Axis A object. E.g. 0x6060 Mode of Operation for Axis A is 0x6860 for Axis B.

MOTOR CONNECTIONS

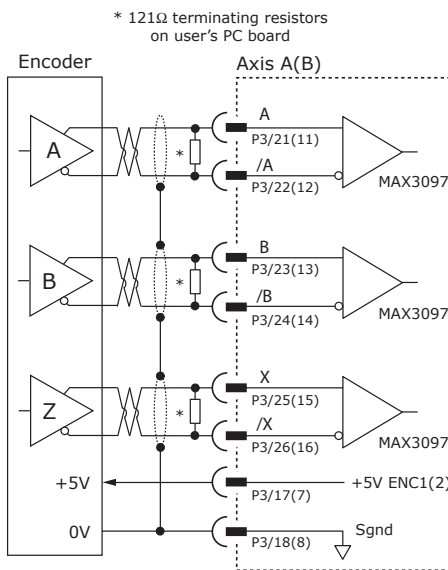
Motor connections consist of: phases, Halls, encoder, thermal sensor, and brake. The phase connections carry the drive output currents that drive the motor to produce motion. The Hall signals are three digital signals that give absolute position feedback within an electrical commutation cycle. The encoder signals give position feedback and are used for velocity and position modes, as well as sinusoidal commutation. A thermal sensor that indicates motor overtemperature is used to shut down the drive to protect the motor. A brake can provide a fail-safe way to prevent movement of the motor when the drive is shut-down or disabled.

QUAD A/B INCREMENTAL ENCODER WITH FAULT PROTECTION

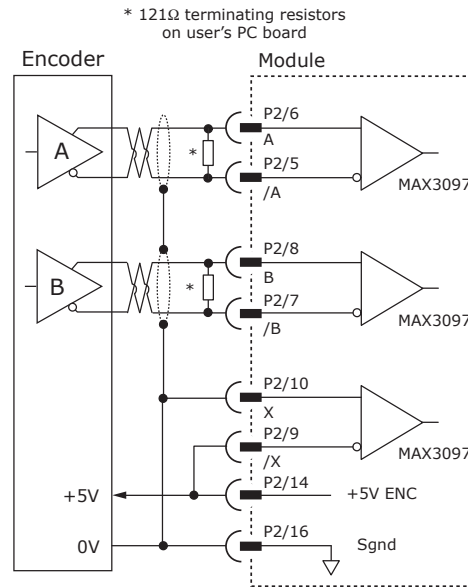
Encoders with differential line-driver outputs provide incremental position feedback via the A/B signals and the optional index signal (X) gives a once per revolution position mark. The MAX3097 receiver has differential inputs with fault protections for the following conditions:

- Short-circuits line-line:** This produces a near-zero voltage between A & /A which is below the differential fault threshold.
 - Open-circuit condition:** The 121Ω terminator resistor will pull the inputs together if either side (or both) is open. This will produce the same fault condition as a short-circuit across the inputs.
 - Low differential voltage detection:** This is possible with very long cable runs and a fault will occur if the differential input voltage is < 200mV.
 - ±15kV ESD protection:** The 3097E has protection against high-voltage discharges using the Human Body Model.
 - Extended common-mode range:** A fault occurs if the input common-mode voltage is outside of the range of -10V to +13.2V
- If encoder fault detection is selected (CME2 main page, Configure Faults block, Feedback Error) and an encoder with no index is used, then the X and /X inputs must be wired as shown below to prevent the unused index input from generating an error for low differential voltage detection.

DIGITAL QUADRATURE ENCODER INPUT
5V



A/B CONNECTIONS (NO INDEX)
5V



Encoder Signal	P3 Pins	
	Axis A	Axis B
A	21	11
/A	22	12
B	23	13
/B	24	14
X	25	15
/X	26	16
+5V ENC	17	7
Sgnd	18	8

CME2 -> Motor/Feedback -> Feedback

Motor Encoder:

MOTOR CONNECTIONS (CONT'D)

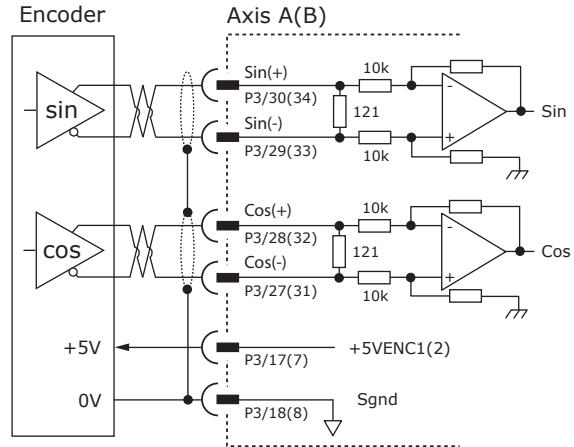
ANALOG SIN/COS INCREMENTAL ENCODER

The sin/cos inputs are differential with 121 Ω terminating resistors and accept 1 Vp-p signals in the format used by incremental encoders with analog outputs, or with ServoTube motors.

CME2 -> Motor/Feedback -> Feedback

Motor Encoder:

Encoder Signal	P3 Pins	
	Axis A	Axis B
Sin(+)	30	34
Sin(-)	29	33
Cos(+)	28	32
Cos(-)	27	31
+5V ENC	17	7
Sgnd	7	8



PANASONIC INCREMENTAL A ENCODER

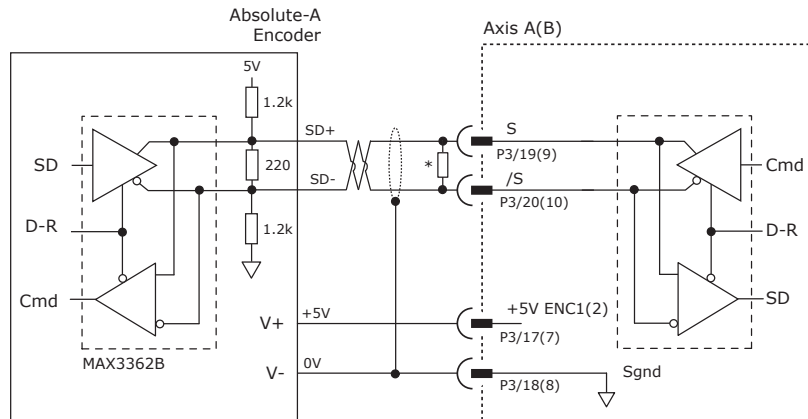
This is a "wire-saving" incremental encoder that sends serial data on a two-wire interface in the same fashion as an absolute encoder.

CME2 -> Basic setup -> Feedback

Bits:

Counts per rev:

Encoder Signal	P3 Pins	
	Axis A	Axis B
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8



* 121Ω terminating resistor on user's PC board

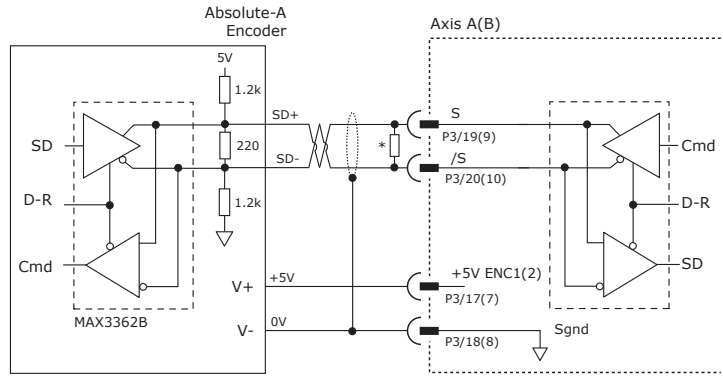
FEEDBACK CONNECTIONS

ABSOLUTE A ENCODER, TAMAGAWA, AND PANASONIC

CME2 -> Motor/Feedback -> Feedback

Bits: = counts per rev
 Number of Revolutions: turns
 Number of Counts Per Rev Bits to Ignore:
 Bit Rate:
 2.5 MB/s 4 MB/s

Encoder Signal	P3 Pins	
	Axis A	Axis B
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8



* 121Ω terminating resistor on user's PC board

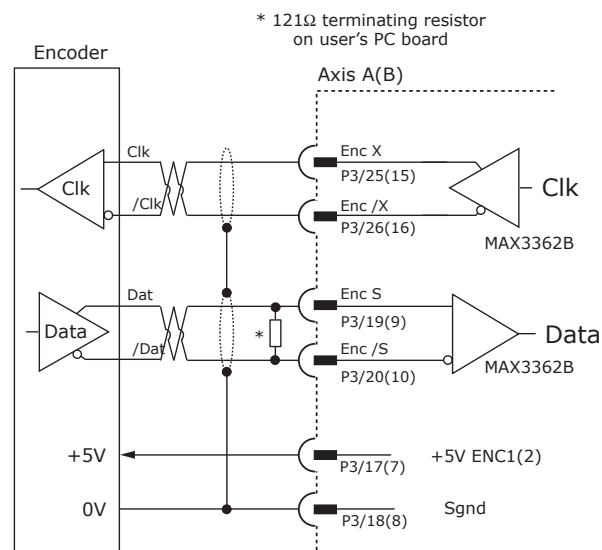
SSI ABSOLUTE ENCODER

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The Accelnet drive provides a train of clock signals in differential format (Clk, /Clk) 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. Data from the encoder in differential format (Dat, /Dat) MSB first. Binary or Gray encoding is selectable. When the LSB goes high and a dwell time has elapsed, data is ready to be read again.

CME2 -> Motor/Feedback -> Feedback

Motor Encoder
 counts per rev
 number of Encoder Bits
 Binary Gray

Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8



* 121Ω terminating resistor on user's PC board

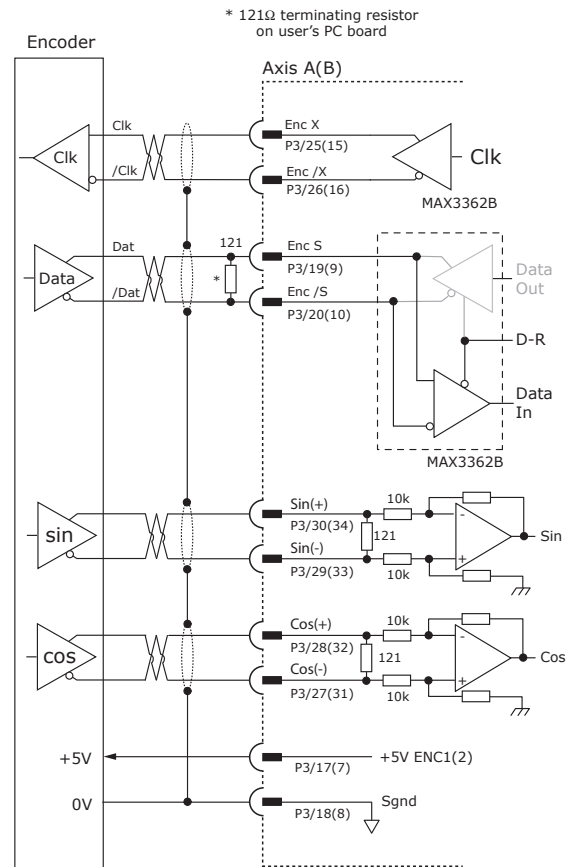
ENDAT ABSOLUTE ENCODER

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

CME2 -> Motor/Feedback -> Feedback

Bits: = counts per rev
 Number of Revolutions: turns
 Enable Incremental 1Vpp sin/cos

Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
Sin(+)	30	34
Sin(-)	29	33
Cos(+)	28	32
Cos(-)	27	31
+5V ENC	17	7
Sgnd	18	8

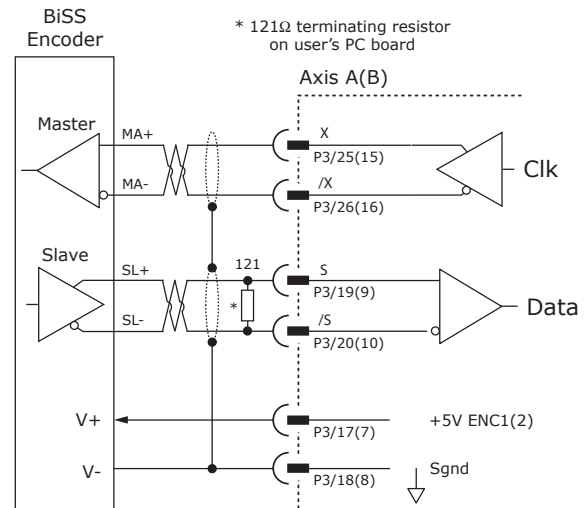


BISS (B & C) ABSOLUTE ENCODER

CME2 -> Motor/Feedback -> Feedback

Bits: = counts per rev
 Number of Revolutions: turns
 Number of Alignment Bits:
 BiSS B BiSS C

Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8



DIGITAL HALL SIGNALS

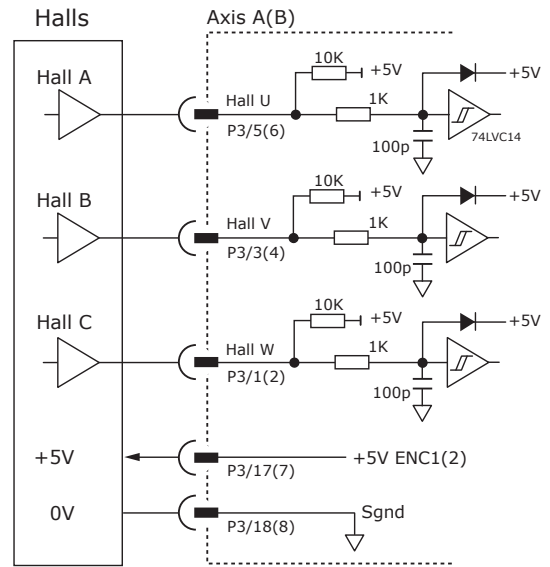
Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much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

CME2 -> Basic Setup -> Feedback Options

Hall Type:
 Hall Phase Correction

Encoder Signal	P3 Pins	
	Axis A	Axis B
Hall U	5	6
Hall V	3	4
Hall C	1	2
+5V ENC	17	7
Sgnd	18	8

HALL INPUTS 5V

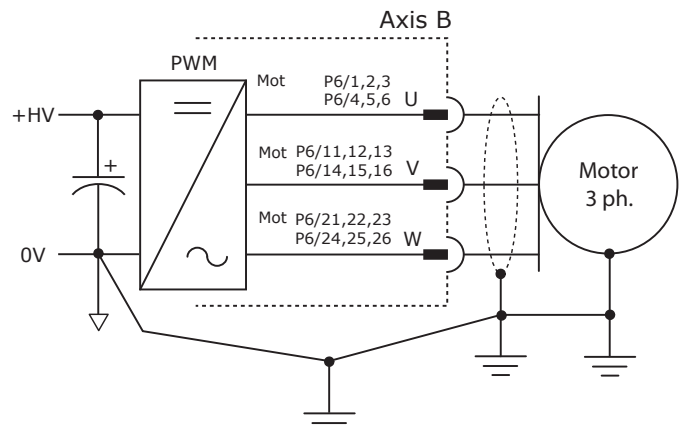
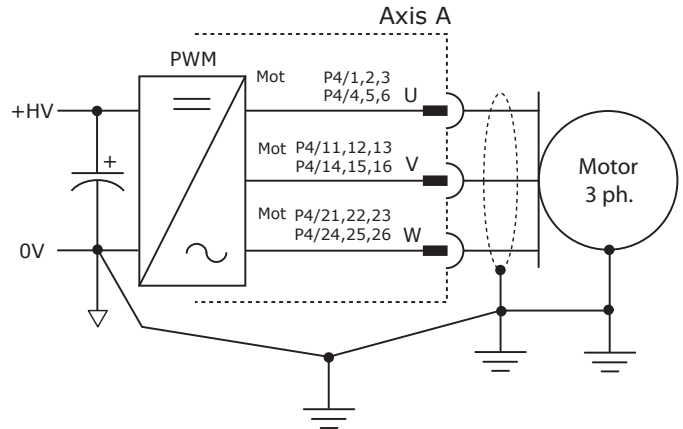


MOTOR PHASE CONNECTIONS

The drive output is a three-phase PWM inverter that converts the DC bus voltage (+HV) into three sinusoidal voltage waveforms that drive the motor phase-coils. Cable should be sized for the continuous current rating of the drive. 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 HV ground terminal (J2-1) for best results. When driving a DC motor, the W output is unused and the motor connects between the U & V outputs.

CME2 -> Basic Setup -> Motor Options

Motor Family:
 Brushless Brush



MOTOR OVER TEMP INPUT

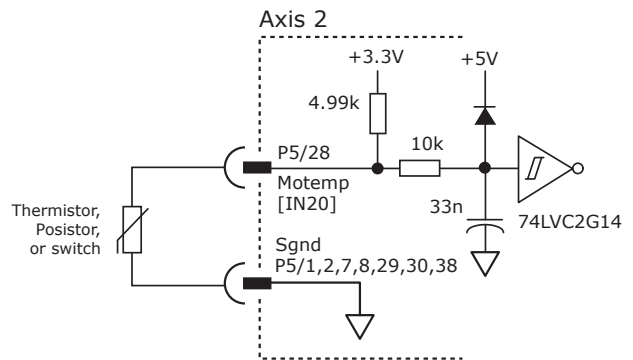
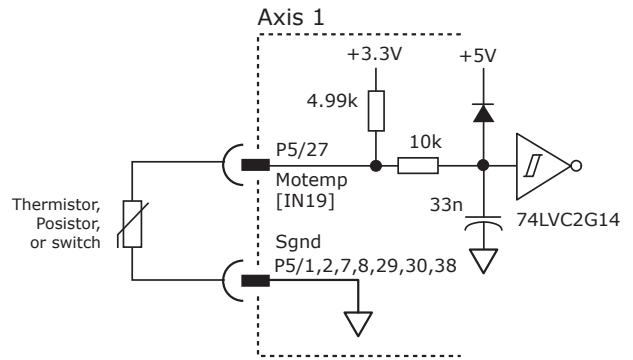
The 4.99k pull-up resistor works with PTC (positive temperature coefficient) thermistors that conform to BS 4999:Part 111:1987 (table below), or switches that open/close indicating a motor over-temperature condition. The active level is programmable.

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

CME2 -> Input / Output

[IN5] Motor Temp-HI Disables 0 ms

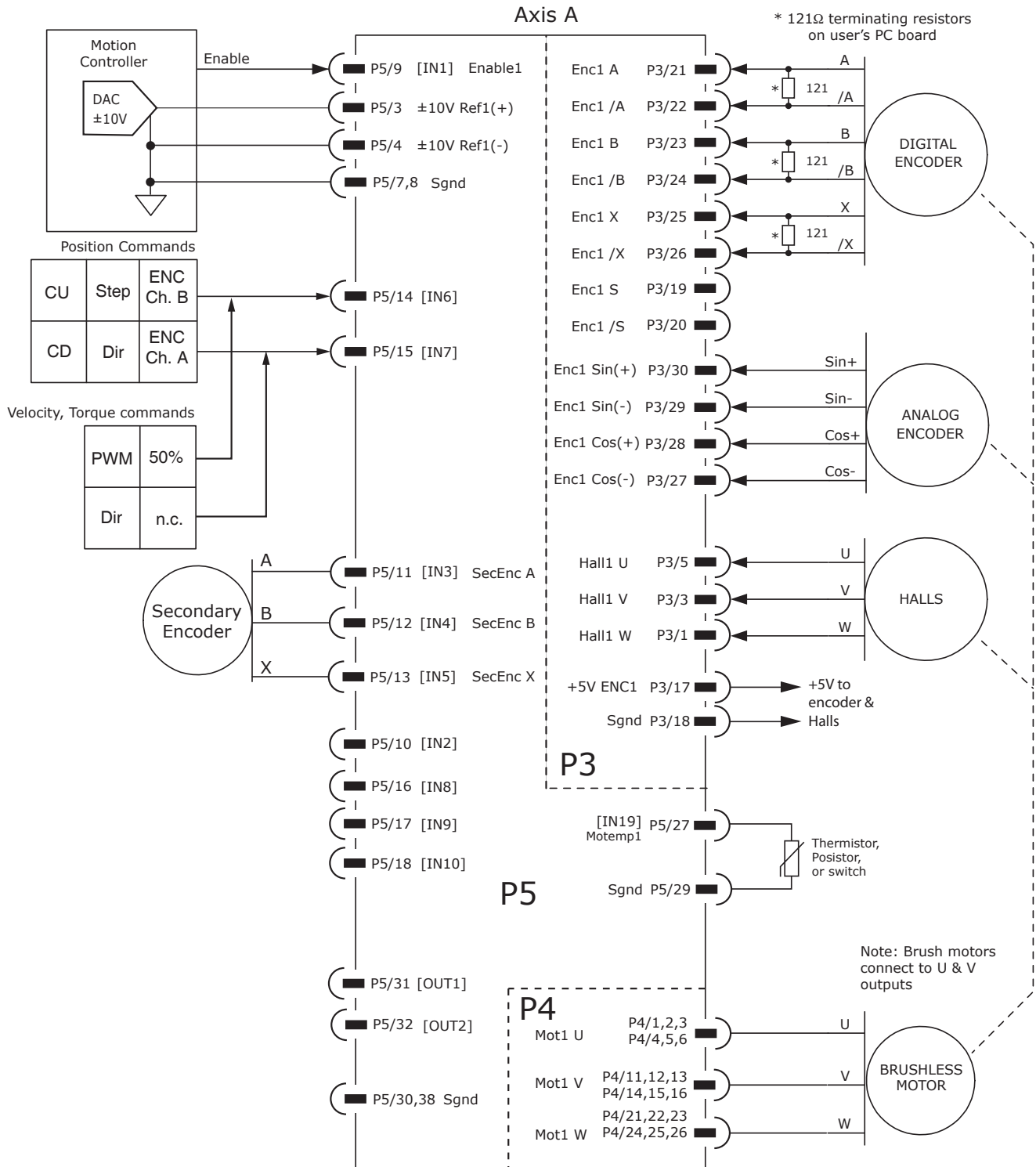
24V tolerant



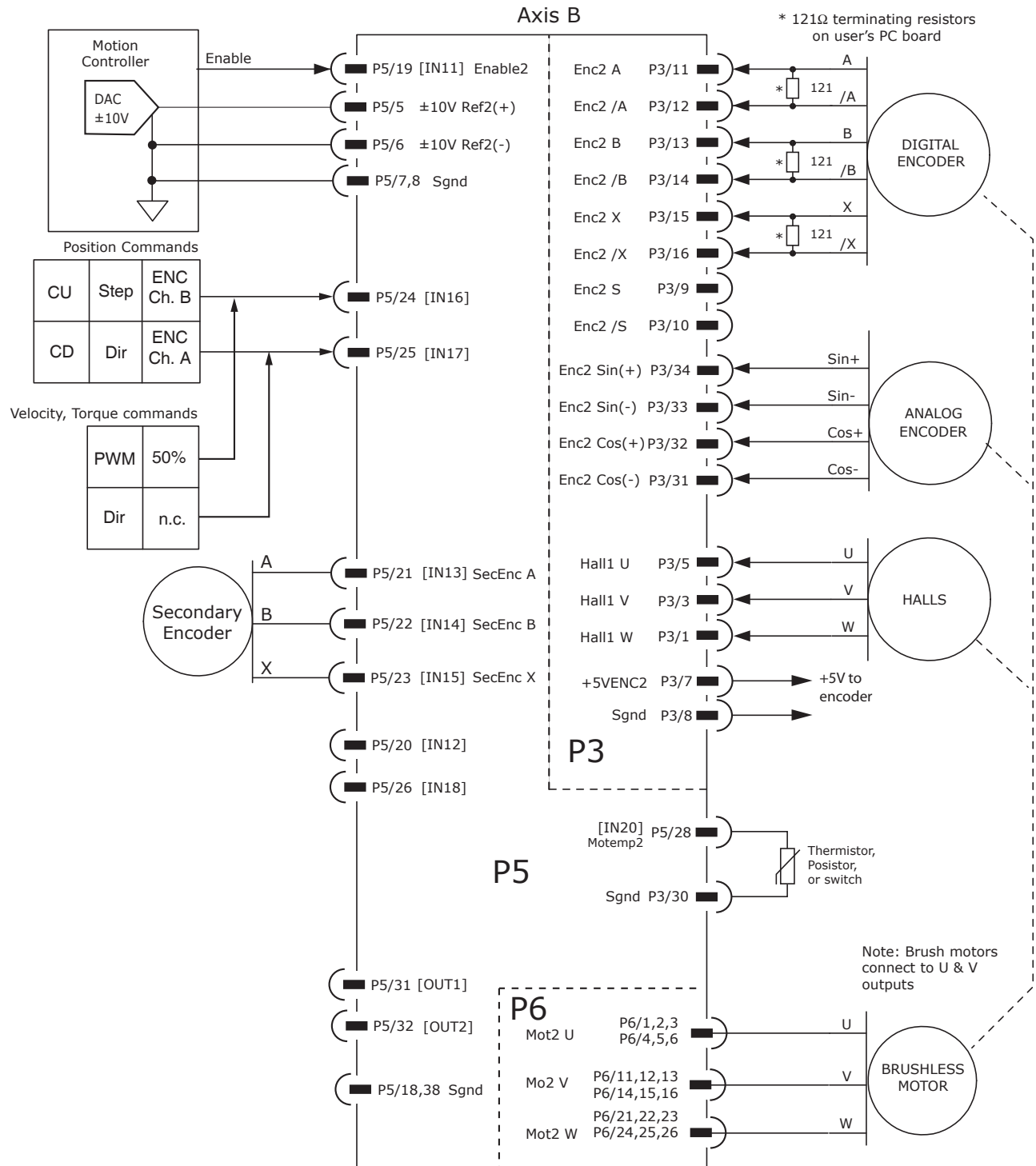
Notes:

1. P5 signals and pin assignments are defaults and may be programmed for different functions.

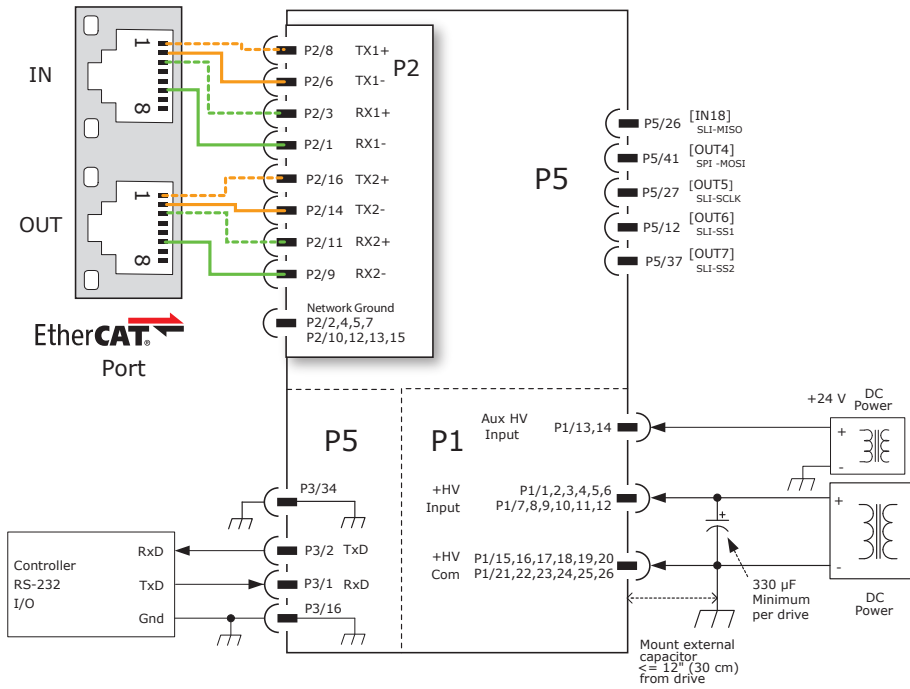
AXIS A CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



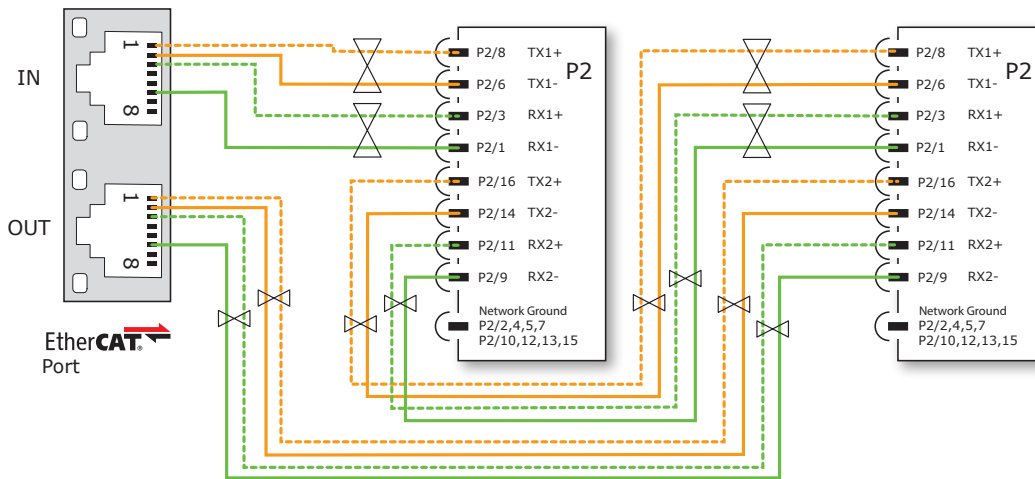
AXIS B CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



COMMON CONNECTIONS FOR AXES A,B



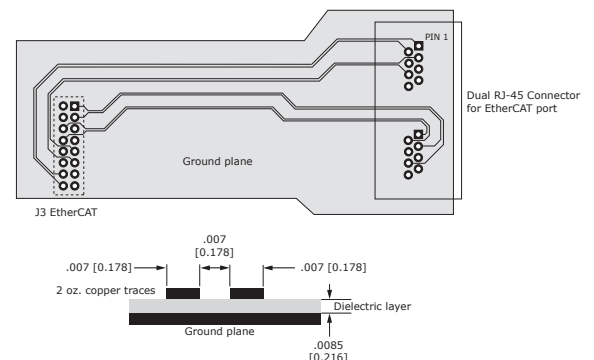
ETHERCAT CONNECTIONS FOR MULTIPLE MODULES



PRINTED CIRCUIT BOARD DESIGN FOR ETHERCAT SIGNALS

EtherCAT signal routing must produce a controlled impedance to maintain signal quality. This graphic shows some principles of PCB design that should be followed. Traces for differential signals must have controlled spacing trace-to-trace, trace thickness, and spacing above a ground plane. All these things and the properties of the dielectric between ground plane and signals affect the impedance of the traces. The dimensions shown here are typical.

The graphic on p. 4 detailing the EtherCAT connections shows resistors and a capacitor in the AE2 for terminating the unused conductors. As an alternative to adding traces back to the drive connector J3 for these signals, the same parts can be placed on the board at the RJ-45 connector, leaving only the differential EtherCAT signals to be routed with controlled impedance. When multiple modules are on a PCB these terminator signals are not daisy-chained and need only to connect to one set of R-C components at the RJ-45.



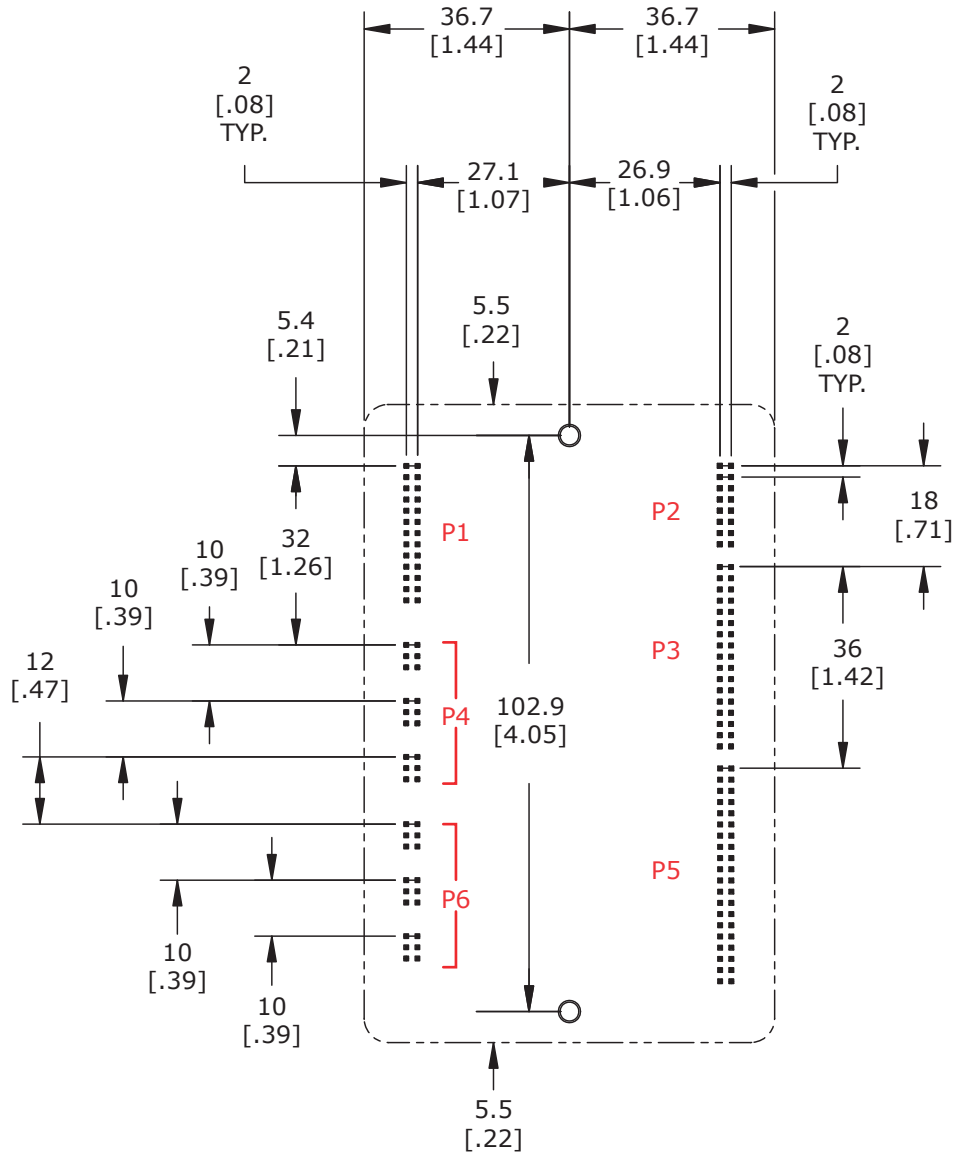
PRINTED CIRCUIT BOARD FOOTPRINT

Dimensions are mm [in]

TOP VIEW

Viewed from above looking down on the connectors or PC board footprint to which the module is mounted

Signal Grouping for current-sharing See Note 1



Mounting Hardware:

Qty	Description	Mfgr	Part Number	Remarks
3	Socket Strip	Samtec	SQW-113-01-L-D	P1, P4, P6 HV & Motors
1	Socket Strip	Samtec	SQW-120-01-L-D	P5 Control
1	Socket Strip	Samtec	SQW-117-01-L-D	P3 Feedback
1	Socket Strip	Samtec	SQW-108-01-L-D	P2 EtherCAT
2	Standoff 6-32 X 1/4"	PEM	KFE-632-8ET	

Notes

1. P1, P4, P6 signals of the same name must be connected for current-sharing (see graphic above).
2. To determine copper width and thickness for J3 signals refer to specification IPC-2221. (Association Connecting Electronic Industries, <http://www.ipc.org>)
3. Standoffs should be connected to etches on pc board that connect to frame ground for maximum noise suppression and immunity.

PC BOARD CONNECTORS & SIGNALS

**CONNECTOR NAMING (P1, P2, ETC)
APPLIES TO THE AE2 MODULE AND NOT
TO PC BOARD MOUNTED SOCKETS**

P4 AXIS A MOTOR

Mounting board connector:
Samtec SQW-113-01-F-D

Signal	Pin	Signal
MOT U	2	1
MOT U	4	3
MOT U	6	5
n.c.	8	7
n.c.	10	9
MOT V	12	11
MOT V	14	13
MOT V	16	15
n.c.	18	17
n.c.	20	19
MOT W	22	21
MOT W	24	23
MOT W	26	25

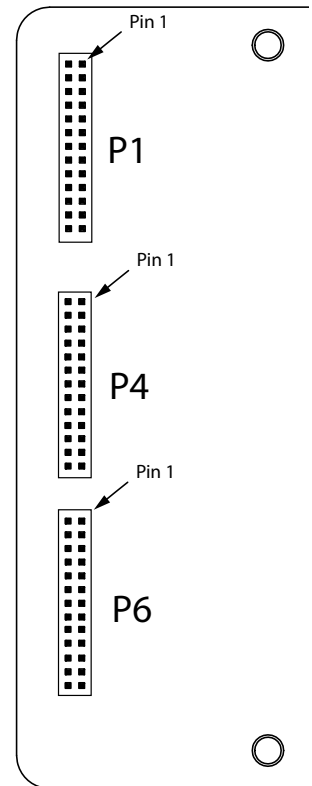
P1 POWER

Mounting board connector:
Samtec SQW-113-01-F-D

Signal	Pin	Signal
+HV	2	1
+HV	4	3
+HV	6	5
+HV	8	7
+HV	10	9
+HV	12	11
HVaux	14	13
HVGnd	16	15
HVGnd	18	17
HVGnd	20	19
HVGnd	22	21
HVGnd	24	23
HVGnd	26	25

TOP VIEW

Viewed from above looking down on the connectors or PC board footprint to which the module is mounted



P6 AXIS B MOTOR

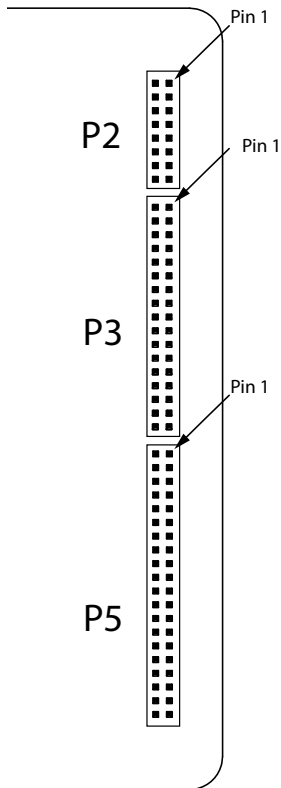
Mounting board connector:
Samtec SQW-113-01-F-D

Signal	Pin	Signal
MOT U	2	1
MOT U	4	3
MOT U	6	5
n.c.	8	7
n.c.	10	9
MOT V	12	11
MOT V	14	13
MOT V	16	15
n.c.	18	17
n.c.	20	19
MOT W	22	21
MOT W	24	23
MOT W	26	25

P2 ETHERCAT

Mounting board connector:
Samtec SQW-108-01-F-D

Signal	Pin	Signal
NetGnd	2	1 RX1-
RX1 Term	4	3 RX1+
TX1-	6	5 NetGnd
TX1+	8	7 TX1 Term
NetGnd	10	9 RX2-
RX2 Term	12	11 RX2+
TX 2-	14	13 NetGnd
TX2+	16	15 TX2 Term



P3 FEEDBACK

Mounting board connector:
Samtec SQW-117-01-F-D

Signal	Pin	Signal
Axis B Hall W	2	1 Axis A Hall W
Axis B Hall V	4	3 Axis A Hall V
Axis B Hall U	6	5 Axis A Hall U
Signal Gnd	8	7 Axis B +5VENC
Axis B Enc /S	10	9 Axis B Enc S
Axis B Enc /A	12	11 Axis B Enc A
Axis B Enc /B	14	13 Axis B Enc B
Axis B Enc /X	16	15 Axis B Enc X
Signal Gnd	18	17 Axis A +5VENC
Axis A Enc /S	20	19 Axis A Enc S
Axis A Enc /A	22	21 Axis A Enc A
Axis A Enc /B	24	23 Axis A Enc B
Axis A Enc /X	26	25 Axis A Enc X
Axis A Cos(+)	28	27 Axis A Cos(-)
Axis A Sin(+)	30	29 Axis A Sin(-)
Axis B Cos(+)	32	31 Axis B Cos(-)
Axis B Sin(+)	34	33 Axis B Sin(-)

P5 CONTROL

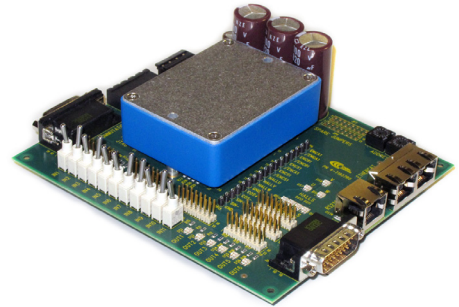
Mounting board connector:
Samtec SQW-120-01-F-D

Signal	Pin	Signal
Signal Gnd	2	1 Signal Gnd
Axis A Ref(-)	4	3 Axis A Ref(+)
Axis B Ref(-)	6	5 Axis B Ref(+)
Signal Gnd	8	7 Signal Gnd
HS [IN2]	10	9 [IN1] HS Axis A Enable
Axis A Sec Enc B HS [IN4]	12	11 [IN3] HS Axis A Sec Enc A
Axis A PLS HS [IN6]	14	13 [IN5] HS Axis A Sec Enc X
HS [IN8]	16	15 [IN7] HS Axis A DIR
HS [IN10]	18	17 [IN9] HS
HS [IN12]	20	19 [IN11] HS Axis B Enable
Axis B Sec Enc B HS [IN14]	22	21 [IN13] HS Axis B Sec Enc A
Axis B PLS HS [IN16]	24	23 [IN15] HS Axis B Sec Enc X
SLI-MISO [IN18]	26	25 [IN17] HS Axis B DIR
Axis B Motemp [IN20]	28	27 [IN19] Axis A Motemp
Signal Gnd	30	29 Signal Gnd
MOSFET [OUT2]	32	31 [OUT1] MOSFET
SLI-MOSI [OUT4]	34	33 [OUT3] MOSFET
SLI-SS1 [OUT6]	36	35 [OUT5] SLI-SCLK
Signal Gnd	38	37 [OUT7]
RS-232 TxD	40	39 RS-232 RxD

DESCRIPTION

The Development Kit provides mounting and connectivity for one AE2 drive. Solderless jumpers ease configuration of inputs and outputs to support their programmable functions. Switches can be jumpered to connect to digital inputs 1~20 so that these can be toggled to simulate equipment operation. LED's provide status indication for the digital outputs, encoder A/B/X/S signals, and Hall signals. Test points are provided for these signals, too, making it easy to monitor these with an oscilloscope.

Dual EtherCAT connectors make daisy-chain connections possible so that other EtherCAT devices such as Copley's Accelnet Plus or Xenus Plus Ethercat drives can easily be connected. Rotary switches are provided to set the EtherCAT slave "station alias" Device ID.

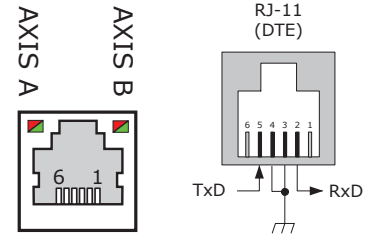


RS-232 CONNECTION

The RS-232 port is used to configure the drive for stand-alone applications, or for configuration before it is installed into an EtherCAT network. CME 2™ software communicates with the drive over this link and is then used for complete drive setup. The EtherCAT Device ID that is set by the rotary switch can be monitored, and a Device ID offset programmed as well

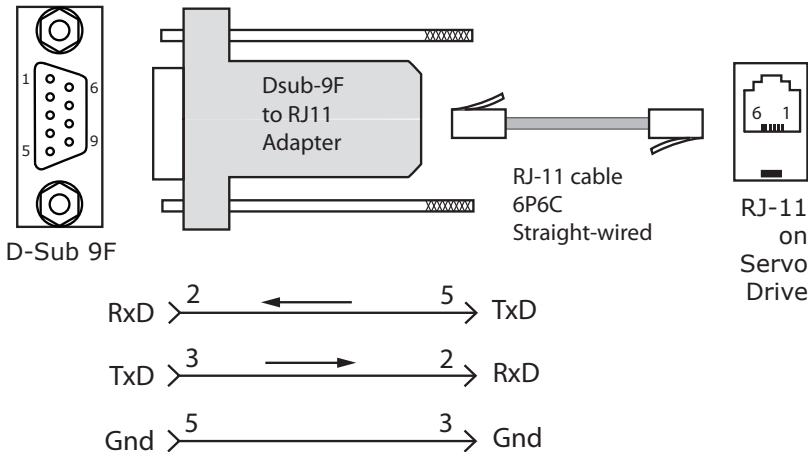
The RS-232 connector, J8, is a modular RJ-11 type that uses a 6-position plug, four wires of which are used for RS-232. A connector kit is available (SER-CK) that includes the modular cable, and an adaptor to interface this cable with a 9-pin RS-232 port on a computer.

J8: SERIAL PORT



SER-CK SERIAL CABLE KIT

The SER-CK provides connectivity between a D-Sub 9 male connector and the RJ-11 connector J8 on the Development Kit. It includes an adapter that plugs into the COM1 (or other) port of a PC and uses common modular cable to connect to the XEL. The connections are shown in the diagram below.



Don't forget to order a Serial Cable Kit SER-CK when placing your order for an AE2 Development Kit!

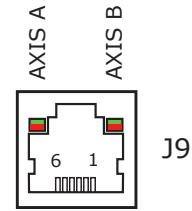
ETHERCAT CONNECTIONS

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

ETHERCAT STAT LED

The bi-color STAT LED combines the functions of the RUN and ERR LEDs. Green and red colors alternate, and each color has a separate meaning:

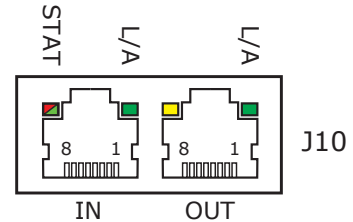
- | | |
|---|---|
| Green is the "RUN" or EtherCAT State Machine: | Red is the "ERR" indicator: |
| Off = INIT state | Blinking = Invalid configuration |
| Blinking = PRE-OPERATIONAL | Single Flash = Unsolicited state change |
| Single Flash = SAFE-OPERATIONAL | Double Flash = Application watchdog timeout |
| On = OPERATIONAL | |



L/A (LINK/ACT) LED

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



AXIS LEDS

Two bi-color LEDs give the state of the AE2 axes. 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 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/Slow-Blinking = Drive OK but NOT-enabled. Will run when enabled.
- 4) Green/Fast-Blinking = Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
- 5) 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"> • Short circuit (Internal or external) • Drive over-temperature • Motor over-temperature • Feedback Error • Following Error | <ul style="list-style-type: none"> • Over-voltage • Under-voltage • Motor Phasing Error • Command Input Fault |

EtherCAT DEVICE ID

In an EtherCAT network, slaves are automatically assigned fixed addresses based on their position on the bus. When a device must have a positive identification that is independent of cabling, a Device ID is needed. In the AE2 DevKit, this is provided by two 16-position rotary switches with hexadecimal encoding. These can set the Device ID of the drive from 0x01~0xFF (1~255 decimal). The chart shows the decimal values of the hex settings of each switch.

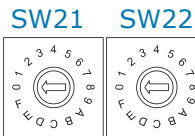
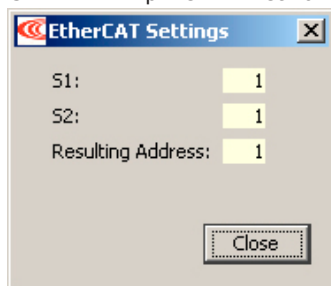
Example 1: Find the switch settings for decimal Device ID 107:

- 1) Find the highest number under SW21 that is less than 107 and set SW21 to the hex value in the same row: 96 < 107 and 112 > 107, so SW21 = 96 = Hex 6
- 2) Subtract 96 from the desired Device ID to get the decimal value of switch SW22 and set SW22 to the Hex value in the same row: SW22 = (107 - 96) = 11 = Hex B

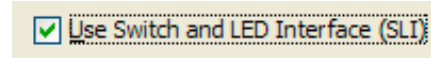
EtherCAT Device ID Switch Decimal values

	SW21	SW@2
HEX	DEC	
0	0	0
1	16	1
2	32	2
3	48	3
4	64	4
5	80	5
6	96	6
7	112	7
8	128	8
9	144	9
A	160	10
B	176	11
C	192	12
D	208	13
E	224	14
F	240	15

CME2 -> Amplifier -> Network Configuration



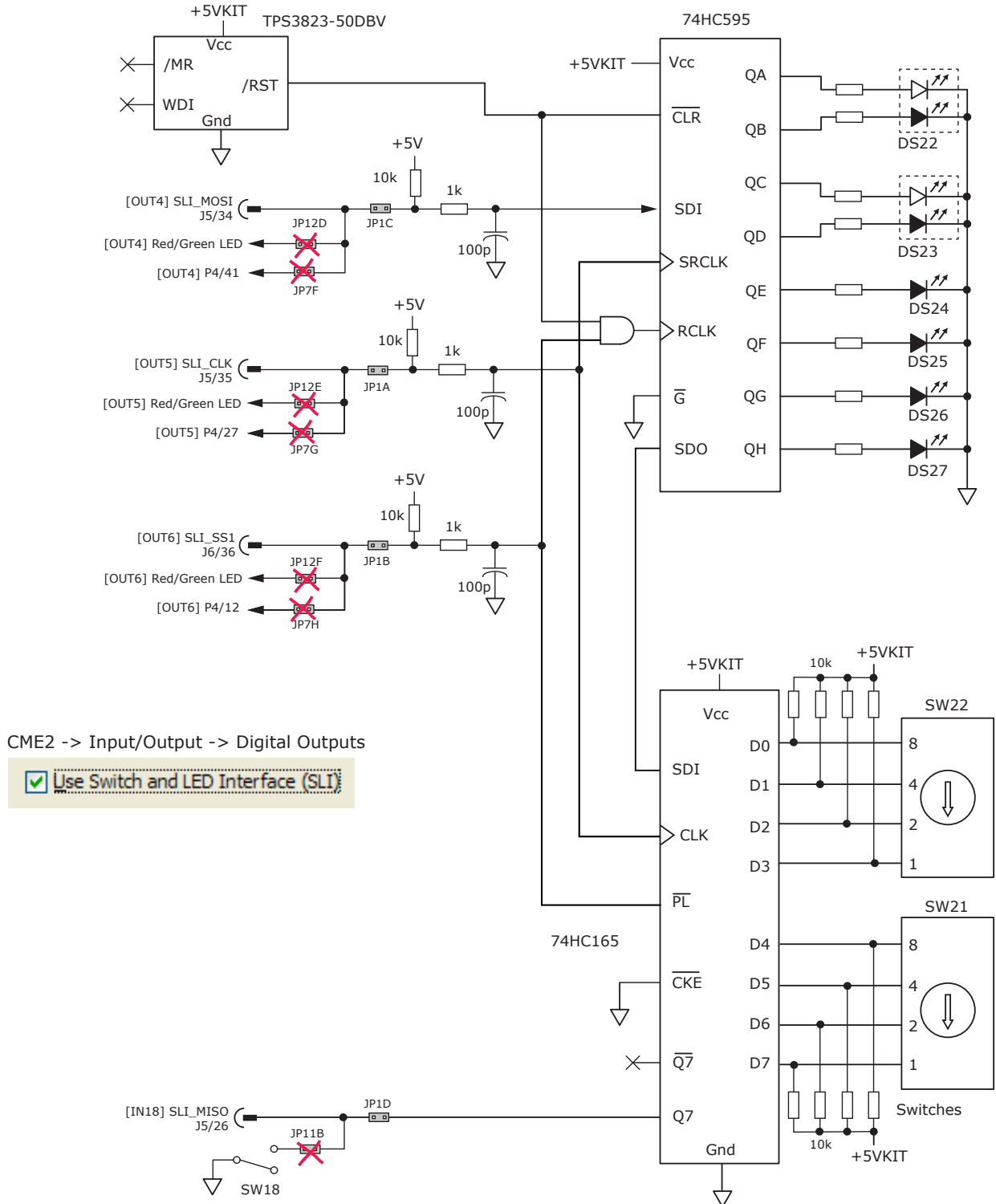
CME2 -> Input/Output -> Digital Outputs



EtherCAT DEVICE ID (STATION ALIAS) SWITCH CONNECTIONS

The graphic below shows the connections to the EtherCAT Device ID switches and to the status LEDs for the AE2 and EtherCAT. The switches are read once after the drive is reset, or powered-on. When changing the settings of the switches, be sure to either reset the drive, or to power it off-on. Outputs [OUT4,5,6] and input [IN18] operate as an SLI (Switch & LED Interface) port which reads the settings on the EtherCAT Device ID switches, and controls the LEDs on the serial and EtherCAT port connectors.

The jumpers marked with red "X" should be removed so that SW18, or external connections to the signals do not interfere with the operation of the SLI port.



5V POWER SOURCES

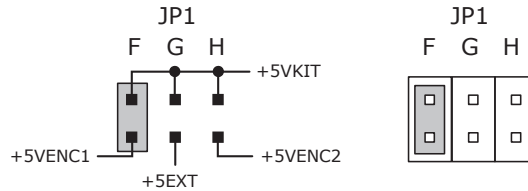
The feedback connectors J9 & J10 each have a connection to a +5V power supply in the AE2.

The signal name of Axis A power is +5VENC1, and for Axis B it is +5VENC2.

The components on the DevKit that drive the LEDs and read the Device ID switches are connected to the signal +5VKIT.

Jumpers on JP1 can connect these circuits to a choice of 5V power. These include either 5V supply in the AE2, or an external 5V power supply connected to J7.

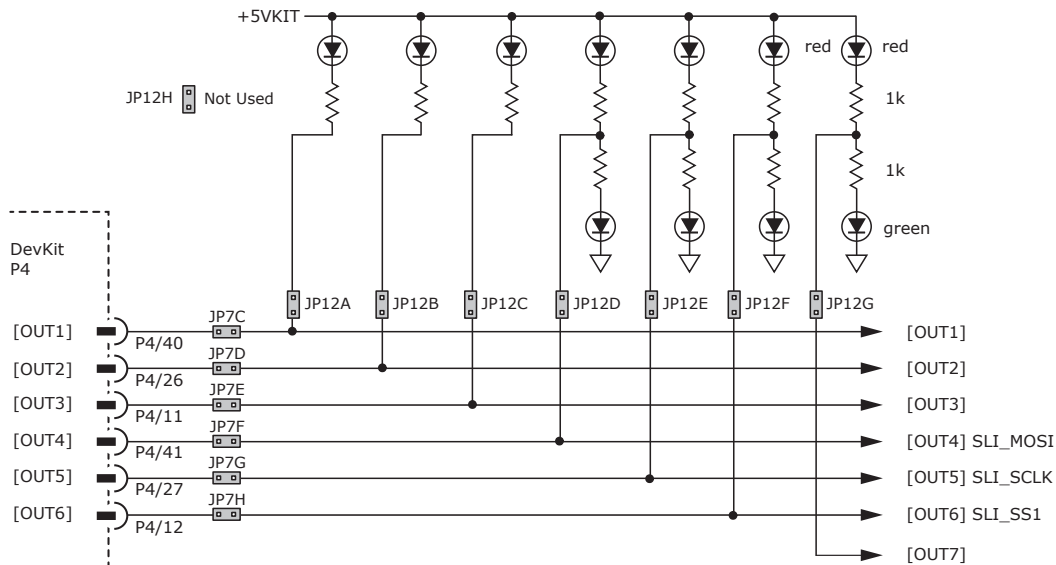
The graphic below shows the connections between +5VKIT and the other sources of 5V power.



**IMPORTANT: ONLY ONE SHORTING PLUG CAN BE USED ON JP1-F, G, OR H POSITIONS
USE OF MORE THAN ONE PLUG WILL DAMAGE 5V POWER SUPPLIES IN THE AE2**

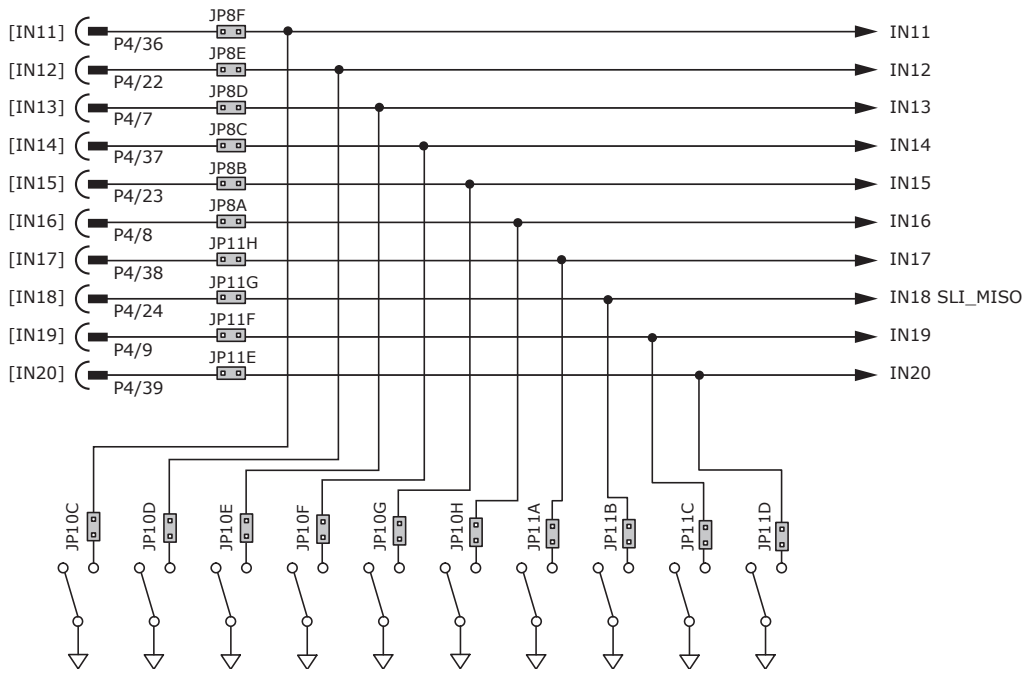
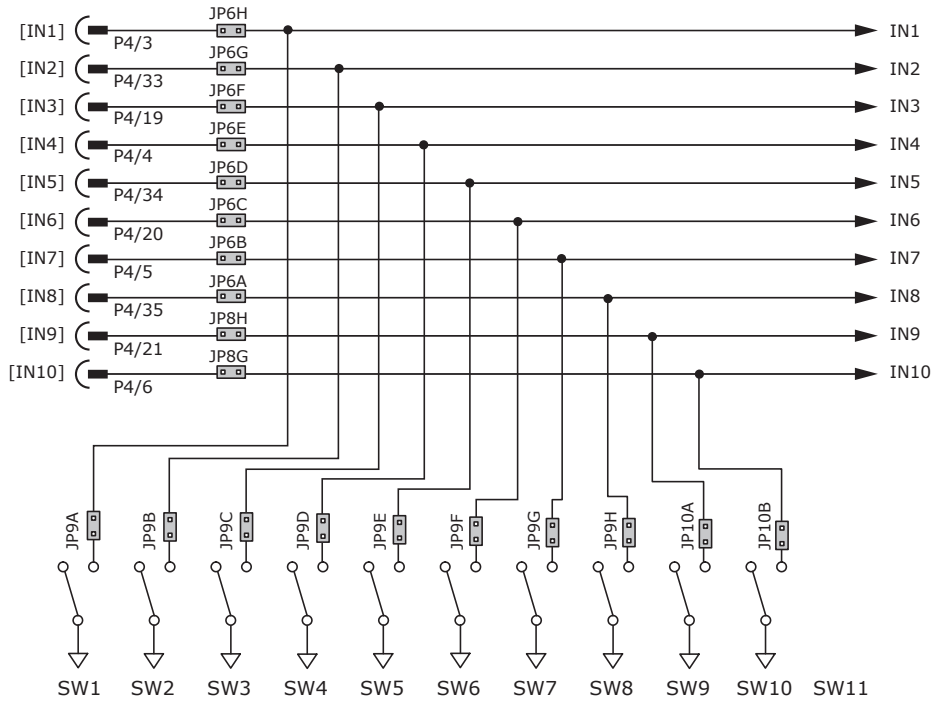
LOGIC OUTPUTS

There are seven logic outputs that can drive controller logic inputs or relays. If relays are driven, then flyback diodes must be connected across their terminals to clamp overvoltages that occur when the inductance of the relay coil is suddenly turned off. Outputs 4,5,6 & 7 are CMOS types that pull up to 5V or down to ground. When these outputs go high it turns on the green LED. When they are low, the red LED is turned on. Outputs 1,2, & 3 are MOSFET types that sink current when ON, and appear as open-circuit when OFF. When these outputs are ON a red LED is turned on. When the outputs are OFF, the red LED is off. The green LED is not used on these outputs.



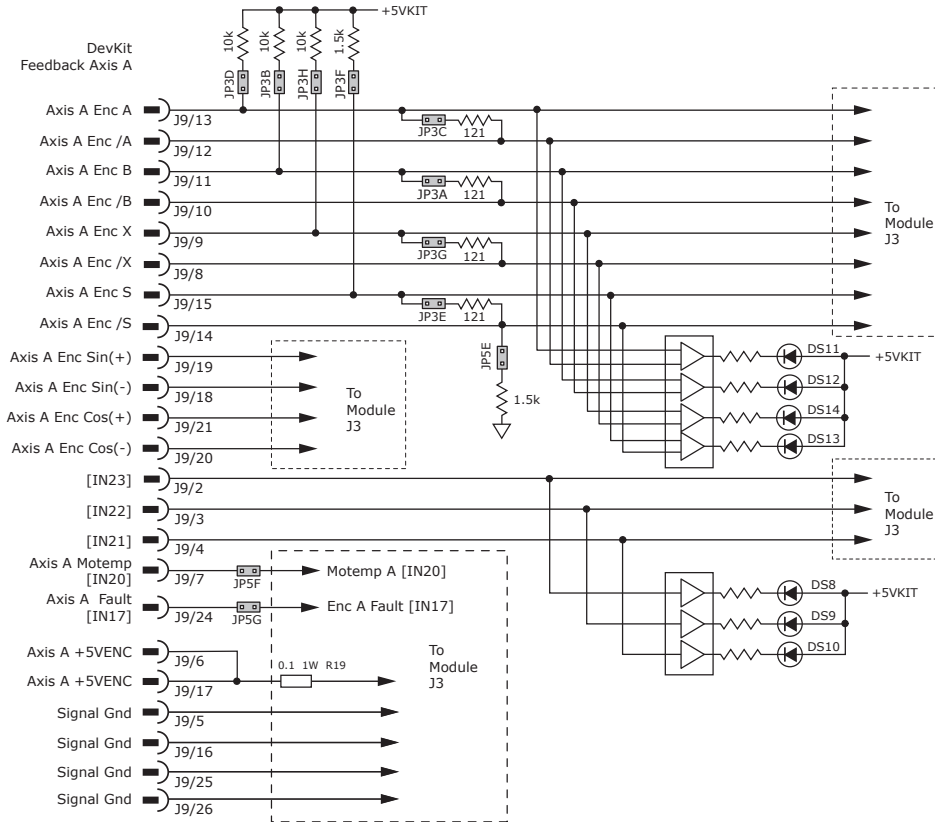
LOGIC INPUTS & SWITCHES

The Development Kit has jumpers that can connect the AE2 digital inputs to switches on the kit, or to the Signal connector J5. As delivered, all of these jumpers are installed as shown. If connecting to external devices that actively control the level of an input, it is desirable to disconnect the switch which could short the input to ground. For example, if [IN1] is connected to an external device for the Enable function, then jumper JP9A should be removed to take the switch SW1 out of the circuit. The figure below shows these connections.

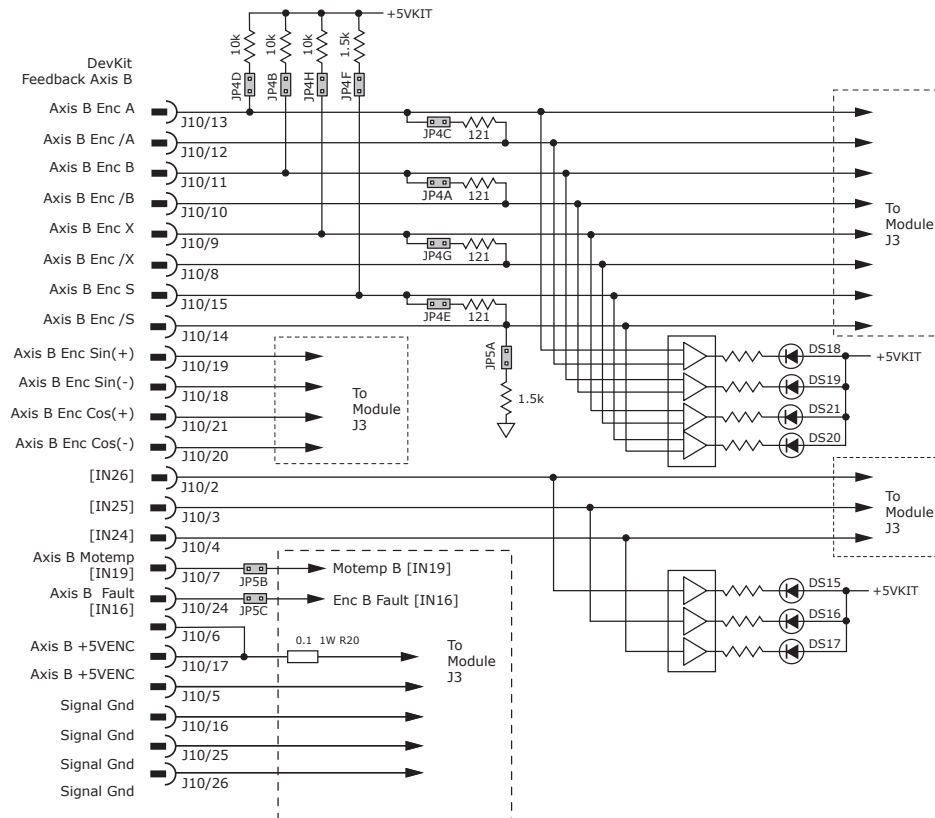


MOTOR FEEDBACK CONNECTORS J9 & J10

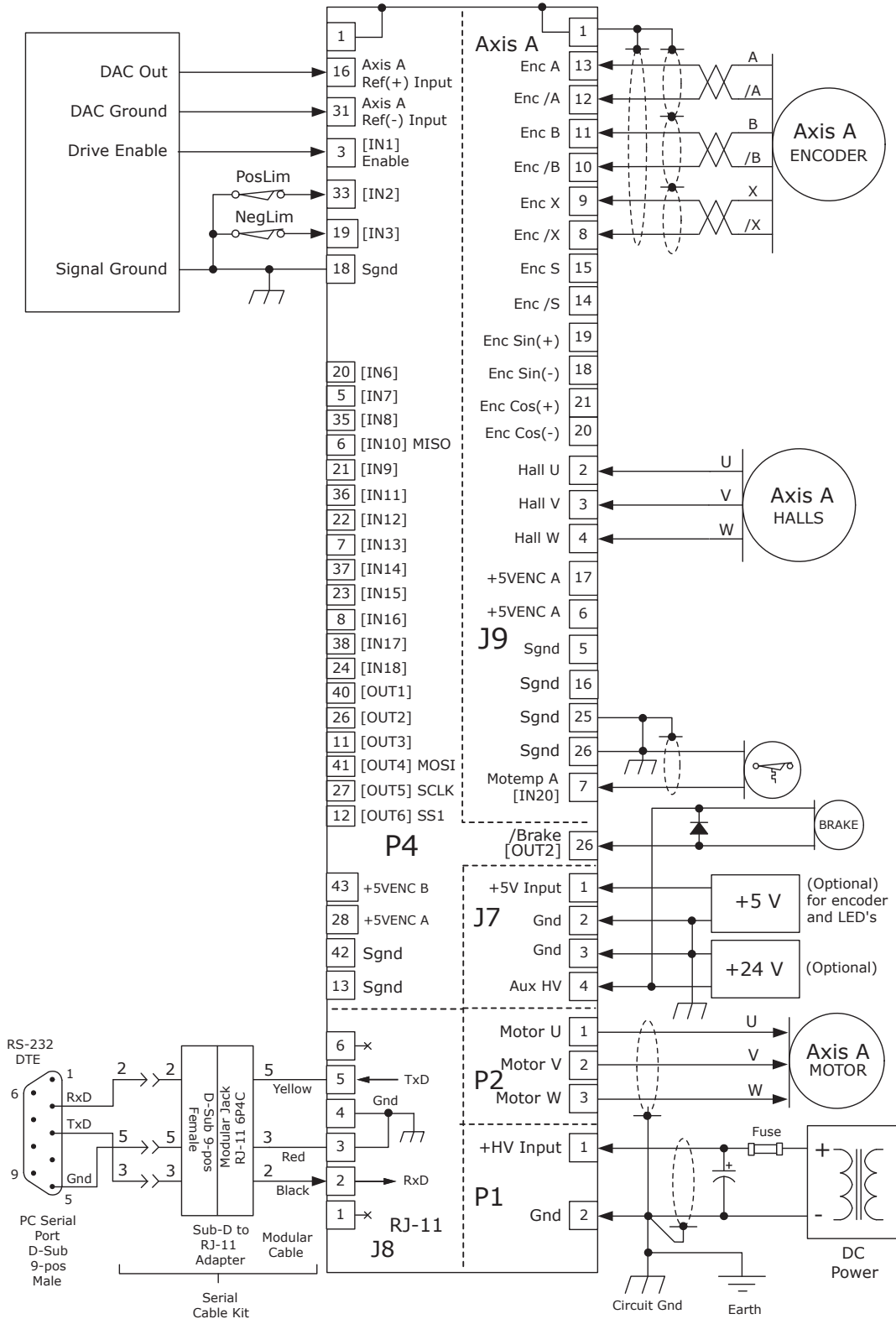
AXIS A



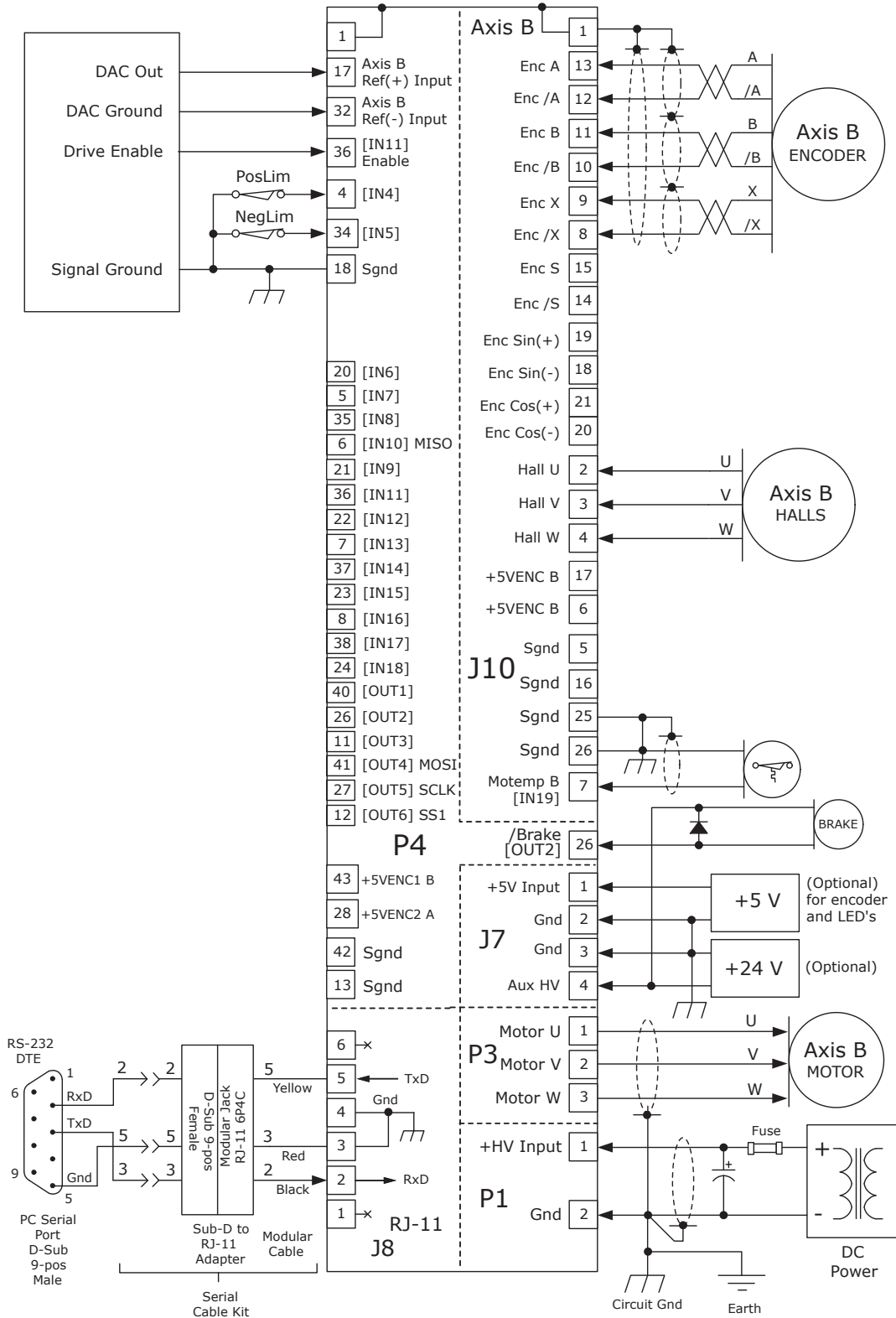
AXIS B



DEVELOPMENT KIT CONNECTIONS: AXIS A



DEVELOPMENT KIT CONNECTIONS: AXIS B



DEVELOPMENT KIT CONNECTORS

The Development Kit mounts a single AE2 module and enables the user to test and operate the AE2 before it is mounted onto a PCB in the target system.

P1 CABLE CONNECTOR:

2 position 5.08 mm Euro-Style plug
 Copley: 153-003265
 Amphenol PCD: ELFP02210
 Tyco Buchanan: 796635-2

P1: HV

Signal	Pin
+HV	1
HV Gnd	2

J7 CABLE CONNECTOR:

4 position 5.08 mm Euro-Style plug
 Copley: 153-003263
 Amphenol PCD: ELFP04210
 Tyco Buchanan: 796635-4

J7: AUX HV & 5V

Signal	Pin
5V Ext	1
Sgnd	2
HV Gnd	3
HV Aux	4

J9, J10 CABLE CONNECTORS:

26 pos. High-density D-Sub, male plug
 Copley: 153-003258
 Norcomp: 180-026-103L001
 Backshell
 Copley: 153-003257
 Norcomp: 979-015-020R121

P2: AXIS A MOTOR

Signal	Pin
Motor U	1
Motor V	2
Motor W	3

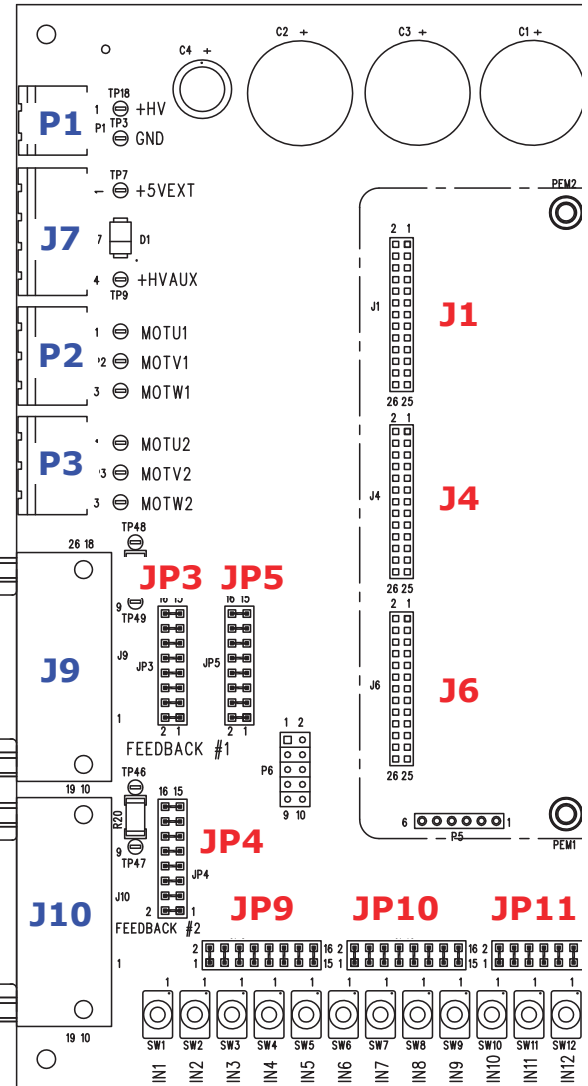
P3: AXIS B MOTOR

Signal	Pin
Motor U	1
Motor V	2
Motor W	3

J9: AXIS A FEEDBACK

J10: AXIS B FEEDBACK

J9, J10: FEEDBACK A,B



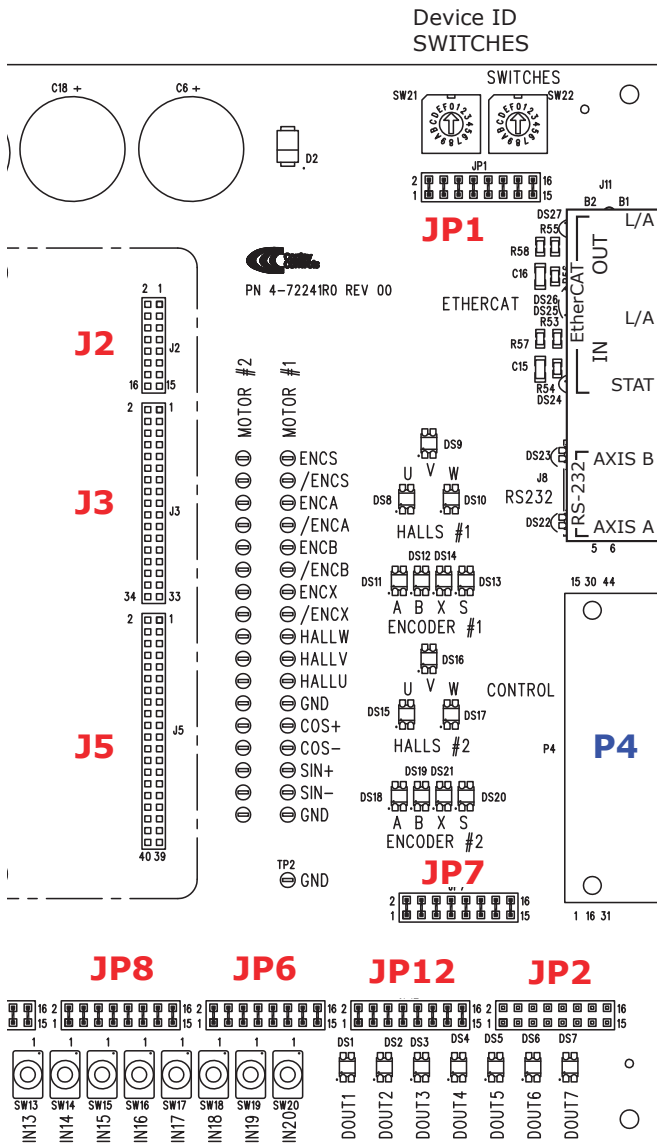
PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
26	Signal Gnd	18	Sin(-)	9	Enc X
25	Signal Gnd	17	+5VENC*	8	Enc /X
24	Enc Fault	16	Signal Gnd	7	Motemp**
23	Index(+)	15	Enc S	6	+5VENC*
22	Index(-)	14	Enc /S	5	Signal Gnd
21	Cos(+)	13	Enc A	4	Hall W
20	Cos(-)	12	Enc /A	3	Hall V
19	Sin(+)	11	Enc B	2	Hall U
		10	Enc /B	1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

* The AE2 has two independent 5V encoder power supplies, and each is rated for 400 mA.

Axis	Supply	Connections
A	Axis A+5VENC	J9-6, J9-17, P4-28
B	Axis B +5VENC	J10-6, J10-17, P4-43

** Each axis has a motor overtemp input as shown in the chart below.

Axis	Name	Input	Connections
A	Axis A Motemp	[IN19]	J9-7, P4-9
B	Axis B Motemp	[IN20]	J10-7, P4-39



J11: ETHERCAT

Pin	Signal
1	TX+
2	TX-
3	RX+
6	RX-

J8: RS-232

Pin	Signal
1	n.c.
2	RxD
3	Sgnd
4	Sgnd
5	TxD
6	n.c.

P4: CONTROL AXES A,B

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
15	n.c.	30	n.c.	44	n.c.
14	n.c.	29	Sgnd	43	Ax A +5VENC
13	Sgnd	28	Ax B +5VENC	42	Sgnd
12	[OUT6] SLI-SS1	27	[OUT5] SLI-SCLK	41	[OUT4] SLI-MOSI
11	[OUT3]	26	[OUT2]	40	[OUT1]
10	Sgnd	25	Sgnd	39	[IN20] Axis B Motemp
9	[IN19] Axis A Motemp	24	[IN18] SLI-MISO	38	[IN17] HS
8	[IN16] HS	23	[IN15] HS	37	[IN14] HS
7	[IN13] HS	22	[IN12] HS	36	[IN11] HS
6	[IN10] HS	21	[IN9] HS	35	[IN8] HS
5	[IN7] HS	20	[IN6] HS	34	[IN5] HS
4	[IN4] HS	19	[IN3] HS	33	[IN2] HS
3	[IN1] HS	18	Sgnd	32	[REF-] Ax B
2	Sgnd	17	[REF+] Ax B	31	[REF-] Ax A
1	Frame Gnd	16	[REF+] Ax A		

P4 CABLE CONNECTOR:

44 pos. High-density D-Sub, female plug
 Copley: 153-003264
 Norcomp: 180-044-203L001
 Backshell
 Copley: 153-003261
 Norcomp: 979-025-020R121

THERMAL MANAGEMENT

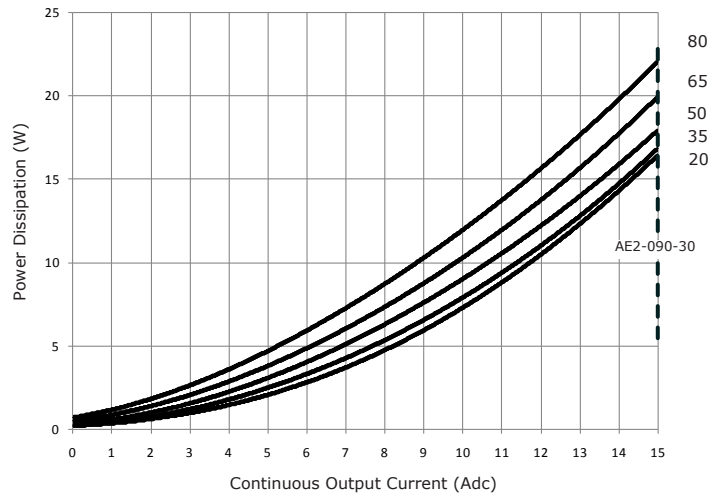
The charts on this page show the internal power dissipation for different models under differing power supply and output current conditions. The values on the chart represent the continuous current that one of the two axes would provide during operation. The +HV values are for the average DC voltage of the drive power supply.

When the total power dissipation is known the maximum ambient operating temperature can be found using different mounting and cooling means from the chart in Step 2.

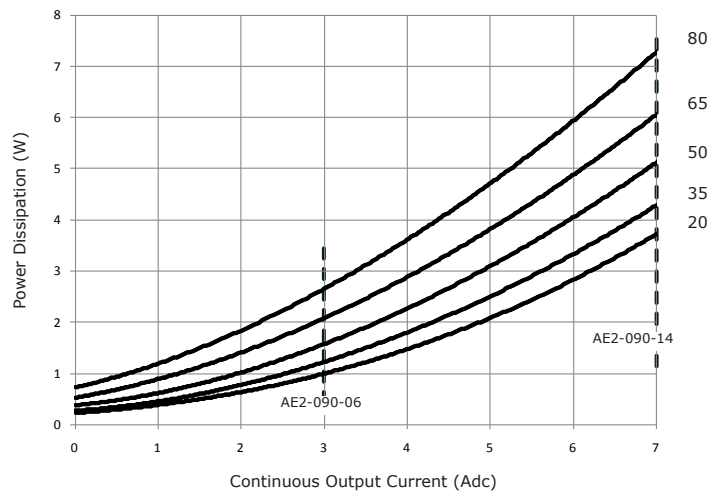
STEP 1: FIND THE POWER DISSIPATION FOR EACH AXIS

Using the output current for an axis, find the power dissipation based on the HV power supply voltage. Add these to find the total power dissipation for Step 2.

AE2-090-30

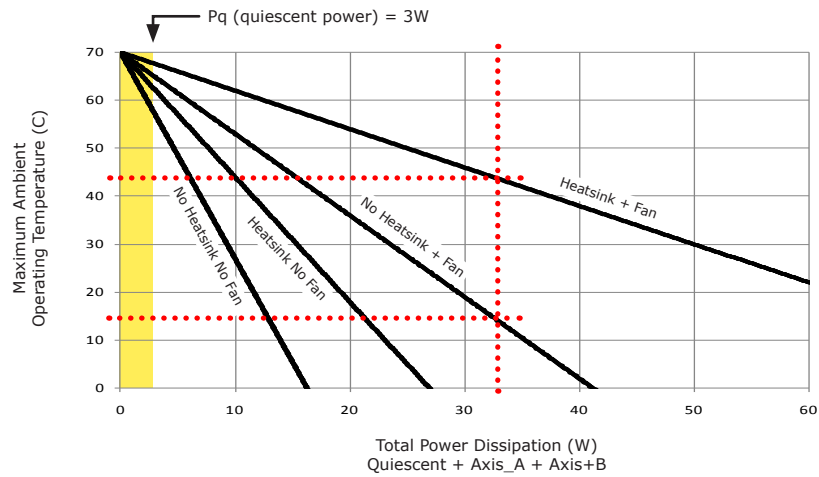


AE2-090-06, AE2-090-14



STEP 2: FIND MOUNTING AND COOLING MEANS REQUIRED FOR DIFFERENT AMBIENT TEMPERATURES

Find the total power dissipation for the AE2 using the charts on the opposite page. Add the power for Axis A and Axis B, then add the quiescent power. Find a point on the X-axis of this chart for that power and draw a vertical line from it. Draw a horizontal line from the point where the vertical line crosses the cooling condition lines. Read the maximum ambient operating temperature where the horizontal line meets the Y-axis.



HEATSINK OPTIONS

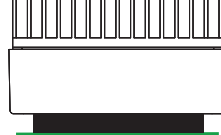
Rth expresses the rise in temperature of the drive per Watt of internal power loss. The units of Rth are °C/W, where the °C represent the rise above ambient in degrees Celsius. The data below show thermal resistances under convection, or fan-cooled conditions for the no-heatsink, and AE2-HS heatsink.

NO HEATSINK



AIR FLOW	C/W
CONVECTION	4.3
FORCED AIR (300 LFM)	1.7

HEATSINK (AE2-HK)



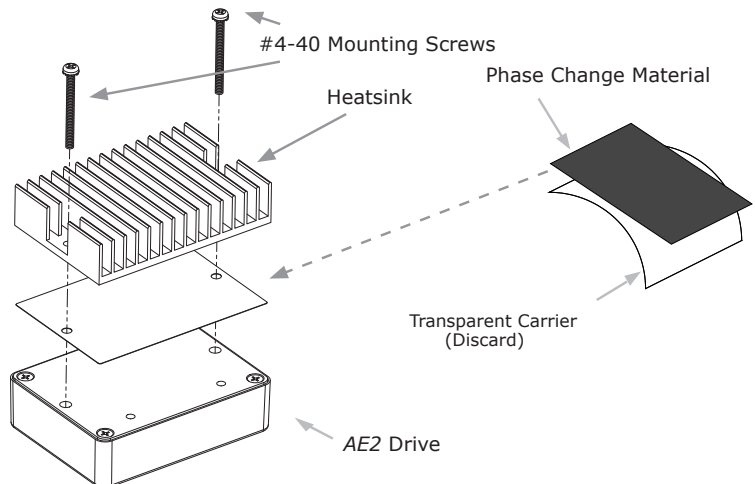
AIR FLOW	C/W
CONVECTION	2.6
FORCED AIR (300 LFM)	0.8

HEATSINK INSTALLATION

The heatsink is mounted using the same type of screws used to mount the drive without a heatsink but slightly longer. Phase change material (PSM) is used in place of thermal grease. This material comes in sheet form and changes from solid to liquid form as the drive warms up. This forms an excellent thermal path from drive heatplate to heatsink for optimum heat transfer.

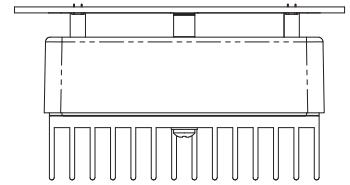
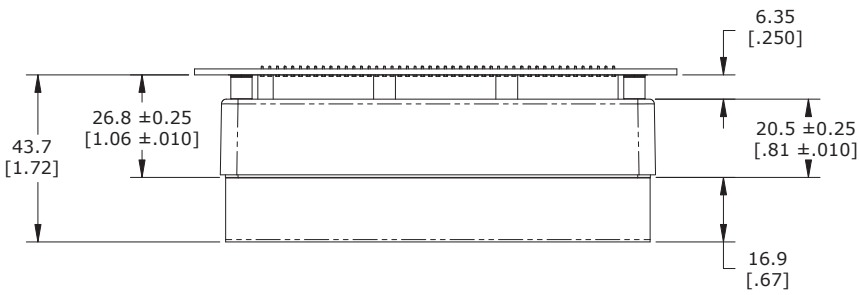
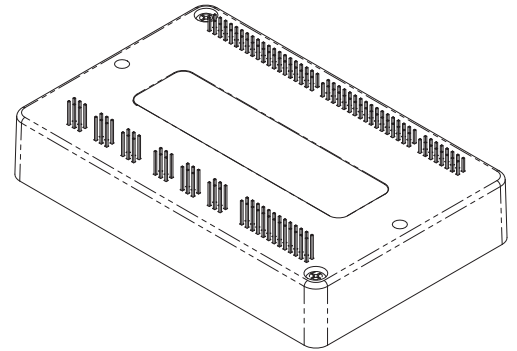
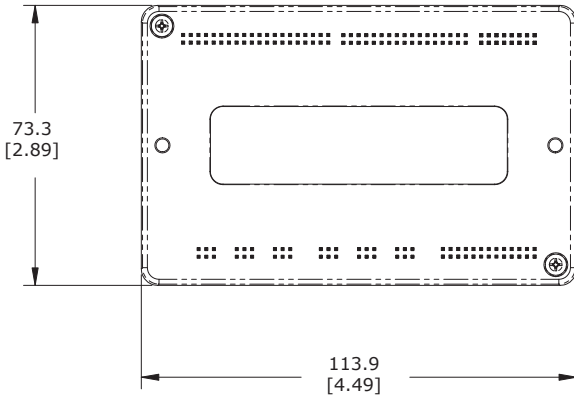
STEPS TO INSTALL

1. Remove the PSM (Phase Change Material) from the clear plastic carrier.
2. Place the PSM on the Accelnet aluminum heatplate taking care to center the PSM holes over the holes in the drive body.
3. Mount the heatsink onto the PSM again taking care to see that the holes in the heatsink, PSM, and drive all line up.
4. Torque the #4-40 mounting screws to 3~5 lb-in (0.34~0.57 N·m).



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DIMENSIONS



Units: mm [in]

MASTER ORDERING GUIDE

AE2-090-06	Accelnet AE2 servo drive, 3/6 A, 90 Vdc
AE2-090-14	Accelnet AE2 servo drive, 7/14 A, 90 Vdc
AE2-090-30	Accelnet AE2 servo drive, 15/30 A, 90 Vdc
AEK-090-02	Development Kit for AE2 servo drives



ACCESSORIES

	QTY	DESCRIPTION
Connector Kit for Development Kit AEK-CK-02	1	P1: Connector, Euro, 2 Terminal, 5.08 mm, Female
	1	J7: Connector, Euro, 4 Terminal, 5.08 mm, Female
	2	P2,P3: Connector, Euro, 3 Terminal, 5.08 mm, Female
	2	J9,J10: 26 Pin Connector, High Density, D-Sub, Male, Solder Cup
	2	J9,J10: 26 Pin Connector Backshell
	1	P4: 44 Pin Connector, High Density, D-Sub, Female, Solder Cup
	1	P4: 44 Pin Connector Backshell
Heatsink Kit AE2-HK	1	Heatsink for AE2
	1	Heatsink Thermal Material
	4	Heatsink Hardware
AEK-NC-10		Ethernet Network Cable, 10 ft
AEK-NC-01		Ethernet network cable, 1 ft
CME 2		CME 2 Drive Configuration Software on CD-ROM
SER-CK		Serial Cable Kit

16-01582 Document Revision History

Revision	Date	Remarks
00	March 7, 2017	Initial released version

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Note: Specifications subject to change without notice