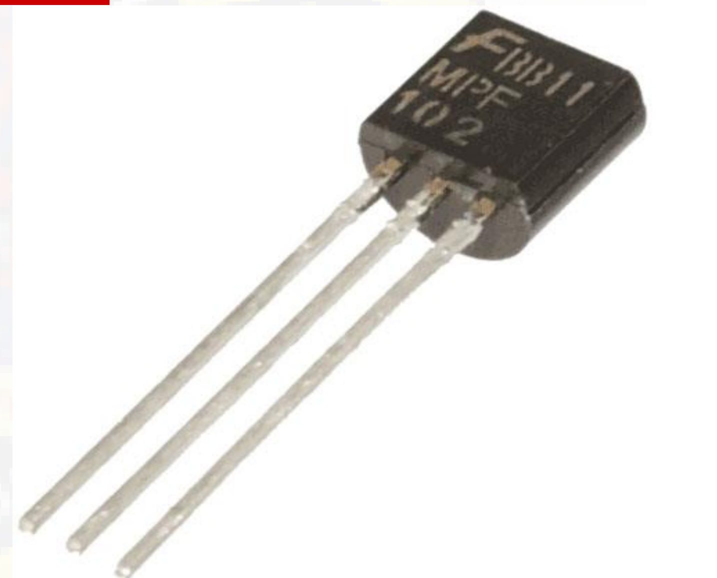
UNIT IV

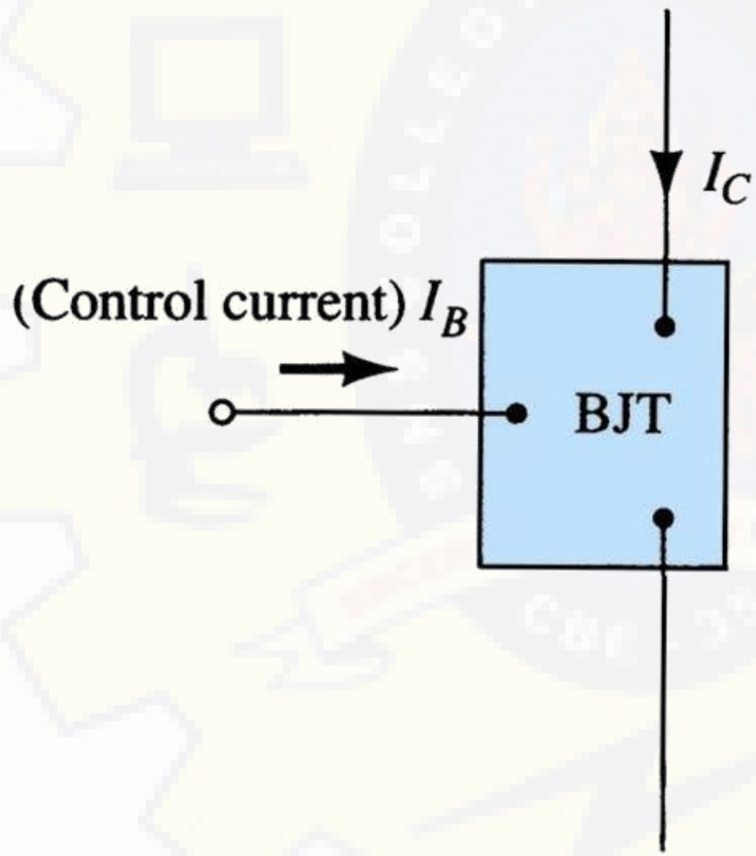


JUNCTION FIELD EFFECT TRANSISTOR

Introduction (FET)

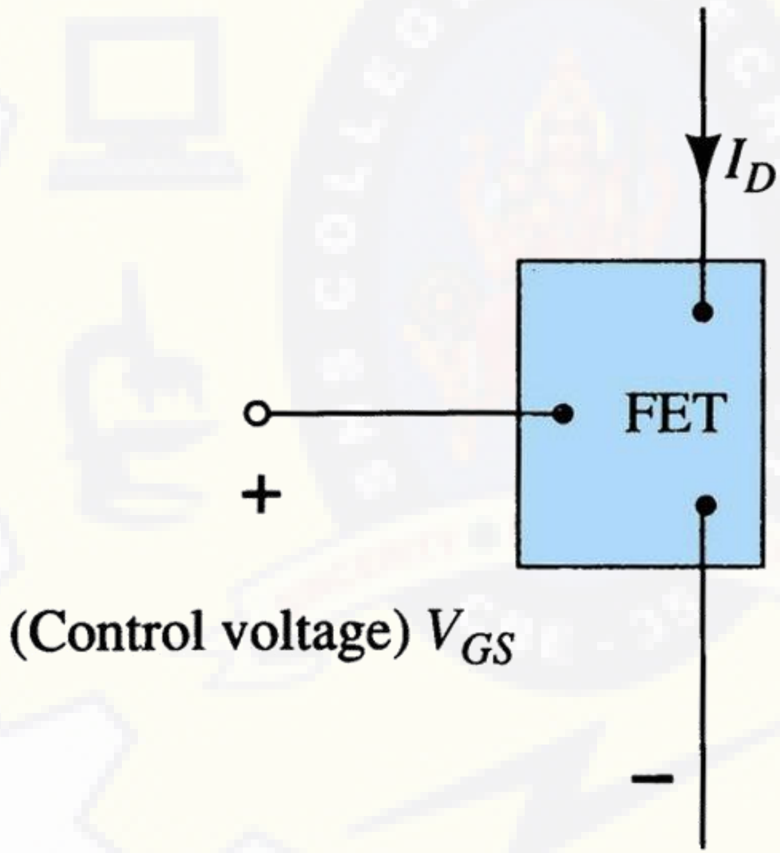
- Field-effect transistor (FET) are important devices such as BJTs
- Also used as amplifier and logic switches
- What is the difference between JFET and BJT?

BJT is Current-controlled



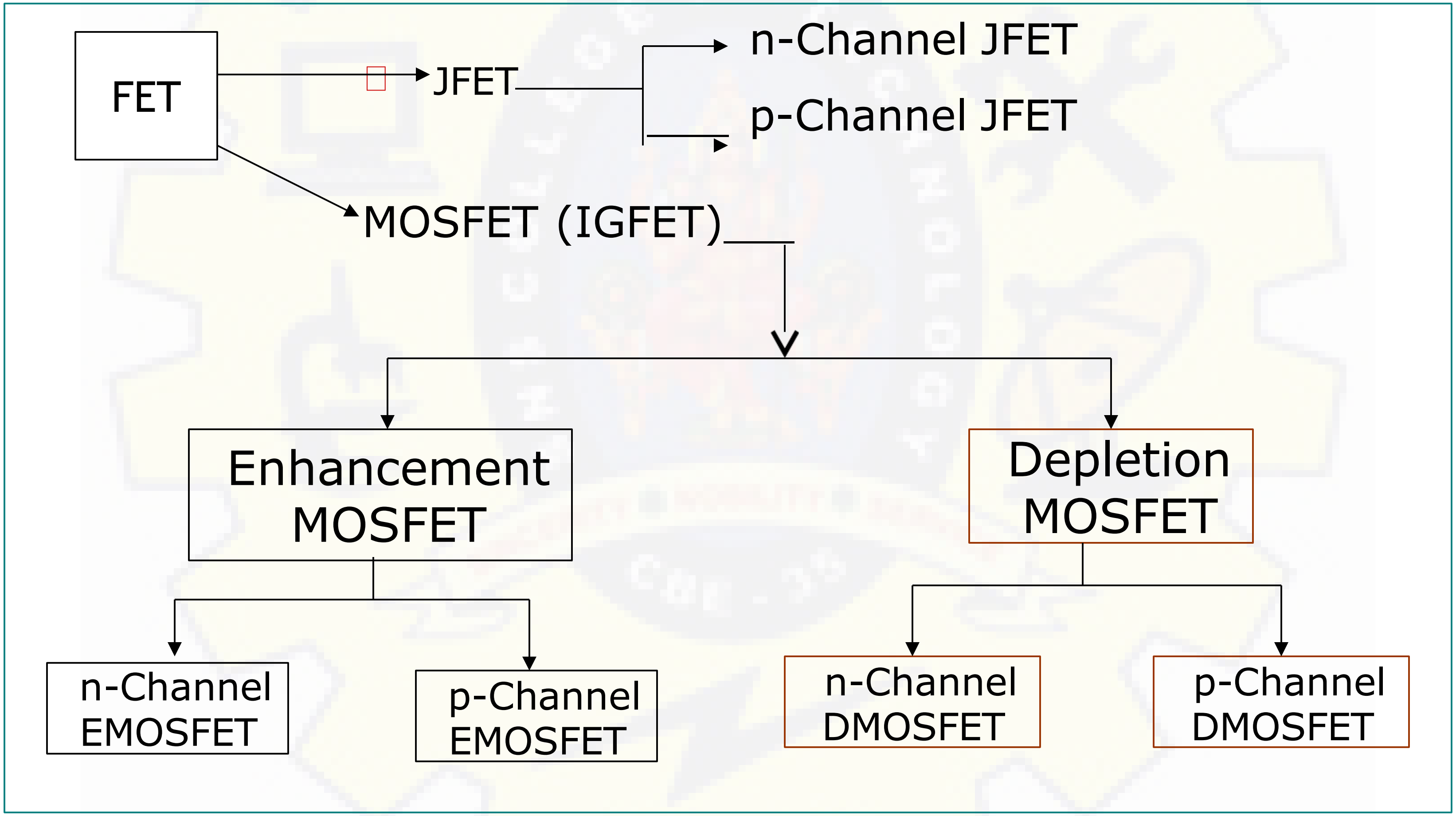
(a)

FET is Voltage-controlled



(b)

Types of Field Effect Transistors (The Classification)



Introduction.. (Advantages of FET over BJT)

- High input impedance (MΩ) (Linear AC amplifier system)
- Temperature stable than BJT
- Smaller than BJT
- Can be fabricated with fewer processing
- BJT is bipolar – conduction both hole and electron
- FET is unipolar – uses only one type of current carrier
- Less noise compare to BJT
- Usually use as an Amplifier and logic switch

Disadvantages of FET

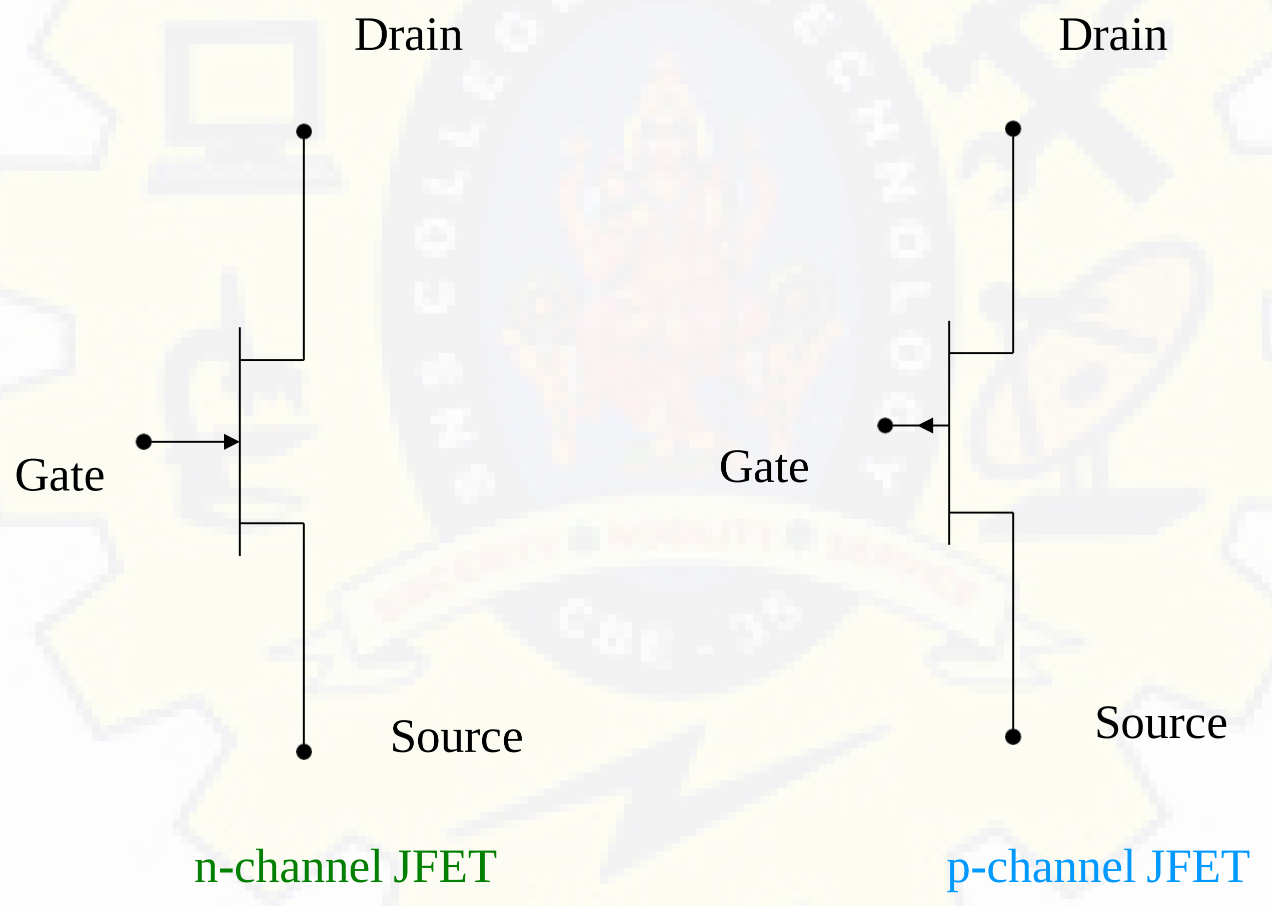
- Easy to damage compare to BJT

Junction field-effect transistor..

- There are 2 types of JFET
  - n-channel JFET
  - p-channel JFET

- Three Terminal
  - Drain – D
  - Gate -G
  - Source – S

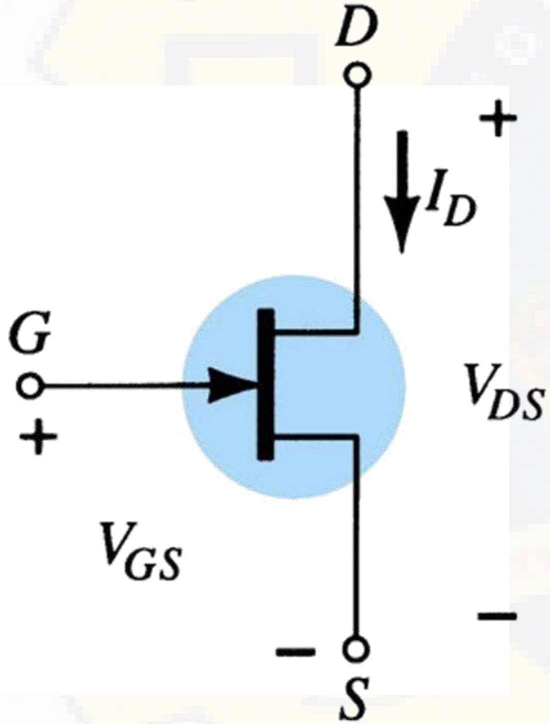
SYMBOLS


Drain
Gate
Source
n-channel JFET
Drain
Gate
Source
p-channel JFET

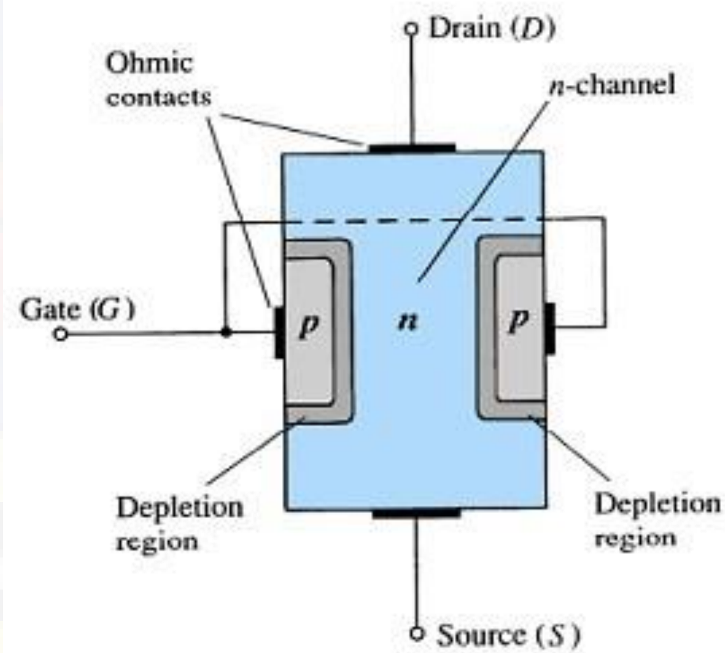
N-channel JFET

- N channel JFET:
  - Major structure is n-type material (channel) between embedded p-type material to form 2 p-n junction.
  - In the normal operation of an n-channel device, the Drain (D) is positive with respect to the Source (S). Current flows into the Drain (D), through the channel, and out of the Source (S)
  - Because the resistance of the channel depends on the gate-to-source voltage (V_{GS}), the drain current (I_D) is controlled by that voltage

N-channel JFET..



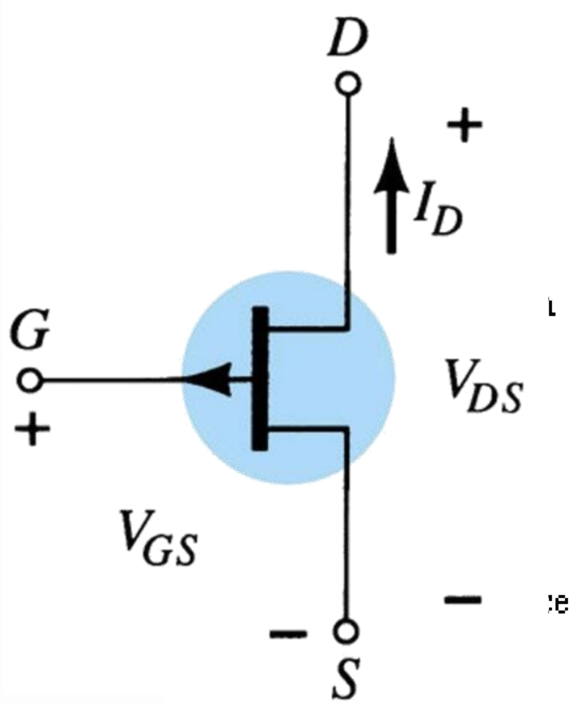
(a)



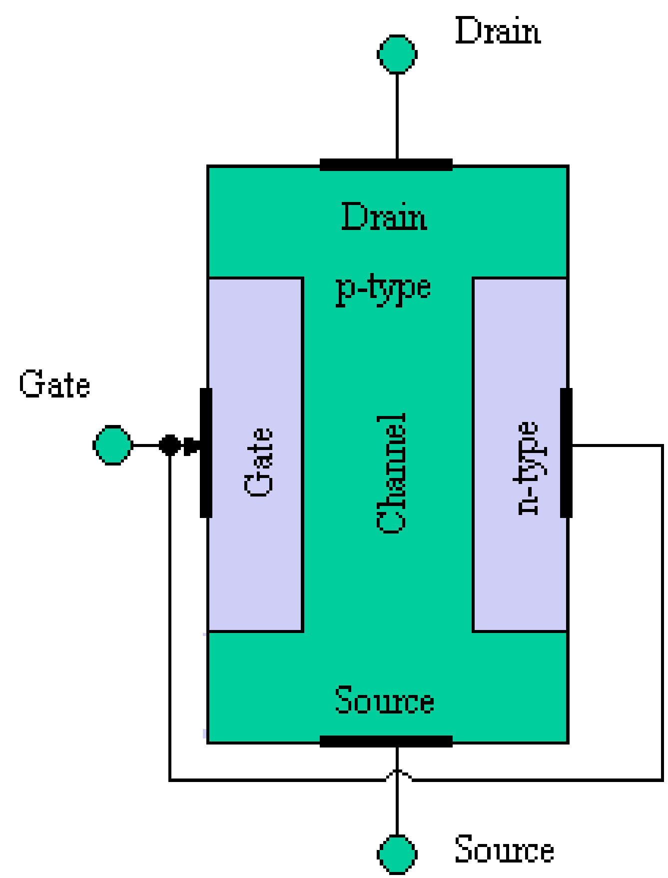
P-channel JFET

- P channel JFET:
  - Major structure is p-type material (channel) between embedded n-type material to form 2 p-n junction.
  - Current flow : from Source (S) to Drain (D)
  - Holes injected to Source (S) through p-type channel and flowed to Drain (D)

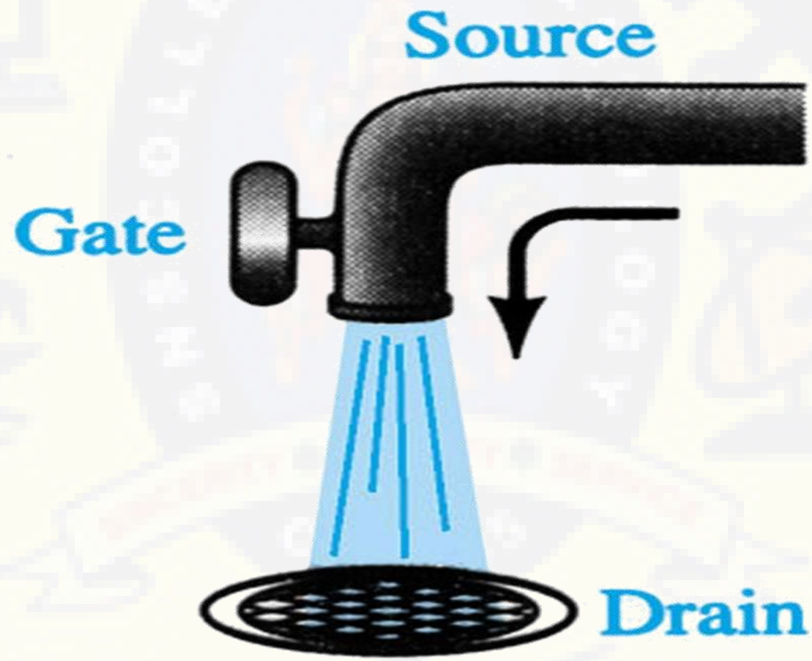
P-channel JFET..

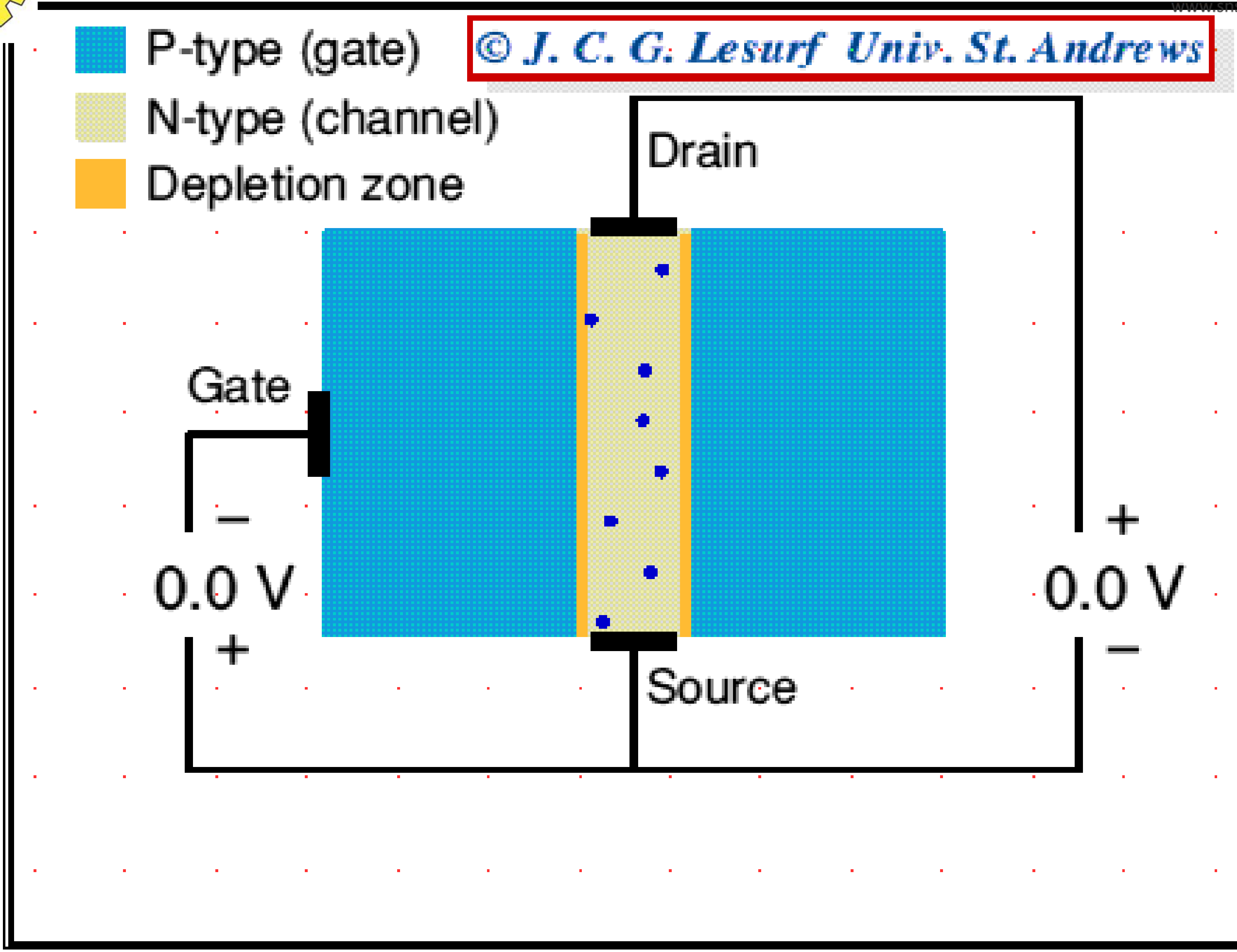


(b)



Water analogy for the JFET control mechanism




P-type (gate)
N-type (channel)
Depletion zone
© J. C. G. Lesurf Univ. St. Andrews
Drain
Gate
–
0.0 V
+
+
0.0 V
–
Source

JFET Operating Characteristics

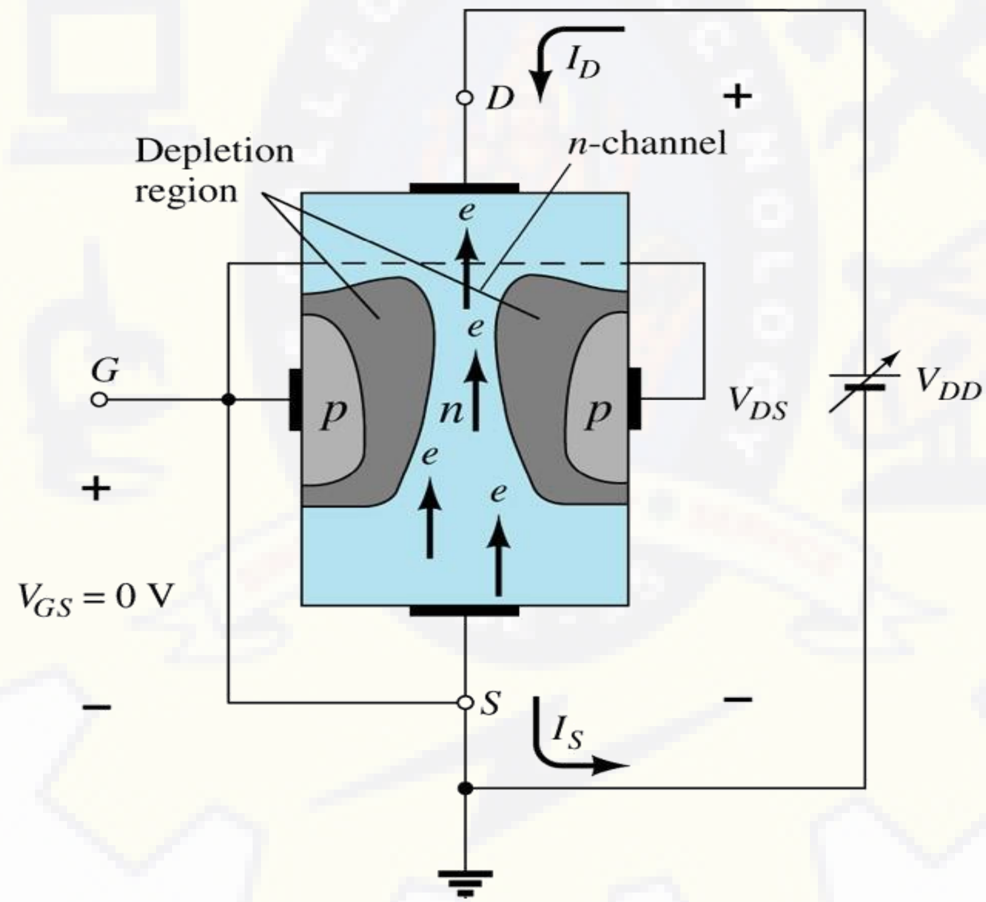
There are three basic operating conditions for a JFET:

- $V_{GS} = 0$, V_{DS} increasing to some positive value
- $V_{GS} < 0$, V_{DS} at some positive value
- Voltage-controlled resistor

JFET Characteristic for V_{GS} = 0 V and 0<V_{DS}<|V_p|

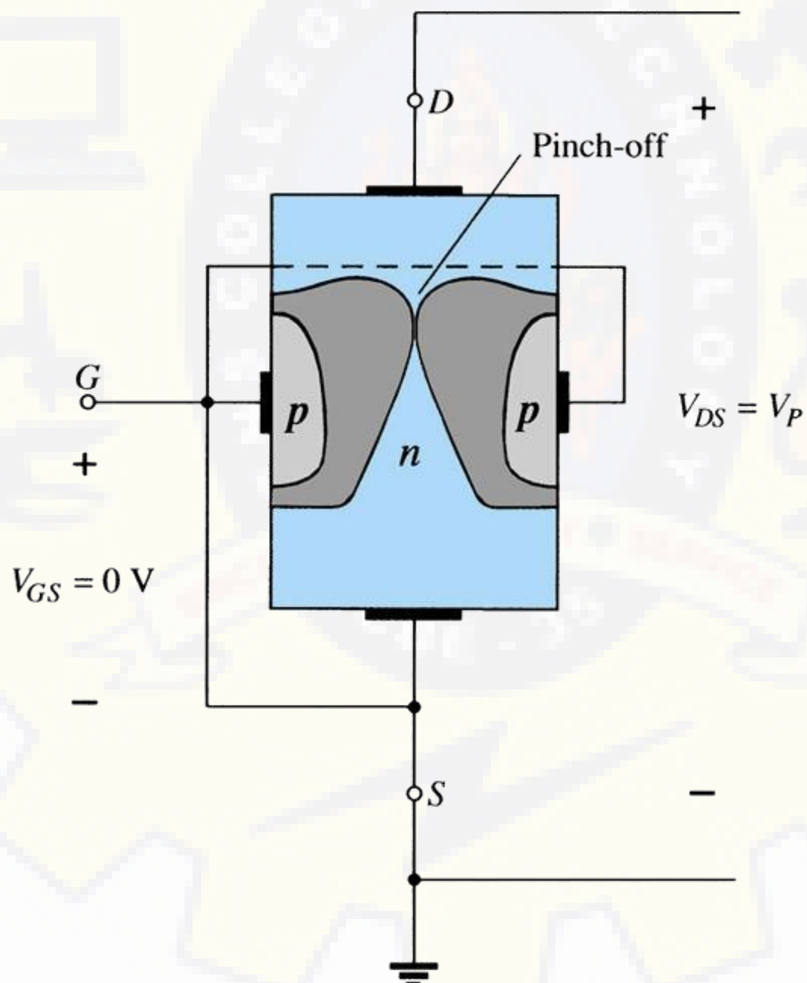
- To start, suppose V_{GS}=0
- Then, when V_{DS} is increased, I_D increases. Therefore, I_D is proportional to V_{DS} for small values of V_{DS}
- For larger value of V_{DS}, as V_{DS} increases, the depletion layer become wider, causing the resistance of channel increases.
- After the pinch-off voltage (V_p) is reached, the I_D becomes nearly constant (called as I_D maximum, I_{DSS}-Drain to Source current with Gate Shorted)

JFET for V_{GS} = 0 V and $0<V_{DS}<|V_p|$



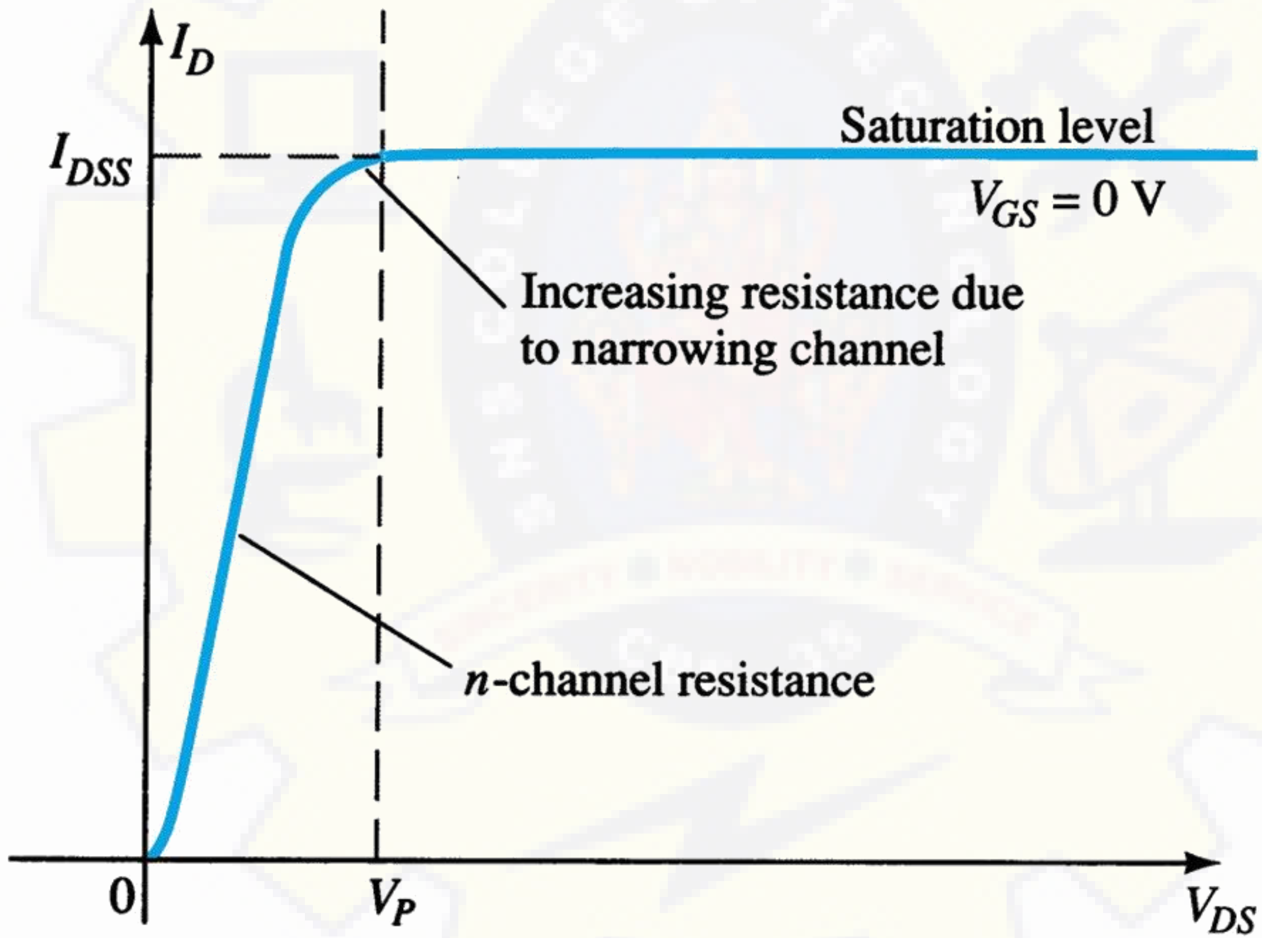
Channel becomes narrower as V_{DS} is increased

Pinch-off (V_{GS} = 0 V, V_{DS} = V_P).



I_D versus V_{DS}

for V_{GS} = 0 V and $0<V_{DS}<|V_p|$



JFET Characteristic Curve

$V_{GS} < 0$, V_{DS} at some positive value

JFET Characteristic Curve..

- For negative values of V_{GS}, the gate-to-channel junction is reverse biased even with $V_{DS}=0$
- Thus, the initial channel resistance of channel is higher.
- The resistance value is under the control of V_{GS}
- If V_{GS} = pinch-off voltage(V_P)

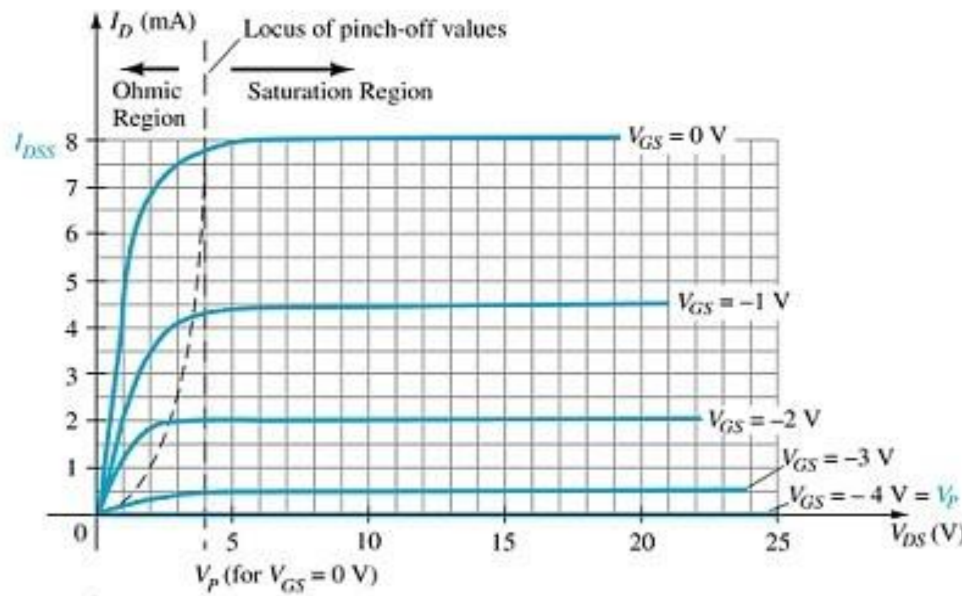
  The device is in cutoff ($V_{GS}=V_{GS(off)} = V_P$)
- The region where I_D constant – The saturation/pinch-off region
- The region where I_D depends on V_{DS} is called the linear/ohmic region

$V_{GS} < 0$, V_{DS} at some positive value

JFET Operating Characteristics

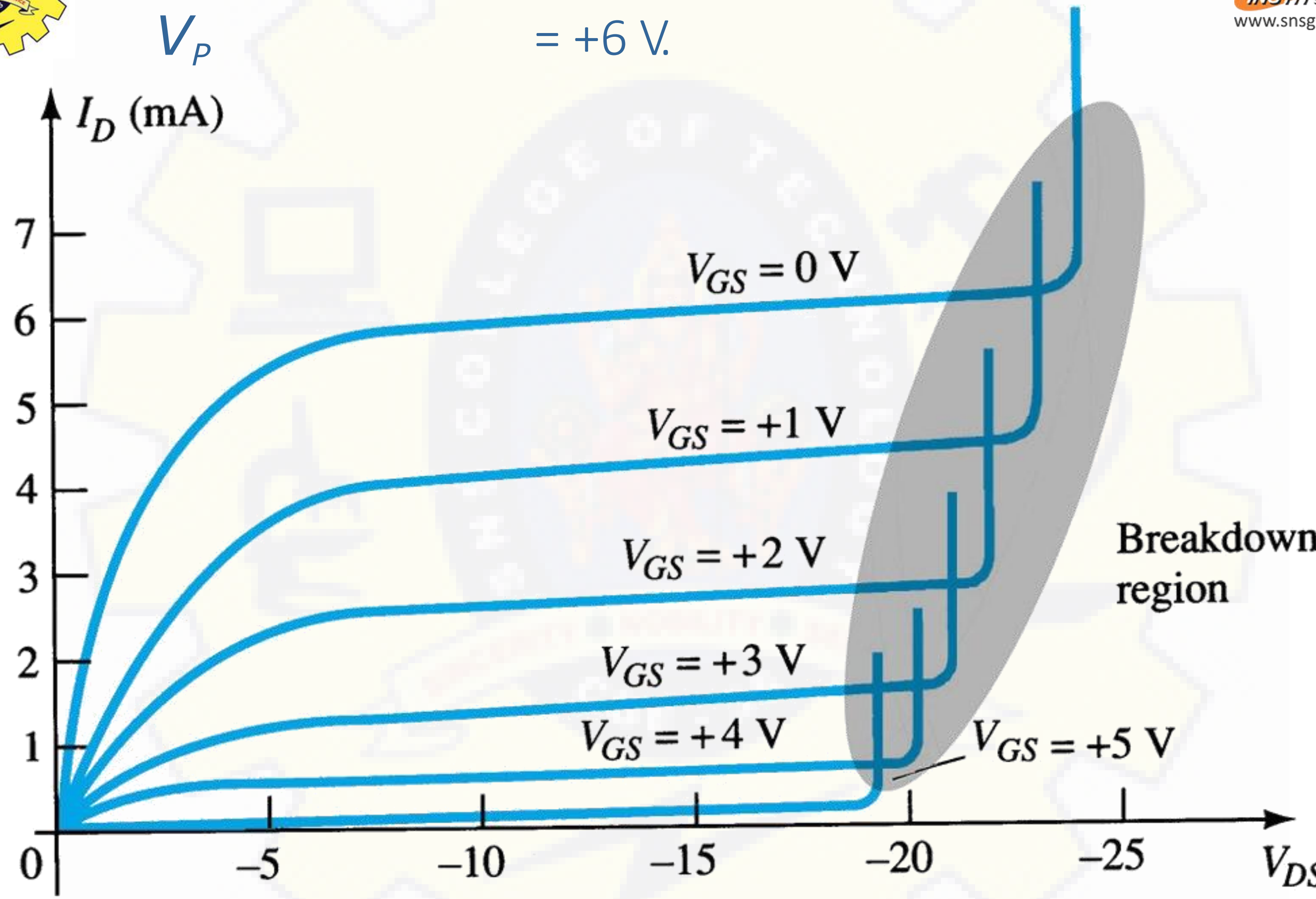
As V_{GS} becomes more negative:

- **The JFET experiences pinch-off at a lower voltage (V_P).**
- **I_D decreases ($I_D < I_{DSS}$) even though V_{DS} is increased.**
- **Eventually I_D reaches 0 A. V_{GS} at this point is called V_p or $V_{GS(off)}$.**



Also note that at high levels of V_{DS} the JFET reaches a breakdown situation. I_D increases uncontrollably if $V_{DS} > V_{DSmax}$.

p-Channel JFET characteristics with I_{DSS} = 6 mA and V_P = +6 V.



Transfer Characteristics

The input-output transfer characteristic of the JFET is not as straight forward as it is for the BJT. In BJT:

$$I_C = \beta\, I_B$$

which β is defined as the relationship between I_B (input current) and I_C (output current).