EXPERIMENT – 6

Aim of the experiment: To generate a sinusoidal waveform using a function generator and measure its frequency and voltage amplitude using a Cathode Ray Oscilloscope (CRO) or a Digital Storage Oscilloscope (DSO).

Apparatus required: 50 MHz, 2 Ch, Cathode Ray Oscilloscope or Digital Storage Oscilloscope, function generator or waveform generator, BNC-to-BNC coaxial cable - 1m.

Setting up the instrument

CATHODE RAY OSCILLOSCOPE (CRO)

- Setting up a CRO for making measurements requires a function generator as well.
- Plug in the power cords and power ON the CRO and the function generator. Allow some warm-up time.
- Set the output of the function generator to 1 kHz, 1 Vp-p, Sine wave.
- Make sure all pushbuttons on the front panel of the CRO are in the released position and none of them remains depressed, initially at least.
- There is a small LCD screen on the front panel that displays the Attenuator (V/div) setting of both the input channels (CH1 & CH2) and the time-base (TB) setting.
- You may also note that there is an asterisk (*) mark close to CH2. This means that you can change the setting of CH2 using the attenuator [V/div] knob. To change the setting of CH1, momentarily depress the [V/div] knob, the asterisk (*) will shift towards CH1; it toggles.
- Now you may adjust the setting of CH1. To change the time-base (TB) setting, use the [Time/div] knob.
- Set CH1 to 5 V/div and TB to 1ms/div. Next, rotate and bring the [Y shift 1] knob to the mid-level of its full span. Do the same for [Y shift 2] and [X shift] knobs. You should be able to see the trace on the CRO screen. Again, use the [X shift] and [Y shift] knobs to center the trace properly.

Fig-1. Actual image of a relevant portion of the front panel of a cathode ray oscilloscope (CRO)

- Now, using a BNC-to-BNC cable, connect the output of the function generator to the CH1 or CH2 input of the CRO, as per your choice.
- A sinusoidal waveform must appear on the CRO screen. Gently rotate the [V/div] knob a few klicks clockwise to scale the signal appropriately as desired. Never allow the signal to span vertically out of the screen. That would mean the signal exceeds the measuring range setting of the instrument, jeopardizing its operability.

- Also, gently rotate the time-base [Time/div] knob a few klicks either way to scale the signal appropriately along the time axis. The setting must suit your requirements. Go ahead with making measurements over the waveform and recording your observations.

DIGITAL STORAGE OSCILLOSCOPE (DSO)

One of the key differences between the CRO front panel controls and those of a DSO is that the knobs have no end-locking position. This is because, mostly *potentiometers* are used in CROs, whereas *encoders* are used in DSOs and in some modern CROs. So, if you rotate a potentiometer, you will realize that its angular span is nearly 270 degrees, whereas the encoders do not have an end-locking. They can be rotated endlessly.

Fig-2. Actual image of the front panel of a digital storage oscilloscope (CRO)

Owing to the intricate and highly sophisticated design and the versatility of measurement tasks that can be carried out using a DSO, it usually appears to be much more complex which it actually is. Moreso because it has a petrifying front panel and an even more intricate menu, navigating through which can be really prohibitive. Have faith in the sophistication of the system; intel is inside, that comes to your rescue. The heart of the DSO is a 486DX2 processor, that is powerful and versatile enough to make the user's life easier. Most intricacies are handled internally. It has a very logically arranged menu that provides complete control to the user.

For novices however, it also has an in-built help text at the press of a [HELP] button. If you are reluctant to read the help text, there are two blue buttons on the front panel, the [DEFAULT SETUP] and the [AUTO]. Pressing them one after the other will do the job for you in seconds.

Bottom line is that, setting up a DSO is a lot easier than setting up a CRO.

Principle: Frequency and amplitude of a time varying signal can be readily measured using a CRO or a DSO. The graticule on the DSO screen and the front panel knob settings for sensitivity along the vertical axis or time-base setting along the horizontal axis.

1. Amplitude measurement: A CRO/DSO can be suitably adjusted to view a signal on its screen. The vertical span of a signal on the screen can be exactly measured using the graticule on the CRO screen. The vertical sensitivity setting on the CRO multiplied by the span (as viewed against the graticule) of the signal along the vertical axis would be the voltage amplitude of the signal at its input.

$$V_{pk-pk} = Vertical\ span\ of\ the\ signal \times Vertical\ sensitivity\ setting$$

2. Frequency measurement: horizontal span of the signal against the graticule multiplied by the time-base setting divided by the number of complete cycles of the signal along the horizontal axis in that particular span would be the time-period of the waveform. The inverse of this would be its frequency.

$$T = \frac{horizontal\ span\ of\ the\ signal\ \times\ timebase\ setting}{no.of\ complete\ cycles\ in\ that\ span}$$

$$\nu = \frac{1}{T}$$

Procedure and precautions:

1. Place a CRO / DSO and a function generator on your working table, connect their mains power cords to the power outlets and power them up.
2. Set the input attenuator (volts/div) setting to a fairly high value, like 5 V/div.
3. Connect the output of the function generator to the input channel #1 of the CRO / DSO.
4. If you are using a DSO, locate two blue buttons [DEFAULT SETUP] and [AUTO SET].
5. Press [DEFAULT SETUP] wait for 3 seconds and then press [AUTO SET], the signal from the function generator will be displayed on the screen.
6. Note down the vertical span of the signal against the graticule on the screen and the [volts/div] attenuator setting of the relevant channel.
7. Also note down the horizontal span of the signal for a couple of / several complete cycles and the time base setting as well.
8. Using the recorded data, proceed with the calculations as outlined in the following section.

Calculations:

A. To calculate the voltage of a sinusoidal signal

The volts/div setting on the front panel of the oscilloscope is = $= 0.2\ V/div$ (say)

and the peak to peak (vertical) span of the signal is = $= 6.2\ div$ (say)

this right away translates to $= 6.2\ div\ \times 0.2 \frac{V}{div} = 1.24\ V_{p-p}$

that is $1.24\ V\ peak\ to\ peak$

B. To calculate the frequency of a sinusoidal signal

There are 7 T (time periods) in 9.6 horizontal scale divisions and $1\ div\ =\ 0.5\ ms$

Therefore, there are 7 T (time periods) in $9.6\ \times 0.5\ ms$

Therefore, $1\ T$ (time period) $= \frac{(9.6\ \times 0.5)}{7}\ ms$

Therefore, $frequency\ = \frac{7}{(9.6\ \times 0.5)}\ Hz$

Observations:

Table-1: CRO / DSO readings for the measurement of voltage amplitude of a sinusoidal signal produced by a function generator.

S.No.	Vertical span of signal on screen	Vertical attenuator setting	Amplitude of observed signal (V)	Amplitude of signal from the Function generator readout (V_0)	Ratio
	(div)	(Volts/div)	(Volts)	(Volts)	V/V_0
1.					
2.					
3.					
4.					
5.					

Table-2: CRO / DSO readings for the measurement of frequency of a sinusoidal signal produced by a function generator.

S.No.	No. of complete cycles of the waveform	Horizontal span of those complete cycles	Time base setting	Total time for n complete cycles	Time period (T)	Frequency measured using DSO / CRO (f)	Frequency of signal displayed on the Function generator readout (f_0)	Ratio f/f_0
	(n)	(div)	(s/div)	(s)	(s)	(Hz)	(Hz)	
1.								
2.								
3.								
4.								
5.								

Results and discussion:

It can be clearly seen that the ratios are close to unity, implying thereby that the measurements are quite accurate.

Digital storage oscilloscope is a fabulous equipment for the measurement of amplitude and frequency of time varying electrical signals over a wide range of frequencies. It is capable of displaying the exact profile of signals that vary rapidly with time.