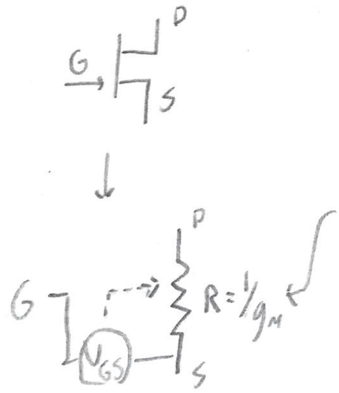
JFET basics - Ohmic!



In the ohmic region, $I_{DS} \propto V_{DS}$ (generally prop. to)

In other words, we can define a transconductance G (units: ℧ "mho")

$g_M \equiv \frac{1}{r_{DS}} \equiv \frac{I_{DS}}{V_{DS}}$. We avoid "$R_{ohmic}$" because it's not truly ohmic or resistive — there's a lot of subtleties we're ignoring.

V_{GS} controls the "resistance" (really transconductance) of the JFET.

JFET equations.

$$I_{DS} = \frac{2 I_{DSS}}{V_{GS_{off}}^2}\left[(V_{GS} - V_{GS_{off}})V_{DS} - V_{DS}^2/2\right]$$

⇓

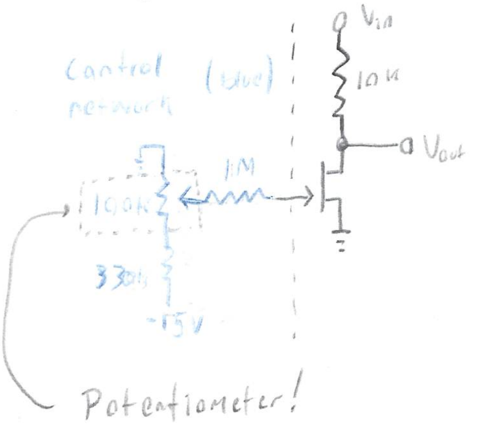
$$g_m = 1/r_{DS} = I_D/V_{DS} = \frac{2 I_{DSS}}{V_{GS_{off}}^2}\left[V_{GS} - V_{GS_{off}} - V_{DS}/2\right]$$

Definitions:

- $I_{DS} = I_D$ drain-source current
- V_{GS} gate-source voltage
- V_{DS} drain-source voltage
- $V_{GS_{off}}$ V_{GS} where $I_D = 0$ $\forall V_{DS}$ (from datasheet)

↳ think voltage dividers when studying JFETs in Lab 6.

Ex. 6-1 "uncompensated attenuator"

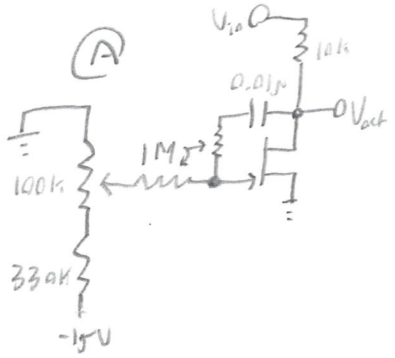


The control network is only used to control V_{GS} ($V_S = 0 \Rightarrow V_{GS} = V_G$).

This setup allows $V_{GS} \in (0, 3.5)$ V, plenty of range for our purposes.

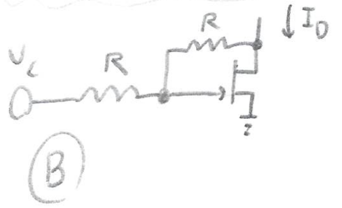
You can measure attenuation for this circuit (V_{out}/V_{in}) as a function of V_{GS}. You'll also observe nonlinearities.

Ex. 6-2 "compensated attenuator"



The capacitor only allows AC to pass, so any DC offset at $V_D = V_{out}$ is ignored.

I'll follow a simpler example (B) which you can apply to 6-2 & 6-3.



KCL:

$$\frac{V_{GS}-V_c}{R} + \frac{V_{GS}-V_{DS}}{R} = 0 \Rightarrow V_{GS} = \frac{V_c + V_{DS}}{2}.$$

JFET:

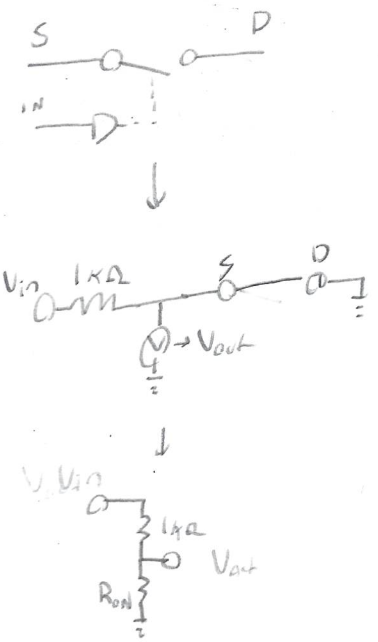
$$g_m = I_D/V_{GS} = \frac{2I_{DSS}}{V_{GS_{off}}^2}\left[V_{GS} - V_{GS_{off}} - V_{DS}/2\right]$$

now:

$$= \frac{2I_{DSS}}{V_{GS_{off}}^2}\left(\frac{V_c}{2} - V_{GS_{off}}\right)$$

So g_m is <u>linear</u> in V_c. (wow!)

Ex. 6-5 CMOS switches



Rare in modern devices - everything's digital. We'll do that in Lab 10. For now, CMOS uses digital (IN) to control pass-thru of an analog signal (S→D).

Measuring R_{ON} is just another voltage divider!

As usual, $V_{out} = \left(\frac{R_{ON}}{R_{ON}+1k\Omega}\right) V_{in}$ ← attenuation

* Remember, scope probes have R_{in} & C_{in}! see manual/datasheets!