4-AXIS DIGITAL DRIVE
FOR STEPPER MOTORS

CANopen

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

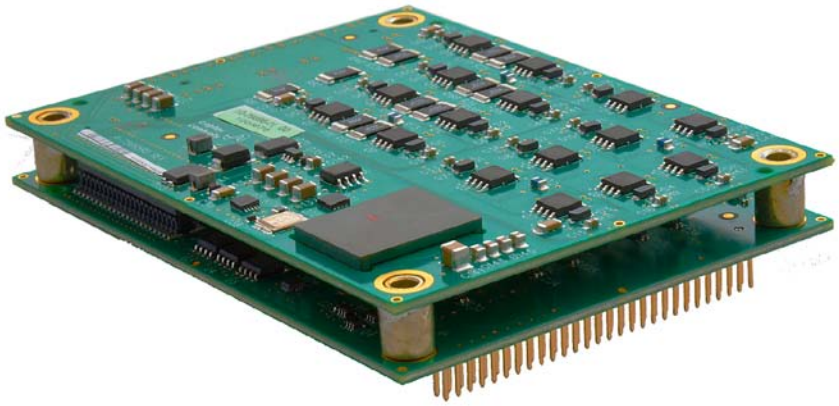
Command Interface
- CANopen
- ASCII and discrete I/O
- Stepper commands
- Master encoder (Gearing/Camming)

Communications
- CANopen
- RS-232

Feedback
- Digital quad A/B/X encoder

I/O Digital
- 24 HS inputs
- 8 MOSFET outputs

I/O SPI
- 1 HS input
- 4 HS outputs



Dimensions: mm [in]
- 101.6 x 76.2 x 20.83 [4.00 x 3.00 x 0.83]

Model	Ic	Ip	Vdc
SP4-055-03	3	3	14~55

DESCRIPTION

Stepnet SP4 is a four-axis, high-performance, DC powered drive for position, and velocity control of stepper motors via CANopen. Using advanced FPGA technology, the *SP4* provides a significant reduction in the cost per node in multi-axis CANopen systems.

Each of the four axes in the *SP4* operate as *CANopen* nodes under DSP-402 for motion control devices. Supported modes include: Profile Position-Velocity, Interpolated Position Mode (PVT), and Homing.

Servo mode allows position/velocity/torque control. Servo mode allows CANopen or digital PWM control of position/velocity/torque. In microstepping mode stepper command pulses and master encoder for camming or gearing is supported.

Twenty-four high-speed digital inputs with programmable functions are provided. There are eight MOSFET outputs that are 24V compatible.

An SPI port is provided with one high-speed input and four high-speed digital outputs. If not used for SPI, the input and outputs are programmable for other functions.

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

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	SP4-055-03	
OUTPUT POWER (each axis)		
Peak Current	3 (2.12)	Adc (Arms-sine), ±5%
Peak time	1	Sec
Continuous current	3 (2.12)	Adc (Arms-sine) per phase (Note 1)
Maximum Output Voltage	Vout = HV*0.97 - Rout*Iout	
INPUT POWER (module)		
HVmin~HVmax	+14 to +55	Vdc Transformer-isolated
Ipeak	3	Adc (1 sec) peak
Icont	3	Adc continuous (Note 1)
Aux HV	+14 to +55 Vdc , 6 W max with all four encoders powered, 3 W max with no encoders	
PWM OUTPUTS		
Type	Dual H-bridge MOSFET , 12.5 kHz center-weighted PWM, space-vector modulation	
PWM ripple frequency	25 kHz	
CONTROL MODES		
CANopen: Profile Position, Profile Velocity, Homing		
Position, open-loop, from stepper commands (CW/CCW, Pls/Dir, quad A/B)		
Discrete I/O: camming, internal indexer		
COMMAND INPUTS		
Type	CANopen, galvanically isolated from drive circuits	
Signals & format	CAN_H, CAN_L, CAN_GND	
Data protocol	CANopen Device Profile DSP-402	
Node-ID Selection	Programmable, or via digital inputs. Each axis has a programmable unique, non-zero node-ID	
Digital	PWM/Polarity (Pls/Dir), Step/Direction (CW/CCW), 2 MHz max Quad A/B encoder, 2 MLine/sec (8Mcount/sec after quadrature)	
Indexing	Up to 32 sequences can be launched from digital inputs or ASCII commands	
Camming	Quad A/B digital encoder, up to 10 Cam tables can be stored in flash memory	
ASCII	RS-232 (see RS-232 Port, page 2)	
DIGITAL CONTROL		
Digital Control Loops	Current, velocity, position. 100% digital loop control	
Sampling rate (time)	Current loop: 12.5 kHz (80 µs), Velocity & position loops: 2.5 kHz (400 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	
DIGITAL INPUTS		
[IN1~24]	High-speed digital, 100 ns RC filter, 10 kΩ pull-up to +3.3 Vdc, +5V compatible 74LVC14 Schmitt trigger, V_T+ = 1.1~2.0 Vdc, V_T- = 0.8~1.5 Vdc, V_H = 0.3~1.2 Vdc	
[IN25]	SPI port MISO input, 47 ns RC filter, 1 kΩ pull-up to +3.3 Vdc 74LVCG14, V_T+ = 1.3~2.2 Vdc, V_T- = 0.6~1.5 Vdc, V_H = 0.4~1.2 Vdc, +5V compatible	
DIGITAL OUTPUTS		
[OUT1~8]	Open-drain MOSFET with 1 kΩ pull-up with series diode to +5 Vdc 300 mAdc max, +30 Vdc max. Functions programmable	
[OUT9~12]	SPI port MOSI, SCLK, SS1, & SS2 signals, 74AHCT125 line drivers, +5V levels Iout: -0.8 mA source at VOH= 2.4V, 6 mA sink at VOL= 0.5V	
DC POWER OUTPUT		
[ENC5V]	+5 Vdc, 500 mA max for total of four axes, thermal and short-circuit protected	
FEEDBACK		
Digital Incremental Encoder	Four groups of 3 HS digital inputs programmed as A/B/X encoder inputs Single-ended, +5V compatible 2 Mline/sec (8 Mcounts/sec) max when driven by active-output devices	
CANOPEN COMMUNICATION PORT		
Signals	CAN_H, CAN_L, CAN_GND optically isolated from drive circuits	
Terminator	External, user-supplied on mounting board	
Speed	1 Mbit/sec maximum, programmable	
Indicators	None	
Address Selection	Software programmable, four CAN nodes per driver (one per axis, unique, non-zero addresses) SP4 appears as four consecutive CAN addresses. Axis A takes the programmed address, axes B,C, & D appear as the programmed address +1, +2, and +3	
Protocol	CANopen Application Layer DS-301 V4.01, CAN V2.0b Physical Layer	
Device	DSP-402 Device Profile for Drives and Motion Control	
Isolation	Isolated from Signal Ground, +32 Vdc max working voltage with respect to Signal Ground	
RS-232 PORT		
Signals	RxD, TxD, Gnd for operation as a DTE device; referenced to Signal Ground in SP4 circuits	
Mode	Full-duplex, DTE serial port for drive setup and control, 9,600 to 115,200 Baud	
Protocol	ASCII or Binary format	

Notes:

1) Forced-air cooling may be required for operation at full output power on all axes.

MOTOR CONNECTIONS (PER AXIS)		
Phases A, /A, B, /B	PWM outputs to 2-phase, 4-wire bipolar stepper motors	
Digital Incremental Encoder	Quadrature signals, (A, B, X), using inputs [IN26~37] 2 MHz maximum line frequency (8 M counts/sec) when driven by active devices	
Encoder power	(See DC POWER OUTPUTS section)	
PROTECTIONS		
HV Overvoltage	+HV > 55 Vdc	Drive outputs turn off until +HV < 55 Vdc
HV Undervoltage	+HV < +14 Vdc	Drive outputs turn off until +HV > +14 Vdc
Drive over temperature	Heat plate > 90°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	
MECHANICAL & ENVIRONMENTAL		
Size mm [in]	101.6 x 76.2 x 20.83 [4.00 x 3.00 x 0.83]	
Weight	<tbd> kg [<tbd> lb]	
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	Forced air cooling may be required for continuous power output	

AGENCY STANDARDS CONFORMANCE (PENDING)

Approvals

UL recognized component to UL 61800-5-1

Electrical Safety

IEC/UL/CSA 61800-5-1: 2007 Low voltage directive 2006/95/ED

EMC

IEC 61800-3:2004

Markings

UL Recognized component (Canada and USA)

CE

Hazardous Substances

Lead-free and RoHS compliant

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
CAN Profile Position	•	
CAN Profile Velocity		•
CAN Profile Torque		
CAN Homing	•	
CAN Interpolated Position	•	
Quad A/B Encoder	•	
Digital Pls/Dir	•	
Digital CW/CCW	•	
Digital PWM		•

CAN = CANopen DS-402

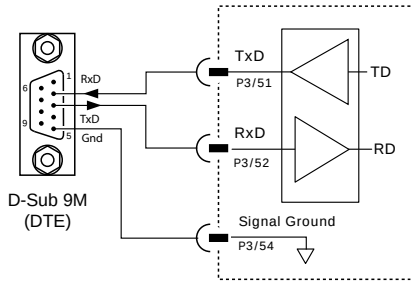
CME 2 SOFTWARE

Drive setup is fast and easy using *CME 2* software. All of the operations needed to configure the drive are accessible through this powerful and intuitive program. Auto-phasing of brushless motor Hall sensors and phase wires eliminates “wire and try”. Connections are made once and *CME 2* does the rest thereafter. Encoder wire swapping to establish the direction of positive motion is eliminated.
Motor data can be saved as .CCM files. Drive data is saved as .CCX files that contain all drive settings plus motor data. This eases system management as files can be cross-referenced to drives. Once a drive configuration has been completed systems can be replicated easily with the same setup and performance.

RS-232 COMMUNICATION

The SP4 is configured via a three-wire, full-duplex RS-232 port that operates as a DTE from 9,600 to 115,200 Baud. CME 2 software communicates with the drive over this link for commissioning and adjustments.
When operating as a stand-alone drive that takes command inputs from an external controller, CME 2 is used for configuration. When operated as a CAN node, CME 2 is used for programming before and after installation in a CAN network. The SP4 can also be controlled via CME 2 while it is in place as a CAN node. During this process, drive operation as a CAN node is suspended. When adjustments are complete, CME 2 relinquishes control of the drive and returns it to the CAN node state. Multiple drives can communicate over a single RS-232 port by daisy-chaining the master drive to other drives using CAN cables. The master drive does the RS-232 communication with the system and echoes the commands to the other drives over the CAN bus.

RS232 PORT



CME2 -> Tools -> Communications Wizard

CANOPEN

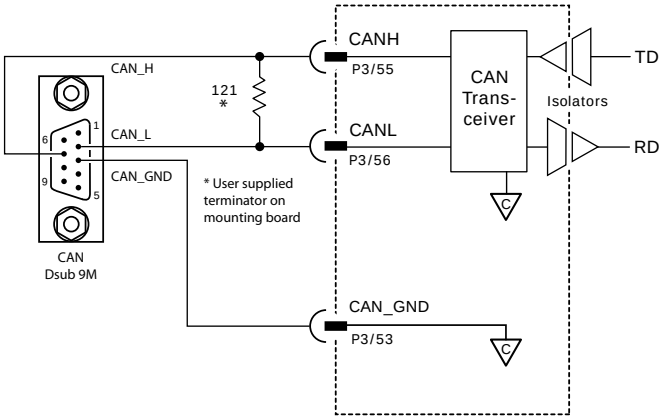
Based on the CAN V2.0b physical layer, a robust, two-wire communication bus originally designed for automotive use where low-cost and noise-immunity are essential, CANopen adds support for motion-control devices and command synchronization. The result is a highly effective combination of data-rate and 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

Stepnet 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 Node-ID. A maximum of 127 CAN nodes are allowed on a single CAN bus. Up to seven digital inputs can be used to produce CAN Node-IDs from 1~127, or the Node-ID can be saved to flash memory in the module. Node-ID 0 is reserved for the CANopen master on the network.

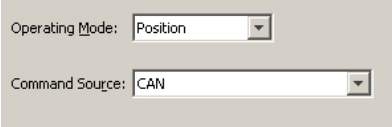
CANOPEN NETWORK CONNECTIONS

The graphic below shows connections between the SP4 and a Dsub 9M connector on a CAN card. The terminator shown should be on the mounting board of the last SP4 on the bus. The Node-ID (address) of the SP4 may be set by programming it into flash memory in the drive.



HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Operating Mode Options



INPUT/OUTPUT

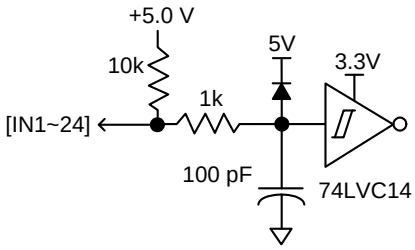
DIGITAL INPUTS

SP4 has 24 high-speed digital inputs, all of which have programmable functions.
They are compatible with 5V logic and have 100 ns R/C filters when driven by devices with active pull-up/pull-down outputs.

Programmable functions of the digital inputs include:

- Drive Enable
- Positive Limit switch
- Negative Limit switch
- Digital Command Inputs
- Home switch
- Drive Reset
- Motion abort

HIGH-SPEED DIGITAL INPUTS
+5 VDC MAX



SIGNALS & PINS

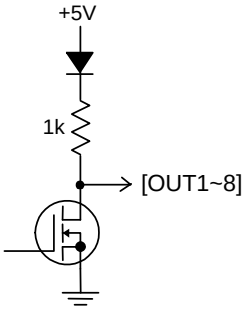
The pins in the chart are on connector P3. The functions shown are the defaults.
These can be programmed for other functions.

Functions					Axis A		Axis B		Axis C		Axis D	
					Pins	Signal	Pins	Signal	Pins	Signal	Pins	Signal
Enable					15	[IN1]	21	[IN7]	27	[IN13]	33	[IN19]
Pos Limit					16	[IN2]	22	[IN8]	28	[IN14]	34	[IN20]
Neg Limit					17	[IN3]	23	[IN9]	29	[IN15]	35	[IN21]
Enc A	Pulse	CW	PWM	PWM 50%	19	[IN5]	25	[IN11]	31	[IN17]	37	[IN23]
Enc B	Dir	CCW	Polarity	n/a	20	[IN6]	26	[IN12]	32	[IN18]	38	[IN24]

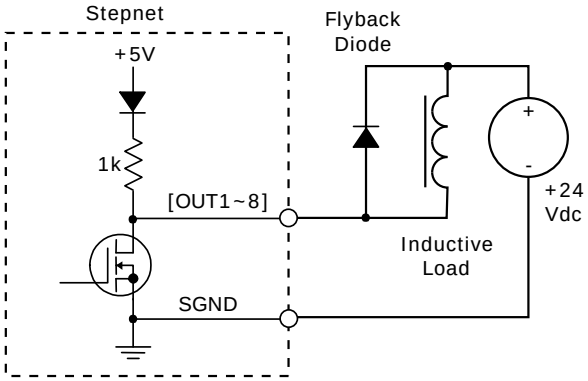
DIGITAL OUTPUTS

Digital outputs [OUT1~8] are open-drain MOSFETs with 1 kΩ pull-up resistors in series with a diode to +5 Vdc. They can sink up to 300 mAdc from external loads operating from power supplies to +30 Vdc. The outputs are typically configured as drive fault and motor brake. Additional functions are programmable. As a drive fault output, the active level is programmable to be HI or LO when a fault occurs. As a brake output, it is programmable to be either HI or LO to release a motor brake when the drive is enabled. When driving inductive loads such as a relay, an external fly-back diode is required. A diode in the output is for driving PLC inputs that are opto-isolated and connected to +24 Vdc. The diode prevents conduction from +24 Vdc through the 1 kΩ resistor to +5 Vdc in the drive. This could turn the PLC input on, giving a false indication of the drive output state.

DIGITAL OUTPUTS
30 VDC, 300 MA MAX



DRIVING INDUCTIVE LOADS

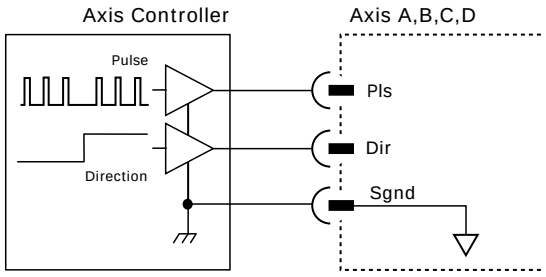


DIGITAL COMMAND INPUTS

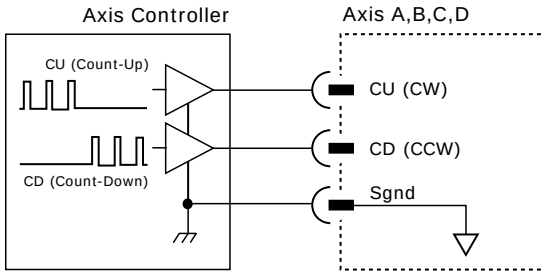
Digital commands are single-ended format and should be sourced from devices with active pull-up and pull-down to take advantage of the high-speed inputs. The active edge (rising or falling) is programmable for the Pulse/Dir and CU/CD formats.

DIGITAL POSITION

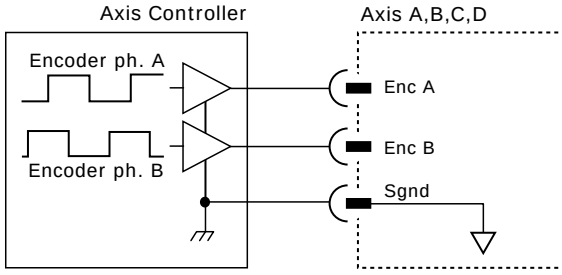
PULSE & DIRECTION



CU/CD (PULSE UP / PULSE DOWN)

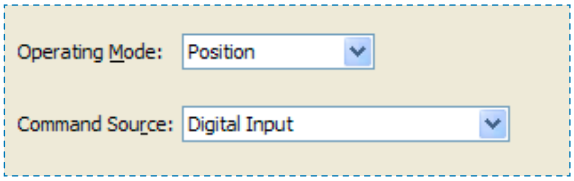


QUAD A/B ENCODER



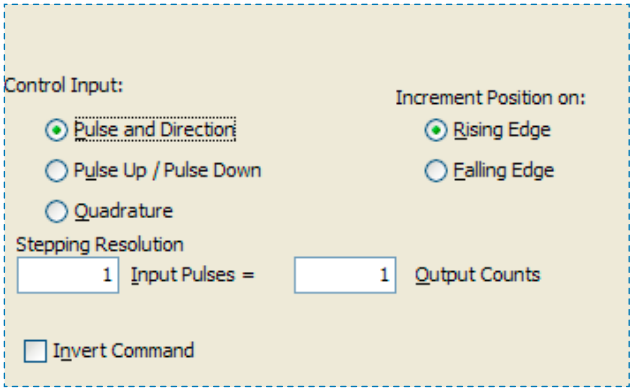
HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Operating Mode Options



HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Operating Mode Options



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

SIGNALS & PINS

The pins in the chart are on connector P3. The functions shown are the defaults. These can be programmed for other functions.

Functions			Axis A		Axis B		Axis C		Axis D	
			Pins	Signal	Pins	Signal	Pins	Signal	Pins	Signal
Enc A	Pulse	CW	19	[IN5]	25	[IN11]	31	[IN17]	37	[IN23]
Enc B	Dir	CCW	20	[IN6]	26	[IN12]	32	[IN18]	38	[IN24]

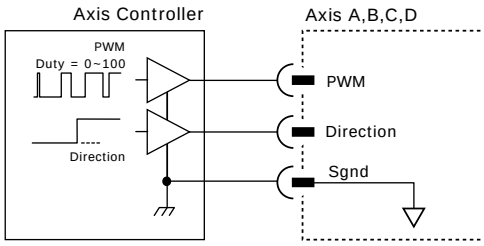
Note:

1) The functions shown for [IN5~6], [IN11~12], [IN17~18] and [IN23~24] apply when they are used as digital command inputs for position control. These inputs are programmable if not used for these functions.

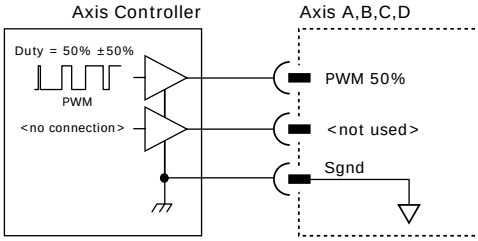
DIGITAL COMMAND INPUTS (CONT'D)

DIGITAL TORQUE, VELOCITY

PWM COMMAND (100% DUTY CYCLE)

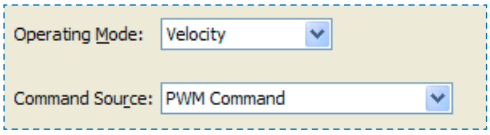


PWM COMMAND (50% DUTY CYCLE)

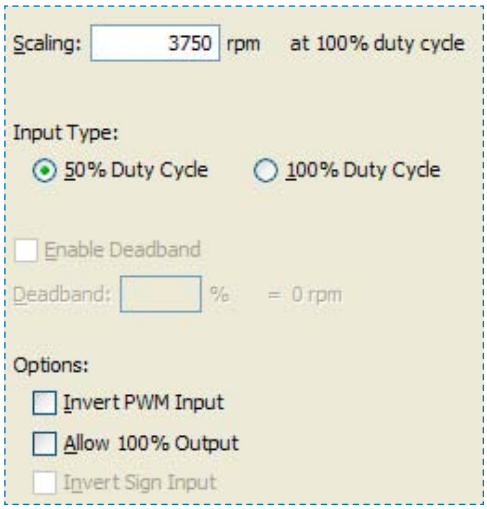


HOW IT LOOKS IN CME2

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.

SIGNALS & PINS

The pins in the chart are on connector P3

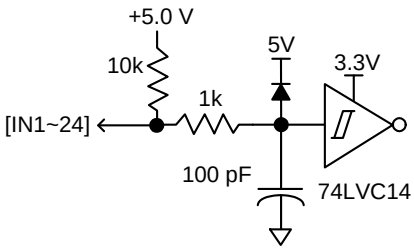
Function		Axis A		Axis B		Axis C		Axis D	
		Pins	Signal	Pins	Signal	Pins	Signal	Pins	Signal
PWM	PWM 50%	19	[IN5]	25	[IN11]	31	[IN17]	37	[IN23]
Polarity	n/a	20	[IN6]	26	[IN12]	32	[IN18]	38	[IN24]

Note:
1) The functions shown for [IN5~6], [IN11~12], [IN17~18] and [IN23~24] apply when they are used as digital command inputs for position control. These inputs are programmable if not used for these functions.

DIGITAL COMMAND INPUTS

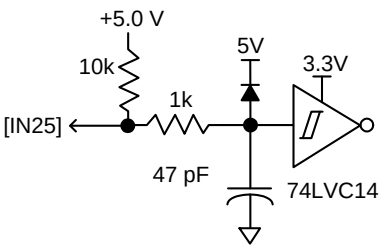
HIGH SPEED INPUTS [IN1~24]

5V tolerant



HIGH SPEED INPUT [IN25]

5V tolerant



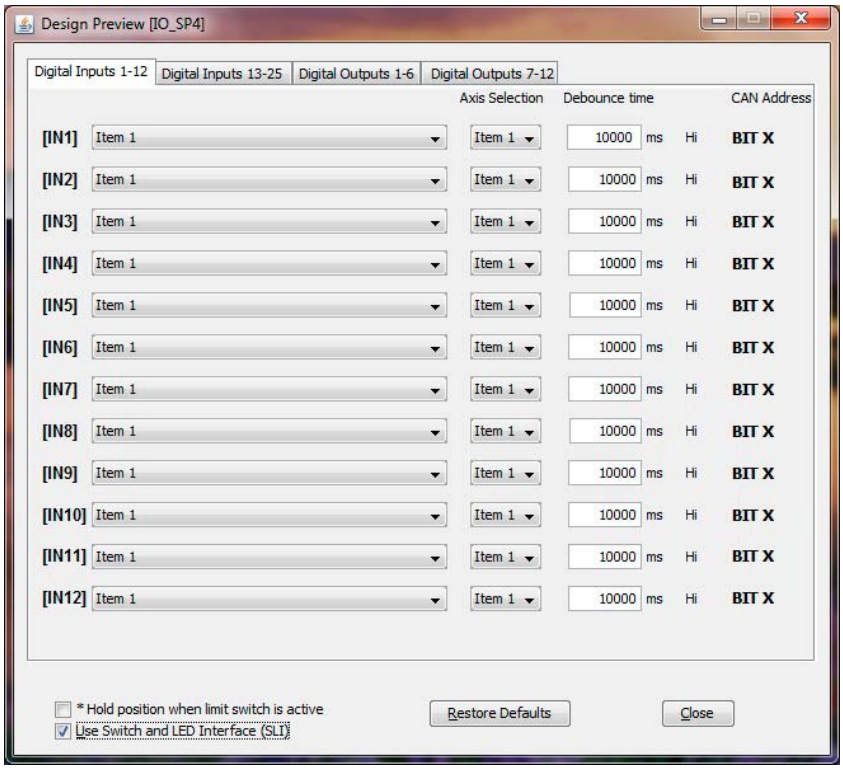
HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN1~25	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 1-12



HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN1~12	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc

DIGITAL INPUT PINS AND STRUCTURE

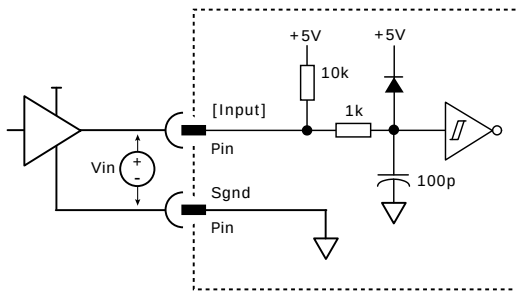
Functions					Axis A		Axis B	
					Pins	Signal	Pins	Signal
Enable					15	[IN1]	21	[IN7]
Pos Limit					16	[IN2]	22	[IN8]
Neg Limit					17	[IN3]	23	[IN9]
Enc A	Pulse	CW	PWM	PWM 50%	19	[IN5]	25	[IN11]
Enc B	Dir	CCW	Polarity	n/a	20	[IN6]	26	[IN12]

Notes:

1) Input functions shown for [IN1] and [IN7] are the default functions.
   These inputs are programmable if not used for these functions.
2) The functions shown for [IN5~6] and [IN11~12] apply when they are used as digital command inputs for position, velocity, or torque control. These inputs are programmable if not used for these functions.

HIGH SPEED DIGITAL INPUTS [IN1~IN12]

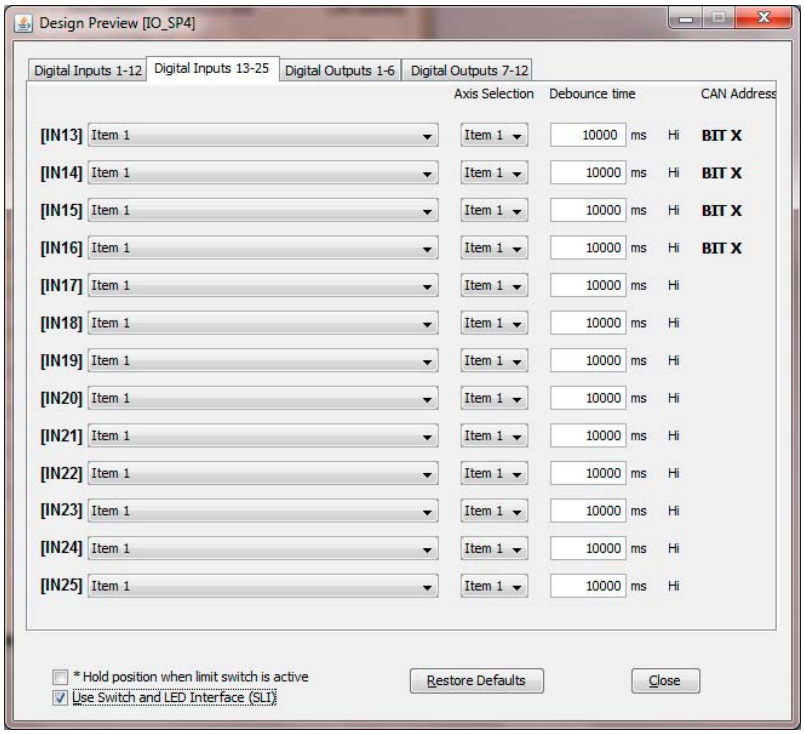
5V tolerant



DIGITAL INPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Inputs 13-25



HI/LO DEFINITIONS: INPUTS

Input	State	Condition
IN13~24	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc

IN25 SPI_MISO

If the SPI port is not used, [IN25] is programmable for other functions.

Input	State	Condition
IN25	HI	Vin >= 2.2 Vdc
	LO	Vin <= 0.8 Vdc
P2 Pin	9	[IN25]

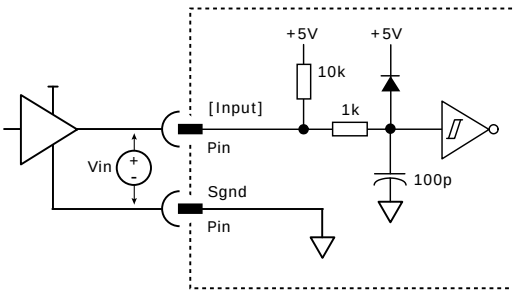
Note: The 100 pF capacitor shown is 47 pF for IN25.

DIGITAL INPUT PINS AND STRUCTURE

Functions					Axis C		Axis D	
					P3 Pins	Signal	P3 Pins	Signal
Enable					27	[IN13]	33	[IN19]
Pos Limit					28	[IN14]	34	[IN20]
Neg Limit					29	[IN15]	35	[IN21]
Enc A	Pulse	CW	PWM	PWM 50%	31	[IN17]	37	[IN23]
Enc B	Dir	CCW	Polarity	n/a	32	[IN18]	38	[IN24]

Notes:
1) Inputs functions shown for [IN13] and [IN19] are the default functions. These inputs are programmable if not used for these functions.
2) The functions shown for [IN17~18] and [IN23~24] apply when they are used as digital command inputs for position, velocity, or torque control. These inputs are programmable if not used for these functions.

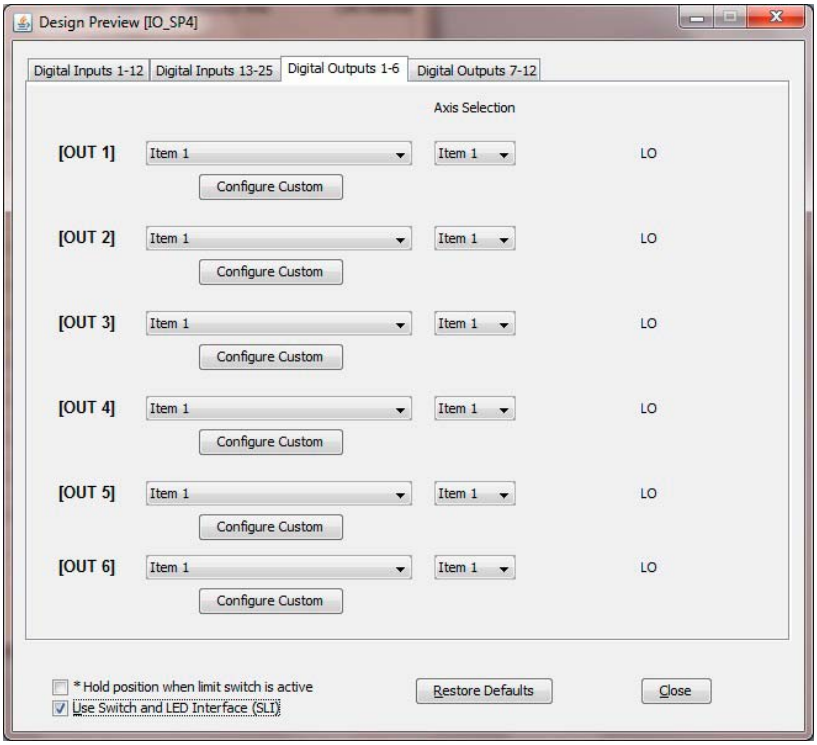
HIGH SPEED DIGITAL INPUTS [IN13~IN25]



DIGITAL OUTPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Outputs 1-6



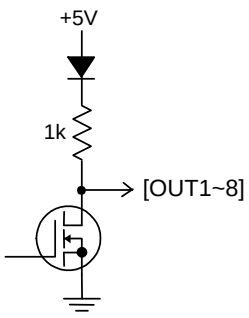
HI/LO DEFINITIONS: OUTPUTS 1~6

Output	State	Condition
OUT1~6	HI	MOSFET OFF
	LO	MOSFET ON

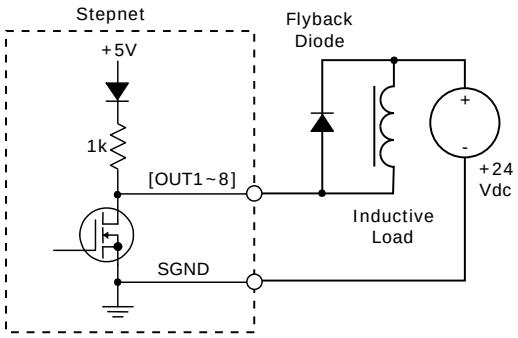
DIGITAL OUTPUTS PINS AND STRUCTURE

Function	Pin
[OUT1]	41
[OUT2]	42
[OUT3]	43
[OUT4]	44
[OUT5]	45
[OUT6]	46

MOSFET DIGITAL OUTPUTS



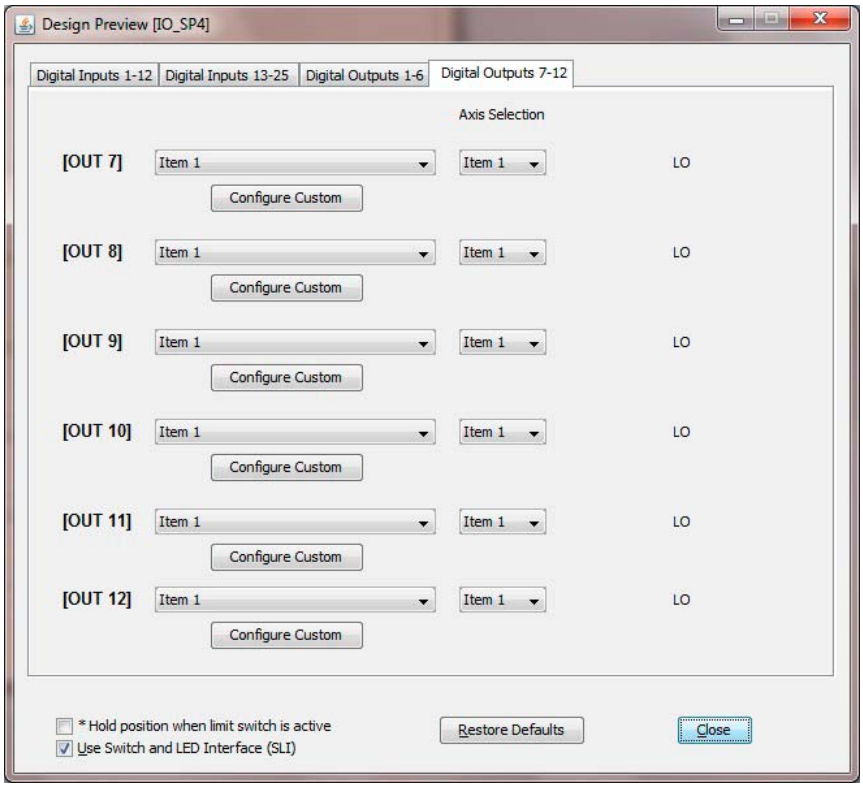
MOSFET DIGITAL OUTPUTS: INDUCTIVE LOADS



DIGITAL OUTPUT DETAILS

HOW IT LOOKS IN CME2

CME2 -> Main Page-> Input/Output -> Digital Outputs 7-12



HI/LO DEFINITIONS: OUTPUTS

Output	State	Condition
OUT7~8	HI	MOSFET OFF
	LO	MOSFET ON
OUT9~12	HI	Vout >= 2.2 Vdc
	LO	Vout <= 0.8 Vdc

MOSFET OUTPUTS & PINS

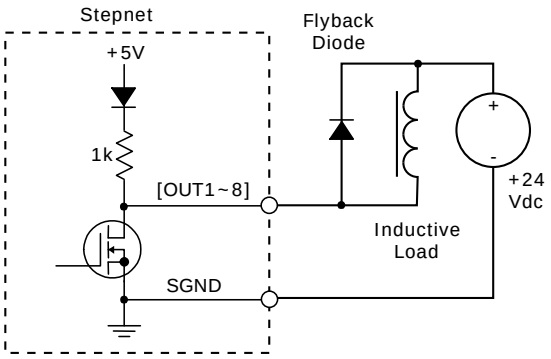
Output	P5 Pin
[OUT7]	47
[OUT8]	48

SPI OUTPUTS & PINS

Output	P5 Pin
[OUT9]	31
[OUT10]	32
[OUT11]	33
[OUT12]	34

MOSFET DIGITAL OUTPUTS [OUT7~8] WITH INDUCTIVE LOAD

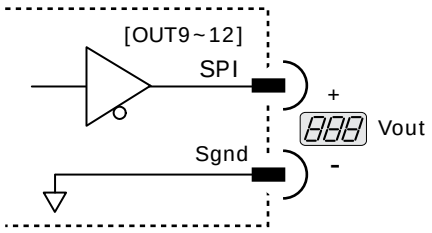
300 mA max, 30Vdc max



HIGH SPEED DIGITAL (SPI) OUTPUTS [OUT9~12]

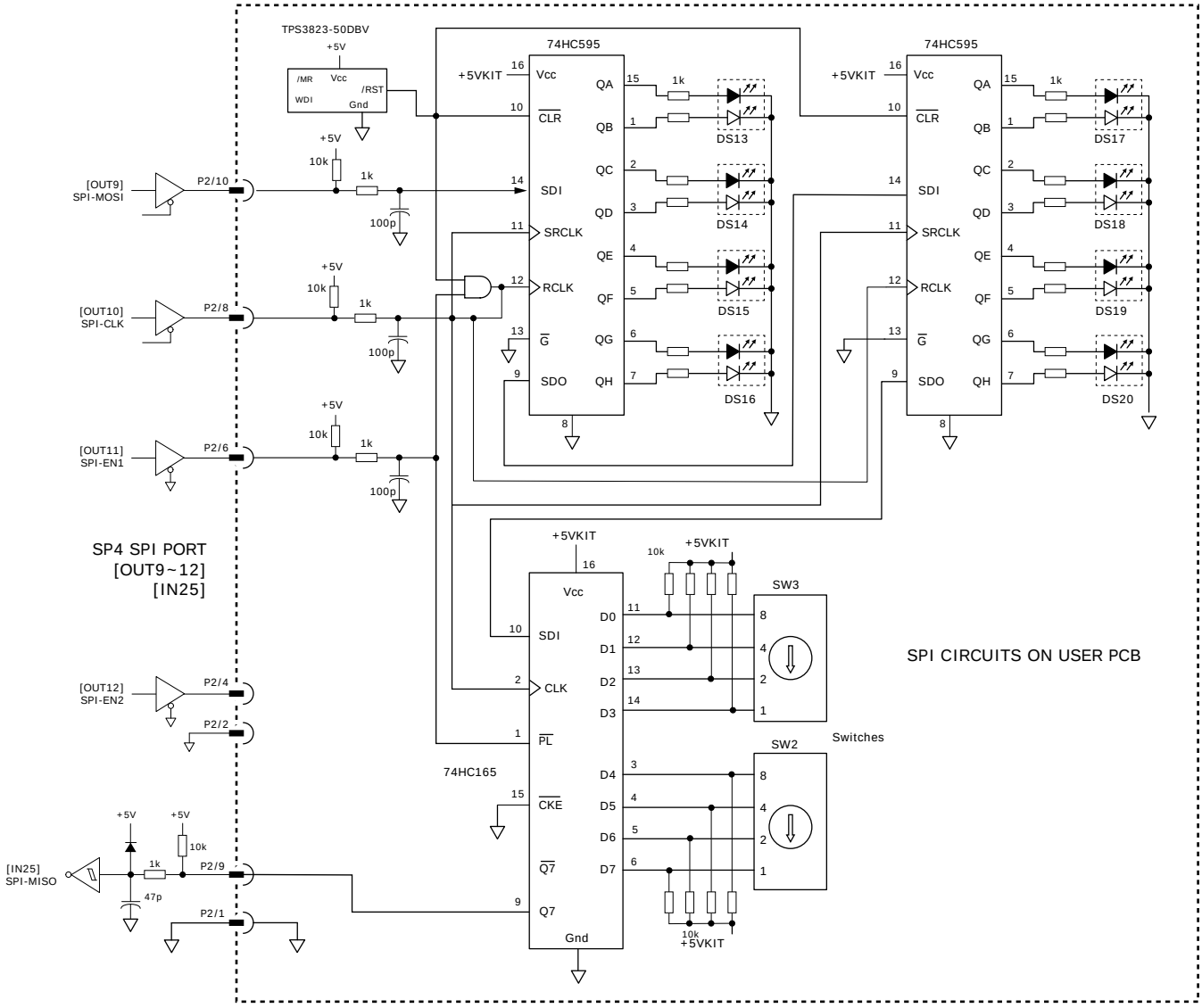
74HCT125

5V max



SPI PORT

This graphic shows all of the SPI port outputs and input together. The connections shown are those used on the SP4 Development Kit as an example of the port's usage for inputs and outputs.



HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
[OUT9~12]	HI	Vout >= 2.2 Vdc
	LO	Vout <= 0.8 Vdc

SIGNALS & PINS

Output	P2 Pin
[OUT9]	10
[OUT10]	8
[OUT11]	6
[OUT12]	4
[IN25]	9
Sgnd	2

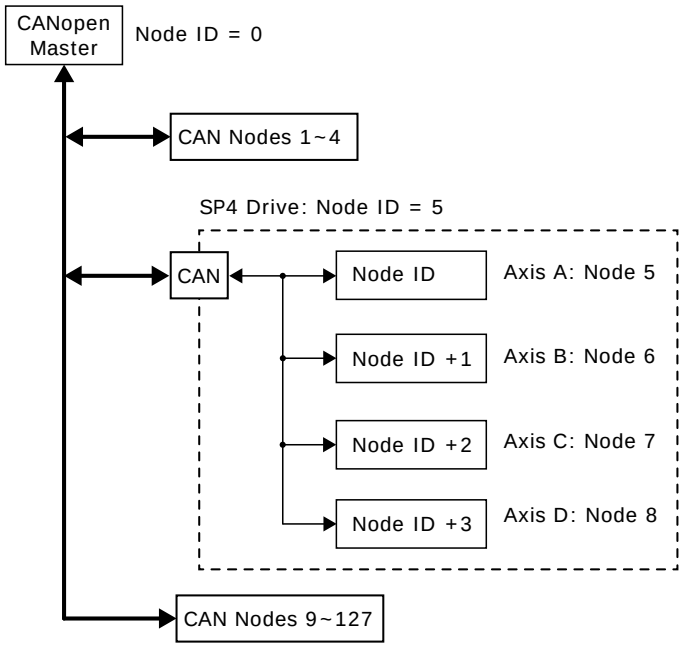
CANOPEN NODE-ID (ADDRESS)

CANOPEN AND NODE ID

The Node-ID of the SP4 can be set in flash memory, or read from 16-position switches via an SPI port. An SPI port circuit and switches is included in the SP4 Development Kit. Users can add this circuit to their own mounting boards. The Node ID can be set in flash memory using Copley CME2 software.

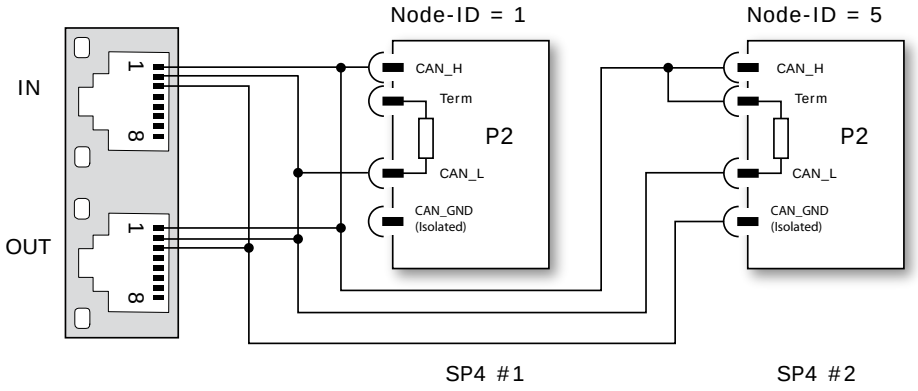
On a CAN network, the SP4 will appear as four nodes. When the "base" Node-ID is configured either via SPI or flash programming, it will address Axis A. Axes B,C, and D will then be automatically assigned Node-ID's based on the base ID. The Axis-B ID will be Axis-A ID +1. Axis-C will be Axis-A +2, and Axis-D will be Axis-A ID+3.

Whatever Node-ID is assigned to the SP4, a total of four IDs with consecutive values are required. In the graphic below, the base ID of the SP4 is set to 5 resulting in IDs of 5,6,7, and 8 for the four axes. Node-ID 0 is reserved for the CANopen Master, and the maximum Node-ID allowed is 127. This leaves ID 1~4, and 9~127 available for use by other devices on the network.



CANOPEN CONNECTIONS FOR MULTIPLE MODULES

The graphic below shows two SP4 wired to a CAN network. The lowest Node-ID allowable on a CAN network is 1 which will allocate IDs 1,2,3, and 4 for SP4 #1. SP4 #2 must have a minimum Node-ID equal to Node-ID#1+4 which equals 5 as shown.

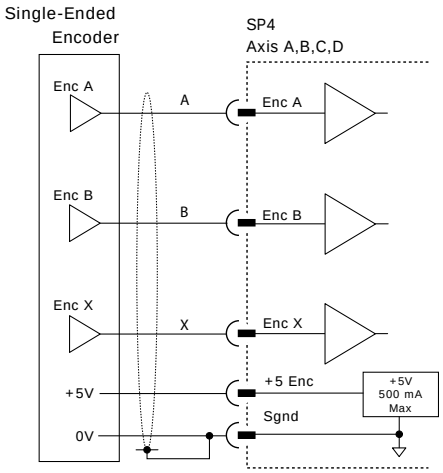


MOTOR CONNECTIONS

Motor connections consist of: phases, encoder, 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. A brake can provide a fail-safe way to prevent movement of the motor when the drive is shut-down or disabled.

SINGLE-ENDED ENCODER CONNECTIONS

Single-ended (SE) encoders must have active outputs (not open-collector). Cables should be shielded because SE encoders are more susceptible to electrical interference than differential-output encoders. And, they not be routed together with the phase connections which have PWM waveforms that could couple noise into encoder cabling.

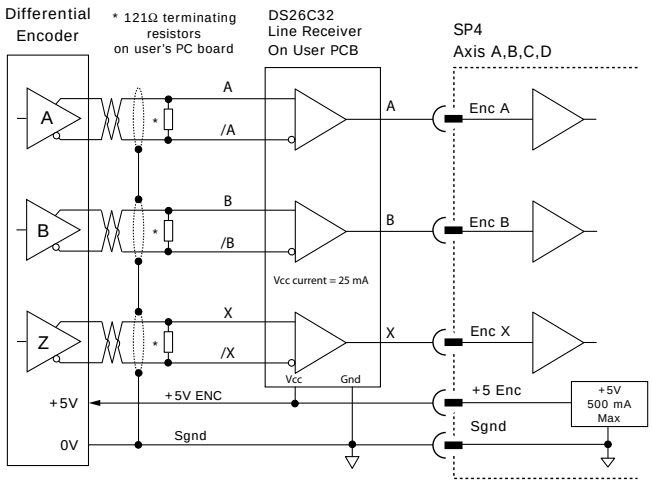


CME2 -> Motor/Feedback -> Feedback

Important:
The SP4 +5V output is rated at 500 mA max which must be shared between encoders that are connected to it. If the combined current of four encoders is greater than 500 mA, then the mounting board of the SP4 must have +5V to power the devices.
If external +5V power is used for encoders, DO NOT CONNECT THIS TO THE +5V OUTPUT OF THE SP4. Encoders and/or other circuits may be powered either from external or SP4 +5V outputs as long as they both connect to Signal Ground.

DIFFERENTIAL ENCODER CONNECTIONS

To convert differential encoder outputs to single-ended signals, a line receiver must be mounted to the users PC board. Terminating resistors are also recommended to ensure signal quality. The maximum +5V output current from the SP4 is 500 mA which must support a maximum of four encoders. When using line receivers for differential encoders, the user must consider the total +5V power required for the four encoders and line receivers. If this exceeds 500 mA (2.5W) then the line receivers and/or encoders should be powered from a +5V source on the mounting PC board.



This graphic shows both encoder and line-receiver powered from the SP4 +5V output. If four encoders are connected like this, and assuming 25 mA for each line-receiver, then the available +5V power for each encoder would be 100 mA.
If the encoder power requirement is greater than 100 mA, then external +5V on the mounting board must be used in addition to the +5V from the SP4.

If external +5V power is used for encoders, DO NOT CONNECT THIS TO THE +5V OUTPUT OF THE SP4.

SIGNALS & PINS

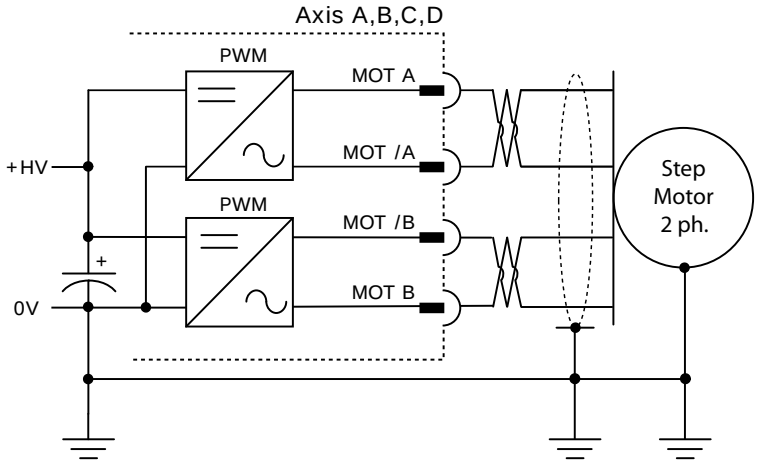
The pins in the chart are on connector P3

Functions	Axis A	Axis B	Axis C	Axis D
	Pins	Pins	Pins	Pins
Enc A	1	2	7	8
Enc B	3	4	9	10
Enc X	5	6	11	12

MOTOR CONNECTIONS (CONT'D)

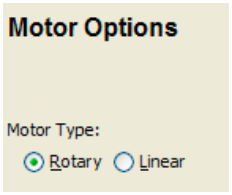
MOTOR PHASE CONNECTIONS

The drive outputs are two H-bridge PWM inverters that convert the 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.



HOW IT LOOKS IN CME2

CME2 -> Basic Setup -> Motor Options

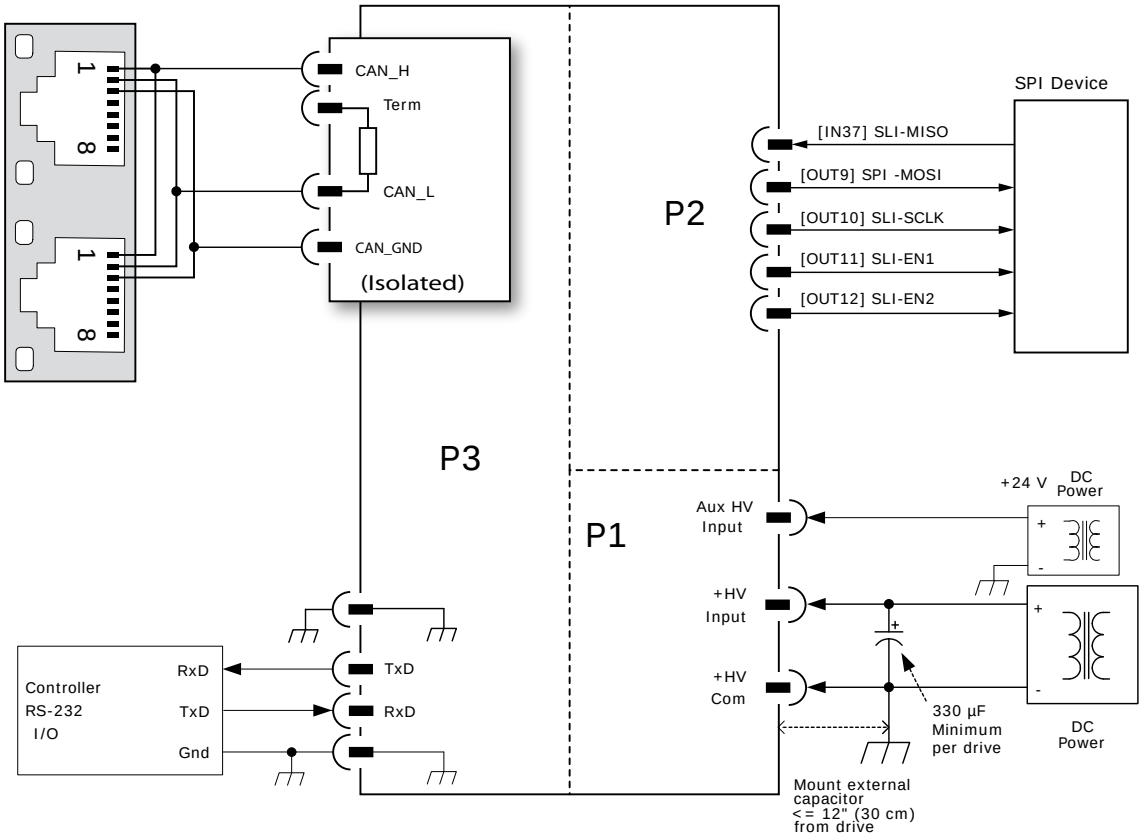


SIGNALS & PINS

The pins in the chart are on connector P1

Functions	Axis A	Axis B	Axis C	Axis D
	Pins	Pins	Pins	Pins
Mot A	18	26	34	42
Mot /A	17	25	33	41
Mot B	16	24	32	40
Mot /B	15	23	31	39
+HV	1,2,3,4			
Pgnd	5,6,7,8			
+AuxHV	9			

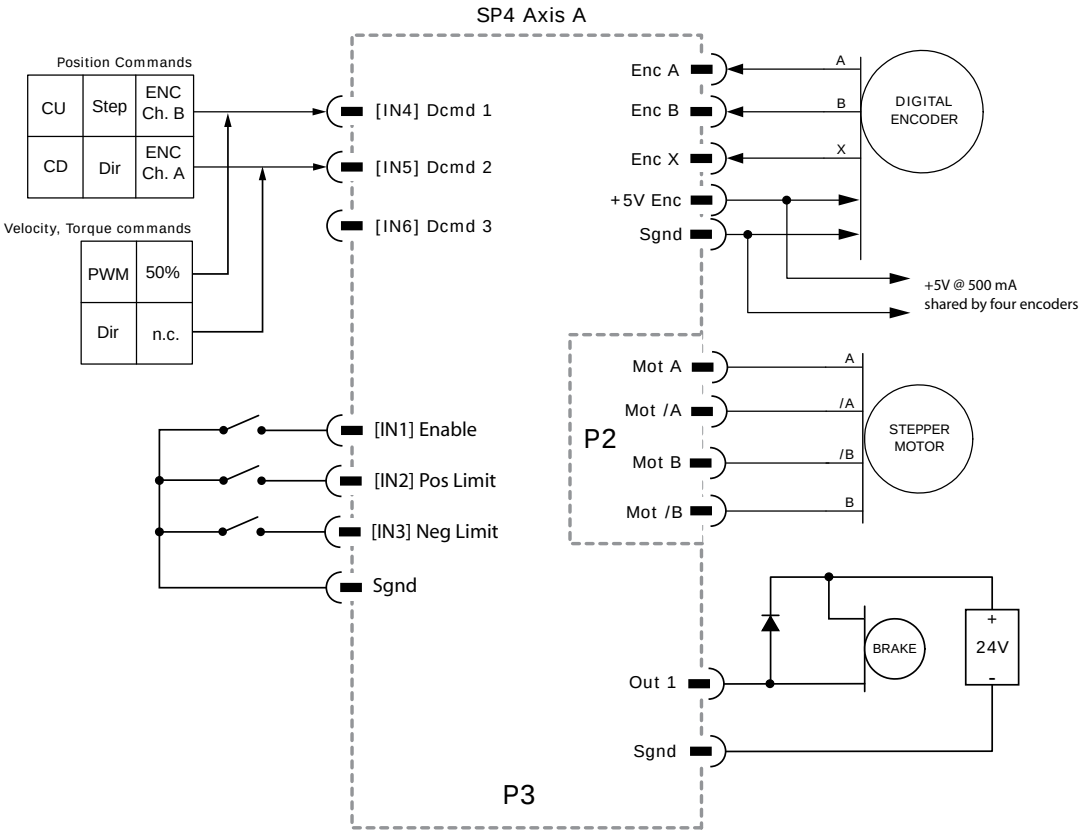
COMMON CONNECTIONS FOR ALL AXES



CONNECTIONS FOR I/O AND ENCODERS

AXIS-A SIGNALS & PINS

Axis A is shown as an example. The tables below show the pins for the same-named signals for axes B, C, and D.



INPUT SIGNALS & PINS

Functions						Axis A		Axis B		Axis C		Axis D	
						Pins	Signal	Pins	Signal	Pins	Signal	Pins	Signal
Enable						15	[IN1]	21	[IN7]	27	[IN13]	33	[IN19]
Programmable						16	[IN2]	22	[IN8]	28	[IN14]	34	[IN20]
Programmable						17	[IN3]	23	[IN9]	29	[IN15]	35	[IN21]
Dcmd 1	Enc A	Pulse	CW	PWM	PWM 50%	19	[IN5]	25	[IN11]	31	[IN17]	37	[IN23]
Dcmd 2	Enc B	Dir	CCW	Polarity	n/a	20	[IN6]	26	[IN12]	32	[IN18]	38	[IN24]

Notes:
1) Inputs functions shown for [IN1], [IN7], [IN13], and [IN19] are the default functions. These inputs are programmable if not used for these functions.
2) The functions shown for [IN5~6], [IN11~12], [IN17~18] and [IN23~24] apply when they are used as digital command inputs for position control. These inputs are programmable if not used for these functions.

ENCODER SIGNALS & PINS

Functions	Axis A	Axis B	Axis C	Axis D
	Pins	Pins	Pins	Pins
Enc A	1	2	7	8
Enc B	3	4	9	10
Enc X	5	6	11	12

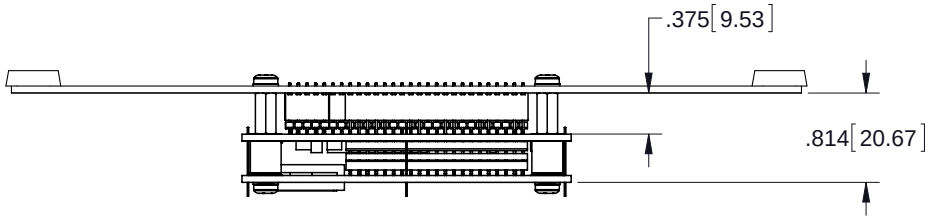
The pins in these charts are on connector P3

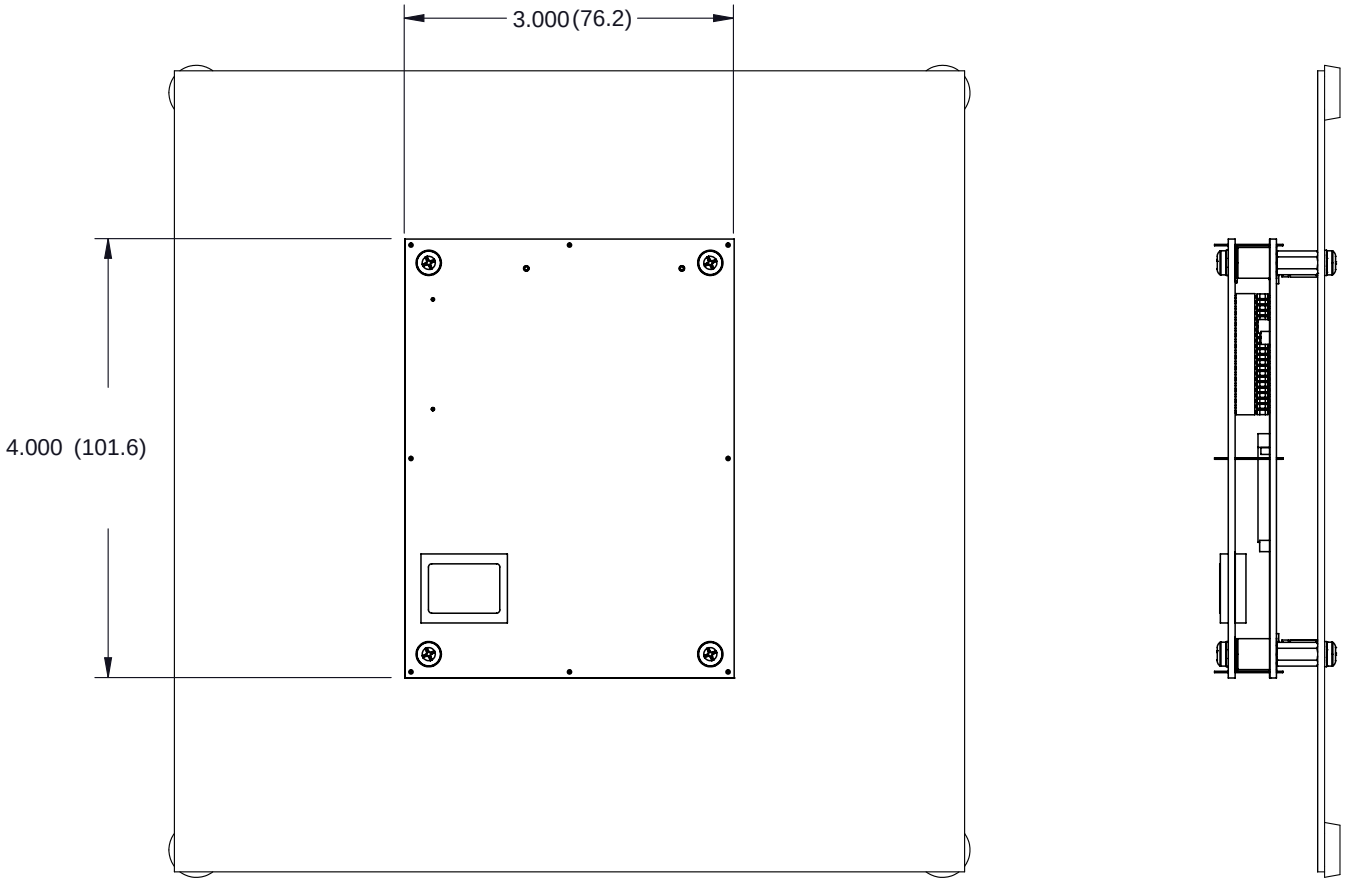
MOSFET OUTPUTS & PINS

Output	P5 Pin
[OUT1]	41
[OUT2]	42
[OUT3]	43
[OUT4]	44
[OUT5]	45
[OUT6]	46
[OUT7]	47
[OUT8]	48

MODULE DIMENSIONS

Units in inch (mm)



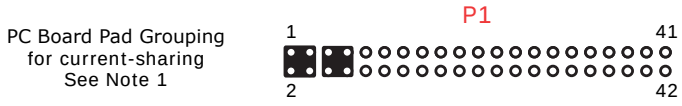


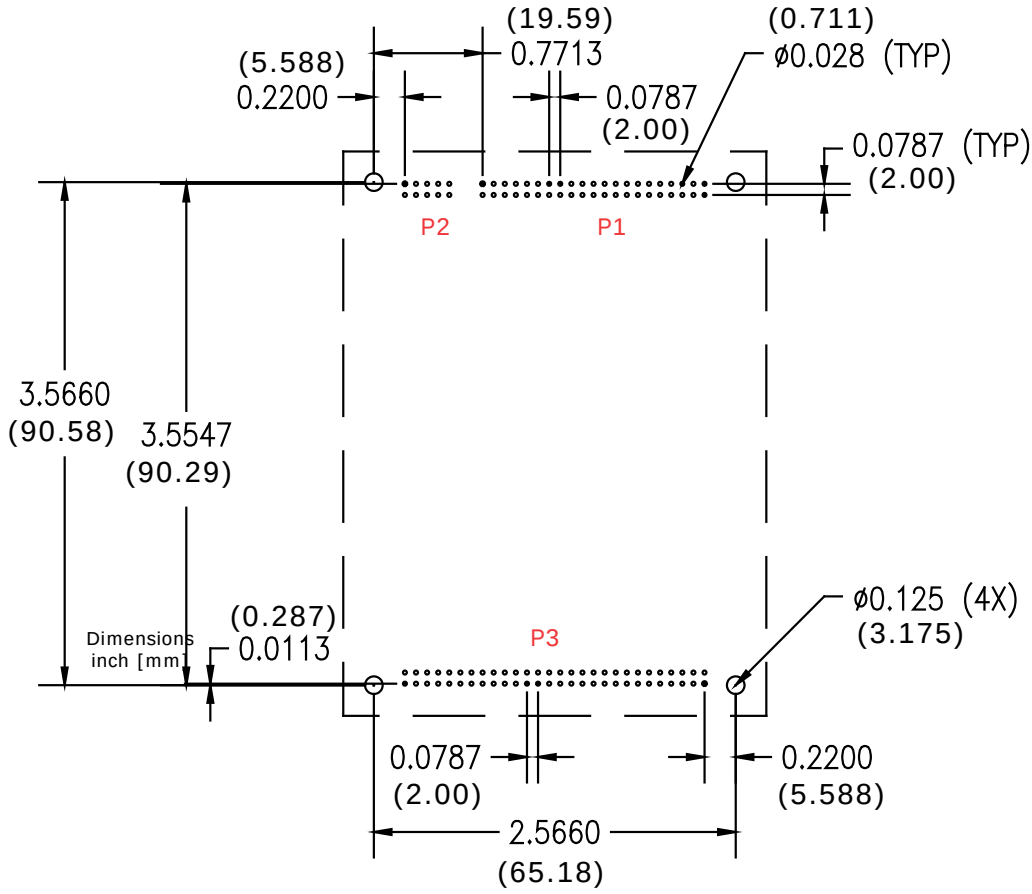
PRINTED CIRCUIT BOARD FOOTPRINT

Dimensions are inch (mm)

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
1	Socket Strip	Samtec	SQW-121-01-L-D	P1: HV, Aux, & Motor
1	Socket Strip	Samtec	SQW-105-01-L-D	P2: SPI port
1	Socket Strip	Samtec	SQW-128-01-L-D	P3: Input/Output
2	Standoff 6-32 X 1/4"	PEM	KFE-632-8ET	

Notes

1. P1 signals of the same name must be connected for current-sharing (see graphic above).
2. To determine copper width and thickness for P1 signals refer to specification IPC-2221. (Association Connecting Electronic Industries, http://www.ipc.org)

MOUNTING PC BOARD CONNECTORS & SIGNALS

P1 POWER

Mounting board connector:
Samtec SQW-121-01-L-D

Axis	Signal	Pin		Signal	Axis
D	Mot /A	41	42	Mot A	D
	Mot /B	39	40	Mot B	
No connections		37	38	No connections	
		35	36		
C	Mot /A	33	34	Mot A	C
	Mot /B	31	32	Mot B	
No connections		29	30	No connections	
		27	28		
B	Mot /A	25	26	Mot A	B
	Mot /B	23	24	Mot B	
No connections		21	22	No connections	
		19	20		
A	Mot /A	17	18	Mot A	A
	Mot /B	15	16	Mot B	
No connections		13	14	No connections	
		11	12		
HVaux		9	10		
HV Gnd		7	8	HV Gnd	
		5	6		
+HV		3	4	+HV	
		1	2		

P2 SPI PORT

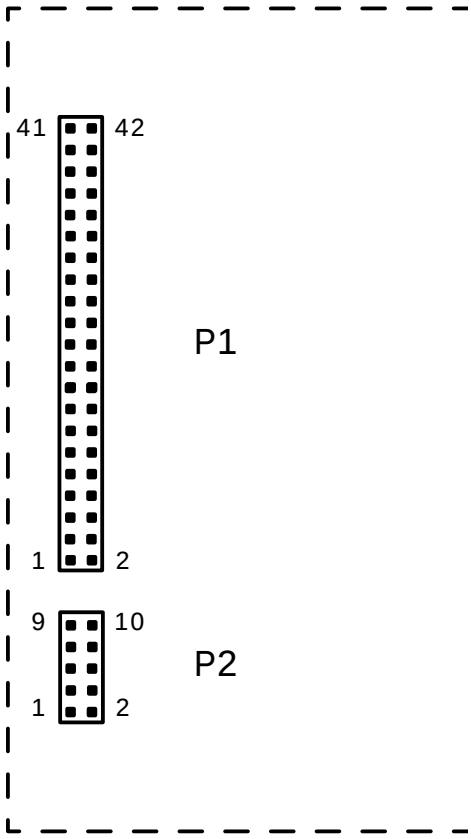
Mounting board connector:
Samtec SQW-105-01-L-D

Signal	Pin		Signal
SPI-MISO	9	10	SPI-MOSI
Sgnd	7	8	SPI-CLK
Sgnd	5	6	SPI-EN1
+5V-ENC	3	4	SPI-EN2
Sgnd	1	2	Sgnd

Signal names in this chart are default settings that configure the port for the SPI function. If the SPI function is not used, the input and outputs on P2 are programmable for other functions.

TOP VIEW

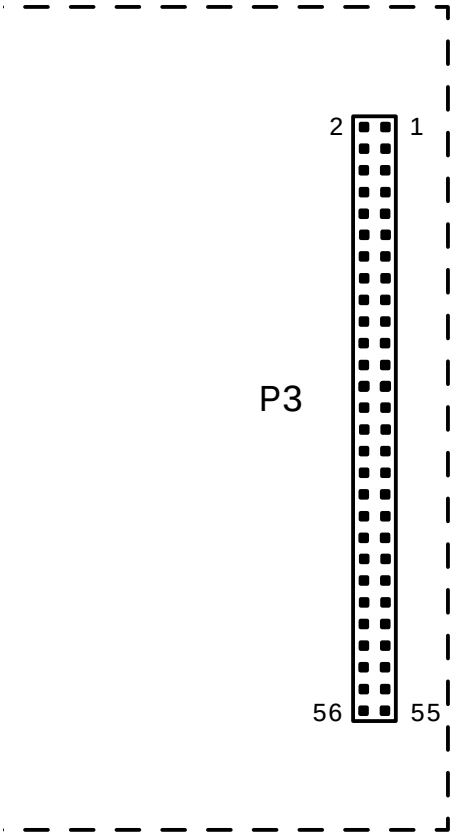
Viewed from above looking down on the connectors or PC board footprint to which the module is mounted



CONNECTOR NAMING (P1, P2, ETC) APPLIES TO THE SP4 MODULE AND NOT TO PC BOARD MOUNTED SOCKETS

TOP VIEW

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



CONNECTOR NAMING (P1, P2, ETC) APPLIES TO THE SP4 MODULE AND NOT TO PC BOARD MOUNTED SOCKETS

P3 INPUT/OUTPUT

Mounting board connector:
Samtec SQW-128-01-L-D

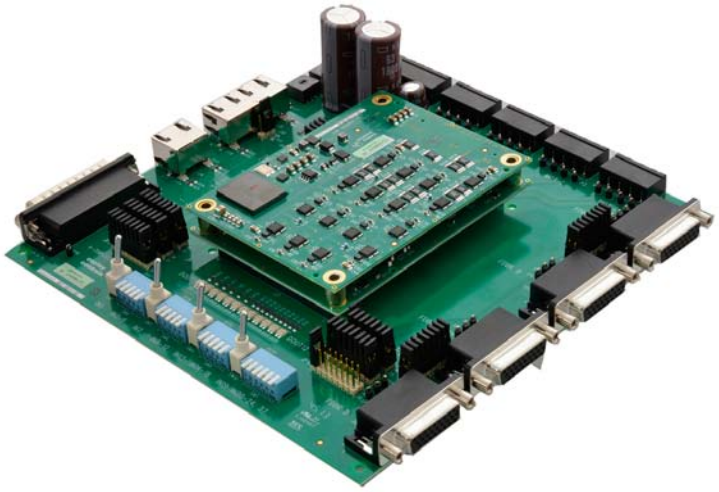
Signal	Pin		Signal
ENC-A Axis-B	2	1	Axis-A ENC-A
ENC-B Axis-B	4	3	Axis-A ENC-B
ENC-X Axis-B	6	5	Axis-A ENC-X
ENC-A Axis-D	8	7	Axis-C ENC-A
ENC-B Axis-D	10	9	Axis-C ENC-B
ENC-X Axis-D	12	11	Axis-C ENC-X
ENC5V	14	13	Signal Gnd
Axis-A HS [IN2]	16	15	[IN1] HS Axis-A Enable
Pulse Axis-A HS [IN4]	18	17	[IN3] HS Axis-A
Index Axis-A HS [IN6]	20	19	[IN5] HS Axis-A Dir
Axis-B HS [IN8]	22	21	[IN7] HS Axis-B Enable
Pulse Axis-B HS [IN10]	24	23	[IN9] HS Axis-B
Index Axis-B HS [IN12]	26	25	[IN11] HS Axis-B Dir
Axis-C HS [IN14]	28	27	[IN13] HS Axis-C Enable
Pulse Axis-C HS [IN16]	30	29	[IN15] HS Axis-C
Index Axis-C HS [IN18]	32	31	[IN17] HS Axis-C Dir
Axis-D HS [IN20]	34	33	[IN19] HS Axis-D Enable
Pulse Axis-D HS [IN22]	36	35	[IN21] HS Axis-D
Index Axis-D HS [IN24]	38	37	[IN23] HS Axis-D Dir
Signal Gnd	40	39	Signal Gnd
MOSFET [OUT2]	42	41	[OUT1] MOSFET
MOSFET [OUT4]	44	43	[OUT3] MOSFET
MOSFET [OUT6]	46	45	[OUT5] MOSFET
MOSFET [OUT8]	48	47	[OUT7] MOSFET
Signal Gnd	50	49	Signal Gnd
RS-232 RxD	52	51	RS-232 TxD
Signal Gnd	54	53	CAN_GND
CAN_L	56	55	CAN_H

Signal names in this chart are default settings.
Digital inputs [IN1~IN24] are programmable for other functions.
Outputs [OUT1~OUT8] are programmable for other functions.

DESCRIPTION

The Development Kit provides mounting and connectivity for one SP4 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 Stepnet Plus or Xenus Plus CANopen drives can easily be connected. Rotary switches are provided to set the CANopen slave Node-ID (address).



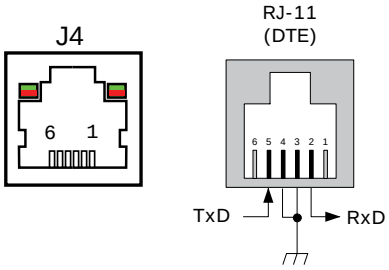
RS-232 CONNECTION

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 Node-ID that is set by the rotary switch can be monitored, and a Node-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.

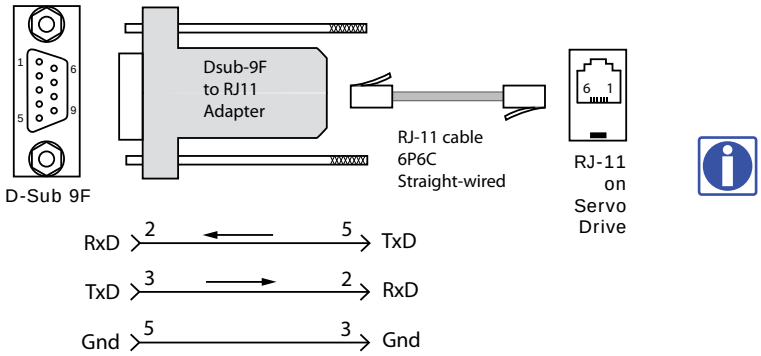
The LEDs on J4 are for the CANopen network status of Axis A & B, and are not associated with the RS-232 port function.

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.



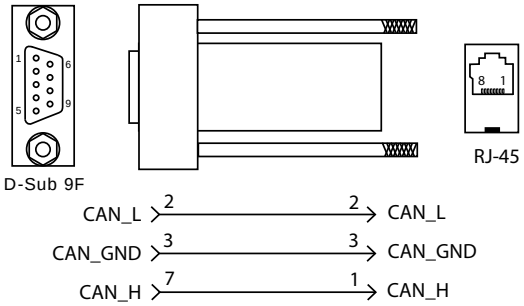
Don't forget to order a Serial Cable Kit SER-CK when placing your order for an SP4 Development Kit!

CANOPEN CONNECTORS

Dual RJ-45 connectors that accept standard Ethernet cables are provided for CAN bus connectivity. Pins are wired-through so that drives can be daisy-chained and controlled with a single connection to the user's CAN interface. A CAN terminator should be placed in the last drive in the chain. The SP4-NK connector kit provides a D-Sub adapter that plugs into a CAN controller and has an RJ-45 socket that accepts the Ethernet cable.

SPK-NK CAN CONNECTOR KIT

The kit contains the SP4-CV adapter that converts the CAN interface D-Sub 9M connector to an RJ-45 Ethernet cable socket, plus a 10 ft (3 m) cable and terminator. Both connector pin-outs conform to the CiA DR-303-1 specification.



INDICATORS (LEDS)

The AMP LEDs DS17~20 at switches SW1, 7, 9, and 10 show the operational state of each axis of the SP4.
The STATUS LEDs on J9 & J4 show the state of the CANopen NMT (Network Management) state-machines of each axis in the drive. Details on the NMT state-machine can be found in the CANopen Programmers Manual, §3.1: http://www.copleycontrols.com/Motion/pdf/CANopenProgrammersManual.pdf

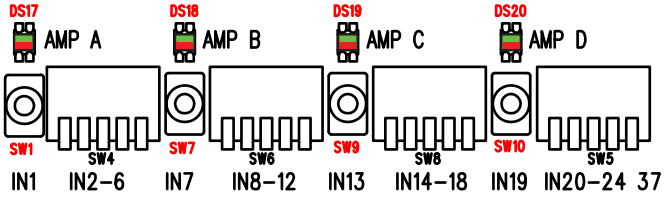
AMP LEDS

Four bi-color LEDs show the states of each axis of the SP4 by changing color, and either blinking or remaining solid.
The possible color and blink combinations are:

- *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 change to *Green/Solid* 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.

Drive Fault conditions. Faults are programmable to be either transient or latching:

- Over or under-voltage
- Motor over-temperature
- Encoder +5 Vdc fault
- Short-circuits from output to ground
- Drive over-temperature
- Internal short circuits
- Short-circuits from output to output



STATUS LEDS

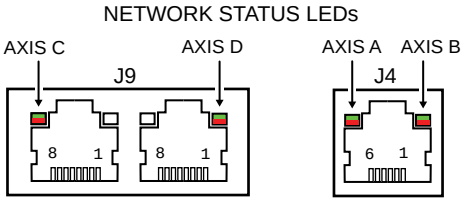
Four bi-color LEDs on J9 & J4 give the state of the NMT state-machine of each axis by changing color, and either blinking or remaining solid. The possible color and blink combinations are:

RUN (GREEN)

- *Off* — *Init*
- *Blinking* — *Pre-operational*
- *Single-flash* — *Stopped*
- *On* — *Operational*

ERROR (RED)

- *Off* — *No error*
- *Blinking* — *Invalid configuration, general configuration error*
- *Single Flash* — *Warning limit reached*
- *Double Flash* — *Error Control Event (guard or heartbeat event) has occurred*
- *Triple Flash* — *Sync message not received within the configured period*
- *On* — *Bus Off, the CAN master is bus off*



Note: Red & green led on-times do not overlap.
LED color may be red, green, off, or flashing of either color.

CANopen Node ID (ADDRESS)

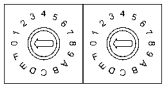
On a CANopen network, each device must have unique, non-zero Node-ID. In the SP4 DevKit, this is provided by two 16-position rotary switches with hexadecimal encoding. These can set the Node-ID of the drive's Axis A from 0x01~0xFF (1~255 decimal). The chart shows the decimal values of the hex settings of each switch.

CME2 -> Amplifier -> Network Configuration

Example 1: Find the switch settings for decimal Node-ID 107 (0x6B):

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 Node-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
3) This example will produce the following CAN addresses for the SP4:
   Axis A = 107 (0x6B), Axis B = 108 (0x6C), Axis C = 109 (0x6D), Axis D = 110 (0x6E)

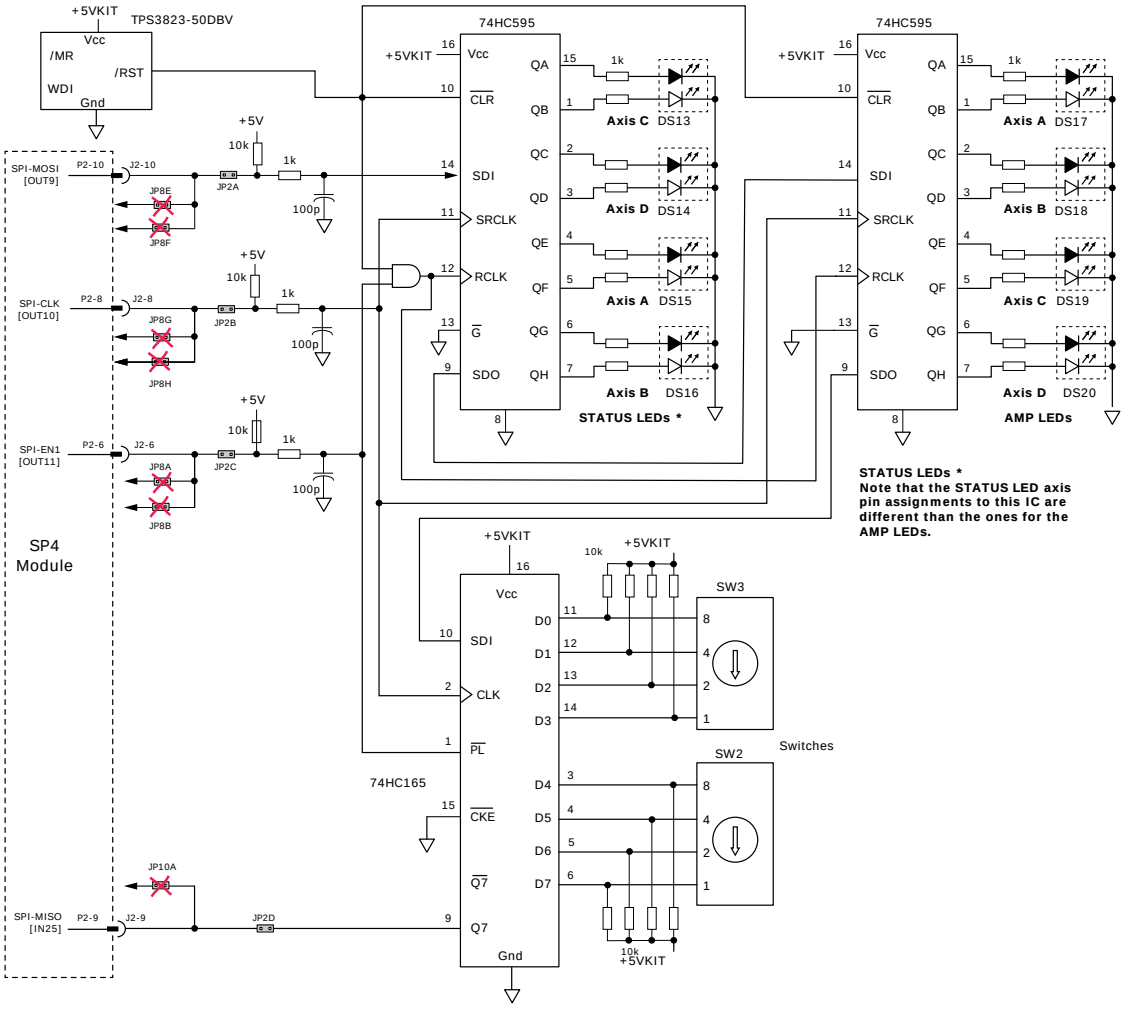
SW2 SW3



CME2 -> Input/Output -> Digital Outputs

CANopen Node-ID Switch Decimal values

	SW2	SW3
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



CANopen NODE-ID (ADDRESS) SWITCH CONNECTIONS

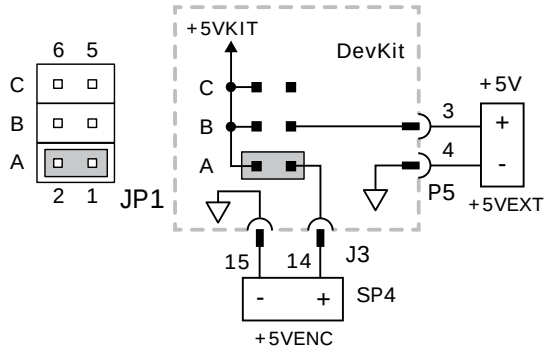
This graphic shows the connections to the CANopen Node-ID switches and to the status LEDs for the SP4 and CANopen. The switches are read once after the drive is reset, or powered-on. When changing the settings of the switches, be sure to either reset the drive, or to power it off-on. Outputs [OUT4,5,6] and input [IN18] operate as an SPI (Switch & LED Interface) port which reads the settings on the CANopen Node-ID 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 SPI port.

+5V POWER

The encoder +5VENC power on the feedback connectors J5~J8 is connected directly to the +5VENC power output from the SP4.

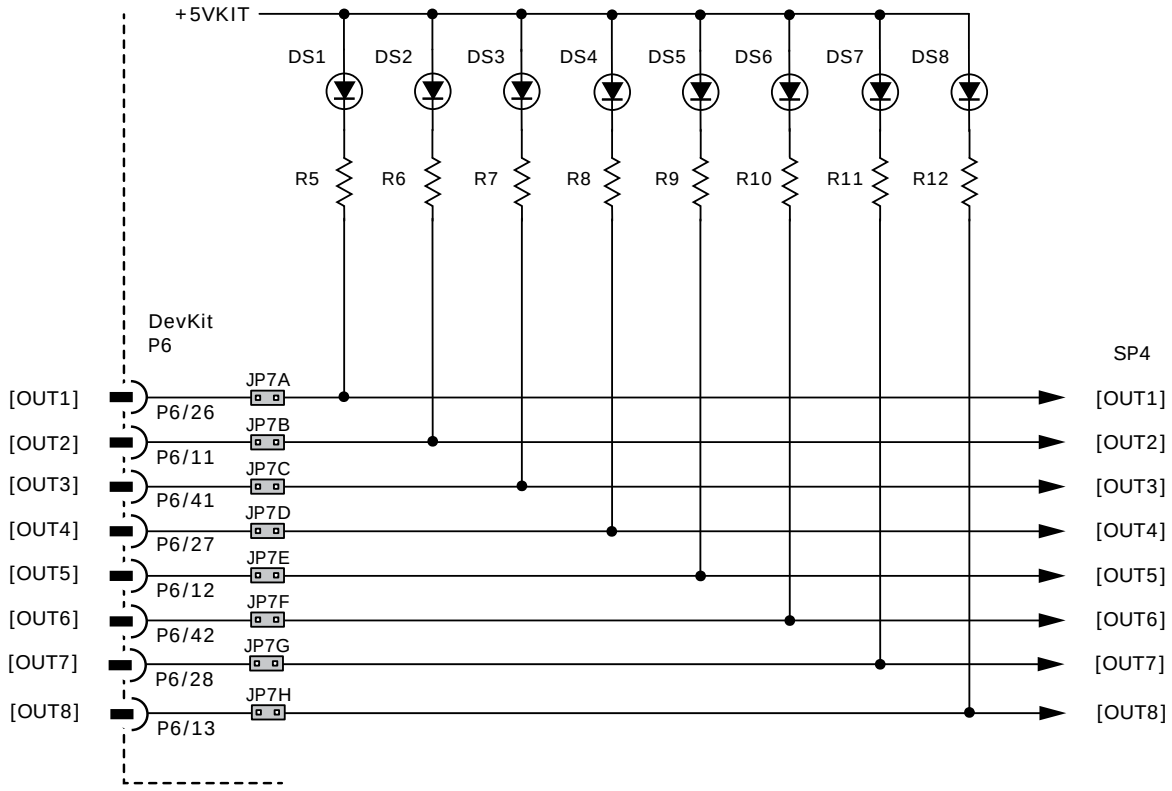
The SPI port components on the DevKit that drive the LEDs and read the Node-ID (address) switches connects to the signal +5VKIT.
And the +5VKIT connects to a jumper on JP1 that selects source of the +5V power.
This can be powered from either the +5VENC power from the SP4, or from an external +5V power supply that connects to P5-3.
The default "A" position (on JP1 pins 1~2) selects the +5VENC from the SP4 as the power source for the +5VKIT.
Moving the jumper to the "B" position (pins 3~4) selects the external +5V power source for +5VKIT.
As noted below, only one jumper should be used to select the source of power for +5VKIT.



IMPORTANT: ONLY ONE SHORTING PLUG CAN BE USED ON JP1-A or JP1-B POSITIONS
USE OF MORE THAN ONE PLUG WILL DAMAGE 5V POWER SUPPLIES IN THE SP4

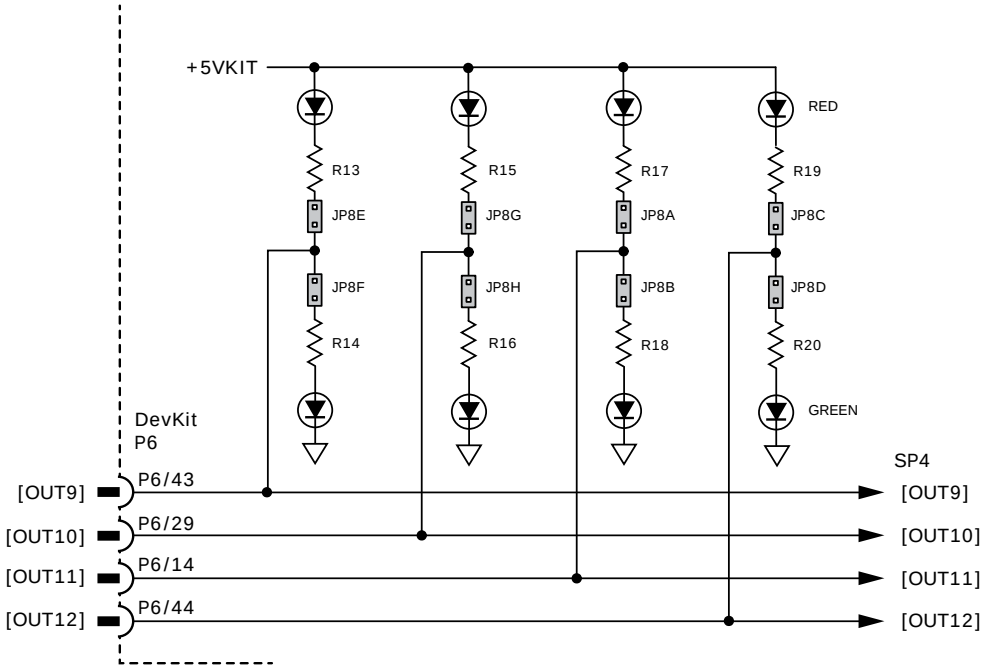
MOSFET OUTPUTS

There are eight MOSFET 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. LED indicators connected to the outputs will be ON when the output is MOSFET is ON and the output voltage will be near 0V. 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 OUTPUTS

Outputs 9~12 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.

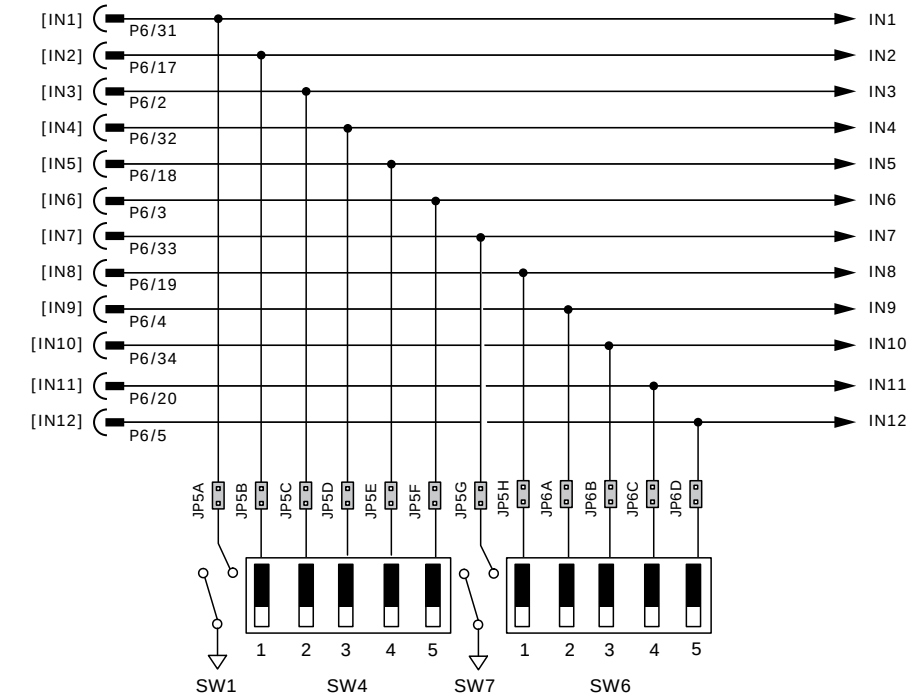


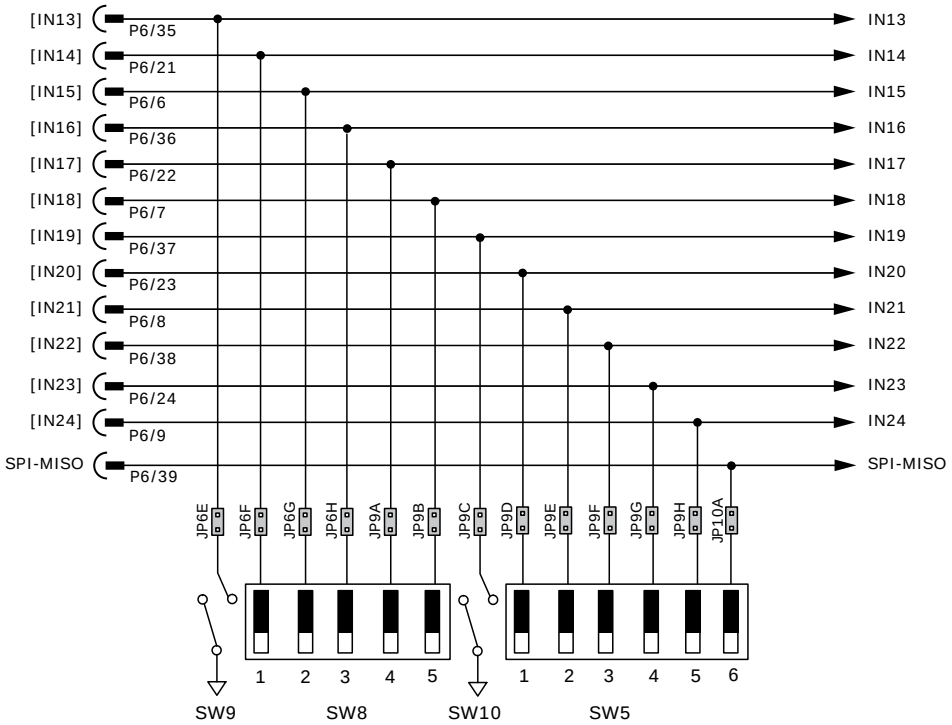
LOGIC INPUTS & SWITCHES

The Development Kit has jumpers that can connect the SP4 digital inputs to switches on the kit, or to the Signal connector J6.

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 JP5A should be removed to take the switch SW1 out of the circuit. The figure below shows these connections.





DEVELOPMENT KIT CONNECTORS

The Development Kit mounts a single SP4 module and enables the user to test and operate the SP4 before it is mounted onto a PC board in the target system.

J5 AXIS A | J6 AXIS B | J7 AXIS C | J8 AXIS D FEEDBACK

PIN	SIGNAL
26	Signal Gnd
25	Signal Gnd
24	n.c.
23	n.c.
22	n.c.
21	n.c.
20	n.c.
19	n.c.

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

PIN	SIGNAL
9	Enc X
8	n.c.
7	n.c.
6	+5VENC
5	Signal Gnd
4	Table 1 (below)
3	
2	
1	Frame Gnd

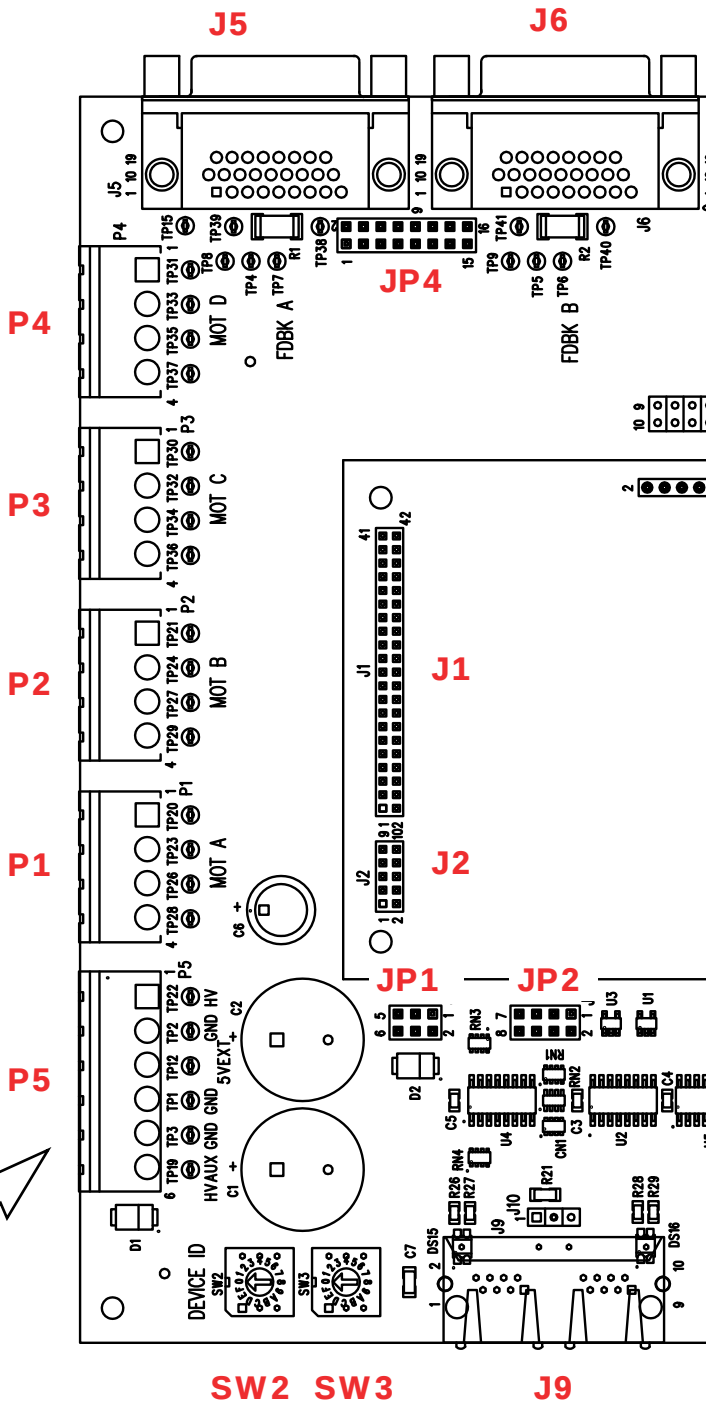


TABLE 1

This shows the signals connected to these pins on the axis feedback connectors J5~J8. The jumpers connect these pins to signals in the SP4.

Pin	Axis A		Axis B		Axis C		Axis D	
2	IN2	JP4-A	IN8	JP4-E	IN14	JP3-A	IN20	JP3-E
3	IN3	JP4-B	IN9	JP4-F	IN15	JP3-B	IN21	JP3-F
4	IN4	JP4-C	IN10	JP4-G	IN16	JP3-C	IN22	JP3-G
7	IN5	JP4-D	IN11	JP4-H	IN17	JP3-D	IN23	JP3-H

P4: AXIS D MOTOR
P3: AXIS C MOTOR
P2: AXIS B MOTOR
P1: AXIS A MOTOR

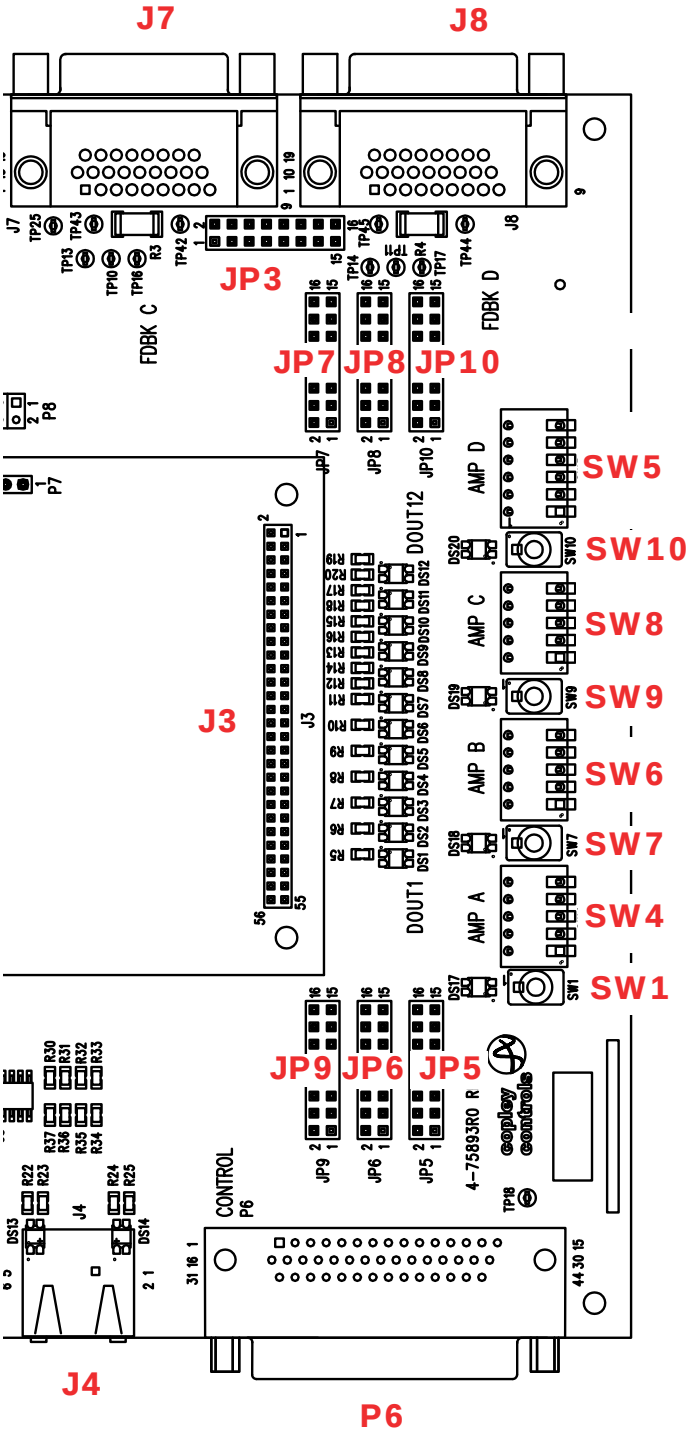
Connector, Euro, 4 Terminal, 5.08 mm

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

P5: HV, AUX, GND

Connector, Euro, 5 Terminal, 5.08 mm

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



SW 1,7,9,10: ENABLE INPUTS

Axis ->	Axis A	Axis B	Axis C	Axis D
Enable	SW1	SW7	SW9	SW10
Input	[IN1]	[IN7]	[IN13]	[IN19]
Jumper	JP5A	JP5G	JP6E	JP9C

DIP SWITCH INPUT CONNECTIONS

Axis ->	SW4	SW6	SW8	SW5
1	[IN2]	[IN8]	[IN14]	[IN20]
2	[IN3]	[IN9]	[IN15]	[IN21]
3	[IN4]	[IN10]	[IN16]	[IN22]
4	[IN5]	[IN11]	[IN17]	[IN23]
5	[IN6]	[IN12]	[IN18]	[IN24]

P6: CONTROL

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
15	Sgnd	30	+5VENC	44	[OUT12]
14	SPI-SS1	29	SPI-CLK	43	SPI-MOSI
13	[OUT8]	28	[OUT7]	42	[OUT6]
12	[OUT5]	27	[OUT4]	41	[OUT3]
11	[OUT2]	26	[OUT1]	40	Sgnd
10	Sgnd	25	+5VENC	39	SPI-MISO
9	[IN24]	24	[IN23]	38	[IN22]
8	[IN21]	23	[IN20]	37	[IN19]
7	[IN18]	22	[IN17]	36	[IN16]
6	[IN15]	21	[IN14]	35	[IN13]
5	[IN12]	20	[IN11]	34	[IN10]
4	[IN9]	19	[IN8]	33	[IN7]
3	[IN6]	18	[IN5]	32	[IN4]
2	[IN3]	17	[IN2]	31	[IN1]
1	Frm Gnd	16	Sgnd		

MASTER ORDERING GUIDE

SP4-055-03	*Stepnet Plus SP4* stepper drive, 3/3A, 14~55 Vdc
SPK-055-04	Development Kit for *Stepnet Plus SP4*

ACCESSORIES

	QTY	Connector	DESCRIPTION
Connector Kit for Development Kit SPK-CK-04	1	P5	Connector, Euro, 6 Terminal, 5.08 mm
	4	P1~P4	Connector, Euro, 4 Terminal, 5.08 mm
	1	P6	44 Pin Connector, High Density, D-Sub, Male, Solder Cup
			44 Pin Connector Backshell
	4	J5~J8	26 Pin Connector, High Density, D-Sub, Female, Solder Cup
	4		26 Pin Connector Backshell
SER-CK		J4	Serial Cable Kit

CONNECTORS & ACCESSORIES FOR CANOPEN OPERATION

	QTY	Connector	DESCRIPTION
Network Cable Kit SPK-NK	1	J7	D-Sub 9F to RJ-45 Adapter
	1		CAN bus RJ-45 terminator
	1		CAN bus network cable, 10 ft (3 m)
SPK-CV	1		D-Sub 9F to RJ-45 Adapter
SPK-NC-10	1		CAN bus Network Cable, 10 ft (3 m)
SPK-NC-01	1		CAN bus Network Cable, 1 ft (0.3 m)
SPK-NT	1		CAN bus Network Terminator