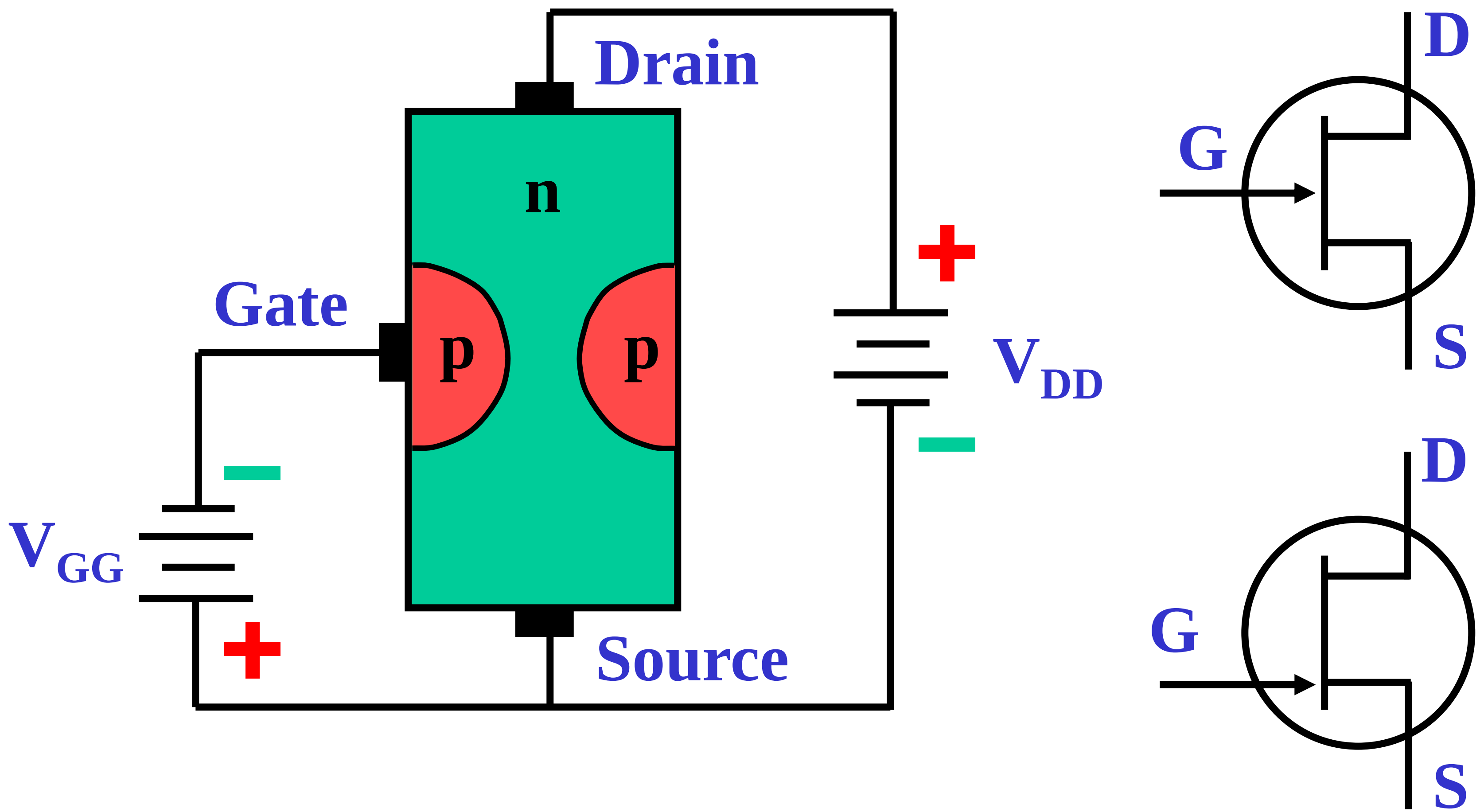
J-FET
(Junction Field Effect Transitor)

Elektronika
(TKE 4012)

Eka Maulana

maulana.lecture.ub.ac.id

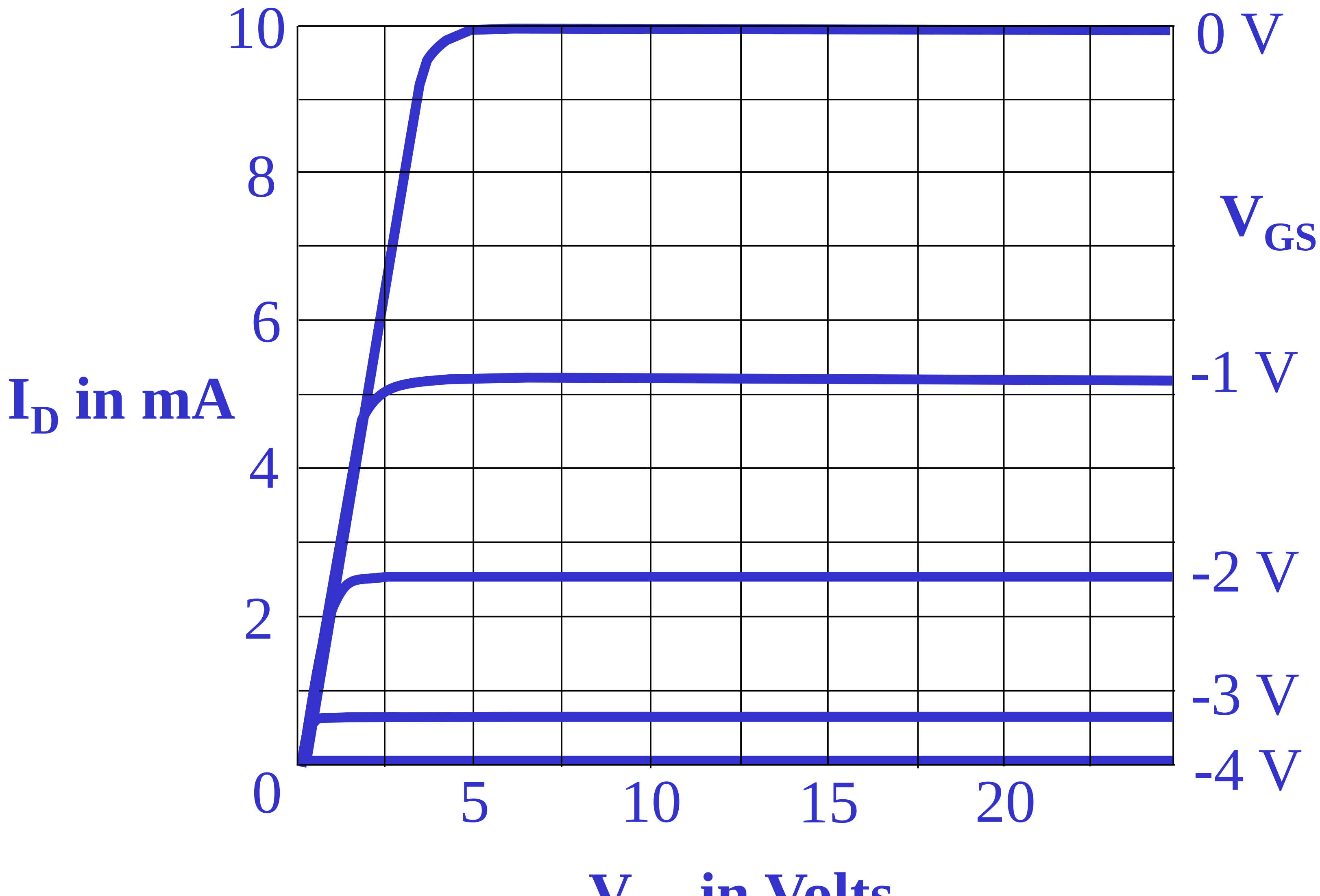
Junction field effect transistor (JFET)



JFET

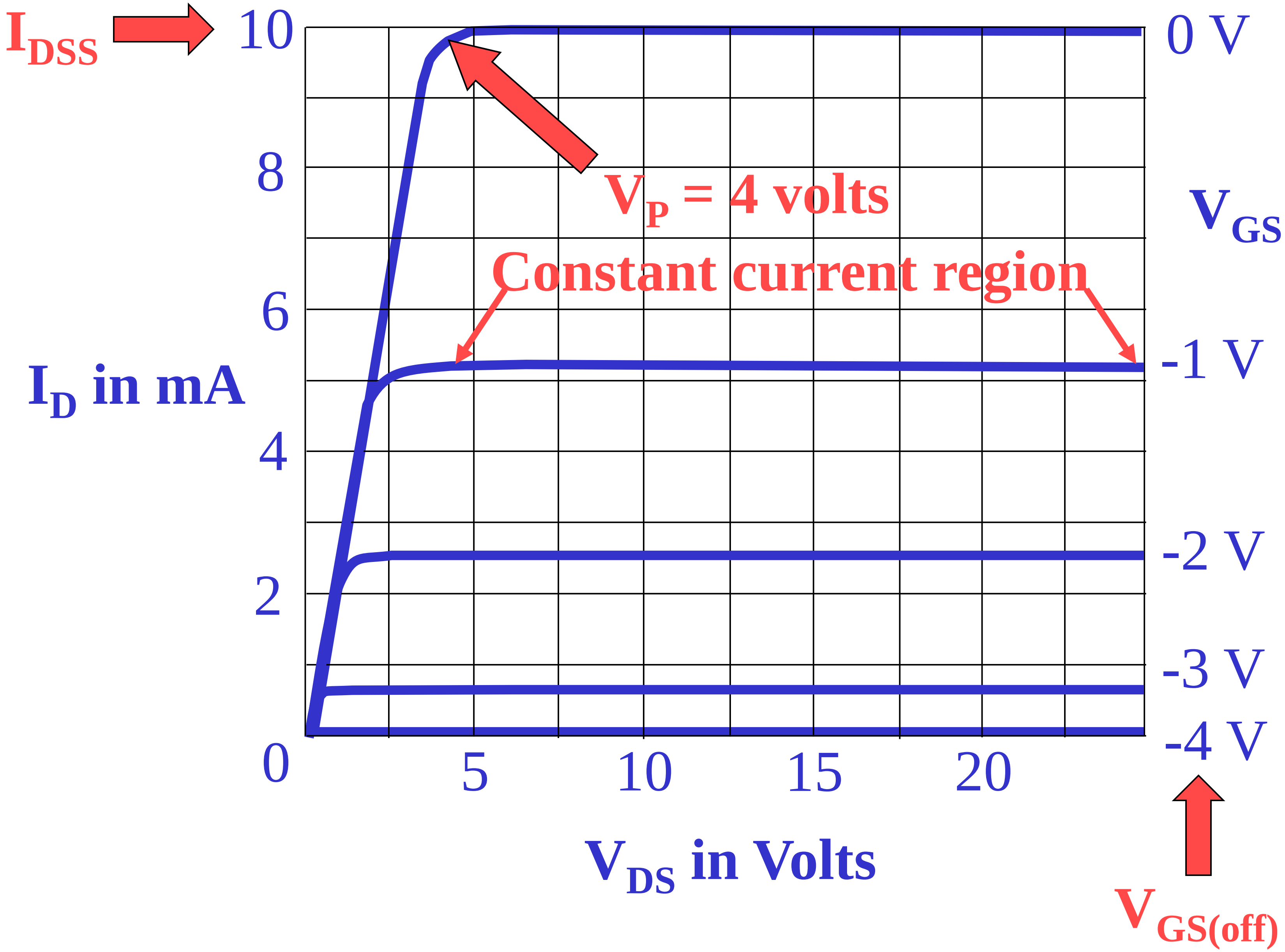
- Unipolar device (one polarity of charge carrier)
- Voltage controlled (gate voltage controls drain current)
- High input impedance
- No minority carrier storage
- Source and drain are interchangeable in most low-frequency applications

Drain family of curves



Drain curves

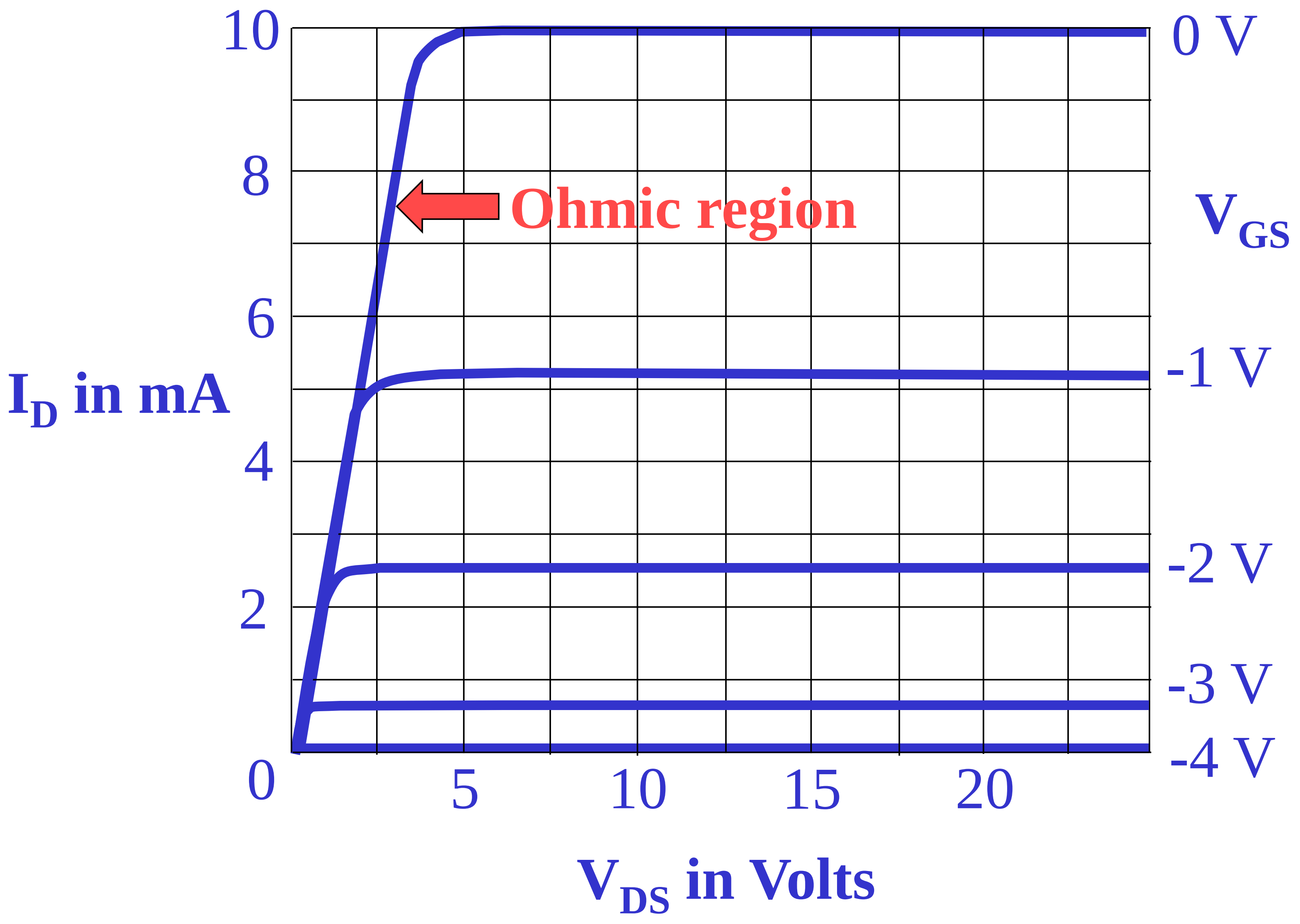
- With V_{GS} = 0 the drain current is maximum at I_{DSS}
- V_P = the pinchoff voltage
- When $V_{DS} = V_P$ the depletion layers almost touch
- With $V_{DS} > V_P$ the JFET acts as a current source
- $V_{GS(off)} = -V_P$



I_{DSS}
10
8
6
4
2
0
I_D in mA
5
10
15
20
V_{DS} in Volts
0 V
V_{GS}
-1 V
-2 V
-3 V
-4 V
$V_{GS(off)}$
V_P = 4 volts
Constant current region

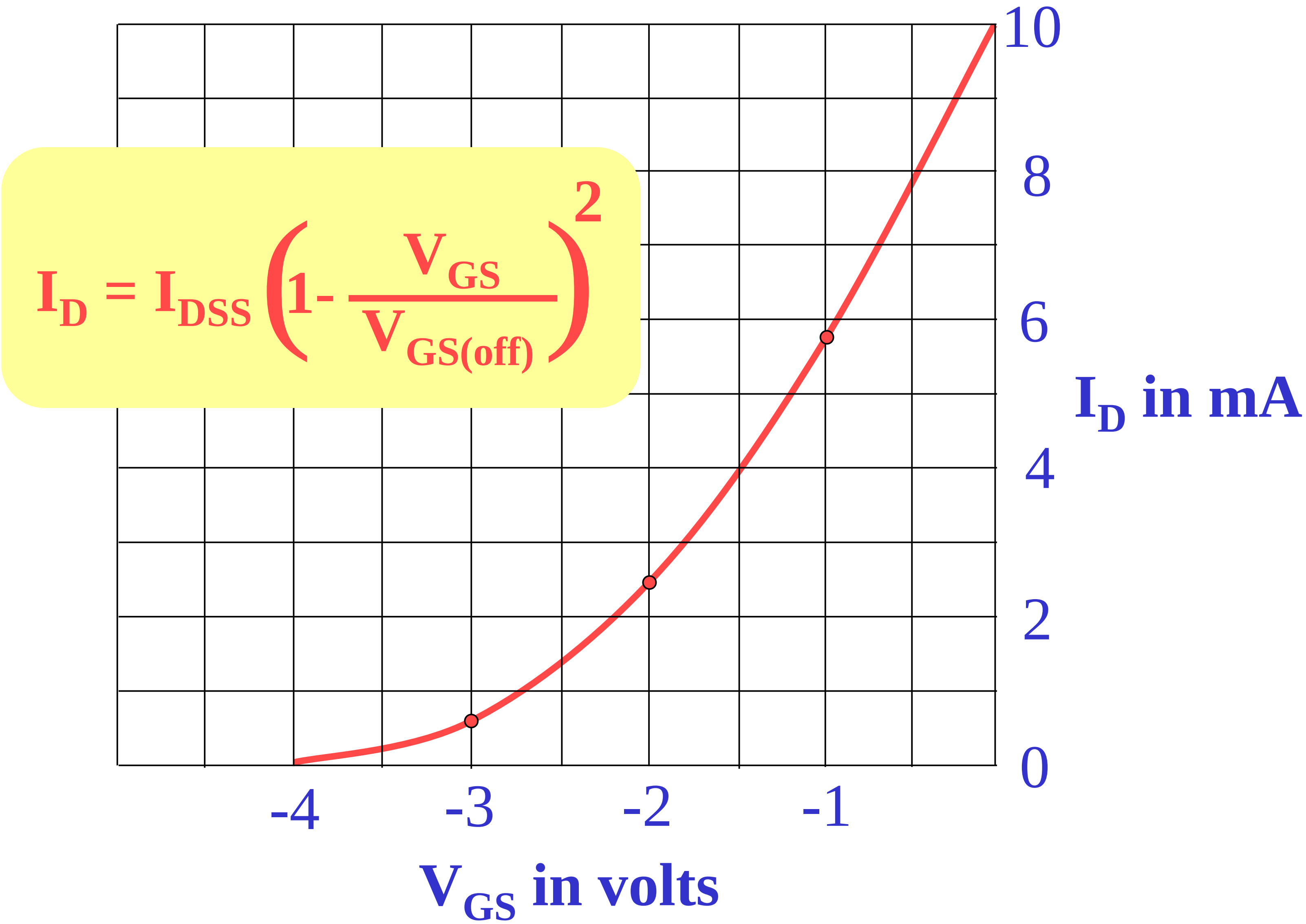
Ohmic region

- V_P separates the active region from the ohmic region.
- The ohmic region is the almost vertical part of the drain curve.
- In this region, a JFET acts as a resistor.
- $R_{DS} = V_P/I_{DSS}$

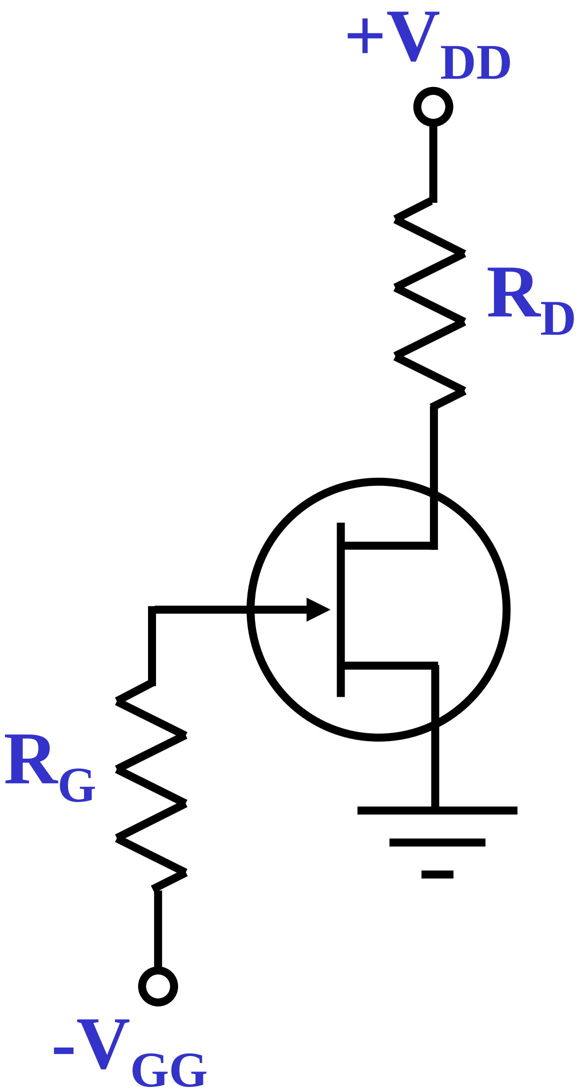


10
8
6
4
2
0
5
10
15
20
I_D in mA
V_DS in Volts
Ohmic region
0 V
V_GS
-1 V
-2 V
-3 V
-4 V

Transconductance curve

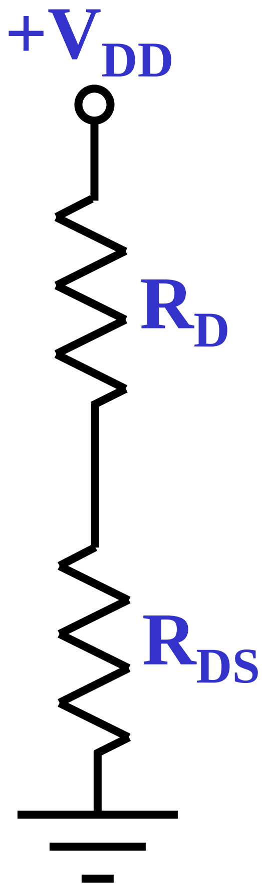


Gate bias is suitable for the *ohmic region*.



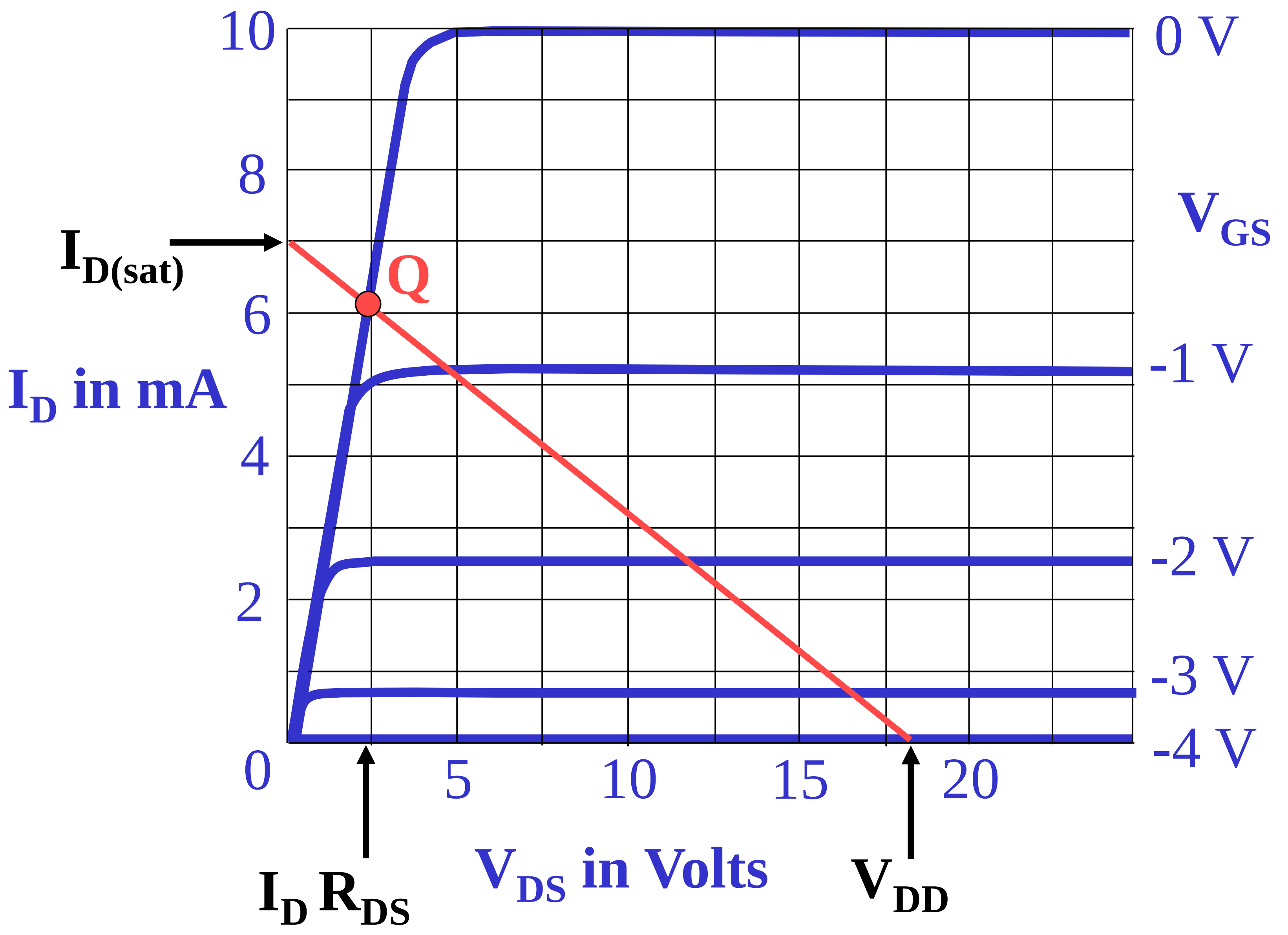
$$I_{D(sat)} = \frac{V_{DD}}{R_D}$$

Use 0 volts for V_{GS} and $I_{D(sat)} \ll I_{DSS}$.

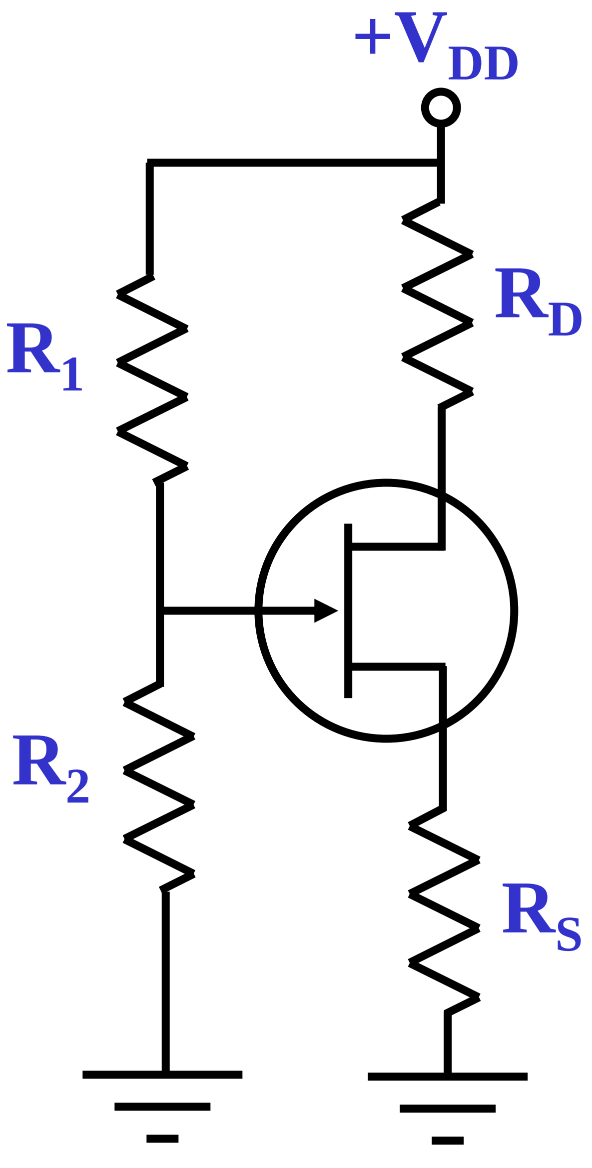


Equivalent circuit

Q point in the ohmic region



Voltage-divider bias



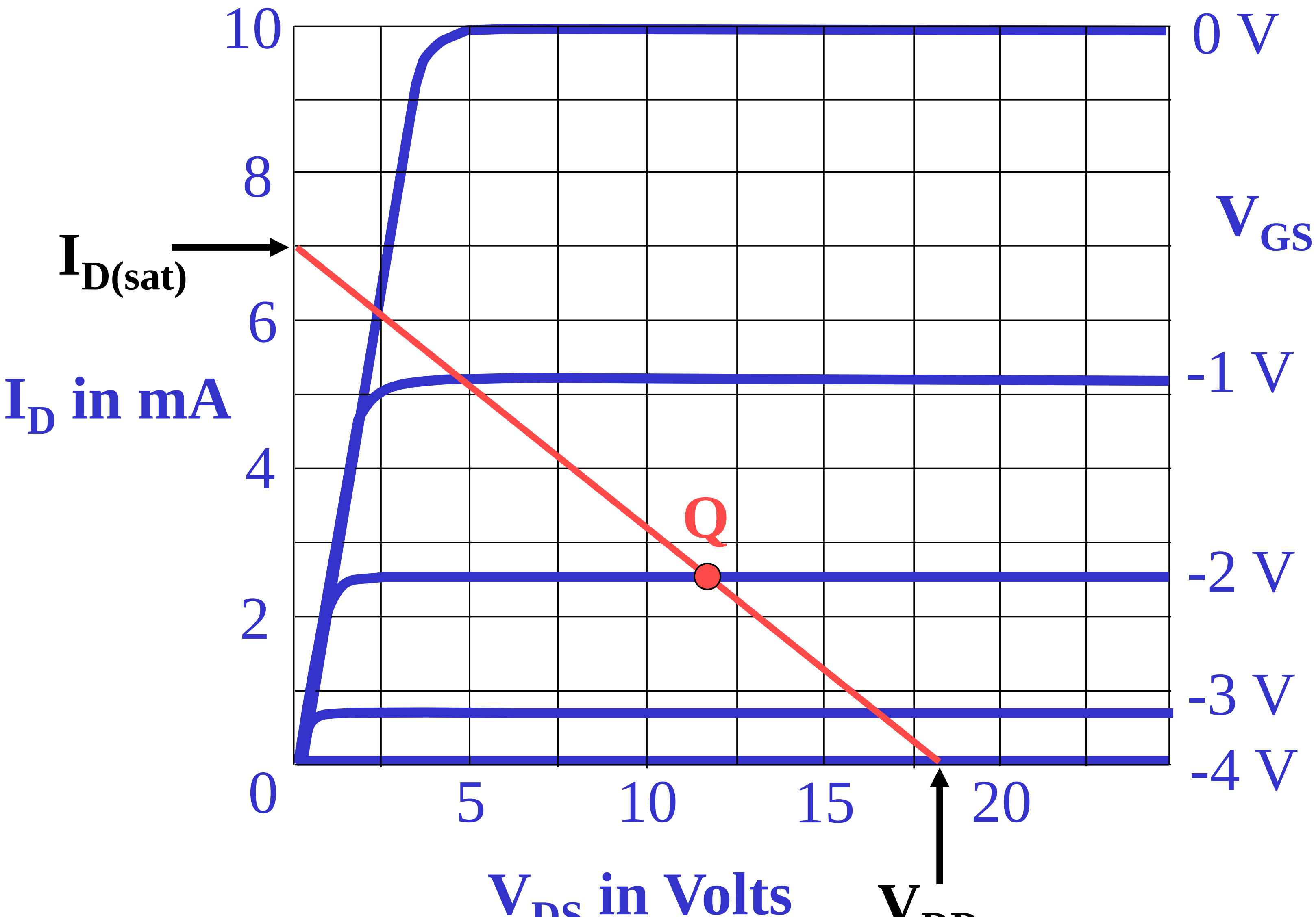
Gate bias is not suitable for the active region.

$$I_{D(sat)} = \frac{V_{DD}}{R_D + R_S}$$

$$V_S = V_G - V_{GS}$$

$$I_{DQ} = \frac{V_G - V_{GS}}{R_S}$$

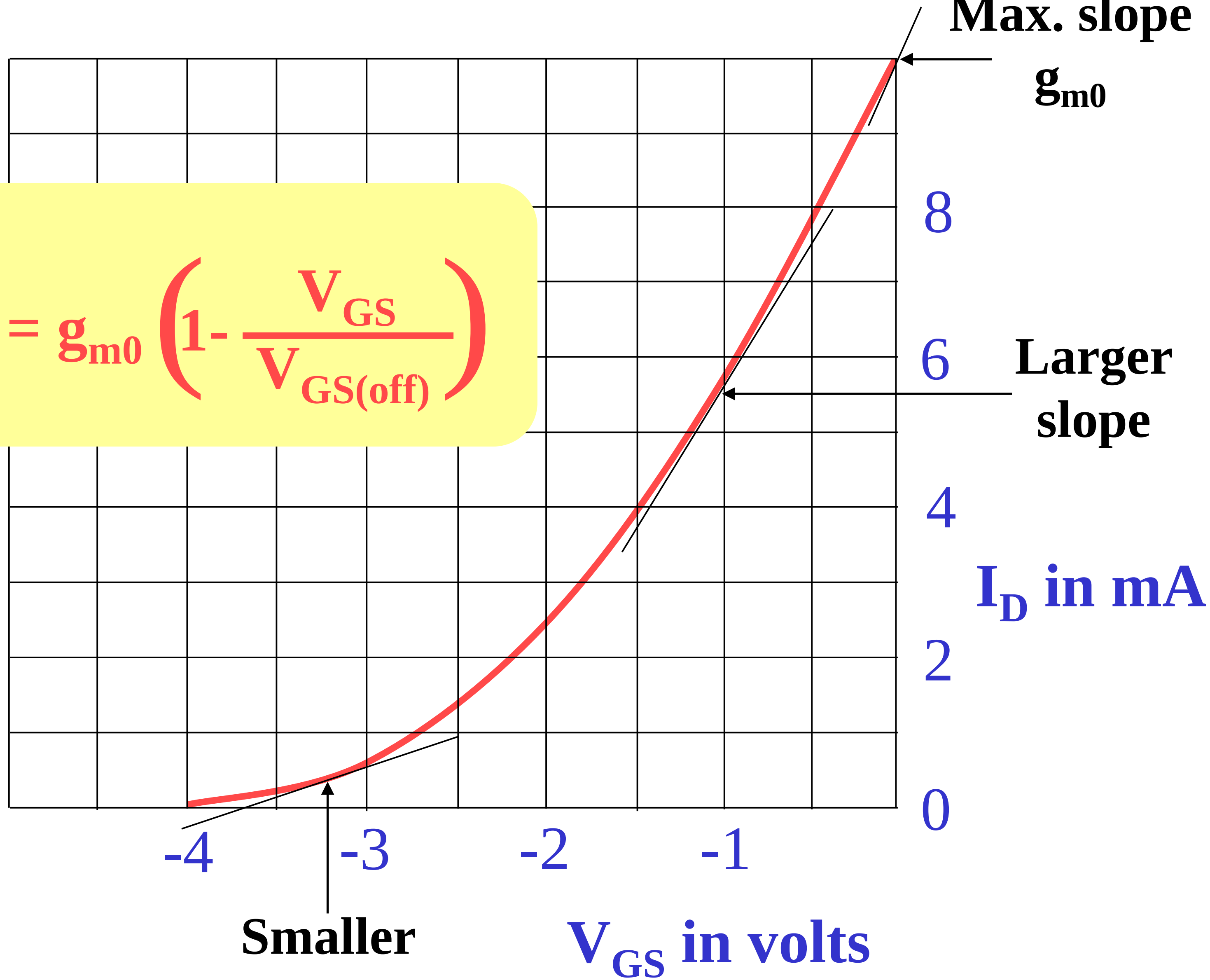
Q point in the active region



Transconductance

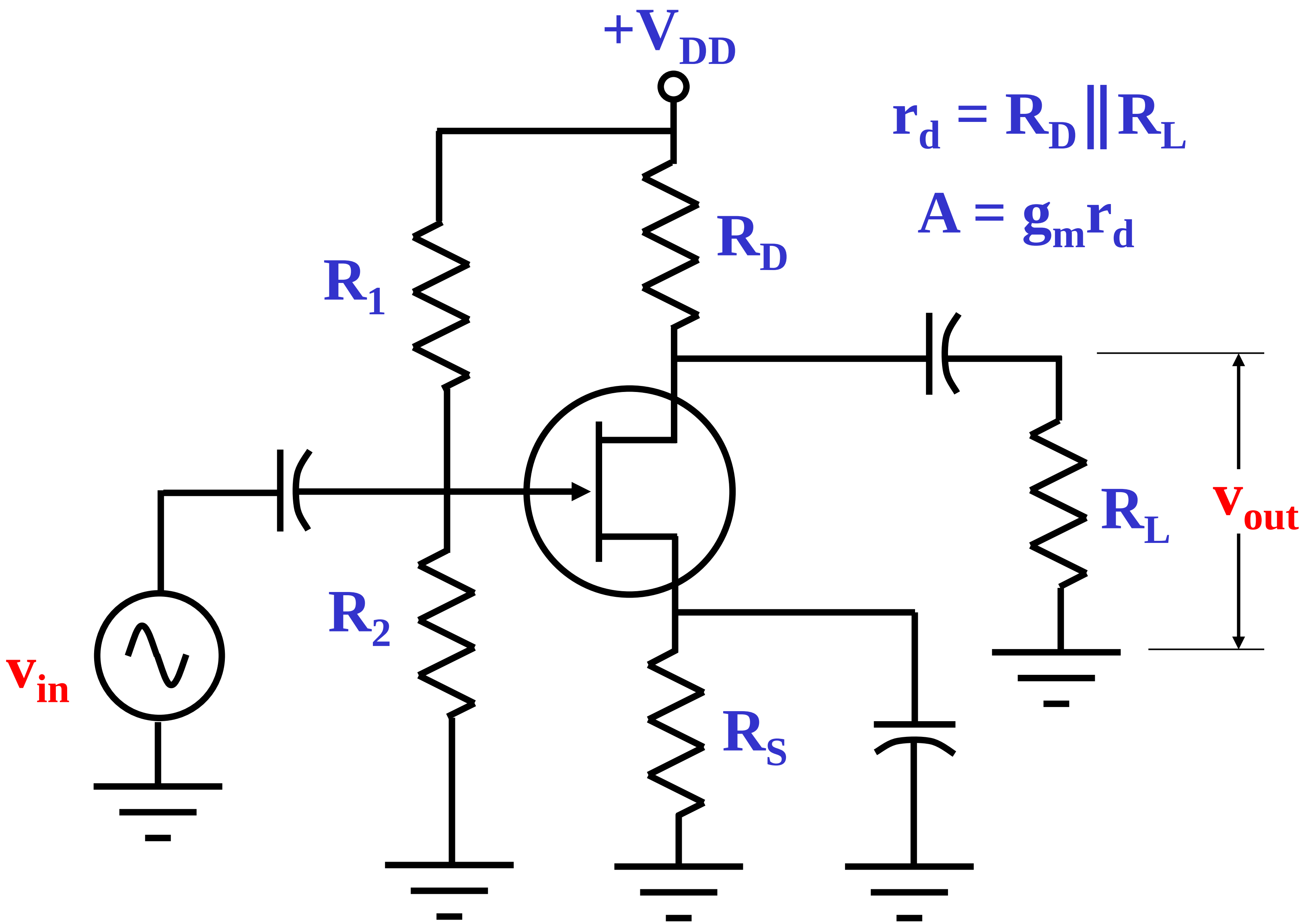
- Tells how effective the gate voltage is in controlling the drain current.
- $g_m = i_d/v_{gs}$
- Common units for JFETs are the micromho (μmho) or the more modern microsiemen (μS).
- g_m is the slope of the transconductance curve.
- g_{m0} is the maximum value and occurs at $V_{GS} = 0$.

Transconductance curve

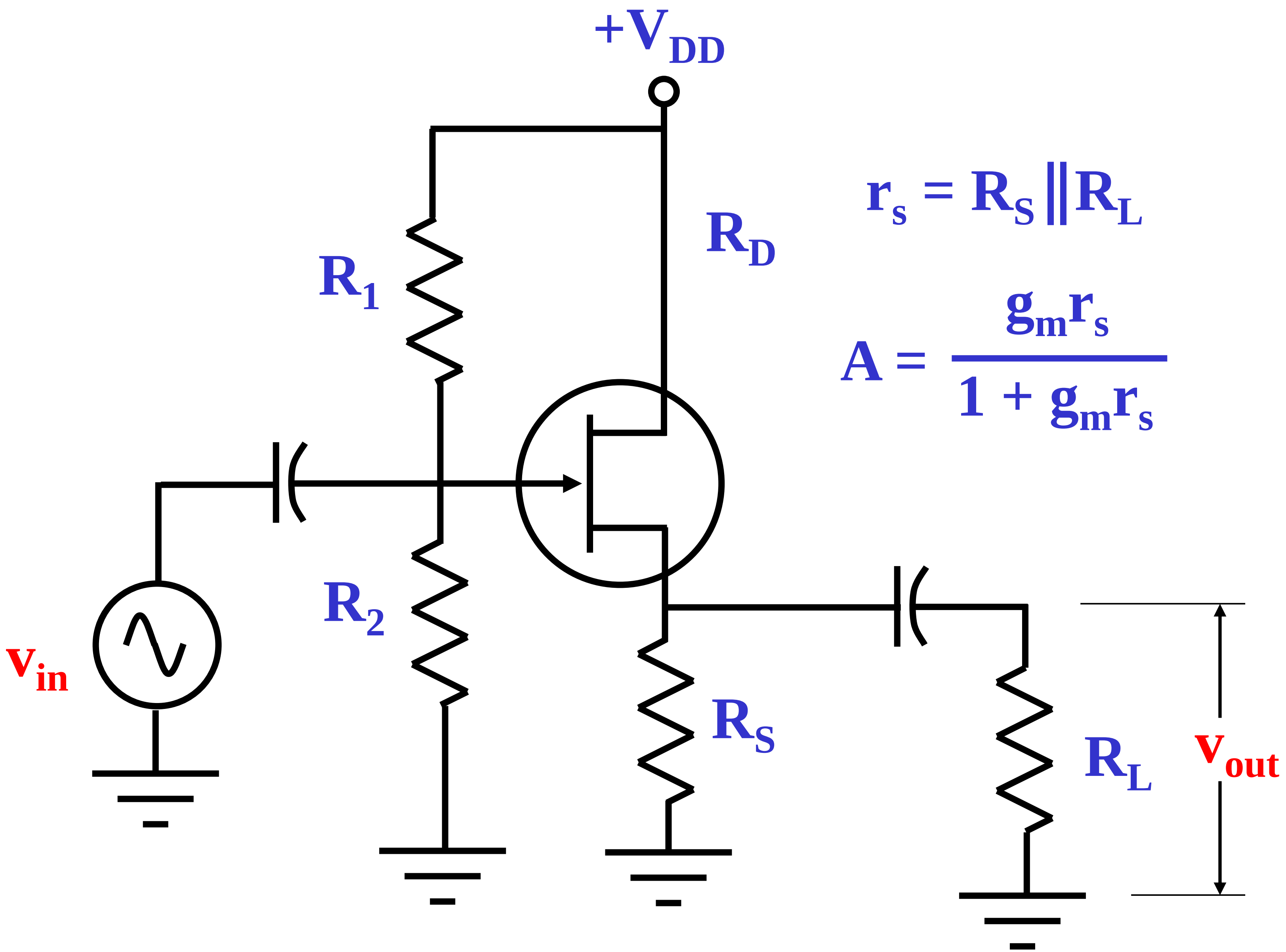


$$g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$$

Common-source amplifier



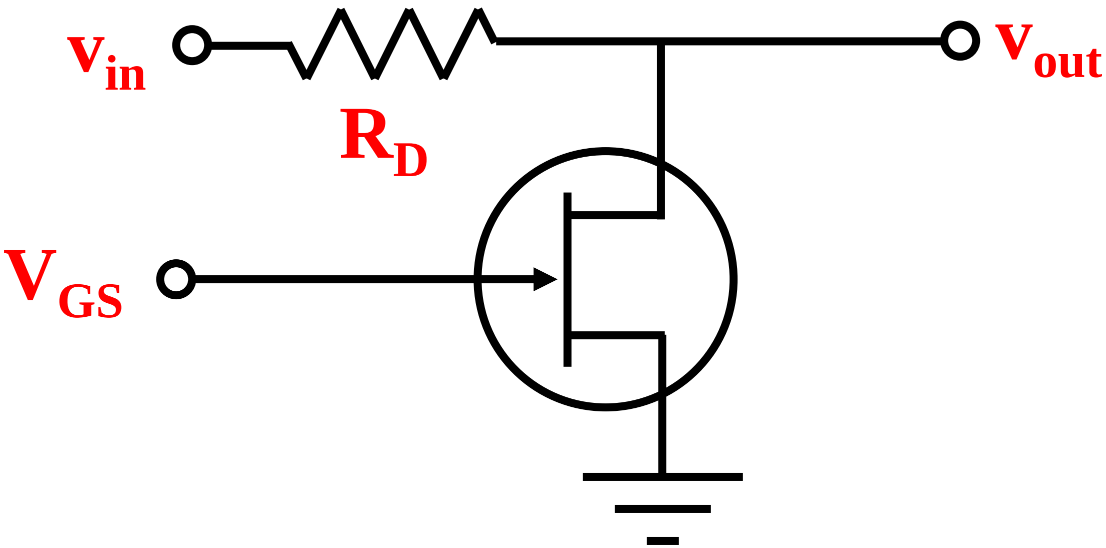
Source follower



$$r_s = R_S \| R_L$$

$$A = \frac{g_m r_s}{1 + g_m r_s}$$

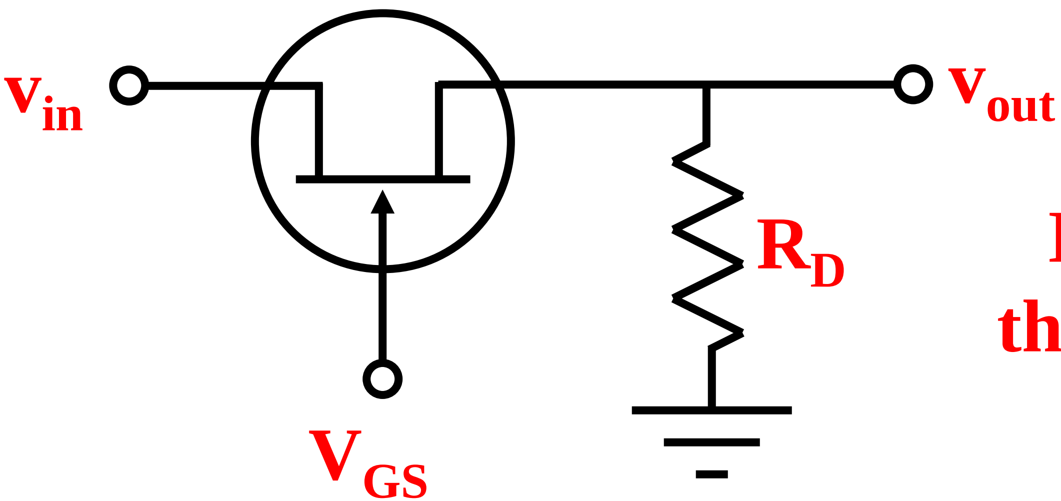
Shunt analog switch



$v_{in} < 100$ mV

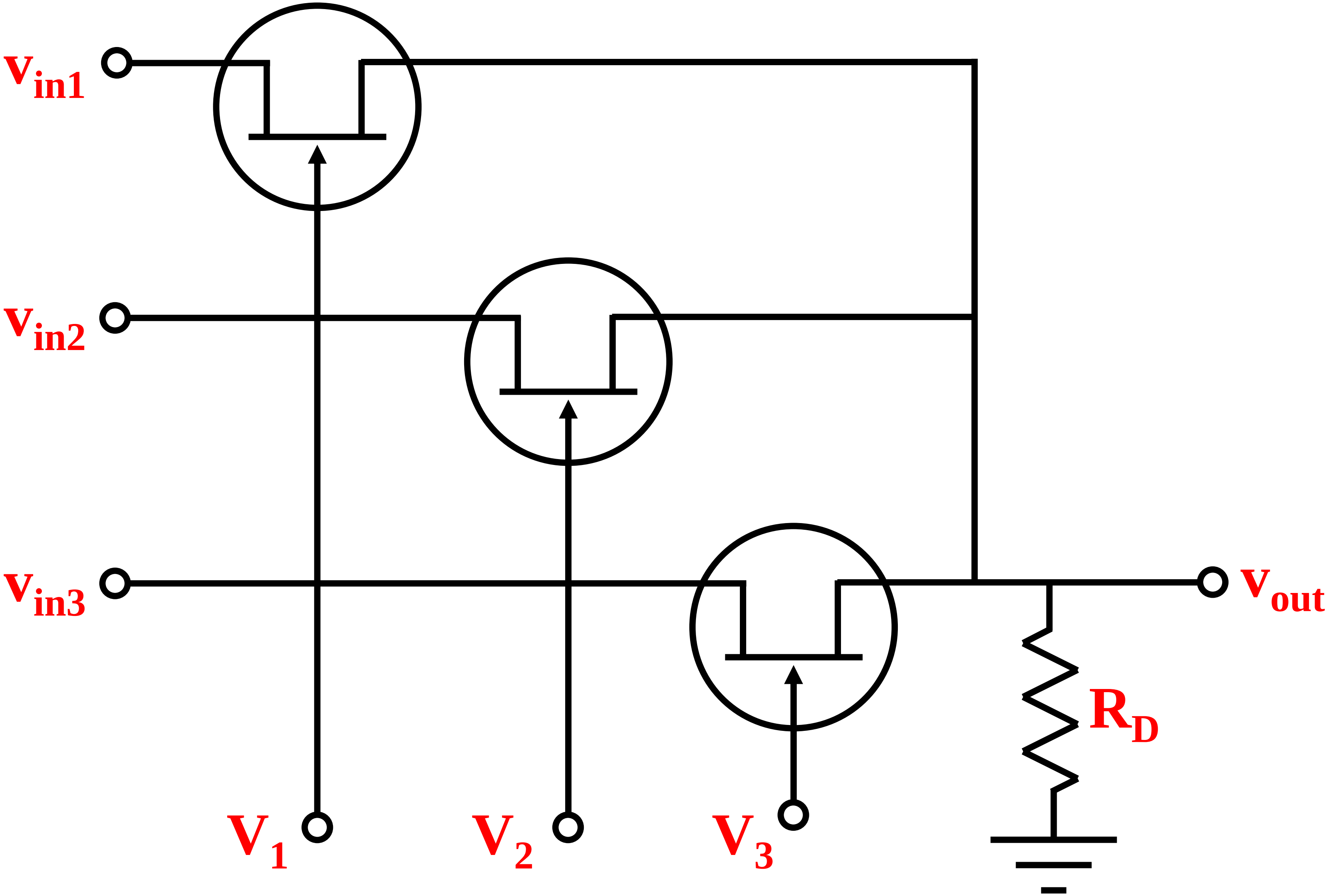
$R_D >> R_{DS}$

Series analog switch



Better on-off ratio than the shunt switch

Multiplexer



Voltage-controlled resistance

- Operates in the ohmic region with V_{GS} values between 0 and cutoff.
- Works well for ac signals of 200 mV_{PP} or less.
- Small-signal resistance: $r_{ds} = V_{DS}/I_D$
- As V_{GS} becomes more negative, r_{ds} increases.
- Both series and shunt operation can be used.