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

**n-FET**

- Input: Gate
- Output: drain current (I_D)

**n-p-n BJT**

- Input: Base
- Output: collector current (I_C)

- The input controls an output current in both circuit types.

Circuit types:

- Amplifier
- Switch
- Current source
FET & BJT differences

**FET**

- **Input (gate)**
  - draws no current
  - gate voltage, up to 10^6 V

- **has no forward-biased diode junction**
  - manufacturing variances can be quite small

- **I_D = k(V_{GS} - V_T)^3**
  - gate bias V_{GS}
  - controls the output current I_D
  - V_T: threshold voltage

**BJT**

- **Input (base)**
  - draws current

- **E_n is much lower**

- **has forward biased B-E diode junction**

- **I_C = I_B \cdot I_0**
  - base current I_B
  - controls the output current I_C
FET vs BJT, continued

Power-Supply Note

-15V or +12V

-15V or -12V

circuit uses
BJTs

+Vcc

-Vcc

circuit uses
FETs

+Vdd

-Vdd
FET vs BST continued

where they're used:

- **as discrete components, FETs are less common**
  - common uses of discrete FETs:
    - **power switches** - JFETs are ideal for this, ZPA or 25V is possible
    - **current diodes** - uses JFETs, see below
    - **input stage for amplifiers** - JFETs provide a high Zm for the instrument, which might use BJT's 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

\[ I_D (\text{output}) \]

\[ I_{LS} \]

\[ I_{G} \]

\[ V_{GS} (\text{input}) \]

\[ V_I \]

\[ V_{G,S} \]

\[ I_D = k(\sqrt{V_{G,S} - V_I})^2 \]

Curve is always "depletion mode"
$I_D = h (V_{GS} - V_T)$ shown for n-channel MOSFET

The curve is

-Only for $V_{GS} > V_T$

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 $V_{GS} > 10V$
  - Transistor's output current can become large "ON"
Current diodes

A FET used as a current source

\[ V \quad \text{voltage source} \]
\[ \text{load} \]
\[ \text{loss} \]

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.

\[
\text{Input A} \quad \text{Output} \quad \text{Input B} \quad \text{and gate}
\]

Output of logic chip can source sink only milliams of current

\[
\text{Input A} \quad \text{and} \quad \text{Input B} \quad \text{sink}
\]

Big light bulb turns on when both A and B are TRUE

\[
\text{Load D}
\]
MOSFET handling precautions

Static electricity kills!

* When handling, ground yourself first, then don't move body.

* Storage, use special conductive bags or foam.

Caution: For integrated circuits, discrete devices, & circuit boards.