Lab 12
MOSFET variable gain amplifier and amplitude modulation

Pre-Lab

1. Decide which NMOS transistor to use for the experiment.
2. Sketch the experiment setup in the first section (step 1). Tentatively estimate the channel resistance based on measurements from your previous lab.
3. Sketch the variable gain amplifier in the second section. Guess at the size of the feedback resistor based on the estimated channel resistance from before.
4. Sketch the demodulation circuit in the fourth section and write the expression for the capacitance.

In this lab you will use the NMOS as a variable gain resistor to amplitude modulate a carrier with a signal. Using a rectifier and low-pass filter you will then demodulate the original signal from the carrier.

Measuring the channel resistance

1. Pick a NMOS transistor on the MOSFET IC, but not the one whose source is connected to V_{SS}! Bias $V_{DD} = +8\,\text{V}$ and $V_{SS} = -5\,\text{V}$ using voltage dividers from $\pm 15\,\text{V}$ supplies. Connect the source to ground and the gate to a variable $0 - 6\,\text{V}$ supply through a $100\,\text{k}\Omega$ resistor. The drain is connected to V_{DD} through a resistor, R_D.
2. For several values of the gate voltage (in the 0-6 V range), measure the drain current and v_{DS} for small values of v_{DS} (you will need to adjust R_D to make v_{DS} small).
3. Use these measurements to compute and plot the channel resistance as a function of gate voltage. Decide, for use later, on a mid-range gate voltage for which the resistance varies roughly linearly with gate voltage.

Building the variable gain amplifier

In this section you will build a variable gain amplifier using an op-amp, in which the gain is controlled by the voltage on the NMOS gate.

4. Using the same setup as in the previous section use the NMOS as a variable gain resistor in a non-inverting amplifier, connecting the source to ground and the drain to the inverting input on an op-amp (Use the LF411 with the $\pm 15\,\text{V}$ supplies). Pick a feedback resistor which produces a gain in the range of 10 to 100 for the mid-range gate voltage.

5. Apply a small-amplitude sinusoidal carrier of moderately high frequency to the non-inverting input of the amplifier. How high can you go in frequency before you loose gain?

6. Pick a carrier frequency well below the maximum frequency and show how you can control the output amplitude of the amplifier by varying the gate voltage.

Amplitude modulation

In this section you will modulate a sinusoidal signal (the carrier) with a lower-frequency input signal.

7. Attach a second function generator to the gate, through a $100\,\mathrm{k}\Omega$ resistor, and use it to supply a signal of much lower frequency with an offset equal to the mid-range gate voltage from earlier. Show how the output signal amplitude is modulated by the gate signal.

8. Attach a second $100\,\mathrm{k}\Omega$ between drain and gate. Does this reduce the distortion?

Building the demodulation circuit

In this section you will use a simple rectifier to demodulate the low-frequency input signal from the carrier.

9. Attach the op-amp output through a diode to a $1\,\mathrm{k}\Omega$ resistor to create a half-wave rectifier with positive voltage swing only. Plot an example of the modulated rectified carrier (it may be easier to trigger on the signal input).

10. Use a capacitor to create a low-pass filter with a time-constant much longer than the carrier and much shorter than the signal.

11. Plot the output signal together with the input signal. Are they similar?