EECS2210: Electronic Circuits & Devices

Lab #4

BJT AC Characteristics

Introduction and Objective

The objective of this experiment is to explore basic Bipolar Junction Transistor (BJT) AC characteristics.

Goals of this experiment:

- Correlate hand calculation results with those produced using LTspice simulation.
- Design the circuit to work in the requested conditions and evaluate it with the measurements.

Hand Calculation and Prelab

1. In Fig.1, calculate I_C and V_{CE} and determine if the transistor operates in the linear (active) mode (assume V_{BE} =0.7V).
2. Considering a β=300 for this transistor, calculate r_π, g_m, r_{in} and the small-signal voltage gain of the circuit.
3. Perform a transient simulation of the circuit in LTspice for the duration of 10ms and measure the voltage gain of the amplifier by comparing the peak-to-peak value of the input and output sinusoidal. Assume Vin is a sine wave with a frequency of 10kHz and an amplitude of 100mV (select 2N3904 as the model of the transistor).
4. What is your suggestion to increase the gain of this circuit? Elaborate your answer.
5. Considering a maximum total power consumption of 30mw and using the same R1 and R2 as in Fig. 1, what is the g_m?
6. With the same R1 and R2 as in Fig.1, and assuming the same g_m from step5, determine the values of R_C and R_E to achieve a voltage gain of 160 V/V. (hint: you can add capacitors to the circuit to bypass a certain resistor to increase the voltage gain.)
7. Simulate your circuit and validate your design by measuring the gain. (that is, perform a transient simulation with a duration of 1ms and Vin with frequency of 10kHz and amplitude of 1mV.)

Lab Experiments

1. Using 2N3904 transistor implement the circuit shown in Fig.1.
2. Measure I_C, I_B, and V_{CE} and determine if the transistor is working in the linear operating region.
3. Calculate r_π, g_m, r_{in} based on the measurement.
4. Apply a sine wave with a frequency of 10kHz and an amplitude of 100mV and measure the gain by comparing the peak-to-peak values of input and output waveforms on the oscilloscope. You can use cursors or the scope's built-in function for measuring waveforms peak-to-peak.
5. Build the circuit you have designed in step6 of the prelab.
6. Apply a sine wave with a frequency of 10kHz and an amplitude of 1mV and validate that the circuit have the gain and power consumption that it was designed for.
7. Explain the advantages of your circuit compared to the circuit in the last slide of Week 6's lecture.

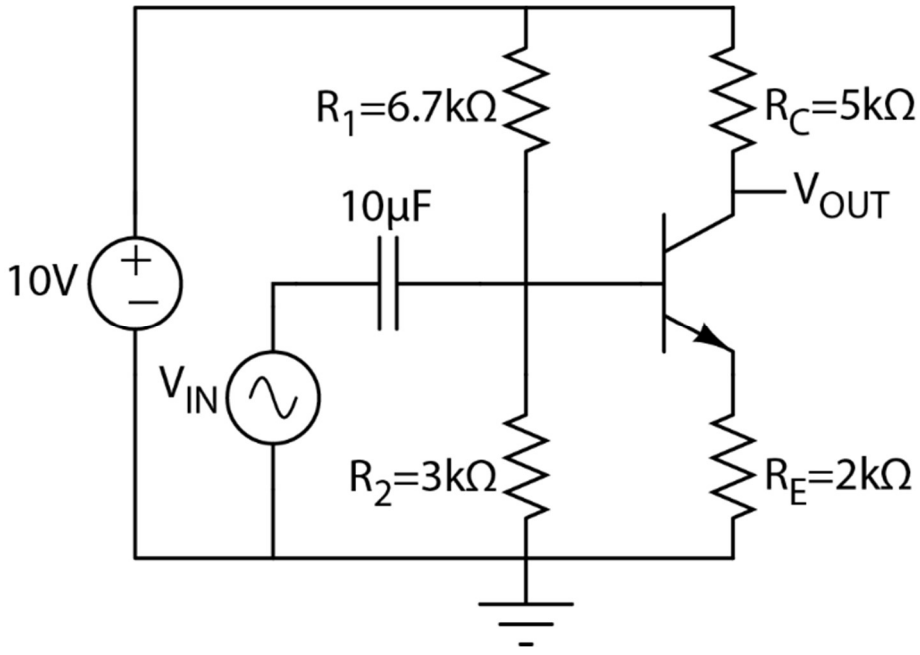

Figure 1