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MID-7604/7602 ACCESSORY

This user guide describes the electrical and mechanical aspects of the MID-7604/7602 power amplifier accessory and describes how to use the MID-7604/7602 with your motion controller.

Contents

322454A-01 *September 1999*

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.

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.

overline — Indicates the signal is active-low.

Introduction

Your MID-7604/7602 accessory is a complete power amplifier and system interface for use with four or two axes of simultaneous stepper motion control. Ideally suited to industrial and laboratory applications, the MID-7604/7602 has everything you need to connect motors, encoders, limit switches, I/O, and other motion hardware to National Instruments motion controllers.

The MID-7604/7602 can drive a broad range of stepper motors with its rugged microstepping bipolar chopper driver and user-selectable current-per-phase settings. In all configurations, power supplies are built in and use standard 240/120 VAC for operation. Electronics are fan cooled to assure reliable operation.

The MID-7604/7602 simplifies 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. The MID-7604/7602 connects to National Instruments motion controllers via a 68-pin, high-density interconnect cable.

The MID-7604/7602 has four 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. The MID-7604/7602 also has a host bus power interlock that activates an internal driver inhibit signal if the host computer is shut down or the motion controller interface cable is disconnected. The inhibit input

from the back panel connectors also inhibits the stepper drives when activated.

The MID-7604/7602 is packaged in a rugged, lightweight enclosure that can be used as a benchtop unit or rack-mounted using a 19-in. standard rack kit.

What You Need to Get Started

To set up and use your MID-7604/7602 accessory, you will need the following items:

- ❑ The MID-7604/7602 accessory and *MID-7604/7602 Accessory User Guide*
- ❑ Power cord (IEC type)
- ❑ One of the following shielded cable assemblies, as applicable:
  - SH68-C68-S, part number 186381A-02
  - SHC68-C68-S, part number 186380A-02

Detailed specifications for the MID-7604/7602 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 it 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.

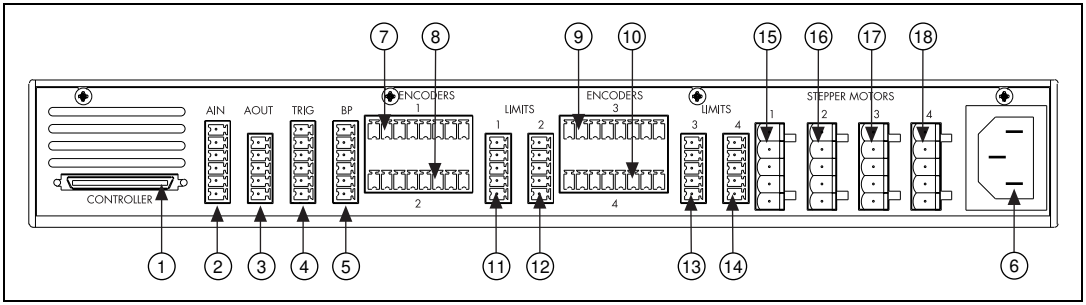
Do not substitute parts or modify equipment. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the device. Return the device to National Instruments for service and repair to ensure that its safety features are not compromised.

When connecting or disconnecting signal lines to the MID-7604/7602 terminal block screw terminals, make sure the lines are powered off. Potential differences between the lines and the MID-7604/7602 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 MID-7604/7602 device can create a shock or fire hazard or can damage any or all of the motion controllers connected to the MID-7604/7602 chassis, the host computer, and the MID-7604/7602 device. National Instruments is *not liable for any damages or injuries* resulting from incorrect signal connections.

Installation and Connector Wiring

Figure 1 shows connectors located on the back panel of your MID-7604/7602.



1	Motion Controller Connector	**Encoder Connectors**	**Limit Connectors**	**Motor Connectors**
2	Analog Input Connector	7 Axis 1	11 Axis 1	15 Axis 1
3	Analog Output Connector	8 Axis 2	12 Axis 2	16 Axis 2
4	Trigger Connector	9 Axis 3	13 Axis 3	17 Axis 3
5	Breakpoint Connector	10 Axis 4	14 Axis 4	18 Axis 4
6	AC Power			

Figure 1. MID-7604/7602 Back Panel Connectors

Caution Be sure to turn off the enable switch and the main AC power to your MID-7604/7602 and host computer before connecting the accessory to your motion controller.

Connect the motion controller to the MID-7604/7602 with the interface cable. Wire the motor power, limit switch, encoder, and I/O terminal blocks as described in this document and to your specific system requirements.

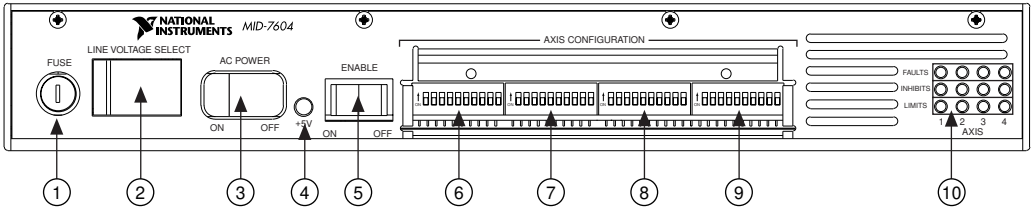
Use the LINE VOLTAGE SELECT switch to configure the MID-7604/7602 for 120 VAC, 60 Hz or 240 VAC, 50 Hz operation. For proper operation, you must set this switch to match your power source.

Warning The MID-7604/7602 main input fuse on the front panel must be changed if the line voltage is changed from the factory setting. Refer to the *Specifications* section of this document for fuse specifications.

Finally, install the power cord into the back panel AC connector and plug it into a correctly rated power source.

Front Panel Switches

Figure 2 shows the front panel for your MID-7604/7602. The DIP switches are shown with the detachable metal cover plate removed.



1	Main Input Fuse	5	Enable Switch	8	Axis 3 DIP Switch Bank
2	Line Voltage Select Switch	6	Axis 1 DIP Switch Bank	9	Axis 4 DIP Switch Bank
3	Power Switch	7	Axis 2 DIP Switch Bank	10	LED Status Array
4	Green Power LED				

Figure 2. MID-7604/7602 Front Panel

There are two rocker switches on the MID-7604/7602 front panel, AC POWER and ENABLE. Refer to Figure 2 for the location of these switches.

The AC POWER switch energizes the motor bus (+24 V) and the logic (+5 V) power supplies. When switched on, the green power LED labelled +5 V illuminates. If this LED fails to illuminate, check the power cord and main input fuse on the front panel.

The ENABLE switch enables or inhibits the stepper drivers. If the ENABLE switch is in the inhibit position (OFF), the stepper drivers are inhibited and the yellow LEDs, the middle row of the LED status array, for all axes illuminate. See the *Front Panel LEDs* section of this document for more information.

Both the AC POWER and ENABLE switches can inhibit the stepper drivers. However, as long as the AC POWER switch is on, only the stepper driver output stages are disabled. The remaining circuitry remains active, including the quadrature encoder circuit.

Warning The MID-7604/7602 main input fuse on the front panel must be changed if the line voltage is changed from the factory setting. Refer to the *Specifications* section of this document for fuse specifications.

Host Bus Interlock Circuit

The MID-7604/7602 has a host bus interlock circuit that monitors the presence of +5 V from the host computer and disables the MID-7604/7602 when the voltage is not present or falls out of tolerance. This circuit shuts down the stepper drives for all axes by activating the inhibit when the host computer is disconnected from the MID-7604/7602 or inadvertently shut down. Activation of the host bus interlock circuitry illuminates the yellow LEDs (middle row) of the LED status array for all axes. See the *Front Panel LEDs* section of this document for more information.

Front Panel LEDs

The front panel LEDs consist of a single green LED to indicate if the main power is active and an LED status array of 3 rows by 4 columns that provides a variety of status information. Refer to Figure 2 for the location of the front panel LEDs.

If the DC power supplies are active, the green power LED illuminates. If this LED fails to illuminate, check the power cord and the main input fuse on the front panel.

The LED status array is arranged by motor axes. Each of the four columns represents an axis, and each of the three rows represents a particular status. Table 1 summarizes the axes and statuses to which the different LEDs in the 3 × 4 array correspond.

Table 1. Front Panel LED Indicators

Status	Motor Axis			
Driver Fault Output (red)	1	2	3	4
Driver Inhibit (yellow)	1	2	3	4
Limit Status (green)	1	2	3	4

Driver Fault Output LEDs

The top row of LEDs indicates the status of the stepper drivers. When an LED illuminates red, there is either an overcurrent condition or a problem with the motor bus voltage on that axis.

Driver Inhibit LEDs

The middle row of LEDs indicates if a motor axis is inhibited. An axis is inhibited and the LED illuminates yellow if the host bus interlock circuitry is activated from the back panel, if the ENABLE switch on the front panel is in the inhibit position, if the motion controller's inhibit signal is low, or if the per-axis inhibit input is actively driven. The polarity of the per-axis inhibit input is selectable from the front panel DIP switches. See the *Front Panel DIP Switch Settings* section of this document for more information.

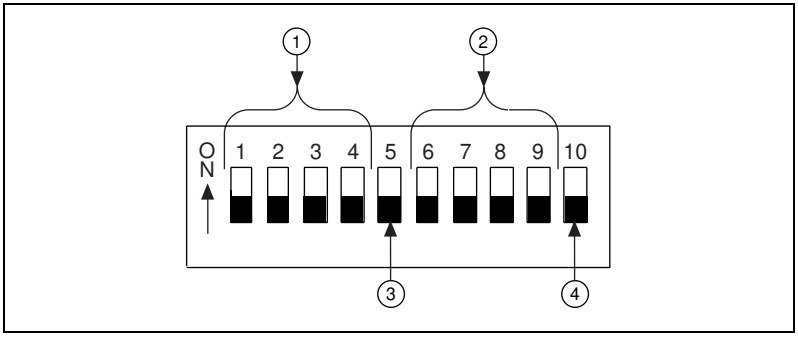
Limit Status LEDs

The bottom row of LEDs indicates if a limit switch is currently active. The LED illuminates green if either the forward or reverse limit switch is active for each axis. The polarity for the limit status LEDs is selectable from the front panel DIP switches. See the *Front Panel DIP Switch Settings* of this document for more information.

Front Panel DIP Switch Settings

The MID-7604/7602 front panel has a detachable metal plate that, when removed, provides access to four 10-position DIP switch banks. Refer to Figure 2 for the location of these switches.

The first nine DIP switches on each 10-position DIP switch bank are used to configure the microstep rate, peak output current, and current reduction for each axis. The DIP switch banks for axes 1 and 2 contain a global DIP switch, switch 10, which sets the polarity of the inhibit input and the polarity of the limit status LED, respectively.



1	Peak Current Output Switches	4	Global Polarity Switch (unused on axes 3 and 4 DIP switch banks
2	Microstep Rate Switches		
3	Current Reduction Switch		

Figure 3. DIP Switch Bank Layout

Microstepping Selection

The MID-7604/7602 uses bipolar chopper, two-phase microstepping drivers with a broad range of microstep rates. The factory-default setting is 10-times microstepping (2,000 steps/rev with standard 1.8º stepper motors). Table 2 shows the DIP switch settings for all possible microstep settings. DIP switches 6 through 9 control the microstep rate on a per axis basis.

Table 2. Microstep Rate 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

Output Current Settings

The MID-7604/7602 can provide 0.20–1.4 A peak (0.14–1 A RMS) depending on the peak output current DIP switch settings for each axis. DIP switches 1 through 4 control the peak output current. Table 3 shows the DIP switch settings for all possible peak output current settings.

Table 3. Peak Output Current DIP Switch Setting

Switch	Peak Output (A)	Switch	Peak Output (A)
	1.40		0.35
	1.20		0.30
	1.00		0.28
	0.85		0.27
	0.70		0.25
	0.60		0.24
	0.55		0.23
	0.50 (factory default)		0.20

You can configure the MID-7604/7602 stepper drivers in a current reduction mode on a per axis basis. This is useful to minimize motor heating when you are not stepping. When current reduction is enabled, the current decreases by 50% when no stepping has occurred for approximately 500 ms. DIP switch 5 controls current reduction on a per axis basis. When this DIP switch is on, current reduction is enabled. When this DIP switch is off, current reduction is disabled. The factory default setting is current reduction enabled.

Table 4 shows the available settings for DIP switch 5.

Table 4. Current Reduction DIP Switch Settings

Switch Setting	Operation
	Current reduction enabled (factory default)
	Current reduction disabled

Inhibit Input Polarity Setting

The MID-7604/7602 has a DIP switch that globally sets the polarity for the inhibit input for all axes. DIP switch 10 on the axis 1 DIP switch bank controls this setting. Refer to Figures 2 and 3 for the location of this switch.

The factory-default setting of DIP switch 10 is active-low. If the inhibit input is active, the axis is inhibited and the yellow status LED (middle row) illuminates for the axis. Table 5 shows the DIP switch setting for the inhibit input polarity selection.

Table 5. Inhibit Input Polarity DIP Switch Settings

Axis 1 Switch Setting	Operation
	Active-high
	Active-low (factory default)

Limit Status LED Polarity Setting

The MID-7604/7602 has a DIP switch that globally sets the polarity for the Limit Status LED. DIP switch 10 on the axis 2 DIP switch bank controls this setting. Refer to Figures 2 and 3 for the location of this switch.

The factory-default setting is active-low. If either the reverse or forward limits for an axis are active, the green status LED (on the bottom row) for the axis illuminates. This DIP switch only alters the polarity for the LEDs, not the actual limit to the motion controller. Table 6 shows the DIP switch setting for the Limit Status LED polarity selection.

Table 6. Limit Status LED DIP Switch Settings

Axis 2 Switch Setting	Operation
	Active-high
	Active-low (factory default)

Back Panel Connector Wiring

Motor Power Terminal Blocks

For motor power wiring, each MID-7604/7602 axis has a separate 5-position removable screw terminal block. Figure 4 shows a typical stepper motor configuration pin assignment.

Note The dotted loop indicates a shielded cable. A line above a signal indicates that the signal is active-low.

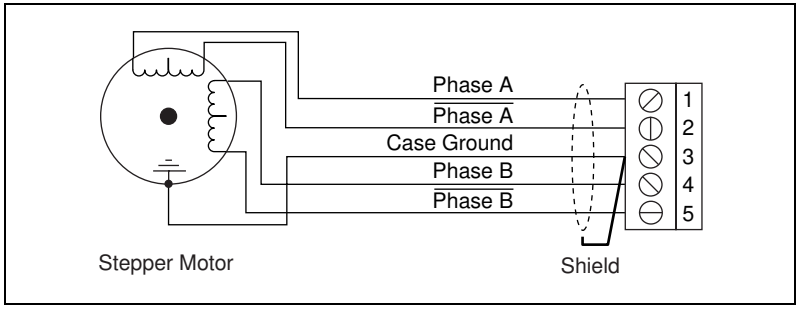


Figure 4. Typical Full-Coil Stepper Motor (2-Phase Type) Terminal Block Pin Assignment

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 MID-7604/7602 contains bipolar chopper drivers. The stepper motors must be wired in a 4-wire configuration as shown in Figure 4. Unused lead wires must be isolated and not connected. See the *Stepper Motor*

Configurations section in this document 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 (ground) or each other.

Encoder Terminal Blocks

For quadrature incremental encoder signals, each MID-7604/7602 axis has a separate 8-position removable screw terminal block. Where applicable, the MID-7604/7602 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 5 shows the typical encoder wiring pin assignment for single-ended signal input.

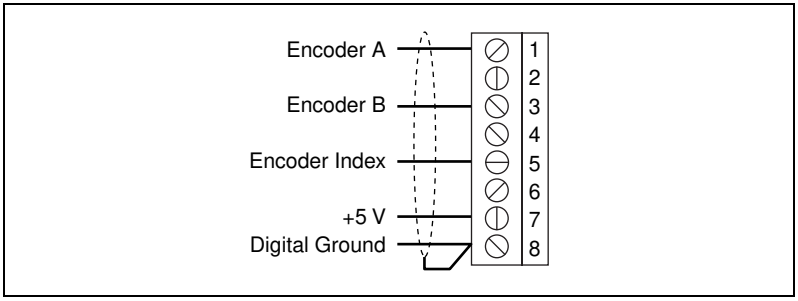


Figure 5. Typical Single-Ended Encoder Wiring Pin Assignment

Figure 6 shows the typical encoder wiring pin assignment for differential line driver signal inputs.

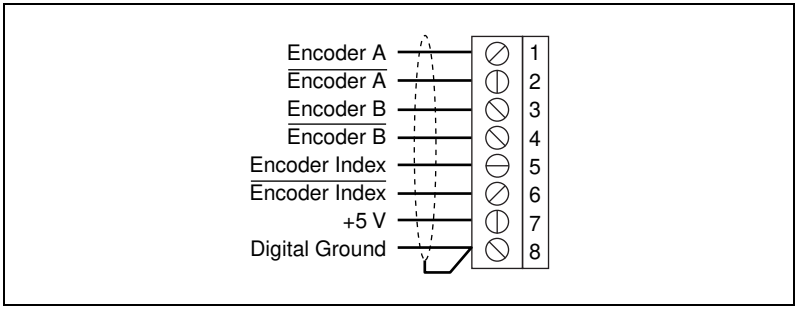


Figure 6. Typical Differential Line Driver Encoder Wiring Pin Assignment

If the encoder cable length is greater than 10 ft, use encoders with line driver outputs for your applications. Power for a +5 V encoder—generated by a power supply inside the MID-7604/7602—is available on pin 7.

Note If you require other encoder power voltages, reference an external power supply to the Digital Ground signal on the 8-pin encoder terminal block.

The MID-7604/7602 supports 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 signal must occur when both Phase A and Phase B signals are low, as shown in Figure 7. If the Index polarity is inverted, try reversing the Index and $\overline{\text{Index}}$ signals on differential encoders or using the $\overline{\text{Index}}$ input on single-ended encoders.

Figure 7 shows the proper encoder phasing for CW (forward) motor rotation.

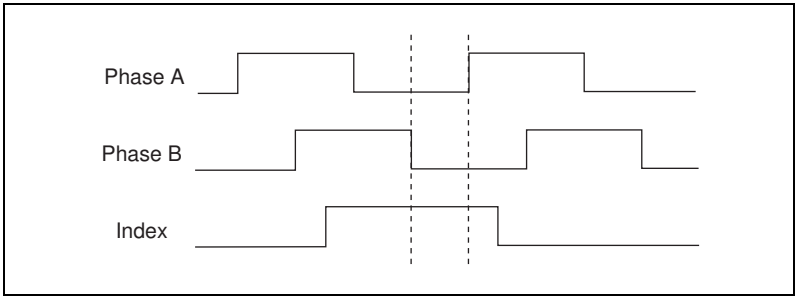


Figure 7. Encoder Signal Phasing, CW Rotation

Closed-loop stepper applications require consistent directional polarity between the motor and encoder for correct operation. The MID-7604/7602 standard directional polarity is as follows:

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

Figure 8 shows clockwise and counter-clockwise motor rotation.

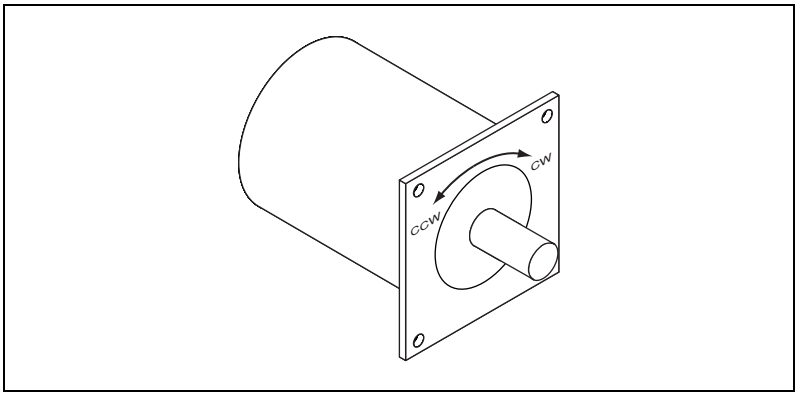


Figure 8. Clockwise and Counter-Clockwise Motor Rotation

When connecting the encoder wiring to your MID-7604/7602, use shielded wire of at least 24 AWG. Analog noise filters filter the encoder inputs in the MID-7604/7602. You must use cables with twisted pairs and an overall shield for improved noise immunity and enhanced encoder signal integrity. Figure 9 shows twisted pairs in a shielded cable.

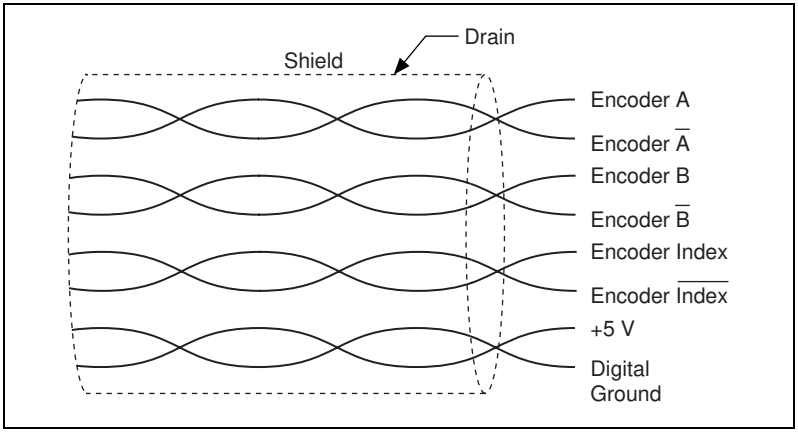


Figure 9. Shielded Twisted Pairs

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

For end-of-travel limit, home, inhibit input, and inhibit output connections, MID-7604/7602 axes have a separate, 6-position removable screw terminal connector block. Figure 10 shows the limit switch terminal block pin assignments.

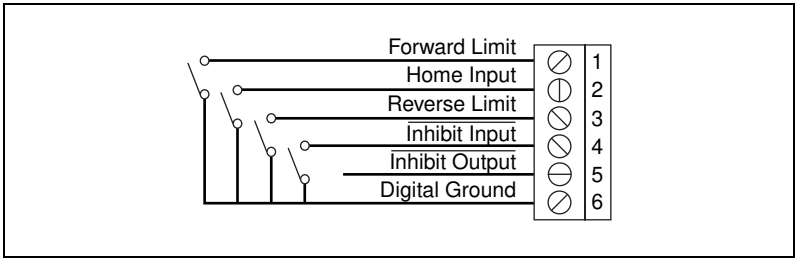


Figure 10. Limit Switch Terminal Block Pin Assignment
(Passive Limit Switch Connection Example)

The inhibit output signal is asserted low from the MID-7604/7602 when an axis is inhibited. This signal can be useful for actuating mechanical brakes or for monitoring an axis status. An axis is inhibited if the host bus interlock circuitry is activated, if the ENABLE switch on the front panel is in the inhibit position, if the motion controller's inhibit signal is low, or if the per-axis inhibit input is actively driven.

The MID-7604/7602 stepper drive remains in a reset state for 100 ms after being inhibited. You can lose steps if you attempt to issue a start motion command within 500 ms from the deassertion of the stepper drive inhibit. A Kill command will assert the inhibit signal from the controller and a Halt command will deassert the inhibit signal from the controller. The yellow LEDs (middle row) on the front panel illuminate if an axis is currently inhibited (killed state). You should execute a halt stop to deassert the inhibit signal from the controller, after which you must wait at least 500 ms before executing a start.

Breakpoint and Trigger Terminal Blocks

Both the breakpoint and trigger connectors use a 6-pin removable terminal block.

The trigger terminal block provides access to the trigger input lines, +5 V supplied from the MID-7604/7602, and digital ground. The breakpoint terminal block provides access to the breakpoint output lines, +5 V supplied by the MID-7604/7602, and digital ground. Figures 11 and 12 show the breakpoint and trigger 6-position terminal block assignments.

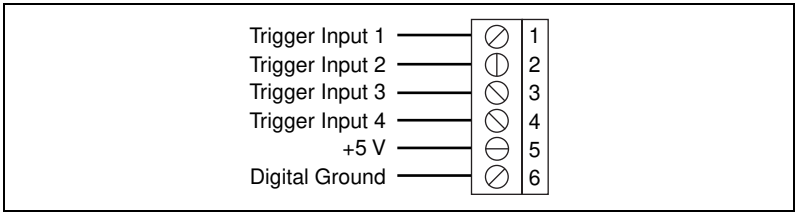


Figure 11. Trigger Terminal Block Pin Assignment

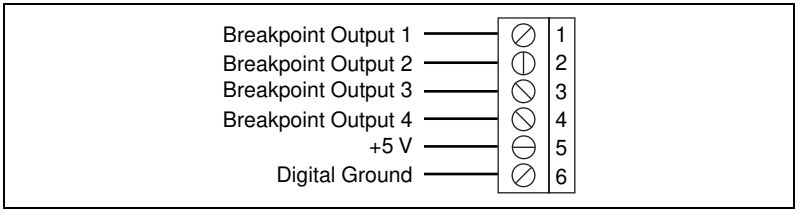


Figure 12. Breakpoint Terminal Block Pin Assignment

Analog I/O Terminal Blocks

There are two analog I/O connectors on the MID-7604/7602. The analog input connector uses a 6-pin removable terminal block and the analog output connector uses a 5-pin removable terminal block.

The analog input terminal block provides access to four analog-to-digital converter channels, an analog reference voltage from the converter circuit, and an analog input ground signal. The analog output terminal block provides access to four digital-to-analog converter channels with ±10 V output range and analog output ground. Refer to Figures 13 and 14 for terminal block pin assignments.

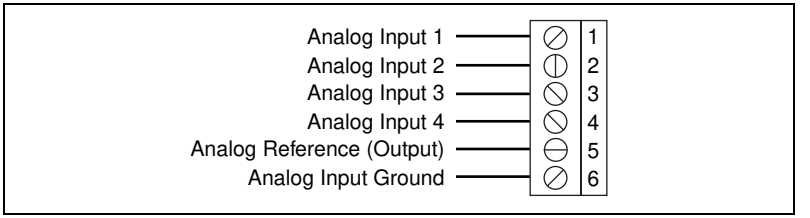


Figure 13. Analog Input Terminal Block Pin Assignment

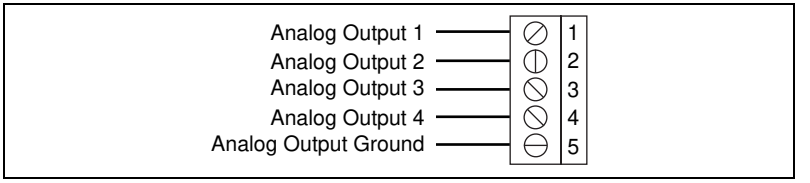


Figure 14. Analog Output Terminal Block Pin Assignment

Amplifier/Driver Command Signals

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

- Step and Direction signals (MID-7604/7602 standard)
- Independent CW and CCW pulses

The MID-7604/7602 uses stepper drivers that have active-low step and direction inputs. You must configure the stepper outputs of your motion controller for Step and Direction signals with inverted (active-low) polarity.

Stepper Motor Configurations

This section describes the various industry-standard winding configurations for stepper motors and shows how to connect them to a MID-7604/7602. The MID-7604/7602 is compatible with all configurations of two-phase stepper motors.

Caution The MID-7604/7602 is not compatible with 5-lead unipolar stepper motors or 5-phase stepper motors.

2-phase stepper motors come in 4-, 6-, and 8-wire variations. Figure 15 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.

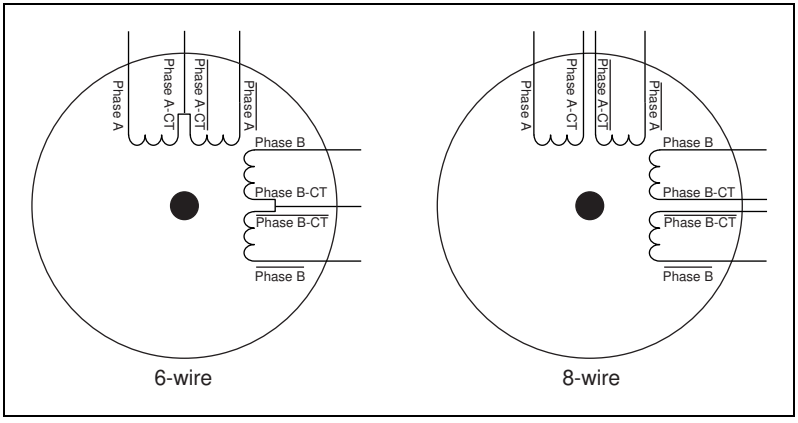


Figure 15. 6-Wire and 8-Wire Stepper Motors

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 16 produces the most torque per amp, but has the disadvantage of higher inductance and poorer high-speed performance.

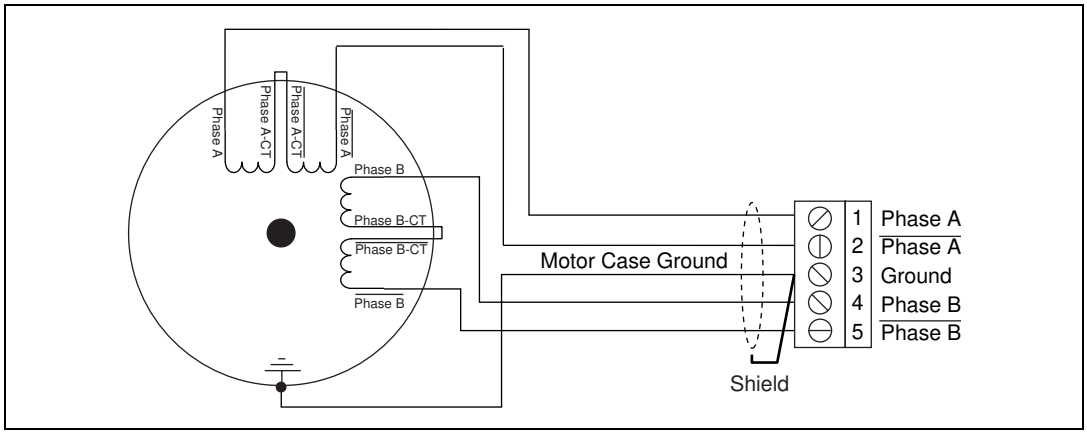


Figure 16. Series Stepper Motor Wiring (Higher Torque, Lower Speed)

Alternatively, you can wire 8-wire stepper motors in parallel as shown in Figure 17. This configuration produces better high-speed performance but requires more current to produce rated torque.

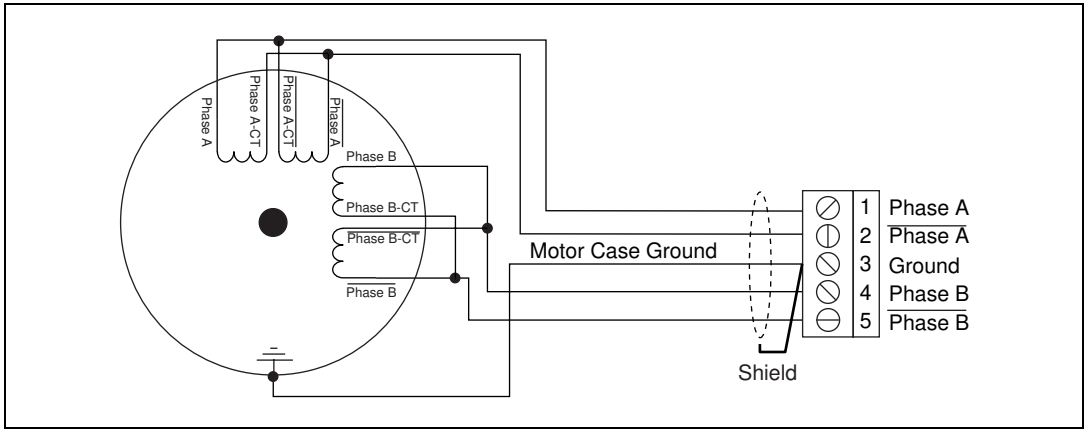


Figure 17. Parallel Stepper Motor Wiring (Higher Speed, Lower Torque)

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 18. 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.

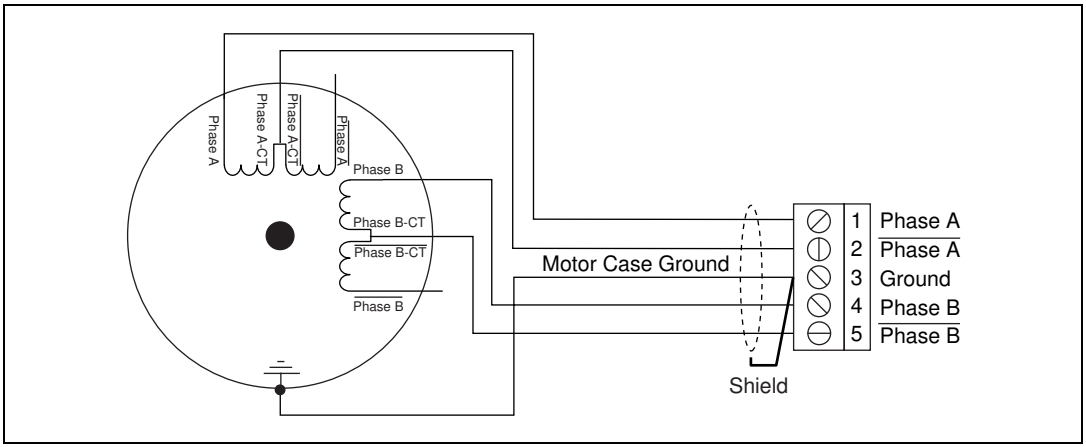


Figure 18. Half-Coil Stepper Motor Wiring

Figure 19 shows the wiring for a typical 4-wire motor.

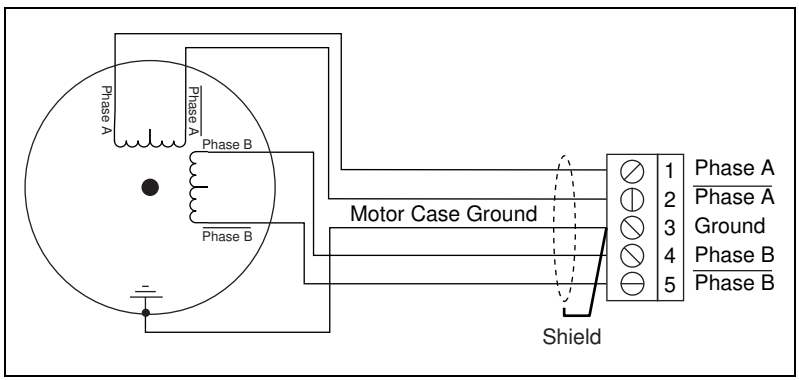


Figure 19. 4-Wire Motor Wiring

Specifications

The following specifications apply only to the MID-7604/7602. 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 MID-7604/7602 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.

Stepper Drive Amplifier

Type .....IM481H modular hybrid, bipolar chopper

Chopping frequency .....20 kHz

Motor bus voltage .....24 VDC nominal

Current per phase .....0.20–1.4 A peak (0.14–1 A RMS) (factory setting is 0.50 A peak)

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

Encoder Interface

Inputs .....Quadrature, incremental

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

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

Voltage range.....0–5 VDC

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

Maximum quadrature frequency.....1 MHz

Limit and Home Switch Inputs

Voltage range.....0–12 VDC

Compatibility .....Signal pass-through

Inhibit Inputs

Voltage range ..... 0–12 VDC

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

Compatibility ..... Signal pass-through

Inhibit Output

Voltage range ..... 0–5 VDC

Output low voltage ..... 0.5 V at 16 mA

Output high voltage ..... 2.4 V at 3.2 mA

Trigger Input

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

Compatibility ..... Signal pass-through

Breakpoint Output

Compatibility ..... Signal pass-through

Analog Input

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

Compatibility ..... Signal pass-through

Analog Output

Compatibility ..... Signal pass-through

Included Connectors

Encoders	8-position mini-combicon 3.81 mm plug (1 per axis)
Limits	6-position mini-combicon 3.81 mm plug (1 per axis)
Motors	5-position combicon 5.08 mm plug (1 per axis)
Breakpoints	6-position mini-combicon 3.81 mm plug (1 total)
Triggers	6-position mini-combicon 3.81 mm plug (1 total)
Analog output	5-position mini-combicon 3.81 mm plug (1 total)
AC power	Detachable AC power cord (IEC standard type)
Motion I/O	68-pin female high density VHDCI type

Safety

Designed to meet UL Standard for Safety for Power Conversion Equipment, UL 508C, and EN 50178—Electronic equipment for use in power installations

Installation Category II, Pollution degree 2

Environment

Operating temperature	0 to 45 ºC (32 to 113 ºF)
Storage temperature	–20 to 70 ºC (–4 to 158 ºF)
Humidity	10% to 90% (noncondensing)

Power Supply

Input voltage ..... 90–138 VAC / 204–264 VAC, 47–63 Hz

Input fuse..... 4 A, 240 VAC
6.3 A, 120 VAC (factory default)

Input fuse dimensions ..... 5 × 20 mm

Host Bus Voltage Interlock

PC bus host voltage threshold..... 4.5 VDC

Physical

Length ..... 30.7 cm (12.1 in.)

Width..... 25.4 cm (10 in.)

Height..... 4.3 cm (1.7 in.)

Weight..... 4.5 kg (10 lb.)

Support Information

Worldwide Technical Support and Product Information

www.natinst.com

National Instruments Corporate Headquarters

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 794 0100

Worldwide Offices

Australia 03 9879 5166, Austria 0662 45 79 90 0, Belgium 02 757 00 20, Brazil 011 284 5011,
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