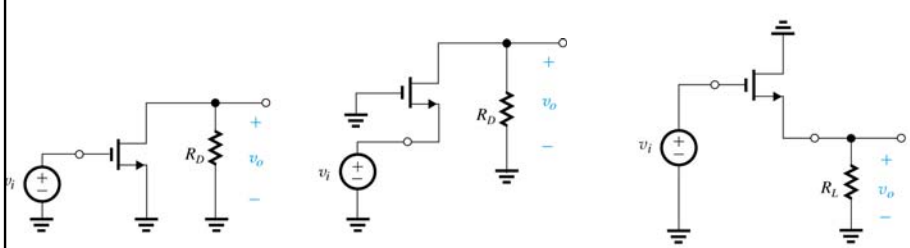
MOSFET Amplifier Configuration

- Single stage
- The signal is fed to the amplifier represented as v_{sig} with an internal resistance R_{sig}.
- MOSFET is represented by its small signal model.
- Generally interested of gain, input and output resistance (overall amplifier circuit not only the small signal model).

MOSFET Amplifier Configuration

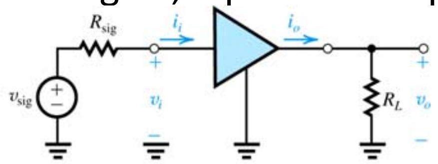
- Considering only the small signal not the bias



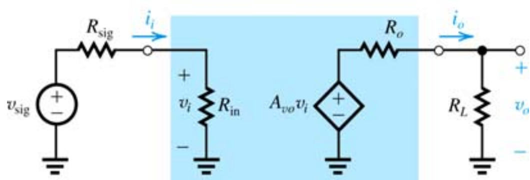
(a) Common Source (CS) (b) Common Gate (CG) (c) Common Drain (CD)

Characterizing Amplifiers

- Find gain, input and output resistance



(a)



(b)

$$R_{in} = \frac{v_i}{i_i}$$

$$A_{vo} = \left.\frac{v_o}{v_i}\right|_{R_L=\infty}, A_v = \frac{v_o}{v_i}$$

$$G_v = \frac{v_o}{v_{sig}}$$ Overall voltage gain

Amplifier Configuration

- Common Source
- Common Source with a source resistance
- Common gate
- Common drain or voltage follower

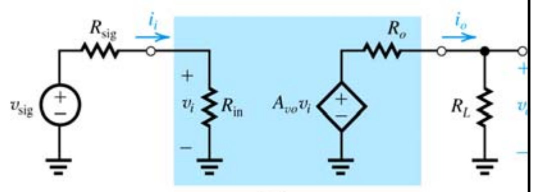
Amplifiers

$$v_o = A_{vo} v_i \frac{R_L}{R_L + R_o}$$

$$v_i = v_{sig} \frac{R_{in}}{R_{in} + R_{sig}}$$

$$A_v = A_{vo} \frac{R_L}{R_L + R_o}$$

$$G_v = \frac{v_o}{v_{sig}} = \frac{R_{in}}{R_{in} + R_{sig}} A_{vo} \frac{R_L}{R_L + R_o}$$

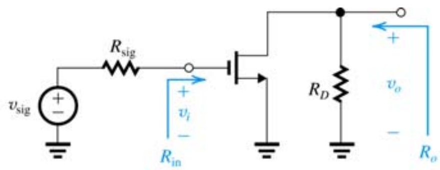


(b)

Common Source

- Most widely used configuration
- In multistage amplifiers, the bulk of the gain is from common source.
- The source is grounded, making it common between input and output.
- We can use hybrid π model.

Common Source



For R_o, set v_i=0

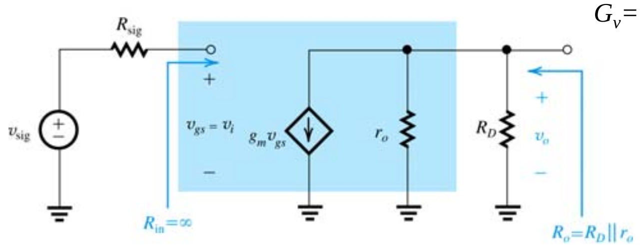
$$R_o = r_0 \parallel R_D$$

$$A_{vo} = -g_m (r_0 \parallel R_D)$$

$$R_i = \infty$$

(a)

A_V= ?
G_v=?

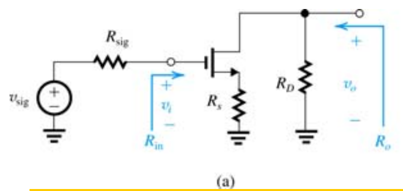


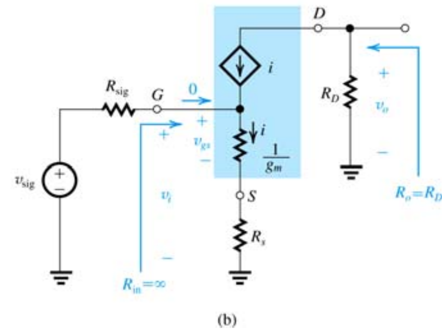
(b)

Common Source with Source R

- For simplicity, r_0 is not included.
- No effect on discrete implementation, not so for IC's
- R_s provides a negative feedback to control the magnitude of the signal to prevent nonlinear distortion.
- Also reduces the voltage gain and extends the useful bandwidth.

Common Source with Source R

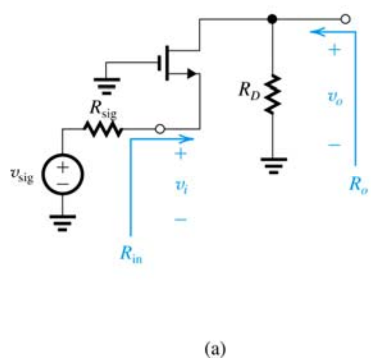


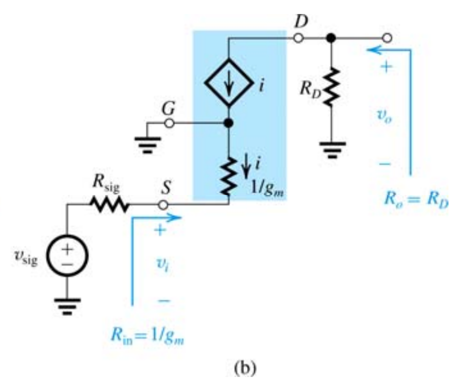


$$v_{gs} = -g_m v_i \frac{1/g_m}{1/g_m + R_S}$$

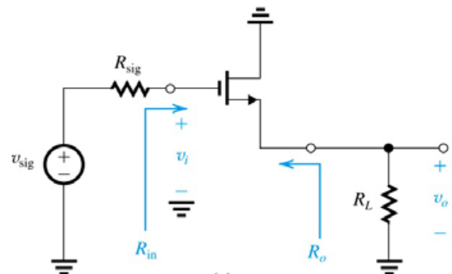
$$v_{gs} = \frac{v_i}{1+g_m R_S}$$

Common Gate Amplifier





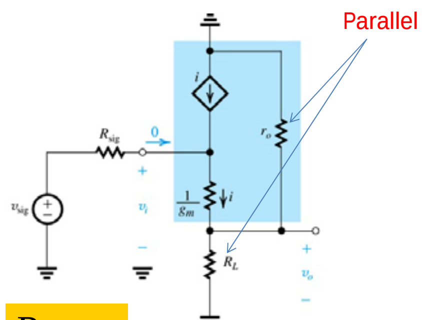
Common Drain Amplifier – Source Follower



(a)

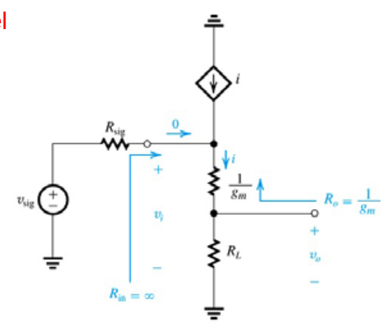
Since there is a resistance RL connected to the source, it is easier to use the T-model

Common Source – Voltage Follower



(b)

$R_i = \infty$

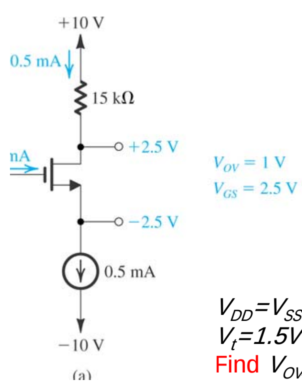


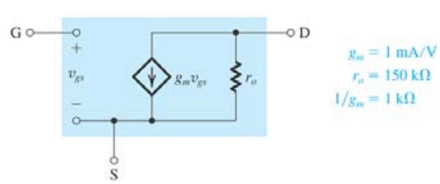
(c)

Comparison

	CS	CS+RS	CG	CD
Rin	∞	∞	$\frac{1}{g_m}$	∞
Rout	RD || ro	R_D	R_D	$1/g_m$
G	$-g_m(R_D \|\| R_L \|\| r_o)$	$A_v = \frac{g_m(R_D\|\|R_L)}{1+g_m R_s}$	$G_v = \frac{(R_D\|\|R_L)}{1/g_m + R_{sis}}$	$G_v = A_v = \frac{R_L}{1/g_m + R_L}$

Example E5.37





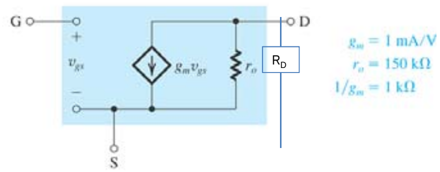
$V_{DD}=V_{SS}=10V$, $I=0.5$ mA, $R_G=4.7M\Omega$, $R_D=15K\ \Omega$, $V_t=1.5V$ $k_n=1mA/V^2$ $V_A=75V$

Find V_{OV}, V_{GS}, V_G, V_S, V_D, g_m, r_o

What is the max. possible voltage swing at drain and the MOSFET remains in saturation?

Example 5.38

Find R_{in}, A_{vo}, R_o, G_v, *with and without* r_o R_{sig}=100KΩ and R_L = 15 KΩ

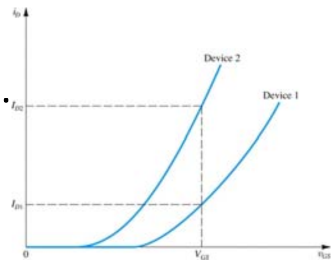


Biasing in MOS Amplifiers

- How to choose the operating point?
- Want a stable Q-point (known I_D and V_{DS}) to ensure operation in the saturation region.

Biasing -- Fixing V_{GS}

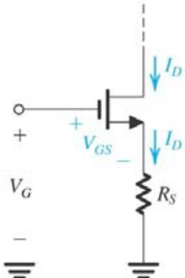
- I_D depends on μ, C_{ox}, W/L and V_t, and V_{GS}
- C_{ox}, V_{GS} (even W/L) can vary across devices of the same type.
- Constant V_{GS} Not a good idea .
- μ,C_{ox} are a f(t)

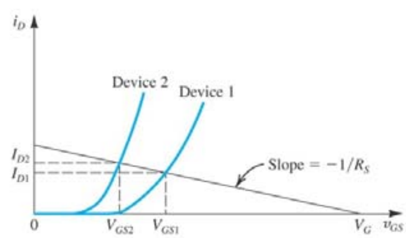


Microelectronic Circuits, Sixth Edition Sedra/Smith

Biasing – Fixing V_G and R_S

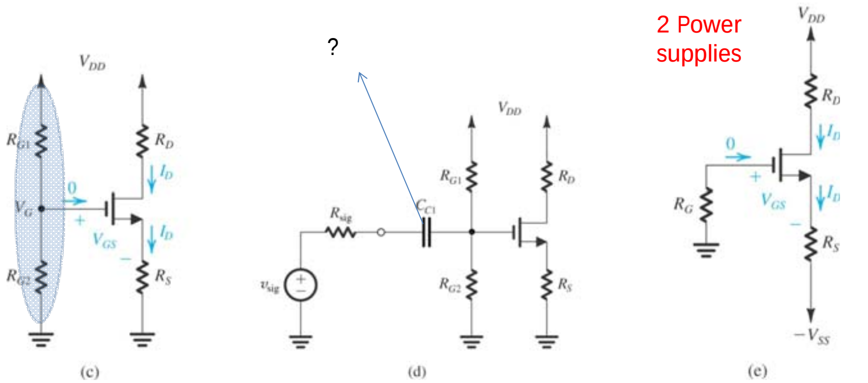
- R_S provides a negative feedback to stabilize I_D





Biasing – Fixing V_G and R_S

- Uses one power supply
- What is the effect on input resistance when you add v_{gs} signal



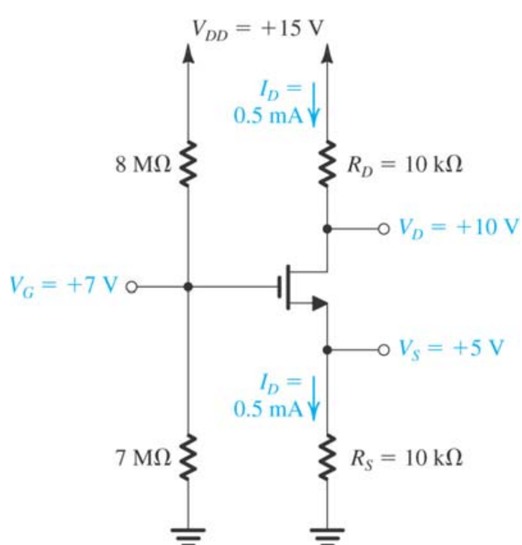
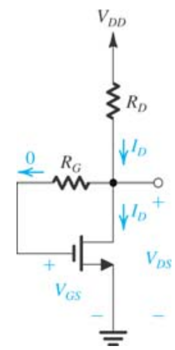


Figure 5.53 Circuit for Example 5.12.

Biasing – D-to-G Resistor

- $V_{GS} = V_{DS} = V_{DD} - I_D R_D$
- $V_{DD} = V_{GS} + I_D R_D$
- Provides a feedback resistor to

Stabilize I_D



Biasing – Constant Current Source

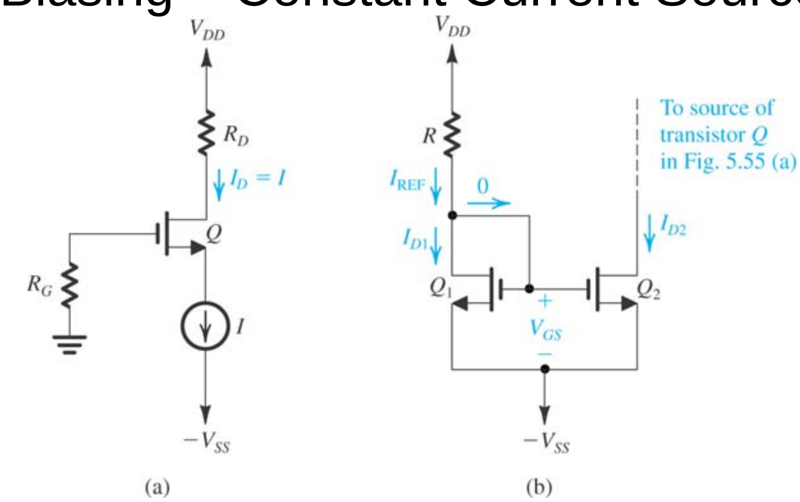


Figure 5.55 (a) Biasing the MOSFET using a constant-current source *I*. (b) Implementation of the constant-current source *I* using a current mirror.

Frequency Response