ESC201 Introduction to Electronics Lab 2 Handout for Lab Experiments
Familiarization with DC and AC Sources, I-V Characteristics and Network Theorems

Experiment 1: Internal Resistance of the DSO and FG

1. Make a potential divider using two 1 MΩ resistors (i.e., $R_1 = R_2 = 1$ MΩ in Fig. E1a), connect +5 V from the DC supply to the input of the potential divider, measure the voltage at the output of the potential divider using a DMM (as shown in Fig. E1a) and note it down.
2. Now, remove the DMM and measure the voltage at the output of the divider by connecting it only to DSO CH-1 as shown in Fig. E1a (do not connect DSO CH-2). Observe, measure and note down the result. Compare this result with that in the previous part and estimate the input resistance R_i of DSO CH-1, and write it down. It is given that the input resistance R_i of the DMM used in the lab is very high (20 MΩ) and the internal resistance of the DC power supply in lab is very low (<10 mΩ) (not shown in Fig. E1a).
3. Repeat the step above for CH-2 of the DSO only and estimate the input resistance R_i of the DSO CH-2.
4. Connect CH-1 of the DSO to the FG output of 5 V *sin*(ωt) of 1 kHz frequency, measure the output on the DSO and note it down. Now, connect R = 100 Ω between the output of the FG and the ground as shown in Fig. E1b, measure the output on the DSO and note it down. Estimate the output resistance R_S of the FG (i.e., the Thevenin resistance of the n0n-ideal voltage source), after comparing the two results.

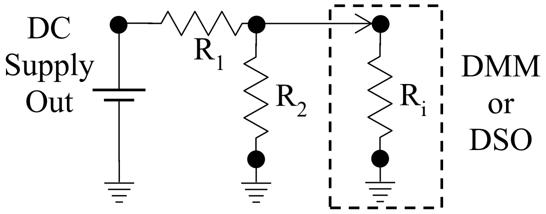

Figure E1a

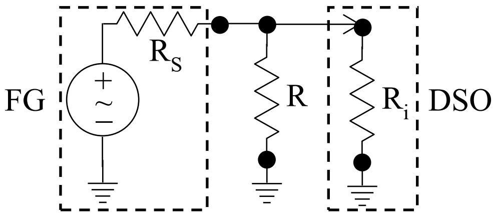

Figure E1b

Experiment 2: I-V Characteristics of Resistor and Maximum Power Transfer

Wire the circuit of Fig. E2 shown below. The resistor with an arrow shown is a potentiometer R_P of variable resistance. The two terminals of the dotted box are one of the ends and the middle node of the potentiometer given to you in lab. Apply a ±10V peak triangular wave of 200 Hz frequency from the FG as the input V_{in} to the circuit. Use CH 1 of the DSO to measure the voltage across the potentiometer R_P and CH 2 of the DSO to the output of DA to measure the voltage across R = 100 Ω. Make sure that you are getting waveforms on both channels of the DSO (CH-1 & CH-2). Put the display in the XY mode (with acquire mode in high resolution), and adjust the dot (align the zeroes of both the X and Y signals) to the centre of the DSO display.

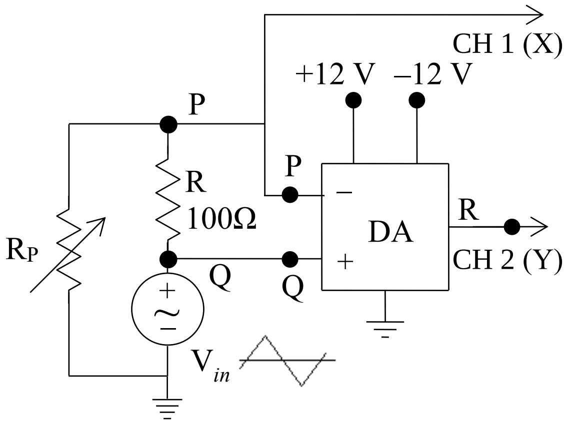

Figure E2

Be sure to connect the +12 V, –12 V, and the Ground connections to the PCB for the DA to work properly.

1. See the XY plot on the DSO and verify that you are getting the correct I-V characteristic of a resistor. You may have to adjust/choose the voltage setting of the channels as required (0.5 V/div or 0.2 V/div).
2. Now vary the potentiometer and see how the XY plot is changing. Write down your observation.
3. Observe the voltages from CH-1 and CH-2 in Normal time mode. Multiply the two voltages shown in CH1 and CH2 using "Math" function of the DSO to get the power dissipation across the potentiometer.
4. Vary the value of R_P and measure the average power P_{avg} using the measure function of the DSO. Find R_P and P_{avg} at which P_{avg} is maximum and verify that this happens at $R_P = R_S + R$.

Experiment 3: Superposition and Thevenin's Theorems with DC Voltage Sources

Special Note on Making Connection on the Breadboard:

In an electrical circuit, you can define only one unique ground. The ground is defined by either the DC power supply or the FG input. If you have more than one supplies, for example, two separate DC power supplies or a DC power supply and an FG input, the ground of both the input signals must be the same.

To apply a negative DC power supply, you must draw the input from the negative terminal of the dual power supply and the ground of the supply must be connected to the ground of your circuit. To apply a negative DC power supply, you ***cannot*** draw the supply from a positive power supply and switch the positive supply line and the ground line, thinking that it might reverse the polarity of the signal. It is not possible simply because the ground of the supply must always be the unique ground defined in the circuit.

While experimentally verifying the Superposition theorem, you should not short circuit the DC power supplies and/or the FG output. Instead, you have to remove the DC power supply and/or the FG, and replace the DC power supply and/or the FG with a wire, thus giving ***zero*** (**0**) Volts.

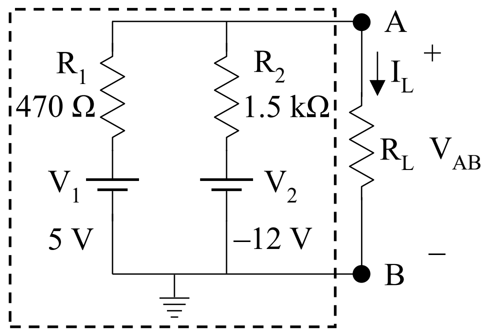

Figure E3

	R_L = 220 Ω	R_L = 680 Ω
V_1 = 5V source acting alone	V_{AB} =	V_{AB} =
V_2 = –12V source acting alone	V_{AB} =	V_{AB} =
Entire Circuit	V_{AB} =	V_{AB} =

Table E3

For this experiment, use DMM only to measure node voltages in the circuit (do not use the DSO).

Wire the circuit of Fig. E3 shown above. Note that, to give the – 12 V DC voltage, you have to use the dual power supply and draw the power from the negative terminal.

Take (i) R_L = 220 Ω, and (ii) R_L = 680 Ω, and fill out the Table E3 below by performing the following steps to verify the Superposition theorem and find the Thevenin equivalent.

1. Measure V_{AB} for these two values of R_L when only V_1 = 5V source is acting alone.
2. Measure V_{AB} for these two values of R_L when only V_2 = –12V source is acting alone.
3. Measure V_{AB} for these two values of R_L when both V_1 = 5V and V_2 = –12V are acing together. From the experimental data of Table E1, verify the Superposition theorem and comment.
4. From the measured V_{AB} for the two values of R_L in part 3 above, calculate I_L in each case individually to find two (I_L, V_{AB}) points, and plot the (I_L, V_{AB}) characteristic of the circuit inside the dotted box.
5. From the (I_L, V_{AB}) characteristic obtained above in part 4, calculate the Thevenin voltage V_{TH} and the Thevenin resistance R_{TH} of the circuit inside the dotted box. Verify the result with that from the theory.

Experiment 4: Observing I-V Characteristic of Linear Two-terminal Network on DSO

Wire the circuit of Fig. E4 shown below. Apply a ±10V peak triangular wave of 200 Hz frequency from the FG as the input V_{in} to the circuit. Make sure that you are getting waveforms on both channels of the DSO (CH-1 & CH-2). Put the display in the XY mode (with acquire mode in high resolution), and adjust the knob to align the zeroes of both the X and Y signals to the zeroes of the corresponding axes of the DSO display.

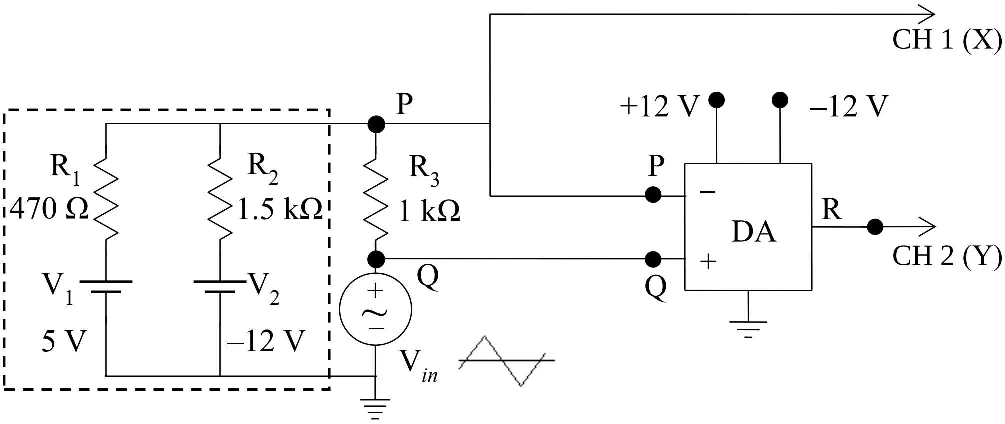

Figure E4

Be sure to connect the +12 V, –12 V, and the Ground connections to the PCB for the DA to work properly.

1. See the XY plot of the circuit on the DSO and verify that you are getting the correct I-V characteristic. You may have to adjust/choose the voltage setting of the channels as required (0.5 V/div or 0.2 V/div). Using the 'Cursor' function, measure the X and Y intercept of the I-V characteristic that you see on DSO. Plot the I-V characteristic and write down the value of the X and Y intercept in the plot.
2. From the I-V characteristic obtained above in part 1, calculate the Thevenin voltage V_{TH} and the Thevenin resistance R_{TH} of the circuit inside the dotted box. Compare the results with that obtained in part 5 of experiment 3 in the previous page, and comment.

Experiment 5: Superposition Theorem with both DC and AC Voltage Sources

For this experiment, use DSO only to measure node voltages in the circuit (do not use the DMM).

Wire the circuit of Fig. E5 shown below with R_L = 680 Ω given that a ±12 V dc dual supply and a sinusoidal ac source of amplitude 5 V and frequency 200 Hz are available.

1. Observe and measure V_{AB} using the DSO for individual voltage source acting alone, one by one, as shown in Table E5. Write down your observation and plot the waveforms obtained in each case.
2. Observe and measure V_{AB} on the DSO for the entire circuit of Fig. E5 and plot the waveform obtained. Experimentally verify the superposition theorem from the above results and comment.

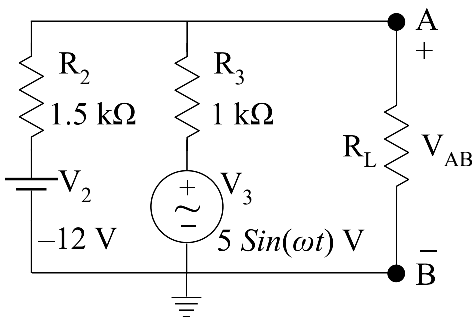

Figure E5

	R_L = 680 Ω
DC voltage source acting alone	Observe, Measure and Plot V_{AB}
AC voltage source acting alone	Observe, Measure and Plot V_{AB}
Entire Circuit	Observe, Measure and Plot V_{AB}

Table E5