EE 230: Analog Circuits Lab
Lab No. 9

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1 Common Source (CS) Amplifier with Resistive Load

1.1 Aim of the experiment

Making a common source amplifier circuit with a resistive load, amplifying the small signal AC component of the input Voltage.

1.2 Methods

An input voltage consisting of a DC component and a small signal AC component is applied. The DC component is used to bias the MOSFET in saturation.

1.3 Design

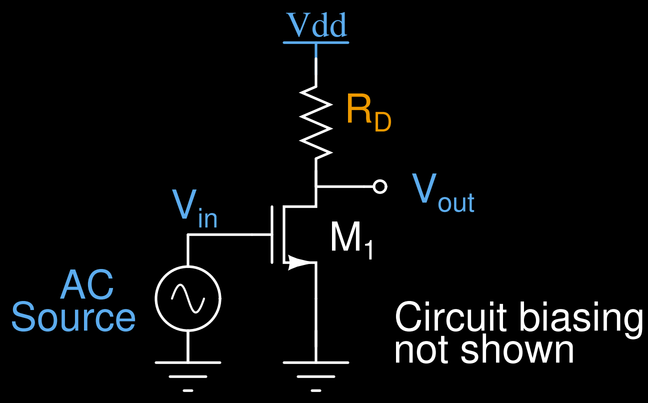
for the above circuit:

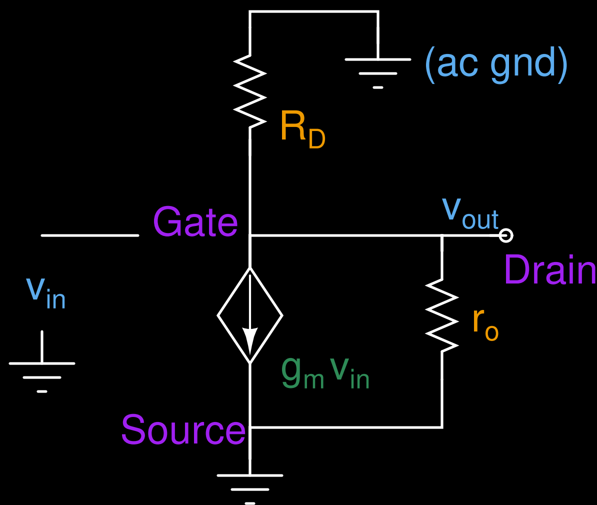
1. V_{bias} = DC component of V_{in}, is given by:

$$V_{bias} = \frac{V_{DD} - V_m}{1 + \frac{A_v}{2}} + V_{Th} \tag{1}$$

where V_m is the margin volatge, which has been chosen to be 0.5V.
2.

$$A_v = -g_m R_D = -k_n(V_{bias} - V_{Th})R_D \tag{2}$$





1.4 Experiment Results

The calculations yielded the following values:
Assuming $A_v = 20$dB, which is a gain of 10,
taking $V_{in} = V_{bias} + V_{SS}$, with $V_{SS} = 10\sin(wt)$ mV,
we get $V_{bias} = 1.126$V
$R_D = 30.3$kΩ, taking the standard value, 32.1kΩ.

The large difference in the calculated and experimental result occurs because the MOSFET parameters used in the calcultaions are not the same as the parameters of the actual MOSFET used in the experiment.

	Calculated Value	Experimental Result
V_{outAC}(magnitude(mV))	100.0	100.3
V_{outDC}(V)	#1.023	2.4
gain	10	10.3

Table 1: Caption

1.5 Conclusion and Inference

This experiment demonstrated the method to bias a MOSFET in the correct region to use it for the intended task, and also demonstrated a common source small signal amplifier.

1.6 Experiment completion status

This experiment was completed entirely in the lab.

2 Common Source (CS) Amplifier with Diode Connected Load

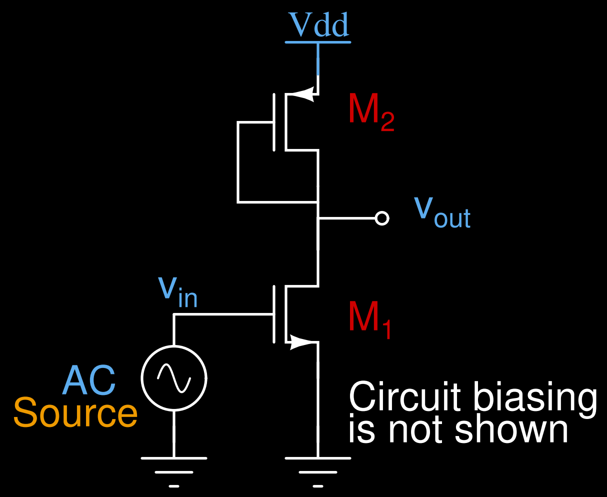
2.1 Aim of the experiment

Making a common source amplifier circuit with a Diode Connected Load, amplifying the small signal AC component of the input Voltage.

2.2 Methods

An input voltage consisting of a DC component and a small signal AC component is applied. The DC component is used to bias the MOSFET in saturation.

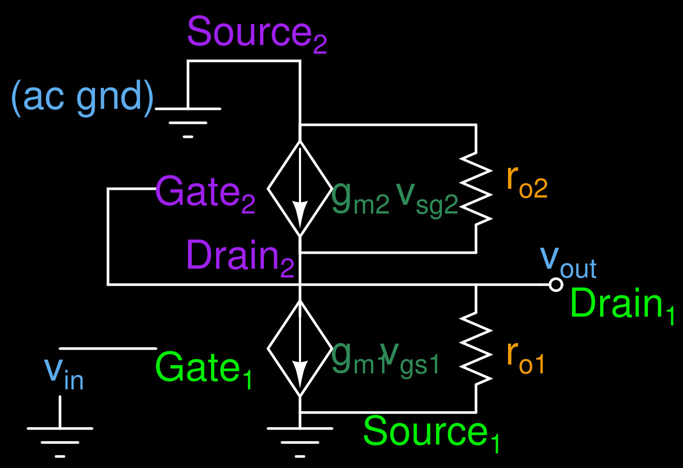
2.3 Design



for the above circuit:

1. V_{bias} = DC component of V_{in}, is given by:

$$V_{bias} = \sqrt{\frac{k_{p2}}{k_{n1}}}(V_{DD} - V_{out} - V_{th2}) + V_{th1} \tag{3}$$



where V_m is the margin volatge, which has been chosen to be 0.5V.
2.

$$A_v = -\sqrt{\frac{k_{n1}}{k_{p2}}} \tag{4}$$

2.4 Experiment Results

For $V_{DD} = 5$V. The calculations yielded the following values:
taking $V_{in} = V_{bias} + V_{SS}$, with $V_{SS} = 10\sin(wt)$ mV,
We have the following values of the result :- V_{in} (bias) = 1.6253 V
V_{out} (bias) = 2.1658V (calculated) and V_{in} (bias) = 2.37V (measured on ISO)
V_{out} (V_{pp}) = 44mV
$A_v = 1.833$

2.5 Conclusion and Inference

This experiment demonstrated the method to bias a MOSFET in the correct region to use it for the intended task, and also demonstrated a common source small signal amplifier. The PMOS was used as a diode load in this experiment.

2.6 Experiment completion status

This experiment was completed entirely in the lab.

3 Current Mirror Design

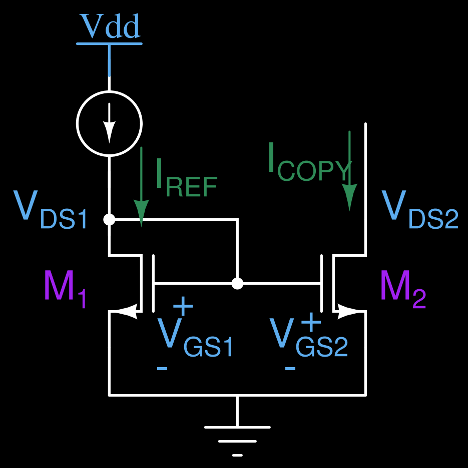
3.1 Aim of the experiment

Making a current mirror circuit to reflect the current in a branch of the circuit to another branch.

3.2 Methods

A DC input voltage is applied to the circuit and the resistance is adjusted to match the given current value, then the drain voltage of the other MOSFET is varied using DC sweep so as to bring the other MOSFET in saturation mode as well.

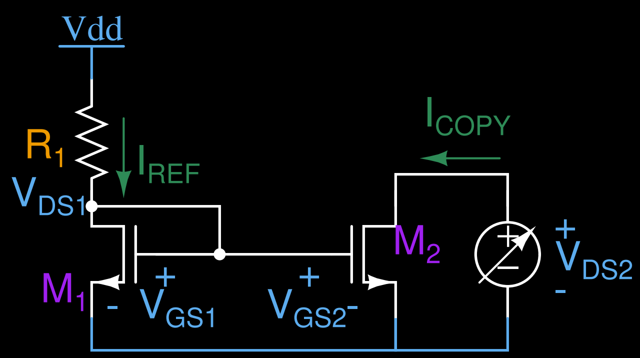
3.3 Design



for the above circuit:

$$\frac{I_{COPY}}{\frac{W_2}{L_2}} = \frac{I_{REF}}{\frac{W_1}{L_1}} \tag{5}$$

since the two NMOS' are identical, $I_{COPY} = I_{REF}$
But we have to ensure that both the MOSFETs are in saturation mode.



3.4 Experiment Results

For V_{DD} = 8V, the calculations yielded the following values:
R1 = 2.46kΩ (measured) and R1 = 2.36kΩ (calculated)
I_{REF} = 2mA (measured) and I_{REF} = 2.06mA (calculated)
V_{DS1} = 3.275V

Now, sweeping V_{DS2} to set up I_{COPY} as 2mA.

$V_{DS2}(V)$	$I_{REF}(mA)$	$I_{COPY}(mA)$	$V_{DS1}(V)$
0	2.06	0	3.27
0.5	2.06	0.96	3.27
1	2.06	1.62	3.27
1.5	2.06	2.11	3.27
2	2.06	2.34	3.27
2.5	2.06	2.44	3.27
3	2.06	2.47	3.27
3.5	2.06	2.48	3.27
4	2.06	2.50	3.27
4.5	2.06	2.51	3.27
5	2.06	2.51	3.27
5.5	2.06	2.52	3.27
6	2.06	2.52	3.27
6.5	2.06	2.52	3.27
7	2.06	2.52	3.27
7.5	2.06	2.52	3.27
8	2.06	2.53	3.27

At V_{DS1} = 1.5V, the error between I_{REF} & I_{COPY} is minimum.
We can design a cascaded current mirror where $I_{REF} = I_{COPY1}$ & $I_{REF2} = I_{COPY1}$ & change the value of resistor such that $I_{REF} = N \cdot I_{COPY}$

3.5 Conclusion and Inference

This experiment demonstrated the working of a current mirror and the method to adjust the drain voltages to get the MOSFETs operating in saturation mode.

3.6 Experiment completion status

This experiment was completed entirely in the lab.