Data acquisition programming basics

Learning objective

Learning how to program basic data acquisition functions in the **LabVIEW** graphical programming environment.

Initial setup

Connect the **NI USB-6001** data acquisition board to one of the computer's USB ports.

Open the **Measurement & Automation Explorer** (**NI MAX**) program and, under **My System** / **Devices and Interfaces**, check that the **NI USB-6001** data acquisition board is connected (the icon on the left has to be green).
Click the **Self-Test** button to check that the board is functioning normally.

The figures below may look different from the situation on your computer, where only one data acquisition board may be listed.

For programming data acquisition operations in **LabVIEW**, **tasks** are first created in **NI MAX** and then accessed in the graphical programming environment.

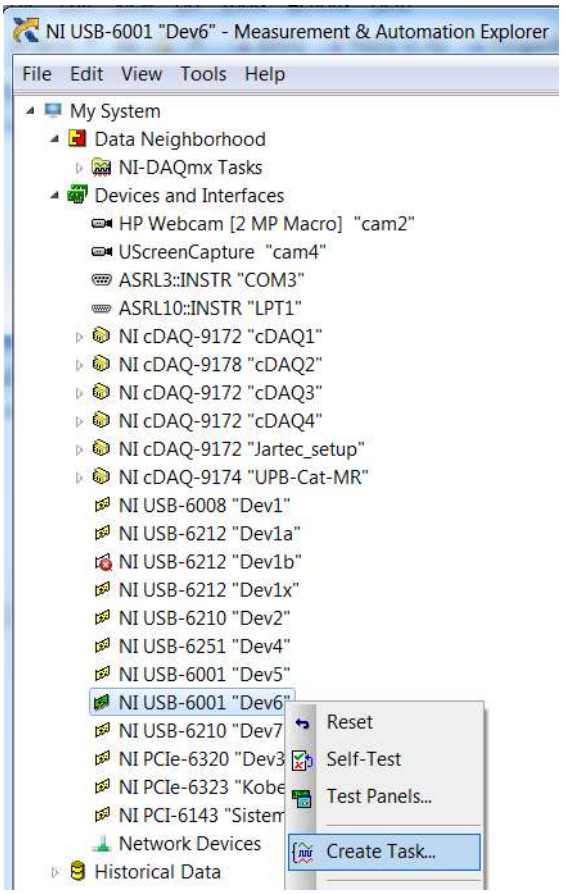


Fig. 3.1: *Creating a new task in* ***NI MAX***

To create a task related to a data acquisition board, right click on the board's name in the **Devices and Interfaces** category and select the **Create Task...** option (Fig. 3.1).

To create an **Analog Input** task:

- Open the **Acquire Signals** category (Fig. 3.2);
- From the **Analog Input** category, select the **Voltage** option;
- Press the **Next >** button;
- From your board's list of channels, select the first analog input channel (**ai0**) (Fig. 3.3);
- Press again the **Next >** button;
- Enter a name for the task (**Lab 3 AI**) (Fig. 3.4);
- Press the **Finish** button.

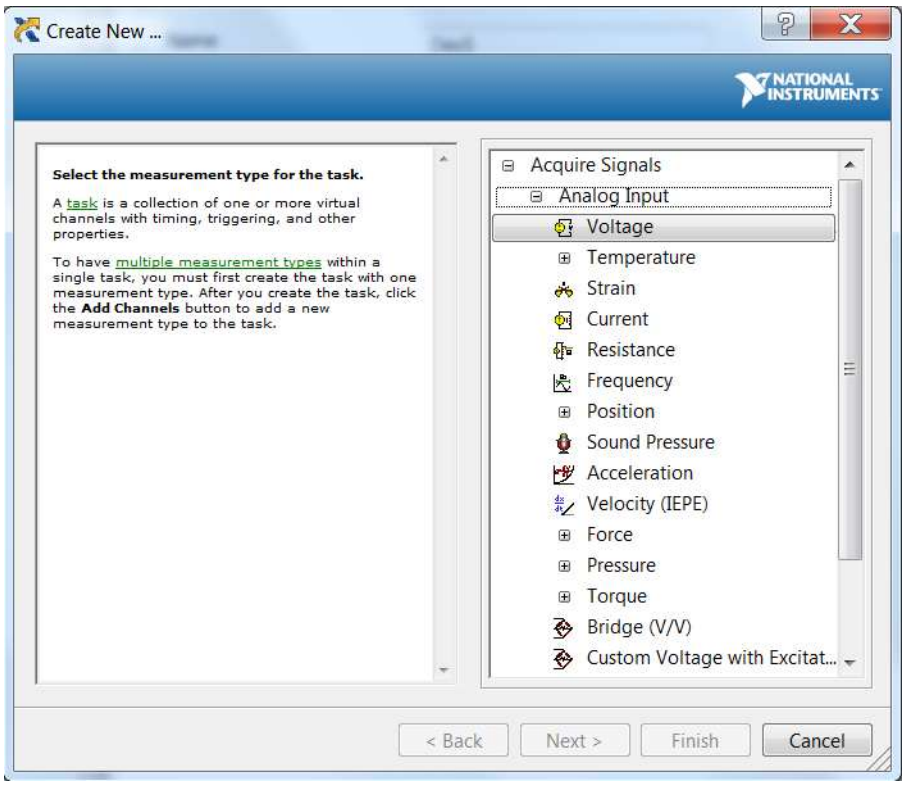


Fig. 3.2: *Selecting the measurement type for an analog input task*

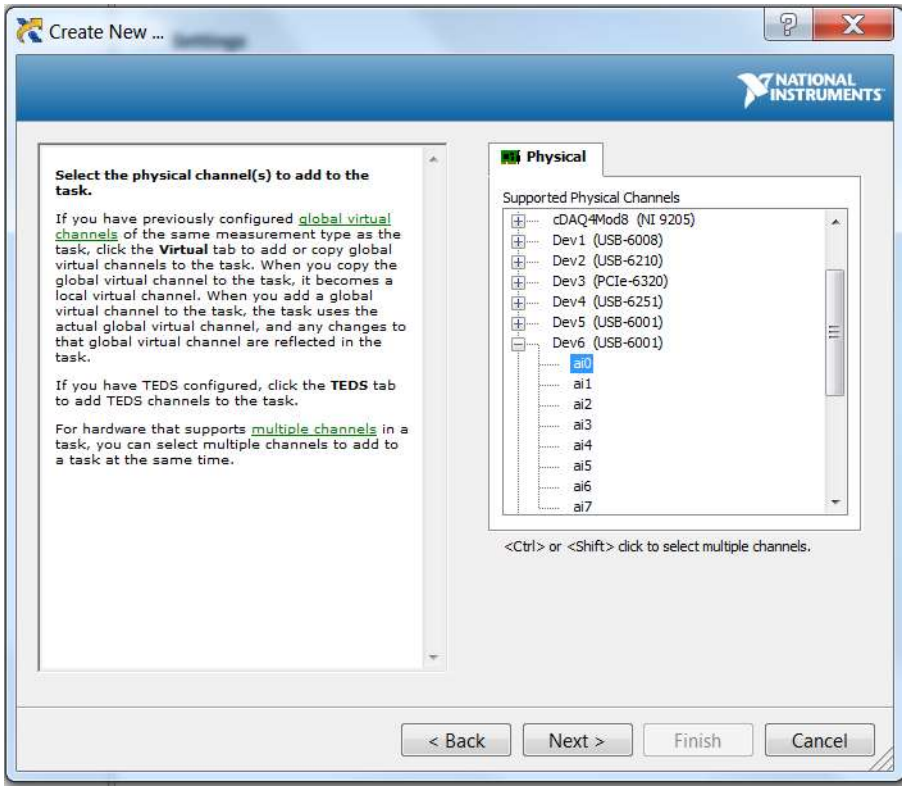


Fig. 3.3: *Selecting the analog input channel*

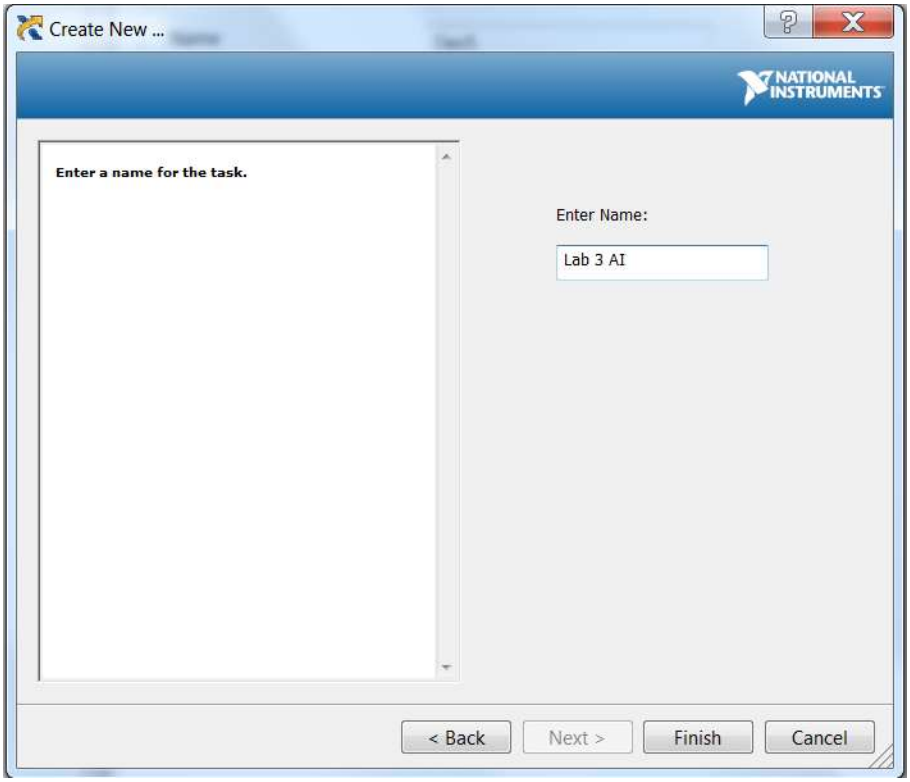


Fig. 3.4: *Naming the analog input task*

Your newly created task will be listed in the **NI-DAQmx Tasks** category and its properties will appear in the right side of the **NI MAX** window.
Set the following task's parameters (Fig. 3.5):

- Signal Input Range to -5 ... 5 Volts;
- Terminal Configuration: Differential;
- Acquisition Mode: Continuous Samples;
- Samples to Read: 1,000;
- Rate (Hz): 10,000.

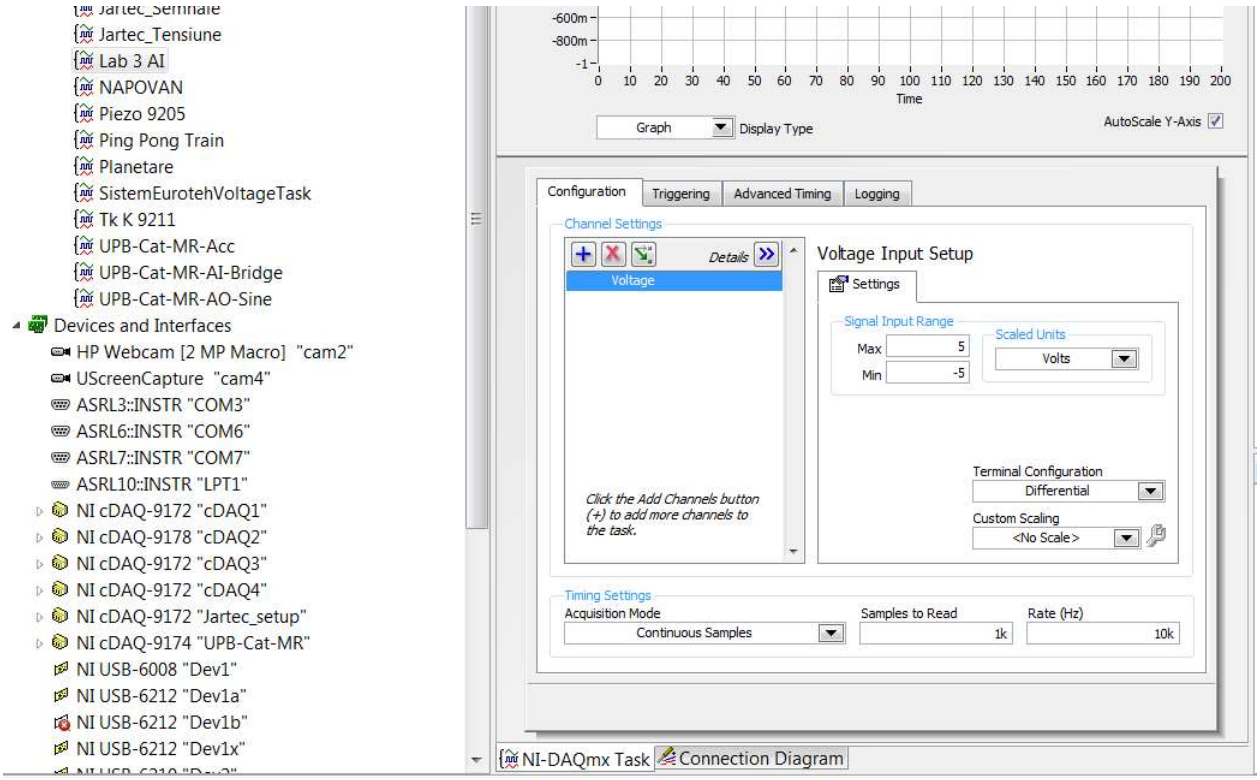


Fig. 3.5: *Setting the analog input task parameters*

In the **Connection Diagram** tab (Fig. 3.6) you can check how the wires have to be correctly connected.

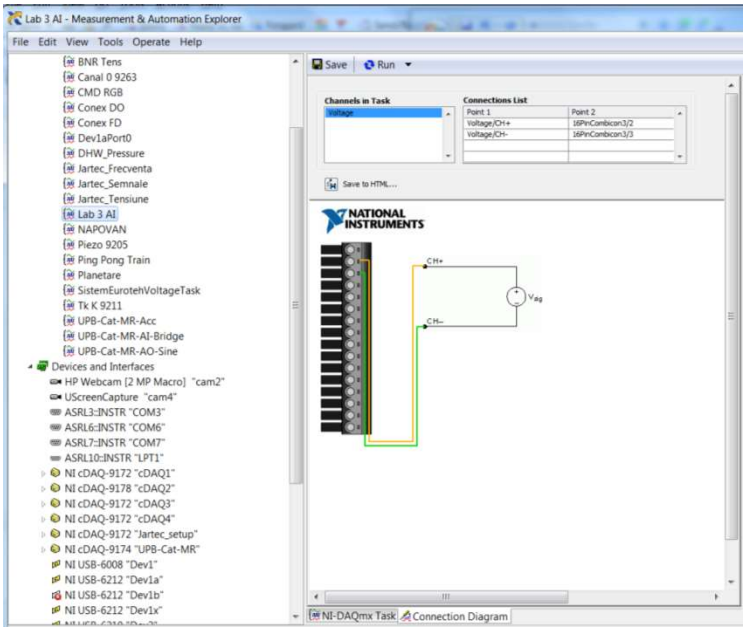


Fig. 3.6: *Analog input task connection diagram*

Save and then run the task.
Eventually change the plot formatting by clicking on the plot legend in the graph's upper right corner (Fig. 3.7).

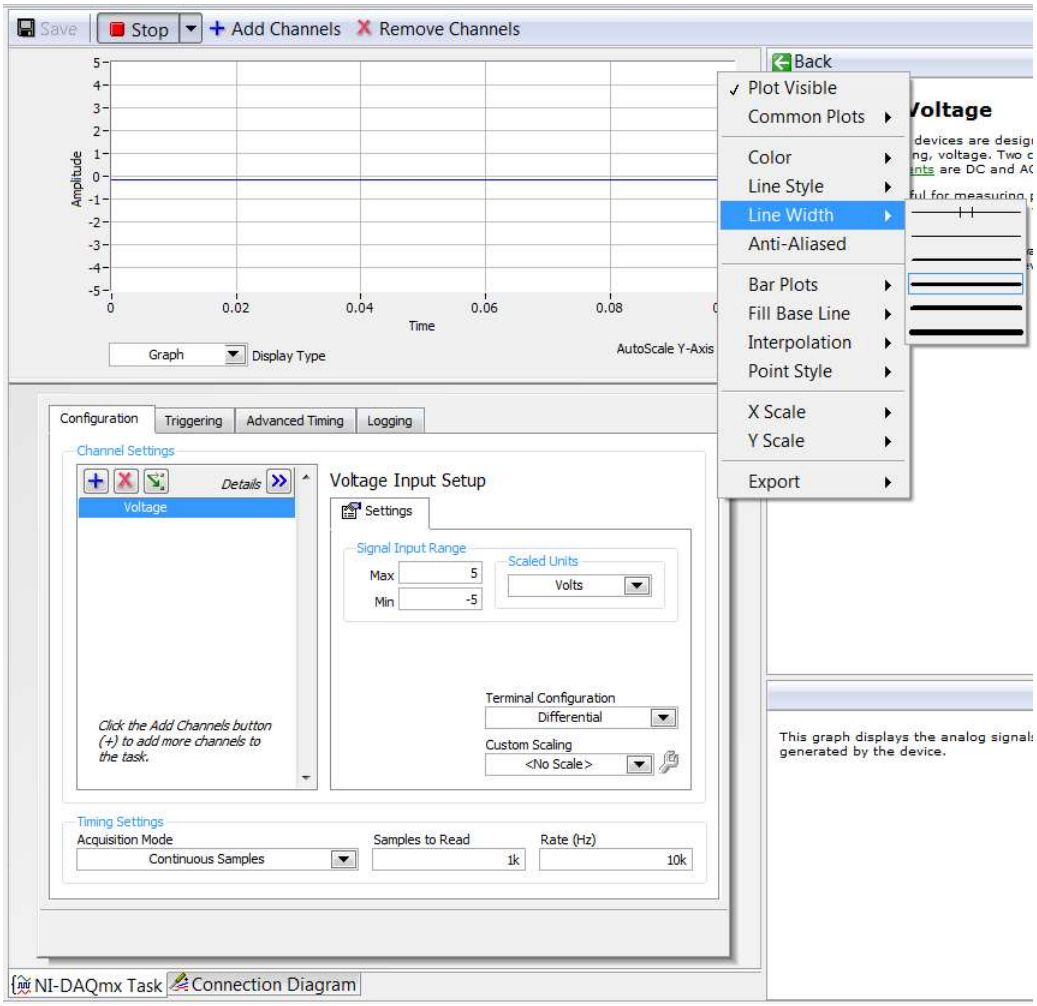


Fig. 3.7: *Testing the analog input task*

Change the **Display type** to the **Table** option (Fig. 3.8) for displaying the measured values in numeric format.
If no signal is connected to the board's analog input channel **ai0**, then the measured value has to be somewhere close to zero Volts.

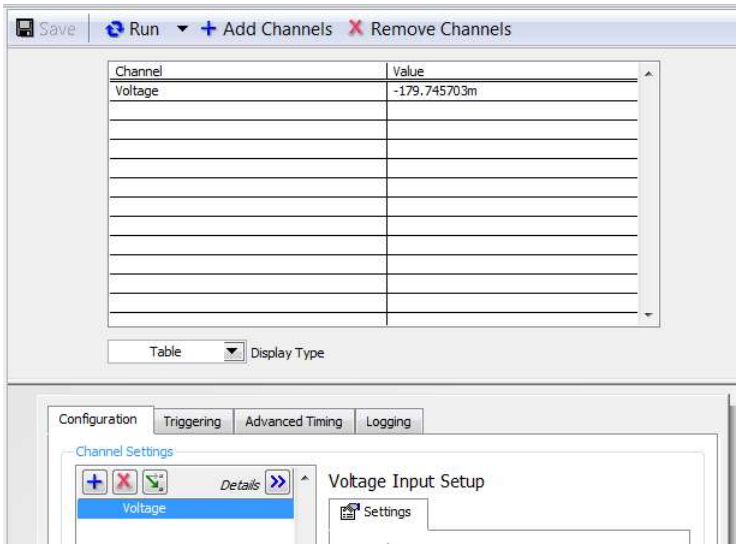


Fig. 3.8: *Displaying the measured values in numeric format*

NI MAX tasks can be accessed in **LabVIEW** using the functions from the **Measurement I/O – NI-DAQmx** functions palette (Fig. 3.9).

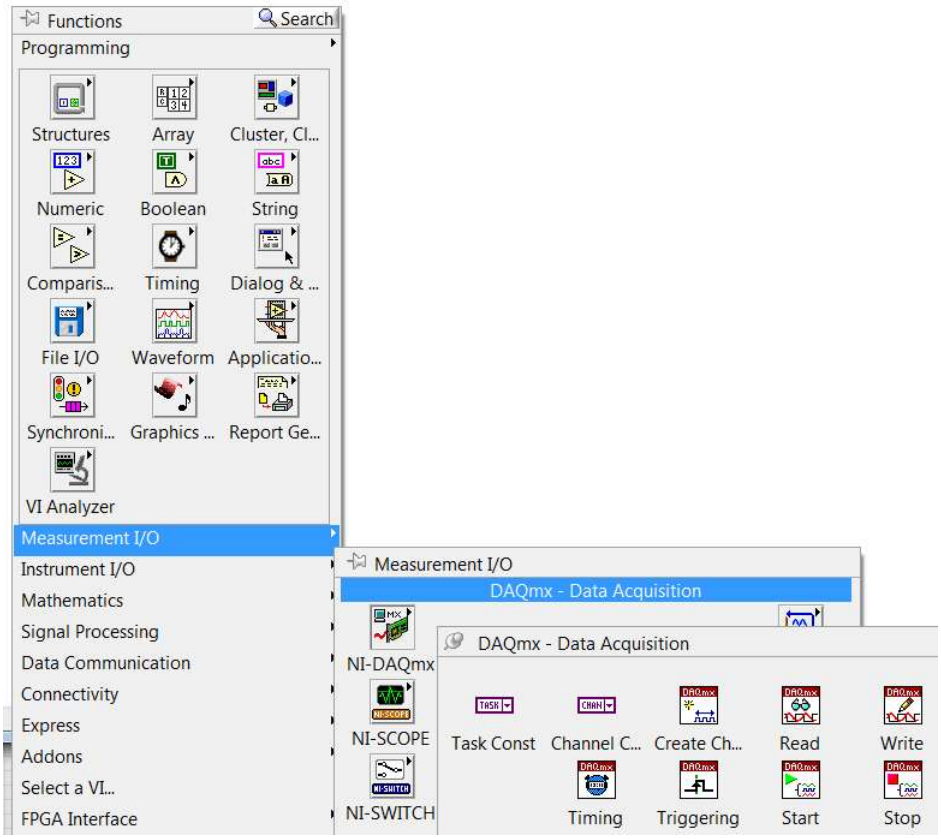


Fig. 3.9: *LabVIEW Measurement I/O – NI-DAQmx functions palette*

Generally, for running an **NI MAX** task in **LabVIEW**, the task has first to be started, then data read or write operations can be performed, and finally the task has to closed.

For starting the **Lab 3 AI** task previously created in **NI MAX**, first place a **DAQmx Start Task** function in the block diagram of a new Virtual Instrument (Fig. 3.10).

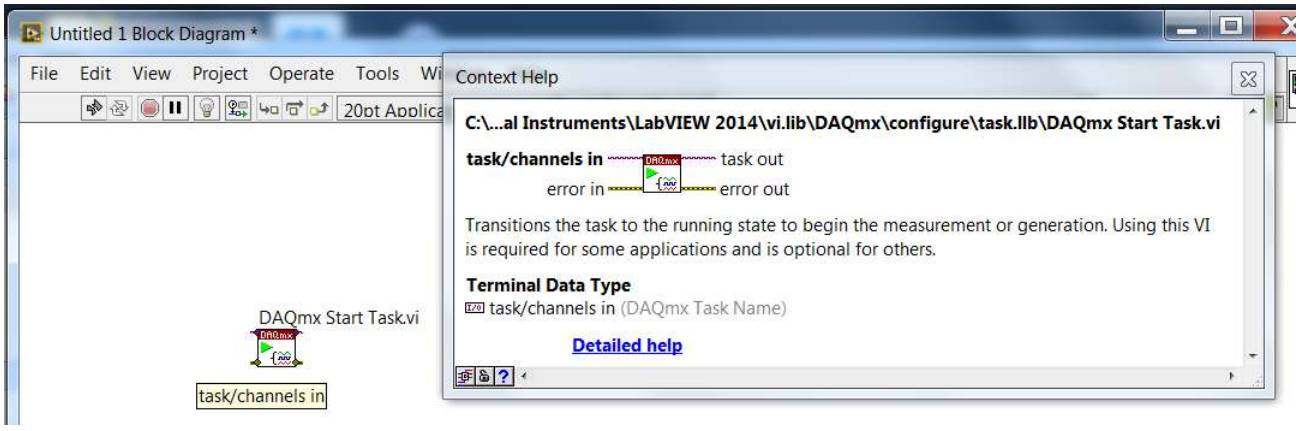


Fig. 3.10: *Placing a DAQmx Start Task function*

For defining which task to be started, create and link a constant to the function's **task/channels in** input (Fig. 3.11) and then, opening the constant's list, select the **Lab 3 AI** task (Fig. 3.12).

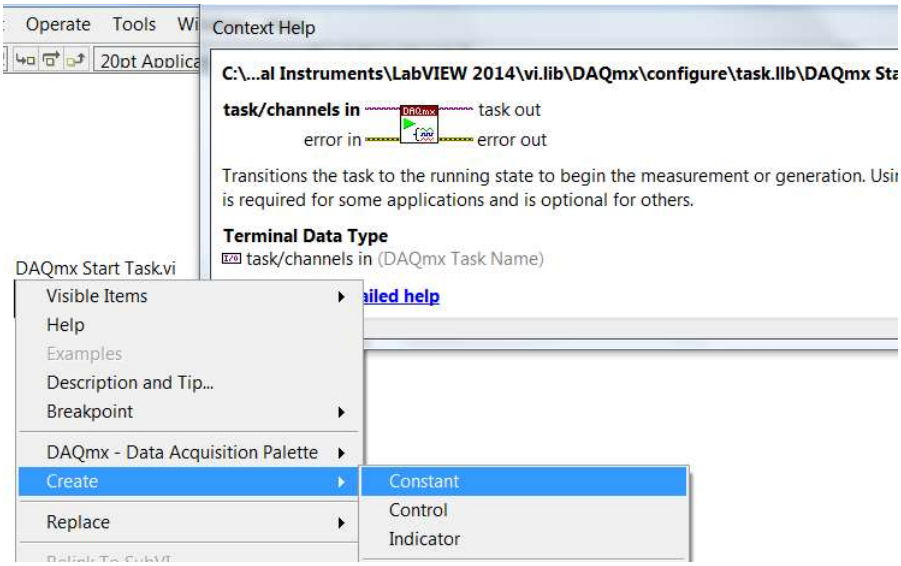


Fig. 3.11: *Creating a constant for the function's task/channels in input*

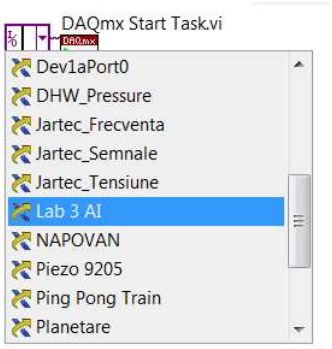


Fig. 3.12: *Selecting the **Lab 3 AI** task*

Because the task was configured in **NI MAX** for continuous samples, when the **DAQmx Start Task** function will be executed, the data acquisition board will start to measure on analog input channel **ai0**, at a rate of 10,000 values per second.
The measured values will be stored in the board's internal memory buffer.
Because the **Samples to Read** parameter was configured in **NI MAX** to 1,000 samples, the buffer maximum size will be set to 1,000 values.

Place a **DAQmx Read** function in the block diagram and, from its polymorphic VI selector (Fig. 3.13), select **Analog** / **Single Channel** / **Multiple Samples** / **1D DBL** option (Fig. 3.14).

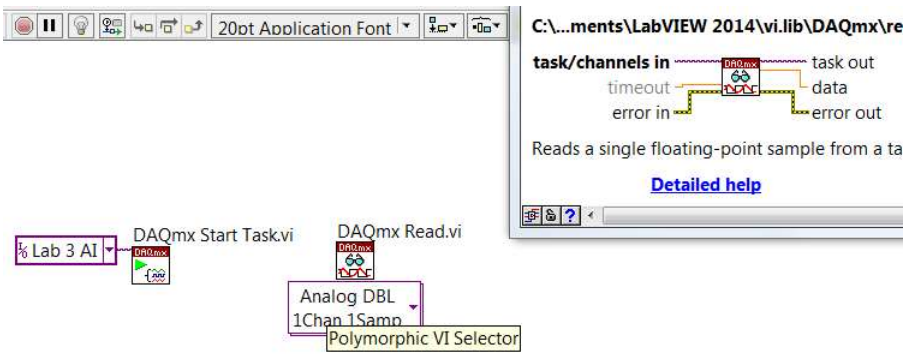


Fig. 3.13: *Placing a **DAQmx Read** function in the block diagram*

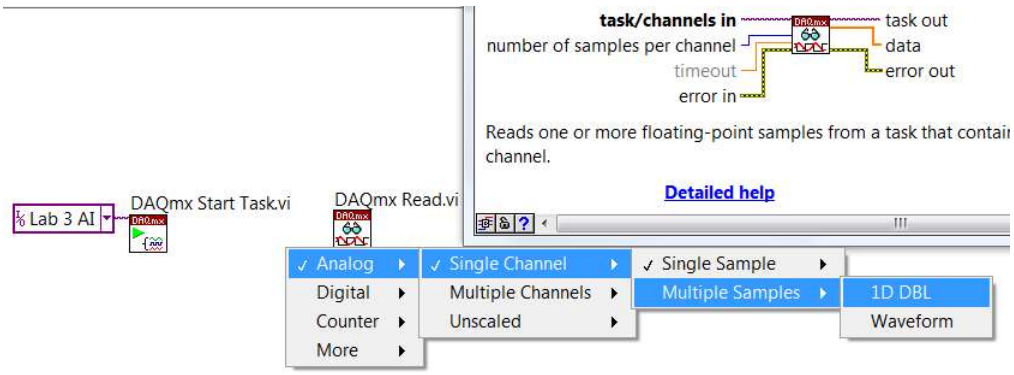


Fig. 3.14: *Selecting an option from the polymorphic VI selector*

Link a 1,000 constant to the **number of samples per channel** input of the **DAQmx Read** function.
Each time the **DAQmx Read** function will be executed, 1,000 values will be read from the data acquisition board's internal memory buffer and made available at the function's **data** output terminal.

Place a **DAQmx Stop Task** function and connect the **task/channels in** and **task out** terminals. Connect also the **error in** and **error out** terminals (Fig. 3.15).

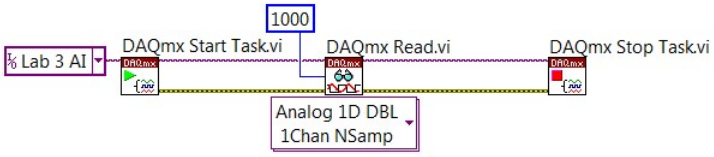


Fig. 3.15: *Completed functions sequence in the block diagram*

In the front panel:

- Place a **Waveform Chart** indicator (Fig. 3.16);
- Name its axis **Volts** and **Points**;
- Set its **History Length** parameter to 100,000 values (Fig. 3.17);
- Make its scale legend visible;
- Activate the **AutoScale X** option.

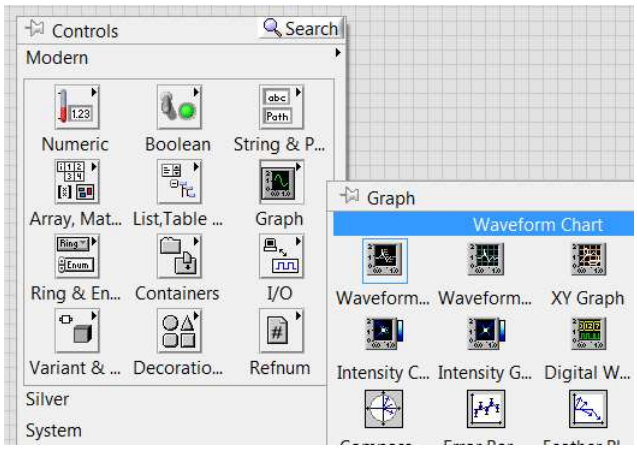


Fig. 3.16: *Selecting a **Waveform Chart** indicator to be placed in the front panel*

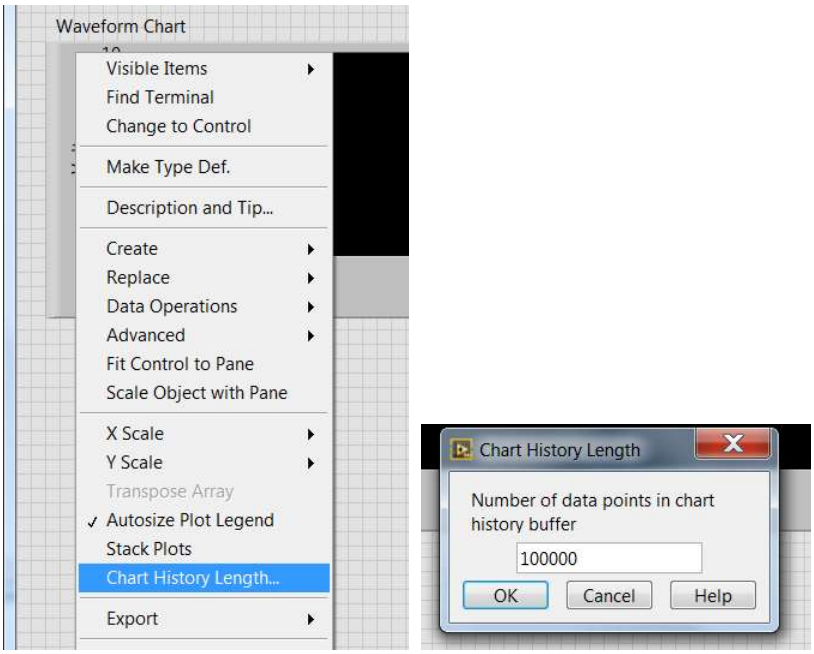
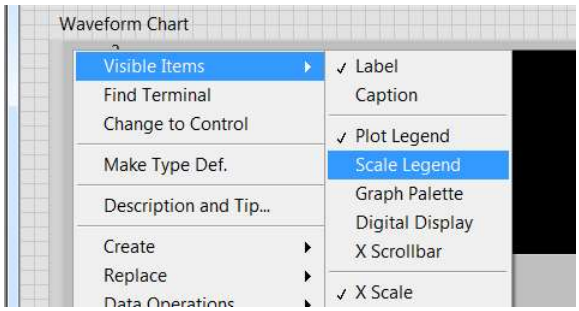
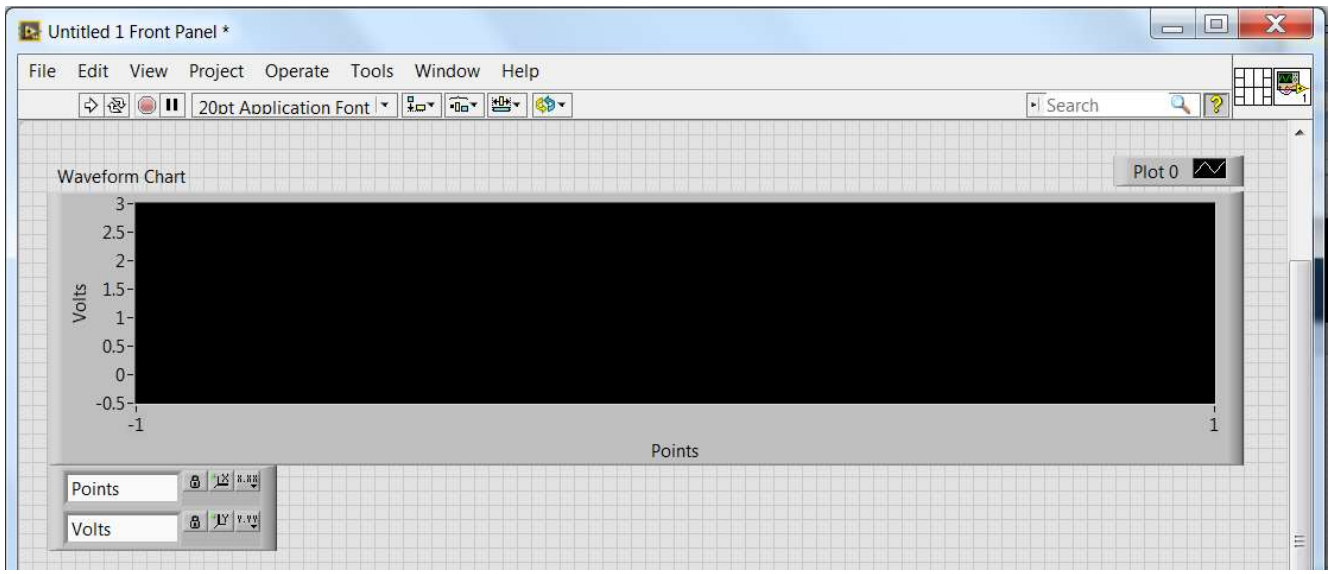
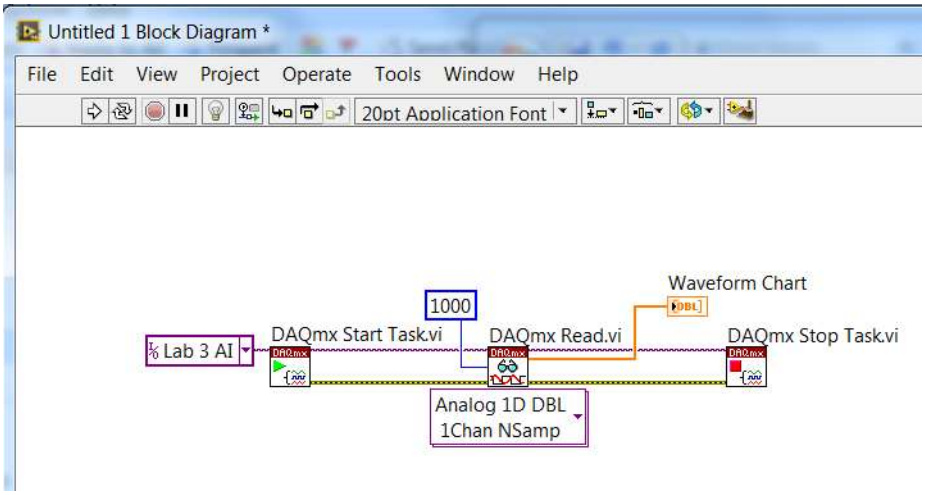


Fig. 3.17: *Setting the* ***Chart History Length*** *parameter*

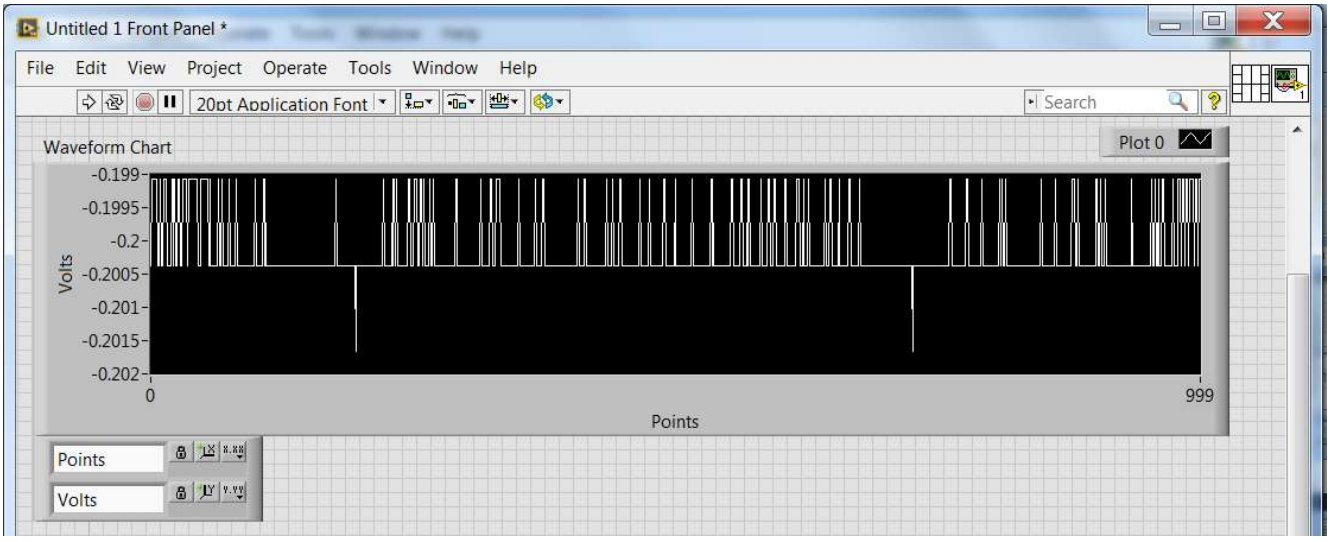




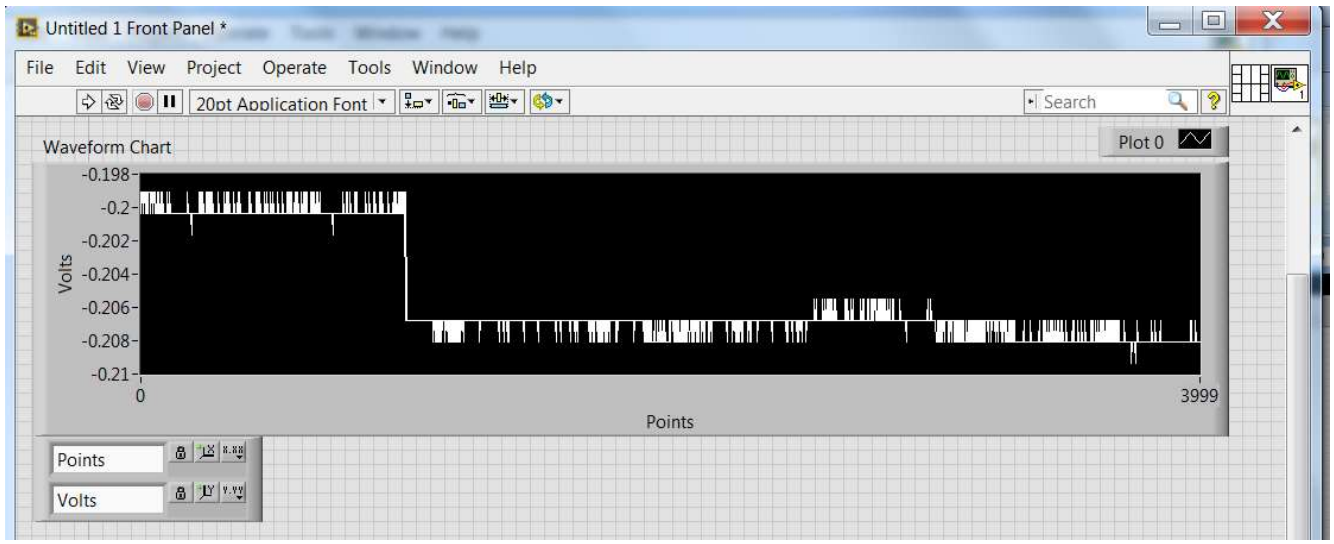
In the block diagram, connect the data output terminal of the DAQmx Read function to the Waveform Chart terminal.



Run the virtual instrument.
Like running the task in NI MAX before, because no signal is connected to the board's analog input channel, the measured value will be somewhere close to zero.

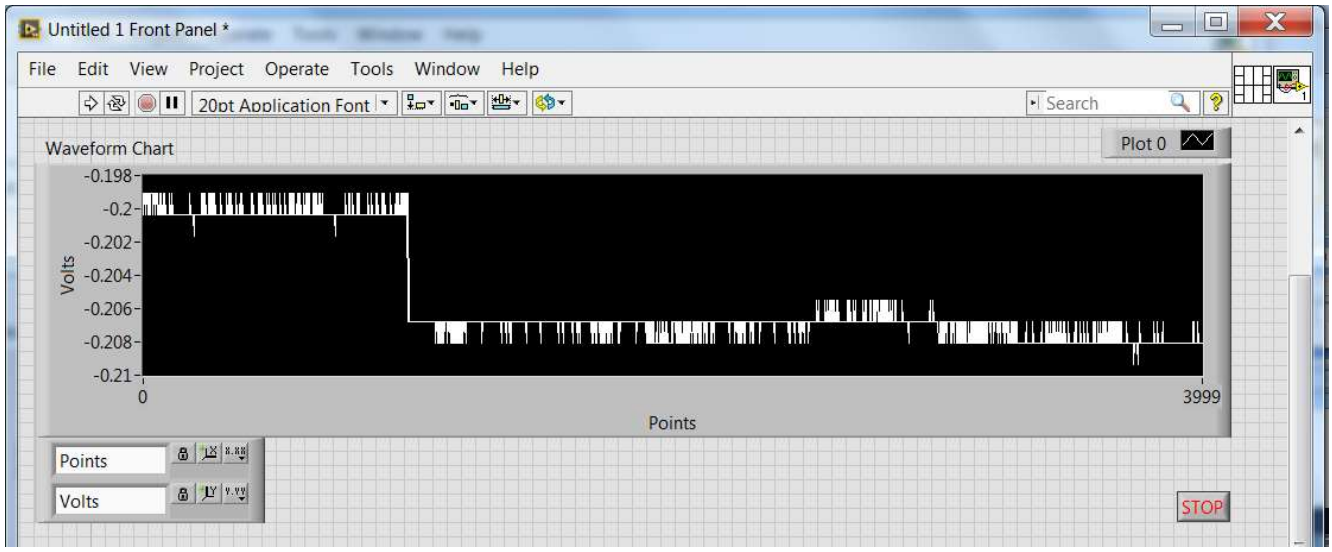


Small voltage variations may appear if the virtual instrument is run several times.

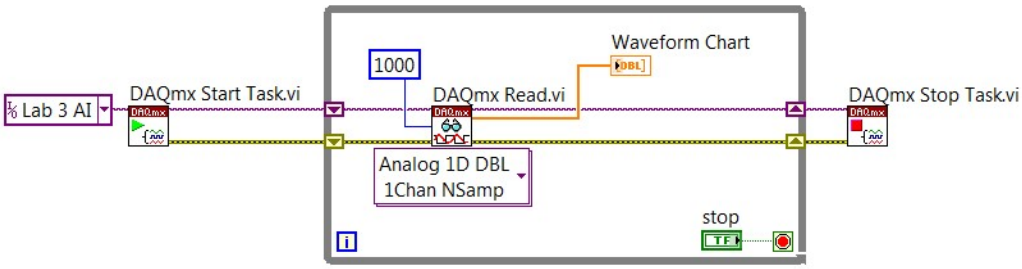


Use the virtual instrument to measure the voltage of one or two AA batteries.

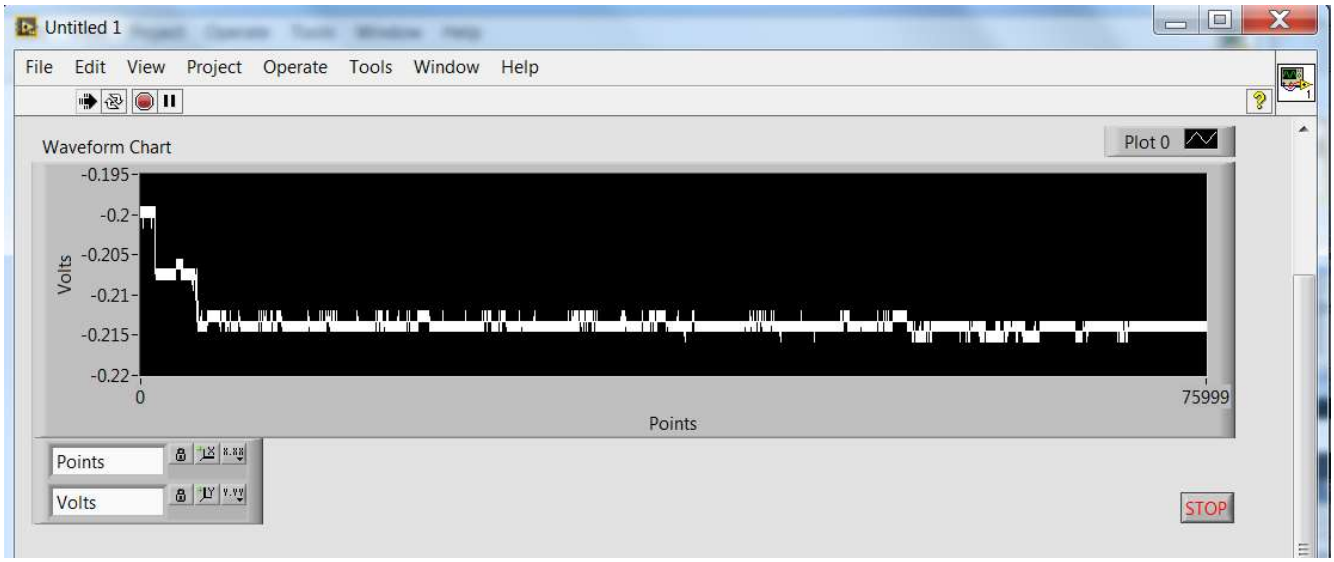
Place a STOP button on the virtual instrument's front panel.



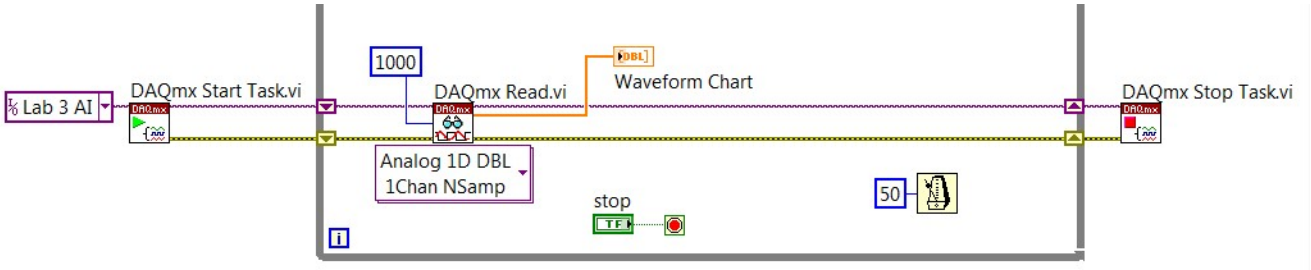
In the block diagram, place a While loop arround the DAQmx function and connect the STOP button to the loop's conditional terminal.
The virtual instrument will first start the Lab 3 AI task, then will repeteadly read 1,000 values from the data acquisition board's buffer at each iteration of the While loop, until the STOP button will be pressed.
In the end, the Lab 3 AI task will be closed.



Run the virtual instrument, eventually measuring the batteries voltage.



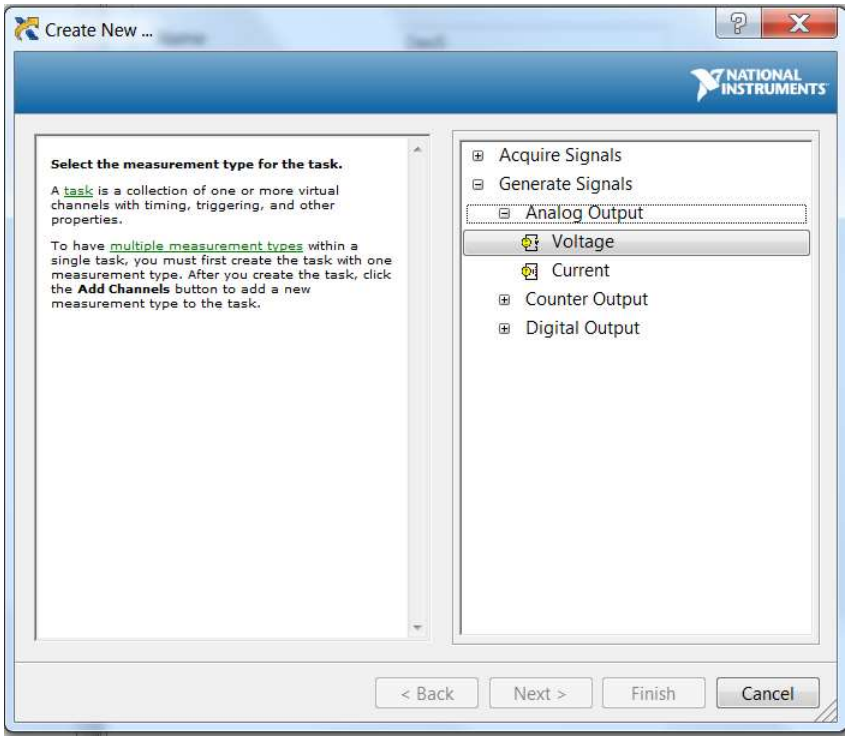
Place an Wait Until Next ms Multiple function inside the While loop and connect a 50 ms constant to its input.
Run the virtual instrument.
Stop the virtual instrument, change the constant's value to 100 and run again.
Stop the virtual instrument, change the constant's value to 200 and run again.
Stop the virtual instrument, change the constant's value to 2000 and run again.
Stop the virtual instrument, notice what happens and try to explain why.

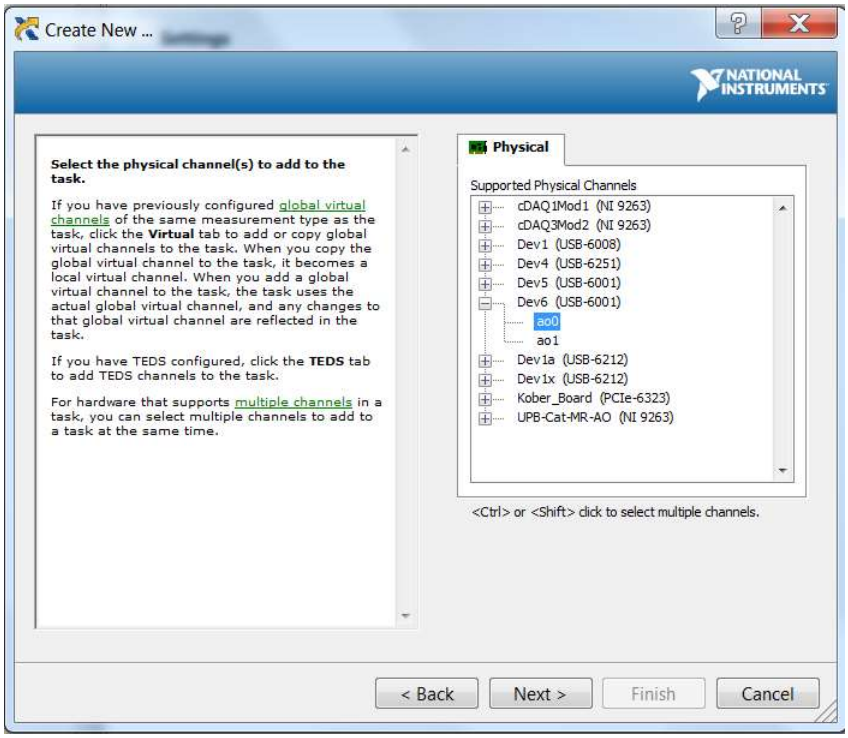


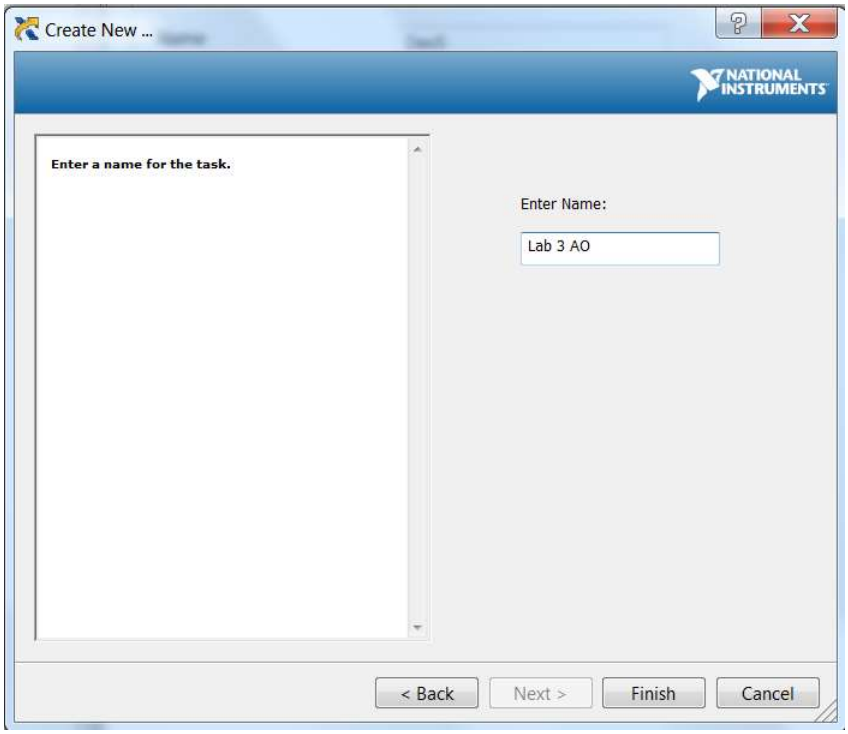
To create an Analog Output task in NI MAX:

- Open the Generate Signals category;

- From the Analog Output category, select the Voltage option;
- Press the Next > button;
- From your board's list of channels, select the first analog output channel (ao0);
- Press again the Next > button;
- Enter a name for the task (Lab 3 AO);
- Press the Finish button.



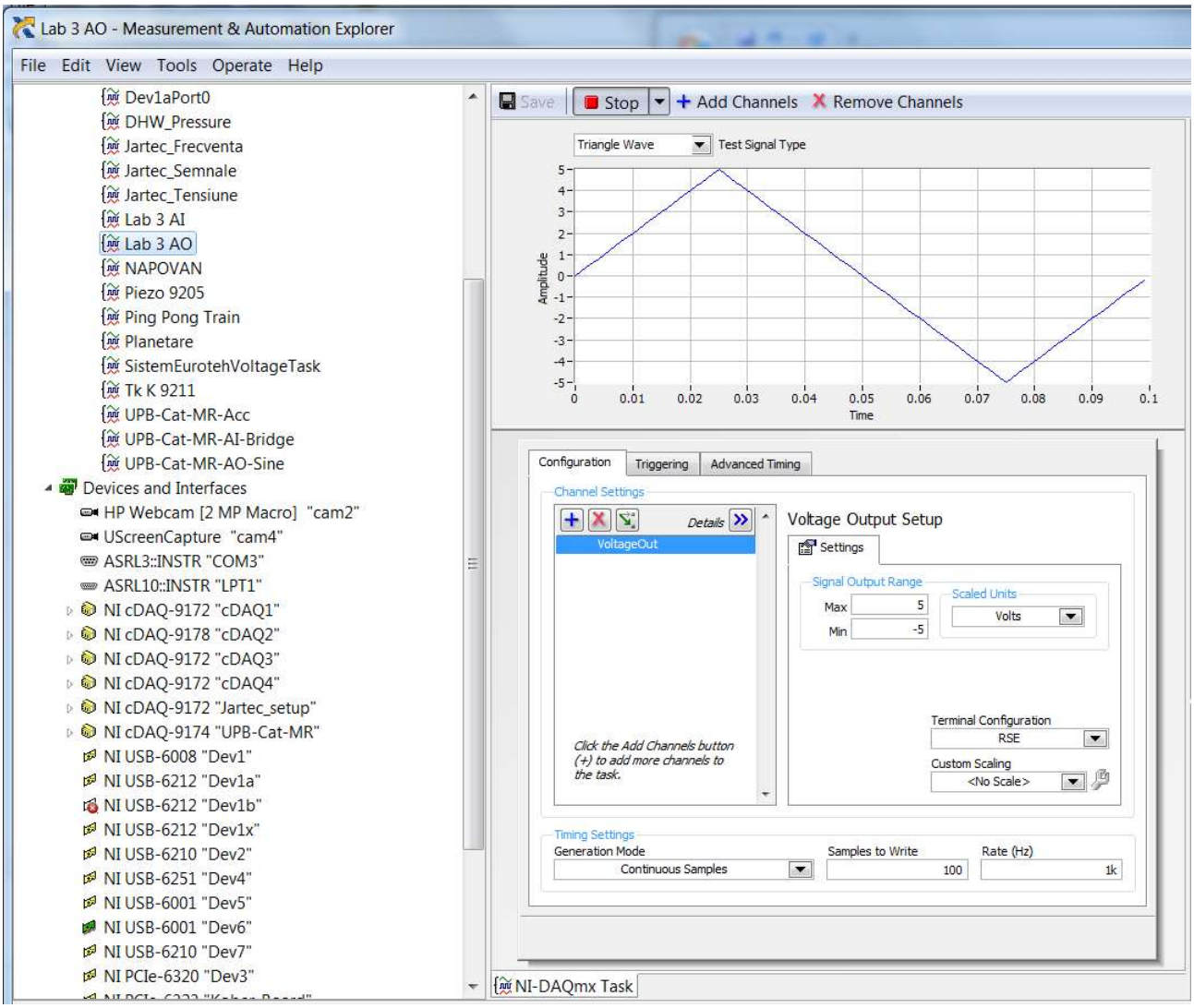




The new task will be listed in the NI-DAQmx Tasks category and its properties will appear in the right side of the NI MAX window.
Set the following task's parameters:

- Signal Output Range to -5 ... 5 Volts;

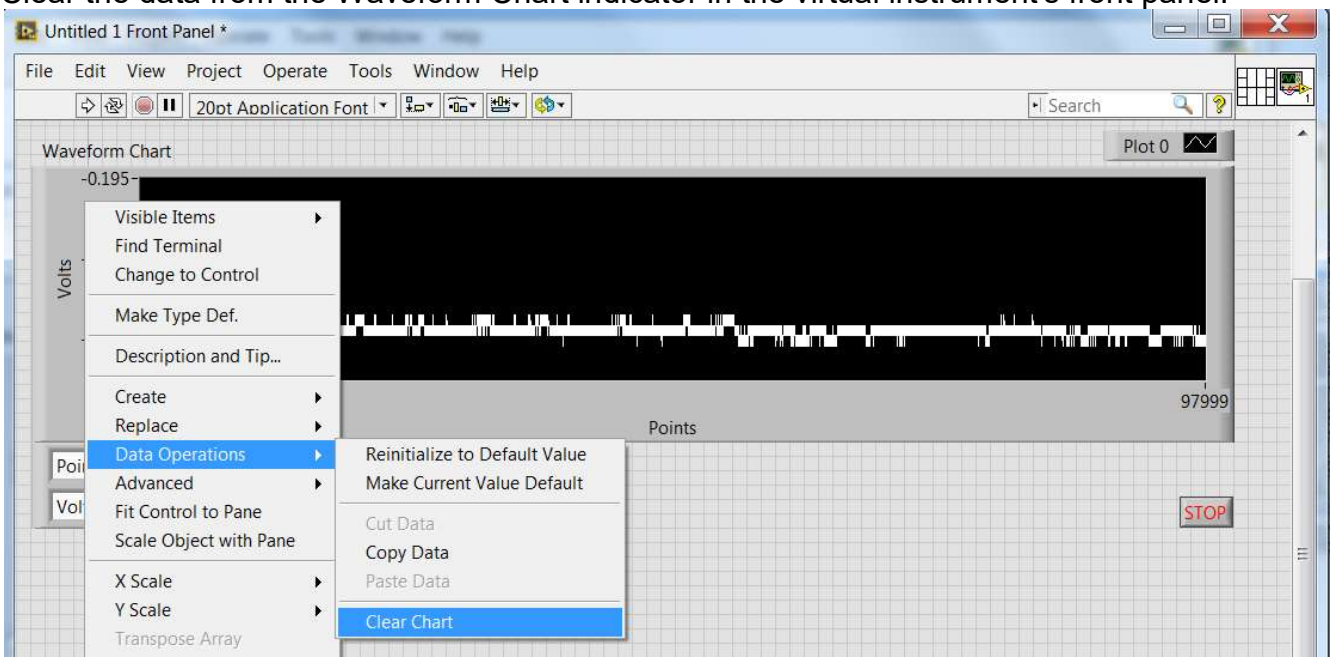
- Terminal Configuration: RSE;
- Generation Mode: Continuous Samples;
- Samples to Write: 100;
- Rate (Hz): 1,000.



Connect a wire between terminals **AO 0** and **AI 0** of the data acquisition board (Fig. 2.7), for measuring, on the analog input channel ai0, the signal generated on the analog output channel ao0.
To check that the setup is correct:

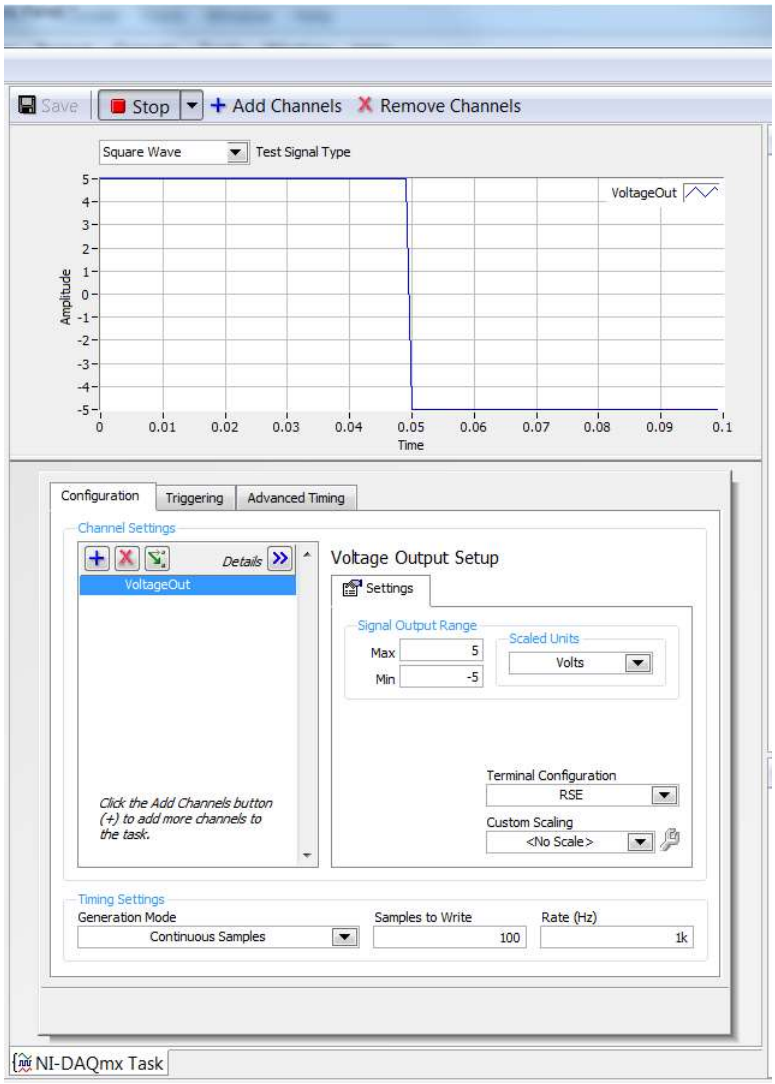
- Run the Lab 3 AO task;
- Set the Terminal Configuration parameter of the Lab 3 AI task also to RSE;
- Run the Lab 3 AI task;
- Set the Test Signal Type parameter of the Lab 3 AO task to Sine, Square or Triangle Wave and check on the analog input task's graph that the generated signal is correctly measured.

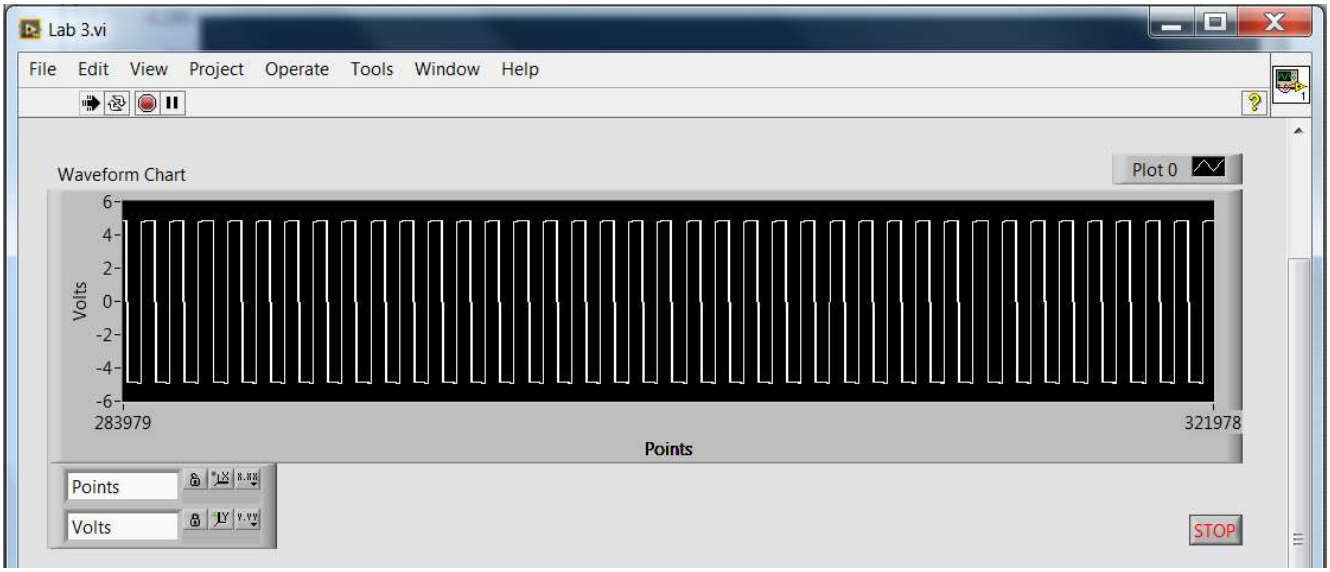
Clear the data from the Waveform Chart indicator in the virtual instrument's front panel.



While changing the Test Signal Type parameter of the Lab 3 AO task to Sine, Square or Triangle Wave, check the measured signal by running the virtual instrument.

Knowing that the virtual instrument is measuring 10,000 values per second on channel ai0, compute the frequency of the signal generated on the ao0 channel.


Save
Stop
Add Channels
Remove Channels
Square Wave
Test Signal Type
VoltageOut
Amplitude
Time
Configuration
Triggering
Advanced Timing
Channel Settings
Details
VoltageOut
Click the Add Channels button (+) to add more channels to the task.
Voltage Output Setup
Settings
Signal Output Range
Max
5
Min
-5
Scaled Units
Volts
Terminal Configuration
RSE
Custom Scaling
<No Scale>
Timing Settings
Generation Mode
Continuous Samples
Samples to Write
100
Rate (Hz)
1k
NI-DAQmx Task


Lab 3.vi
File
Edit
View
Project
Operate
Tools
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Help
Waveform Chart
Plot 0
Volts
283979
321978
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Points
Volts
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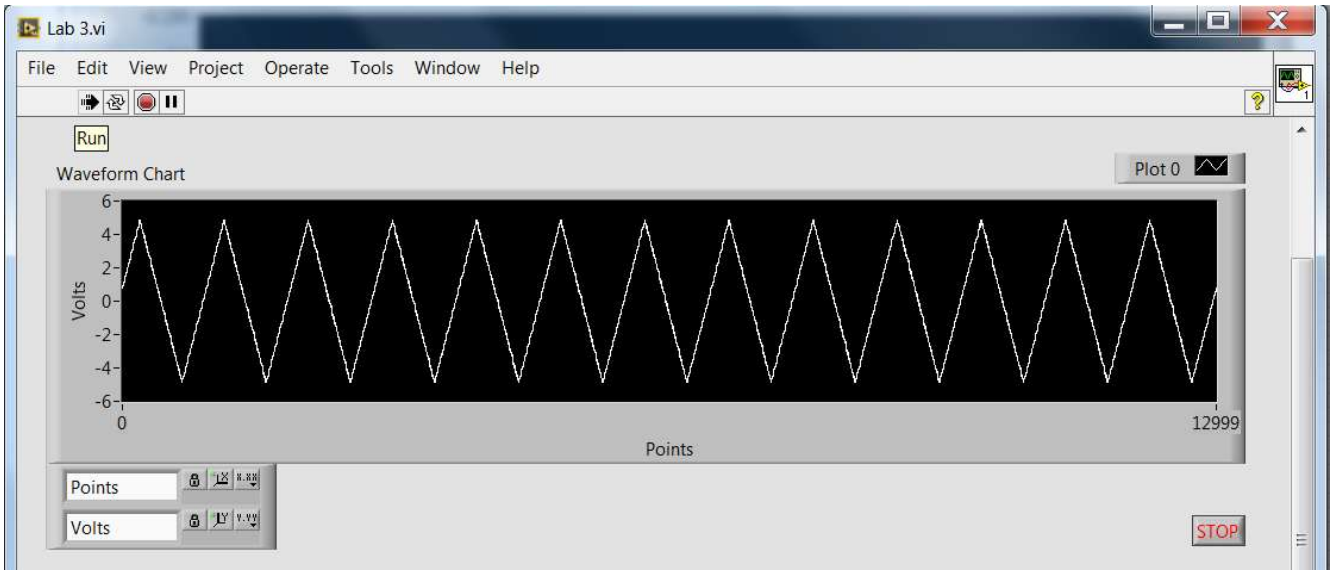
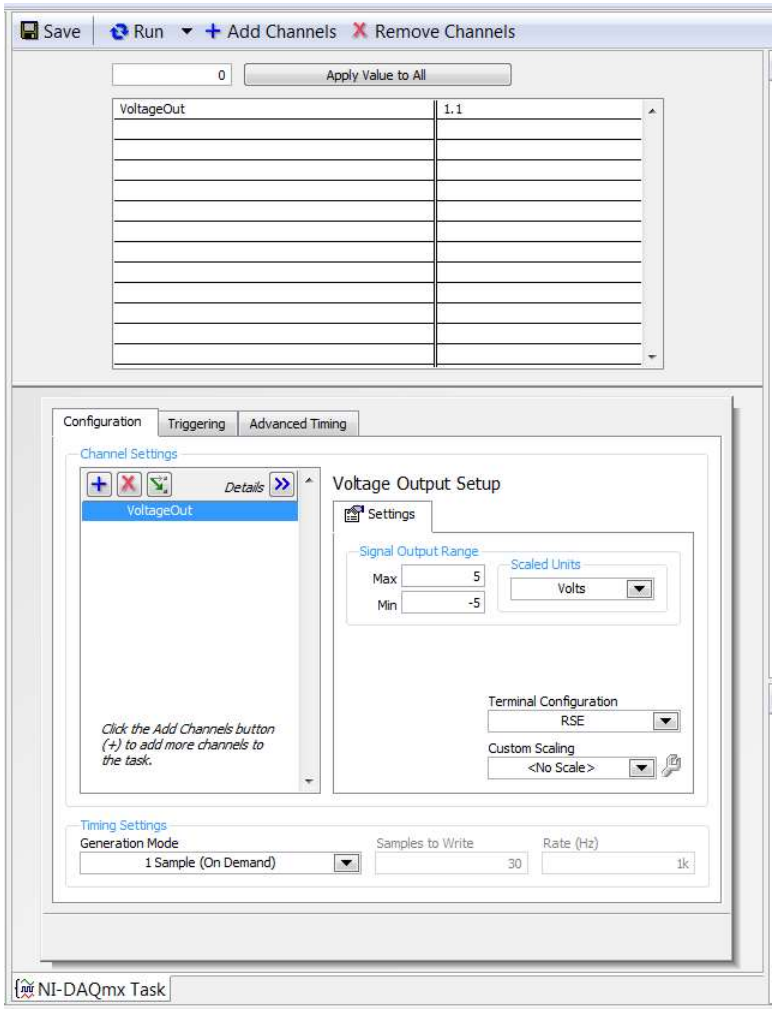
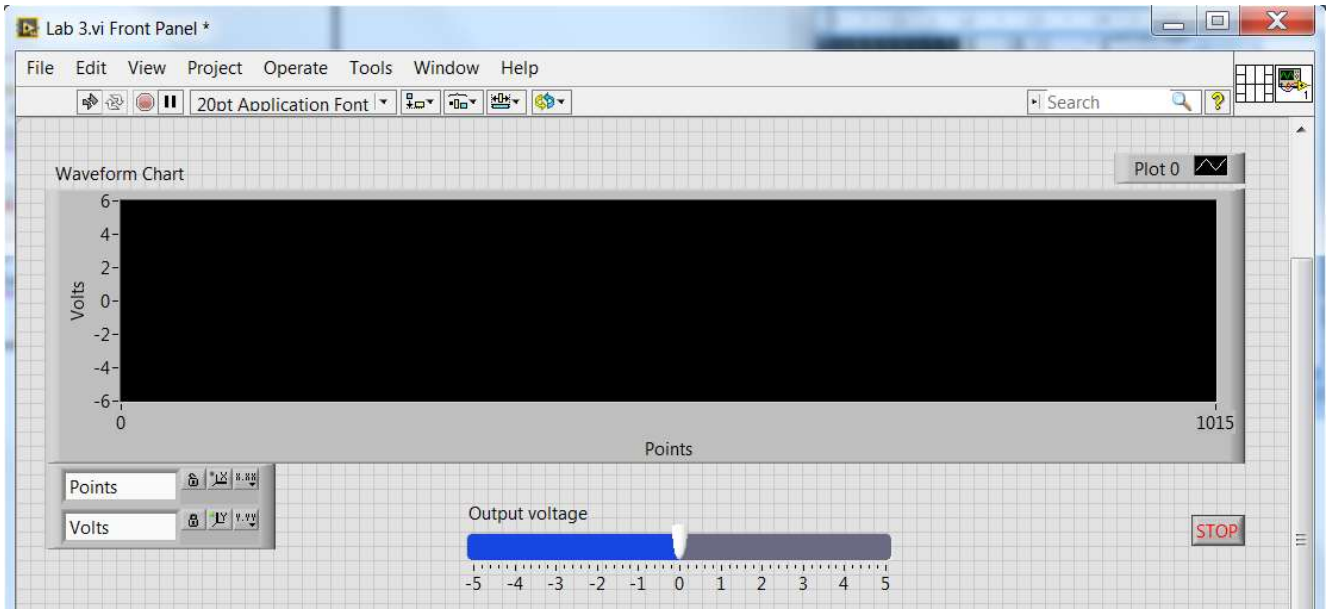


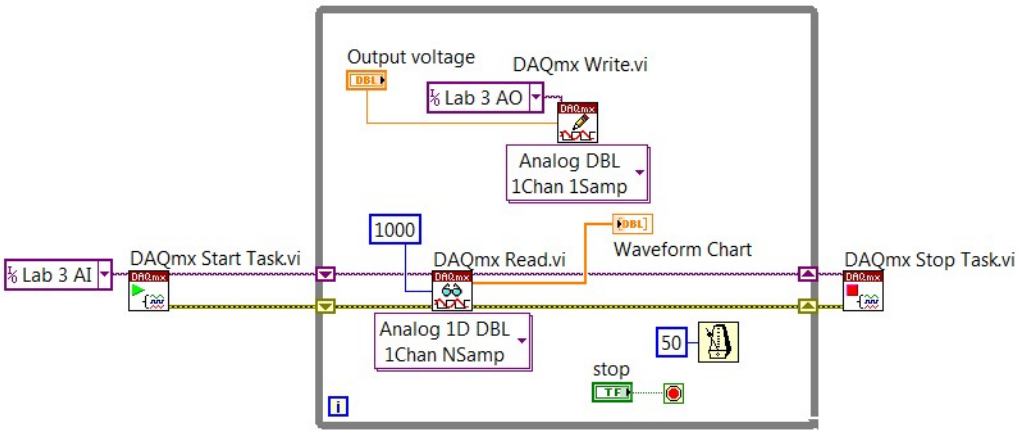
In NI MAX, change the Generation Mode parameter of the Lab 3 AO task to 1 Sample (On Demand).



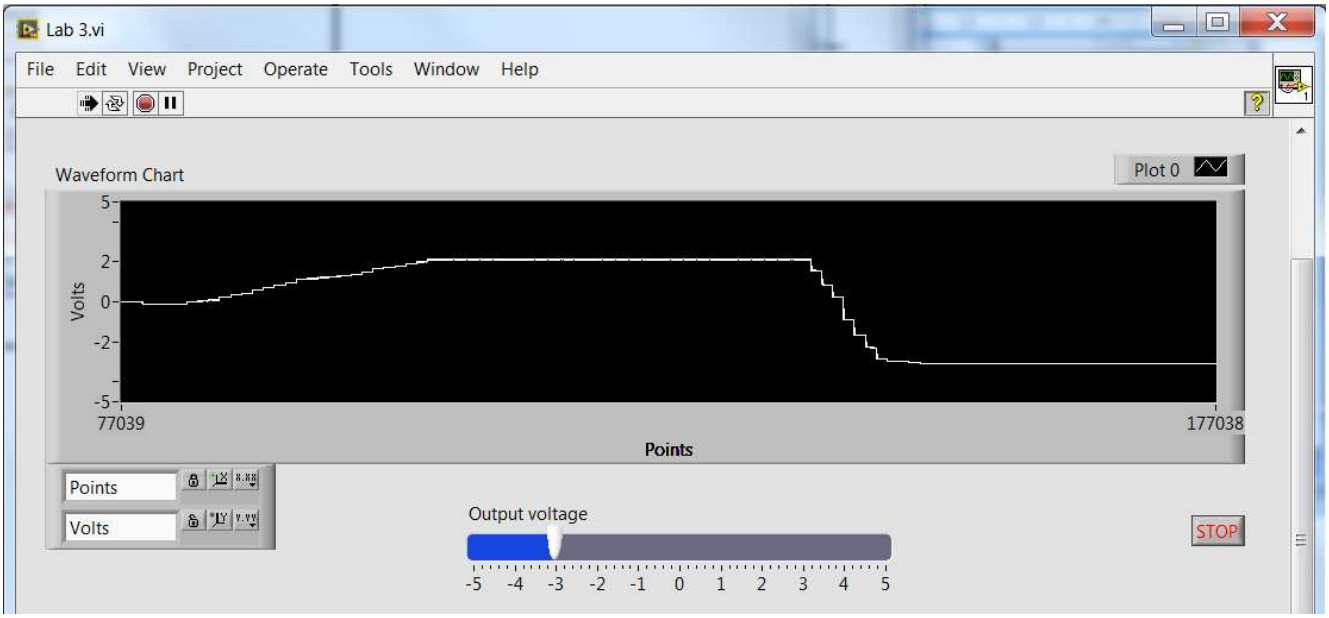
In the virtual instrument's front panel, place a Horizontal Pointer Slide control, name it Output voltage and set its scale limits to -5 and 5.



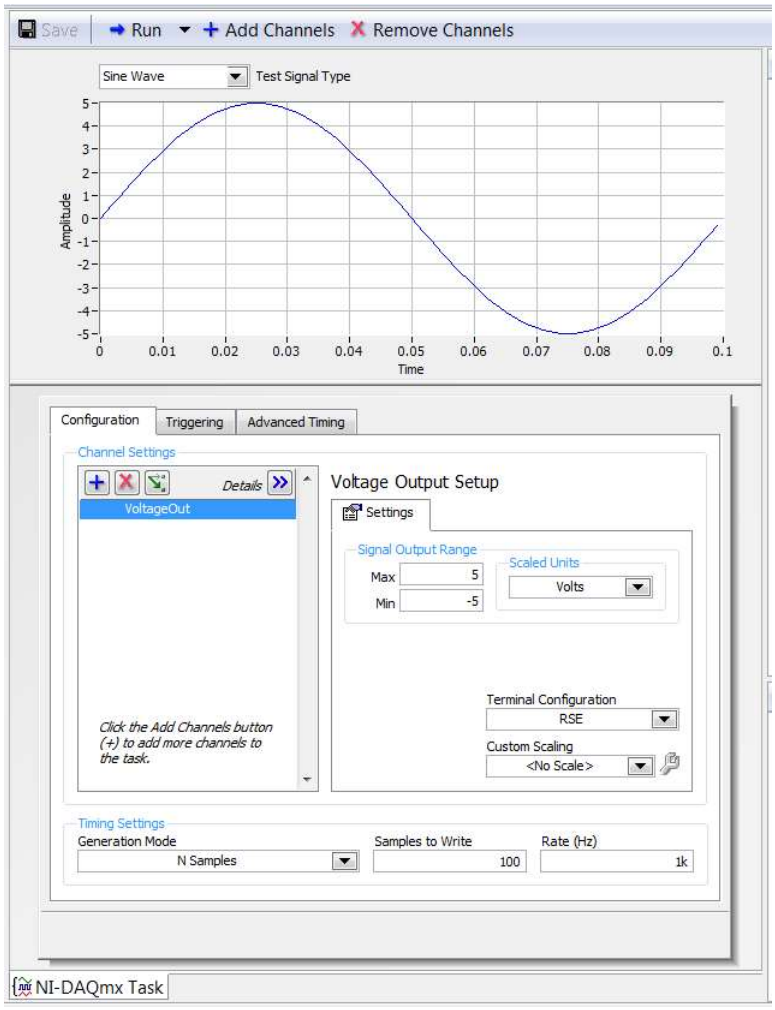
Place a DAQmx Write function in the block diagram and, from its polymorphic VI selector, select Analog / Single Channel / Single Sample / DBL option.
Link the necessary constant value to its task/channels in input.
Link the Output voltage terminal to the data input of the DAQmx Write function.
Because the Lab 3 AO task is set to 1 Sample (On Demand) generation mode, the value of the voltage generated at the ao0 channel will change at each iteration of the While loop.
There is no need in this mode for starting the task separately, because the function's autostart input has True as default value.
There is also no need for stopping the analog output task, because the task is conmpleted and stops alone after generating one new value.



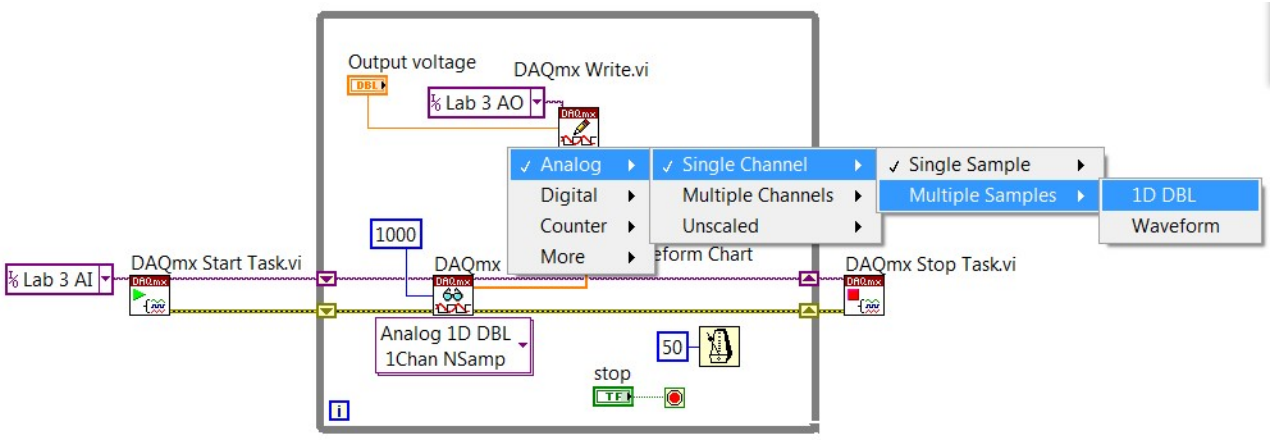
Run the virtual instrument, change the value of the Output voltage control on the fron panel and watch the measured value modifying accordingly.



In NI MAX, change the Generation Mode parameter of the Lab 3 AO task to N Samples.

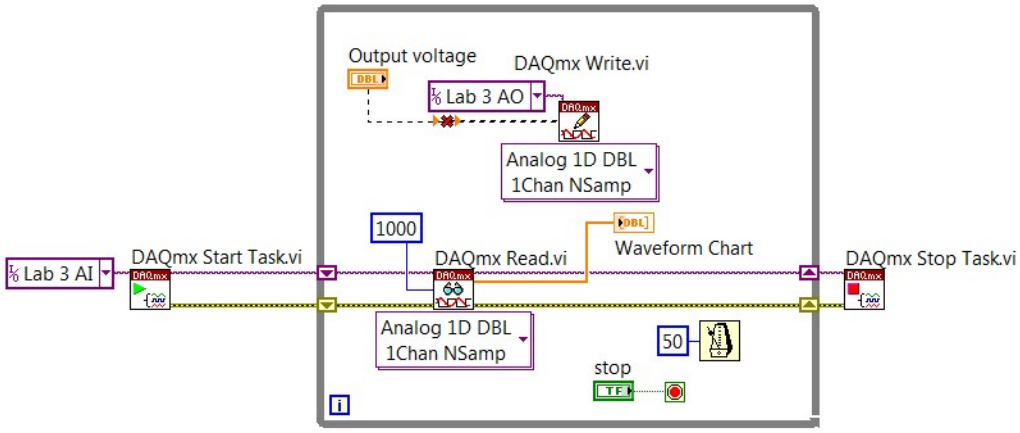


From the polymorphic VI selector of the DAQmx Write function, select Analog / Single Channel / Multiple Samples / 1D DBL option.

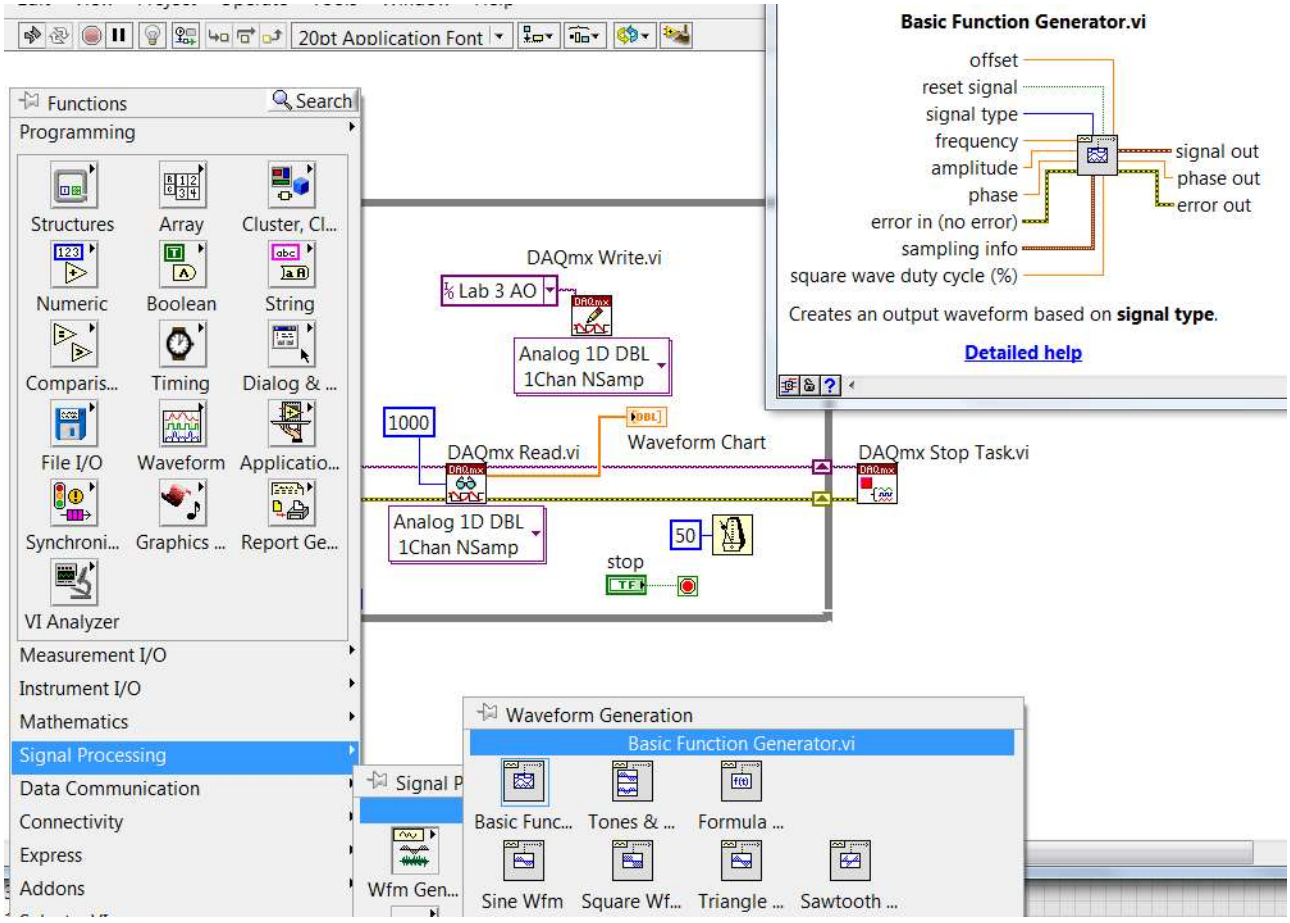


The link from the Output voltage terminal will be broken now, because the DAQmx Write function is expecting for an array of data at its data input, not only for a scalar value.

Delete the broken wire and delete or move the Output voltage terminal somewhere outside the While loop.

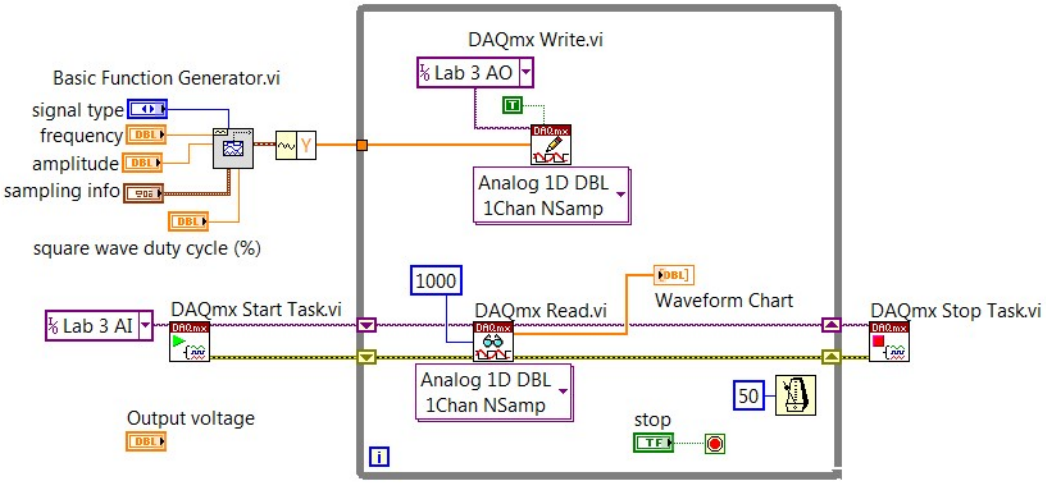


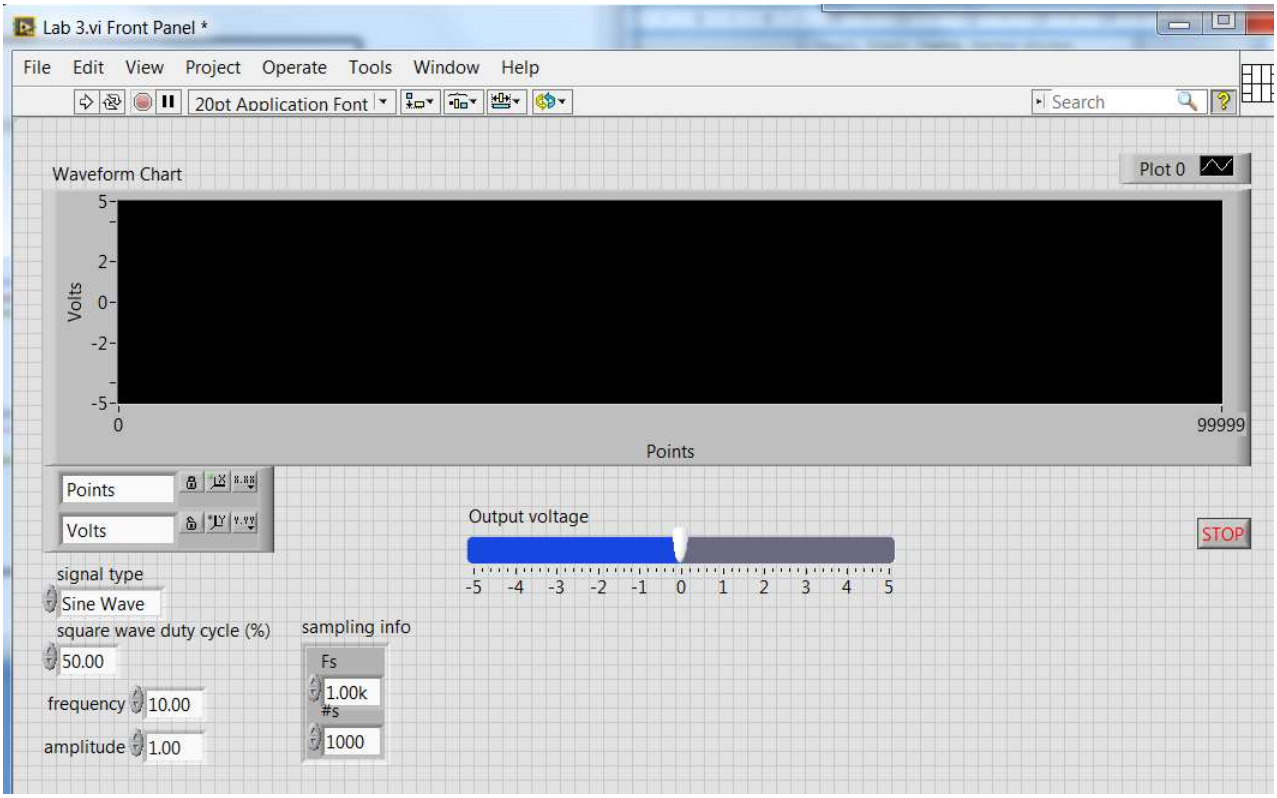
For providing the array of data to be generated as output voltage, the Basic Function Generator can be used (Signal Processing / Waveform Generation function palette).



Create the necessary controls for providing the parameters for the Basic Function Generator.

Because the Basic Function Generator provides, at its signal out terminal, a Waveform data type, a Get Waveform Components function will be needed to extract the Y array of data and pass it to the DAQmx Write function.
Note that, this time, a true value will have to be linked to the auto start input of the DAQmx Write function, or the task will have to be started using the DAQmx Start Task function.





Run the virtual instrument and try to explain why the measured values seem to be not as expected.

Try to explain why the measured values are correctly displayed when the block diagram is like in ....