NI 6711/6713/6731/6733
CALIBRATION PROCEDURE

Introduction

This document contains step-by-step instructions for calibrating National Instruments 6711/6713/6731/6733 for PCI/PXI/CompactPCI analog output (AO) devices. Use this calibration procedure in conjunction with the ni671xCal.dll file, which contains specific functions required for calibrating NI 6711/6713/6731/6733 devices.

✎ **Note** Refer to ni.com/support/calibrat/mancal.htm for a copy of the ni671xCal.dll file.

What Is Calibration?

Calibration consists of verifying the measurement accuracy of a device and adjusting for any measurement error. Verification is measuring the performance of the device and comparing these measurements to the factory specifications. During calibration, you supply and read voltage levels using external standards, then you adjust the module calibration constants. The new calibration constants are stored in the EEPROM. The calibration constants are loaded from memory as needed to adjust for the error in the measurements taken by the device.

Why Should You Calibrate?

The accuracy of electronic components drifts with time and temperature, which can affect measurement accuracy as the device ages. Calibration restores these components to their specified accuracy and ensures that the device still meets NI standards.

NATIONAL INSTRUMENTS

How Often Should You Calibrate?

The measurement requirements of your application determine how often the NI 6711/6713/6731/6733 must be calibrated to maintain accuracy. NI recommends that you perform a complete calibration at least once every year. You can shorten this interval to 90 days or six months based on the demands of your application.

Calibration Options: External Versus Internal

The NI 6711/6713/6731/6733 has two calibration options: an internal, or self-calibration, and an external calibration.

Internal Calibration

Internal calibration is a much simpler calibration method that does not rely on external standards. In this method, the device calibration constants are adjusted with respect to a high-precision voltage source on the NI 6711/6713/6731/6733. This type of calibration is used after the device has been calibrated with respect to an external standard. However, external variables such as temperature can still affect measurements. The new calibration constants are defined with respect to the calibration constants created during an external calibration, ensuring that the measurements can be traced back to the external standards. In essence, internal calibration is similar to the auto-zero function found on a digital multimeter (DMM).

External Calibration

External calibration requires using a high-precision DMM. During external calibration, the DMM supplies and reads voltages from the device. Adjustments are made to the device calibration constants to ensure that the reported voltages fall within the device specifications. The new calibration constants are then stored in the device EEPROM. After the onboard calibration constants have been adjusted, the high-precision voltage source on the device is adjusted. An external calibration provides a set of calibration constants that you can use to compensate for the error in the measurements taken by the NI 6711/6713/6731/6733.

Equipment and Other Test Requirements

This section describes the equipment, test conditions, documentation, and software you need to calibrate the NI 6711/6713/6731/6733.

Test Equipment

To calibrate the NI 6711/6713/6731/6733, you need a high-precision DMM that is at least 10 ppm (0.001%) accurate. NI recommends that you use the Agilent 3458A DMM for calibration.

If you do not have an Agilent 3458A DMM, use the accuracy specifications to select a substitute calibration standard.

If you do not have custom connection hardware, you may need a connector block such as the NI CB-68 and a cable such as the SH6868-D1. These components give you easy access to the individual pins on the 68-pin I/O connector.

Test Conditions

Follow these guidelines to optimize connections and test conditions during calibration:

- Keep connections to the NI 6711/6713/6731/6733 short. Long cables and wires act as antennae, picking up extra noise, which 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 and 28 °C. To operate the module at a specific temperature outside this range, calibrate the device at that temperature.

- Keep relative humidity below 80%.

- Allow a warm-up time of at least 15 minutes to ensure that the measurement circuitry is at a stable operating temperature.

Software

Because the NI 6711/6713/6731/6733 is a PC-based measurement device, you must have the proper device driver installed in the calibration system before attempting calibration. For this calibration procedure, you need NI-DAQ version 6.9.2 or earlier installed on the calibration computer. NI-DAQ, which configures and controls the NI 6711/6713/6731/6733, is available at ni.com/downloads.

NI-DAQ supports a number of programming languages, including LabVIEW, LabWindows/CVI, Microsoft Visual C++, Microsoft Visual Basic and Borland C++. When you install the driver, you only need to install support for the programming language that you intend to use.

You also need copies of the `ni671xCal.dll`, `ni671xCal.lib`, and `ni671xCal.h` files.

The DLL provides calibration functionality that does not reside in NI-DAQ, including the ability to protect the calibration constants, update the calibration date, and write to the factory calibration area. You can access the functions in this DLL through any 32-bit compiler. The factory calibration area and the calibration date should only be modified by a metrology laboratory or another facility that maintains traceable standards.

Configuring the NI 6711/6713/6731/6733

The NI 6711/6713/6731/6733 must be configured in NI-DAQ, which automatically detects the device. The following steps briefly explain how to configure the device in NI-DAQ. Refer to the *NI 671X/673X User Manual* for detailed installation instructions. You can install this manual when you install NI-DAQ.

1. Power down the computer.

2. Install the NI 6711/6713/6731/6733 in an available slot.

3. Power on the computer.

4. Launch Measurement & Automation Explorer (MAX).

5. Configure the NI 6711/6713/6731/6733 device number.

6. Click **Test Resources** to ensure that the NI 6711/6713/6731/6733 is properly working.

The NI 6711/6713/6731/6733 is now configured.

Note After a device is configured in MAX, the device is assigned a device number, which is used in each of the function calls to identify which DAQ device to calibrate.

Writing the Calibration Procedure

The calibration procedure in the *Calibrating the NI 6711/6713/6731/6733* section provides step-by-step instructions on calling the appropriate calibration functions. These calibration functions are C function calls from NI-DAQ that are also valid for Microsoft Visual Basic and Microsoft Visual C++ programs. Although LabVIEW VIs are not discussed in this procedure, you can program in LabVIEW using the VIs that have similar names to the NI-DAQ function calls in this procedure. Refer to the

Flowcharts section for illustrations of the code used at each step of the calibration procedure.

Often you must follow a number of compiler-specific steps to create an application that uses NI-DAQ. Refer to the *NI-DAQ User Manual for PC Compatibles* at `ni.com/manuals` for details about the required steps for each of the supported compilers.

Many of the functions listed in the calibration procedure use variables that are defined in the `nidaqcns.h` file. To use these variables, you must include the `nidaqcns.h` file in the code. If you do not want to use these variable definitions, you can examine the function call listings in the NI-DAQ documentation and the `nidaqcns.h` file to determine what input values are required.

Documentation

For information about NI-DAQ, refer to the following documentation:

• *NI-DAQ Function Reference Help*
   (**Start»Programs»National Instruments»NI-DAQ»NI-DAQ Help**)

• *NI-DAQ User Manual for PC Compatibles* at `ni.com/manuals`

These two documents provide detailed information about using NI-DAQ. The function reference help includes information on the functions in NI-DAQ. The user manual provides instructions on installing and configuring DAQ devices and detailed information on creating applications that use NI-DAQ. These documents are the primary references for writing the calibration utility. For further information on the device you are calibrating, you may also want to install the device documentation.

Calibrating the NI 6711/6713/6731/6733

To calibrate the NI 6711/6713/6731/6733, complete the following steps:

1. Verify the performance of the NI 6711/6713/6731/6733. This step, which is described in the *Verifying the Performance of the NI 6711/6713/6731/6733* section, confirms whether the device is in specification prior to adjustment.

2. Adjust the NI 6711/6713/6731/6733 calibration constants with respect to a known voltage source. This step is described in the *Adjusting the NI 6711/6713/6731/6733* section.

3. Re-verify the performance to ensure that the NI 6711/6713/6731/6733 is operating within its specifications after adjustment.

Verifying the Performance of the NI 6711/6713/6731/6733

Verification determines how well the device is meeting its specifications. The verification procedure is divided into the major functions of the device. Throughout the verification process, refer to the tables in the *Specifications* section to see if the device needs adjustment.

Verifying Analog Output

This procedure verifies the AO performance of the NI 6711/6713/6731/6733. NI recommends testing all channels of the device. However, to save time, you can test only the channels used in your application. Make sure that you have read the *Equipment and Other Test Requirements* section before starting this procedure.

1. Disconnect all cables to the device. Make sure the device is not connected to any circuits other than those specified by the calibration procedure.

2. To internally calibrate the device, call the Calibrate_E_Series function with the following parameters set as indicated:

    •   **calOP** set to ND_SELF_CALIBRATE

    •   **setOfCalConst** set to ND_USER_EEPROM_AREA

    •   **calRefVolts** set to 0

3. Connect the DMM to DAC0OUT as shown in Table 1.

Table 1. Connecting the DMM to DAC0OUT

Output Channel	DMM Positive Input	DMM Negative Input
DAC0OUT	DAC0OUT (pin 22)	AOGND (pin 56)
DAC1OUT	DAC1OUT (pin 21)	AOGND (pin 55)
DAC2OUT	DAC2OUT (pin 57)	AOGND (pin 23)
DAC3OUT	DAC3OUT (pin 25)	AOGND (pin 58)
DAC4OUT	DAC4OUT (pin 60)	AOGND (pin 26)
DAC5OUT	DAC5OUT (pin 28)	AOGND (pin 61)
DAC6OUT	DAC6OUT (pin 30)	AOGND (pin 63)
DAC7OUT	DAC7OUT (pin 65)	AOGND (pin 63)
Note: Pin numbers are given for 68-pin I/O connectors only. If you are using a 50-pin I/O connector, refer to the device user manual for signal connection locations.		

4. Refer to the table from the *Specifications* section that corresponds to the device you are verifying. This specification table shows all acceptable settings for the device.

5. Call `AO_Configure` to configure the device for the appropriate device number, channel, and output polarity (the NI 6711/6713/6731/6733 devices support only bipolar output range). Use channel 0 as the channel to verify. Read the remaining settings from the specification table for the device.

6. Call `AO_VWrite` to update the AO channel with the appropriate voltage. The voltage value is in the specification table.

7. Compare the resulting value shown by the DMM to the upper and lower limits on the specification table. If the value falls between these limits, the device has passed the test.

8. Repeat steps 3 through 5 until you have tested all values.

9. Disconnect the DMM from DAC0OUT, and reconnect it to the next channel, making the connections from Table 1.

10. Repeat steps 3 through 9 until you have verified all channels.

11. Disconnect the DMM from the device.

You have now verified the AO channels of the device.

Verifying the Performance of the Counter

This procedure verifies the performance of the counter. The NI 6711/6713/6731/6733 devices have only one timebase to verify, so you only need to verify counter 0. Because you cannot adjust this timebase, you can only verify the performance of counter 0. Make sure that you have read the *Equipment and Other Test Requirements* section, and then follow this procedure:

1. Connect the counter positive input to GPCTR0_OUT (pin 2) and the counter negative input to DGND (pin 35).

✎ **Note** Pin numbers are given for 68-pin I/O connectors only. If you are using a 50-pin I/O connector, refer to the device documentation for signal connection locations.

2. Call `GPCTR_Control` with **action** set to `ND_RESET` to place the counter in a default state.

3. Call `GPCTR_Set_Application` with **application** set to `ND_PULSE_TRAIN_GNR` to configure the counter for pulse-train generation.

4. Call `GPCTR_Change_Parameter` with **paramID** set to `ND_COUNT_1` and **paramValue** set to 2 to configure the counter to output a pulse with an off time of 100 ns.

5. Call `GPCTR_Change_Parameter` with **paramID** set to `ND_COUNT_2` and **paramValue** set to 2 to configure the counter to output a pulse with an on time of 100 ns.

6. Call `Select_Signal` with **signal** and **source** set to
    `ND_GPCTR0_OUTPUT` to route the counter signal to the GPCTR0_OUT
    pin on the device I/O connector.

7. Call `GPCTR_Control` with **action** set to `ND_PROGRAM` to start the
    generation of the square wave. The device begins to generate a 5 MHz
    square wave when `GPCTR_Control` completes execution.

8. Compare the value read by the counter to the test limits shown in the
    appropriate table in the *Specifications* section. If the value falls
    between these limits, the device has passed this test.

9. Disconnect the counter from the device.

You have now verified the device counter.

Adjusting the NI 6711/6713/6731/6733

This procedure adjusts the AO calibration constants. At the end of each
calibration procedure, these new constants are stored in the factory area
of the device EEPROM. An end-user cannot modify these values, which
provides a level of security that ensures users do not accidentally access or
modify any calibration constants adjusted by the metrology laboratory.

This step in the calibration process calls functions in NI-DAQ and in
the `ni671x.dll`. For further information on the functions in the
`ni671x.dll`, refer to the comments in the `ni671x.h` file.

1. Disconnect all cables to the device. Make sure the device is not
    connected to any circuits other than those specified by the calibration
    procedure.

2. To internally calibrate the device, call the `Calibrate_E_Series`
    function with the following parameters set as indicated:

    *   **calOP** set to `ND_SELF_CALIBRATE`
    *   **setOfCalConst** set to `ND_USER_EEPROM_AREA`
    *   **calRefVolts** set to `0`

3. Connect the calibrator to the device according to Table 2.

Table 2. Connecting the Calibrator to the Device

6711/6713/6731/6733 Pins	Calibrator
EXTREF (pin 20)	Output High
AOGND (pin 54)	Output Low
Pin numbers are given for 68-pin connectors only. If you are using a 50-pin connector, refer to the device documentation for signal connection locations.	

4. To find out the date of the last calibration, call `Get_Cal_Date`, which is included in the `ni671x.dll`. **CalDate** stores the date when the device was last calibrated.

5. Set the calibrator to output a voltage of 5.0 V.

6. Call `Calibrate_E_Series` with the following parameters set as indicated:

   • **calOP** set to `ND_EXTERNAL_CALIBRATE`

   • **setOfCalConst** set to `ND_USER_EEPROM_AREA`

   • **calRefVolts** set to `5.0`

Note If the voltage supplied by the source does not maintain a steady 5.0 V, you receive an error.

7. Call `Copy_Const` to copy the new calibration constants to the factory-protected portion of the EEPROM. This function also updates the calibration date.

8. Disconnect the calibrator from the device.

The device is now adjusted with respect to the external source. After the device is adjusted, you can verify the AO operation by repeating the *Verifying Analog Output* section.

Specifications

The following tables are accuracy specifications to use when verifying and adjusting the NI 6711/6713/6731/6733. The tables show the specifications for 1-year and 24-hour calibration intervals.

Using the Tables

The following definitions describe how to use the specification tables in this section.

Range

Range refers to the maximum allowable voltage range of an input or output signal. For example, if a device is configured in bipolar mode with a range of 20 V, the device can sense signals between +10 and –10 V.

Polarity

Polarity refers to the positive and negative voltages of the input signal that can be read. Bipolar means the device can read both positive and negative voltages. Unipolar means that the device can read only positive voltages.

Test Point

The Test Point is the voltage value that is input or output for verification purposes. This value is broken down into Location and Value. Location refers to where the test value fits within the test range. Pos FS refers to positive full-scale, and Neg FS refers to negative full-scale. Value refers to the voltage to be verified, and Zero refers to the outputting of zero volts.

24-Hour Ranges

The 24-Hour Range column contains the upper limits and lower limits for the test point value. If the device has been calibrated in the last 24 hours, the test point value should fall between the upper and lower limit values. These limit values are expressed in volts.

1-Year Ranges

The 1-Year Range column contains the upper limits and lower limits for the test point value. If the device has been calibrated in the last year, the test point value should fall between the upper and lower limit values. These limits are expressed in volts.

Counters

Because you cannot adjust the resolution of the counter/timers, these values do not have a 1-year or 24-hour calibration period. However, the test point and upper and lower limits are provided for verification purposes.

Table 3. Analog Output for the NI 6711/6713

Range (V)	Polarity	Test Point		24-Hour Ranges		1-Year Ranges	
		Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
0	Bipolar	Zero	0.0	–0.0059300	0.0059300	–0.0059300	0.0059300
20	Bipolar	Pos FS	9.9900000	9.9822988	9.9977012	9.9818792	9.9981208
20	Bipolar	Neg FS	–9.9900000	–9.9977012	–9.9822988	–9.9981208	–9.9818792

Table 4. Analog Output for the NI 6731/6733

Range (V)	Polarity	Test Point		24-Hour Ranges		1-Year Ranges	
		Location	Value (V)	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
0	Bipolar	Zero	0.0	–0.0010270	0.0010270	–0.0010270	0.0010270
20	Bipolar	Pos FS	9.9900000	9.9885335	9.9914665	9.9883636	9.9916364
20	Bipolar	Neg FS	–9.9900000	–9.9914665	–9.9885335	–9.9916364	–9.9883636

Table 5. Counter

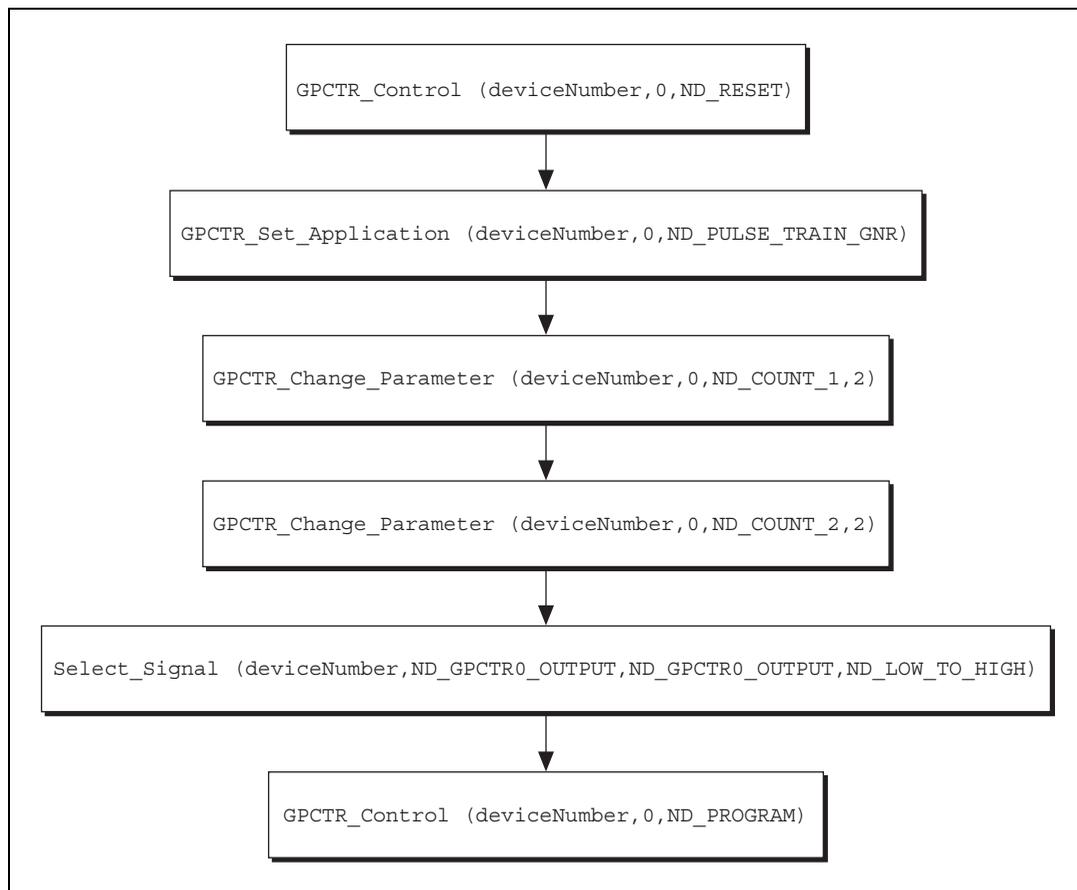| Set Point (MHz)	Upper Limit (MHz)	Lower Limit (MHz)
5	4.9995	5.0005

Flowcharts

These flowcharts show the appropriate NI-DAQ function calls for verifying and adjusting the NI 6711/6713/6731/6733. Refer to the *Calibrating the NI 6711/6713/6731/6733* section, the *NI-DAQ Function Reference Help* (**Start»Programs»National Instruments»NI-DAQ» NI-DAQ Help**), and the *NI-DAQ User Manual for PC Compatibles* at ni.com/manuals for additional information on the software structure.

Verifying Analog Output
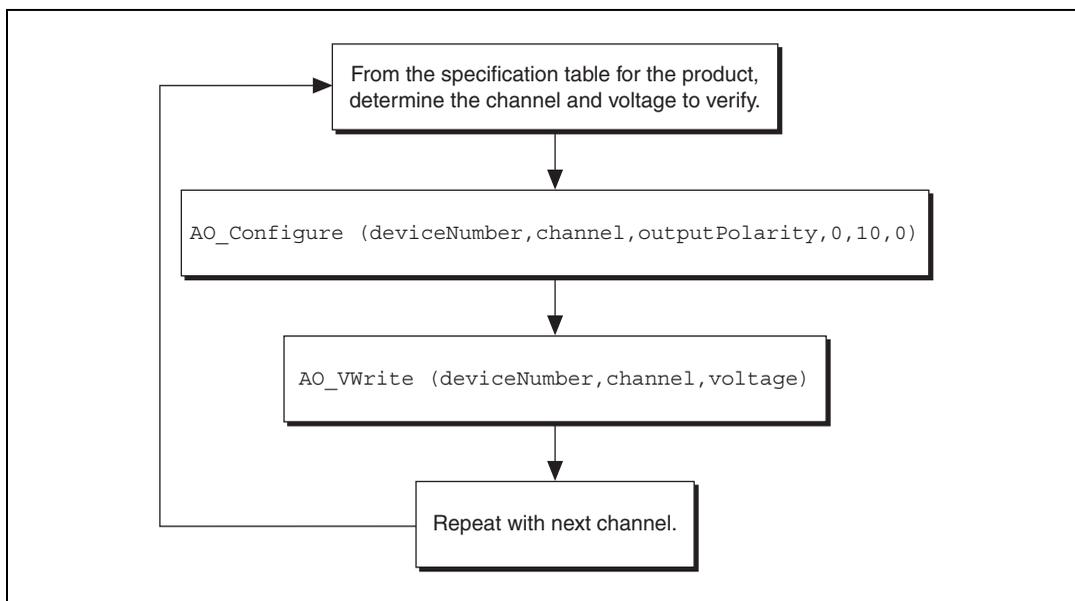
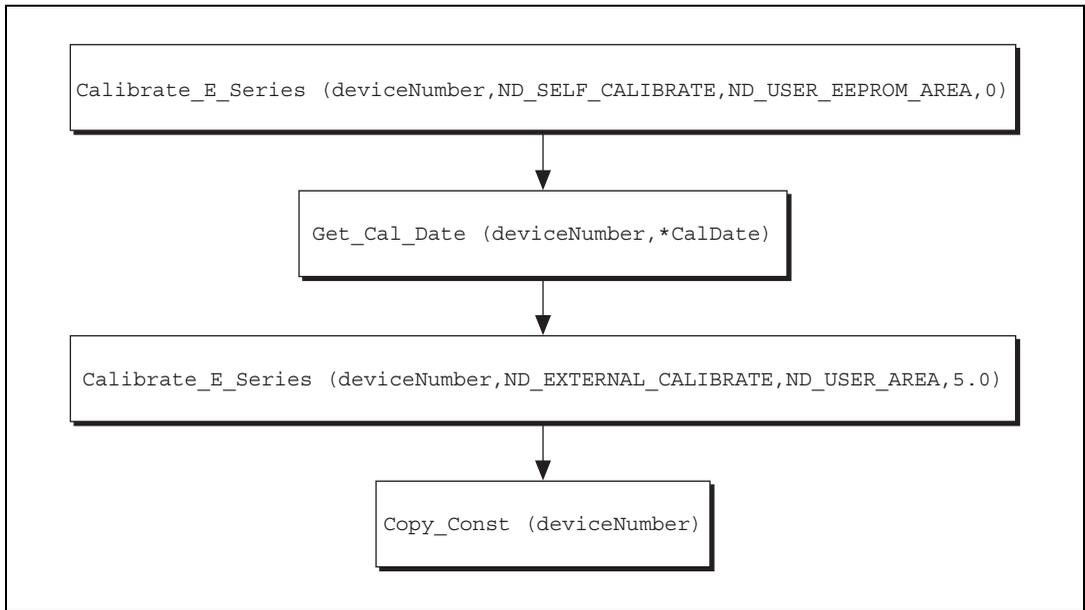**Figure 1.** Verifying Analog Output

Verifying the Counter

Figure 2. Verifying the Counter

Adjusting the NI 6711/6713/6731/6733

```
Calibrate_E_Series (deviceNumber,ND_SELF_CALIBRATE,ND_USER_EEPROM_AREA,0)
```

```
Get_Cal_Date (deviceNumber,*CalDate)
```

```
Calibrate_E_Series (deviceNumber,ND_EXTERNAL_CALIBRATE,ND_USER_AREA,5.0)
```

```
Copy_Const (deviceNumber)
```

Figure 3. Adjusting the NI 6711/6713/6731/6733