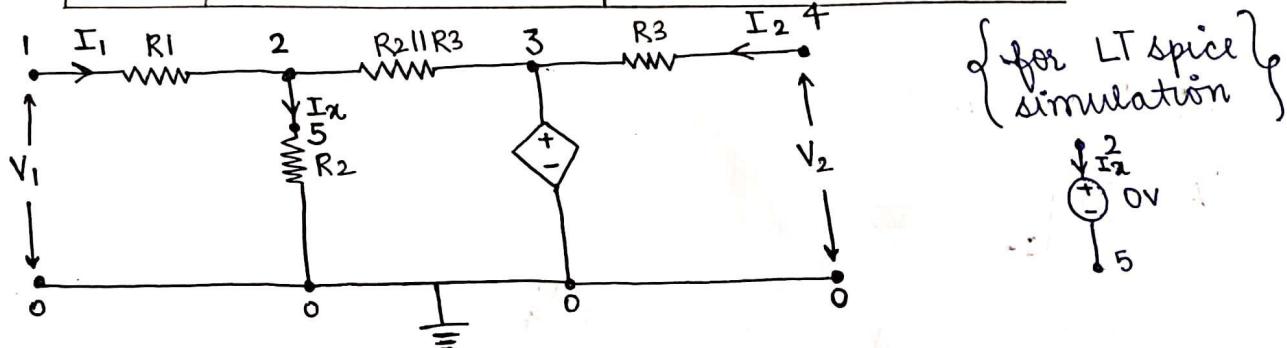


# ASSIGNMENT

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2017 B2A80528P  
Tut Sec. - 1

## Problem-1 (DC Analysis and Parametric Sweep)

S. No.	Resistor Name	Value in kΩ
1.	R <sub>1</sub>	11 k
2.	R <sub>2</sub>	17 k
3.	R <sub>3</sub>	7 k
4.	K	16 k



Calculations —

① Z parameters :-

OC at port 2

$$I_1 R_1 + I_x R_2 = V_1 \quad \text{--- (a)}$$

$$(I_1 - I_x)(R_3 || R_2) + K I_x - R_2 I_x = 0 \quad \text{--- (b)}$$

$$\Rightarrow I_x = \left[ \frac{R_3 || R_2}{R_2 - K + (R_3 || R_2)} \right] I_1$$

$$Z_{11} = \frac{V_1}{I_1} = R_1 + \frac{R_2 (R_3 || R_2)}{R_2 - K + (R_3 || R_2)}$$

$$V_2 = K I_x \quad \text{--- (c)}$$

$$Z_{21} = \frac{V_2}{I_1} = \frac{K (R_3 || R_2)}{R_2 - K + (R_3 || R_2)}$$

$$\Rightarrow Z_{11} = 25.15 \text{ k}\Omega$$

$$\& Z_{21} = 13.3145 \text{ k}\Omega$$

OC at port 1

$$V_2 = I_2 R_3 + K I_x \quad \text{--- (d)}$$

$$V_2 = I_2 R_3 + (R_3 || R_2) I_x + R_2 I_x \quad \text{--- (e)}$$

$$\Rightarrow \frac{V_2 - I_2 R_3}{K} = I_x$$

$$Z_{22} = \frac{V_2}{I_2} = R_3$$

$$V_1 = R_2 I_x \quad \text{--- (f)}$$

$$Z_{12} = \frac{V_1}{I_2} = \frac{R_2}{K} [R_3 - R_2]$$

$$\Rightarrow Z_{21} = 7 \text{ k}\Omega$$

$$\& Z_{12} = 0 \text{ k}\Omega$$

② Hybrid parameters :-

$$H_{11} = \left[ \frac{Z_{11}}{1} - \frac{Z_{12}Z_{21}}{Z_{22}} \right]$$

$$= 25.15 \text{ k}\Omega$$

$$H_{12} = \frac{Z_{12}}{Z_{22}}$$

$$= 0$$

$$H_{21} = -\frac{Z_{21}}{Z_{22}}$$

$$= -1.9021$$

$$H_{22} = \frac{1}{Z_{22}}$$

$$= 0.14286 \text{ m}\Omega$$

③ ABCD parameters :-

$$A = \left. \frac{V_1}{V_2} \right|_{I_2=0} = \frac{Z_{11}}{Z_{21}} = 1.8889$$

$$C = \left. \frac{I_1}{V_2} \right|_{I_2=0} = \frac{1}{Z_{21}} = 0.07511 \text{ m}\Omega$$

SC at port 2 —

$$V_1 = I_1 R_1 + R_2 I_x \quad \textcircled{a}$$

$$(I_1 - I_x)(R_3 \parallel R_2) + K I_x = R_2 I_x \quad \textcircled{b}$$

$$R_3 I_2 + K I_x = 0 \quad \textcircled{c}$$

$$\Rightarrow I_x = -\frac{R_3 I_2}{K}$$

$$B = \left. \frac{V_1}{I_2} \right|_{V_2=0} = \frac{R_3 R_1}{K} \left[ \frac{(R_3 \parallel R_2)}{R_2 - K + (R_3 \parallel R_2)} \right] + \frac{R_2 R_3}{K}$$

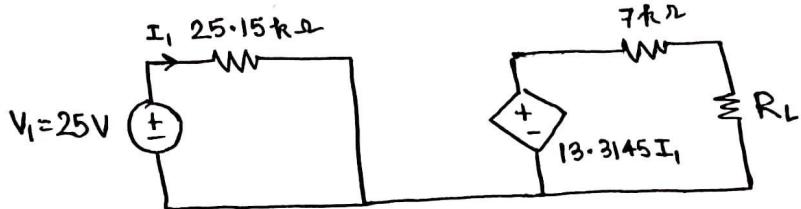
$$D = \left. \frac{-I_1}{I_2} \right|_{V_2=0} = \frac{R_3}{K} \left[ \frac{R_2 - K + (R_3 \parallel R_2)}{R_3 \parallel R_2} \right]$$

$$\Rightarrow B = 11.4423 \text{ k}\Omega$$

$$D = 0.5257$$

→ Load Resistance for Max. Power

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$$\text{for max. power, } R_L = Z_{22}$$

$$R_L = 7 \text{ k}\Omega$$

SPICE Code —

$V_{in}$	1	0	{ $v_i$ }
$V_{out}$	4	0	{ $v_o$ }
$R_1$	1	2	$11\text{k}$
$R_2$	5	0	$17\text{k}$
$V_c$	2	5	0
$R_3$	3	4	$7\text{k}$
$R_4$	2	3	$4.958\text{k}$
$H_1$	3	0	$16\text{k}$

\*\* For  $Z_{11}$  &  $Z_{21}$  \*\*

$I_{out}$  0 34 { $i_o$ }

- param  $v_i = 25$
- param  $i_o = 0$

\*\* For  $Z_{12}$  &  $Z_{22}$  \*\*

$I_{in}$  0 1 { $i_{in}$ }

- param  $i_i = 0$
- param  $v_o = 25$

\*\* For  $H_{11}$  &  $H_{21}$  \*\*

- param  $v_o = 0$
- param  $v_i = 25$

\*\* For  $H_{12}$  &  $H_{22}$  \*\*

$I_{in}$  0 1 { $i_{in}$ }

- param  $i_i = 0$
- param  $v_o = 25$

\*\* For A & C \*\*

Iout 0 54 {i0}

• param i0=0

• param vi=25

\*\* For B & D \*\*

• param v0=0

• param vi=25

\*\* For Pmax \*\*

RL 54 0 {Rmax}

• param vi=25

• Step param Rmax 1k 20k 1k

$$\text{Power} = I(R_L) \times V(4)$$

$$P_{\max} \rightarrow R_L = 7.00167 \text{ k}\Omega$$

• end

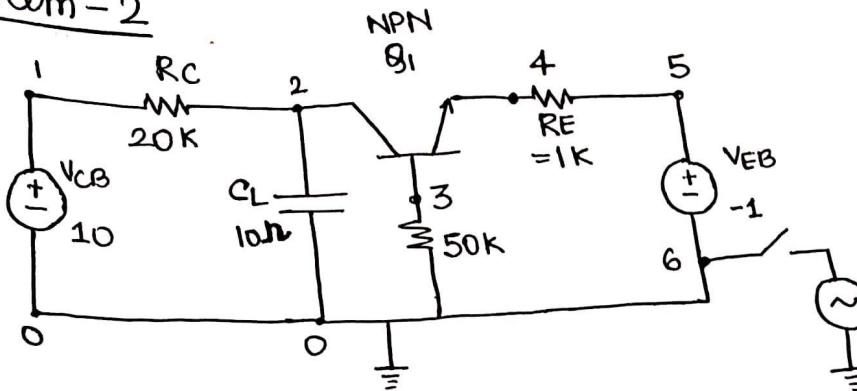
• end

## Comparison

Parameter	Hand Calculations	SPICE Simulator
Z <sub>11</sub>	25.15 kΩ	25.14668 kΩ
Z <sub>21</sub>	13.3145 kΩ	13.314532 kΩ
Z <sub>12</sub>	0 kΩ	0 kΩ
Z <sub>22</sub>	7 kΩ	7.000007 kΩ
H <sub>11</sub>	25.15 kΩ	25.14668 kΩ
H <sub>12</sub>	0	0
H <sub>21</sub>	-1.9021	-1.9020738
H <sub>22</sub>	0.14286 mV	0.142857 mV
A	1.8889	1.8886633
B	11.4423 kΩ	13.22066 kΩ
C	0.07511 mV	0.0706879 mV
D	0.5257	0.525742
R <sub>L</sub>	7 kΩ	7.00167 kΩ

## Problem - 2

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[sine-wave input]

SPICE Code -

### I) DC - Operating point analysis -

V<sub>CB</sub> 1 0 10

V<sub>EB</sub> 5 0 -1

R<sub>C</sub> 1 2 20k

R<sub>3</sub> 3 0 50k

R<sub>E</sub> 4 5 1 k

C<sub>L</sub> 2 0 10n

Q1 2 3 4 0 BC108B

• model BC108B NPN-----

• v<sub>op</sub>

• end

Output :

V(1) : 10

voltage

V(5) : -1

voltage

V(2) : 3.95271

voltage

V(3) : -0.0647981

voltage

V(4) : -0.696339

voltage

I<sub>c</sub>(Q1) : 0.000302365

device - current

I<sub>b</sub>(Q1) : 1.29597 × 10<sup>-6</sup>

device - current

I<sub>e</sub>(Q1) : -0.000303664

device - current

I(C1) : 3.95271 × 10<sup>-20</sup>

device - current

I(R<sub>e</sub>) : 0.000303661

device - current

I(R<sub>3</sub>) : -1.29596 × 10<sup>-6</sup>

device - current

I(R<sub>C</sub>) : 0.000302365

device - current

I(V<sub>eb</sub>) : 0.000303661

device - current

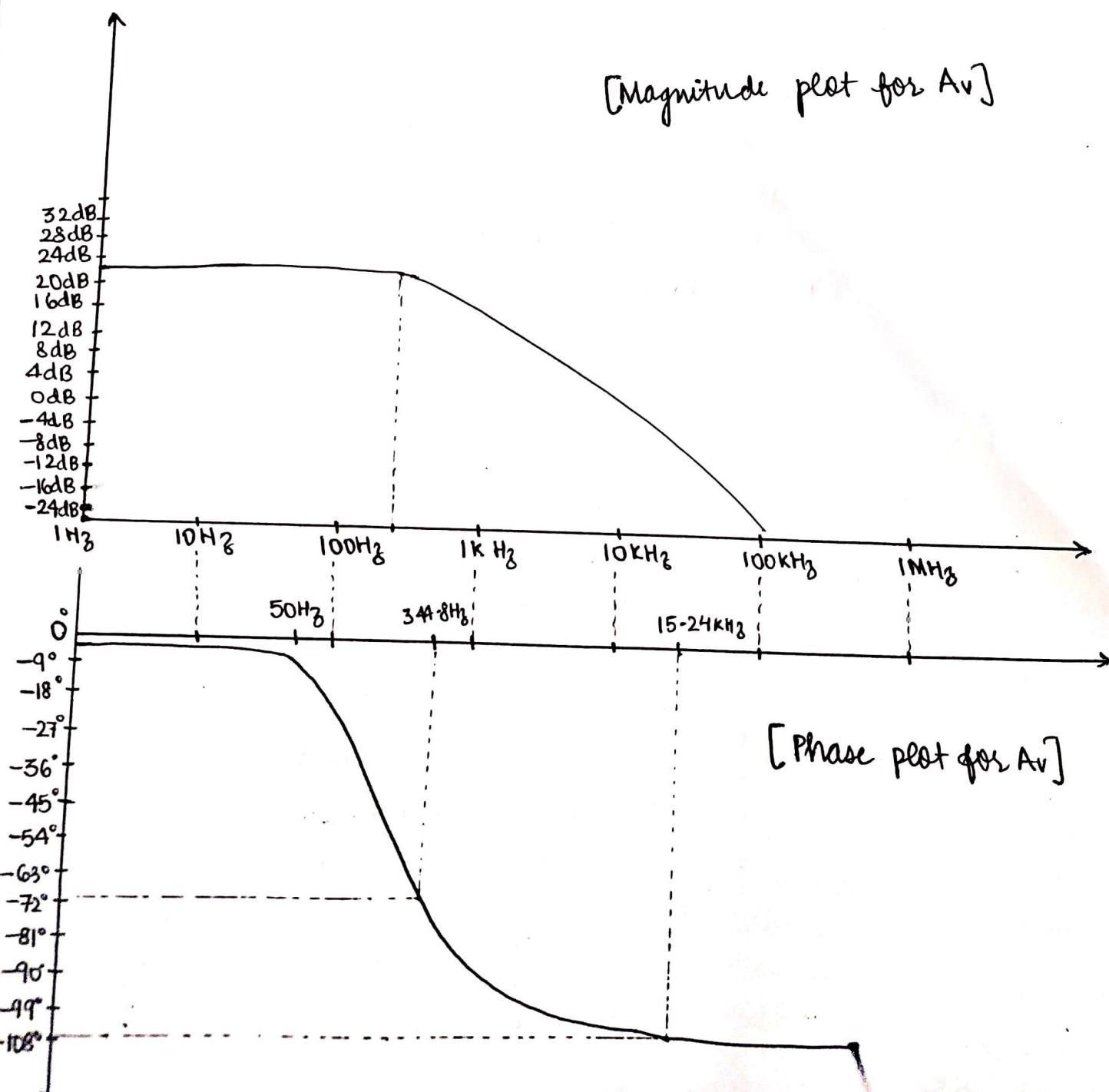
I(V<sub>cb</sub>) : -0.000302365

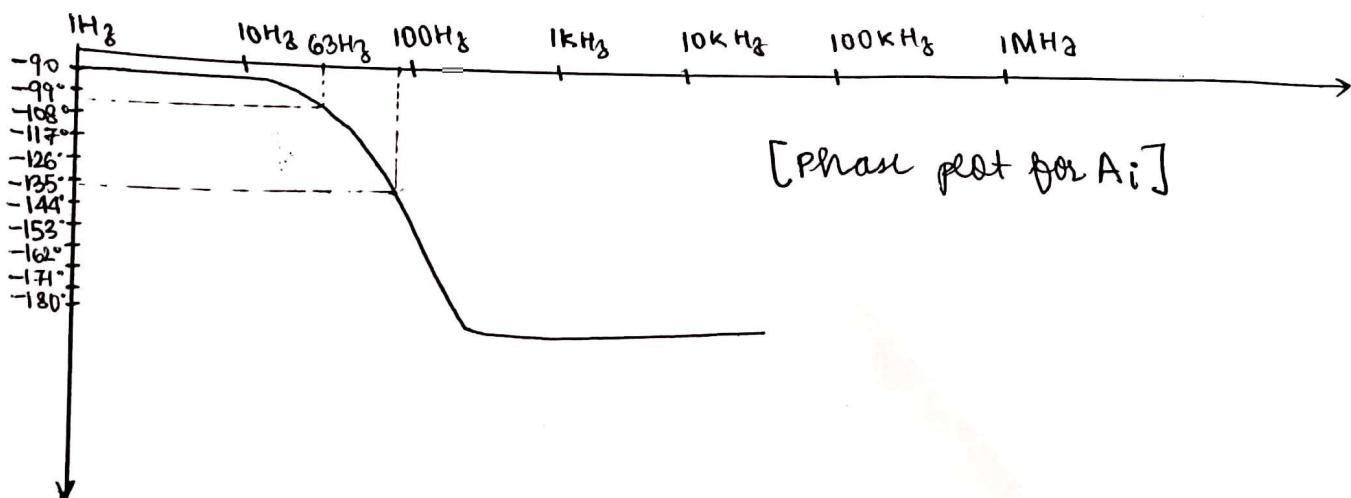
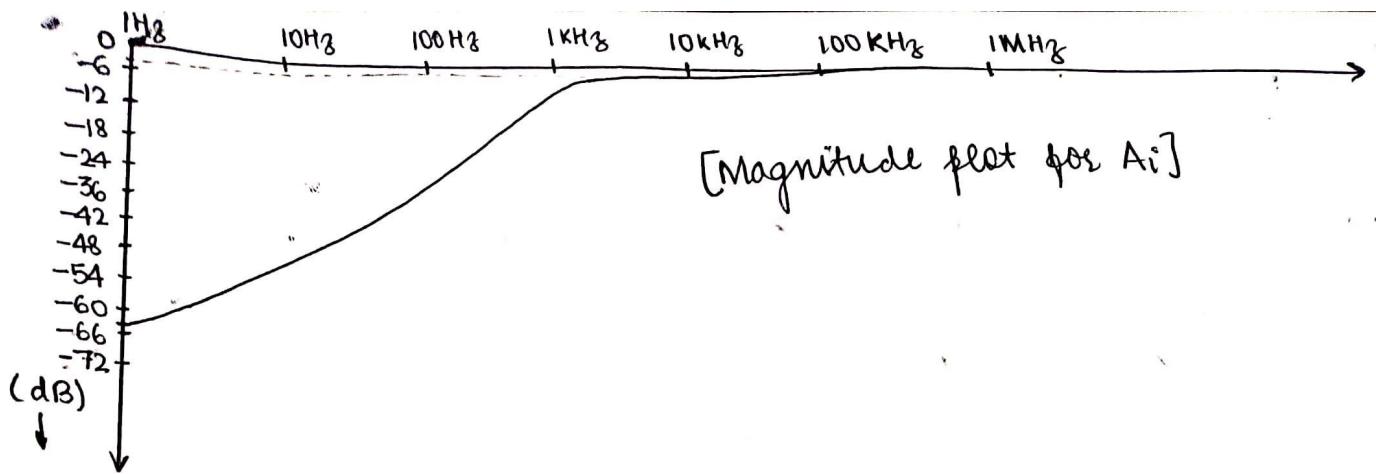
device - current

(II) Bode - plots (Av & Ai) :-

VCB	1	0	10	
VEB	5	0	-1	AC 1
RC	1	2	20K	
R3	3	0	50K	
RE	4	5	1 K	
CL	2	0	10n	
Q1	2	3	4	0 BC108B

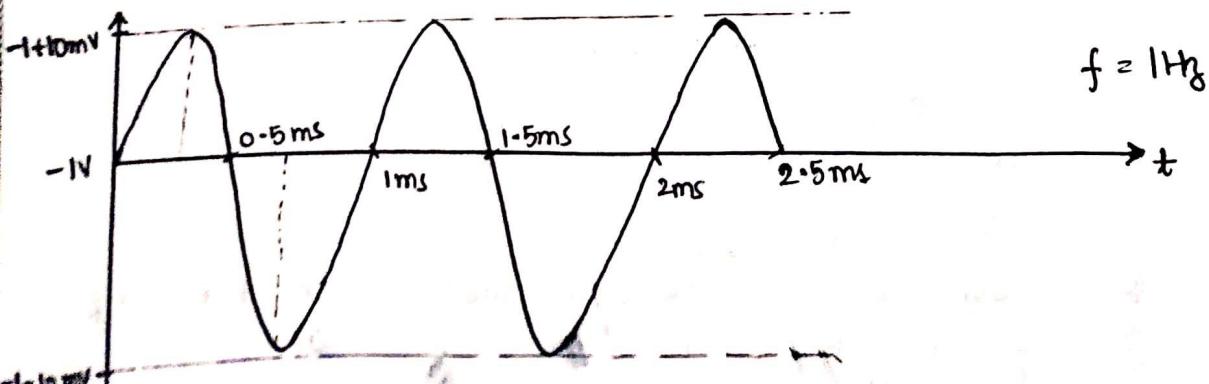
- Model BC 108B NPN -- -
- ac vct 100 1 100k
- end

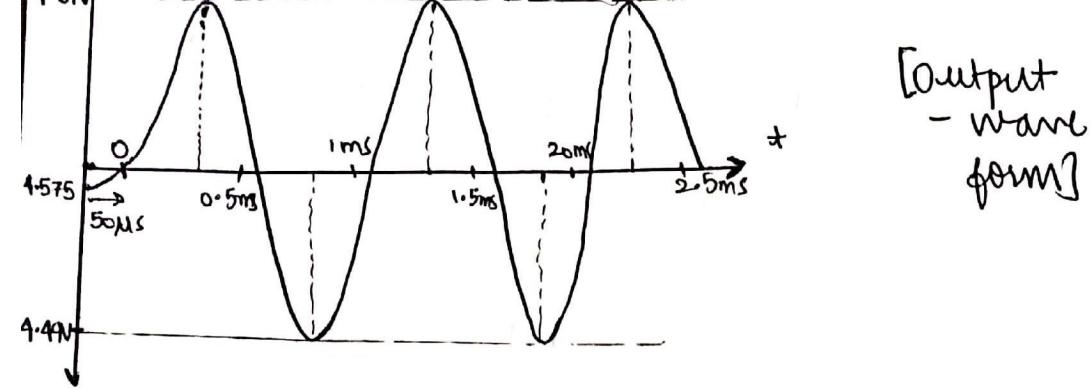




### III Output - waveform for a sin - wave excitation -

VCB	1	0	10		
VEB	5	6	-1		
RC	1	2	20k		
R3	3	0	50k		
RE	4	5	1k		
CL	2	0	10n		
V <sub>in ac</sub>	6	0	$\sin(0 \ 10n \ 1k)$		
Q1	2	3	4	0	BC108B
• model	BC108B NPN --				
• gain	5m				
• end					





[Output  
- wave  
form]

#### IV At R<sub>out</sub> and R<sub>m</sub> -

VCB 1 0 10

VEB 5 6 -1

RC 1 2 20k

R3 3 0 50k

RE 4 5 1k

CL 2 0 10n

V<sub>inac</sub> 6 0 sin(0 10n 1k)

Q1 2 3 4 0 BC108B

• model BC108B NPN ---

• tf. V(2) VEB

• end

Output :-

R <sub>out</sub> → 19.6016 kΩ
R <sub>m</sub> → 1.29258 kΩ

② \*\* Impact of R<sub>3</sub> on AV, A<sub>i</sub>, R<sub>m</sub> & R<sub>out</sub> \*\*

• param R3var = 50k

VCB 1 0 10

\* VEB 5 6 -1 AC1 // Uncommented for Av & A<sub>i</sub>

\* VEB 5 6 -1 // Uncommented for R<sub>m</sub> & R<sub>out</sub>

RC 1 2 20k

R3 3 0 {R3var}

RE 4 5 1k

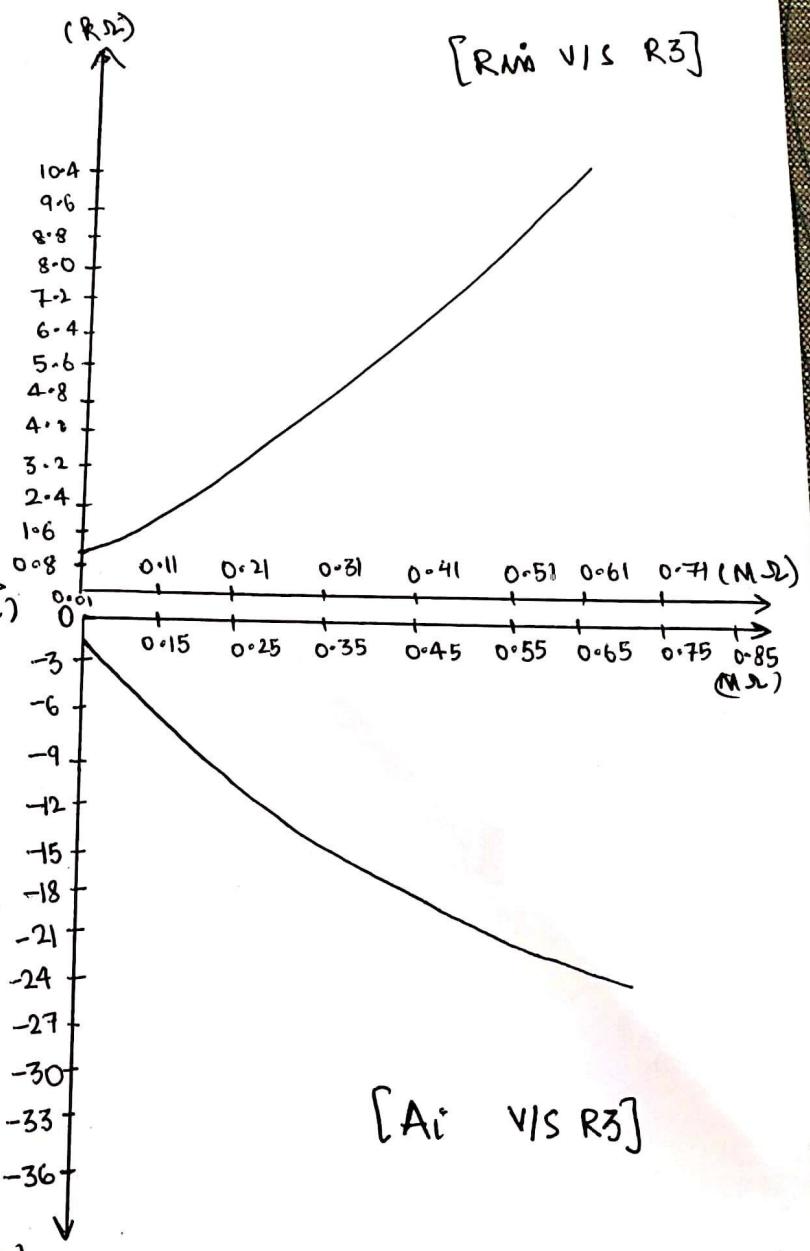
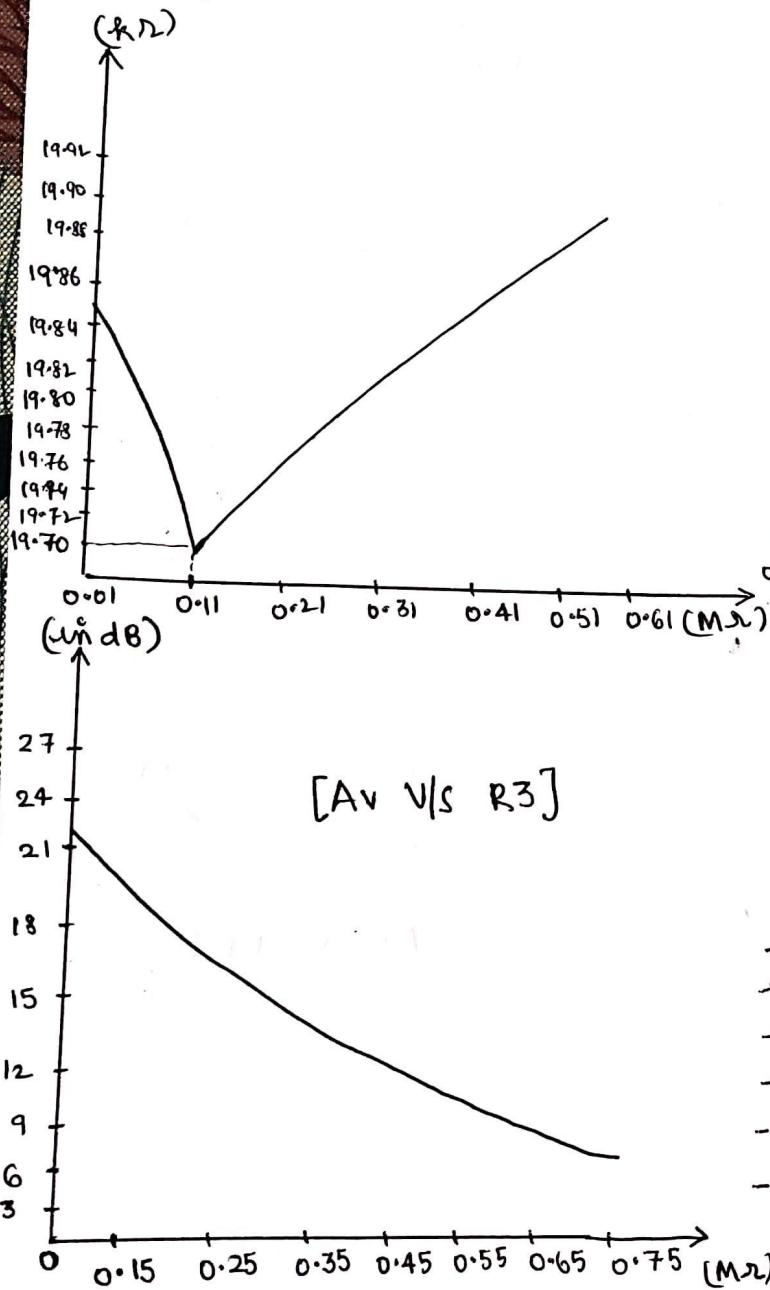
CL 2 0 10n

\* V<sub>inac</sub> 6 0 sin(0 10m 1k) // Uncommented for R<sub>m</sub> & R<sub>out</sub>

Q1 2 3 4 0 BC108B

• model BC108D NPN --  
 \* ac oet 100 1 100k // for AV & Ai  
 \* df V(2) VEB // for Rin & Rout  
 • step param R3var 50k 1050k 100k  
 • end

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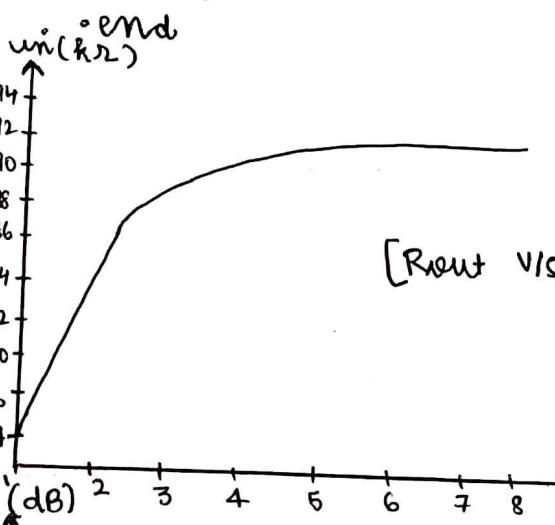
④ \*\* Impact of RE on AV, Ai, Rin, Rout \*\*

• param REvar = 1k;

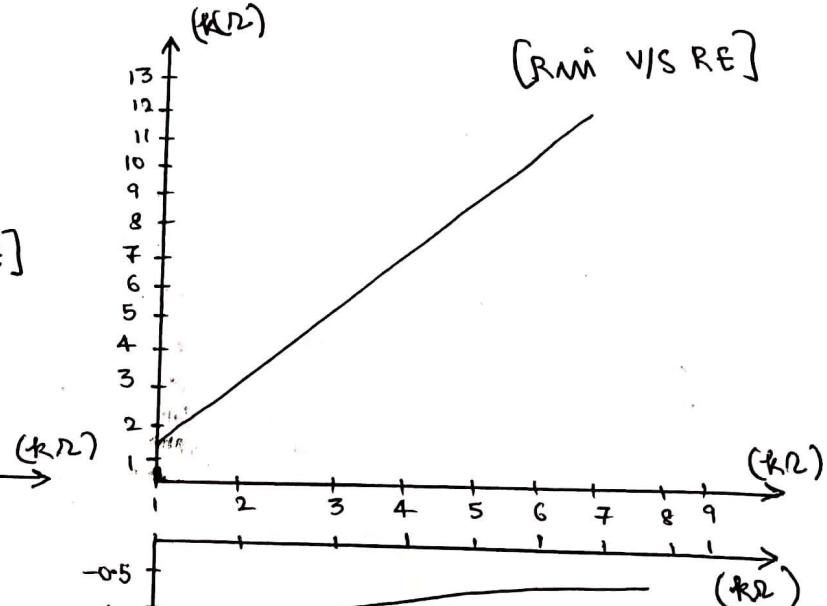
VCB	1	0	10	
* VEB	5	0	-1	AC 1 // Uncomment for AV & Ai
* VEB	5	6	-1	// Uncomment for Rin & Rout
RC	1	2	20k	
R3	3	0	50k	
RE	4	5	{ REvar }	

CL 2 0 10n

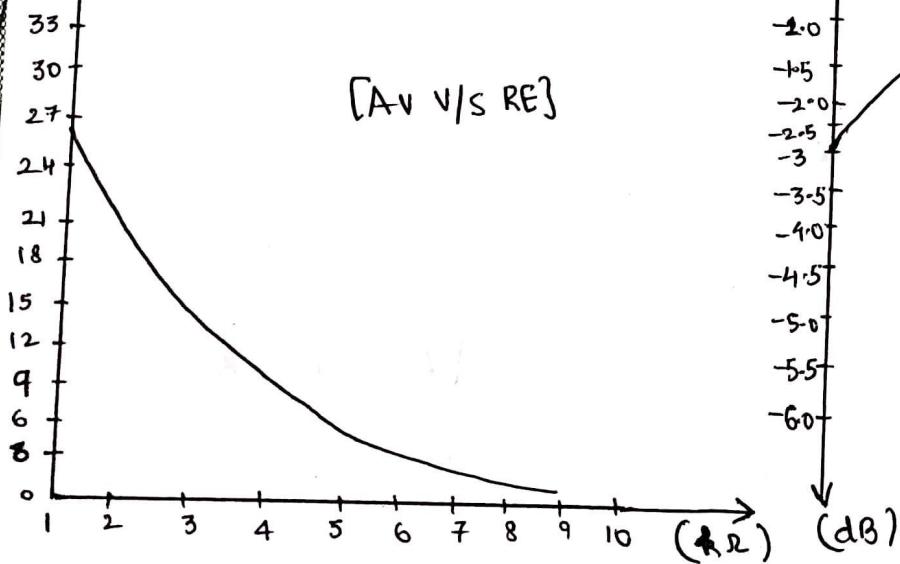
- \* V<sub>inac</sub> 6 0 sin(0 10m 1k) // Uncomment for R<sub>in</sub> & R<sub>out</sub>
- I<sub>1</sub> 2 3 4 0 BC108B
- model BC108B NPN --
- \* • ac vact 100 1 100k // Uncomment for A<sub>V</sub> & A<sub>i</sub>
- \* • f<sub>f</sub> V(2) VEB // Uncomment for R<sub>in</sub> & R<sub>out</sub>
- dcp param RE var 1k 10k 1k



[R<sub>out</sub> v/s RE]



[R<sub>in</sub> v/s RE]



[A<sub>V</sub> v/s RE]



[A<sub>i</sub> v/s RE]

④ \*\* Impact of VEB on A<sub>V</sub>, A<sub>i</sub>, R<sub>in</sub> & R<sub>out</sub> \*\*

• param VEB var = -1.5

VCB 1 0 10

\* VEB 5 0 { VEB var } A<sub>e</sub> 1 // Uncomment for A<sub>V</sub> & A<sub>i</sub>

\* VEB 5 6 { VEB var } // Uncomment for R<sub>in</sub> & R<sub>out</sub>

RC 1 2 20k

R3 3 0 50k

RF 4 5 1k

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\* Vnmac 6 0 sin(0 10m 1k) //Uncomment for Rin & Rout  
Q1 2 3 4 0 BC108B  
\* model BC108B NPN  
\* ac vact 100 1 100k //Uncomment for Av & Ai  
\* tf V(2) VEB // Uncomment for Rin & Rout  
\* step param VEBvar -1.5 -0.6 0.1  
\* end

