EXPERIMENT # 8

AVERAGE AND RMS VALUES

OBJECTIVE:

1- To measure the average and root mean square (r.m.s) values of some electrical signals.
2- To compare the calculated and experimental values.

Pre-Lab Assignment

1- For the periodic signals shown in Figure 1, find:

a) The average value of each signal.
b) The r.m.s. value of each signal.

2- For the periodic signals shown in Figure 2, find the average value of each signal.

APPARATUS: Oscilloscope
Signal Generator
Digital Multimeter (DMM)

THEORY:

1- Average Value:

The average value of a periodic signal *f(t)* is defined as:

$$f_{avg} = \frac{1}{T}\int_0^T f(t)dt = \frac{area \quad under \quad one \quad period}{period} \qquad (1)$$

2- The Root Mean Square value:

The r.m.s. value of a periodic signal *f(t)* is defined as :

$$f_{rms} = \sqrt{\frac{1}{T}\int_0^T f^2(t)dt} = \text{Square root of the average of } f^2 \text{ (t).} \qquad (2)$$

For a general sinusoidal signal *f(t)* = $A\cos(\omega t + \phi)$., it is easy to show that

$$f_{avg} = 0 \qquad (3)$$

$$f_{max} = \frac{A}{\sqrt{2}} \qquad (4)$$

For a signal that consists of a DC and AC parts such as, $f(t) = B + A\cos(\omega t + \phi)$ where, B = constant, it is equally easy to show that the average value is equal to the DC part only, namely:

$$f_{avg} = B \qquad (5)$$

Procedure:

1- Set the oscilloscope controls as follows:

Time / Div.	0.2 ms	Volts / Div.	0.5 V
Vertical Display	A	Coupling	D.C.

2- Connect the output of the signal generator to channel A of the oscilloscope.
3- Set the signal generator to a sinusoid of 2000 Hz and a peak to peak voltage $V_{p\text{-}p} = 2$ V.
4- Adjust the DC offset of the signal generator to zero, so that the signal you obtain on the oscilloscope has no DC value (similar to the signals of Figure 1). This is done by first setting the oscilloscope control to ground then moving ground level to the middle of the screen).

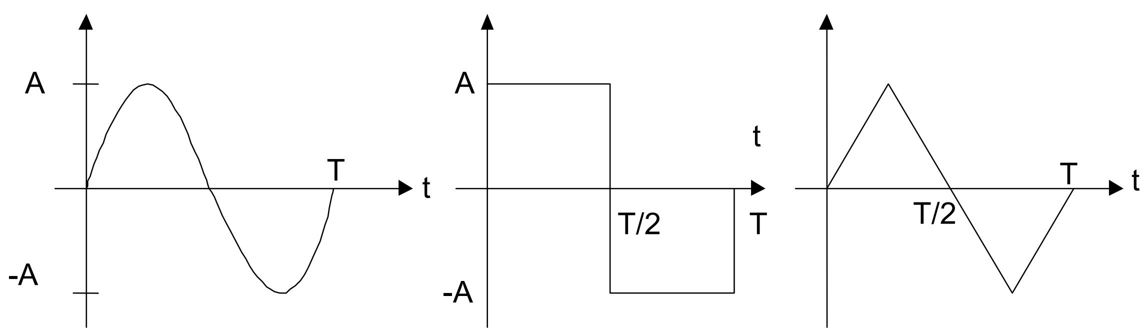

Figure 1

5- Measure :

a) The average value of the signal with a DMM (set the voltmeter to D.C.).
b) The r.m.s. value of the signal with a DMM (set the voltmeter to AC).
c) The period of the signal from the oscilloscope. Then calculate the corresponding frequency from the relation f = 1/T.

6- Repeat steps 3-5 for a square signal with the same V_{p-p} and frequency.
7- Repeat steps 3-5 for a triangular signal with the same V_{p-p} and frequency.
8- Repeat the measurement of the average value for the same signals as in previous steps with the following changes:

a) Adjust the ground level to the bottom of the screen.
b) Adjust the D.C. offset of the signal generator, so that the signals start from zero and reach a peak value of 2 V as shown in Figure 2.

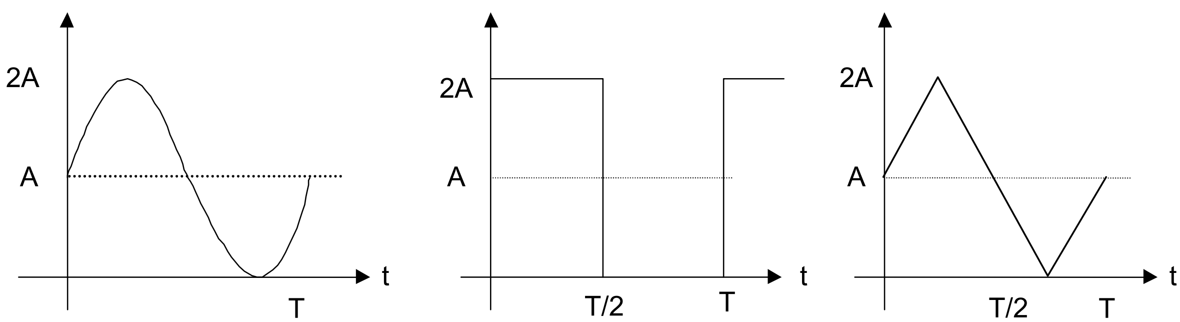

Figure 2

Report:

1- Complete the Tables in your report sheets.
2- Comment on the causes of errors between the measured and calculate values.

Question:

1- The frequency of the voltage in your house is 60 Hz. How much time is required for the waveform to complete three cycles?
2- What is the difference between AC and DC coupling of the oscilloscope? Explain how to use them to measure the average value of any periodic signal.
3- Some meters are calibrated to read r.m.s. Value of sinusoidal waveforms from the basic unit that responds to the peak value of the waveform. In terms of the peak value, V_p , the meter will read $\frac{V_p}{\sqrt{2}}$, which is the correct r.m.s value for a sinusoidal signal. Can this meter be used to read the correct rms value for other waveforms like square, triangular, etc? Comment.

TABLE 1

	Sinusoidal	Square	Triangular
T (ms)			
f (Hz)			
Average Value (Calculated)			
Average Value (Experimental)			
% Error			
R.M.S. Value (Calculated)			
R.M.S. Value (Experimental)			
% Error			

TABLE 2

	Sinusoidal	Square	Triangular
Average Value (Calculated)			
Average value (Experimental)			
% Error			