Electronics & Measurements Laboratory Manual

Laboratory Manual
Electronics & Measurements Laboratory

Department of Electronics & Instrumentation Engineering

VALLURUPALLI NAGESWARA RAO VIGNANA JYOTHI INSTITUTE OF ENGINEERING & TECHNOLOGY

AN AUTONOMOUS INSTITUTE

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Vignana Jyothi Nagar, Bachupally, Nizampet (S.O.), Hyderabad - 500 090. Telangana State, India.

(22PC2EI212) ELECTRONIC AND MEASUREMENTS LABORATORY

COURSE OBJECTIVES:
• To identify various semiconductor diodes and transistors
• Understand the characteristics and frequency response of semiconductor devices
• To make students design basic measuring circuits like bridges

COURSE OUTCOMES: After completion of the course, the student should be able to
CO-1: Understand the specifications of various semiconductor devices and their characteristics
CO-2: Analyze the frequency response of various semiconductor devices
CO-3: Appreciate the use of various bridges for measurement of R, L and C

List of Experiments:

1. V-I characteristics of PN junction diode and Zener diode under forward and reverse bias.
2. Full-wave Rectifier without filter and with filters
3. Input and Output characteristics of CE transistor configuration
4. Input and Output characteristics of CB transistor configuration
5. Input and Output characteristics of CC transistor configuration
6. Characteristics of FET
7. Frequency response of CE Amplifier.
8. Frequency response of CS Amplifier.
9. Measurement of resistance using wheat stone bridge.
10. Measurement of low resistance using kelvin bridge.
11. Measurement of capacitance using Schering bridge.
12. Measurement inductance using Maxwell's bridge and measurement of L, C and R using Q meter.

EXP-1
V-I CHARACTERISTICS OF PN JUNCTION DIODE AND ZENER DIODE UNDER FORWARD AND REVERSE BIAS

EXP- 1A.
V-I CHARACTERISTICS OF PN JUNCTION DIODE

Aim:

a) To plot the V–I characteristics of a Semiconductor PN – Junction diode.
b) To find the following parameters from the Forward & Reverse characteristics.

i) Cut in voltage-V_γ
ii) Static forward resistance R_F
iii) Reverse saturation current-I_{co}
iv) Dynamic forward resistance-r_f
v) Dynamic reverse resistance-R_r

Apparatus:

1) A PN Junction Diode (DR25 / 1N4148), 180Ω & 10K.Ω Resistors
2) Power Supply (0-30V)
3) Digital multimeter (0-1V)
4) Ammeter (0-100mA)
5) Ammeter (0-500µA)

Circuit diagram:
Forward characteristics of a Diode is shown in Fig.1.

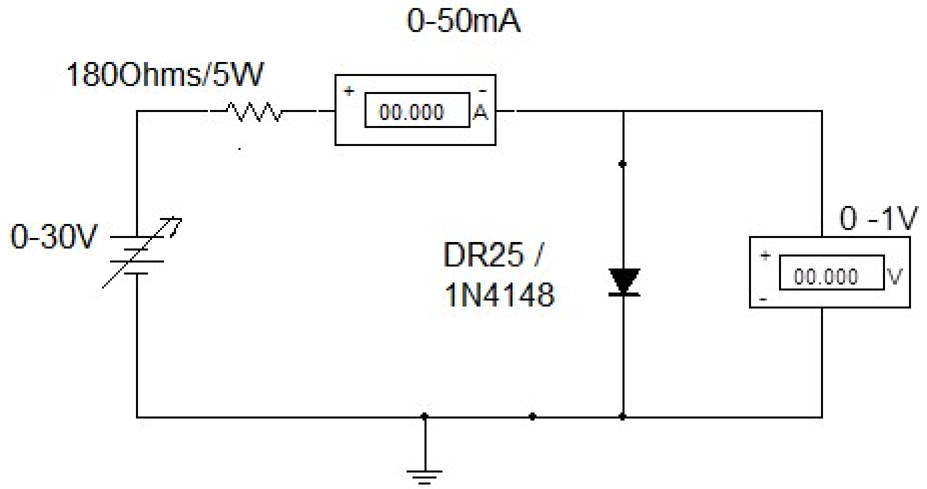


Fig.1

Theory :

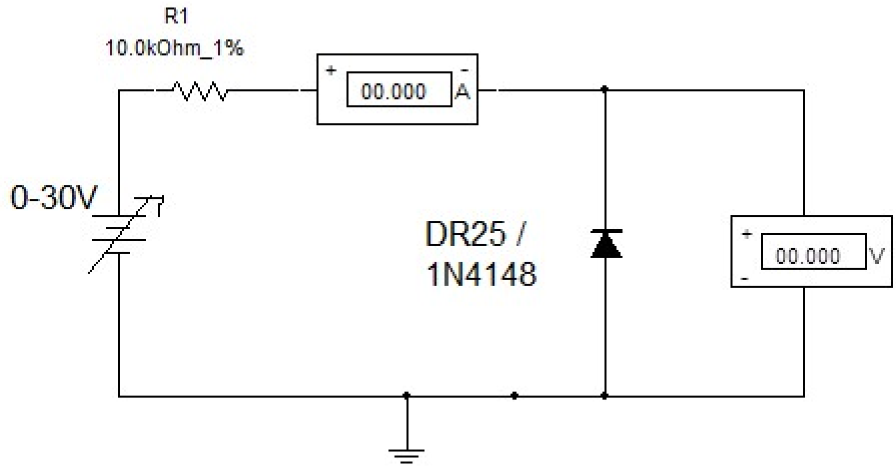
Under forward bias configuration the positive terminal of the battery is connected to P-side and negative terminal of the battery is connected to N-side as shown in the figure above. Large amount of current flows through the junction under this condition.

When P-N junction is forward biased, the holes are repelled from the positive electrode and the electrons from the negative electrode of the power supply, and are forced to move towards the junction. Some of the holes and electrons in the depletion region recombine themselves. This reduces the width of the depletion layer and the height of the potential barrier. As a result of this more number of majority charge carriers flow through the P-N junction.

Procedure :

i. Ensure that D.C Power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.
ii. Connect the circuit as shown in Fig –1 for forward characteristics making use of silicon diode.
iii. Vary the power supply voltage such that the voltage across the diode is varied 0-1V in steps of 0.1 volts .Note down V_f and I_f in the table.
iv. Draw the V_f, I_f characteristics and find out the cut – in voltage V_r for diode from it. Ensure that the current through the diode does not exceed 50mA.
v. Repeat the experiment using germanium diode.
vi. Present the results at the end of the experiment.
vii. Estimate the forward resistance of the diode from the relation = [ΔV_f / ΔI_f]

Circuit diagram:
Reverse characteristics of a Diode is shown in Fig.2.



Theory :

In the reverse bias positive electrode of the battery is connected to N-side and the negative electrode to P-side. When a P-N junction is reverse biased, the holes in the P region are attracted towards the negative electrode of the battery and the electrons in the N region are attracted towards the positive electrode.

Thus the majority carriers are drawn away from the junction. This widens the Depletion layer and increases the height of the potential barrier. Hence there is no current flow due to majority carriers under reverse bias. A small amount of current due to diffusion of minority charge carriers across the junction flows through the reversed biased PN junction. Generation of the minority carriers is dependent upon the ambient temperature and is independent of the applied reverse voltage, as can be seen from the graph.

Procedure:
i. Connect the circuit as shown in Fig-2 for reverse bias characteristics making use of a Silicon diode
ii. Vary the voltage across the diode from 0-20 volts in steps of 1V and record the reverse saturation current in µA.

iii. Draw the reverse characteristics Vr, Ir .

iv. Find out the reverse saturation current Ir. Estimate the reverse resistance R_r from the Characteristic curve from the relation $R_r = [\Delta V_r / \Delta I_r]$

v. Repeat the experiment using germanium diode.

vi. Present the results at the end of the experiment.

Forward Characteristics

TABLE-I

V_f (Volts)	I_f (mA)
0.0	
0.1	
-	
-	
-	
-	
-	
-	
1.0	

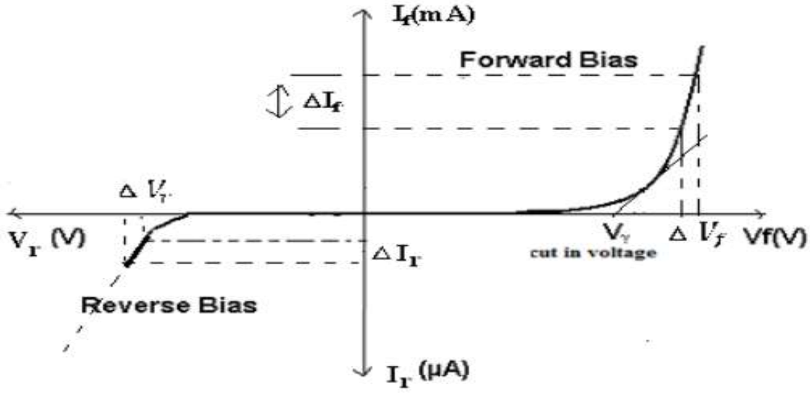
Reverse Characteristics

TABLE-II

V_r (Volts)	I_R (µA)
0.0	
2.0	
-	
-	
-	
-	
-	
20.0	

Forward and Reverse Characteristic curves :

The observations are plotted in Fig.3



Results:

The parameters of the Silicon and Germanium diodes are estimated from the static forward and reverse characteristics and are presented below.

The Cut-in Voltage of Si diode is = __________ V

The Static resistance of the diode in forward bias = __________

The Dynamic Resistance of the diode in forward bias = __________

Discussions:

1. What are the cut-in voltages for the two diodes used ? Give reasons why they are different?
2. What is meant by forward and reverse bias ?
3. Name the applications of the diodes.
4. What is meant by depletion layer or intrinsic / Space charge region
5. What is meant by recombination?
6. Write examples of N type & P type materials?
7. What is reverse Saturation Current?

EXP- 1B

ZENER DIODE CHARACTERISTICS

Aim :

To Plot the V – I Characteristics of a Zener diode.

Apparatus :

i. Circuit Board containing 8Z2 Zener diode, 180Ω & 10K.Ω Resistors
ii. Regulated Power supply (0-30V)
iii. Ammeters (0 - 50mA) – 3 No.s
iv. Decade Resistance Box
v. Voltmeter (0-20V)

Circuit

Zener Diode under Reverse Bias :

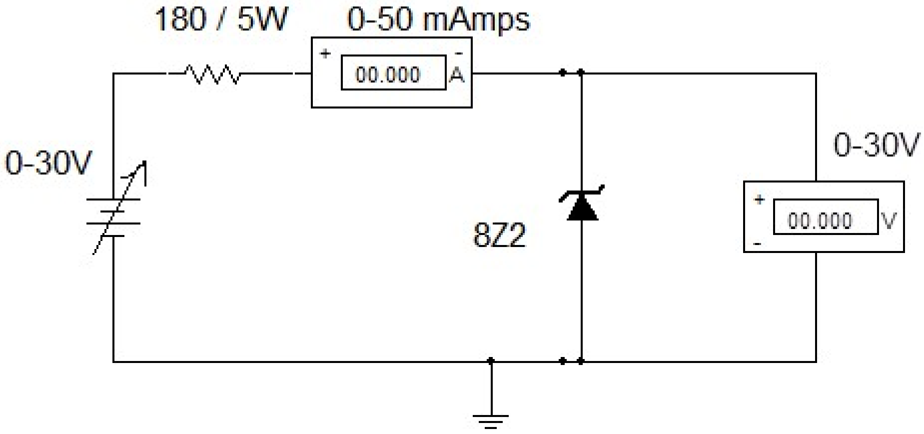


Fig.1

Theory:

When the Zener Diode is operated under forward biased condition it behaves exactly similar to an ordinary P-N Junction Diode. It exhibits the same identical characteristics.

The Zener diode is a Silicon PN junction device. It is operated in the reverse breakdown region. When a reverse voltage across a diode is increased a critical voltage called a breakdown voltage is reached at which the reverse current increases rapidly. The reverse breakdown of a PN junction may occur either due to Avalanche breakdown effect or Zener breakdown effect or both.

Procedure:

i. Connect the circuit as per the Diagram shown in Fig –1
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.
iii. Vary the power supply such that the increment in the input voltage, Vi is 2V. Record the corresponding values of Vz voltage across the Zener Diode and Iz current through the Zener as shown in Table-I. Do not exceed the Zener current Iz more than the 50 mA.
iv. Plot V – I characteristics of Zener diode in reverse bias region as shown in graph Identify the Zener break down voltage Vz.

v. Calculate the resistance of the Zener diode in the linear part of the breakdown region with the help of the formula $R_Z = [\Delta V_Z \ / \ \Delta I_Z]$

vi. Present the results at the end of the experiment.

Table-I: v – i characteristics of Zener diode Under Reverse Bias

SUPPLY VOLTAGE Vi (volts)	VOLTAGE ACROSS ZENER Vz (Volts)	CURRENT THROUGH ZENER Iz(ma)
0.0		
20.0		

RESULTS:

i. Zener breakdown voltage V_{br} =

ii. Zener resistance in the breakdown region R_Z =

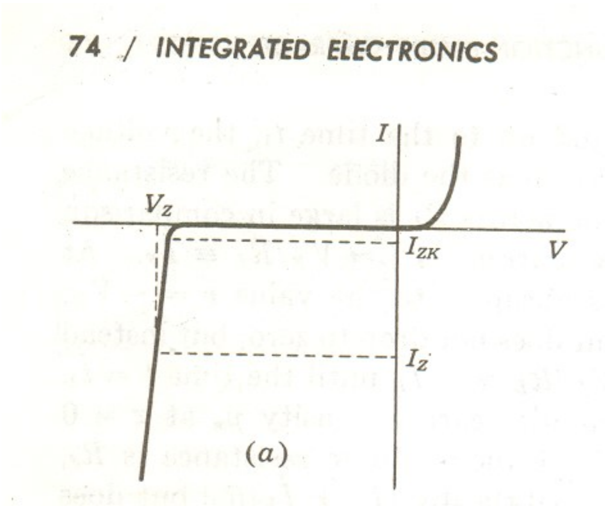
Discussions:

i. Name the applications of Zener diodes?

ii. Explain Zener effect and avalanche effect?

iii. Why Zener diode characteristics are taken in reverse bias?

Expected Graph:



$R_Z = [\Delta V_Z \ / \ \Delta I_Z]$ Ir

EXP-2

FULL-WAVE RECTIFIER WITHOUT FILTER AND WITH FILTERS

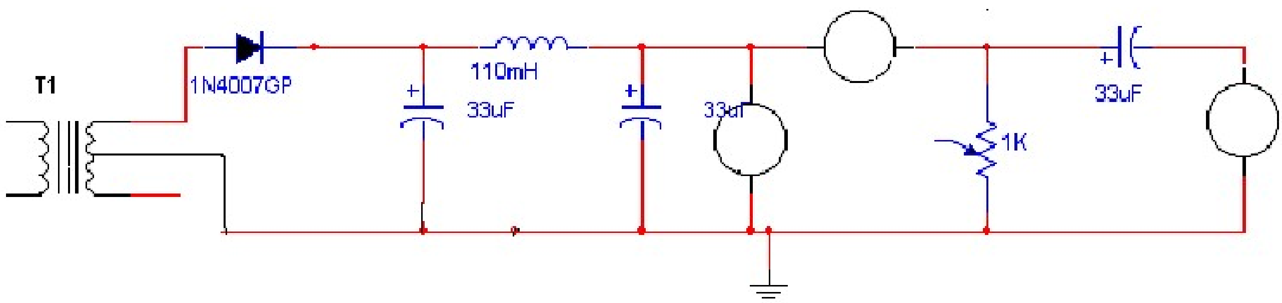
HALF – WAVE RECTIFIER

AIM: a) To connect a Half - Wave rectifier.
b) To measure D.C. and ripple voltages for different filter configurations.
c) To observe the out put wave forms using a CRO and
d) To study the load characteristics of the rectifier without any filter and with C, L and π section filters.

APPARATUS:

Circuit board.
Ammeter (0-100mA)
Voltmeter (0-30V)
Patch cords.
Cathode ray Oscilloscope.

CIRCUIT DIAGRAM:



PROCEDURE :

1. Connect the circuit diagram as shown in figure.

2. Note down the voltage at secondary of transformer with AC digital voltmeter.

3. To study the performance of the Half- wave rectifier Without any filter and with different filters.

a) Record the observations in the following table by noting down the Vdc and Vac corresponding to different Idc load currents. First note down the No-load voltage Vdc and Vac corresponding to Idc=0. Then increase the load current insteps of 5mA up to a maximum of 50 mA by varying the load resistance Rl. At each value of Idc note down the corresponding value theVdc, Vac(RMS value of ripple out put voltage) and corresponding out put wave forms.

TABLE

Idc (mA)	Vdc (volts)	Vac V(rms)	RL = Vdc / Idc	Ripple factor ρ=Vac/Vdc	%Regulation r={(Vnl-Vl)/Vnl }x100

0 5 10 . . . 50	*				

*Note -Vdc corresponding to Idc=0 will be the no-load voltage = Vnl.

Plot the graphs a) Idc vs Vdc b) Calculate the % of regulation at different load currents and Plot the graph as shown in the diagram using the formula.

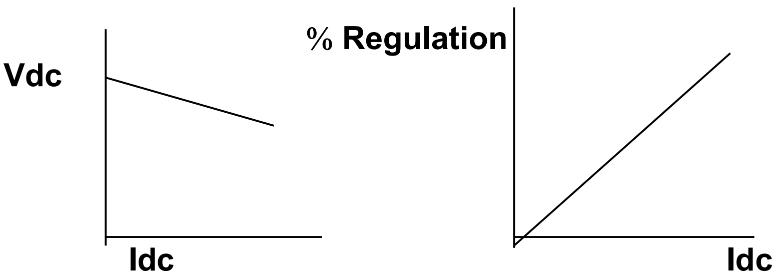
% Regulation r = {(Vnl-Vl)/Vl} x 100 , Idc = constant (=25mA),ripple factor will be zero at Idc=0(since Vnl and Vl be the same at Idc=0).

ρ = Iac / Idc = Vac / Vdc.

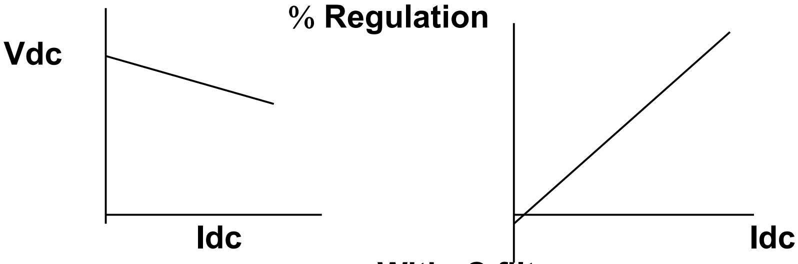
4. To study the performance of Half-wave rectifier without any filter and with different filters repeat the experimental procedure of step 3 in corresponding to 1.Shunt capacitor filter 2. Inductor filter. 3.L-section filter 4. π - section filter.

Compare the result of step 3 and 4 with theoretical values.

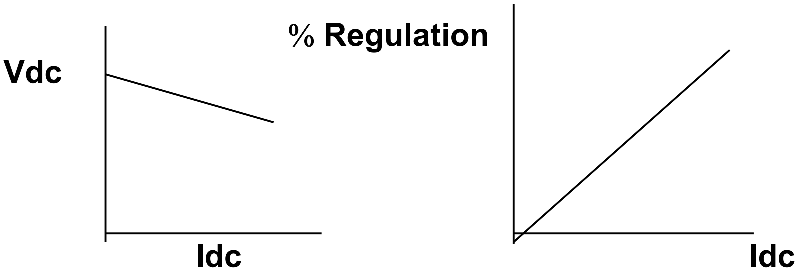
<u>Model Graphs :</u>



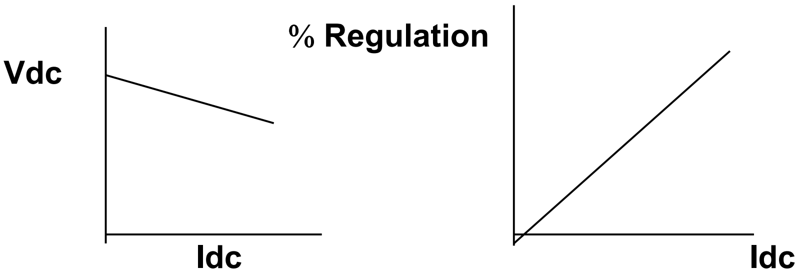
With out filter



With C filter



With L Sectiont filter



With Π filter

<u>Results & Discussions :</u>

It is observed Experimentally that

1.---------- filter gives better regulation.

2. --------- filter gives better ripple factor.

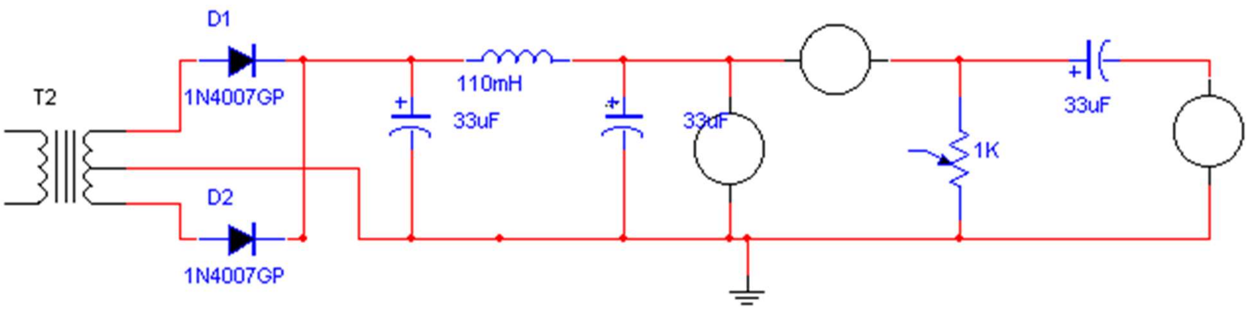
FULL - WAVE RECTIFIER

AIM : a) To connect a Full - Wave rectifier.
b) To measure D.C. and ripple voltages for different filter configurations.
c) To observe the out put wave forms using a CRO and
d) To study the load characteristics of the rectifier without any filter and with C L and π section filters.

APPARATUS :

Circuit board.
Ammeter (0-100mA)
Voltmeter (0-30V)
Patch cords.
Cathode ray Oscilloscope.

CIRCUIT DIAGRAM :



THEORY:

Any electrical device, which offers a low resistance to current in one direction but the high resistance to the current in the opposite direction, is called rectifier. They are capable of converting a sinusoidal input waveform into a Uni directional waveform.

PROCEDURE

1.Connect the circuit diagram as shown in figure.

2.Note down the voltage at secondary of the transformer with AC digital voltmeter.

3. To study the performance of the Half- wave rectifier Without any filter and with different filters.

a) Record the observations in the following table by noting down the Vdc and Vac corresponding to different I_{dc} load currents. First note down the No-load voltage Vdc and V_{ac} corresponding to Idc=0. Then increase the load current insteps of 5mA up to a maximum of 50 mA. At each value of Idc note down the corresponding value Vdc, Vac(RMS value of ripple out put voltage) and the corresponding out put wave forms.

TABLE :

Idc (mA)	Vdc (volts)	Vac (Vrms)	RL = Vdc / Idc	Ripple factor ρ=Vac/Vdc	%Regulation r={(Vnl-Vl)/Vnl }x100
0					
5					
10					
.					
.					
.					
50					

* Note- Vdc corresponding to Idc=0 will be the no-load voltage = Vnl.

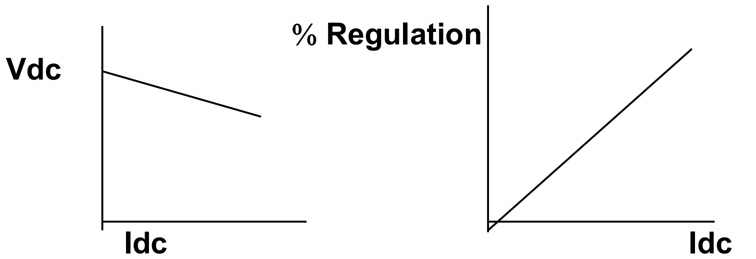
Plot the graphs a) Idc vs Vdc b) Calculate the % of regulation at different load currents and plot the graph Il as shown in the diagram using the formula.
% Regulation r = {(Vnl-Vl)/Vl} x 100 | Il = constant (=25mA),which will be zero at Il=0(since Vnl and Vl be the same at Il=0).

ρ = Iac / Idc = Vac / Vdc.

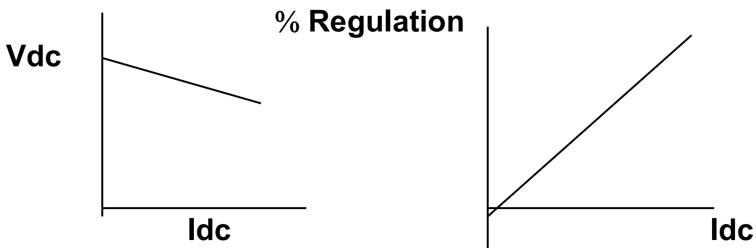
4. To study the performance of Half-wave rectifier without any filter and with different filters repeat the experimental procedure of step 3 in corresponding 1.Shunt capacitor filter 2. Inductor filter. 3.L-section filter 4. π - section filter.

Compare the reading of step 3 and 4 with theoretical values.

Model Graphs :



With out filter



With C filter

Results & Discussions :

It is observed Experimentally that

1.----------- filter gives better regulation.

2.----------- filter gives better ripple factor.

EXP-3
STATIC CHARACTERISTICS OF TRANSISTOR IN COMMON BASE CONFIGURATION

Aim :
To obtain the input and output characteristics of the given transistor in CB configuration.

Apparatus :
i. Circuit board containing CL100 Transistor, Resistors
ii. Ammeters (0-50mA) – 2 Nos.
iii. Voltmeters (0-1 V,& 0-30 V)
iv. Patch cords.
v. Regulated Power Supply.

1. Input Characteristics :

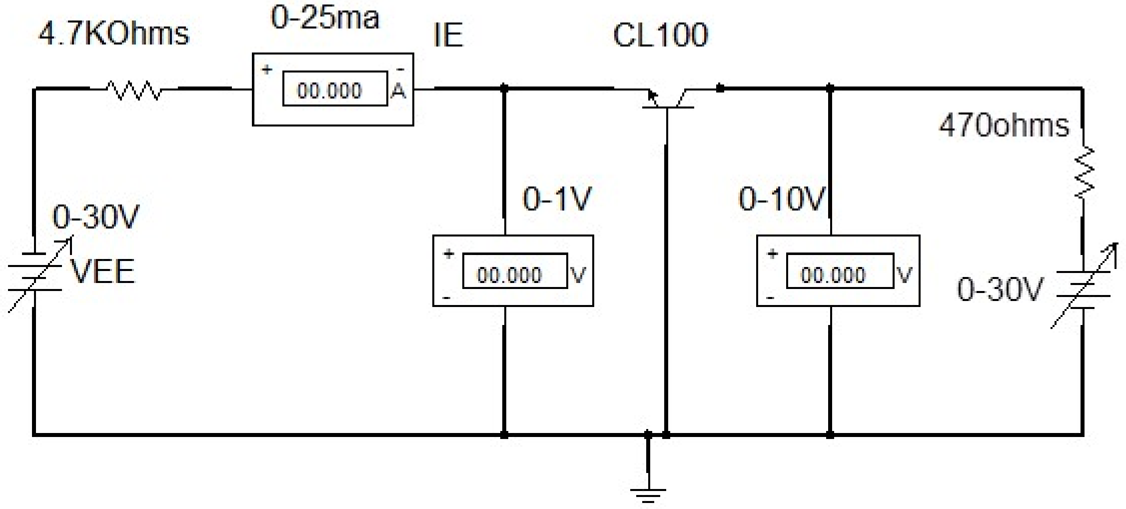


Fig.1

Theory:
Input characteristic curves give the relationship between the emitter current [I_E] and the emitter to base voltage[V_{EB}] for a constant collector to base voltage [V_{CB}]. As the collector to base voltage (V_{CB}) is increased above one volt, the curve shifts upwards. It occurs due to the phenomenon called "Base width Modulation" or "Early Effect".

Procedure:
i. Connect the circuit as shown in Fig-1.
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.
iii. Switch ON the power supply. Adjust V_{cc} such that Vcb is zero.
iv. Vary I_E with the help of V_{EE} in steps(say 2mA)and record the corresponding values of V_{BE} in the Table-I shown below. Make sure that the collector current, I_c does not exceed 25mA.
v. This set of observations gives the input characteristics With V_{CB}=0V.
vi. Repeat steps from 1 to 4 for different values of V_{CB} say V_{CB} = 5V , 10V and for V_{CB} open (This can be done by opening one of the out put terminals.)
vii. Draw the input characteristics I_E Vs V_{EB} for different values of V_{CB} as shown In Fig.3(a).

viii. Present all the results at the end of the experiment.

Table-I: Input Characteristics

S. No.	V_{CB} = 0 V		V_{CB} = 5 V		V_{CB} = 10 V		V_{CB} = OPEN	
	I_E (mA)	V_{EB} (V)	I_E (mA)	V_{EB} (V)	I_E (mA)	V_{EB} (V)	I_E (mA)	V_{EB} (V)
1	0							
2	5							
3	10							
.	15							
.	20							
	25							

2. Output Characteristics:
The Circuit diagram for the study of output characteristics of a Transistor in common-base configuration is shown in Fig.2.

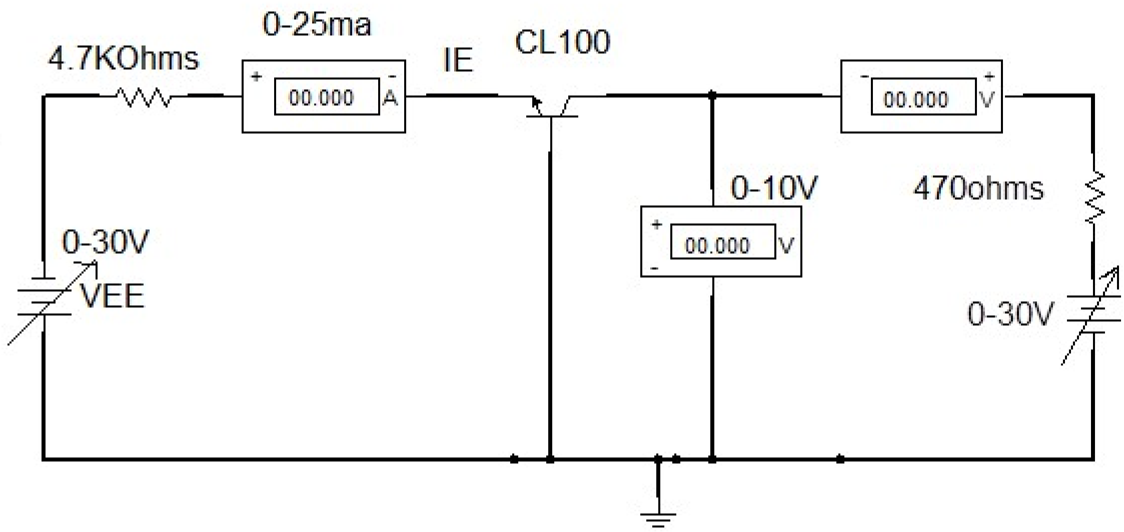


Fig.2

Theory:

Output characteristic curves give the relationship between the collector current (I_C) and the collector to base voltage (V_{CB}) for a constant emitter current (I_E). The curve may be divided into three important regions namely saturation region, active region, and cut-off region.

Procedure:

i. Connect the circuit as per the circuit Diagram shown in Fig – 2.
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the Minimum position and current control knob in maximum position.
iii. Switch ON the power supply. Adjust V_{EE} to get I_E=0 mA.
iv. Fix the collector to base voltage (V_{CB}). Record the corresponding values of collector currents, I_C in the table shown below .

v. Repeat the steps from 1 to 4 for different values of I_E from 1 to 10ma.(not exceed to 25 ma)

vi. Draw the output characteristics V_{CB} Vs I_C for different values of V_{CB}.

vii. Present all the results at the end of the experiment.

Table – II: Output Characteristics

S. No.	I_E=0mA		I_E=10 mA		I_E=20 mA		I_E=30 mA	
	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)	V_{CB} (V)	I_C (mA)
1 2 3 . .	0 10							

Results:

The input and output characteristics are drawn and are shown in Fig.3(a)and Fig.3(b). The following hybrid parameters are estimated from the graphs.

From the input characteristics we obtain

$$h_{ib} = [\Delta V_{EB} / \Delta I_E] \quad \text{at } V_{CB} = \text{constant.}$$
$$h_{rb} = [\Delta V_{EB} / \Delta V_{CB}] \text{ at } I_E = \text{constant.}$$

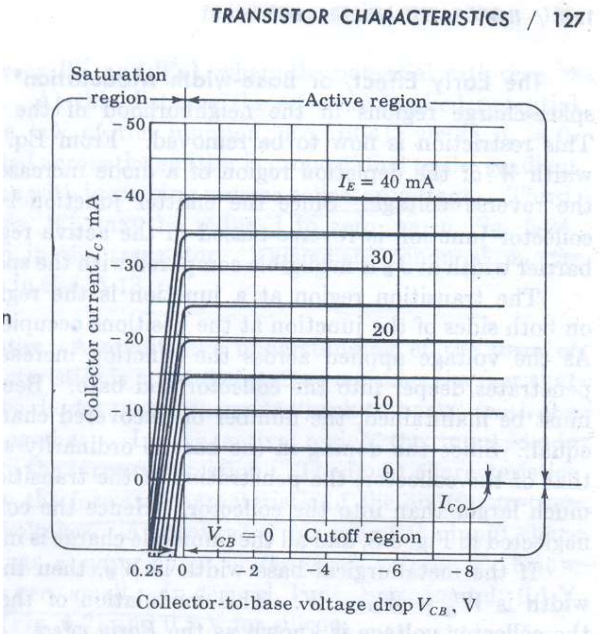
From the output characteristics we obtain

$$h_{ob} = [\Delta Ic / \Delta V_{CB}] \quad \text{at } I_E = \text{constant.}$$
$$h_{fb} = [\Delta Ic / \Delta I_E] \quad \text{at } V_{CB} = \text{constant}$$

Discussions :

i. Indicate the various regions, (Active region, Saturation region and cut off region) on the Out put characteristics of the transistor and discuss them.

ii. What does early effect or Base width modulation means?



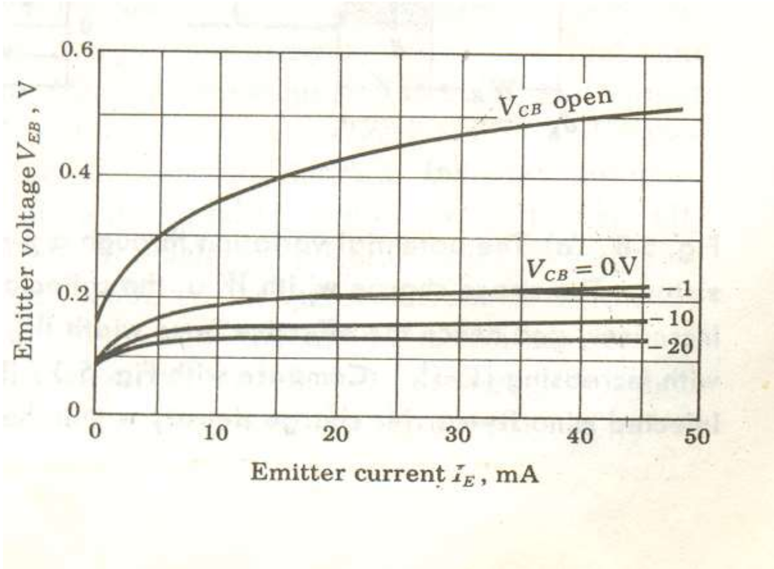


Fig.3

hib = $[\Delta V_{EB} / \Delta I_E]$ at V_{CB} = constant. hob = $[\Delta I_c / \Delta V_{CB}]$ at I_E = constant.

hrb = $[\Delta V_{EB} / \Delta V_{CB}]$ at I_E = constant hfb = $[\Delta I_c / \Delta I_E]$ at V_{CB}= constant

EXP-4
STATIC CHARACTERISTICS OF TRANSISTOR IN COMMON EMITTER CONFIGURATION

AIM:
To obtain the input and output characteristics of given transistor in CE configuration.

APPARATUS:
i. Circuit board
ii. Ammeters (0-50mA) – 2 Nos.
iii. Voltmeters (0-1 V, 0-30 V)
iv. Patch cords.
v. Regulated Power Supply.

1. Input Characteristics.

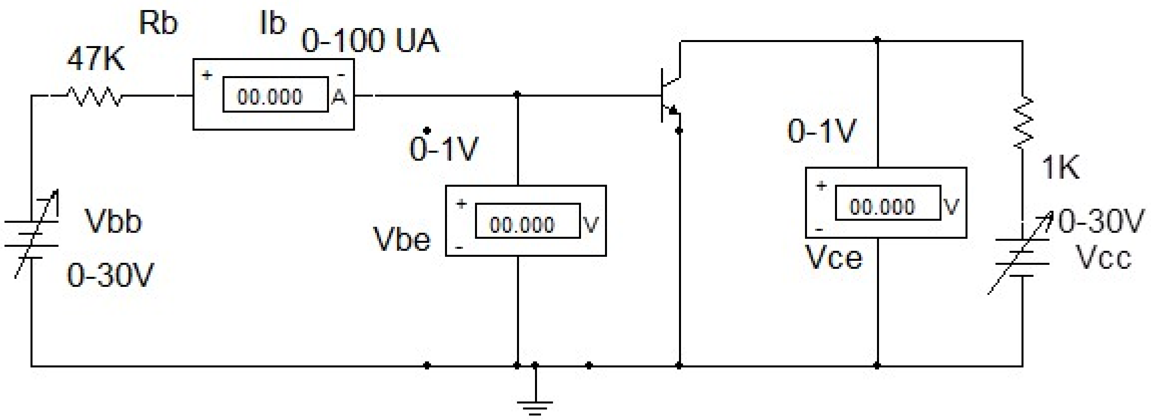


Fig.1

Theory:

These curves give the relationship between the base current (I_B) and the base to emitter voltage (V_{BE}) for a constant collector to emitter voltage (V_{CE}). As the collector to emitter voltage is increased above 1V, the curves shifts down wards because as V_{CE} is increased, the depletion width in the base region increases and this reduces the effective base width, which in turn reduces the base current.

Procedure :

i. Connect the circuit as shown in Fig-1.
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.
iii. Switch ON the power supply. Adjust V_{CC} such that V_{CE}=0V (this can also be done by Switching OFF the Vcc supply and shorting the two outputs leads. Vary I_B with the help of V_{BB} in steps of 10μA and record the corresponding values of V_{BE} in the Table –I shown below and record the corresponding values of V_{BE} (base to emitter voltage).

iv. Make sure that the collector current I_c does not exceed 25mA. This set of readings gives the input characteristics of V_{CE}=0V.
v. Repeat steps (1-4) for different values of V_{CE} say V_{CE} =0.1 v, 0.2V, 0.3V, 1V.
vi. Draw input characteristic I_B Vs V_{BE} for different values of V_{CE}.
vii. Estimate h-parameters from the characteristic curves.

viii. Present all the results at the end of the experiment.

Table – I: Input Characteristics

SNO	V_{CE}=0V		V_{CE}=0.2V		V_{CE}=0.4V		VCE=1V	
	I_B (μ Amp)	V_{EB} (V)	I_B (μ Amp)	V_{EB} (V)	I_B (μ Amp)	V_{EB} (V)	I_B (μ Amp)	V_{EB} (V)

2. Output Characteristics:

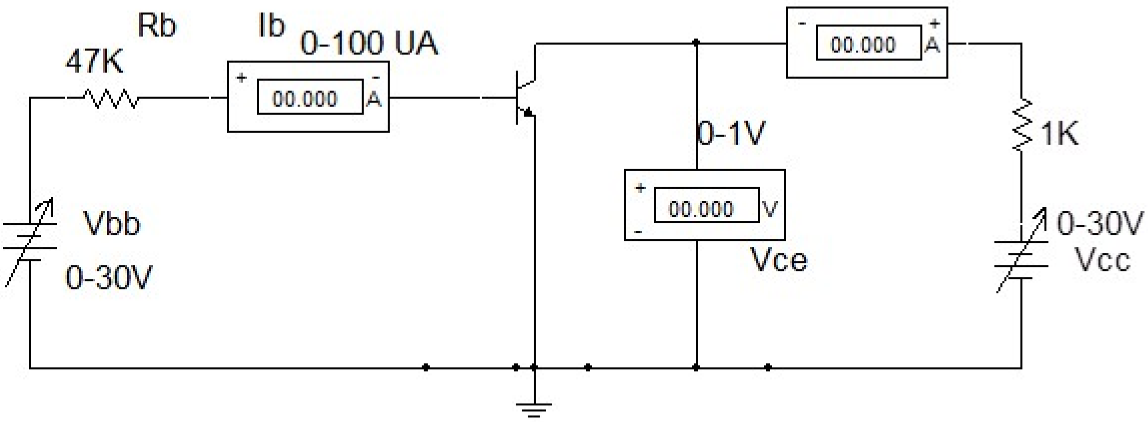


Fig.2

Theory:

Output characteristic gives the relationship between the collector to emitter voltage (V_{CE}) and collector current(I_C) for a constant base current (I_B).

The curves may be divided into three important regions namely Saturation region Active region and Cut-off region.

Procedure:

i. Connect the circuit as per the Diagram shown in Fig – 2

ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position. Switch ON the power supply.

iii. With the help of power supply V_{EE} make the input current I_B=10μA. Vary collector to Emitter voltage (V_{CE}) in suitable steps of 0.1 volts starting from 0 volts. Record the corresponding values of collector currents I_C, in the Table-II. This set of readings gives the output characteristics for I_B=10μA.

iv. Repeat step iii for different values of base current say I_b=10μA-100μA in steps of 10μA.

v. Draw the output characteristic V_{ce} vs I_C.

vi. Estimate h-parameters from the characteristics curve.

vii. Present all the results at the end of the experiment.

Table-II: Output Characteristics

S.No.	I_B=20μA		I_B=40μA		I_B=60μA		I_B=80μA	
	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)	V_{CE} (Volts)	I_C (mA)

Results:

The input and output characteristics are drawn & are shown in Fig.3(a)and Fig.3(b). The e following hybrid parameters are estimated from the graphs.

From the input characteristics

hie= $\Delta V_{BE}/ \Delta I_b$ at V_{CE}= constant.

hre= $\Delta V_{BE}/ \Delta V_{CE}$ at I_b= constant.

From the output characteristics

h_{oe}= $\Delta Ic / \Delta V_{CE}$ at I_B=constant.

h_{fe}= $\Delta Ic / \Delta I_b$ at V_{CE}= constant

Discussions :

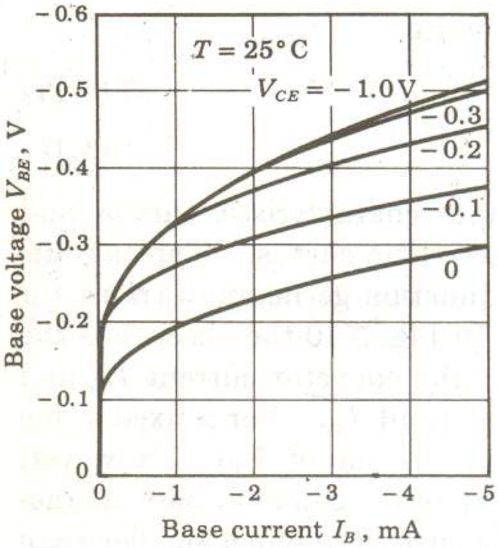
i. Indicate the various regions, (Active region, Saturation region and cut off region) on the out put characteristics of the transistor.

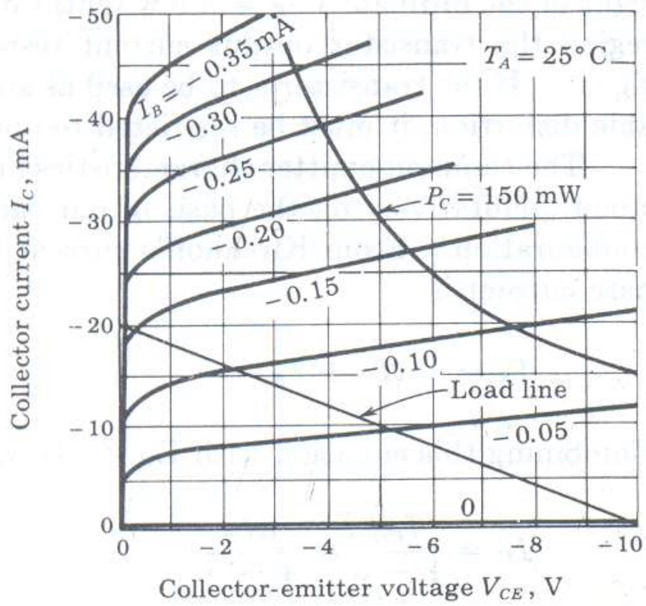
ii. Estimate Ic and V_{ce} from the circuit shown

iii. What are the differences between common emitter and common base input and out put characteristics?

Input Characteristics

Output Characteristics





$h_{ie} = \Delta V_{BE} / \Delta I_B$ at V_{CE} = constant.

$h_{re} = \Delta V_{BE} / \Delta V_{CE}$ at I_B = constant

$h_{oe} = \Delta I_c / \Delta V_{CE}$ at I_B = constant.

$h_{fe} = \Delta I_c / \Delta I_B$ at V_{CE} = constant

EXP-5
STATIC CHARACTERISTICS OF TRANSISTOR IN COMMON COLLECTOR CONFIGURATION

Aim:
To obtain the input and output characteristics of given transistor in CC configuration.

Apparatus:
1. Circuit board containing BC107 / CL100 Transistor & Resistors
2. Ammeters (0-50mA) – 2 Nos.
3. Voltmeters (0-1 V, 0-30 V)
4. Patch cords.
5. Regulated Power Supply.

2. Input Characteristics :
The Circuit diagram for the study of input characteristics of a Transistor in common-collector configuration is shown in

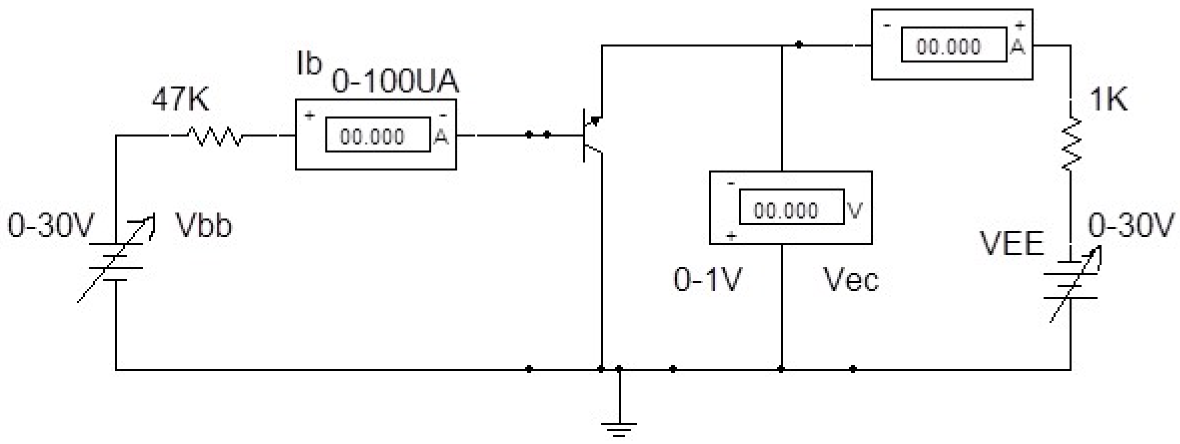


Fig.1

Theory :
Input characteristic curves give the relationship between the base current (I_B) and the base to collector voltage (V_{BC}) for a constant collector to base voltage (V_{EC})

Procedure :

i. Connect the circuit as shown in Fig-1.
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.
iii. Switch ON the power supply. Adjust V_{EC} =2V
iv. Vary I_B with the help of V_{BB} in steps of 10µA and record the corresponding values of V_{BC} in the Table –I. Make sure that the collector current I_C does not exceed 25mA.
v. Repeat steps from i to iv for different values of V_{EC} say V_{EC} =5V, 10V and for V_{BC} open (This can be done by opening one of the output terminals).
vi. Draw the input characteristics I_B verses V_{BC} for different values of V_{EC} in Fig.3(a).
vii. Estimate h-parameters from the characteristics curve.
viii. Present all the results at the end of the experiment

Table – I Input Characteristics

S.No.	V_{CE} =2V		V_{CE} =5V		V_{CE} =10V		V_{CE} =open	
	I_B (μA)	V_{BC} (Volts)	I_B (μA)	V_{BC} (Volts)	I_B (μA)	V_{BC} (Volts)	I_B (μA)	V_{BC} (Volts)
1.	0		0		0		0	
2.	5		5		5		5	
3.	10		10		10		10	
4.	20		20		20		20	
5.	30		30		30		30	
6.	40		40		40		40	
7.	50		50		50		50	

Output Characteristics :

The Circuit diagram for the study of output characteristics of a Transistor in common-collector configuration is shown in Fig.2

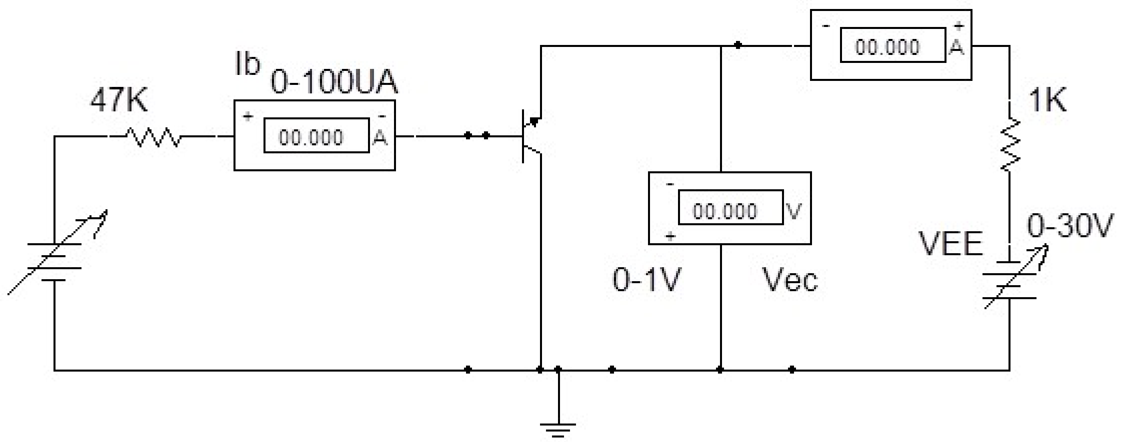


Fig.2

Theory :

The output characteristics curves give the relationship between collector to emitter voltage (V_{EC}) and the emitter current (I_E)

Procedure :

i. Connect the circuit as shown in Fig-2.

ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.

iii. Switch ON the power supply. Adjust Ib=20μA

iv. Fix the base current volue(Ib) . Record the corresponding values of emitter current (I_E) by varying the volues of V_{CE} from 1 TO 20 in the steps of 2V by adjusting V_{EE}.

v. Repeat steps from i to iv for different values of Ib say Ib=0μA,40μA,60μ

vi. Draw the output characteristics for different values of V_{EC} in Fig.3(b).

vii. Present all the results at the end.

Table – II Output Characteristics

S.No.	I_B =20(μA)		I_B =40(μA)		I_B =60(μA)		I_B =80(μA)		I_B =100(μA)	
	V_{EC} (Volts)	I_E (mA)	V_{EC} (Volts)	I_E (mA)	V_{EC} (Volts)	I_E (mA)	V_{EC} (Volts)	I_E (mA)	V_{EC} (Volts)	I_E (mA)
1.										
2.										
3.										
4.										
5.										
6.										
7.										

Results :

The input and output characteristics are drawn and the following hybrid parameters are estimated from the graphs.

hic = $\Delta V_{BC} / \Delta I_b$ at V_{EC}= constant.

Hrc = $\Delta V_{BC} / \Delta V_{EC}$ at I_B= constant.

Are computed from the input characteristics

hoc = $\Delta I_E / \Delta V_{EC}$ at $I_{B=}$constant.

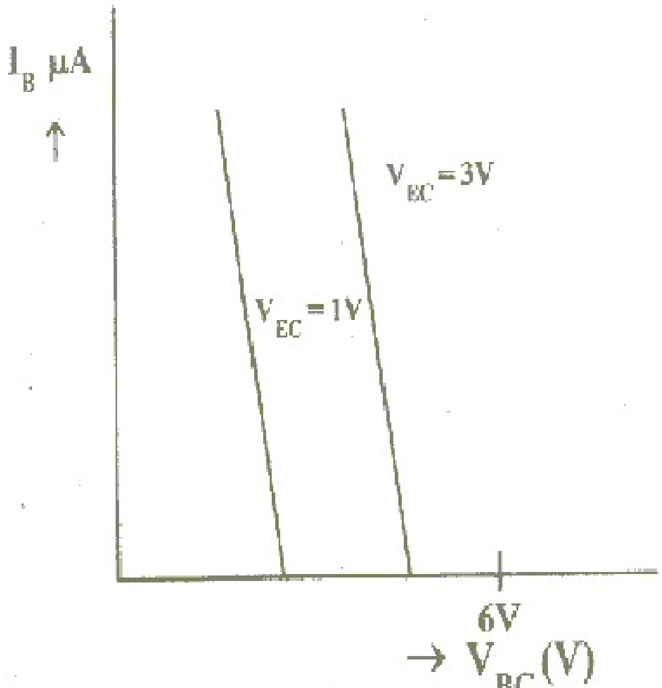
Hfc = $\Delta I_E / \Delta I_B$ at V_{EC}= constant

Are computed from the output characteristics

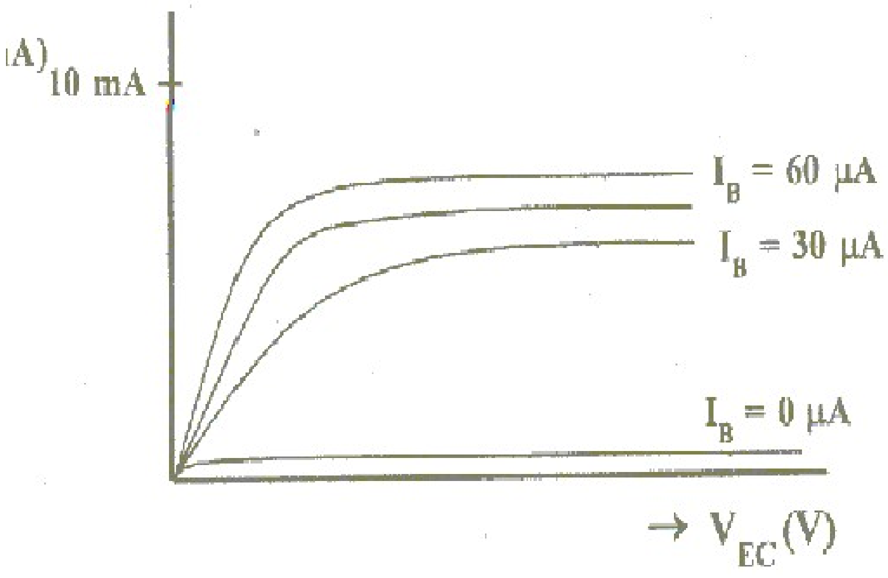
Discussions : Indicate the various regions (Active region, Saturation region and cut-off region) on the output characteristics of the transistor and discuss them.

$h_{ic} = \Delta V_{BC} / \Delta I_b$ at V_{EC}= constant. $h_{oc} = \Delta I_E / \Delta V_{EC}$ at I_B=constant.

$h_{rc} = \Delta V_{BC} / \Delta V_{EC}$ at I_B= constant. $h_{fc} = \Delta I_E / \Delta I_B$ at V_{EC}= constant



(b)



EXP-6
FIELD EFFECT TRANSISTOR - STATIC CHARACTERISTICS

Aim :

a) To obtain the static characteristics (output and transfer characteristics) of a given Field Effect Transistor (FET).

b) Identify the Ohmic, Pinch-off and breakdown regions of the characteristics and

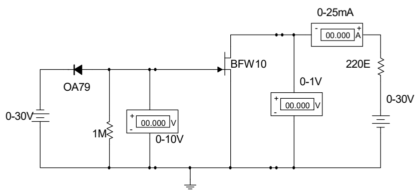
c) To estimate the values of drain resistance (rd), trans-conductance gm and the amplification factor –A from the characteristics.

Apparatus :

i. Circuit board with a FET, Diode, Resistors, BFW10, OA79
ii. Milli Ammeters (0-25mA)
iii. Voltmeter (0-30 V)
iv. Patch cords
v. Regulated Power Supply

Circuit Diagram:

The circuit diagram for studying the characteristics of a FET is shown in Fig.1



Theory:

The Field effect Transistor is a three terminal unipolar device in which the current through the device is controlled by the electric field, unlike the case of bipolar transistors. Hence, they offer very high input impedance compared to bipolar devices. A reverse biased diode is included in the path of the gate to protect the FET from any accidental forward biasing. A high input impedance digital voltmeter should be connected between the gate and source.

(i). Drain Characteristics or output characteristics:

These curves give the relationship between the drain to source voltage V_{ds} and drain current I_d for different values of gate to source voltage V_{gs}. As V_{gs} is increased pinch-off voltage is reached at lower value of drain current and V_{ds} also decreases as compared to that when V_{gs} is zero.

(ii). Transfer characteristics or input characteristics:

These curves gives the relationship between drain current I_d and gate to source voltage V_{gs} for different values of drain to source voltage V_{ds}. These are also called as Trans-conductance curves.

Procedure:

i. Make the connections as shown in the circuit Diagram shown in fig-1.
ii. Ensure that the power supply is switched OFF. Keep the voltage control knob in the minimum position and current control knob in maximum position.

Output characteristics:

Set V_{gs} = -1Volts by varying V_{gg}. Gradually increase the drain to source voltage by varying V_{dd} from 0 – 10 Volts in steps of I volt and note down the drain current I_d .
ii. Repeat this for V_{gs} = -2 Volts and V_{gs} = -3.0 Volts.------------------
iii. Record the observations in Table-I
iv. Plot V_{ds} versus I_d for different values of V_{gs}.
v. Draw the output characteristics V_{ds} versus I_d as shown in Fig.2(a), and calculate the drain resistance r_d from the graph in the linear region of the characteristics by

$$r_d = [\Delta V_{ds} / \Delta I_d] \quad \text{at } V_{gs} = \text{constant.}$$

vi. Present all the results at the end of the experiment.

TABLE-I : Output characteristics

S.No.	V_{gs} =- 0.0V		V_{gs} = -1V		V_{gs} =-2V		V_{gs} =-3V	
	V_{ds}(V)	I_d (mA)	V_{ds} (V)	I_d (mA)	V_{ds} (V)	I_d (mA)	V_{ds} (V)	I_d (mA)
	0.0 1.0 - - - - 10.0							

Transfer characteristics:

i. Set V_{ds} = 2 Volts by varying V_{dd} .
ii. Increase V_{gs} from 0 to 5 volts in steps of 0.5 volts gradually and note down the values for Id.
iii. Repeat this for V_{ds} = 5 volts and V_{ds} = 10 Volts.
iv. Plot the graph V_{gs} versus I_d for constant V_{ds} as shown in Fig.2(b) and calculate the Trans-conductance (g_m) from the graph in the linear region of the characteristics

$$g_m = [\Delta I_d/\Delta V_{gs}] \quad \text{at } V_{ds} = \text{constant.}$$

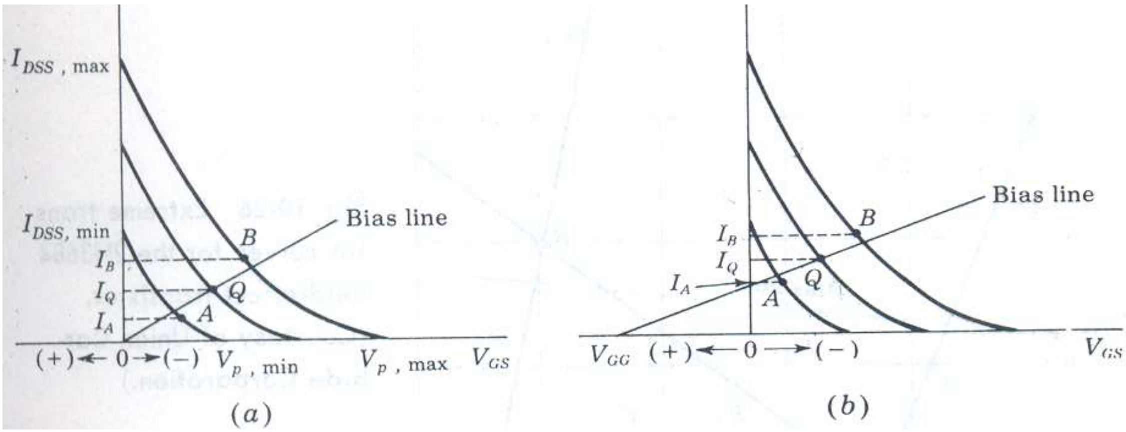
v. Present all the results at the end of the experiment.

TABLE-II : Transfer characteristics

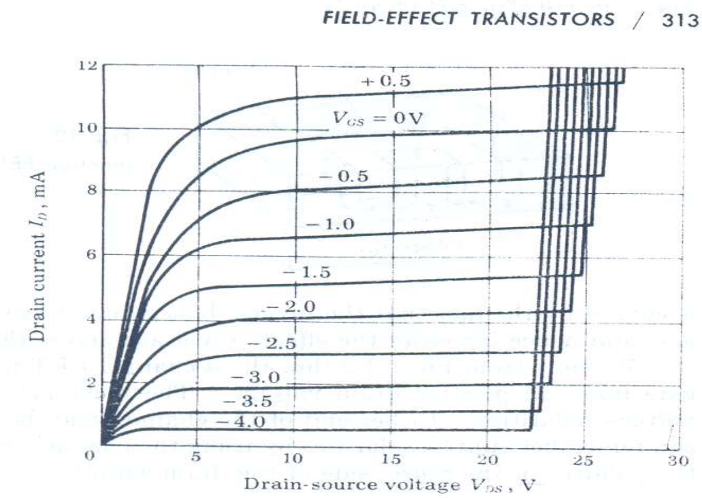
V_{ds} = 2 V		V_{ds} = 4 V		V_{ds} = 6 V	
V_{gs} (V)	I_d (mA)	V_{gs} (V)	I_d (mA)	V_{gs} (V)	I_d (mA)

Discussions:

i. Why FET is called unipolar device?
ii. What are the differences between FET& UJT?
iii. Why FET is called voltage control device?



Transfer Characteristics
Drain or Output Characteristics



RESULT:

1.The parameters of the FET are

Drain resistance r_d =
Transconductance g_m =
Amplification factor $\mu = r_d \cdot g_m$

EXP-7

FREQUECY RESPONSE OF C.E AMPLIFIER

AIM ;

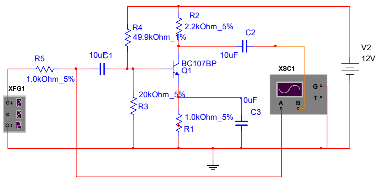
i) To obtain maximum signal handling capacity (over load characteristic) by plotting the out put voltage verses the input voltage a fixed frequency of 1 KHz (in the mid frequency band).

ii) To measure the I/P impedance and O/P impedance of the amplifier.

iii) To obtain the frequency response of the amplifier
a) Gain Vs Frequency b) Phase difference Vs Frequency.

APPARATUS: C.R.O , D.C Regulated power supply , signal generator , transistor BC107, resistors, capacitors, bread board, patch cords.

CIRCUIT DIAGRAM :



PROCEDURE :

1. Connect the circuit as shown in figure, and check for the D.C conditions of the transistor to ensure that it is in active region . Obtain the maximum signal handling capacity (also known as over load characteristic) at constant input signal frequency of 1 KHz as follows (i.e), Vary the input voltage from 0 to 2V in suitable steps 10mV.

Plot the characteristic of out put voltage Vs input voltage. Indicate the point where the distortion begins to set in the O/P. The corresponding amplitude of the I/P voltage gives the maximum signal handling capacity for the amplifier.

2.

a) Measurement of input impedance :

Fix the frequency at 1KHz note the values of Vs ,Vi and calculate the input impedance Zi by using the following equations.

$I_{in} = (V_s – V_i) / R_s$ $Z_i = V_i / I_{in}$.

b) Measurement of out put impedance :

At 1KHz frequency note the un-load o/p voltage V0. Then Connect a decade resistance box across the O/P terminals and adjust its value such that V0 falls to half of the unloaded value. The reading on the decade resistance box gives the value of out put impedance Z0.

3. Gain Vs frequency response :

i) Keeping the input voltage constant (below maximum signal handling capacity) vary the frequency from 10 Hz onwards in suitable steps up to a frequency where the out put voltage falls to less than half of the maximum out put voltage in the mid band.

ii) Plot a graph of gain (Vo/Vi) Vs frequency on a semi log graph sheet and determine the bandwidth.

OBSERVATIONS :

Vi = voltsrms.

S.NO	FREQUENCY	Vo (V)	Av = (Vo/Vi)	Av(db)=20 log(Vo/Vi)

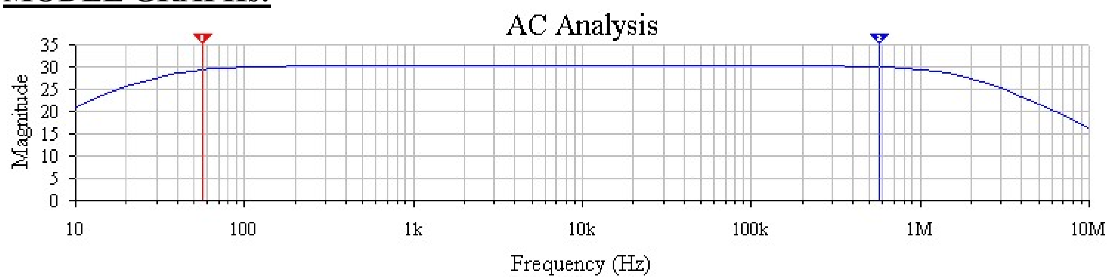
b) Phase difference Vs frequency response :-

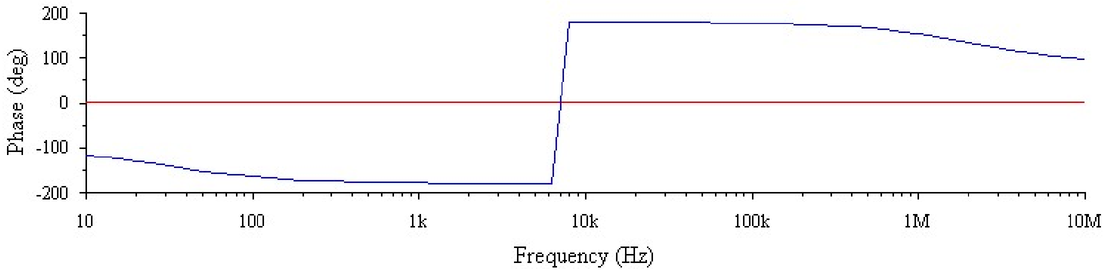
iv) Using C.R.O measure the phase difference between Vin and Vout as the frequency of the input signal is varied in suitable steps and tabulate the results as shown below. Plot the phase Vs frequency.

FREQUENCY OFI/P SIGNAL	a	b	Ø = invers sin(b/a)

Note : Find the phase difference between the input and the output signals at 2 or 3 frequencies in the lower frequency, mid-frequency and the High –frequency segments of the characteristic.

MODEL GRAPHs:





RESULT :

SNO	PARAMETER	THEORITICAL	EXPERIMENTAL
1.	Maximum signal handling capacity		
2.	Input impedance		
3.	Out put impedance		
4.	Mid band voltage gain		
5.	3db gain		
6.	Lower half power frequencyf1=very small		
7.	Upper half power Frequency f2		
8.	Band width B=(f2-f1) = f2		

RESULTS & DISCUSSION :

1. The phase difference between in put and out put for an emitter follower at the mid frequency is -----------------.
2. For emitter follower which parameter or characteristics are highest compare it with C.B configuration.
3. Operation of emitter follower.
4. The feed back used in emitter follower --------------------.

EXP-8
FREQUENCY RESPONSE OF CS AMPLIFIER

AIM ;

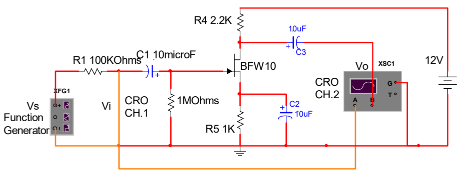
i) To obtain maximum signal handling capacity (over load characteristic) by plotting the out put voltage verses the input voltage a fixed frequency of 1 KHz (in the mid frequency band).

ii) To measure the I/P impedance and O/P impedance of the amplifier.

iii) To obtain the frequency response of the amplifier
a) Gain Vs Frequency   b) Phase difference Vs Frequency.

APPARATUS: C.R.O , D.C Regulated power supply , signal generator , transistor BC107, resistors, capacitors, bread board, patch cords.

CIRCUIT DIAGRAM :



PROCEDURE :

1. Connect the circuit as shown in figure, and check for the D.C conditions of the transistor to ensure that it is in active region . Obtain the maximum signal handling capacity (also known as over load characteristic) at constant input signal frequency of 1 KHz as follows (i.e), Vary the input voltage from 0 to 2V in suitable steps 10mV.

Plot the characteristic of out put voltage Vs input voltage. Indicate the point where the distortion begins to set in the O/P. The corresponding amplitude of the I/P voltage gives the maximum signal handling capacity for the amplifier.

2.

a) Measurement of input impedance :

Fix the frequency at 1KHz note the values of Vs ,Vi and calculate the input impedance Zi by using the following equations.

$I_{in} = (V_s – V_i) / R_s$ $Z_i = V_i / I_{in}$.

b) Measurement of out put impedance :
At 1KHz frequency note the un-load o/p voltage V0. Then Connect a decade resistance box across the O/P terminals and adjust its value such that V0 falls to half of the unloaded value. The reading on the decade resistance box gives the value of out put impedance Z0.

3. Gain Vs frequency response :

iii) Keeping the input voltage constant (below maximum signal handling capacity) vary the frequency from 10 Hz onwards in suitable steps up to a frequency where the out put voltage falls to less than half of the maximum out put voltage in the mid band.

iv) Plot a graph of gain (Vo/Vi) Vs frequency on a semi log graph sheet and determine the bandwidth.

OBSERVATIONS :

Vi = volts.

S.NO	FREQUENCY	Vo (V)	Av = (Vo/Vi)	Av(db)=20 log(Vo/Vi)

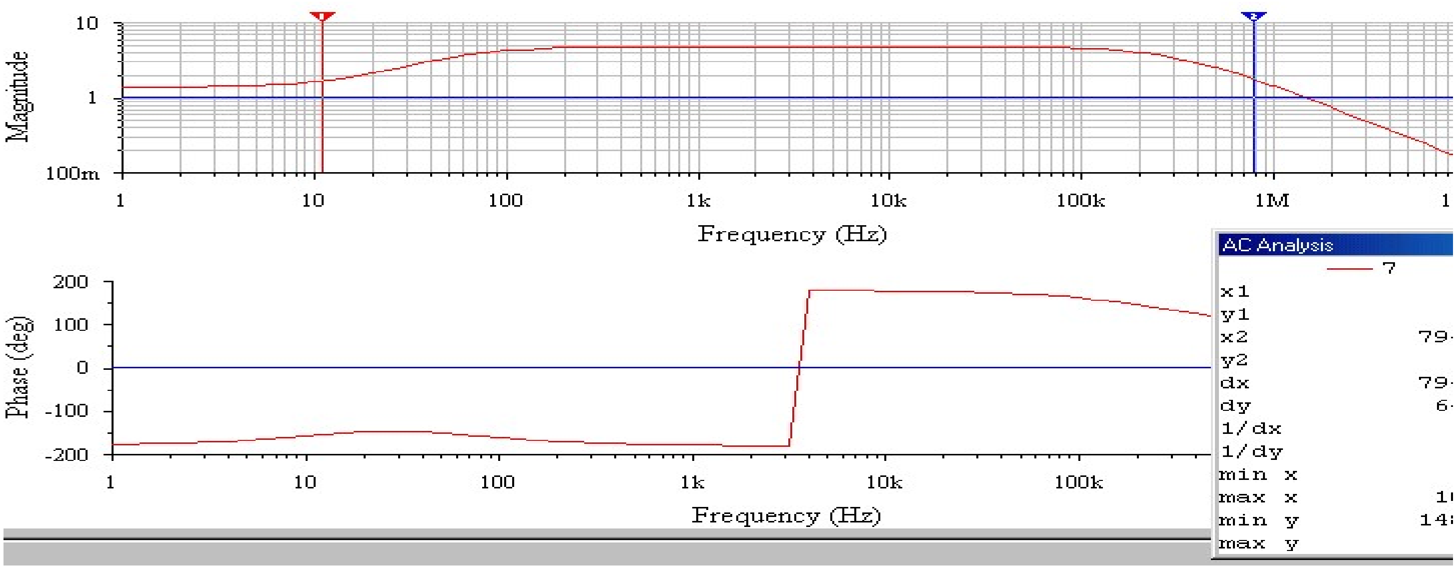
b) Phase difference Vs frequency response :-

iv) Using C.R.O measure the phase difference between Vin and Vout as the frequency of the input signal is varied in suitable steps and tabulate the results as shown below. Plot the phase Vs frequency.

FREQUENCY OFI/P SIGNAL	a	b	Ø = invers sin(b/a)

Note : Find the phase difference between the input and the output signals at 2 or 3 frequencies in the lower frequency, mid-frequency and the High –frequency segments of the characteristic.

MODEL GRAPHs:



SNO	PARAMETER	THEORITICAL	EXPERIMENTAL
1.	Maximum signal handling capacity		
2.	Input impedance		
3.	Out put impedance		
4.	Mid band voltage gain		
5.	3dbgain		
6.	Lower half power frequencyf1=very small		
7.	Upper half power frequency f2		
8.	Band width B=(f2-f1) = f2		

RESULTS & DISCUSSION :

1. The phase difference between in put and out put for common source FET amplifier at the mid frequency is -----------------.

EXP-9
MEASUREMENT OF RESISTANCE USING WHEATSTONE BRIDGE

Aim: To Measure Unknown Resistance using Wheat Stone Bridge

Apparatus:

i. Physitech's Wheat Stone Bridge Trainer Kit
ii. Decade Resistance Box – 1 No
iii. Connecting Wires
iv. iv. Multi Meter/ CRO (Optional)

Theory:

The most commonly used techniques for the measurement of Resistance, Capacitance & Inductance are those of bridge measurement. The word "bridge" refers to the fact that in such measurements two points in the circuit are bridged by a detector which detects either a potential difference or a null between them. Bridges are used extensively by National Standards Laboratories to maintain electrical standards by facilitating the calibration and intercomparison of standards and substandards. They are used to measure the resistance, capacitance. and inductance of actual components, and do this by comparison with standards of these quantities. In a large number of transducers nonelectrical quantities are converted into corresponding changes in resistance, capacitance, or inductance, and this has led to the use of bridges in a wide variety of scientific and industrial measurements.

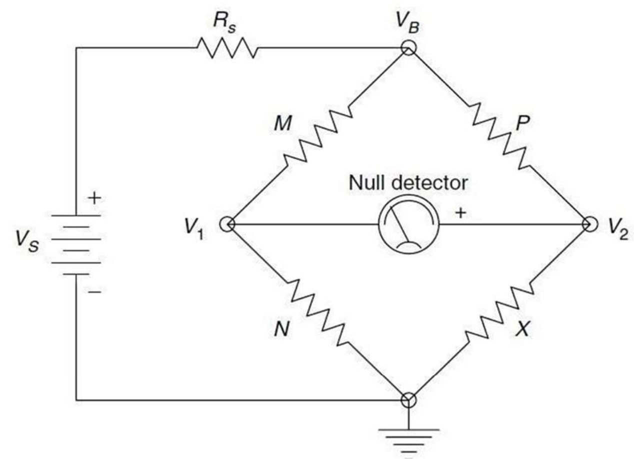


FIGURE 1 Basic Wheatstone bridge with dc excitation

The simplest form of a d.c. four-arm resistance bridge is the Wheatstone bridge. which is suitable for the measurement of medium range of resistance typically in the range from 10. Ω to 0.1 MΩ), or to measure some physical quantity, such as *The null is detected with a sensitive, centre scale, dc* temperature, light intensity or strain, which causes a known *voltmeter which draws negligible current* change in resistance as is shown in Figure 1.

If we assume that the null detector in Figure 1 is a high input impedance voltmeter, then in the null condition is

$$V_o = V_2 - V_1.$$

The voltages at the corners of the bridge are given by the voltage divider relations:

$V_2 = V_B \frac{N}{N+M}$ $\quad V_1 = V_B \frac{X}{P+X}$

Hence at null $V_0 = V_B\left[\frac{N}{\;} - \frac{X}{\;}\right] =$

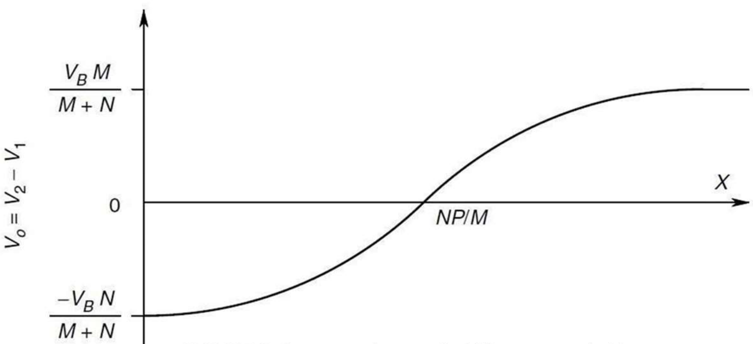


FIGURE 2 Output voltage of a Wheatstone bridge as a function of the unknown (X) arm

Since $V_0 = 0$ at null, the well-known relation for the unknown resistor, X, is given by:

$$X = \frac{N * P}{M}$$

The bridge can be used in either a balanced, i.e., null, mode or a deflection mode. In the balanced mode the resistance to be measured is R_1, and R_3 is a variable standard resistance. R_2 and R_4 set the ratio. The detector which may be either a galvanometer or an electronic detector, is used to detect a null potential between the points A and B of the bridge. A null occurs when $R_1 = (R_2/R_4)\,R_3$.

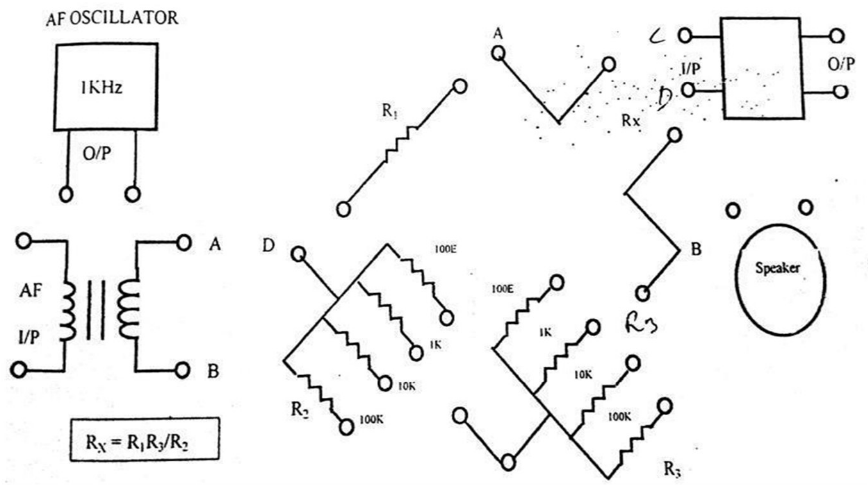
The bridge is balanced either manually or automatically using the output signal fromthe detector in a feedback loop to find the null position. The null condition is independent of the source resistance R_s, of the voltage source supplying the bridge or the sensitivity or inputresistance, Rd, of the detector. These, however, determine the precision with which balance condition can be determined.

Self-heating generally limits the bridge supply voltage and hence the output voltage. Amplification of the bridge output voltage has to be undertaken with an amplifier having a high Common Mode Rejection Ratio (CMRR), since the output from the bridge is in general small, and the common- mode signal applied to the amplifier is $V_s/2$.

The Other Method's available for the measurement of medium range of resistances are

i. Ammeter – Voltmeter Method.
ii. Substitution Method.
iii. Ohm – Meter Method.

Circuit Diagram:



Procedure:

The Balance Condition of the Wheat Stone Bridge can be done by Checking the BalanceCondition of the Bridge Circuit by any of the following Three Methods

- ✓ Using a Digital Multi – Meter.
- ✓ Using a CRO.

Before Conducing the Experiment Decide on the Method for Checking the Balance Condition of the Bridge Circuit

i. Connect the AF Oscillator Output to the Input of Isolation Amplifier Transformer.

ii. Connect the terminals of Isolation Amplifier Transformer Output to the "A" & "C" Terminals of the Bridge Circuit.

iii. Connect a DRB in place of the Unknown Resistor R_x and select any particular values for R_2 & R_3 depending on the range of Resistance to be measured.

iv. Switch "ON" the Physitech's Wheat Stone Bridge Trainer Kit.

v. Observe the sine wave at the secondary of the Isolation Transformer on CRO/ Multi – Meter.

vi. Connect the "B" & "D" Terminals of the Bridge Circuit to the Input Terminals of CRO/ Multi – Meter in ac Voltage Mode in the Range 0 – 2 Volts.

vii. Vary the Knob of the Potentiometer R_1 so that the Balance/ Null point can be observed in the CRO/ Multi – Meter. Note down the Value of R_1 for which the Balance Condition has been obtained.

viii. The Null Condition can also be observed by using the Speaker setup present on the Kit. Connect the Output "B" & "D" Terminals of the Bridge Circuit to the Input Terminals of an Imbalance Amplifier, Connect the Amplifier Output to the Speaker Terminals. Adjust the Variable Arm Resistance R_1 for a minimum/ No Sound in the Speaker.

ix. Set the Unknown Resistance Rx to different values as shown in Table and tabulate the corresponding values of the Balancing Resistor R_1.

x. Proceed to performing calculations of R_x from the values of the Resistance Values of R_1 for which the Balance Condition in the Wheat Stone Bridge is obtained.

xi. Find the error in measurement of R_x in Table, by calculating the values of R_x from the values of the Balancing Resistors R_1 and comparing them with the values actually set through the DRB.

Calculations:

$$R_{x(Measured)} = R_1 * \frac{R_3}{R}$$

Tabulation of Measured Data:

S.No	$R_{X(Applied)}$ (KΩ)	Ratio(R_3/R_2)	$R_{1(Measured)}$ (KΩ)	$R_{X(Measured)}$ (KΩ)	% Error
1		0.1			
2		0.1			
3		0.1			
4		1			
5		1			
6		1			
7		1			
8		10			
9		10			
10		10			

Result:

The Unknown Resistance R_x has been measured with help of Wheat Stone Bridge.

EXP-10
MEASUREMENT OF RESISTANCE USING KELVIN BRIDGE

Aim: To Measure Unknown Small Resistances using Kelvin Double Bridge

Apparatus:

i. Physitech's Kelvin Bridge Trainer Kit
ii. Connecting Wires
iii. Multi Meter

Theory:

The Kelvin Bridge is a specialized circuit used to measure very low resistances, such as ammeter shunts and motor armatures.

Kelvin bridges are null devices used to measure low values of resistance in the range 10 μ Ω –10 Ω.

The basic circuit for a Kelvin bridge is shown in Figure 1. Note that this bridge differs from a Wheatstone bridge by having four resistors in the right half circuit.

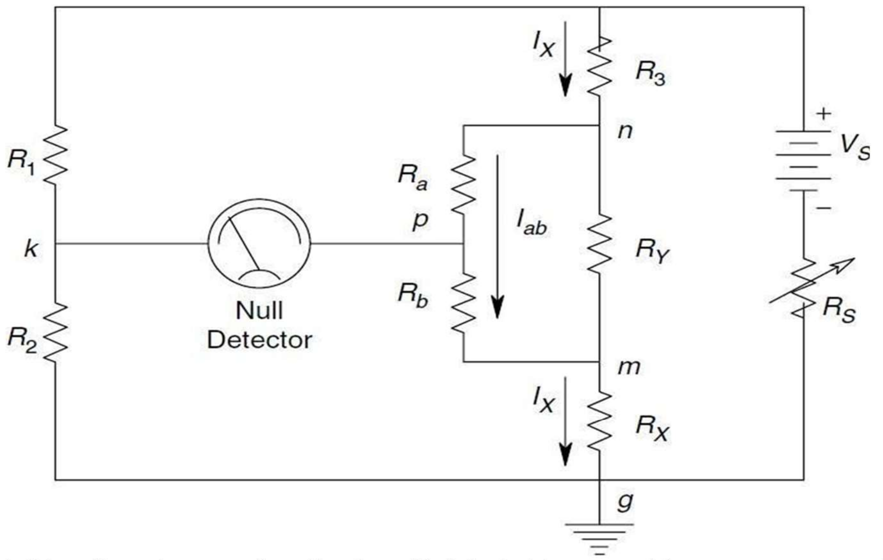


FIGURE 1 Circuit and current paths in a Kelvin bridge used to measure very low resistances, R_X.

To derive the conditions for null, it is noted that at null, V_k = V_p. V_k can be written by the voltage divider expression as:

$$V_k = V_S \frac{R_2}{R_1 + R_2}$$

&

$$V_p = V_{pm} + V_m = I_{ab}R_b + I_xR_x$$

Where $I_{ab} = I_x \frac{R_y}{R_a + R_b + R_y}$ and $I_x = \dfrac{V_S}{R_3 + R_x + \left(\dfrac{R_y(R_a + R_b)}{R_a + R_b + R_y}\right)}$

Thus at Null Condition

$$V_S \frac{R_2}{R_1 + R_2} = \frac{V_s}{R_3 + R_x + \left[\dfrac{R_y(R_a + R_b)}{R_a + R_b + R_y}\right]} \left[R_x + \frac{R_bR_y}{R_a + R_b + R_y}\right]$$

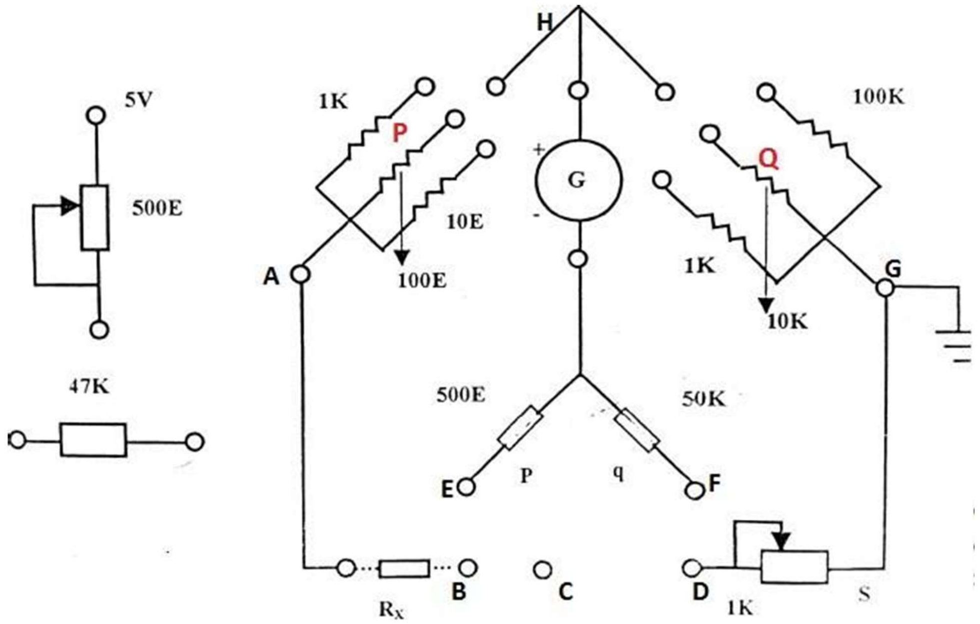
Let $\frac{R_a}{R_b} = \frac{R_1}{R_2} = \alpha$.

Substituting the value of α in the above Equation, and arriving at the Kelvin Bridge Balance Condition we get

$$R_x = \frac{R_3}{\alpha} = \frac{R_3 R_2}{R_1}$$

Generally, the resistances in the Kelvin Bridge are relatively small, so the battery or dc working voltage source, V_S, must be able to source considerable current.

Circuit Diagram:



Procedure:

i. Through the 47 K Ω Resistor, excite the system with a constant current source. (from the 500 Ω Resistance, connect a patch cord to the 47 K Ω Resistor and from the other end of the 47 K Ω, connect to *Point A*)

ii. Connect the Unknown Resistance Rx present on the kit in place of the Unknown Resistor R_x and select any particular values for P & Q depending on the range of Resistance to be measured.

iii. Make the following Connections

   a. Connect patch cords between the points ***B*** & ***C, C*** & ***E, D*** & ***F*** *and* ***C*** & ***D.***

   b. Connect a Digital Multi meter in μ Amp range

iv. Switch "ON" the Physitech's Kelvin's Double Bridge Trainer Kit.

v. Adjust the Vary the Knob of the Potentiometer ***S*** so that the Balance/ Null point can beobserved in the Multi – Meter. Note down the Value of S for which the Balance Condition has been obtained.

vi. Set the Unknown Resistance Rx to different values as shown in Table and tabulate thecorresponding values of the Balancing Resistor S.

vii. Proceed to performing calculations of R_x from the values of the Resistance Values of Sfor which the Balance Condition in the Wheat Stone Bridge is obtained.

viii. Find the error in measurement of R_x in Table, by calculating the values of R_x from thevalues of the Balancing Resistors S and comparing them with the actual values.

Calculation:

$$Rx(measured) = S(measured) * \frac{P}{Q}$$

$$\%Error = \frac{Rx(applied) - Rx(measured)}{Rx(applied)} * 100$$

Tabulation of Measured Data:

S.No	$R_{X(Applied)}$ (Ω)	Ratio (P/Q)	$S_{(Measured)}$ (Ω)		$R_{X(Measured)}$ (KΩ)	% Error
1						
2						
3						
4						
5						
6						
7						
8						

Result:

The Unknown Resistance R_x has been measured with help of Kelvin's Bridge.

EXP-11
MEASUREMENT OF CAPACITANCE USING SCHERING'S BRIDGE

Aim: To Measure Unknown Inductance using Schering's Bridge

Apparatus:

i. Physitech's Schering's Bridge Trainer Kit
ii. Decade Capacitace Box – 1 No
iii. Connecting Wires
iv. Multi Meter/ CRO (Optional)

Theory:

AC Bridges

Vector (circle) diagrams were used to illustrate how the complex V_o behaves due to the interaction of the two variable bridge elements when reaching a null.

Figure 1 illustrates a general ac bridge, in which the arms are impedances, having real and imaginary parts. In general, the ac bridge output voltage can be written as a complex (vector) equation:

$$V_0 = V_s \left[\frac{Z_X}{Z_X + Z_P} - \frac{Z_N}{Z_N + Z_M}\right]$$

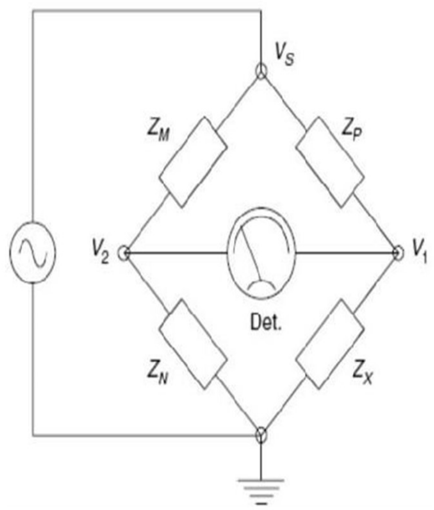


FIGURE 1 General configuration for an ac bridge. Det. is the null detector; it is a sensitive ac voltmeter assumed to have infinite input resistance.

From above equation, we find that at null, where V_o= 0, we can write the vector equation as:

$$Z_M Z_X = Z_N Z_P$$

- The De Sauty bridge is a deceptively simple bridge which is often used to produce anoutput voltage that is proportional to a small change, δC, in one of the capacitors, rather than to measure capacitance.

The Schering Bridge

The Schering bridge is useful for measuring capacitors with high losses (high Ds). In finding the balance conditions for this bridge, it is expedient to use the parallel R-C equivalent circuit, as shown in Figure 2.

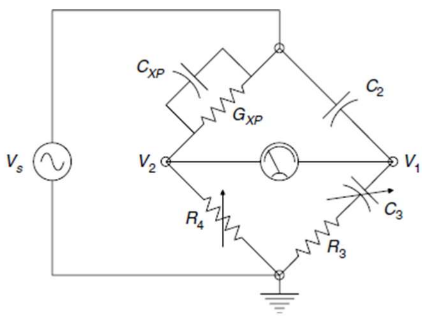


FIGURE 2 A Schering bridge, used to measure capacitors with high D.

At null, we can write,

$$Z_X Z_3 = Z_2 Z_4 \text{ or } Z_3 Y_2 = Y_X Z_4$$

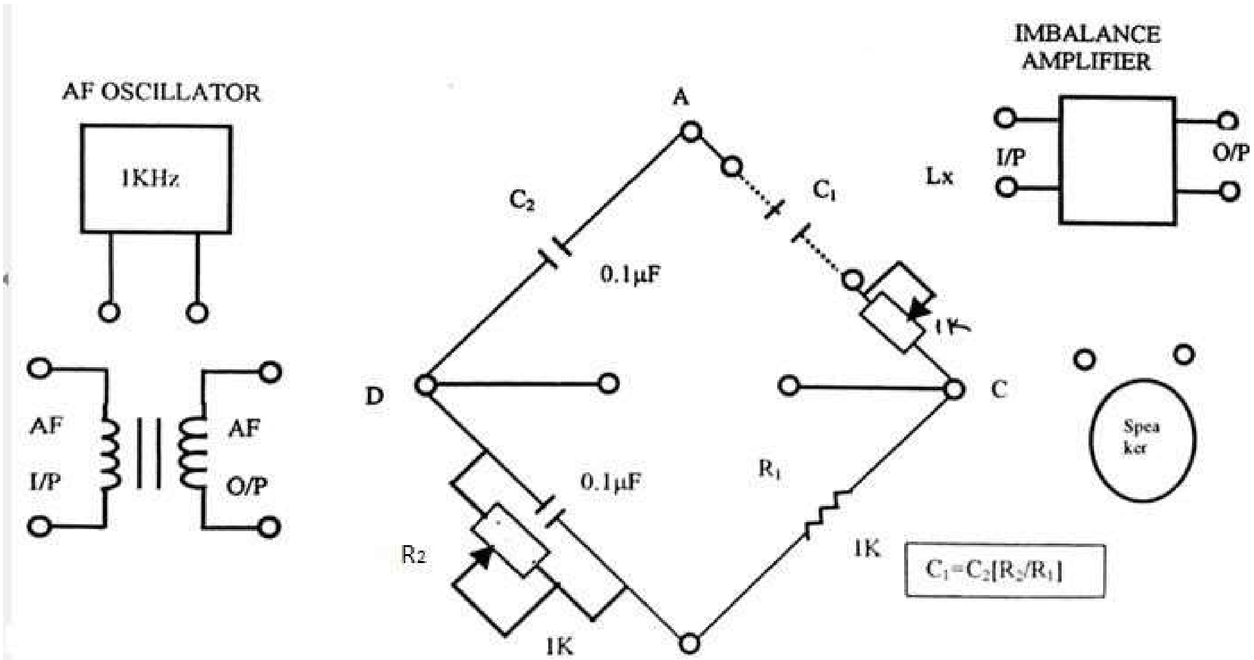
Thus

$$(R_3 + 1/j\omega C_3) j\omega C_2 = (G_{XP} + j\omega C_{XP})_4$$

By Equating the Real and Imaginary Terms, the Condition at Balance are obtained as

$$C_{XP} = {}_3C_2/R_4$$
$$R_{XP} = {}_4C_3/C_2$$
$$D_P = 1/(\omega C_{XP} R_{XP}) = \omega C_3 R_3$$

Circuit Diagram:



Procedure:

The Balance Condition of the Schering's Bridge can be done by Checking the BalanceCondition of the Bridge Circuit by any of the following Three Methods

- ✓ Speaker Set – up Present on the Kit.
- ✓ Using a Digital Multi – Meter.
- ✓ Using a CRO.

❖ Before Conducing the Experiment Decide on the Method for Checking the BalanceCondition of the Bridge Circuit

i. Connect the AF Oscillator Output to the Input of Isolation Amplifier Transformer.

ii. Connect the terminals of Isolation Amplifier Transformer Output to the "A" & "B"Terminals of the Bridge Circuit.

iii. Connect a DCB/ Capacitors present on the kit in place of the Unknown CapacitanceC_x.

iv. Switch "ON" the Physitech's Schering's Bridge Trainer Kit.

v. Observe the sine wave at the secondary of the Isolation Transformer on CRO/ Multi – Meter.

vi. Connect the "C" & "D" Terminals of the Bridge Circuit to the Input Terminals of CRO/ Multi – Meter in ac Voltage Mode in the Range 0 – 2 Volts.

vii. Vary the Knob of the Potentiometer R_1 so that the Balance/ Null point can be observed in the CRO/ Multi – Meter. Note down the Value of R_1 for which the Balance Condition has been obtained.

viii. The Null Condition can also be observed by using the Speaker setup present on the Kit. Connect the Output "C" & "D" Terminals of the Bridge Circuit to the Input Terminals of an Imbalance Amplifier, Connect the Amplifier Output to the SpeakerTerminals. Adjust the Variable Arm Resistance R_1 for a minimum/ No Sound in the Speaker.

ix. Set the Unknown Capacitance C_x to different values as shown in Table and tabulatethe corresponding values of the Balancing Resistor R_1.

x. Proceed to performing calculations of C_x from the values of the Resistance Values of C_3 for which the Balance Condition in the Schering's Bridge is obtained.

xi. Find the error in measurement of C_x in Table, by

Calculations:

$$C_{1(Measured)} = \frac{R_{2(Measured)}}{R_2} * C_2$$

$$\%Error = \frac{C1(Applied) - C1(measured)}{C1(Applied)} * 100$$

Tabulation of Measured Data:

S.No	$C_{1\,(Applied)}$	$R_{2\,(Measured)}$ (Ω)	$C_{1\,(Measured)}$	% Error
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Result:

The Unknown Capacitance C_1 has been measured with help of Schering Bridge.

EXP-12
MEASUREMENT OF INDUCTANCE USING MAXWELL'S BRIDGE AND MEASUREMENT OF L,C AND R USING Q-METER

Aim: To Measure Unknown Inductance using Maxwell's Bridge

Apparatus:

i. Physitech's Maxwell's Bridge Trainer Kit
ii. Decade Inductance Box – 1 No
iii. Connecting Wires
iv. Multi Meter/ CRO (Optional)

Theory:

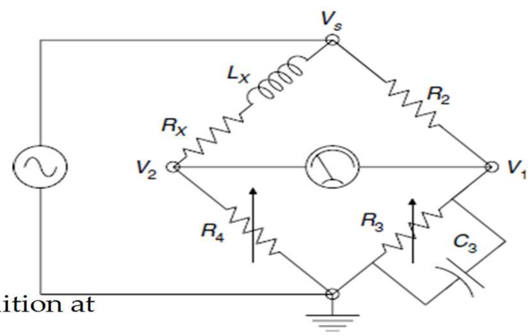
Bridges Used to Measure Inductance

The inductance bridges can be subdivided into bridges that are optimal in terms of reaching null, for measuring high Q inductors and those best suited for the measurement of low Q inductors.

- Parallel Inductance Bridge is used to measure high Q inductors ($1 < Q < \infty$)
- The Hay Bridge uses the series R-L model for an inductor to measure the inductance and Q of high Q coils.
- The Owen Bridge uses the conventional series inductance model and is best used on large, low Q inductors.
- The Anderson Bridge gives the best convergence to nulls for low Q coils.
- Measurement of circuit parameters at high frequencies (including video and radio frequencies) requires special apparatus such as the Q-Meter, or instruments such as RF Impedance Analyser.

The Maxwell Bridge

Maxwell bridge is used to measure low Q inductors having Q_s in the range of 0.02 – 10.



At null:

$$Z = Z_2 Y_3 Z_4$$

or $$(R_X + j\omega L_X) = R_2(G_3 + j\omega C_3)R_4$$

By Equating the Real and Imaginary Terms, the Condition at Balance are obtained as

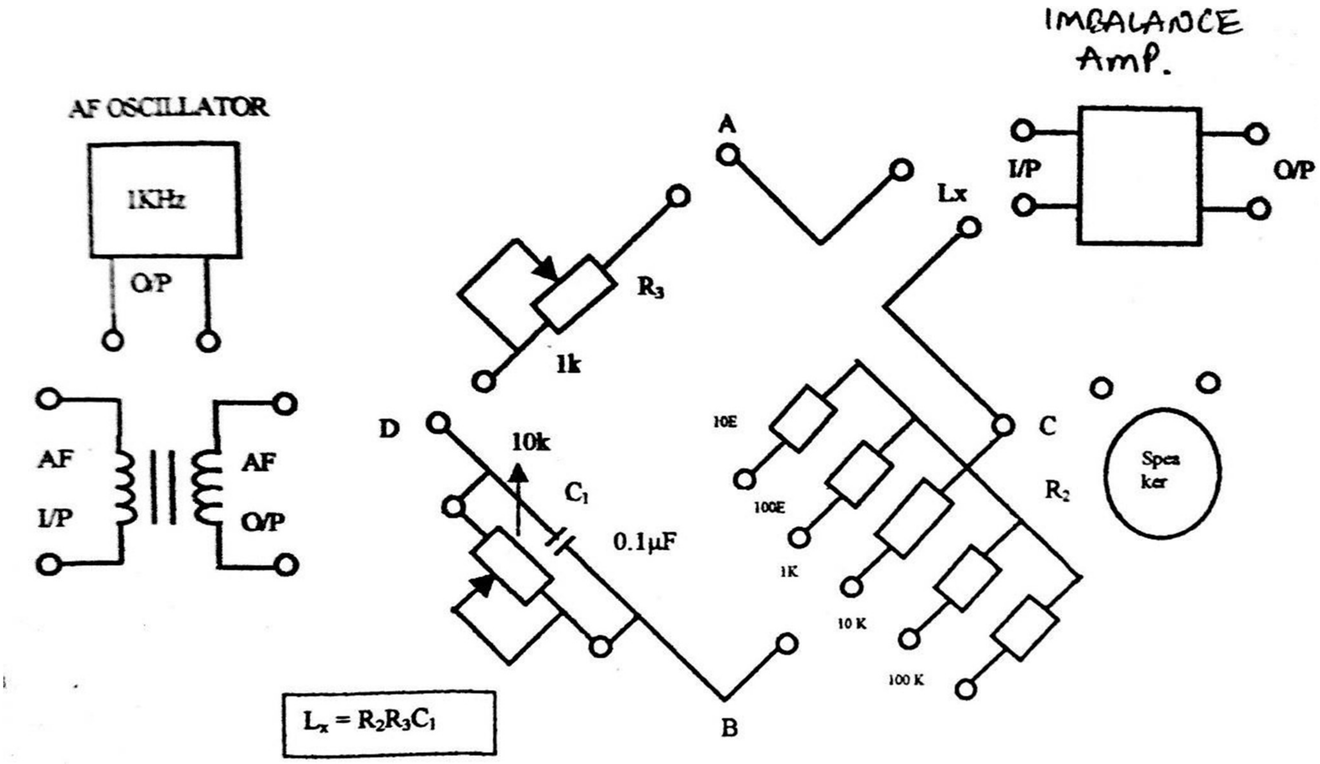
$$L_X = C_3 R_2 R_4$$

$$R_X = R_2 R_4 / R_3$$

$$Q_X = L_X / R_X = \omega C_3 R_3$$

Thus R_4 is calibrated in inductance units and the R_3 scale reads Q.

Circuit Diagram:



Procedure:

The Balance Condition of the Maxwell's Bridge can be done by Checking the BalanceCondition of the Bridge Circuit by any of the following Three Methods

- ✓ Speaker Set – up Present on the Kit.
- ✓ Using a Digital Multi – Meter.
- ✓ Using a CRO

Before Conducing the Experiment Decide on the Method for Checking the Balance Conditionof the Bridge Circuit

i. Connect the AF Oscillator Output to the Input of Isolation Amplifier Transformer.
ii. Connect the terminals of Isolation Amplifier Transformer Output to the "A" & "B"Terminals of the Bridge Circuit.
iii. Connect a DIB in place of the Unknown Inductance L_x and select any particular value for R_2 depending on the range of Resistance to be measured.
iv. Switch "ON" the Physitech's Maxwell's Bridge Trainer Kit.
v. Observe the sine wave at the secondary of the Isolation Transformer on CRO/ Multi – Meter.
vi. Connect the "C" & "D" Terminals of the Bridge Circuit to the Input Terminals of CRO/ Multi – Meter in ac Voltage Mode in the Range 0 – 2 Volts.
vii. Vary the Knob of the Potentiometer R_3 so that the Balance/ Null point can be observed in the CRO/ Multi – Meter. Note down the Value of R_3 for which the Balance Condition has been obtained.
viii. The Null Condition can also be observed by using the Speaker setup present on the Kit. Connect the Output "B" & "D" Terminals of the Bridge Circuit to the Input Terminals of an Imbalance Amplifier, Connect the Amplifier Output to the SpeakerTerminals. Adjust the Variable Arm Resistance R_1 for a minimum/ No Sound in the Speaker.
ix. Set the Unknown Inductance Lx to different values as shown in Table and tabulatethe corresponding values of the Balancing Resistor R_3 & Multiplier Resistance R_2.
x. Proceed to performing calculations of L_x from the values of the Resistance Values of R_3 for which the Balance Condition in the Maxwell's Bridge is obtained.
xi. Find the error in measurement of L_x in Table, by calculating the values of L_x from the values of the Balancing Resistors R_3 and comparing them with the values actually set through the DIB.

Calculations:

$$L_{x(Measured)} = R_{3(Measured)} * R_2 * C_1$$

$$\% \, Error = \frac{L_{x(Applied)} - l_{x(Measured)}}{L_{x(applied)}} * 100$$

Tabulation of Measured Data:

S.No	$L_{X(Applied)}$	Multiplier Resistance (R_2)	$R_{3(Measured)}$ (Ω)	$L_{X(Measured)}$	% Error
1		100 KΩ			
2		100 KΩ			
3		10 KΩ			
4		10 KΩ			
5		1 KΩ			
6		1 KΩ			
7		100 Ω			
8		100 Ω			
9		10 Ω			
10		10 Ω			

Result:

The Unknown Inductance L_x has been measured with help of Maxwell's Bridge.

EXP-12B

MEASUREMENT OF R, L, C, AND Q FACTOR USING LCR-Q METER

Aim:

To measure the values of resistance, capacitance, inductance and also the quality factor of the inductors.

Apparatus:

(i) LCR-Q meter

(ii) Resistors – 5 Nos. (different values)

(iii) Capacitors – 5 Nos. (different values)

(iv) Decade Inductance Box (DIB)

(v) Connecting wires

Circuit Diagram:

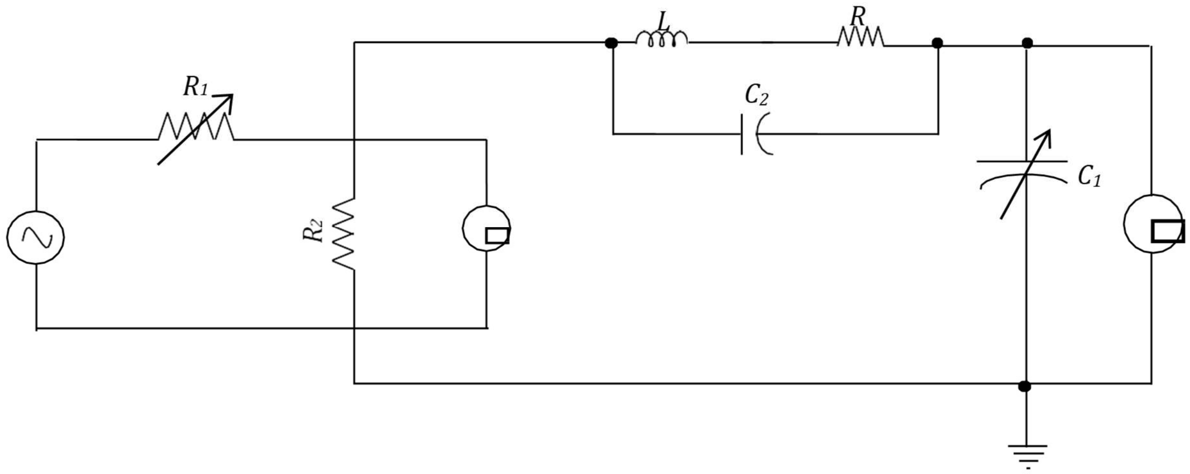


Figure B.1.1

Theory

LCR-Q meter, which is commonly called just a "Q meter", is used to measure the values of resistance, capacitance, and inductance. In addition, Q meter is also used to measure the quality factor of an inductor coil. Measurement of quality factor of a coil is important in designing oscillator circuits. The quality factor is a ratio of the reactance of a coilto its internal resistance. The lower the internal resistance, higher is the quality factor. Or, thehigher the frequency of oscillation, higher is the quality factor. Since the internal resistance of an inductor coil is ideally 0 Ω, the quality factor of an ideal inductor coil is ∞.

Quality factor of an inductor is thus given as $Q = \frac{\omega L}{R}$, where $\omega = 2\pi f$ is the angular frequency of oscillation, L is the inductance, and R is the internal resistance. The expected value of Q factor is calculated using the frequency f indicated on the instrument

Procedure:

i. Pick up various resistors and capacitors.

ii. Note down the theoretical value of the resistance based on the colour coding of the resistor.

iii. Insert the two terminals of the resistors in the slots provided for this purpose in the Q meter.

iv. Set the lower row of the three buttons on the right side of the instrument as marked in the legend on the Row 1 or Row 2 of the left panel of the instrument. Please make sure that you choose the right row for the particular resistor, based on its theoretical value. Note down the reading along with the units (indicated by the LED below the display panel).

v. Repeat the steps (ii) to (iv) for all resistors.

vi. Note down the theoretical value of the capacitor based on the imprint on the capacitor package. Ceramic capacitors, which are flat in their shape, have a three-digit number scheme '*abc*' which must be interpreted as that the capacitor has a capacitance of '$ab \times 10^{c}$' pF. Electrolytic capacitors, which are usually cylindrical in their shape, have the capacitance value directly imprinted on their packaging along with the relevant units.
vii. Insert the two terminals of the capacitors in the slots provided for this purposein the Q meter. The polarity of the terminals is important in case of electrolytic capacitors. Thus, the negative terminal is marked by a band that runs towards the negative terminal, which is also indicated by a shorter lead than the positive terminal.

viii. Set the lower row of the three buttons on the right side of the instrument as marked in the legend on the Row 3, 4 or 5 (Row 5 for electrolytic capacitors only) of the left panel of the instrument. Please make sure that you choose the right row for the particular capacitor, based on its theoretical value and its type (ceramic or electrolytic). Note down the reading along with the units (indicated by the LED below the display panel).

ix. Repeat the steps (vi) to (viii) for all capacitors.

x. Set a value of inductance using the DIB and note it down as the theoretical value.

xi. Connect the positive and negative terminals of the DIB to the slots provided for this purpose in the Q meter, using connecting wires.

xii. Set the lower row of the three buttons on the right side of the instrument as marked in the legend on the Row 6 or Row 7 of the left panel of the instrument. Please make sure that you choose the right row for the particular inductance range, based on its theoretical value. Note down the reading along with the units (indicated by the LED below the display panel) as the practical value of the inductance.

Calculations:

$$Q = \frac{\omega L}{R} = \frac{2\pi f L}{R}$$

Tabulation of Measured Data

i. Resistance:

#	Theoretical Value (Ω)	Value shown on LCR-Q Meter (Ω)
1		
2		
3		
4		
5		

ii. Capacitance:

#	Theoretical Value (μF)	Value shown on LCR-Q Meter (μF)
1		
2		
3		
4		
5		

iii. Inductance:

#	Theoretical Value (mH)	Value shown on LCR-Q Meter (mH)	Internal Resistance R (Ω)	Expected Q factor	Q factor shown on LCR-Q meter
1					
2					
3					
4					
5					

Result :

The values of various resistors, capacitors, and inductors are found using the LCRQ meter. The quality factor was also computed for these particular inductance values andwas compared with the quality factor indicated by the LCR-Q meter.

END