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# CALIBRATION PROCEDURE

# NI 6601/6602

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This document contains information and instructions for calibrating the National Instruments 6601/6602 data acquisition devices.

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NATIONAL INSTRUMENTS

# Introduction

## What Is Calibration?

*Calibration* consists of verifying the measurement accuracy of a device and adjusting for any measurement error. For the NI 6601/6602, calibration is simply verifying the measurement accuracy of the crystal oscillator on the device because the crystal oscillator is not user-adjustable. *Verification* is measuring the performance of a device and comparing these measurements to the factory specifications. If the device fails after calibration, return it to NI for repair or replacement. For more information about how to contact NI for repair or replacement, refer to the *Technical Support Information* document.

## Why Should You Verify?

The accuracy of timing components drifts with time and temperature, which can affect measurement accuracy. Verification determines whether the device still meets NI standards.

## How Often Should You Verify?

Calibrate the NI 6601/6602 at a regular interval as defined by the measurement accuracy requirements of your application. NI recommends that you perform a complete calibration at least once every year. You can shorten this interval based on the accuracy requirements of your application.

# Software and Documentation

You will need the following software and documentation to verify the NI 6601/6602. You can find these resources on the NI Web site at `ni.com`:

- Traditional NI-DAQ (Legacy) 7.4.4
- *Traditional NI-DAQ (Legacy) C Function Reference Help* file
- *Traditional NI-DAQ User Manual* document

## Software

This calibration procedure requires using the Traditional NI-DAQ (Legacy) 7.4.4. Traditional NI-DAQ supports a number of application development environments (ADEs) and 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 ADE or programming language you will use.

## Documentation

The *Traditional NI-DAQ (Legacy) C Function Reference Help* file and the *Traditional NI-DAQ User Manual* document contain detailed information about using the Traditional NI-DAQ driver. The help file includes detailed information about the driver functions. You can access the help file by selecting **Start»All Programs»National Instruments»NI-DAQ**. The *Traditional NI-DAQ User Manual* document provides instructions on installing Traditional NI-DAQ. This manual also includes detailed information about creating applications that use the Traditional NI-DAQ driver. These are your primary references for writing your calibration utility. You can also refer to the documentation for the programming language you are using. For further information about the products you are calibrating, refer to the *NI 660x User Manual*.

# Test Equipment

Verifying the NI 6601/6602 devices requires the following equipment:

- A highly stable 10 MHz, 5 MHz, or 1 MHz clock source that is accurate to within 1 ppm. NI recommends using the PXI-6608 to provide the stable clock. The PXI-6608 provides a 10 MHz clock that is accurate to 0.075 ppm over 1 year.
- An SH68-68-D1 cable or a standard 68-pin cable connector
- A 68-pin breakout box (if you are using a clock source other than the PXI-6608)

# Test Conditions

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

- Keep connections to the device as short as possible. Long cables and wires act as antennae by picking up extra noise that can affect measurements.
- Maintain an ambient temperature of approximately 25 °C.
- Keep relative humidity below 80%.
- Use shielded copper wire for all cable connections to the device. Use twisted-pair wire to eliminate noise and thermal offsets.
- Allow a warm-up time of at least 15 minutes to ensure the measurement circuitry is at a stable operating temperature.

# Calibration Process

This section contains instructions for verifying the operation of the crystal oscillator on the NI 6601/6602 devices using a stable clock source. Verifying the performance of the oscillator on an NI 6601/6602 device requires two counters on the NI 6601/6602 device—counters 0 and 1. Counter 1 uses a stable clock as the source to generate a 50 ms single pulse, which is applied to the GATE of counter 0. The 20 MHz timebase on the NI 6601/6602 device, which is derived from the crystal oscillator, is the SOURCE of counter 0. You will count the number of clock edges of the 20 MHz timebase that occur during the 50 ms single pulse and calculate the frequency of the oscillator to determine if the device is within its specifications. Figure 1 shows a simple diagram of the process.

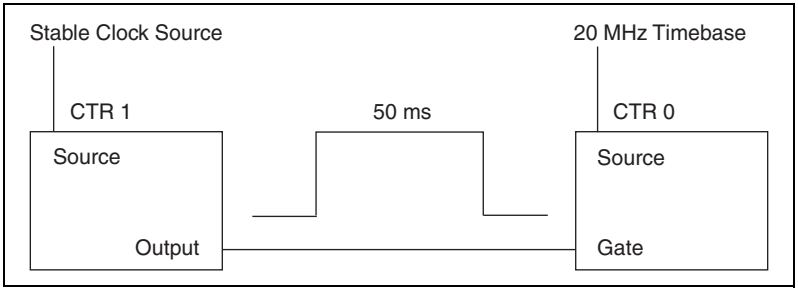



**Figure 1.** NI 6601/6602 Verification Process

The frequency measurement will have an uncertainty that is equal to the sum of the stable clock error and the quantization error caused by the counter. The clock error should be 1 ppm or less, as specified in the *Test Equipment* section of this document. The quantization error, which is the inherent uncertainty in digitizing an analog value, will always be up to 50 ns. Using a measurement duration of 50 ms gives a quantization error as follows:

$$\frac{50\text{ ns}}{50\text{ ms}} = 1\text{ ppm}$$

The sum of the stable clock error, 1 ppm, and the quantization error, 1 ppm, gives a total measurement uncertainty of 2 ppm. You can reduce measurement uncertainty by using a more stable clock, by increasing the measurement duration, or both. The calculations presented at the end of this document allow for a 2 ppm measurement uncertainty.

Both Traditional NI-DAQ and LabVIEW programming instructions are presented in the following sections. Choose the appropriate instructions for your programming environment.

## Setting Up the Stable Clock

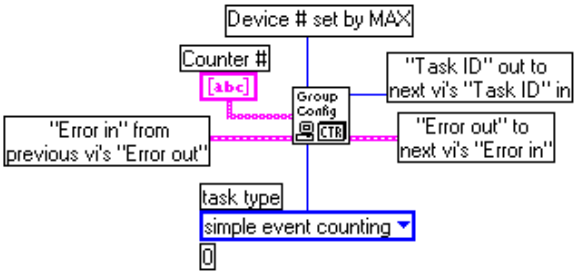
This section describes how to set up the clock. NI recommends using the PXI-6608 to provide the stable clock. You can use an alternative stable clock if it meets the specifications described in the *Test Equipment* section of this document. Instructions for both clock alternatives are included in the following two sections, *Setting Up a PXI-6608 Clock Source* and *Setting Up an Alternative Clock Source*.

### Setting Up a PXI-6608 Clock Source

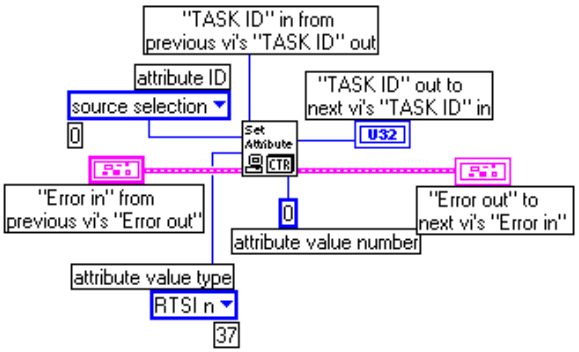
To set up a PXI-6608 as the stable clock source, complete the following steps:

1. Power on the 6608 device.
2. Wait 15 minutes to allow the measurement circuitry in the device to warm up.

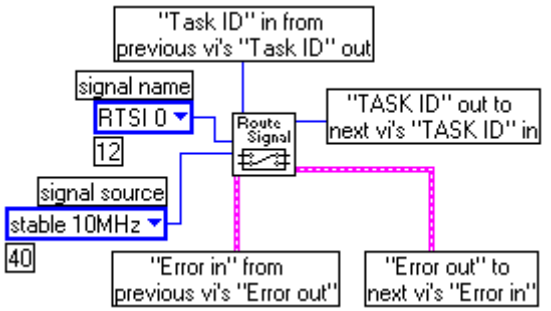
3. Route the 10 MHz stable clock of the PXI-6608 onto PFI_35.
   a. Configure counter 1 on the PXI-6608 to perform simple event counting.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Set_Application` with the following parameters:<br>**deviceNumber**: The value set by Measurement & Automation Explorer (MAX)<br>**gpctrNum**: `ND_COUNTER_1`<br>**application**: `ND_SIMPLE_EVENT_CNT` |  |

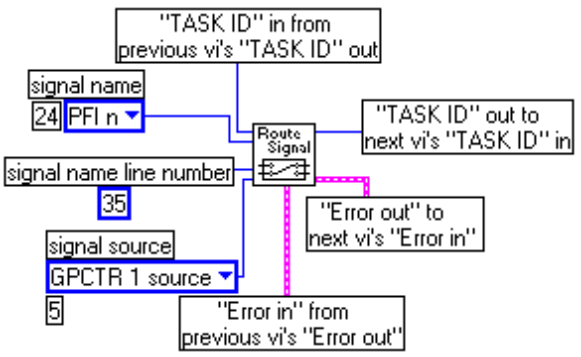
   b. Configure the **source** of counter 1 as RTSI line 0.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**paramID**: `ND_SOURCE`<br>**paramValue**: `ND_RTSI_0` |  |

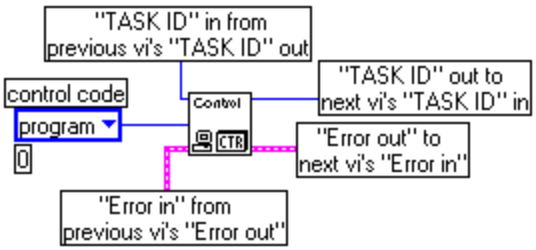
c. Route the stable 10 MHz clock on the PXI-6608 onto RTSI line 0.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `Select_Signal` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**signal**: `ND_RTSI_0`<br>**source**: `ND_STABLE_10_MHZ`<br>**sourceSpec**: `ND_DONT_CARE` |  |

d. Configure the **source** of counter 1 to be available on PFI line 35.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `Select_Signal` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**signal**: `ND_PFI_35`<br>**source**: `ND_GPCTR1_SOURCE`<br>**sourceSpec**: `ND_DONT_CARE` |  |

e. Program counter 1 to arm it.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**action**: `ND_PROGRAM` |  <br>"TASK ID" out connects to "TASK ID" in of step 14 in the *Measuring the Frequency of the NI 6601/6602 Device* section. |

## Setting Up an Alternative Clock Source

To set up a clock source other than a PXI-6608, complete the following steps:

1. Ensure that the clock source meets the requirements listed in the *Test Equipment* section.
2. Power the clock device.

**Note** After you complete the clock setup procedure, the clock is running and generating pulses.

# Connecting the Clock Source to the NI 6601/6602 Device

This section describes how to connect the clock source to the NI 6601/6602 device, whether you are using a PXI-6608 or another clock source.

## Connecting a PXI-6608 to the NI 6601/6602 Device

Connect the PXI-6608 clock source to the NI 6601/6602 device using an SH68-68-D1 cable, which connects to the I/O connector of each device.

## Connecting an Alternative Clock Source to the NI 6601/6602 Device

To connect an alternative clock source to the NI 6601/6602 device, complete the following steps:

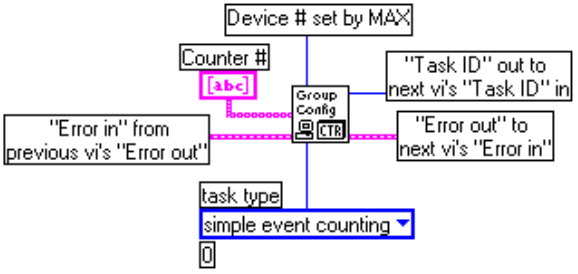
1. Connect the NI 6601/6602 device to a 68-pin breakout box using the SH68-68-D1 cable.
2. Connect the clock source to pins 7 and 41 of the 68-pin breakout box using twisted-pair wires.
   - Connect the clock to pin 7. Pin 7 corresponds to PFI_35, which is the SOURCE of counter 1 on all NI 6601/6602 devices.
   - Connect the ground of the clock to pin 41, which is digital ground.

# Measuring the Frequency of the NI 6601/6602 Device

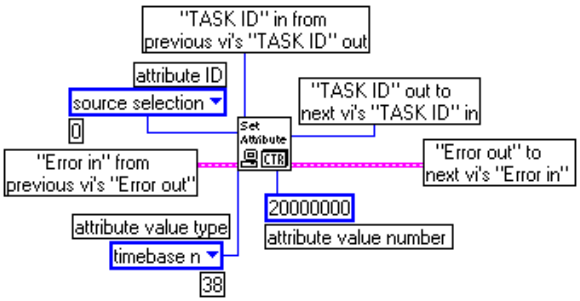
**Note** If you are verifying the PXI-6602 on a PXI chassis, the measured frequency is that of the PXI backplane clock instead of the onboard oscillator. To verify the onboard oscillator, you must calibrate the PXI-6602 on a PCI chassis using a CompactPCI-to-PCI adapter.

To measure the frequency of the NI 6601/6602 device for verification, complete the following steps:

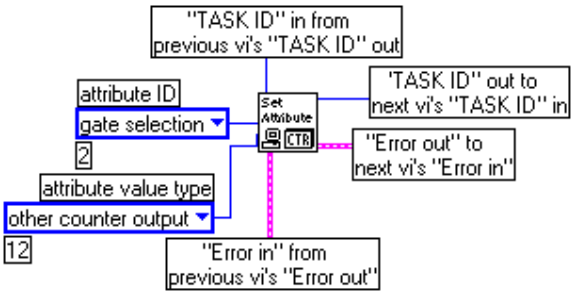
1. Configure counter 0 to perform simple event counting.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Set_Application` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**application**: `ND_SIMPLE_EVENT_CNT` |  |

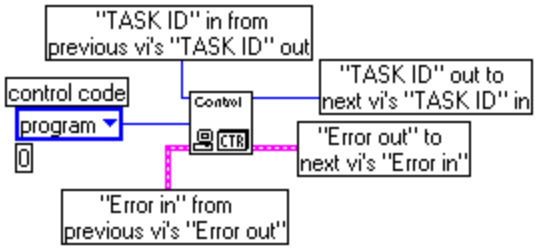
2. Set the **source** of counter 0 to be the 20 MHz timebase.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**paramID**: `ND_SOURCE`<br>**paramValue**: `ND_INTERNAL_20_MHZ` |  |

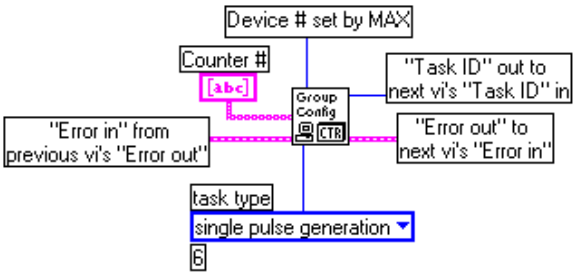
3. Configure the **gate** of counter 0 to be the **output** of counter 1.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**paramID**: `ND_GATE`<br>**paramValue**: `ND_OTHER_GPCTR_OUTPUT` |  |

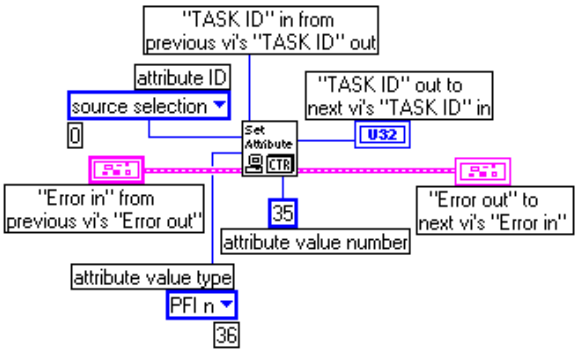
4. Arm counter 0 to perform simple event counting.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**action**: `ND_PROGRAM` |  <br>"TASK ID" out connects to "TASK ID" in of step 11. |

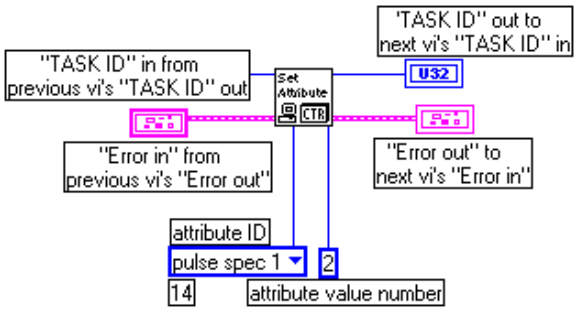
5. Configure counter 1 to perform single-pulse generation.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Set_Application` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**application**: `ND_SINGLE_PULSE_GNR` |  |

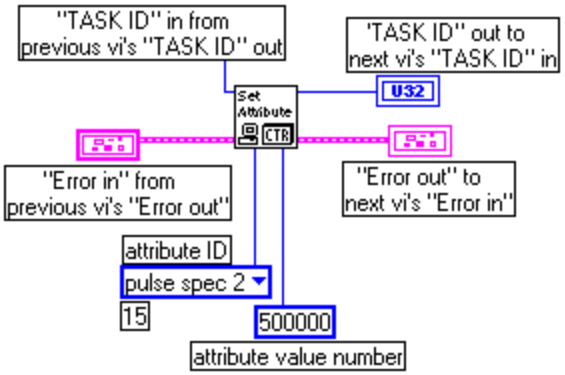
6. Configure **source** of counter 1 to be PFI line 35.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**paramID**: `ND_SOURCE`<br>**paramValue**: ND_PFI_35 |  |

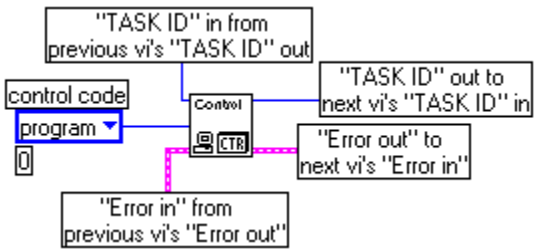
7. Set the pulse delay for the single-pulse generation.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**paramID**: `ND_COUNT_1`<br>**paramValue**: 2 |  |

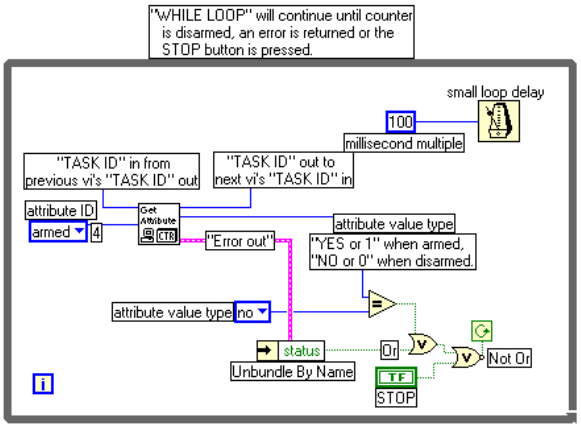
8. Set the pulse width for the single-pulse generation. The following example assumes a 10 MHz source (period = 100 ns) for counter 1. Therefore, the pulse width is 100 ns × 500000 = 50 ms. If you use a frequency other than 10 MHz, adjust the number accordingly. For a frequency F, 1/F × `ND_COUNT_2` should equal 50 ms.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Change_Parameter` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**paramID**: `ND_COUNT_2`<br>**paramValue**: `500000` |  |

9. Program counter 1 to perform single-pulse generation.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**action**: `ND_PROGRAM` |  |

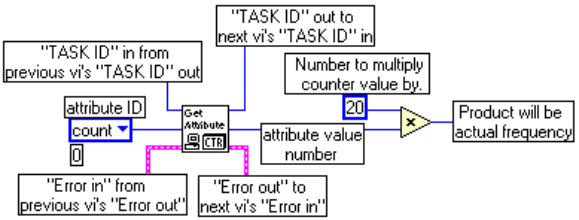
10. Loop until counter 1 has completed pulse generation.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_WATCH` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**entityID**: `ND_ARMED`<br>**entityValue**: A user-declared variable<br>See example code in the next paragraph. |  <br>"TASK ID" out connects to "TASK ID" in of step 13. |

### Example Code for GPCTR Watch

```
i16 iStatus = 0;
u32 ulArmed = ND_YES;
do
{
iStatus = GPCTR_Watch (deviceNumber, ND_COUNTER_1, ND_Armed, &ulArmed);}
while ((ulArmed==ND_YES) && (iStatus==0));
```

11. Calculate the frequency of the device.
    a. Retrieve the count from counter 0. The count represents the number of cycles of the 20 MHz timebase in 50 ms.
    b. Multiply the count returned above by 20 to calculate the number of pulses that should occur in one second, (50 ms × 20 = 1 s), which is the *measured frequency* of the 20 MHz timebase.

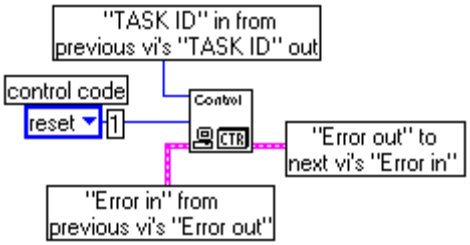
| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Watch` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**entityID**: `ND_COUNT`<br>**entityValue**: A user-declared variable<br>See example code in the next paragraph. |  <br>"TASK ID" in connects to "TASK ID" out of step 4. |

### Example Code for GPCTR Watch

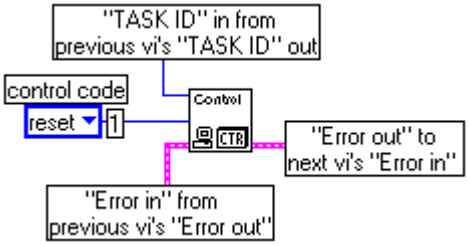
```
u32 ulCount = 0;

iStatus = GPCTR_WATCH (deviceNumber, ND_COUNTER_0, ND_COUNT, &ulCount);
ulCount = ulCount * 20;
```

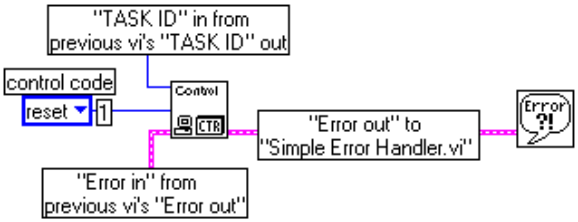
12. Reset counter 0 to its original state.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_0`<br>**action**: `ND_RESET` |  |

13. Reset counter 1 to its original state.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**action**: `ND_RESET` |  <br>"TASK ID" in connects to "TASK ID" out of step 10. |

14. Reset counter 1 on the PXI-6608 to its original state, if necessary.

| Traditional NI-DAQ Function Call | LabVIEW Block Diagram |
|---|---|
| Call `GPCTR_Control` with the following parameters:<br>**deviceNumber**: The value set by MAX<br>**gpctrNum**: `ND_COUNTER_1`<br>**action**: `ND_RESET` |  <br>"TASK ID" in connects to "TASK ID" out of step 3e in the *Setting Up the Stable Clock* section. |

You have now completed measuring the frequency of the crystal oscillator on the NI 6601/6602 device.

## Comparing the Measured Frequency to the NI 6601/6602 Device Specifications

Compare the calculated frequency from step 11 in the previous section with the following values:

- If the frequency you measure falls between the upper limit of 20,001,500 Hz and the lower limit of 19,998,500 Hz, the device is operating within its specifications.
- If the frequency you measure is above 20,001,500 Hz, the device is nonfunctional. Return the device to NI for repair or replacement.
- If the frequency you measure is below 19,998,500 Hz, the device is nonfunctional. Return the device to NI for repair or replacement.

You have completed verifying the operation of the NI 6601/6602 device.

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