COURSE OF TECHNICAL INSTRUCTION

LABORATORY PROJECTS

TECHNICIANS - IN - TRAINING
SECOND YEAR

Engineering Training Section, Headquarters, Postmaster-General's Department, Melbourne C.2.

THE AUSTRALIAN POST OFFICE

COURSE OF TECHNICAL INSTRUCTION

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LABORATORY PROJECTS — SECOND YEAR

ISSUED 1961
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Contents:—

1964 AMENDMENTS INDICATED WITH ★ IN TEXT

THE SINE WAVE.

The term "SINE WAVE" is used to express the shape of a wave form of e.m.f. generated when a conductor is rotated at a constant speed in a uniform magnetic field. As the sine wave is the basis of all alternating current work, it is necessary to fully understand its generation, and the relationship between values.

<u>AIM</u>: To construct a sine wave and to study various alternating current values.

<u>NOTE</u>: All calculations corrected to 2 decimal places.

<u>METHOD</u>: Theoretical circuit used as in Fig. 1.

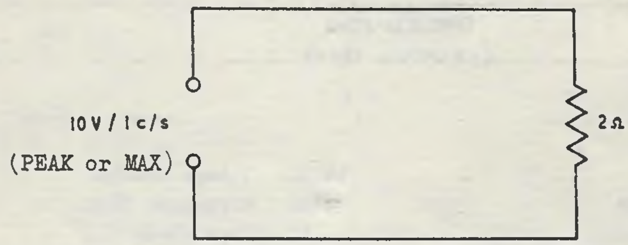

FIG. 1.

<u>STEP 1</u>. Using Ohms Law calculate the maximum value of current in the circuit. Record in Table 1.

<u>STEP 2</u>. Using the sine tables calculate the instantaneous value of current each 1/24th of a second, that is, each 15°.

$$I_{inst.} = \text{Max. Value X Sine } \theta.$$

<u>STEP 3</u>. From your results in Step 2 plot a graph of current through the load resistor against time for one cycle on Graph 1.

<u>STEP 4</u>. (i) Calculate the average value of current, given that:-

3.19 AMPS Average Value = 0.637 of Max. Value. ( )

(ii) Calculate the effective or R.M.S. value of current given that:-

3.54A. Effective or R.M.S. Value = .707 of Max. Value ( )

(Mark R.M.S. Value on graph.)

<u>STEP 5</u>. From your results in Step 4 calculate the following relationships -

I effective ...1.11... times the Average Value.

Average Value ..1/1.11.. of $I_{R.M.S.}$ or effective.

E_{max} 10 VOLTS	I_{max} ..5.. AMPS	R ...2.. OHMS

TABLE 1.

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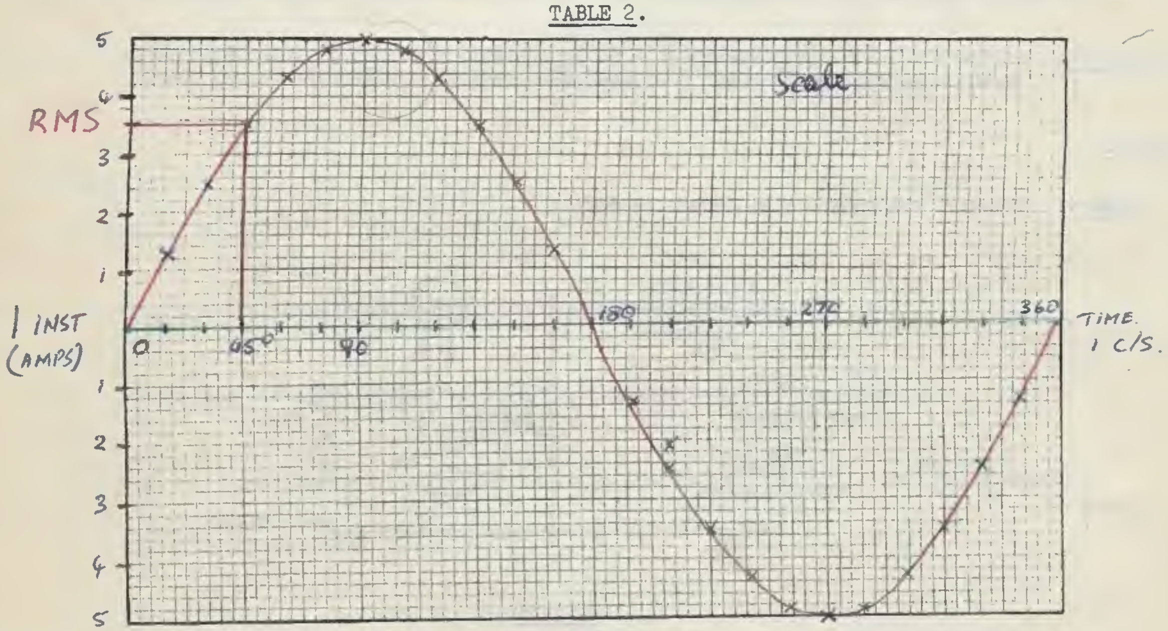
PROJECT NO. 1

θ	SIN θ	I INST.	θ	SIN θ	I INST.	θ	SIN θ	I INST.	θ	SIN θ	I INST.
15	·2588	1·29	105	·9659	4·83	195	·2588	1·29	285	·9659	4·83
30	·5	2·50	120	·8860	4·33	210	·5	2·50	300	·8860	4·33
45	·7071	3·54	135	·7071	3·54	225	·7071	3·54	315	·7071	3·54
60	·8860	4·33	150	·5	2·50	240	·8860	4·33	330	·5	2·50
75	·9659	4·83	165	·2588	1·29	255	·9659	4·83	345	·2588	1·29
90	1	5	180	0	0	270	1	5	360	0	0

TABLE 2.



GRAPH 1.

TEST QUESTIONS:

1. A conductor is rotated at a constant speed in a uniform magnetic field, and, has a maximum e.m.f. of 30 volts induced across it. What are the values of the instantaneous voltages and their polarities at the following instants?

   (i) 60° + 25·98 VOLTS (ii) 210° − 15 VOLTS

2. Define the term "Effective" or "R.M.S." value of alternating current IS THAT VALUE OF AC WHICH HAS THE SAME HEATING EFFECT AS A SIMILAR VALUE OF DC ON THE SAME LOAD

3. A transformer has a secondary voltage of 50 Volts; to which of the following values does this refer -

   (i) ~~Instantaneous~~ (ii) ~~Average~~ (iii) Effective or R.M.S. (iv) Peak ~~or Max.~~

4. A capacitor is rated at 400 peak volts. Calculate the following values which can be applied without risk.

   (i) A.C. Sine Wave Voltage of 283 volts. (ii) D.C. Voltage of 400V volts.

7p

RESISTANCE IN AN A.C. CIRCUIT.

In a resistive circuit, the current and voltage reach their maximum and minimum values at the same instant; they are said to be "in step" or "in phase".

In low frequency alternating current circuits, as in D.C. circuits- Ohms Law applies.

AIM: To prove that in a resistive A.C. circuit -

(i) Ohms Law applies

(ii) Resistance value is unaffected by frequency variation (neglecting skin effect).

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2) Milliammeter 0-10mA (Multimeter 1mA-10A), Resistors 2kΩ, 5kΩ, 10kΩ, Oscillator (variable), and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

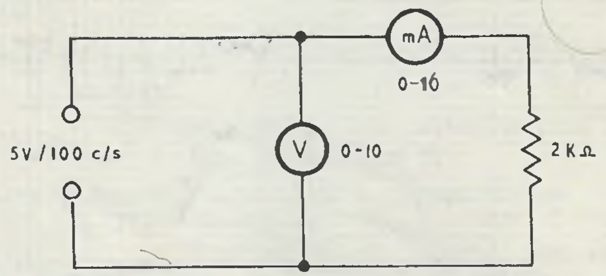


FIG. 1.

STEP 2. Adjust the supply voltage to read 5 Volts at 100 c/s. Measure the circuit current. Record in Table 1.

STEP 3. Increase the supply voltage to 10 Volts. Measure the circuit current. Record in Table 1.

STEP 4. With supply voltage at 10 Volts connect the 5kΩ, and 10kΩ resistors respectively. Measure the circuit currents. Record in Table 1.

STEP 5. Replace 100 c/s supply with 200 c/s, connect the 10kΩ resistor, adjust the supply voltage to read 10 Volts. Measure the circuit current. Record in Table 1.

STEP 6. Using Ohms Law calculate the resistance of the circuit for each step.

STEP 7. Compare the practical and theoretical values of resistance in Table 1.

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Laboratory Projects **PROJECT NO. 2**

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RESISTANCE	FREQUENCY	VOLTS	CURRENT	$R = \frac{E}{I}$
2,000Ω	100 c/s	5 VOLTS	2.5 mA ✓	2000Ω ✓
2,000Ω	"	10 VOLTS	5 mA ✓	2000Ω ✓
5,000Ω	"	10 VOLTS	2 mA ✓	5000Ω ✓
10,000Ω	"	10 VOLTS	1 mA ✓	10,000Ω ✓
10,000Ω	200 c/s	10 VOLTS	1 mA ✓	10,000Ω ✓

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TABLE 1.

TEST QUESTIONS:

1. In a resistive circuit -

1 (i) When the supply voltage is doubled, the circuit current increases. ~~remains the same.~~ ~~decreases.~~ ✓

1 (ii) When the supply voltage is constant and the frequency doubled the current ~~increases.~~ remains the same. ~~decreases.~~ ✓

1 (iii) In an A.C. circuit the current is directly ~~inversely~~ proportional to the supply voltage ~~circuit resistance~~ and ~~directly~~ inversely proportional to the ~~supply voltage.~~ circuit resistance.

$\therefore \quad I = \frac{E}{R}$ ✓

1 (iv) The current and voltage are said to be in phase ~~out of phase~~ and the phase angle is ....0..... degrees. ✓

1 (v) Power in a resistive A.C. circuit is calculated from the formulae (a) $P = E \times I$ ✓ (b) $P = I^2 R$ ✓ (c) $P = \frac{E^2}{R}$ ✓

CAPACITANCE IN AN A.C. CIRCUIT.

A capacitor is a device which stores energy in the form of a static charge. When an e.m.f. is applied, the charge causes a rise in P.D. across the plates and a resultant electric field between them.

When an alternating voltage is connected, the plates alternately charge and discharge. The opposition that a capacitor offers to alternating current in termed Capacitive Reactance (X_C) and is found from the formula -

$$X_C = \frac{1}{2\pi fC}$$

The value of current in this type of circuit can be found from the restatement of Ohms Law for capacitive circuits.

$$I = \frac{E}{X_C}$$

In a purely capacitive circuit the current leads the voltage by 90 degrees.

AIM: To prove that the principle of Ohms Law applies in a capacitive circuit.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-10mA (or 0-60) (Multimeter 1mA-10A). Oscillator 1000 c/s, Capacitors 0.1μF, 0.05μF, Switch and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

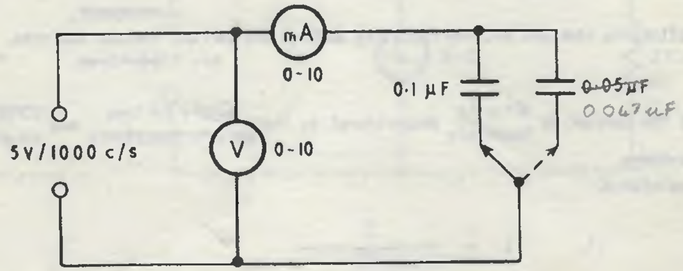

FIG. 1.

STEP 2. Adjust the supply voltage to read 5 Volts. Measure the circuit current. Record in Table.1.

STEP 3. Increase the supply voltage to 10 Volts. Measure the circuit current. Record in Table 1.

STEP 4. Connect the 0.05μF capacitor and repeat steps 2 and 3.

STEP 5. Using the formula $X_C = \frac{E}{I}$, calculate the capacitive reactance for each step. Record in Table 1.

STEP 6. Using the formula $X_C = \frac{1}{2\pi fC}$, calculate the capacitive reactance for each step. Record in Table 1.

STEP 7. Compare the results of steps 5 and 6.

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Laboratory Projects **PROJECT NO. 3**

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C	FREQ.	E	I mA	$X_c = \frac{1}{2\pi f C}$	$X_c = \frac{E}{I}$
0·1	1000 c/s	5	3	1592 ✓	1500
0·1	"	10	6	1592 ✓	1500
0·~~05~~ ·047	"	5	1·5	3387 ✓	3333 ✓
0·~~05~~ 0·047	"	10	3	3387 ✓	3333 ✓

TABLE 1.

★ TEST QUESTIONS:

1. From your results :-

(i) When E is doubled the circuit current increases. ~~remains the same.~~ ~~decreases.~~ ✓

(1) (ii) When the capacitance is halved the capacitive reactance increases ✓ ~~remains~~ ~~decreases~~ the same and the circuit current ~~increases.~~ ~~remains~~ the same. decreases. ✓

2. In a capacitive circuit :-

(i) The circuit current (I) leads ✓ ~~lags~~ the supply voltage (E) by ~~180~~ ~~0~~ 90 ✓ degrees.

(1) (ii) The circuit current is directly ✓ ~~inversely~~ proportional to the voltage but ~~directly~~ inversely ✓ proportional to the CAPACITIVE REACTANCE ✓

3. When the capacitors of FIG. 1 are connected in parallel, the total capacitance increases ~~decreases~~ and the ✓ capacitive reactance ~~increases.~~ decreases. ✓

(1)

4. When an alternating supply of 5 volts at a frequency of 800c/s is applied to a capacitor, the circuit current is 50mA. What is the value of the capacitor?

$X_c = I \times E = ~~\;~~ 100$ ~~m~~

$C = \frac{1}{2\pi F X_c}$

$C = \frac{199\ 1592}{10^4} \times \frac{1}{800} \times \frac{1}{100}$ = [~~756 mF~~ or ~~756 uF~~]

$= 1.99\ uF$

EFFECT OF FREQUENCY ON CAPACITIVE REACTANCE.

Capacitive reactance is the opposition that a capacitor offers to alternating current and is found from the formula –

$$X_C = \frac{1}{2\pi fC}$$

Capacitive reactance varies with – (i) frequency of supply
(ii) value of capacitance.

When stating values of capacitive reactance the frequency must be given. For example a 2μF capacitor has an X_C of 100Ω at 796 c/s.

AIM: To prove that in a capacitive circuit the capacitive reactance varies with frequency.

APPARATUS: Voltmeter 0–10V (Multimeter A.P.O. No.2), Milliammeter 0–10mA (Ammeter 1mA–10A), Oscillator Variable, Capacitor 0.1μF and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

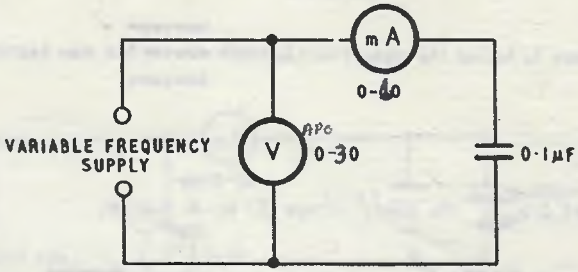

FIG. 1.

STEP 2. Adjust the frequency to 200 c/s with the supply voltage (E) at 25 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Maintain the supply voltage at 25 Volts increase the frequency in 200 cycle steps to 1400 c/s. Measure the circuit current for each step. Record in Table 1.

STEP 4. Using the formula $X_C = \frac{E}{I}$, calculate the capacitive reactance for each step. Record in Table 1.

STEP 5. Using the formula $X_C = \frac{1}{2\pi fC}$, calculate the capacitive reactance for each step. Record in Table 1.

STEP 6. Compare the results of steps 4 and 5.

STEP 7. Plot a graph of capacitive reactance versus frequency on Graph 1.

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Laboratory Projects **PROJECT NO. 4**

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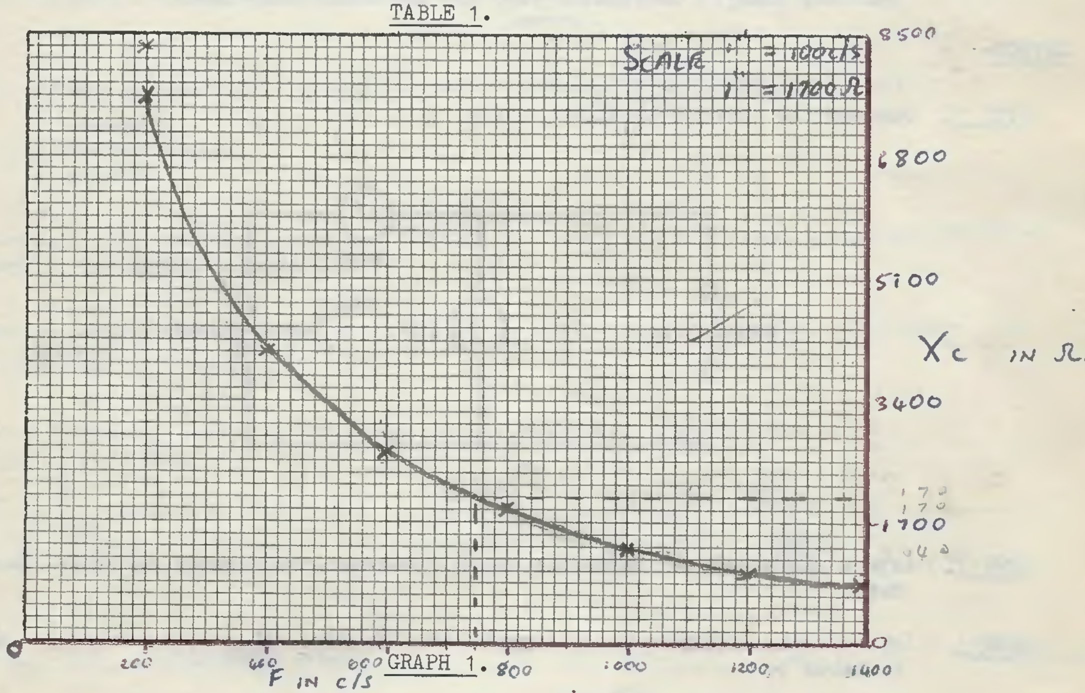
FREQ.	C	E	I m A	$X_c = \frac{I}{2\pi fC}$	$X_c = \frac{E}{I}$
200	0·1	25	3	7,860	8,333·3̇
400	"	"	6	3,980	4,166·6̇
600	"	"	9	2,653·3̇	2,666·6̇
800	"	"	12	1,990	2,083·3̇
1000	"	"	15	1,592	1,666·6̇
1200	"	"	18	1,326·6̇	1,388·8̇
1400	"	"	21	1,137·1	1,190·5

TABLE 1.



GRAPH 1.

★ TEST QUESTIONS:

1. When the frequency of a supply voltage is increased capacitive reactance ~~increases.~~ ~~remains~~ the same. decreases.

2. When the voltage and frequency are constant and another 0.1 F capacitor is connected in series, the capacitive reactance ...INCREASES..., and the current ...DECREASES...

3. From Graph 1, state the Capacitive reactance of (i) a 0.1 F capacitor at 750c/s ....2040.... ohms.

   (ii) a 0.5 F capacitor at 750c/s ....408.... ohms.

   (iii) a 0.5 F capacitor at 1500c/s ....816.... ohms.

INDUCTANCE IN AN A.C. CIRCUIT.

An inductor is a device which stores energy in the form of a magnetic field.

Inductance is the property of a inductor to oppose any change in current. When current changes, the induced e.m.f. opposes the change (Lenz's Law).

Inductive reactance (X_L) is a measure of the opposition that an inductor offers to alternating current and is found from the formula -

$$X_L = 2\pi fL$$

The value of current in this type of circuit can be found from the restatement of Ohms Law for inductive circuits -

$$I = \frac{E}{X_L}$$

In an inductive circuit the circuit current lags the supply voltage by 90°.

AIM: To prove that the principle of Ohms Law applies in a inductive circuit.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-10mA (Multimeter 1mA-10A). Inductor 80mH(2) Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

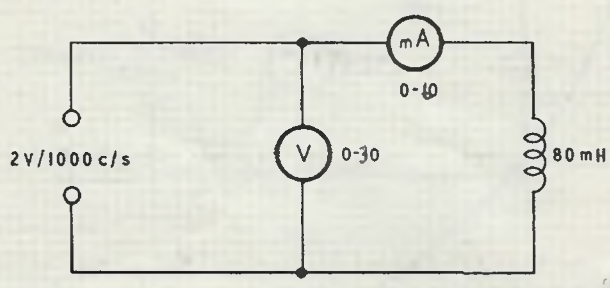


FIG. 1.

STEP 2. Adjust the supply voltage to 10 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Increase the supply voltage to 20 Volts. Measure the circuit current. Record in Table 1.

STEP 4. Connect the two 80mH inductors in series and repeat steps 2 and 3.

STEP 5. Using the formula $X_L = \frac{E}{I}$ calculate the inductive reactance for each step. Record in Table 1.

STEP 6. Using the formula $X_L = 2\pi fL$ calculate the inductive reactance for each step. Record in Table 1.

STEP 7. Compare the results of Steps 5 and 6.

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FREQ.	L	E	I mA	$X_L = 2\pi f L$	$X_L = \frac{E}{I}$
1000	80mH	10	20	500 Ω	500 Ω
1000	80mH	20	40	500 Ω	500 Ω
1000	160mH	10	10	1000 Ω	1000 Ω
1000	160mH	20	20	1000 Ω	1000 Ω

TABLE 1.

TEST QUESTIONS:

1. From your results :-

   (i) When the supply voltage is doubled the circuit current increases. ~~remains the same.~~ ~~decreases.~~

   (ii) When the value of inductance is increased the inductive reactance increases ~~remains the same~~ ~~decreases~~ and the circuit current ~~increases.~~ ~~remains the same.~~ decreases.

2. In an inductive circuit, the circuit current is ..DIRECTLY.... proportional to the supply voltage and ..INVERSELY.. proportional to the inductive reactance.

3. In an inductive circuit the circuit current ~~leads~~ ~~is~~ lags in phase with the supply voltage by ~~180~~ ~~0~~ 90 degrees. This angle is called the ....PHASE........ angle.

4. What value of inductance is required to give a circuit current of 50mA when the supply voltage is 50V. (Given that - $2\pi f = 5000$.)

$X_L = \frac{E}{I}$ .... $L = \frac{X_L}{2\pi f L}$

$X_L = \frac{50}{.05}$ .... $L = \frac{1000}{5000}$

$X_L = 1000\ \Omega$ .... $L = \cdot 2 = 200\ mH.$

EFFECT OF FREQUENCY ON INDUCTIVE REACTANCE.

Inductive reactance is a measure of the opposition that an inductor offers to alternating current and is found from the formula -

$$X_L = 2\pi fL$$

Inductive reactance varies with - (i) frequency of supply

(ii) value of inductance

When stating values of inductive reactance the frequency must be given. For example a 80mH inductor has an inductive reactance (X_L) of 400Ω at 800 c/s.

AIM: To prove that in an inductive circuit, inductive reactance varies with frequency.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2) Milliammeter 0-60mA (Ammeter 1mA-10A) Inductor 80mH, Oscillator Variable, and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

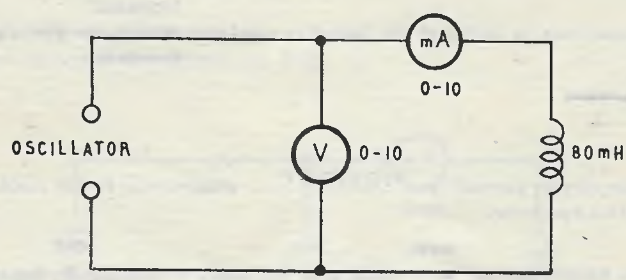

FIG. 1.

STEP 2. Adjust the frequency to 600 c/s and the supply voltage to 15 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Maintaining the supply voltage at 15 Volts, increase the frequency in 200 cycle steps to 1400 c/s. Measure the circuit current for each step. Record in Table 1.

STEP 4. Using the formula $X_L = \frac{E}{I}$ calculate the inductive reactance for each step. Record in Table 1.

STEP 5. Using the formula $X_L = 2\pi fL$ calculate the inductive reactance for each step. Record in Table 1.

STEP 6. Compare the results of Steps 4 and 5.

STEP 7. From your results plot a graph of inductive reactance versus frequency on Graph 1.

Laboratory Projects **PROJECT NO. 6**

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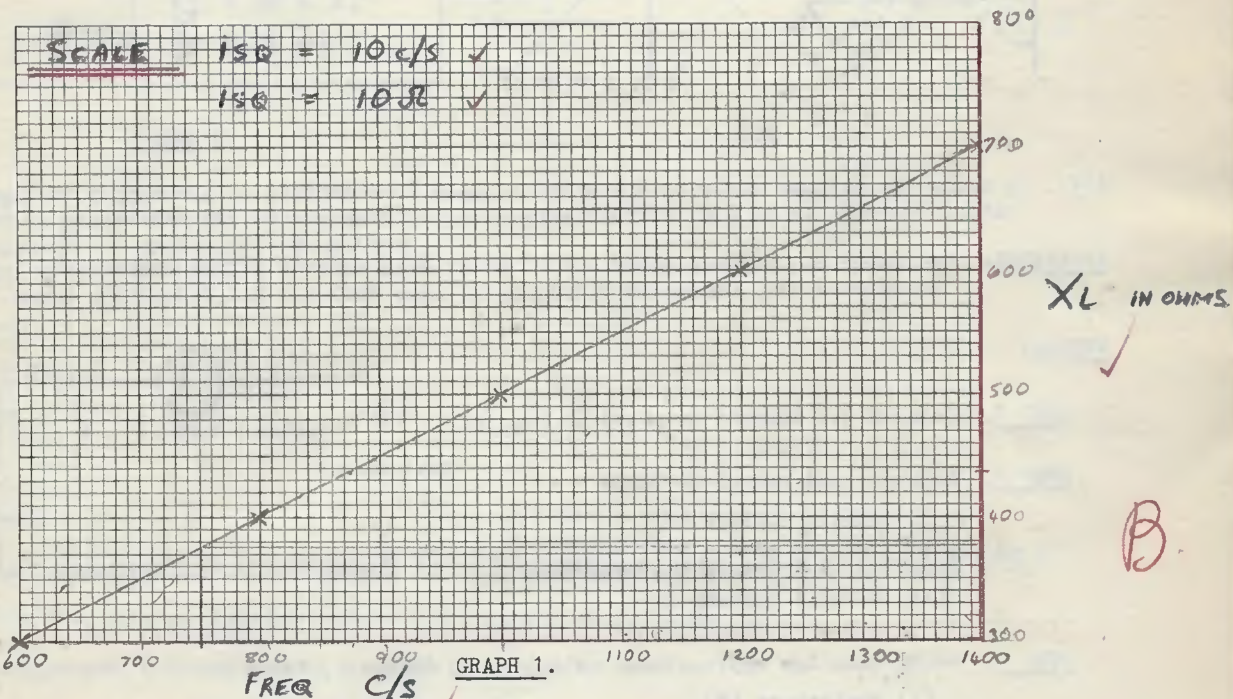
L	FREQ.	E	I mA	$X_L = 2\pi f L$	$X_L = \frac{E}{I}$
80 mH	600	15	50	300	300 Ω
"	800	"	37	400	405 Ω
"	1000	"	30	500	500 Ω
"	1200	"	25	600	600 Ω
"	1400	"	21	700	714 Ω

TABLE 1.



GRAPH 1.

★ TEST QUESTIONS:

1. From your results - When the frequency is doubled the inductive reactance increases. ~~remains the same.~~ ~~decreases.~~

2. List the two factors that affect inductive reactance -

(i) FREQUENCY (ii) INDUCTANCE

3. From your graph state the inductive reactance of (i) a 80mH inductor at 750c/s 375 ohms.

(ii) a 400mH inductor at 750c/s 1875 ohms.

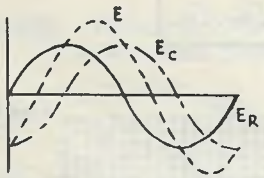
(iii) a 400mH inductor at 1500c/s 3750 ohms.

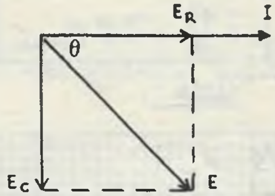
CAPACITANCE AND RESISTANCE IN SERIES.

When alternating current passes through a circuit consisting of resistance and capacitance in series the total opposition is termed impedance. Symbol Z. The circuit conditions can be calculated from the restatements of Ohms Law for A.C. circuits -

$$I = \frac{E}{Z} \qquad Z = \frac{E}{I} \qquad Z = \sqrt{R^2 + X_C^2}$$

In a circuit with capacitance and resistance in series the P.D. across the resistance (E_R) is in phase with the circuit current (I), the P.D. across the capacitance (E_C) lags the circuit current by 90°, and the resultant supply voltage is obtained by graphical or vectorial addition as shown in Fig. 1.





The phase difference is shown on the vector diagram by angle θ and is calculated from -

$$\tan\theta = \frac{E_C}{E_R} \text{ or } \frac{X_C}{R}$$

FIG. 1.

AIM: To study the voltage distribution and the phase relationship of the supply voltage and circuit current in an A.C. circuit consisting of capacitance and resistance in series.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2) Milliammeter 0-60mA (Multimeter 1mA-10A), Resistance 1kΩ, Capacitor 0.1µF, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

STEP 2. Measure, and record in Table 1 -

(i) Supply voltage (E)
(ii) Voltage across the resistor (E_R)
(iii) Voltage across the capacitor (E_C)
(iv) Circuit current (I).

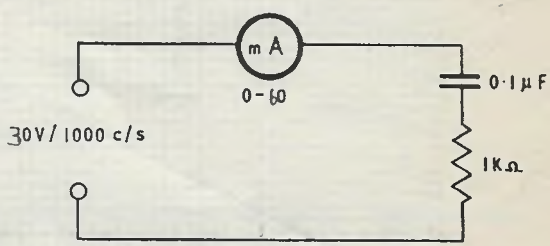


FIG. 2.

STEP 3. Using Ohms Law applications calculate in Column 1, Table 2 -

(i) Resistance (R)
(ii) Capacitive reactance (X_C)
(iii) Impedance (Z).

STEP 4. Using the formulae stated calculate in Column 2, Table 2 -

(i) Capacitive reactance (X_C)
(ii) Impedance (Z)

STEP 5. Compare the results of steps 3 and 4.

STEP 6. (i) Draw a vector to scale using the results in Table 1.
(ii) Measure the phase angle and insert on the vector.
(iii) Calculate the phase angle.

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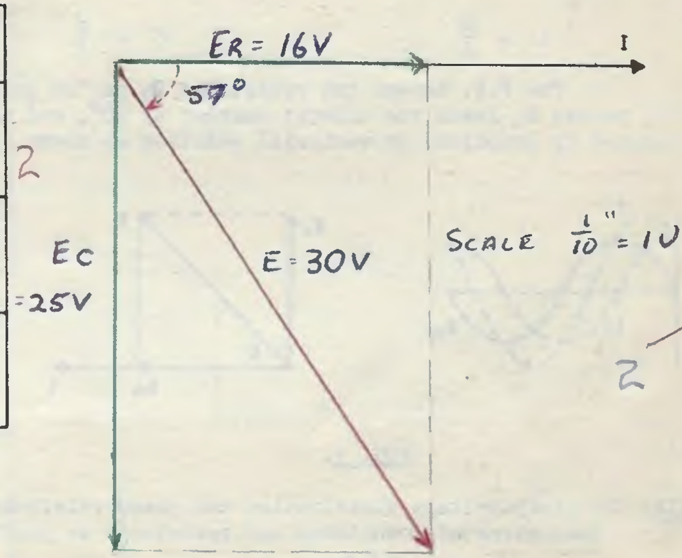
E 30 VOLTS	E_R 16 VOLTS	E_C 25 VOLTS	I 16 mA

TABLE 1.

1	2
$R = \frac{E_R}{I}$ = 1000	$R = 1K\Omega$
$X_C = \frac{E_C}{I}$ = 1562·5	$X_C = \frac{1}{2\pi f C}$ X_C = 1592
$Z = \frac{E}{I}$ = 1875	$Z^2 = R^2 + X_C^2$ Z = 1880

TABLE 2.



PHASE ANGLE

$\tan \theta = \frac{E_C}{E_R} = \frac{25}{16} = 1{\cdot}5625$

From tables

tan 1.5625 = 57° 23'

∴ Angle θ = 57 degrees.

B.

★ TEST QUESTIONS:

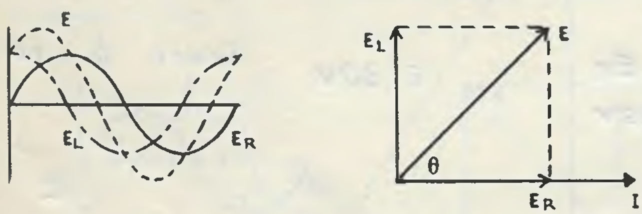
1. The circuit phase angle is the time difference in degrees between the supply voltage and the circuit CURRENT
2. The values of E_R and E_C must be added vectorally to find the value of E
3. When the capacitance is halved, state the effect on -
   (i) Capacitive reactance INCREASES (ii) The impedance INCREASES
   (iii) The circuit current DECREASES (iv) The phase angle INCREASES
4. When the value of series resistance is increased, the phase angle ~~increases.~~ ~~does not change.~~ decreases.
5. A circuit consisting of a resistor ~~100~~ 150 Ω and a capacitor 1 µF are connected in series to an alternating voltage of ~~65~~ 50 volts ~~800~~ 796 cycles per second.
   Calculate
   (i) X_C 200 ohms (iii) E_R 30 volts. (v) Calculate the phase angle of circuit. 53° 8'
   (ii) Z 250 ohms (iv) E_C 40 volts.

INDUCTANCE AND RESISTANCE IN SERIES.

When an alternating current passes through a circuit consisting of inductance and resistance in series the total opposition is termed impedance.
The circuit conditions can be calculated from the restatement of Ohms Law for A.C. circuits -

$$I = \frac{E}{Z} \qquad Z = \frac{E}{I} \qquad Z = \sqrt{R^2 + X_L^2}$$

The P.D. across the resistance E_R is "in phase" with the circuit current (I), the P.D. across E_L leads the circuit current by 90°, and the resultant supply voltage (E) is obtained by graphical or vectorial addition as shown in Fig. 1.



The phase difference is shown on the vector diagram by the Angle θ and is calculated from -

$$\tan\theta = \frac{E_L}{E_R} \quad \text{or} \quad \frac{X_L}{R}$$

FIG. 1.

AIM: To study voltage distribution and phase relationship in an alternating current circuit consisting of inductance and resistance in series.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Multimeter 1mA-10A), Resistor 1kΩ, Inductor 80mH, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E).
(ii) P.D. across the inductor (E_L).
(iii) P.D. across the resistor (E_R).
(iv) Circuit current (I).

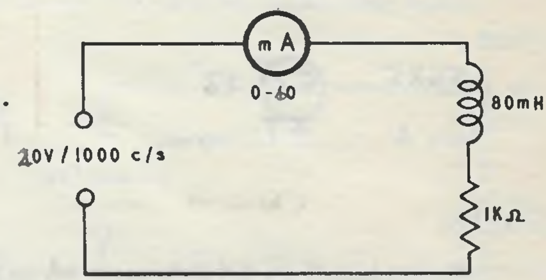


FIG. 2.

STEP 3. Using Ohms Law applications calculate in Column 1, Table 2 -

(i) Inductive reactance (X_L).
(ii) Resistance (R).
(iii) Impedance (Z).

STEP 4. Using the formulae stated calculate in Column 2, Table 2 -

(i) Inductive reactance (X_L).
(ii) Impedance (Z).

STEP 5. Compare the results of steps 3 and 4.

STEP 6. (i) Draw a vector diagram to scale, using the results in Table 1.
(ii) Measure the phase angle and record on the vector.
(iii) Calculate the phase angle.

Laboratory Projects

2nd Year

PROJECT NO. 8

10/10

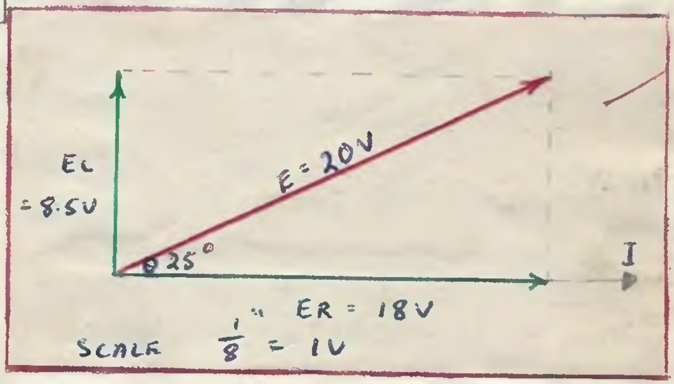
2

E 20 VOLTS	E_L 8.5 VOLTS	E_R 18 VOLTS	I 18 mA

TABLE 1.

1	2
$R = \frac{E_R}{I} = 1000\Omega$	$R = 1K\Omega$
$X_L = \frac{E_L}{I} = 472\Omega$	$X_L = 2\pi fL$ $X_L = 502.4\Omega$
$Z = \frac{E}{I} = 1111\Omega$	$Z^2 = R^2 + X_L^2$ $Z = 1118.5\Omega$

TABLE 2.



PHASE ANGLE

$\tan\theta = \frac{E_L}{E_R} = \frac{8.5}{18} = .4722$

From tables

tan .4722 = 25° 16'

∴ Angle θ = 25 degrees 16'

TEST QUESTIONS:

1. From your results complete the following statements -

(i) The circuit current ~~is in phase with~~ lags the supply voltage by 25 degrees.

(ii) The circuit current ~~is in phase~~ leads with the P.D. across the inductance by 90 degrees.

(iii) The circuit current is in phase with the P.D. across the resistance by 0 degrees.

B

2. State the methods of adding (i) in phase voltages DIRECTLY (ii) out of phase voltages VECTORIALLY

3. When the resistance of the circuit is doubled state the effect on -

(i) the impedance INCREASES

(ii) the circuit current DECREASES

(iii) the phase angle DECREASES

INDUCTANCE, CAPACITANCE AND RESISTANCE IN SERIES (1).

When alternating current flows in a circuit consisting of inductance, capacitance and resistance in series, a P.D. exists across each component.

With respect to the circuit current, E_R is in phase, E_L leads by 90° and E_C lags by 90°.

The vector sum of the P.D's equals the supply voltage. Impedance is the total opposition offered by this type of circuit to A.C. and is calculated from the restatement of Ohms Law for A.C. circuits -

$$I = \frac{E}{Z} \qquad Z = \frac{E}{I} \qquad Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The resultant phase angle the circuit current makes with the supply voltage is found from -

$$\tan\theta = \frac{E_X}{E_R} \text{ or } \frac{X}{R}$$

AIM: To study the voltage distribution and the phase relationship in a series circuit, consisting of resistance, inductance and capacitance.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2) Milliammeter 0-60mA (Multimeter 1mA-10A), Inductor 80mH, Capacitor 0.1μF, Resistor 1kΩ, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

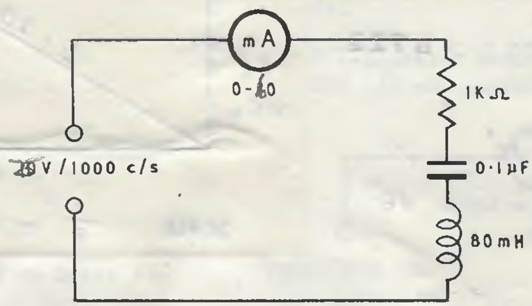


FIG. 1.

STEP 2. Measure and record in Table 1 -

(i) Supply Voltage (E)
(ii) P.D. across the inductor (E_L)
(iii) P.D. across the resistor (E_R)
(iv) P.D. across the capacitor (E_C)
(v) Circuit current (I).

STEP 3. Using Ohms Law applications calculate in Column 1, Table 2 -

(i) Resistance (R)
(ii) Capacitive reactance (X_C)
(iii) Inductive reactance (X_L)
(iv) Impedance (Z).

STEP 4. Using the formulae stated calculate in Column 2, Table 2 -

(i) Capacitive reactance (X_C)
(ii) Inductive reactance (X_L)
(iii) Impedance (Z).

STEP 5. Compare the results of steps 3 and 4.

STEP 6. (i) From values in Table 1 construct a vector diagram to scale.
(ii) With the aid of a protractor measure the phase angle θ and record on the completed vector.
(iii) Calculate the phase angle.

Laboratory Projects

2nd Year

10/10 TLR

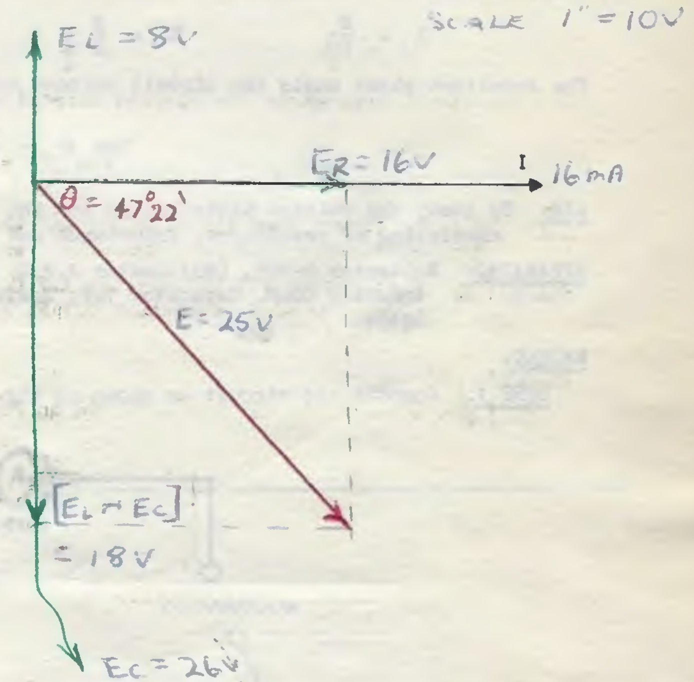
PROJECT NO. 9

E 25 VOLTS	E_L 8 VOLTS	E_R 16 VOLTS	E_c 26 VOLTS	I 16 mA

TABLE 1.

1	2
$R = \frac{E_R}{I} = 1000\Omega$	$R = 1K\Omega$
$X_C = \frac{E_C}{I} = 1625\Omega$	$X_C = \frac{1}{2\pi f C}$ $X_C = 1592$
$X_L = \frac{E_L}{I} = 500\Omega$	$X_L = 2\pi f L$ $X_L = 502.5$
$Z = \frac{E}{I} = 1562.5$	$Z^2 = R^2 + (X_L - X_C)^2$ $Z = 1478$

TABLE 2.



PHASE ANGLE

$\tan\theta = \frac{E_X}{E_R} = \frac{18}{16} = 1.1250$

From tables

tan 1.1250 = 48° 22'

∴ Angle θ = 48 degrees LEADING

TEST QUESTIONS:

1. From your vector the resultant circuit is capacitive. ~~resistive.~~ ~~inductive.~~

2. Define "Impedance"

IS THE TOTAL OPPOSITION OFFERED BY A CCT TO AC & CONSISTS OF RESISTANCE & REACTANCE.

3. When the resistance of the circuit (FIG. 1) is doubled the impedance increases ~~decreases~~ because $Z = \sqrt{R^2 + (X_C \sim X_L)^2}$

4. With respect to (3) -

(i) The circuit current ~~increases.~~ decreases.

(ii) The P.D. across the inductance ~~increases.~~ decreases

(iii) The phase angle ~~increases.~~ decreases.

B.

INDUCTANCE, CAPACITANCE AND RESISTANCE IN SERIES (2).

When alternating current flows in a circuit consisting of inductance, capacitance and resistance in series, a P.D. exists across each component.

With respect to the circuit current, E_R is in phase, E_L leads by 90^o, and E_C lags by 90^o. The vector sum of the P.D's equals the supply voltage.

Impedance is the total opposition offered by this type of circuit to A.C. and is calculated from the restatement of Ohms Law for A.C. circuits -

$$I = \frac{E}{Z} \qquad Z = \frac{E}{I} \qquad Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The resultant phase angle the circuit current makes with the supply voltage is found from -

$$\tan\theta = \frac{E_X}{E_R} \text{ or } \frac{X}{R}$$

AIM: To study the voltage distribution and the phase relationship in a series circuit, consisting of resistance, inductance and capacitance.

APPARATUS; Voltmeter 0-10V, (Multimeter A.P.O. No.2) Milliammeter 0-10mA (Multimeter 1mA-10A), Inductor 80mH, Capacitor 1µF, Resistor 1kΩ, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

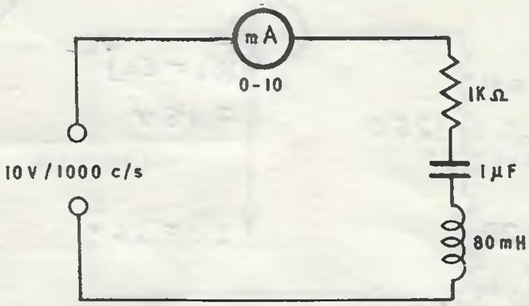


FIG. 1.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E)
(ii) P.D. across the inductor (E_L)
(iii) P.D. across the resistor (E_R)
(iv) P.D. across the capacitor (E_C)
(v) Circuit current (I).

STEP 3. Using Ohms Law applications calculate in Column 1, Table 2 -

(i) Resistance (R)
(ii) Capacitive reactance (X_C)
(iii) Inductive reactance (X_L)
(iv) Impedance (Z).

STEP 4. Using the formulae stated calculate in Column 2, Table 2 -

(i) Capacitive reactance (X_C)
(ii) Inductive reactance (X_L)
(iii) Impedance (Z).

STEP 5. Compare the results of steps 3 and 4.

STEP 6. (i) From values in Table 1 construct a vector diagram to scale.
(ii) With the aid of a protractor measure the phase angle θ and insert on the vector.
(iii) Calculate the phase angle.

E ------ VOLTS	E_L ----- VOLTS	E_R ----- VOLTS	E_C ----- VOLTS	I ------ mA

TABLE 1.

1	2
$R = \frac{E_R}{I} =$	$R = 1K\Omega$
$X_C = \frac{E_C}{I} =$	$X_C = \frac{1}{2\pi f C}$ $X_C =$
$X_L = \frac{E_L}{I} =$	$X_L = 2\pi f L$ $X_L =$
$Z = \frac{E}{I} =$	$Z^2 = R^2 + (X_L - X_C)^2$ $Z =$

TABLE 2.

I

PHASE ANGLE

$\tan \theta = \frac{E_X}{E_R} =$ ------------- =

From tables

tan .... = ...

∴ Angle θ = ... degrees.

TEST QUESTIONS:

1. From your vector the resultant circuit is capacitive. / resistive. / inductive.

2. When the inductance of the circuit (FIG. 1) is doubled -

the inductive reactance increases / remains the same / decreases

the impedance increases / remains the same / decreases

the circuit current increases / remains the same / decreases

the P.D. across the inductor increases / remains the same / decreases

the P.D. across the capacitor increases / remains the same / decreases

the resultant phase angle increases / remains the same / decreases

INDUCTANCE, CAPACITANCE AND RESISTANCE IN SERIES (3).

When a varying frequency alternating current supply is connected to inductance resistance and capacitance in series such as bell and capacitor in a telephone circuit, the circuit current increases until it reaches a maximum at one particular frequency (resonant frequency). When the frequency is further increased the circuit current decreases.

AIM: To study

(i) the effect of a varying frequency on a telephone ringing circuit.

(ii) the impedance offered by this circuit at voice frequency.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Ammeter 1mA-10A), Telephone Bell 59U; Capacitor 1.7μF, Oscillator Variable and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

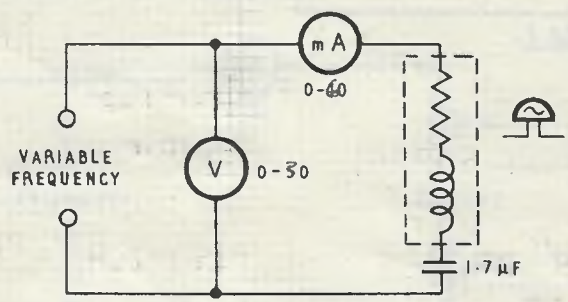


FIG. 1.

STEP 2. Increase the frequency to 15 c/s and adjust the supply voltage (E) to 25 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Maintaining the supply voltage (E) at 25 Volts increase the frequency in 5 cycle steps to 45 c/s. Measure the circuit current for each step. Record in Table 1.

STEP 4. Maintaining the supply voltage (E) at 25 Volts increase the frequency to 1000 c/s. Measure the circuit current. Record in Table 1.

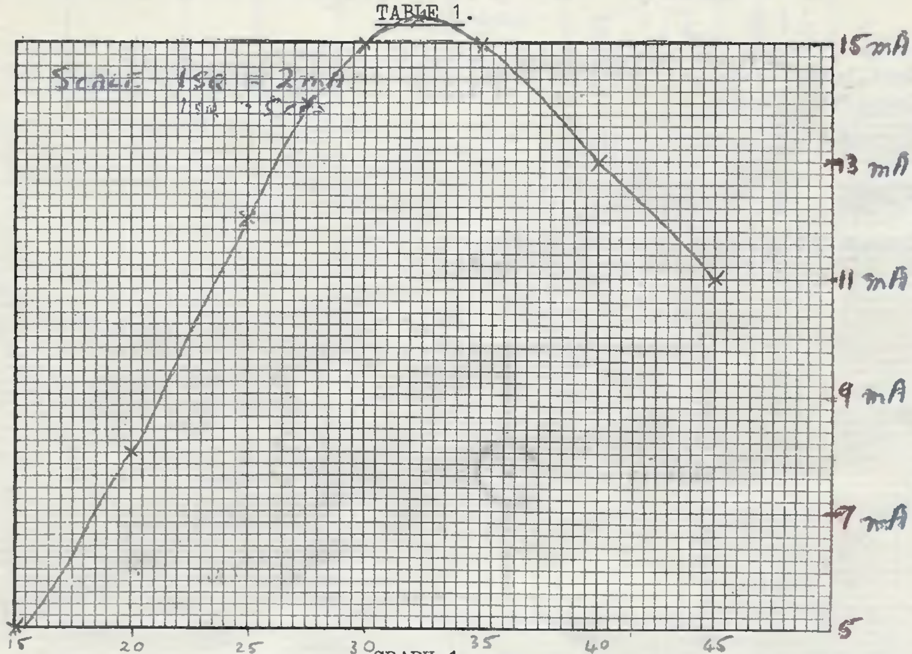
STEP 5. Plot a graph of frequency versus current on Graph 1.

10/10

27½	25	14 ✓	32½	25	15.5 ✓
FREQUENCY	VOLTS	CURRENT	FREQUENCY	VOLTS	CURRENT
15	25	5 ✓	35	25	15 ✓
20	25	8 ✓	40	25	13 ✓
25	25	12	45	25	11 ✓
30	25	15 ✓	1000	25	1mA ✓

2/2

TABLE 1.



1mA

4/4

GRAPH 1. Fc/s

TEST QUESTIONS:

1. From your results :-

   (i) At what frequency did electrical resonance take place? ....

   (ii) Calculate the impedance of the circuit at :-

30 c/s	1000 c/s
$Z = \frac{E}{I}$ = 1667Ω	$Z = \frac{E}{I}$ = 25KΩ ✓

1/1

B.

2. In a telephone circuit the bell and capacitor are across the line during conversation. What effect does this have on speech currents? ....IT HAS NO EFFECT AT ALL.... ✓ 1/1

   Why is this so?

   BECAUSE AT VF THE Z IS SO HIGH AS COMPARED WITH THE SPEECH CURRENT CIRCUIT ONLY NEGLIABLE I FLOWS THROUGH IT. 2/2

EFFECT OF FREQUENCY IN L, C AND R SERIES CIRCUITS.

When a variable frequency supply is connected to a circuit consisting of L, C and R in series, at one particular frequency the effect of the inductance and capacitance are equal but opposite, and, the circuit behaves as if it contains of resistance alone.

AIM: To study the effect of frequency variation through resonance in an A.C. circuit consisting of L, C and R in series.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2) Milliammeter 0-10mA (Multimeter 1mA-10mA), Oscillator Variable, Inductor 80mH, Resistor 200Ω, Capacitor 0.33µF, and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

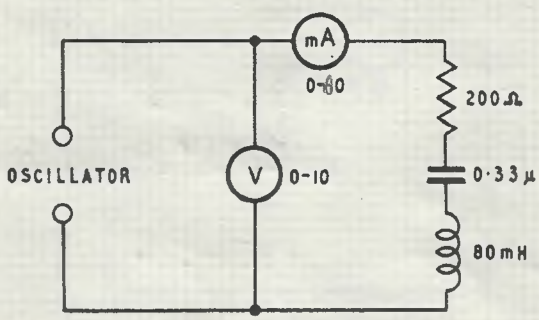


FIG. 1.

STEP 2. Adjust the frequency to 600 cycles with the supply voltage at 8 Volts. Measure the circuit current. Record in Table 1.

STEP 3. With the supply voltage at 8 Volts, increase the frequency as per Table 1 up to 1400 cycles. Measure the circuit current for each step. Record in Table 1.

STEP 4. Calculate in Table 1 the impedance for each step.

STEP 5. Plot a graph of -

(i) Circuit current versus frequency.

(ii) Impedance versus frequency.

STEP 6. Indicate the resonant frequency on the graph.

10/10

Laboratory Projects

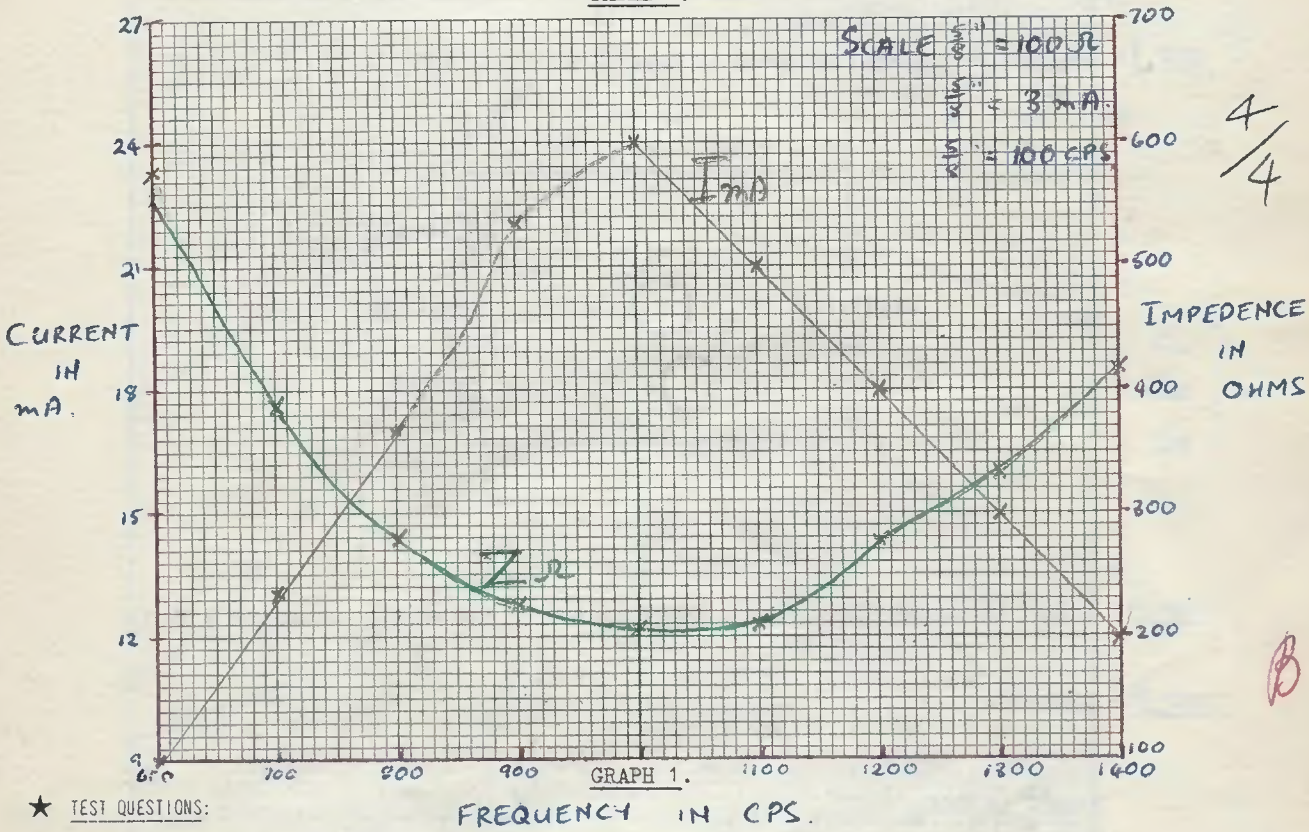
2nd Year

PROJECT NO. 12

FREQ.	E	I mA	Z = E/I	FREQ.	E	I mA	Z = E/I
600	5	9	556	1000	5	24	208
700	5	13	384.5	1100	5	21	210
800	5	17.5	280	1200	5	18	278
900	5	22	227	1300	5	15	333
				1400	5	12	416

TABLE 1.

2/2



GRAPH 1.

4/4

B

★ TEST QUESTIONS:

1. In a circuit consisting of L, C and R in series at resonance -

(i) X_L is ~~greater than~~ equal to ~~less than~~ X_C (ii) Z is ~~greater than~~ equal to ~~less than~~ R (iii) Z is minimum ~~maximum~~ (iv) I is ~~minimum~~ maximum

2/2

2. When the resistance of a series resonant circuit is halved the circuit current is doubled ~~not changed~~ ~~halved~~ therefore E_L and E_C will be doubled. ~~the same.~~ halved. Any variation in resistance does not change the resonant frequency of the circuit. ~~increases~~ ~~decreases~~

2/2

EFFECT OF FREQUENCY ON E_R E_L AND E_C IN A SERIES A.C. CIRCUIT.

In a circuit consisting of L, C and R is series at resonance the potential drops across the reactive components are equal and can exceed the supply voltage many times.

AIM: To study the effect of frequency variation on E_R, E_L and E_C in an A.C. series circuit.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Oscillator Variable, Inductor 80mH, Resistor 200Ω, Capacitor 0.33µF and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

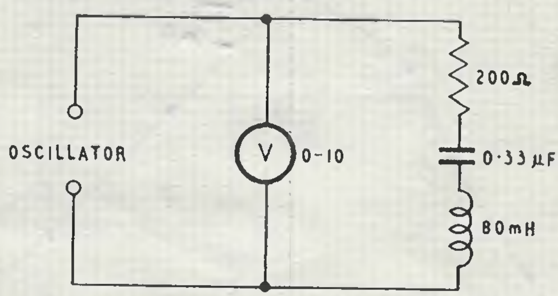


FIG. 1.

STEP 2. Adjust the supply frequency to 600 cycles with the supply voltage at 2 Volts.

STEP 3. Measure -

(i) E_R (ii) E_L (iii) E_C

Record in Table 1.

STEP 4. With the supply voltage at 2 Volts increase the frequency as per Table 1 up to 1400 cycles.
Repeat Step 3 for each value.

STEP 5. Plot a graph of -

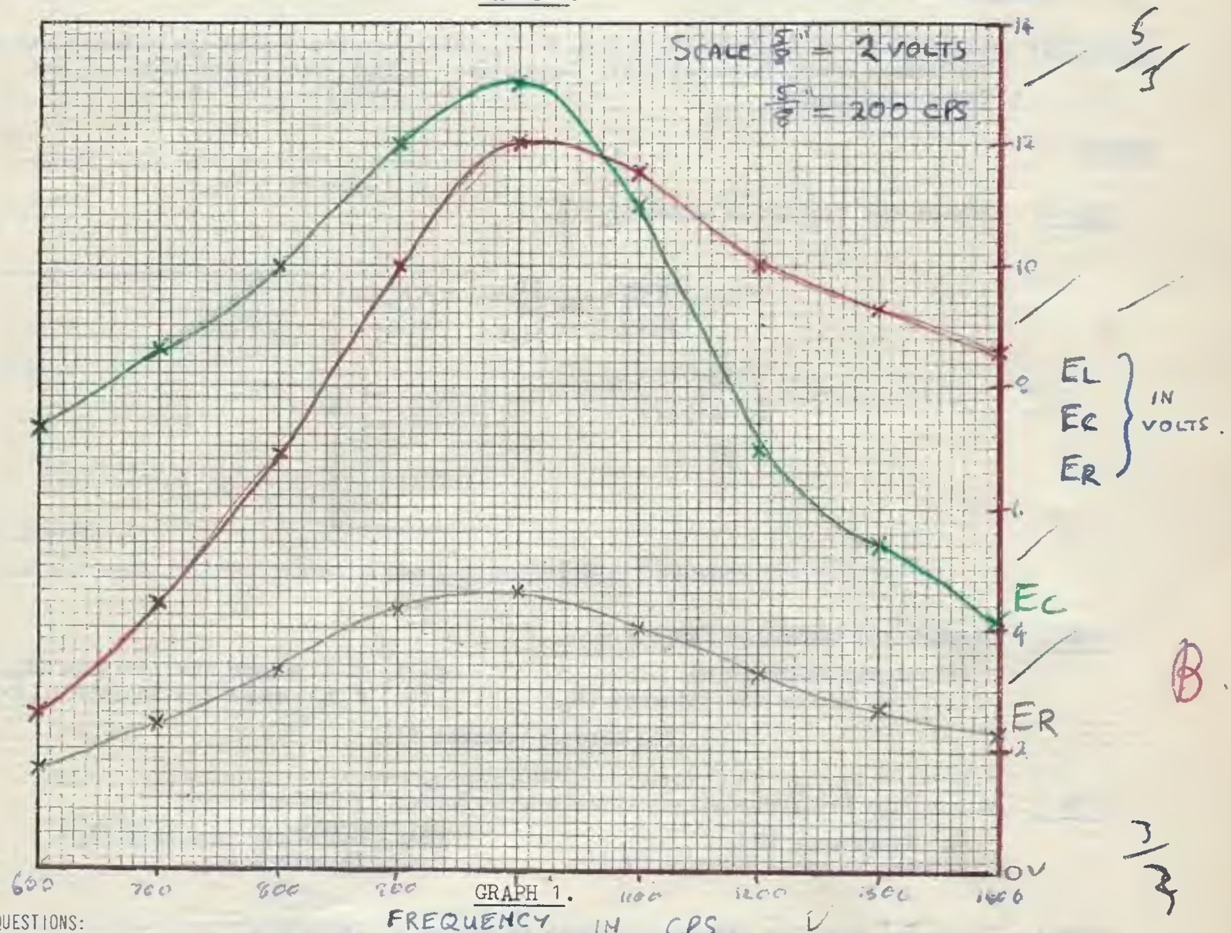
(i) E_R (ii) E_L (iii) E_C against frequency on Graph 1.

10/10

FREQ.	E_R	E_L	E_C	FREQ.	E_R	E_L	E_C
600	1·7	2·6	7·3	1000	4·6	12	11
700	2·4	4·4	8·6	1100	4	11·5	9
800	3·3	6·9	10	1200	3·3	10	7
900	4·3	10	12	1300	2·7	9·3	5·4
				1400	2·3	8·6	4·2

TABLE 1.

2/2



GRAPH 1.

5/5

B

3/3

TEST QUESTIONS:

1. Below the resonant frequency E_C is greater than ~~the same as~~ ~~less than~~ E_L.

2. Above the resonant frequency E_L is greater than ~~the same as~~ ~~less than~~ E_C.

3. At resonance E_R ~~is greater than~~ equals ~~is less than~~ the supply voltage.

SERIES RESONANCE.

When a variable frequency supply is connected to a circuit consisting of L, C and R in series, at one particular frequency the circuit behaves as if it consists of resistance alone, and, the circuit current (I) is "in phase" with the supply voltage (E). This is the resonant frequency of the circuit.

The ratio of the P.D. developed across the reactance, to the P.D. across the resistance is indicated by a number called the Q factor.

This ratio or voltage magnification is dependent upon the relative values of reactance and resistance, and is found from -

$$Q = \frac{X_L}{R} \quad \text{or} \quad \frac{E_L}{E} \quad (\text{as } E = E_R.)$$

AIM: To study the voltage distribution in a series circuit consisting of L, C and R at resonance.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-10mA (Multimeter 1mA-10A), Resistance 200Ω, Inductor 80mH, Capacitance 0.33µF, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

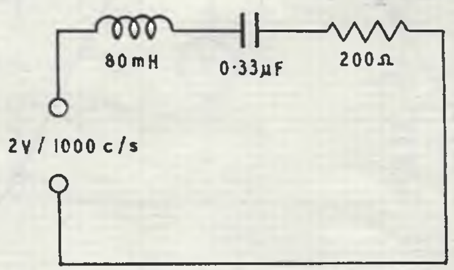


FIG. 1.

STEP 2. Measure and record in Table 1 -

(i) Supply Voltage (E).
(ii) P.D. across the inductor (E_L).
(iii) P.D. across the resistor (E_R).
(iv) P.D. across the capacitor (E_C).
(v) Circuit current (I).

STEP 3. Using Ohms Law applications calculate in Column 1, Table 2 -

(i) Resistance (R).
(ii) Capacitive reactance (X_C).
(iii) Inductive reactance (X_L).
(iv) Impedance (Z).

STEP 4. Using the formulae stated calculate in Column 2, Table 2 -

(i) Inductive reactance (X_L).
(ii) Capacitive reactance (X_C).
(iii) Impedance (Z).

STEP 5. Compare the results of steps 3 and 4.

STEP 6. Draw a vector diagram to scale, of the results in step 2.

Laboratory Projects **PROJECT NO. 14**

2nd Year

E---- VOLTS	E_L-----VOLTS	E_R----VOLTS	E_C-----VOLTS	I ----- mA

TABLE 1.

1	2
$R = \frac{E_R}{I} =$	$R = 200\Omega$
$X_L = \frac{E_L}{I} =$	$X_L = 2\pi f L$ $X_L =$
$X_C = \frac{E_C}{I} =$	$X_C = \frac{1}{2\pi f C}$ $X_C =$
$Z = \frac{E}{I} =$	$Z^2 = R^2 + (X_L - X_C)^2$ $Z =$

TABLE 2.

Q FACTOR

$Q = \frac{E_L}{E_R}$ = ---------- = ...

∴ Q of circuit = ...

TEST QUESTIONS:

1. From your results and vector diagram list five conditions that exist when a series circuit is resonant.

(i) ....

(ii) ....

(iii) ....

(iv) ....

(v) ....

2. A circuit consisting of L, C and R is resonant at 1000 c/s. When the frequency of the supply is decreased, the resultant circuit becomes capacitive. / resistive. / inductive.

3. A 80mH inductor and a 0.33 μF Capacitor resonates at 1000 c/s. When the inductance is increased to 160 mH, what value of capacity is needed for resonance at the same frequency.

Answer ....

CAPACITANCE AND RESISTANCE IN PARALLEL.

When an alternating e.m.f. is connected to a circuit consisting of capacity and resistance in parallel the circuit current will divide into two branches I_R and I_C.

The current through the resistor (I_R) is "in phase" with the supply voltage (E), the current through the capacitor (I_C) leads the supply voltage by 90°.

The circuit current (I) is the vector sum of I_R and I_C and leads the supply voltage (E) by some angle between 0° and 90° as in Fig. 1.

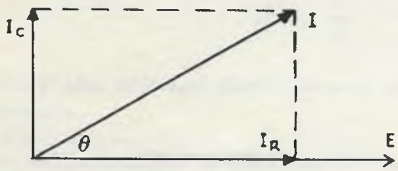


FIG. 1.

The phase angle θ is calculated from

$$\tan\theta = \frac{I_C}{I_R}$$

The total opposition a parallel circuit offers to alternating current is termed impedance and is calculated from -

$$Z = \frac{E}{I}$$

AIM: To study (i) the current distribution, (ii) phase relationship in a circuit consisting of capacitance and resistance in parallel.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Ammeter 1mA-10A), Oscillator 1000 c/s, Capacitor 0.1µF, Resistor 1kΩ and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E).
(ii) Circuit current (I).
(iii) Current through the resistor (I_R).
(iv) Current through the capacitor (I_C).

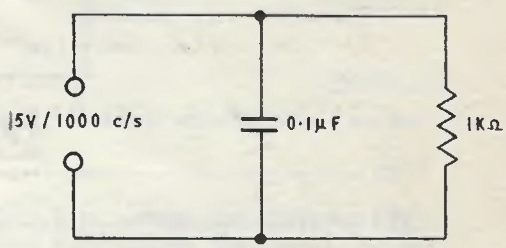


FIG. 2.

STEP 3. Using formulae stated, calculate in Table 2 -

(i) Resistance (R).
(ii) Capacitive reactance (X_C).
(iii) Impedance (Z).
(iv) Current through the resistor (I_R).
(v) Current through the capacitor (I_C).
(vi) Circuit Current (I).

STEP 4. Compare the results of steps 3(iv), (v) and (vi) with the results of step 2.

STEP 5. (i) Prepare a vector diagram from the results of step 2.
(ii) Measure the circuit current on the vector and compare with the meter reading in Table 1.
(iii) Calculate the phase angle.
(iv) Measure the phase angle and compare with the calculated value.

8½ R

E 15 VOLTS	I 19 mA	I_R 15.5 mA	I_c 9.5 mA

1/1

TABLE 1. PRACTICAL VALUES

R = 1KΩ	$I_R = \frac{E}{R}$ 15mA
$X_c = \frac{1}{2\pi f C}$ X_c = 1592 Ω	$I_c = \frac{E}{X_c}$ 9.3mA
$Z = \frac{E}{I}$ 847 Ω	$I = \sqrt{I_R^2 + I_c^2}$ I = 18.6

1½/2

TABLE 2. THEORITICALL VALUES

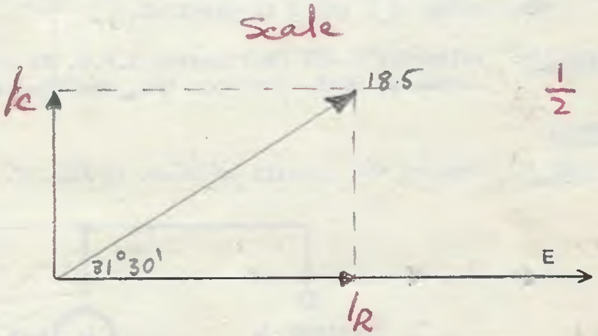
PHASE ANGLE THEORY

$\tan = \frac{I_C}{I_R} = \frac{9.5}{15.5} = 0.6129$

1 From tables PRACTICAL VALUES

tan 0.6129 = 31° 30'

∴ Angle = 31° 30' degrees. ✓



1/2

★ TEST QUESTIONS:

1. In a circuit containing Capacitance and Resistance in parallel :-

 (i) The P.D. across the resistor is ~~less than~~ / ~~greater than~~ / the same as the supply voltage. ✓

 (ii) The P.D. across the capacitor is ~~less than~~ / ~~greater than~~ / the same as the supply voltage. ✓

 (iii) The current and voltage of the resistive branch are in / ~~out of~~ phase. ✓

 (iv) The currents I_R and I_C are ~~in~~ / out of phase and must be ADDED VECTORALLY to calculate the circuit current. ✓

 (v) When C and R are connected in parallel to an alternating current supply, the circuit current ~~lags~~ / leads / ~~is in phase with~~ the supply voltage. ✓

2. Complete the following statement -
 When the capacitance of the circuit FIG. 1 is doubled -

 I_C doubles ✓ / ~~remains the same~~ / ~~halves~~. I_R ~~doubles~~ / remains the same ✓ / ~~halves~~, the circuit current increases ✓ / ~~remains the same~~ / ~~decreases~~,

 the circuit impedance ~~increases~~ / ~~remains the same~~ / decreases ✓, and the phase angle increases ✓ / ~~remains the same~~ / ~~decreases~~

INDUCTANCE AND RESISTANCE IN PARALLEL.

When an alternating e.m.f. is connected to a circuit consisting of inductance and resistance in parallel the circuit current (I) divides into two branches I_L and I_R.

The current in the resistive branch (I_R) is "in phase" with the supply voltage (E), the current in the inductive branch (I_L) lags the supply voltage by 90^o.

The circuit current (I) is the vector sum of I_L and I_R and lags the supply voltage by some angle between 0^o and 90^o as in Fig. 1.

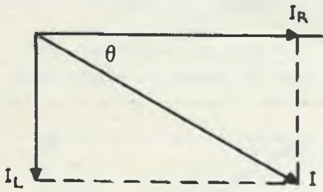


FIG. 1.

The phase angle θ is calculated from -

$$\tan \theta = \frac{I_L}{I_R}$$

The total opposition a parallel circuit offers to alternating current is termed impedance (Z) and is calculated from -

$$Z = \frac{E}{I}$$

AIM: The study (i) the current distribution (ii) the phase relationship in a circuit consisting of L and R in parallel.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-10mA (~~Ammeter~~ 1mA-10A), Inductor 80mH, Resistor 1kΩ, Oscillator 1000 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

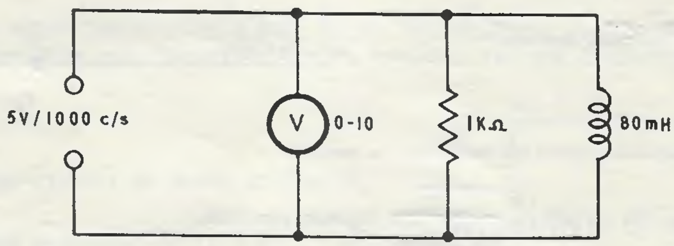


FIG. 2.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E).
(ii) Circuit current (I).
(iii) Current through the resistor (I_R).
(iv) Current through the inductor (I_L).

STEP 3. Using formulae stated, calculate in Table 2 -

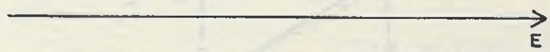
(i) Resistance (R).
(ii) Inductive reactance (X_L).
(iii) Impedance (Z).
(iv) Current through the resistor (I_R).
(v) Current through the inductor (I_L).
(vi) Circuit current (I).

STEP 4. Compare the results of step 3(iv), (v) and (vi) with the results of step 2.

STEP 5. (i) Prepare a vector diagram from results of step 2.
(ii) Measure the circuit current on the vector and compare with the meter reading in Table 1.
(iii) Calculate the phase angle.
(iv) Measure the phase angle and compared with the calculated value.

E ------ VOLTS	I ------- mA	I_R ------ mA	I_L ------ mA

TABLE 1.



R = 1KΩ	$I_R = \frac{E}{R} =$
$X_L = 2\pi f L$ $X_L =$	$I_L = \frac{E}{X_L} =$
$Z = \frac{E}{I} =$	$I = \sqrt{I_R^2 + I_L^2}$ $I =$

TABLE 2.

PHASE ANGLE

$\tan \theta = \frac{I_L}{I_R} =$ .... =

From tables

tan .... = ...

∴ Angle θ = ... degrees.

★ TEST QUESTIONS:

1. From your results and vector diagram:-

   (i) The circuit current (I) is the Vector Sum of .... and .... and leads / lags the supply voltage by .... degrees.

2. When the resistance is decreased to 500 ohms:-

   (i) I_R increases / remains the same / decreases, (I_R = ...)

   (ii) The circuit current increases / remains the same / decreases, since the circuit current (I) is the Vector Sum of .... and ....

   (iii) The resultant impedance increases / remains the same / decreases, since Z = ... and the circuit phase angle increases / decreases

L, C AND R IN PARALLEL (1).

When an alternating e.m.f. is connected to a circuit consisting of L, C and R in parallel the circuit current divides into three branches, I_L, I_C and I_R. The current in the resistive branch (I_R) is "in phase" with the supply voltage, the current in the inductive branch lags the supply voltage by 90^o, the current in the capacitive branch leads by 90^o. The circuit current is the vector sum of I_R and $I_L - I_C$ as in Fig. 1.

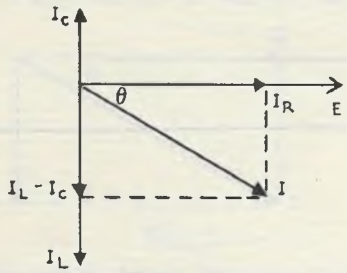


FIG. 1.

The phase angle θ is calculated from -

$$\tan \theta = \frac{I_L - I_C}{I_R}$$

AIM: To study (i) the current distribution and, (ii) the phase relationship in a circuit consisting of L, C and R in parallel.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2) Milliammeter 0-10mA (Multimeter 1mA-10A), Oscillator 1000 c/s, Inductor 80mH, Capacitor 0.1µF, Resistor 1kΩ and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

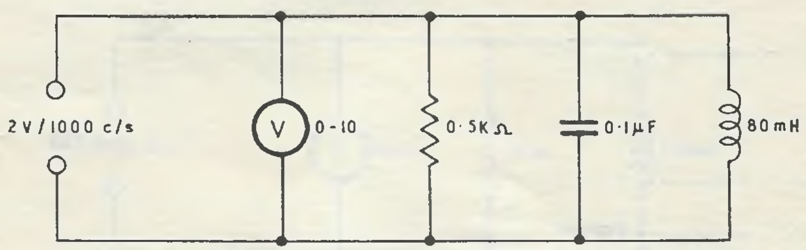


FIG. 2.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E).
(ii) Circuit current (I)
(iii) Current through the inductor (I_L).
(iv) Current through the capacitor (I_C).
(v) Current through the resistor (I_R).

STEP 3. Using formulae stated, calculate in Table 2 -

(i) Resistance (R).
(ii) Capacitive reactance (X_C).
(iii) Inductive reactance (X_L).
(iv) Impedance (Z).
(v) Current through the capacitor (I_C).
(vi) Current through the inductor (I_L).
(vii) Current through the resistor (I_R).
(viii) Circuit current (I).

STEP 4. Compare the results of steps 3(v) to (viii) with the results of step 2.

STEP 5.
(i) Prepare a vector diagram from the results in Table 1.
(ii) On the completed vector measure the resultant circuit current and compare with the meter reading in Table 1.
(iii) Calculate the phase angle.
(iv) Measure the phase angle and compare with the calculated value.

10/10

Laboratory Projects

2nd Year

PROJECT NO. 17

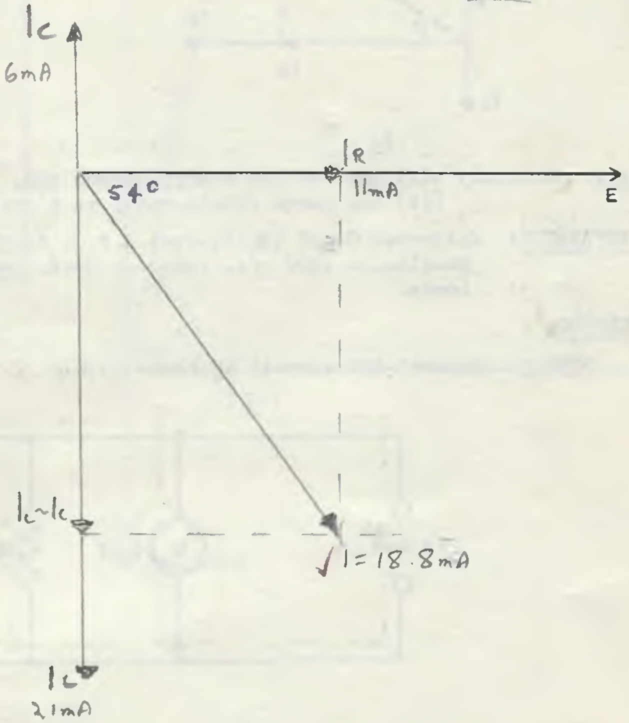
E 10V VOLTS	I 18 mA	I_R 11 mA	I_c 6 mA	I_L 21 mA

TABLE 1.

R = 0·5KΩ	$I_R = \frac{E}{R} =$ 10mA
$X_C = \frac{1}{2\pi fC}$ $X_C =$ 1592 Ω	$I_C = \frac{E}{X_C} =$ 6·28 mA
$X_L = 2\pi fC$ $X_L =$ 502·5 Ω	$I_L = \frac{E}{X_L} =$ 19·9mA
$Z = \frac{E}{I} =$ 588Ω	$I = \sqrt{I_R^2 + (I_L - I_C)^2}$ I = 16·8mA

TABLE 2.

SCALE 1mA = 1/8 IN.



PHASE ANGLE

$\tan\theta = \frac{I_L - I_C}{I_R}$ = ... =

From tables

tan 1·3620 = 53° 43'

∴ Angle θ = 53° 43' LAGGING

★ TEST QUESTIONS:

1. From your results:-

(i) The circuit current (I) is the Vector Sum of ....IR.... and ....IL & Ic....

(ii) The circuit current ~~leads~~ lags the supply voltage by 53° 43' degrees.

2. When the value of capacitance in Fig. 2 is increased to 0.5μF, X_C, ~~increases~~, ~~remains the same~~, decreases, I_C, increases ~~remains the same~~, and decreases

the resultant phase angle is ~~increased~~ decreased

3. What would be the effect on the following when the value of resistance in Fig. 2 is disconnected

I_L ....REMAINS SAME.... I_C ....REMAINS SAME....

Circuit current ....DECREASES....

L, C AND R IN PARALLEL (2).

When an alternating e.m.f. is connected to a circuit consisting of L, C and R in parallel the circuit current divides into three branches, I_L, I_C and I_R. The current in the resistive branch (I_R) is "in phase" with the supply voltage, the current in the inductive branch lags the supply voltage (E) by 90°, the current in the capacitive branch leads by 90°. The circuit current is the vector sum of I_R and $I_C - I_L$ as in Fig. 1.

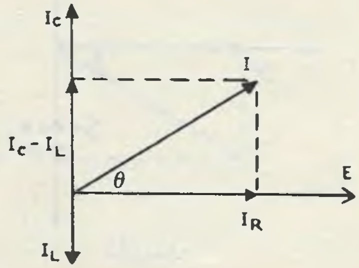


FIG. 1.

The phase angle θ is calculated from –

$$\tan\theta = \frac{I_C - I_L}{I_R}$$

AIM: To study (i) the current distribution; and,
(ii) the phase relationship in a circuit consisting of L, C and R in parallel.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Multimeter 1mA-10A), Oscillator 1000 c/s, Inductor 80mH, Capacitor 1μF, Resistor 1kΩ and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 2.

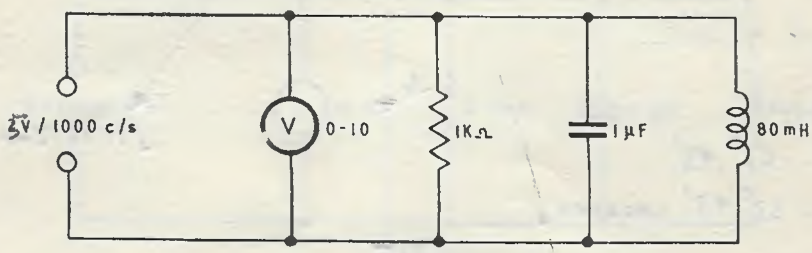


FIG. 2.

STEP 2. Measure and record in Table 1 –

(i) Supply voltage (E)
(ii) Current through the inductor (I_L)
(iii) Current through the resistor (I_R)
(iv) Current through the capacitor (I_C)
(v) Circuit current (I)

STEP 3. Using formulae stated, calculate in Table 2 –

(i) Resistance (R)
(ii) Capacitive reactance (X_C)
(iii) Inductive reactance (X_L)
(iv) Impedance (Z)
(v) Current through the capacitor (I_C)
(vi) Current through the inductor (I_L)
(vii) Current through the resistor (I_R)
(viii) Circuit current (I).

STEP 4. Compare the results of step 3(v) to (viii) with the results of step 2.

STEP 5. (i) Prepare a vector diagram from the results in Table 1.
(ii) On the completed vector measure the resultant circuit current and compare with the meter reading in Table 1.
(iii) Calculate the phase angle.
(iv) Measure the phase angle and compare with the calculated value.

10/10

PRACTICAL

E 5 VOLTS	I 24 mA	IR 5 mA	IC 35 mA	IL 10 mA

(1)

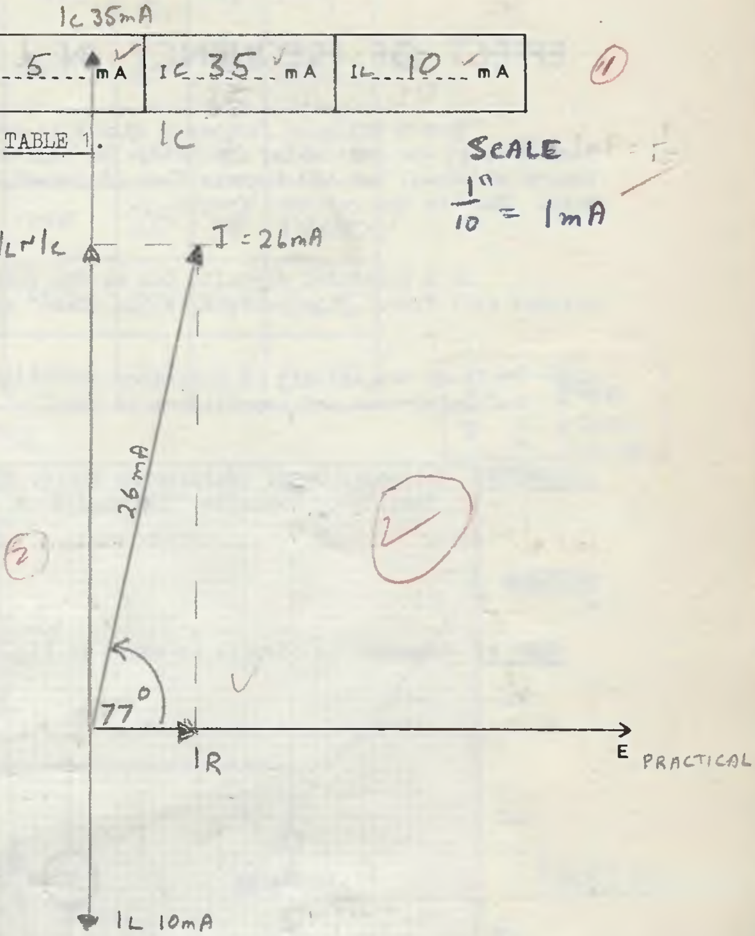
TABLE 1.

THEORY

$R = 1K\Omega$	$I_R = \frac{E}{R}$ 5mA
$X_C = \frac{1}{2\pi f C}$ $X_C = 159.2\Omega$	$I_C = \frac{E}{X_C}$ 32 mA
$X_L = 2\pi f L$ $X_L = 502.4\Omega$	$I_L = \frac{E}{X_L}$ 9.9 mA
$Z = \frac{E}{I}$ 25.2	$I = \sqrt{I_R^2 + (I_C - I_L)^2}$ $I = 22.2$ mA

(2)

TABLE 2.



(2)

THEORY PHASE ANGLE

$\tan\theta = \frac{I_C - I_L}{I_R} = 4.32 =$

From tables

$\tan 4.32 = 76°53'$

$\therefore$ Angle $\theta = 76°53'$ LEADING

(1)

★ TEST QUESTIONS:

1. From your results:-

(i) The circuit current (I) is the Vector Sum of IR and IL~IC

(ii) The circuit current leads ~~lags~~ the supply voltage (E) by 76°53' degrees.

2. When the resistance of the circuit is doubled -

I_R, ~~increases~~ ~~remains the same~~ decreases   I, ~~increases~~ ~~remains the same~~ decreases   Z, increases ~~remains the same~~ ~~decreases~~

(1)

3. When the frequency is increased:-

I_C, increases ~~remains the same~~ ~~decreases~~ because $I_C = \frac{E}{I_C}$, $X_C = \frac{1}{2\pi f C}$ I_L, ~~increases~~ ~~remains the same~~ decreases because $I_L = \frac{E}{X_L}$ $X_L = 2\pi f L$

and the phase angle increases ~~remains the same~~. ~~decreases~~

(1)

4. How do the results of this project differ from those of project 17.

17 IS INDUCTIVE PROJECT 18 IS CAPACITIVE

(1)

EFFECT OF FREQUENCY IN L AND C PARALLEL CIRCUITS

When a variable frequency supply is connected to a circuit consisting of L and C in parallel, at one particular frequency the currents in the inductive branch and the capacitive branch are equal but 180 degrees "out of phase", thus the resultant or circuit current is zero. This is the resonant frequency.

In a practical circuit, due to the resistance of the inductor, a low value of circuit current will flow. This current is "in phase" with the supply voltage.

AIM: To study the effects of frequency variation through resonance, in a circuit consisting of inductance and capacitance in parallel.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Multimeter 1mA-10A), Oscillator Variable, Inductor 80mH, Capacitor 0.33μF and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

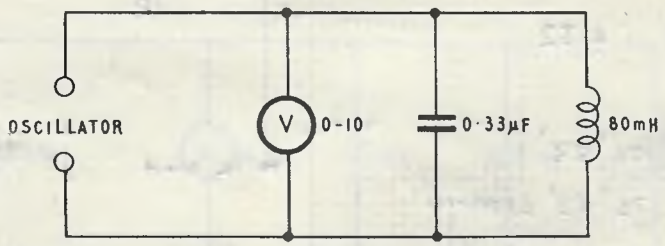


FIG. 1.

STEP 2. Adjust the frequency to 600 c/s and the supply voltage (E) to 20 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Maintaining the supply voltage at 5 Volts increase the frequency in 100 cycle steps to 1400 c/s. Measure the circuit current for each step. Record in Table 1.

STEP 4. Calculate in Table 1 the impedance for each step.

STEP 5. Plot a graph of circuit current versus frequency (Graph 1).

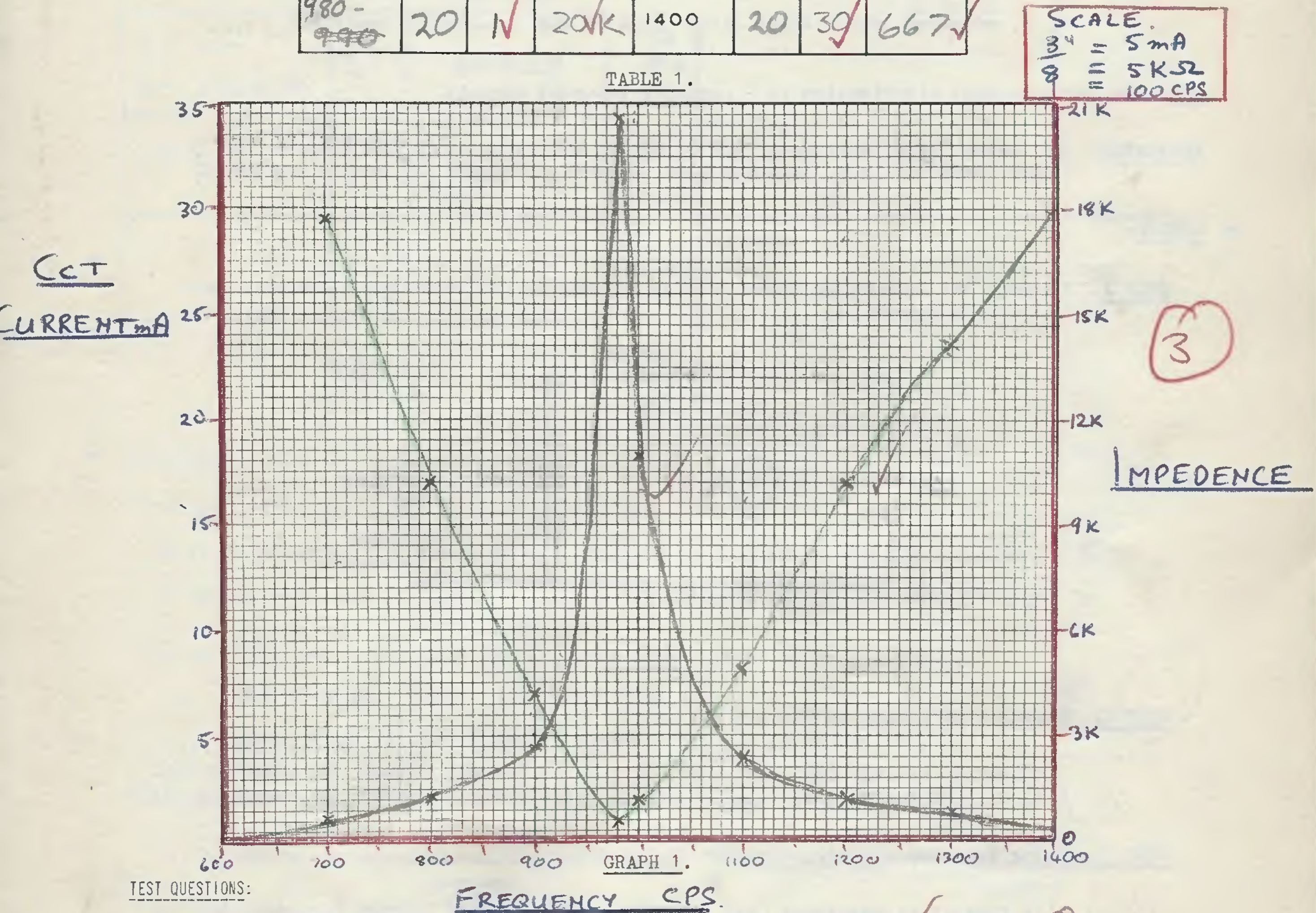
STEP 6. On the same graph plot impedance versus frequency.

Laboratory Projects **PROJECT NO. 19**

2nd Year

FREQ.	E	I mA	Z = E/I	FREQ.	E	I mA	Z = E/I
600	20	43	465	1000	20	2	10000
700	20	29	690	1100	20	9	2353
800	20	17	1176	1200	20	16	1250
900	20	7	2852	1300	20	23.5	865
980 - ~~990~~	20	1	20K	1400	20	30	667

TABLE 1.



GRAPH 1.

TEST QUESTIONS:

1. From your results :-

(i) What is the resonant frequency of the circuit? ......980 CPS......

(ii) What is the circuit impedance at resonance? ......20 KΩ......

(iii) What is the effect on the circuit impedance when the frequency is increased above resonance.

......DECREASE FREQUENCY CCT BECOMES CAPACITIVE......

PARALLEL RESONANCE.

When an alternating e.m.f. is connected to a circuit consisting of L and C in parallel, the circuit current divides into two branches I_L and I_C.

At one particular frequency (resonant frequency) where $I_L = I_C$ the circuit current is zero; therefore at resonance the impedance of the circuit is infinite.

In a parallel circuit, the Q factor is a number which indicates how many times the circulating current at resonance is greater than the circuit current. Q factor is calculated from -

$$Q = \frac{I_C \text{ or } I_L}{I}$$ where I_C or I_L is taken as the circulating current.

AIM: To study current distribution in a parallel resonant circuit.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2), Milliammeter 0-60mA (Ammeter 1mA-10A), Oscillator 1000 c/s, Inductor 80mH, Capacitor 0.33μF, and Connecting Leads.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1. Adjust frequency for minimum current (1,000c/s approx.).

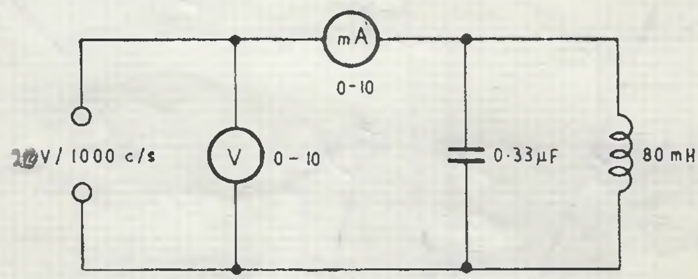


FIG. 1.

STEP 2. Measure and record in Table 1 -

(i) Supply voltage (E)
(ii) Circuit current (I)
(iii) Current through the inductor (I_L)
(iv) Current through the capacitor (I_C).

STEP 3. Using formulae stated, calculate in Table 2 -

(i) Capacitive reactance (X_C)
(ii) Inductive reactance (X_L)
(iii) Impedance (Z)
(iv) Current through the capacitor (I_C)
(v) Current through the inductor. (I_L)
(vi) Circuit current (I)
(vii) Q factor.

STEP 4. Compare the results of step 3(iv) to (vi) with the measured values in Table 1.

STEP 5. Prepare a vector diagram from the results in Table 1.

9½

Laboratory Projects | PROJECT NO. 20

2nd Year

PRAC

E _20_ VOLTS	I _1·6_ mA	I_C _43_ mA	I_L _41_ mA

(1)

SCALE ¼ in = 10 mA

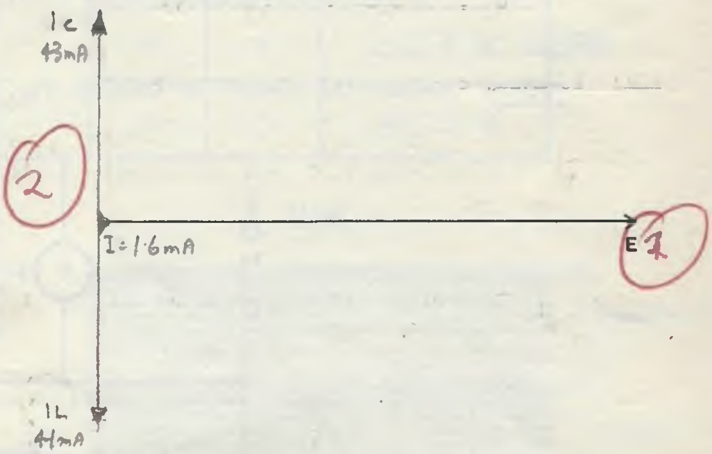
TABLE 1.

THEORY

$X_C = \frac{1}{2\pi f C}$ X_C = 482·4 Ω	$I_C = \frac{E}{X_C}$ 41·4 mA
$X_L = 2\pi f L$ X_L = 502·5 Ω	$I_L = \frac{E}{X_L}$ 39·3 mA
$Z = \frac{E}{I}$ 952	$I = I_C - I_L$ I = 2·1 mA
	$Q = \frac{I_C}{I}$ 20

TABLE 2.

(2)



(1)

★ TEST QUESTIONS:

1. From your results :-

The circuit current is minimum ~~maximum~~ and is ..IN.... phase with the supply voltage, with a phase angle of ......0°......

The impedance of the parallel circuit at resonance is AT A MAXIUM — INFINITY (1)

2. List two methods used to make a circuit resonate when the circuit current lags the supply voltage.

(i) DECREASE THE INDUCTANCE ✗ (½)

(ii) INCREASE THE CAPACITY

3. A circuit consisting of L and C in parallel is resonant at 1000c/s. When the frequency is increased

(i) The inductive reactance increases ~~remains the same~~ ~~decreases~~, and the current in the inductive branch (I_L) ~~increases~~ ~~remains the same as~~ decreases (1)

I_L = ...E/XL...

(ii) The capacitive reactance ~~increases~~ ~~remains the same~~ decreases, and the current in the capacitive branch (I_C) increases ~~remains the same~~ ~~decreases~~

as I_C = ...E/Xc.....

(iii) I_C is therefore greater than ~~equal to~~ ~~less than~~ .....IL..... and the circuit current ...leads... the applied voltage. (1)

METAL RECTIFIERS.

A metal rectifier is a semi-conductor device which allows current to pass more readily in one direction than the other.

When the voltage is increased in the conducting direction, the resistance decreases to a low value, thus, the rectifier has a non-linear resistance voltage characteristic.

AIM: To study -

(i) the voltage/current characteristic;
(ii) the voltage/ resistance characteristic of a metal rectifier.

APPARATUS: Voltmeter 0-50V (Multimeter A.P.O. No.2), Milliammeter 0-100mA (Multimeter 50μA-1A) Variable D.C. Supplies 0-20V, 0-3V, Metal Rectifier 1/6C and Connecting Leads.

METHOD:

STEP 1: Connect the circuit as shown in Fig. 1.

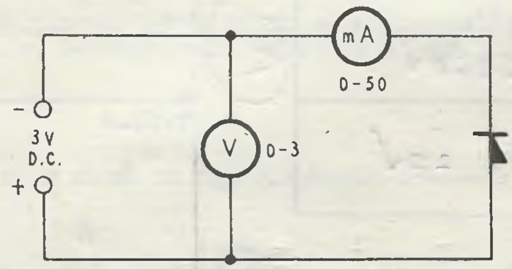


FIG. 1.

STEP 2: Adjust the input voltage to 2 Volts. Measure the circuit current. Record in Table 1.

STEP 3: Decrease the input voltage in 0.5 Volt steps to 0 Volts. Measure the circuit current for each step. Record in Table 1.

STEP 4: Connect the circuit as shown in Fig. 2.

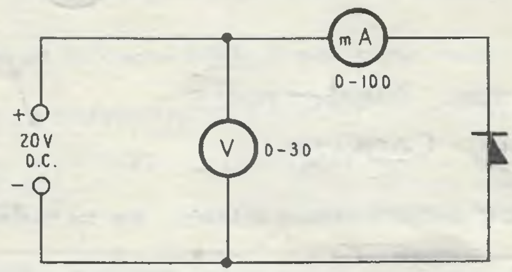


FIG. 2.

STEP 5: Adjust the input voltage to 20 Volts. Measure the circuit current. Record in Table 1.

STEP 6: Decrease the input voltage in 5 Volt steps to 0 Volts. Measure the circuit current for each step. Record in Table 2.

STEP 7: Calculate values of resistance in Tables 1 and 2.

COMPLETE GRAPH & QUESTION MB 5/10 MB

STEP 8. (i) Complete a graph of Current/Voltage for conducting and non-conducting directions on Graph 1.

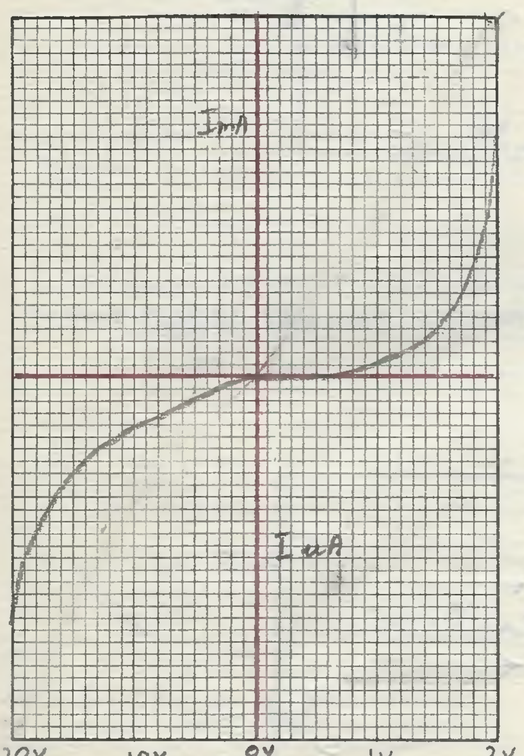
(ii) Complete a graph of Resistance/Voltage for each step on Graph 2.

E	I	R = $\frac{E}{I}$ Ω
2·0	4·3	470
1·5	2·0	750
1·0	·2	5000
0·5	0	∞

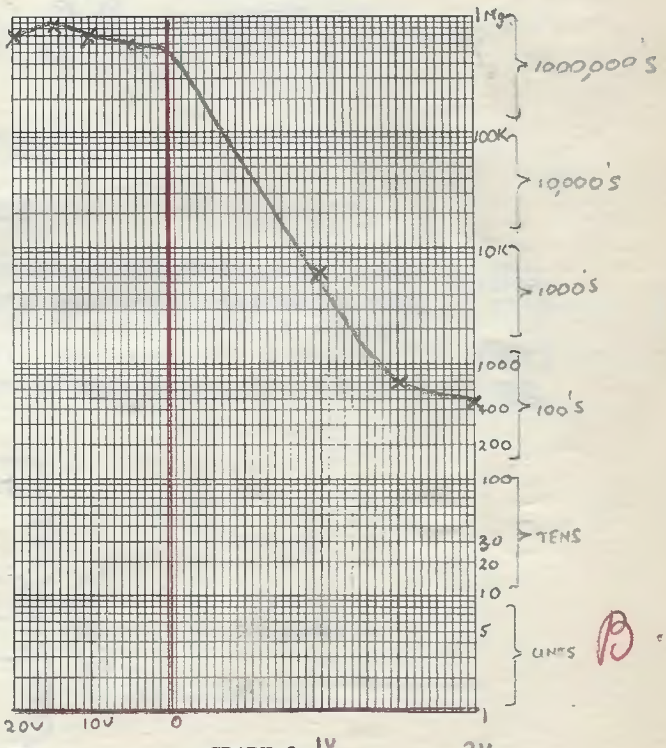
TABLE 1.

E	I µA	R = $\frac{E}{I}$
20	30	667 K
15	22	682 K
10	15	667 K
5	10	500 K

TABLE 2.



GRAPH 1.



GRAPH 2.

B

TEST QUESTIONS:

1. From your graphs -

Compare the resistance of the rectifier, forward and reverse, when the input voltage is 2 Volts.

IN THE FORWARD DIRECTION R IS VERY LOW + IN THE REVERSE DIRECTION IT IS VERY HIGH

RECTIFICATION.

Metal rectifiers can be used for half or full wave rectification, that is, to change alternating current into direct current pulses.

AIM: To study metal rectifiers connected for half and full wave rectification.

APPARATUS: Voltmeter 0-50V (Multimeter A.P.O. No.2) Transformer 4012A, Resistor 0.5kΩ, Metal Rectifiers 1/12A, Supply Voltage 50V 50c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

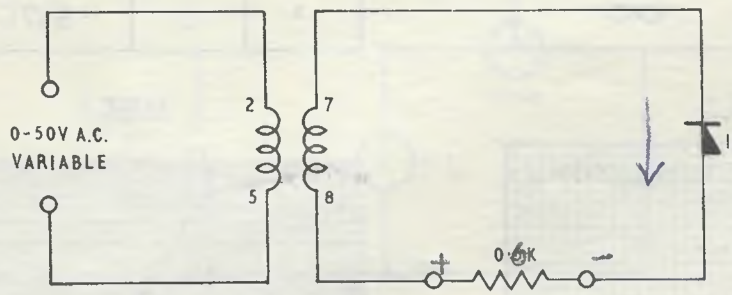


FIG. 1.

STEP 2. Adjust the supply voltage to 20 Volts.
Measure the P.D. across load resistor. Record value in Table 1 and polarity on Fig. 1.

STEP 3. Connect the circuit as shown in Fig. 2.

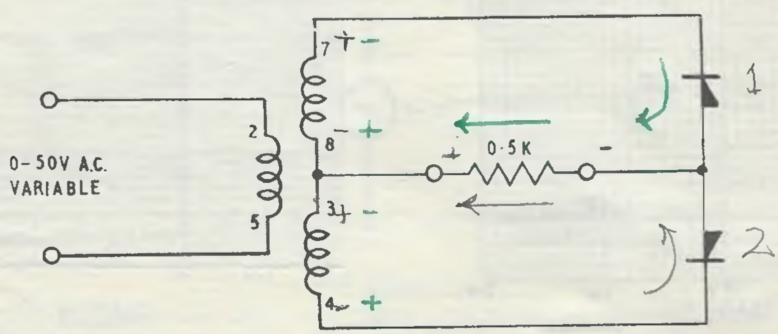


FIG. 2.

STEP 4. Adjust the supply voltage to 20 Volts.
Measure the P.D. across the load resistor. Record value in Table 1 and polarity on Fig. 1.

7/10

CIRCUIT	LOAD	VOLTS	I
HALF WAVE	0·6kΩ	3·5	7mA
FULL WAVE	0·6kΩ	6·2	14mA

2

TABLE 1.

TEST QUESTIONS:

1. From your results in Table 1 -

   (i) The voltage across the load resistor on full-wave rectification is approx ....DOUBLE.... that on half-wave rectification. 1

   Give reason for your answer.

   REASON.. X

   ....

   (ii) Using the circuit (FIG. 2) explain briefly how full-wave rectification is effected.

   ASSUME POLARITIES IN 1ST HALF CYCLE AS SHOWN RECT 2 CONDUCTS | ∴ PD DROP ACROSS LOAD AS SHOWN – 2ND HALF ~ RECT 1 CONDUCTS

B.

EFFECTS OF FILTERS.

An output filter is used to reduce or eliminate the A.C. component or "ripple" from the direct current output of a rectifying circuit.

AIM: To analyse filtering methods.

APPARATUS: Supply Voltage 12V AC, Rectifier Bridge, Milliammeter 0-10mA (Multimeter DC 50µA-1A), Load resistor 2.2kΩ, Receiver, Capacitor 4µF, Inductor 14H 60mA, and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

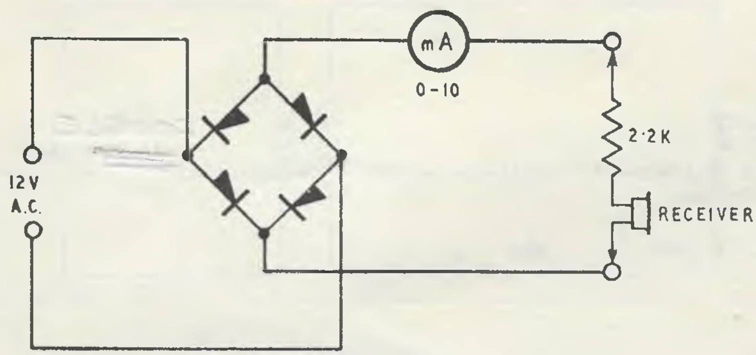


FIG. 1.

STEP 2. Listen with the receiver-note value of direct current as indicated by meter.
Note: 100 c/s ripple heard in receiver.

STEP 3. Connect the circuit as shown in Fig. 2.

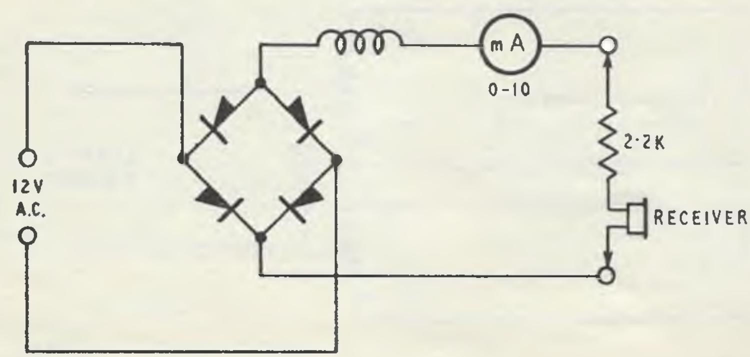


FIG. 2.

STEP 4. Listen with the receiver with the inductor in circuit.
Note the effect on ripple content compared to negligible decrease in current.

STEP 5. Connect the circuit as shown in Fig. 3.

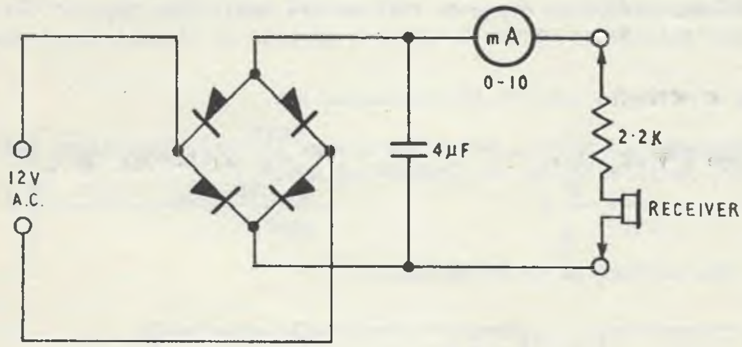


FIG. 3.

STEP 6. Listen with the receiver.

Again note the effect on ripple content and value of direct current.

TEST QUESTIONS:

1. In Step 4 the ripple content through the receiver increases / remains the same / decreases because the inductor offered a high / low reactance to the 100 cycle ripple frequency.

2. In Step 6 the ripple content through the receiver increases / remains the same / decreases due to the high / low reactance shunt path of the capacitance at the ripple frequency.

3. In effect, FIGS. 2 and 3 are respectively ~~high pass~~ / ~~band pass~~ / low pass filters.

TYPES OF FILTERS.

In Telecom. many different types of filters are used. The type of filter used in a particular circuit and the values of the components depends on circuit requirements.

AIM: To study types of filters used in telecommunication.

APPARATUS: Supply Voltage 12V 50 c/s, Rectifier Bridge (1/12A), Capacitors 4µF, Inductor 14H 60mA, Receiver, Resistor 2.2kΩ and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

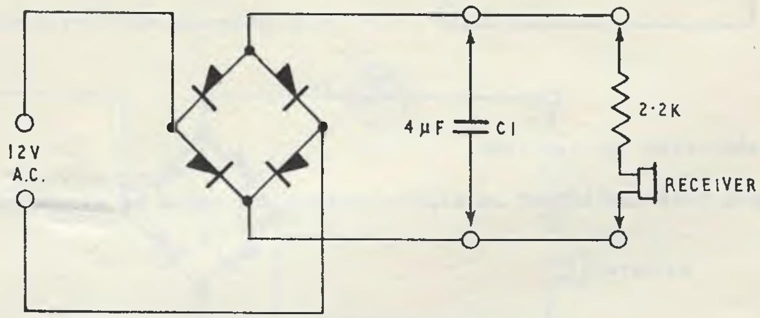


FIG. 1.

STEP 2. Listen with the receiver. Note the level of the ripple content.

STEP 3. Connect the capacitor C1 in circuit as shown in Fig. 1.

STEP 4. Listen with the receiver. Note the level of ripple decrease.

STEP 5. Connect the inductor (L) in circuit as shown in Fig. 2.

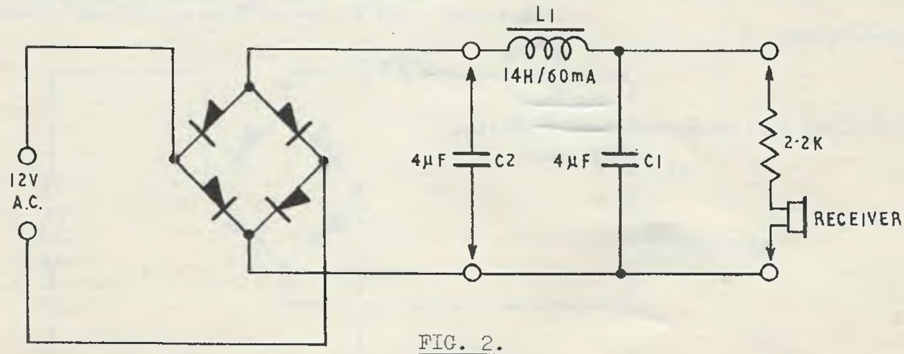


FIG. 2.

STEP 6. Listen with the receiver and note the effect in ripple level.

STEP 7. Connect the capacitor C2 into circuit as shown in Fig. 2. Listen across the receiver and note the effect in ripple level.

DEMONSTRATION

STEP 8. Connect the C.R.O. across the resistor. Repeat Steps 3, 5, 7. For each step record the input and output wave form of 2 cycles on Graphs 1, 2 and 3.

GRAPH 1.

GRAPH 2.

GRAPH 3.

TEST QUESTIONS:

1. In the filter circuit (Fig. 2) the inductor is in series ~~parallel~~ with the output and offers a high ~~low~~ reactance to the ripple frequency, whilst the capacitors being in parallel with the output offer a ~~high~~ low reactance ~~series~~ shunt path for the ripple frequency.

2. From Graph 3b the output of a capacitor input filter is ~~varying direct~~ direct ~~alternating~~ current.

3. Under what circumstances could a resistor be used in place of the inductor?

VALVE CONSTANTS (1).

The inherent characteristics of an electron tube that determine its suitability for a particular purpose are termed CONSTANTS, of which there are three -

(i) Amplification factor (μ) $\frac{\text{change } E_a}{\text{change } E_g}$ for same change I_a.

(ii) Anode resistance (r_a) $\frac{\text{change } E_a}{\text{change } I_a}$ E_g constant

(iii) Mutual conductance (g_m) $\frac{\text{change } I_a}{\text{change } E_g}$ E_a constant.

AIM: To plot a "family" of mutual characteristic (I_a/E_g) curves of a triode electron tube, and to determine from them values for the tube constants at a typical working point.

APPARATUS: Voltmeter 0-300V (Multimeter A.P.O. No.2), Milliammeter 0-50mA (Multimeter D.C. 50μA-1A), HT Supply 0-250V, Variable D.C. Supply 0-15V, Electron Tube 12AU7 and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

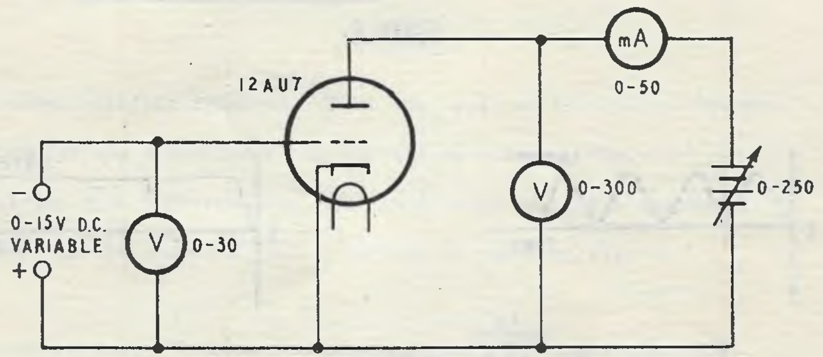


FIG. 1.

STEP 2. Adjust the anode voltage to read 150 Volts with the grid voltage at zero. Measure the anode current. Record in Table 1.

STEP 3. Maintaining E_a constant at 150 Volts, increase the grid voltage in 3 Volt steps to -15 Volts. Measure the anode current for each step. Record in Table 1.

STEP 4. Decrease the anode voltage to 125 Volts. Repeat step 3.

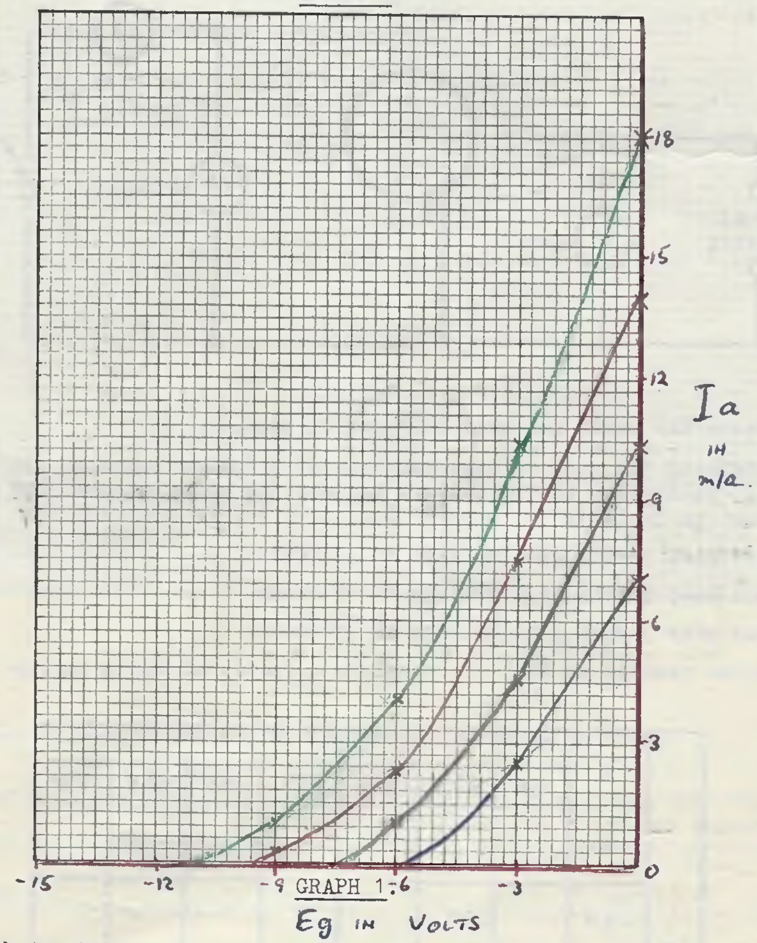
STEP 5. Decrease the anode voltage to 100 Volts. Repeat step 3.

STEP 6. Decrease the anode voltage to 75 Volts. Repeat step 3.

STEP 7. From the results in Table 1, complete a family of I_a/E_g curves on Graph 1.

	Ea	Eg					
		0V	−3V	−6V	−9V	−12V	−15V
Ia mA.	150V	18	10.5	4	1	0	0
	125V	14	7.5	2.25	.25	.0	0
	100V	10.25	4.5	1	0	0	0
	75V	7	2.5	0	0	0	0

TABLE 1.



GRAPH 1.

TEST QUESTIONS:

1. From your results in Table 1, calculate the amplification factor of the triode used.

   $\mu = \frac{\Delta E_a}{\Delta E_g} = \frac{50}{3} = 16.\dot{6}$ ✓

2. From your completed graph, calculate the mutual conductance in (i) milliamps/Volt $g_m = \frac{\Delta I_a}{\Delta E_g} = \frac{6.3}{3} = 2.1\ mA/V$ ✓

   (ii) Micromhos $g_m = \frac{6.3}{3} \times \frac{1000}{1} = 2{,}100\ \mu$ MHOS

3. Calculate anode resistance $R_a = \frac{\Delta E_a}{\Delta I_a}$ Eg CONSTANT

   $\therefore R_a = \frac{25}{2.75} \times \frac{1000}{1} = 9090.9\ \Omega$ ✓

VALVE CONSTANTS (2).

The constants of an electron tube can also be determined from the anode characteristics. These characteristics are given in most valve data books.

AIM: To plot a "family of anode characteristics (I_a/E_a) curves of a triode electron tube, and to determine from them values for the tube constants at a typical working point.

APPARATUS: Voltmeter (Multimeter A.P.O. No.2), Milliammeter 0-50mA (Multimeter D.C. 50µA-1A), HT Supply 0-250V, Variable D.C. Supply 0-9V, Electron Tube 12AU7 and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

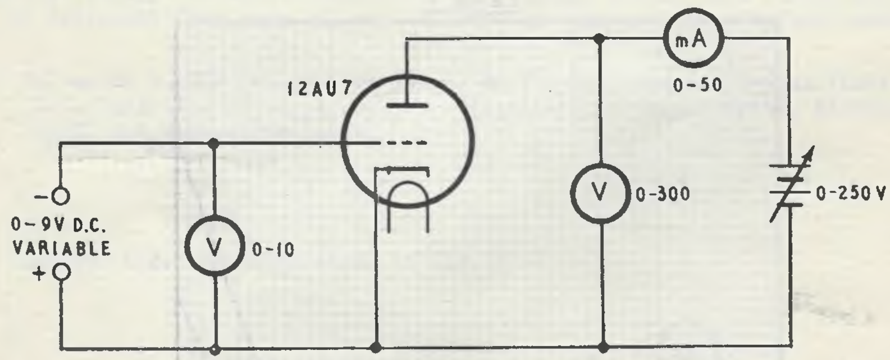


FIG. 1.

STEP 2. Decrease the anode and grid voltages to zero.

STEP 3. Maintaining the grid voltage constant at 0 Volts, increase the anode voltage in 25 Volt steps to 150 Volts. Measure the anode current for each step. Record in Table 1.

STEP 4. Repeat step 3 with grid voltage of -3 Volts.

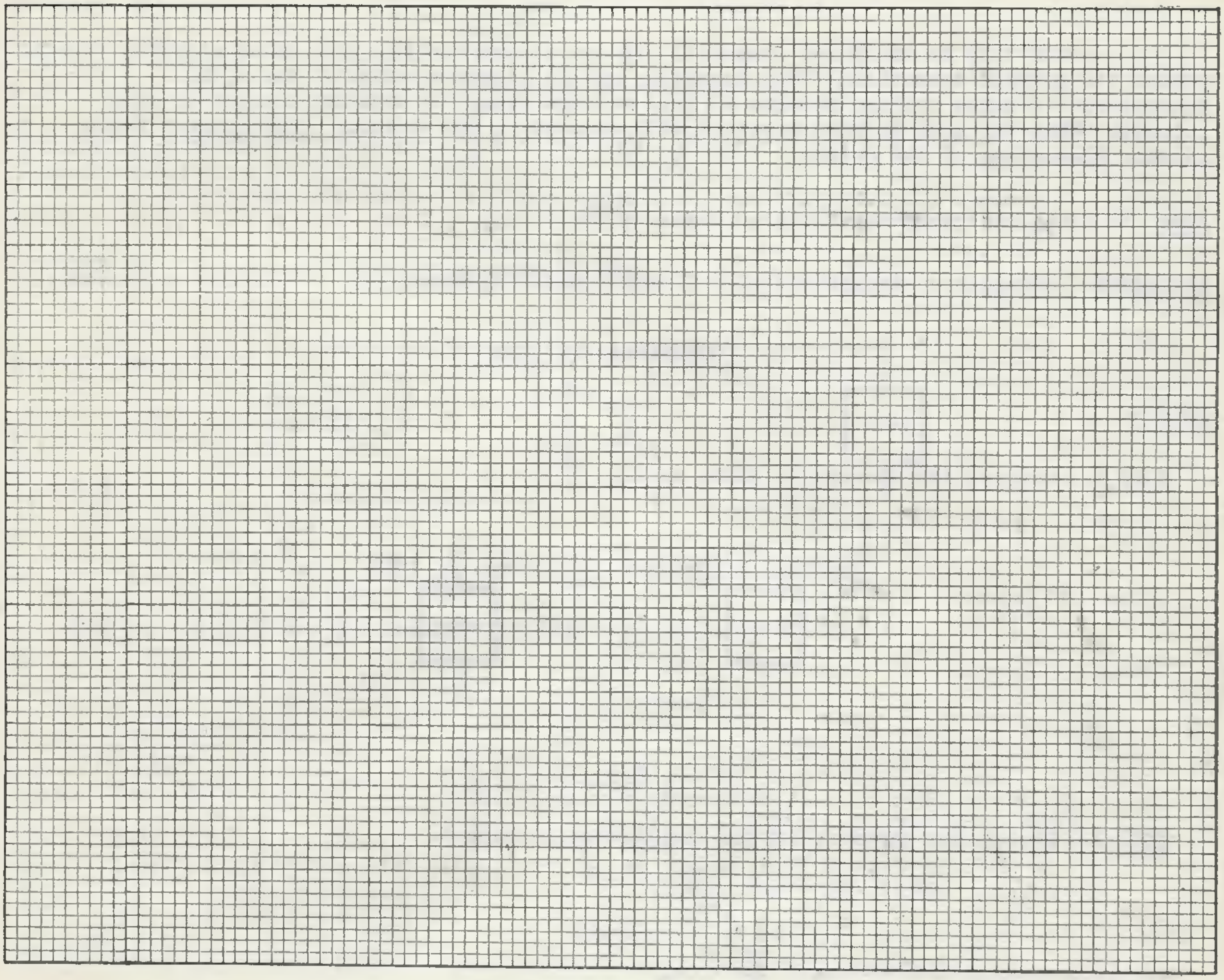
STEP 5. Repeat step 3 with grid voltage of -6 Volts.

STEP 6. Repeat step 3 with grid voltage of -9 Volts.

STEP 7. From the results in Table 1, complete a family of E_a/I_a curves on Graph 1.

	E_g	E_a						
		0V	25V	50V	75V	100V	125V	150V
I_a	0V							
	-3V							
	-6V							
	-9V							

TABLE 1.



GRAPH 1.

TEST QUESTIONS:

1. From your results calculate the anode resistance of the electron tube used for the experiment.

   r_a = ...

   ....

2. Calculate amplification factor ....

   ....

3. Calculate mutual conductance ....

   ....

NEED FOR GRID BIAS.

Grid bias is the fixed potential applied to the control grid of an electron tube to ensure its correct operation. When operating on the linear section of the I_a/E_g characteristic curve uniform changes in grid voltage result in uniform changes in anode current. When the grid is made positive with respect to the cathode, grid current flows causing distortion of the output.

AIM: To study the necessity for grid bias.

APPARATUS: Oscillator, Amplifiers, C.R.O. and Connecting Leads.

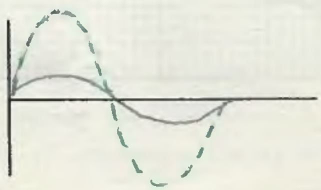
DEMONSTRATION.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

FIG. 1.

STEP 2. Record the waveform of the oscillator on Graph 1.



GRAPH 1.

STEP 3. Connect the circuit as shown in Fig. 2.

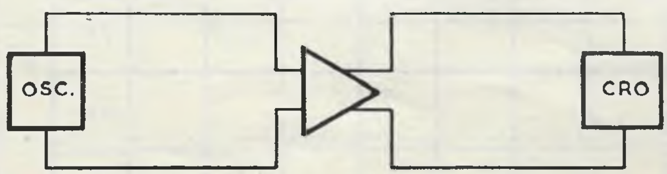


FIG. 2. AMPLIFIER CORRECTLY BIASSED.

STEP 4. Record the waveform of the amplifier on Graph 2.

Laboratory Projects

2nd Year

PROJECT NO. 27

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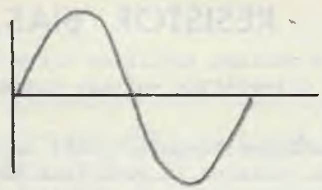


GRAPH 2.

STEP 5. Connect the circuit as shown in Fig. 3.

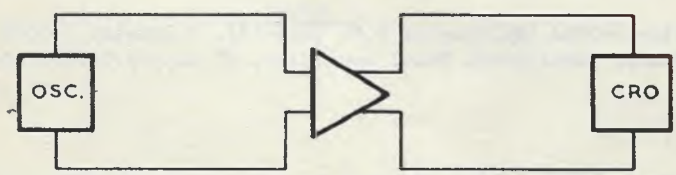
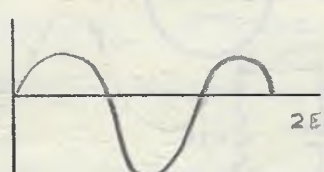


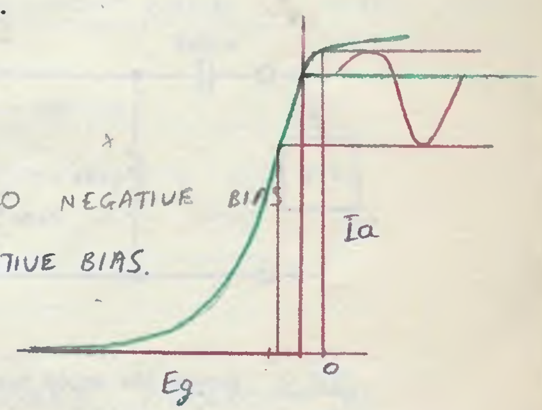
FIG. 3. AMPLIFIER INCORRECTLY BIASSED.

STEP 6. Record the waveform of the amplifier on Graph 3.



ZERO NEGATIVE BIAS

ZERO NEGATIVE BIAS.



GRAPH 3.

TEST QUESTIONS:

1. (i) When an amplifier is unbiased the positive ~~negative~~ half cycle of the input signal becomes distorted.

   (ii) Explain with sketches how this distortion is produced.

   ....

   ....

   ....

★ 2. State two methods of obtaining grid bias:-

   (i) BATT BIAS (i) CATHODE RESISTOR BIAS

7P

PRACTICAL TRIODE VOLTAGE AMPLIFIER WITH CATHODE RESISTOR BIAS.

A triode when used as a voltage amplifier converts small alternating voltage changes in the input circuit, into larger alternating voltage changes in the output circuit.

To ensure correct operation with undistorted output cathode resistor bias is used. Anode current through the cathode resistor is such that the grid is negative with respect to the cathode. A capacitor is generally placed in parallel with the resistor to bypass the A.C. component of anode current.

AIM: To observe a cathode resistor biassed triode electron tube when connected as a voltage amplifier.

APPARATUS: Milliammeter 0-50mA (Multimeter D.C. 50µA-1A), Voltmeter 0-100V (Multimeter A.P.O. No.2), Oscillator, Model Amplifier, HT supply 0-250V and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

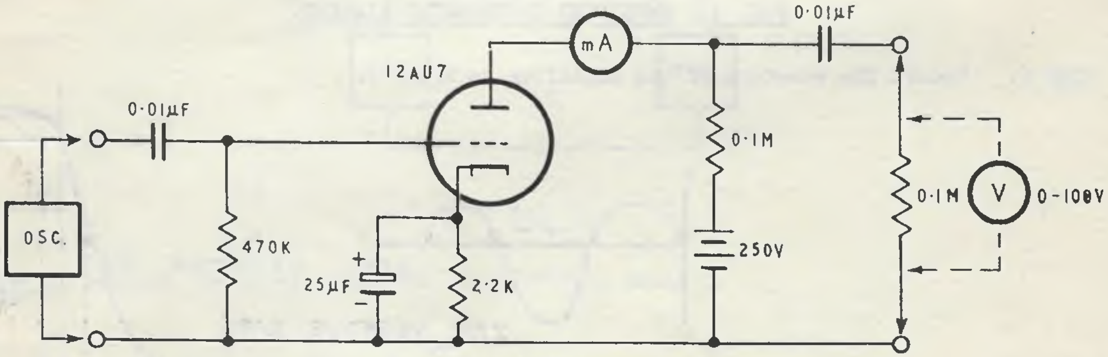


FIG. 1.

STEP 2. Record the anode current in Table 1.

STEP 3. Calculate in Table 1 the value of bias voltage.

STEP 4. Measure the value of grid bias (across the bias resistor) and compare with calculated value in Table 1. 8 V

STEP 5. Connect the oscillator to the input. Adjust the input to 1 Volt at a frequency of 1000 c/s.

STEP 6. Measure the output voltage and record.

Output voltage .....10....... Volts.

STEP 7. Calculate the voltage gain.

$$\text{Voltage Gain} = \frac{E\ output}{E\ input} = \frac{10}{1} = 10 \text{ VOLTS GAIN}$$

2

R_K	I_a	$E_{BIAS} = I_a \times R_K$
2.2K	3.6 mA	7.92 V

2

TABLE 1.

★ TEST QUESTIONS:

1. What is meant by "distortion" in an amplifier?

"DISTORTION" OCCURS WHEN THE OUTPUT WAVE FORM HAS NOT GOT THE SAME CHARACTERISTICS AS THE INPUT WAVE i.e. WAVE SHAPE.

2. On what part of the I_a/E_g characteristic must the valve be operated to prevent distortion?

THE LINEAR SECTION ~~IN THE CENTER~~ 0

3. How is the operating point on the I_a/E_g characteristic established? What factors in the circuit of Fig. 1 determine the operating point?

0

4. Why must the value of input voltage to the amplifier be limited? TO PREVENT DISTORTION AS SIGNAL WILL ENTER THE UPPER OR LOWER BEND

5. What is the effect, on the output voltage and therefore the gain of the amplifier of disconnecting the cathode by-pass capacitor in Fig. 1?

THE OUTPUT IS ONLY 2/5 TH'S THAT OF THE ORIGINAL AND THE GAIN OF THE AMPLIFIER DECREASES

OSCILLATOR (L/C).

An oscillator is essentially an amplifier with positive feed back which generates an alternating current signal. In an L/C oscillator the frequency of the generated signal depends upon the values of the tuned circuit components.

AIM: To study the operation of a tuned grid oscillator.

APPARATUS: Oscillator Board, 100V HT Supply, Filament Supply, Variable Oscillator, C.R.O. Receiver and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

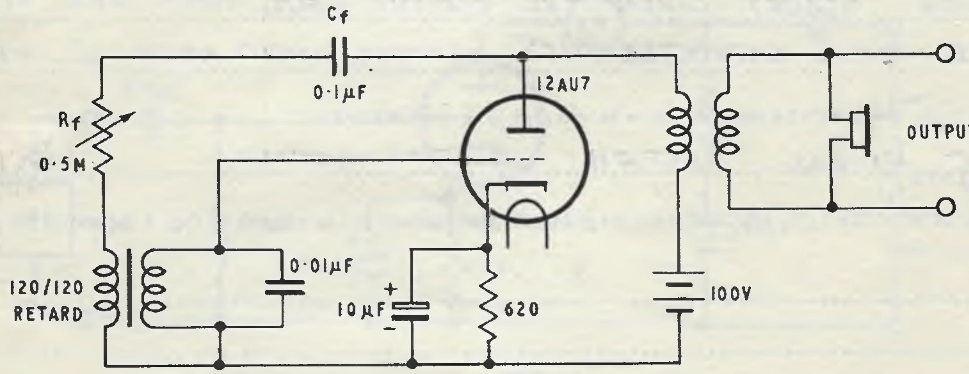


FIG. 1.

STEP 2. Listen with the receiver and vary the feed back control (Rf) until the circuit just oscillates.

STEP 3. Replace the 0.01μF capacitor with the 0.002μF capacitor and listen with the receiver. Vary the feed back resistor until the circuit just oscillates.

STEP 4. Repeat steps 2 and 3 several times comparing the pitch (frequency) of the output signals.

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Laboratory Projects **PROJECT NO. 29**

2nd Year

DEMONSTRATION

STEP 1. Connect the circuit as shown in Fig. 2.

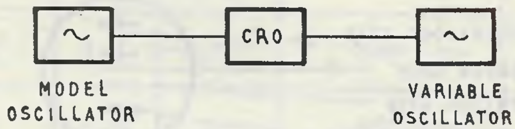


FIG. 2.

STEP 2. Instructor to measure the frequency of the model oscillator with -

(i) the 0.01μF capacitor

(ii) the 0.0027μF capacitor.

Record frequency in Table 1.

MODEL OSCILLATOR	
0·01μF	0·002μF
1200 c/s	____ c/s

TABLE 1.

TEST QUESTIONS:

1. What is an oscillator? IS A DEVICE USED FOR THE PRODUCTION OF A CONTINIOUS AC SIGNAL OF A DESIRED WAVE SHAPE & FREQ FROM A DC SUPPLY ✓ 2/2

★ 2. List 3 fundamental characteristics of all oscillators.

(1) POSITIVE FEED BACK ✓

(2) AMPLIFICATION TO MEET THE ENERGY LOST IN THE LOAD ✓

(3) A SUITABLE ARRANGEMENT OF THE CIRCUIT CONSTANTS ✓ 3/3

3. From your results:-

(i) When the value of capacitance in Fig. 1 was decreased to 0.0027μF the frequency increases. ~~remains the same.~~ ~~decreases.~~ ✓

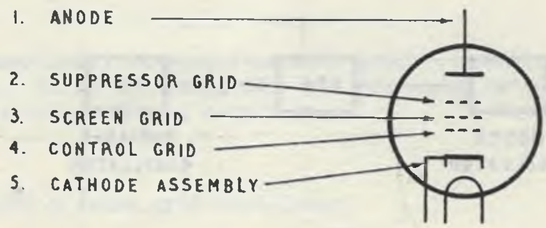
(ii) When the value of feedback resistor was decreased the amplitude ~~increases.~~ ~~remains the same.~~ decreases. ✗

(iii) If the tuning capacitor is changed to 0.02μF, what is the output frequency?

34·64 c/s ✗

PENTODE ELECTRON TUBE (1).

A Pentode electron tube has five elements.



The inclusion of the screen grid increases the anode impedance and thereby the amplification factor of the tube also.

The suppressor grid overcomes the effects of secondary emission.

AIM: To study the anode characteristic I_a/E_a of a pentode electron tube.

APPARATUS: Voltmeter 0-10V, 0-300V (Multimeter A.P.O. No.2), Milliammeter 0-50mA (Multimeter D.C. 50μA-1A), HT supply 0-250V, Variable D.C. Supply 0-10V, Screen Supply 150V, Electron tube 6AU6 and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

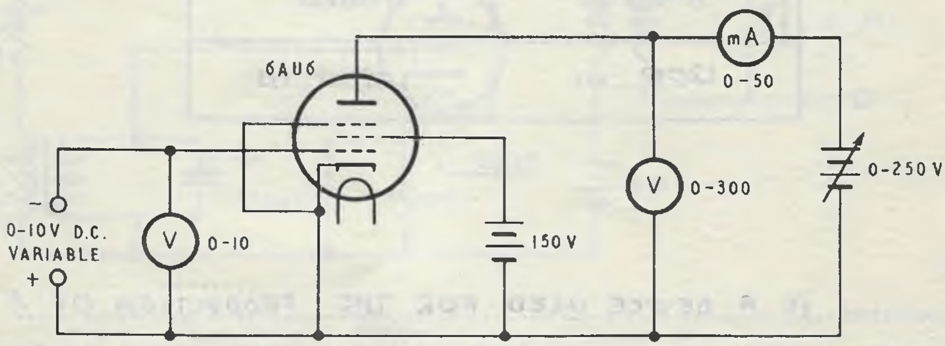


FIG. 1.

STEP 2. Adjust (i) the screen voltage to ~~150 Volts~~ FIXED AT 105V
(ii) the control grid voltage to -0 Volts
(iii) the anode voltage to zero.

STEP 3. Increase the anode voltage in ~~25 Volt~~ steps to ~~250 Volts~~ 225 V.
Measure the anode current for each step. Record in Table 1.

OMMIT {
STEP 4. Increase the control grid voltage to -2 Volts. Repeat step 3.

STEP 5. Increase the control grid voltage to -3 Volts. Repeat step 3.

STEP 6. Increase the control grid voltage to -4 Volts. Repeat step 3.
}

STEP 7. From the results in Table 1, complete a family of I_a/E_a curves on Graph 1.

9/10 20.

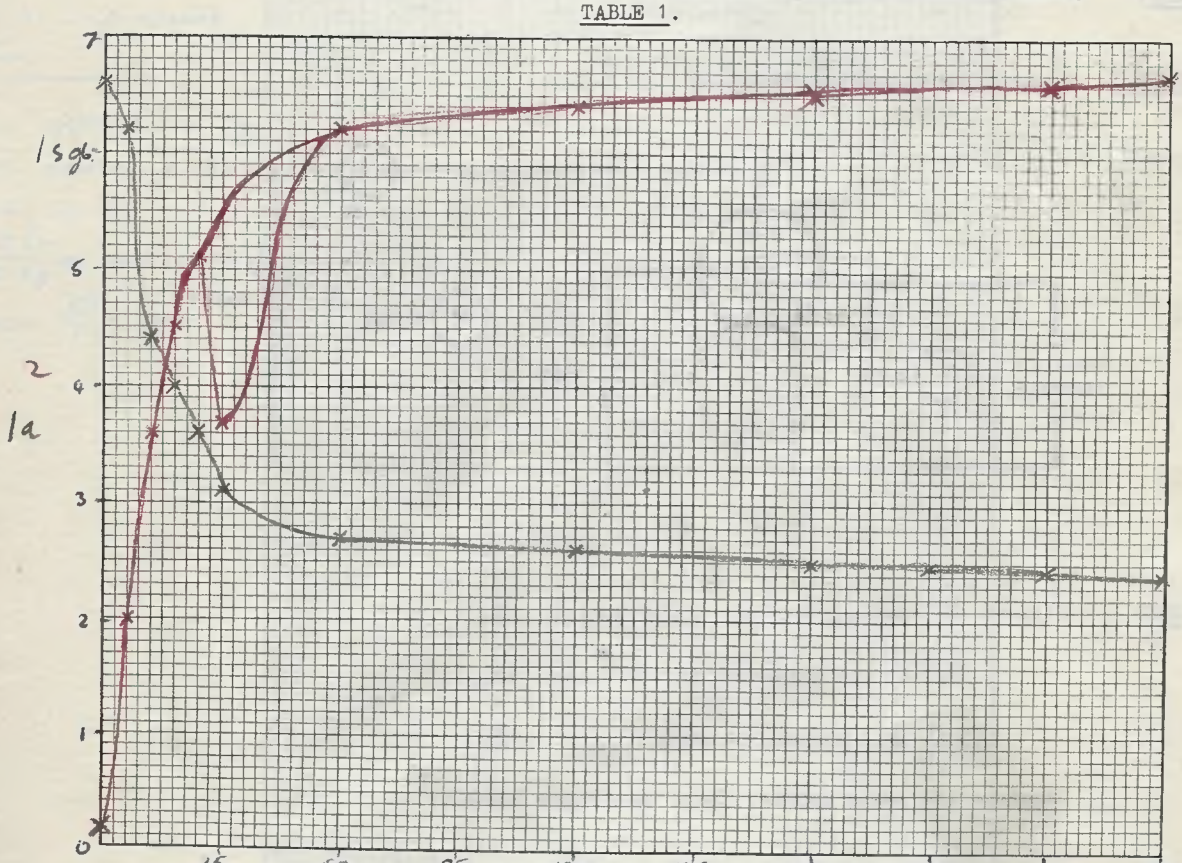
Laboratory Projects **PROJECT NO. 30**

2nd Year

E_a	I_a		E_a	I_a	
	Ia	Isg.		Ia	Isg.
0	.2	6.6	~~150~~ 50	6.2	2.7
~~25~~ 5	2	6.2	~~175~~ 100	6.4	2.6
~~50~~ 10	3.6	4.4	~~200~~ 150	6.5	2.5
~~75~~ 15	4.5	4	~~225~~ 200	6.6	2.5
~~100~~ 20	5.1	3.6	~~250~~ 225	6.7	2.5
~~125~~ 25	3.7	3.1			

2

TABLE 1.



GRAPH 1.

TEST QUESTIONS:

1. Explain the function of (i) Screen grid (ii) Suppressor grid

2. (i) INCREASE AMP FACTOR ✓ (ii) REDUCES SECONDARY EMMISSION ✓

2. Calculate Anode Impedance. Compare with triode.

230 KΩ

PENTODE ELECTRON TUBE (2).

Small changes in grid potential of a pentode electron tube will produce changes in anode current.

AIM: To study the grid voltage - anode current characteristic of a pentode electron tube.

APPARATUS: Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-50mA (Multimeter D.C. 50μA-1A), HT Supply 0-250V, Screen Supply 150V, Variable D.C. Supply 0-10V, Electron Tube 6AU6, and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

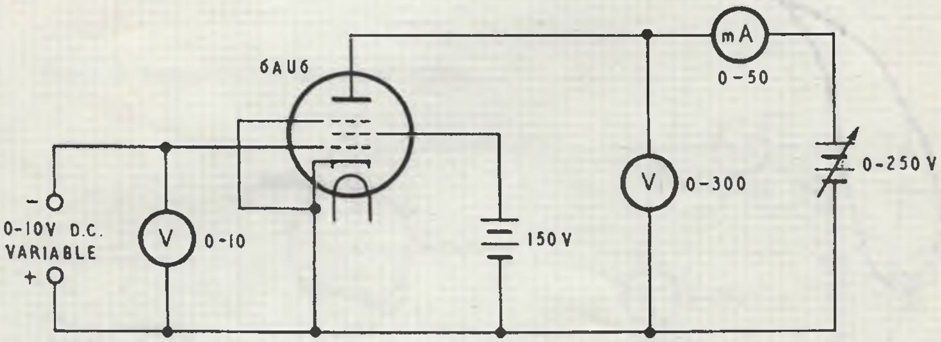


FIG. 1.

STEP 2. Adjust (i) Anode potential to 250 Volts. (E_a)

(ii) Screen potential to 150 Volts. (E_{sg})

(iii) Grid voltage to zero. (E_g)

Measure the anode current (I_a). Record in Table 1.

STEP 3. Increase the grid potential (E_g) in 1 Volt step to -6 Volts.

Measure the anode current (I_a) for each step. Record in Table 1.

STEP 4. From the results in Table 1, complete a I_a/E_g curve on Graph 1.

E_g	I_a ________ mA	E_g	I_a ________ mA
0 V	7	− 4 V	0
− 1 V	5	− 5 V	0
− 2 V	1·6	− 6 V	0
− 3 V	·75		

TABLE 1.

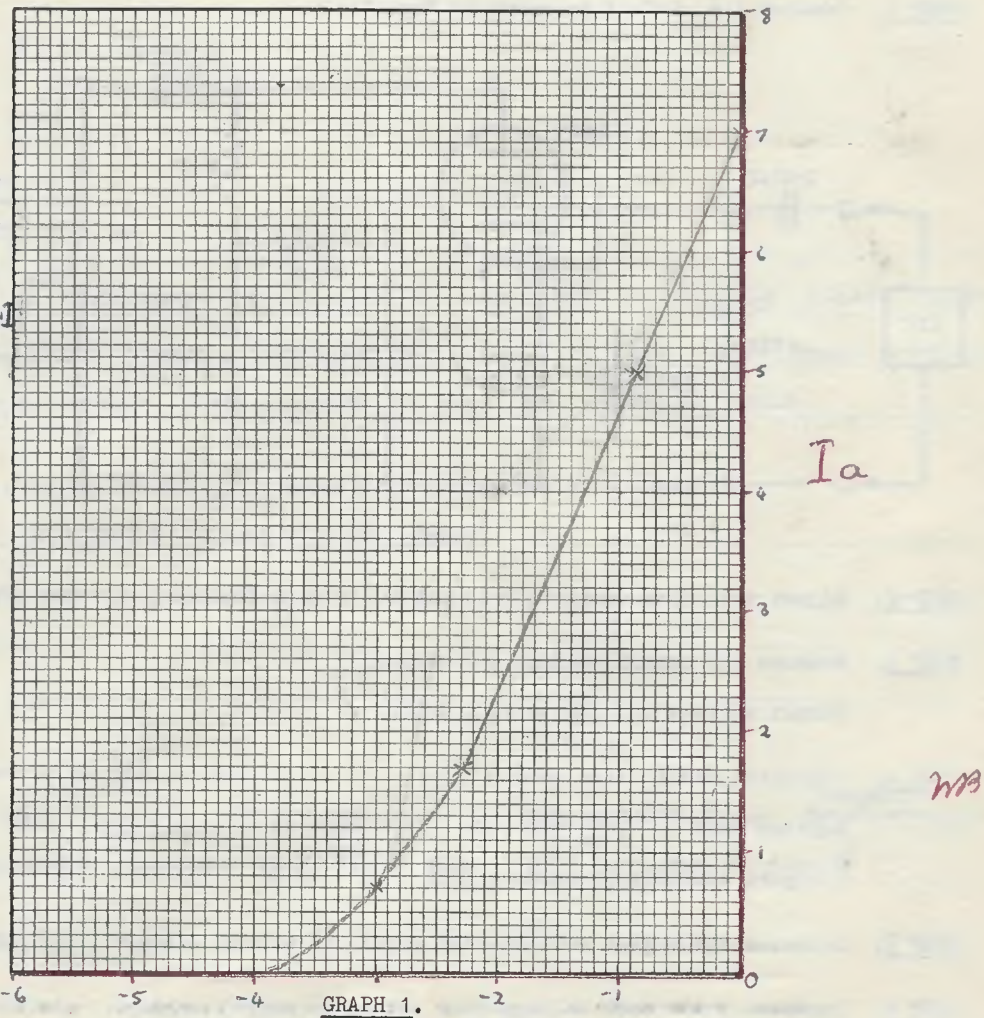
FROM PROJECT 30

A 50V CHANGE IN Ea CAUSES A ·2mA CHANGE IN Ia

A ·1V CHANGE IN Eg WOULD CAUSE A ·2mA CHANGE IN Ic

$\mu = \frac{\Delta E_a}{\Delta E_g}$ FOR SAME CHANGE IN I

$\therefore \mu = \frac{50}{\cdot 1} = 500$



GRAPH 1.

Eg

TEST QUESTIONS:

1. Calculate the mutual conductance of the electron tube used for the experiment (compare with triode) ....
....

2. Briefly explain why a pentode has a higher anode resistance than a triode .. BY INCLUSION OF SCREEN GRID

PRACTICAL PENTODE VOLTAGE AMPLIFIER.

A pentode when connected as a voltage amplifier allows small input voltages to be increased many times. This increase is possible because of the high anode impedance resulting from the inclusion of the screen grid. A capacitor is generally connected between the screen grid and the cathode to bypass the A.C. component of screen grid current.

AIM: To observe a pentode when connected as a voltage amplifier.

APPARATUS: Voltmeter 0-100V, 0-3V (Multimeter A.P.O. No.2), Oscillator, Model Amplifier and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

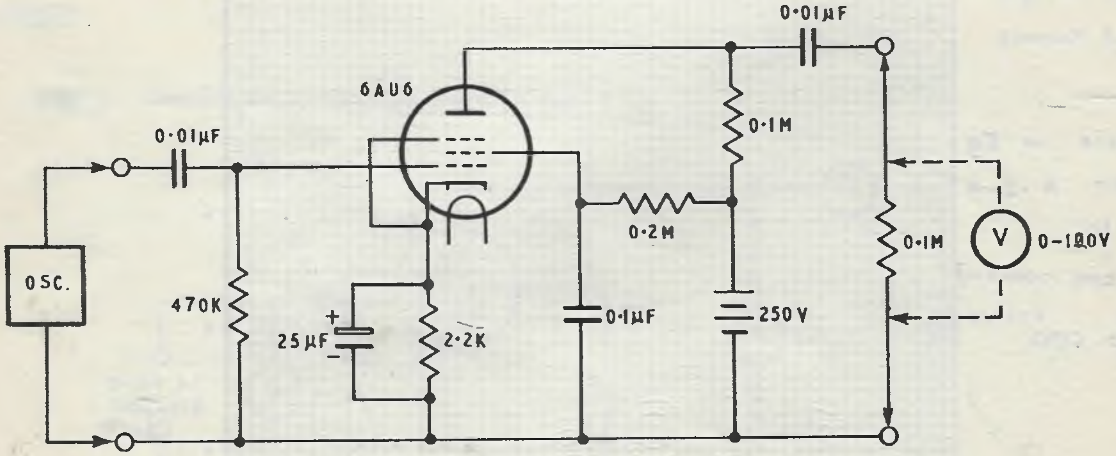


FIG. 1.

STEP 2. Adjust the input oscillator to 0.5 Volts with frequency of 1000 c/s.

STEP 3. Measure the output voltage and record.

2 Output voltage = ... 52 ..... Volts. ✓

STEP 4. Calculate the voltage gain.

$$\text{Voltage Gain} = \frac{\text{E output}}{\text{E input}} = \frac{52}{.5} = 104 \checkmark$$

(Compare with Step 7 Project 28.)

STEP 5. Decrease the screen voltage-note effect on output voltage. DECREASES ✓

STEP 6. Increase the screen voltage-note effect on output voltage. INCREASES ✓

STEP 7. Open the screen bypass capacitor-note effect on output voltage. DECREASES ✓

STEP 8. Vary the anode voltage-note effect on output voltage.

DECREASE IN ANODE VOLTAGE DECREASES THE OUTPUT ∴ THEY VAIRY PROPORTIONALLY ✓

6/10 20.

Laboratory Projects **PROJECT NO. 32**

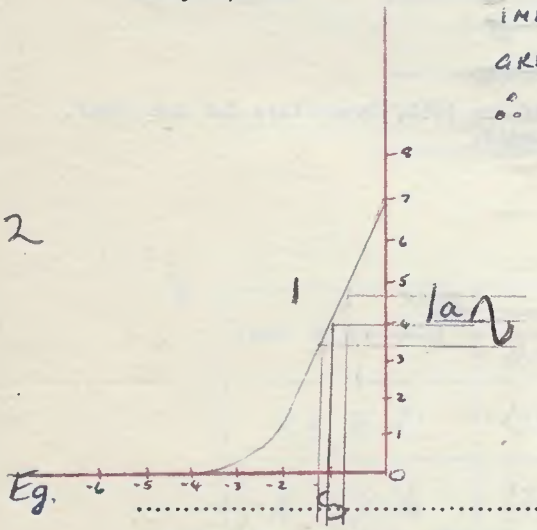
2nd Year

TEST QUESTIONS.

1. With the aid of I_a/E_g characteristic curve, briefly explain the operation of a Pentode electron tube as a voltage amplifier.

INPUT SIGNAL VARIES THE PD ACROS THE GRID WHICH VARIES THE ANODE CURRENT ∴ EAL varies

2



WHEN A PENTODE IS CONN AS AN AMP IT ALLOWS SMALL INPUT VOLTAGE TO BE INCREASED MANY TIMES DUE TO THE HIGH ANODE IMPEDANCE RESULTING FROM THE INCLUSION OF THE SCREEN GRID.

2. Explain why the voltage amplification of the Pentode was greater than that of the triode.

THE PENTODE INCREASES THE μ

3. Explain the reason for the effect in Step 7.

1 VARIATIONS OCCUR ACROSS RS WHICH ~~VARY THE~~ ~~PROPORTION~~ POTENTIAL ON ~~THE SCREEN WHICH~~ OPPOSES ~~Eg~~ the signal input E.

VOLTAGE DOUBLER.

A voltage doubler is a type of rectifying circuit in which the direct current output voltage is approximately twice that of the alternating input voltage. The current output depends on the value of the capacitors.

AIM: To study the operation of a voltage doubler circuit.

APPARATUS: Voltmeter 0-30V (Multimeter A.P.O. No.2) Rectifiers 1/6A, Capacitors 4µF and 100µF, Resistors 33kΩ, 10kΩ, 3.3kΩ, and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

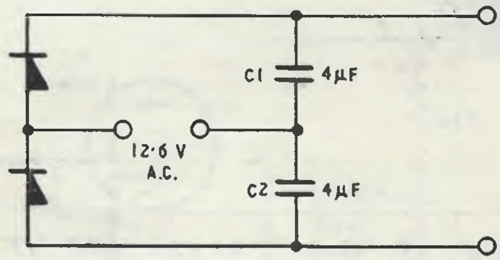


FIG. 1.

STEP 2. Measure the input voltage. (Convert to peak value.)

$E_{peak} = E_{effective} \times 1.414$

E_{peak} = ... × 1.414 = ... Volts.

Record in Table 1.

STEP 3. With the D.C. Voltmeter, measure -

(i) Voltage across C_1

(ii) Voltage across C_2

(iii) Output voltage.

Record in Table 1.

STEP 4. Connect the 33kΩ resistor across the output terminals.
Measure -

(i) P.D. across load resistor

(ii) Load current.

Record in Table 2.

STEP 5. Replace the 33kΩ resistor with 10kΩ and repeat step 4.

STEP 6. Connect the 3.3kΩ resistor and repeat step 4.

★ STEP 7. Replace the 4µF capacitors with 100µF capacitors and repeat steps 4, 5 and 6.

10

Laboratory Projects

2nd Year

PROJECT NO. 33

INPUT	17·6 VOLTS PEAK
C1	16 VOLTS D.C.
C2	16 VOLTS D.C.
OUTPUT	32 VOLTS D.C.

2 ✓

TABLE 1.

★

LOAD RESISTANCE	C1, C2 = 4μF		C1, C2 = 100μF	
	OUTPUT E	LOAD I	OUTPUT E	LOAD I
33 KΩ	25V	·75 mA	26 V	·75 mA
4·7 KΩ	14V	3 mA	15 V	3.25 mA
3·3 KΩ	12·5V	3·5mA	13·5V	3·5 mA

✓2

TABLE 2.

? 8

TEST QUESTIONS:

1. From the results in Table 1.

The capacitors C1 and C2 charge to the peak ~~average~~ ~~effective~~ value of the input voltage. ✓1

The output voltage is the sum ~~product~~ ~~difference~~ of the individual voltages across the capacitors. ✓1

2. Define regulation IS THE % OF VARIATION OF TV BETWEEN NO LOAD AND LOAD CONDITIONS ✓1

★ 3. From the results in Table 2.

(i) The output voltage ~~increases~~ ~~remains the same~~ decreases when the load current is increased. ✓1

(ii) This is caused by THE CAPACITORS DISCHARGING THROUGH LOAD MORE QUICKLY. ✓1

(iii) Why is better regulation obtained with larger capacitors? BECAUSE THEY STORE MORE ELECTRONS CAUSING A LARGER CHARGE ✓1

GERMANIUM DIODE.

A germanium diode is a semi-conducting device having characteristics similar to a metal rectifier.

When a D.C. voltage of correct polarity is applied to a germanium diode, it offers a low resistance and allows a current to flow. In this connection the diode is said to be conducting.

When the voltage is reversed, the diode offers a high resistance and only a minute current will flow. In this connection the diode is in the non-conducting or high resistance direction.

AIM: To study the characteristics of a germanium diode.

APPARATUS: Germanium Diode (OA79); Variable D.C. Supply 0-20V 0-3V, Milliammeter 0-50mA, Microammeter 0-100µA (Multimeter D.C. 50µA-1A), Voltmeter 0-50V (Multimeter A.P.O. No.2) and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

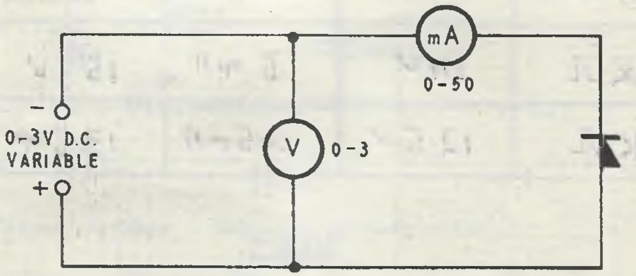


FIG. 1.

STEP 2. Adjust the input voltage to 2.0 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Decrease the input voltage to zero on 0.5 Volt steps. Measure the circuit current for each Step. Record in Table 1.

STEP 4. Connect the circuit as shown in Fig. 2.

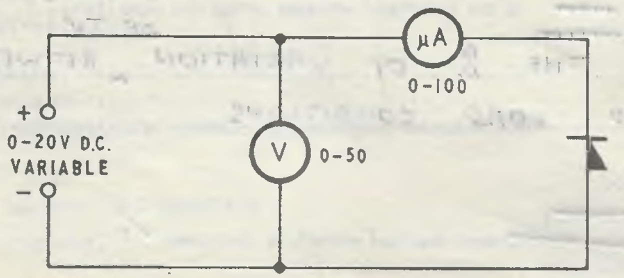


FIG. 2.

STEP 5. Adjust the input voltage to 20 Volts. Measure the circuit current. Record in Table 2.

STEP 6. Decrease the input voltage in 5 Volt steps to zero. Measure the current for each step. Record in Table 2.

Laboratory Projects

2nd Year

Late 8/10

PROJECT NO. 34

STEP 7. Calculate the value of resistance for each current reading in Tables 1 and 2.

STEP 8. From your results plot a graph of

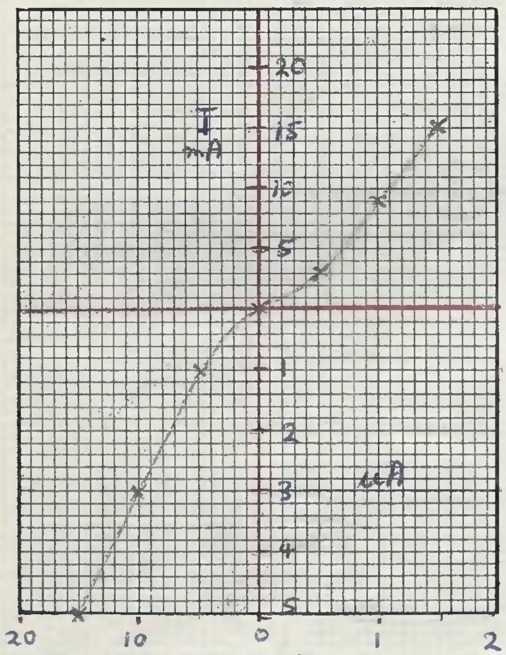
(i) current versus voltage. (ii) resistance versus voltage.

E	I	$R = \frac{E}{I}$
2·0V		
1·5V	15mA	100 Ω
1·0V	9mA	111 Ω
0·5V	3mA	166·7 Ω
0V	0	0 Ω

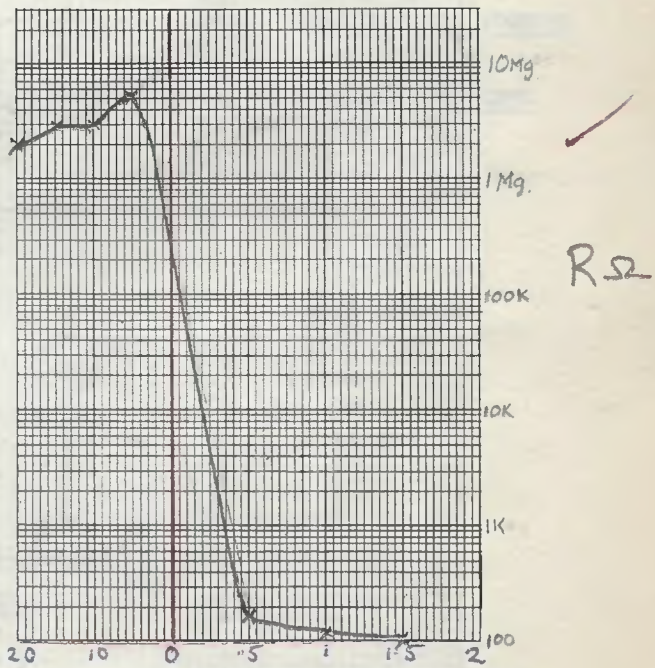
TABLE 1.

E	I	$R = \frac{E}{I}$
20V	10uA	2 MΩ
15V	5uA	3 MΩ
10V	3uA	3 MΩ
5V	1uA	5 MΩ
0V	—	

TABLE 2.



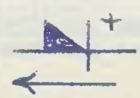
GRAPH 1. E VOLTS



GRAPH 2. E VOLTS

TEST QUESTIONS.

1. Draw the symbol of a germanium diode, and indicate the conducting direction.



2. State two advantages of a germanium diode compared to a metal rectifier.

(i) TAKES GREATER I .... (ii) LESS OPPOSITION IN FOWARD DIRECTION

ZENER DIODE.

A zener diode is a silicon junction diode, whose reverse current remains extremely small below a certain value, the "Zener Voltage". Then, as the reverse voltage is raised slightly, the reverse current increases rapidly.

These characteristics allow the Zener Diode to be used as a voltage limiter or voltage regulator.

AIM: To study the operation of a zener diode.

APPARATUS: Zener Diode (Z2A33, 5%) Variable D.C. Supply 0-6V, Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-100mA (Multimeter 50µA-1A) and Connecting Leads.

CAUTION. MAXIMUM CURRENT MUST NOT EXCEED 85mA.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

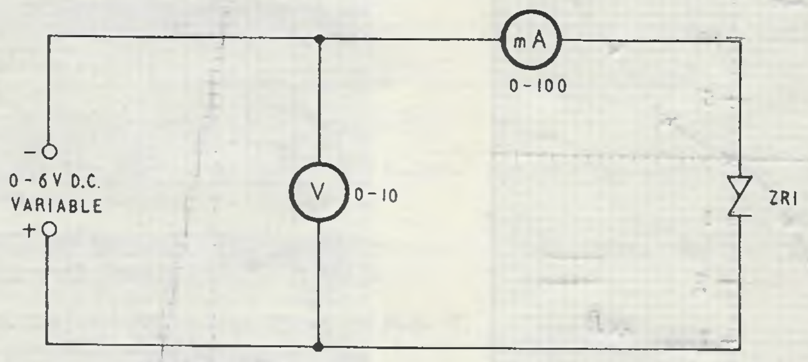


FIG. 1.

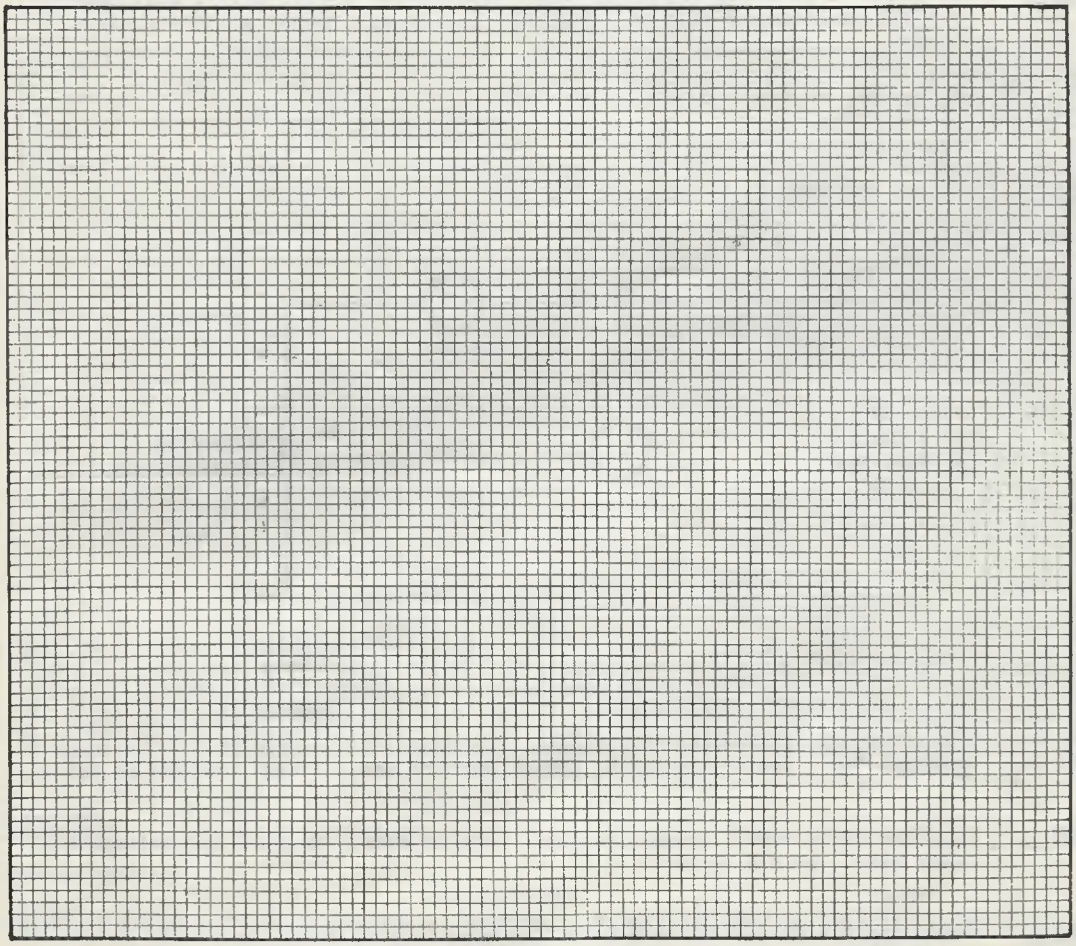
STEP 2. Adjust the input voltage to 1 Volt. Measure the circuit current. Record in Table 1.

STEP 3. Increase the input voltage as per Table 1 to 3.0 Volts. Measure the circuit current for each step. Record in Table 1.

STEP 4. From the results in Table 1, complete a graph of E and I of the Zener diode reverse characteristic.

REVERSE VOLTS	REVERSE CURRENT
1V	
2V	
2·5V	
3V	

TABLE 1.



GRAPH 1.

TEST QUESTION.

1. What is a Zener diode? ....

THERMISTOR - DIRECTLY HEATED.

Thermistors are resistors having a high negative temperature co-efficient of resistance.

When current is passed through a thermistor the heating effect causes the resistance to decrease. A thermistor is therefore a current sensitive device having a non linear resistance characteristics.

AIM: To study the resistance versus current characteristic of a typical thermistor.

APPARATUS: Thermistor Type CZ10, Voltmeter 0-50V (Multimeter A.P.O. No.2), Milliammeter 0-100mA (Multimeter 50μA-1A), Variable D.C. supply 0-50V and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

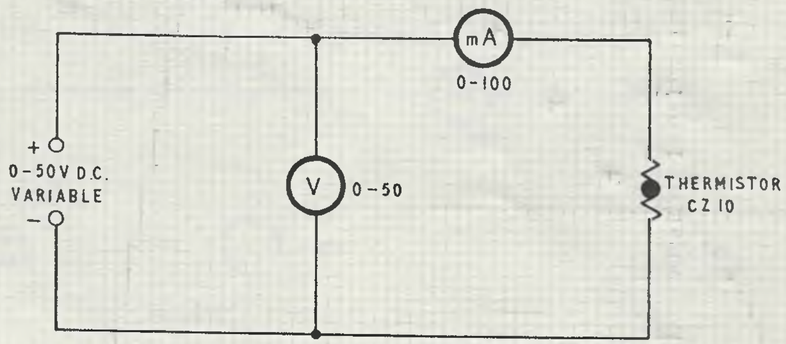


FIG. 1.

STEP 2. Increase the circuit current to 10mA. Measure the voltage. Record in Table 1.

STEP 3. Increase the circuit current in 10mA steps to 60mA. Measure the voltage for each step. Record in Table 1.

STEP 4. Calculate the values of resistance for each step in Table 1.

STEP 5. From results in Table 1 plot a graph of resistance versus current on Graph 1.

I mA	E VOLTS	$R = \frac{E}{I}$
10		
20		
30		
40		
50		
60		

TABLE 1.

GRAPH 1.

TEST QUESTIONS.

1. From your results.

   When the current was increased the resistance remained constant / increased / decreased therefore the thermistor has a neutral / negative / positive temperature co-efficient of resistance.

2. Sketch the symbol of a directly heated thermistor ....

THERMISTOR - INDIRECTLY HEATED.

A thermistor is a resistor having a very high negative temperature co-efficient of resistance.

The thermistor element consists of a small bead of resistance material which is formed on two parallel wires. These may be -

(i) directly heated

(ii) indirectly heated.

AIM: To study the temperature (current) versus resistance characteristic of an indirectly heated type thermistor.

APPARATUS: Thermistor (Type B25), Ohm-Meter (Multimeter A.P.O. No.2 Ohms x 100) Milliammeter 0-20mA (Multimeter 50µA-1A), Variable D.C. Supply 0-50V, and Connecting Leads.

CAUTION. WAIT 60 SECONDS BETWEEN EACH STEP FOR STABILISATION.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

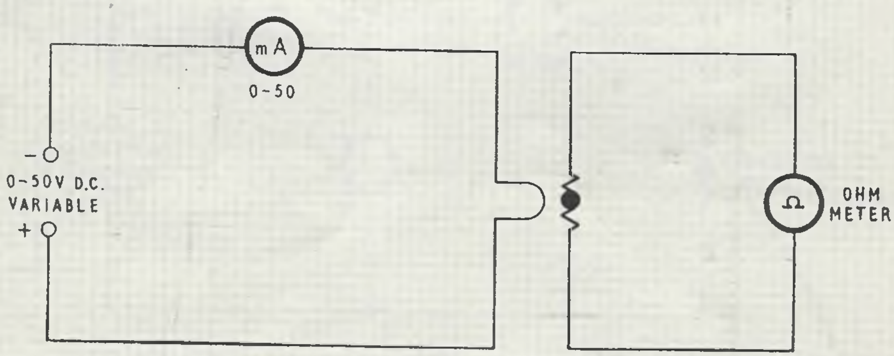


FIG. 1.

STEP 2. Measure the resistance. Record in Table 1.

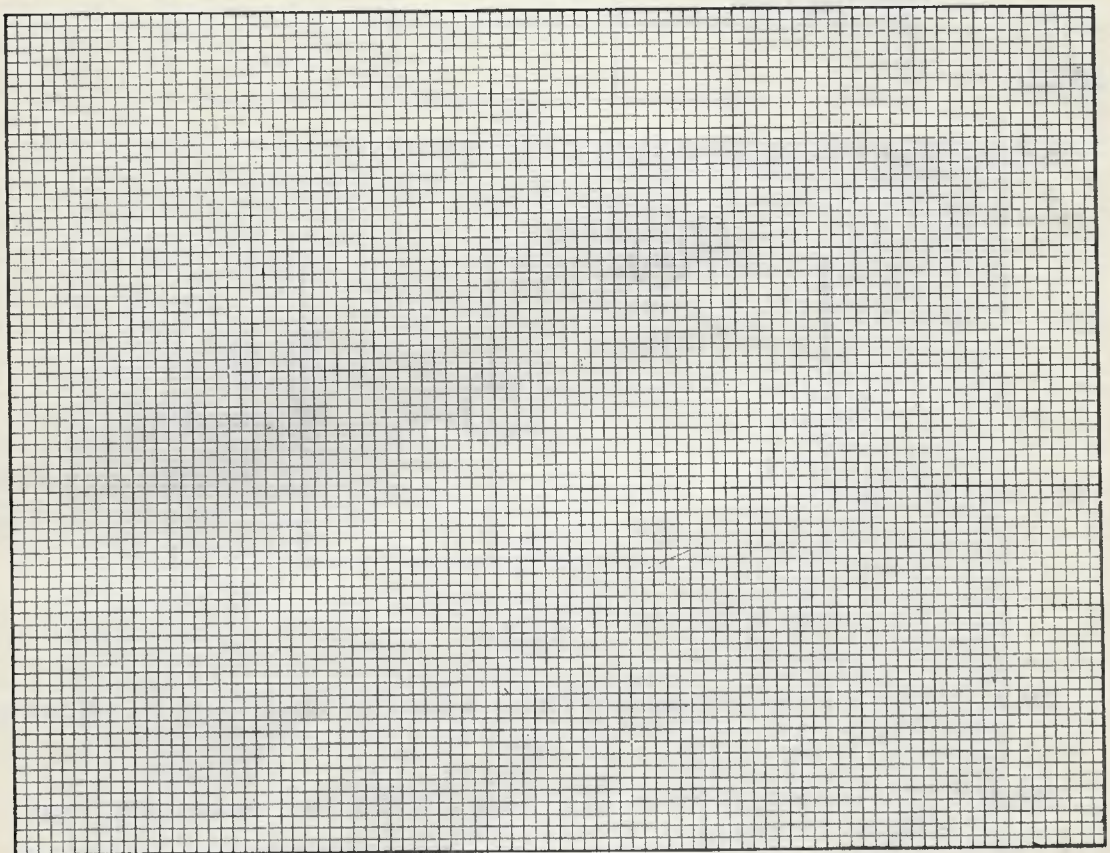
STEP 3. Increase the current of the heater to 5mA. Measure the resistance. Record in Table 1.

STEP 4. Increase the current of the heater in 5mA steps to 20mA. Measure the resistance for each step. Record in Table 1.

STEP 5. From results in Table 1 plot a graph of resistance versus heater current (temperature) on Graph 1.

HEATER CURRENT	RESISTANCE
0 mA	
5 mA	
10 mA	
15 mA	
20 mA	

TABLE 1.



GRAPH 1.

TEST QUESTIONS.

1. Sketch the symbol of an indirectly heated thermistor ....

2. From your results -

(i) When the heater current (temperature) is increased the resistance remains constant / increases / decreases

(ii) What is the resistance of the thermistor when cold? ....

VARISTOR.

A varistor is a voltage dependent semi-conducting material (silicon-carbide), the resistance of which varies with the applied voltage.

When used as a spark quench across a relay it has the advantage of being non-polarised and self restoring.

AIM: To study the voltage/resistance characteristic of a voltage dependent resistor.

APPARATUS: Varistor (Phillips type VDR P-128), Milliammeter 0-100mA (Multimeter DC 50µA-1A), Voltmeter 0-50V (Multimeter A.P.O. No.2), Variable D.C. Supply 0-50V and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

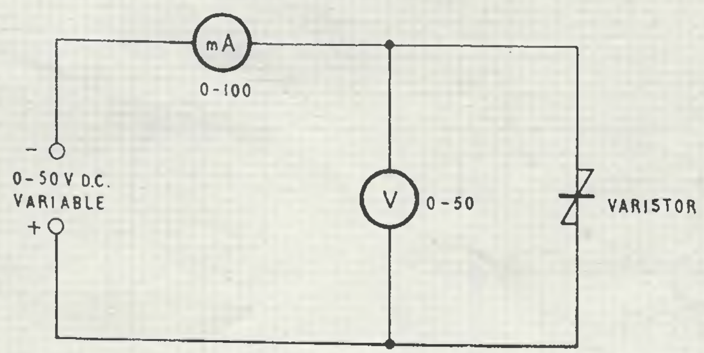


FIG. 1.

STEP 2. Adjust the input voltage to 5 Volts. Measure the circuit current. Record in Table 1.

STEP 3. Increase the input voltage as in Table 1 to 24 Volts. Measure the circuit current for each step. Record in Table 1.

STEP 4. Calculate the resistance for each step in Table 1.

STEP 5. From results of Table 1 plot a graph of resistance versus voltage on graph 1.

STEP 6. Reverse voltage supply and repeat steps 2 and 3. (Compare current readings.)

E VOLTS	I mA	$R = \frac{E}{I}$
5		
10		
15		
17·5		
20		
22·5		
24		

TABLE 1.

GRAPH 1.

TEST QUESTIONS.

1. Sketch the symbol of a varistor.

2. From your graph, describe the characteristics of a voltage dependent resistor ....

....

TRANSISTOR - COMMON BASE.

A transistor or crystal triode is a semi-conductor device, one of its most important application being in amplifiers. In contrast to electron tubes, transistors are essentially current controlled devices.

When connected so that the base electrode is common to both input and output circuits (common base configuration), current amplification Alpha is the ratio of the change in collector current (I_C) to the change in emitter current (I_E) or $\alpha = \frac{\text{small change } I_C}{\text{small change } I_E}$

Voltage amplification is possible because of the low impedance input circuit (emitter base) and the high impedance output circuit (collector base).

Leakage current I_{CO} is largely determined by thermally released "minority current carriers" making the transistor sensitive to temperature change.

AIM: To study transistor behaviour in common base configuration.

APPARATUS: Transistor OC70, Milliammeter 0-10mA (Multimeter A.P.O. No.2), Milliammeter 0-50μA, 0-10mA (Multimeter DC 50μA-1A) Battery 1.5V, 4.5V Tapped, Potentiometer 5kΩ5W, Resistor 1kΩ and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

(500Ω resistor protects emitter base junction as this is connected in the conducting direction.)

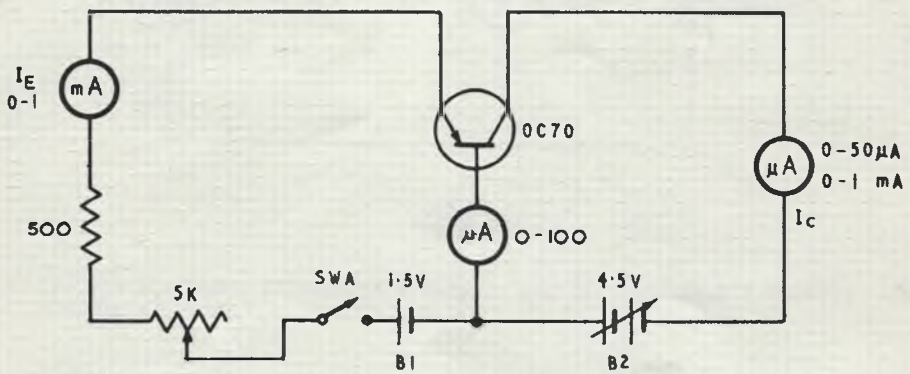


FIG. 1.

STEP 2. Note the collector current (with the input open circuit). Measure the leakage current I_{CO} as indicated by I_C meter. Record in Table 1.

★ STEP 3. Change range of I_C meter to 0-1mA. Close the switch SWA. Adjust the emitter current (I_E) to 0.6mA and measure the collector current (I_C) and base current (I_B). Record in Table 2.

STEP 4. Increase the emitter current in 0.2mA steps to 1mA. Measure the collector current and base current for each step.

STEP 5. Increase collector voltage in 1.5V steps to 4.5V. Measure the collector current for each step. Record in Table 3.

LEAKAGE CURRENT (I_{co})	-------- μA

TABLE 1.

EMITTER CURRENT	0·6 mA	0·8 mA	1 mA
COLLECTOR CURRENT			
BASE CURRENT			

TABLE 2.

Note:- $I_E = I_C + I_B$.

COLLECTOR VOLTAGE (E_c)	COLLECTOR CURRENT (I_c)
1·5 V	mA
3·0 V	mA
4·5 V	mA

TABLE 3.

Note:- Collector Impedance $= \frac{\text{Change } E_C}{\text{Change } I_C}$

★ TEST QUESTIONS:

1. Draw a labelled sketch to show the construction of a P.N.P. transistor.
2. Draw the symbol used to represent a P.N.P. transistor.
3. From your results, calculate the current gain alpha (α).
4. In the common base configuration, the emitter current (I_E) is the addition of .... and .... and the value of collector current (I_C) is independant of ....
5. When the collector voltage is increased, the collector current remains the same, therefore the collector of output increases / decreases output impedance is large / small.

TRANSISTOR - VOLTAGE AMPLIFIER COMMON BASE.

A transistor is a semi-conductor device used for amplification and is current controlled. Amplification, in common base configuration, Alpha (α) is the ratio of the change in collector current (I_C) to the change in emitter current (I_E) or $\alpha = \frac{\text{change } I_C}{\text{change } I_E}$.

Project 39 showed that the collector current changes are slightly less than the emitter current changes; voltage and power gains are achieved however owing to the fact that nearly all of the current emitted by the low impedance input circuit is collected in the high impedance output circuit.

$$\text{Voltage Gain} = \frac{\text{Change } E_C}{\text{Change } E_E}$$

AIM: To demonstrate the voltage gain of a transistor in common base configuration.

APPARATUS: Transistor OC.70, Voltmeter 0-10V (Multimeter A.P.O. No.2), Milliammeter 0-10mA (Multimeter D.C. 50µA-1A), Resistors 1kΩ, 5kΩ, Potentiometer 5kΩ5W, Batteries 1.5V and 9V and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

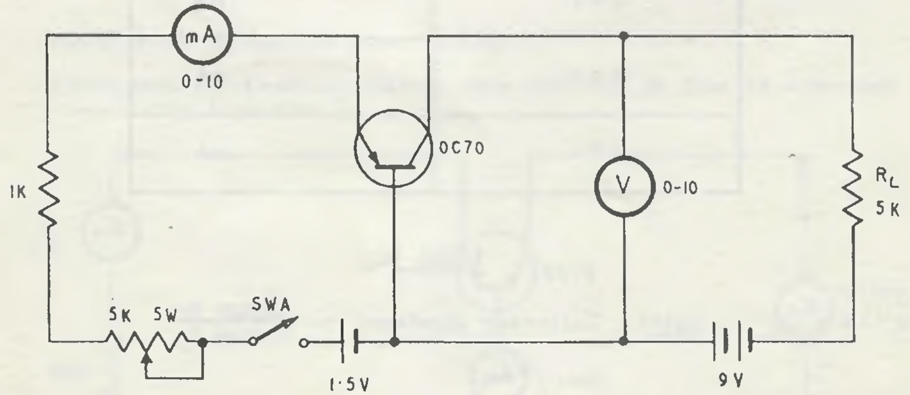


FIG. 1.

STEP 2. Calculate the input resistance.

(i) Decrease the potentiometer to zero ohms.

(ii) Measure the emitter current (I_E) and record. I_E = ... mA.

(iii) Total R = $\frac{E}{I_E}$ = $\frac{1.5}{\quad}$ = ... ohms.

(iv) R emitter = Total R - 1000 = ... = ... ohms.

STEP 3. Adjust the emitter current to 1.2mA. Measure collector voltage = ... Volts.

STEP 4. Adjust the emitter current to 0.7mA. Measure collector voltage = ... Volts.

STEP 5. Calculate change in collector voltage. Record in Table 1.

STEP 6. Calculate the change in emitter voltage.

= change in emitter current X resistance emitter (Step 2).

= = mV.

Record in Table 1.

CHANGE E_E	CHANGE E_C	V GAIN = $\frac{\text{CHANGE } E_C}{\text{CHANGE } E_E}$

TABLE 1.

STEP 7. Calculate in Table 1 the voltage gain.

NOTE: We have assumed that the input impedance as calculated in Step 2 remains constant during Steps 3 and 4.

The input impedance does rise slightly as the input current is reduced. However, as it is still very low compared to the output impedance, this does not affect the aim of the project, although the figure obtained in Step 6 is an approximation.

TEST QUESTIONS.

1. The input impedance emitter base junction biased in the forward direction is large / small.

2. Voltage gain in common base circuit is possible due to the high / low input impedance and the high / low output impedance.

3. The phase change between input and output voltage is 180 degrees / 0 degrees. / 90 degrees

TRANSISTOR - COMMON EMITTER (1).

When the transistor is connected with the emitter electrode common to both the input and output circuits (common emitter configuration), the current amplification "Beta" (β) is the ratio of the change in base current (I_B) to the resulting change in collector current (I_C),

$$\text{that is } \beta = \frac{\text{Change } I_C}{\text{Change } I_B} \quad E_C \text{ constant}$$

Leakage current I_{co} is largely determined by the thermally released "minority current carriers", making the transistor sensitive to temperature change.

The value of leakage current in common emitter configuration is greater than that of common base.

AIM: To study transistor behaviour in common emitter configuration in comparison to common base configuration.

APPARATUS: Transistor OC.70, Resistor 10kΩ, Potentiometer 0.5MΩ, Battery 1.5V and 6V. Milliammeter 0-500μA (Multimeter DC 50μA-1A), Milliammeter 0-1, 0-10mA (Multimeter A.P.O. No.2) and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

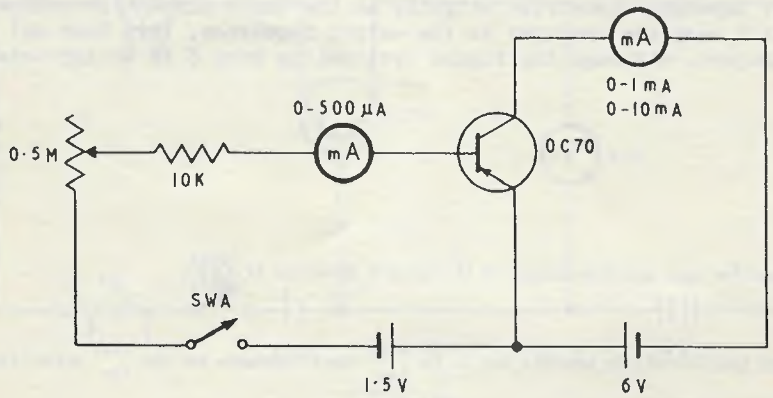


FIG. 1.

STEP 2. With SWA open, measure the leakage current (I_{co}). Record in Table 1. (Compare with Project 39 Step 2.)

STEP 3. Hold and warm the transistor for 30 seconds. Measure leakage current (I_{co}). Record in Table 1. Note that the transistor is temperature sensitive. (Test will not be effective when ambient temperature approaches blood heat.)

STEP 4. Close the switch SWA. Adjust the base current (I_B) to 20μA. Measure the collector current (I_C). Record in Table 2.

STEP 5. Increase the base current (I_B) in 20μA steps to 100μA. Measure the collector current (I_C) for each step. Record in Table 2.

LEAKAGE CURRENT AT ROOM TEMP.	----μA
LEAKAGE CURRENT AFTER RISE IN TEMP.	----μA

TABLE 1.

BASE CURRENT (I_B)	COLLECTOR CURRENT (I_C)
20 μA	
40 μA	
60 μA	
80 μA	
100 μA	

TABLE 2.

TEST QUESTIONS.

1. Calculate the current gain (Beta) of the transistor, for a change in base current (I_B) of 40 to 80μA.

$$(\beta) = \frac{\text{change in collector current } I_C}{\text{change in base current } I_B}$$

The phase change between input and output is 180 degrees / 0 degrees. / 90 degrees

2. Briefly account for the higher leakage current of transistors in common emitter configuration when compared with common base circuits.

TRANSISTOR - COMMON EMITTER (2).

The input resistance, in common emitter circuits depends upon the base voltage and base current, and can be found from the E_B/I_B static characteristic curve.

For small signal considerations the input resistance can be calculated -

$$\text{Input resistance} = \frac{\text{small change base voltage } E_B}{\text{small change base current } I_B}$$

AIM: To study the base input characteristic of a transistor (common emitter).

APPARATUS: Transistor Model, Microammeter 0-100μA, (Multimeter D.C. 50μA-1A), Voltmeter 0-1V (Multimeter A.P.O. No.2), Batteries 1.5V and 4.5V and Connecting Leads.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

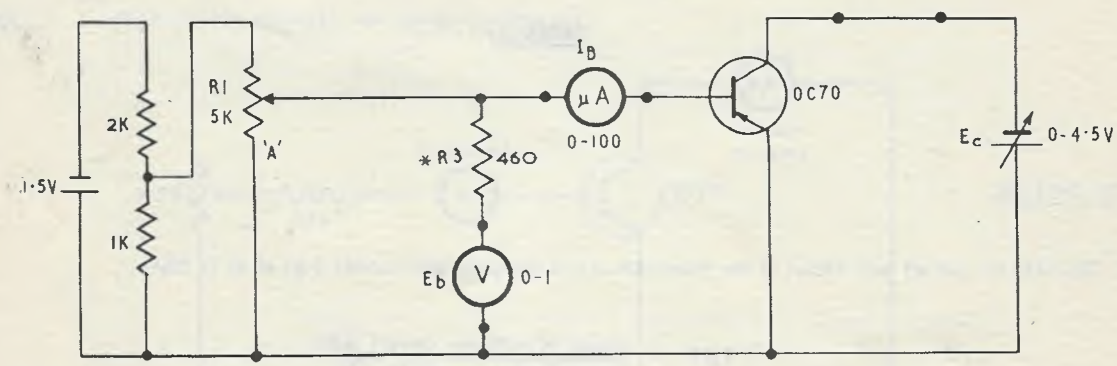


FIG. 1.

* Note: To convert the A.P.O. Multimeter 0-1mA range to 0-1 Volts for Base Voltage readings, use the 460 ohm R3 resistor.

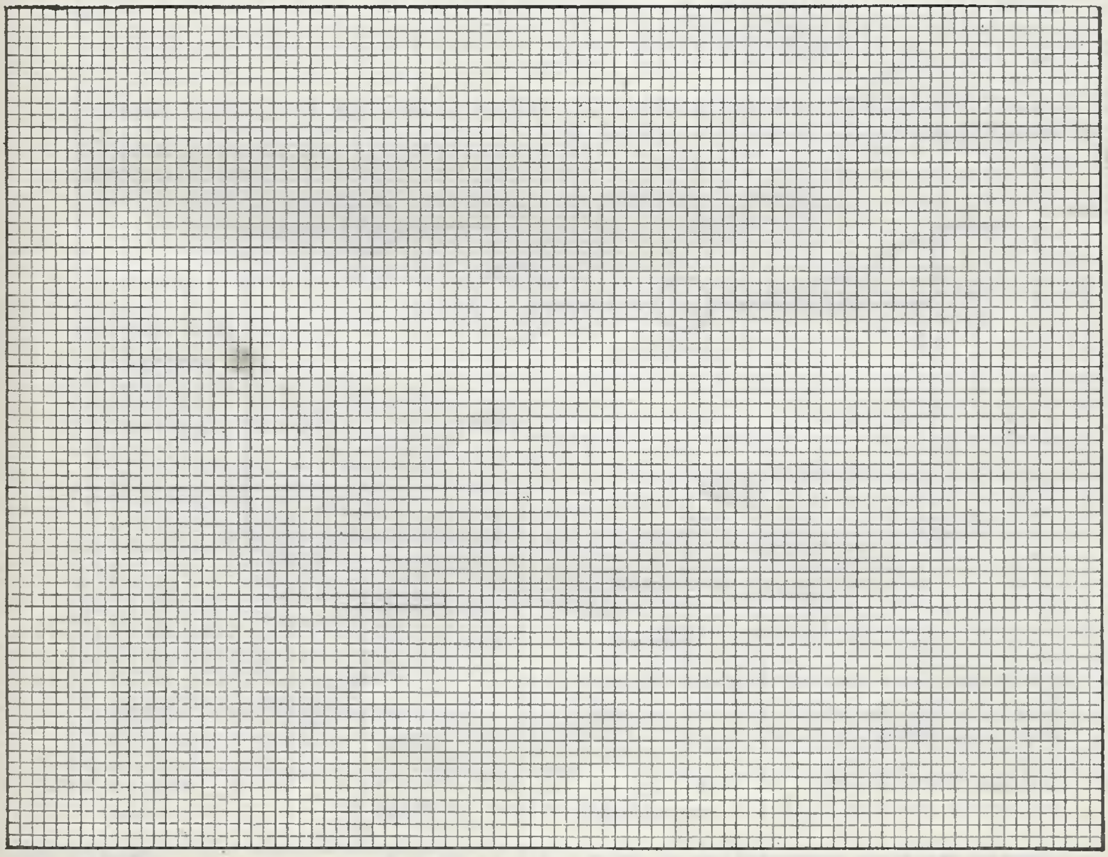
STEP 2. Before closing supply ensure potentiometer at point "a".

STEP 3. Adjust the collector voltage to - 4.5 Volts. Increase the base voltage in 50mV steps to 300mV. Measure the base current. Record in Table 1.

STEP 4. From the results in Table 1, plot a graph of I_B versus E_B on Graph 1.

COLLECTOR VOLTAGE −4·5V			
E_B	I_B	E_B	I_B
50 mV		200 mV	
100 mV		250 mV	
150 mV		300 mV	

TABLE 1.



GRAPH 1.

TEST QUESTIONS:

1. From your results calculate the input resistance for -

(i) A change E_B 150-200mV (E_C - 4.5) ....

TRANSISTOR - COMMON EMITTER (3).

The output or collector impedance of a transistor circuit is the opposition offered to the A.C. output current.

In common emitter circuits the output impedance depends upon –

$$\frac{\text{Change in collector voltage } E_C}{\text{Change in collector current } I_C}$$

The output impedance can be found from the E_C/I_C static characteristic curve.

AIM: To study the collector voltage versus collector current characteristic of a transistor (common emitter).

APPARATUS: Transistor model, Microammeter 0–100µA, (Multimeter DC 50µA – 1A) Milliammeter 0–10mA, (Multimeter A.P.O. No.2) Supply Voltage 1.5V and 4.5V Tapped and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1. Before connecting the battery supply ensure the potentiometer is at point "A".

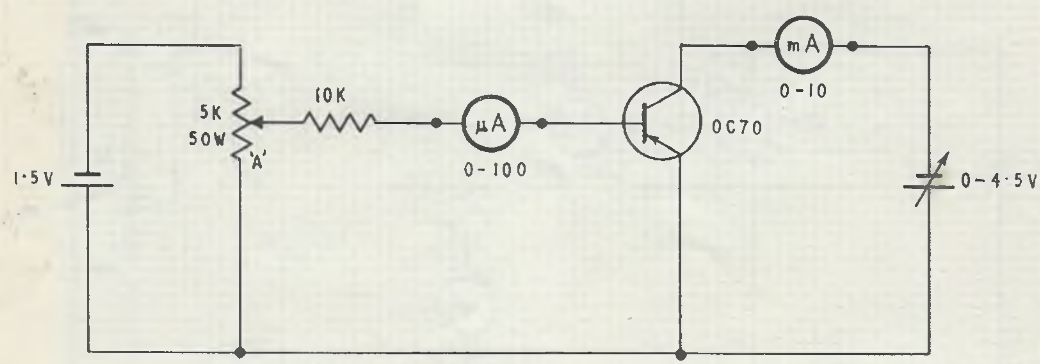


FIG. 1.

STEP 2. Adjust the base current (I_B) to 25µA. Increase the collector voltage to 1.5 Volts. Measure the collector current. Record in Table 1.

STEP 3. Increase the collector voltage (E_C) in 1.5 Volt steps to 4.5 Volts. Measure the collector current (I_C) for each step. Record in Table 1.

STEP 4. Increase the base current (I_B) to 50µA. Repeat Step 3.

STEP 5. Increase the base current (I_B) to 75µA and repeat Step 3.

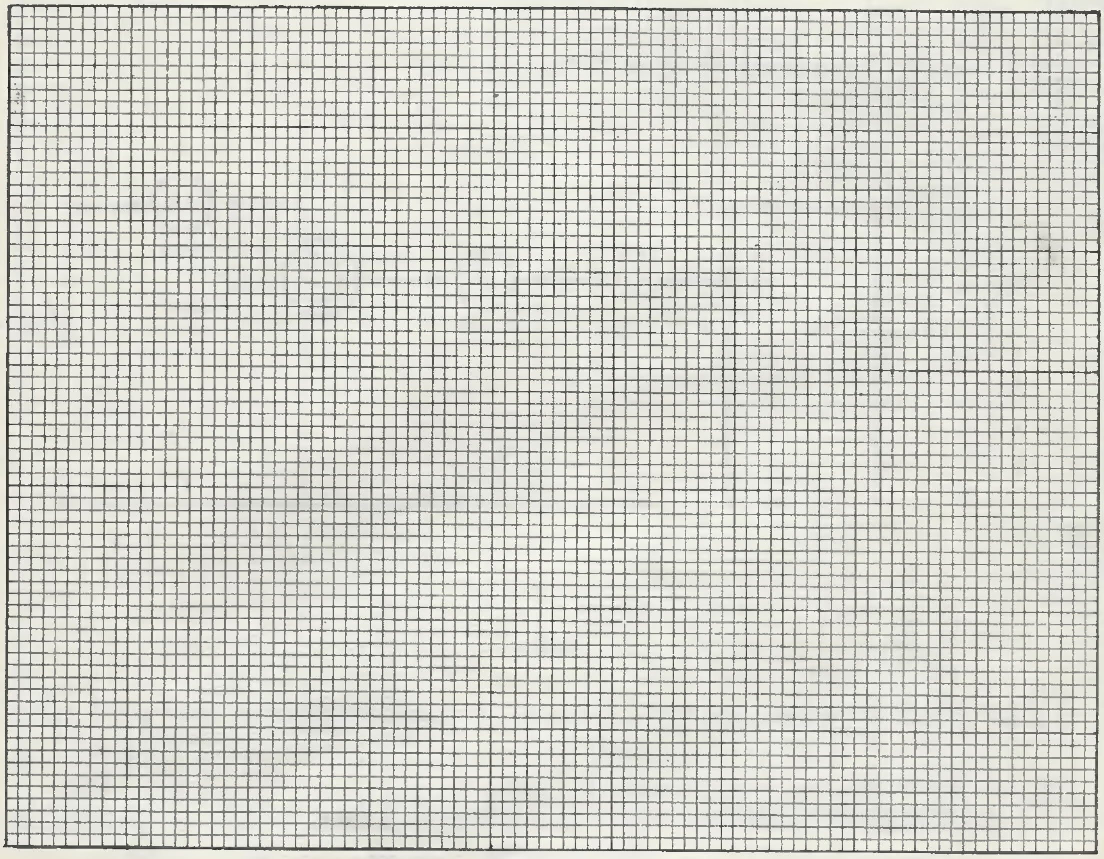
STEP 6. Increase the base current (I_B) to 100µA and repeat Step 3.

STEP 7. From the results in Table 1, complete a family of I_C/E_C curves in Graph 1.

STEP 8. Note similarity to pentode E_a/I_a curves project No. 30.

$I_B = 25\mu A$		$I_B = 50\mu A$		$I_B = 75\mu A$		$I_B = 100\mu A$	
E_c	I_c	E_c	I_c	E_c	I_c	E_c	I_c
1·5 V		1·5 V		1·5 V		1·5 V	
3·0 V		3·0 V		3·0 V		3·0 V	
4·5 V		4·5 V		4·5 V		4·5 V	

TABLE 1.



GRAPH 1.

TEST QUESTIONS.

1. From your Graph (i) Calculate the current gain of the transistor used for the experiment.

   ....

   (ii) Calculate the output impedance with (I_B) 75µA and a change in Collector Voltage (E_C) from 3V to 4.5V.

   ....

TRANSISTOR - COMMON EMITTER (4).

Current gain in common emitter circuits Beta (β) is the ratio of the change in Collector Current to the change in Base Current. Amplification can be calculated from the I_C/I_B static characteristic curve.

AIM: To study the static characteristic curve (I_C/I_B) of a transistor (common emitter).

APPARATUS: Transistor Model, Microammeter 0-100μA, (Multimeter DC 50μA - 1A) Milliammeter 0-10mA, (Multimeter A.P.O. No.2) Battery 1.5V and 4.5V Tapped and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

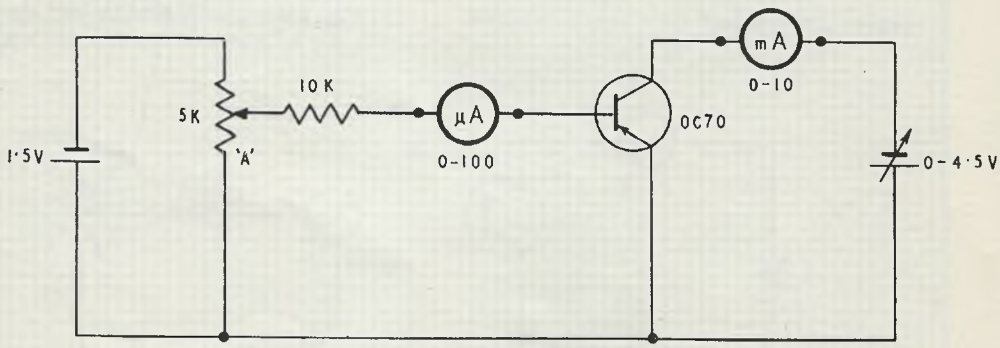


FIG. 1.

STEP 2. Before connecting the supply, ensure that the potentiometer is at point "A".

STEP 3. Adjust the collector voltage (E_C) to -3 Volts.
Measure the Collector Current (I_C). Record in Table 1.

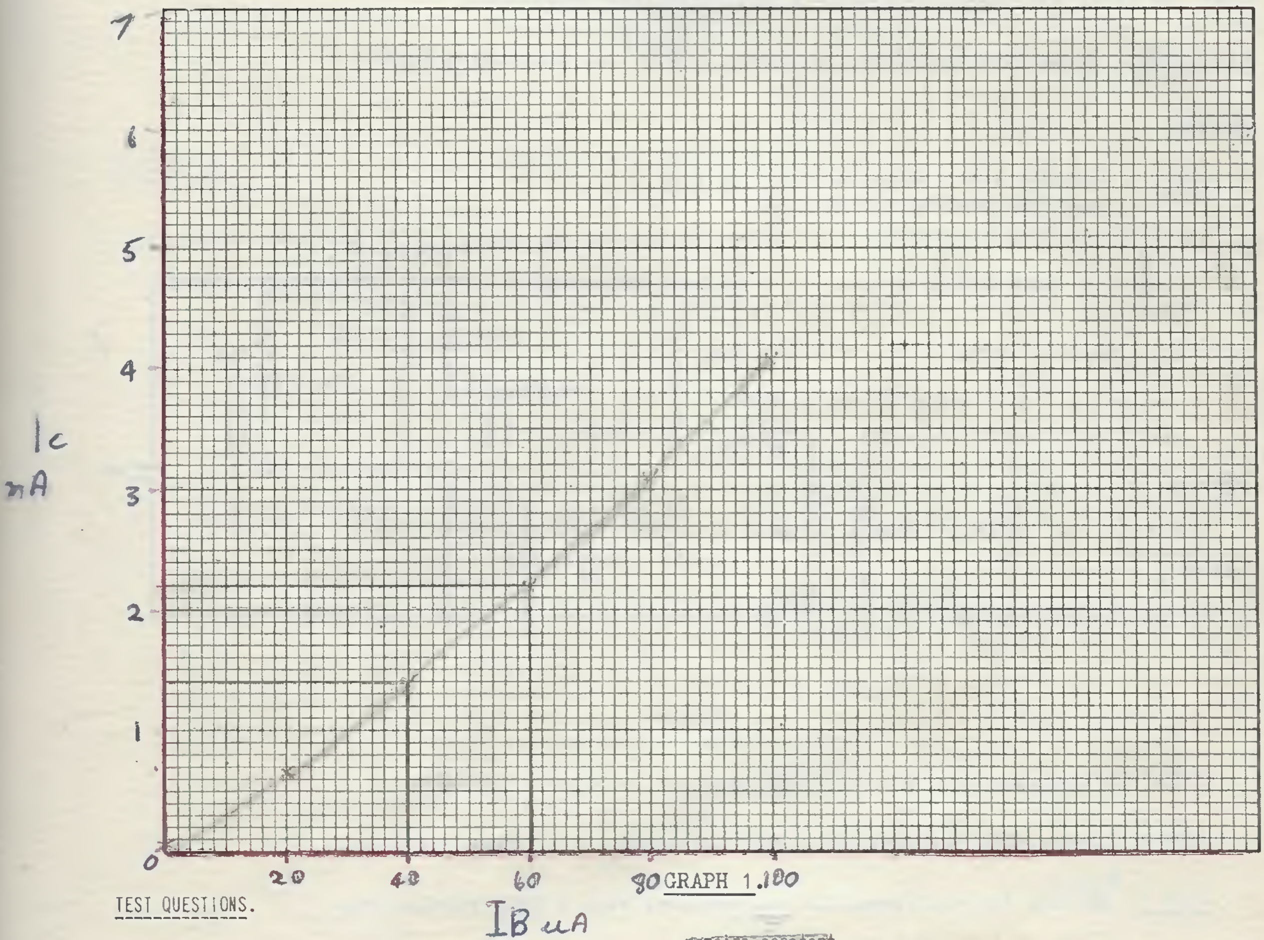
STEP 4. With (E_C) constant at -3 Volts, vary the base current (I_B) in 20μA steps to 100μA.
Measure the collector current (I_C) for each step. Record in Table 1.

STEP 5. From the results in Table 1, plot a graph of I_C/I_B on Graph 1.

COLLECTOR VOLTAGE - 3 VOLTS			
I_B	I_c	I_B	I_c
0	.05 mA	60 µA	2.2 mA
20 µA	.65 mA	80 µA	3.1 mA
40 µA	1.4 mA	100 µA	4.1 mA

10/10

TABLE 1.



GRAPH 1.

TEST QUESTIONS.

1. When the Bias Current is increased the Collector Current ~~remains constant~~ increases ~~decreases~~

2. Small changes in Base Current cause ~~small~~ ~~no~~ large changes in Collector Current.

3. Calculate the current gain of the transistor used.

$B = \frac{\Delta Ic}{\Delta Ib}$ WITH Ic FIXED $= \frac{.8 mA}{20 uA} = 40$

TRANSISTOR AMPLIFIER - COMMON EMITTER.

A transistor used as an amplifier allows small changes in input current to control larger changes in the output circuit.

$$\text{Current amplification} - \frac{\text{Change } I_C}{\text{Change } I_B}$$

$$\text{Voltage amplification} - \frac{\text{Change } E_C}{\text{Change } E_B}$$

AIM: To study the amplification of a common emitter amplifier.

APPARATUS: Transistor Amplifier, Receiver, T.M.S. and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.
ADJ OSC OUTPUT TO 0dbm

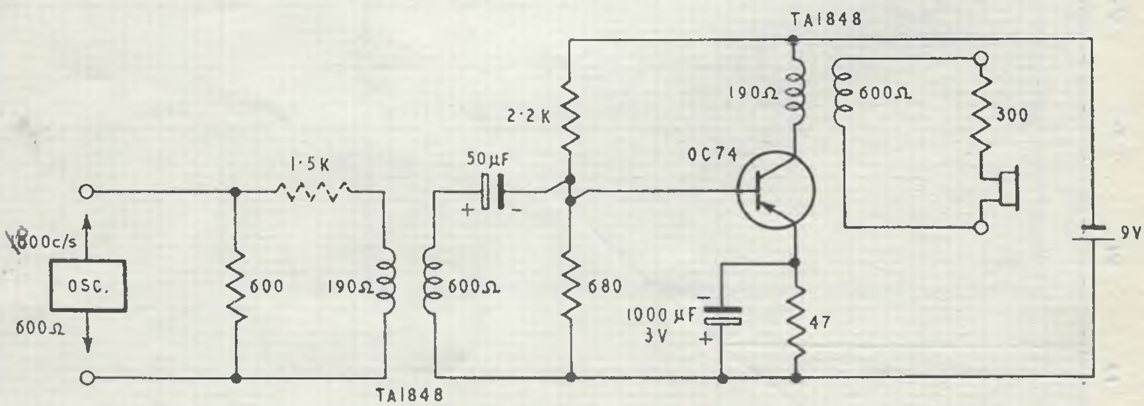


FIG. 1.

NOTE: To decrease gain insert 1500Ω resistor in primary circuit.

STEP 2. Listen with receiver to - (i) the input. (ii) the output.

STEP 3. Replace the 300Ω resistor and receiver with a 600Ω termination. (Bypass)

STEP 4. ~~Adjust the T.M.S. to Zero.~~
With the range switch at [redacted] 0 read the input and record in Table 1.

STEP 5. With the range switch at + 20 read the output and record in Table 1.

STEP 6. Calculate the gain of the amplifier in Table 1.

10/10

Laboratory Projects

2nd Year

PROJECT NO. 45

INPUT	-1 dbm	✓
OUTPUT	+17 dbm	✓
GAIN	18 db	✓ 2

TABLE 1.

TEST QUESTIONS.

1. Calculate the output power of the amplifier when the input power is 2mW.

db = 10 Log $\frac{P_1}{P_2}$ 18 = 10 Log $\frac{P_1}{2}$ 1·8 ANTILOG = $\frac{P_1}{2}$

6

OUTPUT 126 mW ✓

2. What type of bias is used for Fig. 1.

2 COMBINATION BIAS ✓

OSCILLATOR - TRANSISTOR TUNED BASE.

An oscillator is an electronic device which generates an alternating current. The frequency of the generated signal depends upon the tuned circuit components.

An oscillator is an amplifier with positive feed back, where energy is fed back from the output to the input to overcome the circuit losses and to sustain oscillation.

AIM: To study the operation of a tuned base transistor oscillator.

APPARATUS: Oscillator Model, Battery 9V, Receiver, C.R.O. and Connecting Leads.

METHOD: DEMONSTRATION.

STEP 1. Connect the circuit as shown in Fig. 1.

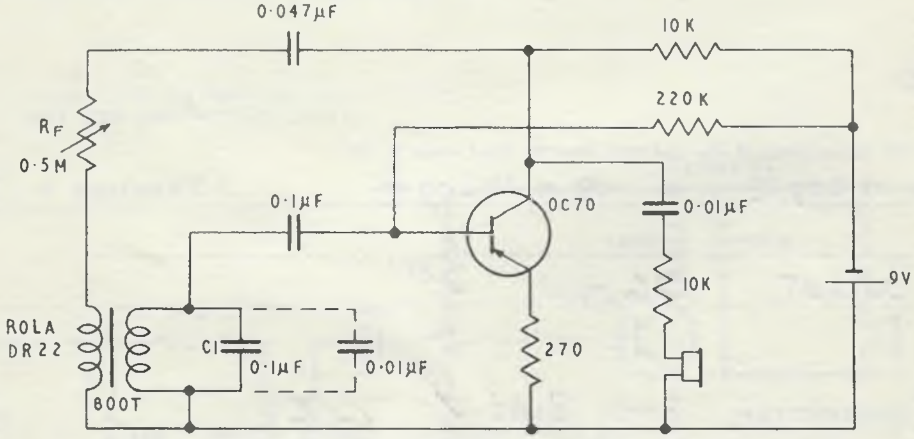


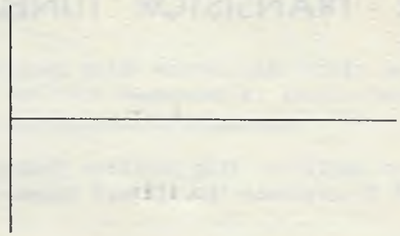
FIG. 1.

STEP 2. Connect the C.R.O. to the output and record the wave shape on Graph 1.

GRAPH 1.

STEP 3. Replace the 0.1μF (C1) capacitor with the 0.01μF capacitor.

STEP 4. Connect the C.R.O. to the output and record the wave shape on Graph 2.



GRAPH 2.

PROJECT.

STEP 1. Connect the circuit as shown in Fig. 1.

STEP 2. Listen across the output.

STEP 3. Replace the 0.1μF capacitor with the 0.01μF capacitor and repeat Step 2.

STEP 4. Switch off. Reverse one side of feedback transformer. Switch on and listen across the output.

TEST QUESTIONS.

1. When the value of the capacitance is decreased the frequency increases / remains the same / decreases.

2. When the feed back resistance is increased the frequency increases / remains the same / decreases, and the amplitude increases / remains the same / decreases.

3. Briefly account for the effect in Step 4.

....

....

....

OSCILLATOR - TRANSISTOR TUNED COLLECTOR.

An oscillator is an electronic device which generates an alternating current. The frequency of the generated signal is dependent upon the tuned circuit components.

An oscillator is an amplifier with positive feed-back, where energy is fed back from the output to the input to overcome the circuit losses and to sustain oscillation.

AIM: To study the operation of a tuned collector transistor oscillator.

APPARATUS: Oscillator Model, Battery 9V, C.R.O. Receiver and Connecting Leads.

METHOD: DEMONSTRATION.

STEP 1. Connect the circuit as shown in Fig. 1.

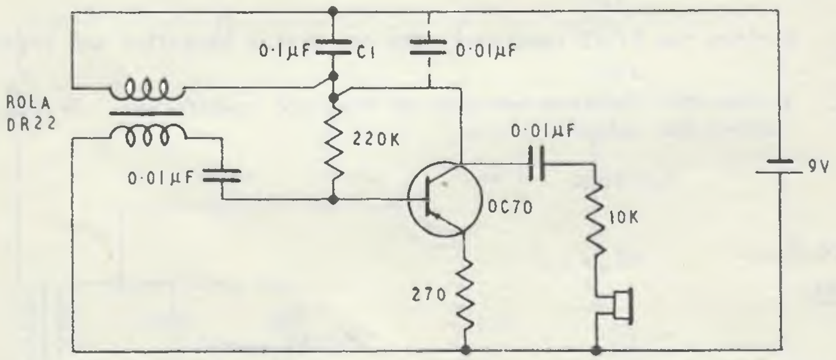
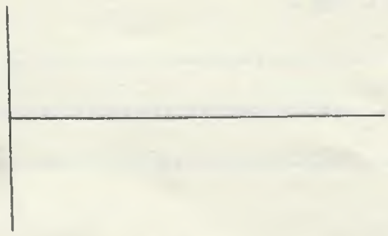


FIG. 1.

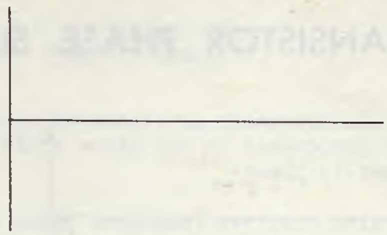
STEP 2. Connect the C.R.O. to the output and record the wave shape on Graph 1.



GRAPH 1.

STEP 3. Replace the 0.1μF (C1) capacitor with the 0.01μF capacitor.

STEP 4. Connect the C.R.O. to the output and record the wave shape on Graph 2.



GRAPH 2.

PROJECT

STEP 1. Connect the circuit as shown in Fig. 1.

STEP 2. Listen across the output.

STEP 3. Replace the 0.1μF capacitor with the 0.01μF capacitor and repeat Step 2.

TEST QUESTIONS.

1. When the value of the capacitance is decreased, the frequency increases / remains the same / decreases.

2. What is the purpose of the 200kΩ resistor.

....

....

OSCILLATOR - TRANSISTOR PHASE SHIFT.

An oscillator is an electronic device which generates an alternating current. The frequency is dependent upon the value of components in the phase shift network being such that only one frequency is fed back to the base in phase.

An oscillator is an amplifier with positive feed-back where energy is fed back from the output to the input to overcome the circuit losses and to sustain oscillation.

AIM: To study the operation of a phase shift transistor oscillator.

APPARATUS: Oscillator Model, Battery Supply 9V, C.R.O., Receiver and Connecting Leads.

METHOD: DEMONSTRATION.

STEP 1. Connect the circuit as shown in Fig. 1.

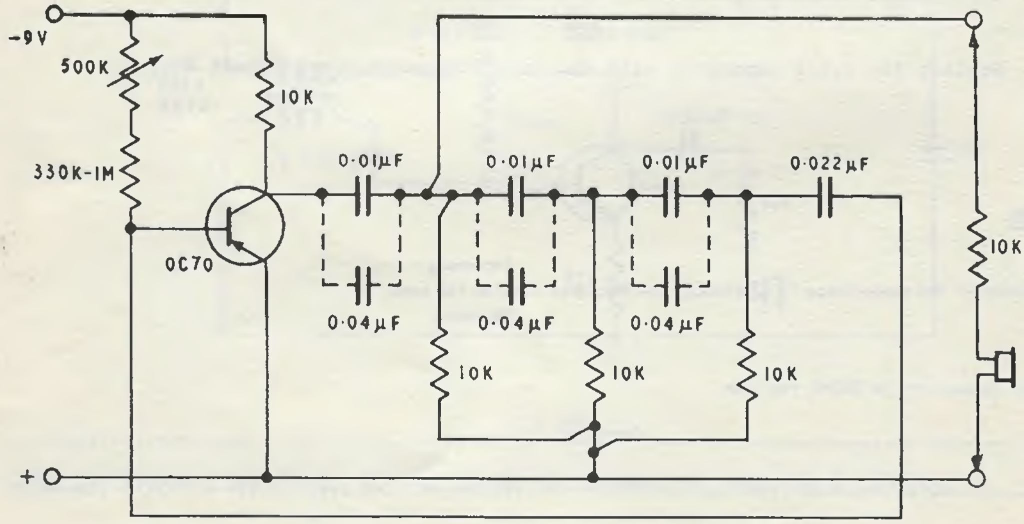
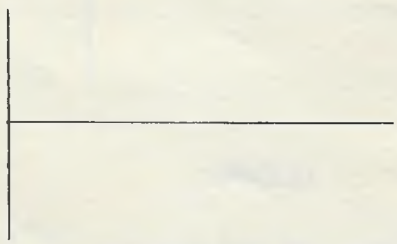


FIG. 1.

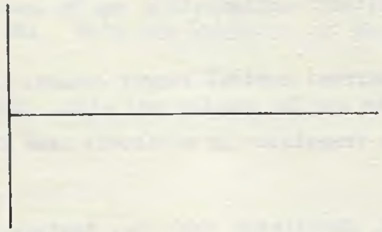
STEP 2. Connect the C.R.O. to the output.
Record the wave shape in Graph 1.



GRAPH 1.

STEP 3. Connect a 0.04µF capacitor in parallel with each of the 0.01µF capacitors.

STEP 4. Connect the C.R.O. to the output.
Record the wave shape in Graph 2.



GRAPH 2.

PROJECT.

STEP 1. Connect the circuit as shown in Fig. 1.

STEP 2. Listen across the output.

STEP 3. Connect the 0.04µF capacitors in parallel with the 0.01µF capacitors and repeat Step 2.

TEST QUESTIONS.

1. In Fig. 1 when the capacitance is increased the frequency increases / remains the same / decreases.

2. Calculate the phase angle of 0.01µF and 10kΩ at 1000 c/s.

....

....

SWITCHING TRANSISTORS (1).

Transistors in common emitter configuration can be used as switching devices to operate relays etc.

Small changes in input current control larger changes in output current.

AIM: To study the operation of a transistor in a circuit used for operating a relay from D.C. or A.C. pulses.

APPARATUS: Model Switching Board, Oscillator 1000 c/s, Battery Supply and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

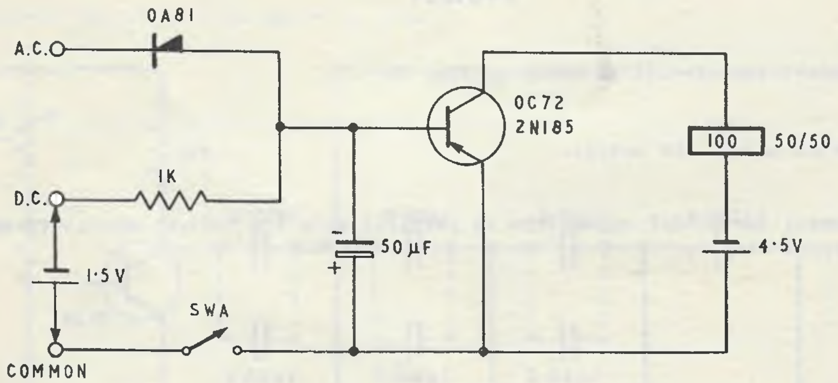


FIG. 1.

STEP 2. Close the switch SWA. Note the relay operation.

STEP 3. Open the switch SWA. Note the relay releases.

STEP 4. Connect the circuit as shown in Fig. 2.

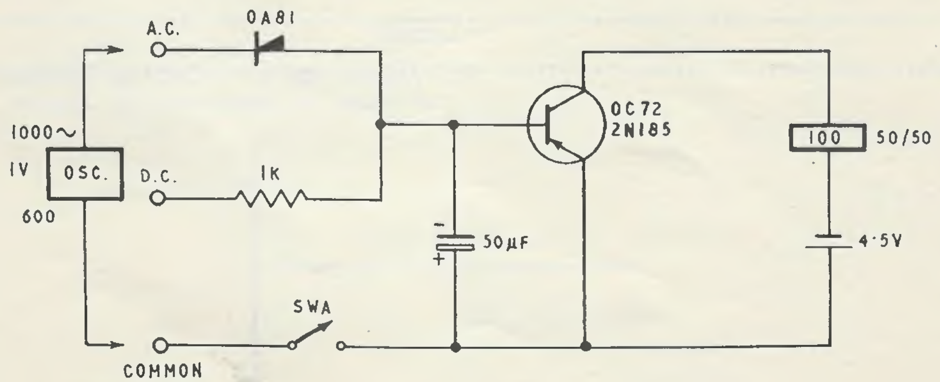


FIG. 2.

STEP 5. At a frequency of 1000 c/s, adjust the oscillator voltage to approx. 1 Volt R.M.S.

STEP 6. Close the switch SWA. Note the operation of the relay.

STEP 7. Open the switch SWA. Note the release of the relay.

TEST QUESTIONS.

1. In Fig. 1.

When the D.C. supply voltage is connected to the input, negative / positive bias is connected to the base, thus increasing / decreasing the collector current. This causes the relay to ....

2. In Fig. 2.

When 1000 c/s is connected to the input, the relay operates. Why is this so?

....

....

....

....

SWITCHING TRANSISTORS (2).

Switches can be classified broadly into three groups -

(i) Manually controlled
(ii) Electrically controlled
(iii) Electronically controlled.

Electronic switching circuits using transistors can be operated or switched at a much higher frequency than the mechanical or electromechanical methods, as there is less transit switching time, and no mechanical parts.

Transistors can be used to operate a counting device as in the bi-stable circuit of Fig. 1. Pulses are applied to the input, and for every two input pulses the indicator operates once. This type of circuit can be used for binary counting.

AIM: To study pulse switching in a transistor circuit.

APPARATUS: Transistor Model and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

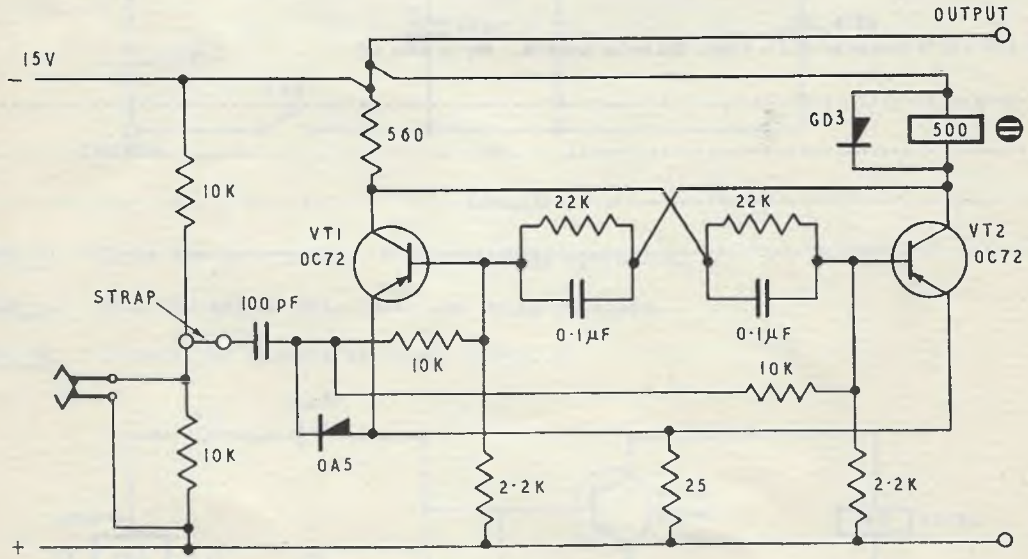


FIG. 1.

STEP 2. Note which transistor is switched. When the indicator is released VT1 is in the switching condition. When the indicator is operated VT2 is in the switching condition.

STEP 3. Apply one pulse to the input from the dial. Note that when VT2 is switched the indicator operates and remains operated.

STEP 4. Apply a second pulse from the dial.
Note that the indicator releases. (VT1 is switched.)

STEP 5. Apply two pulses. Observe that indicator operates once.

DEMONSTRATION.

STEP 6. Connect the various models together. Remove strap (Fig. 1) from all models except No. 1 as in Fig. 2.

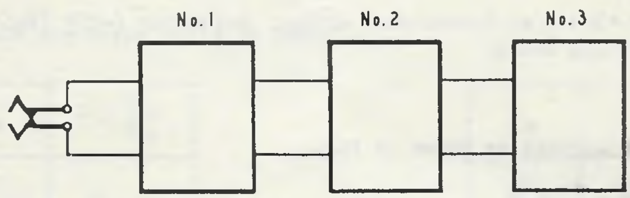


FIG. 2.

STEP 7. Explain briefly using model method of binary counting.

TEST QUESTIONS.

1. From your observations, how many input pulses were required to operate and release the indicator once.

....

....

2. In Fig. 1.

When VT2 is conducting, VT1 is cut off. Why is this so?

....

....

....

TRANSFORMER - TURNS RATIO.

Turns ratio or transformation ratio (T) is the ratio of the SECONDARY turns (N_S) to the PRIMARY turns (N_P) -

$$T = \frac{N_S}{N_P}$$

The secondary voltage (E_S) is dependent upon the primary voltage (E_P) and the turns ratio (T) -

$$E_S = E_P \, T$$

AIM: To prove that the secondary voltage of a transformer is dependent on its turns ratio.

APPARATUS: Oscillator 1000 c/s, Transformer 4012A; Voltmeter 0-50V (Multimeter A.P.O. No.2) and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

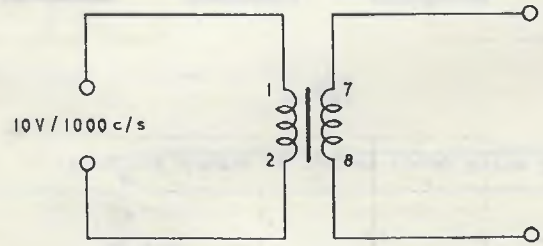


FIG. 1.

STEP 2. Measure E_P and E_S. Record in Table 1.

STEP 3. Calculate the turns ratio in Table 1.

STEP 4. Connect the circuit as shown in Fig. 2.

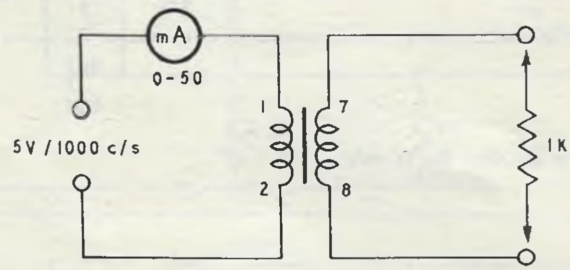


FIG. 2.

STEP 5. Measure E_P and E_S. Record in Table 2.

STEP 6. Calculate the turns ratio in Table 2.

STEP 7. Connect the circuit as shown in Fig. 3.

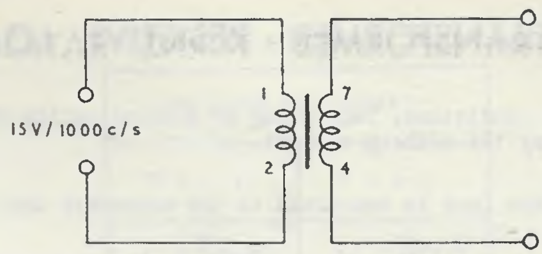


FIG. 3.

STEP 8. Measure E_p and E_S. Record in Table 3.

STEP 9. Calculate the turns ratio in Table 3.

E_p	E_s	$T = \frac{E_s}{E_p}$
10v	10v	1

TABLE 1.

E_p	E_s	$T = \frac{E_s}{E_p}$
5v	5v	1

TABLE 2.

E_p	E_s	$T = \frac{E_s}{E_p}$
15v	28.2	1.88

TABLE 3.

TEST QUESTIONS.

1. From your results -

(i) When $E_S = E_P$ the secondary turns ..EQUAL ✓.. the primary turns, and the turns ratio is ....1 ✓....

(ii) When the turns ratio is 4 and the primary turns are 100, the secondary turns are ....400 ✓....

(iii) When the secondary turns are 1000 and the turns ratio is 8, the primary turns are ....125 ✓....

TRANSFORMER - RESISTIVE LOAD.

Under no load conditions, increasing or decreasing the secondary turns of a transformer does not vary the primary current.

When a resistive load is connected to the secondary the primary current increases.

For a given applied voltage, the magnitude of the primary current is dependent upon -

(i) Value of resistive load.

(ii) The turns ratio.

AIM: To study the effects of load resistance and turns ratio on the primary current.

APPARATUS: 1000c/s Oscillator, Transformer 4012A, Milliammeter 0-50mA (Multimeter DC 50μA-1A), Resistors 1kΩ, 600Ω and 150Ω and Connecting Leads.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

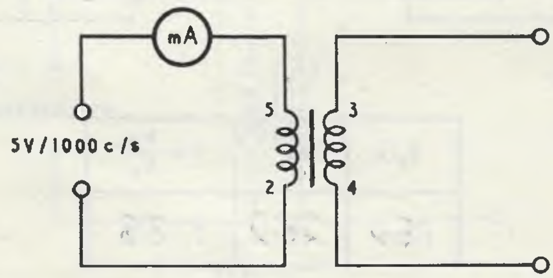


FIG. 1.

STEP 2. Measure the no load primary current. Record in Table 1.

STEP 3. Connect the 1kΩ resistor to the secondary. Measure the primary current. Record in Table 2.

STEP 4. Replace the 1kΩ resistor with (i) 600Ω and (ii) 150Ω and in each case measure the primary current. Record in Table 2.

STEP 5. Increase the turns ratio to 2:1.

STEP 6. Measure the no load primary current. Record in Table 1.

STEP 7. Compare results of steps 2 and 6 in Table 1.

STEP 8. Connect the 1kΩ resistor to the secondary. Measure the primary current. Record in Table 2.

STEP 9. Replace the 1kΩ resistor with (i) 600Ω and (ii) 150Ω and in each case measure the primary current. Record in Table 2.

NO LOAD SECONDARY	
T = 1 : 1	T = 2 : 1
I_p : 3mA	I_p : 3mA

TABLE 1.

RESISTIVE SECONDARY LOAD		
T = 1 : 1	R_L = 1KΩ	I PRIMARY 5mA
	R_L = 600Ω	" 8mA
	R_L = 150Ω	" 33mA
T = 2 : 1	R_L = 1KΩ	I PRIMARY 20mA
	R_L = 600Ω	" 33mA
	R_L = 150Ω	"

TABLE 2.

TEST QUESTIONS.

1. When a resistive load is connected to the secondary of a transformer, energy absorbed by the load is provided by -

THE PRIMARY VOLTAGE INDUCING ENERGY FROM ITS SUPPLY INTO THE SECONDARY LOAD ✓

2. (i) When the turns ratio of a transformer with a resistive load is increased, the primary current increases ✓ ~~remains the same~~ ~~decreases~~

(ii) Why is this so? A LARGER VOLTAGE IS INDUCED INTO THE SECONDARY & PROVIDED R REMAINS THE SAME I_S IS INCREASED

TRANSFORMER - REFLECTED IMPEDANCE.

The value of impedance reflected into the primary winding of a transformer depends on -

(i) Turns Ratio.

(ii) Impedance of secondary load.

AIM: To study impedance transformation in a transformer with varying turns ratios and resistive loads.

APPARATUS: 1000c/s Oscillator, Milliammeter 0-50mA (Multimeter DC 50μA-1A), Voltmeter 0-10V (Multimeter A.P.O. No. 2), Resistors 150Ω, 600Ω 1kΩ 4kΩ and 2.4kΩ, Transformer 4012A and Connecting Leads.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

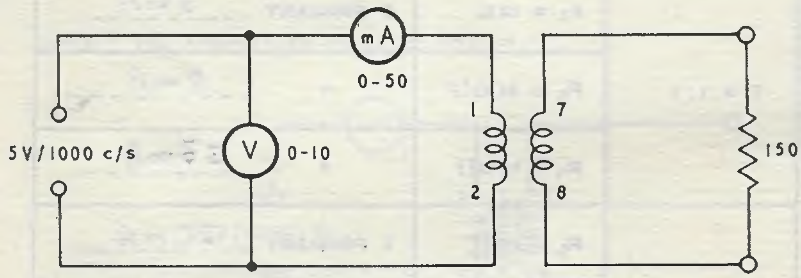


FIG. 1.

STEP 2. Adjust the primary voltage to 5 volts. Measure I_p. Record in Table 1.

STEP 3. Calculate the reflected impedance of the primary winding in Table 1.

STEP 4. Replace the 150 ohm resistor with (i) 600 ohm, then (ii) 1000 ohm. Repeat Steps 2 and 3 for each value of resistance.

STEP 5. Increase the turns ratio to 2:1 and connect the 600Ω resistor to the secondary.

STEP 6. Adjust the primary voltage to 5 volts. Measure I_p. Record in Table 2.

STEP 7. Calculate the reflected impedance of the primary winding in Table 2.

STEP 8. Replace the 600Ω resistor with (i) 2400Ω, then (ii) 4000Ω. Repeat Steps 6 and 7 for each value of resistance.

STEP 9. Compare the primary impedance values of Table 1 and Table 2.

TURNS RATIO = 1:1			
SECONDARY LOAD	E_p	I_p	$Z_p = \frac{E_p}{I_p}$
~~150 Ω~~ 2000	5V	2.5mA	2000 Ω ✓
~~600 Ω~~ 5000	5V	1mA	5000 Ω ✓
1000Ω	5V	.5mA	10000 Ω ✓

TABLE 1.

TURNS RATIO = 2:1			
SECONDARY LOAD	E_p	I_p	$Z_p = \frac{E_p}{I_p}$
~~600 Ω~~ 2000 Ω	5V	10mA	500 Ω ✓
~~2400 Ω~~ 5000 Ω	5V	4mA	1250 Ω ✓
~~4000 Ω~~ 10000 Ω	5V	2mA	2500 Ω ✓

TABLE 2.

TEST QUESTIONS.

1. (i) When the turns ratio is 1 and the resistance of the secondary load is increased, the primary current ~~increases~~ ~~remains the same~~ decreases, and, the reflected impedance in the primary increases ~~remains the same~~ ~~decreases~~.

(ii) Why is this so? SECONDARY LOAD INCREASED IS DECREASES BECAUSE IS↓ = E/Z↑ ∴ IP DECREASED BECAUSE IP↓ = IS↓ × T

2. From your results, prove that $T^2 = \frac{Z_s}{Z_p} = \frac{2000}{500} = 4 \quad T = \sqrt{4} = 2.$

TRANSFORMER - IMPEDANCE MATCHING.

For most practical purposes maximum possible power is transferred from a source of supply to a load, when the load impedance equals the impedance of the source.

In A.C. circuits, unequal impedance are matched by means of a transformer with a suitable turns ratio.

$$\text{Primary Impedance } (Z\ ) = \frac{\text{Secondary Impedance } (Z_S)}{\text{Turns ratio }^2\ (T^2)}$$

AIM: To study impedance matching in a transformer with varying turns ratios and resistive loads.

APPARATUS: 1000c/s Oscillator with 600Ω output. Milliammeter 0-50mA (Multimeter DC 50μA-1A), Voltmeter 0-10V (Multimeter A.P.O. No.2), Resistors 50Ω 150Ω 400Ω 600Ω and 1kΩ, Transformer 4012A and Connecting Leads.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

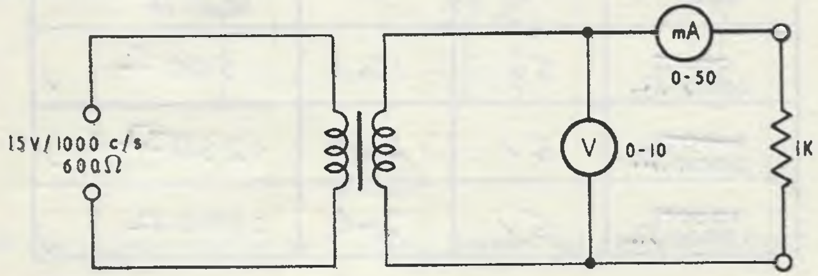


FIG. 1.

STEP 2. Adjust the primary voltage to 15 volts. Measure E_S and I_S. Record in Table 1.

STEP 3. Replace the 1000 ohm resistor with (i) 600 ohm (ii) 400 ohm. Repeat Step 2 for each value of resistance.

STEP 4. Calculate values of power for each step in Table 1.

STEP 5. Vary the turns ratio to 1:2 and reconnect the 400Ω load resistor.

STEP 6. Readjust the primary voltage to 15 volts. Measure E_S and I_S. Record in Table 2.

STEP 7. Replace the 400 ohm resistor with (i) 150 ohm (ii) 50 ohm.

STEP 8. Repeat step 6 for each value of resistance.

STEP 9. Calculate values of power for each step in Table 2.

TURNS RATIO = 1:1			
SECONDARY LOAD	E_s	I_s	P (mW) = E x I (mA)
1000 Ω			mW
600 Ω			mW
400 Ω			mW

TABLE 1.

TURNS RATIO = 1:2			
SECONDARY LOAD	E_s	I_s	P (mW) = E x I (mA)
400Ω			
150Ω			
50Ω			

TABLE 2.

TEST QUESTIONS.

1. From your results.

   In Step 1 (load 150 ohms), if the turns ratio was 1:2 calculate the impedance of the primary.

   ....

   ....

2. (i) Calculate the reflected impedance of a secondary resistive load of 5000Ω through a transformer having 5000 turns secondary and 1000 turns primary.

   (ii) Calculate the resistance of load when the internal resistance of a generator is 200Ω and the transformer has 5000 turns primary and 1000 turns secondary.

AMMETERS.

An ammeter is used to measure the current in a circuit. Most ammeters are capable of accurate measurements, but reliable readings can only be obtained by using a meter which is suitable for the particular circuit conditions.

Using an unsuitable ammeter will affect normal circuit conditions and give incorrect readings.

AIM: To study the use of ammeters in varying circuit conditions.

APPARATUS: Milliammeter 100Ω 0–1mA, Milliammeter 0–1mA, (Multimeter A.P.O. No.2), Resistors 2kΩ and 50kΩ, Battery Supply and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

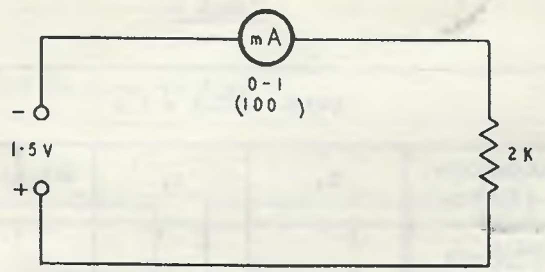


FIG. 1.

STEP 2. Measure the circuit current. Record in Table 1.

STEP 3. Replace the 100Ω/1mA meter with the A.P.O. Multimeter 0–1mA. Measure the circuit current. Record in Table 1.

STEP 4. Using Ohms Law calculate the circuit current in Table 1. Compare with the measured values of Steps 2 and 3.

STEP 5. Connect the circuit as shown in Fig. 2.

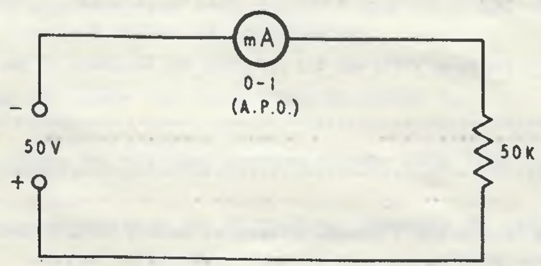


FIG. 2.

STEP 6. Measure the circuit current. Record in Table 2.

STEP 7. Using Ohms Law, calculate the circuit current in Table 1. Compare with the measured value of Step 6.

CIRCUIT RESISTANCE 2KΩ			
METER R	E	I	$I = \frac{E}{R}$
100Ω			
500Ω			

TABLE 1.

CIRCUIT RESISTANCE 50KΩ			
METER R	E	I	$I = \frac{E}{R}$
500Ω			

TABLE 2.

TEST QUESTIONS.

1. From your results in Table 1 -

Which meter is more suitable for use with the circuit conditions of Fig. 1..

Why is this so? ....

....

....

....

VOLTMETERS.

A voltmeter is used to measure the voltage of a circuit, or the P.D. across circuit components. Most voltmeters are capable of accurate measurements but reliable readings can only by obtained by using a meter which is suitable for the particular circuit conditions.

Using an unsuitable voltmeter will affect normal circuit conditions, and give incorrect readings.

AIM: To study the use of voltmeters in varying circuit conditions.

APPARATUS: Voltmeter 100Ω/Volt, Voltmeter 1000Ω/Volt, Resistors 1kΩ, 1.5kΩ, 50kΩ, 75kΩ, 100kΩ Battery Supply and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

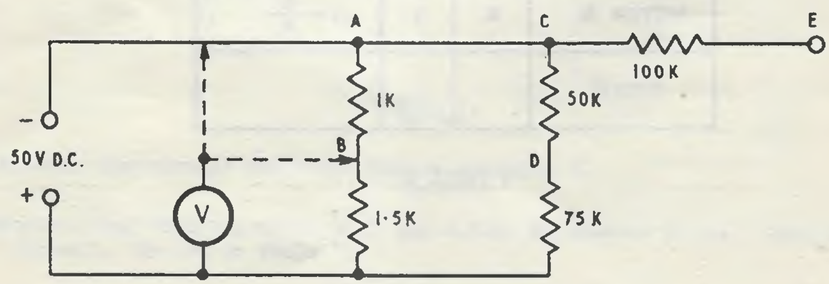


FIG. 1.

STEP 2. Using the 100Ω/Volt meter, measure the P.D. between 50V positive and points A, B, C, D, and E. Record in Table 1.

STEP 3. Using the multimeter A.P.O. No.2 repeat Step 2.

STEP 4. Calculate the P.D. between 50V positive and points A, B, C, D and E in Table 1. Compare with the measured values of Steps 2 and 3.

MEASUREMENTS BETWEEN 50V + & POINTS	METER 100 Ω VOLT MEASUREMENTS	CALCULATIONS	MULTIMETER A.P.O. MEASUREMENTS
A			
B			
C			
D			
E			

TABLE 1.

TEST QUESTIONS.

1. From your results in Table 1 -

(i) Which meter more accurately measures the circuit P.Ds.?

....

(ii) Why is this so? ....

2. Is the measured reading at point "E" correct? ....

Give reasons for your answer ....

....

....

A.C. METERS.

A moving coil meter is unsuitable for measurement of A.C., as each reversal of current tends to reverse the deflection of the pointer.

When a moving coil meter is adapted to read A.C. by the use of rectifiers, the deflection of the pointer corresponds to the average value of the pulses, but the scale is calibrated to the R.M.S. or "effective" value, which is 1.11 times greater for an alternating current with a pure sine wave.

AIM: To adapt a moving coil meter to read A.C.

APPARATUS: Milliammeter 0-10mA (Multimeter A.P.O. No. 2) Milliammeter 0-10mA (Multimeter A.C. 1mA-10A) Resistor 10kΩ Rectifiers 2/2A, Battery Supply and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

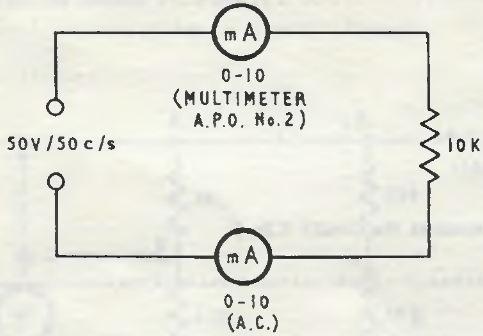


FIG. 1.

STEP 2. Note the deflection of the pointers.

STEP 3. Connect the circuit as shown in Fig. 2.

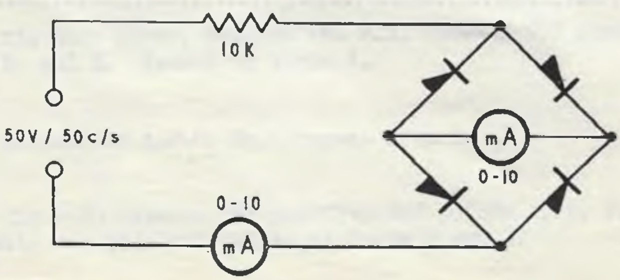


FIG. 2.

STEP 4. Measure the circuit current. Record in Table 1.

STEP 5. Calculate the R.M.S. value. Record in Table 1.

METER READINGS
AVERAGE VALUE = _____ mA
R.M.S. = 1·11 x AVERAGE = ___ mA

TABLE 1.

TEST QUESTIONS.

1. When a moving coil meter is connected to a sinusoidal A.C. source, the scale reading shows 95mA. State the name given to the value of current which governs the meter's deflection, and calculate its magnitude.

....

....

....

2. When a moving coil meter with bridge rectifier is used to measure D.C., calculate the actual value of direct current in the circuit when the scale reading is 5.55mA.

Answer .... mA.

VACUUM TUBE VOLTMETER.

To measure small P.D.'s in high impedance circuits it is necessary to use a voltmeter having an impedance much higher than the part of the circuit under test. A V.T.V.M. is a suitable instrument for this purpose as it has an impedance of approximately 10MΩ.

AIM: To study the V.T.V.M. when used to measure voltage.

APPARATUS: V.T.V.M., 1000Ω/Voltmeter, Resistors 1MΩ and 4MΩ, Oscillator Model Board, 50V Supply, 250V H.T. Supply, Filament Supply and Connecting Leads.

METHOD:

DEMONSTRATION.

STEP 1. Connect the circuit as shown in Fig. 1.

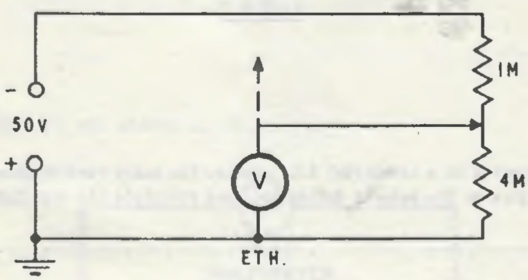


FIG. 1.

STEP 2. Adjust the supply voltage to 50 Volts.

STEP 3. Using V.T.V.M., measure the P.D. across each resistor. Record in Table 1.

STEP 4. Using Voltmeter 1000Ω/Volt, repeat Step 3.

STEP 5. Compare the results of Steps 3 and 4 in Table 1.

STEP 6. Connect the circuit as shown in Fig. 2.

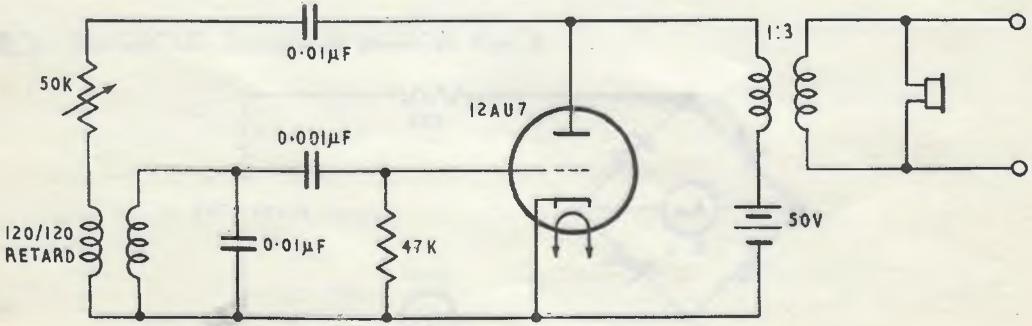


FIG. 2.

STEP 7. Using V.T.V.M., measure the voltage between the grid and cathode.

STEP 8. Using Voltmeter 1000Ω/Volt, repeat Step 7.

STEP 9. Compare the results of Steps 7 and 8 in Table 2.

METER	P.D.	
	1MΩ	4MΩ
1000Ω/ VOLT		
V.T.V.M.		

TABLE 1.

METER	P.D.
1000Ω/VOLT	
V.T.V.M.	

TABLE 2.

TEST QUESTIONS.

1. State the advantage of using a V.T.V.M. for measuring a P.D. in a high impedance circuit.

....

....

2. From your results in Table 2.

Explain the reason for the different readings.

....

....

....

....

OSCILLOSCOPE - FAMILIARIZATION.

The oscilloscope which is one of the most versatile instruments used in the field of electronics, displays a graph of voltage variations with respect to time.

AIM: To become familiar with the controls of a cathode ray oscilloscope.

APPARATUS: Cathode Ray Oscilloscope.

★ METHOD: NOTE:- Control names to be altered to suit the available C.R.O.

STEP 1. Note the position and the functions of controls listed below -

(i) Intensity - controls the level of brightness.

(ii) Focus - in conjunction with the intensity control sets the sharpness of trace.

(iii) Horizontal Shift - shifts the trace horizontally.

(iv) Vertical Shift - shifts the trace vertically.

(v) Sweep Range Selector - sets the oscilloscope for viewing different frequencies.

(vi) Sweep Frequency Adjust - fine adjustment for (v).

(vii) Sync Adjust - eliminates horizontal drift by varying the synchronization amplitude.

(viii) Sync Selector - selects either internal or external synchronization.

(ix) Vertical Attenuator - adjusts the height of the waveform.

(x) Vertical Amplitude - provides fine adjustment of (ix).

(xi) Horizontal Input Selector - selects internal or external input to horizontal amplifier.

(xii) Horizontal Amplitude - provides width adjustment.

TO BE COMPLETED & MARKED

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STEP 2.

(i) Set the Select Sweep Range and Sweep Frequency Adjust to the centre of their range.

(ii) Set the Vertical and Horizontal Shift Controls to the centre of their range.

(iii) Set the Sync Selector to Internal, and the Sync Adjust to minimum.

(iv) Turn the oscilloscope on, and the Intensity to 75% of full control. Set the Vertical Amplitude control to minimum.

(v) Set the Horizontal Amplitude of 75% of full control.

(vi) Centre the trace.

(vii) Adjust the Intensity and Focus.

(viii) Vary the Horizontal Amplitude and note the effect on the width of trace (for a 5" screen the trace is approximately 4" wide).

STEP 3. Note the positions and designations of the terminals provided for connection of external voltages to the deflecting plates.

★ TEST QUESTIONS.

B.

1. List two applications of an Oscilloscope.

VOLTAGE MEASURMENTS ✓ 1

2. FREQ MEASURMENTS ✓ 1

2. State the function of the following terminals.

(i) The Vertical or "Y" amplifier CONNECTS INPUT VIA AMP TO Y PLATE ✓

(ii) The Vertical or "Y" plates .. CONNECTS INPUT TO Y PLATE ✓

(iii) The Horizontal or "X" amplifier CONNECTS INPUT VIA X AMP TO X PLATE ✓

(iv) The Horizontal or "X" plates CONNECTS INPUT TO X PLATE

(v) External Sychronization TO GET BOTH WAVE FORMS IN PHASE USING AN EXTERNAL SOURCE OF SUPPLY. ✓

OSCILLOSCOPE.

The oscilloscope displays a pattern of voltage variation with respect to time.

The instantaneous position of the electron beam is dependent upon -

(i) the potential applied to the vertical plates.

(ii) the potential applied to the horizontal plates.

AIM: To move the electron beam to various positions on the screen.

APPARATUS: C.R.O., Battery Supply 45V, Voltmeter 50-0-50V, Potentiometer 5kΩ 50W and Connecting Leads.

CAUTION: Reduce the intensity control until the spot is just visible.

★ METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

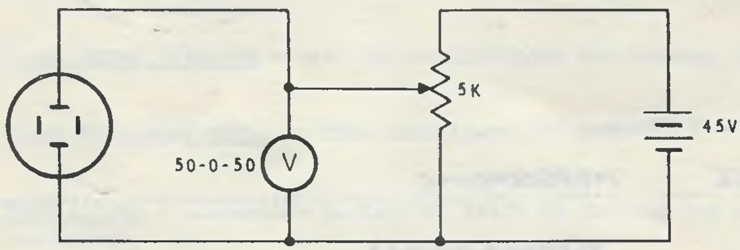

FIG. 1.

STEP 2. Adjust the supply voltage to zero.
Note the position of the electron beam. Record in Fig. 2.

STEP 3. Increase the supply voltage in 5 Volt steps to +15 Volts.
Note the position of the electron beam for each step. Record in Fig. 2.

STEP 4. Decrease the supply voltage in 5 Volt steps to zero.
Note the position of the electron beam for each step. Compare with Fig. 2.

STEP 5. Reverse the supply voltage and repeat steps 2 to 4.

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STEP 6. Connect the variable voltage supply to the horizontal plates.

STEP 7. Adjust the supply voltage to zero.
Note the position of the electron beam. Record in Fig. 3.

STEP 8. Increase the supply voltage in 5 Volt steps to 15 Volts.
Note the position of the electron beam for each step. Record in Fig. 3.

STEP 9. Decrease the supply voltage in 5 Volt steps to zero.
Note the position of the electron beam for each step. Compare with Fig. 3.

STEP 10. Reverse the supply voltage and repeat steps 7 to 9.

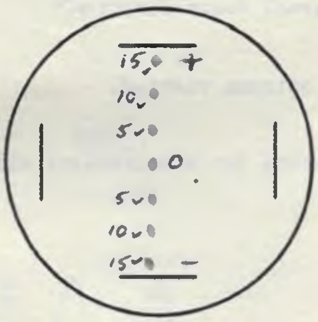

FIG. 2.

FIG. 3.

B

TEST QUESTIONS.

1. In the normal position the electron beam is in the ....CENTRE.... of the screen. When the voltage on the upper vertical plates is increased in a positive direction the beam moves ~~across~~ up the screen, when the voltage is ~~down~~ reversed the beam moves ....DOWN....

2. When a potential is applied to the horizontal plates, the beam moves ....ACROSS.... the screen, the distance the beam moves depends on ....THE POTENTIAL OF THE HORIZONTAL PLATES....

OSCILLOSCOPE - VIEWING WAVEFORM.

The oscilloscope is used to display a pattern of voltage variation with respect to time.

AIM: To study the waveform of a signal with the C.R.O.

APPARATUS: Variable Frequency Oscillator, C.R.O. and Connecting Leads.

★ METHOD:

STEP 1. (i) Turn on the power switch and allow the C.R.O. to warm up.

(ii) Set the Horizontal Selector to Internal Sweep position

(iii) Adjust the Focus and Intensity for optimum viewing.

(iv) Adjust the Horizontal Amplitude Control for a convenient width of line.

(v) Centre the line on the screen.

STEP 2. Connect the circuit as shown in Fig. 1.

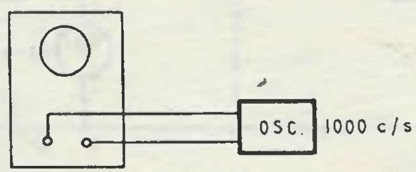

FIG. 1.

STEP 3. (i) Adjust the Vertical Amplitude Control for desired height.

(ii) Set the Sync-Selector to Internal Sync.

(iii) Set the Sweep Range Selector and the Sweep Frequency Adjust for two cycles of waveform on the screen. (Note position.)

(iv) Adjust the Sync to prevent horizontal drift of pattern.

TO BE COMPLETED & MARKED.

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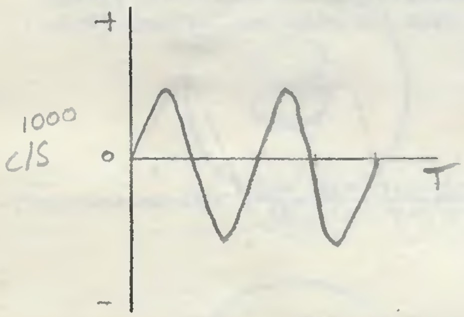
STEP 4. With Sweep Controls in the same position, adjust the Oscillator to 500 c/s.

STEP 5. Repeat Step 4 with 1500 c/s.

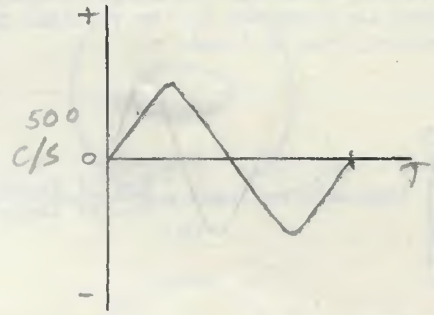
STEP 6. Repeat Step 4 with 2000 c/s.

★ TEST QUESTIONS.

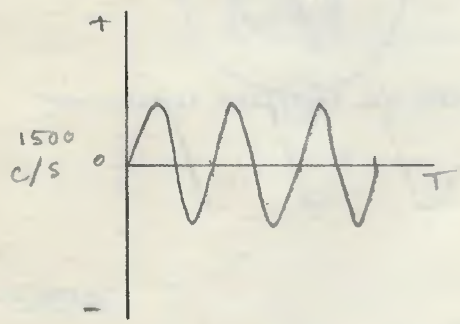
1. From your observations in Steps 3, 4, 5 and 6, complet Graphs 1 to 4 respectively.



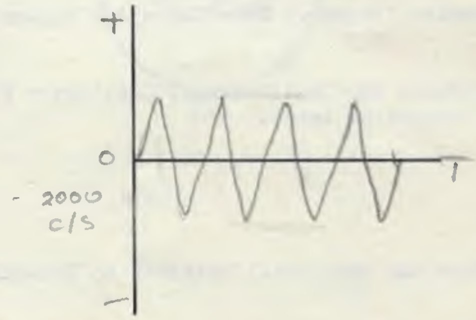
GRAPH 1.



GRAPH 2.



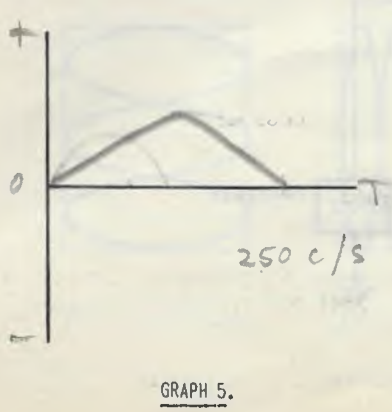
GRAPH 3.



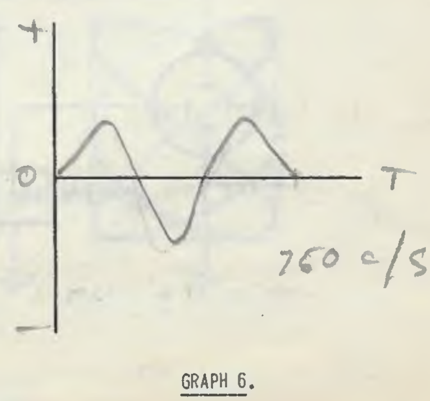
GRAPH 4.

B.

2. Show the patterns you would expect on the screen when the oscillator frequency is (i) 250c/s and (ii) 750c/s.



GRAPH 5.



GRAPH 6.

OSCILLOSCOPE - FREQUENCY MEASUREMENT.

The cathode ray oscilloscope can be used to determine frequency by means of Lissajous figures.

These figures are obtained by applying two sine wave voltages simultaneously to the two sets of deflection plates. The known frequency is connected to the horizontal plates whilst the unknown is connected to the vertical plates. From the resultant pattern (Fig. 1) the unknown frequency can be found.

$$\text{Unknown Frequency} = \frac{\text{No. of loops touching horizontal side}}{\text{No. of loops touching vertical side}} \times \text{Known frequency.}$$

FIG. 1.

AIM: To determine frequency from lassajous figures.

APPARATUS: Cathode Ray Oscilloscope, Oscillator Fixed 1000 c/s, Oscillator Variable and Connecting Leads.

METHOD:

STEP 1. Turn the Horizontal Selector to External.

STEP 2. Connect the circuit as shown in Fig. 2.

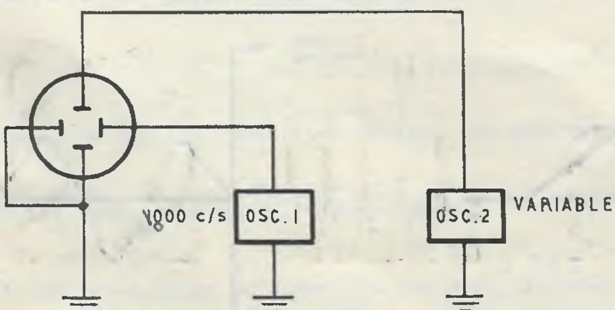


FIG. 2.

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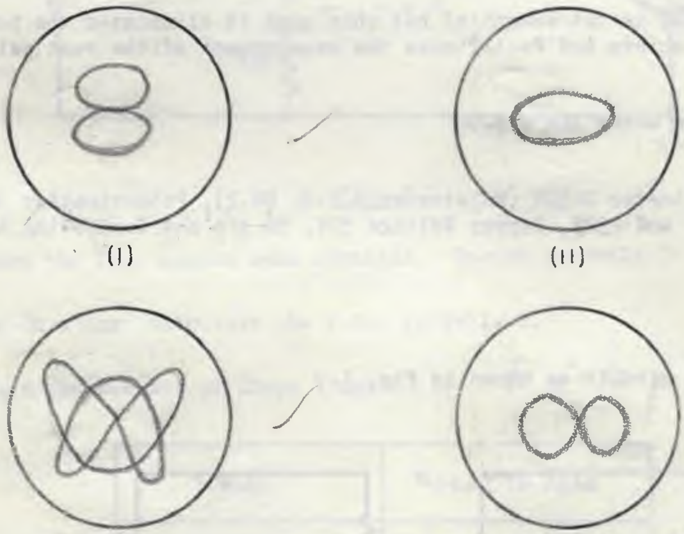
STEP 3. Set the variable oscillator to a frequency of -

(i) 800 c/s (4) (iii) ~~1500~~ 1200 c/s

(ii) 4000 c/s (8) (iv) ~~2000~~ 1600 c/s.

Record the pattern for each frequency on Figures 1-4 respectively.

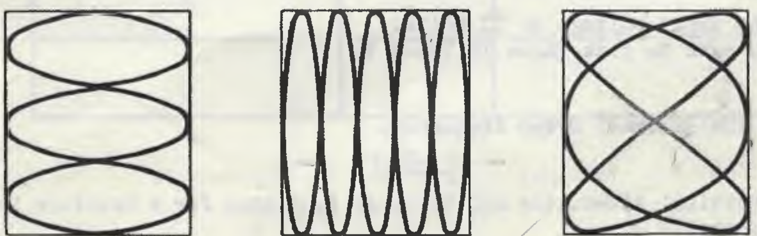


(I) (II) (III) (IV)

B.

TEST QUESTIONS.

1. When a known frequency of 5 kc/s is applied to the horizontal deflecting plates, determine the unknown frequency from the Lissajous patterns below.



(i) ...1.7K... c/s. (ii) ...25K... c/s. (iii) ...3.3K... c/s.

OSCILLOSCOPE - VOLTAGE MEASUREMENT.

The oscilloscope can be used to measure the peak to peak value of alternating voltage. When the C.R.O. is calibrated by applying a known voltage and calculating the volts per inch of screen, the unknown voltage can be found by direct comparison.

NOTE:- An internal sweep is not essential but when used it eliminates the possibilities of danger to the screen and facilitates the measurement of the vertical deflection.

AIM: To measure voltage using the C.R.O.

APPARATUS: C.R.O., Voltmeter 0-50V (Multimeter A.P.O. No.2), Potentiometer 5kΩ, Resistors 10kΩ, 15kΩ and 25kΩ, Supply Voltage 50V, 50 c/s and Connecting Leads.

METHOD:

STEP 1. Connect the circuit as shown in Fig. 1.

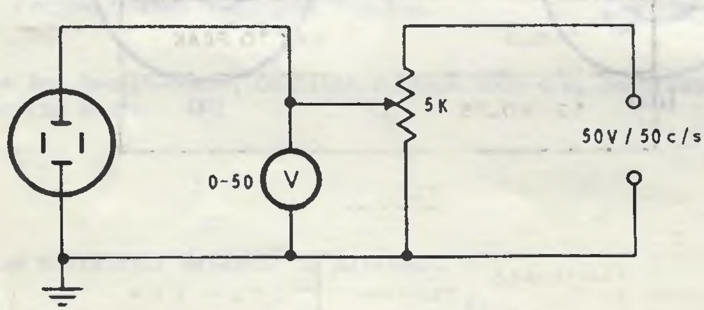


FIG. 1.

STEP 2. Adjust the input voltage to 50 Volts.
Calculate peak to peak value in Table 1.

STEP 3. Increase the Internal Sweep frequency.

STEP 4. Set the Vertical Attenuator and Vertical Amplitude for a waveform height of 2.8 inches.

NOTE POSITION OF CONTROLS.

STEP 5. Disconnect the input voltage from the C.R.O.

STEP 6. Connect the circuit as shown in Fig. 2.

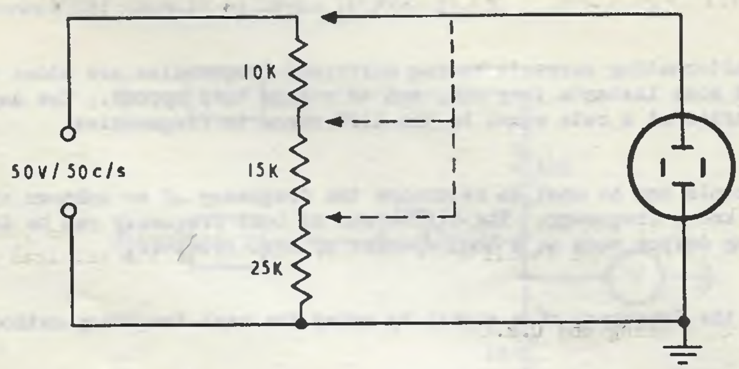


FIG. 2.

STEP 7. Measure the P.D. across each resistor. Record in Table 2.

STEP 8. Using Ohms Law, calculate the P.Ds. in Table 2.

STEP 9. Compare the results of Steps 7 and 8.

E_{RMS}	$E_{PEAK\ TO\ PEAK}$
50 VOLTS	

TABLE 1.

RESISTANCE	MEASURED P.D.	CURRENT	P.D. = I x R

TABLE 2.

TEST QUESTIONS.

1. Before measuring voltage the C.R.O. must be calibrated against a .... voltage.

2. When the C.R.O. is used to measure alternating voltage, it measures the peak to peak / effective / average voltage.

FREQUENCY MEASUREMENT (B.F. METHOD).

When two alternating currents having different frequencies are added together over a period of time, at some instants they aid, and at others they oppose. The amplitude of the resultant current varies at a rate equal to the difference in frequencies.

This principle can be used to determine the frequency of an unknown signal by "beating" it with a known frequency. The difference or beat frequency can be detected by a meter or a monitoring device such as a loud-speaker or head receiver.

AIM: To determine the frequency of a signal by using the beat frequency method.

APPARATUS: 2 Variable Oscillators, Resistor, Voltmeter 0-10V (Multimeter A.P.O. No.2), Amplifier, Loud-speaker, Head Receiver and Connecting Leads.

METHOD:

DEMONSTRATION

STEP 1. Connect the circuit as shown in Fig. 1.

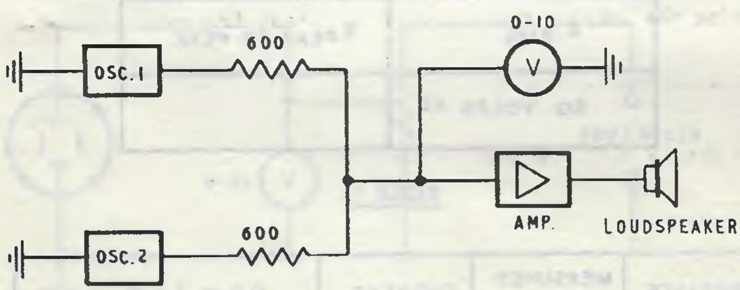


FIG. 1.

STEP 2. Set oscillator 1 to approx. 1,000 c/s.

STEP 3. Vary oscillator 2 until the signals start to beat -

Note (i) the variation of the meter.

(ii) the beat tone from the loud-speaker.

STEP 4. Continue to vary oscillator 2 until "Zero beat" is reached.

STEP 5. Record the frequency. .... c/s.

PROJECT.

STEP 1. Connect the circuit as shown in Fig. 2.

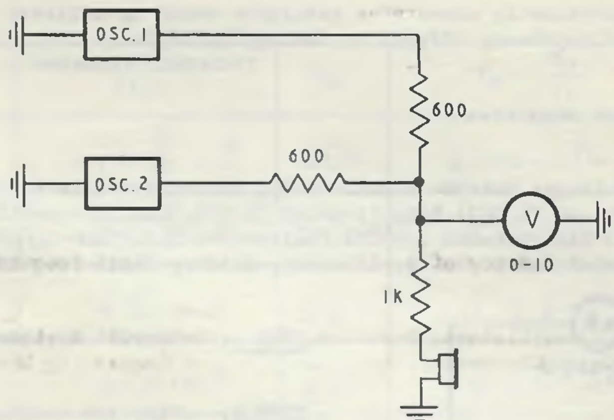


FIG. 2.

STEP 2. Adjust oscillator 1 to approximately 2000 c/s.

STEP 3. Determine the unknown frequency by the "beat frequency" method.

Answer .... c.p.s.

STEP 4. Repeat Step 2 with new unknown frequency.

Answer .... c.p.s.

TEST QUESTIONS.

1. The "beat frequency" is the .... in frequency between the known and the unknown frequencies.

2. When the two frequencies are identical, the beat frequency is ....

VOLTAGE REGULATION - SATURABLE CHOKE.

Voltage regulation by means of a saturable choke is achieved by using the output D.C. to vary the input impedance offered to the applied A.C.

AIM: To study voltage regulation.

APPARATUS: Supply Voltages 50V/50 c/s, 50V D.C., Saturable Choke (Trimax TP 1633 240/115V 0.7/1.35A or TA 763) Potentiometer 5k 50W, Milliammeter 0-50mA (Multimeter A.C. 1mA-10A) Milliammeter 0-500mA (Multimeter D.C. 50µA-1A), Voltmeter 0-50V (Multimeter A.P.O. No.2), Inductor, Battery Eliminator and Connecting Leads.

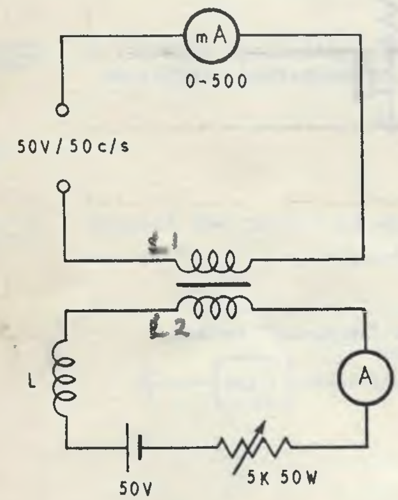


FIG. 1.

STEP 1. Connect the circuit as shown in Fig.1.

STEP 2. Vary the current through the saturable choke. Note the effect on the input A.C.

IVA L2 INCREASED DE — IVA L1 INCREASES DE

STEP 3. With the direct current at zero, measure the primary current. Record in Table 1.

STEP 4. Increase the direct current in 50mA steps to 200mA. Measure the primary current for each step. Record in Table 1.

STEP 5. Calculate the primary impedance for each value of direct current, in Table 1.

DEMONSTRATION

STEP 6. Connect the circuit as shown in Fig. 2.

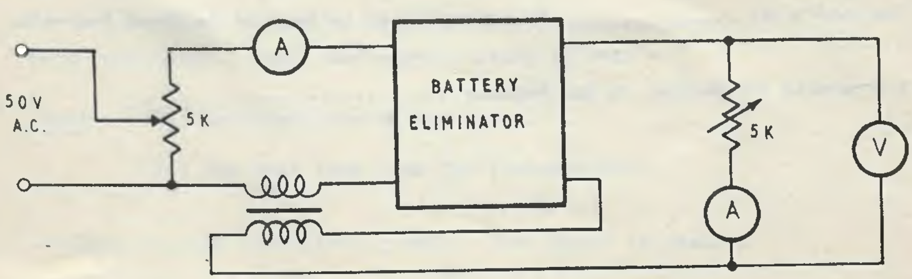


FIG. 2.

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STEP 2. Demonstrate (i) Manual regulation.

(ii) Automatic regulation.

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DIRECT CURRENT	PRIMARY CURRENT (I_p)	E_p	$Z_p = \frac{E_p}{I_p}$
0 mA	$16\frac{2}{3}$ mA	50V	3000Ω ✓
50 mA	$33\frac{1}{3}$ mA	50V	1500Ω ✓
100 mA	45 mA	50V	1111·1Ω ✓
150 mA	60 mA	50V	850 Ω ✗
200 mA			

TABLE 1.

TEST QUESTIONS.

1. What is the function of the saturable choke?

   2 TO BECOME MAGNETICALLY SATURATED BY DC THRU L2 AND TO DECREASE INDUCTIVE REACTANCE TO AC THRU L1 ✓

2. When the secondary load current increases, the P.D. across the load resistor ~~increases~~ ~~remains the same~~ decreases, and the impedance of the primary circuit ~~increases~~ ~~remains the same~~ decreases. 2 2