2-AXIS DIGITAL SERVO DRIVE
FOR BRUSHLESS/BRUSH MOTORS

Control Modes
- Profile Position-Velocity-Torque, Interpolated Position, Homing
- Camming, Gearing
- Indexer

Command Interface
- CANopen
- ASCII and discrete I/O
- Stepper commands
- ±10V position/velocity/torque command
- PWM velocity/torque command
- Master encoder (Gearing/Camming)

Communications
- CANopen
- 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 / encoder out
- 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]

Model	Ic	Ip	Vdc
AP2-090-06	3	6	14-90
AP2-090-14	7	14	14-90
AP2-090-30	15	30	14-90

DEVELOPMENT KIT

DESCRIPTION

Accelnet AP2 is a high-performance, DC powered servo drive for position, velocity, and torque control of brushless and brush motors. Using advanced FPGA technology, the *AP2* provides a significant reduction in the cost per node in multi-axis CANopen systems.

Each of the two nodes in the *AP2* operates as an CANopen node using the CANopen protocol DSP-402 for motion control devices. Supported modes include: Profile Position-Velocity-Torque, Interpolated Position Mode (PVT), and Homing.

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

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

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

An SPI (Switch & LED Interface) function is supported by another high-speed input and four high-speed digital outputs. If not used for SPI, the input and outputs are programmable for other functions. Three open-drain MOSFET 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	AP2-090-06	AP2-090-14	AP2-090-30		
OUTPUT POWER					
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	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					
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

CANopen: Profile Position, Profile Velocity, & Profile Torque, Interpolated Position (PVT), Homing
Analog ±10 Vdc, camming, internal indexer and function generator
Digital PWM/Polarity current/velocity and Step/Direction position commands
Discrete I/O: camming, internal indexer and function generator

COMMAND INPUTS

Type	CANopen
Signals & format	TX+, TX–, RX+, RX–; 100BaseTX
Data protocol	CANopen Device Profile DSP-402
Address Selection	Programmable, or via digital inputs
Analog	±10 Vdc, torque/velocity/position control
Digital	High speed inputs for PWM/Polarity and Step/Direction
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
Bandwidths	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

DIGITAL INPUTS

Number	20
[IN1~17]	High-speed digital, 1 µs RC filter, 10 kΩ pull-up to +3.3 Vdc, 74HC14 Schmitt trigger
[IN18]	SPI port MISO input, 47 ns RC filter, 1 kΩ pull-up to +3.3 Vdc, 74HC14 Schmitt trigger
[IN19~20]	Motor temperature switch, 330 µs RC filter, 4.99 kΩ pull-up to +3.3 Vdc, 74HCT2G14 Schmitt trigger

ANALOG INPUTS

Number	2
Type	±10 Vdc, 12-bit resolution, differential

DIGITAL OUTPUTS

Number	7
[OUT1~3]	Open-drain MOSFET with 1 kΩ pull-up with series diode to +5 Vdc 100 mAdc max, +30 Vdc max. Functions programmable
[OUT4~7]	SPI port MOSI, SCLK, SS1, & SS2 signals, 74AHCT125 line drivers

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)
26LS32 differential line receiver with 121 Ω terminating resistor between complementary inputs

Analog Incremental Encoder — Sin/cos format (sin+, sin-, cos+, cos-), differential, 1 Vpeak-peak, ServoTube motor compatible

Absolute:

SSI — Clock (X, /X), Data (S, /S) signals, 4-wire, clock output from AEP, 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
SD+, SD- (S, /S) signals, 2.5 or 4 MHz, 2-wire half-duplex communication
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 AEP, data returned from encoder

Encoder power — Two outputs: +5 Vdc ±2% @ 400 mAdc max, current limited to 750 mAdc @ +1 Vdc if output overloaded

Commutation:

Digital Hall signals, single-ended, 1.5 µs RC filter, 15 kΩ pull-up to +5 Vdc, 74LVC14 Schmitt trigger

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
Protocol	ASCII or Binary format

MOTOR CONNECTIONS (PER AXIS)

Phase U, V, W	PWM outputs to 3-phase ungrounded Wye or delta connected brushless motors, or DC brush motors
Hall U, V, W	Digital Hall signals, single-ended, 1 µs RC filter, 10 kΩ pull-up to +5 Vdc, 74HC14 Schmitt trigger
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)
Analog Incremental Encoder	Sin/cos format (sin+, sin-, cos+, cos-), differential, 1 Vpeak-peak X or S input may be firmware configured to latch position or time
Heidenhain EnDat 2.2	Serial data and clock signals (DATA, /DATA, CLK, /CLK), differential; optionally sin/cos signals
Heidenhain EnDat 2.2, SSI	Serial data and clock signals (DATA, /DATA, CLK, /CLK), differential
BiSS	MA+, MA-, SL+, SL-
Nikon A	SD+, SD-
Hall & encoder power	+5 Vdc ±2% @ 400 mAdc max, current limited to 750 mAdc @ +1 Vdc if output overloaded
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 < +20 Vdc	Drive outputs turn off until +HV > +20 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^2T 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	<tbd>
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 2004/108/EC (EMC Directive)

EN 55011: 2007	CISPR 11:2003/A2:2006 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 2006/95/EC (Low Voltage Directive)

IEC 61010-1:2001	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

Underwriters Laboratory Standards

UL 61010-1, 2nd Ed.: 2004	Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use

UL File Number E249894

CANOPEN

Based on the CAN V2.0b physical layer, a robust, two-wire communication bus originally designed for automotive use where low-cost and noise-immunity are essential, CANopen adds support for motion-control devices and command synchronization. The result is a highly effective combination of data-rate and low cost for multi-axis motion control systems. Device synchronization enables multiple axes to coordinate moves as if they were driven from a single control card.

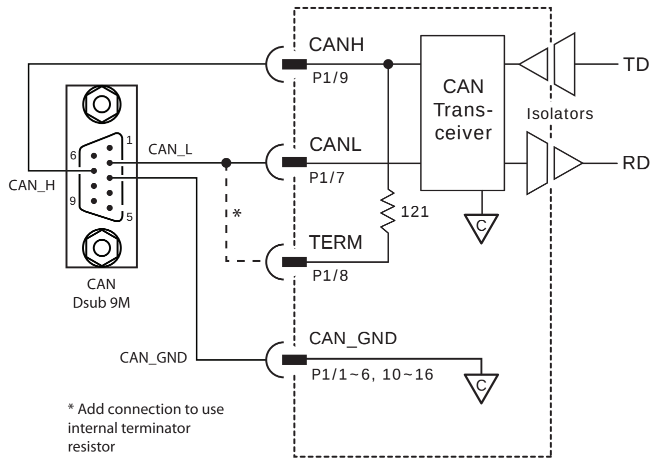
CANOPEN COMMUNICATION

Accelnet uses the CAN physical layer signals CANH, CANL, and GND for connection, and CANopen protocol for communication.
Before installing the drive in a CAN system, it must be assigned a CAN address. A maximum of 127 CAN nodes are allowed on a single CAN bus. Up to seven digital inputs can be used to produce CAN addresses from 1~127, or the address can be saved to flash memory in the module. Address 0 is reserved for the CANopen master on the network.
For more information on CANopen communications, download the CANopen Manual from the Copley web-site: CANopen Manual

CANOPEN COMMAND INPUT

The graphic below shows connections between the AP2 and a Dsub 9M connector on a CAN card. If the AP2 is the last node on a CAN bus, the internal terminator resistor can be used by adding a connection on the PC board as shown. The node address of the AP2 may be set by using digital inputs, or programmed into flash memory in the drive.

CME2 -> Basic Setup -> Operating Mode Options

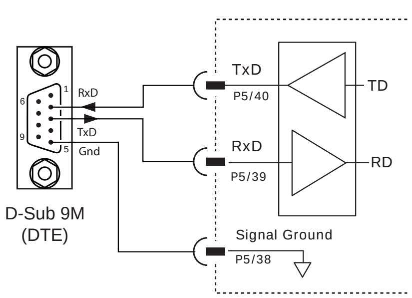


RS-232 COMMUNICATIONS

AP2 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 *AP2* RS-232 port are through P2 The graphic below shows the connections between an *AP2* and a computer COM port which is a DTE device.

CME2 -> Tools -> Communications Wizard

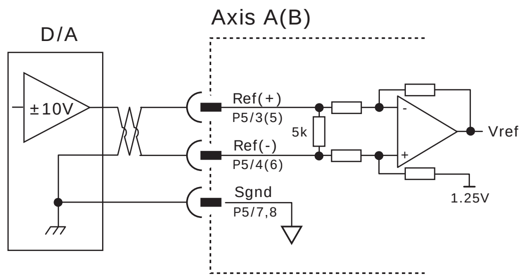
RS232 PORT



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.



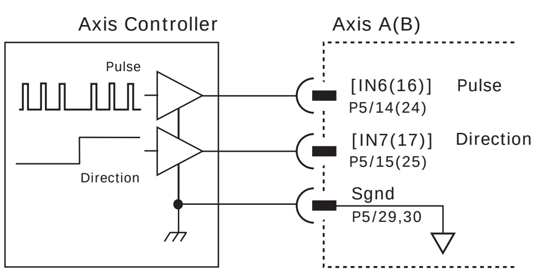
CME2 -> Basic Setup -> Operating Mode Options

DIGITAL COMMAND INPUTS

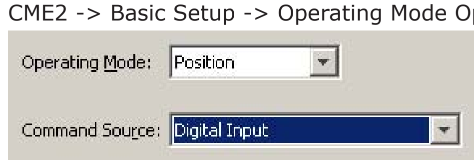
Digital commands are single-ended format and should be sourced from devices with active pull-up and pull-down to take advantage of the high-speed inputs. The active edge (rising or falling) is programmable for the Pulse/Dir and CU/CD formats.

DIGITAL POSITION

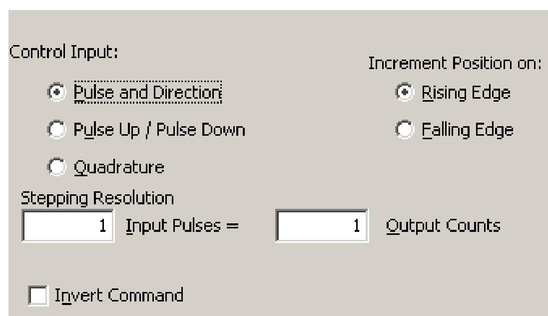
PULSE & DIRECTION



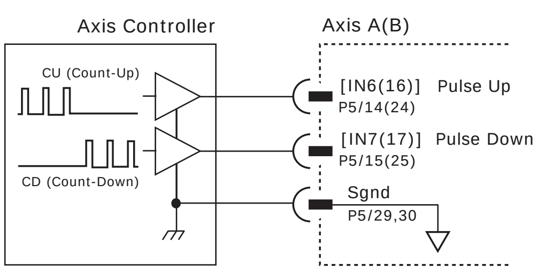
CME2 -> Basic Setup -> Operating Mode Options



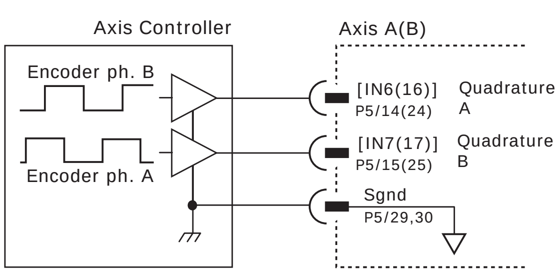
CME2 -> Basic Setup -> Operating Mode Options



CU/CD



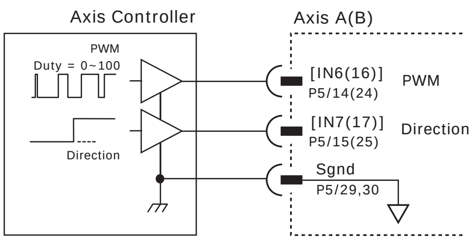
QUAD A/B ENCODER



DIGITAL COMMAND INPUTS (CONT'D)

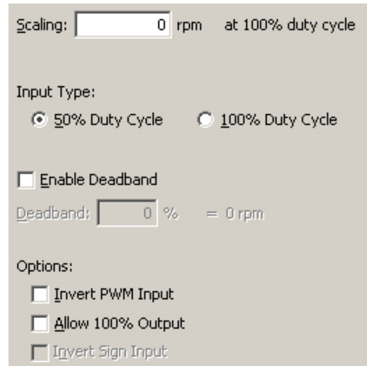
DIGITAL TORQUE, VELOCITY

PWM COMMAND (100% DUTY CYCLE)

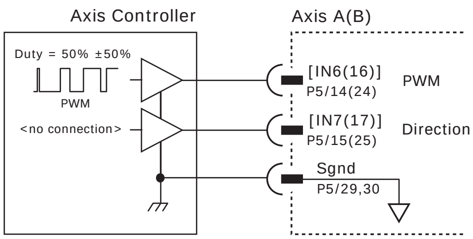


CME2 -> Basic Setup -> Operating Mode Options

CME2 -> Main Page-> PWM Command



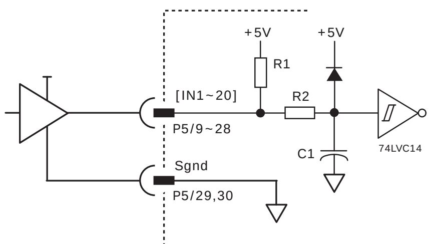
PWM COMMAND (50% DUTY CYCLE)



INPUT-OUTPUT

HIGH SPEED DIGITAL INPUTS

7V tolerant

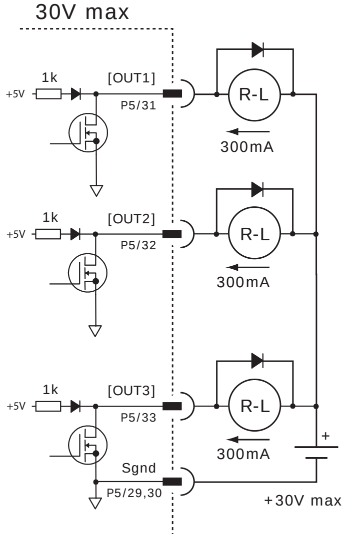


Input	P2 Pin	R1	R2	C1
IN1	9	10k	1k	100p
IN2	10			
IN3	11			
IN4	12			
IN5	13			
IN6	14			
IN7	15			
IN8	16			
IN9	17			
IN10	18			

Input	P2 Pin	R1	R2	C1
IN11	19	10k	1k	100p
IN12	20			
IN13	21			
IN14	22			
IN15	23			
IN16	24			
IN17	25			
IN18	26			47p
IN19	27	4.99k	10k	33n
IN20	28			

DIGITAL OUTPUTS

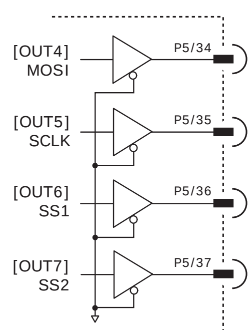
30V max



MOSFET

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

5V max

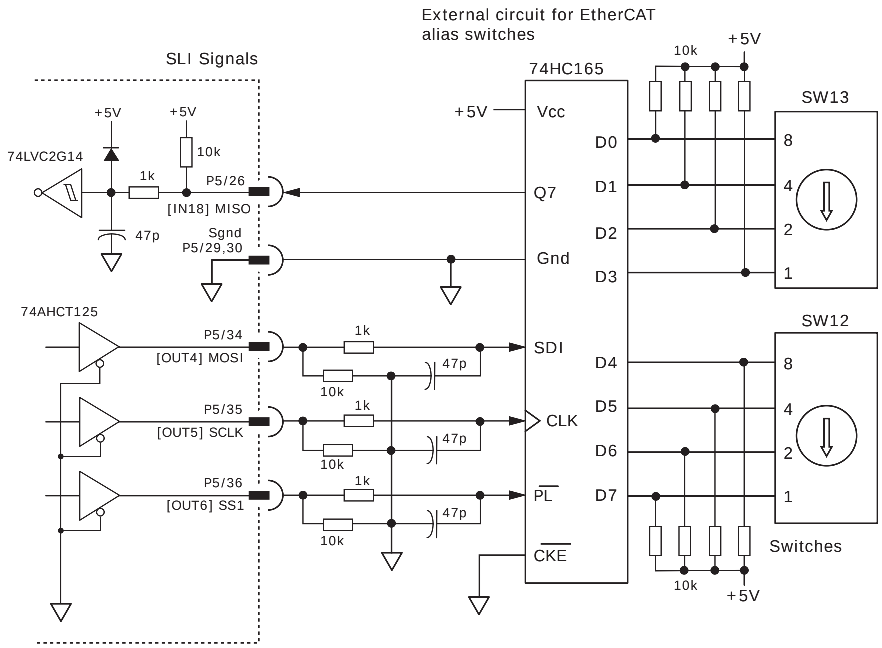


74HCT125

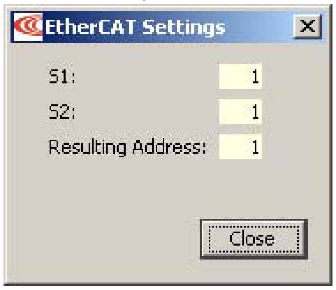
Output	P5 Pin
OUT1	31
OUT2	32
OUT3	33
OUT4	34
OUT5	35
OUT6	36
OUT7	37

CANOPEN ALIAS (NODE ADDRESS) SWITCHES

The SLI (Switch & LED Interface) port takes in the 8 signals from the two BCD encoded switches that set the CANopen alias address and controls the LEDs on the CANopen port connectors.
The graphic below shows the circuit for reading the CANopen address 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 AP2 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 addressing range of 0~255.



CME2 -> Amplifier -> Network Configuration



CANOPEN DUAL AXES AND THE OBJECT DICTIONARY

Single-axis CANopen 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 AP2 appears as a single slave node on an CANopen 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 AP2 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.

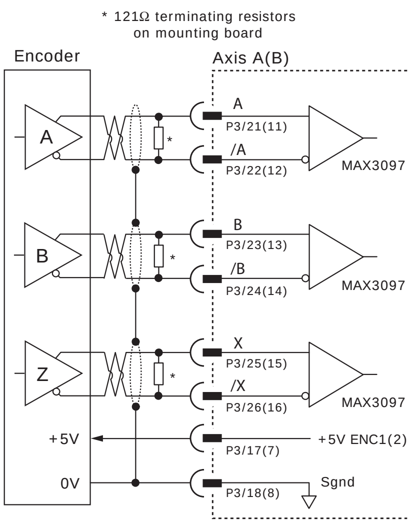
±15kV ESD protection: The 3097E has protection against high-voltage discharges using the Human Body Model.

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*.

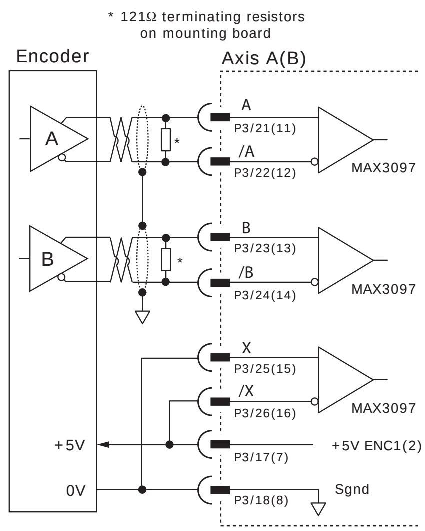
DIGITAL QUADRATURE ENCODER INPUT

5V



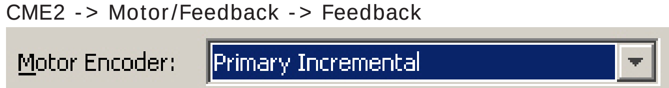
A/B CONNECTIONS (NO INDEX)

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

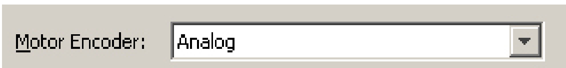


MOTOR CONNECTIONS (CONT'D)

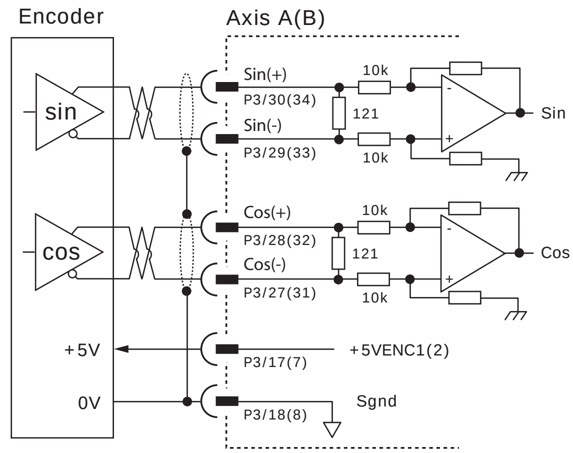
ANALOG SIN/COS INCREMENTAL ENCODER

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



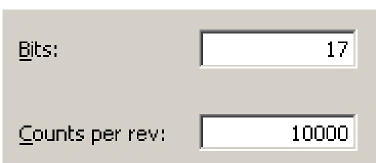
Encoder Signal	P3 Pins	
	Axis A	Axis B
Sin(+)	30	34
Sin(-)	29	33
Cos(+)	28	32
Cos(-)	27	31
+5V ENC	17	7
Sgnd	7	8



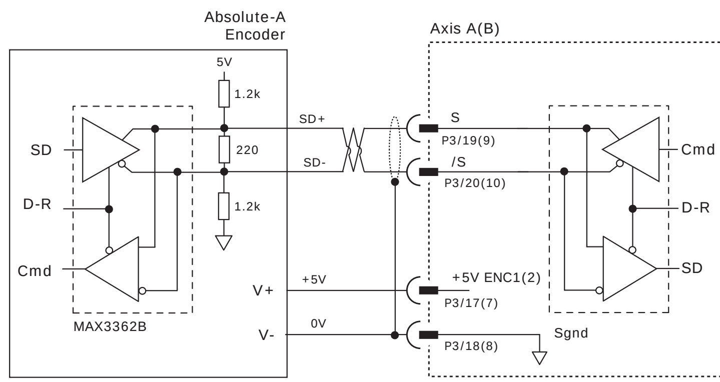
PANASONIC INCREMENTAL A ENCODER

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



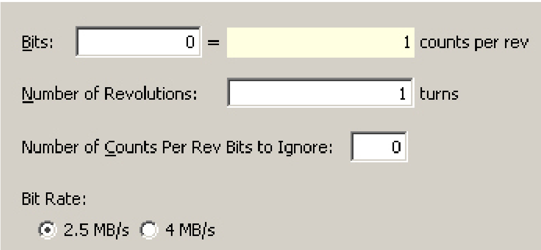
Encoder Signal	P3 Pins	
	Axis A	Axis B
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8

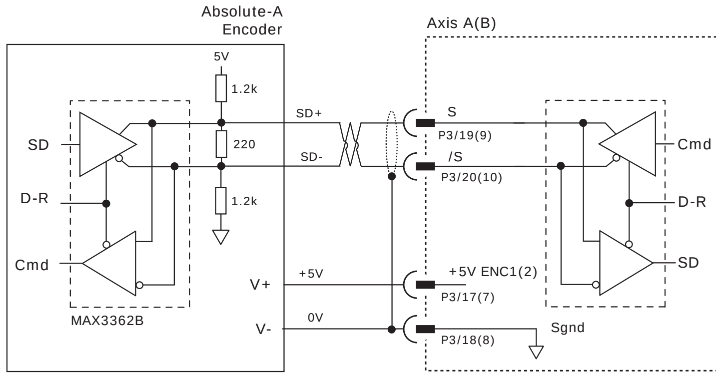


FEEDBACK CONNECTIONS

ABSOLUTE A ENCODER, TAMAGAWA, AND PANASONIC

CME2 -> Motor/Feedback -> Feedback



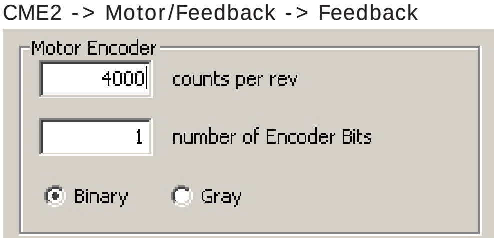


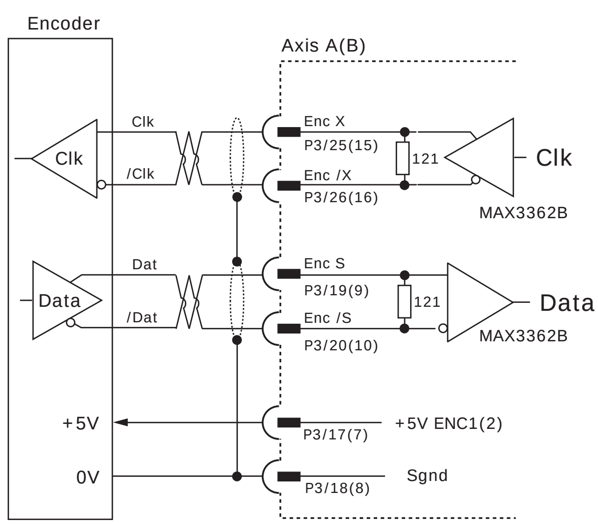
Encoder Signal	P3 Pins	
	Axis A	Axis B
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8

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



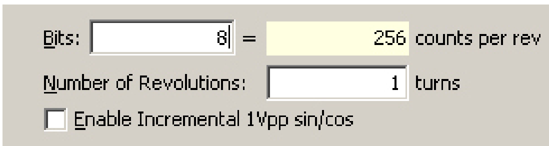


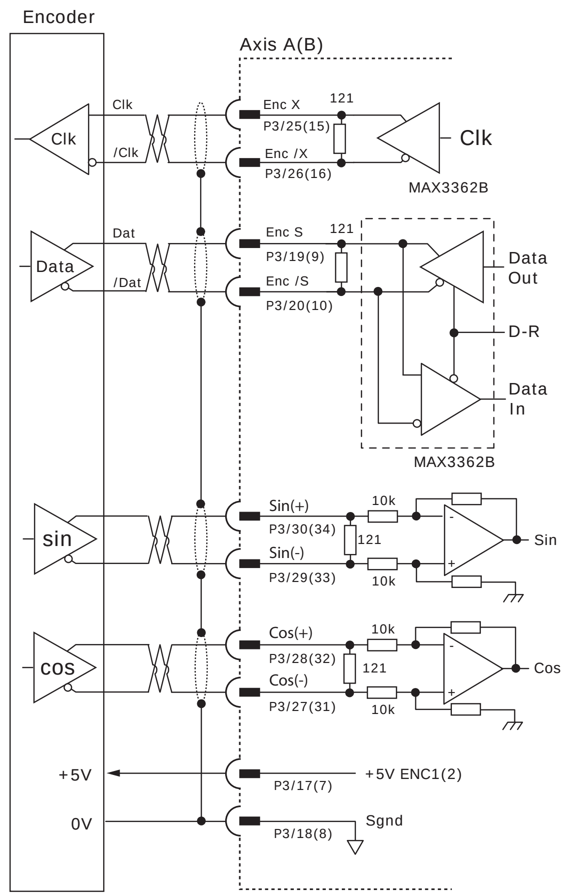
Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8

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

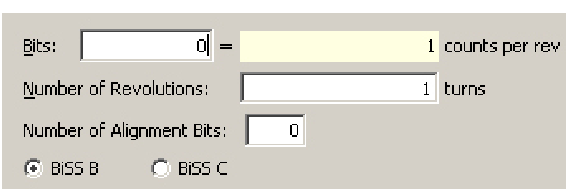


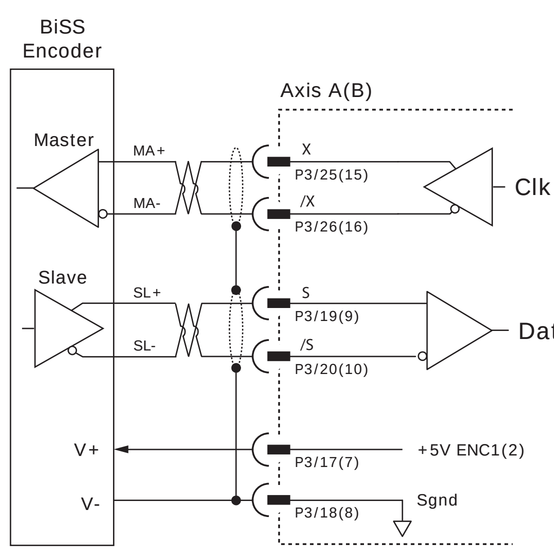


Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
Sin(+)	30	34
Sin(-)	29	33
Cos(+)	28	32
Cos(-)	27	31
+5V ENC	17	7
Sgnd	18	8

BISS (B & C) ABSOLUTE ENCODER

CME2 -> Motor/Feedback -> Feedback



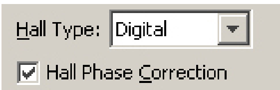


Encoder Signal	P3 Pins	
	Axis A	Axis B
X	25	15
/X	26	16
S	19	9
/S	20	10
+5V ENC	17	7
Sgnd	18	8

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.

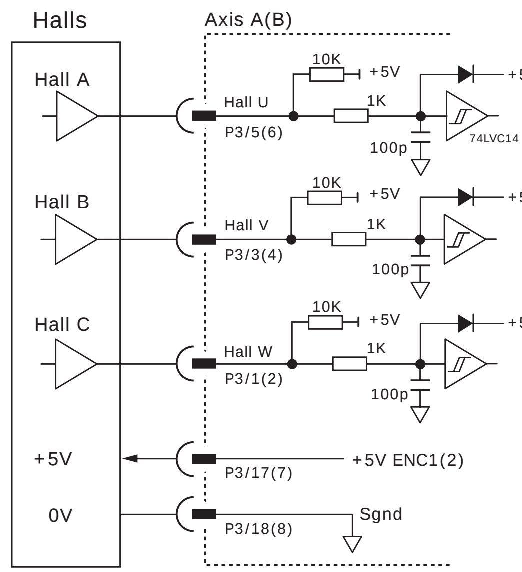
CME2 -> Basic Setup -> Feedback Options



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

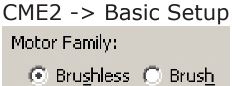
5V

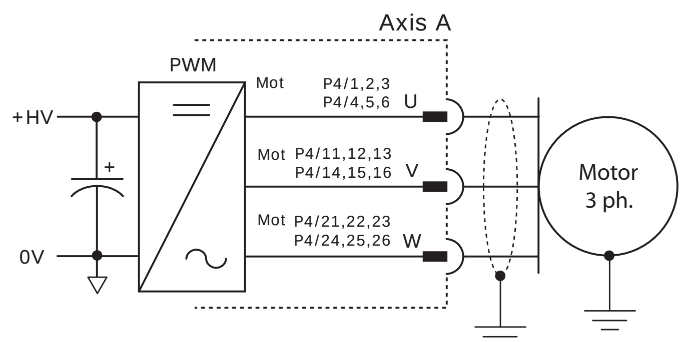


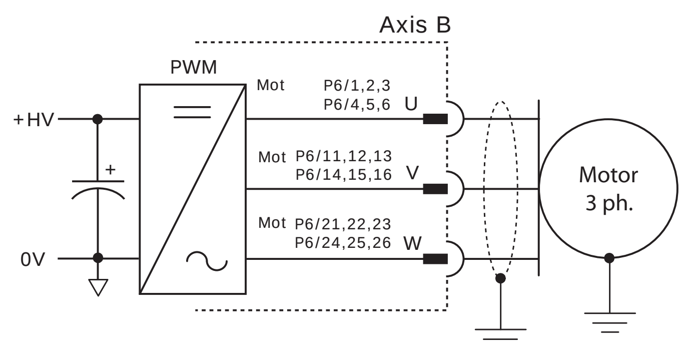
MOTOR PHASE CONNECTIONS

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







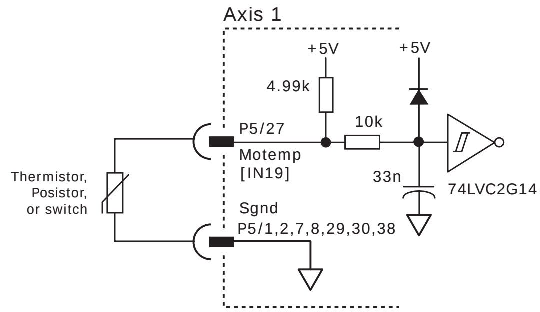
MOTOR OVER TEMP INPUT

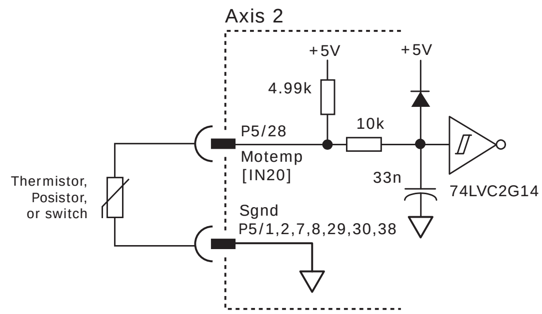
The 4.99k pull-up resistor works with PTC (positive temperature coefficient) thermistors that conform to BS 4999:Part 111:1987 (table below), or switches that open/close indicating a motor over-temperature condition. The active level is programmable.

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

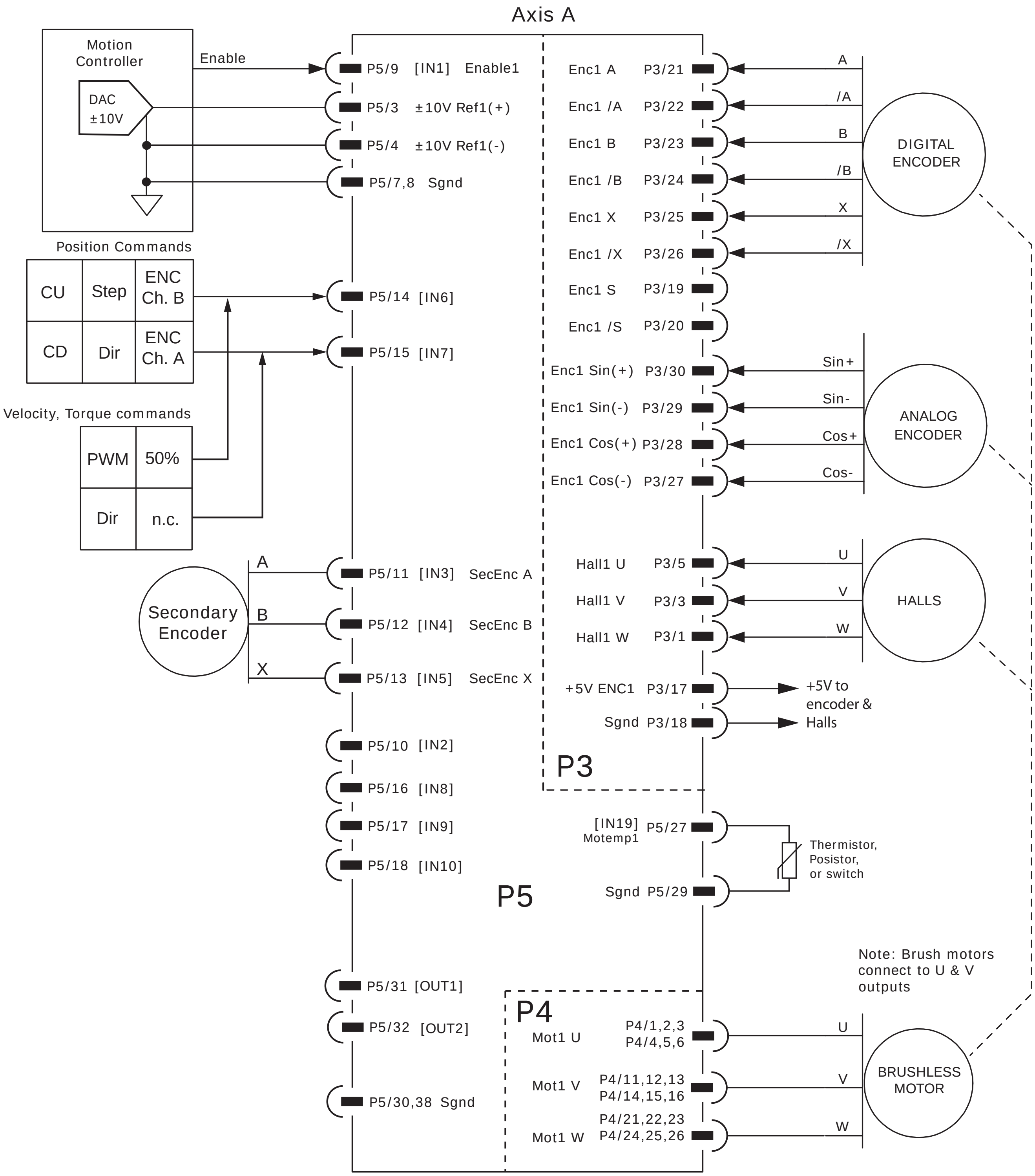
24V tolerant



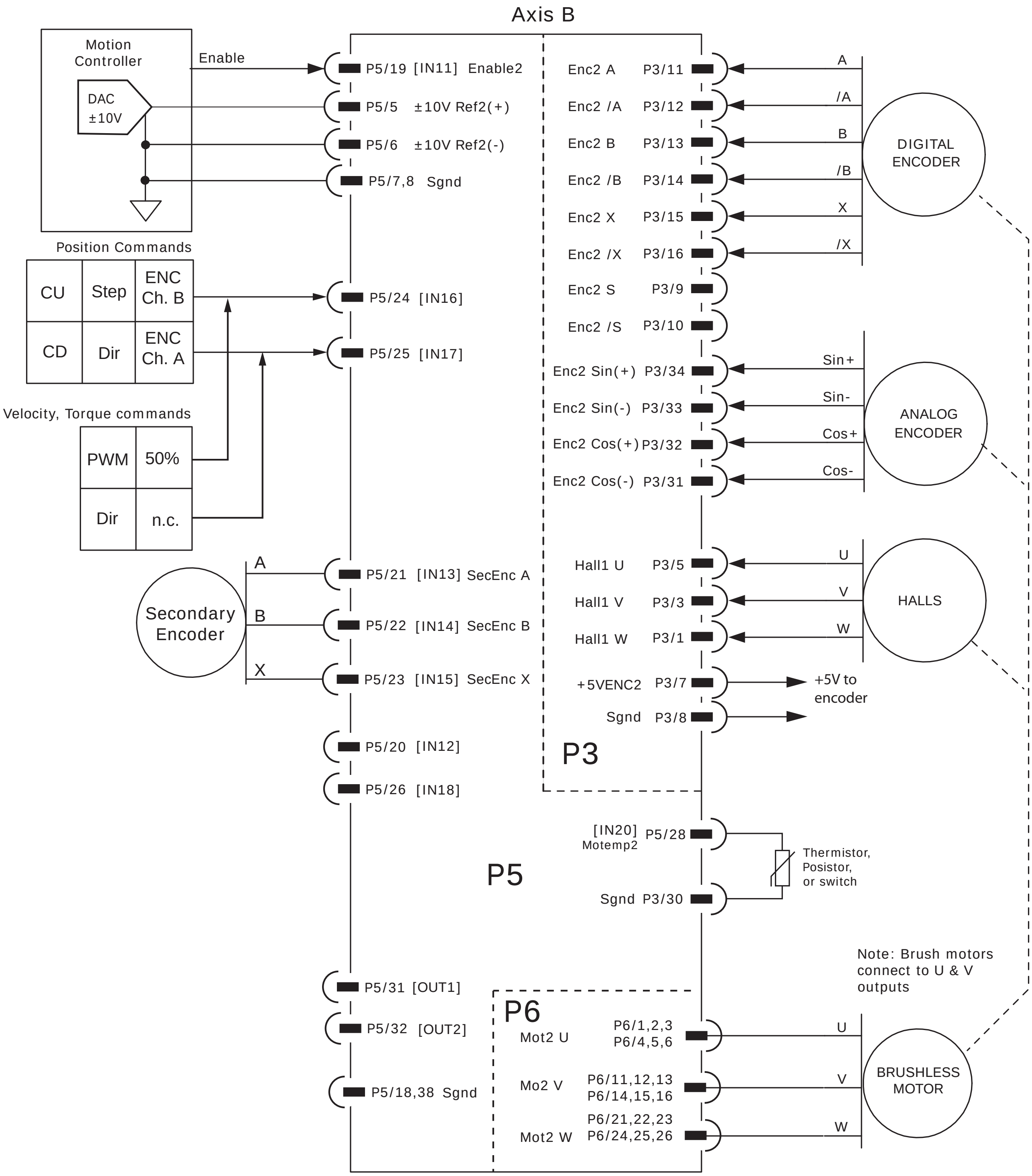


Notes:
1. P5 signals and pin assignments are defaults and may be programmed for different functions.

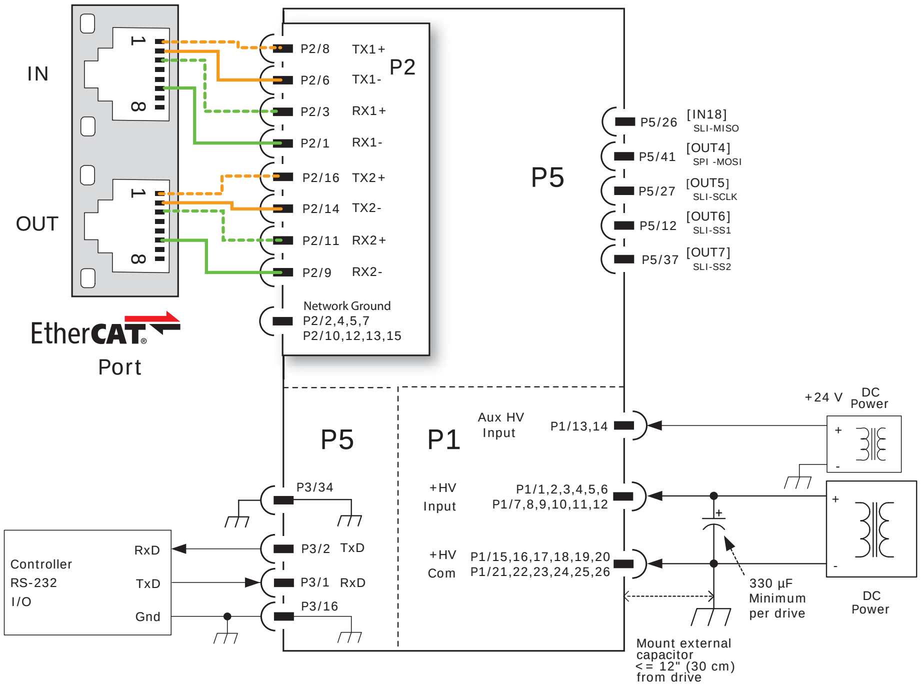
AXIS A CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



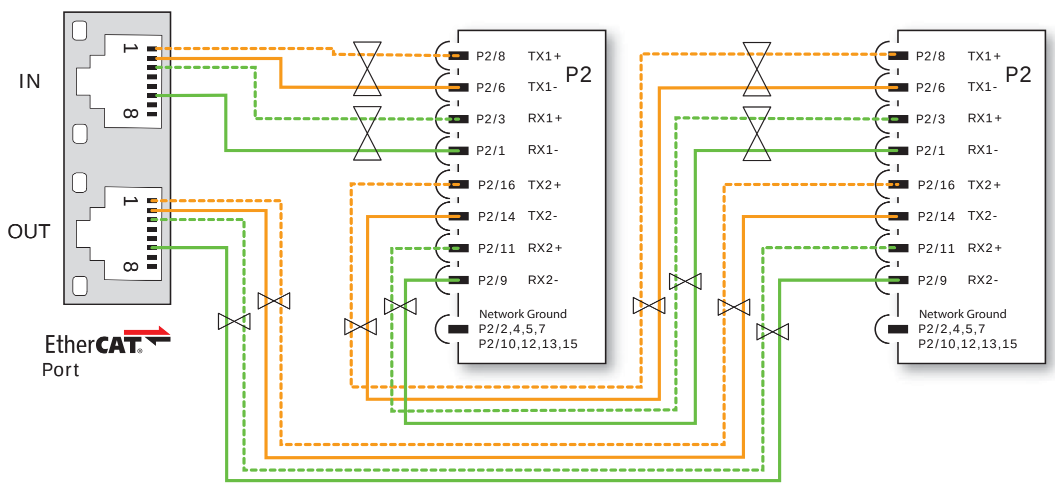
AXIS B CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



COMMON CONNECTIONS FOR AXES A,B

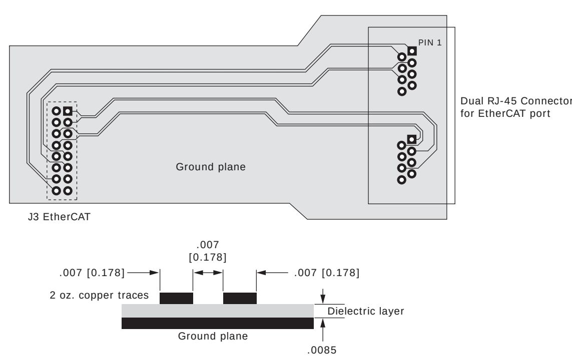


CANOPEN CONNECTIONS FOR MULTIPLE MODULES



PRINTED CIRCUIT BOARD DESIGN FOR CANOPEN SIGNALS

CANopen 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-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 CANopen connections shows resistors and a capacitor in the AP2 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 CANopen 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.

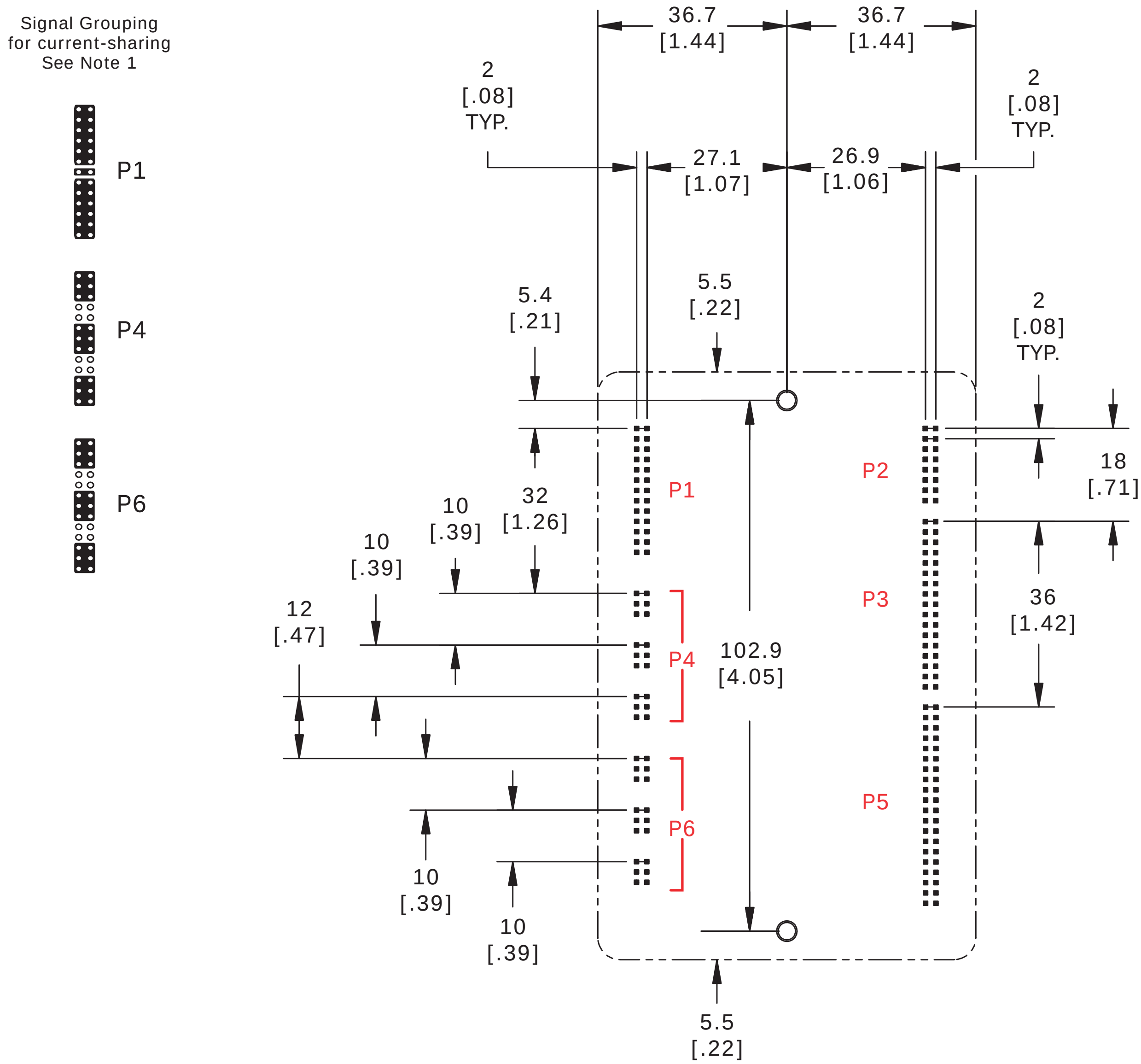


PRINTED CIRCUIT BOARD FOOTPRINT

Dimensions are mm [in]

TOP VIEW

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



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 CANopen
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

P1 POWER

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

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

CONNECTOR NAMING (P1, P2, ETC) APPLIES TO THE AP2 MODULE AND NOT TO PC BOARD MOUNTED SOCKETS

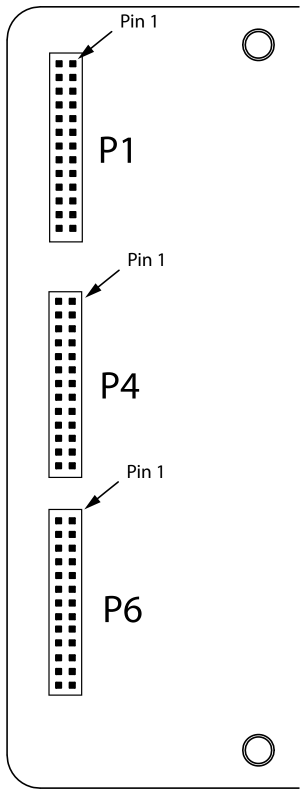
P4 AXIS A MOTOR

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

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

TOP VIEW

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



P6 AXIS B MOTOR

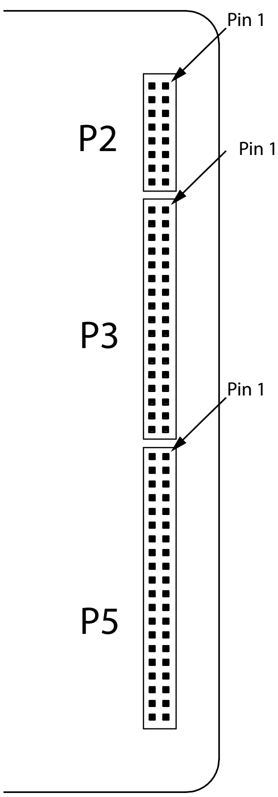
Mounting board connector:
Samtec SQW-113-01-F-D

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

P2 CANOPEN

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

Signal	Pin		Signal
CAN_GND	2	1	CAN_GND
CAN_GND	4	3	CAN_GND
CAN_GND	6	5	CAN_GND
TERM	8	7	CAN_L
CAN_GND	10	9	CAN_H
CAN_GND	12	11	CAN_GND
CAN_GND	14	13	CAN_GND
CAN_GND	16	15	CAN_GND



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

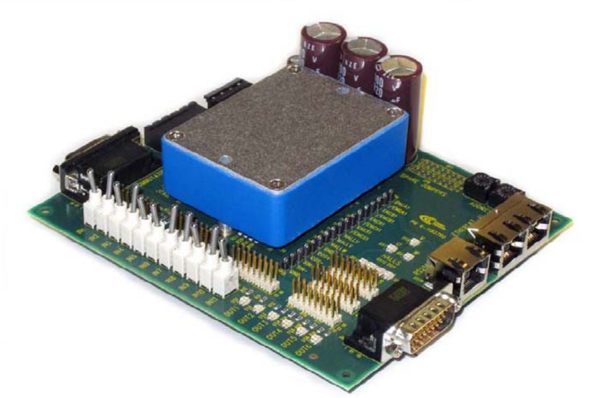
Mounting board connector:
Samtec SQW-120-01-F-D

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] SLI-SS2
RS-232 TxD	40	39	RS-232 RxD

DESCRIPTION

The Development Kit provides mounting and connectivity for one AP2 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 CANopen connectors make daisy-chain connections possible so that other CANopen devices such as Copley's Accelnet Plus or Xenus Plus CANopen drives can easily be connected. Rotary switches are provided to set the CANopen slave "station alias" address.

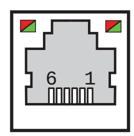


RS-232 CONNECTION

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

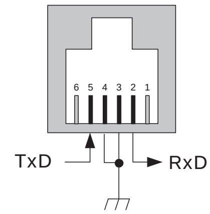
The RS-232 connector, J8, is a modular RJ-11 type that uses a 6-position plug, four wires of which are used for RS-232. A connector kit is available (SER-CK) that includes the modular cable, and an adaptor to interface this cable with a 9-pin RS-232 port on a computer.

J8



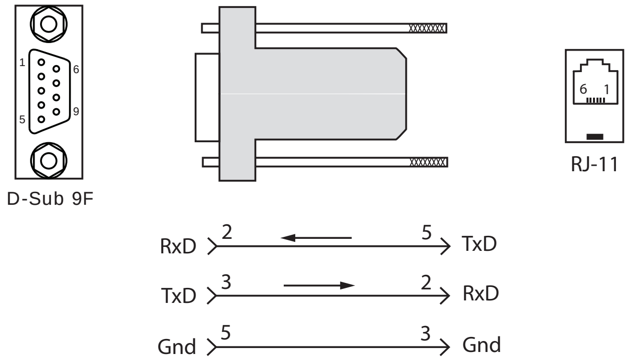
J8 SIGNALS

RJ-11
(DTE)



SER-CK SERIAL CABLE KIT

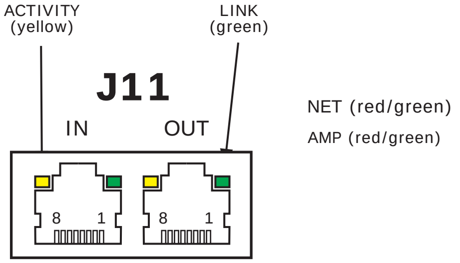
The SER-CK provides connectivity between a D-Sub 9 male connector and the RJ-11 connector J8 on the Development Kit. It includes an adapter that plugs into the COM1 (or other) port of a PC and uses common modular cable to connect to the XEL. The connections are shown in the diagram below.



Don't forget to order a Serial Cable Kit SER-CK when placing your order for an AP2 Development Kit!

CANOPEN 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 'up-stream', 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.



CANOPEN LEDS (ON RJ-45 CONNECTORS)

Green and yellow LEDs indicate the state of the CANopen physical link:

Green is the "Link" indicator: Yellow is the "Activity" indicator

The table below shows the state of these LEDs based on the condition of the physical layer of the network.

Link	Act	State	Remarks
Yes	No	On	Good cable and drives, no activity
Yes	Yes	Flickering	Good cable and drives, network is active
No	(N/A)	Off	Bad cable or drive, no activity

J11: CANopen PORTS

RJ-45 receptacles,
8 position, 4 contact

PIN	SIGNAL
1	CAN_H
2	CAN_L
3	CAN_GND

NET STATUS LED

A bi-color LED indicates the state of the CANopen bus.
Green and red colors alternate, and each color has a separate meaning:

Green is the "RUN" or CANopen State Machine:
Off = INIT state
Blinking = PRE-OPERATIONAL
Single Flash = SAFE-OPERATIONAL
On = OPERATIONAL

Red is the "ERR" indicator:
Blinking = Invalid configuration
Single Flash = Unsolicited state change
Double Flash = Application watchdog timeout

AMP STATUS LED

A bi-color LED gives the state of the Accelnet drive.
Colors do not alternate, and can be solid ON or blinking:

Green/Solid = Drive OK and enabled. Will run in response to reference inputs or CANopen commands.
Green/Slow-Blinking = Drive OK but NOT-enabled. Will run when enabled.
Green/Fast-Blinking = Positive or Negative limit switch active. Drive will only move in direction not inhibited by limit switch.
Red/Solid = Transient fault condition. Drive will resume operation when fault is removed.
Red/Blinking = Latching fault. Operation will not resume until drive is Reset.

CANopen ADDRESS (NODE ADDRESS)

In an CANopen network, slaves are automatically assigned addresses based on their position in the bus. But when the device must have a positive identification that is independent of cabling, a Station Alias is needed. In the AP2 DevKit, this is provided by two 16-position rotary switches with hexadecimal encoding. These can set the address of the drive from 0x01~0xFF (1~255 decimal). The chart shows the decimal values of the hex settings of each switch.

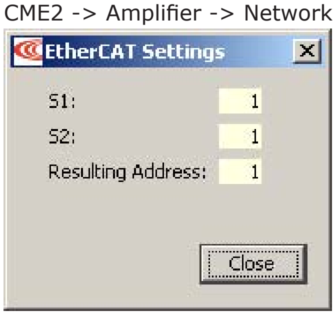
Example 1: Find the switch settings for decimal address 107:

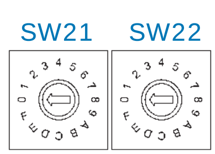
1) Find the highest number under SW21 that is less than 107 and set SW21 to the hex value in the same row: 96 < 107 and 112 > 107, so SW21 = 96 = Hex 6
2) Subtract 96 from the desired address to get the decimal value of switch SW22 and set SW22 to the Hex value in the same row: SW22 = (107 - 96) = 11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

CANopen Address 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

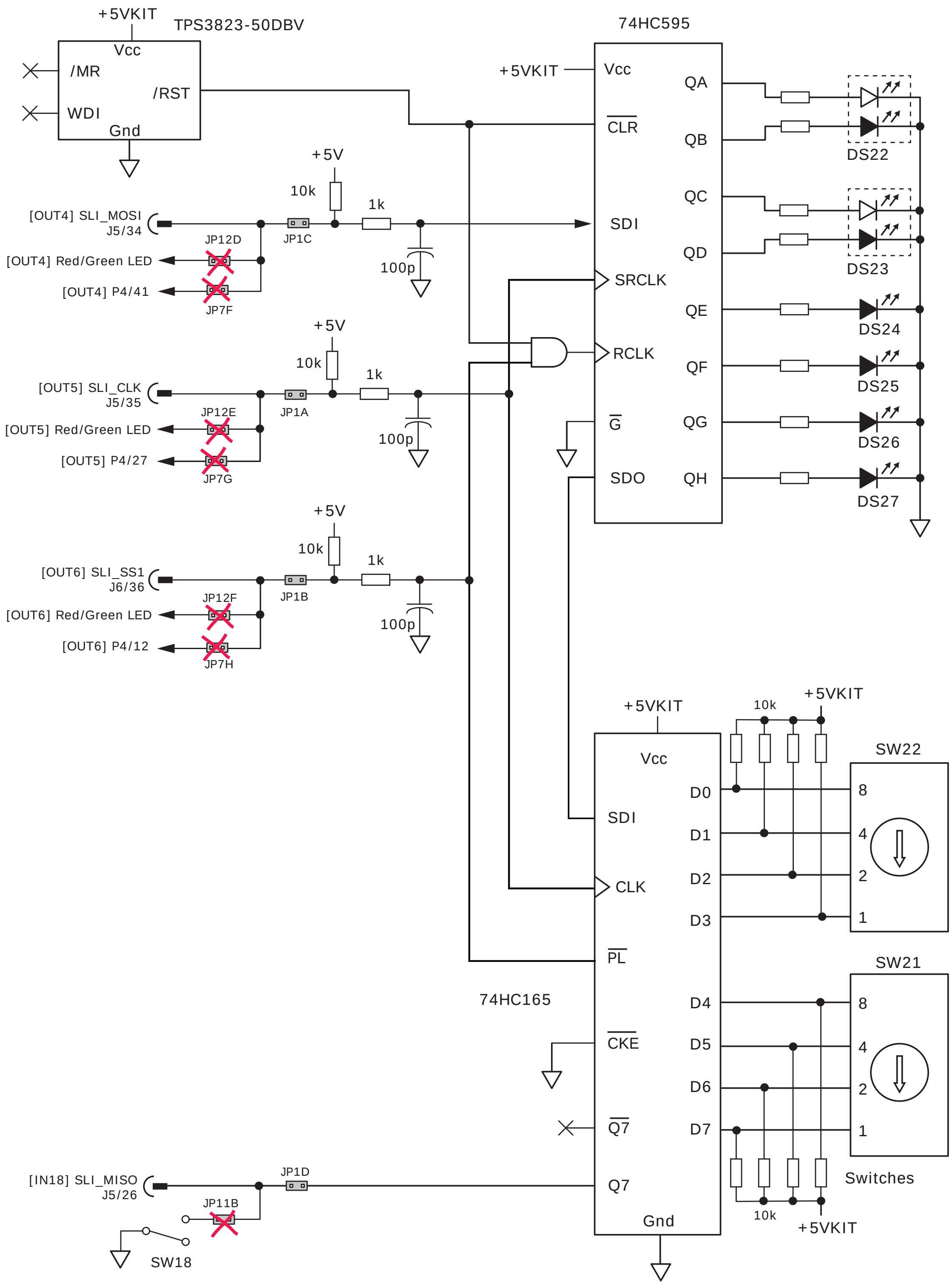




CANopen ADDRESS (STATION ALIAS) SWITCH CONNECTIONS

The graphic below shows the connections to the CANopen address switches and to the status LEDs for the AP2 and CANopen. 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 CANopen address switches, and controls the LEDs on the serial and CANopen 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.



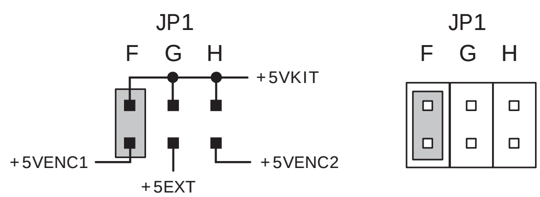
5V POWER SOURCES

The feedback connectors J9 & J10 each have a connection to a +5V power supply in the AP2.
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 address 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 AP2, or an external 5V power supply connected to J7.

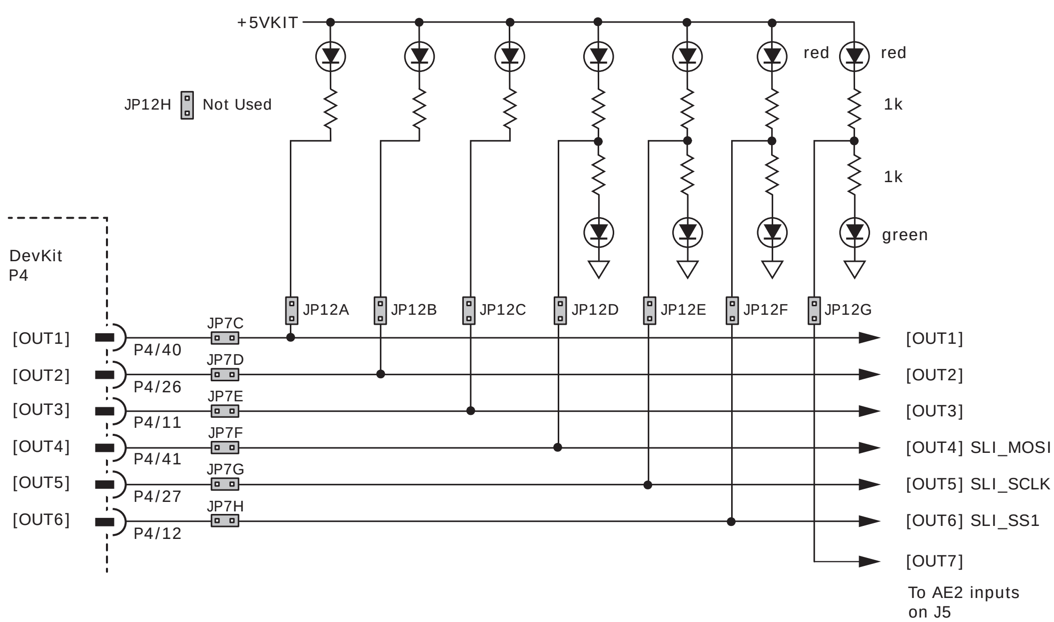
The graphic below shows the connections between +5VKIT and the other sources of 5V power.



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 AP2

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.

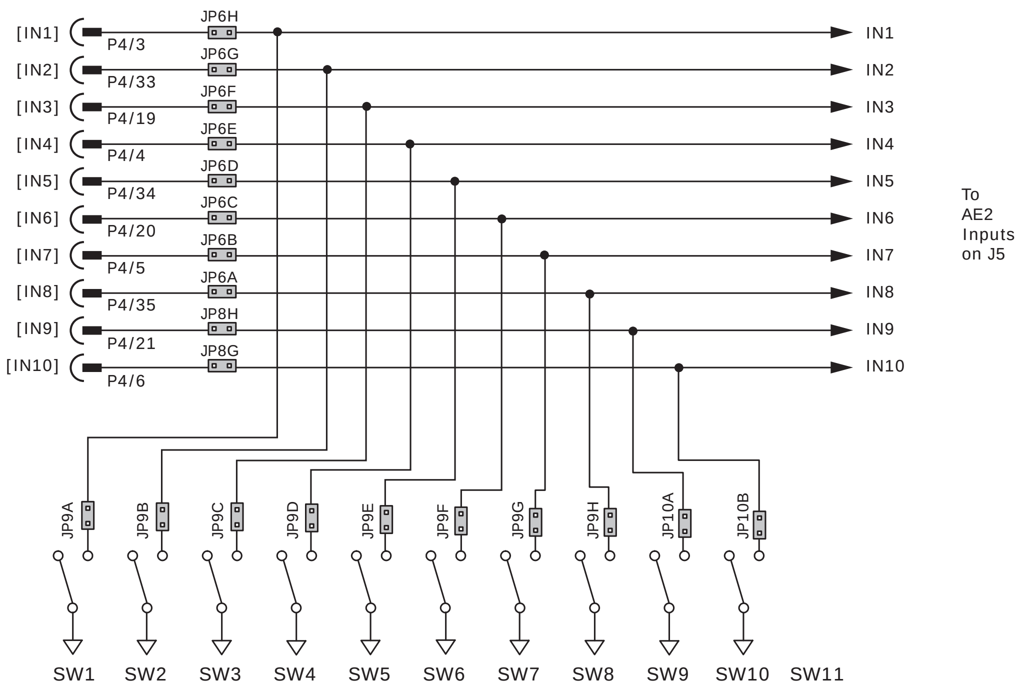


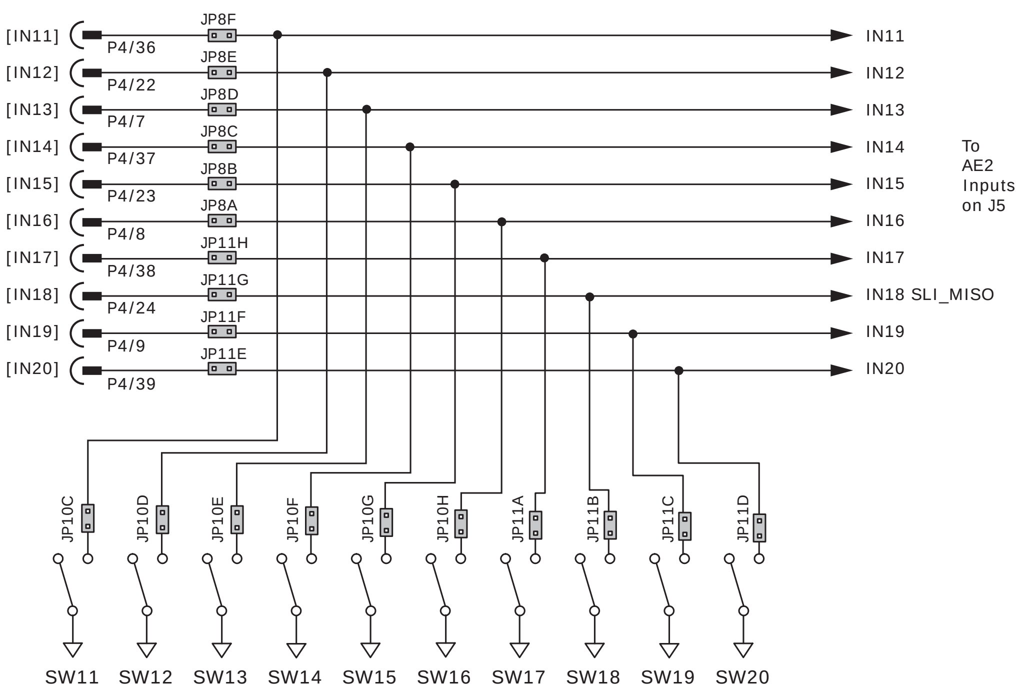
LOGIC INPUTS & SWITCHES

The Development Kit has jumpers that can connect the AP2 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.

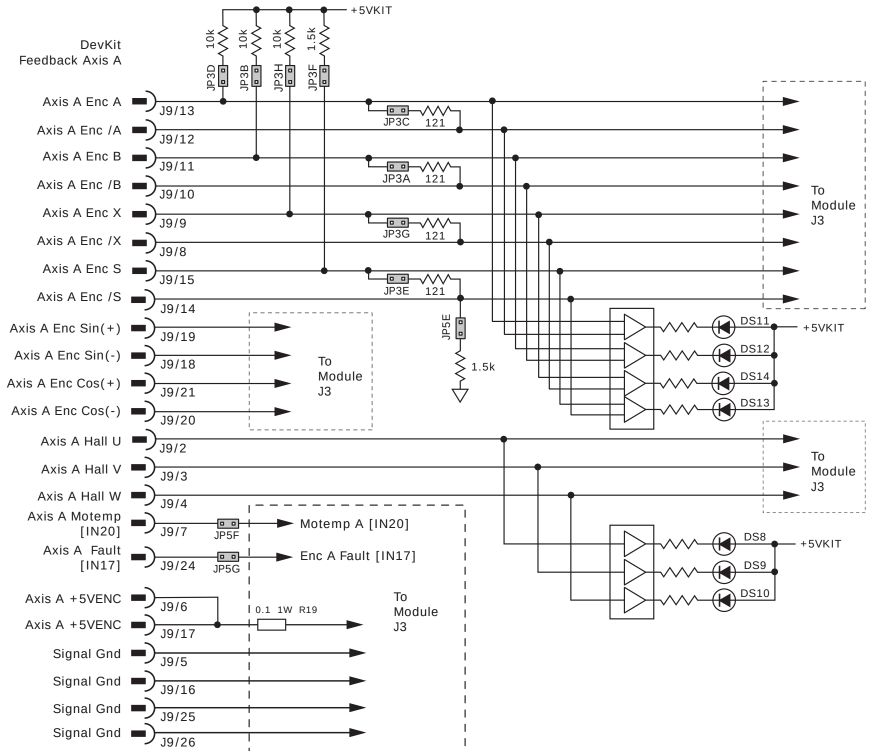
For example, if [IN1] is connected to an external device for the Enable function, then jumper JP9A should be removed to take the switch SW1 out of the circuit. The figure below shows these connections.



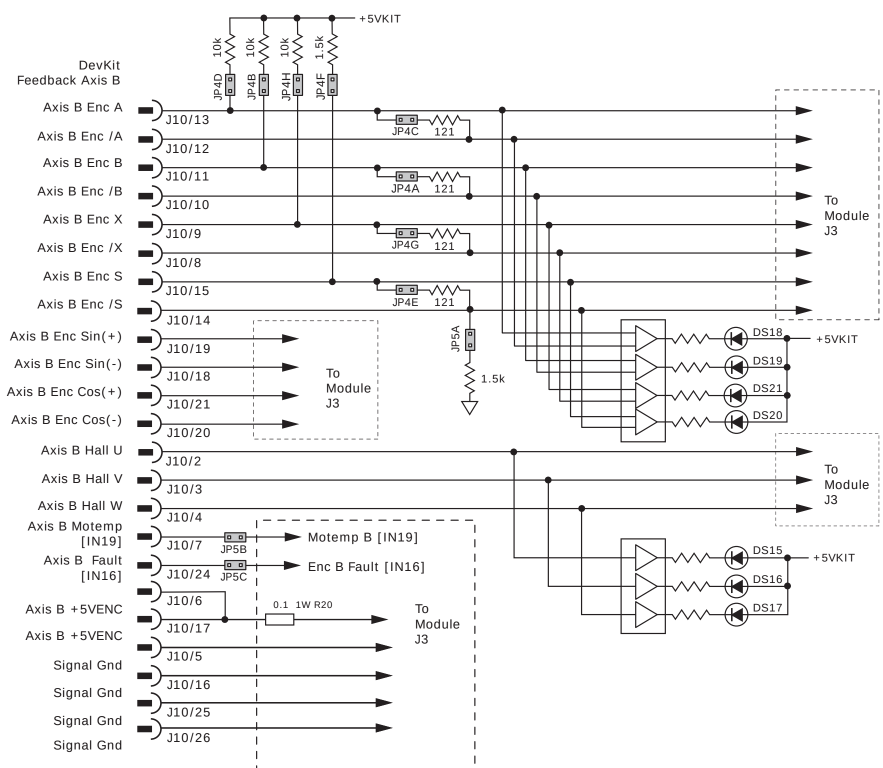


MOTOR FEEDBACK CONNECTORS J9 & J10

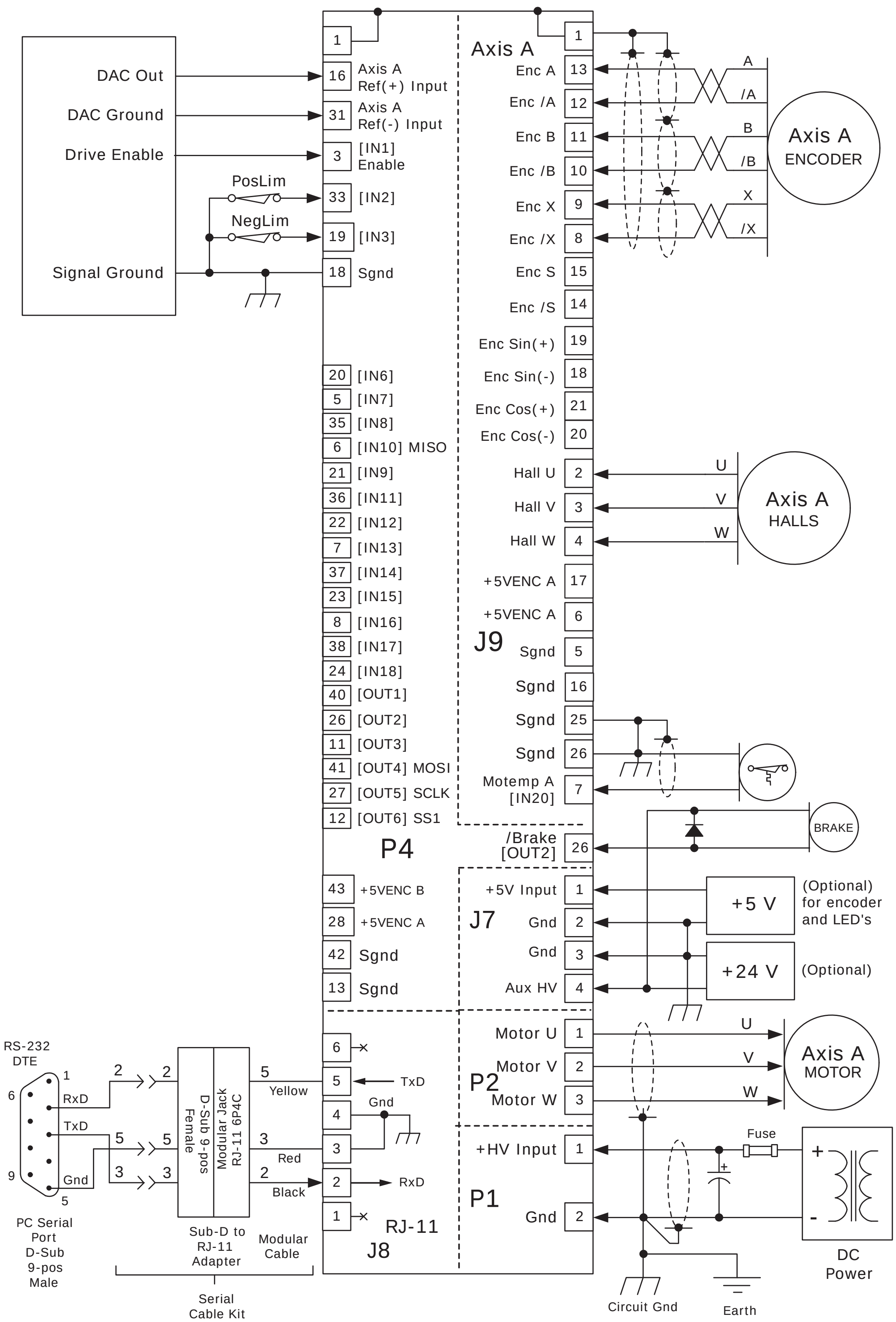
AXIS A



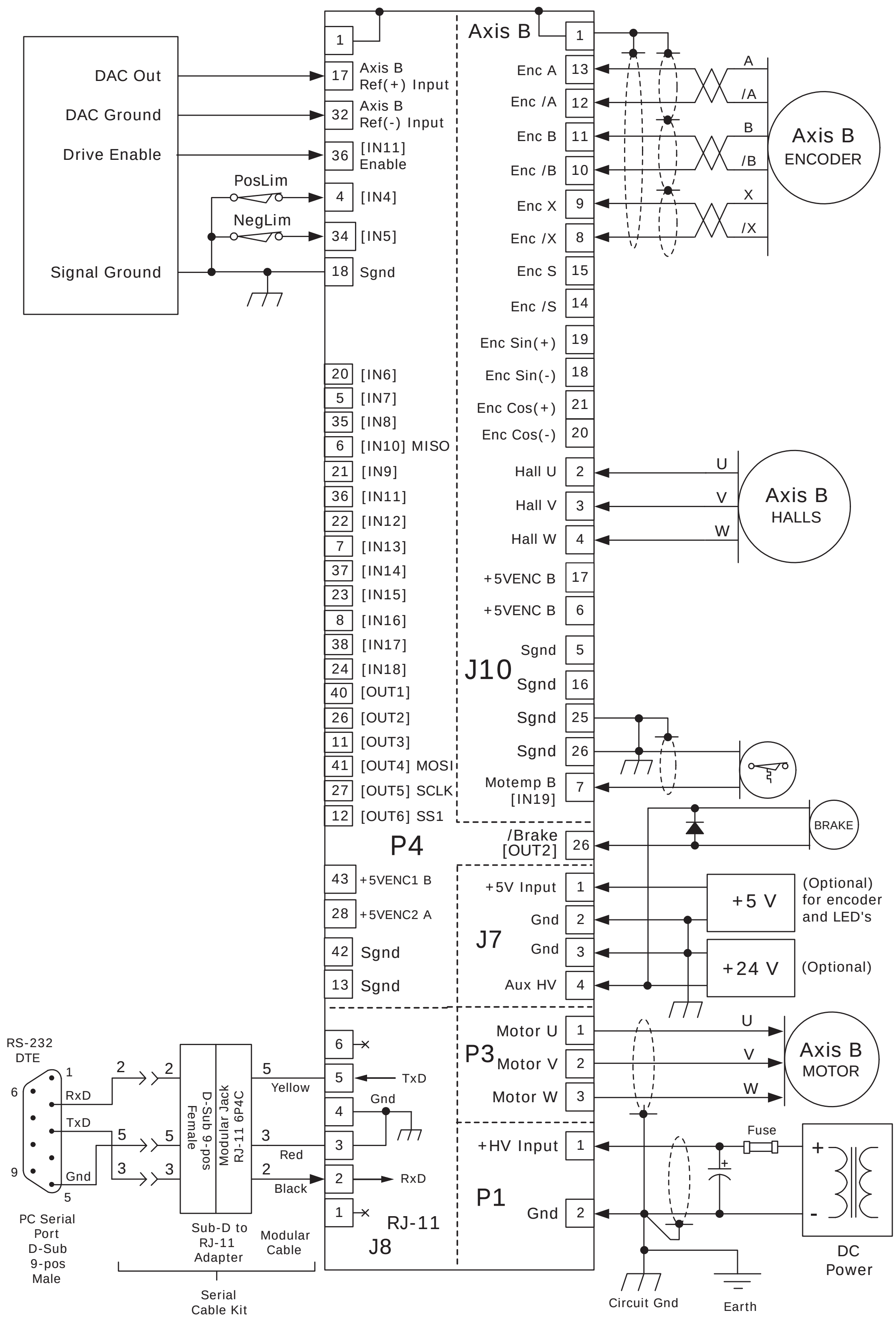
AXIS B



DEVELOPMENT KIT CONNECTIONS: AXIS A



DEVELOPMENT KIT CONNECTIONS: AXIS B



DEVELOPMENT KIT CONNECTORS

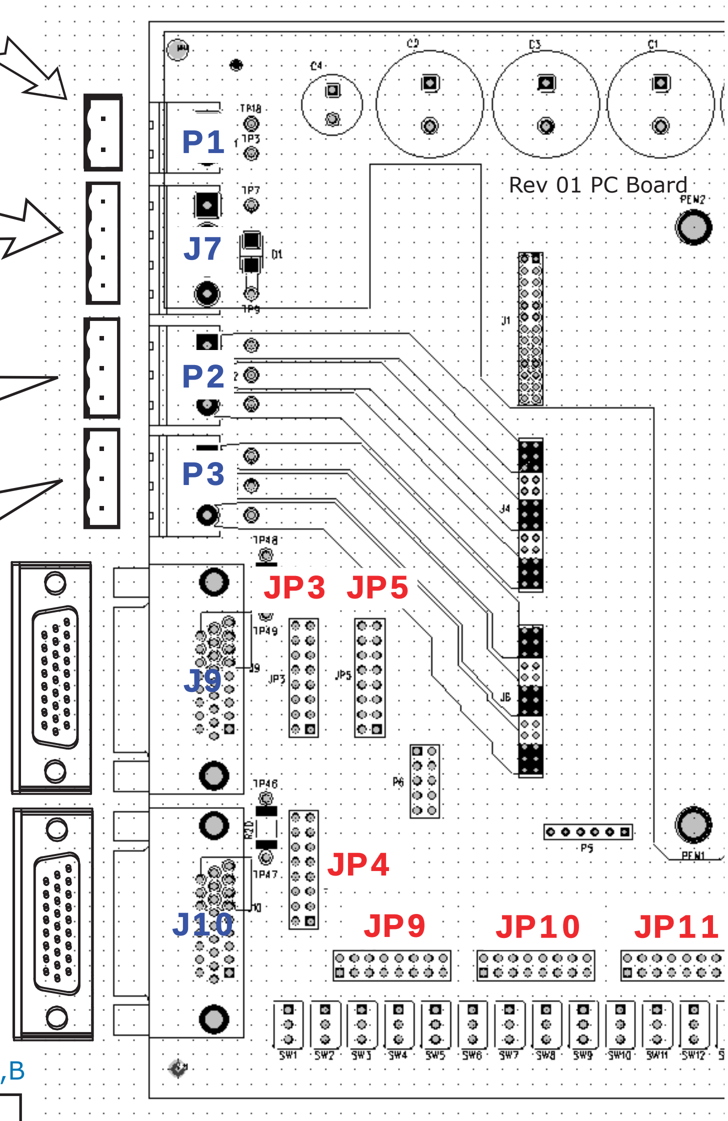
The Development Kit mounts a single AP2 module and enables the user to test and operate the AP2 before it is mounted onto a PC board in the target system.

P1: HV

Signal	Pin
+HV	1
HV Gnd	2

J7: AUX HV & 5V

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



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

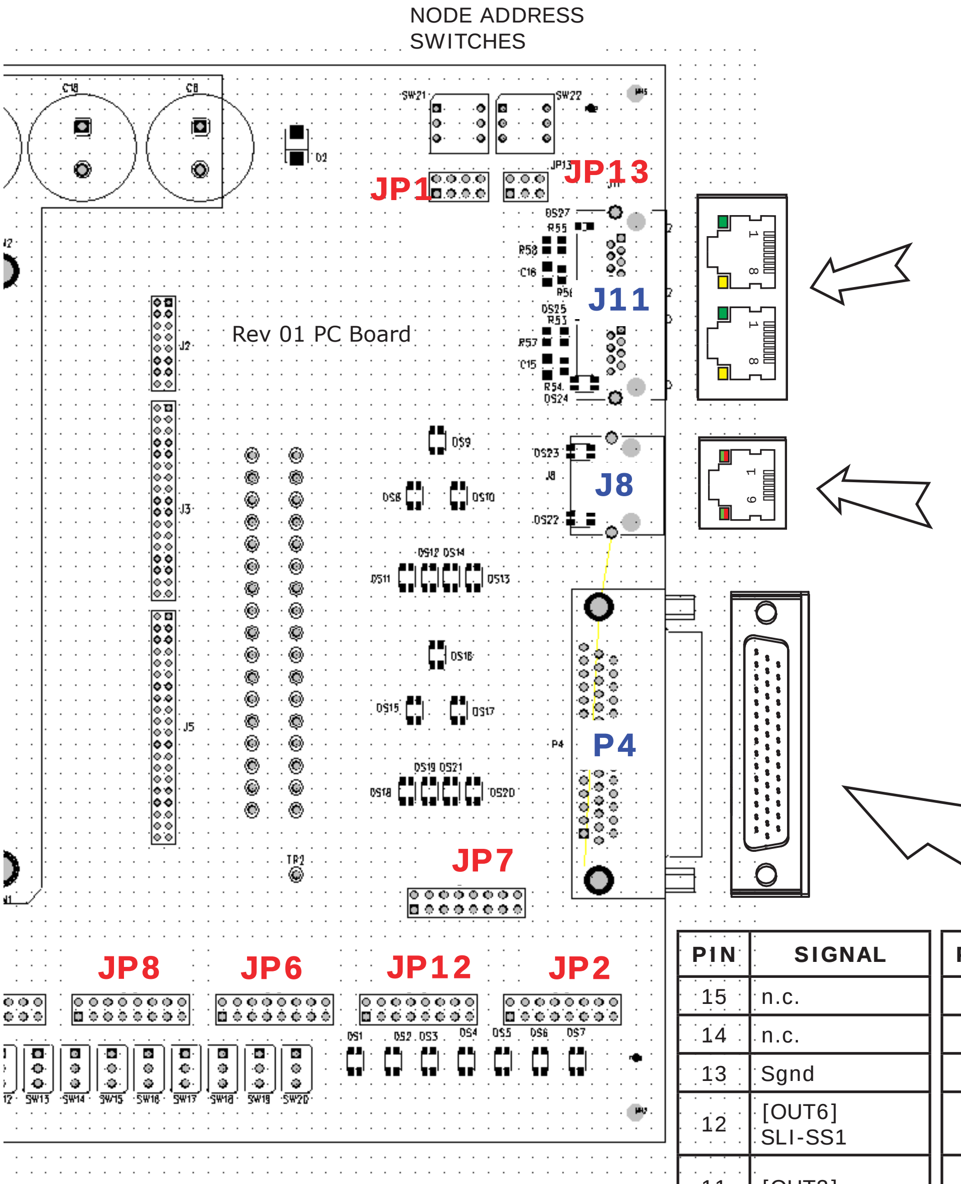
PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
26	Signal Gnd	18	Sin(-)	9	Enc X
25	Signal Gnd	17	+5V ENC*	8	Enc /X
24	Enc Fault	16	Signal Gnd	7	Motemp**
23	Index(+)	15	Enc S	6	+5V ENC*
22	Index(-)	14	Enc /S	5	Signal Gnd
21	Cos(+)	13	Enc A	4	Hall W
20	Cos(-)	12	Enc /A	3	Hall V
19	Sin(+)	11	Enc B	2	Hall U
		10	Enc /B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

* The AP2 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: CANOPEN

Pin	Signal
1	CAN_H
2	CAN_L
3	CAN_GND

J8: RS-232

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

P4: CONTROL 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		

THERMAL MANAGEMENT

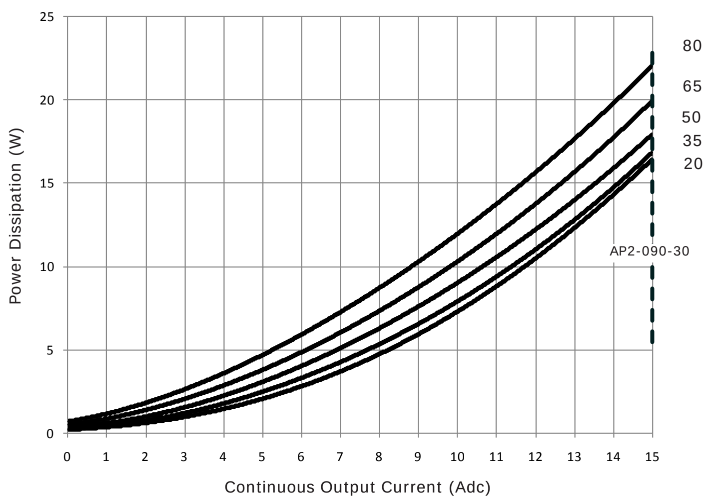
The charts on this page show the internal power dissipation for different models under differing power supply and output current conditions. The values on the chart represent the continuous current that one of the two axes would provide during operation. The +HV values are for the average DC voltage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

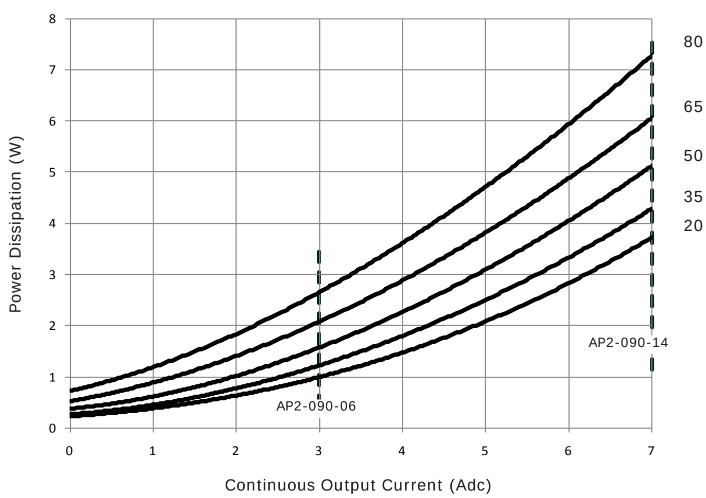
STEP 1: FIND THE POWER DISSIPATION FOR EACH AXIS

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.

AP2-090-30



AP2-090-06, AP2-090-14

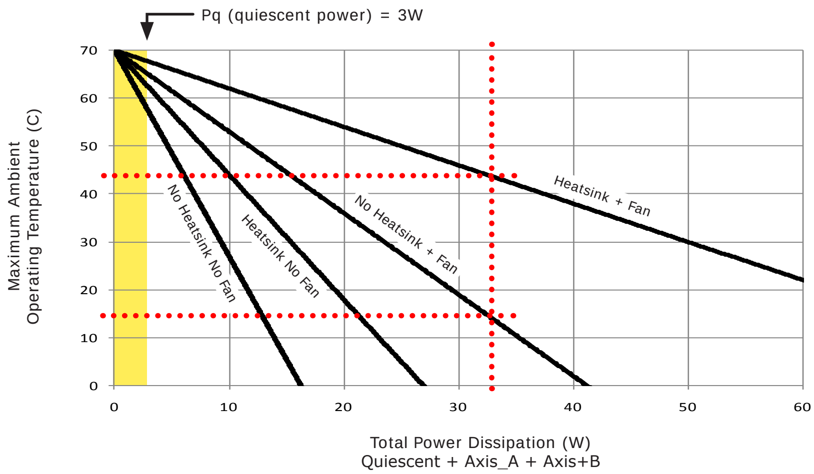


STEP 2: FIND MOUNTING AND COOLING MEANS REQUIRED FOR DIFFERENT AMBIENT TEMPERATURES

Find the total power dissipation for the AP2 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.



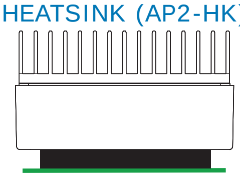
HEATSINK OPTIONS

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 AP2-HS heatsink.

NO HEATSINK

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

HEATSINK (AP2-HK)



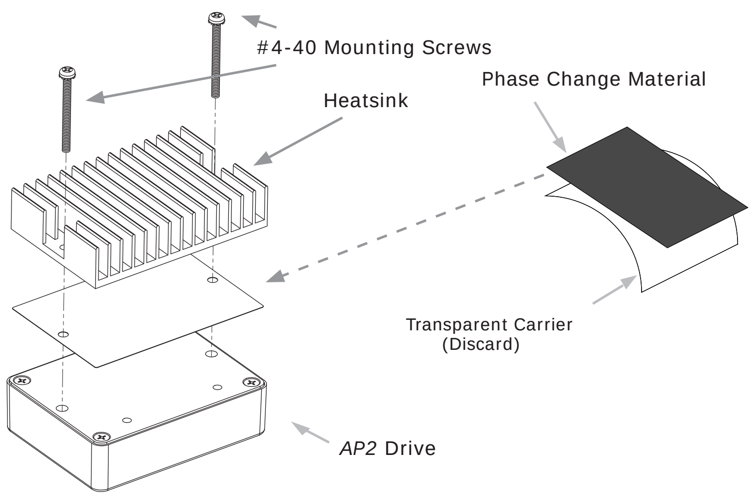
AIR FLOW	C/W
CONVECTION	2.6
FORCED AIR (300 LFM)	0.8

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).



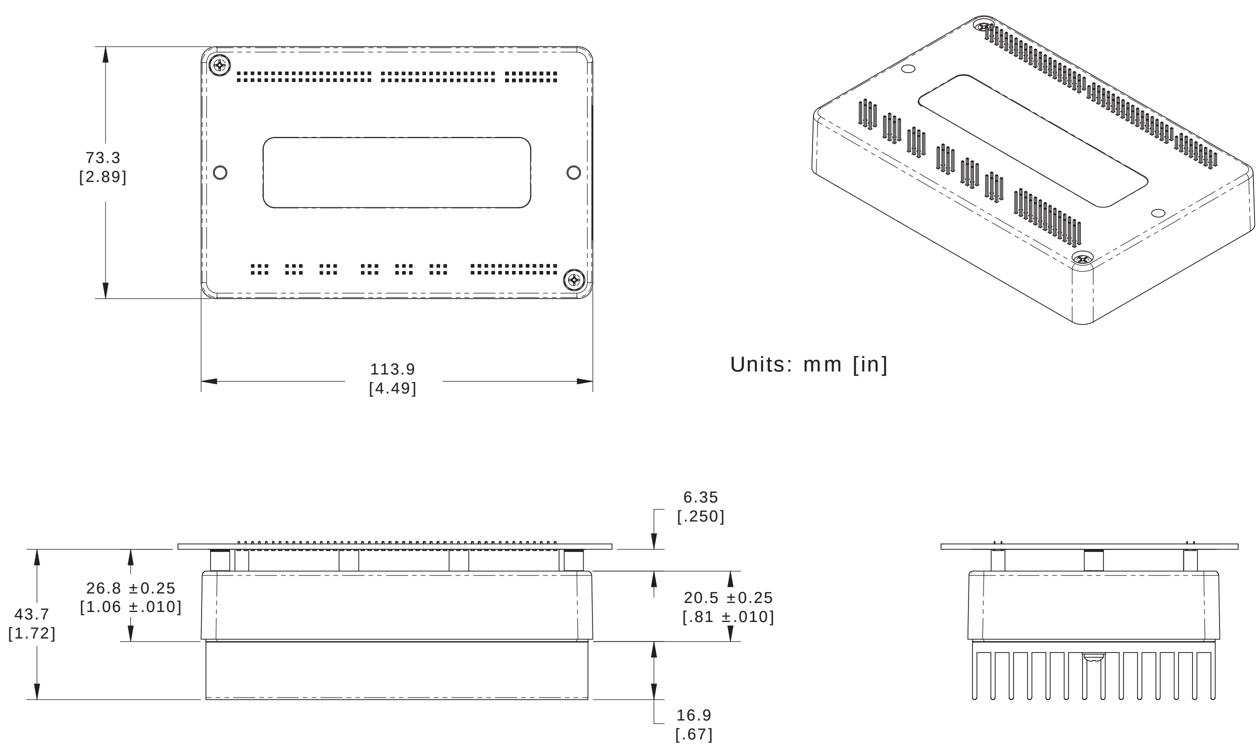
MASTER ORDERING GUIDE

AP2-090-06	*Accelnet* AP2 servo drive, 3/6 A, 90 Vdc
AP2-090-14	*Accelnet* AP2 servo drive, 7/14 A, 90 Vdc
AP2-090-30	*Accelnet* AP2 servo drive, 15/30 A, 90 Vdc
APK-090-02	Development Kit for AP2 servo drives

ACCESSORIES

	QTY	DESCRIPTION
Connector Kit for Development Kit APK-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	P4: 44 Pin Connector, High Density, D-Sub, Female, Solder Cup
	1	P4: 44 Pin Connector Backshell
Heatsink Kit AP2-HK	1	Heatsink for AP2
	1	Heatsink Thermal Material
	4	Heatsink Hardware
APK-NC-10		Ethernet Network Cable, 10 ft
APK-NC-01		Ethernet network cable, 1 ft
CME 2		CME 2 Drive Configuration Software on CD-ROM
SER-CK		Serial Cable Kit

DIMENSIONS



Note: Specifications subject to change without notice

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