# **MEP 365 Thermal Measurements**

# Getting Familiar with measurement and instrumentation

# **Experiment No. 1**

Oct. 2016

Name	Computer No

Date of the experiment	
Date of submission	

# **1- Objectives**

To get familiar with the fundamental measurement instruments and learn how to use them.

## **2-Introduction**

Measurement is an every day activity in our life. Engineers should be capable to know basic instruments, and how to use them. Mechanical engineers in particular should also know instruments used to measure related variables such as temperature, pressure, flow rate, force and alike. This lab session is designed to give a student an introduction about basic instruments. Among the instrument to be presented are:

- 1-Digital Multi-Meter (DMM)
- 2-Oscilliscope & function generator
- 3-Temperature measuring devices
  - a- Thermometers
  - b- RTD (Resistance Temperature Detector)
  - c- Thermistor
  - d- Thermocouple

In the following section a brief idea about each of the above instrument will be given. More details about theses instruments can be found in your textbook, the library, or the internet

## 2.1 Digital Multi-meter

There are many types of multi-meters and manufacturers. Multi-meters come as analog (dial) or digital type. The most common used type today is the digital one. Generally multi-meters are used to measure electric variables such as voltage (both AC and DC) resistance, capacitance and current. Figure 1 shows a photo of a typical Digital Multi-Meter (DMM). More sophisticated multi-meters can be used to:

- measure electric power
- measure transistor characteristics
- test for continuity (with sound buzzer)
- test diodes and transistors
- measure temperature using thermocouple probe



Figure 1 shows a picture of a typical digital multi-meter

### 2.2 Oscilloscope & function generator

Oscilloscope is an instrument that can graphically display signal (usually time varying) such voltage (i.e. since wave). Once the signal is displayed on the screen, its characteristics can be measured such as wave period (and frequency), and peak to peak value (or amplitude). Most oscilloscope can display two input signals, other can display more than that. Figure 2 shows a picture of an oscilloscope. A typical sine wave is shown on Fig. 3. Notice that the frequency of the signal can be found once the time period is measured using

$$f=1/T$$
 (1)

where

f is the frequency in Hz

T is the wave period in seconds.

The time of signal usually displayed in the x axis of the oscilloscope. The period of a signal T is the time between two peaks of the signal.

The function generator is basic a device that is capable of producing different signals (sine wave, square wave, triangular wave) with different amplitude and frequencies. To study periodic signals, the wave generated by the function generator is fid to the oscilloscope.



Figure 2 An Oscilloscope



Figure 3 Typical shape of sine wave

### 2.3 Basic Temperature measurement

Temperature is very important variable in our daily life. Medical doctor measure human body temperature, weather specialists reports the maximum and minimum daily temperatures, and so on. Temperature is a very important variable in the study of a mechanical engineer (Thermal section), An introduction on measuring this variable is introduced here. There are many methods to measure temperature. The objective in this experiment is not to do a detailed calibration experiment for temperature measurement; instead the goal is to introduce few instruments used to measure the temperature. The instruments and devices that will be illustrated in the session are:

a) Thermometer: the temperature is measured due to the thermal expansion of mercury or other liquids. The mercury is kept in the bulb. The expansion is indicated on the scale of the stem of the thermometer.

b) RTD (Resistance Temperature Detector): Here the electric resistance of the special wire (usually platinum) is an indication of the temperature. The RTD resistance increases with temperature.

c) Thermistor: Again the electric resistance is utilized to measure temperature, but here since the material of the thermistor is a semi conductor, the resistance decreases with the temperature.

d) Thermocouple: When two dissimilar wires are joint at one end, there will be an emf (Electro Motive Force) or voltage generated at the other end. The generated voltage is proportional to the joint or junction temperature. There are many well know types of thermocouples that are made of certain specified materials. Type T for example is made from copper and constantan. Type K is made from chromel and alumel, and type J is made from iron and constantan. Of course the voltage generated from these types differs even for the same junction temperature.

### **3 Procedures**

### 3.1 Resistance measurement using multi-meter and color code

Inspect the multi-meter available in our laboratory. See the capabilities of the device; notice the variables that can be measured by turning the main knob. Notice generally that the multi-meter can measure AC and DC voltages, resistance and current. Notice also the probes of the multi-meter, and where to put them correctly in order to measure voltage, resistance, or current.

The value of the resistance for some resistance types can be found using the color bands found on the resistance. These color bands are generally four small rings of color on the resistance. Some resistances have five bands of color on them. For four band color resistor, hold the resistance so that you see three colors to your left and one color at the other right end of the resistor. Usually the color on the resistance appears as shown on Figure 4. The three color close to each others give the value of the resistor, and single ring of color at right gives the accuracy (or tolerance) of the resistance as a percentage of the resistance value. The following equation then can be used to calculate the resistance

$$R=ab*10^{c} \pm tol$$
(3)

### Where

a, b and c values are given in Table 1 according to the colors on the resistance. Notice here that a is not multiplied by b



Figure 4 Color codes for resistances

a h and c	hands		tol b	and
a o and c oands			101 0	and
color	value		Gold	±5 %
Black	0		Silver	±10 %
Brown	1		Nothing	±20 %
Red	2			
Orange	3			
Yellow	4			
Green	5			
Blue	6			
Violet	7			
Gray	8			
White	9			

For a resistance with the following colors Brown-Black-Orange, and silver for tol, the values of a, b and c from table 1 are 1, 0, and 3, so using the equation above, the resistance value is  $10k\Omega\pm10\%$ . The tolerance is  $\pm10\%$ since the tolerance color is silver.

You will be given three resistances, measure them using the multi-meter. Also see the colors on the resistances, and calculate the resistance value based on equation 3. Record your findings in Table 2 below.

1 able 2 measurement of resistance	Table 2	measurement	of resistance
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#	R (as measured by the	Resistance colors	R (as indicated by the	Tol
	multi-meter		color)	(%)
1				
2				
3				

## 3.2 Measurement of voltage using the multi-meter

You will be given three batteries to measure the voltage of each. Use the main knob of the multi-meter to select DC voltage on the multi-meter, and measure the voltage of each and indicate its value on the table below. On the same table, measure the voltage from AC/DC power supply provided to you in the lab., and record its value also in Table 3.

# Table 1 Color codes for resistances

#	Battery type	Voltage [ ]
1		
2		
3		
4	AC/DC power supply	

### Table 3 Voltage measurement

### 3.3 Measure continuity using the multi meter

The laboratory instructor will give you bunch of wires; use the multi-meter to identify the two end of each wire using the continuity (sound buzzer) feature in the multi-meter. Move the knob to sound buzzer, connect one end of the multi-meter leads to one end of one wire and the other lead to the wire at the other end, when sound is heard then you have identified the wire.

### 3.4 Measurement of the output voltage of a voltage divider circuit

Voltage circuit divider is used extensively in measurement. The circuit is shown below. Here the current through the circuit is given by

$$i=V_i/(R_1+R_2)$$
 (4)

the output voltage then is given by

$$V_0 = i^* R_2 = (V_i / (R_1 + R_2))^* R_2$$
(5)

Voltage divider circuit is shown in Figure 5. You will see a setup of a breadboard similar to the circuit. For the circuit shown below, measure  $V_i$ ,  $R_1$ ,  $R_2$ , and  $V_o$  and write the values in the Table 4 below. Also calculate the output voltage using the above equation (5) and write the value in the table.



Figure 5 Voltage divider circuit

Vi	R <sub>1</sub>	<b>R</b> <sub>2</sub>	Vo	Vo
Input	Resistance R <sub>1</sub>	Resistance R <sub>2</sub>	Output voltage	Output voltage
voltage			(measured)	(calculated)

Table 4 Voltage divider measurement

# 3.5 Using the Oscilloscope to identify and characterize a periodic signal

Here, a sine wave signal will be generated by the function generator, and will be captured by the oscilloscope. The steps for the procedure are:

1-With the help of the laboratory instructor, use the function generator to generate a sine wave with frequency 100 Hz, and peak to peak voltage between 3-30 volts.

2-Using a BNC-BNC cable to connect the output port of the function generator to channel 1 in the oscilloscope.

3-The divisions for x-axis (i.e. time) will be indicated on the screen. You can play with the horizontal knob to adjust it so that the signal will be complete and readable on the screen.

4-You can also adjust the vertical y-axis so that it is easy to measure peak to peak voltage

5-Record the wave period and peak-to-peak voltage on the table below. Also calculate the frequency using equation (1) above.

6-At least repeat the measurement for 3 set of readings by changing the frequency, f, the peak-to-peak voltage  $V_{p-p}$  or both on the function generator

#	Hz [From	function	$(V_{p-p})_G$	Period,	Frequency,	$(V_{p-p})_O$	Remarks
	generator]		[V]	T [s]	f [Hz]	[V]	
Signal 1							
Signal 2							
Signal 3							
Signal 4							

Table 5 Oscilloscope measurement

### 3.6 Measuring temperature by different means

The following probes and devices will be provided to at the lab.

- 1-Fluid in glass thermometer
- 2-RTD sensor with readout
- 3-Thermistor with read out
- 4-Therocouple with readout

Inspect each of the above devices. Notice the device accuracy, capabilities and shape. On the table below record the room temperature as indicated by the instrument. Also the laboratory instructor will adjust the cold bath to a fixed temperature. Use the above temperature instruments to measure the temperatures. Record the temperatures on the Table 6 below. The cold bath will be set to a specified temperature,  $T_{set}$ . Measure the cold temperature using different instruments, and record the temperature in the table below.

Table 6 Basic temperature measurements

#	Thermo-meter	RTD reading	Thermistor	Thermocouple
	reading		reading	reading
Room temperature				
Cold bath temperature				
[T <sub>set</sub> = ]				

In the table below list all the instruments used in this laboratory session and the purpose of each

Table 7 List	t of instrument a	and device us	sed during tl	his lab session
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No	Instrument or device	Purpose
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

At the end of this lab. period write one paragraph **conclusion** about the activity performed during this lab session.

# Grade distribution

No	Item	Grade
1	Attend the lab. session on the assigned date and participate in the experiment	20
	activities	
2	Fill all the tables as described in the experiment handout	20
3	List all the instruments and devices used in this lab. session and function or	10
	purpose of each [Table 7]	
4	Select one of the instrument or devices as you have listed them in Table 7, or	20
	follow the instructor suggestion. Search the local market for selected measuring	
	instrument. Indicate the technical data of the device and cost	
5	Conclusion statement	10
6	Overall impression about the report and neatness of the report	20
	Sum	100