Analog Electronic Circuits Lab (EC2.103, Spring 2024)

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Instructions:

1. Systematically record all your observations in the lab book (mandatory)
2. Save results in USB or take pictures
3. Make meaningful tables to summarize your findings and show it to the instructor(s) during the lab session only
4. Bring your calculators and DMM (if available)
5. Handle equipment carefully and report in case of any incidence
6. Enjoy your time in lab and strengthen your understanding about circuits

Experiment-5

BJT Amplifier

In this lab, a single stage Common Emitter (CE) voltage amplifier studied in lecture (shown in Fig. 1) will be characterized with DC, AC and transient measurements. Some equations are given

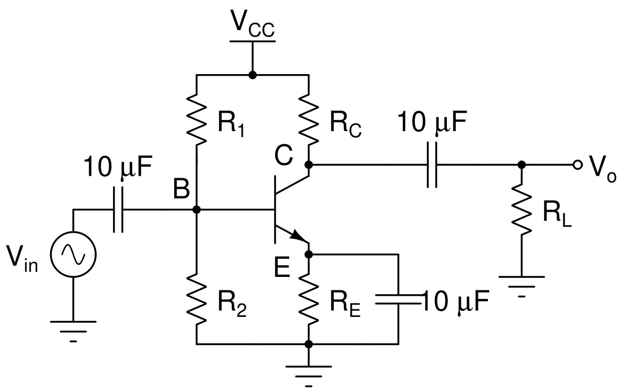

Figure 1: Single stage common emitter voltage amplifier

below for the DC analysis of the circuit.

$$V_B = \frac{R_2}{R_1 + R_2} V_{CC} \tag{1}$$

$$V_E = V_B - V_{BE} \tag{2}$$

$$V_C = V_{CC} - I_C R_C \tag{3}$$

$$I_E = \frac{V_E}{R_E} \tag{4}$$

$$I_C = \frac{\beta}{\beta + 1} I_E \tag{5}$$

$$I_B = \frac{I_E}{\beta + 1} \tag{6}$$

1. **DC analysis**
The resistors R_1 and R_2 are 5.6 kΩ and 1 kΩ, respectively, $R_L = 1\ k\Omega$ and $V_{CC} = 12$ V. Using DC signal analysis, find the values of R_C and R_E to obtain a collector current of 1.5 mA and mid-band voltage gain of 5.
(*Hint: gain =* $g_m R_o$ *and* $g_m = \frac{I_{CQ}}{V_T}$*, you may use* V_{BE} *= 0.7 V and* β *= 150*)

2. **Transient response and total harmonic distortion (THD)**
   (a) Connect the circuit as shown in Fig. 1 using transistor and resistor values obtained from previous DC analysis.
   (b) Apply a Sine wave of amplitude 25 mV and frequency 1 kHz as input and use $R_L = 1\ K\Omega$.
   (c) Measure the amplitude of output voltage (V_o) and calculate the voltage gain, A_v of the amplifier.
   (d) As shown in Table 1, measure and report amplitude of fundamental component (V_1) 2^{nd} to 5^{th} harmonics for different amplitude (V_{in}) of input signal. Report for V_{in} = {2 mV, 10 mV, 20 mV, 50 mV, 100 mV, 500 mV, 1 V} and calculate corresponding THD. (*Hint:* $THD = \frac{\sqrt{V_2^2+V_3^2+V_4^2+V_5^2}}{V_1}$*, use FFT to measure harmonics*)

V_{in}	V_1	$Harmonic\ 2\ (V_2)$	$Harmonic\ 3\ (V_3)$	$Harmonic\ 4\ (V_4)$	$Harmonic\ 5\ (V_5)$	THD

Table 1

3. **Frequency response**
   (a) For $R_L = 1\ K\Omega$ and $V_{in} = 10\ mV$, vary the frequency of input signal f_{in} ={10 Hz, 50 Hz, 100 Hz, 500 Hz, 1 kHz, 10 kHz, 100 kHz,1 MHz, 10 MHz, 20 MHz}. Report parameters shown in Table 2 and find the -3 dB frequencies f_L and f_H. Are you able to find both f_L and f_H with the equipment available in this lab? *(Hint: The highest frequency from the function generator might be less than the upper -3 dB frequency (f_H) of the amplifier.)*

f_{in}	V_{in}	V_o	$A_v = \frac{V_o}{V_{in}}$	A_v (in dB)

Table 2

   (b) Use analysis option in DSO and plot the frequency response and verify the results (A_v, f_L and f_H) with the previous part (3(a)).
   (c) Verify the measured values of f_L and f_H with hand calculations. *(Hint: f_L arises due to coupling cap at base and collector, f_H due to parasitic capacitor. $f = \frac{1}{2\pi RC}$)*
   (d) Use a capacitor load $C_L = 440\ pF$ in place of R_L and repeat the previous experiment to report A_v, f_L and f_H from the frequency response option of the DSO. Give table and plot. Do you clearly observe f_H now? What is the reason? Which node sets f_H? Verify the measured value of f_H with the calculated value.