1. For the circuit in Fig. P1: (12%)
   (a) Derive the transfer function . What is the "function" of this circuit?
   (b) Derive the expression for the high-frequency gain and the 3-dB frequency.
   (c) Design the circuit to obtain a high-frequency input resistance of 10 k Ω, a high-frequency gain of 40 dB, and a 3-dB frequency of 1000 Hz.
   (d) At what frequency does the magnitude of the transfer function reduce to unity?

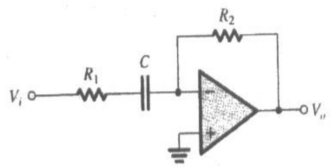


Fig. P1

2. For a common-emitter amplifier in Fig. P2, neglect $r_x$ and $r_o$, and assume the current source to be ideal. (20%)
   (a) Derive the expression for the midband gain.
   (b) Derive the expression for the break frequencies cause by $C_E$ and $C_C$, respectively.
   (c) Give an expression for the amplifier voltage gain A(s).
   (d) For $R_{sig} = R_C = R_L = 10$ k Ω, $\beta = 100$, and $I = 1$ mA, find the value of the midband gain.
   (e) Select values for $C_E$ and $C_C$ to place the two break frequencies a decade apart and to obtain a lower 3-dB frequency of 100 Hz while minimizing the total capacitance.

3. Consider the circuit in Fig. P3 for the case: $I = 200\ \mu$A and $V_{OV} = 0.25$ V, $R_{sig} = 200$ k Ω, $R_D = 50$ k Ω, $C_{gs} = C_{gd} = 1$ pF. (18%)
   (a) Find the dc gain.
   (b) Find the high-frequency poles.
   (c) Estimate the value of $f_H$.

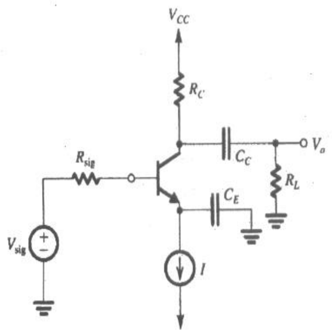


Fig. P2

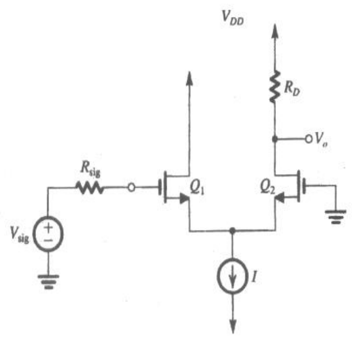


Fig. P3

4. For a shunt-shunt amplifier circuit shown below, the operational amplifier has open loop gain $\mu = 10^3\,V/V$, input resistance $R_{id} = 200\text{K}\Omega$, common-mode input resistance $R_{icm} = \infty$, and output resistance $r_o = 10\text{K}\Omega$. Use the feedback method to find: (20%)
(a) the feedback factor $\beta$
(b) the closed loop gain of the feedback amplifier
(c) the voltage gain $V_o/V_s$
(d) the input resistance $R'_{of}$
(e) the output resistance $R'_{if}$

5. Consider the circuit as shown below, where both diodes have the same junction area as the output transistors. At $20^\circ\text{C}$ the quiescent current is 5 mA and $|V_{BE}| = 0.6\text{V}$. Through a manufacturing error, the thermal coupling between the output transistors and the biasing diode-connected transistors is removed. After some output activity, the output devices heat up to $60^\circ\text{C}$ while the biasing devices remain at $20^\circ\text{C}$. Thus while the $V_{BE}$ of each device remains unchanged, the quiescent current in the output devices increases. To calculate the new current value, there are two effects to consider: $I_s$ increases by about $10\%/^\circ\text{C}$, and $V_T = KT/g$ since $T = (273^\circ + \text{temperature in } ^\circ\text{C})$ where $V_T = 25\text{mV}$ only at $20^\circ\text{C}$. Assume $\beta_N$ remains constant. (10%)
(a) What is the new values of $I_Q$ ?
(b) If the power supply is $\pm 10\text{V}$, what additional power is dissipated?

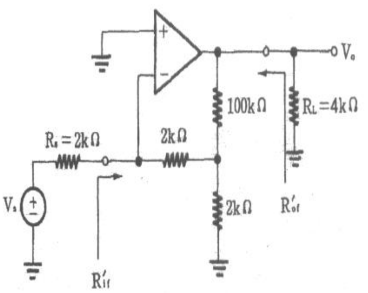


Fig. P4

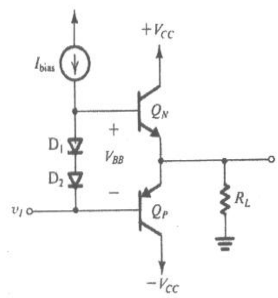


Fig. P5

6. Consider the circuit as shown below, where the operational amplifier is assumed to be ideal, Q is the pole quality factor, and $CR = 2Q/\omega_0$. (20%)
   (a) Analyze the circuit to find out its transfer function $V_o/V_s$.
   (b) Find the voltage-driver ratio $R_2/(R_1+R_2)$ so that the circuit realizes an all-pass function.
   (c) Find the voltage-driver ratio $R_2/(R_1+R_2)$ so that the circuit realizes a notch function.

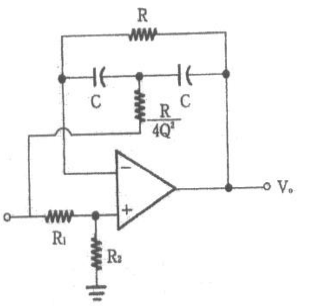


Fig. P6

The following numbers may be useful for your computation:

| | |
|---|---|
| $e^1 \approx 2.71828$ | $1.1^{25} \approx 10.83$ |
| $e^{11} \approx 5.99\times10^4$ | $1.1^{40} \approx 45.26$ |
| $e^{24} \approx 2.65\times10^{10}$ | $1.4^{30} \approx 24201.43$ |
| $e^{37} \approx 1.17\times10^{16}$ | $1.4^{15} \approx 155.57$ |
| $e^{21.12} \approx 1.49\times10^9$ | |
| $e^{21.33} \approx 1.83\times10^9$ | |
| $e^{13.34} \approx 6.22\times10^5$ | |
| $e^{13.55} \approx 7.67\times10^5$ | |