INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI

Department of Electronics & Electrical Engineering

EE102: Basic Electronics Laboratory

Expt.No. 7 & 8: Common Emitter Amplifier

Objectives:

1. To carry out an approximate DC and AC analysis of the given CE amplifier.
2. To determine the voltage gain, the "maximum undistorted peak-to-peak output voltage swing" (MUOVS) and the maximum input voltage for undistorted output.
3. To study the effect of emitter bypass capacitor on voltage gain.

Materials Required:

1. Equipment: Breadboard, Function Generator, Oscilloscope, Multi-Output Power Supply, Digital Multimeter.
2. Components: NPN type 2N2222A (One), 470Ω (One), 1kΩ (One), 2.2kΩ (One), 22kΩ (One), 100kΩ (One), 10μF (Two), 22μF (One), 1kΩ Pot (One)

Precautions and Guidelines:

1. You are expected to come to the Lab with a neat report showing all calculations regarding the Pre Lab Work.
2. You will be allowed to perform the experiment only after the instructor has checked the report.

Pre-Lab Work:

1. Carry out an approximate DC analysis by using the values given in Fig.1 and by making use of the assumptions I_{R1}, $I_{R2} >> I_B$, so that $I_{R1} \approx I_{R2}$ and $V_{BE} \approx 0.65V$. Estimate the DC quantities (quiescent values) V_B, V_E, V_C, I_E ($\approx I_C$).
2. Draw the small signal equivalent of the circuit in Fig.1 and compute the voltage gain as
   $$A_V = -(\beta.R_C)/(r_b) \approx -(R_C)/(r_e) = -(R_C.I_E)/(V_T) \approx -(R_C.I_C)/(V_T)$$
   Take $V_T \approx 25mV$ (at room temp).
3. Compute MUOVS = 2 x Min $\{V_{CC} - V_C, V_C - V_E\}$.
4. How do you decide that the + terminal of C_1 (an electrolytic capacitor) should be connected to the R_1–R_2 node and the – terminal to the source v_i? Likewise, for C_2 and C_E.

Part A: Measuring DC Quantities (Quiescent Values)

1. Before assembling the circuit, measure the actual values of the resistors by means of a Digital Multimeter (DMM). The actual values thus determined are to be used in calculating the currents.
2. Assemble the circuit, apply V_{CC} and note the following: (a) measure V_{BE} using a DMM and it should be around 0.6V ~ 0.7V indicating that BE junction is forward biased. (b) Measure V_C and check if $V_E < V_C < V_{CC}$. A value of V_C midway between V_E and V_{CC} is preferable.

3. Measure V_B, V_E, V_C and V_{CC} and determine I_B, I_E, I_C and hence β ($\beta = I_C/I_B$).
4. Compute A_V using the experimentally determined values of R_C and I_C. Use V_T=25mV.

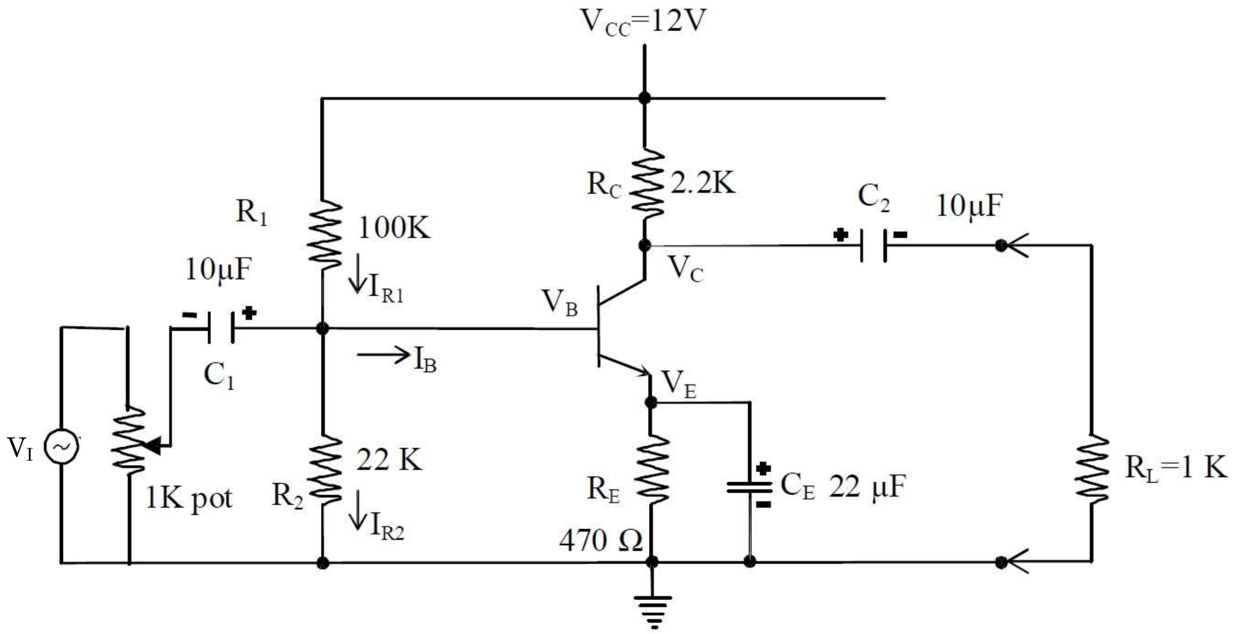

Fig.1

Part B: Voltage Gain Without Load Resistance

1. Disconnect C_2. Adjust Function Generator to get approximately 10-20mV peak-to-peak sinusoid at 1kHz (display in Channel 1 of CRO). Apply this voltage at amplifier input V_I.
2. Display the collector voltage in Channel 2 of CRO (use DC coupling). Note the 180° phase difference between the input and the output.
3. Adjust V_{I},p-p amplitude to get a convenient value for peak-to-peak collector voltage V_C,p-p (say 2V). Use appropriate vertical sensitivity (V/div). Note the corresponding V_I,p-p (mV).
4. Experimentally obtained voltage gain is therefore computed as:

$$A_V = -(V_{C,p-p})/(V_{I,p-p}).$$

Part C: Maximum Undistorted Output Voltage Swing (MUOVS)

1. Increase V_I,p-p slowly till you observe a slight flattening of V_C,p-p waveform at its peaks (either positive peaks or negative peaks). The peak-to-peak value of the output signal (just at the onset of distortion/clipping) is the MUOVS. Measure the corresponding V_I,p-p, the peak-to-peak input voltage.
2. Now increase V_I,p-p beyond this point and observe the output waveform. The sinusoid gets increasingly flattened and becomes more like a square wave (overdriving an amplifier leads to heavy distortion).

Part D: Voltage Gain With Load Resistance

1. The output of an amplifier normally drives a load resistance R_L which may represent an actual load like an ear-phone or a loudspeaker, or the input impedance of another stage of the amplifier.

2. Connect R_L (see Fig.1) to the collector through the coupling capacitor C_2 (C_2 blocks the DC voltage at the collector and allows only the AC i.e. the signal component to pass through).
3. Measure A_V with R_L connected. (you would observe a reduced Av since $R_{C,eff} = R_C || R_L$.

Part E: Effects of C_E on A_V

1. Get back to the conditions in Part A i.e. V_I at 1 kHz, its amplitude adjusted to get $V_{C,p\text{-}p} \approx 2V$.
2. Now, remove C_E (with circuit powered) and note the drastic reduction in $V_{C,p\text{-}p}$. You have to change to appropriate V/div in your CRO. Determine the gain of the CE amplifier with unbypassed R_E.
3. Compare your observation with the theoretical value
$$A_V = -\alpha R_C/(R_E+r_e) \approx -R_C/R_E.$$
4. Display and sketch $V_{I,p\text{-}p}$ and V_E waveforms. Note the amplitudes and the phase-relationship between them.
5. Display and sketch V_E and V_C. Note the amplitudes and the phase relationship. Please note that you are in DC coupling mode of the CRO. Please ensure that when you pressed the ground options in Channel 1 and Channel 2, both the horizontal traces (of the channels) are coinciding. Also ensure that the V/div of Channel 1 is equal to V/div of Channel 2.
6. Increase $V_{I,p\text{-}p}$ gradually and observe how V_E and V_C change. Continue to increase $V_{I,p\text{-}p}$ till you observe the +ve peak of V_E (almost) touching the negative peak of V_C. When this occurs, we say that the BJT has gone into saturation ($V_{CE} \approx 0$).
7. What do you observe if $V_{I,p\text{-}p}$ is increased beyond this point?

Part F: Lab Report

Prepare and submit a lab report as specified in the general instructions regarding the lab. Include the answers to the following questions in the report:

1. Why is V_C such that $V_E < V_C < V_{CC}$ a preferred value in step 2 of Part A?
2. Compare the experimentally determined values of the currents and voltages in step 3 of part A with those you obtained through approximate analysis.
3. Compare the experimentally determined value of β in step 3 of part A with the approximate value given by the Lab Instructor.
4. Compare the experimentally determined value of the voltage gain A_V in step 4 of Part B with the computed values obtained in step 4 of Part A. Also compare this value with the value estimated in the Pre Lab Work.
5. What is the utility of knowing MUOVS in the design of an amplifier?