Argus^{PLUS} Module EtherCAT

GEM

DIGITAL SERVO DRIVE FOR BRUSH & BRUSHLESS MOTORS

CONTROL MODES
- Cyclic Synchronous Position-Velocity-Torque (CSP, CSV, CST)
- Profile Position-Velocity-Torque, Interpolated Position, Homing
- Indexer, Point-to-Point, PVT
- Camming, Gearing
- Position, Velocity, Torque

COMMAND INTERFACE
- CANopen application protocol over EtherCAT (CoE)
- ASCII and discrete I/O
- Stepper commands
- ±10V Position/Velocity/Torque
- PWM Velocity/Torque command
- Master encoder (Camming, Gearing)

COMMUNICATIONS
- EtherCAT
- RS-232
- RS-422

FEEDBACK
- *Dual Absolute Encoder Ports*
- *Absolute*
    - SSI
    - EnDat 2.1 & 2.2
    - Absolute A
    - Tamagawa
    - Panasonic
    - Sanyo Denki
    - BiSS (B&C)
- *Incremental*
    - Digital quad A/B encoder
    - Analog Sin/Cos encoder
    - Aux. encoder / encoder out
- *Other*
    - Digital Halls
    - Resolver (-R models)

I/O DIGITAL
- 6 High-speed inputs
- 4 Opto-isolated inputs
- 1 Motor over-temp input
- 4 High-speed outputs
- 4 Opto-isolated outputs
- 1 Opto-isolated motor brake output

I/O ANALOG
- 1 Reference input, 16-bit

SAFE TORQUE OFF (STO)
- SIL 3, Category 3, PL d

DIMENSIONS: IN [MM]
- 3.10 x 2.40 x 0.92 [78.7 x 60.1 x 23.4]

Model	Ic	Ip	Vdc
GEM-055-60	30	60	9~55
GEM-055-60-R	30	60	9~55
GEM-090-60	30	60	14~90
GEM-090-60-R	30	60	14~90

DESCRIPTION

GEM sets new levels of performance, connectivity, and flexibility. CANopen application protocol over EtherCAT (CoE) communication provides a widely used cost-effective industrial bus. A wide range of absolute encoders are supported.

Both isolated and high-speed non-isolated I/O are provided. For safety critical applications, redundant power stage enable inputs can be employed.

GENERAL SPECIFICATIONS

Test conditions: Wye connected load: 2 mH line-line. Ambient temperature = 25 °C. Power input = 55 Vdc

MODEL		GEM-055-60(-R)	GEM-090-60(-R)	
OUTPUT CURRENT				
	Peak Current	60 (42.4)	60 (42.4)	Adc (Arms)
	Peak time	1	1	Sec
	Continuous current	30 (21.2)	30 (21.2)	Adc (Arms)
	Peak Output Power	5.4	5.4	kW
	Continuous Output Power	2.7	2.7	kW
INPUT POWER				
	HVmin to HVmax	+9 to +55	+14 to +90	Vdc
	Ipeak	60	60	Adc
	Icont	30	30	Adc
	Aux HV	+9 to +55	+14 to +90	Vdc (2.5 W max)

PWM OUTPUTS		
	Type	MOSFET 3-phase inverter, 16 kHz center-weighted PWM carrier, space-vector modulation
	PWM ripple frequency	32 kHz

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)
	PWM frequency	16 kHz
	Bus voltage compensation	Changes in bus or mains voltage do not affect bandwidth
	Minimum load inductance	500 µH line-line
	Resolution	16-bit capture of U & V phase currents

COMMAND INPUTS		
	EtherCAT:	CAN application protocol over EtherCAT (CoE): Cyclic Synchronous Position/Velocity/Torque, Profile Position/Velocity/Torque, Interpolated Position (PVT), Homing
		Internally isolated from Signal Ground, 32 V max working voltage vs. Signal Ground
	Stand-alone mode:	
	Analog Torque, Velocity, Position reference	±10 Vdc, 16 bit resolution Dedicated differential analog input
	Digital Position reference	Pulse/Direction, CW/CCW Stepper commands (2 MHz maximum rate)
		Quad A/B Encoder 2 M line/sec, 8 Mcount/sec (after quadrature)
	Digital Torque & Velocity reference	PWM , Polarity PWM = 0% - 100%, Polarity = 1/0
		PWM 50% PWM = 50% ±50%, no polarity signal required
		PWM frequency range 1 kHz minimum, 100 kHz maximum
		PWM minimum pulse width 220 ns
	Indexing	Up to 32 sequences can be launched from inputs or ASCII commands.
	Camming	Up to 10 CAM tables can be stored in flash memory
	ASCII	RS-232, 9600~115,200 Baud, 3-wire, RJ-11 connector, referenced to Signal Ground

DIGITAL INPUTS		
	Number	11
	[IN1,2,3,4,5,6]	Digital, non-isolated, Schmitt trigger, 0.1 µs RC filter, 7 Vdc compatible, 10 kΩ pull-up to +5 Vdc
		Vt+ = 2.5~3.5 Vdc max, Vt- = 1.3~2.2 Vdc min, Vh = 0.7~1.5 Vdc min, SLI port MISO signal
	[IN7,8,9,10]	Digital, opto-isolated, single-ended, ±15~30 Vdc compatible, bi-polar, with common return
		Rated impulse ≥ 800 V, Vin-LO ≤ 6.0 Vdc, Vin-HI ≥ 10.0 Vdc, Input current ±3.6 mA @ ±24 Vdc, typical
	[IN11]	Defaults as motor overtemp input on feedback connector, 24 Vdc max, programmable to other functions
		Other digital inputs are also programmable for the Motemp function
		330 µs RC filter, 4.99 kΩ pull-up to +5 Vdc, Vt+ = 2.5~3.5 Vdc, VT- = 1.3~2.2 Vdc, VH = 0.7~1.5 Vdc
	Functions	All inputs are programmable, [IN1] defaults to the Enable function and is programmable for other functions.analog input

ANALOG INPUT		
	[AIN±]	Differential, -10 to +15 Vdc, 5.36 kΩ input impedance, 16-bit resolution, 16 kHz acquisition rate
		Bandwidth (-3 dB) of analog signal path: ≥ 14 kHz, common-mode range -10 to +15 Vdc

DIGITAL OUTPUTS		
	Number	9
	[OUT1~4]	Isolated, two-terminal SSR with 1 Ω series resistor and 36 V Zener diode for driving inductive loads
		Ton = 5 ms max, @ 300 mA, Toff = 2 ms max @ 300 mA
		Maximum working voltage with respect to ground: 32 Vdc, rated impulse voltage ≥ 800 Vdc
	[OUT5~8]	High speed, SLI port MOSI, SCLK, & EN1 signals, 74AHCT125 line drivers; +5 Vdc tolerant
		Output current: ±25 mA max @ ±5 Vdc
	[OUT9 BRAKE]	Isolated, MOSFET, 1 A max, external flyback diode required, Turn-ON & Turn-OFF delay 250 µs max
		GATE output can drive an external MOSFET for brakes requiring higher current
		Maximum working voltage with respect to ground: 32 Vdc, rated impulse voltage ≥ 800 Vdc
	Functions	Default functions are shown above, programmable to other functions

RS-232 PORT		
	Signals	RxD, TxD, Gnd in 6-position, 4-contact RJ-11 style modular connector, non-isolated
	Mode	Full-duplex, DTE serial communication port for drive setup and control, 9,600 to 115,200 baud
	Protocol	Binary and ASCII formats, EIA/TIA-232E voltage levels, ±5.0 minimum output, ±30 V input voltage range

RS-422 PORT		
	Signals	A/Y(+), B/X(-), Gnd from ISL32455 tranceiver, optically isolated
	Mode	Half-duplex, RS-422 slave, 9,600 bps to 230.4 kbps
	Protocol	Binary and ASCII formats

NOTES:
1. Brake output [OUT9] is programmable as motor brake, or as general purpose digital output.
2. When STO feature is used, the 24V power supply must be a SELV or PELV type with the maximum output voltage limited to 60 Vdc or lower.

Argus^PLUS Module EtherCAT — GEM

copley controls

GENERAL SPECIFICATIONS

DC OUTPUTS

Number	1	
Ratings	+5 Vdc @ 500 mA thermal and overload protected	

SAFE TORQUE OFF (STO)

Function	PWM outputs are inactive and current to the motor will not be possible when the STO function is asserted
Standard	Designed to IEC-61508-1, IEC-61508-2, IEC-61800-5-2, ISO-13849-1
Safety Integrity Level	SIL 3, Category 3, Performance level d
Inputs	2 two-terminal: STO-IN1+,STO-IN1-, STO-IN2+, STO-IN2-
Type	Opto-isolators, 24V compatible, Vin-LO ≤ 6.0 Vdc or open, Vin-HI ≥ 15.0 Vdc,
Input current (typical)	STO-IN1:11.2 mA, STO-IN2: 11.2 mA
Response time	2 ms from Vin ≤6.0 Vdc to interruption of energy supplied to motor
Disabling	Wiring a shorting plug with jumpers (see page 6) will disable the STO function

PROTECTIONS

HV Overvoltage -055 models	+HV > 55 Vdc	Drive outputs turn off until +HV ≤ 55 Vdc
HV Undervoltage -055 models	+HV < 9 Vdc	Drive outputs turn off until +HV ≥ 9 Vdc
HV Overvoltage -090 models	+HV > 90 Vdc	Drive outputs turn off until +HV ≤ 90 Vdc
HV Undervoltage -090 models	+HV < 14 Vdc	Drive outputs turn off until +HV ≥ 14 Vdc
Drive over temperature	Heat plate > 80°C.	Drive outputs turn off
Short circuits	Output to output, output to ground, internal PWM bridge faults	
I^2T Current limiting	Programmable: continuous current, peak current, peak time	
Motor over temperature	Digital inputs programmable to detect motor temperature switch	
Feedback Loss	Inadequate analog encoder amplitude or missing incremental encoder signals	

MECHANICAL & ENVIRONMENTAL

Size mm [in]	3.10 x 2.40 x 0.92 [78.7 x 60.1 x 23.4]
Weight	4.2 oz (120 g) without 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	IEC 60068-2
Cooling	Heat sink and/or forced air cooling required for continuous power output
Altitude	≤ 2000 m (6560 ft) per IEC 60068-2-13

AGENCY STANDARDS CONFORMANCE

Standards and Directives
  Functional Safety
    IEC 61508-1, IEC 61508-2, EN (ISO) 13849-1, IEC 61800-5-2
  Electrical Safety
    Directive 2014/35/EU – Low Voltage, UL 61800-5-1:2016
  EMC
    Directive 2014/30/EU, IEC 61800-3:2017, Category C3
  Restriction of the Use of Certain Hazardous Substances (RoHS)
    Directive 2011/65/EU (RoHS II)

Approvals
    UL and cUL recognized component to UL 61800-5-1
    UL Functional Safety to IEC 61800-5-2
    EMC to IEC 61800-3

FUNCTIONAL SAFETY

CE UL®

ISO 13849-1
Up to PL d (Cat 3)
IEC 61800-5-2
Up to SIL 3

RoHS Directive 2011/65/EU is now part of the CE marking procedure

⚠ **DANGER**	***Refer to the 16-01599 Argus Plus GEM & GPM Modules User Guide***
	The information provided in the manual must be considered for any application using the GEM drive STO feature. ***Failure to heed this warning can cause equipment damage, injury, or death.***

GENERAL SPECIFICATIONS

FEEDBACK

All Channels

MAX3097 differential line receivers for A, B, 5 MHz maximum line frequency (20 M counts/sec)
MAX3362 differential line transceivers for S, X, 5 MHz maximum line frequency (20 M counts/sec)
Fault detection for open/shorted inputs, or low signal amplitude, selectable for A/B/X or A/B
External terminators required for fault detection, 121 Ω for A & B channels, 130 Ω for X
Internal 1 kΩ biasing pull-ups to +5V: X & S, internal 1 kΩ biasing pull-downs to Sgnd: /X & /S

Incremental encoders:

Digital Incremental Encoder	Quadrature signals, (A, /A, B, /B, X, /X), differential (X, /X Index signals not required)
Analog Incremental Encoder	Sin/Cos, differential, internal 121 Ω terminators between ± inputs, 1.0 Vp-p typical, 1.45 Vp-p maximum, Common-mode voltage 0.25 to 3.75 Vdc, , ±0.25 V, centered about 2.5 Vdc
	Signals: Sin(+), Sin(-), Cos(+), Cos(-),
	Frequency: 300 kHz maximum line (cycle) frequency, interpolation 16 bits/cycle (4096 counts/cycle)

Absolute encoders:

Heidenhain EnDat 2.2, SSI	Serial Clock (X, /X), Data (S, /S) signals, differential 4-wire,
	External 121 Ω terminator required for Clock, 221 Ω for Data
Heidenhain EnDat 2.1	Clock (X, /X), Data (S, /S), Sin/Cos (Sin+, Sin-, Cos+, Cos-) signals
	Internal 121 Ω terminators between Sin/Cos inputs,
	External 121 Ω terminator required for Clock, 221Ω for Data
Absolute A, Tamagawa Absolute A, Panasonic Absolute A Format	
	SD+, SD- (S, /S) signals, 2.5 or 4 MHz, 2-wire half-duplex, external 221 Ω terminator required
	Position feedback: 13-bit resolution per rev, 16 bit revolution counter (29 bit absolute position data)
	Status data for encoder operating conditions and errors
BiSS (B&C)	MA+, MA- (X, /X), SL+, SL- (S, /S) signals, 4-wire, clock output from drive,
	data returned from encoder
	External 121 Ω terminator required for MA, 221 Ω for SL

Resolver:

Type	Brushless, single-speed, 1:1 to 2:1 programmable transformation ratio
Resolution	14 bits (equivalent to a 4096 line quadrature encoder)
Reference frequency	8.0 kHz
Reference voltage	2.8 Vrms, auto-adjustable by the drive to maximize feedback
Reference maximum current	100 mA
Maximum RPM	10,000+

HALLS

Digital:

U, V, W: Single-ended, 120° electrical phase difference between U-V-W signals,
Schmitt trigger, 1.5 µs RC filter, 24 Vdc compatible, 15 kΩ pull-up to +5 Vdc
Vt+ = 2.5~3.5 Vdc, VT- = 1.3~2.2 Vdc, VH = 0.7~1.5 Vdc

Analog:

U & V: Sin/Cos format (Sin+, Sin-, Cos+, Cos-), differential, 1 Vpeak-peak ±20%,
BW > 300 kHz, 121 Ω terminating resistors between Sin+ & Sin-, Cos+ & Cos- inputs
16-bit resolution, BW ≥ 300 kHz, with zero-crossing detection

MULTI-MODE ENCODER PORT

As Input:	See Digital Incremental Encoder above for electrical data on A, B, & X channels, or
	Absolute encoders using X or S channels. External terminators required as shown above
As Emulated Output:	Quadrature A/B encoder emulation with programmable resolution to 4096 lines (65,536 counts)
	per rev from analog Sin/Cos encoders or resolvers.
	A, /A, B, /B, outputs from MAX3032 differential line driver, X, /X, S, /S from MAX 3362 line drivers
As Buffered Output:	Digital A/B/X encoder signals from primary digital encoder are buffered as shown above, 5 MHz max

5V OUTPUT

Number	1
Ratings	+5 Vdc @ 500 mA thermal and overload protected

16-01558 Document Revision History

Revision	Date	Remarks
00	March 27, 2017	Preliminary version
01	April 4, 2017	Initial released version
02	December 6, 2017	Added 90V models, change 90V model min voltage to 14 Vdc, corrected DevKit model number, added thermal data, remove large heatsink, add HS kit to accessories.
03	June 7, 2018	Corrections to STO graphic and signal namings
04	February 15, 2019	Updated photo on first page and edited the Feedback section
05	March 13, 2019	Corrected SSI encoder description
06	September 17, 2020	Update to latest data in Argus Plus GEM & GPM Modules User Guide
07	October 22, 2020	Add Functional Safety logo and ISO, IEC text
08	October 28, 2021	Updated Peak Time information from 2 seconds to 1 second. Updated conformance with RoHS message.

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 protocol over EtherCAT (CoE) based on DSP-402 for motion control devices. More information on EtherCAT can be found on the EtherCAT Technology Group web-site: https://www.ethercat.org/default.htm
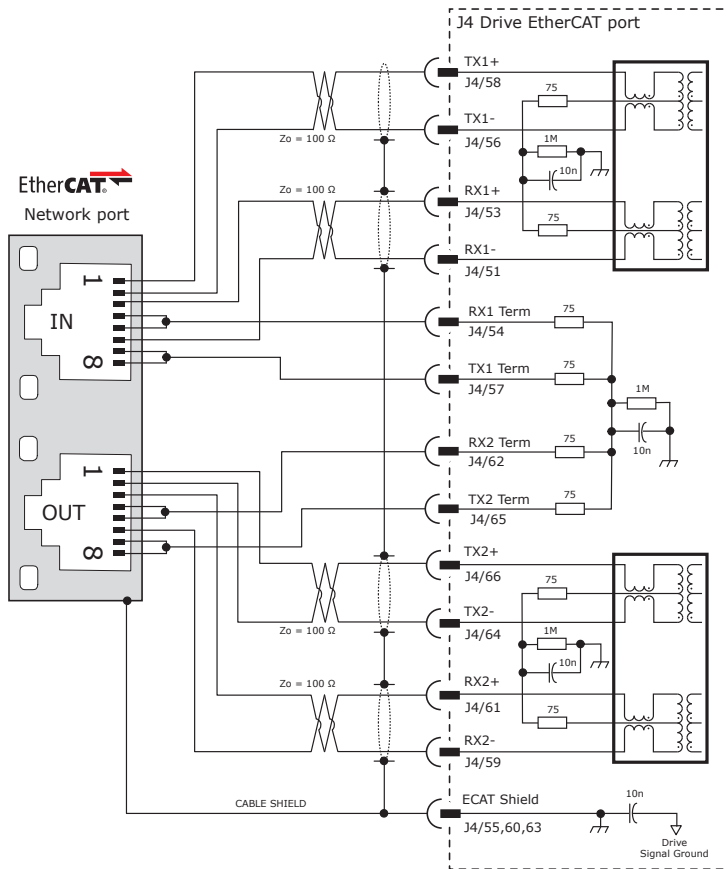

ETHERCAT CONNECTIONS

Page 23 shows guidelines for PC board layout and designing for EtherCAT signals.

Page 31 shows the dual EtherCAT cable connections on the Development Kit.

Magnetics are in the servo drive. External RJ-45 connectors do not require integrated magnetics.

RS-232 COMMUNICATIONS

GEM 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 *GEM* RS-232 port are through P4 The graphic below shows the connections between an *GEM* and a computer COM port which is a DTE device.
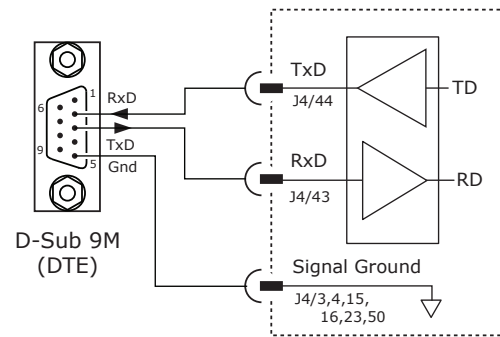
RS-422 COMMUNICATIONS

RS-422 is a two-wire differential half-duplex port that operates from 9600 to 230.4 kbps. The graphic shows the connections between a *GEM* and the Development Kit RS-422 port P9. The RS ground is RS422GND and is only in the isolated RS422 circuit. It should connect to Signal Ground on the user's PC board or other 0V electrical circuit.

A, B, and C are the signal labels in the RS422 specification.
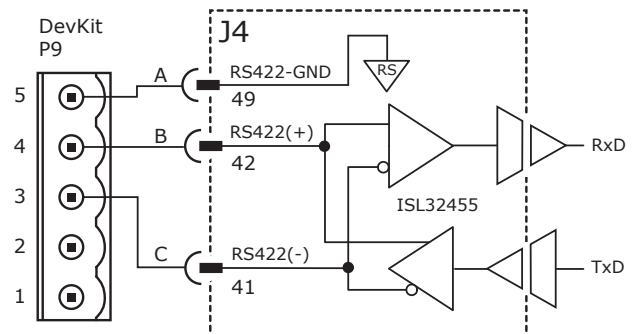
SAFE TORQUE OFF (STO)

DESCRIPTION

The GEM provides the Safe Torque Off (STO) function as defined in IEC 61800-5-2. Three opto-couplers are provided which, when de-energized, prevent the upper and lower devices in the PWM outputs from being operated by the digital control core. This provides a positive OFF capability that cannot be overridden by the control firmware, or associated hardware components. When the opto-couplers are activated (current is flowing in the input diodes), the control core will be able to control the on/off state of the PWM outputs.

INSTALLATION

⚠️ **DANGER**	*Refer to the 16-01599 Argus Plus GEM & GPM Modules User Guide*
	The information provided in the manual must be considered for any application using the GEM drive STO feature. *Failure to heed this warning can cause equipment damage, injury, or death.*

STO BYPASS (DISABLING)

In order for the PWM outputs of the drive to be activated, current must be flowing through all of the opto-couplers that are connected to the STO-1 and STO-2 terminals of J4, and the drive must be in an ENABLED state. When the opto-couplers are OFF, the drive is in a Safe Torque Off (STO) state and the PWM outputs cannot be activated by the control core to drive a motor. This diagram shows connections that will energize all of the opto-couplers from an internal current-source. When this is done the STO feature is disabled and control of the output PWM stage is under control of the digital control core.

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

STO DISABLING CONNECTIONS

Current must flow through all of the opto-couplers before the drive can be enabled
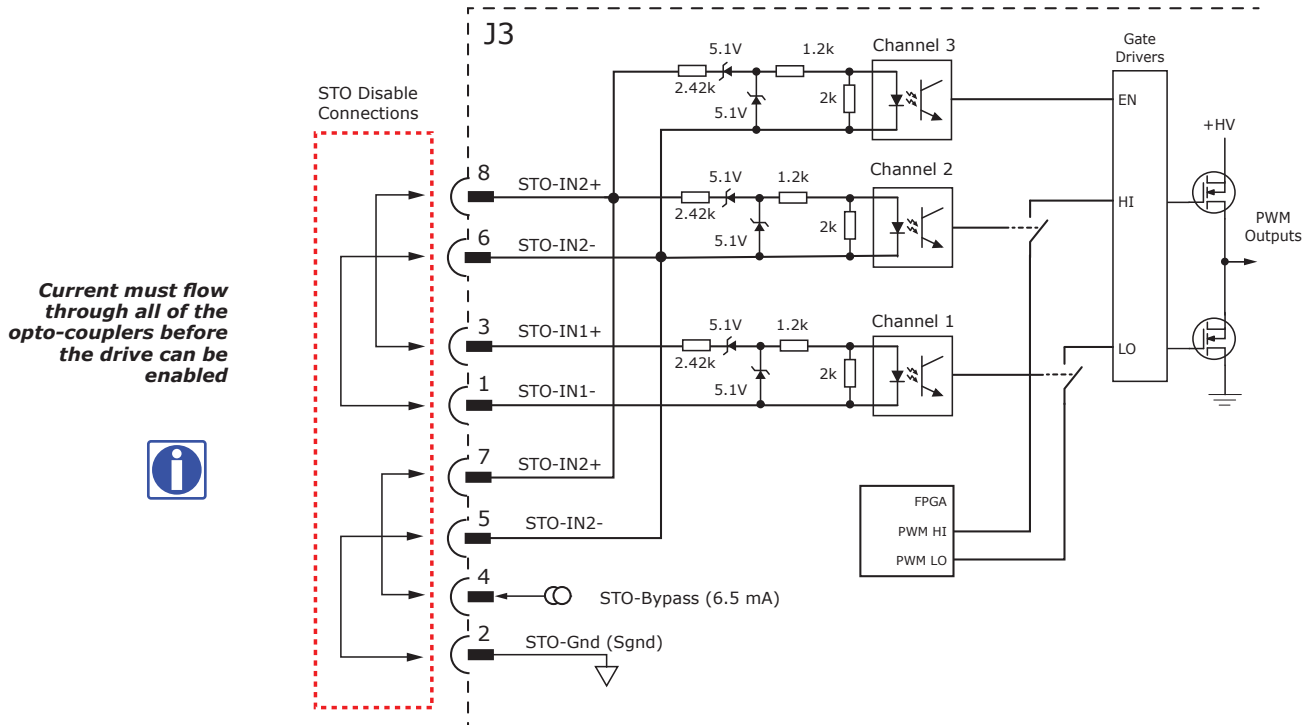
J3 SIGNALS

SIGNAL	PIN	PIN	SIGNAL
STO-IN1(-)	1	2	STO-GND
STO-IN1(+)	3	4	STO-BYPASS
STO-IN2(-)	5	6	STO-IN2(-)
STO-IN2(+)	7	8	STO-IN2(+)

DIGITAL COMMAND INPUTS: POSITION

PULSE & DIRECTION
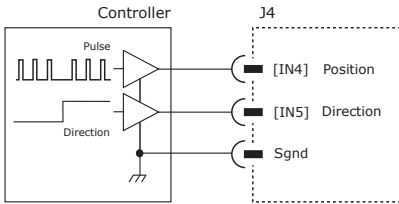
Pulses on IN4 will increment the target position. The active edge of pulses is programmable as Rising or Falling and the direction of the position change is programmable.

Also programmable is the Stepping Resolution. Two parameters, Input Pulses and Output Pulses determine the ratio of Output Pulses to Input Pulses.

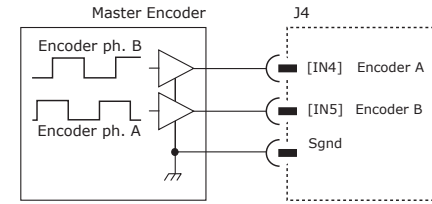If Input Pulses = 10 and Output Pulses = 2 then 5 Input Pulses will produce 1 Output Pulse.

CU/CD
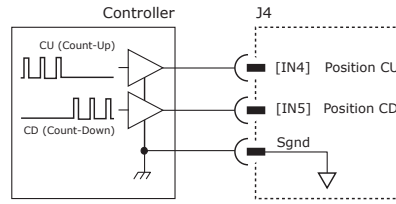
Pulses on IN4 will increment the target position and pulses on IN5 will decrement the position.

The active edge, direction of the position change, and Stepping Resolution are programmable as in Pulse/Dir.

QUAD A/B ENCODER

The Quad A/B encoder is two rising and falling pulse trains 90 degrees out of phase. The Ratio of Input Counts to Output Counts is programmable. The direction produced by the counts can be inverted.

DIGITAL COMMAND INPUTS: VELOCITY, TORQUE

PWM & DIRECTION
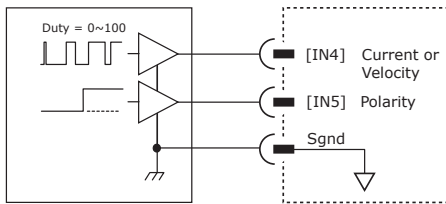
A pulse-train on IN4 with a constant frequency and variable duty-cycle will increment/decrement the target Velocity or Current. Stepping Resolution is not used.
Minimum and maximum Pulse Widths are programmable.

Also programmable is the Stepping Resolution. Two parameters, Input Pulses and Output Pulses determine the ratio of Output Pulses to Input Pulses.

If Input Pulses = 10 and Output Pulses = 2 then 5 Input Pulses will produce 1 Output Pulse.

50% PWM
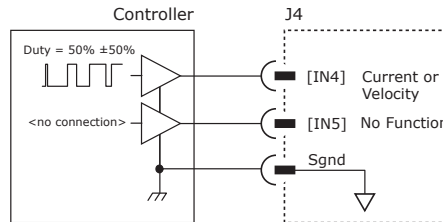
A pulse-train on IN4 with a constant frequency and variable duty-cycle will increment/decrement the target Velocity or Current. As shown, 50% duty cycle commands 0 output, 100% duty cycle is maximum positive output, 0% duty cycle is maximum negitive output.

The PWM input can be inverted to reverse the Pos/Neg output direction.

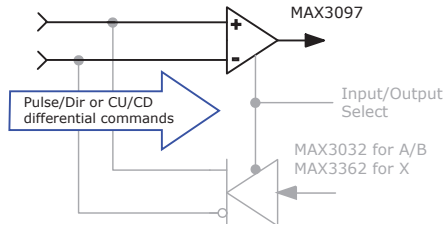Scaling of the output current at min/max duty cycles is programmable.

CONNECTIONS

| Input	J4 Pins
IN4	19
IN5	22
Sgnd	3,4,15,16,23,50,52

POSITION COMMAND INPUTS: DIFFERENTIAL
- Pulse & Direction
- CW & CCW (Clockwise & Counter-Clockwise)
- Encoder Quad A & B
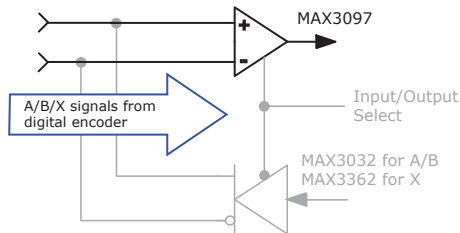- Camming Encoder A & B input

SIGNALS & PINS

Signal	J4 Pins
Pulse, CW, Encoder A, Vel-Curr-Mag, Vel-Curr-50%	8
/Pulse, /CW, Encoder /A, /Vel-Curr-Mag, /Vel-Curr-50%	7
Direction, CCW, Encoder B, Vel-Curr-Pol	10
/Direction, /CCW, Encoder /B, /Vel-Curr-Pol	9
Quad Enc X, Absolute Clock	14
Quad Enc /X, /Absolute Clock	13
Enc S, Absolute (Clock) Data	12
Enc /S, / Absolute (Clock) Data	11
Signal Ground	3,4,15,16, 23,50,52

CURRENT or VELOCITY COMMAND INPUTS: DIFFERENTIAL
- Current/Velocity Magnitude & Direction
- Current/Velocity 50%
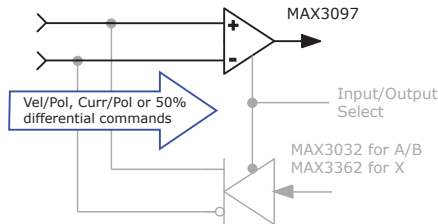
SECONDARY FEEDBACK: INCREMENTAL
- Quad A/B/X incremental encoder

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

OUTPUT TYPES

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

EMULATED FEEDBACK OUTPUTS: DIFFERENTIAL
  Firmware produces emulated quad A/B signals from feedback
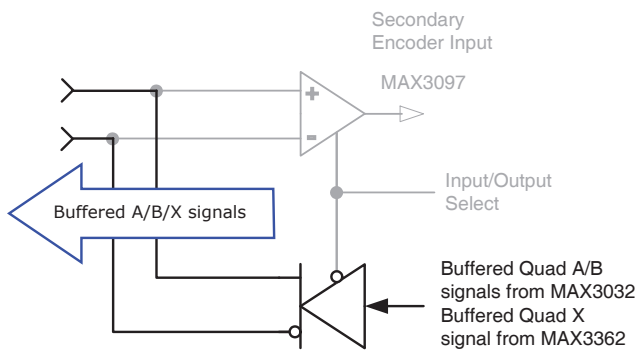 data from the following devices:
- Absolute encoders
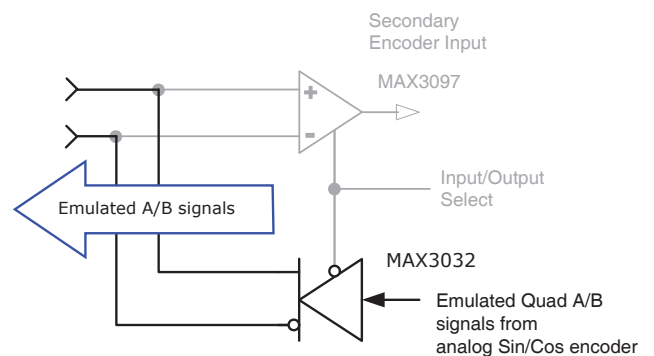- Analog Sin/Cos incremental encoders

SIGNALS & PINS

Signal	J4 Pins
Encoder A	8
Encoder /A	7
Encoder B	10
Encoder /B	9
Encoder X	14
Encoder /X	13
Signal Ground	3,4,15, 16,23,50,52
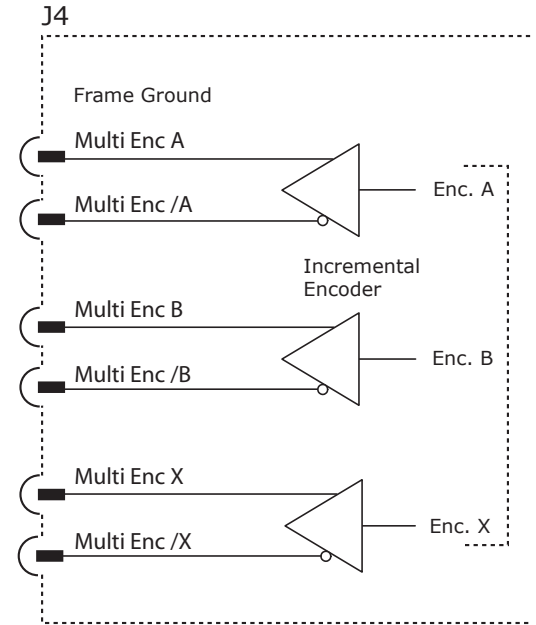
BUFFERED QUAD A/B/X OUTPUTS

EMULATED QUAD A/B OUTPUTS

HIGH SPEED INPUTS: IN1, IN2, IN3, IN4, IN5, IN6

- Digital, non-isolated, high-speed
- Progammable pull-up/pull-down
- 12V Compatible
- Programmable functions

SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	VT+ ≥ 2.5~3.5Vdc
	LO	VT- ≤ 1.3~2.2 Vdc
	Hys	VH 0.7~1.5 Vdc
	Max	+12 Vdc
	Min	0 Vdc
Pull-up/down	R1	10 kΩ
Low pass filter	R2	1 kΩ
	C1	100 pF
	RC[1]	0.1 µs

CONNECTIONS

Input	J4 Pins
IN1	18
IN2	17
IN3	20
IN4	19
IN5	22
IN6	21
Sgnd	3,4,15,16, 23,50,52
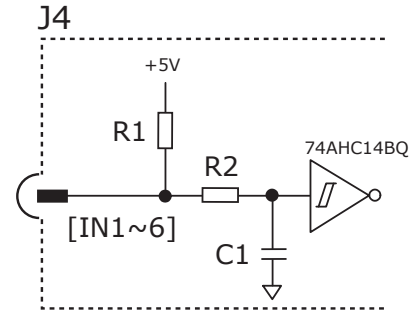
Notes:
1) The R2*C2 time constant applies when input is driven by active HI/LO devices

MOTOR OVERTEMP INPUT: IN11

- Digital, non-isolated
- Motor overtemp input
- 24V Compatible
- Programmable functions

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

SPECIFICATIONS

Input	Data	Notes
Input Voltages	HI	VT+ ≥ 2.5~3.5Vdc
	LO	VT- ≤ 1.3~2.2 Vdc
	Hys	VH 0.7~1.5 Vdc
	Max	+12 Vdc
	Min	0 Vdc
Pull-up	R1	4.99 kΩ
Low pass filter	R2	10 kΩ
	C1	33 nF
	RC[1]	330 µs
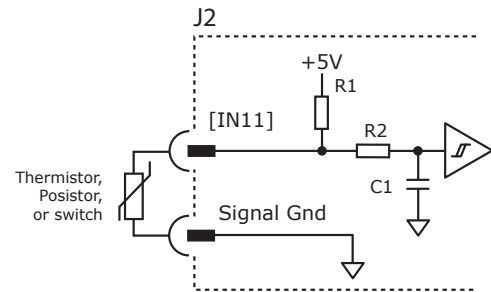
BS 4999:Part 111:1987

Property	ohms
Resistance in the temperature range 20°C to +80°C	60~750
Resistance at 85°C	≤1650
Resistance at 95°C	≥3990
Resistance at 105°C	≥12000

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

CONNECTIONS

| Input	J2 Pins
IN11	17
Sgnd	8,18,21,22

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

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

SPECIFICATIONS		
Input	Data	Notes
Input Voltages	HI	Vin ≥ ±10.0 Vdc *
	LO	Vin ≤ ±6.0 Vdc *
	Max	±30 Vdc *
Input Current	±24V	±3.6 mAdc
	0V	0 mAdc

* Vdc Referenced to ICOM terminals.

CONNECTIONS	
Signal	J4 Pins
IN7	27
IN8	25
IN9	26
IN10	24
ICOM	28
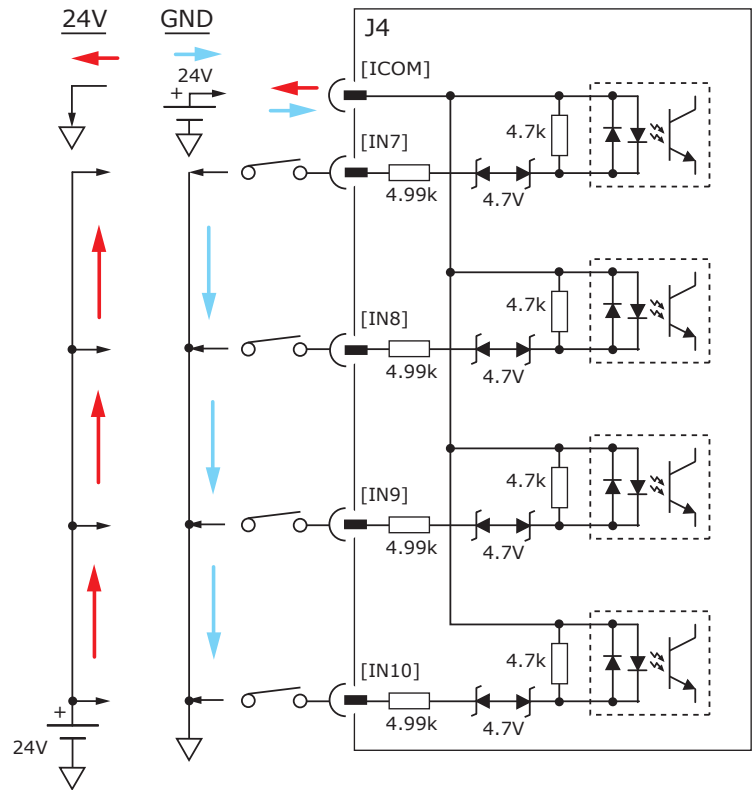
ANALOG INPUT: AIN1

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

As a reference input it takes position/velocity/torque commands from a controller. If not used as a command input, it can be used as general-purpose analog input.

SPECIFICATIONS

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

CONNECTIONS

Signal	J4 Pins
AIN(+)	2
AIN(-)	1
Sgnd	3,4,15,16,23,50,52
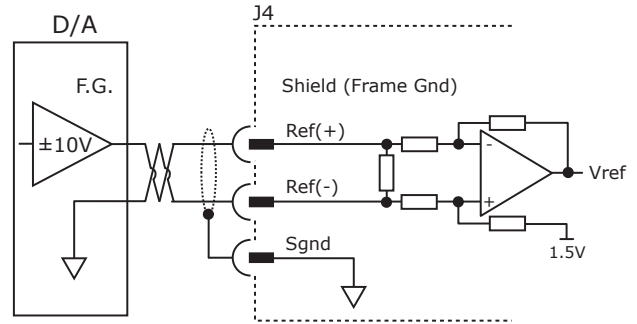
OPTO-ISOLATED OUTPUTS: OUT1, OUT2, OUT3, OUT4

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

SPECIFICATIONS

Output	Data	Notes
ON Voltage OUT(+) - OUT(-)	Vdc	0.5V @ 300 mAdc
Output Current	Iout	300 mAdc max
Turn-on Time	Ton	5 ms max @ 300 mA
Turn-off Time	Toff	2 ms max @ 300 mA
Working Voltage	Vmax	+32 Vdc max referenced to ground, ≥800 Vdc rated impulse voltage
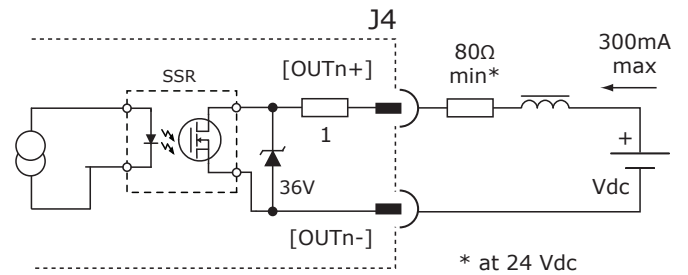
HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
OUT1~4	HI	Output SSR is ON, current flows
	LO	Output SSR is OFF, no current flows

CONNECTIONS: J4 PINS

Signal	(+)	(-)
OUT1	30	29
OUT2	32	31
OUT3	34	33
OUT4	36	35

HIGH-SPEED OUTPUT: OUT5, OUT6, OUT7, OUT8

- CMOS buffer
- 74AHCT1G125
- Programmable functions

SPECIFICATIONS

Output HI	Data	Notes
Vout HI	Voh	3.8 Vdc
Iout HI	Ioh	-8.0 mAdc
Vout LO	Vol	0.44 Vdc
Iout LO	Iol	8.0 mAdc
Vout Max	Vom	+5 Vdc

CONNECTIONS

Signal	J4 Pins
OUT 5	38
OUT 6	37
OUT 7	40
OUT 8	39
Sgnd	3,4,15,16,23,50,52
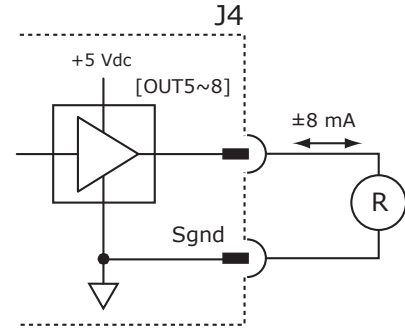
OPTO-ISOLATED MOTOR BRAKE OUTPUT: OUT9

- Brake output [OUT9]
- Opto-isolated
- 24V Compatible
- Programmable functions
- Gate output to drive external MOSFET

SPECIFICATIONS

Output	Data	Notes
Voltage Range	Vbrk	+24 Vdc compatible +32 Vdc max referenced to ground, ≤800 Vdc rated impulse voltage
Output Current	Ids	1.0 Adc
On-Time	Ton	250 µs max @ 200 mA

The brake circuits are optically isolated from all drive circuits and frame ground. For a flyback diode across the brake to be effective, the Brake-24V and Brake-Gnd must be connected as shown and the 24V power supply must be referenced to the user's common ground.

HI/LO DEFINITIONS: OUTPUTS

Input	State	Condition
BRAKE [OUT9]	HI	Output transistor is OFF Brake is un-powered and locks motor Motor cannot move Brake state is Active
	LO	Output transistor is ON Brake is powered, releasing motor Motor is free to move Brake state is NOT-Active

CME Default Setting for Brake Output [OUT9] is "Brake - Active HI"

Active = Brake is holding motor shaft (i.e. the *Brake is Active*)
Motor cannot move
No current flows in coil of brake
CME I/O Line States shows [OUT9] as HI
BRK Output voltage is HI (24V), MOSFET is OFF
Servo drive output current is zero
Servo drive is disabled, PWM outputs are off

Inactive = Brake is not holding motor shaft (i.e. the *Brake is Inactive*)
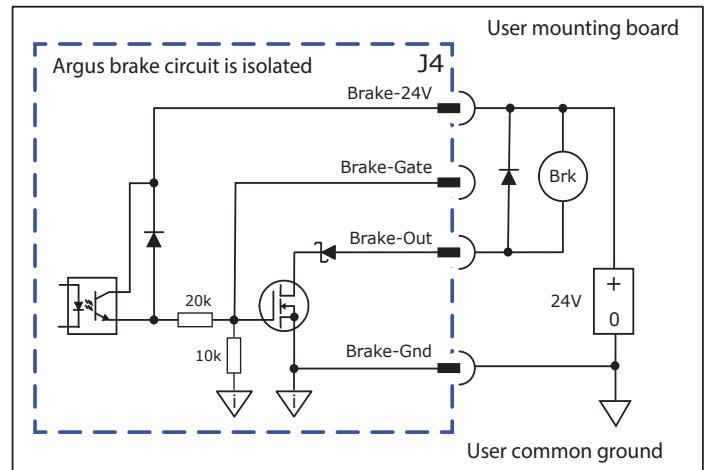Motor can move
Current flows in coil of brake
CME I/O Line States shows [OUT9] as LO
BRK output voltage is LO (~0V), MOSFET is ON
Servo drive is enabled, PWM outputs are on
Servo drive output current is flowing

J4 CONNECTIONS

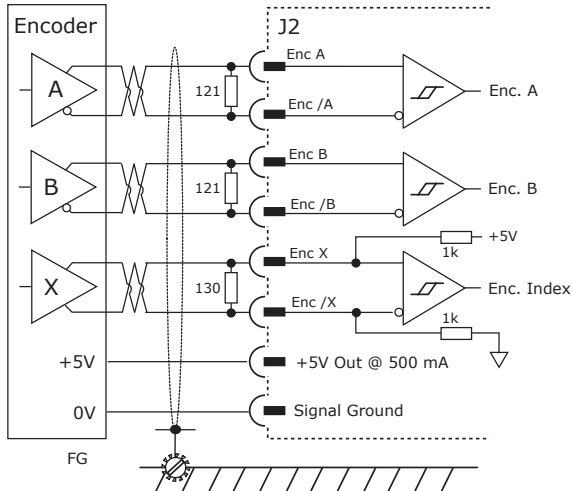| Pin	Signal
45	Brake-24V
48	Brake-Gate
47	Brake-Out
46	Brake Gnd

FEEDBACK CONNECTIONS

QUAD A/B ENCODER WITH FAULT PROTECTION

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

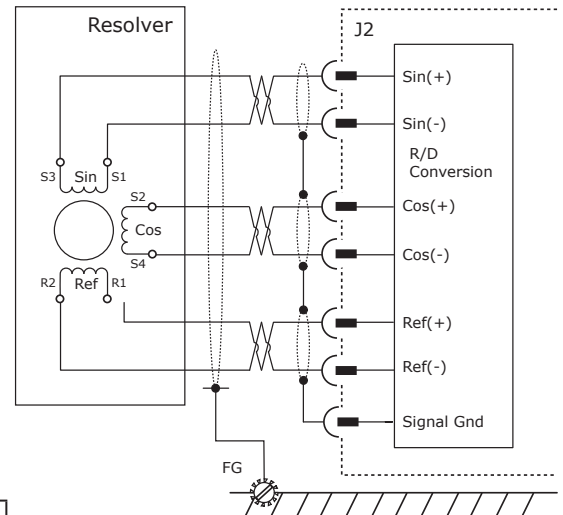|	
Short-circuits line-line:	This produces a near-zero voltage between a channel pair which is below the differential fault threshold.
Open-circuit condition:	A terminator resistor will pull a channel pair together if either side (or both) is open. This will produce the same fault condition as a short-circuit across the inputs.
Low differential voltage detection:	This is possible with very long cable runs and a fault will occur if the differential input voltage is < 200mV.
±15kV ESD protection:	The 3097E has protection against high-voltage discharges using the Human Body Model.
Extended common-mode range:	A fault occurs if the input common-mode voltage is outside of the range of -10V to +13.2V

QUAD ENCODER WITH INDEX

A/B/X SIGNALS

Signal	J2 Pins
Enc A	10
Enc /A	9
Enc B	12
Enc /B	11
Enc X	16
Enc /X	15
+5V	19,20
Sgnd	8,18,21,22

Sgnd = Signal Ground

RESOLVER

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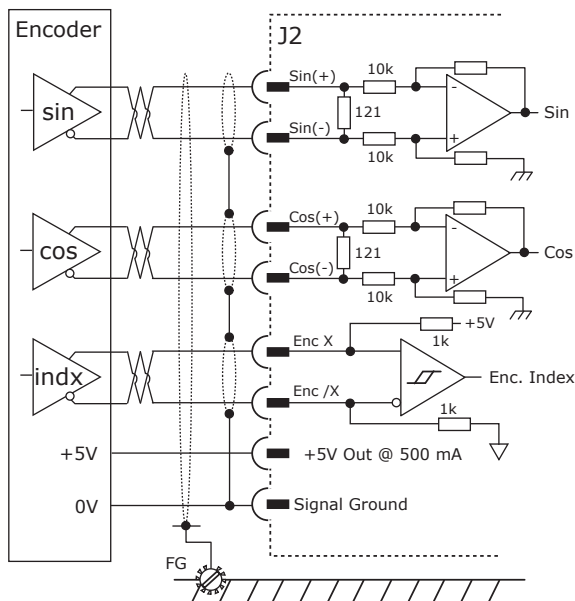

ANALOG SIN/COS INCREMENTAL ENCODER

The Sin/Cos inputs are analog differential with 121 Ω terminating resistors and accept 1 Vp-p signals in the format used by incremental encoders with analog outputs.
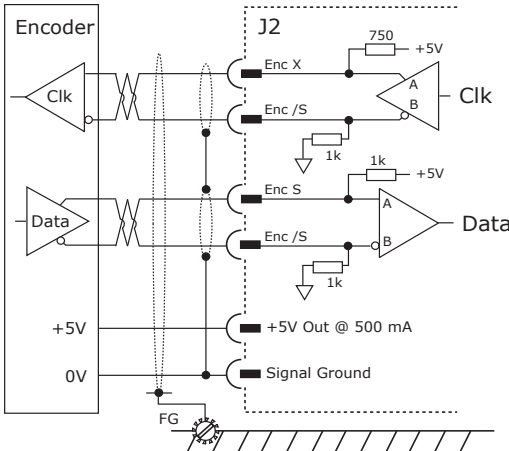The index input is digital, differential.

SIN/COS SIGNALS

Signal	J2 Pins
Sin(+)	2
Sin(-)	1
Cos(+)	4
Cos(-)	3
X	16
/X	15
+5V	19,20
Sgnd	8,18,21,22

Sgnd = Signal Ground
F.G. = Frame Gnd

RESOLVER SIGNALS

Signal	J2 Pins
Sin(+)	2
Sin(-)	1
Cos(+)	4
Cos(-)	3
Ref(+)	24
Ref(-)	23
Sgnd	8,18,21,22

FEEDBACK CONNECTIONS

SSI ABSOLUTE ENCODER

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The GEM drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock pulses. The number of encoder data bits and counts per motor revolution are programmable.

The hardware bus consists of two signals: SCLK and SDATA. The SCLK signal is only active during transfers. Data is clocked in on the falling edge of the clock signal.


BiSS ABSOLUTE ENCODER

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

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

SSI,BiSS SIGNALS

SSI	BiSS	J2 Pins
Clk	MA+	16
/Clk	MA-	15
Data	SL+	14
/Data	SL-	13
+5V		19,20
Sgnd		8,18,21,22

Note: Single (outer) shields should be connected at the controller end. Inner shields should only be connected to Signal Ground on the drive.
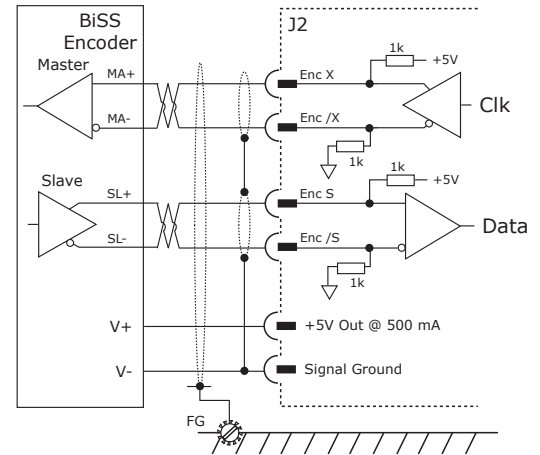
ENDAT ABSOLUTE ENCODER

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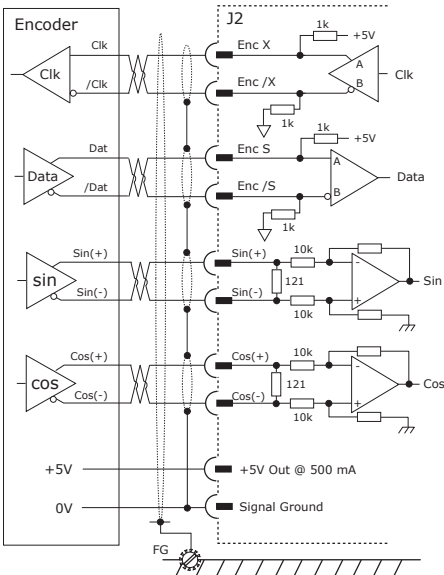

ENDAT SIGNALS

Signal	J2 Pins
Clk	16
/Clk	15
Data	14
/Data	13
Sin(+)	2
Sin(-)	1
Cos(+)	4
Cos(-)	3
+5V	19,20
Sgnd	8,18,21,22

Sgnd = Signal Ground

ABSOLUTE-A ENCODER

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

- Absolute A
- Tamagawa Absolute A
- Panasonic Absolute A Format
- Sanyo Denki Absolute A
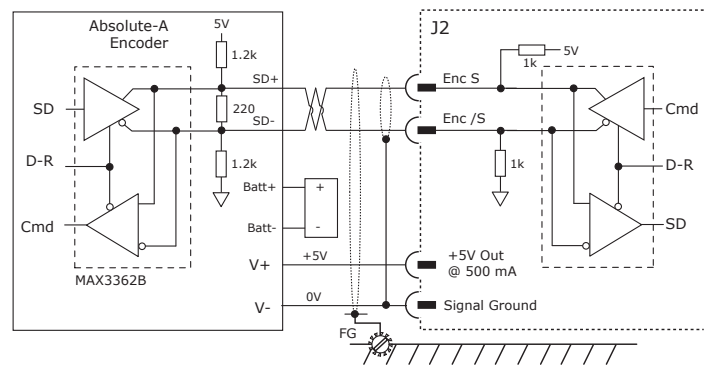
ABSOLUTE-A SIGNALS

| Signal	J2 Pins
Data	14
/Data	13
+5V	19,20
Sgnd	8,18,21,22

Sgnd = Signal Ground

MOTOR CONNECTIONS

BRUSHLESS MOTOR CONNECTIONS

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

MOTOR SIGNALS

| Signal	J1 Pin
Mot U	41~46
Mot V	31~36
Mot W	21~26
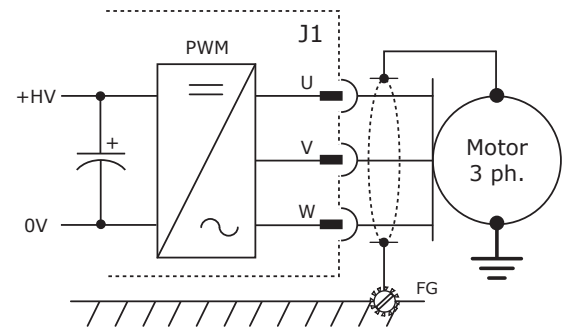
BRUSH MOTOR CONNECTIONS

DC motors have two terminals and are commutated by internal brushes. Only two terminals are used and the polarity determins the direction of motion.

Cable should be sized for the continuous current rating of the motor. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame ground for best results.

MOTOR SIGNALS

| Signal	J1 Pin
Mot U	41~46
Mot V	31~36
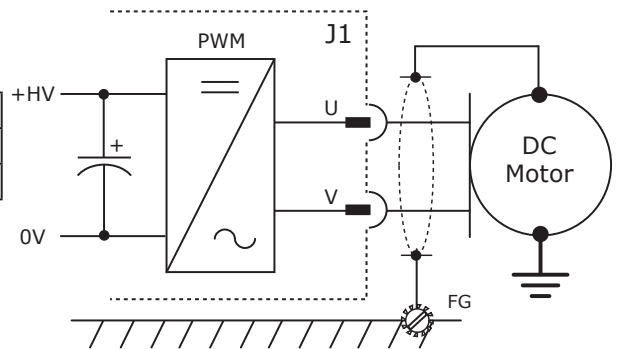
DIGITAL HALL SIGNALS

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

HALL SIGNALS

Signal	J2 Pins
Hall U	5
Hall V	6
Hall W	7
+5V	19,20
Sgnd	8,18,21,22

# Argus *PLUS* Module *EtherCAT*

GEM
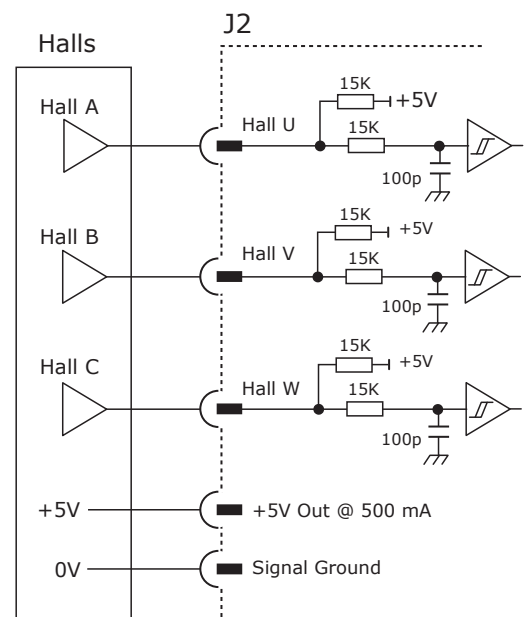
POWER SUPPLY GROUNDING

This shows the drive HV GND connecting to Frame Ground (FG) and Earth Ground. This keeps 0V in the drive at 0V Ground. Voltage drops across the power-supply wiring will appear at the (-) terminals of the power supplies due to the cable length and current but this has no effect on the voltages of circuits and devices. The heatplate has no connection to drive circuits and standoffs provide a PE (Protective Earth) path to earth.
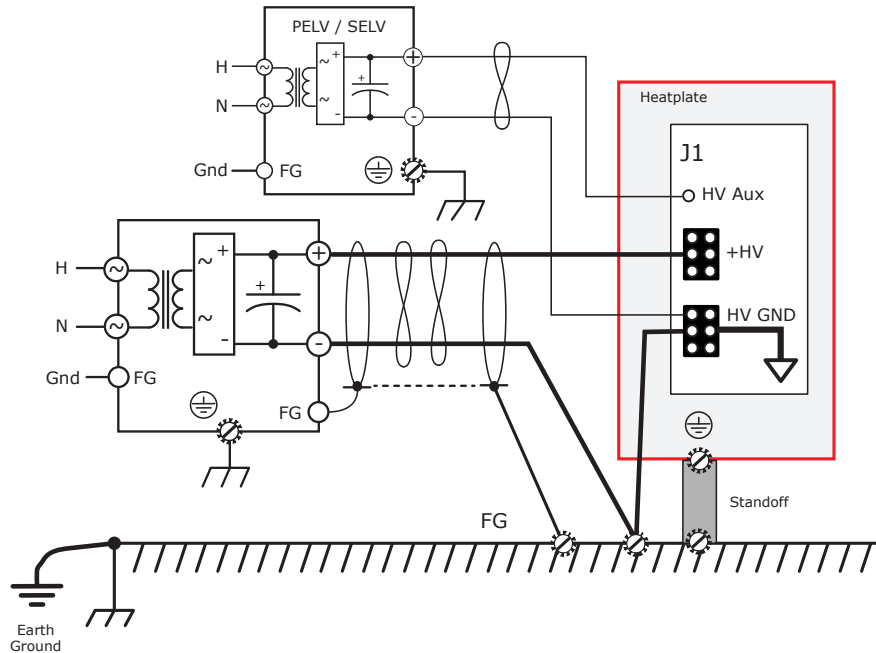


MOTOR CONNECTION GROUNDING

This shows the shielding on the feedback and PWM connections to the motor.
Capacitive coupling between the motor windings and case plus coupling between the UVW cable and shield finds a return path via FG and HV GND. Grounding the motor feedback shield only to the FG avoids the PWM coupling in the motor shield.
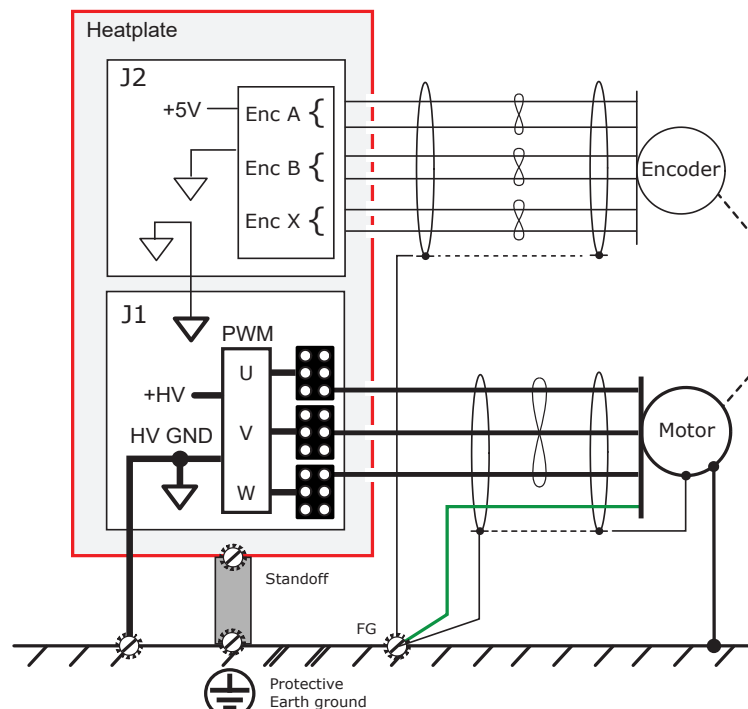
PROTECTIVE EARTH GROUNDING

This shows how a Protective Earth (PE) connection can be made with the GEM drive.

The standoffs shown are solid with tapped holes on each end. In preperation for mounting the GEM the standoffs should be retained with four screws (not shown) inserted from the bottom of the PC board. These retain the spacers and make ohmic contact with conductive traces on the PC board. As shown all four standoffs are connected by a trace which has an extension to one of the mounting holes. This should be a plated-through hole to connect to earth either by standoff to the equipment bonded enclosure or by cable to earth ground. When the drive is placed on the standoffs the next step is to place the thermal pad taking care to align the two corner holes with the drive heatplate. Following that the heatsink can be placed, again with care to align with the drive heatplate holes. Finally install the screws to retain the heatsink. This will press two of the heatsink corners with notches in the thermal pad to make contact with the drive heatplate, providing a conductive path. From the heatplate, contact is made with the spacers and finally to the mounting board etch and to earth.
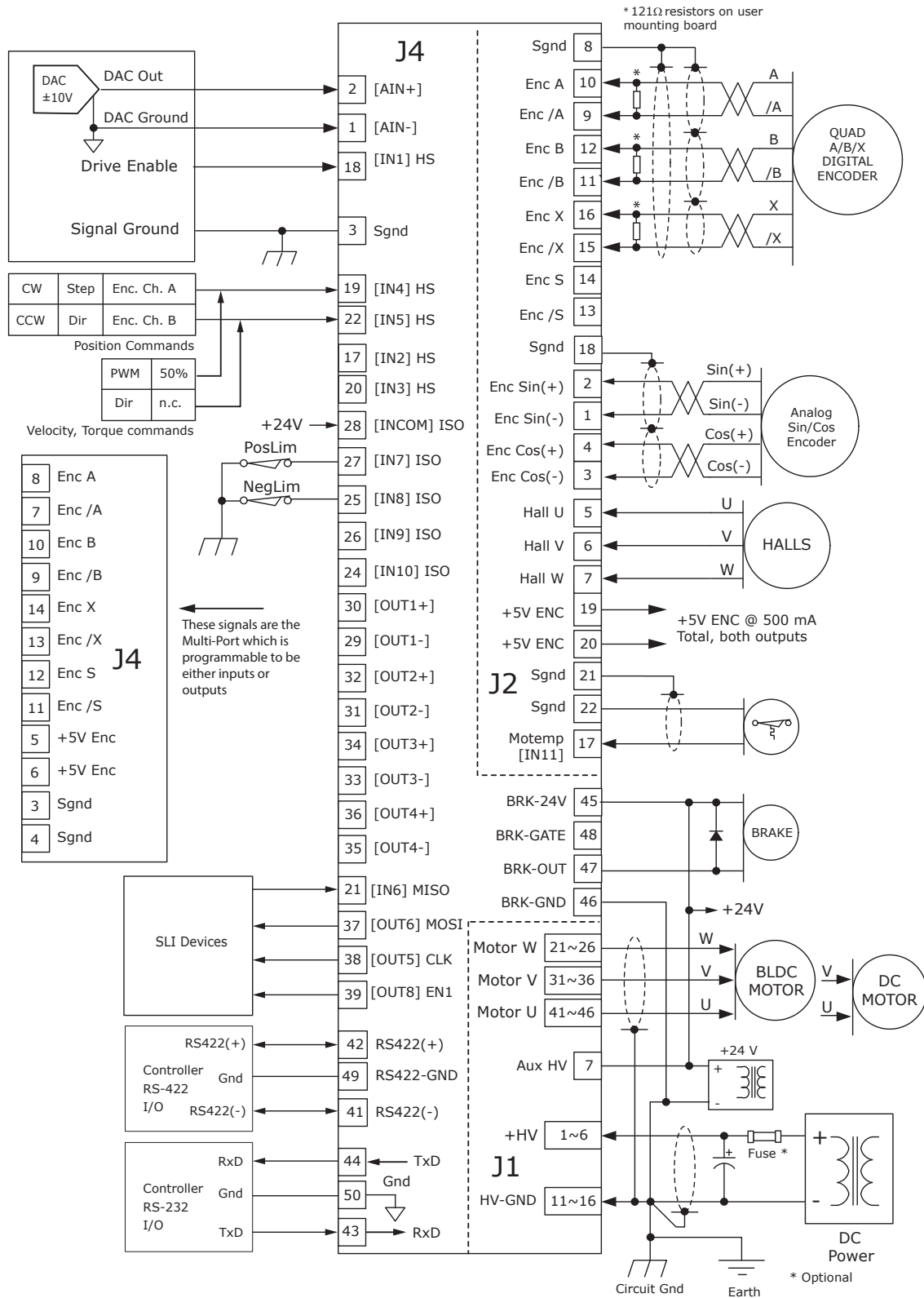
Protective Earth (PE)
Connections

PE
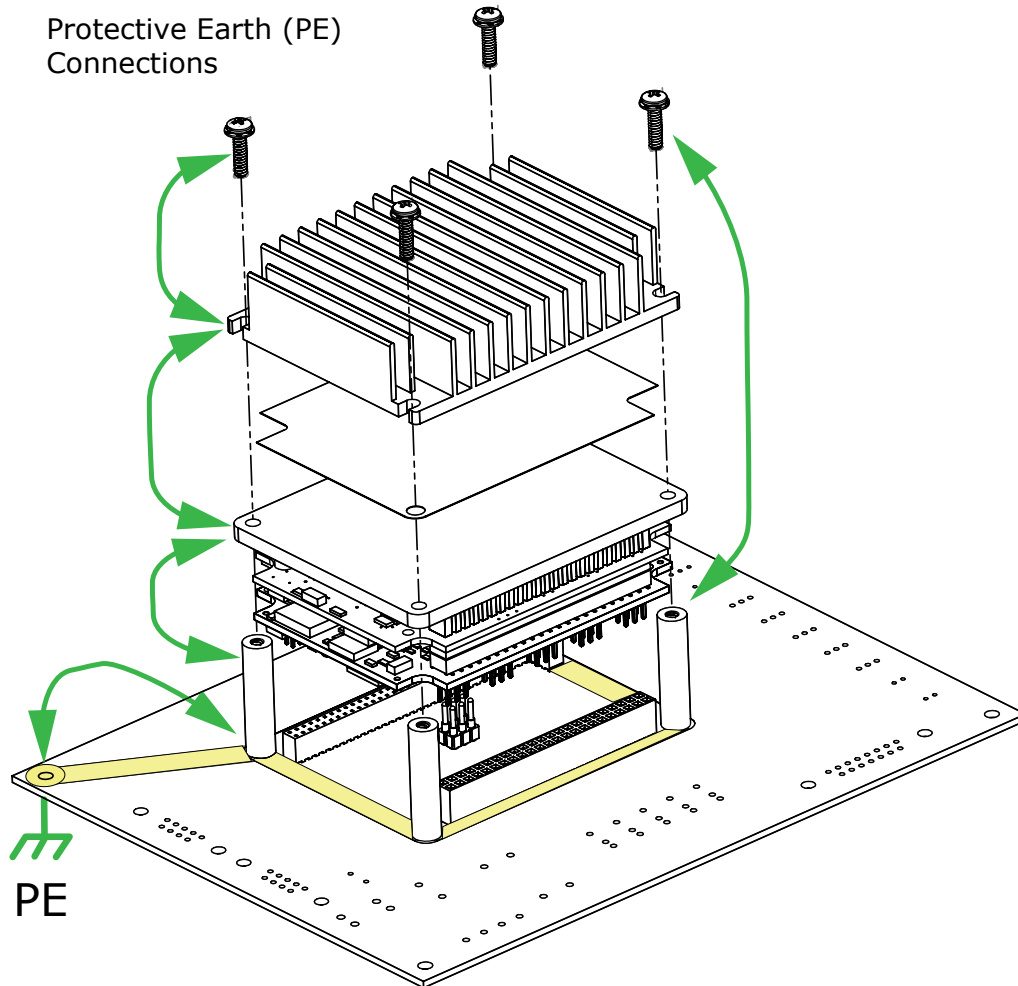
CONNECTORS & SIGNALS
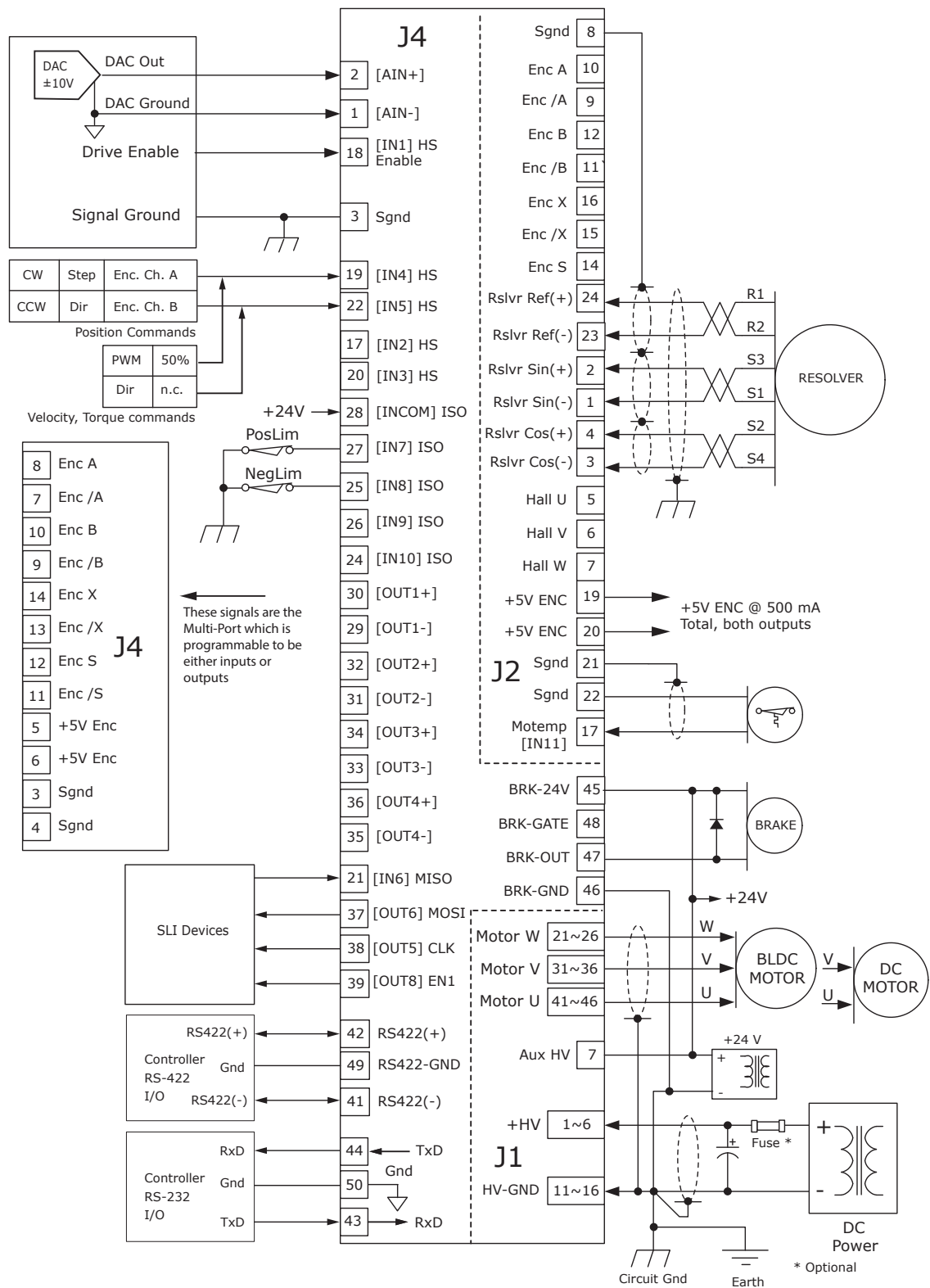
CONNECTIONS FOR ABSOLUTE ENCODER WITH DUPLEX CLOCK/DATA
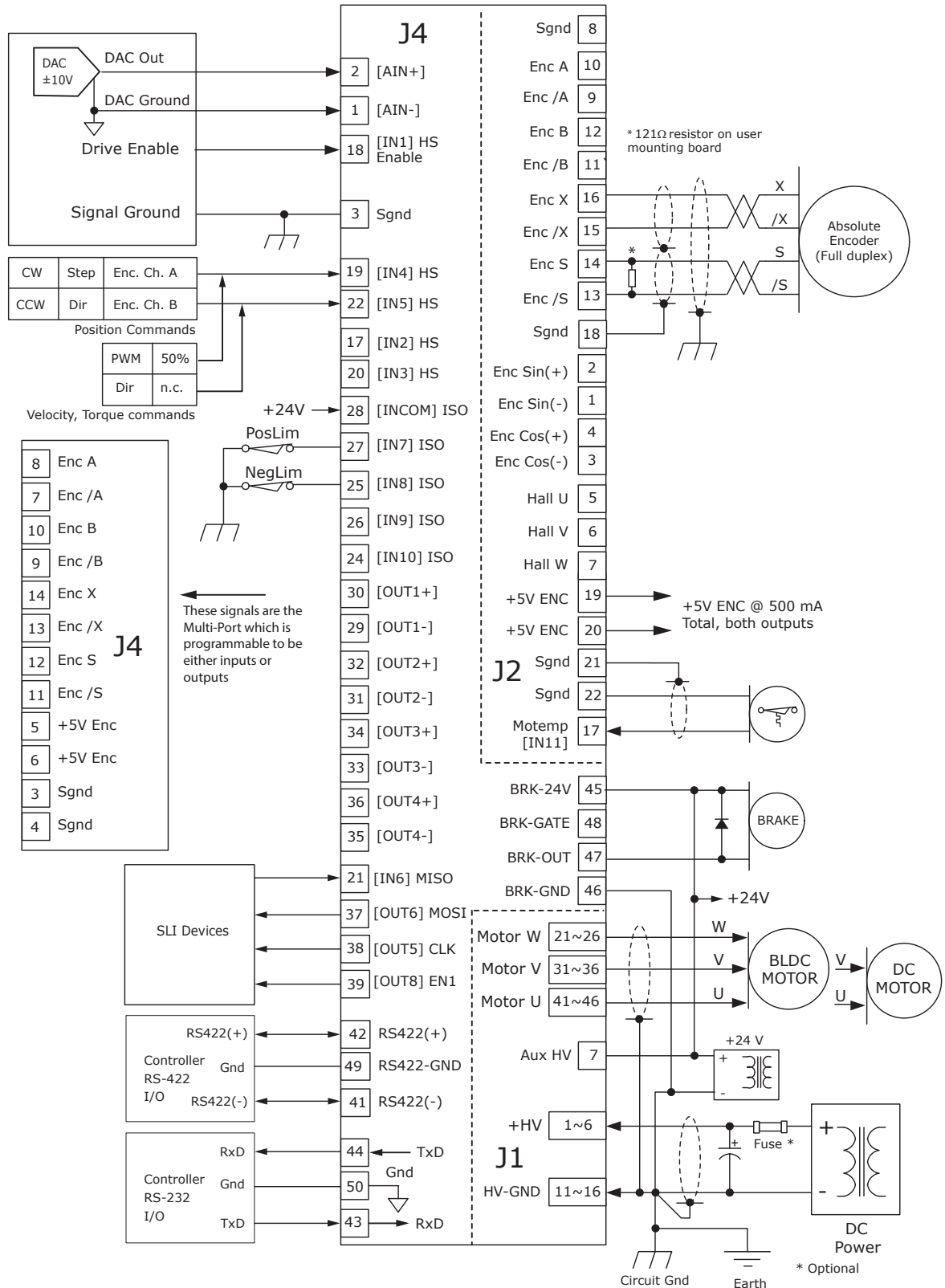
CONNECTIONS FOR INCREMENTAL DIGITAL OR ANALOG ENCODERS

CONNECTORS & SIGNALS

CONNECTIONS FOR RESOLVERS (-R OPTION)

DIMENSIONS IN[MM]

J1 POWER & MOTOR

Signal	J1 Pin		Signal
+HV	2	1	+HV
	4	3	
	6	5	
N/C	8	7	HV Aux
	10	9	N/C
HV Gnd	12	11	HV Gnd
	14	13	
	16	15	
N/C	18	17	N/C
	20	19	
Mot W	22	21	Mot W
	24	23	
	26	25	
N/C	28	27	N/C
	30	29	
Mot V	32	31	Mot V
	34	33	
	36	35	
N/C	38	37	N/C
	40	39	
Mot U	42	41	Mot U
	44	43	
	46	45	

TOP VIEW

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

J1 **J4** **J2** **J3**

J1: HV & Motor
    Dual row, 2 mm- centers
    46 position female header
    SAMTEC SSQ-123-01-L-D

J2: Feedback
    Dual row, 2 mm- centers
    24 position female header
    SAMTEC SQT-112-01-L-D

J3: Safety
    Dual row, 2 mm- centers
   8 position female header
    SAMTEC SQT-104-01-L-D

J4: Control
    Dual row, 2 mm- centers
    66 position female header
    SAMTEC SQT-133-01-L-D

J4 CONTROL

Signal	P1 Pin		Signal
TX2TERM	65	66	TX2+
ECAT-SHLD	63	64	TX2-
RX2+	61	62	RX2TERM
RX2-	59	60	ECAT-SHLD
TX1TERM	57	58	TX1+
ECAT-SHLD	55	56	TX1-
RX1+	53	54	RX1TERM
RX1-	51	52	ECAT-SHLD
RS422-GND	49	50	Sgnd
Brake-Out	47	48	Brk-Gate
Brake-24V	45	46	Brake-Gnd
RS232 RxD	43	44	RS232 TxD
RS422(-)	41	42	RS422(+)
HS [OUT8] SLI-EN1	39	40	[OUT7] HS
HS [OUT6] SLI-MOSI	37	38	[OUT5] HS SLI-CLK
[OUT4-] ISO	35	36	ISO [OUT4+]
[OUT3-] ISO	33	34	ISO [OUT3+]
[OUT2-] ISO	31	32	ISO [OUT2+]
[OUT1-] ISO	29	30	ISO [OUT1+]
[IN7] ISO	27	28	ISO [INCOM]
[IN8] ISO	25	26	ISO [IN9]
Sgnd	23	24	ISO [IN10]
[IN6] HS SLI-MISO	21	22	HS [IN5]
[IN4] HS	19	20	HS [IN3]
[IN2] HS	17	18	HS [IN1]
Sgnd	15	16	Sgnd
Enc /X	13	14	Enc X
Enc /S	11	12	Enc S
Enc /B	9	10	Enc B
Enc /A	7	8	Enc A
+5V ENC	5	6	+5V ENC
Sgnd	3	4	Sgnd
[AREF-]	1	2	[AREF+]

J2 FEEDBACK

Signal	P3 Pin		Signal
RES-REF-	23	24	RES-REF+
Sgnd	21	22	Sgnd
+5V ENC	19	20	+5V ENC
[IN11]	17	18	Sgnd
ENC /X	15	16	ENC X
ENC /S	13	14	ENC S
ENC /B	11	12	ENC B
ENC /A	9	10	ENC A
HALL W	7	8	Sgnd
HALL U	5	6	HALL V
COS-	3	4	COS+
SIN-	1	2	SIN+

J3 SAFETY

SIGNAL	PIN	PIN	SIGNAL
STO-IN1(-)	1	2	STO-GND
STO-IN1(+)	3	4	STO-BYPASS
STO-IN2(-)	5	6	STO-IN2(-)
STO-IN2(+)	7	8	STO-IN2(+)

PRINTED CIRCUIT BOARD FOOTPRINT

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

J1 Signal Grouping
for current-sharing
See Note 1

2   1

46   45

J1   J4

J2

J3
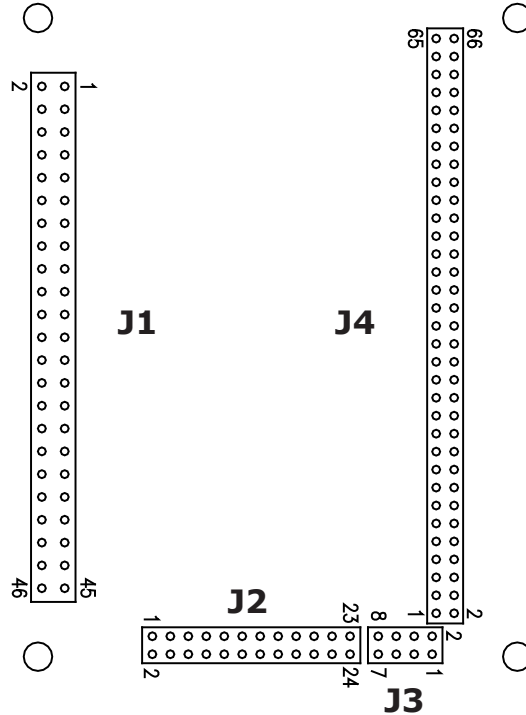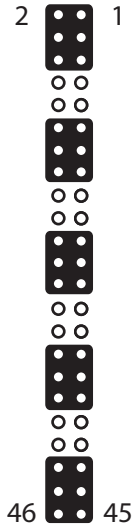
PCB Hardware:

Qty	Description	Mfgr	Part Number	Remarks
1	Socket Strip	Samtec	SSQ-123-01-L-D	J1 HV & Motor
1	Socket Strip	Samtec	SQT-112-01-L-D	J2 Feedback
1	Socket Strip	Samtec	SQT-104-01-L-D	J3 Safety
1	Socket Strip	Samtec	SQT-133-01-L-D	J4 Control
2	Standoff	PEM	KFE-4/40-8ET	#4/40 X 1/4"

Additional Hardware (not shown above)

2   Screw, #4-40 x 1.25" Phillips Pan Head External Tooth Lockwasher SEMS, Stainless, or steel with nickel plating, Torque to 3~5 lb-in (0.34~0.57 N·m)

Notes

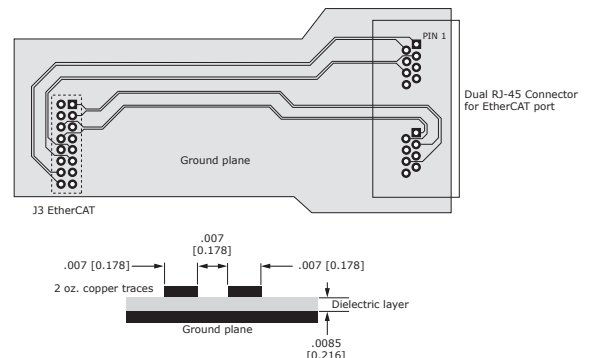1. J1 signals of the same name must be connected for current-sharing (see graphic above).

2. To determine copper width and thickness for J1 signals refer to specification IPC-2221. (Association Connecting Electronic Industries, http://www.ipc.org)

3. Standoffs or mounting screws should connect to etch on pc board that connect to frame ground for maximum noise suppression and immunity.

PRINTED CIRCUIT BOARD DESIGN FOR ETHERCAT SIGNALS

EtherCAT signal routing must produce a controlled impedance to maintain signal quality. This graphic shows some principles of PC board 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.
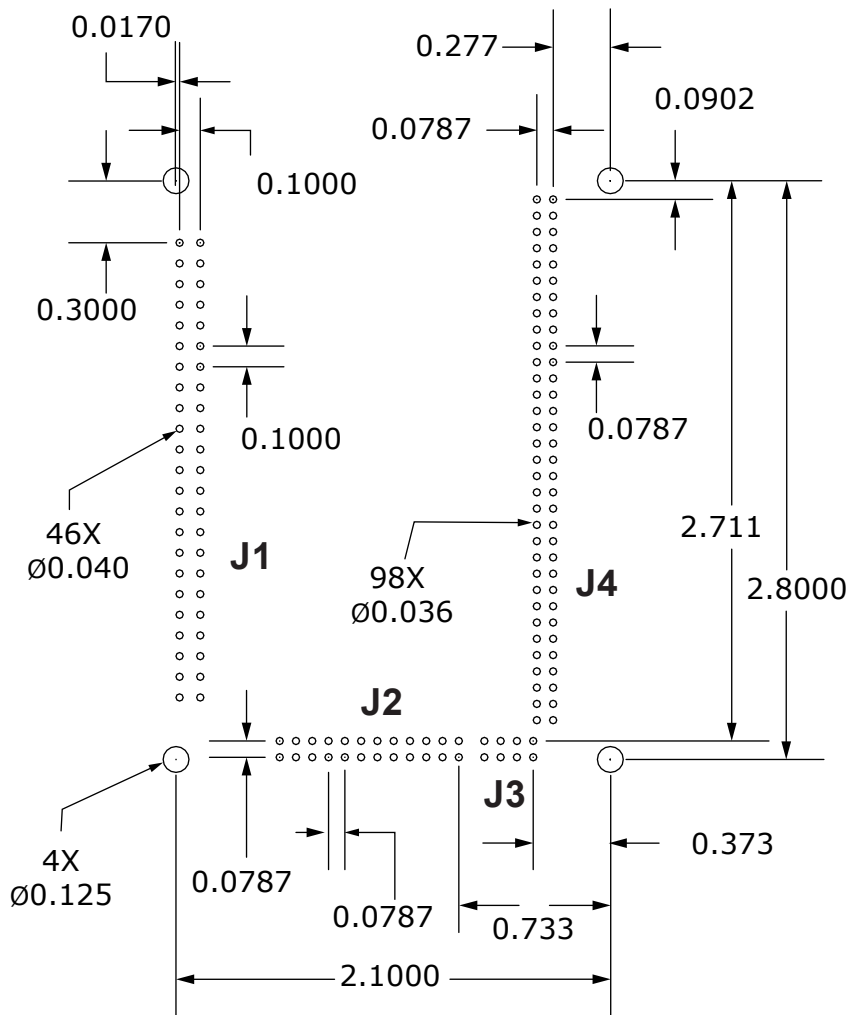
The graphic on p. 5 detailing the EtherCAT connections shows resistors and a capacitor in the drive for terminating the unused conductors. As an alternative to adding traces back to the drive connector J4 for these signals, the same parts can be placed on the board at the RJ-45 connector, leaving only the differential EtherCAT signals to be routed with controlled impedance.

PIN 1

Dual RJ-45 Connector
for EtherCAT port

Ground plane

J3 EtherCAT

.007 [0.178]   .007 [0.178]   .007 [0.178]

2 oz. copper traces

Ground plane

Dielectric layer

.0085 [0.216]

PRINTED CIRCUIT DRILLING DIMENSIONS

Notes:
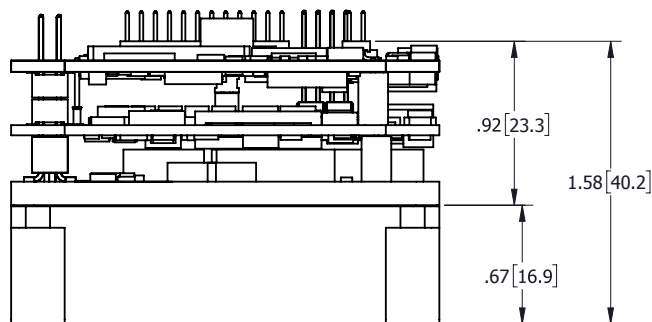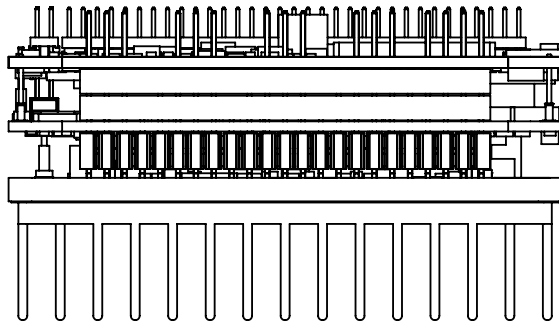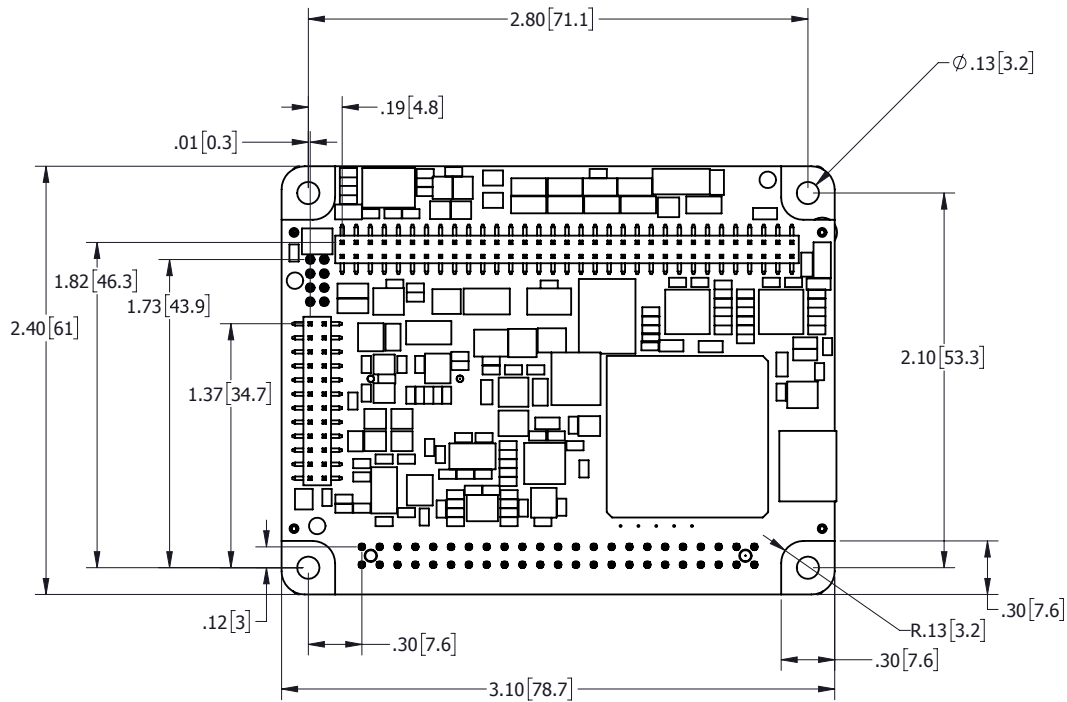1. This shows the drilling dimensions looking down on the mounting surface of the PC board.

Dimensions are in inches

2.80[71.1]

.19[4.8]

.01[0.3]

∅.13[3.2]

1.82[46.3]

1.73[43.9]

2.40[61]

1.37[34.7]

2.10[53.3]

.12[3]

.30[7.6]

R.13[3.2]

.30[7.6]

.30[7.6]

3.10[78.7]

.92[23.3]

1.58[40.2]

.67[16.9]

Dimensions are in inches[mm]

MOUNTING WITH USER HARDWARE
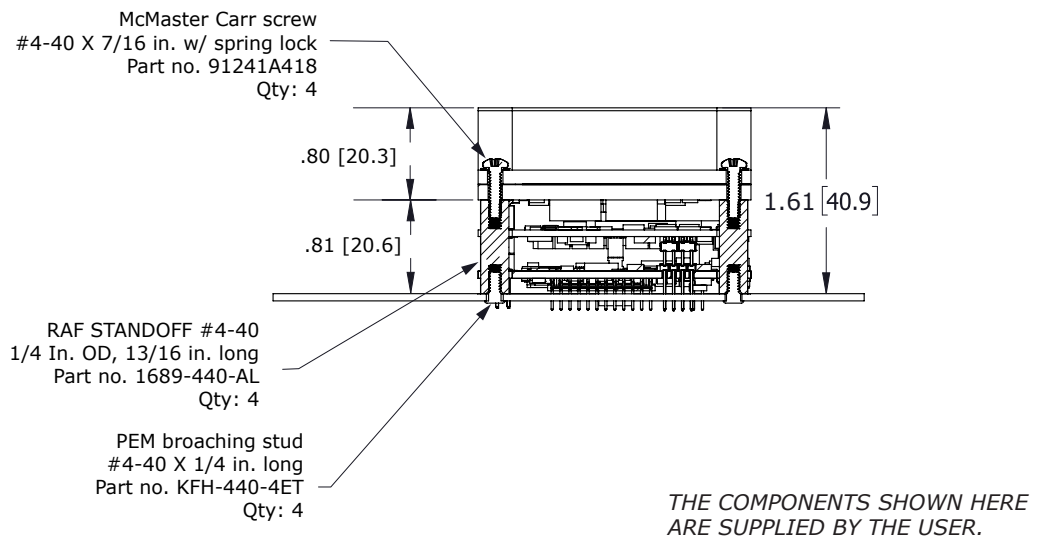
The GEM drives can be mounted in these configurations:

Soldered   All drive pins are soldered. This is recommended to use the rated continuous current of the drive.

Socketed   All drive pins connect to sockets. The drive can be inserted and extracted from the mounting board.
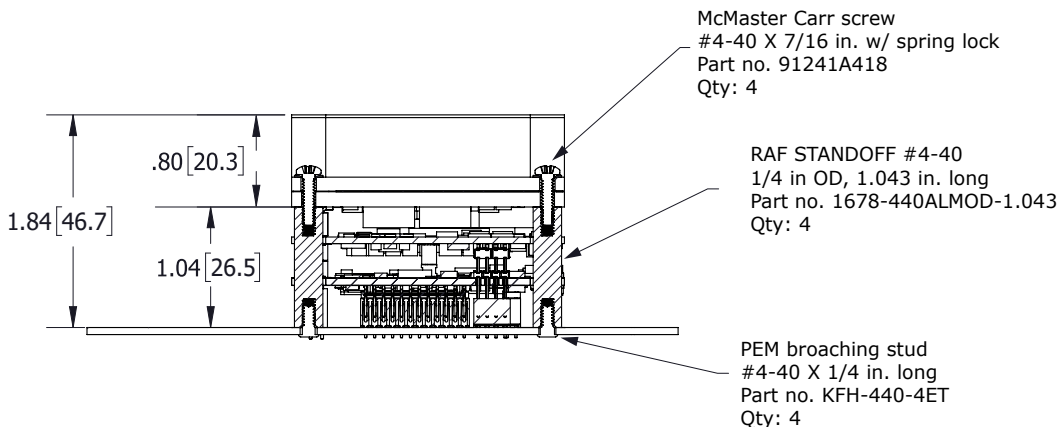
ALL ABOUT STANDOFFS

In all configurations, the standoffs must be metal because they connect the drive heatplate to a trace on the PC board that connects to earth, providing a PE (Protective Earth) connection.

Standoffs pass through notches in the corners of the drive PC boards.

The notch width is 0.3 in [7.62 mm] and can accept 0.25 in [6.35 mm] standoffs.
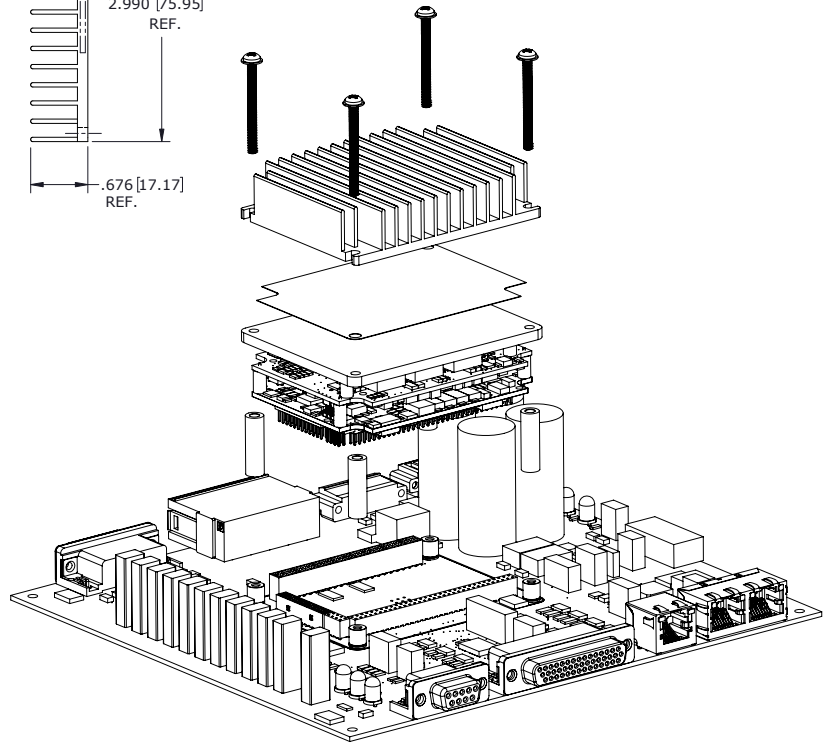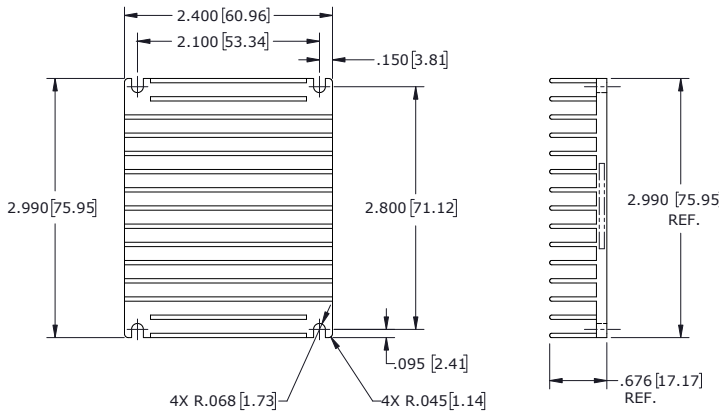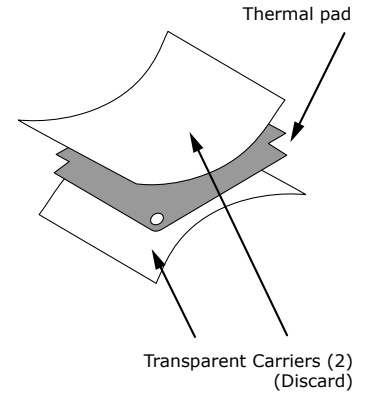
MOUNTING METHODS: SOLDERED

McMaster Carr screw
#4-40 X 7/16 in. w/ spring lock
Part no. 91241A418
Qty: 4

.80 [20.3]

.81 [20.6]

1.61 [40.9]

RAF STANDOFF #4-40
1/4 In. OD, 13/16 in. long
Part no. 1689-440-AL
Qty: 4

PEM broaching stud
#4-40 X 1/4 in. long
Part no. KFH-440-4ET
Qty: 4

THE COMPONENTS SHOWN HERE ARE SUPPLIED BY THE USER.

MOUNTING METHODS: SOCKETED

McMaster Carr screw
#4-40 X 7/16 in. w/ spring lock
Part no. 91241A418
Qty: 4

.80 [20.3]

1.84 [46.7]

1.04 [26.5]

RAF STANDOFF #4-40
1/4 in OD, 1.043 in. long
Part no. 1678-440ALMOD-1.043
Qty: 4

PEM broaching stud
#4-40 X 1/4 in. long
Part no. KFH-440-4ET
Qty: 4

copley controls **GEM**

DEVELOPMENT KIT HEATSINK MOUNTING

A thermal pad is used in place of heatsink grease. The pad is die-cut to shape and has holes for the heat sink mounting screws. There are two protective sheets, blue on one side and clear on the other. Both must be removed when the interface pad is installed.

1: Remove the blue protective sheet from one side of the pad.
2: Place the interface pad on the drive, taking care to center the pad holes over the heatplate mounting holes.
3: Remove the clear protective sheet from the pad.
4: Mount the heatsink onto the drive taking care to see that the holes in the heatsink, interface pad, and drive all line up.
5: Torque the 4-40 mounting screws to 5 in-lb, 80 in-oz, 0.56 Nm.

Thermal pad

Transparent Carriers (2)
(Discard)

2.400 [60.96]
2.100 [53.34]
.150 [3.81]
2.990 [75.95]
2.800 [71.12]
.095 [2.41]
4X R.068 [1.73]
4X R.045 [1.14]
2.990 [75.95] REF.
.676 [17.17] REF.

GEM-HK HEATSINK KIT

ITEM	Part	Qty
1	Heatsink Hardware Kit, contains 2 screws, 4-40, 1.25 in, Philips with locking washers	2
2	Heatsink, GEM	1
3	Thermal pad, GEM	1
4	Spacer Hardware Kit, contains 4 spacers, round, 6 mm diam, 3 mm ID, 20 mm long, AL	1

POWER DISSIPATION

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 the drive would provide during operation. The +HV values are for the average DC voltage of the drive power supply. To see if a heatsink is required or not, the next step is to determine the temperature rise the drive will experience when it's installed. For example, if the ambient temperature in the drive enclosure is 40 °C, and the heatplate temperature is to be limited to 80° C or less to avoid shutdown, the maximum rise would be 80C - 40C. or 40° C.

Dividing this dissipation by the thermal resistance of 3.5º C/W with no heatsink gives a dissipation of 11.4 W. This line is shown in the charts. For power dissipation below this line, no heatsink is required. The vertical dashed line shows that a heatsink is required for operation at the rated continuous current.
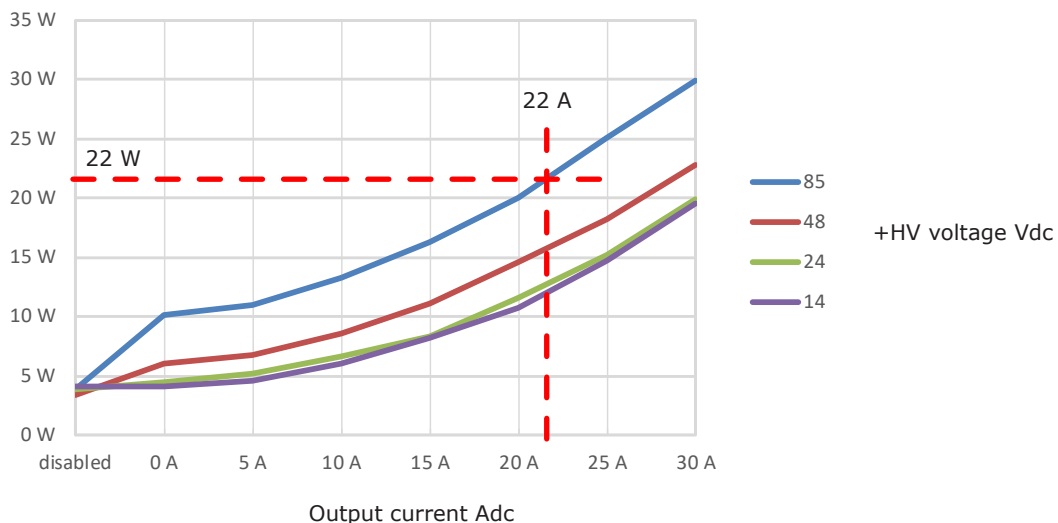
GEM-055-60, GEM-055-60-R

Dissipation vs. Output Current & +HV
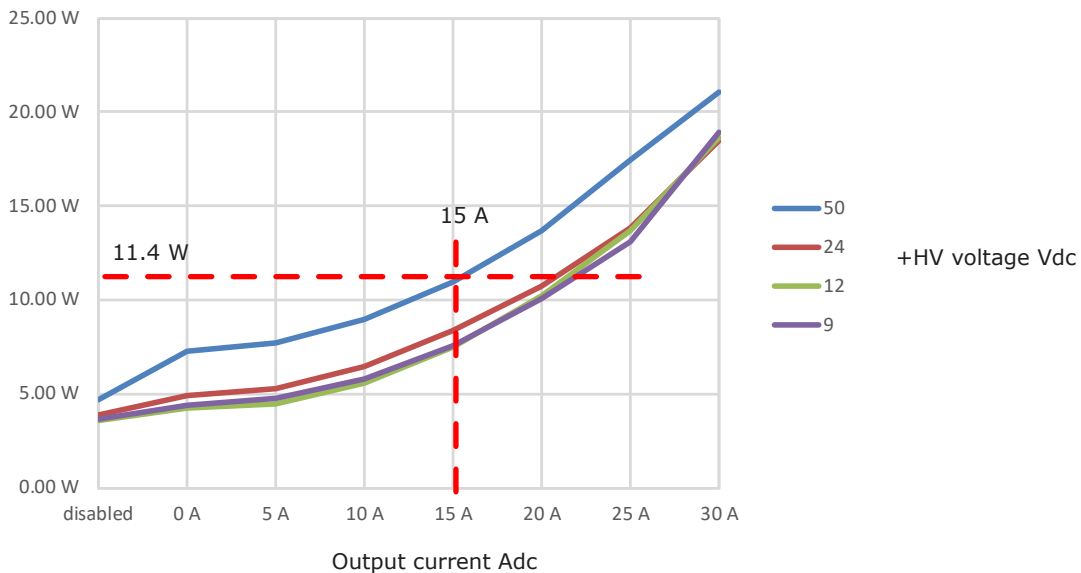
GEM-090-60, GEM-090-60-R

Dissipation vs. Output Current & +HV

THERMAL RESISTANCE VS. MOUNTING & COOLING

These tables show the thermal resistance Rth in degrees-C per Watt (C/W) for typical mounting and cooling configurations. LFM is Linear Feet per Minute, the velocity of air flow produced by a fan directed in line with the heatsink fins.
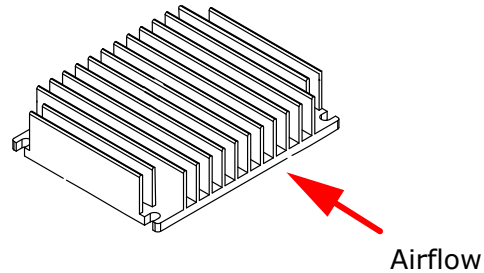
NO HEATSINK

LFM	0	300
Rth	3.5	1.3

HEATSINK

LFM	0	300
Rth	2.0	0.9

Airflow

FIND COOLING MEANS WITH DISSIPATION AND AMBIENT TEMPERATURE KNOWN

Given: Tamb = 32 ºC (89.6 ºF), +HV dissipation = 20.5 W, Aux-HV dissipation = 6 W
         Tmax = 80 ºC (drive shut-down temperature)

Find: Thermal resistance Rth:
         Delta-T = Tmax - Tamb = 80 - 32 = 48 ºC
         Total dissipation = 20.5 + 6 = 26.5 W
         Rth = Delta-T / dissipation = ºC / Watt = 48 / 26.5 = 1.8 ºC/W

From the tables above, there are two configurations that provide Rth less than 1.8 ºC/W:
         No heat sink, forced air at 300 LFM
         With heat sink, forced air at 300 LFM

FIND MAX AMBIENT TEMP WHEN DRIVE CONFIGURATION IS KNOWN

Given: Heatsink, forced-air at 300 LFV, dissipation is 26.5 W
         Rth = 0.9 ºC/W
         Tmax = 80 ºC (drive shut-down temperature)

Find: Max ambient operating temperature
         Delta-T = 26.5 W x 0.9 ºC/W = 23.9 ºC

         Max Tamb = Tmax - Delta-T = 90 – 23.9 = 66 ºC
         Max ambient operating temperature is 45 °C so it can operate up to this temperature

copley controls

GEM

DESCRIPTION

The Development Kit provides mounting and connectivity for one GEM drive. Solderless jumpers ease configuration of inputs and outputs to support their programmable functions. Switches can be jumpered to connect to digital inputs 1~10 so that these can be toggled to simulate equipment operation. Dual EtherCAT connectors make daisy-chain connections possible so that other EtherCAT devices such as Copley's Argus Plus or Xenus Plus Ethercat drives can easily be connected.

P7: 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 software communicates with the drive over this link and is then used for complete drive setup. The EtherCAT Device ID that is set by the rotary switch can be monitored, and a Device ID offset programmed as well.

The RS-232 connector, P7, 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.

P7
RS-232
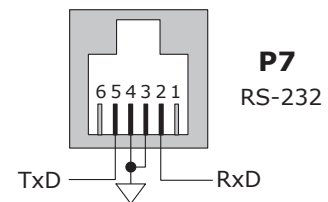
SER-CK SERIAL CABLE KIT

The SER-CK provides connectivity between a D-Sub 9 male connector and the RJ-11 connector P8 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.

Dsub-9F to RJ11 Adapter

RJ-11 cable 6P6C Straight-wired

RJ-11 on Servo Drive

D-Sub 9F

RxD 2 ← 5 TxD
TxD 3 → 2 RxD
Gnd 5 → 3 Gnd
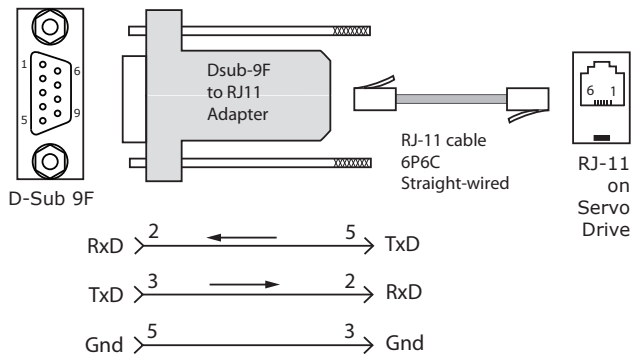
Don't forget to order a Serial Cable Kit SER-CK when placing your order for an GEM Development Kit!

P9: RS-422 COMMUNICATIONS

RS-422 is a two-wire differential half-duplex port that operates from 9600 bps to 230.4 kbps. Connections to the *RS-422* port are through P9. The graphic below shows the connections between a *GEM* and a computer RS-422 port.

DevKit P9

Drive J4

RS422GND J4/49
RS422(+) J4/42
RS422(-) J4/41

ISL32455

RxD
TxD
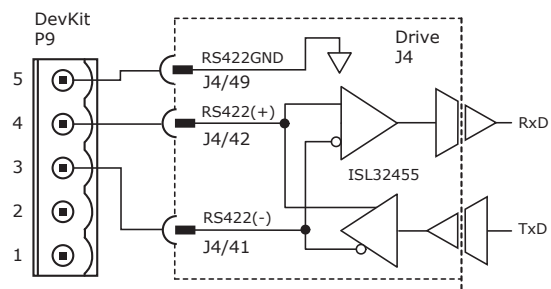
P8: ETHERCAT CONNECTIONS

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

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 "RUN" or EtherCAT State Machine:
Off	=	INIT
Blinking	=	PRE-OPERATIONAL
Single Flash	=	SAFE-OPERATIONAL
On	=	OPERATIONAL

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

AMP   STAT

P7
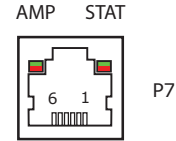
L/A (LINK/ACT) LED

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

L/A   L/A

P8

IN   OUT
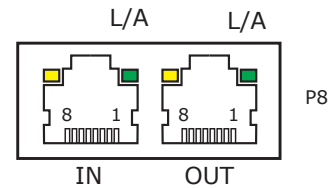
AMP LED

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

- *Green/Solid*   =   Drive OK and enabled. Will run in response to reference inputs or EtherCAT 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. Falts are programmable to be either transient or latching:

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 GEM 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 S2 that is less than 107 and set S2 to the hex value in the same row: 96 < 107 and 112 > 107, so S2 = 96 = Hex 6
2) Subtract 96 from the desired Device ID to get the decimal value of switch S1 and set S1 to the Hex value in the same row: S1 = (107 - 96) = 11 = Hex B
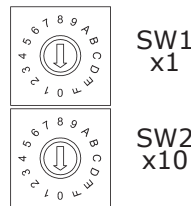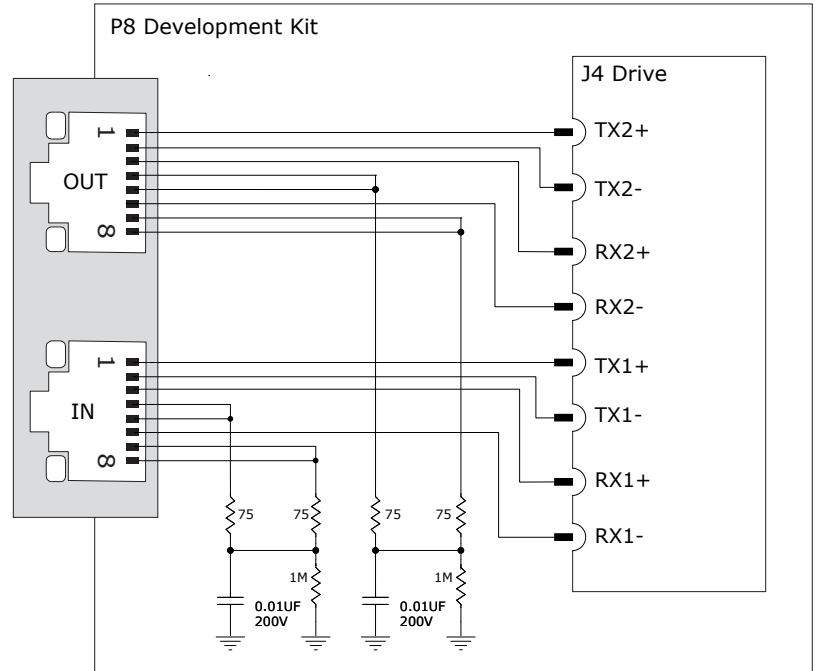
EtherCAT
Device ID Switch
Decimal values

	S2	S1
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

SW1
x1

SW2
x10

ETHERCAT CONNECTORS

ETHERCAT CONNECTORS

Dual RJ-45 connectors that accept standard Ethernet cables are provided for EtherCAT connectivity.

PIN	IN SIGNAL	OUT SIGNAL
1	TX1+	TX2+
2	TX1-	TX2-
3	RX1+	RX2+
4	75 Ω to 1 MΩ || 10 nF R/C	75 Ω to 1 MΩ || 10 nF R/C
5		
6	RX1-	RX2-
7	75 Ω to 1 MΩ || 10 nF R/C	75 Ω to 1 MΩ || 10 nF R/C
8		

SAFE TORQUE OFF (STO)

DESCRIPTION

If the STO feature will not be used, the STO function can be disabled by adding jumpers to a connector for P5 as shown below.
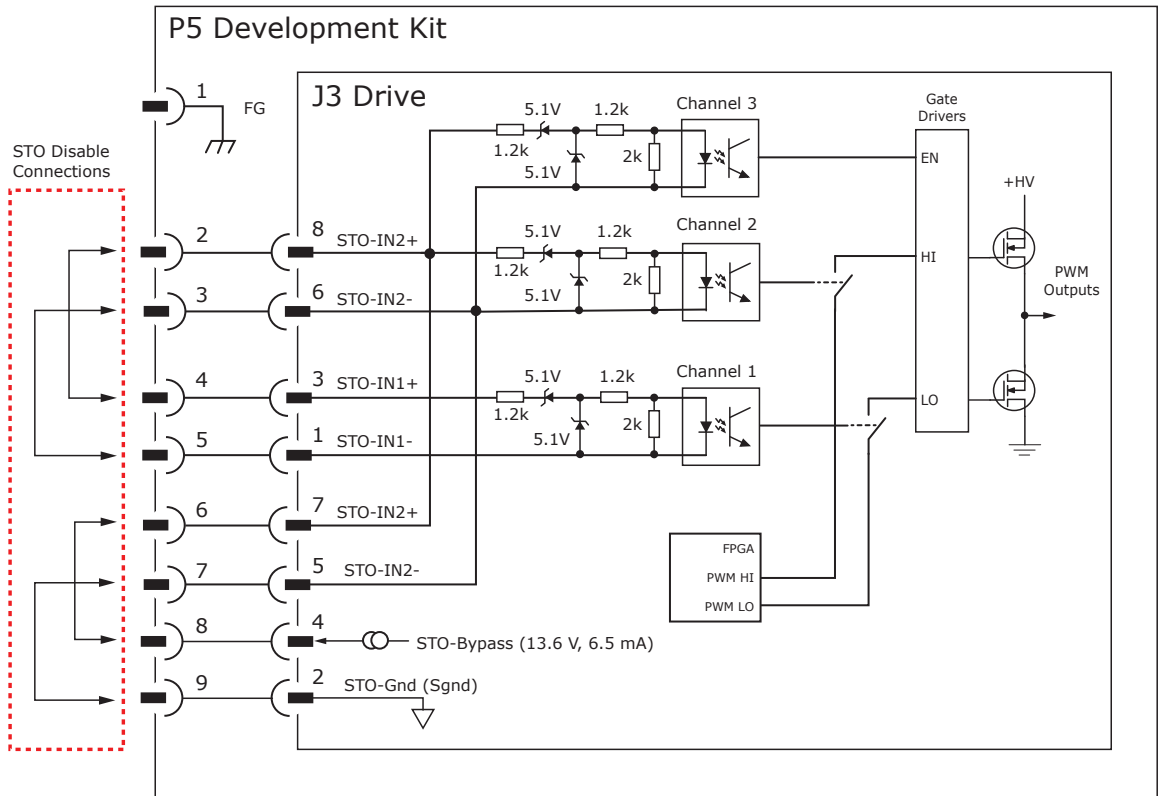
ETHERCAT DEVICE ID SWITCHES

### ETHERCAT DEVICE ID (STATION ALIAS) SWITCH CONNECTIONS

The graphic below shows the connections to the EtherCAT Device ID switches. These are read 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 [OUT5,6,8] and input [IN6] 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 CAN port connectors. In addition to the SLI function, the port can operate as an SLI interface.

The jumpers marked with red "X" should be removed so that SW13, or external connections to the signals do not interfere with the operation of the SLI port. The "X" on [OUT6] shows that no connections should be made to this by the user when the SLI port is active.
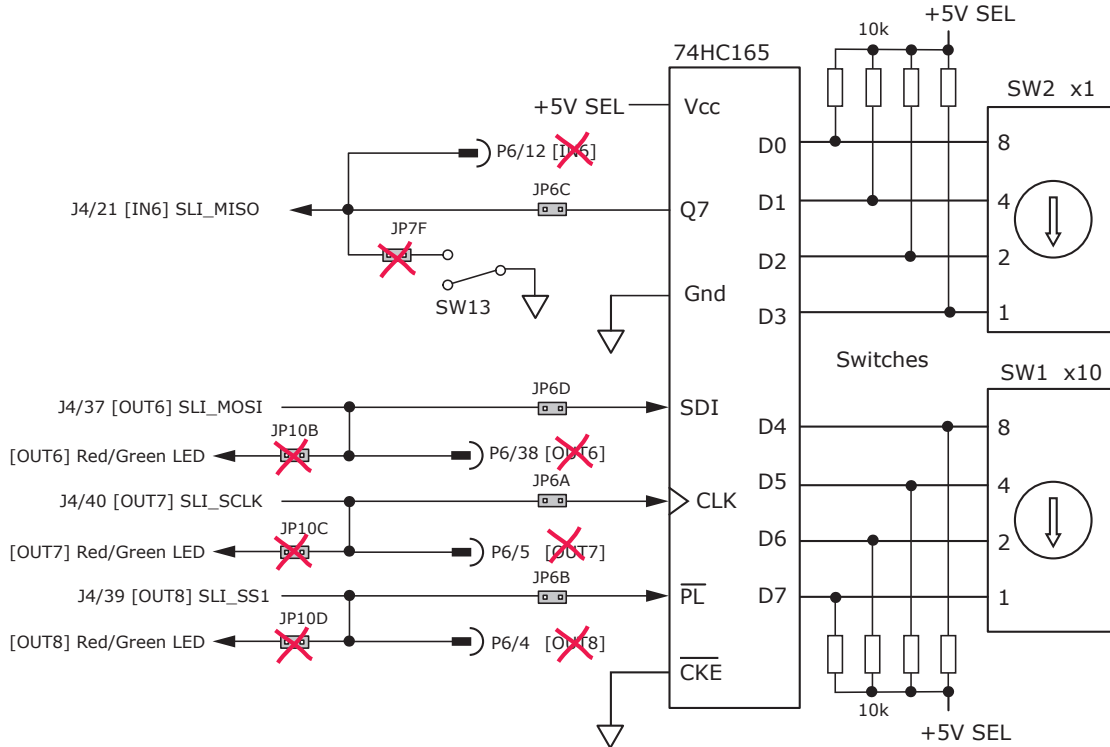
5V POWER SOURCES

Power for circuits on the Development Kit (+5V SEL) can be supplied either from the 5V from the servo drive (+5V ENC), or from an external +5V power supply (+5 EXT). Jumper JP14 selects the source of the +5V SEL from either the drive or from the external source.
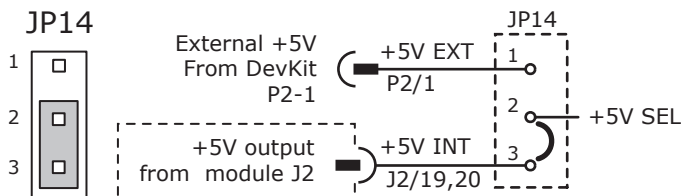
CONNECTORS & SIGNALS

LOGIC INPUTS & SWITCHES

The Development Kit has jumpers that can connect the GEM digital inputs to switches on the kit, or to the Signal connector P8.

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 JP7A should be removed to take the switch SW1 out of the circuit. The figure below shows these connections.
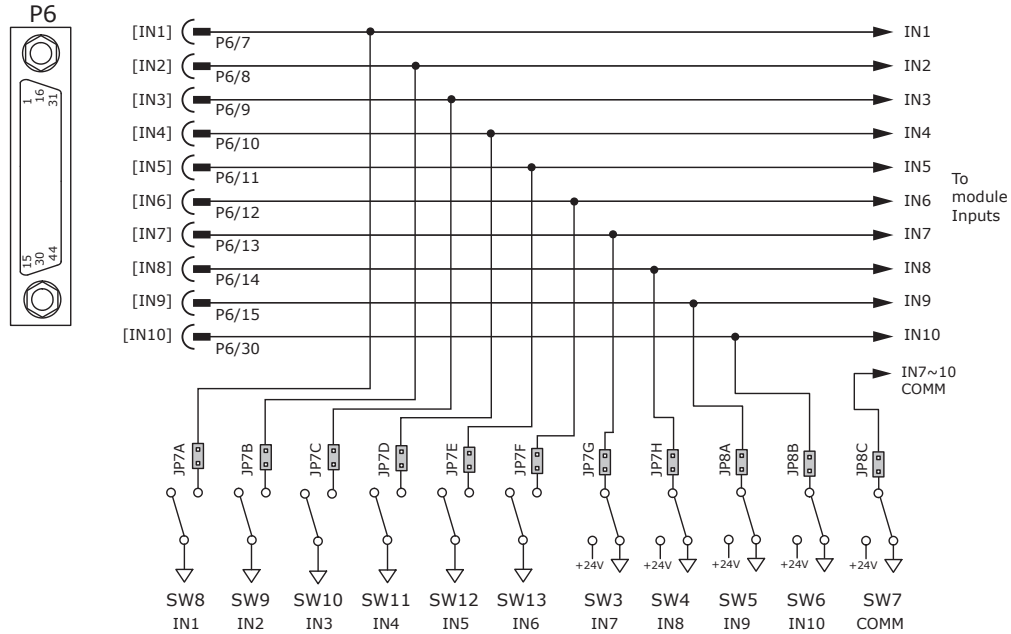
LOGIC OUTPUTS

There are 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 5,6,7 & 8 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, & 4 are two-terminal opto-isiolated types. With the jumpers in place as shown, when the outputs are ON they will drive current through the LEDs DS3~6.
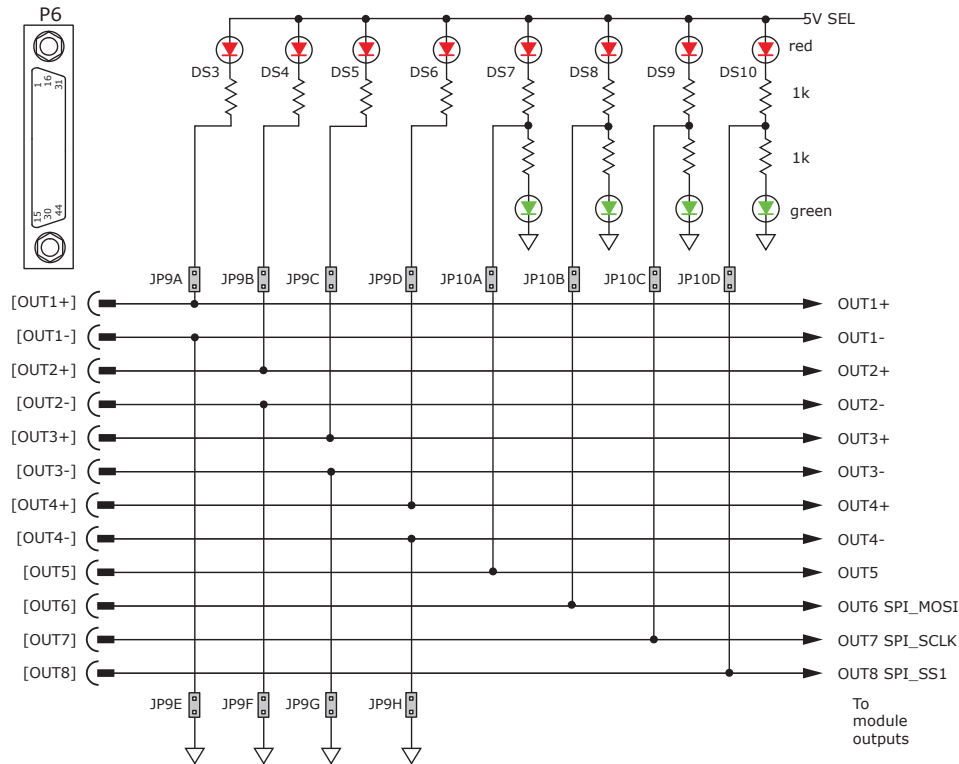
FEEDBACK CONNECTORS & SIGNALS

MOTOR FEEDBACK CONNECTOR P4

For motors with differential encoders: install jumpers JP1B, JP1C, JP1A to connect terminators across A, B, and X inputs.

For motors with single-ended encoders: remove jumpers JP1B, JP1C, JP1A to disconnect the terminators.
   Then use the A, B, and X inputs for the encoder. The /A, /B, and /X inputs are then biased by dividers to work with
   the single-ended encoder signals.

A motor temperature sensor that connects to [IN11] must have jumper JP8D removed to prevent switch SW14 from
   grounding the Motemp[IN11] signal.

Absolute encoders such as the Nikon A type that use 2-wire bidirectional signals require biasing the lines when they are in a quiescent state.
   Jumpers JP11A, JP11B, and JP1D must be in place to provide line termination and biasing.

LED's are provided to show the status of the encoder and Hall signals.
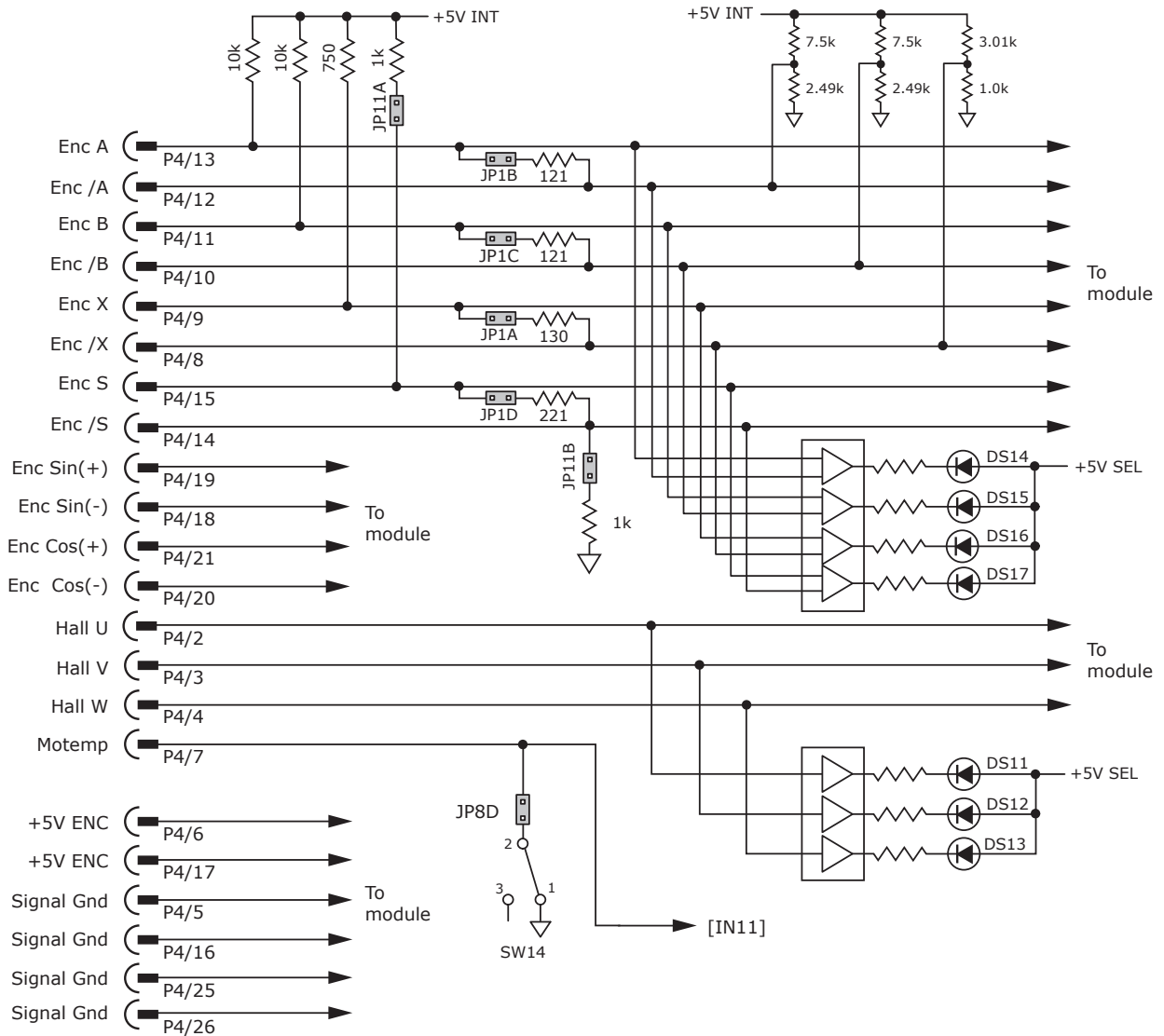
BRAKE CONNECTOR & SIGNALS

The brake circuit in the GEM is optically isolated from the other drive circuits. And the brake circuit in the Development Kit is isolated from other circuits in the kit. Jumpers are provided that connect the kit brake circuits to the +24V (HVAUX) power and +HVCOM (HV power ground and Signal Ground).

With the jumpers in place, supplying +24V to P2-4 and ground to P2-3 will power the brake circuit.

When this is done a low-current brake can be connected to P1-3 and P1-4, or a higher-current brake can be connected between P1-4 and P1-2. The +24V power supply must be able to supply the required current to energize the brake.
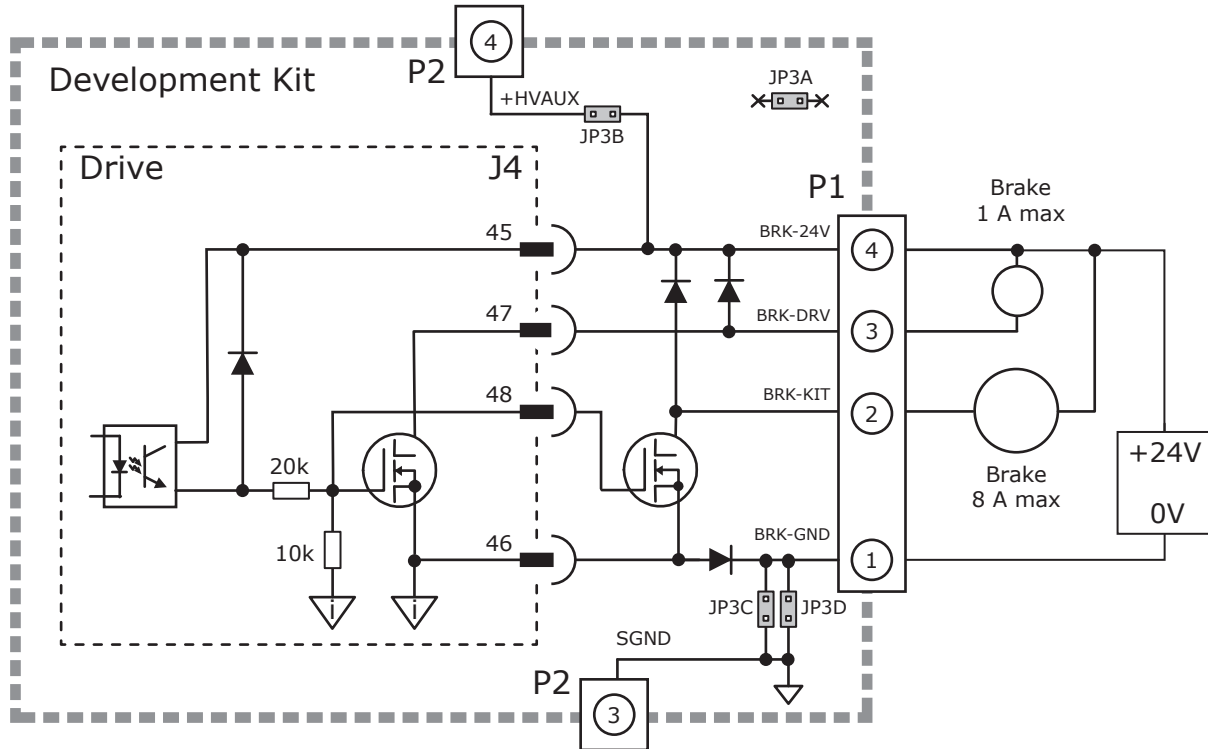
IMPORTANT:
To use the internal flyback diodes in the Development Kit the 24V power supply must be connected between P1 pins 4 and 1 as shown.

copley controls

DEVELOPMENT KIT CONNECTIONS
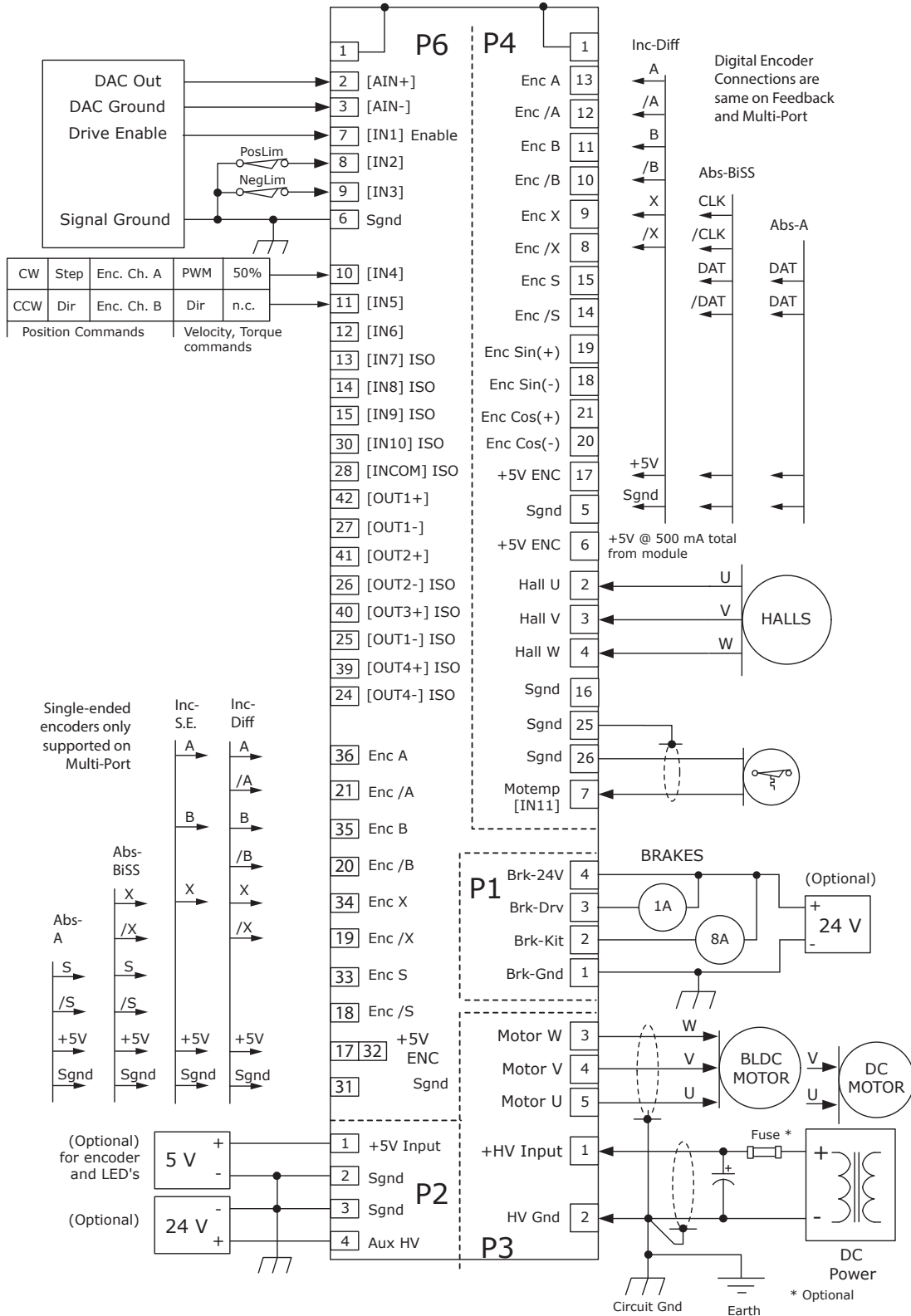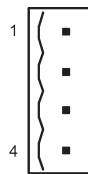
DEVELOPMENT KIT CONNECT0RS

P9 (See table on page 39)

P1 BRAKE

Signal	Pin
BRK-GND	1
BRK-KIT	2
BRK-DRV	3
BRK-24V	4

P2 AUX HV & +5V

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

P3 MOTOR & +HV POWER

Signal	Pin
+HV	1
HV Gnd	2
Motor W	3
Motor V	4
Motor U	5

P4 FEEDBACK

INPUT SWITCHES

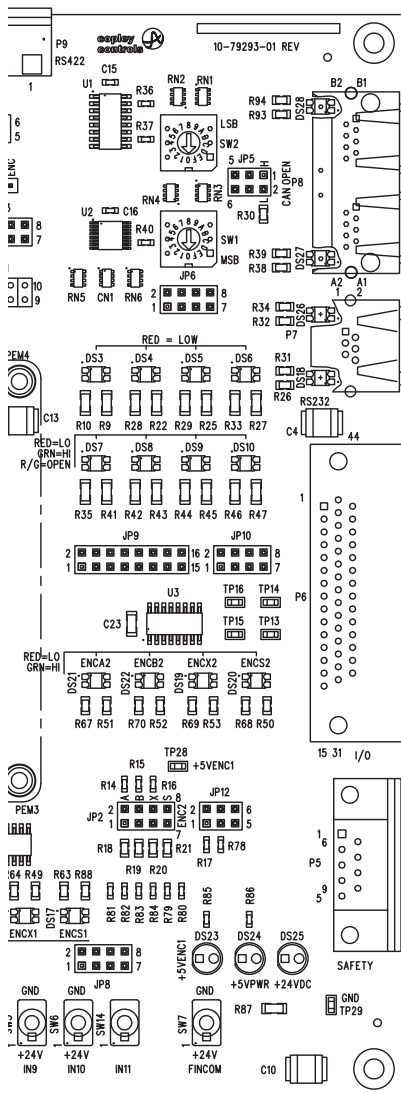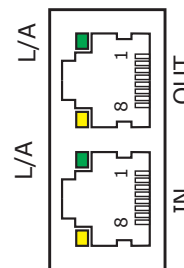| PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
26	Signal Gnd	18	Sin(-)	9	Enc X
25	Signal Gnd	17	+5V Enc	8	Enc /X
24	N.C.	16	Signal Gnd	7	[IN11] Motemp*
23	Rslvr Ref(+)	15	Enc S	6	+5V ENC
22	Rslvr Ref(-)	14	Enc /S	5	Signal Gnd
21	Cos(+)	13	Enc A	4	Hall W
20	Cos(-)	12	Enc /A	3	Hall V
19	Sin(+)	11	Enc B	2	Hall U
		10	Enc /B	1	Frame Gnd
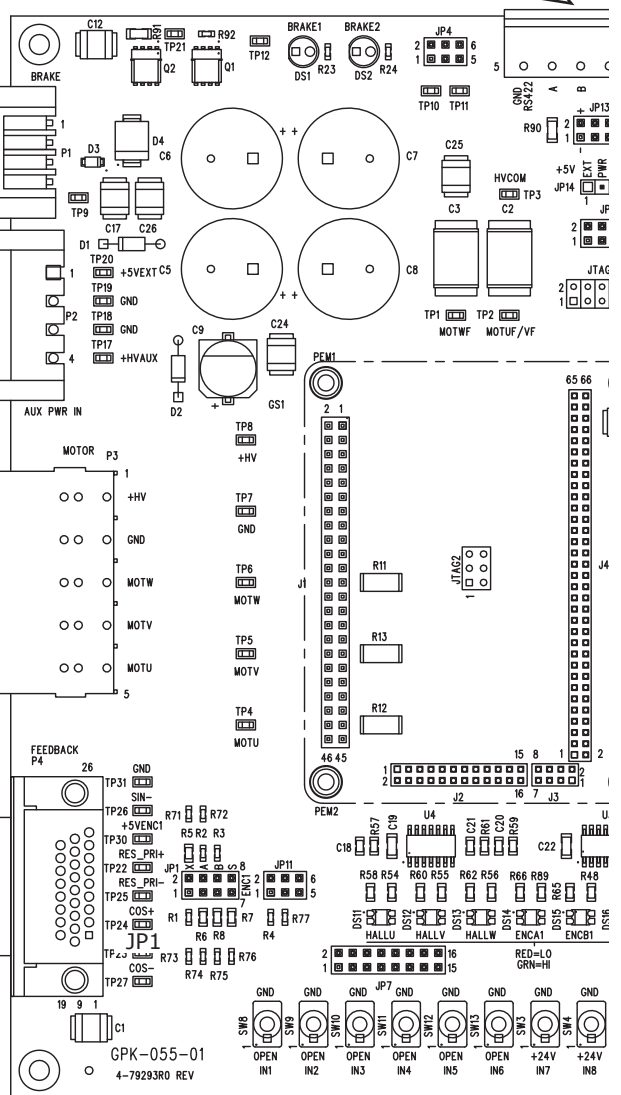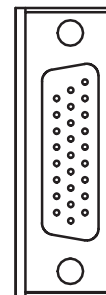
* Signal connections on the PC board are affected by jumper placement
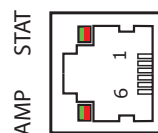
DEVELOPMENT KIT CONNECT0RS

P9 (See table below)

P8

P7

P6

P5

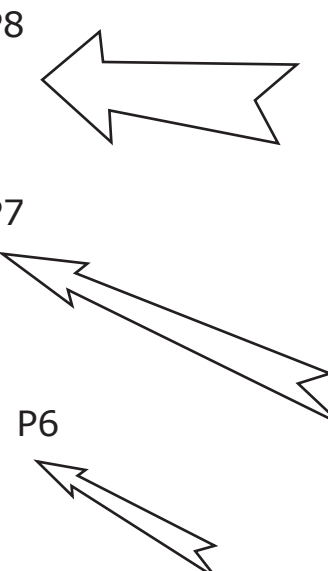P8 ETHERCAT

L/A   L/A   OUT

L/A   L/A   IN

See pinouts on page 28

P7 RS-232

AMP   STAT

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

P6 CONTROL

PIN	SIGNAL	PIN	SIGNAL	PIN	SIGNAL
1	Frame Gnd	16	Signal Gnd	31	Signal Gnd
2	[AIN-]	17	+5V ENC	32	+5V ENC
3	[AIN+]	18	/S Multi-Port	33	S Multi-Port
4	[OUT8] SLI-EN1	19	/X Multi-Port	34	X Multi-Port
5	[OUT7] SLI-CLK	20	/B Multi-Port	35	B Multi-Port
6	Signal Gnd	21	/A Multi-Port	36	A Multi-Port
7	[IN1] HS	22	Signal Gnd	37	Signal Gnd
8	[IN2] HS	23	[OUT5] SLI-CLK	38	[OUT6] SLI-MOSI
9	[IN3] HS	24	[OUT4-] ISO	39	[OUT4+] ISO
10	[IN4] HS	25	[OUT3-] ISO	40	[OUT3+] ISO
11	[IN5] HS	26	[OUT2-] ISO	41	[OUT2+] ISO
12	[IN6] HS	27	[OUT1-] ISO	42	[OUT1+] ISO
13	[IN7] ISO	28	[INCOM] ISO	43	N.C.
14	[IN8] ISO	29	N.C.	44	Signal Gnd
15	[IN9] ISO	30	[IN10] ISO		

P9 RS-422
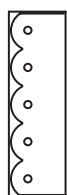
Pin	Signal
1	N.C.
2	N.C.
3	RS422(-)
4	RS422(+)
5	RS422-GND

P5 SAFETY
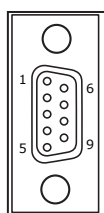
PIN	SIGNAL	PIN	SIGNAL
1	Frame Gnd	6	STO-2(+)
2	STO-2(+)	7	STO-2(-)
3	STO-2(-)	8	STO-BYPASS
4	STO-1(+)	9	STO-GND
5	STO-1(-)		

ORDERING INFORMATION

ORDERING GUIDE

GEM-055-60	*GEM* Servo Drive, 30/60 Adc, 9~55 Vdc, with encoder feedback
GEM-055-60-R	*GEM* Servo Drive, 30/60 Adc, 9~55 Vdc, with resolver feedback
GEM-090-60	*GEM* Servo Drive, 30/60 Adc, 14~90 Vdc, with encoder feedback
GEM-090-60-R	*GEM* Servo Drive, 30/60 Adc, 14~90 Vdc, with resolver feedback

Example: Order one *Argus Plus GEM* drive, 30/60 Adc, 14~90 Vdc with resolver feedback, Development Kit, Connector Kit, Serial Cable Kit, and Heatsink Kit

Qty	Item	Remarks
1	GEM-090-60-R	*Argus Plus GEM* servo drive with resolver feedback
1	GEK-090-01	Development Kit
1	GEK-CK	Connector Kit for Development Kit
1	SER-USB-RJ11	USB to Serial Cable Kit
1	GEM-HK	Heatsink Kit (See page 27 for instructions to mount drive and heatsink to the Development Kit)

Accessories

GEK-090-01	Development Kit for all GEM models
GEK-CK	Connector Kit for Development Kit (see details below)
GEM-HK	Heatsink Kit (Heatsink, thermal pad, and hardware)
SER-CK	Serial Cable Kit: 9-pin Dsub receptacle to 6-pin modular adapter, plus modular cable for DevKit
SER-USB-RJ11	Serial Interface Cable: USB to RJ11 for DevKit P7, 5.9 ft (1.8 m)

GEK-CK Connector Kit for Development Kit

Ref	Name	Qty	Description	Manufacturer P/N
P1	Brake	1	Plug, 4 position, 3.5 mm, female	Wago: 734-104/107-000
		1	Tool, wire insertion & extraction, 734 series	Wago: 734-231
P2	Aux HV	1	Plug, 4 position, 5.08 mm, female	Wago: 231-304/107-000
		1	Tool, wire insertion & extraction, 231 series	Wago: 231-159
P3	HV & Motor	1	Plug, 5 position, 7.62 mm, female	Phoenix Contact: 1778094
P4	Feedback	1	Connector, high-density DB-26M, 26 position, male, solder cup	Norcomp: 180-026-103L001
		1	Metal Backshell, DB-15, RoHS	Norcomp: 979-015-020R121
P5	Safety	1	Connector, DB-9M, 9-position, standard, male	Norcomp: 1710009-103L001
		1	Metal Backshell, DB-9, RoHS	Norcomp: 979-009-020R-121
P6	Control	1	Connector, high-density DB-44M, 44 position, male, solder cup	Norcomp: 180-044-103L001
		1	Metal Backshell, DB-25, RoHS	Norcomp: 979-025-020R121
P9	RS-422	1	Connector, terminal block, female, 0.20 in, 5-position	TE/AMP: 796635-5

Other Connectors

P7	RS-232	Serial Cable Kit	Copley: SER-CK
P8	Network	Ethernet Network cable, 10 ft (3 m)	Copley: GEK-NC-10
		Ethernet Network cable, 1 ft (0.3 m)	Copley: GEK-NC-01

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Note: Specifications subject to change without notice