800-1513
800-1519

DIGITAL SERVO DRIVE
for BRUSHLESS or BRUSH MOTORS

Control Modes
- Indexer, Point-to-Point, PVT
- Camming, Gearing, Position, Velocity, Torque

Command Interface
- *Stepper commands*
  Single-ended or Differential selectable
- CANopen, DeviceNet
- ASCII and discrete I/O
- ±10V position/velocity/torque command
- PWM velocity/torque command
- Master encoder (Gearing/Camming)

Communications
- CANopen/DeviceNet
- RS232

Feedback
- Digital Quad A/B encoder
- Secondary encoder / emulated encoder out
- Analog sin/cos encoder
- Digital Halls

I/O - Digital
- 12 inputs, 4 outputs

Accessories
- External regen resistors
- External edge filter

Dimensions: in [mm]
- 7.5 x 5.5 x 2.5 [191 x 140 x 64]

Model	Vac	Ic	Ip
800-1513	100 - 240	12	36
800-1519	100 - 240	6	18

DESCRIPTION

The *800-1513/1519* combines CANopen networking with 100% digital control of brushless or brush motors in an off-line powered package that can operate from single or three-phase mains. These models have stepper signal inputs that are programmable as either single-ended or differential.

800-1513/1519 operates as a Motion Control Device under the DSP-402 protocol of the CANopen DS-301 V4.01 (EN 50325-4) application layer. DSP-402 modes supported include: Profile Position, Profile Velocity, Profile Torque, Interpolated Position Mode (PVT), and Homing .

Drive commissioning is fast and simple using *CME 2*™ software operating under Windows® communicating with *800-1513/1519* via CAN or an RS-232 link. CAN address selection is by a 16-position rotary switch on the front panel. If there are more than fifteen devices on a CAN bus, the additional address bits needed can come from programmable inputs, or can be set in flash memory. Profile Position Mode does a complete motion index on command with S-curve acceleration & deceleration, top speed, and distance programmable. In PVT mode, the controller sends out a sequence of points each of which is an increment of a larger, more complex move than a single index or profile. The drive then uses cubic polynomial interpolation to “connect the dots” such that the motor reaches each point (**P**osition) at the specified velocity (**V**elocity) at the prescribed time (**T**ime). Homing mode is configurable to work with a variety of limit, index, and home switches such that the drive moves the motor into a position that has an absolute reference to some part of the machine.

Nine logic inputs are programmable as limit or home switches, stepper/encoder pulse inputs, reset, digital torque or velocity reference, or motor-temperature. A tenth input is dedicated to the drive Enable function. Three programmable logic outputs are for reporting an drive fault or other status indications. A fourth optically-isolated output can drive a motor brake from the external +24 Vdc power supply or can be programmed as a logic output.

In addition to CANopen motion commands, *800-1513/1519* can operate as a stand-alone drive. Current and velocity modes accept ±10 Vdc analog, digital 50% PWM or PWM/polarity inputs. In position mode inputs can be incremental position commands from step-motor controllers in Pulse/Direction or CW/CCW format, as well as A/B quadrature commands from a master-encoder. Pulse to position ratio is programmable for electronic gearing.

Power output of the drive varies with the input power which can range from 100 to 240 Vac, and from 47 to 63 Hz. Either single or three phase mains can be used giving *800-1513/1519* the ability to work in the widest possible range of industrial settings. Signal and control circuits are isolated from the high-voltage power supply and inverter stage that connect to the mains. A +24 Vdc input powers control circuits 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: Wye connected load: 2 mH line-line. Ambient temperature = 25 °C. Power input = 230 Vac, 60 Hz, 1 Ø

MODEL	800-1519	800-1513	
OUTPUT CURRENT			
Peak Current	18 (12.7)	36 (25.5)	Adc (Arms, sinusoidal)
Peak time	1	1	s
Continuous current (Note 1)	6 (4.24)	12 (8.5)	Adc (Arms, sinusoidal)
INPUT POWER			
Mains voltage, phase, frequency		100~240	Vac, ±10%, 1 Ø or 3 Ø, 47~63 Hz
Mains current		20	Arms
+24 Vdc Control power		+20 to +32 Vdc, 500 mA max	*Required for operation*

DIGITAL CONTROL		
Digital Control Loops	Current, velocity, position. 100% digital loop control	
Sampling rate (time)	Current loop: 15 kHz (67 µs), Velocity & position loops: 3 kHz (333 µs)	
Bus voltage compensation	Changes in bus or mains voltage do not affect bandwidth	
Minimum load inductance	200 µH line-line	
REFERENCE INPUTS (NOTE: DIGITAL INPUT FUNCTIONS ARE PROGRAMMABLE)		
Stand-alone mode		
Digital position reference	Pulse/Direction, CW/CCW	Stepper commands (2 MHz maximum rate) programmable as single-ended or differential
Analog torque & velocity reference	±10 Vdc, 12 bit resolution	Dedicated differential analog input
Input impedance	74.8 kΩ	Between Ref(+), Ref(-)
		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
As CAN node		
CANopen bus	Position & Velocity Mode commands	Homing, Profile, and Interpolated profile modes
DIGITAL INPUTS		
Number	10	
Inputs 1~6, 11, 12	74HC14 Schmitt trigger operating from 5.0 Vdc with RC filter on input, 10 kΩ to +5 Vdc or ground (selectable)	
Logic levels	Vin-LO < 1.35 Vdc, Vin-HI >3.65 Vdc	
Pull-up, pull-down control	Inputs are divided into three groups with selectable connection of input pull-up/down resistor to +5 Vdc or ground for each group: [IN1,2,3], [IN4,5], [IN6,7,8, 9,10,11,12]	
Enable [IN1]	1 dedicated input with 330 µs RC filter for drive enable. Active level programmable, +24 Vdc max	
GP [IN2,3,4,5,11,12]	6 General Purpose inputs with 330 µs RC filter, programmable functions, and active level select, +24 Vdc max	
HS [IN6,9,10]	5 High-Speed Inputs inputs with 100 ns RC filter, programmable functions, and active level select, +12 Vdc max	
HS [IN 7,8,9,10]	Programmable single-ended or differential high-speed inputs (see p. 6~7). [IN7,8] not available in single-ended mode	
DIGITAL OUTPUTS (NOTE 2)		
Number	4	
[OUT1], [OUT2], [OUT3]	Current-sinking MOSFET with 1 kΩ pullup to +5 Vdc through diode	
Current rating	1 Adc max, +40 Vdc max. Functions programmable	
	External flyback diode required if driving inductive loads	
Brake [OUT4]	Opto-isolated, current-sinking with flyback diode to +24 Vdc, 1 Adc	
QUADRATURE ENCODER OUTPUTS		
Maximum frequency	18 M-counts, post-quadrature (4.5 M-lines/sec)	
Encoder feedback models		
Operation	Motor encoder signals are buffered and appear on J7	
Signals	A, /A, B, /B, X, /X	
Driver	26LS31 differential line driver	
RS-232 PORT		
Signals	RxD, TxD, Gnd in 6-position, 4-contact RJ-11 style modular connector	
Mode	Full-duplex, serial communication port for drive setup and control, 9,600 to 115,200 baud	
Protocol	Binary and ASCII formats	
CAN PORTS		
Signals	CANH, CANL, Gnd in 8-position RJ-45 style modular connector, wired as per CAN Cia DR-303-1, V1.1	
Format	CAN V2.0b physical layer for high-speed connections compliant	
Data	CANopen Device Profile DSP-402	
Address selection	16 position rotary switch on front panel with 3 additional address bits available as digital inputs or programmable to flash memory (7-bit addressing, 127 devices per CAN network)	
STATUS INDICATORS		
Amp Status	Bicolor LED, drive status indicated by color, and blinking or non-blinking condition	
CAN Status	Bicolor LED, status of CAN bus indicated by color and blink codes to CAN Indicator Specification 303-3	

REGENERATION			
Cut-In Voltage	+HV > 390 Vdc		Regen output is on, (optional external) regen resistor is dissipating energy
Drop-Out Voltage	+HV < 380 Vdc		Regen output is off, (optional external) regen resistor not dissipating energy
Tolerance	±2 Vdc		For either Cut-In or Drop-Out voltage
Hysteresis	10 ±0.5 Vdc		Differential between Cut-In & Drop-Out voltage

NOTES:

1. Heatsinking and/or forced-air cooling is required for continuous output power rating
2. Brake[OUT4] is programmable as motor brake, or as general purpose digital output

GENERAL SPECIFICATIONS (CONTINUED)

PROTECTIONS

HV Overvoltage	+HV > 400 Vdc	Drive PWM outputs turn off until +HV is less than overvoltage
HV Undervoltage	+HV < 60 Vdc	Drive PWM outputs turn off until +HV is greater than undervoltage
Drive over temperature	IGBT > 80 °C ±3 °C	Drive PWM outputs turn off until IGBT temperature is below threshold
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	Drive shuts down when motor over-temperature switch changes to high-resistance state, or opens	
Feedback power loss	Fault occurs if feedback +5 Vdc output is < 85% of nominal value	

MECHANICAL & ENVIRONMENTAL

Size	7.55 in (191,8 mm) X 5.57 in (141,5 mm) X 2.57 in (65,3 mm)
Weight	3.0 lb (1.36 kg) for drive without heatsink 1.9 lb (0.86 kg) for XSL-HS heatsink, 1.26 lb (0.57 kg) for XSL-HL heatsink
Ambient temperature	0 to +45 °C operating, -40 to +85 °C storage
Humidity	0% to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cooling	Heat sink and/or forced air cooling required for continuous power output

FEEDBACK SPECIFICATIONS

DIGITAL ENCODER

Type	Quadrature, differential line driver outputs
Signals	A, /A, B, /B, (X, /X, index signals optional)
Frequency	5 MHz line frequency, 20 MHz quadrature count frequency

ANALOG ENCODER

Type	Sin/cos, differential line driver outputs, 0.5 Vpeak-peak (1.0 Vpeak-peak differential) centered about 2.5 Vdc typical. Common-mode voltage 0.25 to 3.75 Vdc
Signals	Sin(+), sin(-), cos(+), cos(-)
Frequency	230 kHz maximum line (cycle) frequency
Interpolation	10 bits/cycle (1024 counts/cycle)

DIGITAL HALLS

Type	Digital, single-ended, 120° electrical phase difference
Signals	U, V, W
Frequency	Consult factory for speeds >10,000 RPM

ENCODER POWER SUPPLY

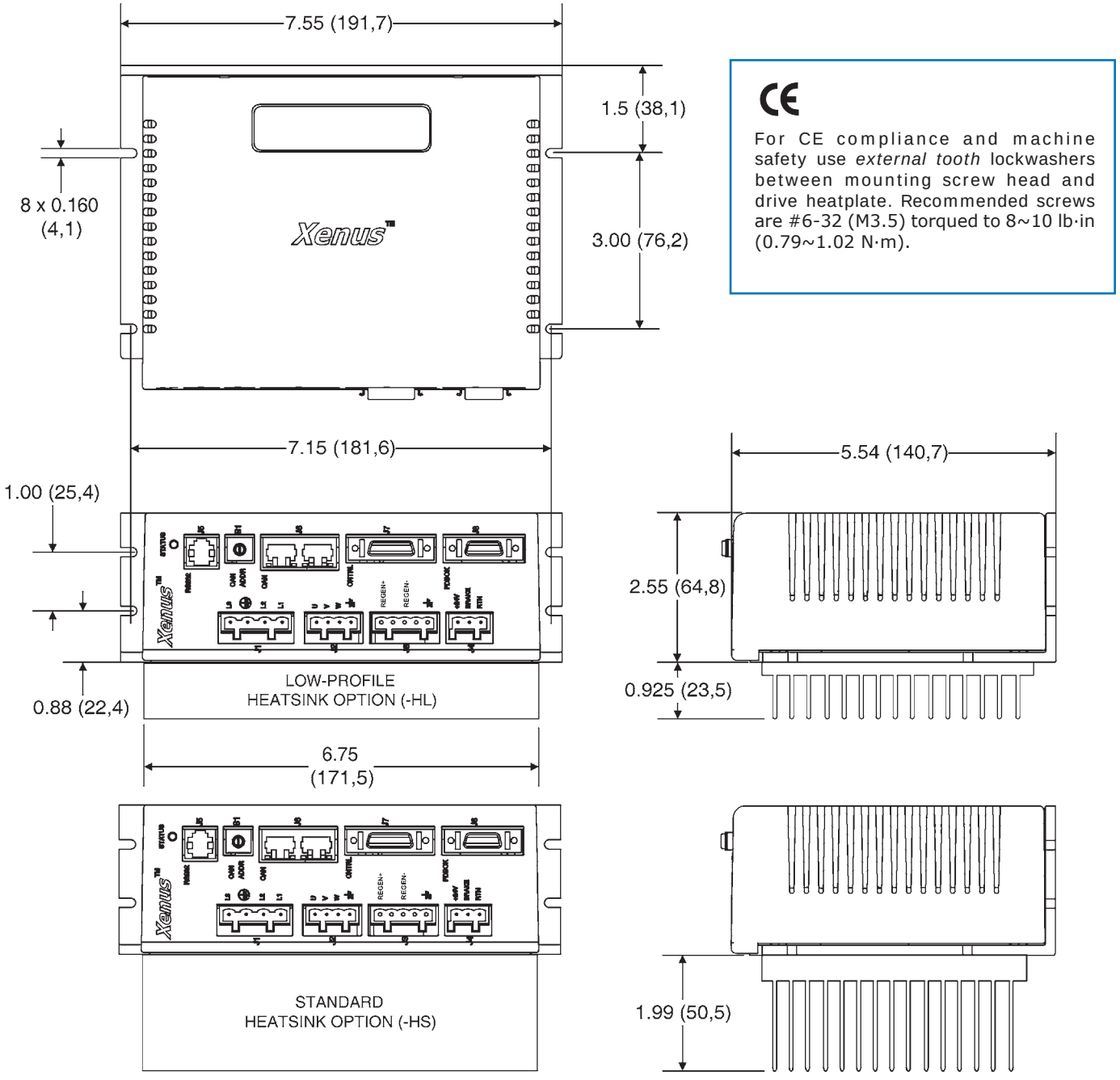
Power Supply	+5 Vdc @ 400 mA to power encoders & Halls
Protection	Current-limited to 750 mA @ 1 Vdc if overloaded Encoder power developed from +24 Vdc so position information is not lost when AC mains power is removed

MOTOR CONNECTIONS

Phase U, V, W	PWM outputs to 3-phase ungrounded Wye or delta connected brushless motors
Hall U, V, W	Hall signals
Digital Encoder	A, /A, B, /B, (X,/X)
Analog Encoder	Sin(+), sin(-), cos(+), cos(-)
Hall & encoder power	+5 Vdc @ 400 mA maximum (Note 3)
Motemp [IN5]	Motor overtemperature sensor input. Active level programmable. 4.99 kΩ to +5 Vdc or ground Disables drive when motor over-temperature condition occurs Same input circuit as GP digital inputs
Signal ground	Return for encoder, Halls, and temperature sensor
Brake [OUT4]	Current-sinking motor brake driver
+24 Vdc	From external power supply, +24 Vdc power supply to power motor brake
Frame ground	For motor cable shield

DIMENSIONS

Inches (mm)



For CE compliance and machine safety use *external tooth* lockwashers between mounting screw head and drive heatplate. Recommended screws are #6-32 (M3.5) torqued to 8~10 lb·in (0.79~1.02 N·m).

Weights:

Drive	3.0 lb (1.36 kg)
XSL-HS	1.9 lb (0.86 kg)
XSL-HL	1.26 lb (0.57 kg)

COMMUNICATIONS

CME 2 SOFTWARE

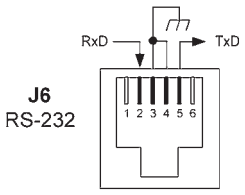
Drive setup is fast and easy using *CME 2* software. All of the operations needed to configure the drive are accessible through this powerful and intuitive program. Auto-phasing of brushless motor Hall sensors and phase wires eliminates "wire and try". Connections are made once and *CME 2* does the rest 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 *800-1513/19* is configured via a three-wire, full-duplex RS-232 port that operates 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* can be used for programming before and after installation in a CAN network. The *800-1513/19* 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.



CANOPEN NETWORKING

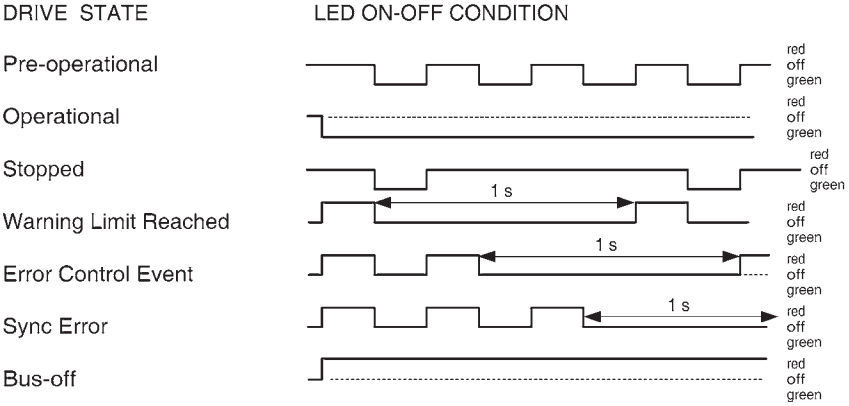
Based on the CAN V2.0b physical layer, a robust, two-wire communication bus originally designed for automotive use where low-cost and noise-immunity are essential, CANopen adds support for motion-control devices and command synchronization. The result is a highly effective combination of data-rate and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

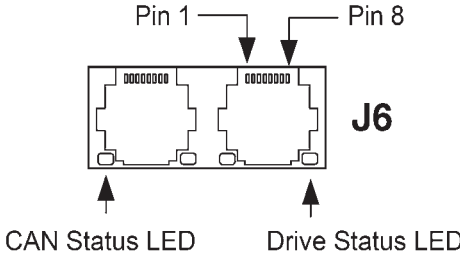
The *800-1513/19* uses the CAN physical layer signals CANH, CANL, and GND for connection, and CANopen protocol for communication. Before installing the drive in a CAN system, it must be assigned a CAN address. A maximum of 127 CAN nodes are allowed on a single CAN bus. The rotary switch on the front panel controls the four lower bits of the seven-bit CAN address. When the number of nodes on a bus is less than sixteen, the CAN address can be set using only the switch.

For installations with sixteen or more CAN nodes on a network CME 2 can be used to configure the drive to use the rotary switch, or combinations of digital inputs and programmed offset in flash memory to configure the drive with a higher CAN node address.

CAN STATUS LED



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



Drive Fault conditions:

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

Faults are programmable to be either transient or latching

AMP STATUS LED

A single bi-color LED gives the state of the driver by changing color, and either blinking or remaining solid.

The possible color and blink combinations are:

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

DIFFERENTIAL / SINGLE-ENDED DIGITAL COMMAND INPUTS

Current, velocity, and position modes are supported using digital signals in either differential or single-ended format. Controllers that output differential signals should be able to drive 121 Ω terminating resistors across the command inputs. Single-ended output controllers should have active outputs. When inputs are configured for single-ended operation, inputs [IN7] and [IN8] are not available. In differential operation these inputs become the (-) inputs for the command signals. The table below shows the functions of the inputs in single-ended and differential configurations for the various operating modes.

Current/velocity mode

In PWM 100% operation, the PWM signal controls the magnitude and the DIR input controls polarity. In PWM 50% operation only one signal is used to control magnitude and polarity. When the PWM signal is at 50%, the drive output is zero. Thereafter the outputs become increasingly negative as the duty cycle moves toward 0%, and increasingly positive as it moves toward 100%. By default, when the PWM input is either grounded or open the drive output drops to zero. This is a safety measure so that if the control connector J7 was removed, or a wire was to break, then the drive output would not go to maximum. Using CME 2 this feature can be cancelled to allow ground or open inputs to command 0% or 100% of drive output when in PWM 100% mode, or negative and positive full output when in PWM 50% mode.

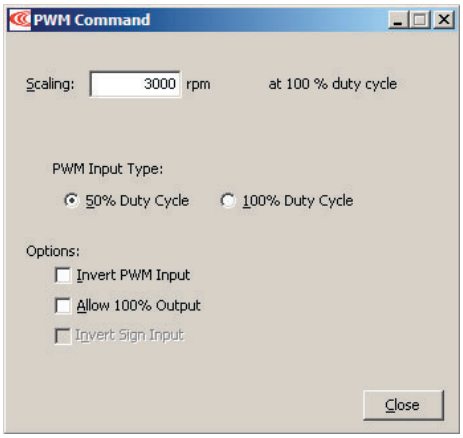
Position mode

Position control inputs can be in stepper or quad A/B encoder format. Stepper signals are called CW/CCW (clockwise/counterclockwise), CU/CD (count-up/count-down), or Pulse/Dir (pulse/direction). Quad A/B encoder signals enable the drive to operate as a slave to a master encoder.

INPUT SIGNALS AND MODES

INPUT	SINGLE	DIFFERENTIAL	POSITION MODE			CURRENT / VELOCITY MODE	
[IN9]	IN	IN(+)	CW (CU)	PULSE	QUAD A	PWM 100%	PWM 50%
[IN7]	N.C.	IN(-)					
[IN10]	IN	IN(+)	CCW (CD)	DIR	QUAD B	DIR	N.C.
[IN8]	N.C.	IN(-)					

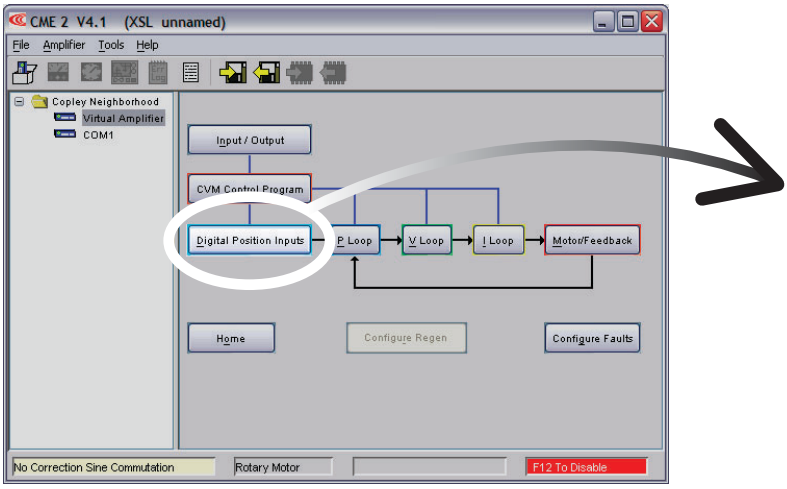
Note: N.C. = No Connection

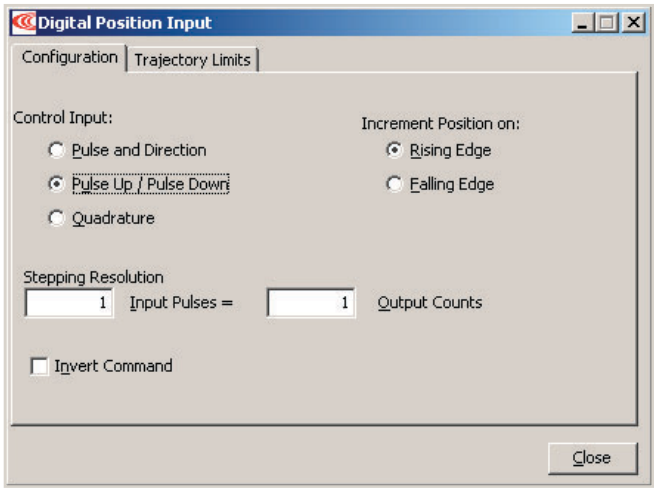


Current/velocity PWM input mode selections

DIGITAL INPUT SET-UP

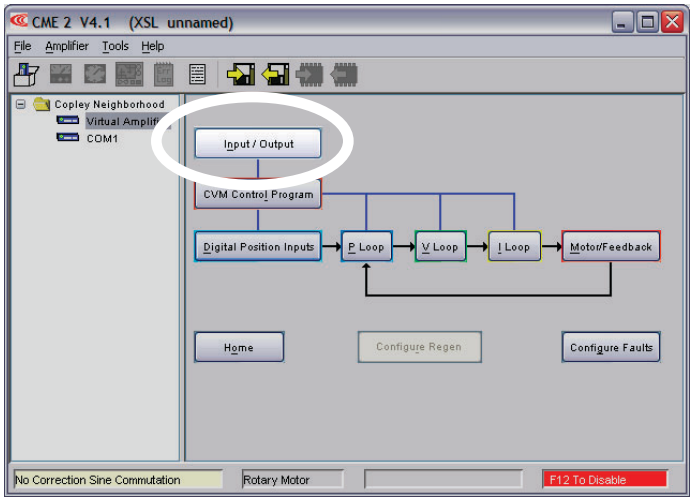
The position modes in the chart above are selected in CME 2 using the screen shown below





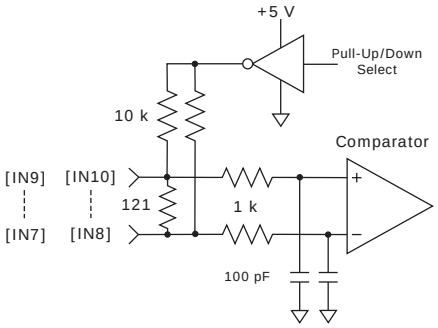
SINGLE-ENDED OR DIFFERENTIAL TYPE INPUT SELECTION

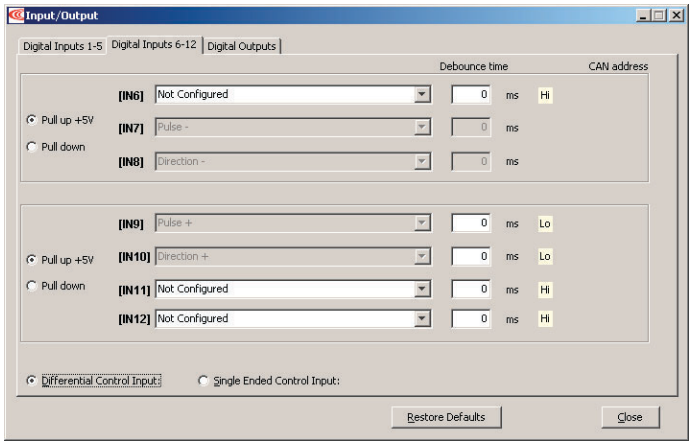
From the CME 2 main page, click on the Input / Output box to bring up the screens shown below. It is on these screens that the choice of single-ended or differential is made, as well as the pull-up or pull-down choice. The input circuit configurations are shown.



DIFFERENTIAL INPUTS

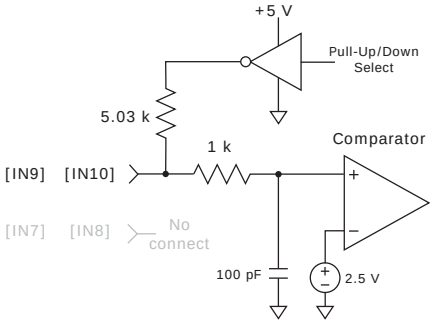
With the Differential Control Inputs item selected [IN9] and [IN10] become the (+) side of the inputs and [IN7] and [IN8] become the (-) side. Pull-up and pull-down selections are still active but have no effect as the inputs use the difference between (+) and (-) and this is zero if the inputs are open and are both at ground or +5 V.

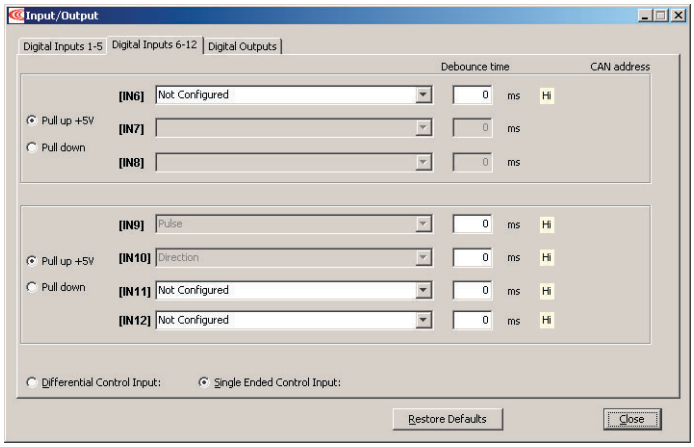




SINGLE-ENDED INPUTS

With Single Ended Control Inputs selected, [IN9] and [IN10] remain the active inputs but [IN7] and [IN8] are disabled.





COMMAND INPUTS

CANOPEN

As an intelligent node on a distributed-control network the drive can operate in current, velocity, or position mode with all control loops closed in the drive. Using Copley's CMO (Copley Motion Objects) or CML (Copley Motion Libraries) software, multiple drives can be controlled from high-level languages such as Visual Basic or C++. CANopen operation supports Profile Position, Profile Velocity, Profile Torque and Homing modes. In addition to these operating modes, all of the drive configuration parameters are available in CAN mode offering great flexibility of operation and control.

ASCII

RS-232 communications provides a simple hardware control capability for the drive in applications that don't require the power or flexibility provided by CANopen operation. And, while RS-232 does not support multi-drop connections like RS-485, multiple drives (or other Copley CANopen drives) can be controlled from a single COM port. This is done by setting the CAN address of the drive that connects to the COM port to "0", and then using CAN cables to connect other Copley drives in daisy-chain fashion. The "0" drive now acts as a CAN bus master communicating with the other drives over the CAN. The effect is to have the ability to communicate with multiple ampifiers from a single RS-232 port.

DEVICENET

DeviceNet operation is a communications protocol that uses the CAN bus for the hardware layer. It is employed by Allen-Bradley PLC's and enables *800-1513/19* drives to be controlled directly from A-B PLC's.

INDEXING

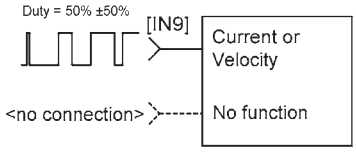
As an indexing drive, *800-1513/19* can be controlled from digital I/O lines or via CANopen, ASCII, or DeviceNet communications. Up to 32 sequences can be addressed with an additional priority sequence that can be launched from a single input or data-command. A sequence can consist of moves, homing, gain changes, time delays, wait-for-input, set-output, or camming, with each containing combinations of these. Additional flexibility is provided by the ability to replace program constants (i.e. move distance) with register addresses. A register is a storage location in drive RAM memory and can be changed via RS-232, CANopen, or DeviceNet communications. Using this technique a PLC can launch an index with digital I/O, and change the parameters over an ASCII link to find-tune the machine operation without changing the basic PLC program.

CAMMING

In camming mode *800-1513/19* synchronizes its motion with the encoder of an external device using cam tables that are stored in flash memory. A cam-table consists of two columns of numbers the first of which contains master encoder position values, and the second of which contains slave positions. When the cam profile is initiated position feedback from the external master encoder is compared to entries in the master column. When the master encoder position equals a value in the master column, the position in the slave column is sent to the drive's position loop. In this way, non-linear motion profiles can be executed from an encoder that tracks the position of moving machinery. Initiation of a camming move can be done with the master-encoder's index signal or from a digital input. For testing or stand-alone operation the master encoder can be internal to the drive where it's frequency is programmable. Up to 10 cam tables can be stored in the drive and each can have its own master encoder, trigger source and offsets.

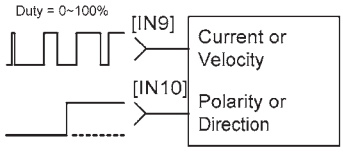
DIGITAL REFERENCE INPUTS

In stand-alone mode, digital reference inputs control drive current or velocity in the same fashion as the analog reference input, but do it using digital signals.
Digital inputs [IN9] and [IN10] have high-speed input filters and can be programmed for signals in several formats.
Current (torque, force) or velocity commands can be in one or two-wire format. In the one-wire format (50% PWM), a single input takes a square waveform that has a 50% duty cycle when the drive output should be zero. Thereafter, increasing the duty cycle toward 100% will command a maximum positive output, and decreasing the duty cycle toward 0% will produce a maximum negative output.



50% PWM Format

In two-wire format (PWM/Direction), one input takes a PWM waveform of fixed frequency and variable duty cycle, and the other input takes a DC level that controls the polarity of the output current. A 0% duty cycle will command zero current, and a 100% will produce a maximum. The direction of the force or torque produced will depend on the polarity of the DC signal on the direction input. In either mode, inputs are programmable to treat 0% or 100% inputs as faults as a safety measure should a cable break.



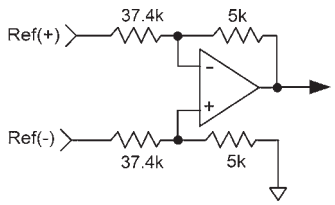
PWM/Direction Format

PWM U-V REFERENCE INPUTS

In most applications *800-1513/19* uses encoder and/or Hall feedback from the motor for *commutation*. This is the process by which motor currents are constantly adjusted so that they produce a magnetic field in the windings that is at ±90 degrees electrical with the magnetic field of the permanent-magnets so that torque or force is produced in proportion to the magnitude of the currents. For controllers that perform this function externally to the drive, the PWM U-V mode is provided. This provides control of the magnitude and polarity of the currents in the U & V phases of the motor, and sets the W phase current equal to the sum of the U-V currents times (-1).

ANALOG REFERENCE INPUT

A single ±10 Vdc differential input takes inputs from controllers that use PID or similar compensators, and output a current command to the drive. Drive output current or velocity vs. reference input voltage is programmable.



INPUT / OUTPUT

DIGITAL INPUTS

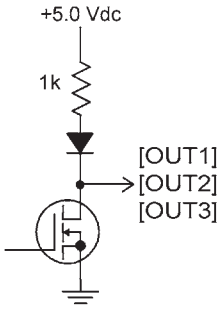
800-1513/19 has ten digital inputs, nine of which have programmable functions. Input [IN1] is dedicated to the drive Enable function. This is done to prevent accidental programming of the input in such a way that the controller could not shut it down.
Two types of RC filters are used: GP (general purpose) and HS (high speed). Input functions such as Pulse/Dir, CW/CCW, Quad A/B are wired to inputs having the HS filters, and inputs with the GP filters are used for general purpose logic functions, limit switches, and the motor temperature sensor. Programmable functions of the digital inputs are:

- Positive Limit switch
- Negative Limit switch
- Home switch
- Drive Reset
- Pulse & Direction, or CW/CCW step motor position commands
- Quad A/B master encoder position commands
- CAN address bits
- Motor over-temperature
- Reference input attenuation select (zero or divide by eight)

In addition to the active level and function for each programmable input, the input resistors are programmable in four groups to either pull up to +5 Vdc, or down to ground. Grounded inputs with HI active levels interface to PLC's that have PNP outputs that source current from +24 Vdc sources. Inputs pulled up to +5 Vdc work with open-collector, or NPN drivers that sink current to ground.

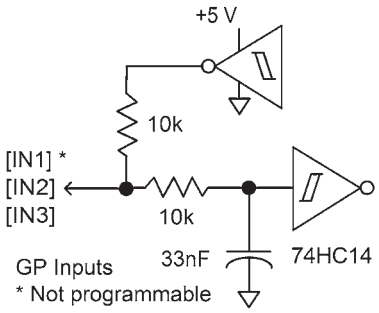
DIGITAL OUTPUTS

The digital outputs are open-drain MOSFETs with 1 kΩ pull-up resistors in series with a diode to +5 Vdc. They can sink up to 1 Adc from external loads operating from power supplies to +30 Vdc.
The output functions are programmable. The active state of the outputs is programmable to be on or off.
When driving inductive loads such as a relay, an external fly-back diode is required. The internal 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.

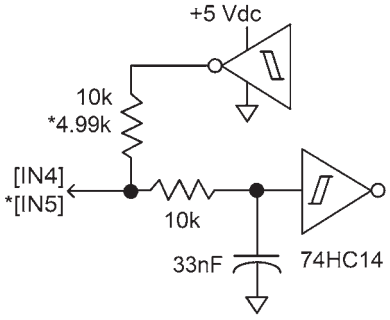


DIGITAL INPUT CIRCUITS

24VDC MAX



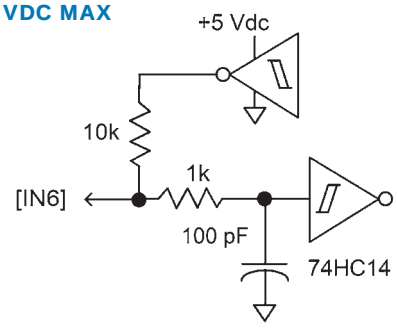
24VDC MAX



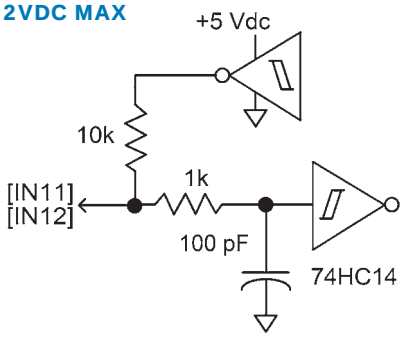
BRAKE OUTPUT [OUT4]

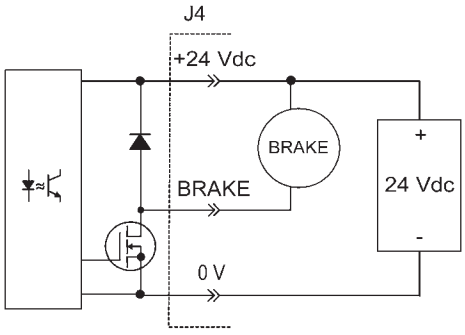
This output is an open-drain MOSFET with an internal flyback diode connected to the +24 Vdc input. It can sink up to 1A from a motor brake connected to the +24 Vdc supply.
The operation of the brake is programmable with *CME 2*. It can also be programmed as a general-purpose digital output.

12VDC MAX



12VDC MAX



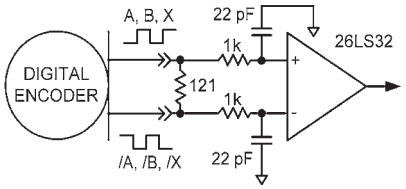


FEEDBACK

DIGITAL ENCODERS

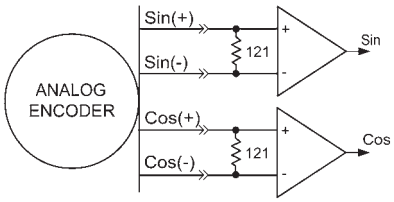
The motor encoder interface is a differential line-receiver with R-C filtering on the inputs. The circuit is shown below. Encoders with differential outputs are required because they are less susceptible to noise that can be degrade single-ended outputs. Encoder cables should use twisted-pairs for each signal pair: A & /A, B & /B, Index & /Index. An overall shield should be used, and for longer cables, shields for individual pairs may be necessary to guarantee signal integrity.

The encoder signals are made available to the controller via the signal connector J7, where they are re-transmitted by differential line-drivers. This eliminates split cables that would have to route the motor encoder signals to both drive and controller, as well as providing a good signal quality termination of the encoder signals at the drive.

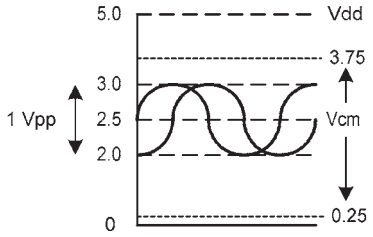


ANALOG ENCODERS

800-1513/1519 supports analog encoder signals for position feedback.The Sin and Cos inputs are differential with 121 Ω terminating resistors and accept 1.0 Vp-p signals in the A/B format used by encoders with analog outputs such as Heidenhain, Stegman, and Renishaw.



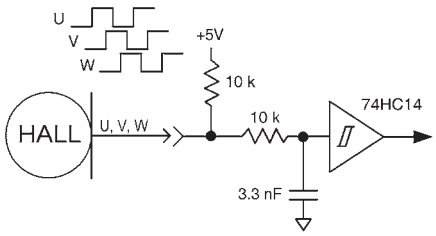
Sin/Cos Encoder Signals



Vdd = Encoder supply voltage
Vcm = Common-Mode Voltage

DIGITAL HALL SIGNALS

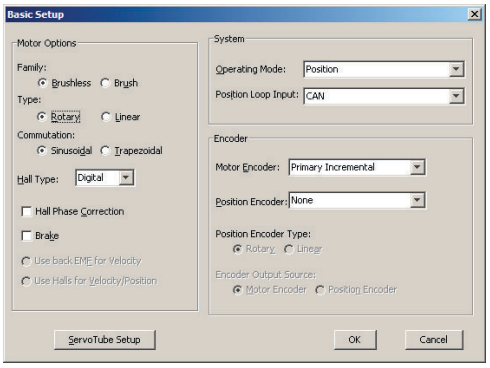
Use of these signals is optional. *800-1513/1519* is capable of auto-phasing using encoder signals and motor movement on power-up. Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced 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 in the *800-1513/1519* they are used for commutation-initialization after startup, and for checking the motor phasing after the amplifer has switched to sinusoidal commutation.



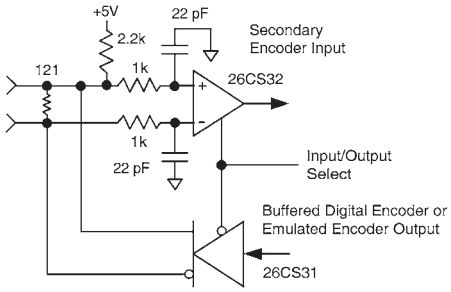
MULTI-MODE ENCODER PORT

This port consists of three differential input/output channels that take their functions from the drive Basic Setup.
For dual-loop position-mode operation that employs a primary encoder on the motor, and a secondary encoder on the load, the port works as an input receiving the secondary encoder's quad A/B/X signals.
For stand-alone operation with an external motion controller, the signals from the digital encoder on the motor are buffered and made available at the control signal connector for transmission to the controller. This eliminates split-wired motor cables with dual connectors that take the encoder signals to both drive and controller.
When used with ServoTube motors, or other motors using analog encoders with sin/cos signal format, the drive interpolates the sin/cos signals to a resolution that is programmable. The incremental changes in position are then converted to digital quad A/B/X format for use by the external motion controller.

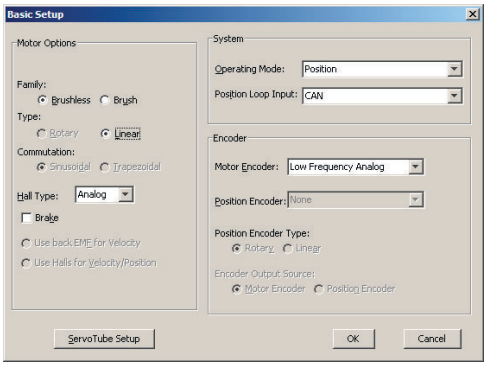
BUFFERED OUTPUTS FROM PRIMARY QUAD A/B/X ENCODER



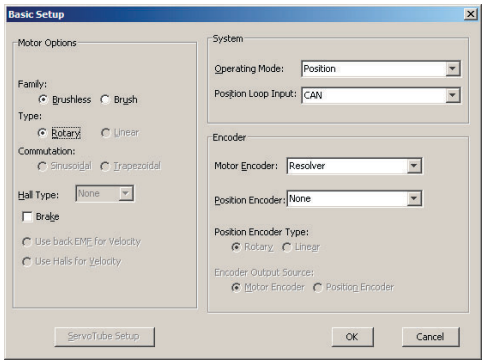
FUNCTIONAL DIAGRAM OF ONE CHANNEL



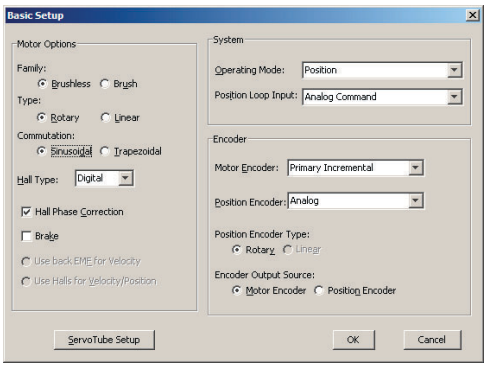
EMULATED QUAD A/B OUTPUTS FROM SERVOTUBE MOTORS



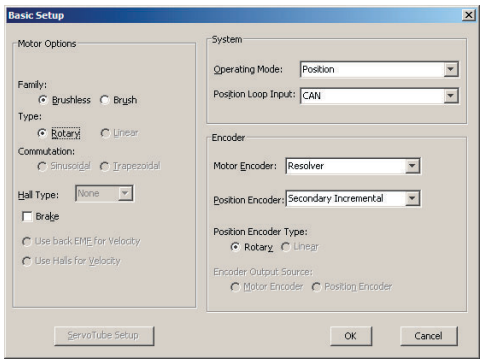
EMULATED QUAD A/B OUTPUTS FROM RESOLVER MOTORS



BUFFERED OUTPUTS FROM DIGITAL PRIMARY ENCODER OR EMULATED QUAD A/B OUTPUTS FROM ANALOG POSITION ENCODER

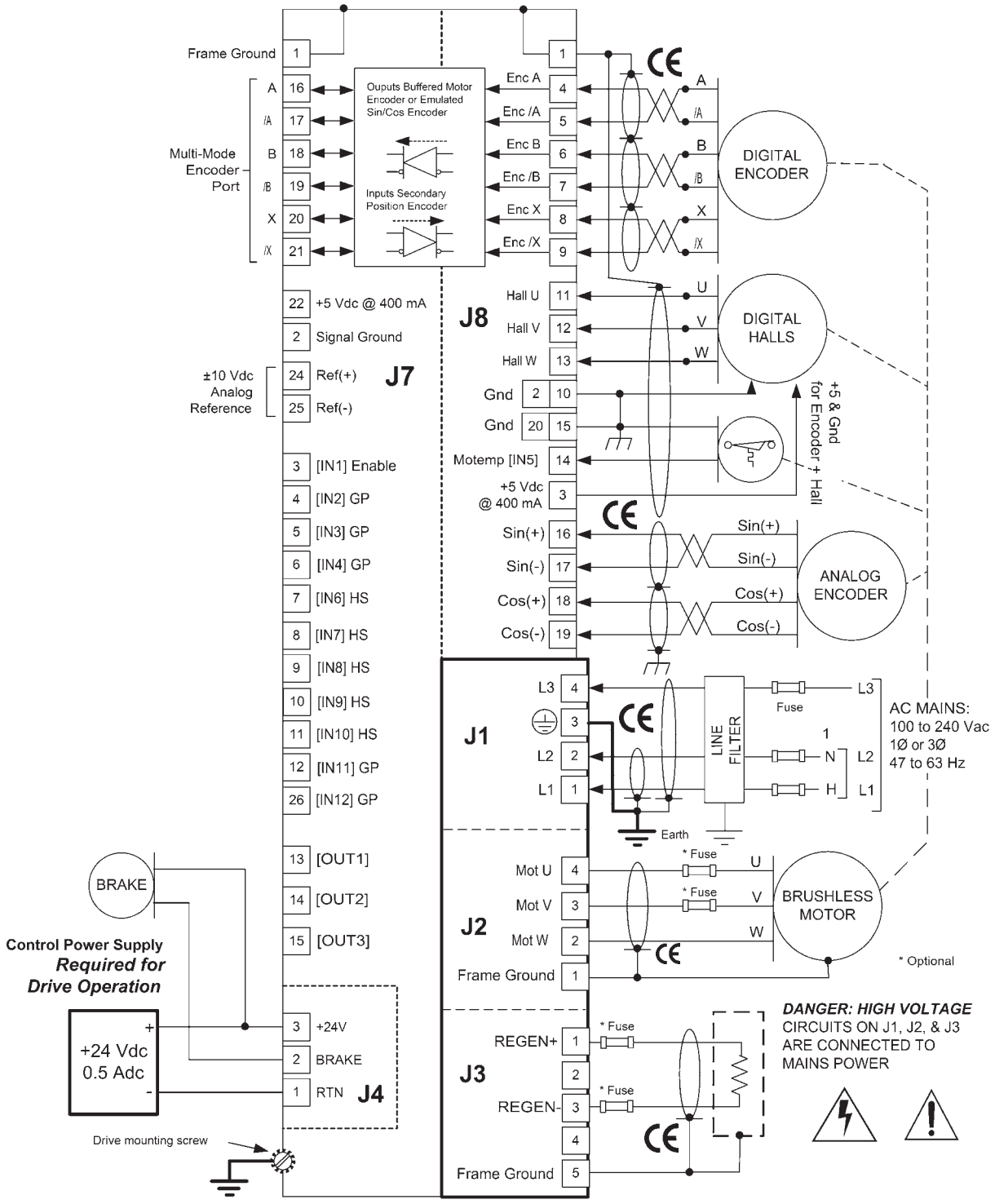


DIGITAL POSITION ENCODER INPUT FOR RESOLVER MOTORS



DRIVE CONNECTIONS

CE = Shielded cables required for CE compliance



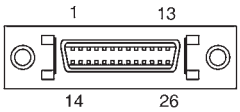
Notes:
1. The total output current from the +5 Vdc supply to J7-22 and J8-3 cannot exceed 400 mAdc.

ACCESSORY CABLE CONNECTIONS

SIGNAL CABLE (XSL-CC-10)

Cable assembly: CCC p/n 59-00785-000
Molded connector mates with drive J7 and has flying-lead terminations.

CONNECTOR (FRONT VIEW)

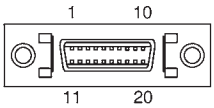


Signal	Pin	Color (Body/Stripe	Pair		Color (Body/Stripe	Pin	Signal
Frame Ground	1	Color varies with Cable Revision level See table below	1a	8a	White/Violet	14	[OUT2]
Signal Ground	2		1b	8b	Violet/White	15	[OUT3]
Enable [IN1]	3	White/Brown	2a	9a	White/Grey	16	Multi-Encoder A
GP Input [IN2]	4	Brown/White	2b	9b	Grey/White	17	Multi-Encoder /A
GP Input [IN3]	5	White/Pink	3a	10a	Tan/Brown	18	Multi-Encoder B
GP Input [IN4]	6	Pink/White	3b	10b	Brown/Tan	19	Multi-Encoder /B
HS Input [IN6]	7	White/Orange	4a	11a	Tan/Pink	20	Multi-Encoder X
HS Input [IN7]	8	Orange/White	4b	11b	Pink/Tan	21	Multi-Encoder /X
HS Input [IN8]	9	White/Yellow	5a	12a	Tan/Orange	22	+5 Vdc @ 400 mA
HS Input [IN9]	10	Yellow/White	5b	12b	Orange/Tan	23	Signal Ground
HS Input [IN10]	11	White/Green	6a	13a	Tan/Yellow	24	Analog Ref(+)
GP Input [IN11]	12	Green/White	6b	13b	Yellow/Tan	25	Analog Ref(-)
[OUT1]	13	White/Blue	7a	7b	Blue/White	26	[IN12] GP Input

FEEDBACK CABLE (XSL-FC-10)

Cable assembly: CCC p/n 59-00786-000
Molded connector mates with drive J7 and has flying-lead terminations.

CONNECTOR (FRONT VIEW)



Signal	Pin	Color (Body/Stripe	Pair		Color (Body/Stripe	Pin	Signal
Frame Ground	1	Color varies with Cable Revision level See table below	1a	8a	White/Violet	11	Digital Hall U
Signal Ground	2		1b	8b	Violet/White	12	Digital Hall V
+5 Vdc @ 400 mA	3	White/Brown	2a	9a	White/Grey	13	Digital Hall W
Encoder Input A	4	Brown/White	2b	9b	Grey/White	14	[IN5] Temp Sensor
Encoder Input /A	5	White/Pink	3a	10a	Tan/Brown	15	Signal Ground
Encoder Input B	6	Pink/White	3b	10b	Brown/Tan	16	Analog Sin(+)
Encoder Input /B	7	White/Orange	4a	11a	Tan/Pink	17	Analog Sin(-)
Encoder Input X	8	Orange/White	4b	11b	Pink/Tan	18	Analog Cos(+)
Encoder Input /X	9	White/Yellow	5a	12a	Tan/Orange	19	Analog Cos(-)
Signal Ground	10	Yellow/White	5b	12b	Orange/Tan	20	Signal Ground

CABLE REVISION LEVEL AND CONDUCTOR COLORS FOR PINS 1 & 2

		Rev B	Rev C
Signal	Pin	Color (Body/Stripe)	
Frame Ground	1	White/Tan	Brown
Signal Ground	2	Tan/White	Orange

Conductor colors for pins 1 & 2 in cables of Rev B (and prior) could be difficult to distinguish between those of pins 3 & 4. These cables will be superceded by cables of Rev C (or higher) which have the conductor colors changed for easier identification. The changes are shown in the table to the left.

Note: Cable shields connect to connector shells and not to conductors. The shells of drive J7 & J8 are connected to the earth ground terminal on power connector J1 and to the drive chassis. When the cables above are connected to the drive a continuous path from cable shield to earth is established for shielding and CE compliance.

WARNING: Hazardous voltages exist on connections to J1, J2, & J3 when power is applied, and for up to 30 seconds after power is removed.

J1 Mains Connections

J1 CABLE CONNECTOR:
Wago 721-204/026-045
*(51118287 or 721-204/026-045/RN01-0000)
Euro-style 7,5 mm pluggable female terminal block with preceding ground receptacle
Cable: AWG 12, 600 V recommended for XSL-230-36 and XSL-230-40 models, AWG 14, 600V for XSL-230-18
Shielded cable required for CE compliance

Signal	Pin
Mains Input L3	4
Protective Ground	3
Mains Input L2	2
Mains Input L1	1

J2 Motor Outputs

J2 CABLE CONNECTOR:
Wago 721-104/026-047
*(51118008 or 721-104/026-047/RN01-0000)
Euro-style 5,0 mm pluggable female terminal block
Cable: AWG 12, 600 V recommended for XSL-230-36 and XSL-230-40 models, AWG 14, 600V for XSL-230-18
Shielded cable required for CE compliance

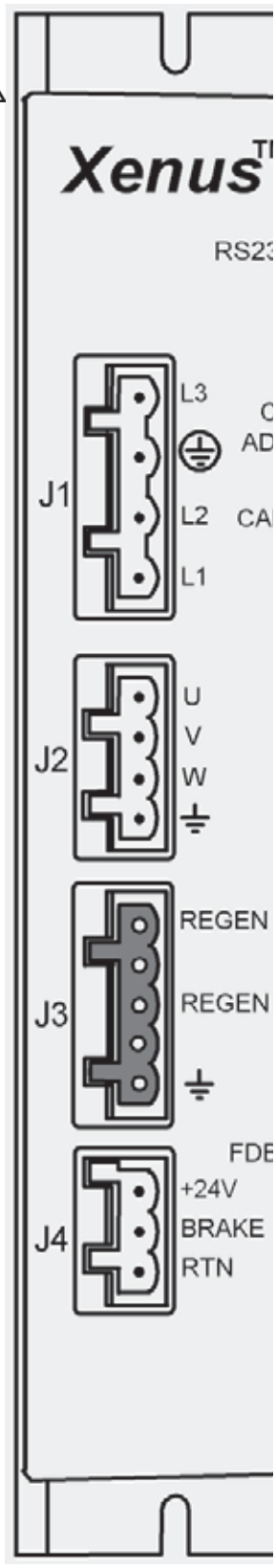
Signal	Pin
Motor Phase U	4
Motor Phase V	3
Motor Phase W	2
Cable Shield	1

J3 Regen Resistor

J3 CABLE CONNECTOR:
Wago 721-605/000-043
*(51111277 or 721-605/000-043/RN01-0000)
Euro-style 5,0 mm pluggable male terminal block
Cable: AWG 12, 600 V recommended for XSL-230-36 and XSL-230-40 models, AWG 14, 600V for XSL-230-18
Shielded cable required for CE compliance

Signal	Pin
Regen Resistor	1
No Connection	2
Regen Resistor	3
No Connection	4
Cable Shield	5

WIRE INSERTION/EXTRACTION TOOL:
Used on J1, J2, J3 & J4
Wago 231-131



NOTE: AN EXTERNAL +24 VDC POWER SUPPLY IS REQUIRED FOR OPERATION

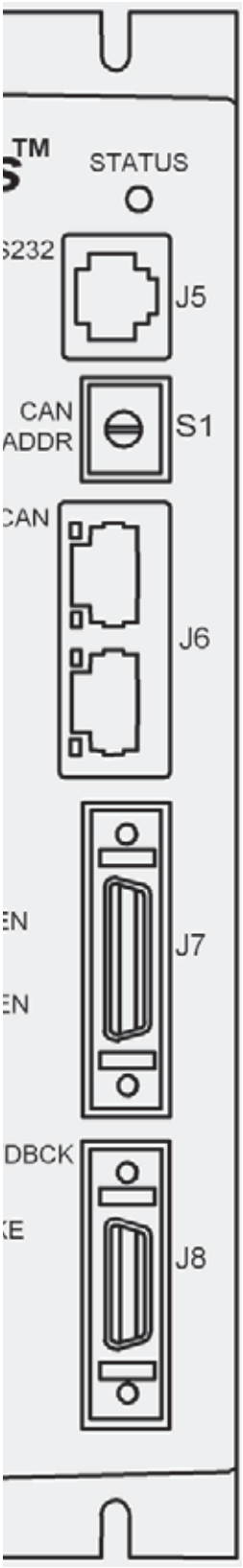
J4 +24 VDC & Brake

Signal	Pin
+24 Vdc Control Power	3
Brake Output [OUT4]	2
0V (+24 Vdc Return)	1

ISOLATED CIRCUIT

J4 CABLE CONNECTOR:
Wago 721-103/026-047
*(51117974 or 721-103/026-047/RN01-0000)
Euro-style 5,0 mm pluggable terminal block

** Wago connector part numbers in () are RoHS compliant*



J5 RS-232

Pin	Signal
6	No connect
5	TxD Output
4	Ground
3	Ground
2	RxD Input
1	No connect

J5 Cable Connector:

RJ-11 style, male, 6 position
Cable: 6 conductor modular type

Notes:
1. CAN circuits are opto-isolated from drive circuits.
2. CAN_GND connects to drive Signal Ground.
3. CAN_SHLD and CAN_V+ are wired-thru on both J6 connectors and have no connection to drive.

ISOLATED CIRCUIT

J6 CAN Bus

Pin	Signal
1	CAN_H
2	CAN_L
3	CAN_GND
4	No connection
5	No connection
6	(CAN_SHLD)
7	CAN_GND
8	(CAN_V+)

J6 Cable Connector:

RJ-45 style, male, 8 position
Cable: 8-conductor modular type

J7 Control Signals

Signal	Pin		Signal
Frame Ground	1	14	[OUT2]
Signal Ground	2	15	[OUT3]
Enable [IN1]	3	16	Multi-Mode Encoder A
GP Input [IN2]	4	17	Multi-Mode Encoder /A
GP Input [IN3]	5	18	Multi-Mode Encoder B
GP Input [IN4]	6	19	Multi-Mode Encoder /B
HS Input [IN6]	7	20	Multi-Mode Encoder X
HS Input [IN7]	8	21	Multi-Mode Encoder /X
HS Input [IN8]	9	22	+5 Vdc @ 400 mA
HS Input [IN9]	10	23	Signal Ground
HS Input [IN10]	11	24	Ref(+) Input
GP Input [IN11]	12	25	Ref(-) Input
[OUT1]	13	26	[IN12] GP Input

J7 Cable Connector:

Solder Cup, 26 position male,
1.27 mm pitch
Cable: 26 conductor, shielded
Standard with Snap locks
3M: 10126-3000 VE connector
3M: 10326-52F0-008 backshell
Rugged with Screw-locks
Molex: 54306-2619 connector
Molex: 54331-0261 backshell

J8 Motor Feedback

Signal	Pin		Signal
Frame Ground	1	11	Digital Hall U
Signal Ground	2	12	Digital Hall V
+5 Vdc @ 400 mA	3	13	Digital Hall W
Encoder A Input	4	14	[IN5] Temp Sensor
Encoder /A Input	5	15	Signal Ground
Encoder B Input	6	16	Encoder Sin(+) Input
Encoder /B Input	7	17	Encoder Sin(-) Input
Encoder X Input	8	18	Encoder Cos(+) Input
Encoder /X Input	9	19	Encoder Cos(-) Input
Signal Ground	10	20	Signal Ground

J8 Cable Connector:

Solder Cup,20 position male,
1.27 mm pitch
Cable: 20 conductor, shielded
Standard with Snap locks
3M: 10120-3000VE connector
3M: 10320-52F0-008 backshell
Rugged with Screw-locks
Molex: 54306-2019 connector
Molex: 54331-0201 backshell

Note: Molded cable assemblies are available for J7 & J8.
See Accessories on last page

DRIVE POWER SOURCES

An external +24 Vdc power supply is required, and powers an internal DC/DC converter that supplies all the control voltages for drive operation. Use of an external supply enables CAN communication with the drive when the mains power has been removed.

Power distribution in *800-1513/1519* is divided into four sections: +24 Vdc, CAN, signal, and high-voltage. Each is isolated from the other and all are isolated from the chassis.

EXTERNAL +24 VDC

The primary side of the DC/DC converter operates directly from the external +24 Vdc supply and is isolated from other drive power sections. The Brake output [OUT4] operates in this section and is referenced to the +24 Vdc return (0V). It sinks current from an external load connected to the external +24 Vdc power source.

INTERNAL SIGNAL POWER

The signal power section supplies power for the DSP controller as well as logic inputs and outputs. Motor feedback signals such as Halls, encoder, and temperature sensor operate from this power source. All signal circuits are referenced to signal ground. This ground should connect to the control system circuit ground or common so that drive and controller inputs and output voltage levels work properly with each other.

MAINS POWER

Mains power drives the high-voltage section. It is rectified and capacitor-filtered to produce +HV which the PWM stage converts into voltages that drive either three phase brushless, or DC brush motors. An internal solid-state switch together with an external power resistor provides regenerative energy dissipation when the mechanical energy of the motor is converted back into electrical energy that could charge the internal capacitors to an overvoltage condition. All the circuits in this section are “hot”, that is, they connect directly to the mains and must be considered high-voltages and a shock hazard requiring proper insulation techniques during installation.

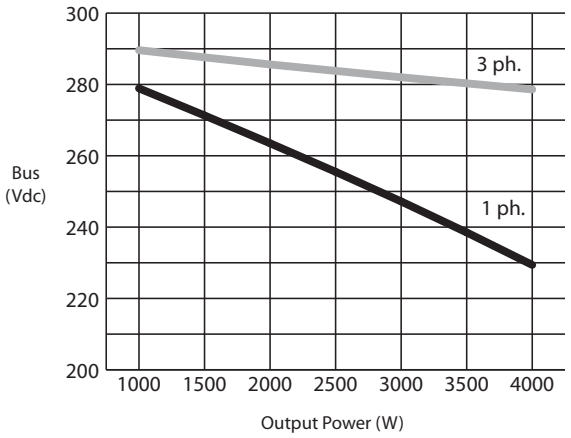
OUTPUT VOLTAGE

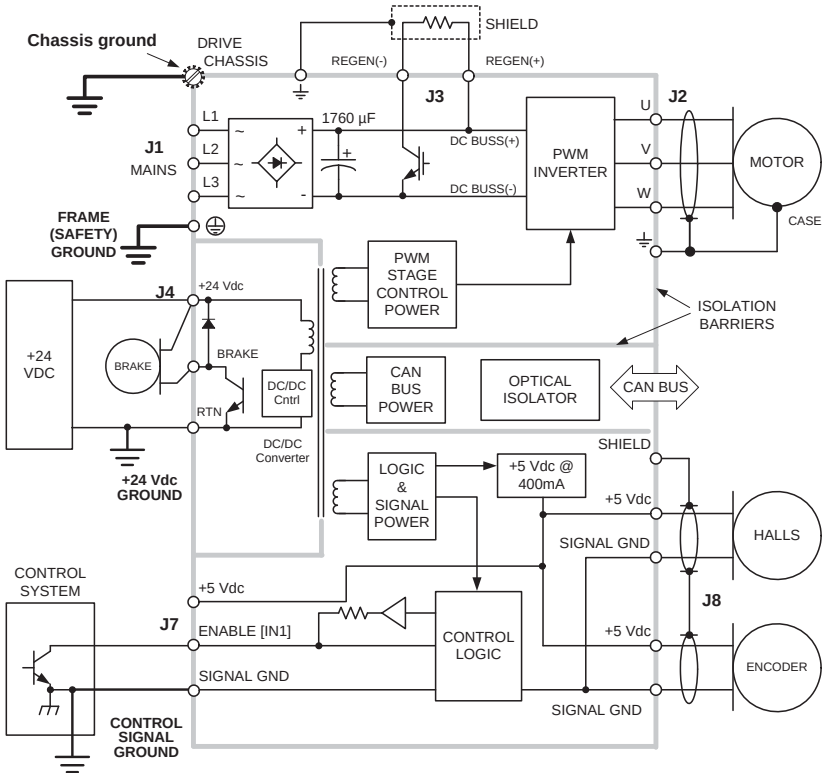
When the drive is disabled the DC bus voltage is equal to the mains voltage (Vac) × 1.41. But, as the output power increases, energy is drawn from the internal capacitor bank producing ripple on the bus. The motor terminal voltage is the sum of BEMF (Back EMF), and resistive and inductive voltage drops and changes when motor speed and current change. When the current loop demands a voltage that is greater than the lowest points of the ripple voltage, voltage-limiting will occur. The chart below shows the available bus voltage when connected to 1 or 3-phase mains for a range of drive output powers. A given output power can be produced by a combination of current and motor speed and has to be calculated for each application. But the chart is a general guideline to the available voltage to drive the load as the real output Watts increase.

CAN INTERFACE

CAN power and interface circuits are optically isolated from amplifier circuits.

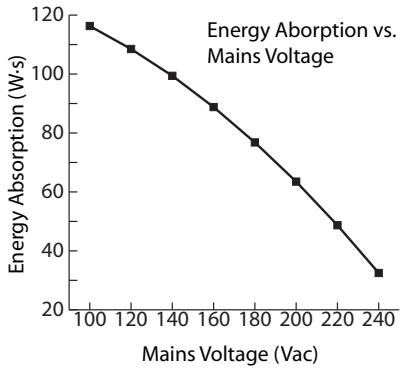
DC Bus Voltage vs. Output Power
Single & Three-phase AC Power Input at 208 Vac





REGENERATION

The chart below shows the energy absorption in W·s for a *800-1513/1519* drive operating at some typical mains voltages. When the load mechanical energy is greater than these values an external resistor is available as an accessory.



GROUNDING

GROUNDING FOR SAFETY

The ground symbol inside a circle on J1-3 is the primary safety ground connection for the drive. The purpose of the safety ground is to provide a path to earth for any fault currents from the mains that could arise from a failure in the drive that could make a connection between the mains and the drive chassis. The ground connection is designed to keep the chassis at earth potential in such a case until circuit-interrupting devices on the mains open and disconnect the drive from the mains. The contact for this is longer than the contacts for the mains at J1-1, J1-2, and J1-4 which ensures that the ground connection is established before the mains connect, and is maintained until the mains are disconnected. Wiring to this grounding terminal should be made with wire of the same gauge as that used for the mains connections, and is typically colored green with a yellow stripe. The safety ground connection should not pass through any circuit-interrupting devices such as circuit-breakers or fuses, and should connect to a point that is at earth-ground potential. If connecting to a "star" ground point on an equipment panel there should also be a wired path from the star ground to an earthing ground point. This will ensure that there is a low-resistance path to earth for any fault currents and guarantees the integrity of the ground connection if there is corrosion between the panel and its enclosure.

FRAME (CHASSIS) GROUNDING

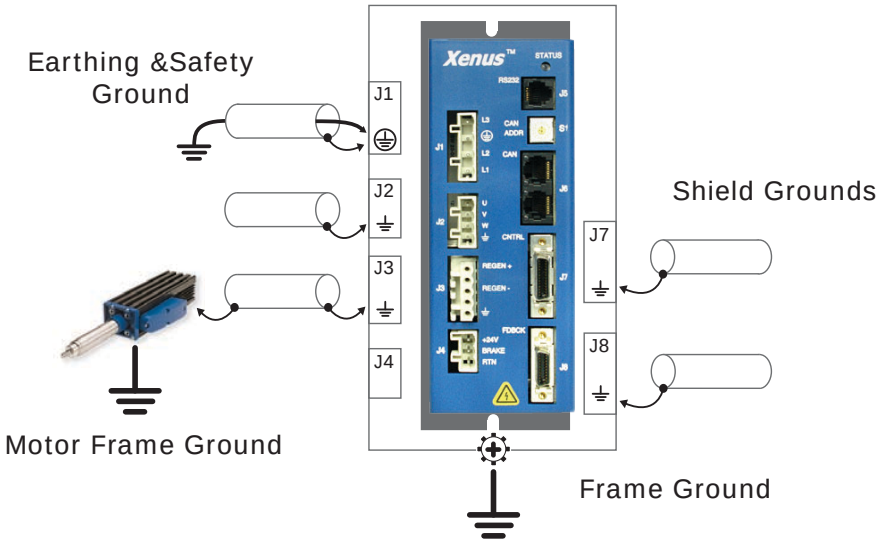
The ground connection at J1-3 is the primary drive ground connection to machine earth ground. It provides not only a path to earth for fault currents in the drive high-voltage circuits, but also a path to earth for electric fields that originate in the drive as a result of its operation. But, noise produced by electronic circuits covers a range of frequencies and the effectiveness of grounding connections decreases as the frequencies increase. While the best length for the drive primary ground is as short as possible, it may be longer and when this occurs, the effectiveness of the ground connection in reducing EMI at higher frequencies is reduced. Grounding the drive frame directly to a mounting surface that is earthed can provide a shorter path to earth and can provide improved EMI reduction.
This can be done by using external-tooth lock washers between the mounting screws and drive chassis. The teeth will cut through the anodizing on the drive chassis and make the shortest possible connection between the drive and machine earth ground.

GROUNDING FOR SHIELDING

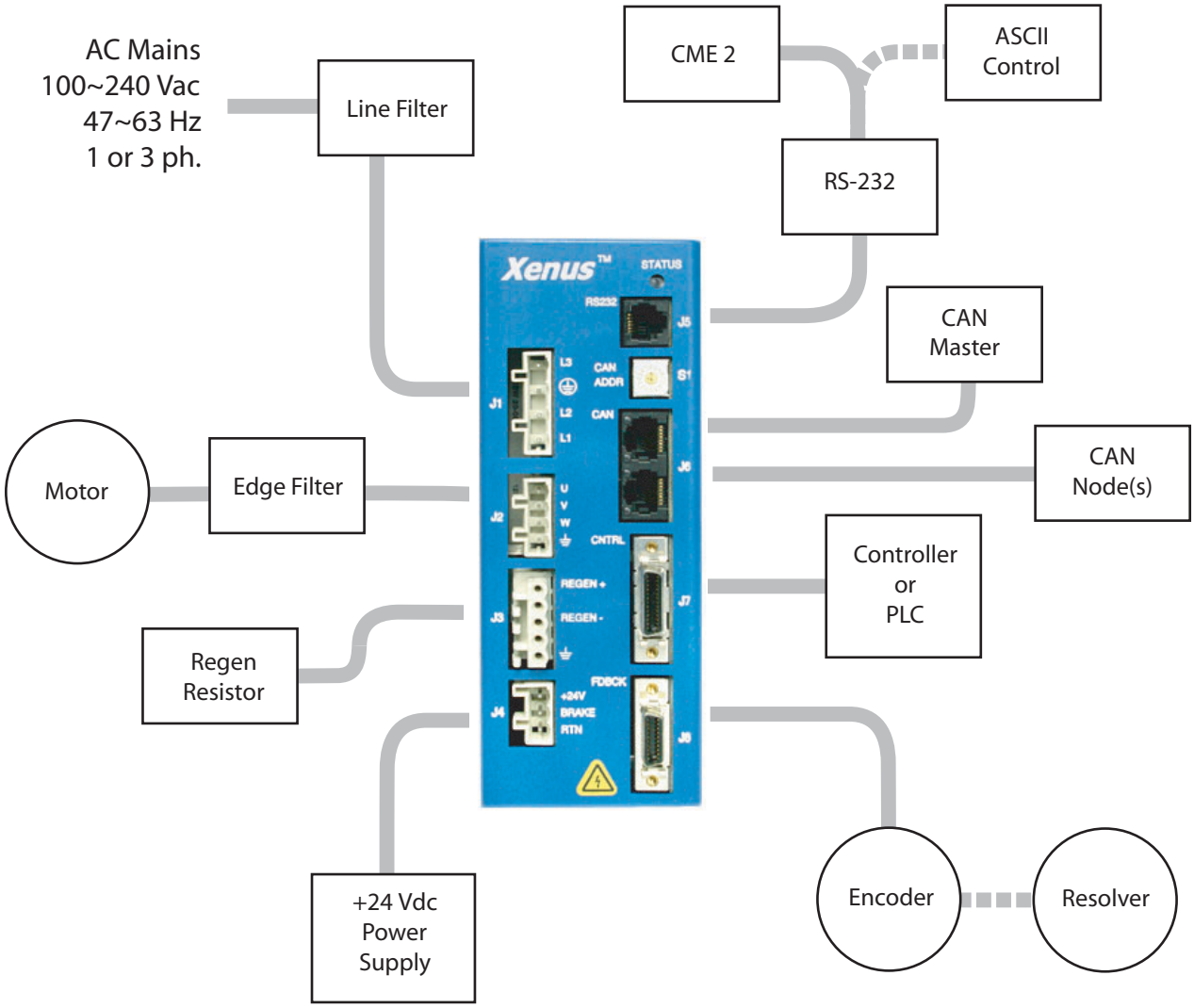
Shielding of electronic circuits has two primary functions. First of these is the reduction of EMI (Electro Magnetic Interference) to levels that comply with agency approval criteria. The second is to protect the drive circuits from external EMI such as radio transmissions and static discharge. This type of shielding is required for CE emissions and susceptibility compliance. Cable shields of this type connect to the drive chassis (frame) and are not intended to carry fault currents from the mains. Shield connection points on J2 and J3 are marked with a ground symbol without a circle, indicating that these are not safety-grounds, but are for shielding. The control and feedback connectors J7 & J8 have a frame ground connection on pin 1, and the connector shells also connect to the frame ground. When using the connector kit XSL-CA that has molded cables for control and feedback, the shields on the molded cables are wired to the connector shells. If using the XSL-CK kit with solder-cup connectors for J7 & J8, the cable shield can connect to pin 1 as well as the clamp that screws around the cable for retention.
CAN bus connections on J6 are isolated from all other drive circuits. Since molded, shielded cables are used for the CAN connections, the shield connections are maintained between two cables when they connect to the drive in a daisy-chain configuration.
There is no frame ground connection at J4, the 24V power input and brake output. These circuits are isolated from all drive circuits and the drive chassis.
Because motor connections are high-voltage and high-current the cable shield has both a safety and EMI reduction function. Motor cases can be safety-grounded at the motor by earthing the frame, or by a grounding conductor in the motor cable that connects to J2-1. This cable should be of the same gauge as the other motor phase cables so that it can carry fault currents that could flow if a motor winding were to short to the motor frame. These currents can be detected by the drive which will shut-down for an over-current fault. In addition to a grounding conductor in the motor cable, the cable shield can also connect to J2-1. The connection between the shield and motor frame is made in most cases, but depending on the installation, lower EMI emissions may result when the shield connects only to the drive and not at the motor frame.

GROUNDING FOR CONTROL

Circuits that connect to J5, J7 and J8 such as drive command inputs, RS-232 port, digital I/O points, and motor feedback are referenced to a common point that is called signal ground. This ground is isolated from the drive chassis, CAN ports, 24V control and brake circuits, and the high-voltage PWM and regenerative braking circuits.
Signal ground should connect to a point on the control system which is the circuit ground, and which may also connect to earth for the control system's ground reference point. When this connection is made, all the control circuits will share a common point of zero potential, and making a single connection between the drive and control system ground also eliminates a ground-loop that could occur if drive signal ground were to be connected to different points that could be at different potentials due to current on power supply return conductors, for example.
There are two signal ground connections on J7, the control connector, and it is recommended to connect both of these to the control system's signal ground.
The feedback connector J8 has multiple signal ground connections which can simplify wiring when Halls and motor encoders have separate ground connections.

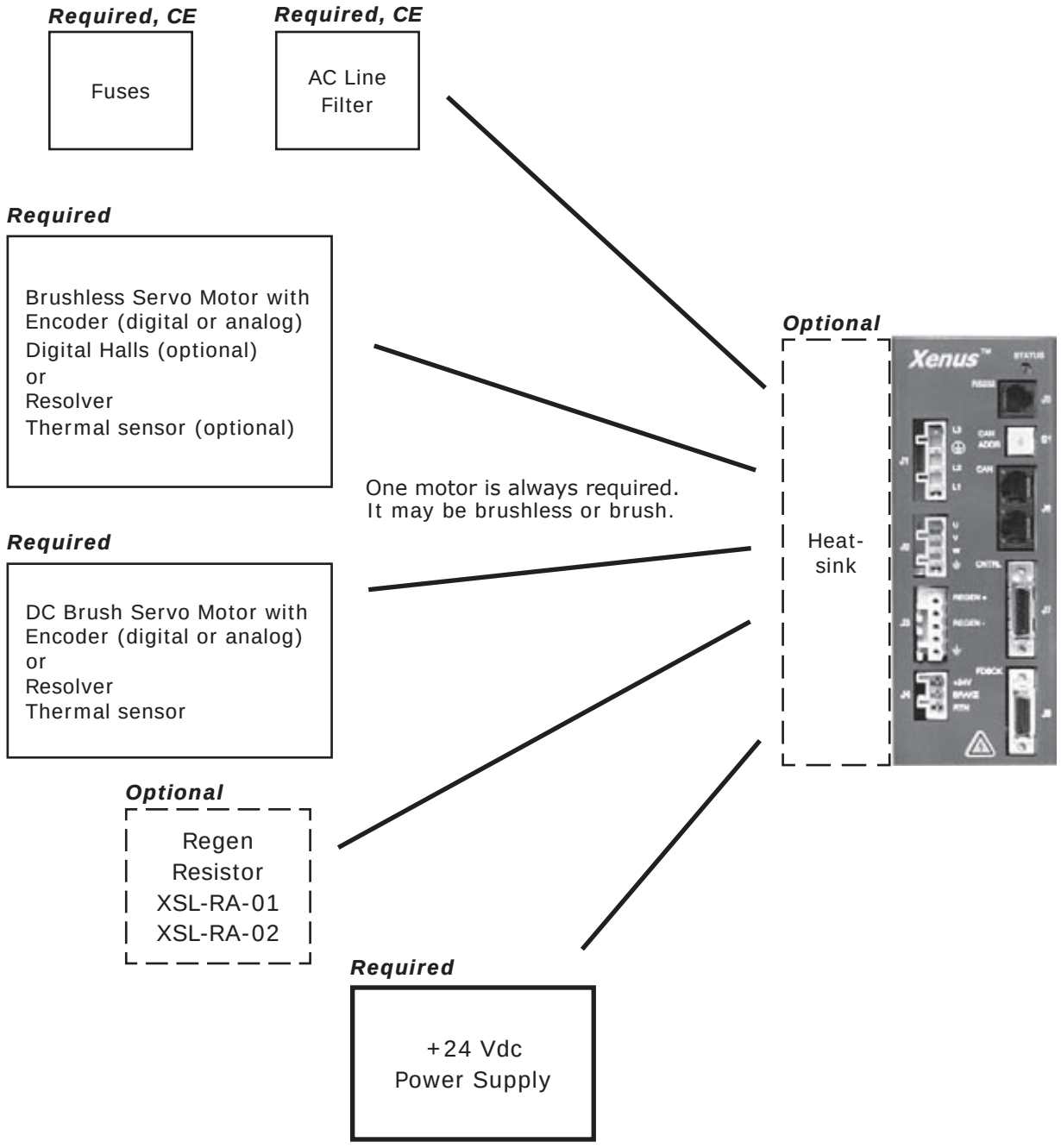


INSTALLATION

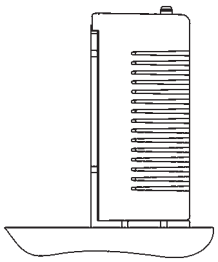


PARTS USED IN ALL CONFIGURATIONS

Each component is labeled *Required*, *Optional*, or *CE*.
Required components are necessary for operation of the drive in all cases.
Optional components depend on the particular application.
CE after Required indicates that these parts are necessary for CE compliance.

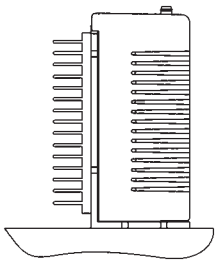


HEATSINK & FAN CONFIGURATIONS



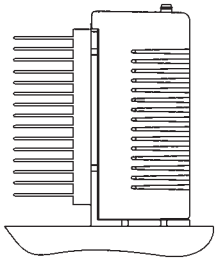
NO HEATSINK
NO FAN

NO HEATSINK
WITH FAN



LOW-PROFILE
HEATSINK
NO FAN

LOW PROFILE HEATSINK
WITH FAN

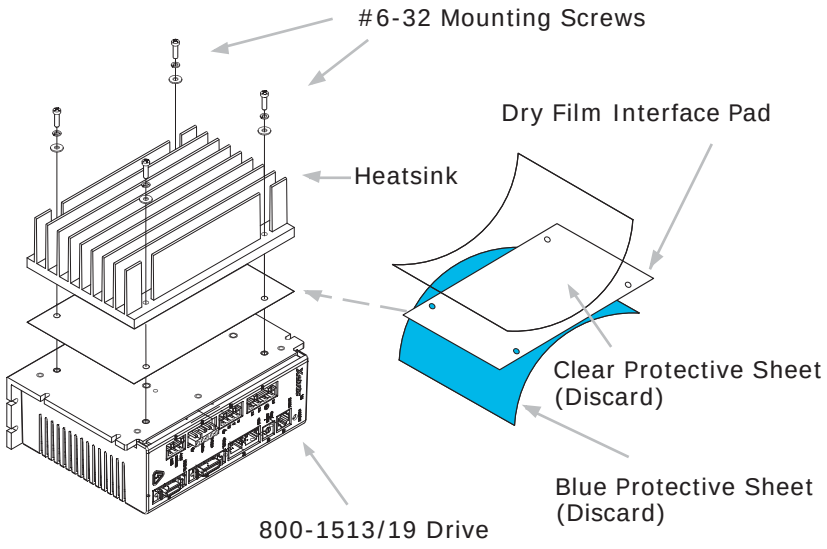


STANDARD HEAT-
SINK
NO FAN

STANDARD HEATSINK
WITH FAN

HEATSINK MOUNTING

A dry-film interface pad is used in place of thermal 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.



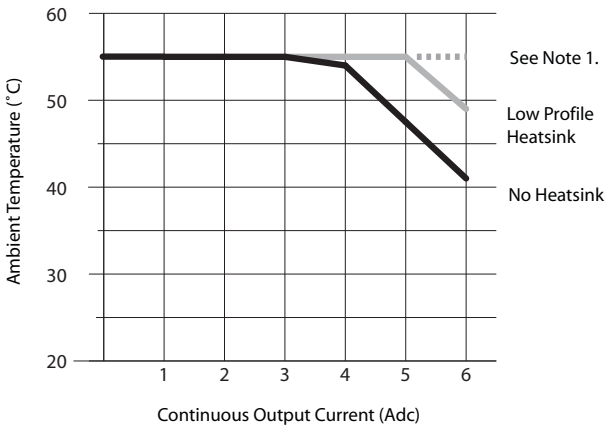
STEPS TO INSTALL

1. Remove the blue protective sheet from one side of the pad and place the pad on the drive. Make sure that the holes in the pad align with the holes on the drive.
2. Remove the clear protective sheet from the pad.
3. Mount the heatsink onto the drive taking care to see that the holes in the heatsink, pad, and drive all line up.
4. Torque the #6-32 mounting screws to 8~10 lb-in (0.9~1.13 N·m).

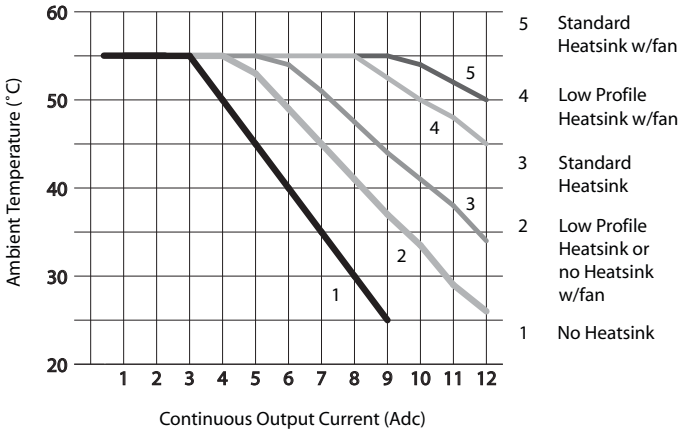
MAXIMUM OPERATING TEMPERATURE VS HEATSINK TYPE & AIR CIRCULATION

The charts below show that maximum ambient temperature vs. continuous output current for the 800-1513/1519 models. The cooling options are no heatsink, standard heatsink, and low-profile heatsink. For each of these the drive can be operated with convection or forced-air cooling.

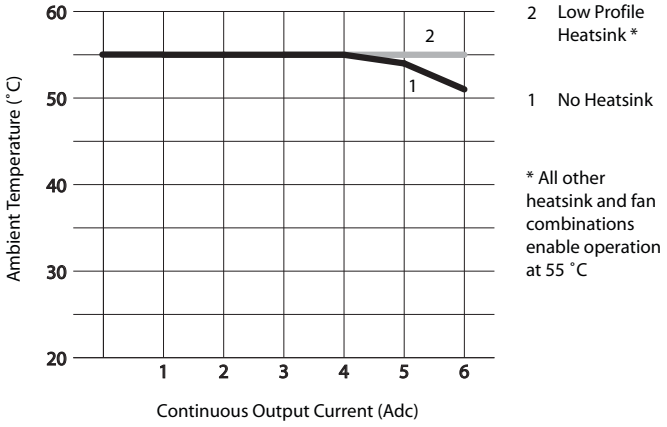
Model: 800-1513
Mains: 120 Vac



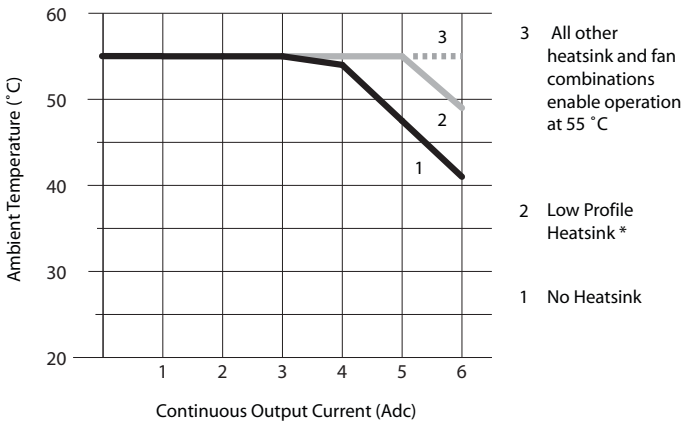
Model: 800-1513
Mains: 240 Vac



Model: 800-1519
Mains: 120 Vac



Model: 800-1519
Mains: 240 Vac



ORDERING GUIDE

MODEL	DESCRIPTION
800-1513	Servo Drive 12/36 A
800-1519	Servo Drive 6/18 A

Example: Order one 800-1513 drive, 12/36 A with solder-cup connector kit, *CME 2*™ CD, and a serial cable kit:

Qty	Item	Remarks
1	800-1513	*800-1513* Servo Drive
1	XSL-CK	Connector Kit
1	CME 2	*CME 2*™ CD
1	SER-CK	Serial Cable Kit

ACCESSORIES

Note: Wago part numbers in parentheses are RoHS compliant.

	QTY	REF	DESCRIPTION	MANUFACTURER PART NO.
XSL-CK **Connector Kit with Solder-Cup Connectors for J7 & J8**	1	J1	Plug, 4 position, 7.5 mm, female	Wago: 721-204 / 026-045 (51118287 or 721-204/026-045/RN01-0000)
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-104 / 026-047 (51118008 or 721-104/026-047/RN01-0000)
	1	J3	Plug, 5 position, 5.0 mm, male	Wago: 721-605 / 000-043 (51111277 or 721-605/000-043/RN01-0000)
	1	J4	Plug, 3 position, 5.0 mm, female	Wago: 721-103 / 026-047 (51117974 or 721-103/026-047/RN01-0000)
	4	J1~4	Tool, wire insertion & extraction (for J1~4)	Wago: 231-131
	1	J7	Connector, 26 position, solder-cup	3M: 10126-3000VE
	1		Back shell, for 26 pin connector	3M: 10326-52F0-008
	1	J8	Connector, 20 position, solder-cup	3M: 10120-3000VE
	1		Back shell, for 20 position connector	3M: 10320-52F0-008
XSL-CA **Connector Kit with Molded Cables for J7 & J8**	1	J1	Plug, 4 position, 7.5 mm, female	Wago: 721-204 / 026-045 (51118287 or 721-204/026-045/RN01-0000)
	1	J2	Plug, 4 position, 5.0 mm, female	Wago: 721-104 / 026-047 (51118008 or 721-104/026-047/RN01-0000)
	1	J3	Plug, 5 position, 5.0 mm, male	Wago: 721-605 / 000-043 (51111277 or 721-605/000-043/RN01-0000)
	1	J4	Plug, 3 position, 5.0 mm, female	Wago: 721-103 / 026-047 (51117974 or 721-103/026-047/RN01-0000)
	4	J1~4	Tool, wire insertion & extraction (for J1~4)	Wago: 231-131
	1	J7	Cable assembly, control, 10 ft (3 m)	Molex 52316-2611, plug assy, Molex 52370-2610, boot cover
	1	J8	Cable assembly, feedback, 10 ft (3 m)	Molex 52316-2011, plug assy, Molex 52370-2010, boot cover
CME2	J5		*CME 2*™ Drive Configuration Software (CD-ROM)	
SER-CK			RS-232 Serial Cable Kit	
XSL-CC-10	J7		Cable + molded connector, control, 10 ft (3 m)	Molex 52316-2611, plug assy, Molex 52370-2610, boot cover
XSL-FC-10	J8		Cable + molded connector, feedback, 10 ft (3 m)	Molex 52316-2011, plug assy, Molex 52370-2010, boot cover
Connectors & software for CANopen operation				
XSL-NK	1		Sub-D 9-position female to RJ-45 adapter	
CANopen Connector Kit	1		CAN bus terminator	
	1		CAN bus Network Cable, 10 ft (3 m)	Kristamicro: 60-662BY
XSL-CV		J6	Sub-D 9-position female to RJ-45 adapter	
XSL-NC-10			CAN bus Network Cable, 10 ft (3 m)	Kristamicro: 60-662BY
XSL-NC-01			CAN bus Network Cable, 1 ft (0.3 m)	Kristamicro: 60-660BY
XSL-NT			CAN bus Network Terminator	
CMO		1	CD with CMO software	
CML		1	CD with CML software (note: license fee required)	
Heatsink kits for field installation (optional)				
XSL-HL Heatsink Kit Low Profile	1		Heatsink, low profile	
	1		Heatsink thermal material	
	4		Heatsink hardware	
XSL-HS Heatsink Kit Standard	1		Heatsink, standard	
	1		Heatsink thermal material	
	4		Heatsink hardware	
Regeneration resistors (optional)				
XSL-RA-01			Regen Resistor Assembly (for XSL-230-18 models)	
XSL-RA-02			Regen Resistor Assembly (for XSL-230-36, XSL-230-40 models)	
Edge Filter				
XSL-FA-01			Edge Filter for Amplifier Outputs	
XSL-FK			Edge Filter Connector Kit	