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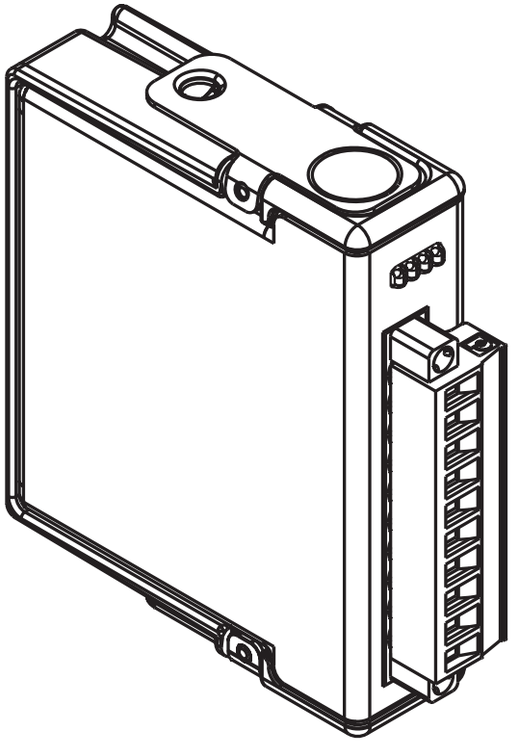
OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9501

Stepper Drive

Français Deutsch 日本語 한국어 简体中文

ni.com/manuals

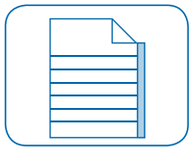


NATIONAL INSTRUMENTS™

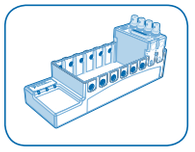
This document describes how to use the National Instruments 9501 module and includes specifications and pin assignments for the NI 9501.

Note The safety guidelines and specifications in this document are specific to the NI 9501. The other components in the system may not meet the same safety ratings and specifications. Refer to the documentation for each component in the system to determine the safety ratings and specifications for the entire system.

Related Information



NI CompactRIO Documentation
ni.com/info ⇨ cseriesdoc



Chassis Compatibility
ni.com/info ⇨ compatibility



Software Support
ni.com/info ⇨ rdsoftwareversion



Services
ni.com/services

Safety Guidelines

Operate the NI 9501 only as described in these operating instructions.

Safety Guidelines for Hazardous Locations

The NI 9501 is suitable for use in Class I, Division 2, Groups A, B, C, D, T4 hazardous locations; Class I, Zone 2, AEx nA IIC T4 and Ex nA IIC T4 hazardous locations; and nonhazardous locations only. Follow these guidelines if you are installing the NI 9501 in a potentially explosive environment. Not following these guidelines may result in serious injury or death.



Caution Do not disconnect I/O-side wires or connectors unless power has been switched off or the area is known to be nonhazardous.



Caution Do not remove modules unless power has been switched off or the area is known to be nonhazardous.



Caution Substitution of components may impair suitability for Class I, Division 2.

Caution For Division 2 and Zone 2 applications, install the system in an enclosure rated to at least IP 54 as defined by IEC/EN 60079-15.

Caution For Division 2 and Zone 2 applications, install a protection device between the input signal and the V_{sup} pin. The device must prevent the V_{sup}-to-channel voltage from exceeding 42 V if there is a transient overvoltage condition.

Special Conditions for Hazardous Locations Use in Europe and Internationally

This equipment has been evaluated as Ex nA IIC T4 Gc equipment under DEMKO Certificate No. 07 ATEX 0626664X and is IECEx UL 14.0089X certified. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations, in ambient temperatures of –40 °C ≤ Ta ≤ 70 °C. If you are using the NI 9501 in Gas Group IIC hazardous locations, you must use the device in an NI chassis that has been evaluated as Ex nC IIC T4, Ex IIC T4, Ex nA IIC T4, or Ex nL IIC T4 equipment.

Caution You must make sure that transient disturbances do not exceed 140% of the rated voltage.

Caution The system shall only be used in an area of not more than Pollution Degree 2, as defined in IEC 60664-1.

Caution The system shall be mounted in an ATEX/IECEx-certified enclosure with a minimum ingress protection rating of at least IP54 as defined in IEC/EN 60079-15.

Caution The enclosure must have a door or cover accessible only by the use of a tool.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) as stated in the product specifications. These requirements and limits are designed to provide reasonable protection against harmful interference when the product is operated in its intended operational electromagnetic environment.

This product is intended for use in industrial locations. As such, there is no guarantee that harmful interference will not occur in a particular installation, when the product is connected to a test object, or if the product is used in residential areas. To minimize

the potential for the product to cause interference to radio and television reception or to experience unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any changes or modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

Caution To ensure compliance with the applicable regulatory requirements, product installation requires either special considerations or user-installed, add-on devices. See the product installation instructions for further information.

Caution The inputs/outputs of this product can be damaged if subjected to Electrostatic Discharge (ESD). To prevent damage, industry-standard ESD prevention measures must be employed during installation, maintenance, and operation.

Special Guidelines for Marine Applications

Some products are Lloyd's Register (LR) Type Approved for marine (shipboard) applications. To verify Lloyd's Register

certification for a product, visit `ni.com/certification` and search for the LR certificate, or look for the Lloyd's Register mark on the product label.



Caution In order to meet the EMC requirements for marine applications, install the product in a shielded enclosure with shielded and/or filtered power and input/output ports. In addition, take precautions when designing, selecting, and installing measurement probes and cables to ensure that the desired EMC performance is attained.

NI 9501 Hardware Overview

The NI 9501 is a stepper motor drive for use with 2-phase hybrid stepper motors in either bipolar or unipolar winding configuration. It uses an advanced PWM algorithm that reduces torque ripple, lowers emissions, minimizes power loss, and creates smoother motion during microstepping.



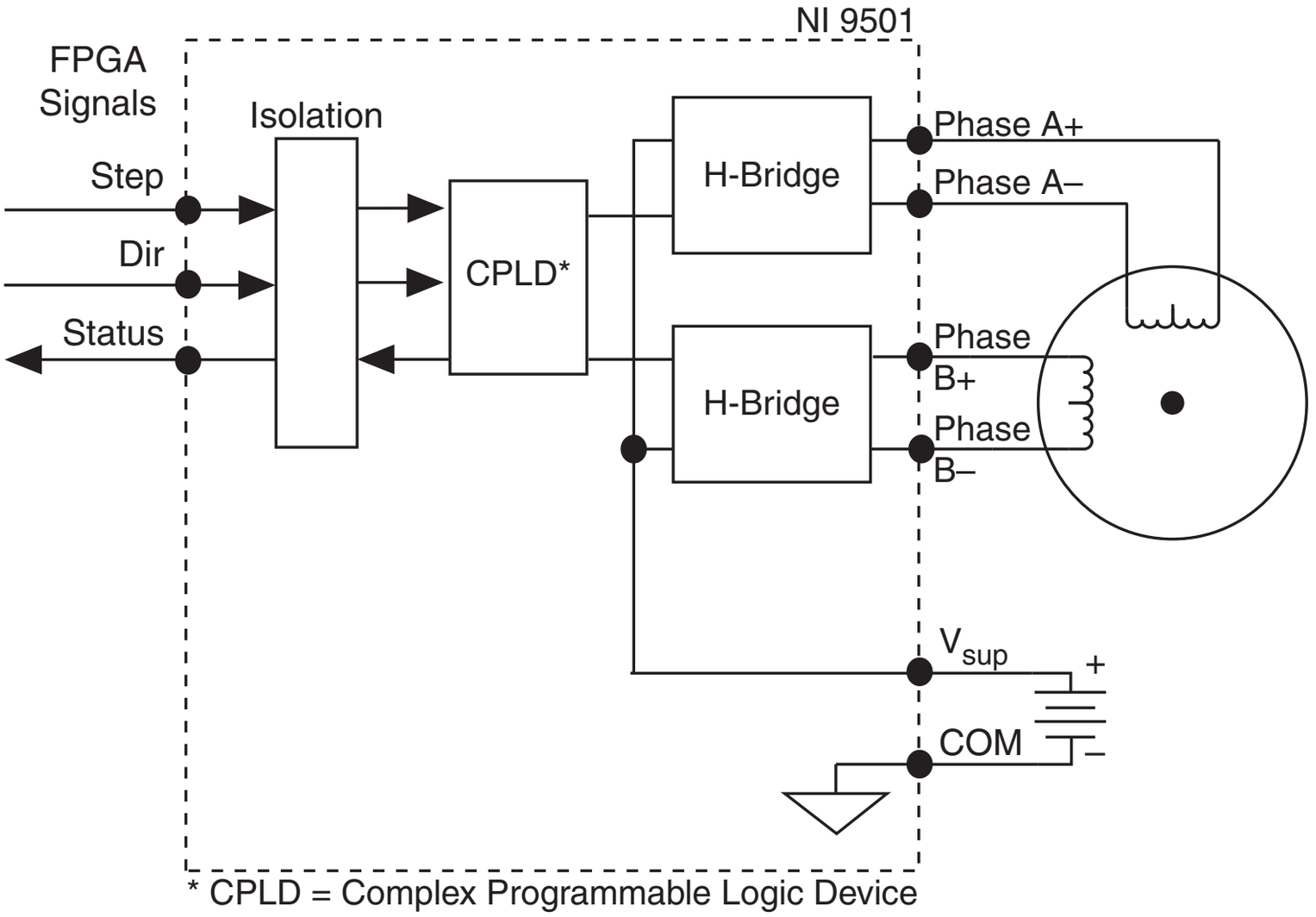
Note National Instruments offers NEMA 17 and NEMA 23 stepper motors compatible with the NI 9501. Go to `ni.com/motion/stepper` for more information about NI stepper motors.

The NI 9501 supports software-programmable full step, half step, and microstepping rates up to 256. When full-stepping, a resonance occurs at low speeds, generally defined as speeds between 50 and 150 RPM. This low-speed resonance causes vibration and reduces the motor torque. Using microstepping during this speed range provides much smoother motion and higher motor torque, effectively eliminating the low-speed resonance. At speeds over 150 RPM, the benefits of microstepping decrease and can eventually have an overall negative impact on performance by providing lower motor torque compared to full-stepping. Refer to the *NI 9501* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for information about microstepping options.

The NI 9501 also provides for phase current reduction after the motor stops moving for a certain amount of time using the **Enable Current Reduction** property in software. Unlike servo motors, the stepper motor coil remains fully energized when the motor is not moving. This allows for strong holding torque, but generates substantial heat in the motor. Many applications do not require maximum holding torque when the motor is at rest, which means that the motor is wasting power. The amount of current reduction and delay before current reduction becomes active

is software-programmable. Refer to the *NI 9501* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about current reduction.

Figure 1. NI 9501 Block Diagram



Connecting the NI 9501

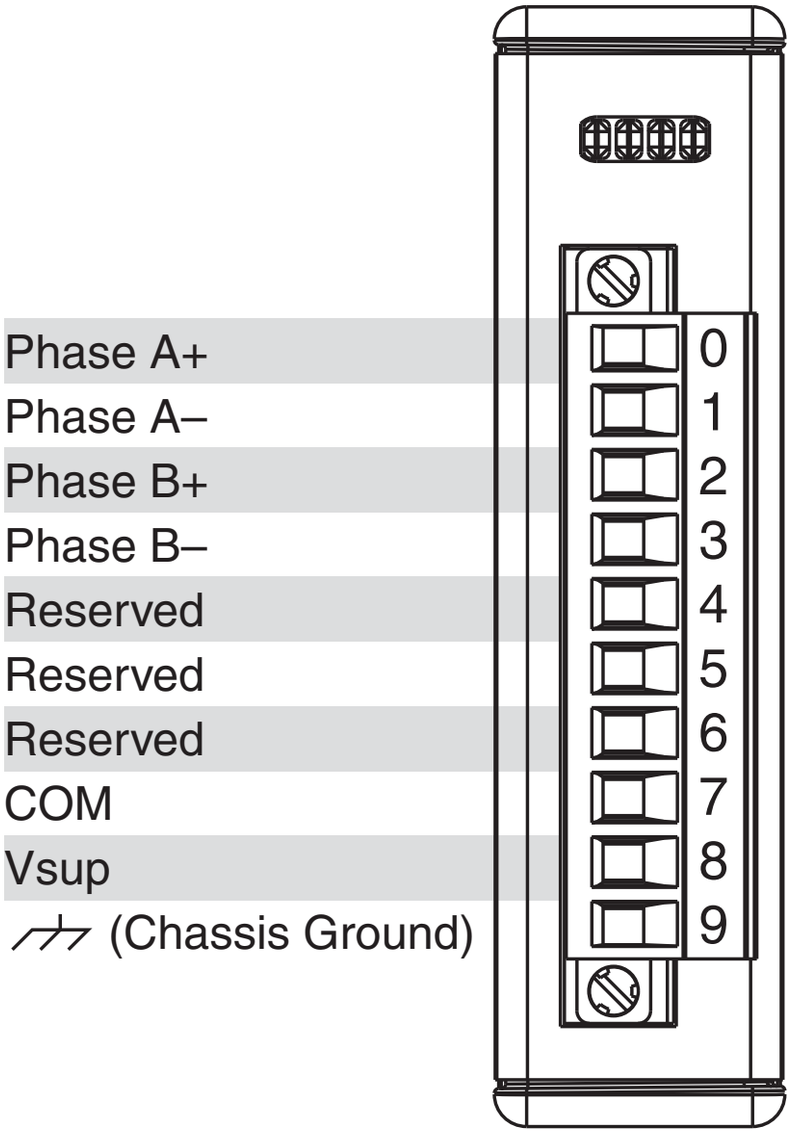
The NI 9501 has a 10-terminal detachable screw-terminal connector that provides connections for the stepper motor signals, a motor DC power supply, COM, and chassis ground. Refer to Figure 2 for the pin assignments.

Caution To ensure EMC compliance, special considerations are required for all cable connections. Refer to the *Cable Requirements for EMC Compliance* section.

Note You must use 2-wire ferrules to create a secure connection when connecting more than one wire to a single terminal on the NI 9501 screw terminal.

Caution Do *not* turn on or plug in the motor DC power supply until the screw-terminal connector is fully inserted.

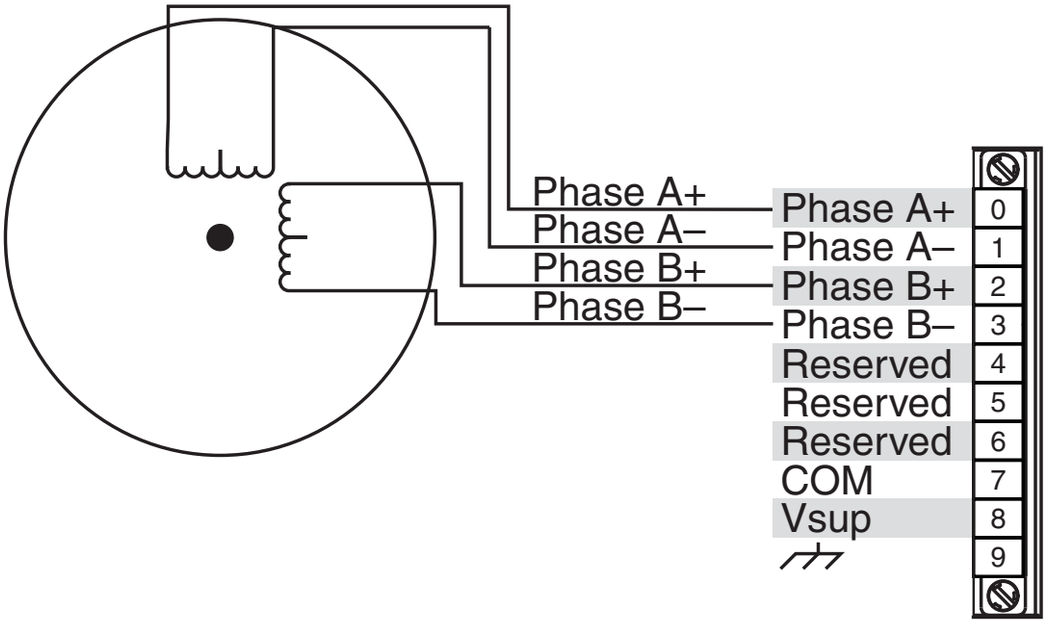
Figure 2. NI 9501 Connections



Motor Power Signals

The Phase A± and Phase B± signals power the stepper motor. Figure 3 shows a typical bipolar stepper motor connection.

Figure 3. Typical Bipolar Stepper Motor (2-Phase Type) Connection



Caution The stepper motor terminals on this drive are energized when the module is enabled. Do not connect wires to or disconnect wires from the NI 9501 when it is enabled.

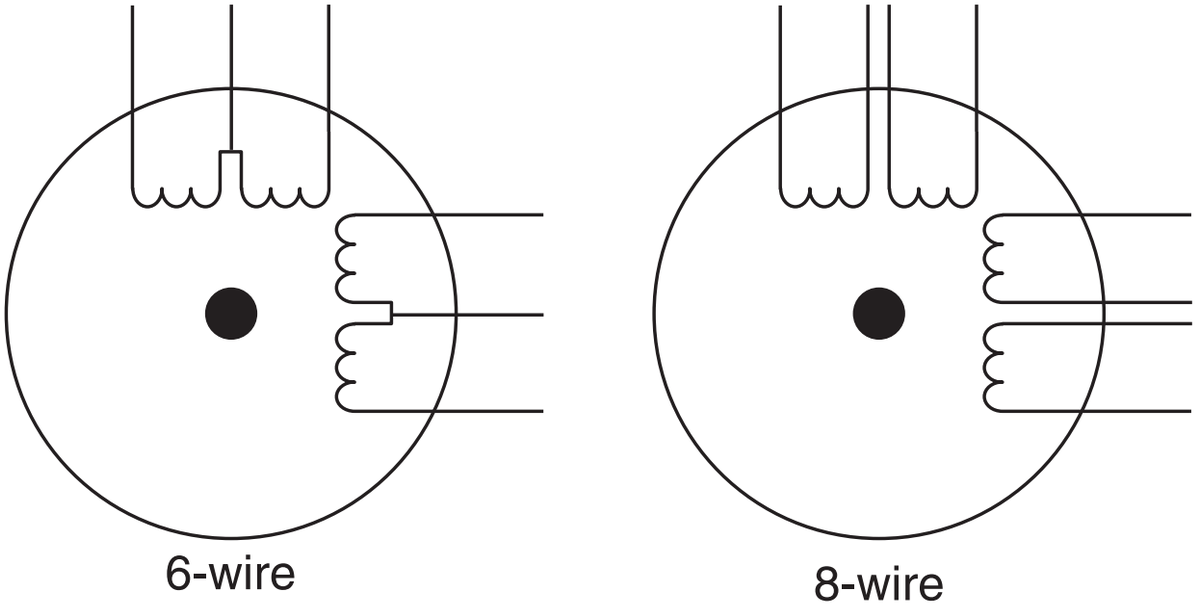
Use a multiconductor cable with an overall shield and conductors of 20 AWG or larger for the motor power cable.

The NI 9501 contains bipolar chopper drivers. Two-phase stepper motors come in 4-, 6-, and 8-wire variations. You must wire the stepper motors in a 4-wire configuration as shown in Figure 3.

Caution Never connect unused stepper motor terminals to pin 9 (Chassis Ground) or to each other.

When using a 6- or 8-wire stepper motor you must leave unused lead wires disconnected. Figure 4 shows a 6-wire and an 8-wire stepper motor.

Figure 4. 6-Wire and 8-Wire Stepper Motors



A 4-wire motor is the same as a 6-wire motor except that the center taps (CT) are not brought out. To use a 6-wire motor in a 4-wire configuration you can isolate the center taps for a series (full coil) configuration. Series configurations produce the most torque per amp but have the disadvantage of poorer high-speed performance.

Figure 5. 6-Wire Series Stepper Motor Connection (Higher Torque, Lower Speed)

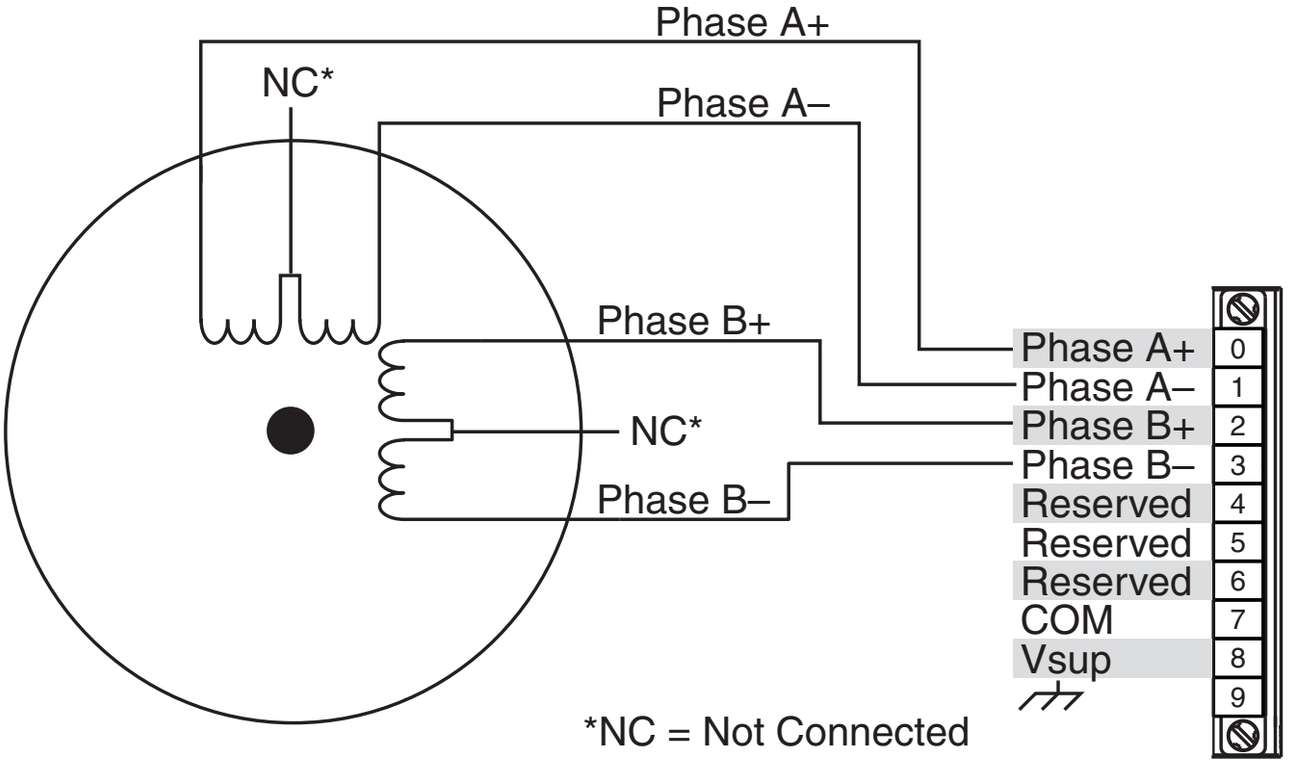
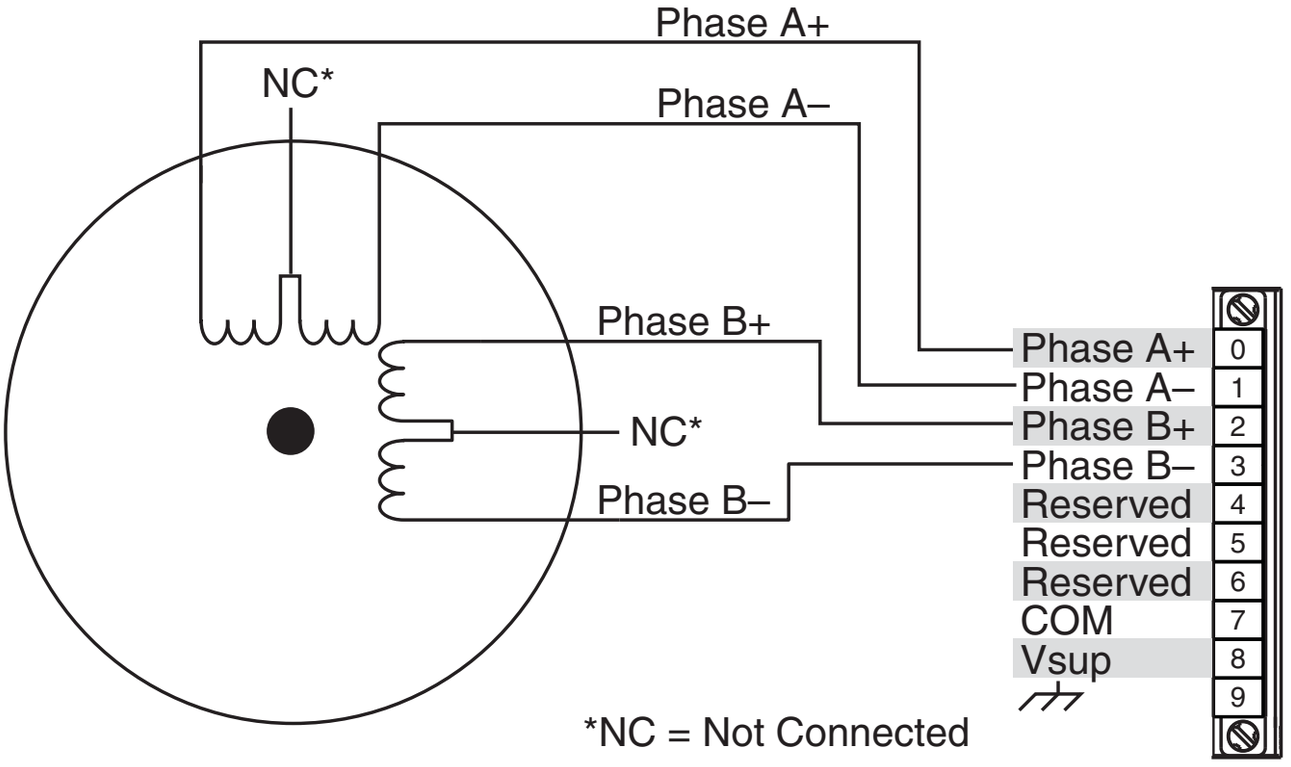
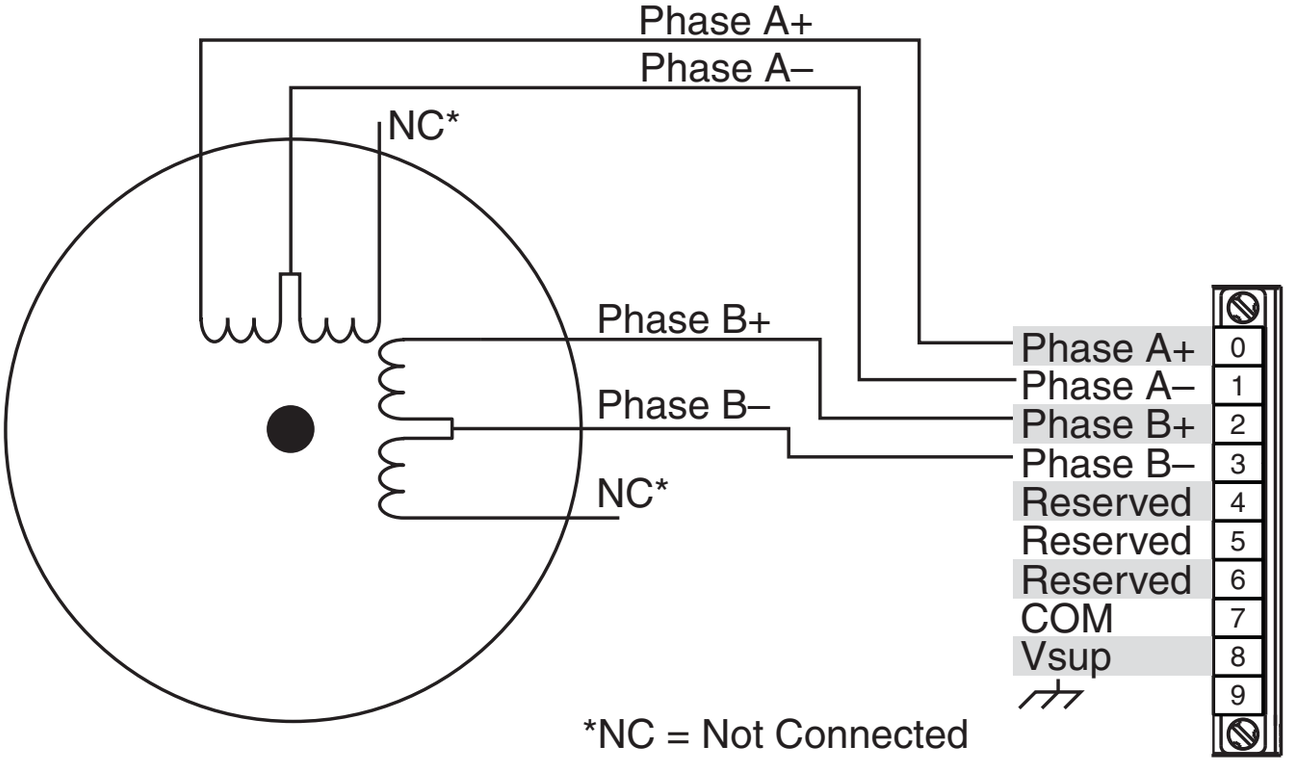


Figure 6. 6-Wire Series Stepper Motor Connection (Higher Torque, Lower Speed)



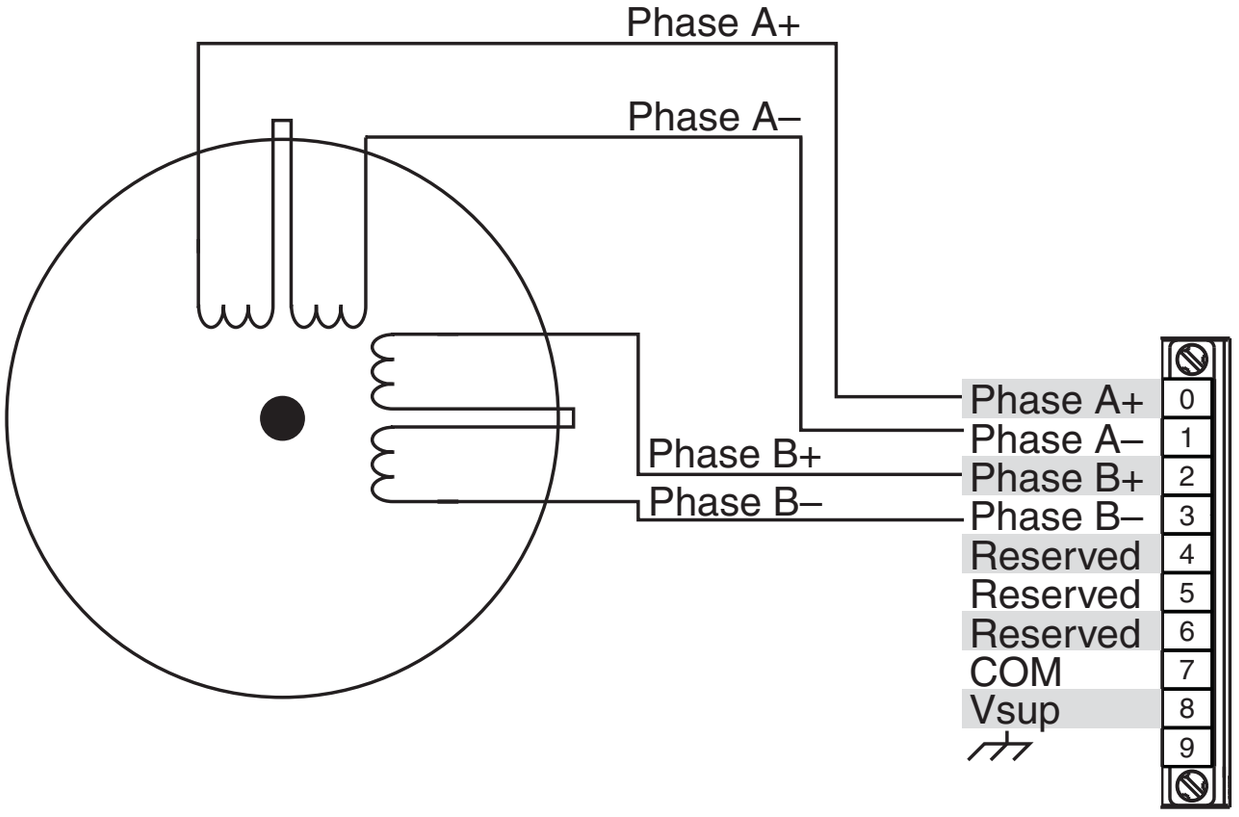
You can obtain improved high-speed performance with a 6-wire motor by using a half-coil configuration shown in Figure 7. This configuration sacrifices low-speed torque for better high-speed performance. With this configuration, it is typically not possible to produce the rated torque of the motor without the risk of the motor overheating because only half of the windings are used.

Figure 7. 6-Wire Half-Coil Stepper Motor Connection (Higher Speed, Lower Torque)



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

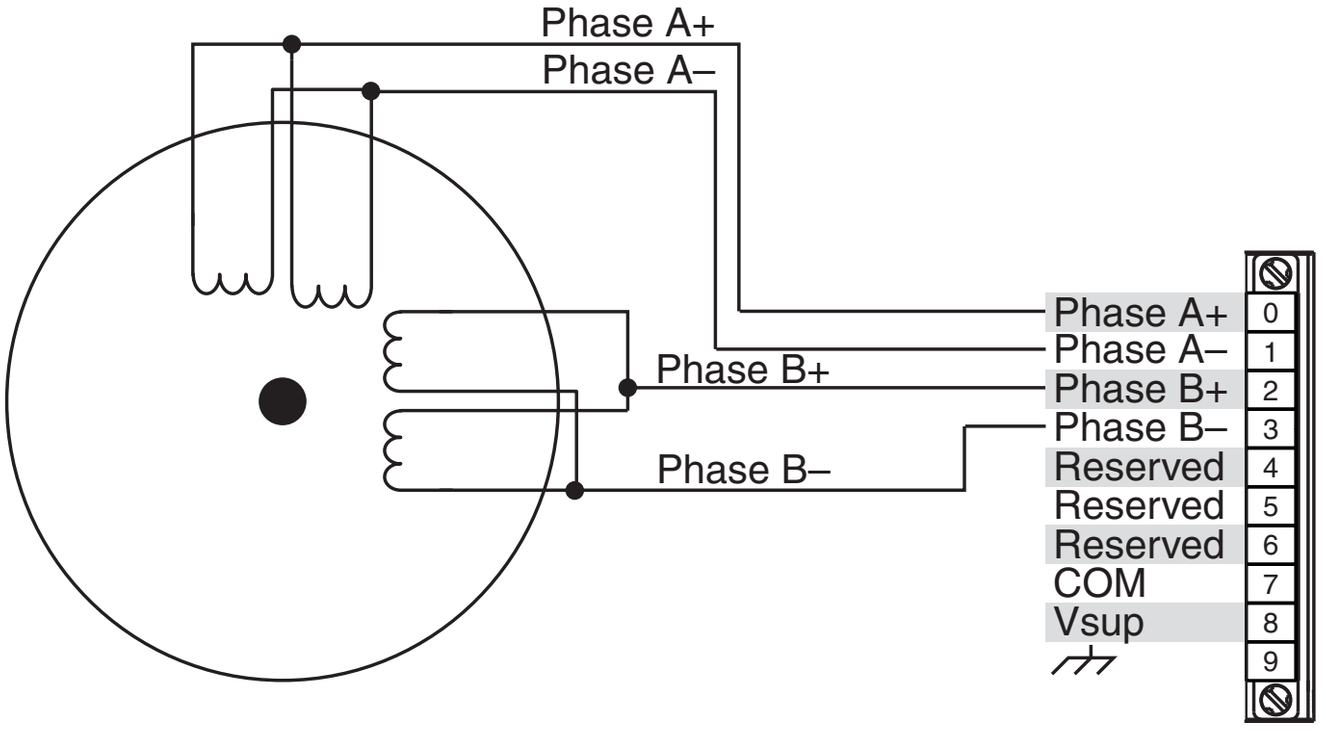
Figure 8. 8-Wire Series Stepper Motor Connection (Higher Torque, Lower Speed)



Notice that an 8-wire motor wired in a series configuration is virtually identical to a 6-wire motor and typically has the same high torque but low-speed characteristics.

Alternatively, you can connect 8-wire stepper motors in a parallel configuration as shown in Figure 9. This configuration produces better high-speed performance but requires more current to produce rated torque.

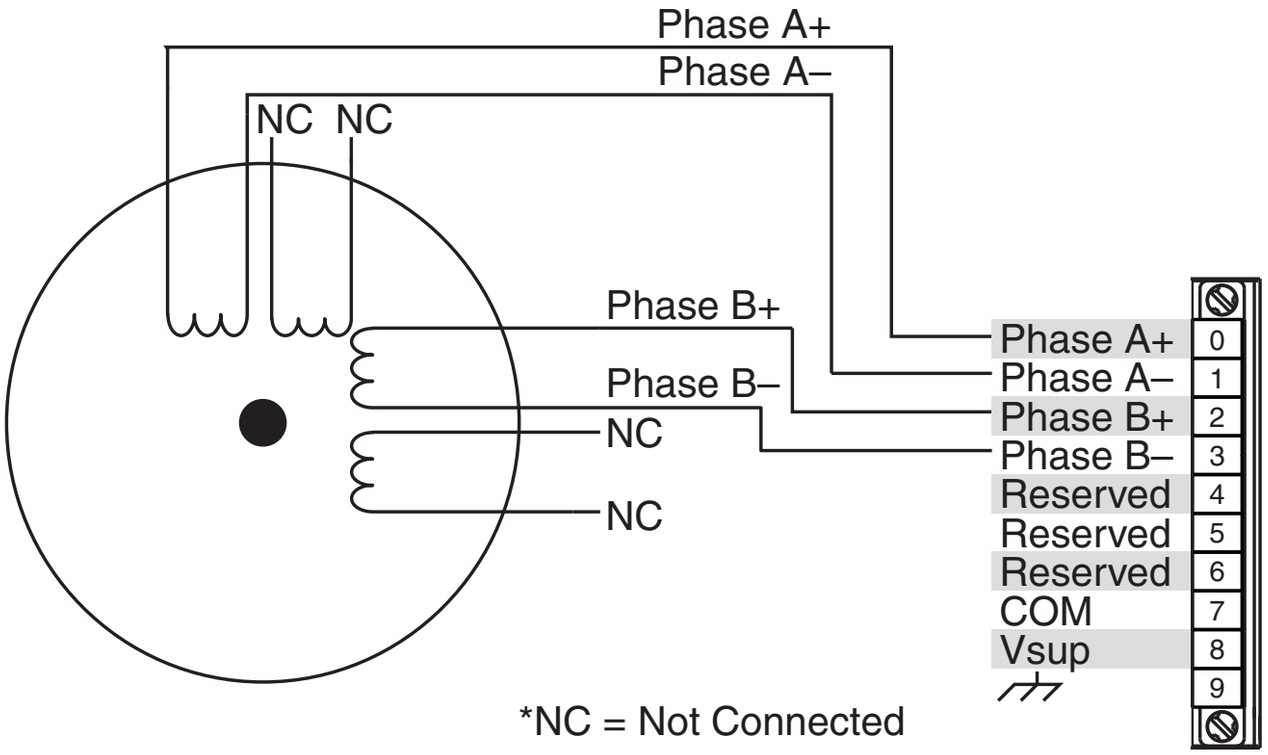
Figure 9. 8-Wire Parallel Stepper Motor Connection (Higher Speed, Lower Torque)



Finally, you can connect 8-wire stepper motors in a half-coil configuration as shown in Figure 10. The half-coil 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 used.

Figure 10. 8-Wire Half-Coil Stepper Motor Connection

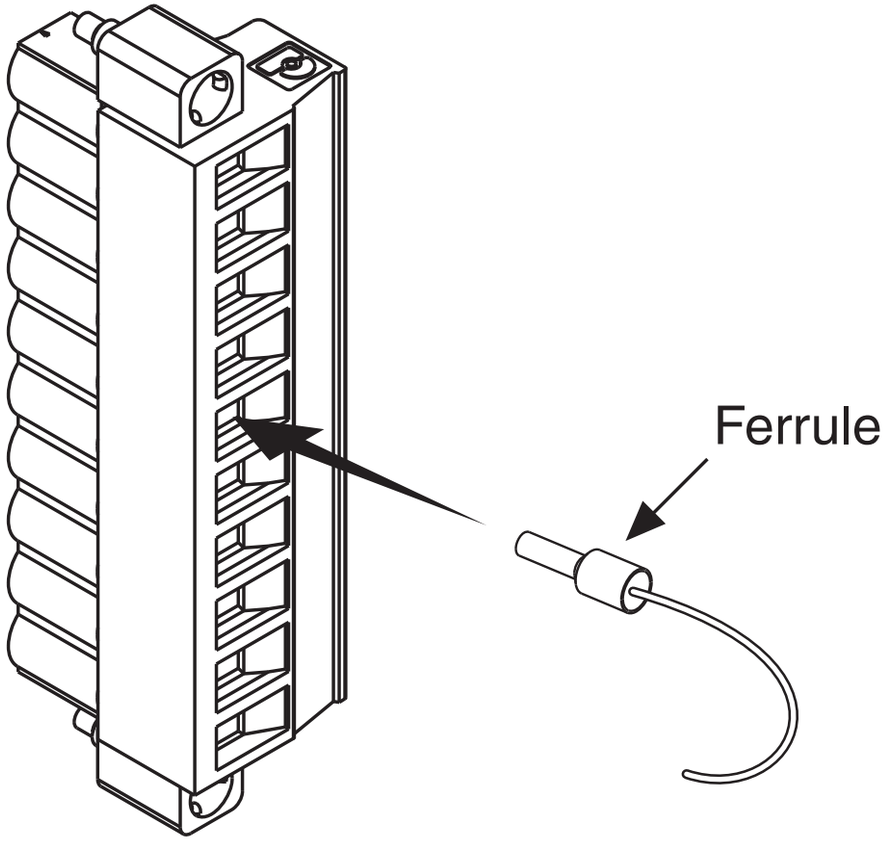


Wiring for High Vibration Applications

If an application is subject to high vibration, National Instruments recommends that you use ferrules to terminate wires to the detachable screw-terminal connector.

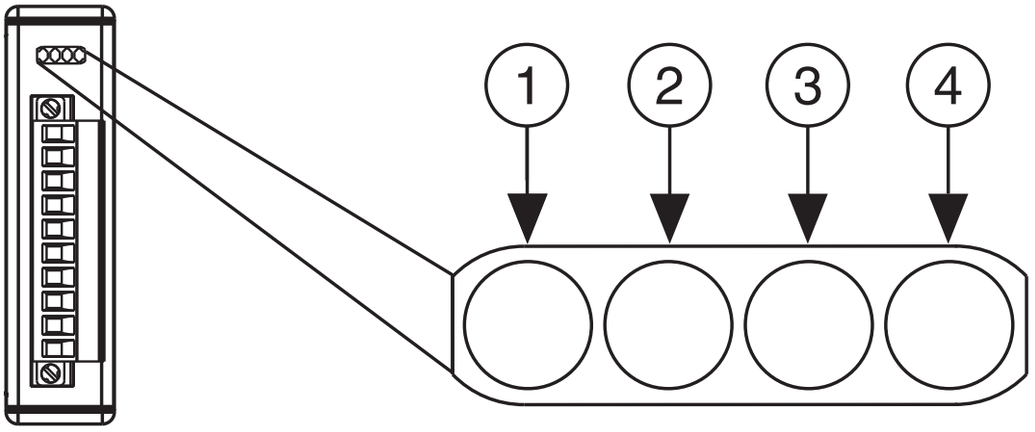
Refer to Figure 11 for an illustration of using ferrules.

Figure 11. 10-Terminal Detachable Screw-Terminal Connector with Ferrule



LED Indicators

The NI 9501 has four LEDs to display status information.



1	Enabled (green)	3	User (yellow)
2	Vsup (Motor Power) (green)	4	Fault (red)

Enabled

The Enabled LED (green) illuminates when the drive is enabled and the output power stage is active, and is flashing when the drive is disabled and the output power stage is inactive. Refer to the *NI 9501* topic in the *LabVIEW Help*, available by selecting **Help» LabVIEW Help**, for information about enabling the drive.

Vsup

The Vsup LED (green) illuminates when the motor DC power supply is properly connected.

User

You can define the User LED (yellow) to meet the needs of your application. Use the User LED I/O node to turn this LED on and off. Refer to the *NI 9501* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for information about the NI 9501 User LED I/O node.

Fault



Caution If the Fault LED is lit, determine the cause of the fault and correct it before enabling the drive.

The Fault LED (red) illuminates when a fault occurs. A fault disables the drive. Causes for fault are the following:

- Vsup undervoltage



Caution Vsup greater than 40 V will result in damage to the NI 9501.

- Vsup overvoltage

Hot-Swap Behavior

The NI 9501 is always disabled when it is first inserted in the chassis, regardless of whether Vsup is present or not. You can enable the drive using the **Enable Drive** method in software. Refer to the *NI 9501* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about enabling the drive.

When the NI 9501 is removed from the chassis while it is enabled, the power to the motor is removed and the motor decelerates to a stop based on its own friction.

Sleep Mode

This module supports a low-power sleep mode. Support for sleep mode at the system level depends on the chassis that the module is plugged into. Refer to the chassis manual for information about support for sleep mode. If the chassis supports sleep mode, refer to the software help for information about enabling sleep mode. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Typically, when a system is in sleep mode, you cannot communicate with the modules. In sleep mode, the system consumes minimal power and may dissipate less heat than it does in normal mode. Refer to the *Specifications* section for more information about power consumption and thermal dissipation.

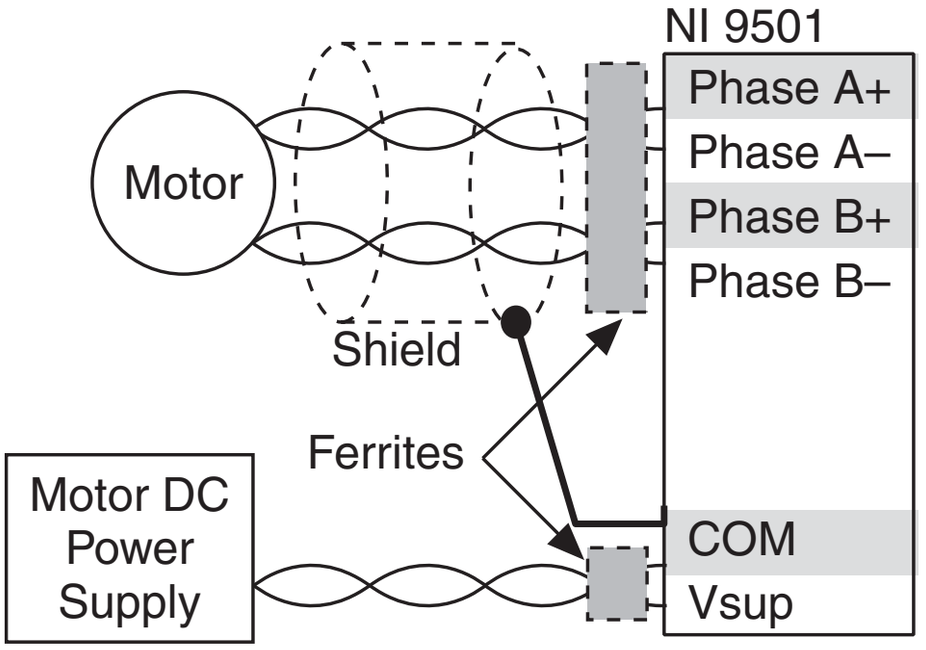
Cable Requirements for EMC Compliance

Select and install cables for the NI 9501 in accordance with the following requirements:

- Do not tie the motor case to the NI 9501 chassis ground.
- The motor power cable must be a multiconductor cable with an overall shield.
- Tie the motor cable shield to COM at the module side only. Do not tie the motor cable shield to the motor case.
- Install a clamp-on ferrite bead onto both the motor cable and Vsup cable, as shown in Figure 13. Power to the module must be off when adding ferrites.

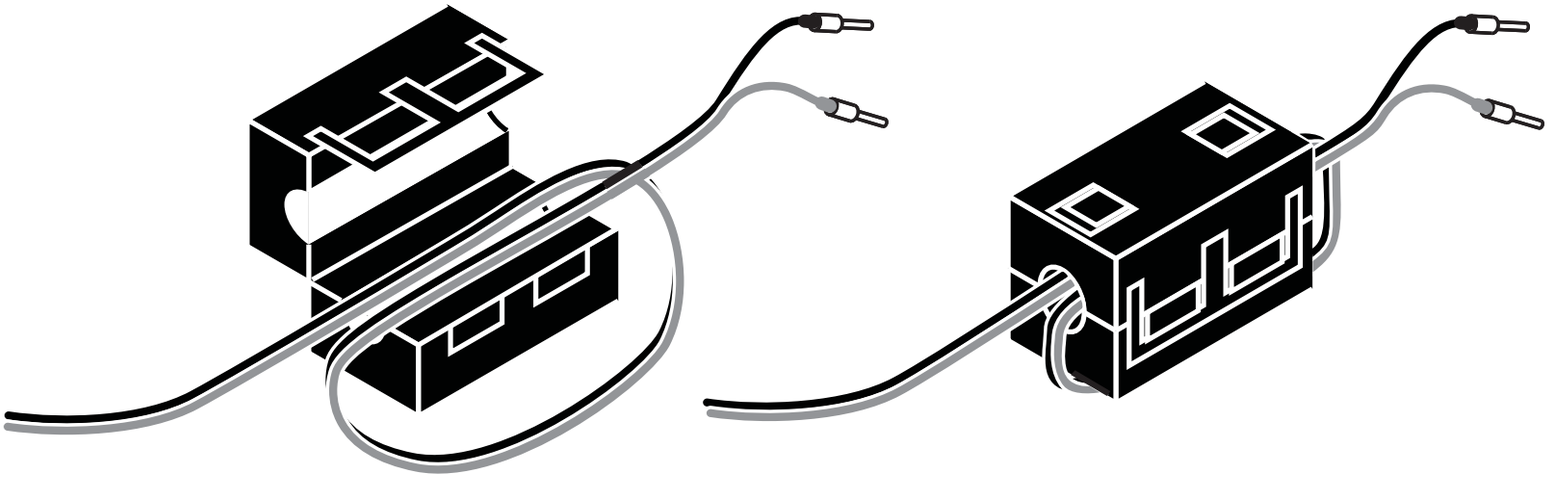
Note The wire connecting the motor cable shield to COM bypasses the ferrite as shown in Figure 12.

Figure 12. NI 9501 Cable Connection



- Clamp-on ferrites must be connected to the motor cable and Vsup cable as close to the module as possible with a full turn as shown in Figure 13. Placing the ferrite elsewhere on the cable noticeably impairs its effectiveness.

Figure 13. Installing a Ferrite



- Determine the clamp-on ferrite beads to install based on twice the motor cable and Vsup cable diameter. Order the appropriate ferrite beads from NI.

NI Part Number	Aperture Size mm (inches)
781233-01	7.0 (0.275)
781233-02	10.2 (0.402)
777297-01	13.4 (0.528)

Specifications

The following specifications are typical for the temperature range -40 to 70 °C unless otherwise noted. All voltages are relative to COM unless otherwise noted.

Input/Output Characteristics

Motor DC power supply (Vsup)	+9 to +30 VDC
Max step pulse rate	5 MHz
Minimum phase inductance	1 mH
Type	Bipolar chopper
Chopping frequency	20 kHz
Current per phase	3 A RMS (4.24 A peak)
Current reduction	0%, 25%, or 50%
Microstepping selections	x2, 4, 8, 16, 32, 64, 128, 256 (software-selectable)
Vsup capacitance	750 µF
MTBF	Contact NI for Bellcore MTBF specifications.

Drive Protection

Undervoltage..... <6 V

Caution Vsup greater than 40 V will result in damage to the module.

Overvoltage..... >32 V

Power Requirements

Power consumption from chassis

- Active mode ..... 500 mW max
- Sleep mode ..... 2.5 mW max

Thermal dissipation (at 70 °C)

- Active mode ..... 1.5 W max
- Sleep mode ..... 2.5 mW max

Physical Characteristics

If you need to clean the module, wipe it with a dry towel.

Tip For two-dimensional drawings and three-dimensional models of the C Series module and connectors, visit `ni.com/dimensions` and search by module number.

Screw terminal wiring

Gauge	0.2 mm^2 to 2.5 mm^2 (26 to 14 AWG copper) conductor wire with 10 mm (0.39 in.) of insulation stripped from the end
Temperature rating	90 °C
Torque for screw terminals	0.5 to 0.6 N · m (4.4 to 5.3 lb · in.)
Wires per screw terminal	One wire per screw terminal, two when using 2-wire ferrule
Ferrules	0.25 mm^2 to 2.5 mm^2

Connector securement

Securement type	Screw flanges provided
Torque for screw flanges	0.2N · m (1.80 lb · in.)

Weight ..... 144 g (5.1 oz)

Safety Voltages

Connect only voltages that are within the following limits.

Channel-to-COM ..... 0 to +30 VDC max, Measurement Category I

Isolation

- Channel-to-channel ..... None
- Channel-to-earth ground
  - Continuous ..... 60 VDC, Measurement Category I
  - Withstand ..... 1000 V_{rms}, verified by a 5 s dielectric withstand test

Measurement Category I is for measurements performed on circuits not directly connected to the electrical distribution system referred to as *MAINS* voltage. MAINS is a hazardous live electrical supply system that powers equipment. This category is for measurements of voltages from specially protected secondary circuits. Such voltage measurements include signal levels, special equipment, limited-energy parts of equipment, circuits powered by regulated low-voltage sources, and electronics.

Caution Do *not* connect the NI 9501 to signals or use for measurements within Measurement Categories II, III, or IV.

Hazardous Locations

U.S. (UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, AEx nA IIC T4
Canada (C-UL)	Class I, Division 2, Groups A, B, C, D, T4; Class I, Zone 2, Ex nA IIC T4
Europe (DEMKO)	Ex nA IIC T4

Power Supply Requirements

Caution You must use a UL Listed ITE power supply marked *LPS* with the NI 9501.

Safety and Hazardous Location Standards

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 61010-1, CSA 61010-1
- EN 60079-0:2012, EN 60079-15:2010
- IEC 60079-0: Ed 6, IEC 60079-15; Ed 4
- UL 60079-0; Ed 5, UL 60079-15; Ed 3
- CSA 60079-0:2011, CSA 60079-15:2012



Note For UL and other safety certifications, refer to the product label or the *Online Product Certification* section.

Electromagnetic Compatibility

This product meets the requirements of the following EMC standards for electrical equipment for measurement, control, and laboratory use:

- EN 61326-1 (IEC 61326-1): Class A emissions; Industrial immunity
- EN 55011 (CISPR 11): Group 1, Class A emissions
- AS/NZS CISPR 11: Group 1, Class A emissions
- FCC 47 CFR Part 15B: Class A emissions
- ICES-001: Class A emissions



Note For the standards applied to assess the EMC of this product, refer to the *Online Product Certification* section.



Note For EMC compliance, operate this device with shielded cabling.

CE Compliance CE

This product meets the essential requirements of applicable European directives as follows:

- 2014/35/EU; Low-Voltage Directive (safety)
- 2014/30/EU; Electromagnetic Compatibility Directive (EMC)
- 94/9/EC; Potentially Explosive Atmospheres (ATEX)

Online Product Certification

Refer to the product Declaration of Conformity (DoC) for additional regulatory compliance information. To obtain product certifications and the DoC for this product, visit `ni.com/certification`, search by module number or product line, and click the appropriate link in the Certification column.

Shock and Vibration

To meet these specifications, you must panel mount the system and affix ferrules to the end of the screw terminal wires.

Operating vibration

Random (IEC 60068-2-64)..... 5 g_{rms}, 10 to 500 Hz

Sinusoidal (IEC 60068-2-6) ..... 5 g, 10 to 500 Hz

Operating shock
(IEC 60068-2-27)..... 30 g, 11 ms half sine,
50 g, 3 ms half sine,
18 shocks at 6 orientations

Environmental

National Instruments C Series modules are intended for indoor use only, but may be used outdoors if installed in a suitable enclosure. Refer to the manual for the chassis you are using for more information about meeting these specifications.

Operating temperature
(IEC 60068-2-1, IEC 60068-2-2) ..... -40 to 70 °C

Storage temperature
(IEC 60068-2-1, IEC 60068-2-2) ..... -40 to 85 °C

Ingress protection..... IP 40

Operating humidity
(IEC 60068-2-56)..... 10 to 90% RH,
noncondensing

Storage humidity
(IEC 60068-2-56)..... 5 to 95% RH,
noncondensing

Maximum altitude..... 2,000 m

Pollution Degree (IEC 60664)..... 2

Environmental Management

NI is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial to the environment and to NI customers.

For additional environmental information, refer to the *Minimize Our Environmental Impact* web page at ni.com/environment. This page contains the environmental regulations and directives with which NI complies, as well as other environmental information not included in this document.

Waste Electrical and Electronic Equipment (WEEE)



EU Customers At the end of the product life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers, National Instruments WEEE initiatives, and compliance with WEEE Directive 2002/96/EC on Waste and Electronic Equipment, visit ni.com/environment/weee.

电子信息产品污染控制管理办法 （中国 RoHS）



中国客户 National Instruments 符合中国电子信息产品中限制使用某些有害物质指令 (RoHS)。关于 National Instruments 中国 RoHS 合规性信息，请登录 ni.com/environment/rohs_china。 (For information about China RoHS compliance, go to ni.com/environment/rohs_china.)

Worldwide Support and Services

The National Instruments website is your complete resource for technical support. At ni.com/support you have access to everything from troubleshooting and application development self-help resources to email and phone assistance from NI Application Engineers.

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer’s declaration of conformity. This system affords the user protection for electromagnetic compatibility (EMC) and

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