Ahsanullah University of Science and Technology

Department of Electrical and Electronic Engineering

LABORATORY MANUAL

FOR

ELECTRICAL AND ELECTRONIC SESSIONAL COURSE

Student Name :

Student ID :

Course no : EEE - 1278

Course Title : Introduction to Electrical Circuits and Machines Lab

For the students of

Industrial and Production Engineering

1st Year, 2nd Semester

Experiment No.	: **01**
Name of the Experiment	: **Verification of Ohm's Law.**

OBJECTIVE:

To verify the following two equivalent forms of Ohm's Law:

a. Express I as a function of V and R.
b. Express V as a function of I and R.

THEORY:

Ohm's law describes mathematically how voltage 'V', current 'I' and resistance 'R' in a circuit are related. According to this law:

"The current in a circuit is directly proportional to the applied voltage and inversely proportional to the circuit resistance".

<u>Formula for voltage:</u>
For a constant value of R, V is directly proportional to I
i.e. $V = IR$

<u>Formula for current:</u>
For a constant value of V, I is inversely proportional to R
i.e. $I = V/R$

EQUIPMENTS:

- Variable DC power supply -1 piece
- Digital multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances: 1 KΩ, 2.2 KΩ, 3.3 KΩ, 4.7 KΩ, 5.6 KΩ, 10 KΩ -1 piece each.
- Trainer Board
- Connecting Wires.

CIRCUIT DIAGRAM:

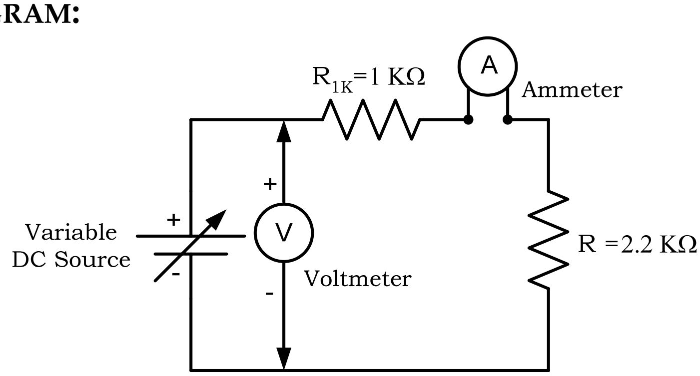


Figure 2.1: Verification of Ohm's Law

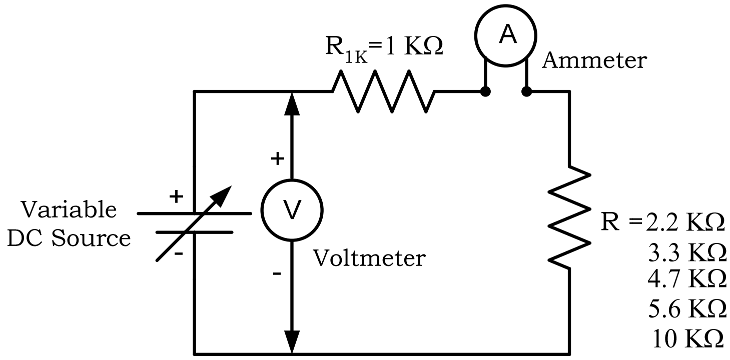


Figure 2.2: Verification of Ohm's Law

PROCEDURES:

Current versus voltage:

a. Construct the circuit of Figure 2.1. Do not switch on the power supply.
b. Turn on the power supply and adjust it to 5V by using Voltmeter. Measure the current I by ammeter and record it in the Table 2.2.
c. Increase the values of voltage as shown in the Table 2.2. Measure the current I in turn and record the values in Table 2.2.
d. Calculate the values of current I by using $I=V/R_T$. Use measured values of resistances.

Current versus resistance:

a. Construct the circuit of Figure 2.2. Do not switch on the power supply.
b. Turn on the power supply and adjust it to 20V by using Voltmeter. Measure the current I by ammeter for R=2.2 KΩ (Use measured values) and record it in the Table 2.3.
c. Turn off the power supply and remove the resistance 2.2 KΩ. Replace it by resistor 3.3 KΩ.
d. Now turn on the power supply. Measure and record the current I in turn, at each of the resistance settings shown in the Figure 2.2.
e. Calculate the values of resistance R_T by using $R_T=V/I$. Use measured values of voltage and current.

DATA SHEET:

Table 2.1: Measuring Resistances by using Ohmmeter

Nominal values of R (KΩ)	Measured values of R(KΩ) by using Ohmmeter
1	
2.2	
3.3	
4.7	
5.6	
10	

Table 2.2: Current versus voltage

Supply Voltage (V)	Measured I by using Ammeter (A)	$R_T = R_{1K} + R_{2.2K}$ [Use measured values of R]	Calculate I (amp) $I=V/R_T$
5			
10			
15			
20			
25			

Table 2.3: Current versus resistance

Supply Voltage (V)	Measured I by using Ammeter (A)	R_T (KΩ) Use measured values of R	Calculate $R_T = V/I$ (KΩ)
20		$R_T = R_{1K} + R_{2.2K}$ $R_T =$	
20		$R_T = R_{1K} + R_{3.3K}$ $R_T =$	
20		$R_T = R_{1K} + R_{4.7K}$ $R_T =$	
20		$R_T = R_{1K} + R_{5.6K}$ $R_T =$	
20		$R_T = R_{1K} + R_{10K}$ $R_T =$	

____

Signature of the Teacher

ASSIGNMENTS:

1. What can you say about the relationship between voltage and current, provided that the resistance is fixed?

2. Plot a graph of I versus V keeping the value of resistance constant. Use measured values of I and V. Comment on the graph briefly.

3. Plot a graph of I versus R_T keeping the value of supply voltage constant. Use measured values of I and $R_{T.}$ Comment on the graph briefly.

Experiment No.	: **02**
Name of the Experiment:	**To investigate the characteristics of a series DC circuit and to verify Kirchoff's Voltage Law (KVL).**

OBJECTIVE:

The objective of this experiment is to investigate the characteristics of a series DC circuit and to verify Kirchoff's Voltage Law (KVL).

THEORY:

In a series circuit (Figure 3.1) the current is same through all of the circuit elements.

The equivalent Resistance, $R_T = R_1 + R_2 + R_3$.

By Ohm's Law, the Current is

$$I = \frac{V_{Supply}}{R_T}$$

KVL states that the voltage rises must be equal to the voltage drops around a close circuit. Applying Kirchoff's Voltage Law around closed loop of Figure 3.1, we find,

$$V_{Supply} = V_1 + V_2 + V_3$$

Where, $V_1 = IR_1$, $V_2 = IR_2$, $V_3 = IR_3$

Current I is same throughout the circuit for figure 3.1.

The voltage divider rule states that the voltage across an element or across a series combination of elements in a series circuit is equal to the resistance of the element divided by total resistance of the series circuit and multiplied by the total impressed voltage. For the elements of Figure 3.1

$$V_1 = \frac{R_1 E}{R_T}, \quad V_2 = \frac{R_2 E}{R_T}, \quad V_3 = \frac{R_3 E}{R_T}$$

EQUIPMENTS:

- Variable DC power supply -1 piece
- Digital Multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances: 100Ω, 220Ω, 470Ω -1 piece each.
- Trainer Board-1 piece
- Connecting Wires.

CIRCUIT DIAGRAM:

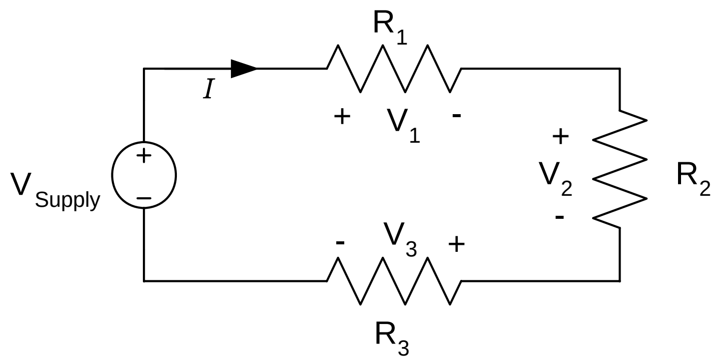


Figure 3.1

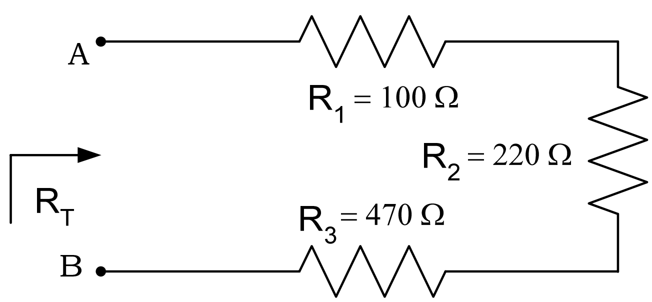


Figure 3.2

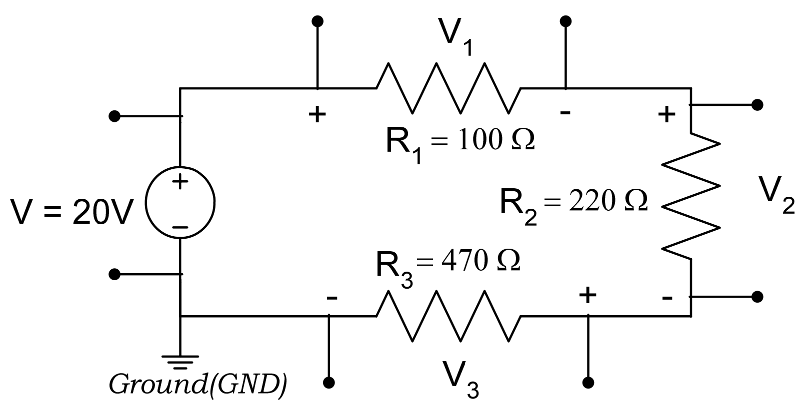


Figure 3.3

PROCEDURE:

1. Measure the resistances having values 100Ω, 220Ω & 470Ω by using Ohmmeter and record the values in Table 3.1.
2. Construct the circuit as shown in Fig 3.2.
3. Then measure input resistance R_T across points A-B using Ohmmeter and record that value in Table 3.1.
4. Now construct the circuit as shown in Fig 3.3. Turn on the DC power supply and set the DC supply to 20V by using Voltmeter.
5. Measure voltage across each resistor with Voltmeter and record in the Table 3.1
6. Calculate V_1, V_2 and V_3 using Voltage Divider Rule (VDR). ***[Use measured values of resistances for all calculations.]***

ASSIGNMENTS:

1. What can you deduce about the characteristics of a series circuit from observation Table 3.1?

2. From the data found in Table 3.1, mathematically prove that the current in the series network of figure 3.3 is equal for each resistance.

3. Verify KVL from the data obtained in Table 3.1.

DATA SHEET:

Table 3.1:

Nominal values of Resistance (Ω)	Measured values of Resistance by Ohmmeter (Ω)	Equivalent Resistance, R_T		Measured voltage across each resistor (V)	Calculated Voltage using VDR (V)
		Measured R_T by using Ohmmeter (Ω)	Calculated $R_T = R_1 + R_2 + R_3$ (Ω)		
R_1=100				V_1=	
R_2=220				V_2=	
R_3=470				V_3=	

Calculation:

Signature of the Teacher

Experiment No.	: **03**
Name of the Experiment:	**To investigate the characteristics of a Parallel DC circuit and to verify Kirchoff's Current Law (KCL).**

OBJECTIVE:

The objective of this experiment is to investigate the characteristics of a parallel DC circuit and to verify Kirchoff's Current Law (KCL).

THEORY:

In a parallel circuit (Figure 4.1) the voltage across parallel elements is the same.

The total or equivalent resistance (R_T) is given by,

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + --------- + \frac{1}{R_N}$$

If there are only two resistors in parallel, it is more convenient to use,

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

In any case, the total resistance will always be less than the resistance of the smallest resistor of the parallel network.

KCL states that the currents entering a node must be equal to the currents leaving that node. For the network of Figure 4.1 the currents are related by the following expression:

$$I_T = I_1 + I_2 + I_3 + --------- + I_N$$

Applying current divider rule (CDR) for a circuit of only two resistors in parallel as shown in figure 4.2,

$$I_1 = \frac{R_2 I_T}{R_1 + R_2} \quad \text{and} \quad I_2 = \frac{R_1 I_T}{R_1 + R_2}$$

For equal parallel resistors, the current divides equally and the total resistance is the value of one divided by the **'N'** number of equal parallel resistors, i.e.:

$$R_T = \frac{R}{N}$$

For a parallel combination of N resistors, the current I_1 through R_1 is:

$$I_1 = I_T \times \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + --------- + \frac{1}{R_N}}$$

EQUIPMENTS:

- Variable DC power supply -1 piece
- Digital Multimeter (DMM)/ Analog multimeter-1 piece.
- Resistances: 1KΩ, 2.2 KΩ, 4.7 KΩ -1 piece each.
- Trainer Board-1 piece
- Connecting Wires.

CIRCUIT DIAGRAM:

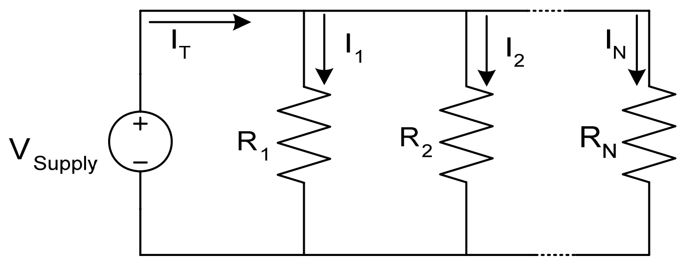


Figure 4.1

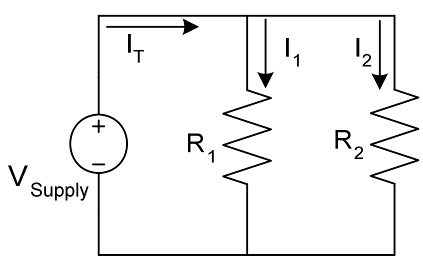


Figure 4.2

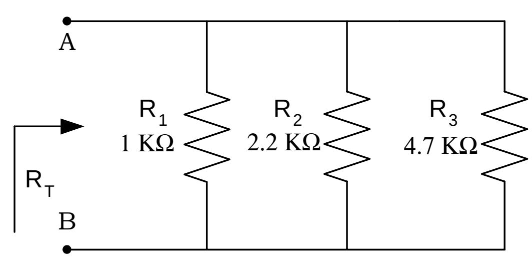


Figure 4.3

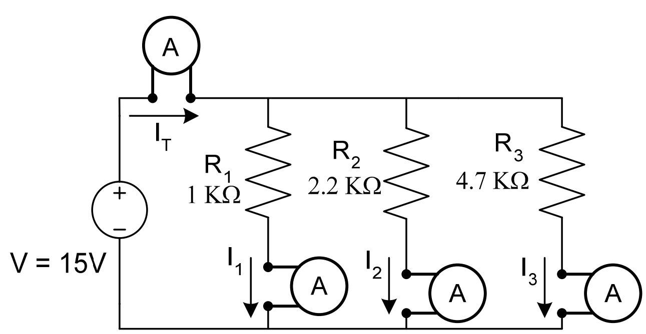


Figure 4.4

PROCEDURE:

1. Measure the resistances having values 1 KΩ, 2.2 KΩ & 4.7 KΩ by using Ohmmeter and record the values in Table 4.1.
2. Construct the circuit as shown in Fig 4.3.
3. Then measure input resistance R_T across points A-B using Ohmmeter and record that value in Table 4.1.
4. Now construct the circuit as shown in Fig 4.4. Turn on the DC power supply and set the DC supply to 15V by using Voltmeter.
5. Measure the currents I_T, I_1, I_2 and I_3 by using Ammeter and record in the Table 4.1.
6. Calculate I_1, I_2 and I_3 using Current Divider Rule (CDR). ***[Use measured values of resistances for all calculations.]***

ASSIGNMENTS:

1. What can you deduce about the characteristics of a parallel circuit from observation Table 4.1?

2. From the data found in Table 4.1, Calculate I_1, I_2 and I_3 using Ohm's Law.

3. Verify KCL from the data obtained in Table 4.1.

DATA SHEET:

Table 4.1:

Nominal values of Resistance (KΩ)	Measured values of Resistance by Ohmmeter (KΩ)	Equivalent Resistance, R_T		Measured current through each resistor (A)	Calculated Current using CDR (A)
		Measured R_T by using Ohmmeter (KΩ)	Calculated $\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ (KΩ)		
R_1=1				I_1=	
R_2=2.2				I_2=	
R_3=4.7				I_3=	

Calculation:

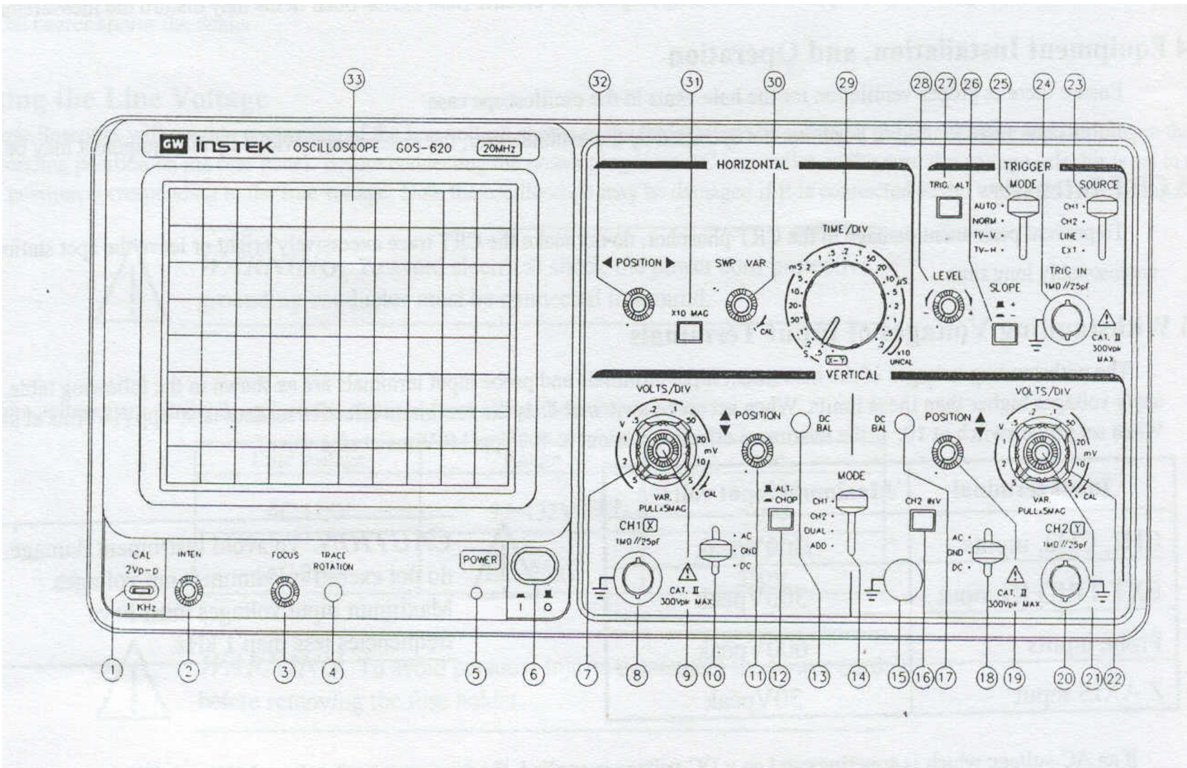
Signature of the Teacher

Experiment No.	: **04**
Name of the Experiment	: **Introduction to Oscilloscope Operation.**

OBJECTIVE:

This experiment is designed for the under-graduate students to introduce themselves and to be familiar with the oscilloscope and its operation. This experiment will help the students to have basic ideas about key functions of different knobs of oscilloscope and also to know how to measure voltage/current of a circuit-using oscilloscope as a measuring instrument.

FRONT VIEW OF THE LABORATORY OSCILLOSCOPE:



Introduction to front Panel:

The front panel consists of the following parts:

- *CRT*
- *Vertical axis*
- *Triggering*
- *Time*
- *Others*

BRIEF DESCRIPTION:

1. **CRT:**
    a) Power (***6***)
    The main power switch.
    b) Inten (***2***)
    Controls the brightness of the spot.
    c) Focus (***3***)
    For focusing the spot for sharp image.
    d) Trace rotation (***4***)
    For aligning the horizontal trace in parallel with graticule lines.
    e) Filter (***33***)

2. **Vertical axis:**
    a) CH1 (X) input (***8***)
    Vertical input of CH1. When in X-Y mode this acts as an X-axis input
    b) CH2 (Y) input (***20***)
    Vertical input of CH2. When in X-Y mode this acts as a Y-axis input
    c) AC-GND-DC (***10,18***)
    Switch for selecting connection mode between input signal and vertical amplifier.
    d) Volt/Div (***7,22***)
    Selection of vertical axis sensitivity, from 5mV/Div to 5V/Div in 10 ranges.
    e) Variable (***9,21***)
    f) CH1 & CH2 DC BAL (***13,17***)
    g) Position (***11,19***)
    Control the position of the vertical trace or spot.
    h) Vert mode (***14***)
    There are four positions to switch the operation of CH1 and CH2.When position in either CH1 or CH2; then oscilloscope operates as single channel instrument with CH1 or CH2 respectively. When position in DUAL then the oscilloscope operates as dual–channel of both CH1 and CH2. When position in ADD, then oscilloscope displays the algebraic sum (CH1+CH2) or difference (CH1-CH2). During difference operation, CH2 INV must be pushed.
    i) ALT/CHOP (***12***)
    When this switch is released then CH1 and CH2 are alternately displayed. When this switch is engaged then CH1 and CH2 are chopped and displayed simultaneously.
    j) CH2 INV (***16***)
    This inverts the CH2 input signal when this knob is pushed in.

3. Triggering:

a) EXT TRIG IN input terminal (***24***)

b) SOURCE (***23***)

1) **CH1:** When Vert mode switch is at DUAL/ADD position select CH1 for internal triggering.
2) **CH2:** When Vert mode switch is at DUAL/ADD position select CH2 for internal triggering.
3) **TRIG.ALT:** It will alternately select CH1 and CH2 for internal triggering.
4) **Line**
5) **EXT**

c) SLOPE (***26***)

1) **'+':** Triggering occurs when triggering signal crosses triggering level in +ve going direction.
2) **'—':** Triggering occurs when triggering signal crosses triggering level in –ve going direction.

d) LEVEL (***28***)

To display synchronized stationary waveform and set a start point of it.

e) TRIGGER MODE (***25***)

4. Time Base:

a) TIME/DIV (***29***)

Ranges are available from 0.2 μsec/div to 0.5 sec/div in 20 steps.

X-Y mode: This position is used when oscilloscope functions as an X-Y oscilloscope.

b) SWP.VAR (***30***)

c) Position (***32***)

Control the position of the horizontal trace or spot.

d) x 10 MAG (***31***)

When this button is pushed, magnification of 10 occurs.

5. Others:

a) CAL (***1***)

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

b) GND (***15***)

The ground terminal of the oscilloscope mainframe.

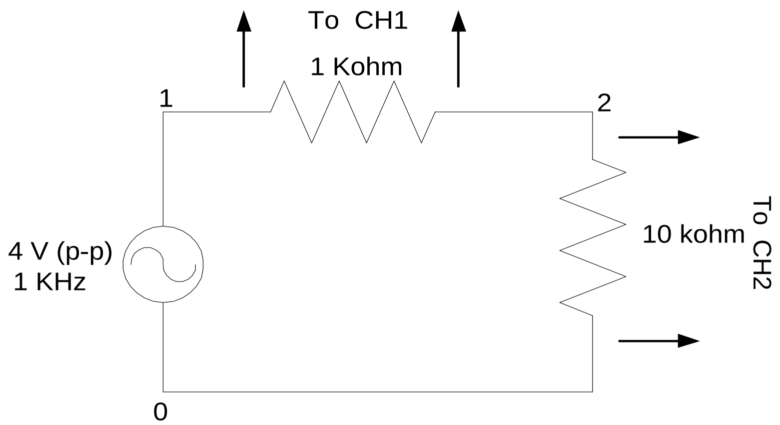
BASIC OPERATION WITH OSCILLOSCOPE:

1. Single channel operation.
2. Dual-channel operation.
3. ADD operation.
4. Frequency measurement
5. Sweep Magnification
6. X-Y Operation.
7. To display two input signals still on oscilloscope

EQUIPMENTS:

1. Oscilloscope – 1 unit
2. Oscilloscope probe (10 x)– 2 pieces
3. Signal Generator – 1 unit
4. Signal Generator probe – 1 piece
5. Resistor 1kΩ, 10kΩ
6. Bread Board – 1 piece.
7. Multi-meter

CIRCUIT DIAGRAM:



PROCEDURES:

1. Connect the circuit according to the above circuit diagram.
2. Set the AC-GND-DC of CH1 in the GND position and align the trace with horizontal central line and then set to AC position.
3. Now apply sine wave of 1 kHz from signal generator to CH1 and adjust its magnitude to 4V (p-p) by varying the attenuator knob of the signal generator.
4. If the signal is not still just slowly vary the 'level' knob to make it still.
5. Now disconnect the signal from CH1 and apply to terminals between 1 and 0.

6. Don’t change the attenuator knob throughout the experiment.
7. Now connect the oscilloscope probes across 1 kΩ resistor to CH1 and across 10 kΩ resistors to CH2 according to circuit diagram.
8. Push CH2 INV button.

1. Single channel operation:

a) Set the AC-GND-DC of both channels in the GND position and align the trace with horizontal central line and then set to AC position.
b) Adjust the FOCUS control so that the trace image appears sharply.
c) Set the VOLTS/DIV switch at 1 V and TIME/DIV switch at 0.5 ms position so that signal waveform is displayed clearly.
d) Adjust vertical POSITION and horizontal POSITION controls in appropriate position so that the displayed waveform is aligned with the graticule and voltage (p-p) and period (T) can be read conveniently.
e) Set the Vert mode to CH1 and measure the p-p voltage across 1 kΩ resistor. Find the rms value of the signal from the following diagram:
   Vrms =Vmeasured (p-p)/(2*√2) volt.
f) Measure the voltage across 1 kΩ resistor by multimeter and compare with the measured value.
g) Set the Vert mode to CH2 and repeat procedure (e).
h) Change the signal frequency to 100Hz, 10 kHz and observe the waveform.

2. Dual-channel operation:

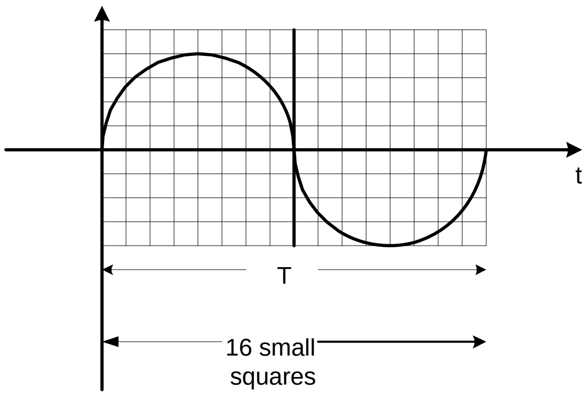
a) Set the Vert mode switch to DUAL state so that both channels are displayed simultaneously. To display each channel separately change the vertical POSITION control of both channel to convenient position.
b) When ALT/CHOP switch is released (ALT mode) signals respectively to CH1 and CH2 appear on screen alternately.
c) When ALT/CHOP switch is pushed (CHOP mode) signals respectively to CH1 and CH2 are switched at 250 kHz.

3. ADD operation:

a) When Vert mode switch is at ADD position then the displayed signal is the algebraic sum of CH1 and CH2.if the CH2 INV switch is pushed then displayed signal is the difference of CH1 and CH2.
b) Observe the waveform for both cases and draw.

4. **Frequency measurement:**

a) The frequency of any waveform can be measured by adjusting the TIME/DIV control knob of oscilloscope. Adjust the TIME/DIV control knob to position 0.5 ms to observe the waveform.
b) Now measure the frequency of the wave using the following formula:
1 large square or 5 small squares = t sec, here t = 0.5 ms
# of small squares required to represent a full cycle of wave =n sec
Where, n may have fraction value.
Time period, T = (n/5) × t s
Frequency, f = 1/T Hz



Now compare this value with the main signal frequency.
c) Now vary the TIME/DIV control knob to different position and repeat (b).

5. **Sweep Magnification:**

a) Set the TIME/DIV switch at 0.5 ms and VOLTS/DIV at 1 V. Set AC-GND-DC position at GND position and align the trace with horizontal central line.
b) Set the Vert mode at CH1 and AC-GND-DC at AC and then push x 10 MAG button.
c) The displayed waveform will be expanded 10 times to the right and left with the centre of the screen as the centre of expansion.

6. **X-Y operation:**

a) Set the TIME/DIV switch at X-Y position. Now CH1 acts as X-axis input and CH2 as Y-axis input.
b) X-Y positions are adjusted by horizontal position and CH2 vertical position control respectively.
c) Adjusted the amount of vertical Y-axis with CH2 VOLTS/DIV controls.

d) Adjust the amount of horizontal X-axis with CH1 VOLTS/DIV controls.
e) Observe the waveforms and draw.

7. To display two input signals still on oscilloscope:

a) Apply 2v (p-p), 1 kHz ac signal (sine wave) from signal generator-1 to CH1 of oscilloscope.
b) Set VOLT/DIV of CH1 to 1 V and TIME/DIV to convenient position to observe the wave shape clearly.
c) Repeat (1) from signal generator-2 to CH2 of oscilloscope.
d) Set VOLT/DIV of CH2 to 0.5 v.
e) Now set the Vert mode to DUAL position and observe the wave shapes.
f) Note two waves that were displayed individually still are not still now.
g) Set the SOURCE to CH1 and then CH2 position and observe what happens.
h) Push the TRIG. ALT button and observe the wave shapes.

Note:

1) Don't put any sort of electrical equipments (such as signal generator, dc supply etc.) on the top of the oscilloscope.
2) Place the oscilloscope away from any magnetic field (as far as possible)
3) If the GND horizontal line deviates significant amount then adjust it by rotating the position of oscilloscope.
4) Always check the 10x switch of probe according to your measurement.
5) Always avoid common grounding resulting from improper connection of knobs in the circuit.

COMMON MISTAKES USING OSCILLOSCOPE:

1) Changing the calibration knob during experiment.
2) Changing the SWP.VAR knob during experiment.
3) Improper 10x max for probe.
4) Improper 10x max for frequency.
5) Ground level adjustment during measurement.

Experiment no: **5**
Experiment name: **Study of a Single-Phase Transformer.**

Introduction:

A transformer is a static device by means of which electric power in one circuit is transferred into electric power in another circuit of the same frequency. It can raise or lower voltage in the circuit with a corresponding decrease or increase in current. So the volt-ampere rating of two circuits remains same. The simple structure of a 1-ϕ transformer is shown below:

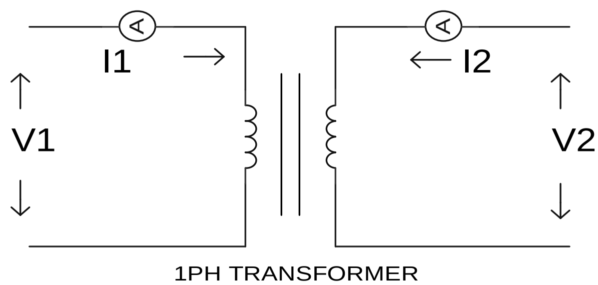


Fig: Simple structure of a 1-ϕ transformer

As the volt-ampere rating of two sides are same so

$$V_1 * I_1 = V_2 * I_2$$

$$\text{i.e. } V_1/V_2 = I_2/I_1 \text{ ....} (1)$$

Again the induced voltage in the transformer is directly proportional to the no of turns surrounding the transformer windings. So

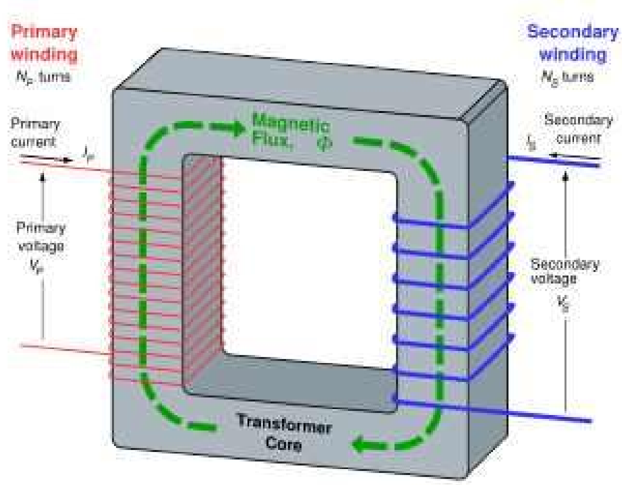
$$V_1 \propto N_1 \quad \text{and} \quad V_2 \propto N_2$$

$$\text{i.e. } V_1/V_2 = N_1/N_2 \text{ ----------------------- } (2)$$

Combining these two equations, (1) and (2) we get

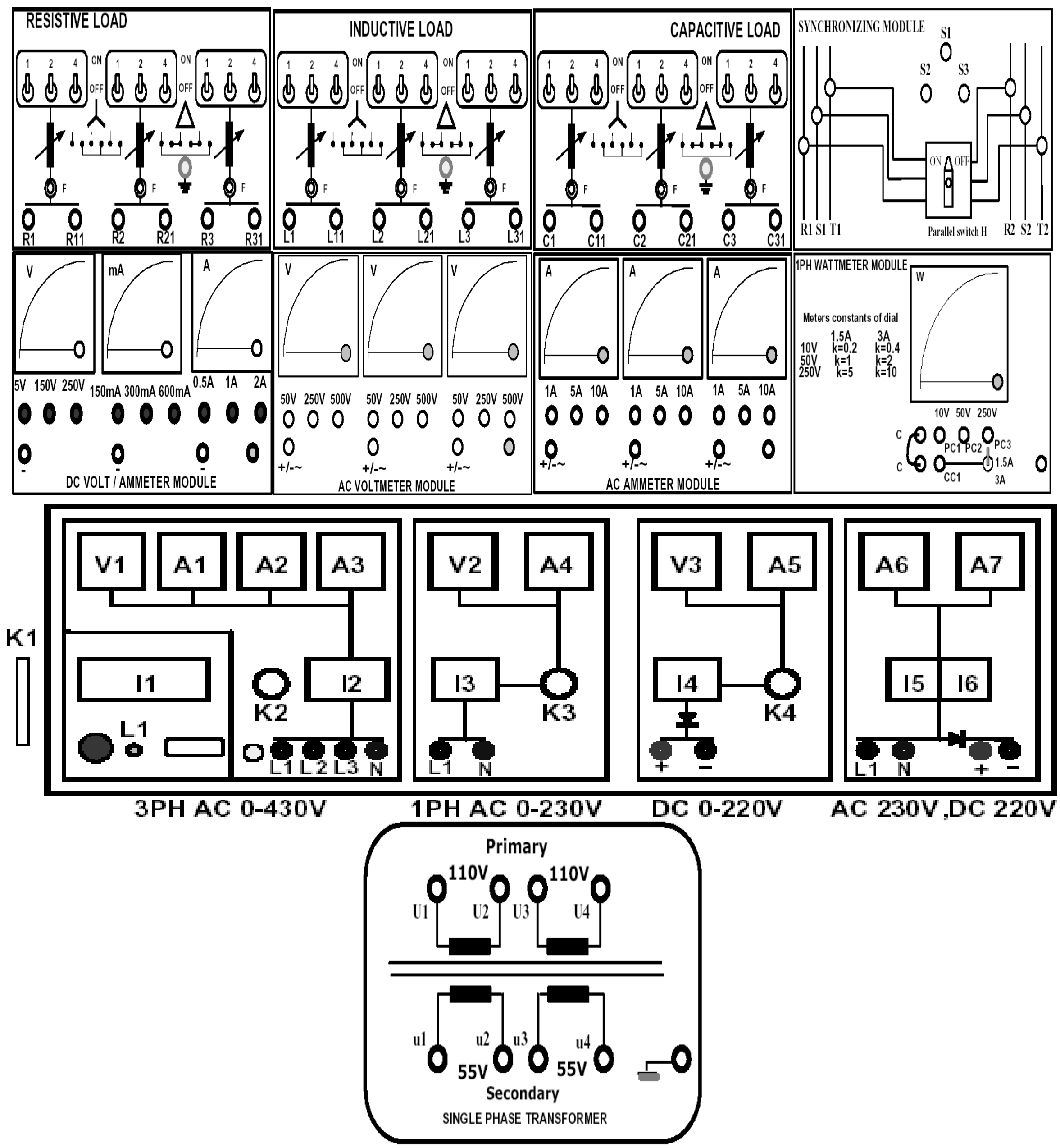
$$V_1/V_2 = I_2/I_1 = N_1/N_2$$

Where N_1/N_2 is called the transformation ratio or simply turns ratio of a transformer



Equipments:

1. Universal Power Supply Module
2. 1PH Transformer
3. AC Ammeter Module 0-1A
4. AC Voltmeter Module 0-250 V
5. Resistive Load
6. 1PH Wattmeter Module

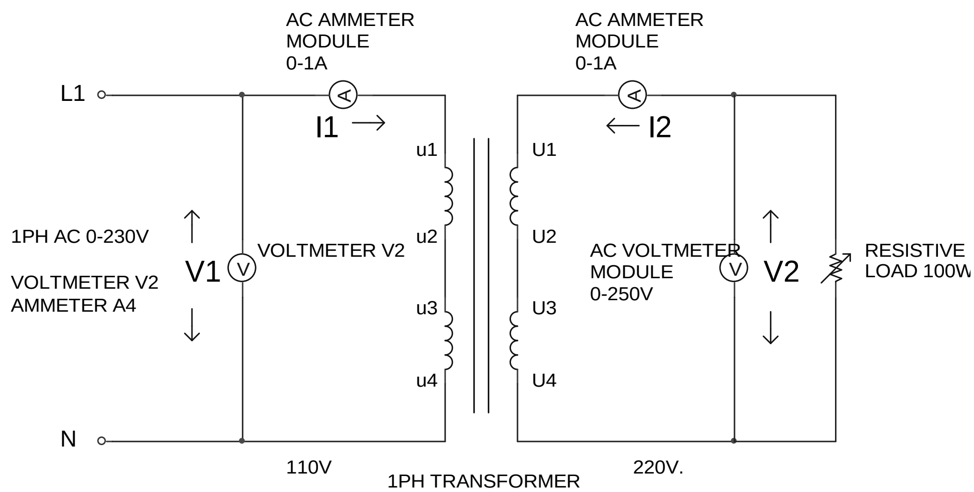


Ratio Test:

For a transformer, we know, the transformation ratio is given by

$$\frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{N_1}{N_2}$$

We shall determine the transformation ratio by measuring the voltages and currents both in the primary and secondary side.



1. Make sure all the switches (I1, I2, I3, I4, I5, I6) on the Power Supply are turned OFF (downwards).
2. Make sure all the variable knobs (K1, K3, K4) are at the min, counter clock wise (CCW) position.
3. Make sure all the switches (1,2,4) of the Resistive Load Module are OFF (downwards)

4. Make connections according to the above diagram.
5. Verify the connection by your Lab Teacher

6. Turn ON Switch I1 (upwards).
7. Turn Key K2 Clock Wise Once, the Indicator Lamp L1 becomes Green.

8. Make sure the 3PH supply Voltmeter V1 reading 400V.

9. Turn Knob K3 at min (CCW)
10. Turn ON switch I3 (upwards).
11. Slowly Increase 1PH AC Voltage to 110V, Turn Knob K3 CW, Voltmeter V2 reading 110V

12. Increase the Resistive Load by turning ON the switches (1,2,4) of the Resistive Load Module.
13. Increase Load until the current becomes 0.5A, so that power >= 100W

14. Note the voltages and currents both in the primary and secondary from the AC Voltmeter & Ammeter Module