BME 212 Electronics Laboratory

Week#2 Basic Laboratory Equipments

Basic Laboratory Equipments

Multimeter

A digital multimeter (DMM) is a test tool used to measure electrical values. It is a standard diagnostic tool in the electrical/electronic industries.

Measurements that can commonly be done using a multimeter are;

- Resistance
- Voltage
- Current
- Capacitance
- Frequency
- Temperature, etc.

Caution! Multimeters are connected serially to measure the current and in parallel to measure the voltage. Before starting the measurement, checking the connections on the multimeter is highly important to avoid burning the fuses and making the correct measurements.

Basic Laboratory Equipments (Cont.)

Waveforms and Function Generators

Waveforms:

A waveform graphically represents a variable as a function of time. A DC (direct current) voltage or current is a fixed value and does not vary with time. An AC (alternating current) voltage or current varies with time. The basic wave shapes used in electronics are shown in Figure 1.

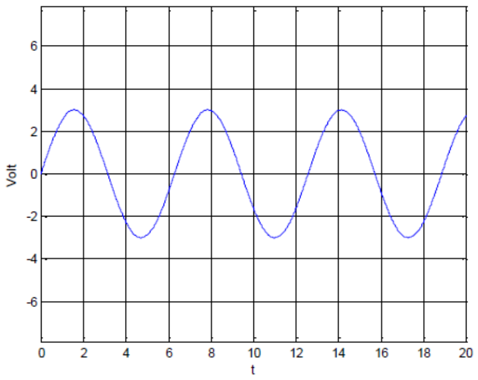

Figure 1.a Sinusoidal wave

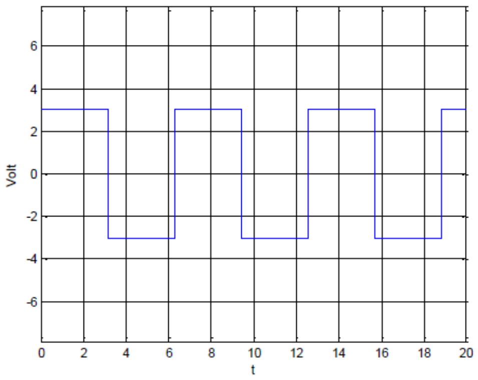

Figure 1.b Square wave

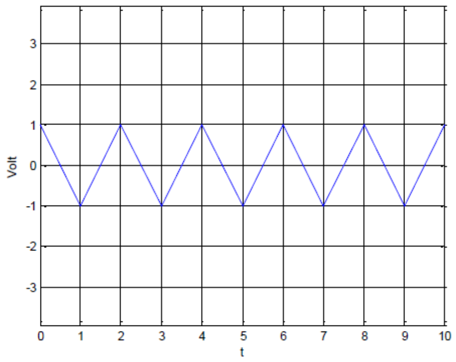

Figure 1.c Triangle wave

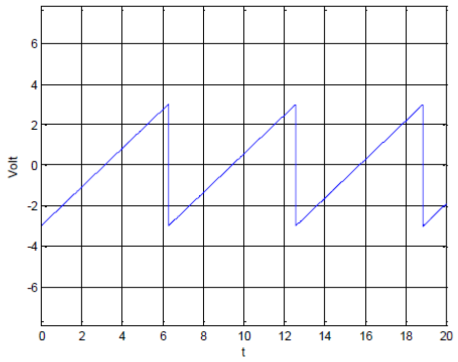

Figure 1.d Sawtooth wave

Waveforms (Cont.)

The sine wave is one of the fundamental wave shapes used in electrical systems and many electronic analog circuits such as audio amplifiers.

The square wave and rectangle wave are used extensively in digital circuits as well as analog electronics.

The triangle wave and saw-tooth wave are used in wave shaping and timing circuits.

A saw-tooth voltage is used in televisions and oscilloscopes to control the trace of the electron beam on the surface of the screen (called cathode ray tube, CTR).

The exponential waveform is also used in timing and wave-shaping circuits [3].

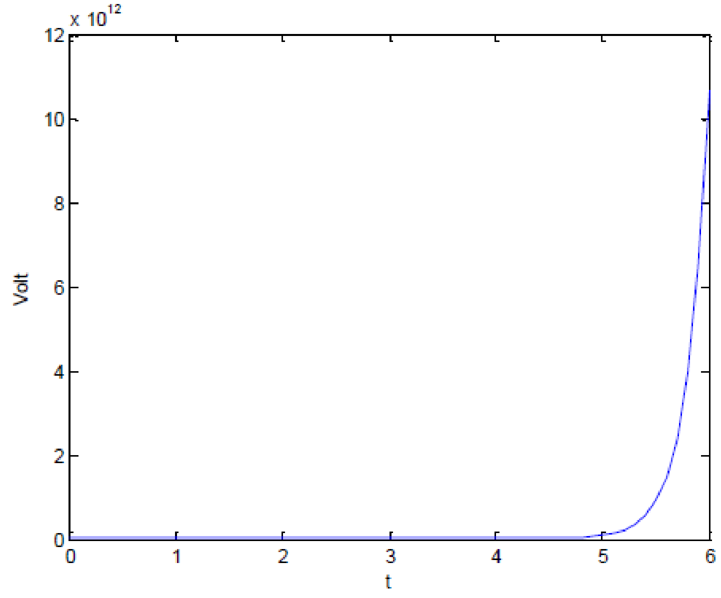

Figure 1.e Exponential wave

Important Parameters for Alternating Waveforms

- **Period (T):** The time interval between successive repetitions of a periodic waveform.
- **Frequency (f):** The number of cycles that occur in 1 second.
- **Instantaneous value:** The magnitude of a waveform at any instant of time.
- **Peak amplitude:** The maximum value of a waveform as measured from its average, or mean, value, denoted by the letters Em or Vm.
- **Peak-to-peak value:** The sum of the magnitude of the positive and negative peaks; denoted by Ep-p or Vp-p.

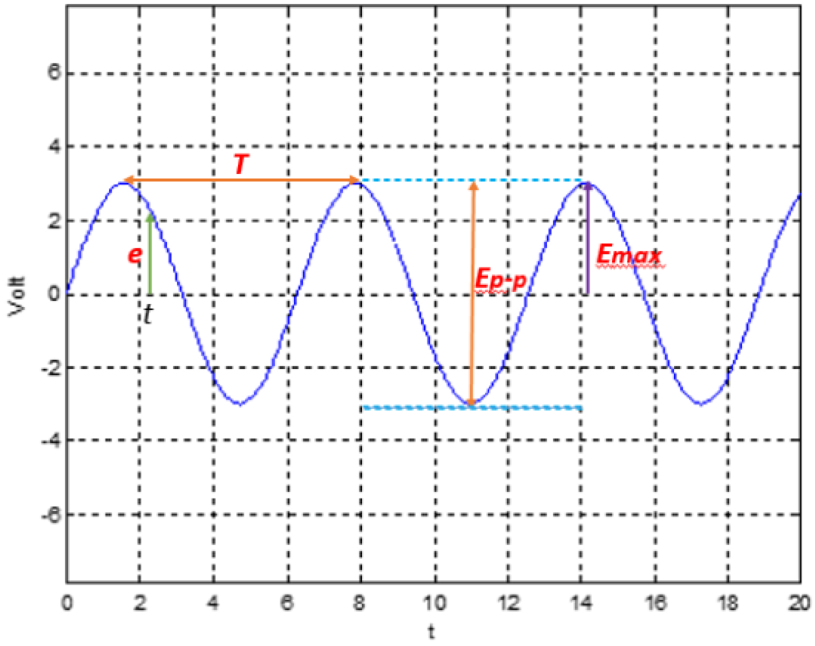

Figure 2. Important parameters for a sinusoidal voltage

Phase Relationships

Alternating current (AC) voltages and currents can be ***in phase*** or ***out of phase*** with each other by a difference in angle. This is called ***phase angle*** and is represented by the Greek letter theta **(θ)**.

When two sine waves are at the same frequency and their waveforms pass through zero at different times, and when they do not reach maximum positive amplitude at the same time, they are out of phase with each other.

On the other hand, when two sine waves have the same frequency, and when their waveforms pass through zero and reach maximum positive amplitude at the same time, they are in phase with each other [4]. An example of out-of-phase sine waves are shown in Figure 3.

The equation for determining the phase angle can be introduced using the definition in Figure 3. Both sinusoidal functions have the same frequency, hence permitting the use of either waveform to determine the period.

For the waveform in Figure 3, the period encompasses four divisions. The phase shift between the waveforms is one division. Since the full period represents a cycle of 360o, the phase angle between waveforms can be found using the following formula.

Phase Relationships (Cont.)

$$\theta = \frac{phase\ shift(number\ of\ division)}{Period\ (number\ of\ division)}\ x\ 360^o$$

Substituting measurements in the equation,

$\theta = (1/4)x360°$

$= 90°$

Therefore; signal e leads signal i by 90°

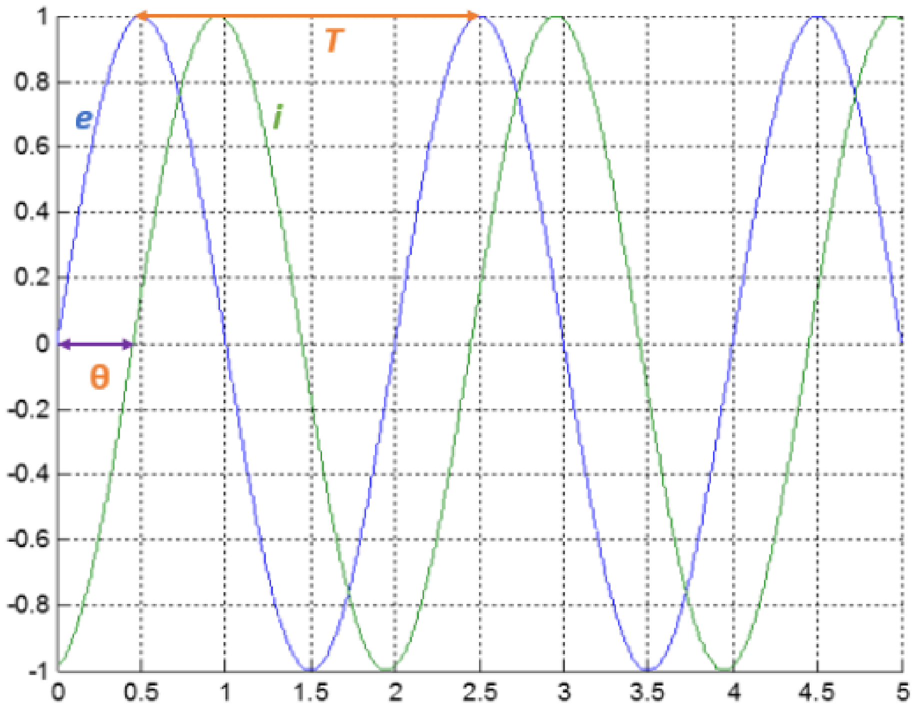

Figure 3. Finding the phase difference

Effective (RMS) Value

The effective value of an AC signal is the value of a direct current which when applied to a given circuit for a given time, produces the same expenditure of energy as produced by the alternating current when flowing through the same circuit for the same period [5].

Effective value is also called the root-mean-square (rms) value. This term comes from the mathematical method used to find its value [4]. The effective value of any quantity plotted as a function of time can be found as:

$$I_{eff} = \sqrt{\frac{\int_0^T i^2(t)dt}{T}}$$

For the case of a pure sinusoidal waveform, the rms value equals to $1/\sqrt{2}$ or 0.707 times it peak value.

Function Generators

The function generator is an instrument which generates different types of waveforms. The most common waveforms are sine wave, sawtooth wave, triangular wave and square wave. Function generators typically provide a DC offset adjustment that allows the user to add a positive or negative DC level to the generator output. Figure 4(a), 4(b) and 4(c) show how adding variying amount of DC to a sine wave can produce different waveforms.

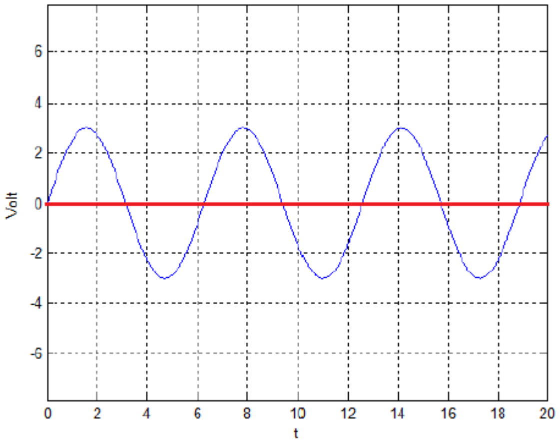

Figure 4(a). Sine wave with no DC

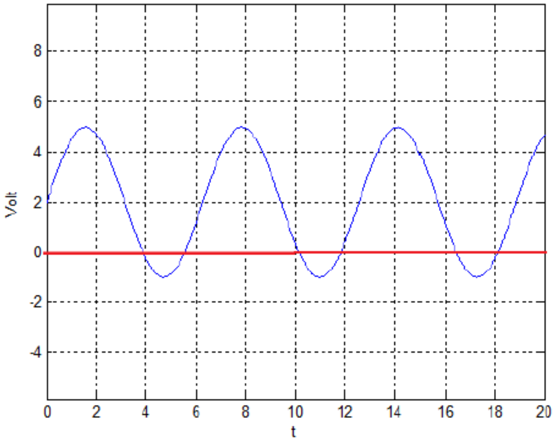

Figure 4(b). Sine wave with positive DC

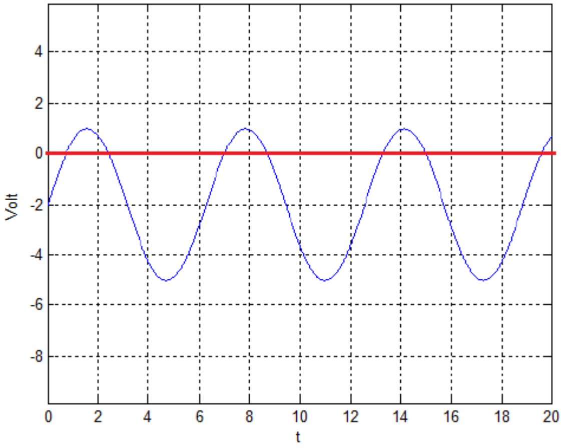

Figure 4(c). Sine wave with negative DC

Oscilloscope

The primary function of an oscilloscope is to display an exact replica of a voltage waveform as a function of time.

This picture of the waveform can be used to determine quantitative information such as the amplitude and frequency of the waveforms as well as qualitative information such as the shape of the waveform.

The oscilloscope can also display more than one waveform at the same time for comparison and measure their time and phase relationships.

Figure 5 shows a typical display of a sine wave using an oscilloscope.

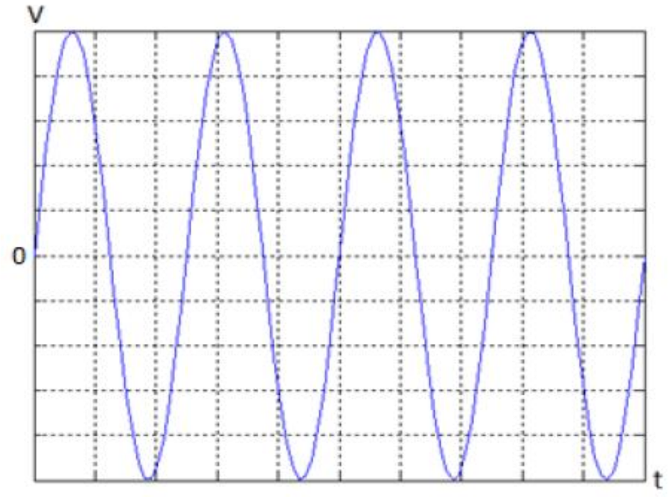

Figure 5

Oscilloscope (Cont.)

RMS voltage is not as easy to determine, at least not directly from an analog oscilloscope.

But the relationship between the zero-to-peak and RMS values for a sine wave is known.

Since, VRMS = 0.707 for our example V0-p = 0.707 (2.5 Volt) = 1.76 Volts RMS.

So, an analog oscilloscope cannot measure RMS voltage directly, but it does give the user enough information to compute the value for simple waveforms.

With the advancement of technology, most digital oscilloscopes can calculate the RMS value internally and display the result on the screen.