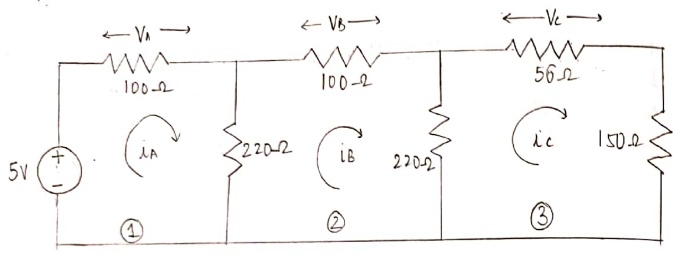
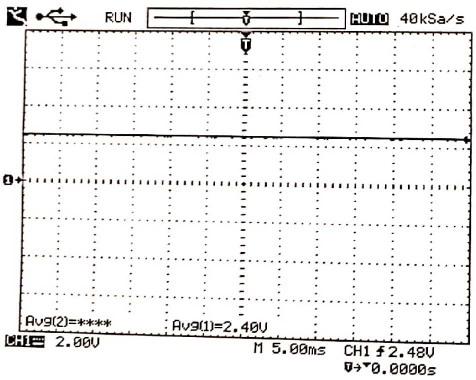


MESH ANALYSIS



Voltage across 100 Ω resistance (V_A)

$V_A = 2.40\,V$

$I_A = 0.024\,A$

Date 03.09.19

Expt. No. 2.

Page No. ~~03.~~ 7

EXPERIMENT-2 — title

AIM: To use mesh and nodal analysis to solve electrical circuits and verify the same.

APPARATUS USED: Resistors (100 Ω, 56 Ω, 220 Ω, 150 Ω), bread board, connecting wires, multimeter, power supply and digital storage oscilloscope.

a) MESH ANALYSIS:

PROCEDURE:

1. Solve the network shown in fig 1 using mesh analysis and compute i_A, i_B and i_C theoretically.
2. Obtain the components and connect the network as in figure.
3. Measure the currents i_A, i_B, i_C using DSO and verify.
4. Observe the KVL and KCL at loops and nodes and verify.
5. Repeat the experiment with any other circuit with available components.

CALCULATIONS:

Using KVL in loop 1, 2 and 3

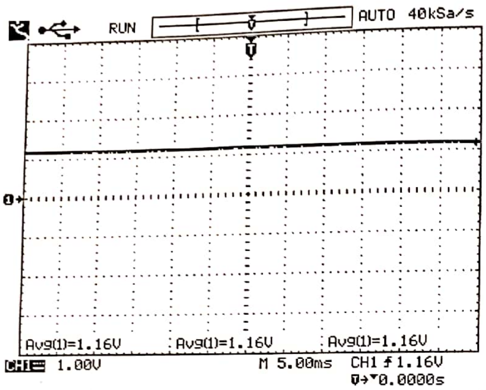
$5 - 100 i_A - 220(i_A - i_B) = 0$ {loop 1}

$\Rightarrow 5 - 320 i_A + 220 i_B = 0$ ... (i)

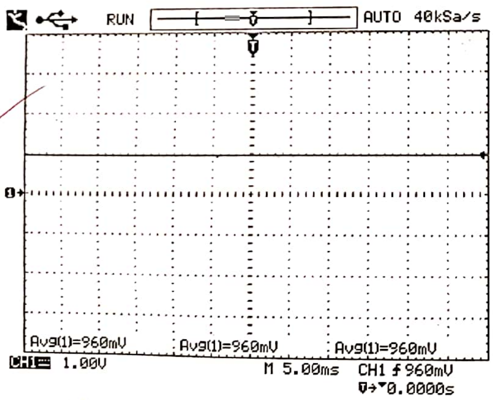
$-220(i_B - i_A) - 100 i_B - 220(i_B - i_C) = 0$ {loop 2}

$\Rightarrow 220 i_A - 540 i_B + 220 i_C = 0$ ... (ii)

Teacher's Signature



Voltage across 100Ω resistor (V_B)
$V_B = 1.16$ V
$i_B = 0.0116$ A



Voltage across 150Ω resistor (V_C)
$V_C = 960$ mV
$i_C = 0.0064$ A

Expt. No. ____________ Date ____________ Page No. ____________

$-220(i_C - i_B) - 56 i_C - 150 i_C = 0$ {loop 3}
$\Rightarrow 220 i_B - 426 i_C = 0$ ... (iii)

On solving (i), (ii) and (iii),
$i_A = 0.024$ A, $i_B = 0.0124$ A, $i_C = 0.0064$ A

By practical calculations,
$V_A = 2.4$ V, $V_B = 1.16$ V, $V_C = 960$ mV
$i_A = 0.024$A, $i_B = 0.0116$ A, $i_C = 0.0064$ A

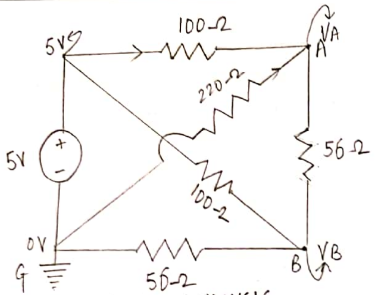
ERROR :

	Relative error
$\Delta i_A = (0.024 - 0.024)$ A $= 0$A	0%
$\Delta i_B = (0.0124 - 0.0116)$ A $= 0.0008$A	6.89%
$\Delta i_C = (0.0064 - 0.0064)$ A $= 0$A	0%

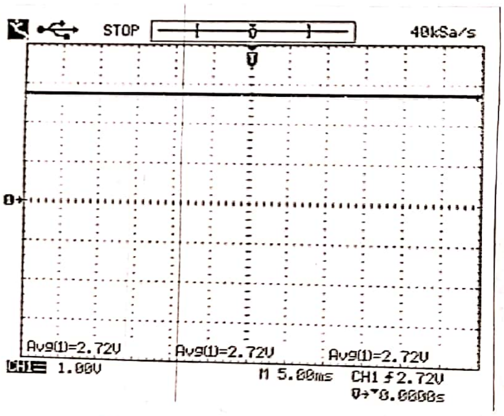
b) NODAL ANALYSIS :

PROCEDURE :
1. Solve the network shown in the figure using nodal analysis and compute node voltages at A and B theoretically.
2. Obtain the components and connect the network.
3. Measure the node voltages at A and B using DSO and verify.
4. Also, observe the KVL and KCL at all loops and nodes and verify.
5. Repeat the experiment with any other circuit with the available components.

Teacher's Signature ____________



NODAL ANALYSIS



Voltage at Junction A (V_A)
$V_A = 2.72V$

Date ____________

Expt. No. ____________ Page No. ____________

CALCULATION:

Applying KCL at junction A and B,

$$\frac{V_A - 5}{100} + \frac{V_A}{220} + \frac{V_A - V_B}{56} = 0 \qquad \{\text{at } A\}$$

$$\frac{V_B - 5}{100} + \frac{V_B}{56} + \frac{-(V_A - V_B)}{56} = 0$$

On solving, we get

$V_A = 2.73$ V $\qquad V_B = 2.16$ V

By practical experiment,
$V_A = 2.72V \qquad V_B = 2.20$ V

ERROR:

	Relative error
$\Delta V_A = \lvert 2.72 - 2.73 \rvert = 0.01$ V	0.36%
$\Delta V_B = \lvert 2.20 - 2.16 \rvert = 0.04$ V	1.85%

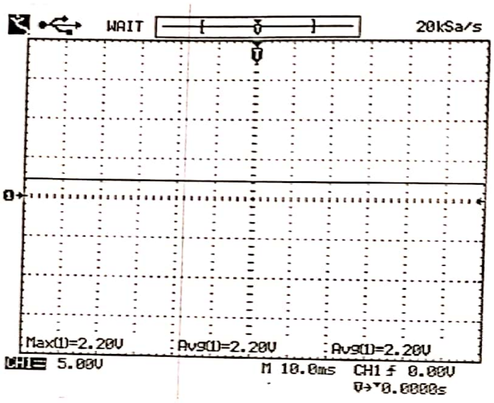
RESULTS:

In mesh analysis, the experimental values of $i_A = 0.024$A, $i_B = 0.0116$A, $i_C = 0.0064$A.
In nodal analysis the voltages at two junctions A and B are $V_A = 2.72V$ and $V_B = 2.20$ V.

DISCUSSION:

Circuits were solved in this experiment using mesh and nodal analysis. Same circuits were created on a bread

Teacher's Signature ____________



Voltage at Junction b (V_b)
$V_b = 2.20V$

Expt. No. ______ Date ______ Page No. ______

board and the measures of current and voltages were confirmed using a DSO.

Precautions:

1. The connecting wires must be fixed tightly.
2. DSO coupling must be set to D.C. to obtain results.
3. The value of resistances must be checked with a multi-meter.

CONCLUSION:

Kirchoff's voltage and current laws were used to solve the given circuits. Hence, we get the following values:

	Experimental	Theoretical
a)	i_A = 0.024 A	i_A = 0.024 A
	i_B = 0.0116 A	i_B = 0.0124 A
	i_C = 0.0064 A	i_C = 0.0064 A
b)	V_A = 2.72 V	V_A = 2.73 V
	V_B = 2.20 V	V_B = 2.16 V

Excellent

Teacher's Signature ______ 17/9/19

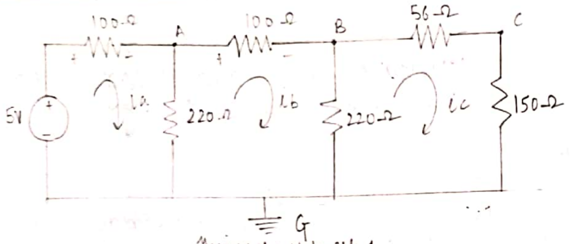
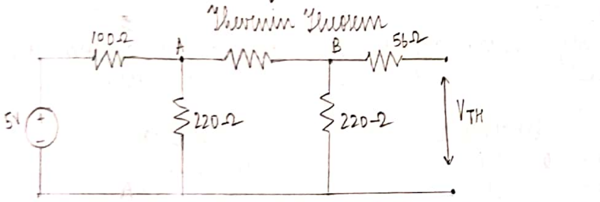
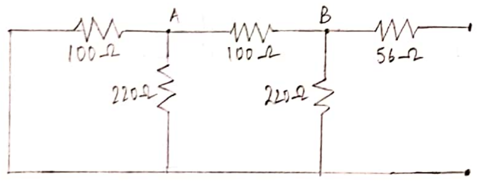


Figure 1: Network 1

Thevenin Theorem



Step I: (To calculate V_{TH}) $V_{TH} = 1.945$ V



Step II (to calculate R_{TH})
$R_{TH} = 151.5\Omega$

Date 17.09.19

Expt. No. 3.

Page No. 11

EXPERIMENT - 3
THEVENIN'S AND SUPERPOSITION THEOREM

AIM: To verify Thevenin's and superposition practically.

APPARATUS REQUIRED: Resistors (100 Ω, 56 Ω, 220 Ω, 150 Ω), Bread board, connecting wires, oscilloscope and power supply, multimeter

1 THEVENIN'S THEOREM

PROCEDURE:

1. Measure the open circuit voltage at CG by removing the 150 Ω resistor in the network of fig 1
2. Now, short CG by a wire and measure current through the shorted wire.
3. Replace the shorted wire with a known resistance and measure current through it.
4. Verify the Thevenin's theorem using the data in 1, 2 and 3

CALCULATION:

Using KVL,

$5 - 320\, i_A + 220\, i_B = 0$ (loop 1)

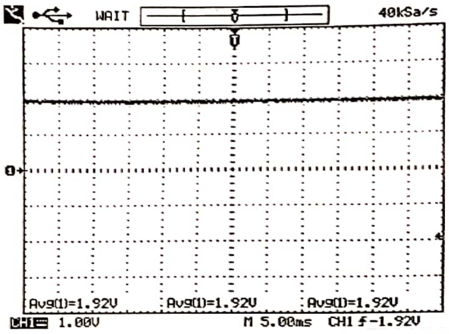
$220\, i_A - 540\, i_B + 220\, i_C = 0$ (loop 2)

$426\, i_C = 220\, i_B$ (loop 3)

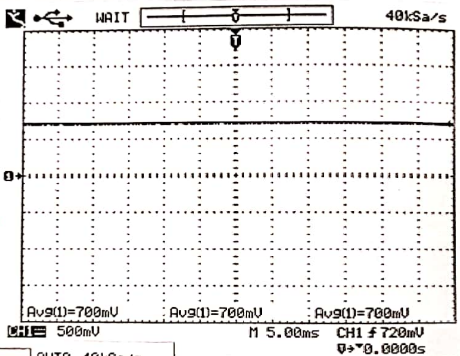
$i_A = 0.024$ A , $i_B = 0.0124$ A , $i_C = 0.0064$ A

By opening the circuit, (removing CG) →
Applying KCL,

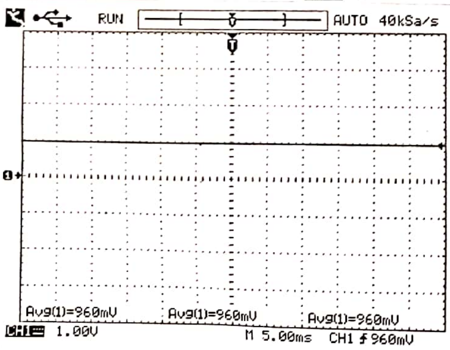
Teacher's Signature



$V_{TH} = V_{BG} =$ Voltage across 220Ω resistor



Voltage across 56Ω resistor while shorting
∴ i across shorted wire $= \frac{700}{56} = 0.125$ A



Voltage across 150Ω resistor.

Expt. No. 3 Date 17.09.19
Page No. 12

$\frac{V_A-5}{100} + \frac{V_A}{220} + \frac{V_A-V_B}{100} = 0$ (at Node A)

$\frac{V_B-V_A}{100} + \frac{V_B}{220} = 0$ (at B)

On solving, $V_A = 2.829$ V, $V_B = 1.945$ V

Also, $V_{TH} = V_B = 1.945$ V (∵ they are connected in ||)

In fig, by shorting the 5V battery, to calculate R_{TH}

$\Rightarrow \frac{1}{100} + \frac{1}{220} = \frac{1}{R_{eq1}} \Rightarrow R_{eq1} = 68.75\,\Omega$, in series with 100Ω gives us 168.75Ω

$R_{eq2} = \frac{168.75 \times 220}{168.75+220} = 95.498\,\Omega$,

in series with 56Ω $\Rightarrow R_{TH} = 151.498\,\Omega \approx 151.5\,\Omega$

Also, in the equivalent circuit, $i_{150\Omega} = \frac{V_{TH}}{R_{TH}+R_L(150\Omega)}$

$= \frac{1.945}{151.5+150} = 0.00645$ A

On practical calculations,

$V_{BG} = V_{220\Omega} = 1.92\text{ V} = V_{TH}'$, I_{sc}

$\Delta V_{150\Omega} = 960$ mV $\Rightarrow i_{150\Omega}' = \frac{960}{1000 \times 150} = 0.0064$ A

R_{th} expt by not calc

ERROR: Relative Error

$\Delta V_{TH} = |V_{TH}' - V_{TH}| = 0.025$ V — 1.285%

$\Delta i_{150\Omega} = |i_{150\Omega}' - i_{150\Omega}| = 0.00005$ A $= 0.05$ mA — 0.78%

Teacher's Signature ____________

Scanned by CamScanner

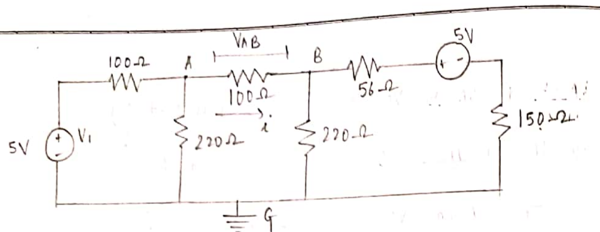


Figure 2(i): Network 2

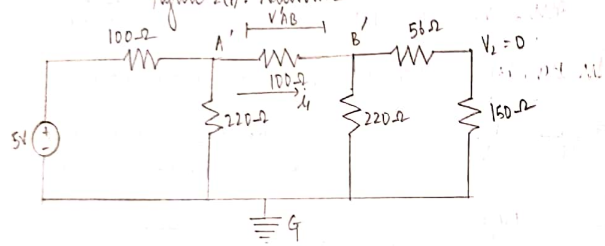


Figure 2(ii): Network 2 with $V_2 = 0$

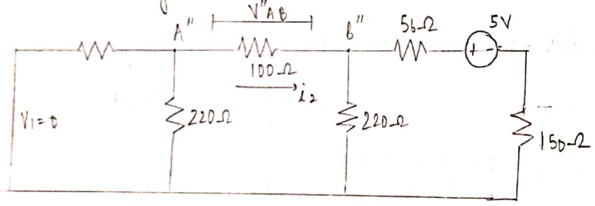


Figure 2(iii): Network 2 with $V_1 = 0$

2. SUPERPOSITION THEOREM:

PROCEDURE:

1. Connect the circuit as shown in figures and measure i_1 and i_2 respectively.
2. Also compute the current 'i' in the circuit.
3. Verify the superposition theorem from the readings/observations.

CALCULATIONS:

On performing the experiment,

In fig (i), $V_{100\Omega} = 316\ mV$

$\Rightarrow i_{100\Omega} = \frac{V_{100\Omega}}{100\Omega} = \frac{316}{100} = 3.16\ mA = i$

In fig (ii),

$V'_{100\Omega} = 1.24\ V$

$\Rightarrow i_{1\ 100\Omega} = \frac{1.24}{100} = 0.0124\ A$

In fig (iii),

$V''_{100\Omega} = -920\ mV$

$\Rightarrow i_{2\ 100\Omega} = -\frac{920}{1000 \times 100} = -0.0092\ A$

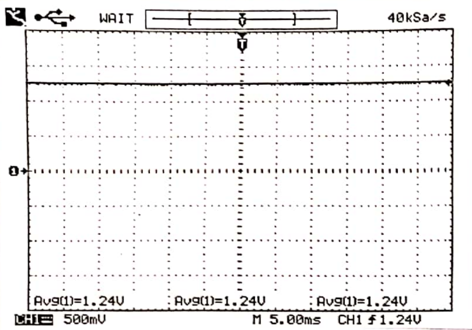
$i' = i_1 + i_2 = 0.0124\ A - 0.0092\ A = 0.0032\ A$
$= 3.20\ mA$

ERROR:

$\Delta i = |i - i'| = 0.04\ mA$

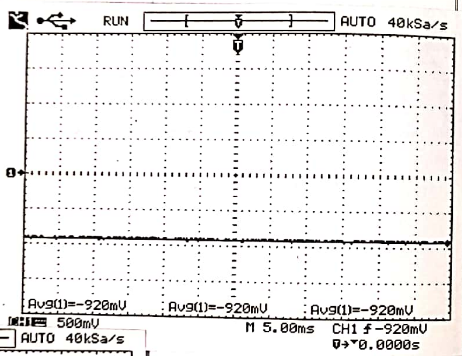
Relative error $= \frac{0.04}{3.16} \times 100 = 1.265\%$

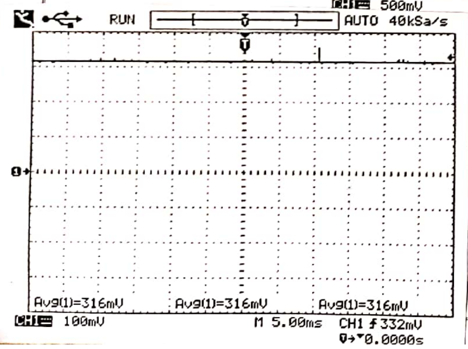
Teacher's Signature



(ii)
Voltage across 100Ω resistor
$i_1 = \frac{1.24}{100} = 0.0124\,A$

Voltage across 100Ω (iii)
resistor,
$i_2 = \frac{-920}{100 \times 1000} = -0.0092\,A$





Voltage across 100Ω (i)
$i = \frac{316}{100} = 3.16\,mA$

Expt. No. 3
Date 17.09.19
Page No. 14

RESULT :

a) In the case of Thevenin Theorem,
V_{TH} (theoretical) = 1.945 V , V_{TH} (practical) = 1.92 V
$i_{150\Omega}$ (theoretical) = 0.00645 A , $i_{150\Omega}$ (practical) = 0.0064 A

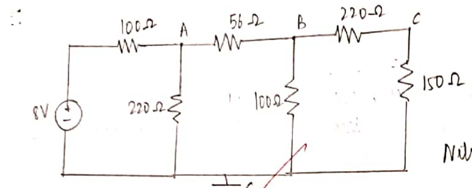
b) In the case of Superposition Theorem,
i (using superposition) = 3.20 mA
i (directly) = 3.16 mA

DISCUSSION :
The Thevenin and the Superposition Theorem were used to solve circuits and verified experimentally by measuring voltage and hence current along circuit elements.

Precautions :
1) Avoid loose connections in the network.
2) Direct contact between wires should be prevented to avoid short circuiting.
3) Resistances must be measured carefully.

CONCLUSION :
The Thevenin theorem and Superposition theorem are verified using the DSO, within the limits of experimental error, namely 0.78% and 1.265% respectively.

Teacher's Signature
20/9/19



Network 1

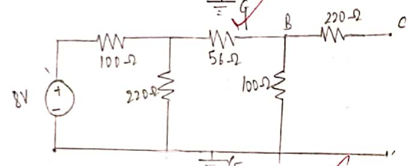


fig 1

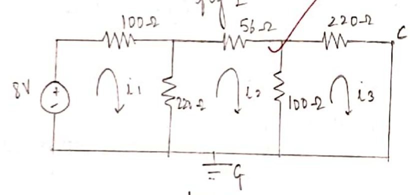


fig 2

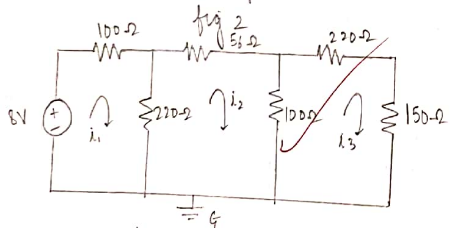


fig 3 (complete circuit)

Date 20.09.19

Expt. No. 4 Page No. 15

EXPERIMENT - 4

NORTON'S AND MAXIMUM POWER TRANSFER THEOREM

OBJECTIVE: To verify Norton's and maximum power transfer theorem practically.

APPARATUS USED: Bread board, resistors, connecting wires, power supply, multimeter, oscilloscope.

1. NORTON'S THEOREM:

PROCEDURE:

1) Short CG by a wire and measure current through the shorted wire.
2) Measure open circuit voltage at CG by removing the 150Ω resistor in fig 1.
3) Replace the shorted wire with a known resistance and measure the current through it.
4) Verify the Norton's Theorem using data 1, 2, 3.
5) Test the same for any other circuit and verify.

CALCULATIONS: (fig 1)

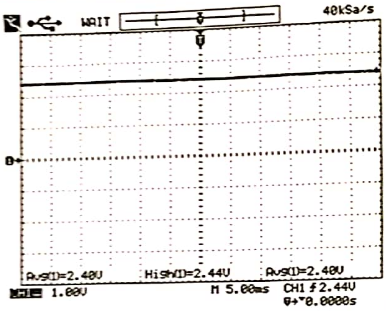
In the circuit, Applying nodal voltage analysis (KCL) at A and B.

$$\frac{V_B}{100} + \frac{V_B - V_A}{56} = 0 \quad \text{—(1)}$$

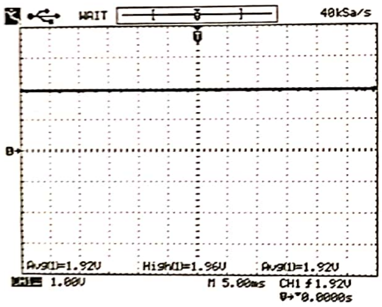
$$\frac{V_A - 8}{100} + \frac{V_A}{220} + \frac{V_A - V_B}{56} = 0 \quad \text{—(2)}$$

On solving $V_B = 2.447\,V = V_{TH} = V_N$

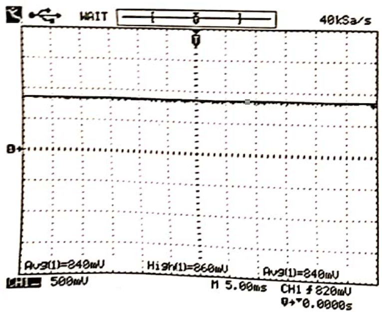
Teacher's Signature



$V_B = V_{across}\ 100\ \Omega$
$= V_{CG} = 2.40V$



$V_{across}\ 220\ \Omega$
$= 1.92V$



$V_{across}\ 150\ \Omega$
$= 840 mV$

Also, calculating $R_{TH} = R_{eq}$ from the circuit,

$R_{TH} = 275.506\ \Omega = R_N$

On shorting the CG and solving the circuit, (fig 2)

$8 - 100 i_1 - 220 (i_1 - i_2) = 0$ —— (i)

$-220(i_2 - i_1) - 56 i_2 - 100(i_2 - i_3) = 0$ —— (ii)

$-100(i_3 - i_2) - 220 i_3 = 0$ —— (iii)

we get, $i_1 = 0.04454$ A

$i_2 = 0.02842$ A

$i_3 = 8.8824 \times 10^{-3}$ A $= i_{sc}$

Voltage across 220 Ω, $V = (8.8824 \times 10^{-3})(220)$

$= 1.94128$ V

Also, $R_N = \frac{V_{TH}}{i_{sc}} = \frac{V_{TH}}{i_{sc}} = \frac{2.447}{8.8824 \times 10^{-3}} = 275.5\ \Omega$

Now,

Replacing shorted wire by a known resistor and measuring current through it, by applying KVL in (fig 3)

$8 - 100 i_1 - 2220 (i_1 - i_2) = 0$ —— (i)

$-220(i_2 - i_1) - 56 i_2 - 100(i_2 - i_3) = 0$ —— (ii)

$-100(i_3 - i_2) - 220 i_3 - 150 i_3 = 0$ —— (iii)

On solving,

$i_1 = 0.04358$ A, $i_2 = 0.027$ A, $i_3 = 5.751 \times 10^{-3}$ A

Voltage across 150 Ω $= 5.751 \times 10^{-3} \times 150 = 862.6$ mV

and $I_L = \frac{I_N R_N}{R_N + R_L} = \frac{8.824 \times 10^{-3} \times 275.5}{275.5 + 150}$

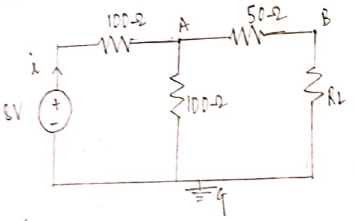
$= 5.713 \times 10^{-3}$ A

Practically,

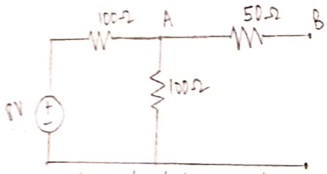
$V_B = V_{CG} = 2.40V$, $i_N = \frac{V_{220}}{220} = \frac{1.92}{220} = 0.00872A$

Teacher's Signature ____

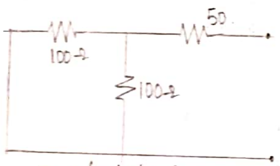
Scanned by CamScanner



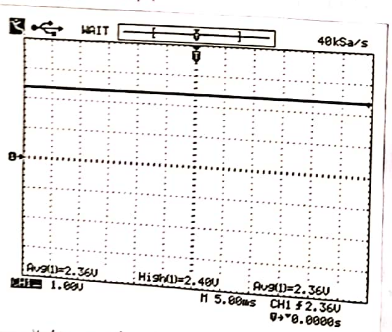
Network 2



To calculate $V_A = V_{TH}$



To calculate R_{TH}



Voltage drop across 150Ω = 2.36 V

Expt. No. ________ Date ________ Page No. ________

$i_{150} = \frac{V_{150}}{150} = \frac{840\,mV}{150} = 5.6\,mA$

$R_N = \frac{V_{TH}}{i_N} = \frac{2.4}{0.00872} = 275.23\,\Omega$ $\quad I_L = \left(\frac{R_N}{R_N + R_L}\right) \times I_N$

$= \frac{0.087 \times 275.23}{275.23 + 150} = 5.631\,mA$

ERROR:

	Relative Error
$\Delta V_{TH} = \lvert \Delta V_T - \Delta V_P \rvert = \lvert 2.447 - 2.40 \rvert = 0.047\,V$	1.92%
$\Delta I_N = \lvert \Delta I_T - \Delta I_P \rvert = \lvert 8.882 - 8.72 \rvert = 0.162\,mA$	1.82%
$\Delta I_{150} = \lvert \Delta I_{T150} - \Delta I_{P150} \rvert = \lvert 5.751 - 5.6 \rvert = 0.151\,mA$	2.62%

2. MAXIMUM POWER TRANSFER THEOREM:

PROCEDURE:

1. In the circuit, derive the value of load resistance R_L required for maximum power transfer.
2. Obtain the components and connect the circuit for various values of R_L including the value obtained in step I
3. Compute the input power, output power, and efficiency for different R_L and verify the maximum power transfer theorem.

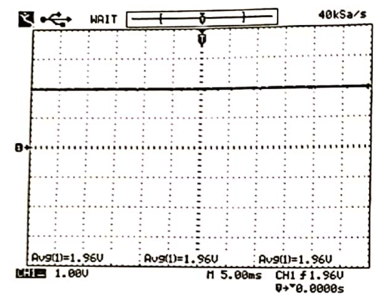
CALCULATIONS:

In the circuit, opening R_L and applying KCL at A,

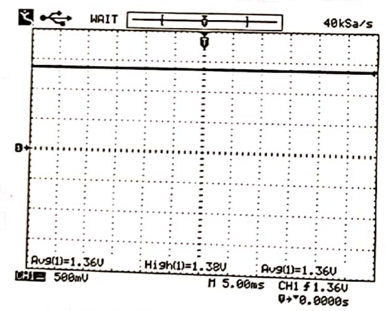
$\frac{V_A}{100} + \frac{V_A - 8}{100} = 0$

$\Rightarrow \frac{V_A}{50} = \frac{8}{100} \quad \Rightarrow V_A = 4V$

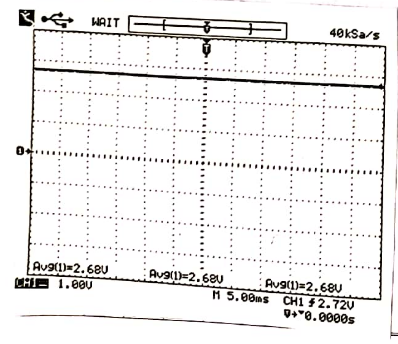
Teacher's Signature ________



Voltage drop across 100 Ω = 1.96 V



Voltage drop across 56 Ω = 1.36 V



Voltage drop across 220 Ω = 2.68 V

Date ______

Expt. No. ______ Page No. ______

$\therefore V_{TH} = V_A = 4V$ and shorting 8 V source to calculate R_{TH}, we get

$$R_{TH} = \left(\frac{100+50}{2}\right) = 100\,\Omega$$

$\therefore$ By Maximum Power Transfer theorem, $R_L = R_T = 100\,\Omega$

(as $V_{RL} = \frac{R_L}{R_L + R_{TH}} \cdot V_{TH}$

$$\Rightarrow P_{RL} = \frac{(V_{RL})^2}{R_L} = \frac{V_{TH}^2 R_L^2}{(R_L+R_{TH})^2 R_L} = \frac{16 R_L}{(R_L+100)^2}$$

for maxima, $\frac{dP_{RL}}{dR_L} = 0 \Rightarrow R_L = 100\,\Omega$)

OBSERVATIONS:

For a source voltage V = 8V.

S.No.	$R_L (\Omega)$	i (A)	Pinput (W)	V_{RL} (V)	Poutput (W)	Efficiency ($\frac{P_{in}}{P_{out}} \times 100$)
1.	150	0.048	0.384	2.36	0.0371	9.66%
2.	100	0.050	0.4	1.96	0.0384	9.60%
3.	56	0.059	0.472	1.36	0.033	6.99%
4.	220	0.046	0.368	2.68	0.032	8.87%

RESULT:

1) Hence, we can see that the maximum power across the output is obtained at $R_L = 100\,\Omega$. Hence, maximum power theorem is verified.
2) In the case of Norton, Theorem,

Teacher's Signature ______

Expt. No. ______ Date ______ Page No. 19

$V = V_{CG} = 2.40V$

$i_N = \frac{V_{220}}{220} = 0.00872A$

$I_L = \left(\frac{R_N}{R_N+R_L}\right) I_N = 5.631mA$ (Using Norton Equivalent)

and practically, $I_L = I_{150} = \frac{V_{150}}{150} = 5.6mA$

$\therefore$ Error in $I_L = \Delta I_L = 0.031mA$, % error $= 0.55\%$.

Hence, Norton's Theorem is verified.

DISCUSSION:

Precautions and Sources of Error:

1. Avoid loose connections in network.
2. Direct contact between wires should be prevented to avoid short circuiting.
3. Resistances should be measured carefully. In the case of max power theorem, 56 Ω resistor was used in place of 50 Ω which may have caused slight deviation in the calculations.

CONCLUSION:

Norton's Theorem and Maximum Power Transfer Theorem were verified practically within experimental limits with errors as indicated.

Calculations are to be done in Thevenins equivalent ckt.

9.5/10

1/10/19.

Teacher's Signature ______

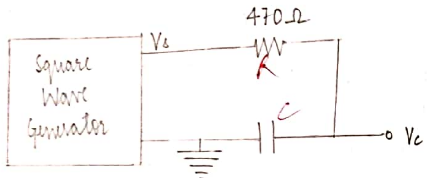
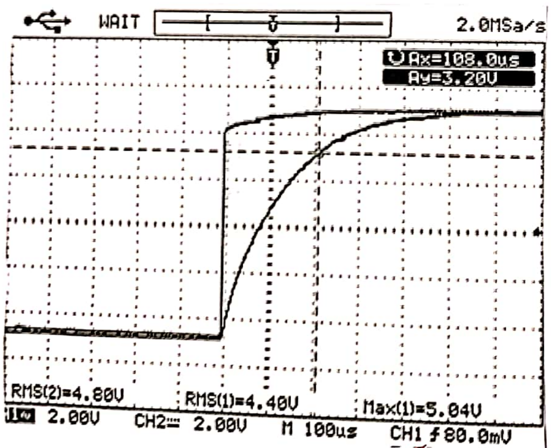


Figure 1A



$V_{cmax} = 5.04V$

3.185 V reached in 108 μs.

Date 8.10.19

Expt. No. 5.

Page No. 20

EXPERIMENT-5

RC AND RL TRANSIENT ANALYSIS

AIM: (1) To observe and take the complete response of an RC and RL circuit to step input.

(2) To determine the time constant and check with the theoretically calculated value.

APPARATUS: Square wave generator, DSO, resistor, capacitor, inductor, connecting wires, bread board.

1. RC CIRCUIT:

PROCEDURE:

1. Connect the circuit as shown in fig 1A. Observe and trace the waveform appearing on the oscilloscope. Set the frequency in range 200 - 500 Hz.
2. Verify theoretically.

CALCULATIONS:

$\tau_{theoretical} = RC = 470 \times 0.22 \times 10^{-6}$

$= 103.4 \times 10^{-6} s$

Peak voltage, $V_{cmax} = 5.04$ V

Voltage reached in 1 time constant, i.e.,

τ seconds $= 63.2\%$ of 5.04 V

$= 3.185$ V

$\tau_{experimental} = 108$ μs

$= 108 \times 10^{-6} s$

Teacher's Signature

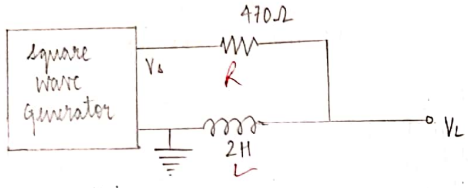
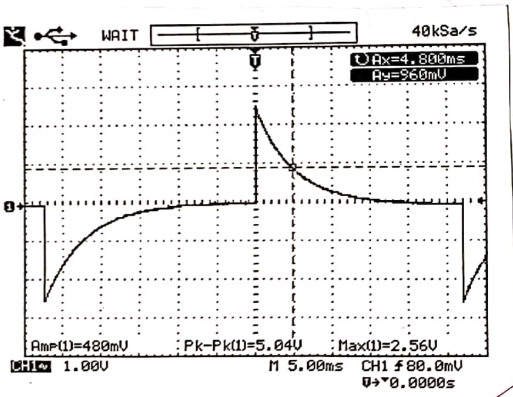


Figure 2A



$V_{Lmax} = 2.56\,V$

947.2 mV reached in 4.8 ms

ERROR:

Error in $\tau_{RC} = |103.4 \times 10^{-6} - 108 \times 10^{-6}|$

$= 4.6 \times 10^{-6}$

Relative error = 4.45%

2) RL CIRCUIT:

PROCEDURE:

1) Connect the circuit as shown in fig 2A. Observe and trace the waveform appearing on the oscilloscope. Set frequency in range 200-500 Hz.

2) Verify theoretically.

CALCULATIONS:

$\tau_{theoretical} = \frac{L}{R} = \frac{2}{470} = 4.26 \times 10^{-3}\,s$

Peak voltage = 2.56 V

Voltage reached in 1 time constant, i.e. τ seconds,

= 37% of 2.56 V

= 947.2 mV

$\tau_{experimental} = 4.8\,ms$

ERROR:

Error in $\tau_{LR} = |4.26 \times 10^{-3} - 4.8 \times 10^{-3}|$

$= 0.54 \times 10^{-3}$

Relative error = 12.67%

Date

Expt. No.   Page No.

RESULT: The time constant τ in the RC circuit is 108 μs, with an error of 4.45% from the theoretical value (103.4 μs). In RL circuit, it is 4.8×10^{-3} s, with an error of 12.67% from the theoretical value (4.26×10^{-3} s).

DISCUSSION:

Precautions and Sources of Error:

1. The square waveform from the function / pulse generator may be checked on DSO and adjusted to proper size before applying it to the circuit.
2. The connections might become lose during the experiment which results in vague readings.
3. Constant voltage supply across the resistor results in heating which affects readings.
4. Exact values were difficult to reach using the tracker.

CONCLUSION:

Hence, the response of an RC and RL circuit was observed on the DSO. The time constants were determined and compared with theoretically calculated values within experimental limits.

Vikrant
22/10/19

9

Teacher's Signature

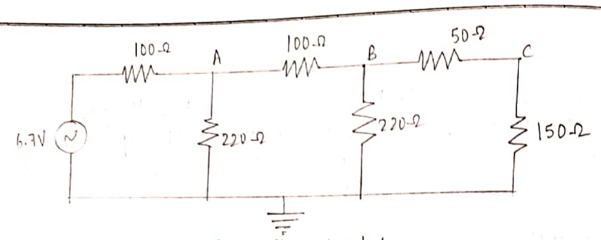


Fig 1 (i) Network 1

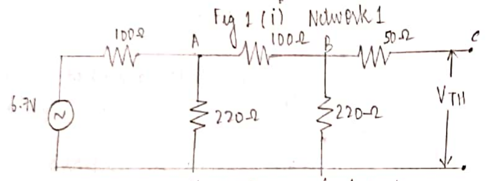


Fig 1 (ii) To calculate VTH

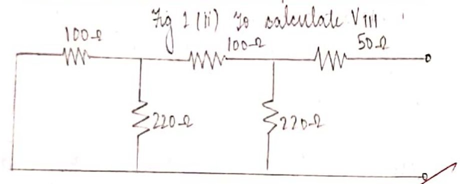
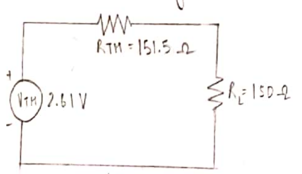


Fig 1 (iii) To calculate RTH



Thevenin Equivalent

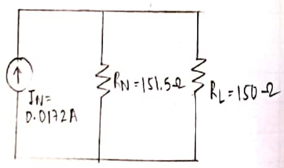


Fig 1 (iv) Norton Equivalent

Date 15.10.19

Expt. No. 6. Page No. 23

EXPERIMENT - 6

THEVENIN'S, NORTON'S AND SUPERPOSITION THEOREM IN AC CIRCUITS

AIM: To verify Thevenin's, Norton's and superposition theorem practically.

APPARATUS: Bread board, resistors, connecting wires, AC power supply, transformer, DC power supply, multimeter, oscilloscope, pen drive.

THEVENIN'S AND NORTON'S THEOREM:

PROCEDURE:

1. Measure open circuit voltage at CG by removing the 150 Ω resistor in the wire in fig 1
2. Now short CG by a wire and measure current through the shorted wire.
3. Replace the shorted wire with a known resistance and measure the current through it.
4. Verify the Thevenin's and Norton's theorem using the data 1, 2, 3.

CALCULATIONS:

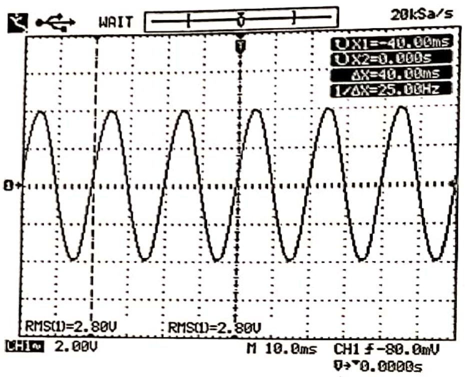
Theoretically, a) Thevenin's Theorem

to find V_{TH} from fig 1 (ii), by applying KCL,

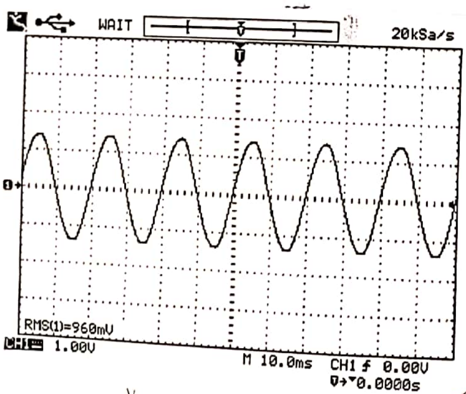
$$\frac{V_A - 6.7}{100} + \frac{V_A}{220} + \frac{V_A - V_B}{100} = 0 \quad \ldots (1)$$

$$\frac{V_B - V_A}{100} + \frac{V_B}{220} = 0 \quad \ldots (2)$$

Teacher's Signature



$V_{eq} = V_{220\Omega} = 2.8V$ (RMS)



$V_{56\Omega} = 960\,mV$

from ① and ②, $V_A = 3.791\,V$, $V_B = V_{TH} = 2.61\,V$

Also, calculating R_{TH} from fig 1(iii), $R_{TH} = 151.5\,\Omega$

$\therefore\ i_{theoretical}$ (across 150Ω) $= \dfrac{V_{TH}}{R_{TH}+150} = \dfrac{2.61}{151.5+150} = 8.65\,mA$

Practically,

$i_{150} = \dfrac{V_{150}}{150\Omega} = \dfrac{1.32}{150} = 8.8\,mA$ (directly)

$V_{TH} = V_{eq} = V_{220\Omega} = 2.8\,V$

$i_{sc} = i_{56\Omega} = \dfrac{V_{56\Omega}}{56\Omega} = \dfrac{960\,mV}{56} = 17.14\,mA$

$\therefore\ R_{TH} = \dfrac{V_{TH}}{i_{sc}} = \dfrac{2.8}{17.14\times10^{-3}} = 163.3\,\Omega$

$i_{150} = \dfrac{V_{TH}}{R_{TH}+150} = \dfrac{2.8}{163.3+150} = 8.93\,mA$

Error:

1) $\Delta i_{150} = |i_{TH} - i_P| = |8.65 - 8.8| = 0.15\,mA$

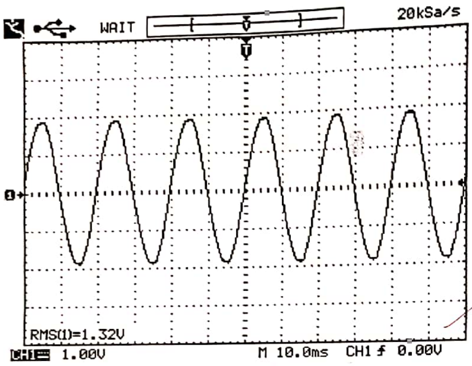
% error = 1.73%

2) for practical verification,

$\Delta i_{150} = |8.93 - 8.8| = 0.13\,mA$

% error = 1.45%

b) Norton's Theorem



$V_{150\Omega} = 1.32V$

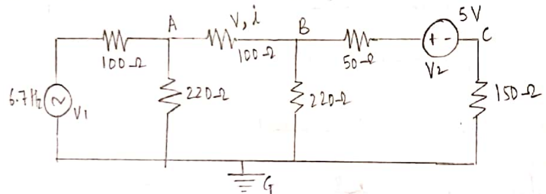


Fig 2(i): Network 2

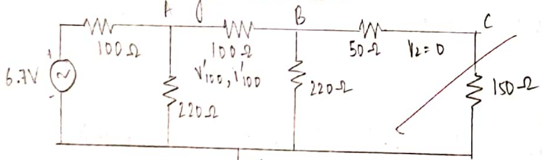


Fig 2(ii)

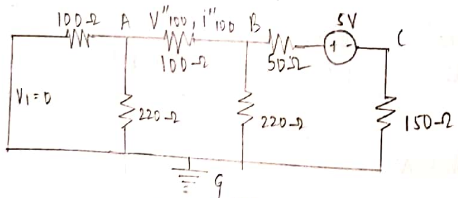


Fig 2 (iii)

Date

Expt. No. Page No.

Consider the Norton Equivalent circuit (fig 1(iv))

Theoretically,

$$i_N = \frac{V_{TH}}{R_{TH}} = \frac{2.61}{151.5} = 0.0172A$$

$$i_{150} = \frac{R_{TH}}{R_L + R_{TH}} \times i_N = \frac{151.5}{150+151.5} \times 0.0172 = 8.642mA$$

Practically,

$$V_{TH} = V_{220\Omega} = 2.8V$$

$$i_{sc} = i_N = \frac{V_{56}}{56\Omega} = 17.14mA$$

$$R_{TH} = \frac{V_{TH}}{i_N} = \frac{2.8}{17.14 \times 10^{-3}} = 163.3\Omega$$

$$i_{150} = \frac{163.3}{163.3+150} \times 0.01714 = 8.91mA$$

and directly, $i_{150} = \frac{V_{150\Omega}}{150\Omega} = \frac{1.32}{150} = 8.8mA$

Error:

1) $\Delta i_{150} = |i_{th} - i_p| = |8.642 - 8.8| = 0.158mA$

% error = 1.828%

2) for practical verification,

$\Delta i_{150} = |8.91 - 8.8| = 0.11mA$

% error = 1.23%

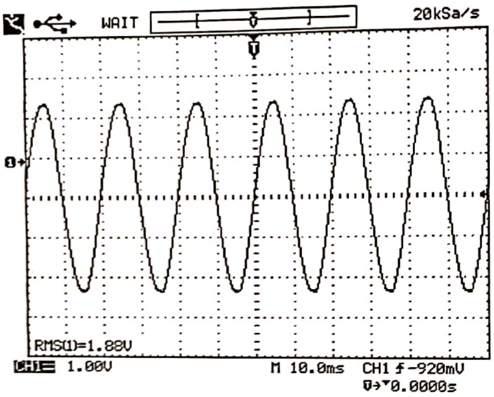
c) Superposition Theorem:

On performing the experiment,

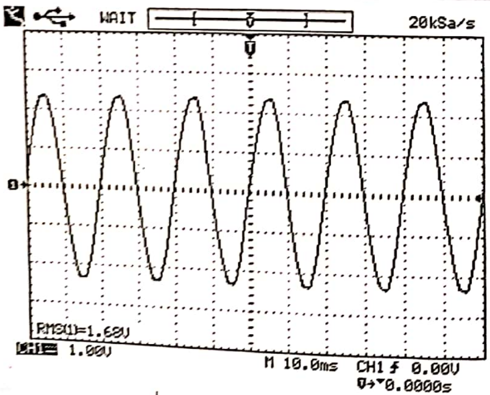
in fig 2(i), $V_{100\Omega} = 1.88V$ (rms)

$$i_{100\Omega} = \frac{V_{100\Omega}}{100} = 0.0188A$$

Teacher's Signature



$V_{100\Omega} = 1.88V$ (fig 2(i))



$V'_{100\Omega} = 1.68V$ (fig 2(ii))

Date ______

Expt. No. ______ Page No. ______

in fig 2 (ii), $V'_{100\Omega} = 1.68\,V$ (rms)

$$i'_{100} = \frac{V'_{100}}{100} = 0.0168\,A$$

in fig 2 (iii), $V''_{100\Omega} = -920\,mV$ (avg)

$$i''_{100} = \frac{-920 \times 10^{-3}}{100} = -0.0092\,A$$

from (ii) and (iii), by superposition principle,

$$i_{res\,100\Omega} = \sqrt{(i'_{100})^2 + (i''_{100})^2} = \sqrt{(0.0168)^2 + (0.0092)^2}$$
$$= 0.0191\,A$$

Error:

$$\Delta i_{100\Omega} = |0.0191 - 0.0188| = 0.0003\,A$$

% error = 1.57%

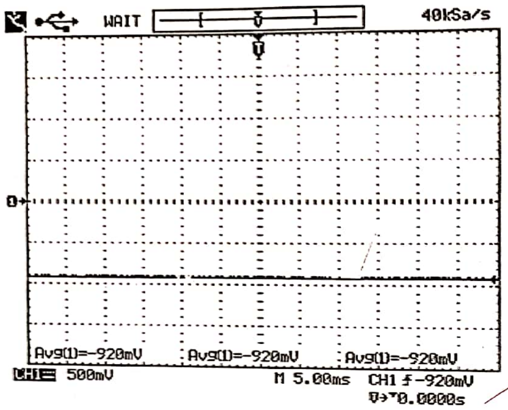
PROCEDURE FOLLOWED:

1) Connect the circuit as shown in diagrams (fig (i), (ii), (iii)) and measure the currents i_{100} and i'_{100} respectively.
2) Also compute the current i in the circuit of diagram.
3) Verify superposition theorem from the readings / observations.
4) Test the same for any other circuit and verify.

RESULTS:

Thevenin's, Norton's and Superposition Theorem are verified for given AC circuits with errors of 1.45%, 1.23% and 1.57% respectively.

Teacher's Signature ______



$V''_{100\Omega} = -920\,mV$ (fig 2(iii))

DISCUSSION:

Precautions and Sources of Error:

1. The value of the resistances must be carefully checked before use.
2. Transformer was used for AC power supply of 6.7 V (rms) for isolation.
3. For AC value, RMS values were taken while for DC values, Avg values were taken.

CONCLUSION:

Thus, Thevenin, Norton and Superposition theorem were successfully verified within experimental errors.

22/10/19

10

Teacher's Signature ______

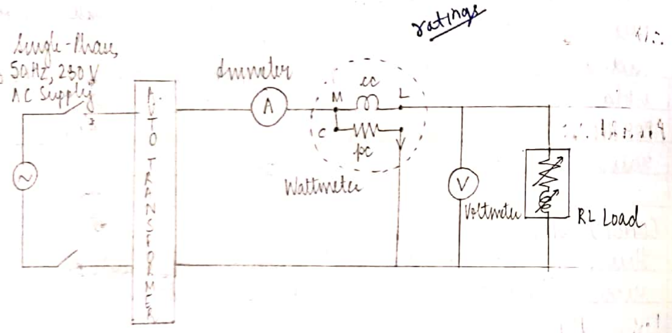


Fig 1. Circuit for power measurement (A.C.)

Date 22.10.19

Expt. No. 7.

Page No. 28

EXPERIMENT - 7

POWER MEASUREMENT IN AC CIRCUITS

AIM: Single-phase circuit power measurement using one Wattmeter Method

APPARATUS:

1) Moving Iron Ammeter (0-5A)
2) Moving Iron Voltmeter (0-500V)
3) Electrodynamics Wattmeter (0-300W)
4) Choke coils and resistances

PROCEDURE:

1) Make the connections as shown in the figure for both Resistive and R-L Loads. If the current coil of wattmeter can't carry the load current use a current transformer in conjunction with it.
2) For a particular set up of RL load note the meter readings. Do the same for resistive loads.
3) Calculate the power factor in both the cases.

CALCULATIONS:

a) $$\text{P.F.} = \frac{\text{Power (Watt)}}{\text{Apparent Power (VA)}}$$

where Apparent Power = Voltmeter reading × Ammeter reading

b) Power = Wattmeter reading × Multiplying factor of wattmeter.

Teacher's Signature

OBSERVATIONS:

Multiplying factor of wattmeter = 2

1.

S.No.	Volts (V)	Amps (A)	Watt (W)	Apparent Power (VA)	P.F.	Error	Nature of Load
1.	230	1.00	105	230.00	0.913	8.7%	Resistive
2.	228	2.91	325	663.48	0.98	2%	Resistive
3.	227	3.90	440	885.30	0.994	0.59%	Resistive

Multiplying factor of wattmeter = 4

2.

S.No.	Volts (V)	Amps (A)	Watt (W)	Apparent Power (VA)	P.F.	Nature of Load
1.	230	0.28	12	64.4	0.745	R-L
2.	230	0.66	24	151.8	0.632	R-L
3.	228	0.76	30.5	173.28	0.704	R-L

Calculations ?

Date 22.10.19

Expt. No. 7 Page No. 29

RESULT:

1. The power factor for the resistive circuit is 0.9623 (mean) with a deviation (mean) of 3.76% from ideal value (1).
2. The power factor for the R-L load circuit is 0.693 (mean).

DISCUSSION:

Power measurement of AC circuits is an important process due to the extensive application in everyday life. The power factor calculation indicates that for a resistive circuit, p.f. is nearly 1 (ideally, equal to 1) while for R-L load, it generally lies between 0.3 - 0.8

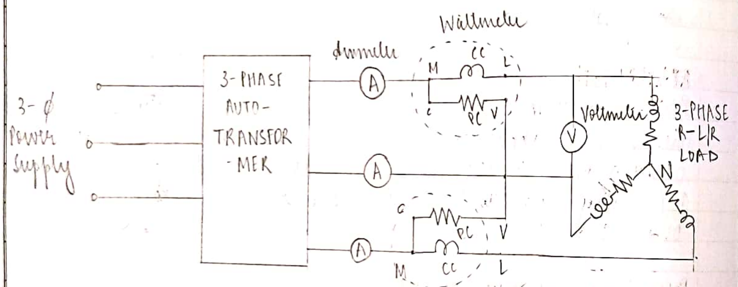
Precautions and Sources of Error:

1. The circuit was operating at high voltage of 230V. Thus, safety measures were taken to prevent shocks.
2. Connections should not be loose.

CONCLUSION:

Thus, power measurements were performed on A.C. circuits and power factors were calculated as indicated.

Teacher's Signature 20/10/19



CIRCUIT DIAGRAM FOR POWER MEASUREMENTS

Date 29.10.19

Expt. No. 8

Page No. 30

EXPERIMENT-8

AIM: Three-phase circuit power measurement using two wattmeter method.

APPARATUS:

1) Moving Iron Ammeter (0-5A)
2) Moving Iron Voltmeter (0-500 V)
3) Electrodynamics Wattmeter (0-300W)
4) choke coil and resistors

PROCEDURE:

1) Make the connections as shown in the figure on the left side.
2) First measure the power with resistive load and in this case two-wattmeter reading will be the same
3) connect the choke coil of same inductances in each phase.
4) Increase or decrease the inductances by equal amounts and record the meter readings.
5) Calculate the power factor by calculations shown below.

CALCULATIONS:

Real Power is the wattmeters' readings. Sum multiplied by the multiplication factor for that configuration.

Power of one wattmeter be W_1 and second wattmeter be W_2.

$$\text{Real Power} = (W_1 + W_2) \times M.F.$$

Also, real power for a 3-φ A.C. circuit using two-wattmeter method is $\sqrt{3} V_L I_L \cos\phi$, V_L is line voltage, I_L is line current.

Teacher's Signature

Date

Expt. No. Page No. 31

Apparent Power = $\sqrt{3} V_\ell I_\ell$

$\therefore$ Power Factor = $\frac{\text{Real Power}}{\text{Apparent Power}}$ = $\cos\phi$

Power Factor is to be calculated by $P.F. = \frac{W}{\sqrt{3} V_\ell I_\ell}$, $W = W_1 + W_2$

Take Obs 1 where $V_\ell = 440V$, $I_\ell = 1.05A$

$W_1 = 110W$, $W_2 = 90W \Rightarrow W = W_1 + W_2 = 200W$, $M.F = 4$

$$P.F = \frac{200 \times 4}{\sqrt{3} \times 440 \times 1.05} = 0.9997$$

Similarly, P.F is calculated for other readings.

RESULT:

1) The power factor for the resistive circuit on average is 0.99358 with a deviation (mean) of 0.64% from ideal value(1)

2) The power factor for the R-L load circuit (mean) is

ERROR IN MEASUREMENT OF POWER FACTOR

S.No.	Power Factor	Error	Relative Error
1.	0.999	$\|1-0.999\|=0.001$	0.1%
2.	0.989	$\|1-0.989\|=0.011$	1.1%
3.	0.992	$\|1-0.992\|=0.008$	0.8%

error in the avg p.f. for resistive load circuit

$$= \left(\frac{|1-0.99358|}{1}\times 100\right)\%$$

$$= 0.642\%$$

good

Date 02.11.19

Expt. No. 9

Page No. 33

EXPERIMENT - 9

OBJECTIVES:

1) To study the constructional details of a single-phase transformer
2) To display the B-H curve for the core material used on an oscilloscope.
3) Waveforms of exciting current and induced voltage at different flux levels.

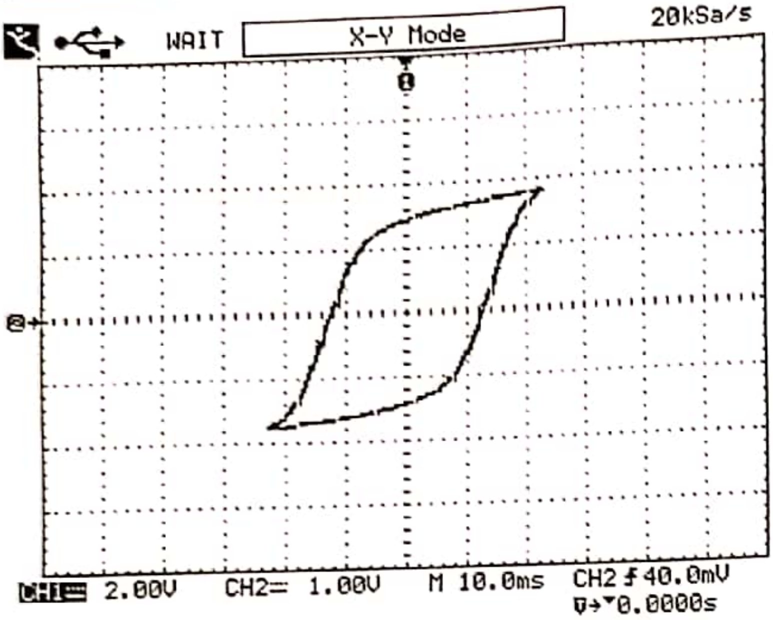
APPARATUS:

1. Transformer under test
2. Single phase two winding transformers with tappings to be used as an isolated supply for the experiment.
3. Oscilloscope ; multimeter
4. A rheostat, with a current rating more than no load current of the transformer under test.
5. ~~Two~~ One voltmeters, one with voltage range equivalent to the full voltage rating and the other with 10% of the voltage rating and the other with one multi-range.
6. ~~Two~~ One ammeters, one with current range equivalent to full load current rating and the other with multi-range.
7. Load to be used on the secondary.
8. A 0.5 or 1 watt resistance of the order of 1 mega ohm and a mica or paper capacitor of the order of 1 micro F for making an integrating circuit.
9. Single phase auto-transformer with full load current rating.

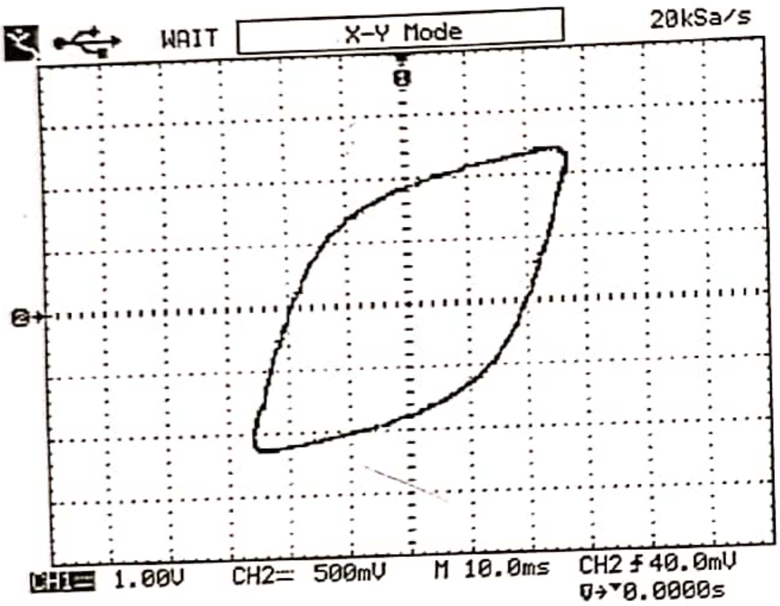
THEORY:

A single-phase transformer essentially consists of two

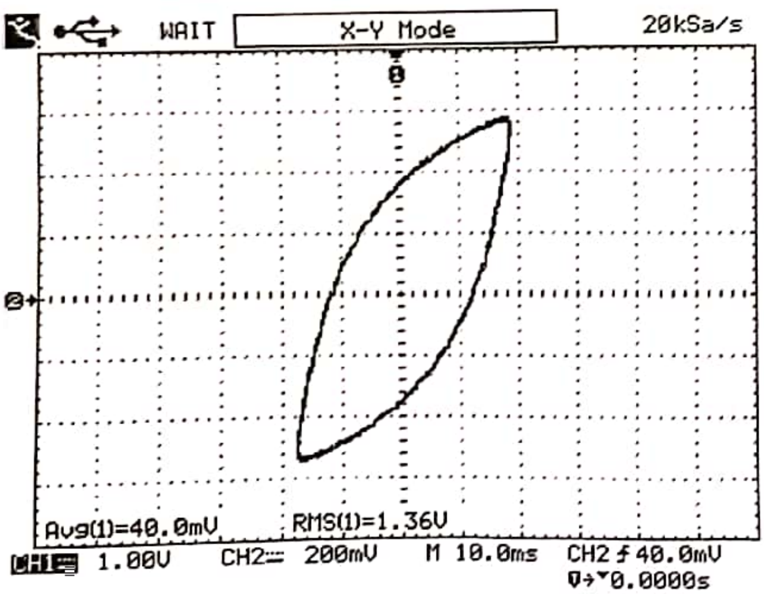
Teacher's Signature



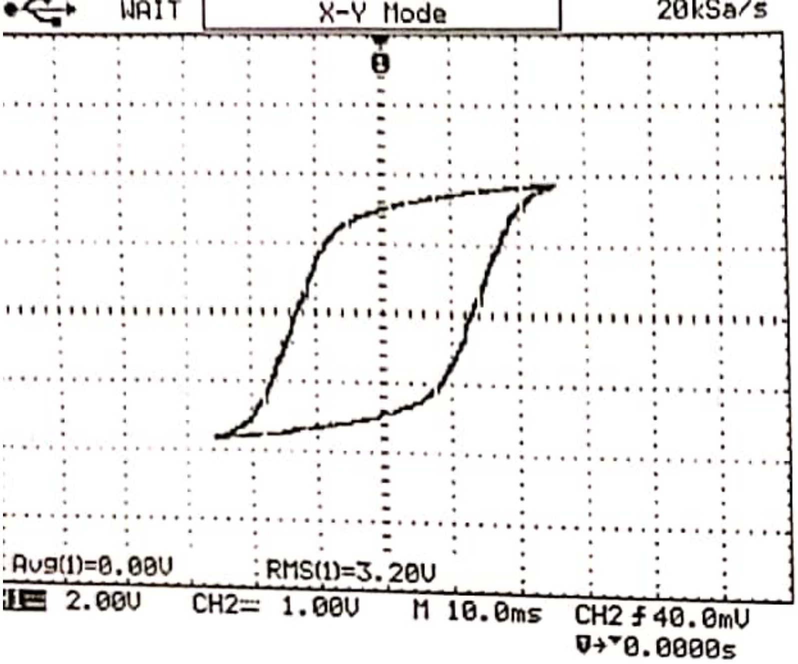
V = 172.5 V
R = 23.6 Ω



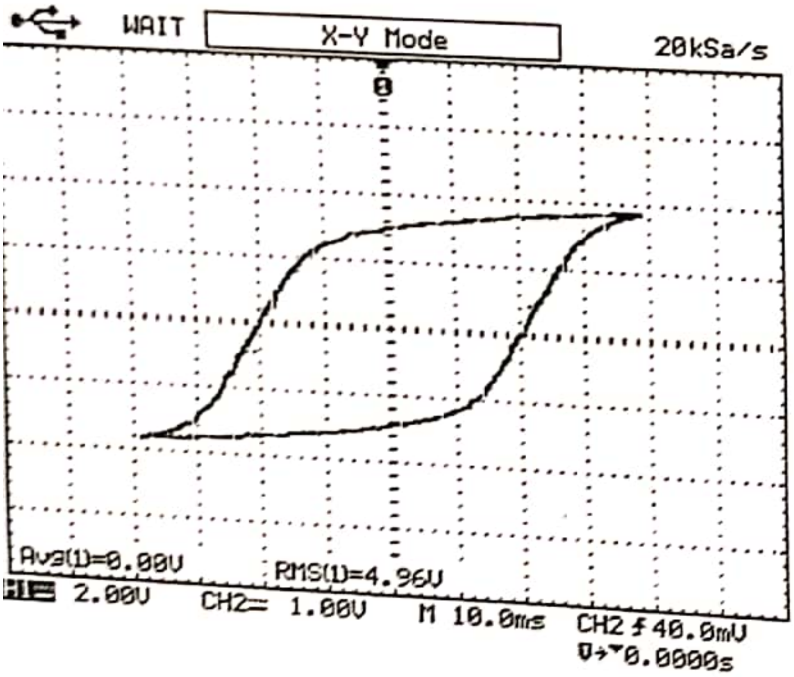
V = 115 V
R = 23.6 Ω



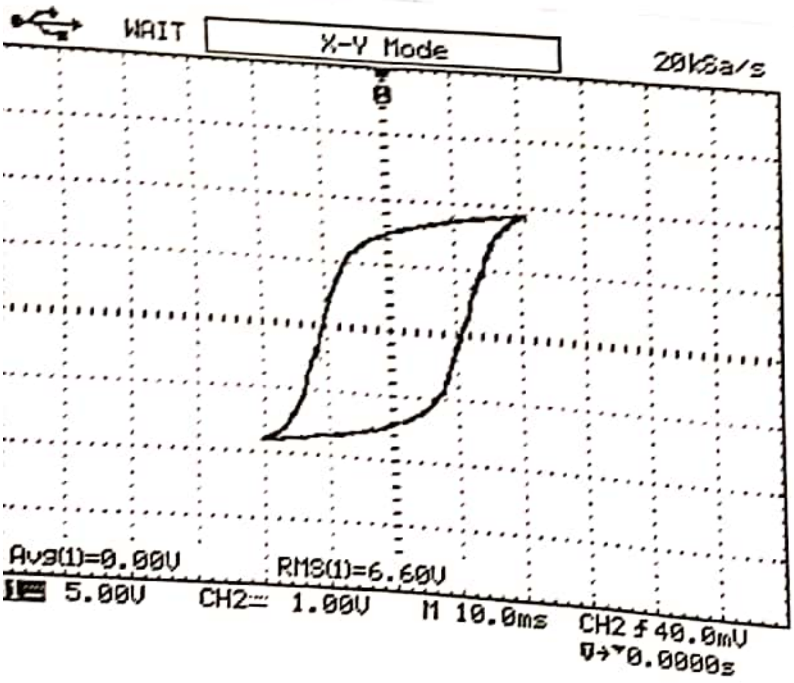
V = 57.5 V
R = 23.6 Ω



V= 180V
R= 23.6Ω



V = 180V
R= 36.7Ω



V = 180V
R= 49.2Ω

EXPERIMENT 10 : SINGLE PHASE TRANSFORMER OC AND SC TEST

OBJECTIVE: To determine parameters and losses by conducting open circuit and short circuit tests on a single phase transformer.

EQUIPMENT:

1. Rheostat
2. Voltmeter (0-250V)
3. Ammeter (for O.C. test 0-1A, for S.C. test, 0-5A)
4. One multi range wattmeter (0-150W)
5. Multimeter

OPEN CIRCUIT TEST:

PROCEDURE:

1. Make the connections as shown in the figure.
2. The secondary of transformer under test is kept open and full voltage is applied to the primary. Low current range ammeter and high voltage voltmeter are used.
3. Read the no load current, power and applied voltage.
4. Take the readings by varying the applied voltage.
5. Plot the Open Circuit Characteristic (OCC).

SHORT CIRCUIT TEST:

1. Now use the high current rating of ammeter and low voltage rating of voltmeter.
2. Short the secondary and apply the reduced voltage to the primary so that the full load current passes through the windings.

Teacher's Signature ______

Date

Expt. No.

Page No.

3. Take the readings of voltage, current and power.
4. Take readings at 50% and 25% of rated current.
5. Plot Short Circuit Characteristic (SCC)

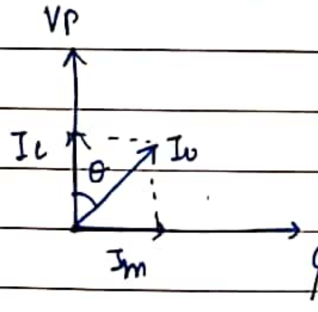
CALCULATIONS:

a) (i) Open circuit:-

$P = VI\cos\theta \Rightarrow \cos\theta = \frac{P}{VI} = \frac{\text{Wattmeter reading}}{V_p \cdot I_p} = \frac{14.25\times 2}{230\times 0.24}$

$= 0.516$

$R_c = \frac{V^2}{P} = \frac{(230)^2}{14.25\times 2} = 18.5614\ \Omega$



$I_m = I_0 \sin\theta$

$= 0.24 \sin(\cos^{-1}(0.516))$

$= 0.205\ A$

$X_m = \frac{V_p}{I_m} = 1121.95 j\ \Omega$

Expt. No. ________ Page No. ________

Date ________

$X_{eff} = \sqrt{Z_{sc}^2 - R_{sc}^2} = 2.13\,\Omega$

(ii) $R_{eff} = 2.77\,\Omega$

$Z_{sc} = 3.45\,\Omega$

$X_{eff} = 2.05\,\Omega$

(iii) $R_{eff} = 2.91\,\Omega$

$Z_{sc} = 3.5\,\Omega$

$X_{eff} = 1.944\,\Omega$

In open circuit, $R_c\,avg = 1846.82\,\Omega$

$X_m\,avg = 1201.22j\,\Omega$

In short circuit, $R_{eff}\,(avg) = 2.73\,\Omega$

$X_{eff}\,(avg) = 2.04j\,\Omega$

RESULT: $R_c(avg) = 1846.82\,\Omega$ and $X_m\,avg = 1201.22j\,\Omega$ are determined by open circuit test and $R_{eff}\,(avg) = 2.73\,\Omega$ and $X_{eff}\,(avg) = 2.04j\,\Omega$ are determined by short circuit test.

DISCUSSION:

Certain approximations were made while performing the tests.

1. O.C. Test: $R_1 << R_c$, thus $I_{oc} \approx I_0$ (neglecting the voltage drop $= I_1$ across series impedance)

2. S.C. Test: $I_0 << I_{sc}$ (2-5% of I_{sc})

Thus, shunt branch parameters got neglected.

I_{sc} is rated current (4.35A) or below.

Teacher's Signature ________

Date

Expt. No. Page No.

Precautions and Sources of Error:

1. Taking wattmeter reading was difficult in short circuit test due to small value.
2. Make sure that the connections were not loose.
3. Do not exceed the rated current value in S.C. test.

CONCLUSION:

Thus, circuit parameters were obtained for a single phase transformer using O.C and S.C. Test.

Teacher's Signature