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List of Attributes:

Vdc	DC supply
R	Resistor
C	Capacitor
DC	Direct Current
AC	Alternating Current
DC-Sweep	Variation of a DC parameter
AC-Sweep	Variation of a AC parameter
RL	Load Resistor
Req	Equivalent Resistances
B	Beta

Introduction:

In this assignment, it is needed to study different types of amplification circuits and compare their different parameters. Application of these circuits will be discussed.

Then, a common emitter configuration based amplifier will be designed using the given parameters. Gain at the output will be observed. Then, another stage will be added for improving the output. Two circuits will be connected with the capacitor.

Effect of addition of capacitor in parallel with RE will be observed. At the end, the circuit will be analyzed using the given comments.

Objective:

The aim of the assignment is to demonstrate that you can design and simulate transistor amplifier circuits. You are required to design and evaluate (using simulation) a single stage and two stage amplifiers, for each one you must provide all design calculations along with a circuit schematic. Simulate the circuits using a suitable software like LTSpice / Multisim and provide a set of simulation results to confirm the performance of your design. It is necessary to justify the choice of components for your design and show that you can assess the quality of your design in terms of efficiency and reliability.

Theory:

An amplifier is an electrical circuit that boosts the voltage, current, or power of a low input. Amplification is the process of enhancing the intensity of a short pulse.

The common emitter amplifier is a voltage amplifier that consists of three basic single-stage bipolar junction transistors. The base terminal provides the amplifier's intake, the collector terminal provides the output, and the emitter terminal is shared by both ends. The typical emitter amplifier's basic symbol is displayed below.

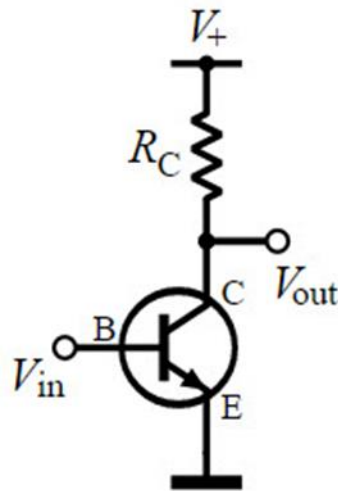


Figure 1: CE Amplifiers

The forward bias across the emitter-base junction grows throughout the upper half cycles whenever a signal is put across it. This boosts the collector current by increasing the flow of electrons from the emitter to the collector through the base. As the collector current rises, the voltage across the collector load resistor R_C lowers. [1]

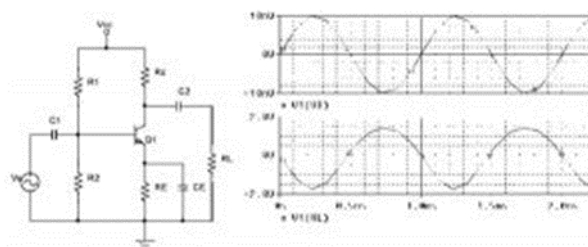


Figure 1: Operation

The forward bias voltage across the emitter-base junction is reduced by the negative half. The collector current in the whole collector resistor R_C reduces as the collector-base voltage lowers. As a result, the collector resistor appears across the amplified load resistance. Above is a diagram of the typical emitter power amplifier. [2]

Working of Common Emitter Amplifier:

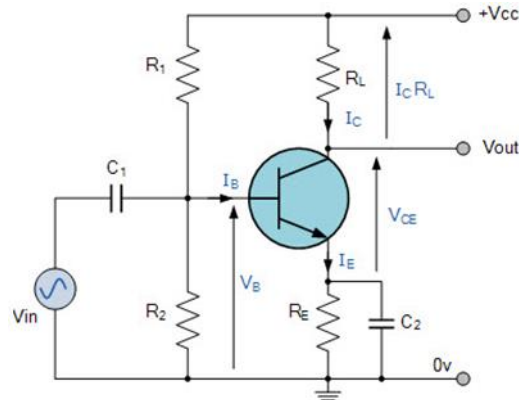


Figure 3: Common Emitter Amplifier Circuit

The common emitter amplifier circuit is shown in the circuit diagram below, and it includes voltage divider biasing, which is utilized to deliver the base bias voltage as needed. A potential divider with two resistors is linked in such a way that the midway is utilized to supply base bias voltage in the voltage divider biasing.

In a typical emitter amplifier, there are several sorts of electrical parts. The forward bias is controlled by the R_1 resistor, the growth of bias is controlled by the R_2 resistor, and the load resistance is controlled by the R_L resistor. Thermal stability is provided by the R_E resistor. The C_1 capacitor, also known as the coupling capacitor, is used to isolate the AC signals from the DC biasing voltage.

The biased vs boost common emitter amplifier transistor properties are shown in the diagram. When the R_2 resistor is increased, the forward bias increases as well, and R_1 and bias are inversely related. A tiny base current flows when an alternating current is delivered to the base of the transistor in the common emitter amplifier circuit. As a result, the RC resistance allows a huge quantity of current to pass through the collector. As a result, the collector circuit has a large amount of current, which amplifies the weak signal, making ordinary emitter transistors operate as amplifiers. [3]

Apparatus:

Multisim (Software only)

Procedure:

- 1) Create the given circuit of common emitter amplifier on multisim having 4 resistors only.
- 2) Use the given values in formulas to calculate the values of the resistors required.
- 3) Also, find these values of voltages the base, collector and the emitter.
- 4) Now, simulate the circuit for DC bias analysis, and compare the values of V_B , V_E , and V_C with the theoretically obtained values.
- 5) If values are close, than DC analysis is completed.
- 6) Now, connect the capacitor for AC analysis, Apply an AC input to observe the amplification at the output.
- 7) Output will be observed using transient analysis.
- 8) To find AC frequency response, carry output AC sweep analysis. Both magnitude and phase plots will be obtained.
- 9) Now, create similar circuit and cascade them to increase the gain.
- 10) Observe the responses to do the analysis.

Results/Tasks:

Task 1:

Applications and basic comparison is given below: [4]

The three different kinds of transistor configurations are:

i. Common base transistor configuration:

It is used as Pre-amplifiers in the microphone circuit. It is used in Used for providing high output impedance in UHF and VHF amplifiers.

ii. Common emitter transistor configuration:

It is used in Audio Amplifiers It is used in Microphones, RADIO, and Music Players It is used in the Frequency generation circuit to increase the strength of the input signal.

iii. Common collector transistor configuration

It is used for impedance matching. It is used for driving heavy loads because it provides high current gain.

Rest of the parameters are given below:

Basic circuit	Common emitter	Common collector	Common base
Voltage gain	high	less than unity	high, same as CE
Current gain	high	high	less than unity
Power gain	high	moderate	moderate
Phase inversion	yes	no	no
Input impedance	moderate $\approx 1\text{ k}$	highest $\approx 300\text{ k}$	low $\approx 50\Omega$
Output impedance	moderate $\approx 50\text{ k}$	low $\approx 300\Omega$	highest $\approx 1\text{ Meg}$

Figure 2: Comparison

Task 2 :

Design:

$R_L = 600 \text{ ohm}$

$V_{CC} = 10\text{v}$

Gain=8

Transistor Type: 2n2222 or BC109 (NPN) [5]

$V_C = v_{cc}/2$

$V_C = 10/2 = 5\text{v}$

$V_C = I_C * R_L$

$I_C = V_C / R_L = 5/600 = 8.333\text{mA}$

Since, V_E is 10 to 15% of V_{CC}

$V_E = 0.15 * V_{CC} = 1.5\text{v}$

$R_E = V_E / I_E = 1.5/8.333\text{m} = 180 \text{ ohm (approx)}$

Let $\beta = 143$

$I_C = \beta * I_B$

$I_B = I_C / \beta$

$= 8.333\text{m} / 143 = 58.27\text{uA}$

$V_B = V_E + 0.7$

$= 1.5 + 0.7$

$= 2.2\text{v}$

$I_{R1R2} = 10 * I_B = 582.7\text{uA}$

For value of R_{1yy}

$R_1 = (V_{CC} - V_B) / (10 * I_B) = (10 - 2.2) / (10 * 58.27\text{u})$

$R_1 = 13.385\text{k ohm}$

$R_2 = V_B / (10 * I_B)$

$= 2.2 / (10 * 58.27\text{uA})$

$R2=3.775\text{k ohm}$

Function of Components:

Two resistors are used at the input base terminal for dividing the input voltage.

Load is connected at the terminal.

One capacitor will be used at the input for AC coupling. [6]

One DC blocking capacitor is used at the emitter in parallel with R_E .

Multisim Circuit:

The following circuit is made in multisim for dc bias analysis:

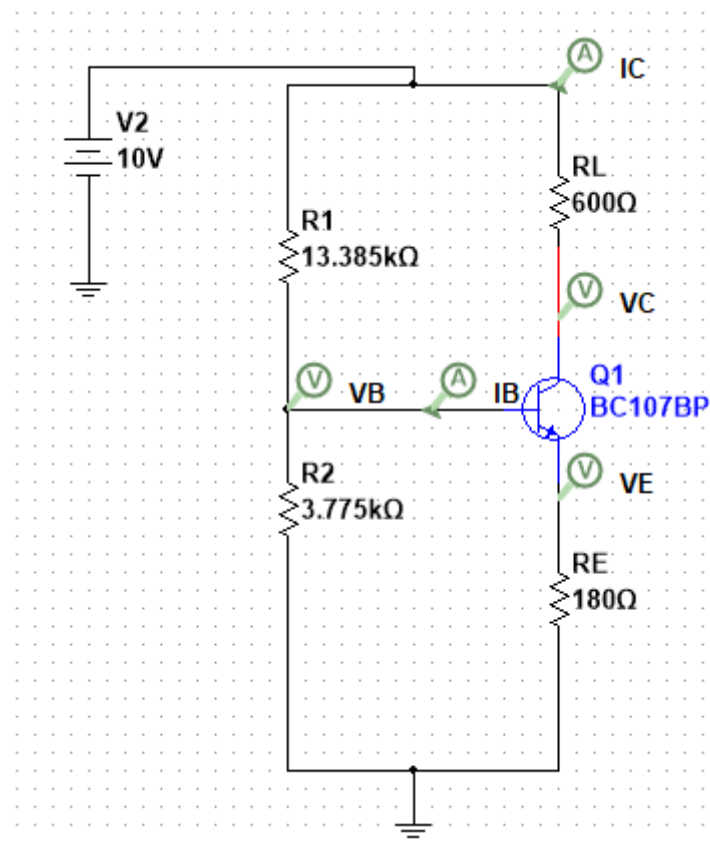


Figure 3: Multisim Circuit

Results of DC analysis:

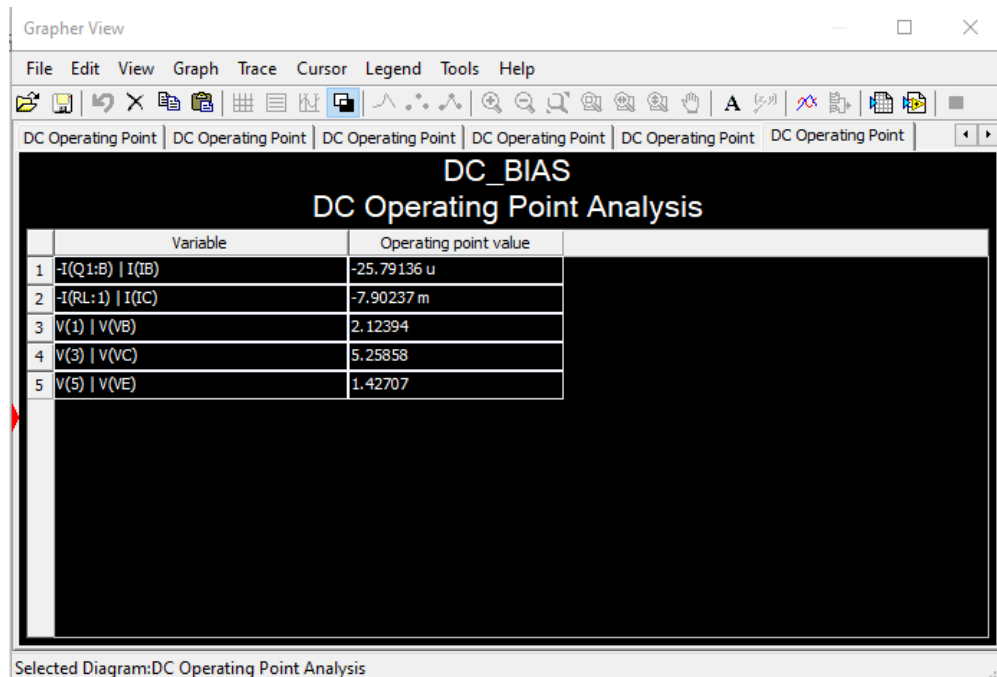


Figure 4: DC bias

Observing the dynamic range of the Circuit:

For this an AC source is needed.

Let $C1=C2=5\mu F$

Phase Plot of the system is given below:

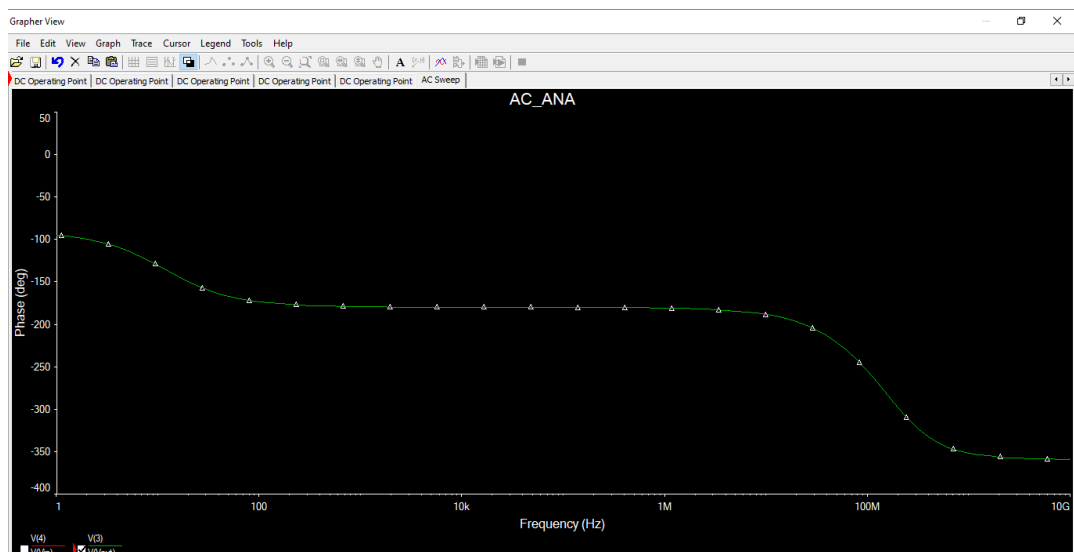


Figure 5: Phase Plot

Magnitude plot of the system is give below:

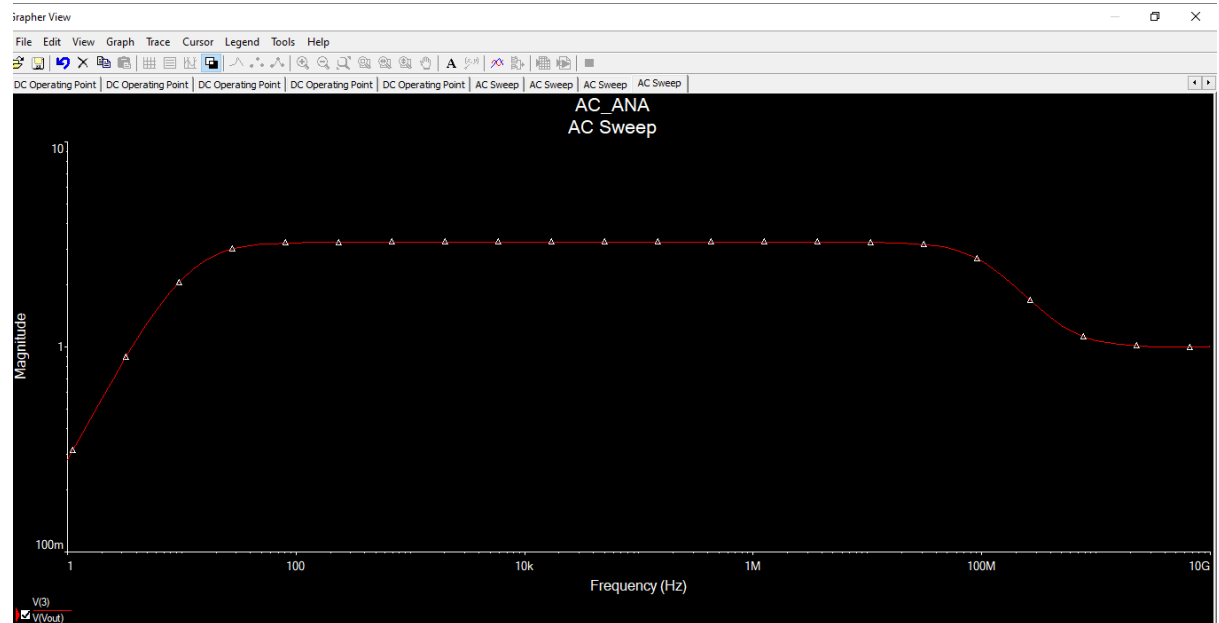


Figure 6: Magnitude Plot

AC analysis:

Output Voltage without Capacitor:

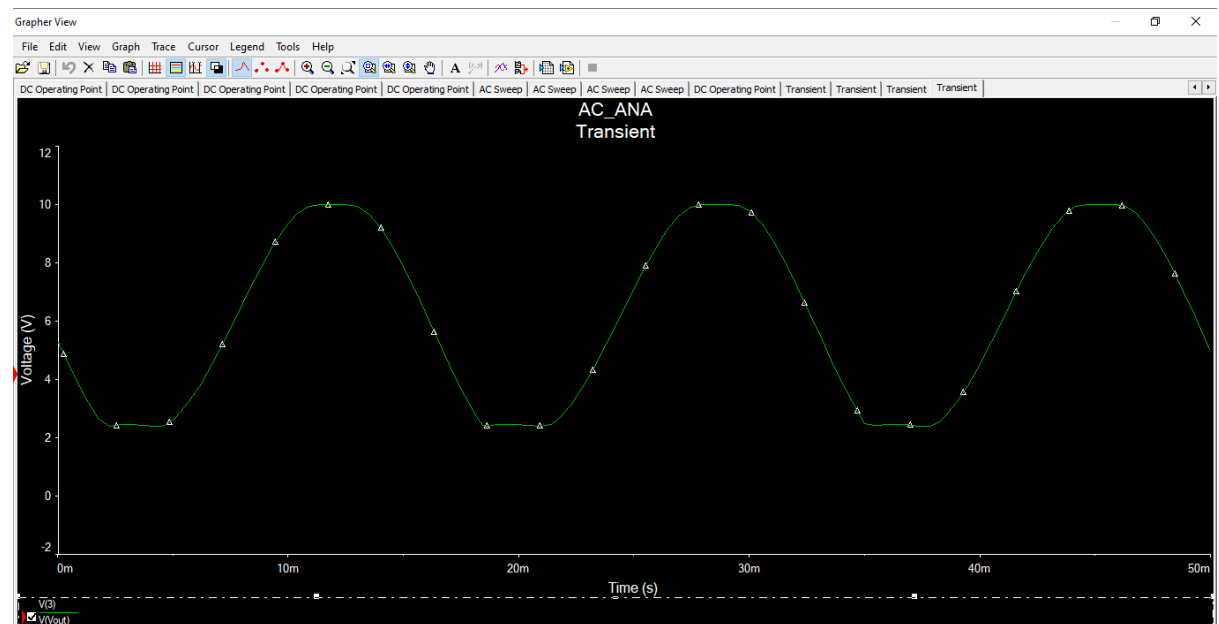


Figure 7: Amplified Output

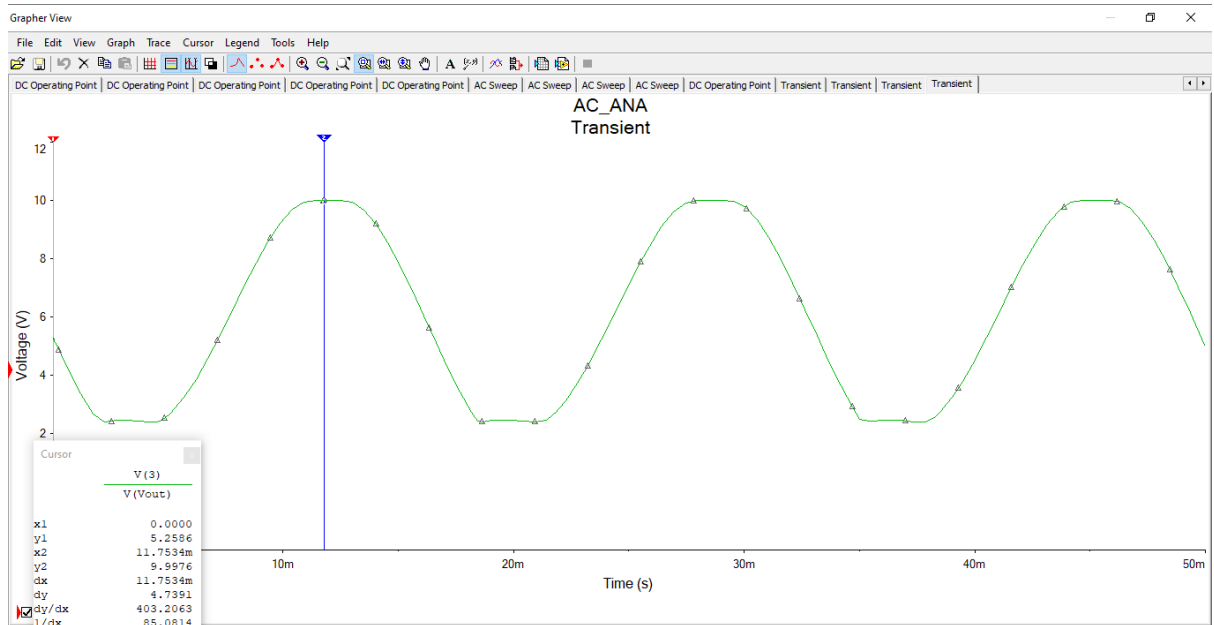


Figure 8: Output Response

After connecting the capacitor at the emitter, we have the following circuit:

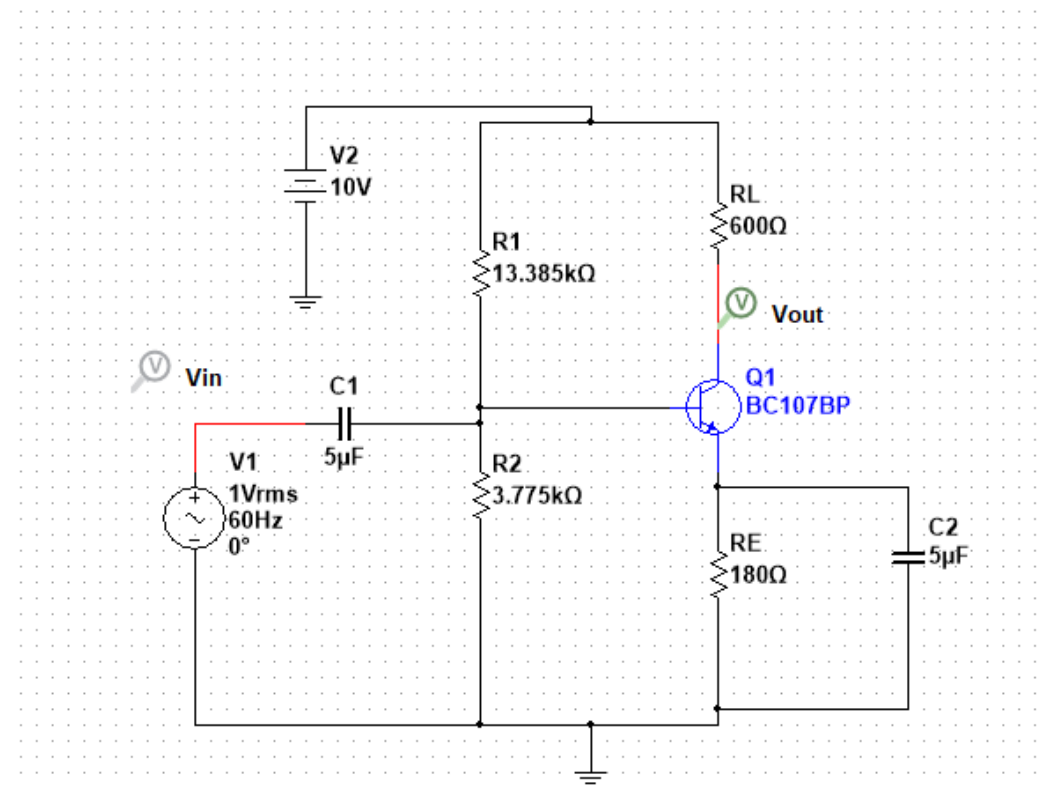


Figure 9: Modified Circuit

Since $RE' = RE \parallel XC \rightarrow$ Now, gain will more due to lower emitter resistance.
Improved output:

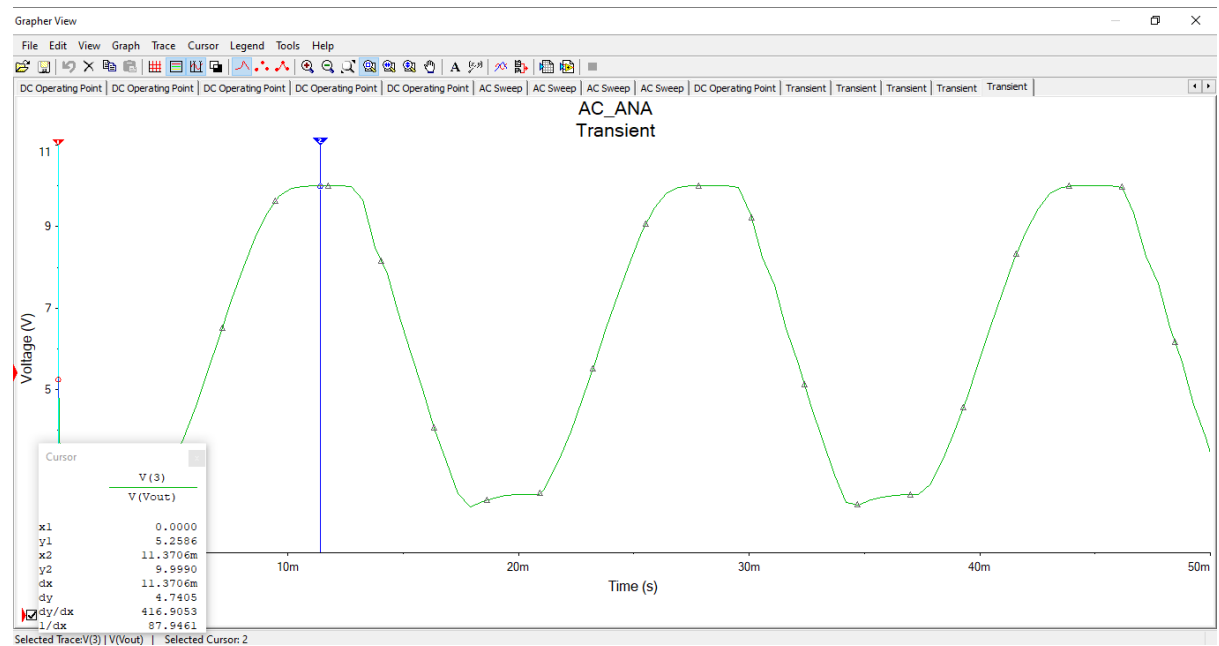


Figure 10: Improved Output

Cascading the Circuit:

Previous $G_1 = 1.41$
 $G_2 = 50/1.41 = 35.46$

$G_2 = R_L/R_E = 35.46$

If
 $R_L = 600 \text{ ohm}$
 Then
 $R_E = 16.92 \text{ ohm}$

Resultant circuit and output is given below:

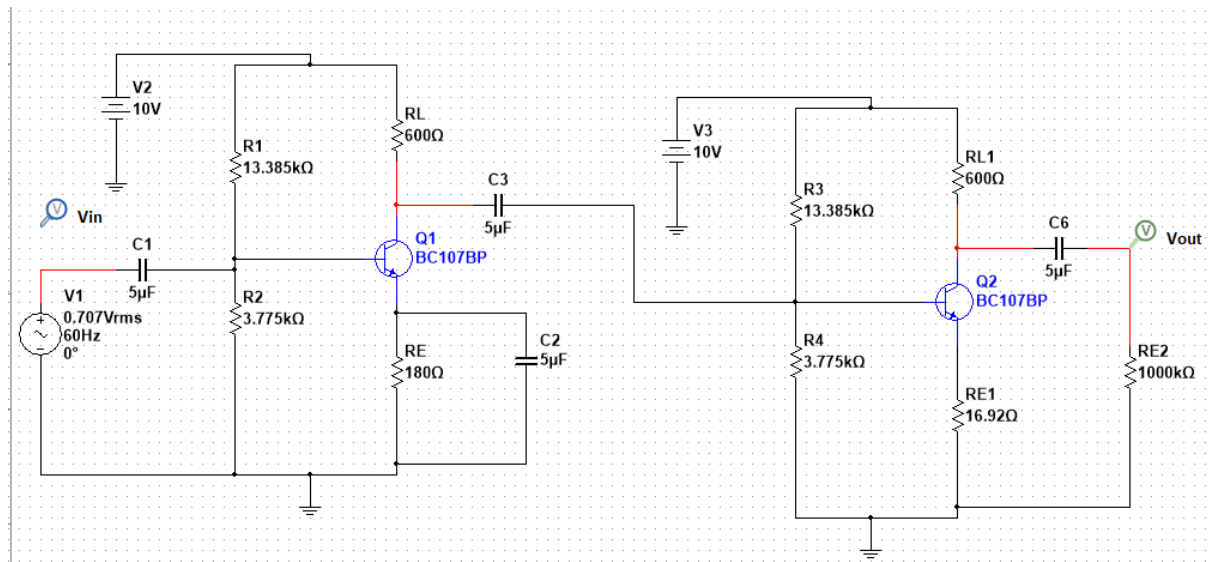


Figure 11: Cascaded Circuit

Since, circuit no longer lies in the linear region, output is non-sinusoidal.

Analysis:

At the start, DC analysis is carried out to observe the biasing status of the system:

Expected DC values are:

$V_C=5\text{v}$

$V_B=2.2\text{v}$

$V_E=1.5\text{v}$

Obtained values are:

$V_C=5\text{v}$

$V_B=2.12\text{v}$

$V_E=1.42\text{v}$

Slight discrepancy is owing to the slightly different value of beta of the model type BC107 in multisim library.

Input impedance is at the base: $R_1 \parallel R_2 = 2.94\text{k ohm}$ (by ignoring internal impedance)

Input impedance is at load: 600 ohm

A clear amplification is observed with some DC component at the output added. If a capacitor is added, it will remove that component.

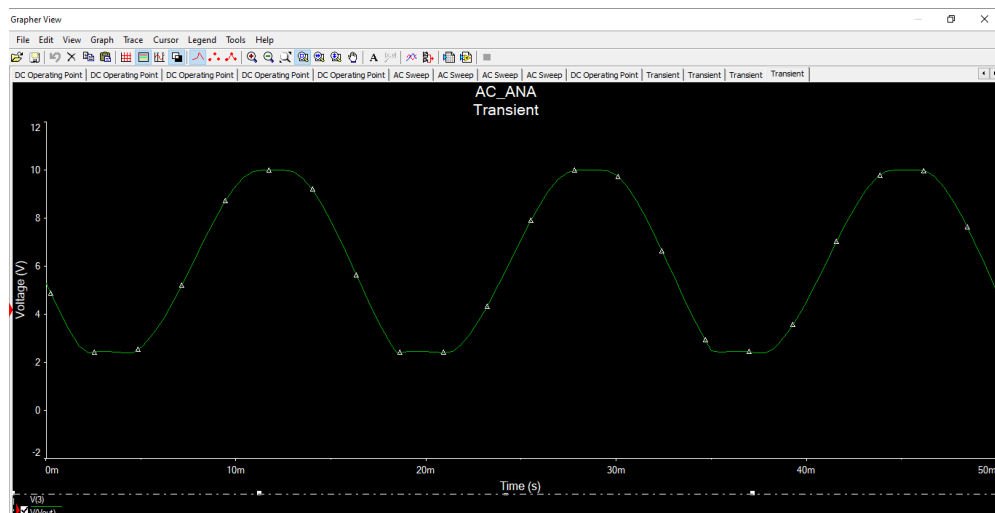


Figure 13: Transient Response

Discussion

At the start, a single stage amplifier is designed. Then the gain is increased by adding a second stage. Thus, the gain is increase to 50. Total gain is the product of two individual gains.

Thus, this circuit can be used for amplifying the signal to 50 times of its original value.

If the load resistance is comparable to the RC value, then the output is distorted. If its value is low as compared to the value of RC, the output is less affected. This is because of ecxtra load attached to the BJT. It is shown by connecting a very high impedance, output became a square wave instead of simple sinusoid.

A small resistive load can be handled by this type of amplifier without much distorting the output.

Conclusion:

Common emitter amplifier is made then cascaded with another amplifier to increase the gain. Effect of the capacitor on the output voltage is observed. AC coupling capacitor is attached to put the input. Output capacitor for blocking the DC voltage is used. Another capacitor is attached at the junction of three two emitter type BJTs to remove the DC component added to the system. Thus, system is successfully designed and output s observed according to the calculations.

References:

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