

# Calibrating E/S Series Devices with Calibration Executive

This document contains instructions for loading and running the National Instruments Calibration Executive procedure for E/S Series devices with Traditional NI-DAQ.

## Contents

---

Equipment and Other Test Requirements .....	2
Test Equipment .....	2
Connectors .....	2
Test Conditions .....	3
Calibration Temperature Considerations .....	3
Documentation .....	4
Software .....	4
Calibration Executive Procedures .....	5
Setting Up the E/S Series Device for Calibration .....	5
Loading and Running the Calibration Executive Procedure .....	6
Viewing the Calibration Report .....	7
Modifying the Font Size in a Calibration Report .....	7
Measurement Uncertainty Considerations and Calculations .....	7
Counter Uncertainty .....	8
Analog Input Uncertainty .....	9
Analog Output Uncertainty .....	10
Troubleshooting Guidelines .....	10
Traditional NI-DAQ Errors and Other Errors .....	11
Error Code –10005 .....	11
Error Code –10842 .....	11
Error Code –15 .....	12
Other Error Codes .....	13
Specifications .....	13
Technical Support Resources .....	13
NI Web Support .....	13
Worldwide Support .....	14

# Equipment and Other Test Requirements

---

This section describes the equipment, test conditions, documentation, and software needed to calibrate E or S Series devices.

## Test Equipment

To calibrate an E/S Series device, you need a calibrator, a digital multimeter (DMM), and a counter. NI recommends using the following test equipment:

- Calibrator—Fluke 5700A
- DMM—Agilent (HP) 34401A
- Counter—Agilent (HP) 53131A
- Low thermal copper EMF plug-in cables—Fluke 5440A-7002.  
Do not use standard banana cables.



**Note** The Calibration Executive procedure runs in automated mode if you use IVI-supported calibration standards. For more information about automated versus manual modes, refer to the *Calibration Executive Software User Manual*.

If you do not have the recommended test equipment, use the following accuracy requirements to select substitute calibration standards.

- A calibrator that is 4 to 10 times more accurate than the analog-to-digital converter (ADC) on the E/S Series device. When calibrating a 12-bit device, the calibrator should be at least 50 ppm (0.005%) accurate. When calibrating a 16-bit device, the calibrator should be at least 10 ppm (0.001%) accurate.
- A multiranging 5 1/2 digit DMM with an accuracy of 15 ppm.

## Connectors

The automated Calibration Executive procedure for E/S Series devices is designed to work with the following connection hardware:

- An E Series calibration fixture. For S Series devices (for example, NI 61XX), use revision B or later of the calibration fixture.
- A connector cable, as described in Table 1.

**Table 1.** Recommended Cables

<b>Device</b>	<b>Cable</b>
E/S Series devices with a 68-pin SCSI II connector	SH68-68-EP
E/S Series devices with a 68-pin VHDCI connector (for example, DAQCard-6036E)	SHC68-68-EP
E/S Series devices with a 100-pin connector (for example, PCI/PXI-6025E, PCI/PXI-6031E, PCI/PXI-6033E, PCI/PXI-6071E)	SH1006868. Connect the 68-pin cable labeled MIO-16 to the accessory. The 68-pin cable labeled Extended I/O remains unconnected.

## Test Conditions

Follow these guidelines to optimize the connections and the environment during calibration:

- Keep connections to the E/S Series device short. Long cables and wires act as antennae, picking up extra noise that can affect measurements.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Maintain a temperature between 18 °C and 28 °C.
- Keep the relative humidity below 80%.
- Warm up the E/S Series device for at least 15 minutes to ensure that its measurement circuitry is at a stable operating temperature.

## Calibration Temperature Considerations

Temperature change affects the measurement characteristics of a device. To account for these changes, the tested specifications include the effects of temperature drift. For the E/S Series devices, valid temperature drift is  $\pm 10$  °C from the last external calibration temperature.

# Documentation

In addition to this calibration procedure, you may want to refer to the following documents:

- *Calibration Executive Software User Manual*
- *E Series Calibration Fixture Installation Guide*
- Hardware documentation for the E/S Series device you are calibrating

You can download the latest versions of these documents from [ni.com/manuals](http://ni.com/manuals).

You also may need to refer to the *Measurement & Automation Explorer Help for Traditional NI-DAQ*. You can access this help file by launching Measurement & Automation Explorer (MAX) and selecting **Help»Help Topics»Traditional NI-DAQ** from the main menu.

# Software

For information about installing and uninstalling Calibration Executive procedures, refer to the *Calibration Executive Software User Manual*.

The Calibration Executive setup program installs Calibration Executive and the associated files listed in Table 2.

**Table 2.** Calibration Executive Directories and Supporting Files

Directory Name	Contents
Program Files\National Instruments\Calibration Executive\Procedures\E Series S Series	Directory structure that contains the calibration procedure and this document
Program Files\National Instruments\Calibration Executive\Procedures\E Series S Series\Limits	Microsoft Access databases that store the calibration limits
Program Files\National Instruments\Calibration Executive\Procedures\E Series S Series\Support Files	Support files such as bitmaps and DLLs

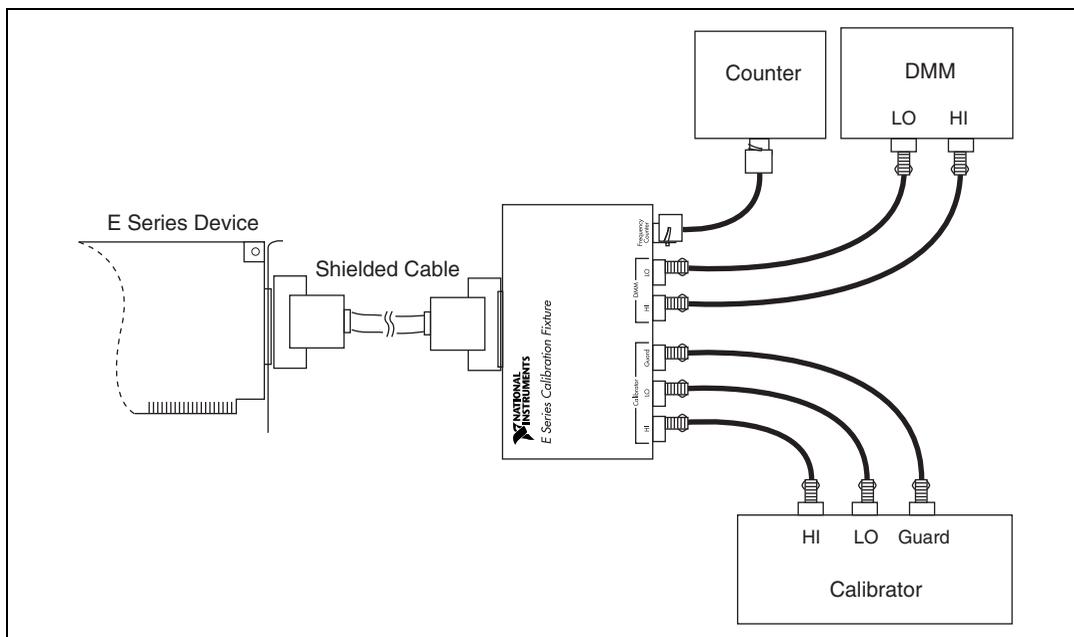
# Calibration Executive Procedures

This section explains how to set up and run the Calibration Executive procedure. In automated mode, the procedure takes about 30 minutes. In manual mode, the calibration procedure can take as long as one hour.

## Setting Up the E/S Series Device for Calibration

To set up the device for calibration, complete the following steps:

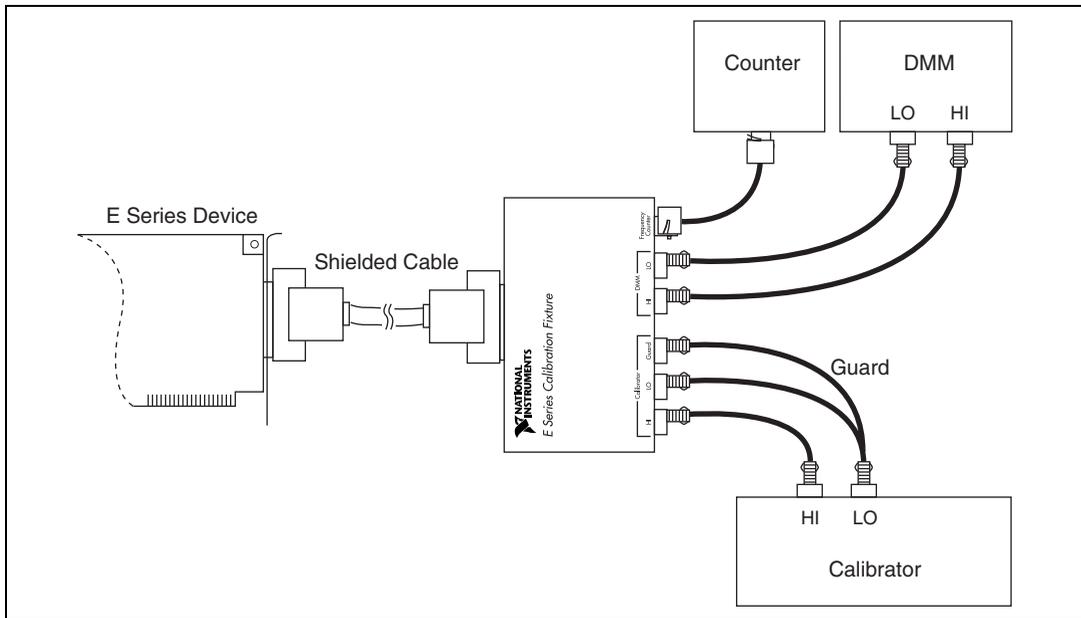
1. Install the E/S Series device in the host computer.
2. Configure the hardware with MAX. Refer to the *Measurement & Automation Explorer Help for Traditional NI-DAQ* or visit [ni.com/support](http://ni.com/support) for more configuration information.
3. Connect the appropriate shielded cables between the E/S Series device, the calibration fixture, and the standards, as shown in Figures 1 and 2.



**Figure 1.** Connecting the Counter, DMM, and Calibrator



**Note** Fluke 5500A and 5520A calibrators do not have guard connectors. You must connect the LO cable with the guard cable, and then connect the guard cable into the LO terminal on the calibrator, as shown in Figure 2.



**Figure 2.** Connecting the Counter, DMM, and Fluke 5500A/5520A Calibrator

## Loading and Running the Calibration Executive Procedure

To load and run the Calibration Executive procedure, complete the following steps:

1. Launch Calibration Executive.
2. Follow the Calibration Configuration Wizard to load the E/S Series calibration procedure. For more information about loading and running the calibration procedure, refer to the *Calibration Executive Software User Manual*.
3. When the procedure is loaded, click **Run Procedure**.
4. When the Calibration Executive procedure asks you whether to calculate measurement uncertainty, select **Yes** or **No**. If you select Yes, you are prompted to select the appropriate uncertainty files based on the standards you are using and the date the standards were last calibrated.

5. When the Calibration Executive procedure prompts you for information about the installed hardware, enter the following information:
  - **Device Number**—The Traditional NI-DAQ device number assigned to the E/S Series device by MAX when you configured the hardware.
  - **Supported Products**—The appropriate device from the menu that lists the devices supported by the calibration procedure.

## Viewing the Calibration Report

When the calibration procedure is finished, complete the following steps to view the calibration report.

1. Select **View»Reports**.
2. Click **View**.

## Modifying the Font Size in a Calibration Report

If you have selected the HTML format and the text size in the calibration report is too large, you can decrease the size as follows:

- In Internet Explorer, modify the text size by selecting **View»Text Size** and then selecting the appropriate size from the menu.
- In Netscape, modify the text size by selecting **View»Decrease Font**.



**Note** If the E/S Series device fails after calibration, refer to the [Troubleshooting Guidelines](#) section. If the device still fails after you complete the troubleshooting procedures, return it to NI for repair or replacement.

# Measurement Uncertainty Considerations and Calculations

---

For information about how Calibration Executive handles measurement uncertainty, refer to the *Calibration Executive Software User Manual*.

The components of uncertainty vary depending on which test is running. The E/S Series device calibration procedure runs up to three main tests, depending on which device you are calibrating. Each test takes different uncertainty components into account.

After Calibration Executive calculates all the components of uncertainty, the components are converted to a 1-sigma normal distribution, and are then combined using the root-sum-square method. The combined standard uncertainty is then multiplied by an appropriate coverage factor, taking degrees of freedom into account, to arrive at the reported expanded

uncertainty of measurement, which corresponds to a coverage probability of approximately 95%. The following sections describe the uncertainty budgets for counter, analog input, and analog output uncertainties for E/S Series devices.

## Counter Uncertainty

This section describes the components of counter uncertainty in the E/S Series device Calibration Executive procedure.

You must manually calculate final expanded counter uncertainty at a 95% confidence level based on the manufacturer's specifications for the counter and your own Type A calculations. Enter this value when the procedure prompts you for it. A suggested final expanded uncertainty value is computed as follows:

$$\text{Counter Uncertainty} = \sqrt{(\text{Type A Uncertainty})^2 + (\text{Type B Uncertainty})^2}$$

where

$$\text{Type A Expanded Uncertainty} = 1.96 \times \frac{\text{Std. Dev. of Measurements Taken}}{\sqrt{10}}$$

where 10 is the number of measurements taken.

Type B uncertainty can be calculated as shown in the following example, which measures a 5 MHz square wave signal (which has negligible trigger error) with a one second gate time. This example is for an HP53132A counter with a high-stability oven that was calibrated three days before.

$$\text{Type B Uncertainty} = \text{Systematic Uncertainty} \pm 1.96 \times \text{RMS Resolution} =$$

$$\left[ \left( \pm \text{Time Base Error} \pm \frac{t_{acc}}{\text{Gate Time}} \right) \pm 1.96 \times \left( \frac{4 \times \sqrt{t_{res}^2 + (2 \times \text{Trigger Error}^2)}}{\text{Gate Time} \times \sqrt{\text{Number of Samples}}} + \frac{t_{jitter}}{\text{Gate Time}} \right) \right] \times \text{Frequency}$$

where

*Number of Samples* is 200,000 (because frequency > 200 kHz)

*Gate Time* is 1 second

*Time Base Error* is *Temp. Stability* × (3 Days \* *Daily Aging Rate*)

*t<sub>acc</sub>* is the timebase accuracy of the counter (from the hardware documentation)

$t_{jitter}$  is the jitter specification of the counter (from the hardware documentation)

$t_{res}$  is the rms resolution of the counter (from the hardware documentation)

$$= 2.5 \times 10^{-9} + 3 \times (5 \times 10^{-10})$$

$$= 4.0 \times 10^{-9}$$

$$\text{Type B Uncertainty} = \left[ \left( \pm 4.0 \times 10^{-9} \pm \frac{1 \times 10^{-11} s}{1 s} \right) \pm 1.96 \times \left( \frac{4 \times \sqrt{(255 \times 10^{-12} s)^2 + (1.96 \times 0)}}{1 s \times \sqrt{200,000}} + \frac{3 \times 10^{-12} s}{1 s} \right) \right] \times 5 \text{ MHz}$$

$$= [\pm 4.0 \times 10^{-9} \pm 1.96 \times (2.01 \times 10^{-12} + 3 \times 10^{-12})] \times 5 \text{ MHz}$$

$$= (\pm 4.0 \times 10^{-9} \pm 9.8 \times 10^{-12}) \times 5 \text{ MHz}$$

$$= \pm 20.05 \text{ mHz}$$

## Analog Input Uncertainty

Table 3 contains the names and descriptions of the components of analog input uncertainty in the E/S Series device Calibration Executive procedure.

**Table 3.** Analog Input Uncertainty

Uncertainty Component	Description
Calibrator uncertainty	Retrieved from the calibrator uncertainty text file <sup>1</sup>
Resolution uncertainty of the E/S Series device	$= \frac{1}{2} \left( \frac{\text{Resolution of E or S Series Device}}{\sqrt{3}} \right)$ <p>where <i>Resolution of the E or S Series Device</i> is the range of the E/S Series device divided by the number of levels in the ADC. The <math>\sqrt{3}</math> term in the denominator results from assuming a rectangular distribution of probabilities of the measurement values.</p>
Type A uncertainty	$= \frac{\text{Standard Deviation of Measurements Taken}}{\sqrt{10,000}}$ <p>where 10,000 is the number of measurements taken</p>
Leads, wiring, and calibration fixture	Insignificant compared with other uncertainty components
<sup>1</sup> For more information about the text file format, refer to the <i>Calibration Executive Software User Manual</i> .	

## Analog Output Uncertainty

Table 4 contains the names and descriptions of the components of analog output uncertainty in the E/S Series device Calibration Executive procedure.

**Table 4.** Analog Output Uncertainty

Uncertainty Component	Description
DMM uncertainty	Retrieved from the DMM uncertainty text file. <sup>1</sup>
Resolution uncertainty of the E/S Series device	$= \frac{1}{2} \left( \frac{\text{Resolution of E or S Series Device}}{\sqrt{3}} \right)$ <p>where <i>Resolution of the E or S Series Device</i> is the range of the E/S Series device divided by the number of levels in the digital-to-analog-converter (DAC). The <math>\sqrt{3}</math> term in the denominator results from assuming a rectangular distribution of probabilities of the measurement values.</p>
Type A uncertainty	$= \frac{\text{Standard Deviation of Measurements Taken}}{\sqrt{10}} \times 1.06$ <p>where 10 is the number of measurements taken and 1.06 accounts for the t-distribution.</p>
Leads, wiring, and calibration fixture	Insignificant compared with other uncertainty components.
<sup>1</sup> For more information on the text file format, refer to the <i>Calibration Executive Software User Manual</i> .	



**Note** If you use the recommended test equipment and follow the test conditions guidelines, the vast majority of the uncertainty for the analog input tests is due to the resolution uncertainty of the ADC on the E/S Series device. The majority of the uncertainty for the analog output tests is due to the resolution uncertainty of the DAC on the E/S Series device. Other uncertainty components are negligible compared to these components.

## Troubleshooting Guidelines

This section describes common problems you might encounter when calibrating an E/S Series device and explains how to correct the problem.

If the E/S Series device is not recognized by MAX, verify that you followed the configuration guidelines. Additional configuration information is available at [ni.com/support](http://ni.com/support). If MAX fails to recognize the E/S Series device after you reconfigure and refresh (<F5>), contact NI technical support.

If the E/S Series device fails after calibration, complete the following steps:

1. Check the connections and run the Calibration Executive procedure again.
2. Verify that you do not have an SCXI chassis configured in MAX. Remove the configuration if it is present and run the Calibration Executive procedure again.
3. If the calibration still fails after you complete steps 1 and 2, try inputting or outputting the failed test points using the test panel in MAX. For example, if the analog input (AI) failed at 0.98 V, input that value from the calibrator, as follows:
  - a. Launch the Traditional NI-DAQ test panel in MAX.
  - b. Click the **Analog Input** tab.
  - c. Set the **High Limit** to 1.00 V and set the **Low Limit** to -1.00 V for bipolar readings.
  - d. Check the Average Reading indicator.

If the Average Reading still fails after you complete steps 1–3, contact NI for repair or replacement. If the Average Reading passes, you can change the calibration report to indicate the passing value.



**Note** If you have Microsoft Access 2000 or later, you can also modify the database containing the test results. The default installation directory of this database is Program Files\National Instruments\Calibration Executive\Databases\Calibration Reports.mdb. For more information on the database format, refer to the *Calibration Executive Software User Manual*.

## Traditional NI-DAQ Errors and Other Errors

This section describes some of the common errors that can occur when calibrating an E/S Series device.

### Error Code -10005

Error code -10005 indicates that the device number you selected is not configured or recognized in MAX. Configure the device in MAX and restart Calibration Executive.

### Error Code -10842

Error code -10842 has different causes depending on whether the device you are calibrating is an AT-bus E Series device or another type of E/S Series device.

◆ Error code **-10842** with AT-bus E Series devices

Error code **-10842** during internal calibration of an AT-bus E Series device may indicate that an interrupt request (IRQ) level was not assigned by the operating system. Test the resources in MAX to confirm this error.

To correct the error, go to [ni.com/support/install](http://ni.com/support/install) and complete the following steps of the *Hardware Installation/Configuration Troubleshooter*.

1. For **Hardware**, enter data acquisition (DAQ).
2. For **Bus Type**, enter AT/ISA (Plug and Play).
3. Enter your operating system and click **Submit**.
4. Look for information about resource conflicts or resource issues.

If the information in the *Hardware Installation/Configuration Troubleshooter* does not correct the problem, contact NI for technical support. The [Technical Support Resources](#) section contains information on how to contact NI.

◆ Error code **-10842** with all other E/S Series devices

Error code **-10842** during internal calibration of other E/S Series devices indicates that the hardware is not responding correctly and the device needs repair. When you contact NI for repair, explicitly indicate that the E/S Series calibration function returns error **-10842** during internal calibration.

## Error Code -15

Error code **-15** at the beginning of the calibration procedure indicates that the computer may be configured to use commas as decimal places.

Calibration Executive only supports using periods (.) for decimal places. To change this configuration on the computer, complete the following steps:

1. Select **Start»Settings»Control Panel**.
2. Click **Regional Options**.
3. Click the **Numbers** tab and change the Decimal Symbol from a comma (,) to a period (.). Change the Digit Grouping Symbol from (,) to (,).



**Note** If you change the Regional Settings or Regional Options on the computer, remember to change them back to the default settings after running the Calibration Executive procedure.

## Other Error Codes

You can find more information on other error codes in the *Status Codes* section of the *Traditional NI-DAQ Function Reference Help*. To launch this help file, select **Start»Programs»National Instruments»NI-DAQ»Traditional NI-DAQ Function Reference Help**.



**Note** For a list of DAQmx error codes in LabVIEW, refer to the *LabVIEW Help*. To launch this help file, select **Start»Programs»National Instruments»LabVIEW»VI, Function, & How-to Help**. Within the help file, select **Running and Debugging VIs»Error Codes and Messages»Ranges of LabVIEW Error Codes**.

## Specifications

---

For E/S Series device specifications, refer to one of the following documents:

- The manual calibration procedure for the device, which is available for download at [ni.com/calibration](http://ni.com/calibration)
- The product data sheet, which is available for download at [ni.com/products](http://ni.com/products)
- The hardware documentation for the device, which is available for download at [ni.com/manuals](http://ni.com/manuals)

## Technical Support Resources

---

### NI Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of [ni.com](http://ni.com).

A Declaration of Conformity (DoC) is our claim of compliance with the Council of the European Communities using the manufacturer's declaration of conformity. This system affords the user protection for electronic compatibility (EMC) and product safety. You can obtain the DoC for your product by visiting [ni.com/hardref.nsf](http://ni.com/hardref.nsf). If your product supports calibration, you can obtain the calibration certificate for your product at [ni.com/calibration](http://ni.com/calibration).

# Worldwide Support

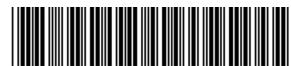
National Instruments corporate headquarters is located at 11500 North Mopac Expressway, Austin, Texas, 78759-3504. National Instruments also has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of [ni.com](http://ni.com). Branch office Web sites provide up-to-date contact information, support phone numbers, email addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. For telephone support in the United States, dial 512 795 8248. For telephone support outside the United States, contact your local branch office:

Australia 1800 300 800, Austria 43 0 662 45 79 90 0,  
Belgium 32 0 2 757 00 20, Brazil 55 11 3262 3599,  
Canada (Calgary) 403 274 9391, Canada (Ottawa) 613 233 5949,  
Canada (Québec) 450 510 3055, Canada (Toronto) 905 785 0085,  
Canada (Vancouver) 514 685 7530, China 86 21 6555 7838,  
Czech Republic 420 224 235 774, Denmark 45 45 76 26 00,  
Finland 385 0 9 725 725 11, France 33 0 1 48 14 24 24,  
Germany 49 0 89 741 31 30, Greece 30 2 10 42 96 427,  
India 91 80 51190000, Israel 972 0 3 6393737, Italy 39 02 413091,  
Japan 81 3 5472 2970, Korea 82 02 3451 3400, Malaysia 603 9131 0918,  
Mexico 001 800 010 0793, Netherlands 31 0 348 433 466,  
New Zealand 0800 553 322, Norway 47 0 66 90 76 60,  
Poland 48 22 3390150, Portugal 351 210 311 210,  
Russia 7 095 783 68 51, Singapore 65 6226 5886,  
Slovenia 386 3 425 4200, South Africa 27 0 11 805 8197,  
Spain 34 91 640 0085, Sweden 46 0 8 587 895 00,  
Switzerland 41 56 200 51 51, Taiwan 886 2 2528 7227,  
Thailand 662 992 7519, United Kingdom 44 0 1635 523545

IVI™, LabVIEW™, National Instruments™, NI™, ni.com™, NI-DAQ™, and SCXI™ are trademarks of National Instruments Corporation. Product and company names mentioned herein are trademarks or trade names of their respective companies. For patents covering National Instruments products, refer to the appropriate location: **Help»Patents** in your software, the `patents.txt` file on your CD, or [ni.com/patents](http://ni.com/patents).

© 2004 National Instruments Corp. All rights reserved.



370935A-01

Apr04