

assignment5

full credit by June 18, 2026, 11:59:00 PM CST, closes June 21, 2026, 11:59:00 PM CST

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Section: 1142_E227020_2

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Problem 1. (1 point)

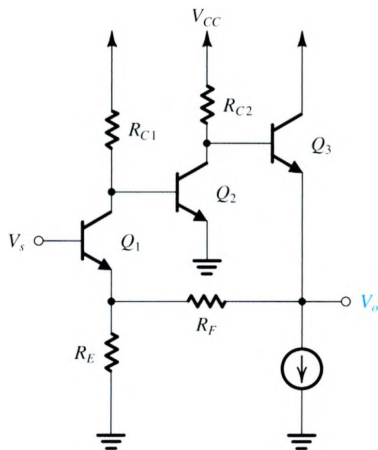
Design a feedback amplifier to have an ideal closed-loop gain of 17 and to have an amount of feedback of at least 50 dB.

What is the required value of β ? _____ (V/V)

What is the minimum required value of the open-loop gain A ? _____ (V/V)

What is the corresponding realized value of closed-loop gain A_f ? _____ (V/V)

Problem 2. (1 point)



The figure shows a series-shunt feedback amplifier without details of the bias circuit.

(a) If R_E is selected to be 60Ω , find the value for R_F that results in a closed-loop gain with an ideal value of $19V/V$.

(b) If Q_1 is biased at $0.6mA$, Q_2 is at $1.5mA$, Q_3 is at $6.3mA$, and assuming that the transistors have $\beta = 100$ and larger r_o , and that $R_{C1} = 2.3k\Omega$ and $R_{C1} = 0.8k\Omega$, find the value of the loop gain $A\beta$ and hence of the closed-loop gain A_f .

$R_F =$ _____ Ω
 $A\beta =$ _____ V/V
 $A_f =$ _____ V/V

Problem 3. (1 point)

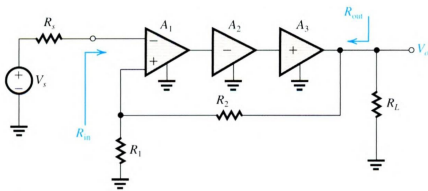
Below shows a three-stage feedback amplifier:

A_1 has an $76\text{k}\Omega$ differential input resistance, a 20V/V open-circuit differential voltage gain, and a $2.5\text{k}\Omega$ output resistance.

A_2 has a $5.5\text{k}\Omega$ input resistance, a 25mA/V short-circuit transconductance, and a $22\text{k}\Omega$ output resistance.

A_3 has a $19\text{k}\Omega$ input resistance, unity open-circuit voltage gain, and a $1\text{k}\Omega$ output resistance.

The feedback amplifier feeds a $0.9\text{k}\Omega$ load resistance and is fed by a signal source with a $11\text{k}\Omega$ resistance.



(a) If $R_1 = 18\text{k}\Omega$, Find the value of R_2 that results in an ideal closed-loop gain of 5 V/V .

$R_2 = \underline{\hspace{2cm}}\text{ k}\Omega$

(b) Find the value of the open-loop gain $A \equiv V_o/V_s$.

$A = \underline{\hspace{2cm}}\text{ V/V}$

(c) Find the feedback factor β and the amount of feedback.

$\beta = \underline{\hspace{2cm}}\text{ V/V}$

Amount of feedback $(1 + \beta A) = \underline{\hspace{2cm}}$

(d) Find the closed-loop gain A_f .

$A_f = \underline{\hspace{2cm}}\text{ V/V}$

(e) Find the feedback amplifier's input resistance R_{in} .

$R_{in} = \underline{\hspace{2cm}}\text{ M}\Omega$

(f) Find the feedback amplifier's output resistance R_{out} .

$R_{out} = \underline{\hspace{2cm}}\text{ }\Omega$

(g) If the high-frequency response of the open-loop gain A is dominated by a pole at 100Hz , what is the upper 3-dB frequency of the closed-loop gain.

$f = \underline{\hspace{2cm}}\text{ kHz}$

(h) If for some reason A_1 is drops to half its nominal value, what is the absolute percentage change in A_f ?

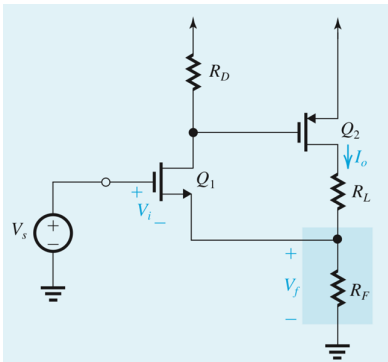
Absolute Percentage change = $\underline{\hspace{2cm}}\%$

Problem 4. (1 point)

For the feedback transconductance amplifier shown in Fig. 4, evaluate the closed-loop transconductance gain A_f and the output resistance with feedback R_{of} .

$$g_{m1} = g_{m2} = 4 \text{ mA/V}, \quad R_D = 20 \text{ k}\Omega, \quad r_{o2} = 20 \text{ k}\Omega,$$
$$R_F = 100 \text{ }\Omega, \quad R_L = 1 \text{ k}\Omega.$$

For simplicity, neglect r_{o1} , and take r_{o2} into account only when calculating the output resistance.



Find A_f in mA/V:

$$A_f =$$

_____ mA/V

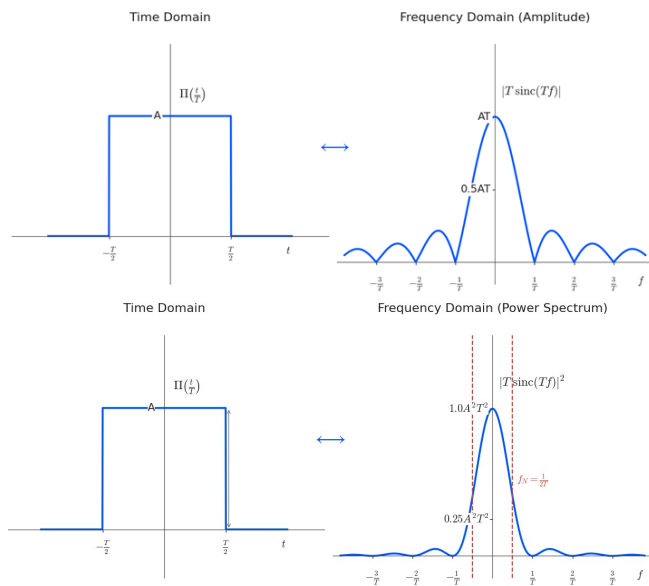
Find R_{of} in k Ω :

$$R_{of} =$$

_____ k Ω

Problem 5. (1 point)

In recent years, AI servers have needed to transmit large amounts of digital data between chips, modules, and systems. As a result, high-speed wireline transmission has become increasingly important. Although digital signals look like square waves composed of 0 and 1 in the time domain, they actually contain many high-frequency components in the frequency domain, as shown by the sinc-shaped spectrum in the figure.



As the transmission speed increases, the symbol period (T) becomes shorter, requiring higher circuit bandwidth. If the bandwidth is insufficient, high-frequency components are attenuated, causing waveform distortion and making data detection harder. Therefore, feedback is important in high-speed receiver circuits because it can extend bandwidth and stabilize the frequency response.

Therefore, in a high-speed wireline transmitter or receiver, the Nyquist frequency is an important bandwidth reference. If the symbol period is T , the Nyquist frequency is

$$f_N = \frac{1}{2T}$$

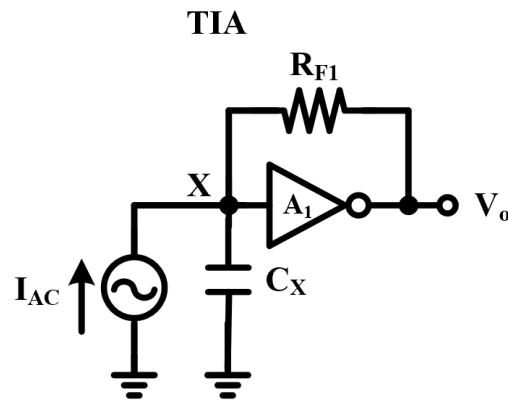
If we want to transmit data at a rate of 50 Gb/s. This means that a binary signal, either 0 or 1, is transmitted 50×10^9 times per second. What is the Nyquist frequency?

Nyquist frequency = _____ GHz

Assume all transistor operate in saturation in all of the problems.

In a high-speed wireline receiver, the input signal is often a small AC current. A transimpedance amplifier, or TIA, is used to convert this input current into an output voltage.

The circuit contains an amplifier A_1 , a feedback resistor R_F , and an input capacitance C_X at node X . The feedback resistor samples the output voltage and feeds a current back to the input node. Therefore, this is a shunt-shunt feedback circuit.



Assume:

$$R_F = 1.76k\Omega$$

$$C_X = 139.4fF$$

The amplifier A_1 is modeled as an ideal amplifier:

Gain is 20 V/V

Transfer Function is $\frac{V_o}{I_{AC}} = \frac{A_0}{1 + \frac{s}{\omega_p}}$

$$\omega_p = \text{_____ rad/s}$$

$$|A_0| = \text{_____ V/A}$$

Problem: Source Degeneration as Local Feedback

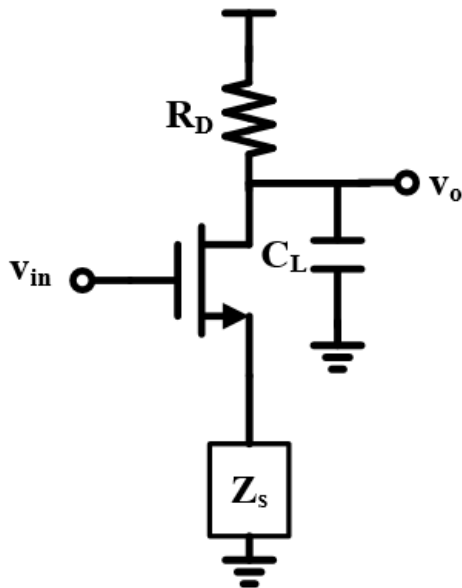
A common-source amplifier uses a source degeneration impedance Z_S , as shown in the figure. Source degeneration is a form of local negative feedback.

When the gate voltage increase then the drain current i_d increases, the source voltage v_s also increases. Since

$$v_{gs} = v_{in} - v_s$$

an increase in v_s reduces v_{gs} . As a result, the drain current is reduced. Therefore, the circuit feeds back a signal that opposes the original current change. This is why source degeneration is called local negative feedback.

CS Amplifier With Source Degeneration



$$g_m = 39.4\text{mS}$$

$$Z_s = 0.96\text{k}\Omega$$

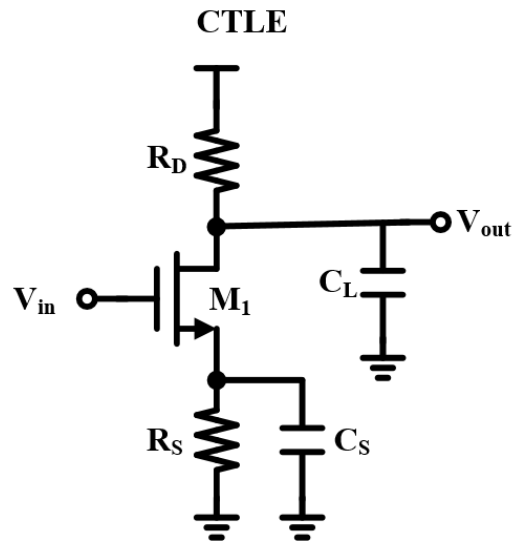
By what factor does source degeneration increase the bandwidth of a CS amplifier compared with the case without source degeneration?

factor = _____

A CTLE, or continuous-time linear equalizer, is commonly used in high-speed wireline receivers. In wireline channels, high-frequency signal components are usually attenuated more than low-frequency components. This causes slower signal transitions, waveform distortion.

The CTLE helps solve this problem by boosting the high-frequency components of the received signal. In this circuit, R_S provides source degeneration at low frequency, which reduces the gain. At high frequency, C_S becomes a short circuit and bypasses (R_S), so the gain increases. Therefore, the CTLE has higher gain at high

As a result, the CTLE can compensate for high frequency component loss, and improve the signal quality at the receiver.



$$g_m = 39.4\text{mS}$$

$$R_s = 0.96\text{k}\Omega$$

$$C_s = 128.8\text{fF}$$

$$R_D = 0.78\text{k}\Omega$$

$$C_L = 200\text{fF}$$

Transfer Function is $\frac{V_{out}}{V_{in}} = \frac{A_1(1 + \frac{\omega}{\omega_z})}{(1 + \frac{s}{\omega_{p1}})(1 + \frac{s}{\omega_{p2}})}$

$$\omega_{p1} < \omega_{p2}$$

$$\omega_{p1} = \text{_____ rad/s}$$

$$\omega_{p2} = \text{_____ rad/s}$$

$$\omega_z = \frac{\quad}{\quad} \text{rad/s}$$
$$A_1 = \frac{\quad}{\quad} V/V$$

As you can see, by suppressing the low-frequency components, we can relatively enhance part of the high-frequency components, which helps increase the overall system bandwidth.