CANARA

ENGINEERING COLLEGE

Benjanapadavu, Mangalore-574219

Subject Code: 10ESL37

ANALOG ELECTRONICS LAB MANUAL

DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

CONTENTS

DIODE CLIPPING CIRCUITS

Aim: To design and test diode clipping circuits for peak clipping and peak detection.

Components required:

-Power Supply

-Diodes IN4007or BY127

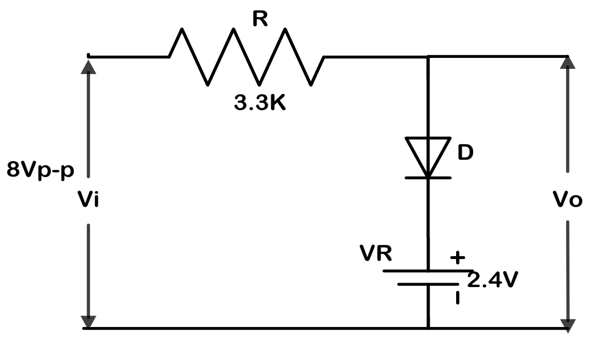
-Resistors

Procedure:

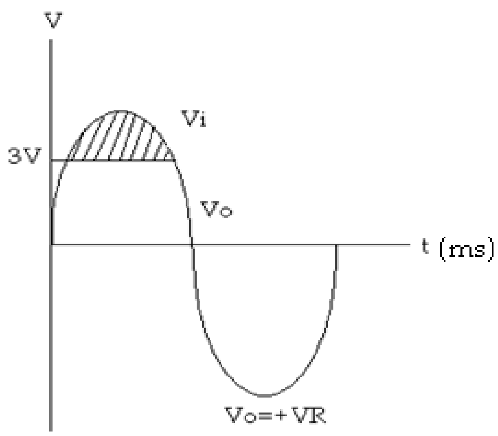
- Make the Connections as shown in the circuit diagram
- Apply sinusoidal input Vi of 1 KHz and of amplitude 8V P-P to the circuit.
- Observe the output signal in the CRO and verify it with given waveforms.
- Apply Vi and Vo to the X and Y channel of CRO and observe the transfer characteristic waveform and verify it.

I) **Positive Clipping Circuit:**

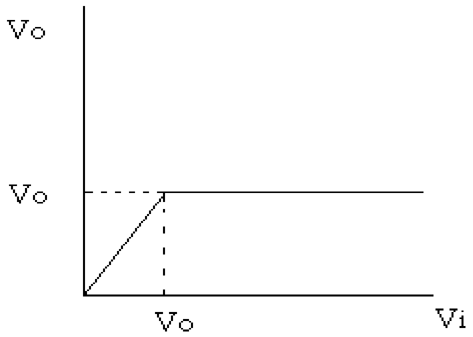
Circuit Diagram:



Waveforms:



Transfer Characteristics:



To find the value of R:

Given: R_f =100Ω, R_r =100KΩ

R_f - Diode forward resistance

R_r - Diode reverse resistance

R= $\sqrt{R_f R_r} = \sqrt{100 \times 100 \times 10^3}$ =3.16KΩ

Choose R as 10 KΩ

Let the output voltage be clipped at +3V

∴ V_{omax} =3V

From the circuit diagram,

$V_{omax} = V_r + V_{ref}$

Where V_r is the diode drop = 0.6V

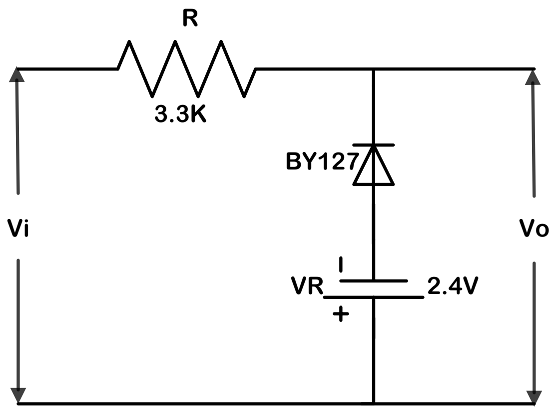
∴ $V_{ref} = V_{omax} - V_r$

=3 - 0.7

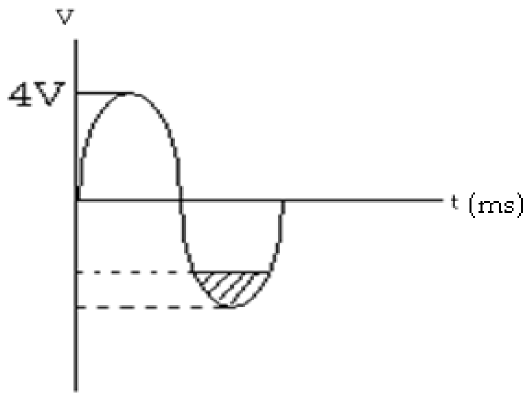
V_{ref} = 2.3 V

II) **Negative Clipping Circuit:**

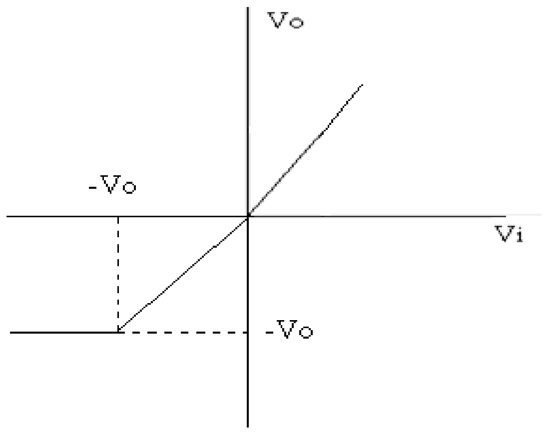
Circuit Diagram:



Waveforms:



Transfer Characteristics:



Let the output voltage be clipped at -3V

V_{omin} = -3V

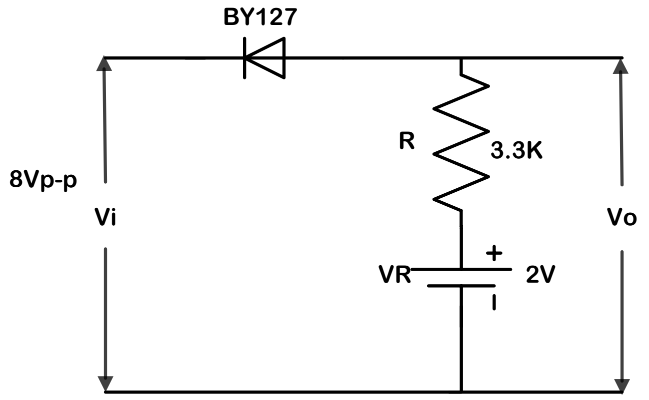
$V_{omin} = -V_r+V_{ref}$

$V_{ref} = V_{omin+}V_r = -3 + 0.7$

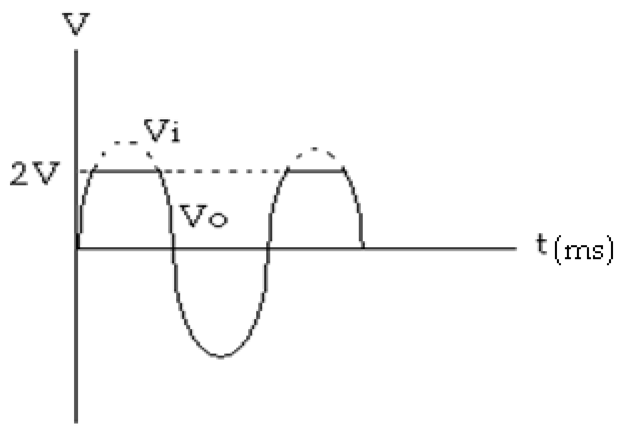
$\mathbf{V_{ref} = -2.3V}$

III) **Diode Series Clipping / Positive Peak Clipper:**

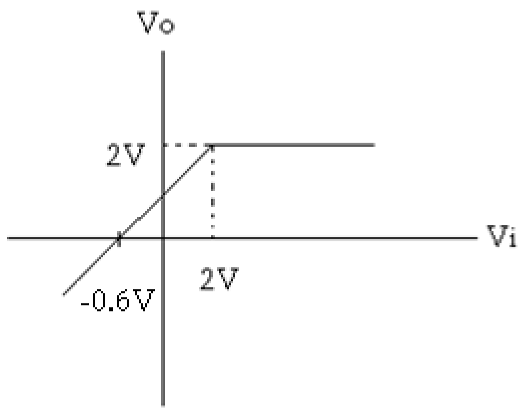
Circuit Diagram:



Waveforms:



Transfer Characteristics:

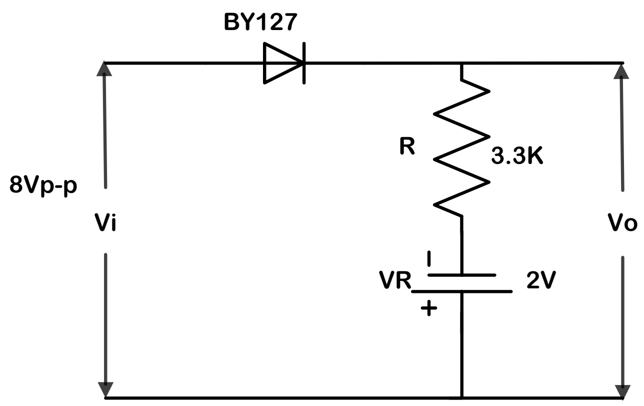


Let the output voltage be clipped at 2V

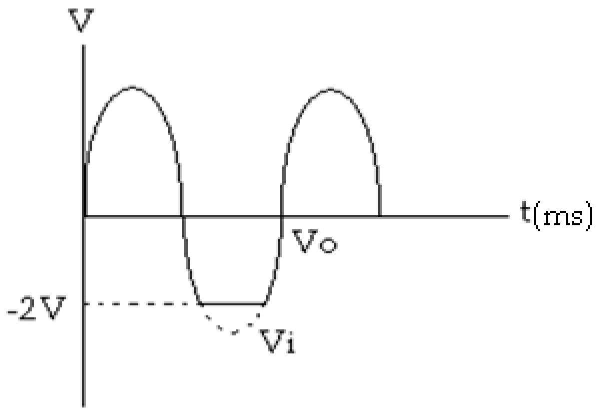
$\mathbf{V_{omax} = V_{ref} = 2V}$

IV) **Negative Peak Clipper:**

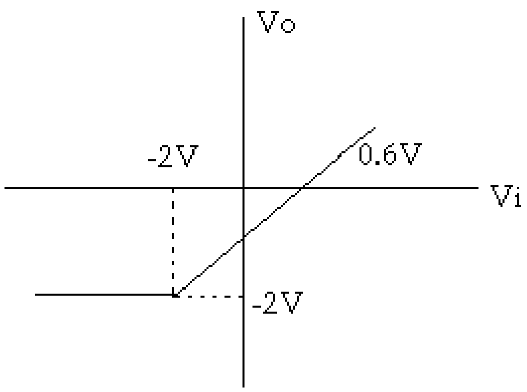
Circuit Diagram:



Waveforms:



Transfer Characteristics:

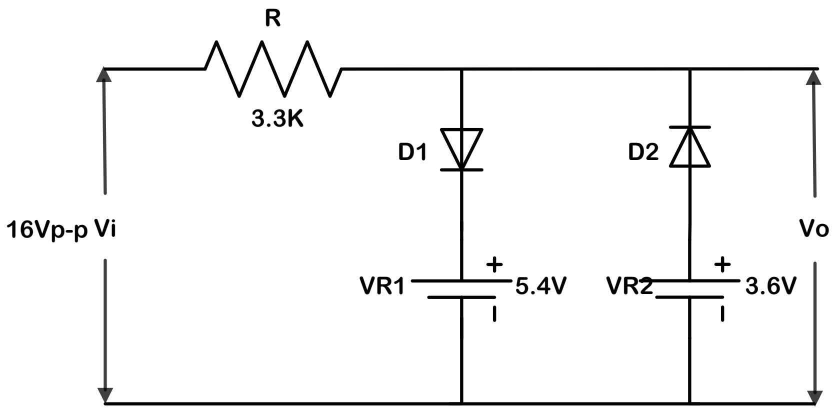


Let the output voltage be clipped at -2V

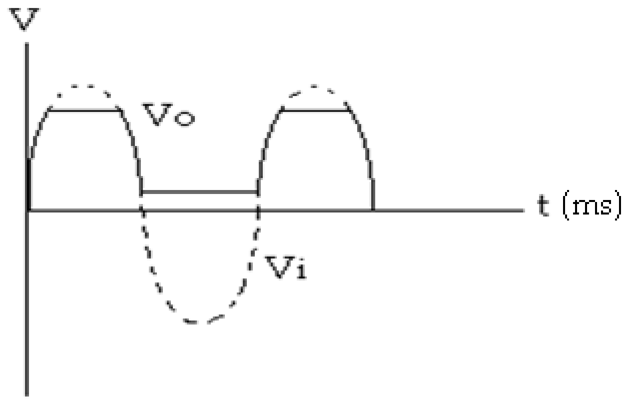
$\mathbf{V_{omin} = V_{ref} = -2V}$

V) **Clipping at two independent levels:**

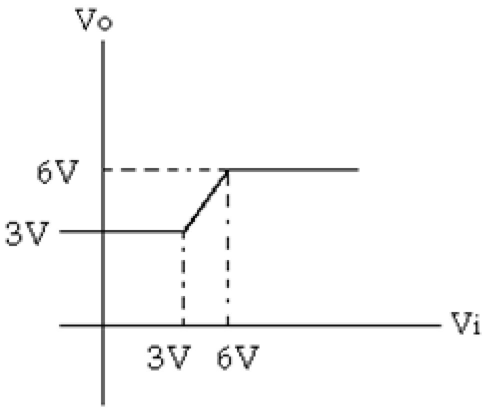
Circuit Diagram:



Waveforms:



Transfer Characteristics:



Let $V_{omax} = 6V$ and $V_{omin} = 3V$

$\therefore V_{omax} = V_{r1} + V_r$

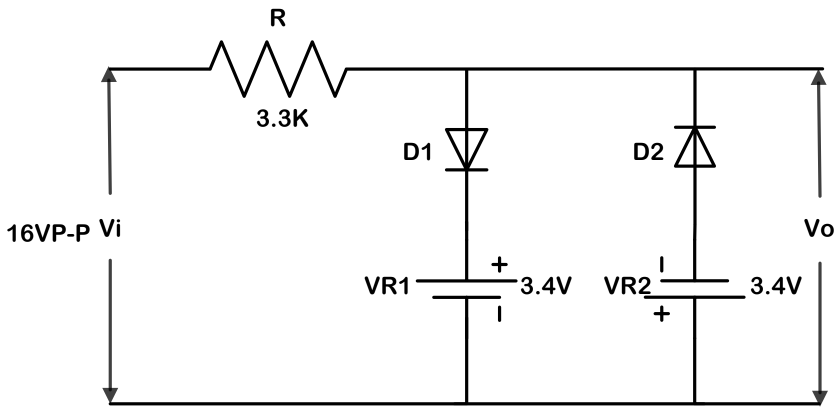
$\mathbf{V_{r1} = V_{omax} - V_r = 6 - 0.7 = 5.3V}$

$V_{omin} = V_{r2} - V_r$

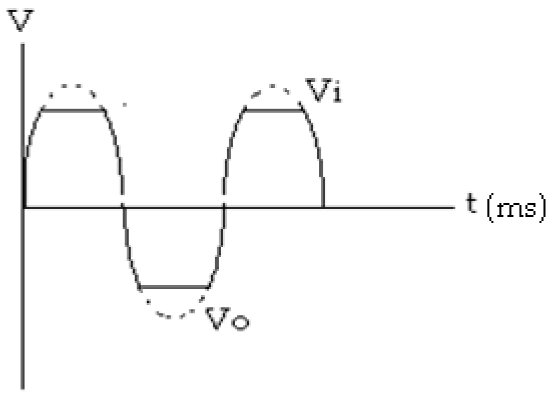
$\mathbf{V_{r2} = V_{omin} + V_r = 3 + 0.7 = 3.7V}$

VI) **Double ended clipper to generate a symmetric square wave:**

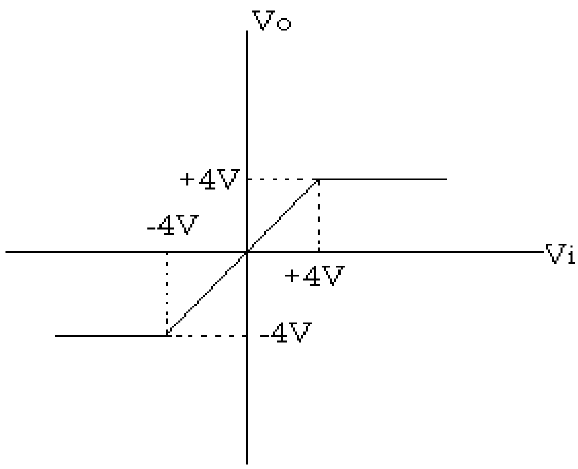
Circuit Diagram:



Waveforms:



Transfer Characteristics:



Let $V_{R1} = V_{R2} = V_R$, $V_{omax} = 4V$

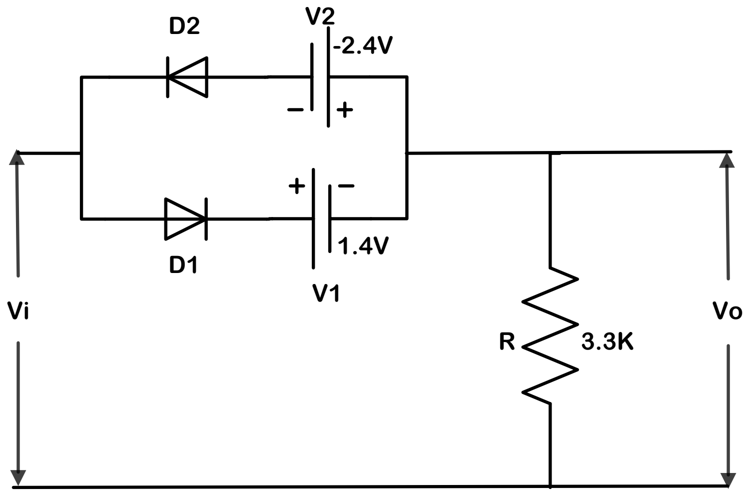
$V_{omax} = V_R + V_r$

$V_R = V_{omax} – V_r = 4 – 0.7$

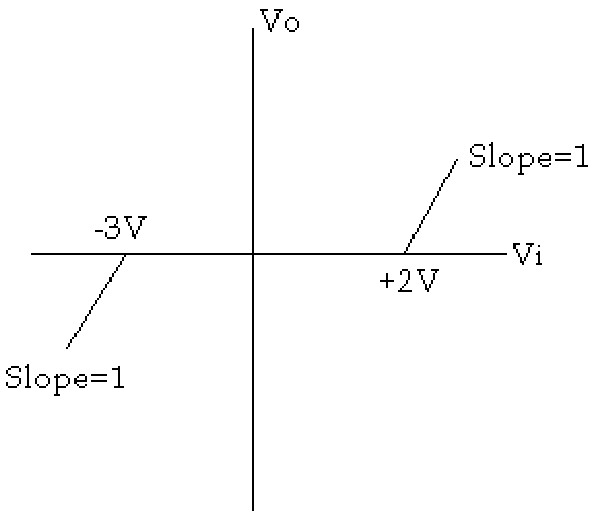
$\mathbf{V_R = 3.3V}$

VII) **To Clip a sine wave between +2V and -3V level:**

Circuit Diagram:



Transfer Characteristics:



To Clip a sine wave between +2V and -3V level

$V_o = V_1 + V_r$

$V_1 = V_o - V_r = 2-0.7$

$\mathbf{V_1 = 1.4V}$

$V_o = V_2 - V_r$

$-3 = V_2 – 0.7$

$V_2 = -3 + 0.7$

$\mathbf{V_2 = -2.3V}$

CLAMPING CIRCUITS

Aim: Design and test positive and negative clamping circuit for a given reference voltage.

Components required:

- Power Supply
- CRO
- Signal Generator
- Diode BY 127
- Resistors
- Capacitor

Design:

R_f – Diode forward resistance = 100Ω

Rr – Diode Reverse resistance = 1M Ω

R = $\sqrt{R_f R_r}$ = 10KΩ

$RC \gg T$ let T = 1ms f(1KHz)

Let RC = 10T

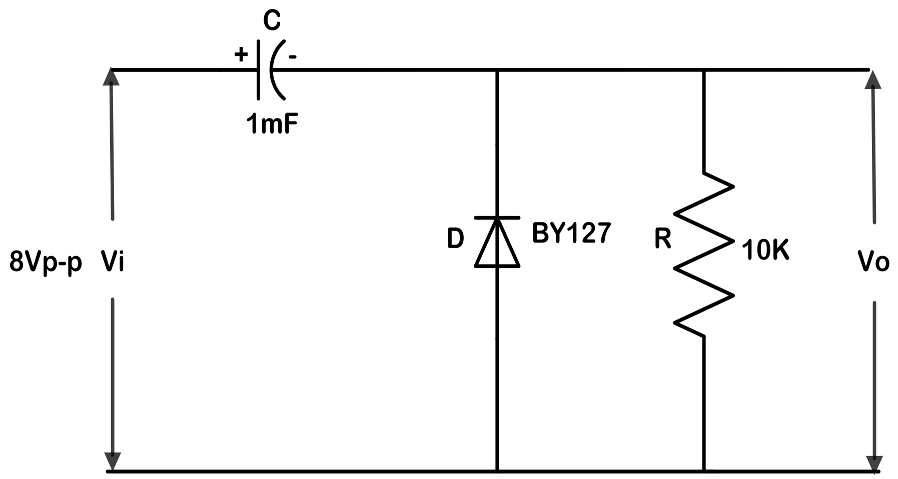
RC = 10ms

C = 1μF

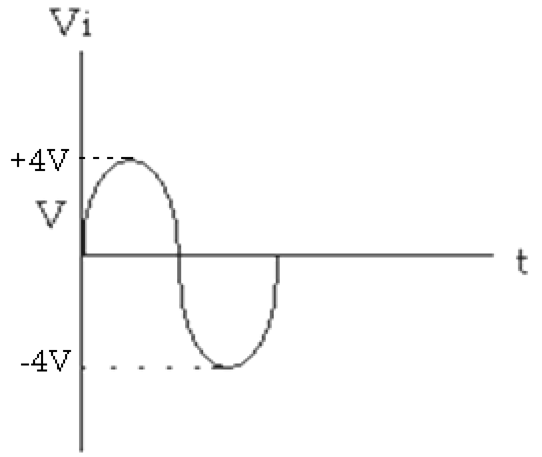
R = 10KΩ

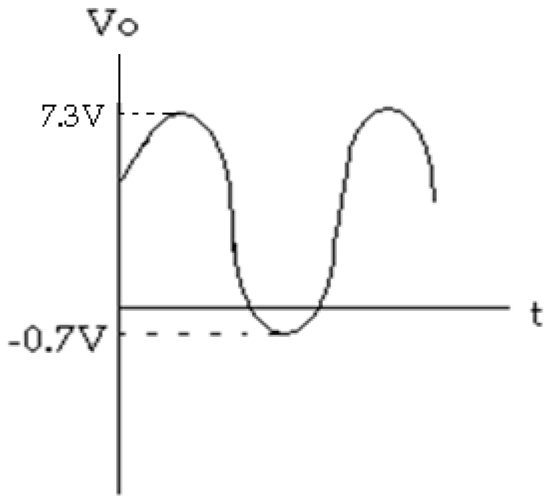
I) **Positive Clamping Circuits:**

Circuit Diagram:

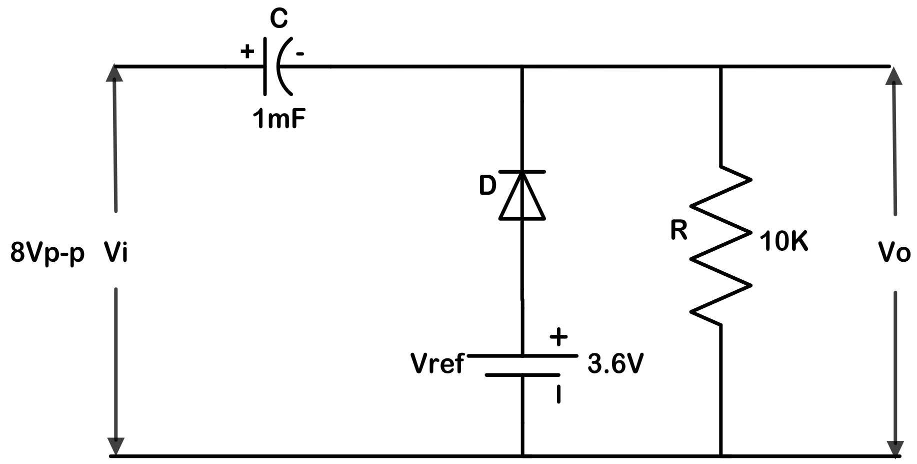


Waveforms:

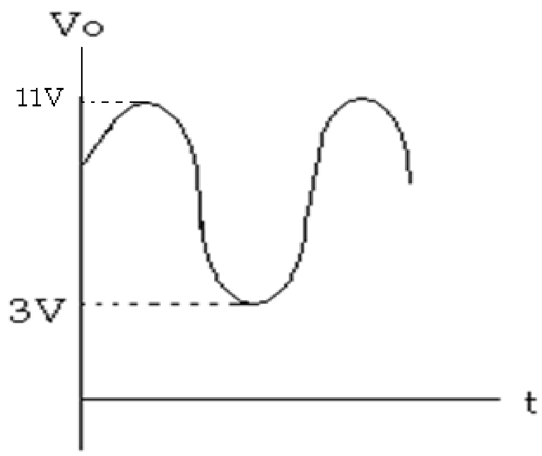




II) **Design a Clamping Circuit to Clamp Negative Peak at +3V:**



Waveforms:



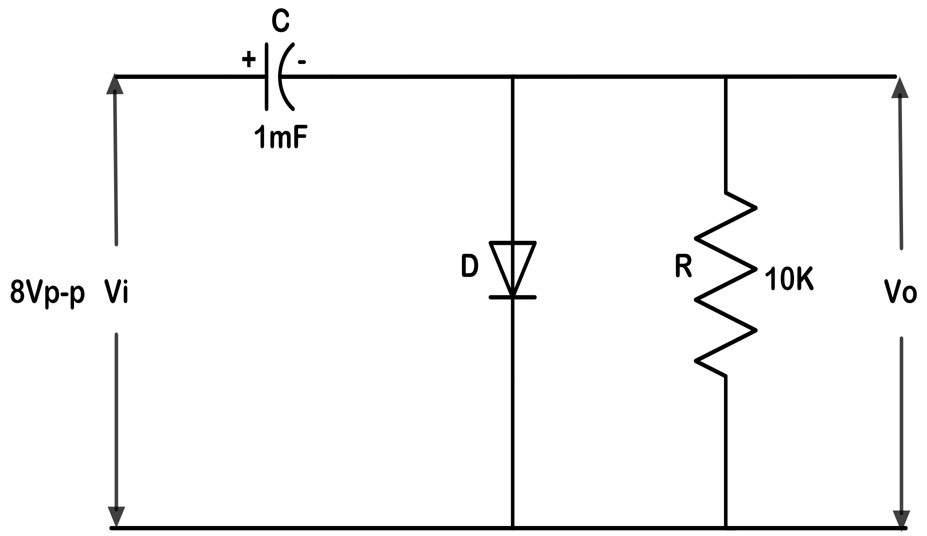
$V_o = V_\vartheta + V_{ref}$

$3 = -0.7 + V_{ref},$

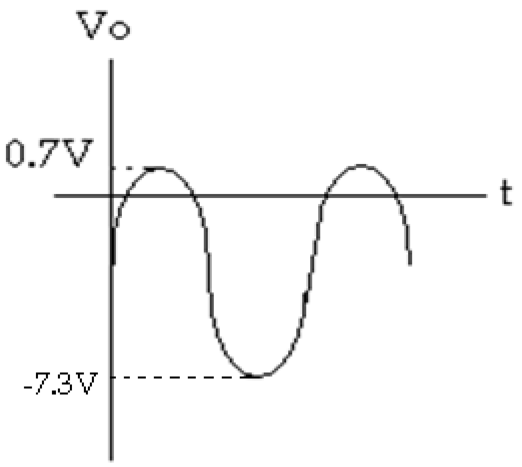
$\mathbf{V_{ref} = 3.7}$

III) **Negative Clamping Circuit:**

Circuit Diagram:

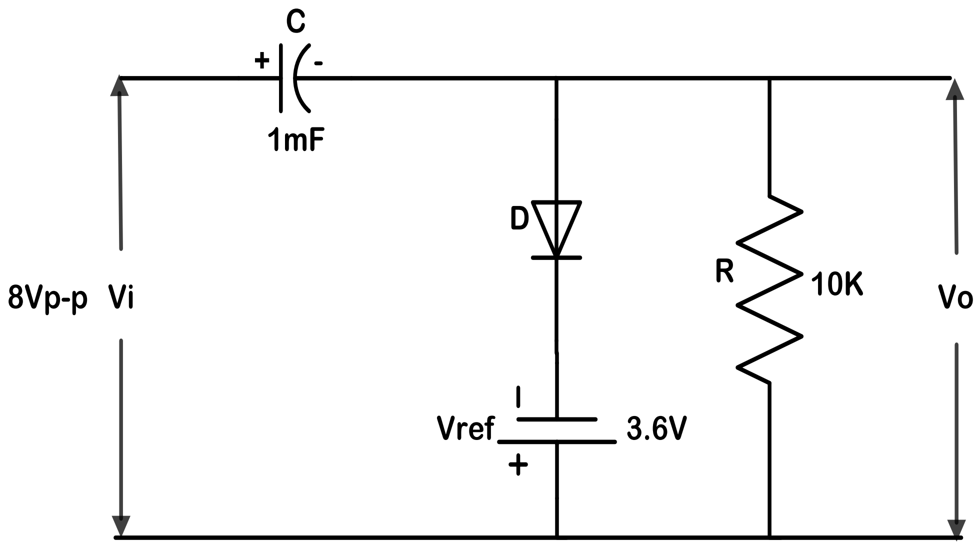


Waveforms:

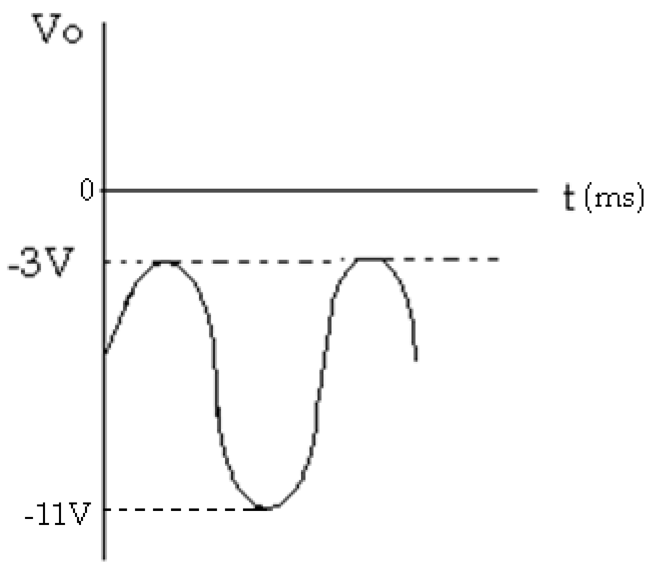


IV) **Design a Clamping Circuit to clamp Positive Peak at -3V:**

Circuit Diagram:



Waveforms:



$V_o = V_\vartheta - V_{ref}$

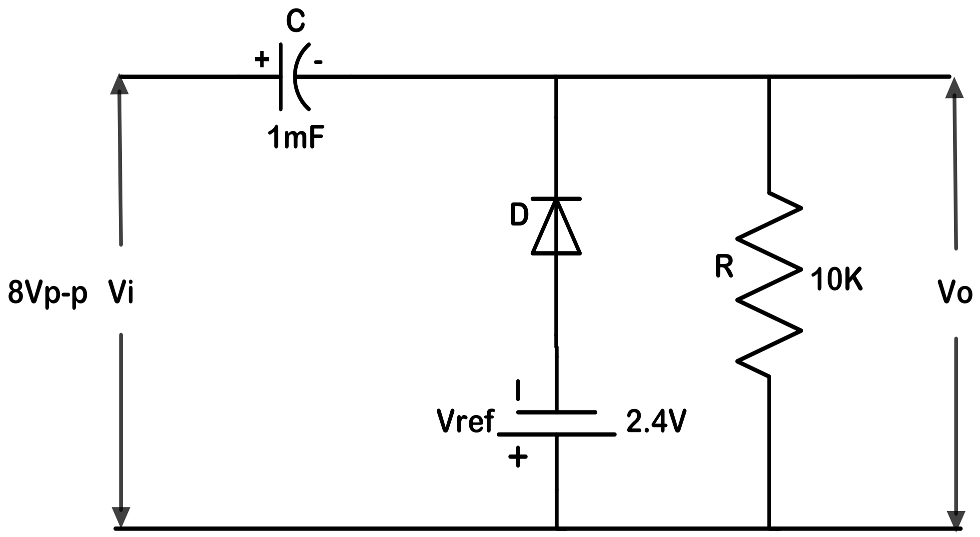
$V_{ref} = - V_o + V_\vartheta$

$= +3+0.7$

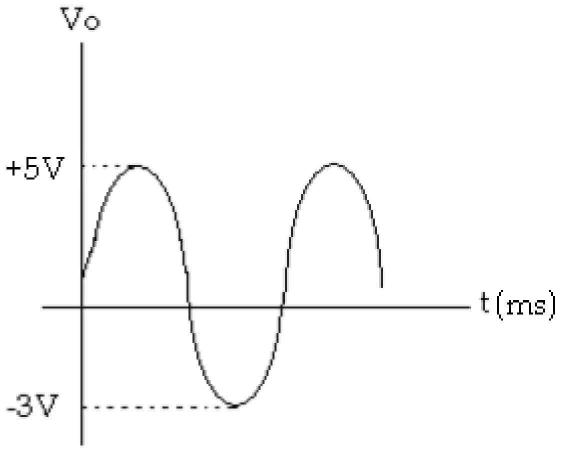
$\mathbf{V_{ref} = 3.7}$

V) **Design a Clamping Circuit to Clamp Negative Peak at -3V:**

Circuit Diagram:



Waveforms:



$V_o = -(V_\vartheta + V_{ref})$

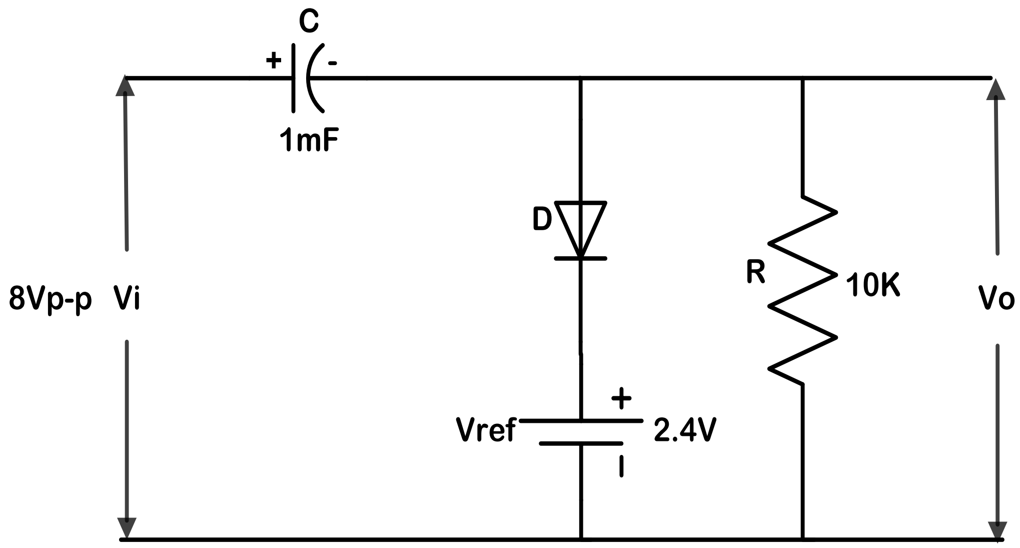
$V_{ref} = -V_o - V_\vartheta$

$= -0.7 - (-3)$

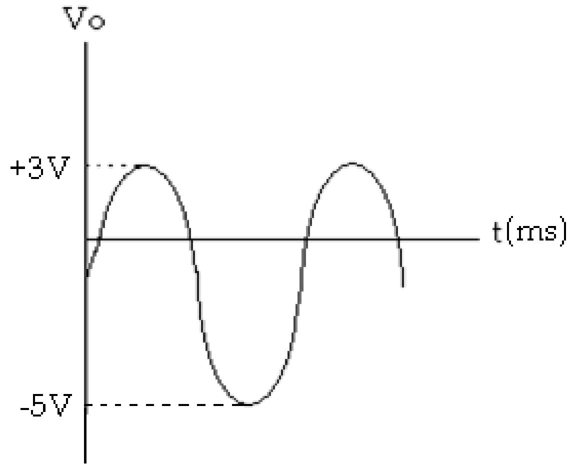
$\mathbf{V_{ref} = +2.3V}$

VI) Design a Clamping Circuit to clamp Positive Peak at +3V:

Circuit Diagram:



Waveforms:



$V_o = V_\vartheta + V_{ref}$

$V_{ref} = V_o - V_\vartheta$

$= 3 - 0.7$

$\mathbf{V_{ref} = 2.7V}$

Procedure:

- Rig up the circuit.
- Apply sinusoidal input signal of 8V P-P from signal generator.
- Observe the output waveform in the CRO.
- Note down the readings from the CRO and compare it with the expected values.

RECTIFIER CIRCUITS

Aim: To design and test Half wave, Full wave, Bridge Rectifier circuits with & without capacitor filter and determine the Ripple factor, Regulation & Efficiency.

Components required:

- Resistors
- Diodes
- 12-0-12V Transformer
- Capacitor

Calculations:

Assume R_L = 4.7KΩ, C = 220µF

I) Half wave Rectifier:

1. Ripple Factor without Filter (Theoretical) = 1.21
2. Percentage Regulation = $\frac{R_f}{R_L} \times 100$ (R_f = Diode forward resistance)
3. Rectifier Efficiency η = $\frac{0.406}{1+\frac{R_f}{R_L}} \simeq 40.6$ %
4. Ripple Factor without Filter $\Upsilon = \frac{1}{2\sqrt{3}\, f R_L C}$ (f = frequency = 50Hz)

II) Full wave Rectifier:

1. Ripple Factor without Filter = 0.48
2. Percentage Regulation = $\frac{R_f}{R_L} \times 100$
3. Rectifier Efficiency η = $\frac{0.81}{1+\frac{R_f}{R_L}} = 81$ %
4. Ripple Factor without Filter $\Upsilon = \frac{1}{4\sqrt{3}\, f C R_L}$

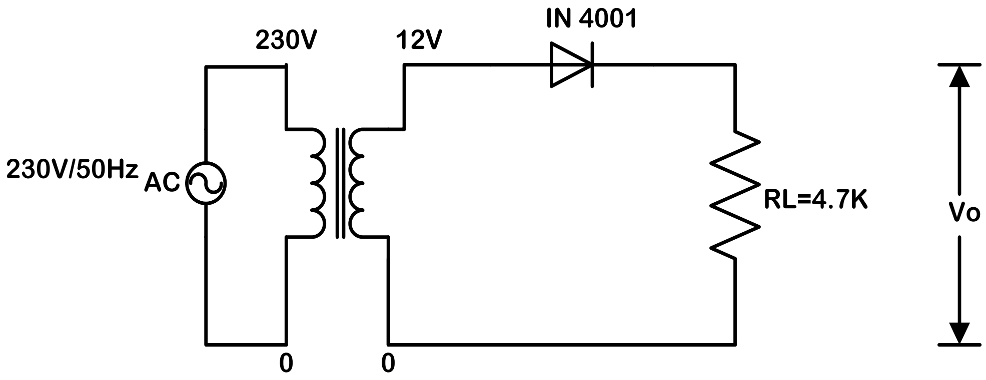
III) Bridge Rectifier:

1. Ripple Factor without Filter = 0.48
2. Percentage Regulation = $\frac{R_f}{R_L} \times 100$
3. Rectifier Efficiency η = $\frac{0.81}{1+\frac{R_f}{R_L}} = 81$ %

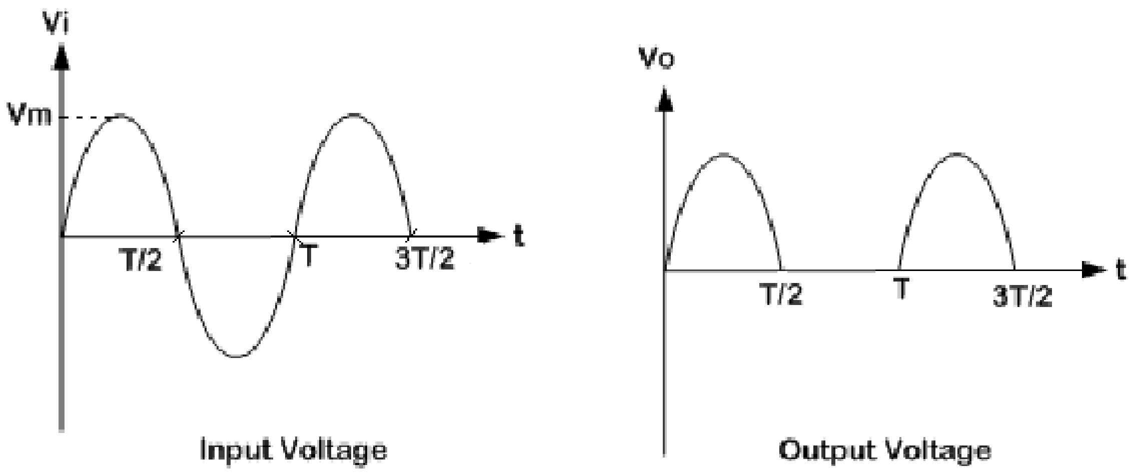
4. Ripple Factor without Filter $\Upsilon = \frac{1}{4\sqrt{3}\, fR_L C}$

I) Half wave Rectifier without Filter:

Circuit Diagram:



Waveforms:



Peak output voltage V_m=

$V_{dc} = \frac{Vm}{\pi} =$

$V_{rms} = \frac{Vm}{2} =$

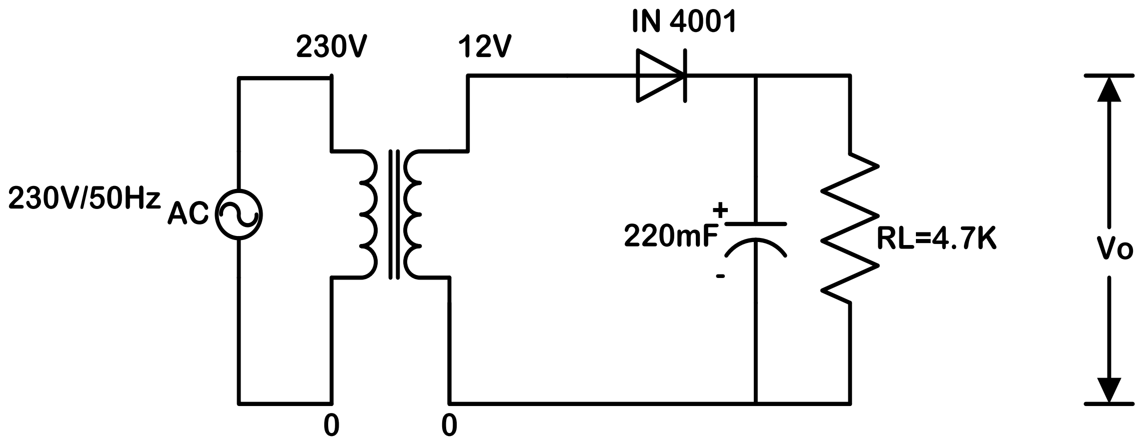
$V_{ac} = \sqrt{V_{rms^2} - V_{dc^2}} =$

Ripple Factor $\Upsilon = \frac{V_{ac}}{V_{dc}} =$

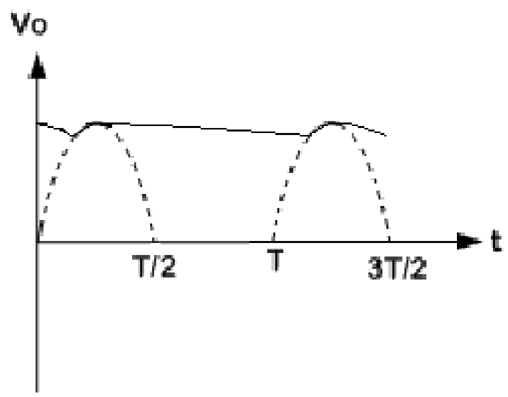
Rectifier efficiency $\eta = \frac{P_{dc}}{P_{ac}} = \frac{V_{dc^2}}{V_{rms^2}} =$

$$\% \text{ Regulation} = \frac{V_{dc(NL)} - V_{dc\,(FL)}}{V_{dc\,(FL)}} \times 100 =$$

II) Half wave Rectifier with Filter:



Waveforms:



Peak output Voltage V_m =

Ripple Factor = $\frac{V_{ac}}{V_{dc}}$ =

$V_{dc} = \frac{V_m}{1+\frac{1}{2fR_LC}}$ =

$V_{ac} = \frac{V_{rp-p}}{2}$ =

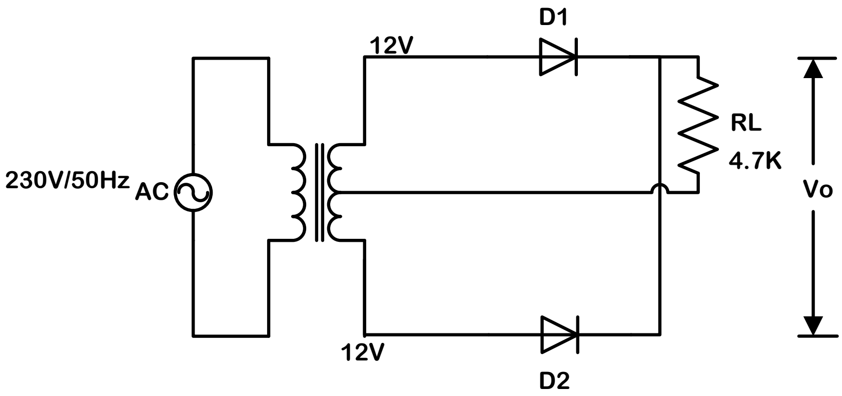
$V_{rms} = \sqrt{V_{dc}^2 + V_{ac}^2}$ =

Rectifier efficiency $\eta = \frac{P_{dc}}{P_{ac}} = \left[\frac{V_{dc}}{V_{rms}}\right]^2$ =

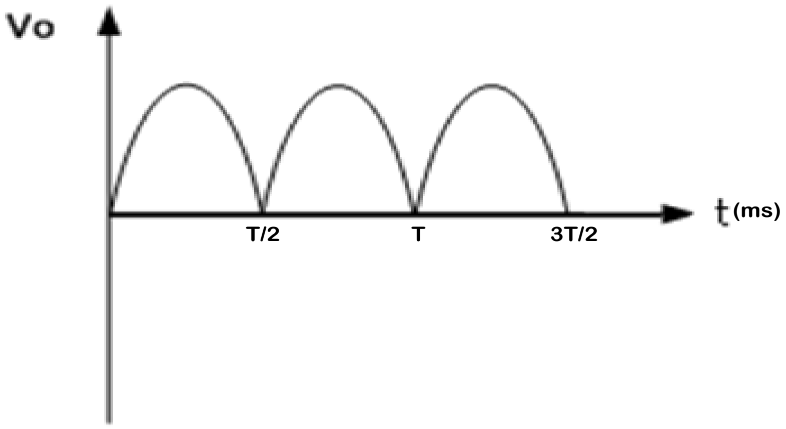
$$\% \text{ Regulation} = \frac{V_{dc(NL)} - V_{dc(FL)}}{V_{dc(FL)}} \times 100 =$$

III) Full wave Rectifier without Filter:

Circuit Diagram:



Waveforms:



$$V_{dc} = \frac{2Vm}{\pi} =$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} =$$

$$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2} =$$

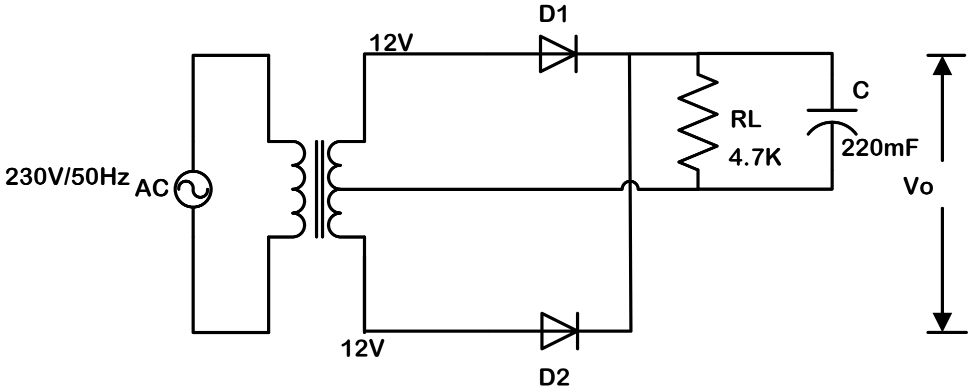
$$\Upsilon = \frac{V_{ac}}{V_{dc}} =$$

$\eta = \frac{P_{dc}}{P_{ac}} = \left[\frac{V_{dc}}{V_{rms}}\right]2=$

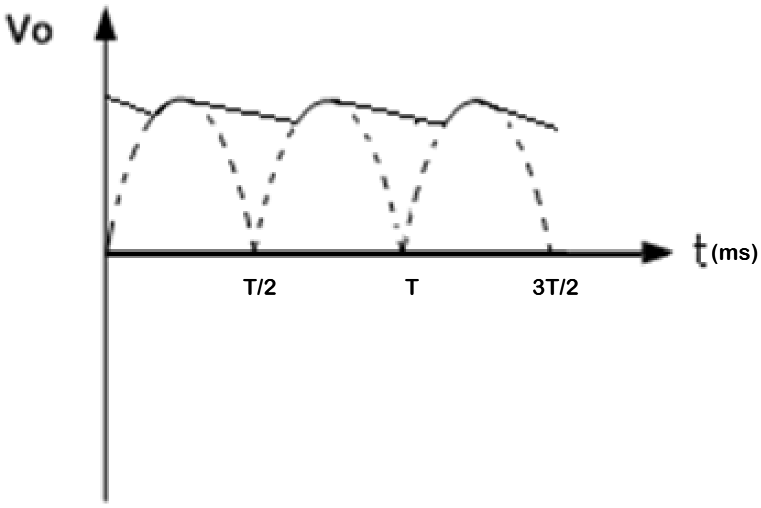
$\% \text{ Regulation} = \frac{V_{dc(NL)} - V_{dc\,(FL)}}{V_{dc\,(FL)}} \times 100 =$

IV) Full wave Rectifier with Filter:

Circuit Diagram:



Waveforms:



$V_{dc} = \frac{V_m}{1+\frac{1}{4fR_LC}} =$

$V_{ac} = \frac{V_{r-(p-p)}}{2\sqrt{3}} =$

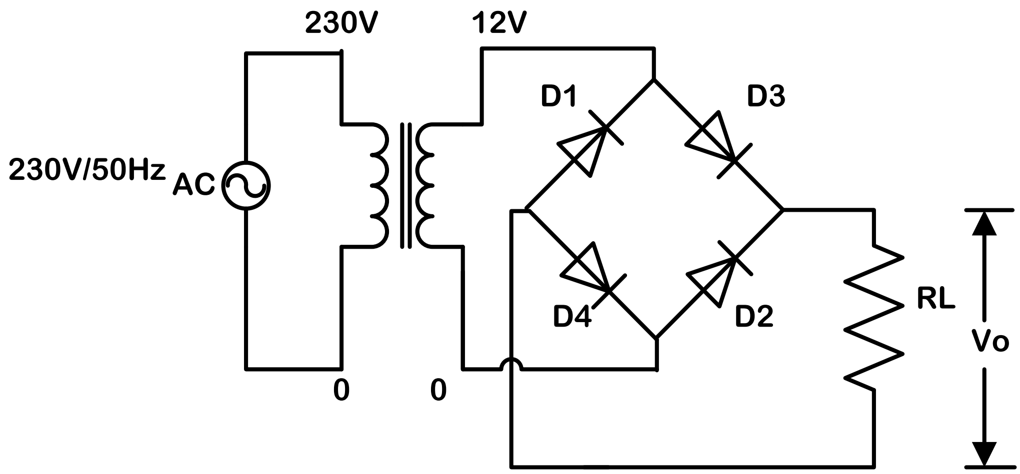
$\Upsilon = \frac{V_{ac}}{V_{dc}} =$

$V_{rms} = \sqrt{V_{dc}^2 + V_{ac}^2} =$

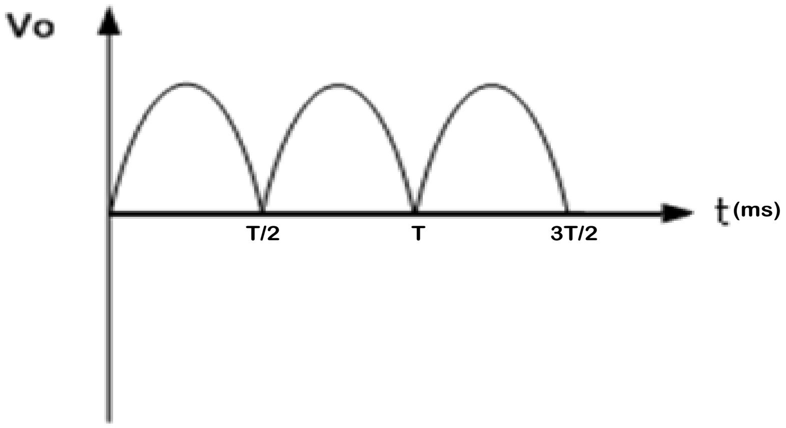
$\eta = \frac{P_{dc}}{P_{ac}} = \left[\frac{V_{dc}}{V_{rms}}\right]^2 =$

V) Bridge Rectifier without Filter:

Circuit Diagram:



Waveforms:



$V_{dc} = \frac{2V_m}{\pi} =$

$V_{rms} = \frac{V_m}{\sqrt{2}} =$

$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2} =$

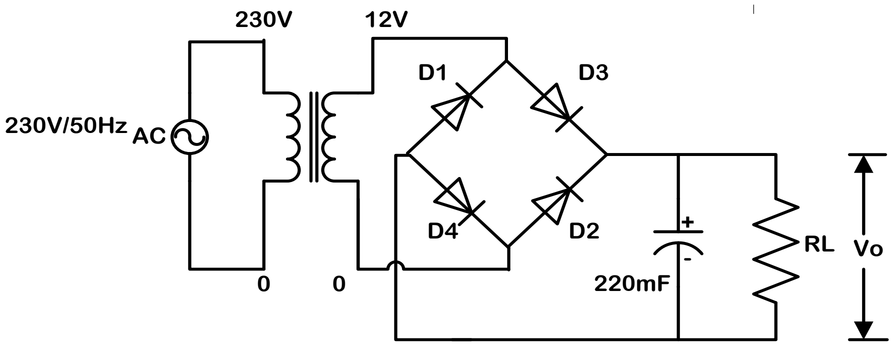
$\gamma = \frac{V_{ac}}{V_{dc}} =$

$\eta = \frac{P_{dc}}{P_{ac}} = \left[\frac{V_{dc}}{V_{rms}}\right]^2 =$

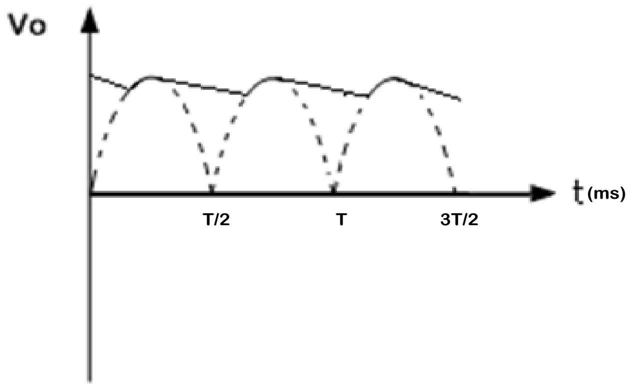
% Regulation = $\frac{V_{dc(NL)} - V_{dc\,(FL)}}{V_{dc\,(FL)}} \times 100 =$

VI) Bridge Rectifier with Filter:

Circuit Diagram:



Waveforms:



$V_{dc} = \frac{V_m}{1+\frac{1}{4fR_LC}} =$

$V_{ac} = \frac{V_{r-(p-p)}}{2\sqrt{3}} =$

$\Upsilon = \frac{V_{ac}}{V_{dc}} =$

$V_{rms} = \sqrt{V_{dc}^2 + V_{ac}^2} =$

$\eta = \frac{P_{dc}}{P_{ac}} = \left[\frac{V_{dc}}{V_{rms}}\right]2 =$

Procedure:

- Make the Connections as shown in the circuit diagram
- Apply 230V AC supply from the power mains to the primary of the transformer
- Observe the voltage across secondary to get V_m , the peak value in CRO
- Use relevant formula to find V_{dc} and V_{rms} of both Full wave and Half wave rectifier & draw the waveforms
- Find out the Ripple factor, Regulation and Efficiency by using the formula.

Conclusions:

RC-COUPLED AMPLIFIER

Aim: To design and setup an RC Coupled amplifier using BJT & to find the input and output impedance of the RC-Coupled amplifier.

Components Required:

- Transistor
- Capacitor
- Resistors
- Signal Generator
- CRO

Design:

Let $V_{cc} = 10V$

$I_c = 5mA$

$\beta = 100$

To find R_E:

$V_{RE} = \frac{Vcc}{10} = \frac{10}{10} = 1V$

i.e. $I_E R_E = 1V$

$R_E = \frac{1V}{I_E} = \frac{1V}{I_C} = \frac{1V}{5mA} = 200\Omega$

Select $R_E = 220\Omega$

To find R_C:

$V_{CE} = \frac{Vcc}{2} = \frac{10}{2} = 5V$

Apply KVL to CE loop,

$V_{CC} - I_C R_C - V_{CE} - V_{BE} = 0$

$10 - 5mR_C - 5 - 1 = 0$

$R_C = 800\Omega$

Select R_C as $820\ \Omega$

To find R_1:

From the above biasing circuit,

$V_B = V_{BE} + V_{RE} = 0.7 + 1 = 1.7V$

$I_C = \beta I_B$ or $I_B = \frac{I_C}{\beta} = \frac{5m}{100} = 0.05mA$

Assume 10 I_B flows through R_1

$$\therefore R_1 = \frac{Vcc - V_B}{10\ I_B} = \frac{10 - 1.7}{10 \times 0.050}$$

R_1 = 16.6KΩ

Select R_1 as 18KΩ

Assume 9 I_B flows through R2

$$\therefore R_2 = \frac{V_B}{9 I_B} = \frac{1.7}{9 \times 0.050m} = 3.7K\Omega$$

Select R_2 as 3.9KΩ

Bypass capacitor C_E and coupling Capacitor C_{C1} and C_{C2}

Let $X_{CE} = \frac{1}{10} R_E$ at f = 100Hz

i.e. $\frac{1}{2\pi f\, C_E} = \frac{R_E}{10}$

$$\therefore C_E = \frac{10}{2\pi \times 100 \times 220} = 72.3\mu F$$

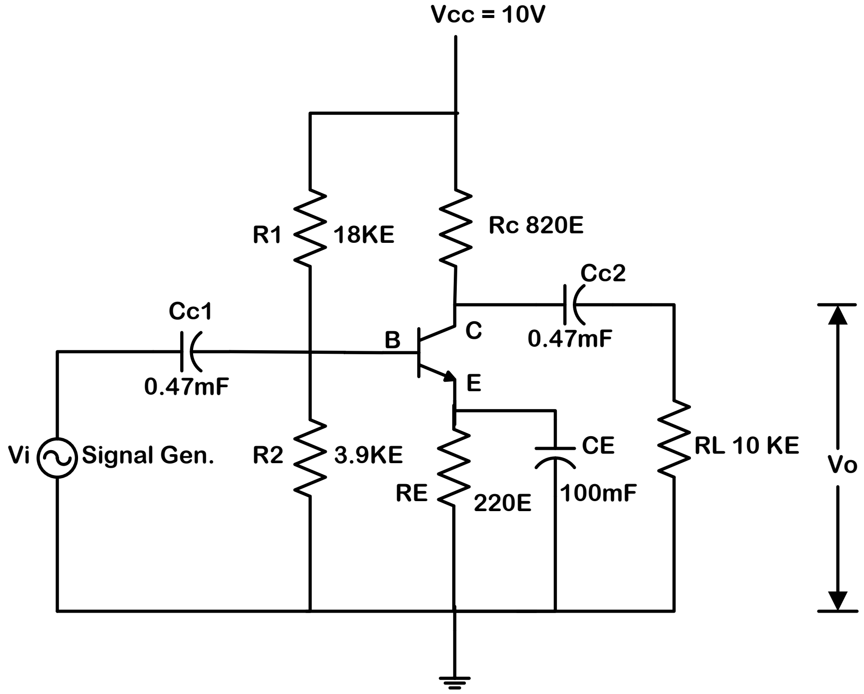
Select C_E as $100\mu F$

Also use $C_{C1} = C_{C2} = 0.47\ \mu F$

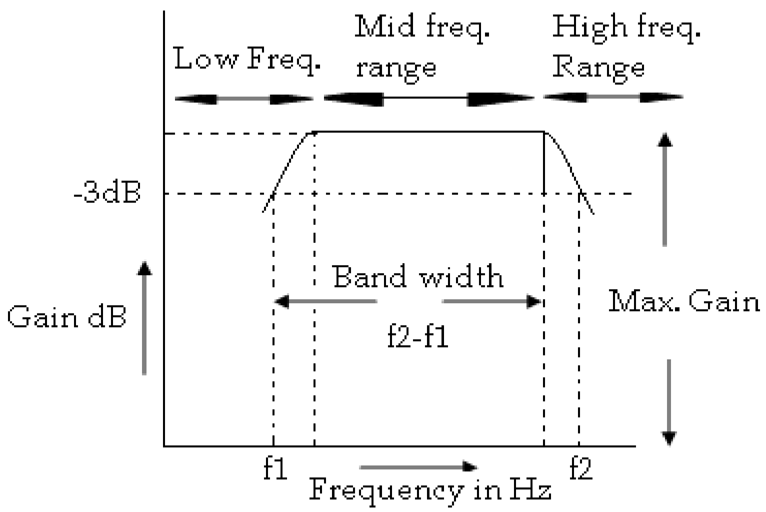
Procedure:

- Rig up the circuit
- Apply the sinusoidal input of 50m(P-P) and observe the input and output waveforms simultaneously on the CRO screen
- By varying the frequency of the input from Hz to maximum value and note down the output voltages
- Plot the frequency response (gain in dB vs log f) and determine the bandwidth from the graph

Circuit Diagram:



Waveforms:



Tabular Column:

Freq. in Hz	$V_{o\ P\text{-}P}$	$A_V = V_o / V_1$	Gain in dB = $20 \log_{10} A_V$
50 Hz			
100 Hz			
200 Hz			
300 Hz			
500 Hz			
1KHz			

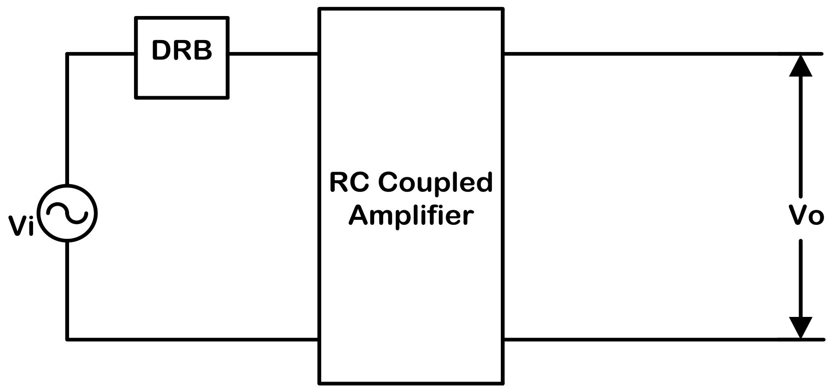
1.2 KHz . . 2 KHz 3 KHz 4 KHz . 200KHz 300KHz . 2 MHz			

<u>To measure input impedance and output impedance:</u>

I) <u>Input impedance (Ri):</u>

<u>Procedure:</u>

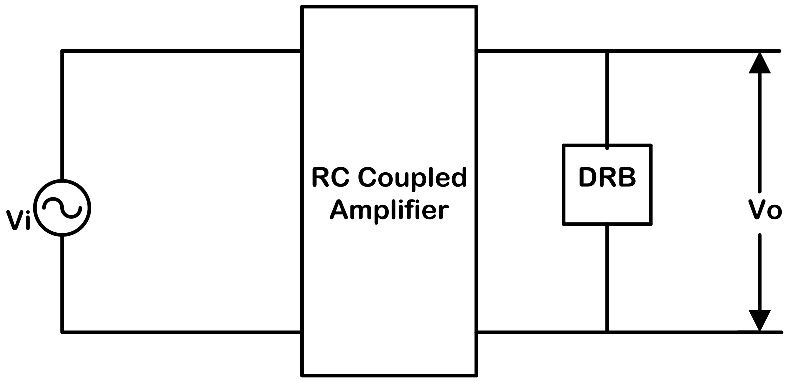
- Connect the circuit as shown
- Set the DRB to a minimum value
- Set the output to a convenient level and note down the output voltage
- Increase the DRB value till V_O becomes half of the maximum amplitude
- The corresponding DRB value gives input impedance



II) <u>Output impedance (R_O):</u>

<u>Procedure:</u>

- Connect the circuit as shown
- Set the DRB to a maximum value
- Set the output to a convenient level and note down the output voltage
- Increase the DRB value till V_O becomes half of the maximum amplitude
- The corresponding DRB value gives input impedance



Result:

Bandwidth: __________Hz
Input Impedance: __________Ω
Output Impedance: __________Ω

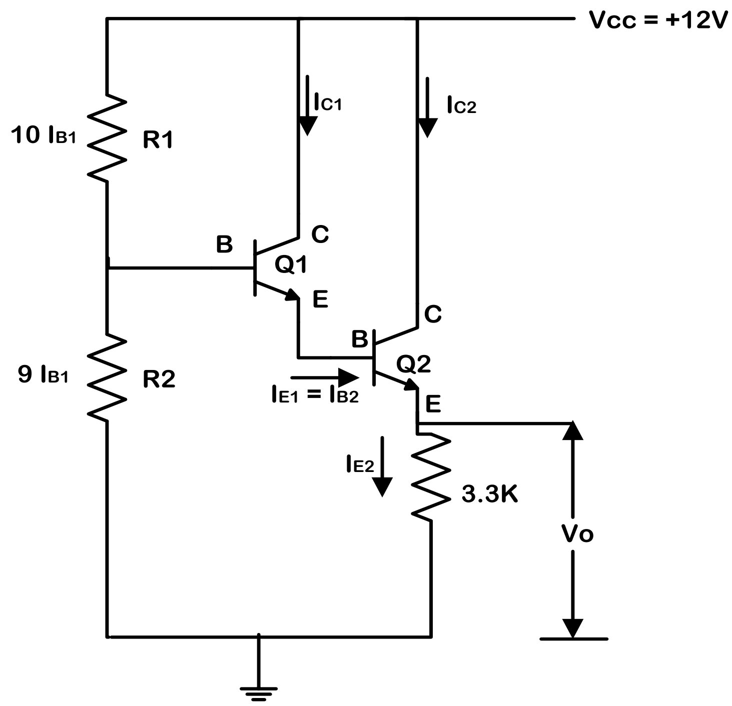
DARLINGTON EMITTER FOLLOWER

Aim: To determine a BJT Darlington Emitter Follower and determine the Gain, Input and Output impedances.

Components required:

- -Transistor (SL100)
- - Resistors
- - Signal Generator
- - CRO
- - Capacitors

Biasing Circuit:



Design:

Let V_{cc} = 12V

I_{c2} = 2mA

β = 100

From Biasing Circuit,

$V_{B1} = 2V_{BE} + V_{RE}$

$V_{B1} = 1.4 + 6$

$V_{B1} = 7.4V$

Let $V_{B2} = \frac{V_{CC}}{2} = \frac{12}{2} = 6V$

$I_{E2}R_E = 6V$

$R_E = \frac{6}{2_m} = 3K\Omega$

Select RE =3.3KΩ

$I_{B2} = \frac{I_{C2}}{\beta} = \frac{2m}{100} = 0.02mA$

$I_{B1} = \frac{I_{C1}}{\beta} = \frac{I_{B2}}{\beta} = \frac{0.02m}{100} = 0.0002mA$

Assume 10 I_B flows through R_1

$R_1 = \frac{V_{CC} - V_{B1}}{10 I_{B1}} = \frac{12 - 7.4}{10 \times 0.0002m} = \frac{4.6}{2 \times 10^{-3} \times 10^{-3}} = 2.3M\Omega$

Assume 9 I_B flows through R_2

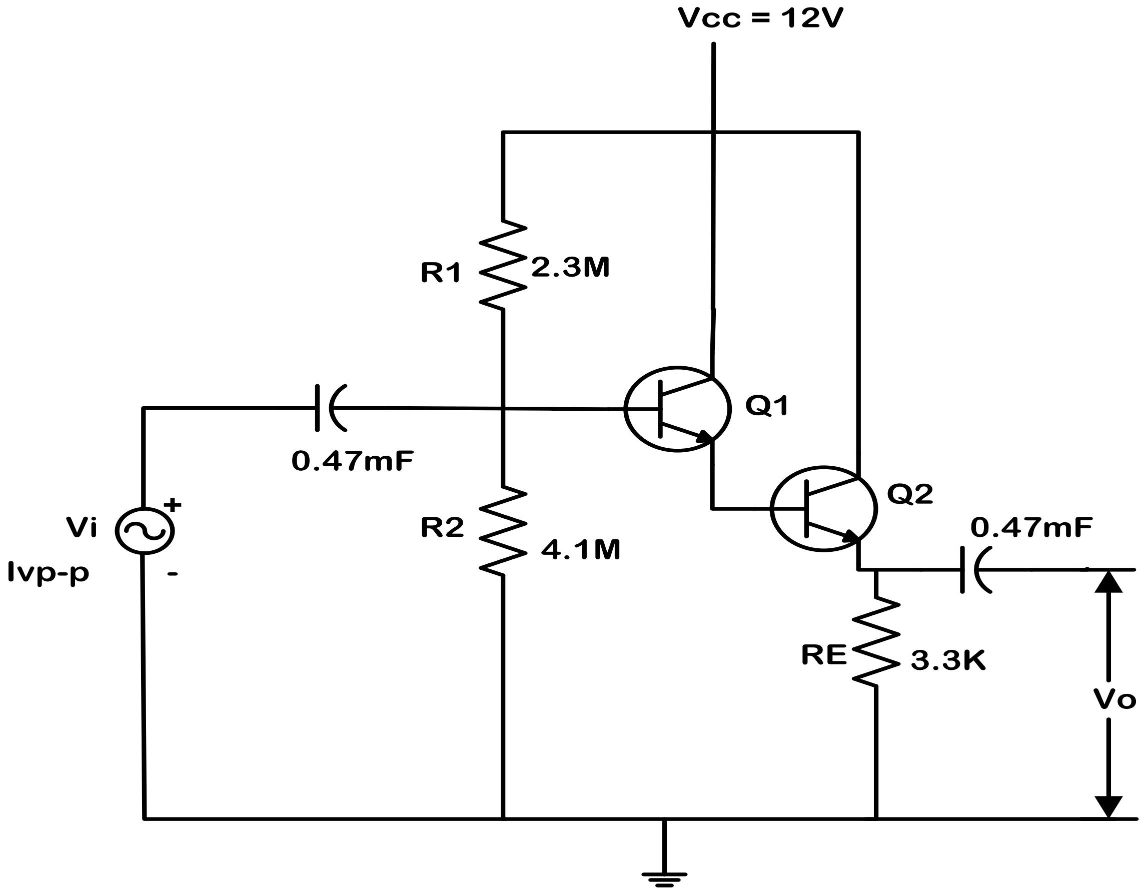
$R_2 = \frac{V_B}{9\, I_B} = \frac{7.4}{9 \times 0.0002m} = \frac{7.4}{1.8 \times 10^{-3} \times 10^{-3}} = 4.1M\Omega$

Choose the coupling capacitor C_{C1} and C_{C2} as 0.47µF

Procedure:

- Connect the circuit as shown in the circuit diagram.
- Set the Signal generator amplitude as 1V peak to peak and observe the input and output waveforms simultaneously on the CRO.
- By varying the frequency of the input from Hz range to MHz range and note the frequency range of the signal and corresponding voltage.
- The output voltage remains constant in mid frequency range.
- Tabulate the readings in tabular column.
- Plot the graph with frequency along X-axis and gain in dB along Y-axis.
- From the graph determine the bandwidth.

Circuit Diagram:



Tabular Column:

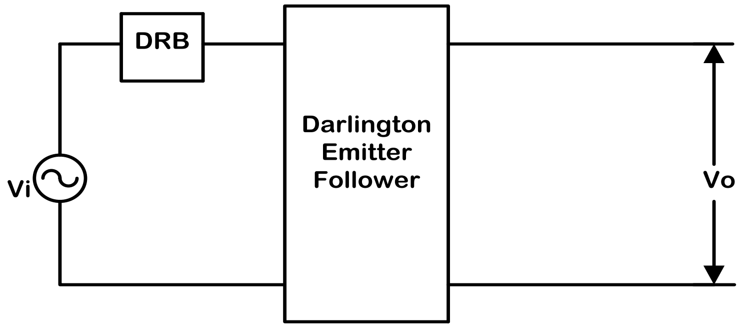
Freq. in Hz	$V_{o\ P-P}$	$A_V = {V_o}/{V_1}$	Gain in dB $= 20 \log_{10} A_V$
50 Hz			
100 Hz			
200 Hz			
500 Hz			
1kHz			
2Khz			
3Khz			
4Khz			
200Khz			
300Khz			
.			
.			
3 MHz			

To measure input impedance and output impedance:

I) Input impedance (Ri):

Procedure:

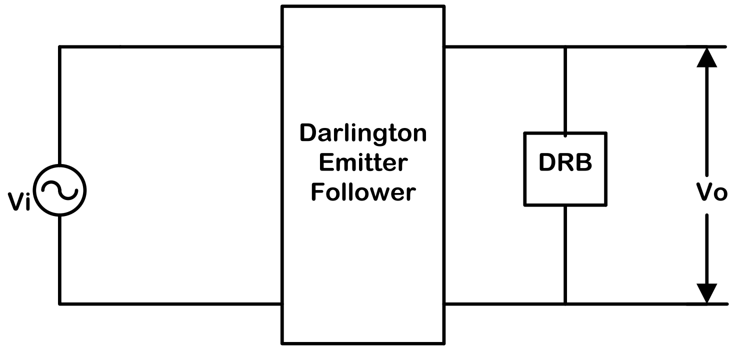
- Connect the circuit as shown
- Set the DRB to a minimum value
- Set the output to a convenient level and note down the output voltage
- Increase the DRB value till V_O becomes half of the maximum amplitude
- The corresponding DRB value gives input impedance



II) Output impedance (R_O):

Procedure:

- Connect the circuit as shown
- Set the DRB to a maximum value
- Set the output to a convenient level and note down the output voltage
- Increase the DRB value till V_O becomes half of the maximum amplitude
- The corresponding DRB value gives input impedance



Result:

Bandwidth: ___________Hz
Input Impedance: ___________Ω
Output Impedance: ___________Ω

R.C.PHASE SHIFT OSCILLATOR

Aim: To design and test the RC Phase shift Oscillator for the frequency of 1KHz.

Components required:

- -Transistor (BC 107)
- Resistors
- CRO
- Capacitors

Design:

V_{CC} = 12V

I_C = 2mA

V_{RC} = 40% V_{CC} = 4.8V

V_{RE} = 10% V_{CC} = 1.2V

V_{CE} = 50% V_{CC} = 6V

To find R_C, R_1, R_E & R_2

We Have,

$V_{RC} = I_C R_C$=4.8V

R_C = 2.4KΩ

Choose R_C = 2.2KΩ

$V_{RE} = I_E R_E$=1.2V

R_E = 600Ω

Choose R_E = 680Ω

h_{fe} = 100 (For BC 107)

$I_B = \frac{I_C}{h_{fe}}$ = 20mA

Assume current through R_1 = 10 I_B & through R_2 = 9 I_B

$VR_1 = V_{CC} - V_{R2}$

= 10V

Also, VR_1 =10 I_B R_1=10.1V

$R_1 = 50K\Omega$

Choose $R_1 = 47K\Omega$

$VR_2 = V_{BE+}V_{RE}$

$= 0.7+1.2$

$= 1.9V$

Also, $VR_2 = 9\ I_B\ R_2 = 1.9V$

$R_2 = 10.6K\Omega$

Choose $R_1 = 12K\Omega$

To find C_C & C_E

$$X_{CE} = \frac{1}{2\pi C_E} = \frac{1}{10} R_E = \frac{680}{10} = 68\Omega$$

For ϑ = 20Hz

$C_E = 117\mu F$

Choose $C_E = 220\ \mu F$

$$X_{CC} = \frac{1}{2\pi C_C} = \frac{R_C}{10} = 220\Omega$$

For ϑ = 20Hz

Choose $C_C = 47\ \mu F$

Design of ϑ Selective Circuit:

Required ϑ of oscillations f = 1KHz

$$f = \frac{1}{2\pi R_{C\sqrt{6}+\frac{4R_C}{R}}}$$

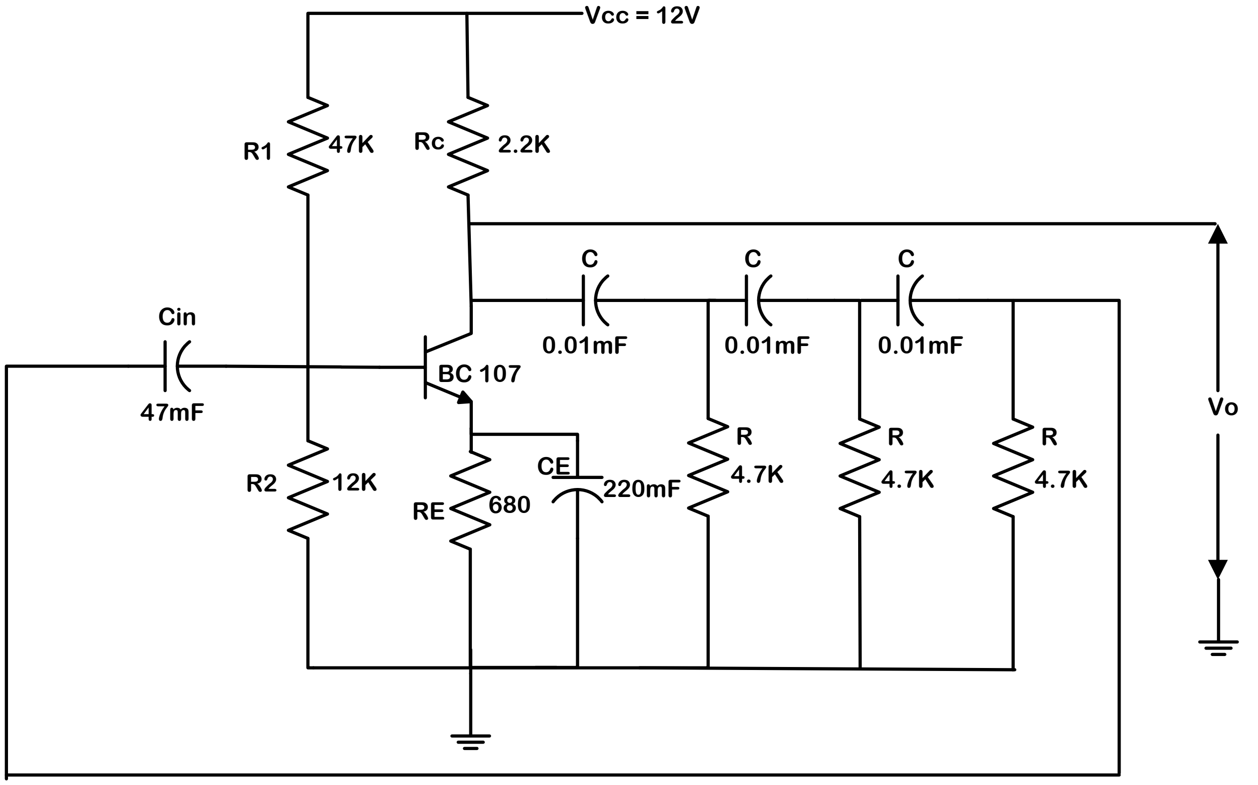
Take R= 4.7KΩ & C=0.01μF

Procedure:

- Rig up the circuit as shown in the figure
- Observe the sinusoidal output voltage.

- Measure the frequency and compare with the theoretical values.

Circuit Diagram:



Result:

Frequency

Theoretical: 1KHz

Practical: _________

VERIFICATION OF NETWORK THEOREMS

Aim: To verify Thevenin's & Maximum power transfer theorem for DC Circuits.

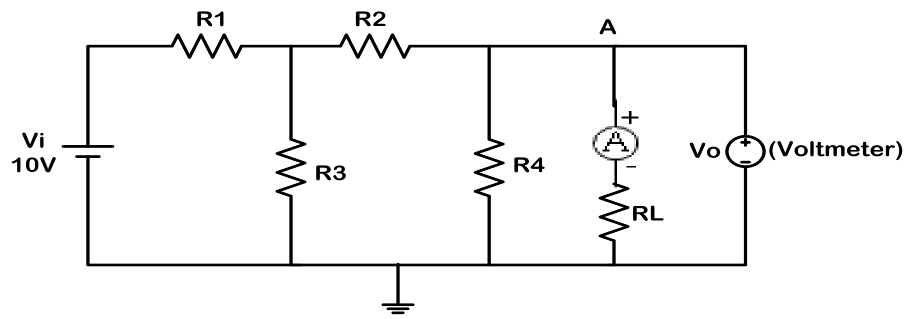
Components Required:

- Resistor
- DRB
- Ammeter (DC)
- Multimeter

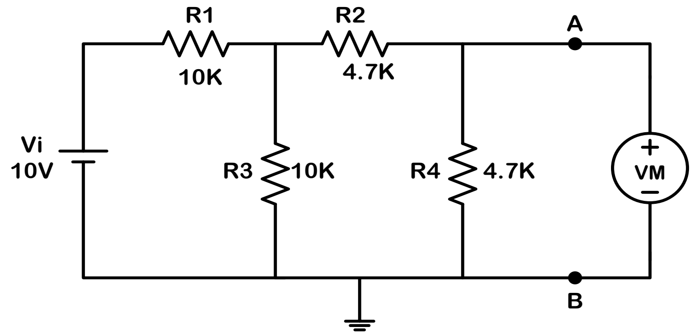
I) **Thevenin's Theorem:**

Circuit Diagram:

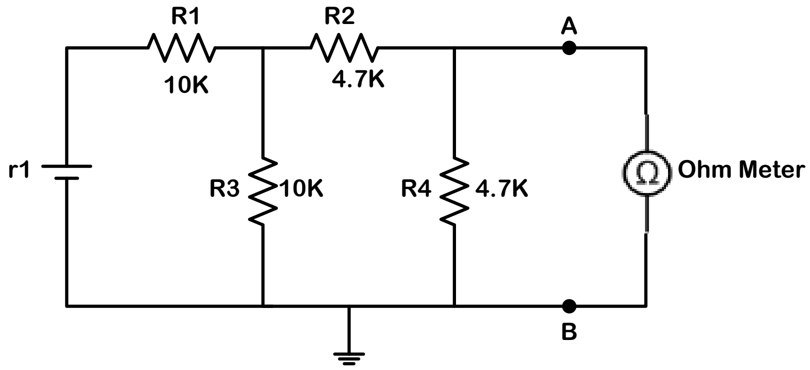
a) **Given Resistor Network:**

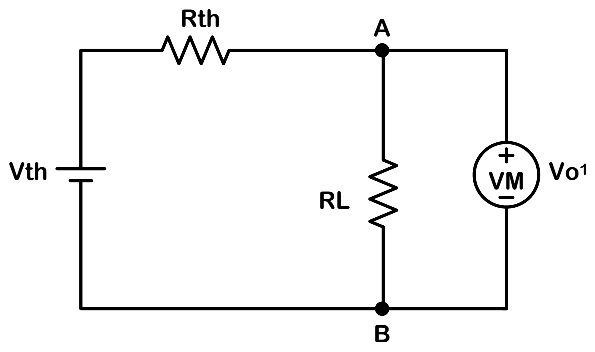


b) **Thevenin's Voltage – Experimental Setup:**



c) **Thevenin's Resistance – Experimental Setup:**





Calculations:

Assume $V_i = 10V$, R_1=10KΩ, R_2=4.7KΩ, R_3=10KΩ, R_4=4.7KΩ, R_L=10KΩ

At node 1:

$$\frac{V_1-10}{10K} + \frac{V_1-V_2}{4.7K} + \frac{V_1}{10K} = 0$$

$$V_1\left[\frac{1}{10K} + \frac{1}{4.7K} + \frac{1}{10K}\right] - \frac{V_2}{4.7K} = \frac{1}{1K}$$

$4.128\times 10^{-4}V_1 - 2.128\times 10^{-4}V_2 = 1m$ -------------(1)

At node 2:

$$\frac{V_2-V_1}{4.7K} + \frac{V_2}{4.7K} = 0$$

$4.26\times 10^{-4} V_2 - 2.128\times 10^{-4}V_1 = 0$ -------------(2)

From (1) & (2)

$\mathbf{V_1 = 3.27V}$

$\mathbf{V_2 = V_{th} = V_m = 1.635V}$

$R_{th} = ([(10 \parallel 10) + 4.7] \parallel 4.7)K$

$= ((\frac{10\times10}{20}) \times 4.7 \parallel 4.7)K$

$= ((5+4.7) \parallel 4.7)K$

$= (9.7 \parallel 4.7)K$

$\mathbf{R_{th} = 3.16K\Omega}$

$I_L = \frac{V_{th}}{R_{th}+R_L} = \frac{1.63}{3.16K+10K} = 0.124mA$

$\mathbf{I_L = 0.124mA}$

$V_{O^1} = I_L \times R_L$

$= 0.1238m \times 10K = 1.24V$

$\mathbf{V_{O^1} = 1.24V}$

Procedure:

- Rig up the circuit as shown in the Fig I(a), measure the voltage across load R_L using DC Voltmeter. Note voltage as V_O.
- Connect the circuit as in Fig I(b), measure the voltage across terminals AB. Note down the voltage reading as V_{OC}.
- Rig up the circuit as shown in the Fig I(c), switch of the DC voltage source. The resistance 'r', represents internal resistance of the voltage source.
- Measure resistance across terminals AB using multimeter. Note down the resistance value as R_O.
- Now rig up the circuit as shown in the Fig I(d), switch on the power supply and measure the voltage drop across the load resistance R_L using the multimeter, note down voltage as V_O^1.
- Compare the voltages V_O and V_O^1, they must agree each other, which verifies Thevenins theorem.

Observations:

Voltage across load R_L in the circuit Fig I(a), V_O=

Current through load R_L in the circuit Fig I(a), I_O=

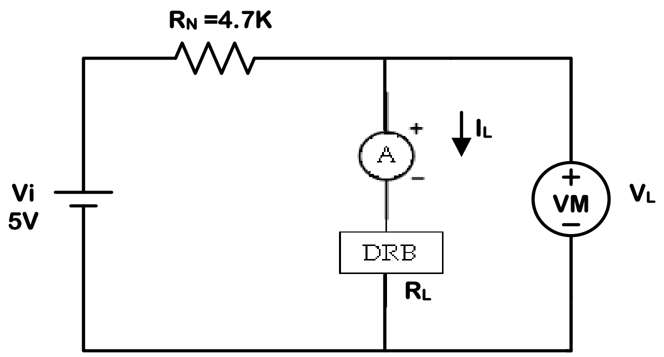
Thevenins Voltage in Fig I(b), V_{OC} =

Thevenins Resistance in Fig I(c), R_O =

Voltage across load R_L in Thevenins equivalent circuit in Fig I(d), V_O^1 =

II) **Maximum Power Transfer Theorem:**

Circuit Diagrams:



Calculations:

Choose $R_N = 4.7K\Omega$

$$-5 + 4.7K\, I_L + R_L\, I_L = 0$$

$$9.4K\, I_L = 5$$

$$\mathbf{I_L = 0.53mA}$$

Maximum Power:

$$P = I_L^2 R_L$$

$$= 1.32mw$$

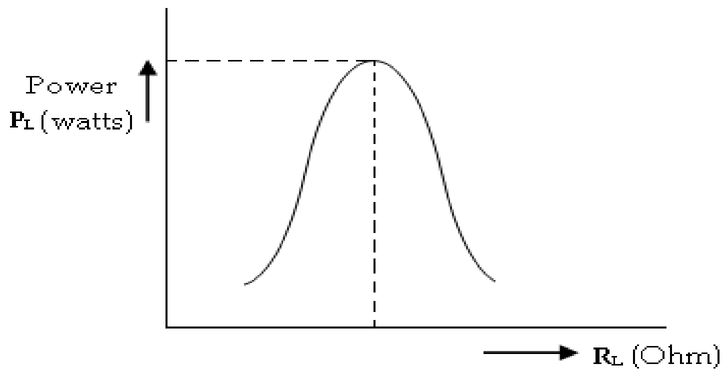
Procedure:

- Rig up the circuit as shown in the Fig II
- Set the input Dc voltage $V_i = 5V$
- Vary the resistance R_L using DRB in regular steps and note down the corresponding voltmeter and ammeter readings.
- Plot the graph of power Vs Resistance R_L.
- Determine the resistance R_L at which power is maximum (From the Graph)

Tabular Column:

R_L (Ω)	I_L (mA)	V_L (volts)	$P_L = V_L I_L$(watts)
1 K			
2 K			
3 K			
4 K			
4.1 K			
4.2 K			
.			
.			
5 K			
6 K			
10 K			

Specimen Graph:



SERIES AND PARALLEL RESONANCE CIRCUITS

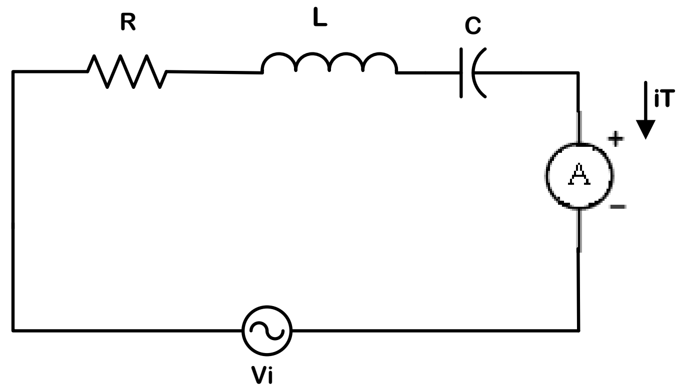
Aim: To test and verify the working/functioning of Series and Parallel resonance circuits and plots its response

Components Required:

- Resistor, Decade Resistance Box
- Decade Capacitance Box
- Decade Inductance Box
- Function Generator
- AC Voltmeter, Ammeter

I) Series Resonance:

Circuit Diagram:



Procedure:

- Set up the circuit as in Fig
- Set input voltage V_m = 5v using signal generator and vary the frequency from 100Hz to 1MHz in regular steps.
- Note down he corresponding voltage and current.
- Plot the graph of Frequency Vs Current
- Find Resonance Frequency, Quality Factor and Bandwidth from the graph obtained and compare with the theoretical values.

Calculations:

Take R = 100Ω, L = 10mH, C = 0.1μF

Resonance Frequency $f_o = \frac{1}{2\pi\sqrt{LC}} =$

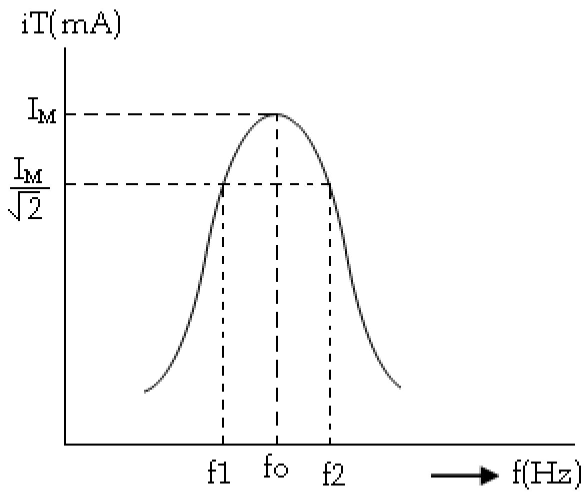
Quality factor of Series Resonance Circuit $Q_o = \frac{W_O L}{R} = \frac{1}{W_O C R} =$

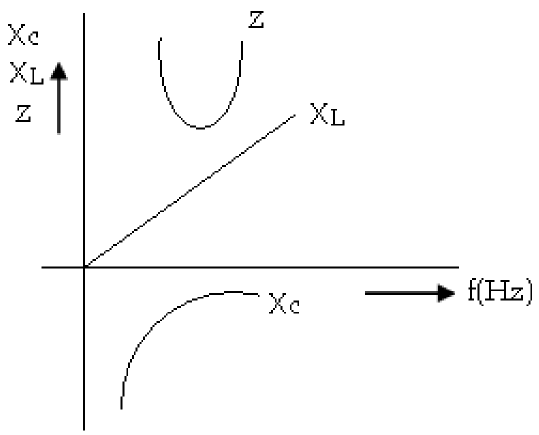
Bandwidth $B_W = \frac{w_O}{Q_O} =$

Observations:

Frequency (Hz)	Total Current i_T(mA)	X_C (Ω)	X_L (Ω)	$Z = \frac{v}{iT}$ (Ω)	$Z = \sqrt{R^2 + (X_L - X_o)^2}$(Ω)
1 KHz **2 KHz** **3 KHz** **4 KHz** . . . **10 KHz**					

Model Graph:





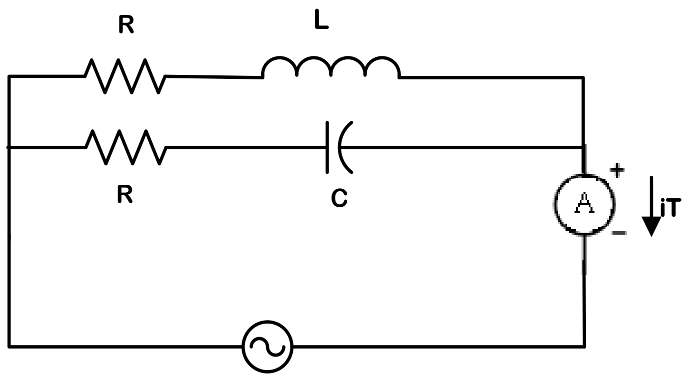
From the Graph,

Resonance Frequency f_o =

Bandwidth BW = $f_2 - f_1$ =

II) Parallel Resonance:

Circuit Diagram:



Procedure:

- Set up the circuit as in Fig
- Set input voltage V_m = 5v using signal generator and vary the frequency from 100Hz to 1MHz in regular steps.
- Note down he corresponding voltage and current readings and calculate impedance $Z = \frac{V_T}{I_T}$
- Plot the graph of Frequency Vs Impedance.
- Find Resonance Frequency, Quality Factor and Bandwidth from the graph obtained and compare with the theoretical values.

Calculations:

Take R_L= 4.7KΩ, R_C = 4.7KΩ, L = 10mH, C = 0.1µF

Resonance Frequency fo = $\frac{1}{2\pi\sqrt{LC}}$, if R_L= R_C

Quality factor of Series Resonance Circuit Q_o = $\frac{R}{W_O L}$ = $W_O RC$ =

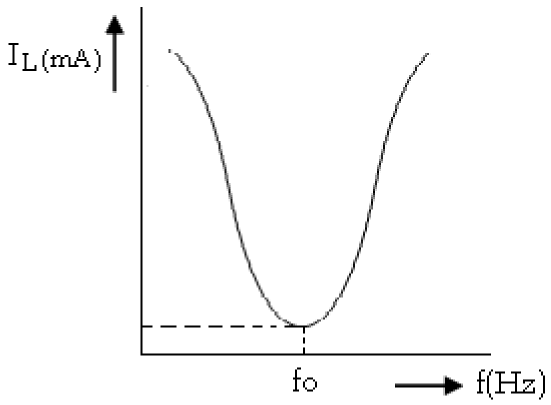
Bandwidth B_W =

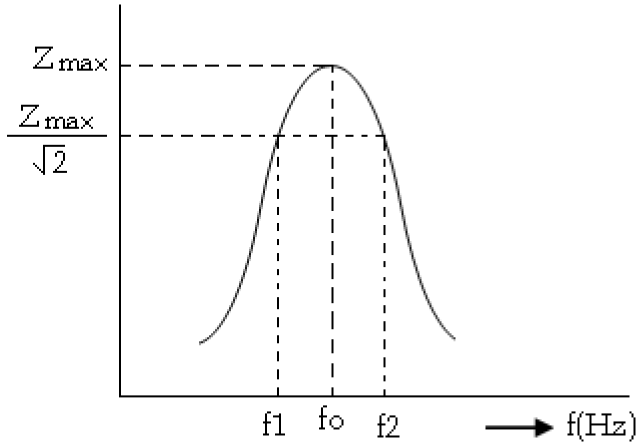
Observations:

V_m = 5V

Frequency (Hz)	Total Current i_T(mA)	X_C (Ω)	X_L (Ω)	$Z = \frac{v}{iT}$ (Ω)
1 KHz **2 KHz** **3 KHz** **4 KHz** . . **10 KHz**				

Specimen Graph:





From the Graph,

Resonance Frequency f_o =

Bandwidth BW = $f_2 - f_1$ =

Results:

Parameters		Series Resonance	Parallel Resonance
Resonance Frequency	Theoretical		
	Observed		
Bandwidth	Theoretical		
	Observed		
Quality Factor	Theoretical		
	Observed		

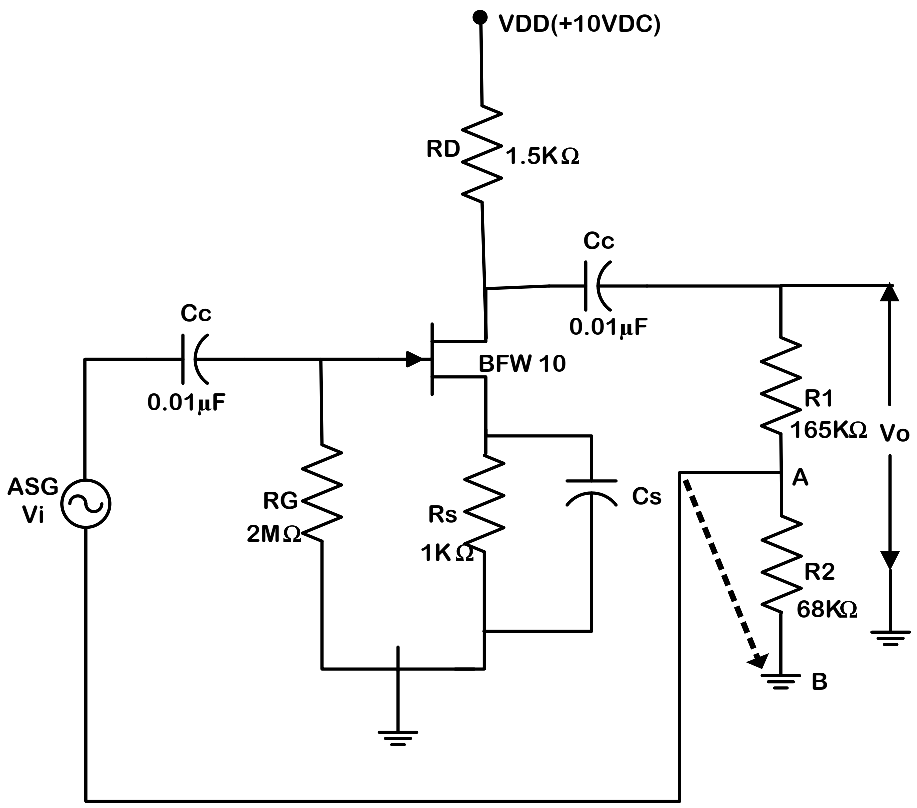
VOLTAGE SERIES FEEDBACK AMPLIFIER

Aim: Design of a FET Voltage series feedback amplifier and determine the gain, frequency response, input and output impedances with and without feedback.

Components required:

- Power supply
- Multimeter
- CRO
- Function Generator
- AC mill voltmeters
- FET BW 10/11
- Resistors
- Capacitors

Circuit Diagram:



Design:

I_{DSS} = 10mA

V_P = -3V (From Data Sheet)

Given, Q condition is I_D = 2mA, V_{DS} = 5V = $\frac{V_{DD}}{2}$

$$I_D = I_{DSS}[1-(\frac{V_{GS}}{V_P})]^2$$

We Know that,

$$[\frac{I_D}{DSS}]^{1/2} = 1-(\frac{V_{GS}}{V_P})$$

$$1 - 0.44 = \frac{V_{GS}}{3}$$

R_S: $V_{GS} = - 0.55 \times 3 = -1.65V$

$I_D R_S = |V_{GS}|$

Choose R_S = 1KΩ

R_D: $V_{DD} = V_{DS} + I_D (R_S + R_D)$

$5 = 2 \times 10^3[1K + R_D]$

Choose R_D = 1.5 KΩ

R_G: I_{gs} = 1000nA (From Data Sheet)

Before conduction, minority carriers have to be drained out, for this R_G would be usually very large. Further input impedance of the amplifier would be equal to R_G itself.

Thus, $I_{gs} R_G = V_{gs}$

$R_G = \frac{V_{gs}}{I_{gs}} = 1.65M\Omega$

Choose R_G = 2 MΩ

C_S: Should act as a short circuit at lowest frequency of interest

$XC_S = \frac{1}{100} R_S = 10\Omega$ 1t 500Hz (say)

$\therefore C_S = \frac{1}{2\pi f XC_S} \Rightarrow C_S = 33\mu F$

Choose C_S = 33 or 47µF

Theoretically gain A_V without feedback is calculated as

$A_V = -gm R_D$

For the above circuit,

g_m is computed as bellow,

We have, $I_D = I_{DSS}(1-\frac{V_{gs}}{V_P})^2$

Differentiating with respect to V_{gs}

$$\left|\frac{\partial I_D}{\partial V_{GS}}\right| = 2I_{DSS}(1+\frac{V_{GS}}{V_P})(\frac{1}{V_P})$$

$$\frac{\partial I_D}{\partial V_{GS}} = g_m \quad \therefore g_m = 2(10)(1+\frac{1.65}{3})(\frac{1}{3})$$

$$g_m = 10\ mA/V$$

$$\therefore |A_V| = g_m \times R_D = 10\times 1.5 = 15$$

To Design feedback circuit (R_1, R_2)

Let us Assume gain with feedback desired is 2

i.e. $A_{Vf} = 2$

Then $A_{Vf} = \frac{A_V}{1+A_V\beta}$ where $\beta = \frac{R_2}{R_1+R_2}$

(Practically we may not get $A_V = 15$;

It is better to measure A_V practically & design R_1 & R_2)

E.g: Say $A_V = 4.8$ (Practical Value)

$$\therefore A_{Vf} = \frac{A_V}{1+A_V\beta}$$

$$\frac{2}{4.8} = \frac{1}{1+4.8\beta}$$

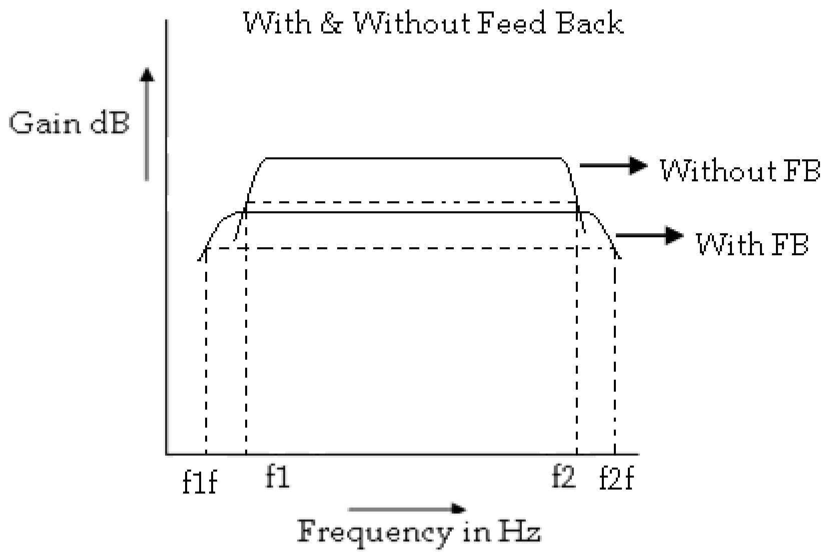
$$R_1 = 2.4\ R_2$$

Choose R_2 = 68KΩ, R_1 = 165KΩ (150KΩ + 15KΩ)

Procedure:

- Rig up the circuit as shown in the circuit diagram.
- Check Q conditions i.e,. measure V_{DS} and V_{GS}.
- Set Vi = 1V or 2V at 10 KHz on Audio signal Generator and measure gain A_V without feedback.
- Disconnect short of Green and Black terminal of signal generator to avoid grounding problem or isolate ground of signal generator.
- Measure V_O with feedback & find A_{Vf} the gain with feedback. Note A_{Vf} is less than AV
- To plot freq response, note output voltage with and without feedback from 100Hz to 10MHz

Frequency response:



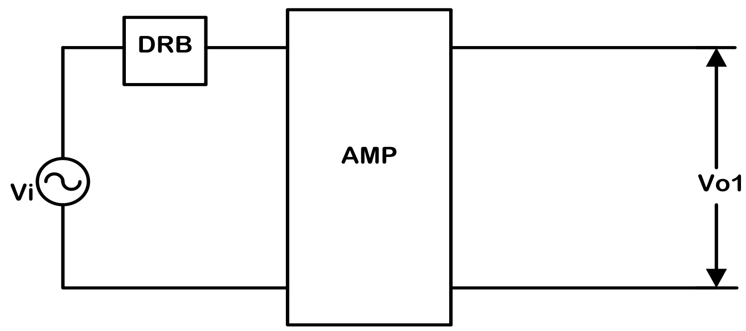
Here one can observe that effect of feedback is gain decreases but Bandwidth increases.

To measure input impedance and output impedance:

I) Input impedance (Zi):

Procedure:

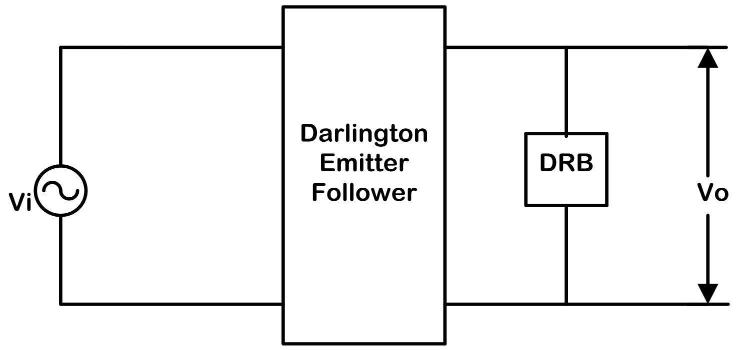
- Connect the circuit as shown
- Set all knobs of DRB to 0Ω
- Apply input sinusoidal wave (20 to 40 mV_{p-p})
- Fix input frequency in mid freq range (say 15 KHz) and measure output voltage V_O.
- Increase resistance on DRB, till V_O reduces to half the value this gives $V_{O1} = \frac{V_O}{2}$. The DRB values now gives input impedance Zi of amplifier.



II) Output impedance (R_O):

Procedure:

- Connect the circuit as shown
- Set all knobs of DRB to maximum value.
- Apply input sinusoidal wave (20 to 40 mV)
- Fix input frequency 15 KHz and measure output voltage.
- Decrease resistance on DRB, till output voltage reduces to half the value of V_O. Now $V_{O2} = \frac{V_O}{2}$. The DRB values now gives output impedance Zo of amplifier.



Observation:

Gain with feedback :__________
Gain without feedback :__________

Frequency	V_O	A_V	A_{VF}	Z_i	Z_O
100 Hz 200 Hz . . . 1kHz 2KHz . . 100 KHz					

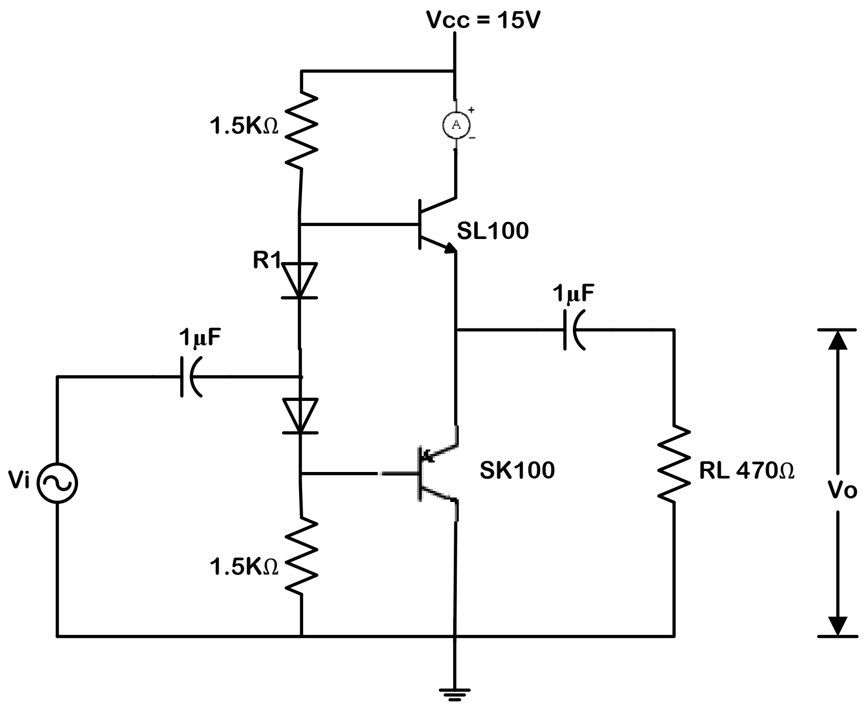
CLASS 'B' PUSH-PULL AMPLIFIER

Aim: To design and test the performance of transformer less Class 'B' Push-Pull Amplifier and to determine its conversion efficiency.

Components Required:

- Diodes IN 4001
- Transistor SL100, SK100
- Resistors
- Capacitors

Circuit Diagram:



Design:

Given V_{CC} = 15V, R_L = 470Ω

$$V_{CE1} = V_{CE2} = \frac{V_{CC}}{2} = 7.5V$$

$$V_{B1} = V_{CE2} + V_{BE1} = 7.5 + 0.7 = 8.2V$$

Assume I_1 = 5mA

$$R_1 = \frac{V_{CC} - V_{B1}}{I_1} = 1.36K\Omega$$

$$R_2 = \frac{V_{R2}}{I_1} = \frac{V_{B1} - V_{D1} - V_{D2}}{I_1} = 1.36K\Omega$$

Choose $R_1 = R_2 = 1.5K\Omega$

Choose C_i = C_2 = 1µF

$P_i(dc) = V_{CC} I_{dc}$

$P_o(ac) = \frac{V_m^2}{2R_L}$

Efficiency $\eta = \frac{P_{O(ac)}}{P_{i(dc)}}$

Procedure:

- Connect the circuit as shown in the circuit diagram.
- Apply the input voltage V_i = 5V
- Keeping the voltage constant, vary the frequency from 100Hz to 1MHz in regular steps and note down the output voltage in each case.
- Plot the gain Vs Frequency graph.
- Note down the dc current I_{dc}
- Calculate the efficiency.

Observations:

V_i = 5V

Freq. in Hz	V_o	Gain=Vo/Vi	Gain in dB = 20 log Vo/Vi
50 Hz 100 Hz 200 Hz 500 Hz 1 KHz 2 KHz 3 KHz 5 KHz 10 KHz . . . . 1MHz 2 MHz			

Result:

Efficiency η =

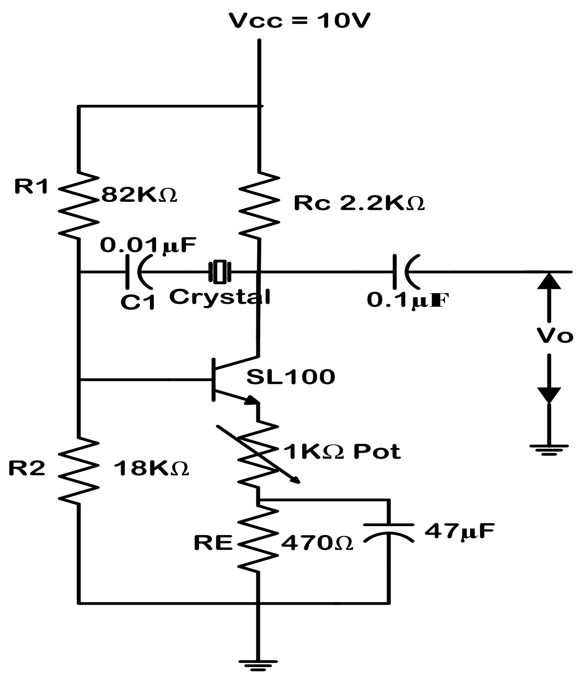
CRYSTAL OSCILLATOR

Aim: To design and test the performance of BJT - Crystal Oscillator for $f_O > 100$ KHz.

Components Required:

- Crystal 2MHz
- Transistor SL100
- Resistors
- Capacitors

Circuit Diagram:



Design:

Given $V_{CC} = 10V$, $\beta = 200$, $I_C = 2mA$

To find R_E:

$$V_{RE} = \frac{V_{CC}}{10} = \frac{10}{10} = 1V$$

$I_E R_E = 1$, $I_E \simeq I_C$

$$R_E = \frac{V_{RE}}{I_C} = \frac{V_{RE}}{I_C} = \frac{1}{2\times10^{-3}} = 500\Omega$$

Choose R_E =470Ω

To find R_C:

Applying KVL

$V_{CC} - I_C R_C - V_{CE} - V_{RE} = 0$ $\qquad [V_{CE} = \frac{V_{cc}}{2}]$

$10 - 2\times 10^{-3} R_C - 5 - 1 = 0$

$4 - 2\times 10^{-3} R_C = 0$

$R_C = 2K\Omega$

Choose R_C = 2.2KΩ

From the biasing circuit

$V_B = V_{BE} + V_{RE}$

$= 0.7 + 1$

$= 1.7V$

To find I_B:

$I_B = \frac{I_C}{I_B} = \frac{2\times 10^{-3}}{200} = 0.01mA$

Assume 10 I_B flows through R_1

$R_1 = \frac{V_{CC} - V_B}{10 I_B} = \frac{10 - 1.7}{10\times 0.01m} = 83K\Omega$

Choose R_1 = 82KΩ

Assume 9 I_B flows through R_2

$R_2 = \frac{V_B}{9\, I_B} = \frac{1.7}{9\times 0.01m} = 18\ K\Omega$

Choose R_2 = 18KΩ

Assume coupling capacitor **C_{C1}** and **C_{C2}** as **0.47µF**

Procedue:

- Make the connections as shown in circuit diagram.
- Vary 1KΩ potentiometer so as to get an undistorted sine wave at the output.
- Note down the frequency of the output wave and compare it with the theoretical frequency of oscillation.

Result:

Frequency : Theoretical: 2MHz Practical:

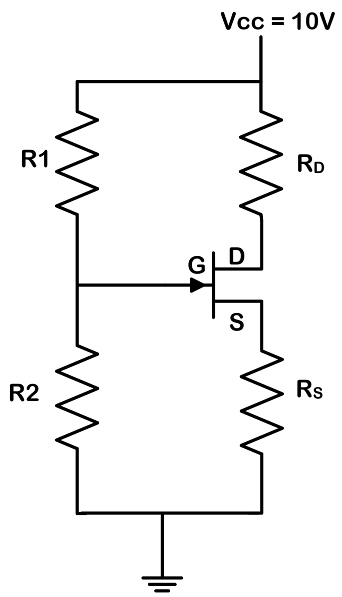
FET HARTLEY & COLPITTS OSCILLATOR

Aim: To design Hartley & Colpitts Oscillator for given frequency using FET.

Components Required:

- FET (BFW11)
- Resistors
- Capacitors
- CRO

Biasing Circuit:



Design:

V_{DD} = 10V, $V_{DS} = \frac{V_{DD}}{2}$ =5V

For ϑ FET, I_{DSS} = 11.5mA

V_P = -3V

V_{GS} = -1.7V

$I_D = I_{DSS}\left[1 - \frac{V_{GS}}{V_P}\right]^2$

$I_D = 11.5\times 10^{-3}\left[1 - \frac{1.7}{3}\right]^2$

I_D = 2mA

Applying KVL to the outer loop

$V_{DD} = I_D(R_D + R_S) + V_{DS}$

$R_D + R_S = \frac{V_{DD}-V_{DS}}{I_D} = \frac{10-5}{2m} = 2.1K\Omega$

Let $R_D = 1K\Omega$ & $R_S = 1.5K\Omega$

Use 1K pot in series with 1.5KΩ for R_S

$$\frac{V_{DD}R_2}{R_1+R_2} = V_{GS} + V_{RS}$$

$$\frac{R_2}{R_1+R_2} = \frac{V_{GS}+I_D R_S}{V_{DD}} = \frac{-1.7+(2\times10^{-3})\times1.5K}{10}$$

$$\frac{R_2}{R_1+R_2} = 0.13$$

$R_2 = 0.13R_1 + 0.13R_2$

$0.87R_2 = 0.13R_1$

$$\frac{R_2}{R_1} = \frac{0.13}{0.87} = 0.149$$

R_1= 1MΩ

R_2= 0.149 R_1

R_2= 150KΩ (Choose R_2 as 82KΩ)

Hartley Oscillator:

Tank Circuit Design:

$f_O = \frac{1}{2\pi\sqrt{LC}}$ Where $L = L_1 + L_2$

f_O = 100KHz

$L = \frac{1}{4\pi^2 f_{o^2} C}$ let C = 330pF

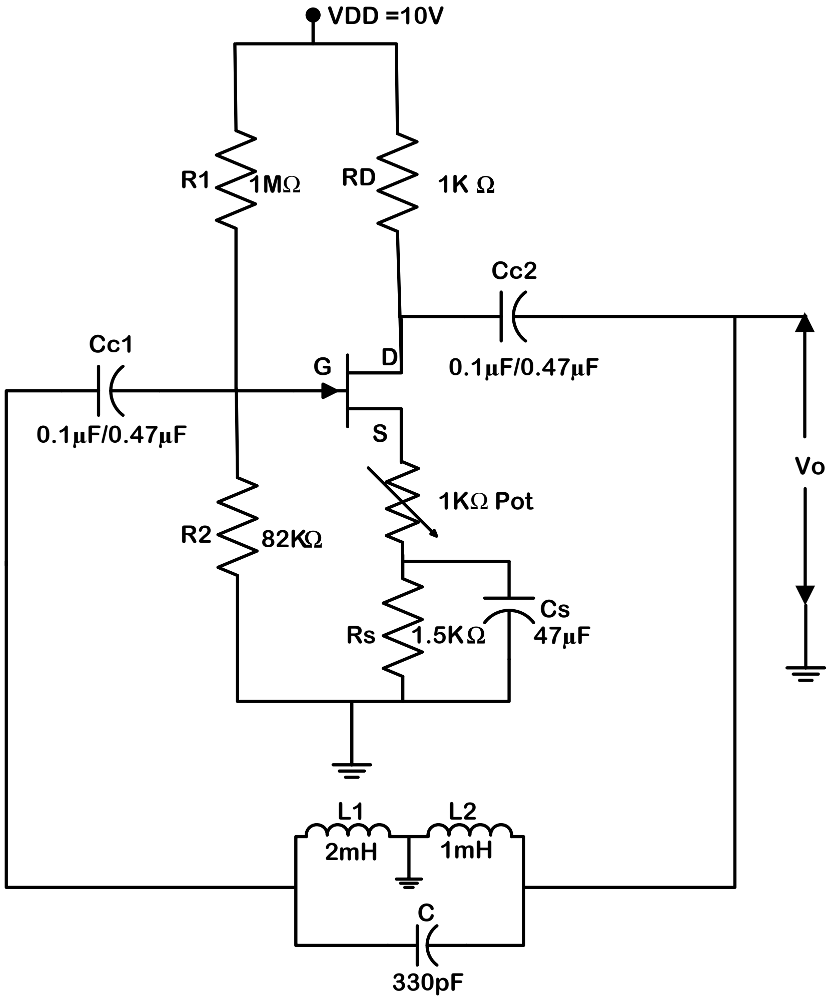
$$L = \frac{1}{4\times(3.14)^2(100\times10^3)^2\times330\times10^{-12}}$$

L = 7.68mH

L_1 = 5mH

L_2 = 2.6mH

Circuit Diagram:



Colpitts Oscillator:

$f_O = \frac{1}{2\pi\sqrt{LC_{eq}}}$ $C = \frac{C_1 C_2}{C_1 + C_2}$

$f_O = 100KHz$

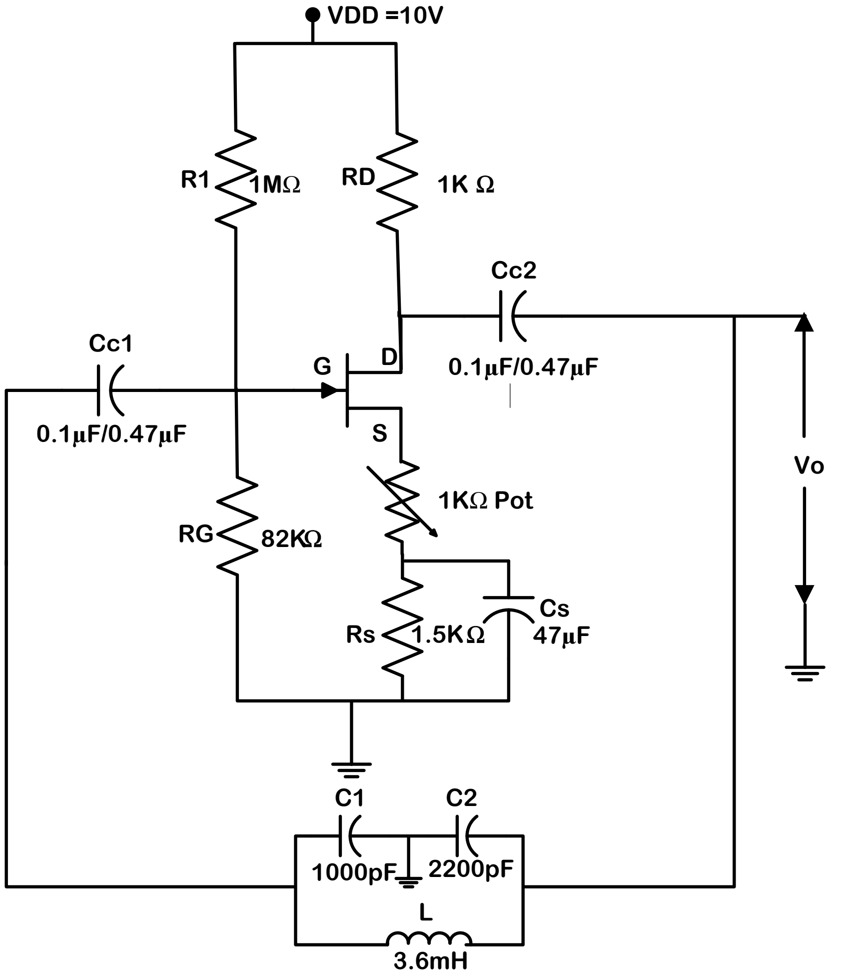
$C = \frac{1000 \times 2200 \times 10^{-24}}{(1000+2200) \times 10^{-12}}$

C = 687.5pF

$L = \frac{1}{4\pi^2 f_{o^2} C} = \frac{1}{4 \times (3.14)^2 (100 \times 10^3)^2 \times 687.5 \times 10^{-12}}$

L = 3.6mH

Circuit Diagram:



Procedue:

- Make the connections as shown in circuit diagram.
- Observe the sinusoidal output voltage.
- Measure the frequency and compare with the theoretical values.

Result:

Hartley Oscillator:

Theoretical Frequency : 100KHz

Practical Frequency :

Amplitude of the sine wave :

Colpitts Oscillator:

Theoretical Frequency : 100KHz

Practical Frequency :

Amplitude of the sine wave :

VIVA-VOCE QUESTIONS

[1] What are conductors, insulators, and semi-conductors? Give examples.
[2] Name different types of semiconductors.
[3] What are intrinsic semiconductors and extrinsic semiconductors?
[4] How do you get P-type and N-type semiconductors?
[5] What is doping? Name different levels of doping.
[6] Name different types of Dopants. .
[7] What do you understand by Donor and acceptor atoms?
[8] What is the other name for p-type and N-type semiconductors?
[9] What are majority carriers and minority carriers?
[10] What is the effect of temperature on semiconductors?
[11] What is drift current?.
[12] What is depletion region or space charge region?
[13] What is junction potential or potential barrier in PN junction?
[14] What is a diode? Name different types of diodes and name its applications
[15] What is biasing? Name different types w.r.t. Diode biasing
[16] How does a diode behave in its forward and reverse biased conditions?
[17] What is static and dynamic resistance of diode?
[18] Why the current in the forward biased diode takes exponential path?
[19] What do you understand 1?y Avalanche breakdown and zener breakdown?
[20] Why diode is called unidirectional device.
[21] What is PIV of a diode
[22] What is knee voltage or cut-in voltage?
[23] What do you mean by transition capacitance or space charge capacitor?
[24] What do you mean by diffusion capacitance or storage capacitance?
[25] What is a transistor? Why is it called so? .
[26] Name different types, of transistors?
[27] Name different configurations in which the transistor is operated
[28] Mention the applications of transistor. Explain how transistor is used as switch
[29] What is transistor biasing? Why is it necessary?
[30] What are the three different regions in which the transistor works?
[31] Why transistor is called current controlled device?
[32] What is FET? Why it is called *so?*
[33] What are the parameters of FET?
[34] What are the characteristics of FET?
[35] Why FET is known as voltage controlled device?
[36] What are the differences between BJT and FET?
[37] Mention applications of FET. What is pinch off voltage.
[38] What is an amplifier? What is the need for an amplifier circuit?
[39] How do you classify amplifiers? ,
[40] What is faithful amplification? How do you achieve this?
[41] What is coupling? Name different types of coupling
[42] What is operating point or quiescent point?
[43] What do you mean by frequency response of an amplifier?

[44] What are gain, Bandwidth, lower cutoff frequency and upper cutoff frequency?
[45] What is the figure of merit of an amplifier circuit?
[46] What are the advantages of RC coupled amplifier?
[47] Why a 3db point is taken to calculate Bandwidth?
[48] What is semi-log graph sheet? Why it is used to plot frequency response?
[49] How do you test a diode, transistor, FET?
[50] How do you identify the terminals of Diode, Transistor& FET?
[51] Mention the type number of the devices used in your lab.
[52] Describe the operation of NPN transistor. Define reverse saturation current.
[51] Explain Doping w.r.t. Three regions of transistor
[52] Explain the terms hie/hib, hoe/hob, hre/hrb, hre/hfb.
[53] Explain thermal runaway. How it can be prevented.
[54] Define FET parameters and write the relation between them.
[55] What are Drain Characteristics and transfer characteristics?
[56] Explain the construction and working of FET
[57] What is feedback? Name different types.
[58] What is the effect of negative feedback on the characteristics of an amplifier?
[59] Why common collector amplifier is known as emitter follower circuit?
[60] What is the application of emitter follower ckt?
[61] What is cascading and cascoding? Why do you cascade the amplifier ckts.?
[62] How do you determine the value of capacitor?
[63] Write down the diode current equation.
[64] Write symbols of various passive and active components
[65] How do you determine the value of resistor by color code method?
[66] What is tolerance and power rating of resistor?
[67] Name different types of resistors.
[68] How do you classify resistors?
[69] Name different types of capacitors.
[70] What are clipping circuits? Classify them.
[71] Mention the application of clipping circuits.
[72] What are clamping circuits? Classify them
[73] What is the other name of clamping circuits?
[74] Mention the applications of clamping circuits.
[75] What is Darlington emitter follower circuit?
[76] Can we increase the number of transistors in Darlington emitter follower circuit?
[77] Name different types of Emitter follower circuits.
[78] What is an Oscillator? Classify them.
[79] What are damped & Un-damped Oscillations?
[80] What are Barkhausen's criteria?
[81] What type of oscillator has got more frequency stability?
[82] What is the disadvantage of Hartley & Colpit's Oscillator?
[83] Why RC tank Circuit Oscillator is used for AF range?
[84] Why LC tank Circuit Oscillator is used for RF range?
[85] What type of feedback is used in Oscillator circuit?
[86] In a Transistor type No. SL 100 and in Diode BY 127, what does SL and BY stands for?
[87] Classify Amplifiers based on: operating point selection.

[88] What is the efficiency of Class B push pull amplifier?
[89] What is the drawback of Class B Push pull Amplifier? How it is eliminated.
[90] What is the advantage of having complimentary symmetry push pull amplifier?
[91] What is Bootstrapping? What is the advantage of bootstrapping?
[92] State Thevenin's Theorem and Maximum power transfer theorem.
[93] What is the figure of merit of resonance circuit?
[94] What is the application of resonant circuit?
[95] What is a rectifier? Classify.
[96] What is the efficiency of half wave and full wave rectifier?
[97] What is the advantage of Bridge rectifier of Centre tapped type FWR.
[98] What is the different between Darlington emitter follower circuit & Voltage follower circuit using Op-Amp. Which is better.

BIBLIOGRAPHY

[1] "Electronic devices and circuit theory", Robert L. Boylestad and Louis Nashelsky.
[2] "Integrated electronics", Jacob Millman and Christos C Halkias.
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[4] "Electronic devices and circuits", G.K.Mittal.