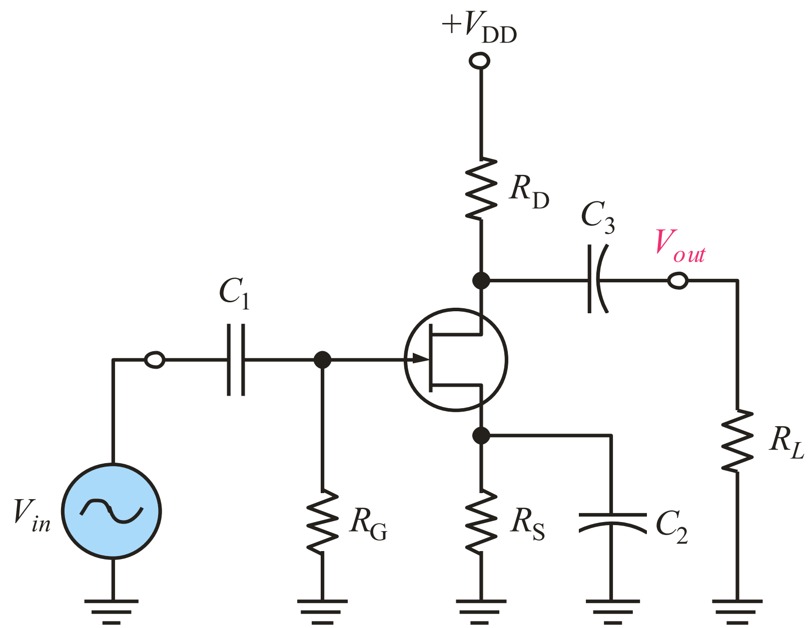
Lecture 12: Field Effect Transistors (FETs) (3)

Chapter-9: Sections 9.1 (Floyd, 10Th Edition)

JFET Common Source Amplifier, MOSFET Common Source Amplifier, Examples

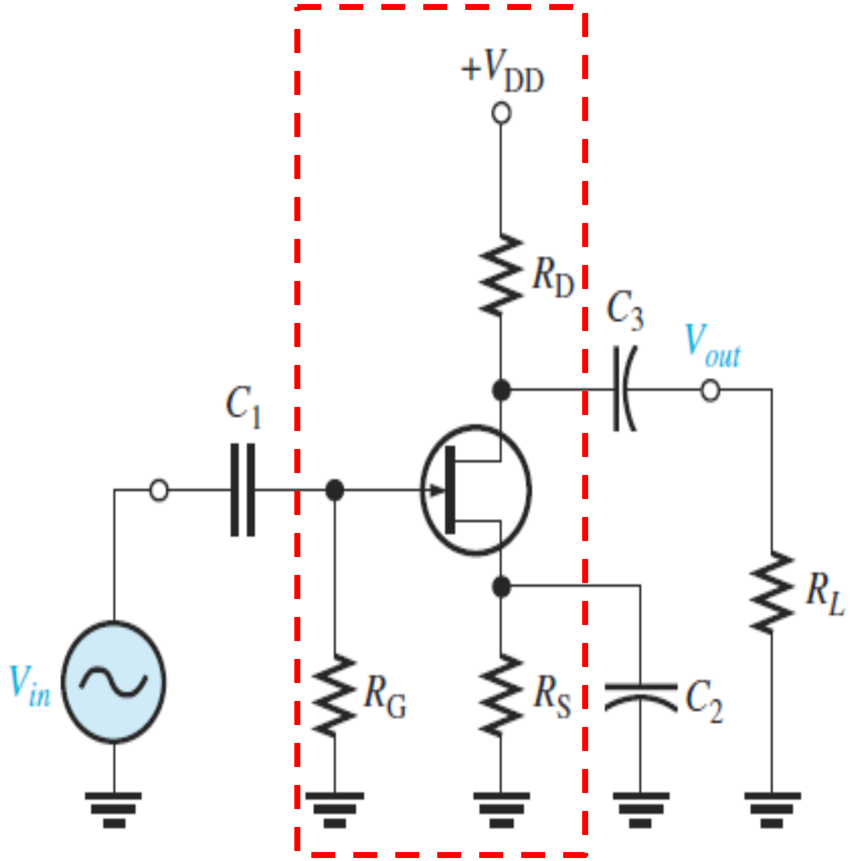
Common Source JFET Amplifier

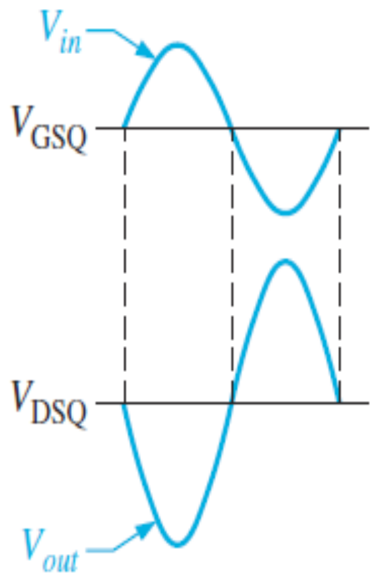
In a CS amplifier, the input signal is applied to the gate and the output signal is taken from the drain. The amplifier has higher input resistance and lower gain than the equivalent CE amplifier.



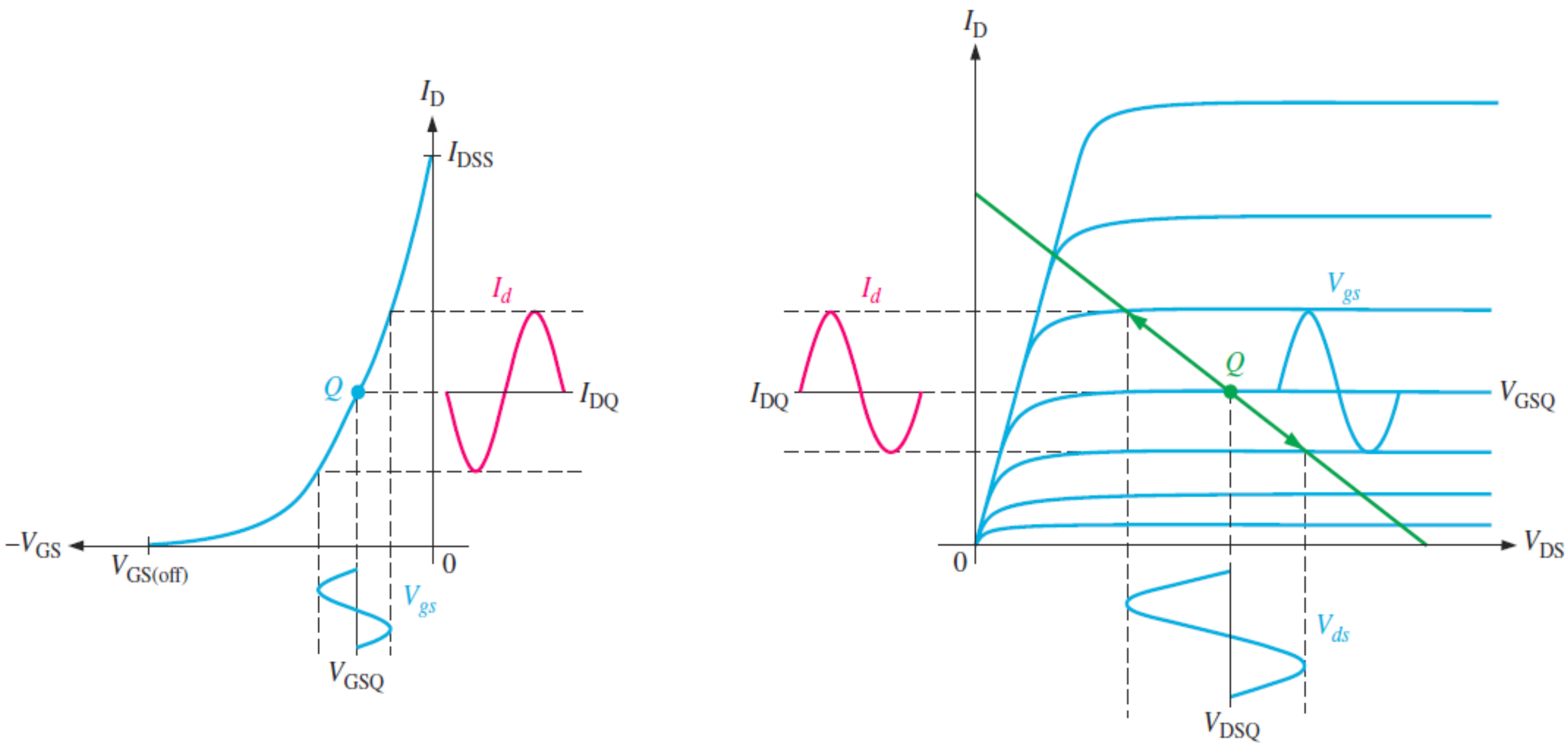
The voltage gain is given by the equation $A_v = -g_m R_d$.

Common Source Amplifier (Cont'd)



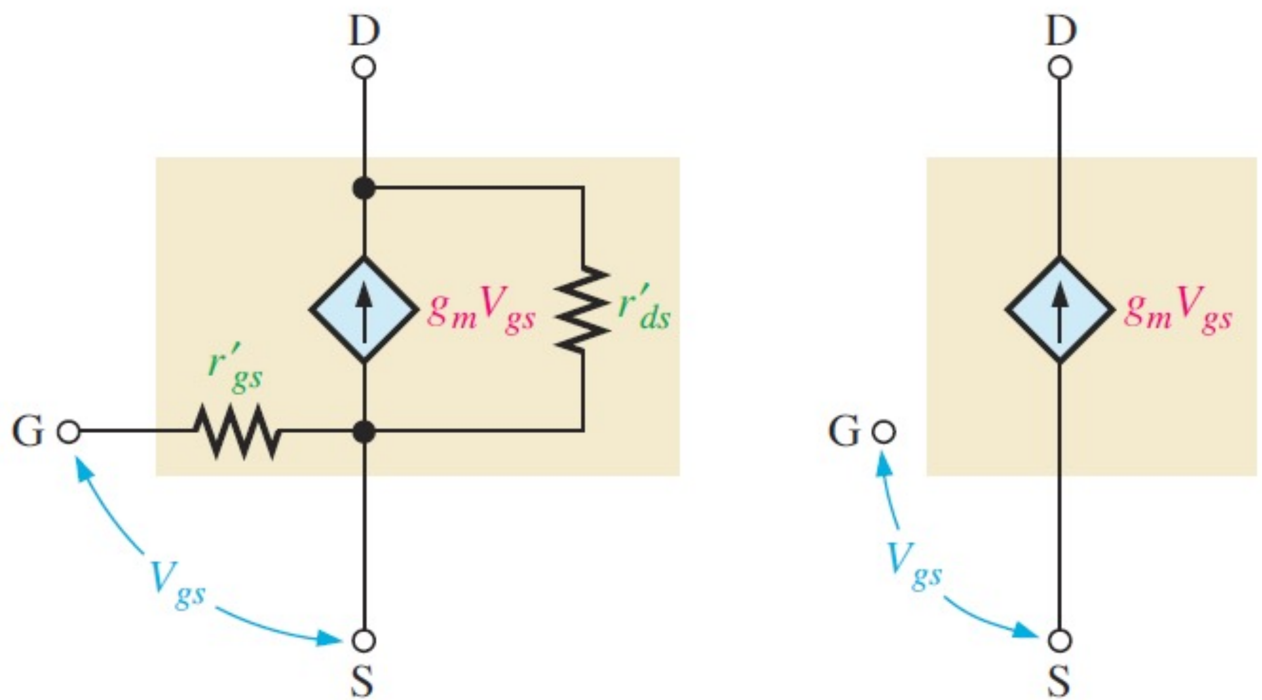


Common Source Amplifier (Cont'd)



small signal variations can be significantly amplified

Small Signal Model



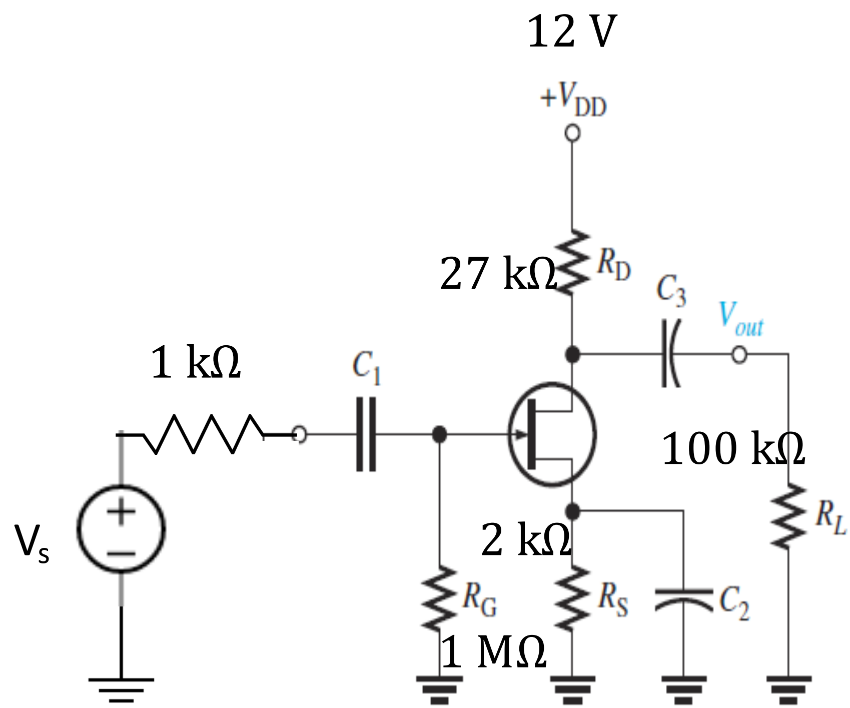
(a) Complete (b) Simplified

Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.

Solution 1:

First, we perform DC analysis to determine bias point.



$$\text{As } I_G = 0,\ V_G = 0\ V$$

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

$$V_S = I_{DS}R_S = 2k\Omega \times I_{DS}$$

Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.

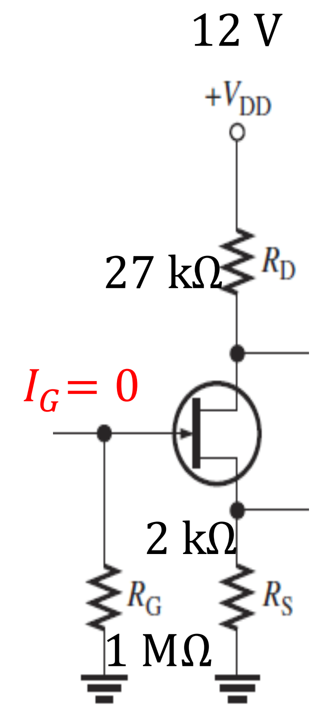
Solution 1:

Substitute $V_{GS} = V_G - V_s = -I_{DS}R_S = -2000\times I_{DS}$

$$I_{DS} = -\frac{V_{GS}}{2000}$$

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

$$-\frac{V_{GS}}{2000} = 1\times10^{-3}\times\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2$$



Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.

Solution 1:

$$-\frac{V_{GS}}{2000} = 1\times10^{-3}\times\left(1-\frac{V_{GS}}{-1}\right)^2$$

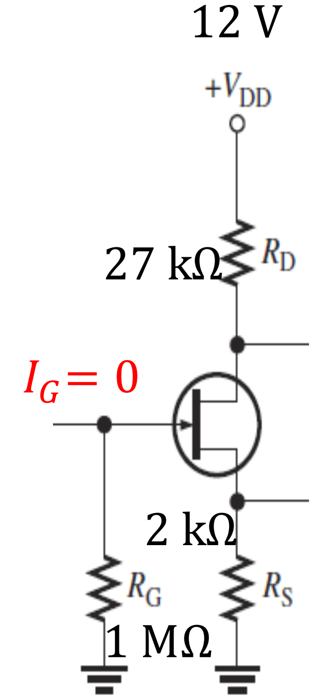
$$V_{GS} = -2\times\left(1+\frac{V_{GS}}{1}\right)^2$$

$$V_{GS} = -2\times(1+2V_{GS}+V_{GS}^2)$$

$$2V_{GS}^2+5V_{GS}+2=0$$

$$(2V_{GS}+1)(2V_{GS}+2)=0$$

$V_{GS} = -0.5\ \mathrm{V}$ Or $V_{GS} = -2\ \mathrm{V}$



Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.

Solution 1:

$$V_{GS} = -0.5 \text{ V}$$

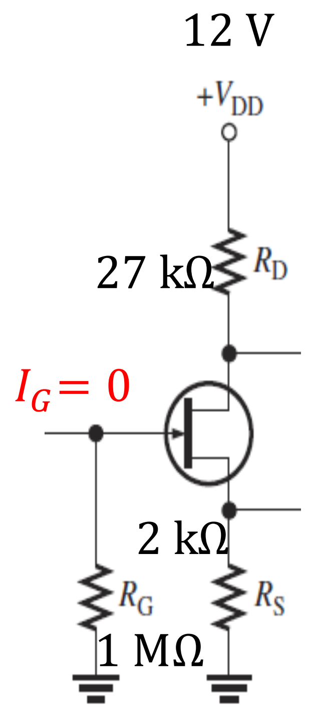
$$I_{DS} = 1\times10^{-3}\left(1 - \frac{-0.5}{-1}\right)^2$$

$$I_{DS} = 0.25\ mA$$

$$V_{DS} = V_{DD} - R_D I_{DS} - R_S I_{DS}$$

$$V_{DS} = 12 - 27k\Omega\times0.25\ mA - 2k\Omega\times0.25\ mA$$

$$V_{DS} = 4.75\ V$$

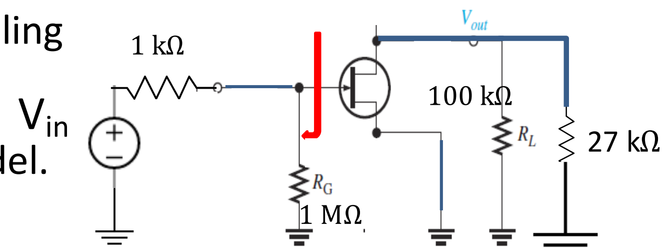


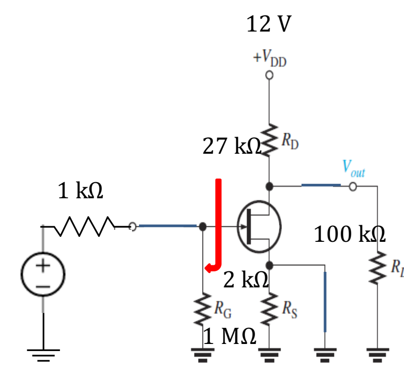
Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.

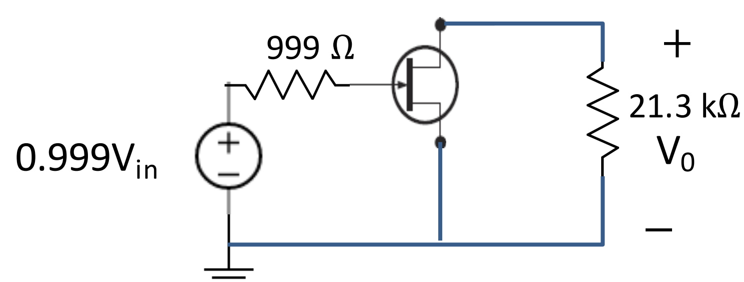
Solution 1:

- Now we perform ac analysis.
- All DC voltages are grounded and all coupling capacitors are shorted.
    - Replace transistor by small signal model.





$V_{TH} = 0.999V_{in}$ $\quad R_{TH} = 999\ \Omega$



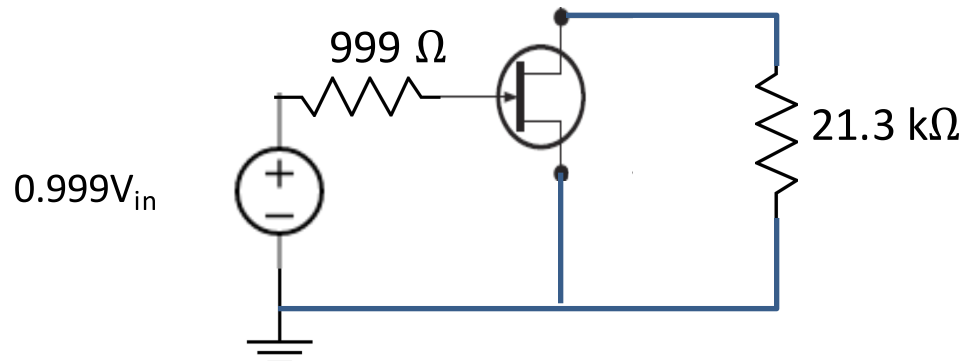
$$V_0 = -g_m \times R_T \times V_{gs}$$

$$= -g_m \times R_T \times 0.999V_{in}$$

$$\frac{V_0}{V_{in}} = -0.999 g_m R_T$$

Example for Common-Source Amplifier

Problem 1: Determine the gain of the shown common source amplifier having I_{DSS} = 1 mA and $V_{GS(off)}$= − 1 V.



Solution 1:

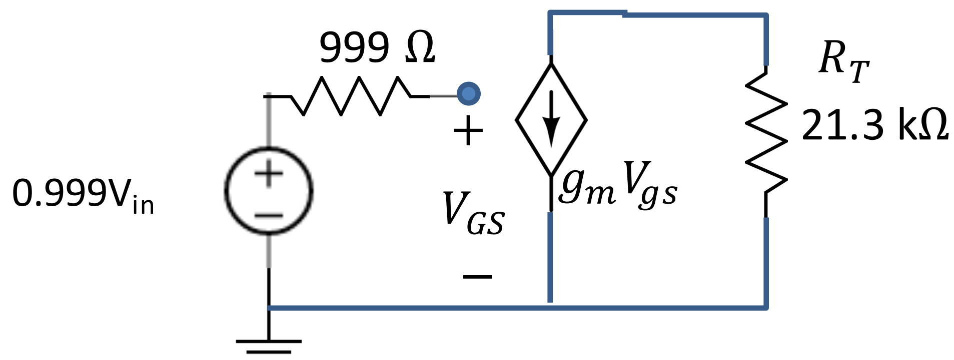
$$\frac{V_0}{V_{in}} = -0.999 g_m R_T$$

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

$$g_m = \frac{2I_{DSS}}{|V_{GS(off)}|}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$$

$$g_m = \frac{2\times10^{-3}}{|1|}\left(1 - \frac{-0.5}{-1}\right)$$

$$g_m = 1\ mA/V$$



$$\text{Gain} = \frac{V_0}{V_{in}} = -0.999 g_m R_T = -0.999\times10^{-3}\times21.3k\Omega = -21.3$$

E-MOSFET Common Source Amplifier

The E-MOSFET is a normally off device. The *n*-channel device is biased by making the gate positive with respect to the source. A voltage-divider biased E-MOSFET amplifier is shown.