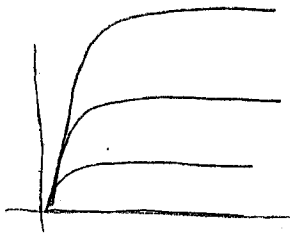
Large signal model of FET.

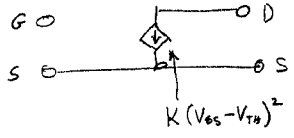
Triode region --

$$i_D = K\left(2(V_{GS}-V_{TH})V_{DS} - V_{DS}^2\right)$$ ← depends on both V_{GS} and V_{DS}

Saturation region --

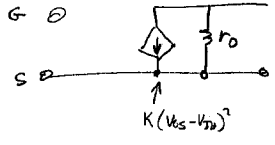
$$i_D = K(V_{GS}-V_{TH})^2$$ ← does not depend on V_{DS}

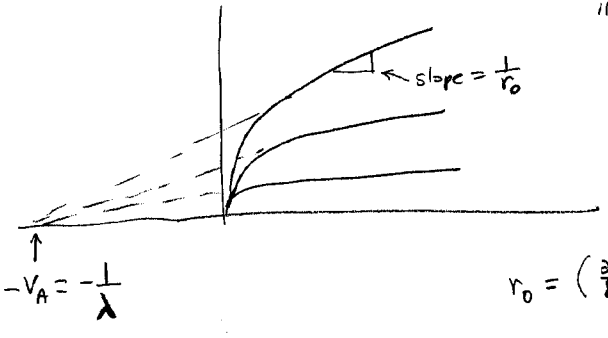




in more detail (5.1.7)

$$i_D = K\left((V_{GS}-V_{TH})^2(1-\lambda V_{DS})\right)$$





"Channel length modulation"

results in a finite output resistance

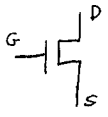
$$r_o = \left(\frac{\partial i_D}{\partial V_{DS}}\right)\Bigg|_{V_{GS}=\text{const}}$$

$$r_o = \frac{1}{\lambda K_n (V_{GSQ}-V_{TH})^2}$$

Examples:

Device specs:

$K = 2\frac{ma}{V^2}$ $\quad \lambda = 0$ $\quad V_{TH} = 1$



ⓐ $V_{GS} = 3$, $V_{DS} = 5$

Region = saturation $(V_{GS}-V_{TH}) < V_{DS}$

$i_D = K(V_{GS}-V_{TH})^2$

$= 2(3-1)^2$ ma

$= 2(2)^2$ ma

$= 8$ ma

ⓑ $V_{GS} = 2$, $V_{DS} = 5$

Saturation $(V_{GS}-V_{TH}) < V_{DS}$

$i_D = K(V_{GS}-V_{TH})^2$

$= 2(2-1)^2$

$= 2(1)$

$= 2$ ma

ⓒ $V_{GS} = 1$, $V_{DS} = 5$

Region = cutoff $V_{GS}-V_{TH} = 0$

$i_D = K(V_{GS}-V_{TH})^2$

$= 2(1-1)$

$= 0$

cut off

ⓓ $V_{GS} = 3$, $V_{DS} = 1$

triode $(V_{GS}-V_{TH}) > V$

$i_D = K\left(2(V_{GS}-V_{TH})V_{DS} - V_{DS}^2\right)$

$= 2\left(2(3-1)1 - 1^2\right)$

$= 2(2(2)-1)$

$= 2(4-1)$

$= 2(3)$

$= 6$ ma

HW — Read 5.0 — 5.1 (understand) pre-read 5.2 on

p	#	
252	1, 2, 3	Overview only: subthreshold
257	4	breakdown
260	5	body effect
~~271~~	~~6~~	

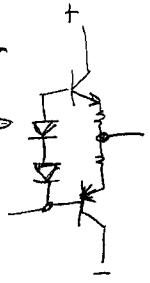
A variant on 4.68 --- (harder!)

Microphone puts out 1mv (peak)

You need to drive a speaker to 50 watts.

You need a volume control.

Use a complementary emitter-follower output stage →



"Hum" must be at least 80 dB below full output.

All transistors have minimum $\beta = 50$.

$V_A = 100$

You have both NPN and PNP in "small", "medium", and "large".

"small"	"medium"	"large"
½ watt	5 watts	50 watts.
30 volts	100 volts	100 volts

Design the complete amplifier, including power supply.

Try to minimize cost, but don't worry about small stuff.
The biggest costs are the heat sink, power transformer, and large capacitors.

Start in class, Wednesday
Finish as homework
Review Friday
Be ready to do a problem of this complexity on the final.