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# Analog Electronic Circuits Lab (EC2.103, Spring 2022)

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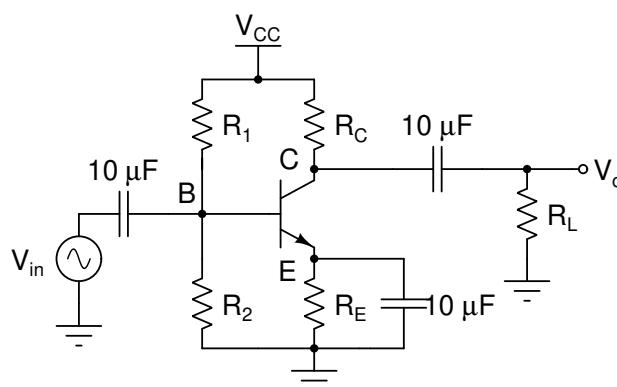
## Instructions:

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
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## 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.

$$V_B = \frac{R_2}{R_1 + R_2} V_{CC} \quad (1)$$

$$V_E = V_B - V_{BE} \quad (2)$$

$$V_C = V_{CC} - I_C R_C \quad (3)$$

$$I_E = \frac{V_E}{R_E} \quad (4)$$

$$I_C = \frac{\beta}{\beta + 1} I_E \quad (5)$$

$$I_B = \frac{I_E}{\beta + 1} \quad (6)$$

### 1. DC analysis

The resistors  $R_1$  and  $R_2$  are  $5.6\text{ k}\Omega$  and  $1\text{ k}\Omega$ , respectively,  $R_L = 1\text{ k}\Omega$  and  $V_{CC} = 12\text{ V}$ . Using DC signal analysis, find the values of  $R_C$  and  $R_E$  to obtain a collector current of  $1.5\text{ mA}$  and mid-band voltage gain of 5.

(Hint:  $\text{gain} = g_m R_o$  and  $g_m = \frac{I_{CQ}}{V_T}$ , you may use  $V_{BE} = 0.7\text{ V}$  and  $\beta = 150$ )

### 2. Transient response and total harmonic distortion (THD)

- Connect the circuit as shown in Fig. 1 using transistor and resistor values obtained from previous DC analysis.
- Apply a Sine wave of amplitude  $1\text{ V}$  and frequency  $1\text{ kHz}$  as input and use  $R_L = 1\text{ K}\Omega$ .
- Measure the amplitude of output voltage ( $V_o$ ) and calculate the voltage gain,  $A_v$  of the amplifier.
- As shown in Table 1, measure and report amplitude of  $2^{nd}$  to  $5^{th}$  harmonics for different amplitude ( $V_m$ ) of input signal. Report for  $V_m = \{10\text{ mV}, 50\text{ mV}, 100\text{ mV}, 200\text{ mV}, 400\text{ mV}, 500\text{ mV}, 800\text{ mV}, 1\text{ V}, 1.2\text{ V}, 1.4\text{ V}, 1.6\text{ V}, 1.8\text{ V}, 2\text{ V}\}$  and calculate corresponding THD. (Hint:  $THD = \frac{V_2^2 + V_3^2 + V_4^2 + V_5^2}{V_m^2}$ , use FFT to measure harmonics)

$V_m$	$V_o$	Harmonic 2 ( $V_2$ )	Harmonic 3 ( $V_3$ )	Harmonic 4 ( $V_4$ )	Harmonic 5 ( $V_5$ )	THD

Table 1

### 3. Frequency response

- For  $R_L = 1\text{ K}\Omega$  and  $V_m = 10\text{ mV}$ , vary the frequency of input signal  $f_{in} = \{10\text{ Hz}, 50\text{ Hz}, 100\text{ Hz}, 500\text{ Hz}, 1\text{ kHz}, 10\text{ kHz}, 100\text{ kHz}, 1\text{ MHz}, 10\text{ MHz}, 20\text{ MHz}\}$ . 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.)

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

Table 2

- 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)).
- 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.  $f = \frac{1}{2\pi RC}$ )
- Use a capacitor load  $C_L = 440\text{ pF}$  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.