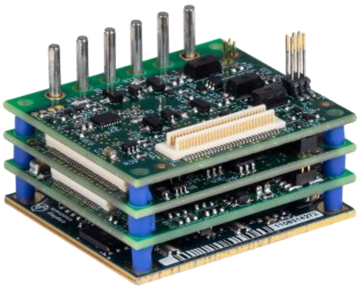
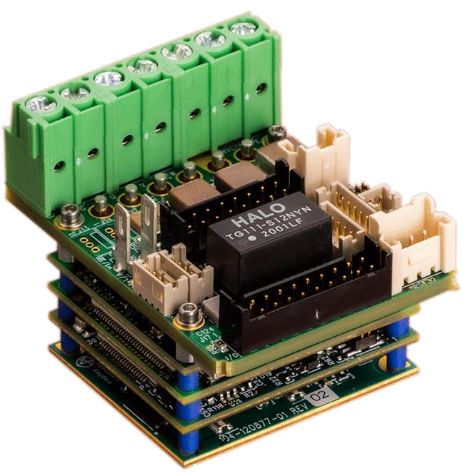
NANO User Guide



NES/NPS
Module



NES/NPS-Z
EZ

NES/NPS-D
DEV

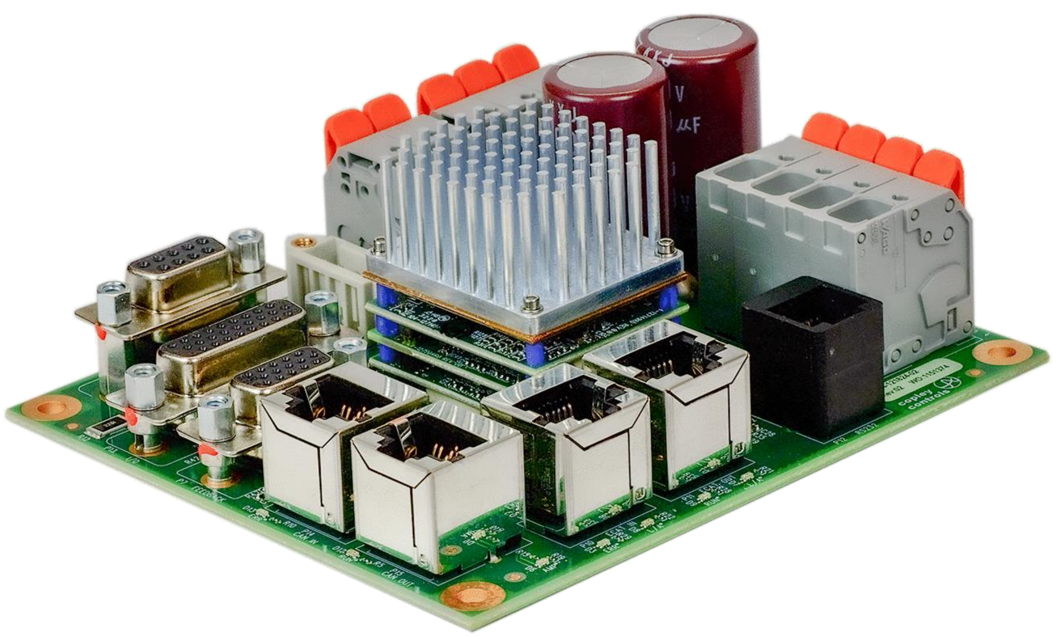


Table of Contents

1 About This Manual

1.1 Title, Number, Revision

Title	NANO User Guide
Document Number	16-121699
Current Revision	02

1.2 Revision History

Revision	Date	ECO	Comments
AA	April 6, 2022	ECO-081119	Initial release
00	September 7, 2022	ECO-081736	Releasing for UL
01	September 15 2023	ECO-083840	Update guide and add new Section 4.4 (Nano Module Installation Instructions).
02	November 1, 2023	ECO-084471	Add 180-30 thermal data, clarify J2 (STO) pinouts and update guide with recent edits.

1.3 Overview and Scope

This manual describes the operation and installation of the NANO standard module drives manufactured by Copley Controls. All NANO products have serial numbers that incorporate the week and year of production into their first 4 digits (WWYY).

1.4 Original Instructions

This manual is considered to be "original instructions" as defined in EC Directive 2006/42/EC and the contents have been verified by Copley Controls.

1.5 Related Documentation

The following documents can be found on the Copley Controls website: www.copleycontrols.com.

- CANopen Programmer's Manual
- CME User Guide
- EtherCAT User Guide
- CMO (Copley Motion Objects) Programmer's Guide
- Indexer 2 User Guide
  (describes use of Indexer Program to create motion control sequences)
- ASCII Programmer's Guide (describes how to send ASCII format commands over a drive's serial bus to set up and control one or more drives)
- Parameter Dictionary
- Absolute and Serial Encoder Guide

1.6 EC Declaration of Conformity

CE

copley controls

Analogic Motion Controls

EC DECLARATION OF CONFORMITY

Objects of this declaration:

Product Description	Model Numbers
Nano Standard Module EtherCAT SN: 9xx23xxxx	NES-090-10, NES-090-10-D, NES-090-10-Z NES-090-70, NES-090-70-D, NES-090-70-Z, NES-180-10, NES-180-10-D, NES-180-10-Z, NES-180-30, NES-180-30-D, NES-180-30-Z
Nano Standard Module CANopen SN: 9xx23xxxx	NPS-090-10, NPS-090-10-D, NPS-090-10-Z NPS-090-70, NPS-090-70-D, NPS-090-70-Z, NPS-180-10, NPS-180-10-D, NPS-180-10-Z, NPS-180-30, NPS-180-30-D, NPS-180-30-Z

We, Analogic Corporation d/b/a Copley Controls 20 Dan Rd. Canton, MA USA under the sole responsibility of the manufacturer, hereby declare that the objects of this declaration manufactured by us and described above are in conformity with EC Directives 2006/42/EC (Machinery Directive), 2014/30/EU (Electromagnetic Compatibility Directive) and 2011/65/EC (RoHS Directive). EU Authorised Representative: Authorised Representative Service, 77 Camden Street Lower, Conformity Dublin, D02 XE80, Ireland is authorised to compile the technical files for these models. Conformity is declared under the following relevant Union harmonisation legislation:

RoHS

EN 63000:2018 Technical documentation for the assessment of electrical and electronic products with respect to the restriction of hazardous substances

ELECTROMAGNETIC CAPATIBILITY (EMC)

EN 61800-3: 2018 (IEC 61800-3: 2017) Adjustable Speed Electric Power Drive Systems – Part 3: EMC Requirements and specific Test Methods. Category 3 PDS.

PRODUCT SAFETY

EN 61800-5-1:2007/A1:2017 (IEC 61800-5-1:2016) Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements Electrical, Thermal and Energy

FUNCTIONAL SAFETY

EN 61800-5-2:2017 (IEC 61800-5-2:2016) Adjustable Speed Electric Power Drive Systems – Part 5-2: Safety Requirements – Functional

EN ISO 13849-1:2015 Safety of Machinery – Safety-Related Parts of Control Systems – Part 1: General Principles for Design

These products also comply with the following Underwriters Laboratories standard

UL 61800-5-1-2016 Adjustable Speed Electric Power Drive Systems – Part 5-1: Safety Requirements – Electrical, Thermal and Energy (File No. E168959)

Testing Performed By:

Underwriters Laboratories 1285 Walt Whitman Road Melville, NY www.ul.com

The Compliance Management Group, 257 Simarano Drive, Marlboro, MA www.cmgcorp.net

Year in which the CE Marking was affixed: 2023

Signed for and on behalf of the above-named manufacturer

Place and date of issue: *Canton, MA USA 05/31/2023*

Name, function: *Gary Escher, Director of Quality*

Signature:

Analogic dba Copley Controls
EU Authorised Representative: Authorised Representative Service, 77 Camden Street Lower, Dublin, D02 XE80, Ireland

16-135726 rev00

1.7 Abbreviations and Acronyms

Acronym	Description
Safety-Related	
a,b,c,d,e	Denotation of performance level (PL)
Cat	Category
CCF	Common Cause Failure
DC	Diagnostic Coverage
EMC	Electro Magnetic Compatibility
HFT	Hardware Fault Tolerance
MTTF	Mean Time to Failure
MTTFd	Mean Time to Dangerous Failure
PDS(SR)	Power Drive Systems (Safety Related)
PE	Protective Earth
PELV	Protected Extra Low Voltage (power supply)
PFD	Probability of Dangerous Failure upon Demand
PFH	Probability of Failure per Hour
PL	Performance Level
PWM	Pulse Width Modulation
S, S1, S2	Severity of Injury
SELV	Safety Extra Low Voltage (power supply)
SFF	Safety Failure Fraction
SIL	Safety Integrity Level
SIL CL	Safety Integrity Level Claim Limit, SIL Capability
STO	Safe Torque Off
UMB	User Mounting Board
Vdc	Volts DC (Direct Current)
Copley Controls Related	
NES	NANO EtherCAT
NPS	NANO CANopen
Module	Drive Assembly with pins/sockets for direct PCB Mounting
EZ (-Z)	Drive Assembly with very compact wire-to-board Connectors
DEV (-D)	Drive Assembly with larger wire-to-board connectors and added DC Bus Capacitance

1.8 Comments

Copley Controls welcomes your comments on this User Guide.
For contact information, see www.copleycontrols.com.

1.9 Copyrights

- NANO is a registered trademark of Copley Controls.
- CME is a registered trademark of Copley Controls.
- EtherCAT is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany.

1.10 Document Disclaimer

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1.11 Naming of Drives

NANO will be used when a topic applies to all Nano models (NES, NPS, -Z, -D).

1.12 Product Warnings

DANGER	**DANGER: HAZARDOUS VOLTAGES.** Exercise caution when installing and adjusting. Persons responsible for installing and commissioning NANO NES & NPS servo drives must be experienced and trained in all aspects of electrical equipment installations. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**RISK OF ELECTRIC SHOCK.** DC Supplies used to power NANO NES & NPS drives must be transformer-isolated and provide reinforced insulation from AC mains power. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**RISK OF UNEXPECTED MOTION WITH NON-LATCHED FAULTS.** After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without operator intervention. In this case, motion may re-start unexpectedly. Configure faults as latched unless a specific situation calls for non-latched behavior. When using non-latched faults, be sure to safeguard against unexpected motion. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**USING CME OR SERIAL COMMANDS MAY AFFECT OR SUSPEND CAN OR ETHERCAT OPERATIONS.** When operating the drive as a CAN or EtherCAT node over a network, the use of CME or ASCII serial commands may affect network operations in progress. Using such commands to initiate motion may cause network operations to suspend. Network operations may restart unexpectedly when the commanded motion is stopped. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**LATCHING AN OUTPUT DOES NOT ELIMINATE THE RISK OF UNEXPECTED MOTION WITH NON-LATCHED FAULTS.** Associating a fault with a latched, custom-configured output does not latch the fault itself. After the cause of a non-latched fault is corrected, the drive re-enables without operator intervention. In this case, motion may re-start unexpectedly. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**USE EQUIPMENT AS DESCRIBED.** Operate drives within the specifications provided in this manual. **FAILURE TO HEED THIS WARNING CAN CAUSE EQUIPMENT DAMAGE, INJURY, OR DEATH.**
DANGER	**REFER TO THE INFORMATION IN SECTION 7 OF THIS USER MANUAL REGARDING STO AND FUNCTIONAL SAFETY.** The information provided within must be considered for any application using the STO feature. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE, INJURY OR DEATH**
WARNING	**DO NOT PLUG OR UNPLUG CONNECTORS WITH POWER APPLIED.** The connecting or disconnecting of cables while the drive has VLOGIC and/or +HV power applied is not recommended. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE.**
WARNING	**CONSIDER THE POSSIBILITY OF OVERVOLTAGE EVENTS RESULTING FROM REGENERATIVE BRAKING PARTICULARLY WHEN POWERING +HV AND VLOGIC FROM THE SAME SUPPLY.** The VLOGIC voltage must not exceed the maximum rating (60V) under any circumstances. **FAILURE TO HEED THIS WARNING MAY CAUSE EQUIPMENT DAMAGE.**

Observe all relevant state, regional and local safety regulations when installing and using this product.
Be sure that all wiring complies with the National Electrical Code (NEC) or its national equivalent, and all prevailing local codes.
There are no user serviceable parts in the NANO servo drives.
Disassembling or otherwise tampering with internal components will void the warranty.

2 INTRODUCTION

2.1 NANO Module Overview

The NANO drives (NES, NPS) provide 100% digital control of brushless or brush servo motors in very compact DC powered, modular packages. NANO drives are intended for use in automated manufacturing and test machinery, robotics and similar applications requiring high performance motion control. All models support a wide range of feedback devices including digital quadrature encoders, BiSS, SSI Absolute A encoders, and digital Halls. The Copley Serial Resolver (CSR) adapter enables standard NANO drives to use resolver feedback. And all of these models provide a certified SIL 3, CAT 3 Ple Safe Torque Off (STO) function. For more information on STO for these models, see Section 7.

NANO models can operate in several basic ways:

- NES models operate as slave devices on an EtherCAT network. Servo drives can perform the CoE (CANopen protocol over EtherCAT) operating modes with the additional cyclic-synchronous position, velocity, and torque modes.
- NPS models operate as nodes on a CAN network. CANopen compliance allows the drive to take instruction from a master application to perform torque, velocity, and position profiling, interpolated position, and homing operations. Multiple drives can be tightly synchronized for high performance coordinated motion.
- All models can receive current, velocity or position commands from an external controller.
  In current and velocity modes, they can 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 and Direction or Count Up/Count Down format, as well as A/B quadrature commands from a master-encoder. Pulse-to-position ratio is programmable for electronic gearing. In addition to these hardware control modes, there is network control from EtherCAT or CANopen controllers.
- Controlled directly over RS-232 serial links with simple serial commands
  (ASCII or serial-binary format).
- All models work as stand-alone controllers running CVM control programs with Indexer 2.

2.2 NANO Module Models

Package Style	EtherCAT Models	CANopen Models	Ic	Ip	Vdc	VLOGIC
Module	NES-090-10	NPS-090-10	5	10	9~90	9~60
	NES-090-70	NPS-090-70	35	70		
	NES-180-10	NPS-180-10	5	10	20~180	
	NES-180-30	NPS-180-30	15	30		
DEV	NES-090-10-D	NPS-090-10-D	5	10	9~90	
	NES-090-70-D *	NPS-090-70-D *	35	70		
	NES-180-10-D	NPS-180-10-D	5	10	20~180	
	NES-180-30-D	NPS-180-30-D	15	30		
EZ	NES-090-10-Z	NPS-090-10-Z	5	10	9~90	
	NES-090-70-Z **	NPS-090-70-Z **	35	70		
	NES-180-10-Z	NPS-180-10-Z	5	10	20~180	
	NES-180-30-Z	NPS-180-30-Z	15	30		

Ic = Continuous Output Current, Adc (peak of sine)
Ip = Peak Output Current, Adc (peak of sine)
Vdc = HV power supply voltage (DC, line-isolated)
VLOGIC = Power supply for drive control circuits and external encoder +5 Vdc
* The NES-090-70-D and NPS-090-70-D models are soldered into the DEV boards.
** The NES-090-70-Z and NPS-090-70-Z models are soldered into the EZ boards.

3 SPECIFICATIONS

3.1 Agency Approvals

These specifications apply to all models.

Specification	Requirement
Approvals	UL and cUL recognized component to: UL 61800-5-1, UL 61800-5-2 IEC 61800-5-1, IEC 61800-5-2
Functional Safety	IEC 61508-1, IEC 61508-2, IEC 61508-3 (SIL 3) Directive 2006/42/EC (Machinery) ISO 13849-1 (Cat 3, PL e) IEC 61800-5-2 (SIL3)
Product Safety	Directive 2014/35/EU (Low Voltage) IEC 61800-5-1
EMC	Directive 2014/30/EU (EMC) IEC 61800-3 IEC 61800-5-2
Hazardous Substances	Restriction of the Use of Certain Hazardous Substances *(*RoHS*)* Directive 2011/65/EU and its amendments 2015/863/EU
Markings	CE, UL

3.2 Input Power

Input voltage connected to +HV is required for operation of the drives. Input voltage connected to VLOGIC is also required and powers the communications, feedback, and I/O functions but not the PWM outputs. For +HV supply voltages ≤ 60 Vdc, VLOGIC may be powered from the same supply as +HV as long as the supply voltage never exceeds 60 V. When using a single supply for both +HV and VLOGIC, care must be taken in applications with the potential for regenerative braking energy being returned to +HV. Such regenerative braking energy could “pump up” the +HV bus to levels greater than 60 V exceeding the VLOGIC maximum voltage rating and causing damage to the NANO drive.

VLOGIC is recommended for drives operating on a control network because it enables the network master to maintain communication with the drives when the +HV has been removed, most commonly for safety or EMO (Emergency Off) conditions.

Specification	**NES/NPS-090-10** **NES/NPS-090-10-D** **NES/NPS-090-10-Z**	**NES/NPS-090-70** **NES/NPS-090-70-D** **NES/NPS-090-70-Z**	**NES/NPS-180-10** **NES/NPS-180-10-D** **NES/NPS-180-10-Z**	**NES/NPS-180-30** **NES/NPS-180-30-D** **NES/NPS-180-30-Z**	**Units**
+HV	+9 to +90	+9 to +90	+20 to +180		Vdc
+HV Max	+95	+95	+185		Vdc
I Peak	10	70	10	30	Adc
I Peak Time	1				Second
I Continuous	5	35	5	15	Adc
VLOGIC	+9 to +60				Vdc
VLOGIC Max	+60				Vdc
VLOGIC Power	3 typical, 6 with max encoder +5 V output				W

* The actual +HV current is dependent on the input voltage and motor load and operating conditions. The Maximum +HV currents shown above occur when the drive is operating from the maximum input voltage and is producing the rated continuous output current at the maximum output voltage. Unit is Adc.

** VLOGIC supply current depends on the number of encoders connected to the drive. The maximum current draw given assumes that the encoder +5V output is loaded to 500mA Unit is Vdc.

Note: When the STO feature is used, VLOGIC must be supplied from SELV or PELV power supplies.

WARNING

Refer to the AN136 Accelnet External Regen Application Note, Part Number 16-125661.

VLOGIC +9~60. 24V power is recommended. If common to HV do not exceed 60V. Use REGEN protection, and diode isolation from HV.

3.3 Output Power

Specification	NES/NPS-090-10 NES/NPS-090-10-D NES/NPS-090-10-Z	NES/NPS-090-70 NES/NPS-090-70-D NES/NPS-090-70-Z	NES/NPS-180-10 NES/NPS-180-10-D NES/NPS-180-10-Z	NES/NPS-180-30 NES/NPS-180-30-D NES/NPS-180-30-Z	Units
I Peak *	10 (7.07)	70 (49.5)	10 (7.07)	30 (21.2)	Adc (Arms)
I Peak Time	1				Second
I Continuous **	5 (3.54)	35 (24.8)	5 (3.54)	15 (10.6)	Adc (Arms)
Peak Output Power	1.8	6.3	1.8	5.4	kWatt
Continuous Output Power	0.9	3.15	0.9	1.8	
Encoder +5V	250 per encoder, 500 max				mA
Peripheral +5V	150				mA
Peripheral +3.3V	150				mA
Efficiency	97% @ rated max Vdc and rated continuous current				%
Output Type	3-phase MOSFET inverter, 16 kHz center-weighted, PWM space-vector modulation				
PWM Ripple	32				kHz
Load Inductance	200 line-to-line ***				μH
	* Adc is peak of sine, Arms is RMS of sine. ** Heat sinking and/or forced air cooling may be required for continuous output power rating. *** Consult factory for operation with inductance lower than 200 μH.				

3.4 Control Loops

Type Current, Velocity, Position	100% digital.
Sampling rate (time) Current Velocity Position	16 kHz (62.5 μs) 4 kHz (250 μs) 4 kHz (250 μs)
Current Loop Small Signal Bandwidth	> 2.5 kHz (Typical, tuning and load impedance dependent)
Programmable Digital Filters	Analog Reference Velocity Loop Input Velocity Loop Output1, Output2, Output3 Velocity Loop Output1 filter default: is 200 Hz low pass Current Loop Input1, Input2 Input Shaping Analog Reference
Bus Voltage Compensation	Changes in +HV voltage do not affect tuning.

Digital Command Inputs

Digital Position Command	Pulse and direction, Count up / Count down	Maximum rate: 4 MHz (with active driver)
	Pulse, count minimum width	220 ns
	Quadrature A/B encoder maximum rate	2 M line/sec (8 M count/sec after quadrature)
Digital Current & Velocity Command	PWM and Polarity	PWM = 0~100%, Polarity = 1/0 PWM Frequency: 1~100 kHz
	PWM 50%	PWM: 50% ±50%, 1~100 kHz
	PWM Minimum pulse width	220 ns
Indexing	Up to 32 sequences can be launched from digital inputs or ASCII commands via RS-232 input	
Camming	Up to 10 CAM tables can be stored in flash memory	
Serial ASCII	RS-232, 9600~230,400 Baud, 3-wire, RxD, TxD, SGND Module: Non-isolated, TTL levels referenced to SGND EZ and DEV: Non-isolated, RS-232 Transceiver (ADM3101E)	

3.5 Analog Input

Update rate is 16 kHz (62.5 µs)

Specification	**Data**
Channels	1
Name	AIN1
Type	Differential, non-isolated, 12-bit resolution
Measurement Range	±10 Vdc
Maximum Differential Input Voltage Min/Max Input Voltage to Ground	±10 Vdc -11 to +11 Vdc, each input
Input Impedance	5.5 kΩ
Conversion rate	4 k samples/sec
Anti-aliasing filter -3 dB frequency	14.5 kHz
Function	Programmable: Current, Velocity, or Position command General purpose analog input.

3.6 Digital Inputs

Update rate (scan time) is 4 kHz (250 µs). Functions are programmable.
The default functions of these inputs are programmable to other functions.
SLI is Switch & LED Interface where outputs and an input work together to read network address switches and control LEDs that indicate the drive status and operating state.
When they are not used for the SLI function, the outputs and input can be programmed for other functions.

NES, NPS

Specification	IN1~IN3	IN4~5	IN6
Type	Digital, non-isolated Schmitt trigger w/ RC filter, 3.3 V logic	Digital, non-isolated Schmitt trigger w/ RC filter, 3.3 V logic	Digital, non-isolated Schmitt trigger w/ RC filter, 3.3 V logic
RC Filter	100 ns	100 ns	33 µs
Pull-up to +5V	10 kΩ	10 kΩ	4.99 kΩ
Input Voltage Range *	0~12 Vdc	0~12 Vdc	0~12 Vdc
Input Low threshold voltage VT-	0.6 Vdc	0.6 Vdc	0.6 Vdc
Input High threshold voltage VT+	2.2 Vdc	2.2 Vdc	2.2 Vdc
Default Function	IN1 – Enable IN2~IN3 – Not Configured With -D and -Z boards these are driven by 24V tolerant inputs	IN4~5 are pass-through on the -D and -Z boards	Motemp on feedback connector for motor overtemp sensor on -D and -Z boards

* The DEV (-D) and EZ (-Z) models have components that make IN1~3 compatible with +24 Vdc signals.

3.7 Safe Torque Off (STO)

Refer to **Section 7** for specifications related to this function.

3.8 Digital Outputs

NES, NPS

Specification	OUT1~4 @ 5 Vdc
Type	74HCT2G14
Vout HI	4.18~4.32 Vdc @ -4.0 mA
Vout LO	0.15~0.26 Vdc @ 4.0 mA
Default Function	Out 1~4 are programmable Out 4 can control brake circuit on -D and -Z boards

3.9 Encoders

NES, NPS

Encoder +5V Power Output

All NANO modules have the same rating of 500 mA total for the +5V encoder outputs.

Specification	Data
Number	2
Voltage Output	+5 Vdc ±2%
Current per Output	250 mA nominal, 500 mA maximum* (*Note that the maximum total current for both outputs combined is 500 mA).
Short Circuit Protection	1.0 amp short-circuit shutoff
Function	Provides power for motor encoders and/or Hall sensors

Primary Encoder Input: ENC*1

Digital Absolute and Incremental Encoders

Specification	Data
Channels	A, B, X
Type	A, B: MAX3283 RS-485 receiver X: MAX3283 RS-485 receiver MAX14783 as clock pulse transmitter for Biss absolute
Signals Incremental	A, /A, B, /B, X, /X
Signals Absolute	Clk, /Clk (X, /X), Data, /Data (A, /A) for 2-channel encoders Clk-Dat, /Clk-Dat (X, /X) for bidirectional encoders
Input Voltage Range	-7V to+12V common-mode maximum
Input Voltage Biasing	None
Receiver Differential Threshold Voltage Vth	-200 mV min, -50 mV max, -125 mV typical,
Receiver input Hysteresis	25 mV
Termination Resistors	Module: None. External terminators required for signal quality. EZ (-Z), DEV (-D): 121 Ω for A, B channels, 130 Ω with 1k Ω pull-up to +5V for X channel, 1K Ω pull-down to SGND for /X channel
Maximum Frequency	5 MHz Line/sec (20 Mcount/sec)
Encoder +5V	500 mA max, shared between primary and secondary encoders, 250 mA each nominal. Protected against thermal overload and short-circuits to ground (Short-circuit to ground causes temporary shutdown of drive circuits)
Compatible Encoders	Quad A/B/X incremental, SSI, BiSS absolute

NES, NPS

Secondary Encoder Input: ENC*2

Digital Incremental Encoders

Specification	Data
Channels	A, B, X
Type	MAX3283 RS-485 receiver
Signals Incremental	A, /A, B, /B, X, /X
Input Voltage Range	-7V to+12V common-mode maximum
Input Voltage Biasing	None
Receiver Differential Threshold Voltage Vth	-200 mV min, -50 mV max, -125 mV typical,
Receiver Input Hysteresis	25 mV
Termination Resistors	Module: None. External terminators required for signal quality. EZ (-Z), DEV (-D): 121 Ω for A, B channels, 130 Ω with 1k Ω pull-up to +5V for X channel, 1K Ω pull-down to SGND for /X channel
Maximum Frequency	5 MHz Line/sec (20 Mcount/sec)
Encoder +5V	500 mA max, shared between primary and secondary encoders, 250 mA each nominal. Protected against thermal overload and short-circuits to ground (Short-circuit to ground causes temporary shutdown of drive circuits)
Compatible Encoders	Quad A/B/X incremental, absolute encoders not supported

Digital Hall Sensors

Specification	Data
Channels	3 (U, V and W)
Type	74LVC3G17 Schmitt trigger +3.3 V 15 kΩ pull up resistor to internal +5 Vdc
Input Voltage Range	5V compatible
Low Level Input Voltage	0.84 Vdc max
High Level Input Voltage	1.87 Vdc min
RC Filter Time Constant	1.5 μSec when driven by active sources.
Function	Commutation of brushless motors in trapezoidal mode. Commutation initialization and phase error detection in sinusoidal mode.

3.10 Serial Interface

RS-232

The serial port operates the same in all NANO models. After a power-on or drive reset, the Baud rate defaults to 9600. Thereafter, it can be set to a higher rate by setting ASCII parameter 0x90 to the desired rate: Common settings are: 9600, 19200, 57600, and 115,300 (230,400 maximum) Baud. After sending 0x90, the drive will reply immediately at the higher Baud rate so the sender should wait some time (10 ms or more) before resuming communications with the drive at the newly programmed higher rate.

Important Note:

The serial port on the Modules operates at TTL levels. To have RS-232 standard levels, a transceiver must be added on the user pc board. The DEV (-D) and EZ (-Z) models do include an RS-232 transceiver circuit. Details can be found in section 4.7.

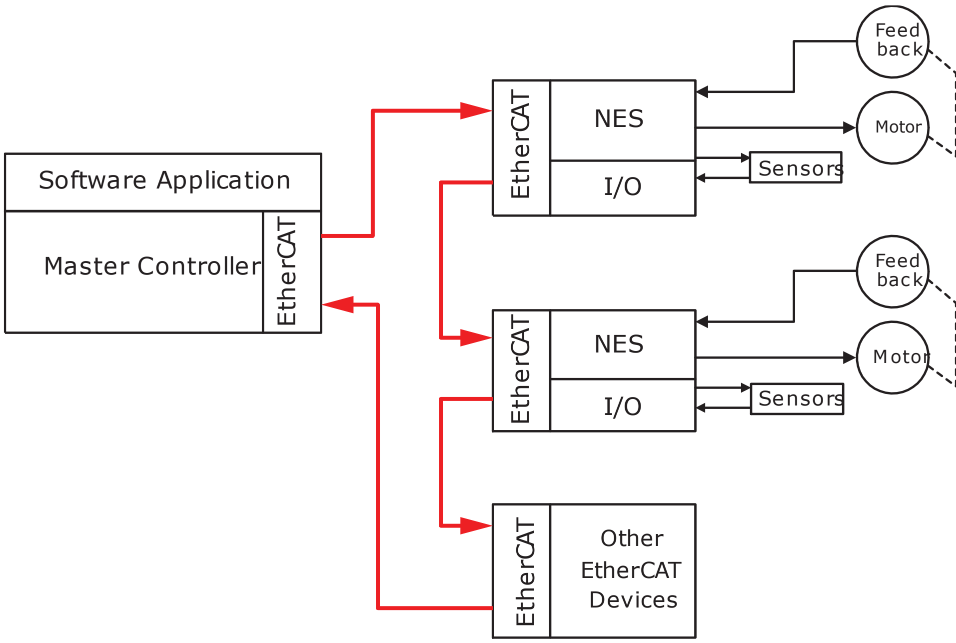
Parameter	Data
Channels	1, full-duplex, DTE serial
Type	RS-232 transceiver
Signals	TTL Rxd, Txd, Gnd
Baud Rate	9600 to 230,400 Baud (defaults to 9600 on power up or reset)
Data Format	N, 8, 1
Flow Control	None
Protocol	Binary or ASCII format

3.11 Network Interfaces

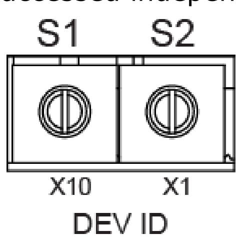
Specification	NES	NPS
Signals	Ethernet 100BASE-TX: RX1+, RX1-, TX1+, TX1- RX2+, RX2-, TX2+, TX2-	CAN_H, CAN_L, CAN_Gnd (CAN +5 Vdc Pass though only)
Isolation	Module: No. External magnetics are required. EZ (-Z) and DEV (-D): Yes. Isolating magnetics are included.	Module: No. Isolation (if desired) and a CAN transceiver are required EZ (-Z) and DEV (-D): No. Non-isolated CAN transceiver is included.
Data Format	EtherCAT	CAN V2.0b physical layer for high-speed connections compliant
Protocol	CANopen Application protocol over EtherCAT (CoE) based on CiA 402	CiA 402: CANopen device profile for drives and motion control
Supported Modes	Cyclic Synchronous Position, Velocity Torque (CSP, CSV, CST) Profile Current, Velocity, and Position PVT, Homing	Profile Current, Velocity, Torque Interpolated Position, Homing, Indexer, Point-to-Point, PVT Camming, Gearing
Node Address Selection	EZ board: Slaves are automatically assigned addresses based on their position on the bus. Station Alias address can be defined by inputs or saved to flash memory. DEV board: Two 16-position hexadecimal rotary switches define a cabling-independent Station Alias.	EZ board and DEV board: Slaves are automatically assigned addresses based on their position on the bus. Station Alias address can be defined by inputs or saved to flash memory.
Cable	Cat 5 or Cat-5e minimum 100 m maximum length between nodes	Cat 5 or Cat-5e minimum with 121 Ω terminator across CAN_H and CAN_L on last node in the chain.
Bus Termination	No termination required.	A 121 Ω resistor across CAN_H and CAN_L at the CAN master, and at the last device on the CAN network.

3.12 EtherCAT Interface: NES

The NES accepts CAN application protocol over EtherCAT (CoE) commands. EtherCAT supports two types of addressing nodes on the network: auto-increment and fixed. Nodes on an EtherCAT network are automatically addressed by their physical position on the network. The first drive found on the network is auto-increment address -1 (0xFFFF). The second address is -2 (0xFFFE), and so forth. Fixed addresses are assigned by the master when it scans the network to identify all the nodes and are independent of the physical position on the network. Fixed addresses begin with 1001 (0x3E9) and increment thereafter as nodes are found.



As an alternate to the default addressing, switches S1 and S2 may be used to program a drive’s Device ID, or Station Alias with a value between 0x01 and 0xFF (1-255 decimal). In dual axis drives, the second drive follows the first’s Device ID value. Use of a station alias guarantees that a given drive can be accessed independently of the cabling configuration.

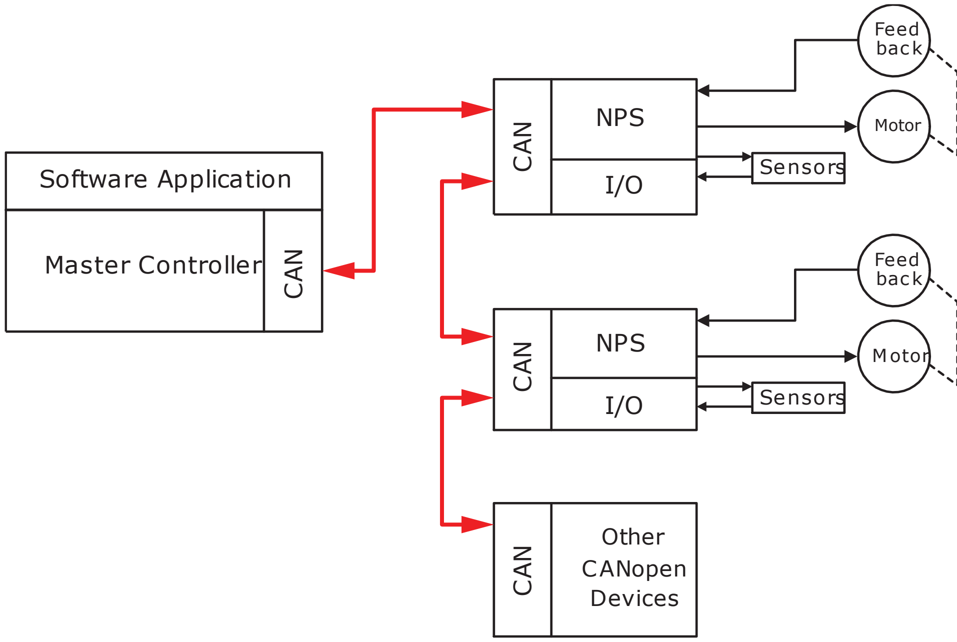


The fixed address and station alias are always available. If the switch-based station alias is used, it is the responsibility of the user to ensure that each drive has a unique station alias. Address switches are provided on the DEV board models and are read via a small microcontroller that connects to the main Nano processor via a serial interface (ASYNC_xXD2). Copley makes this programmed microcontroller available to customers who wish to implement address switches on their own board. See Section 3.15 for details.

For more information on EtherCAT addressing and operations, see the CME User Guide and Copley EtherCAT User Guide.

3.13 CAN Architecture: NPS

The NPS supports CAN networking. As shown below, in a CAN motion control system, control loops are closed on the individual drives, not across the network. A master application coordinates multiple devices, using the network to transmit commands and receive status information. Each device can transmit to the master or any other device on the network. CANopen provides the protocol for mapping device and master internal commands to messages that can be shared across the network.



CAN Addressing

A CANopen network can support up to 127 nodes. Each node must have a unique and valid seven-bit address (Node ID) in the range of 1-127. (Address 0 is reserved and should only be used when the drive is serving as a CME serial port multi-drop gateway).

There are several basic methods for setting the CAN address, as described below. These methods can be used in any combination, producing a CAN address equal to the sum of the settings.

Addressing Method	Description
Use switches	If the address number <= 127, CAN address can be set using the CAN ADDR switches only
Use inputs	Use the drive's programmable digital inputs (user selects how many and which inputs are used)
Use programmed value	Program address into flash only

For more information on CAN addressing, see the CME User Guide.

Address switches are provided on the DEV board models and are read via a small microcontroller that connects to the main Nano processor via a serial interface (ASYNC_xXD2). Copley makes this programmed microcontroller available to customers who wish to implement the address switches on their own board. See the Ordering Guide in Appendix A for details.

For more information on CANopen operations, see the following Copley Controls documents:

- CANopen Programmer's Manual
- CML Reference Manual
- CMO (Copley Motion Objects) Programmer's Guide

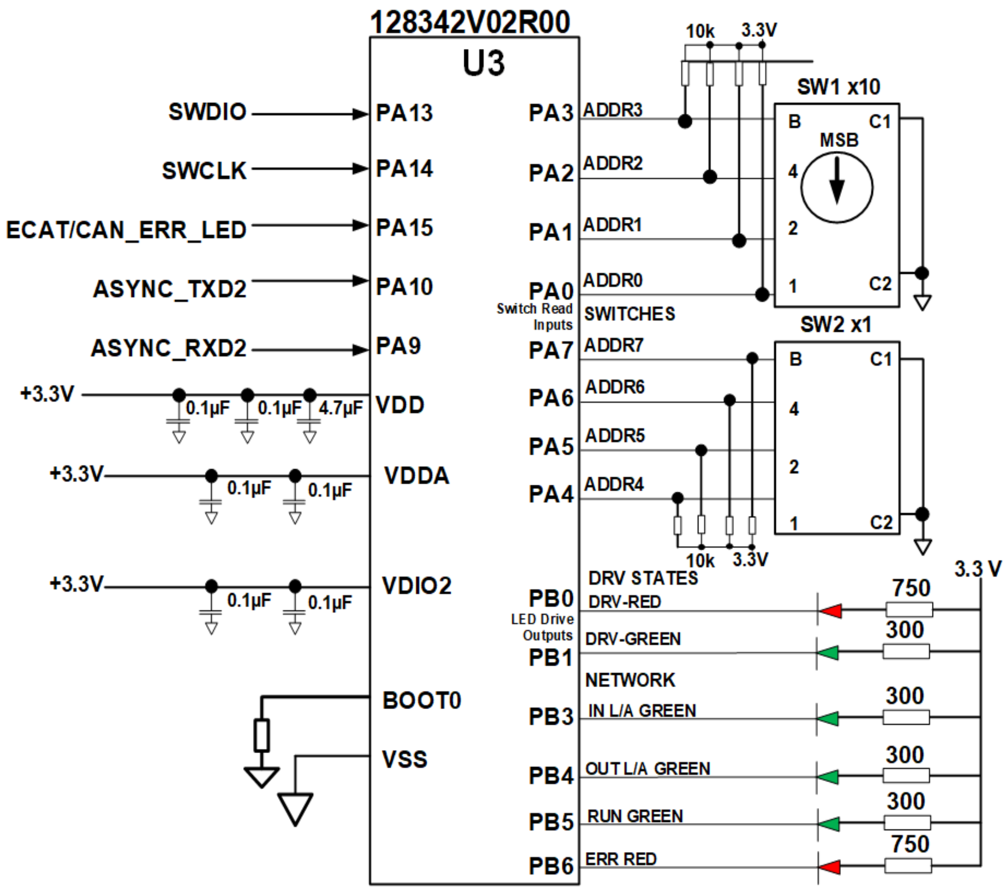
3.14 Status Indicators

There are no status indicators on the NANO modules. There are status indicators on the NES-D, NPS-D, and NES-Z, NPS-Z models. Details are provided in Sections 5 and 6.

Note that the status indicators on the EZ (-Z) and DEV (-D) models are controlled via a small microcontroller that connects to the main Nano processor via a serial interface (ASYNC_xXD2). This same microcontroller is also used to read addresses switches on the DEV models. Copley makes this programmed microcontroller available to customers who wish to implement address switches and/or status indicator control on their own board. See Section 3.15 for details.

3.15 Address Switch and Status Indicator Interface

The following diagram shows the connections to the EtherCAT switches and status LEDs. The switches 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 power it OFF-ON.



Device ID Switch Connections and LEDS

Ordering Information: U3

In the above diagram, U3 can be purchased through the Copley approved supplier, Arrow Electronics.

Contact Information:
Arrow Electronics
4 Technology Drive
Peabody, MA 01960
Phone: (978) 538-8500

Refer to the table below for more details.

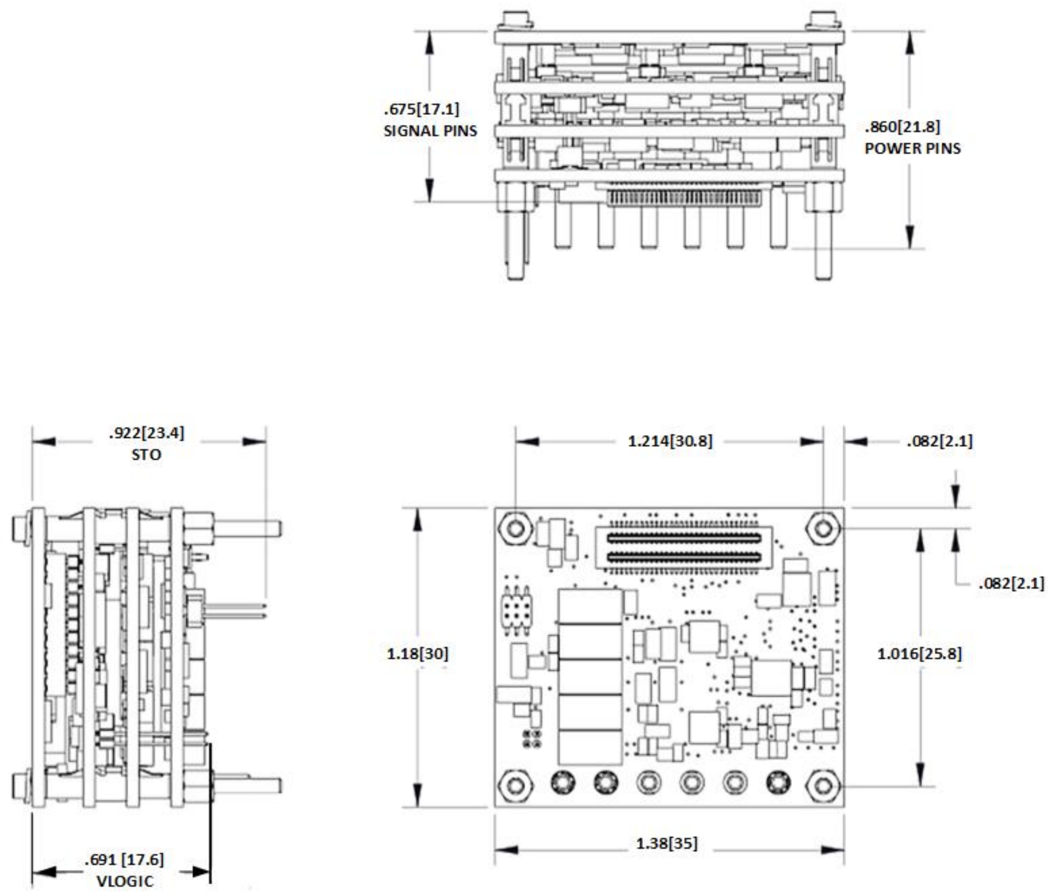
Part Number	Supplier	Description
128342V02R00	Arrow Electronics	Pre-programmed uC for Address Switch and LED

3.16 Protections

Fault Condition	Threshold
Drive Overtemperature	PWM outputs are held off if the Temperature of MOSFET bridge is above the set-point of 90°±3°C. User programmable as either latching or non-latching via CME.
DC Bus Overvoltage	+HV > 95 ± 1Vdc, (90 V models) +HV > 185 ± 1Vdc, (180 V models) PWM outputs and regen are held off when +HV is greater than the overvoltage set point. The overvoltage fault shall be user selectable as either latching or non-latching via CME.
DC Bus Undervoltage	+HV < 9 Vdc ± 1 Vdc (90 V models) +HV < 20 Vdc ± 1 Vdc (180 V models) PWM outputs for both axes and regen are held off when +HV is less than the undervoltage set-point. The undervoltage fault is non-latching.
Encoder Power	+5 Vdc, 500 mA maximum, protected for overload or shorts. Shared by dual encoders
Short Circuits	Output-to-output, output-to-GND, output-to-HV, internal PWM bridge faults, regen+ to GND, and regen-to-HV. Motor outputs and regen held off when a short circuit condition occurs in motor or regen output stages. Short-circuit faults are user-selectable as either latching or non-latching via CME.
I^2T Current Limiting	User programmable. Output current is limited to programmed value once I^2T limit is reached. User shall have the option to trigger a latched fault upon overcurrent via CME.
Motor Over-Temperature	Programmable input with two thresholds: the first one triggers an over-temperature warning and the second one disables the drive. Expected thresholds are 100~200ºC.
Loss of BiSS Encoder feedback	PWM outputs held off in the event feedback is removed. User selectable as either latching or non-latching via CME.

3.17 Dimensions

NES, NPS Modules



Dimensions: Inch [mm]

See Section 4.2 for PCB mounting details.

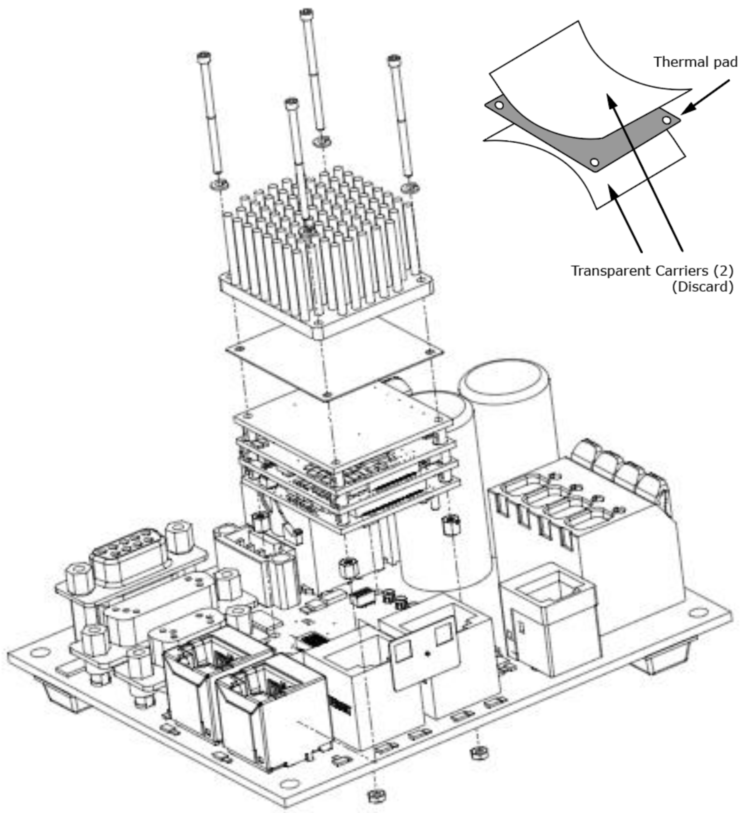
DEVELOPMENT KITS

NES-D, NPS-D

NES-D 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 side. Remove both sheets 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, be sure to center the pad holes over the heat plate mounting holes.
3. Remove the clear protective sheet from the pad.
4. Mount the heatsink onto the drive. Make sure the holes in the heatsink, interface pad, and drive are aligned.
5. Torque the _#0-80 mounting screws to 1 in-lb, 16 in-oz, 0.113 Nm.

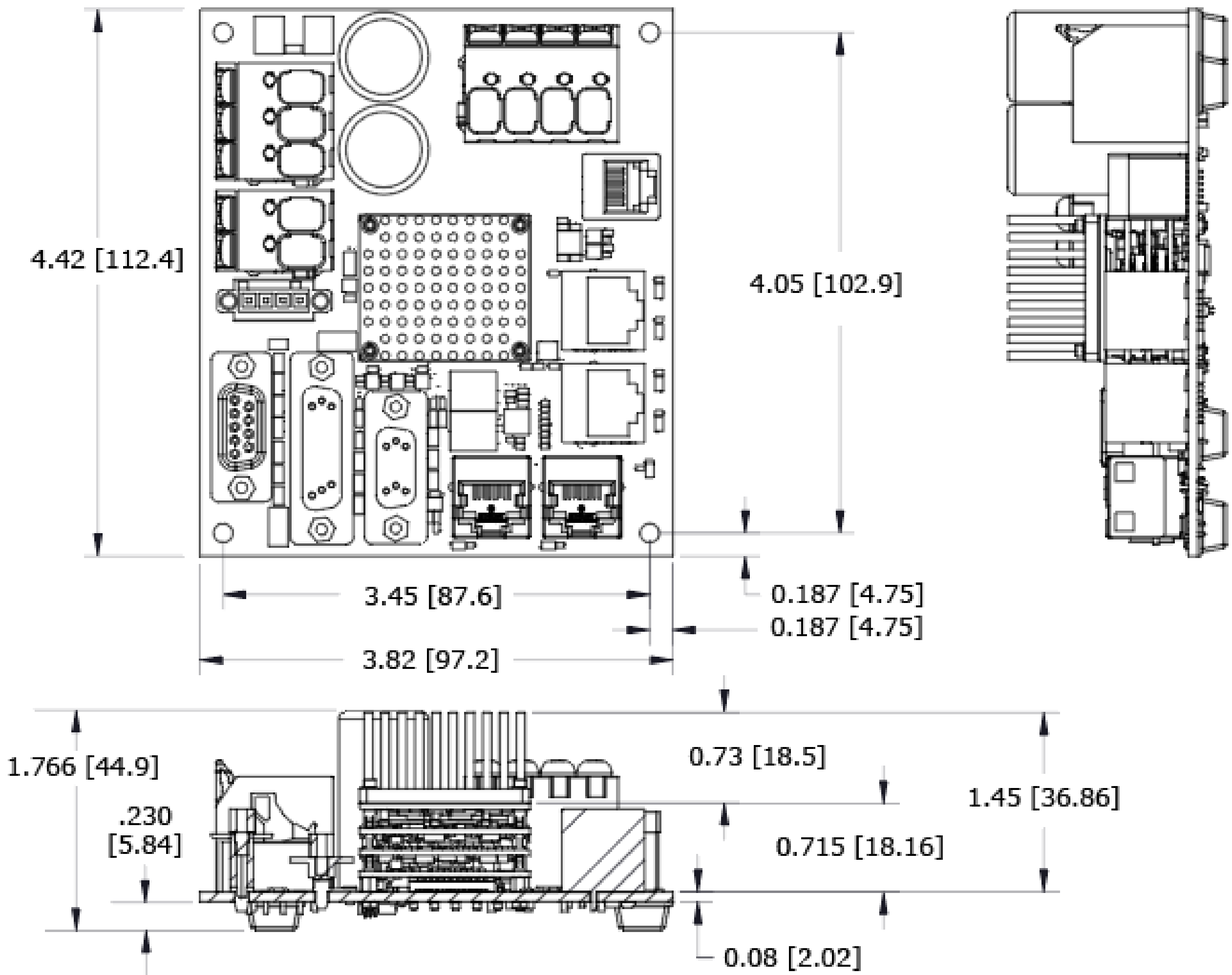


NES-D and NPS-D Heatsink Mounting Diagram

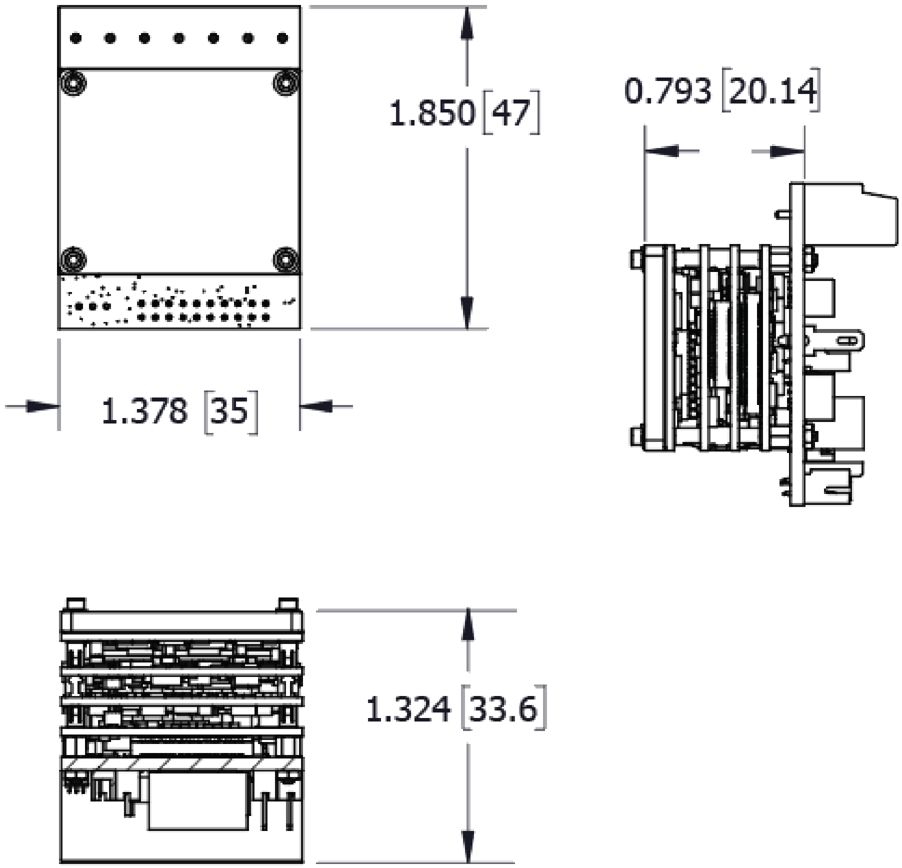
N-HK Heatsink Kit

Item	Description	Quantity
1	Screw, #0-80, hex, socket cap screw, 1 in [25.4 mm], stainless steel	4
2	Heatsink, 0.728 [18.49] tall, pins	1
3	Thermal pad, NES	1
4	Spacer, hex, 0.125 in [3.18 mm], 0-80 UNC 2B thread, 0.120 in [3.05 mm] tall, AL	4
5	Washer, medium split lock, #0, 18-8, stainless steel	4
6	Nut, #0-80, fine thread, stainless steel	4
7	Ifixit Opening Tool	1
Note: The NES-090-70-D and NES-180-30-D are shipped from the factory with the Heatsink included.		

NES-D Dimensions



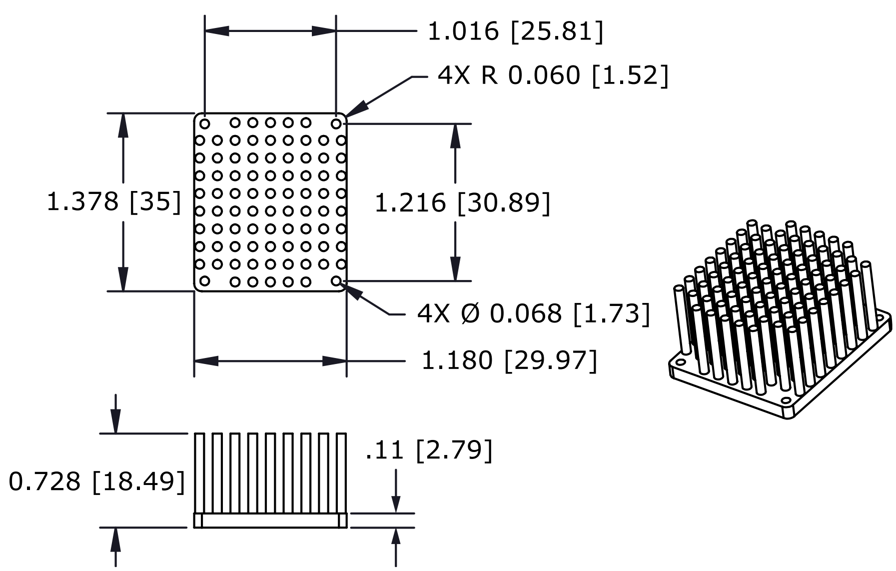
NES-Z, NPS-Z



NES-Z Dimensions

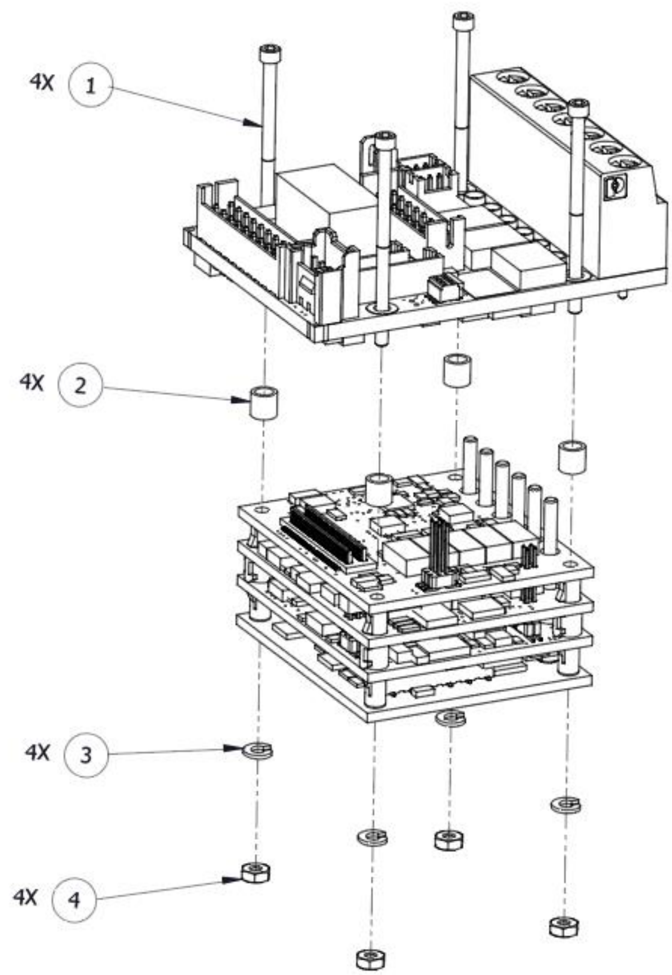
Heatsink Kit

N-HK Heatsink Dimensions



NES-Z: MECHANICALS

In the NES-Z Components diagram, it shows the location of the parts in the drive when it is shipped. Screw lengths of 1” [25.4 mm] are used to connect the nuts and washers and secure the parts together. When the user secures the nuts to the underside of the board to mount the board to the panel, include the nut height to determine the minimum length of the screw required. For mounting to a panel with tapped holes, the 1” [25.4 mm] screw should be sufficient.



NES-Z Components Diagram

Item	Qty	Description	Manufacturer, Part Number
1	4	Screw, 1”, hex, 0-80, 18-8 THD, 80-1 SS	Fastenal: 0171020
2	4	Spacer, 3 mm, 0.090” I.D, 0.125” O.D.	Bivar: 937-3MM
3	4	Washer, split, 0.062 ID, 18-8, 0.137” O.D. SS	Fastenal: 017926
4	4	Nut, 0-80, 1/8”, hex, socket, cap 18-8 SS	Fastenal: 0173909

Mechanical and Environmental

NES, NPS Dimensions

Specification	Data
Size	1.38 x 1.18 x 0.92 in [35 x 30 x 23.4 mm]
Weight	1.0 oz [29 g]

NES-D, NPS-D Dimensions

Specification	Data
Size	3.82 x 4.42 x 1.77 in [97.2 x 112.4 x 45 mm]
Weight	7.8 oz [221 g], for optional heatsink add 0.58 oz [16.5 g]

Note: For NES-090-70-D and NES-180-30-D assemblies, the heatsinks are installed at the factory. For NES-090-10, NES-090-10-D, NES-180-10 and NES-180-10-D assemblies, the heatsinks are optional.

NES-Z, NPS-Z Dimensions

Specification	Data
Size	1.38 x 1.85 x 1.32 in [35 x 47 x 33.N6 mm]
Weight	2.0 oz [57 g]

NES-HK, NPS-HK Heatsink Kits

Specification	Data
Size	1.37 x 1.18 x 0.728 [35 x 29.97 x18.49]
Weight	0.58 oz [16.5 g]

All Models

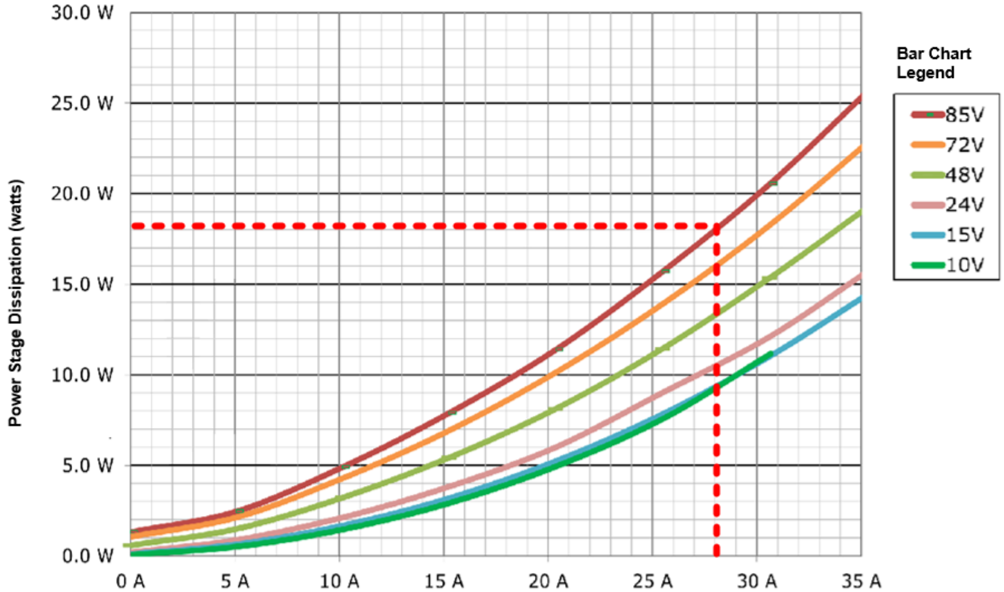
Specification	Data
Ambient Temperature	Operating: 0 to +45°C [0 to +113 F] in accordance with IEC 60068-2-1:2007 and IEC 60068-2-2:2007 Storage: -40 to +85 °C (-40 to 185 F) in accordance with IEC 60068-2-1:2007 and IEC 60068-2-2:2007
Humidity	0 to 95 %, non-condensing per IEC 60068-2-78:2001
Altitude	≤ 2000 m (6560 ft) per IEC 60068-2-13:1983
Vibration	2 g peak, 10~500 Hz (Sine), per IEC 60068-2-6:2007
Shock	10 g, 10 ms, half-Sine pulse, per IEC 60068-2-27:2008
Contaminants	Pollution degree 2, IP00, per IEC 60664-1:2007
Cooling	Heat sink and/or forced air cooling required for continuous power output
Environment	IEC 60068-2

3.18 Thermals: PWM Output Stage Dissipation

Output Power Dissipation vs. Output Current and +HV

NES/NPS-090-70

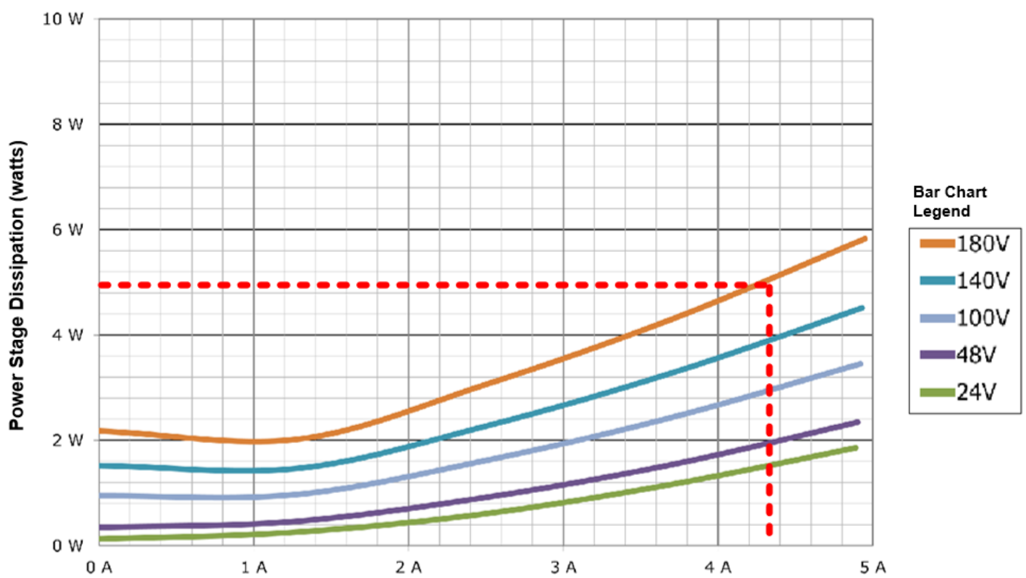
The following chart shows the power dissipation in the drive when the PWM outputs are driving a motor. Adding the PWM dissipation to the Vlogic dissipation will yield the total dissipation in Watts for the drive. In the chart, the dotted lines show a dissipation of 18 W. at a continuous current of 28 Adc and +HV = 85 Vdc.



Continuous Current (Adc)

NES/NPS-180-10

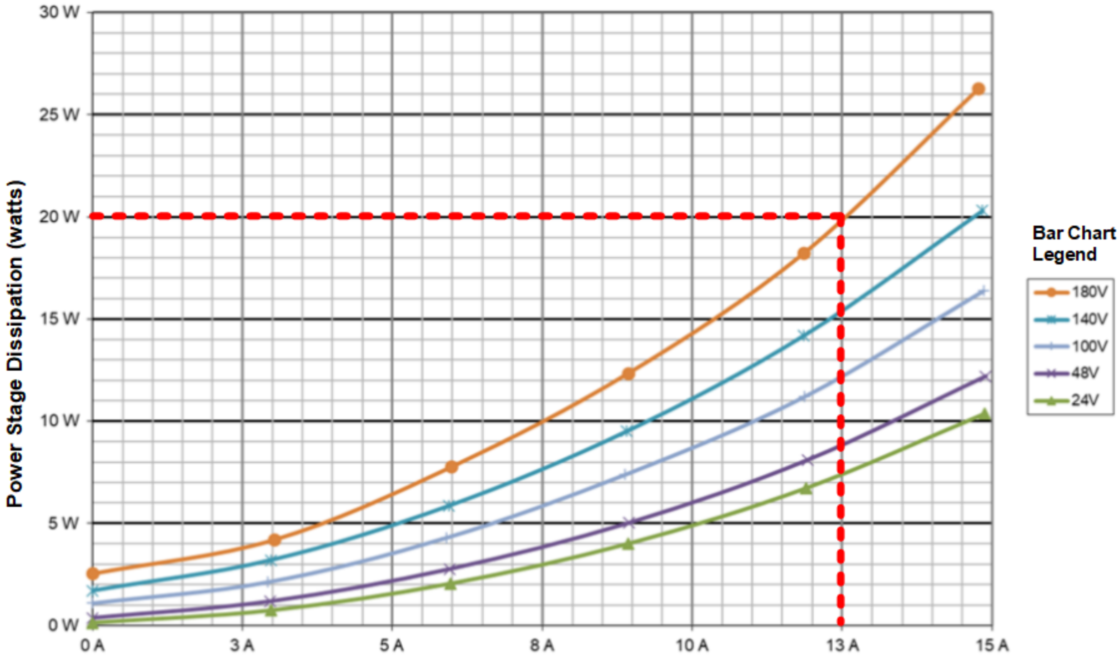
The following chart shows the power dissipation in the drive when the PWM outputs are driving a motor. Adding the PWM dissipation to the Vlogic dissipation will yield the total dissipation in Watts for the drive. In the chart, the dotted lines show a dissipation of 5.2 W. at a continuous current of 4.4 Adc and +HV = 180 Vdc.



Continuous Current (Adc)

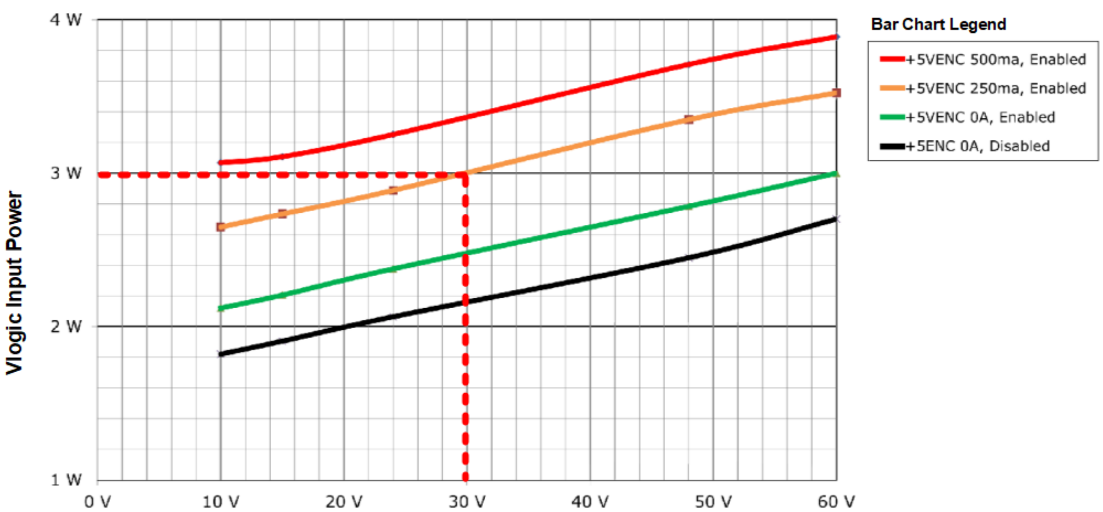
NES/NPS-180-30

In the chart below, it shows the power dissipation in the drive when the PWM outputs are driving a motor. Adding the PWM dissipation to the Vlogic dissipation will yield the total dissipation in Watts for the drive. In the chart, the dotted lines show a dissipation of 20 W. at a continuous current of 13 Adc and +HV = 180 Vdc.



Continuous Current (Adc)

In the chart below, it shows the power dissipation in the Vlogic circuits that power the drive's control circuits and the external encoders. Adding the PWM dissipation to the Vlogic dissipation will yield the total dissipation in Watts for the drive. In the chart, the dotted lines show a dissipation of 3.0 W. at Vlogic = 30 Vdc, when the drive is in an Enabled state and outputting 250 mA for an encoder.



Vlogic Voltage

Thermal Resistance

In the Heatsink table, it shows the thermal resistance Rth in degrees-C per Watt (C/W) for typical cooling configurations. The drive has the standard "pins" heatsink mounted with a sheet of thermal material placed between the drive and the heatsink.

The acronym, LFM, is Linear Feet per Minute. LFM is defined as the velocity of air flow produced by a fan directed in line with the heatsink fins.

HEATSINK

LFM	0	100	200	300	400
Rth	5.3	3	2.5	1.6	1.3

FIND COOLING MEANS WITH DISSIPATION AND AMBIENT TEMPERATURE KNOWN

Given: Tamb = 32 ºC (89.6 ºF), PWM dissipation = 18 W, VLOGIC dissipation = 3 W
Tmax = 80 ºC (drive shut-down temperature minus 10 ºC for margin)

Find: Thermal Resistance Rth:
Delta-T = Tmax - Tamb = 80 - 32 = 48 ºC
Total dissipation = 18 + 3 = 21 W
Rth = Delta-T / dissipation = ºC / Watt = 48 / 21 = 2.3 ºC/W

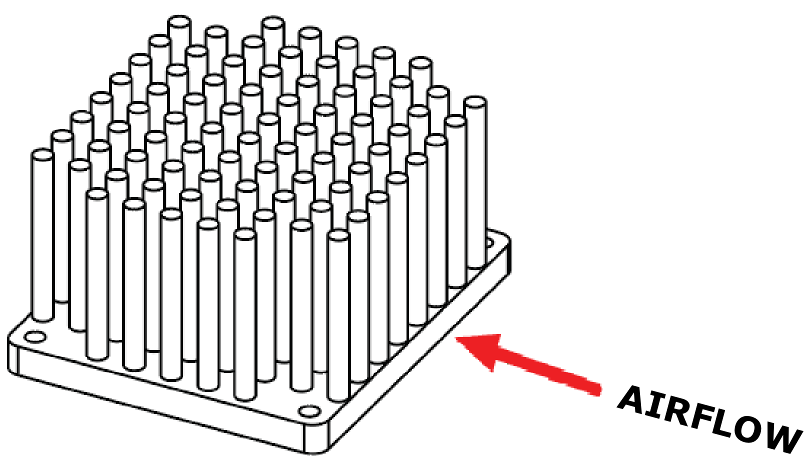
From the above table, there is one configuration that provides Rth less than 2.3 ºC/W:

With heat sink, forced air at 300, 400 LFM

FIND MAX AMBIENT TEMP WHEN DRIVE CONFIGURATION IS KNOWN

Given: Heatsink, forced-air at 300 LFM, dissipation is 26.5 W
Rth = 1.6 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 = 80 – 23.9 = 56.1 ºC
Max. ambient operating temperature is 45 °C so it can operate up to this temperature.



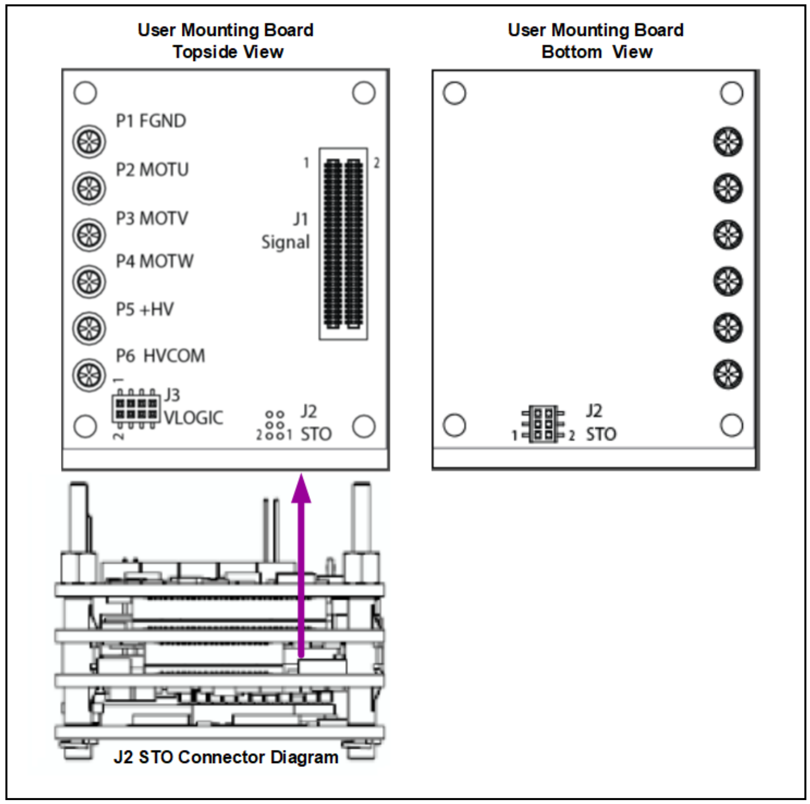
Airflow Direction

4 CONNECTIONS AND WIRING - MODULES

4.1 PC Board Connectors and Pinout: NES, NPS

The following diagrams and tables show the pins and signals located on the user mounting board.

Name	Pin
FGND	P1
Mot U	P2
Mot V	P3
Mot W	P4
+HV	P5
HVCOM	P6

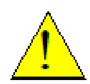


J3 VLOGIC

Name	Pin	Pin	Name
N.C.	2	1	N.C.
VLOGIC	4	3	HVCOM
	6	5	
N.C.	8	7	N.C.

J2 STO

Name	Pin	Pin	Name
STO_STATUS _OUTPUT	6	5	STO_STATUS _OUTPUT_RTN
STO2_IN	4	3	STO2_RTN
STO1_IN	2	1	STO1_RTN



Note: The STO Connector J2 is mounted on the bottom side of the PCB.

ALL PIN NUMBERING INFORMATION FOR MODULE-LEVEL STO CONNECTIONS IN THIS DOCUMENT IS PIN NUMBERING CORRESPONDING TO THE BOTTOM ENTRY SOCKET (J2) ON THE USER MOUNTING BOARD. USER MOUNTING BOARDS MUST BE DESIGNED FOLLOWING THIS PIN NUMBERING CONVENTION.

Because the STO header on the Nano Module itself connects to the User Mounting Board via a bottom entry socket, the pin numbering for the header as marked on the Nano module is the mirror image of that for the bottom entry socket on the User Mounting Board.

Ref Des	Label	Mfgr	Part Number	Description	QTY
P1	Signal	WCON	3620-S060-022G3R02	Header, 60 pos, 0.5 mm pitch	1
J2	STO	Samtec	CLM-103-02L-D-BE	Header, 6 pos, 1 mm pitch	1
J3	VLOGIC	WCON	2521-2040MG3CUNR1	Header, 8 pos, 1 mm pitch	1
P1~P6	+HV, Motor	WINPIN	WP-WJ018GER1	RCPTL Outer Sleeve Crown Spring	6

*Note: In the Table, the asterisk indicates the part numbers to purchase reels of these components.
Refer to the following vendor to contact for approved value-added partner Action Electronics.
Action Electronics, Inc.
Walpole, MA 02081-02522-US
Phone: (508) 668-5621

J1 SIGNAL - NES

Signal	J1 Pin		Signal
REFIN1-	1	2	REFIN+
AGND	3	4	SGND
(ENABLE) IN1	5	6	IN2
IN3	7	8	IN4
IN5	9	10	IN6
SGND	11	12	SGND
DOUT1	13	14	DOUT2
DOUT3	15	16	DOUT4 (BRAKE)
SGND	17	18	SGND
+3.3V_TXRX1	19	20	[RX1+] RXPA
+3.3V_TXRX2	21	22	[RX1-] RXNA
[Tx2-] TXNB	23	24	[TX1+] TXPA
[Tx2+] TXPB	25	26	[TX1-] TXNA
[Rx2-] RXNB	27	28	SGND
[Rx2+] RXPB	29	30	ASYNC_RXD1
SGND	31	32	ASYNC_TXD1
SGND	33	34	SGND
ASYNC_RXD2	35	36	N.C.
ASYNC_TXD2	37	38	N.C.
HALLU	39	40	HALLV
HALLW	41	42	+3.3V
ENCA1_UBC_DAT	43	44	/ENCA1_UBC_DAT
ENCB1	45	46	/ENCB1
ENCX1_UBC_CLK	47	48	/ENCX1_UBC_CLK
SGND	49	50	SGND
ENCA2	51	52	/ENCA2
ENCB2	53	54	/ENCB2
ENCX2	55	56	/ENCX2
+5VENC	57	58	+5V
+5VENC	59	60	+3.3V

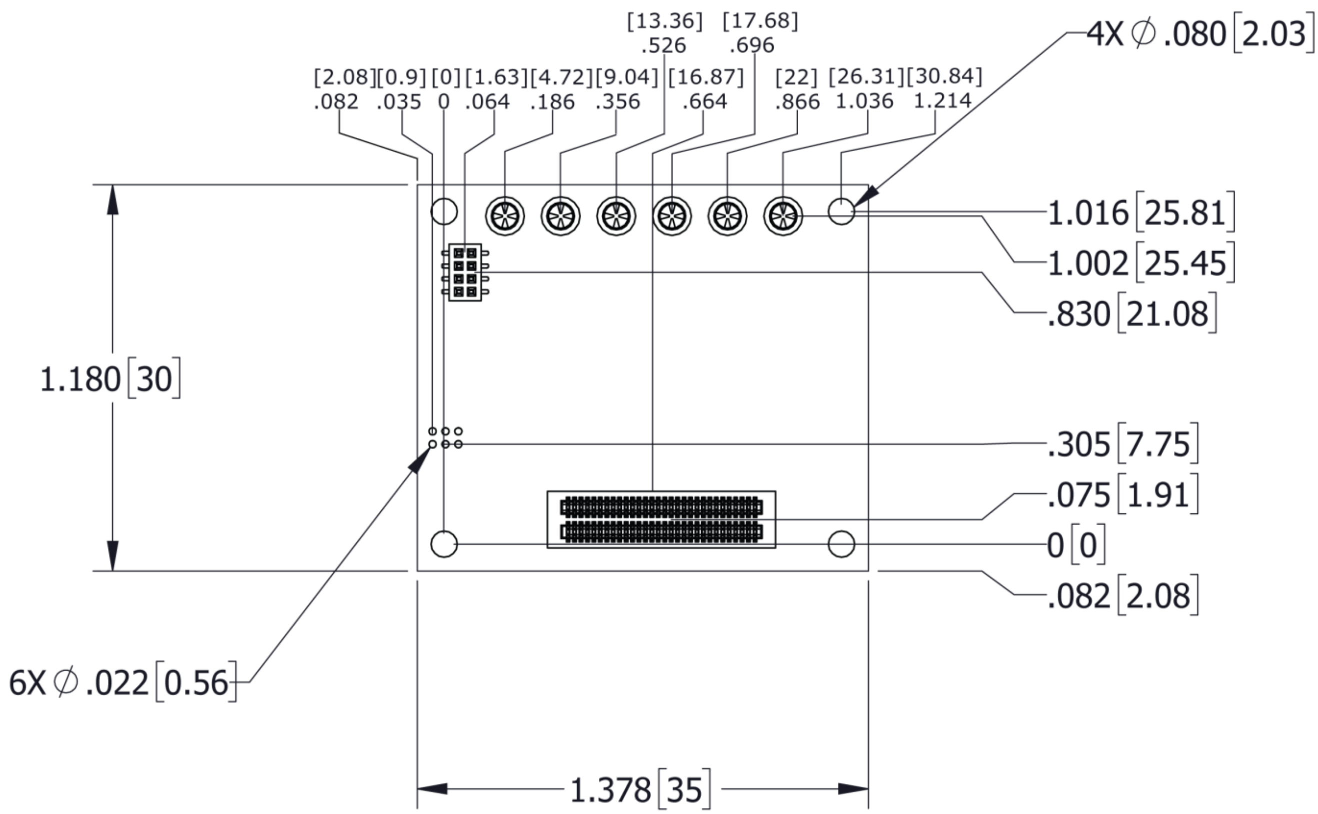
J1 SIGNAL - NPS

Signal	J1 Pin		Signal
REFIN1-	1	2	REFIN+
AGND	3	4	SGND
(ENABLE) IN1	5	6	IN2
IN3	7	8	IN4
IN5	9	10	IN6
SGND	11	12	SGND
DOUT1	13	14	DOUT2
DOUT3	15	16	DOUT4 (BRAKE)
SGND	17	18	SGND
N.C.	19	20	N.C.
N.C.	21	22	N.C.
N.C.	23	24	N.C.
N.C.	25	26	N.C.
N.C.	27	28	SGND
N.C.	29	30	ASYNC_RXD1
SGND	31	32	ASYNC_TXD1
SGND	33	34	SGND
ASYNC_RXD2	35	36	CANTX
ASYNC_TXD2	37	38	CANRX
HALLU	39	40	HALLV
HALLW	41	42	+3.3V
ENCA1_UBC_DAT	43	44	/ENCA1_UBC_DAT
ENCB1	45	46	/ENCB1
ENCX1_UBC_CLK	47	48	/ENCX1_UBC_CLK
SGND	49	50	SGND
ENCA2	51	52	/ENCA2
ENCB2	53	54	/ENCB2
ENCX2	55	56	/ENCX2
+5VENC	57	58	+5V
+5VENC	59	60	+3.3V

4.2 NES, NPS PC Board Mounting

PC BOARD MOUNTING DIMENSIONS

The following diagram shows the topside view of the user mounting PC board for the drive. The STO (J2) connector is mounted on the underside of the PC board. The topside view shows the clearance holes for the STO connector mating pins.



User Mounting Board Dimensions (Topside View)

Notes:1. To determine the copper width and thickness for P1~P6 signals, refer to specification IPC-2221. (Association Connecting Electronic Industries, http://www.ipc.org)

2. Standoffs should be connected to etches on pc board that connect to frame ground for maximum noise suppression and immunity.
3. The Nano Module drives do not emit noise above 70 dB(A) when they are mounted and operating.

4.3 NANO Module Installation Instructions

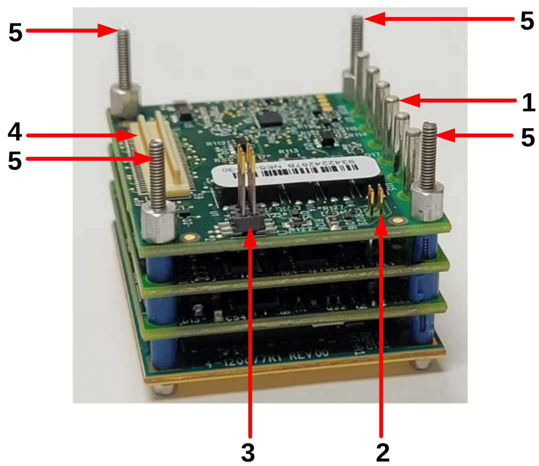
The Nano NES/NPS modules are very compact and have a mix of larger power connections and very small signal connections. It is important to follow these handling, installation and removal instructions to prevent any chance of damage and bending of the smaller signal pins in particular. Please note that the screws and standoffs delivered with the Nano module also aid in the alignment and control the module stack height relative to the user mounting board into which it is installed.

NANO Connector Locations

Nano NES/NPS modules are shipped with a customized protective foam block covering the connectors and pins designed to prevent damage during shipping and handling. It is best to keep this foam block in place up until the time the module is installed in the user mounting board.

The diagram and legend below identify the locations of the connectors.

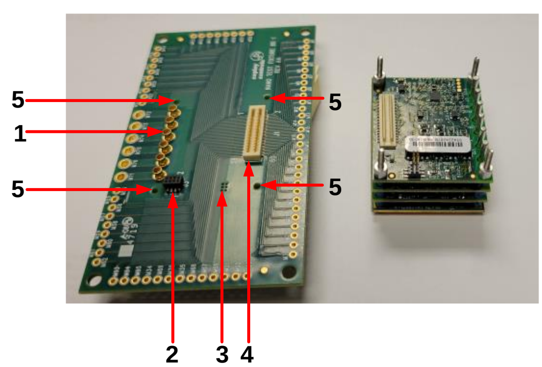
Legend		
Item	**Description**	**Quantity**
1	Power Contacts	6
2	V-Logic Header	1
3	STO Header	1
4	Signal Connector	1
5	Mounting Screws	4



NANO User Mounting Board Mating Connector Locations

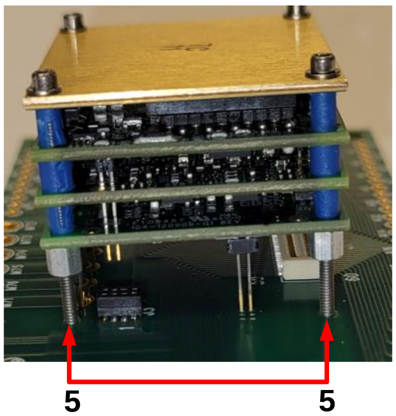
The diagram and legend below identify the NANO mating connector locations for an example see the user mounting board.

Legend		
Item	**Description**	**Part Number**
1	Power Contacts Winpin	WP-WJ018G3R1
2	V-Logic Socket Wcon	2521-204MG3CUNR1
3	STO Socket Samtec	CLM-103-02-L-D-BE
4	Signal Connector Wcon	3620-S060-022G202
5	Mounting Holes	0.080” Clearance

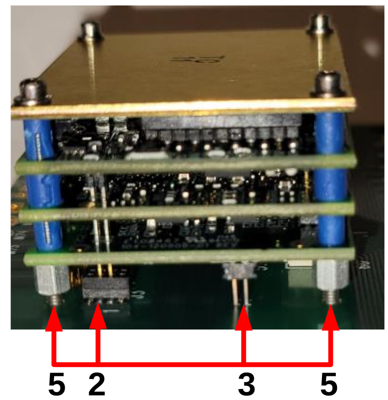


INSTALLING THE NANO MODULE

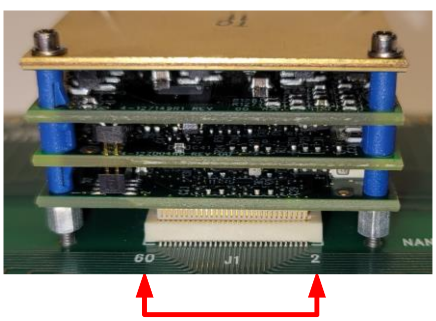
1.-Pre-align the mounting screws (Item 5) with the corresponding holes on the user mounting board.



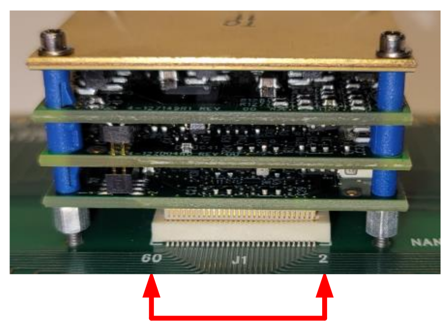
2.-Align the STO Header (Item 3) to the board.
3.-Seat the power pins (Item 1) to the corresponding sockets.
4.-Lower the V-Logic Header (Item 2) pins into the clearance holes.



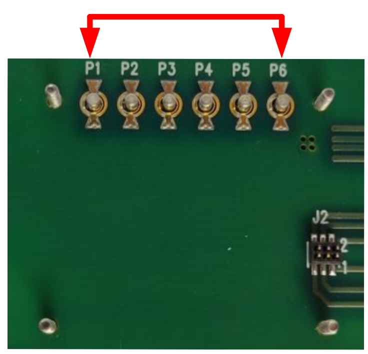
5.-Align the Signal Connector (Item 4) to the socket.



6.-To complete the assembly, press down to snap the Signal Connector to the socket.



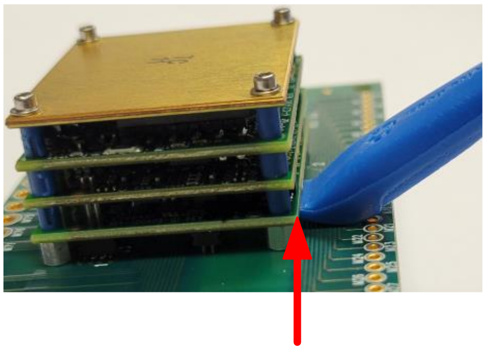
7.-The Nano power contacts (Item 1) and STO header pins (Item 3) will be visible from the bottom of the assembly.



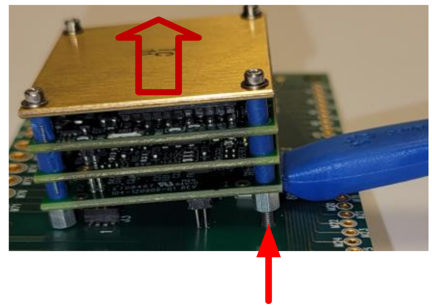
Removing the Nano Module

To remove the Nano module from the board, do the following:

1. Use the Nano extraction tool (included in the N-HK Heatsink Kit and available separately from Digikey in packs of 5, IFixit PN:IF145-335-1) to locate an area close to the Signal Connector (Item 4) to remove the module.

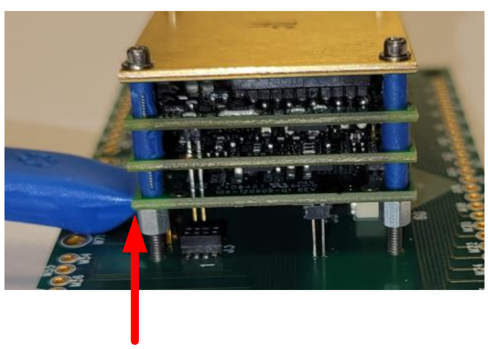


2. Place the Nano extraction tool below the module and detach the Signal Connector (Item 4).
   Note: When you remove the Nano module, do not bend the pins. To prevent damage to the fine-pitch components, lift the Nano module slightly upward from the board.



3. Place the extraction tool on the power contact side (Item 1) of the module and gently lift the side. Remove the headers straight upright from the mating connectors, to prevent the pins from bending. (See location 5).

Note: To prevent damage to the pins or the fine pitch components, lift the Nano module straight upright from the board. Do not tilt or rotate the Nano module, as it will cause the pins to bend.
Hint: After removing the module, re-install the protective foam block to prevent potential damage to the Nano pins during handling.



4.4 Grounding Considerations

Signal Ground and HVCOM are all connected in the drive. The HV and PWM outputs carry high currents, and the signal circuits and I/O are low-current circuits.

User equipment connecting to the drive's non-isolated circuits should have a circuit ground that is at the same potential as the drive's Signal Ground.

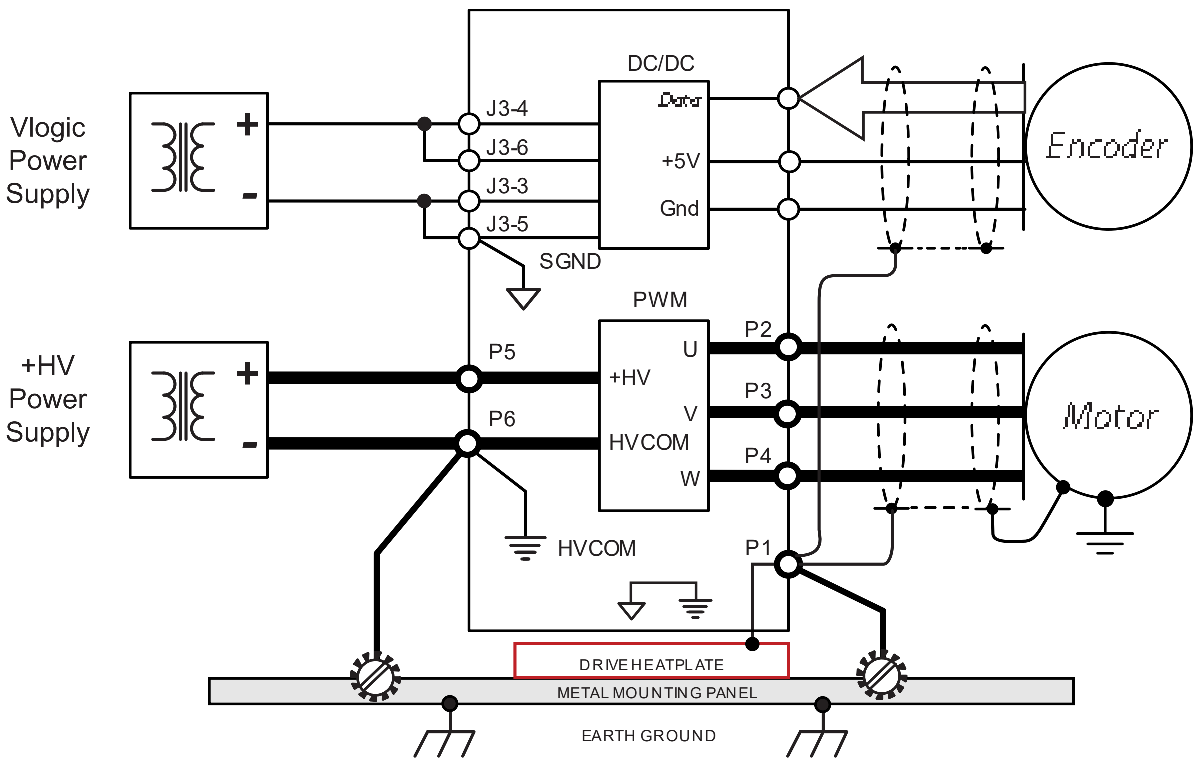
DC Power Grounding

The graphic below shows the basic elements of a DC power supply system for a NANO drive. The NANO drives are Protective Class I equipment in regard to protection against electric shock. Accordingly, the drives have both basic insulation between circuits and accessible conductive parts and a means of connecting a protective earthing conductor to prevent accessible conductive parts from becoming hazardous live in the event of a failure of the basic insulation. Power pin P1 on the module drive provides this path between the heat plate and FG (Frame Ground). Note that the NANO drives require that the DC power supply be galvanically isolated from AC mains as shown in the figure below.

The PE markings are shown to illustrate the connection made by P1 between the drive heat plate and earth ground. This provides the Protective Earth connection.

The (-) terminal of the power supply is connected by a short, direct path to the frame ground terminal (sometimes called the "star" or equipment ground). This practice is common when drives are in the same cabinet with short connections to the drives.

The DC power wiring is shown as a shielded, twisted pair of a gauge suitable for the input current rating of the drive. The shield should connect to the FG terminal of the power supply on one end, and to an FG grounding point near the drive for best results.



Motor Connection Grounding

On NANO modules, the connection to Frame Ground is made by power pin P1 that connects the drive heat plate to a copper trace on the mounting PC board with a path to earth on the other end. The motor cable shield should connect to this trace. Connection of cable shield to this point is made to provide electrical noise reduction and to prevent the motor housing from becoming hazardous live in the event of an insulation failure. Protective earth connections for the motor housing are subject to local electrical codes and must be reviewed for compliance with those codes. It is the responsibility of the end user to ensure compliance with local electrical codes and any other applicable standards. It is strongly recommended that the motor also be connected to protective earth connection points located as close to the motor as possible. In many applications, the machine frame is used as a primary or supplemental protective earth connection point for the motor housings.

Motor Cable Shielding

Shields on motor cables reduce emissions from the drive and help protect internal circuits from interference due to external sources of electrical noise. The shields shown in the wiring diagrams are also required for CE compliance. Motor cable shields should be tied to Frame Ground at the drive end, and tied to the motor frame on the motor end. Motors are typically grounded to equipment frames, too.

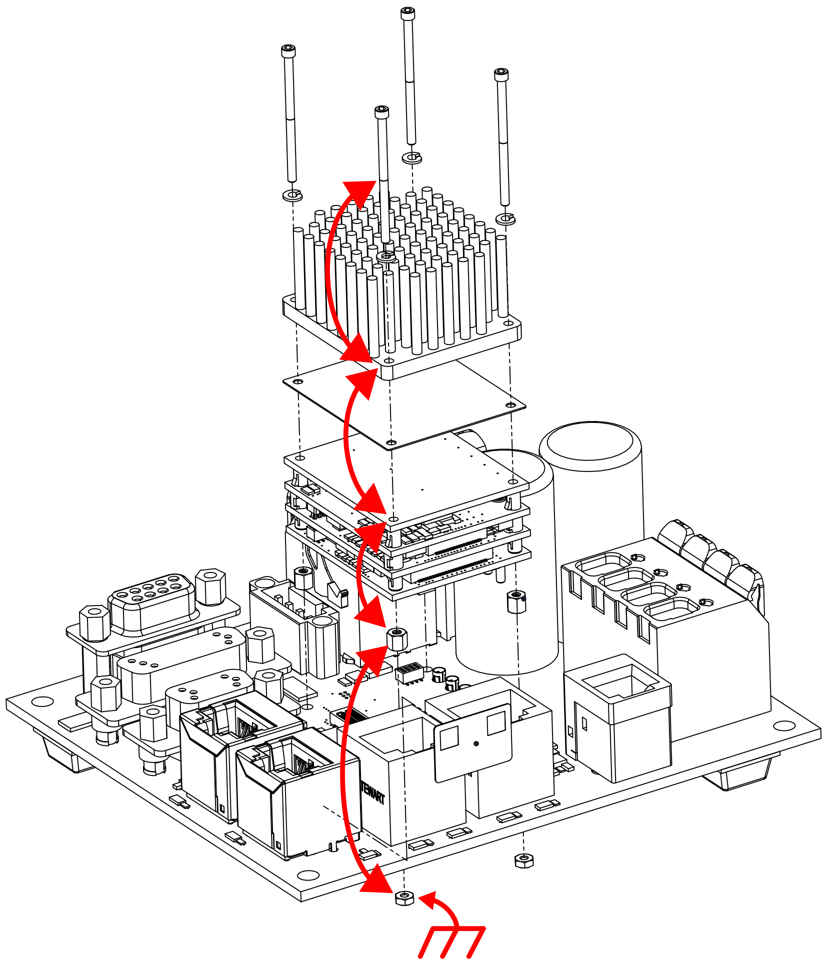
Feedback Cable Shielding

Shields on feedback cables reduce emissions from the drive and help protect internal circuits from interference due to external sources of electrical noise.

Protective Earth Grounding

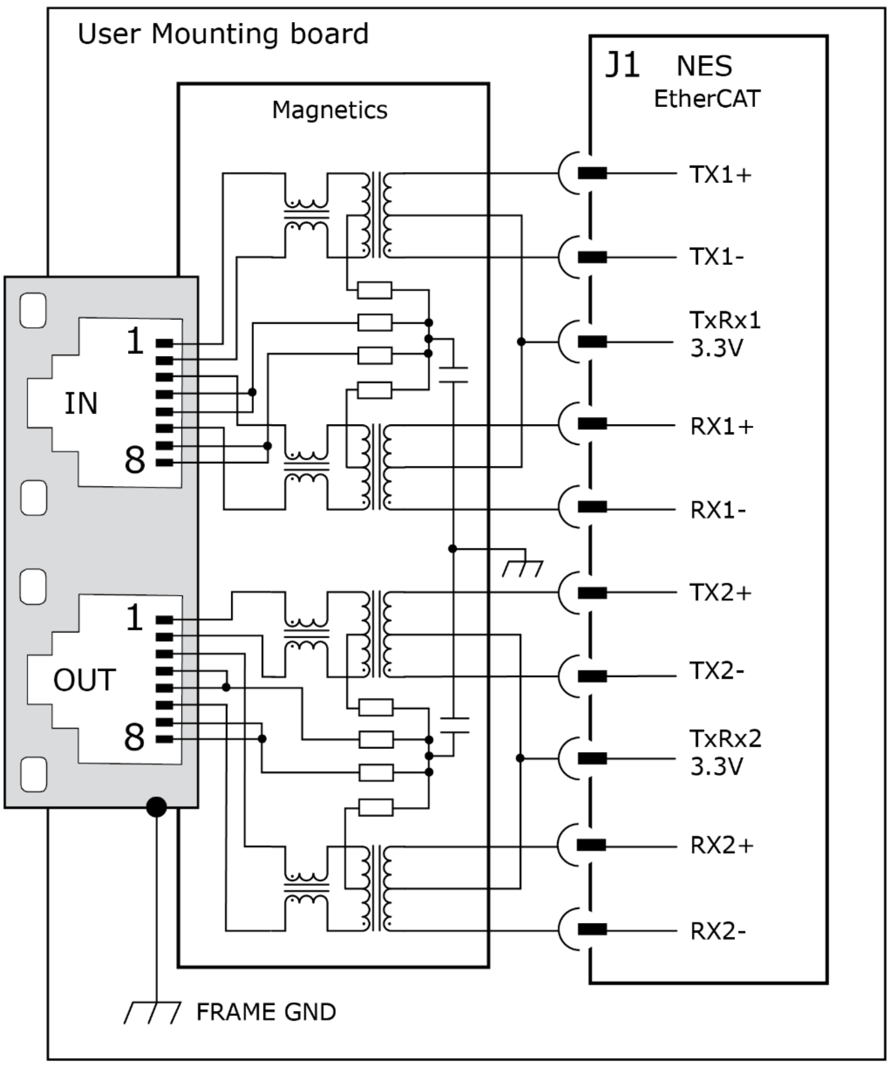
The following diagram shows how a Protective Earth (PE) connection can be made with an NES/NPS-D to ensure that the heatsink is properly connected to PE.

Pin P1 on the Nano module is connected directly to the heatsinking surface on the Nano. This connection is carried through on the -D board to connector J4 pin 1 (PE). The thermal interface pad that provides a low thermal impedance connection between the Nano heat dissipating surface and the heatsink is an electrical insulator. The mounting screws and associated hardware provide a means for electrically connecting the heatsink to PE. The screw heads make a solid electrical connection to the heatsink via the washers and the nuts at the other end of the screws make a solid electrical connection between the screw and the PE traces on the -D board. Users designing their own user mounting board need to follow the same approach to ensure that heatsinks attached to the Nano have a proper connection to PE.



4.5 EtherCAT Communications NES

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 CANopen application protocol over EtherCAT (CoE) based on CiA 402 for motion control devices.
More information on EtherCAT can be found on this website: http://ethercat.org.



Network RS-45

IN Name	Pin	OUT Name
TX1+	1	TX2+
TX1-	2	TX2-
RX1+	3	RX2+
R/C	4	R/C
	5	
RX1-	6	RX2-
R/C	7	R/C
	8	

Drive J1

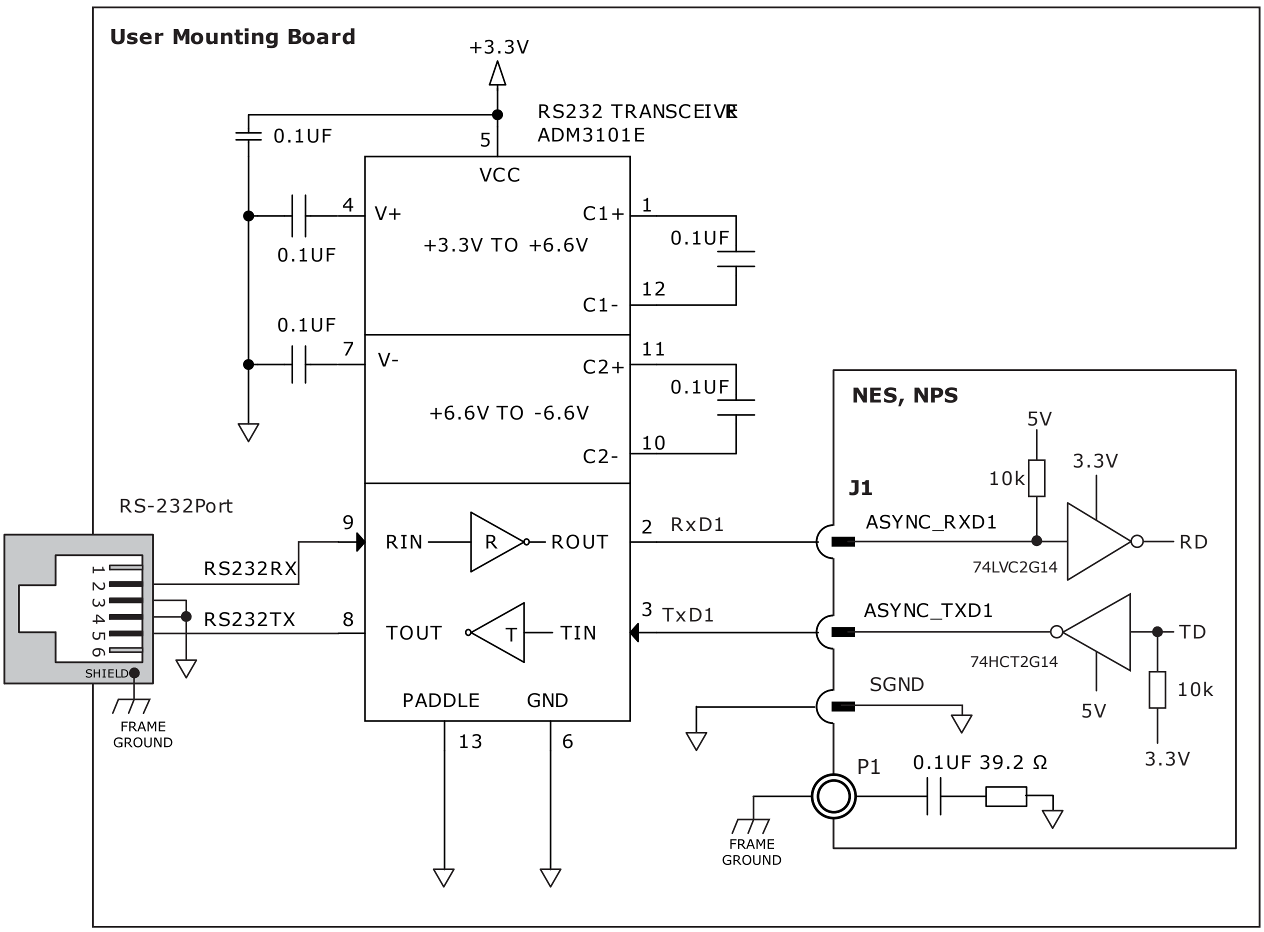
Name	Pin
TX1+ [TXPA]	24
TX1- [TXNA]	26
+3.3V_TXRX1	19
RX1+ [RXPA]	20
RX1- [RXNA]	22
Tx2+ [TXPB]	2
Tx2- [TXPB]	23
+3.3V_TXRX2	21
Rx2+ [RXPB]	29
Rx2- [RXNB]	27

Note: P10 and P11 on the NES-D board have integral magnetics and accept standard network cables for EtherCAT communications.

4.6 RS-232 Communications NES, NPS

The serial port is a full-duplex, three-wire (RxD, TxD, Sgnd) type that operates from 9,600 to 230,400 Baud. It can be used by CME for drive configuration or setup by external equipment sending serial commands (ASCII or serial-binary format). The circuit shown here is in the EZ board. It converts the TTL signals in the drive into the ANSI RS-232 levels which are the standard for serial communications and computer COMM ports.

The circuit shown here is used on the -D and -Z boards and is recommended for user's PC boards. It converts the single-ended TTL signal levels in the NES into ANSI RS-232 levels which are the standard for serial communications and computer COM ports.



Port Signal	P12 Pins
RS232 RxD	2
RS232 TxD	5
SGND	3,4

NANO Signal	J1 Pins
ASYNC_RXD1 (RS232 RxD)	30
ASYNC_TXD1 (RS232 TxD)	32
SGND	34

4.7 Digital Command Inputs: Position

Stand-Alone Mode digital POSITION-CONTROL Inputs

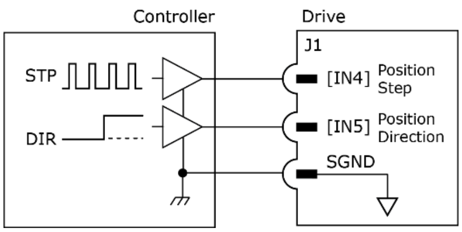
NANO drives work with motion controllers that output pulses to command position.
These formats are supported:

- Step/Direction
- Count-Up/Count-Down (CU/CD)
- A/B Quadrature Encoder

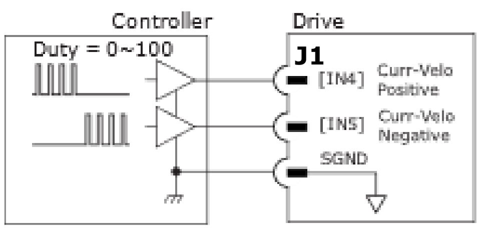
In Step/Direction mode, a pulse-train controls motor position, and the direction is controlled by a DC level at the Direction input.

In CU/CD mode, (Count-Up/Count-Down) signals command the motor to move CW or CCW depending on which input the pulse-train is directed to. The motor can also be operated in an electronic gearing mode by connecting the inputs to a quadrature encoder on another motor. In all cases the ratio between input pulses and motor revolutions is programmable.

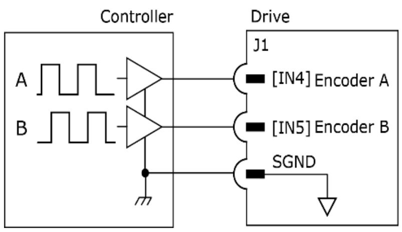
In Quad A/B mode, two signals that emulate encoder outputs control position are, direction, and velocity.



STEP/DIRECTION INPUTS



COUNT-UP/COUNT-DOWN INPUTS



QUAD A/B ENCODER INPUTS

Signal	J1 Pins
IN4	8
IN5	9

J1 SGND Pins
4,11,12,17,18,28,31,33,34,49,50

4.8 Digital Command Inputs: Velocity, Torque

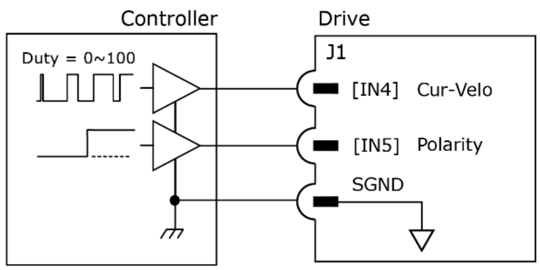
Stand-Alone Mode Digital VELOCITY/TORQUE CONTROL Inputs

NANO drives work with motion controllers that output pulses to command velocity and torque (current). These formats are supported:

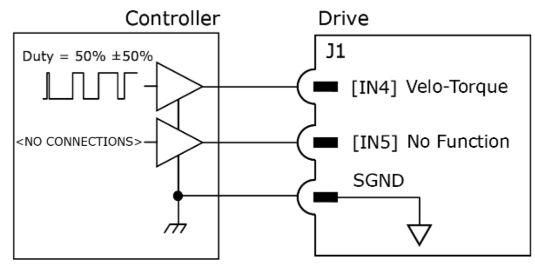
- PWM/Direction
- PWM 50%

In PWM/Direction mode, a pulse-train with variable duty cycle on IN4 controls Velocity or Torque from 0~100% and IN5 HI or LO controls the direction of the Velocity or polarity of the Torque.

In 50% PWM mode, a single 50% duty cycle signal on IN4 commands 0 Velocity/Torque. Increasing the duty cycle to 100% commands positive Velocity/Torque. Decreasing the duty cycle to 0% commands negative Velocity/Torque.



PWM/Direction



PWM 50%

Signal	J1 Pins
IN4	8
IN5	9

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

4.9 High Speed Inputs: IN1, IN2, IN3,IN4, IN5

The five digital inputs to the NES/NPS are programmable to a selection of functions. All have 100 ns RC filters when driven by active sources (CMOS, TTL, etc.) and all have 10 kΩ pull-up resistors to +5 Vdc. In addition to the selection of functions, the active level for each input is individually programmable. Input level functions have programmable HI or LO to activate the function. Input transition functions are programmable to activate on LO -> HI, or HI -> LO transitions.

CONNECTIONS

Signal	J1 Pins
IN1	5
IN2	6
IN3	7
IN4	8
IN5	9

INPUT LEVEL FUNCTIONS

Active on Hi or Lo Level

- Drive Enable, Enable with Clear Faults, Enable with Reset
- PWM Sync
- Positive Limit Switch
- Negative Limit Switch
- Home Switch
- Encoder Fault
- Motor Temperature Sensor Input
- Motion Abort
- High-Resolution Analog Divide

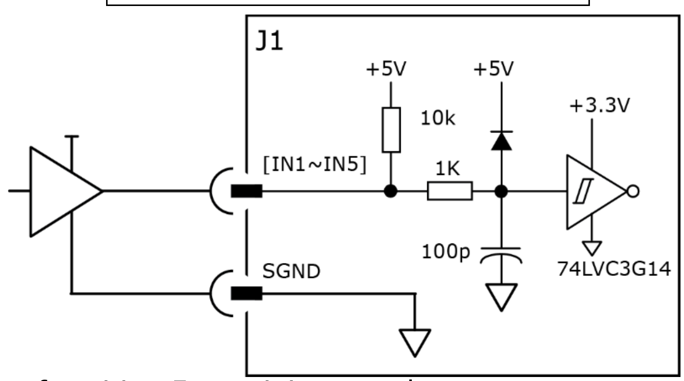
INPUT TRANSITION FUNCTIONS

Active on Hi-Lo or Lo-Hi Transition

- Clear Faults & Event Latch
- Drive Reset
- PWM Sync Input
- Trajectory Update
- Count Input Edges, Save to Register
- High-Speed Position Capture
- Simulated Absolute Encoder Burst
- Abort Move if > N Counts From Destination in Register

Input	Data	Notes
Input Voltages	HI	V_T+ =1.42~2.38 Vdc
	LO	V_T+ = 0.68~1.6 Vdc
	Hys	V_H+ = 0.44~1.26
	Max	+12 Vdc
	Min	0 Vdc
Pull-Up	R1	10 kΩ
Low Pass Filter	R2	1 kΩ
	C1	100 pF
	RC	IN1~5: 0.1 µs IN6: 33 µs

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50



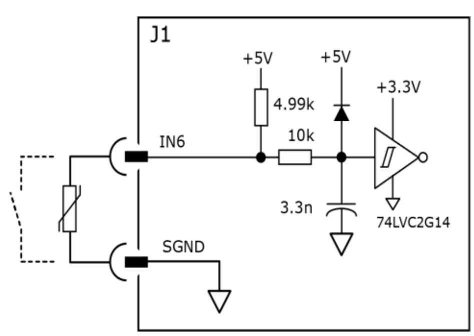
* Encoder index pulse capture for IN1~5
2.5 us minimum pulse width,
0.1 us between active edge of input and capture of position,5 us minimum pulse

WARNING	**Consult the Factory for Adapting 24V logic to 5V logic.**
	5V logic. Do not exceed 12V. Do not connect a 24V logic to this input.

4.10 High Speed Input: IN6

Signal	J1 Pins
IN6	10
SGND	(See above)

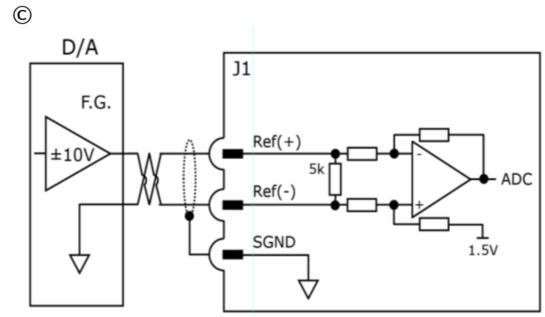
Input IN6 has a 33 microsecond rise time RC filter when driven by active sources (CMOS,TTL, etc.), with a 4.99 kΩ pullup resistor to +5 VDC. Input IN6 is designed to interface with an industry standard PTC thermistor IAW BS 49990111(1987) for built-in thermal protection of the motor as a default. If not used for the Motemp function, IN6 can be re-programmed for other input functions.



4.11 Analog Input: AIN1

As a reference input, it takes Position/Velocity/Torque commands from a controller.
If it is not used as a command input, it can be used as general-purpose analog input.

Property	Data	Notes
Input Voltage	Vref	±10 Vdc
Input Resistance	Rin	5.00 kΩ
Resolution	12	Bits *



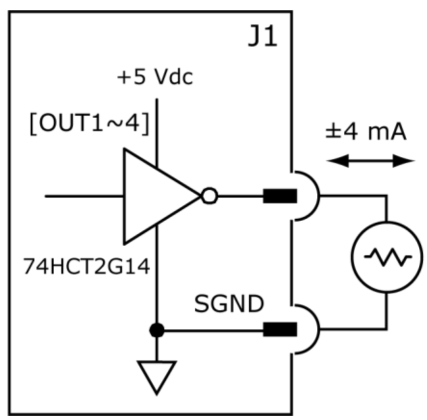
Signal	J1 Pins
Ain(+)	2
Ain(-)	1

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

4.12 Digital Outputs: OUT1~4

Digital outputs [OUT1~4] are CMOS inverters. They operate from +5 Vdc and source/sink 4 mAdc.

Output Functions
- Fault
- Custom Event
- PWM Sync
- Custom Trajectory status
- Custom Position-Triggered Output
- Program Control
- Brake Control (OUT4, see following page)



Signal	J1 Pins
OUT1	13
OUT2	14
OUT3	15
OUT4	16

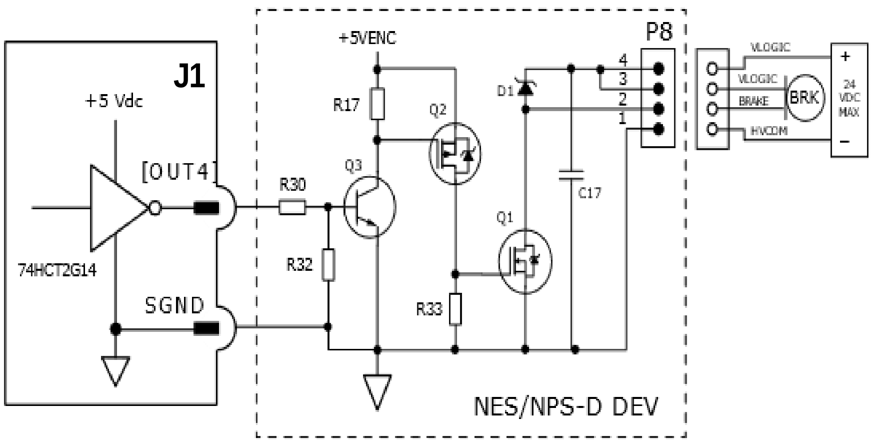
J1 Sgnd Pins
3,4,11,12,33,34,49,50

4.13 Brake Output: OUT4

The default function of OUT4 is control of a motor holding brake using the DEV board that has components to sink the higher current of the brake. If it is not used for brake control, it can be programmed as a logic output. The brake output is a pulse-train with programmable parameters that can be adjusted for the brake's operating voltage.

The Custom Brake Configuration provides these parameters:

Vlogic:	The DC voltage that powers the drive's control circuits, encoders, etc.
Initial Voltage	Applied to the brake by duty-cycling OUT4 to brake's rated voltage.
Time at Initial Voltage	Sufficient time to open the brake after which switches to Holding Voltage.
Holding Voltage	A lower voltage that is adequate to hold the brake open without overheating.
PWM Period	62.5 µs (16 kHz) is the default and is programmable.



OUTPUT 4 FUNCTION

- Motor holding brake when NES/NPS is mounted to a DEV board or user PCB with the same circuit.
- Same functions as OUT1~3 if drive is used without brake

Brake Circuit Parts
Q1: CSD19538Q2T
Q2: DMP56D0UFB-7
Q3: DN0150BLP4-7
D1: DFLS1100
R30: 24.9k, 0.1 W
R32: 49.9k, 0.1 W
R17: 49.9k, 0.1 W
R33: 10k, 0063 W
C17: 4.7 µF, 100 V

Note: The circuit shown above
is rated at 3A maximum.

CME Default Setting for [OUT4] is "Custom Brake Output."

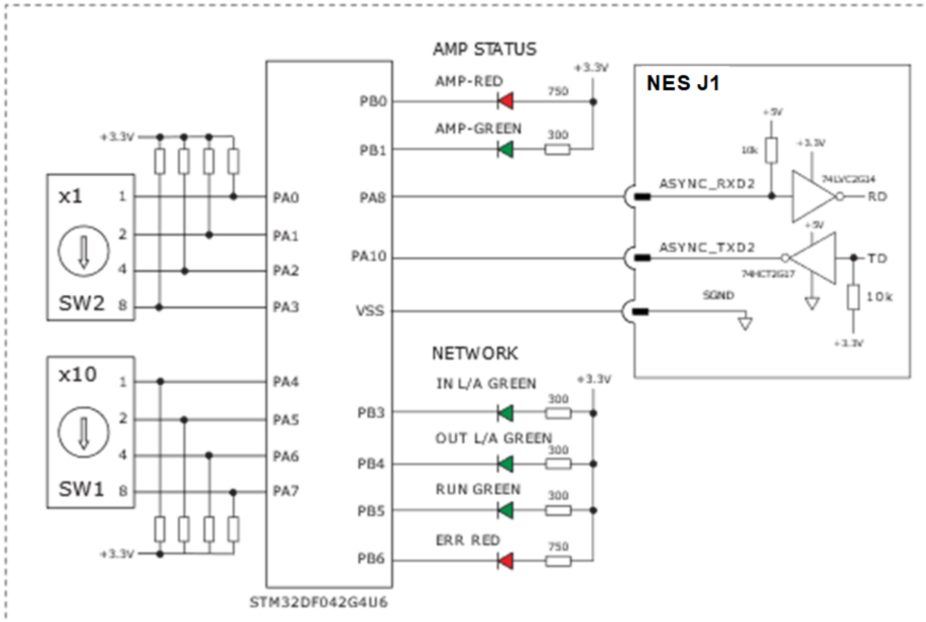
Active = Brake is holding motor shaft (i.e., the Brake is Active).
Motor cannot move.
No current flows in coil of brake.
CME I/O Line States shows [OUT4] as LO.
BRK Output voltage is HI (24V), MOSFET Q1 is OFF.
Servo drive output current is zero.
Servo drive is disabled, PWM outputs are off.

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 [OUT4] as HI.
BRK output voltage is LO (~0V), MOSFET Q2 is ON.
Servo drive is enabled, PWM outputs are on.
Servo drive output current is flowing.

4.14 SLI (Switch & LED Interface) PORTS

These secondary serial ports can operate as SLI (Switch and LED Interface) ports for controlling LEDs and reading the settings of the network address switches.
The graphics below show them in SLI mode.

NES

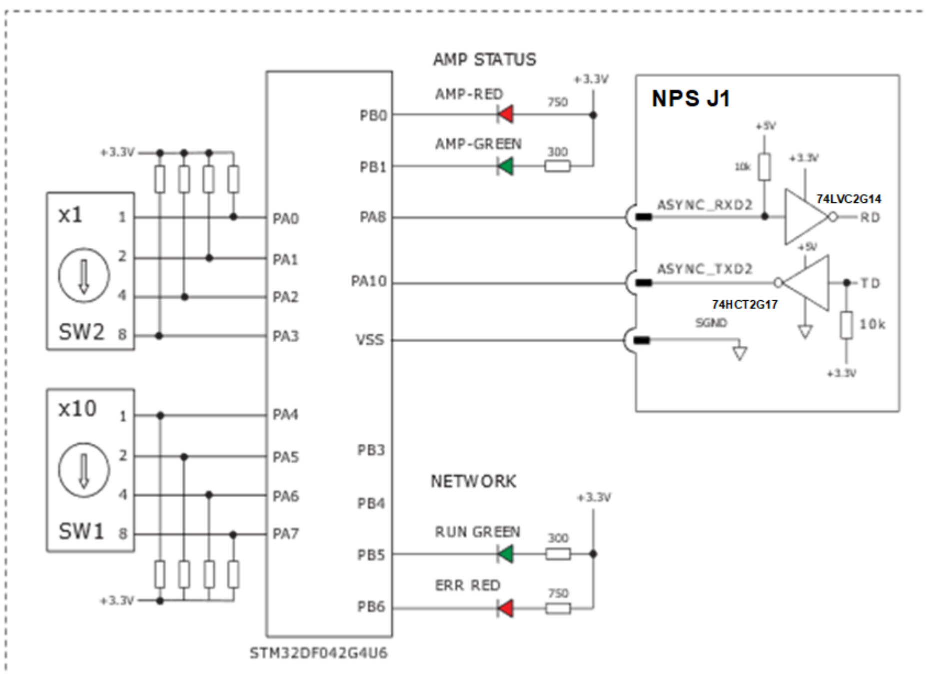


CONNECTIONS

Signal	**J1 Pins**
ASYNC_RXD2	35
ASYNC_TxD2	37

J1 Sgnd Pins
4,11,12,17,18,28, 31,33,34,49,50

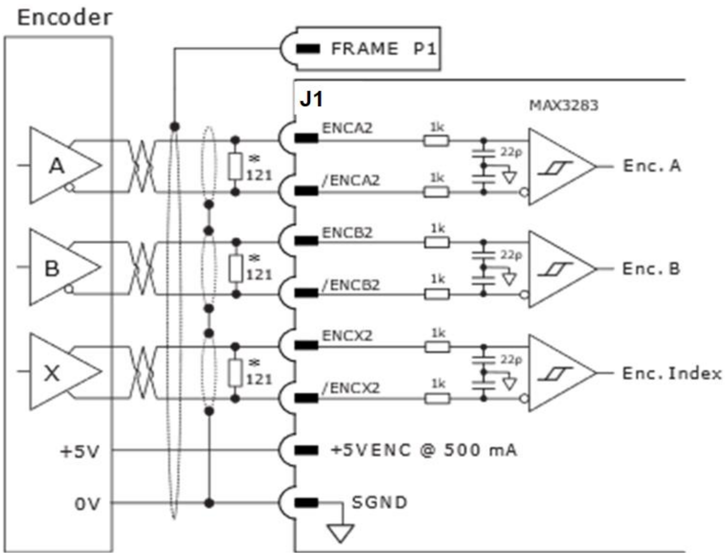
NPS



4.15 ENCODER 1 (Primary Encoder)

INCREMENTAL ENCODER

Incremental encoders have two outputs A & B that are 90 degrees electrical apart.
This produces four HI/LO combinations (counts) of the A and B signals for every line on the encoder disk. Decoding these indicates the direction of rotation as well as the angular distance moved. But it does not reveal the absolute position of the motor shaft. The Index signal is a single output once per revolution that indicates the absolute angular position of the motor.



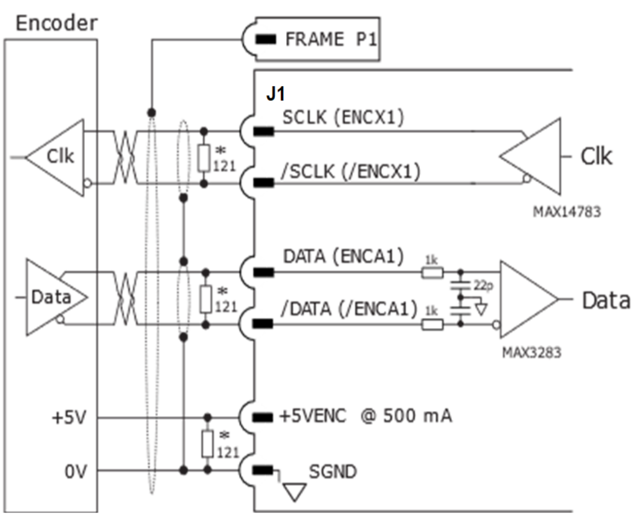
A/B/X SIGNALS

Signal	J1 Pins
ENCA1	43
/ENCA1	44
ENCB1	45
/ENCB1	46
ENCX1	47
/ENCX1	48
+5VENC	57,59
SGND	49, 50

* Note: The 121Ω resistors are supplied by the user and should be on the mounting board for good signal quality.

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 NES 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.



SSI SIGNALS

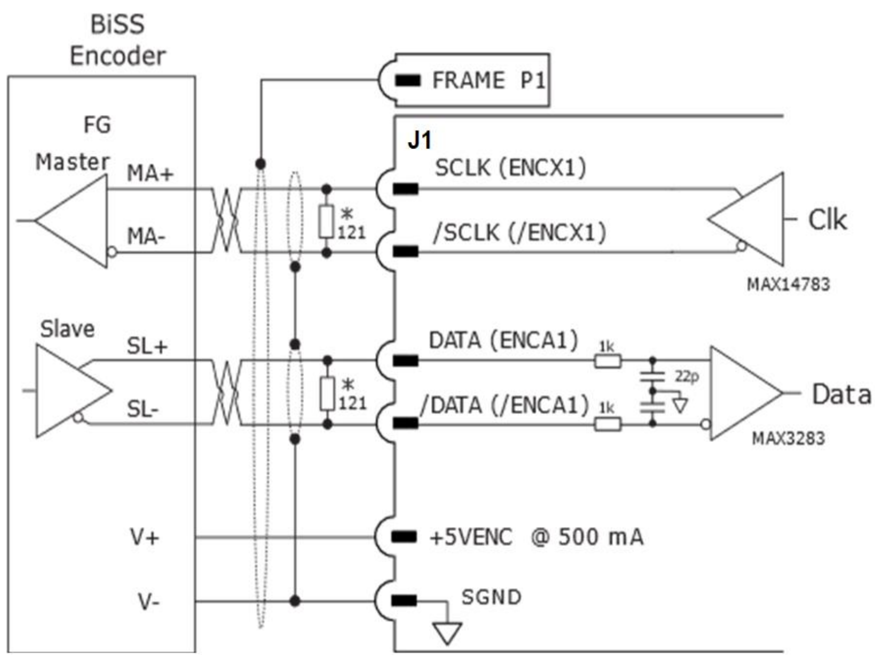
Signal	J1 Pins
SCLK (ENCX1)	47
/SCSL (/ENCX1)	48
SDATA (ENCA1)	43
/SDATA (/ENCA1)	44
+5VENC	57, 58
SGND	49, 50

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

BiSS-C Absolute Encoder

BiSS-C is an Open-Source digital interface for sensors and actuators. BiSS-C 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 including. actuators
- Bidirectional
  -BiSS C-protocol: Continuous mode



BiSS-C SIGNALS

Signal	J1 Pins
MA+ (ENCX1)	47
MA- (/ENCX1)	48
SL+ (ENCA1)	43
SL-(/ENCA1)	44
+5VENC	57, 58
SGND	49, 50

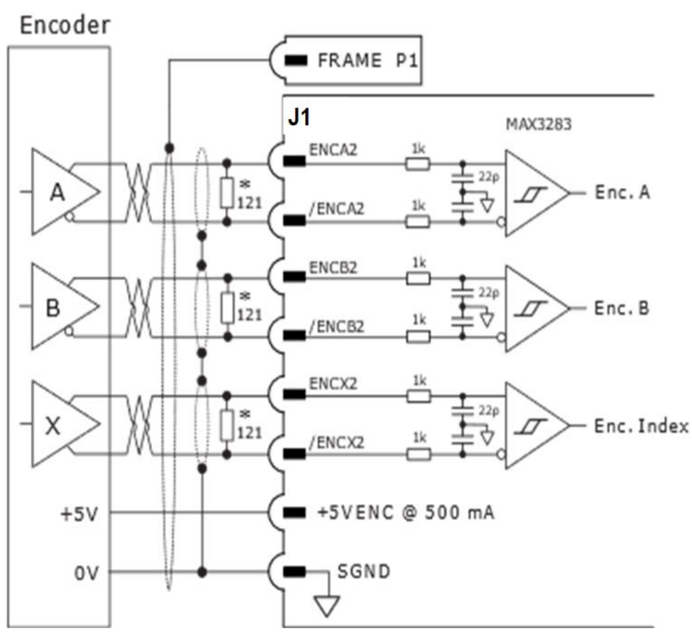
* Note: The 121Ω resistors are supplied by the user and should be on the mounting board for good signal quality.

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

4.16 ENCODER 2 (Secondary Encoder)

INCREMENTAL ENCODER

Incremental encoders have two outputs A & B that are 90 degrees electrical apart.
This produces four HI/LO combinations (counts) of the A and B signals for every line on the encoder disk. Decoding these indicates the direction of rotation as well as the angular distance moved.
But it does not reveal the actual position of the motor shaft. The Index signal is a single output once per revolution that indicates the absolute angular position of the motor.



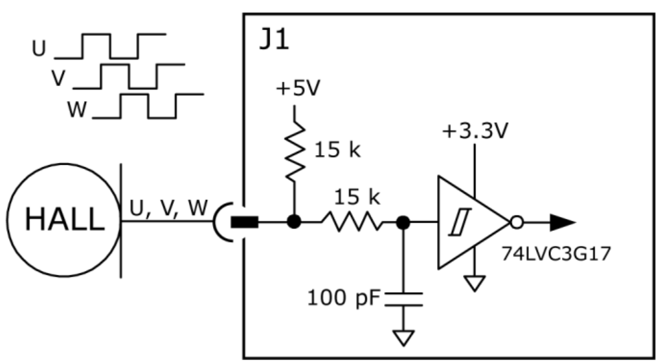
A/B/X SIGNALS

Signal	J1 Pins
ENCA2	51
/ENCA2	52
ENCB2	53
/ENCB2	54
ENCX2	55
/ENCX2	56
+5VENC	57,59
SGND	49, 50

* Note: The 121Ω resistors are supplied by the user and should be on the mounting board for good signal quality.

4.17 Hall Sensors

Hall sensors in a brushless motor detect the magnetic field in the motor and provide commutation feedback without an encoder. When used with incremental encoders, they enable the motor to operate without a phase-finding cycle.



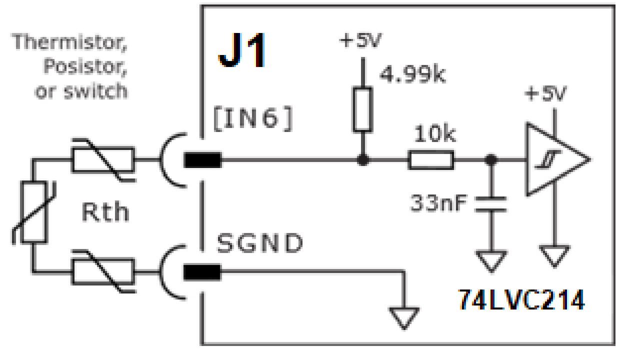
J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

Signal	J1 Pins
HALLU	39
HALLV	40
HALLW	41
+5VENC	57, 59
SGND	49, 50

4.18 Motor Overtemp: IN6

Input IN6 has a 33 microsecond rise time RC filter when driven by active sources (CMOS,TTL,etc), with a 4.99 kΩ pullup resistor to +5 VDC. Input IN6 is designed to interface with an industry standard PTC thermistor IAW BS 49990111(1987) for built-in thermal protection of the motor as a default. If not used for the Motemp function, IN6 can be re-programmed for other input functions.

Input	Data	Notes
Input Voltages	HI	VT+ = 1.42~2.38 Vdc
	LO	VT- = 0.68~1.6 Vdc
	Hys	VH 0.44~1.26
	Max	+12 Vdc
	Min	0 Vdc
Pull-up	R1	4.99 kΩ
Low pass filter	R2	10 kΩ
	C1	33 nF
	RC	33 µs

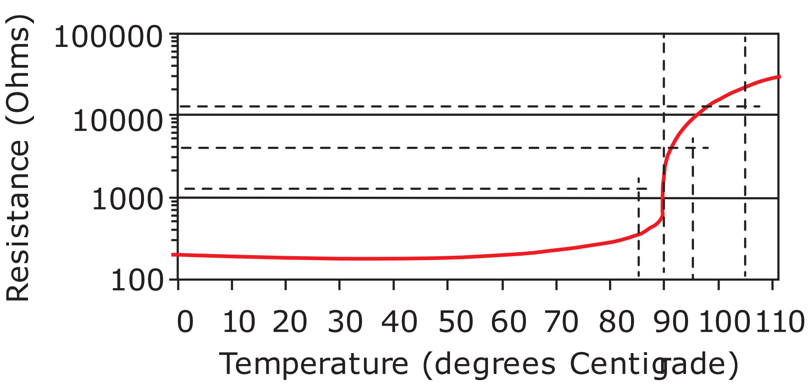


For VT+ = 2.5V, Rth = 4.99 k, For VT+ = 3.5V, Rth = 11.6 k
For VT- = 1.3V, Rth = 1.75k, For VT- = 1.5V, Rth = 3.92k
Rth is either a single sensor, or a sum of them in series as shown in the above table.

CONNECTIONS

Signal	J1 Pins
IN6	10

J1 Sgnd Pins
4,11,12,17,18,28,31,33,34,49,50

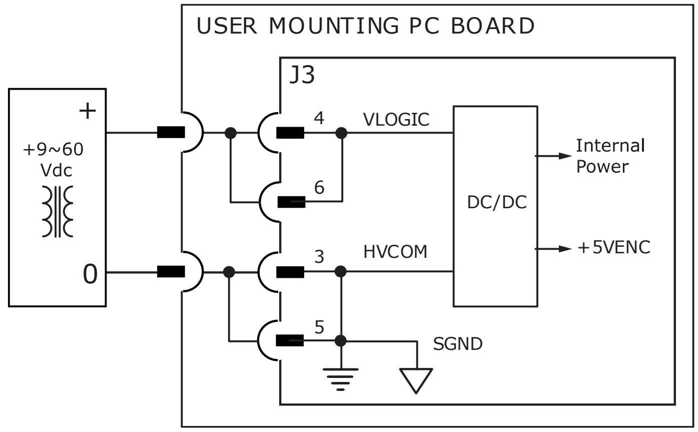


Property	Value	Units
Resistance in the temperature range -20°C to 70°C	60 to 750	Ohms
Resistance at 85°C	≤1650	Ohms
Resistance at 95°C	≥3990	Ohms
Resistance at 105°C	≥12000	Ohms
Response time (RC) for a 20°C to 100°C temperature change to produce an overtemp error	≤3	Seconds
Maximum continuous voltage	30	Vdc

4.19 VLOGIC

DESCRIPTION

VLOGIC powers the internal logic and control circuits in the drive. When using the STO feature, it must be produced by power supplies with transformer isolation from the mains and PELV or SELV ratings and a maximum output voltage of 60 Vdc. If the motor can operate from voltages of 55 Vdc or less, the +HV and VLOGIC can be driven from a single power supply.

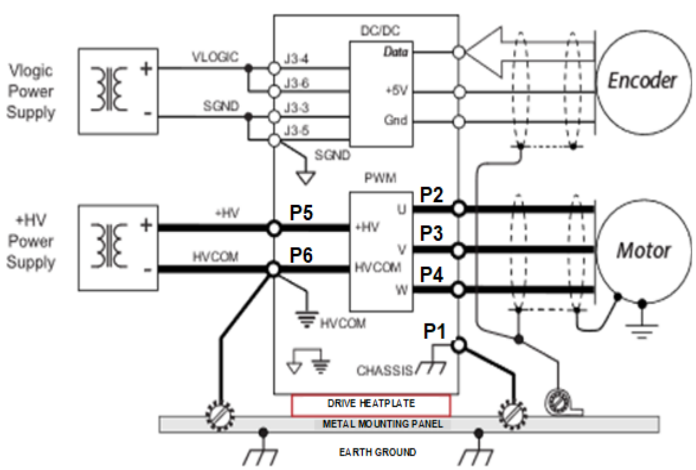


Signal	J3 Pins
VLOGIC	4, 6
HVCOM	3, 5

4.20 +HV, VLOGIC, and GROUND

The drive main power, +HV, is typically supplied by unregulated DC power supplies. These must be isolated from the mains, and all circuits should be grounded to earth at some point. The +HV supply connects to P5 and P6. For good wiring practice, the +HV wires should be twisted together for noise suppression, and the power supply should not be grounded. Doing this ensures that the higher currents flowing in these conductors will not flow through any circuit grounds where they might induce noise.

During deceleration, mechanical energy in the motor and load is converted back into electrical energy that must be dissipated as the motor comes to a stop. While some of this is converted to heat in the motor windings, the rest of it will flow through the drive into the power supply. An external storage capacitor should be used if the load has appreciable inertia, and this should be sized such that adding the undissipated energy from the motor will not raise the voltage beyond the point at which the drive shuts down. When this is not possible, an external 'dumper', or regenerative energy dissipater must be used which acts as a shunt regulator across the +HV and Gnd terminals.



Signal	J3 Pins
VLOGIC	4, 6
HVCOM	3, 5

Signal	Pins
+HV	P5
HVCOM	P6

Description	Data
Wire size	22~10 AWG
Recommended Wire	22~10 AWG, 600 V, Shielded cable required for CE compliance

PE CONNECTIONS

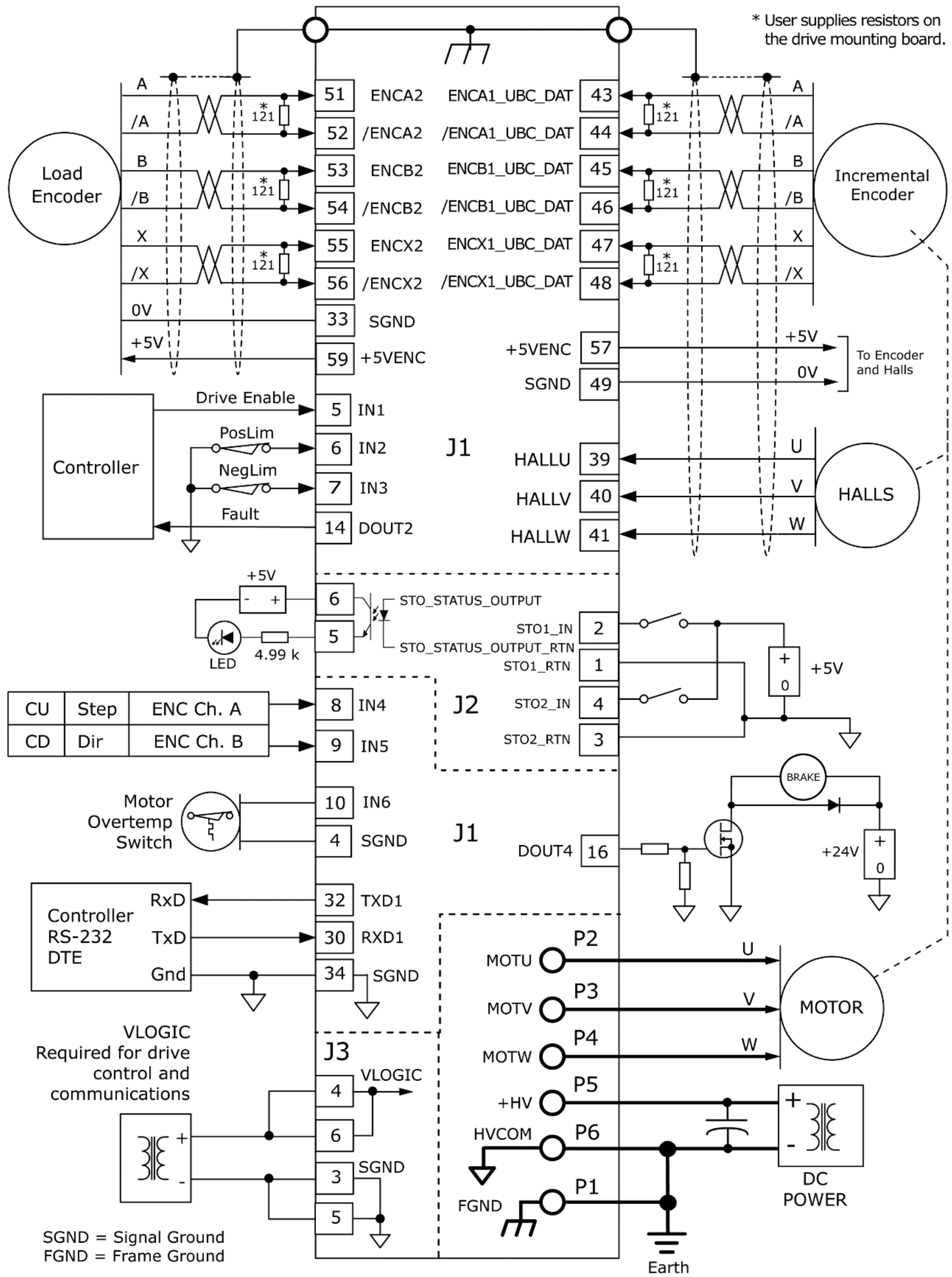
There should be a connection between the PE (Protective Earth) terminal to an earthed grounding point. HVCOM and Signal Ground are connected in the drive. This wiring ensures that the motor frame will always be at ground potential. Using shielded cable which connects to the motor frame and earth ground close to the drive provides a return path for currents induced in the shield and motor by the PWM outputs. P-clamps provide the best way to ground the shield for high-frequency noise suppression.

4.21 Typical Connections

Incremental Encoder

The following diagram shows the NES/NPS connections.

Note: In the diagram, the asterisk indicates the user is required to supply the resistors on the user mounting board.

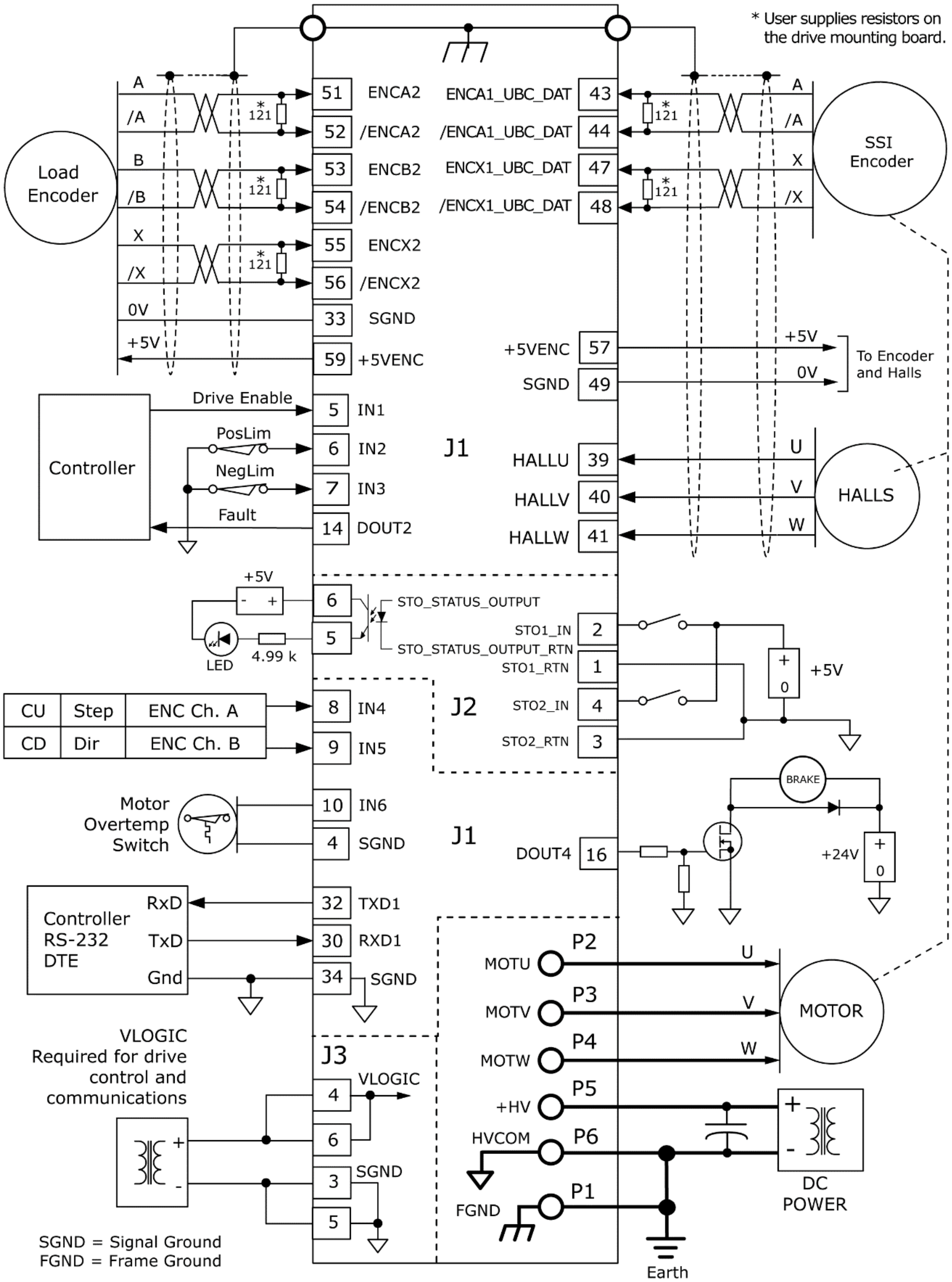


NES/NPS Connections Diagram

SSI Absolute Encoder

The following diagram shows the NES/NPS connections.

Note: In the diagram, the asterisk indicates the user is required to supply the resistors on the user mounting board.

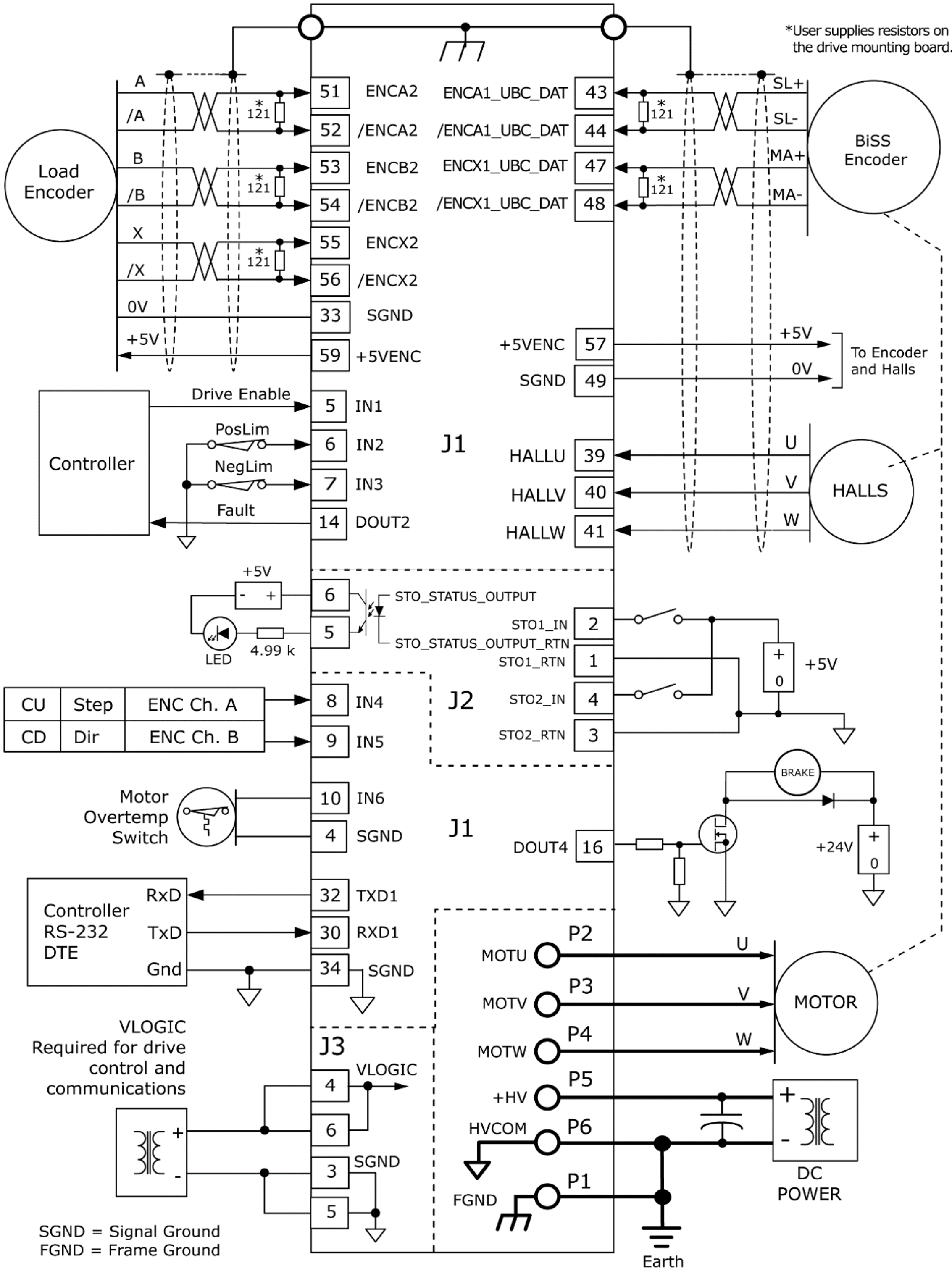


NES/NPS Connections Diagram

BiSS Absolute Encoder

The following diagram shows the NES/NPS connections.

Note: In the diagram, the asterisk indicates the user is required to supply the resistors on the user mounting board.



NES/NPS Connections Diagram

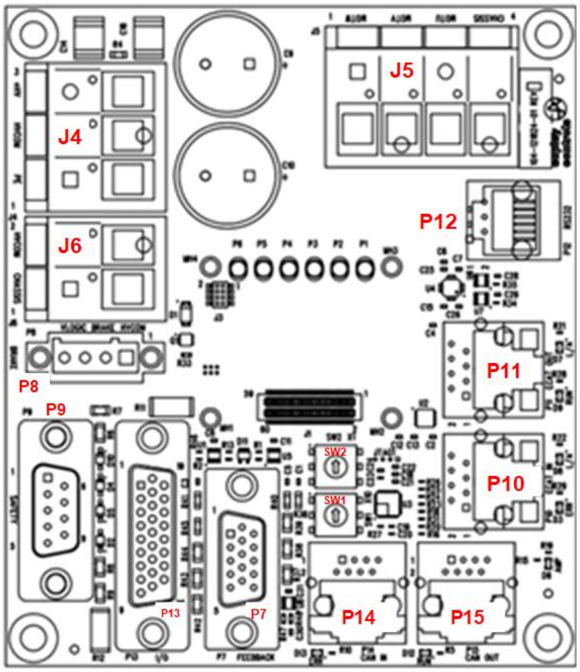
5 Connections and Wiring: -D Boards

5.1 NES/NPS-D Board Connectors

The NES/NPS-D board provides mounting and connectivity for one NES or NPS drive.
Dual network connectors make devices easily connected.

J4 +HV

Signal	Pin
+HV	3
HVCOM	2
PE	1



J5 MOTOR

Pin	Signal
1	MOTW
2	MOTV
3	MOTU
4	FGND

P12 RS-232

Pin	Signal
6	N.C.
5	TxD
4	SGND
3	SGND
2	RxD
1	N.C.

J6 GROUNDS

Signal	Pin
HVCOM	2
FGND	1

P10 ECAT IN

Pin	Signal
8	FGND
7	N.C.
6	RXNA [RX1-]
5	VDD33TXRX1
4	RXPA [RX1+]
3	TXNA [TX1-]
2	VDD33TXRX1
1	TXPA [TX1+]

P11 ECAT OUT

Pin	Signal
8	FGND
7	N.C.
6	RXNB [RX2-]
5	VDD33TXRX2
4	RXPB [RX2+]
3	TXNB [TX2-]
2	VDD33TXRX2
1	TXPB [TX2+]

P9 STO

Signal	Pin		Signal
FGND	1	6	STO_STATUS_OUTPUT
STO1_24V_IN	2	7	STO_STATUS_OUTPUT_RTN
STO1_RTN	3	8	SGND
STO2_24V_IN	4	9	VLOGIC +24V
STO2_RTN	5		

P13 I/O & Encoder 2

Pin	Signal
1	FGND
2	REFIN1-
3	REFIN+
4	IN1_24VTOL
5	IN2_24VTOL
6	IN3_24VTOL
7	IN4
8	N.C.
9	N.C.

Pin	Signal
10	IN5
11	N.C.
12	N.C.
13	N.C.
14	N.C.
15	SGND
16	DOUT1
17	DOUT2
18	DOUT3

Pin	Signal
19	SGND
20	+5VENC
21	/ENCX2
22	ENCX2
23	/ENCB2
24	ENCB2
25	/ENCA2
26	ENCA2

P7 ENCODER 1

Pin	Signal
1	FGND
2	REFIN1-
3	HALLU
4	+5VENC
5	SGND

Pin	Signal
6	HALLV
7	/ENCX1_UBC_CLK
8	ENCX1_UBC_CLK
9	HALLW
10	OVERTEMP_IN

Pin	Signal
11	/ENCB1
12	ENCB1_
13	/ENCA1_UBC_DAT
14	ENCA1_UBC_DAT
15	SGND

NES/NPS-D Board Connectors (Continued)

Connex	Name	Description	Manufacturer P/N
J1	I/O	60 Pin dual row 0.50 mm socket	WCON: 3620-S060-022G3R02
J2	STO	6 Pin dual row 1.00 mm socket	Samtec: CLM-103-02-L-D-BE
J3	VLOGIC	8 Pin dual row 1.00 mm header	WCON: 2521-204MG3CUNR1
P1~6	+HV, Gnds, Motor	6 Pin sockets, single row	Winpin: WP-WJ01863B1
J4	+HV Power	3 Pin single row 4 mm lever actuated terminal block	Wago: 2606-3103/020-000
J5	Motor output	4 Pin single row 4 mm lever actuated terminal block	Wago: 2606-3104/020-000
J6	HVCOMM & FGND	2 Pin single row 4 mm lever actuated terminal block	Wago: 2606-3102/020-000
P7	Primary Feedback	15 Pin high-density vertical D-Sub	Harting: 09561517512
P8	VLOGIC, Brake	4 Pin single row 1.27 mm header	Wago: 734-134/108-000
P9	Safety	9 Pin standard density vertical D-Sub	KYCON: K88X-ED9SBR
P10/P11	EtherCAT Network	Vertical RJ-45 connector with magnetics	BEL FUSE INC: SI-16001-F
P12	RS-232	Serial data communication	Molex: 42410-6170
P13	Secondary Fdbk	26 Pin high-density vertical D-Sub	Harting: 09562517512
P14/P15	CANopen Network	Vertical RJ-45 connector	BEL FUSE INC: SS-60000-008

Note:
Connectors J1~J3 and P1~P6 connect only to the drive when it is affixed to the DEV board.
All other connectors connect to the user’s mounting board.

5.2 P9: STO Safe Torque Off

P9 Receptacle

Data	Development Kit
Description	D-sub, 9 pole, female
Manufacturer PN	Kycon, K88X-ED9SBR

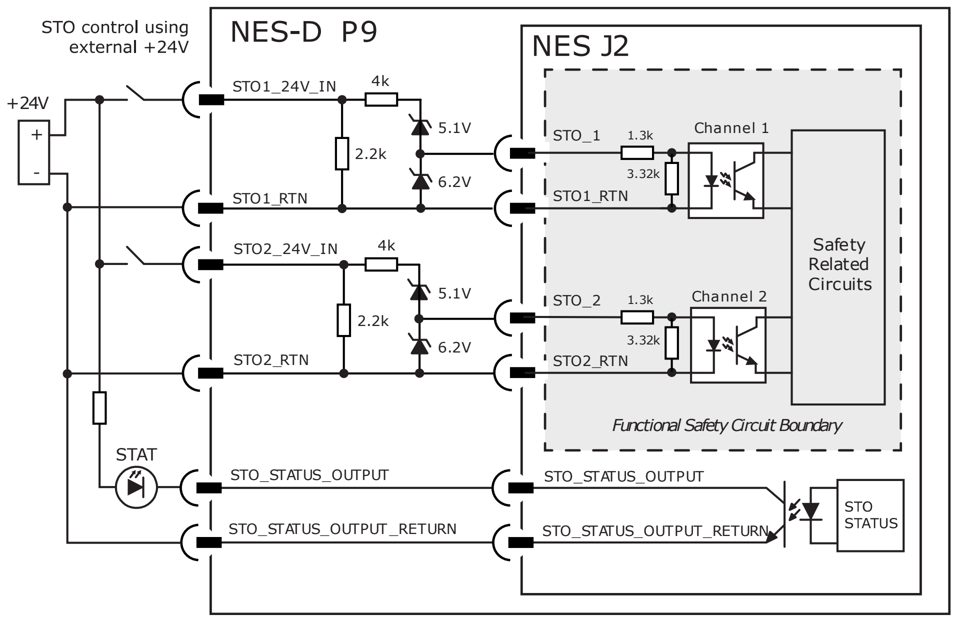
P9 Plug

Data	Development Kit
Description	D-sub, 9 pole, male, solder cup
Manufacturer PN	Norcomp, 171-009-103L001
Description	Backshell, DB-9
Manufacturer PN	Norcomp, 979-009-020R-121

Signal	Description
Vin-Low	≤ 6.00 Vdc or open
Vin-High	≥ 15.0 Vdc
Vin-Typical	24 Vdc
Vin-Max	30 Vdc
Input current	11.2 mA @ Vin = 24 Vdc
Response Time	1.5 ms from Vin ≤ 6.0 Vdc to interrupt torque produced in the motor

P9 Plug Signals

Signal	P9 Pins	Signal	P9 Pins
FGND	1	STO_STATUS_OUTPUT	6
STO1_24V_IN	2	STO_STATUS_OUTPUT_RTN	7
STO1_RTN	3	SGND	8
STO2_24V_IN	4	VLOGIC	9
STO2_RTN	5		



Important Note: If the STO inputs are driven from a single 24V power supply, they must be connected in parallel. Both (+) inputs are connected in parallel and connect to STO-Bypass or a 24V source. All (-) inputs are connected in parallel and connect to STO-GND or Sgnd.

5.3 P12: RS-232

Receptacle

Description	Modular jack, 1 port, 6 pole
Manufacturer PN	Molex, 42410-6170

Signals

P12 Pin	Signal	Function
1	N/C	No connection
2	RxD	Receive data input from computer
3	Sgnd	Signal Ground
4	Sgnd	Signal Ground
5	TxD	Transmit data output to computer
6	N/C	No connection

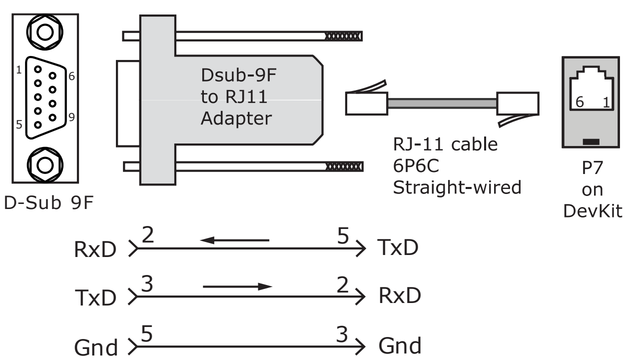
Note: 6-position, 4-contact, modular connector (RJ-11 style).

RS-232 Serial Cable Kits

Part Number	Description
SER-CK	Serial Cable Kit: 9-Pin Dsub receptacle to 6-pin modular adapter, plus modular cable for Development Kit.
SER-USB-RJ11	Serial Interface Cable: USB to RJ11

This table shows the part numbers for different drive families:

SER-CK Serial Cable Kit Signals



Dsub Signal	Pin	Color	Pin	Drive Signal
Rxd	2	Green	5	TxD
TxD	3	Red	2	RxD
Ground	5	Black	3	Sgnd

SER-USB-RJ11 Cable Kit

This device provides connectivity between a USB connector and the RJ-11 connector P12 on the EZ board.

5.4 P13: Digital Command Inputs Position

STAND-ALONE MODE DIGITAL POSITION-CONTROL INPUTS

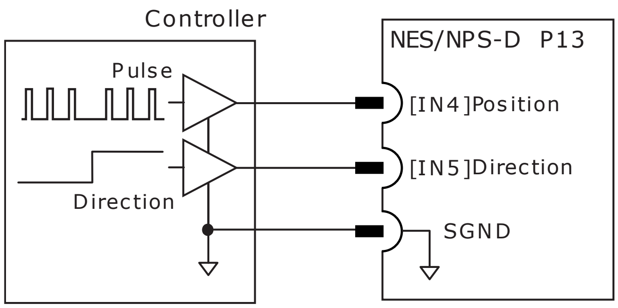
NES/NPS works with motion controllers that output pulses to command position.
These formats are supported:

- Step/Direction
- Count-Up/Count-Down (CU/CD)
- A/B Quadrature Encoder

In Step/Direction mode, a pulse-train controls motor position, and the direction is controlled by a DC level at the Direction input. CU/CD (Count-Up/Count-Down) signals command the motor to move CW or CCW depending on which input the pulse-train is directed to. The motor can also be operated in an electronic gearing mode by connecting the inputs to a quadrature encoder on another motor. In all cases the ratio between input pulses and motor revolutions is programmable.

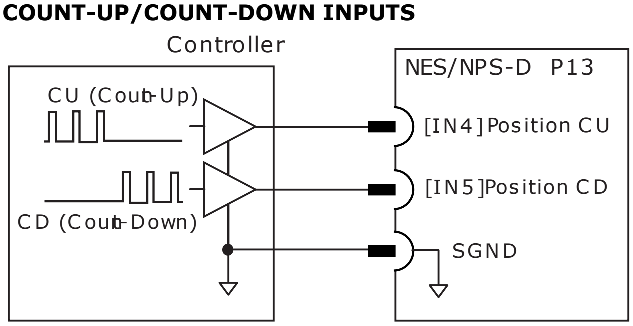
In Quad A/B mode, two signals that emulate encoder outputs control position, direction, and velocity.

STEP/DIRECTION INPUTS



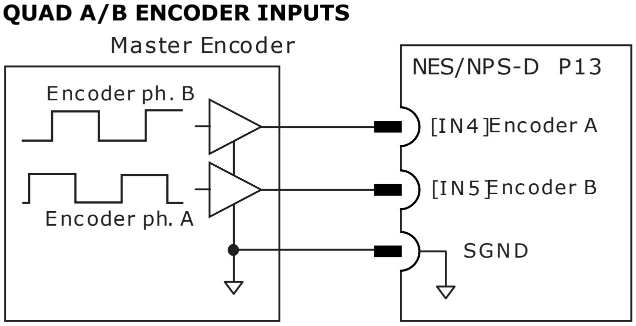
Signal	P13 Pins
IN4	7
IN5	10

COUNT-UP/COUNT-DOWN INPUTS



P13 Sgnd Pins
15,19

QUAD A/B ENCODER INPUTS



5.5 P7: Primary Feedback Enc1

Digital Quad A/B incremental and absolute BiSS-C and SSI encoders are supported.

Receptacle

Data	Development Kit
Description	D-Sub High Density, 15 pole, female
Manufacturer PN	Harting: 09561517512

Plug

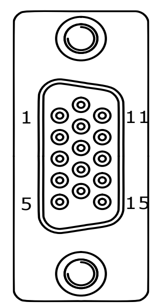
Description	D-Sub High Density, 15 pole, male, solder cup
Manufacturer PN	Norcomp, 180-015-103L001
Description	Backshell, 9 positions, metallized plastic
Manufacturer PN	3M: 3357-9209
Plug is included in EZ Development Board Connector Kit NS-D-CK	

Plug Signals

Pin	Signal
1	FGND
2	+5VENC
3	HALLU
4	+5VENC
5	SGND

Pin	Signal
6	HALLV
7	/ENCX1_UBC_CLK
8	ENCX1_UBC_CLK
9	HALLW
10	OVERTEMP_IN

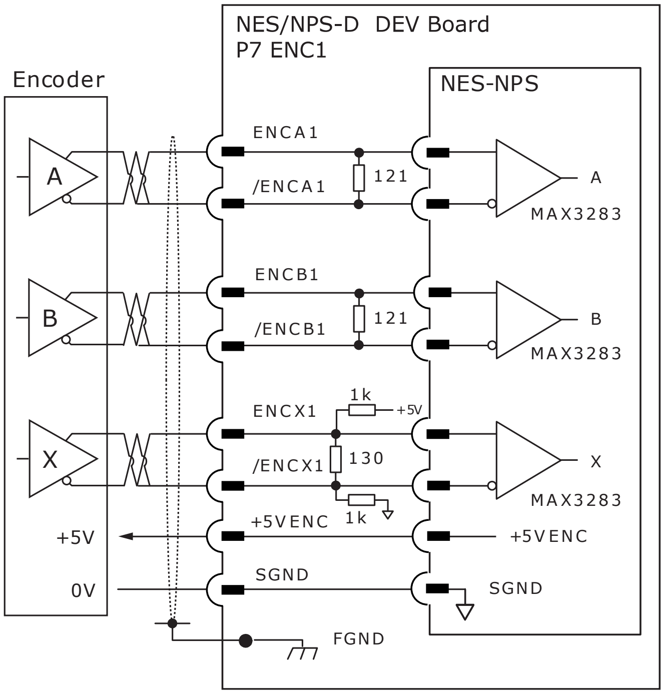
Pin	Signal
11	/ENCB1
12	ENCB1
13	/ENCA1_UBC_DAT
14	ENCA1_UBC_DAT
15	SGND



P7: Quad A/B with Index

Encoders with differential line-driver outputs are required (single-ended encoders are not supported) and provide incremental position feedback via the A/B signals. The optional index signal (X) gives a once per revolution position mark.

ENC1 is the Motor encoder and should be used in single-encoder applications.
In dual-encoder applications, it can be assigned as Primary or Secondary using CME.



Signal	P7 Pins
ENCA1_UBC_DAT	14
/ENCA1_UBC_DAT	13
ENCB1	12
/ENCB1	11
ENCX1_UBC_CLK	8
/ENCX1_UBC_CLK	7
+5VENC	2,4
SGND	5,15
FGND	1

P7: SSI Absolute Encoder

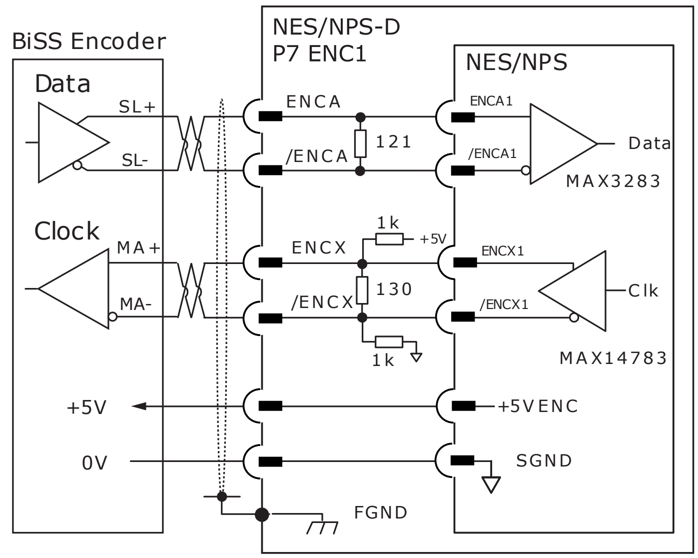
The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The drive provides a train of clock signals in differential format to the encoder which initiates the transmission of the position data on the subsequent clock 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.

Signal	SSI	BiSS	P4 Pins
Enc1 X	SCLK	MA+	8
Enc1 /X	/SCLK	MA-	7
Enc1 A	SDATA	SL+	14
Enc1 /A	/SDATA	SL-	13
+5V			2,4
SGND			5,15

P7: 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.

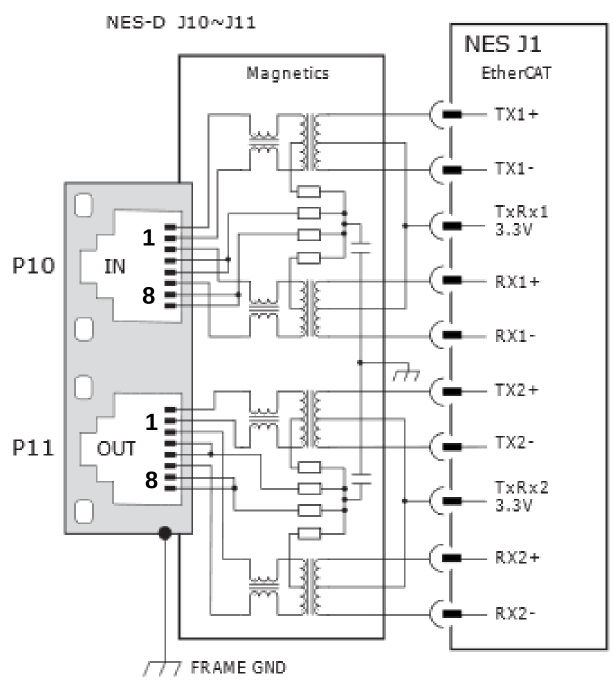
- Serial Synchronous Data Communication
- Cyclic at high speed
- 2 unidirectional lines Clock and Data
  - -Line delay compensation for high speed data transfer
  - -Request for data generation at slaves
  - -Safety capable: CRC, Errors, Warnings
  - -Bus capability incl. actuators
- Bidirectional
-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



5.6 P10-P11 Plug NES EtherCAT Signals

Pin	P10 Signal	Function
1	TX2+	Transmit data +
2	TX2-	Transmit data-
3	RX2+	Receive data +
4	TXRX2 Term	Terminator
5	TXRX2 Term	Terminator
6	RX2-	Receive data -
7	TXRX2 Term	Terminator
8	TXRX2 Term	Terminator

Pin	P11 Signal	Function
1	TX1+	Transmit data +
2	TX1-	Transmit data-
3	RX1+	Receive data +
4	TXRX1 Term	Terminator
5	TXRX1 Term	Terminator
6	RX1-	Receive data -
7	TXRX1 Term	Terminator
8	TXRX1 Term	Terminator



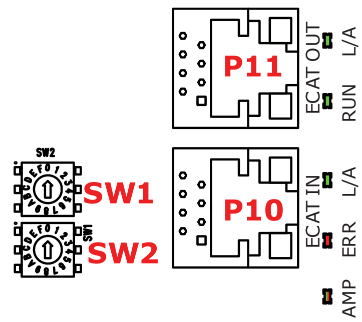
Dual RJ-45 sockets accept standard Ethernet cables and are categorized as 100BASE-TX (100 Mb/sec) ports. Cat 5 or Cat 5e (or higher) cables should be used. The IN port connects to a master, or to the OUT port of a device that is ‘upstream’ between the drive and the master. The OUT port connects to ‘downstream’ nodes. If a drive is the last node on a network, only the IN port is used. No terminator is required on the OUT port.

P10-11 NES EtherCAT Status Indicators

Reference the ETG.1300 standard which defines the LED operation and labeling of the LEDs.

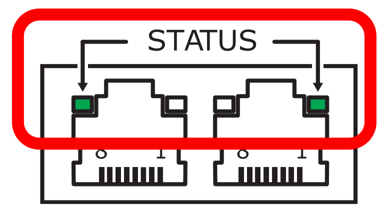
RUN Green: Shows the state of the ESM (EtherCAT State Machine).	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Safe-operational
ON	= Operational
ERR Red: Shows errors such as watchdog timeouts and unsolicited state changes in the NES due to local errors.	
OFF	= EtherCAT communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	= Local error, slave has changed EtherCAT state autonomously.
DOUBLE FLASH	= PDO or EtherCAT watchdog timeout, or an application watchdog timeout has occurred.

L/A Green: Indicates the state of the physical EtherCAT network and activity on the network:			
LED	**Link**	**Activity**	**Condition**
ON	Yes	No	Port Open
FLICKERING	Yes	Yes	Port Open with activity
OFF	No	(N/A)	Port Closed



CANopen Network Status Indicators: NPS

RUN Green: Shows the state of the CANopen network state machine.	
OFF	= INIT
BLINKING	= Pre-operational
SINGLE-FLASH	= Stopped
ON	= Operational
ERR Red: Shows status of CAN physical layer and errors such as watchdog timeouts and unsolicited state changes in the drive due to local errors.	
OFF	= No errors, communications are working correctly.
BLINKING	= Invalid configuration, general configuration error.
SINGLE FLASH	= Warning limit reached; an error counter of the CAN controller has reached or exceeded the warning level.
DOUBLE FLASH	= Error control event. A guard event or heartbeat event has occurred.
ON	Bus off. The CAN controller is bus off.

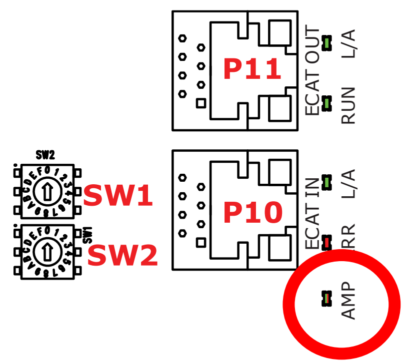


AMP STATUS LED

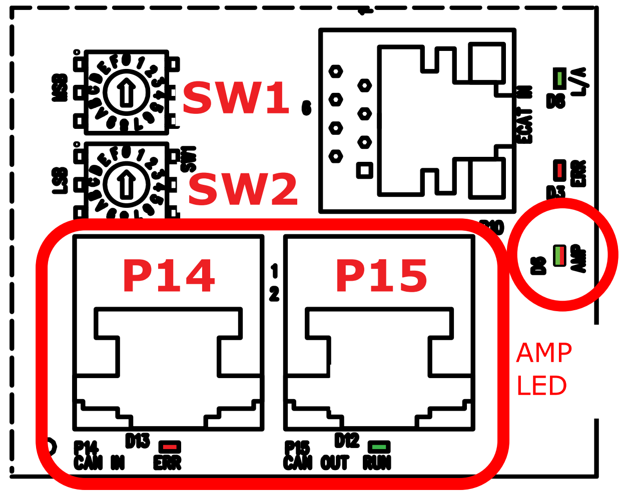
A bi-color LED gives the state of the drive. Colors do not alternate and can be solid ON or blinking. If multiple conditions occur, only the top-most condition will be displayed. When that condition is cleared the next one below will show.

LED	Description
RED/BLINKING	= Latching fault. Operation can not resume until drive is Reset.
RED/SOLID	= Transient fault condition. Drive can resume operation when the condition causing the fault is removed.
GREEN/SLOW-BLINKING	= Drive OK but NOT-enabled. Can run when enabled.
GREEN/FAST-BLINKING	= Positive or Negative limit switch active. Drive can only move in direction inhibited by limit switch.
GREEN/SOLID	= Drive OK and enabled. Can run in response to reference inputs or EtherCAT commands.

Latching Faults (* Default)	Optional (Programmable)
Short circuit (Internal or external)	Over-voltage
Drive over-temperature	Under-voltage
Motor over-temperature	Motor Phasing Error
Feedback Error	Command Input Lost
Following Error	Motor Wiring Disconnected
STO Active	Over Current (latched)



5.7 P14-P15: CAN Network



P14-P15 NPS CAN SIGNALS

Pin	Signal
1	CAN_H
2	CAN_L
3	CAN_GND
4	*
5	*
6	*
7	CAN_GND

*Note: These signals are pass-through from P14 to P15 and have no connections to the drive circuits.

DRIVE STATUS AMP LED

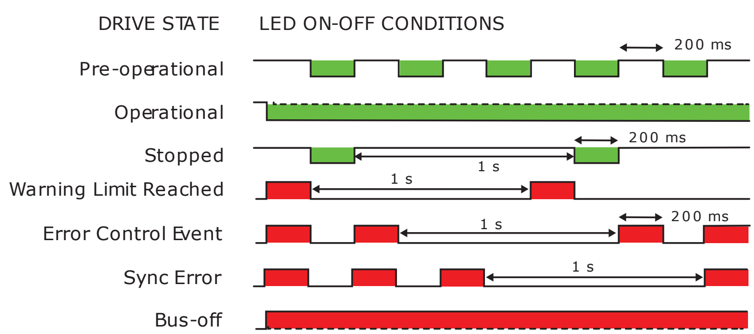
A bi-color LED "AMP" gives the state of the drive. Colors do not alternate and can be solid ON or blinking. If multiple conditions occur, only the top-most condition will be displayed.
When that condition is cleared, the next condition (in the table below) will show.

LED	Description
RED/BLINKING	= Latching fault. Operation can not resume until drive is Reset.
RED/SOLID	= Transient fault condition. Drive can resume operation when the condition causing the fault is removed.
GREEN/SLOW-BLINKING	= Drive OK but NOT-enabled. Can run when enabled.
GREEN/FAST-BLINKING	= Positive or Negative limit switch active. Drive can only move in direction inhibited by limit switch.
GREEN/SOLID	= Drive OK and enabled. Can run in response to reference inputs or CANopen commands.

Latching Faults (* Default)	Optional (Programmable)
Short circuit (Internal or external)	Over-voltage
Drive over-temperature	Under-voltage
Motor over-temperature	Motor Phasing Error
Feedback Error	Command Input Lost
Following Error	Motor Wiring Disconnected
STO Active	Over Current (latched)

CANOPEN NETWORK STATUS INDICATORS: NPS

The green LED "RUN" shows the state of the CAN state machine.
The red LED "ERR" shows the status of the CAN physical layer and errors due to missing messages.



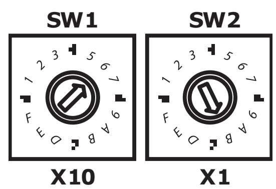
Green = RUN, Red = ERR

CAN & EtherCAT Network Device ID

When a device must have a positive identification a Device ID i1 s needed. In the Dev board 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 SW1 that is less than 107 and set SW1 to the hex value in the same row: 96 < 107 and 112 > 107, so SW1 = 96 = Hex 6
2) Subtract 96 from the desired Device ID to get the decimal value of switch SW2 and set SW2 to the Hex value in the same row: SW2 = (107 - 96) = 11 = Hex B



CAN
Device ID Switch
Decimal Values

	SW1	SW2
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	Not used for CAN Addr	8
9		9
A		10
B		11
C		12
D		13
E		14
F		15

5.8 P8: VLOGIC & Brake

Receptacle

Description	Connector, female, 4-pole, 3.5 mm
Manufacturer	Wago: 734-134/108-000

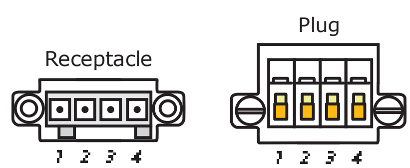
Plug

Description	Plug, female, screw flange, 4-pole, 3.5 mm
Manufacturer PN	Wago: 734-104/107-000
Wire Size	AWG 28~14 solid, 0.08~1.5 mm^2 fine stranded

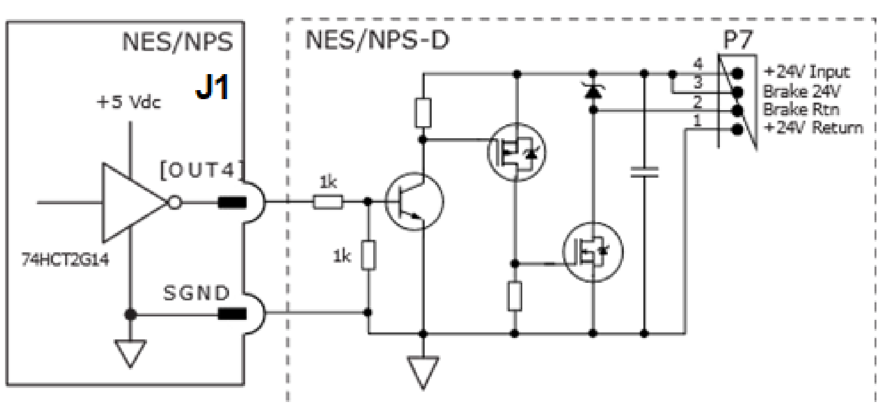
Plug included in NES/NPS-D Connector Kit NS-D-CK

Signals

Pin	Signal
4	VLOGIC
3	Brake
2	Brake
1	HVCOM



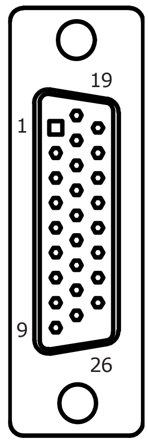
Output	Data
Voltage Range	+60 Vdc
Output Current	1.0 Adc

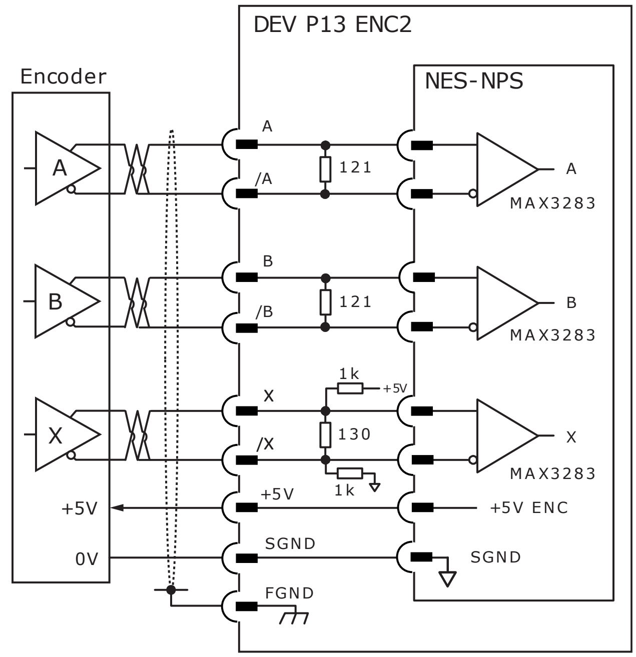


5.9 P13: Secondary Feedback Encoder2

ENC2 supports Quad A/B/X encoders.
Absolute encoders are not supported.

Signal	P13 Pins
Enc2 A	26
/Enc2 A	25
Enc2 B	24
/Enc2 B	23
Enc2 X	22
/Enc2 X	21
+5V	20
SGND	15,19





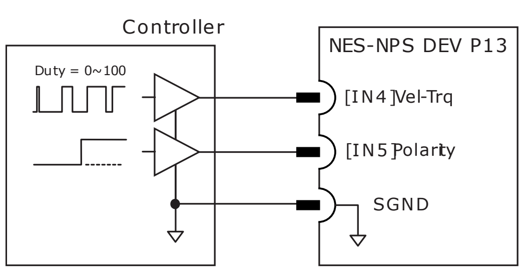
5.10 P13: Digital Command Inputs: Velocity, Torque

Stand-Alone Mode Digital VELOCITY/TORQUE CONTROL Inputs

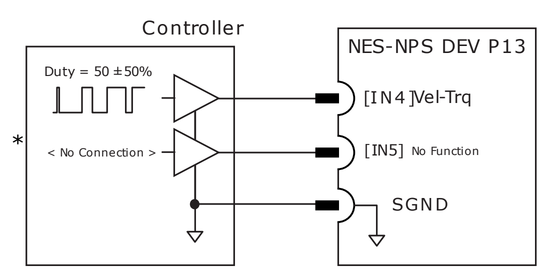
NANO drives work with motion controllers that output pulses to command velocity and torque (current). These formats are supported:

- PWM/Direction
- PWM 50%

In PWM/Direction mode, a pulse-train with variable duty-cycle controls motor Vel/Trq, and the polarity or direction is controlled by HI/LO levels at the Direction input.
With PWM 50% operation there is a single signal. A 50% duty cycle produces zero output. Increasing the duty cycle to 100% produces a full-scale output in one direction and 0% duty cycle produces a full-scale output in the opposite direction.



PWM/DIRECTION INPUTS



PWM 50%

5.11 NES/NPS-D Connector Kit: NS-D-CK

Ref	Name	Description	Manufacturer P/N	QTY
P7	Primary Feedback	15 Pin high-density vertical D-Sub	Norcomp: 180-015-103L001	1
P8	VLOGIC, Brake	Terminal block, 4 Pin single row	Wago: 734-104/107-000	1
P9	Safety	9 Pin standard density vertical D-Sub	AMP: 205204-4	1
		Contacts, crimp, snap-in, 24~20 AWG	TE: 66506-9	9
P7, P9	See P7, P9	Connector shell, 9 pin	3M: 3357-9209	2
P13	I/O	26 Pin high-density vertical D-Sub	Norcomp: 180-026-103L001	1
		Metal shell, 15 pin	3M: 3357-9215	1
P8	Tool	For P8	Wago: 734-231	1

5.12 P13: I/O Receptacle

Description	D-sub, 26 pole, high-density, female
Manufacturer PN	Harting: 09562517512

Plug

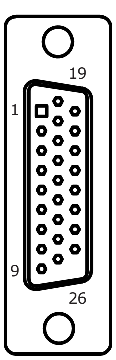
Description	D-sub, 26 pole, high-density, male, solder-cup
Manufacturer PN	Norcomp, 180-026-103L001
	Metal shell, 15 pin
Wire Size	AWG 28~12 solid, 0.08~2.5 mm^2 fine stranded

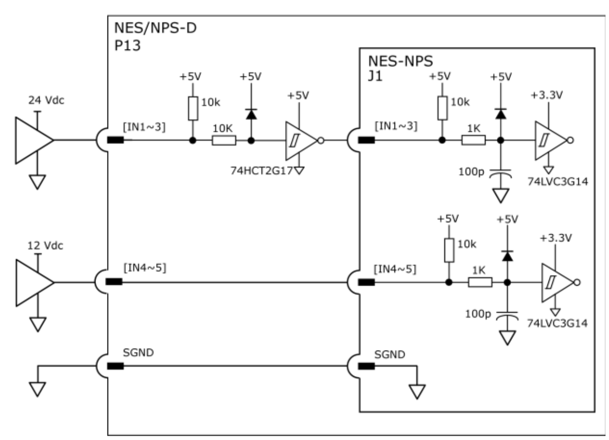
Plug Signals

Pin	Signal
1	FGND
2	Aref--
3	Aref+
4	IN1 24V
5	IN2 24V
6	IN3 24V
7	IN4 12V
8	N.C.
9	N.C.

Pin	Signal
10	IN5 12V
11	N.C.
12	N.C.
13	N.C.
14	N.C.
15	SGND
16	OUT1
17	OUT2
18	OUT3

Pin	Signal
19	SGND
20	+5V
21	Enc2 /X
22	Enc2 X
23	Enc2 /B
24	Enc2 B
25	Enc2 /A
26	Enc2 A

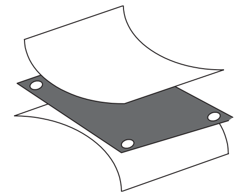


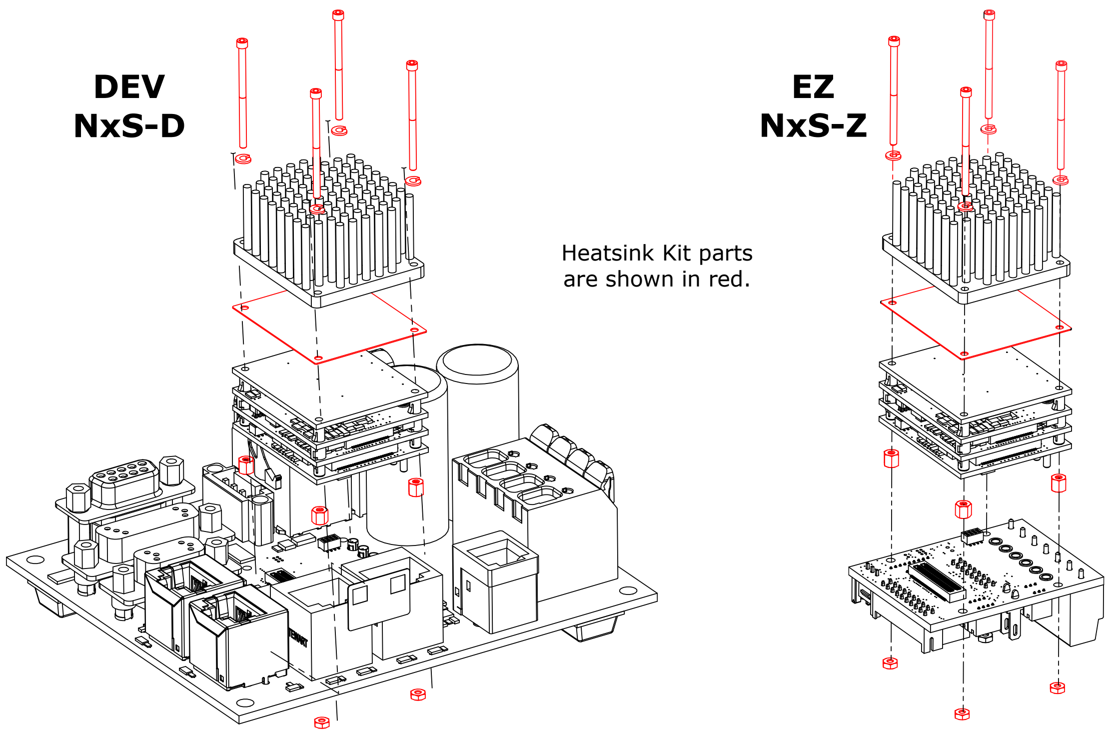


5.13 DEV & EZ Boards Heatsink Mounting

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 heatplate, 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 heatplate all line up.
5: Torque the M2.5 mm mounting screws to 4 in-lb, 64 in-oz, 0.45 Nm.



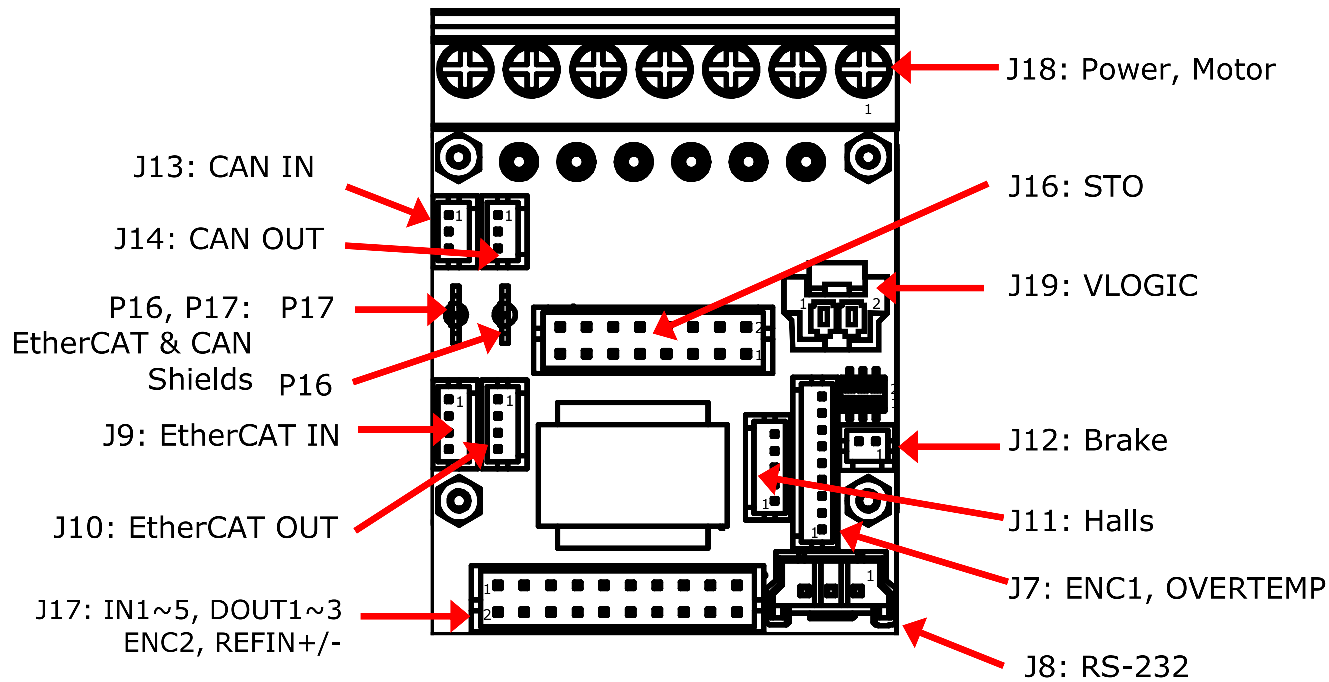


-HK Heatsink Kit	**Quantity**
Heatsink: pin-fin, 35 x 30.9 x 18.5 mm, aluminum	1
Thermal pad, die cut, 35 x 30.9 x 18.5 mm	1
Hardware Kit for N-HK	1
Tool: wedge-tip, hook-tip, polymer, 5-pak	1
Assembly drawing	1

Hardware Kit for N-HK	**Quantity**
Standoff: 0.120 tall, .125 hex, 080 thread, aluminum	4
Screws: Machine, 0-80X1, hex socket cap, part threaded 18-8 SS	4
Nuts: 0-80 1/8 HEX .05 THK 18-8 SS	4
Washers: LK SPLIT NO 0 .062 ID .137 OD .017 THK 18-8 SS	4

6 Connections and Wiring: -Z Boards

6.1 Connectors



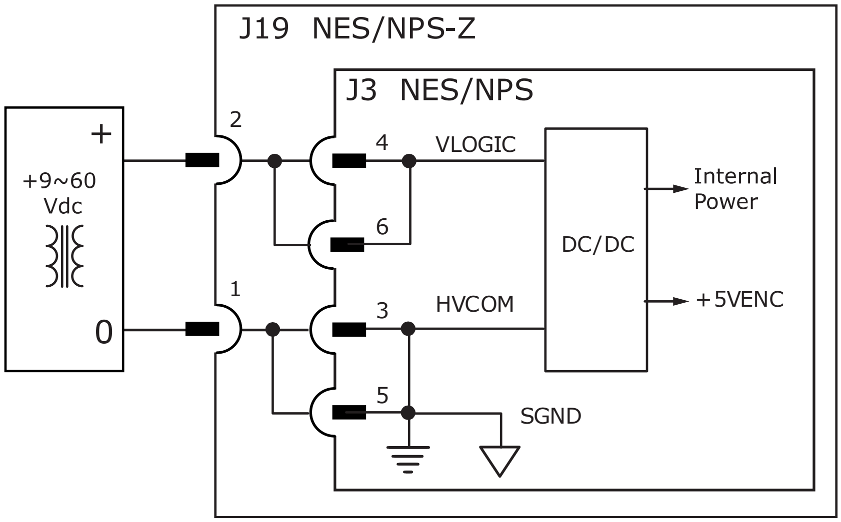
Ref	Name	Description	Manufacturer P/N
J7	ENC1, Motemp	9 Pin Header, 1.25mm, single row	Hirose: DF13-9P-1.25DSA(76)
J8	RS-232	3 pin header, 2mm, 2A per pin	Molex: 035362-350
J9, J10	EtherCAT IN	Hirose: 1.25mm pitch miniature crimping connector,4 pin	Hirose: DV13-4P-1.25DSA(76)
J11	Halls	5 pin header, 1.25mm, single row	Hirose: DF13-5P-1.25DSA(76)
J12	Brake	Brake: 2 pin header, 1.25mm, single row	Hirose: DF13-2P-1.25DSA(76)
J13, J14	CAN	3 pin header, single row, 1.25mm	Hirose: DF13-3P-1.25DSA
J16	STO	16 Pin dual row header, 2mm	Hirose: DF11-16DP-2DSA
P16~17	CAN & ECAT Shields	FASTON tabs, 0.110	TE: 735187-2
J17	Signal: In, Out, ENC2, REFIN	20 pin dual row, 2mm, 2A per pin	Hirose: DF11-20DP-2DSA
J18	Motor, +HV, Grounds	7 pin high current connector, 20A	Phoenix: 1935828
J19	VLOGIC	2 pin header, 2mm, 2A per pin	Molex: 035362-0250

6.2 EZ-OEM Connector Kit: NS-Z-CK

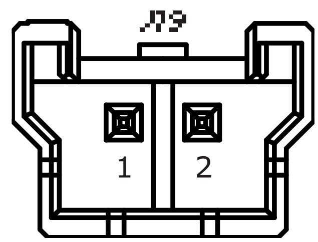
Qty	Ref	Name	Description	MFGR Part Number
1	J12	Brake	CONN WIRE-MT HSG SKT 1X2P 1.25MM LKG NYL BEIGE	Hirose: DF13-2S-1.25C
2	J13, J14	CAN	CONN WIRE-MT HSG SKT 1X3P 1.25MM LKG NYL BEIGE	Hirose: DF13-3S-1.25C
2	J9, J10	EtherCAT	CONN WIRE-MT HSG SKT 1X4P 1.25MM LKG NYL BEIGE	Hirose: DF13-4S-1.25C
1	J11	Halls	CONN WIRE-MT HSG SKT 1X5P 1.25MM LKG NYL BEIGE	Hirose: DF13-5S-1.25C
1	J7	ENC1, Motemp	CONN WIRE-MT HSG SKT 1X9P 1.25MM LKG NYL BEIGE	Hirose: DF13-9S-1.25C
24	J7,J9,J10, J11,J12,J13,J14		CONN CONTC SKT CRMP 30-26GA 1MM MAX INSUL DIA AU	Hirose: DF13-2630SCFA
1	J16	STO	CONN WIRE-MT HSG RCPT 2X8P 2X2MM LKG NYL BLK	Hirose: DF11-16DS-2C
1	J17	IN1~5, DOUT1~3, ENC2, AREF	CONN WIRE-MT HSG RCPT 2X10P 2X2MM LKG NYL BLK MATING 129846	Hirose: DF11-20DS-2C
36			CONN CONTC SKT CRMP 28-24GA 1.45MM MAX INSUL DIA AU	Hirose: DF11-2428SCFA(04)
1	J19	Vlogic	CONN WIRE-MT HSG RCPT 1X2P 2MM LKG POLYEST NAT	Molex: 35507-0200
1	J8	RS-232	CONN WIRE-MT HSG RCPT 1X3P 2MM LKG POLYEST NAT	Molex: 35507-0300
2	P16, P17	Cable Shields	FASTON RCPT .11-.125W .02THK 26-22GA POSTIVE LOCK	TE: 353249-2
3		DF13 Wires	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLK AU 12IN	Hirose:H4BBG-10112-B6
19		DF13 Prewire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD WHT AU 12IN	Hirose:H4BBG-10112-W6
20		DR11 Wires	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD WHT AU 12IN	Hirose:H3BBG-10112-W6
3		DF11 GP	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD RED AU 12IN	Hirose:H3BBG-10112-R6
3		DF13 Wire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD RED AU 12IN	Hirose:H4BBG-10112-R6
1		P6, HVCOM	CBL ASSY SKT CONTC TO FREE END 1COND 24GA 7STRD BLK SN 12IN	Hirose:0502128000-12-B4
1		J19, +VLOGIC	CBL ASSY SKT CONTC TO FREE END 1COND 24GA 7STRD RED SN 12IN	Hirose:0502128000-12-R4
3		DF11	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLK AU 12IN	Hirose:H3BBG-10112-B6
1		Brake Wire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLU AU 12IN	Hirose:H4BBG-10112-L6
1	J16	STO Bypass PCB	BD ASSY, STO BYPASS BOARD	Copley: NS-Z-STO

6.3 J19: VLOGIC

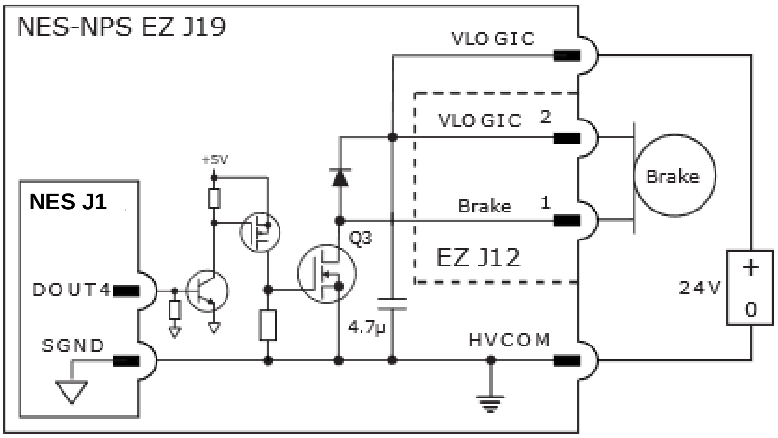
VLOGIC has a range of 9~60 Vdc.
It powers the internal control circuits and the circuit that provides +5V for encoders.

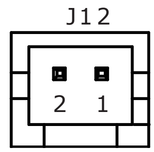


Pin	Signal
2	VLOGIC
1	SGND



6.4 J12: Brake





J12 Brake

Signal	Pins
VLOGIC	2
Brake	1

HI/LO Definitions: Outputs

Input	State	Condition
Brake (OUT4)	LO	Output MOSFET Q3 is OFF. Brake is un-powered and locks motor. Motor cannot move. Brake state is Active.
	HI	Output MOSFET Q3 is ON. Brake is powered, releasing motor. Motor is free to move. Brake state is NOT-Active.

Specifications

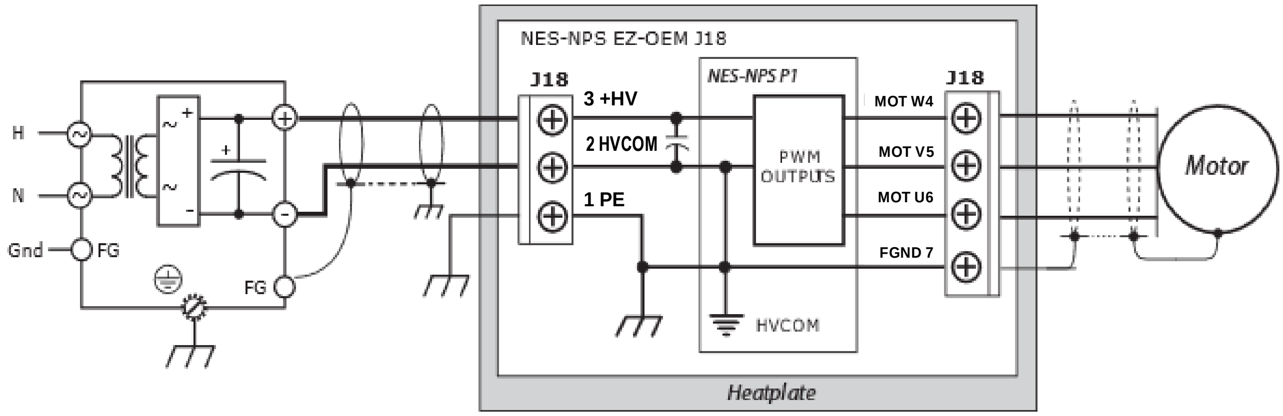
Output	Data	Notes
Voltage Range	Max	+30 Vdc
Output Current	Ids	1.0 Adc

CME Default Setting for Brake Output [OUT4] is "Brake - Active Low."

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 [OUT4] as LO.
BRK Output voltage is HI (24V), MOSFET Q3 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 [OUT4] as HI.
BRK output voltage is LO (~0V), MOSFET Q3 is ON.
Servo drive is enabled, PWM outputs are ON.
Servo drive output current is flowing.

6.5 J18: Motor, +HV, HVCOM, FGND



Name	Description	Manufacturer P/N
J18	High Current Connector	Wago: 2606-3103/020-000

Description	Data
Wire size	22~10 AWG
Recommended Wire	22~10 AWG, 600 V, Shielded cable required for CE compliance

Pin	Signal
3	+HV
2	HVCOM
1	PE

Pin	Signal
4	Motor W
5	Motor V
6	Motor U
7	FGND

+HV
The +HV power supply outputs connect to J18 pins 2 & 3. The cable shield shown is optional and is primarily for reduction of RF emissions from the drive. As shown, it connects to the case of the power supply. Note that the minus terminal is not grounded externally. This is because currents in the cables produce voltage drops. Grounding the supply at the drive ensures that such voltage drops do not appear in the drive circuits.

MOTOR
Pins 4,5,6 are for the motor windings. Motor cables typically have connections for the phases and for grounding the motor's frame. The grounding wire is commonly colored green with a yellow stripe. This should connect to the PE terminal of the motor connector.

Grounds
J18 Pin 1 is the PE (Protective Earth) terminal. This is connected to the heatsinking surface of the Nano module. The FGND terminal J18 pin 7 is connected internally to the PE terminal and is intended as a connection point for shields on mating cables.

PE CONNECTIONS
There should be a connection between the PE (Protective Earth) terminal to an earthed grounding point. PE and Ground are connected in the drive. This wiring ensures that the motor frame will always be at ground potential. Using shielded cable which connects to the motor frame and earth ground close to the drive provides a return path for currents induced in the shield and motor by the PWM outputs. P-clamps provide the best way to ground the shield for high-frequency noise suppression.

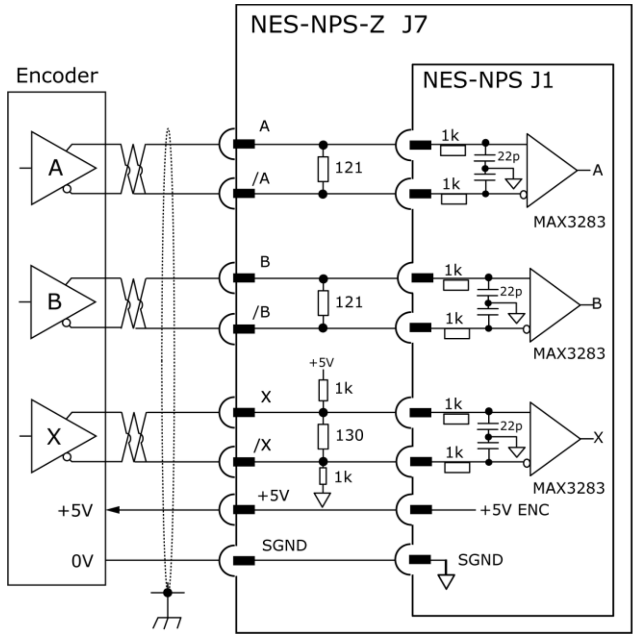
J5 Motor
Pins 4,5,6 are used for the motor windings.

6.6 J7: Primary Feedback Enc1

Incremental A/B/X Encoder

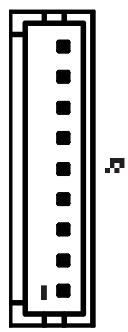
J7 ENC1 INPUTS

Signal	Pins
ENCA1	4
/ENCA1	3
ENCB1	6
/ENCB1	5
ENCX1	8
/ENCX1	7
OVERTEMP IN6	9
+5 V	2
SGND	1



ABSOLUTE SSI ENCODER

The SSI (Synchronous Serial Interface) is an interface used to connect an absolute position encoder to a motion controller or control system. The NPS 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.



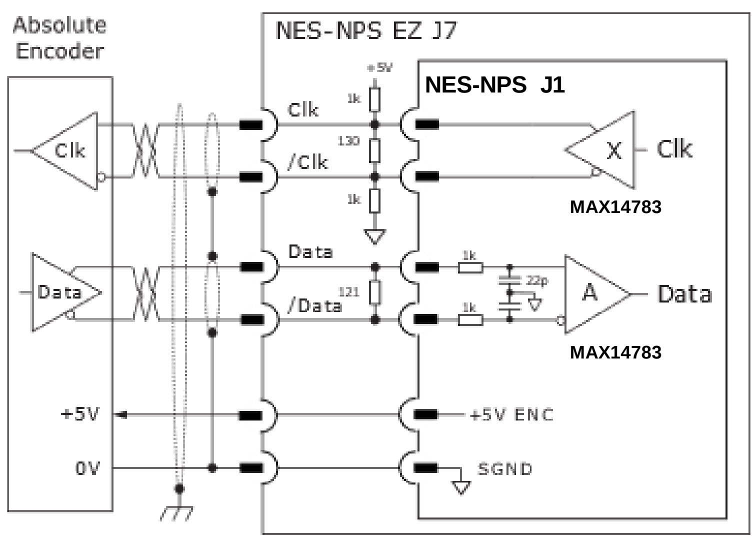
J7 INPUTS

SSI	BiSS	Pins
Clk	MA+	8
/CLK	MA-	7
Data	SL+	4
/Data	SL-	3
+5V		2
SGND		1

BiSS-C absolute Encoder

BiSS-C is an Open Source digital interface for sensors and actuators. BiSS-C 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 C-protocol: Continuous mode

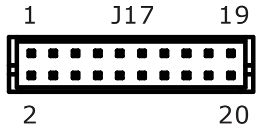


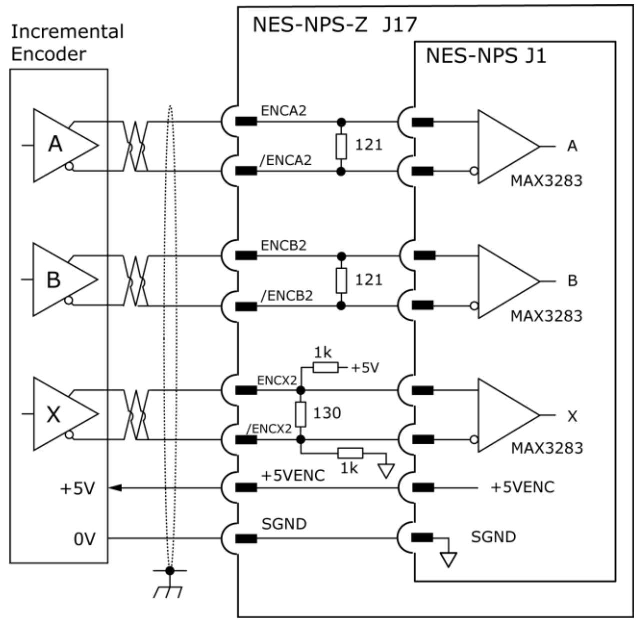
6.7 J17: Secondary Feedback Enc2

J17 ENC2 INPUTS

Signal	Pins
ENCA2	4
/ENCA2	2
ENCB2	15
/ENCB2	13
ENCX2	7
/ENCX2	5
+5 V	9
SGND	11,17

Note: ENC2 is the secondary encoder and supports digital A/B/X encoders only.





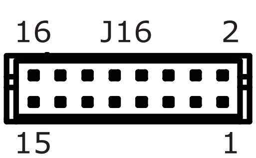
6.8 J16: STO Safe Torque Off

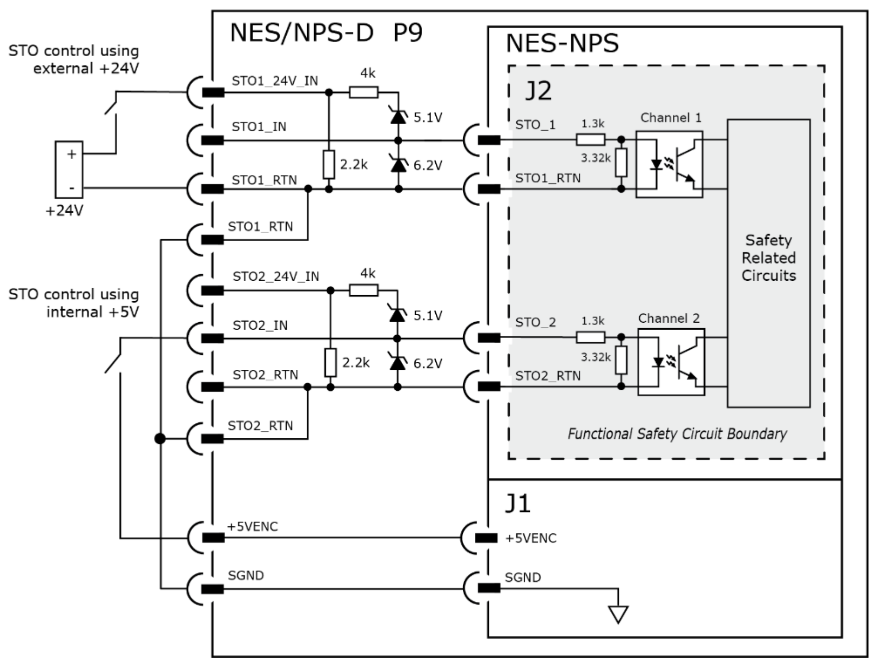
DESCRIPTION

This shows the use of external 24V to energize one STO input and internal +5V to energize the other. Both STO inputs must be energized in order to enable the drive.

J16 STO

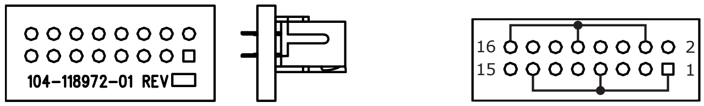
Signal	Pins
STO1_24V_IN	2
STO1_IN	4
STO1_RTN	1,3
STO2_24V_IN	8
STO2_IN	10
STO2_RTN	7,9
STO_STATUS_OUTPUT	15
STO_STATUS_OUTPUT_RTN	14
+5V OUTPUT	16
SGND	13





J16 STO BYPASS BOARD

The STO Bypass Board is a connector with internal jumpers arraigned so that it will energize the STO inputs. This deactivates the STO function allowing the drive to be enabled and disabled by a control system. The Bypass Board connections are shown outlined in red in the graphic below.



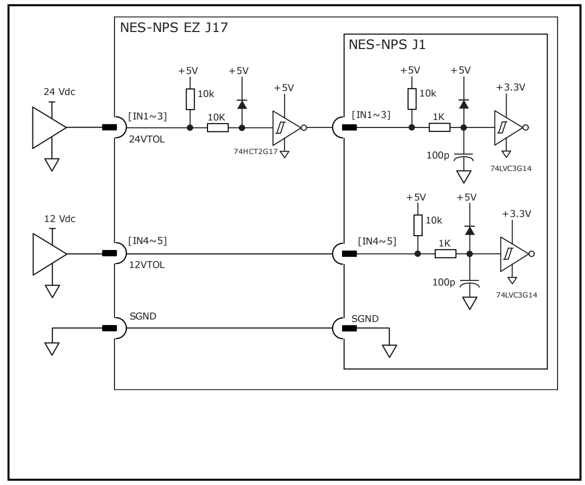
6.9 J17: I/O

Logic Inputs

Inputs 1~3 are 24V tolerant.
Inputs 4~5 are 12V tolerant.

Functions Programmable:

- Amp Enable-LO Clear Faults on rising or falling edge
- Amp Enable-HI Clear Faults on rising or falling edge
- Amp Enable-LO Enables with Reset
- Amp Enable-HI Enables with Reset
- Amp Enable-LO Enables
- Amp Enable-HI Enables
- POS Limit-HI Inhibits*
- POS Limit-LO Inhibits*
- NEG Limit-HI Inhibits*
- NEG Limit-LO Inhibits*
- Reset on LO/HI Transition
- Reset on HI/LO Transition
- Motor Temp-HI Disables
- Motor Temp-LO Disables
- Home Switch-Active HI
- Home Switch-Active LO
- Motion Abort-Active HI
- Motion Abort-Active LO
- High Res Analog Divide-Active HI
- High Res Analog Divide-Active LO
- Trajectory Update on LO/HI Transition
- Trajectory Update on HI/LO Transition
- High Speed Position Capture on LO/HI Transition
- High Speed Position Capture on HI/LO Transition
- PWM Sync Input
- Encoder Fault-Active HI
- Encoder Fault-Active LO



J17 INPUTS

Signal	Pins
IN1_24VTOL	6
IN2_24VTOL	8
IN3_24VTOL	10
IN4	18
IN5	20
+5 V	9
SGND	11,17

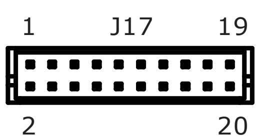
J17 OUTPUTS

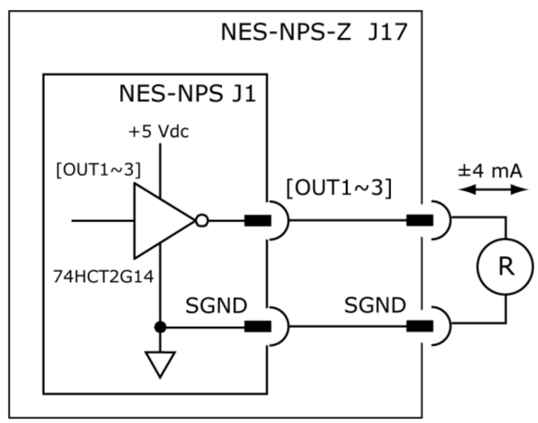
Signal	Pins
DOUT1	12
DOUT2	14
DOUT3	16
SGND	11,17

Logic Outputs

Outputs can source/sink 4 mA DC.
Functions Programmable:

- Not Configured
- Fault-Active High
- Fault-Active Low
- Brake-Active High
- Brake-Active Low
- PWM Sync Output
- Custom Event
- Custom Trajectory Status
- Custom Position Triggered Output
- Program Control-Active High
- Program Control-Active Low
- External Regen-Active High
- External Regen-Active Low
- STO Status-Active High
- STO Status-Active Low





6.10 J17: Digital Command Inputs Position

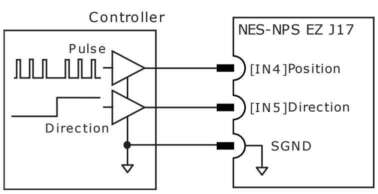
Stand-Alone Mode digital POSITION-CONTROL Inputs

NES/NPS works with motion controllers that output pulses to command position.
These formats are supported:

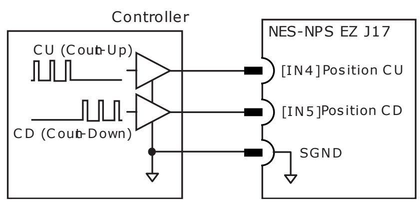
- Step/Direction
- Count-Up/Count-Down (CU/CD)
- A/B Quadrature Encoder

In Step/Direction mode, a pulse-train controls motor position, and the direction is controlled by a DC level at the Direction input. CU/CD (Count-Up/Count-Down) signals command the motor to move CW or CCW depending on which input the pulse-train is directed to. The motor can also be operated in an electronic gearing mode by connecting the inputs to a quadrature encoder on another motor. In all cases the ratio between input pulses and motor revolutions is programmable.

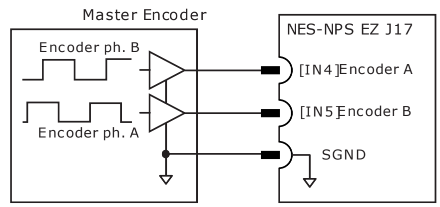
In Quad A/B mode, the two signals that emulate encoder outputs control position are, direction and velocity.



STEP/DIRECTION INPUTS



COUNT-UP/COUNT-DOWN INPUTS



QUAD A/B ENCODER INPUTS

Signal	J17 Pins
IN4	18
IN5	20

J17 Sgnd Pins
11,17

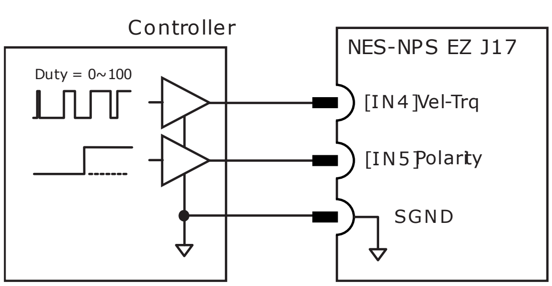
6.11 J17: Digital Command Inputs Velocity, Torque

Stand-Alone Mode Digital VELOCITY/TORQUE CONTROL Inputs

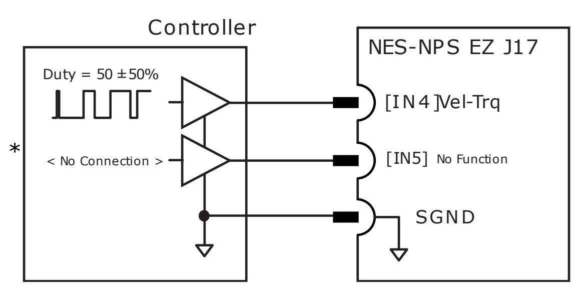
NES/NPS work with motion controllers that output pulses to command velocity and torque (current). These formats are supported:

- PWM/Direction
- PWM 50%

In PWM/Direction mode, a pulse-train with variable duty-cycle controls motor Vel/Trq, and the polarity or direction is controlled by HI/LO levels at the Direction input.
With PWM 50% operation there is a single signal. A 50% duty cycle produces zero output. Increasing the duty cycle to 100% produces a full-scale output in one direction and 0% duty cycle produces a full-scale output in the opposite direction.



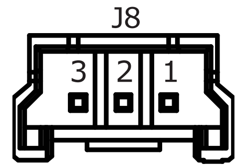
PWM/DIRECTION INPUTS



PWM 50 % Duty Cycle

6.12 J8: RS-232

Receptacle



Description	3 pin header, 2mm, 2A per pin
Manufacturer PN	Molex: 035362-350

Cable Plug

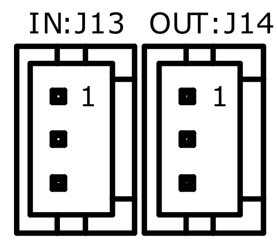
Description	3 pin plug
Manufacturer PN	Molex: 035362-350

Signals

J8 Pin	Signal	Function
1	SGND	Signal Ground
2	RxD	Receive data input from computer
3	TxD	Transmit data output to computer

6.13 CAN Network

Receptacle



Description	Dual 3 pin header, 2mm, 2A per pin
Manufacturer PN	Hirose: DF13-3P-1.25DSA(76)

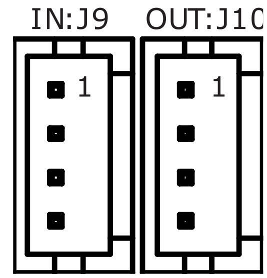
Cable Plug

Description	3 pin plug
Manufacturer PN	Hirose: DF13-3S-1.25C
Description	Socket, crimp, 30~26, 1mm, qty 3
Manufacturer PN	Hirose: DV13-2630SCFA

6.14 J9, J10: NES EtherCAT Signals

Receptacle

Description	Dual 4 pin header, 2mm, 2A per pin
Manufacturer PN	Hirose: DF13-4P-1.25DSA(76)



Cable Plug

Description	4 pin plug
Manufacturer PN	Hirose: DF13-4S-1.25C
Description	Socket, crimp, 30~26, 1mm, qty 4
Manufacturer PN	Hirose: DV13-2630SCFA

Signals

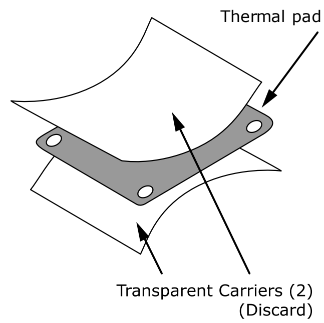
J9 Pin	Signal	Function: EtherCAT IN
1	RXPA	EtherCAT Receive Line 1+
2	RXNA	EtherCAT Receive Line 1-
3	TXPA	EtherCAT Transmit Line 1+
4	TXNA	EtherCAT Transmit Line 1-

J10 Pin	Signal	Function: EtherCAT OUT
1	RXPB	EtherCAT Receive Line 1+
2	RXNB	EtherCAT Receive Line 1-
3	TXPB	EtherCAT Transmit Line 1+
4	TXNB	EtherCAT Transmit Line 1-

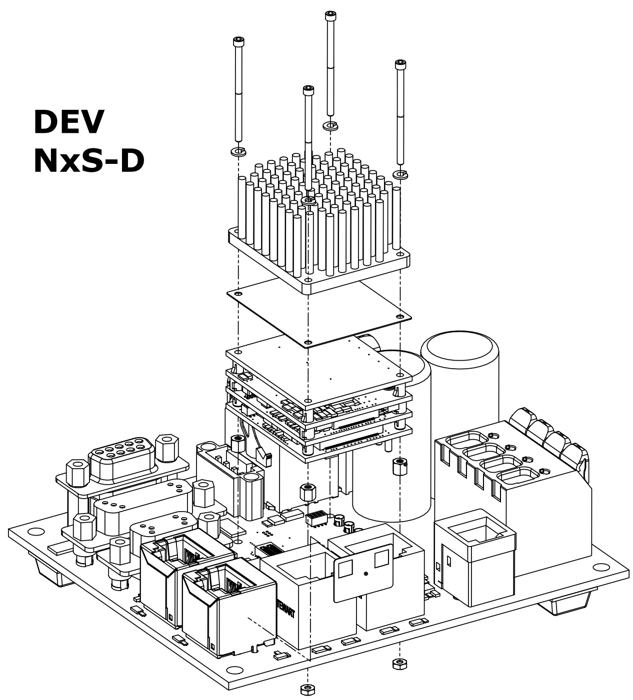
6.15 Heatsink

A thermal pad is used in place of heatsink grease. The pad is die-cut to shape and has notches 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 _#0-80 mounting screws to 4 in-lb,
   64 in-oz, 0.45 Nm.



DEV
NxS-D



N-HK: Heatsink Kit

Item	Description	Quantity
1	Screw, #0-80, hex, socket cap screw, 1 in [25.4 mm]. stainless steel	4
2	Heatsink, NES/NPS, 0.728 [18.49] tall, pins	1
3	Thermal pad, NES/NPS	1
4	Spacer, hex, 0.125 in [3.18 mm], 0-80 UNC 2B thread, 0.120 in [3.05 mm] tall, AL	4
5	Washer, medium split lock, #0, 18-8, stainless steel,	4
6	Nut, #0-80, fine thread, stainless steel	4
7	Ifixit Opening Tool	1

7 Safe Torque Off (STO)

Overview

This chapter is intended to inform the reader about the Functional Safety features of the NES/NPS drives and to provide information on the steps required to install it into systems so that a target level of Functional Safety performance can be achieved. The scope of this chapter is limited to those aspects of Functional Safety that relate to the installation, operation, and maintenance of the NES/NPS drives.

Disclaimer

This manual contains information on the Safe Torque Off (STO) feature of the NES/NPS drives and how it may be incorporated into an industrial motion control system. While every effort has been made to ensure the completeness and accuracy of this manual it must be emphasized that the responsibility for functional safety in the overall system into which the drive is installed rests ultimately with the manufacturer of the system into which the NES/NPS drives are installed.

The equipment manufacturer must take into account all the aspects of the system in which the NES/NPS drives are components.

Copley Controls does not accept any liability for direct or indirect injury or damage caused by the use of information in this document. The equipment manufacturer is always responsible for the safety of its product and its suitability under applicable laws.

Copley Controls hereby disclaims all liabilities that may result from this document.

Risk Assessment & Responsibility of the Installer

The STO feature of the NES/NPS drives is capable of the safety integrity level (SIL) and category/performance level (PL) stated in this manual and operates in accordance with the characteristics and limitations described herein. But it must be noted that the drive STO function is intended to be used only as one element of an overall safety chain and is not a complete safety function unto itself. Therefore, the suitability for use of the NES/NPS drives in each application must be determined in part by one or more risk assessments of the overall safety of the end machine conducted in accordance with the applicable standards. Such risk assessments normally consist of a thorough review of overall machine operation to identify potential hazards. For each identified hazard, typical risk assessments take into account the severity of any potential injury resulting from the hazard, the frequency of exposure of persons to the hazard and the probability that persons are able to avoid the hazard if it were to occur. The machine designer is solely responsible for conducting any necessary risk assessments and for the ultimate determination as to the suitability of the NES/NPS drives and the STO function for use in realizing a given overall safety function. The installer should be experienced in motion control and functional safety.

Operate drives within the specifications provided in this document

The information in this manual is specific to the functional safety features of the NES/NPS drives. The user must use this manual for proper and safe installation and overall commissioning of the drives.

Risk of electric shock

The NES/NPS drives are made for operation from transformer-isolated, DC power supplies. Therefore, hazardous voltages are connected to and exist within these drives under normal operating conditions. Persons responsible for installing and commissioning these drives must be experienced in all aspects of electrical equipment installations.

Disclaimer

There are no user serviceable parts in the NES/NPS drives.
Disassembly of the PC boards or tampering with components will void the warranty.

Definitions

There are certain terms used throughout this document that serve an important role in describing the operation and behavior of the NES/NPS STO feature.
These terms are discussed and defined as follows:

Activate

This term is used to refer to action taken that results in the safe state being entered.
In the case of the STO feature, the STO function is activated (made active) by making the voltage at one or both STO inputs less than or equal to the maximum rated de-energize threshold voltage.

De-Activate

This term is used to refer to action taken that results in the safe state being exited. In the case of the STO feature, the STO function is de-activated (made inactive) by making the voltage at both STO inputs greater than or equal to the minimum rated energize threshold voltage.

Energize

This term refers to the application of voltage greater than or equal to the minimum rated energize threshold voltage to an individual STO input. Note that simultaneously energizing both STO inputs results in the STO function being de-activated.

De-Energize

This term refers to the application of voltage less than or equal to the maximum rated de-energize threshold voltage to an individual STO input. Note that de-energizing an STO input results in the STO function being activated.

7.1 STO Reference Standards

ISO-13849-1

Safety of machinery Safety-related parts of control systems
Part 1: General Principles for Design

ISO 13849-2

Safety of machinery
Safety-related parts of control systems — Part 2: Validation

IEC 61508-1

Functional safety of electrical/electronic/programmable electronic safety-related systems
Part 1: General requirements

IEC 61508-2

Functional safety of electrical/electronic/programmable electronic safety-related systems
Part 2: Requirements for electrical/electronic/programmable electronic safety related systems

IEC 61508-3

Functional safety of electrical/electronic/programmable electronic safety-related systems
Part 3: Software requirements

IEC 61800-5-1

Adjustable speed electrical power drive systems
Part 5-1: Safety requirements – Electrical, thermal and energy

IEC 61800-5-2

Adjustable speed electrical power drive systems
Part 5-2: Safety requirements – Functional

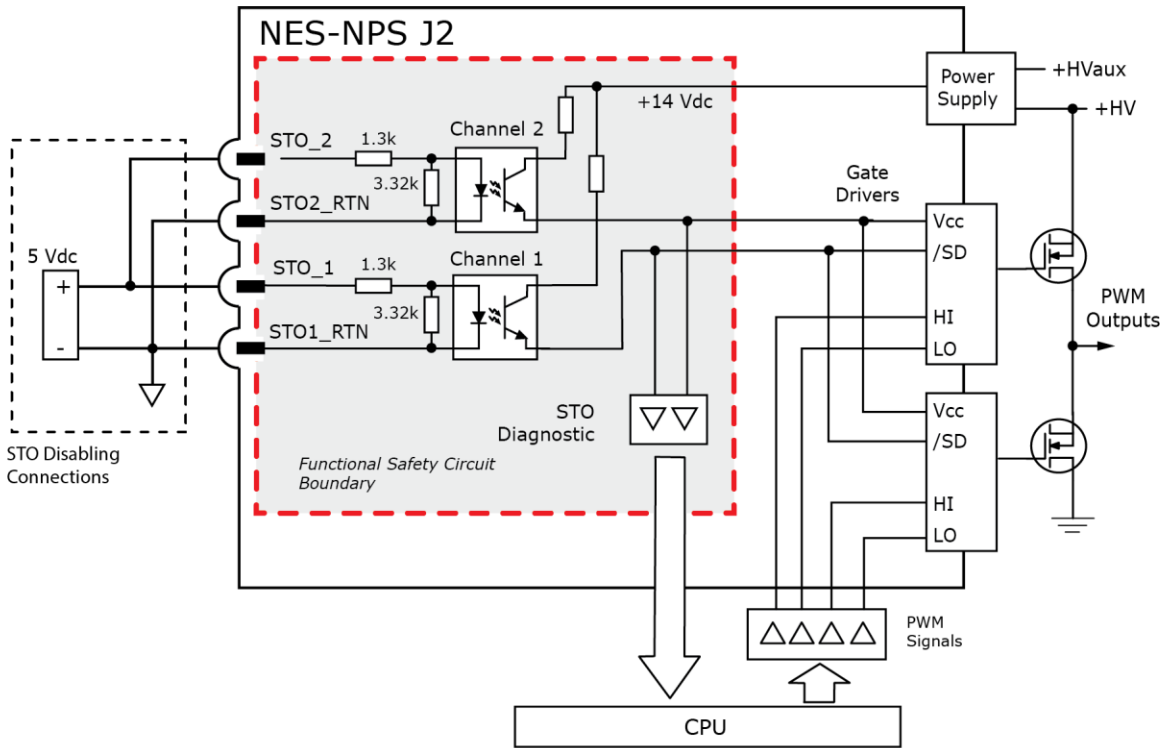
IEC 60664-1

Product Safety Considerations for Insulation Coordination of Low-Voltage Equipment
Table F.2 Clearances to Withstand Transient Overvoltages

7.2 STO Architecture and Function

The STO function in the NES/NPS is suitable for use in safety loops up to SIL 3 and/or Cat. 3 PL e performance. Because Cat. 3 PL e performance requires that the safety function continues to operate even in the event of two failures, the STO circuit has a built-in diagnostic capability. This architecture is shown in the system block diagram below. The dotted red outline represents the components in the drive that implement the safety function.

NES-NPS STO Safety Control



In the Safe State, the drive will not produce torque or force in the motor. The STO function achieves and maintains a safe state by disabling the ability of the attached motor to produce torque/force. This halts any drive induced acceleration already in process and prevents initiation of motion. The expectation is that an inability of the motor to produce torque/force translates into a reduction of risk of hazardous motion for the larger system.

The STO circuit concept involves disabling the ability of the motor drive output stages to produce current. The output stage consists of one subset of high side output MOSFETs that switch motor terminals to the positive rail of the DC bus (+HV), and a second subset of low side output devices that switch motor terminals to negative rail of the DC bus (HVCOM). The STO circuit architecture is derived from the fact that current flow in the motor, and therefore torque/force production, requires both subsets to function. STO Channel 1 disables the drive by removing the /SD signals to the MOSFET gate-drivers. STO Channel 2 disables the drive by removing +14V (Vcc) to the MOSFET gate-drivers. But any one channel by itself is sufficient to prevent the initiation of motion or halt drive induced acceleration when the STO function is activated.

Each STO channel receives an input in the form of a voltage applied to STO_IN1 (+,-) and STO_IN2 (+,-). Both STO inputs must be simultaneously energized in order for torque/force to be produced. To achieve the rated SIL and PL capability, both STO inputs must be held simultaneously de-energized by the larger system when the STO function is activated. In a typical machine application, each STO input is driven by a voltage from a SELV or PELV power supply and switched through a safety relay. By definition, the output of a SELV or PELV rated power supply is a maximum of +60 Vdc in a fault condition. Therefore, a constraint on the larger system is that the power supply used to energize the STO inputs must be an SELV or PELV type.

7.3 STO Channel Operation

STO Function Active = No force/torque production is possible in motor.
STO Function Inactive = Force/torque production in motor is under control of the drive.

<table>
<tr><th>STO IN1</th><th>STO IN2</th><th>STO Function State</th></tr>
<tr><td>0</td><td>0</td><td>STO function is active, both inputs de-energized</td></tr>
<tr><td>1</td><td>0</td><td rowspan="2">STO function is active, one input de-energized</td></tr>
<tr><td>0</td><td>1</td></tr>
<tr><td>1</td><td>1</td><td>STO function is inactive, both inputs energized</td></tr>
</table>

The table above shows the operation of the STO channels.
0 = Voltage applied to the STO input is less than or equal to the rated maximum de-energize level.
1 = Voltage applied to the STO input is greater than or equal to the rated minimum energize level.

A motion control system design for Cat. 3 PL e, and/or SIL 3 rating must use 2 channels for the STO function.

7.4 STO Function Specifications

Specification	Requirement
Operation	When STO is active, motor current that can cause rotation (or motion in the case of a linear motor) is not applied. The PWM output is disabled and cannot source or sink current. This STO function is defined in IEC-61800-5-2, clause 4.2.2.2
Standards Conformance	IEC-61508-1, IEC-61508-2, IEC-61508-3, IEC-61800-5-2, ISO 13489-1
Safety Integrity Level	SIL 3
Category & Performance Level	Category 3, Performance Level PL e
Certifications	UL Functional Safety Mark (Pending)
Signals (Functional Safety Related)	STO-IN1(+), STO-IN1(-), STO-IN2(+), STO-IN2(-), Frame ground (shield)
Signals (for Disabling)	STO-Bypass, STO-Gnd
STO DC Power Source	SELV or PELV power supply required
STO Input Energize Voltage	Vin-HI ≥ +3.0 Vdc between STO-INx(+) and STO-INx(-), 7.0 Vdc max
STO Input De-energize Voltage	Vin-LO ≤ +0.8 Vdc or open between STO-INx+ and STO-Inx
Input current (typical)	STO-IN1: 8.45 ±0.2 mA, STO-IN2: 8.45 ±0.2 mA @ 3.3V input voltages Current flow is into STO-IN1(+) and STO-IN2(+) and out of STO-IN1(-) and STO-IN2(-). STO inputs must be connected in parallel when driven from a single power supply.
Response Time	From Vin ≤ 0.8 Vdc or open to PWM outputs disabled (off): ≤ 1.5 ms
Type	Opto-isolators, +24 VDC compatible
Maximum cable length	30 m (98.4 ft)
Diagnostic Coverage	The STO circuit design implements automatic diagnostic testing of the signal path integrity for both STO channels to achieve 60% ≥ SFF < 90%. A dedicated STO diagnostics microcontroller is used to implement the diagnostic algorithm completely separate from the main motor control and communications algorithms running on the Arm processor. Therefore only the firmware running on the diagnostics microcontroller is considered part of the safety implementation.

7.5 Environmental Specifications

Specification	Requirement
Operating Temperature	0 °C to 45 °C per IEC 60068-2-1 and IEC 60068-2-2
Operating Humidity	0 to 95 %RH, non-condensing per IEC 60068-2-78
Storage Temperature	-40 °C to 85 °C per IEC 60068-2-1 and IEC 60068-2-2
Altitude	≤ 2000 m per IEC 60068-2-13
Contaminants	Pollution Degree 2 per IEC 60664-1
Mechanical Shock	10*g*, 10 ms, 1/2 Sine Pulse per IEC 60068-2-27
Vibration	2*g*, peak, 10~500 Hz (Sine) per IEC 60068-2-6

7.6 Safety Related Parameters

IEC 61508-1			
SIL	3	HFT	1
PFH	1.98×10^{-10}	SFF	90%
PFD	3.06×10^{-4}	PTI	Once per year

ISO 13849-1			
PL	e	Category	3
CCF	80	$MTTF_D$	100 years
DC	90.14%		

7.7 Regulatory Specifications

Specification	Requirement
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	IEC 61508-1, IEC 61508-2, IEC 61508-3, EN (ISO) 13849-1, ISO 13849-2, IEC 61800-5-2.
Electrical Safety	Directive 2014/35/EU – Low Voltage, UL 61800-5-1:2016
Machinery	Directive 2006/42/EC
EMC	Directive 2014/30/EU IEC 61800-3:2017, Category C3
Markings	Label is visible on PC board
Hazardous Substances	Lead free and RoHS compliant

7.8 Limitations and Necessary Risk Reductions

Electrical Isolation

The STO function does not provide electrical isolation between the drive and the motor. Hazardous voltages may be present on the motor output terminals even with the STO function activated.

DC Brush Motors

Failure of a MOSFET in the outputs of the drive that renders the MOSFET a virtual short-circuit might result in continuous torque/force production in a DC motor.
Unlike brushless motors that limit rotation to one half of an electrical cycle,
a DC motor can rotate uncontrollably under a failed MOSFET scenario.

IMPORTANT: The STO function cannot be used with DC brush motors.

180 Degree Electrical Movement

In the event of MOSFET failures in the PWM outputs, unexpected motor movement of up to 180 electrical degrees can occur. It is the responsibility of the designer of the larger system to assess and address any hazards that this unexpected movement could create.

Loads and Other Torque/Force Producing Sources

The STO function produces an uncontrolled stop of category 0 as described in
IEC 60204-1. Any motor that is moving when the STO function is activated will coast to a stop unless there are other forces operating on the same load. The STO function only removes torque/force produced by current flow from the drive to the associated motor. Torque/force created by gravity-influenced loads or other torque/force producing components mechanically connected to the motor shaft cannot and will not be affected by the drive STO function. It is the responsibility of the designer of the larger system to assess and address any hazards arising from torque/force producing sources.

+HV DC Power Supply

The power supply used to provide +HV power to a 90V model NANO NES/NPS must have protections to limit the output voltage to 100 Vdc or less even in a single fault condition. The power supply used to provide +HV power to a 180V model NANO NES/NPS must have protections to the limit the output voltage to 200 Vdc or less even in a single fault condition. Furthermore, the power supply output must have galvanic isolation from AC mains that meets the requirements for reinforced or double insulation.

VLOGIC DC Power Supply STO

The VLOGIC power supply must have protections to limit the output voltage to 60 Vdc or less even in a single fault condition. Furthermore, the power supply output must have galvanic isolation from AC mains that meets the requirements for reinforced or double insulation. If the drive +HV can be 60 Vdc or less, then the VLOGIC can be driven from a single SELV or PELV type source.

CONTROL MODES AND STO

The drive can control the position, velocity, and torque of motors while operating from a number of control sources. But it can only do this when the STO function is inactive. And, although the digital control core and firmware of the drive can observe the state of the STO function, it cannot interact with, or exercise any control over the STO function.

The STO function operates completely independently of the control core of the drive. It does not depend on the control core for its operation and the control core of the drive has no control over the STO function.

STO INPUT SIGNAL LEVEL

The STO inputs (STO-IN1, STO-IN2) in the Development Kits are +24V compatible with +30V maximum ratings. The STO inputs in the modules alone work from +5V.

In typical machinery, STO inputs are driven from a safety relay or similar device with 24Vdc level signals. The NES/NPS models are not designed as stand-alone devices and are designed for installation as components on the end user motherboard. It is the responsibility of the designer of the larger system to take this into consideration. A constraint on the larger system is that the power supply used to drive the STO inputs must be a SELV or PELV type.

STO DC POWER SUPPLY

The recommended DC power for STO inputs on the NES/NPS development kits should be +24 Vdc nominal, +30 Vdc maximum, and must be supplied by power supplies with a SELV or PELV rating.

WIRING TO THE STO INPUTS

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. Fault exclusion requirements are given in ISO 13849-2 and IEC 61800-5-2.

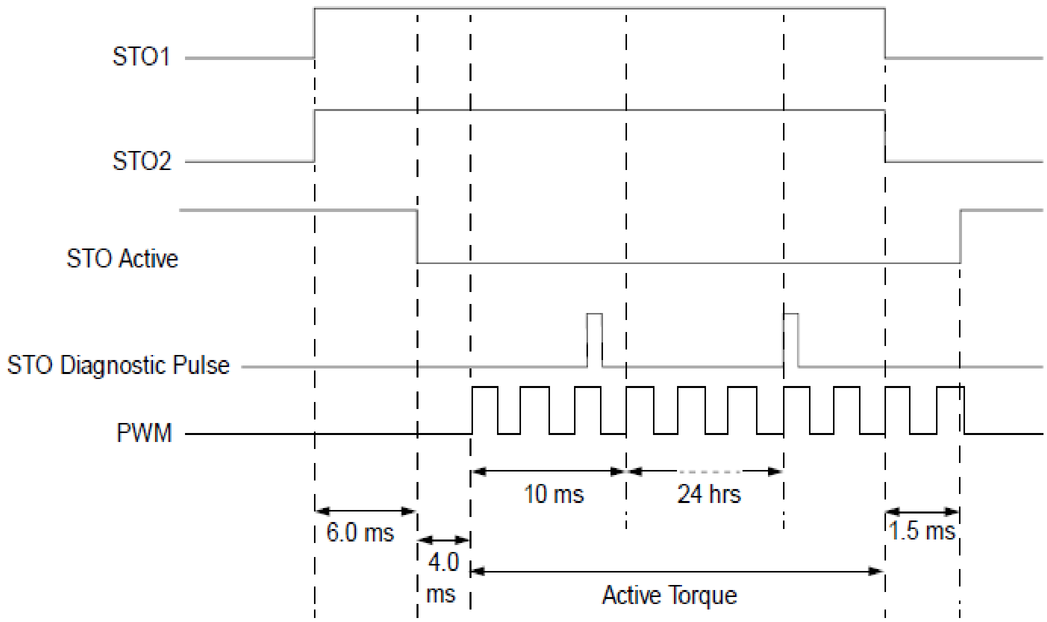
Connections to the STO inputs must provide spacing that is greater than the minimum creepage and clearance of 1.24 mm. that is required for fault exclusion when considering the FMEDA (Failure Modes, Effects, and Diagnostic Analysis) of the system.

PERIODIC STO TESTING INTERVAL

The STO circuit design implements diagnostics testing to monitor the integrity of the signal path for both STO channels. These internal diagnostics tests are periodic and automatic. Therefore, no operator intervention is needed for periodic STO testing.

INTERNAL DIAGNOSTICS PULSES

The internal diagnostics test sends short (430 microseconds) pulses that propagate through the STO circuits and monitors a response to verify hardware integrity of each channel without interfering with drive operation. When both STO1 and STO2 inputs are energized, the diagnostics test runs within 20 milliseconds. If the diagnostics test passes, the diagnostics test shall run every 24 hours as STO1 and STO2 remain energized. If the STO diagnostics test detects a failure, then the drive shall enter a safe state and the test shall be run every 5 seconds until the tests passes on STO1 and STO2 input channels. The following figure is intended as a visualization of the internal diagnostics testing.



Internal Diagnostics Test Diagram

7.9 PC Board Design for STO

User Mounting Board (UMB) Design

UMB Design Rules

The UMB board design should incorporate three zones, each with different design rules.

- STO
- Signals
- Power & Motor

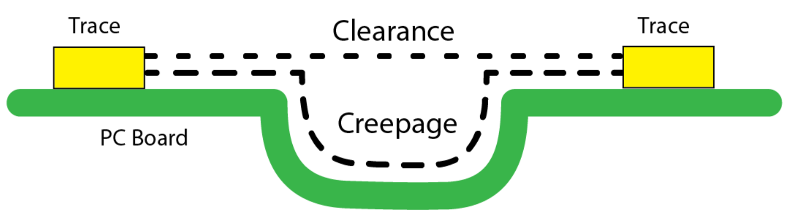
Standard IPC 2152 is used to determine trace thickness and widths needed to carry the required currents. Standard IEC 60664-1 provides the spacing of conductors that will provide the necessary insulation required to ensure that the circuits in each zone function well without interfering with circuits in other zones.

PCB Spacings

The NANO drives do not have the shielding and grounding provided by enclosed panel-mounting drives. As a result, the user must provide for grounding and spacing of conductors in their PCB design.

Spacings of conductors on the UMB are of two types: Clearance and Creepage. These are illustrated in the graphic below.

- *Clearance* is the straight line distance between two traces.
  Primarily affected by air pressure (altitude) and voltage between the traces.
- *Creepage* is the distance between traces over the surface of the UMB.
  Primarily affected by air pressure (altitude) and humidity.
- Spacings between safety and non-safety circuits must be designed to exclude the possibility of short circuit faults between safety and non-safety circuits.



Spacings are based on the Pollution Degree which is defined in IEC 60664-1.
The NANO are designed for Pollution degree 2:

- Pollution Degree 2: Normally only nonconductive pollution occurs.
  Occasionally, however, a temporary conductivity caused by condensation is to be expected, when the drive is out of operation.

Reference Designs

These can be found on the Copley website www.copleycontrols.com
under Support / Nano / Drawings:

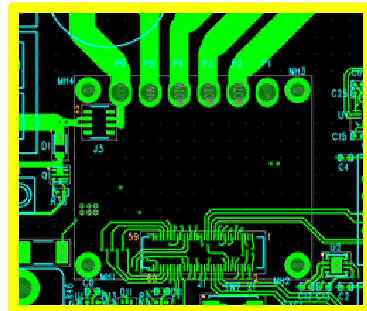
Nano Module DEV Board NES-D/NPS-D Reference Design

Nano Module EZ Boad NES-Z/NPS-Z Reference Design

Circuit Zoning

- High-voltage & current: Input from the DC power supply.
- Low-voltage: Signal I/O and feedback
- STO Safety inputs

Six high-current traces are used for the +HV, HVCOM, PE, and motor U/V/W outputs. Traces used on the pc board are paired on top and bottom layers, connected by vias. This gives a 3 oz, 0.50-inch width copper

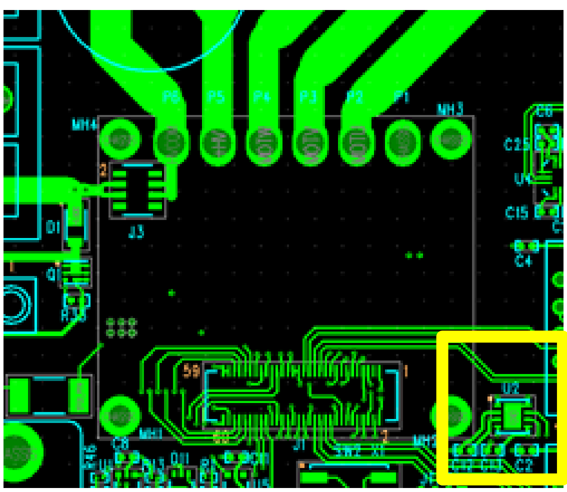


Mandatory Design Rules for STO

When the STO feature of the drive is used, these rules are required. Sufficient clearance and creepage distances must exist for the STO connections in order to exclude certain short circuit faults from consideration in the FMEDA.

STO Circuits Zone

- YELLOW: STO inputs



Note: This graphic shows the traces from the EZ board as an example of the zones on the UMB that have different rules for spacings etc.

STO Circuits Creepage & Clearance for Outer Layers of PC Boards

- No conformal coating
- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion against short circuits.

Description	Creepage & Clearance
Between adjacent STO circuits	0.200 mm
Between STO circuits and Low Voltage circuits	0.200 mm
Between STO circuits and High Voltage circuits	0.63 mm
Between STO circuits and chassis	0.63 mm
Between Low Voltage circuits and High Voltage circuits	0.63 mm
Between Low Voltage circuits and chassis	0.63 mm
Between High Voltage circuits and chassis	0.63 mm

STO Circuits Creepage & Clearance for Inner Layers of PC Boards

- No conformal coating
- Creepage and clearance based on standard IEC 60664-1
- Dominant requirement: Fault Exclusion against short circuits.

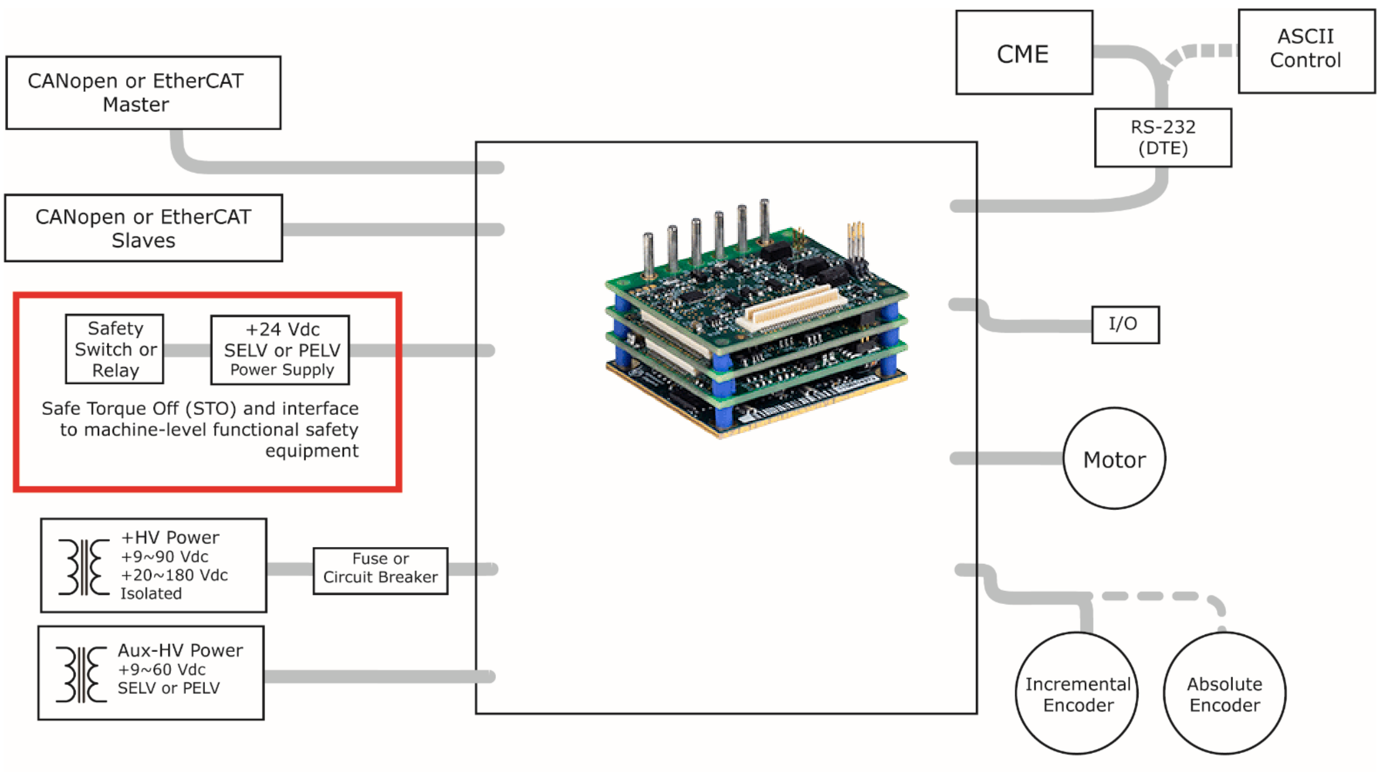
Description	Creepage & Clearance
Between adjacent STO circuits	0.200 mm
Between STO circuits and Low Voltage circuits	0.200 mm
Between STO circuits and High Voltage circuits	0.50 mm
Between STO circuits and chassis	0.50 mm
Between Low Voltage circuits and High Voltage circuits	0.50 mm
Between Low Voltage circuits and chassis	0.50 mm

7.10 Installation Overview

This graphic shows the elements of a complete NES & NPS drive installation.

The STO feature and interface to the machine-level functional safety equipment are highlighted in red to emphasize the aspects of the installation that are addressed in this guide.

Installation Interface Diagram



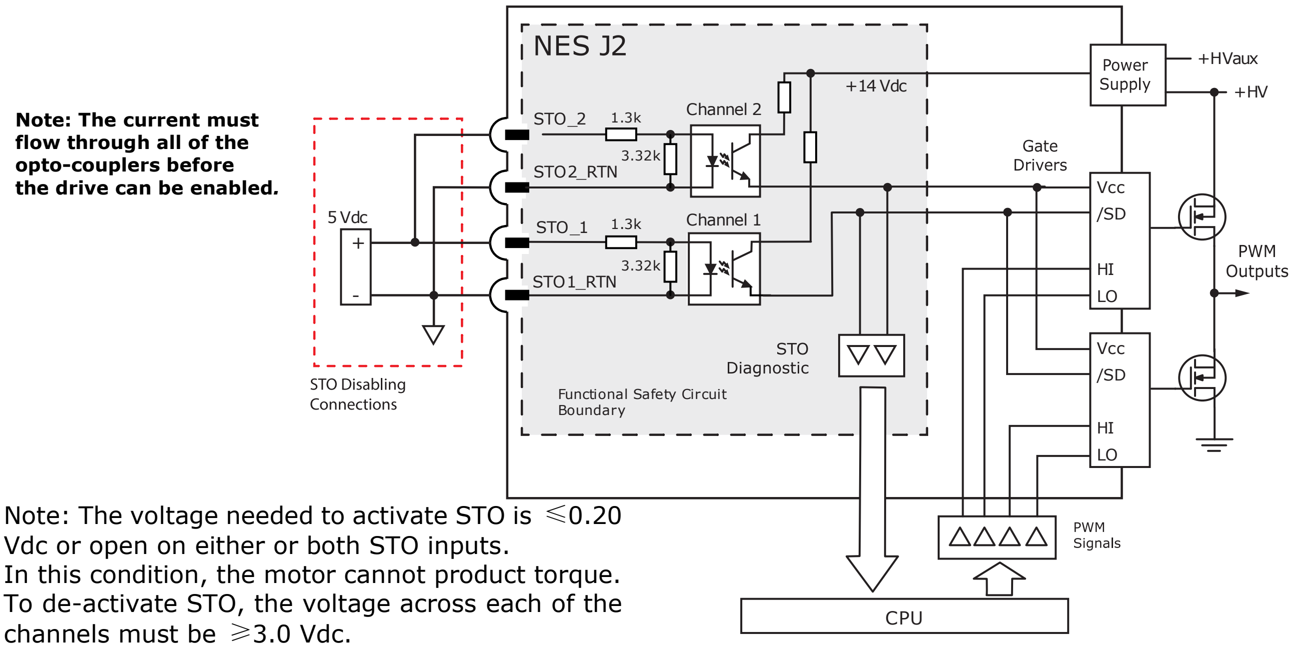
STO DISABLE

In order for the PWM outputs of the NES to be activated, current must be flowing through the opto-couplers that are connected to the STO-IN1 and STO-IN2 terminals and the drive must be in an ENABLED state. When either of 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 both of the opto-couplers from a 5V 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 the STO feature is not used, these connections must be made in order for the drive to be enabled.

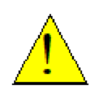
STO Disable Connections



Note: The voltage needed to activate STO is ⩽0.20 Vdc or open on either or both STO inputs.
In this condition, the motor cannot product torque.
To de-activate STO, the voltage across each of the channels must be ⩾3.0 Vdc.
In this condition, the motor can produce torque.

J2 STO

Signal	Pin		Signal
STO_STATUS_OUTPUT	6	5	STO_STATUS_OUTPUT_RTN
STO2_IN	4	3	STO2_RTN
STO1_IN	2	1	STO1_RTN



ALL PIN NUMBERING INFORMATION FOR MODULE-LEVEL STO CONNECTIONS IN THIS DOCUMENT IS PIN NUMBERING CORRESPONDING TO THE BOTTOM ENTRY SOCKET (J2) ON THE USER MOUNTING BOARD. USER MOUNTING BOARDS MUST BE DESIGNED FOLLOWING THIS PIN NUMBERING CONVENTION. Because the STO header on the Nano Module itself connects to the User Mounting Board via a bottom entry socket, the pin numbering for the header as marked on the Nano module is the mirror image of that for the bottom entry socket on the User Mounting Board.

STO Operation

STO Input Voltage	STO State
STO-IN1 AND STO-IN2 ≥ +3.0 Vdc	STO Inactive. Drive can be enabled to produce torque
STO-IN1 OR STO-IN2 ≤ +0.8 Vdc	STO Active. Drive cannot be enabled to produce torque
STO-IN1 OR STO-IN2 Open	STO Active. Drive cannot be enabled to produce torque

STO Status

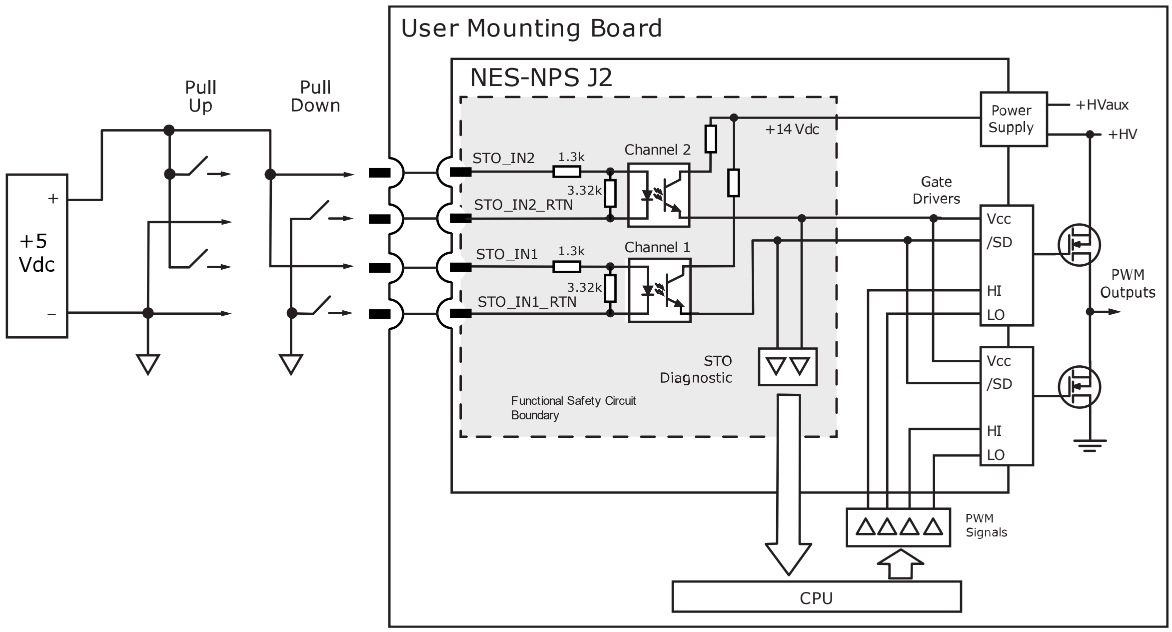
A digital output can be programmed to be active when the drive is disabled by the STO function. The active level of the output is programmable to be HI or LO.

7.11 STO: Installation for NES & NPS Modules

Energizing STO Inputs

This diagram shows the two STO channels that are the essential channels to prevent current flow in the motor when the STO function is activated. These inputs can be driven by either current sourcing or sinking devices.

STO Inputs from 5V Control Signals on User Mounting Board



STO Power Requirements for User Board

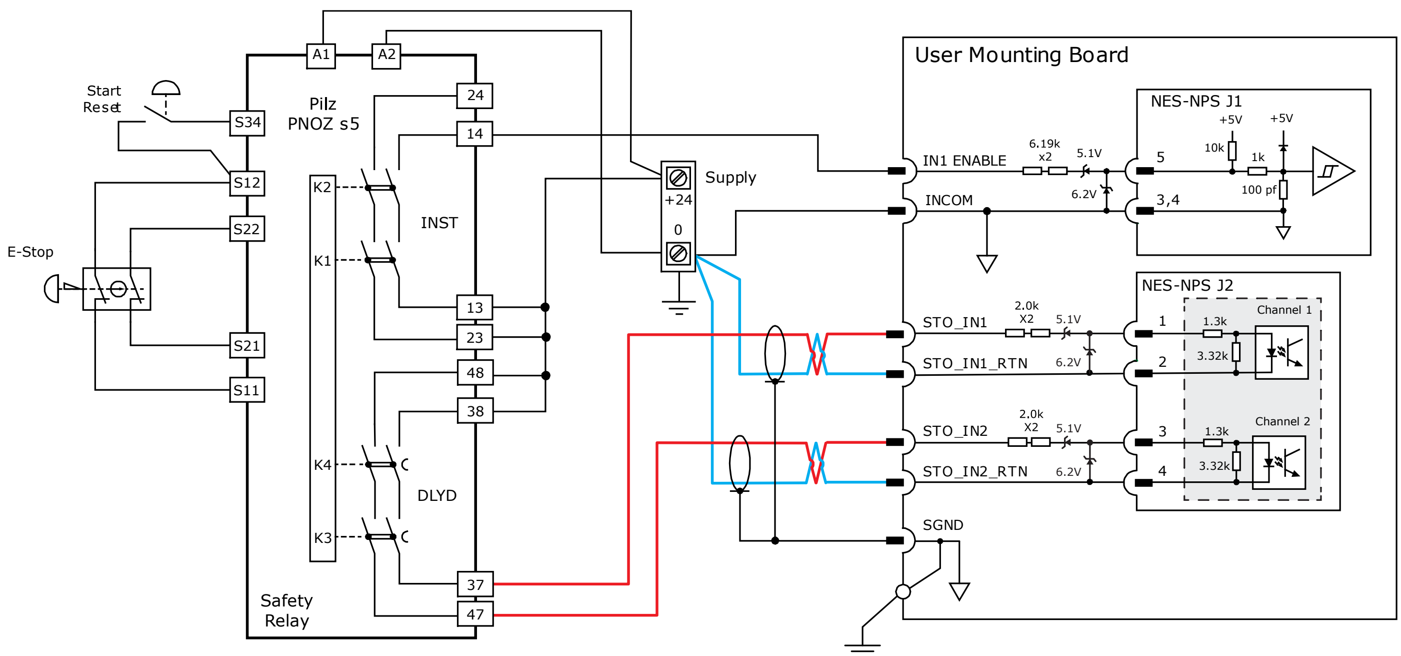
The +5 Vdc power supply for the STO inputs must be SELV or PELV rated.
(Refer to Section 7.4)

STO Wiring Requirements

Electrical connections to the STO inputs must meet the requirements for fault exclusions for short circuits between conductors and short circuits between conductors and other conductive parts or earth or the protective bonding conductor. These requirements are given in ISO 13849-2 and IEC 61800-5-2.

When driven from a single +5 Vdc power supply, the STO inputs must be connected in parallel as shown above. Driving the STO inputs in series would require a higher voltage than the nominal +5 Vdc, and if one of the STO inputs or its wiring were to fail as a short-circuit, it would apply the full DC power to a single input.

Example Wiring Diagram (SIL 3 and Cat. 3 PL e STO Implementation)



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Emergency Stop: Stopping Category 1

The graphic above shows a wiring example for implementing a SIL 3, Cat. 3 PL e emergency stop function using a NES/NPS drive. The example shows a safety relay with two sets of output contacts: – one set (K1, K2) reacts immediately to changes on the safety relay inputs and the other set (K3, K4) reacts after a user-programmable delay.

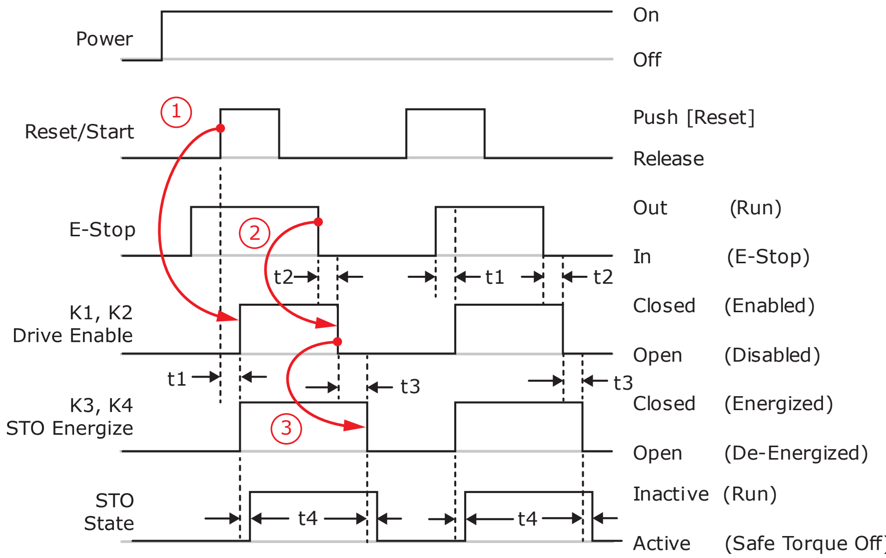
A double pole, single throw E-stop switch is used to drive two independent inputs to the safety relay. A momentary switch is wired to the safety relay reset input and is used to reset the relay at start-up and after an E-stop event. The ENABLE input on the drive is wired to one of the immediate response (INST) contacts.

The drive is programmed such that when the ENABLE input is de-energized, the drive decelerates the motor speed in a controlled fashion. After the user-programmed delay time, contacts K3 and K4 open and de-energize the STO inputs to the drive. The drive STO function responds accordingly, and the safe state is entered within the specified drive STO response time. This type of implementation brings the motor speed to near zero before the STO function is activated. It is important to note that the safe state is not entered immediately upon actuation of the E-stop button. The safe state is entered only after the STO inputs have become de-energized and the specified STO response time has elapsed.

NES & NPS Configuration

K1/K2 drive [IN1], the input for the drive Enable function. The [INCOM] signal for [IN1] connects to ground. When +24 Vdc is applied to [IN1] it will enable the NES & NPS if no other inputs are configured as Enables and no Enable inputs are inactive. If more than one input is configured as Enable, then all must be active to enable the drive.
The PNOZ relay uses both contacts of the delayed relay for two-channel control of the STO function, which is necessary for SIL 3, Cat. 3 PL e.

Example STO Timing



Term	Description
Power	+24 VDC supplied to the safety relay
Reset/Start	Momentary push-button that causes the K1~K2 relay contacts to close, supplying power to the STO inputs of the drive, and de-activating the STO function. This allows the drive to produce torque/force in the motor when it is enabled.
E-Stop	The latching push-button switch inputs to the safety relay. The HI level of this indicates that the button has been released, opening the NC (Normally Closed) contacts.
K1, K2	The instantaneous contacts in the relay. A HI level indicates that the contacts are closed, supplying power to an Enable input of the drive to place it in an enabled state.
K3, K4	Relay contacts that will open after a pre-set time delay. This allows time for the drive to remain in an enabled state while is performs a controlled deceleration that brings the motor to a standstill before the STO function is activated, preventing any torque/force production in the motor.
t1	Switch-on delay. If the E-Stop button is out, this is the delay after the Reset/Start button is pressed in and the K1~K4 relay contacts close, deactivating the STO function and enabling the drive (1).
t2	Delay-on de-energization. When the E-Stop button is pressed in (E-Stop), this is the delay to the opening of the K1~K2 contacts which disables the drive, initiating a controlled deceleration of the motor (2).
t3	Waiting period. This is the time-delay that allows for the controlled deceleration of the motor. When the E-Stop button is pressed in, this is the time delay to the K3~K4 contact opening which will activate the STO (3).
t4	STO response time. This is the time between the de-energizing of the drive STO inputs (K3~K4 contacts open) and the entry into the safe-state.

STO Validation Testing

Proper operation of a safety function must be validated at various points in the product lifetime of the end-use machine.

Validation tests, in accordance with the checklist on the following page, must be conducted by an authorized person experienced in the functional safety of machines. Validation tests must be conducted.

Check	Requirement
☐	At initial installation and start-up of the safety function.
☐	After any changes related to the safety function (wiring, components, settings, etc.)
☐	After any maintenance work related to the safety function.
☐	At the required periodic test intervals.

Preliminary Checks

Before powering the drive, and commencing with the functional safety tests, check the following:

Check	Requirement
☐	Specifically ensure that proper grounding, shielding, overcurrent, and overvoltage protection measures are in place in regards to electrical safety and electromagnetic compatibility.
☐	That the wiring between the machine level safety circuits and the drive STO inputs meets the requirements set forth in this manual and those in IEC 61800-5-2 and ISO 13849-1 for wiring-associated fault exclusions.
☐	That the motor and associated load is free to move.
☐	That any other safety measures or warnings needed to ensure safe execution of periodic tests are in place

Start-Up Checklist

Chk	Requirement	Comments	Initials
☐	Ensure that the drive can be run and stopped freely during the commissioning.		
☐	Stop the drive (if running), and safely remove +HV power from the drive.		
☐	Check the STO-IN1 and STO-IN2 circuits and connections against a wiring diagram.		
☐	Apply +HV mains power to the drive. Energize both the STO-IN1 and STO-IN2 circuits.		
☐	Test the operation of the STO-IN1 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN1 circuit.		
☐	Test the operation of the STO-IN2 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Then, energize the STO-IN2 circuit.		
☐	Restart the drive and check that the motor runs normally		
☐	Test the operation of the STO-IN1 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN1 circuit		
☐	Test the operation of the STO-IN2 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive's control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Then, energize the STO-IN2 circuit		
☐	Restart the drive and ensure that the drive and motor operate normally.		

STO Status Indications

Although they are not and must not be considered part of the safety function, indications of the STO status are available from the NES & NPS drive for convenience purposes. Specifically, two user-accessible data objects bits, and the CME Control Panel provide some information on STO status. The data objects and CME are not part of the drive safety function.

STO Circuit Status Data Objects

The NES & NPS have a variety of data objects that can be read by the end user via EtherCAT, or serial communications.
The status of the STO circuit is available in DS-402 parameter 0x219D (ASCII 0x139).

Bits	Safety Circuit Status 0x219D (ASCII 0x139)
0,1	STO-IN1 status 00 Safe disabled and the drive is in a safe state. 01 Reserved 10 Test failed 11 Safe enabled and the drive is running in a normal operation.
2,3	STO-IN2 status Same as STO-IN1
4	Set (1) if no valid data is being received from the microcontroller
8-11	Safety processor firmware version
16-19	4 bits give details of what the failure was for STO-IN1 The values of these are: 0 Working normally 1 Timeout waiting for safety status info from the microcontroller. 2 Invalid status info received from the microcontroller. 8~15 Safety microcontroller is reporting a failure code
20-23	4 bits give details of what the failure was STO-IN2 The values are the same as those in STO-IN1
Bit	**Latching Fault Status Register 0x2183**
14	Set (1) when STO function is active and preventing the drive from producing torque

Troubleshooting

The status of the STO function in the NES/NPS servo drives can be viewed via data objects accessible over CANopen or EtherCAT connections, or by using the configuration software CME. Other Copley software products such as CMO (Copley Motion Objects), CML (Copley Motion Libraries), CPL (Copley Programming Language) and ASCII communications can read the status of the STO function.

The data parameters are not part of the drive safety function. They are informational only and cannot be relied upon for any safety related functions of the user.

How to tell if the STO function is active.

- The voltage to one or both of the STO channels in the drive is < +0.8 Vdc, or open.
- Bit 0 OR bit 1 of ASCII parameter 0x139 (DS-402 0x219D) is set (1).
- Bit 6 of the DS-402 Status Word 0x6041 will be set (1), indicating a switch-on-disabled state. This bit is controlled by any input that is programmed for the Enable function, and by the STO function. When bit is set (1), then it is necessary to check 0x219D (ASCII 0x139) to see if bit 0 or bit 1 is set (1). If this condition is true, then the STO function is active.

How to tell if the STO function is inactive.

- The voltage applied to both STO inputs of the drive is ≥ +3.0 Vdc (wired in parallel).
- Bit 0 AND bit 1 of ASCII parameter 0x139 (DS-402 0x219D) are zero.
- Bit 2 of the CANopen Status Word 0x6041 (Axis A) or 0x6841 (Axis B) is set(1), indicating a hardware-enabled state. The drive cannot be hardware-enabled until all inputs programmed as Enable inputs are true AND the bits 0 AND bit 1 in the STO function status parameter (0x219D) are zero.

Why can't the STO function be deactivated?

- The voltage between STO-IN1(+) and STO-IN1(-) is < +0.8 Vdc OR the voltage between STO-IN2(+) and STO-IN2(-) is < +0.8 Vdc. Both of these voltages must be ≥ +3.0 Vdc to deactivate the STO function.

Why can't the STO function be activated?

- The voltage between STO-IN1(+) and STO-IN1(-) is > +3.0 Vdc AND the voltage between STO-IN2(+) and STO-IN2(-) is > +3.0 Vdc. One or both of these voltages must be < +0.8 Vdc to activate the STO function.

The drive is hardware-enabled but the motors don't move.

- The STO function may be active. Check object 0x219D to see if either bit 0 OR bit 1 is set (1). If either of bits 0 or 1 are set, or if both are set, then the STO function will be activated.

7.12 Maintenance

Ease of Accessibility and Replacement of Internal Parts

There are no user-replaceable parts in the NES & NPS.
The warranty will be void if the user attempts any repairs.
For safety and to assure compliance with documented system data, only Copley Controls shall perform repairs to the NES & NPS.

Chk	Requirement	Comments	Initials
☐	Ensure that the drive can be run and stopped freely during the commissioning.		
☐	Stop the drive (if running), and safely remove +HV power from the drive.		
☐	Check the STO-IN1 and STO-IN2 circuits and connections against a wiring diagram.		
☐	Apply +HV power to the drive. Energize both the STO-IN1 and STO-IN2 circuits.		
☐	Test the operation of the STO-IN1 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Energize the STO-IN1 circuit.		
☐	Test the operation of the STO-IN2 function when the motor is stopped. Give a stop command for the drive (if running) and wait for the motor to come to a standstill. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit and give a start command for the drive. Ensure that the motor remains at a standstill. Energize the STO-IN2 circuit.		
☐	Restart the drive and check that the motor runs normally		
☐	Test the operation of the STO-IN1 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN2 energized, de-energize the STO-IN1 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive’s control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN1 circuit		
☐	Test the operation of the STO-IN2 function when the motor is running: Start the drive and ensure that the motor is running. While keeping STO-IN1 energized, de-energize the STO-IN2 circuit. Ensure that the motor stops. Reset any latching fault that may have occurred (these depend on the drive’s control mode settings). Try to start the drive. Ensure that the motor stays at a standstill. Energize the STO-IN2 circuit		
☐	Restart the drive and ensure that the drive and motor operate normally.		

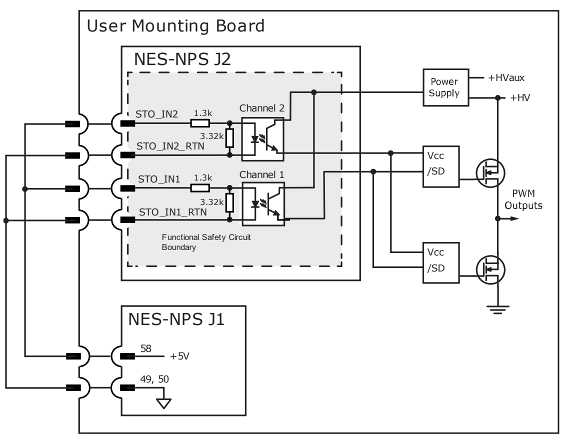
Disabling & Suspension of Safety Functions: STO Disabling

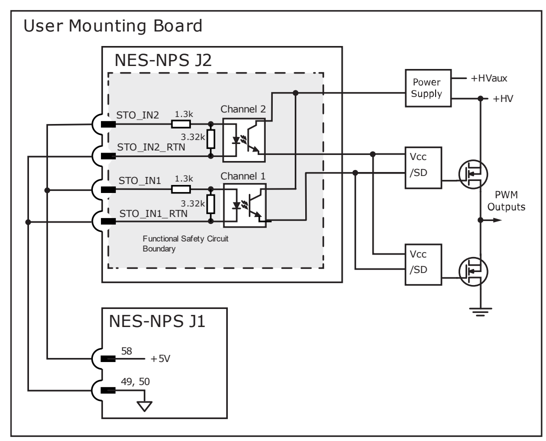
Disabling (bypassing) means de-activating the STO function. A convenient method for disabling the STO function is shown here for those installations that do not use the STO function.

An internal power source in the drive is brought out to the Safety connector. Connecting the STO inputs between this bypass power source and ground supplies power to the STO opto-couplers, energizing them, and enabling the PWM outputs to be controlled by the drive. The figure below shows the connections to either mute the STO function permanently, or to bring it out to a connector so that the user can wire it into their system.

STO Disabling Connections: NES & NPS

These figures show the disabling connections for two configurations. The figure on the left brings the disabling connections out to the user from their mounting board to give them access to the STO feature. The figure on the right shows the disabling connections made permanently on the user board for applications that do not use the STO function.





External Disabling Connections **Internal Disabling Connections**

Decommissioning

Before decommissioning any safety system from active service, do the following:

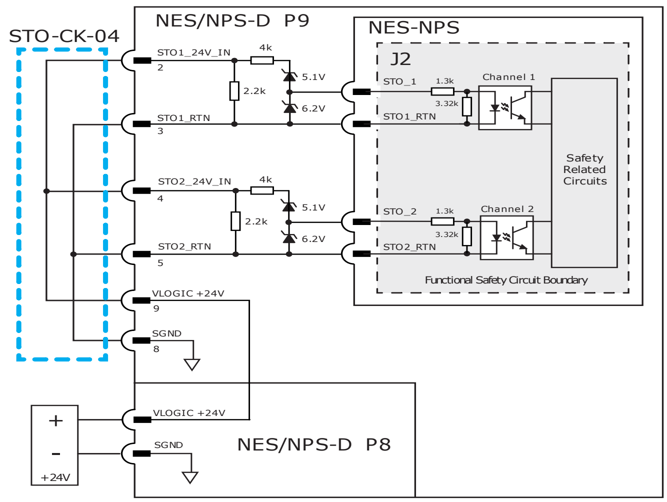
1. Evaluate the impact of decommissioning on adjacent operating units and facilities or other field services.
2. Conduct a proper review and obtain required authorization.
3. Ensure that the safety functions remain appropriate during decommissioning activities.
4. Implement appropriate change procedures for all decommissioning activities.

STO Disabling with Dev Kit

P9 of the NS-D-CK connector kits comprise a connector and backshell. With pins connected as shown, inserting it into P9 of the Development Kit will disable the STO function, allowing normal operation of the drive when the STO function is not required. As shown below, the STO inputs are energized in parallel using the STO-24V from the drive.

STO Disabling with STO-CK-04 Bypass Jumper on -D Dev Kit

This uses the VLOGIC that is required for normal operation of the drive. It connects internally to pin 9 of the P9 connector. From there a jumper in the STO-CK-04 connects it to the 24V inputs on P9.



Another jumper connects SGND to the STOx_RTN ground inputs.

Decommissioning

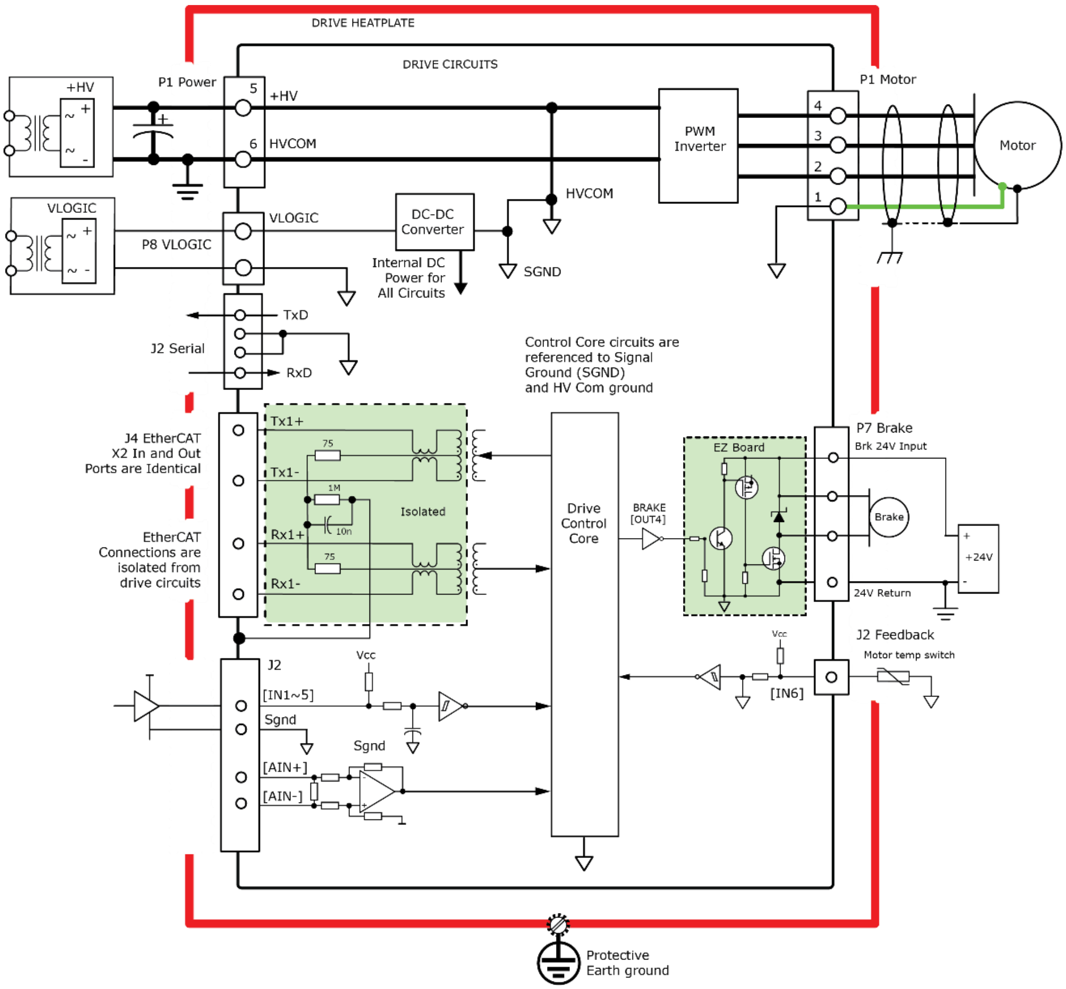
Before decommissioning any safety system from active service, do the following:

1. Evaluate the impact of decommissioning on adjacent operating units and facilities or other field services.
2. Conduct a proper review and obtain required authorization.
3. Ensure that the safety functions remain appropriate during decommissioning activities.
4. Implement appropriate change management procedures for all decommissioning activities.

8 Operational Theory

8.1 Drive Input Power

Power distribution within NANO NES/NPSs has a common ground which is isolated from the heat plate. The CANopen & EtherCAT network signals are isolated from all of the drive circuits.



VLOGIC Power

An internal DC/DC converter operates from the VLOGIC input and creates the logic/signal operating voltages. This enables the drive to stay on-line when the +HV power has been disconnected for emergency-stop or operator-intervention conditions. Network and serial communications remain active so that the drive can be monitored by the control system when the +HV is removed. The control core, feedback devices, and network connections are all maintained by the VLOGIC power so that the system controller has visibility of the drive status, motor position, I/O states, etc. When the +HV is 60 Vdc or less, it and the VLOGIC can be driven from a single power supply. When using the STO feature, the VLOGIC must be produced by a power supply with transformer isolation from the mains, PELV or SELV rating, and a maximum output voltage of 60 Vdc.

+HV Power

The +HV input drives the high-voltage PWM outputs.

8.2 Commutation Modes

The drives support three commutation modes to drive brush and brushless motors:

- AC brushless sinusoidal: U-V-W PWM outputs are sinusoidal with 120 degrees of separation.
- DC brushless trapezoidal: U-V-W PWM outputs DC values at 60 degree increments
- DC brush: U-V outputs are DC values from the maximum positive and negative ratings.

IMPORTANT: The STO function cannot be used with DC brush motors.

In most applications, sinusoidal commutation is preferred over trapezoidal, because it reduces torque ripple and offers the smoothest motion at any velocity or torque. In the sinusoidal commutation mode, an encoder is required for brushless sinusoidal commutation. Halls are sufficient for trapezoidal commutation. When driving a DC brush motor, the drive operates as a traditional H-Bridge drive. All the commutation modes are used to produce current in the motor resulting in acceleration of a load.

8.3 Feedback

All of the NANO NES/NPS drives support digital quadrature encoders, and two absolute encoder formats, BiSS and SSI. They typically use Hall sensors for the commutation of brushless motors when incremental encoders are used. Without Halls, algorithmic phase initialization (aka ‘wake ‘n shake’) occurs when the drive is first enabled. Absolute encoders can be auto-phased using CME and the results saved in the drives flash memory, eliminating the need for Halls. Brush motors are self-commutating and do not require feedback for torque production.

8.4 Synchronization

Using EtherCAT, the distributed clock feature can be used to establish PWM switching frequency synchronization among the network connected drives. Typically, one drive acts as the Sync 0 reference clock. The master then adjusts the Sync 0 frequency and phase in the slaves to so that they are all in-sync.

Over CANopen, one drive produces a Sync message that carries a high-resolution time-stamp. The other drives on the network receive the Sync message and adjust their internal clocks so that all of the drives on the network have their PWM frequencies synchronized.

8.5 Input Command Types

The drive can be controlled by a variety of external sources: analog voltage or digital inputs, CAN network (CANopen), EtherCAT, CoE (CANopen application protocol over EtherCAT), or from an RS-232 serial connection using ASCII commands. The drive can also function as a stand-alone motion controller running an internal CVM or CPL program or using its internal function generator.

Analog Command Input

Overview

The drive can be driven by an analog voltage signal through the analog command input which has a range of ±10 Vdc. The drive converts the signal to a current, velocity, or position command as appropriate for current, velocity, or position mode operation, respectively.
The analog input signal is conditioned by the scaling, dead band, and offset settings.

Scaling

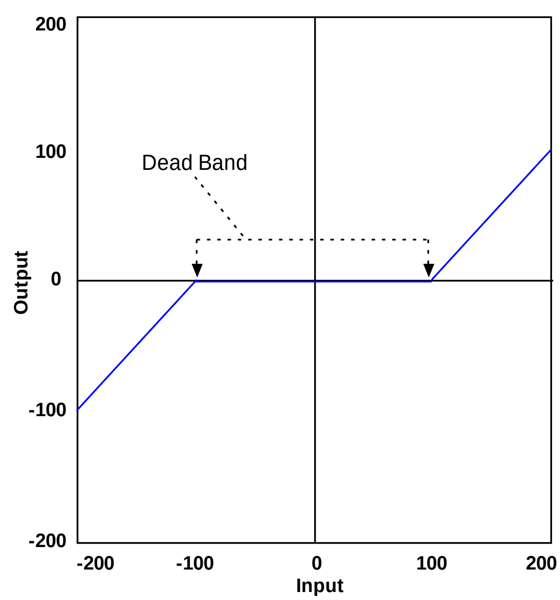
The magnitude of the command generated by an input signal is proportional to the input signal voltage. Scaling controls the input-to-command ratio, allowing the use of an optimal command range for any given input voltage signal range.

For example, in current mode, with default scaling, +10 Vdc of input generates a command equal to the drive's peak current output; +5 Vdc equals half of that.

Scaling could also be useful if, for example, the signal source generates a signal range between 0 and +10 Vdc, but the command range only requires +7.5 Vdc of input. In this case, scaling allows the drive to equate +7.5 Vdc with the drive's peak current (in current mode) or maximum velocity (in velocity mode), increasing the resolution of control.

Dead Band

To protect against unintended response to low-level line noise or interference, the drive can be programmed with a "dead band" to condition the response to the input signal voltage. The drive treats anything within the dead band ranges as zero and subtracts the dead band value from all other values. For instance, with a dead band of 100 mV, the drive ignores signals between −100 mV and +100 mV, and treats 101 mV as 1 mV, 200 mV as 100 mV, and continues in the same sequence.



Offset

To remove the effects of voltage offsets between the controller and the drive in open loop systems, CME provides an Offset parameter and a Measure function. The Measure function takes 10 readings of the analog input voltage over a period of approximately 200 ms, averages the readings, and then displays the results. The Offset parameter allows the user to enter a corrective offset to be applied to the input voltage.

The offset can also set up the drive for bi-directional operation from a unipolar input voltage. An example of this would be a 0 to +10 Vdc velocity command that had to control 1000 rpm CCW to 1000 rpm CW. Scale would be set to 2000 rpm for a +10 Vdc input and Offset set to -5V. After this, a 0 Vdc input command would be interpreted as -5 Vdc, which would produce 1000 rpm CCW rotation. A +10 Vdc command would be interpreted as +5 Vdc and produce 1000 rpm CW rotation.

Monitoring the Analog Command Voltage

The analog input voltage can be monitored in the CME control panel and oscilloscope. The voltage displayed in both cases is after the offset and deadband have been applied.

Analog Command in Position Mode

The NANO Analog Position command operates as a relative motion command. When the drive is enabled the voltage on the analog input is read. Then any change in the command voltage will move the axis a relative distance, equal to the change in voltage, from its position when enabled.

To use the analog position command as an absolute position command, the drive must be homed every time it is enabled. The Homing sequence may be initiated by CAN, ASCII serial, CVM or CPL Indexer program commands.

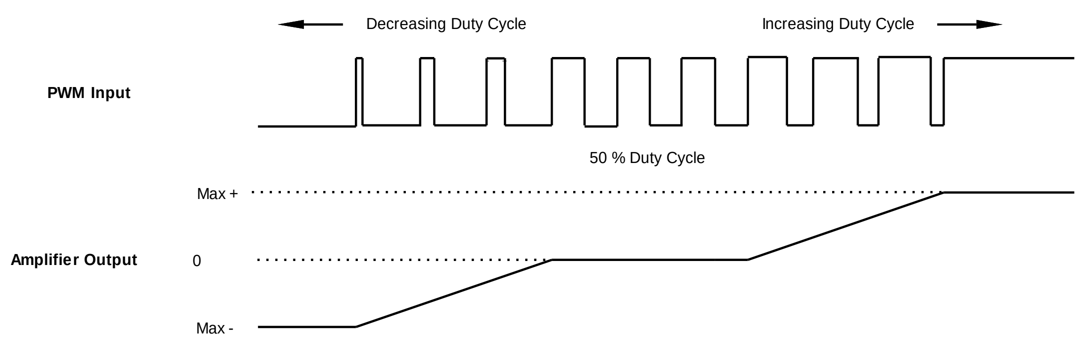
PWM Input Commands

Two Formats

The drive can accept a pulse width modulated signal (PWM) signal to provide a current command in current mode and a velocity command in velocity mode. The PWM input can be programmed for two formats: 50% duty cycle (one-wire) and 100% duty cycle (two-wire).

50% Duty Cycle Format (One-Wire)

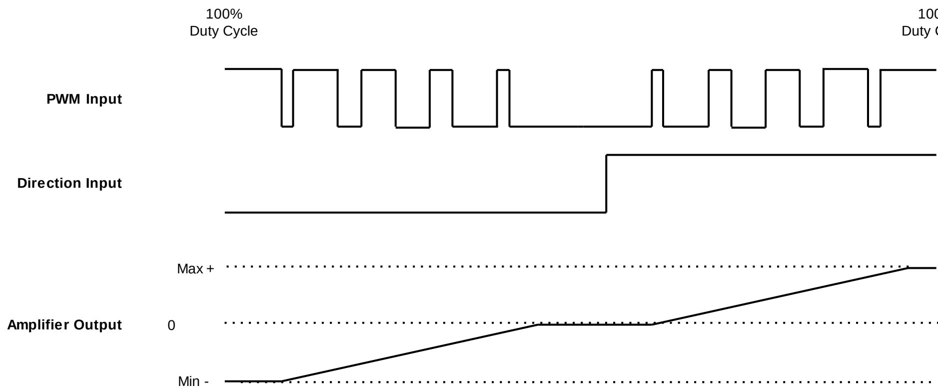
The input takes a PWM waveform of fixed frequency and variable duty cycle. As shown below, a 50% duty cycle produces zero output from the drive. Increasing the duty cycle toward 100% commands a positive output, and decreasing the duty cycle toward zero commands a negative output.



The command can be inverted so that increased duty cycle commands negative output and vice versa.

100% Duty Cycle Format (Two-Wire)

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. A 0% duty cycle creates a zero command, and a 100% duty cycle creates a maximum command level. The command can be inverted so that increasing the duty cycle decreases the output and vice versa.



Protection from 0 or 100% Duty Cycle Commands

In both formats, the drive can be programmed to interpret 0 or 100% duty cycle as a zero command. This prevents the 0% or 100% commands that would result from a controller failure or a cable break which could result in the input pulled up to +5V or pulled-down to Signal Ground (0V).

Digital Input Commands

Three Formats

In position mode, the drive can accept position commands via two digital inputs, using one of these signal formats: pulse and direction, count up/count down, and quadrature.

In all three formats, the drive can be configured to invert the command.

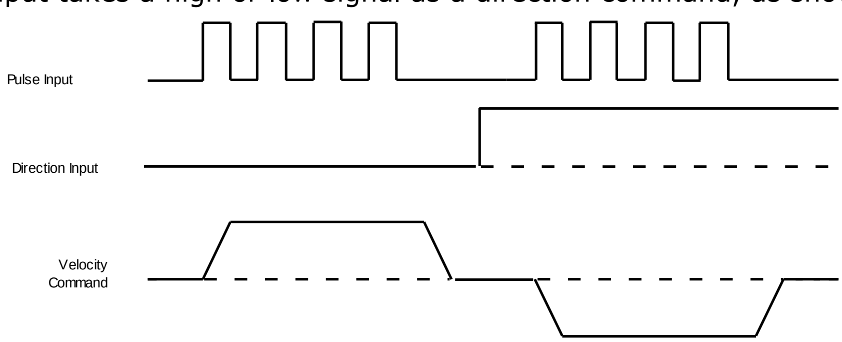
Pulse Smoothing

In position mode, the drive's trajectory generator ensures smooth motion even when the command source cannot control acceleration and deceleration rates.

When using digital or analog command inputs, the trajectory generator can be disabled by setting the Max Accel limit to zero. (Note that when using the CAN bus, serial bus, EtherCAT, or CVM Control Program, setting Max Accel to zero prevents motion.)

Pulse and Direction Format

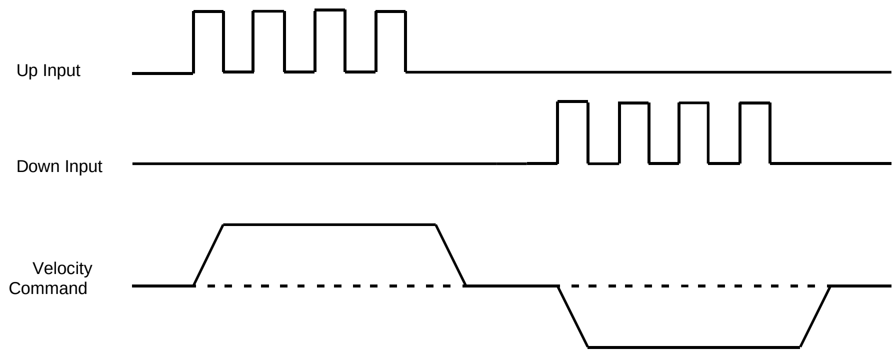
In pulse and direction format, one input takes a series of pulses as motion step commands, and another input takes a high or low signal as a direction command, as shown below.



The drive can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.

Count Up/Count Down Commands

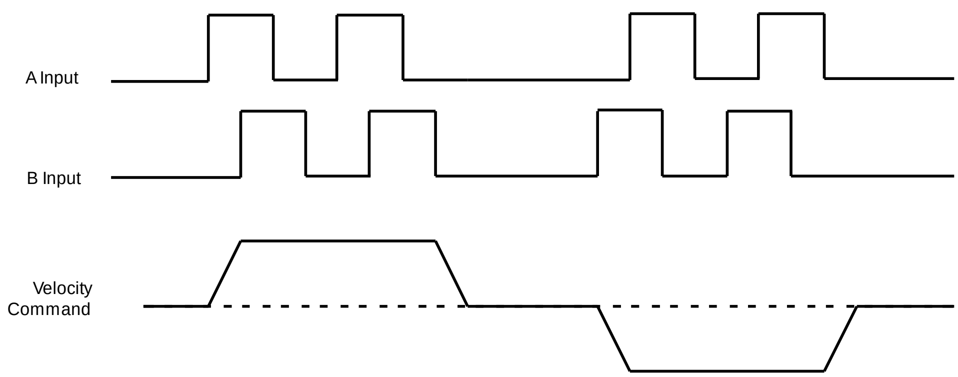
In the Count Up/Down format, one input takes each pulse as a positive step command, and another takes each pulse as a negative step command, as shown below.



The drive can be set to increment position on the rising or falling edge of the signal. Stepping resolution can be programmed for electronic gearing.

Quadrature Format Commands

In Quadrature format, A/B quadrature commands from a master encoder (via two inputs) provide velocity and direction commands, as shown below.



The ratio can be programmed for electronic gearing.

8.6 Communications

The drives support multiple communication interfaces, each used for different purposes.

Interface	Description
EtherCAT (NES)	Drives support CANopen application protocol over EtherCAT (CoE) via a 100BASE-TX physical layer.
CAN interface (NPS)	When operating as a CAN node, the drive takes command inputs over a CANopen network. CAN communications are described in the next section.
RS-232 Serial	The RS-232 port is a three-wire, DTE, full-duplex port. Control commands can be sent over the RS-232 port using Copley Controls ASCII interface commands. In addition, CME software communicates with the drive (using a binary protocol) over this link for drive commissioning, adjustments, and diagnostics. Note that CME can be used to make adjustments even when the drive is being controlled over the CAN interface or by the digital inputs.

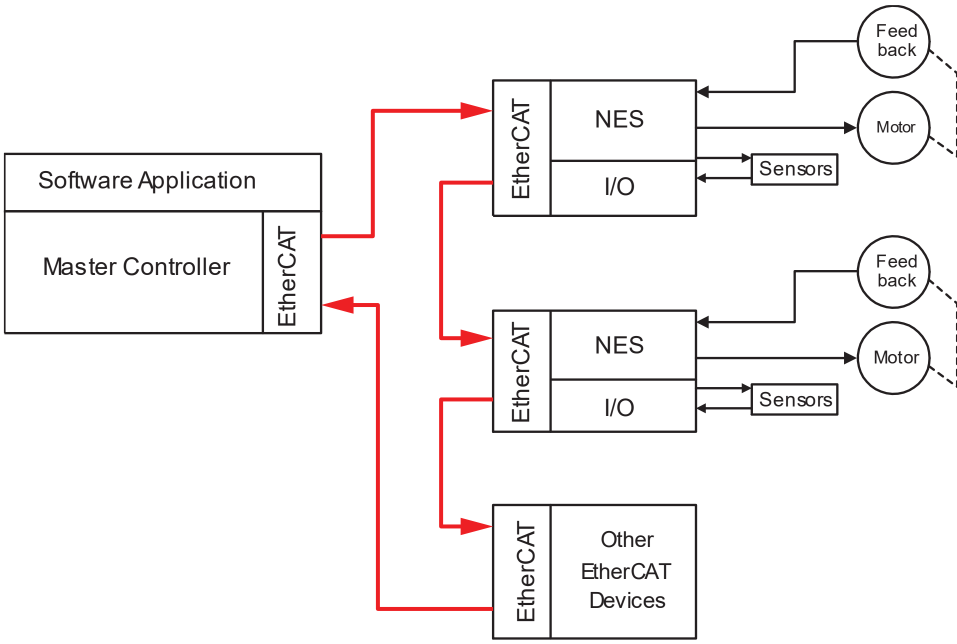
! DANGER	**Using CME can affect or suspend CAN operations.**
	When operating the drive as a CANopen node, use of CME to change drive parameters can affect CANopen operations in progress. Using CME to initiate motion can cause CANopen operations to suspend. The operations may restart unexpectedly when the CME move is stopped. **Failure to heed this warning can cause equipment damage, injury, or death.**

EtherCAT Communication Details: NES

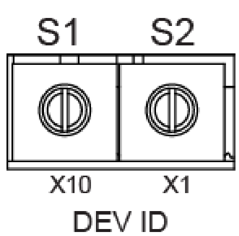
This model accepts CANopen application protocol over EtherCAT (CoE) commands.

EtherCAT Addressing

EtherCAT supports two types of addressing nodes on the network: auto-increment and fixed. Nodes on an EtherCAT network are automatically addressed by their physical position on the network. The first drive found on the network is address -1 (0xFFFF). The second is -2 (0xFFFE) and continues in the same sequence. Fixed addresses are assigned by the master when it scans the network to identify all of the nodes and are independent of the physical position on the network. Fixed addresses begin with 1001 (0x3E9) and increment thereafter as nodes are found. Each dual axis drive is addressed as a single physical node on the EtherCAT network having two axes of motion.



As an alternate to the default addressing, switches S1 and S2 may be used to program a drive's Device ID, or Station Alias with a value between 0x01 and 0xFF (1-255 decimal). In dual axis drives, the second drive follows the first's Device ID value. Use of a station alias guarantees that a given drive can be accessed absolutely independent of the cabling configuration.



The fixed address and station alias are always available. If the switch-based station alias is used, it is the responsibility of the user to ensure that each drive has a unique station alias.

CAN Communication Details: NPS

CAN Network and CANopen Profiles for Motion

These drives communicate over a two-wire Controller Area Network (CAN).
The CAN specification defines the data link layer of a fast, reliable network and is an international standard ISO 11898-1. The physical layer is a two-wire, serial-data connection.

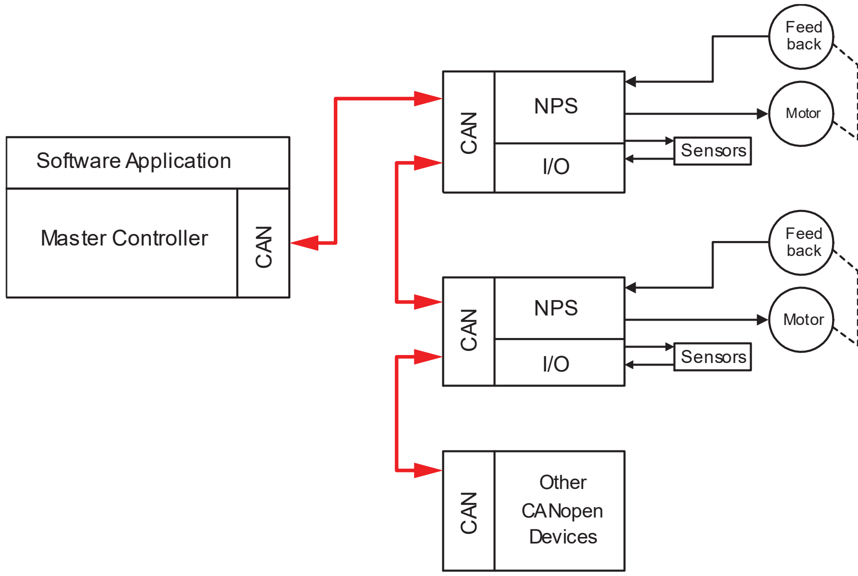
CANopen is the CAN-based higher-layer protocol for embedded control systems. CiA 402 is the CANopen profile for drives and motion controllers, internationally standardized in IEC 61800-7-201 and IEC 61800-7-301. It is supported by Copley CANopen servo and stepper drives, allowing them to operate in the following modes of operation: Profile Position, Profile Velocity, Profile Torque, Interpolated Position, and Homing.

Supported CANopen Modes

- **Profile Position**: Mode 1
  The drive is programmed with a velocity, a relative or absolute target position, acceleration, and deceleration rates. On command, a complete motion profile is executed, traveling the programmed distance, or ending at the programmed position. The drive supports both trapezoidal and s-curve profiles.
- **Profile Velocity**: Mode 3
  The drive is programmed with a velocity, a direction, and acceleration and deceleration rates. When the drive is enabled, the motor accelerates to the set velocity and continues at that speed. When the drive is halted, the velocity decelerates to zero.
- **Profile Torque**: Mode 4
  The drive is programmed with a torque command. When the drive is enabled, or the torque command is changed, the motor torque ramps to the new value at a programmable rate. When the drive is halted, the torque ramps down at the same rate.
- **Homing**: Mode 6
  Used to move the axis from an unknown position to a known reference or zero point with respect to the mechanical system. The homing mode is configurable to work with a variety of combinations of encoder index, home switch, and limit switches.
- **Interpolated Position** (PVT, or Position, Velocity, Time): Mode 7
  The controller sends the drive a sequence of points, each of which is a segment of a larger, more complex move, rather than a single index or profile. The drive then uses cubic polynomial interpolation to “connect the dots” so that the motor reaches each point at the specified velocity at the programmed time.

CANopen Architecture

As shown below, in a CANopen motion control system, control loops are closed in the individual drives, not across the network. A master application coordinates multiple devices, using the network to transmit commands and receive status information. Each device can transmit to the master or any other device on the network. CANopen provides the protocol for mapping device and master internal commands to messages that can be shared across the network.



CAN Addressing

A CANopen network can support up to 127 nodes. Each node must have a unique and valid seven-bit address (Node ID) in the range of 1-127. Address 0 is reserved for the CAN master and should only be used when the drive is serving as a CME serial port multi-drop gateway.

The graphic above is an example of addressing for two Copley drives as the first two devices on a network that also contains other CAN devices.

There are several methods for setting the CAN address, as described below. These methods can be used in any combination, producing a CAN address equal to the sum of the settings.

Addressing Method	Description
Address switches	If the address number <= 127, CAN address can be set using the CAN ADDR switches only.
Digital inputs	Use the drive's programmable digital inputs (user selects how many (1-7) and which inputs are used).
Programmed value in flash memory	Program the address into flash only.

For more information on CAN addressing, see the CME User Guide.

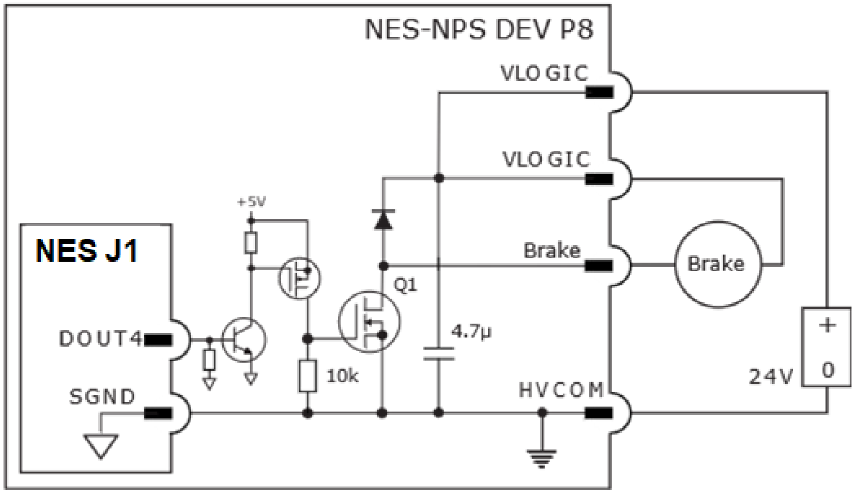
For more information on CANopen operations, see the following Copley Controls documents:

- CANopen Programmer's Manual
- CML Reference Manual
- CMO (Copley Motion Objects) Programmer's Guide

8.7 Brake Operation

BRAKE OUTPUT: OUT4

Many control systems employ a brake to hold an axis when the drive is disabled.
NES/NPS drives have digital OUT4 that can drive brakes up to 1 A.
For brakes with higher current ratings, OUT4 can drive an external MOSFET.

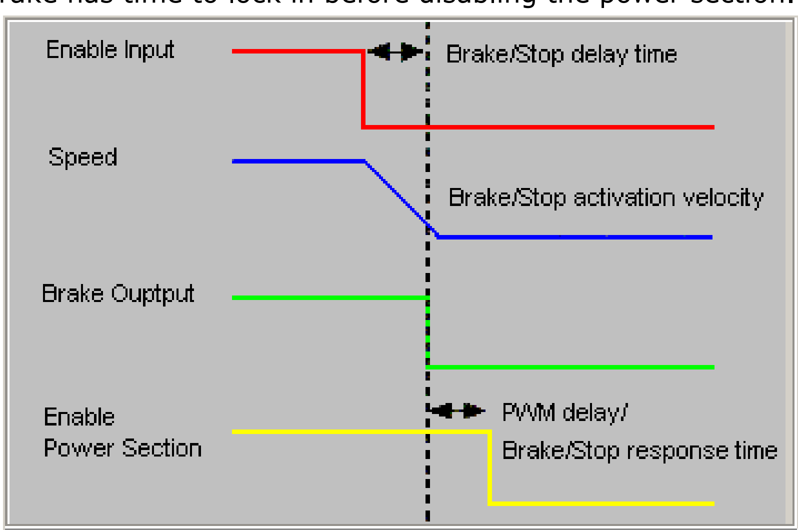


BRAKE/STOP SEQUENCES

Disabling the drive by a hardware or software command starts the following sequence of events. The motor begins to decelerate (at Abort Deceleration rate in position mode or Fast Stop Ramp rate in velocity mode). At the same time, the Brake/Stop Delay Time count begins. This allows the drive to slow the motor before applying the brake.

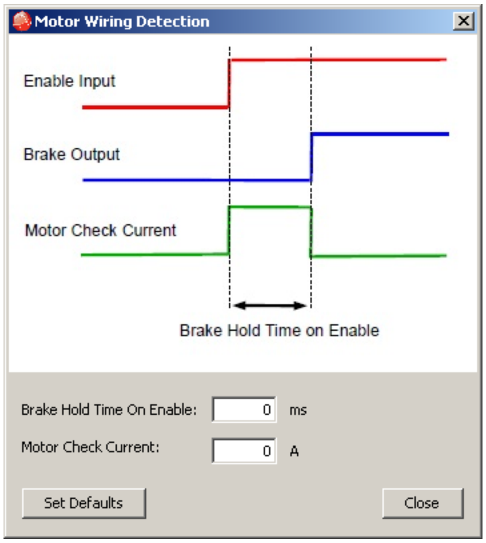
When the motor slows to Brake/Stop Activation Velocity OR the Brake/Stop Delay Time expires, the brake output activates and PWM Delay Brake/Stop Response Time count begins.

When response time has passed, the drive's output stages are disabled. This delay ensures the brake has time to lock in before disabling the power section.



Motor Wiring Detection

When a brake is in use, the drive can check for a disconnected motor. Upon enable, the drive will apply current to the motor output while keeping the brake engaged for the Brake Hold Time on Enable. If no current can be detected in the windings, the brake will not be released and a Wiring Detection Fault will occur. If the motor is connected and current can be detected, the brake will be released after the programmable time expires.

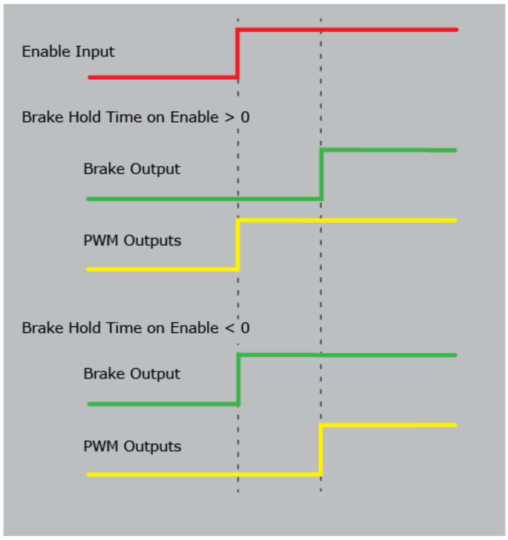


Motor Brake Enable Delay Time

The programmable value in the Motor Wiring Detection also sets the time between the activation of the brake and PWM outputs of the drive.

- When the value is positive, the PWM outputs will turn on when the drive is enabled, and the brake will be released after the programmable delay expires.
- When the value is negative, the brake is released immediately when the drive is enabled and the PWM outputs are enabled after the programmable delay expires.

The graphic below is not part of CME, but shows the timings in the same colors as the Brake setting screen.



8.8 Protection

Faults Overview

NANO NES/NPS detect and respond to a set of conditions regarded as faults, such as drive over temperature and excessive following error. When any fault occurs, with the exception of a following error, the drive's PWM output stage is disabled, the fault type is recorded in the drive's internal error log (which can be viewed with CME). On Development Kits, the drive status (AMP) LED changes to indicate a fault condition exists.

A digital output can also be programmed to activate on a fault condition. The Following Error fault behaves with slight differences, as described in Following Error Fault Details.

The drive's PWM output stage can be re-enabled after the fault condition is corrected and the drive faults are cleared. The process for clearing faults varies depending on whether the fault is configured as non-latched or latched. The fault-clearing descriptions below apply to all faults except for the following error fault, which is described in Following Error Fault Details.

Clearing Non-Latched Faults

The drive clears a non-latched fault, without operator intervention, when the fault condition is corrected.

! **DANGER**	**Risk of unexpected motion with non-latched faults.** After the cause of a non-latched fault is corrected, the drive re-enables the PWM output stage without operator intervention. In this case, motion may re-start unexpectedly. Configure faults as latched unless a specific situation calls for non-latched behavior. When using non-latched faults, be sure to safeguard against unexpected motion. **Failure to heed this warning can cause equipment damage, injury, or death.**

Clearing Latched Faults

A latched fault is cleared only after the fault has been corrected and at least one of the following actions has been taken:

- Power-cycle the VLOGIC to the drive
- Cycle (disable and then enable) an enable input that is configured as Enable with Clear Faults or Enable with Reset
- Open the CME Control Panel and press Clear Faults or Reset buttons.
- Clear the fault over the CAN or EtherCAT network, or serial connection.

Example: Non-Latched vs. Latched Faults

When the drive temperature reaches the over-temperature level, the drive disables the PWM outputs. The drive temperature then cools into the normal operating range. If the Drive Over Temperature fault is not latched, the fault is automatically cleared and the drive's PWM outputs are re-enabled. If the fault is latched, the fault remains active and the drive's PWM outputs remain disabled until the faults are specifically cleared (as described above).

Fault Descriptions

The set of possible faults is described below. For details on limits and ranges, see Fault Levels.

Fault Description	Fault Occurs When...	Fault is Corrected When...
* Short Circuit Detected	Output to output, output to ground, internal PWM bridge fault.	Short circuit has been removed.
* Amp Over Temperature	Drive's internal temperature exceeds specified temperature.	Drive temperature falls below specified temperature.
* Motor Over Temperature	Motor over-temperature switch changes state to indicate an over-temperature condition.	Temperature switch changes back to normal operating state.
Over Voltage	Bus voltage exceeds specified voltage limit.	+ DC bus voltage returns to specified voltage range.
Under Voltage	Bus voltage falls below specified voltage limit.	+ DC bus voltage returns to specified voltage range.
* Feedback error	Over current condition detected on the output of the internal +5 Vdc supply used to power the encoders not connected or levels out of tolerance.	Encoder power returns to the specified voltage range. Feedback signals stay within specified levels.
Motor Phasing Error	Encoder-based phase angle does not agree with Hall switch states. This fault can occur only with brushless motors set up using sinusoidal commutation. It does not occur with Halls correction turned off.	Encoder-based phase angle agrees with Hall switch states.
* Following Error	User set following error threshold exceeded.	See Position and Velocity Errors (8.9).
Command Input Fault	Loss of PWM input, or network command data	PWM signals restored, network communications resume
Motor Wiring Disconnected	Used with motor brakes, a programmable time during which current-flow in the motor will be tested before the brake is released. If current is not detected, it is a fault.	Motor current is detected during programmable delay before brake is released to stop the motor.
Over Current (Latched)	Optional: The I2T current-limit for the drive has been reached	Reduce drive current

* Configured as latching by default. Programmable to be non-latching.

8.9 Position and Velocity Errors

Error-Handling Methods

In Position mode, the difference between the limited position output of the trajectory generator and the actual motor position is the position or following error. The drive's position loop uses complementary methods for handling position errors: following error fault, following error warning, and a position-tracking window.

Likewise, in Velocity or Position mode, any difference between the limited velocity command and actual velocity is a velocity error. The drive's velocity loop uses a velocity tracking window method to handle velocity errors. (There is no velocity error fault).

Following Error Faults

When the position error reaches the programmed fault threshold, the drive immediately faults. (The following error fault can be disabled.) For detailed information,
see Following Error Fault Details below.

Following Error Warnings

When the position error reaches the programmed warning threshold, the drive immediately sets the following error warning bit in the status word. This bit can be read over a CAN or EtherCAT. It can also be used to activate a digital output.

Position and Velocity Tracking Windows

When the position error exceeds the programmed tracking window value, a status word bit is set. The bit is not reset until the position error remains within the tracking window for the programmed tracking time. A similar method is used to handle velocity errors.

For detailed information, see Tracking Window Details in the following page.

Position Error Reaches Fault Level

As described earlier, position error is the difference between the limited position output of the trajectory generator and the actual position. When position error reaches the programmed following error fault level, the drive faults (unless the following error fault is disabled.) As with a warning, a status bit is set. In addition, the fault is recorded in the Error Log. Additional responses and considerations depend on whether the fault is non-latched or latched, as described below.

Drive Response to Non-Latched Following Error Fault

When a non-latched following error fault occurs, the drive drops into velocity mode and applies the Fast Stop Ramp deceleration rate to bring the motor to a halt. The drive PWM output stage remains enabled, and the drive holds the velocity at zero, using the velocity loop.

Resuming Operations After a Non-Latched Following Error Fault

The clearing of a non-latched following error depends on the drive's mode of operation. Issuing a new trajectory command over the CAN bus or the ASCII interface, will clear the fault and return the drive to normal operating condition.

If the drive is receiving position commands from the digital or differential inputs, then the drive must be disabled and then re-enabled using the drive's enable input or though software commands. After re-enabling, the drive will operate normally.

Drive Response to a Latched Following Error Fault

When a latched following error fault occurs, the drive disables the output PWM stage without first attempting to apply a deceleration rate. If a motor brake is in use, the brake output will turn off immediately, engaging the motor brake.

Resuming Operations After a Latched Following Error Fault

A latched following error fault can be cleared using the steps used to clear other latched faults:

- Power-cycle the drive. If VLOGIC is used, then both VLOGIC and +HV must be turned off/on. If either one is >= Minimum Vdc, the drive will not reset.
- Cycle (disable and then enable) an enable input that is configured as Enable with Clear Faults or Enable with Reset
- Open the CME Control Panel and press Clear Faults or Reset buttons.
- Clear the fault over the CANopen or EtherCAT network, or serial bus.

Tracking Window Details

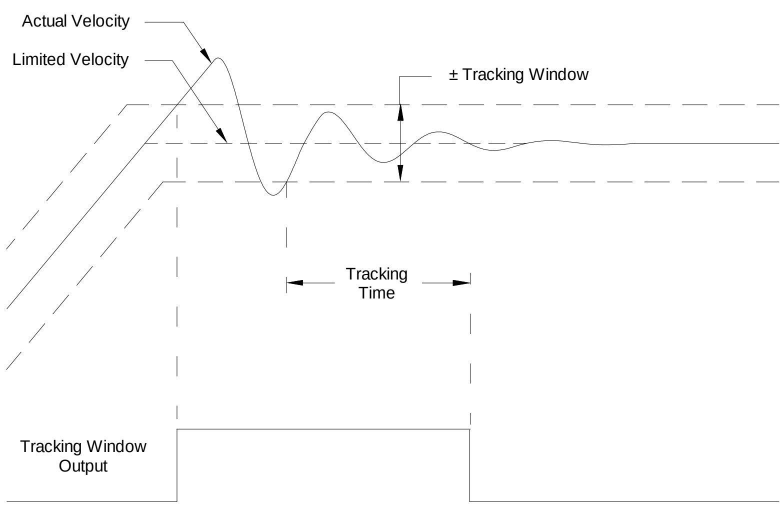
Proper Tracking Over Time

As described earlier, position error is the difference between the limited position output of the trajectory generator and the actual position. Velocity error is the difference between commanded and actual velocity.

When the position or velocity error exceeds the programmed tracking window value, a status word bit is set. The bit is not reset until the error remains within the tracking window for the programmed tracking time.

Velocity Tracking Illustration

The following diagram illustrates the use of tracking window and time settings in velocity mode.



8.10 Digital Inputs

Digital Inputs

All of the drives feature 6 programmable digital inputs. IN1~5 are high-speed 3.3 V Schmitt triggers. IN6 defaults as the motor over-temp input, changing state when a temperature-sensitive resistor switches to a high-resistance state.

Debounce Time

To prevent undesired multiple triggering caused by switch bounce upon switch closures, each input can be programmed with a debounce time. The programmed time specifies how long an input must remain stable at a new state before the drive recognizes the state. The debounce time is ignored if the input is used as a digital command input.

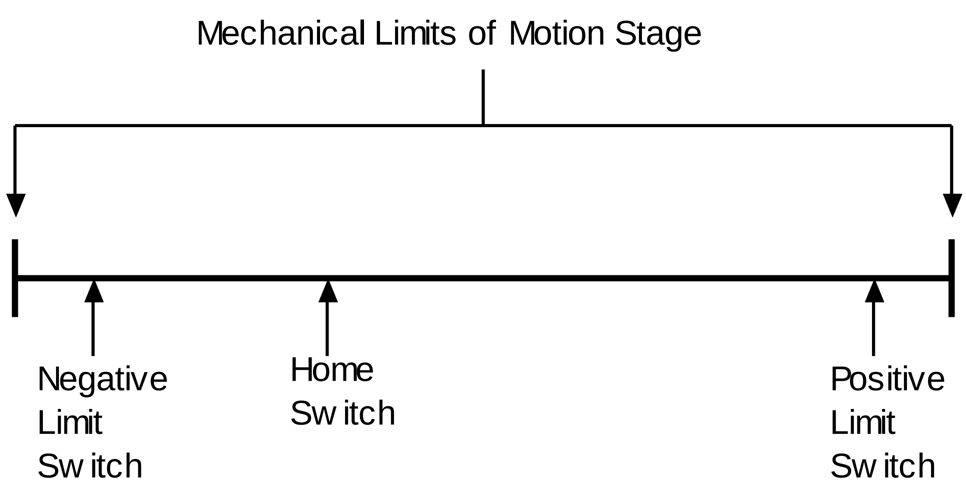
Limit Switches

Use Digital Inputs to Connect Limit Switches

Limit switches help protect the motion system from unintended travel to the mechanical limits. With the drive operating as a CAN or EtherCAT node, an input can also be programmed as a home limit switch for homing operations over the network.

Diagram: Sample Placement of Limit Switches

The following diagram shows these limit switches in use on a sample motion stage.



How the Drive Responds to Limit Switch Activation

The drive stops any motion in the direction of an active limit switch, as described below. The response is identical in current and velocity modes, and slightly different in position mode.

Mode	Drive Response to Active Positive (or Negative) Limit Switch
Current Velocity	Drive prohibits travel in positive (or negative) direction. Travel in the opposite direction is still allowed. Drive status indicator flashes green at fast rate. Warning is displayed on CME Control Panel and CME Control Panel limit indicator turns red.
Position	Drive stops responding to position commands until the drive is disabled and re-enabled, or the fault is cleared over the CANopen interface. Drive status indicator flashes green at fast rate. Warning is displayed on CME Control Panel and CME Control Panel limit indicator turns red. Default behavior: If, after re-enabling the amp, the limit switch is still active, the drive will only allow movement in the opposite direction. "Hold position" behavior: If the *Hold position when limit switch is active option is set, the drive prevents any motion while a limit switch is active. CAUTION: If the drive is switched back to current or velocity mode with this option selected, the limit switches will no longer function. For more information on *Hold position when limit switch is active, see the CME User Guide.

Using Custom Output to Signal Limit Switch Activation

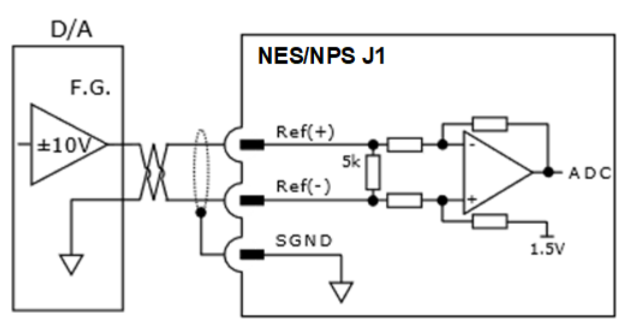
In addition to the response described above, any of the drive's digital outputs can be configured to go active when a positive or negative limit switch is activated.
For more information, see the CME User Guide.

8.11 Analog Input

As a reference input, it takes Position/Velocity/Torque commands from a controller.
If it is not used as a command input, it can be used as general-purpose analog input.

Specifications	Data	Notes
Input Voltage	Vref	±10 Vdc
Input Resistance	Rin	5.0 kΩ

Name	P1 Pins
Ref (+)	2
Ref (-)	1



8.12 Outputs

These drives have 4 programmable digital outputs. OUT1~4 are CMOS inverters.
They operate from +5V and can source/sink 4 mAdc. Output functions are listed below:

- Fault-Active High
- Fault-Active Low
- Brake-Active High
- Brake-Active Low
- PWM Sync Output
- Custom Event
- Custom Trajectory Status
- Custom Position-Triggered Output
- Program Control-Active High
- Program Control-Active Low
- External Regen-Active High
- External Regen-Active Low
- STO Status-Active High
- STO Status-Active Low

8.13 I^2T Time Limit Algorithm

The current loop I^2T limit specifies the maximum amount of time that the peak current can be applied to the motor before it must be reduced to the continuous limit or generate a fault. This chapter describes the algorithm used to implement the I^2T limit.

I^2T Overview

The I^2T current limit algorithm continuously monitors the energy being delivered to the motor using the I^2T Accumulator Variable. The value stored in the I^2T Accumulator Variable is compared with the I^2T setpoint that is calculated from the user-entered Peak Current Limit, I^2T Time Limit, and Continuous Current Limit. Whenever the energy delivered to the motor exceeds the I^2T setpoint, the algorithm protects the motor by limiting the output current or generates a fault.

Calculating the I^2T Setpoint Value

The I^2T setpoint value has units of Amperes^2-seconds (A^2S) and is calculated from programmed motor data. The setpoint is calculated from the Peak Current Limit, the I^2T Time Limit, and the Continuous Current Limit as follows:

I^2T setpoint = (Peak Current Limit^2 – Continuous Current Limit^2) * I^2T Time Limit

I^2T Algorithm Operation

During drive operation, the I^2T algorithm periodically updates the I^2T Accumulator Variable at a rate related to the output current Sampling Frequency. The value of the I^2T Accumulator Variable is incrementally increased for output currents greater than the Continuous Current Limit and is incrementally decreased for output currents less than the Continuous Current Limit. The I^2T Accumulator Variable is not allowed to have a value less than zero and is initialized to zero upon reset or +24 Vdc logic supply power-cycle.

ACCUMULATOR INCREMENT FORMULA

At each update, a new value for the I^2T Accumulator Variable is calculated as follows:

I^2T Accumulator Variable n+1 = I^2T Accumulator Variable n +
((Actual Output Current n+1)^2 – Continuous Current Limit^2) * Update period

After each sample, the updated value of the I^2T Accumulator Variable is compared with the I^2T setpoint. If the I^2T Accumulator Variable value is greater than the I^2T Setpoint value, then the drive limits the output current to the Continuous Current Limit. When current limiting is active, the output current will be equal to the Continuous Current Limit if the commanded current is greater than the Continuous Current Limit. If instead the commanded current is less than or equal to the Continuous Current Limit, the output current will be equal to the commanded current.

I^2T CURRENT LIMIT ALGORITHM – APPLICATION EXAMPLE

I^2T EXAMPLE: PARAMETERS

Operation of the I^2T current limit algorithm is best understood through an example.
For this example, a motor with the following characteristics is used:

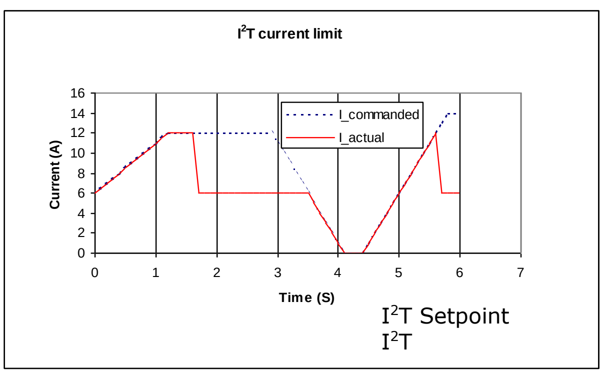
- Peak Current Limit – 12 A
- I2T Time Limit – 1 S
- Continuous Current Limit – 6 A

From this information, the I^2T setpoint is:

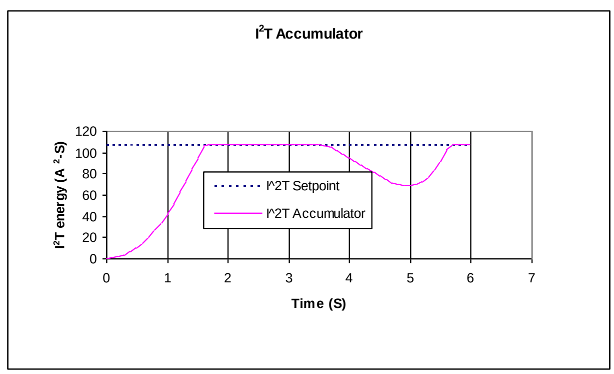
I^2T setpoint = (12 A^2–6 A^2) * 1 S = 108 A^2S

I^2T EXAMPLE: PLOT DIAGRAMS

The plots that follow show the response of a drive (configured w/ I^2T setpoint = 108 A^2S) to a given current command. For this example, DC output currents are shown in order to simplify the waveforms. The algorithm essentially calculates the RMS value of the output current, and thus operates the same way regardless of the output current frequency and wave shape.



(A)



(B)

At time 0, plot diagram A shows that the actual output current follows the commanded current. Note that the current is higher than the continuous current limit setting of 6 A. Under this condition, the I^2T Accumulator Variable begins increasing from its initial value of zero. Initially, the output current linearly increases from 6 A up to 12 A over the course of 1.2 seconds. During this same period, the I^2T Accumulator Variable increases in a non-linear fashion because of its dependence on the square of the current.

At about 1.6 seconds, the I^2T Accumulator Variable reaches a value equal to the I^2T setpoint. At this time, the drive limits the output current to the continuous current limit even though the commanded current remains at 12 A. The I^2T Accumulator Variable value remains constant during the next 2 seconds since the difference between the actual output current and the continuous current limit is zero.

At approximately 3.5 seconds, the commanded current falls below the continuous current limit and once again the output current follows the commanded current. Because the actual current is less than the continuous current, the I^2T Accumulator Variable value begins to fall incrementally.

The I^2T Accumulator Variable value continues to fall until at approximately 5.0 seconds when the commanded current goes above the continuous current limit again. The actual output current follows the current command until the I^2T Accumulator Variable value reaches the I^2T setpoint and current limiting is invoked.

A: Ordering Guide and Accessories

This chapter lists part numbers for drives and accessories. Contents include the following:

NES: EtherCAT, Standard

Part Number	Description
NES-090-10	Nano Micro Module EtherCAT NES servo drive, 5/10 A, 90 Vdc
NES-090-70	Nano Micro Module EtherCAT NES servo drive, 35/70 A, 90 Vdc
NES-180-10	Nano Micro Module EtherCAT NES servo drive, 5/10 A, 180 Vdc
NES-180-30	Nano Micro Module EtherCAT NES servo drive, 15/30 A, 180 Vdc
NES-090-10-D	Nano Micro Module EtherCAT NES-D, not soldered, no heat sink
NES-090-70-D	Nano Micro Module EtherCAT NES-D, **soldered**, with heat sink
NES-180-10-D	Nano Micro Module EtherCAT NES-D, not soldered, no heat sink
NES-180-30-D	Nano Micro Module EtherCAT NES-D, not soldered, with heat sink
NES-090-10-Z	Nano Micro Module EtherCAT NES-Z, not soldered, no heat sink
NES-090-70-Z	Nano Micro Module EtherCAT NES-Z, **soldered**, no heat sink
NES-180-10-Z	Nano Micro Module EtherCAT NES-Z, not soldered, no heat sink
NES-180-30-Z	Nano Micro Module EtherCAT NES-Z, not soldered, no heat sink

NPS: CAN, Standard

Part Number	Description
NPS-090-10	Nano Micro Module *CAN* NPS servo drive, 5/10 A, 90 Vdc
NPS-090-70	Nano Micro Module *CAN* NPS servo drive, 35/70 A, 90 Vdc
NPS-180-10	Nano Micro Module *CAN* NPS servo drive, 5/10 A, 180 Vdc
NPS-180-30	Nano Micro Module *CAN* NPS servo drive, 15/30 A, 180 Vdc
NPS-090-10-D	Nano Micro Module *CAN* NPS-D, not soldered, no heat sink
NPS-090-70-D	Nano Micro Module *CAN* NPS-D, **soldered**, with heat sink
NPS-180-10-D	Nano Micro Module *CAN* NPS-D, not soldered, no heat sink
NPS-180-30-D	Nano Micro Module *CAN* NPS-D, not soldered, with heat sink
NPS-090-10-Z	Nano Micro Module *CAN* NPS-Z, not soldered, no heat sink
NPS-090-70-Z	Nano Micro Module *CAN* NPS-Z, **soldered**, no heat sink
NPS-180-10-Z	Nano Micro Module *CAN* NPS-Z, not soldered, no heat sink
NPS-180-30-Z	Nano Micro Module *CAN* NPS-Z, not soldered, no heat sink

Accessories for NES

Part Number	Description
N-HK	Heatsink Kit

Accessories for NES-D

Part Number	Description
NS-D-CK	NES-D CONNECTOR KIT
STO-CK-04	NES-D BYPASS JUMPER
N-HK	Heat Sink Kit
SER-USB-RJ11	USB to 6-pin modular adapter

Accessories for NPS

Part Number	Description
N-HK	Heatsink Kit

Accessories for NPS-D

Part Number	Description
NS-D-CK	NPS-D CONNECTOR KIT
STO-CK-04	NPS-D BYPASS JUMPER
N-HK	Heat Sink Kit
SER-USB-RJ11	USB to 6-pin modular adapter
CAN-USB-01	Single Channel CAN-USB Interface
N-DEV-NK	CANopen Network Kit

DEV Connector Kit for NES, NPS: NS-D-CK

Qty	REF	Name	Description	MFGR Part Number
1	P8	VLOGIC and Brake	CONNECTOR, TERMINAL-BLOCK, 4-POLE, 3.5 MM	WAGO: 734-104/107-000
1			TOOL, FOR P8	WAGO: 734-231
2	P7, P9	I/O	CONNECTOR COVER, D-SUB, 9-PIN	3M: 3357-9209
1	P9	Safety	CONNECTOR, D-SUB, 9-POSITION, SIZE 1	TE: 205204-4
1	P9	Safety	CONTACT, PIN, CRIMP, SNAP-IN, 24~20 AWG	TE: 66506-9
1	P13	I/O	CONNECTOR COVER, D-SUB, 15-PIN	3M: 3357-9215
1	P7	FEEDBACK	Connector, D-Sub, 15-pin (HD), male, solder cup	Norcomp: 180-015-103L001
1	P13	I/O	CONNECTOR, D-SUB, 26-PIN (HD), MALE, METAL SHELL	Norcomp: 180-026-103L001

Accessories for NES, NPS-Z

Part Number	Description
NS-Z-CK	NES-Z CONNECTOR KIT
SER-USB-M	USB to 3-pin Molex adapter cable

EZ OEM Connector Kit for NES, NPS: NS-Z-CK

QTY	REF	Name	Description	MFGR Part Number
1	J12	Brake	CONN WIRE-MT HSG SKT 1X2P 1.25MM LKG NYL BEIGE	HIROSE: DF13-2S-1.25C
2	J13, J14	CAN	CONN WIRE-MT HSG SKT 1X3P 1.25MM LKG NYL BEIGE	HIROSE: DF13-3S-1.25C
2	J9, J10	EtherCAT	CONN WIRE-MT HSG SKT 1X4P 1.25MM LKG NYL BEIGE	HIROSE: DF13-4S-1.25C
1	J11	Halls	CONN WIRE-MT HSG SKT 1X5P 1.25MM LKG NYL BEIGE	HIROSE: DF13-5S-1.25C
1	J7	ENC1, Motemp	CONN WIRE-MT HSG SKT 1X9P 1.25MM LKG NYL BEIGE	Hirose: DF13-9S-1.25C
24	J7,J9,J10,J11,J12,J13, J14		CONN CONTC SKT CRMP 30-26GA 1MM MAX INSUL DIA AU	Hirose: DF13-2630SCFA
1	J16	STO	CONN WIRE-MT HSG RCPT 2X8P 2X2MM LKG NYL BLK	Hirose: DF11-16DS-2C
1	J17	IN1~5, DOUT1~3, ENC2, AREF	CONN WIRE-MT HSG RCPT 2X10P 2X2MM LKG NYL BLK MATING 129846	Hirose: DF11-20DS-2C
36			CONN CONTC SKT CRMP 28-24GA 1.45MM MAX INSUL DIA AU	Hirose: DF11-2428SCFA(04)
1	J19	Vlogic	CONN WIRE-MT HSG RCPT 1X2P 2MM LKG POLYEST NAT	Molex: 35507-0200
1	J8	RS-232	CONN WIRE-MT HSG RCPT 1X3P 2MM LKG POLYEST NAT	Molex: 35507-0300
2	P16, P17	Cable Shields	FASTON RCPT .11-.125W .02THK 26-22GA POSTIVE LOCK	TE: 353249-2
3		DF13 Wires	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLK AU 12IN	Hirose: H4BBG-10112-B6
19		DF13 Prewire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD WHT AU 12IN	Hirose: H4BBG-10112-W6
20		DR11 Wires	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD WHT AU 12IN	Hirose: H3BBG-10112-W6
3		DF11 GP	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD RED AU 12IN	Hirose: H3BBG-10112-R6
3		DF13 Wire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD RED AU 12IN	Hirose: H4BBG-10112-R6
1		P6, HVCOM	CBL ASSY SKT CONTC TO FREE END 1COND 24GA 7STRD BLK SN 12IN	Hirose 0502128000-12-B4
1		J19, +VLOGIC	CBL ASSY SKT CONTC TO FREE END 1COND 24GA 7STRD RED SN 12IN	Hirose: 0502128000-12-R4
3		DF11	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLK AU 12IN	Hirose: H3BBG-10112-B6
1		Brake Wire	CBL ASSY SKT CONTC TO SKT CONTC 1COND 26GA 7STRD BLU AU 12IN	Hirose: H4BBG-10112-L6
1	J16	STO Bypass PCB	BD ASSY, STO BYPASS BOARD	Copley: NS-Z-STO

N-HK: Heatsink Kit

Item	Description	Quantity
1	Screw, #0-80, hex, socket cap screw, 1 in [25.4 mm]. stainless steel	4
2	Heatsink, NES/NPS, 0.728 [18.49] tall, pins	1
3	Thermal pad, NES/NPS	1
4	Spacer, hex, 0.125 in [3.18 mm], 0-80 UNC 2B thread, 0.120 in [3.05 mm] tall, AL	4
5	Washer, medium split lock, #0, 18-8, stainless steel,	4
6	Nut, #0-80, fine thread, stainless steel	4
7	Ifixit Opening Tool	1

NANO User Guide

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