22.302 Experiment 2

Quantifying Electrical Energy

Introduction

Measurement engineering is defined as the proper selection and use of instrumentation systems for the purpose of experimentation, condition monitoring, and process control. One of the main components of an instrumentation system is the transducer. The transducer is an analog device which is used to convert a change in a mechanical or thermal quantity to an electric signal that can be quantified.

The purpose of this experiment is to explore methods used to quantify electrical energy. Direct current (DC) and alternating current (AC) signals will be generated with a function generator and a +/- 20 volt DC power supply. A digital multimeter and analog oscilloscope will be used to quantify various signals. The 3dB down point of the multimeter will be determined, indicating that measurement systems have a limited accuracy range depending on the frequency of the signal.

Pre-Lab Assignment

1. Read chapter 1 and 3 - Wheeler and Ganji text.
2. Do problem 3.1 in the text. Report the answer for G= and GdB=
3. Solve problem 3.2. The output voltage is
4. Do problem 3.13 in the text. The resistor values are
5. A multimeter measures an 8.0 volt 100 Hz sine wave. Determine the peak-peak voltage, peak voltage, and period.
Assignment 1: Initialize the oscilloscope

The initialization of the oscilloscope is required to set the instrument to a point from which all measurements can be referenced. The following procedure should be used when the oscilloscope is used to quantify signals generated from transducers.

Procedure

1. Display System Controls
   a. Verify that the power is off.
   b. Set the INTENSITY control to the mid range position.
   c. Turn the FOCUS knob completely clockwise.

2. Vertical System Controls
   a. Turn the channel 1 POSITION control completely counterclockwise.
   b. Set the left vertical MODE switch to CH. 1, the middle switch to NORM, and the right switch to ALT.
   c. Set channel 1 and 2 VOLTS/DIV switches to the least sensitive setting (5 VOLTS/DIV).
   d. Turn the CAL control knob in the center of the VOLTS/DIV knob fully clockwise

3. Horizontal System Controls
   a. Set the HORIZONTAL MODE switch to X1.
   b. Rotate the SEC/DIV switch to 0.5 milliseconds per division.
   c. Turn the CAL control knob in the center of the SEC/DIV knob fully clockwise.

4. Trigger System Controls
   a. Set the SLOPE switch for a positive waveform (up).
   b. Adjust the LEVEL control to approximately mid-range.
   c. Set the MODE switch to P-P AUTO.
   d. Set the HOLD-OFF control completely counterclockwise to the MIN position.
   e. Set the left SOURCE switch to CH1.
   f. Set the COUPLING switch to DC.

5. Turn the oscilloscope on by pressing the power button. Allow the oscilloscope to warm up for a few moments.

6. Press the BEAM FIND button while rotating the vertical and horizontal POSITION controls to approximately center the trace on the cathode ray tube (CRT).

7. Release the BEAM FIND button and center the resulting beam on the CRT using the HORIZONTAL and VERTICAL POSITION knobs.

8. Adjust the FOCUS and INTENSITY control knobs as necessary.

The oscilloscope is now set to quantify electric signals. This initialization process should be employed whenever the oscilloscope is used to quantify the output from a transducer.
Assignment 2: Quantifying Sinusoidal Waveforms

A digital multimeter can be used to measure current, resistance, and the voltage of a signal. When an AC signal is recorded, the multimeter displays the root mean square (Vrms) value which can be used to obtain the peak (Vp), and peak-peak (Vpp) values of the wave. The oscilloscope is capable of measuring voltage only. However, unlike the multimeter, the oscilloscope displays the signal on a CRT allowing the period (T) and frequency of the signal to be calculated.

Procedure

1. Refer to figure # 1 for proper equipment configuration. Use channel # 1 as the input to the oscilloscope and the MAIN as the output from the function generator. Set the function generator to output a 100 Hz sinewave at a maximum amplitude.

![Figure#1 Equipment used to quantify electric energy](image)

2. Set the oscilloscope channel #1 COUPLING to AC. Adjust the VOLTS/DIV and SEC/DIV knobs as necessary.

3. Observe the signal with the digital multimeter and oscilloscope. Record the Vpp, Vp, Vrms, and period of the signal.

4. Adjust the amplitude on the function generator to output a 5.0 Vrms, 100 Hz. sinewave. Record the Vpp, Vp, Vrms, and period.

5. Set the function generator output frequency to 10,000 Hz. Record the Vpp, Vp, Vrms, and period.
Assignment 3: Two Channel Analysis

In assignment #2, the digital multimeter was used to quantify the amplitude of an AC signal. In order to quantify a DC signal, the multimeter AC/DC switch must be set to DC. The oscilloscope is capable of measuring two signals simultaneously. Each signal can be comprised of an AC and DC component. If only the AC component of the signal is to be monitored, the oscilloscope should be set to AC coupling. If both the AC and DC components of the signal are desired, the oscilloscope should be set to DC coupling. The objective of this assignment is to introduce two channel analysis using the oscilloscope and examine the effects of AC/DC coupling.

Procedure

1. Refer to figure #2 for proper equipment configuration.

![Figure #2 Two channel analysis with AC / DC coupling](image)

2. Set the left MODE switch to BOTH. This will allow channels #1 and #2 to be viewed simultaneously.
3. Set the output of the function generator to 5 Vrms at 1000 Hz. Connect the output from the function generator to channel #1 of the oscilloscope.
4. Connect the output from the LA 300 power supply to channel #2 of the oscilloscope.
5. Set the oscilloscope channel #2 COUPLING to GND.
6. Zero the trace on the CRT for channel #2 using the VERTICAL POSITION control.
7. Set the oscilloscope channel #2 COUPLING to DC.
8. Adjust the output voltage from the LA 300 power supply to 10 Vdc.
9. Record the Vpp, Vp, Vrms and periods associated with channels #1 and #2.
10. Set the oscilloscope channel #2 COUPLING to AC.
Assignment 4: Digital Multimeter Upper Usable Frequency Range

The multimeter can be used to measure the RMS voltage of an AC signal, but it has an upper usable frequency called the 3dB down point. The 3 dB down point is defined as the frequency at which the measured voltage (Vo) drops to 1/sqrt(2) of the actual input voltage (Vi). The 3 dB down point will be determined by generating a sinusoidal wave at a constant amplitude with the function generator. The amplitude of the signal will be recorded with the multimeter and oscilloscope at various frequencies. The 3dB down point can then be determined by plotting the ratio of the measured voltage (Vo) to the input voltage (Vi) in dB (Eq. 3.2 on p. 36 in text) versus frequency. The frequency at which the ratio drops by 3 dB is the 3dB down point.

Procedure

1. Equipment configuration will be identical to assignment #2 (refer to figure #1).

2. Set the output from the function generator to 5 volts peak-peak at 100 Hz.

3. Vary the output frequency from 100 Hz. to approximately 1 MHz. in 10 to 15 steps. At each frequency setting, record the voltage on the oscilloscope (Vi) and on the digital multimeter (Vo).

4. Plot the dB value versus frequency. Determine where the multimeter begins to become inaccurate. Increase the resolution of the measurement as needed.

Post-Lab Analysis

1. Tabulate the quantities measured in assignments #2 and #3.

2. What is the primary difference between the oscilloscope and digital multimeter?

3. Explain the difference between AC and DC coupling.

4. What purpose does the function generator serve?

5. What is the 3 dB down point of the Fluke 8010A multimeter?

6. Plot the Vo/Vi in dB vs. frequency from assignment #4.