2-AXIS DIGITAL DRIVE
FOR STEPPER MOTORS

Control Modes
- Position (Microstepping)
- Position/Velocity/Torque (Servo Mode)
- Indexer, Point-to-Point, PVT
- Camming, Gearing

Command Interface
- CAN application layer over EtherCAT (CoE)
- ASCII and discrete I/O
- Stepper commands
- ±10V or PWM velocity/torque (servo mode)
- Master encoder (Gearing/Camming)

Communications
- EtherCAT
- RS-232

Feedback
- Digital quad A/B encoder

I/O
- Digital: 26 inputs, 7 outputs
- Analog: 2 inputs

Dimensions: mm [in]
- 114 x 73 x 21 [4.5 x 2.9 x 0.83]

EtherCAT Conformance tested

Model	Ic	Ip	Vdc
SE2-090-07	5	7	14~90
SE2-090-10	10	10	14~90

DEVELOPMENT KIT

DESCRIPTION

Stepnet SE2 is a dual-axis, high-performance, DC powered drive for position, velocity, and torque control of stepper motors via EtherCAT, an Ethernet-based fieldbus. Using advanced FPGA technology, the *SE2* provides a significant reduction in the cost per node in multi-axis EtherCAT systems.

Each of the two drives in the *SE2* operate as an *EtherCAT* slave using the CAN application layer over EtherCAT (CoE) protocol of DSP-402 for motion control devices. Supported modes include: Profile Position-Velocity, Cyclic Synchronous Position-Velocity, Interpolated Position Mode (PVT), and Homing. Servo mode allows ±10V analog or digital PWM control of position/velocity/torque. In microstepping mode stepper command pulses and master encoder for camming or gearing is supported.

Twenty-three 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 another high-speed input and four high-speed digital outputs. If not used for SLI, 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 = Bipolar stepper: 2 mH + 2 Ω per phase. Ambient temperature = 25°C, +HV = HV_{max}

MODEL	SE2-090-07	SE2-090-10	
OUTPUT POWER (each axis)			
Peak Current	7 (5)	10 (7.1)	Adc (Arms-sine), ±5%
Peak time	1	1	Sec
Continuous current	5 (3.5)	10 (7.1)	Adc (Arms-sine) per phase (Note 1)
Maximum Output Voltage			Vout = HV*0.97 - Rout*Iout
INPUT POWER (module)			
HVmin~HVmax	+14 to +90	+14 to +90	Vdc Transformer-isolated
Ipeak	14	11	Adc (1 sec) peak
Icont	10	11	Adc continuous (Note 1)
Aux HV	+14 to +HV Vdc @ 500 mAdc maximum, 2.5 W		
PWM OUTPUTS (each axis)			
Type	Dual H-bridge MOSFET , 16 kHz center-weighted PWM, space-vector modulation		
PWM ripple frequency	32 kHz		
CONTROL MODES			
EtherCAT: CAN application layer over EtherCAT (CoE): Profile Position/Velocity & Profile Torque (servo mode) Interpolated Position (PVT), Homing, Cyclic Synchronous Position/Velocity			
Position/velocity, open-loop, microstepping			
Position/velocity/torque, closed-loop, servo mode			
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, velocity/torque control in servo mode		
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 stepper 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		
ANALOG INPUTS			
Number	2		
Type	±10 Vdc, 12-bit resolution, differential		
DIGITAL INPUTS			
Number, type	24, 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, 21~26]	High-speed digital, 100 ns RC filter, 10 kΩ pull-up to +3.3 Vdc		
[IN18]	SLI port MISO input, 47 ns RC filter, 1 kΩ pull-up to +3.3 Vdc 2, 74LVC2G14, V_T+ = 1.3~2.2 Vdc, V_T- = 0.6~1.5 Vdc, V_H+ = 0.4~1.2 Vdc		
[IN19~20]	Motor temperature switch, 330 µs RC filter, 4.99 kΩ pull-up to +3.3 Vdc		
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		
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		
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)			
MAX3094 differential line receiver with 121 Ω terminating resistor between complementary inputs for A,B,X inputs			
MAX3362 line transceivers for X and S signals			
Encoder power	Two outputs: +5 Vdc ±2% @ 400 mAdc max each output		

Notes:

1) Heatsink is required for continuous current ratings.

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 (each axis)

Phases A, /A, B, /B	PWM outputs to 2-phase, 4-wire bipolar stepper motors
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)
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	
I^2T Current limiting	Programmable: continuous current, peak current, peak time	
Motor over temperature	Digital inputs programmable to detect motor temperature switch	

MECHANICAL & ENVIRONMENTAL

Size mm [in]	114 x 73 x 21 [4.5 x 2.9 x 0.83]
Weight	0.19 kg [0.42 lb] module only, no 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 2004/108/EC (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 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.: 2008	Electrical Equipment for Measurement, Control and Laboratory Use; Part 1: General Requirements

UL File Number E249894

CONTROL MODES AND COMMAND INPUTS

This chart shows the possible combinations of Control Modes and the Command Inputs that are available in each mode. Servo mode is the use of encoder feedback to operate the stepper as a brushless motor.

	Control Mode			
Command Source	Position	Velocity	Torque	Servo
CAN Profile Position	•			O
CAN Profile Velocity		•		O
CAN Profile Torque			•	R
CAN Homing	•			O
CAN Interpolated Position	•			O
Quad A/B Encoder	•			O
±10V		•	•	R
Digital Pls/Dir	•			O
Digital CW/CCW	•			O
Digital PWM		•	•	R

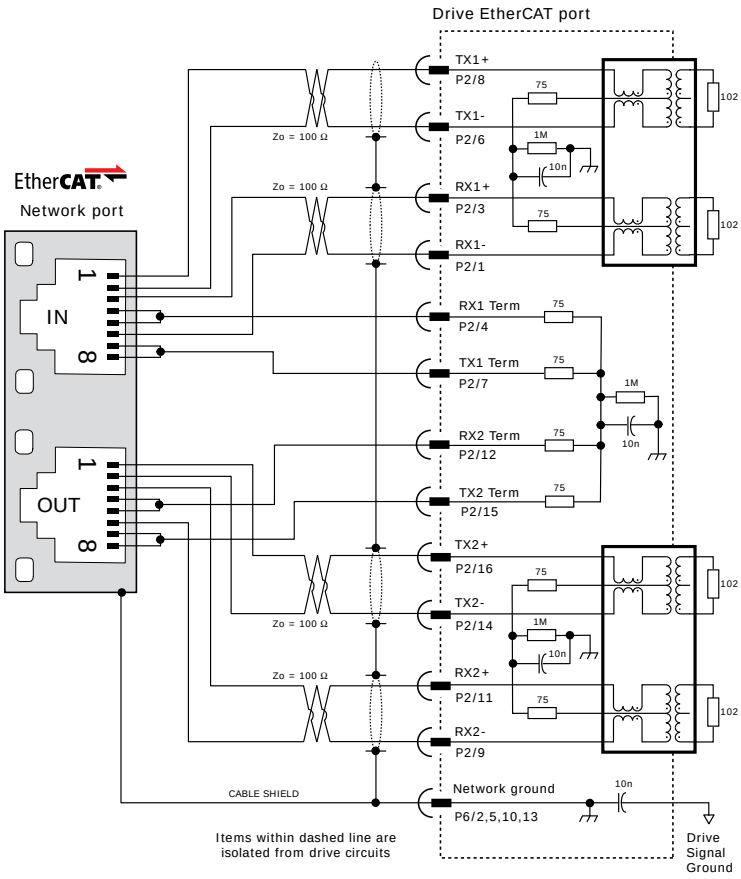
Servo Mode: O = optional, R = required

CAN = CANopen DS-402

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



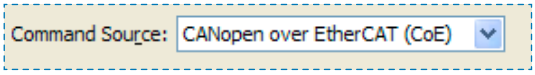
ETHERCAT CONNECTIONS

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.

HOW IT LOOKS IN CME2

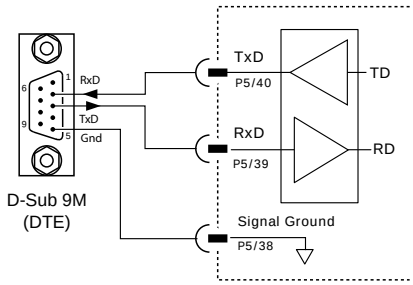
CME2 -> Basic Setup -> Operating Mode Options



RS-232 COMMUNICATIONS

SE2 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 *SE2* RS-232 port are through P2 The graphic below shows the connections between an *SE2* and a computer COM port which is a DTE device.

RS232 PORT



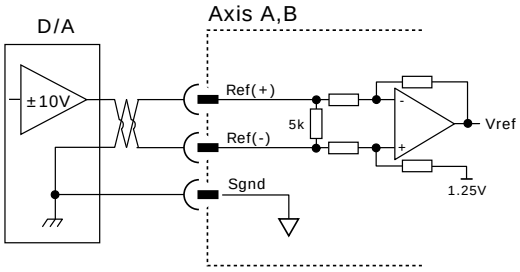
HOW IT LOOKS IN CME2

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.



SIGNALS & PINS

±10V Signal	P5 Pins	
	Axis A	Axis B
Ref(+)	3	5
Ref(-)	4	6
Sgnd	7	8

HOW IT LOOKS IN CME2

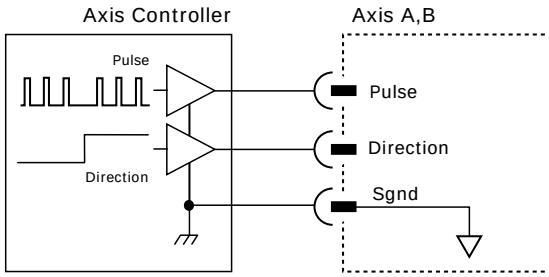
CME2 -> Basic Setup -> Operating Mode Options

DIGITAL COMMAND INPUTS

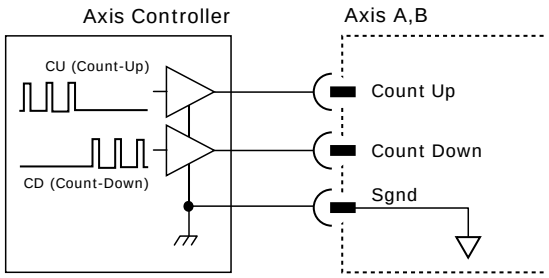
Digital commands are single-ended format and should be sourced from devices with active pull-up and pull-down to take advantage of the high-speed inputs. The active edge (rising or falling) is programmable for the Pulse/Dir and CU/CD formats.

DIGITAL POSITION

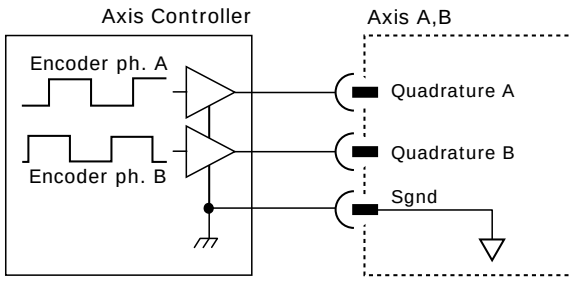
PULSE & DIRECTION



CU/CD

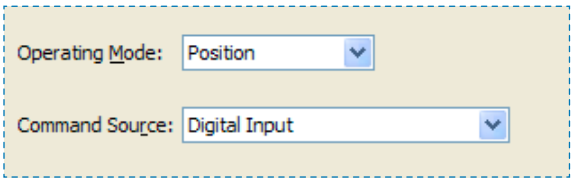


QUAD A/B ENCODER



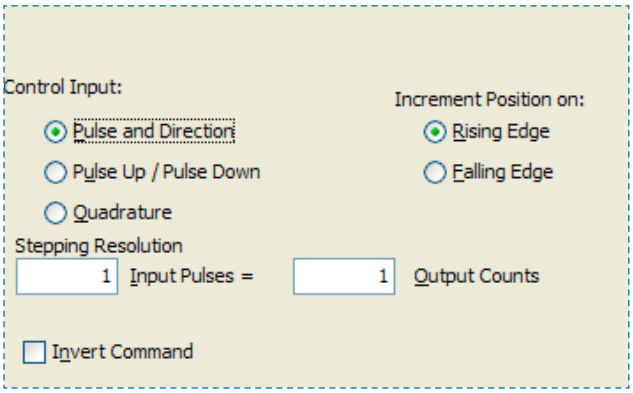
HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Operating Mode Options



HOW IT LOOKS IN CME2

CME2 -> Main Page -> Digital Inputs



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

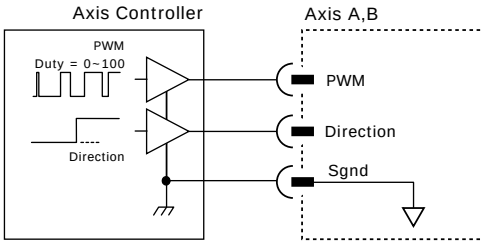
SIGNALS & PINS

Signal Types			P5 Pins		Input	
			Axis A	Axis B	Axis A	Axis B
Pulse	Count Up	Quad A	14	24	[IN6]	[IN16]
Dir	Count Down	Quad B	15	25	[IN7]	[IN17]

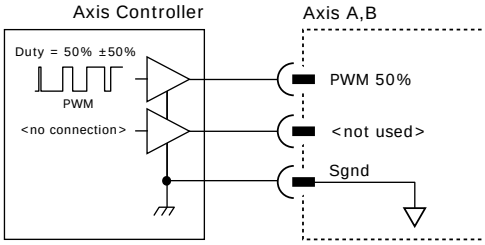
DIGITAL COMMAND INPUTS (CONT'D)

DIGITAL TORQUE, VELOCITY

PWM/DIR COMMAND (100% DUTY CYCLE)



PWM COMMAND (50% DUTY CYCLE)

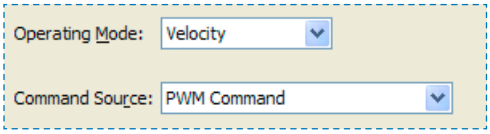


SIGNALS & PINS

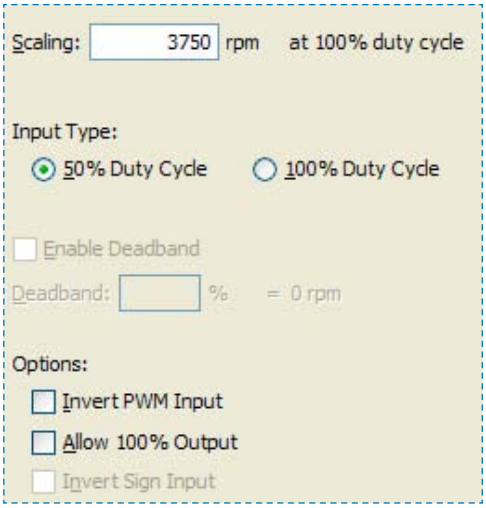
Signal Types		P5 Pins		Input	
		Axis A	Axis B	Axis A	Axis B
PWM	PWM 50%	14	24	[IN6]	[IN16]
Dir	< not used>	15	25	[IN7]	[IN17]

HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Operating Mode Options



CME2 -> Main Page-> PWM Command

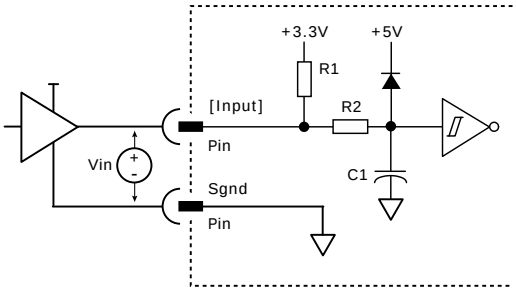


This screen shows the 50% Duty Cycle selection. Other modes are selectable via radio buttons and pull-down menus for Operating Mode and Command Source.

DIGITAL INPUTS

HIGH SPEED DIGITAL INPUTS

7V tolerant



HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN1~18 IN21~26	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc
IN19~20	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.6 Vdc

DIGITAL INPUT PINS AND STRUCTURE

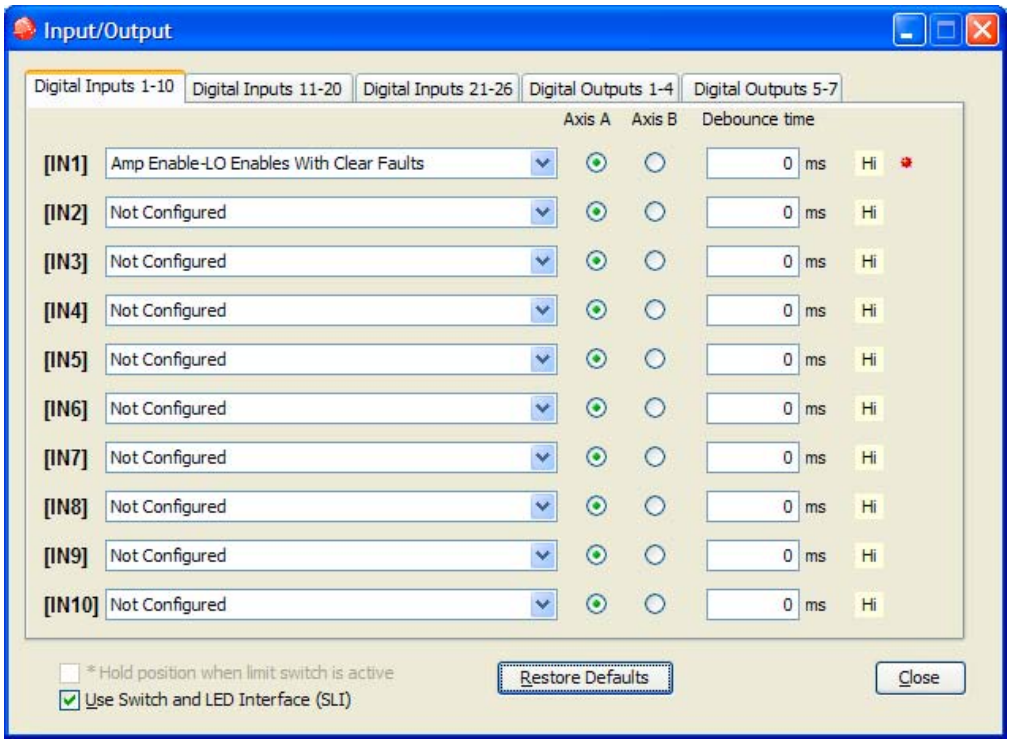
Input	P2 Pin	R1	R2	C1
IN1	9	10k	1k	100p
IN2	10			
IN3	11			
IN4	12			
IN5	13			
IN6	14			
IN7	15			
IN8	16			
IN9	17			
IN10	18			
IN11	19			
IN12	20			
IN13	21			

Input	P2 Pin	R1	R2	C1
IN14	22	10k	1k	100p
IN15	23			
IN16	24			
IN17	25			
IN18	26			47p
IN19	27	4.99k	10k	33n
IN20	28			
IN21	P3-1	10k	1k	100p
IN22	P3-3			
IN23	P3-5			
IN24	P3-2			
IN25	P3-4			
IN26	P3-6			

DIGITAL INPUT DETAILS

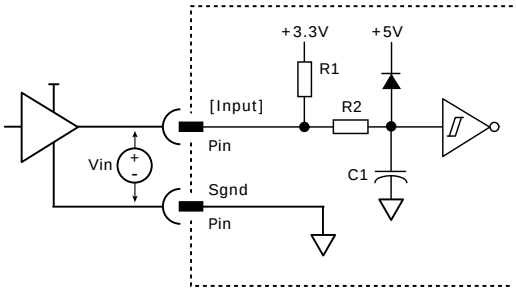
HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Inputs 1-10 (Defaults)



HIGH SPEED DIGITAL INPUTS

7V tolerant



DIGITAL INPUT PINS AND STRUCTURE

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			

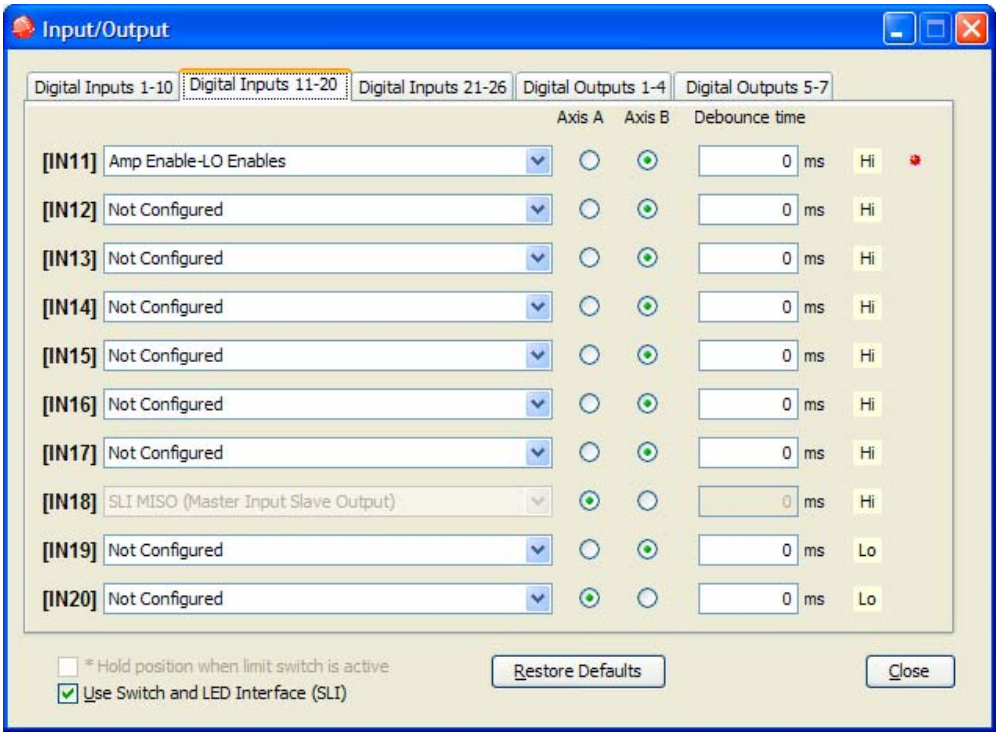
HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN1~10	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc

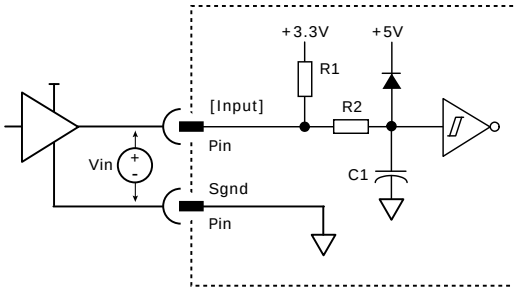
DIGITAL INPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Inputs 11-20 (Defaults)



HIGH SPEED DIGITAL INPUTS



DIGITAL INPUT PINS AND STRUCTURE

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

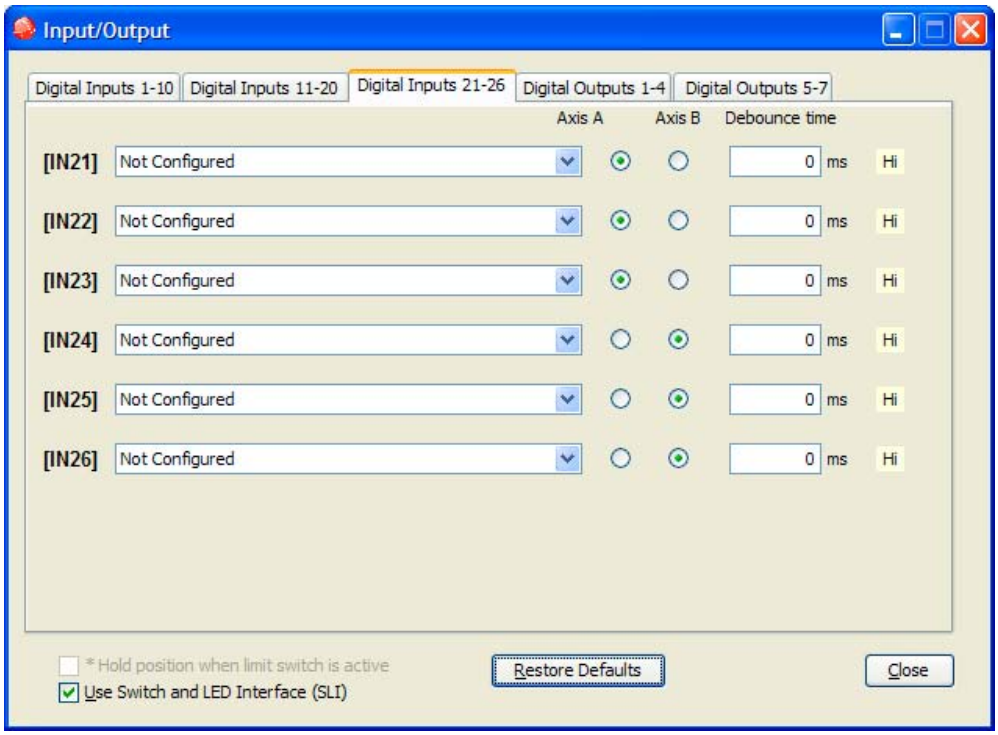
HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN11~18	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc
IN19~20	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.6 Vdc

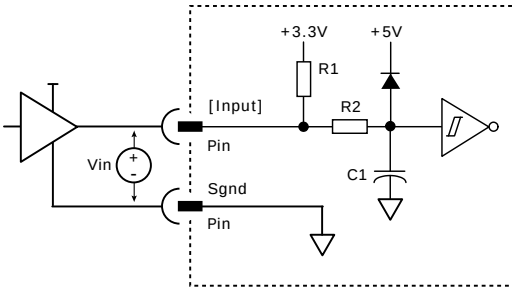
DIGITAL INPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Inputs 21-26 (Defaults)



HIGH SPEED DIGITAL INPUTS



DIGITAL INPUT PINS AND STRUCTURE

Input	P2 Pin	R1	R2	C1
IN21	P3-1	10k	1k	100p
IN22	P3-3			
IN23	P3-5			
IN24	P3-2			
IN25	P3-4			
IN26	P3-6			

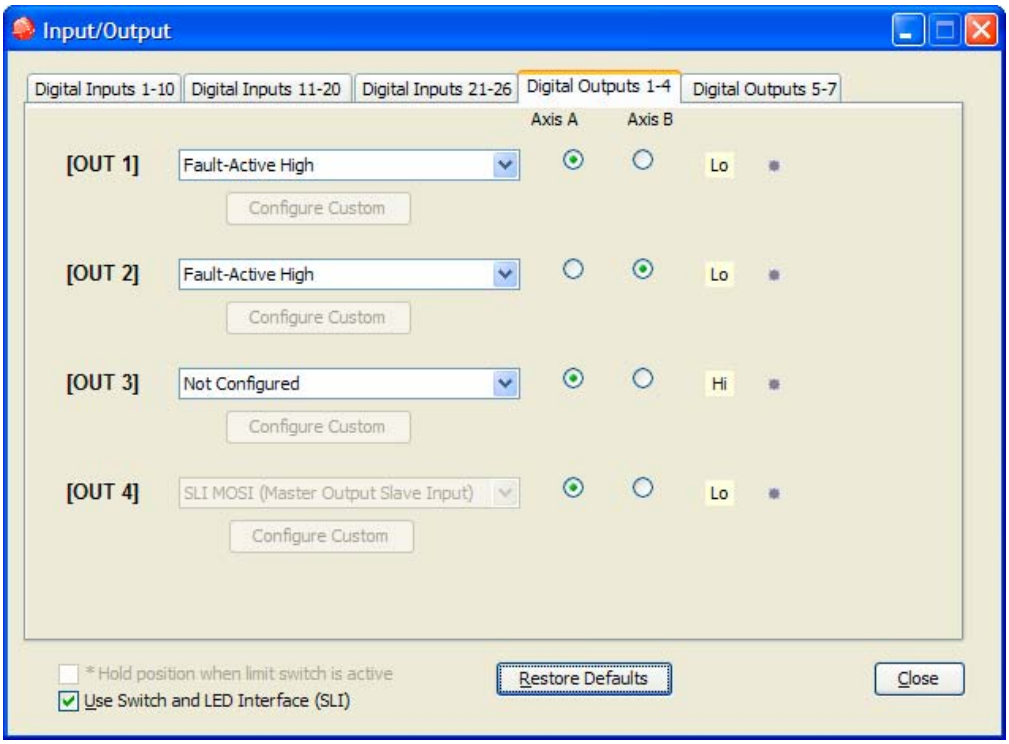
HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN21~26	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc

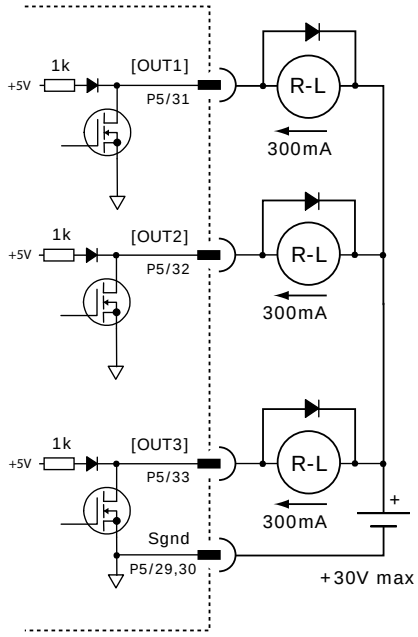
DIGITAL OUTPUT DETAILS

HOW IT LOOKS IN CME2

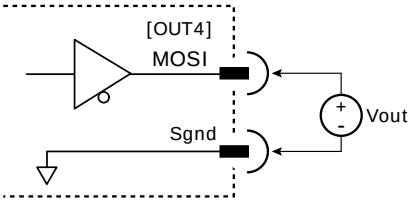
CME2 -> Main Page-> Input/Output -> Digital Outputs 1-4 (Defaults)



MOSFET DIGITAL OUTPUTS [OUT1~3]



HIGH SPEED DIGITAL [OUT4]



74HCT125
5V max

HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
OUT1~3	HI	MOSFET OFF
	LO	MOSFET ON
OUT4	HI	Vout >= 2.2 Vdc
	LO	Vout <= 0.8 Vdc

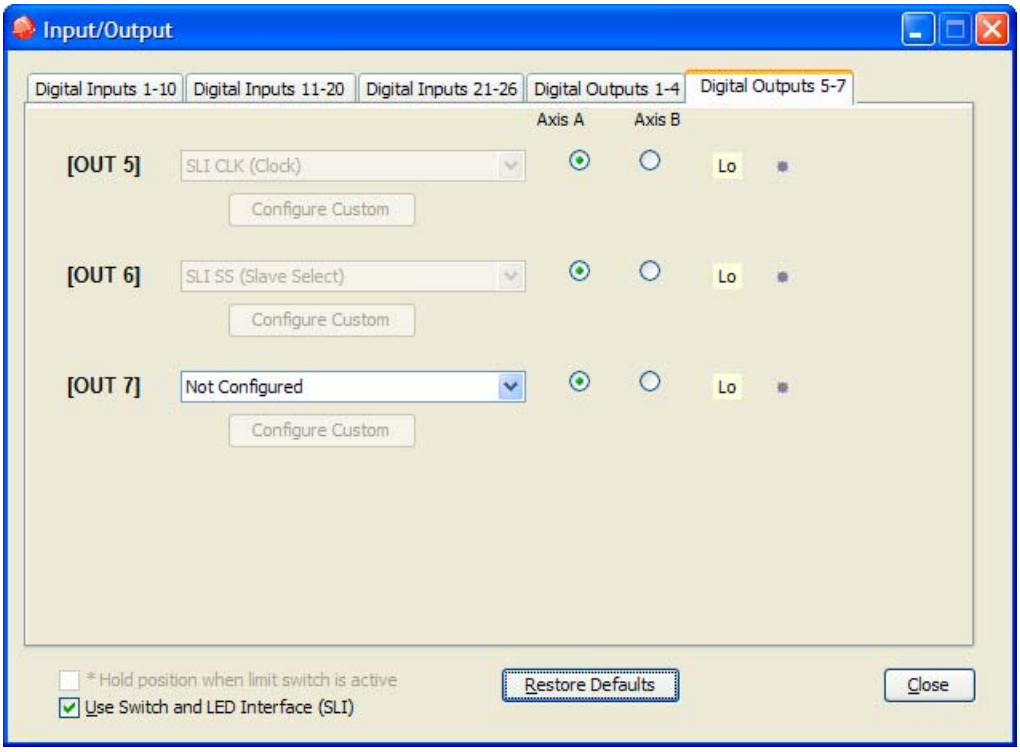
SIGNALS & PINS

Output	P5 Pin
OUT1	31
OUT2	32
OUT3	33
OUT4	34

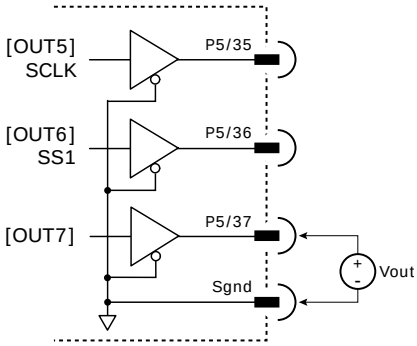
DIGITAL OUTPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Outputs 1-4 (Defaults)



HIGH SPEED DIGITAL [OUT5~7]



74HCT125
5V max

HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
OUT4~7	HI	Vout >= 2.2 Vdc
	LO	Vout <= 0.8 Vdc

SIGNALS & PINS

Output	P5 Pin
OUT5	35
OUT6	36
OUT7	37

ETHERCAT DEVICE ID (STATION ALIAS) SWITCHES

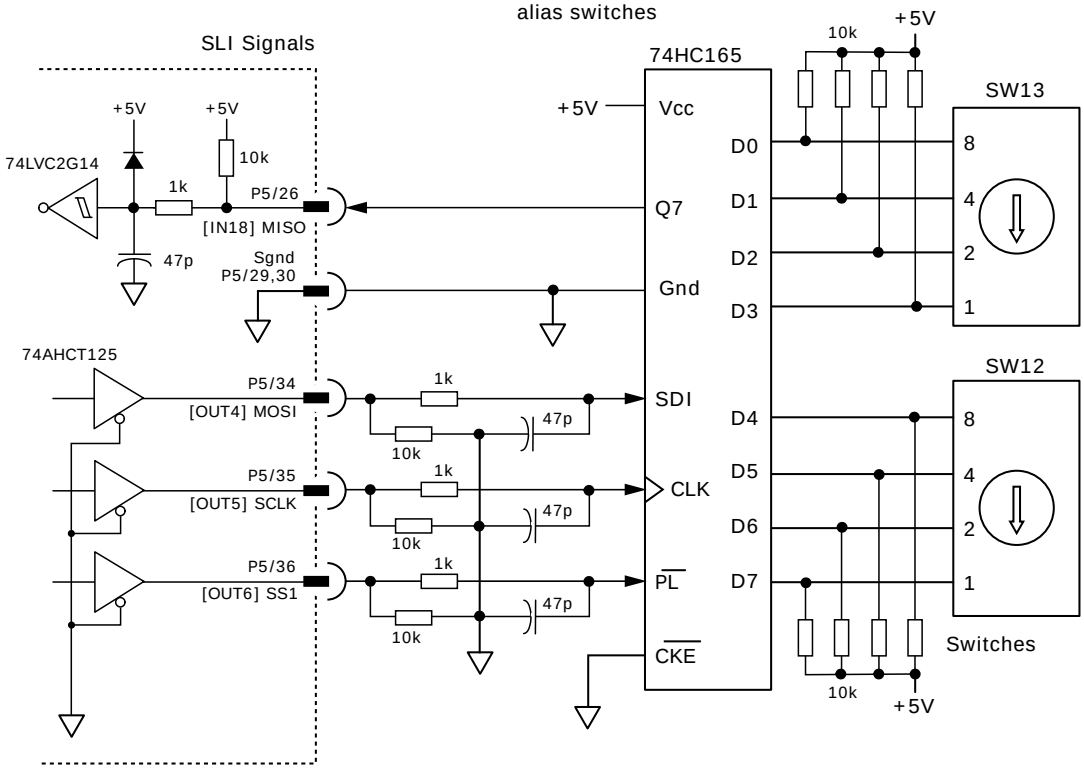
The SLI (Switch & LED Interface) port takes in the 8 signals from the two BCD encoded switches that set the EtherCAT alias device ID and controls the LEDs on the EtherCAT port connectors.
The graphic below shows the circuit for reading the EtherCAT device ID switches.
The 74HC165 works as a parallel-in/serial-out device.
The 10k pull-down resistors pull the shift register inputs to ground when the SE2 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 a device ID range of 0~255.

CME2 -> Input/Output -> Digital Outputs

HOW IT LOOKS IN CME2

CME2 -> Amplifier -> Network Configuration

External circuit for EtherCAT alias switches



ETHERCAT 2-AXIS AND THE OBJECT DICTIONARY

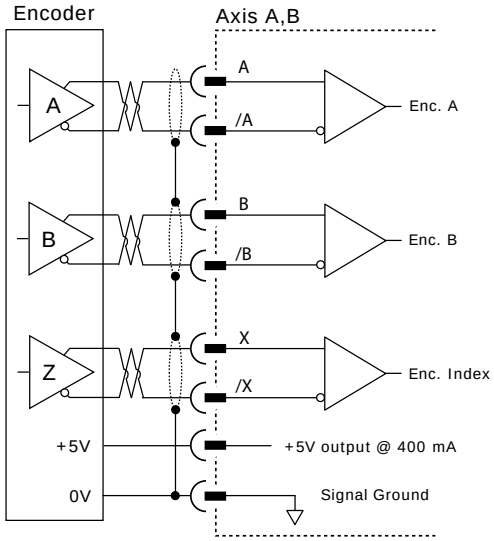
Single-axis EtherCAT devices use objects in the range of 0x6000 to 0x67FF for standardized data that are read or written via the network as defined in CAN-CiA document CiA 301 *CANopen Application Layer and Communication Profile.* The SE2 appears as a single slave node on an EtherCAT network that contains 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 SE2 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, encoder, thermal sensor, and brake. The phase connections carry the drive output currents that drive the motor to produce motion. 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.

DIGITAL QUADRATURE ENCODER INPUT

5V



ENCODER SIGNALS & PINS

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

HOW IT LOOKS IN CME2

CME2 -> Motor/Feedback -> Feedback

MOTOR CONNECTIONS (CONT'D)

MOTOR PHASE CONNECTIONS

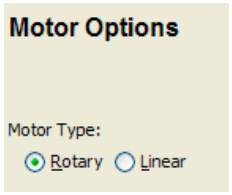
The drive outputs are two H-bridge PWM inverters that convert-sthe DC bus voltage (+HV) into sinusoidal voltage waveforms that drive the motor phase-coils. Cable should be sized for the continuous current rating of the drive. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the drive HV ground terminal for best results.

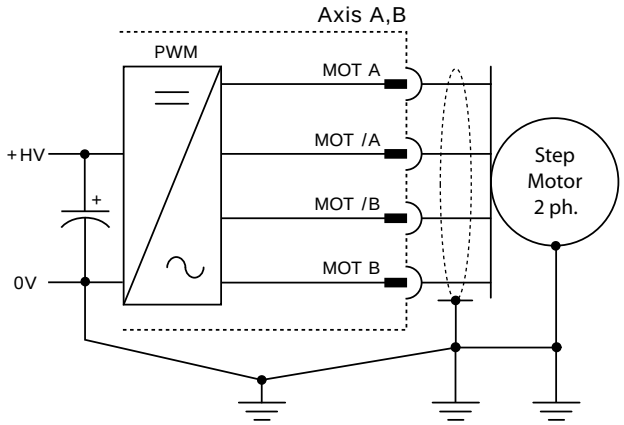
SIGNALS & PINS

Motor Signal*	Axis A	Axis B
	P4-pins	P6-pins
Phase A	1~4	
Phase /A	7~10	
Phase /B	15~18	
Phase B	21~24	
Shield	Sgnd	

HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Motor Options





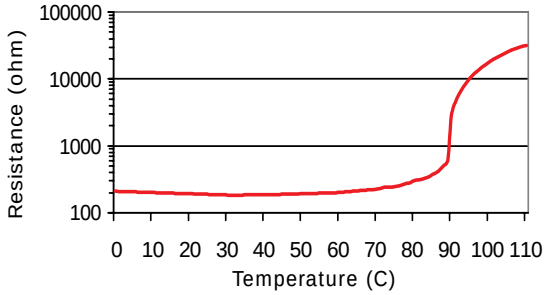
MOTOR OVER TEMP INPUT

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.

BS 4999 PTC THERMISTOR PROPERTIES

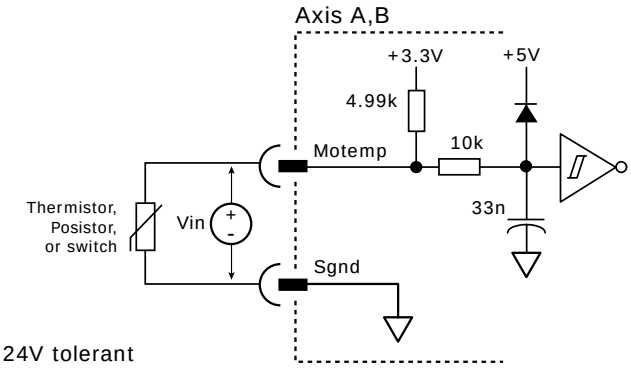
Property	Ohms
Resistance in the temperature range 20°C to +70°C	60~750
Resistance at 85°C	≤1650
Resistance at 95°C	≥3990
Resistance at 105°C	≥12000

BS 4999 TYPICAL RESISTANCE VS TEMPERATURE



HOW IT LOOKS IN CME2

CME2 -> Input / Output



24V tolerant

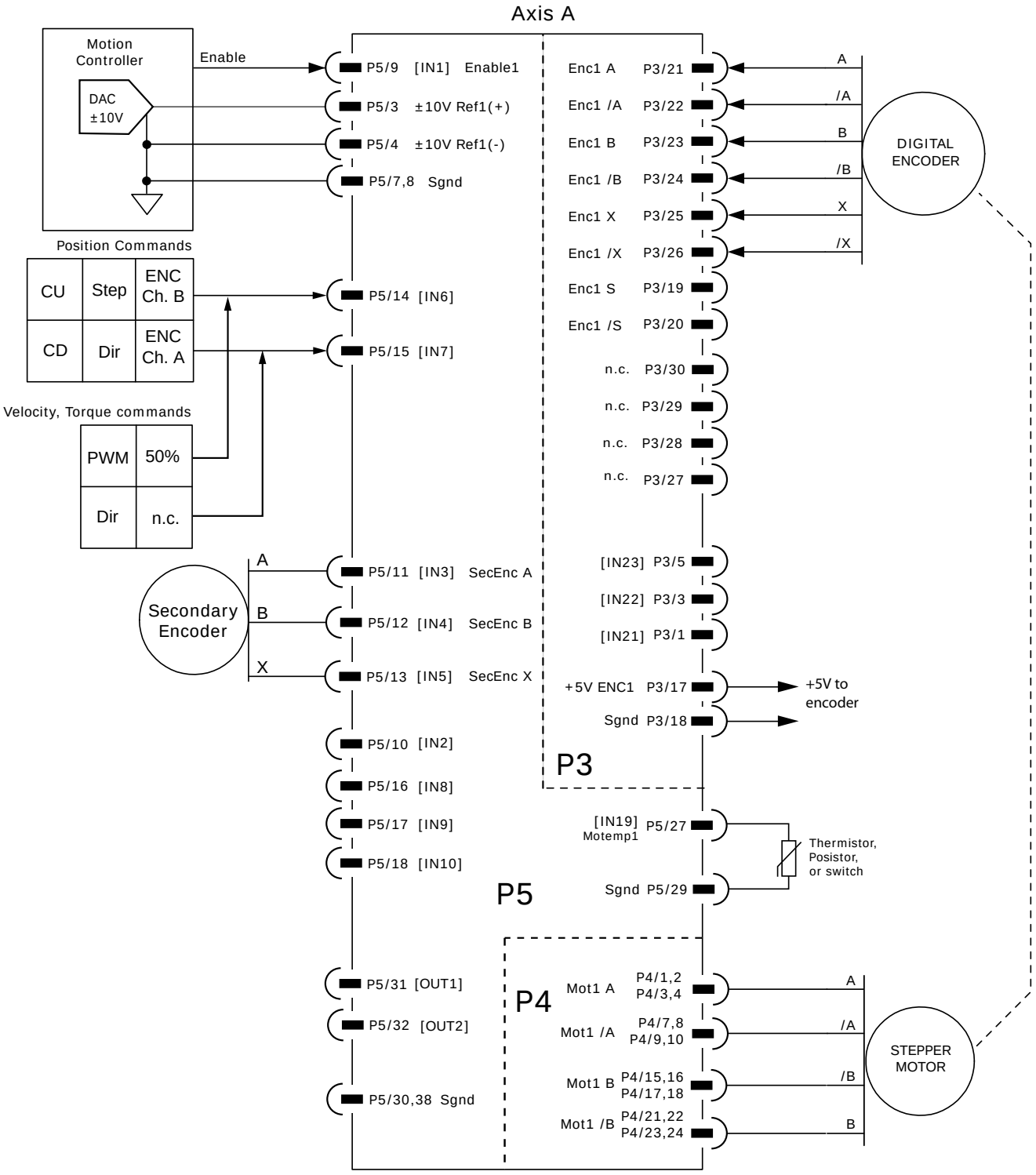
HI/LO DEFINITIONS: MOTEMP

Input	State	Condition
IN19~20	HI	Vin >= 1.2 Vdc
	LO	Vin <= 0.6 Vdc

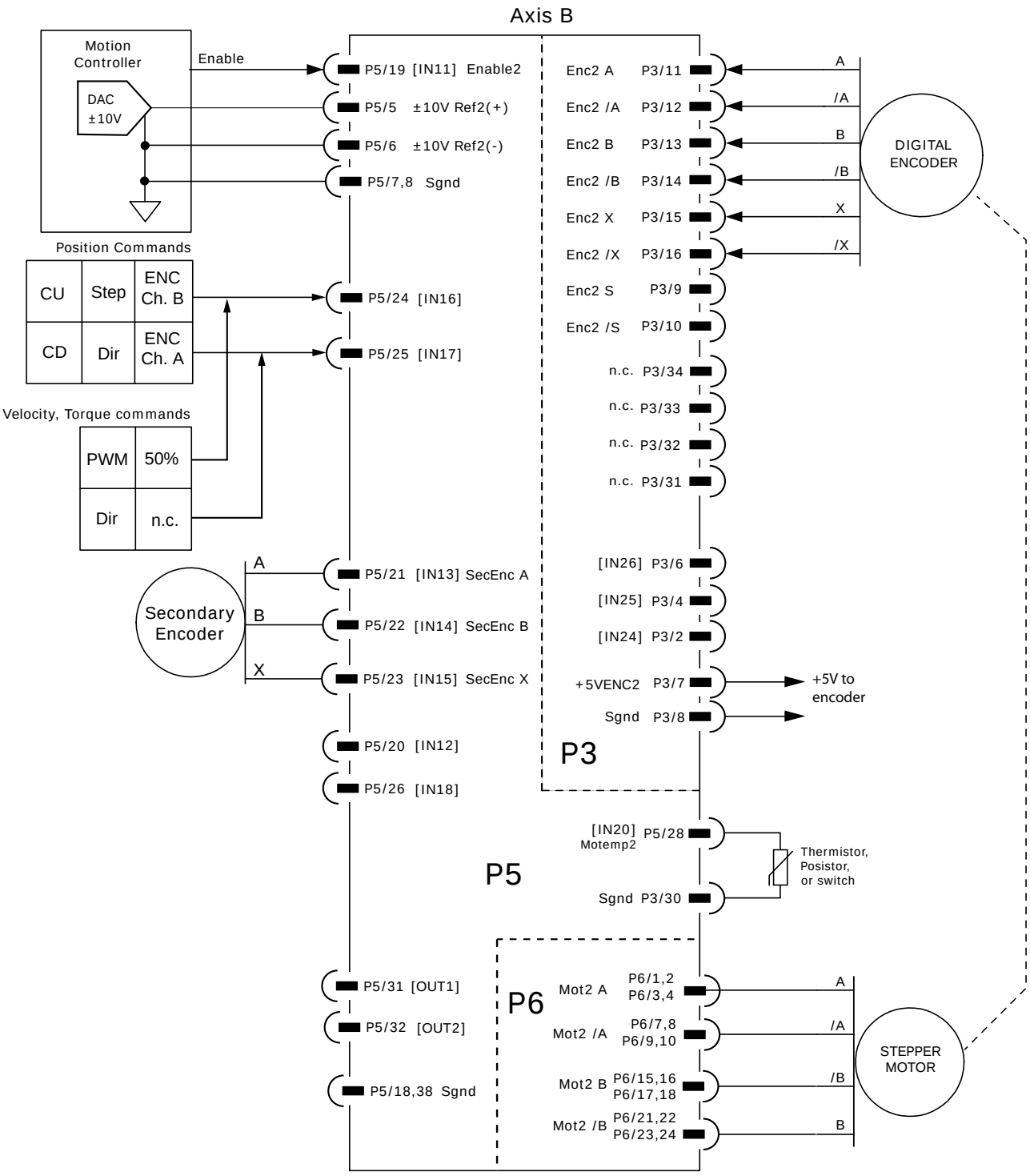
SIGNALS & PINS

Signal	Axis A	Axis B
	P5-pins	
Motemp	27	28
Input	[IN19]	[IN20]

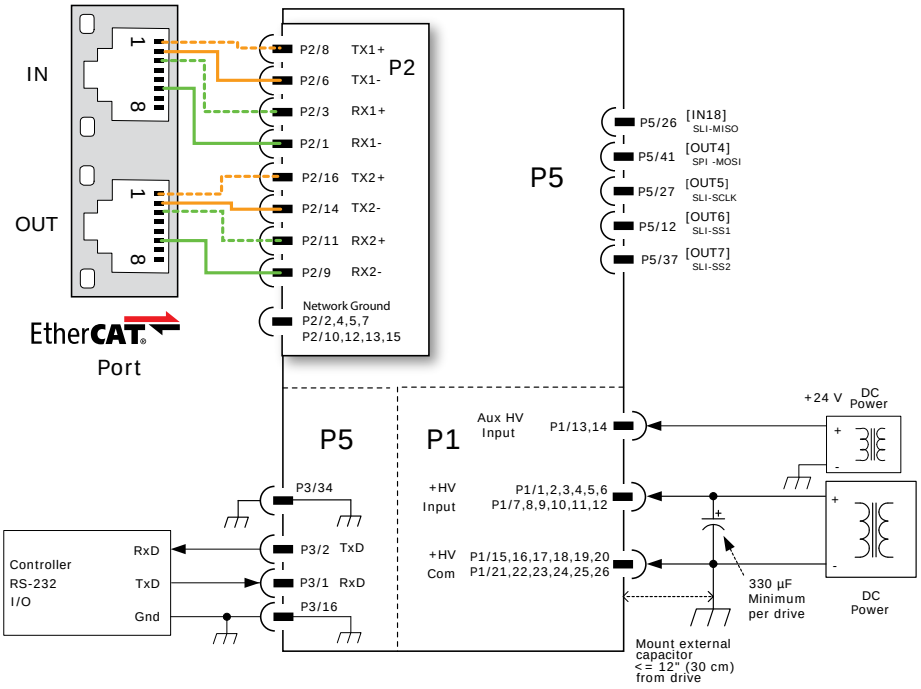
AXIS A CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



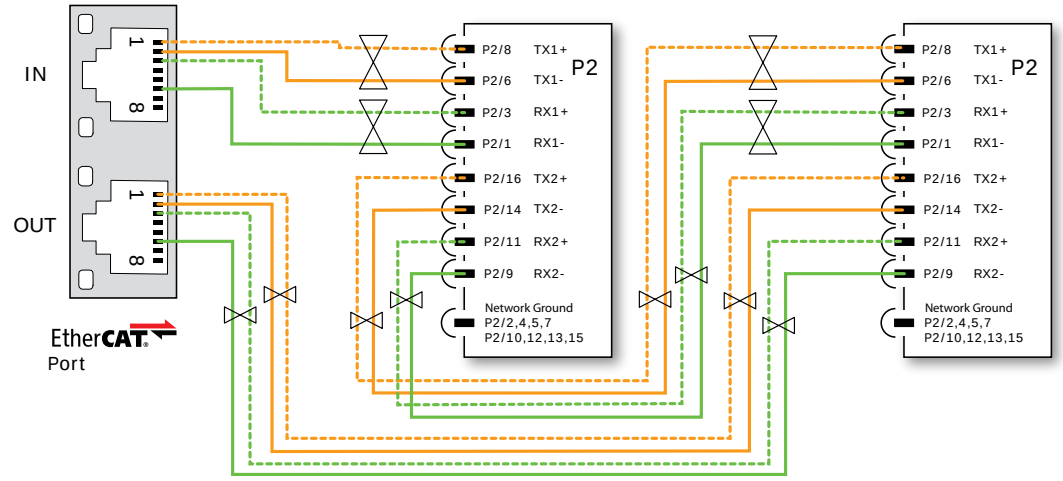
AXIS B CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS



COMMON CONNECTIONS FOR AXES A,B

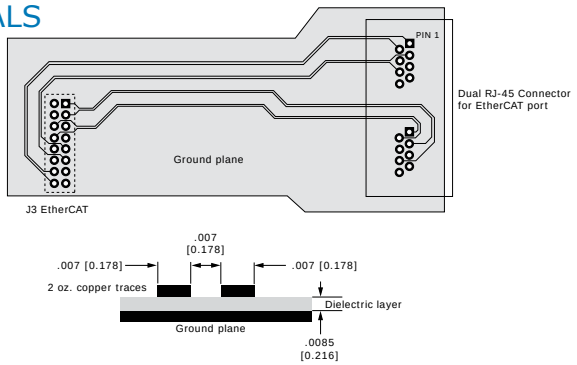


ETHERCAT CONNECTIONS FOR MULTIPLE MODULES



PRINTED CIRCUIT BOARD DESIGN FOR ETHERCAT SIGNALS

EtherCAT signal routing must produce a controlled impedance of 100 ohms 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 EtherCAT connections shows resistors and a capacitor in the SE2 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.



THIS PAGE LEFT BLANK
INTENTIONALLY

PC BOARD CONNECTORS & SIGNALS

CONNECTOR NAMING (P1, P2, ETC) APPLIES TO THE SE2 MODULE AND NOT TO PC BOARD MOUNTED SOCKETS

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

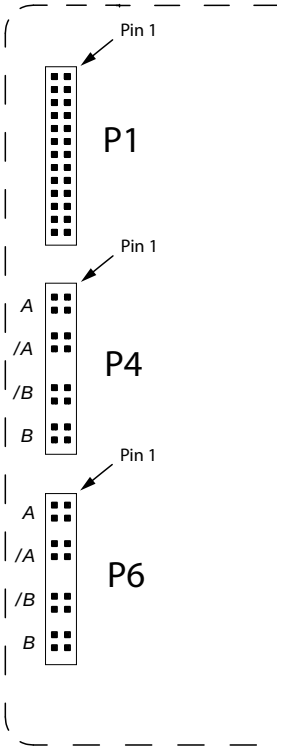
P4 AXIS A MOTOR

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

Signal	Pin		Signal
MOT A	2	1	MOT A
MOT A	4	3	MOT A
n.c.	6	5	n.c.
MOT /A	8	7	MOT /A
MOT /A	10	9	MOT /A
n.c.	12	11	n.c.
n.c.	14	13	n.c.
MOT /B	16	15	MOT /B
MOT /B	18	17	MOT /B
n.c.	20	19	n.c.
MOT B	22	21	MOT B
MOT B	24	23	MOT B

TOP VIEW

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



Note: The sequence of motor signals for the module is different than the sequence for Development Kit connectors!

DevKit	*Module*
A	*A*
/A	*/A*
B	*/B*
/B	*B*

P6 AXIS B MOTOR

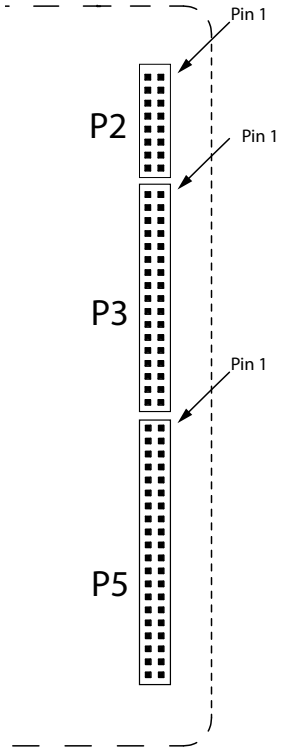
Mounting board connector:
Samtec SQW-113-01-F-D

Signal	Pin		Signal
MOT A	2	1	MOT A
MOT A	4	3	MOT A
n.c.	6	5	n.c.
MOT /A	8	7	MOT /A
MOT /A	10	9	MOT /A
n.c.	12	11	n.c.
n.c.	14	13	n.c.
MOT /B	16	15	MOT /B
MOT /B	18	17	MOT/ B
n.c.	20	19	n.c.
MOT B	22	21	MOT B
MOT B	24	23	MOT B

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
HS [IN24]	2	1	[IN21] HS
HS [IN25]	4	3	[IN22] HS
HS [IN26]	6	5	[IN23] HS
Signal Gnd	8	7	Axis B +5V Enc
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 +5V Enc
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
n.c.	28	27	n.c.
n.c.	30	29	n.c.
n.c.	32	31	n.c.
n.c.	34	33	n.c.

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
HS [IN4]	12	11	[IN3] HS Axis
HS [IN6]	14	13	[IN5] HS Axis
HS [IN8]	16	15	[IN7] HS Axis
HS [IN10]	18	17	[IN9] HS
HS [IN12]	20	19	[IN11] HS
HS [IN14]	22	21	[IN13] HS
HS [IN16]	24	23	[IN15] HS
SLI-MISO [IN18]	26	25	[IN17] HS
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

DEVELOPMENT KIT

DESCRIPTION

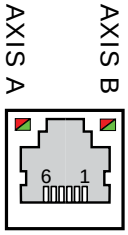
The Development Kit provides mounting and connectivity for one SE2 drive. Solderless jumpers ease configuration of inputs and outputs to support their programmable functions. Switches can be jumpered to connect to digital inputs 1~20 so that these can be toggled to simulate equipment operation. LED's provide status indication for the digital outputs, and encoder A/B/X/S 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 Stepnet Plus or Xenus Plus Ethercat drives can easily be connected. Rotary switches are provided to set the EtherCAT slave "station alias" device ID.

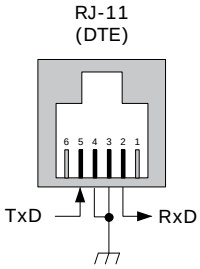
RS-232 CONNECTION

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 Slave 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.

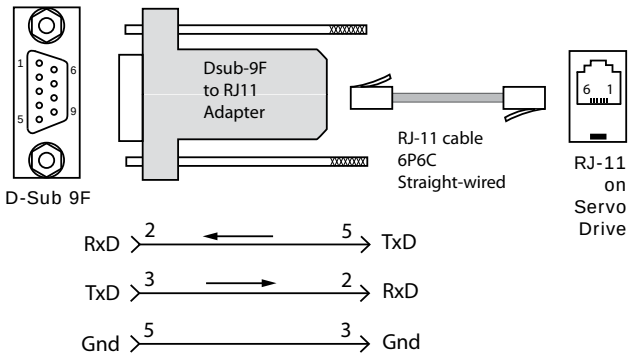


J8 SIGNALS



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 SE2 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

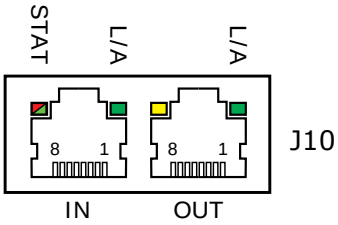
The bi-color STAT LED combines the functions of the RUN and ERR LEDs.
Green and red colors alternate, and each color has a separate meaning:

Green is the "RUN" or EtherCAT State Machine:

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



L/A (LINK/ACT) LED

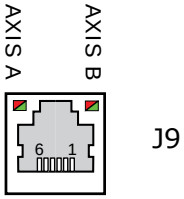
A green LED indicates the state of the EtherCAT network:

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 SE2 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
- Short circuit (Internal or external)
- Drive over-temperature
- Motor over-temperature
- Feedback Error
- Following Error

Optional (programmable)
- Over-voltage
- Under-voltage
- Motor Phasing Error
- Command Input Fault

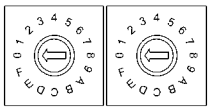
EtherCAT DEVICE ID

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 SE2 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

SW21 SW22



CME2 -> Amplifier -> Network Configuration

CME2 -> Input/Output -> Digital Outputs

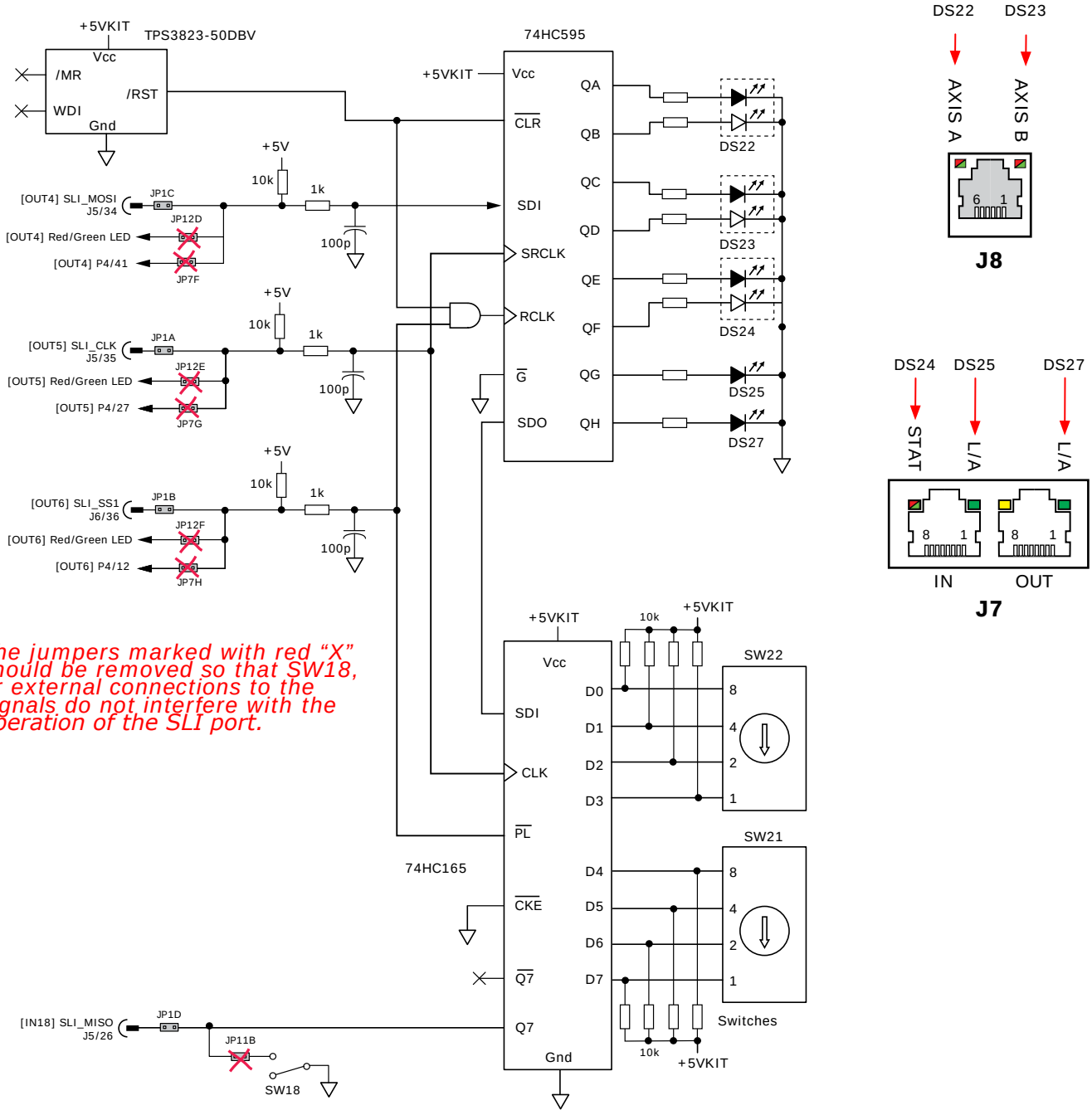
ETHERCAT DEVICE ID SWITCH DECIMAL VALUES

	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

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 SE2 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.

CME2 -> Input/Output -> Digital Outputs



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.

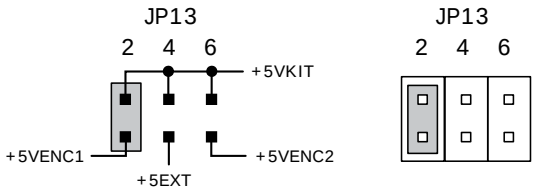
5V POWER SOURCES

The feedback connectors J9 & J10 each have a connection to a +5V power supply in the SE2. 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 SE2, or an external 5V power supply connected to J7.

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

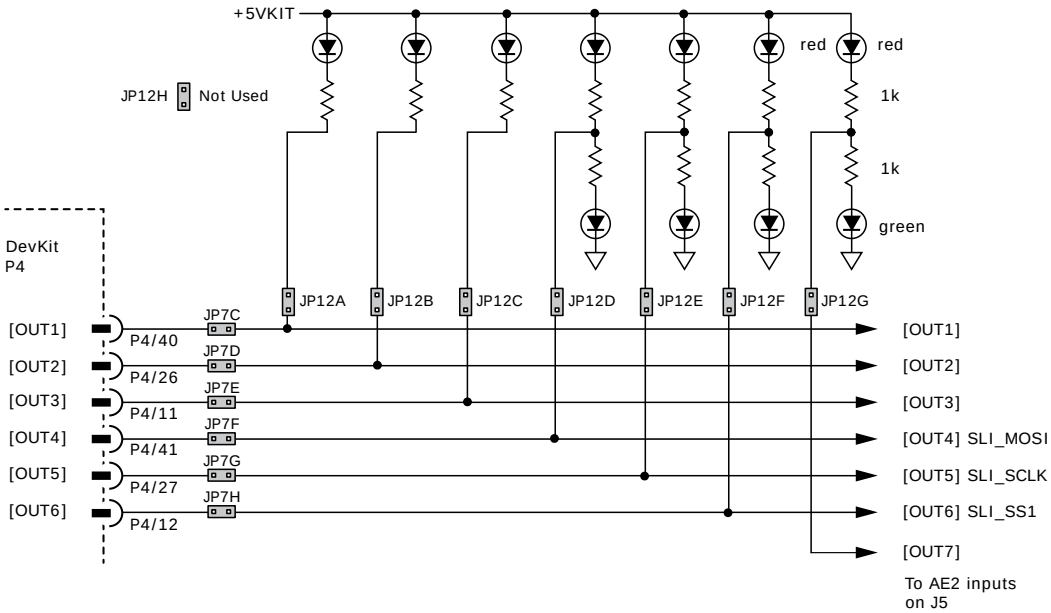


IMPORTANT: ONLY ONE SHORTING PLUG CAN BE USED ON JP13-2, 4, OR 6 POSITIONS

USE OF MORE THAN ONE PLUG WILL DAMAGE 5V POWER SUPPLIES IN THE SE2

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.

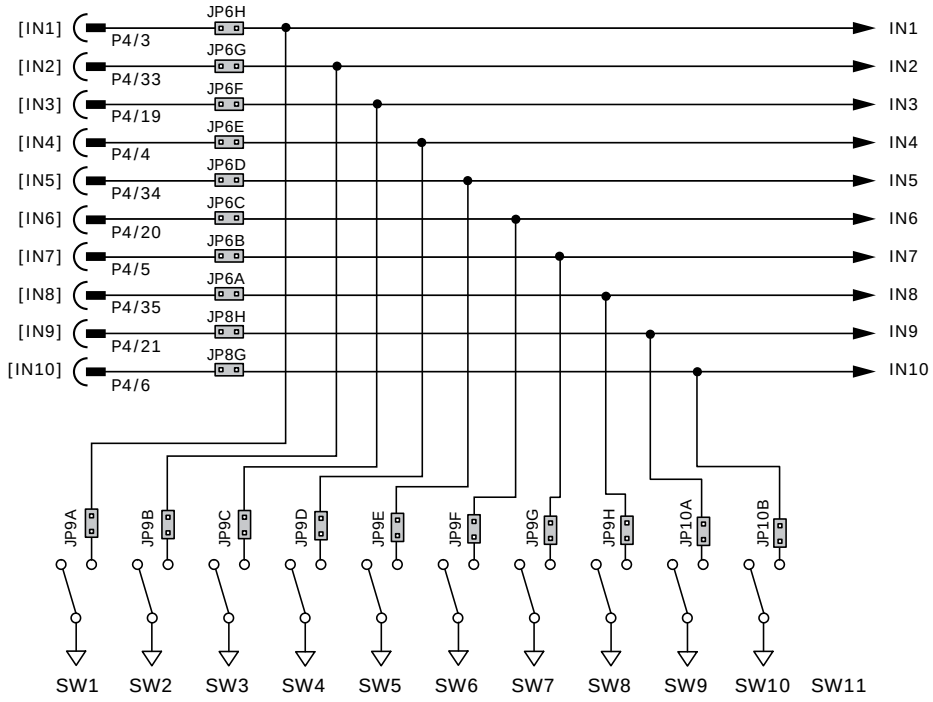


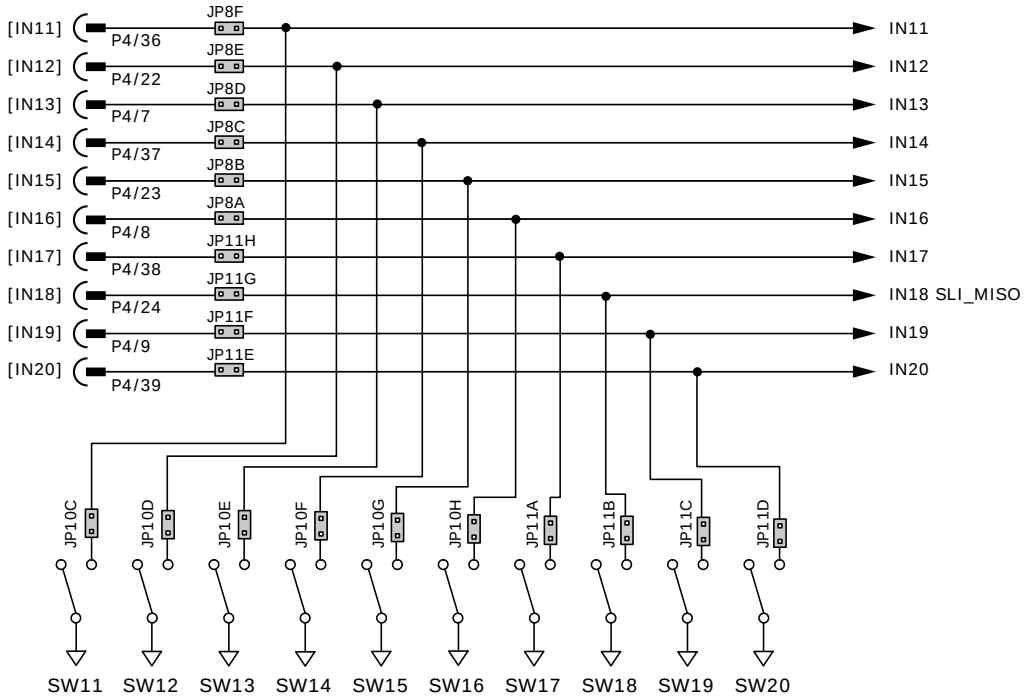
LOGIC INPUTS & SWITCHES

The Development Kit has jumpers that can connect the SE2 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.

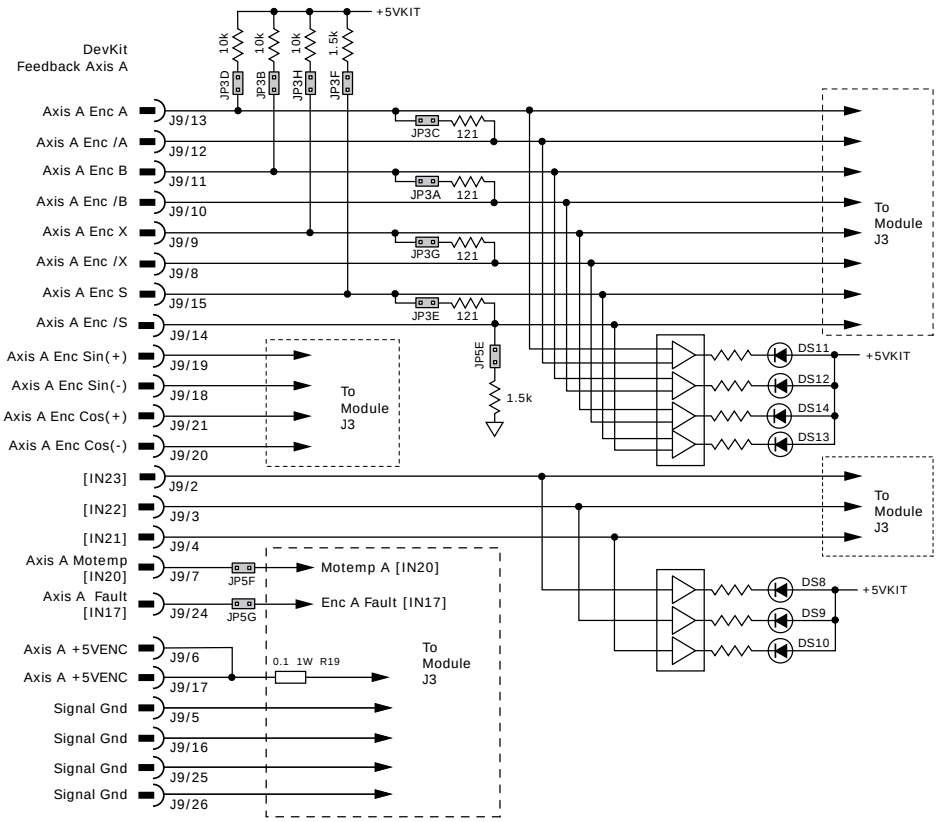
For example, if [IN1] is connected to an external device for the Enable function, then jumper JP9A should be removed to take the switch SW1 out of the circuit. The figure below shows these connections.



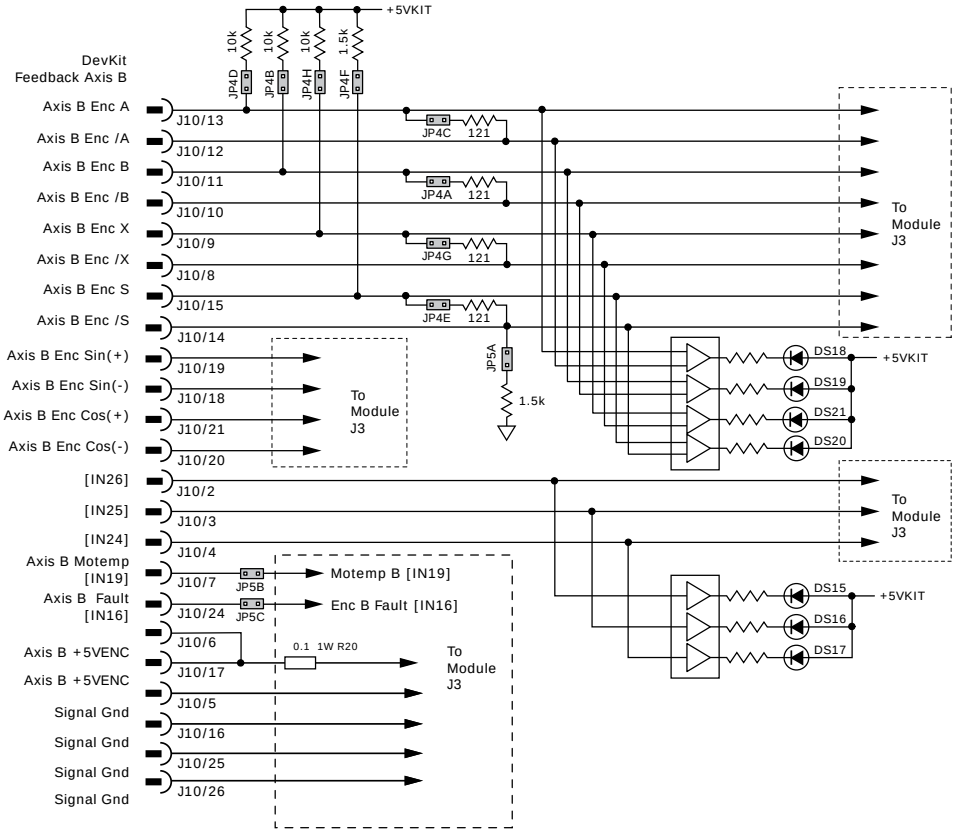


MOTOR FEEDBACK CONNECTORS J9 & J10

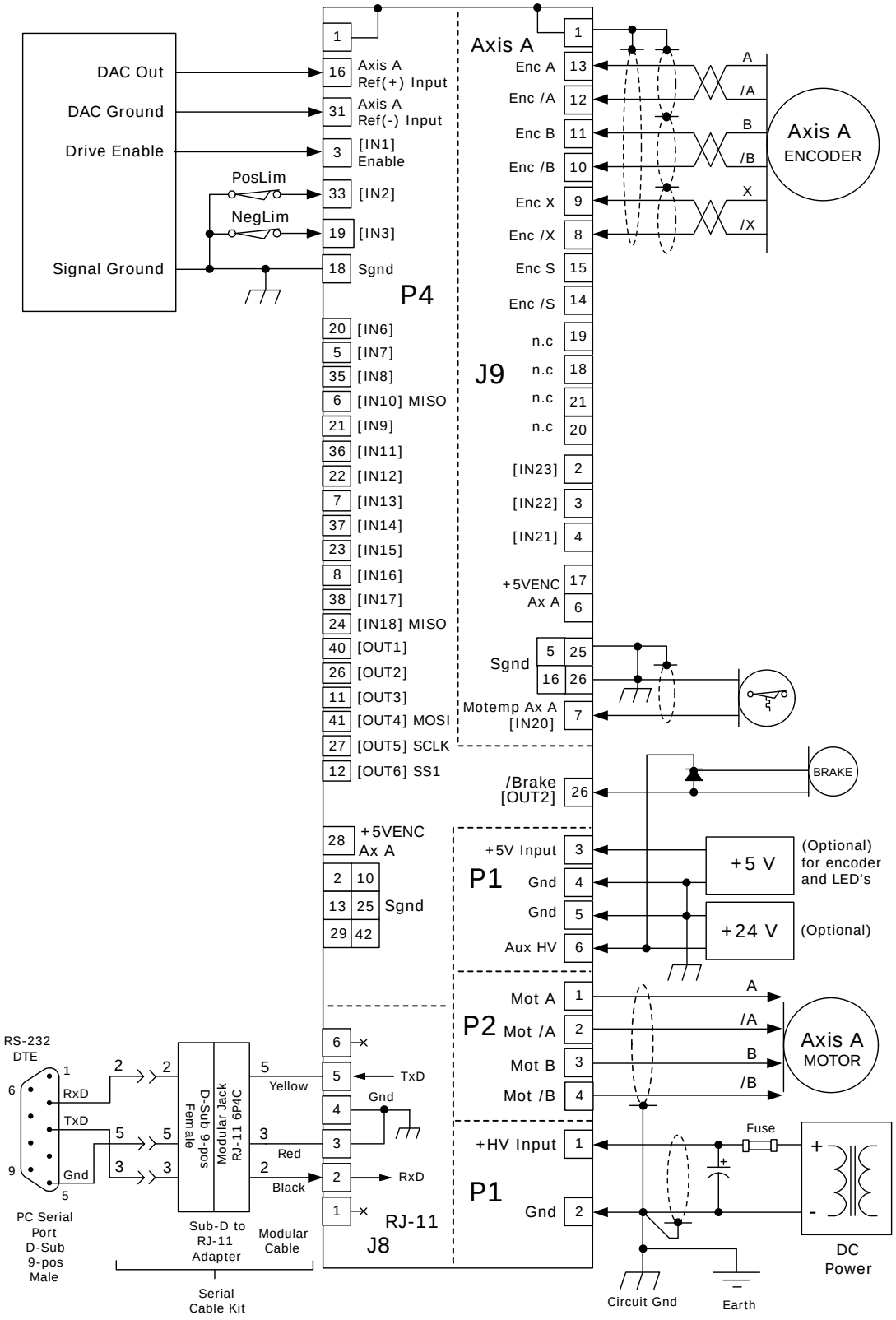
AXIS A



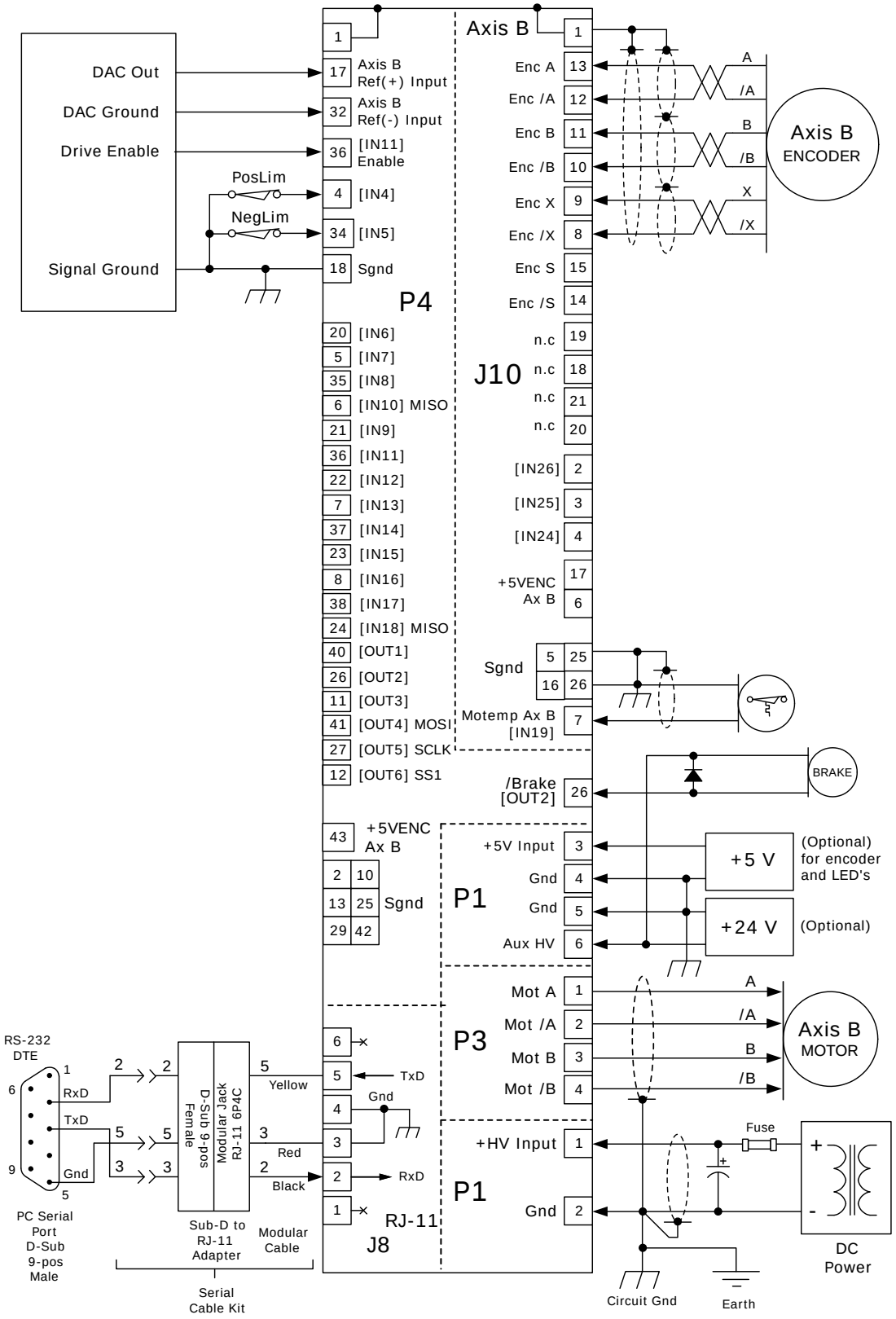
AXIS B



DEVELOPMENT KIT CONNECTIONS: AXIS A



DEVELOPMENT KIT CONNECTIONS: AXIS B



DEVELOPMENT KIT CONNECTORS

The Development Kit mounts a single SE2 module and enables the user to test and operate the SE2 before it is mounted onto a PC board in the target system.

P1: HV

Signal	Pin
+HV	1
HV Gnd	2
+5V Ext	3
Sgnd	4
HV Gnd	5
HV Aux	6

P2: AXIS A MOTOR

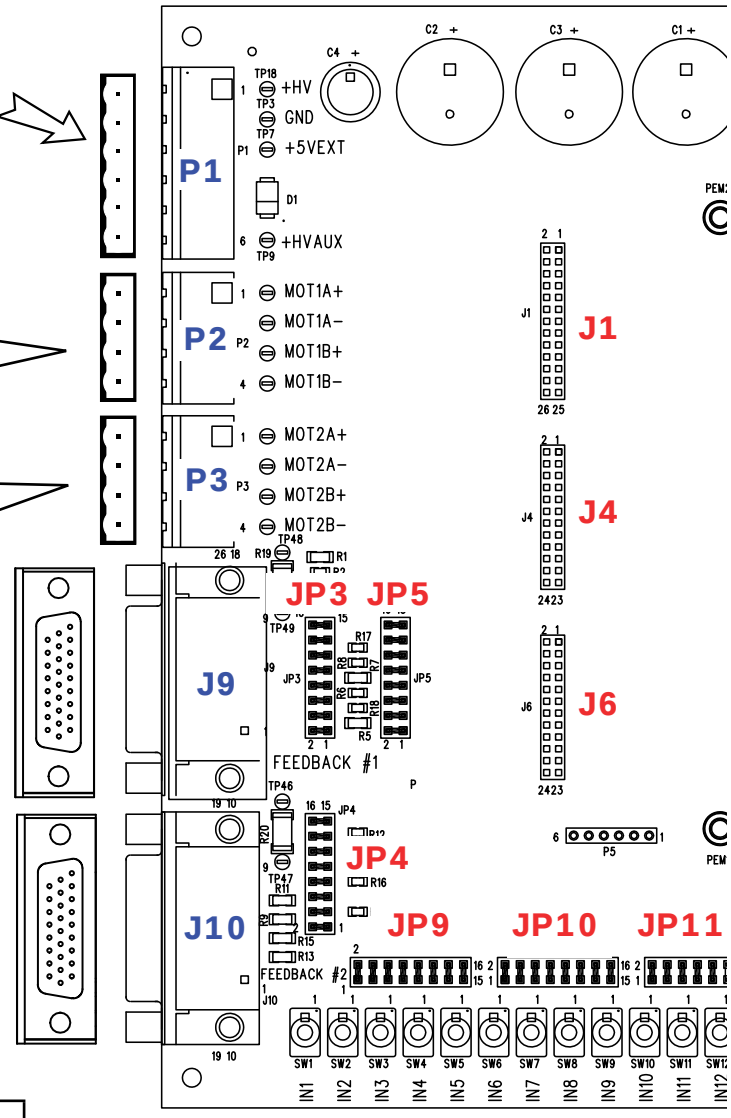
Signal	Pin
Motor A	1
Motor /A	2
Motor B	3
Motor /B	4

P3: AXIS B MOTOR

Signal	Pin
Motor A	1
Motor /A	2
Motor B	3
Motor /B	4

J9: AXIS A FEEDBACK

J10: AXIS B FEEDBACK



J9(J10): FEEDBACK A(B)

PIN	SIGNAL
26	Signal Gnd
25	Signal Gnd
24	[IN17(16)]
23	Enc X
22	Enc /X
21	n.c.
20	n.c.
19	n.c.

PIN	SIGNAL
18	n.c.
17	+5VENC*
16	Signal Gnd
15	Enc S
14	Enc /S
13	Enc A
12	Enc /A
11	Enc B
10	Enc /B

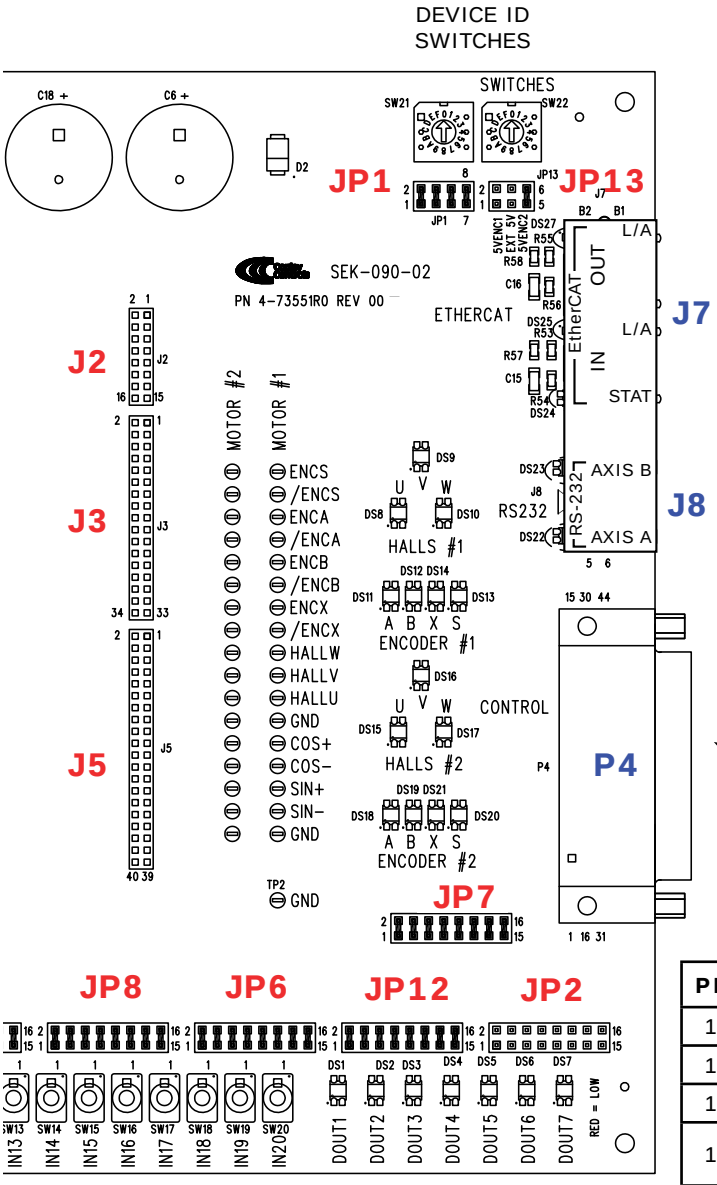
PIN	SIGNAL
9	Enc X
8	Enc /X
7	Motemp**
6	+5VENC*
5	Signal Gnd
4	[IN21(24)]
3	[IN22(25)]
2	[IN23(26)]
1	Frame Gnd

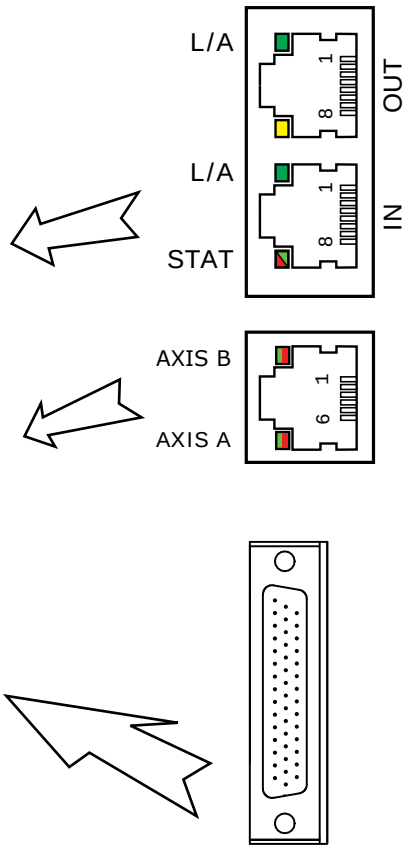
* The SE2 has two independent 5V encoder power supplies, and each is rated for 400 mA.

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	[IN20]	J9-7, P4-39
B	Axis B Motemp	[IN19]	J10-7, P4-9





J7: 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 A,B

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
15	n.c.	30	n.c.	44	n.c.
14	n.c.	29	Sgnd	43	Ax B +5VENC
13	Sgnd	28	Ax A +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 A Motemp
9	[IN19] Axis B 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.

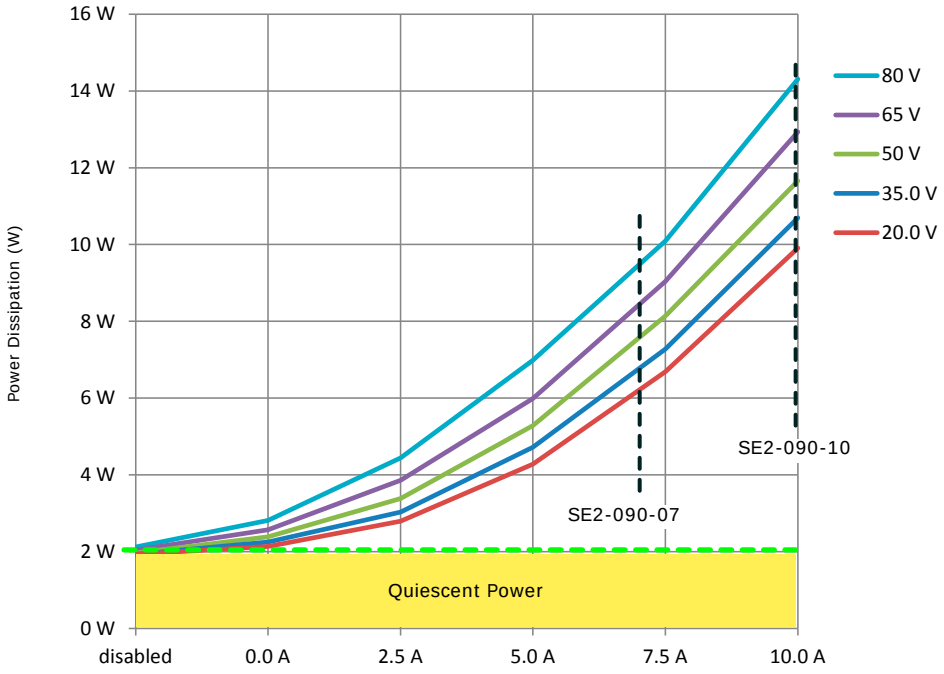
When the total power dissipation is known the maximum ambient operating temperature can be found using different mounting and cooling means from the chart in Step 2.

STEP 1: FIND THE POWER DISSIPATION FOR EACH AXIS

Using the output current for the A-axis, find the power dissipation based on the HV power supply voltage. Using the current for the B-axis, and the same HV voltage, find the dissipation for that axis.

Add the A-axis and B-axis dissipation to find the total power dissipation for Step 2.

SE2-090-07 & SE2-090-10

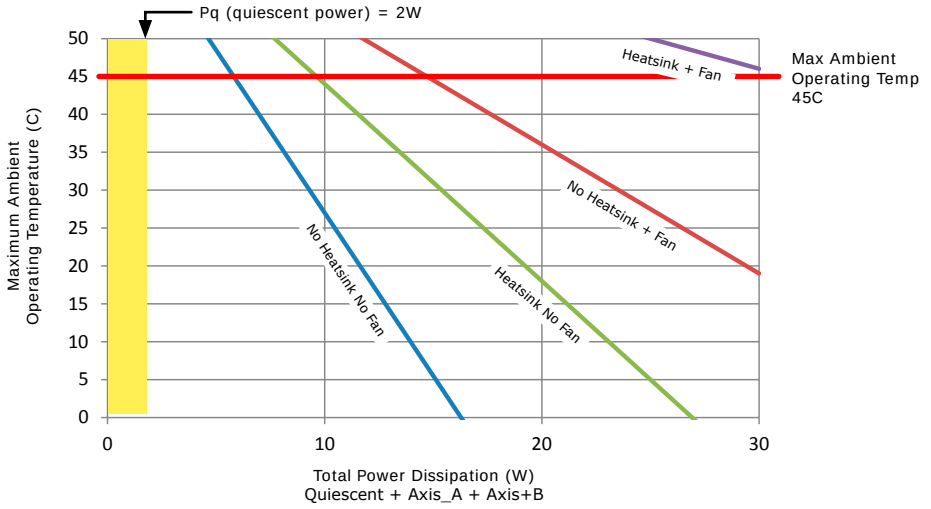


STEP 2: FIND MOUNTING AND COOLING MEANS REQUIRED FOR DIFFERENT AMBIENT TEMPERATURES

Find the total power dissipation for the SE2 using the charts on the opposite page. Add the powers for Axis A and Axis B. 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.



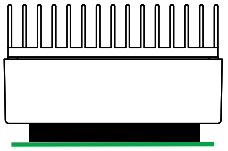
HEATSINK OPTIONS

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 SE2-HS heatsink.

NO HEATSINK

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

HEATSINK (SE2-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.

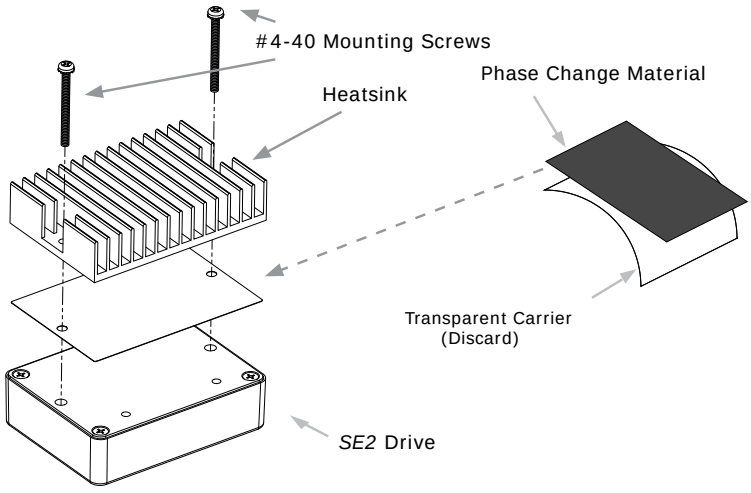
STEPS TO INSTALL

1. Remove the PSM (Phase Change Material) from the clear plastic carrier.

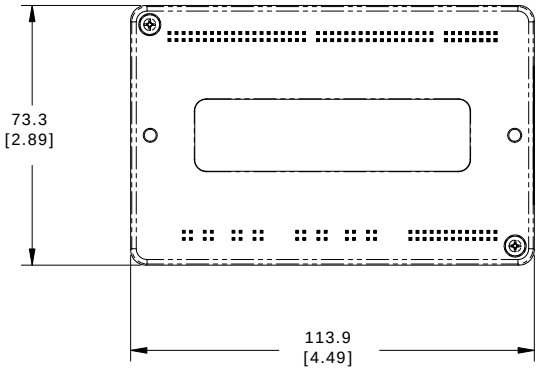
2. Place the PSM on the *Accelnet* aluminum heatplate taking care to center the PSM holes over the holes in the drive body.

3. Mount the heatsink onto the PSM again taking care to see that the holes in the heatsink, PSM, and drive all line up.

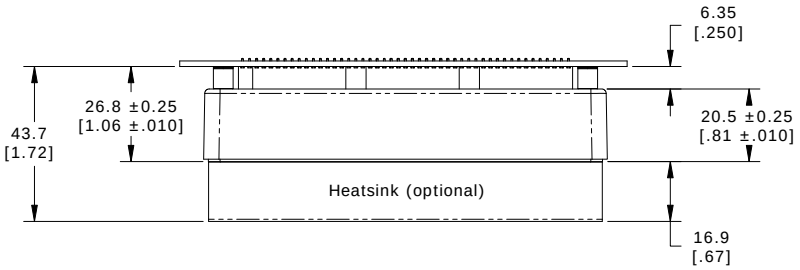
4. Torque the #4-40 mounting screws to 3~5 lb-in (0.34~0.57 N·m).

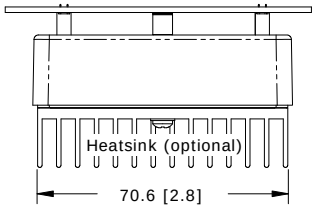


MODULE DIMENSIONS



Units: mm [in]





MASTER ORDERING GUIDE

SE2-090-07	*Stepnet* SE2 stepper drive, 5/7 A, 20~90 Vdc
SE2-090-10	*Stepnet* SE2 stepper drive, 10/10 A, 20~90 Vdc
SEK-090-02	Development Kit for SE2

EtherCAT Conformance tested

ACCESSORIES

	QTY	Connector	DESCRIPTION
Connector Kit for Development Kit SEK-CK-02	1	P1	Connector, Euro, 6 Terminal, 5.08 mm
	2	P2, P3	Connector, Euro, 4 Terminal, 5.08 mm
	1	P4	44 Pin Connector, High Density, D-Sub, Male, Solder Cup
			44 Pin Connector Backshell
	2	J9, J10	26 Pin Connector, High Density, D-Sub, Female, Solder Cup
	2		26 Pin Connector Backshell
Heatsink Kit SE2-HK	1		Heatsink for SE2
	1		Heatsink Thermal Material
	4		Heatsink Hardware
SER-CK		J8	SE2 Development Kit Serial Cable Kit
CME 2			CME 2 Drive Configuration Software on CD-ROM
CMO			CD with CMO Software
CML			CD with CML Software (Note: license fee required)

CABLES FOR ETHERCAT OPERATION

	QTY	Connector	DESCRIPTION
SEK-NC-10	1		EtherCAT Network Cable, 10 ft (3 m)
SEK-NC-01	1		EtherCAT Network Cable, 1 ft (0.3 m)

Note: Specifications subject to change without notice