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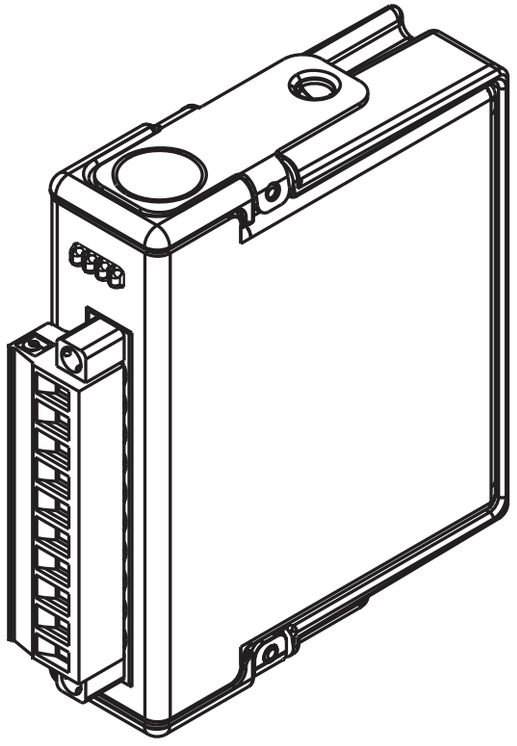
OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9502

Brushless Servo Motor Drive

Français Deutsch 日本語 한국어 简体中文

ni.com/manuals

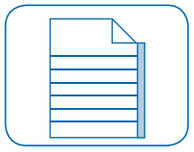


NATIONAL INSTRUMENTS™

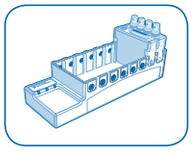
This document describes how to use the National Instruments 9502 module and includes specifications and pin assignments for the NI 9502.

Note The safety guidelines and specifications in this document are specific to the NI 9502. 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 9502 only as described in these operating instructions.

Safety Guidelines for Hazardous Locations

The NI 9502 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 9502 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 Vsup pin. The device must prevent the Vsup-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 9502 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 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.



Caution To ensure compliance with the applicable regulatory requirements, product installation requires special considerations and user-installed, add-on devices. Refer to the *Connecting the NI 9502* and *Cable Requirements for EMC Compliance* sections for details.

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 9502 Hardware Overview

The NI 9502 is a brushless servo motor drive. It contains motor outputs for a brushless servo motor, Hall effect sensor inputs, and power connections.

The NI 9502 returns the motor current to the LabVIEW FPGA module for use in a current loop or for monitoring. NI 9502 status information such as drive status and drive faults are also returned to the LabVIEW FPGA module. Refer to the *NI 9502* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about the available status information.

Depending on software settings, the NI 9502 can operate in either Trapezoidal or Field Oriented Control (FOC) commutation mode. Refer to the *NI 9502* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about the available modes.

The LabVIEW SoftMotion Module provides VIs and example programs that make it easier to use the NI 9502 in FOC commutation mode. Refer to `ni.com/info` and enter `nismpkg` for more information about the SoftMotion Module.

Figure 1 shows the NI 9502 working with the LabVIEW FPGA module in Trapezoidal commutation mode.

Figure 1. NI 9502 Trapezoidal Commutation Mode Block Diagram

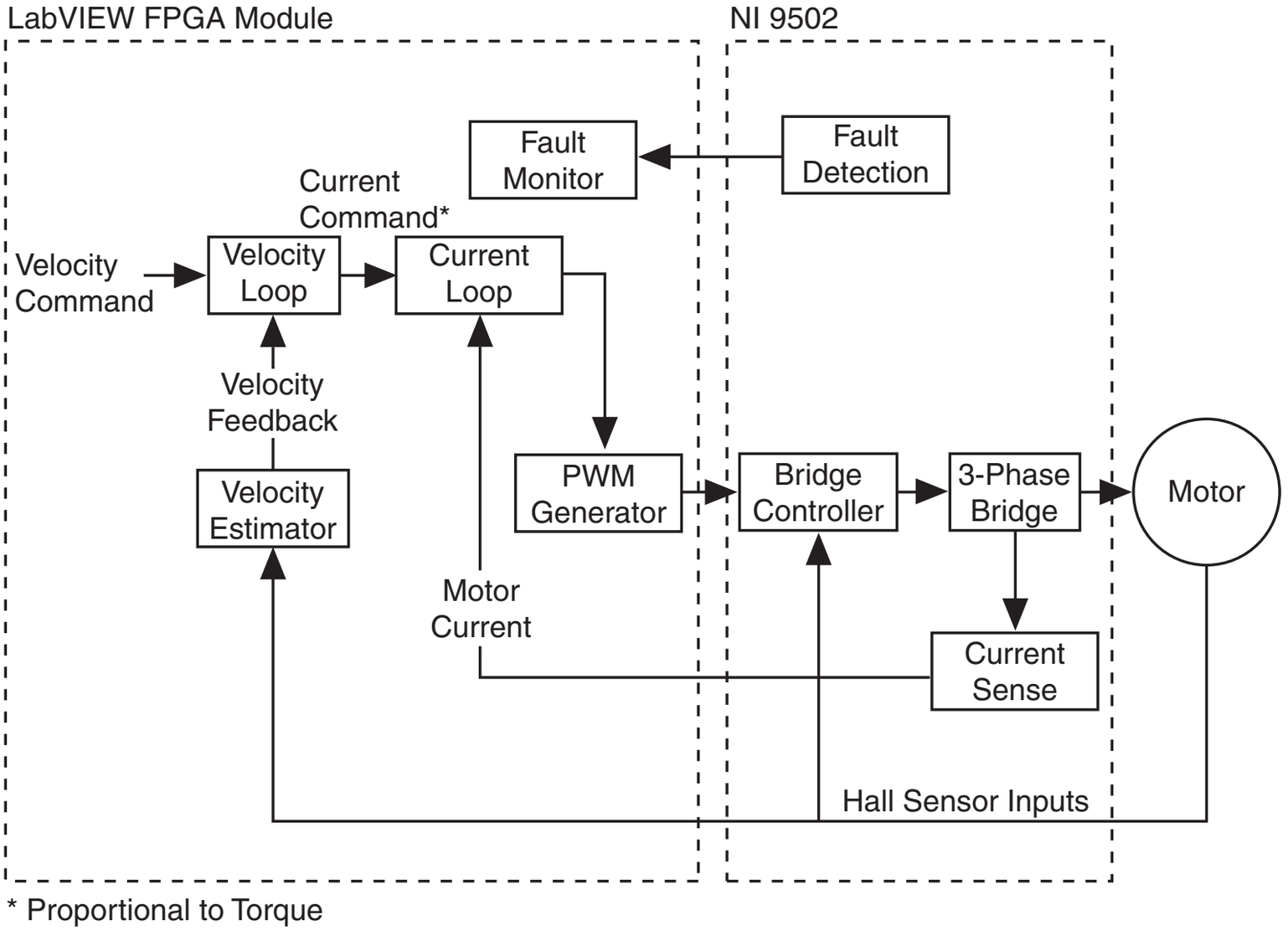
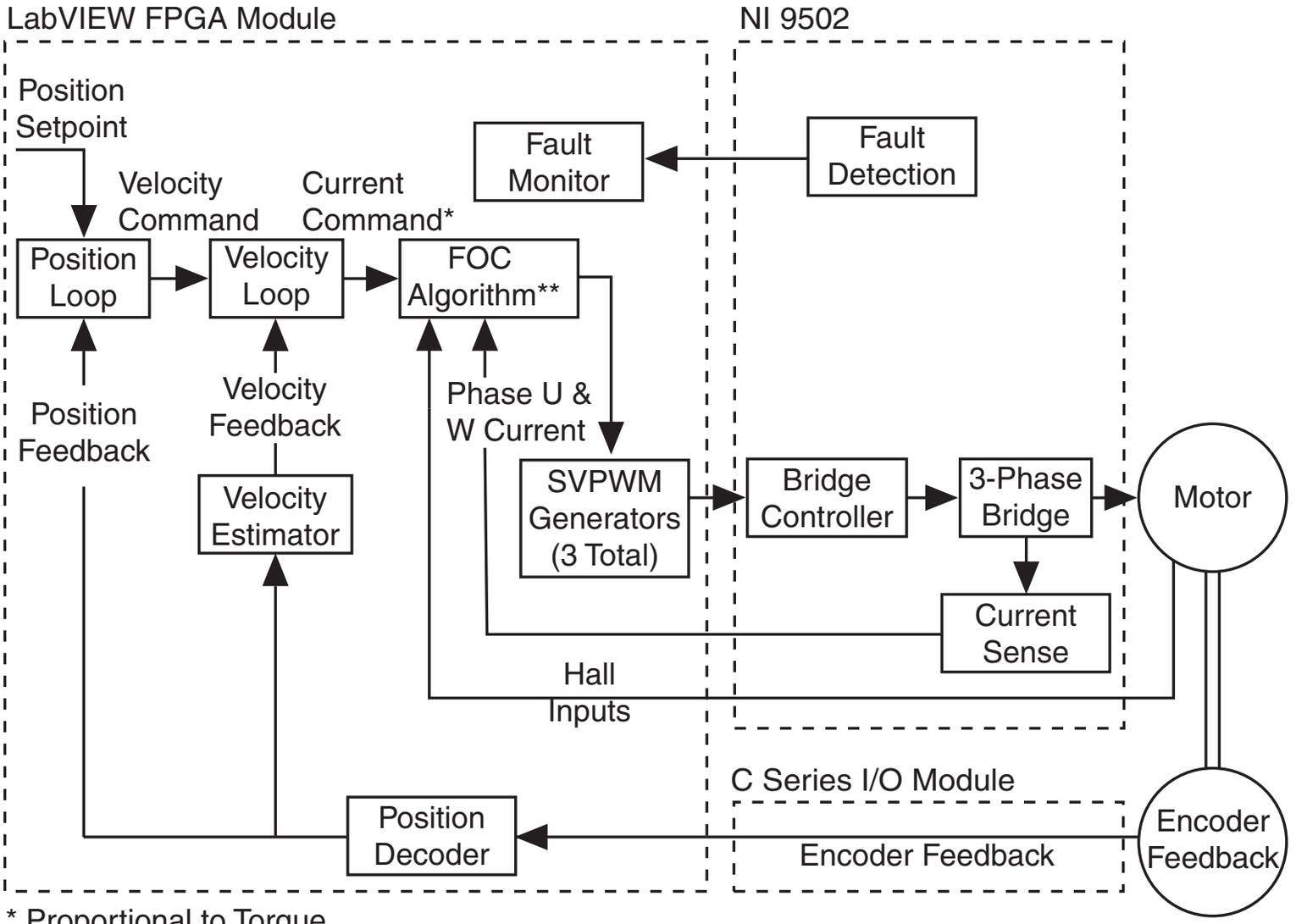


Figure 2 shows the NI 9502 working with the LabVIEW FPGA module in FOC commutation mode.

Figure 2. NI 9502 FOC Commutation Mode Block Diagram



* Proportional to Torque

** Available with the LabVIEW NI SoftMotion Module Premium

Connecting the NI 9502

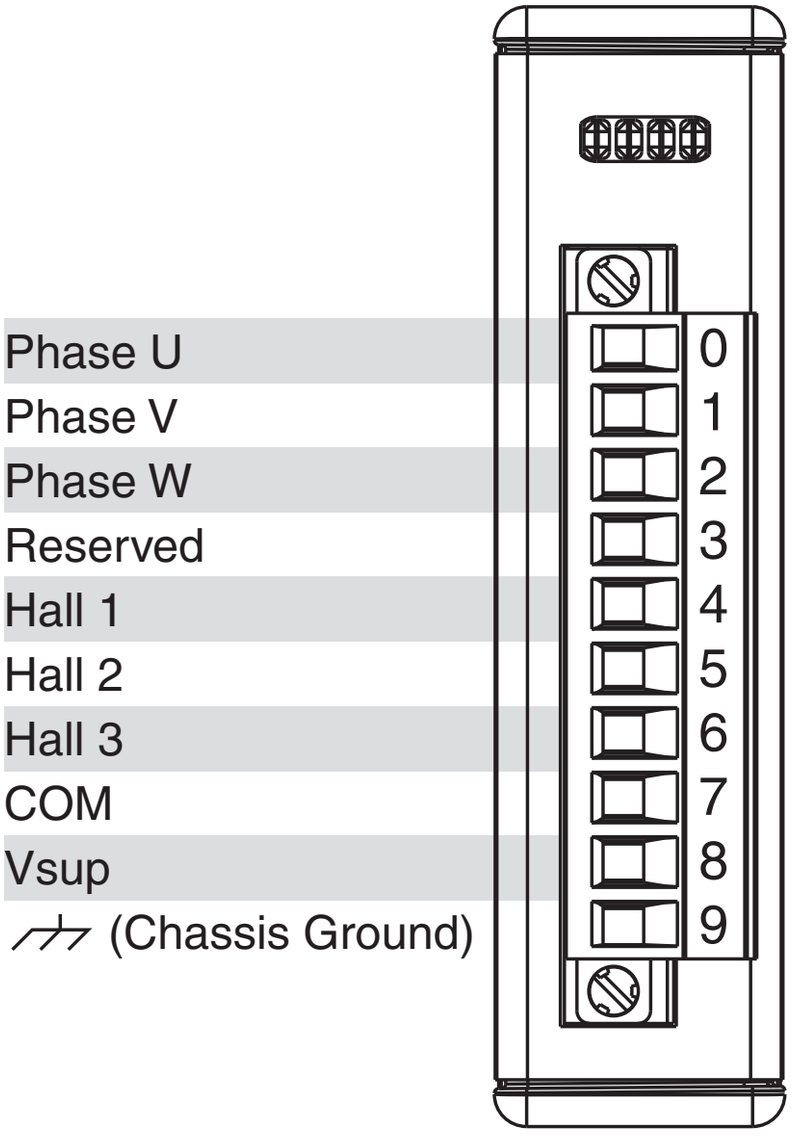
The NI 9502 has a 10-terminal detachable screw-terminal connector that provides connections for the brushless servo motor signals, Hall effect sensors, a 9 to 30 VDC power supply, COM, and chassis ground. Refer to Figure 3 for the pin assignments.

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 9502 screw terminal. Refer to Figure 4 for an illustration of using ferrules.

Caution Do *not* turn on or plug in the motor DC power supply until the screw-terminal connector is fully inserted and the two connector flange screws are tightened.

Figure 3. NI 9502 Connections

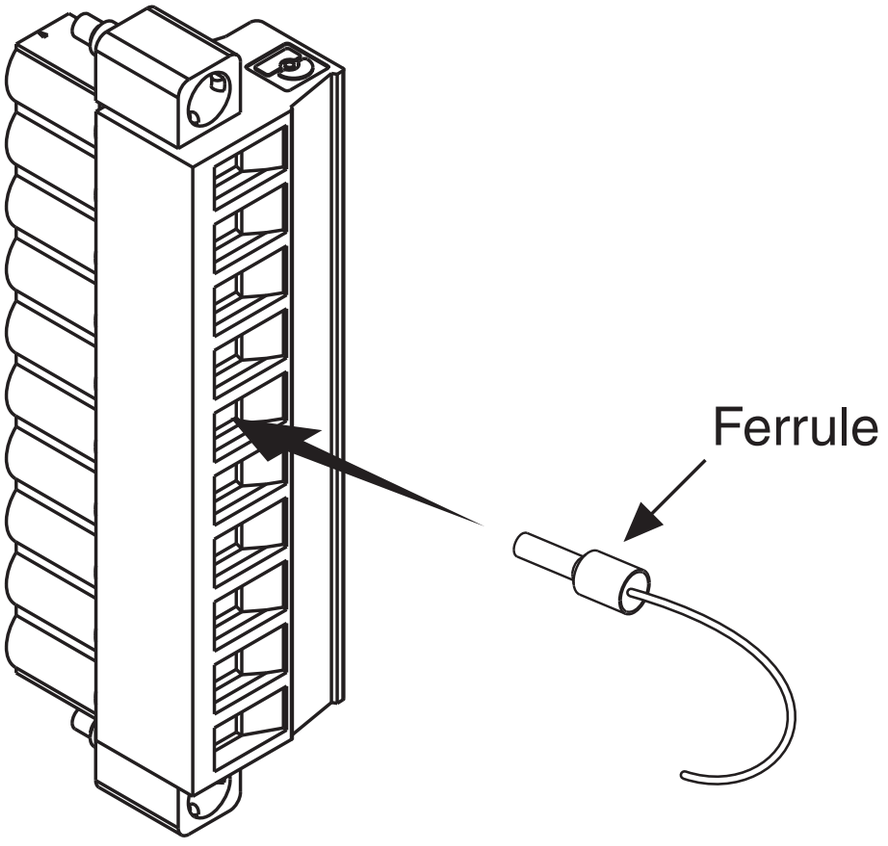


Wiring for High Vibration Applications

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 4 for an illustration of using ferrules.

Figure 4. 10-Terminal Detachable Screw-Terminal Connector with Ferrule



Motor Power Signals

The Phase U, Phase V, and Phase W connections provide PWM outputs to 3-phase ungrounded Wye or delta connected permanent magnet brushless motors. Refer to the motor documentation for motor phase wiring information.

Caution The motor terminals on this drive are energized when the module is enabled. Do *not* connect wires to or disconnect wires from the NI 9502 when it is enabled.

Use a multiconductor cable with an overall shield and conductors of 12 to 20 AWG for the motor cable. Figure in the *Cable Requirements for EMC Compliance* section shows a simplified connection diagram.

Hall Effect Sensor Connections

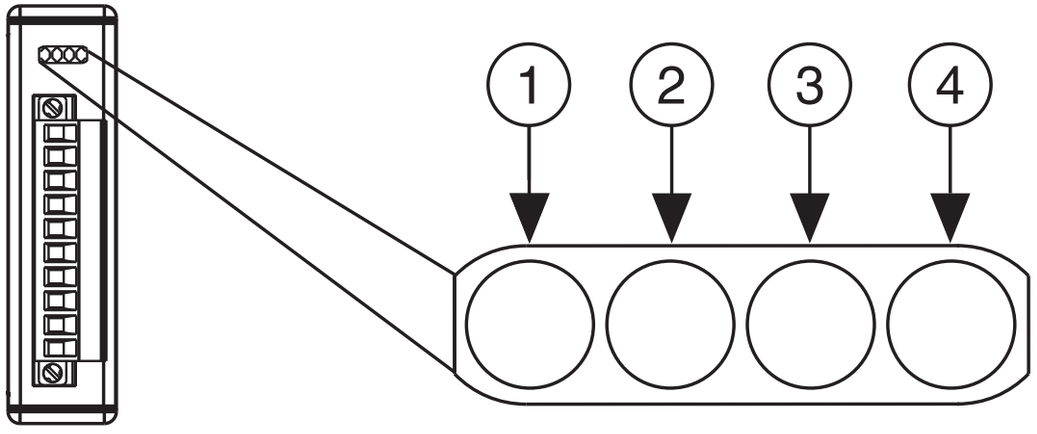
Use the Hall 1, Hall 2, and Hall 3 inputs to connect the motor Hall effect sensors. For proper phase switching to occur, the Hall sensors from the motor must be connected to the correct Hall inputs on the NI 9502 module. The Hall sensor phase sequence is motor-dependent, so selecting the correct inputs may require manually testing the motor wiring. Refer to the *Connecting Hall Effect Sensors for Trapezoidal Commutation* topic in the *LabVIEW*

Help, available by selecting **Help»LabVIEW Help**, for information about determining the proper Hall input connections to the NI 9502 module when using the NI 9502 module in trapezoidal commutation mode.

Note The LabVIEW SoftMotion Module provides an example that allows you to automatically determine the phasing for FOC commutation mode.

LED Indicators

The NI 9502 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 9502* 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 9502* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for information about the NI 9502 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 a fault are the following:

- Vsup undervoltage. Refer to the *NI 9502 Module Faults* topic in the *LabVIEW Help*, available by selecting **Help» LabVIEW Help**, for more information about this fault.



Caution Vsup greater than 40 V will result in damage to the NI 9502.

- Vsup overvoltage



Caution Current greater than ±8 A will result in damage to the NI 9502.

- Overcurrent
- Module current sampling fault. Refer to the *NI 9502 Module Faults* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about this fault

Hot-Swap Behavior

The NI 9502 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 9502* topic in the *LabVIEW Help*, available by selecting **Help»LabVIEW Help**, for more information about enabling the drive.

When the NI 9502 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 and the drive is disabled. 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 9502 in accordance with the following requirements:

- Use only shielded cables to connect the NI 9502 to a motor and a power supply.
- Terminate the motor and power supply cable shields to the COM terminal of the NI 9502. In addition, terminate the cable shields at the other end to either earth ground or the chassis of the connected motor and/or power supply.
- Install snap-on, ferrite beads to the cables as follows:
  - Install a snap-on ferrite bead from Table 2 on each phase wire of the motor cable within one (1) centimeter of the NI 9502 (marked as Ferrite 1 in Figures and). All other wires, including the cable shields, should bypass these ferrites as shown in Figures and . Select the ferrite with the smallest aperture that will fit the actual wires used.

– Install a snap-on ferrite bead from Table 1 on the power supply cable (marked as Ferrite 2 in Figure) and the motor cable (marked as Ferrite 3 in Figure) as close to the NI 9502 as practical. If a single, shielded cable is used, install only one ferrite bead (marked as Ferrite 2 in Figure) as shown. If two cables are used, install two ferrites from Table 1 as shown in Figure . The ferrite beads should encompass the entire cable, including the cable shield. Select the ferrite with the smallest aperture that will fit the actual cable(s) used.

– Ferrite beads can be ordered from the National Instruments Web site at `ni.com` by selecting *Order by Part Number.*

Power to the module must be off when adding ferrites.

Table 1. Ferrite Sizing Chart for Power Supply and Motor Side Cables

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)

Table 2. Ferrite Sizing Chart for Module Side Motor Phase Cables

NI Part Number	Aperture Size mm (inches)
781233-02	10.2 (0.402)
781950-01	5.10 (0.201)

Figure 5. NI 9502 Cable Connection (One Cable Option)

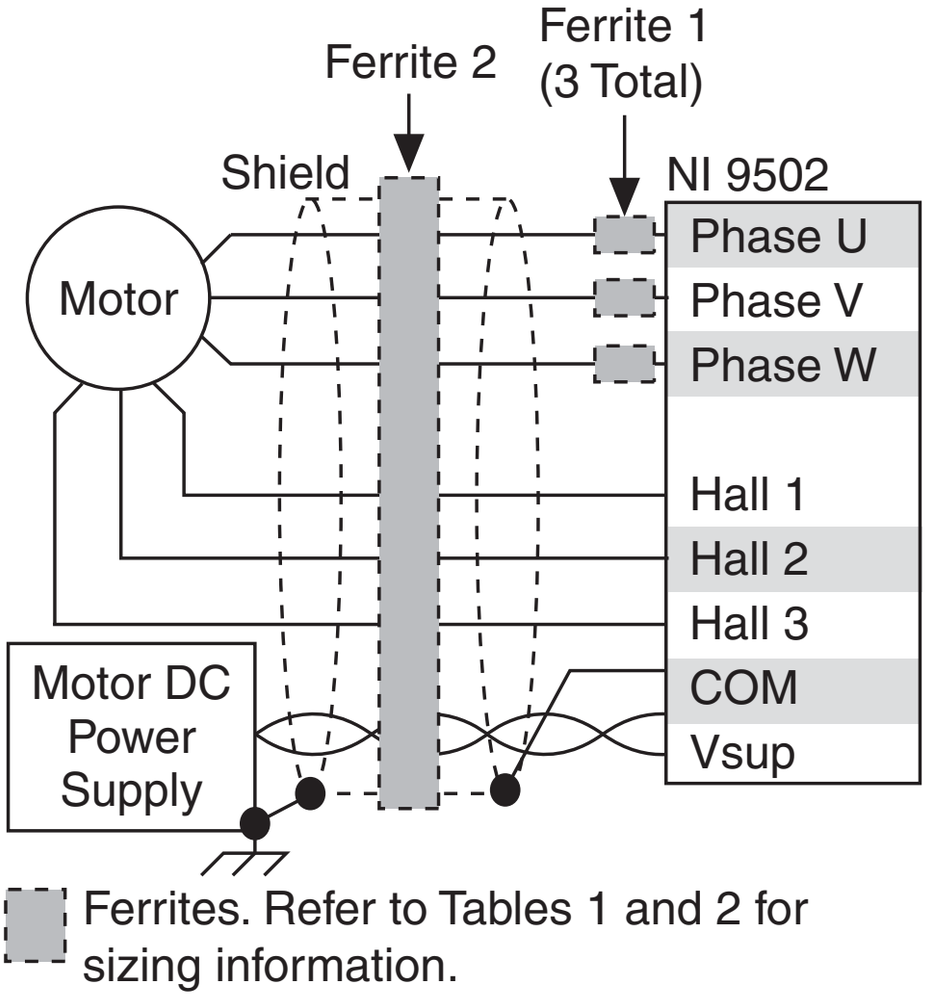
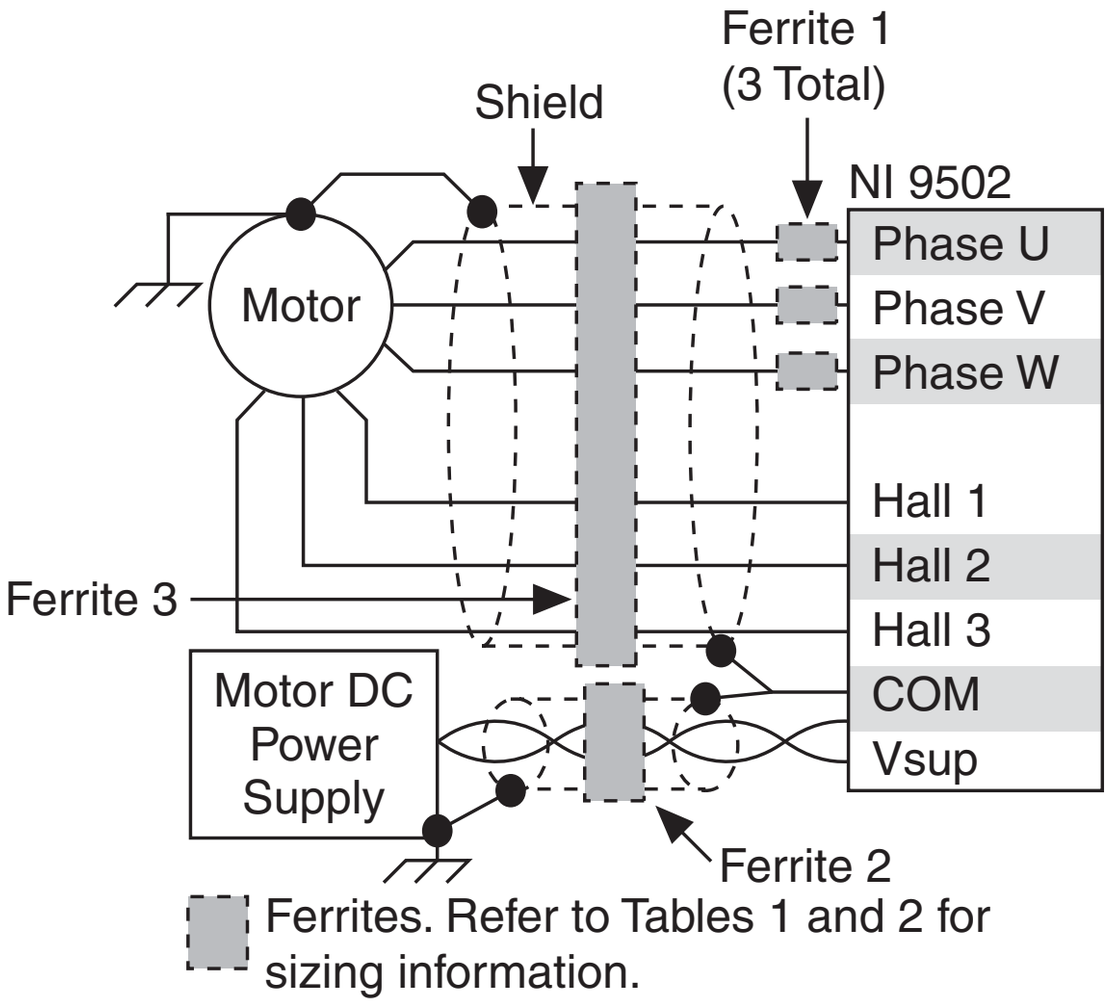


Figure 6. NI 9502 Cable Connection (Two Cable Option)



Specifications

The following specifications are typical for the temperature range -40 to 70 °C and a PWM rate of 20 kHz for Trapezoidal commutation mode and 10 kHz for FOC commutation mode unless otherwise noted. All voltages are relative to COM unless otherwise noted.

Input/Output Characteristics

Motor outputs

Current	4 A (2.8 Arms) continuous/ 8 A (5.6 Arms) peak
Maximum peak time	1 second
Minimum dwell time between peaks	15 seconds
Peak output power	0.2 kW
Continuous output power	0.1 kW
Commutation	Field Oriented Control or Trapezoidal

- Modulation
  - Field oriented control ..... Center-aligned PWM with space vector modulation
  - Trapezoidal ..... Left-aligned PWM
- Minimum inductance ..... 250 µH
- PWM ripple frequency ..... 20 kHz[1]

Current loop[1]

- ADC resolution ..... 12 bits
- Current range ..... ±8 A
- Sampling rate ..... 10 kHz (100 µs)
- Bandwidth ..... 2.5 kHz with specified minimum inductance, varies with tuning and load

Hall inputs

- Digital logic levels
  - Voltage ..... -0.25 to 5.25 V
  - High, VIH ..... 2.4 V min
  - Low, VIL ..... 0.8 V max

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[1] Specifications based on the installed examples.

Input current
(0 V ≤ Vin ≤ 4.5 V) ..... ±2 mA max

Motor DC power supply (Vsup)..... +9 to +30 VDC

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 ..... 700 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.



Note 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 Vrms, 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 9502 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 9502.

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 grms, 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

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

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

Maximum altitude..... 2,000 m

Indoor use only.

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.

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Worldwide Support and Services

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