385L / 5585 - Laboratory 2 - Introduction to AC Measurements – 06 FEB 2017
Due: 20 FEB 2017

Objectives:

1. Proper use of a digital multimeter for AC voltage and current measurements
2. Proper use of an oscilloscope for AC measurements
3. Demonstration of phasor relationships

Equipment and Parts:

1. Digital multimeter and probes
2. Oscilloscope, probes and operations handbook
3. Breadboard and related power supply
4. Signal generator
5. Frequency meter

Prior to attempting any of the following procedures, carefully read the manual for the oscilloscope, signal generator, and frequency meter. Be sure all precautions are followed when using this equipment prior to applying power to the circuit.

2-1 Introduction to the Oscilloscope

If you have limited experience with oscilloscopes, it is strongly recommended that you complete the training as detailed in the Tektronix training manual or view the Textronix online library: http://www.tek.com/learning/oscilloscope-tutorial. Make sure to get the manual specific for the scope at your bench.

2-2 AC Voltage measurements

Connect the frequency generator to the Ch 1 input of the oscilloscope using a BNC cable. Set the oscilloscope to trigger on channel 1 and set for manual trigger. Set the signal generator for a sine wave with approximately 1 kHz frequency – the DC offset should be at 0V and the amplitude should be 5V p-p (peak-to-peak). Adjust the trigger level from 0 to 6V, and observe the display of the oscilloscope. What happens if the scope is set to trigger on channel 2? Can a trace be displayed on the screen? Set a DC offset of 0.5 V and notice the effect on the displayed waveform when the coupling is switched from DC to AC.

Using a BNC tee connect the signal generator output to the DMM and to the oscilloscope. For several settings of the signal generator, record the amplitude of the AC signal and the DC offset of the wave using the oscilloscope – also, record the reading from the DMM for both AC and DC voltage. Make these measurements at the following frequencies: 10, 20, and 50 Hz as well as 1, 2, 5, 10, 20 and 50 kHz. How do the readings from the DMM compare to those from the oscilloscope? If there are any discrepancies are they functions of frequency?

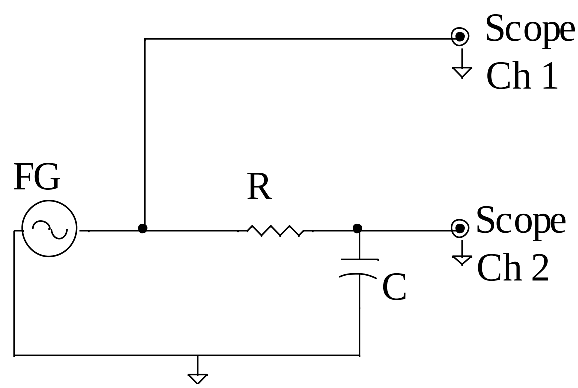
Repeat the above measurements for a square wave and for a triangle wave. How do the RMS values for a sine, square, and triangle wave differ? Does the DMM record true RMS values for all frequencies and waveforms?

2-3 Time / Frequency Measurements

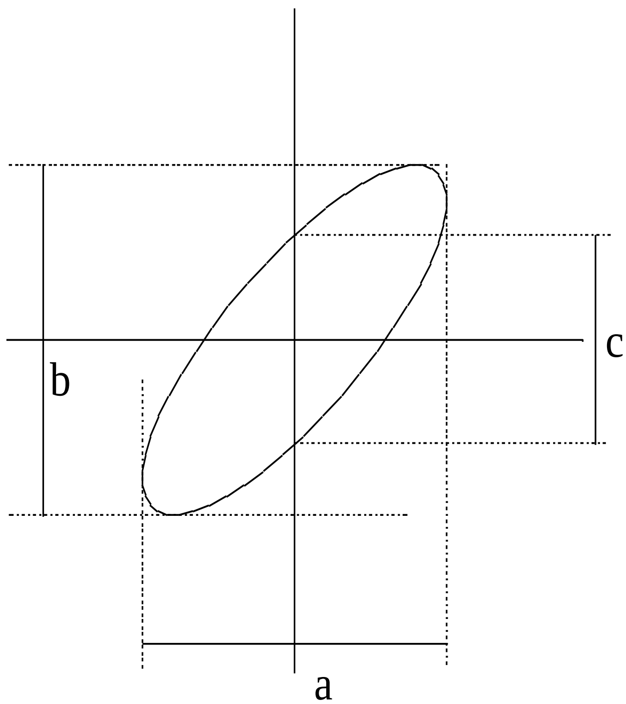
Connect the frequency meter and oscilloscope to the signal generator with a BNC tee. Set the trigger on the frequency meter to zero volts with a gate of 1 sec. Slowly adjust the frequency of the signal generator. Notice the effect on the displayed waveform. Adjust the time base to display at least one full oscillation of the AC signal. Measure the period of the wave using the oscilloscope and compare this to the reading from the frequency meter. This can be performed using the cursor feature of the oscilloscope. Which instrument provides a more accurate measure of the period?

2-4 Low-Pass and High-Pass Filters

Wire the circuit shown in the figure RIGHT, with a resistance of approximately 100 kΩ and a capacitance of 0.01 μF (note the polarity). The signal generator and oscilloscope should be connected to the circuit through the BNC connectors on the top of the power supply box. Measure the input and output amplitudes as a function of frequency from 10 Hz to 100 kHz, in 1, 2, 5 steps (10, 20, 50, 100, 200, 500, etc.) with an input signal amplitude of 10 V.



READ THROUGH ENTIRE SECTION



Plot the gain versus the log of the frequency; this is called a Bode plot (LEFT). Determine the cut-off-frequency. Compare the values of X_c calculated from the nominal component values with the value of X_c determined from the experimental V(out)/V(in) ratio.

With the signal generator at 100 kHz, set the scope time base to observe 1 to 5 cycles. Note that the signal across the capacitor lags the signal across the signal generator. This phase shift can be measured as the fraction of a cycle delayed times 360°. An easy way to measure the phase shift is through the use of the X-Y mode of the oscilloscope. Switch the scope display to X-Y. The oscilloscope display should appear as in the figure LEFT. Record the amplitude values in volts for each frequency used in the previous section. The gain is the ratio of **a**/**b** provided the vertical signal is the input signal. The phase angle is given by $\sin^{-1}$(**c**/**b**), again provided b is the input signal.

Recommendations to perform the measurement of **a**, **b**, and **c** are:

1. Ground the vertical input and align the trace with the horizontal centerline. Measure the length of the trace giving the quantity **a**.
2. Switch the vertical input to DC and ground the horizontal amplifier input. Center the trace horizontally. Measure the length of the trace giving the quantity **b**.
3. Switch the horizontal input to DC and measure **c**.

These values can be used to calculate the gain and phase. Compare the measured phase angles with the theoretical value of θ. Use the X_c values obtained from both nominal component values and values obtained in the previous section. Discuss your results.

Wire a high pass filter by interchanging the resistor and capacitor of the low pass filter. Repeat the above measurements, calculations and discussion for this circuit type. Ultimately, what is the frequency dependence of the capacitive reactance – how is that used to make a high vs. low pass filter?