EE 330 Laboratory 9
Discrete Semiconductor Amplifiers

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Contents

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Objective:

The objective of this laboratory experiment is to become familiar with applications of MOS and Bipolar transistors as small-signal amplifiers. Both BJTs and MOSFETs are semiconductor devices that can be used in both analog and digital applications. In this lab, MOS transistors will come from the EDU1000 MOSFET array. The BJT that will be used is the PN2222 .

In this experiment, you will be measuring waveforms, operating points, and gains. All of these measurements should be made with the oscilloscope. The multimeter that is on the laboratory bench should not be used for any measurements in this experiment.

Note: Remember to set your Function Generator to 'High Z' from 'Output Menu'

Discussion:

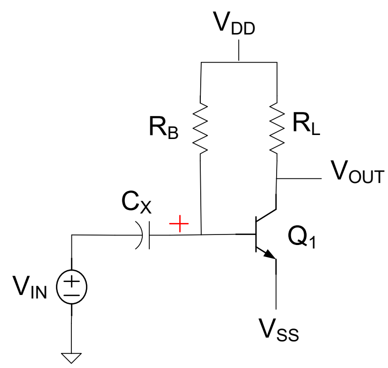
Although the major emphasis in this course has been on integrated devices, discrete transistors will be used in this experiment.

Components Needed:

PN2222 BJT, EDU1000 transistor array, and any operational amplifier you are familiar with (LM324, LMC660, etc). Data sheets for these components are posted on the EE 330 class web site.

Part 1 Common-Emitter Amplifier

A Common-Emitter amplifier is shown. The value of β for the PN2222 varies considerably from one device to another. In the data sheet that is linked on the class web page, the parameter β is designated as h_{FE}. The large variations in the values of this parameter should be apparent from the data sheet. You will need to measure the value of β for your transistor. The coupling capacitor should be large; in the 1uF range or larger. Note the polarity of the electrolytic coupling capacitor is critical.



Capacitor Coupled Common Emitter Amplifier

a. Use a large resistor for R_B (over 300kΩ) and measure the I_C and I_B current when $V_{DD} = 12V$, $V_{SS} = 0V$, and R_L to 5KΩ. Use $I_c = \beta I_B$ to calculate the $\beta\ (or\ h_{fe})$ of your device. Connecting the capacitor and V_{in} is not necessary for this step.

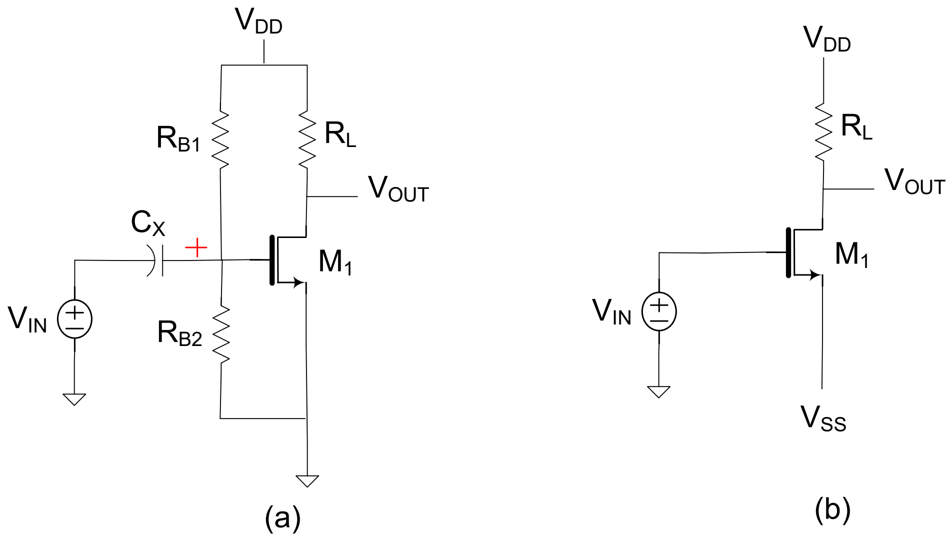
b. After this value for β is measured, determine the value of R_B necessary to establish a quiescent collector current of 1mA when $V_{DD} = 12V$, $V_{SS} = 0V$, and R_L to 5KΩ .

c. Add capacitor if you did not initially, measure V_{out}, and calculate your gain. Compare the theoretical small-signal voltage gain with what is measured for this circuit. In this measurement, use a 1KHz sinusoidal input signal with the input amplitude adjusted so that the output signal swing is 4Vpp.

d. Gradually increase the amplitude of the input until clipping distortion is observed on the output. How big can the output signal be without clipping?

Part 2 Common Source Amplifier

Two common-source amplifiers are shown below. The one on the left uses the resistors R_{B1}, R_{B2} the capacitor C_X, and the voltage source V_{DD} for biasing. The one on the right uses the two voltage sources V_{DD} and V_{SS} for biasing.



Common Source Amplifiers

Derive an expression for and compare the voltage gains of **these two amplifiers** if the transistor is operating in the saturation region. **Then build and test the two circuits**. When building the amplifier, use $V_{DD} = 5V, R_L = 10K$ and design for a voltage gain of -5. Select the remaining components to achieve the required gain. Test the circuits with a sinusoidal input voltage of 100mV 0-P and frequency of 1KHz. Compare the measured voltage gain with the calculated gain.

Part 3 Amplifier Design

Build and test a small-signal voltage amplifier using the BJT as the active device with a small signal gain of -10 that can drive a 5K load resistor. If you use the circuit of Part 3, the resistor R_L can be considered as the load.