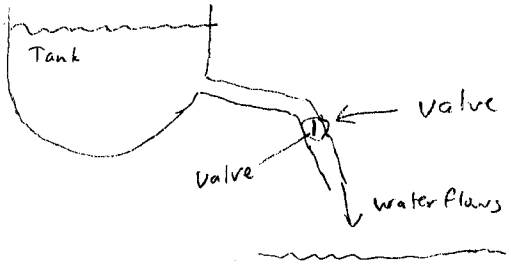
Introduction to amplifiers

Or--- how do we get "gain"?

Idea --- think of a fluid system:

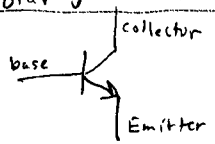


valve controls the flow - it only takes a little bit of energy to control lots of flow.

Back to electronics ---

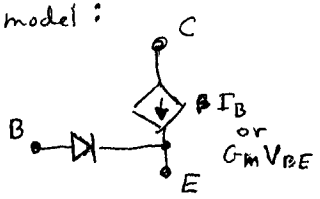
Two kinds of devices:

Bipolar junction transistor

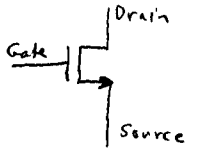


Current flows from collector to emitter controlled by the base (actually by base current)

Simple model:

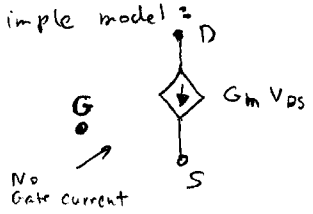


Field effect transistor



current flows from drain to source controlled by the gate (actually by gate to source voltage)

Simple model:



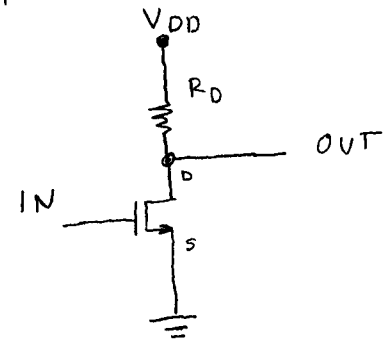
Both types only work when current is flowing in the indicated direction.

They only sink current

absorb power.

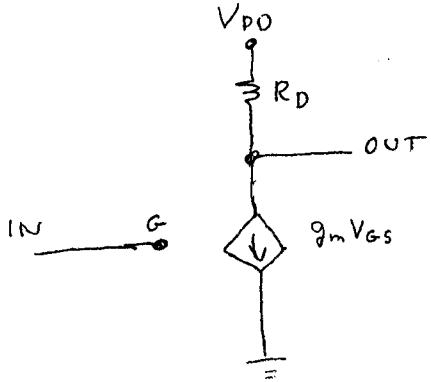
They cannot generate power.

Simple "common source" amplifier:

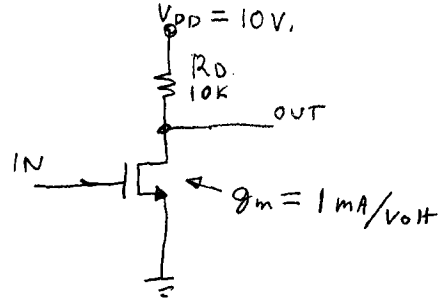


Using "Linear" model for now. Not very accurate!

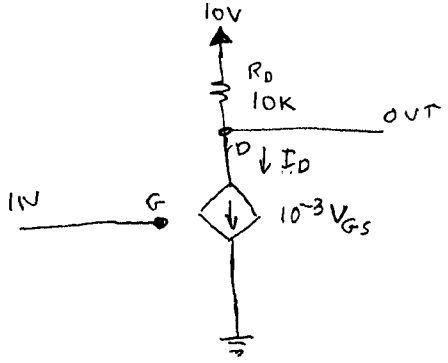
Substitute the model:



Try it with some values ...



Substitute the model:



V_{GS}	I_D	V_{R_D}	V_{GS}	
0	0	0	10	"Active" region
.1	.1 mA	1	9	
.2	.2mA	2	8	
.5	.5mA	5	5	
.9	.9mA	9	1	
1.0	1 mA	10	0	
1.1	1.1mA	11	−1	← model not valid (saturation)*
−.1	−.1mA	−1	11	← model not valid (cutoff)

.1 volt change in input produces 1 volt change in output

Gain = $\frac{\Delta OUT}{\Delta IN} = -10$

This model is only valid for $V_{DS} > 0$ and $I_D > 0$

Observations:

① model is only valid in Active region.

How do we amplify AC?

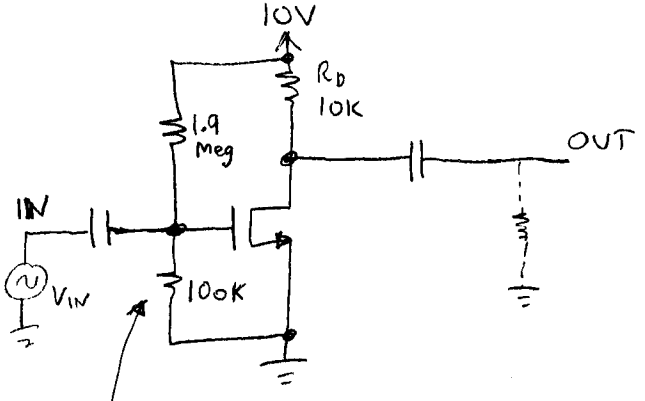
How do we amplify DC that is both positive and negative?

Are there other configurations?

To amplify AC ...

→ Add "bias" to preset the device to the middle of the active region.

→ Use capacitors to couple the signal in and out:



Select resistors to put drain at the midpoint of active region = 5V.

Make $V_{GS} = .5V$

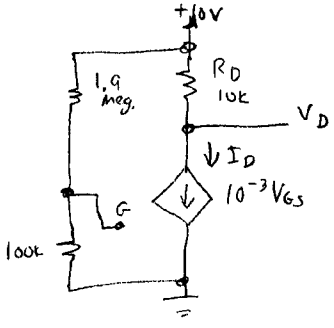
Make them high. (There's no gate current)

Analysis:

You must do it twice —

1. DC
2. AC

DC — Find the "operating point"



$$V_G = (10)\frac{100K}{100K + 1.9meg}$$
$$= .5V.$$

$$I_D = 10^{-3}V_{GS}$$
$$= (10^{-3})(.5)$$
$$= .5 \times 10^{-3} = .5\ mA.$$

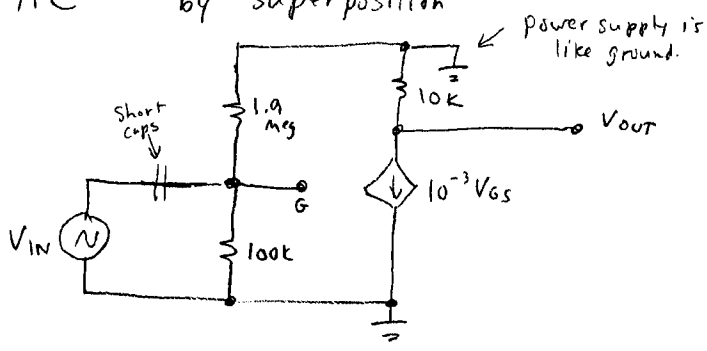
$$V_{RD} = IR$$
$$= (.5\ mA)(10K)$$
$$= 5\ volts$$

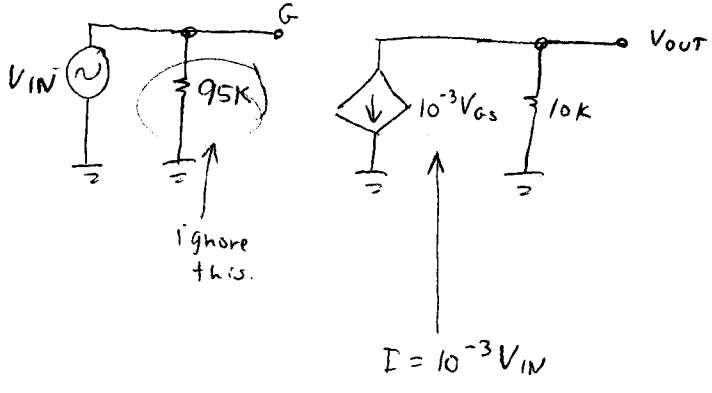
$$V_{DS} = V_{DD} - V_{RD}$$
$$= 10 - 5$$
$$= 5$$

Stop here if the operating point is not reasonable.

This one is ok.

AC — by superposition





KCL ---

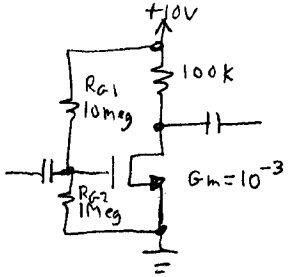
$$10^{-3}V_{IN} + \frac{V_{OUT}}{10K} = 0$$
($10K = 10^4$)

$$\frac{V_{OUT}}{V_{IN}} = -(10^{-3})(10^4)$$
$$= -10$$

Only when it stays in the active region.

Homework

Use the linear model of the MOSFET---

① 

a. Find operating point (node voltages)

b. Determine if it is in the Active region

c. if so, Find the AC gain.

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② Determine the value for R_{G1} to make $V_{DS} = 5$ v.

then Find the AC gain

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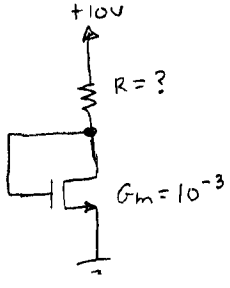
③ 

Find the value of R for $V_{DS} = 5$

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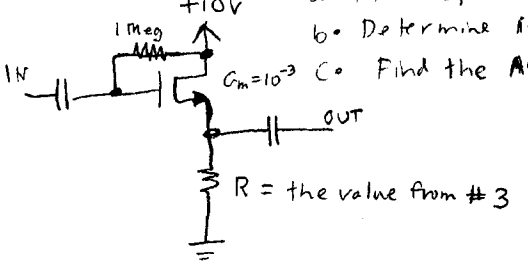
④ Here's another circuit -- ("source follower")



a. Find operating point

b. Determine if in active region

c. Find the AC gain