MEHRAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY, JAMSHORO

DEPARTMENT OF ELECTRONIC ENGINEERING
ELECTRONIC WORKSHOP # 02
Oscilloscope and Function Generators

Roll. No:	Date:
Checked by:	Grade:

Object: To become familiar with Oscilloscopes and Function Generators.

Apparatus: Oscilloscope and function generator

Theory:

Electronic circuits need to be tested for their functionality. This is done by applying test signals as input to the circuits and observing their response. This requires a device which generates test signals and another device for observing the circuit response to those test signals.

A Function Generator is a device that is used to produce (generate) test signals for testing electronic circuits. These can generate a number of periodically varying electrical signals. These are one of the most versatile sources available, allowing us to manipulate several parameters such as:

1. **Function or wave shape-** All function generators can generate three basic types of waveforms i-e Sinusoidal, Triangular and Rectangular. They can also produce composite waveforms which are combinations of any two or all the three waveforms. This can be done using the waveform shape select control. Figure-1 shows the basic waveshapes that can be generated by a function generator.
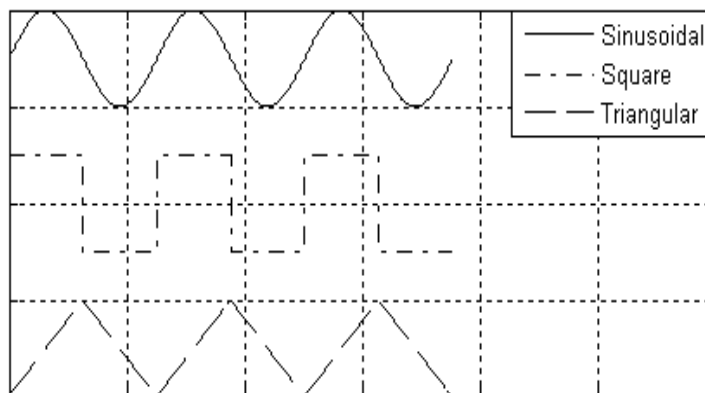

Figure-1: The Sinusoidal, Square and Triangular Waveforms

2. **Time Period or Frequency-** A wide range of frequencies can be generated (0.01Hz to 10 MHz or even more). Adjusting the Frequency Multiplier and the Frequency Selector knob helps select the frequency of the generated signal.
3. **Amplitude-** The amplitude of the output signal can be increased and decreased over a wide range using the attenuation control.
4. **Dc Level-** If one wants to add a DC offset to our signal so as to move the signal above or below the ground line than this can be done using the DC Offset control.
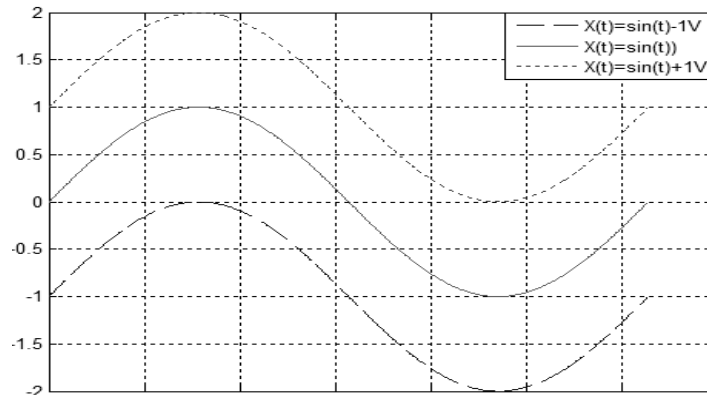

Figure-2: Positive and Negative DC levels

5. **Frequency Sweep-** Function Generators also allow us to sweep the frequency both linearly and logarithmically, this option is available in the new digital function generators.
6. **Modulated Signals-** Digital Function Generators allow us to produce Amplitude, Frequency and Pulse Amplitude Modulated signals as well.

Function generators also have probe connections for taking the signal outputs.
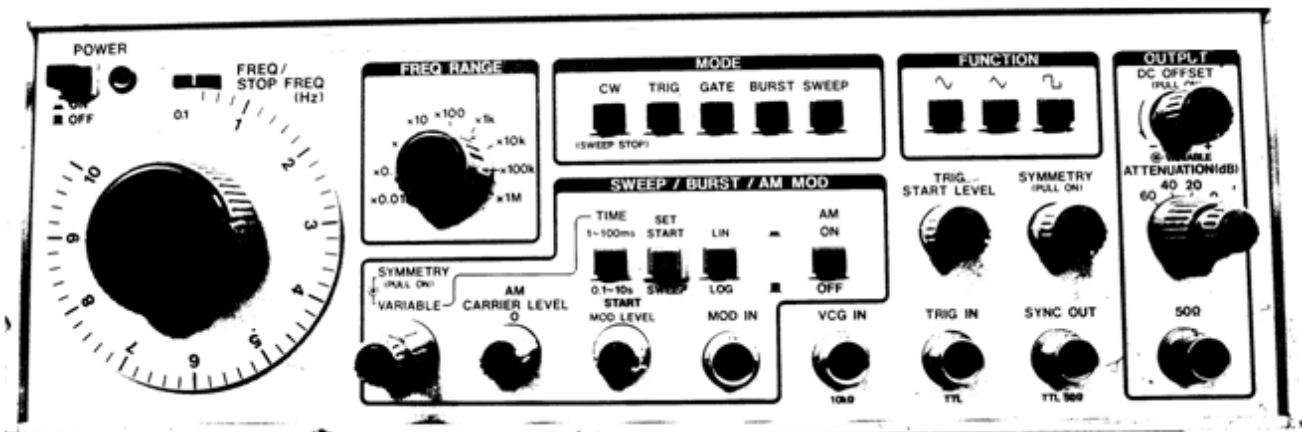

Figure-.3: Function Generator Front Panel

An Oscilloscope (or simply a Scope for short) is a device that lets you observe circuit responses in form of waves or oscillations on a screen and possibly make measurements as well. The graph that appears against a grid on the screen is called a Trace. The Horizontal and Vertical axes represent Time and Amplitude respectively. Each square on the grid is called a Division and this is used to calculate the amplitude as well as time period of the signal. Each division is further divided into 5 subdivisions with each subdivision representing 0.2 divisions. Most oscilloscopes consist of two inputs called Channels, which help you observe two signals simultaneously. Each channel has the following controls:

1. **Volts/Division-** This is used to scale the signal so that it can be accommodated within the screen and no part of the signal goes beyond the display area. This is also known as the Vertical Scale. The amplitude of the signal is then given by:

$$Amplitude(p-p) = \ Number\ of\ vertical\ blocks\ covered\ by\ signal\ x\ Vertical\ Scale$$

2. **Coupling-** There are three ways in which the signal can be coupled to the channel, namely GND, AC and DC.
    i. GND- This lets you see the ground (reference) line for the signal.
    ii. AC- This lets you AC couple the signal i-e any DC component in the signal is filtered out before displaying it on the screen.
    iii. DC- This lets you DC couple the signal i-e displays the complete signal including its AC as well as DC part.
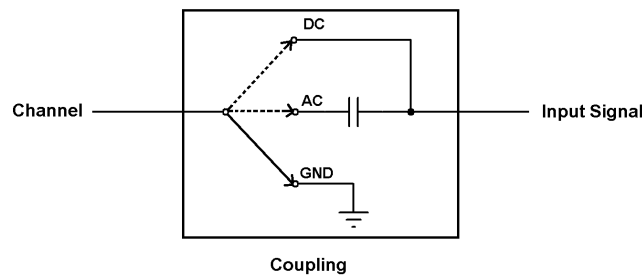

Figure-4: Coupling in an Oscilloscope

3. **Vertical Position-** This lets you move the waveform up and down on the screen. It is used for setting the ground line on the origin.
4. **Input Mode-** This control is common for both the channels, this lets you chose the input channel or combination mechanism for the display. It consists of four options, CH1, CH2, Alternate, Chop and Add. When this control is on Alternate, the channels are displayed alternately in successive sweeps, in the Chop mode, both the channels can be viewed simultaneously and the Add mode displays the sum/difference of the two channels.

5. **Invert-** This is present on only one of the channels (mostly Channel 2), this inverts the displayed signal. It is used for subtracting one signal from the other using the Add input mode.
6. **X-Y Mode-** Most oscilloscopes also have an X-Y mode option that lets you plot one channel against the other. This can be used to plot I-V curves.
7. **10x-** The probes for each channel have a 10x switch on their heads, which divides the signal by 10 before displaying it on the scope thus allowing for much larger signals to be displayed on the screen.

The controls used for manipulating the horizontal axis of the signal are:

1. **Time/Division-** This is similar to the Volts/Division control described above, and lets you scale the time period of the signal i-e either compress it or stretch it horizontally. The time period of the signal is then given as:

$$Time\ Period = \ Number\ of\ horizontal\ blocks\ covered\ by\ one\ cycle\ x\ Horizontal\ Scale$$

2. **Horizontal Position-** This lets you move the trace either to the left or to the right. This is used to position the waveform in such a way so that its starting point touches the origin.
3. **X10 Magnifier-** This allows you to measure a frequency 10 times higher than the normal range of the oscilloscope. This is used to measure time deflections.

The controls discussed above were used to change the waveform on the screen. The oscilloscope uses a horizontal sweep to catch the input signal after equal intervals of time thus making the signal seem stationary on the screen (ideally). This is done with the help of the trigger controls:

1. **Level and Slope-** This lets you select the amplitude and the slope (+ve or –ve) at which to begin the sweep.
2. **Mode-** This consists of the Normal, Auto and Single Sweep modes, the normal mode produces a sweep only when the signal (from the source selected) crosses the set value of level moving in the direction of the Slope. The Auto mode produces a free running sweep. The Single mode is used to produce only one cycle of a sweep and is generally used for non-repetitive signals.
3. **Source-** This switch lets you choose the source for the trigger, the options are CH1, CH2, Line, Ext and Ext÷10. The CH1 and CH2 select either Channel 1 or Channel 2 for the trigger input, the Line input causes the sweep to be triggered on the AC power line, Ext and Ext÷10 causes it to trigger on any external signal.
4. **Coupling-** The coupling switch lets you select the coupling used for the trigger source; this consists of DC and AC options. The AC and DC options, respectively, AC couple and DC couple the trigger source.

An oscilloscope also has Intensity (make the trace brighter/dull), Focus (change the focus of the trace), Probe connectors (BNC connectors for connecting the probes), a Cursor Function (lets you measure the amplitude, time period, frequency, phase difference etc automatically) and a Calibration Output. The intensity should not be very high nor the focus be made blurry as it could result in the damage of eyesight. The calibration Output lets you Calibrate the oscilloscope. Before making any observation with the Oscilloscope, one must calibrate both the channels to make sure that the observations are correct to the maximum possible accuracy. The oscilloscope generates a signal called the Calibration Signal, which is a square wave of 1 KHz i-e a Time Period of 1ms. This signal is observed on both the channels one by one, any error in the observation is corrected before making any other observation. There is a limit to the highest frequency that can be displayed on an oscilloscope. Most of the oscilloscopes can display signals with a maximum frequency of 20 MHz.
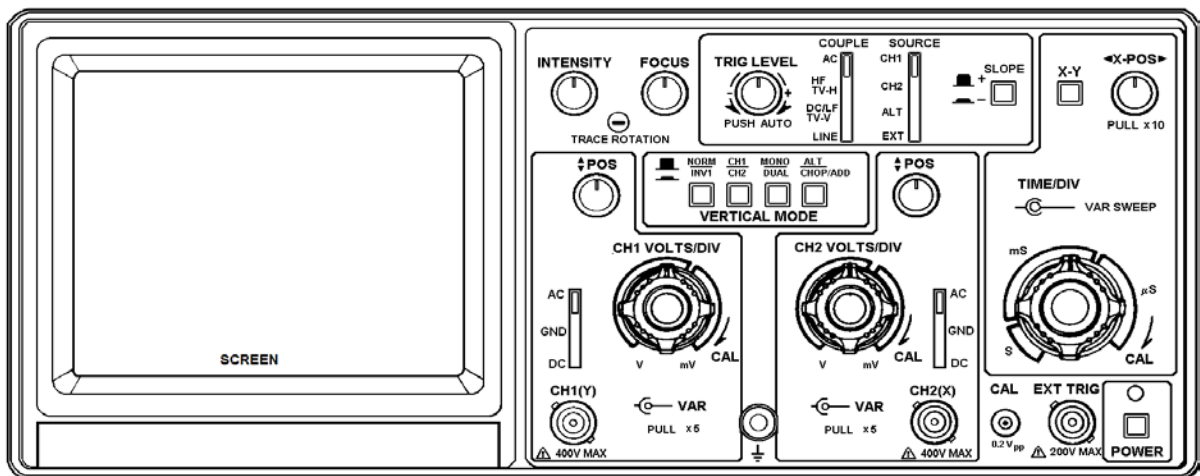

Figure-5: Oscilloscope Front Panel

Procedure:

1. Turn on both pieces of equipment.
2. Plug the probes to the probe inputs on the oscilloscope.
3. Select Channel 1 and select GND from the Channel Coupling switch, if it is not already on the origin, use the vertical position knob to bring the Ground line down to the origin.
4. Repeat the above step for Channel 2 also.
5. Connect the probe of Channel 1 to the calibration output. Use the volts/division switch to set the vertical scale to 0.5 volts/division.
6. Remove the probe of Channel 1 form the calibration output and repeat the same for Channel 2.
7. To calibrate the time scale, connect any of the probes of Channel 1 or Channel 2 to the calibration output, use the horizontal position switch to move the wave horizontally so that its starting point rests on the origin.

8. Set the Vertical Coupling switch to AC, connect the probe of Channel 1 as well as Channel 2 to the function generator output.
9. Press the Sine key on the function generator and set the frequency multiplier knob to 1 and the frequency selector knob to KHz.
10. Use the attenuation switch on the Function Generator to set the amplitude to 2 Volts (p-p), while observing on the oscilloscope.
11. Measure the amplitude and the time period using the formula given in theory. Use the cursor function and measure the amplitude and the time period and fill in the table
12. Do this for several frequencies.
13. Press Alt or Chop on the vertical coupling switch and view both the waveforms simultaneously.
14. Change the Channel mode to add and observe the waveform on the screen.
15. Press the Invert control and observe the change.
16. Observe different shapes of waveforms that the function generator can produce by using the Waveform shape switch. Also observe the waveform by pressing two or more of the button together.
17. Set the Coupling mode to DC. Using the DC offset knob on the function generator, lift the signal level up by 2 divisions on the oscilloscope. Now switch the coupling mode to AC and observe the difference.
18. Repeat the above step but move the signal 2 divisions down instead.
19. Take another function generator, press the sine key and while observing on the oscilloscope, set the frequency to 1 KHz and the amplitude to 2 Volts (p-p).
20. Now observe the signal from the first function generator on channel 1 and the signal from the second generator on channel 2 (chop mode).
21. Now calculate the time difference between (using the block method) the starting points of both the waveforms and use the formula described below to calculate the phase difference between the two waves. You will also need to calculate the period of the waves.
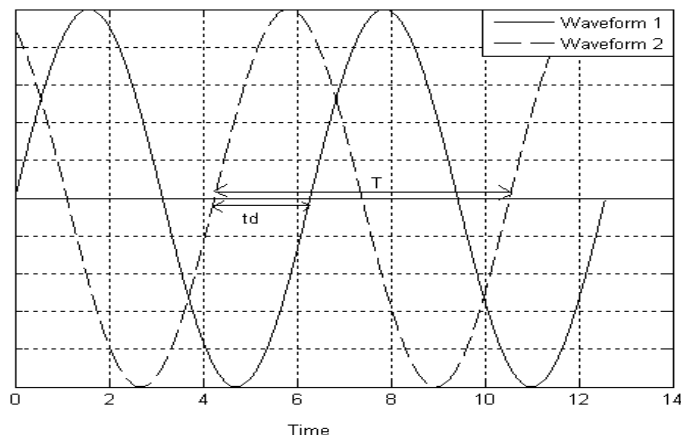
$$Phase\ Difference = \frac{td}{T} x360°$$

Figure 2.5: Phase difference between two sine waves

Observation:

S N.o	Function Generator Frequency	Observed Frequency		Error between F.G Freq. and Calculated Freq.	Error between F.G Freq. and Cursor Func. Freq.
		Calculated	Cursor Function		
1.					
2.					
3.					
4.					
5.					

Table 2.1: Determining Inaccuracy in the generated frequency

Questions:

1. Draw the waveform generated when the sinusoidal and rectangular waveforms are combined.

_____
_____
_____

2. What is the purpose of the volts/division and the time/division control?

_____
_____
_____

3. What does one mean by coupling?

_____
_____
_____