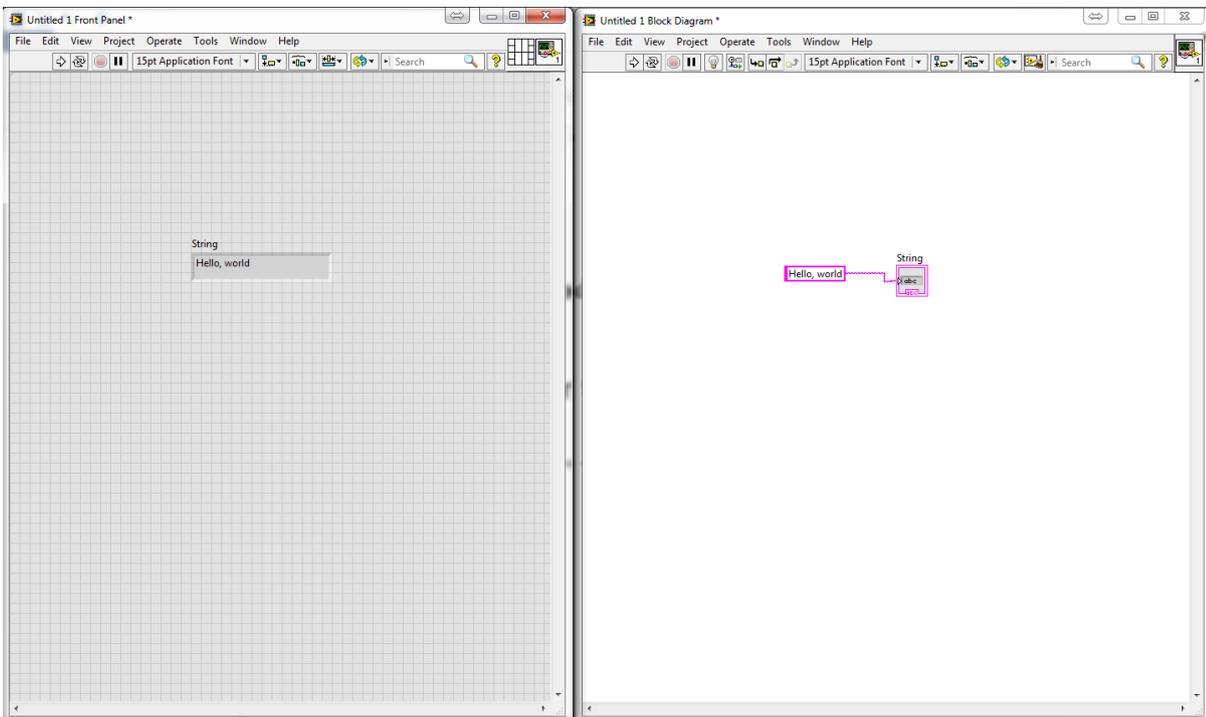# LabVIEW

Day 1

1 Introduction

First open NI labview and create a new project then a blank VI (virtual instrument).

Labview has two windows: 1. **Front panel** (User interface for input and output), 2. Graphic code (called **block diagram**).

2 Hello, world! program

1) In the **front panel** create a "**string indicator"** by dragging and dropping the function found in the control panel. **(Right click>>string & path)** (You can also find these functions using the '**search**' box)

2) Right click in the **block diagram** and create a "**string constant**".

3) Wire them together. Type 'Hello, World!' in the '**string constant**' on the block diagram, and press run and observe the front panel.Your program should look like the picture above.

For more information about components placed on the front panel or block diagram, press 'help' in the menu bar then click 'show context help'. This provides more information when the cursor hovers over a component.

Labview has different data types: string (text), numeric (numbers), boolean (true or false), array (an array of number) etc. For numerical types of data, you can perform some basic mathematical functions.

Exercise 1). Create a programme as shown in the figure below. The meter (in **numeric>>meter**) shows the sum of the value you enter in the two '**numeric control (numeric>>numeric control)'** boxes. You can change the scale of the meter by **right clicking on the meter -> properties -> scale**.
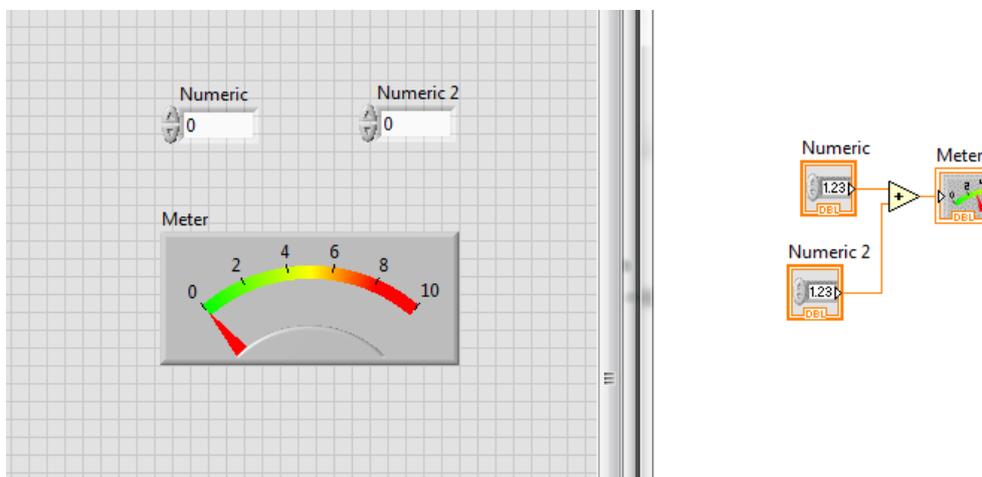
3 While loop

A program inside a while loop stays running until a condition is met. The condition is set by wiring a true or false control to the . The 'i' at the left bottom corner counts how many iterations the loop has been executed.

Exercise 2). Create a while loop (**Structure>>while loop**) to the above program so that it will keep running until a 'STOP' (**Boolean>>STOP**) button is pressed.
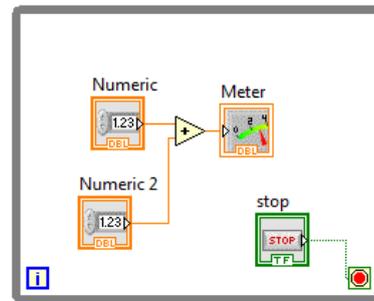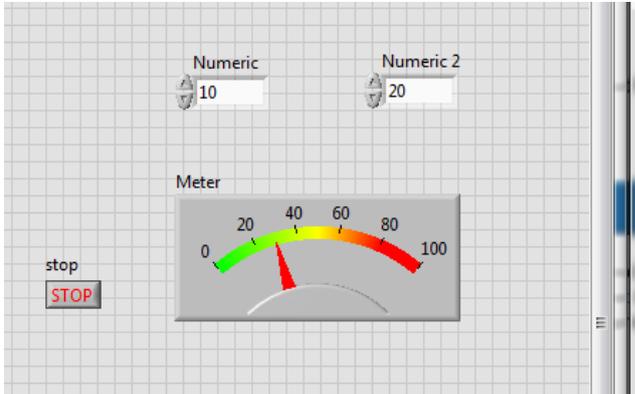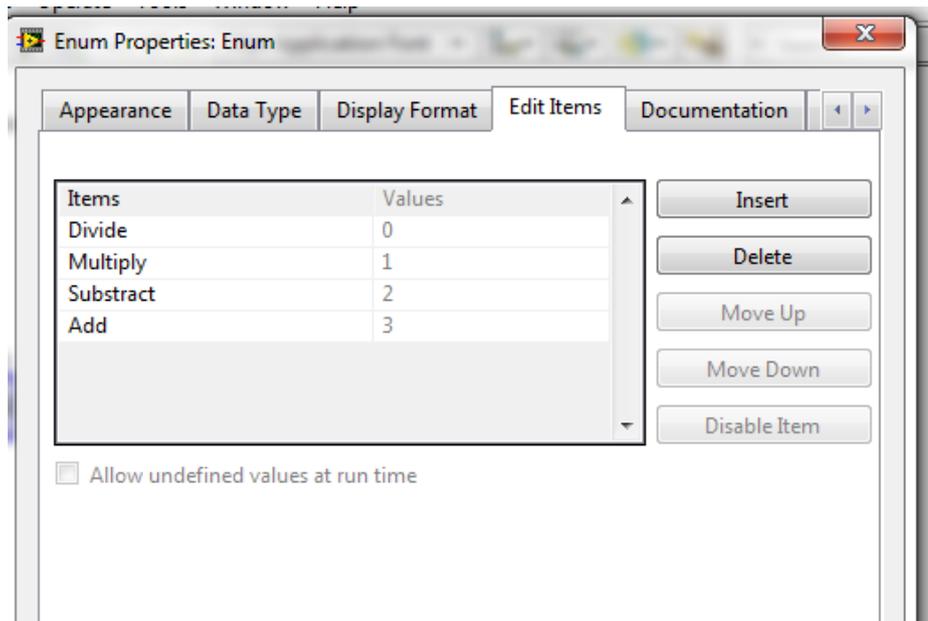

4 Case structure

A **case structure** can have more than one subdiagram, i.e. more than one 'case'. A selector (can be numeric, string or boolean) is wired to the terminal to determine which case is to be executed.

Exercise 3). Use the **case structure** to allow user to select add, substract, multiply and divide functions.

1) Delete all the wires and the **'add' operator** you have in the above programme.

2) Right click in the **Front Panel**, '**ring & enum>>enum**'. In the **properties** of the enum box, go to '**Edit items**' and insert 4 items -add, substract, multiply, divde.

3) Create a '**case structure (structure>>case structure)**' in your **Block Diagram** and wire the '**enum**' to the '**?**'.

4) Right click on the border of the **case structure** and click '**Add Case for Every Value**'. You will see that your case structure now has 4 different cases and you can use the arrow to select one.

5) Drag and drop the corresponding operators to each case and wire them with the **numeric controls** and the **meter**. Your program should look like the diagram below.

6) Run the program and see what happens when you change the case in the enum.
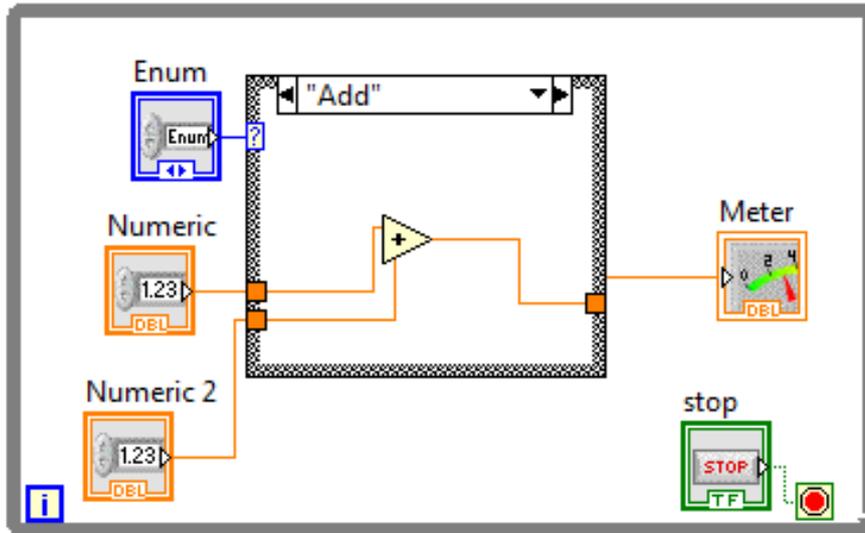
5 Data acquisition

We use a National Instruments 6008 data acquisition device (DAQ) in this class to perform data acquisition. It has 8 analog inputs (**AI**), 2 analog outputs (**AO**, up to 5 V) and 12 digital I/O.

Exercise 3) Testing your DAQ. First, connect the DAQ to your computer, a green LED next to the USB port will flash.

1) Fire up **NI MAX (Measurement and Automation Explorer)**, go to '**Device and Interfaces**', you should see a **NI-6008 device** in the list. Click '**Self-Test**', it should say '**The self-test completed successfully**'.

2) Connect the LED and resistor as shown in the below circuit diagram (The longer leg is the anode – positive end). Connect the analogue output (**AO0**) on the DAQ to positive and ground (**GND**) to negative. We have provided you with a 10 ohm (Brown), a 1 kohm (Blue) and a 1 Mohm (Blue with a yellow line) resistors. In this case, you will need the 1 kohm resistor to limit the current passing through the LED. Otherwise, your LED might blow up.
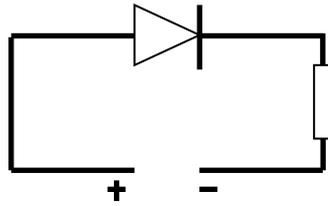
3) To light up the LED, go to **'Test Panels'>>'Analog Output'** and select your channel. Set **5V** as your output voltage and press '**Update'**, your LED should light up. Change the output voltage to **0V** to turn the LED off.

Exercise 4) Blink a LED for a number of times.

1) To control the DAQ in Labview, right click in the **Block diagram>>Measurement I/O>>NI DAQmx>>DAQ Assist**. Select **Generate Signal>>Analog Output>>Voltage**. Choose your channel (**AO0**) and finish. In the configuration page, keep everything as default and then press **OK**.

2) A **DAQ Assistant** will appear in the Block Diagram. Wire a **numeric constant** to '**Data**' to control the voltage output of the DAQ. Set this to 5V.

3) Create another '**DAQ Assistant**' and set to 0V to turn the LED off.

4) Add a time delay after each DAQ Assistant by using **Timing>>Time Delay** (1 second should be enough). You can control the flow of the diagram by wiring '**Error Out**' to '**Error In**'. Place all of them in a **while loop**. You should have a diagram that looks like this:
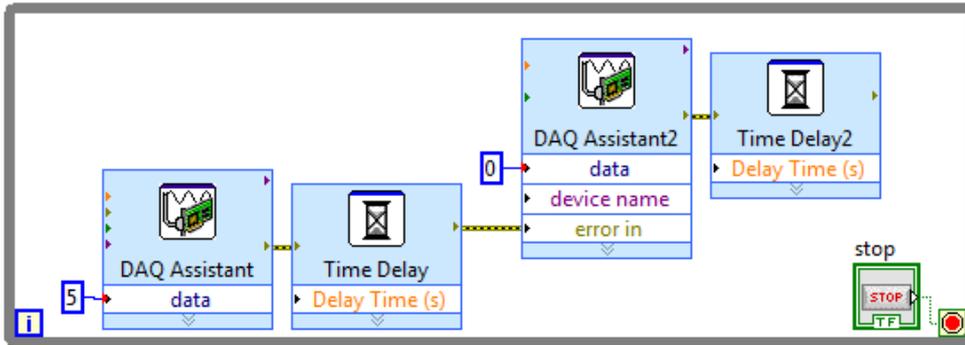
5) Click Run, your LED will start to blink!

6) Now, to use the **For Loop** to control how many times the LED blinks. First, right click on the edge of the **While Loop >> Replace with For Loop**. There is an 'N' on the top left of the **For Loop** box.

7) Right click on the left node of the '**N**' and select '**create control**'. This control box will appear on your main Labview panel. This controls how many times the **For Loop** is executed. Now enter a number in the box and test your program.
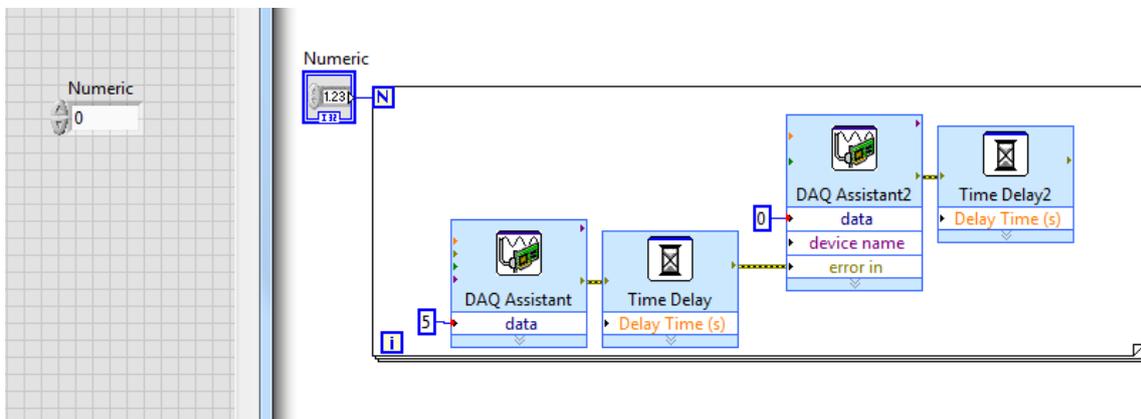

Exercise 5) Measure photodiode response to light.

1) Connect your photodiode according to the circuit diagram below. The signal generated by the photodiode is monitored by the voltage variation across the resistor.

2) Create a **DAQ assistant** to measure the analog input. In **DAQ Assist**, **Aquire signal>>Analog Input>>Voltage**, select your channel and keep everything else as default.

3) To display the voltage value as a function of time on a graph, create a '**Waveform graph**'(**right click>>Graph)** in the **front panel**. Wire the data from the DAQ assistant to the graph. To save the data, drop a '**File I/O>>Write To Measurement File**'. In the setting dialogue, choose '**Text(lvm)**', X Value '**One column only**'. You can do some other settings as you wish. Now wire them the together as the figure below.

4) Shine a light onto the photodiode to observe the change. Open the LVM file you have saved using Notepad.
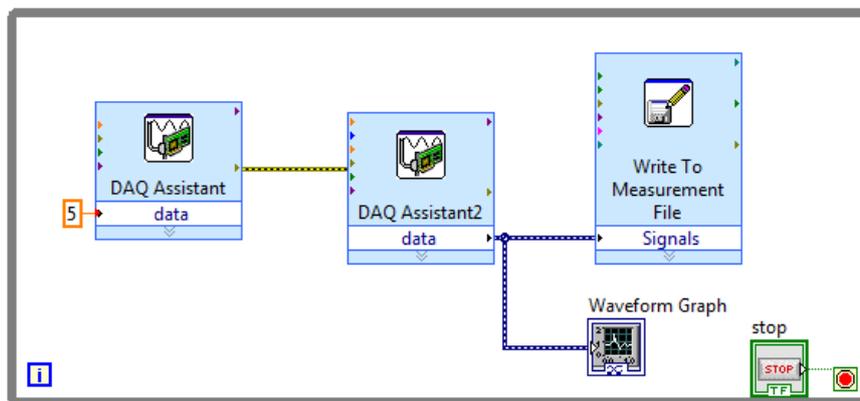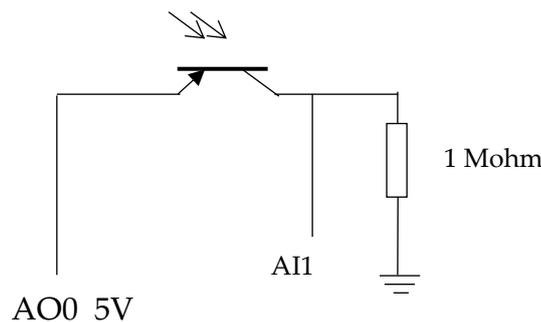
Exercise 6) Measure diode characteristic

We apply a voltage across a diode and measure its current to obtain a diode I-V characteristic curve.

The circuit diagram is shown below. In this exercise, a voltage sweeps from 0 to 5V and is generated from the analog output by using a **for loop**. The voltage across the diode can be measured from the analog input, V_{ai}. The current can be calculated using $I=(V_{ao}-V_{ai})/R$.

Now, create a labview file as shown below. First, you will need to create two **numeric controls**. One is to set the maximum voltage and one is to set the number of steps for the voltage scan. You can change the name of the **numeric controls** to 'Max V' and 'No of steps'. Wire 'no of steps' to the '**N'** to control how many times it will loop. Now the voltage output in each step will be 'Max V'/'No of step' * **i**, i indicates which iteration you are at and i starts from 0. Now wire this number to the DAQ Assistant for analog output. Drop a DAQAssistant for analog input to measure the voltage across the diode.

To create a XY graph, go to '**Graph>>Ex XY graph**'. Remember that the data output from the DAQ Assistant will need to convert to double precision (**DBL**). Go to '**numeric>>conversion>>To Double precision float'**.

Once the voltage is measured, you can calculate the current in the circuit.

Wire the current to **Y Input** and voltage to **X Input** in the '**Build XY graph**'. Make sure the **Reset** on the **Build XY graph** box is false otherwise the graph will reset itself in each loop. You can save the measurement data using the '**Write to measurement file**'. This needs to be outside the **for loop**. When you

wire more than 1 signal to the '**Write to Measurement File**', the two current and voltage signals will be bundled automatically into one.
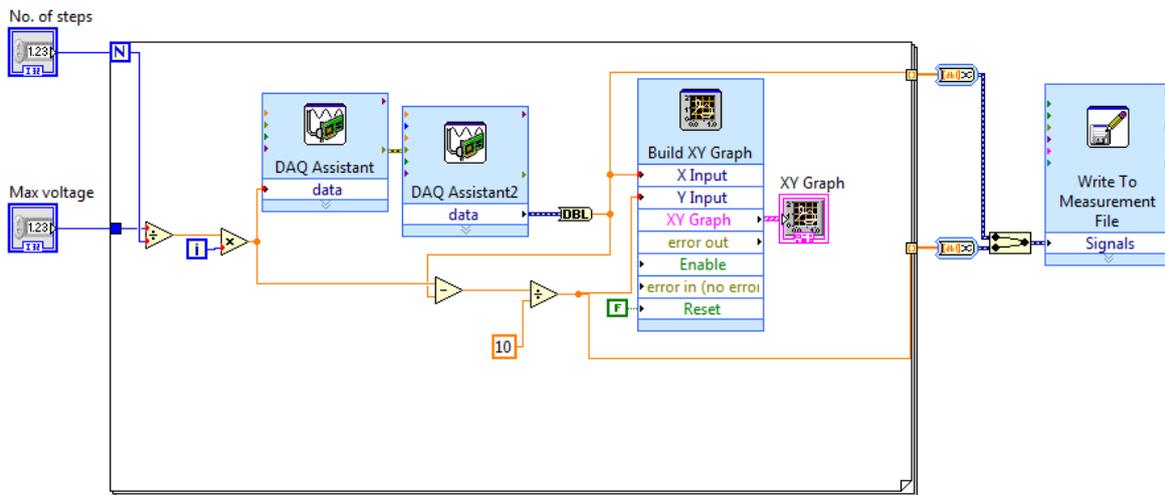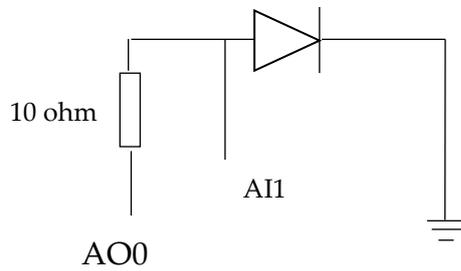
You can run your VI. The Max V generated by the DAQ is 5 V. Use at least 15 steps to obtain a smooth diode characteristic curve.

Day 2

Electrical Characterisation of an Op Amp

Safety

All procedures and experiments in this practical do not involve any hazardous or unsafe activities.

All students must comply with the Laboratory rules, be familiar with the 'Department Safety in Laboratories' document, and endeavour to follow good laboratory practices.

Read the script carefully, listen to the SD and JD briefing, and follow instructions carefully. If you do not understand instructions then consult JD.

Pre-Lab Work

What properties does the op amp have?

What are op amps used for?

What electrical characteristics of transistors are advantageous to construct the op amp circuit?

Today because of a shortage of power supply units please return to your allocated lab group

The industry standard 741 chip, is an integrated circuit operational amplifier available from many manufacturers. The actual silicon chip is encapsulated in a plastic encasing, and it contains 20 transistors, 11 resistors and a few capacitors. Look up the spec sheet of these circuit and see that it

indeed has these components interconnected in a special manner to create a very useful device.

The standard circuit symbol for an op amp is the triangle, with the various connections shown in Fig.1. In the usual top view of the plastic encapsulated version there are 8 pins numbered in an anticlockwise sequence starting from the top left corner, which can be identified by the notch in the 'top' of the package and the indent spot against pin 1. In the 741 frequency compensation is internal and pins 1 and 5 for offset null are rarely required, making this circuit very easy to use at medium frequencies, such as audio applications. The power connections are usually plus and minus 15 volts from a stabilised power supply, and the input and output signals can then be up to ± 12 volts, at low (mA) current.

Figure 1:
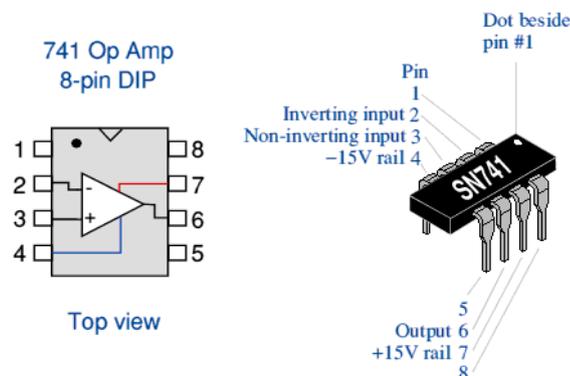
Two basic applications - there are hundreds of others - use negative feedback for stable and predictable performance; see figures 4 and 7. A proportion of the output signal (determined by the choice of resistor R_f) is feedback the negative input to produce, as far as possible, a zero voltage difference between the two input terminals of the amplifier. The gain of the

amplifier depends on the mode of connection (whether inverting etc.) and the value of the input (R_{in}) and feedback (R_f) resistors. Look up the theory of the op amp and familiarise yourself with what different circuits can do.

You are given with:

(i)   A few 741 operational amplifiers, wires and assorted resistors.

(ii)   A stabilised power supply (CAUTION: BOX CONTAINS MAINS VOLTAGES) for the internal circuitry with external connections.

(iii) A standard breadboard to construct the circuit, which will consist: Op-Amp configurations, voltage divider, connection to the power supply, and DAQ (Data acquisition card).

Experimentation

1. Your first task is to use LabView software (you should already be familiar with the basics of using LabView) and a DAQ (Data acquisition) card to generate and acquire voltage waveforms. Open Labview and build the circuit illustrated in Figure 2 to generate a sinusoidal 0-5 volts signal in AO0 and read it back in AI0.

Figure 2:
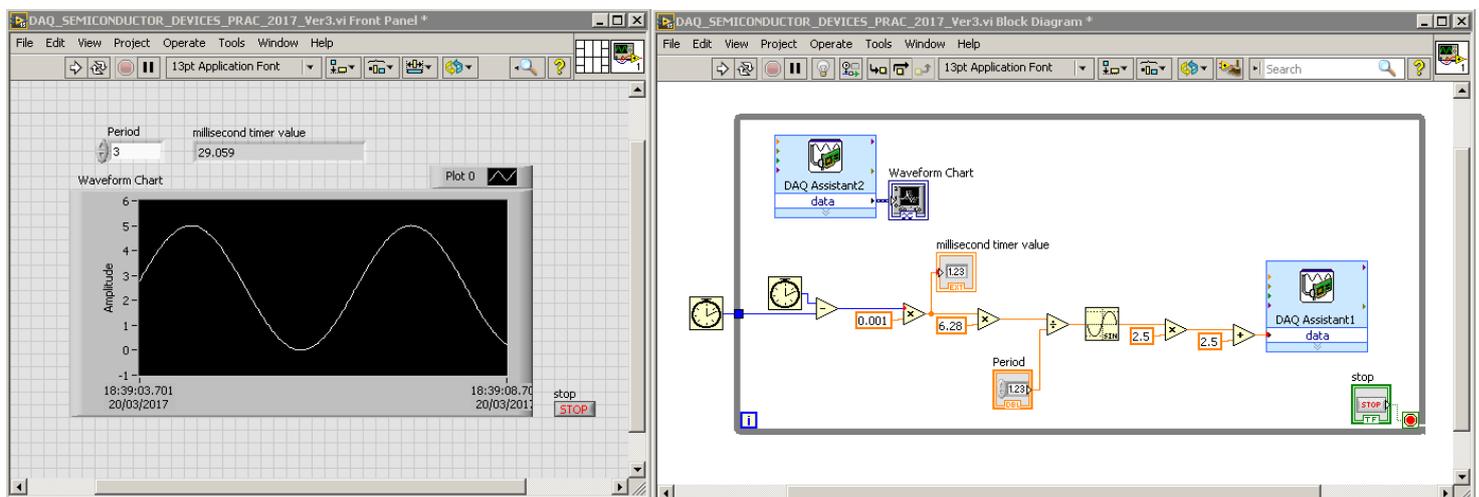
Help: The DAQ Assistant path is illustrated in Figure 3 below. Once you place the DAQ Assistant box 1, select Generate, Analog Signal, Analog Output, Port 0 (AO0). This will generate a Signal on pin 14 with respect to GND (eg pin 16). To construct the rest of the circuit use the right click, and search functions like the Sine, product, sum, etc. Once the DAQ Assist 1 is done, place another DAQ assist, number 2, and instead of generating, select acquire signal, voltage, analog input 0, AI0. The connection diagram of AI0 is shown below. After this connect the pin 14 (AO0) to pin 2 (AI0+), and pin 3 (AI0-) to pin 1 (GND).
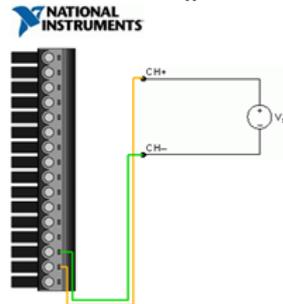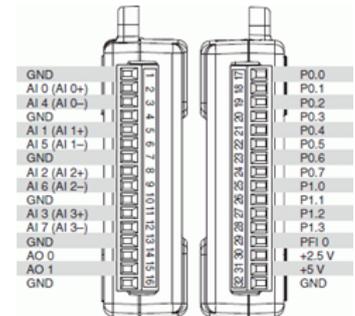
Figure 3:

DAQ assist path
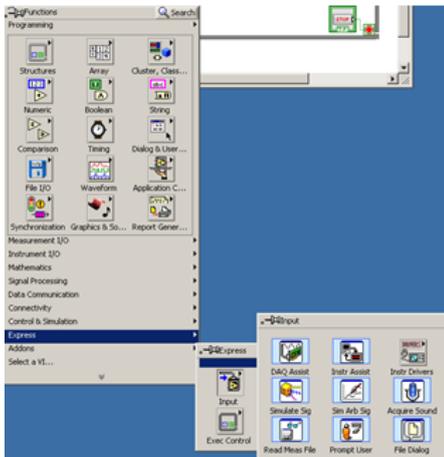
Hover on input and right click to add control, constants or indicators
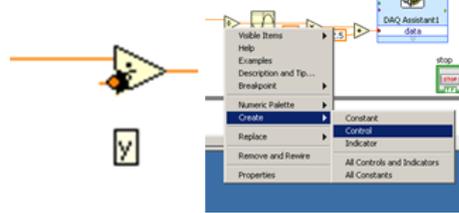
Connection of AI0 (pins 2 and 3)

Pinout of the USB acquisition card

2. The first typical configuration of an operational amplifier that will be investigated is the voltage follower. Using the breadboard, some small wires, and the voltage power supply construct the circuit in Figure 4. To help you familiarise yourself with the way this circuit can be built in a breadboard please refer to Figure 5.
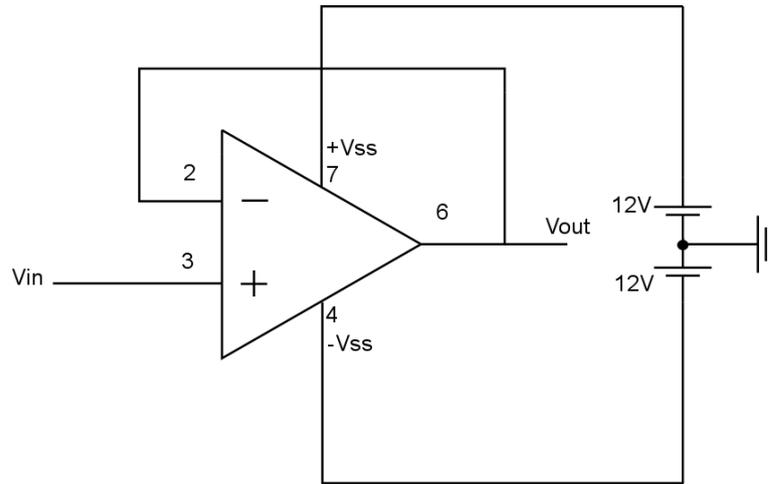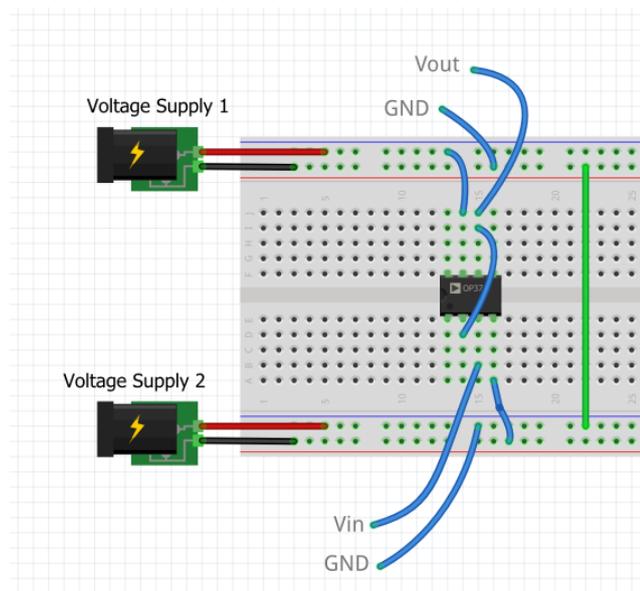
Figure 4: Voltage follower

Figure 5: Breadboard example

3. You will now add to your LabView program an additional voltage input in the data acquisition (DAQ) box. Double click the DAQ Assist 2 and add a voltage input on channel AI2 (Pins 8 and 9). This is illustrated in Figure 6. Once you have done this, use a cable to connect the Sinusoidal signal generated before to the input of you operational amplifier. Then also connect Vout and GND from your voltage follower in (2), Figure 5, to the Analog Input 2 of the

acquisition card you have just created. Show that you can visualise and plot two signals (Vin and Vout in the op amp). Compare these two signals. Check what the voltage follower does in theory and see if this is accomplished in practice.
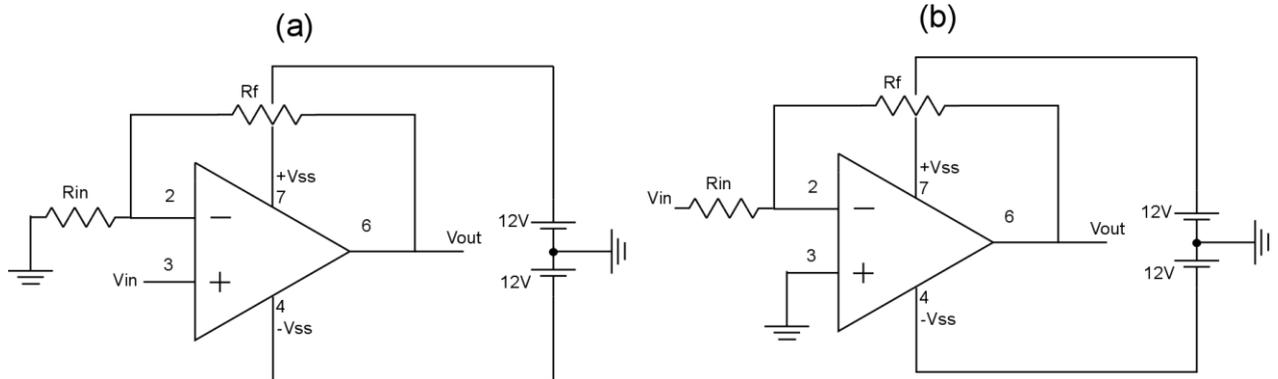
Figure 6:
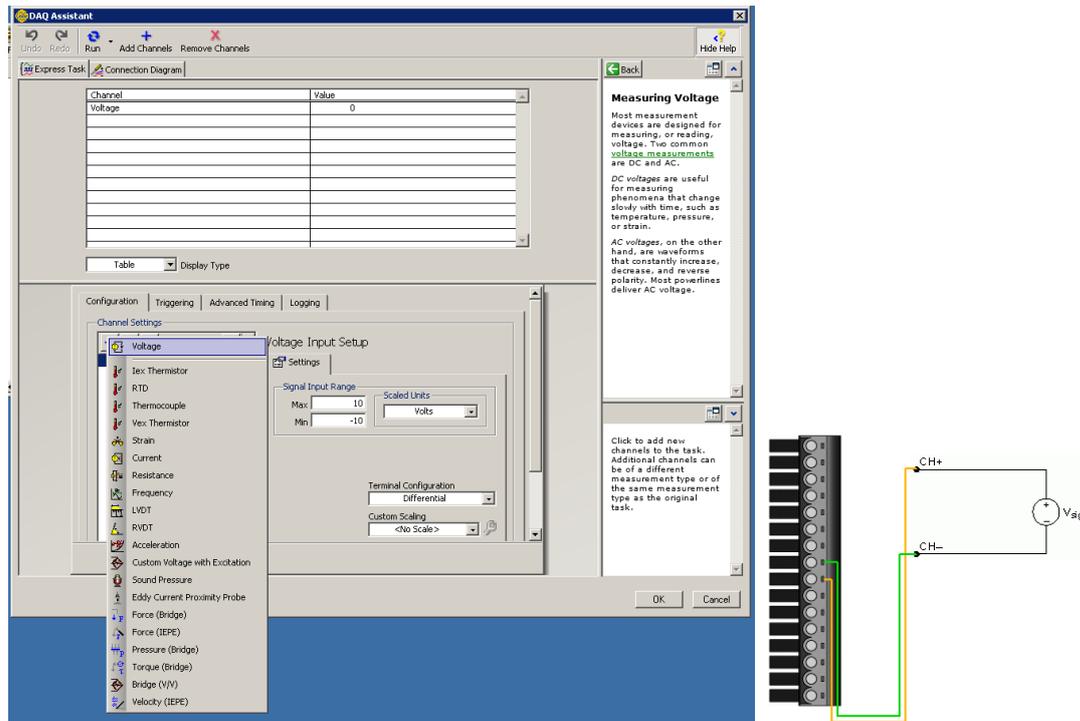
4. The second common application of an op amp is the voltage amplifier. You will now be exploring a range of voltage amplification configurations. First modify your circuit in Figure 4 by adding two 10 K Ohm resistors as Rin and Rf shown in Figure 7.a. Are your resistors exactly 10 K Ohm? What are the new values of Vin and Vout of this configuration as displayed in your Labview software? What amplification factor are you getting? Can you construct a function f such that $V_{out} = f(Rin, Rf, V_{in})$? What would it be theoretically? Change Rf to 5 K Ohm and repeat. Change Rf to 2 K Ohm and repeat. Note: It helps to construct a plot of V_{out} vs V_{in} to determine the function.

5. Now input the voltage in pin 2 of your Op Amp, as illustrated in Fig 7.b. What do you obtain for Vin and Vout, what amplification factor, and function f do you get? Use Rf of 10 K, 5 K, and 2 K Ohms.

Figure 7:

6. Now replace Rf in Figure 7.b by a diode 1N4001 with the P side on the op amp pin 2, and the N side on the op amp pin 6. Look up the specification sheet of the diode if you need to know what the P and N sides are. What Vin vs Vout are you reading in Labview? What amplification factor are you obtaining? Can you create a new f? What would it be theoretically?

7. Change the diode to a 1N4148 diode and repeat 6.

Write a brief ½ page report outlining your findings and show to the JD or SD in the lab before you leave.

References

Horowitz and Hill "The art of electronics", Cambridge Univ Press, 1980.

Solid State Electronic Devices, BG Streetman, Prentice Hall

Guidance on setting up the acquisition card, using the prototyping board, and doing a good lab report can be found on:

http://semiconductor.materials.ox.ac.uk/sbonilla