Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

Course Title:	Electronic Circuits I
Course Number:	ELE404
Semester/Year (e.g.F2016)	W2025

Instructor:	Md Waselul Haque Sadid

Assignment/Lab Number:	Lab 0 - Intro
Assignment/Lab Title:	Introductory Lab

Submission Date:	Jan 30, 2025
Due Date:	Jan 31, 2025 10am

Student LAST Name	Student FIRST Name	Student Number	Section	Signature*
Malik	Hamza	501112545	11	Ham Malik

*By signing above you attest that you have contributed to this written lab report and confirm that all work you have contributed to this lab report is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: http://www.ryerson.ca/senate/current/pol60.pdf

ELE 404: Electronics I
Introductory Lab

Introduction

The main objective of this lab is to help you acquaint yourself with the labs in ELE404, in terms of their structure, nature of preparation required, and equipment. The lab will refresh you on one of the most effective circuit analysis techniques, namely, the *superposition* technique, albeit from a standpoint that you have probably not seen before. Furthermore, this lab will also set the stage for teaching the concept of capacitive coupling of AC signals with DC circuits.

It is highly recommended that you **carefully study the Appendix** of this manual, **for a quick overview on the equipment** you will be using regularly in this series of labs.

PRE-LAB ASSIGNMENT

P1. Consider the circuit of **Figure 1**. Assume that the capacitor is short for AC signals and open for DC signals. Also, assume that voltage v_S in **Figure 1** is a 20-kHz sinusoid with a peak-to-peak swing of 4.0 V (or, equivalently, with an rms value of 1.41 V). Thus, let $v_S(t) = 2\sin(\omega t)$, where $\omega = 2\pi \times 20{,}000\ rad/s$. Then, use the "superposition" principle to manually find the waveforms of voltages v_I and v_O (i.e., the time functions $v_I(t)$ and $v_O(t)$). Use ***Matlab*** or Excel to plot your expressions for $v_I(t)$ and $v_O(t)$, for two cycles (periods), and present the result as **Graph P1**. Also, complete **Table P1** based on your calculations. See the **Reminder** below. Show all work.

Hint

Superposition can be exercised in various ways. For example, one way would be to consider the response of a circuit as the sum of the response due to the AC sources (while the DC sources are "*off*") and the response due to the DC sources (while the AC sources are *"off"*). Remember that, regardless of AC or DC, an *"off"* voltage source means a short link, whereas an *"off"* current source means an open circuit.

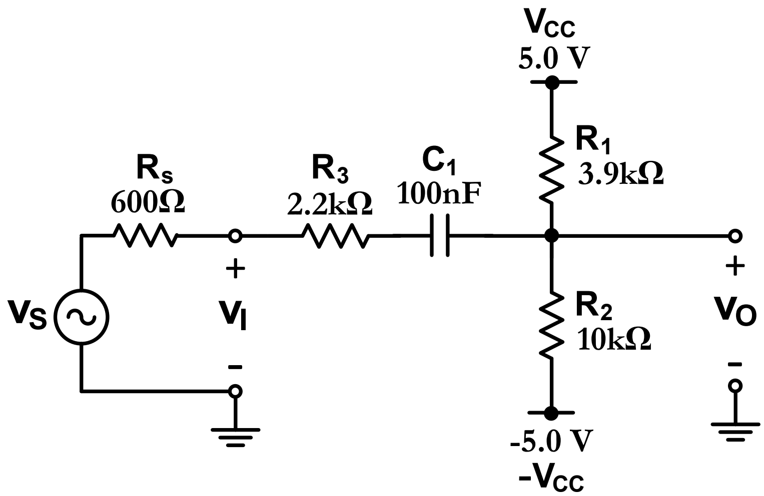


Figure 1. A circuit involving both AC and DC voltages.

Reminder

The "***DC***" value (also known as the ***"average" or "mean"***) of a periodic waveform $v(t)$ is defined by the following integral:

$$V_{dc} = \frac{1}{T} \int_{\tau=0}^{T} v(\tau) d\tau$$

where T is the period of the waveform. **All meters in their *DC measurement mode* display the DC or average value of the incoming signal**.

The ***"rms"*** value of $v(t)$, is defined by the following integral

$$V_{rms} = \sqrt{\frac{1}{T} \int_{\tau=0}^{T} v^2(\tau) d\tau}$$

which is the square root of the average of the square of the waveform! **Modern meters in their *AC measurement mode* display the rms value of the incoming signal, as defined by the above integral.** A very famous special case, which is often incorrectly generalized, is that of a sinusoidal waveform: The rms value of a sinusoid is $V_{rms} = V_m/\sqrt{2}$, where V_m is the peak value of the sinusoid.

Many modern meters are also capable of doing the so-called AC+DC measurements. In its ***AC+DC measurement mode***, a meter can calculate the rms value of a waveform that consists of a DC component and an AC component. Thus, the meter **displays the following**:

$$V_{RMS} = \sqrt{V_{dc}^2 + V_{rms}^2}$$

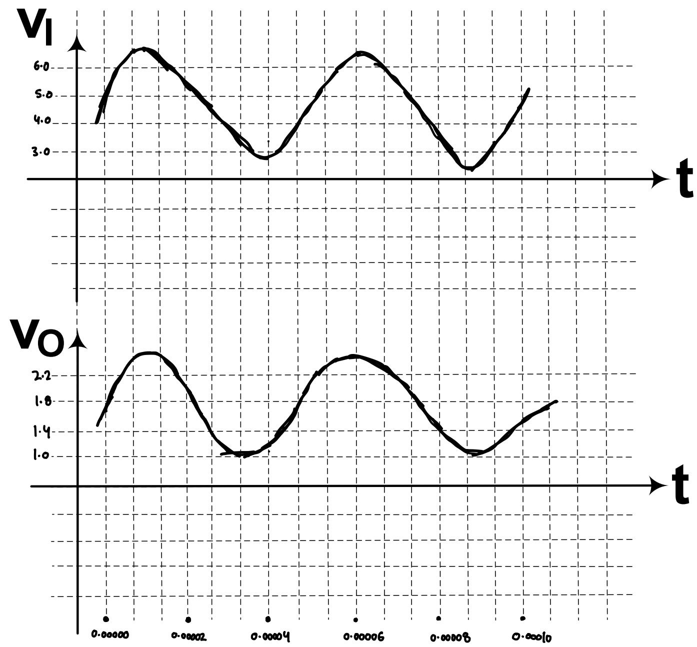
where:

V_{dc}: The DC (average) component of $v(t)$, which the meter displays in its ***DC measurement mode***

V_{rms}: The rms value of the AC component of $v(t)$, which the meter displays in its ***AC measurement mode***

V_{RMS}: The rms value of $v(t)$ as a whole, which the meter displays in its ***AC+DC measurement mode***

In the discussion above, we used v(t) to symbolize a signal. However, the discussion applies to any signal in general, irrespective of its physical nature, voltage, current, etc.



Graph P1. Waveforms of v_I and v_O, for the circuit of Figure 1.

Table P1(corresponding to Figure 1)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	4.812V	4.622V	1.767V	1.680V	2.468V

EXPERIMENTS AND RESULTS

E1. Start by constructing the circuit of **Figure 2**, which consists of two independent sub-circuits, i.e., sub-circuit (a) and sub-circuit (b), as **Figure 2** indicates. Your signal generator (also known as the "function generator") has a built-in (or Thevenin equivalent) resistance of 50 Ω, while we need a source resistance, R_S, of 600 Ω, as **Figure 2** illustrates. Therefore, to achieve a source resistance of $R_s = 600\,\Omega$, place a 560-Ω resistor in series with the output of the signal generator (and do not worry about the extra 10 ohms!). Thus, consider the original signal generator and your added 560-Ω resistor as the signal generator that the circuit of **Figure 2** is calling for. **Figure 3** illustrates the concept.

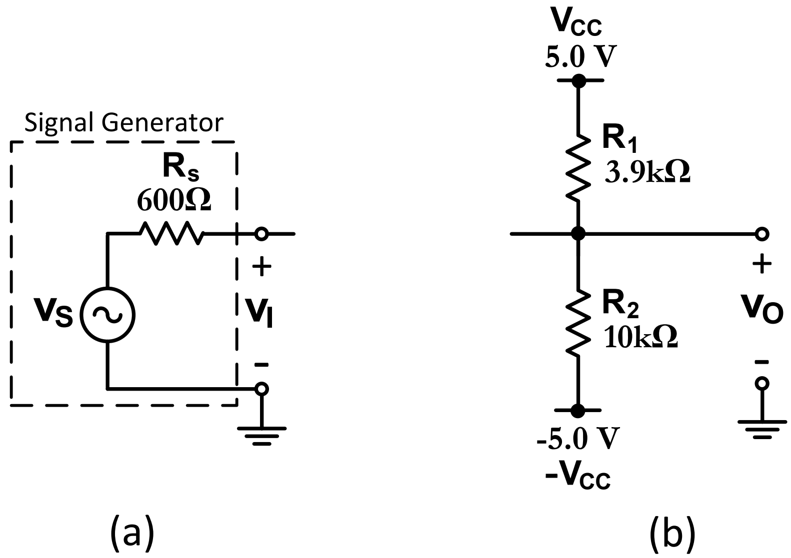


Figure 2. Circuit for Step E1.

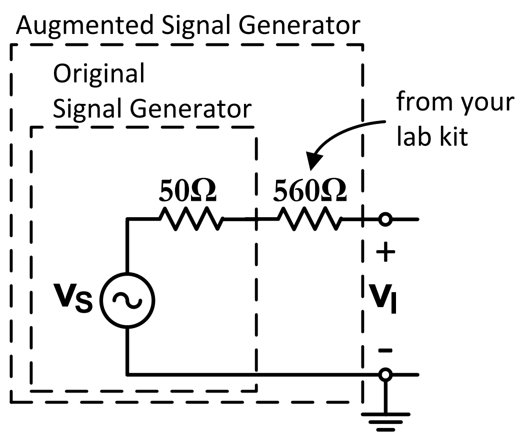


Figure 3. Implementation of the signal generator for the circuit of Figure 2.

Set the signal generator to produce a 20-kHz symmetrical sinusoidal voltage with a magnitude of 4 V peak-to-peak as its Thevenin equivalent voltage v_S. However, since you cannot have access to v_S, you must achieve the aforementioned goal by monitoring/measuring the terminal voltage v_I. Thus, monitor v_I by your oscilloscope and set your signal generator to produce a 20-kHz symmetrical sinusoidal voltage with a magnitude of 4 V peak-to-peak (see the ***"Tips"***, below). Note that, **since nothing other than the oscilloscope probes is connected to the output of the signal generator at this stage, you are, in effect, setting v_S** through the aforementioned exercise.

Next, using the multimeter, measure the following quantities and complete **Table E1**:

- The rms value of the AC component of v_I (multimeter in the AC voltage measurement mode)
- The DC value of v_I (multimeter in the DC voltage measurement mode)
- The rms value of the AC component of v_O (multimeter in the AC voltage measurement mode)
- The DC value of v_O (multimeter in the DC voltage measurement mode)
- The rms value of v_O as a whole, that is including its DC and AC components (multimeter in the AC+DC voltage measurement mode)

Tips

- *The voltages must be measured with reference to the (common) ground.*
- *Connect **Channel 1** of the oscilloscope to v_I and also use it as the **trigger source** for the oscilloscope. Set **Channel 1** to the **DC-coupled mode**, with a voltage sensitivity of 1 V/div; set the oscilloscope **time-base** to 10 μsec/div.*
- *For each measurement, ensure the multimeter is in the suitable corresponding mode.*

Table E1 (corresponding to Figure 2)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	1.52V	0 V	0V	2.2V	1.34V

E2. Change the circuit of **Figure 2** to that of **Figure 4.** Make sure that you disconnect the DC power supply from the circuit, and connect the uncommon terminals of R_1 and R_2 (which were connected to the power supply lines V_{CC} and $-V_{CC}$) to the ground by two short wires. Also, before inserting R_3 into the circuit, make sure that v_I has the same peak-to-peak swing (i.e., 4 V) and frequency (i.e., 20 kHz) as those it had in **Step E1**. Using the oscilloscope, capture the waveforms of v_I and v_O for two cycles. Using the USB utility of the oscilloscope, save the two captured waveforms as **Graph E2.** Note that the amplitude of v_I decreases once the resistor R_3 is inserted into the circuit.

Using the multimeter, measure and record the quantities indicated in **Table E2**.

Tips

- *Connect **Channel 1** of the oscilloscope to v_I and **Channel 2** to v_O, and use **Channel 1** as the **trigger source** for the oscilloscope. Set both channels to the **DC-coupled mode**, with voltage sensitivities of 1 V/div (for **Channel 1**) and 1 V/div (for **Channel 2**); set the oscilloscope **time-base** to 10 μsec/div.*

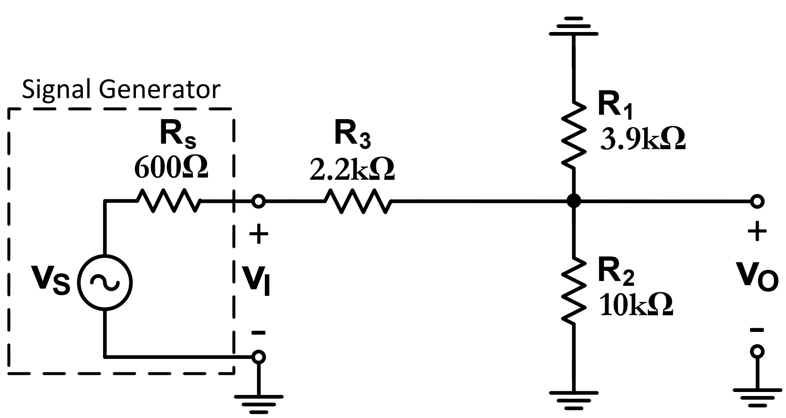


Figure 4. Circuit for Step E2.

Table E2 (corresponding to Figure 4)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	0.157V	0.281	0.57 V	0.15	1.012 V

E3. Change the circuit of **Figure 4** to that of **Figure 5** and repeat experiment **E2**. Thus, reconnect the power supply lines to the circuit. First take R_3 out and, once again, make sure that v_I has the same peak-to-peak swing and frequency as those it had in **E1** (i.e., 4 V and 20 kHz).

Capture the waveforms of v_I and v_O for two cycles, and save them as **Graph E3.** Using the multimeter, measure and record the quantities indicated in **Table E3**.

Tips

- *Same as those for **E2**.*

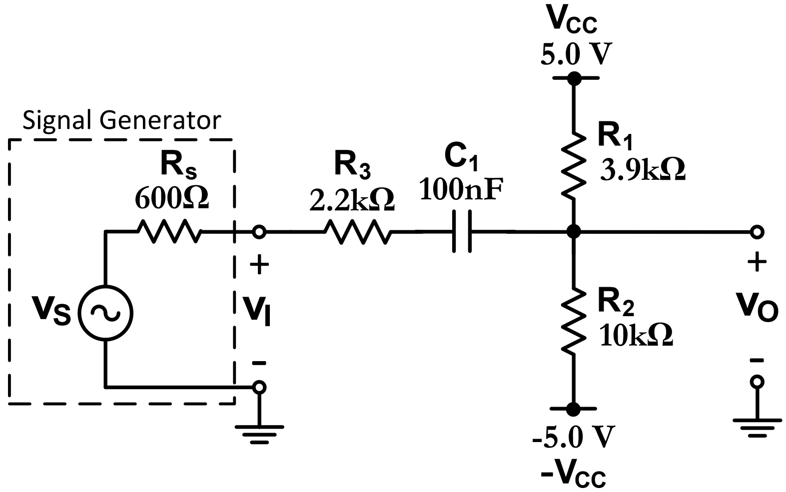


Figure 5. Circuit for Step E3.

Table E3 (corresponding to Figure 5)

v_S *(p-p)*	v_I *(rms)*	v_I *(dc)*	v_O *(rms)*	v_O *(dc)*	v_O *(RMS)*
4 V	1.40V	0V	0.7V	2.2 V	1.18V

CONCLUSIONS AND REMARKS

C1. Compare the results of **Table P1** and **Table E3**, and comment on the reasons for discrepancies, if any. Do the results agree with the equation presented in **Part P1** for the rms value of a composite signal?

C2. Justify the waveform of v_O in **E3,** based on the principle of "***superposition***" and what you observed in experiments **E1** and **E2**.

C3. Using Multisim or any other circuit simulation software, simulate the circuit shown in **Figure 1** (which is the same as the circuit in **Figure 5**), based on the assumption that the voltage v_S is a 20-kHz sinusoidal signal with a peak-to-peak swing of 4 V. In the lab report, attach the resulting simulated waveforms for v_S, v_I, and v_O, all plotted on one single frame and labeled clearly. Additionally, include the schematic diagram of the simulated circuit by printing from the screen in Multisim. Compare the waveforms obtained from the simulation with those of **Graph E3,** and comment.

Appendix—INTRODUCTION TO EQUIPMENT

Digital Multimeter

A1. The digital multimeter (or simply, the multimeter) is a multi-purpose instrument whose main function is to measure AC and DC voltages, AC and DC currents, and resistance. Most modern multimeters, however, can also measure capacitance, signal magnitudes in dB, frequency, connectivity, and much more. **You have two *Fluke 45* digital multimeters at your workstation.**

Examine your multimeter and familiarize yourself with the following:

- Different major functions that the multimeter can perform
- The way the multimeter must be set up for measuring voltages, small currents (in the range of mA), and resistances
- The way the multimeter must be set up for DC and AC measurements

Breadboard

A2. The breadboard, also called the prototyping board, offers a convenient way for rapid prototyping of simple electronic circuits. **Figure 6** shows the top view of a typical breadboard. As the figure shows, the breadboard has many tapered holes (receptacles) that are connected in groups to corresponding metallic strips which are enclosed and insulated from each other by a milky plastic enclosure. Thus, thin wires and pins of small electronic components can be inserted into the holes to make electrical connection with other components.

As **Figure 6** shows, the breadboard shown here has four horizontal rows of holes, two at the top and two at the bottom. Thus, the rows are paired and marked with a blue line and a minus sign, and with a red line and a plus sign. In each of these rows, the holes are interconnected, but isolated from those of the other rows. These rows are commonly used as power supply and ground bars for the circuit.

Figure 6 also shows that the breadboard has two sets of vertical columns, each with 5 holes, which are separated from each other by a trench. Thus, the holes in each column are interconnected, but isolated from those of the other columns (and rows). The columns, numbered in the breadboard of Figure 6 from 1 to 63, are commonly used to establish connections between circuit components as well as Integrated Circuits (ICs) in a Dual In-Line Package (DIP). For example, the breadboard of Figure 6 hosts a 14-pin chip (ALD1106) and an 8-pin chip (LF411CN). In particular, pin 1 of ALD1106 is connected to holes A-15, B-15, C-15, D-15, and E-15, whereas pin 14 is connected to F-15, G-15, H-15, I-15, and J-15, and so on.

Figure 7 summarizes the foregoing description by illustrating that the holes within each rectangle are interconnected, but isolated from the other holes.

It should be pointed out that more sophisticated packages of breadboards are commercially available. **Figure 8** shows an example where two breadboards are installed on a metallic back plate furnished with power supply receptacles.

Examine your breadboard. Using the multimeter in the "***connectivity check***" mode and two small pieces of wire connected to its probes, check the following:

- Interconnectivity of the holes of a row or a column; and
- Connectivity of the holes of a row or column to those of another row or column.

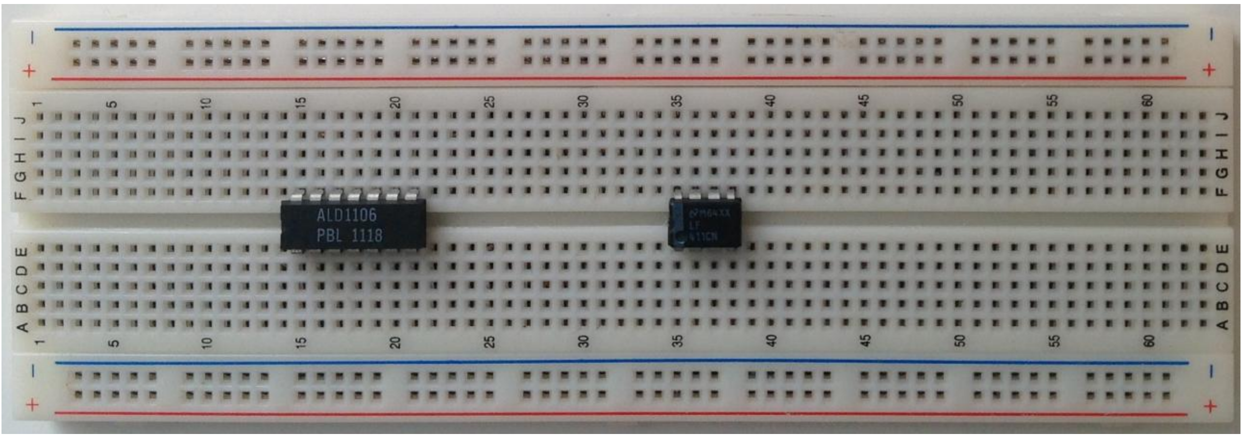


Figure 6. Top view of the breadboard.

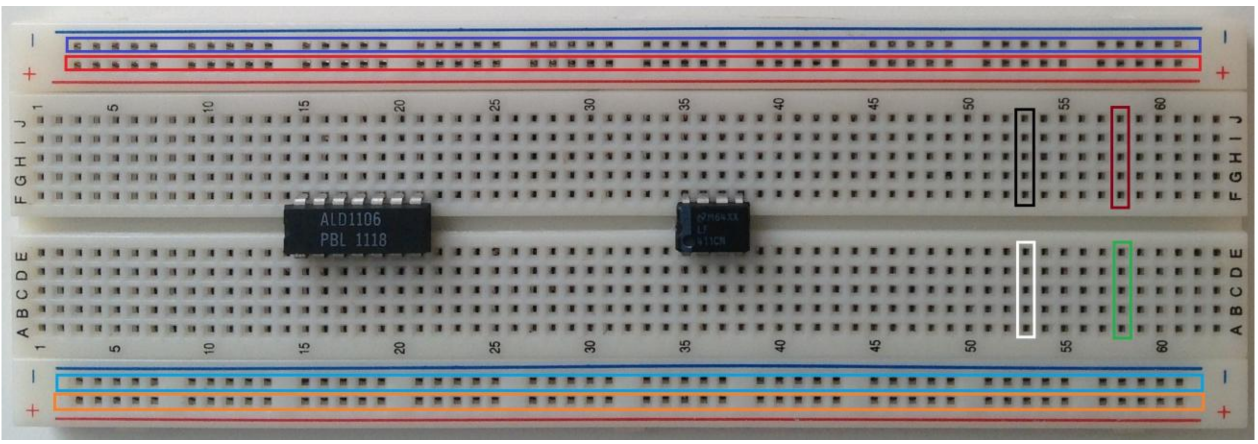


Figure 7. Picture showing the groups of interconnected holes.

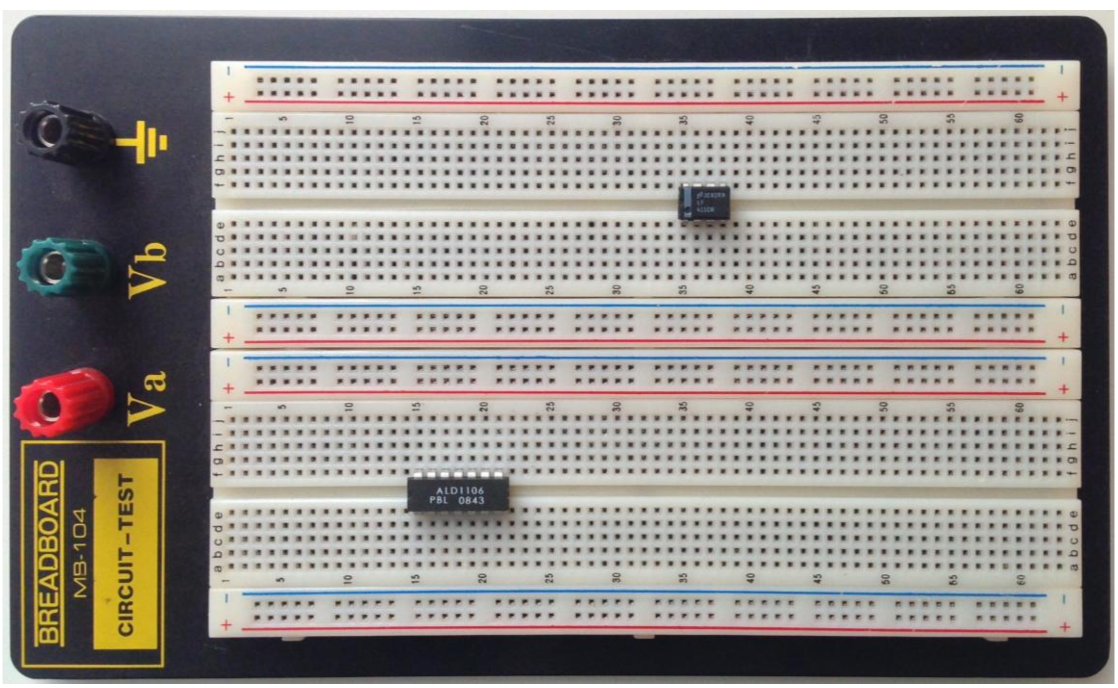


Figure 8. Two breadboards installed on a metallic back plate with power supply receptacles.

Bench-Top Power Supply

A3. The power supply has three ports. Two of the ports have a common ground and thus provide positive and negative potentials with respect to the ground. The third port, however, is isolated from the other two. All three ports are isolated from the power line earth. **You have one *E3630A* power supply on your desk.**

Examine the power supply and identify the following:

- The maximum voltage and current available at each port
- The ground terminal of the power supply

Oscilloscope

A4. The oscilloscope is an instrument for monitoring waveforms and signals. It has more than one channel (up to 4) and can thus be used for simultaneous monitoring of multiple signals. The oscilloscope can also plot signals against one another (***the X-Y mode***). **You have one *KEYSIGHT DSOX1102G* oscilloscope on your desk.**

Examine the oscilloscope in order to become familiar with the:

- Probes and their BNC connectors
- Screen and its grid
- Vertical voltage-per-division and time-per-division (time-base) controls
- Vertical and horizontal position controls
- DC and AC signal coupling modes and their control
- Trigger source and level controls

Signal Generator (Function Generator)

A5. The signal generator is an instrument that can produce time-varying signals of different shape, magnitude, and frequency. **You have one *GW-Instek GFG-8216A* signal generator on your desk.**

Examine the signal generator provided at the workstation and become familiar with the:

- Output connectors and cable
- Waveform selection buttons
- Amplitude and frequency controls
- DC offset control

TA Copy of Results

Table E1 (corresponding to Figure 2)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	1.52V	0V	0V	2.2V	1.34V

Table E2 (corresponding to Figure 4)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	1.40V	0V	0.7V	2.2V	1.18V

Table E3 (corresponding to Figure 5)

v_S (p-p)	v_I (rms)	v_I (dc)	v_O (rms)	v_O (dc)	v_O (RMS)
4 V	1.40V	0V	0.7V	2.2V	1.18V

TA Copy

	Partner's Name	Set-Up (out of 10)	Data Collection (out of 10)	Participation (out of 5)
1	HamzaMalik			
2	Ryan Taing			

Hamid