NATIONAL INSTRUMENTS™

NI 6703/6704 FOR PCI/PXI/COMPACTPCI

Introduction

This document contains step-by-step instructions for calibrating the NI 6703/6704 for PCI/PXI/CompactPCI. Use this calibration procedure in conjunction with the `ni6704Cal.dll` file, which contains specific functions required for calibrating the NI 6703/6704 for PCI/PXI/CompactPCI.

Note Refer to `ni.com/support/calibrat/mancal.htm` for a copy of the `ni6704Cal.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 National Instruments standards.

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How Often Should You Calibrate?

The measurement requirements of your application determine how often the NI 6703/6704 for PCI/PXI/CompactPCI needs to 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

NI 6703/6704 for PCI/PXI/CompactPCI products have two calibration options, an internal or self-calibration, and an external calibration.

Internal Calibration

The NI 6703/6704 for PCI/PXI/CompactPCI performs continuous internal calibration using special calibration channels. Both the NI 6703 for PCI/PXI/CompactPCI and the NI 6704 for PCI/PXI/CompactPCI have 16 voltage outputs and two voltage calibration channels. The NI 6704 for PCI/PXI/CompactPCI also has 16 current outputs and two current calibration channels. All the output and calibration channels are scanned and refreshed together. The outputs of the calibration channels for the NI 6703 for PCI/PXI/CompactPCI and NI 6704 for PCI/PXI/CompactPCI are continuously compared to the onboard reference, and the offset and gain of the 16-bit digital-to-analog converter (DAC) are adjusted to minimize the error of the calibration channels. Because the NI 6703 for PCI/PXI/CompactPCI and NI 6704 for PCI/PXI/CompactPCI have excellent channel-to-channel matching of offset and gain errors, minimizing the error on the calibration channels also minimizes the error for all of the voltage and current outputs.

External Calibration

External calibration requires a high-precision digital multimeter (DMM) to measure error on the NI 6703/6704 for PCI/PXI/CompactPCI outputs. The error is then corrected with a set of calibration constants that adjust the offset and gain of the 16-bit DAC to ensure that the output voltages and currents fall within the device specifications.

Because of the NI 6703/6704 for PCI/PXI/CompactPCI calibration circuitry, the only calibration adjustment you must make is to adjust the values of the calibration channels to account for time- or temperature-related drift of the onboard reference.

Equipment and Other Test Requirements

This section describes the equipment, test conditions, documentation, and software you need to calibrate the NI 6703/6704 for PCI/PXI/CompactPCI.

Test Equipment

To calibrate the NI 6703/6704 for PCI/PXI/CompactPCI, you need a high-precision DMM that is at least 10 ppm (0.001%) accurate. NI recommends that you use the Hewlett-Packard 3458A DMM for calibration.

If you do not have a Hewlett-Packard 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 6703/6704 for PCI/PXI/CompactPCI 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 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 6703/6704 for PCI/PXI/CompactPCI 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 the latest version of NI-DAQ installed on the calibration computer. NI-DAQ, which configures and controls the NI 6703/6704 for PCI/PXI/CompactPCI, 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 a copy of the `ni6704Cal.dll`, `ni6704Cal.lib`, and `ni6704Cal.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. The factory calibration area and the calibration date should only be modified by a metrology laboratory or another facility that maintains traceable standards. You can access the functions in this DLL through any 32-bit compiler.

Configuring the NI 6703/6704 for PCI/PXI/CompactPCI in NI-DAQ

The NI 6703/6704 for PCI/PXI/CompactPCI must be configured in NI-DAQ, which automatically detects the device. The following steps briefly explain how to configure NI-DAQ. Refer to the *PCI/PXI-6703/6704 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 6703/6704 for PCI/PXI/CompactPCI in an available slot.

3. Power on the computer.

4. Launch Measurement & Automation Explorer (MAX).

5. Configure the NI 6703/6704 for PCI/PXI/CompactPCI device number.

6. Click the **Test Resources** button to ensure that the NI 6703/6704 for PCI/PXI/CompactPCI is working properly.

The NI 6703/6704 for PCI/PXI/CompactPCI is now configured.

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

Writing the Calibration Procedure

The calibration procedure in the *Calibrating the NI 6703/6704 for PCI/PXI/CompactPCI* 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 Visual Basic programs. Although LabVIEW VIs are not discussed in this procedure, you can

program in LabVIEW using the VIs that are named similarly 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 products you are calibrating, you may also want to install the device user manual.

Calibrating the NI 6703/6704 for PCI/PXI/CompactPCI

To calibrate the NI 6703/6704 for PCI/PXI/CompactPCI, complete the following steps:

1. Verify the performance of the NI 6703/6704 for PCI/PXI/CompactPCI. This step, which is covered in the *Verifying the Performance of the NI 6703/6704 for PCI/PXI/CompactPCI* section, confirms whether the device is in specification prior to adjustment.

2. Adjust the NI 6703/6704 for PCI/PXI/CompactPCI calibration constants with respect to a known voltage source. This step is described in the *Adjusting the NI 6703/6704 for PCI/PXI/CompactPCI* section.

3. Reverify the performance to ensure that the NI 6703/6704 for PCI/PXI/CompactPCI is operating within its specifications after adjustment.

Verifying the Performance of the NI 6703/6704 for PCI/PXI/CompactPCI

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 later in this document to see if the device needs to be adjusted.

Verifying Voltage Output

This procedure verifies whether the output of voltage channel 0 is within specifications. Because of the channel-to-channel matching of the NI 6703/6704 for PCI/PXI/CompactPCI voltage channels, if voltage channel 0 is operating within specifications, all the voltage channels should be operating within specifications. However, if you want to verify the channels individually, this procedure can be easily expanded to verify all the voltage channels. Perform the procedure once for each value of the channel parameter from 0 to 15. Each time you repeat the procedure, you also need to connect the appropriate channel to the DMM. Refer to the *PCI/PXI-6703/6704 User Manual* at ni.com/manuals for the pin numbers corresponding to each channel. To verify the voltage output, make sure that you have read the *Equipment and Other Test Requirements* section, and complete the following steps:

1. Call the Get_Cal_Date function contained in ni6704Cal.dll to determine the previous calibration date of the NI 6703/6704 for PCI/PXI/CompactPCI.

2. Connect the DMM to the NI 6703/6704 for PCI/PXI/CompactPCI as shown in the following table:

Signal Name	Description	NI 6703/6704 for PCI/PXI/CompactPCI Output	DMM Input
VCH0	Voltage Channel 0	Pin 34	High
AGND0	Analog Ground 0	Pin 68	Low

3. Place the DMM in voltage mode.

4. Call AO_VWrite to output 0.0 V on voltage channel 0. Set the following parameters:

   - **chan**—0
   - **voltage**—0.0

5. Compare the resulting value shown by the DMM to the upper and lower limits listed in Table 1 in the *Specifications* section. If the value falls between these limits, the device passes the test.

6. Call `AO_VWrite` to output 10.0 V on voltage channel 0. Set the following parameters:

   • **chan**—0

   • **voltage**—10.0

7. Again, compare the resulting value shown by the DMM to the upper and lower limits listed in Table 1 in the *Specifications* section. If the value falls between these limits, the NI 6703/6704 for PCI/PXI/CompactPCI passes voltage verification.

8. Disconnect the DMM from the NI 6703/6704 for PCI/PXI/CompactPCI.

You have now verified the voltage output of the NI 6703/6704 for PCI/PXI/CompactPCI.

Verifying Current Output (NI 6704 for PCI/PXI/CompactPCI Only)

This procedure verifies that the current output of channel 16 is within specifications. Because of the channel-to-channel matching of the NI 6704 for PCI/PXI/CompactPCI current channels, if current channel 16 is operating within specifications, all the current channels should be operating within specifications. However, you can verify the channels individually for each current channel. Perform the procedure once for each value of the channel parameter from 16 to 31. You also need to connect the appropriate channel to the DMM each time you repeat the procedure. Refer to the *PCI/PXI-6703/6704 User Manual* for the pin numbers corresponding to each channel.

To verify current output, complete the following steps:

1. Call the `Get_Cal_Date` function to determine the previous calibration date of the NI 6704 for PCI/PXI/CompactPCI.

2. Connect the DMM to the NI 6704 for PCI/PXI/CompactPCI as shown in the following table:

Signal Name	Description	NI 6704 for PCI/PXI/CompactPCI Output	DMM Input
ICH16	Current Channel 16	Pin 67	High
AGND16	Analog Ground 16	Pin 68	Low

3. Place the DMM in current mode.

4. Call `AO_VWrite` to output 0.1 mA on current channel 16. Set the following parameters:

   • **chan**—16

   • **voltage**—0.1

5. Compare the resulting value shown by the DMM to the upper and lower limits listed in Table 2 in the *Specifications* section. If the value falls between these limits, the device passes the test.

6. Call `AO_VWrite` to output 20.0 mA on current channel 16. Set the following parameters:

   • **chan**—16

   • **voltage**—20.0

7. Again, compare the resulting value shown by the DMM to the upper and lower limits listed in Table 2 in the *Specifications* section. If the value falls between these limits, the device passes current verification.

8. Disconnect the DMM from the NI 6704 for PCI/PXI/CompactPCI.

You have now verified the current output of the NI 6704 for PCI/PXI/CompactPCI.

Adjusting the NI 6703/6704 for PCI/PXI/CompactPCI

At the end of each calibration procedure, new constants are stored in the user calibration area of the NI 6703/6704 for PCI/PXI/CompactPCI, ensuring that the device stores a permanent record of the calibration constants. Storing the calibration constants here also ensures that the constants automatically load when the NI 6703/6704 for PCI/PXI/CompactPCI is powered up.

Adjusting Voltage Output

For the voltage outputs, you need to make offset and gain adjustments. Adjust offsets first, followed by gains. Adjust offset and gain again to ensure accuracy. This second set of offset and gain adjustments is necessary because a large initial change in one of the calibration channels can affect the accuracy of the other calibration channel.

The following table lists the offset and gain channel numbers:

Calibration Channel	NI 6703 for PCI/PXI/CompactPCI Channel Numbers	NI 6704 for PCI/PXI/CompactPCI Channel Numbers
Voltage Offset	16	32
Voltage Gain	17	34

To measure voltage outputs, complete the following steps:

1. Call `Set_DAQ_Device_Info` to configure the NI 6703/6704 for PCI/PXI/CompactPCI so that you can access the calibration channels. Set the following parameters:

   - **infoType**—`ND_CALIBRATION_ENABLE`
   - **infoValue**—`ND_YES`

2. Connect the DMM to the NI 6703/6704 for PCI/PXI/CompactPCI as shown in the following table:

Signal Name	Description	NI 6703/6704 for PCI/PXI/CompactPCI Output	DMM Input
VCH0	Voltage Channel 0	34	High
AGND0	Analog Ground 0	68	Low

3. Place the DMM in voltage mode.

4. Call `AO_VWrite` to output 0.0 V on voltage channel 0. Set the following parameters:

   - **chan**—0
   - **voltage**—0.0

5. Call `AO_VWrite` with the channel set to the voltage offset channel. Adjust the **voltage** parameter until the DMM reads as close to 0.0 V as possible. The value you write to the voltage offset channel is close to 0.0 V. Increasing the voltage value lowers the magnitude of the voltage on voltage channel 0. Decreasing the voltage value increases the magnitude of the voltage on voltage channel 0.

6. Call `AO_VWrite` to output 10.0 V on voltage channel 0. Set the following parameters:

   - **chan**—0
   - **voltage**—10.0

7. Call `AO_VWrite` with the channel set to the voltage gain channel. Adjust the **voltage** parameter until the DMM reads as close to 10.0 V as possible. The value you write to the voltage gain channel is close to 10.0 V. Increasing the voltage value lowers the magnitude of the voltage on voltage channel 0. Decreasing the voltage value increases the magnitude of the voltage on voltage channel 0.

You have now adjusted the voltage output.

Adjusting Current Output (NI 6704 for PCI/PXI/CompactPCI Only)

For the current outputs, you need to adjust offset and gain. Adjust offset first, followed by gain. Adjust both offset and gain again to ensure accuracy. This second set of offset and gain adjustments is necessary because a large initial change in one of the calibration channels can affect the accuracy of the other calibration channel. Refer to the offset and gain channel numbers in the following table:

Calibration Channel	NI 6704 for PCI/PXI/CompactPCI Channel Numbers
Current Offset	33
Current Gain	35

To adjust current output, complete the following steps:

1. Call `Set_DAQ_Device_Info` to configure the NI 6704 for PCI/PXI/CompactPCI so you can access the calibration channels. Set the following parameters:
   - **infoType**—`ND_CALIBRATION_ENABLE`
   - **infoValue**—`ND_YES`
2. Connect the DMM to the NI 6704 for PCI/PXI/CompactPCI as shown in the following table:

Signal Name	Description	NI 6704 for PCI/PXI/CompactPCI Output	DMM Input
ICH16	Current Channel 16	Pin 67	High
AGND16	Analog Ground 16	Pin 68	Low

3. Place the DMM in current mode.

4. Call `AO_VWrite` to output 0.1 mA on current channel 16. Set the following parameters:

    • **chan**—16
    • **voltage**—0.1

5. Call `AO_VWrite` with the channel set to the current offset channel. Adjust the **voltage** parameter until the DMM reads as close to 0.1 mA as possible. The value you write to the current offset channel is close to 0.01 mA. Increasing the voltage value lowers the magnitude of the current on current channel 16. Decreasing the voltage value increases the magnitude of the current on current channel 16.

6. Call `AO_VWrite` to output 20.0 mA on current channel 16. Set the following parameters:

    • **chan**—16
    • **voltage**—20.0

7. Call `AO_VWrite` with the channel set to the current gain channel. Adjust the **voltage** parameter until the DMM reads as close to 20.0 mA as possible. The value you write to the current gain channel is close to 19.608 mA. Increasing the voltage value lowers the magnitude of the current on current channel 16. Decreasing the voltage value increases the magnitude of the current on current channel 16.

You have now adjusted the current output.

Saving Calibration Values

After you have adjusted the calibration constants, you must store the new calibration constants in the user calibration area of the NI 6703/6704 for PCI/PXI/CompactPCI EEPROM to ensure that the new calibration values are permanently saved and automatically loaded when the NI 6703/6704 for PCI/PXI/CompactPCI is powered on. If the calibration is being performed by a metrology laboratory or another facility that maintains traceable standards, the calibration values should also be stored in the factory calibration area. Calibration constants stored in the factory calibration area cannot be overwritten by the user.

To save the calibration constants and update the calibration dates, complete the following steps:

1. Call `AO_Calibrate` to store the new calibration constants in the user calibration area of the EEPROM. Set the following parameters:

    • **operation**—2
    • **calibrationArea**—1

2. Call `Set_DAQ_Device_Info` to configure the NI 6703/6704 for PCI/PXI/CompactPCI so it is no longer possible to access the calibration channels. Set the following parameters:

   - **infoType**—`ND_CALIBRATION_ENABLE`
   - **infoValue**—`ND_NO`

3. If the calibration is being performed by a metrology laboratory or another facility that maintains traceable standards, call the `Copy_Cal` function in the `ni6704Cal.dll`. Calling this function copies the calibration values to the factory calibration area and updates the calibration date to match the system clock of the calibration computer.

The NI 6703/6704 for PCI/PXI/CompactPCI is now adjusted.

Verifying the New Calibration Constants

You can verify the new calibration constants by repeating the *Verifying the Performance of the NI 6703/6704 for PCI/PXI/CompactPCI* section.

Specifications

The following tables are the specifications to use when calibrating the NI 6703/6704 for PCI/PXI/CompactPCI. 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.

Test Point

The test point is the voltage value that is input or output for verification purposes.

24-Hour Ranges

The 24-hour range column contains the upper limits and lower limits for the test point value. If the NI 6703/6704 for PCI/PXI/CompactPCI has been calibrated in the last 24 hours, the test point value should fall between the upper and lower limit values.

1-Year Ranges

The 1-year range column contains the upper limits and lower limits for the test point value. If the NI 6703/6704 for PCI/PXI/CompactPCI has been calibrated in the last year, the test point value should fall between the upper and lower limit values.

Table 1. Voltage Output Specifications

Test Point Value (V)	24-Hour Ranges		1-Year Ranges	
	Lower Limit (V)	Upper Limit (V)	Lower Limit (V)	Upper Limit (V)
9.9	9.8991019	9.9008981	9.8989435	9.9010565
0.0	−0.0007100	0.0007100	−0.0007100	0.0007100
−9.9	9.9008981	−9.8991019	−9.9010565	−9.8989435

Table 2. Current Output Specifications (NI 6704 for PCI/PXI/CompactPCI Only)

Test Point Value (mA)	24-Hour Ranges		1-Year Ranges	
	Lower Limit (mA)	Upper Limit (mA)	Lower Limit (mA)	Upper Limit (mA)
0.1	0.0985616	0.1014384	0.09855	0.10145
20	19.997885	20.002115	19.995565	20.004435

Flowcharts

The following flowcharts show the appropriate NI-DAQ function calls for verifying and adjusting the NI 6703/6704 for PCI/PXI/CompactPCI. Refer to the *Calibrating the NI 6703/6704 for PCI/PXI/CompactPCI* section of this document, the *NI-DAQ Function Reference Help,* and the *NI-DAQ User Manual for PC Compatibles* for additional information on the software structure.
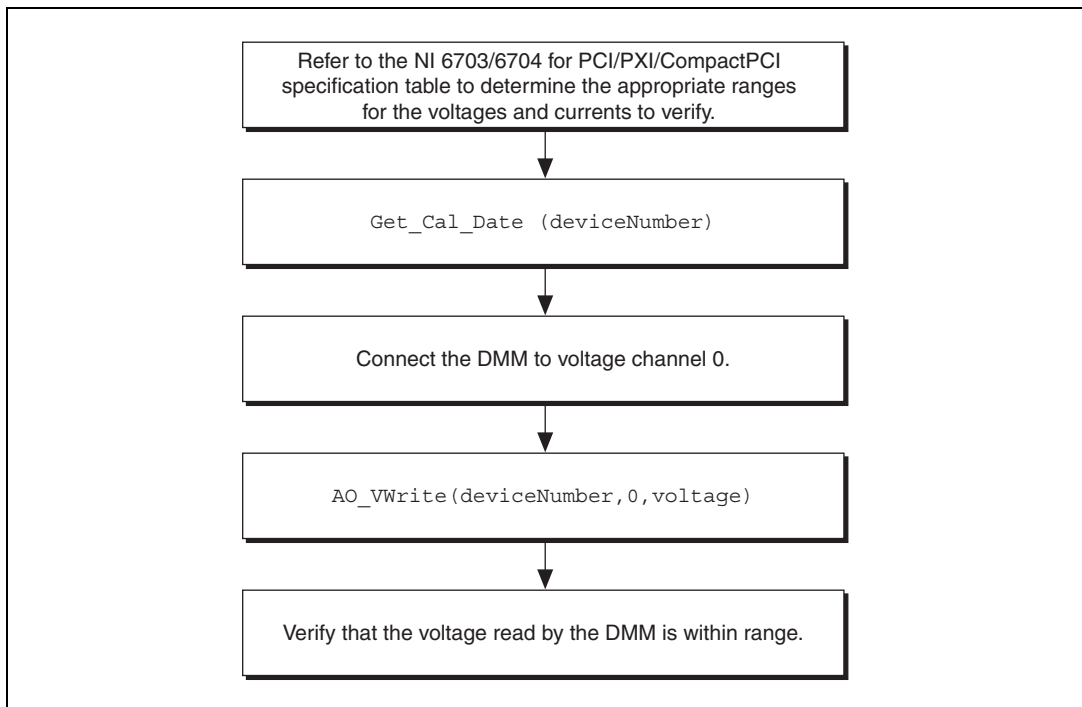
Voltage Output Verification

Figure 1. Voltage Output Verification

Current Output Verification (NI 6704 for PCI/PXI/CompactPCI Only)

```
Refer to the NI 6703/6704 for PCI/PXI/CompactPCI
specification table to determine the appropriate ranges
for the voltages and currents to verify.
```

```
Get_Cal_Date (deviceNumber)
```

```
Connect the DMM to current channel 16.
```

```
AO_VWrite(deviceNumber,16,voltage)
```

```
Verify that the current read by the DMM is within range.
```
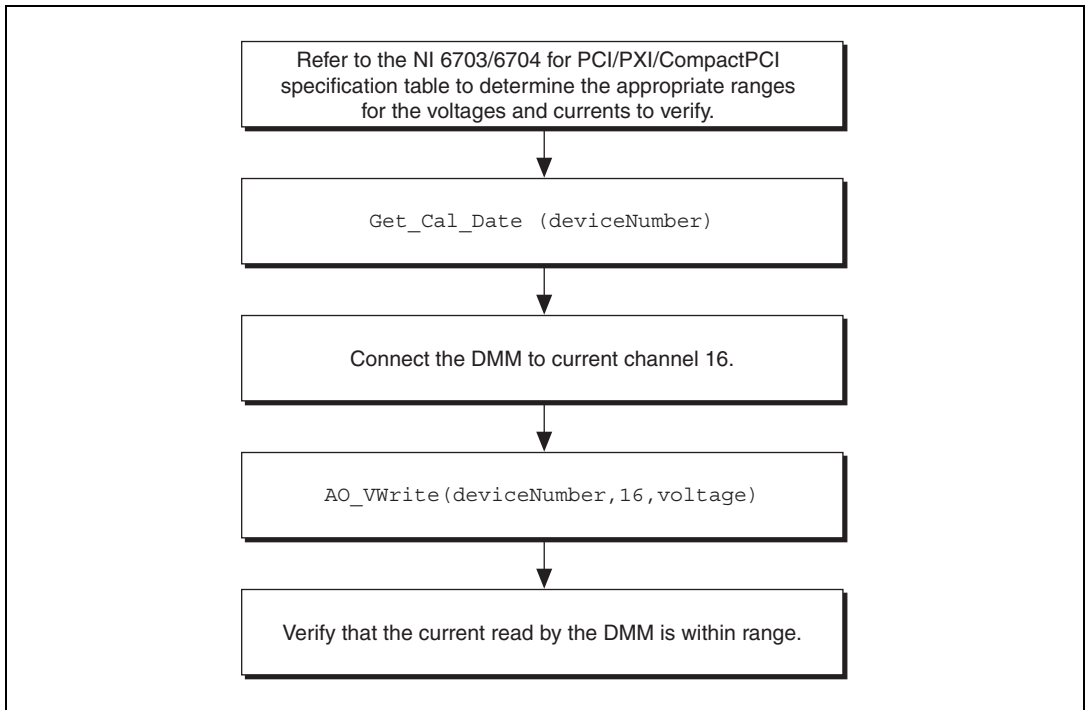
Figure 2. Current Output Verification (NI 6704 for PCI/PXI/CompactPCI Only)

Voltage Output Adjustment

```
Set_DAQ_Device_Info(deviceNumber,ND_CALIBRATION_ENABLE,ND_YES)
```

↓

Connect the DMM to voltage channel 0.

↓

```
AO_VWrite(deviceNumber,0,0.0)
```

↓

NI 6703 for PCI/PXI/CompactPCI: `AO_VWrite(deviceNumber,16,voltage)`
Adjust voltage until the DMM reads 10.0 V.
NI 6704 for PCI/PXI/CompactPCI: `AO_VWrite(deviceNumber,32,voltage)`
Adjust voltage until the DMM reads 10.0 V.

↓

```
AO_VWrite(deviceNumber,0,10.0)
```

↓

NI 6703 for PCI/PXI/CompactPCI: `AO_VWrite(deviceNumber,17,voltage)`
Adjust voltage until the DMM reads 10.0 V.
NI 6704 for PCI/PXI/CompactPCI: `AO_VWrite(deviceNumber,34,voltage)`
Adjust voltage until the DMM reads 10.0 V.

Figure 3. Voltage Output Adjustment

Current Output Adjustment

```
Set_DAQ_Device_Info(deviceNumber,ND_CALIBRATION_ENABLE,ND_YES)
```

Connect the multimeter to current channel 16.

```
AO_VWrite(deviceNumber,16,0.1)
```

`AO_VWrite(deviceNumber,33,voltage)` Adjust voltage until the DMM reads 0.1 mA.

```
AO_VWrite(deviceNumber,16,20.0)
```

`AO_VWrite(deviceNumber,35,voltage)` Adjust voltage until the DMM reads 20.0 mA.
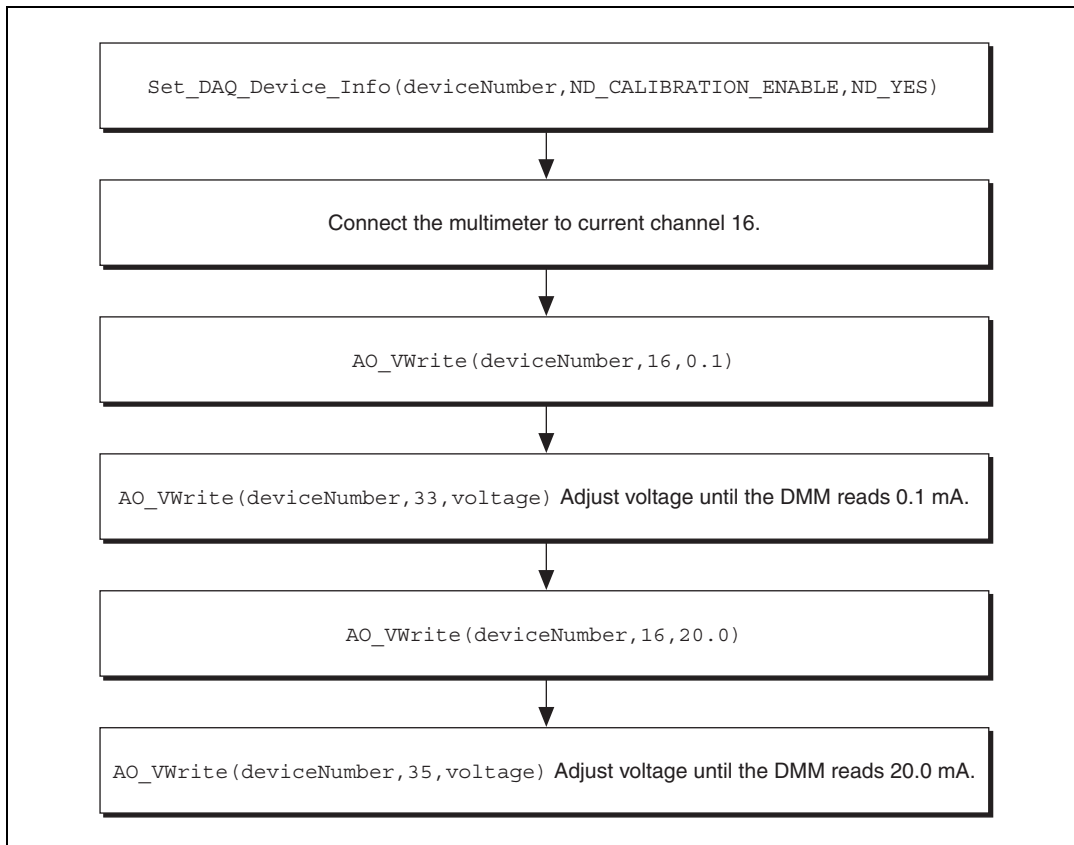
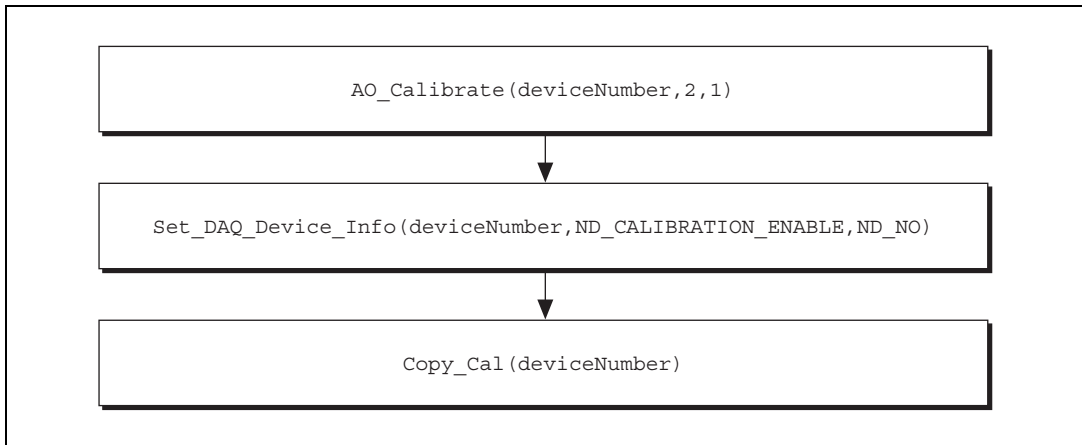**Figure 4.** Current Output Adjustment (NI 6704 for PCI/PXI/CompactPCI Only)

Saving Calibration Values

Figure 5. Saving Calibration Values