East West University

Post Lab Report

Course Code: EEE 102
Course Name: Electronic circuit-1

Name of the experiment: Open Ended Lab Project

Submitted to:

Md. A A Ferdous

Dept. of Electrical and Electronic Engineering

East West University

Submitted by:

Md. Srabon Islam Ramim
ID No: 2020-2-80-046

Date of Submission: 36th Septembert 2021.
Date of allocation: 17th August 2021.

OBJECTIVE: The objective of this experiment is to design an amplifier using a BJT with some given parameter.

PROBLEM STATEMENT: Designing a common emitter BJT amplifier with the given data and target as follows.

Given data:

1. Supply voltage V_{cc} = 15 V
2. Transistor has Beta = 100
3. Load resistance R_L = 2k
4. Input signal V_{in} = 50m*V* (peak to peak) at 10kHz.

Target to achieve:

1. Input resistance R_i >= 2k
2. Voltage gain A_v = < -50 (V/V)
3. Output resistance R_0 <= 4k

Circuit diagram:

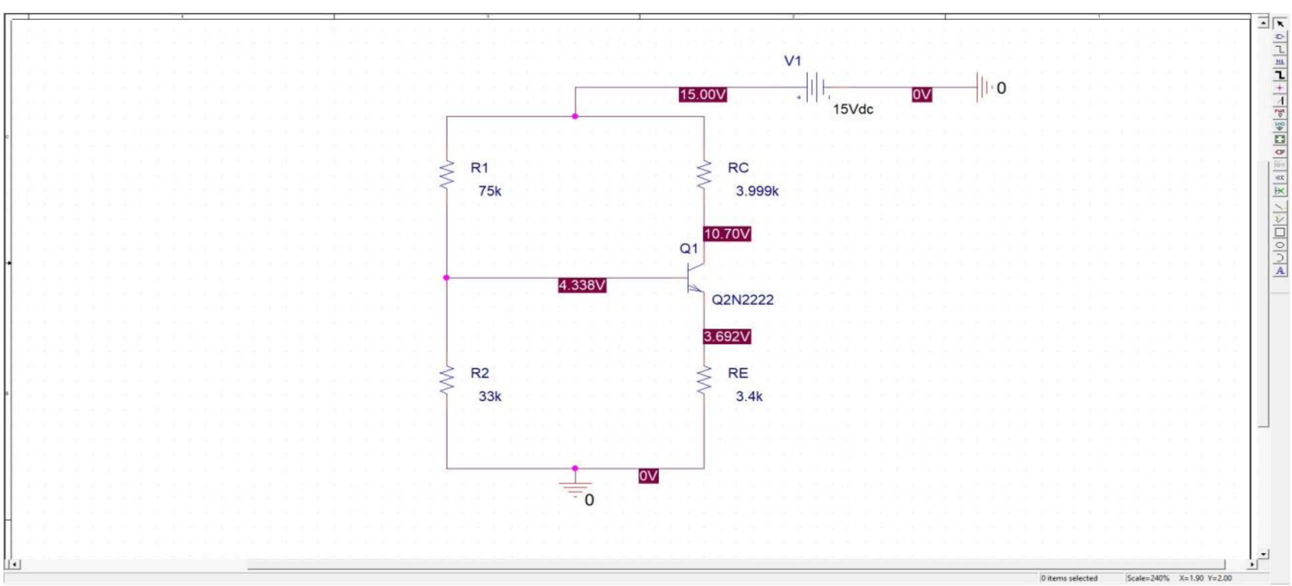


Fig-1: Circuit diagram for DC biasing.

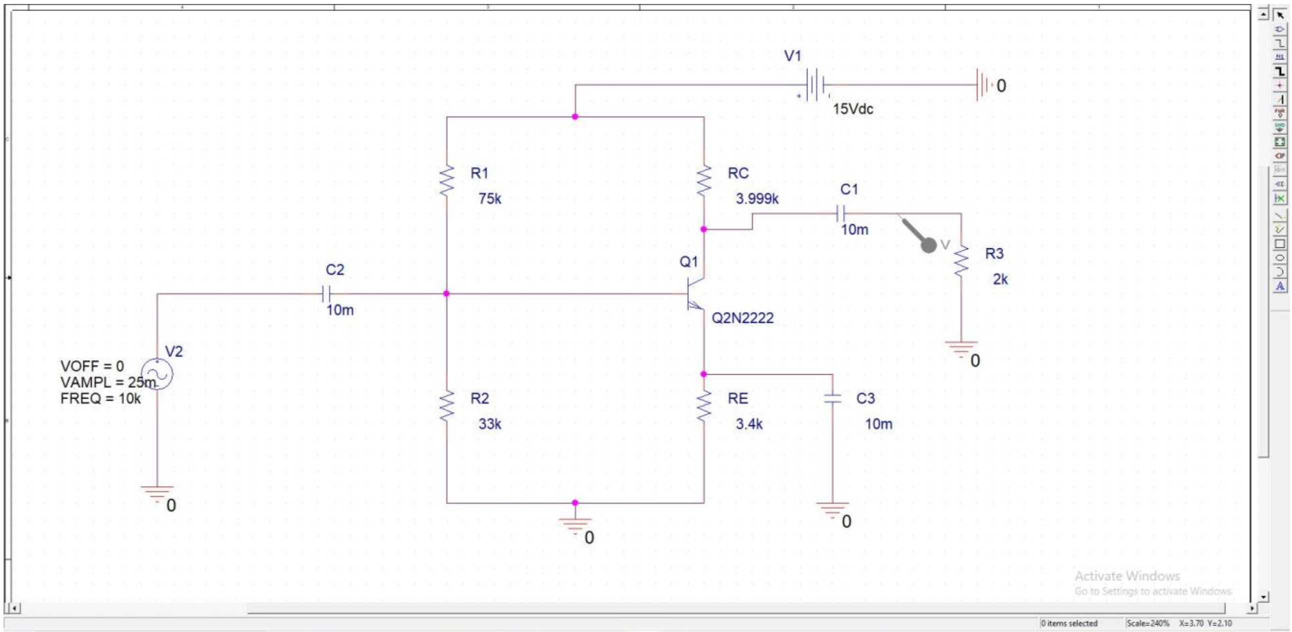


Fig-2: Circuit diagram showing amplifier circuit.

DETAILED STEPS AND CALCULATION OF THE DESIGN:

Step 1: Draw the small signal equivalent circuit to assume the values of resistors and we get $V_{be} = V_{in}$

Step 2: Then we wrote node equation at V_0, assumeing R_C<= 4k. I have assumed R_c= 3.999k. since $V_{be} = V_{in}$, I am using voltage gain -60 V/V to find other resistors value.

Step 3: After calculating the equation we get the value of g_m. As we found g_m, now we can get I_c, I_B, and I_E.

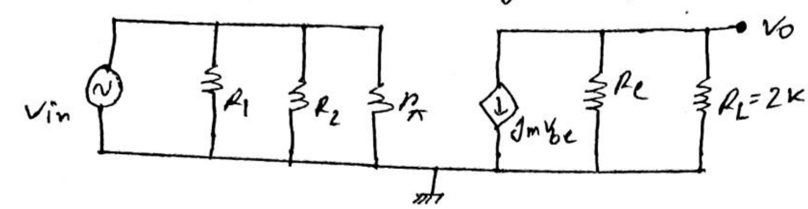
Step 4: Now R_Π= ß/gm, and following the design rule we get V_{CE} from $V_{CE} = V_{cc}/2$. Now we can calculate V_C, V_B and V_E. As we found V_E we can also calculate R_E.

Step5: As we have R_E, we can get R_2 and also can get the current across the R_2.

Step 6: Now we have to calculate I_{R1}. After having the value of I_{R1}, we can calculate R_1.

Step7: Now, we can get R_{in} as we have R_1, R_2 and R_Π.
Step 8: For get V_{CE}=7.2V the value of R_1, R_2, R_C, R_E, has been changed latter.

To get gain 60, a small signall equavalent circuit,



here,

$V_{be} = V_{in}$

If we wrote node equation at, V_o

$V_o/2 + V_o/R_c + g_m v_{be} = 0$

$\Rightarrow V_o/V_{in} \left(1/2 + 1/R_c \right) = -g_m$

$\Rightarrow -60/2 + \left(-60/R_c \right) = -g_m$

$\Rightarrow 30 + 15.037 = g_m$

$\Rightarrow g_m = 45.0$ mA/V ;

$\therefore I_c = 1.17$ mA

$I_B = 0.0117$ mA

$I_E = 1.181$ mA

Following design rule; $V_{CE} = 15/2 = 7.5$, $V_c = 7.5 + (1.17 \times 3.99) = 12.17$ V

& $V_E = 12.17 - 7.5 = 4.67$ V

$\therefore R_E = V_E/I_E = 4.67/1.181 = 3.95$ kΩ $\quad \therefore R_2 \le 39.89$ kΩ

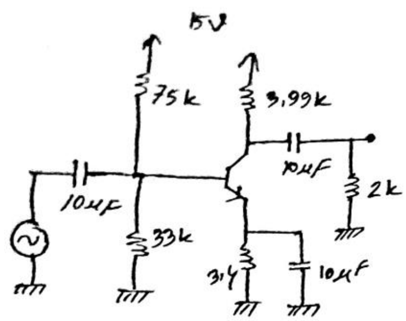
$V_B = V_E + 0.7 = 5.37 \quad \therefore I_{R_2} = 0.134$ mA

$\therefore R_1 = \dfrac{15 - 5.37}{0.145}$ $\quad I_{R_1} = 0.134 + 0.0117$

$= 0.145$ mA

$= 66.41$ kΩ

Fig-3: Assumption for R_1, R_2, R_C, R_E.



Node equation at Base

$$V_B/R_2 + \frac{V_B - V_{cc}}{R_1} + I_B = 0$$

$$\Rightarrow V_B\left(1/R_2 + 1/R_1\right) = V_{cc}/R_1 - I_B$$

$$\Rightarrow V_B\left(1/33 + 1/75\right) = 15/75 - I_B$$

$$\Rightarrow V_B = 4.585 - 22.91\, I_B \quad \text{——} \ (1)$$

Again, $V_E = (1+\beta) I_B R_E$

$= 343.4\, I_B$

We know,

$$V_{BE} = 0.7$$

$$\Rightarrow V_B - V_E = 0.7$$

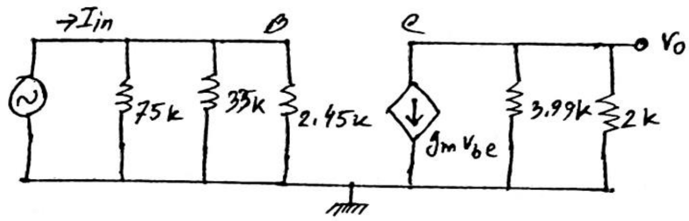
$$\Rightarrow I_B = \frac{4.583 - 0.7}{343.4 + 22.91}$$

$$= 10.58 \times 10^{-3}\, mA$$

$$\therefore I_e = 1.58\, mA$$

$$\therefore g_m = 40.7\, mA/V$$

$$r_\pi = 2.45\, k\Omega$$



Node equation at V_0

$$V_o\left(1/2 + 1/3.99\right) = -g_m V_{be}$$

$$\Rightarrow V_o/V_{in} = -\frac{40.7}{0.750} = 54.22 \ V/V$$

$$\therefore A_V = 54.22 \ V/V$$

Fig-4: Design calculation.

EQUIPMENT LIST:

1. Number of Resistors = 5
   One resistor (75k), one resistor (3.999k), one resistor (3.4k), one resistor (2k) and one resistor (33k)
2. Number of Capacitors = 3 (10uF)
3. One Q2N2222 BJT.

EXPERIMENT PROCEDURE (PSPICE):

1. Draw the dc part of the circuit. That is Q1, R1, R2, RC, RE and 15V source.
2. Use R2 = 33k. This will give a V_{CE} of nearly 7.2 V.
3. Clicked on the BJT > go to edit Model > edit instance model text and changed the value of bf= 126. It will give us BETADC = 100
4. Run the simulation with bias point calculation only. Check V_{CE}. And found approximately 7.2V.
5. Wrote the values of VC, VE, and VB.
6. Write BETADC from analysis > examine output file.
7. Now added the rest of the components.
8. Set Vin as VSIN. Set its frequency to 10kHZ, amplitude to 25mV, and VOFF to 0V.
9. Setup simulation to transient. Set final time to 400 us, step ceiling to 1 us.
10. Simulate the circuit and observed the output. It was a sine wave.
11. Measured the peak-to-peak values of the output signal and input signal.
    Observe the current through Vin and measure its peak-to-peak value.
12. Measured the peak-to-peak value of open circuit voltage. To do that, changed the R_L value to 100GΩ.
13. Measured the peak-to-peak value of short circuit current. To do that, changed R_L value to 1mΩ.

<u>From simulation:</u>

V_C = 10.70 *V*
V_E = 3.69*V*
V_B = 4.33*V*
Value of BETA_DC= 100
Peak-to-peak value of the output voltage =879.281-(-2184) =3064 m*V*
Peak-to-peak value of the input voltage = 25-(-25) =50m*V*

Voltage gain,

$$A_V = \frac{V_O}{V_{in}}$$

$$= \frac{3064}{50}$$

$= 61.28\ V/V$

Peak-to-peak value of the input current = 24.3μA

$$R_{in} = \frac{V_{in}}{I_{in}}$$

$$= \frac{(50 \times 10^{-3})}{24.3 \times 10^{-6}}$$

=2.057kΩ

Peak-to-peak value of the open circuit voltage = 8.62V
Peak-to-peak value of the Short circuit current =2377.896μA

$$R_0 = \frac{8.62}{2380.9 \times 10^{-6}}$$

= 3.65 kΩ

Table-1: Comparison between experimental and theoretical data.

	A_v(V/V)	**R_{in} (k)**	**R_0 (k)**
From calculation	**54.22**	**2.21**	**3.999**
From simulation	**61.28**	**2.05**	**3.65**

Comment: There is little bit difference between calculated values and simulation values which is avoidable.

Discussion: This experiment helps us learn designing an amplifier circuit by using a BJT with some given parameters. The experiment also helps us to build and simulate electronic circuits and perform measurements using electronic equipment.