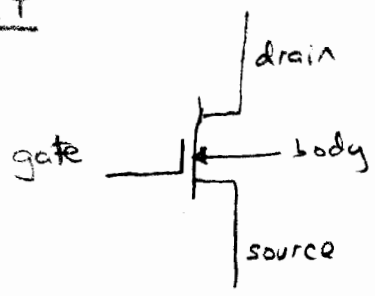
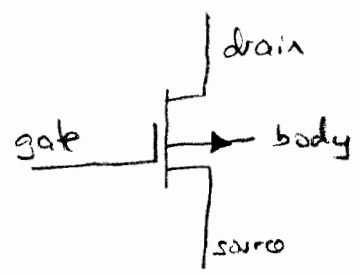


"Field Effect Transistor" = FET

MOSFET



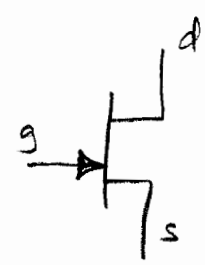
n-channel MOSFET



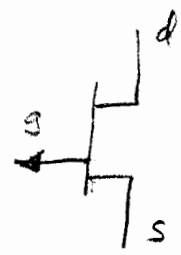
p-channel MOSFET

the body pin is often unconnected on MOSFET

JFET



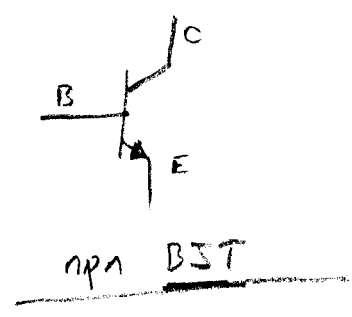
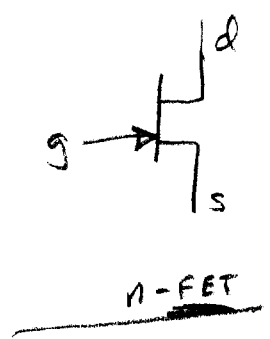
n-channel JFET



p-channel JFET

↑  
n-channel performs better,  
for JFETs

FET & BJT similarities



<u>input:</u>	gate	base
<u>output:</u>	d-s current $I_D$	c-E current $I_C$

↑ the input controls an output current in both

<u>circuit types</u>	amplifier switch current source	amplifier switch current source
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# FET & BJT differences



FET

input (gate)  
draws NO  
current

↳ ultra-high  
 $Z_{in}$ , up to  $10^{14} \Omega$

has no forward-biased  
diode junction

manufacturing variances,  
parameters really bad

$$I_D = k(V_{GS} - V_T)^2$$

↑  
gate bias  $V_{GS}$   
controls the  
output current  $I_D$

$V_T$  = threshold voltage



BJT

input (base)  
draws current

$Z_{in}$  is much lower

has forward biased  
B-E diode junction

not as bad, but still  
significant

$$I_C = h_{FE} I_B$$

base current  $I_B$   
controls the  
output current  $I_C$

## FET vs. BJT, continued

power-supply notation

	<u>+15V or +12V</u>	<u>-15V or -12V</u>
circuit uses BJTs	$+V_{CC}$	$-V_{EE}$
circuit uses FETs	$+V_{DD}$	$-V_{SS}$

# FET vs BJT continued

where they're used:

as discrete components, FETs are less common

common uses of discrete FETs:

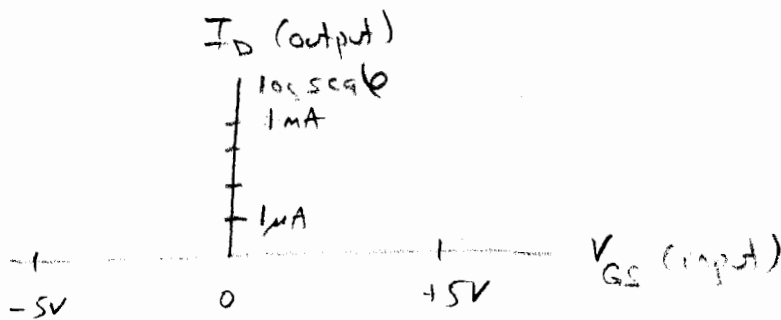
- power switches - MOSFETs are ideal for this, 200A or 1kV is possible
- current diodes - uses JFETs, see below
- input stage for amplifiers - JFETs provide a high  $Z_{in}$  for the instrument, which might use BJTs elsewhere in circuit

in ICs (integrated circuits), FETs are very common

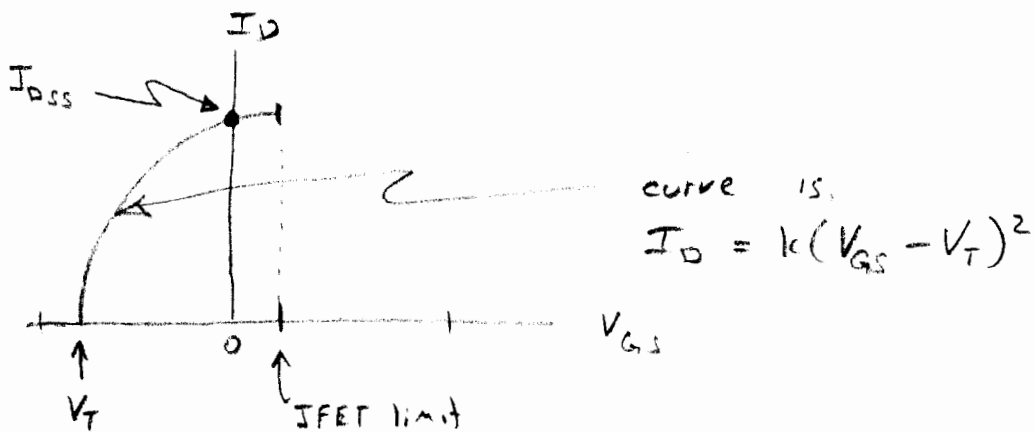
- logic chips, e.g., CMOS for computer
- input stages of op-amps
- special FET chips, e.g., analog switch

# FET current-voltage characteristic curves

graph output current vs. input voltage



## JFET

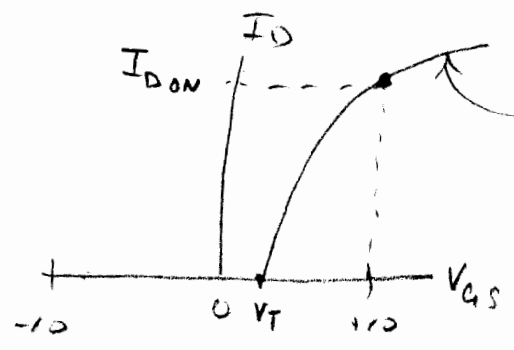


curve straddles

$V_{GS} = 0 \Rightarrow$  "depletion mode"

JFETs are always "depletion mode"

MOSFET



$I_D = k(V_{GS} - V_T)^2$  shown for n-channel MOSFET

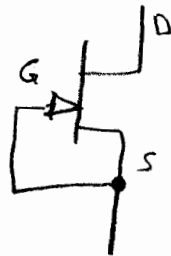
the curve is entirely for  $V_{GS} > 0$ , transistor is "enhancement mode"

for power switching with MOSFET

- apply an input of  $V_{GS} = 0$  (or any  $V_{GS} < V_T$ )  
 & there will be no output current,  
 $I_D = 0 \Rightarrow$  "OFF"
- apply an input  $V_{GS} \approx +10V$   
 & transistor's output current can become large "ON"

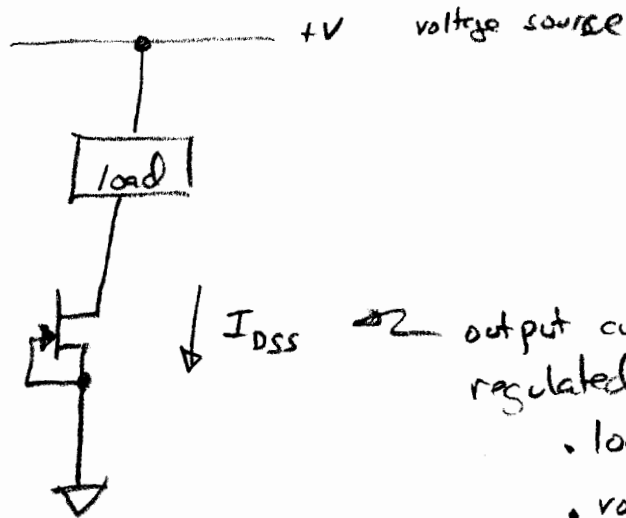
Current diodes

↑ a JFET used as a current source



short the gate & source  
⇒ 2-terminal device

use as a current source:



↔ output current is regulated, regardless of:

- load resistance
- voltage input

compared to other current sources:

advantage: • simplicity

• output current not very dependent on load resistance

disadvantage: very sensitive to temp (0.4% per degree C)



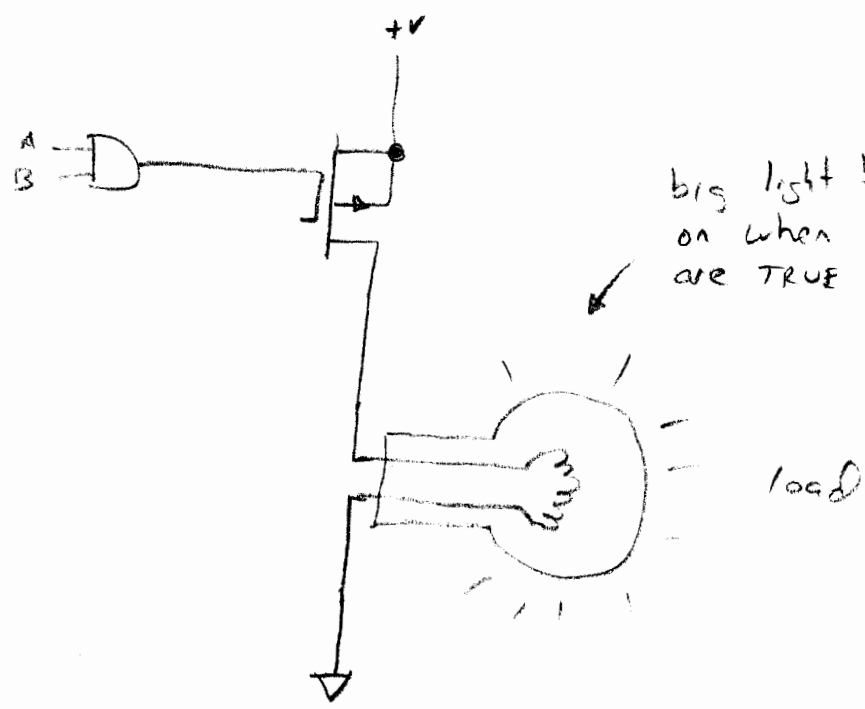
# Typical Application of Power Mosfet for switching

Suppose you want to pass a large current thru a load when two logic inputs are TRUE.



AND gate

output of logic chip can source/sink only milliamps of current



big light bulb turns on when both A & B are TRUE

## MOSFET handling precaution

static electricity kills!

- when handling, ground yourself first, then don't move body
- storage, use special conductive bags or foam

↗ precautions for integrated circuits, discrete devices, & circuit boards