EE4105: Project Report

A report submitted to the

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EE4105 Electronic Project

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1 Introduction

Amplifiers, such as the common emitter BJT amplifiers, are essential components in electronics, increasing the strength of input signals to produce larger output signals with the same waveform. Proper biasing of transistors is crucial for amplifier functionality, ensuring correct operation and signal integrity. With applications ranging from broadcasting to wireless technology and audio equipment, amplifiers play a fundamental role in signal processing and transmission.

1.1 Problem Statement

Here we have to implement a Common Emitter BJT Amplifier with the following specifications.

- Voltage gain = 270
- Bandwidth = 6.5 MHz

1.2 Objectives

1. Analyze the structure and operational principles of BJT amplifiers.
2. Determine component values, including resistors and capacitors, to meet specified requirements (Gain and Bandwidth).
3. Create a schematic and simulate the common emitter amplifier circuit design in Proteus.
4. Employ PCB layout using Proteus to implement the amplifier circuit and visualize it in 3D.
5. Analyze and contrast theoretical values with experimental outcomes.

1.3 Methodology

1. Researching BJT common emitter amplifier to derive component values according to specifications.
2. Choosing suitable component according to derived values and assumptions.
3. Calculating to determine component values based on specified characteristics.
4. Simulating the design using Proteus software.
5. Addressing any issues and refining the design.
6. Implementing the circuit design on a printed circuit board using Proteus software.
7. Evaluating both theoretical and practical performance of the design and summarizing important points in the report conclusion.

2 Design of the amplifier

2.1 Required components

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Unit
V_{CBO}	Collector-Base Voltage ($I_E = 0$)	50	V
V_{CEO}	Collector-Emitter Voltage ($I_B = 0$)	45	V
V_{EBO}	Emitter-Base Voltage ($I_C = 0$)	6	V
I_C	Collector Current	100	mA
I_{CM}	Collector Peak Current	200	mA
P_{tot}	Total Dissipation at $T_C = 25\ ^oC$	500	mW
T_{stg}	Storage Temperature	-65 to 150	^oC
T_j	Max. Operating Junction Temperature	150	^oC

$V_{BE(sat)}$*	Base-Emitter Saturation Voltage	$I_C = 10$ mA $I_B = 0.5$ mA $I_C = 100$ mA $I_B = 5$ mA		0.7 0.9	
$V_{BE(on)}$*	Base-Emitter On Voltage	$I_C = 2$ mA $V_{CE} = 5$ V $I_C = 10$ mA $V_{CE} = 5$ V	0.58	0.66	0.7 0.77
h_{FE}	DC Current Gain	$I_C = 2$ mA $V_{CE} = 5$ V for **BC547B** for **BC547C**	 200 420		 450 800
f_T	Transition Frequency	$I_C = 10$ mA $V_{CE} = 5$ V f = 100MHz	100		

Figure 2-1 : Datasheet of BC547BP Transistor

As seen in the above Figure 2-1 data sheet the BC547BP transistor is well selected for our amplifier circuit in order to obtain the given specifications (Gain 270, Bandwidth 6.5MHz). Therefor we used BC547BP transistor for our circuit.

From calculations we obtain the resistor and capacitors values according to the given specifications. Therefore, the standard resistors and capacitors we used for the circuit are as follows,

Resistors,

- $R_C = 1800\Omega$
- $R_E = 1k\Omega$
- $R1 = 15k\Omega$
- $R2 = 5.6k\Omega$
- $R3 = 15\Omega$

Capacitors,

- $C1 = 1\mu F$
- $C2 = 1\mu F$
- $C_E = 220\mu F$
- $C3 = 1nF$

2.2 Mathematical calculations

According to the transistor output characteristics let's take $V_{CE} = 8V$,

$$\frac{V_{CC}}{2} \geq V_{CE}$$
$$\frac{V_{CC}}{2} \geq 8V$$
$$V_{CC} \geq 12V$$

Then let's select $V_{cc} = 20\ V$

Also let's take $I_C = 4mA$,

$$r_e = \frac{26\ mV}{I_C}$$
$$r_e = \frac{26\ mV}{4\ mA}$$
$$r_e = 6.5\ \Omega$$

$$\text{Gain} = \frac{R_C}{r_e}$$
$$270 = \frac{R_C}{6.5\Omega}$$
$$R_C = 1755\ \Omega$$

Using Kirchhoff's voltage law,

$$V_{CC} = I_C R_C + I_E R_E + V_{CE}$$

When $V_{CE} = 0$,

$$20\ V = 4\times10^{-3}\times1755 + 4\times10^{-3}\times R_E$$

(Assume that $I_C = I_E$ as I_B is really small)

$$R_E = 1245\ \Omega$$

$$V_E = I_E R_E$$
$$= 4\times10^{-3}\ A\times 1245\Omega$$
$$= 4.98\ V$$

$$V_B = 0.7V + V_E$$

(Bias voltage 0.7V for Si transistor)

$$V_B = 0.7\ V + 4.98\ V$$
$$V_B = 5.68\ V$$

Since I_B is small,

$$\frac{R_1}{R_1+R_2} \times V_{CC} = V_B$$

$$\frac{R_1}{R_1+R_2} \times 20\,V = 5.68$$

$$5.68R_1 = 14.32R_2$$

Let's take R1= 14.32kΩ and R2 = 5.68kΩ

Let's calculate β value,

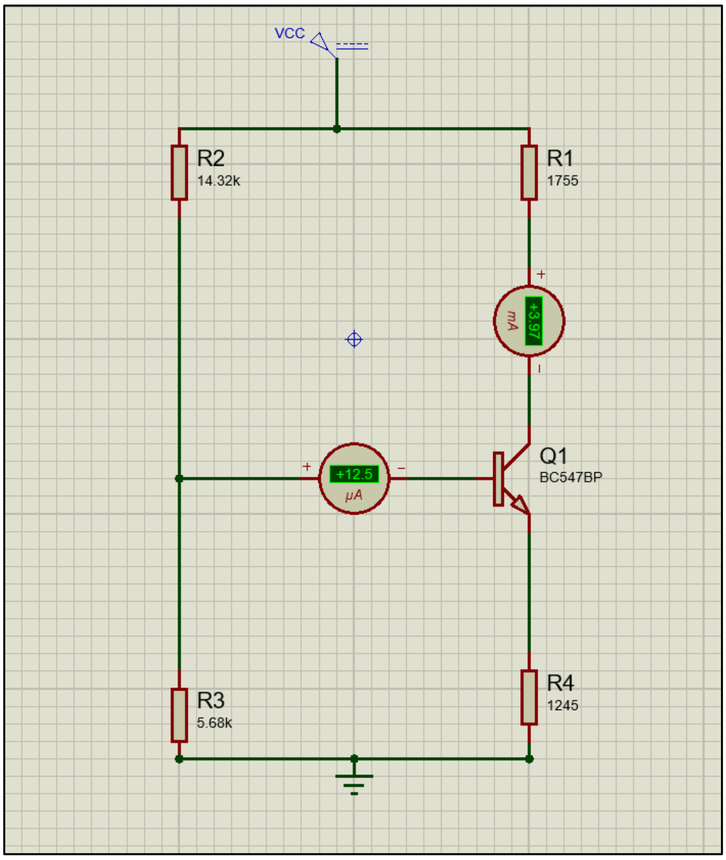

Figure 2-2 : Calculating beta value using proteus schematic

Using the above I_C and I_B values we can calculate the β value,

$$\beta = \frac{I_C}{I_E}$$

$$\beta = \frac{3.97 \times 10^{-3}}{12.5 \times 10^{-6}}$$

$$\beta = 317.6$$

$$R_{eq1} = R_1//R_2//\beta r_e$$

$$R_{eq1} = 1.37\ k\Omega$$

Assume F_L = 100Hz and F_H = 6.5001MHz

$$C_1 = \frac{1}{2\pi f R_{eq1}}$$

$$C_1 = \frac{1}{2\pi \times 100 \times 1.37 \times 10^3}$$

$$C_1 = 1.16\ \mu F$$

$$R_{eq2} = R_E // r_e$$

$$R_{eq2} = 6.466\ \Omega$$

$$C_E = \frac{1}{2\pi f R_c}$$

$$C_E = \frac{1}{2\pi \times 100 \times 6.466}$$

$$C_E = 246.14\ \mu F$$

$$R_{eq3} = R_c = 1755\ \Omega$$

$$C_2 = \frac{1}{2\pi f R_c}$$

$$C_2 = \frac{1}{2\pi \times 100 \times 1755}$$

$$C_2 = 0.907\ \mu F$$

Let's calculate the low pass filter values,

$$C_{LPF} = 1nF$$

$$R_{LPF} = \frac{1}{2\pi f C_{LPF}}$$

$$R_{LPF} = \frac{1}{2\pi \times 6.5 \times 10^6 \times 1 \times 10^{-9}}$$

$$R_{LPF} = 24.485\ \Omega$$

3 Implementation of the circuit

3.1 Captures of Schematic

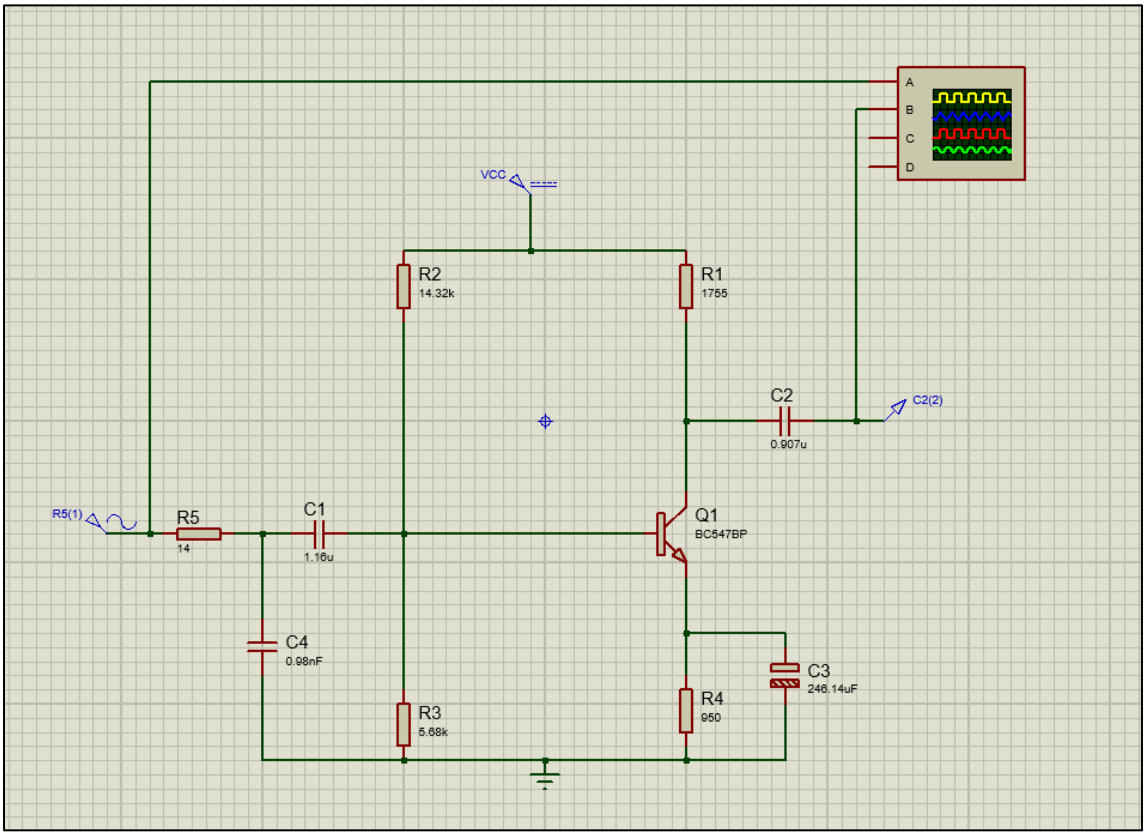

Figure 3-1 : Proteus schematic design of BJT amplifier

3.2 PCB Layout Design

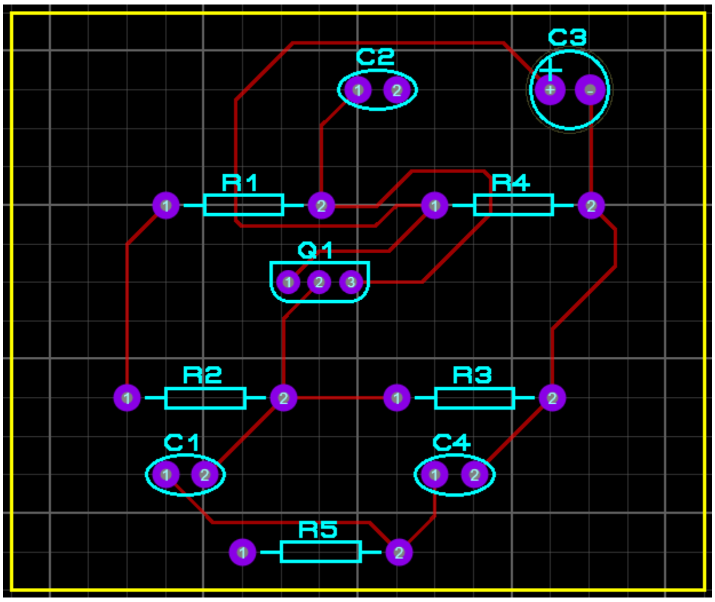

Figure 3-2 : PCB layout of design

3.3 3D View of the Circuit

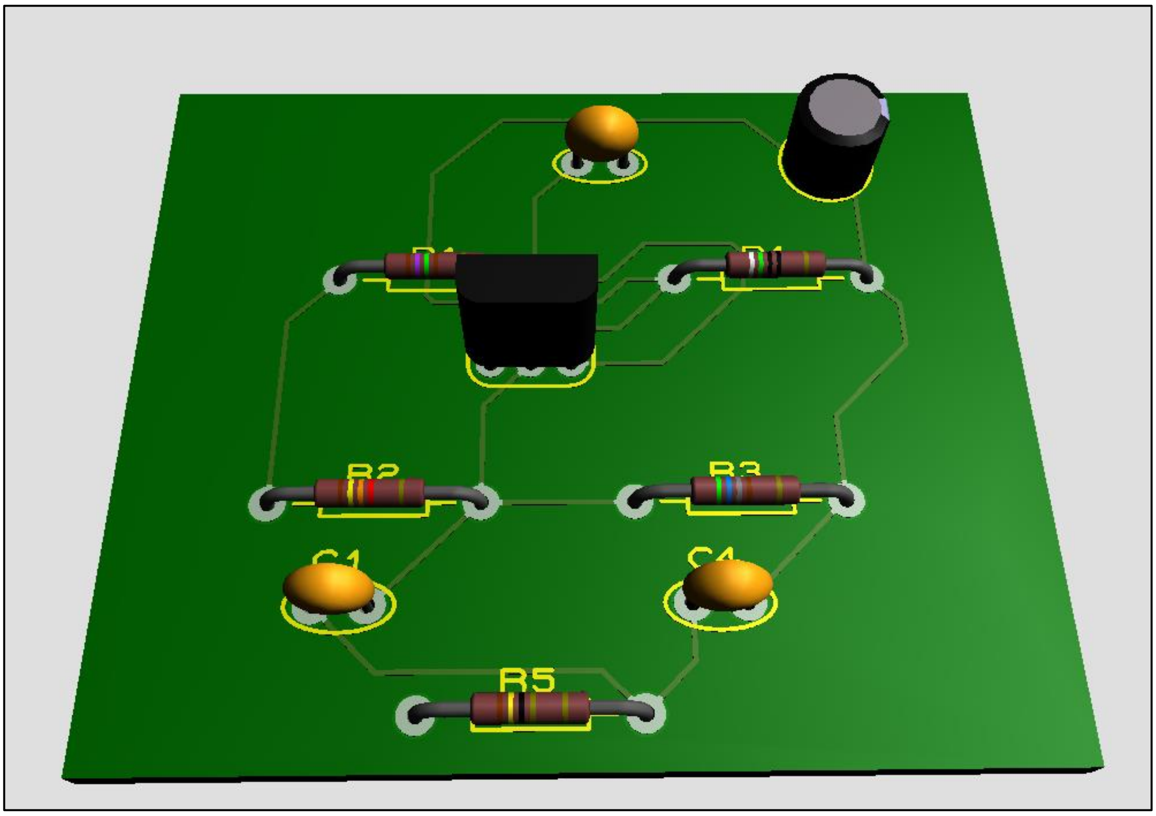

Figure 3-3 : 3D view of design amplifier

3.4 Practically implemented circuit

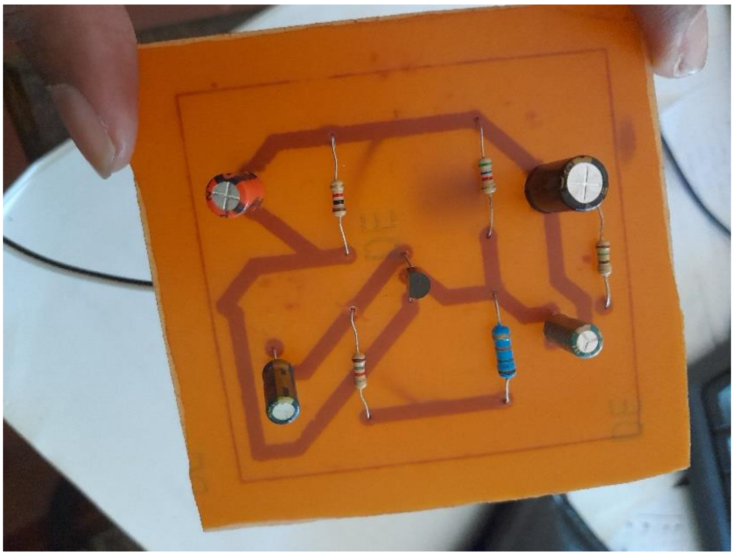

Figure 3-4 : Top View of the Implemented PCB

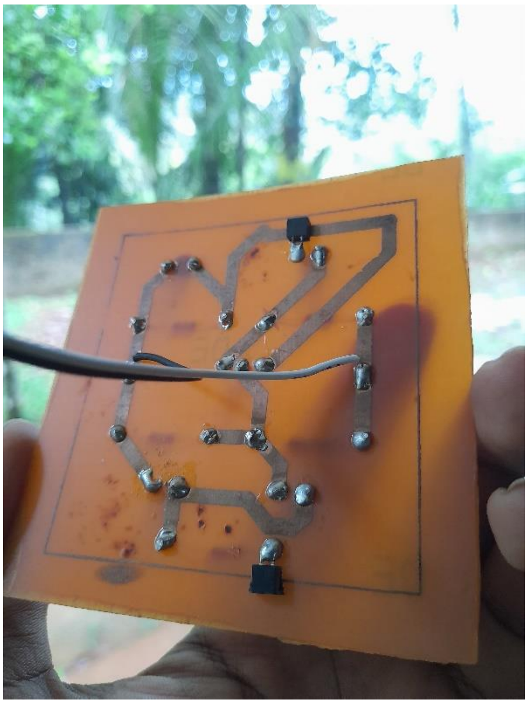

Figure 3-5 : Bottom View of the Implemented PCB

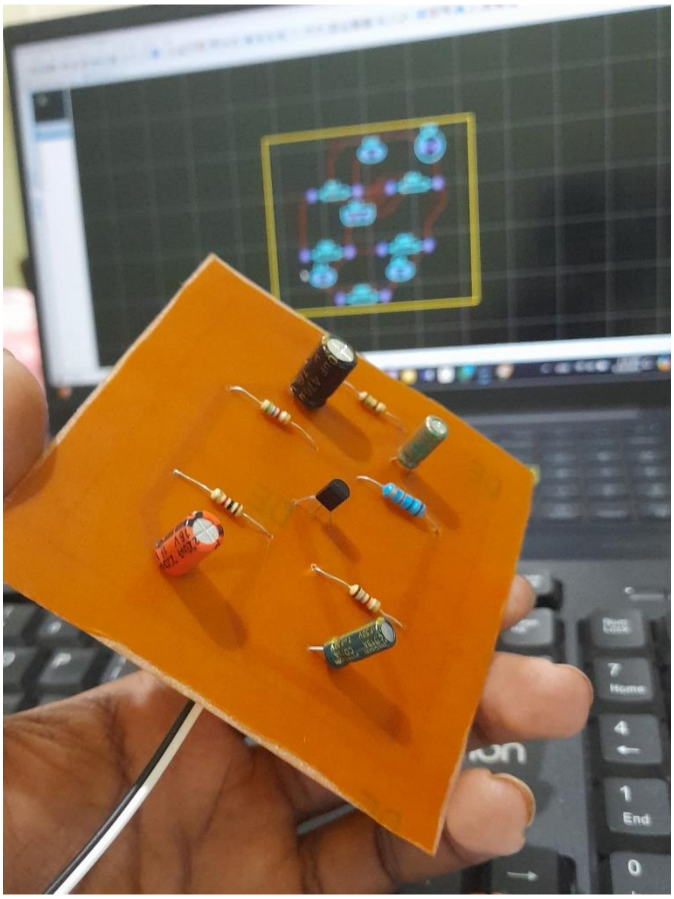

Figure 3-6 : PCB with all components

4 Results

4.1 Proteus simulation results

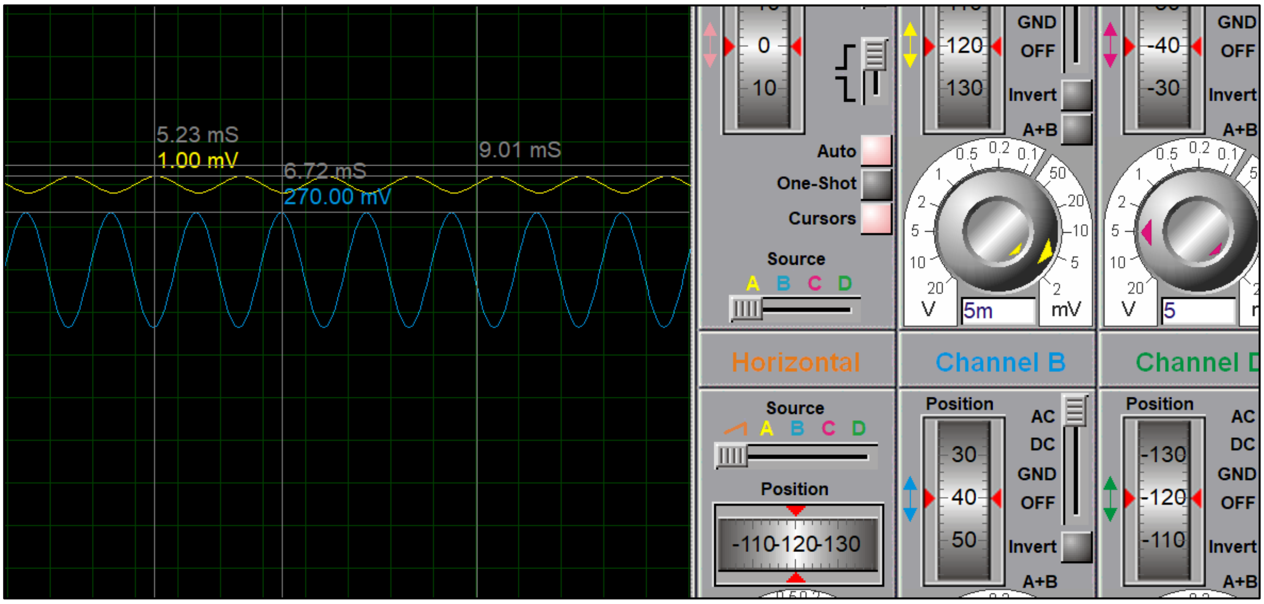

Figure 4-1 : Oscilloscope Output in Proteus

$$V_{IN} = 1mV$$

$$V_{out} = 270mV$$

$$Gain = \frac{V_{out}}{V_{IN}}$$

$$Gain = \frac{270mV}{1mV} = 270$$

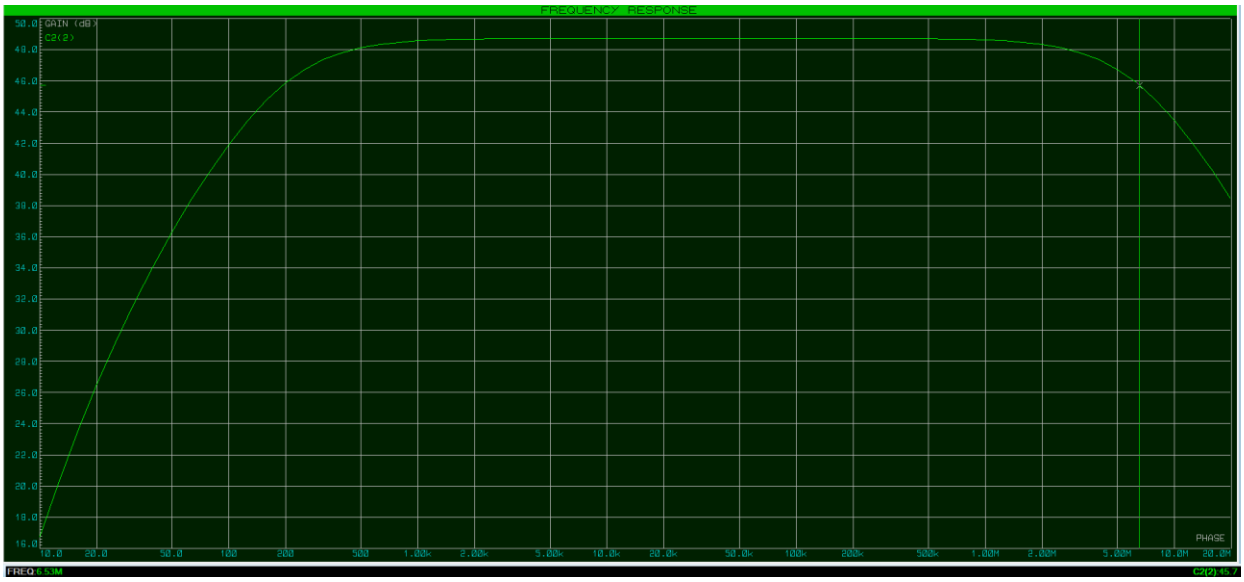

Figure 4-2 : Frequency Response for the Final Circuit

$$Pass\ Band\ Gain = 48.7$$

$$Low\ Cutoff\ Frequency = 45.7\ at\ 192Hz$$

$$High\ Cutoff\ Frequency = 45.7\ at\ 6.53MHz$$

$$Bandwidth\ of\ the\ Amplifier = 6.53MHz - 192Hz$$

$$Bandwidth\ of\ the\ Amplifier = 6.53MHz$$

5 Discussion

In the theoretical values it gives the gain as 48.63dB value, but in the proteus simulation it gives the gain as 48.7dB. And also, the bandwidth of the amplifier also we couldn’t be able to obtain the exact value. Main reason might be the deviation of the values could be the calculated resistors and capacitors values are not compatible with the standard resistors and capacitors values. And also, we did the testing under the normal conditions, but the transistors are properly working on the special conditions as given in the data sheet. Those may be some of the result for the deviation of the gain and bandwidth values.

When we compare the theoretical values with experimental values , we can notice that there is a considerable difference with expected and observed values as we had to use approximated valued capacitors and resistors for our PCB.