FACULTY OF ENGINEERING TECHNOLOGY

Lab 08

The Oscilloscope

BTE2122
Electrical Fundamentals and Circuit Analysis 1 Laboratory

Lab Objectives

By the end of this lab, students should be able to:

1. Describe the operation of an oscilloscope
2. Use an oscilloscope to measure dc and ac voltages
3. Measure period and frequency of an ac waveform
4. Measure amplitude and peak-to-peak voltage
5. Measure instantaneous voltage.

Student names	Student ID	Section	Group

Due Date:

Delivery Date:

1.0 Concept

An oscilloscope is a very useful piece of electronic test equipment. Mostly everyone has seen an oscilloscope in use, in the form of a heart-rate monitor (electrocardiogram) of the type seen in doctor's offices and hospitals. Oscilloscope is used mainly in AC circuits but it is also useful for other measurements in DC circuits or other applications.

A digital oscilloscope measures a waveform by taking a sample of the waveform during a period called sampling time. By displaying the samples after signal processing, the accurate waveform can be viewed on the screen. The digital oscilloscope also stores the samples in its memory. This feature enables us to save the waveform and measure other characteristics of the waveform later.

Horizontal Time Base

Both input waveforms are always displayed with the same time base, which may be adjusted over a wide range by the Time/Div knob. The horizontal sweep rate depends upon an internal oscillator (actually, a ramp generator of variable frequency) and the internal horizontal deflection amplifiers. The time base calibration may be checked by connecting a BNC cable with leads or an oscilloscope probe from the 1.0 kHz output (PROBE COMP ≈ 5V) on the front of the oscilloscope to an input; this output provides a stable square wave (5 Volt) with 1.00 ms period.

AUTOSET

Pressing AUTOSET will set the controls for a default usable display. It is a time saver when you lost your display or you are not getting a stable display.

XY mode

A useful feature in comparing the phase of two waveforms is XY mode (DISPLAY > XY Display > Triggered XY). When set at the XY mode, the internal time base is disconnected.

Triggering

In order for waveforms displayed on the scope to appear stationary, it is necessary to synchronize the horizontal sweep with the input wave. This may be accomplished by setting the trigger source to Channel 1 (if Channel 1 is being used). Set the Trigger Menu >> Normal & Source >> Ch 1. The stability of the triggering is controlled by the Trigger Level knob.

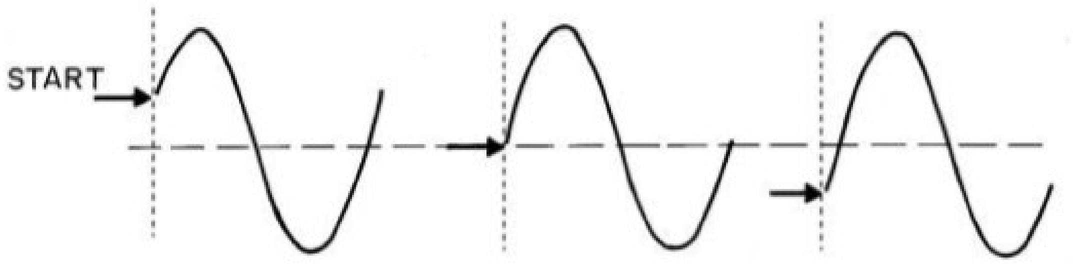

Figure 1

If you move the trigger level greater than the peak or trough level, you will see the running waveform. It is similar to setting Auto mode in an analog scope. Digital scopes have special control to capture the signal if the signal is lost or unstable. When you press the AUTOSET button, the scope sets vertical, horizontal and trigger controls automatically. You can then manually adjust any of these controls if you need to optimize the display

AC and DC signals

An AC Signal is different from a DC signal in that it changes direction and polarity. It is not enough simply to change magnitude; direction and polarity must be changed in order for an electrical signal to be an AC Signal. Ac Signals are primarily sine waves, square waves and triangle waves. These tend to be periodic waveforms, they repeat at anticipated times. AC signals vary in period and amplitude.

An AC sine wave begins at point zero. It increases in amplitude until a maximum is reached 90 into an alternation. If the increase was positive in direction this will be the positive peak value. The signal will then begin to decrease in value until the value is zero. This occurs at the 180 point. The signal will then begin to increase in the opposite direction, changing the polarity of the signal until it reaches a maximum negative potential, 270 into the alternation. After the signal reaches a maximum negative voltage the signal begins to increase until its amplitude is zero 360 into the alternation. At this point the signal repeats. This is referred to as one complete cycle of alternation.

When considering the value of an AC Signal, there are three amplitude values to be familiar with. Measured from the positive peak to the negative peak is the peak-to-peak quantity. When measuring just the positive peak or the negative peak, this is known as the peak value. Peak value is half of the peak-to-peak value. Both peak-to-peak and peak values may be measured on the oscilloscope. Another value is the root-mean-square (RMS). RMS is the AC value measured with a VOM or DMM. RMS is calculated by multiplying the peak value by .707 or dividing by 1.414.

$$VRMS = V_p \times .707 \text{ or } VRMS = \frac{V_p}{1.414}$$

RMS is also known as the effective value of the quantity. Peak-to-peak voltage and peak voltage is represented in Figure 2.

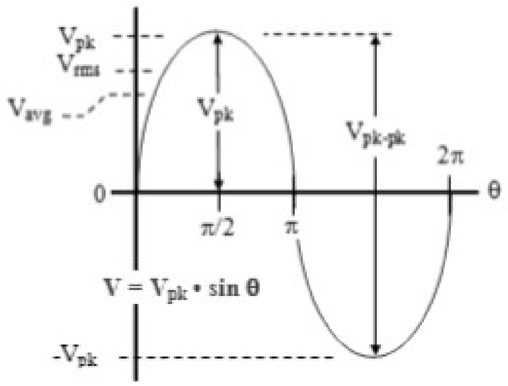

Figure 2

The amount of time necessary to complete one cycle of alternation is known as the period of the signal. The lower the period of the signal, the more often the signal repeats in one second. The greater the period the less often the signal repeats in one second. The number of times a signal repeats in one second is known as the frequency of the signal. The period of the signal is the reciprocal of the frequency and is measured in seconds. The frequency of a signal is the reciprocal of the period and is measured in hertz, 1/period = frequency and 1/frequency = period. Frequency is determined the same way for sine waves, square waves and triangle waves. Voltage, current, and power may also be represented as AC waveforms.

2.0 Experiment set-up

Following are the items needed for the experiment. The equipment is available in the lab while the components will be given at the beginning of the class. Please use the components carefully as they will be collected at the end of the lab.

3.0 Equipment and Components

1. Two DC power supply
2. Digital multi-meter
3. Connecting cables
4. Function generator
5. Oscilloscope
6. Two 1kΩ and two 3.3kΩ resistors

4.0 Experiment

4.1 Measuring DC voltage with the oscilloscope

1. Connect channel 1 to 10X probe and set triggering to Auto. With 0V applied ensure the trace is on the Y-axis zero line. Set the scale to 1VOLTS/DIV.

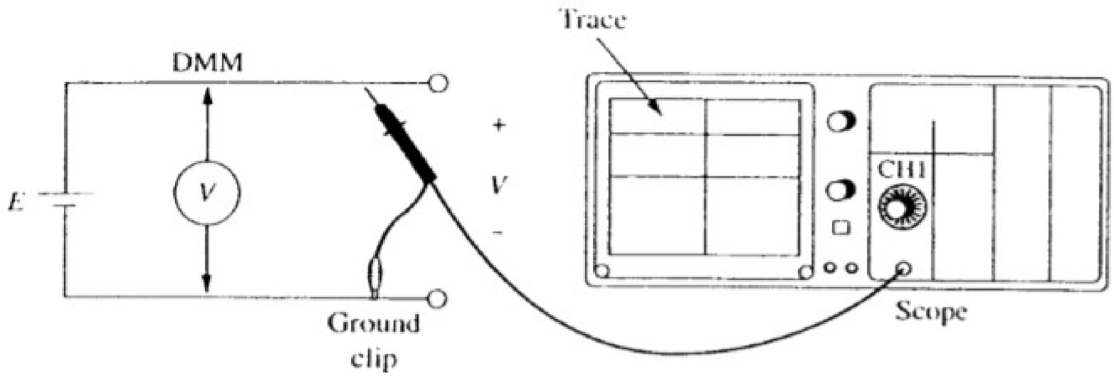

Figure 3

2. Connect the probe as in Figure 3 and set VOLTS/DIV to 1V. With the voltmeter, set the power supply to 2V and note the deflection on the screen. From this deflection, compute the measured voltage. (It should equal the applied voltage). Record the results in Table 1.

Table 1

Probe	Input voltage	VOLTS/ DIV Setting	Voltage from cursor method
10X	2V	1-V	
10X	4V	2-V	
10X	15V	5-V	

3. Change VOLTS/DIV to 2V, set E=4V, and note the position of the trace. Enter the data in Table 1 and compute V. Repeat for E=15V at 5VOLTS/DIV.
4. Move the input coupling switch to AC. Set the supply to the voltages of Table 1. What happens? Why?

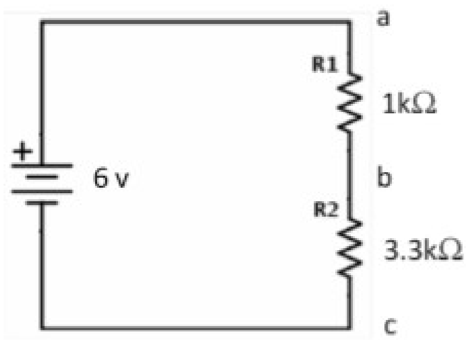

Figure 4

5. Construct the circuit in Figure 4.
6. Use the channel 1 to measure the voltage across R1. Place the ground of the probe on point b and the probe at point a.
7. Use the channel 2 probe to measure the voltage across R2. Place the probe at point c. **Do not place the ground from channel 2 in the circuit. Only use one probe**

ground at a time. The grounds are common. To place both in the circuit at once would result in short around one of the loads and possibly damage the oscilloscope.

8. Invert Channel 2 and change the volts/div scale for each channel and notice what happen to the trace. Determine which scale will enable the most accurate measurement. Determine the voltage value.
   V = ______________________ on scale ______________________
9. Use the add mode and notice what happens to the trace.
10. What is the voltage value?
    V = ______________________

4.2 Measuring AC voltage with the oscilloscope

Replace the DC source of figure 3 with a signal generator. Set your scope to AC coupling, triggering to positive slope and mode to Normal.

1. Set the generator to a 2kHz sine wave with 2Vp-p amplitude. Set the scope timebase to 100µS/Div and the vertical control to 1VOLTS/DIV. Sketch the waveform in Figure 4.
2. Construct the circuit in Figure 5

Figure 5

3. Set the oscilloscope to measure AC voltage, center the trace in center of the screen and set the trigger to channel 1.
4. Set time/div to 1ms/div and voltage/div of channel 1 to 2v/div.
5. Set the function generator for 1KHz and adjust the voltage to 10 vp-p.
6. Use the oscilloscope to measure the voltage across the resistor and the period of the waveform.
   V = ______________________, T = ______________________
7. Set the coupling to AC coupling then to DC coupling.
   *** What are the differences in measurements if any?
   ____
   ____
   ____

5.0 Discussion

1. What is the difference between AC coupling and DC coupling?
2. What is the effect of using the add mode?
3. Why do we invert channel 2 when measuring the two voltage?

4. Why would you only use one probe ground when comparing two different voltages?
5. What is the relation between period and frequency? Show the equations.

6.0 Conclusion

What can you conclude from this lab session?