Date:

EXPERIMENT 1
SINGLE-STAGE COMMON-EMITTER AMPLIFIER

Objectives

- To carry out the DC Analysis of BJT experimentally.
- To experimentally compute the gain of the CE Amplifier.
- To experimentally test the effect of the emitter bypass capacitor on the amplifier's gain.
- To support the experimental results with hand analysis calculations and ORCAD simulation.

Background

Signal amplification is the process of producing an exact replica of an input signal but with larger amplitude. The need for amplification arises because transducers provide signals that are said to be weak. Such signals are too small for reliable processing since processing is much easier if the signal amplitude is larger.

Recalling that the BJT is a three terminal active device, we find that in single stage BJT amplifiers there is always a common terminal between the input and output ports i.e., one of the three BJT terminals is used as input, one as output and the last terminal is common between the two ports.

Experimental Procedure

<u>Part1: DC Measurements</u>

1. Connect the DC circuit as shown in figure 1. In this schematic the biasing is accomplished by the aid of the bias resistor divider, R_1 and

R_2. The DC Q-point is adjusted such that the V_{CE} is placed in the middle of the BJT characteristics.

2. Monitor the collector–emitter voltage, by connecting the voltmeter between the collector and the emitter. Measure the value of V_{CE}.

V_{CE} = ……………………………………

3. In a similar manner, measure the value of the emitter–base voltage V_{BE} :

V_{BE} = ……………………………………

4. Calculate the collector current I_C as V_{RC} / R_C , where V_{RC} is the voltage drop across the collector resistance (R_C) measured by connecting the voltmeter between V_{CC} and the collector terminal.

V_{RC} = ………………….. and I_C = …………………………….

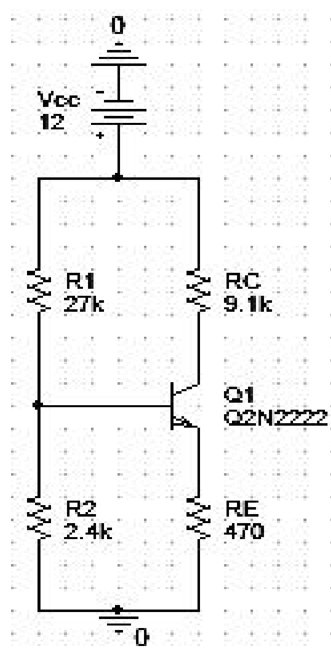

Figure 1: BJT Amplifier DC Circuit

5. Calculate the emitter current by the aid of the voltage across the emitter resistance (R_E).

V_{RE} = …………………… and I_E = ……………………………

6. Now we can compute the value of the base current I_B.

I_B = …………………………

7. Knowing the emitter, collector and base currents, calculate the forward common-emitter current gain of the transistor as given by: $\beta = I_C / I_B$ and the forward common-base current gain as given by: $\alpha = I_C / I_E$.

β = …………………… and α = …………………………

Part 2: BJT Model Parameters Computation

8. Compute the BJT model parameters by the aid of the DC operating point values, knowing that the thermal voltage V_T is taken as 25mV, and the early voltage of the transistor V_A is 74 volt.

$$r_\pi = \frac{\beta V_T}{I_C} = \text{………………………………}$$

$$g_m = \frac{I_C}{V_T} = \text{………………………………}$$

$$r_o = \frac{V_A}{I_C} = \text{………………………………}$$

Part 3: AC Measurements

(a) Voltage Gain Measurement

9. Connect the BJT amplifier in the common-emitter configuration as shown in figure 2. Connect the Function Generator to the input of the amplifier (node V_S) and adjust it to generate a sinusoidal signal at a frequency 10 kHz and amplitude 100 mV.

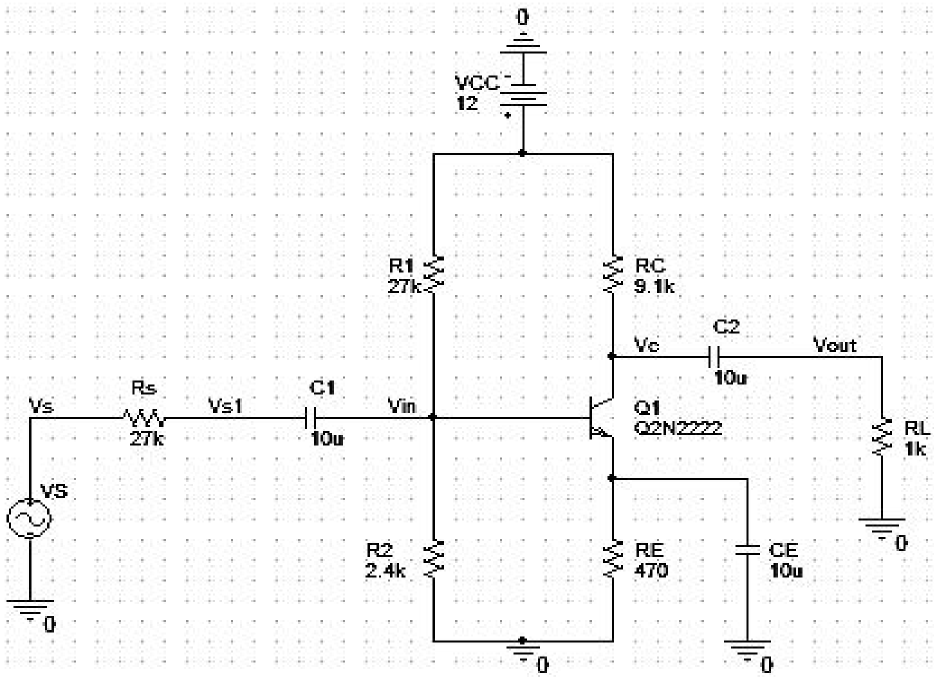

Figure 2: BJT Common Emitter Configuration

10. Connect the oscilloscope at nodes V_{s1} and V_{in} , i.e., before and after capacitor C_1. What do you conclude?

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11. Connect channel 1 of the oscilloscope to the input of the amplifier (node V_S) and channel 2 to the amplifier output (V_{out}).

12. Record the peak–to–peak amplitude of the input signal (V_{spp}) and the output signal (V_{opp}) after measuring it using the oscilloscope. Then calculate the voltage gain.

V_{spp} = …………………………… and V_{opp} = ………………………

$A_v = V_{opp} / V_{spp}$ = …………… and $A_{v\,dB}$ = ………………………

13. Compare the input signal with output signal. What is the approximate phase relationship between the two signals?

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(b) Input Resistance Measurement

14. To measure the input resistance of the amplifier remove R_s and V_s. Connect an external supply V_X (amplitude 100mV and freq. 10 kHz) in series with a resistor $R_X = 100\ \Omega$ to the amplifier as shown in figure 3.

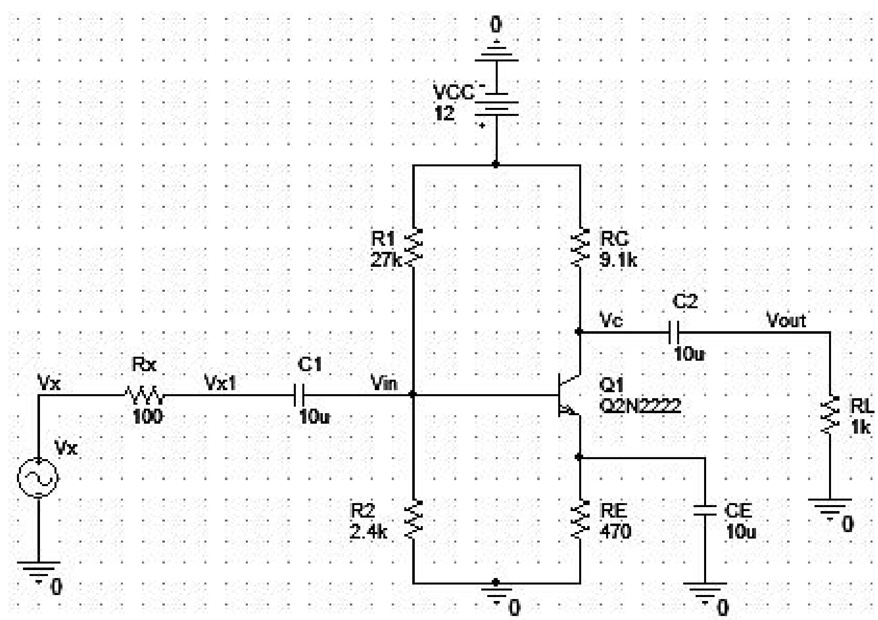

Figure 3: Setup for measuring the input resistance of the common emitter amplifier

15. Connect the oscilloscope channel 1 to node V_X and channel 2 to node V_{X1}. The amplifier's input current I_X can now be calculated by subtracting the oscilloscope channel readings and dividing it over the resistor value.

V_{xpp} = ... and V_{x1pp} = ...

$$I_{Xpp} = \frac{V_{xpp} - V_{xpp}}{R_X} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

16. Now calculate the input resistance as

$$R_{in} = \frac{V_{xpp}}{I_{xpp}} = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

(c) Output Resistance Measurement

17. Now repeat the procedure in step 14 to measure the amplifier's output resistance, this time by removing R_L, deactivating the input source and connecting V_X and R_X to the amplifier's output as shown in figure 4.

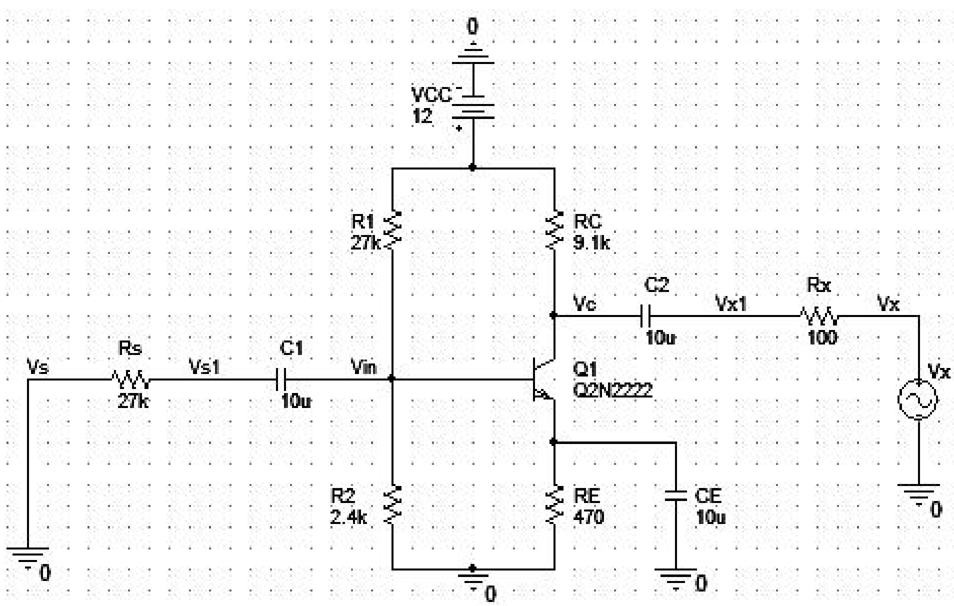

Figure 4: Setup for measuring the output resistance of the common emitter amplifier

V_{xpp} = ... and V_{x1pp} = ...

$$I_{Xpp} = \frac{V_{xpp} - V_{xpp}}{R_X} = \text{... ... ...}$$

$$R_{out} = \frac{V_{xpp}}{I_{xpp}} = \text{... ... ...}$$

Prelab Questions

1. Carry out the hand analysis for the common emitter amplifier shown in figure 2. Compute the DC operating point, the model parameters, the voltage gain in dB, the input resistance and the output resistance.
2. Using the ORCAD Simulator, simulate the common-emitter amplifier of figure 2. Carry out the Bias-point analysis to get the operating point of the amplifier . From the ORCAD output file present detailed information about the transistor's model and parameters.
3. Using ORCAD's Time-Domain analysis, plot the signal at nodes V_s , V_{s1} , V_{in} , V_c and V_{out}. What do you conclude? Then compute the voltage gain, input resistance and output resistance?

Postlab Questions

1. Compare between your theoretical analysis, simulation results and practical measurements. Give an explanation for any deviation in your results.

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2. Repeat all the above questions in case of removing the emitter bypass capacitor. What do you conclude ?

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