EE 330 Laboratory 8
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, etc).

Part 1 Voltage Controlled Amplifier

The circuit shown serves as a voltage controlled amplifier when the transistor M_1 is biased to operate in the triode region. Use any NMOS from EDU1000. The transistor is effectively a resistor with one end connected to ground and the other end connected to feedback network. As the dc voltage V_{CONT} changes, the effective resistance of transistor changes, and the gain of the amplifier changes as well.

$$R_{FET} = \frac{V_{ds}}{I_D} = \left[\mu * C_{OX} * \frac{W}{L} * \left(V_{gs} - V_T\right)\right]^{-1}$$

From information obtained in the datasheet, determine R so that the voltage gain is 50 with V_{CONT} = 2.5V. Use the long channel NMOS on your MOS array. **Choose V_{in} so that your output is as big as possible but is not clipped**. What does V_{CONT} need to be changed to for a gain of 2? Experimentally verify the operation of this circuit. Use ± 15V biasing for the op amp.

For both setups, record your V_{in}, V_{out}, and the FFT of both signals. Compare the FFT of your V_{in} and V_{out} and comment on their differences. Why are they different? (Think of how the transistor is operating)

Note: to get FFT from the oscilloscope -> math -> FFT. You might need to scale your window horizontally to see the full FFT.

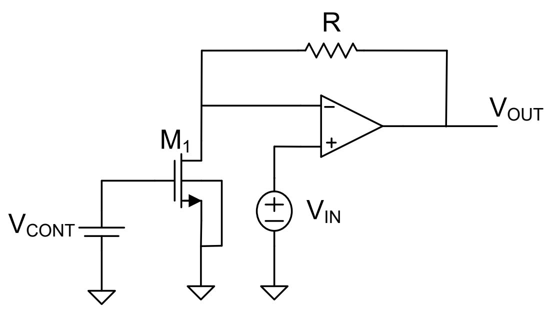

Fig. 1. Voltage Controlled Amplifier.

Part 2 Fast Fourier Transform and distortion

Fast Fourier transform (FFT) is used to convert a signal from time domain to frequency domain, listing the frequencies present in the signal and their energies. A pure signal should have only 1 frequency, but due to distortion, other frequencies crop up in the FFT and degrades it.

To highlight the effects of distortion on a signal, repeat part 1, but instead of generating V_{in} from the function generator, use your computer's audio jack instead. Play some music from the computer, amplify it, and then listen to it via a speaker. Comment on how the music sounds differently between the high-gain and the low-gain setup.

Note: The computer's output voltage is AC, to ensure that your transistor's Drain to Bulk PN junction is not forward bias, set your bulk voltage to -1V. Also, for the low-gain setup, you might need to increase your V_{in} amplitude to hear the effect clearer.

Part 3 A Nonlinear Application

Two circuits are shown. Analytically predict the relationship between V_{OUT} and V_{IN} for $-2V < V_{IN} < 2V$ and verify experimentally. Also predict the output if the input is a 1KHz sinusoidal waveform of 4V p-p value and experimentally verify. Use an n-channel MOSFET from the EDU1000 for M_1 and use a 1N4148 diode for D_1. Comment on what useful functions these circuits provide. Use ± 6V biasing for the op amp. You can choose any resistor in the 1 kΩ - 100 kΩ range for R.