EL 103 Basic Electronic Circuits

Experiment 1 **Autumn, 2017**

Familiarization with Basic Lab Equipment

This laboratory session will be devoted to getting familiar with the features and usages of the multipurpose test equipment called "Advanced Oscilloscope Caddo 803 & Caddo 4065", which incorporates (i) a **Digital Multimeter** (DMM), (ii) a **Cathode Ray Oscilloscope** (CRO), (iii) a Frequency Counter, (iv) a **DC Power Supply** and (v) a **Function Generator** (FG). Of these, all the units except the Frequency Counter will be used extensively in this course. The CRO is by far the most complex equipment of all these, and hence deserves very careful attention.

<u>Experiments to be performed</u>

REMEMBER: THE FUNCTION GENERATOR (FG) IS A VOLTAGE SOURCE.
THE CRO IS A VOLTMETER.

1. Get familiar with the breadboard schematic given in Fig. 1.1. All interconnections among the different equipment as well as all circuit assembly **must** be done on the breadboard.

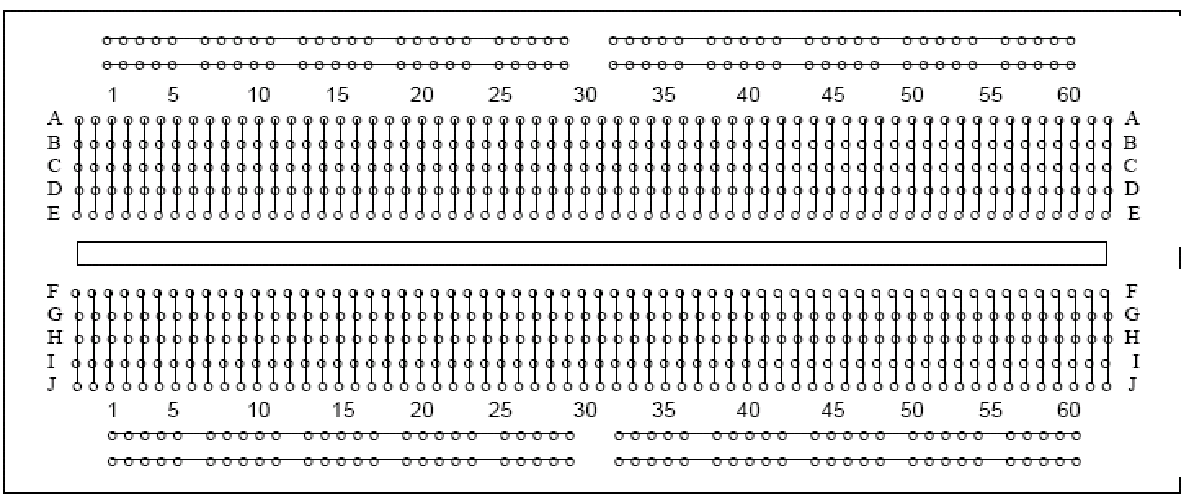
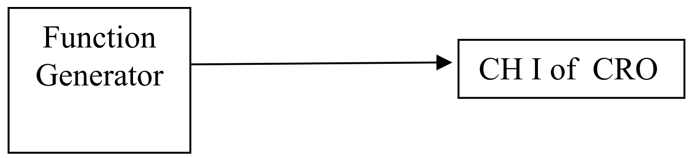


Fig. 1.1 Schematic of a breadboard

2. Switch on only the function generator.
   a. Looking at its own display panel, set the frequency to 1 kHz (using FREQUENCY VARIABLE knob).
   b. Set the wave shape to sinusoidal (FUNCTION button).
   c. Make sure that both the ATTEN buttons are <u>not</u> pressed.
   d. Turn the "DC offset" button to its most anti-clockwise position.
   e. Turn the "Amplitude" button to its most clockwise position.
   f. For the rest of the experiment, do not change any of the above settings (except in 3. c-d, i-k and in parts 6 and 7).
3. Switch on the CRO.
   a. Turn the "Volts/div" knobs to a setting of 5 V.

b. Turn the “time/div” knob to a setting of 0.5 ms.
c. Make sure that ALL buttons on the CRO are in their not pressed position (except the POWER button!).
d. Keep the “Cal” knob in its most anti-clockwise position, throughout the experiment.

4. Connect the FG to Ch. I (Y). Take the output of the FG from the “Output (50 Ω)” point, and not the “Mod in” point.



a. Plot what you see on the CRO. Measure the amplitude of the displayed signal.
b. Turn the “Volts/div” knob for Ch. I to 10 V, and to 2 V. What happens to the displayed waveform? Measure the amplitude of the waveform for both the settings. What is this knob doing?
c. Set the attenuation to “20dB” using the ATTEN button in the Function Generator. What happens to the waveform? Try to measure the amplitude. Turn the “Volts/div” knob of Ch I clockwise to a suitable position so that the amplitude can be measured more accurately, and measure the amplitude again. Find the ratio of the amplitudes you measured, without and with the “20dB” setting. (What is the function of the “ATTEN (dB)” buttons?).
d. Set the attenuation to “OFF”. Turn the “Volts/div” knob of Ch I back to 5 V.
e. Measure the time period of the displayed waveform. From the time period, find the frequency.
f. Turn the “time/div” knob to 1 ms. Measure the time period again. What is the “time/div” knob doing?
g. Press the “X10” on the CRO button. Measure the time period again.
h. Release the “X10” button. Turn the “time/div” knob back to 0.5 ms.
i. Change the frequency on the FG to 10 kHz. What happens to the CRO display? Turn the “time/div” knob on the CRO clockwise until you see a clear waveform. Measure the time period, and from it, the frequency. (What does the “time/div” knob do?).
j. Press the “GND” button for Ch. I. What do you see now? (The “GND” button grounds the plates of the CRO, so that a zero voltage is displayed on the screen). Release the “GND” button.
k. Press the “AC/DC” button for Ch. I. Nothing will happen. Now slowly turn the “DC OFFSET” knob on the FG, clockwise. What effect does this have on the displayed waveform? (Ignore the clipping of the waveform).
l. Release the “AC/DC” button, and move the “DC OFFSET” knob slowly. What happens?
(The “DC OFFSET” button in the FG adds a dc voltage to the symmetric sinusoidal signal. When released, the “AC/DC” button is on AC, and this removes any dc components from the input signal. When on DC, the dc component is included in the displayed waveform.).
m. Turn the “DC OFFSET” knob back to its most anti-clockwise position.
n. Turn the “LEVEL” knob slowly. (Make sure that you are able to see the left-most point of the displayed waveform, by turning the “⇦ ⇨” knob). Does anything happen?
o. Press the “AUTO/LEVEL” button in the CRO.
p. Turn the “LEVEL” knob slowly. What does this knob do (when the “AUTO/LEVEL” button is pressed)? Recall the amplitude of the displayed waveform. Note down the voltages at which the waveform disappears from the screen.
q. Release the “AUTO/LEVEL” button.

5. Press the Volts/Div knob. Observe that the asterisk (*) now shifts on V2 in the display.
6. Now turn the “Volts/div” knob to 10 V. Remove the cable from Ch. I, and connect it to Ch. II.

a. What do you see on the screen?

b. Press the “Ch I/II” button. What do you see now? What does the “Ch I/II” button do?
c. Press the “GND” button of Ch. II, bring the horizontal line to the center of the screen by moving the vertical movement knob of Ch. II. Release the “GND” button.
d. Press the “INV CH II” button. What does it do? Release the “INV CH II” button.
e. Press the “+/–” button. What does it do? Release the “+/–” button.

7. Now connect the circuit of Fig. 1.2. (Do not change any settings on the CRO).
   a. Turn the “Volts/div” `knob of V2 (CH II) to 5 V.
   b. What do you see on the CRO? Measure the amplitude of the displayed signal.
   c. Release the “CH I/II” button. What do you see now? Measure the amplitude of the displayed signal.
   d. Press the “Mono/Dual” button. What do you see now? What is the “Mono/Dual” button doing?
   e. Press the “GND” button of Ch. II. Describe what you see now. Release the “GND” button.

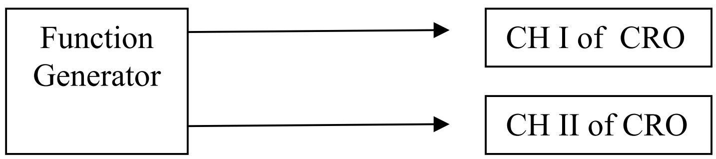


Fig. 1.2

   f. Press the “GND” button of Ch. I. Describe what you see now. (Do not press or change any other settings).
   g. Press the “Ch I/II” button. What happens now? (The “Ch I/II” button acts as the “TRIG I/II” button, in “Dual” mode. The trigger is taken from Ch. I when the “Ch I/II” button is in its released position, and from Ch. II when in the pressed position. Since Ch. I was grounded, in part e. above, no trigger can be generated from this channel, and so the waveform is unsteady when trigger is taken from this channel. But when the “Ch I/II” button is pressed, the trigger is taken from Ch II, and the waveform becomes steady again).
   h. Release the “GND” button of Ch. I.
   i. Release the “CH I/II” button. Release also the “Mono/Dual” button.
   j. Press the “xy” button. What do you see now? What does the “xy” button do? (Note that the “CH I/II” and “Mono/Dual” buttons must be in their released position when the “xy” button is pressed, for correct operation).
   k. Press the “GND” button of Ch. II. Explain what happens. Turn the “Volts/div” knob of channel I (asterisk on V1) , and explain what happens.
   l. Release the “GND” button of Ch. II, and bring the “Volts/div” knob of Ch. I to 5 V.
   m. Press the “GND” button of Ch. I. Explain what happens. Turn the “Volts/div” knob of channel II, and explain what happens.
   n. Release the “GND” button of Ch. I, and bring the “Volts/div” knob of Ch. II (asterisk on V2) to 5 V.
   o. Release the “xy” button. Press the “Mono/Dual” button. (You will see two sinusoids again).
   p. Release the “Mono/Dual” button. Which waveform do you see (Ch. I or Ch. II)? Measure the amplitude.
   q. Press “Ch I/II”. Which waveform do you see now (Ch. I or Ch. II)?
   r. Press the “Alt/Chop” button (which acts as “ADD” when in “Mono” mode). Make sure both the “Volts/div” knobs are on 5 V. Measure the amplitude.
   s. Press “INV CH II”. Measure the amplitude. What has happened?
   t. Release “INV CH II”. Release “Alt/Chop”.
8. On the FG, change the frequency to about 1.5 Hz. Press the “Mono/Dual” button.
   a. Turn the “time/div” knob to 0.2 s. Describe what you see.

b. Press the "Alt/Chop" button. Describe what you see. What do you think this button is doing?
c. Release the "Alt/Chop" button. Change the "time/div" knob back to 0.5 ms. Change the frequency on the FG back to 1 kHz. Release the "Mono/Dual" button.

9. Understand the functioning of the "Function" button of the FG, by pressing the buttons, and observing their effect on the displayed waveform.
10. Get familiar with all the features of the DMM and use it in the **DC VOLTAGE** mode to measure and note the three voltages generated by the DC POWER SUPPLY. Using the DMM in the **RESISTANCE** mode, measure the values of the given resistor and capacitor. Find the value of resistance using the color code (Table 1) and verify this value with the value measured using DMM.

Color	Digit	Multiplier	Tolerance (%)
Black	0	10^0 (1)	
Brown	1	10^1	1
Red	2	10^2	2
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	0.5
Blue	6	10^6	0.25
Violet	7	10^7	0.1
Grey	8	10^8	
White	9	10^9	
Gold		10^{-1}	5
Silver		10^{-2}	10
(none)			20

Table 1: Resistance color code scheme

Main Features of the CRO

A CRO consists of a Cathode Ray Tube (CRT) and electronic circuits necessary for generating the voltages required for its proper operation. The electron gun of the CRT generates a focused electron beam that impinges on the fluorescent screen of the CRT after passing between horizontal and vertical deflecting plates. The beam creates a bright spot on the screen, which can be moved both horizontally and vertically by means of voltages applied to the respective deflecting plates. If these voltages are periodic functions of time with sufficiently high frequency, the back and forth movement of the spot on the screen appears as a continuous line by virtue of persistence of vision. In general, the resulting graph on the screen will keep changing with time, and hence the picture will be jumbled. But if the voltages applied to the deflecting plates are so synchronized th*at the spot repetitively draws the same graph on the screen, then the pattern on the screen would appear stationary. This is achieved in a CRO in two different ways in the two main modes of operation of a CRO:

(a) y-t mode – This mode enables one to observe the graph of the voltage applied to the vertical (y) plates as a function of time (t). This is achieved as follows: A saw-tooth voltage is applied to the horizontal deflection plates, which makes the electron beam move with a constant velocity from one end (left) of the CRO screen to the other (right), horizontally, and then return very fast to the beginning (left). The slope of the saw-tooth determines the speed of the beam's (horizontal) movement. Due to the linearity of the saw-tooth waveform, the horizontal axis can be treated as the time axis, with the time scale adjustable in calibrated steps (expressed in **sec/cm**) by suitably setting the slope of the sawtooth voltage. The voltage we want to observe on the CRO screen is applied to the y-input, which is connected internally to the vertical deflecting plates (after amplifying it as necessary by an amplifier**)**.

(b) x-y mode – In this mode, the graph of the voltage at the y-input is plotted against the voltage at the x-input, by applying these voltages to the vertical and horizontal deflecting plates, respectively.

In order that the waveform displayed in the y-t mode appears stationary, it is necessary to **trigger** the sawtooth voltage so that the spot starts moving from the left extremity of the screen at the same time that the voltage being observed crosses a particular voltage value, so that one gets a stationary pattern on the screen. All CROs incorporate trigger control circuitry to achieve this, with provisions for selecting the triggering waveform out of (i) the input signal being displayed, (ii) an externally applied trigger input, or (iii) the a-c supply line voltage. Triggering can be done either in the automatic (AT) mode where the sawtooth always starts rising at the positive zero-crossing of the triggering waveform, or in the **NORMAL** mode where the user can select the voltage value (or "level") of the triggering waveform.

An x-y display will give a stationary display only if the x and y signals are harmonics of the same fundamental frequency. Lissajous' figures are produced if both the voltages are sinusoidal.

Most practical CROs provide a **dual-trace** option, whereby two signals can be simultaneously displayed on two **channels** using the same time base. This is achieved either in the **ALT** (alternate) mode by applying the two input waveforms alternately to the vertical deflecting plates in alternate sawtooth cycles, or in the **CHOPPED** mode by switching between the two inputs at a very fast rate within every sawtooth cycle. Use ALT for high frequency signals, and CHOP for low frequency signals.