Basics of Electrical and Electronic Circuits (ECE101-Lab.)

Experiment 1 **Spring 2025**

Familiarization with Basic Test Equipment

This laboratory session is meant to give you a basic familiarity with the features and usages of test instruments like DSO, Function generator, DC Power supply, Digital Multimeter.

The main test instrument you will be using throughout this course is called an **Oscilloscope**, although it incorporates several capabilities in addition to the basic features of an Oscilloscope. Understanding all the features of this instrument will be beyond the scope of this course, and we will restrict ourselves to the basic features necessary for performing the experiments planned for this course. These features will be explained in the following paragraphs. You will find two different brand names – Agilent and Keysight – for this instrument, though the instrument is the same, due to a change in the name of the manufacturing company itself.

Main Features of an Oscilloscope

An Oscilloscope is an instrument used to produce a display of the two signals applied to the two channels (denoted by **CH1** and **CH2**) of the oscilloscope, in two possible modes.

(a) Y-t mode – This mode enables one to obtain the graphs of the voltages applied to the two channels plotted as a function of time The horizontal axis thus forms a **Time Base**, with the time scale of the graph adjustable in calibrated steps expressed in **s/ms/μs**, indicating the time represented by roughly 1cm on the horizontal scale of the graph. The applied voltages are amplified by two separate Channel Amplifiers to produce a convenient view. The voltage gains of these amplifiers decide the voltage scale of the graph, expressed in calibrated steps of **V/mV**, indicating the voltage represented by 1 division (≈ 1cm) on the vertical scale of the graph.

(b) X-Y mode – In this mode, the graph of the voltage applied to **CH2** (**Y**) against the voltage applied to **CH1** (**X**) is obtained, after amplifying the two applied voltages as necessary by the same channel amplifiers used in the **Y-t** mode. The amplifications used for **CH1** and **CH2** now decide the horizontal and vertical voltage scales of the graph respectively, adjustable in calibrated steps. An **x-y** display will give a stationary display only if the two signals are coherent with respect to each other.

In order that the waveform displayed in the **Y-t** mode appears stationary, it is necessary to define the origin of the horizontal (time) axis with respect to some specific reference signal, referred to as the **trigger** source. This can be selected out of (i) **CH1** input voltage, (ii) **CH2** input voltage, (iii) an **EXT**ernally applied trigger input voltage or (iv) the a-c supply **LINE** voltage. The essential function of triggering is to enable the user to define the origin of the time axis at a suitable point on the triggering waveform, by fixing

(i) the desired **slope** (rising or falling) of the waveform at that point and
(ii) the value of the voltage (**level**) at that point on the waveform.

The **slope** is selected by a simple two-position switch, and the **level**, by a control knob.

Digital Storage Oscilloscope (DSO)

A **DSO** achieves the Oscilloscope features described above as follows:

(i) The applied voltages are sampled at a rate decided by the setting of the **Time Base**, as chosen by the user on the basis of the frequency of the signals.

(ii) the Time Window used for sampling ranges from the screen width in terms of the Time Base to twice the screen width, depending on the design of the **DSO**.

(iii) these sample values are then converted into their digital equivalents, thereby generating a time series of numbers representing each signal.

(iv) this time series is then stored in digital form in appropriate electronic memory.

(v) the stored numbers are then scanned at a rate decided by the **Time Base** setting and applied to an LCD display to generate the required display on an LCD screen. **DSO** displays a graph of amplitude versus time.

<u>Digital Voltmeter</u>

As the values of the applied voltage are stored in the instrument in a digital form, all DSOs provide digital readouts of different properties of the applied waveform, e.g. dc value, rms value, peak-to-peak value, maximum value, minimum value, frequency etc.

<u>Function Generator (WAVEGEN)</u>

This generates different waveforms (Sine / Square / Ramp / Pulse / TTL). The **WAVEFORM** and its three parameters – **FREQUENCY**, **AMPLITUDE** and **DC OFFSET**
– are selectable through control knobs. The values selected for all these parameters are displayed at the bottom of the screen. One must remember, however, that these displayed values are only indicative of what the **WAVEGEN** is supposed to generate as its output, and their actual values may depend on the external connections made to the **WAVEGEN** output. The ranges of frequency and voltage that can be generated are specified for every instrument by the manufacturer.

Experiments to be performed

1. Connect the **WAVEGEN** output to the **CH1** input of the **DSO** through BNC cables, using the Breadboard for joining together the free ends of the BNC cables (red -signal, black- ground).
2. Select the following settings of the **WAVEGEN**:
   Waveform – Sinusoidal, **Frequency** – 1kHz, **Amplitude** – 4V p-p, **DC Offset** – zero. Observe other the signal waveform and note down their types (square wave/ ramp/ triangular etc) in your record (*capture the waveform and comment*).
3. Now go back to the wavegen setting for the sinusoidal waveform. On the **DSO**, select **CH1** only, keeping **CH2** OFF, and set the **DSO** as follows: **Coupling** – **DC, Trigger** – **Auto**, **Trigger Slope** – ***rising***, **Run/Stop** switch – **Run**.
4. With the **Trigger source** selected as **CH1**, adjust the voltage scale and the **Time Base** setting to obtain graphs showing 2-3 cycles of the waveforms within the screen. Vary the **Trigger level** and observe how the point on the graph at the time origin follows the level and slope of the **Trigger**. Note that the graph does not remain stationary when the **Trigger level** goes beyond the range of the voltage waveform. *Write your observations in the observation section.*
5. Now set the **Trigger** mode as **Normal**, with other settings as in **step 3.** Repeat **step 4** and note that, unlike what was observed in the **Auto** mode, the graph gets "***frozen***" when the **Trigger level** goes beyond the range of the voltage. Repeat these observations with the **Run/Stop** switch set in the **Stop** position. Explain the difference in the observations made in the two settings of **Run/Stop**.

Trigger	Run position	Stop position
Auto		

Normal		

6. Connect the **PROBE COMP** signal provided in the **DSO** to **CH2** input and repeat **step 4** with all possible choices of the **Trigger source**. As the two signals are not coherent, both of them will never give stationary graphs together. Sketch the stationary graphs obtained, and relate them with the **Trigger source** chosen. Disconnect the **PROBE COMP** signal from the **CH2** input.

7. Measure the peak-to-peak value of Voltage and the frequency of the **WAVEGEN** output at **DSO** by the three different methods listed below and verify that they give the same results:

(i) Measure the peak-to-peak height of the graph along the vertical axis and the length of a complete period along the horizontal axis by counting the number of divisions. Calculate the peak-to-peak value and the frequency of the **WAVEGEN** output from the **Voltage** and **Time** scales displayed on the top of the **DSO** screen.

(ii) Make the same measurements using **Cursors**, which give direct readings for the distances between the cursors along the vertical and horizontal axes. Familiarise yourself with all the features like **Source** and **Track** associated with the cursors.

(iii) Use the **Measurement** feature of the **DSO** to get these values from direct digital readouts of the peak-to-peak value and frequency. Familiarize yourself with all the possible measurements one can make by using **the Add Measurement** option.

Method	V_{max}	V_{min}	V_{max} - V_{min}	V_{pp}	Time Period	Frequency
i						
ii						
iii						

DC power supply and Multimeter: Identify the available DC power supply and measure the output voltage of each using multimeter in voltmeter mode and compare with display readings.

Voltage Sources Channel	Company Name (Make)	Type (Fixed/ Variable/dual Mode)	Voltage Range (from Display of Power supply) (Max-Min)		Voltage Range (from multimeter readings) (Max-Min)		Current Rating on (Power Supply channel)
			V_{max}	V_{min}	V_{max}	V_{min}	
1							
2							
3							

Results:

Conclusion: It must be in your words and be based on your understanding/ learning in the experiment.