BME 211 Circuit Analysis Laboratory

Experiment #5: Function Generators, Oscilloscopes, Resistors in AC Circuits, Power Calculation in AC Circuits

Objective

The objective of this experiment is to gain familiarity with two fundemantal measurement and test equipments, namely the function generator and oscilloscope. Relation between voltage and current in purely resistive circuits for AC supplies will be studied. Finally the definitions used in power calculations in AC circuits will be covered.

Background

1. Resistive AC Circuits

The simplest type of AC circuit is a resistive circuit, such as the one shown in Figure 5.1. The purely resistive circuit behaves similarly to as it does to a pure DC source. The waveforms in Figure 5.2 show that the voltage and current are in-phase in a purely resistive circuit with AC applied. An in-phase relation exists when the minimum and maximum values of both voltage and current occur at the same time interval.

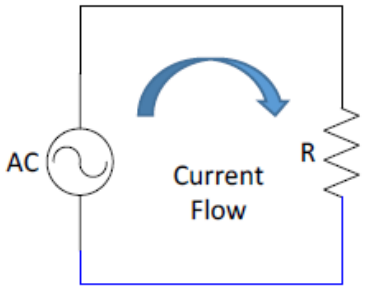

Figure 5.1 Resistive AC circuit

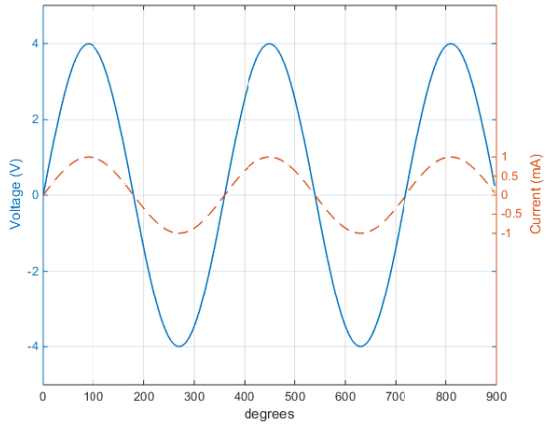

Figure 5.2 Voltage and current waveforms of a resistive AC circuit

2. Power Calculations in AC Circuits

An AC voltage $v(t)$ that is applied on an impedance Z and the corresponding current $i(t)$ are shown in the Figure 5.3. The instantaneous power $p(t)$ is given in Equation 5.1.

$$p(t) = v(t)i(t)$$

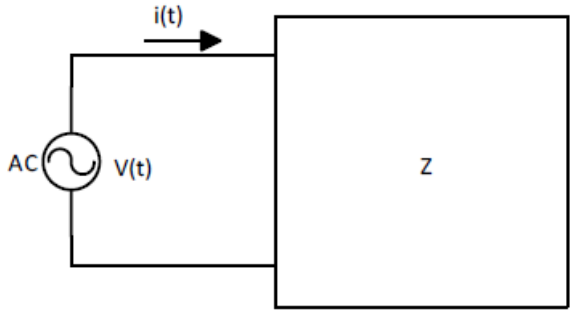

Figure 5.3 One port network with impedance Z

If $v(t)$ and $i(t)$ are periodic with period T, the rms or the ***effective values*** of the voltage and current are:

$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T v^2(t)dt} \qquad I_{rms} = \sqrt{\frac{1}{T}\int_0^T i^2(t)dt}$$

The ***average power*** disappated by the one-port network given as :

$$P = \frac{1}{T}\int_0^T v(t)i(t)dt$$

The ***average power factor*** pf is defined as

$$pf = \frac{P}{V_{rms}I_{rms}}$$

For the special case where both the current $i(t)$ and voltage $v(t)$ are both sinusoidal, that is;

$$v(t) = V_m \cos(\omega t + \theta_V)$$

and

$$i(t) = I_m \cos(\omega t + \theta_I)$$

The rms values of the voltage and current are

$$V_{rms} = \frac{V_m}{\sqrt{2}} \qquad I_{rms} = \frac{I_m}{\sqrt{2}}$$

The ***average power***, P is $P = V_{rms} I_{rms} \cos(\theta_v - \theta_I)$

The ***power factor***, pf is $pf = \cos(\theta_v - \theta_I)$

The ***reactive power***, Q is $Q = V_{rms} I_{rms} \sin(\theta_v - \theta_I)$

And the ***complex power***, S is $S = P + jQ$

$$S = V_{rms} I_{rms} [\cos(\theta_v - \theta_I) + \mathrm{j}\sin(\theta_v - \theta_I)]$$

Preliminary Work

1. Study the supplementary material
2. Determine the zero-to-peak voltage, the peak-to-peak voltage, period and frequency of the waveform shown in Figure 5.4, if vertical sensitivity is 0.5 volts/division, verticle offset is zero and timebase is 5 msec/div. Calculate the rms values from your readings.

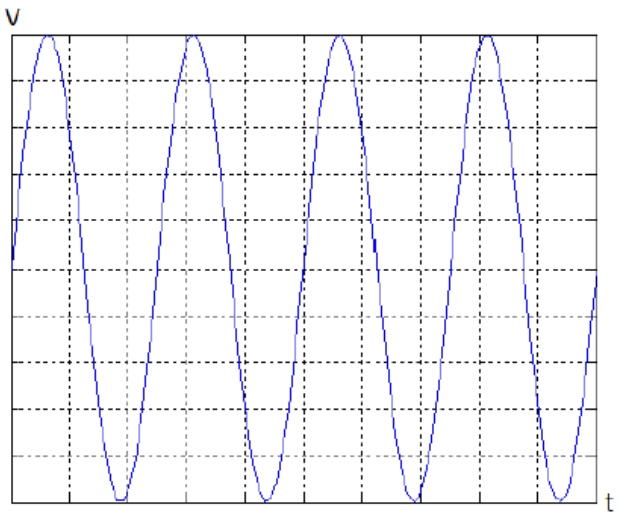

Figure 5.4

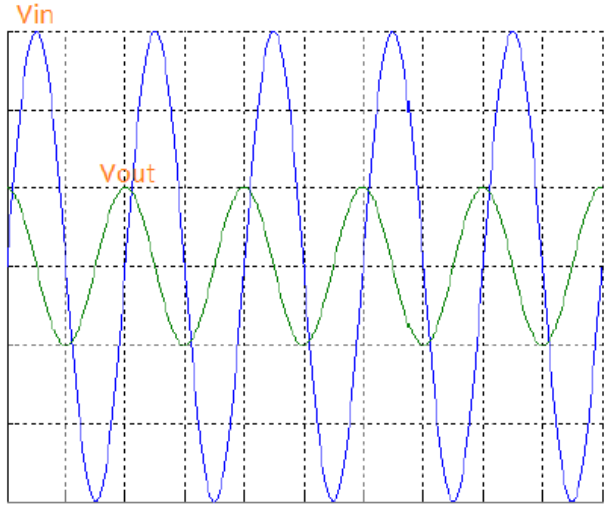

Figure 5.5

3. Determine the phase difference between the V_{out} and V_{in} for the waveformas

4. Determine the RMS values of the waves shown in the Figures 5.6, 5.7 and 5.8.

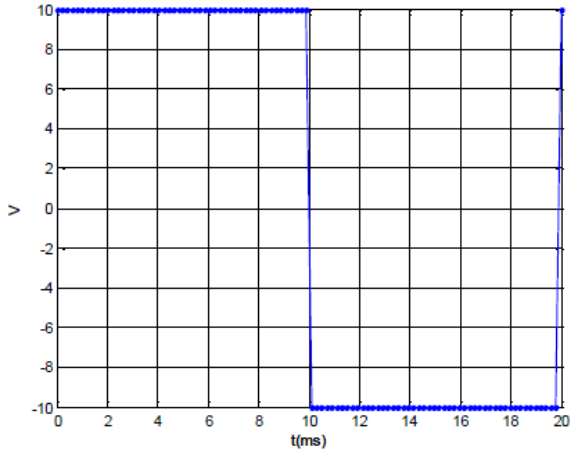

Figure 5.6

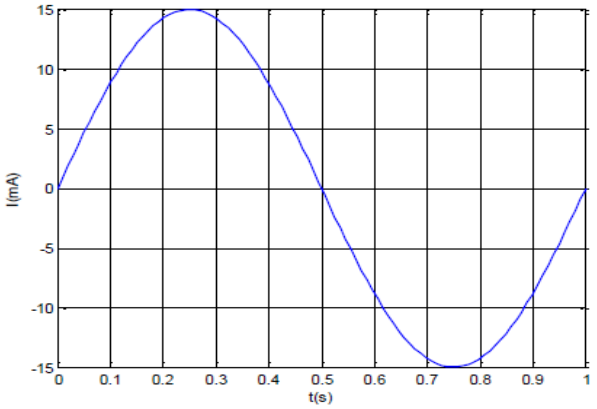

Figure 5.7

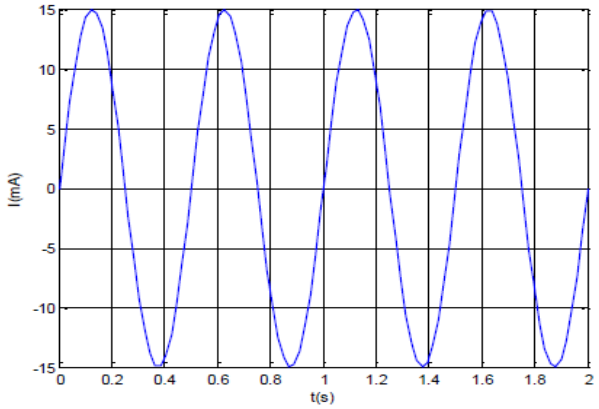

Figure 5.8

5. If v(t) = 10 cos(120πt+30°) and i(t) = 6 cos(120πt+60°), determine the average power, rms value of v(t), and the power factor [9].

Procedure

1. Set up the circuit given in figure x. Adjust V_{ab} = 15 V_{pp} and the frequency of the source to 1 KHz, then observe and plot the generated signal on the graph.

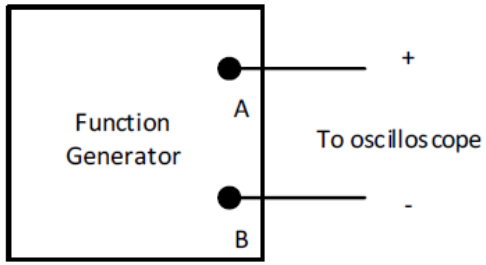

Figure 5.9

2. a) Adjust V_{ab} = 20 V_{pp} and the frequency as 100 Hz, 500 Hz, 1 KHz, 50 KHz, 100 KHz then measure the voltage across resistor for each frequency.

   b) Adjust the frequency of source to 1KHz and V_{ab} as 5 V_{pp}, 10 V_{pp}, 15 V_{pp}, 20 V_{pp} and 25 V_{pp} then measure the voltage across the resistor for each V_{ab}.

   c) Calculate $V_{R(rms)}$ and I_{rms} values for each case and tabulate the results.

$$I_{rms} = \frac{V_{R(rms)}}{R}$$

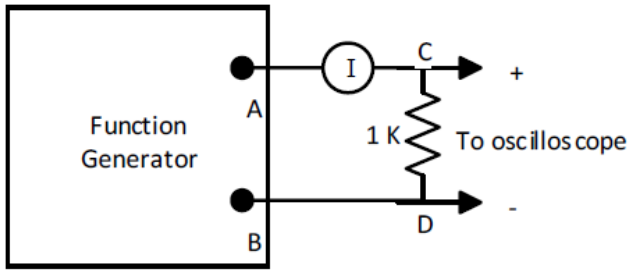

Figure 5.10

BME 211 Report #5

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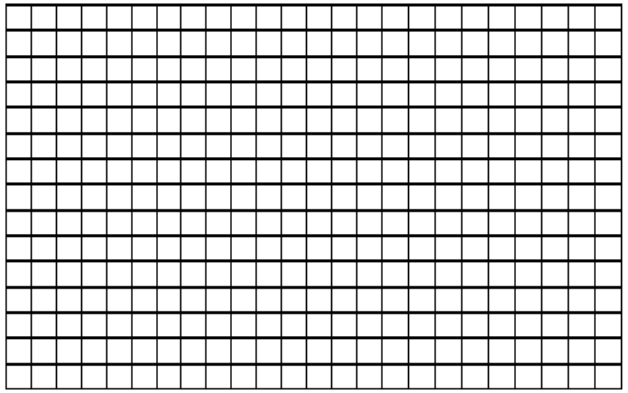
Objective

Results

1. Plotting generated signal:



2. Comparison of calculated and measured values:

   a)

	100 Hz	500 Hz	1 kHz	50 Khz	100 kHz
$V_{1k\Omega}$					
V_{ab}					

Comment:

b)

	5V	10V	15V	20V
$V_{1k\Omega}$				
V_{ab}				

Comments:

c)

	5V	10V	15V	20V
$V_{1k\Omega}$(rms)				
I (rms)				