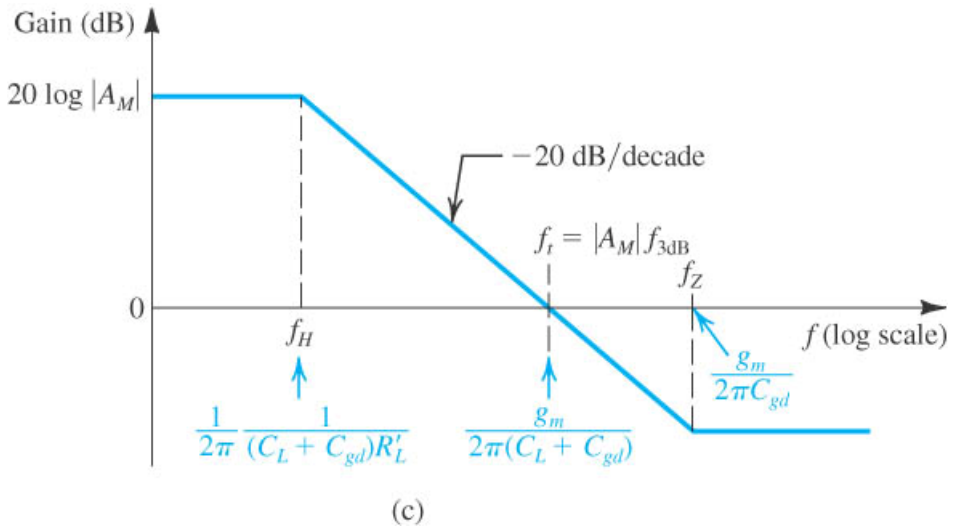
CHAPTER 6

Single-Stage Integrated-Circuit Amplifiers

Frequency Response

- Zeros and poles: dominant pole (at least two octaves away from the nearest pole or zero)
- Open circuits time constants
- Miller's theorem

6.6.5 The situation when R_{sig} is low

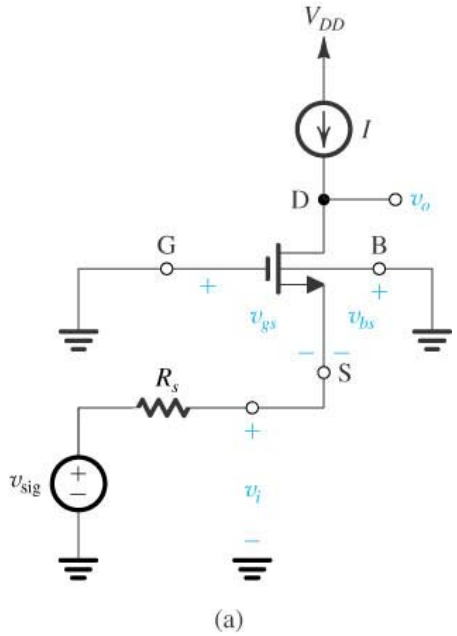


(c)

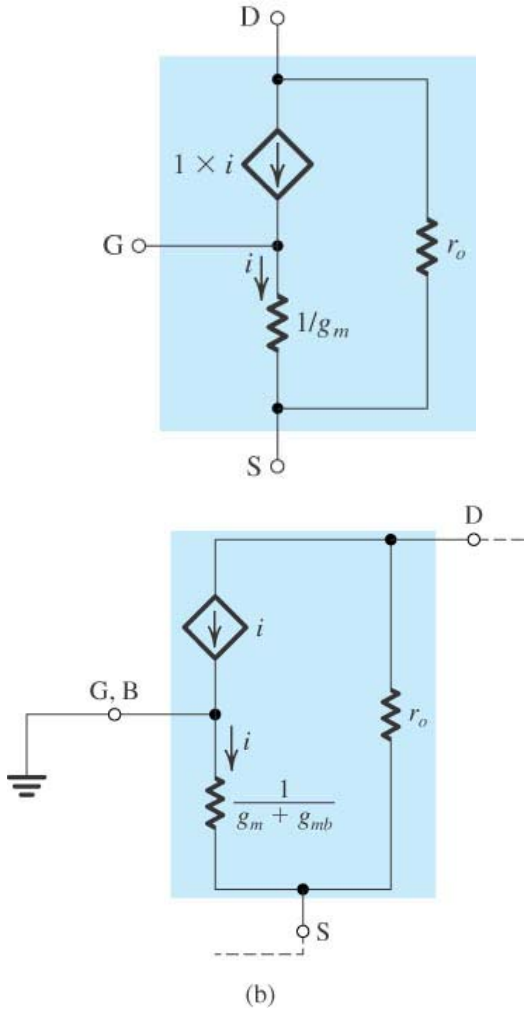
Gain-bandwidth product

$$f_t = |A_M| f_H = g_m R_L' \frac{1}{2\pi(C_L + C_{gd})R_L'} = \frac{g_m}{2\pi(C_L + C_{gd})}$$

6.7.1 The Common Gate Amplifier



(a)



(b)

Drain Current:

$$g_m v_{gs}$$

The Body Effect

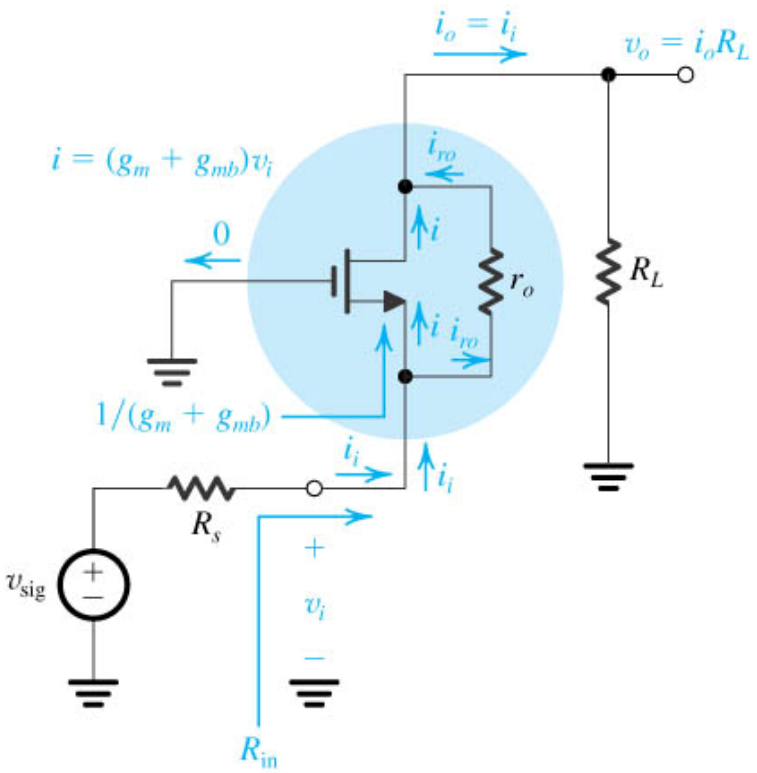
$$g_m v_{gs} + g_{mb} v_{bs}$$

$$g_{mb} = \chi g_m \qquad \chi = 0.1 \sim 0.2$$

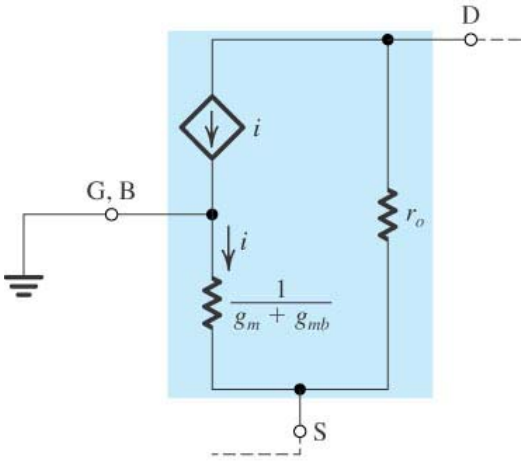
for $v_{gs} = v_{bs}$

$$(g_m + g_{mb}) v_{gs}$$

6.7.1 The Common Gate Amplifier: *Input Resistance*



(c)



(b)

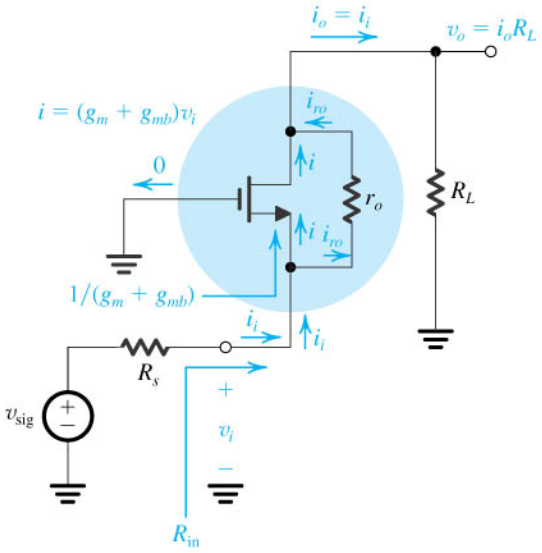
$$R_{in} \equiv \frac{v_i}{i_i} = ?$$

$$R_{in} \equiv \frac{v_i}{i_i} = \frac{r_o + R_L}{1 + (g_m + g_{mb})r_o}$$

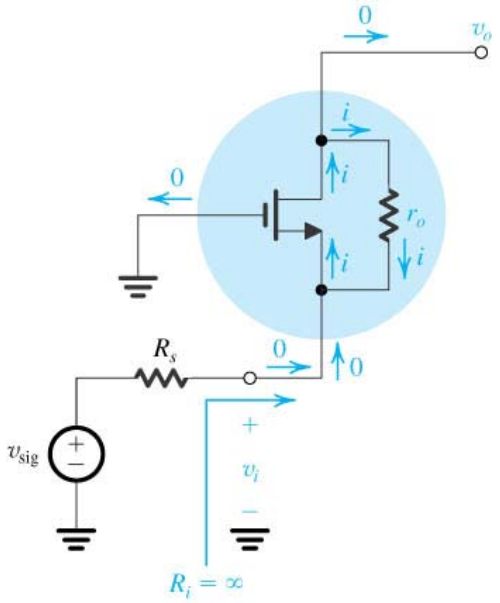
$r_o \to \infty$?

$$\begin{cases} i_i = (g_m + g_{mb})v_i + i_{ro} \\ i_{ro} = \dfrac{v_i - v_o}{r_o} = \dfrac{v_i - i_i R_L}{r_o} \end{cases} \Rightarrow i_i = \left(g_m + g_{mb} + \frac{1}{r_o}\right)v_i \Big/ \left(1 + \frac{R_L}{r_o}\right)$$

6.7.1 The Common Gate Amplifier: $R_L \to \infty$



(c)



(d)

$$R_i \equiv \left.\frac{v_i}{i_i}\right|_{R_L=\infty} = ?$$

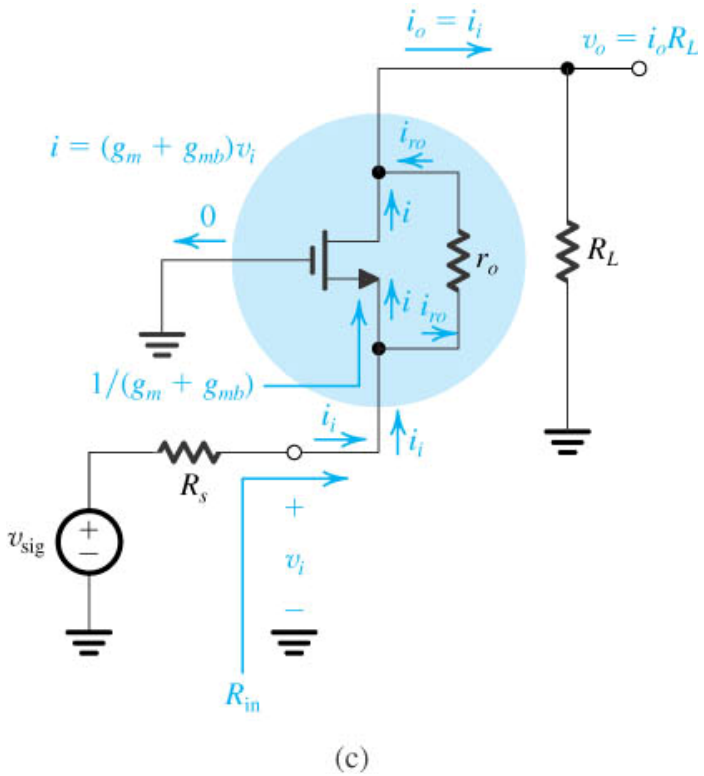
$$R_{in} \equiv \frac{v_i}{i_i} = \frac{r_o + R_L}{1 + (g_m + g_{mb})r_o}$$

$$R_i = \frac{v_i}{i_i} = \infty$$

$$v_o = ir_o + v_i = (g_m + g_{mb})r_o v_i + v_i$$

$$\frac{v_o}{v_i} = 1 + (g_m + g_{mb})r_o > 0$$ **noninverting**

6.7.1 The Common Gate Amplifier: *Voltage Gain*



(c)

$$\begin{cases} v_o = i_i R_L \\ v_i = i_i R_{in} \end{cases} \Rightarrow A_v = \frac{v_o}{v_i} = \frac{R_L}{R_{in}}$$

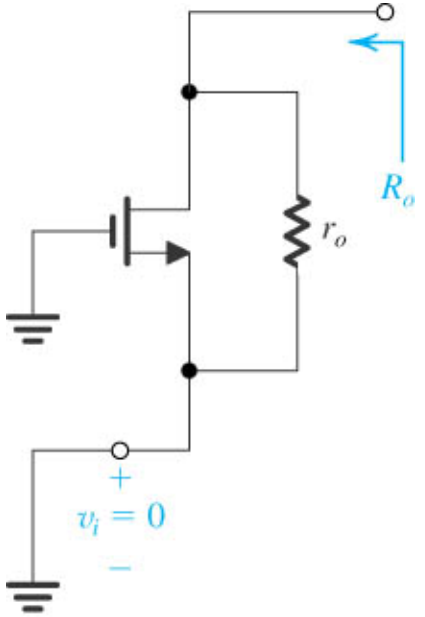
Overall Gain

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

$$G_v = \frac{v_o}{v_{sig}} = \frac{R_L}{R_s + R_{in}}$$

6.7.1 The Common Gate Amplifier:

Output Resistance R_o: $v_i = 0$

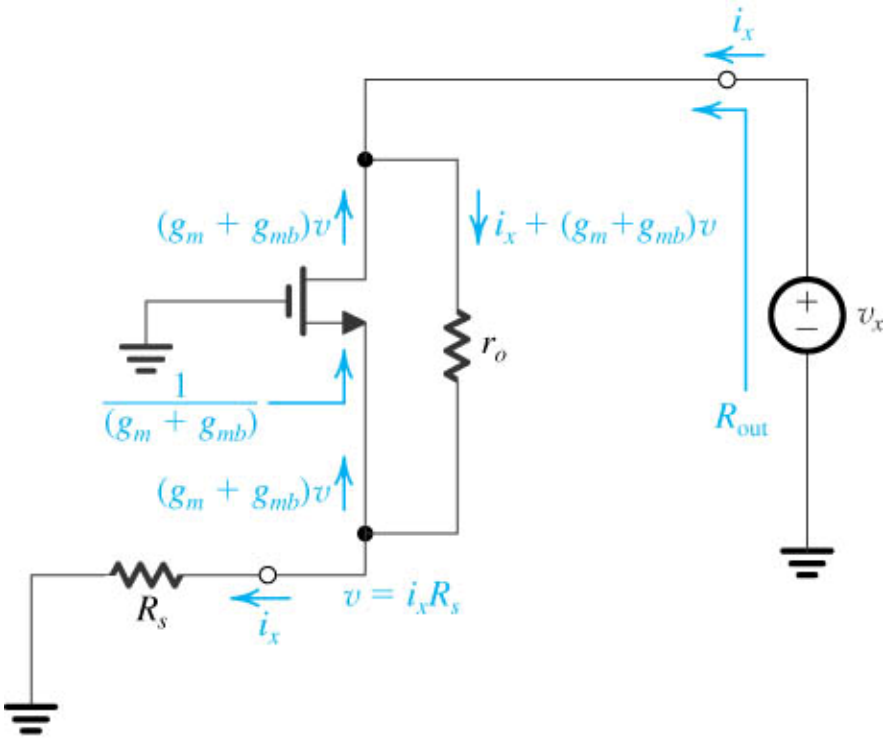


(a)

$$R_o \equiv \left.\frac{v_x}{i_x}\right|_{v_i=0} = r_o$$

6.7.1 The Common Gate Amplifier:

Output Resistance R_{out}: $v_{sig} = 0$



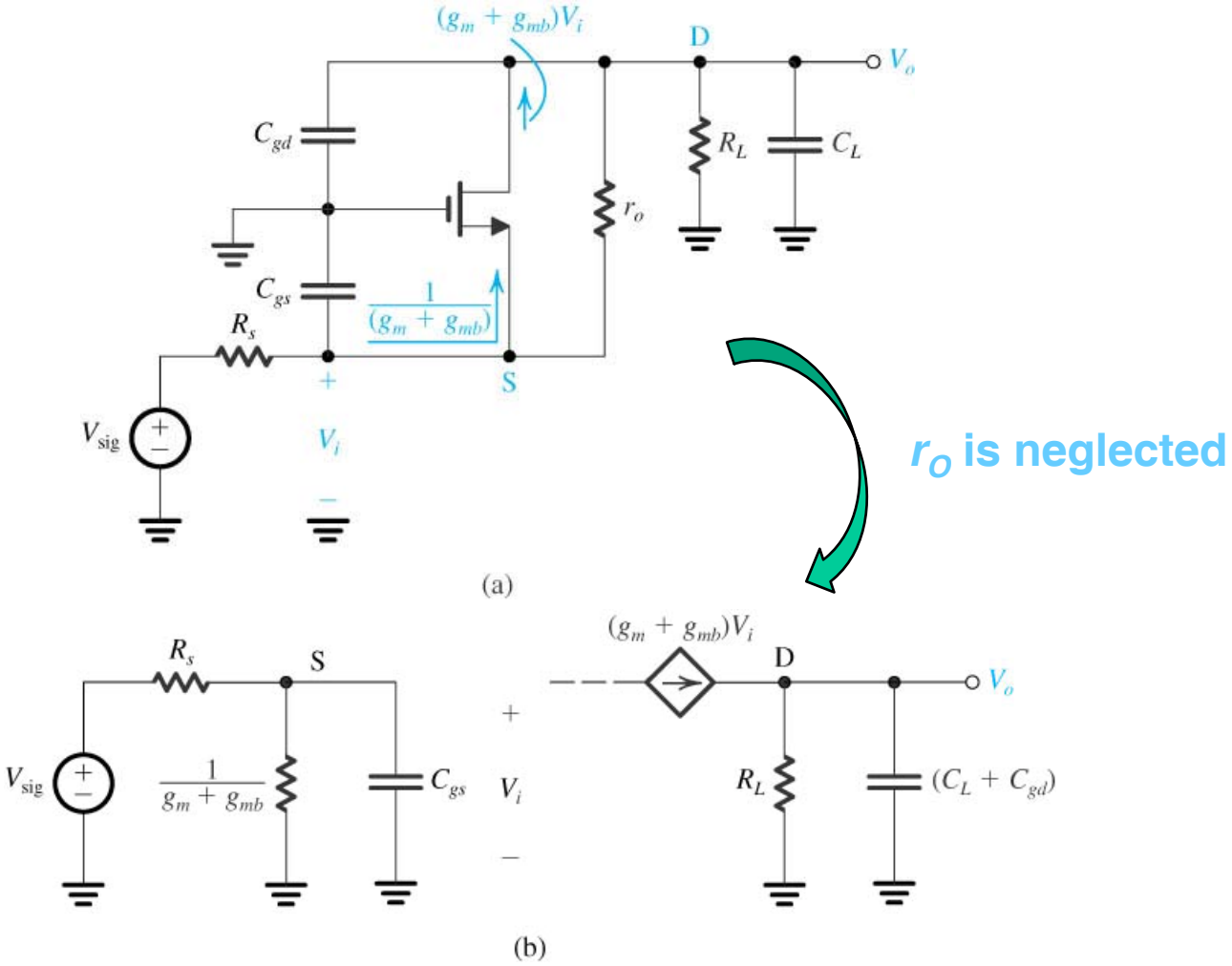
(b)

$$v = i_x R_s$$

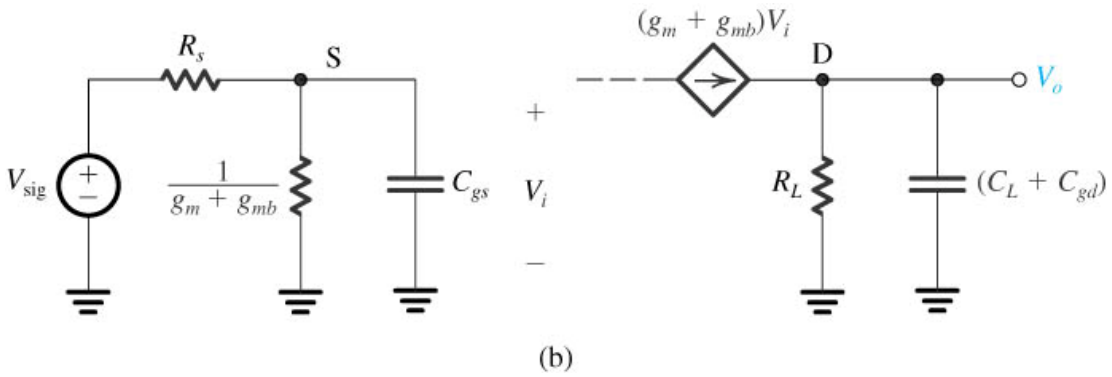
$$v_x = [i_x + (g_m + g_{mb})v]r_o + v$$

$$R_{out} \equiv \frac{v_x}{i_x} = r_o + [1 + (g_m + g_{mb})r_o]R_s$$

6.7.1 The Common Gate Amplifier: *High-frequency*



6.7.1 The Common Gate Amplifier: *High-frequency*



(b)

Two poles (r_O is neglected):

$$f_{P1} = \frac{1}{2\pi C_{gs}\left(R_s \,\|\, \frac{1}{g_m + g_{mb}}\right)}$$

$$f_{P2} = \frac{1}{2\pi (C_{gd} + C_L) R_L}$$

f_{p1} and f_{p2} are usually higher than the frequency of the dominant input pole in the CS stage

Homework

6.67, 6.74, 6.79, D6.83, 6.86

Project