OPERATING INSTRUCTIONS AND SPECIFICATIONS

NI 9478

16-Channel, 0–50 V, Sinking Digital Output Module with Programmable Current Limits

Français Deutsch 日本語 한국어 简体中文

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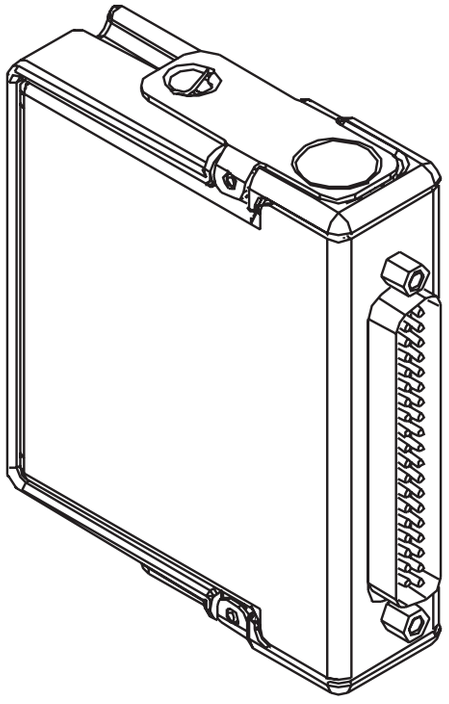

NATIONAL INSTRUMENTS™

This document describes how to use the National Instruments 9478 and includes specifications and pin assignments for the NI 9478. Visit `ni.com/info` and enter `rdsoftwareversion` to determine which software you need for the modules you are using. For information about installing, configuring, and programming the system, refer to the system documentation. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Note The safety guidelines and specifications in this document are specific to the NI 9478. The other components in the system might 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. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Safety Guidelines

Operate the NI 9478 only as described in these operating instructions.

Hot Surface This icon denotes that the component may be hot. Touching this component may result in bodily injury.

Safety Guidelines for Hazardous Locations

The NI 9478 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 9478 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 Zone 2 applications, install the system in an enclosure rated to at least IP 54 as defined by IEC 60529 and EN 60529.

Caution For Zone 2 applications, install a protection device across the external power supply and the COM pin. The device must prevent the external power supply voltage from exceeding 70 V if there is a transient overvoltage condition.

Special Conditions for Hazardous Locations Use in Europe

This equipment has been evaluated as Ex nA IIC T4 equipment under DEMKO Certificate No. 07 ATEX 0626664X. Each module is marked ⟨Ex⟩ II 3G and is suitable for use in Zone 2 hazardous locations. If you are using the NI 9478 in Gas Group IIC hazardous locations or in ambient temperatures of –40 °C ≤ Ta ≤ 70 °C, you must use the device in an NI chassis that has been evaluated as EEx nC IIC T4, Ex nA IIC T4, or Ex nL IIC T4 equipment.

Special Conditions for Marine Applications

Some modules are Lloyd's Register (LR) Type Approved for marine applications. To verify Lloyd's Register certification, visit `ni.com/certification` and search for the LR certificate, or look for the Lloyd's Register mark on the module.

Caution To meet radio frequency emission requirements for marine applications, use shielded cables and install the system in a metal enclosure. Suppression ferrites must be installed on power supply inputs near power entries to modules and controllers. Power supply and module cables must be separated on opposite sides of the enclosure and must enter and exit through opposing enclosure walls.

Connecting the NI 9478

The NI 9478 has a 37-pin DSUB connector that provides connections for the 16 digital output channels.

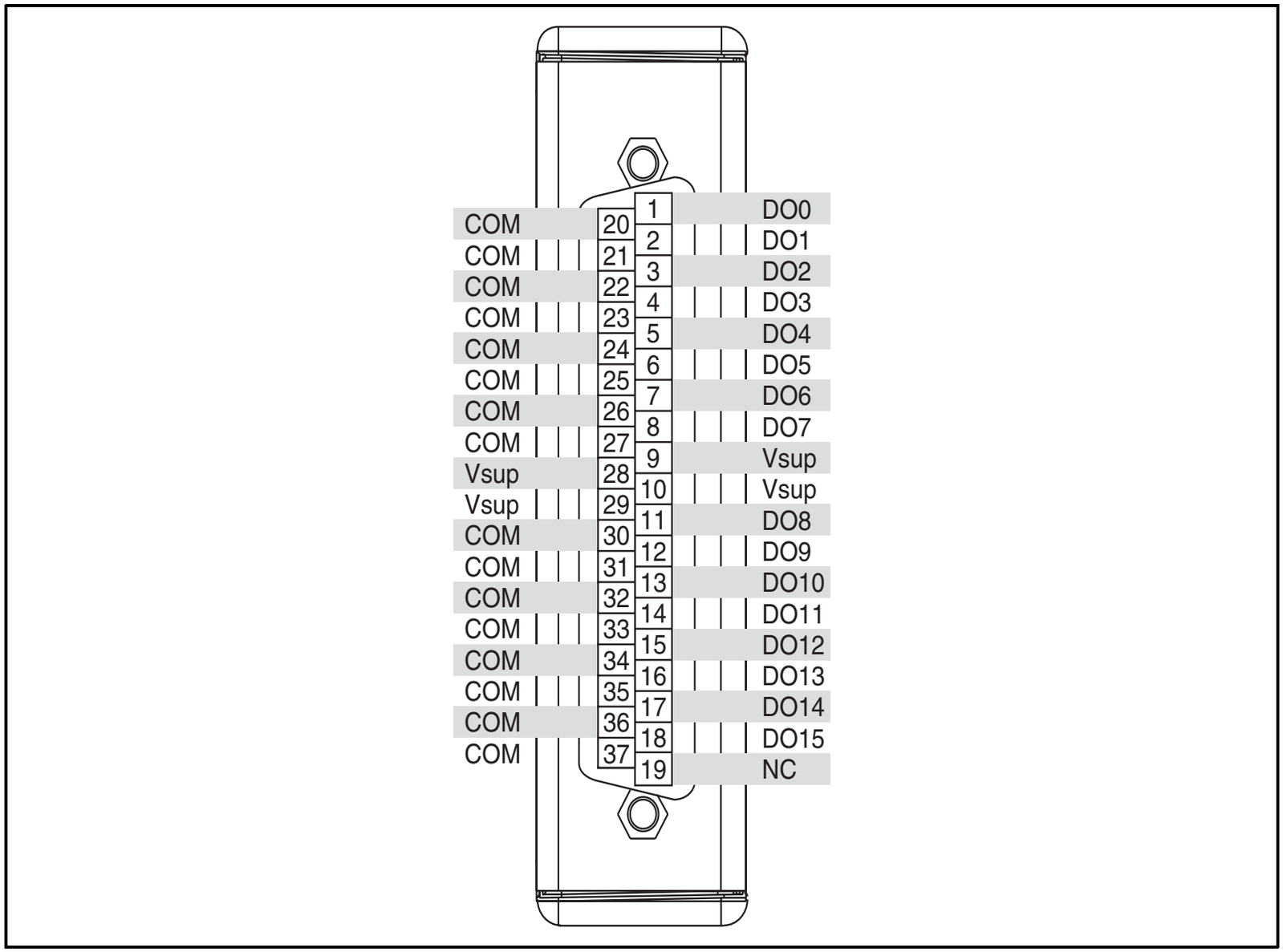

Figure 1. NI 9478 Pin Assignments

Each channel of the NI 9478 has a DO pin to which you can connect the load you want to control. Each channel also has a COM pin. National Instruments recommends you provide independent COM wiring for each channel to minimize current flow in the COM wiring. The COM pins are all connected together internally.

You must connect an external power supply to the NI 9478. This power supply provides the current for the devices you connect to the module. Connect the positive lead of the power supply to V_{sup} and the negative lead of the power supply to COM.

Caution Do not remove or insert modules if the external power supply connected to the V_{sup} pin is powered on.

The NI 9478 has current sinking outputs, meaning the DO pin is driven to COM when the channel is turned on.

You can directly connect the NI 9478 to a variety of industrial devices such as solenoids, motors, actuators, relays, and lamps. Make sure the devices you connect to the NI 9478 are compatible with the output specifications of the module. Refer to the *Specifications* section for more information about the output specifications.

Connect the device to DO and the positive lead of the power supply. Refer to Figure 2 for an illustration of how to connect a device to the NI 9478.

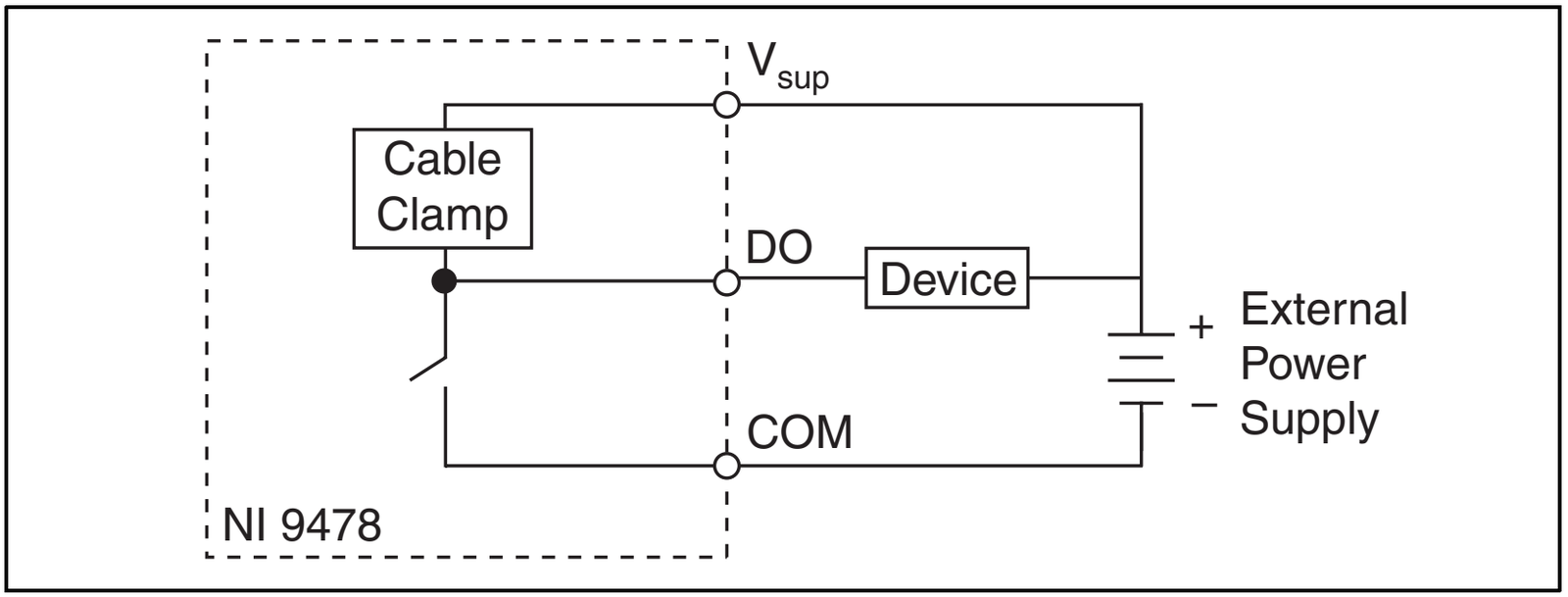

Figure 2. Connecting a Device to the NI 9478

You must connect the V_{sup} pin to the power supply to enable a weak cable clamping diode that protects the module from cable inductance flyback. This flyback voltage results from small amounts of energy stored in the inductance of the cabling. Refer to the *Using Long Cables* section for more information about protection from cable inductance flyback. You still must install an external flyback diode when switching inductive loads. Refer to the *Protecting the Module from Flyback Voltages* section for more information about installing a flyback diode.

Protecting the Module from Flyback Voltages

If the module is switching an inductive or energy-storing device such as a solenoid, motor, or relay, and the device does not have flyback protection, install an external flyback diode as shown in Figure 3. Refer to the *Using Long Cables* section for more information about protection from cable inductance flyback.

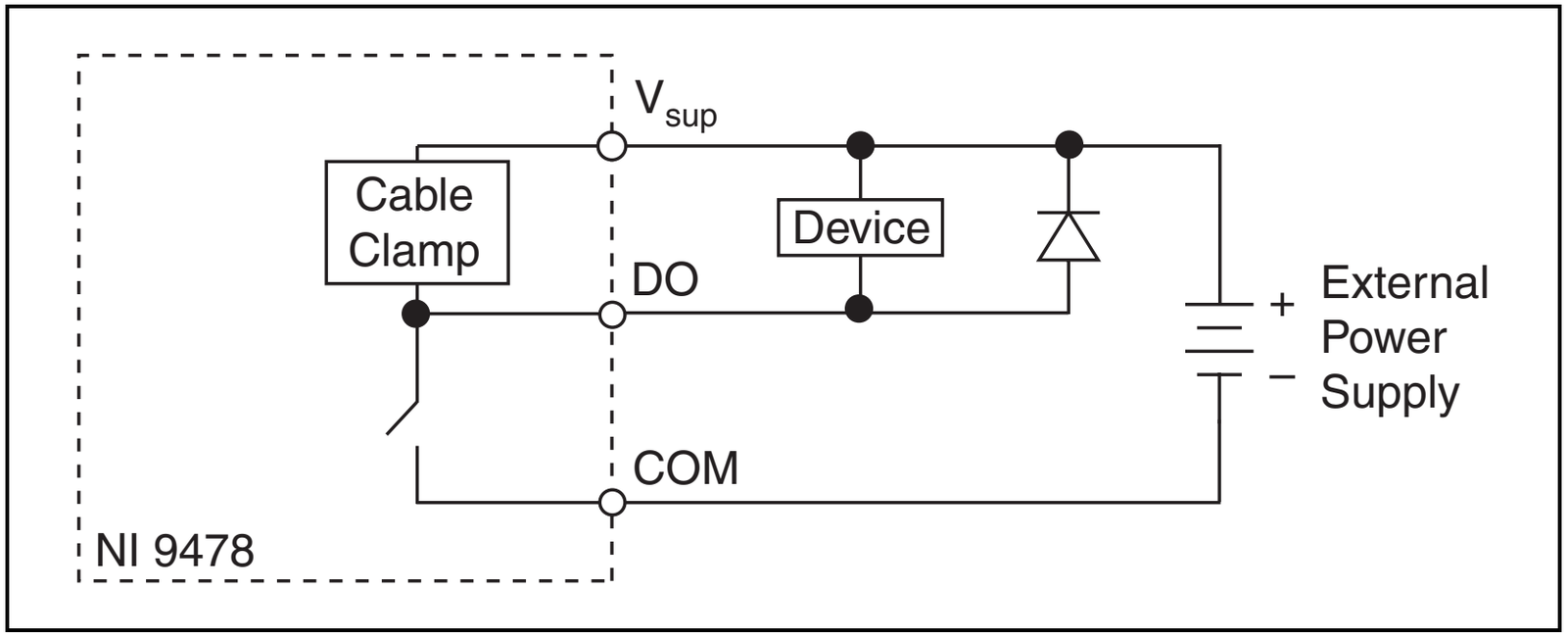

Figure 3. Connecting a Flyback Diode to the NI 9478

Using Long Cables

The inductance of the cabling that connects the NI 9478, the loads, and the external supply stores up energy when a channel is on and passing current through the cables. Each time a channel is turned off, the energy stored in the cables is released as flyback voltage and dissipates as heat in the NI 9478. The total power dissipated in the module increases with higher switching frequencies, higher currents, and longer cable lengths. The cable length is the total distance from the digital output pin of the NI 9478 channel, through the load, through the external power supply, and back to the COM pin, as shown in Figure 4.

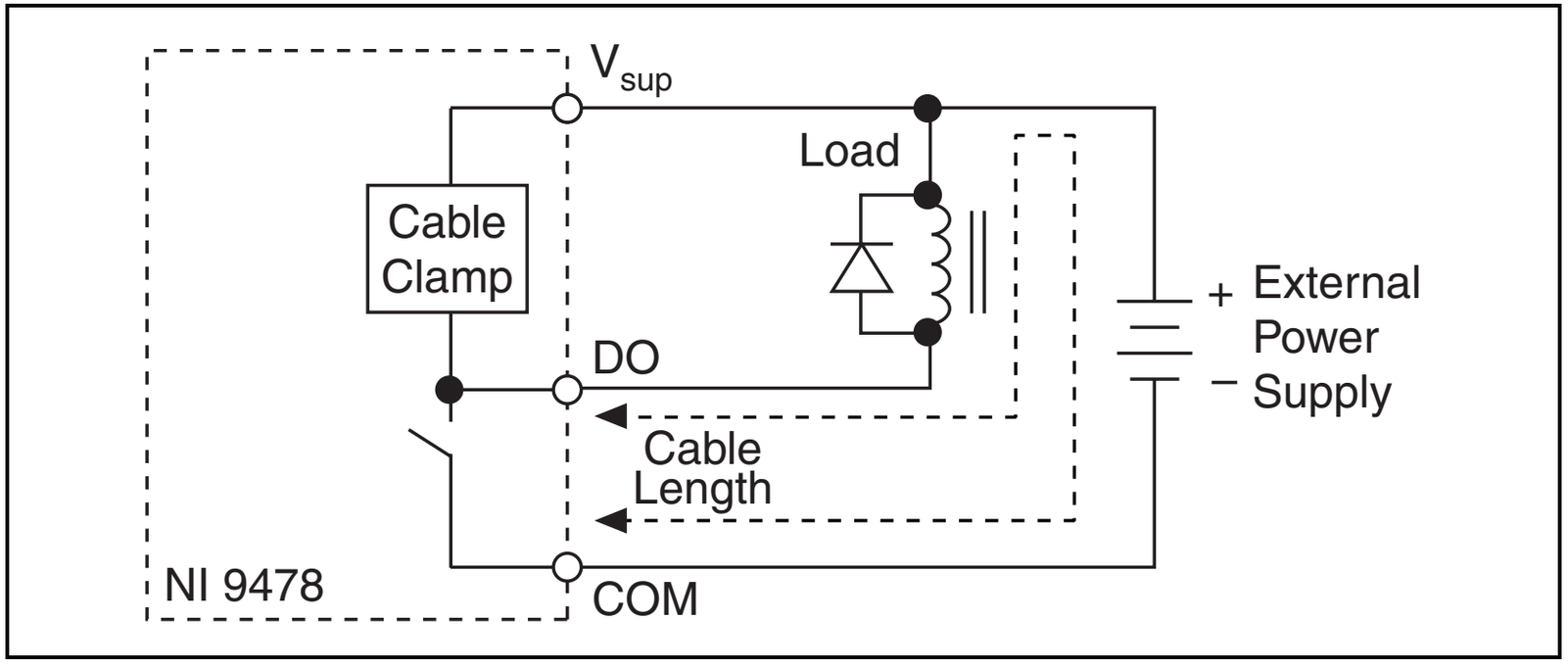

Figure 4. Cable Length of the NI 9478

You can reduce the effective length of the cable by adding a capacitor close to the NI 9478 across the power supply leads and adding a diode from the digital output line to the V_{sup} pin line. National Instruments recommends that you use a capacitor with a capacitance of at least 20 µF. In this case, the effective length of the cable is the distance from the output pin, through the new diode, through the capacitor, and back to the COM pin, as shown in Figure 5.

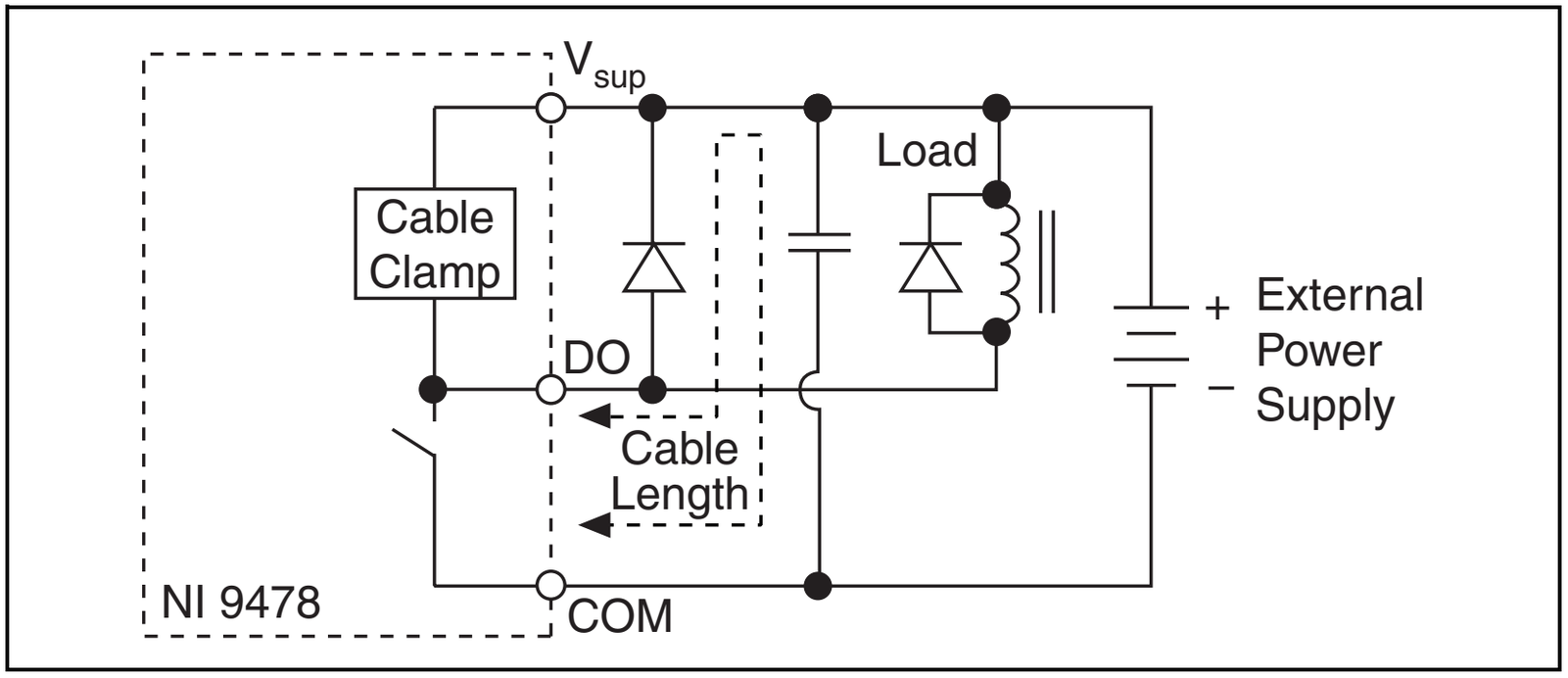

Figure 5. Cable Length of the NI 9478 with a Capacitor and Diode

I/O Protection

The NI 9478 provides protection against overcurrent and short-circuit conditions.

Output Current Limit Thresholds

The NI 9478 provides two configurable current limit thresholds for the module, Limit A and Limit B. The NI 9478 continuously monitors the current through each output channel and detects if the current exceeds either of the current limit thresholds. You can configure the current limit thresholds and check the current limit output status in software to determine if the current through each channel has exceeded the current limit thresholds. Refer to the software help for more information about configuring current limits and checking output status. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Overcurrent Protection

You can configure each channel on the NI 9478 to disable the output if the current through the output exceeds either current limit threshold. This protects the NI 9478 from overcurrent and short-circuit conditions and provides a way to limit the current through an external device.

Some applications require a large inrush current when a channel is first turned on. If this inrush current exceeds the maximum current limit threshold, you may need to disable overcurrent protection by programming the channel to have no current limit. Refer to the software help for more information about configuring current limits. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Caution The NI 9478 is not protected against output overcurrent or short-circuit conditions when overcurrent protection is disabled. If you disable overcurrent protection, ensure that the wiring is correct and that you are operating the NI 9478 within the specifications.

The total amount of current that you can switch with a channel depends on the duty cycle of the channel, the ambient temperature, the switching frequency, and the amount of current switched by other channels within the same module at the same time. Refer to the *Safe Operating Current* section for more information about the current specifications.

Overcurrent Refresh

The NI 9478 provides an overcurrent refresh setting that enables a channel to automatically recover within the specified overcurrent refresh period if the channel exceeds its current limit threshold. If overcurrent refresh is disabled, the channel remains off after an overcurrent condition until software sends a command to turn the channel back on. Refer to the software help for more information about overcurrent refresh. Visit `ni.com/info` and enter `cseriesdoc` for information about C Series documentation.

Safe Operating Current

The maximum allowable output current depends on the output frequency and cable lengths. Higher output currents, higher output frequencies, and longer cable lengths can contribute to power dissipating and heat increasing in the NI 9478. The *Specifications* section gives allowable current and frequency specifications if you use 2 meters of cabling. For other operating conditions, you can find the safe operating specifications for the NI 9478 by calculating the percentage of the total allowable power each output channel dissipates given the output current, frequency, and cable length

for that channel. Use the following equation to calculate the percentage of the total power budget each output channel uses in your application.

$$P = 4\%\left(I_{out}^{2}\right) + \left[0.12\%(length - 0.2)\left(I_{out}^{2}\right) + 0.04\%(I_{out} + 1)\right]freq$$

where P is the percentage of total allowable power the channel uses

I_{out} is the output current in amperes while the channel is on

length is the total cable length in meters, shown in Figure 4

freq is the frequency rate in kHz at which the output channel goes through an on-off cycle

To verify that your application keeps the NI 9478 within safe operating specifications, calculate the average percentage of total allowable power each channel uses, then add together the percentages for all the channels. For operation in ambient temperatures from 55 to 70 °C, the total average power of all channels must remain under 100%. For temperatures below 55 °C, the total average power of all channels can run up to 150%.

Example One

You are driving a load with 2.0 meters of cable through a cycle in which the NI 9478 is on and passing 1.25 A of current for 40 µs, then off for 10 µs. The output period is 50 µs (40 µs + 10 µs) so the output frequency is 20 kHz. The channel uses 14.8% of the total power budget, as shown in the following equation.

$$4\%(1.25^2) + [0.12\%(2.0 - 0.2)(1.25^2) + 0.04\%(1.25 + 1)]20 = 14.8\%$$

Example Two

You are driving a load with 2.0 meters of cable through a cycle in which the NI 9478 first is constantly on and passing 3 A of current for 0.25 seconds, then drives the load at 20 kHz with 1.25 A current for 1.25 seconds, then drives the load off for 4 seconds. While the NI 9478 is constantly on, the output frequency is 0 kHz and the channel uses 36% (4% × 3^2) of the total power budget. *Example One* shows that while the NI 9478 is driving at 20 kHz, the channel uses 14.8% of the total power budget. While the NI 9478 is off, the channel uses 0% of the power budget. The average percentage of total allowable power over the complete 5.5 second cycle is 5%, as shown in the following equation.

$$\frac{36\%(0.25\,\mathrm{s}) + 14.8\%(1.25\ \mathrm{s}) + 0\%(4\,\mathrm{s})}{5.5\,\mathrm{s}} = 5\%$$

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.

Specifications

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

Output Characteristics

Number of channels ..... 16 digital output channels

Output type ..... Sinking

Power-on output state ..... Channels off

Output voltage (V_0) ..... I_0R_0

External power supply voltage range (V_{sup}) ..... 0–50 VDC

Continuous output current (I_0)[1], per channel

- All channels on ..... 1.2 A max
- Four channels on ..... 2.5 A max
- One channel on ..... 5 A max

[1] Refer to the *Safe Operating Current* section for more information about safe operating current.

Switched output current (10 kHz)[1], per channel

- All channels on ..... 1 A max
- Four channels on ..... 2 A max
- One channel on ..... 4 A max

Switched output current (20 kHz)[1], per channel

- All channels on ..... 0.75 A max
- Four channels on ..... 1.67 A max
- One channel on ..... 3.33 A max

Output impedance (R_0) ..... 50 mΩ max

Reversed-voltage protection ..... None

Number of current limit settings ..... 2 (Limit A and Limit B)

Current limit range ..... 0–5.1 A

Current limit resolution ..... 8-bit, 20 mA per LSB

Current limit accuracy ..... 130 mA + 3% of setting, max

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[1] Using up to 2 meters of cabling on each output channel. Refer to the *Safe Operating Current* section for more information.

Overcurrent protection threshold selection per channel	Limit A, Limit B, or No Limit
Overcurrent shutoff response time	1 µs
Overcurrent refresh configuration	Enabled or Disabled
Overcurrent refresh period	20–2550 µs in 10 µs increments
Overcurrent refresh period accuracy	±7% max
Propagation delay	250 ns max
MTBF	823,106 hours at 25 °C; Bellcore Issue 6, Method 1, Case 3, Limited Part Stress Method

Note Contact NI for Bellcore MTBF specifications at other temperatures or for MIL-HDBK-217F specifications.

Power Requirements

Power consumption from chassis

Active mode ..... 1 W max

Sleep mode ..... 25 µW max

Thermal dissipation (at 70 °C)

Active mode ..... 1.5 W max

Sleep mode ..... 25 µW max

Physical Characteristics

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

Weight..... 148 g (5.2 oz)

Safety

Maximum Voltage[1]

Connect only voltages that are within the following limits.

V_{sup}-to-COM.....50 VDC,
Measurement Category I

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 9478 to signals or use for measurements within Measurement Categories II, III, or IV.

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[1] The maximum voltage that can be applied or output between V_{sup} and COM without creating a safety hazard.

Isolation Voltages

Channel-to-channel..... No isolation between channels

Channel-to-earth ground

Continuous ..... 60 VDC, Measurement Category I

Withstand..... 1,000 V, verified by a 5 s dielectric withstand test

Safety 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

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by module number or product line, and click the appropriate link in the Certification column.

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

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

Shock and Vibration

To meet these specifications, you must panel mount the system.

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

Electromagnetic Compatibility

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

- EN 61326 EMC requirements; Industrial Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

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

CE Compliance

This product meets the essential requirements of applicable European directives, as amended for CE markings, as follows:

- 2006/95/EC; Low-Voltage Directive (safety)
- 2004/108/EC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain 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.

Environmental Management

National Instruments is committed to designing and manufacturing products in an environmentally responsible manner. NI recognizes that eliminating certain hazardous substances from our products is beneficial not only to the environment but also to NI customers.

For additional environmental information, refer to the *NI and the Environment* 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 their life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit ni.com/environment/weee.htm.

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.)

Where to Go for Support

The National Instruments Web site 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.

National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. For telephone support in the United States, create your service request at `ni.com/support` and follow the calling instructions or dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 662 457990-0,
Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599,
Canada 800 433 3488, China 86 21 5050 9800,
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,
Finland 358 (0) 9 725 72511, France 01 57 66 24 24,
Germany 49 89 7413130, India 91 80 41190000,
Israel 972 3 6393737, Italy 39 02 41309277, Japan 0120-527196,

Korea 82 02 3451 3400, Lebanon 961 (0) 1 33 28 28,
Malaysia 1800 887710, Mexico 01 800 010 0793,
Netherlands 31 (0) 348 433 466, New Zealand 0800 553 322,
Norway 47 (0) 66 90 76 60, Poland 48 22 3390150,
Portugal 351 210 311 210, Russia 7 495 783 6851,
Singapore 1800 226 5886, Slovenia 386 3 425 42 00,
South Africa 27 0 11 805 8197, Spain 34 91 640 0085,
Sweden 46 (0) 8 587 895 00, Switzerland 41 56 2005151,
Taiwan 886 02 2377 2222, Thailand 662 278 6777,
Turkey 90 212 279 3031, United Kingdom 44 (0) 1635 523545

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