# AEC ASSIGNMENT -4

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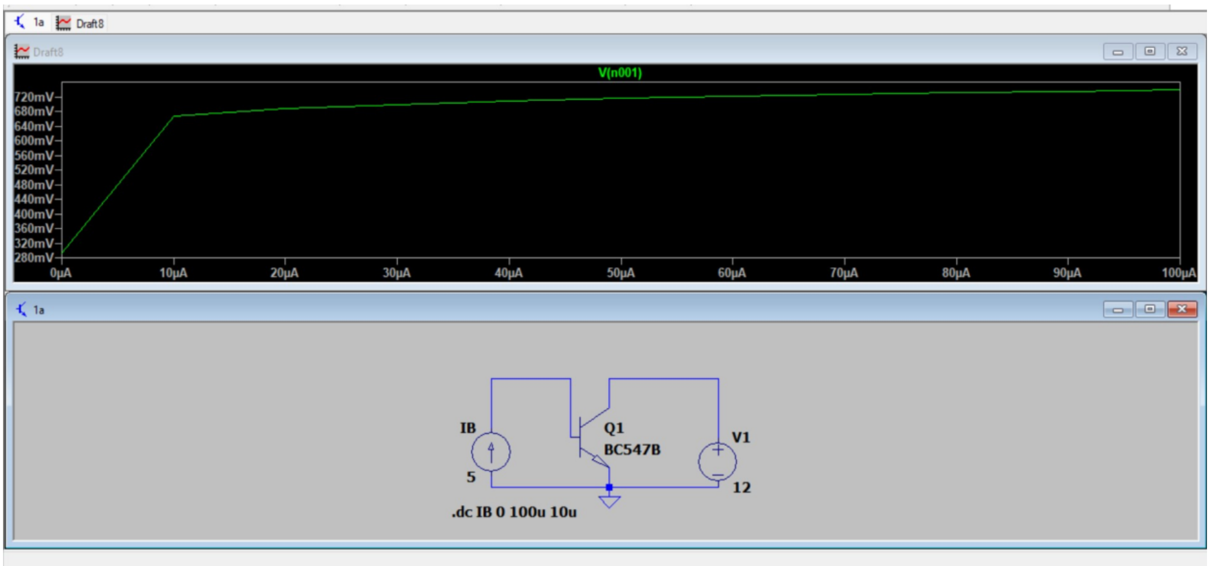
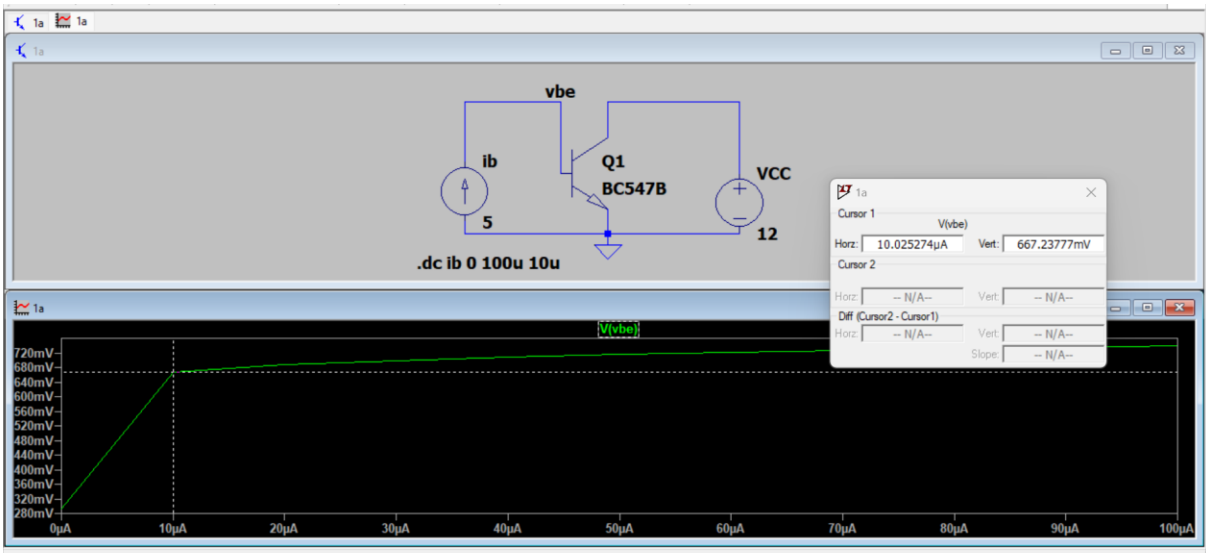
Roll No:- 2023102009

1)

a) Given to sweep IB from 0 to 100uA with a step size of 10uA.

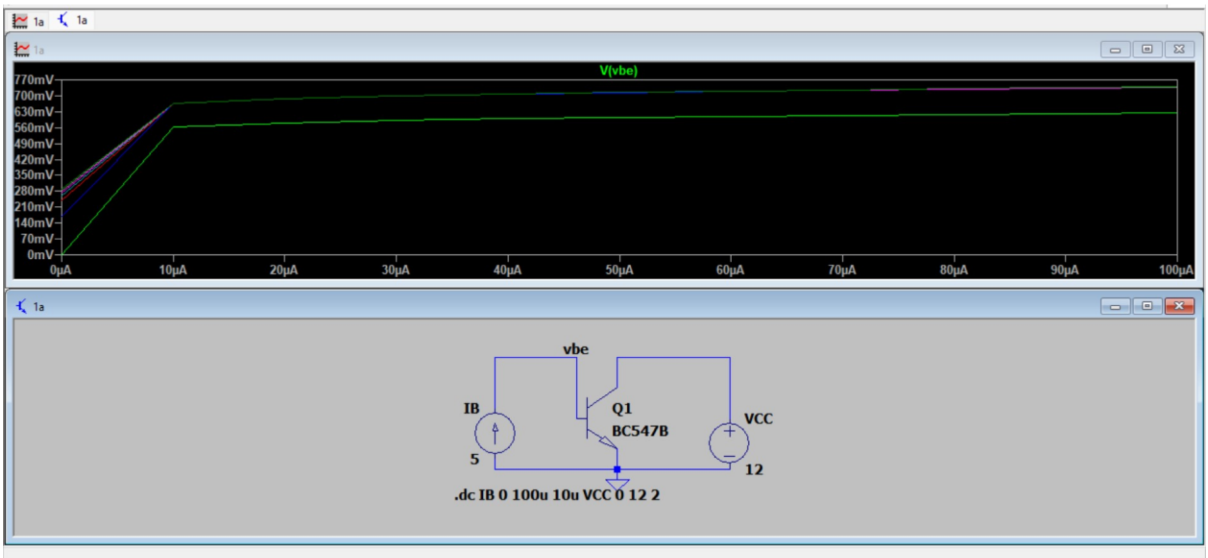
After sweeping IB and plotting VBE vs. IB, the graph obtained is as follows :



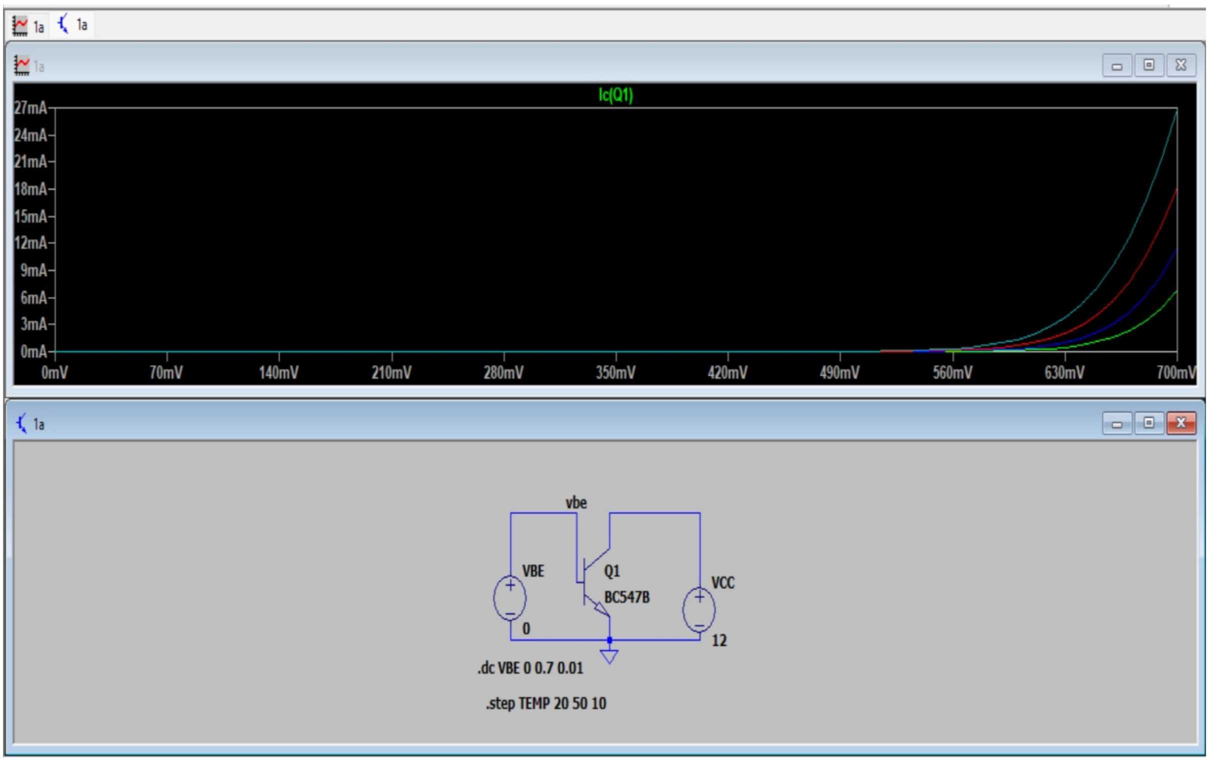




➔ **Forward bias emitter-base junction (EBJ) voltage = 667.23777 mV.**

After conducting an experiment where the IC (collector current) was plotted against VBE (base-emitter voltage) for a given value of VCC (collector-emitter voltage) at different temperatures, the resulting plot is as follows:




b)



As temperature Increases,

$V_T = \frac{KT}{q}$

$I_C = I_S . e^{V_{be}/V_T}$

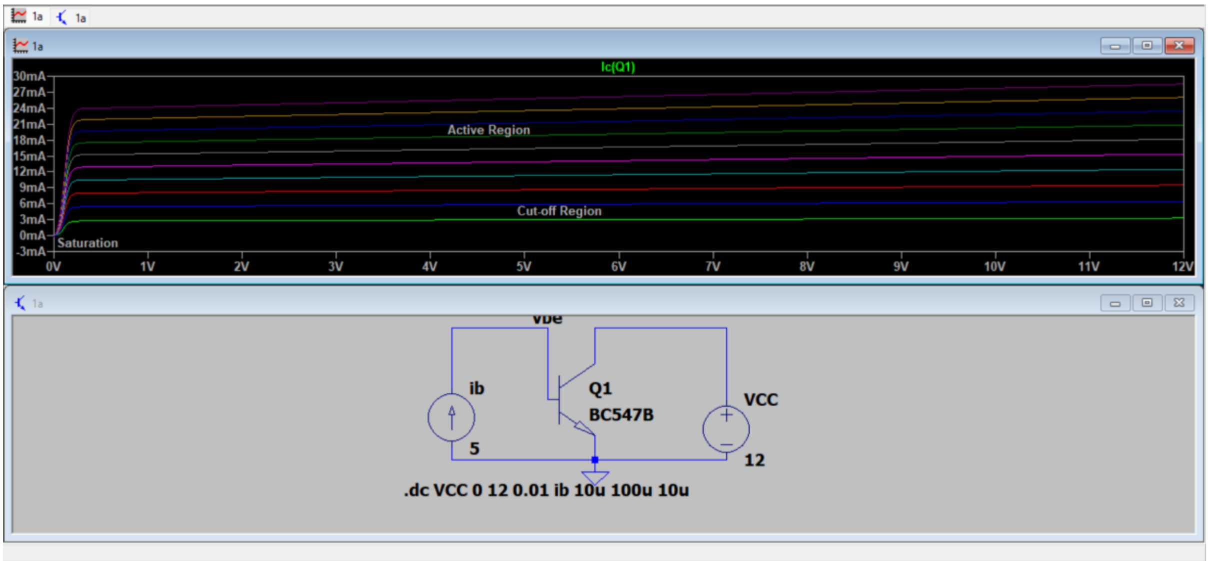
∴ As temperature Increases, $V_T$ Increases.

∴ $e^{V_{be}/V_T}$ decreases

∴ $I_C$ value ↓ses [ Decreases

∴ we get a graph with lower slope.

c)plot of IC vs VCE by sweeping VCC from 0 to 12 V in step size of 0.01 V and sweeping IB = 0 µA to 100 µA in step size of 10 µA :-



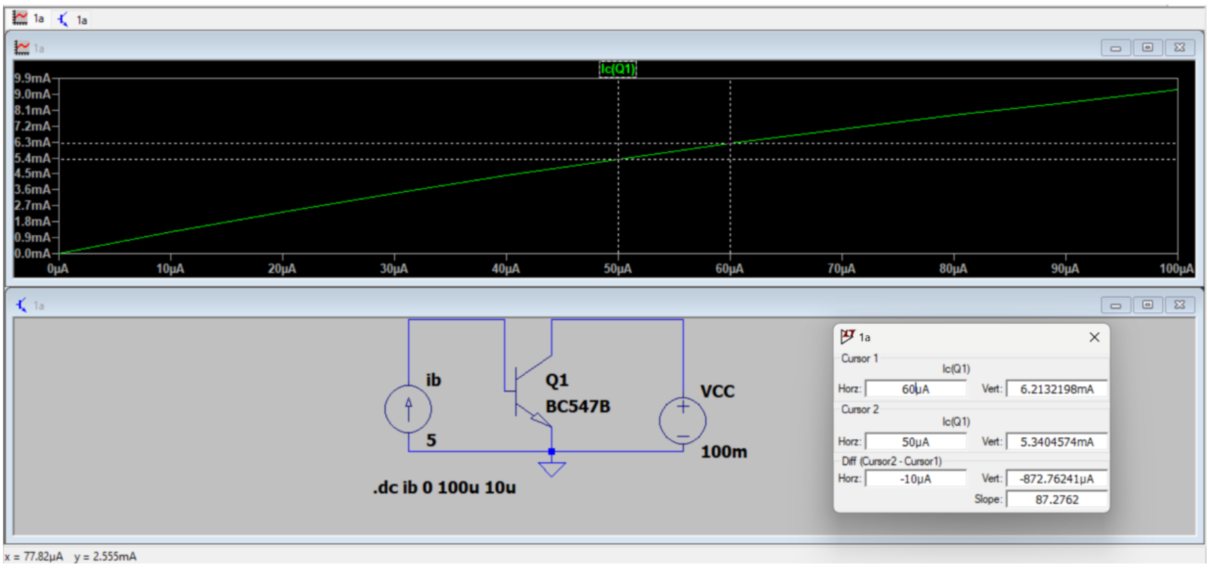
The impacts of various biasing scenarios on the BJT are visible in the two charts above. Forward biasing occurs at the emitter and collector junctions in saturation mode. The lower Ic/Ib ratio indicates a low amount of amplification as a result of this huge current flowing from the emitter to the collector.

We can see how various biasing scenarios affect the BJT in the two plots above. Both the emitter and collector junctions are forward-biased in saturation mode. The lower Ic/Ib ratio indicates that there is less amplification as a result of allowing a significant amount of current to travel from the emitter to the collector.

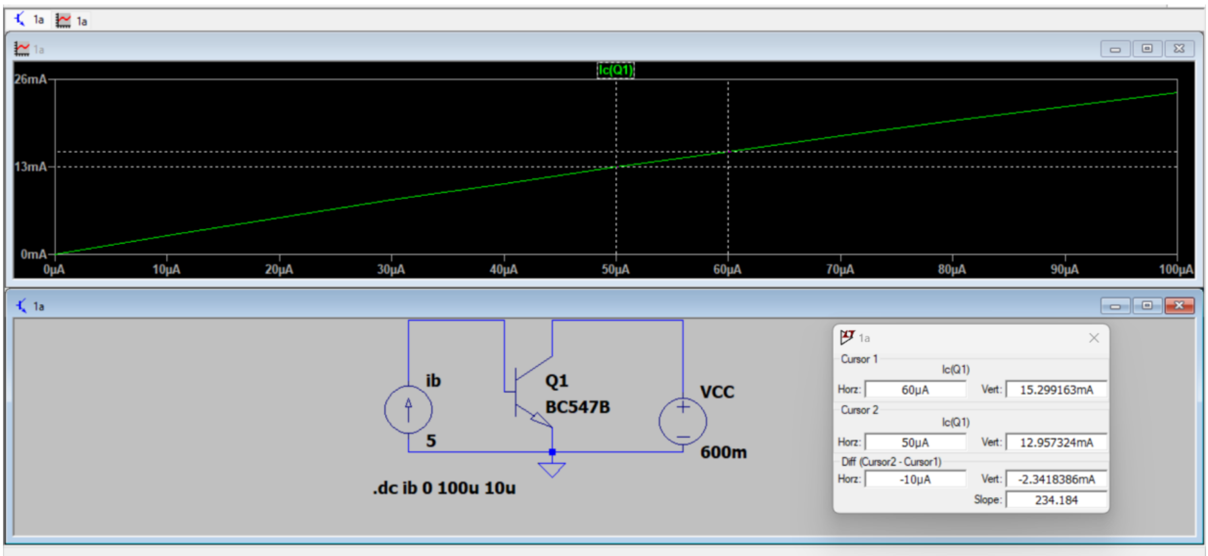
On the other hand, the collector junction is reverse-biased and the emitter junction is forward-biased in the active state. As a result, as indicated by the greater Ic/Ib ratio, a tiny base current governs a big collector current, resulting in a high degree of amplification. It is this biasing configuration that makes the BJT an efficient amplifier.

A forward biased transistor enters the saturation state, which lowers the collector current, at the collector-emitter junction. A reverse biased collector-emitter junction causes a transistor to enter the saturation state, which raises the current gain of the transistor.

tabulate incremental current gain β = ΔIC ΔIB in saturation (at VCE = 100 mV) and active (at VCE = 600 mV) mode :-




| IB | IC |
|---|---|
| 50uA | 5.3404mA |
| 60uA | 6.2132mA |




| IB | IC |
|---|---|
| 50uA | 12.966mA |
| 60uA | 15.305mA |

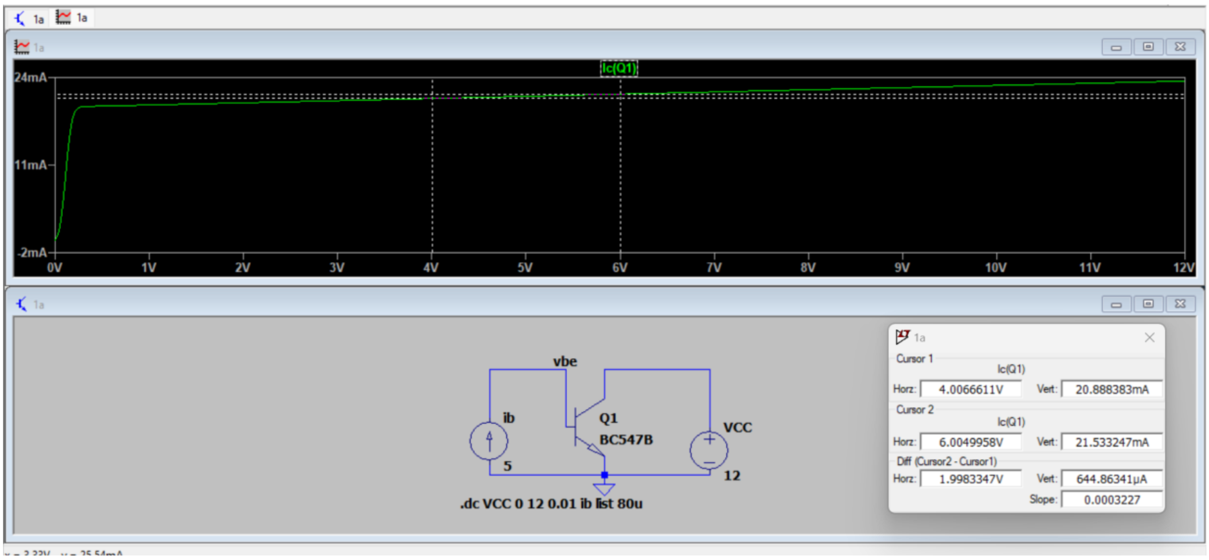
## Table of current gain β = IC/IB at VCE = 1 V

## for different values of IB:

| IB | IC | Beta |
|---|---|---|
| 0uA | 18.045pA | undefined |
| 10uA | 2.8006mA | 280.06 |
| 20uA | 5.4929mA | 274.645 |
| 30uA | 8.065mA | 268.833 |
| 40uA | 10.551mA | 263.775 |
| 50uA | 12.957mA | 259.14 |
| 60uA | 15.329mA | 255.483 |
| 70uA | 17.596mA | 251.371 |
| 80uA | 19.803mA | 247.537 |
| 90uA | 21.954mA | 243.933 |
| 100uA | 24.052mA | 240.52 |

## β value taken :

Average Beta(β) Value =258.528(259 approx).

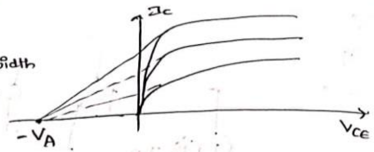



Calculation of VA:

## EARLY EFFECT

(c) Early Effect:

→ It is variation in the effective width of base in BJT due to variation in applied base to collector voltage.



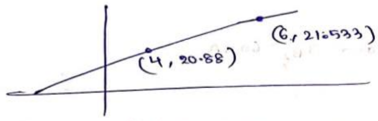

⇒ $I_C = I_S e^{V_{BE}/V_T}\left(1 + \frac{V_{CE}}{V_A}\right)$

→ Ic varies with VCE * In practical transistor in Rev bias current is not equal to zero.

This causes depletion ~~region~~ layer at ~~that~~ that junc^n widens effective base width Increases, transistor gain Increases.

$V_{CE} = 4\,V \Downarrow I_C = 20.88\,mA$ $\qquad$ $V_{CE} = 6\,V \Downarrow I_C = 21.533\,mA$

$$\text{Slope} = 0.0003227 = \frac{I_C}{(V_A + V_{CE})}$$




$$y - 20.88 = 0.00032\,(x - 4)$$

at $y = 0$,

$$\frac{0 - 20.88}{0.00032} = x - 4$$

$$x = V_A = 4 - \frac{20.88 \times 10^{-3}}{0.00032}$$

$$V_A = 4 - 65.25$$

$$\boxed{V_A = 61.25}$$

# Question 2:

## BJT amplifier analysis and design:

Given that VCC = 12 V

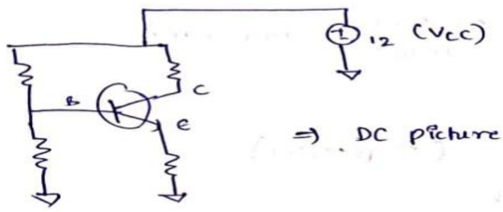
CB = 10 µF, CC = 10 µF, CE = 100 µF

R1 = 18.46 kΩ, R2 = 2.24 kΩ, RE = 2 kΩ, RC = 30.3 kΩ, RL = 1 kΩ

vin = Vmsin(2πfot) V

fo = 1 kHz

2(a)




⇒ DC picture of given circuit.

⇒ for DC $X_C = \frac{1}{j\omega C}$

# Assume $I_B$ is very very small compared to $I_C$ & $I_E$.

$\therefore I_B \simeq 0$

$\omega = 0 \Rightarrow$ so $X_C = \frac{1}{j\omega C} \approx \infty$

$X_C \to \infty$

∴ Capacitors will consider as open.

$V_{BE} = 0.7$ V (Given)

$\boxed{\beta = 259}$ (average of all above measured values)

Voltage divider for $R_1$ & $R_2$

$$V_B = \frac{(12)(R_2)}{R_1 + R_2} = \frac{(12)(2.24)}{2.24 + 18.46} = \frac{(12)(2.24)}{20.7}$$

$\approx 1.2986$ V

$\boxed{V_B = 1.2986 V}$

$V_{BE} = 0.7$ V $= V_B - V_E$

~~VBB~~ $\cancel{V_E \geq V_{BE} > V_B}$

$V_{BE} = V_B - V_E$

$V_E = V_B - V_{BE}$

$= 1.2986 - 0.7$

$\boxed{V_E = 0.5986 V}$

$I_E = \frac{V_E}{R_E}$ (ohm's law at emitter)

$I_E = \frac{V_E}{R_E} = \frac{0.5986}{2 \times 10^3} = 299.3\,\mu A$

$I_C = \frac{\beta}{\beta+1} \times I_E$

$(\because \beta \simeq 259)$

$I_C = \frac{259}{260} \times 299.3$

$= 298.1488$

$\boxed{\therefore I_C = 298.1488\,\mu A}$

$I_B = I_E - I_C \quad (\because I_C + I_B = I_E)$

$\cancel{I_B} = \cancel{298.1488} - 299.3$

$= \cancel{1.38\,\mu A}$

$\therefore \cancel{I_B} =$

$I_B = I_E - I_C$

$= 299.3 - 298.148$

$= 1.152\,\mu A$

$\boxed{\therefore I_B = 1.152\,\mu A}$

$I_B \ll I_C$

$I_B \ll I_E$

$\rightarrow$ our assumption is correct.

$V_C = V_{CC} - I_C R_C$

$= 12 - (298.14 \times 30.3 \times 10^{-3})$

$= 12 - 9.033$

$V_C = 2.967\ V$

$\boxed{\therefore V_C = 2.967\ V}$

$\therefore \boxed{V_C \approx 2.96\,V}$

$V_{BE} \simeq 0.7$ (Given) [Forward BIAS]

$V_C = 2.96\ V$

$V_{CE} > V_{BE} \rightarrow$ Forward Active region

$\therefore$ The BJT is in Active mode.

(b)

| | Theoretical value | Experimental value |
|---|---|---|
| $V_E$ | 0.5986 V | 0.686 V |
| $V_B$ | 1.298 V | 1.296 V |
| $V_C$ | 2.967 V | 1.6465 V |
| $I_B$ | 1.152 μA | 1.23 μA |
| $I_C$ | 298.148 μA | 340.83 μA |
| $I_E$ | 299.3 μA | 342 μA |

(c) calculation of $g_m, r_\pi, r_o$ :

We know, $g_m = \frac{I_C}{V_T} = \frac{298.148 \, \mu A}{25 \, mV}$

$= 11.925 \times 10^{-3}$ simens

Now, $r_\pi = \beta / g_m = \frac{259}{11.925 \times 10^{-3}}$

$= \frac{259000}{11.925} = 21719.077$

$= 21719.077$ ohms ($\Omega$)

And $r_o$ (output Impedence) $= R_L \| R_C$

$= \frac{R_L \cdot R_C}{R_L + R_C} = \frac{(1) \times (30.3) \times 10^6}{(1 + 30.3) \times 10^3}$

$= 968.051 \, k\Omega$

$= 968.051 \times 10^3 \, \Omega$

Also, if we consider Early effect

→ We have to add an other resistance to $R_C$ and $R_L$.

$r_o$ (Resistance due to Early effect) $= \frac{V_A}{I_C}$

$r_o = \frac{61.25}{298.148} \times 10^6 \approx 205.434\ K\Omega$

**d)**

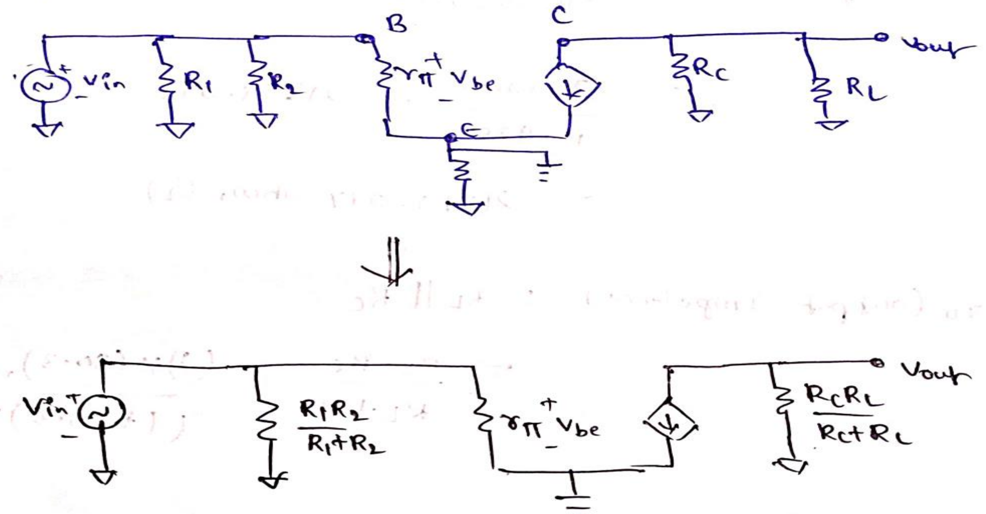
(a) In small signal Equivalent of circuit:

Replacing DC sources with AC equivalent.

* capacitor : $X_C = \frac{1}{j\omega C}$

We have to replace $R_C$ with $1/j\omega C$. If $\omega \to \infty$, $R_C \to 0$

∴ Equivalent circuit



(e.) $A_v' = \frac{V_{out}}{V_{in}}$ → Voltage gain expression for small signal.

$A_v = \frac{V_{out}}{V_{in}}$

$\Rightarrow \frac{V_{out}}{R_L} + \frac{V_{out}}{R_C} = -g_m V_{be}$

$\# \; V_{be} = V_{in}$

$V_{out}\left[\frac{1}{R_L} + \frac{1}{R_C}\right] = -g_m V_{be}$

$\left|\frac{V_{out}}{V_{in}}\right| = \left| -g_m (R_C \parallel R_L)\right|$

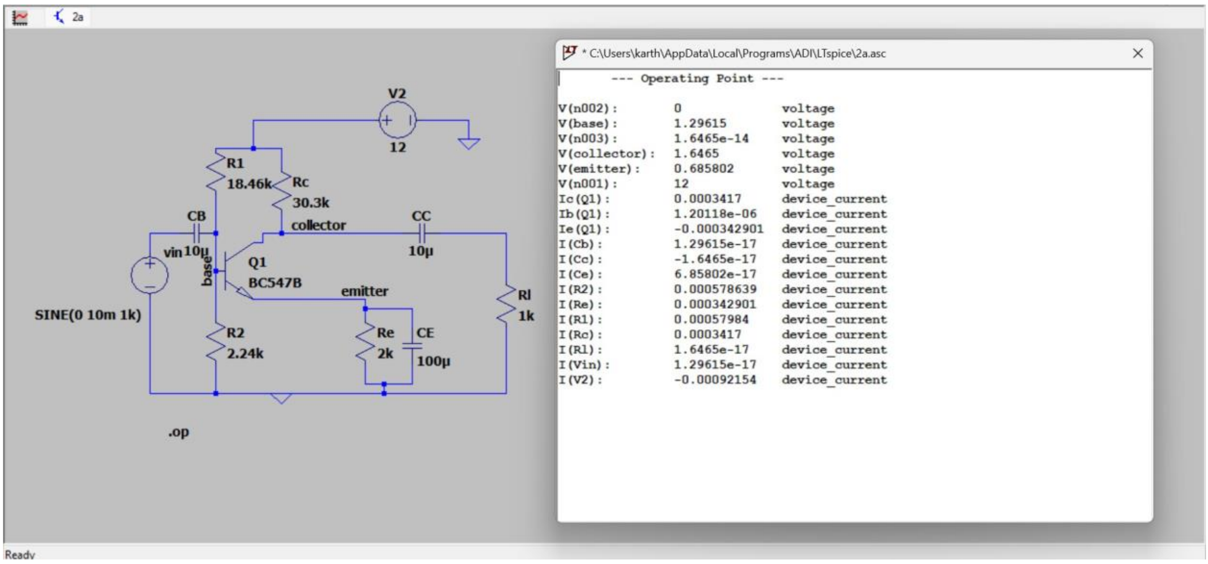
$= |-g_m r_o|$

$A_v = (0.0118)(968.05)$

$= 11.481$

$= -11.481$

-ve sign represents the phase will change by 180°.




## f)

(f) $V_{in} = V_m \sin(2\pi f_0 t)$ ; $f_0 = 1$ KHz

Given $V_m = 10$ mV

∴ $v_{in} = (10 \times 10^{-3}) \sin(2\pi f_0 t)$

∴ V (peak to peak) of $V_{in} = 10 \times 2 = 20$ mV

V (peak to peak) of $V_{out} = 114.22 \times 2$

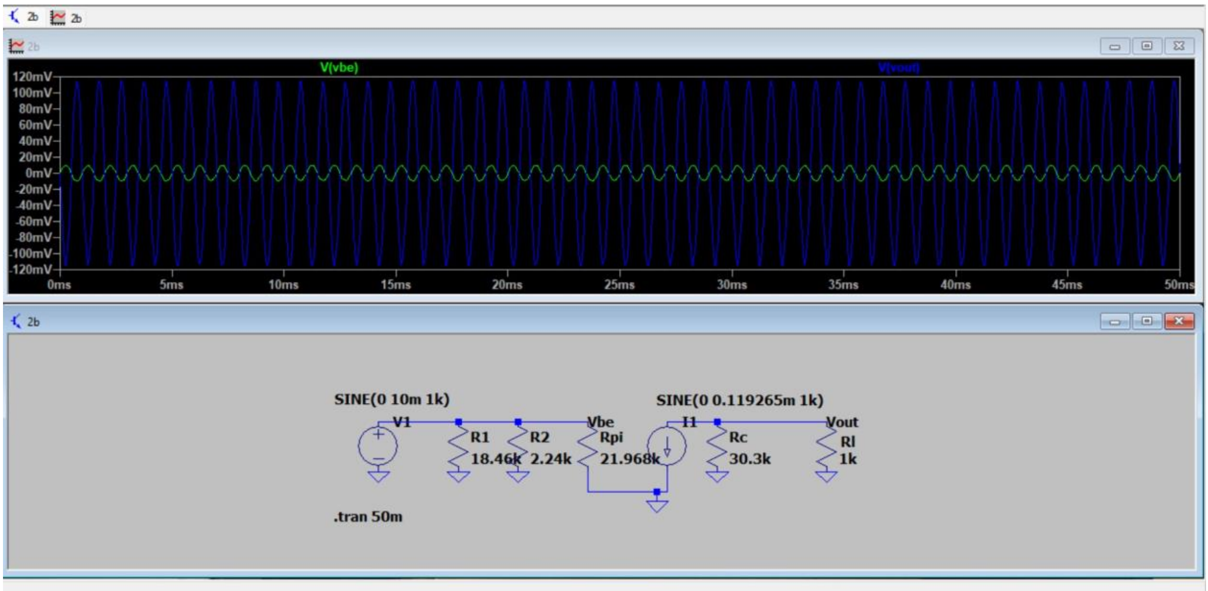
$= 228.44$ mV

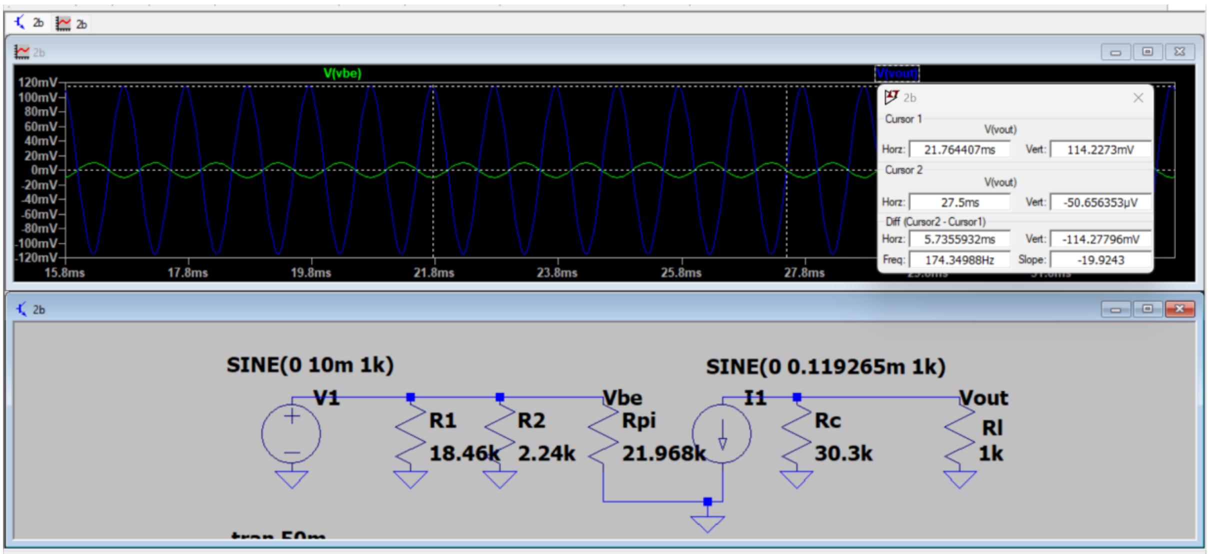
∴ therefore Gain $A_v = \frac{V_{out}}{V_{in}}$

$= \frac{228.44 \text{ mV}}{20 \text{ mV}}$

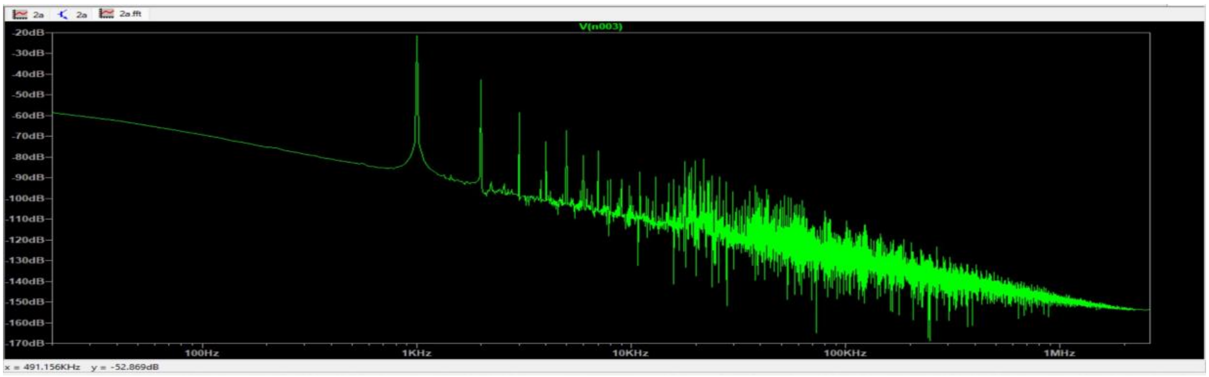
$= 11.422$

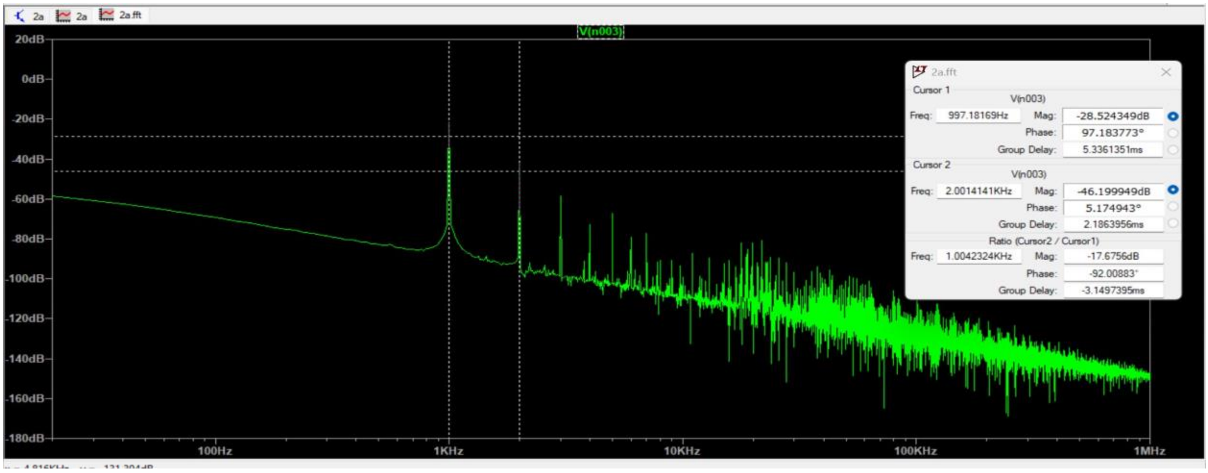
∴ gain $= A_v = \frac{V_{out}}{V_{in}} = 11.422$ #

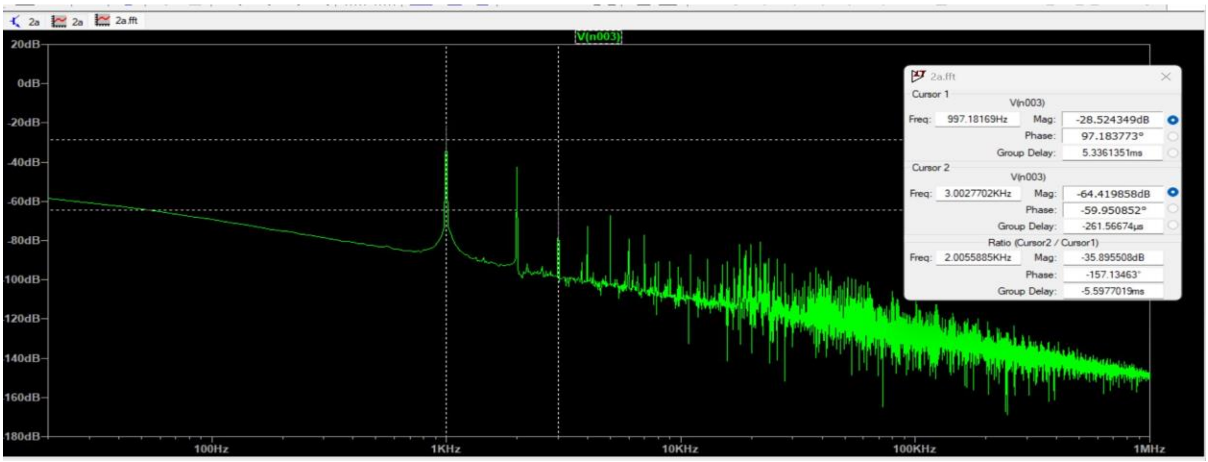

V(vbe)
V(vout)
120mV
100mV
80mV
60mV
40mV
20mV
0mV
-20mV
-40mV
-60mV
-80mV
-100mV
-120mV
0ms
5ms
10ms
15ms
20ms
25ms
30ms
35ms
40ms
45ms
50ms
SINE(0 10m 1k)
V1
R1
18.46k
R2
2.24k
Vbe
Rpi
21.968k
SINE(0 0.119265m 1k)
I1
Rc
30.3k
Vout
Rl
1k
.tran 50m

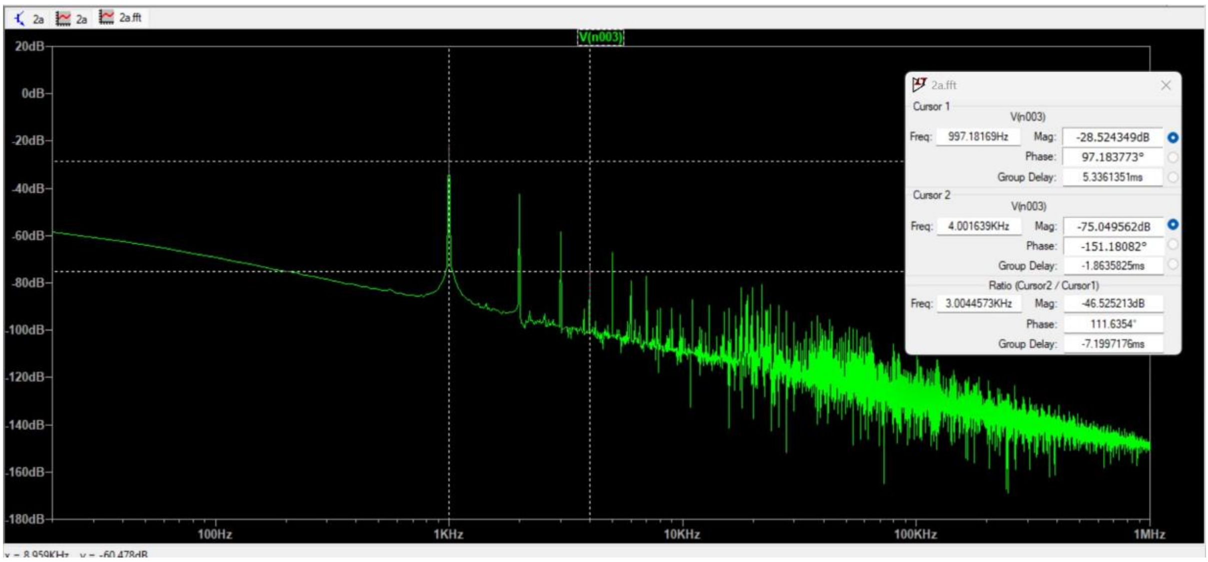

V(vbe)
V(vout)
120mV
100mV
80mV
60mV
40mV
20mV
0mV
-20mV
-40mV
-60mV
-80mV
-100mV
-120mV
15.8ms
17.8ms
19.8ms
21.8ms
23.8ms
25.8ms
27.8ms
Cursor 1
V(vout)
Horz: 21.764407ms
Vert: 114.2273mV
Cursor 2
V(vout)
Horz: 27.5ms
Vert: -50.656353µV
Diff (Cursor2 - Cursor1)
Horz: 5.7355932ms
Vert: -114.27796mV
Freq: 174.34988Hz
Slope: -19.9243
SINE(0 10m 1k)
V1
R1
18.46k
R2
2.24k
Vbe
Rpi
21.968k
SINE(0 0.119265m 1k)
I1
Rc
30.3k
Vout
Rl
1k

g)


V(n003)
-20dB
-30dB
-40dB
-50dB
-60dB
-70dB
-80dB
-90dB
-100dB
-110dB
-120dB
-130dB
-140dB
-150dB
-160dB
-170dB
100Hz
1KHz
10KHz
100KHz
1MHz
x = 491.156KHz y = -52.869dB


2a
2a
2a.fft
V(n003)
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
-120dB
-140dB
-160dB
-180dB
100Hz
1KHz
10KHz
100KHz
1MHz
2a.fft
Cursor 1
V(n003)
Freq: 997.18169Hz
Mag: -28.524349dB
Phase: 97.183773°
Group Delay: 5.3361351ms
Cursor 2
V(n003)
Freq: 2.0014141KHz
Mag: -46.199949dB
Phase: 5.174943°
Group Delay: 2.1863956ms
Ratio (Cursor2 / Cursor1)
Freq: 1.0042324KHz
Mag: -17.6756dB
Phase: -92.00883°
Group Delay: -3.1497395ms


2a
2a
2a.fft
V(n003)
20dB
0dB
-20dB
-40dB
-60dB
-80dB
100dB
120dB
140dB
160dB
180dB
100Hz
1KHz
10KHz
100KHz
1MHz
2a.fft
Cursor 1
V(n003)
Freq: 997.18169Hz
Mag: -28.524349dB
Phase: 97.183773°
Group Delay: 5.3361351ms
Cursor 2
V(n003)
Freq: 3.0027702KHz
Mag: -64.419858dB
Phase: -59.950852°
Group Delay: -261.56674µs
Ratio (Cursor2 / Cursor1)
Freq: 2.0055885KHz
Mag: -35.895508dB
Phase: -157.13463°
Group Delay: -5.5977019ms

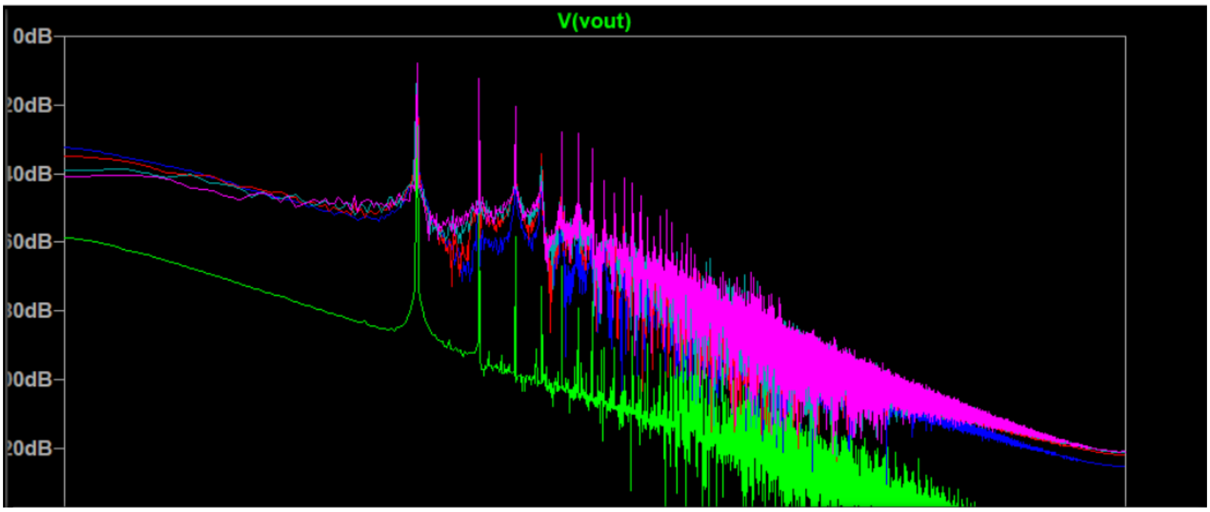

2a
2a
2a.fft
V(n003)
20dB
0dB
-20dB
-40dB
-60dB
-80dB
-100dB
-120dB
-140dB
-160dB
-180dB
100Hz
1KHz
10KHz
100KHz
1MHz
2a.fft
Cursor 1
V(n003)
Freq: 997.18169Hz
Mag: -28.524349dB
Phase: 97.183773°
Group Delay: 5.3361351ms
Cursor 2
V(n003)
Freq: 4.001639KHz
Mag: -75.049562dB
Phase: -151.18082°
Group Delay: -1.8635825ms
Ratio (Cursor2 / Cursor1)
Freq: 3.0044573KHz
Mag: -46.525213dB
Phase: 111.6354°
Group Delay: -7.1997176ms

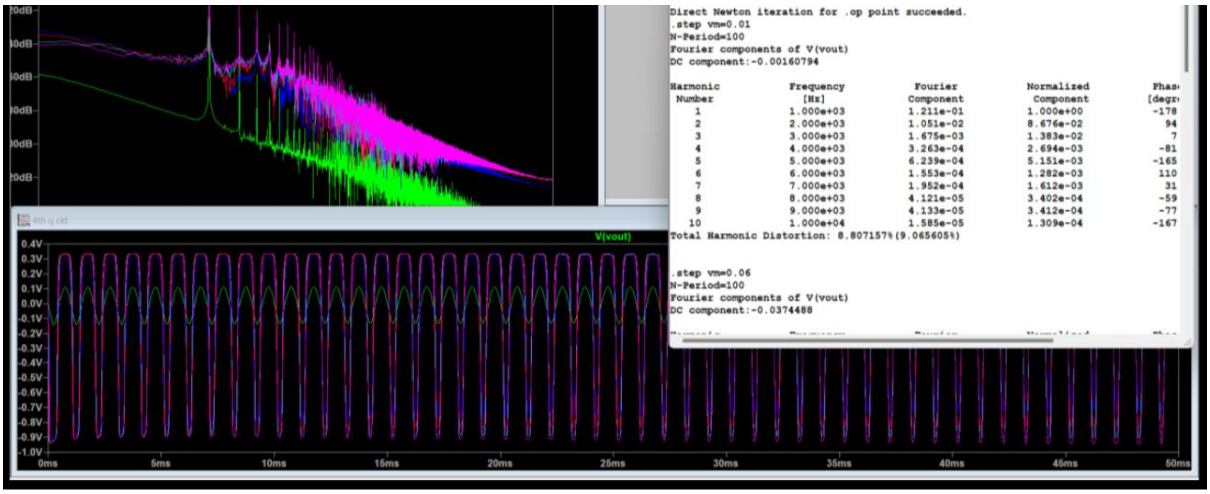
(g)

| Harmonic | frequency | difference (magnitude) |
|---|---|---|
| 2nd | 2000 Hz | 17.6756 dB |
| 3rd | 3000 Hz | 39.8955 dB |
| 4th | 4000 Hz | 46.5621 dB |

fundamental Harmonic = -28.524 dB
(1 KHz)

## h) Total Harmonic Disortion:



THD from log files:

Direct Newton iteration for .op point succeeded.
.step vm=0.01
N-Period=100
Fourier components of V(vout)
DC component:-0.00444391

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|---|---|---|---|---|---|
| 1 | 1.000e+3 | 1.243e-1 | 1.000e+0 | -91.72° | 0.00° |
| 2 | 2.000e+3 | 1.145e-2 | 9.213e-2 | -4.45° | 87.28° |
| 3 | 3.000e+3 | 6.129e-4 | 4.931e-3 | 81.21° | 172.93° |
| 4 | 4.000e+3 | 4.090e-5 | 3.290e-4 | -107.19° | -15.46° |
| 5 | 5.000e+3 | 4.704e-5 | 3.784e-4 | -89.61° | 2.12° |
| 6 | 6.000e+3 | 3.106e-5 | 2.499e-4 | -78.28° | 13.45° |
| 7 | 7.000e+3 | 3.414e-5 | 2.746e-4 | -91.68° | 0.04° |
| 8 | 8.000e+3 | 2.177e-5 | 1.751e-4 | -89.73° | 1.99° |
| 9 | 9.000e+3 | 2.347e-5 | 1.888e-4 | -91.50° | 0.23° |
| 10 | 1.000e+4 | 1.646e-5 | 1.324e-4 | -96.12° | -4.40° |

Partial Harmonic Distortion: 9.226037%
Total Harmonic Distortion: 9.416436%

.step vm=0.06
N-Period=100
Fourier components of V(vout)
DC component:-0.0976359

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|---|---|---|---|---|---|
| 1 | 1.000e+3 | 5.994e-1 | 1.000e+0 | -92.43° | 0.00° |
| 2 | 2.000e+3 | 2.193e-1 | 3.658e-1 | -5.91° | 86.52° |
| 3 | 3.000e+3 | 1.290e-2 | 2.151e-2 | 68.47° | 160.90° |
| 4 | 4.000e+3 | 4.102e-2 | 6.843e-2 | -10.25° | 82.18° |
| 5 | 5.000e+3 | 3.315e-2 | 5.530e-2 | 76.43° | 168.86° |
| 6 | 6.000e+3 | 1.615e-2 | 2.695e-2 | 167.72° | 260.15° |
| 7 | 7.000e+3 | 4.555e-3 | 7.599e-3 | -97.97° | -5.54° |
| 8 | 8.000e+3 | 1.957e-3 | 3.265e-3 | 166.79° | 259.22° |
| 9 | 9.000e+3 | 4.337e-3 | 7.235e-3 | -108.55° | -16.12° |
| 10 | 1.000e+4 | 3.365e-3 | 5.614e-3 | -28.34° | 64.09° |

Partial Harmonic Distortion: 37.799740%
Total Harmonic Distortion: 41.010656%

.step vm=0.11
N-Period=100
Fourier components of V(vout)
DC component:-0.0654543

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|---|---|---|---|---|---|
| 1 | 1.000e+3 | 6.301e-1 | 1.000e+0 | -93.18° | 0.00° |
| 2 | 2.000e+3 | 2.893e-1 | 4.590e-1 | -6.48° | 86.70° |
| 3 | 3.000e+3 | 2.377e-2 | 3.772e-2 | 81.91° | 175.09° |
| 4 | 4.000e+3 | 7.423e-2 | 1.178e-1 | -13.59° | 79.59° |
| 5 | 5.000e+3 | 6.243e-2 | 9.908e-2 | 76.44° | 169.62° |
| 6 | 6.000e+3 | 2.483e-2 | 3.941e-2 | 174.65° | 267.82° |
| 7 | 7.000e+3 | 3.401e-3 | 5.398e-3 | -3.00° | 90.18° |
| 8 | 8.000e+3 | 1.158e-2 | 1.838e-2 | 167.40° | 260.58° |
| 9 | 9.000e+3 | 1.355e-2 | 2.150e-2 | -98.75° | -5.58° |
| 10 | 1.000e+4 | 8.834e-3 | 1.402e-2 | -18.88° | 74.29° |

Partial Harmonic Distortion: 48.827887%
Total Harmonic Distortion: 53.907186%

.step vm=0.16
N-Period=100
Fourier components of V(vout)
DC component:-0.0349351

| Harmonic Number | Frequency [Hz] | Fourier Component | Normalized Component | Phase [degree] | Normalized Phase [deg] |
|---|---|---|---|---|---|
| 1 | 1.000e+3 | 6.110e-1 | 1.000e+0 | -93.73° | 0.00° |
| 2 | 2.000e+3 | 3.320e-1 | 5.434e-1 | -6.73° | 87.00° |
| 3 | 3.000e+3 | 7.375e-2 | 1.207e-1 | 85.02° | 178.75° |
| 4 | 4.000e+3 | 5.963e-2 | 9.760e-2 | -18.34° | 75.38° |
| 5 | 5.000e+3 | 7.905e-2 | 1.294e-1 | 77.01° | 170.73° |
| 6 | 6.000e+3 | 5.004e-2 | 8.191e-2 | 173.74° | 267.46° |
| 7 | 7.000e+3 | 1.526e-2 | 2.497e-2 | -88.05° | 5.68° |
| 8 | 8.000e+3 | 1.155e-2 | 1.891e-2 | 173.98° | 267.70° |
| 9 | 9.000e+3 | 2.313e-2 | 3.786e-2 | -100.09° | -6.36° |
| 10 | 1.000e+4 | 1.868e-2 | 3.057e-2 | -22.23° | 71.50° |

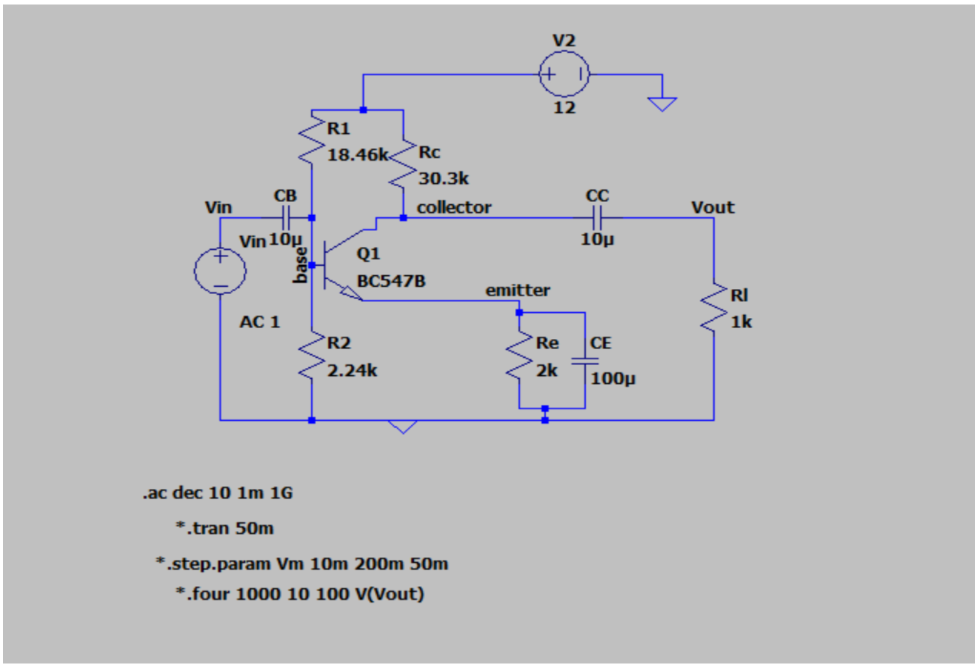
Partial Harmonic Distortion: 58.839092%
Total Harmonic Distortion: 64.698371%

```
.step vm=0.2
N-Period=100
Fourier components of V(vout)
DC component:-0.0158895

Harmonic    Frequency    Fourier     Normalized   Phase      Normalized
 Number       [Hz]      Component    Component   [degree]    Phase [deg]
    1       1.000e+3    5.921e-1     1.000e+0     -94.08°       0.00°
    2       2.000e+3    3.502e-1     5.915e-1      -6.97°      87.11°
    3       3.000e+3    1.092e-1     1.844e-1      85.05°     179.13°
    4       4.000e+3    3.783e-2     6.389e-2     -27.42°      66.66°
    5       5.000e+3    8.070e-2     1.363e-1      76.66°     170.75°
    6       6.000e+3    6.769e-2     1.143e-1     172.77°     266.85°
    7       7.000e+3    3.261e-2     5.508e-2     -96.22°      -2.14°
    8       8.000e+3    4.844e-3     8.180e-3    -165.40°     -71.31°
    9       9.000e+3    2.648e-2     4.472e-2    -100.91°      -6.83°
   10       1.000e+4    2.644e-2     4.465e-2     -22.91°      71.17°
Partial Harmonic Distortion: 65.317514%
Total Harmonic Distortion:   71.573993%


Date: Wed Mar  6 16:49:13 2024
Total elapsed time: 0.370 seconds.

tnom = 27
temp = 27
method = modified trap
totiter = 2891
traniter = 2883
tranpoints = 1297
accept = 1194
rejected = 103
matrix size = 11
fillins = 0
solver = Normal
Avg thread counts: 2.4/4.1/4.1/2.4
Matrix Compiler1:      35 opcodes  0.3/[0.2]/0.2
Matrix Compiler2: off  [0.2]/0.2/0.2
```

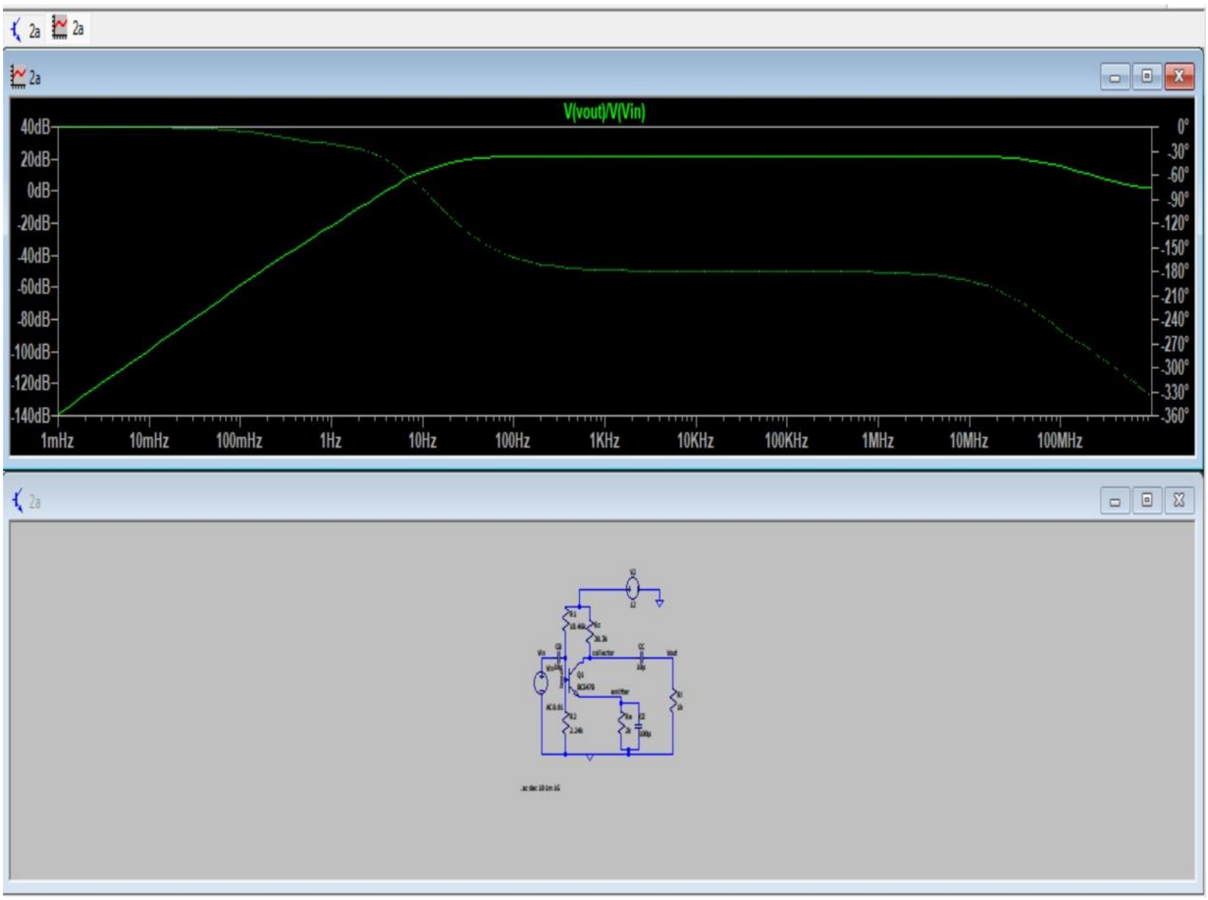
| Vm | Total Harmonic Distortions |
|---|---|
| 10mV | 9.4164 % |
| 60mV | 41.01065 % |
| 110 mV | 53.9071 % |
| 160 mV | 64.6983 % |
| 200 mV | 71.57399 % |

**As Vm increases, the value of output increases; that is, THD is directly proportional to the output of the circuit. Thus we observed increasing values of THD’s when Vm increases.**

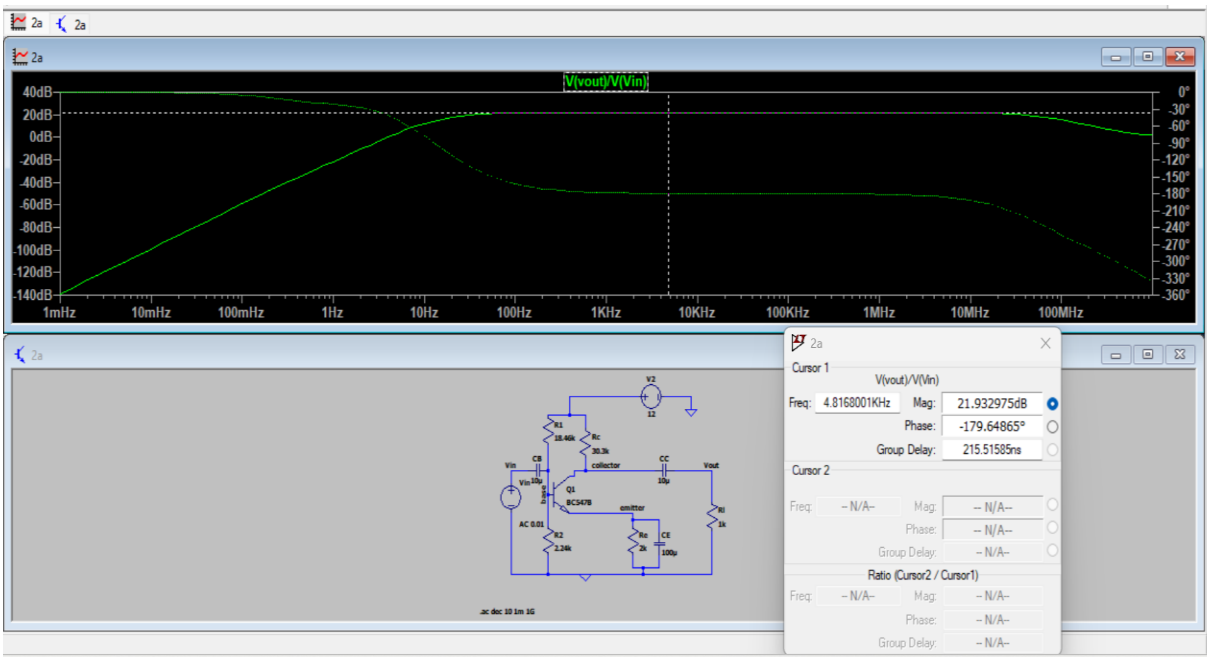
i)

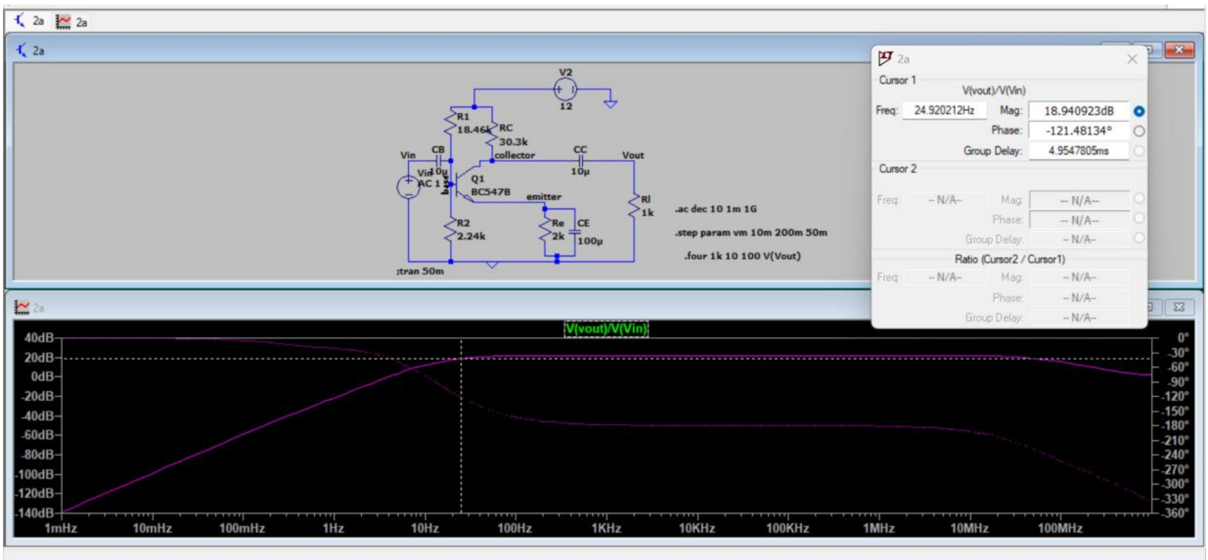


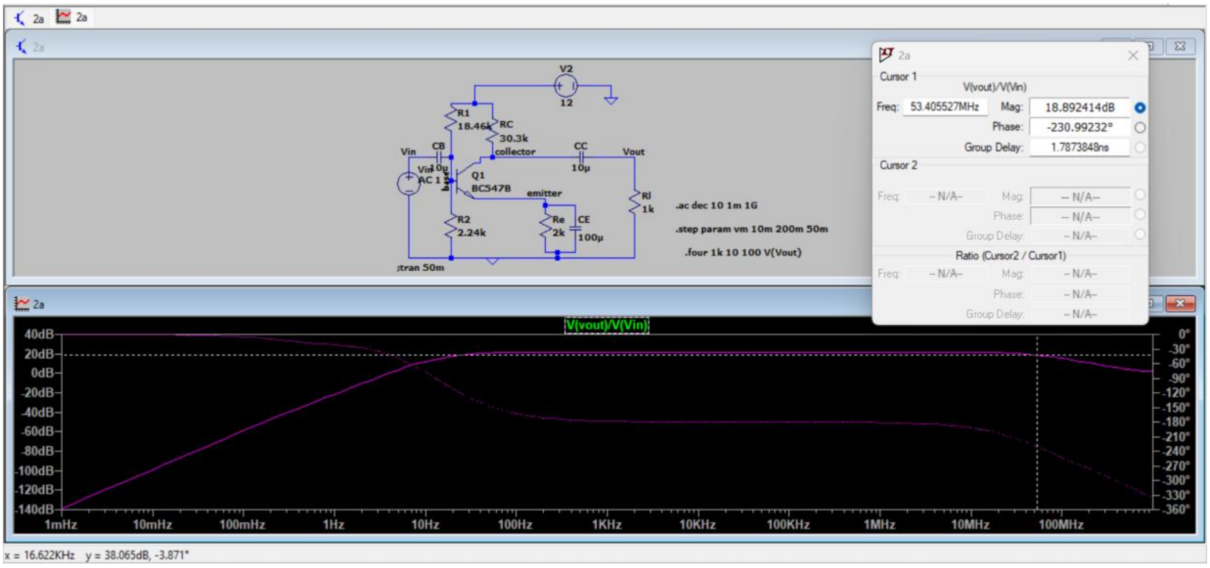
V2
12
R1
18.46k
Rc
30.3k
Vin
CB
collector
CC
Vout
Vin
10µ
10µ
Q1
base
BC547B
emitter
Rl
1k
AC 1
R2
2.24k
Re
2k
CE
100µ
.ac dec 10 1m 1G
*.tran 50m
*.step.param Vm 10m 200m 50m
*.four 1000 10 100 V(Vout)

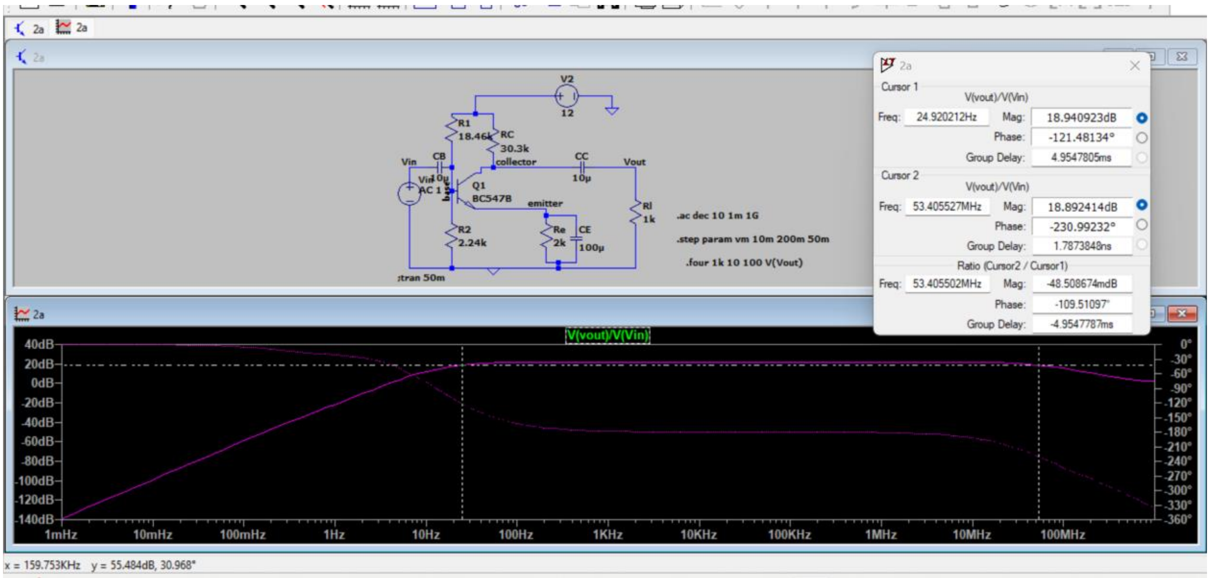



Max value of dB=21.9329 dB




V2
12
R1
18.46k
RC
30.3k
collector
CB
10µ
CC
10µ
Vin
Vout
AC 1
Q1
BC547B
emitter
Rl
1k
R2
2.24k
Re
2k
CE
100µ
.ac dec 10 1m 1G
.step param vm 10m 200m 50m
.four 1k 10 100 V(Vout)
.tran 50m
Cursor 1
V(vout)/V(Vin)
Freq: 24.920212Hz
Mag: 18.940923dB
Phase: -121.48134°
Group Delay: 4.9547805ms
Cursor 2
Ratio (Cursor2 / Cursor1)
V(vout)/V(Vin)

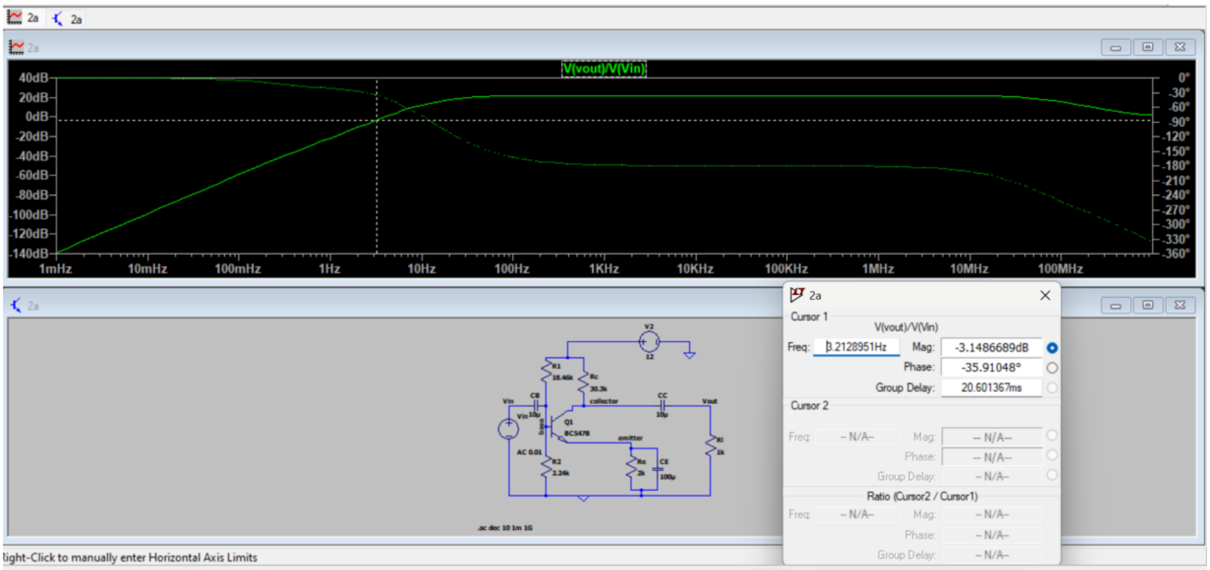

V2
12
R1
18.46k
RC
30.3k
collector
CB
10µ
CC
10µ
Vin
Vout
AC 1
Q1
BC547B
emitter
Rl
1k
R2
2.24k
Re
2k
CE
100µ
.ac dec 10 1m 1G
.step param vm 10m 200m 50m
.four 1k 10 100 V(Vout)
.tran 50m
Cursor 1
V(vout)/V(Vin)
Freq: 53.405527MHz
Mag: 18.892414dB
Phase: -230.99232°
Group Delay: 1.7873848ns
Cursor 2
Ratio (Cursor2 / Cursor1)
V(vout)/V(Vin)
x = 16.622KHz y = 38.065dB, -3.871°


V2
12
R1
18.46k
RC
30.3k
collector
CB
10µ
CC
10µ
Vin
Vout
AC 1
Q1
BC547B
emitter
Rl
1k
R2
2.24k
Re
2k
CE
100µ
.ac dec 10 1m 1G
.step param vm 10m 200m 50m
.four 1k 10 100 V(Vout)
.tran 50m
Cursor 1
V(vout)/V(Vin)
Freq: 24.920212Hz
Mag: 18.940923dB
Phase: -121.48134°
Group Delay: 4.9547805ms
Cursor 2
V(vout)/V(Vin)
Freq: 53.405527MHz
Mag: 18.892414dB
Phase: -230.99232°
Group Delay: 1.7873848ns
Ratio (Cursor2 / Cursor1)
Freq: 53.405502MHz
Mag: -48.508674mdB
Phase: -109.51097°
Group Delay: -4.9547787ms
V(vout)/V(Vin)
x = 159.753KHz y = 55.484dB, 30.968°

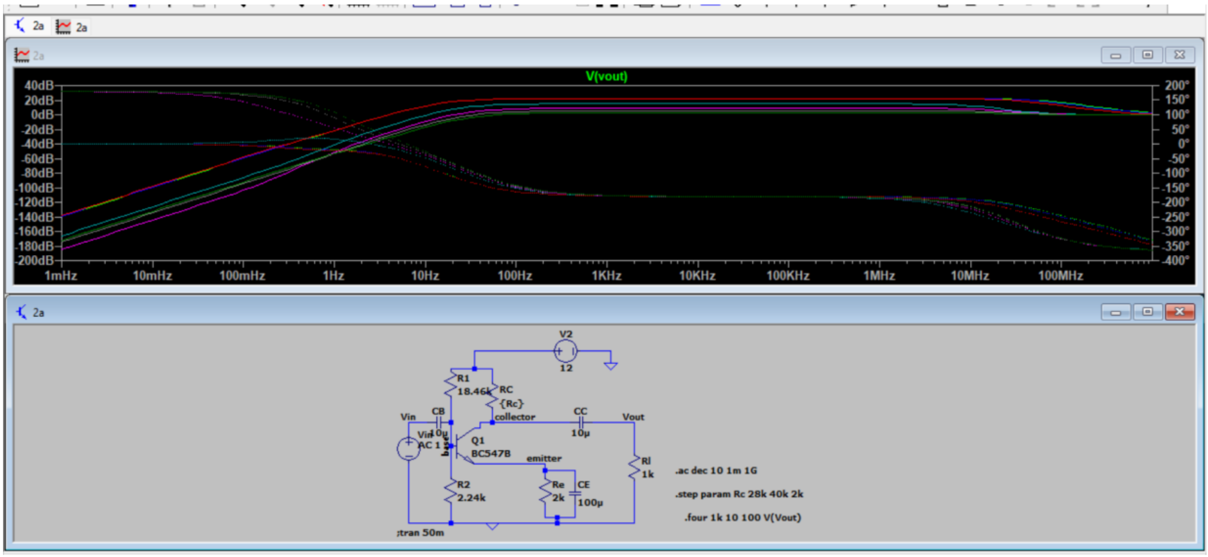
The – 3dB bandwidth =(FL-FH)

=53.4 M Hz

At -3 dB  Measuring frequency:




j)




| Rc | DC Gain |
|---|---|
| 28k | 21.913091dB |
| 30k | 21.928601dB |
| 32k | 21.944322dB |
| 34k | 15.012012dB |
| 36k | 8.7235161dB |
| 38k | 5.045413dB |
| 40k | 2.3402654dB |

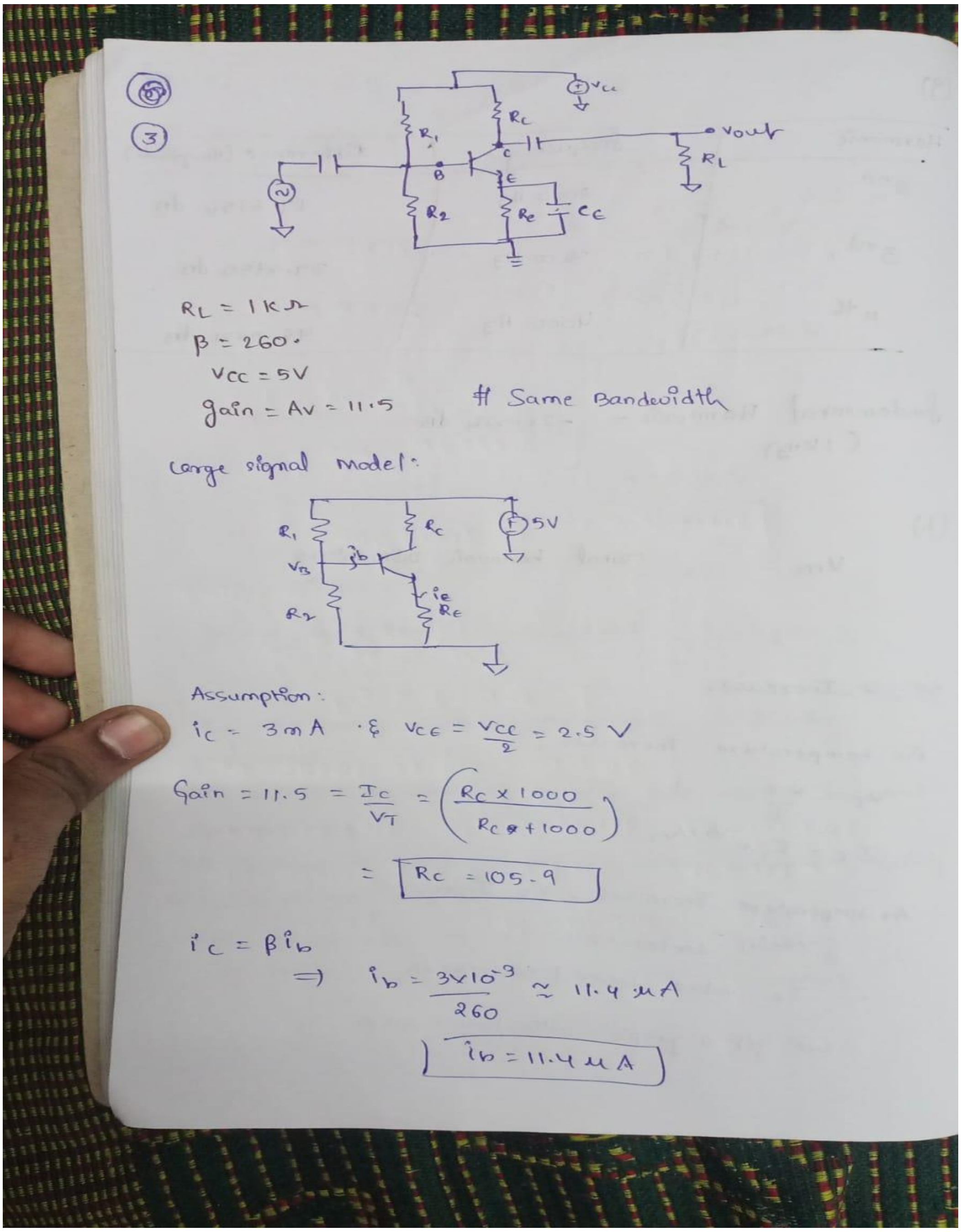
Why the gain is changing? Compare two cases (30 kΩ and 40 kΩ) quantitatively and justify your answers.

The gain in a BJT amplifier is largely determined by the load resistance (Rc). The gain of the amplifier is given by the product of the transconductance (gm) and the load resistance (Rc). The transconductance, in turn, is a function of the collector current (Ic), which remains constant for a given base current (Ib).

When Rc is 30kΩ, the gain is 21.92dB. When Rc increases to 40kΩ, the gain decreases to 2.34dB. This is because as Rc increases, the overall resistance in the circuit increases, which reduces the current flow. As a result, the voltage across the load resistance (which is the output voltage) decreases, leading to a decrease in gain.

In conclusion, the gain of a BJT amplifier is inversely proportional to the load resistance. Hence, an increase in load resistance leads to a decrease in gain.

# Question 3:-



(3)



$R_L = 1K\Omega$

$\beta = 260.$

$V_{CC} = 5V$

gain $= A_V = 11.5$

# Same Bandwidth

Large signal model:



Assumption:

$i_c = 3mA$ & $V_{CE} = \frac{V_{CC}}{2} = 2.5V$

$\text{Gain} = 11.5 = \frac{I_c}{V_T} = \left(\frac{R_C \times 1000}{R_C + 1000}\right)$

$= \boxed{R_C = 105.9}$

$i_c = \beta i_b$

$\Rightarrow i_b = \frac{3 \times 10^{-3}}{260} \approx 11.4\,\mu A$

$\boxed{i_b = 11.4\,\mu A}$

$\alpha = \frac{\beta}{\beta+1}$ $\quad i_e = i_c + i_b$

$i_e = 3.01145 \text{ mA}$

KVL

$i_c R_c + V_{CE} + i_e R_e = 5V$

$3\times10^{-3} \times 105.9 + 2.5 + 3.01145 \times R_e \times 10^{-3} = 5$

$\boxed{R_e = 724.668\,\Omega}$

$V_E = i_e R_E$

$= 3.01 \times 10^{-3} \times 724.6$

$\boxed{V_E = 2.182V}$

$V_B = 0.7 + V_E$

$= 0.7 + 2.182$

$= \boxed{V_B = 2.882V}$

at $R_1$

$\frac{5-V_B}{R_1} = i_c \quad \& \quad \frac{V_B}{R_2} = i_e$

$\boxed{R_1 = 405.9\,\Omega}$

$\boxed{R_2 = \frac{V_B}{i_c} = 957.11\,\Omega}$

$r_\pi = \beta/g_m = \frac{\beta \times V_T}{i_c} = \frac{V_T}{I_B}$.

$= 2.183 \text{ K}\Omega$

$\boxed{\therefore r_\pi = 2.183 \text{ K}\Omega}$

$\alpha = \frac{\beta}{\beta+1}$ $\qquad i_e = i_c + i_b$

$i_e = 3.01145\ mA$

KVL

$i_c R_c + V_{CE} + i_e R_e = 5V$

$3\times10^{-3} \times 105.9 + 2.5 + 3.01145 \times R_e \times 10^{-3} = 5$

$\boxed{R_e = 724.668\ \Omega}$

$V_E = i_e R_E$

$= 3.01 \times 10^{-3} \times 724.6$

$\boxed{V_E = 2.182V}$

$V_B = 0.7 + V_E$

$= 0.7 + 2.182$

$= \boxed{V_B = 2.882V}$

at $R_1$

$\frac{5-V_B}{R_1} = i_c$ & $\frac{V_B}{R_2} = i_e$

$\boxed{R_1 = 705.9\Omega}$

$\boxed{R_2 = \frac{V_B}{i_c} = 957.11\Omega}$

$r_\pi = \beta/g_m = \frac{\beta \times V_T}{i_c} = \frac{V_T}{I_B}$.

$= 2.183\ K\Omega$

$\boxed{r_\pi = 2.183\ K\Omega}$

$$\frac{1}{Z_{in}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{2.183}$$

$$Z_{in} = 342.52\,\Omega$$

$$\therefore f_L = \frac{1}{2\pi Z_{in} C_B} \Rightarrow 28 = \frac{1}{2\pi(342.52)C_B}$$

$$\boxed{C_B = 25.813\,\mu F}$$

$$\frac{1}{Z_{out}} = \frac{1}{R_C} + \frac{1}{R_L}$$

$$\boxed{Z_{out} = 95.759\,\Omega}$$

$$f = \frac{1}{2\pi C_C (Z_{out})} \Rightarrow \boxed{C_C = 92.33\,\mu F}$$

Emitter Impedence :

$$\frac{1}{Z_e} = \frac{1}{R_E} + \frac{\beta+1}{r_\pi}$$

$$\boxed{Z_e = 8.207\,\Omega}$$

$$f_H = \frac{1}{2\pi Z_e C_E} \Rightarrow \boxed{C_E = 107.7\,\mu F}$$

$C_B = 25.8\,\mu F$ $C_C = 92.33\,\mu F$ $C_E = 107.7\,\mu F$

$R_1 = 705.9\,\Omega$ $R_2 = 957.11\,\Omega$ $R_3 = 724.5\,\Omega$

$I_C = 300\,mA$ $R_C = 105.9\,\Omega$ $I_B = 11.45\,\mu A$

Voltage gain

$$= \frac{V_{out}}{V_{in}} = \left| -g_m \left( \frac{R_L R_C}{R_L + R_C} \right) \right|$$

$$= 0.12 \times \frac{105.9 \times 10^3}{10^3 + 105.9}$$

$$= 11.49$$

$$\boxed{A_V = 11.49}$$

Power consumption:

$P_{DC} = V_{CC} \times I_{Drawn}$

for $V_{CC} = 5V$

$I_{drawn} = 6.1395 \text{ mA}$

$P_{DC} = 5 \times 6.139.$

$= 30.64$ m watt

$$\boxed{P_{5V} = 30.64 \text{ m Watt}}$$

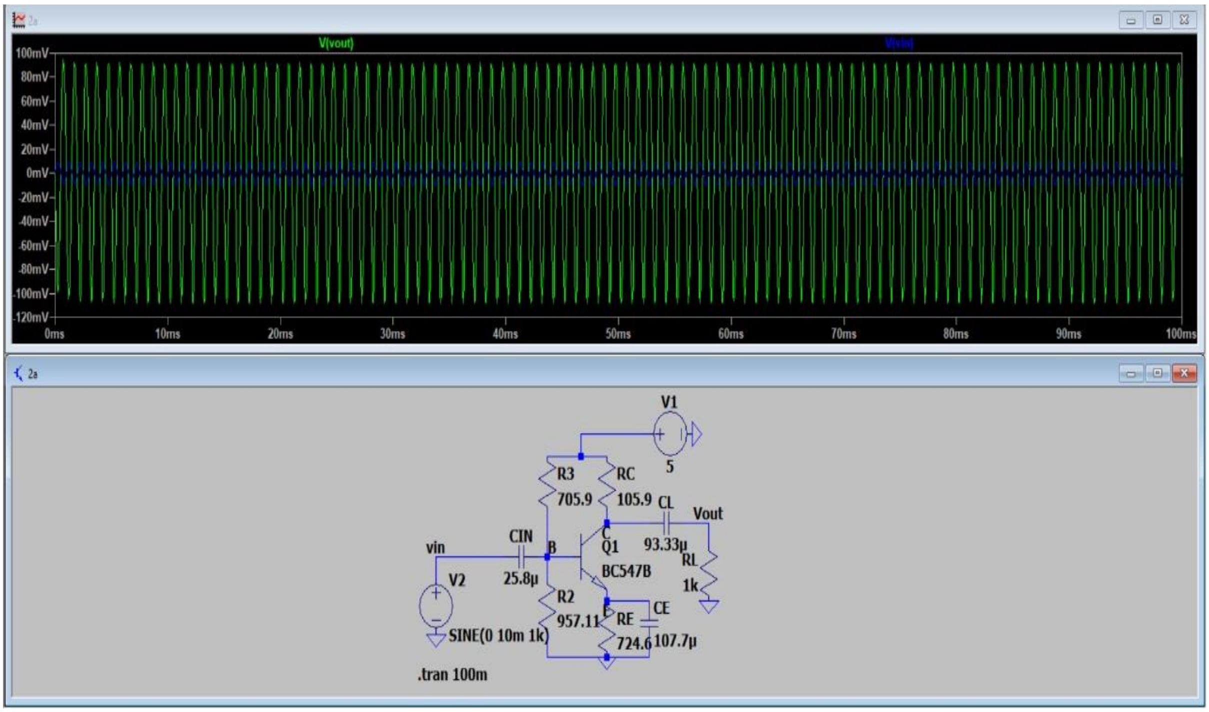
for $V_{CC} = 12V$

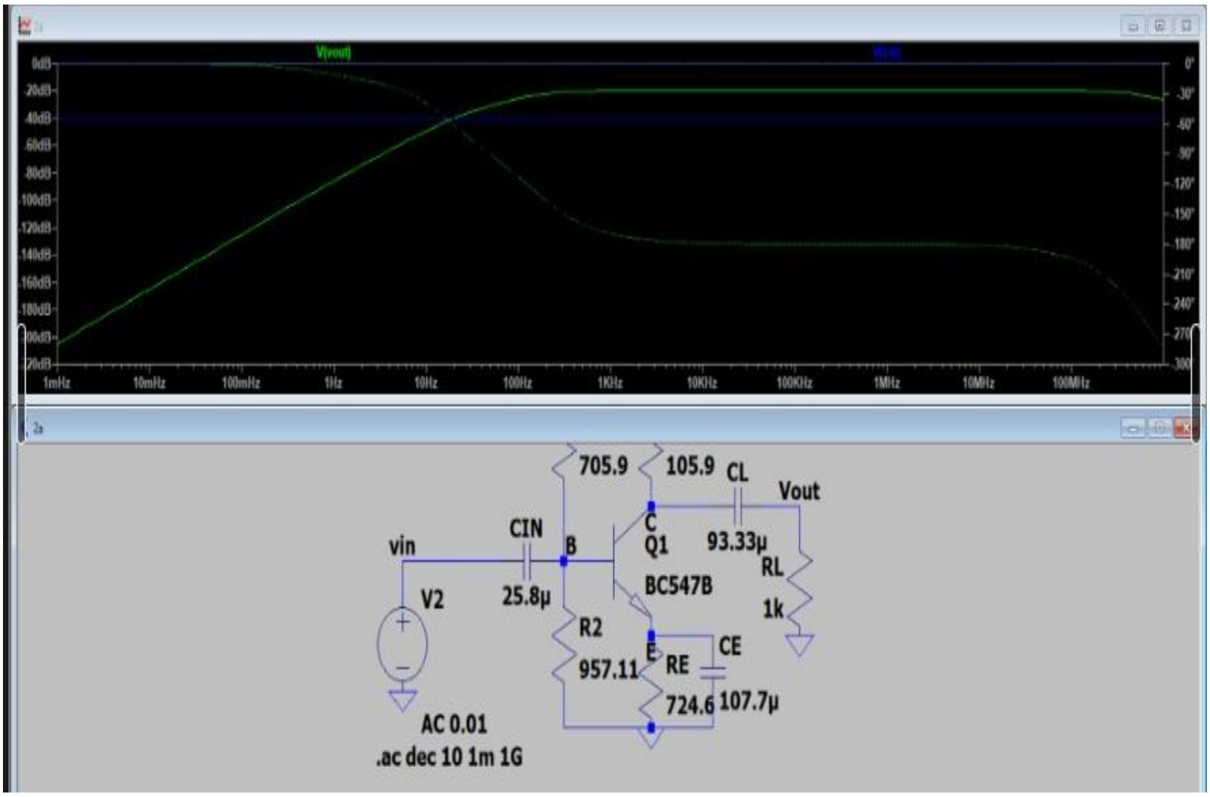
$I_{Drawn} = 0.92 \text{ mV}$

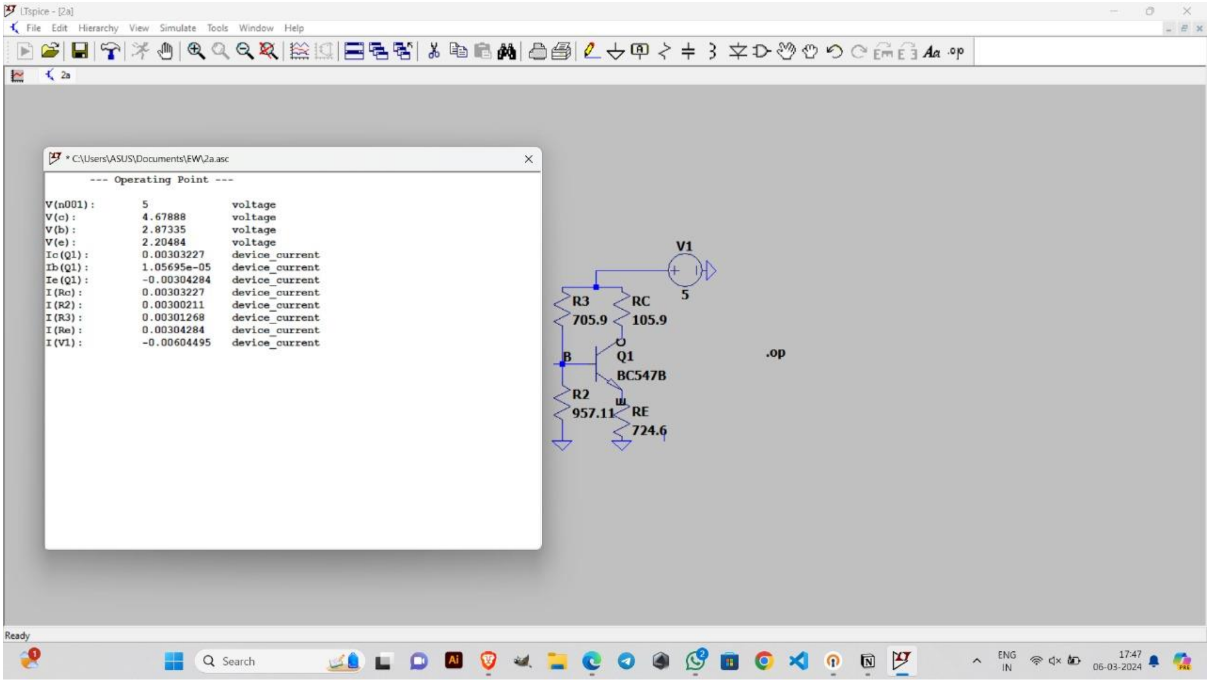
$P_{12V} = 12 \times 0.92 \text{ mA}$

$$\boxed{P_{12V} = 11.06 \text{ m Watt}}$$

## Transient analysis:





LTspice - [2a]
File Edit Hierarchy View Simulate Tools Window Help
2a
* C:\Users\ASUS\Documents\EW\2a.asc
--- Operating Point ---
V(n001): 5 voltage
V(c): 4.67888 voltage
V(b): 2.87335 voltage
V(e): 2.20484 voltage
Ic(Q1): 0.00303227 device_current
Ib(Q1): 1.05695e-05 device_current
Ie(Q1): -0.00304284 device_current
I(Rc): 0.00303227 device_current
I(R2): 0.00300211 device_current
I(R3): 0.00301268 device_current
I(Re): 0.00304284 device_current
I(V1): -0.00604495 device_current
V1
5
R3
705.9
RC
105.9
B
Q1
BC547B
R2
957.11
RE
724.6
.op
Ready
Search
ENG
IN
17:47
06-03-2024