Basic functions of a data acquisition board

Work objective

Learning how to use a data acquisition board for performing some of its basic functions:

- Analog input;
- Analog output;
- Digital input;
- Digital output.

Readings

Access the following information sources:

https://learn.sparkfun.com/tutorials/analog-vs-digital

http://www.diffen.com/difference/Analog_vs_Digital

http://electronics.howstuffworks.com/question7.htm

https://en.wikipedia.org/wiki/Data_acquisition
Data acquisition is the process of sampling signals that measure real world physical conditions and converting the resulting samples into digital numeric values that can be manipulated by a computer.

http://www.ni.com/data-acquisition/what-is/
Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. Compared to traditional measurement systems, PC-based DAQ systems exploit the processing power, productivity, display, and connectivity capabilities of industry-standard computers providing a more powerful, flexible, and cost-effective measurement solution.

https://labjack.com/support/faq/what-is-analog-input
An analog input converts a voltage level into a digital value that can be stored and processed in a computer.

http://www.ddc-online.org/Input-Output-Tutorial/Analog-Inputs.aspx
An analog input is a measurable electrical signal with a defined range that is generated by a sensor and received by a controller.

http://zone.ni.com/reference/en-XX/help/370466V-01/measfunds/diffmeassys/
Differential Measurement System

http://zone.ni.com/reference/en-XX/help/370466V-01/measfunds/refsingleended/
Referenced and Nonreferenced Single-Ended Measurement Systems

http://zone.ni.com/reference/en-XX/help/370466V-01/measfunds/connectaisigs/
The type of input signal source (grounded or floating) and the configuration of the measurement system (differential, single-ended, pseudodifferential) determine how you connect signals to measurement devices.

http://www.ddc-online.org/Input-Output-Tutorial/Analog-Outputs.aspx
An analog output is a measurable electrical signal with a defined range that is generated by a controller and sent to a controlled device, such as a variable speed drive or actuator. Changes in the analog output cause changes in the controlled device that result in changes in the controlled process.

https://labjack.com/support/faq/what-is-analog-output
The analog outputs convert digital values from a computer into a variable voltage level presented on an output terminal. This provides an adjustable output.

https://labjack.com/support/faq/what-are-digital-io
Digital Inputs allow a microcontroller to detect logic states, and Digital Outputs allow a microcontroller to output logic states.

https://www.omega.com/literature/transactions/volume2/digitalio.html

Analog input (voltage measurement)

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.

Click the **Test Panels...** button to open a windows which will allow you to perform most of the functions of a data acquisition board.
Select the **Analog Input** tab for measuring an analog signal.

In the **Channel Name** list, select the first analog input channel of your data acquisition board, named **ai0**.
In the **Mode** list, select the **Continuous** option.
In the **Input Configuration** list, select the **Differential** option.
Set the value of the **Max Input Limit** to 5 V and the value of the **Min Input Limit** to -5 V.
Set the data acquisition **Rate** to 10,000 Hz and the number of **Samples To Read** to 1,000.

Press the **Start** button.
The data acquisition board will start measuring on its analog input channel **ai0** every tenth of a millisecond and will display on the graph 1,000 values at a time every tenth of a second.
Because there is no signal source connected to the analog input channel, you will notice an electrical noise, due to the electrical network in the room, having a periodical shape and a frequency at around 50 Hz (Fig. 2.1).

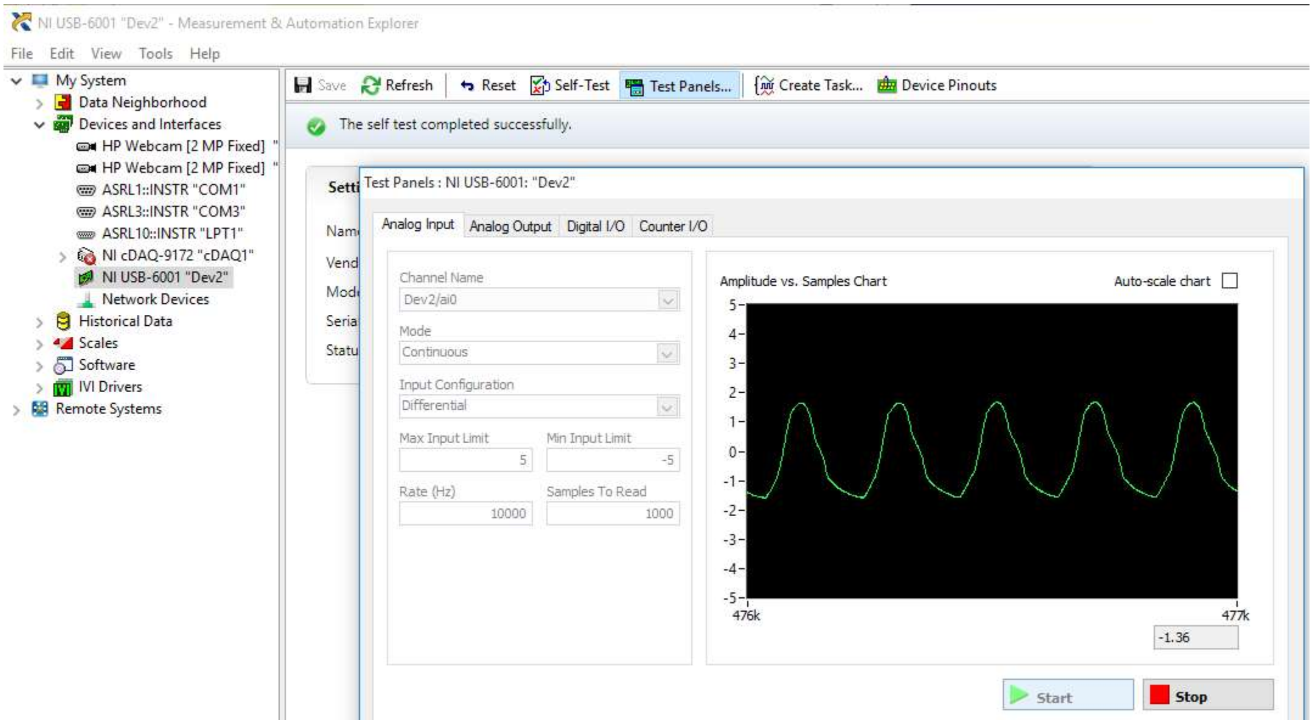

***Fig. 2.1:** Electrical noise sensed by the analog input when no signal is connected*

The analog input channel **ai0**, in differential mode, corresponds to terminals **AI 0** and **AI 4** on the left side of the data acquisition board (Fig. 2.2).
To measure the voltage of the two batteries mounted in the battery box, connect the **+** (red) wire of the battery box to terminal **AI 0** and the **–** (black) wire of the battery box to the **AI 4** terminal (Fig. 2.3).
Check if the measured value (Fig. 2.4) is close to the sum of the two batteries nominal voltage.

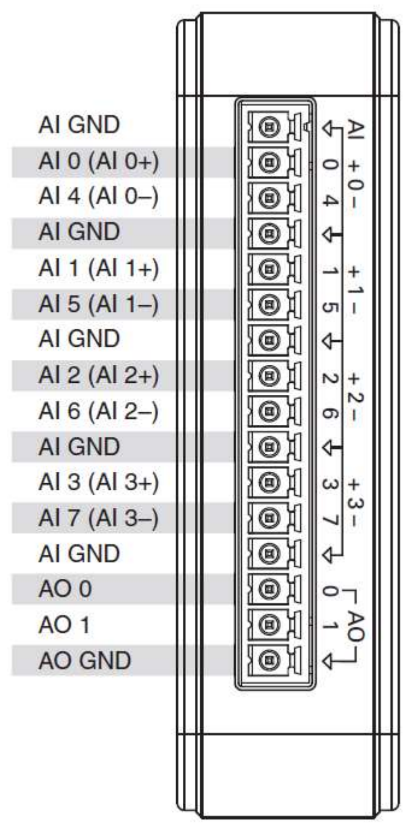

***Fig. 2.2:** USB-6001 left connector*

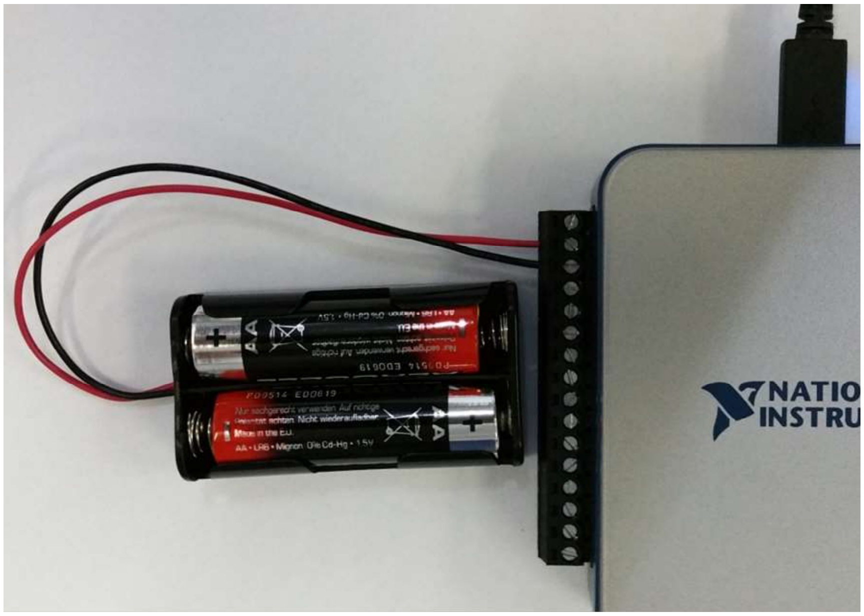

Fig. 2.3: *Connecting the battery box to analog input channel* ***ai0***

Fig. 2.4: *Measured voltage of the two batteries*

Take a battery out from the box, place a wire in its place for closing the electrical circuit (Fig. 2.5) and notice the new measured value of the voltage generated by only one battery (Fig. 2.6).

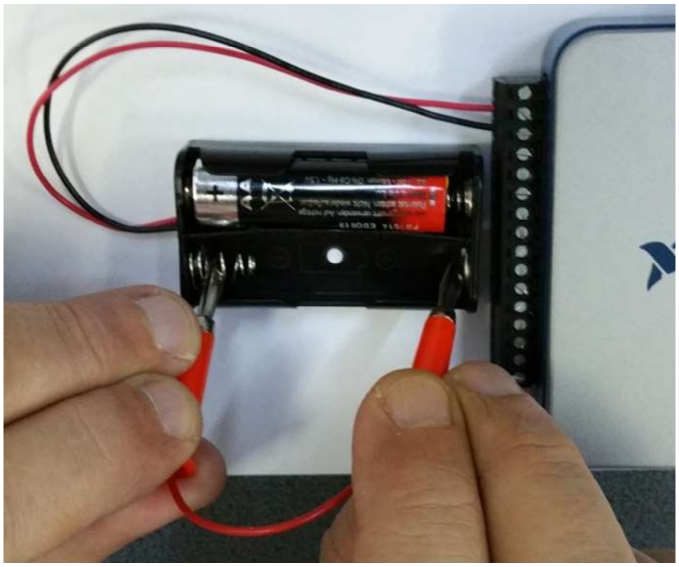

Fig. 2.5: *Closing the electrical circuit with only one battery*

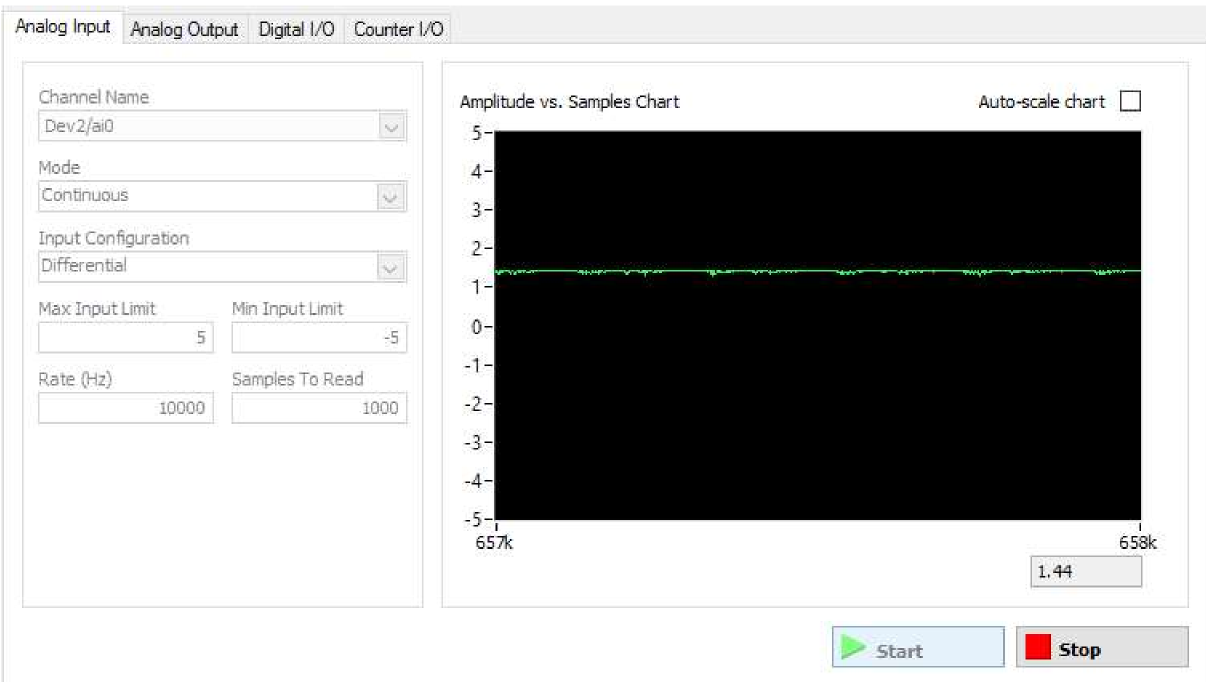

Fig. 2.6: *Measured voltage for one battery*

Press the **Stop** button to stop the measurements.

Analog output (voltage generation)

The **NI USB-6001** data acquisition board can generate only **Referenced Single Ended** (RSE) voltages, either on its **ao0** analog output channel (between the **AO 0** and **AO GND** terminals) or on its **ao1** analog output channel (between the **AO 1** and **AO GND** terminals).

Because the analog input and analog output ground (GND) terminals are internally connected in the data acquisition board, for generating a voltage on the **ao0** analog output channel and measuring it on the **ai0** analog input channel it is enough to connect a wire between terminals **AO 0** and **AI 0** (Fig. 2.7).

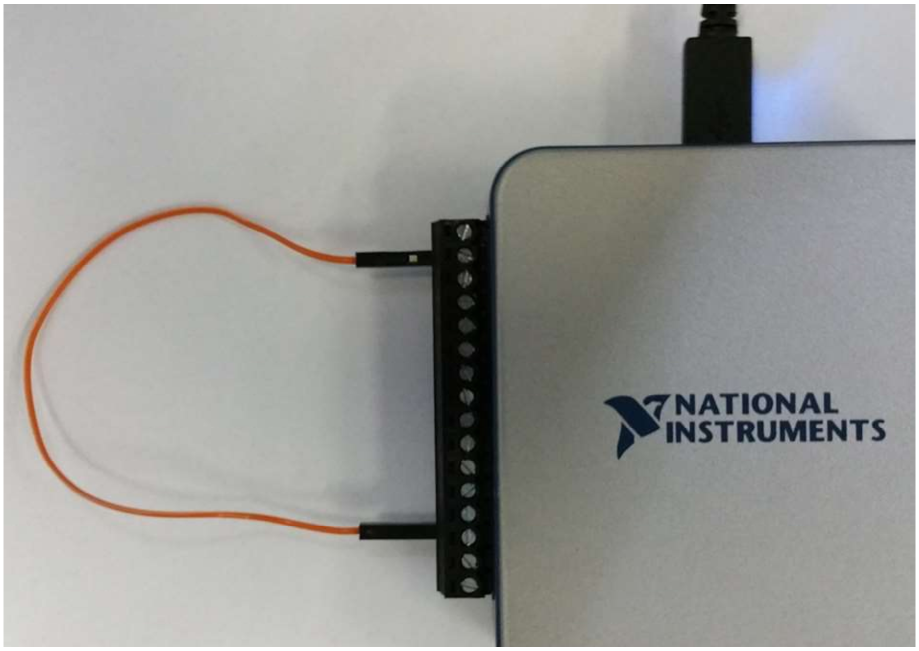

Fig. 2.7: *Connecting **ao0** analog output channel and **ai0** analog input channel*

To generate a continuous voltage (Fig. 2.8):

- Go to the **Analog Output** tab of the test panels;
- In the **Channel Name** list, select the first analog output channel of your data acquisition board, named **ao0**;
- In the **Mode** list, select the **Voltage DC** option;
- Set the value of the **Max Output Limit** to 5 V and the value of the **Min Output Limit** to -5 V;
- Set the **Output Value** control to a value around 2.5 V;
- Press the **Update** button.

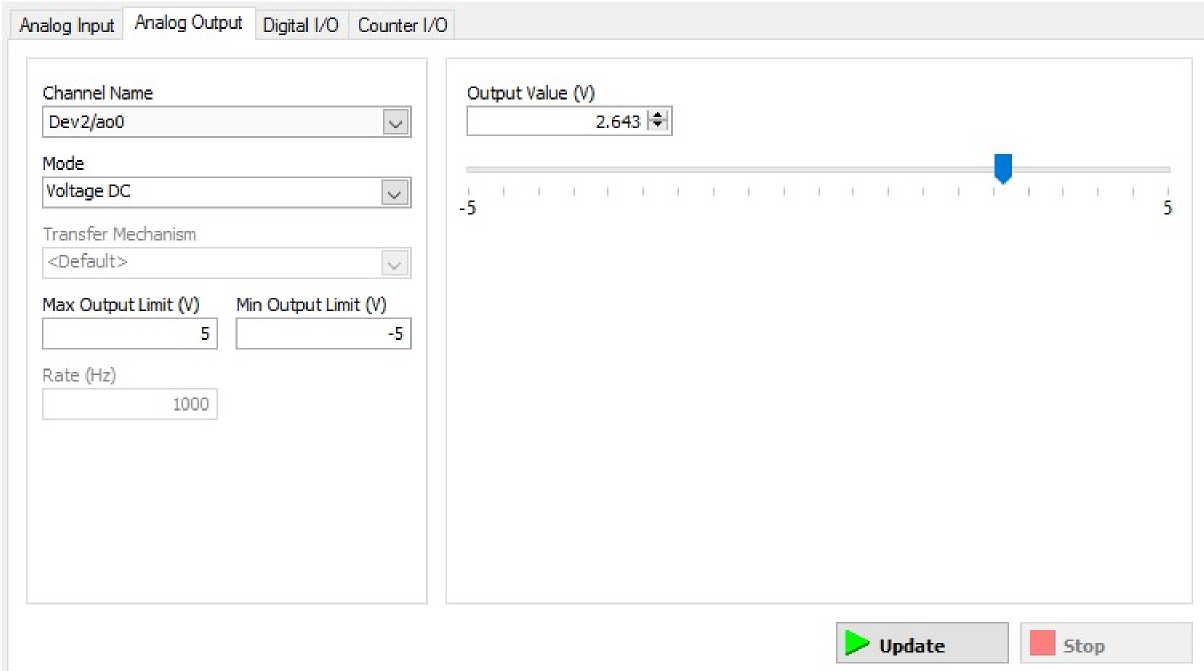

Fig. 2.8: *Generating a continuous voltage*

For measuring the voltage generated on analog output channel **ao0** (Fig. 2.9):

- Go to the Analog Input tab of the test panels;
- In the **Input Configuration** list, select the **RSE** option;
- Press the **Start** button.

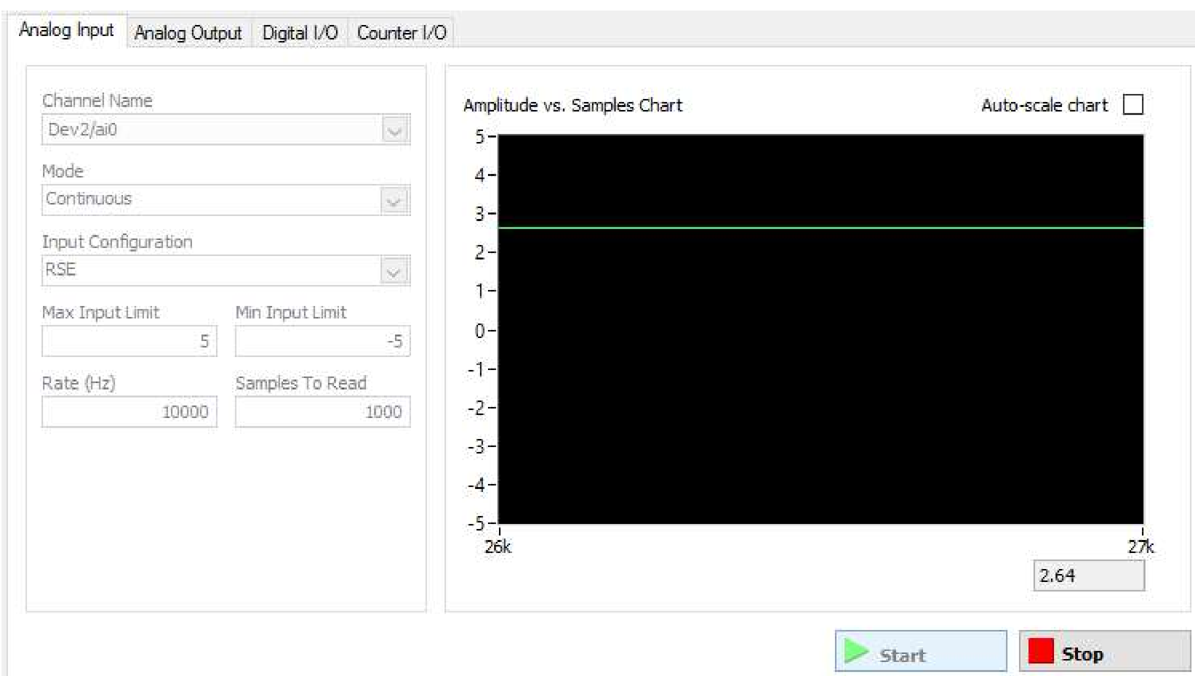

Fig. 2.9: *Measuring the voltage generated on analog output channel* ***ao0***

Go back to the **Analog output** tab and set the **Output Value** control to a value around 3.5 V (Fig. 2.10). Press the **Update** button.

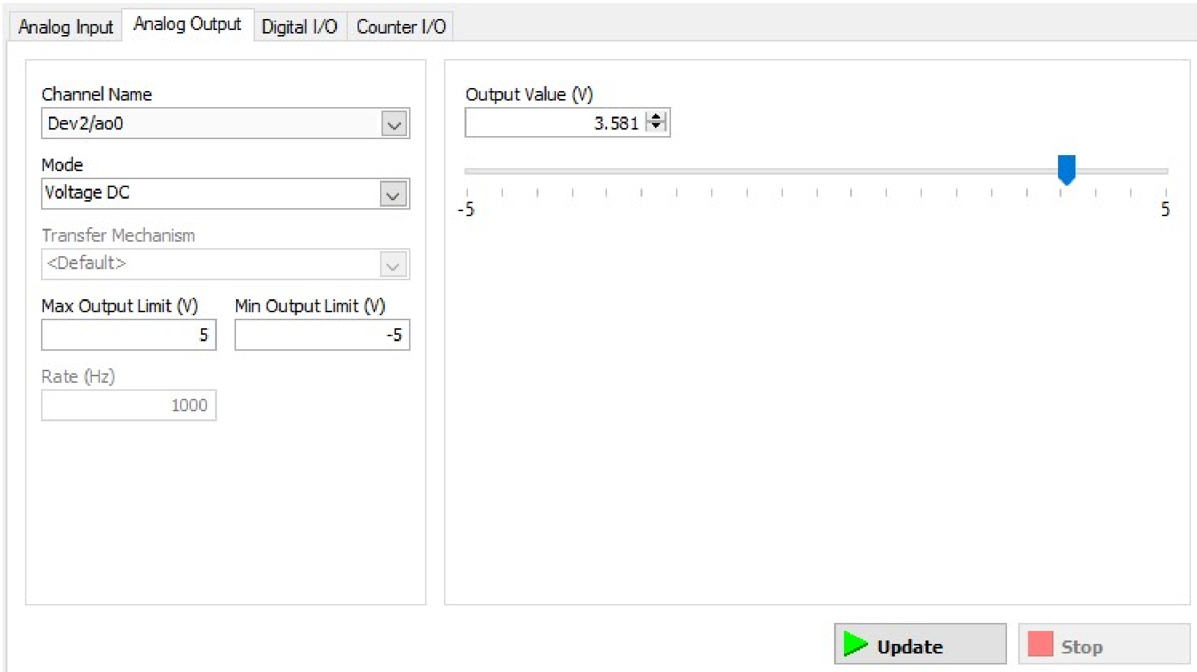

Fig. 2.10: *Changing the value of the generated voltage*

Return to the **Analog Input** tab and notice the change in the measured value (Fig. 2.11).

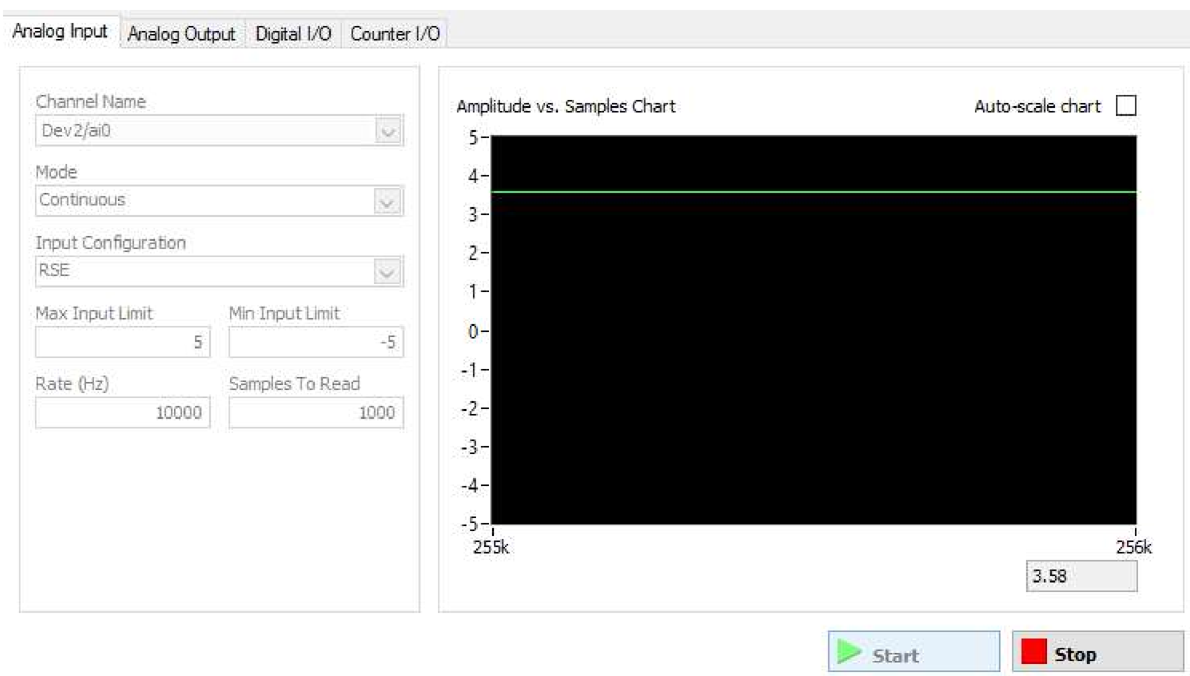

Fig. 2.11: *Measuring the new voltage generated on analog output channel* ***ao0***

For generating a continuous sinewave on the analog output channel **ao0** of the data acquisition board, go back to the **Analog Output** tab (Fig. 2.12) and:

- Select the **Voltage Sinewave Generation** option from the **Mode** list;
- Set the generation's **Rate** value at 1,000 Hz, this having the mean that 1,000 values will be generated each second and the frequency of the generated sinewave will be of 1 Hz (one period per second);
- Set the **Sinewave Amplitude** control to a value of 3 V;
- Press the **Start** button.

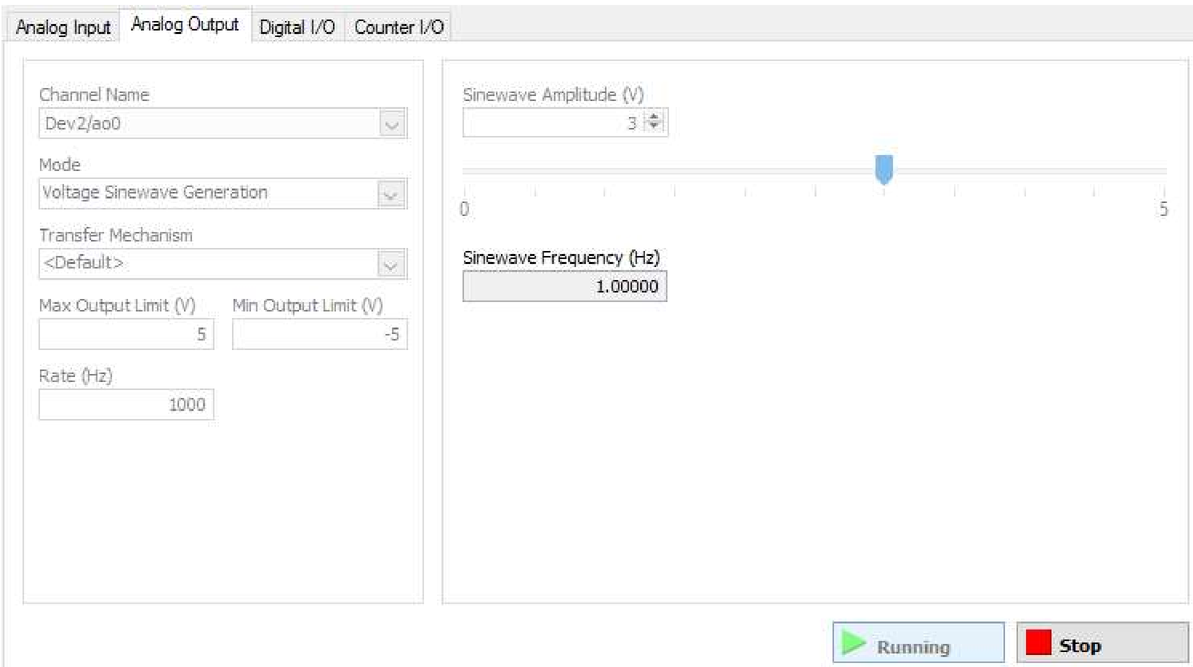

Fig. 2.12: *Generating a continuous 1 Hz sinewave on the analog output channel* ***ao0***

Go back to the **Analog Input** tab and stop the measurement if it's running.
Change the measurement's **Rate** value to 1,000 Hz. The data acquisition board will measure 1,000 values in a second.
Because the **Samples To Read** value is also 1,000, this means that 1,000 new measured values will be graphically displayed each second.
Press the **Start** button and notice that a complete period of the 1 Hz generated sinewave is measured and displayed every second (Fig. 2.13).

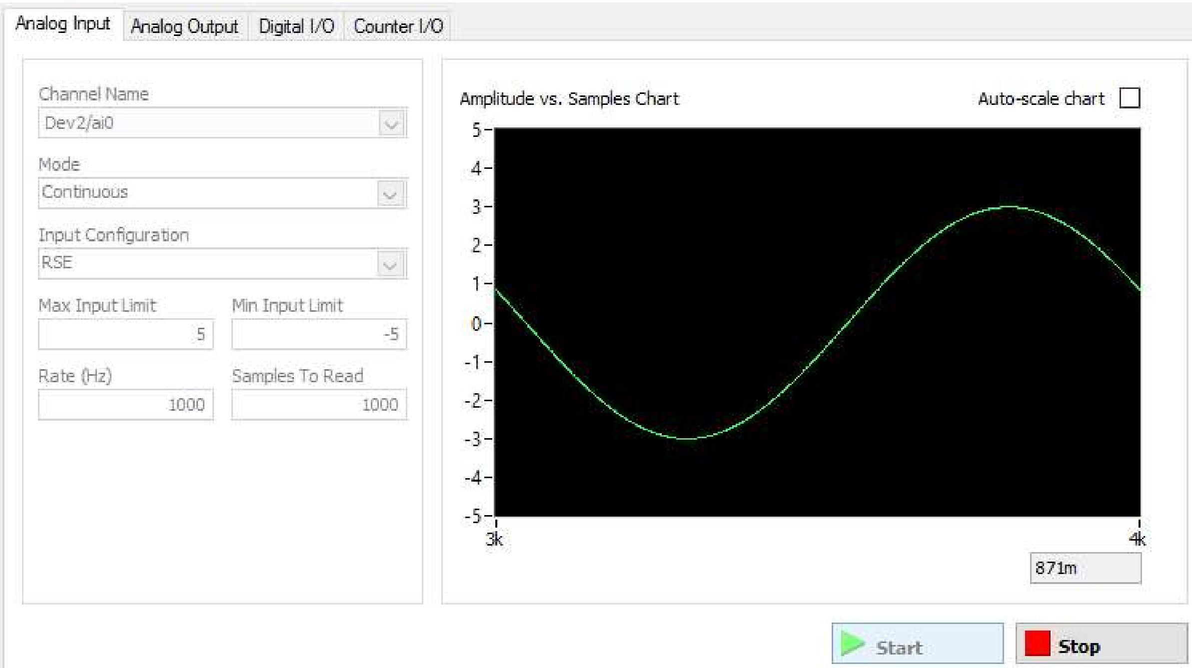

Fig. 2.13: *Measuring the 1 Hz generated sinewave*

Return to the **Analog Output** tab, stop the sinewave generation and change the **Rate** value to 3,000 Hz (Fig. 2.14).
3,000 values will be generated now every second, but notice that the frequency of the generated sinewave will be of 3.00008 Hz and not exactly 3 Hz because, when computing the time between two consecutive generated values, the board is using a finite number of decimals so an error appears.
Press the **Start** button.

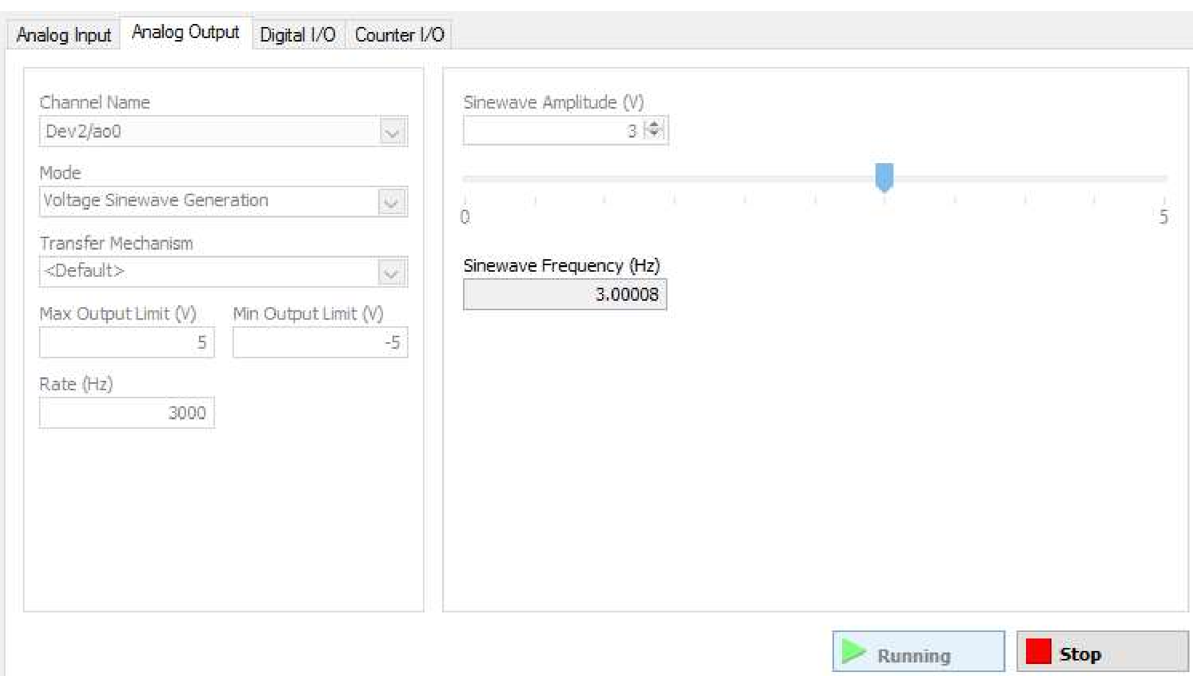

Fig. 2.14: *Generating a continuous ~3 Hz sinewave on the analog output channel* ***ao0***

Go back to the **Analog Input** tab and notice that three complete periods of the ~3 Hz generated sinewave are measured and displayed every second (Fig. 2.15).

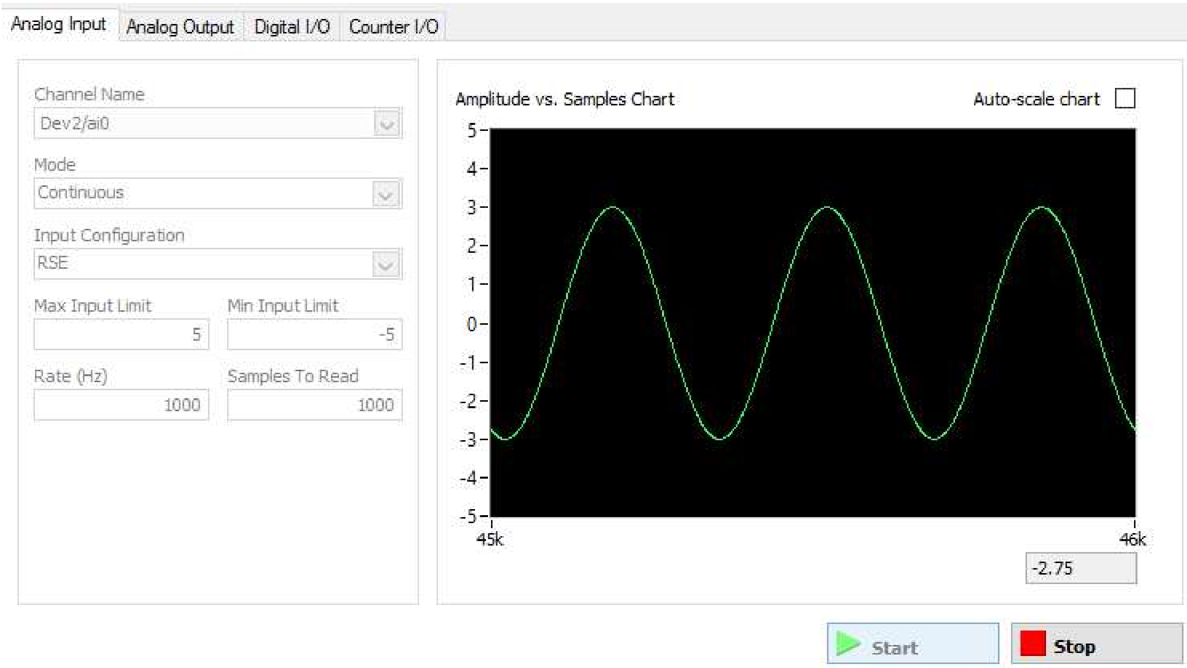

Fig. 2.15: *Measuring the ~3 Hz generated sinewave*

Digital input

For applying a logic **High** signal to digital line 2 on port 0 of the data acquisition board (Fig. 2.16), connect the **+** (red) wire of the battery box to terminal **P0.2** and the **–** (black) wire of the battery box to one of the **D GND** terminals (Fig. 2.17).

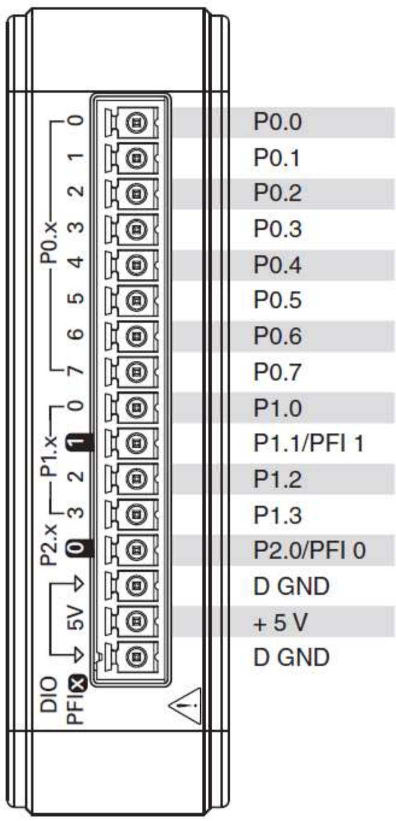

Fig. 2.16: *USB-6001 right connector*

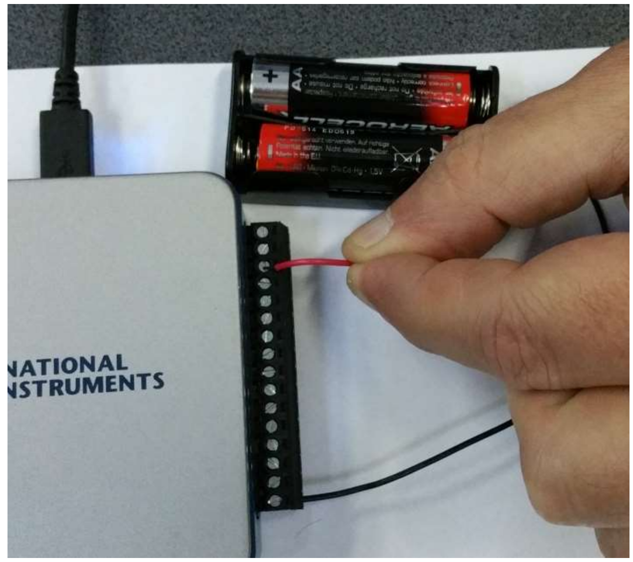

Fig. 2.17: *Connecting the battery box to digital line 2 on port 0*

Go to the **Digital I/O** tab of the test panels and notice that the LED corresponding to line 2 on port 0 is turning green when the wires are connected (Fig. 2.18).

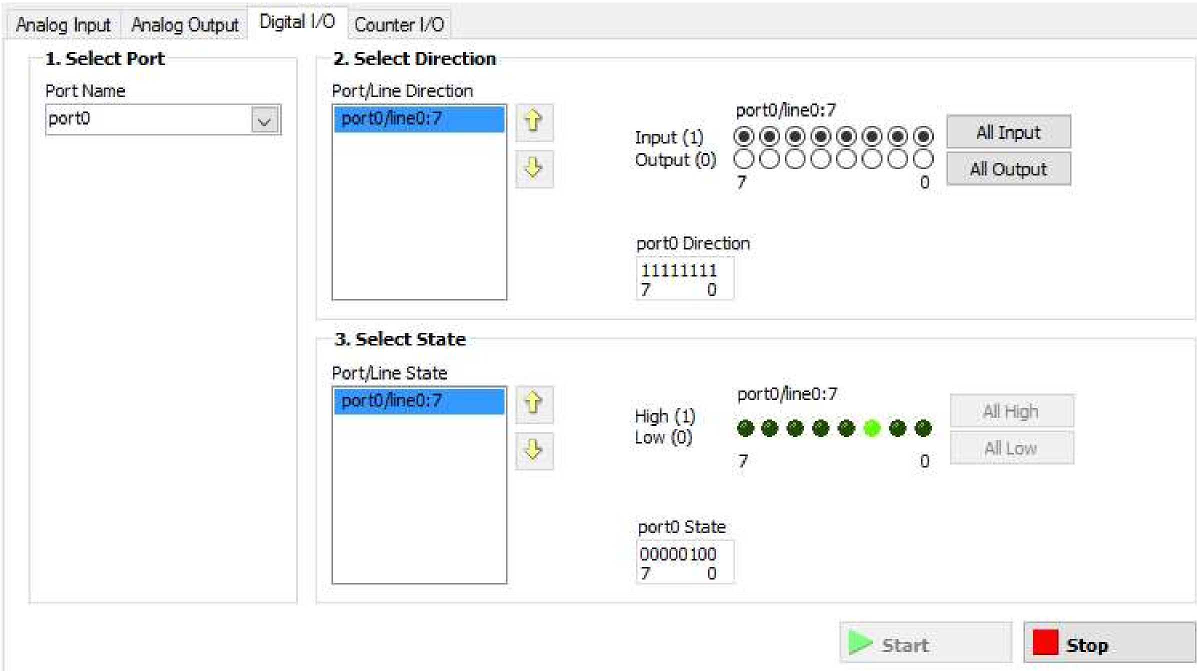

Fig. 2.18: *Logic **High** signal on line 2 on port 0*

Using the breadboard, connect the battery box and the switch in a series circuit wired to line 1 on port 0 (Fig. 2.19).

Take care to connect the red and blue connectors exactly like in the figure !

Notice that the LED corresponding to line 1 on port 0 is turning green each time the switch is pressed (Fig. 2.20 and Fig. 2.21).

This situation corresponds to a "**normally open**" switch.

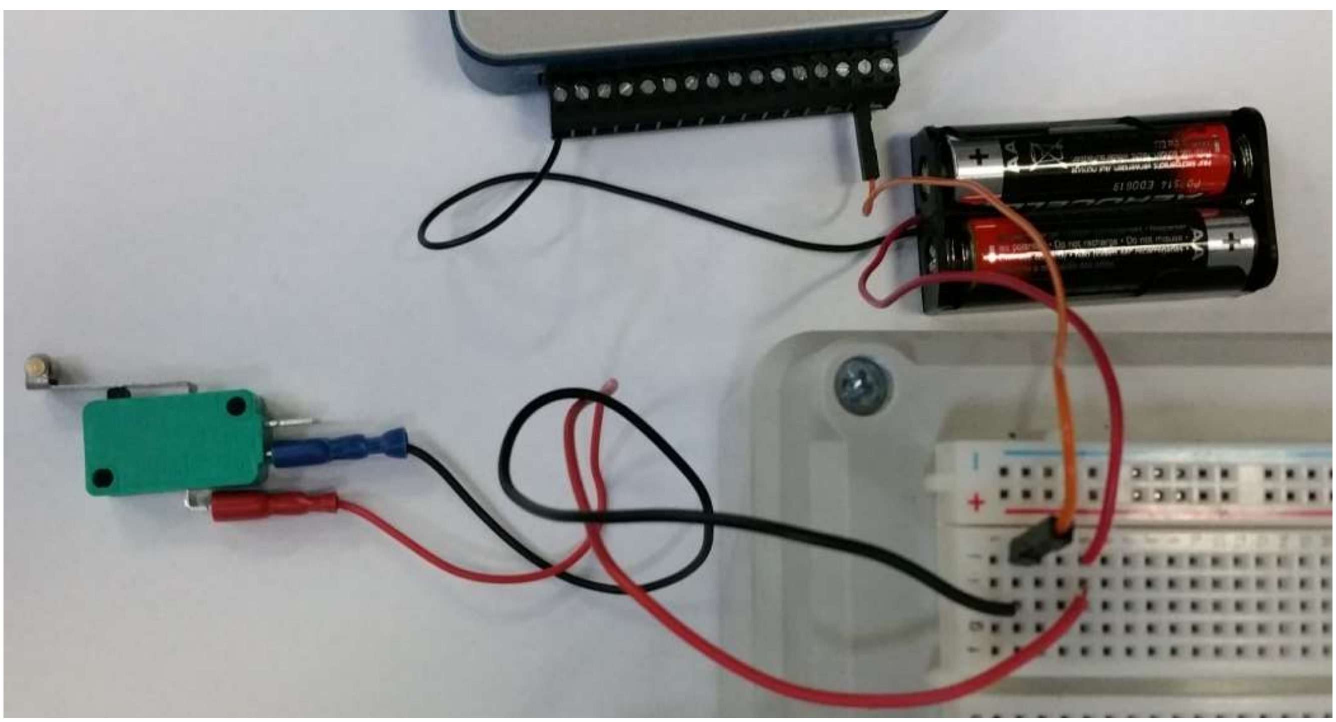

Fig. 2.19: *Connecting a series circuit*

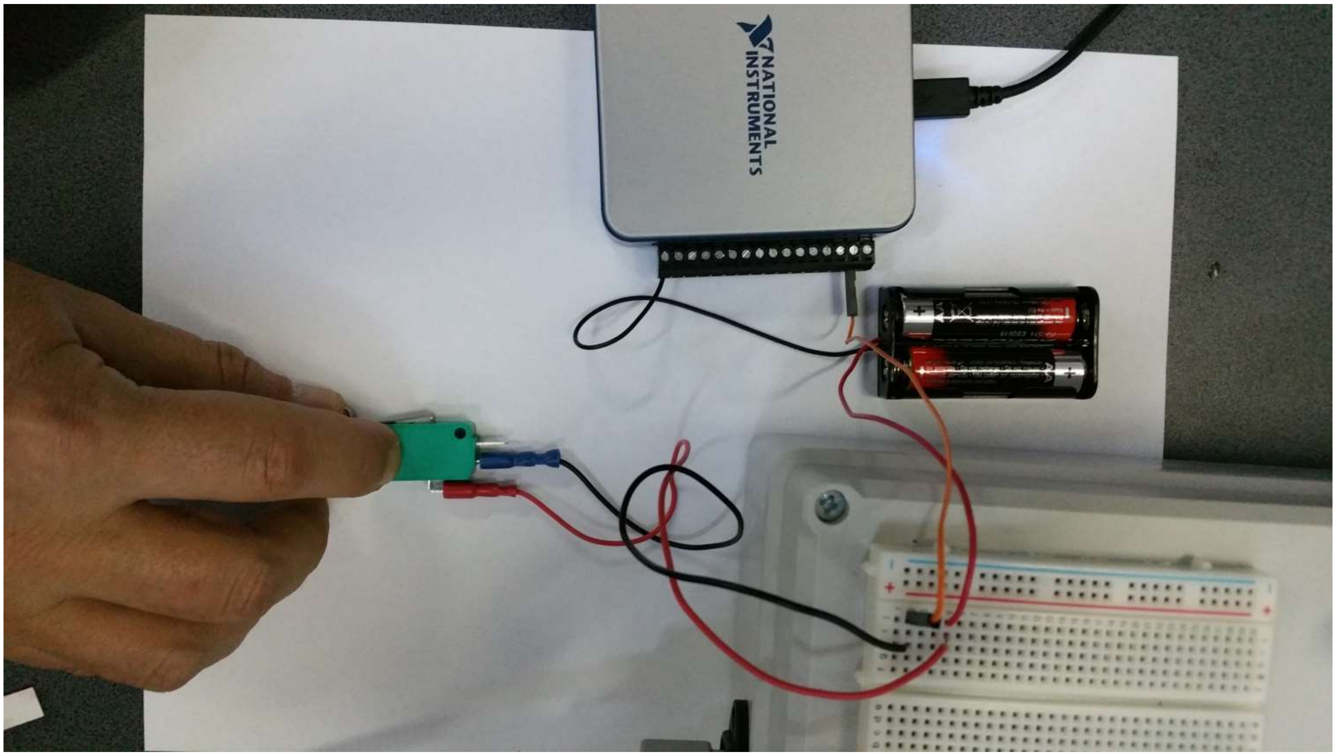

Fig. 2.20: *Pressing the switch for sending a logic **High** signal to line 1 on port 0*

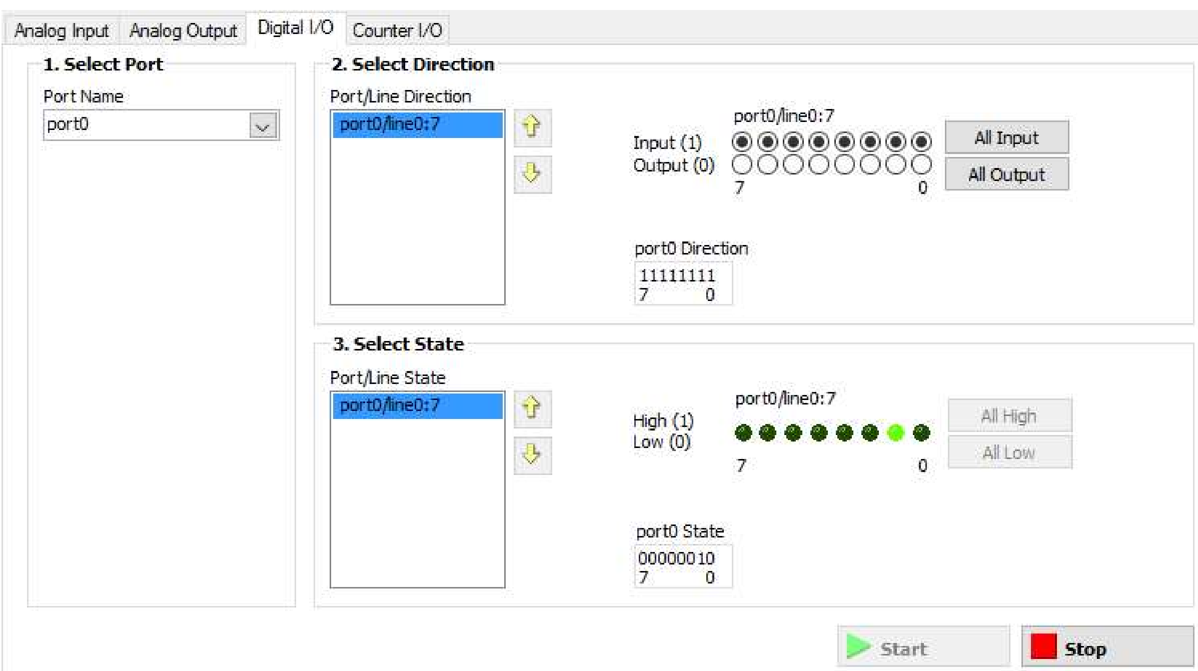

Fig. 2.21: *Sensing the logic **High** signal sent to line 1 on port 0*

Change the position of the blue connector as in Fig. 2.22.
Notice that now the LED corresponding to line 1 on port 0 is turning green when the switch is released and is turning off when the switch is pressed.
This is because changing the position of the blue connector transformed the switch in a "**normally closed**" one.

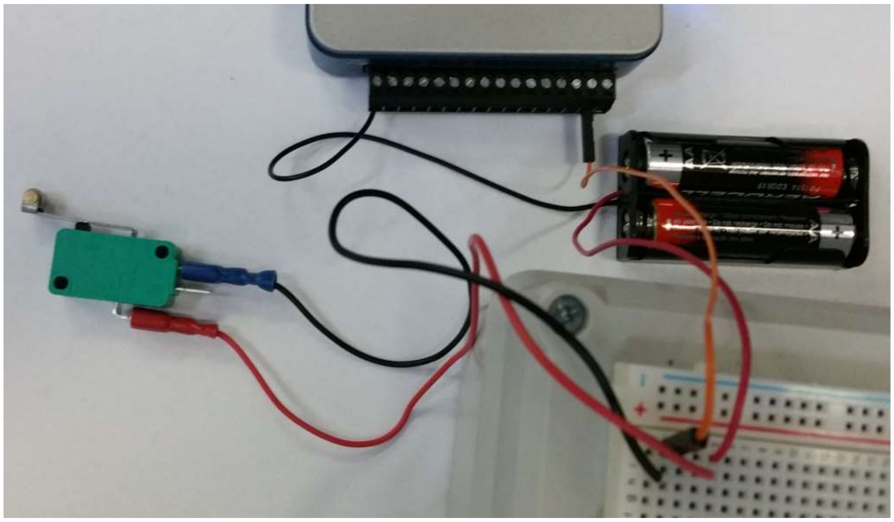

Fig. 2.22: *Changing the position of the blue connector*

Digital output

Build the circuit from Fig. 2.23 and Fig. 2.24, in which you have to:

- Connect the digital line 0 on port 0 of the data acquisition board to the input of the ASR-05DD relay;
- Build a series circuit containing the 5 V DC source, the output of the ASR-05DD relay and a fan.

Take care about the correct signs (+ or -) of the connections !

When the data acquisition board will generate a logic high (5 V) signal on its digital line 0 on port 0, the relay will close its output circuit so the DC source will power the fan.

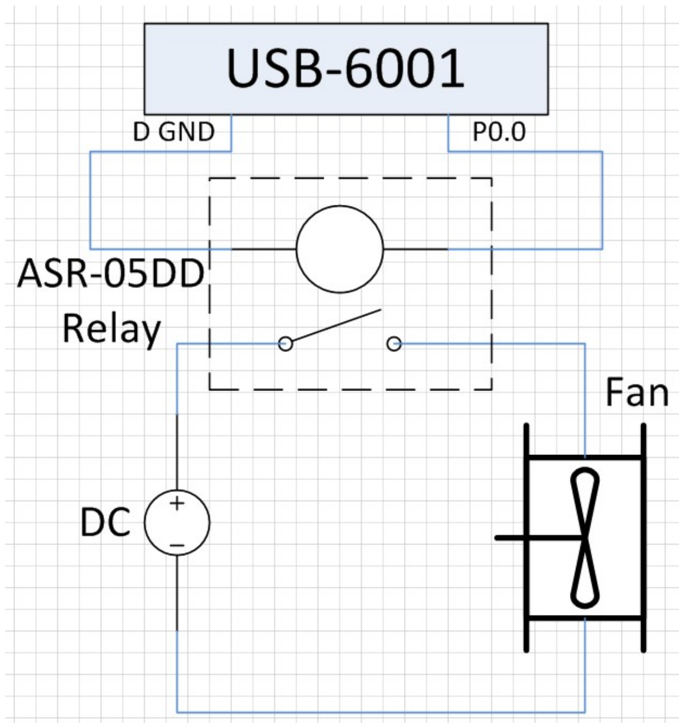

Fig. 2.23: *Schematic for the* ***Digital Output*** *circuit*

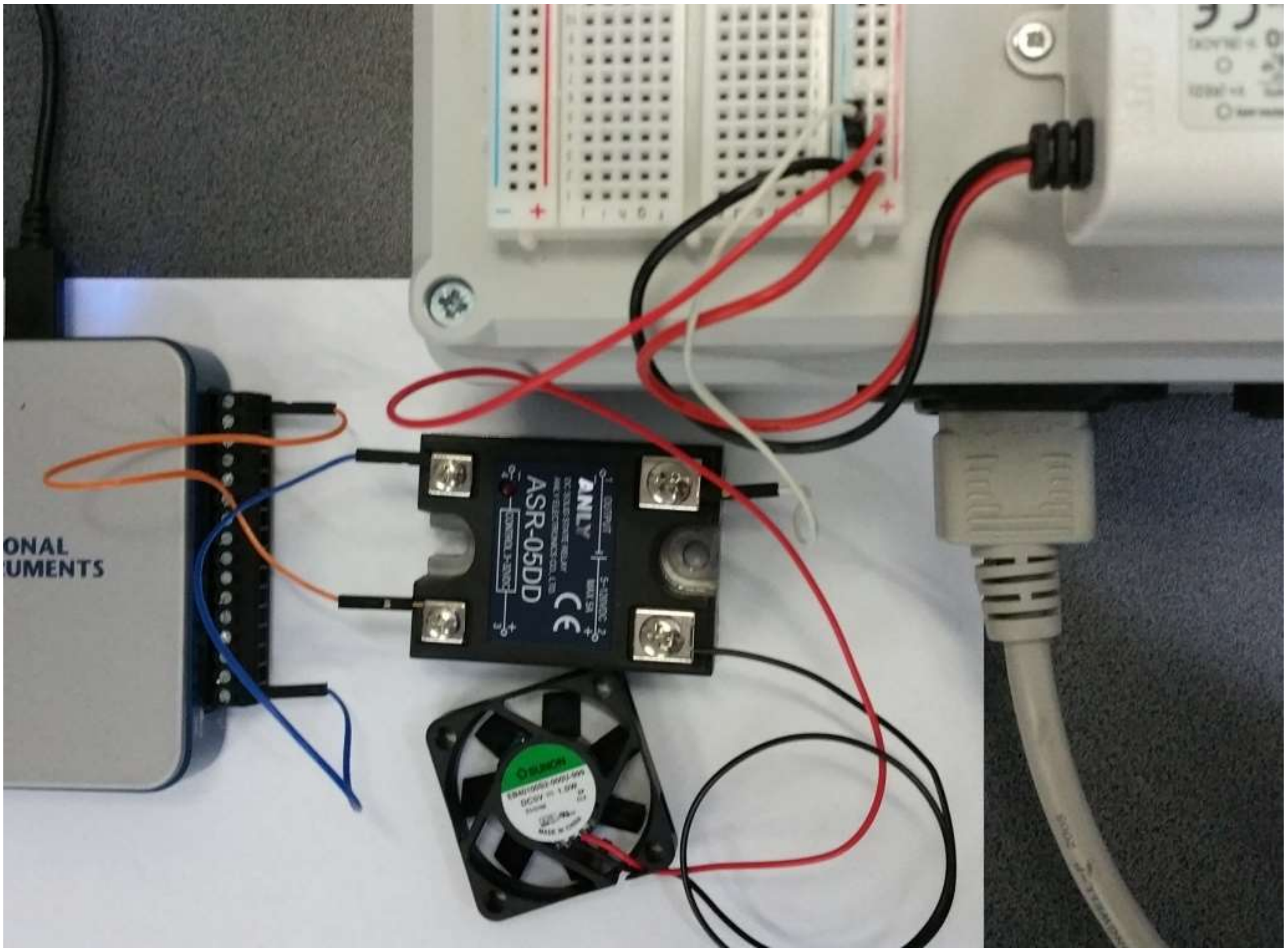

***Fig. 2.24: Digital Output** circuit*

In the **Digital I/O** tab of the test panels (Fig. 2.25):

- Set the direction of digital line 0 on port 0 to **Output**;
- Press the **Start** button;
- Switch digital line 0 on port 0 to the **High** state and observe that the fan will start to rotate (Fig. 2.26).

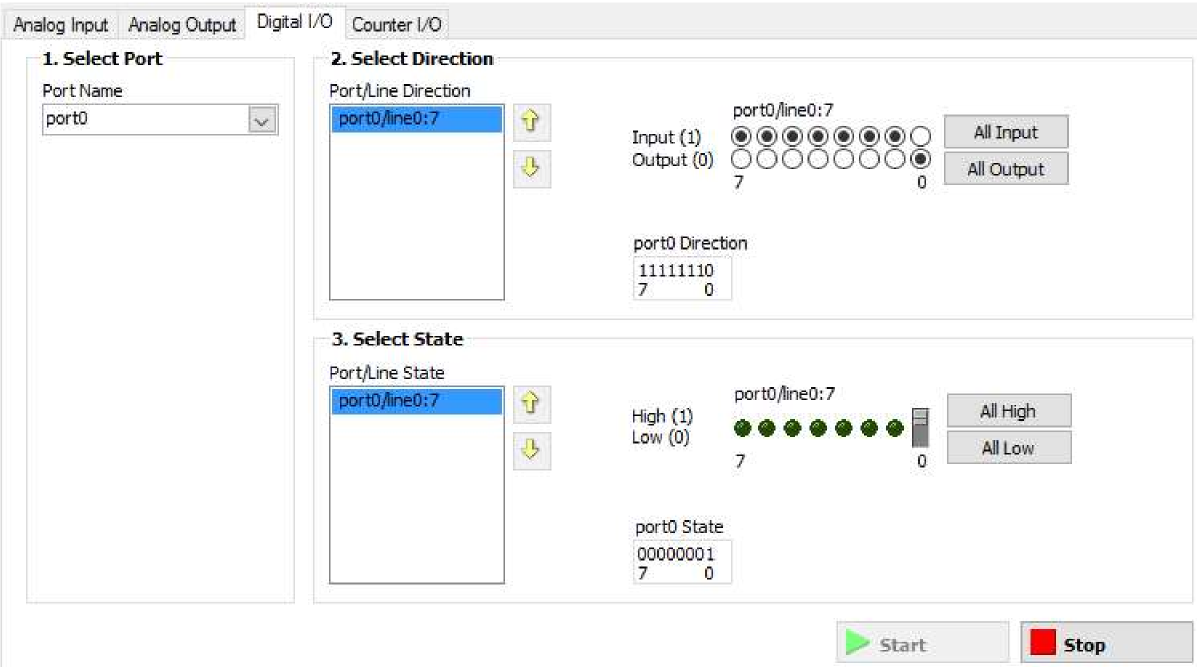

Fig. 2.25: *Setting-up the* ***Digital Output*** *function*

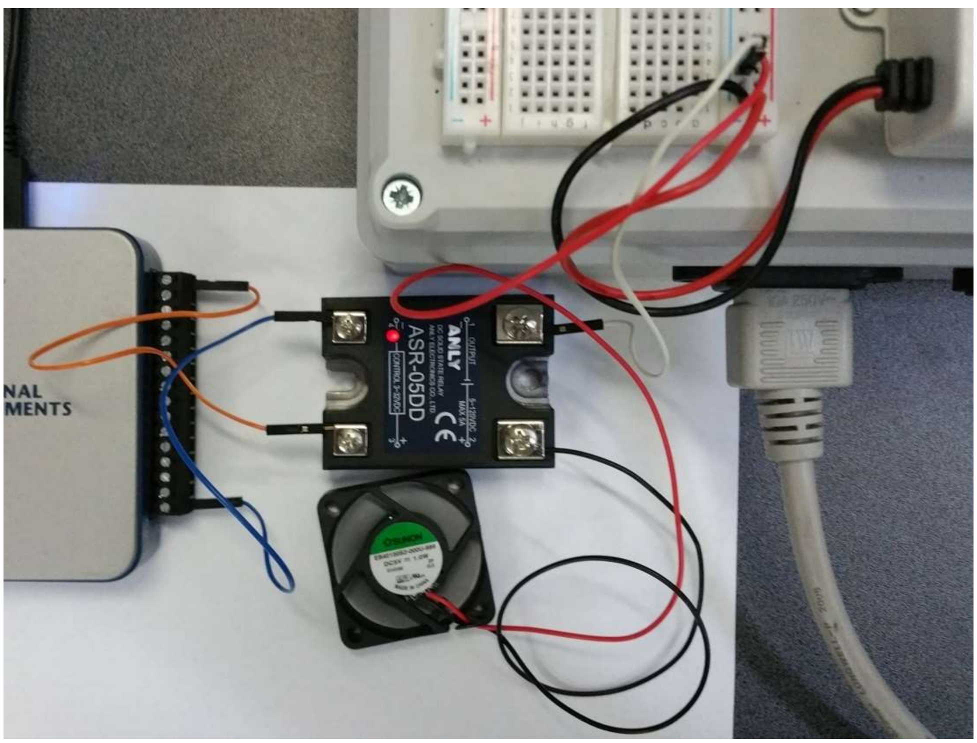

Fig. 2.26: *Rotating the fan when the digital output signal is* ***High***