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NI Educational Laboratory Virtual Instrumentation Suite II Series (NI ELVIS™ II Series) User Manual

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Conventions

The following conventions are used in this manual:

<>	Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.
»	The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **Options»Settings»General** directs you to pull down the **Options** menu, select the **Settings** item, and select **General** from the last dialog box.
	This icon denotes a note, which alerts you to important information.
	This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this icon is marked on the product, refer to the *Read Me First: Safety and Electromagnetic Compatibility* document, shipped with the product, for precautions to take.
	When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock.
	When symbol is marked on a product, it denotes a component that may be hot. Touching this component may result in bodily injury.
bold	Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.
italic	Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.
`monospace`	Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.
NI ELVIS II Series	NI ELVIS II Series refers to both the NI ELVIS II and the NI ELVIS II+.

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1

About NI ELVIS II Series

This document contains information about the *NI Educational Laboratory Virtual Instrumentation Suite II Series (NI ELVIS II Series) User Manual* architecture and instruments.

This chapter provides an overview of the NI ELVIS II Series and its possible uses in various academic disciplines.

What You Need to Get Started

Refer to *Where to Start with NI ELVIS II Series* for a list of hardware, software, documentation, and tools you need to set up and use the NI ELVIS II Series.

NI ELVIS II Series Overview

NI ELVIS II Series uses LabVIEW-based software instruments and a custom-designed workstation and prototyping board to provide the functionality of a suite of common laboratory instruments.

NI ELVISmx is the software that supports NI ELVIS II Series hardware. It provides the following LabVIEW soft front panels (SFPs):

- Arbitrary Waveform Generator (ARB)
- Bode Analyzer
- Digital Reader
- Digital Writer
- Digital Multimeter (DMM)
- Dynamic Signal Analyzer (DSA)
- Function Generator (FGEN)
- Impedance Analyzer
- Oscilloscope (Scope)

Note For more information about either the NI ELVIS II or the NI ELVIS II+ scope, refer to the *NI ELVIS II Series Specifications* document.

- Two-Wire Current Voltage Analyzer
- Three-Wire Current Voltage Analyzer
- Variable Power Supplies

Also included are LabVIEW Express VIs and SignalExpress steps to program NI ELVIS II Series in these environments as well as NI ELVIS instruments integrated into NI Multisim.

Refer to Figure 2-1, *Typical NI ELVIS II Series System (NI ELVIS II shown)*, for an illustration of NI ELVIS II Series hardware.

NI ELVIS II Series in Academic Disciplines

You can use NI ELVIS II Series in engineering, physical sciences, and biological sciences laboratories. Instructors can implement the NI ELVIS II Series curriculum with beginning to advanced classes to provide hands-on experience to students.

NI ELVIS II Series in Engineering

NI ELVIS II Series is suited for teaching basic electronics and circuit design to students in electrical engineering, mechanical engineering, and biomedical engineering. The suite offers full testing, measurement, and datalogging capabilities needed for such training. Students can use the removable NI ELVIS II Series Prototyping Board at home to build circuits, thus using laboratory time more effectively.

NI ELVIS II Series SFP instruments, such as the Bode Analyzer and Dynamic Signal Analyzer, offer instructors an opportunity to teach advanced courses in signal analysis and processing. For example, students can construct software filters in LabVIEW and hardware filters on the prototyping board and compare the performance.

Mechanical engineering students can learn sensor and transducer measurements, in addition to basic circuit design by building custom signal conditioning. Students can install custom sensor adapters on the prototyping board. For example, installing a thermocouple jack on the prototyping board allows robust thermocouple connections. The programmable power supply can provide excitation for strain gauges used in strain measurements.

NI ELVIS II Series in Physical Sciences

Physics students typically learn electronics and circuit design theory. NI ELVIS II Series provides these students with the opportunity to implement these concepts. For example, physics students can use NI ELVIS II Series to build signal conditioning circuits for common sensors such as photoelectric multipliers or light detector sensors.

NI ELVIS II Series in Biological Sciences

Caution The NI ELVIS II Series hardware is *not* environmentally sealed; therefore, exercise caution when using NI ELVIS II Series in chemical and biological applications.

Biomedical engineering departments have challenges that are similar to those of mechanical departments. Students typically learn basic electronics and build instruments such as those used to measure temperature. The prototyping board offers signal conditioning capability for temperature sensors, and the NI ELVISmx SFP instruments are ideal for testing the circuits as students build the signal conditioning circuits.

Related Documentation

The following documents contain information that you might find helpful as you read this manual:

- *Where to Start with NI ELVIS II Series*, available at **Start»All Programs»National Instruments»NI ELVISmx for NI ELVIS & NI myDAQ»Where to Start with NI ELVIS II Series**, or on your software media.
- *NI ELVISmx Help*, available at **Start»All Programs»National Instruments»NI ELVISmx for NI ELVIS & NI myDAQ» NI ELVISmx Help**, or on your software media.
- *NI ELVIS II Series Specifications*, available at `ni.com/manuals`.
- *Getting Started with LabVIEW*, available by selecting **National Instruments»LabVIEW *x.x*»LabVIEW Manuals**.
- *LabVIEW Help*, available by selecting **Help»VI, Function, and How-To Help** from the LabVIEW block diagram or front panel.
- *LabVIEW Fundamentals*, available by selecting **National Instruments»LabVIEW *x.x*»LabVIEW Manuals**.
- *Measurement & Automation Explorer Help for DAQmx*, available by selecting **Help»Help Topics»NI-DAQmx** from the Measurement & Automation Explorer (MAX) window.

- *Getting Started with SignalExpress*, available by selecting **National Instruments»LabVIEW SignalExpress**.
- *NI Express Workbench Help*, available by selecting **Help»Express Workbench Help** from the SignalExpress window.
- *Using NI ELVISmx Instruments in NI Multisim*, available in the NI Multisim *Help*.
- `ni.com/academic` for various academic resources.

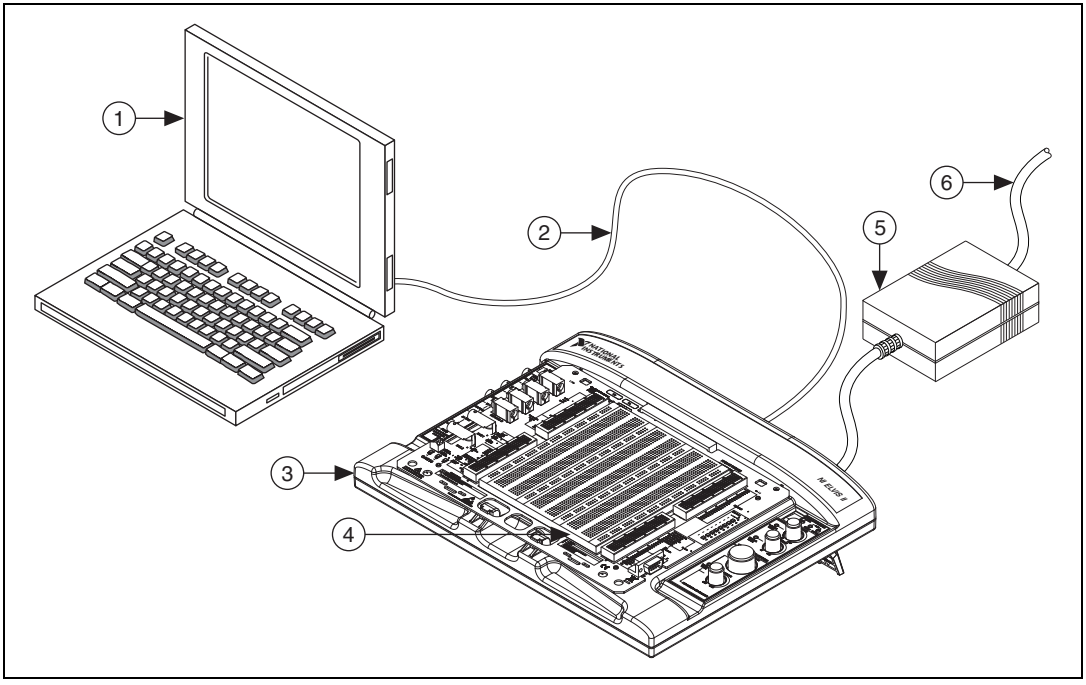
NI documentation is also available at `ni.com`.

2

NI ELVIS II Series Hardware

NI ELVIS II Series combines hardware and software into one complete laboratory suite. This chapter provides an overview of the NI ELVIS II Series hardware.

Figure 2-1 shows a typical NI ELVIS II Series system.



1	Laptop Computer	4	NI ELVIS II Series Prototyping Board
2	USB Cable	5	AC/DC Power Supply
3	NI ELVIS II Workstation	6	To Power Outlet

Figure 2-1. Typical NI ELVIS II Series System (NI ELVIS II shown)

NI ELVIS II Series Workstation

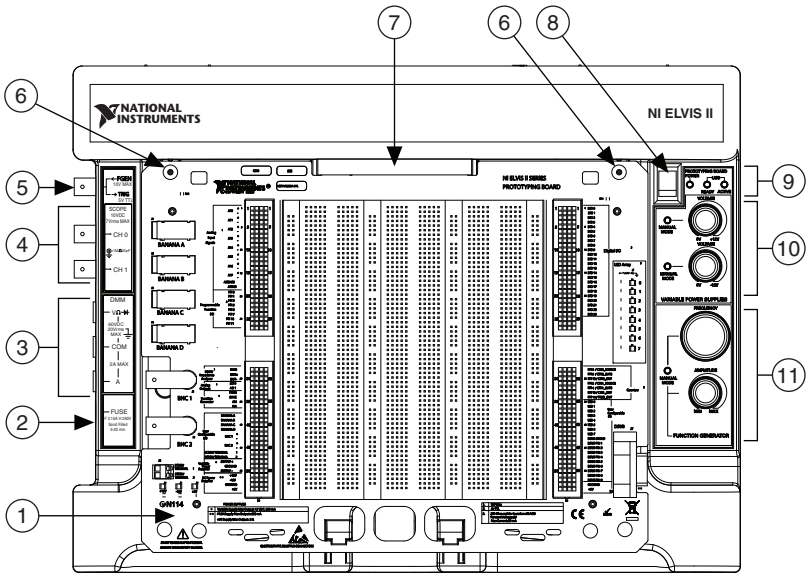
Cautions Refer to the *Read Me First: Safety and Electromagnetic Compatibility* document before connecting or disconnecting any signal wires.

Do not exceed measurement voltage limits for the Oscilloscope (10 VDC, 7 V_{rms} max for the NI ELVIS II, 20 V_{pk} for the NI ELVIS II+) and the DMM (60 VDC, 20 V_{rms}). You must use UL certified scope and DMM probes bearing the UL Mark.

Workstation Top Panel

The workstation provides easy-to-operate knobs for the variable power supplies and function generator, and offers convenient connectivity and functionality in the form of BNC and banana-style connectors to the function generator, scope, and DMM instruments.

Figure 2-2 shows the workstation parts locator diagram.



1 NI ELVIS II Series Prototyping Board	6 Prototyping Board Mounting Screw Holes
2 DMM Fuse	7 Prototyping Board Connector
3 DMM Connectors	8 Prototyping Board Power Switch
4 Oscilloscope Connectors	9 Status LEDs
5 Function Generator Output/Digital Trigger Input Connector	10 Variable Power Supplies Manual Controls
	11 Function Generator Manual Controls

Figure 2-2. Top View of NI ELVIS II Workstation with Prototyping Board (NI ELVIS II shown)

The workstation has the following indicators, controls, and connectors:

- **USB LEDs**
  - **Ready**—Indicates that the NI ELVIS II Series hardware is properly configured and ready to communicate with the host computer.
  - **Active**—Indicates activity on the USB connection to the host computer.

Table 2-1. Workstation USB LED Patterns

ACTIVE LED	READY LED	Description
Off		Main power is off.
Yellow	Off	No connection to the host computer is detected. Make sure NI-DAQmx driver software is loaded and the USB cable is connected.
Off	Green	Connected to a full speed USB host.
Off	Yellow	Connected to a high speed USB host.
Green	Green or Yellow	Communicating with host.

- **Prototyping Board Power Switch and LED**—Controls the power to the prototyping board.

Caution Ensure that the prototyping board power switch is off before inserting or removing it from the workstation.

- **Variable Power Supplies Controls**
  - **Positive Voltage Adjust Knob**—Controls the output voltage of the positive variable power supply. The positive supply can output between 0 and +12 V.
  - **Negative Voltage Adjust Knob**—Controls the output voltage of the negative variable power supply. The negative supply can output between 0 and –12 V.

Note These knobs are only active when the associated variable power supply is set to Manual Mode. An LED next to each knob lights when the variable power supply is in Manual Mode.

- **Function Generator Controls**
  - **Frequency Knob**—Adjusts the output frequency of the generated waveform.
  - **Amplitude Knob**—Adjusts the amplitude of the generated waveform.

Note These knobs are only active when the Function Generator is set to Manual Mode. An LED between the knob lights when the Function Generator is in Manual Mode.

- **DMM Connectors**—60 VDC, 20 V_{rms} max
  - **Voltage, Resistance, and Diode Banana Jack (red)**—The positive input for voltage based DMM functionality.
  - **Common Banana Jack (black)**—The common reference connection for DMM voltage, current, resistance, and diode measurements.
  - **Current Banana Jack (red)**—The positive input for DMM current measurements.
  - **Fuse Cartridge**—Replaceable fuse to protect the current signal path. Refer to the *NI ELVIS II Series Specifications* at `ni.com/manuals` for fuse information

Note The NI ELVIS II Series DMM connections for voltage, current, resistance, and diode measurements are available only through the banana jacks. They are not routed to the prototyping board.

- **Oscilloscope (Scope) Connectors**—10 VDC, 7 V_{rms} max
  - **CH 0 BNC Connector**—The input for channel 0 of the oscilloscope.
  - **CH 1 BNC Connector**—The input for channel 1 of the oscilloscope.

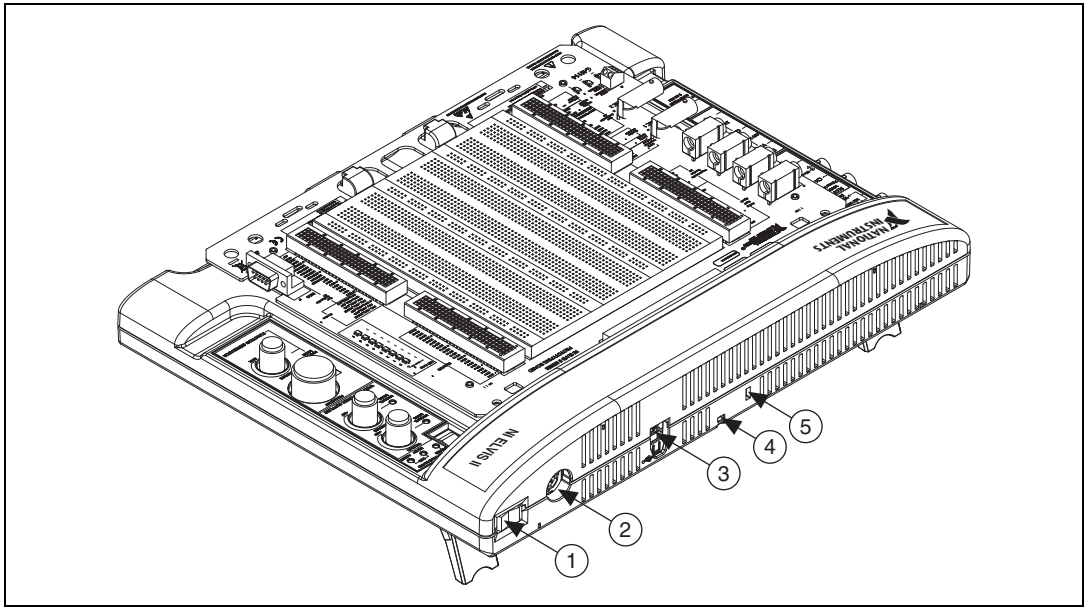
Note The NI ELVIS II Series Oscilloscope channels 0 and 1 are available only through the BNC connectors. They are not internally routed to the prototyping board.

- **FGEN/Trigger Connector**—Optional output of the function generator or a digital trigger input.

Workstation Rear Panel

The workstation rear panel has the following components, as shown in Figure 2-3:

- The workstation power switch. Use this switch to power on or power off the NI ELVIS II Series.
- An AC/DC power supply connection. Use this connector to provide power to the workstation.
- A USB port. Use this to connect the workstation to a computer.
- A cable tie slot. Use this connector to attach cables to the workstation.
- A Kensington security cable lock connector. Use this connector to secure the workstation to a stationary object.

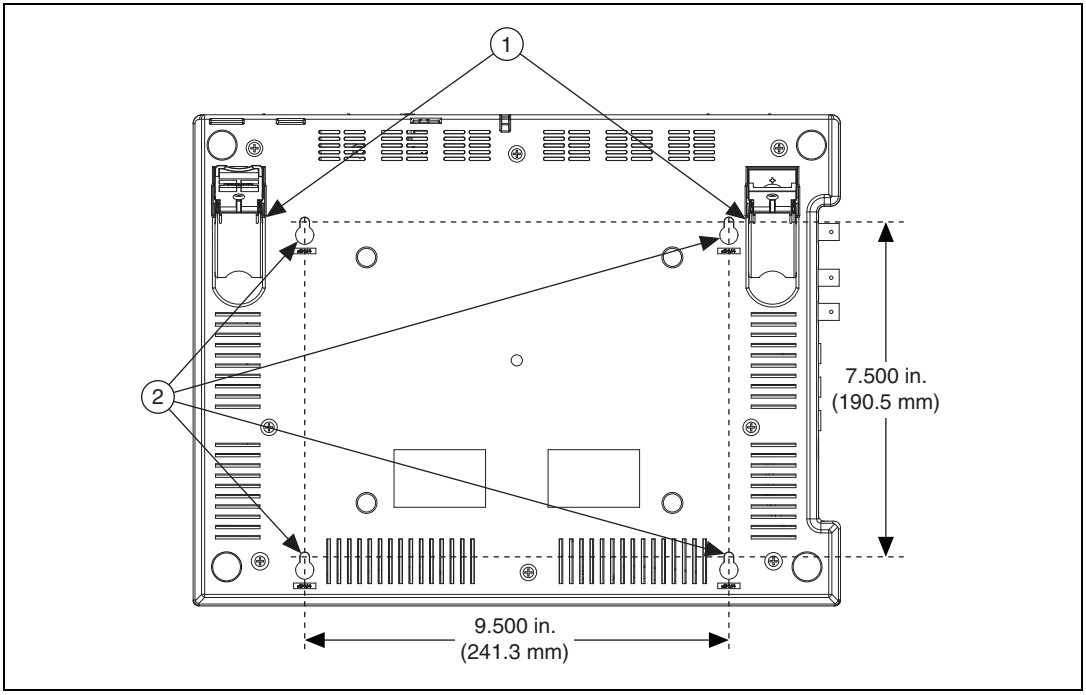


1 Workstation Power Switch	4 Cable Tie Slot
2 AC/DC Power Supply Connector	5 Kensington Security Slot
3 USB Port	

Figure 2-3. Rear View of NI ELVIS II Series System (NI ELVIS II shown)

Workstation Bottom Panel

Two hinged legs are located on the bottom panel to elevate the rear of the workstation. If required, you can mount the workstation on a panel using the dimensional holes shown in Figure 2-4.



1	Hinged Rear Elevation Legs	2	Key Slot Vertical Mounting Holes

Figure 2-4. Bottom View of NI ELVIS II Workstation (NI ELVIS II shown)

Workstation Circuit Protection

The workstation uses solid-state circuit protection on all I/O lines. The only user-serviceable fuse protects the DMM and is accessible through the removable cartridge shown in Figure 2-2.

NI ELVIS II Series Prototyping Board

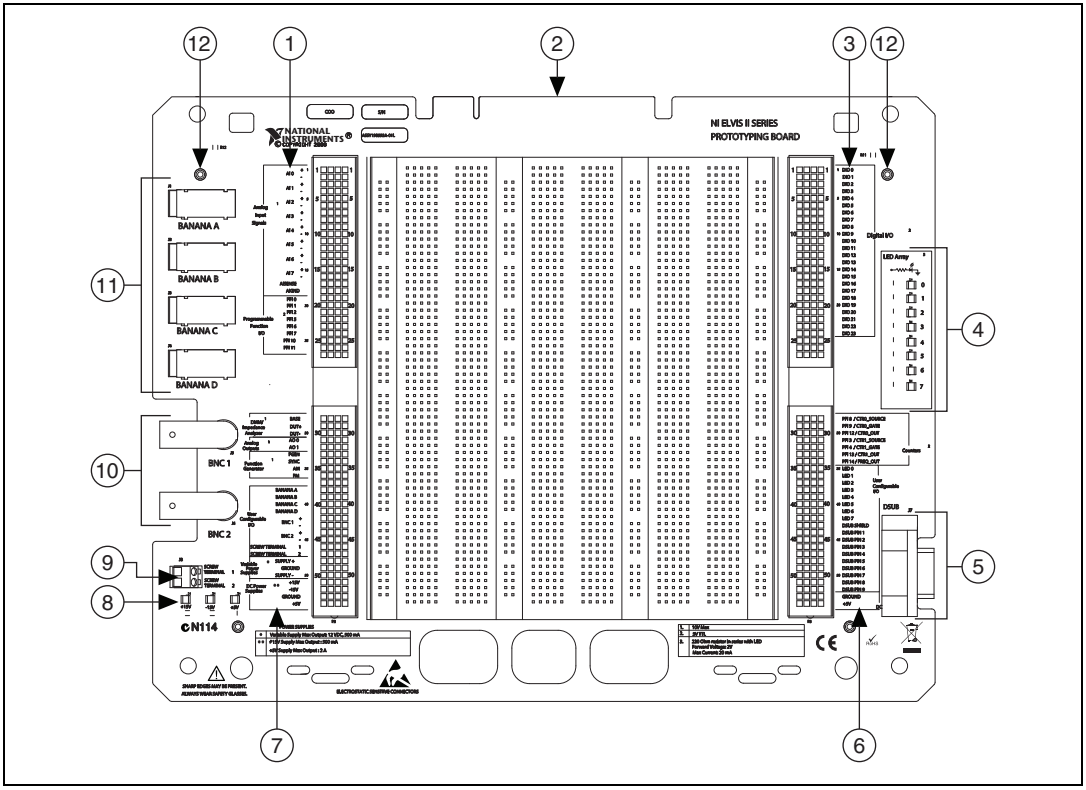
This section describes the NI ELVIS II Series Prototyping Board and how to use it to connect circuits to NI ELVIS II Workstation.

The NI ELVIS II Series Prototyping Board connects to the workstation. The prototyping board provides an area for building electronic circuitry and has the necessary connections to access signals for common applications. You can use multiple prototyping boards interchangeably with the workstation.

Caution Ensure that the prototyping board power switch is off before inserting or removing it from the workstation.

The prototyping board exposes all the signal terminals of the NI ELVIS II Series for use through the distribution strips on either side of the breadboard area. Each signal has a row, and the rows are grouped by function.

Figure 2-5 shows the parts locator diagram for the prototyping board.



1 AI and PFI Signal Rows	8 DC Power Supply Indicators
2 Workstation Interface Connector	9 User-Configurable Screw Terminals
3 DIO Signal Rows	10 User-Configurable BNC Connectors
4 User-Configurable LEDs	11 User-Configurable Banana Jack Connectors
5 User-Configurable D-SUB Connector	12 Screw Positions for Locking
6 Counter/Timer, User-Configurable I/O, and DC Power Supply Signal Rows	
7 DMM, AO, Function Generator, User-Configurable I/O, Variable Power Supplies, and DC Power Supplies Signal Rows	

Figure 2-5. NI ELVIS II Series Prototyping Board

Prototyping Board Power

The prototyping board provides access to ±15 V and a +5 V power supply. You can use these voltage rails to construct many common circuits. Refer to the *NI ELVIS II Series Specifications* at `ni.com/manuals`, for more information about these voltage rails. If any of the power indicators are not

lit when the prototyping board power is enabled, check the connected devices for a short circuit. Turn the prototyping board power switch off and back on to reset the current limiters.

Signal Descriptions

Table 2-2 describes the signals on the prototyping board. The signals are grouped by the functionality section where they are located.

Table 2-2. Signal Descriptions

Signal Name	Type	Description
AI <0..7> ±	Analog Inputs	Analog Input Channels 0 through 7 ±—Positive and negative input channels lines to differential AI channels.
AI SENSE	Analog Inputs	Analog Input Sense—Reference for the analog channels in nonreferenced single-ended (NRSE) mode. For more information about AI modes, refer to Appendix A, *Theory of Operation*.
AI GND	Analog Inputs	Analog Input Ground—Ground reference for the Analog Input signals.
PFI <0..2>, <5..7>, <10..11>	Programmable Function Interface	PFI Lines—Used for static DIO or for routing timing signals.
BASE	3-Wire Voltage/ Current Analyzer	Base excitation for bipolar junction transistors.
DUT+	DMM, Impedance, 2- and 3-Wire Analyzers	Excitation terminal for Capacitance and Inductance measurements (DMM), Impedance Analyzer, 2-Wire Analyzer, and 3-Wire Analyzer.
DUT–	DMM, Impedance, 2- and 3-Wire Analyzers	Virtual ground and current measurement for capacitance and inductance measurements (DMM), the Impedance Analyzer, 2-Wire Analyzer, and 3-Wire Analyzer.
AO <0..1>	Analog Outputs	Analog Output Channels 0 and 1—Used for the Arbitrary Waveform Generator.
FGEN	Function Generator	Function Generator Output.
SYNC	Function Generator	TTL output synchronized to the FGEN signal.
AM	Function Generator	Amplitude Modulation Input—Analog input used to modulate the amplitude of the FGEN signal.
FM	Function Generator	Frequency Modulation Input—Analog input used to modulate the frequency of the FGEN signal.
BANANA <A..D>	User-Configurable I/O	Banana Jacks A through D—Connects to the banana jacks.
BNC <1..2>±	User-Configurable I/O	BNC Connectors 1 and 2 ±—Positive lines tie to the center pins of the BNC connectors; negative lines tie to the shells of the BNC connectors.

Table 2-2. Signal Descriptions (Continued)

Signal Name	Type	Description
SCREW TERMINAL <1..2>	User-Configurable I/O	Connects to the screw terminals.
SUPPLY+	Variable Power Supplies	Positive Variable Power Supply—Output of 0 to 12 V.
GROUND	Power Supplies	Ground.
SUPPLY–	Variable Power Supplies	Negative Variable Power Supply—Output of –12 to 0 V.
+15 V	DC Power Supplies	+15 V Fixed Power Supply.
–15 V	DC Power Supplies	–15 V Fixed Power Supply.
GROUND	DC Power Supplies	Ground.
+5V	DC Power Supplies	+5V Fixed Power Supply.
DIO <0..23>	Digital Input/Output	Digital Lines 0 through 23—These channels are general purpose DIO lines that are used to read or write data.
PFI8 / CTR0_SOURCE	Programmable Function Interface	Static Digital I/O, line P2.0 PFI8, Default function: Counter 0 Source
PFI9 / CTR0_GATE	Programmable Function Interface	Static Digital I/O, line P2.1 PFI9, Default function: Counter 0 Gate
PFI12 / CTR0_OUT	Programmable Function Interface	Static Digital I/O, line P2.4 PFI12, Default function: Counter 0 Out
PFI3 / CTR1_SOURCE	Programmable Function Interface	Static Digital I/O, line P1.3 PFI3, Default function: Counter 1 Source
PFI4 / CTR1_GATE	Programmable Function Interface	Static Digital I/O, line P1.4 PFI4, Default function: Counter 1 Gate
PFI13 / CTR1_OUT	Programmable Function Interface	Static Digital I/O, line P2.5 PFI13, Default function: Counter 1 Out
PFI14 / FREQ_OUT	Programmable Function Interface	Static Digital I/O, line P2.6 PFI14, Default function: Frequency Output
LED <0..7>	User-Configurable I/O	LEDs 0 through 7—Apply 5 V for 10 mA device.
DSUB SHIELD	User-Configurable I/O	Connection to D-SUB shield.
DSUB PIN <1..9>	User-Configurable I/O	Connections to D-SUB pins.
+5 V	DC Power Supply	+5V Fixed Power Supply.
GROUND	DC Power Supply	Ground.

Connecting Signals

Caution Refer to the *Read Me First: Safety and Electromagnetic Compatibility* document before connecting or disconnecting any signal wires.

Analog Input

The NI ELVIS II Series Prototyping Board has eight differential AI channels available—ACH <0..7>. You can configure these inputs in referenced single-ended (RSE) or non-referenced single-ended (NRSE) modes. In RSE mode, each signal is referenced to AIGND. In NRSE mode, each signal is referenced to the floating AISENSE line. Table 2-3 shows the channel mapping for each mode.

Table 2-3. Analog Input Signal Mapping

NI ELVIS II Series Prototyping Board Terminals	Differential Mode (Default)	RSE/NRSE Modes
AI 0 +	AI 0+	AI 0
AI 0 –	AI 0–	AI 8
AI 1 +	AI 1+	AI 1
AI 1 –	AI 1–	AI 9
AI 2 +	AI 2+	AI 2
AI 2 –	AI 2–	AI 10
AI 3 +	AI 3+	AI 3
AI 3 –	AI 3–	AI 11
AI 4 +	AI 4+	AI 4
AI 4 –	AI 4–	AI 12
AI 5 +	AI 5+	AI 5
AI 5 –	AI 5–	AI 13
AI 6 +	AI 6+	AI 6
AI 6 –	AI 6–	AI 14

Table 2-3. Analog Input Signal Mapping (Continued)

NI ELVIS II Series Prototyping Board Terminals	Differential Mode (Default)	RSE/NRSE Modes
AI 7 +	AI 7+	AI 7
AI 7 –	AI 7–	AI 15
AISENSE	—	AI SENSE
AIGND	AI GND	AI GND

Grounding Considerations

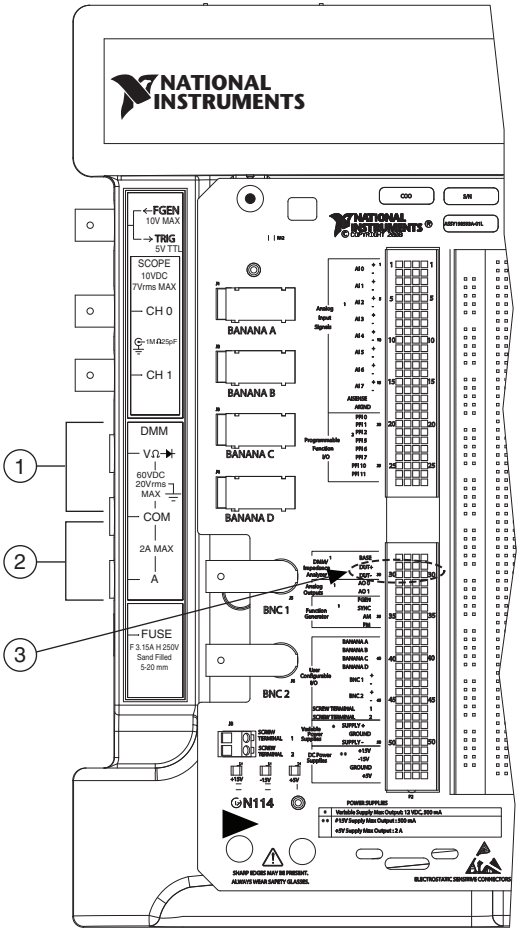
The analog input channels are differential, you must therefore establish a ground point somewhere in the signal path. As long as the signal you are measuring is referenced to one of the AI GND pins, the measurement is correctly referenced. If you are measuring a floating source, such as a battery, connect one end of the signal to the ground.

DMM

Voltage, Current, Resistance, Diode, and Continuity

The primary DMM instrument on NI ELVIS II Series is isolated and its terminals are the three banana jacks on the side of the workstation. For DC Voltage, AC Voltage, Resistance, Diode, and Continuity Test modes, use the VΩ→|– and COM connectors. For DC Current and AC Current modes, use the A and COM connectors. For easy access to circuits on the prototyping board, you can use banana-to-banana cables to wrap the signals from the user-configurable banana jacks to the DMM connectors on the workstation.

Figure 2-6 shows the banana jacks on the workstation used for V/R/Diode/Continuity and for Current.



1	Connectors for Voltage/Resistance/Diode/Continuity
2	Connectors for Current
3	Connectors for Capacitance/Inductance

Figure 2-6. Connections for DMM Measurements (NI ELVIS II shown)

Capacitance and Inductance

The capacitance and inductance measurements of the DMM use the nonisolated Impedance Analyzer terminals, DUT+ and DUT–, on the prototyping board. Refer to Figure 2-6.

Oscilloscope

The NI ELVIS II oscilloscope uses the analog input engine to acquire up to 1.25 MS/s for a single channel or 500 kS/s for two channels with 16-bit resolution.

The NI ELVIS II+ oscilloscope uses dedicated analog-to-digital converters to acquire at 100 Ms/S with 8-bit resolution on one or both channels.

Refer to the *NI ELVIS II Series Specifications* for more information.

Analog Output

NI ELVIS II Series provides access to the two analog outputs at the AO 0 and AO 1 terminals. These channels are used for arbitrary waveform generation. AO 0 is also used internally for BASE excitation in the Three-Wire Voltage/Current Analyzer. For more details, refer to Appendix A, *Theory of Operation*.

Function Generator (FGEN)

The function generator output can be routed to either the FGEN/TRIG BNC connector or the FGEN terminal on the prototyping board. A +5 V digital signal is available at the SYNC terminal. The AM and FM terminals provide analog inputs for the amplitude and frequency modulation of the function generator output.

Power Supplies

The DC power supplies provide fixed output of +15 V, –15 V, and +5 V.

The variable power supplies provide adjustable output voltages from 0 to +12 V on the SUPPLY+ terminal, and 0 to –12 V on the SUPPLY– terminal.

All power supplies on NI ELVIS II Series are referenced to GROUND.

Caution Use the NI ELVIS II Series with a VDC, UL Listed, limited power source (LPS). The power supply must bear the UL Listed mark, LPS. The power supply must meet any safety and compliance requirements of the country of use.

Digital I/O

The digital lines exposed on the prototyping board are internally connected to port 0 of the device. You can configure them as input or output.

Programmable Function Interface (PFI)

The PFI lines are TTL-compatible I/O that can route timing signals to and from the AI, AO, or counter/timer engines. They can also be configured as static digital I/O.

User-Configurable I/O

The prototyping board provides several user-configurable connectors: four banana jacks, two BNC connectors, and a D-SUB connector. Each pin of the connector has a connection to the distribution strips.

Eight bicolor (green/yellow) LEDs are provided for general digital output on the prototyping board. The green anode of each LED is connected to the distribution strip through a 220 Ω resistor, and each cathode is connected to ground. Drive the line with +5 V to turn the LED green or –5 V to turn the LED yellow,

Bode Analyzer

The Bode Analyzer uses the Function Generator to output a stimulus and then uses two analog input channels to measure the response and stimulus respectively.

Two-Wire Current-Voltage Analyzer

Connect the signal to DUT+ and DUT– when using the Two-Wire Current-Voltage Analyzer.

Three-Wire Current-Voltage Analyzer

The Three-Wire Current-Voltage Analyzer uses DUT+, DUT–, and BASE to plot the current-voltage response of a NPN or PNP bipolar transistor. Table 2-4 shows the transistor to prototyping board connections.

Table 2-4. Transistor to Prototyping Board Connections

Transistor Node	Prototyping Board Connections
Base	BASE
Collector	DUT+
Emitter	DUT–

Counter/Timer

The prototyping board provides access to the two counter/timers on the device, which are also accessible from software. These inputs are used for counting TTL signals, edge detection, and pulse generation applications. The CTR0_SOURCE, CTR0_GATE, CTR0_OUT, CTR1_GATE, and CTR1_OUT signals are connected to the default Counter 0 and Counter 1 PFI lines. Refer to the *M Series User Manual* for more information.

3

NI ELVISmx Software

This chapter provides an overview of the NI ELVISmx software available for use with the NI ELVIS II Series.

The NI ELVISmx software, created in LabVIEW, takes advantage of the capabilities of virtual instrumentation. The software includes SFP instruments, LabVIEW Express VIs, and SignalExpress blocks for programming the NI ELVIS II Series hardware.

Using NI ELVIS II Series with SFP Instruments

Note Before opening a SFP, the workstation must be powered on with the USB *READY* LED lit. If you open the SFP before powering on the workstation, an error occurs. Close the SFP, power on the workstation, and open the SFP again.

NI ELVISmx provides SFP instruments, created in LabVIEW, and the source code for the instruments. You cannot directly modify the executable files, but you can modify or enhance the functionality of these instruments by modifying the LabVIEW code, which installs in the following location:

- Windows XP/2000:

  `C:\Documents and Settings\All Users\Shared Documents\National Instruments\NI ELVISmx Source Code`

- Windows 7/Vista:

  `C:\Users\Public\Documents\National Instruments\NI ELVISmx Source Code`

Note For a detailed explanation of the SFP instruments, instructions for taking a measurement with each instrument and information on the other NI ELVISmx Instrument Launcher features, refer to the *NI ELVISmx Help*. To access this help file, go to **Start» All Programs»National Instruments»NI ELVISmx for NI ELVIS & NI myDAQ» NI ELVISmx Help**.

NI ELVISmx Instrument Launcher

The NI ELVIS Instrument Launcher provides access to the NI ELVISmx SFP instruments, additional featured instruments, documentation and online resource links, and personal file access. Launch the Instrument Launcher by navigating to **Start»All Program Files»National Instruments»NI ELVISmx»NI ELVISmx Instrument Launcher**. This opens the suite of LabVIEW SFP instruments.

To launch an instrument, click the button corresponding to the desired instrument. Select the NI ELVIS II Series device from the **Device** control.

Some instruments perform similar operations using the same resources of the NI ELVIS II Series hardware and therefore cannot run at the same time. If you launch two instruments with overlapping functionality that cannot run at the same time, the NI ELVISmx software generates an error dialog describing the conflict. The instrument with the error is disabled and will not function until the conflict is resolved. For information about possible resource conflicts refer to Appendix B, *Resource Conflicts*.

Arbitrary Waveform Generator (ARB)

This advanced-level SFP instrument uses the AO capabilities of the device. You can create a variety of signal types using the Waveform Editor software, which is included with the NI ELVISmx software. You can load waveforms created with the NI Waveform Editor into the ARB SFP to generate stored waveforms. Refer to the *NI ELVISmx Help* for more information about the Waveform Editor.

Since the device has two AO channels, two waveforms may be simultaneously generated. You can choose to run continuously or run once.

Bode Analyzer

By combining the frequency sweep feature of the function generator and the AI capability of the device, a full-function Bode Analyzer is available with NI ELVISmx. You can set the frequency range of the instrument and choose between linear and logarithmic display scales. Refer to the *NI ELVISmx Help* for required hardware connections.

Digital Reader

This instrument reads digital data from the NI ELVIS II Series digital lines. You can read eight consecutive lines at a time: 0..7, 8..15, 16..23 either continuously or you can take a single reading.

Digital Writer

This instrument updates the NI ELVIS II Series digital lines with user-specified digital patterns. You can manually create a pattern or select predefined patterns, such as ramp, toggle, or walking 1s. This instrument can control eight consecutive lines and either continually output a pattern or just perform a single write. The output of the NI ELVISmx Digital Writer SFP stays latched until another pattern is output, the lines it is using are configured for read, or the power is cycled on the NI ELVIS II Series workstation. Output voltage levels of the NI ELVIS II Series digital lines are TTL compatible.

Digital Multimeter (DMM)

This commonly used instrument can perform the following types of measurements:

- Voltage (DC and AC)
- Current (DC and AC)
- Resistance
- Capacitance
- Inductance
- Diode test
- Audible continuity

For capacitance and inductance measurements you must make connections to the DMM/Impedance Analyzer on the prototyping board. For all other measurements make connections to the DMM banana jacks on the workstation.

Dynamic Signal Analyzer (DSA)

This instrument performs a frequency domain transform of the AI or scope waveform measurement. It can either continuously make measurements or make a single scan. You can also apply various window and filtering options to the signal.

Function Generator (FGEN)

This instrument generates standard waveforms with options for the type of output waveform (sine, square, or triangle), amplitude selection, and frequency settings. In addition, the instrument offers DC offset setting, frequency sweep capabilities, and amplitude and frequency modulation. You can route the FGEN to the prototyping board or to the FGEN/TRIG BNC connector on the left side of the workstation.

Impedance Analyzer

This instrument is a basic impedance analyzer that is capable of measuring the resistance and reactance for passive two-wire elements at a given frequency.

Oscilloscope (Scope)

This instrument provides the functionality of the standard desktop oscilloscope found in typical undergraduate laboratories. The NI ELVISmx Oscilloscope SFP has two channels and provides scaling and position adjustment knobs along with a modifiable timebase. You can also choose trigger source and mode settings. The autoscale feature allows you to adjust the voltage display scale based on the peak-to-peak voltage of the AC signal for the best display of the signal. You can choose between digital or analog hardware triggering. You can connect to the NI ELVIS II Series Oscilloscope from the BNC connectors on the side panel of the workstation.

The computer-based scope display has the ability to use cursors for accurate screen measurements.

Two-Wire and Three-Wire Current-Voltage Analyzers

These instruments allow you to conduct diode and transistor parametric testing and view current-voltage curves. The two-wire instrument offers full flexibility in setting parameters such as voltage and current ranges, and can save data to a file. In addition, the three-wire instrument offers base current settings for measurements of NPN and PNP transistors. Refer to *NI ELVISmx Help* for connection details. Both instruments have cursors for more accurate onscreen measurements.

Variable Power Supplies

You can control the output of the positive or negative variable power supply with these SFP instruments. The negative power supply can output between –12 and 0 V, and the positive power supply can output between 0 and +12 V.

Using NI ELVIS II Series with LabVIEW

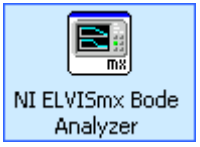
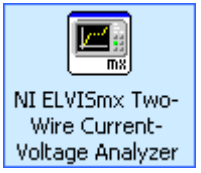
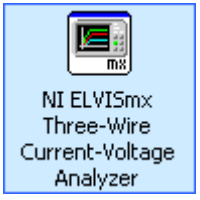
This section provides an overview of using NI ELVIS II Series with LabVIEW.

LabVIEW Express VIs

With NI ELVISmx, the NI ELVIS II Series instruments have an associated LabVIEW Express VI. Express VIs allow you to interactively configure the settings for each instrument. This enables you to develop LabVIEW applications without extensive programming expertise. To access the NI ELVISmx Express VIs, open a LabVIEW block diagram and select **Measurement I/O»NI ELVISmx** from the function palette.

Table 3-1 shows the available NI ELVISmx Express VIs. Refer to the *NI ELVISmx Help* for more information.

Table 3-1. NI ELVISmx Express VIs

NI ELVISmx Express VI			
			
			
			—

Using NI-DAQmx with NI ELVIS II Series

NI ELVIS II Series is supported by NI-DAQmx, and therefore you can program it using the NI-DAQmx API.

Furthermore, some general AI, AO, and timing functionality of the device is available through the workstation and you can program it using NI-DAQmx. Refer to *NI ELVISmx Help* and *NI-DAQmx Help* for more information.

Using NI ELVIS II Series in SignalExpress

To use an NI ELVIS II Series instrument within SignalExpress complete the following steps:

1. Launch SignalExpress.
2. Click the **Add Step** button.
3. If NI ELVISmx is installed, NI ELVISmx is in the list of steps. Expand NI ELVISmx.
4. Choose the instrument to add under **Analog** or **Digital»Acquire** or **Generate Signals**.
5. Select the NI ELVIS II Series device from Device control.
6. Set the various controls on the configuration panel appropriately for the measurement.
7. Run the SignalExpress project.

For more information about using NI ELVIS II Series with SignalExpress, refer to the *NI SignalExpress Workbench Help*, which you can find through the Help menu in SignalExpress.

For more information about SignalExpress, refer to the *Getting Started with SignalExpress Guide*.

4

Calibration

Electronic components such as ADCs are characterized by nonlinearities and drift due to time and temperature. Compensating for these inherent sources of error requires device self-calibration. To improve the accuracy of the system, you should periodically self-calibrate the NI ELVIS II Series.

You can self-calibrate the NI ELVIS II Series by right-clicking the device in MAX and choosing the self-calibration option.

Note Disconnect all cables and remove the prototyping board before running self-calibration.

A

Theory of Operation

Analog Input

Figure A-1 shows the analog input circuitry of NI ELVIS II Series.

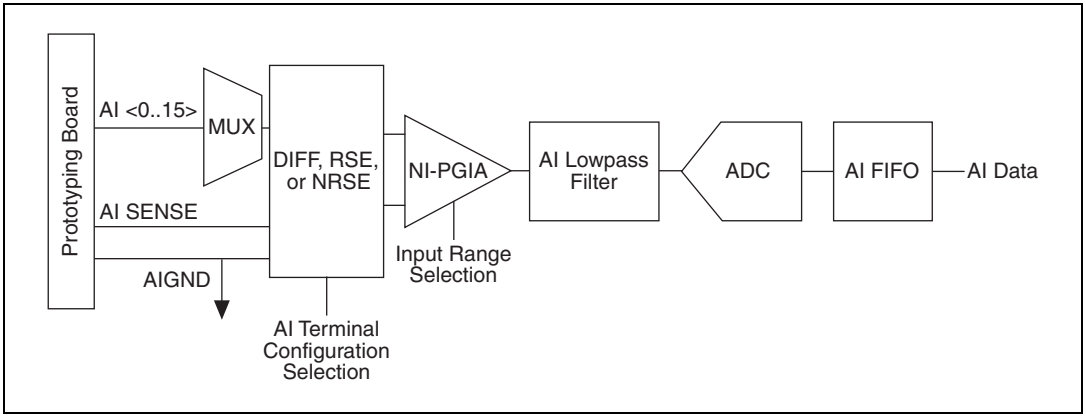


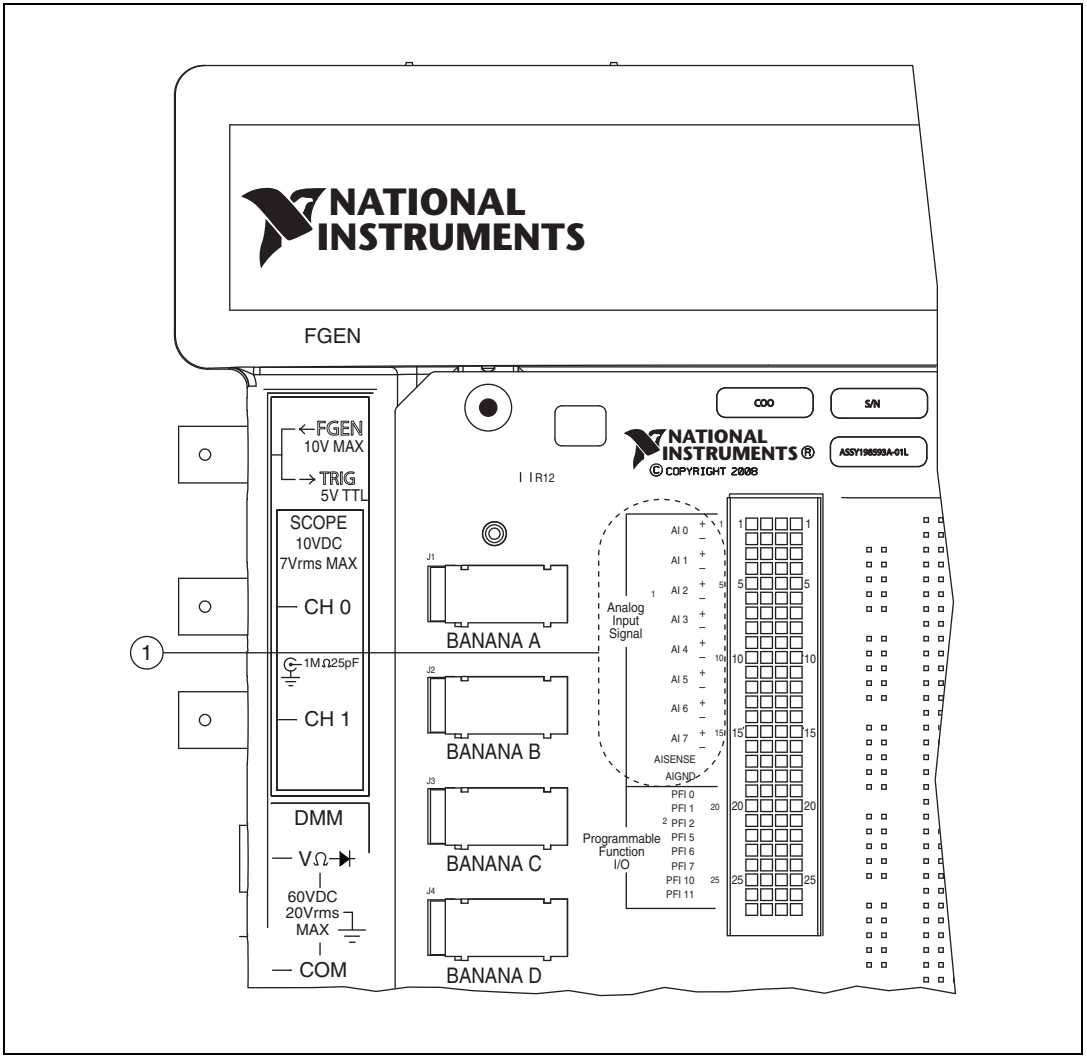
Figure A-1. NI ELVIS II Series Analog Input Circuitry

Analog Input Circuitry

The NI ELVIS II Series provides eight differential (16 single-ended) high-impedance analog input channels available on the NI ELVIS II Series Prototyping Board. These inputs are scanned with a multiplexer into a single analog-to-digital converter.

I/O Connector

You can connect analog input signals to the workstation through the terminals on the prototyping board. The proper way to connect analog input signals depends on the analog input ground-reference settings. Figure A-2 shows the location of the AI connectors on the prototyping board.



1	Analog Input Connections

Figure A-2. NI ELVIS II Prototyping Board Analog Input Connections

Multiplexer

The NI ELVIS II Series uses one analog-to-digital converter (ADC) for analog input measurements. The multiplexers (MUX) route one AI channel at a time to the ADC through the NI-PGIA.

AI Terminal Configuration Selection

AI Terminal Configuration Selection circuitry selects between differential, referenced single-ended, and non-referenced single-ended input modes. Each AI channel in a scan list can use a different mode. Refer to the *Connecting Analog Input Signals* section for more information.

Instrumentation Amplifier (NI-PGIA)

The NI programmable gain instrumentation amplifier (NI-PGIA) is a measurement and instrument class amplifier that minimizes settling times for all input ranges. The NI-PGIA can amplify or attenuate an AI signal to ensure that you use the maximum resolution of the ADC. NI ELVIS II Series uses the NI-PGIA to deliver high accuracy even when sampling multiple channels with small input ranges at fast rates. The NI ELVIS II Series can sample channels in any order at the maximum conversion rate, and you can individually program each channel in a scan list with a different input range.

A/D Converter

The NI ELVIS II Series uses an analog-to-digital converter (ADC) to convert the AI signal into a 16-bit digital number.

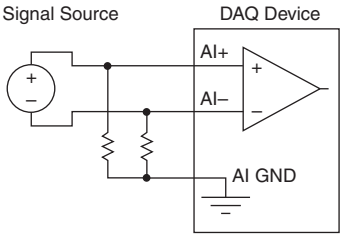
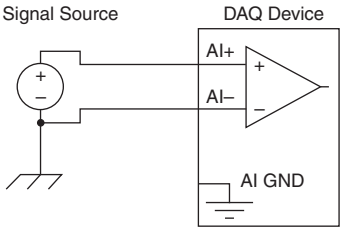
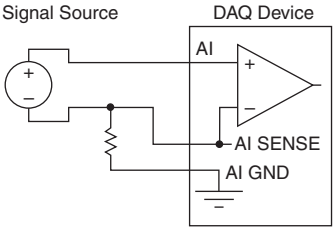
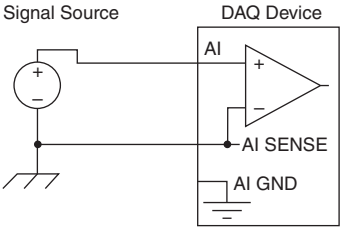
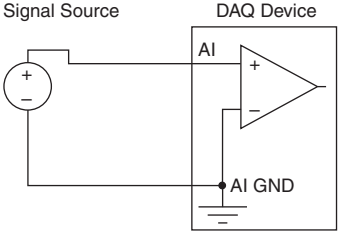
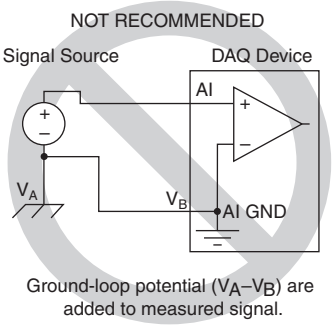
AI FIFO

The NI ELVIS II Series can perform both single and multiple A/D conversions of a fixed or infinite number of samples. A large first-in-first-out (FIFO) buffer holds data during AI acquisitions to ensure that no data is lost.

Connecting Analog Input Signals

Table A-1 summarizes the recommended input configuration for both floating signal sources and ground-referenced signal sources.

Table A-1. Analog Input Configuration

AI Ground-Referenced Setting	Floating Signal Sources* (Not Connected to Building Ground)	Ground-Referenced† Signal Sources
Differential		
Non-Referenced Single-Ended (NRSE)		
Referenced Single-Ended (RSE)		

* Examples of floating signal sources—ungrounded thermocouples, signal conditioning with isolated outputs, and battery devices.

† Example of ground-referenced signal sources—plug-in instruments with non-isolated outputs.

Multichannel Scanning Considerations

The NI ELVIS II Series can scan multiple channels at high rates and digitize the signals accurately. However, you must consider several issues when designing your measurement system to ensure high accuracy of your measurements.

In multichannel scanning applications, accuracy is affected by settling time. When your workstation switches from one AI channel to another AI channel, the device configures the NI-PGIA with the input range of the new channel. The NI-PGIA then amplifies the input signal with the gain for the new input range. Settling time refers to the time it takes the NI-PGIA to amplify the input signal to the desired accuracy before it is sampled by the ADC. Refer to *Settling Time for Multichannel Measurements* in the *NI ELVIS II Series Specifications* for specifics.

The NI ELVIS II Series is designed to have fast settling times. However, several factors can increase the settling time, which decreases the accuracy of your measurements. To ensure fast settling times, do the following:

1. Use low impedance sources.
2. Use short high-quality cabling.
3. Avoid switching from a large to a small input range.

The *Using Low Impedance Sources*, *Using Short High-Quality Cabling*, and *Avoid Switching from a Large to a Small Input Range*, sections contain more information about these factors.

Using Low Impedance Sources

For the fastest settling time, your signal sources must have an impedance of <1 kΩ. Large source impedances increase the settling time of the NI-PGIA, and therefore decrease the accuracy at fast scanning rates.

Settling times increase when scanning high-impedance signals due to a phenomenon called charge injection. Multiplexers contain switches, usually made up of switched capacitors. When one of the channels, for example channel 0, is selected in a multiplexer, those capacitors accumulate charge. When the next channel, for example channel 1, is selected, the accumulated charge leaks backward through channel 1. If the output impedance of the source connected to channel 1 is high enough, the resulting reading of channel 1 can be partially affected by the voltage on channel 0. This effect is referred to as ghosting. If your source impedance is high, you can decrease the scan rate to allow the NI-PGIA more time to settle.

Another option is to use a voltage follower circuit to decrease the impedance seen by the workstation. Refer to the KnowledgeBase document, *How Do I Create a Buffer to Decrease the Source Impedance of My Analog Input Signal?*, by going to `ni.com/info` and entering the Info Code `rdbbis`.

Note The NI ELVIS II Series oscilloscope channels are buffered and therefore immune to ghosting effects from high source impedances. The input impedance of the scope channels, however, is 10 MΩ, which creates a voltage divider against the high source impedance.

Using Short High-Quality Cabling

Using short high-quality cables can minimize several effects that degrade accuracy including crosstalk, transmission line effects, and noise. The capacitance of the cable also can increase the settling time.

National Instruments recommends using individually shielded, twisted-pair wires that are 2 m or less to connect AI signals to the device.

Avoid Switching from a Large to a Small Input Range

Switching from a channel with a large input range to a channel with a small input range can greatly increase the settling time.

Suppose a 4 V signal is connected to channel 0 and a 1 mV signal is connected to channel 1. The input range for channel 0 is –10 V to 10 V and the input range of channel 1 is –200 mV to 200 mV.

When the multiplexer switches from channel 0 to channel 1, the input to the NI-PGIA switches from 4 V to 1 mV. The approximately 4 V step from 4 V to 1 mV is 1,000% of the new full-scale range. For a 16-bit device to settle within 0.0015% (15 ppm or 1 LSB) of the ±200 mV full-scale range on channel 1, the input circuitry must settle to within 0.000031% (0.31 ppm or 1/50 LSB) of the ±10 V range. Some devices can take many microseconds for the circuitry to settle this much.

To avoid this effect, arrange your channel scanning order so that transitions from large to small input ranges are infrequent.

In general, you do not need this extra settling time when the NI-PGIA is switching from a small input range to a larger input range.

Analog Output

Figure A-3 shows the analog output circuitry of NI ELVIS II Series.

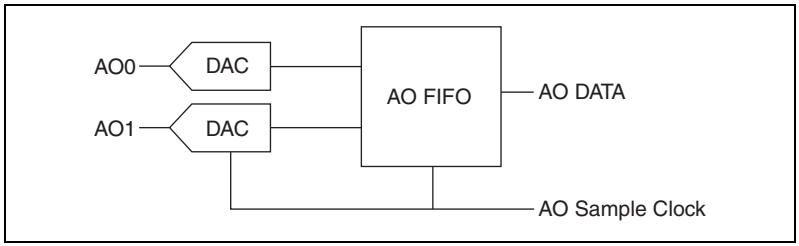


Figure A-3. NI ELVIS II Series Analog Output Circuitry

Analog Output Circuitry

NI ELVIS II Series workstation has two AO channels that are controlled by a single clock and are capable of waveform generation.

DACs

Digital-to-analog converters (DACs) convert digital codes to analog voltages.

AO FIFO

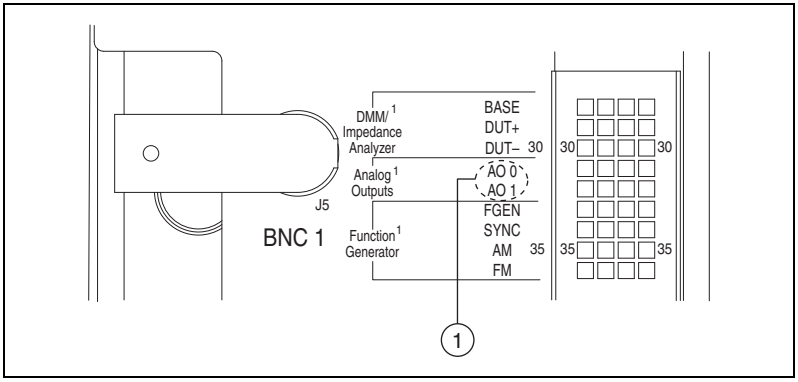
The AO FIFO enables analog output waveform generation. The first-in-first-out (FIFO) memory buffer between the computer and the DACs allows you to download the points of a waveform to the DACs without host computer interaction.

AO Sample Clock

The AO Sample Clock triggers a DAC conversion.

Connecting Analog Output Signals

The analog outputs are accessible on the NI ELVIS II Series Prototyping Board at the AO 0 and AO 1 terminals. Analog outputs are referenced to AIGND. Figure A-4 shows how to make AO connections to the device.



1 Analog Output Prototyping Board Connections

Figure A-4. Analog Output Connections

DMM

This section provides information about the following DMM measurement operations:

- DC voltage
- AC voltage
- DC and AC current
- Resistance
- Diode

Note Refer to the *Impedance Analyzer* section for information about capacitance and inductance measurements.

DC Voltage

Figure A-5 shows the DC Voltage (DCV) measurement circuitry of the NI ELVIS II Series DMM.

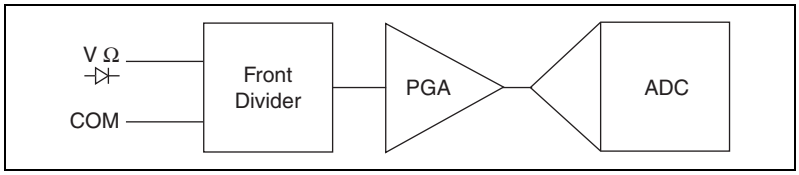


Figure A-5. NI ELVIS II DMM DCV Measurement Circuitry

The front divider can attenuate a large DCV signal to match the input range of the programmable gain amplifier (PGA). If the input DCV signal is not large enough, the front divider is bypassed. The input resistance is the total resistance of the front divider.

The PGA can amplify or attenuate a DCV signal to ensure that it can meet the input range of the ADC.

The analog-to-digital converter (ADC) digitizes the DCV signal by converting the analog voltage into a digital number.

Input Resistance

Figure A-6 shows an equivalent circuit with the 11 MΩ input resistance and illustrates that the voltage source impedance can affect the final accuracy. For example, if the source impedance is 11 kΩ, the error due to the extra attenuation is:

$$\frac{11\ \text{k}\Omega}{11\ \text{M}\Omega} = 0.1\%$$

Be sure to consider this error if it is appropriate for your application.

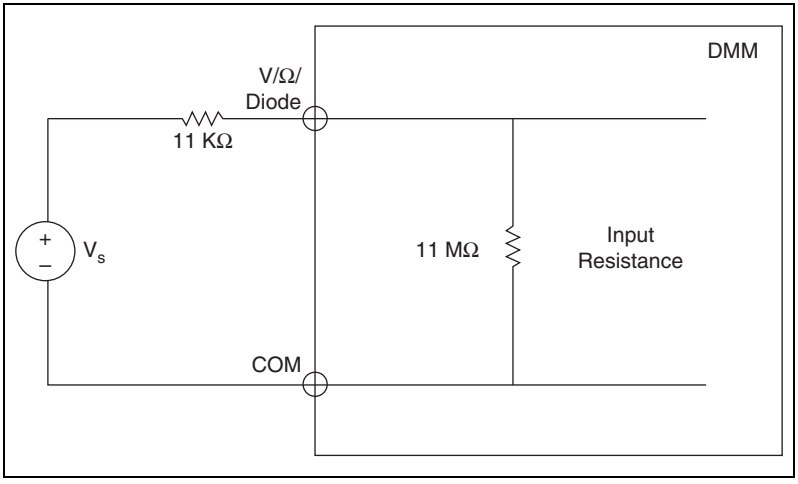


Figure A-6. Example Input Resistance Equivalent Circuitry with 11 kΩ Source Impedance

Offset Nulling

Offset nulling consists of measuring the corresponding zero reading in a measurement path and subtracting this value from subsequent samples.

The way you connect the leads to obtain the zero reading depends upon the type of measurement you are taking.

To perform offset nulling, complete the following steps:

1. Disconnect the device under test (DUT) from the leads that are connected to the DMM.
2. If you are measuring DC voltage, inductance, or resistance, short the input leads to obtain the corresponding zero reading. If you are

measuring DC current or capacitance, leave the leads disconnected (open circuit) to obtain the corresponding zero reading.

3. Record the value of the measurement.
4. Connect the leads to the DUT, and subtract the value measured in step 3 from all subsequent measurements.

You can perform the subtraction operation automatically using the NI ELVISmx DMM SFP offset nulling feature.

AC Voltage

Figure A-7 shows the AC Voltage (ACV) measurement circuitry of NI ELVIS II Series DMM.

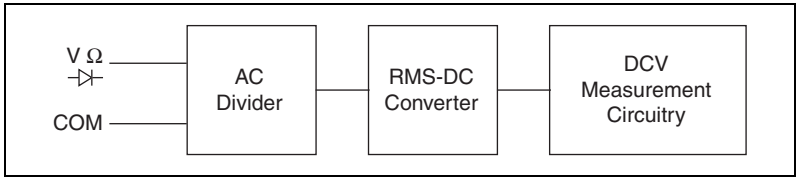


Figure A-7. NI ELVIS II Series DMM ACV Measurement Circuitry

The main purpose of AC Divider is to scale the ACV signals to drive the RMS-DC converter in its linear region.

The RMS-DC Converter converts the ACV signal to a DCV signal based on energy conservation. The output of the converter routes to DCV measurement circuitry for the final measurement result.

The ACV measurement leverages the DCV measurement circuitry. For more information, please refer to the *DC Voltage* section.

Coupling

The AC Voltage mode of the DMM uses a coupling capacitor to remove DC offsets before digitization. This functionality is standard in traditional DMMs. To measure AC voltage in the presence of large DC offsets, such as ripple on a DC power supply, use AC Voltage mode.

Offset Errors

Noise present on the input signal path of a DMM results in offset on the AC RMS function. It is not advisable to reduce this error by doing a subtraction operation (null in the DMM SFP) because the value displayed is the rms sum of the inputs.

For example, assume a 0.5 mV offset error on the 5 V range exists. If an input of 50 mV_{rms} is applied, the reading is:

$$Reading = \sqrt{(S^2 + N^2)}$$

$$Reading = \sqrt{[(50\ mV)^2 + (0.5\ mV)^2]}$$

$$Reading = 50.0025\ mV_{rms}$$

What appeared to be a huge offset error now accounts for only a 0.005% error in the measurement because of the rms conversion. If instead you use the ELVISmx DMM SFP Offset Null feature, the result is:

$$50\ mV - 0.5\ mV = 49.5\ mV$$

This result represents a 1% error.

DC and AC Current

Figure A-8 shows the DMM current measurement circuitry.

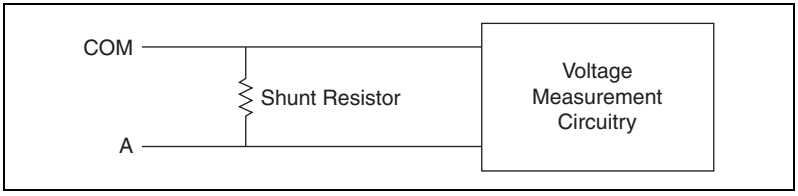


Figure A-8. NI ELVIS II DMM Current Measurement Circuitry

The external current flows through a shunt resistor to generate voltage for the AC or DC voltage measurement circuitry.

Shunt Resistors

The NI ELVIS II Series DMM uses an internal shunt resistor with a temperature coefficient and power ratings selected to reduce resistor self-heating errors. For shunt resistor values, refer to the *NI ELVIS II Series Specifications* document.

Offset Nulling

Refer to offset nulling in the *DC Voltage* section.

Resistance

The NI ELVIS II Series DMM makes resistance measurements using a constant-current technique. A current is supplied to the resistance under test, and the DMM measures the resulting voltage as represented in Figure A-9.

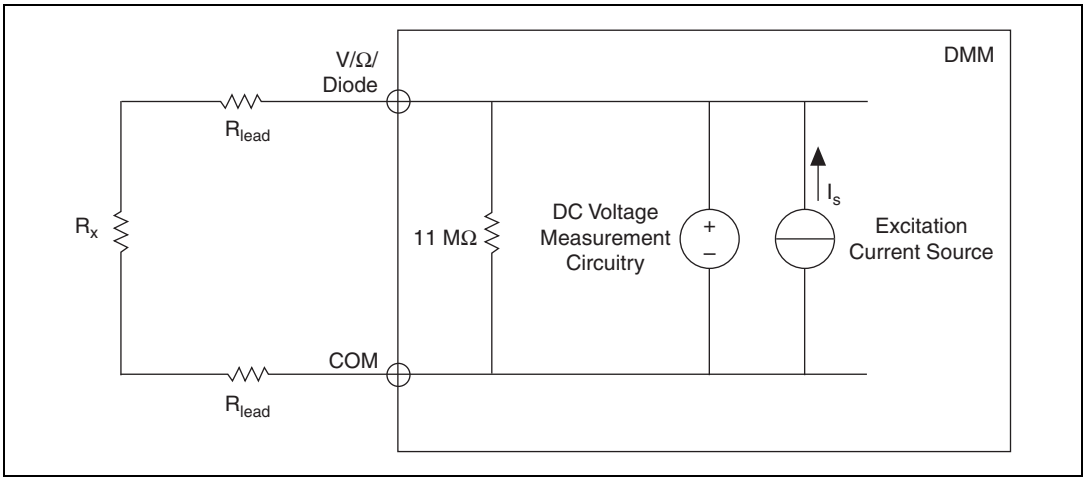


Figure A-9. Resistance Measurement Circuitry

Excitation Current Source

The internal excitation current flows through both an 11 MΩ internal input resistor and an external resistor, but the NI ELVIS II Series calibration algorithm compensates the shunt effect of the internal input resistor. Each resistance range corresponds to different current source value. For more information, refer to the *NI ELVIS II Series Specifications*.

DC Voltage Measurement Circuitry

Resistance mode applies the DC Voltage measurement circuitry to get the resulting voltage across the external resistance. For more information, refer to the *DC Voltage* section.

With a known current and voltage, the DMM can determine resistance using Ohm's Law, as follows:

$$V_M = I_s \times R_T$$

where R_T is the sum of all resistances

$$R_T = R_x + R_{LEAD} + R_{LEAD}$$

Therefore, the value of

$$R_x = \frac{V_M}{I_s}$$

if R_{LEAD} is small or negligible compared to R_x.

Offset Nulling

Refer to offset nulling in the *DC Voltage* section.

Diode

The NI ELVIS II Series can excite a DUT with a constant current source and read the resulting voltage drop using the DCV measurement circuit. Diode mode is useful for testing the forward voltage of p-n junctions and diodes. Refer to the *NI ELVIS II Series Specifications* for details about test currents and voltage measurement ranges.

Oscilloscope

This section provides oscilloscope information for the NI ELVIS II and NI ELVIS II+ separately.

NI ELVIS II

This instrument provides the functionality of the standard desktop oscilloscope found in typical undergraduate laboratories. The Oscilloscope module has two analog inputs and one digital trigger input. You can connect to the NI ELVIS II Scope from the BNC connectors. Each analog channel can input signal by AC/DC coupling, the maximum voltage range is ±10 V. The actual voltage is measured using the AI channels.

The NI ELVISmx – Scope SFP has two channels and provides scaling and position adjustment knobs along with a modifiable timebase. You can also choose the trigger source and mode settings. The autoscale feature allows you to adjust the voltage display scale based on the peak-to-peak voltage of the AC signal for the best display of the signal. For trigger source, you can choose between digital or analog hardware triggering.

Figure A-10 shows the oscilloscope circuitry.

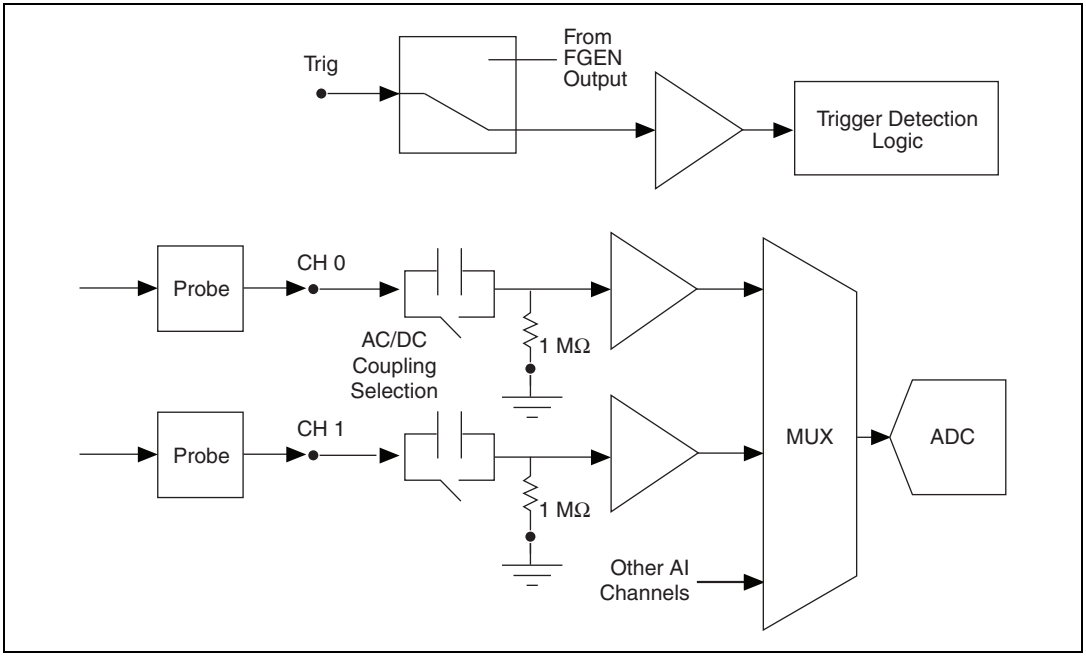


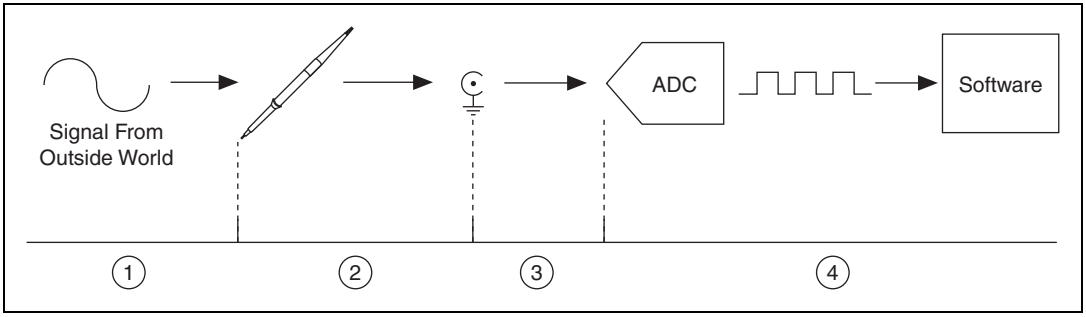
Figure A-10. NI ELVIS II Oscilloscope Measurement Circuitry

The NI ELVIS II Oscilloscope shares the ADC signal path with AI. The maximum sample rate of the scope is 1.25 MS/s. When two channels work at the same time, the maximum rate is 500 kS/s for each channel.

NI ELVIS II+

The NI ELVIS II+ Oscilloscope provides the functionality of a standard desktop oscilloscope found in typical undergraduate laboratories.

Figure A-11 shows the signal chain of the oscilloscope measurement.



1 Outside World to Probe	3 Input Connector to ADC
2 Probe to Input Connector	4 ADC to Software

Figure A-11. Oscilloscope Measurement Signal Chain

The NI ELVIS II+ Oscilloscope is an 8-bit, 100 MS/s scope. This module has two analog inputs and one digital trigger input. You can connect to the NI ELVIS II+ Scope from the BNC connectors. Each analog channel can input a signal using the AC/DC coupling. The maximum voltage range is ±20 V. The actual voltage is measured using the AI channels.

The NI ELVISmx - Scope SFP has two channels and provides scaling and position adjustment knobs along with a modifiable timebase. You can also choose trigger source and mode settings. The autoscale feature allows you to adjust the voltage display scale, based on the peak-to-peak voltage of the AC signal, for the best display of the signal. For a trigger source, you can choose between digital or analog hardware triggering. Figure A-12 shows the NI ELVIS II+ Oscilloscope Chain.

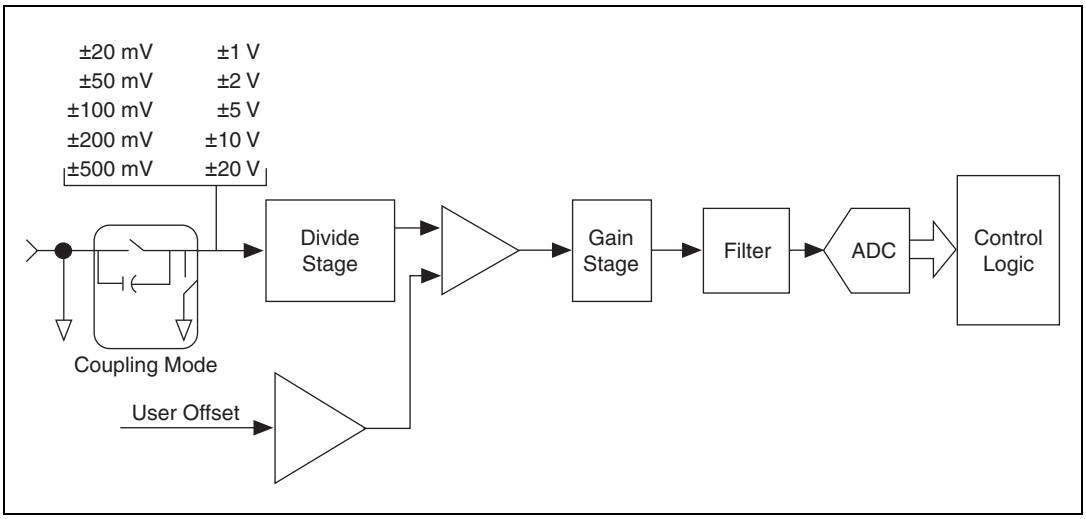


Figure A-12. NI ELVIS II+ Oscilloscope Chain

Vertical Range and User Control Offset

Vertical range is the peak-to-peak voltage span that a digitizer can measure at the input connector. Most digitizers have several choices for vertical range. The NI ELVIS II+ has 10 ranges from 40 mV_{pp} to 40 V_{pp}. For more information refer to the *NI ELVIS II+ Series Specifications*.

Vertical offset is the voltage on which the vertical range is centered. Vertical offset positions a waveform around an arbitrary DC value. The offset setting does the following:

- Add the offset to the user input before the oscilloscope preamplifier.
- Adjust the waveform display position.

Using this offset allows you to examine small changes in the input signal, which can improve the accuracy of your measurement. Set the vertical offset to match the nominal DC voltage and the signal appears centered on the screen.

For example, if you are acquiring the waveform shown in Figure A-13 with a 4 V DC offset that has a 0.5 V amplitude without using vertical offset, you would need to specify a range of 10 V_{pp} to capture the waveform. This will lose the resolution of the ADC. With a 4 V offset setting, you can use a 1 V_{pp} range to get a more accurate acquisition.

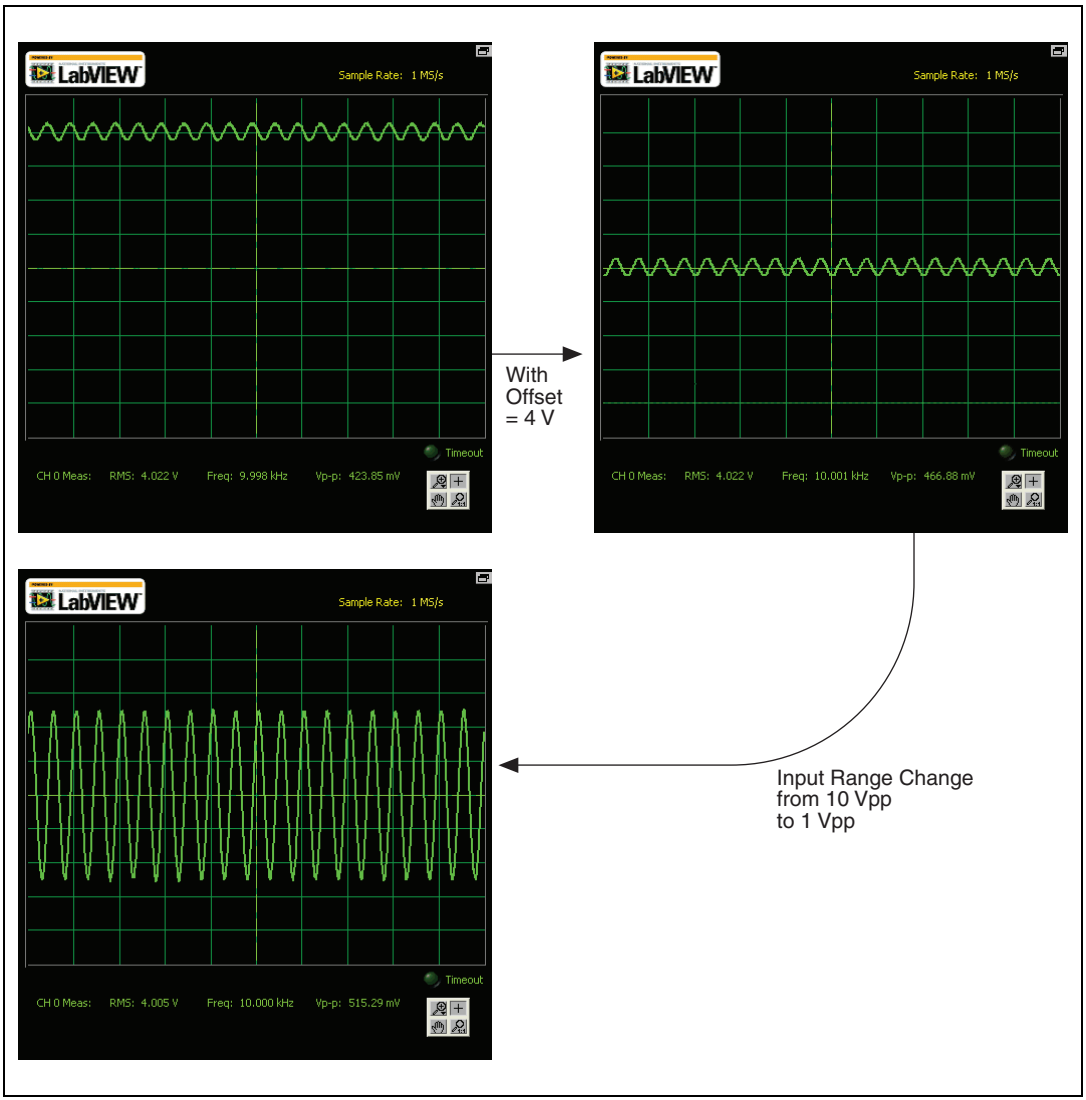


Figure A-13. Waveform Acquisition Offset

Vertical offset does not influence all the parameter measurements such as the waveform amplitude, max value, or min value.

The vertical offset has a similar influence with the vertical position. The vertical position is a display function. Adjust the vertical position to place the waveforms where you want to see them. The waveform baseline locations track adjustments made to their positions.

Vertical offset is a little different as it includes hardware adjustment while vertical position is only a software function. The vertical offset voltage is applied before the oscilloscope preamplifier and can be used to increase the effective dynamic range of the inputs.

Sample Rate and Decimation

The sample rate, specified in samples per second (S/s), is the rate at which a signal is sampled and digitized by an analog-to-digital converter (ADC). According to the Nyquist theorem, a sample rate at least twice the highest frequency of the signal produces accurate measurements if the analog bandwidth is wide enough to let the signal pass through without attenuation. A higher sample rate captures more waveform details for the time domain measurements.

Figure A-14 illustrates a 1 MHz sine wave sampled by a 2 MS/s ADC and a 20 MS/s ADC. The faster ADC digitizes 20 points per cycle of the input signal compared with 2 points per cycle with the slower ADC. In this example, the higher sample rate more accurately captures the waveform shape.

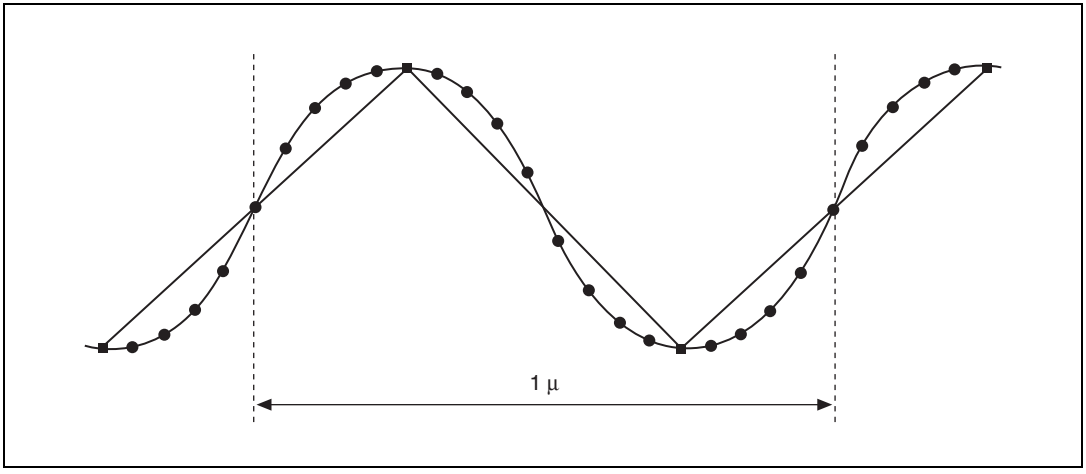


Figure A-14. ADC Sample Rate Comparisons

The NI ELVIS II+ scope maximum sampling rate is determined by the speed of the onboard sample clock(100 MS/s). However, you can achieve other sampling rates by the decimation of the data. In the decimation method, the ADC samples at the rate of the onboard clock and then sends its digital data to a decimator that essentially discards samples at a specific interval to achieve slower effective sampling rates. The valid sampling rates are always an integer divisor of the onboard clock. For example, if the onboard clock is 100 MHz, but you want to sample at 25 MS/s, you must use decimation. The decimation method discards all data except for every fourth data point to achieve exactly 25% of the maximum sample rate.

Memory Depth

Samples are stored in this buffer before transfer to the host computer. Thus acquisition memory size is 16384 8-bit samples per channel. Software allows you to specify buffers of less than these buffer sizes, but only the specified number of points is transferred from onboard memory into the host computer memory.

Trigger

During an acquisition, samples are stored in a circular buffer that is continually rewritten until a trigger is received. After the trigger is received, the NI ELVIS II+ scope continues to acquire posttrigger samples if you have specified a posttrigger sample count. The acquired samples are placed into onboard memory. The number of posttrigger or pretrigger samples is only limited by the amount of onboard memory.

Low Pass Filter Response

The NI ELVIS II+ scope has a software selectable 20 MHz noise filter that limits the bandwidth of the signal path. The filter is intended to reduce noise when the input signal content is 20 MHz or less. Figure A-15 shows a typical frequency response with the 20 MHz noise filter.

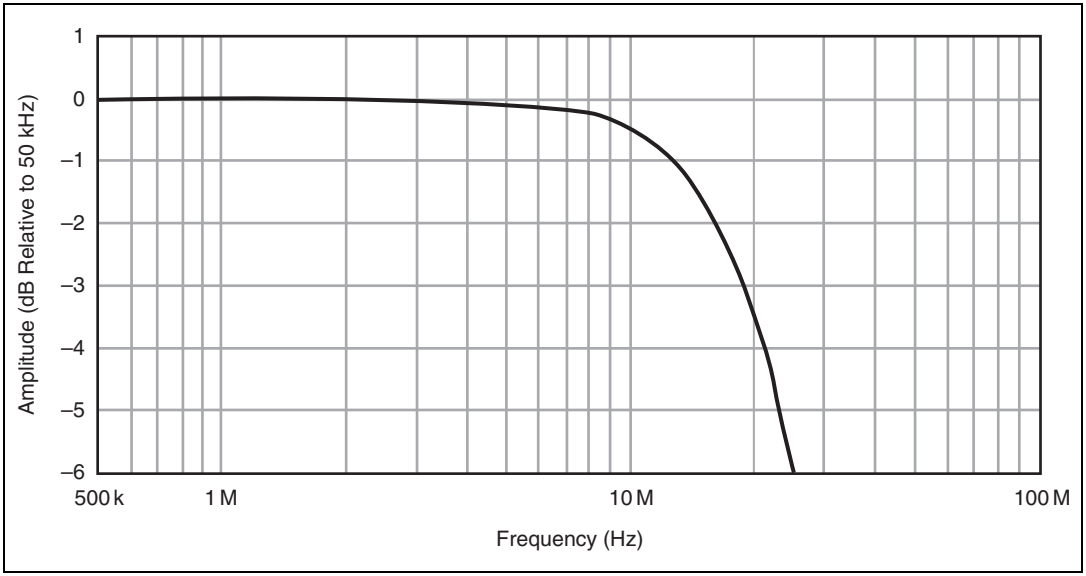


Figure A-15. Typical Frequency Response with 20 MHz Filter

Oscilloscope Probe and Probe Compensation

The NI ELVIS II Series oscilloscope is compatible with attenuating probes. These are useful for measuring high bandwidth signals because the series resistor isolates the cable capacitance of the probe and the input capacitance of the of the scope from the loading signal. Additionally the attenuating probe allows for measurement of higher voltages. Figure A-16 shows the 10X attenuating probe.

Caution Do not exceed measurement voltage limits for the NI ELVIS II Series Oscilloscope (10 VDC, 7 V_{rms} max) and the DMM (60 VDC, 20 V_{rms}). You must use UL certified scope and DMM probes bearing the UL Mark.

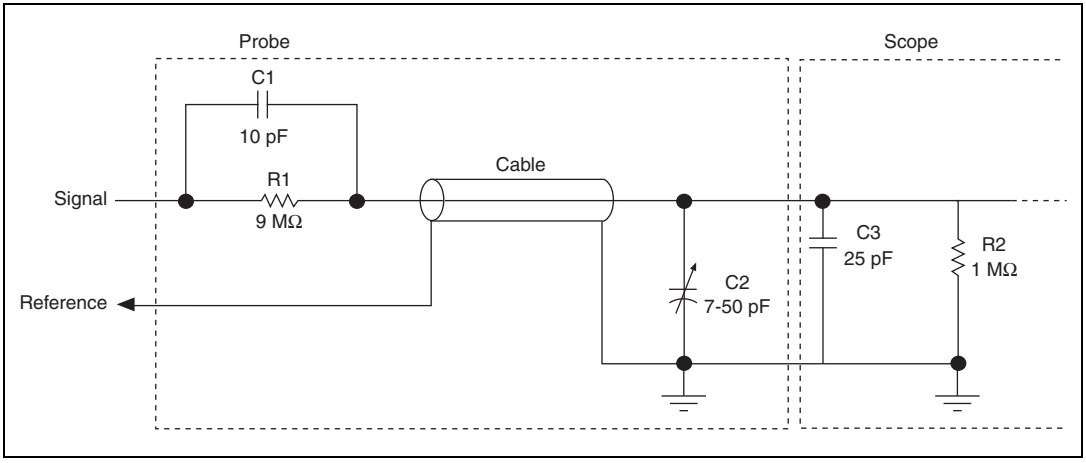


Figure A-16. 10X Attenuating Probe and Oscilloscope Circuitry

Before taking a measurement, make a compensation adjustment of the probe using the following steps:

1. Set the Function Generator as follows:
   - Frequency, 1 kHz
   - Amplitude, 1 V
   - Duty Cycle, 50%
   - Square Wave
2. Perform compensation of the 10X probe on a scope channel by measuring the function generator output.
3. Tune the capacitor on the probe and observe the waveform acquired by the scope.
4. Stop when there is no *undershoot* or *overshoot* of the waveform. Figure A-17 shows probe adjustment compensation scenarios.

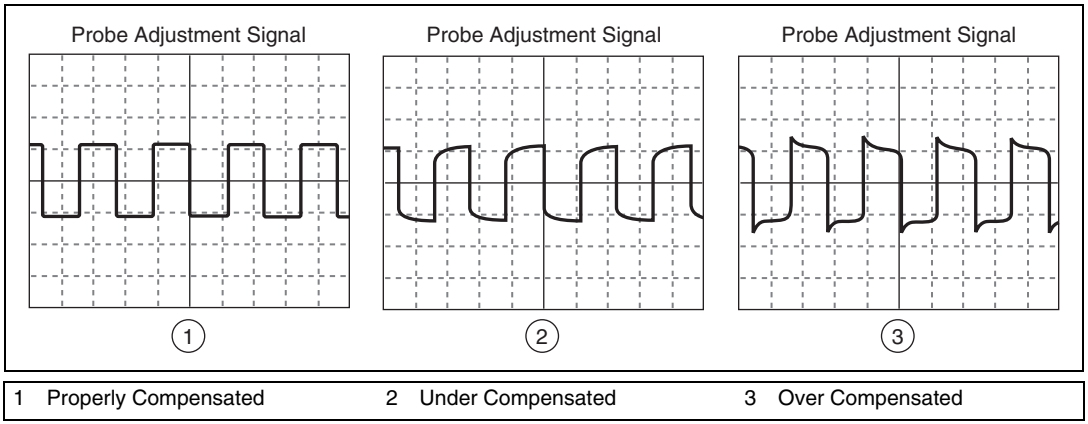


Figure A-17. Probe Adjustment Compensations

Function Generator

The NI ELVIS II Series includes a hardware function generator, which can generate sine, triangle, and square waves. You can adjust the waveform frequency, amplitude, offset and the square wave duty cycle as well as modulate the output amplitude and frequency with dedicated analog inputs. Figure A-18 shows the Function Generator circuitry.

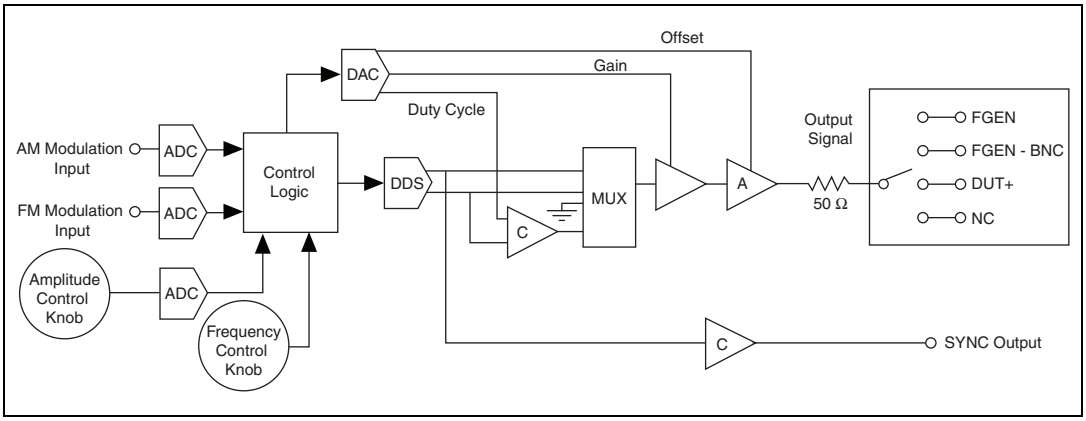
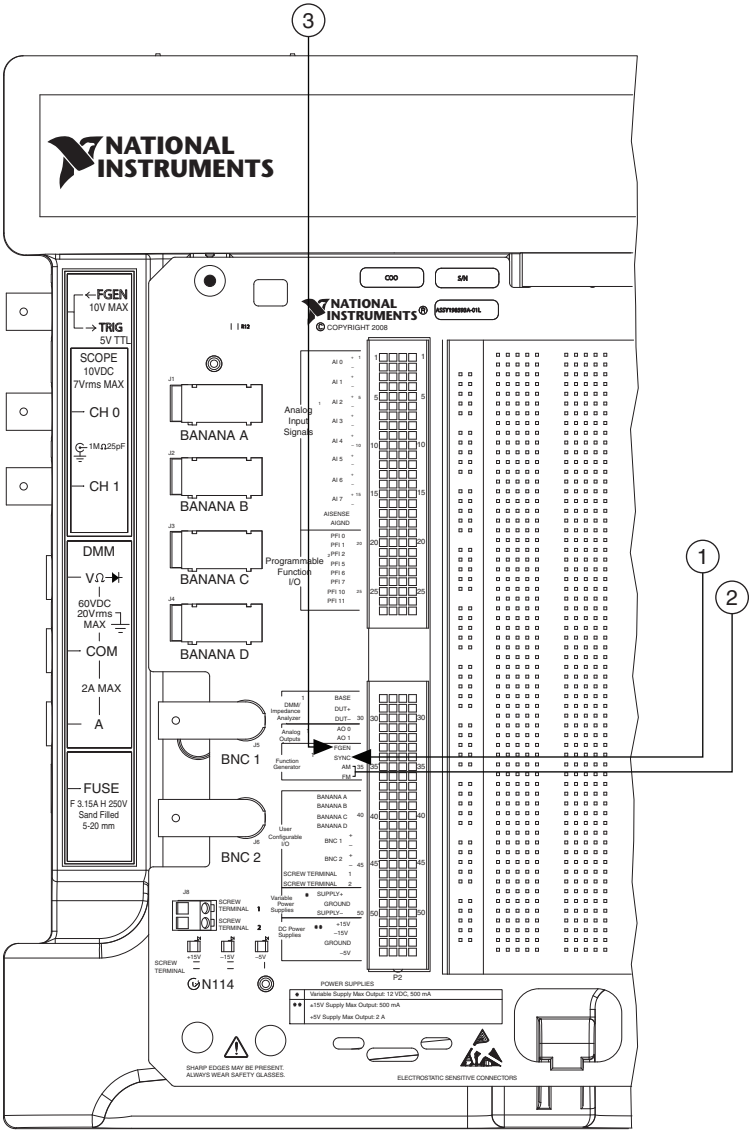


Figure A-18. Function Generator Circuitry

You can route the function generator output signal to the following four destinations:

- FGEN—This is the function generator output terminal on the NI ELVIS II Series Prototyping Board as shown in Figure A-19.
- FGEN BNC—This is the FGEN /TRIG BNC connector on the side of the workstation. This routing is recommended for the best high frequency signal quality.
- DUT+—This is the Impedance Analyzer excitation terminal on the NI ELVIS II Series Prototyping Board as shown in Figure A-19. It is used for excitation in the 2-wire and 3-wire Current-Voltage Analyzers, and DMM Capacitance and Inductance measurements.
- NC—No external connection.

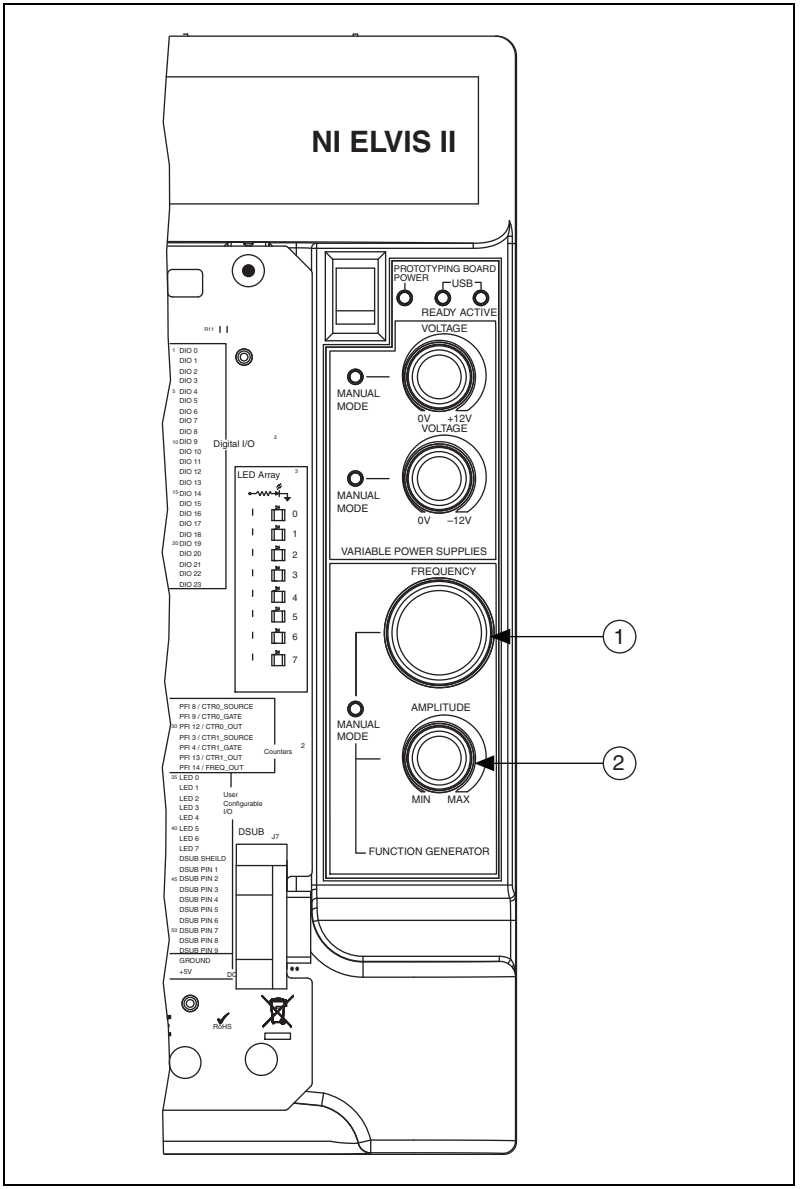
The SYNC output and the AM and FM inputs are available on the NI ELVIS II prototyping board. and are shown in Figure A-19.



1 SYNC Prototyping Board Connection	3 FGEN Prototyping Board Connection
2 AM and FM Prototyping Board Connections	

Figure A-19. SYNC, AM, and FM Inputs

The Function Generator control knobs are shown in Figure A-20.



1	Function Generator Frequency Control Knob	2	Function Generator Amplitude Control Knob

Figure A-20. Function Generator Control Knobs

Function Description

The NI ELVIS II Series Function Generator uses Direct Digital Synthesis (DDS) to generate analog waveforms. The frequency, amplitude, offset, and square waveform duty cycle are controlled digitally.

Frequency

The DDS sets the output frequency by using a 28-bit frequency divider to decimate a 50 MHz timebase. The resulting step size for the frequency set point is:

$$Frequency\ Step = \frac{50\ \text{MHz}}{2^{28}} = 0.18626\ \text{Hz}$$

You can adjust the output frequency with software or manually with the Frequency Control knob on the workstation.

Amplitude

The DDS output signal amplitude is fixed and is multiplied by a 10-bit DAC gain circuit. You can adjust the output amplitude with software or manually with the Amplitude Control knob on the workstation.

Offset

The FGEN output offset is controlled by a 10-bit DAC circuit. You can adjust the output offset of the FGEN waveform output with software using the NI ELVISmx FGEN SFP.

Square Waveform Duty Cycle

For square wave mode, a triangle wave from the DDS is fed into a comparator. By adjusting the reference voltage of the comparator, you can control the duty cycle. The reference voltage is generated by a 10-bit DAC circuit. You can adjust the square waveform output duty cycle in software with the NI ELVISmx FGEN SFP.

Protection

The output of the FGEN output buffer circuit has a 50 Ω source terminator. The NI ELVIS II Series workstation allows a 100 mA maximum output current. If the output current limit is exceeded, the output signal automatically disconnects.

Caution When the prototyping board power switch on the workstation is powered off, the FGEN output is disconnected from the prototyping board. If the FGEN signal is routed to the BNC connector, the output is not disabled by the prototyping board power switch.

FM/AM Modulation

The modulation function of the NI ELVIS II Series FUNCTION GENERATOR is implemented inside the FPGA. The modulation input is acquired by an ADC and applied to the frequency/amplitude modulation. Figure A-21 shows the FM/AM modulation diagram.

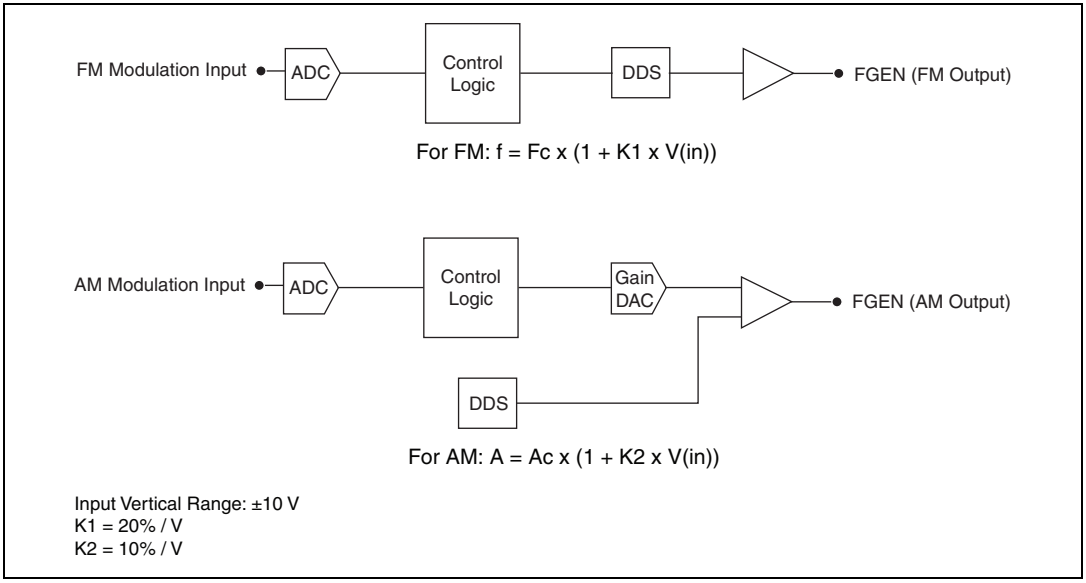


Figure A-21. FM/AM Modulation Diagram

Variable Power Supply

The NI ELVIS II Series has one positive and one negative variable power supply. The positive supply can provide adjustable output voltage from 0 V to +12 V and negative supply can provide –12 V to 0 V.

Figure A-22 shows the diagram of variable power analog circuit.

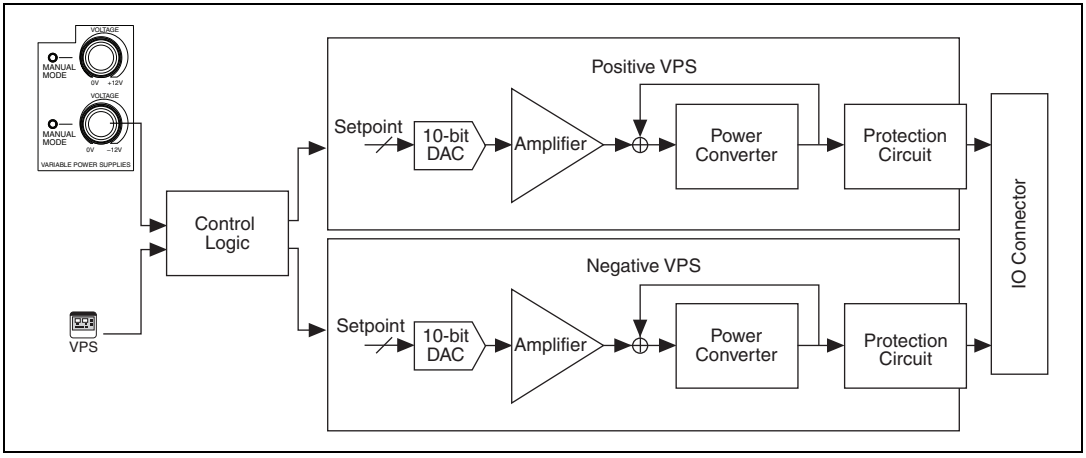


Figure A-22. NI ELVIS II Series Variable Power Supply Circuitry

Variable Power Supply Circuitry

This section describes the elements of the Variable Power Supply circuitry.

DAC

The ELVIS II Series workstation gets the set point from either the manual knob or software. The DAC is used to convert the digital set point to the control voltage.

Amplifier

The amplifier stage scales the control voltage of the DAC output to the correct adjust voltage, which is the input of the regulation loop.

Power Converter

The amplifier output, power converter and its output construct the regulation loop that produces the required output voltage and keeps it stable.

Protection Circuit

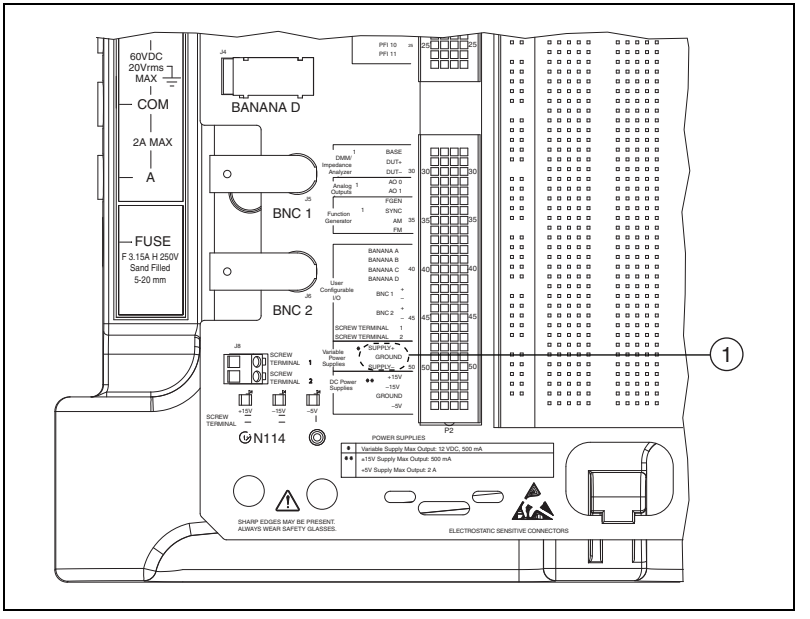
The self-resetting protection circuitry is used to protect the variable power supply circuit from being damaged by over current or over voltage.

The variable power supply internal circuitry is disconnected from the output when a short or over voltage occurs. When the cause of the disconnection is resolved, the variable power supply output recovers automatically.

IO Connector

You can connect to the variable power supply output from the ELVIS II prototyping board at the SUPPLY+ and SUPPLY– terminals. Both supplies are referenced to GROUND. Refer to Figure A-14 for the location of prototyping board connections.

Figure A-23 shows the location of variable power supply connection terminals on the prototyping board.



1 Variable Power Supply Prototyping Board Connections

Figure A-23. Variable Power Supply Connections

2-Wire Current-Voltage Analyzer

The 2-Wire Current-Voltage Analyzer sweeps a voltage across the device under test (DUT) and measures the current flowing through it. The DUT is connected between the DUT+ and DUT– terminals on the NI ELVIS II Series Prototyping Board. The FGEN connects to DUT+ internally and provides the voltage source. Internal AI channels are used to monitor the voltage at DUT+ and current at DUT– through a current-to-voltage (I-V converter). The voltage at DUT+ is measured with channel _DUTPos. The current at DUT– is calculated by dividing the voltage at channel _DUTNeg by the appropriate gain resistance. The I-V converter has three gain ranges to optimize current measurements up to 40 mA. Figure A-24 shows the 2-Wire Current-Voltage Analyzer circuit.

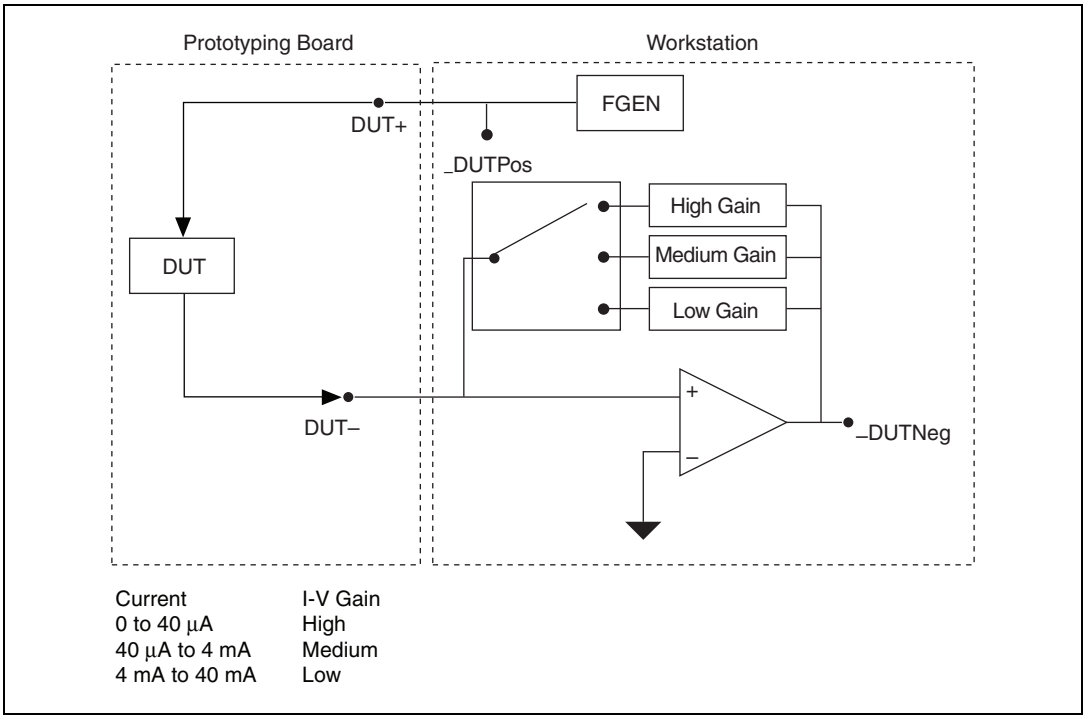


Figure A-24. 2-Wire Current-Voltage Analyzer Circuit

3-Wire Current-Voltage Analyzer

The 3-Wire Current-Voltage Analyzer extends the function of the 2-Wire Analyzer by adding a connection from AO 0 that you can use to excite the base of a bipolar junction transistor. A 634 Ω resistor is in series between AO 0 and the BASE terminal. This allows for current measurements of the base. The channel to measure base current is _Base. Figure A-25 shows the 3-Wire Current-Voltage Analyzer circuit.

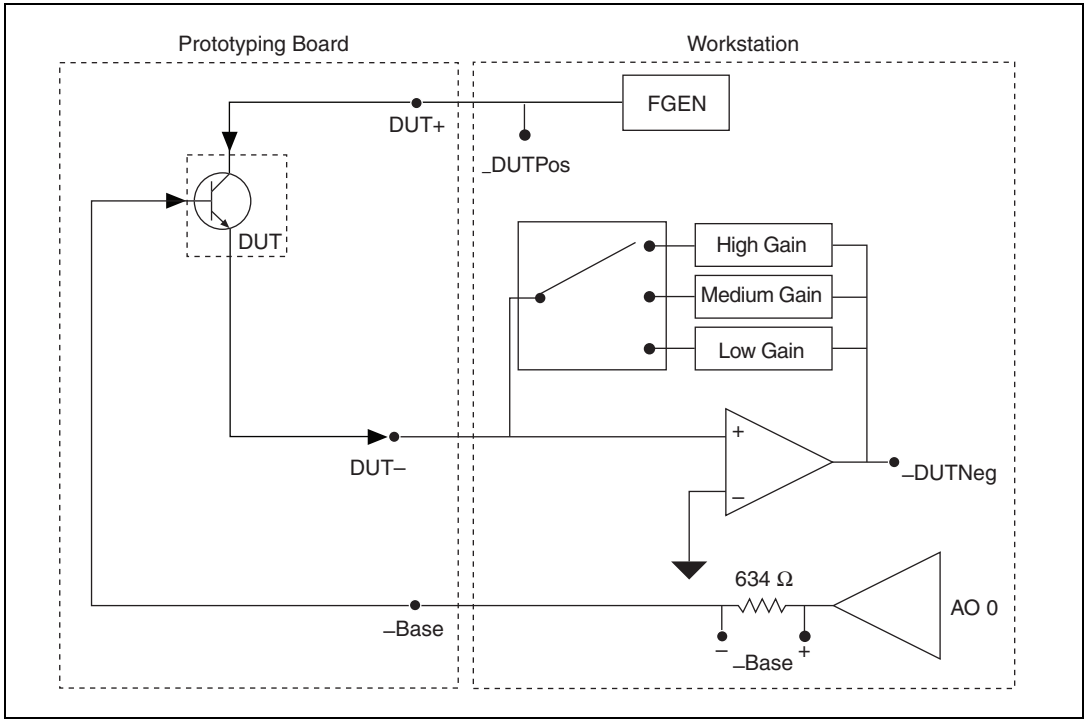


Figure A-25. 3-Wire Current-Voltage Analyzer Circuit

Impedance Analyzer

The Impedance Analyzer can measure specific DUT impedance characteristics. It determines impedance using a sine wave voltage source that is produced by the function generator on the DUT+ pin and measuring the resulting current on DUT–. The Impedance Analyzer calculates phase, magnitude, resistance, and reactance of the DUT. Figure A-26 shows the Impedance Analyzer circuit.

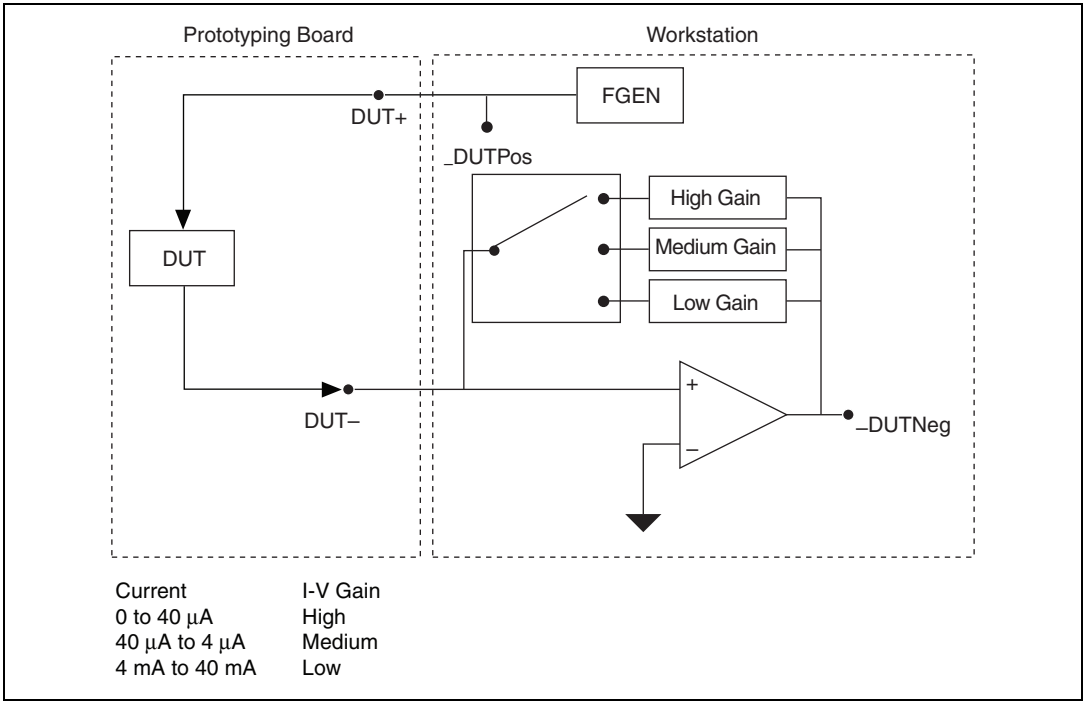


Figure A-26. Impedance Analyzer Circuit

The input current across the DUT– has a programmable gain applied. NI ELVIS II Series workstation has three selectable gain ranges.

Internal Calculations

The following values are stored in the NI ELVIS II EEPROM:

- *Gain Resistor*—Actual calibrated value of each gain resistor (three values). *Gain Resistor* is calibrated at the factory to determine the actual value for the gain resistor.

  The software acquires two waveforms from the _DUTNeg (the signal channel) and _DUTPos (the reference channel). You can calculate the current through the DUT from the following formula:

$$DUT\ Current = \frac{Signal\ Amplitude}{Gain\ Resistor}$$

- *DUT Current* is combined with the *DUT Voltage* (*_DUTPos* reading, the reference channel) to determine the impedance.

$$Impedance\ (\mathrm{Z}) = \frac{DUT\ Voltage}{DUT\ Current} = \frac{Reference\ Amplitude}{Signal\ Amplitude} \times Gain\ Resistor$$

The magnitude of Impedance (Z) is combined with the phase to determine the resistive and reactive components of the DUT. The phase difference of the acquired sine waves is measured in reference to *_DUTPos*. The frequency is user-defined.

$$Resistance = \mathrm{Z} \times \cos\left(\mathrm{phase} \times \frac{\pi}{180}\right)$$

$$Reactance = \mathrm{Z} \times \mathrm{sine}\left(\mathrm{phase} \times \frac{\pi}{180}\right)$$

$$Susceptance = \frac{-1}{Reactance}$$

Inductance Meter

The DMM inductance measurement is a subset of the Impedance Analyzer, and it uses the same circuitry. To get more accurate readings, the function generator output frequency and amplitude is set as shown in Table A-2.

Table A-2. Inductance Measurement Function Generator Output Frequency and Amplitude Settings

Inductance	Signal Amplitude	Signal Frequency	I-V Gain
100 µH to 1 mH	0.5 V	10 kHz	Low
1 mH to 10 mH	0.5 V	1 kHz	Low
10 mH to 100 mH	1 V	1 kHz	Low
Note: Inductance = Reactance ÷ (2π × Frequency)			

Capacitance Measurement

The DMM capacitance measurement is a subset of the Impedance Analyzer, and it uses the same circuitry. To get more accurate readings on capacitors, the function generator output frequency and amplitude set as shown in Table A-3.

Table A-3. Capacitor Measurement Function Generator Output Frequency and Amplitude Settings

Capacitance	Signal Amplitude	Signal Frequency	I-V Gain
50 pF to 500 pF	1 V	10 kHz	High
500 pF to 5 nF	1 V	1 kHz	High
5 nF to 50 nF	1 V	1 kHz	Medium
50 nF to 1 µF	1 V	1 kHz	Low
1 µF to 500 µF	1 V	100 Hz	Low
Note: Capacitance = Susceptance ÷ (2π × Frequency)			

B

Resource Conflicts

Figure B-1 summarizes the resource conflicts you might encounter if you run certain NI ELVIS II+ Series circuitry simultaneously.

To use the information in Figure B-1, find the instrument you want to use in the left column. That row lists all the functions that are resource conflicts. If the intersecting box contains an –, you can use those functions simultaneously without any conflicts.

	DMM - Voltmeter, Ammeter, Resistance, Continuity, Diode	DMM - Inductance, Capacitance	Oscilloscope (NI ELVIS II and AIChannels)	Oscilloscope (NI ELVIS II+ High Speed Channels)	Oscilloscope Digital Trigger Input BNC	Function Generator Prototyping Board	Function Generator BNC	Function Generator Manuel Mode	Variable Power Supply Software Mode	Variable Power Supply Manual Mode	Bode Analyzer	Dynamic Signal Analyzer	Arbitrary Waveform Generator AO 0	Arbitrary Waveform Generator AO 1	Impedance Analyzer	Two-Wire Current–Voltage Analyzer	Three-Wire Current-Voltage Analyzer
DMM - Voltmeter, Ammeter, Resistance, Continuity, Diode	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
DMM - Inductance, Capacitance	X	–	X	–	–	X	X	–	–	X	X	X	X	–	X	X	X
Oscilloscope (NI ELVIS II and AI Channels)	–	X	–	X	–	–	–	–	–	X	X	X	–	–	X	X	X
Oscilloscope (NI ELVIS II+ High Speed Channels)	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Oscilloscope Digital Trigger Input BNC	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–
Function Generator Prototyping Board	–	X	–	–	–	–	X	–	–	–	X	–	–	–	X	X	X
Function Generator BNC	–	X	–	–	X	X	–	–	–	–	X	–	X	–	X	X	X
Function Generator Manual Mode	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Variable Power Supply Software Mode	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Variable Power Supply Manual Mode	–	X1	X1	–	–	–	–	–	–	–	X1	X1	–	–	X1	X1	X1
Bode Analyzer	–	X	X	–	–	X	X	–	–	X1	–	X	–	–	X	X	X
Dynamic Signal Analyzer	–	X	X	–	–	–	–	–	–	X1	X	–	–	–	X	X	X
Arbitrary Waveform Generator AO 0	–	X	–	–	–	–	X	–	–	–	–	–	–	–	X	X	X
Arbitrary Waveform Generator AO 1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Impedance Analyzer	–	X	X	–	–	X	X	–	–	X1	X	X	X	–	–	X	X
Two-Wire Current–Voltage Analyzer	–	X	X	–	–	X	X	–	–	X1	X	X	X	–	X	–	X
Three-Wire Current-Voltage Analyzer	–	X	X	–	–	X	X	–	–	X1	X	X	X	–	X	X	–

Conflict Codes:

– = No conflict

X = Conflict exists

X1 = Conflict exists if Measure Actual Voltages option is enabled in VPS Manual Mode

Figure B-1. NI ELVIS II Series Resource Conflict Matrix

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