Federal Urdu University of Arts,Science & Technology

LAB MANUAL

INSTRUMENTATION & MEASUREMENTS

BASIC ELECTRICAL & ELECTRONICS LAB
DEPARTMENT OF ELECTRICAL ENGINEERING

Prepared By:

Engr. Yousaf Hameed

Lecturer (Lab) Electrical,
FUUAST-Islamabad

Checked By:

Engr. M.Nasim Khan

Senior Lab Engineer Electrical,
FUUAST-Islamabad

Approved By:

Dr.Noman Jafri

Dean,
FUUAST-Islamabad

Name: ____

Registration No: ________________________________

Roll No: ______________________________________

Semester: _____________________________________

Batch: ____

CONTENTS

Exp No	List of Experiments
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14,15,16	

EXPERIMENT NO – 01

FAMILIARIZATION ED-1010 TRAINING SYSTEM

A. Introduction

Electric electronic Trainer ED-1010 is experimental equipment for studding basic theories of electric electronic circuits and performing experiments. ED-1010 is consisted of power console as it main frame, 17 Experimental Modules, and additional 3 optional modules.

Each experimental module has 3-6 experimental circuits that are similar to or correlated with each other. In each circuit, you can experiment on the comparison of characteristics and the change of integers. In addition, thanks to the graphical representation of experimental circuits on each module panel as well as circuit parts actually attached to circuit, you can be more familiar with the training and understand it more easily.

For the purpose of avoiding complexity of circuit, jumper plug with 12mm of spacing is commonly used except particular cases. Thus, wires may not obstruct circuit at the complete configuration of circuit.

You can connect 2 experimental modules to power console at a time. The power console is equipped with 1 AC/DC volt meters that are essential for training. Power for experimental modules is supplied from OUTPUT-1 and OUTPUT-2 at the front of console, which are connected with module input cable. Besides, these outputs are also connected with additional terminals for convenience of training, and each of these terminals has protective circuit against over load. As for the data as results of experiment, you may use PC with ED-1010 Software for the arrangement, and training teacher may also manage it by marking.

Software is managed as follows:

- **Software for student**: Contents are composed of theory, exercise, etc. In this software, student can record data of experiment results in a table together with opinions and questions, with the intention of them to a teacher through Network or Disk.
- **Software for teacher**: With this software, teacher can grade data given by students automatically or manually on the basis of answers that teacher enters in advance. And can easily manage experiment results and records of students with files per student or group of students.

SPECIFICATION

B. MAIN FRAME (POWER CONSOLE)

1) POWER SUPPLY SECTION

- DC Output 0 ~20V, 2A (Connecter & Terminal Output)
  +12V, 1A (Connecter & Terminal Output)
  ± 5V, 1A (Connecter & Terminal Output)
  ± 15V, 1A (Connecter Output)
- AC Output 24V (CT), 0.5A (Connecter & Terminal Output)
  110V, 0.5A (Terminal Output)
  220V, 0.5A (Terminal Output)

2) INDICATION

- Variable Voltage Output………………. 0 -20V FS AVM
  0 -2A FS AAM
- Digital Volt Meter…………………….. AC/DC 2V, 20V FS
- Digital Current Meter…………………. AC/DC 0.2A 2A FS

3) PROTECTION CIRC UIT

- AC Output Circuit ……………………… 12V+12V (24V) (With Reset)
- DC Output Circuit ……………………… +12V, 5V, -5 (With Reset)

4) **INPUT POWER** …………………………….. AC 220V, 50/60Hz

5) **DIMENSION**……………………………….... 600(W) X200(H) X180(D) mm

6) **WEIGHT** ……………………………………...14 Kg (Approx.)

C. MODULE/ACCESSORIES

1) MODULE & STORAGE BOX

- Quantity of Module…………………………… 20ea (Option Module: 3ea included)
- Dimension (Module)…………………………. 310(W)x32(H)x220(D)mm
- Dimension (Storage Box)……………………. 744(W)x900(H)x420(D)mm
- Total Weight …………………………………………….. 145Kg

2) OPERATING SOFTWARE & ACCESSORIES

Operating Software (provided as CD or Floppy Disk)

Hardware Environment

RAM: 8 M-byte or above (Recommendation: 16 M-byte or above)

CPU: IBM PC or Compatible Model 486 or above (Recommendation: Pentium or above)

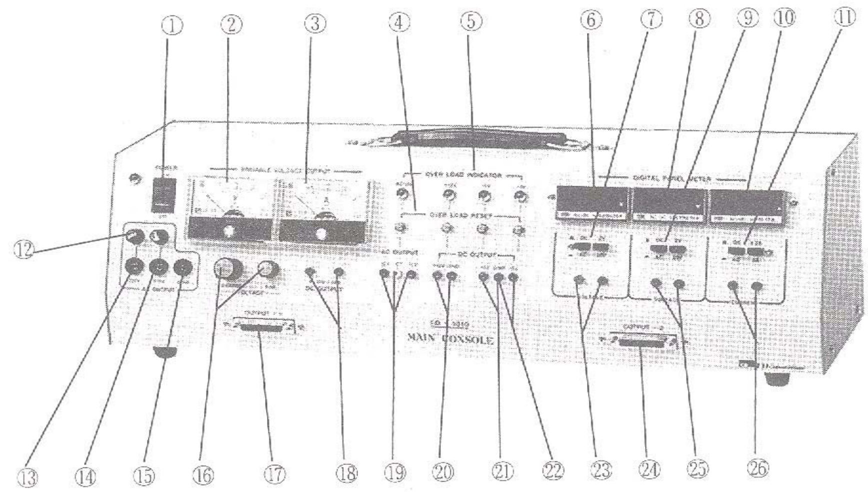
Resolution: 800x600 or above (Recommendation: 1024 x 768 modes)

OS Environment

- Windows95 or Windows NT
- Equipment Guide
- Connection Cord (Jumper included)
- Connector Cable (for connection of Module Power) – 2ea
- AC Power Cord

D. POWER CONSOLE

1) Descriptions on Panel



1. **POWER:** Power ON/OFF switch of Power Console
2. **VOLT-METER:** Volt meter for DC 0-20V variable voltage output
3. **AMPERE-METER:** Shows load current by DC 0-20V output
4. **OVER LOAD RESET:** Button switch for Over Load Reset of AC 24V (12V CT), DC +12V, -5V, +5V outputs
5. **OVER LOAD INDICATOR:** Lamp indicating overload of the outputs in the above④
6. **AC/DC VOLTMETER:** AC/DC 0-20v (FS) Digital Voltmeter
7. **RANGE:** Selective Switch for 0-20V/0-20V of AC/DC and input range of Digital Voltmeter shown in the above ⑥
8. **AC/DC VOLTMETER:** AC/DC 0-20V (FS) Digital Voltmeter
9. **RANGE:** Selective Switch for 0-2V/0-20V of AC/DC and input range of Digital Voltmeter shown in the above ⑨
10. **AC/DC AMMETER:** AC/DC 0-2A (FS) Digital Ammeter
11. **RANGE:** Selective switch for 0-200mA/0-2A of AC/DC and input Range if Digital Ammeter
12. **FUSE HOLDER:** AC 220V (0.5A) and AC 110V (0.5A) output Fuse Holder
13. **220V:** AC 220V output Terminal (4 Ø Safety Terminal)
14. **110V:** AC 220V output Terminal (4 Ø Safety Terminal)
15. **COM:** Common Terminal of AC 110/220V Output

16. **COARSE/FINE:** DC 0-20V Output Voltage Adjuster (FINE is for fine adjustment)
17. **OUTPUT-1:** Connector to connect Power to Experimental Modules
18. **OUTPUT:** DC 0-20V (2A) Output Terminal
19. **AC OUTPUT:** AC 12V, CT, 12V, Output Terminal
20. **+12V/GND:** DC +12V Output Terminal
21. **+5V/GND:** DC +5V Output Terminal
22. **-5V/GND:** DC -5V Output Terminal
23. Input Terminal of AC/DC Digital Voltmeter in ⑥
24. **OUTPUT – 2:** Connector to connect Power to Experimental Module
25. Input Terminal of AC/DC Digital Voltmeter in ⑧
26. Input Terminal of AC/DC Digital Voltmeter in ⑩

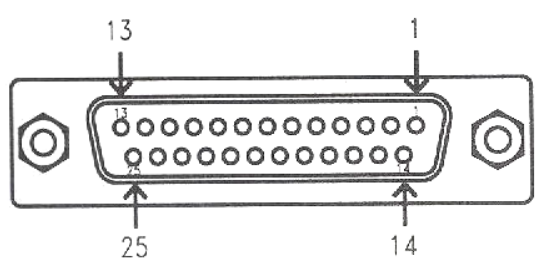
E. Description on Output Connector of Power Console

The following table represents details on Connector for supplying power to the experimental modules attached to Main Frame (OUTPUT-1 and OUTPUT-2) and PCB Connector of experimental modules. At this time, it needs to be remembered that modules do not require all of various AC/DC voltages connected through Connector, during training.

Output Voltage and Connector Pin No.

OUTPUT VOLTAGE	CONSOLE (RS-232C)	MODULE (PCB)	OUTPUT VOLTAGE	CONSOLE (RS-232C)	MODULE (PCB)
AC 12V	1	1	GND	8	9
CT	2	2	+5V	9	10
AC 12V	3	3	GND1	10	11
N.C	-	4	-5V	11	12
+15V	4	5	GND1	12	-
COM	5	6	GND2	13	13
-15V	6	7	DC 0-20V	14	14
+12V	7	8			

* GND2, which is one of DC 0-20V GND terminals, is electrically insulated from GND1 terminal.



F. Operation

Before conducting an experiment using ED1010 Trainer, you need to prepare Modules required for experiment and then operate Power Console as shown in the followings;

(1) Remove all of the output connection wired from output terminal of Power Console if connected.

(2) Turn the power switch of Power Console OFF.

(3) Connect Power Cord which is located on the rear panel to AC power.

(4) Configure circuit of experimental module prepared according to each subject or experiment using Jumper Plug and Jumper Cord.

(5) Connect the output connector (RS-232C) at the front of Power Console with Module using module connection cable.

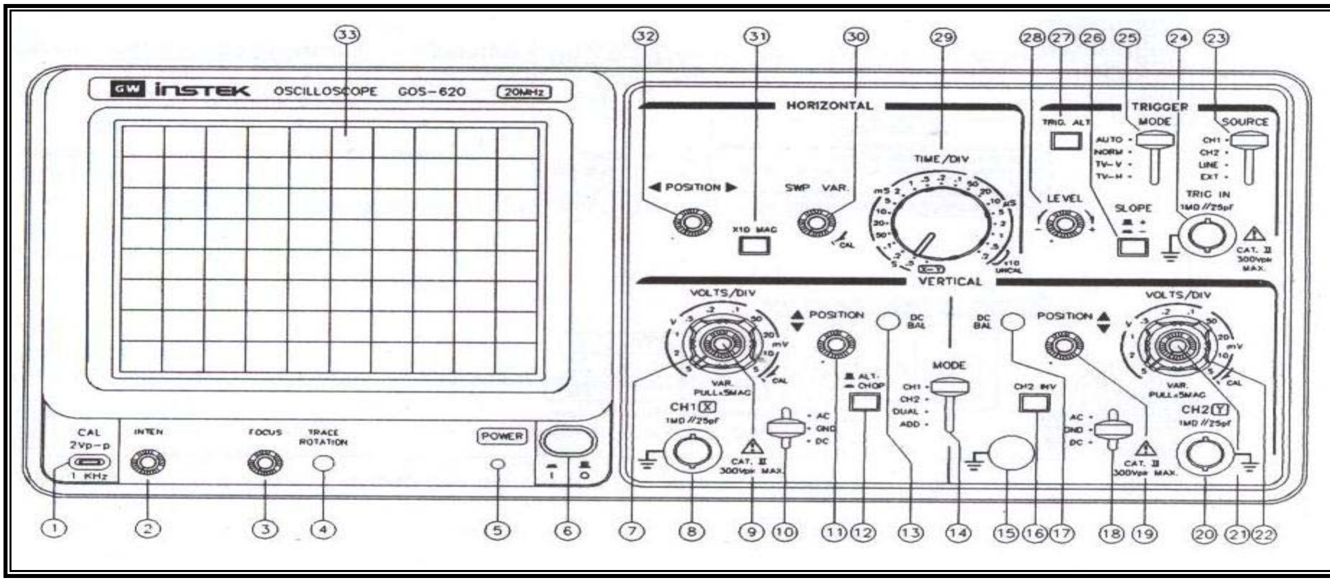
(6) Turn the handle with DC 0-20V of setting range at the front of console to Min. counterclockwise.

(7) Turn the power switch of Console ON to supply power to experimental modules. If necessary, adjust voltage output from Console 2 terminals and DC 0-20V of variable voltage output.

EXPERIMENT NO – 02

STUDY AND THE USE AND WORKING OF OSCILLOSCOPE

Dual Trace Oscilloscope 20MHz (GW INSTEK GOS-620)



Introduction of Front Panel

CRT :

POWER......................(6)
Main power switch of the instrument. When this switch is turned on, the LED (5) is also turned on.

INTEN........................(2)
Controls the brightness of the spot or trace.

FOCUS.......................(3)
For focusing the trace to the sharpest image.

TRACE ROTATION....(4)
Semi-fixed potentiometer for aligning the horizontal trace in parallel with graticule lines.

FILTER.......................(33)
Filter for ease of waveform viewing.

Vertical Axis:

CH 1 (X) input............(8)
Vertical input terminal of CH 1.When in X-Y operation, X-axis input terminal.

CH 2 (Y) input............(20)
Vertical input terminal of CH 2.When in X-Y operation, Y-axis input terminal.

AC-GND-DC..............(10)(18)
Switch for selecting connection mode between input signal and vertical amplifier.
- AC : AC coupling
- GND : Vertical amplifier input is grounded and input terminals are disconnected.
- DC : DC coupling

VOLTS/DIV...............(7)(22)
Select the vertical axis sensitivity, from 5mV/DIV to 5V/DIV in 10 ranges.

VARIABLE................(9)(21)

Fine adjustment of sensitivity, with a factor of ≥1/2.5 of the indicated value. When in the CAL position, sensitivity is calibrated to indicated value. When this knob is pulled out(x5 MAG state), the amplifier sensitivity is multiplied by 5.

CH1 & CH2 DC BAL.(13)(17)

These are used for the attenuator balance adjustment. See page 20 DC BAL adjustments for the details.

▲ ▼ POSITION...........(11)(19)

Vertical positioning control of trace or spot.

VERT MODE............(14)

Select operation modes of CH 1 and CH 2 amplifiers.

CH 1 : The oscilloscope operates as a single-channel instrument with CH 1 alone.

CH 2 : The oscilloscope operates as a single-channel instruments with CH 2 alone.

DUAL : The oscilloscope operates as a dual-channel instrument both CH 1 and CH 2.

ADD : The oscilloscope displays the algebraic sum (CH 1 + CH 2) or difference (CH 1 - CH 2) of the two signals. The pushed in state of CH 2 INV(16) button is for the difference (CH 1 - CH 2).

ALT/CHOP.................(12)

When this switch is released in the dual-trace mode, the channel 1 and channel 2 inputs are alternately displayed (normally used at faster sweep speeds).

When this switch is engaged in the dual-trace mode, the channel 1 and channel 2 inputs are chopped and displayed simultaneously (normally used at slower sweep speeds).

CH2 INV....................(16)

Inverts the CH2 input signal when the CH2 INV switch mode is pushed in The channel 2 input signal in ADD mode and the channel 2 trigger signal pickoff are also inverted.

Triggering:

EXT TRIG IN input terminal........(24)

Input terminal is used for external triggering signal. To use this terminal, set SOURCE switch (23) to the EXT position.

SOURCE.................(23)

Select the internal triggering source signal, and the EXT TRIG IN input signal.

CH 1 : When the VERT MODE switch(14) is set in the DUAL or ADD state, select CH 1 for the internal triggering source signal.

CH 2 : When the VERT MODE switch(14) is set in the DUAL or ADD state, select CH 2 for the internal triggering source signal.

TRIG.ALT(27) : When the VERT MODE switch(14) is set in the DUAL or ADD state, and the SOURCE switch(23) is selected at CH 1 or CH 2, with the engagement of the TRIG.ALT switch(27), it will alternately select CH 1 & CH 2 for the internal triggering source signal.

LINE : To select the AC power line frequency signal as the triggering signal.

EXT : The external signal applied through EXT TRIG IN input terminal(24) is used for the external triggering source signal.

SLOPE.....................(26)

Select the triggering slope.

"+" : Triggering occurs when the triggering signal crosses the triggering level in positive-going direction.

"- " : Triggering occurs when the triggering signal crosses the triggering level in negative-going direction.

LEVEL....................(28)

To display a synchronized stationary waveform and set a start point for the waveform.

Toward "+" : The triggering level moves upward on the display waveform.

Toward "-" : The triggering level moves downward on the display waveform.

TRIGGER MODE....(25)

Select the desired trigger mode.

AUTO : When no triggering signal is applied or when triggering signal frequency is less than 25 Hz, sweep runs in the free run mode.

NORM : When no triggering signal is applied, sweep is in a ready state and the trace is blanked out. Used primarily for observation of signal ≤ 25 Hz.

TV-V : This setting is used when observing the entire vertical picture of television signal.

TV-H : This setting is used when observing the entire horizontal picture of television signal.

(Both TV-V and TV-H synchronize only when the synchronizing signal is negative.)

Time Base

TIME/DIV......…………...(29)

Sweep time ranges are available in 20 steps from 0.2 uS/div to 0.5 S/div.

X-Y : This position is used when using the instrument as an X-Y oscilloscope.

SWP.VAR..........…………..(30)

Vernier control of sweep time. This control works as CAL and the sweep time is calibrated to the value indicated by TIME/DIV. TIME/DIV of sweep can be varied continuously when shaft is out of CAL position. Then the control is rotated in the direction of arrow to the full, the CAL state is produced and the sweep time is calibrated to the value indicated by TIME/DIV. Counterclockwise rotation to the full delays the sweep by 2.5 time or more.

◂ ▸ POSITION......………..(32)

Horizontal positioning control of the trace or spot.

x 10 MAG.......…….…….(31)

When the button is pushed in, a magnification of 10 occurs.

Others

CAL………....……….........(1)

This terminal delivers the calibration voltage of 2 Vp-p, 1kHz, positive square wave.

GND...............…………....(15)

Ground terminal of oscilloscope mainframe.

Introduction of Rear Panel

Z AXIS INPUT...............….(34)

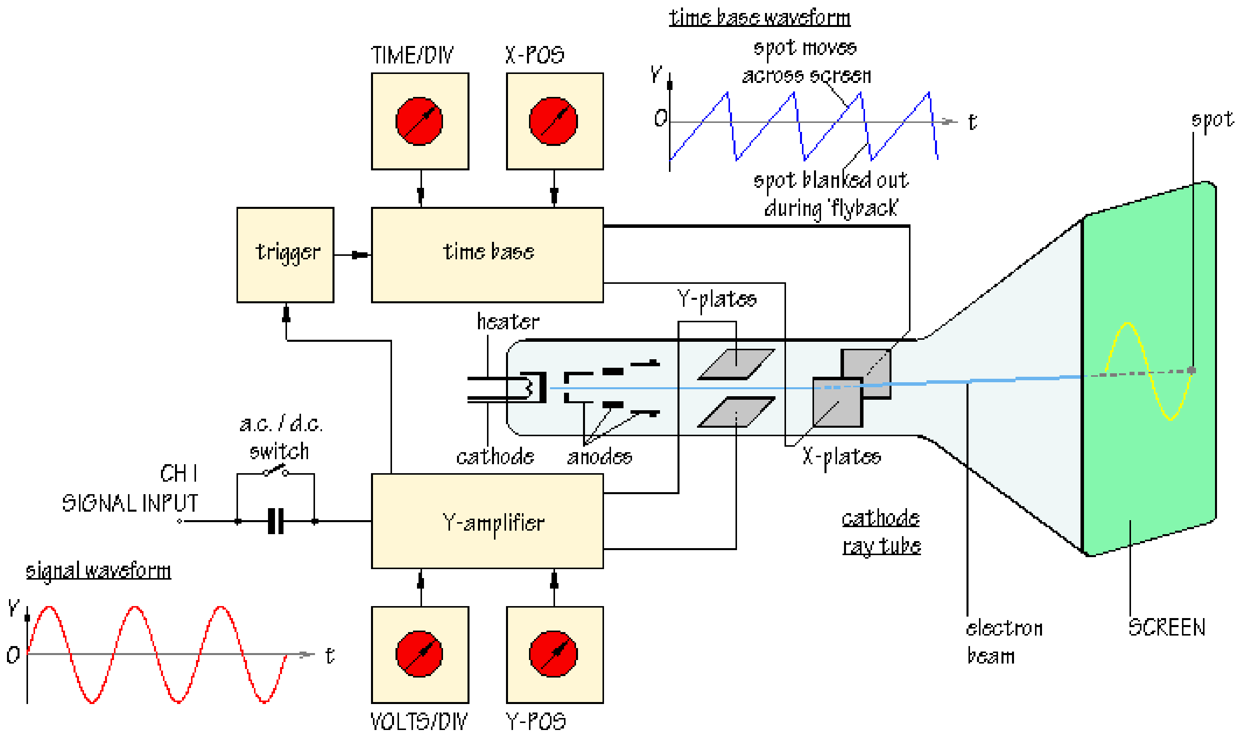
Input terminal for external intensity modulation signal.

CH 1 SIGNAL OUTPUT.....(35)

Delivers the CH 1 signal with a voltage of approximately 20mV per 1 DIV into a 50-ohm termination. Suitable for frequency counting, etc.

How does an oscilloscope work?

An outline explanation of how an oscilloscope works can be given using the block diagram shown below:



Like a television screen, the screen of an oscilloscope consists of a **cathode ray tube**. Although the size and shape are different, the operating principle is the same. Inside the tube is a vacuum. The electron beam emitted by the heated cathode at the rear end of the tube is accelerated and focused by one or more anodes, and strikes the front of the tube, producing a bright spot on the screen.

The electron beam is bent, or deflected, by voltages applied to two sets of plates fixed in the tube. The horizontal deflection plates or **X-plates** produce side to side movement. As you can see, they are linked to a system block called the **TIME BASE**. This produces a saw tooth waveform. During the rising phase of the saw tooth, the spot is driven at a uniform rate from left to right across the front of the screen. During the falling phase, the electron beam returns rapidly from right to left, but the spot is 'blanked out' so that nothing appears on the screen.

In this way, the time base generates the X-axis of the *V*/*t* graph.

The slope of the rising phase varies with the frequency of the saw tooth and can be adjusted, using the TIME/DIV control, to change the scale of the X-axis. Dividing the oscilloscope screen into squares allows the horizontal scale to be expressed in seconds, milliseconds or microseconds per division (s/DIV, ms/DIV, µs/DIV). Alternatively, if the squares are 1 cm apart, the scale may be given as s/cm, ms/cm or µs/cm.

The signal to be displayed is connected to the **input**. The AC/DC switch is usually kept in the DC position (switch closed) so that there is a direct connection to the **Y-amplifier**. In the AC position (switch open) a capacitor is placed in the signal path. As we know, the capacitor blocks DC signals but allows AC signals to pass.

The Y-amplifier is linked in turn to a pair of **Y-plates** so that it provides the Y-axis of the *V*/*t* graph. The overall gain of the Y-amplifier can be adjusted, using the VOLTS/DIV control, so that the resulting display is neither too small nor too large, but fits the screen and can be seen clearly. The vertical scale is usually given in V/DIV or mV/DIV.

The **trigger** circuit is used to delay the time base waveform so that the same section of the input signal is displayed on the screen each time the spot moves across. The effect of this is to give a stable picture on the oscilloscope screen, making it easier to measure and interpret the signal.

Changing the scales of the X-axis and Y-axis allows many different signals to be displayed. Sometimes, it is also useful to be able to change the *positions* of the axes. This is possible using the **X-POS** and **Y-POS** controls. For example, with no signal applied, the normal trace is a straight line across the centre of the screen. Adjusting Y-POS allows the zero level on the Y-axis to be changed, moving the whole trace up or down on the screen to give an effective display of signals like pulse waveforms which do not alternate between positive and negative values.

EXPERIMENT NO – 03

STUDY AND THE USE OF FUNCTION SIGNAL GENERATOR

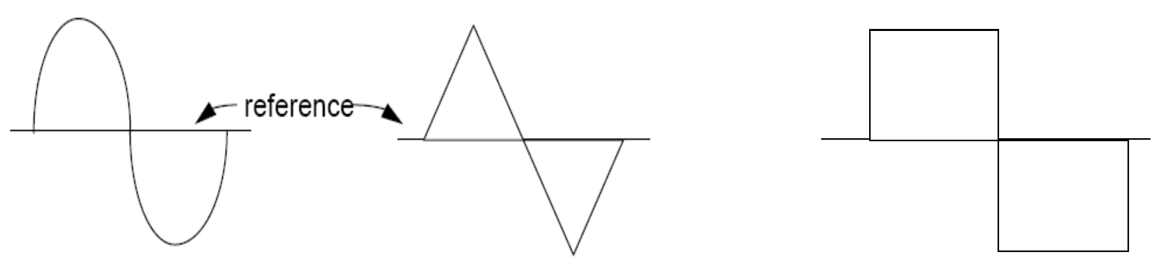
What is a function generator?

A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes. It is used to test the response of circuits to common input signals. The electrical leads from the device are attached to the ground and signal input terminals of the device under test.

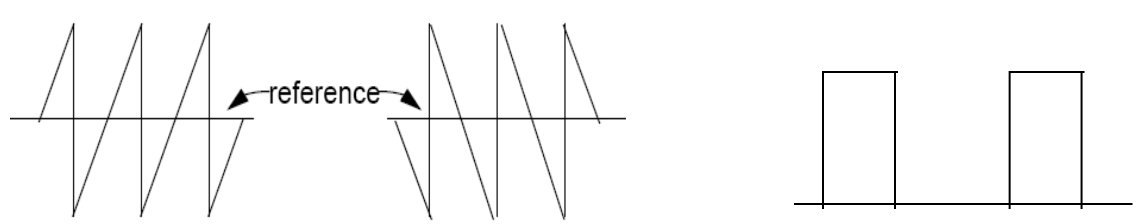
Features and controls

Most function generators allow the user to choose the shape of the output from a small number of options.

- Square wave - The signal goes directly from high to low voltage.
- Sine wave - The signal curves like a sinusoid from high to low voltage.
- Triangle wave - The signal goes from high to low voltage at a fixed rate.



SINE WAVE TRIANGLE WAVE SQUARE WAVE



SAWTOOTH SAWTOOTH PULSE

The amplitude control on a function generator varies the voltage difference between the high and low voltage of the output signal.

The frequency control of a function generator controls the rate at which output signal oscillates. On some function generators, the frequency control is a combination of different controls. One set of controls chooses the broad frequency range (order of magnitude) and the other selects the precise frequency. This allows the function generator to handle the enormous variation in frequency scale needed for signals.

The duty cycle of a signal refers to the ratio of high voltage to low voltage time in a square wave signal.

How to use a function generator

After powering on the function generator, the output signal needs to be configured to the desired shape. Typically, this means connecting the signal and ground leads to an oscilloscope to check the controls. Adjust the function generator until the output signal is correct, then attach the signal and ground leads from the function generator to the input and ground of the device under test. For some applications, the negative lead of the function generator should attach to a negative input of the device, but usually attaching to ground is sufficient.

- When working with AC signals, there are three properties of the signal that we are concerned with: **amplitude**, **period** and **frequency**.

- The **amplitude** of the wave is defined as the maximum magnitude of the wave. The amplitude is the vertical component of the signal and is measured in units of volts (V). Since we are dealing with an AC signal, the voltage will change over a period of time. The maximum voltage of a signal during its cycle is commonly referred to as the **peak voltage (Vp)**.

- The amplitude can be measured from the reference line to the peak (Vp) or from peak-to-peak (Vpp). See Figure below.

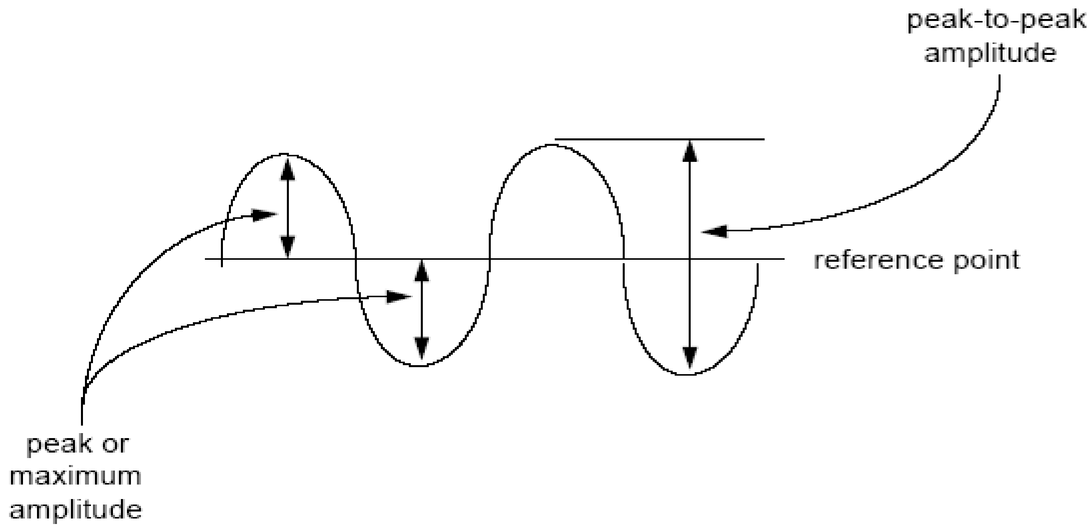


Figure-3

- With a periodic signal that is symmetrical (equidistant above and below the reference point), the peak-to-peak voltage is equal to twice the peak voltage:

$$V_{pp} = 2 * V_p$$

- The **period (T)** of the signal is defined as the time it takes for a signal to complete one full **cycle.** The period is the horizontal component of the signal, measured in units of seconds (s). In Figure below , the period of the signal is measured as 250 milliseconds $(250.0 \times 10^{-3} s)$

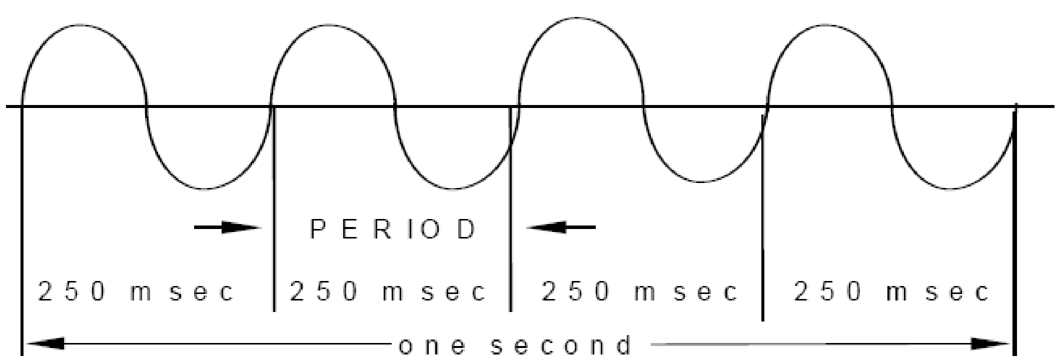


Figure -4

- The **frequency (f)** of the signal is defined as the rate at which a periodic signal repeats. It is usually measured in units of **Hertz (Hz)**, where 1 Hz = 1 cycle per second.
- In Figure 4, above, you can see four(4) cycles occurring within one second; therefore, the signal has a frequency of 4 Hz.
- The frequency, f, of a wave is inversely related to its period (T): f = 1 / T

Example: The period of the signal is 250 milliseconds, therefore the frequency of that signal is: f = 1 / T f = 1 / 250 milliseconds f = 4 Hertz

Table of Scientific prefixes

Abbreviation	Prefix Name	Factor
T	Tera	10^{12}
G	Giga	10^{9}
M	Mega	10^{6}
K	Kilo	10^{3}
m	milli	10^{-3}
µ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}

EXPERIMENT NO – 04

STUDY AND THE USE OF ANALOG MULTI-METERS & DIGITAL LCR METER

“Part 1: Resistance Measurement”

METHOD 1: Resistance Measurement using VOM/ DMM:

1. Resistance is never measured by an ohm-meter in a live network, due to the possibility of damaging the meter with excessively high currents and obtaining readings that have no meaning.
2. Always start with the highest range of the instrument and switch down to the proper range successively.
3. Use the range in which the deflection falls in the upper half of the meter scale.
4. Try to ascertain the polarity of dc voltages before making the measurement.
5. Whenever measuring the resistance of a resistor in a circuit, note whether there are any other resistive elements that could cause an error in the reading. It may be necessary to disconnect one side of the resistor before measuring.
6. Check the zero and ohms adjustments each time the range is changed.
7. When making measurements, grip the test prods by the handles as close to the lead end as possible. Do not allow the fingers to touch the prod tips while measuring.
8. Keep the instruments away from the edge of the workbench, and away from heat and dangerous fumes.
9. There is no zero adjustment on a DMM, but make sure that R=0 ohm when the leads are touching or an adjustment internal to the meter may have to be made. Any resistance above the maximum for a chosen scale will result in an O.L. indication.
10. The ranges are usually marked as multiples of R. For example,

R x 1, R x 10, R x 100, R x 1 k

The value of the resistor can be found by multiplying the reading by the range setting.

For example, a reading of 11 on the R x 1 kΩ range is 11 x 1 kΩ= 11 k Ω, or 11, 000 Ω.

METHOD 2: Resistance Measuring Using Color Coding:

1. The resistance of many resistors can be determined by reading a series of colored bands imprinted on the resistor body. In this scheme called "Resistor Color Code" each color represents a different decimal digit, as shown in fig. 1 and Table 2.

Table 2: Resistor Color Code:

Colour	Digit	Multiplier	Tolerance
Black	0	1	
Brown	1	10	± 1%
Red	2	100	± 2%
Orange	3	1K	
Yellow	4	10K	
Green	5	100K	± 0.5%
Blue	6	1M	± 0.25%
Violet	7	10M	± 0.1%
Grey	8		
White	9		
Gold		0.1	± 5%
Silver		0.01	± 10%
None			± 20%
Digit	Color	Digit	Color
0	**Black**	**7**	**Violet**

The first three bands of the color code are used to specify nominal value of the resistance, and the fourth, or tolerance band, gives the percent deviation from the nominal value that the actual resistor may have. Due to manufacturing variations, the actual resistance may be anywhere in a range equal to the nominal value plus or minus a certain percentage of that value.

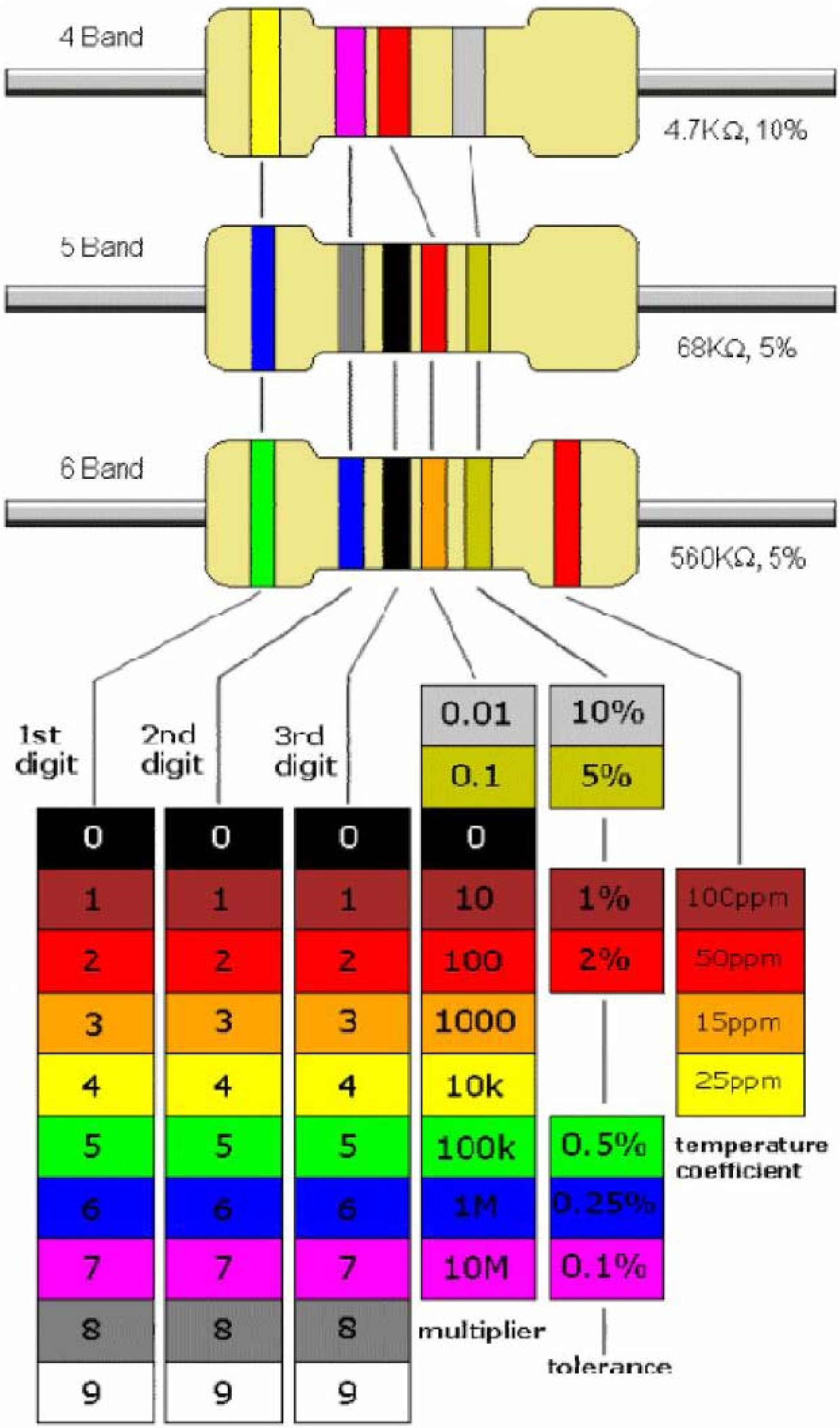

4 Band
4.7KΩ, 10%
5 Band
68KΩ, 5%
6 Band
560KΩ, 5%
1st digit
2nd digit
3rd digit
0.01
0.1
0
10
100
1000
10k
100k
1M
10M
multiplier
10%
5%
1%
2%
0.5%
0.25%
0.1%
tolerance
100ppm
50ppm
15ppm
25ppm
temperature coefficient
0
1
2
3
4
5
6
7
8
9

Figure – 1

Capacitor Colour Code

A colour code was used on polyester capacitors for many years. It is now obsolete, but of course there are many still around. The colours should be read like the resistor code, the top three colour bands giving the value in pF. Ignore the 4th band (tolerance) and 5th band (voltage rating).

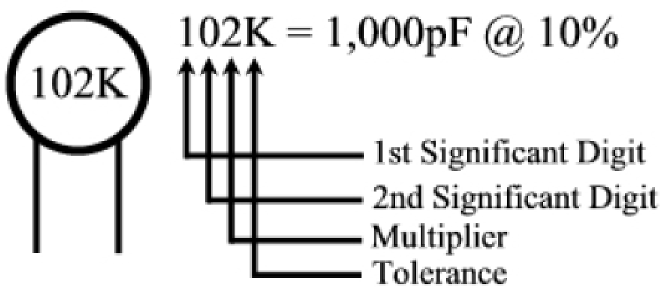
For example: brown, black, orange means
10000pF = 10nF = 0.01μF.

Note that there are no gaps between the colours bands, so 2 identical bands actually appear as a wide band.
For example: **wide red, yellow** means 220nF = 0.22μF.

Colour Code	
Colour	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

NUMERICAL CODES

Numerical Codes are used with non - electrolytic capacitors to specify their capacitance. Usually, these codes are 3 digit long, specifying the capacitance in Pico Farads; the first two digits are Tens and Units, where as the third digit is power of 10.



Common Temperature Coefficient Codes (Ceramic)	
Code	**Tolerance**
C	±0.25pF
J	±5%
K	±10%
M	±20%
D	±0.5pF
Z	+80% / -20%

For example: **102** means 1000pF = 1nF (not 102pF!)
For example: **472J** means 4700pF = 4.7nF (J means 5% tolerance).
For example: **333K** means 33000pF = 33nF (K means 10% tolerance).

Tens	Units	Power of 10	Capacitance
1	0	2	10 x 10^2 pF = 1000 pF = 1nF
4	7	2	47x10^2 pF=4.7nF±5%
3	3	3	33x10^3 pF=33nF±10%

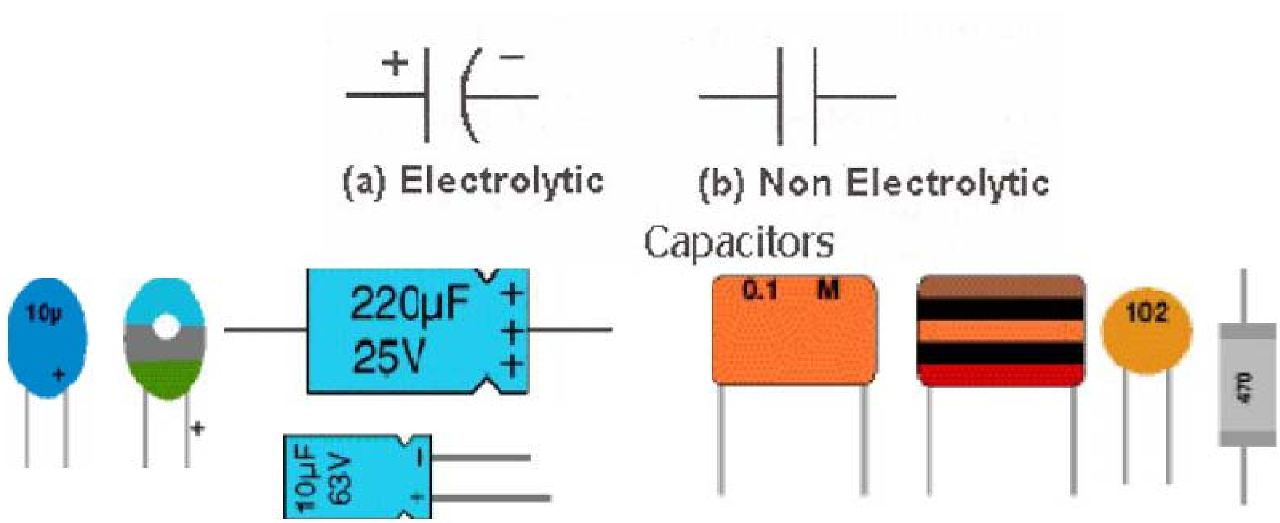
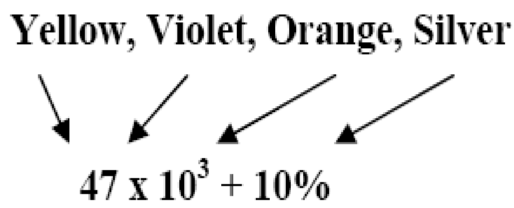


Figure – 2: Capacitors

2. The first two color bands specify the first two digits of the nominal value, and the third band represents the power of 10 by which the first two digits are multiplied.

3- The example below demonstrates these computations.

Solution:-



Thus,
Nominal resistance = 47 x 103 Ω = 47k Ω
The possible range of actual values is:
47 k Ω ± (0.1) 47 k Ω = 47kΩ ± 4.7k Ω
Or From **42.3 kΩ** to **51.7 k Ω**

"Part 2: Capacitance Measurement:"

CAPACITOR:

There are two types of capacitors, i.e. electrolyte and non - electrolyte capacitors. The non-electrolytic capacitors use Paper, Mica, Ceramic, Mylar, Glass, Porcelain, Polycarbonate, and Wax as Insulator. Figure 2 shows symbols of the two types of the capacitor. The difference in the use of the two types of capacitors is that non-electrolytic capacitors can be charged in any direction, where as the Electrolytic ones can only be charged in one direction. Electrolytic Capacitors are Polar; i.e., one of its two plates is Positive and other is Negative, whereas in non-electrolytic capacitors, both the plates are same, having no polarity.

OBSERVATION:-

TABLE –A

Resistors	Colour Bands 1 | 2 | 3 | 4	Colour Bands 1 | 2 | 3 | 4	Nominal Resistances	Maximum Resistances	Minimum Resistances
Example	Red, Red, Black, Gold	2 2 0 5 %	22Ω	23.1Ω	20.9Ω
1					
2					
3					
4					
5					

TABLE - B

Resistor	Measured Value (VOM / DMM)	Falls within specified tolerance
Example	23Ω	Yes
1		
2		
3		
4		
5		

EXPERIMENT NO – 05

STUDY OF PMMC GALVANOMETER

GALVANOMETER

Galvanometer is an electromechanical instrument which is used for the detection of electric currents through electric circuits. Being a sensitive instrument, Galvanometer cannot be used for the measurement of heavy currents. However we can measure very small currents by using galvanometer but the primary purpose of galvanometer is the detection of electric current not the measurement of current.

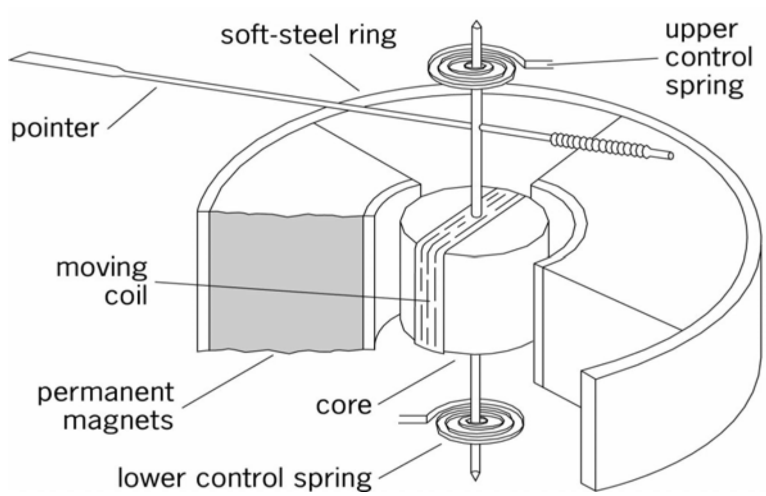
WORKING PRINCIPLE

Galvanometer works on the principle of conversion of electrical energy into mechanical energy. When a current flows in a magnetic field it experiences a magnetic torque. If it is free to rotate under a controlling torque, it rotates through an angle proportional to the current flowing through it.

ESSENTIAL PARTS OF GALVANOMETER

There are five essential parts of a Galvanometer.

1. A **U-shaped** permanent magnet with concave poles.
2. Flat rectangular coil of thin enameled insulated wire
3. A soft iron cylinder
4. A pointer or needle.
5. A scale.



Internal Structure

CONSTRUCTION

The flat rectangular coil of thin enameled insulated wire of suitable number of turns wound on a light nonmetallic or aluminum frame is suspended between the cylindrically concave poles of magnet by a thin phosphor bronze strip. One end of the wire of the coil is soldered to strip. The other end of the strip fixed to the frame of the galvanometer and connected to an external terminal. It serves as one least current lead through which the current enters or leaves the coil. The other end of the wire of the coil is soldered to a loose and soft spiral of wire connected to another external terminal. The soft spiral of a wire serves as the other current lead. A soft-iron cylinder, coaxial with the pole pieces, is placed within the frame of the coil and is fixed to the body of the galvanometer. In the space between it and the pole pieces, where the coil moves freely, the soft iron cylinder makes the magnetic field stronger and radial such that into whatever position the coil rotates, the magnetic field is always parallel to its plane.

WORKING

When a current passes through the galvanometer coil, it experiences a magnetic deflecting torque, which tends to rotate it from its rest position. As the coil rotates it produces a twist in the suspension strip. The twist in the strip produces an electric restoring torque. The coil rotates until the elastic restoring torque due to the strip does not equal and cancels the deflecting magnetic torque, then it attains equilibrium and stops rotating any furthers.

EXPERIMENT NO – 06

DESIGN AND UNDERSTAND THE MEASURING PRINCIPAL OF DC VOLT-METER

THEORY

Multiplier

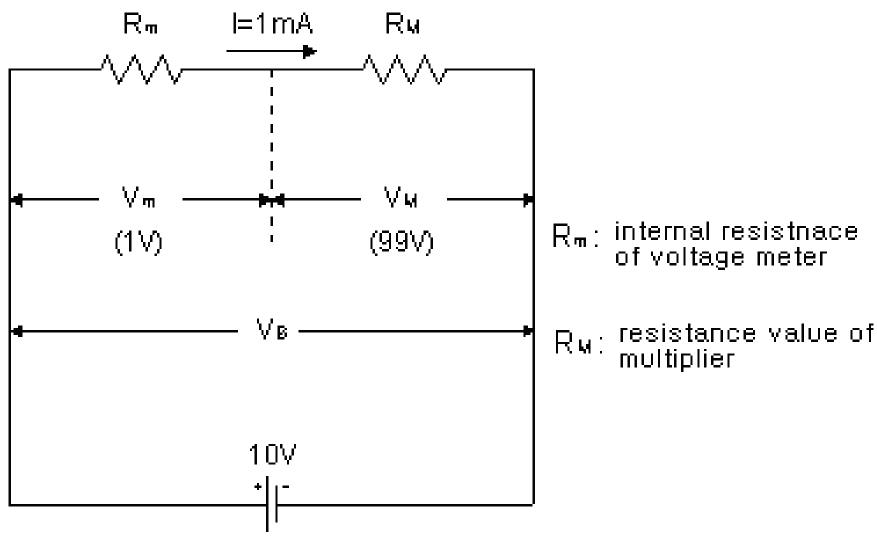


Figure 1-1 Multiplier

Multiplier is a kind of resistor used for widening the range of voltage measurement by connecting to voltage meter in serial. For example, when you want to measure 100V with the voltage meter measurable 1V, it can be measured only with voltage divider absorbing 99V voltage and makes 1V voltage drop in the voltage meter. In Figure 1-1, assume RM is the resistance of multiplier, Rm is the internal resistance of voltage meter, voltage FS (Full Scale: maximum scale, that is, maximum measuring limit) is E1. If the voltage you want to measure is N times of FS input voltage, then the expression of calculation multiplier resistance RM is as follows. At first, voltage Vm, VM flow in Rm and RM can be expressed as Vm = IRm , VM = IRM. So the voltage of the circuit connecting RM in serial is N times of the voltage in case of connecting only voltage meter. So:

$$N = \frac{V_m + V_M}{V_m} = \frac{IR_m + IR_M}{IR_m} = \frac{R_m + R_M}{R_m}$$

In this expression, if voltage value to measure is N times of Vm’s, the resistance of multiplier RM becomes RM = (N - 1) Rm. You can design the multiplier according to the range of voltage measured by knowing maximum measurement range (or FS sensibility) of meter in this way.

VOLTAGE METER

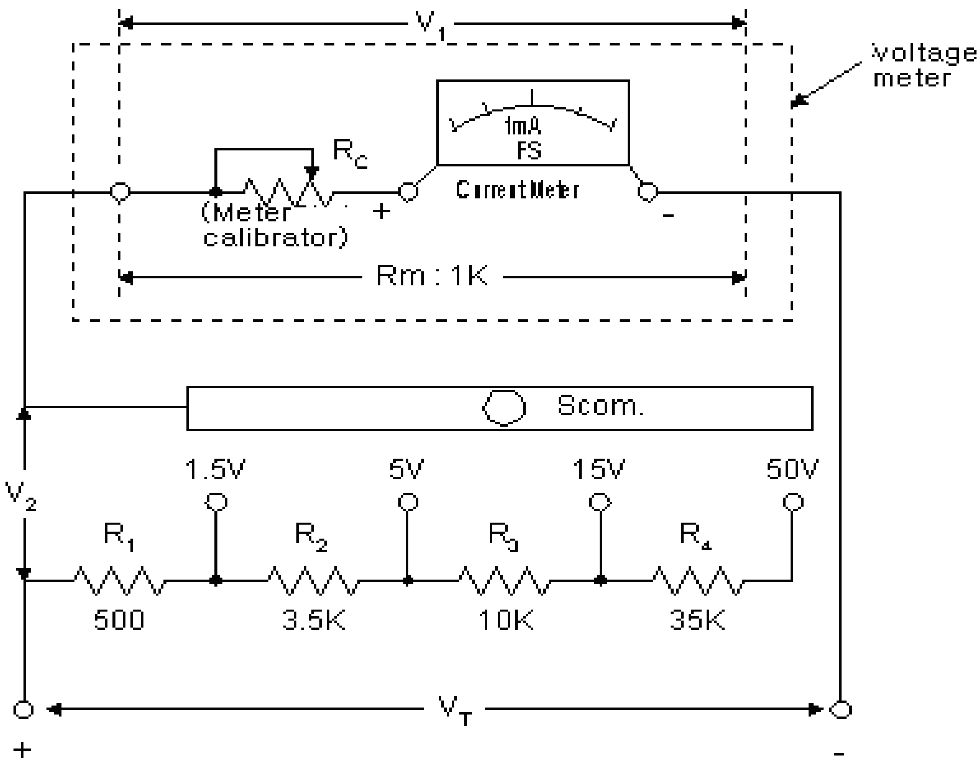


Figure 1 -2 Circuit diagram of voltage meter

Most of voltage meter is made of current meter and the multiplying resistance connected to it in serial as Figure 1-2. In case of DC voltage meter, the current meter whose own FS(full scale) sensibility is from 50μA to 1mA is generally used. And the internal resistance of them is approximately 100Ω~1KΩ. When input voltage is VT, the voltage of voltage meter is V1, the voltage of both sides of multiplier is V2, then VT = V1 + V2. And if internal resistance of voltage is Rm, resistance value of multiplier is RM, then V1 and V2 take the expression as follows;

$$V_1 = \frac{R_m}{R_m + R_M} V_T, \qquad V_2 = \frac{R_M}{R_m + R_M} V_T$$

Therefore, if voltage meter indicates V1 value, real measuring voltage can be taken by multiplying with magnification of measuring range.

PROCEDURE

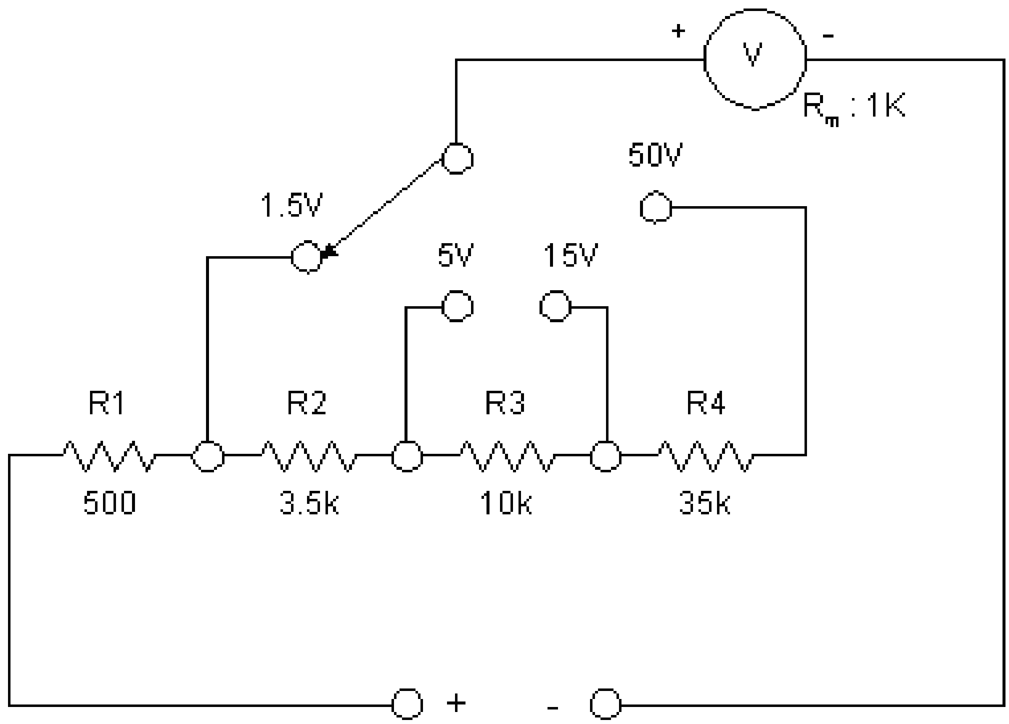


Figure 1-3 Multi-range voltage meter

1. In the circuit-1 of M-2 Connect 1m and 1n for the meter to the 2a and 2b in circuit-2(Meter) respectively. Measure the resistance of multiplier when FS is 1mA in each range and enter them in table 1-1. The FS of meter is 1mA. where, make short 2c-2d in the circuit-2

2. Measure the current when you accept the 1V/ 3V/ 10V/ 12V input voltage toward each range according to table 1-2 using the circuit in Figure 1-3 and enter it in table 1-2.

Table 1-1

Range / Multiplier	1.5V	5V	15V	50V
R1				
R1+R2				
R1+R2+R3				
R1+R2+R3+R4				
Remark				

Table 1-2

Range / Input voltage	CIRCUIT CURRENT IN EACH RANGE			
	1.5V	**5V**	**15V**	**50V**
1V				
3V				
10V				
12V				
Remark				

EXPERIMENT NO – 07

DESIGN AND UNDERSTAND THE MEASURING PRINCIPAL OF DC AMPERE-METER

THEORY

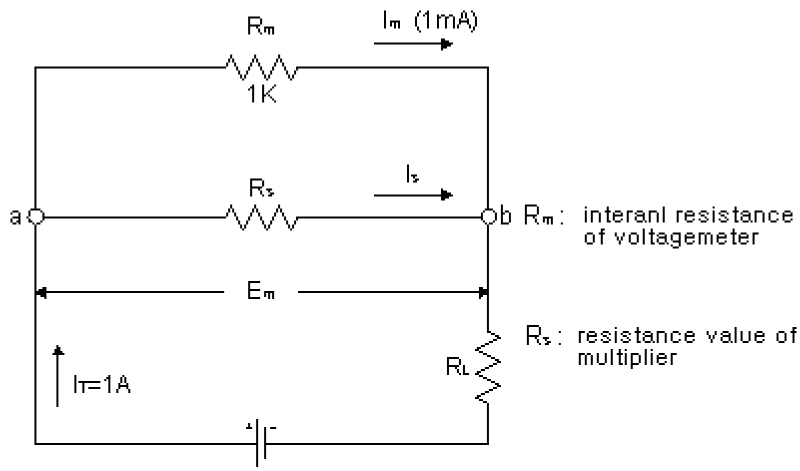


Figure 2-1 Shunt

Shunt is a kind of resistor used for widening the range of current measuring by connecting to current meter in parallel. For example, when you want to magnify measuring range to 100mA, make current meter flowing 1mA, make shunt flowing rest 99mA. And when you want to enlarge measuring range using shunt RS in Figure 2-1, assume the internal resistance of current meter is Rm, the current flowing is Im/IS. When the current to measure is N times of current meters own FS(Full Scale : maximum scale), the resistance of shunt is calculated as follows;

At first, if Em is the FS input voltage of Meter, the current Im/IS flowing Rm/RS is represented with Im = Em / Rm, IS = Em / RS. Therefore, the current measurable when it is connected in parallel is N times higher than the case connected only current meter.

$$N = \frac{I_m + I_S}{I_m} = \frac{\frac{E_m}{R_m} + \frac{E_m}{R_S}}{\frac{E_m}{R_m}} = R_m\left(\frac{1}{R_m} + \frac{1}{R_S}\right) = 1 + \frac{R_m}{R_S}$$

When current value to measure in this expression is N times of Im, the shunt resistance RS is as follows.

$$R_S = \frac{R_m}{(N-1)}$$

Like this, when you know maximum measuring range (FS sensitivity) and internal resistance, you can design the shunt according to the range to measure.

CURRENT METER:

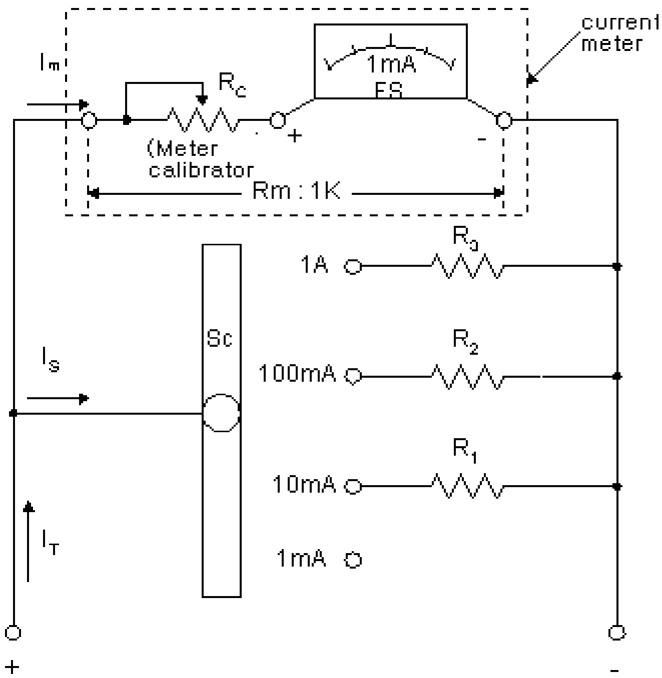


Figure 2-2 Circuit diagram of current meter

Generally, current meter consists of meter and the shunt connected to the meter in parallel. In this case, the sensitivity of meter is 50μA~1mA(FS) and its internal resistance is approximately 100~1kΩ. (The smaller Rm is, the better sensitivity is in equal current) And the shunt used for the measuring a large current (more than 10A) indicates the output voltage of shunt for the connection of meter and the capacitance of the shunt (A). Understand the principle of operation of current meter as you see Figure 2-2. Assume that input current is IT, current meter is Im, and the current flowing shunt is IS, then IT = Im + IS. And assume that the internal resistance of current meter is Rm, resistance value of shunt is RS, then Im and IS have the expression as follows;

$$I_m = \frac{R_s}{R_m + R_s} I_T, \qquad I_s = \frac{R_m}{R_m + R_s} I_T$$

So current meter indicates Im, and you can get real measuring current by multiplying the magnification of range.

PROCEDURE:

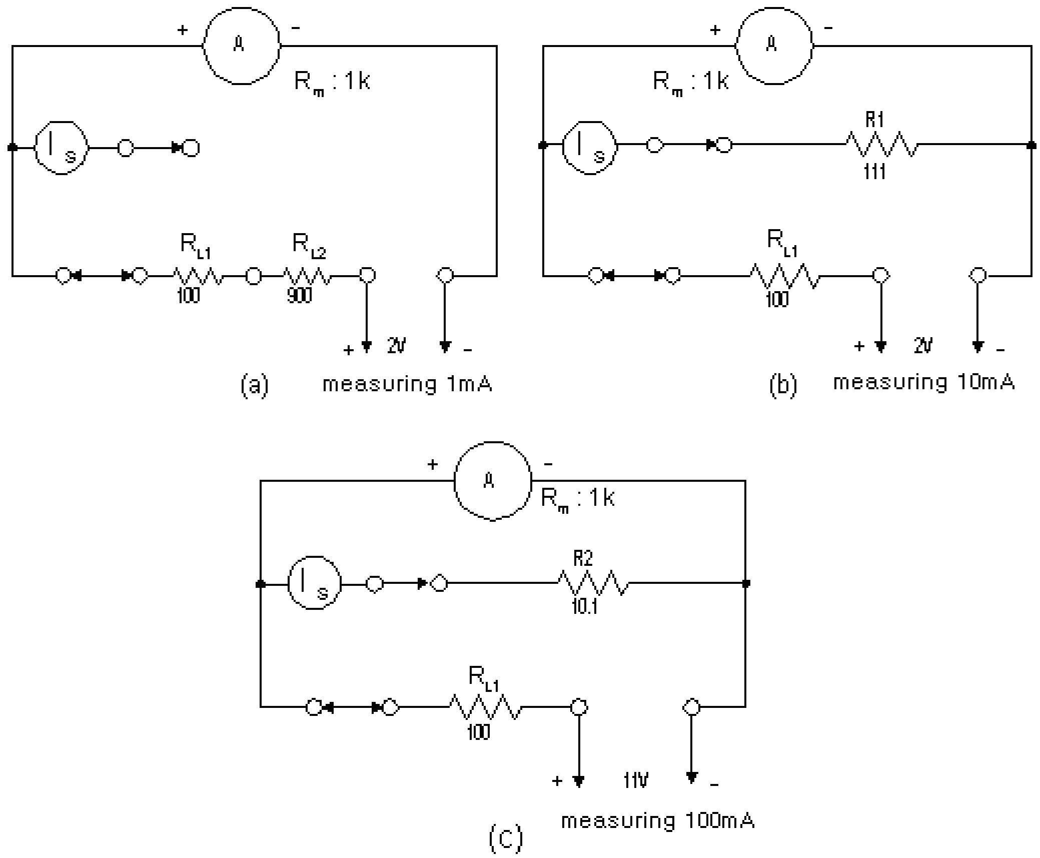


Figure 2-3 FS currnet circuit of each range

1. At first, after connecting 2a and 2b in the circuit-2(meter) to 3m and 3in the circuit-3 using given circuit in circuit-3 of M-2, Connect the circuit as (a)-(c) in Figure 2-3 according to the experiment. Connect the circuit (a) to 3d-3h, circuit (b) to 3e-3I, circuit (c) to 3f-3j, then connect the other current meter between 3a' and 3c. (Make short 2c-2d in circuit-2 and make Rm 1kΩ.)
2. Measure the shunt current (IS) and meter current (A) of each circuit in Figure 2-3의, and enter the current flowing in these circuit value into the blank in table 2-1.

(Note: When you measure IS, you must make the measurement of external current meter as high as possible. That is, the lower its range is, the higher its internal resistance is, it changes circuit impedance. So it is impossible to be correct measuring.)

3. After measure the shunt resistance when FS indicates 1mA toward each ranges, record it into table 2-2. The FS of meter is 1mA. (Hereupon, make short 2c-2d in the circuit-2)

Range / **Circuit**	**1mA**	**10mA** **R1=111ohm**	**100mA** **R2=10.1 ohm**
Current Flowing in shunt[Is]			
Current flowing in meter[Im]	**1mA**		
Measuring current[It]	**1mA**		
Remark			

Table 2-1

Table 2-2

Range[FS]	**1mA**	**10mA**	**100mA**
Resistance Value[ohm]			
Remark			

EXPERIMENT NO – 08

DESIGN AND UNDERSTAND THE MEASURING PRINCIPAL OF OHM-METER

THEORY:

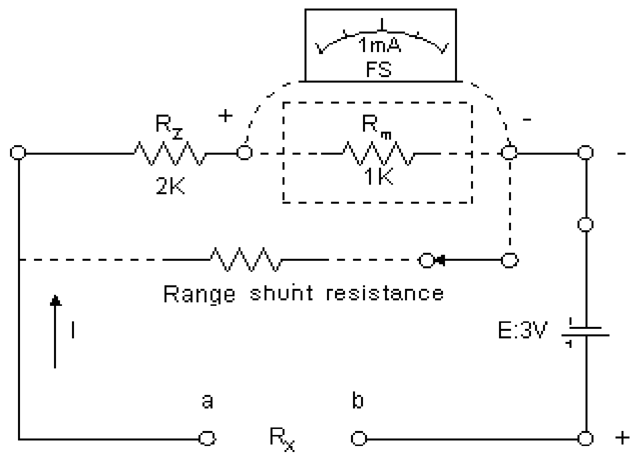


Figure 3-1 Circuit diagram of Ohm-meter

Ohm-Meter consists of Meter, Zero ohm multiplier, range shunt resistor and DC source(battery) as Figure 3-1 The sensitivity of Meter is generally 50μA~1mA (FS) and its internal resistance is generally 100Ω~1KΩ. The most different thing from the general voltage meter and current meter lies in the fact while the status there is no current flow in the meter is 0 V or 0 A in the voltage meter and current meter, but the status there is some current flow is 0Ω in the ohm meter. Therefore, ohm meter is designed for resistance value to be set according to how much the degree meter cannot reach to FS by certain resistance measured. Another feature of ohm meter is the fact that ohm meter should have the DC power source making current flow from ohm meter to resistant material. So general potable ohm meter has its own battery. In the circuit of Figure 3-1, if you use 1mA FS of meter sensitivity and 1KΩ of internal resistance and 3V of DC power resource, you must indicate the direction of meter as 1mA FS to make R_X terminal 0Ω (that is, connected a and b). So total resistance of the circuit would be as follows ;

$$R_z + R_m = \frac{3V}{1mA} = 3k\Omega$$

Therefore, because the internal resistance of meter Rm is 1KΩ,so $R_Z = 3K\Omega - 1K\Omega$. We call RZ resistance as Zero Ohm Multiplier of ohm meter here. But if I is the current flowing in the circuit, the expression to get R_X is as follows :

$$R_x = \frac{E}{I} - (R_z + R_m)$$

It frequently happens in real circuit that the design is somewhat changed like zero adjusting. And resistance meter also has measuring range like current meter. In this case, it has range shunt according to the measuring range.

Experiment Procedure

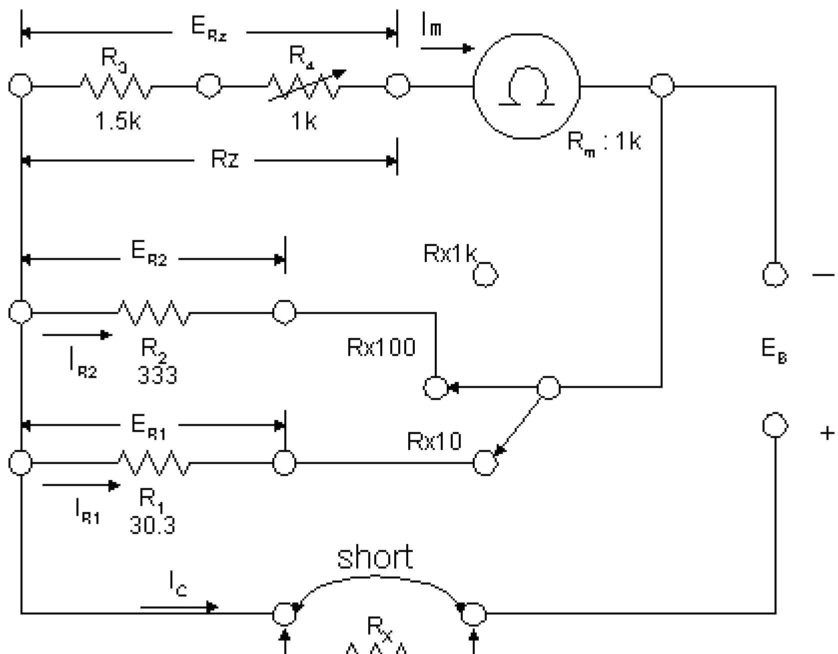


Figure 3-2 Zero adjustment according to power supply voltage of the resistance meter circuit

1. Connect meter terminal(2a, 2b) and battery terminal(2e, 2f) in circuit-2 to meter terminal (4k, 4ℓ) and power terminal (4m, 4n) with care for polarity (At this time, make short 2c-2d in the circuit-2)
2. Measure the current of meter when connect measured resistance toward each range as table 3-1, and enter it into the blank.

   (After varying zero Adj when the resistance is 0Ω, measure it. And when the resistance is R_X 200Ω/ 2kΩ, measure it. It the range is changed, measure by the same way above.)
3. After setting the power of resistance meter 2.5V using a separate external DC power supplier in circuit-4 of M-2, adjust 0 point.

4. Calculate the current by measuring the voltage flowing each resistance, and enter it into the blank of table 3-1. (After making short 4d-4g of ER1, 4e-4h of ER2 according to the selection of range, and measure it.)
5. Measure the voltage after adjusting 0 point of the other power as table 2-6, and enter the calculated value into the blank.

Reference : ***1. R1 design expression of R X 10 (R_x : 0Ω)***

$$\frac{I_m}{I_{R1}} = \frac{1}{99}, \quad I_m = \frac{E_{R1}}{(R_Z + R_m)} \Rightarrow E_{R1} = I_m(R_Z + R_m), \quad I_{R1} = \frac{E_{R1}}{R_1} \Rightarrow R_1 = \frac{E_{R1}}{I_{R1}}$$

$$\therefore R_1 = \frac{E_{R1}}{I_{R1}} = \frac{I_m(R_Z + R_m)}{I_{R1}} = \frac{R_Z + R_m}{99}$$

2. R2 design expression of R X 100 (R_x : 0Ω)

$$\frac{I_m}{I_{R2}} = \frac{1}{9}, \quad I_m = \frac{E_{R2}}{(R_Z + R_m)} \Rightarrow E_{R2} = I_m(R_Z + R_m), \quad I_{R2} = \frac{E_{R2}}{R_2} \Rightarrow R_2 = \frac{E_{R2}}{I_{R2}}$$

$$\therefore R_2 = \frac{E_{R2}}{I_{R2}} = \frac{I_m(R_Z + R_m)}{I_{R2}} = \frac{R_Z + R_m}{9}$$

3. The design expression of circuit current(IC) when terminal measured is short in R X 10

$$I_C = I_m + I_{R1} = \frac{E_B}{R_Z + R_m} + \frac{E_B}{R_1} = \frac{E_B R_1 + E_B(R_Z + R_m)}{R_1(R_Z + R_m)} = \frac{E_B(R_1 + R_Z + R_m)}{R_1(R_Z + R_m)}$$

4. The design expression of circuit current(IC) when terminal measured is short in R X 100

$$I_C = I_m + I_{R2} = \frac{E_B}{R_Z + R_m} + \frac{E_B}{R_2} = \frac{E_B R_2 + E_B(R_Z + R_m)}{R_2(R_Z + R_m)} = \frac{E_B(R_2 + R_Z + R_m)}{R_2(R_Z + R_m)}$$

Table 3-1

Range / Rx	R*10	R*100	R*1000
Current flowing through 0 [ohm]			
Current flowing through 200 [ohm]			
Current flowing through 2k [ohm]			
Remark			

Table 3-2

Measurement / DC(Eb)	**Im=E_{RZ} / R_Z**	**IR1=E_{R1} / R_Z**	**IR_2 = E_{R2} / R_2**
2.5V			
3V			
3.5V			
Remark			

EXPERIMENT NO – 09

UNDERSTAND THE CHARACTERISTICS OF WHEAT STONE BRIDGE CIRCUIT

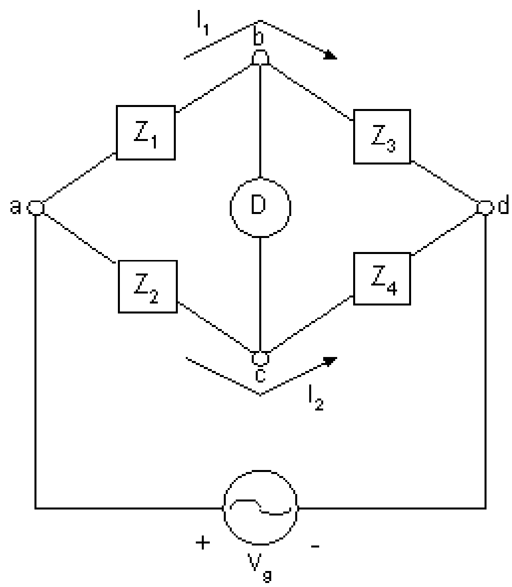


Figure 1-11 Bridge circuit

The Bridge circuit is widely used for measuring R, L, C or frequency. Figure 1-11 shows the Bridge circuit. The galvanometer is most frequently used as detector in the serial Wheatstone bridge who's each Arm is forward resistance. When the current flowing D is "0", this is called as "balanced". In balanced state, the potential difference between both sides of D becomes "0", and there is no current between b point and c point in Figure 1-11. The voltage drop from connecting point 'a' to 'b' must be equal to that from 'a' to 'c' in voltage drop, scale and phase. That is, it satisfies with the condition as follows:

$$Z_1 I_1 = Z_2 I_2, \quad Z_3 I_1 = Z_4 I_2$$

You can get the relation between each impedance from above expression as follows:

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4} \quad \text{OR} \quad Z_1 Z_4 = Z_2 Z_3$$

This is the Bridge's 'condition of balance'. If there are some currents detected in D(Unbalancing), it implies that external power is added to the circuit. This function can be applied to establishing detection circuit.

PROCEDURE:

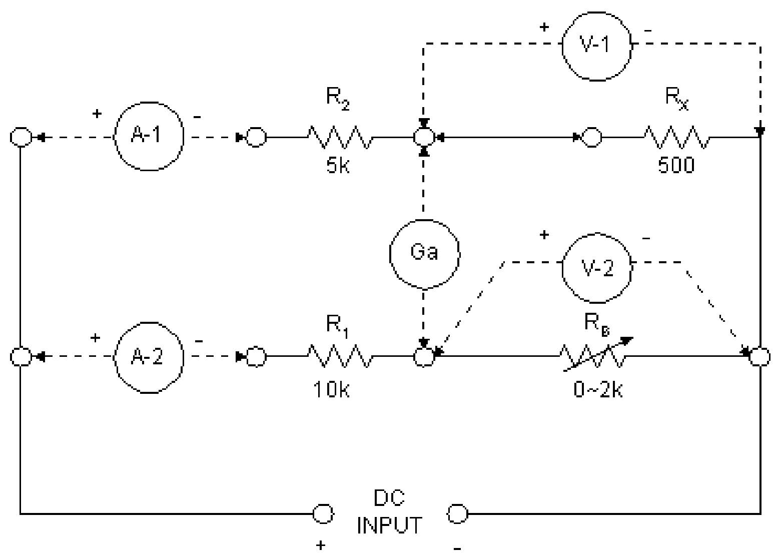


Figure 1-12 Balanced bridge

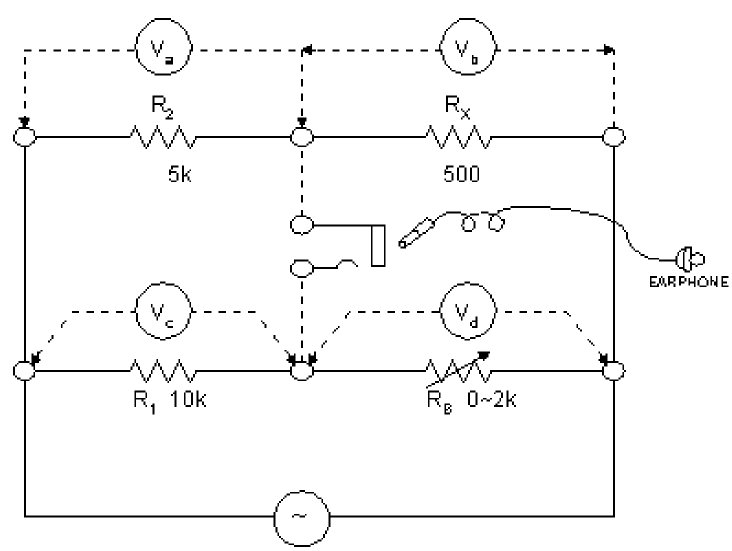


Figure 1-13 Wheatstone bridge

1. Make short 5n-5p in the circuit-5 of M-1, connect the current meter to both sides of 5i-5j/ 5d-5e, and then connect voltage meter to both sides of 5p-5q/ 5f-5g as Figure 1-12.

2. Connect 10V to DC input after connecting galvanometer to Ga, switching off to make safety resistance connected. (Before connect galvanometer, confirm "0" point of meter is adjusted correctly.)

3. After adjusting RB value to make the indicator of galvanometer to be "0", adjust precisely again in the state "switch on". That is, make it balanced state. (At this time, make "GAIN" its clockwise maximum value.) Then measure current and voltage and enter it into the blank of circuit-1 in table 1.

4. After removing power supply connected to 5a-5b and galvanometer connected to 5r-5f' and opening both sides of 5n-5p, measure RB(5f-5g) value with resistance meter and enter it into the circuit-1 in table 1.

5. Calculate R_x value and enter it into the circuit-1 in table 1.

6. Connect the power supply removed in process 4 and galvanometer again and make short both sides of 5n-5p.

7. Now, connect current meter A-1 to both sides of 5k-5ℓ and repeat process 3~5. Then enter it into the blank of circuit-2 in table 1.

8. After making function generator's output sine wave 1000 Hz/10 Vp-p, connect it to 5a-5b instead of D.C. And establish the circuit by making short both sides of 5i-5j/ 5n-5p/ 5d-5e.

9. Connect earphone instead of galvanometer. And adjust R_B not to make a noise. That is, make balanced state.

10. Measure each voltage value and enter them into circuit-1 in table 2.

11. After opening both sides of 5i-5j and making short 5k-5ℓ, record the voltage value into the circuit-2 in table 2.

Table 1

Measurements / Experiment	Ammeter		Voltmeter		RB	RX
	A_1	A_2	V_1	V_2	Measured – Value	Calculated – Value
EXPERIMENT-1 R2 CONNECTION						
EXPERIMENT-2 R2 CONNECTION						
Remarks:						

Table 2

Measurements / Experiment	Va	Vb	Vc	Vd
EXPERIMENT-1 R2 CONNECTION				
EXPERIMENT-2 R2 CONNECTION				
Remarks:				

EXPERIMENT NO – 10

TO UNDERSTAND THE CHARACTERISTICS OF A THERMISTOR

OBJECTIVES:

1. To understand the characteristics of a Thermistor.
2. To measure the resistance of a Thermistor at different temperatures.

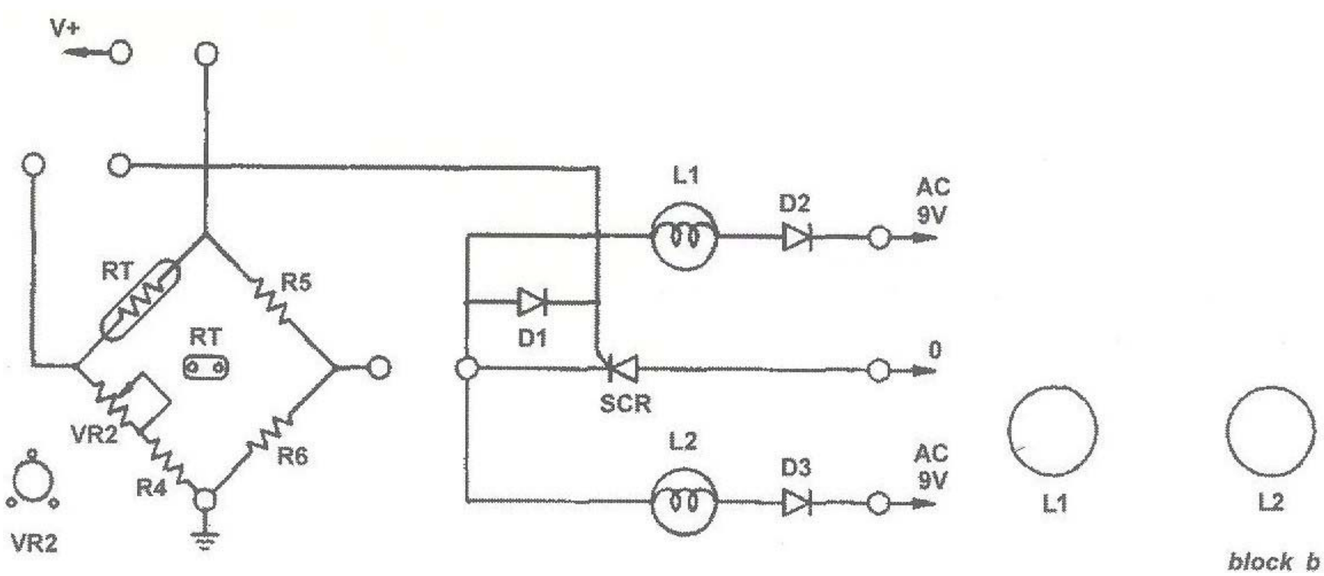
DISCUSSION:

Resistive temperature-sensiting sensors can be classified into two groups: one group called semistor that posses a positive temperature coefficient of resistance, and another group called thermistor that posses a negative temperature coefficient of resistance.

PROCEDURE:

1. Set the module KL-13010 on the main unit KL-21001, and locate the block b.

2. Located the terminals of the Thermistor RT shown in Fig.



3. Measure and record the resistance of RT at room temperature. RT = _____________Ω

4. Hold RT by your thumb and the index finger and observe the change of resistance indicated by the ohmmeter. Is the resistance of RT decreased? Yes /No __________________

5. Warm up RT with a soldering iron of 25W~35W and observe the change indicated by the ohmmeter. Is the resistance of RT decreased Yes /No __________________

6. Keep warming up RT until the resistance reaches a constant value and take away the soldering iron from RT. Measure the resistance of RT. R = __________________ Ω

EXPERIMENT NO – 11

TO CONSTRUCT A TEMPERATURE-CONTROLLED SWITCH CIRCUIT BY USING A THERMISTOR

DISCUSSION:

An application of the characteristics of a Thermistor is shown in Fig. -1. The temperature-controlled switch circuit is composed of the resistive bridge, SCR and lamps. The resistive bridge circuit is constituted by a Thermistor and resistors VR2, R3, R4, and R5. Its output between A and B provides the triggering voltage VAB to the gate of SCR. Two lamps are controlled by the SCR.

As mentioned before, if the equation RT/(VR2+R3) = R4/R5 is true, the bridge circuit will be balanced and its output voltage VAB is zero. This will turn off the SCR and lamps. When an increase in temperature decreases the resistance of RT, the bridge circuit is unbalanced and the positive output voltage +VAB turning on SCR. Then the ac currents flow through SCR and both lamps. The D1 acts as a protection diode to pass the negative VAB. The VR2 is used balance the resistive bridge at a specific temperature, such as at room temperature.

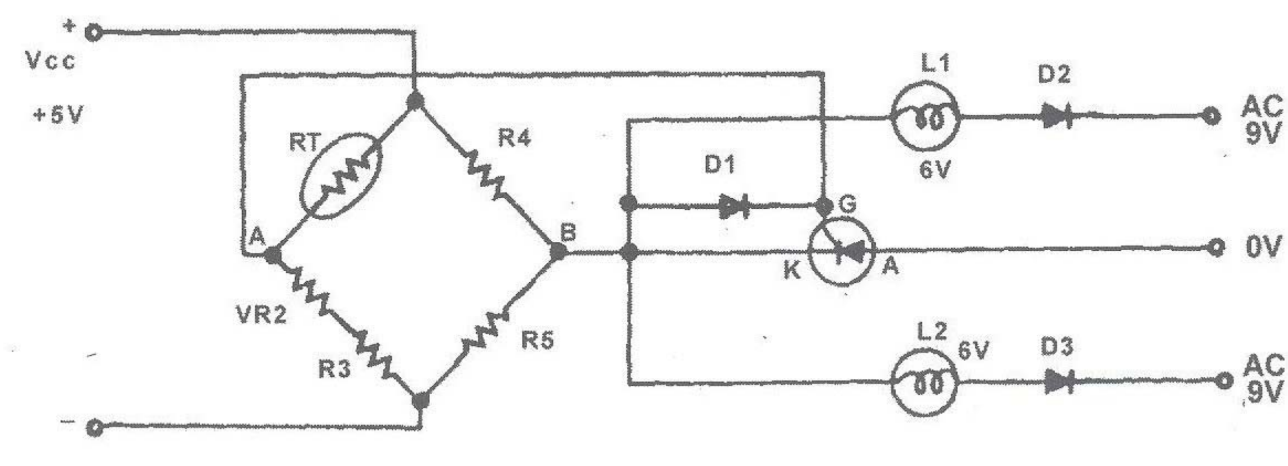


Figure-1

PROCEDURE:

1. Set the module KL-13010 on the main unit KL-210041, and locate the block b.
2. According to Fig. -1 and Fig.-2, complete the experiment circuit with short-circuit clips

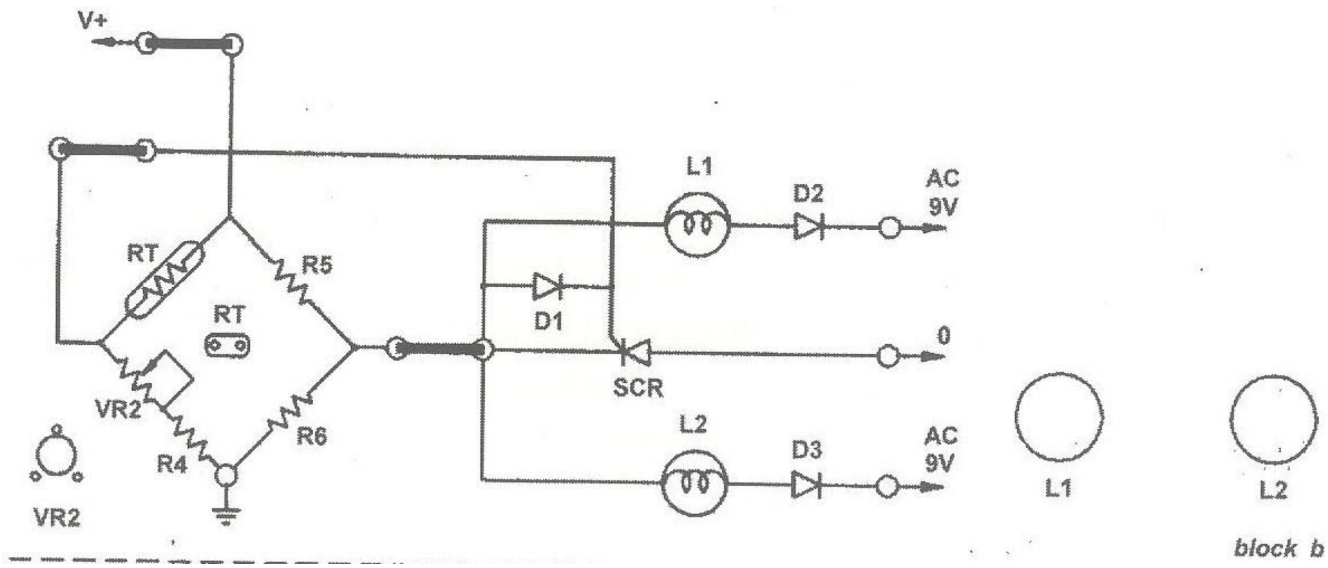


Figure-2

3. Apply the AC power source 9V-0-9V to terminals AC 9V, 0, AC 9V.

4. Apply +5V to V+.

5. Turn VR2 to the point that the lighted lamps L1 and L2 are just turned off. At this time, SCR is turned ___________________ (on or off).

6. Approach a heated soldering iron to RT and observe the states of lamps. Record the results in Table and identify the state of SCR.

7. Take away the soldering iron from RT and observe the states of lamps. Record the results in Table and identify the state of SCR.

Table

L1 State	L2 State	SCR State

EXPERIMENT NO – 12

STUDY AND THE USE OF CURRENT TRANSFORMERS

EXPERIMENT NO – 13

STUDY AND THE USE OF CLAMP METER

It is very important to completely familiarize yourself with the instrument before using. Please read it carefully.

1.1 Included Items

The Current Power Clamp Meter includes the following items:

- Current Power Clamp Meter
- Test leads (1 pair)
- Alligator clips (1 Pair)
- Carrying Case (1 piece)
- Battery (AAA× 4pcs)

1.2 Unit Description

Use the drawing below in conjunction with the following descriptions to familiarize yourself with the unit:

****

[1] Clamp Jaws:	Clamp around the conductor to be tested for picking-up the current signal
[2] Current Direction	Positive display if the current flow through the jaw following by the arrow direction
[3] Liquid Crystal Display:	Indicates value of measurement
[4] Power Switch:	Turns the instrument on and off
[5] Surge Key:	Selects surge mode measurement

[6] Hold key:	Holds reading on the display or selects Minimum / Maximum measurement
[7] Shift key:	Used to select the sub-function of voltage, current, power, and resistance measurements
[8] “V” terminal:	The positive test connector for voltage, frequency, and power measurements
[9] “COM” terminal:	The negative test connector for voltage, frequency, power, and resistance measurements
[10] “Ω” terminal:	One of the test connectors for resistance measurements
[11] MENU key:	Used to select current, voltage, power , and resistance measurements
[12] Range key:	Selects high range or low range measurement
[13] Zero key:	Offsets the display readings to zero
[14] RMS/AVG Switch:	Selects True RMS or Average Sensing Measurement
[15] Jaw Open Handler:	Open the clamp jaws

SPECIFICATIONS

CURRENT /POWER METER
Technical Specifications

DC CURRENT

Range	Accuracy	Resolution	Overload Protection
35A	*1% +15*	*0.06A*	*1000A*
350A	*1% +5*	*0.2A*	
1000A		*1A*	

AC CURRENT

Range	Accuracy		Resolution	Overload Protection
	47/63Hz	Up to 400Hz		
35A	*1% +15*	*2% +10*	*0.03A*	*1000A*
350A	*1% +5*		*0.1A*	
1000A			*1A*	

The accuracy applies from 5% - 100% of the range.

ACTIVE POWER (V×A×COSθ)

Range	Accuracy	Resolution	Overload Protection
3.5KW	2% + 2	2W	Corresponds to V & A measurements
35KW		20W	
350KW		200W	

The accuracy applies from 5% - 100% of the range.

APPARENT POWER (V×A)

Range	Accuracy	Resolution	Overload Protection
3.5KVA	2% + 5	2VA	Corresponds to V & A measurements
35KVA		20VA	
350KVA		200VA	

The accuracy applies form 5% -100% of the range.

REACTIVE POWR (V×A×SINθ)

Range	Accuracy	Resolution	Overload Protection
3.5KVar	2% + 5	2Var	Corresponds to V & A measurements
35KVar		20Var	
350KVar		200Var	

The accuracy applies form 5% -100% of the range.

POWER FACTOR (COSθ)

Range	Accuracy	Resolution	Overload Protection
3.5KW	3% + 10	0.001	Corresponds to V & A measurements
35KW(<400V)			
350KW			

The accuracy applies for $0.5 \leq \cos\theta \leq 1$

***lead, lag display accuracy guarantee for 1> 10A, and PF< 0.965 ($\theta > 15°$)

AC VOLTAGE (45HZ-400HZ)

Range	Accuracy	Resolution	Input Impedance	Overload Protection
350V	1% + 5	0.1V	5MΩ(10pf shunt)	DC 1000A AC 750Vrms
600V		1V		

The accuracy applies from 5% - 100% of the range.

DC VOLTAGE

Range	Accuracy	Resolution	Input Impedance	Overload Protection
350V	1% + 5	0.2V	5MΩ	DC 1000A AC 750Vrms
600V		1V		

SURGE MODE

Range	Description	Accuracy	Acquisition Time
ACA	Capture and retain current surge long enough for reading	3% + 5	20ms

Note: Acquisition time is the minimum duration of surge for rated accuracy. Accuracy improves for longer peak duration. The accuracy applies from 5% of the range.

FREQUENCY

Range	Accuracy	Resolution	Overload Protection
10Hz-1KHz	0.5%	1Hz	AC/DC 400V

RESISTANCE

Range	Accuracy	Resolution	Overload Protection
0-3.3KΩ	± 1%	1Ω	AC/DC 400V

AUDIBLE CONTINUITY CHECK

Range	Description	Resolution	Overload Protection
Ω WITH -)))	The beeper is triggered if the resistance is less than 30Ω	1Ω	AC/DC 400V

The specification given assumes an operation temperature of 18℃ to 28℃, and a 1 year calibration cycle. *Accuracy is ± (%of reading + number of digits)

OPERATION AND USE

2.1 Warning

Electricity, even relatively low voltage or currents can cause severe injury or even death.
Therefore it is vitally important that any electronic instrument such as this Current power Clamp Meter be totally understood before use. Do not use this instrument, or any other piece of electrical or electronic test equipment, without first thoroughly familiarizing yourself with its correct operation and use.

2.2 Cautions

Any input that exceeds the maximum input specification can cause amaze to the instrument.
If dead or partially discharged batteries are left in the instrument for an extended period, damage to the unit could result from leaking batteries. It is important to replace discharged batteries promptly. If the instrument is not to be used for an extended period, always remove the batteries form the unit. Please dispose of used batteries in a proper manner.

Do not use solvents or aromatic hydrocarbons to clean the instrument. These cleaners can damage the plastic case. If cleaning is necessary, use mild solution of warm water and detergent.

2.3 AC Current Measurements

(1) Turn on the meter.
(2) Press the **MENU** key to select current mode. The display will show **AC 000.×** The ×" is the offset reading of the circuit.
(3) Hook the clamp jaws around the conductor to be measured. **(NOTE 1)**

(4) Read the reading on the display.

2.4 DC Current Measurement

1) Turn on the meter.
2) Press the **MENU** key to select current mode.
3) Press the **SHIFT** key to select DC current measurement. The display will show
4) Press the **ZERO** key to zero the display reading.
5) Hook the clamp jaws around the conductor to be measured. (Note 1)
6) Read the reading on the display.

Note: 1. the conductor should be located in the central of the clamp jaws for the best accuracy.

2. The polarity of the reading depends on the current direction.

3. If the current to be measured has AC and DC components, press the **SHIFT** key to select AC + DC current measurement.

4. If the current to be measured is not pure sine wave, the RMS / AVG slide switch must be set at the "RMS" position for detecting the true rms value of the current.

2.5 DC/AC Voltage Measurement

1) Turn on the meter.
2) Press the **MENU** key to select voltage mode. The display will show the "V" annunciator.
3) Press the **SHIFT** key to select **"AC" , "DC" or "AC + DC"** measurements.
4) Connect the red probe to the **"V"** input jack and the black probe into the **"COM"** input jack respectively.
5) Apply the probe tips to the points to be tested. The value will be shown on the display.
6) Over range warning: The reading shows **1** or **-1** when the input signal is over the measuring range.

2.6 AC Power Measurements

1) Turn on the meter.
2) Press the **MENU** key to select power mode. The displays will "KW" annunciator.
3) Connect the red/black probes to the "V" and "COM" input jacks respectively and apply the probe tips to the power source of the loading.

4) Press the **ZERO** key to Zero the display reading.
5) Hook the clamp jaws around one of the conductors from the power source.
6) The display reading is the true power consumption of the loading.
7) Press the **SHIFT** key to enter power factor (con θ) measurement.
8) Wait for about 10 seconds to get the reading of cosθ on the display.
9) Press the **SHIFT** key to enter the apparent power KVA measurement.
10) Wait for about 10 seconds for the reading of the apparent power consumption of the loading on the display.
11) Press the **SHIFT** key to enter the reactive power measurement.
12) Wait for about 10 seconds to get the reading of the reactive power of the loading on the display.

Note: Ranges on Active and Reactive Power are selected via auto range only.

2.7 Resistance Measurement and continuity check

1) Press the **MENU** key to select resistance measurement mode. The display will show the **"Ω"** annunciator.
2) Connect the red probe into the **"Ω"** input jack and the black probe into the **"COM"** input jack respectively.
3) Apply the probe tips to the point to be tested and read the displayed value.
4) In the resistance measurement mode, you can enable the beeper by pressing the **SHIFT** key. The display will show the **"Ω"** annunciator. In this mode the beeper will be triggered if the resistance between the probe tips is less than 30 Ω.

Note: The internal offset voltage of the circuit contributes a few counts on the reading as the input terminals are shorted in the resistance measurement. Use the **ZERO** key to offset the value for the best accuracy when small resistance is measured.

2.8 AC Surge Current Measurements

1) Select AC A measurement mode.
2) Press **SURGE key** to enter surge measurement mode.
3) Press **RANGE** key to select high range (100A) or low range (350A).
4) Hook the clamp jaws around the conductor to be tested.
5) The display will show the peak value of current flow in the conductor.

2.9 Frequency Measurement

The frequency of a power source can be measured in the current mode or the voltage mode.

(1) In the Current mode
   a. Press the MENU key to select current measurement mode.
   b. Press the SHIFT key to select frequency measurement. The display will show the "AC", "V", and "HZ" annunciators.

c. Hook the clamp jaws around the conductor to be tested and read the frequency of the power source on the display.

Note: The minimum threshold current for frequency measurement is 8A.

(2) In the voltage mode

a. Press the MENU key to select voltage measurement mode.
b. Press the SHIFT key to select frequency measurement. The display will show the "AC", "V", and "HZ" annunciators.
c. Connect the red probe to "V" input jack and the black probe to "COM" input jack.
d. Apply the probe tips to the power source to be measured and read the frequency value on the display.

2.10 Crest Factor Measurement

Crest factor is the peak value of a waveform divided by its RMS value. For a sine wave, the crest factor is 1.414. The peak value can not exceed 1000volts or 1000 amps.

(1) In the current measurement mode or voltage measurement mode, press the **SHIFT** key to select crest factor measurement. The "CF" annunciator will be shown on the display.

(2) Hook the jaws around the conductor to be measured and input the power source to be measured into to the "V" and "COM" input jack.

(3) Wait for about 10 seconds, the crest factor value of the input current or the input voltage will be displayed on the display.

2.11 Data Hold and Minimum, Maximum

1) Press the **DH** key during the measurement. The reading of the display will be frozen and **"DH"** annunciator will be shown on the display.
2) Press the **DH** key again to enter minimum and maximum mode. The "MIN" and "MAX" annunciator will be visible on the display. The minimum value of the input signal will be stored automatically.
3) Press the **DH** key again. The minimum value of the input signal will be called up and shown on the display. The "MIN" annunciator will be shown on the display at the same time.
4) Press the **DH** key again, the maximum value of the input signal will be called up and shown on the display. The "MAX" annunciator will be shown on the display at the same time.
5) Press the **DH** key again to return to the normal measurement mode.

2.12 True RMS Measurement and Average Sensing Measurement

The TRMS sensing mode can accurately measure the RMS value of the non-sinusoidal input signal. The average-sensing mode measures the average value of a sinusoidal signal and displays it as an equivalent RMS value. Measurement errors are introduced when the input waveform is distorted. The amount of error depends upon the amount of distortion figure 1 shows the relationship between sine, square, and triangle waveforms, as well as the required conversion factor.

EXPERIMENT NO – 14

STUDY AND THE USE OF ILLUMINATION METER