Computer-Based Instruments

NI 4060 User Manual

Digital Multimeter for PCI, CompactPCI, PXI, USB, and ISA Bus

NATIONAL INSTRUMENTS

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This icon to the left of bold italicized text denotes a note, which alerts you to important information.

This icon to the left of bold italicized text denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash.

This icon to the left of bold italicized text denotes a warning, which advises you of precautions to take to avoid being electrically shocked.

**bold**

Bold text denotes the names of menus, menu items, parameters, dialog boxes, dialog box buttons or options, icons, windows, Windows 95 tabs, or LEDs.

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Bold italic text denotes a note, caution, or warning.

**italic**

Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text from which you supply the appropriate word or value, as in Windows 3.x.

NI 4060

Refers to any one of the devices in the NI 4060 family—NI 4060 (PCI), NI 4060 (PXI), NI 4060 (ISA), NI 4060 (USB).
# Contents

## Chapter 1
Taking Measurements with the NI 4060

- Connecting Signals ............................................................... 1-1
- Introduction to the NI DMM Soft Front Panel .......................... 1-3
- Using the Soft Front Panel ..................................................... 1-5
  - DC and AC Voltage .......................................................... 1-5
  - Two-Wire Resistance .......................................................... 1-6
  - Four-Wire Resistance .......................................................... 1-7
  - DC and AC Current ............................................................ 1-9
  - Diode ................................................................................. 1-10
  - Temperature ....................................................................... 1-11

## Chapter 2
NI 4060 Operation

- Safety Instructions ........................................................................ 2-1
- Measurement Fundamentals ...................................................... 2-2
  - Cabling ............................................................................... 2-2
  - Warm Up ............................................................................. 2-2
  - Selecting the Resolution ......................................................... 2-3
  - Autozero ............................................................................. 2-3
  - Grounding ........................................................................... 2-3
- Voltage Measurements .............................................................. 2-3
  - DC Voltage ......................................................................... 2-3
    - Input Ranges ..................................................................... 2-4
    - Measurement Considerations ........................................... 2-4
      - Input Impedance ............................................................... 2-4
      - Thermal EMF ................................................................... 2-5
      - Noise Rejection ............................................................... 2-5
  - AC Voltage ......................................................................... 2-7
    - Input Ranges ..................................................................... 2-8
    - Measurement Considerations ........................................... 2-8
      - AC Offset Voltage ............................................................. 2-8
      - Frequency Response ......................................................... 2-9
- Resistance Measurements .......................................................... 2-9
  - Two-Wire Resistance Measurements ..................................... 2-9
    - Input Ranges .................................................................... 2-10
    - Continuity Measurements .................................................. 2-10
Contents

Four-Wire Resistance Measurements ............................................................. 2-10
  Input Ranges ..................................................................................... 2-11
Current Measurements .................................................................................. 2-11
  DC Current ..................................................................................... 2-11
    Input Ranges ..................................................................................... 2-12
  AC Current ..................................................................................... 2-12
    Input Ranges ..................................................................................... 2-12
    Measurement Concerns ................................................................. 2-13
      Burden Voltage ........................................................................... 2-13
      Resistor Heating ........................................................................ 2-13
      Errors in AC current measurements ........................................... 2-14
Diode Measurements ................................................................................... 2-14
Scanning ........................................................................................................... 2-14
  AUX I/O Connector and Optional Trigger Cables ..................................... 2-15
Scanning Communication Methods.............................................................. 2-15
    Handshaking Mode ........................................................................ 2-15
    Synchronous Mode ........................................................................ 2-17
    Measurement Concerns ................................................................. 2-18
      Settling Time .............................................................................. 2-18
      Mode and Range Changes ........................................................... 2-19
      Relay Life ..................................................................................... 2-19

Appendix A
Specifications

Appendix B
Fuse Replacement

Appendix C
Customer Communication

Glossary

Index
Figures

Figure 1-1. Connectors on the NI 4060 Family of Products ........................................1-2
Figure 1-2. NI DMM Soft Front Panel ......................................................................1-3
Figure 1-3. Connecting Signals for Voltage Measurements .....................................1-6
Figure 1-4. Connecting Signals for Two-Wire Resistance .......................................1-7
Figure 1-5. Connecting Signals for Four-Wire Resistance .......................................1-8
Figure 1-6. Connecting Signals for Current Measurement .......................................1-9
Figure 1-7. Connecting Signals for Diode Test .........................................................1-10
Figure 1-8. Connecting Signals for RTDs and Thermistors .....................................1-11

Figure 2-1. The Effect of Input Impedance on Signal Measurements .......................2-4
Figure 2-2. Normal Mode Measurement Effects .......................................................2-6
Figure 2-3. Common Mode Measurement Effects ......................................................2-7
Figure 2-4. Circuit for Two-Wire Resistance Measurements ....................................2-9
Figure 2-5. Circuit For Four-Wire Measurements ....................................................2-11
Figure 2-6. Circuit For Current Measurements .......................................................2-12
Figure 2-7. Effect of Burden Voltage on Current Measurements ............................2-13
Figure 2-8. Circuit For Diode Measurements ..........................................................2-14
Figure 2-9. Auxiliary Trigger Cable (SH9MD-2BNC) ..............................................2-15
Figure 2-10. Hardware Connections to an External Multiplexer in Handshaking Mode ......................................................................................................................2-16
Figure 2-11. Handshaking Mode Trigger Timing ......................................................2-16
Figure 2-12. Hardware Connections to an External Multiplexer in Synchronous Mode .....................................................................................................................2-17
Figure 2-13. Synchronous Mode Trigger Timing ......................................................2-18

Figure B-1. Insulator Screw Location on NI 4060 (ISA) .........................................B-1
Figure B-2. Fuseholder Location on NI 4060 (ISA) ................................................B-2
Figure B-3. Insulator Screw Location on NI 4060 (PCI) ..........................................B-3
Figure B-4. Fuseholder Location on NI 4060 (PCI) ................................................B-3
Figure B-5. Fuseholder Location on NI 4060 (PXI) .................................................B-4
Taking Measurements with the NI 4060

Thank you for buying a National Instruments 4060 digital multimeter board. A system based on the NI 4060 offers the flexibility, performance, and size that makes it ideal for service, repair, and manufacturing as well as for use in industrial and laboratory environments. The NI 4060, used in conjunction with your computer, is a versatile, cost-effective platform for high-resolution measurements.

Detailed specifications for the NI 4060 are in Appendix A, Specifications.

Note

Before using any measurement equipment, it is important that you thoroughly understand the safety instructions for that product. The beginning of Chapter 2, NI 4060 Operation, covers the safety guidelines for your NI 4060.

Connecting Signals

Figure 1-1 shows the front panels for the NI 4060 device. These front panels contain five connectors—four banana jacks and one 9-pin mini circular DIN connector.

The four banana jack connectors are high-voltage, safety signal connectors. The 9-pin mini circular DIN connector labeled AUX I/O is a digital signal connector, which carries TTL-level triggering signals for use with external scanning equipment. Scanning is discussed in Chapter 2, NI 4060 Operation.
Chapter 1  Taking Measurements with the NI 4060

Figure 1-1. Connectors on the NI 4060 Family of Products
The banana jack connectors are labeled IN HI +, IN LO –, mA/Ω4W +, and mA/Ω4W –, from top to bottom respectively, right to left on the NI 4060 for USB.

Caution  To prevent possible safety hazards, the maximum voltage between either of the inputs and the ground of the computer should never exceed ±300 VDC or 300 Vrms. The maximum current that can be measured between the current inputs is ±200 mA DC or 200 mA rms.

Introduction to the NI DMM Soft Front Panel

The following sections explain how to make connections to your NI 4060 and take simple measurements using the NI DMM Soft Front Panel, as shown in Figure 1-2. To launch the soft front panel, select Start»Program»National Instruments DMM Soft Front Panel.

The following text describes the options available on the soft front panel.

Value Indicator—This indicator displays the value measured by your NI 4060. The value here is an example only.

Range Indicator—This control displays the range which the NI 4060 is in presently. This indicator is especially useful while in autoranging.

Units Indicator—This indicator displays the measurement units of the value you are measuring. The units are expressed as VAC, VDC, mVAC, mVDC, Ω, kΩ, MΩ, mA AC, or mA DC.
Chapter 1  Taking Measurements with the NI 4060

**Range**—The up and down arrows allow you to change your range. Use the up arrow to select the next highest range. Use the down arrow to select the next lowest range. Clicking **Auto** causes the multimeter to autorange. Autoranging automatically selects the appropriate range for your measurement. The range indicator is useful in determining the range you are in while autoranging.

**Instrument Name**—This control allows you to select the NI 4060 device you will use with the soft front panel. The **Instrument Name** is determined by DAQ::x, where x is the device number from the NI-DAQ Configuration Utility.

**Simulating**—With this control you can simulate using the front panel without actually having an NI 4060 in your system.

**Powerline**—This control allows you to select the powerline frequency of your environment. Use it to determine the powerline rejection on your NI 4060.

**Digits**—Use this control to select your digits of resolution. The lower the resolution, the faster the measurement; the higher the resolution, the slower the measurement.

**Mode**—These controls allow you to select your measurement mode, as follows:

- DC Volts
- AC Volts
- DC Amps
- AC Amps
- Two-Wire Resistance
- Four-Wire Resistance
- Diode
When you have launched the front panel, you must make the following selections before taking measurements:

- Select the device you will be using in the Instrument Name control.
- Select the appropriate powerline frequency for your environment using the Powerline frequency selector.
- Select the resolution at which you are interested in using the Digits control.

You are now ready to take measurements.

Using the Soft Front Panel

The following sections describe procedures for measuring DC and AC voltage, two and four-wire resistance, DC and AC current, diode, and temperature, using the soft front panel. Figures 1-3 through 1-8 depict the NI 4060 for PXI; the same connections apply for all NI 4060 devices.

DC and AC Voltage

This section gives the procedures for measuring DC and AC voltage using the soft front panel.

1. Connect your signal to the top terminal pair, as shown in Figure 1-3. For DC voltages, the HI (red) input terminal is positive and the LO (black) input terminal is negative. For AC voltages, positive and negative terms are irrelevant. On the NI 4060 for USB, the input signals are the right signal pair. The mA/Ω4W sense signals are the left signal pair.
Chapter 1 Taking Measurements with the NI 4060

2. Select the mode you will measure:
   DC Volts
   or
   AC Volts

3. Select the range for your measurement or autoranging:
   DC Volts—± 20 mV, ± 200 mV, ± 2 V, ± 25 V, and ± 250 V;
   AC Volts—20 mV\text{rms}, 200 mV\text{rms}, 2 V\text{rms}, 25 V\text{rms}, and
   250 V\text{rms}. The Value Indicator displays the voltage measured.

Two-Wire Resistance

This section gives the procedures for measuring two-wire resistance using
the soft front panel.

1. Connect the signal to the top terminal pair, as shown in Figure 1-4.
   On the NI 4060 for USB, connect the signal to the right terminal pair.
2. Select two-wire resistance mode.

3. Select the range for your measurement or autoranging. These ranges are 200 \( \Omega \), 2 k\( \Omega \), 20 k\( \Omega \), 200 k\( \Omega \), 2 M\( \Omega \), and 200 M\( \Omega \).

The Value Indicator indicates the resistance measured. See the Two-Wire Resistance Measurements section of Chapter 2, NI 4060 Operation, for more information on two-wire resistance measurements.

### Four-Wire Resistance

Four-wire resistance measurements use both pairs of terminals. This configuration allows you to measure low resistances accurately by eliminating the effects of lead resistance. This section gives the procedures for measuring four-wire resistance using the soft front panel.

1. Connect the top signal pair IN HI + and IN LO −, which is the right pair for the NI 4060 for USB. These signals provide the excitation current.
2. Connect the bottom pair mA/Ω4W + and mA/Ω4W −, which is the left pair for the NI 4060 for USB. These signals sense the voltage across the resistor. These connections are shown in Figure 1-5.

![Figure 1-5. Connecting Signals for Four-Wire Resistance](image)

3. Select four-wire resistance mode.

4. Select the range for your measurement or autoranging. These ranges are 200 Ω, 2 kΩ, 20 kΩ, 200 kΩ, and 2 M.

The Value Indicator indicates the resistance measured. See the Four-Wire Resistance Measurements section of Chapter 2, *NI 4060 Operation*, for more information on four-wire resistance measurements.
DC and AC Current

This section gives the procedures for measuring DC and AC current using the soft front panel.

1. Connect the signal to the bottom terminal pair, as shown in Figure 1-6. On the NI 4060 for USB, connect the signal to the left terminal pair. The HI (red) input terminal is positive, and the LO (black) input terminal is negative.

![Figure 1-6. Connecting Signals for Current Measurement](image)

2. Select the mode you will measure:
   - Amps DC
   - Amps AC

3. Select the range for your measurement or autoranging. The NI 4060 has two input ranges available for measuring DC current, ± 20 mA and ± 200 mA. The NI 4060 also has two input ranges available for
measuring AC current: 20 mA_{rms} and 200 mA_{rms}. The Value Indicator indicates the current measured.

**Diode**

The NI 4060 can excite a device under test and read the resulting voltage drop. Diode mode is useful in testing diodes. Only the 2 V range is available for diode measurements. This section gives the procedures for testing diodes using the soft front panel.

1. Connect the signal to the top terminal pair, as shown in Figure 1-7. On the NI 4060 for USB, connect the signal to the right terminal pair.

![Figure 1-7. Connecting Signals for Diode Test](image)

2. Select diode mode.

The Value Indicator will indicate the voltage drop measured. If the display indicates 2.200 VDC, the diode is either reverse biased or defective. See the Diode Measurements section of Chapter 2, *NI 4060 Operation*, for more information on diode measurements.
Temperature

You can measure temperature using common temperature transducers, such as resistive temperature devices (RTD) and thermistors. You can measure transducers in the two-wire resistance mode, as shown in Figure 1-8. While the soft front panel does not support temperature measurements, you can convert and scale the transducers’ value to temperature programmatically through software.

You can also measure the devices in four-wire resistance mode to eliminate the effects of lead resistance, as shown in Figure 1-5.

Figure 1-8. Connecting Signals for RTDs and Thermistors.
NI 4060 Operation

This chapter contains safety instructions, measurement fundamentals and concerns, and scanning information.

Safety Instructions

Cautions

Do NOT OPERATE THIS INSTRUMENT IN AN EXPLOSIVE ATMOSPHERE OR WHERE THERE MAY BE FLAMMABLE GASES OR FUMES.

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.

To prevent safety hazards, the maximum voltage between either of the inputs and the ground of the computer should never exceed ±300 VDC or 300 Vrms.

Do NOT OPERATE DAMAGED EQUIPMENT. The safety protection features built into this instrument can become impaired if the instrument becomes damaged in any way. If the instrument is damaged, do not use it until service-trained personnel can check its safety. If necessary, return the instrument to National Instruments for service and repair to ensure that its safety is not compromised.

Do not operate this instrument in a manner that contradicts the information specified in this document. Misuse of this instrument could result in a shock hazard.

Do NOT SUBSTITUTE PARTS OR MODIFY EQUIPMENT. Because of the danger of introducing additional hazards, do not install unauthorized parts or modify the instrument. Return the instrument to National Instruments for service and repair to ensure that its safety is not compromised.

Connections that exceed any of the maximum signal ratings on the NI 4060 can create a shock or fire hazard or can damage any or all of the devices connected to the NI 4060. National Instruments is NOT LIABLE FOR ANY DAMAGES OR INJURIES resulting from incorrect signal connections.
Clean instrument and accessories by brushing off light dust with a soft, nonmetallic brush. Remove other contaminants with a stiff nonmetallic brush. The unit must be completely dry and free from contaminants before returning to service.

Measurement Fundamentals

Cabling

The NI 4060 kit contains a pair of test probes with safety banana plugs. These probes meet international safety requirements, including UL 3111 and IEC 1010-1, for the full range of applications supported by the NI 4060. Before using any probes or accessories not supplied by National Instruments, ensure that they meet applicable safety requirements for the signal levels you may encounter.

The test probes connect to the NI 4060 via safety banana jacks. The jacket around the banana jacks prevent you from contacting potentially hazardous voltages connected to the test probes. You can also connect the cable to standard (exposed) banana jack probes or accessories, which should be used only when the voltages are less than 30 Vrms and 42 Vpk, or 60 VDC.

Warm Up

The required warm up time for the NI 4060 is 30 minutes. This warm-up time is important because measurements made with the NI 4060 multimeter can change with temperature. This change is called a thermal drift and has temperature coefficients. To minimize the effects of thermal drift and ensure the specified accuracies, take all measurements after the NI 4060 has had a chance to fully warm up. Depending on your environment, the NI 4060 can operate significantly above ambient temperature. Therefore, measurements made immediately after powering up the system can differ significantly from measurements made after the system has fully warmed up. The NI 4060 temperature coefficient specifications are listed in the Accuracy sections in Appendix A, Specifications.
Selecting the Resolution

The resolution on the NI 4060 multimeter is programmable. You can select from three different resolutions: 5 1/2 digits, 4 1/2 digits, or 3 1/2 digits. These settings allow you to trade off speed for resolution. The 5 1/2 digit setting has the highest resolution and slowest reading rate, while the 3 1/2 digit setting gives you the least resolution and fastest reading rate. Measurement mode and range affect the reading rate by requiring different conversion times to obtain a given resolution for the different modes and ranges.

Autozero

Autozeroing is a technique that removes the effect of temperature drift on the measurement accuracy. Autozeroing disconnects the external signals from the circuit and internally shorts the input of the NI 4060 and takes a measurement. Ideally, this value should be zero, but temperature drifts can cause an offset from zero to occur. By measuring the value with the input leads internally shorted, autozeroing automatically eliminates this error. Autozeroing is not supported in AC voltage, AC current, and diode modes. Autozeroing reduces the reading rate of your measurements by approximately 50%.

Grounding

When measuring ground-referenced signals, connect the ground referenced side of your signal to the IN HI + terminal for best performance.

Voltage Measurements

DC Voltage

Your NI 4060 multimeter uses a high-resolution sigma delta, analog-to-digital converter to sample signals and convert them into a digital form. The analog-to-digital converter is preceded by a series of gain and attenuation circuitry that allow both small and large signals to be measured using the same converter. The NI 4060 uses a digital filter, which heavily rejects powerline frequencies (50–60 Hz) and their harmonics, as well as high frequency noise.
**Input Ranges**

The NI 4060 has five input ranges available for measuring DC voltages. These ranges are ±20 mV, ±200 mV, ±2.0 V, ±25V, and ±250 V. Each range has a 10% overrange. The 250 V range can overrange to 300 V. The 250 V and 25 V input ranges have a 1 MΩ input impedance; the 2 V, 200 mV, and 20 mV ranges have an input impedance greater than 1 GΩ. Take these values into consideration when measuring high impedance sources. When the NI 4060 is powered off, the 250 V and 25 V input range have a 1 MΩ input impedance and the 2 V, 200 mV, and 20 mV ranges have an input impedance of 100 kΩ.

If you are taking measurements that require a high degree of accuracy, you should consider problems associated with input impedance, noise effects, and thermal electromotive forces (thermal EMFs). These effects are discussed in the *Measurement Considerations* section.

**Measurement Considerations**

**Input Impedance**

Figure 2-1 illustrates the input impedance of an NI 4060 and its effect on the measurement of a circuit under test. If you know the source impedance of the circuit being tested, you can correct for the attenuation caused by the NI 4060 in software. Since $R_{in}$ is large, at least 1 MΩ, it will require a large source impedance, $R_s$, to cause a large change in the measured voltage, $V_m$.

Mathematically, the relationship between the measured voltage $V_m$, the source voltage $V_s$, and the input impedance $R_{in}$ is given by:

$$V_m = \frac{V_s R_{in}}{R_s + R_{in}}$$

**Figure 2-1.** The Effect of Input Impedance on Signal Measurements
Thermal EMF

Thermal EMFs, or thermoelectric potentials, are voltages generated at the junctions of dissimilar metals and are functions of temperature. Thermal EMFs in a circuit under test can cause higher than expected offsets that change with temperature.

Noise Rejection

The NI 4060 filters out AC voltages in the DC voltage measurement ranges. However, if the amplitudes of the AC voltages are large compared to the DC voltages, or if the peak value (AC + DC) of the measured voltage is outside the overrange limits, the NI 4060 may exhibit additional errors. To minimize these errors, keep the NI 4060 away from strong AC magnetic sources and minimize the area of the loop formed by the test leads. Choosing the 5 1/2 digit resolution will also help minimize noise from AC sources. If the peak value of the measured voltage is likely to exceed the selected input range, select the next highest input range.

Normal Mode Rejection

Normal mode rejection (NMR) is the NI 4060’s ability to reject a normally (differentially) applied signal. The ability is quantified in the normal mode rejection ratio (NMRR) specification, which indicates the capability of the NI 4060 to reject 50 or 60 Hz and is valid only at the specified frequency and useful only when taking DC measurements. The NMRR is specified at the powerline frequency because this is typically where most measurement noise occurs.

Figure 2-2 shows a 60 Hz signal connected differentially to the NI 4060 in DC Volts mode. $V_m$ is the voltage that will be measured after the signal is rejected. NMR is very useful when trying to measure DC voltages in the presence of large powerline interference.
If you are measuring signals in the presence of large normal mode voltages, consult Appendix A, Specifications, to calculate the additional error to your system. Use the equation in Figure 2-2 to calculate the voltage error due to normal mode voltage.

**Common Mode Rejection**

Common mode rejection (CMR) is the NI 4060’s ability to reject signals that are common to both input terminals. The ability is quantified in the Common mode rejection ratio (CMRR) specification. Theoretically, the floating measurement circuitry of the NI 4060 should have an infinite CMRR. Parasitic resistances and capacitances to earth ground limit the CMR of the NI 4060. This effect is most noticeable when measuring small signals in the presence of a large common mode voltage, as shown in Figure 2-3.

![Figure 2-2. Normal Mode Measurement Effects](image)

\[ V_M = V_S \times \left(\frac{-\text{NMMR}}{20}\right) \]
Using the equation in Figure 2-3, you can calculate the voltage error due to the common mode voltage. If you are measuring signals in the presence of large common mode voltages, consult Appendix A, Specifications, to calculate the additional error to your system.

**Effective Common Mode Rejection**

Effective common mode rejection is the sum of the CMRR and the NMRR at a given frequency. It is the effective rejection on a given noise signal that is applied to both input leads as it gets rejected first by the CMR capability of the instrument then again by its NMR capability. This specification is most useful at the power line frequency where most of the noise resides and is only valid for DC measurements.

**AC Voltage**

In the AC voltage ranges, the NI 4060 measures the AC-coupled RMS value of a signal. The RMS value of a signal is a fundamental measurement of the magnitude of an AC signal. The RMS value of an AC signal can be defined mathematically as the square root of the average of the square of the signal.
In practical terms, the RMS value of an AC signal is the DC value required to produce an equivalent amount of heat in the same resistive load. The NI 4060 first AC-couples the measured signal to remove any DC components and then measures the RMS value of the AC component. This method lets you measure a small AC signal in the presence of a large DC offset.

**Input Ranges**

The NI 4060 has five input ranges available for measuring AC voltages. These ranges are 20 mV$_{\text{rms}}$, 200 mV$_{\text{rms}}$, 2.0 V$_{\text{rms}}$, 25 V$_{\text{rms}}$, and 250 V$_{\text{rms}}$. The impedance in each of these ranges is a 0.068 µF capacitor followed by 1 MΩ. When the NI 4060 is powered off, the 250 V, 25 V, and 2 V input ranges have a 0.068 µF capacitor, followed by a 1 MΩ input impedance. The 200 mV and 20 mV ranges have a 0.068 µF capacitor, followed by an approximate 100 kΩ input impedance.

The NI 4060 can measure AC voltages to its specified accuracy as long as the voltage is at least 10% and no more than 100% of the selected input range. The DC component in any of these ranges can be as high as 250 VDC. Each range has a 10% overrange. The 250 VAC range can overrange up to 300 V.

The AC voltage measurement accuracy depends on many factors, including the signal amplitude, frequency, and waveform shape.

**Measurement Considerations**

**AC Offset Voltage**

The AC measurements of the NI 4060 are specified over the range of 10% to 100% of the full-scale input range. Below 10% of the input range, errors due to the AC voltage offset become significant. This offset, unlike DC voltage offsets, cannot simply be subtracted from the readings or zeroed out because the offset gets converted in the RMS conversion. To minimize the errors due to the AC offset voltage, choose an input range that keeps the measured voltage between 10% and 100% of full scale.
Frequency Response

The accuracy of the NI 4060’s AC voltage measurements is a function of the input signal frequency. Your NI 4060 is calibrated at the factory using a 60 Hz sine wave. Your frequency dependent error will be minimal around this frequency. The error will then increase as you approach the upper and lower bandwidth limits. This additional error is added to the accuracy errors in computing the absolute error.

These additional errors are shown in Appendix A, Specifications. While the NI 4060 is characterized and specified over the 20 Hz to 25 kHz frequency range, measurements outside of this range can still be made with decreased accuracy.

Resistance Measurements

Two-Wire Resistance Measurements

The NI 4060 measures two-wire resistance by passing a current through the device under test and reading the resulting voltage drop through the same connections, as illustrated in Figure 2-4. The resistance value is then computed using Ohm’s Law (R=V/I). To accurately measure the value of a resistor, make sure the resistor is not connected to any other circuits. Erroneous or misleading readings can result if the resistor you are measuring is connected to external circuits that supply voltages or currents, or to external circuits that change the effective resistance of that resistor.

![Figure 2-4. Circuit for Two-Wire Resistance Measurements](image)

\[
R_{\text{unknown}} = \frac{V_{\text{sense}}}{I_{\text{ex}}}
\]

- \( I_{\text{ex}} = 100 \mu A (200 \Omega, 2 k\Omega, 20 k\Omega \text{ ranges}) \)
- \( 1 \mu A (200 k\Omega, 2 M\Omega, 200 M\Omega \text{ ranges}) \)
**Input Ranges**

The NI 4060 has five basic input ranges for two-wire resistance as well as an extended range. The basic ranges are 200 Ω, 2.0 kΩ, 20 kΩ, 200 kΩ, and 2 MΩ. With the extended range, measurements up to at least 200 MΩ are possible.

In the extended ohms range, the NI 4060 adds a 1 MΩ resistor in parallel with the test resistor, and then calculates the value of the resistor being tested. The test current for the 200 Ω, 2.0 kΩ, and 20 kΩ ranges is 100 µA. The test current for the 200 kΩ, 2 MΩ, and 200 MΩ ranges is 1 µA.

**Continuity Measurements**

Many traditional multimeters can take continuity measurements, which test for the presence or absence of continuity between the two test probes. These measurements are simply resistance measurements, where the resistance between the two probes is measured and compared to a set value. You can perform continuity measurements on a circuit by setting the NI 4060 to the 200 Ω range and comparing the measured value to some low resistance value, typically 10 Ω. If the measured value is less than 10 Ω, there is continuity between the test probes.

**Four-Wire Resistance Measurements**

Four-wire resistance measurements work in a similar manner as two-wire resistance measurements. Four-wire resistance measurements separate the current excitation leads from the voltage sense leads.

This method allows the test currents to flow through the device under test while allowing a separate path for the voltage drop to be sensed as illustrated in Figure 2-5. This method is a good alternative to two-wire ohms mode for measuring small resistances (< 100 Ω). The only drawback is that the two-wire ohms method doubles the number of connections for a resistance measurement.

Figure 2-5 illustrates the different paths for the excitation current and the sense voltage. The sense leads should be connected as close as possible to the device to be measured. Any extra lead length between the actual device to be measured and the sense leads will add error to the measurement.
Input Ranges

The NI 4060 has five input ranges for four-wire resistance: 200 Ω, 2.0 kΩ, 20 kΩ, 200 kΩ, and 2 MΩ. Extended ohms is not supported in the four-wire configuration.

Current Measurements

DC Current

The NI 4060 uses the same input circuitry to measure current as it does DC voltage, with the exception that it switches in a 1 Ω current shunt in parallel with the input. Figure 2-6 illustrates how DC current measurements are made.

The current shunt is protected by a 500 mA/250 V fast acting fuse. Refer to Appendix B, *Fuse Replacement*, for instructions on replacing this fuse.
Chapter 2  NI 4060 Operation

Figure 2-6.  Circuit For Current Measurements

**Input Ranges**

The NI 4060 has two input ranges for DC current, ± 200 mA and ± 20 mA. Overranging allows you to measure an additional 10% of your current range. You can measure larger currents using an optional external shunt accessory such as the CSM-10A current shunt, available from National Instruments, or a third-party shunt.

To take measurements using an external shunt, set the voltmeter to DC voltage. Using the value of the resistor, the resulting voltage measured can be scaled and converted to current in software.

**AC Current**

The NI 4060 uses the same input circuitry to measure AC current as it does AC voltage, with the exception that it switches in the same 1 Ω current shunt used in the DC current mode in parallel with the input. The current shunt is protected by a 500 mA/250 V fast acting fuse. Refer to Appendix B, *Fuse Replacement*, for instructions on replacing this fuse.

**Input Ranges**

The NI 4060 has two input ranges for AC current: 200 mA_{rms} and 20 mA_{rms}. Overranging allows you to measure an additional 10% of your current range.
You can measure larger currents using an optional external shunt accessory such as the CSM-10A current shunt available from National Instruments, or a third-party shunt. You can take measurements using an external shunt by setting the voltmeter to AC voltage. Using the value of the resistor, you can scale and convert the resulting voltage measured to current in software.

**Measurement Concerns**

**Burden Voltage**

To measure current, the current must pass through a resistance. While the shunt resistance is where the actual current is being sensed, the current will experience other voltage drops such as the lead resistance and the fuse resistance. These voltage drops add up to the burden voltage, as shown in Figure 2-7.

\[
V_{\text{burden}} = I_{\text{signal}} \cdot (R_{\text{shunt}} + R_{\text{lead1}} + R_{\text{lead2}} + R_{\text{fuse}})
\]

**Resistor Heating**

Larger current measurements can heat the current shunt resistor and cause it to drift. This should not present a problem because the maximum current range is relatively small compared with the shunt power rating and because the current shunt has an excellent temperature coefficient of resistance. However, you should consider this when measuring larger currents over a long period of time.
Chapter 2  NI 4060 Operation

Errors in AC current measurements
The additional errors that apply for AC voltage also apply for AC current. Resistor heating and burden apply in the same manner as they apply in DC current measurements mentioned above. Burden voltage can actually be increased due to the inductance in the measurement path.

Diode Measurements
To properly measure the forward voltage of a diode, make sure that the diode is not connected to any other circuits. The NI 4060 biases the diode with a current of 100 µA and measures the resulting voltage drop, as illustrated in Figure 2-8. Diode measurements are made with a fixed range of 2.0 V.

![Figure 2-8. Circuit For Diode Measurements](image)

Scanning
You can use the NI 4060 with National Instruments multiplexers as well as third party multiplexers that use traditional voltmeter signaling.

Traditional voltmeter signaling is a handshake protocol. In this protocol, the voltmeter starts a measurement when a trigger pulse occurs on its EXT TRIG IN line, and emits a digital pulse on the voltmeter complete (VMC) line when it finishes taking a measurement.
AUX I/O Connector and Optional Trigger Cables

This 9-pin mini DIN connector is on the front panel of your NI 4060.

**Warning**  
This connection is not isolated. It is NOT referenced to your measurement circuit. It is referenced to the ground of your computer. The digital signals on this connector should not operate beyond -0.5 V to 5.5 V of your computer ground. The trigger signals are TTL-compatible.

Using the optional triggering cable available for the NI 4060, you can break out the trigger signals to two female BNC connectors, as shown in Figure 2-9.

![Figure 2-9. Auxiliary Trigger Cable (SH9MD-2BNC)](image)

Scanning Communication Methods

The NI 4060 controls scanning through two methods: handshaking and synchronous.

**Handshaking Mode**

In handshaking mode the voltmeter emits a digital pulse on the VMC line when it finishes taking a measurement on one channel of the multiplexer. This causes the multiplexer to advance to the next channel. When the analog circuitry of the multiplexer has settled, the multiplexer emits a digital pulse on the EXT TRIG IN line. When the NI 4060 receives this pulse, it takes another measurement. Figure 2-10 illustrates the hardware configuration for scanning using this method.
Figure 2-10. Hardware Connections to an External Multiplexer in Handshaking Mode

Figure 2-11 depicts the VMC waveform that is generated by the NI 4060 and shows the specifications for the EXT TRIG IN waveform. The measurement time is not a physical signal; it illustrates how the measurement can be delayed from the trigger.

Figure 2-11. Handshaking Mode Trigger Timing
The polarities shown in Figure 2-11 are for illustration only and are programmable via the instrument driver. The trigger delay time is also user-configurable via the instrument driver. Its defaults are set to allow the NI 4060 to settle to the new input value after the external multiplexer changes channels.

**Synchronous Mode**

In synchronous mode the voltmeter emits a digital pulse on the VMC line when it finishes taking a measurement. This pulse causes the multiplexer to advance to the next channel. After a programmable delay has occurred, the voltmeter takes another measurement without requiring an external trigger. This delay allows the external multiplexer and NI 4060 to settle to the new channel. This method allows you to use multiplexers that do not have the capability to trigger the NI 4060. Figure 2-12 illustrates the hardware configuration for scanning using this method.

![Figure 2-12. Hardware Connections to an External Multiplexer in Synchronous Mode](image)
Figure 2-13 depicts the VMC waveform that is generated by the NI 4060. The measurement time is not a physical signal; it illustrates how the measurement can be delayed from the trigger. The polarities on the timing diagram are for illustration only; they are programmable via the instrument driver. The trigger delay time is also user-configurable via the instrument driver. Its defaults are set to allow the NI 4060 to settle to the new input value after the external multiplexer changes channels, because there is no way for the NI 4060 to know when the external multiplexer has settled. You can use the trigger delay to add additional delay to compensate for the multiplexer setting time.

**Measurement Concerns**

**Settling Time**

Settling time is the time required for a measurement system to stabilize after an input change before that input can be measured accurately. Take care when trying to measure rapidly changing inputs. The NI 4060 settling time is dictated by the measurement range, cable properties, source impedance, and change in input level. The cable used should be short, have low dielectric absorption, and minimal capacitance—Teflon cable is recommended. Your source should have a low output impedance. Settling time becomes especially important in scanning systems. The scanner or multiplexer requires an additional settling time before the measurement can be taken. The NI 4060 software allows for a programmable delay between channels so that both the multimeter and the multiplexer can settle.
Mode and Range Changes

When you change the DMM mode or range, an additional default delay time is inserted before the first measurement. This delay time varies with the digit of resolution, range, and mode selected.

Relay Life

When you use the NI 4060 with an external multiplexer, take care in designing the signal groupings. The internal mode and range changes occur through electromechanical relays. As with any electromechanical device, the relays are subject to wear. You should group signals according to mode to limit the number of mode changes the NI 4060 must cycle through.
Specifications

This appendix lists the specifications of the NI 4060. These specifications are guaranteed between 15° and 35° C unless otherwise specified.

DC Voltage

Accuracy
(% of reading ± µV)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25 °C ± 1° C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± µV/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250.000 V</td>
<td>0.0032% ± 960 µV</td>
<td>0.021% ± 960 µV</td>
<td>0.024% ± 960 µV</td>
<td>0.0017% ± 480 µV</td>
</tr>
<tr>
<td>25.0000 V</td>
<td>0.0032% ± 960 µV</td>
<td>0.021% ± 960 µV</td>
<td>0.024% ± 960 µV</td>
<td>0.0017% ± 480 µV</td>
</tr>
<tr>
<td>2.00000 V</td>
<td>0.0029% ± 10 µV</td>
<td>0.014% ± 10 µV</td>
<td>0.017% ± 10 µV</td>
<td>0.0009% ± 5 µV</td>
</tr>
<tr>
<td>200.000 mV</td>
<td>0.0029% ± 2 µV</td>
<td>0.014% ± 2 µV</td>
<td>0.017% ± 2 µV</td>
<td>0.0009% ± 1µV</td>
</tr>
<tr>
<td>20.0000 mV</td>
<td>0.0029% ± 2 µV</td>
<td>0.014% ± 2 µV</td>
<td>0.017% ± 2 µV</td>
<td>0.0009% ± 1µV</td>
</tr>
</tbody>
</table>

Accuracy numbers are for 5 1/2 digits with autozero on and include the effects of full and zero scale errors, temperature variation, linearity, and noise.

Noise Rejection

NMRR
(10 Hz filter setting, 50/60 Hz power line frequency ±1%)............... 80 dB

ECMRR at DC
(with a 1 kΩ imbalance in HI lead)....... 140 dB

ECMRR at 50/60 Hz
(with a 1 kΩ imbalance in HI lead)....... 150 dB
Appendix A Specifications

Input Characteristics

Input bias current ........................................... 1 nA max
Input resistance .............................................. > 1 GΩ (2 V, 200 mV, 20 mV ranges); 1 MΩ (250 V, 25 V)

DC Current

Accuracy

(% of reading ± µA)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25° C ± 1° C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± µA/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.000 mA</td>
<td>0.015% ± 10 µA</td>
<td>0.039% ± 10 µA</td>
<td>0.042% ± 10 µA</td>
<td>0.0035% ± 1 µA</td>
</tr>
<tr>
<td>20.0000 mA</td>
<td>0.015% ± 10 µA</td>
<td>0.039% ± 10 µA</td>
<td>0.042% ± 10 µA</td>
<td>0.0035% ± 1 µA</td>
</tr>
</tbody>
</table>

Accuracy numbers are for 5 1/2 digits with autozero on and include the effects of full and zero scale errors, temperature variation, linearity, and noise.

Input Characteristics

Input protection...............................Fuse F1 500 mA/250 fast fusing
Shunt resistor .....................................1 Ω
Burden voltage.....................................< 400 mV at 200 mA DC
AC Voltage

Accuracy
(% of reading ± mV)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25° C ± 1° C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± mV/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250.000 V</td>
<td>0.16% ± 170 mV</td>
<td>0.18% ± 350 mV</td>
<td>0.18% ± 350 mV</td>
<td>0.007% ± 20 mV</td>
</tr>
<tr>
<td>25.0000 V</td>
<td>0.16% ± 30 mV</td>
<td>0.18% ± 210 mV</td>
<td>0.18% ± 210 mV</td>
<td>0.007% ± 20 mV</td>
</tr>
<tr>
<td>2.00000 V</td>
<td>0.28% ± 3 mV</td>
<td>0.30% ± 21 mV</td>
<td>0.30% ± 21 mV</td>
<td>0.019% ± 2 mV</td>
</tr>
<tr>
<td>200.000 mV</td>
<td>0.16% ± 0.22 mV</td>
<td>0.18% ± 1.20 mV</td>
<td>0.18% ± 1.20 mV</td>
<td>0.007% ± 0.110 mV</td>
</tr>
<tr>
<td>20.0000 mV</td>
<td>0.28% ± 60 µV</td>
<td>0.30% ± 130 µV</td>
<td>0.30% ± 130 µV</td>
<td>0.019% ± 12 µV</td>
</tr>
</tbody>
</table>

Accuracy numbers are for 5 1/2 digits and include the effects of full and zero scale errors, temperature variation, linearity, and noise, applies for sine waves ≥ 10% of input range. Accuracy may be affected by source impedance, cable capacitances, dielectric absorption, or slew rate.

Noise Rejection
AC CMRR at 50/60 Hz
(with a 1 kΩ imbalance in HI lead)....... > 80 dB

Input Characteristics
Input resistance ........................................ 1 MΩ
Bandwidth .................................................. 20 Hz–25 kHz
Appendix A Specifications

Additional AC Errors

Frequency dependent errors

<table>
<thead>
<tr>
<th>Input Frequency</th>
<th>Additional Error (% of full scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–50 Hz</td>
<td>2%</td>
</tr>
<tr>
<td>50–100 Hz</td>
<td>0%</td>
</tr>
<tr>
<td>100Hz–20 KHz</td>
<td>1%</td>
</tr>
<tr>
<td>20–25 kHz</td>
<td>2%</td>
</tr>
</tbody>
</table>

AC Current

Accuracy

(% of reading ± mA)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25° C ± 1° C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± mA/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200.000 mA</td>
<td>0.18% ± 0.22 mA</td>
<td>0.20% ± 1.2 mA</td>
<td>0.20% ± 1.2 mA</td>
<td>0.009% ± 0.110 mA</td>
</tr>
<tr>
<td>20.0000 mA</td>
<td>0.30% ± 22 µA</td>
<td>0.32% ± 130 µA</td>
<td>0.32% ± 130 µA</td>
<td>0.022% ± 12 µA</td>
</tr>
</tbody>
</table>

Accuracy numbers are for 5 1/2 digits and include the effects of full and zero scale errors, temperature variation, linearity, and noise.

Input Characteristics

Input protection.............................................Fuse F1 500 mA/250 fast fusing
Shunt resistor...............................................1 Ω
Burden voltage...............................................< 400 mV at 200 mA AC
Resistance

Accuracy

(% of reading ± Ω)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25° C ± 1° C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± Ω/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extended Ohm (&gt; 2 MΩ)</td>
<td>0.1% ± 6 kΩ</td>
<td>0.1% ± 60 kΩ</td>
<td>0.1% ± 60 kΩ</td>
<td>0.0072% ± 6 kΩ</td>
</tr>
<tr>
<td>2.00000 MΩ</td>
<td>0.012% ± 9 Ω</td>
<td>0.077% ± 27 Ω</td>
<td>0.080% ± 27 Ω</td>
<td>0.0072% ± 2 Ω</td>
</tr>
<tr>
<td>200.000 kΩ</td>
<td>0.012% ± 5 Ω</td>
<td>0.077% ± 22 Ω</td>
<td>0.080% ± 22 Ω</td>
<td>0.0072% ± 2 Ω</td>
</tr>
<tr>
<td>20.0000 kΩ</td>
<td>0.006% ± 0.09 Ω</td>
<td>0.024% ± 0.3 Ω</td>
<td>0.027% ± 0.3 Ω</td>
<td>0.0020% ± 0.02 Ω</td>
</tr>
<tr>
<td>2.00000 kΩ</td>
<td>0.006% ± 0.05 Ω</td>
<td>0.024% ± 0.2 Ω</td>
<td>0.027% ± 0.2 Ω</td>
<td>0.0020% ± 0.02 Ω</td>
</tr>
<tr>
<td>200.000 Ω</td>
<td>0.006% ± 0.05 Ω</td>
<td>0.024% ± 0.2 Ω</td>
<td>0.027% ± 0.2 Ω</td>
<td>0.0020% ± 0.02 Ω</td>
</tr>
</tbody>
</table>

Accuracy numbers are for the 4-wire resistance mode 5 1/2 digits with autozero on and include the effects of full and zero scale errors, temperature variation, linearity, and noise.

Measurement modes

- Ohms ............................................... 2-wire ohms or 4-wire ohms
- Extended ohms ..................................... 2-wire mode only

Maximum lead resistance ................. 10 Ω (200 Ω range), 1 kΩ (all other ranges)

Test current ........................................ 100 μA for 200 Ω, 2 kΩ, 20 kΩ ranges 1 μA for 2 MΩ, 200 kΩ ranges 1 μA and 1 MΩ in parallel for extended ohms mode

Additional error for 2-wire resistance .... 0.6 Ω
Diode Testing

Accuracy
(% of reading ± μV)

<table>
<thead>
<tr>
<th>Range</th>
<th>24 Hour (25° C ± 1 °C)</th>
<th>90 Day (25° C ± 10° C)</th>
<th>1 Year (25° C ± 10° C)</th>
<th>Temperature Coefficient (% of reading/° C ± μV/° C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 V</td>
<td>0.006% ± 7 μV</td>
<td>0.024% ± 22 μV</td>
<td>0.027% ± 22 μV</td>
<td>0.0020% ± 2 μV</td>
</tr>
</tbody>
</table>

Accuracy numbers are for 5 1/2 digits and include the effects of full and zero scale errors, temperature variation, linearity, and noise.

Test Current ............................................ 100 μA

General Specifications

Settling time ............................................ Affected by source impedance and input signal changes

Warm-up time ............................................ 30 minutes for measurements accurate within specifications

Bus type
- PCI ............................................ slave
- PXI ............................................ slave
- CompactPCI ................................. slave
- ISA ............................................. 8-bit
- USB ............................................ slave

Altitude ............................................ Up to 2,000 m; at higher altitudes the installation category must be derated

Working voltage ........................................... 300 V maximum between either input terminal and earth ground
Appendix A Specifications

Physical

Dimensions

- PCI .................................................. 10.8 by 17.5 cm
  (4.25 by 6.9 in.)
- PXI .................................................. 10 by 16 cm
  (3.9 by 6.33 in.)
- ISA .................................................. 10.8 by 17.5 cm
  (4.25 by 6.9 in)
- USB ................................................. 14.6 by 21.3 by 3.8 cm
  (5.8 by 8.4 by 1.5 in.)

Environment

- Operating temperature ...................... 0° to 55° C
- Storage temperature .......................... –20° to 70° C
- Relative humidity ............................... 10% to 90% noncondensing
Fuse Replacement

This appendix explains how to replace the fuse in your NI 4060. Replace the fuse with one of the fuse types listed in the chart below.

Caution For continued protection against fire, replace only with fuses of the same type and rating. See the following chart for fuse types.

<table>
<thead>
<tr>
<th>Fuse Rating</th>
<th>Fuse Type</th>
<th>Manufacturer</th>
<th>Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 mA/250 V</td>
<td>Fast acting</td>
<td>Schurter</td>
<td>FSF 034.1513</td>
</tr>
<tr>
<td>500 mA/250 V</td>
<td>Fast acting</td>
<td>LittelFuse</td>
<td>217.500</td>
</tr>
</tbody>
</table>

NI 4060 (ISA)

1. Remove all signal connections from your NI 4060, power down your computer, and remove the board.
2. Turn to the back of the board and remove the four screws, as shown in Figure B-1. These screws hold the top and bottom insulator onto the board.

![Figure B-1. Insulator Screw Location on NI 4060 (ISA)]
3. Remove the top and bottom insulator.
4. Turn to the front of the board and locate the 5 by 20 mm glass fuse, as shown in Figure B-2. Visually verify that the fuse is blown and remove it.

![Figure B-2. Fuseholder Location on NI 4060 (ISA)](image)

5. Press the new fuse into the silver holding fixtures until you hear a snap.
6. Reattach the top and bottom covers in the same order as you removed them. Do not operate the NI 4060 without both insulators replaced and fastened.

**NI 4060 (PCI)**

1. Remove all signal connections from your NI 4060. Power down your computer and remove the board.
2. Turn to the back of the board and remove the four screws, as shown in Figure B-3. These screws hold the top and bottom insulators onto the board.
3. Remove the bottom and top insulators.
4. Turn to the front of the board and locate the 5 by 20 mm glass fuse, as shown in Figure B-4. Visually verify that the fuse is blown and remove it.

5. Press the new fuse into the silver holding fixture until you hear a snap.
6. Reattach the top and bottom covers in the same order as you removed them. Do not operate the NI 4060 without both insulators replaced and fastened.
Appendix B  Fuse Replacement

NI 4060(PXI)

1. Remove all signal connections from your NI 4060. Power down your computer and remove the board.
2. Hold the board as shown in Figure B-5 and locate the fuse holder.

![Fuse Holder](image)

Figure B-5. Fuseholder Location on NI 4060 (PXI)

3. Insert a screwdriver into the slot on the fuse holder.
4. Turn counterclockwise.
5. Pull out the holder and remove the blown fuse.
6. Insert the 5 by 20 mm glass fuse into the holder and slide the holder in.
7. Turn the fuse holder clockwise until it snaps shut.
Customer Communication

For your convenience, this appendix contains forms to help you gather the information necessary to help us solve your technical problems and a form you can use to comment on the product documentation. When you contact us, we need the information on the Technical Support Form and the configuration form, if your manual contains one, about your system configuration to answer your questions as quickly as possible.

National Instruments has technical assistance through electronic, fax, and telephone systems to quickly provide the information you need. Our electronic services include a bulletin board service, an FTP site, a fax-on-demand system, and e-mail support. If you have a hardware or software problem, first try the electronic support systems. If the information available on these systems does not answer your questions, we offer fax and telephone support through our technical support centers, which are staffed by applications engineers.

Electronic Services

Bulletin Board Support
National Instruments has BBS and FTP sites dedicated for 24-hour support with a collection of files and documents to answer most common customer questions. From these sites, you can also download the latest instrument drivers, updates, and example programs. For recorded instructions on how to use the bulletin board and FTP services and for BBS automated information, call 512 795 6990. You can access these services at:

- United States: 512 794 5422  
  Up to 14,400 baud, 8 data bits, 1 stop bit, no parity  
- United Kingdom: 01635 551422  
  Up to 9,600 baud, 8 data bits, 1 stop bit, no parity  
- France: 01 48 65 15 59  
  Up to 9,600 baud, 8 data bits, 1 stop bit, no parity

FTP Support
To access our FTP site, log on to our Internet host, ftp.natinst.com, as anonymous and use your Internet address, such as joesmith@anywhere.com, as your password. The support files and documents are located in the /support directories.
Fax-on-Demand Support
Fax-on-Demand is a 24-hour information retrieval system containing a library of documents on a wide range of technical information. You can access Fax-on-Demand from a touch-tone telephone at 512 418 1111.

E-Mail Support (Currently USA Only)
You can submit technical support questions to the applications engineering team through e-mail at the Internet address listed below. Remember to include your name, address, and phone number so we can contact you with solutions and suggestions.
support@natinst.com

Telephone and Fax Support
National Instruments has branch offices all over the world. Use the list below to find the technical support number for your country. If there is no National Instruments office in your country, contact the source from which you purchased your software to obtain support.

<table>
<thead>
<tr>
<th>Country</th>
<th>Telephone</th>
<th>Fax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>03 9879 5166</td>
<td>03 9879 6277</td>
</tr>
<tr>
<td>Austria</td>
<td>0662 45 79 90 0</td>
<td>0662 45 79 90 19</td>
</tr>
<tr>
<td>Belgium</td>
<td>02 757 00 20</td>
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Company _______________________________________________________________________
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_______________________________________________________________________________
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Computer brand____________ Model ___________________ Processor _____________________
Operating system (include version number) __________________________________________
Clock 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: __________________________________________________________________
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The following steps reproduce the problem: __________________________________________
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Glossary

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Meanings</th>
<th>Value</th>
</tr>
</thead>
<tbody>
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Numbers/Symbols

- %: percent
- +: positive of, or plus
- -: negative of, or minus
- /: per
- °: degree
- ±: plus or minus
- Ω: ohm

A

- A: amperes
- AC: alternating current
- AC coupled: the passing of a signal through a filter network that removes the DC component of the signal
Glossary

A/D analog-to-digital

ADC analog-to-digital converter—an electronic device, often an integrated circuit, that converts an analog voltage to a digital number

ADC resolution the resolution of the ADC, which is measured in bits. An ADC with 16 bits has a higher resolution, and thus a higher degree of accuracy, than a 12-bit ADC.

amplification a type of signal conditioning that improves accuracy in the resulting digitized signal and reduces noise

amplitude flatness a measure of how close to constant the gain of a circuit remains over a range of frequencies

aperture time the period of time over which a measurement is averaged; also called the number of powerline cycles

attenuate to reduce in magnitude

autozero technique of internally shorting the internal circuit while disconnecting the measurement to compensate for temperature effects

B

b bit—one binary digit, either 0 or 1

B byte—eight related bits of data, an eight-bit binary number. Also used to denote the amount of memory required to store one byte of data.

bus the group of conductors that interconnect individual circuitry in a computer. Typically, a bus is the expansion vehicle to which I/O or other devices are connected. Examples of PC buses are the PCI and ISA bus.

burden voltage the voltage drop across the input section of the current mode

C

C Celsius

CMRR common-mode rejection ratio—a measure of an instrument’s ability to reject interference from a common-mode signal, usually expressed in decibels (dB)
CompactPCI refers to the core specification defined by the PCI Industrial Computer Manufacturer’s Group (PICMG).

conversion device device that transforms a signal from one form to another. For example, analog-to-digital converters (ADCs) for analog input, digital-to-analog converters (DACs) for analog output, digital input or output ports, and counter/timers are conversion devices.

conversion time the time required, in an analog input or output system, from the moment a channel is interrogated (such as with a read instruction) to the moment that accurate data is available.

coupling the manner in which a signal is connected from one location to another.

CPU central processing unit.

crest factor the ratio of the peak value of the signal to the RMS value of the signal.

CSM current shunt module.

D

DAQ data acquisition—(1) collecting and measuring electrical signals from sensors, transducers, and test probes or fixtures and inputting them to a computer for processing; (2) collecting and measuring the same kinds of electrical signals with A/D and/or DIO boards plugged into a computer, and possibly generating control signals with D/A and/or DIO boards in the same computer.

dB decibel—the unit for expressing a logarithmic measure of the ratio of two signal levels: \( \text{dB} = 20 \log_{10} \frac{V_1}{V_2} \), for signals in volts.

DC direct current.

default setting a default parameter value recorded in the driver. In many cases, the default input of a control is a certain value (often 0) that means use the current default setting.

device a plug-in data acquisition board, card, or pad that can contain multiple channels and conversion devices. Plug-in boards, PCMCIA cards, devices such as the DAQPad-1200, which connects to your computer parallel port, are all examples of DAQ devices.
Glossary

dielectric absorption  a parasitic phenomenon related to capacitors that can cause unexpectedly long settling times in circuits using capacitors with poor dielectric absorption specifications

differential input  an analog input consisting of two terminals, both of which are isolated from computer ground, whose difference is measured

DMM  digital multimeter

DNL  differential nonlinearity—a measure in LSB of the worst-case deviation of code widths from their ideal value of 1 LSB

double insulated  a device that contains the necessary insulating structures to provide electric shock protection without the requirement of a safety ground connection

drivers  software that controls a specific hardware instrument

E

ECMR  Effective Common Mode Rejection—a measure of an instrument’s ability to reject interference from a common-mode signal. This includes both the effects of normal mode rejection and common mode rejection.

EEPROM  electrically erasable programmable read-only memory—ROM that can be erased with an electrical signal and reprogrammed

EXT TRIG IN  external trigger input signal

F

F  farads

filtering  a type of signal conditioning that allows you to filter unwanted signals from the signal you are trying to measure

G

gain  the factor by which a signal is amplified, sometimes expressed in decibels
H

harmonics multiples of the fundamental frequency of a signal

half-power bandwidth the frequency range over which a circuit maintains a level of at least −3 dB with respect to the maximum level

hardware the physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, and so on

Hz hertz—per second, as in cycles per second or samples per second

I

I_ex excitation current

IEC International Electrotechnical Commission

IEEE Institute of Electrical and Electronics Engineers

in. inches

inductance the relationship of induced voltage to current

input bias current the current that flows into the inputs of a circuit

input impedance the measured resistance and capacitance between the input terminals of a circuit

Installation Category classification system for expected transients on electrical supply installations

(Overvoltage Category)

instrument driver a set of high-level software functions that controls a specific plug-in DAQ board. Instrument drivers are available in several forms, ranging from a function callable language to a virtual instrument (VI) in LabVIEW.

interrupt a computer signal indicating that the CPU should suspend its current task to service a designated activity

interrupt level the relative priority at which a device can interrupt

I/O input/output—the transfer of data to/from a computer system involving communications channels, operator interface devices, and/or data acquisition and control interfaces
Glossary

ISA
industry standard architecture

isolation
a type of signal conditioning in which you isolate the transducer signals from the computer for safety purposes. This protects you and your computer from large voltage spikes and makes sure the measurements from the DAQ device are not affected by differences in ground potentials.

isolation voltage
the voltage that an isolated circuit can normally withstand, usually specified from input to input and/or from any input to the amplifier output, or to the computer bus

M

m
meters.

MB
megabytes of memory.

N

NI-DAQ
National Instruments driver software for DAQ hardware.

NMRR
normal mode rejection ratio—a measure of an instrument’s ability to reject a signal applied directly to the differential inputs of the instrument

noise
an undesirable electrical signal—Noise comes from external sources such as the AC power line, motors, generators, transformers, fluorescent lights, soldering irons, CRT displays, computers, electrical storms, welders, radio transmitters, and internal sources such as semiconductors, resistors, and capacitors. Noise corrupts signals you are trying to send or receive.

O

Ohm’s Law
(R=V/I)—the relationship of voltage to current in a resistance

overrange
a segment of the input range of an instrument outside of the normal measuring range. Measurements can still be made, usually with a degradation in specifications.
PCI
Peripheral Component Interconnect—a high-performance expansion bus architecture originally developed by Intel to replace ISA and EISA; it is achieving widespread acceptance as a standard for PCs and workstations and offers a theoretical maximum transfer rate of 132 Mbytes/s.

Peak value
the absolute maximum or minimum amplitude of a signal (AC + DC).

PXI
PCI eXtensions for Instrumentation. PXI is an open specification that builds off the CompactPCI specification by adding instrumentation-specific features.

R
Resistor

RAM
random-access memory

Range error
an error in accuracy that is determined by the input range that is selected. The range error is independent of the value of the signal being measured.

Reading error
an error in accuracy that is determined by the input range, as well as the value being measured.

Reading rate
the rate at which a new measurement is taken. In addition to the measurement speed, the selection of the reading rate affects the filtering, and thus the noise level, of measurements.

Resolution
the smallest signal increment that can be detected by a measurement system. Resolution can be expressed in bits or in digits. The number of bits in a system is roughly equal to 3.3 times the number of digits.

Rms
root mean square—a measure of signal amplitude; the square root of the average value of the square of the instantaneous signal amplitude.

ROM
read-only memory

Rsense
the sense resistor. The voltage across this resistor is measured and converted to a current.
Glossary

S

s
seconds

S
samples

sense
in four-wire resistance the sense measures the voltage across the resistor being excited by the excitation current

settling time
the amount of time required for a voltage to reach its final value within specified limits

S/s
samples per second—used to express the rate at which an instrument samples an analog signal

system noise
a measure of the amount of noise seen by an analog circuit or an ADC when the analog inputs are grounded

T

temperature
the percentage that a measurement will vary according to temperature. See also thermal drift

thermal drift
measurements that change as the temperature varies

thermoelectric potentials
See thermal EMFs.

thermal EMFs
thermal electromotive forces—voltages generated at the junctions of dissimilar metals that are functions of temperature. Also called thermoelectric potentials.

transfer rate
the rate, measured in bytes/s, at which data is moved from source to destination after software initialization and set up operations; the maximum rate at which the hardware can operate

U

UL
Underwriters Laboratory
**Glossary**

**V**

- **V** volts
- **VAC** volts alternating current
- **VDC** volts direct current
- **V_{error}** voltage error
- **VI** virtual instrument—(1) a combination of hardware and/or software elements, typically used with a PC, that has the functionality of a classic stand-alone instrument (2) a LabVIEW software module (VI), which consists of a front panel user interface and a block diagram program
- **VMC** voltmeter complete signal
- **V_{rms}** volts, root mean square value
- **V_{sense}** the voltage that is created across the device under test when excited by a current

**W**

- **waveform shape** the shape the magnitude of a signal creates over time
- **working voltage** the highest voltage that should be applied to a product in normal use, normally well under the breakdown voltage for safety margin
Index

A
AC current measurements, 2-12 to 2-14
  frequency dependent errors (table), A-4
  input ranges, 2-12 to 2-13
  measurement concerns, 2-13 to 2-14
  burden voltage, 2-13
  errors, 2-14
  resistor heating, 2-13
  using Soft Front Panel, 1-8 to 1-9
AC current specifications
  accuracy (table), A-4
  input characteristics, A-4
AC voltage measurement, 2-7 to 2-9
  input ranges, 2-8
  measurement considerations, 2-8 to 2-9
  AC offset voltage, 2-8
  frequency response, 2-9
  using Soft Front Panel, 1-5 to 1-6
AC voltage specifications
  accuracy (table), A-3
  input characteristics, A-3
  noise rejection, A-3
autozeroing, 2-3
AUX I/O connector and optional trigger cables, 2-15
auxiliary trigger cable (SH9MD-2BNC) (figure), 2-15

B
bulletin board support, C-1
burden voltage, AC current measurement, 2-13

C
cabling test probes, 2-2
common mode noise rejection, 2-6 to 2-7

communication methods, 2-15 to 2-19
  handshaking mode, 2-15 to 2-17
  synchronous mode, 2-17 to 2-18
connectors
  AUX I/O connector and optional trigger cables, 2-15
  front panel connectors, 1-1 to 1-3
continuity measurements, 2-10
conventions used in this manual, iv
current measurements, 2-11 to 2-14
  AC current, 2-12 to 2-14
  burden voltage, 2-13
  errors, 2-14
  input ranges, 2-12
  measurement concerns, 2-13 to 2-14
  resistor heating, 2-13
  using Soft Front Panel, 1-8 to 1-9
DC current, 2-11 to 2-12
  circuit (figure), 2-12
  input ranges, 2-12
  using Soft Front Panel, 1-8 to 1-9
diode measurements, 2-14
customer communication, C-1 to C-2

D
DC current measurements, 2-11 to 2-12
  circuit (figure), 2-12
  input ranges, 2-12
  using Soft Front Panel, 1-8 to 1-9
DC current specifications
  accuracy (table), A-2
  input characteristics, A-2
DC voltage measurement, 2-3 to 2-7
  input impedance, 2-4
  input ranges, 2-4
  measurement considerations, 2-4 to 2-7
Index

noise rejection, 2-5 to 2-7
common mode rejection, 2-6 to 2-7
effective common mode rejection, 2-7
normal mode rejection, 2-5 to 2-6
overview, 2-3
thermal EMFs, 2-5
using Soft Front Panel, 1-5 to 1-6
DC voltage specifications
accuracy (table), A-1
input characteristics, A-2
noise rejection, A-1
Digits control, Soft Front Panel, 1-4
diode measurements
accuracy specifications, A-6
circuitry (figure), 2-14
procedure, 2-14
diode mode
connecting signals for diode test (figure), 1-10
selecting on Soft Front Panel, 1-10
diode mode

E
electronic support services, C-1 to C-2
e-mail support, C-2
environment specifications, A-7
errors
AC current measurements, 2-14
additional AC errors (table), A-4

F
fax and telephone support numbers, C-2
Fax-on-Demand support, C-2
four-wire resistance measurements, 2-10 to 2-11
circuit (figure), 2-11
input ranges, 2-11
using Soft Front Panel, 1-7 to 1-8
frequency response, AC voltage measurement, 2-9
front panel, soft. See NI DMM Soft Front Panel.
front panel connectors, 1-1 to 1-3
FTP support, C-1
fuse replacement, B-1 to B-4
fuse types (table), B-1
NI 4060 (ISA), B-1 to B-2
NI 4060 (PCI), B-2 to B-3
NI 4060 (PXI), B-4

G
grounding, 2-3

H
handshaking mode, 2-15 to 2-17
hardware connections (figure), 2-16
trigger timing (figure), 2-16

I
input impedance, DC voltage measurement, 2-4
input ranges
AC current measurements, 2-12 to 2-13
AC voltage measurement, 2-8
DC current measurements, 2-12
DC voltage measurement, 2-4
four-wire resistance measurements, 2-11
two-wire resistance measurements, 2-10
Instrument Name control, Soft Front Panel, 1-4

M
measurements
current measurements, 2-11 to 2-14
AC current, 2-12 to 2-14
Index

I

DC current, 2-11 to 2-12
diode measurements, 2-14
fundamentals
autozeroing, 2-3
cabling test probes, 2-2
fundamentals, 2-2 to 2-3
grounding, 2-3
selecting resolution, 2-3
warm-up time for NI 4060, 2-2
resistance measurements, 2-9 to 2-11
continuity, 2-10
four-wire, 2-10 to 2-11
two-wire, 2-9 to 2-10
using NI DMM Soft Front Panel, 1-5 to 1-11
DC and AC current, 1-8 to 1-9
DC and AC voltage, 1-5 to 1-6
diode mode, 1-10
four-wire resistance, 1-7 to 1-8
temperature, 1-11
two-wire resistance, 1-6 to 1-7
voltage measurements, 2-3 to 2-9
AC voltage, 2-7 to 2-9
DC voltage, 2-3 to 2-7
mode changes
scanning effects, 2-19
using Mode control, 1-4

N

NI 4060. See also NI DMM Soft Front Panel.
connecting signals, 1-1 to 1-3
current measurements, 2-11 to 2-14
fuse replacement, B-1 to B-4
measurement fundamentals, 2-2 to 2-3
overview, 1-1
resistance measurements, 2-9 to 2-11
safety instructions, 2-1 to 2-2
scanning, 2-14 to 2-19
specifications, A-1 to A-7
voltage measurements, 2-3 to 2-9

NI DMM Soft Front Panel
Digits control, 1-4
Instrument Name control, 1-4
Mode control, 1-4
overview, 1-1 to 1-5
Powerline control, 1-4
Range control, 1-4
Range indicator, 1-3
required selections, 1-5
Simulating control, 1-4
Units indicator, 1-3
using for measurements, 1-5 to 1-11
DC and AC current, 1-8 to 1-9
DC and AC voltage, 1-5 to 1-6
diode mode, 1-10
four-wire resistance, 1-7 to 1-8
temperature, 1-11
two-wire resistance, 1-6 to 1-7
Value indicator, 1-3
noise rejection
AC voltage specifications, A-3
DC voltage measurement, 2-5 to 2-7
common mode rejection, 2-6 to 2-7
effective common mode noise rejection, 2-7
effective common mode rejection, 2-7
normal mode rejection, 2-5 to 2-6
DC voltage specifications, A-1
normal mode noise rejection, 2-5 to 2-6

P

physical specifications, A-7
Powerline control, Soft Front Panel, 1-4

R

range changes
scanning effects, 2-19
using Range control, 1-4

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NI 4060 User Manual
Index

Range indicator, Soft Front Panel, 1-3
relay life, scanning effects, 2-19
resistance accuracy specifications, A-5
resistance measurements, 2-9 to 2-11
continuity, 2-10
four-wire resistance, 2-10 to 2-11
circuit (figure), 2-11
input ranges, 2-11
using Soft Front Panel, 1-7 to 1-8
two-wire resistance, 2-9 to 2-10
circuit (figure), 2-9
input ranges, 2-10
using Soft Front Panel, 1-6 to 1-7
resistor heating, AC current
measurement, 2-13
resolution, selecting, 2-3

S
safety instructions, 2-1 to 2-2
scanning, 2-14 to 2-19
AUX I/O connector and optional trigger cables, 2-15
communication methods, 2-15 to 2-19
handshaking mode, 2-15 to 2-17
synchronous mode, 2-17 to 2-18
measurement concerns, 2-18 to 2-19
mode and range changes, 2-19
relay life, 2-19
settling time, 2-18
settling time, 2-18
Simulating control, Soft Front Panel, 1-4
Soft Front Panel. See NI DMM Soft Front Panel.
specifications, A-1 to A-7
AC current, A-4
AC voltage, A-3 to A-4
additional AC errors (table), A-4
DC current, A-2
DC voltage, A-1 to A-2
diode testing, A-6

environment, A-7
general, A-6
physical, A-7
resistance, A-5
synchronous mode, 2-17 to 2-18
hardware connections (figure), 2-17
trigger timing (figure), 2-18

T
technical support, C-1 to C-2
telephone and fax support numbers, C-2
temperature, measuring, 1-11
test probes, cabling, 2-2
thermal EMFs, DC voltage measurement, 2-5
two-wire resistance measurements, 2-9 to 2-10
circuit (figure), 2-9
input ranges, 2-10
using Soft Front Panel, 1-6 to 1-7

U
Units indicator, Soft Front Panel, 1-3

V
Value indicator, Soft Front Panel, 1-3
voltage measurements, 2-3 to 2-9
AC voltage, 2-7 to 2-9
AC offset voltage, 2-8
frequency response, 2-9
input ranges, 2-8
measurement considerations, 2-8 to 2-9
DC voltage, 2-3 to 2-7
input impedance, 2-4
input ranges, 2-4
measurement considerations, 2-4 to 2-7
noise rejection, 2-5 to 2-7
common mode rejection,  
2-6 to 2-7  
effective common mode rejection, 2-7  
normal mode rejection,  
2-5 to 2-6  
overview, 2-3  
thermal EMFs, 2-5  
using Soft Front Panel, 1-5 to 1-6

W

warm-up time for NI 4060, 2-2