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nuDrive Accessory

This user guide describes the electrical and mechanical aspects of the nuDrive power amplifier accessory and describes how to use the nuDrive with your motion controller.

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Conventions

The following conventions are used in this manual:



This icon denotes a note, which alerts you to important information.



This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.



This icon denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

♦ The ♦ symbol indicates that the following text applies only to a specific product.

overline Indicates the signal is active-low.

italic Italic text denotes emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

CF nuDrive Refers to the 4CF-001 and 2CF-001 nuDrives.

CX nuDrive Refers to the 4CX-001 and 2CX-001 nuDrives.

SX nuDrive Refers to the 4SX-211, 2SX-211, 4SX-411, and 2SX-411 nuDrives.

stepper nuDrive Refers to the 4SX-211, 2SX-211, 4SX-411, and 2SX-411 nuDrives.

servo nuDrive Refers to the 4CF-001, 2CF-001, 4CX-001, and 2CX-001 nuDrives.

Introduction

Your nuDrive accessory is a complete power amplifier and system interface for use with up to four axes of simultaneous or independent servo or stepper motion control. Ideally suited to industrial and laboratory applications, your nuDrive has everything you need to connect motors, encoders, limit switches, I/O, and other motion hardware to National Instruments motion controllers.

Table 1 lists the available nuDrives and describes the properties of each nuDrive.

Table 1. nuDrive Properties

nuDrive Type	Number of Axes	Motor Type	Motion Board Cable Connector	Driver/Amplifier Nominal Bus Voltage	Driver/Amplifier Type	AC Input
4SX-411	4	Stepper (2-phase)	50-pin	40 VDC Bus	Microstepping Driver IM483	115 V (50/60 Hz)
2SX-411	2	Stepper (2-phase)	50-pin	40 VDC Bus	Microstepping Driver IM483	115 V (50/60 Hz)
4SX-211	4	Stepper (2-phase)	50-pin	24 VDC Bus	Microstepping Driver IM483	115 V (50/60 Hz)
2SX-211	2	Stepper (2-phase)	50-pin	24 VDC Bus	Microstepping Driver IM483	115 V (50/60 Hz)
4CX-001	4	DC Brush Servo	50-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)
2CX-001	2	DC Brush Servo	50-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)
4CF-001	4	DC Brush Servo	100-pin	48 VDC Bus	DC Brush Servo Amplifier SSA 8/100	115 V (50/60 Hz)
2CF-001	2	DC Brush Servo	100-pin	48 VDC Bus	DC Brush Servo Amplifier S SA 8/100	115 V (50/60 Hz)

The nuDrive can drive a broad range of servo or stepper motors. Servo nuDrives use pulse-width modulation (PWM) amplifiers with a user-specified peak output current rating and a DC bus voltage to drive servo motors. Stepper nuDrives use a rugged microstepping bipolar chopper driver. Stepper driver configurations are available in a wide range of user-specified current per phase and voltage settings to drive stepper motors. In all configurations, power supplies are built in and use standard 115 VAC for operation. Electronics are fan cooled to assure reliable operation.

nuDrives simplify your field wiring through separate encoder, limit switch, and motor power removable screw terminal connector blocks for each axis. The terminal blocks do not require any special wiring tools for installation. Refer to Table 2 for a summary of how to connect various motion controllers to different nuDrives.

Table 2. nuDrive Connectivity

Controller	Connection	nuDrives
All 7344 controllers	SH68-C68-S cable with a 68M-50F step/servo bulkhead cable adapter	4SX-411 2SX-411 4SX-211 2SX-211 4CX-001 2CX-001
All FlexMotion-6C controllers	SH100-100-F shielded cable cable	4CF-001 2CF-001
All 7324/7314 controllers*	SH68-C68-S cable with a 68M-50F step/servo bulkhead cable adapter	4SX-411 2SX-411 4SX-211 2SX-211
Non-73*xx* ValueMotion stepper controllers	SH50-50 shielded cable or NB1 ribbon cable	4SX-411 2SX-411 4SX-211 2SX-211
All ValueMotion servo controllers	SH50-50 shielded cable or NB1 ribbon cable	4CX-001 2CX-001

*For PXI-7324/7314 controllers prior to Rev. C, make the connection using a SH68-68-S cable with a 68M-50F step/servo bulkhead cable adapter.

nuDrives have three levels of amplifier inhibit/disable protection for motion system shut down. The front panel contains both enable and power switches for direct motor inhibiting and system power-down operations. Each nuDrive also has a host bus power interlock that activates an amplifier inhibit signal if the host computer is shut down or the motion controller interface cable is disconnected. On nuDrives with the emergency stop (E-Stop) option enabled, you can wire a 115 V emergency stop switch to the rear panel I/O connector for remote interlock shut down, as described in the *E-Stop Terminal Block* section of this document.

Each nuDrive is packaged in a rugged aluminum enclosure that can be used as a benchtop unit or that can be rack-mounted.

What You Need to Get Started

To set up and use your nuDrive accessory, you will need the following items:

- ❑ The nuDrive accessory and *nuDrive Accessory User Guide*
- ❑ Power cord (IEC type)
- ❑ One or more of the following National Instruments cables and adapters:
  - SH68-68-S shielded cable, part number 185262-02
  - NB1 ribbon cable, part number 180524-20
  - SH50-50 shielded cable, part number 185319-02
  - SH100-100-F shielded cable, part number 185095-02
  - SH68-C68-S shielded cable, part number 186381-02
  - 68M-50F step/servo bulkhead cable adapter, part number 185630-01
- ❑ (Optional) ISO power supply (for FlexMotion-6C boards)

Detailed specifications for the nuDrive accessory are in the *Specifications* section later in this guide.

Safety Information



Warnings Keep away from live circuits. Do *not* remove equipment covers or shields unless you are trained to do so. Hazardous voltages may exist even when the equipment is turned off. To avoid a shock hazard, do *not* perform procedures involving cover or shield removal unless you are qualified to do so and disconnect all field power prior to removing covers or shields.

Do *not* operate damaged equipment. The safety protection features built into this device can become impaired if the device becomes damaged in any way. If the device is damaged, turn the device off and do not use until service-trained personnel can check its safety. If necessary, return the device to National Instruments for service and repair to ensure that its safety is not compromised.

Do *not* operate this equipment in a manner that contradicts the information specified in this document. Misuse of this equipment could result in a shock hazard.

Do *not* substitute parts or modify equipment. Because of the danger of introducing additional hazards, do *not* install unauthorized parts or modify the device. Return the

device to National Instruments for service and repair to ensure that its safety features are not compromised.

When connecting or disconnecting signal lines to the nuDrive terminal block screw terminals, make sure the lines are powered off. Potential differences between the lines and the nuDrive ground create a shock hazard while you connect the lines.

Connections, including power signals to ground and vice versa, that exceed any of the maximum signal ratings on the nuDrive device can create a shock or fire hazard or can damage any or all of the boards connected to the nuDrive chassis, the host computer, and the nuDrive device. National Instruments is *not* liable for any damages or injuries resulting from incorrect signal connections.

Installation and Connector Wiring

Caution Be sure to turn off the enable switches and the main AC power to your nuDrive and host computer before connecting to your motion controller.

Connect the motion controller to the nuDrive interface cable. Wire the motor power, limit switch, encoder, I/O, and E-Stop terminal blocks as per the instructions and diagrams in this manual and/or your specific system requirements. Finally, install the power cord into the rear panel AC connector and plug it into a correctly rated power source.

Note For 50-pin ribbon cable interconnection, be certain that the colored indicator strip (pin 1) on the cable between the motion controller and the 50-pin connector on the rear of the nuDrive is properly aligned and inserted on both ends. 68- and 100-pin cables are keyed metal-shell style.

Front Panel Switches and Host Bus Interlock Circuit

There are two lighted rocker switches on the nuDrive front panel, POWER and ENABLE.

The POWER switch energizes the DC bus and the logic power supplies (+5 V, +12 V), and illuminates to indicate that the main AC power is present. If the POWER switch fails to illuminate, check the power cord and main input fuse in the power connector.

The ENABLE switch enables or inhibits the servo amplifiers or stepper drivers. It illuminates to indicate that it is switched on and that the logic power supply +12 V output is functioning.

Either switch can turn off the motors. However, as long as the nuDrive POWER switch is still on, independent power and enable circuits cause the incremental encoders to continue to track motor position while the amplifiers (drivers) are disabled by the ENABLE switch being off.

Note The ENABLE switch illuminates whenever it is switched on. It does not indicate that the amplifiers/drivers are disabled under the following conditions: E-Stop active (see *E-Stop Terminal Block*), host bus interlock fault, or amplifier/driver protection fault (over current, over temperature, and so on). Conversely, it does not light if the remote enable function is used because the ENABLE switch is off (see *I/O Terminal Blocks*).

The nuDrive has a host bus interlock circuit that monitors the presence of +5 V from the host computer and disables the nuDrive when the voltage disappears or falls out of tolerance. This circuit shuts down the motors by activating the Inhibit, or disable circuit for all axes, when the host computer is disconnected from the nuDrive or inadvertently or unexpectedly shut down.

Rear Panel Connector Wiring

Motor Power Terminal Blocks

For motor power wiring on the nuDrive, each axis has a separate 5-position terminal block with removable screw terminals. There are two types of wiring from the same connector for typical operation. Which of these two configurations you use depends upon whether you are using the servo or stepper version of the nuDrive. Figure 1 shows a typical servo motor configuration pin assignment. Figure 2 shows a typical stepper motor configuration pin assignment.

Note The dotted loop indicates a shielded cable.

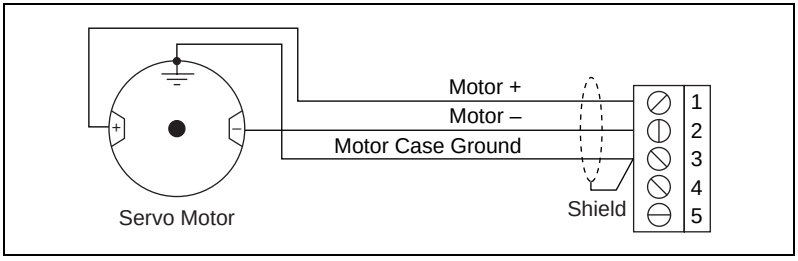


Figure 1. Typical Servo Motor (DC Brush Type) Terminal Block Pin Assignment

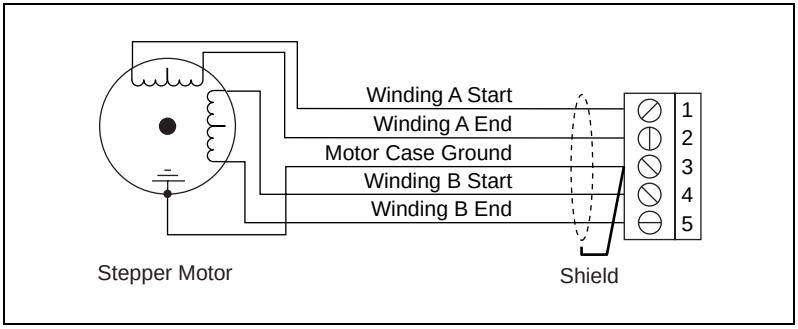


Figure 2. Typical Full-Coil Stepper Motor (2-Phase Type) Terminal Block Pin Assignment

It is recommended you use shielded, 20 AWG wire or larger for the motor power cable. If available, you should connect a case ground wire to pin 3 (Ground/Shield); this helps to avoid ground loops and signal noise problems. (Case ground connects to the motor housing, and not to any of the motor power terminals.)

The stepper nuDrives contain bipolar chopper drivers. The stepper motors must be wired in a four-wire configuration as shown in Figure 2. Unused lead wires must be isolated and not connected. See *Stepper Motor Configurations* for additional information on connecting 6- and 8-wire motors and on the alternate half-coil configuration.

Caution *Never* connect unused center taps or winding terminals to pin 3.

Encoder Terminal Blocks

For quadrature incremental encoder signals, each nuDrive axis has a separate 8-position terminal block with removable screw terminals. Where applicable, the nuDrive accepts two types of encoder signal inputs: single-ended (TTL) or differential line driver. You can accommodate open-collector output encoders by using 2.2 kΩ pullup resistors to +5 VDC.

Figure 3 shows the typical encoder wiring pin assignment for single-ended signal input. Figure 4 shows the typical encoder wiring pin assignment for differential line driver signal inputs.

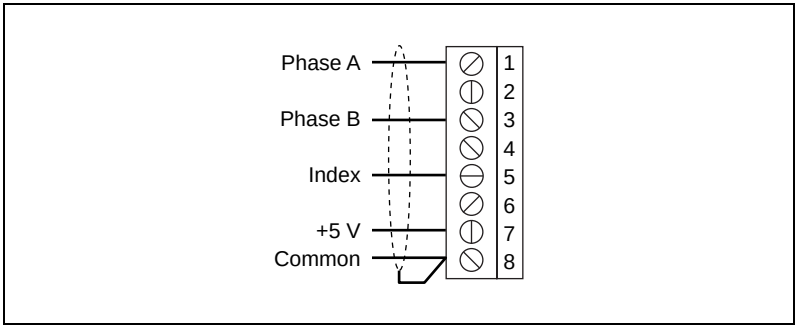


Figure 3. Typical Single-Ended Encoder Wiring Pin Assignment

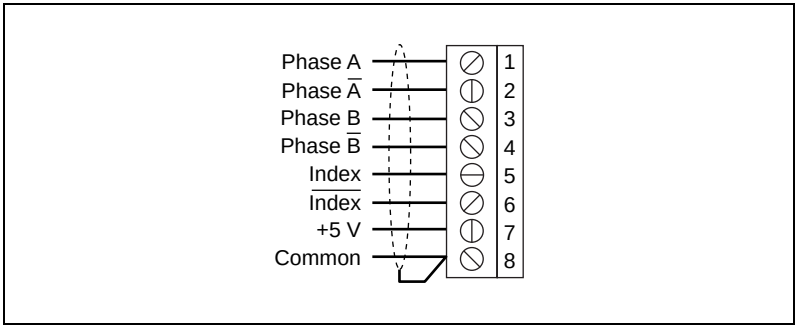


Figure 4. Typical Differential Line Driver Encoder Wiring Pin Assignment

If the encoder cable length is greater than 15 ft, you should use encoders with line driver outputs for your applications. Power for a +5 V encoder is available on pin 7, generated by a power supply inside the nuDrive.

Note If you require other encoder power values, reference an external power supply to the Common (ground) signal on the 8-pin encoder terminal block.

nuDrives have differential inputs for Phase A, Phase B, and Index signals. You can easily accommodate encoders with various phase relationships by swapping the signals and/or connecting them to the inverting inputs as specific applications require. The index pulse must occur when both Phase A and Phase B signals are logic low, as shown in Figure 5. If the Index pulse is inverted, try reversing the Index and $\overline{Index}$ signals on differential encoders or wiring to the $\overline{Index}$ input with single-ended wiring.

Figure 5 shows the proper encoder phasing for CW (forward) motor rotation.

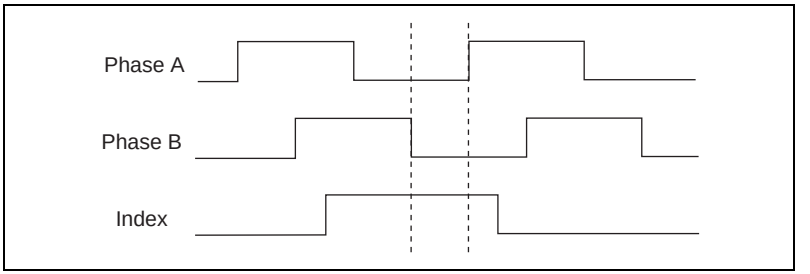


Figure 5. Encoder Signal Phasing, CW Rotation

Servo and closed-loop stepper applications require consistent directional polarity between the motor and encoder for stable operation. The National Instruments motion control standard directional polarity is as follows:

- Positive = forward = clockwise (CW) facing motor shaft
- Negative = reverse = counter-clockwise (CCW) facing motor shaft

Figure 6 shows the clockwise and counter-clockwise motor rotation.

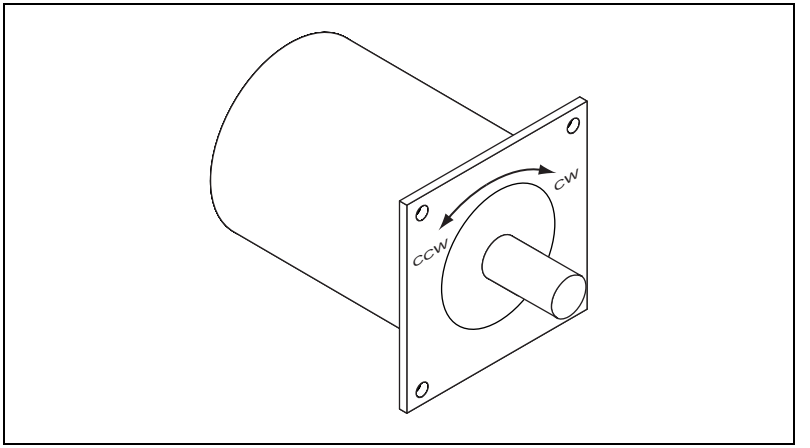


Figure 6. Clockwise and Counter-Clockwise Motor Rotation

When connecting the encoder wiring to your nuDrive accessory, you should use shielded wire of at least 24 AWG. Both analog and digital noise filters filter the encoder inputs in the nuDrive and on the motion controller itself. You must use cables with twisted pairs and an overall shield for improved noise immunity and enhanced encoder signal integrity. Figure 7 shows twisted pairs in a shielded cable.

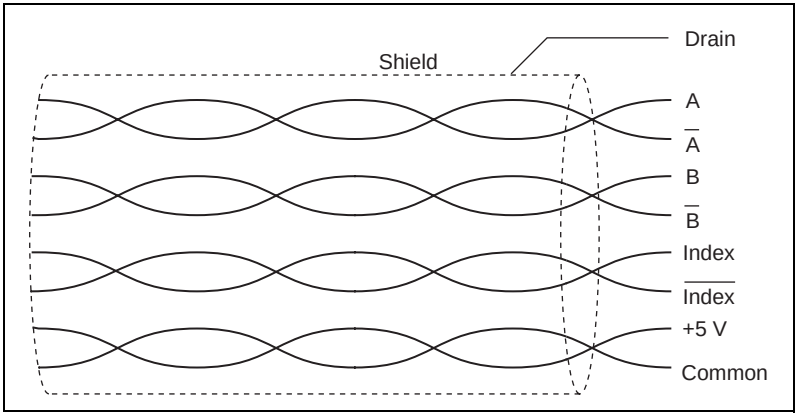


Figure 7. Shielded Twisted Pairs

Note If you use an unshielded cable, noise can corrupt the encoder signals, resulting in lost counts, reduced accuracy, and other erroneous encoder and controller operation.

Limit Switch Terminal Blocks

The limit and home switch connections for the nuDrive axes are configured differently on different nuDrives, as described in the following sections.

CX and SX nuDrive Configuration

For end-of-travel limit and home switch connections, nuDrive axes have a separate, six-position removable screw terminal connector block. All limit signals are filtered in the nuDrive and debounced by the motion controller to reduce noise sensitivity. Refer to Figures 8 and 9 for examples of passive and active limit switch wiring using the terminal block pin assignments on the CX and SX nuDrives.

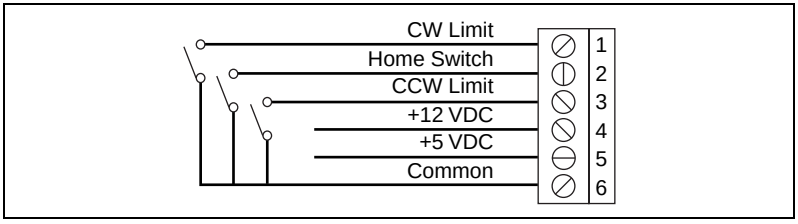


Figure 8. Pin Assignment for the Passive Limit Switch Terminal Block on the CX and SX nuDrives

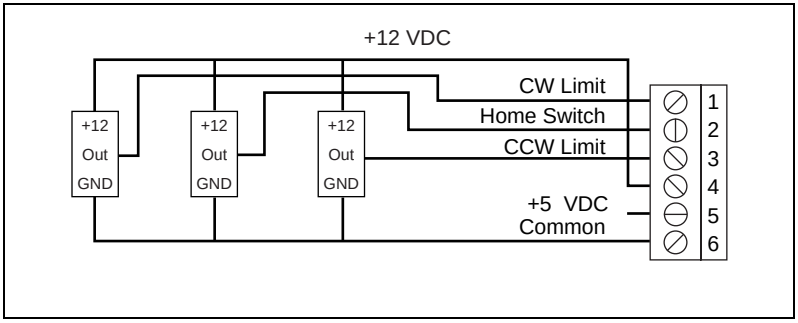


Figure 9. Pin Assignment for the Active Limit Switch Terminal Block on the CX and SX nuDrives

CF nuDrive Configuration

On CF nuDrives, the per-axis High-Speed Capture input signal is available on pin 4 of each limit switch terminal block. Pin 5 provides an External Inhibit input signal for remotely inhibiting the nuDrive axis. All limit signals are filtered in the nuDrive and debounced by the FlexMotion-6C controller to reduce noise sensitivity. The CF nuDrives and FlexMotion-6C controllers provide for optically isolated limit switch inputs, and pin 6 is the isolated (ISO) Common signal connection. Refer to Figure 10 for the CF nuDrive terminal block pin assignments.

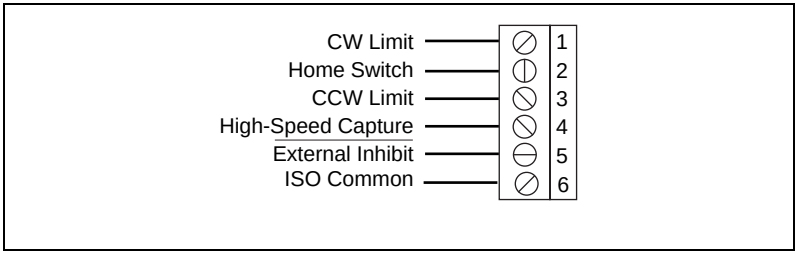


Figure 10. Pin Assignment for the Limit Switch Terminal Block on the CF nuDrive

The Limit, High-Speed Capture, and External Inhibit signals are opto-coupled inputs and require a voltage source. You can either use an external isolated voltage source, or you can use the +5 V and ground signals on the host computer by properly setting a jumper to connect the isolated voltage (input) to 5 V and the ISO Common signal on the FlexMotion-6C board. Refer to the *FlexMotion-6C Hardware User Manual* for more information. Refer to the *I/O Terminal Blocks* section of this guide for more information on the FlexMotion-6C isolated input connection.

Caution The FlexMotion-6C board will be damaged if the isolated voltage selection jumpers on the board are set to use the internal voltage source and an external source is connected directly to these signals on the nuDrive. Be careful to review the configuration of the isolated voltage jumper section prior to powering any FlexMotion-6C circuits or the host PC containing the FlexMotion-6C board.

I/O Terminal Blocks

The I/O connectors are configured differently on different nuDrives, as described in the following sections.

CX and SX nuDrive Configuration

For CX and SX nuDrives, general-purpose digital I/O lines are provided to augment the motion signals. The I/O lines are organized into two separate I/O connectors, with each group using a separate six-position terminal block with removable screws. Figure 11 shows the two six-position I/O terminal block pin assignments.

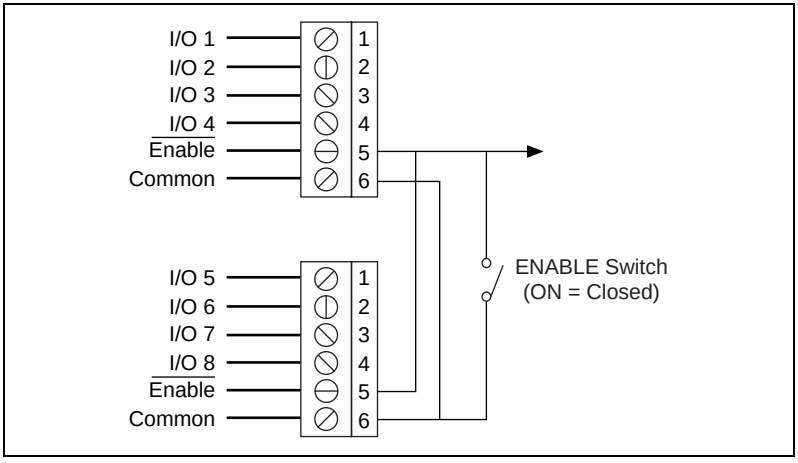


Figure 11. Pin Assignments for the Two Six-Position I/O Terminal Blocks on the CX and SX nuDrives

The ENABLE switch, located on the front panel of your nuDrive, controls the enable signal input. The active-low enable signal input is also available on pin 5 of each I/O terminal block and can remotely enable all axes in the nuDrive. You can use either enable input on the I/O terminal blocks OR the front panel ENABLE switch to enable the nuDrive accessory. E-stop inputs and the host bus interlock also affect the ENABLE function.

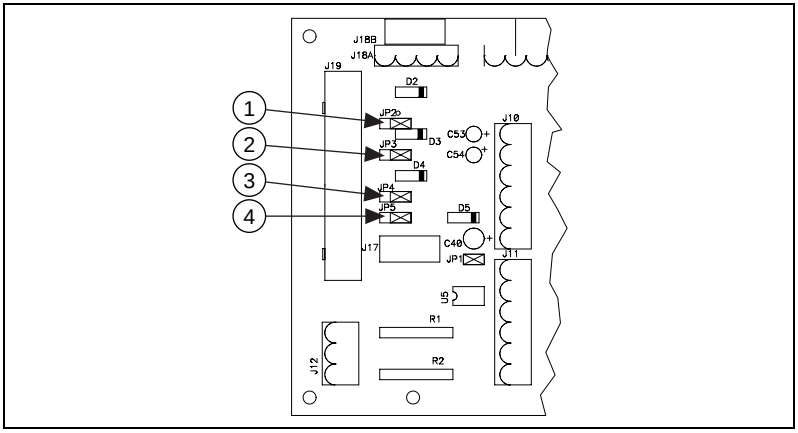
Note The front panel ENABLE switch is wired in parallel to the active-low enable signal of the I/O connector. To use the enable signal in the I/O connector(s), the front panel ENABLE switch must be off (not illuminated).

The ENABLE switch is illuminated whenever it is switched on. It will not indicate that the amplifiers/drivers are disabled under the following conditions: E-Stop (see the *E-Stop Terminal Block* section), Host Bus interlock fault, or amplifier/driver protection fault. Conversely, it will not light if the external Enable function is used via the I/O terminal blocks.

- **SX nuDrives**
  When using an SX nuDrive, I/O pins 5 through 8 reflect the status of the driver inhibits for axes 1 through 4 respectively. Each driver inhibit status signal is the combination of the E-stop, enable, host bus interlock, and per axis inhibit signals.

- **CX nuDrives**
  To use the amplifier inhibit functionality of the 7344 controller, set jumpers JP2 through JP5 to the Inhibit position (recommended). When the jumpers are set to the Inhibit position, I/O lines 5 through 8 reflect the status of the driver inhibits for axes 1 through 4 respectively. To use I/O lines 5 through 8 as general purpose digital I/O signals (required for ValueMotion servo controllers), set jumpers JP2 through JP5 to the Digital I/O position.

Note Your CX nuDrive is shipped with jumpers JP2 through JP5 in the Digital I/O position. These jumpers are located near the left edge of the interface board inside the nuDrive, as shown in Figure 12.



1 JP2 2. JP3 3 JP4 4. JP5

Figure 12. Jumper Locations

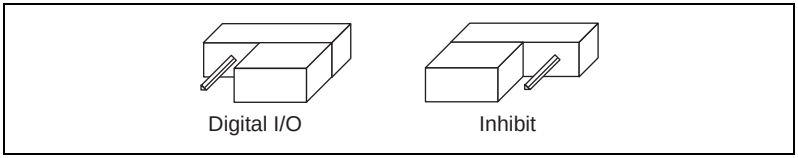


Figure 13. CX nuDrive Jumper Configuration

CF nuDrive Configuration

There are two I/O connectors (upper and lower) on the CF nuDrive. Each I/O connector uses a six-position removable screw terminal block. The upper terminal block provides access to four channels of ±10 V A/D converter analog input as well as analog reference voltage output from the converter circuit and reference common signal connections. The lower terminal block provides access to breakpoint output digital I/O signals as well as an isolated external power supply voltage input connection. Refer to Figures 14 and 15 for the upper and lower FlexMotion-compatible I/O terminal block pin assignments.

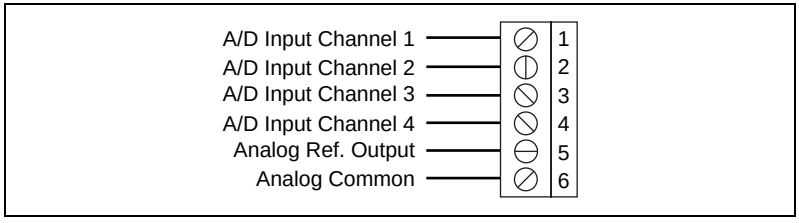


Figure 14. Upper I/O Terminal Block Pin Assignment on the CF nuDrive

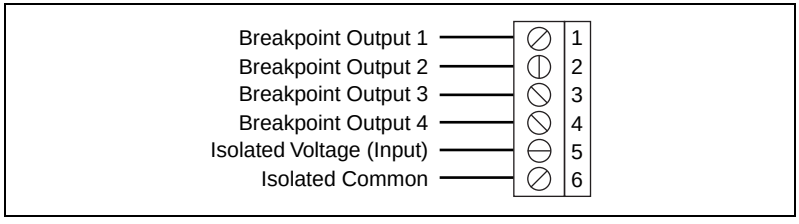


Figure 15. Lower I/O Terminal Block Pin Assignment on the CF nuDrive

The breakpoint output digital signals are opto-coupled outputs and require an isolated voltage source connected to the isolated voltage and isolated common inputs. You can either use an external isolated voltage source, or you can use the +5 V and ground signals on the host computer by properly setting a jumper to connect the isolated voltage (input) to 5 V and the ISO Common signal on the FlexMotion-6C board. Refer to the *FlexMotion-6C Hardware User Manual* for more information.

Amplifier/Driver Command Signals

Servo Amplifier Signals

The servo amplifiers used in the servo versions of the nuDrive accept an industry-standard ±10 V analog torque (current) command signal. Servo motion controllers used with the nuDrive provide this standard output and are programmed to close both the velocity loop and position loop using an enhanced PID algorithm.

Stepper Driver Signals

For stepper drivers, there are two industry standards for command signals:

- Step and Direction signals (nuDrive standard)
- Independent CW and CCW pulses

The nuDrive uses stepper drivers that have active-low step and direction inputs. You must configure the stepper outputs of your stepper controller for Step and Direction signals with inverted (active-low) polarity. This configuration is the National Instruments default output configuration for stepper controller boards and nuDrives.

Optional Configurations

Warning Be sure to turn off the ENABLE switch and disconnect the main AC power as well as the E-Stop 115 VAC input from the nuDrive before opening the nuDrive cover or accessing any components within the nuDrive.

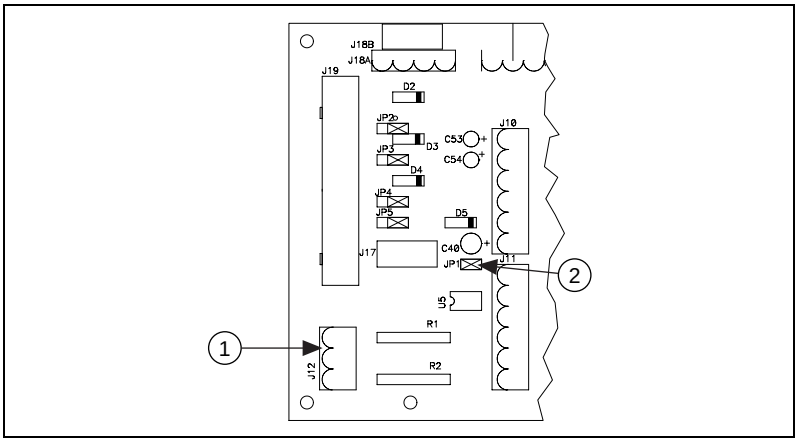
This section describes optional configurations for your nuDrive accessory. The nuDrive is factory configured with default settings appropriate for many applications. If required, you can modify the parameters and settings on the individual axis drivers to meet your specific application requirements.

E-Stop Terminal Block

The E-Stop option has a separate three-position removable screw terminal block on the nuDrive back panel.

Note Your nuDrive is shipped with the E-Stop disabled. To enable the E-Stop, remove the jumper from JP1 located on the interface board inside the nuDrive. JP1 is the single two-pin header near the E-Stop 3 position terminal block.

Figure 16 shows the location of the E-Stop terminal block (and E-Stop configuration jumper) on the interface board.



1 E-Stop	2 JP1

Figure 16. E-Stop Location

If you enable the E-Stop option, you must apply a 115 VAC signal to pins 1 and 3 in addition to the normal nuDrive enable (ENABLE switch or I/O connector enable input, if applicable) for the nuDrive's amplifiers/drivers to be enabled (not inhibited). If you disconnect the 115 VAC with the E-Stop option selected, the amplifiers/drivers are immediately disabled (inhibited) regardless of the status of the ENABLE switch or enable input. Refer to Figure 17 for more information on the E-Stop terminal block pin assignment.

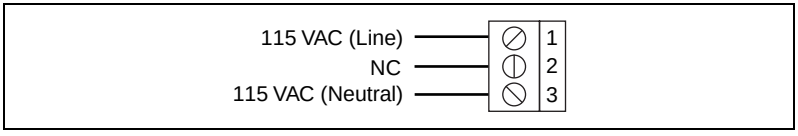


Figure 17. E-Stop Terminal Block Pin Assignment

Note The front panel ENABLE switch will remain illuminated even when the 115 VAC signal is removed from the E-Stop connector, disabling the axes.

Servo Amplifier Configurations

The servo nuDrive uses high-efficiency PWM amplifiers configured as torque blocks (current amplifiers or transconductance amplifiers). The *current gain* is given in amps/volt and defines the relationship of the input command voltage to the current output. The *peak current limit* is the maximum current that your motor can withstand for short periods of time. The *continuous current limit* is the maximum current that your motor can withstand indefinitely.

Figure 18 shows the command voltage input to current output relationship for periods of time less than approximately two seconds. The maximum current output corresponds to the peak current limit, I_{peak}.

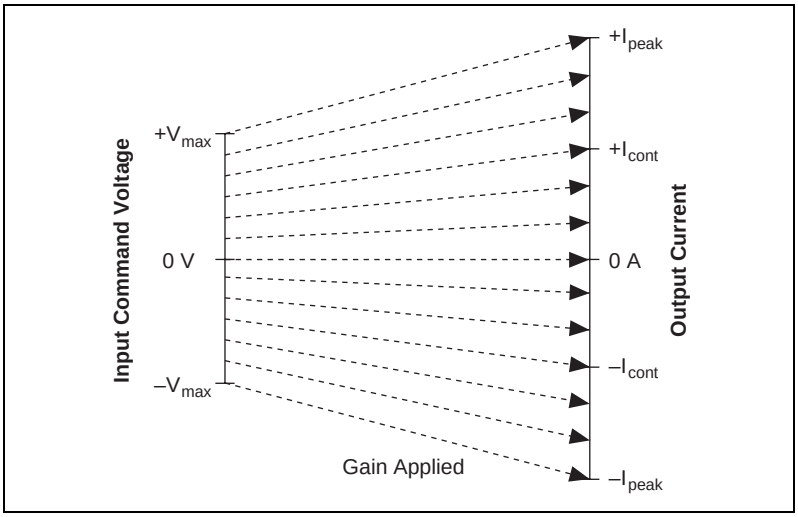


Figure 18. Input Voltage to Output Current Relationship for Periods of Time Less Than Two Seconds

Figure 19 shows the command voltage input to current output relationship for periods of time greater than approximately two seconds. The maximum current output corresponds to the continuous current limit, I_{cont}, so command voltages that would result in a higher current output than I_{cont} when the gain is applied instead result in a current output of I_{cont}.

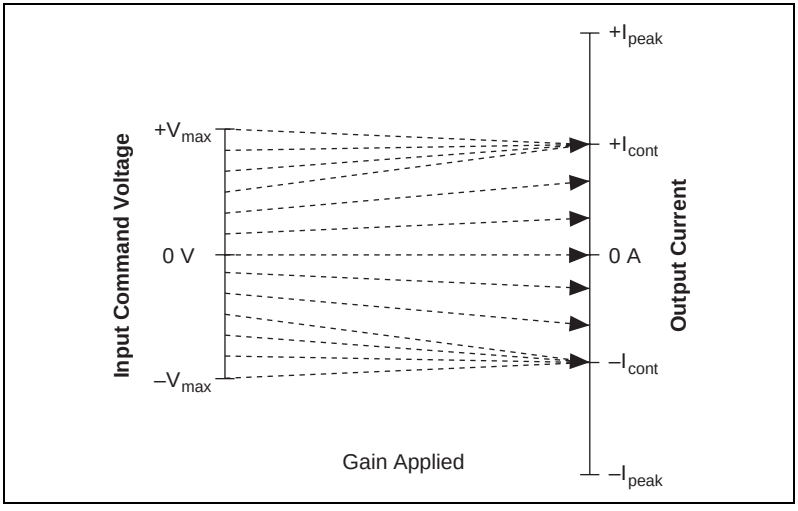


Figure 19. Input Voltage to Output Current Relationship for Periods of Time Greater Than Two Seconds

The amplifier peak and continuous current limits and the current gain have been factory set for 5 A continuous and 10 A peak current output. Verify that these settings are appropriate for your application before powering your motors.

Adjusting Current Gain and Current Limits

You can adjust the current gain and current limits by changing the values of R6, R7, R40, and R42 on the servo amplifiers. The resistors are standard 1/4 W axial leaded type and are plugged into sockets on the PWM per axis servo drives.

Note Some components on your nuDrive are missing from their sockets. These components were removed at the factory to configure the amplifier as a torque (current) block.

Configure the current gain on the nuDrive so that the value of the maximum command voltage, when multiplied by the gain, results in the value of the maximum allowable peak current, as shown in Figure 18.

Calculate the gain using the following formula:

$$Gain = \frac{I_{peak}}{V_{max}}$$

where Gain represents the gain value in amps/volt, I_{peak} represents the maximum allowable peak current, and V_{max} represents the maximum command voltage from your motion controller.

Note ±10 V is the maximum/minimum command voltage for National Instruments motion controllers.

Once you have calculated your gain value, determine the resistor values for R6 and R7 using the following formula:

$$R_{6,7} = \frac{50}{Gain}$$

where $R_{6,7}$ is the value for both resistor R6 and resistor R7 in kΩ.

After setting the gain value, you need to adjust the values of the R40 and R42 resistors to configure your peak current limit and continuous current limits.

Use the following formula to calculate the value for R42, which determines the peak current limit:

$$R42 = \frac{10 \times I_{peak}}{20 - I_{peak}}$$

where R42 represents the resistor value in kΩ and I_{peak} represents the maximum allowable peak current for the motor.

Use the following formula to calculate the value for R40, which determines the continuous current limit:

$$R40 = \frac{2 \times I_{cont}}{8 - I_{cont}}$$

where R40 represents the resistor value in kΩ and I_{cont} represents the maximum allowable continuos current for the motor.

Table 3 lists the factory default values for the current gain and current limits resistors.

Table 3. Default Current Gain and Current Limit Resistor Values

Resistor	Value	Description
R6	47.5 kΩ	Current gain of 1.1 A/V
R7	47.5 kΩ	Current gain of 1.1 A/V
R40	3.3 kΩ	Continuous current limit of 5 A
R42	10 kΩ	Peak current limit of 10 A

Note The 47.5 kΩ value for R6 and R7 actually corresponds to a maximum output current of 10.5 A rather than 10 A (although the actual output current will never exceed the 10 A configured by R42). This is because 47.5 kΩ is the closest standard resistor value below the 50 kΩ value that would correspond to a gain of 1.0 and, therefore, a maximum output current of 10 A. Use the closest resistor value *below* the value you calculate for R40 and R42 to ensure that your current limits do not exceed your motor's specifications. Use the closest resistor value *below* the value you calculate for R6 and R7 to ensure that your gain value provides a maximum current output that matches or exceeds your peak current setting (the drive will not actually output current that exceeds the peak current setting).

As an example, if you used a maximum input command voltage value of ±10 V, and you wanted to set your peak current limit to 6.4 A and your continuous current limit to 2.7 A, you would calculate your resistor values as demonstrated in the following example.

First, calculate the current gain and the resistor values needed to achieve that gain:

$$Gain = \frac{I_{peak}}{V_{max}} = \frac{6.4}{10} = 0.64$$

$$R_{6,7} = \frac{50}{Gain} = \frac{50}{0.64} = 78.1$$

So, you would use the closest resistor value below 78.1 kΩ for resistors R6 and R7.

Then, calculate the values for R40 and R42 as follows:

$$R42 = \frac{10 \times I_{peak}}{20 - I_{peak}} = \frac{10 \times 6.4}{20 - 6.4} = 4.7$$

$$R40 = \frac{2 \times I_{cont}}{8 - I_{cont}} = \frac{2 \times 2.7}{8 - 2.7} = 1$$

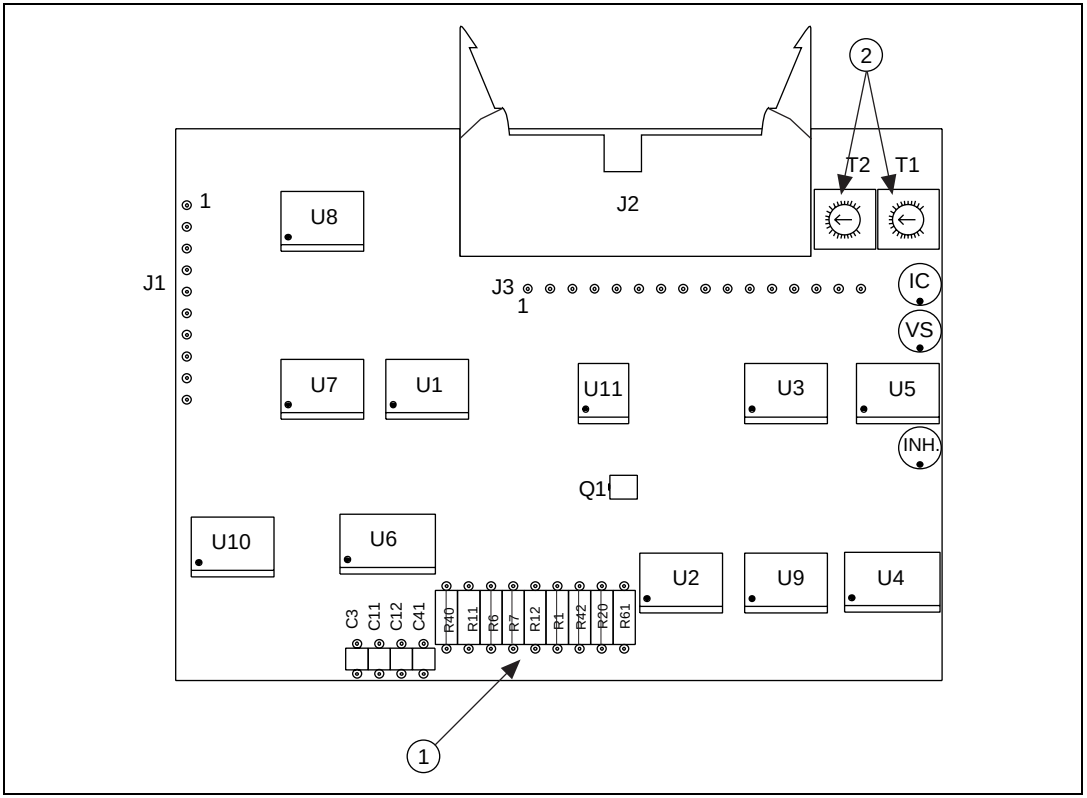
So, you would use the closest resistor values below 4.7 kΩ and 1 kΩ for resistors R42 and R40 respectively.

Caution Do *not* solder or unsolder the resistors on the servo amplifiers. Trim the leads to the proper length, bend them at 90°, and plug them into the sockets.

Balancing the Amplifier Gain

The balance (DC offset) of the amplifier is trimmed to zero at the factory. If you change the current gain and/or current limits settings, it may be necessary to balance the amplifier again. If any motor tends to rotate slowly after it is killed by the ValueMotion or FlexMotion servo controller, you may need to balance the corresponding amplifier.

Figure 20 shows the location of the resistors and trimpots on your SSA-8/100 board.



1 Resistors	2 Trimpots

Figure 20. Servo Amplifier Parts Locator Diagram

Warning You can only adjust the balance while the nuDrive is powered and the amplifier is enabled. Use extreme caution and adjust the trimpot with a plastic trimpot screwdriver designed for the task. High voltages and currents exist within a powered nuDrive. Do *not* attempt to make this adjustment unless you are qualified to do so.

Carefully adjust trimpot T2 on the servo amplifier until the motor ceases to rotate.

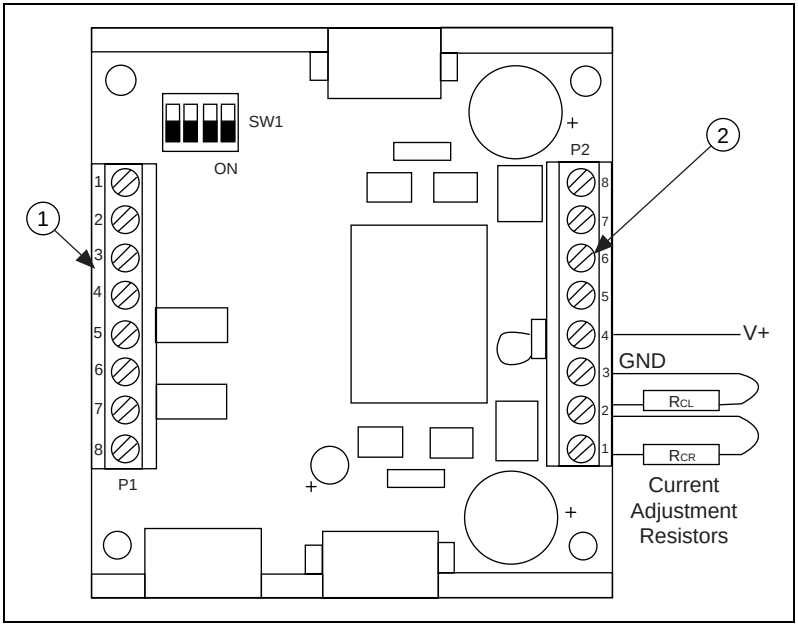
Status LEDs

The amplifiers in the servo nuDrive also have three status LEDs that are useful for troubleshooting potential amplifier faults. The amber LED (labeled **VS**) indicates the presence of DC bus power and should be illuminated whenever the nuDrive is powered on. The center red LED is the overcurrent indicator (labeled **IC**) which should never be illuminated. If it is, check the motor cabling for short circuits between the motor leads and/or short circuits to ground at or around the motor. The third red LED is

located slightly separate from the other two. This is the inhibit status LED (labeled **INH**). If a motor does not move when commanded and this LED is on, check that the nuDrive is enabled via the ENABLE switch, host interlock and external inhibit inputs, and not in an E-Stop condition.

Stepper Driver Configurations

The stepper nuDrive uses bipolar chopper two-phase microstepping drivers with a broad range of microstep ratios and current output settings. The factory-default settings are 10-times microstepping (2,000 steps/rev with standard 1.8° stepper motors) and current limits set to approximately 1 A RMS (1.4 A peak) per phase. All microstep drivers in the nuDrive have an automatic current reduction mode when not stepping to minimize motor heating. The microstep drivers are factory set to default to 50% of the peak current value when no stepping has occurred for about 500 ms. Figure 21 shows the location of the P1 and P2 terminal blocks and shows where you connect the current adjustment resistors on your discrete motion amplifier board in your nuDrive.



1 P1 2 P2

Figure 21. Stepper Driver Parts Locator Diagram

Stepper Motor Current

You can modify the current limit and current reduction settings by changing the values of the current limit resistor (R_{CL}) and current reduction resistor (R_{CR}) on the stepper driver's P2 terminal block.

If your motor specifies the peak output current, then calculate the value of R_{CL} by

$$R_{CL} = \frac{I_{peak}}{0.002}$$

where R_{CL} represents the current limit resistor value in ohms and I_{peak} represents the peak output current.

If your motor specifies the output current as an RMS value, then calculate the value of R_{CL} by

$$R_{CL} = \frac{I_{RMS}}{0.001414}$$

where R_{CL} represents the current limit resistor value in ohms and I_{RMS} represents the output current as an RMS value.

Calculate the value for R_{CR} by

$$R_{CR} = \frac{I_{red} \times R_{CL}}{(0.002 \times R_{CL}) - I_{red}}$$

where R_{CR} represents the current reduction resistor value in ohms, R_{CL} represents the current limit resistor value in ohms, and I_{red} represents the DC output current (in amps) when the nuDrive is operating in current reduction mode.

Table 4 lists the RMS and peak currents for standard values of R_{CL} (5% type 1/4 W resistors).

Warning A current limit resistor (R_{CL}) is always required to keep the drive in a safe operating condition. Be sure to use a current limit resistor with a value no greater than 2.0 kΩ.

Table 4. Output Current versus R_{CL} Value

Output Current (per Phase)		
RMS	**Peak**	**R_{CL} Value (5%, 1/4 W)**
0.26 A	0.36 A	180 Ω (minimum value)
0.31 A	0.44 A	220 Ω
0.38 A	0.54 A	270 Ω
0.47 A	0.66 A	330 Ω
0.55 A	0.78 A	390 Ω
0.65 A	0.95 A	470 Ω
0.8 A	1.1 A	560 Ω
1.0 A	1.4 A	680 Ω (factory default)
1.2 A	1.6 A	820 Ω
1.4 A	2.0 A	1.0 kΩ
1.7 A	2.4 A	1.2 kΩ
2.1 A	3.0 A	1.5 kΩ
2.5 A	3.6 A	1.8 kΩ
2.8 A	4.0 A	2.0 kΩ (maximum value)



Note If you set R_{CR} equal to R_{CL}, then the current reduction will be 50% (I_{red} will be equal to one-half of I_{peak}).

Microstep Selection

The microstepping drivers in your stepper nuDrive have a DIP switch for setting the microstep ratio. Table 5 shows the DIP switch settings for all possible microstep configurations.

Table 5. Microstep Ratio DIP Switch Setting

Binary Selections	
Switch	**Microsteps/Step**
	2 (half step)
	4
	8
	16
	32
	64
	128
	256

Decimal Selections	
Switch	**Microsteps/Step**
	5
	10 (factory default)
	25
	50
	125
	250
	Do not use
	Do not use

Stepper Motor Configurations

This section describes the various industry-standard winding configurations for stepper motors and shows how to connect them to a stepper nuDrive. The nuDrive is compatible with all configurations of two-phase stepper motors.

Note The stepper nuDrive is not compatible with five-lead unipolar stepper motors or five-phase stepper motors; the stepper nuDrive is only compatible with 2-phase type stepper motors.

Two-phase stepper motors come in 4-, 6-, and 8-wire variations. Figure 22 shows a 6-wire and an 8-wire stepper motor respectively. A 4-wire motor is the same as a 6-wire motor except that the center taps (CT) are not brought out.

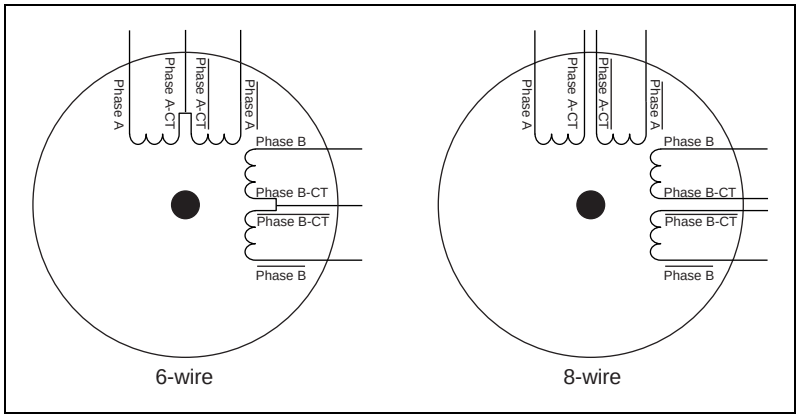


Figure 22. 6-Wire and 8-Wire Stepper Motors

For maximum flexibility, you can connect 8-wire stepper motors in either a series or parallel configuration. Connecting the windings in series as shown in Figure 23 produces the most torque per amp, but has the disadvantage of higher inductance and poorer high-speed performance.

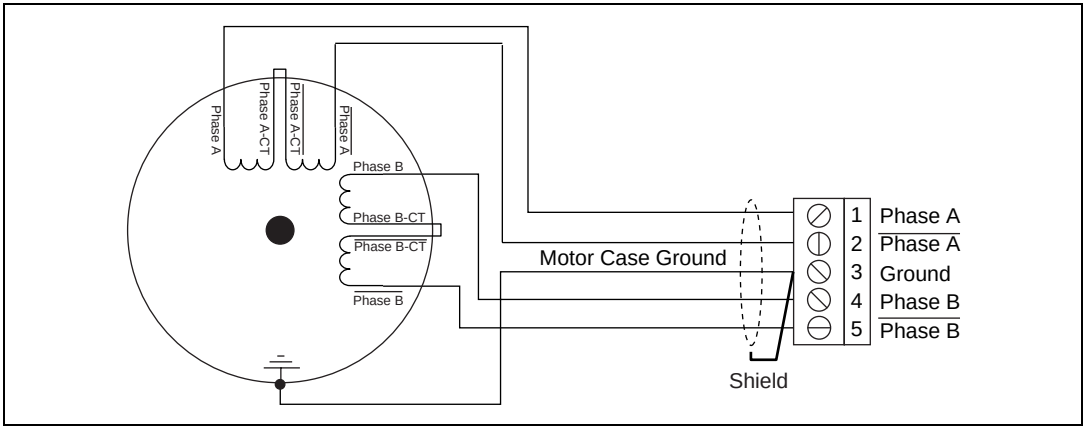


Figure 23. Series Stepper Motor Wiring (Higher Torque, Lower Speed)

Alternatively, 8-wire stepper motors can be wired in parallel as shown in Figure 24. This configuration produces better high-speed performance but requires more current to produce rated torque.

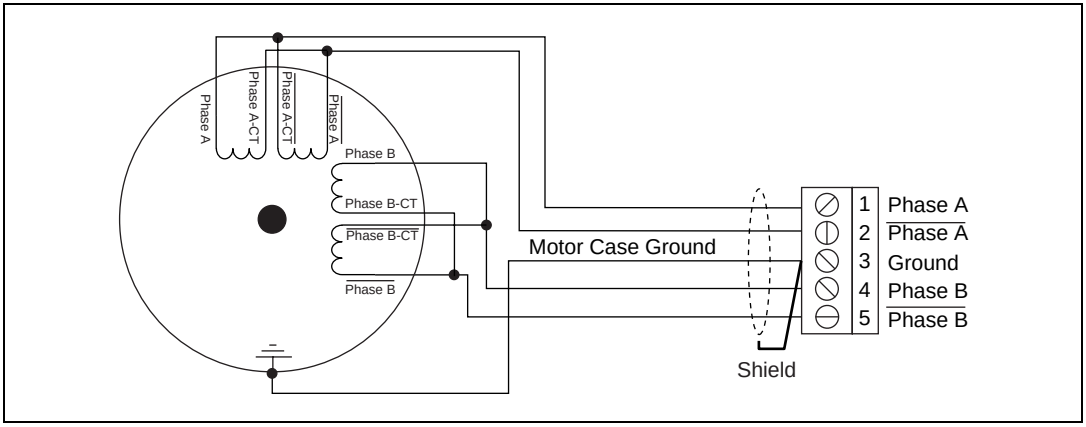


Figure 24. Parallel Stepper Motor Wiring (Higher Speed, Lower Torque)

Notice that an 8-wire motor wired in series is virtually identical to a 6-wire motor and typically has the same high-torque but low-speed characteristics. While a parallel configuration is not possible with a 6-wire motor, high-speed performance can usually be obtained with the half-coil connection shown in Figure 25. This configuration sacrifices low-speed torque for better high-speed performance. With this configuration, it is typically not possible to produce the rated torque of the motor without the risk of the motor overheating because only half of the windings are being used.

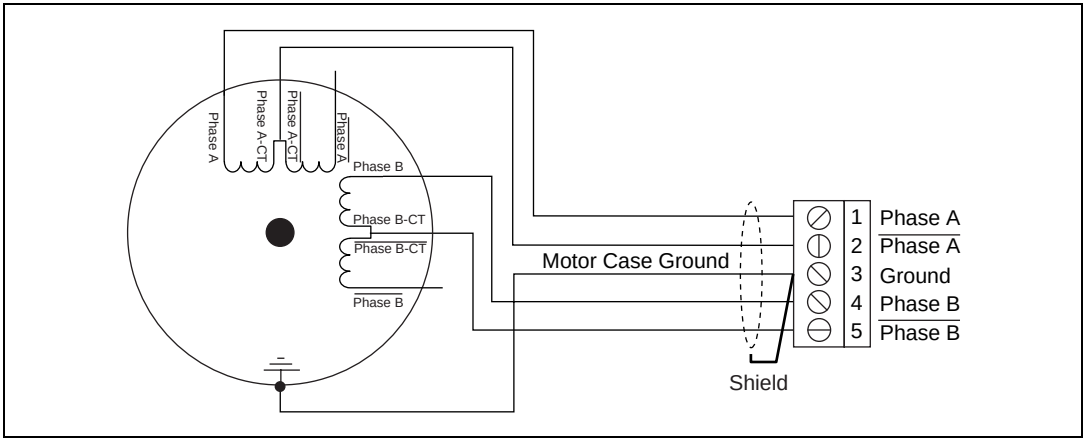


Figure 25. Half-Coil Stepper Motor Wiring

Figure 26 shows the wiring for a typical 4-wire motor.

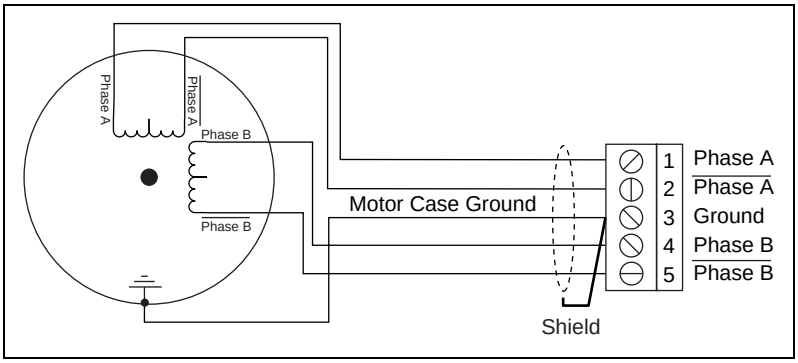


Figure 26. 4-Wire Motor Wiring

Specifications

The following specifications apply only to the nuDrive. To obtain a system specification, you must account for your motion controller. Please refer to your controller specifications to determine overall system specifications.

Some signals have compatibility defined as signal pass-through. This means the nuDrive may have passive filtering on these signals but will not affect the voltage range or current handling capability. Consult your motion controller specifications to determine the allowable voltage range and logic level compatibility of the signal.

Servo Amplifiers

Type ..... Elmo Motion Control SSA 8/100

Peak current limit (2 s)..... 0.8 to 20 A (default 10 A)

Continuous current limit ..... 0.8 to 8 A (default 5 A)

DC-bus motor voltage..... 48 VDC

PWM frequency ..... 20 kHz

Continuous power
(all axes combined)..... 325 W

Stepper Drivers

Type ..... Intelligent Motion Systems (IMS) IM483, bipolar chopper

Current per phase ..... 0.36–4.0 A peak (0.26–2.8 A RMS) (factory setting is 1.4 A peak)

Motor bus voltage ..... 24 or 40 VDC

Microstepping selections ..... ×2, 4, 8, 16, 32, 64, 128, 256 ×5, 10, 25, 50, 125, 250 (default is 10 times)

Encoder Interface (Each Axis)

Inputs ..... Quadrature, incremental

Differential input threshold ..... ±0.3 V (typical)

Single-ended input threshold ..... TTL/CMOS

Voltage range ..... 0 to 5 VDC

Noise filter (RC time constant) ..... 100 ns

Max quadrature frequency ..... 1 MHz

Limit and Home Switch Inputs (Each Axis)

Noise filter (RC time constant) ..... 10 µs

Compatibility ..... Signal pass-through

Configurable I/O

Compatibility ..... Signal pass-through

Connectors (Included)

Encoders ..... 8-pin terminal blocks (1 per axis)

Limits ..... 6-pin terminal blocks (1 per axis)

Motor ..... 5-pin terminal blocks (1 per axis)

I/O ..... 6-pin terminal blocks (2 total)

E-Stop..... 3-pin terminal block (1 total)

AC power ..... Detachable AC power cord (IEC standard type)

Safety

Installation Category II, Pollution Degree 2

Environment

Operating temperature..... 0 to 45 °C (32 to 113 °F)

Storage temperature ..... –20 to 70 °C (–4 to 158 °F)

Humidity ..... 10 to 90% (noncondensing)

Power Supply

Input voltage ..... 115 VAC ±15%, 50–60 Hz

Input Fuse

24 VDC units ..... F5 (5 A, 5 × 20 mm)

40 and 48 VDC units..... F10 (10 A, 5 × 20 mm)

Host Bus Voltage Interlock

Undervoltage threshold..... 4 VDC

Dimensions

Width..... 42.9 cm (16.9 in.)
48.3 cm (19.0 in.) with rack-mounting flanges

Height..... 13.2 cm (5.2 in.) (3 U type)

Depth..... 30.5 cm (12 in.)

Weight..... 20–35 lb (depending on model)

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