电子学基础——第十一次作业

LXQ

2019.12.20

11.4 Construct the Bode plot of $|V_{out}/V_{in}|$ for the stages depicted in Fig. 11-62.

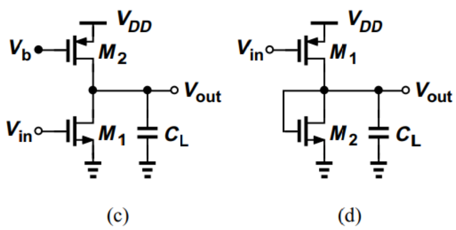


Figure 11-62

解 (c) M_2电流稳定，可视为r_{o1}电阻。则

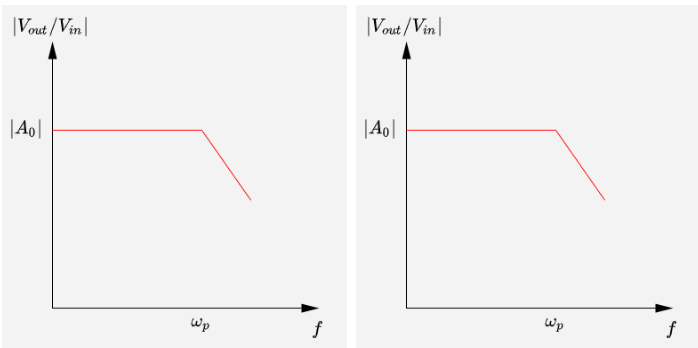
$$A_0 = -g_m(r_{o2}//r_{o1}), \omega_p = \frac{1}{r_{o2}C_L}$$

波特图如图 p11-4-c 所示。

(d) M_2可视为$\frac{1}{g_{m2}}$，则有极点$\omega_p = \frac{g_{m2}}{C_L}$

$$A_0 = -\frac{g_{m1}}{g_{m2}}$$

波特图如图 p11-4-d。



(a) (b)

Figure p11-4

11.6 An amplifier exihibits two poles at 100MHz and 10GHz and a zero at 1GHz. Construct the Bode plot of $|V_{out}/V_{in}|$.

解 如图 p11-6 所示。其中三个斜率发生改变的点为$\omega_{p1} = 100\text{MHz}$, $\omega_z = 1\text{GHz}$, $\omega_{p2} = 10\text{GHz}$.

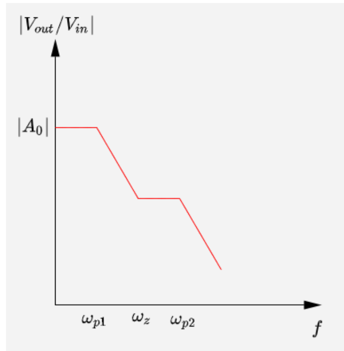


Figure p11-6

11.12 Due to a mannufacturing error, a parasitic resistance R_P has appeared in series with the source of M_1 in Fig. 11-65. Assuming $\lambda = 0$ and neglecting other capacitances, determine the input and output poles of the circuit.

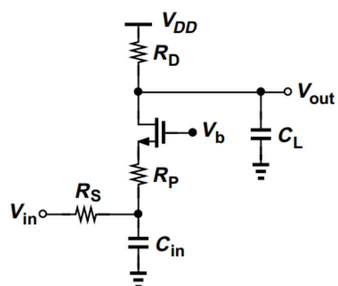


Figure 11-65

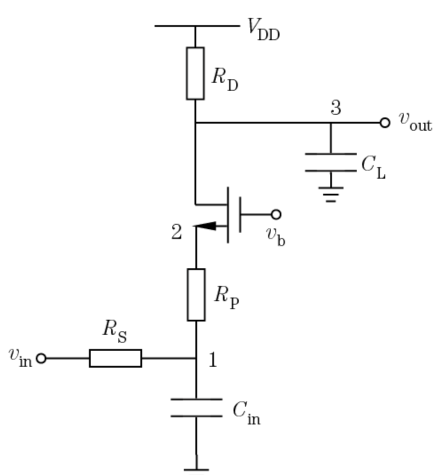


Figure p11-12

解 如图 p11-12 所示。对于节点一，

$$\omega_{p1}=\frac{1}{C_{in}[R_S//(R_P+\frac{1}{g_m})]}$$

节点二仅有分压效果，不产生极点。
对于节点三，

$$\omega_{p2}=\frac{1}{C_L R_D}$$

11.13 Repeat Problem 12 for the circuit shown in Fig. 11-66.

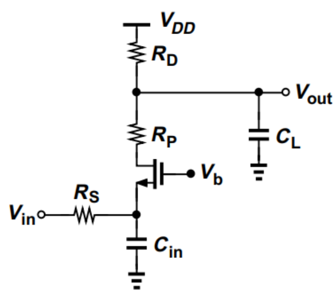


Figure 11-66

解 在输入端，

$$\omega_{p1}=\frac{1}{C_{in}(R_S//\frac{1}{g_m})}$$

在输出端，

$$\omega_{p2}=\frac{1}{C_L(R_D//R_P)}$$

11.14 Repeat Problem 12 for the CS stage depicted in Fig. 11-67.

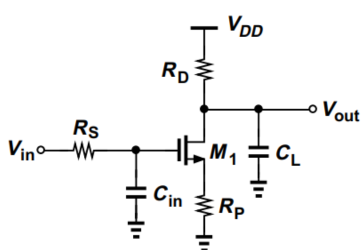


Figure 11-67

解 在输入端，

$$\omega_{p1}=\frac{1}{C_{in}R_S}$$

在输出端，

$$\omega_{p2}=\frac{1}{C_L R_D}$$

11.19 Using Miller's theorem, estimate the input capacitance of the circuit depicted in Fig. 11-71. Assume $\lambda > 0$ but neglect other capacitances. What happens if $\lambda \to 0$?

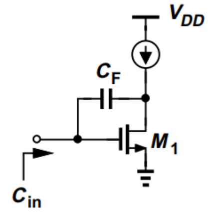


Figure 11-71

解 M_1内部可看作并联电阻r_o，则在小信号电路中可看作r_o连接漏端与地，从而可对C_F应用密勒定理。

$$C_{in} = (1 + g_m r_o) C_F$$

当$\lambda \to 0$，则$C_{in} \to \infty$

11.38 Assuming $\lambda > 0$ and using Miller's theorem, determine the input and output poles of the stages depicted in Fig. 11-80.

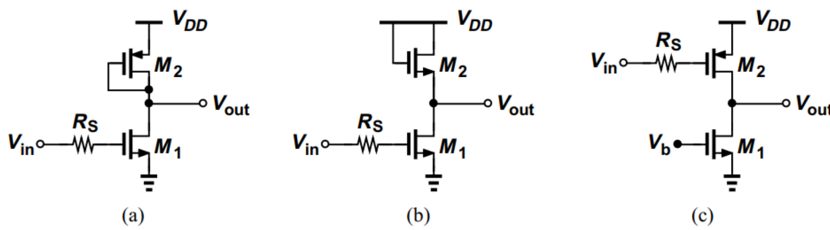


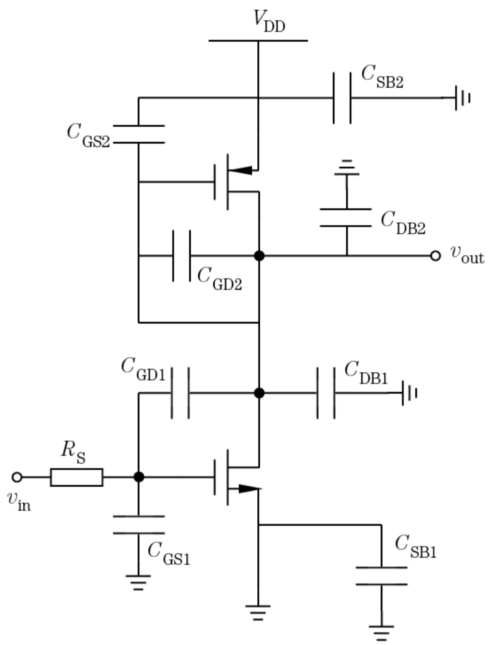
Figure 11-80

解 (a) 画出所有电容的电路以及简化后的电路如图 p11-38-a 所示。其中

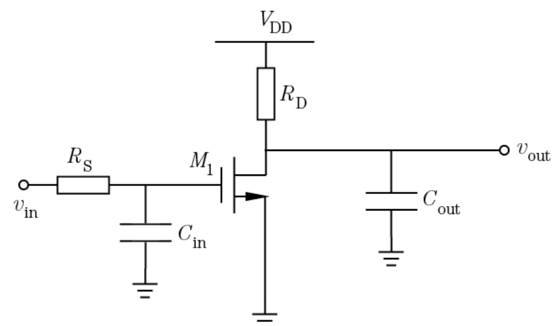
$$\begin{aligned}
R_D &= \frac{1}{g_{m2}} // r_{o2} \\
A_0 &= g_{m1} \left(\frac{1}{g_{m2}} // r_{o2} // r_{o1} \right) \\
C_{in} &= C_{GS1} + C_{GD1} \left(1 + g_{m1} \left(\frac{1}{g_{m2}} // r_{o2} // r_{o1} \right) \right) \\
C_{out} &= C_{DB1} + C_{DB2} + C_{GS2} + C_{GD1} \left[1 + \frac{1}{g_{m1} \left(\frac{1}{g_{m1}} // r_{o2} // r_{o1} \right)} \right]
\end{aligned}$$

其中A_0为电路低频增益，从而

$$\begin{aligned}
\omega_{p1} &= \left[R_S \left[C_{GS1} + C_{GD1} \left(1 + g_{m1} \left(\frac{1}{g_{m2}} // r_{o2} // r_{o1} \right) \right) \right] \right]^{-1} \\
\omega_{p2} &= \left[\left(\frac{1}{g_{m2}} // r_{o2} \right) \left[C_{DB1} + C_{DB2} + C_{GS2} + C_{GD1} \left(1 + \frac{1}{g_{m1} \left(\frac{1}{g_{m1}} // r_{o2} // r_{o1} \right)} \right) \right] \right]^{-1}
\end{aligned}$$



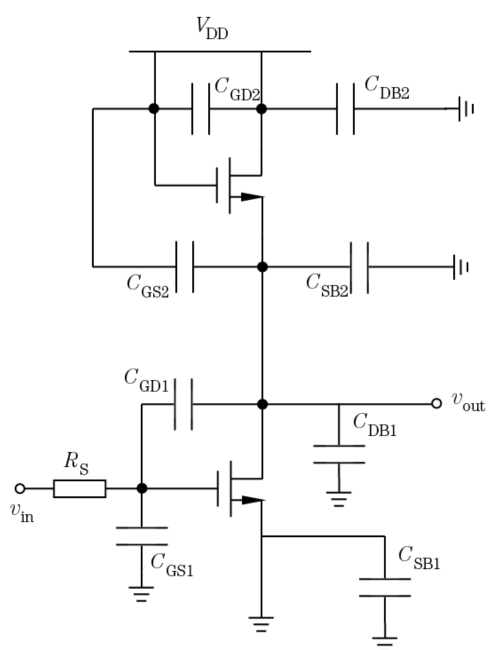
(1) 标出电容



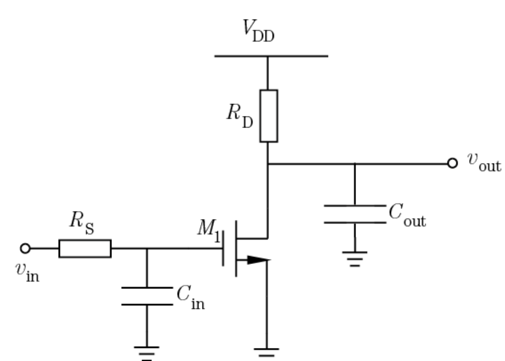
(2) 简化电路

Figure p11-38-a

(b) 画出所有电容后的电路以及简化后的电路如图 p11-38-b 所示。其中



(1) 标出电容



(2) 简化电路

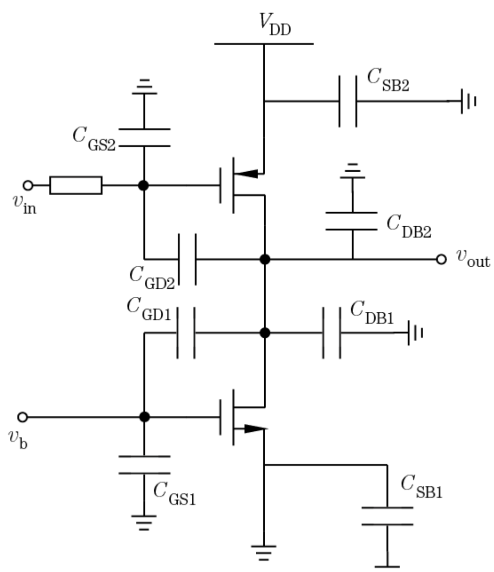
Figure p11-38-b

$$
\begin{aligned}
R_D &= \frac{1}{g_{m2}} // r_{o2} \\
A_0 &= g_{m1}\left(\frac{1}{g_{m2}} // r_{o2} // r_{o1}\right) \\
C_{in} &= C_{GS1} + C_{GD1}\left[1 - g_{m1}\left(\frac{1}{g_{m2}} // r_{o2} // r_{o1}\right)\right] \\
C_{out} &= C_{DB1} + C_{GS2} + C_{SB2} + C_{GD1}\left[1 - \frac{1}{g_{m1}\left(\frac{1}{g_{m2}} // r_{o2} // r_{o1}\right)}\right]
\end{aligned}
$$

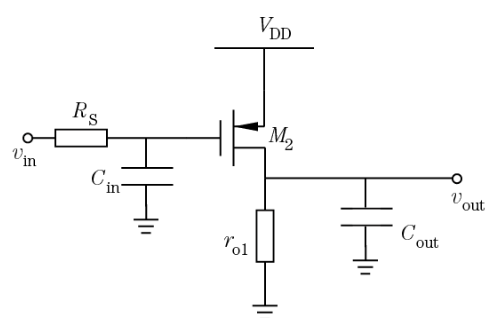
其中A_0为电路低频增益，从而

$$
\begin{aligned}
\omega_{p1} &= \left[R_S\left[C_{GS1} + C_{GD1}\left(1 - g_{m1}\left(\frac{1}{g_{m2}} // r_{o2} // r_{o1}\right)\right)\right]\right]^{-1} \\
\omega_{p2} &= \left[\left(\frac{1}{g_{m2}} // r_{o2}\right)\left[C_{DB1} + C_{GS2} + C_{SB2} + C_{GD1}\left(1 - \frac{1}{g_{m1}\left(\frac{1}{g_{m2}} // r_{o2} // r_{o1}\right)}\right)\right]\right]^{-1}
\end{aligned}
$$

(c) 画出所有电容后的电路以及简化后的电路如图 p11-38-c 所示。其中



(1) 标出电容



(2) 简化电路

Figure p11-38-c

$$
\begin{aligned}
A_0 &= -g_{m1}\left(r_{o2} // r_{o1}\right) \\
C_{in} &= C_{GS2} + C_{GD2}\left[1 + g_{m1}\left(r_{o2} // r_{o1}\right)\right] \\
C_{out} &= C_{DB1} + C_{DB2} + C_{GD1} + C_{GD2}\left[1 + \frac{1}{g_{m1}\left(r_{o2} // r_{o1}\right)}\right]
\end{aligned}
$$

其中A_0为电路低频增益，从而

$$\omega_{p1} = \left[R_S\left[C_{GS2} + C_{GD2}\left(1 + g_{m1}\left(r_{o2}//r_{o1}\right)\right)\right]\right]^{-1}$$
$$\omega_{p2} = \left[r_{o1}\left[C_{DB1} + C_{DB2} + C_{GD1} + C_{GD2}\left(1 + \frac{1}{g_{m1}\left(r_{o2}//r_{o1}\right)}\right)\right]\right]^{-1}$$

11.42 The circuit depicted in Fig. 11-82 is called ana "active inductor". Neglcting other capacitances and assuming $\lambda = 0$, compute Z_{in}. Use Bode's rule to plot $|Z_{in}|$ as a function of frequency and explain why it exhibits inductive behavior.

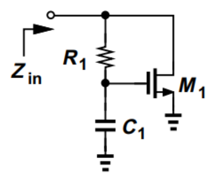


Figure 11-82

解

$$Z_{in} = (R_1 - \mathrm{j}\frac{1}{\omega C_1})//\frac{1}{g_m} = \frac{1}{g_m}\cdot\frac{1 + \mathrm{j}\omega R_1 C_1}{1 + \mathrm{j}\omega C_1(\frac{1}{g_m} + R_1)}$$
$$\omega_z = \frac{1}{R_1 C_1}, \omega_p = \frac{1}{C_1(\frac{1}{g_m} + R_1)}$$

从而可作波特图如图 p11-42 所示，在高频下$|Z_{in}|$更小，显出电导性。

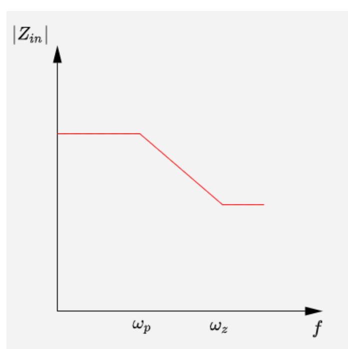


Figure p11-42

11.46 Determine the transfer function of the circuits shown in Fig. 11-86. Assume $\lambda = 0$ for M_1.

解 (a) 画出所有电容后的电路以及简化后的电路如图 p11-46-a 所示。其中

$$R_D = \frac{1}{g_{m2}}//r_{o2}$$
$$A_0 = g_{m1}(\frac{1}{g_{m2}}//r_{o2})$$
$$C_{in} = C_{SB1} + C_{GS1}$$
$$C_{out} = C_{DB1} + C_{DB2} + C_{GD2} + C_{GD1}$$

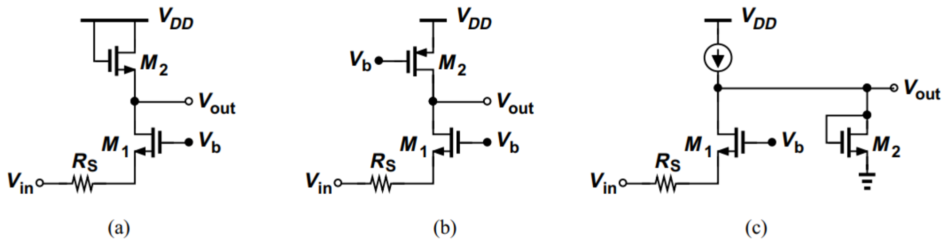
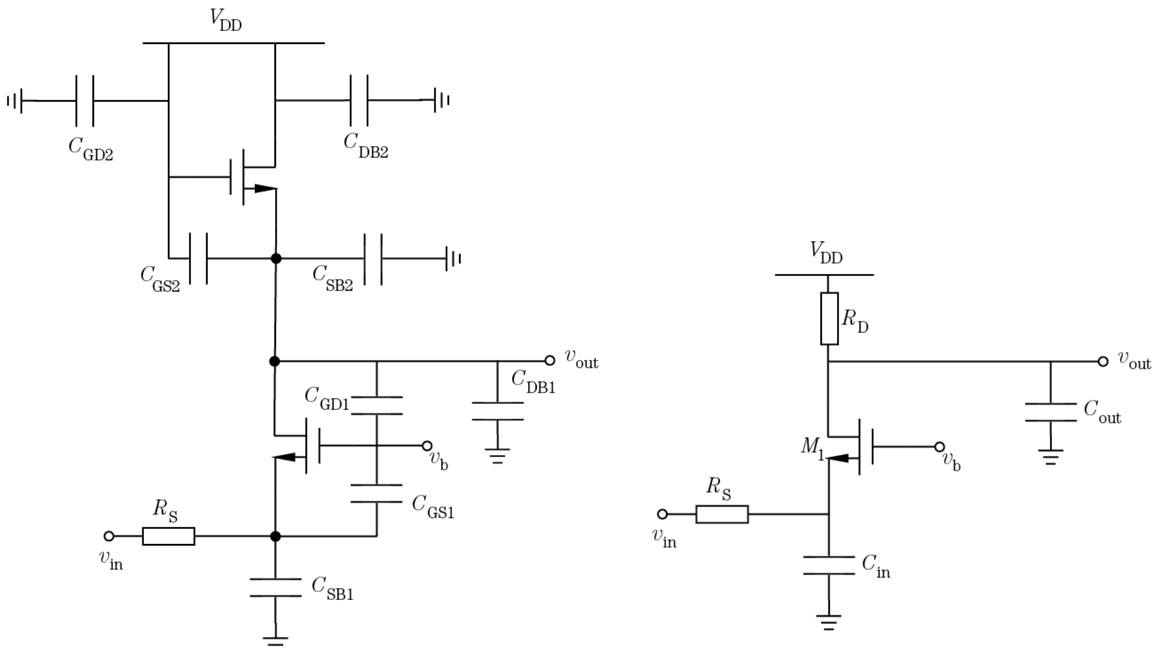


Figure 11-86



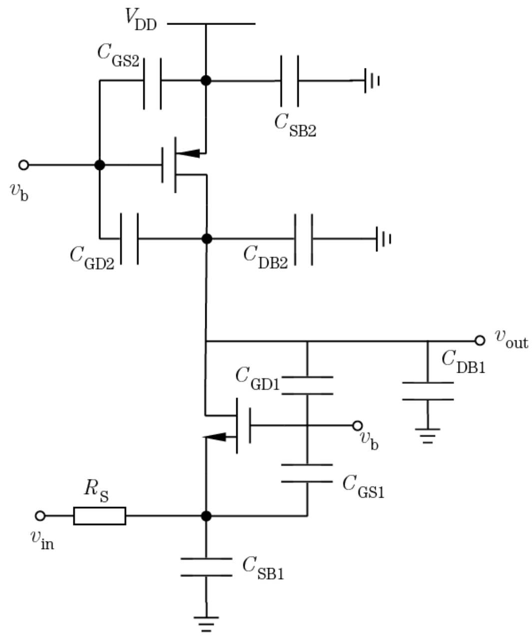
(1) 标出电容 (2) 简化电路

Figure p11-46-a

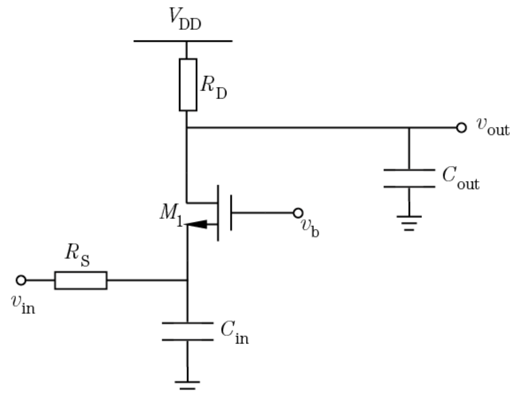
其中A_0为电路低频增益，从而

$$
\begin{aligned}
\omega_{p1} &= [R_S(C_{SB1}+C_{GS1})]^{-1} \\
\omega_{p2} &= \left[\left(\frac{1}{g_{m2}}//r_{o2}\right)(C_{DB1}+C_{DB2}+C_{GD2}+C_{GD1})\right]^{-1} \\
A &= \frac{A_0}{\left(1+\frac{\mathrm{j}\omega}{\omega_{p1}}\right)\left(1+\frac{\mathrm{j}\omega}{\omega_{p2}}\right)} \\
&= \frac{g_{m1}(\frac{1}{g_{m2}}//r_{o2})}{[1+\mathrm{j}\omega R_S(C_{SB1}+C_{GS1})]\left[1+\mathrm{j}\omega\left(\frac{1}{g_{m2}}//r_{o2}\right)(C_{DB1}+C_{DB2}+C_{GD2}+C_{GD1})\right]}
\end{aligned}
$$

(b) 画出所有电容后的电路以及简化后的电路如图 p11-46-b 所示。其中



(1) 标出电容



(2) 简化电路

Figure p11-46-b

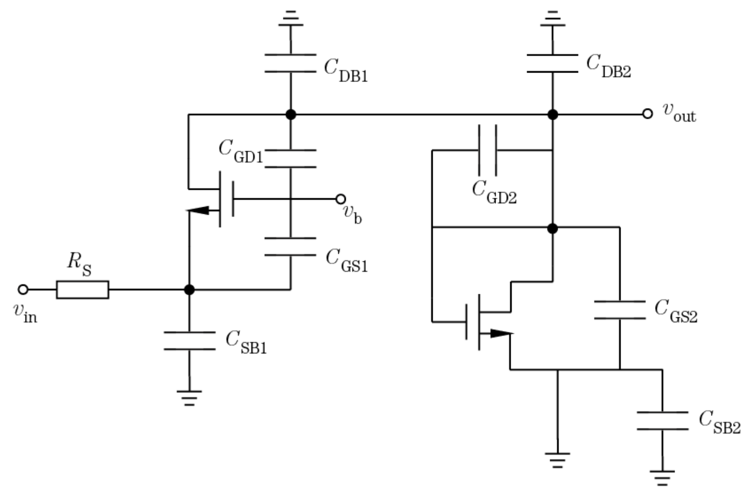
$$
\begin{aligned}
A_0 &= g_{m1} r_{o2} \\
C_{in} &= C_{SB1} + C_{GS1} \\
C_{out} &= C_{DB1} + C_{DB2} + C_{GD2} + C_{GD1}
\end{aligned}
$$

其中A_0为电路低频增益，从而

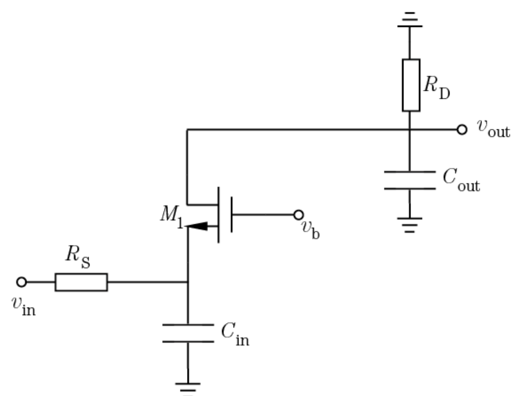
$$
\begin{aligned}
\omega_{p1} &= \left[R_S(C_{SB1} + C_{GS1})\right]^{-1} \\
\omega_{p2} &= \left[r_{o2}(C_{DB1} + C_{DB2} + C_{GD2} + C_{GD1})\right]^{-1} \\
A &= \frac{A_0}{\left(1 + \frac{\mathrm{j}\omega}{\omega_{p1}}\right)\left(1 + \frac{\mathrm{j}\omega}{\omega_{p2}}\right)} \\
&= \frac{g_{m1} r_{o2}}{\left[1 + \mathrm{j}\omega R_S(C_{SB1} + C_{GS1})\right]\left[1 + \mathrm{j}\omega r_{o2}(C_{DB1} + C_{DB2} + C_{GD2} + C_{GD1})\right]}
\end{aligned}
$$

(c) 画出所有电容后的电路以及简化后的电路如图 p11-46-c 所示。其中

$$
\begin{aligned}
R_D &= \frac{1}{g_{m2}} // r_{o2} \\
A_0 &= g_{m1} \left(\frac{1}{g_{m2}} // r_{o2}\right) \\
C_{in} &= C_{SB1} + C_{GS1} \\
C_{out} &= C_{DB1} + C_{DB2} + C_{GS2} + C_{GD1}
\end{aligned}
$$



(1) 标出电容



(2) 简化电路

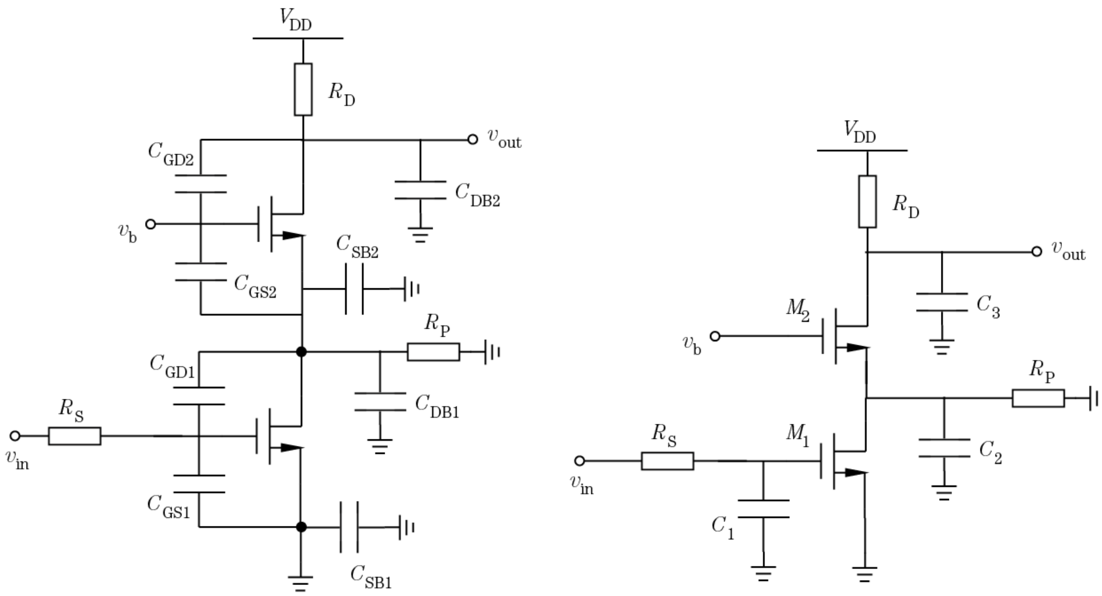
Figure p11-46-c

其中A_0为电路低频增益，从而

$$
\begin{aligned}
\omega_{p1} &= [R_S(C_{SB1} + C_{GS1})]^{-1} \\
\omega_{p2} &= \left[\left(\frac{1}{g_{m2}}//r_{o2}\right)(C_{DB1} + C_{DB2} + C_{GS2} + C_{GD1})\right]^{-1} \\
A &= \frac{A_0}{\left(1 + \frac{\mathrm{j}\omega}{\omega_{p1}}\right)\left(1 + \frac{\mathrm{j}\omega}{\omega_{p2}}\right)} \\
&= \frac{g_{m1}\left(\frac{1}{g_{m2}}//r_{o2}\right)}{[1 + \mathrm{j}\omega R_S(C_{SB1} + C_{GS1})]\left[1 + \mathrm{j}\omega\left(\frac{1}{g_{m2}}//r_{o2}\right)(C_{DB1} + C_{DB2} + C_{GS2} + C_{GD1})\right]}
\end{aligned}
$$

11.50 Due to manufacturing error, a parasitic resistor R_P has appeared in the cascode stage of Fig. 11-90. Assuming $\lambda = 0$ and using Miller's theorem, determine the poles of the circuit.

解 画出所有电容后的电路以及简化后的电路如图 p11-50 所示。其中



(1) 标出电容 (2) 简化电路

Figure 11-50

$$A_0 = -g_{m1}g_{m2}R_D\left(\frac{1}{g_{m2}//R_P}\right)$$

$$C_1 = C_{GS1} + C_{GD1}\left(1 + g_{m1}g_{m2}R_D\left(\frac{1}{g_{m2}}//R_P\right)\right)$$

$$C_2 = C_{SB2} + C_{DB1} + C_{GS2} + C_{GD1}\left(1 + \frac{1}{g_{m1}g_{m2}R_D\left(\frac{1}{g_{m2}//R_P}\right)}\right)$$

$$C_3 = C_{DB2} + C_{GD2}$$

其中A_0为电路低频增益，从而

$$\omega_{p1} = \left[R_S\left(C_{GS1} + C_{GD1}\left(1 + g_{m1}g_{m2}R_D\left(\frac{1}{g_{m2}}//R_P\right)\right)\right)\right]^{-1}$$

$$\omega_{p2} = \left[\left(\frac{1}{g_{m2}}//R_P\right)\left(C_{SB2} + C_{DB1} + C_{GS2} + C_{GD1}\left(1 + \frac{1}{g_{m1}g_{m2}R_D\left(\frac{1}{g_{m2}//R_P}\right)}\right)\right)\right]^{-1}$$

$$\omega_{p3} = [R_D(C_{DB2} + C_{GD2})]^{-1}$$

$$A = \frac{A_0}{\left(1 + \frac{\mathrm{j}\omega}{\omega_{p1}}\right)\left(1 + \frac{\mathrm{j}\omega}{\omega_{p2}}\right)\left(1 + \frac{\mathrm{j}\omega}{\omega_{p3}}\right)}$$