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ER-8/16
User Manual

An 8-Channel or 16-Channel SPDT Relay Accessory
for Data Acquisition Boards

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About This Manual

This manual describes the electrical and mechanical aspects of the ER-8 and ER-16 and contains information concerning their setup, operation, and safety. Both the ER-8 and ER-16 are single-pole double-throw (SPDT) relay accessories for use with other data acquisition (DAQ) products. The ER-8 has eight channels; the ER-16 has 16 channels.

Throughout this manual, ER-8/16 refers to either the ER-8 or ER-16, unless otherwise noted. The ER-8/16 interfaces to any National Instruments DAQ device with digital I/O capabilities for the Macintosh and PC/XT/AT (AT Series, Lab) computers. More specifically, the National Instruments product families that interface with the ER-8/16 are the DIO-24, DIO-32, Lab, E Series, MIO, DAQCards, and 1200 Series devices.

This accessory is designed for low-cost control applications in laboratory testing, production testing, and industrial process monitoring and control.

Organization of This Manual

The *ER-8/16 User Manual* is organized as follows:

- Chapter 1, *Introduction*, describes the ER-8/16; lists what you need to get started and optional equipment; describes software support; and explains how to unpack the ER-8/16.
- Chapter 2, *Setup,* describes how to set up the ER-8/16.
- Chapter 3, *Signal Connections*, describes the signal connections, channel connections, and digital interface to the ER-8/16.
- Chapter 4, *Theory of Operation*, contains a functional overview of the ER-8/16 and explains the operation of each functional unit making up the ER-8/16.
- Appendix A, *Specifications*, lists the specifications of the ER-8/16.
- Appendix B, *I/O Connectors*, contains the connector pinouts and pin descriptions for the ER-8/16.
- Appendix C, *Contact Protection,* contains technical data on contact protection when you are switching inductive loads.
- Appendix D, *Takamisawa VE Series Relay Technical Data,* contains a manufacturer data sheet for the relay used on the ER-8/16.
- Appendix E, *Customer Communication*, contains forms you can use to request help from National Instruments or to comment on our products.
- The *Glossary* contains an alphabetical list and description of terms used in this manual, including abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms.

- The *Index* contains an alphabetical list of key terms and topics used in this manual, including the page where each one can be found.

Conventions Used in This Manual

The following conventions are used in this manual:

bold	Bold text denotes menu items, function panel items, and dialog box buttons or options.
italic	Italic text denotes emphasis, a cross reference, or an introduction to a key concept.
bold italic	Bold italic text denotes a note, caution, or warning.
< >	Angle brackets containing numbers separated by an ellipsis represent a range of values associated with a bit, signal name, or port (for example, ACH<0..7> stands for ACH0 through ACH7).
device	Device refers generically to National Instruments boards, cards, or modules.
ER-8/16	ER-8/16 refers to the ER-8 or ER-16 unless otherwise noted.
DIO device	DIO device refers to National Instruments digital I/O devices such as the AT-DIO-32F, NB-DIO-24, NB-DIO-96, NB-DIO-32F, PC-DIO-24, DAQCard-DIO-24, and PC-DIO-96, unless otherwise noted.
DIO-24 device	DIO-24 device refers to the National Instruments NB-DIO-24, DAQCard-DIO-24, and PC-DIO-24 digital I/O devices unless otherwise noted.
DIO-32 board	DIO-32 board refers to the National Instruments AT-DIO-32F and NB-DIO-32F digital I/O boards unless otherwise noted.
DIO-type board	DIO-type board refers to the National Instruments DIO boards with only digital I/O capabilities. These boards include the DIO-24, DIO-32F, and DIO-96 boards unless otherwise noted.
Lab board	Lab board refers to the National Instruments Lab-LC, Lab-NB, Lab-PC, and Lab-PC+ boards unless otherwise noted.
E Series device	E Series device refers to National Instruments digital I/O devices such as the AT-MIO-16E-2, AT-MIO-64E-3, AT-MIO-16E-10, AT-MIO-16DE-10, AT-MIO-16XE-50, NEC-MIO-16E-4, and NEC-AI-16XE-50, unless otherwise noted.
MIO board	MIO board refers to National Instruments boards such as the AT-MIO-16F-5, AT-MIO-16D, AT-MIO-64F-5, AT-MIO-16, and AT-MIO-16X unless otherwise noted.

DAQCard	DAQCard refers to National Instruments cards such as the DAQCard-500 and DAQCard-700 unless otherwise noted.
1200 Series	1200 Series refers to the National Instruments DAQPad-1200 and DAQCard-1200 unless otherwise noted.
NB	NB refers to the NuBus Series computers.
NI-DAQ	NI-DAQ is used in this manual to refer to the NI-DAQ software for Macintosh and PC compatibles unless otherwise noted.
Macintosh	Macintosh refers to all Macintosh II, Macintosh Quadra, and Macintosh Centris computers except the Centris 610 unless otherwise noted.
PC	PC refers to PC/XT/AT and IBM PS/2, models 25 and 30, computers.
Port A	Port A is used in this manual to refer to port A or port 0 (as in your NI-DAQ manuals).
Port B	Port B is used in this manual to refer to port B or port 1 (as in your NI-DAQ manuals).
Port C	Port C is used in this manual to refer to port C or port 2 (as in your NI-DAQ manuals).
Port D	Port D is used in this manual to refer to port D or port 3 (as in your NI-DAQ manuals).

Abbreviations, acronyms, metric prefixes, mnemonics, symbols, and terms are listed in the *Glossary*.

National Instruments Documentation

The *ER-8/16 User Manual* is one piece of the documentation set for your DAQ system. You could have any of several types of manuals, depending on the hardware and software in your system. Use the different types of manuals you have as follows:

- Your DAQ hardware user manuals—These manuals have detailed information about the DAQ hardware that plugs into or is connected to your computer. Use these manuals for hardware installation and configuration instructions, specification information about your DAQ hardware, and application hints.
- Software manuals—Examples of software manuals you may have are the LabVIEW and LabWindows/CVI manual sets and the NI-DAQ manuals. After you set up your hardware system, use either the application software (LabVIEW or LabWindows/CVI) manuals or the NI-DAQ manuals to help you write your application. If you have a large and complicated system, it is worthwhile to look through the software manuals before you configure your hardware.

- Accessory installation guides or manuals—If you are using accessory products, read the terminal block and cable assembly installation guides or accessory device user manuals. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making your connections.

Customer Communication

National Instruments wants to receive your comments on our products and manuals. We are interested in the applications you develop with our products, and we want to help if you have problems with them. To make it easy for you to contact us, this manual contains comment and configuration forms for you to complete. These forms are in Appendix E, *Customer Communication*, at the end of this manual.

Chapter 1
Introduction

This chapter describes the ER-8/16; lists what you need to get started and optional equipment; describes software support; and explains how to unpack the ER-8/16.

About the ER-8/16

Thank you for buying the National Instruments ER-8/16. The ER-8 consists of eight isolated single-pole double-throw (SPDT) or form C relay channels. The ER-16 consists of 16 isolated SPDT or form C relay channels. The ER-8/16 can serve as a controller or switcher in laboratory testing, production testing, and industrial-process monitoring and control applications. The ER-8/16 operates with full functionality with most National Instruments digital I/O products. It also interfaces with the Lab and MIO boards using the SC-205X Series cable adapters. The ER-8/16 has onboard screw terminals for easy wire attachment. You can also build a 32-channel ER system by daisy-chaining two ER-16s.

Detailed ER-8/16 specifications are in Appendix A, *Specifications*.

What You Need to Get Started

To set up and use your ER-8/16, you will need the following:

- ❑ ER-8 or ER-16
- ❑ *ER-8/16 User Manual*
- ❑ Your DIO-24, DIO-32, Lab, E Series, MIO, DAQCard, or 1200 Series device and documentation
- ❑ SC-205X Series cable adapter if you are using a Lab or MIO board
- ❑ Interface cable (different for DIO-24 and DIO-32 devices, DAQCards, and SC-205X Series adapters)
- ❑ Your computer

Optional Equipment

You can use the following National Instruments products with your ER-8/16.

- Any National Instruments DAQ device with digital I/O capability
- SC-2050 cable adapter with NB1 cable
- SC-2051 cable adapter with NB1 cable
- SC-2052 cable adapter with NB1 cable
- SC-2053 cable adapter with NB1 cable
- SC-2054 48-channel kit with NB5 cable
- SC-2054 96-channel kit with NB5 cable
- SC-2055 cable adapter with NB1 cable
- NB7 cable assembly
- SH6850 shielded cable
- R6850 ribbon cable
- R1005050 ribbon cable
- Type NB5 cable

For more information about optional equipment available from National Instruments, refer to your National Instruments catalog or call the office nearest you.

Refer to Chapter 3, *Signal Connections*, for additional information on cabling, connectors, and adapters.

Software

The ER-8/16 requires no additional software beyond what you are using for your DAQ device.

Unpacking

Your ER-8/16 is shipped in an antistatic package to prevent electrostatic damage to the unit. Electrostatic discharge can damage several components on the ER-8/16. To avoid such damage in handling the unit, take the following precautions:

- Ground yourself via a grounding strap or by holding a grounded object.

- Touch the antistatic package to a metal part of your computer chassis before removing the ER-8/16 from the package.

- Remove the unit from the package and inspect it for loose components or any other sign of damage. Notify National Instruments if the ER-8/16 appears damaged in any way. *Do not* install a damaged unit.

- *Never* touch the exposed pins of connectors.

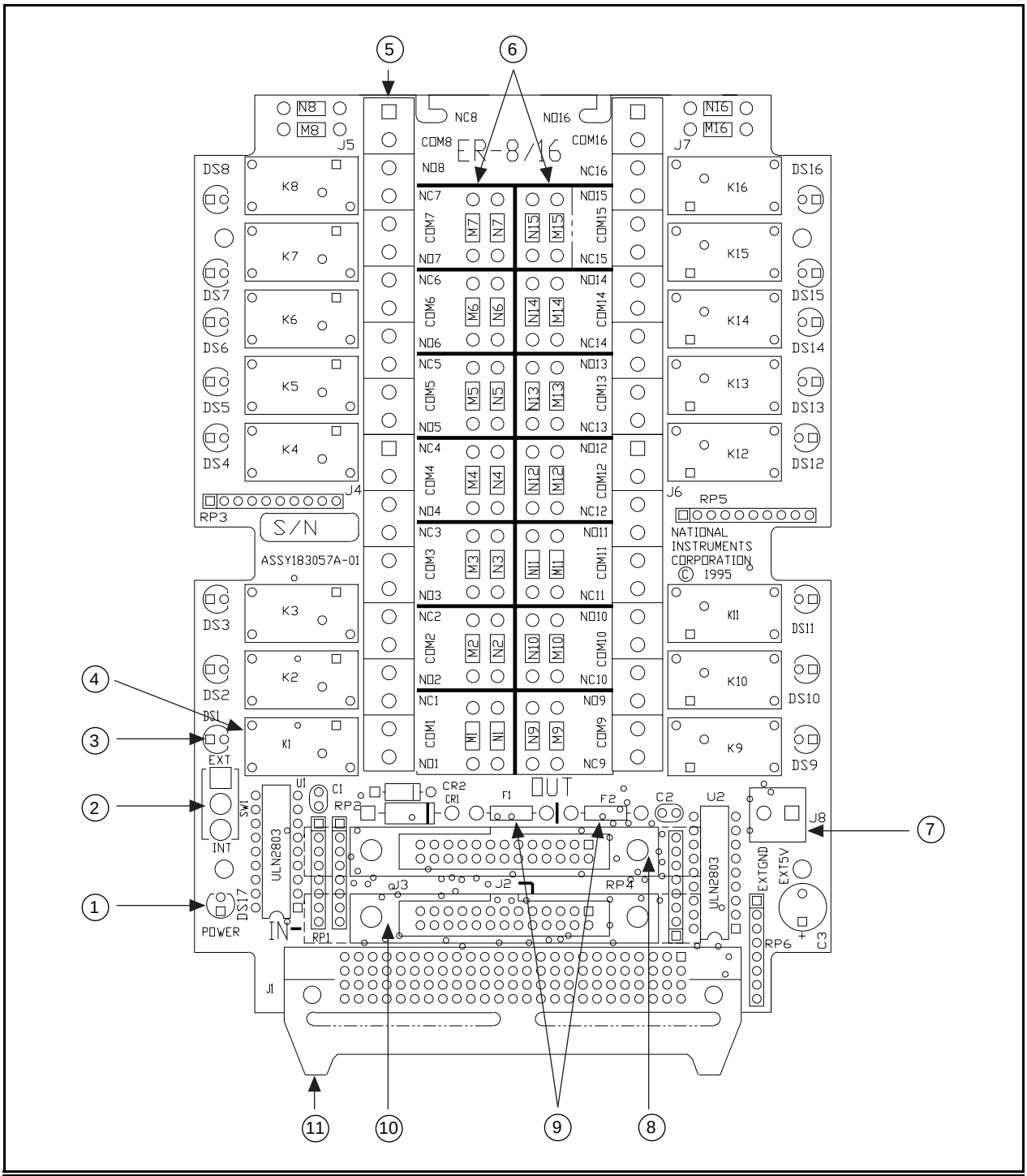
Chapter 2
Setup

This chapter describes how to set up the ER-8/16.

The ER-8 has eight SPDT relays controlled by eight digital lines. Each of these relays has a normally closed (NC) contact that connects to the common (COM) contact when the corresponding digital output line is low, and a normally open (NO) contact that connects to the COM contact when the digital line is high. The contacts are break-before-make so that all three contacts are never shorted.

The ER-8/16 is an accessory to National Instruments DAQ devices with digital I/O. No hardware or software configuration is necessary. To configure the DAQ device driving the ER-8/16, refer to your DAQ hardware user manual.

Figure 2-1 shows the parts locator diagram for the ER-8/16. See Table 2-1 for detailed descriptions of the parts called out on the parts locator diagram.



1	Power LED	4	Channel 1 Relay	7	J8—EXT power supply conn.	10	J2—26-pin IN conn.
2	SW1—power supply switch	5	Screw Terminals	8	J3—26-pin OUT conn.	11	J1—DIO-24 and DIO-32 conn.
3	Channel 1 LED	6	Surge Protector Pads	9	Fuses		

Figure 2-1. ER-8/16 Parts Locator Diagram

Table 2-1. Parts Locator Diagram Descriptions

Callout	Name	Description
1	Power LED	When illuminated red, this LED indicates that the ER-8/16 is receiving power.
2	SW1	This is the main +5 V power supply switch for selecting external or internal supply. Move the switch to EXT if using external supply and to INT if using internal (driving device or ER-16) supply. By default, your ER-8/16 is shipped with SW1 in the EXT position.
3	Channel 1 LED	These DS<1..16> LEDs are illuminated green when the NO contact is shorted to the COM contact for the respective channel. Otherwise the LED is shut off.
4	Channel 1 Relay	These K<1..16> relays are controlled digitally on the ER-8/16.
5	Screw Terminals	The NC<1..16> screw terminals are for the NC contact for channels 1 through 16. The NO<1..16> screw terminals are for the NO contact for channels 1 through 16. The COM<1..16> screw terminals are for the COM contact for the channels 1 through 16.
6	Surge Protector Pads	The M<1..16> pads across NC and COM contacts are for protecting the relay contacts from inductive loads. A resistor and capacitor combination can be placed across these pads to suppress sparking on the relay contacts due to inductive loads. The N<1..16> pads across NO and COM contacts are for protecting the relay contacts from inductive loads. A resistor and capacitor combination can be placed across these pads to suppress sparking on the relay contacts due to inductive loads.
7	J8	This external power-supply connector, EXT +5 V, is for external +5 V supply. EXT GND is the reference for the external +5 V supply, and is connected to the ER-8/16 ground.
8	J3	This 26-pin OUT connector sends the 26-pin daisy-chain cable to the ER-8 or the ER-16.
9	Fuses	F1 and F2 are socketed power supply fuses. You may replace these fuses if they are blown. The fuse is LIT-PICOII, 2 A, 125 V, fast.
10	J2	This 26-pin IN connector receives the 26-pin daisy-chain cable from the ER-16 or SC-205X cable adapter.
11	J1	This 50-pin dual connector has the top connector for DIO-32 boards, and the bottom connector for DIO-24 devices.

Safety Information

The following warnings contain important safety information concerning hazardous voltages.

⚠ **Warning:** ***Connections that exceed any of the maximum input signal ratings on the ER-8/16 can create a shock or a fire hazard, or damage the ER-8/16, your computer, and the DAQ device. Maximum input ratings for each signal are given in Appendix A,*** *Specifications.* ***National Instruments is NOT liable for any damages resulting from signal connections that exceed any of these ratings.***

Do not operate your ER-8/16 in an explosive atmosphere or where there may be flammable gases or fumes.

KEEP AWAY FROM LIVE CIRCUITS. DO NOT REMOVE THE TOP COVER of the ER-8/16 when it is operating or is powered on. If signal wires are connected to the unit, dangerous voltages may exist even when the equipment is turned off. To avoid dangerous electrical shock, do not perform procedures involving cover removal unless you are qualified to do so. Before removing the cover make sure that the computer and the power supply are turned off and that the signal wires connected to the screw terminals do not contain live voltages.

DO NOT OPERATE DAMAGED EQUIPMENT. The safety protection features built into your ER-8/16 can become impaired if it is damaged in any way. If necessary, return the unit to National Instruments for service and repair to ensure that safety is not compromised.

DO NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT. To avoid introducing additional hazards, do not install unauthorized parts or modify your ER-8/16. If necessary, return the unit to National Instruments for service and repair to ensure that safety is not compromised.

When using the unit with high common mode voltages, you must insulate your signal wires appropriately. National Instruments is NOT liable for any damages or injuries resulting from inadequate signal wire insulation.

When connecting or disconnecting signal lines to the ER-8/16 screw terminal, verify that the lines are powered off. Potential differences between the lines and the ER-8/16 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 ER-8/16 can create a shock or a fire hazard, or can damage any or all of the devices connected to the ER-8/16, the host computer, and the ER-8/16. National Instruments is NOT liable for any damages or injuries resulting from incorrect signal connections.

Use and connect to only one of the following connectors when operating the ER-8/16: the DIO-24, DIO-32, or IN connector. National Instruments is NOT liable for any damages resulting from incorrect connections.

Equipment described in this document must be used in an Installation Category II environment per IEC 664. This category requires local level supply mains-connected installation.

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.

Terminals are for use only with equipment that has no accessible live parts.

Use only 26-16 AWG wire with a voltage rating of 300 V and 60° C for controlling 250 V. Prepare your signal wire by stripping the insulation no more than 7 mm.

Connect the signal wires to the screw terminals by inserting the stripped end of the wire fully into the terminals. Tighten the terminals to a torque of 5-7 in.-lb.

Clean devices and terminal blocks by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with deionized water and a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

Connecting the ER-8/16 to Your DAQ Device

The following are general instructions for setting up your ER-8/16. Consult your computer user manual or technical reference manual for specific instructions and warnings.

Warning: ***Connections that exceed any of the maximum rating of the input signals on the ER-8/16 can damage the ER-8/16, your computer, and the DAQ device. Maximum input ratings for each signal are given in Appendix A,*** *Specifications.* ***National Instruments is NOT liable for any damages resulting from signal connections that exceed any of these ratings.***

1. Turn off the host computer power before making any connections.

   Warning: ***Keep away from live circuits. DO NOT REMOVE THE TOP COVER of the ER-8/16 when it is operating or is powered on. If signal wires are connected to the unit, dangerous voltages may exist even when the equipment is turned off. To avoid dangerous electrical shock, do not perform procedures involving cover removal unless you are qualified to do so. Before removing the cover make sure that the computer and the power supply are turned off and that the signal wires connected to the screw terminals do not contain live voltages.***

2. Remove the top cover of your ER-8/16 by removing the four screws located on the bottom of your unit.

3. Connect the 50-pin interfacing cable to the appropriate 50-pin connector located on the front end of the ER-8/16 as shown in Figure 2-2.

   - If you are connecting a DIO-24 device to the ER-8/16, use the DIO-24 50-pin connector. This is the bottom connector.

   - If you are connecting a DIO-32 board to the ER-8/16, use the DIO-32 50-pin connector. This is the top connector.

   Warning: ***Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.***

   Only one of the following connectors should be used and connected when operating the ER-8/16: the DIO-24, DIO-32, or IN connector. National Instruments is NOT liable for any damages resulting from any other connections.

   - If you are daisy chaining the ER-8/16 or using the SC-205X Series cable adapter, connect the 26-pin cable to the correct 26-pin connector, either IN or OUT. For additional information on signal connections and cabling refer to Chapter 3, *Signal Connections*.

4. Switch the +5 V power supply switch (SW1) to the correct position, either INT or EXT. The switch position depends on the number of channels and the type of DAQ device you are using with the ER-8/16. Set the switch to INT if you are using your DAQ device's internal +5 V supply. Set the switch to EXT if you are using an external +5 supply. For additional information on power supply connections, refer to the *Power Supply* section in Chapter 3, *Signal Connections.*

   Note: ***By default, your ER-8/16 is shipped with SW1 set to the EXT position.***

5. Verify the connections and setup.

6. Turn on the external power supply, if necessary, then turn on your computer. The red Power LED should light up indicating that the ER-8/16 is receiving power. If the red Power LED does not light up, verify that the power supply connections and electrical power supply are switched ON. If the connections and external power supply are working, check the electrical continuity on fuses F1 and F2. If the continuity test fails on these fuses, a fuse is blown. You can either replace the fuse yourself or send it to National Instruments for replacement.

   Note: ***The fuses are socketed. If you choose to replace them yourself, the fuse specification is LIT-PICOII, 2 A, 125 V, fast. The manufacturer is Littelfuse, and the manufacturer part number is R251002T1.***

7. You can now test your ER-8/16 *without making any connections to the screw terminals* by writing to port A (0). When you write a digital 1 to port A (0), the DS1 LED should turn green, indicating it is ON. You may also hear a clicking sound. Port A (0) corresponds to channel 1 on the ER-8/16. Use this procedure to test all the channels on your ER-8/16.

   Note: ***LEDs are present only for verifying your digital cable connections.***

   Warning: ***DO NOT connect any wires to the channel screw terminals when you are conducting this test. National Instruments is NOT liable for any damages resulting from such connections.***

   If the ER-8/16 does not respond to the control signals, check your cable connections and try again. If the test fails again, contact National Instruments.

8. Switch off your computer and the external power supply. Make wire connections to the ER-8/16 channels by wiring to the proper screw terminals, marked NC, COM, and NO. For additional information, refer to the *Channel Connections* section in Chapter 3, *Signal Connections.*

9. When you have connected the wires, check the connections again.

10. Replace the top cover and screw it on tightly.

11. Turn on your computer and the external power supply.

Your ER-8/16 is now ready for operation.

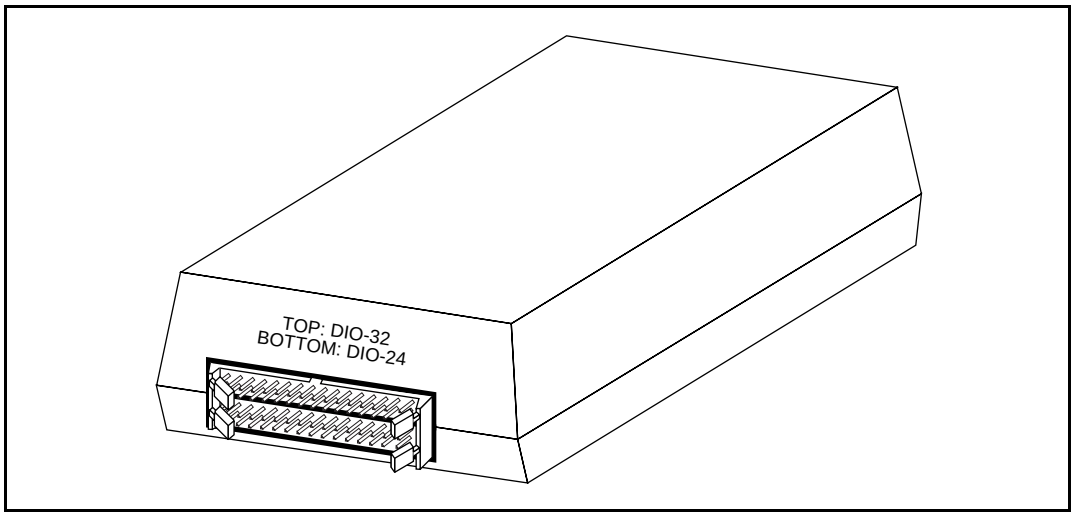


Figure 2-2. The ER-8/16 Front Connector

Chapter 3
Signal Connections

This chapter describes the signal connections, channel connections, and digital interface to the ER-8/16.

Front Connectors

This section describes the signal connections to the ER-8/16 via the I/O connectors for the digital interface.

Warning: ***Connections that exceed any of the maximum ratings of the input signals on the ER-8/16 can damage the ER-8/16, your computer, and the DAQ device. Maximum input ratings for each signal are given in Appendix A,*** *Specifications.* ***National Instruments is NOT liable for any damages resulting from signal connections that exceed any of these ratings.***

Turn off signal sources before connecting or disconnecting any additional signal.

DO NOT attempt to connect your ER-8/16 to any connector for which it is not designed. Incorrect connection can damage your ER-8/16 or the host computer. National Instruments is NOT liable for any damages resulting from incorrect connections.

The front end of the ER-8/16 has two 50-pin connectors. The top connector, DIO-32, is for interfacing to DIO-32 boards, and the bottom connector, DIO-24, is for interfacing to DIO-24 devices.

Warning: ***Use only one connector, either the DIO-24 or the DIO-32 connector. DO NOT connect cables to both connectors.***

Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.

Using DIO-24 Devices

If you are using a National Instruments DIO-24 device to control the ER-8/16, connect the cable to the DIO-24 connector.

You can control a maximum of 24 channels using this connector, one ER-16, and one ER-8. Daisy chain the ER-8 to the ER-16 using the NB7 cable.

The ER-8 uses port A<0..7> to control channels 1 through 8. Port C<0..7> wraps back to the 26-pin OUT connector.

The ER-16 uses port A<0..7> to control channels 1 through 8 and port B<0..7> to control channels 9 through 16. Port C<0..7> wraps back to the 26-pin OUT connector. For additional information on daisy chaining, refer to the *Daisy Chaining the ER-8/16* section later in this chapter.

Using DIO-32 Boards

If you are using a National Instruments DIO-32 board to control the ER-8/16, connect the cable to the DIO-32 connector.

Note: ***You will need an external +5 V power supply if you use this connector.***

Warning: ***Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.***

You can control a maximum of 32 channels using the DIO-32 connector and two ER-16s. Daisy chain one ER-16 to the other ER-16 using the NB7 cable.

The ER-16 uses port A<0..7> to control channels 1 through 8 and port B<0..7> to control channels 9 through 16. Port C<0..7> and port D<0..7> wrap back to the 26-pin OUT connector. For additional information on daisy chaining refer to the *Daisy Chaining the ER-8/16* section later in this chapter.

Power Supply

You can use either your DAQ device's internal +5 V supply or an external +5 V supply to power up your ER-8/16. If you use an external +5 V supply, use the two screw terminals to connect external +5 V and GND. Refer to Figure 2-1 in Chapter 2, *Setup*, for the location of this screw terminal on the ER-8/16.

Warning: ***Connections that exceed any of the input signal maximum ratings on the ER-8/16 can damage the ER-8/16, your computer, and the DAQ device. Maximum input ratings for each signal are given in Appendix A,*** *Specifications.* ***National Instruments is NOT liable for any damages resulting from signal connections that exceed any of these ratings.***

Current requirements for the ER-8/16 are as follows:

Channels	Current (Amps)
8	0.5 A
16	1.0 A
24	1.5 A
32	2.0 A

If you use its internal +5 V supply setting, make sure your device can supply the required amount of +5 V power to the ER-8/16.

Note: ***DIO-32F boards do not provide internal +5 V supply. You will need an external +5 V supply for DIO-32F boards.***

DAQCard-DIO-24 and other DAQCards can provide a maximum of 500 mA of current. You can drive only one ER-8 with the internal supply. You will need an external +5 V supply for driving more than eight channels.

In addition to the above note, refer to Figures 3-3 and 3-4 for information on configurations that require an external +5 V supply.

When you connect more than one ER-8 with any of the SC-205X Series cable adapters, you will need an external +5 V power supply.

Warning: ***Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.***

Use and connect only one of the following connectors when operating the ER-8/16: the DIO-24, DIO-32, or IN connector. National Instruments is NOT liable for any damages resulting from incorrect connections.

If you use your DAQ device's internal +5 V supply, make sure that the power supply switch (SW1) is set to the INT position. If you are using an external +5 V supply, make sure that SW1 is set to the EXT position. Refer to Figure 2-1 for the location of the SW1 switch.

Note: ***By default, your ER-8/16 is shipped with SW1 set to the EXT position.***

Channel Connections

The ER-8/16 has 26 screw terminals. Twenty-four of these screw terminals are for connecting the loads to the relay channels and two screw terminals are for providing the external +5 V supply to the unit. Each channel consists of a COM position, an NC position, and an NO position.

Power-up Conditions

When the digital interface cable is not connected to either connector, the COM contact is connected to the relay NC contact at power up.

When the digital interface cable is connected to any of the connectors, the power-up state depends on the power-up state of the digital signals on the DAQ device. If the power-up state of the digital lines driving the ER-8/16 is low, the COM contact is connected to the relay NC contact. If the power-up state of the digital lines driving the ER-8/16 is high, the COM contact is connected to the relay NO contact.

Wire Gauge

When using the ER-8, you can use up to 16 AWG gauge wire for all channels. If you are using the ER-16 and all channels are in use, use 18 AWG gauge wire, maximum.

Warning: ***When using the ER-8/16 with high voltages, you must insulate your signal wires appropriately. National Instruments is NOT liable for any damages or injuries resulting from inadequate signal wire insulation.***

Make sure that your wires are properly insulated to avoid any short circuit to the other channels, ground, or any other point on the printed wire board (PWB).

Channel Isolation

All contacts have a working voltage of 250 VAC or 30 VDC. This product complies with IEC-1010 for Voltage Installation Category II Pollution Degree 2. Refer to the specifications listed in Appendix A, *Specifications*, for further details before connecting the signals to the relay contacts.

Contact Protection for Inductive Loads

When inductive loads are connected to the relays, a large counter-electromotive force can occur at relay-switching time because of the energy stored in the inductive load. These flyback voltages can severely damage the relay contacts and greatly reduce the relay life.

It is best to limit these flyback voltages at your inductive load by installing, *across your inductive load*, a flyback diode for DC loads, as shown in Figure 3-1, or a metal oxide varistor (MOV) for AC loads. Refer to the Diode Circuit and Varistor Circuit information in the table in the *Contact Protection Circuit* section of Appendix C, *Contact Protection,* for more information.

If placing a diode or an MOV across the load is not possible, use arc suppressor pads on the ER-8/16 to limit the voltage spike generated during the switching of the inductive loads. These pads are between the COM position and the NO position, and between the COM position and the

NC position of the relays. Refer to the CR Circuit information in the table in the *Contact Protection Circuit* section of Appendix C, *Contact Protection,* for more information.

To determine the placement of each arc suppressor, refer to Tables 3-1 and 3-2, which list the channel and suppressor pad assignments.

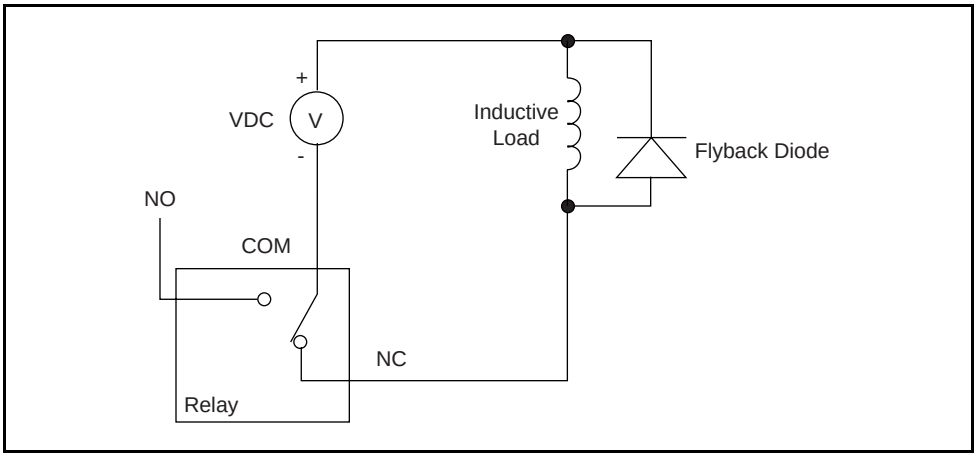


Figure 3-1. Contact Protection Using a Flyback Diode for DC Loads

Table 3-1. Arc Suppressor Placement, COM to NO

COM to NO Channel Number	**Transient Voltage Suppressor Reference Designator**
1	N1
2	N2
3	N3
4	N4
5	N5
6	N6
7	N7
8	N8
9	N9
10	N10
11	N11
12	N12
13	N13
14	N14
15	N15
16	N16

Table 3-2. Arc Suppressor Placement, COM to NC

COM to NC Channel Number	Transient Voltage Suppressor Reference Designator
1	M1
2	M2
3	M3
4	M4
5	M5
6	M6
7	M7
8	M8
9	M9
10	M10
11	M11
12	M12
13	M13
14	M14
15	M15
16	M16

Figure 3-2 shows how to connect a transient voltage suppressor for AC and DC inductive loads.

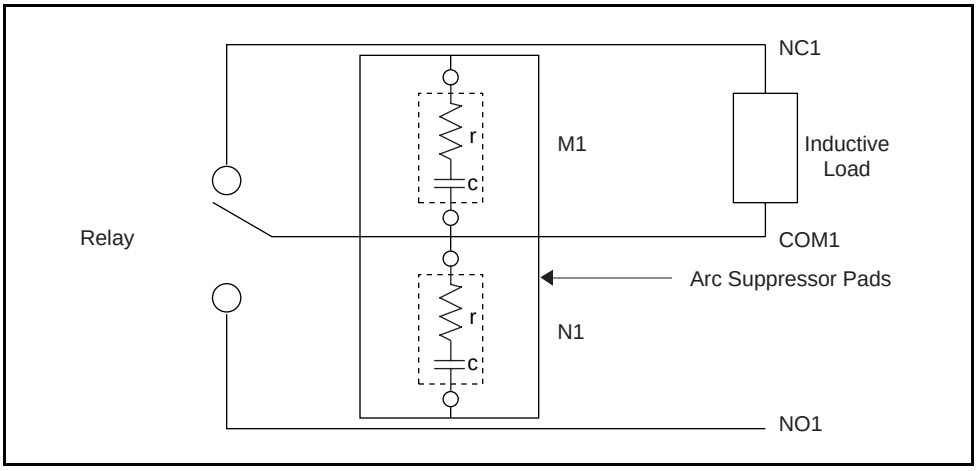


Figure 3-2. Arc Suppressor Pad Locations for Channel 1

Connecting Your Signal Lines

To connect the signal wires to the screw terminals, perform the following steps:

1. Turn off your ER-8/16. Make sure the signal wires you are connecting to the screw terminals are also turned off and do not contain any live voltages. Also make sure the host computer is turned off.

Warning: ***KEEP AWAY FROM LIVE CIRCUITS. DO NOT REMOVE THE TOP COVER of the ER-8/16 when it is operating or is powered on. If signal wires are connected to the ER-8/16, dangerous voltages may exist even when the equipment is turned off. To avoid dangerous electrical shock, do not perform procedures involving cover removal unless you are qualified to do so. Before removing the cover make sure that the computer and the power supply are turned off and that the signal wires connected to the screw terminals do not contain live voltages.***

2. Remove the ER-8/16 top cover by placing a screwdriver in the groove at the bottom of the ER-8/16 and rotating the screwdriver.

3. Install the contact protection, preferably across the load, if your load is inductive. Refer to the *Contact Protection for Inductive Loads* section earlier in this chapter. For additional information refer to Appendix C, *Contact Protection*.

4. Connect the wires to the screw terminals.

5. Bundle the wires at the rear end of the ER-8/16 and use a tie-wrap to tie them together.

6. Replace the top cover so that the bundled wires fall within the smaller rectangular hole in the top cover.

7. Tighten the top cover by fastening the screws to the bottom cover.

Internal Connectors

There are two 26-pin connectors marked IN and OUT on the ER-8/16 PWB. These connectors are visible when you remove the top cover.

Warning: ***KEEP AWAY FROM LIVE CIRCUITS. DO NOT REMOVE THE TOP COVER of the ER-8/16 when it is operating or is powered on. If signal wires are connected to the ER-8/16, dangerous voltages may exist even when the equipment is turned off. To avoid dangerous electrical shock, do not perform procedures involving cover removal unless you are qualified to do so. Before removing the cover make sure that the computer and the power supply are turned off and that the signal wires connected to the screw terminals do not contain live voltages.***

The internal connectors expand the switching system to 24 or 32 channels with the minimum number of cables or accessories. Use the IN connector to interface the ER-8 with the SC-205X Series cable adapters so you can interface your ER-8 to the Lab or MIO boards.

Warning: ***If you are using the IN internal connector, DO NOT connect a cable to any of the front connectors.***

Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.

Daisy Chaining the ER-8/16

To expand your system from 16 channels to 24 channels, connect a 26-pin NB7 ribbon cable from the ER-16 OUT connector to the ER-8 IN connector.

Note: ***DO NOT connect an external supply to the ER-8 (the receiving unit). Verify that SW1 is in the INT position on the receiving unit. Connect the external supply to the sending unit.***

The power supply will also be daisy-chained through the NB7 cable to the expanded system.

To expand your system from 16 channels to 32 channels, connect a 26-pin NB7 ribbon cable from one ER-16 OUT connector to the other ER-16 IN connector.

Note: ***DO NOT connect an external supply to the ER-16 (the receiving unit). Verify that SW1 (see Figure 2-1) is in the INT position on the receiving unit. Connect the external supply to the sending unit.***

The power supply will also be daisy-chained through the NB7 cable to the expanded system.

Warning: ***Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from such connections.***

Using the SC-205X Series with the ER-8

You can use your SC-205X Series cable adapter with the Lab or MIO boards to control the ER-8. Connect the 26-pin cable to the ER-8 IN connector only. In this configuration, you can control only channels 1 through 8. Digital lines—port A<0..7> as shown in Figure 3-3a—control the relays. Port B<0..7> is not used.

Warning: ***When connecting more than one ER-8 with any of the SC-205X Series cable adapters, verify that SW1 (see Figure 2-1) is at the EXT position and that you are using an external power supply.***

Connecting the cable to the wrong connector can damage the ER-8/16 or your DAQ device. National Instruments is NOT liable for any damages resulting from incorrect connections.

DO NOT attempt to connect an ER-16 to any of the SC-205X Series cable adapters.

For additional information on the SC-205X Series cable adapters refer to the *SC-205X Series User Manual.*

DAQ System Configurations with the ER-8/16

The following figures show the possible DAQ system configurations using the ER-8/16 for multichannel control.

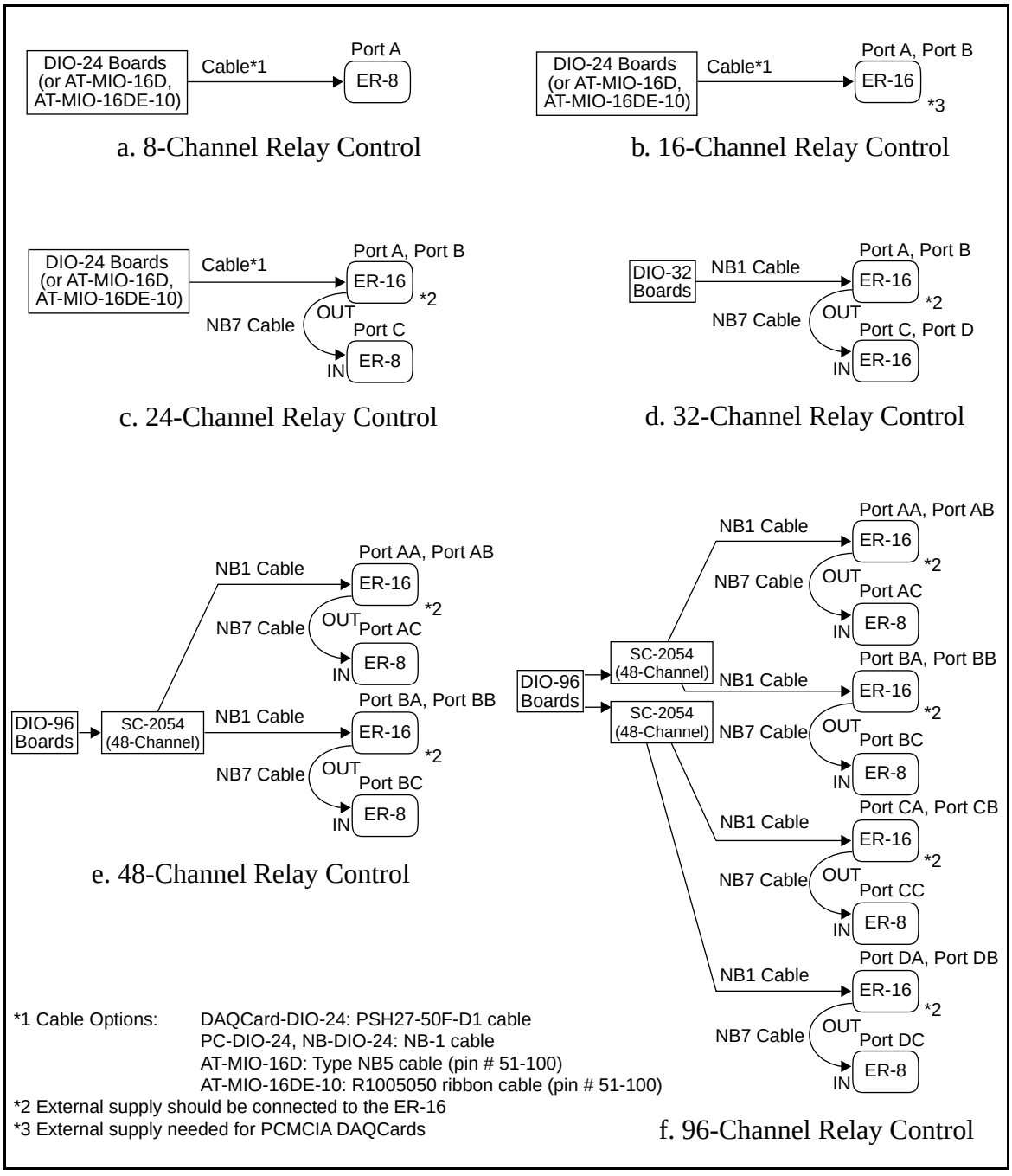
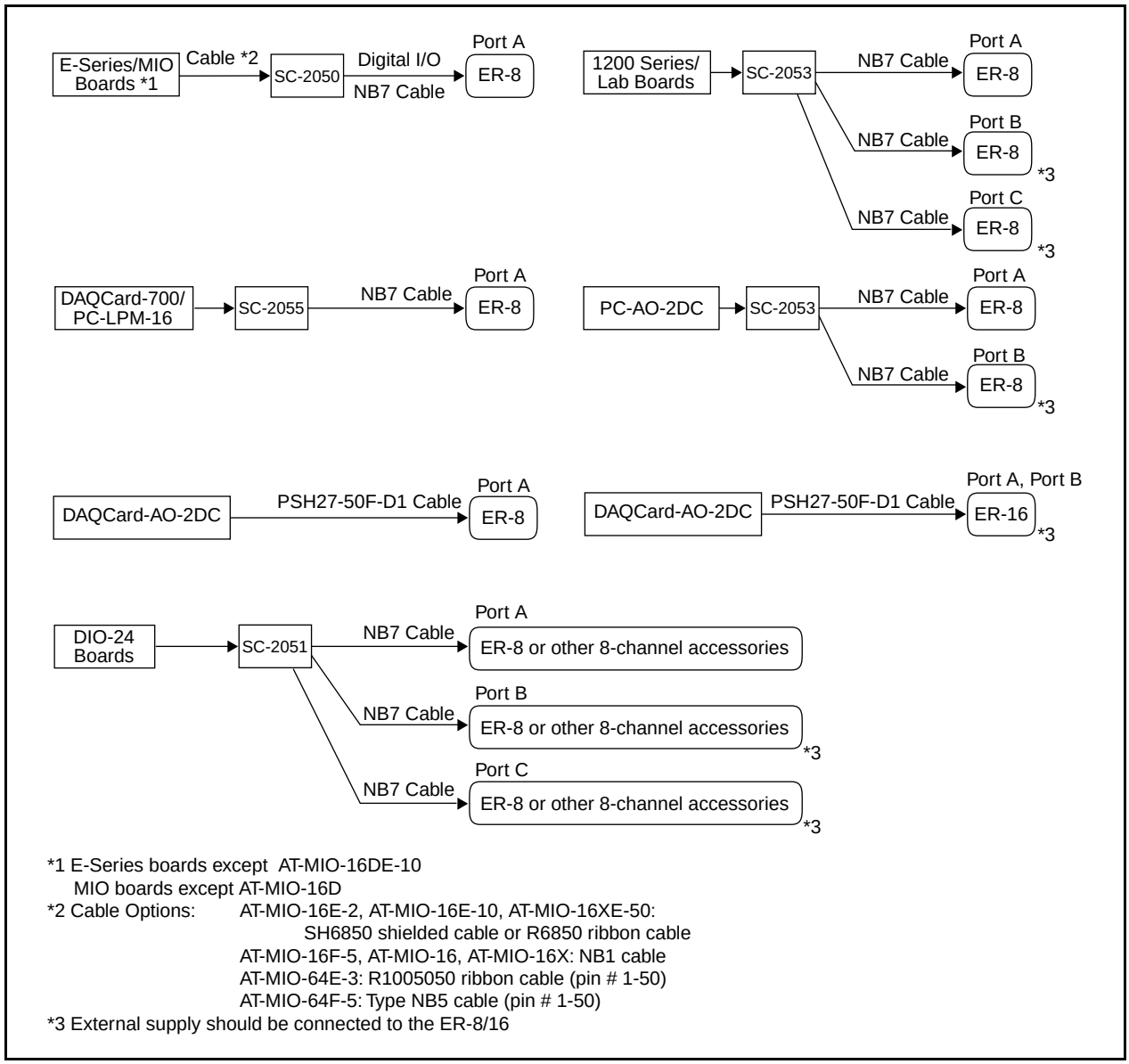


Figure 3-3. ER-8/16 Configurations with DIO Devices

Figure 3-4 shows the possible DAQ system configurations using National Instruments multifunction DAQ devices and the ER-8/16.



*1 E-Series boards except AT-MIO-16DE-10
MIO boards except AT-MIO-16D
*2 Cable Options: AT-MIO-16E-2, AT-MIO-16E-10, AT-MIO-16XE-50:
SH6850 shielded cable or R6850 ribbon cable
AT-MIO-16F-5, AT-MIO-16, AT-MIO-16X: NB1 cable
AT-MIO-64E-3: R1005050 ribbon cable (pin # 1-50)
AT-MIO-64F-5: Type NB5 cable (pin # 1-50)
*3 External supply should be connected to the ER-8/16

Figure 3-4. ER-8/16 Configurations with Multifunction DAQ Devices

Chapter 4
Theory of Operation

This chapter contains a functional overview of the ER-8/16 and explains the operation of each functional unit making up the ER-8/16.

Functional Overview

The ER-8 has eight SPDT relays controlled by eight digital lines connected to the ER-8. Each of these relays has an NC contact that is connected to the COM contact when the corresponding digital output line is low, and an NO contact that is connected to the COM contact when the digital line is high. The contacts are break-before-make, so all three contacts are never short-circuited. The block diagram in Figure 4-1 illustrates the key functional components of the ER-8/16.

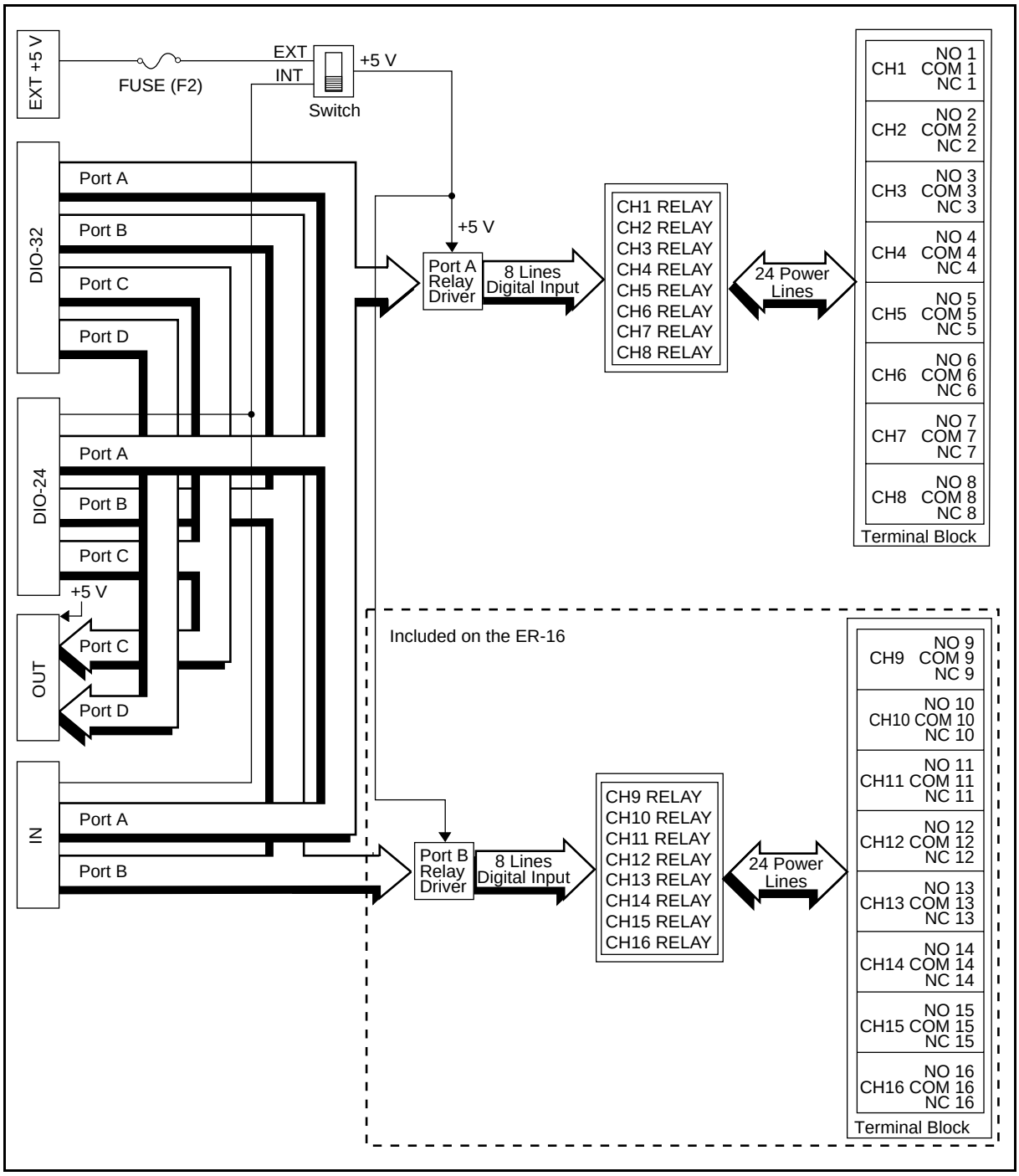


Figure 4-1. ER-8/16 Block Diagram

Digital Interface

There are four connectors with which to interface an ER-8/16 to digital devices or to daisy-chain it to another ER-8/16. The two front connectors are marked DIO-24 and DIO-32; the two internal connectors are marked IN and OUT. Use the internal connectors when daisy-chaining the
ER-8/16 or when using SC-205X Series cable adapters.

Warning: ***Use only one of the connectors—DIO-24, DIO-32, or IN—at a time. Using more than one of these connectors can damage your host computer, DAQ device, and the ER-8/16. National Instruments is NOT liable for any damages resulting from incorrect connections.***

For additional information on signal connections, refer to Chapter 3, *Signal Connections.*

Relay Channels

Figure 4-2 shows the onboard equivalent circuit for the ER-8/16. When the channel receives a digital low signal, the relay for that channel remains unenergized, the NC contact shorts to the COM contact, and the NO contact remains open. When a digital high signal is present on a channel, the relay for that channel is energized, the NO contact shorts to the COM contact, and the NC contact is open.

A green LED just above each relay illuminates when the relay is energized. To reduce the power consumption and to help extend relay life, control the signals so that relays are energized for only short periods of time and only a minimal number of relays are energized.

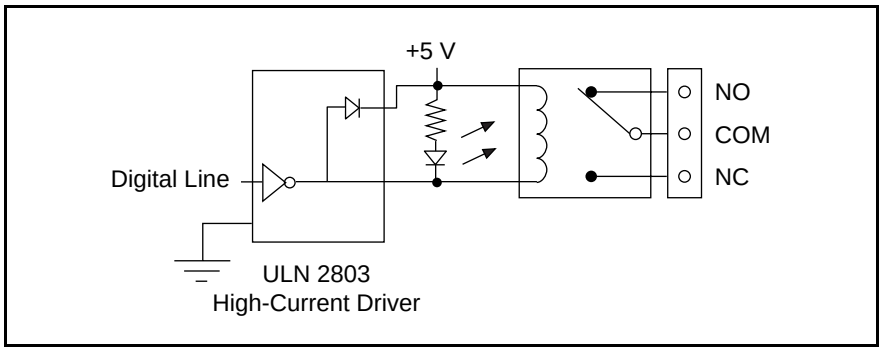


Figure 4-2. ER-8/16 Onboard Equivalent Circuit

Appendix A
Specifications

This appendix lists the specifications for the ER-8/16. These specifications are typical at 25° C and 50% humidity unless otherwise noted.

Channel Rating

Number of channels .....8 channels for ER-8
16 channels for ER-16

Relay type.....SPDT (1 Form C), nonlatching

Max switching capacity (resistive load)[1]
AC.....3 A at 250 VAC
DC.....3 A at 30 VDC

Max working voltage .....250 Vrms (channel to ground)
250 Vrms (channel to channel, same phase)

Switching current .....3 A max per channel
40 A max for ER-16, all channels
24 A max for ER-8, all channels

Channel on resistance.....100 mΩ
Contact material .....Silver-nickel alloy

Life[2]
Mechanical .....10,000,000 operations min
Electrical .....100,000 at rated load

Isolation
Complies with IEC 1010 for Voltage Installation Category II Pollution Degree 2

Operate time.....10 ms
Release time .....5 ms

Power Requirement

External Supply

Voltage .....+5 V (±5%)
Current .....0.5 A for 8 channels
1.0 A for 16 channels
1.5 A for 24 channels
2.0 A for 32 channels

[1] If you operate at high currents, later operation at low currents may not be possible.
[2] Relays are subject to normal wear based on the number of operations.

Physical

Dimensions	17.5 by 5.2 by 12.25 cm (6.9 by 2.05 by 4.82 in.)
Connectors	
External	DIO-24 and DIO-32 50-pin male, latching type, ribbon-cable front connectors
Internal	IN and OUT 26-pin male, latching type, ribbon-cable internal connectors
Channel screw terminals	24 for ER-8, 16 AWG wire max, 48 for ER-16, 18 AWG wire max
Power supply screw terminals	2

Environment

Operating temperature	0° to 50° C
Storage temperature	-55° to 150° C
Relative humidity	5% to 90% noncondensing

Appendix B
I/O Connectors

This appendix contains the connector pinouts and pin descriptions for the ER-8/16.

DIO-24 Connector

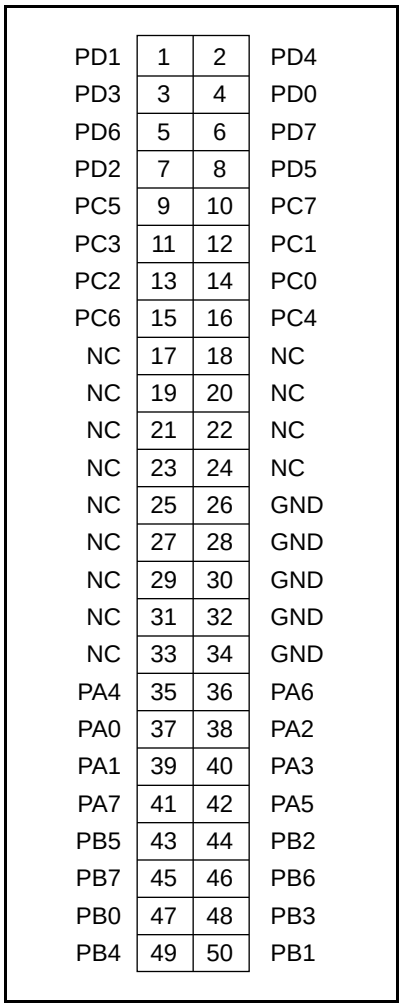
PC7	1	2	NC
PC6	3	4	NC
PC5	5	6	NC
PC4	7	8	NC
PC3	9	10	NC
PC2	11	12	NC
PC1	13	14	NC
PC0	15	16	NC
PB7	17	18	NC
PB6	19	20	NC
PB5	21	22	NC
PB4	23	24	NC
PB3	25	26	GND
PB2	27	28	GND
PB1	29	30	GND
PB0	31	32	GND
PA7	33	34	GND
PA6	35	36	NC
PA5	37	38	NC
PA4	39	40	NC
PA3	41	42	NC
PA2	43	44	NC
PA1	45	46	NC
PA0	47	48	NC
+5 V	49	50	NC

Figure B-1. The DIO-24 Connector

Table B-1. DIO-24 Connector Pin Descriptions

Pin	Signal Name	Description
1, 3, 5, 7, 9, 11, 13 15	PC<7..0>	Port C Channels 7 through 0—These signals are routed back to the 26-pin OUT connector for daisy chaining to another ER-8. Each of these pins controls the relay channel of the daisy-chained ER-8. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
17, 19, 21, 23, 25, 27, 29, 31	PB<7..0>	Port B Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
33, 35, 37, 39, 41, 43, 45, 47	PA<7..0>	Port A Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 36, 38, 40, 42, 44, 46, 48, 50	NC	Not connected.
49	+5 V	+5 V supply—This pin is connected to the internal +5 V signal on the ER-8/16.
26, 28, 30, 32, 34	GND	Ground—These pins are connected to the internal ground on the ER-8/16.

DIO-32 Connector



PD1	1	2	PD4
PD3	3	4	PD0
PD6	5	6	PD7
PD2	7	8	PD5
PC5	9	10	PC7
PC3	11	12	PC1
PC2	13	14	PC0
PC6	15	16	PC4
NC	17	18	NC
NC	19	20	NC
NC	21	22	NC
NC	23	24	NC
NC	25	26	GND
NC	27	28	GND
NC	29	30	GND
NC	31	32	GND
NC	33	34	GND
PA4	35	36	PA6
PA0	37	38	PA2
PA1	39	40	PA3
PA7	41	42	PA5
PB5	43	44	PB2
PB7	45	46	PB6
PB0	47	48	PB3
PB4	49	50	PB1

Figure B-2. The DIO-32 Connector

Table B-2. DIO-32 Connector Pin Descriptions

Pin	Signal Name	Description
6, 5, 8, 2, 3, 7, 1, 4	PD<7..0>	Port D Channels 7 through 0—These signals are routed back to the 26-pin OUT connector for daisy chaining to another ER-8 or ER-16. Each of these pins controls the relay channel of the daisy chained ER-8 or ER-16. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
10, 15, 9, 16, 11, 13, 12, 14	PC<7..0>	Port C Channels 7 through 0—These signals are routed back to the 26-pin OUT connector for daisy chaining to another ER-8 or ER-16. Each of these pins controls the relay channel of the daisy chained ER-8 or ER-16. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
45, 46, 43, 49, 48, 44, 50, 47	PB<7..0>	Port B Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
41, 36, 42, 35, 40, 38, 39, 37	PA<7..0>	Port A Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
26, 28, 30, 32, 34	GND	Ground—These pins are connected to the internal ground on the ER-8/16.
17–25, 27, 29, 31, 33	NC	Not connected.

26-Pin Internal Connectors

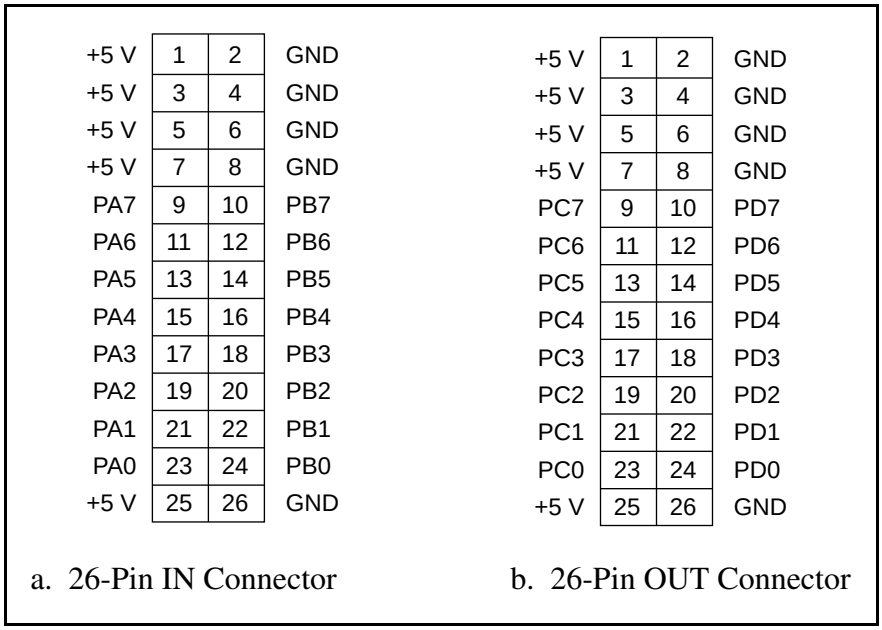


Figure B-3. 26-Pin Internal Connectors

Table B-3. 26-Pin IN Connector Pin Descriptions

Pin	Signal Name	Description
10, 12, 14, 16, 18, 20, 22, 24	PB<7..0>	Port B Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
9, 11, 13, 15, 17, 19, 21, 23	PA<7..0>	Port A Channels 7 through 0—Each of these pins controls the relay channel. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
2, 4, 6, 8, 26	GND	Ground—These pins are connected to the internal ground on the ER-8/16.
1, 3, 5, 7, 25	+5 V	+5 VDC supply—These pins are connected to the internal (INT) +5 VDC supply on the ER-8/16.

Table B-4. 26-Pin OUT Connector Pin Descriptions

Pin	Signal Name	Description
10, 12, 14, 16, 18, 20, 22, 24	PD<7..0>	Port D Channels 7 through 0—These signals are for daisy chaining to another ER-8 or ER-16. Each of these pins controls the relay channel of the daisy chained ER-8 or ER-16. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
9, 11, 13, 15, 17, 19, 21, 23	PC<7..0>	Port C Channels 7 through 0—These signals are for daisy chaining to another ER-8 or ER-16. Each of these pins controls the relay channel of the daisy chained ER-8 or ER-16. A digital high on these pins connects the COM contact of a channel to the NO contact of that channel. A digital low on these pins connects the COM contact of a channel to the NC contact of that channel.
2, 4, 6, 8, 26	GND	Ground—These pins are connected to the ground on the ER-8/16.
1, 3, 5, 7, 25	+5 V	+5 VDC supply—These pins are connected to the +5 V supply on the ER-8/16.

Appendix C
Contact Protection*

This appendix contains technical data on contact protection when you are switching inductive loads.

CONTACT

The contacts are the most important elements of relay construction. Contact performance conspicuously influenced by contact material, and voltage and current values applied to the contacts (in particular, the voltage and current waveforms at the time of application and release), the type of load, frequency of switching, ambient atmosphere, form of contact, contact switching speed, and of bounce.

Because of contact transfer, welding, abnormal wear, increase in contact resistance, and the various other damages which bring about unsuitable operation, the following items require full investigation.

1. Contact circuit voltage, current, and load

[Voltage, AC and DC]

When there is inductance included in the circuit, a rather high counter emf is generated as a contact circuit voltage, and since, to the extent of the value of that voltage, the energy applied to the contacts causes damage with consequent wear of the contacts, and transfer of the contacts, it is necesary to exercise care with regard to control capacity. In the case of DC, there is no zero current point such as there is with AC, and accordingly, once a cathode arc has been generated, because it is difficult to quench that arc, the extended time of the arc is a major cause. In addition, due to the direction of the current being fixed, the phenomenon of contact shift, as noted separately below, occurs in relation to the contact wear. Ordinarily, the approximate control capacity is mentioned in catalogues or similar data sheets, but this alone is not sufficient. With special contact circuits, for the individual case, the maker either estimates from the past experience or makes test on each occasion. Also, in catalogues and similar data sheets, the control capacity that is mentioned is limited to resistive load, but there is a broad meaning indicated for that class of relay, and ordinarily it is proper to think of current capacity as that for 125V AC circuits.

[Current]

The current at both the closing and opening time of the contact circuit exerts an important influence. For example, when the load is either a motor or a lamp, to the extent of the inrush current at the time of closing the circuit, wear of the contacts, and the amount of contact transfer increase, and contact welding and contact transfer make contact separation impossible.

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Aromat Corporation. *Relay Technical Data Book.*

General Application Guidelines

2. Characteristics of Common Contact Materials

Characteristics of contact materials are given below. Refer to them when selecting a relay.

Contact Material	Ag (silver)	Electrical conductivity and thermal conductivity are the highest of all metals. Exhibits low contact resistance, is inexpensive and widely used. A disadvantage is it easily develops a sulfide film in a sulfide atmosphere. Care is required at low voltage and low current levels.
	AgCd (silver-cadmium)	Exhibits the conductivity and low contact resistance of silver as well as excellent resistance to welding. Like silver, it easily develops a sulfide film in a sulfide atmosphere.
	AgW (silver-tungsten)	Hardness and melting point are high, arc resistance is excellent, and it is highly resistant to material transfer. However, high contact pressure is required. Furthermore, contact resistance is relatively high and resistance to corrosion is poor. Also, there are constraints on processing and mounting to contact springs.
	AgNi (silver-nickel)	Equals the electrical conductivity of silver. Excellent arc resistance.
	AgPd (silver-palladium)	At standard temperature, good corrosion resistance and good sulfidation resistance. However, in dry circuits, organic gases adhere and it easily develops a polymer. Gold clad is used to prevent polymer buildup. Expensive.
	PGS alloy (platinum, gold, silver)	Excellent corrosion resistance. Mainly used for low current circuits. (Au : Ag : Pt = 69 : 25 : 6)
Surface Finish	Rh plating (rhodium)	Combines perfect corrosion resistance and hardness. As plated contacts, used for relatively light loads. In an organic gas atmosphere, care is required as polymers may develop. Therefore, it is used in hermetic seal relays (reed relays, etc.). Expensive.
	Au clad (gold clad)	Au with its excellent corrosion resistance is pressure welded onto a base metal. Special characteristics are uniform thickness and the nonexistence of pinholes. Greatly effective especially for low level loads under relatively adverse atmospheres. Often difficult to implement clad contacts in existing relays due to design and installation.
	Au plating (gold plating)	Similar effect to Au cladding. Depending on the plating process used, supervision is important as there is the possibility of pinholes and cracks. Relatively easy to implement gold plating in existing relays.
	Au flash plating (gold thin-film plating)	Purpose is to protect the contact base metal during storage of the switch or device with built-in switch. However, a certain degree of contact stability can be obtained even when switching loads.

3. Contact Protection

• Counter EMF

When switching inductive loads with a DC relay such as relay sequence circuits, DC motors, DC clutches, and DC solenoids, it is always important to absorb surges (e.g. with a diode) to protect the contacts.

When these inductive loads are switched off, a counter emf of several hundred to several thousand volts develops which can severely damage contacts and greatly shorten life. If the current in these loads is relatively small at around 1A or less, the counter emf will cause the ignition of a glow or arc discharge. The discharge decomposes organic matter contained in the air and causes black deposits (oxides, carbides) to develop on the contacts. This may result in contact failure.

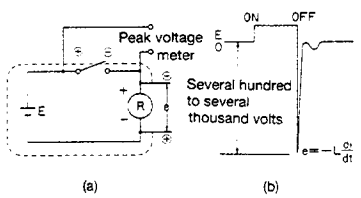


Fig. 13 Example of counter emf and actual measurement on a peak hold meter.

In Fig. 13(a), an emf ($e=-L\frac{di}{dt}$)with a steep waveform is generated across the coil with the polarity shown in Fig. 13(b) at the instant the inductive load is switched off. The counter emf passes through the power supply line and reaches both contacts.

Generally, the critical dielectric breakdown voltage at standard temperature and pressure in air is about 200 to 300 volts. Therefore, if the counter emf exceeds this, discharge occurs at the contacts to dissipate the energy ($\frac{1}{2}Li^2$) stored in the coil. For this reason, it is desirable to absorb the counter emf so that it is 200V or less.

A memory oscilloscope, digital memory, peak hold meter, etc., can be used to measure the counter emf. However, since the waveform is extremely steep, considerable discrepancies may result depending on the precision of the equipment used. The table shows the counter emf of various relays measured on a high precision peak hold meter.

Actual measurement of counter emf on a peak hold meter

Nominal Coil Voltage / Relay Type	6V DC	12V DC	24V DC
R relay (single side stable)	144V	165V	188V
NF4 relay	410V	470V	510V

• Material Transfer Phenomenon

Material transfer of contacts occurs when one contact melts or boils and the contact material transfers to the other contact. As the number of switching operations increases, uneven contact surfaces develop such as those shown in Fig. 14. After a while, the uneven contacts lock as if they were welded together. This often occurs in circuits where sparks are produced at the moment the contacts "make" such as when the DC current is large for DC inductive or capacitive loads or when the inrush current is large (several amperes or several tens of amperes).

Contact protection circuits and contact materials resistant to material transfer such as AgW or AgCu are used as countermeasures. Generally, a concave formation appears on the cathode and a convex formation appears on the anode. For DC capacitive loads (several amperes to several tens of amperes), it is always necessary to conduct actual confirmation tests.

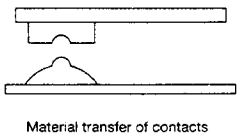
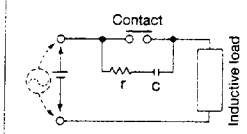
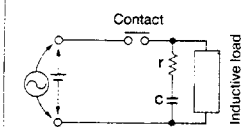
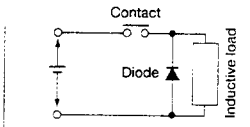
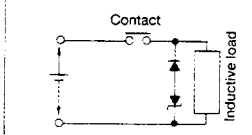
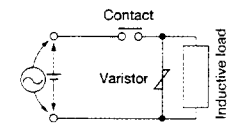


Fig. 14

General Application Guidelines

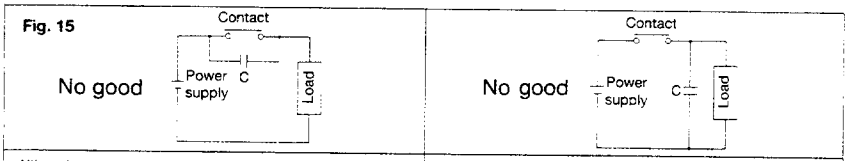
• Contact Protection Circuit
Use of contact protective devices or protection circuits can suppress the counter emf to a low level. However, note that incorrect use will result in an adverse effect. Typical contact protection circuits are given in the table below.

(○: Good ×: No Good)

Circuit	Application AC	Application DC	Features/Others	Device Selection
CR circuit 	*	○	If the load is a timer, leakage current flows through the CR circuit causing faulty operation. * If used with AC voltage, be sure the impedance of the load is sufficiently smaller than that of the CR circuit.	As a guide in selecting r and c, r: 0.5 to 1Ω per 1V contact voltage c: 0.5 to 1μF per 1A contact current Values vary depending on the properties of the load and variations in relay characteristics. Capacitor c acts to suppress the discharge the moment the contacts open. Resistor r acts to limit the current when the power is turned on the next time. Test to confirm. Use a capacitor with a breakdown voltage of 200 to 300V. Use AC type capacitors (non-polarized) for AC circuits.
	○	○	If the load is a relay or solenoid, the release time lengthens. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	
Diode circuit 	×	○	The diode connected in parallel causes the energy stored in the coil to flow to the coil in the form of current and dissipates it as joule heat at the resistance component of the inductive load. This circuit further delays the release time compared to the CR circuit. (2 to 5 times the release time listed in the catalog)	Use a diode with a reverse breakdown voltage at least 10 times the circuit voltage and a forward current at least as large as the load current. In electronic circuits where the circuit voltages are not so high, a diode can be used with a reverse breakdown voltage of about 2 to 3 times the power supply voltage.
Diode and zener diode circuit 	×	○	Effective when the release time in the diode circuit is too long.	Use a zener diode with a zener voltage about the same as the power supply voltage.
Varistor circuit 	○	○	Using the stable voltage characteristics of the varistor, this circuit prevents excessively high voltages from being applied across the contacts. This circuit also slightly delays the release time. Effective when connected to both contacts if the power supply voltage is 24 or 48V and the voltage across the load is 100 to 200V.	—

• Avoid using the protection circuits shown in the figures on the right. Although DC inductive loads are usually more difficult to switch than resistive loads, use of the proper protection circuit will raise the characteristics to that for resistive loads. (Fig. 15)

Fig. 15



Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since energy is stored in C when the contacts open and discharge current flows from C when the contacts close.

Although extremely effective in arc suppression as the contacts open, the contacts are susceptible to welding since charging current flows to C when the contacts close.

• Mounting the Protective Device
In the actual circuit, it is necessary to locate the protective device (diode, resistor, capacitor, varistor, etc.) in the immediate vicinity of the load or contact. If located too far away, the effectiveness of the protective device may diminish. As a guide, the distance should be within 50cm.

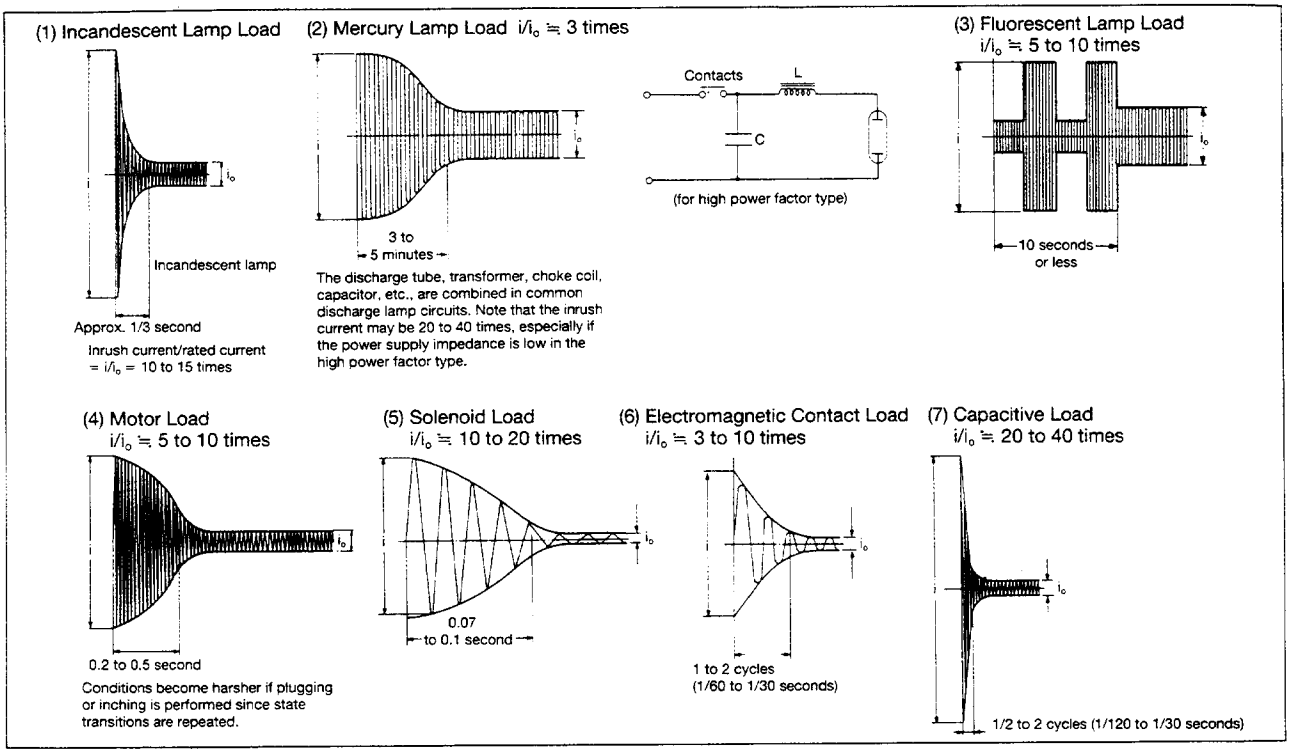
• Abnormal Corrosion During High Frequency Switching of DC Loads (spark generation)
If, for example, a DC valve or clutch is switched at a high frequency, a blue-green corrosion may develop. This occurs from the reaction with nitrogen in the air when sparks (arc discharge) are generated during switching. For relays with a case, the case must be removed or air holes drilled in the case. A similar phenomenon occurs in the presence of ammonia-based gas. Therefore, care is required in circuits where sparks are generated at a high frequency.

• Type of Load and Inrush Current
The type of load and its inrush current characteristics, together with the switching frequency are important factors which cause contact welding. Particularly for loads with inrush currents, measure the steady state current and inrush current and select a relay which provides an ample margin of safety. The table on the right shows the relationship between typical loads and their inrush currents.

Type of load	Inrush current
Resistive load	Steady state current
Solenoid load	10 to 20 times the steady state current
Motor load	5 to 10 times the steady state current
Incandescent lamp load	10 to 15 times the steady state current
Mercury lamp load	Approx. 3 times the steady state current
Sodium vapor lamp load	1 to 3 times the steady state current
Capacitive load	20 to 40 times the steady state current
Transformer load	5 to 15 times the steady state current

General Application Guidelines

Load Inrush Current Wave and Time



• When Using Long Wires

If long wires (100 to 300m) are to be used in a relay contact circuit, inrush current may become a problem due to the stray capacitance existing between wires. Add a resistor (approx. 10 to 50Ω) in series with the contacts. (Fig. 16)

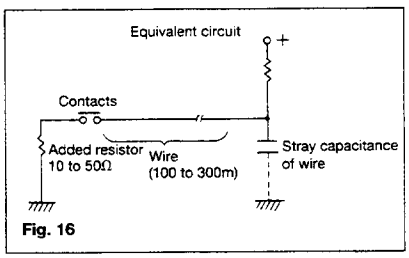


Fig. 16

• Phase Synchronization in Switching AC Loads

If switching of the relay contacts is synchronized with the phase of the AC power, reduced electrical life, welded contacts, or a locking phenomenon (incomplete release) due to contact material transfer may occur. Therefore, check the relay while it is operating in the actual system. However, if problems develop, control the relay using an appropriate phase. (Fig. 17)

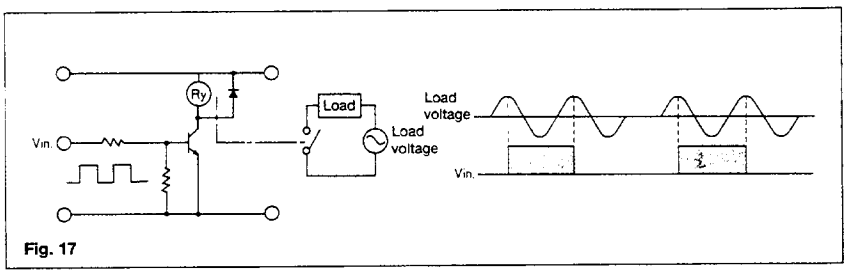


Fig. 17

4. Cautions on Use Related to Contacts

• Connection of load and contacts

Connect the load to one side of the power supply as shown in Fig. 18(a). Connect the contacts to the other side. This prevents high voltages from developing between contacts. If contacts are connected to both side of the power supply as shown in (b), there is a risk of shorting the power supply when relatively close contacts short.

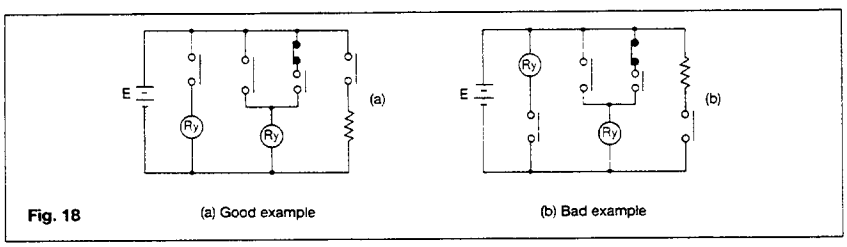


Fig. 18 (a) Good example (b) Bad example

General Application Guidelines

• Dummy Resistor

Since voltage levels at the contacts used in low current circuits (dry circuits) are low, poor conduction is often the result. One method to increase reliability is to add a dummy resistor in parallel with the load to intentionally raise the load current reaching the contacts. Care is required especially for low-level switching circuits (0.1V or less, 0.2mA or less). Contact material and, of course, use of bifurcated contacts must also be taken into consideration.

• Avoid Circuits Where Shorts Occur Between Form A and B Contacts (Fig. 19)

1) The clearance between form A and B contacts in compact control components is small. The occurrence of shorts due to arcing must be assumed.
2) Even if the three N.C., N.O., and COM contacts are connected so that they short, a circuit must never be designed to allow the possibility of burning or generating an overcurrent.
3) A forward and reverse motor rotation circuit using switching of form A and B contacts must never be designed.

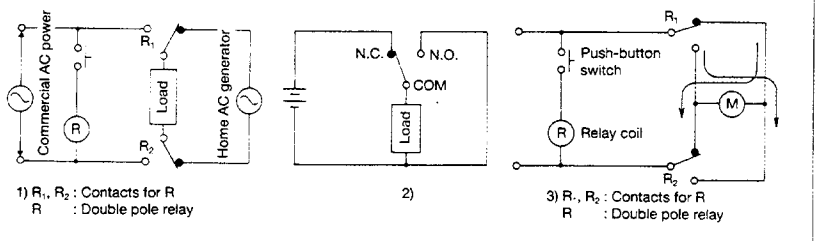


Fig. 19 Bad example of form A and B use

• Shorts Between Different Electrodes

Although there is a tendency to select miniature control components because of the trend toward miniaturizing electrical control units, care must be taken when selecting the type of relay in circuits where different voltages are applied between electrodes in a multi-pole relay, especially when switching two different power supply circuits. This is not a problem that can be determined from sequence circuit diagrams. The construction of the control component itself must be examined and sufficient margin of safety must be provided especially in creepage between electrodes, space distance, presence of barrier, etc.

ELECTRONIC CIRCUIT DRIVE BY MEANS OF A RELAY

• Chatterless electronic circuit

Even though a chatterless characteristic is a feature of relays, this is to the fullest extent a chatterless electrical circuit, much the same as a mercury relay. To meet the requirement for such circuits as the input to a binary counter, there is an electronic chatterless method in which chattering is absolutely not permissible. Even if chattering develops on one side, either the N.O. side contacts or the N.C. side contacts, the flip flop does not reverse, and the counter circuit can be fed pulsed without a miss. (However, bouncing from the N.O. side to N.C. side must be absolutely avoided.) (Fig. 10)

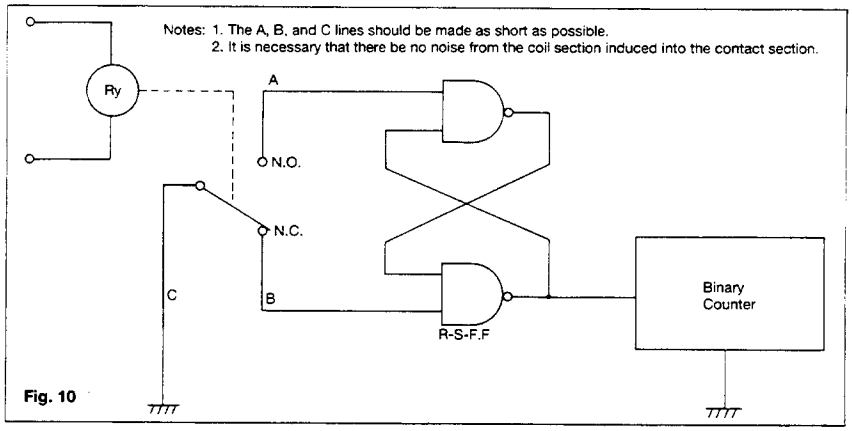


Fig. 10

• Triac drive

With an electronic circuit using a direct drive from a triac, the electronic circuit will not be isolated from the power circuit, and because of this, troubles due to erroneous operation and damage can develop easily. The introduction of a relay drive is the most economical and most effective solution. (Photo coupler and pulse transformer circuits are complicated.)

When a zero cross switching characteristic is necessary, a solid state relay (SSR) should be used. (Fig. 11)

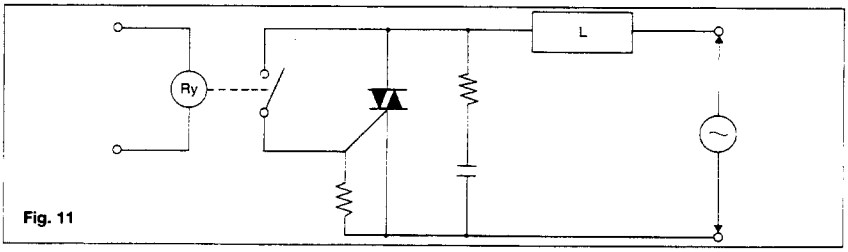


Fig. 11

Appendix D
Takamisawa VE Series Relay Technical Data*

This appendix contains a manufacturer data sheet for the relays used on the ER-8/16.

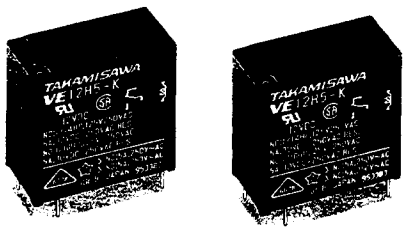
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Farnell Electronics, Inc. *Farnell Relay Products, Takamisawa Relay & SSR General Catalog '95–'96*.

VE Relay

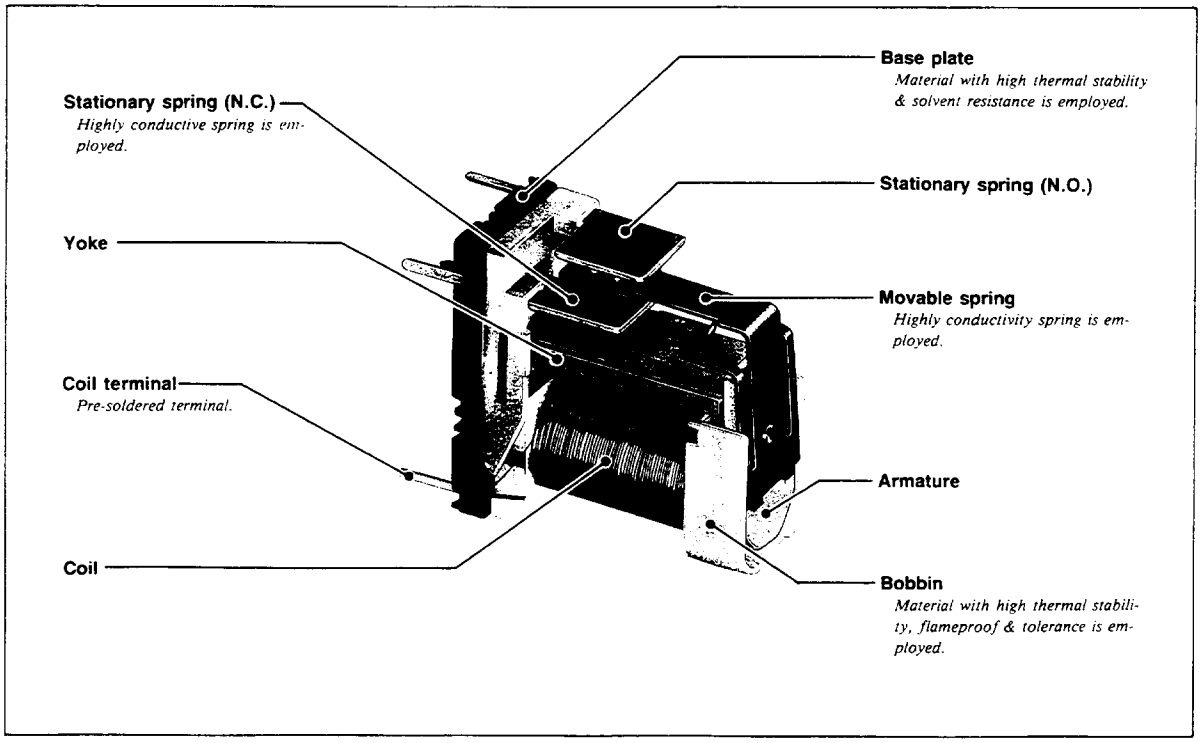
3/5 Amps. Subminiature Slim Type Power Relay

■FEATURES

- **UL, CSA, VDE Recognized**
- **1 Form A (SPST-NO) or 1 Form C (SPDT) Contact**
- **Low Cost, Miniature Relay with Big Performance in Small Package**
  - **— Surge Strength: 4000V or 6000V**
- **Slim Type - Meet High Density Mounting Requirement**
- **Wide Operating Range**
- **Easy Circuit Design with Completely Separated Terminal Arrangement (Coil & Contact Terminals)**
- **Washable Type Backfilled with Nitrogen**



■STRUCTURE



127

VE Relay

■SPECIFICATIONS

CONTACT

- *Arrangement* ..... 1 Form A (SPST-NO) or 1 Form C (SPDT)
- *Material* ..... VE-H5, VE-HM5 : Silver-cadmium oxide alloy
  VE-H, VE-HM : Gold overlay silver-nickel
  VE-HE, VE-HME : Silver-nickel
- *Type* ..... Single Type
- *Resistance (initial)* ..... VE-HM, VE-H : Max. 70mΩ (at 6VDC 1A)
  VE-HME, VE-HE : Max. 100mΩ (at 6VDC 1A)
  VE-HM5, VE-H5 : Max. 200mΩ (at 6VDC 1A)
- *Ratings (resistive)*
  Nominal Load ..... VE-HM, VE-HME, VE-HM5, VE-H5 : 5A 250VAC
  VE-H, VE-HE : 5A 250VAC (NO) 3A 250VAC (NC)
  Max. Switching Power ..... VE-HM, VE-HME, VE-H5, VE-HM5 : 1,250VA
  VE-H, VE-HE : 1,250VA (NO), 750VA (NC)
  Max. Switching Voltage 250VAC, 150VDC
  Max. Switching Current ..... VE-HM, VE-HME, VE-H5, VE-HM5 : 5A
  VE-H, VE-HE : 5A (NO), 3A (NC)
  Max. Carrying Current 7A
  *Min. Switching Load(*1)* ..... VE-HM, VE-H : 5VDC 10mA
  VE-HME, VE-HE, VE-HM5, VE-H5 : 5VDC 100mA
- *Life Expectancy*
  Mechanical ..... 1×10^7 operations
  Electrical ..... 1×10^5 operations (at nominal load ..... Standard Type)
  5×10^4 operations (at nominal load ..... High Sensitive Type)

(*1) *Min. Switching Load mentioned above are reference values. Please perform the confirmation test with the actual load before production since reference values may vary according to switching frequencies, environmental conditions and expected reliability levels.*

COIL

- *Nominal Voltage* ..... 5 to 48VDC
- *Nominal Power (at 20°C)* ..... Standard Type : 360mW
  High Sensitive Type : 250mW
- *Operate Power (at 20°C)* ..... Standard Type : 177mW
  High Sensitive Type : 130mW
- *Operate & Release Voltage* .... Please see Coil Data Chart
- *Max. Continuous Voltage* ..... Please see Characteristic Data

GENERAL

- *Insulation Resistance* ..... Min. 1,000MΩ at 500VDC
- *Dielectric Strength* ..... VE-H, VE-HE, VE-H5 : 750VAC 1 minute (between open contacts)
  VE-HM, VE-HME, VE-HM5 : 1,000VAC 1 minute (between open contacts)
  2,000VAC 1 minute (between coil and contacts)
- *Surge Strength* ..... Standard Type : 4000V
  High Voltage Type : 6000V
  (at 1.2 × 50μs standard surge wave)
- *Temperature Range* ..... Standard Type
  (at nominal voltage) : −40° to +85°C
  High Sensitive Type : −40° to +90°C
- *Time Value* ..... Operate : Max. 10ms
  (at normal voltage) Release : Max. 5ms
- *Vibration Resistance*
  Misoperation ..... 10 to 55 Hz, double amplitude of 3.3mm
  Endurance ..... 10 to 55 Hz, double amplitude of 3.3mm
- *Shock Resistance*
  Misoperation ..... 100 m/s² (11 ± 1 ms)
  Endurance ..... 500 m/s² (6 ± 1 ms)
- *Unit Mass* ..... Approx. 8 g
- *Enclosure* ..... Polybutylene Terephthalate (PBT)

■SAFETY STANDARD & FILE NUMBERS

UL 508 (File No. E56140)
C22.2 No. 14 (File No. LR35579)
VDE 0435

Please be noted that UL/CSA ratings may differ from the standard ratings.

Relay type	Nominal coil voltage	Contact ratings
VE-H	5 to 48VDC	Normally open 1/14PH 125VAC/250VAC 5A 30VDC/250VAC, Resistive Normally close: 1/14HP 125VAC/250VAC 3A 30VDC/250VAC, Resistive
VE-HM	5 to 48VDC	1/12HP 125VAC/250VAC 5A 30VDC/250VAC, Resistive
VE-H5 VE-HM5	5 to 48VDC	Normally open: 1/10HP 125VAC/250VAC 5A 30VDC/250VAC Resistive Normally close: 1/14HP 125VAC/250VAC 5A 30VDC/250VAC, Resistive

■ ORDERING INFORMATION

VE-12HMSE-K-HV-VD
(*)

- Type
- Nominal Voltage
- Contact Rating
  H : Heavy Duty Type
- Contact Arrangement
  Nil : 1 Form C (SPDT)
  M : 1 Form A (SPST-NO)
- Contact Material
  Nil : Gold Overlay Silver-Nickel
  E : Silver-Nickel
  5 : Silver-Cadmium Oxide Alloy
- Coil Sensitivity
  Nil : Standard Type
  S : High Sensitive Type
- Enclosure
  K : Washable Type
- Surge Strength
  Nil : Standard Type (4000V)
  HV : High Voltage Type (6000V)
- VD : UL, CSA, VDE Approved Type

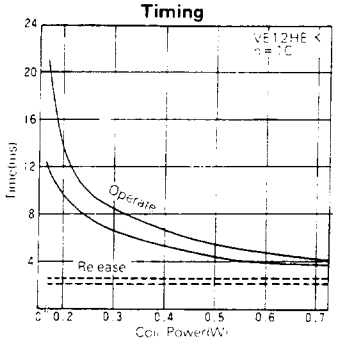
Note) 1. *Actual marking omits the hyphen (—) of (*)*

■ COIL DATA CHART

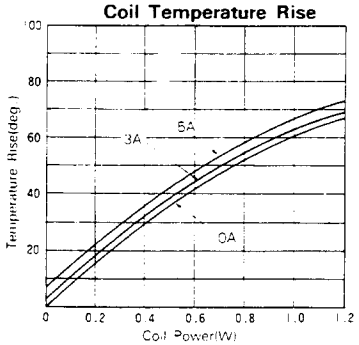
	ORDERING CODE		Coil Nominal Voltage V DC	Coil Resistance Ω ±10% (at 20°C)	Must Operate Voltage V DC (at 20°C)	Must Release Voltage V DC (at 20°C)	Coil Nominal Power mW (at 20°C)
	VE-( )HM, VE-( )HME VE-( )H, VE-( )HE	VE-( )HM5 VE-( )H5					
standard Type	VE- 5H(M)(E)-K	VE- 5H(M)5-K	5	69	3.5	0.25	360
	VE- 6H(M)(E)-K	VE- 6H(M)5-K	6	100	4.2	0.3	360
	VE- 9H(M)(E)-K	VE- 9H(M)5-K	9	225	6.3	0.45	360
	VE-12H(M)(E)-K	VE-12H(M)5-K	12	400	8.4	0.6	360
	VE-18H(M)(E)-K	VE-18H(M)5-K	18	900	12.6	0.9	360
	VE-24H(M)(E)-K	VE-24H(M)5-K	24	1,600	16.8	1.2	360
	VE-48H(M)(E)-K	VE-48H(M)5-K	48	6,400	33.6	2.4	360
High Sensitive Type	VE- 5H(M)S(E)-K	VE- 5H(M)S5-K	5	100	3.6	0.25	250
	VE- 6H(M)S(E)-K	VE- 6H(M)S5-K	6	145	4.3	0.3	250
	VE- 9H(M)S(E)-K	VE- 9H(M)S5-K	9	325	6.5	0.45	250
	VE-12H(M)S(E)-K	VE-12H(M)S5-K	12	575	8.6	0.6	250
	VE-18H(M)S(E)-K	VE-18H(M)S5-K	18	1,300	13.0	0.9	250
	VE-24H(M)S(E)-K	VE-24H(M)S5-K	24	2,310	17.3	1.2	250
	VE-48H(M)S(E)-K	VE-48H(M)S5-K	48	9,220	34.7	2.4	250

■ CHARACTERISTIC DATA

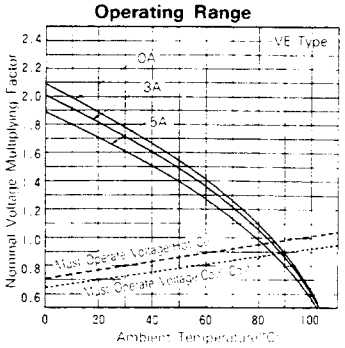
Timing



Coil Temperature Rise

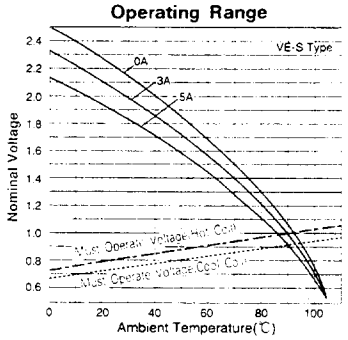


Operating Range

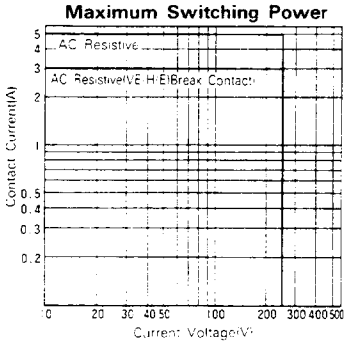


VE Relay

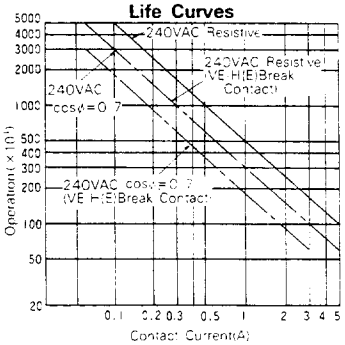
Operating Range



Maximum Switching Power

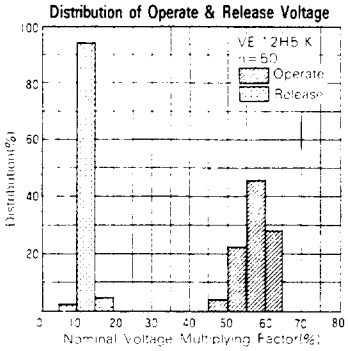


Life Curves

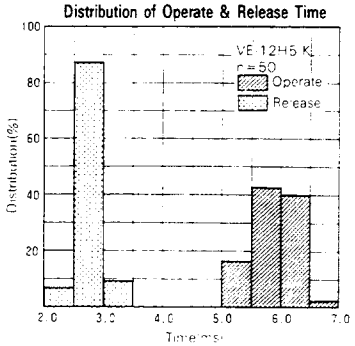


■REFERENCE DATA

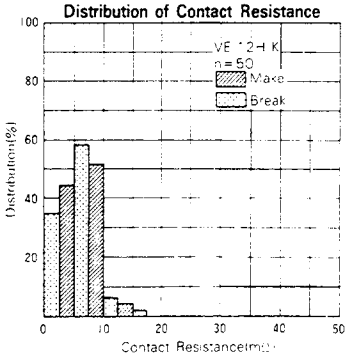
Distribution of Operate & Release Voltage



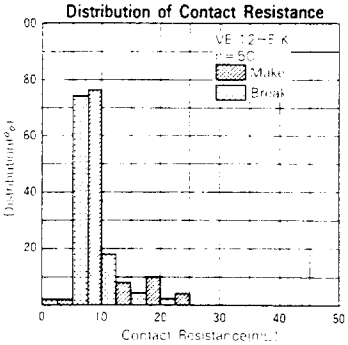
Distribution of Operate & Release Time



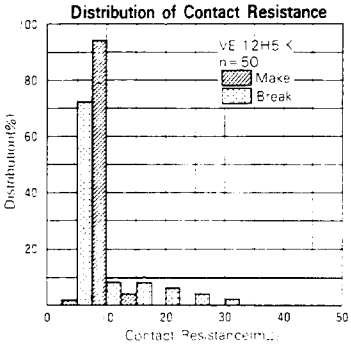
Distribution of Contact Resistance



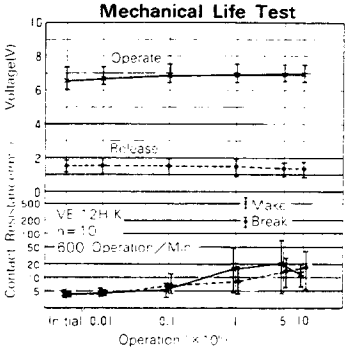
Distribution of Contact Resistance



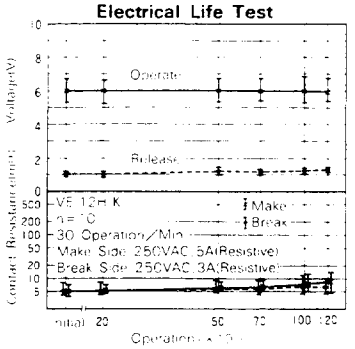
Distribution of Contact Resistance



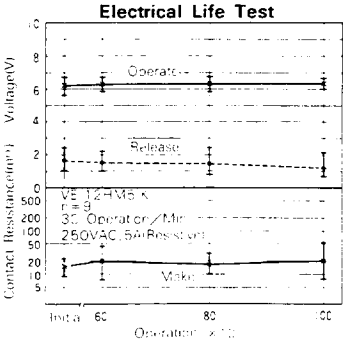
Mechanical Life Test



Electrical Life Test



Electrical Life Test



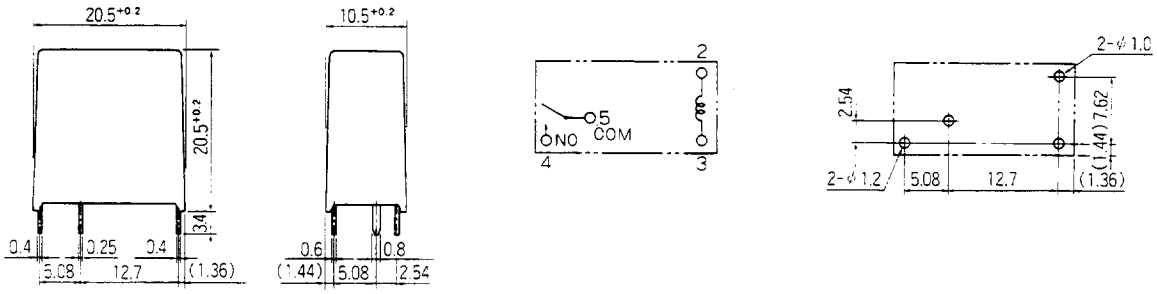
VE Relay

■ DIMENSIONS (in mm)

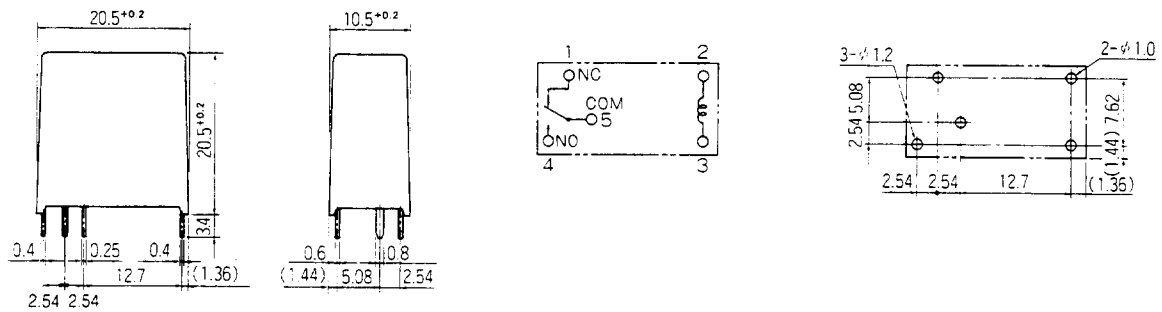
■ WIRING DIAGRAM (BOTTOM VIEW)

■ DRILLING PLAN (in mm) (BOTTOM VIEW)

VE-M Type



VE Type



Appendix E
Customer Communication

For your convenience, this appendix contains forms you can use to request help from National Instruments or to comment on our products. Filling out a copy of the *Technical Support Form* before contacting National Instruments helps us help you better and faster.

National Instruments provides comprehensive technical assistance around the world. In the U.S. and Canada, applications engineers are available Monday through Friday from 8:00 a.m. to 6:00 p.m. (central time). In other countries, contact the nearest branch office. You may fax questions to us at any time.

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Netherlands	0348 433466	0348 430673
Norway	32 84 84 00	32 84 86 00
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Spain	91 640 0085	91 640 0533
Sweden	08 730 49 70	08 730 43 70
Switzerland	056 200 51 51	056 200 51 55
Taiwan	02 377 1200	02 737 4644
U.K.	01635 523545	01635 523154

Technical Support Form

Photocopy this form and update it each time you make changes to your software or hardware, and use the completed copy of this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

If you are using any National Instruments hardware or software products related to this problem, include the configuration forms from their user manuals. Include additional pages if necessary.

Name _____

Company _____

Address _____

_____

Fax (___)_____ Phone (___)_____

Computer brand _____ Model _____ Processor _____

Operating system _____

Speed _____MHz RAM _____MB Display adapter _____

Mouse _____yes _____no Other adapters installed _____

Hard disk capacity _____MB Brand _____

Instruments used _____

National Instruments hardware product model _____ Revision _____

Configuration _____

National Instruments software product _____ Version _____

Configuration _____

The problem is _____

_____

_____

_____

_____

List any error messages _____

_____

_____

_____

_____

The following steps will reproduce the problem _____

_____

_____

ER-8/16 Hardware Configuration Form

Record the settings and revisions of your hardware on the line to the right of each item. Complete a new copy of this form each time you revise your software or hardware configuration, and use this form as a reference for your current configuration. Completing this form accurately before contacting National Instruments for technical support helps our applications engineers answer your questions more efficiently.

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- SW1 Switch Position (INT or EXT) _____
- Power (INT or EXT) _____
- Connector (DIO-24, DIO-32, or IN) _____
- Daisy-Chained (Yes or No) _____
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- Type of Video Board Installed _____
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- Programming Language _____
- Programming Language Version _____
- Other Boards in System _____
- Slots (base I/O addresses) of Other Boards _____

Documentation Comment Form

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Title: **ER-8/16 User Manual**

Edition Date: **December 1996**

Part Number: **371197A-01**

Please comment on the completeness, clarity, and organization of the manual.

If you find errors in the manual, please record the page numbers and describe the errors.

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Glossary

Prefix	Meaning	Value
p-	pico-	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}

°	degrees
Ω	ohms
%	percent
A	amperes
AC	alternating current
AWG	American Wire Gauge
C	Celsius
cm	centimeters
COM	common
DAQ	data acquisition
DC	direct current
EXT	external
GND	ground
Hz	hertz
in.	inches
INT	internal
I/O	input/output
LED	light-emitting diode
MB	megabytes of memory
MOV	metal oxide varistor
NB	NuBus Series computers
NC	normally closed
NO	normally open
PA	port A pin
PB	port B pin
PC	port C pin
PCMCIA	personal computer memory card association

PD	port D pin
PWB	printed wire board
RAM	random-access memory
s	seconds
SPDT	single-pole double-throw
V	volts
VAC	volts alternating current
VDC	volts direct current
Vrms	volts, root-mean-square

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