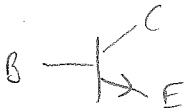
Lecture 7 : FETS

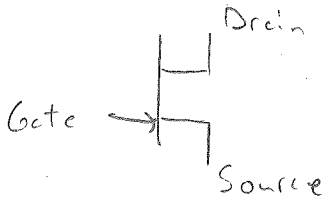
Regular transistor



"bipolar" or "bipolar junction" transistor

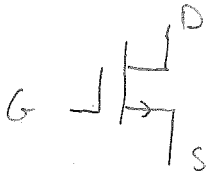
Another type: Field Effect Transistor (FET)

JFET



(no good reason for new names)

MOSFET



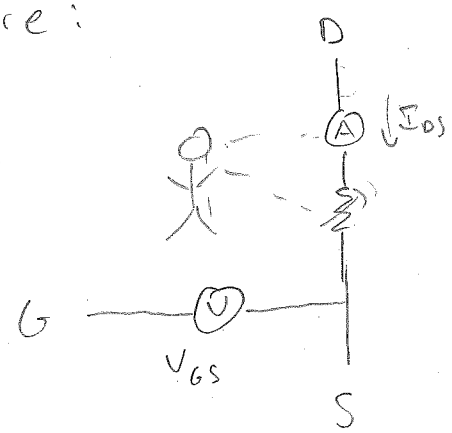
Same basic idea: I_{DS} controlled by gate

But now controlled by gate voltage, not current

I_G nearly zero

⇒ very high input impedance
low power dissipation

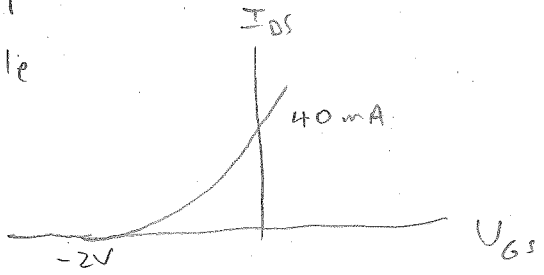
Picture:



"FET man" adjusts R_{DS} according to V_{GS}

Uses a particular function $I(V_{GS})$

Example



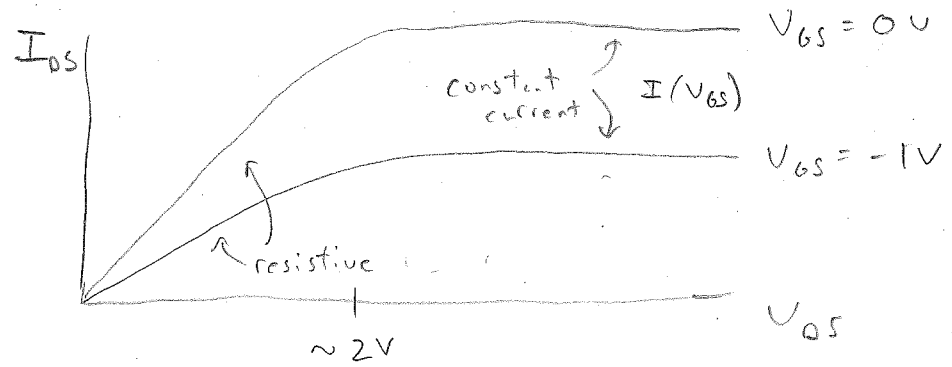
But varies by type of FET,
- from device to device,
with temperature

Like bipolar transistor, only works right if V_{DS} is large enough

For small V_{DS}, acts like a resistor R_{DS}

⇒ FET mens potentiometer doesn't go to zero

But R_{min} does depend on V_{GS}

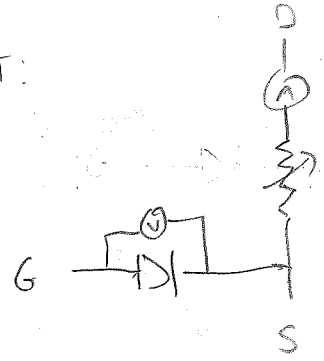


(If you ask for more current, FET men tries harder to turn pot down to zero.)

Two major types: MOSFET & JFET

differ on gate coupling

JFET:



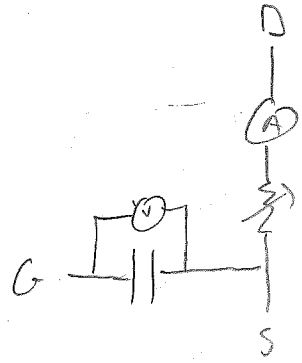
Diode from G to S (like npn transistor)

But don't want any gate current

Need to keep V_{GS} < diode drop

typically $V_{GS} < 0$

MOSFET



Capacitor from G to S

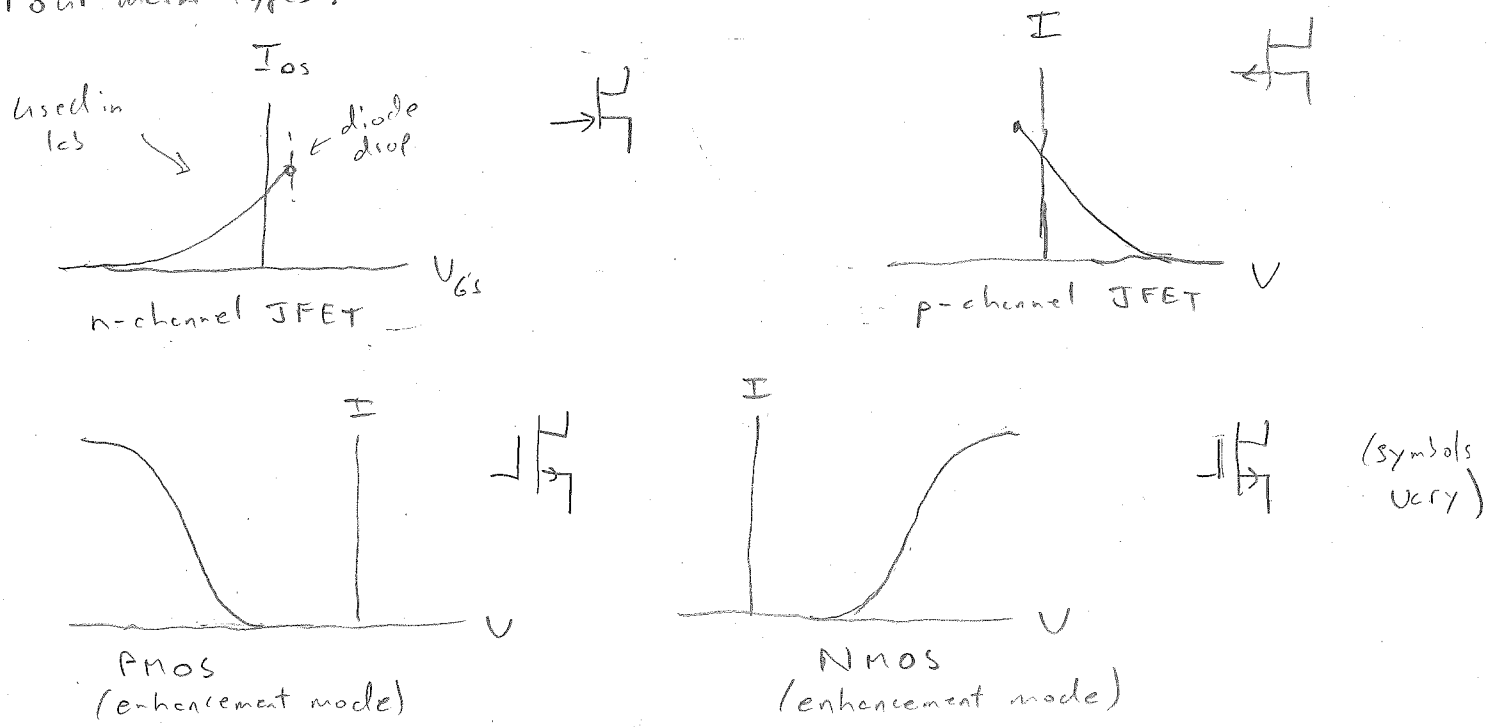
⇒ no dc current

But large V_{GS} breaks capacitor!

Need to be careful of static electricity

Besides this, there are a bunch of subtypes
Different functions $I_{DS}(V_{GS})$

Four main types:

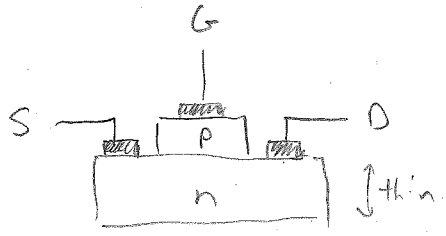


Impossible to keep track of names if you don't work with FETs a lot.
Just remember each FET has its own $I_D(V_{GS})$ function, get from data sheet.

Comparison to bipolar transistors:
BJTs typically have higher gain & current capacity
FETs don't need control current: simplifies design & reduces power consumption

Physics:

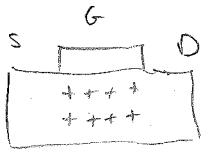
JFET:
(n-channel)



An junction forms diode, as usual

Get conduction from D to S via n-doped material (electron carriers)

Apply $V_G < 0$: pushes electrons away from gate region

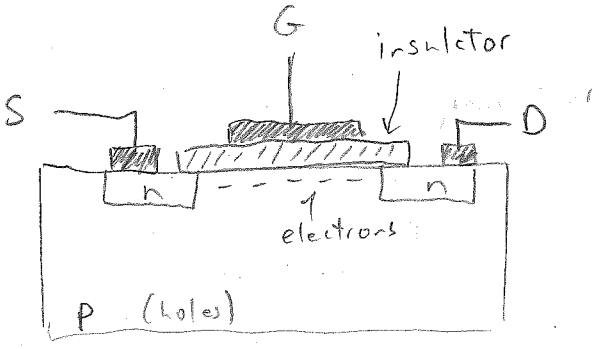


carriers depleted

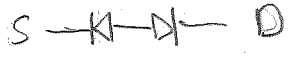
Increases resistance R_{DS}

Big enough V_G, $I_{DS} \to 0$

MOSFET:
(NMOS enhancement)



Here D → S looks like two diodes!



no conduction

If $V_G > 0$ applied, holes repelled from gate region

Large enough V_G, electrons pulled into conduction band

⇒ material starts to look n-type

⇒ get conduction