Electronic Circuits-1

Prof.Dr.Eng.Ahmad Rateb Al-Najjar

CONTENT

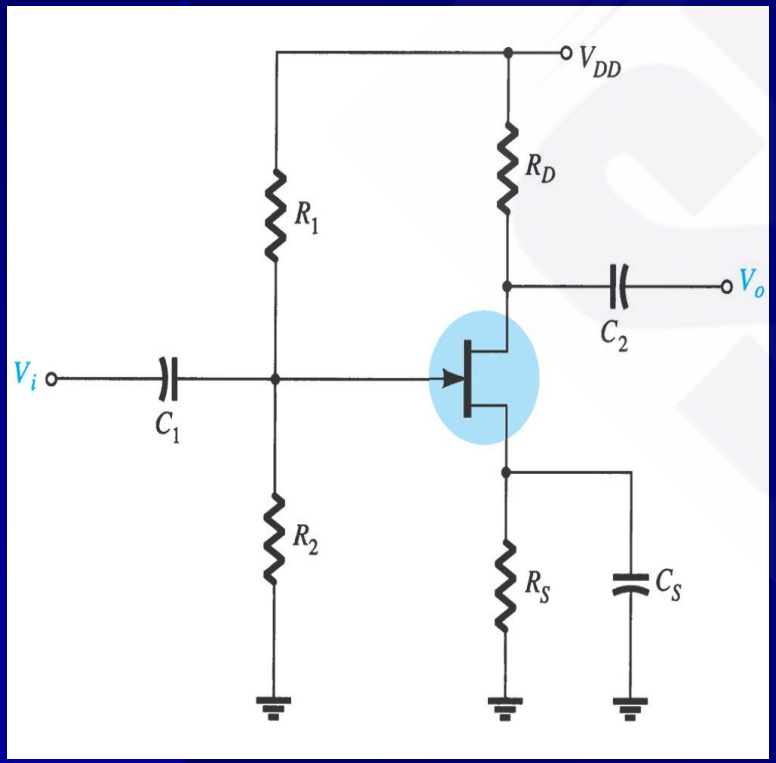
1. BJT Amplifier
2. FET Amplifier
3. Frequency Response of Amplifier
4. Operational Amplifier
5. Audio Power Amplifier
6. Linear-Digital ICs
7. Power Supplies

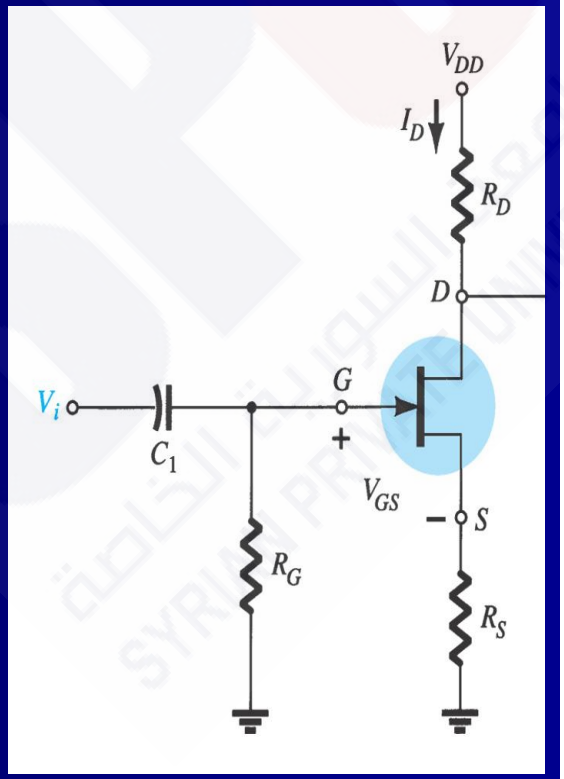
Chapter 2: FET Amplifier

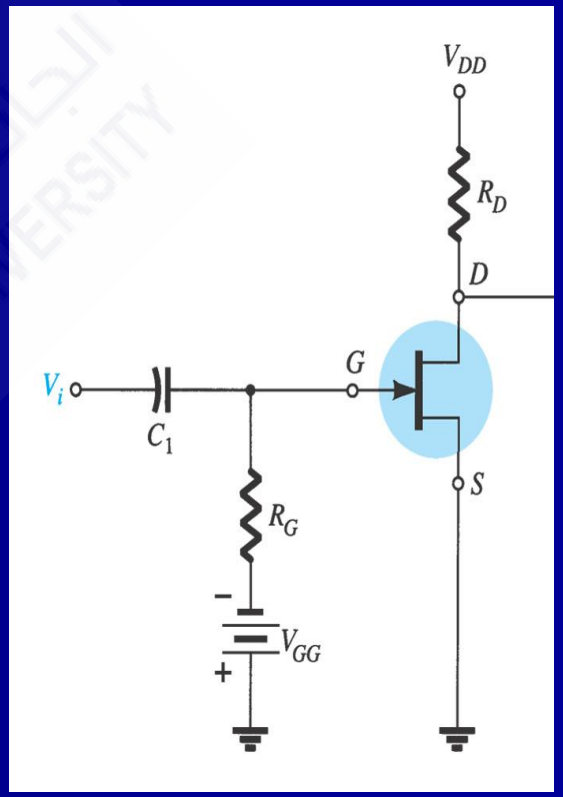
2.1 Review of FET Types and Biasing
2.2 JFET Small-Signal Model (CS,CG & CD)
2.3 Effect of R_L and R_S
2.4 Depletion MOSFET Amplifier
2.5 E-MOSFET Amplifier
2.6 Cascaded System and Amp. Coupling
2.7 Practical Applications

2.1 Review of FET Types and Biasing

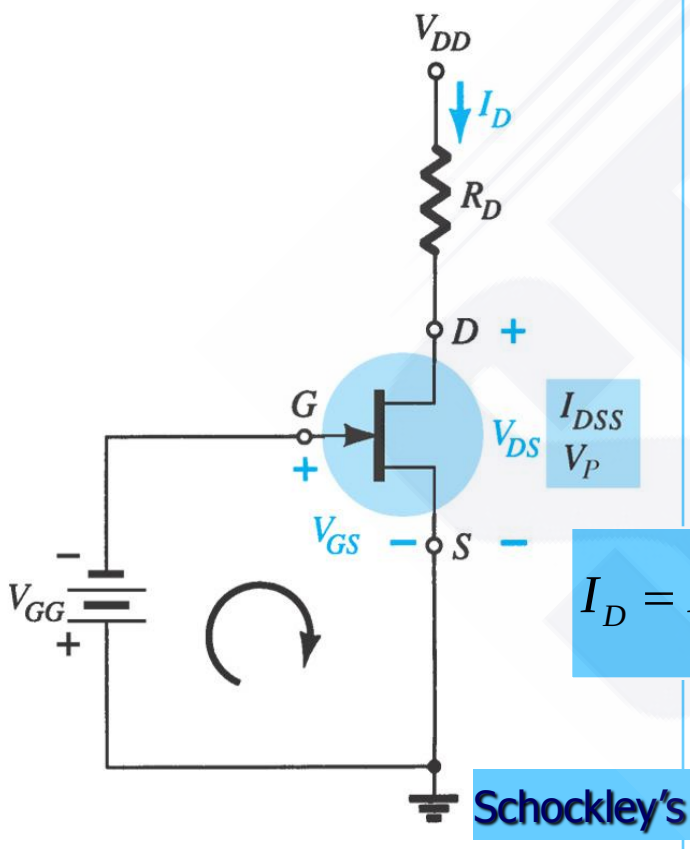
Voltage-Divider Biasing , Self-Bias , Fixed-Bias Configuration



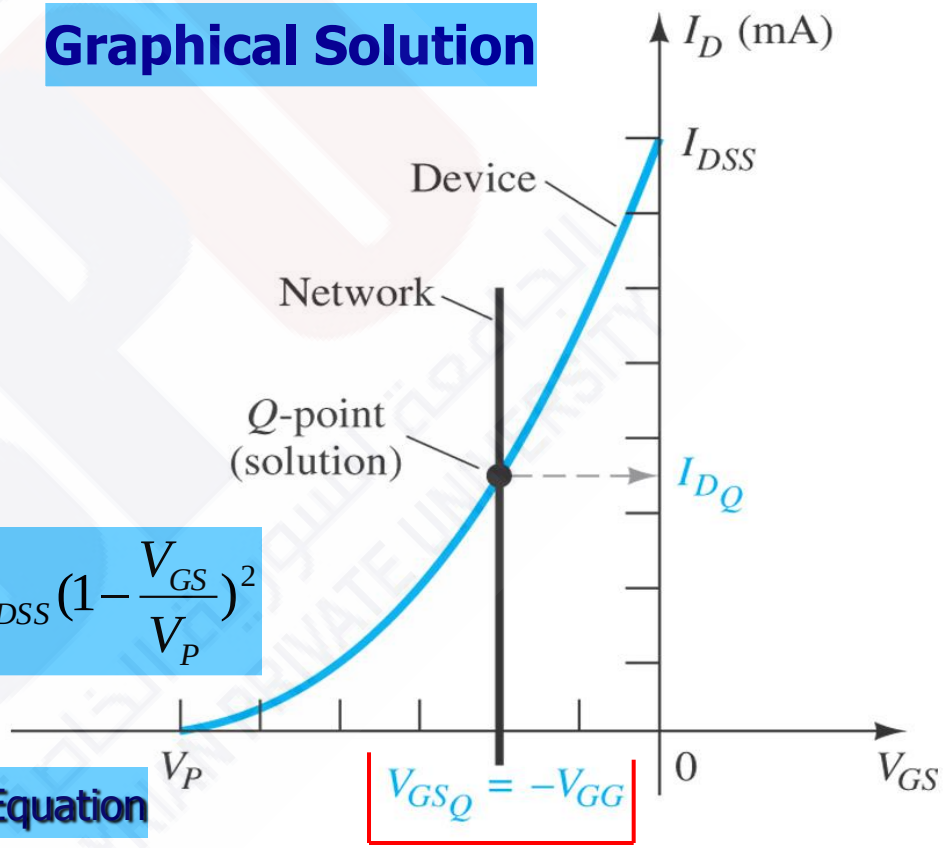




Fixed-Bias Configuration



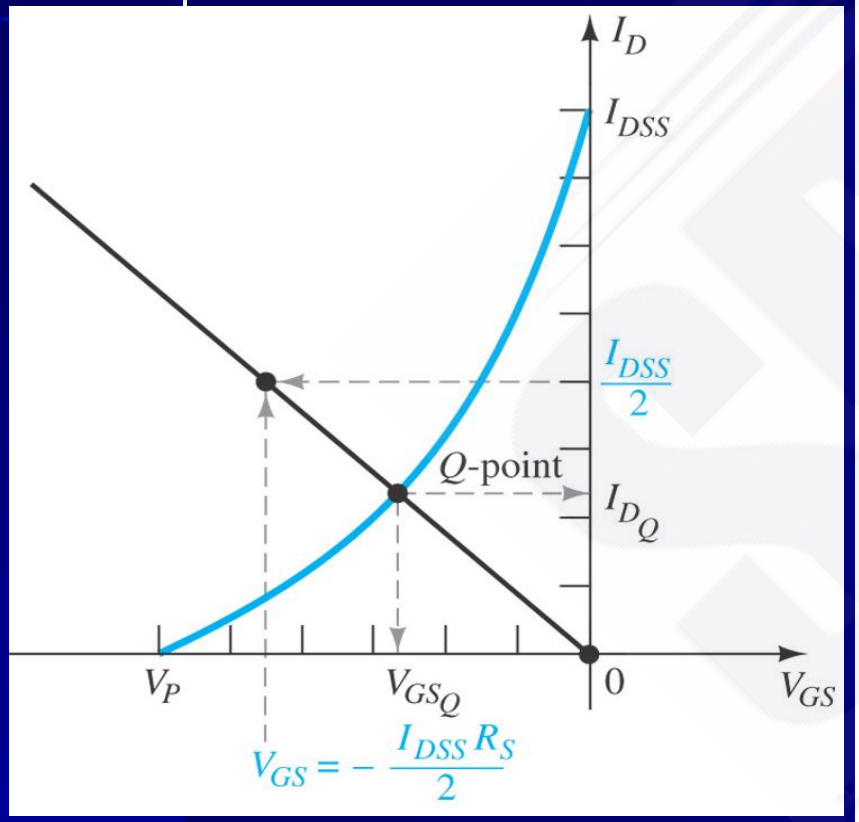
Graphical Solution



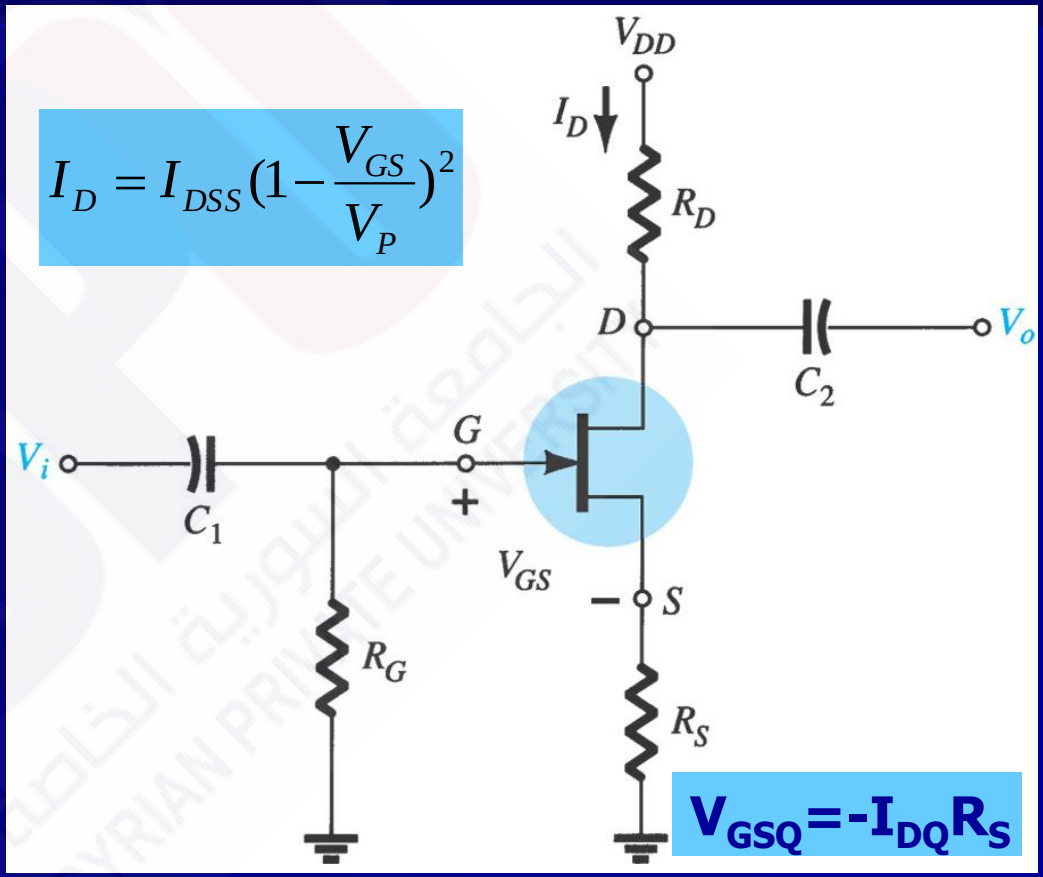
$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

Schockley's Equation

Self-Bias Configuration

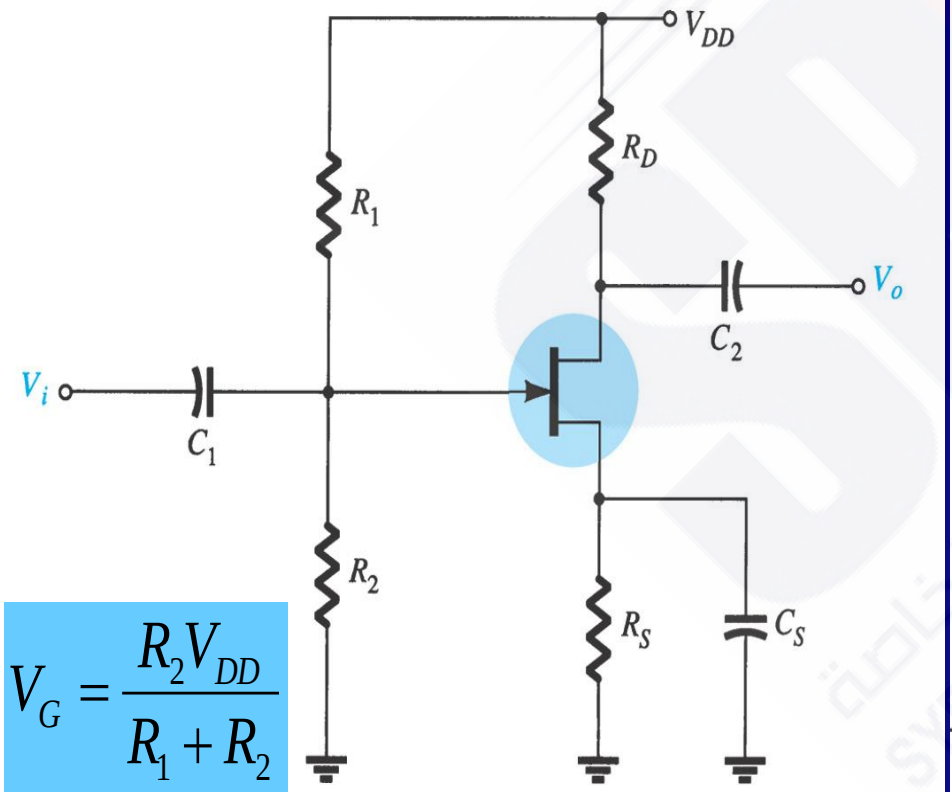


$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

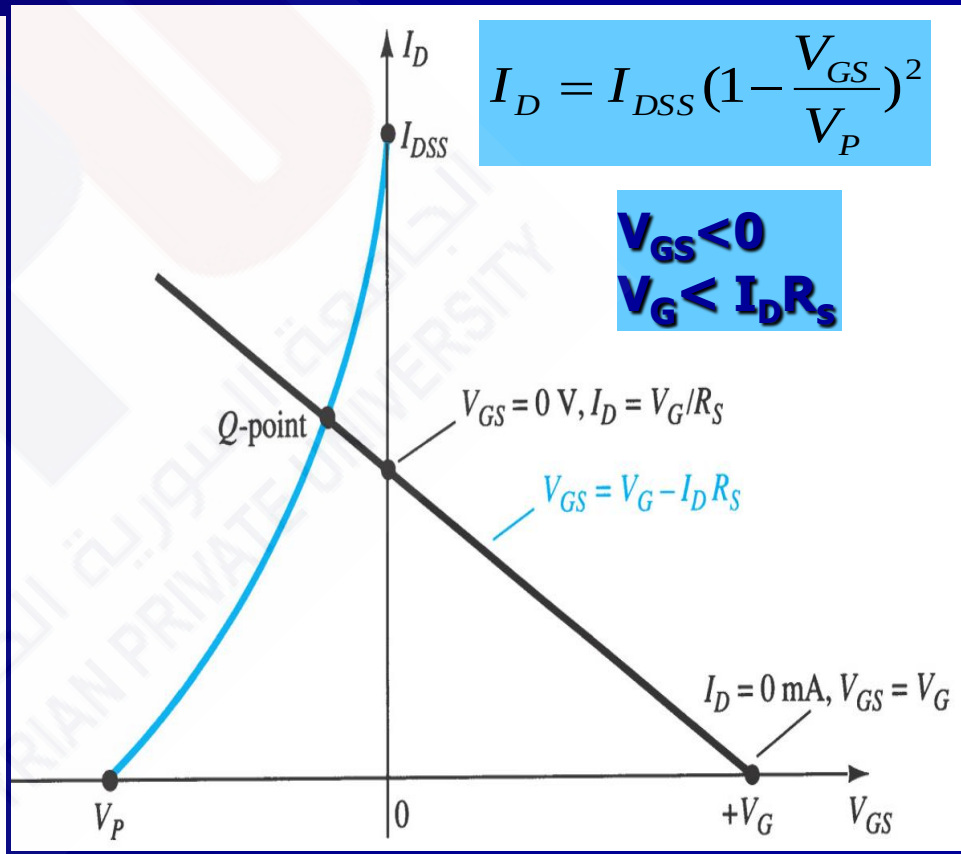


$V_{GSQ} = -I_{DQ}R_S$

Voltage-Divider Biasing



$$V_G = \frac{R_2 V_{DD}}{R_1 + R_2}$$



$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$

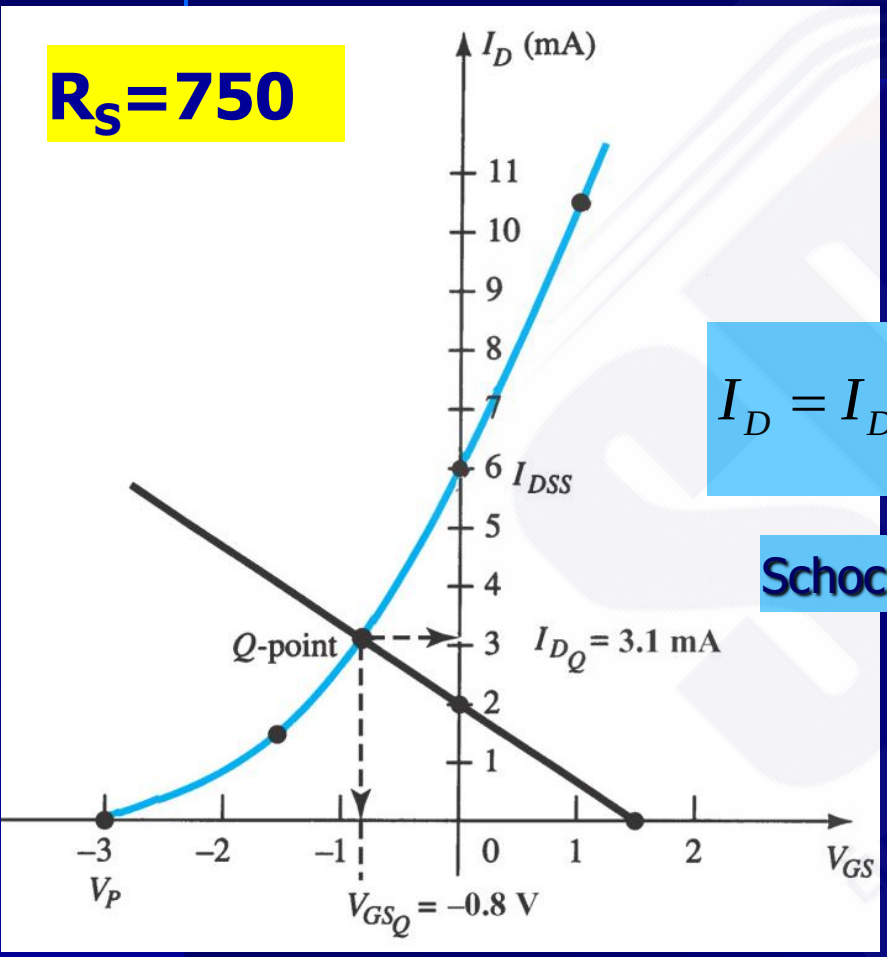
$V_{GS} < 0$

$V_G < I_D R_S$

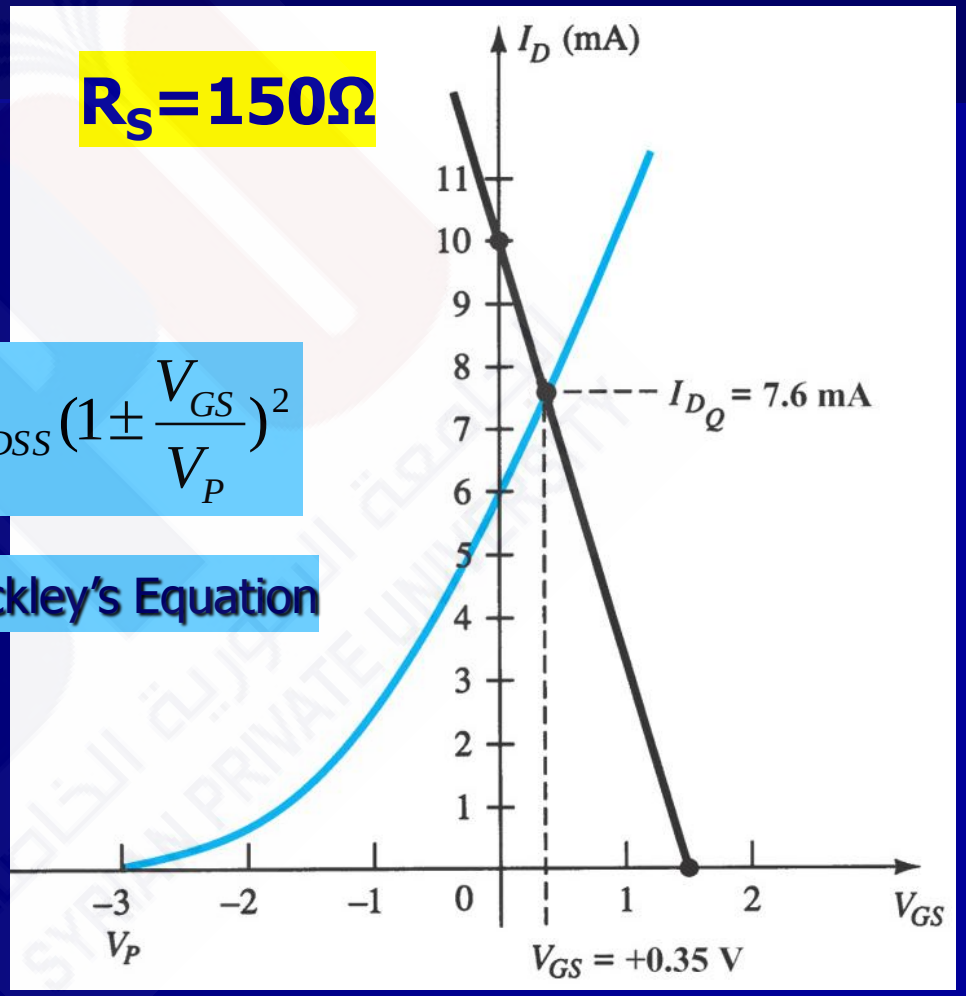

SPU
الجامعة السورية الخاصة
SYRIAN PRIVATE UNIVERSITY

Depletion Mode MOSFET

R_S=750



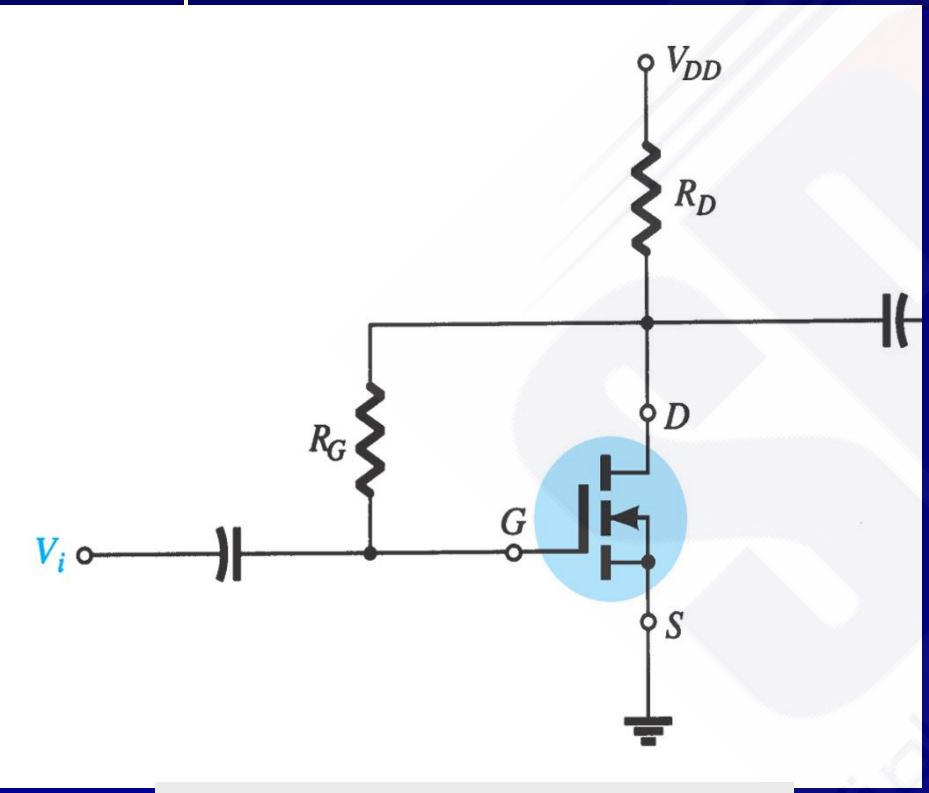
R_S=150Ω

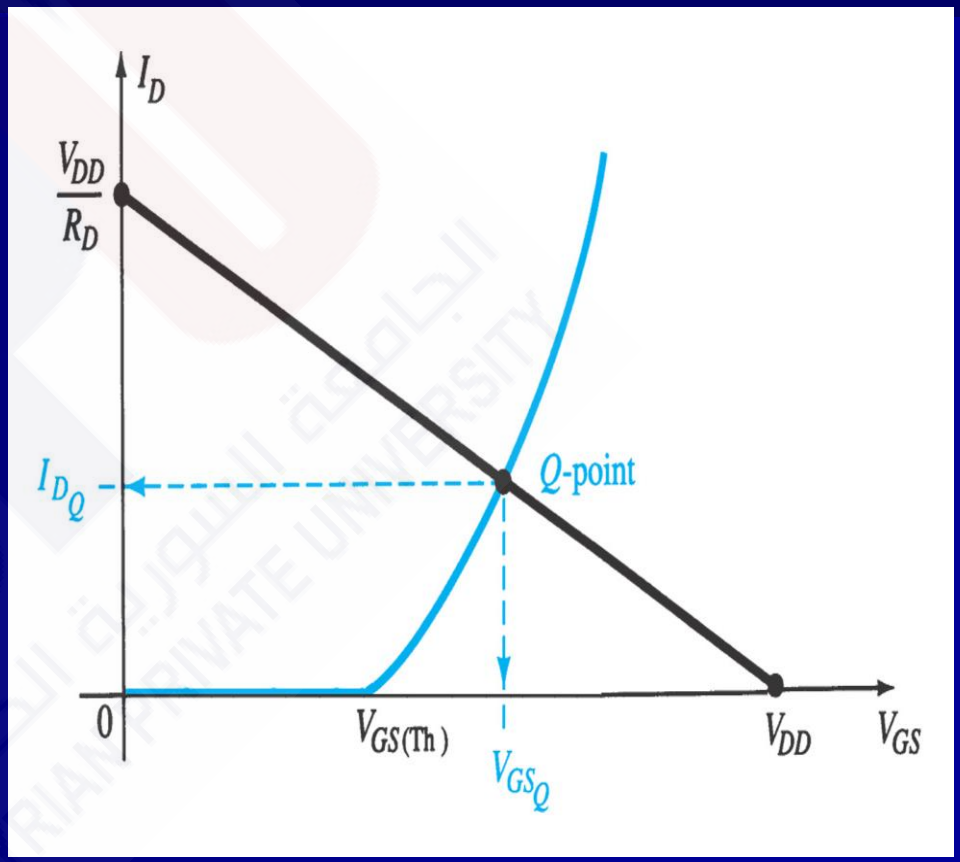


$$I_D = I_{DSS}(1 \pm \frac{V_{GS}}{V_P})^2$$

Schockley's Equation

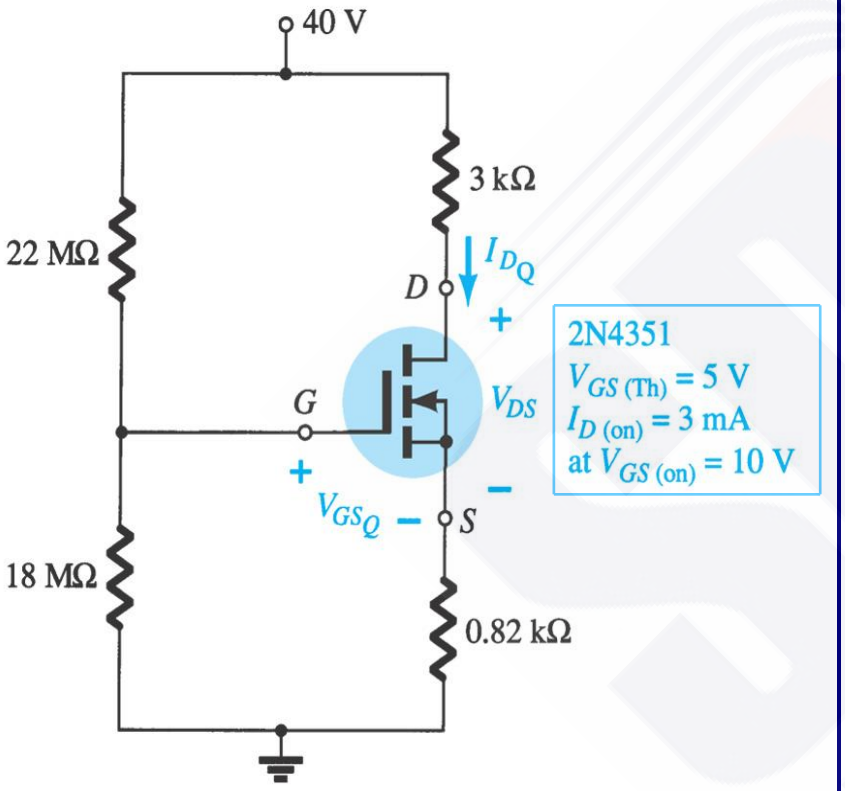
E-MOSFET Feedback Biasing

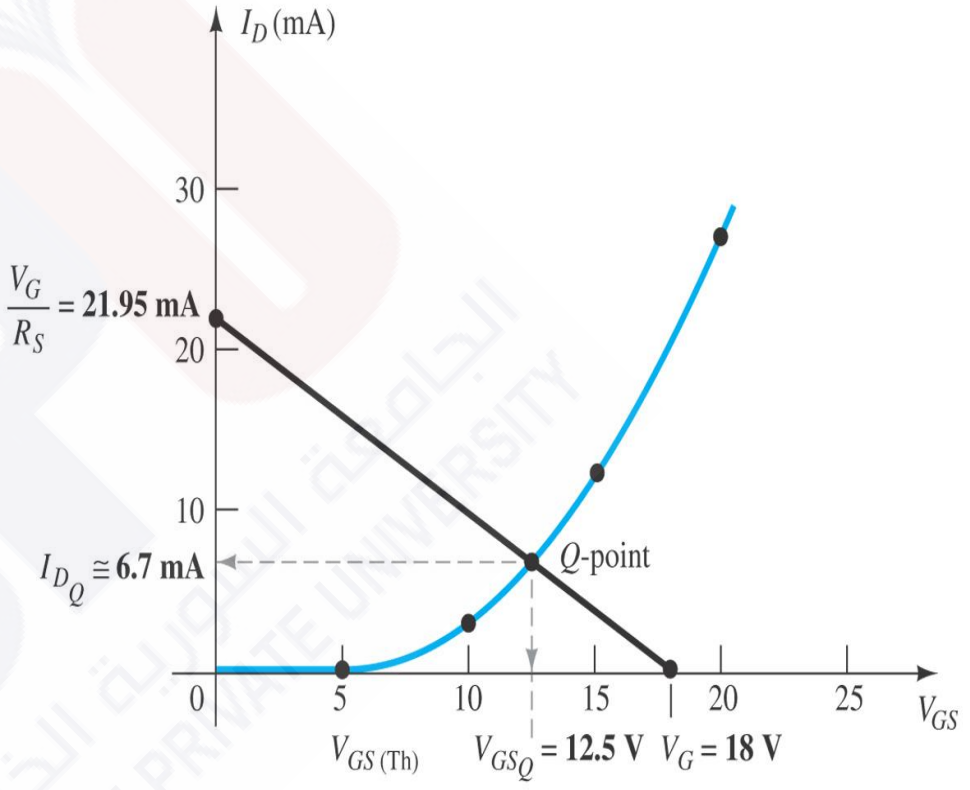




$$V_{GS}=V_{DS}=V_{DD}-I_{DQ}R_D$$

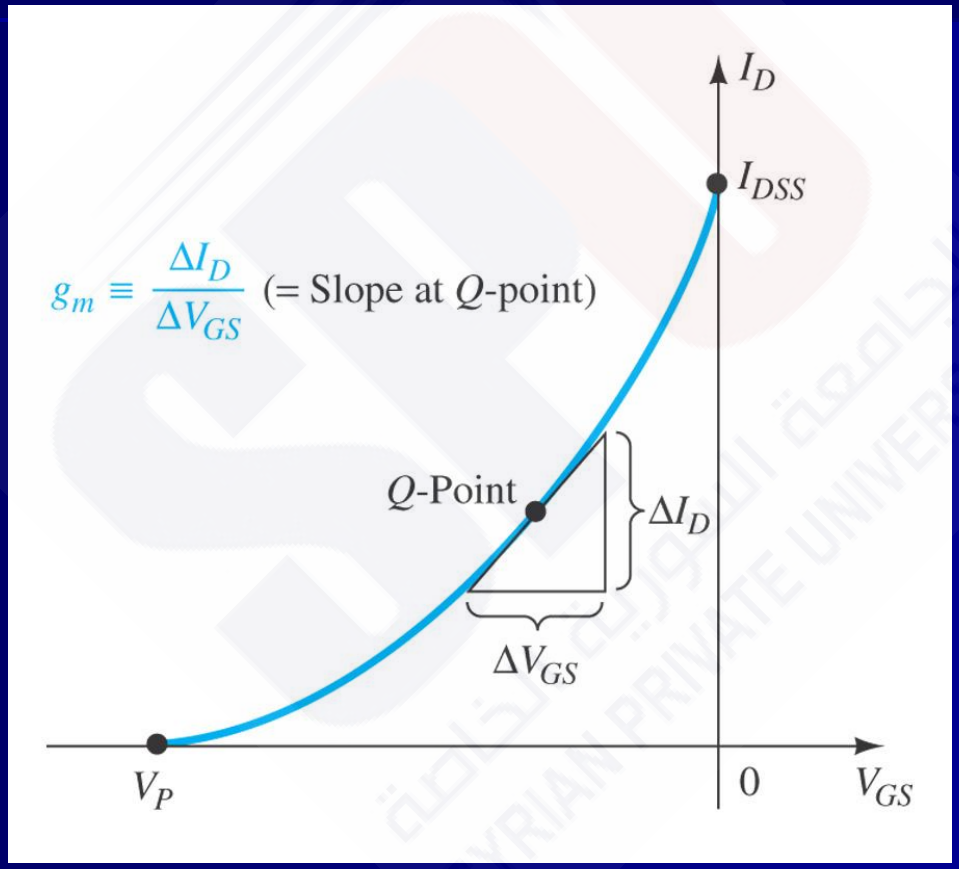
Voltage-Divider Biasing: Example





$$I_D = k(V_{GS} - V_{GS(Th)})^2 \;;\; k = \frac{I_{D(on)}}{(V_{GS(on)} - V_{GS(Th)})^2}$$

2-2 JFET Small-Signal Model (CS,CG & CD)



g_m Graphical Determination

2-2 JFET Small-Signal Model (CS,CG & CD)

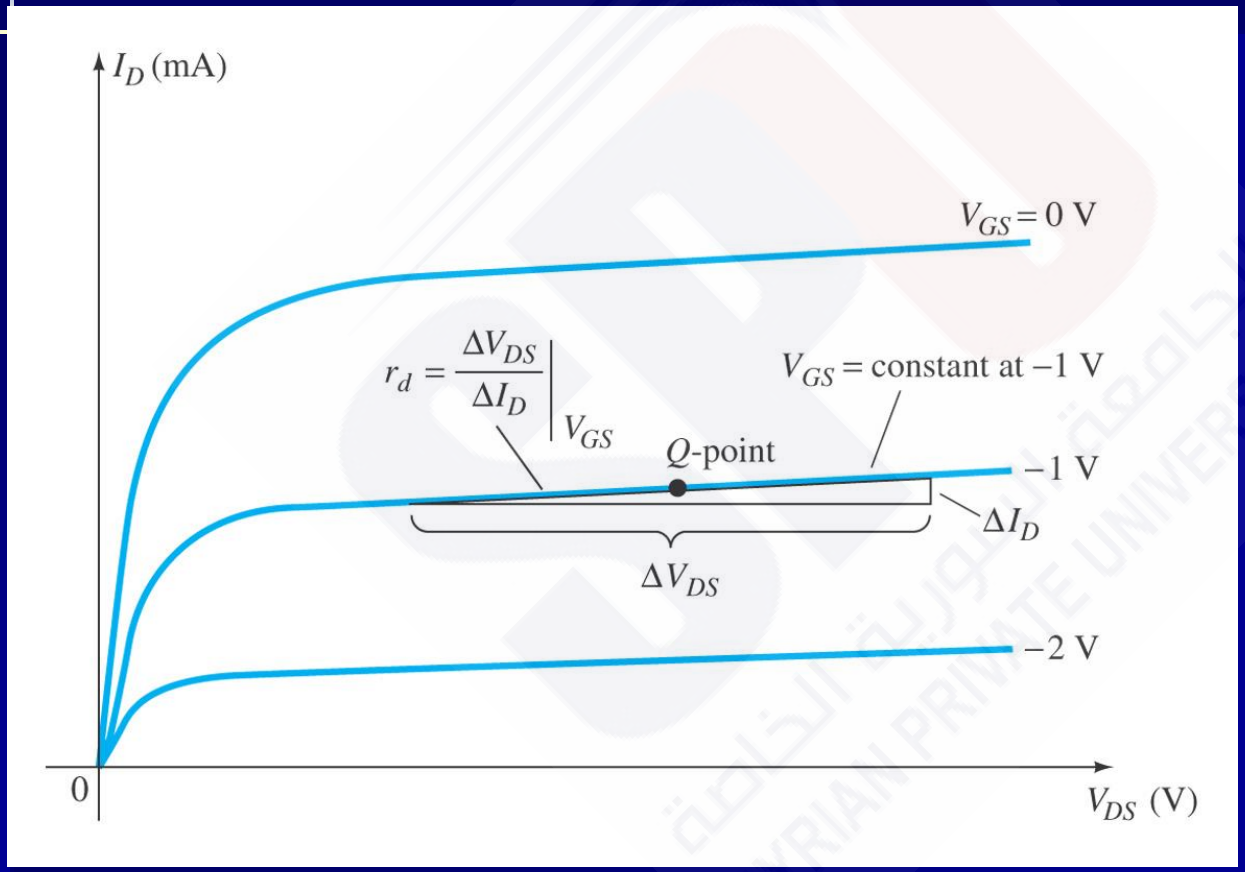
g_m Mathematical Determination

$$g_m = \frac{dI_D}{dV_{GS}} = \frac{2I_{DSS}}{V_P}\left[1 - \frac{V_{GS}}{V_P}\right]$$

$$g_{mo} = \frac{2I_{DSS}}{V_P}\left[1 - \frac{0}{V_P}\right] = \frac{2I_{DSS}}{V_P}$$

$$g_m = g_{mo}\left[1 - \frac{V_{GS}}{V_P}\right] = \frac{2}{V_P}\sqrt{I_D I_{DSS}}$$

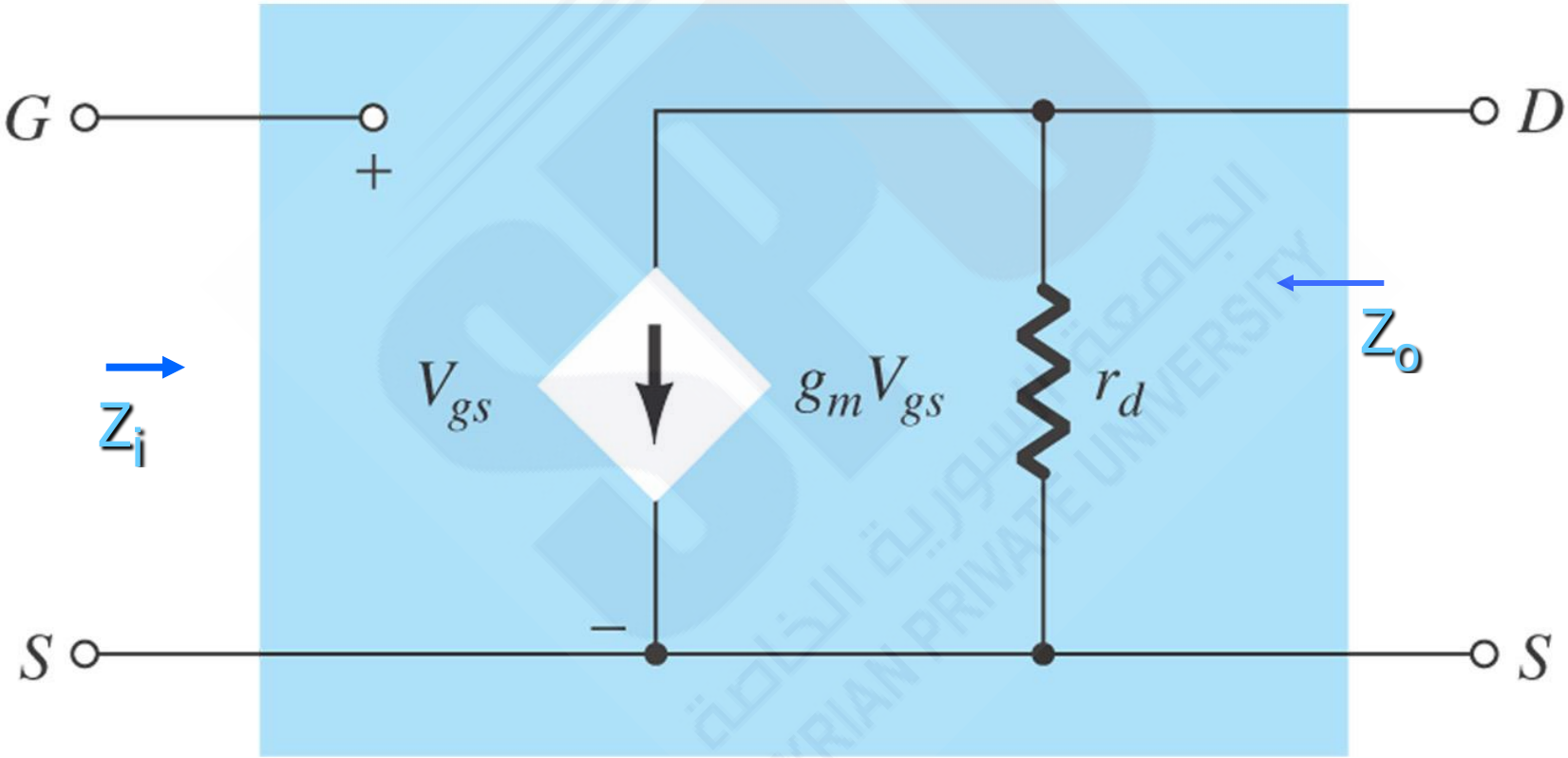
Input Impedance-Z_i & Output Impedance-Z_o



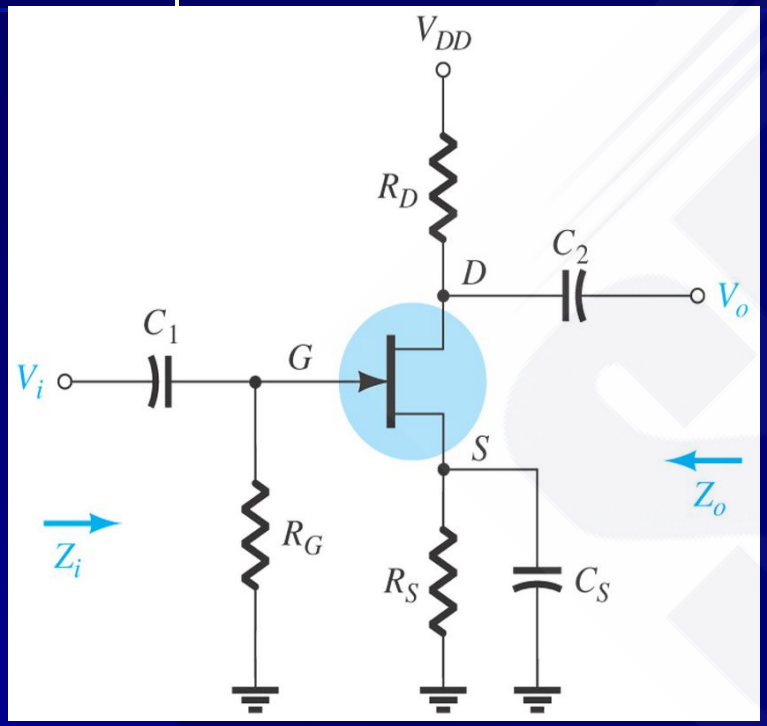
$Z_i = \infty$

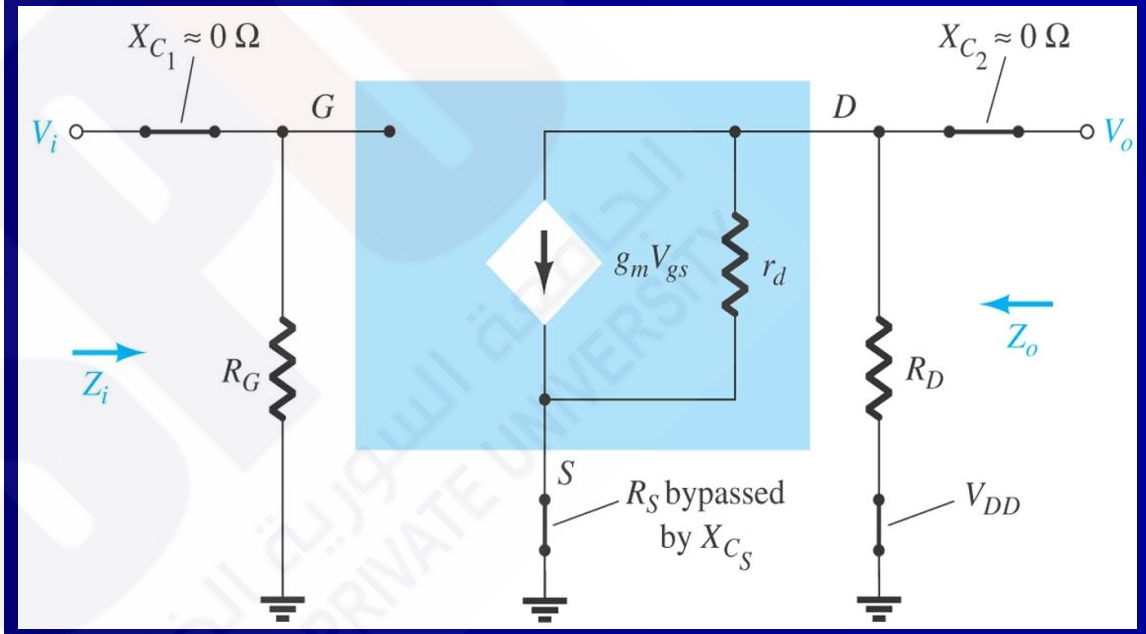
$Z_o = r_d$

FET AC-Equivalent Circuit

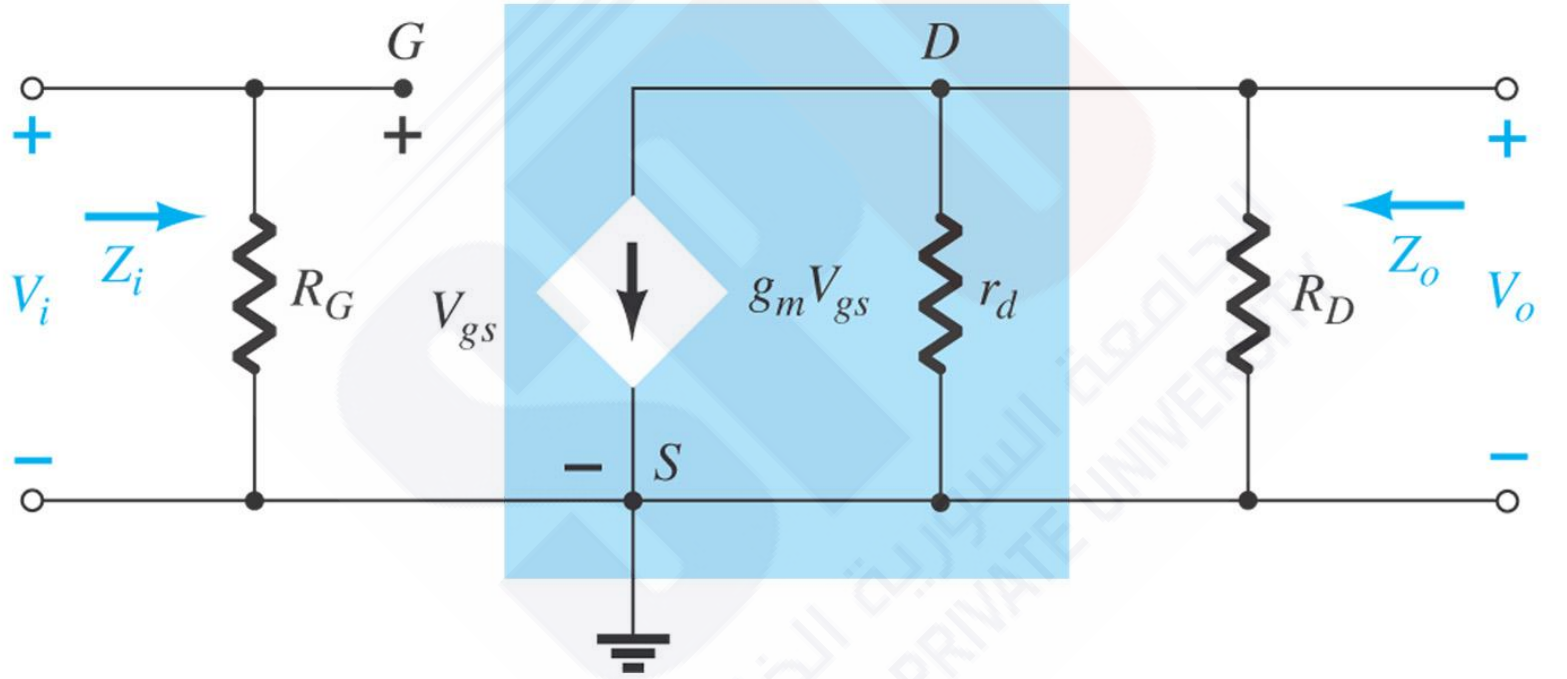


JFET Self-Biased Amplifier



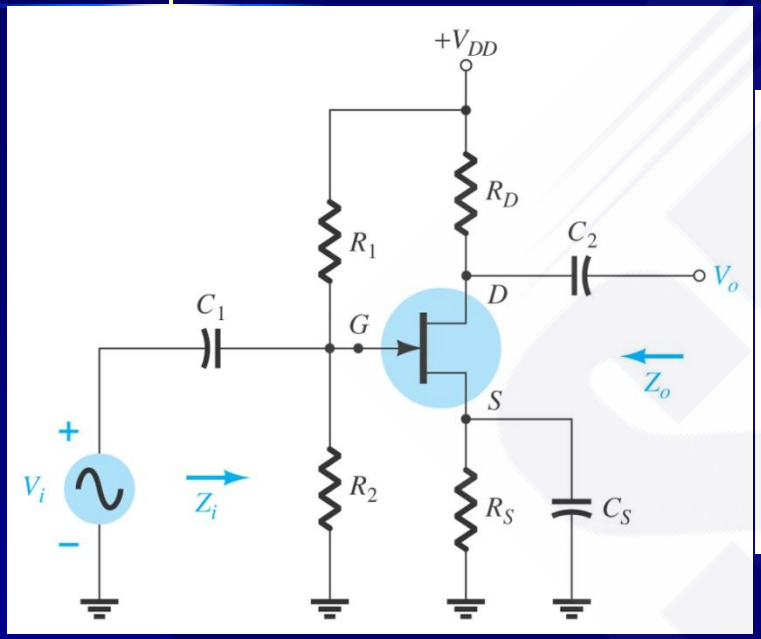


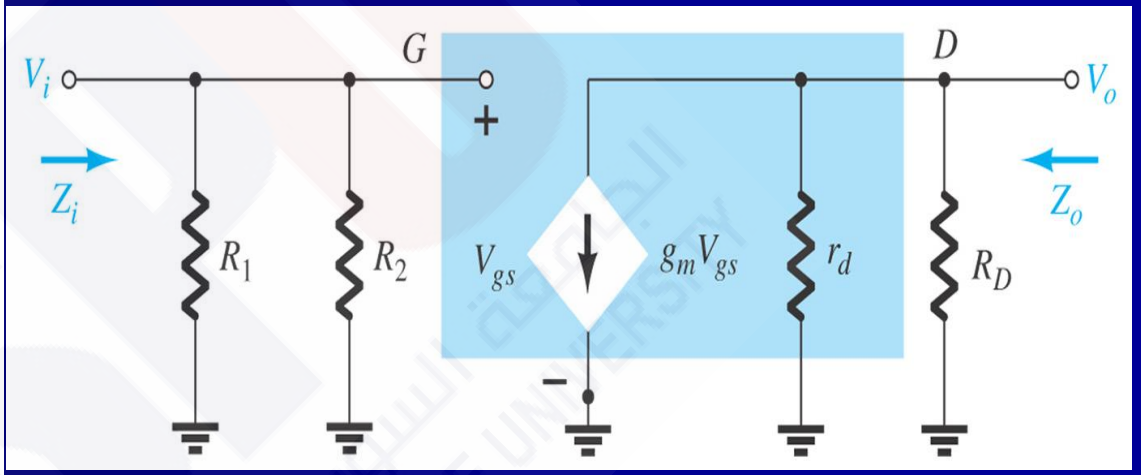
JFET Self-Biased Amplifier



$$Z_i = R_G \;,\; Z_o = R_D \| r_d \;,\; A_v = -g_m (R_D \| r_d)$$

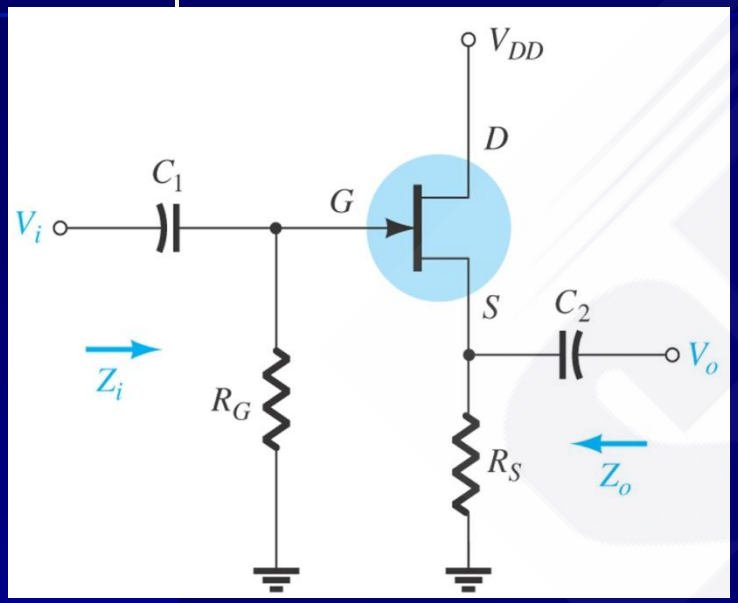
JFET Voltage Divider Configuration

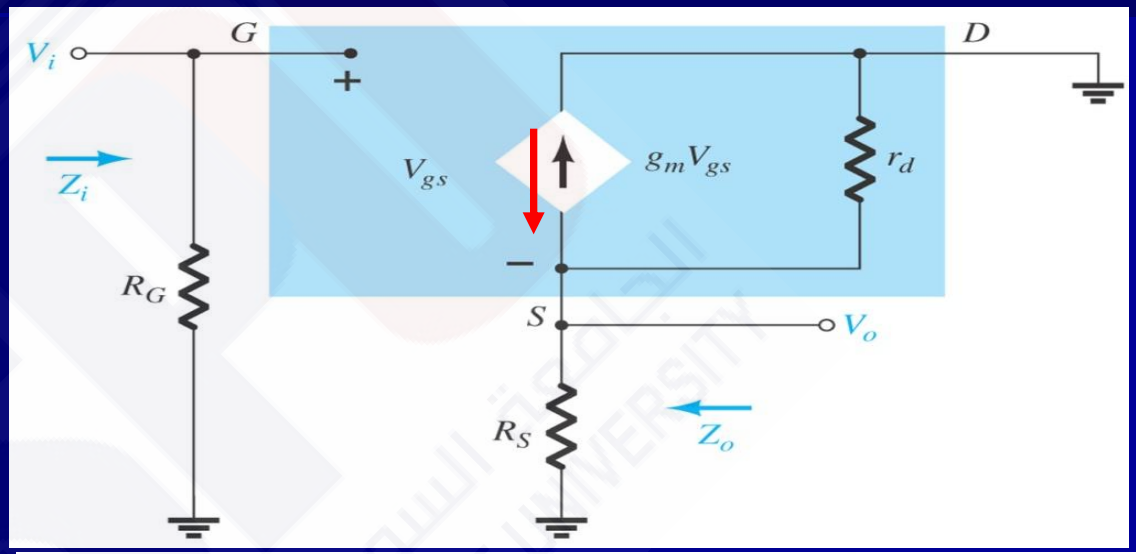




$$Z_i = R_1 \| R_2 \quad , \quad Z_o = R_D \| r_d \quad , \quad A_v = -g_m (R_D \| r_d)$$

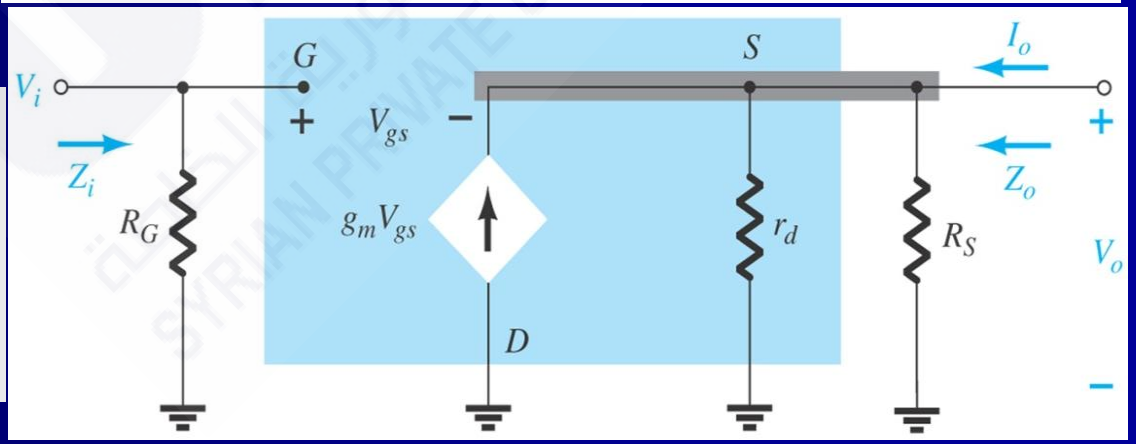
JFET Source Follower (Common-Drain)



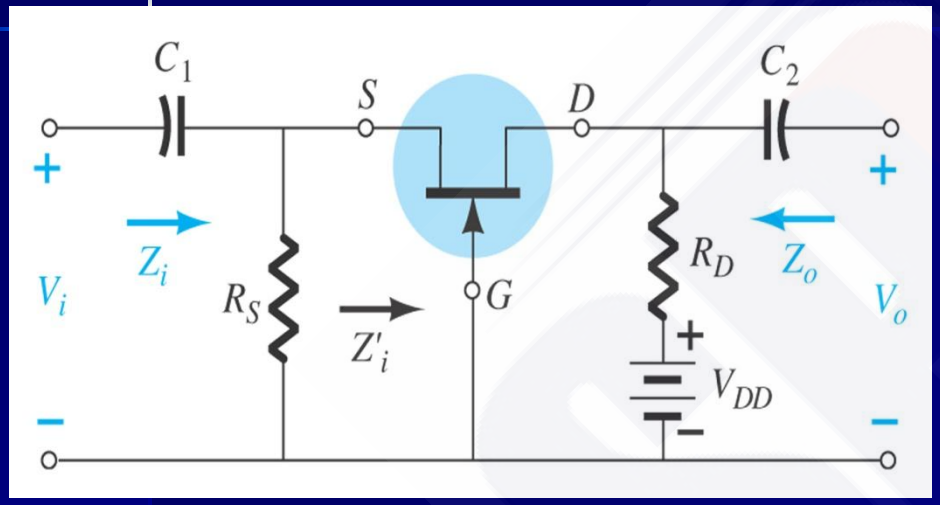


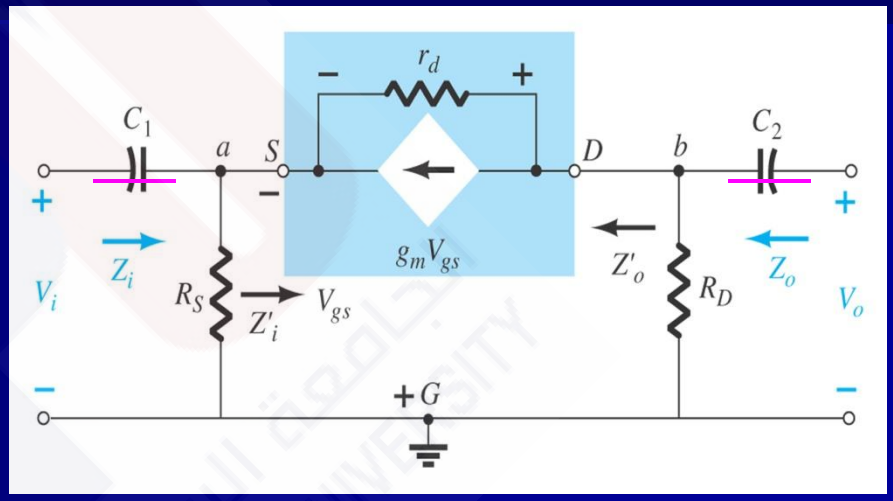
$$Z_i = R_G \quad , \quad Z_o = R_S \| r_d \| 1/g_m$$

$$A_v = \frac{g_m(r_d \| R_s)}{1 + g_m(r_d \| R_s)} = \frac{g_m R_s}{1 + g_m R_s}$$



Common-Gate JFET Amp.



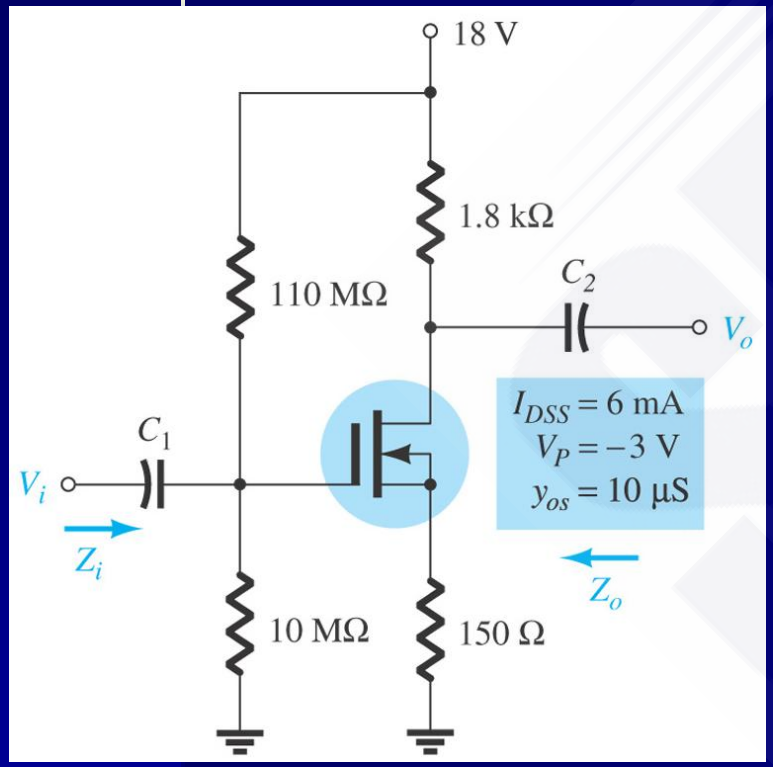


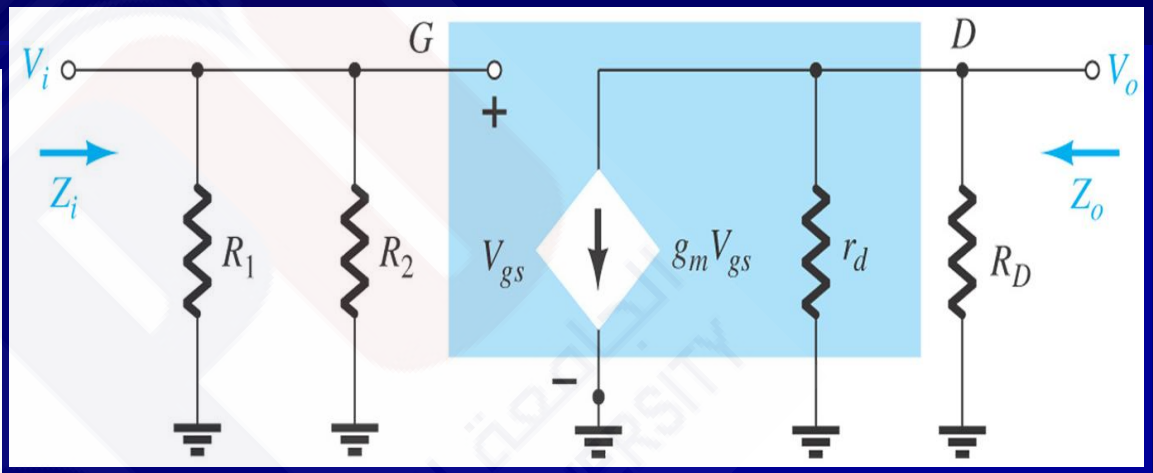
$$Z_i = R_s \left\| \left[\frac{r_d + R_D}{1 + g_m R_D} \right] \approx R_s \| 1/g_m \right.$$

$$A_v = \frac{g_m R_D + R_D / r_d}{1 + R_D / r_d} \approx g_m R_D$$

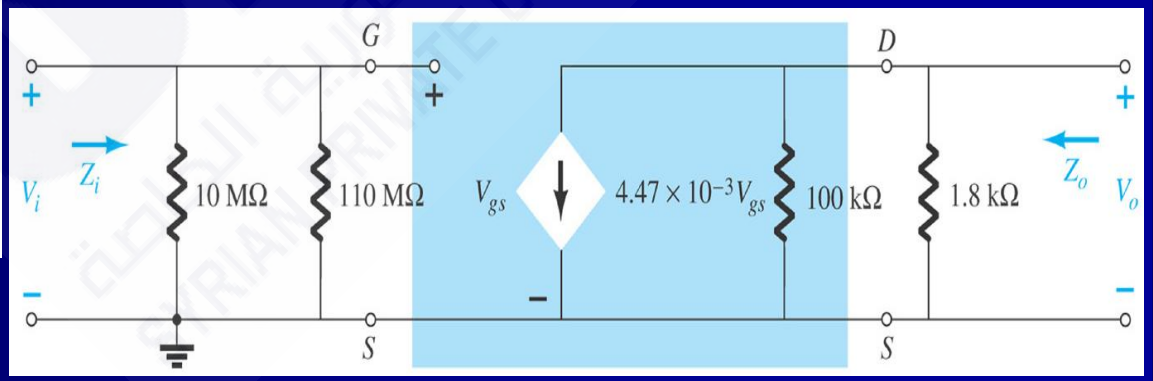
$$Z_o = R_D \| r_d \approx R_D$$

2.3 Depletion MOSFET AMP.





Same Model & Equations as JFET Ones

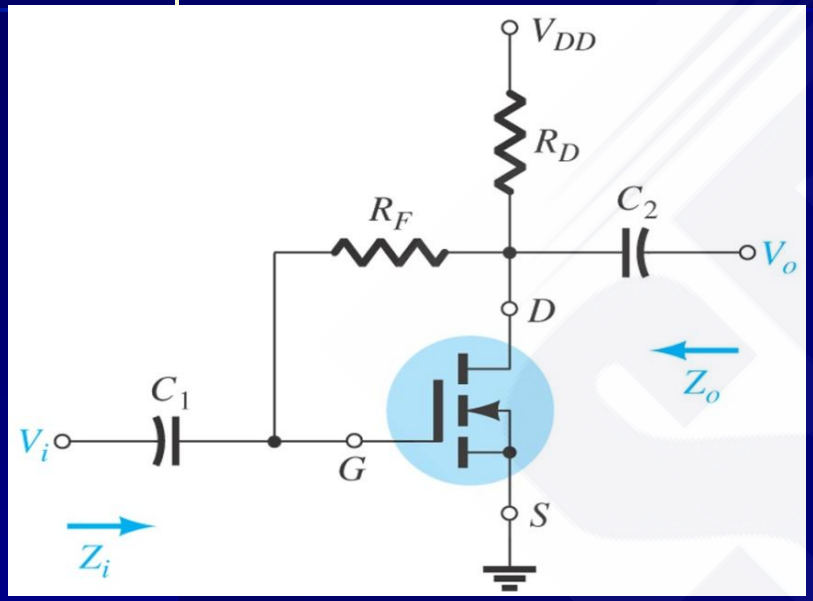


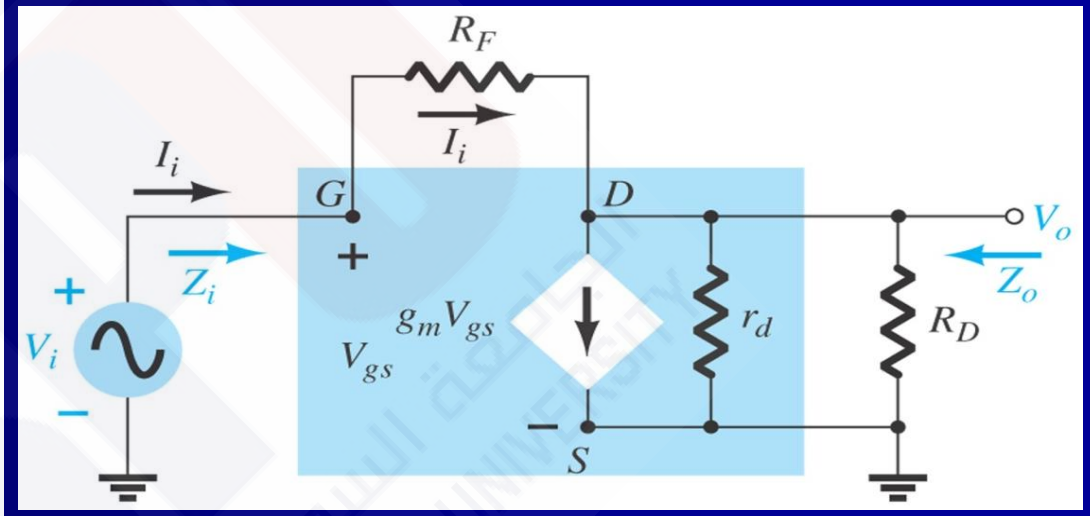
$Z_i = R_1 \| R_2$, $Z_o = R_D \| r_d$

$A_v = -g_m(R_D \| r_d)$

2.4 E-MOSFET AMP.

Drain Feedback Configuration





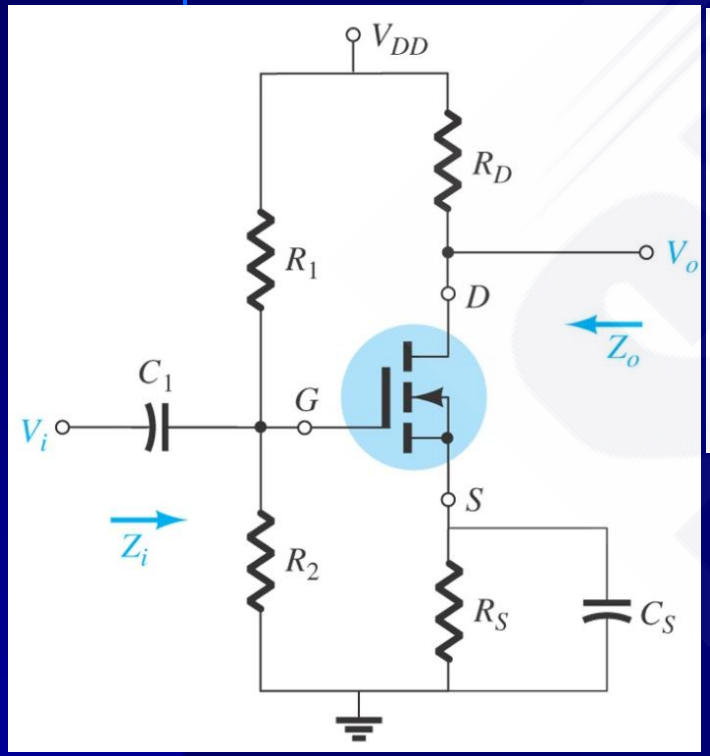
$$Z_i = \frac{R_F + r_d \| R_D}{1 + g_m (r_d \| R_D)} \cong \frac{R_F}{1 + g_m R_D}$$

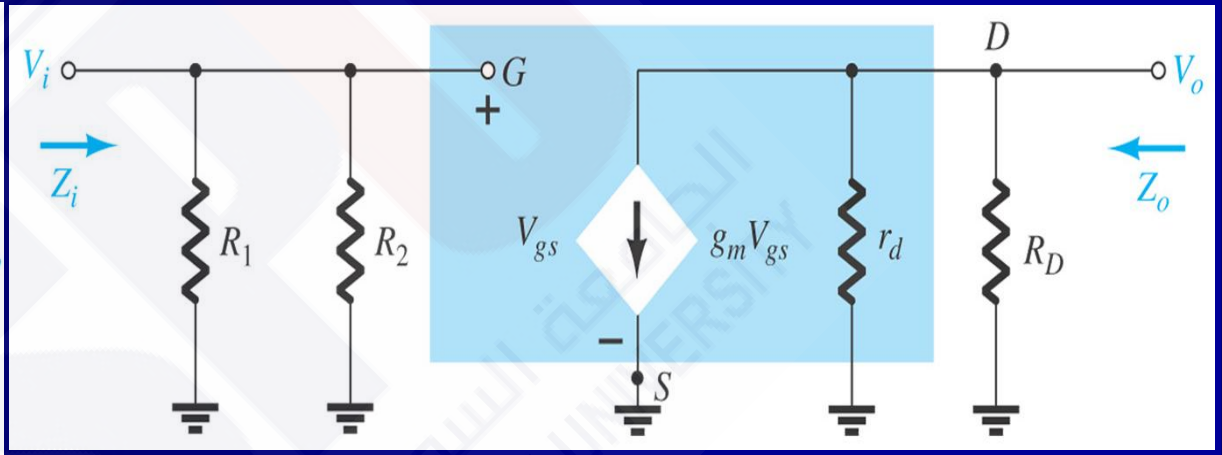
$$A_v = -g_m (r_d \| R_D \| R_F) \cong -g_m R_D$$

$$Z_o = (r_d \| R_D \| R_F) \cong R_D$$

2.4 E-MOSFET AMPLIFIER

Voltage-Divider Configuration



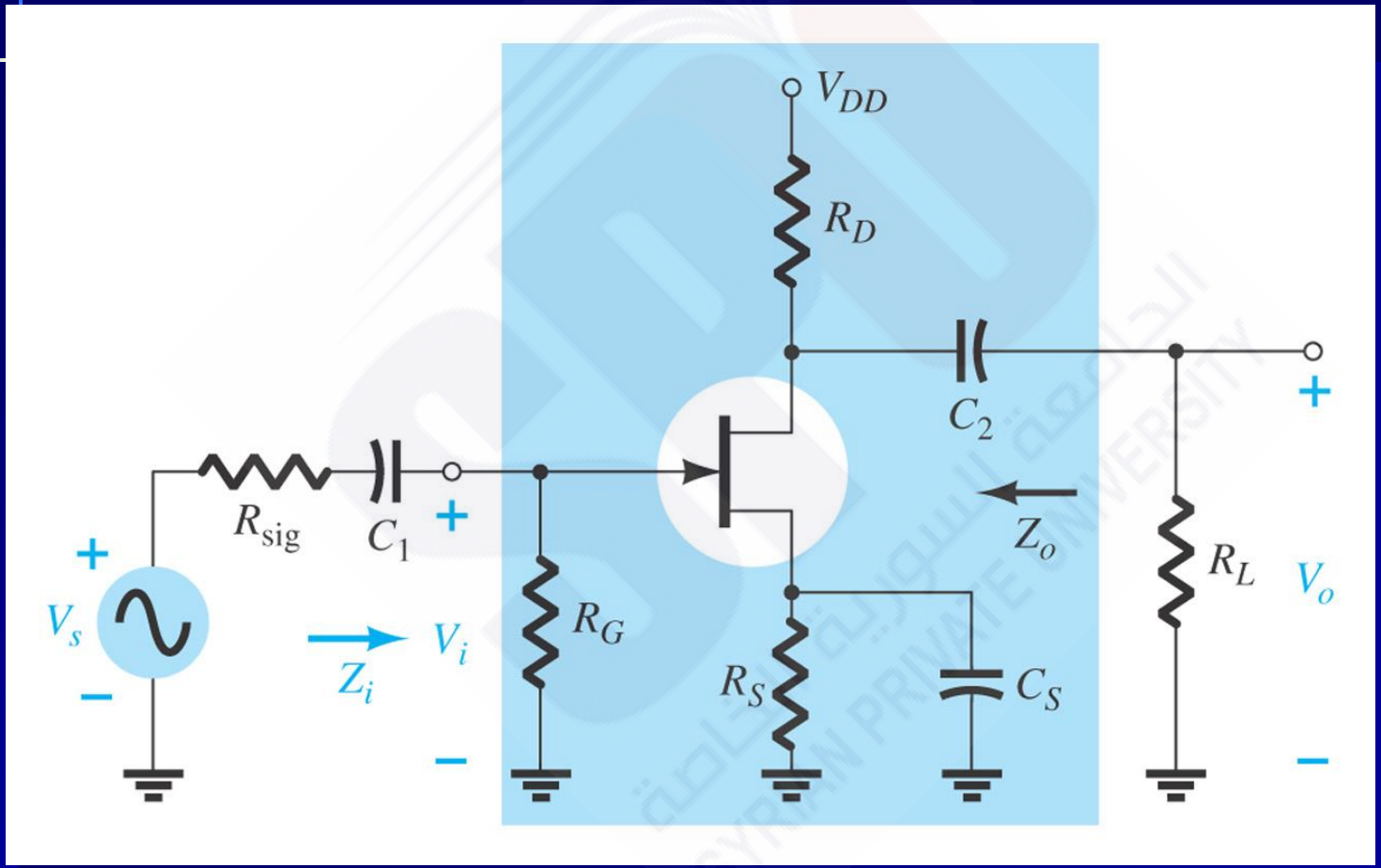


$$Z_i = R_1 \| R_2$$

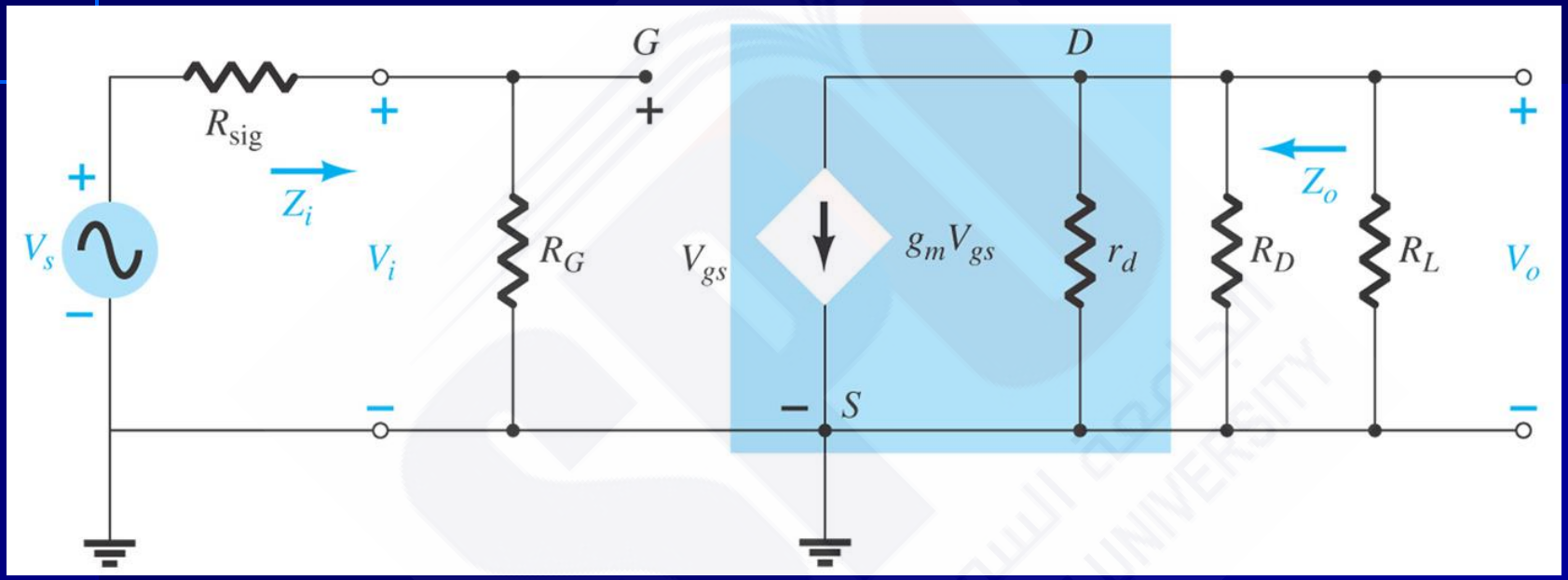
$$A_v = -g_m (r_d \| R_D) \cong -g_m R_D$$

$$Z_o = (r_d \| R_D) \cong R_D$$

2.5 Effect of R_L and R_{sig}



Effect of R_L and R_S

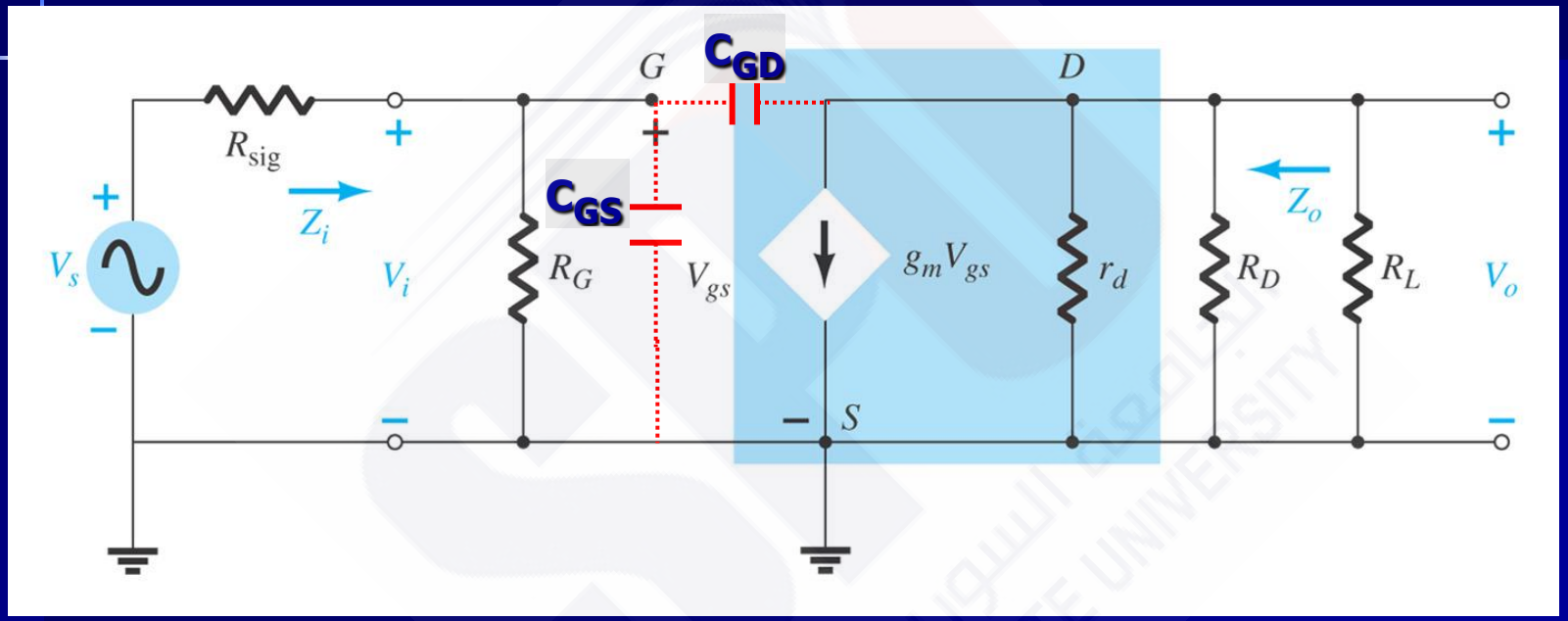


$$A_{vs} = \left(\frac{R_i}{R_i + R_{sig}}\right)\left(\frac{R_L}{R_L + R_o}\right) A_{NL}$$

$$A_{vs} \cong -g_m (R_D \| R_L \| r_d) \cong -g_m (R_D \| R_L)$$

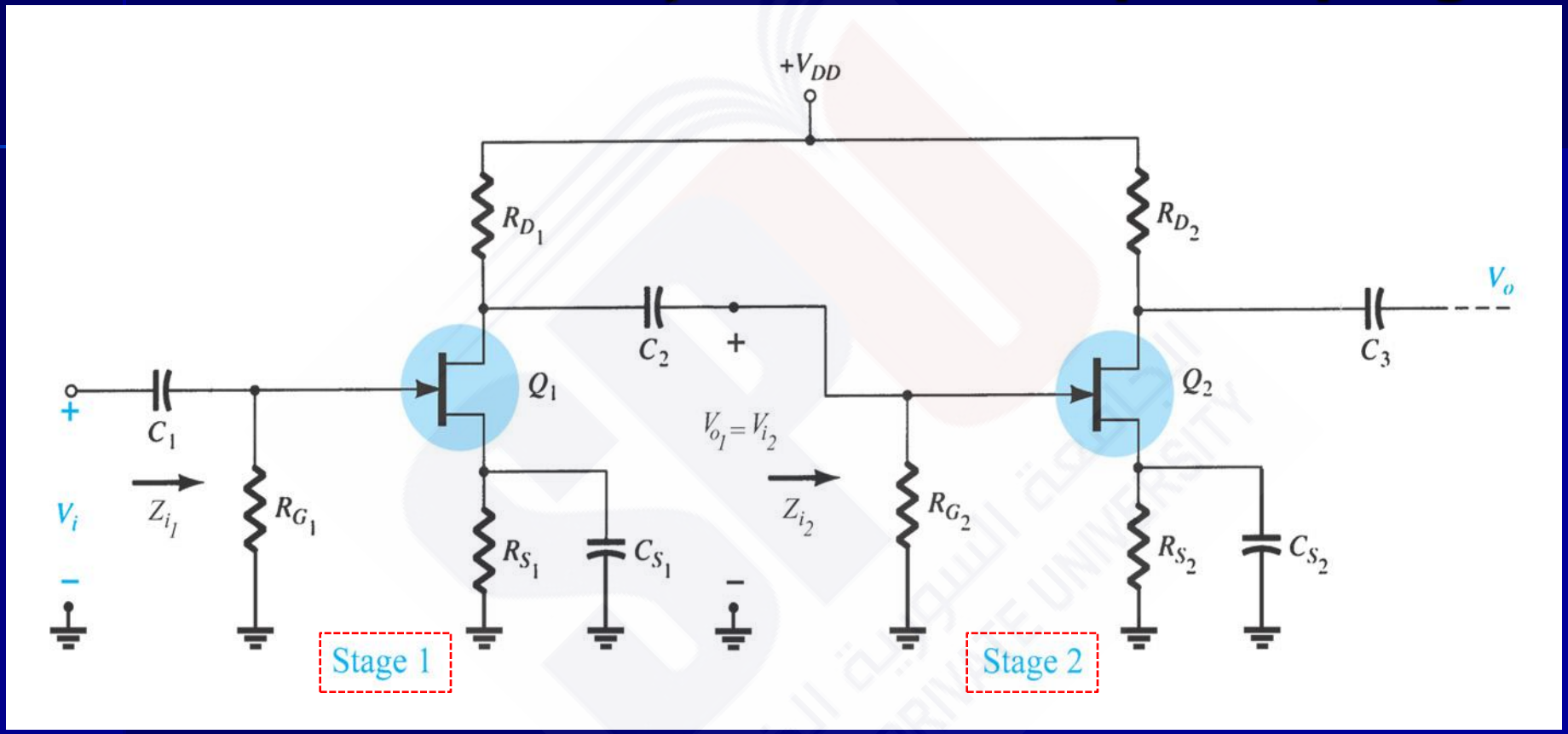
$$Z_i = R_G \quad , \quad Z_o = R_D \| r_d \cong R_D$$

Miller Effect



$$C_i = C_{GS} + C_M = C_{GS} + C_{GD}(1 + A_V)$$

2.6 Cascaded System and Amp. Coupling

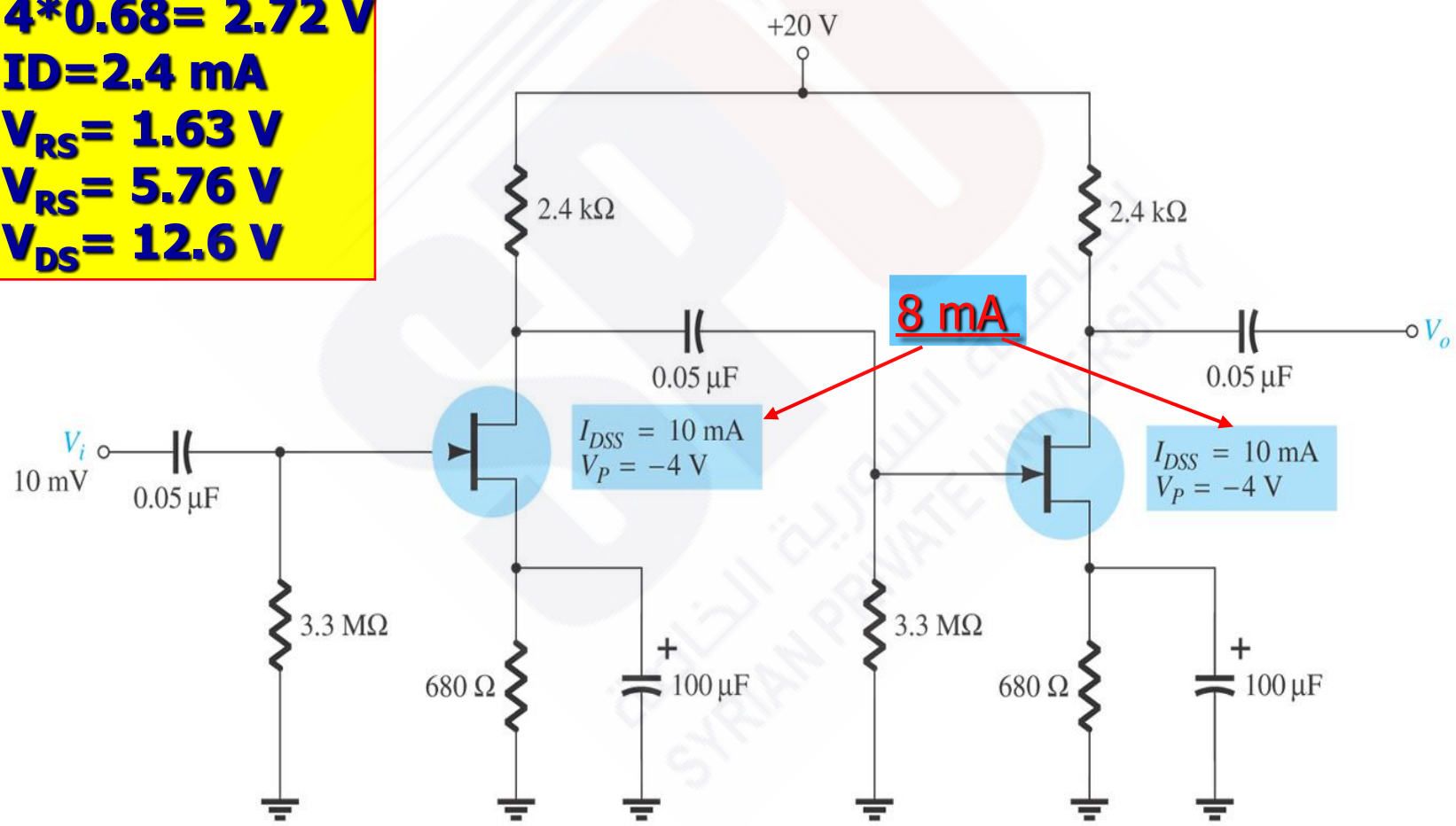


$$A_v = A_{v1} \cdot A_{v2} = g_{m1} R_{D1} \cdot g_{m2} R_{D2}$$

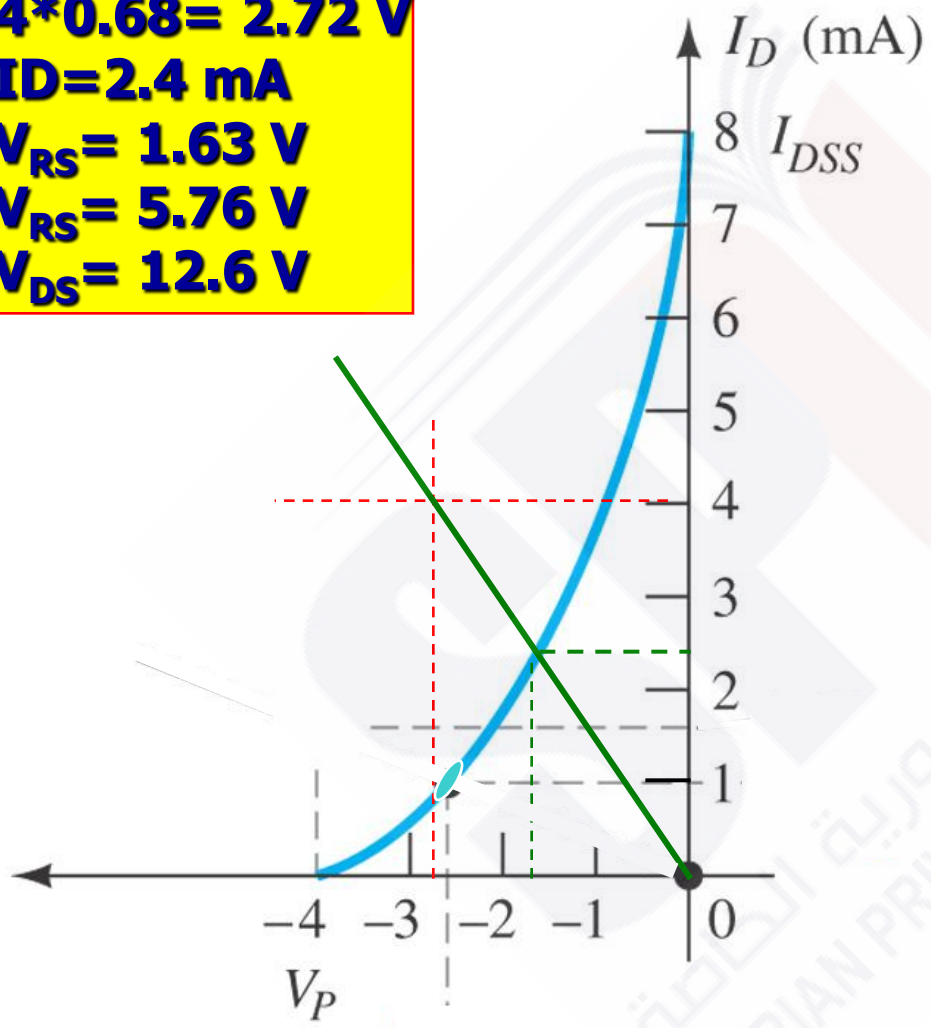
$$Z_i = R_{G1} \quad , \quad Z_o = R_{D2}$$

2.6 Cascaded System and Amp. Coupling

4*0.68= 2.72 V
ID=2.4 mA
V_{RS}= 1.63 V
V_{RS}= 5.76 V
V_{DS}= 12.6 V

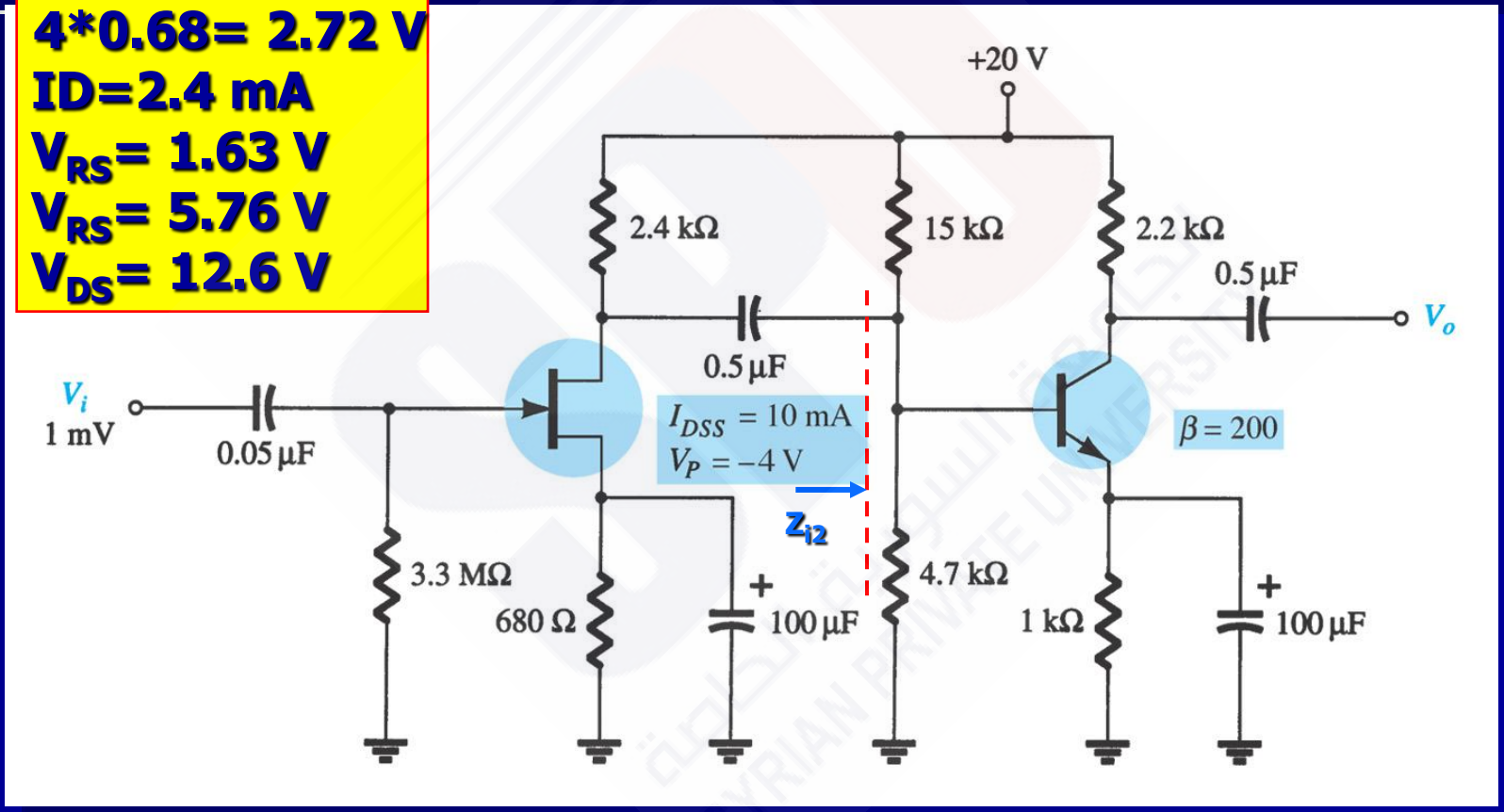


4*0.68= 2.72 V
ID=2.4 mA
V_{RS}= 1.63 V
V_{RS}= 5.76 V
V_{DS}= 12.6 V

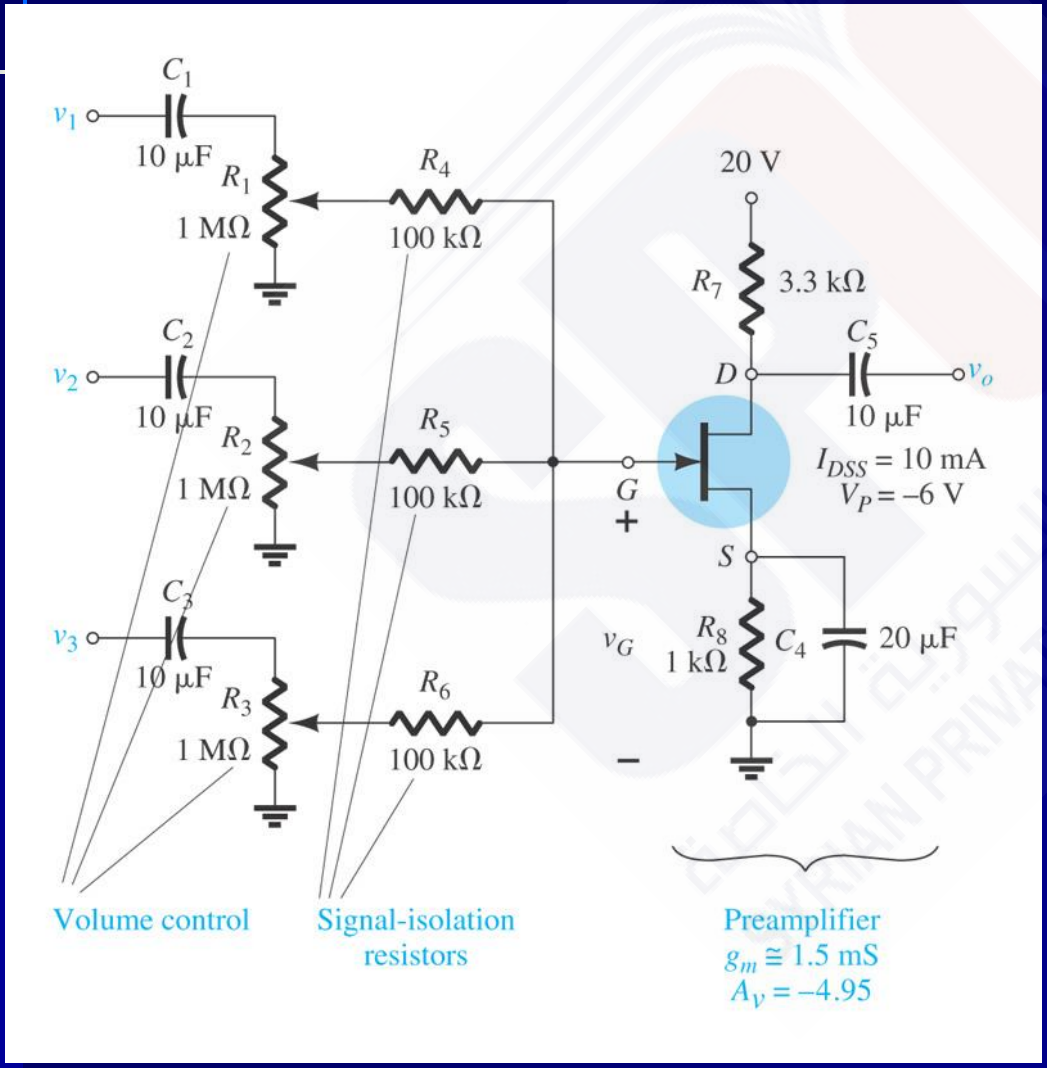


2.6 Cascaded System and Amp. Coupling

4*0.68= 2.72 V
ID=2.4 mA
V_{RS}= 1.63 V
V_{RS}= 5.76 V
V_{DS}= 12.6 V

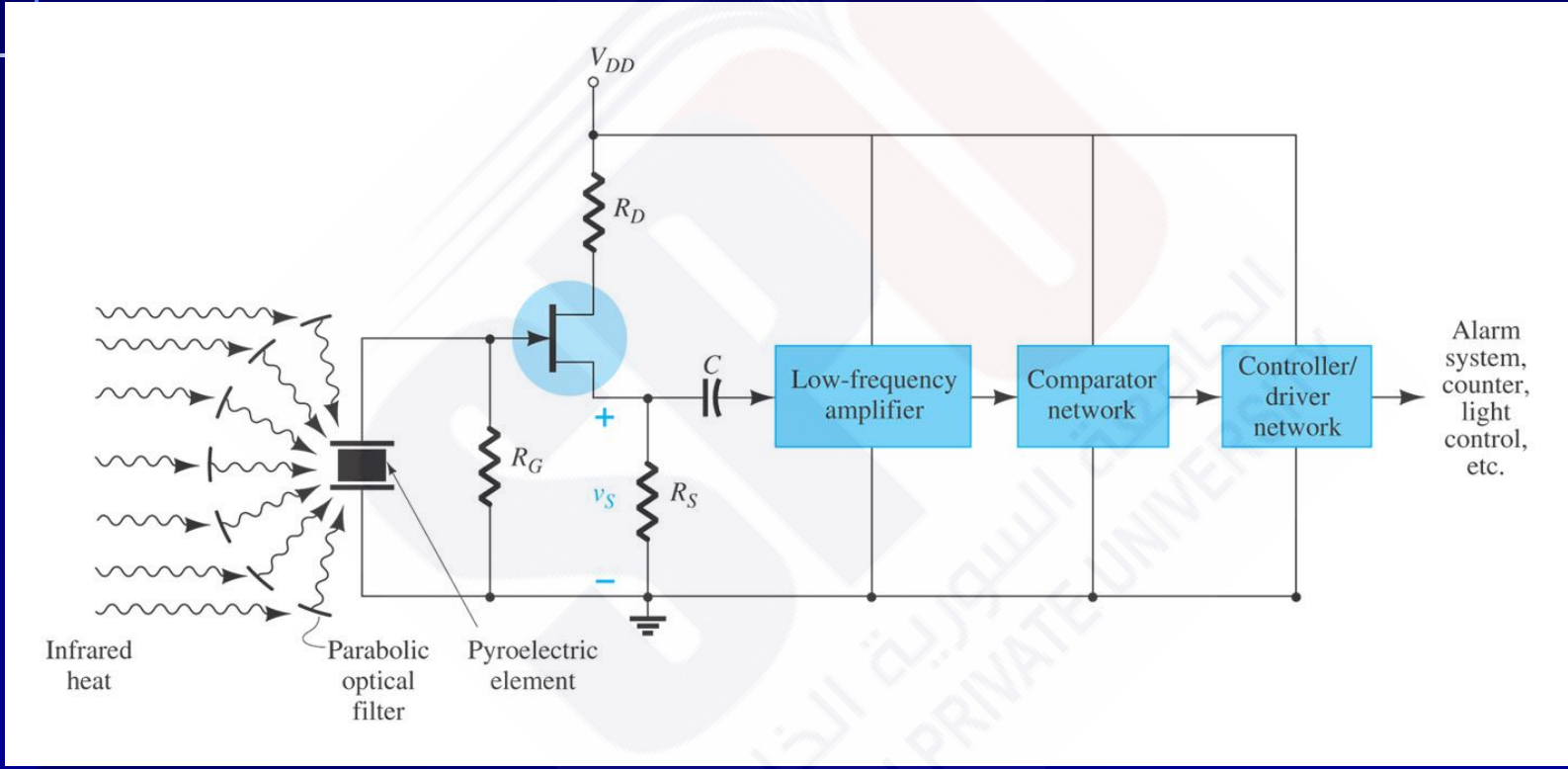


2.7 Practical Applications



3-Channel Audio Mixer

2.7 Practical Applications



Motion-Detection System