HW 04

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Q1. Consider an amplifier whose $F_A(s)$ is given by

$$F_H(s) = \frac{1}{\left(1+\frac{s}{w_{P1}}\right)\left(1+\frac{s}{w_{P2}}\right)}$$

with $w_{P1} < w_{P2}$. Find the ratio w_{P2}/w_{P1} for which the value of the 3dB frequency w_H calculated using the dominant pole approximation differs from that calculated using root sum of squares formula by (a) 10% (b) 1%

$$w_H = 1\Big/\sqrt{\left(\frac{1}{w_{P1}^2}+\frac{1}{w_{P2}^2}+\cdots\right)-2\cdot\left(\frac{1}{w_{Z1}^2}+\frac{1}{w_{Z2}^2}\cdots\right)}$$

$$F_H(s) = \frac{1}{\left(1+\frac{s}{w_{P1}}\right)\left(1+\frac{s}{w_{P2}}\right)} \qquad w_{P1} < w_{P2} \rightarrow w_H \approx w_{P1}$$

$$w_H = \frac{1}{\sqrt{\left(\frac{1}{w_{P1}}\right)^2+\left(\frac{1}{w_{P2}}\right)^2}} = \frac{w_{P1}}{w_{P1}\sqrt{\left(\frac{1}{w_{P1}}\right)^2+\left(\frac{1}{w_{P2}}\right)^2}} = \frac{w_{P1}}{\sqrt{1+\left(\frac{w_{P1}}{w_{P2}}\right)^2}}$$

$$\frac{\Delta w_H}{w_{P1}} = 1-\frac{1}{\sqrt{1+\left(\frac{w_{P1}}{w_{P2}}\right)^2}} = 1-\frac{1}{\sqrt{1+\frac{1}{n^2}}} \qquad n = \frac{w_{P2}}{w_{P1}}$$

(a)

$$\frac{\Delta w_H}{w_{P1}} = 10\% \rightarrow 0.1 = 1-\frac{1}{\sqrt{1+\frac{1}{n^2}}} \rightarrow \sqrt{1+\frac{1}{n^2}} = 1.11$$

$$1+\frac{1}{n^2} = 1.2345$$

$$\frac{1}{n^2} = 0.234$$

$$n^2 = 4.2631$$

$$n = 2.064$$

(b)

$$\frac{\Delta w_H}{w_{P1}} = 1\% \Rightarrow 0.01 = 1-\frac{1}{\sqrt{1+\frac{1}{n^2}}}$$

$$\sqrt{1+\frac{1}{n^2}} = 1.0101$$

$$1+\frac{1}{n^2} = 1.0203$$

$$n^2 = \frac{1}{0.0203} = 49.251$$

$$\boxed{n = 7.017}$$

bu oran pozitif şeylerden dolayı (−)'li olmaz

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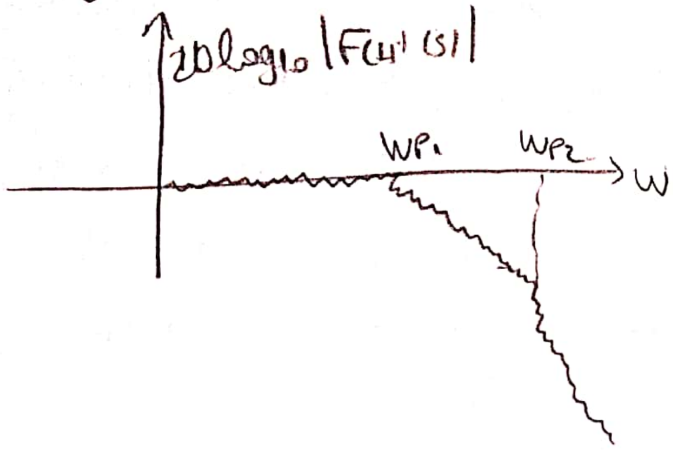
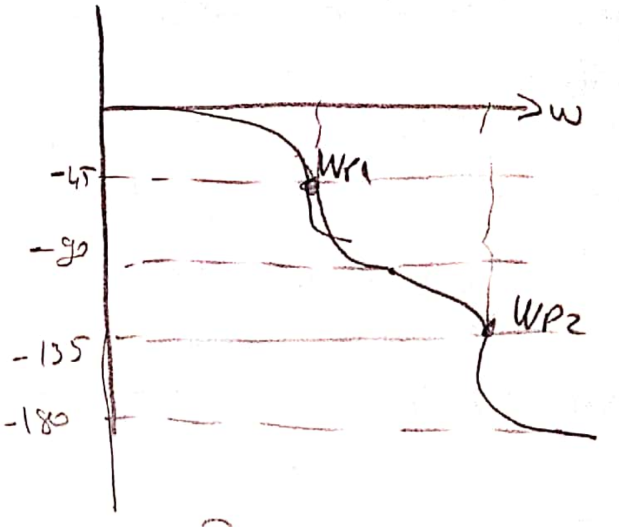
Magnitude Bode Plot



Phase Bode Plot



Q2. The high-frequency response of a direct-coupled amplifier having a dc gain of $-100\,V/V$ incorporates zeros at ∞ and 10^6 rad/s (one at each frequency) and poles at 10^5 rad/s and 10^7 rad/s ~~and poles~~. Write an expression for the amplifier transfer function. Find w_H using (a) the dominant-pole approximation (b) the root-sum-of squares approximation. If a way is found to lower the frequency of the finite ~~of the~~ zero to 10^5 rad/s, what does the transfer function become? What is the 3-dB frequency of the resulting amplifier

$$W_H = 1\Big/\sqrt{\left(\frac{1}{W_{P1}}\right)^2+\left(\frac{1}{W_{P2}}\right)^2-2\left(\frac{1}{W_{Z1}}\right)^2 \ldots}$$

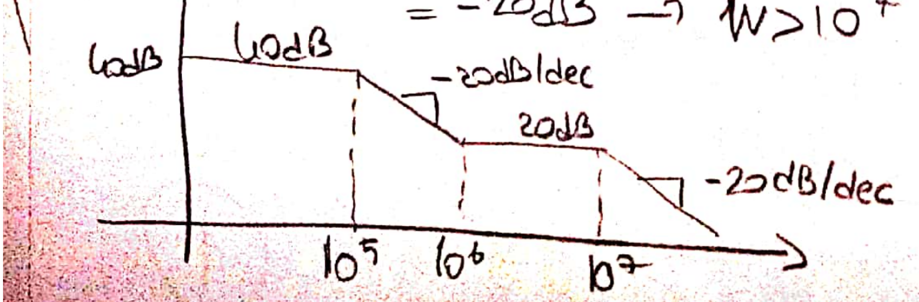
$$H(jw) = -100 \cdot \frac{\left(1+\frac{jw}{\infty}\right)\left(1+\frac{jw}{10^6}\right)}{\left(1+\frac{jw}{10^5}\right)\cdot\left(1+\frac{jw}{10^7}\right)} = \frac{-100\cdot\left(1+\frac{jw}{10^6}\right)}{\left(1+\frac{jw}{10^5}\right)\cdot\left(1+\frac{jw}{10^7}\right)}$$

$20\log_{10}|-100| = 40dB \rightarrow w < 10^5$

$= -20dB \rightarrow 10^5 < w < 10^6$

$20\log_{10}|H(jw)| = 20dB \rightarrow 10^6 < w < 10^7$

$= -20dB \rightarrow w > 10^7$



köşe frekansı

$$W_H \approx 10^5 \, rad/s \qquad W_H \cong \frac{1}{\sqrt{\left(\frac{1}{10^5}\right)^2 + \left(\frac{1}{10^7}\right)^2 - 2\left(\frac{1}{10^6}\right)^2}} = 1.01 \times 10^5 \frac{rad}{s}$$

$$W_H = 1.01 \times 10^5 \frac{rad}{s}$$

10^6 ve 10^5 zero $\longrightarrow \cancel{\left(1+\frac{jw}{10^5}\right)} = 1+\frac{jw}{10^5}$

$$H_{new}(jw) = \frac{-100}{1+\frac{jw}{10^7}} \longrightarrow W_{H,new} = 10^7 \, rad/s$$

$$F_H(s) = \frac{\left(1+\frac{s}{w_{z1}}\right)\cdot\left(1+\frac{s}{w_{z2}}\right)}{\left(1+\frac{s}{w_{P1}}\right)\cdot\left(1+\frac{s}{w_{P2}}\right)} \longrightarrow s \to jw$$

$$|F_H(jw)|^2 = \frac{\left(1+\frac{w^2}{w_{z1}^2}\right)\left(1+\frac{w^2}{w_{z2}^2}\right)}{\left(1+\frac{w^2}{w_{P1}^2}\right)\cdot\left(1+\frac{w^2}{w_{P2}^2}\right)}$$

W_H 3dB freq.

DC power of $F_H(jw) = 1$

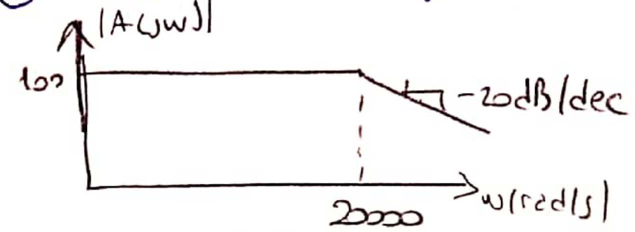
halved $= \frac{1}{2}$

$$10\log_{10}\left(\frac{1}{2}\right) = -3dB \qquad w = w_H$$

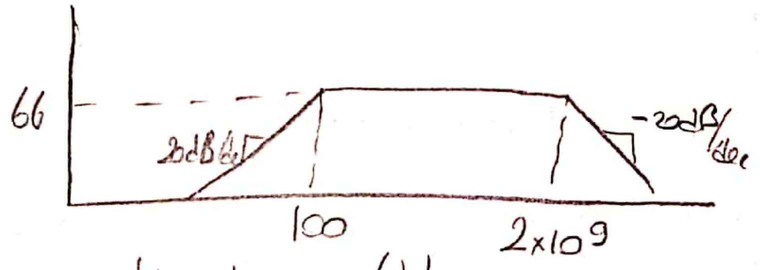
$$|F_H(jw)|^2 = \frac{1}{2} = \frac{\left(1+\left(\frac{W_H}{W_{z1}}\right)^2\right)\left(1+\left(\frac{W_H}{W_{z2}}\right)^2\right)}{\left(1+\left(\frac{W_H}{W_{P1}}\right)^2\right)\left(1+\left(\frac{W_H}{W_{P2}}\right)^2\right)}$$

$$W_H \cong \frac{1}{\sqrt{\frac{1}{W_{P1}^2} + \frac{1}{W_{P2}^2} - 2\left(\frac{1}{W_{z1}^2} + \frac{1}{W_{z2}^2}\right)}} \longrightarrow \text{general formul}$$

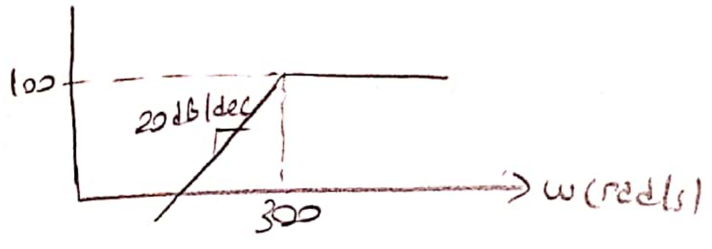
Q3. Estimate the gain in dB at
(a) 10.000 rad/s for Fig. P8.3d
(b) 4000 rad/s for Fig P8.3d
(c) 30000 rad/s for Fig P8.3a
(d) 100.000 rad/s for P8.3d



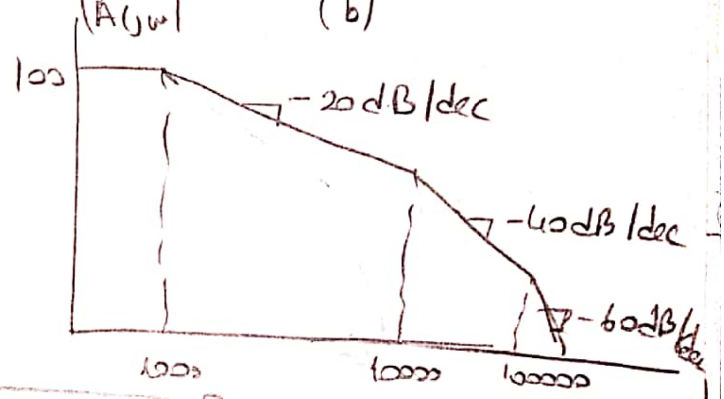
(a)



(b)



(c)



a) $A(jw) = 100 \cdot \dfrac{1}{1+\dfrac{jw}{20000}}$

b) $w=0 \to$ zero
$w = 100$ rad/s $\to$ pole
$w = 2\times10^9 \to$ Pole

$$A(jw) = B \cdot \frac{jw}{\left(1+\frac{jw}{100}\right)\left(1+\frac{jw}{2\times10^9}\right)}$$

$$A(jw) = B \cdot \frac{jw}{\frac{jw}{100} \cdot 1} = 100B$$

$\frac{jw}{100} >> 1$, $\frac{jw}{2\times10^9} << 1$

$$= 20\log_{10} 100B = 66\text{dB}$$

$$= \underbrace{20\log_{10}100}_{40} + 20\log_{10}B = 66$$

$$= 20\log_{10}B = 26$$

$$= \boxed{B = 10^{\frac{26}{20}}}$$

c) $w=0 \longrightarrow$ zero $\qquad A(jw) = B \dfrac{jw}{1+\dfrac{jw}{300}}$

$w=300 \longrightarrow$ pole

for $w \gg 300$ rad/s

$$A(jw) \cong B \frac{jw}{\frac{jw}{300}} = 300B$$

$$20\log_{10} 300B = 100 = \underbrace{20\log_{10} 300}_{49.542} + 20\log_{10} B$$

$20\log_{10} B = 50.457$ $\qquad \boxed{B = 10^{\frac{50.457}{20}} = 10^{2.522}}$

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d) $w = 100$ rad/s $\rightarrow$ pole

$w = 10.000$ rad/s $\rightarrow$ pole

$w = 100000$ rad/s $\rightarrow$ pole

$$A(jw) = B \frac{1}{\left(1+\frac{jw}{100}\right)\left(1+\frac{jw}{10000}\right)\cdot\left(1+\frac{jw}{100000}\right)}$$

$w \ll 100$ rad/s $\rightarrow A(jw) = B$

$20\log_{10} B = 100 \Rightarrow B = 10^{\frac{100}{20}} = \boxed{10^5 = B}$

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d) gain $\rightarrow$ 10.000 rad/s $\rightarrow$ 100 $\longrightarrow$ 10000 rad/s

gain-init = 100 $\qquad$ 2 dec $\rightarrow$ 2dec. -20dB

$100 - 40 = 60$ dB $\qquad -40$

~~st~~ d) gain $\rightarrow$ 4000 rad/s

$$-20\,\text{dB/dec} = \frac{A(jw/4000) - 100}{\underbrace{\log_{10}(4000)}_{3.602} - \underbrace{\log_{10}(100)}_{2}} \Rightarrow -32.04 = A(jw/4000) - 100$$

$$\boxed{A(jw/4000) = 67.96}$$

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gain 100000 rad/s

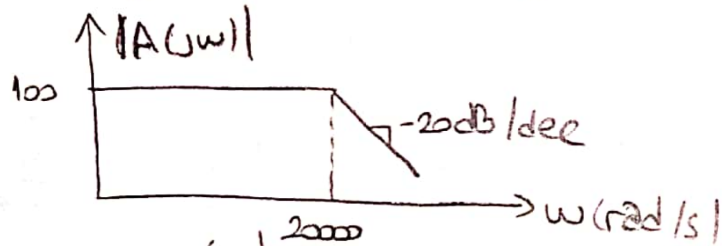
$A\left(\frac{jw}{10000}\right)$ $\quad$ $\underbrace{10000 - 100000}_{1\,dec}$ $\quad$ bu aralıkta 1 dec'de 40dB düşüş yaşanıyor.

$$A\left(\frac{jw}{100000}\right) = \underbrace{A\left(\frac{jw}{10.000}\right)}_{60dB \text{ bulundu}} - 40$$

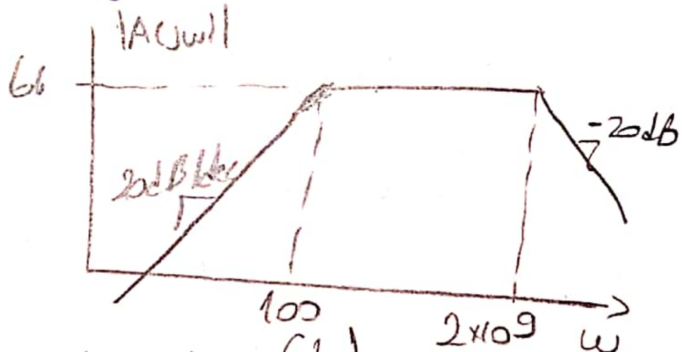
→ 1dec'lik düşüş.

$$A(jw/100.000) = 60 - 40 = \underline{\underline{20dB}}$$

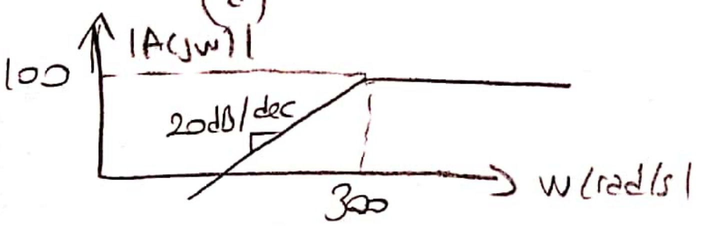
Qu. Estimate the radian frequency where the gain is 0dB for
(a) Fig P8.3a (b) Fig P8.3c (c) fig P8.3d



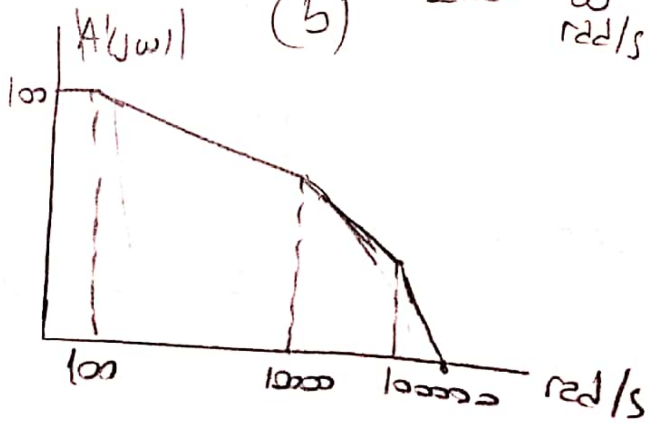
(a)



(b)



(c)



(a)

$$\text{slope} = -20dB/dec = \frac{0 - 100dB}{\log_{10} W_u - \underbrace{\log_{10} 20000}_{4.3010}}$$

$$\log_{10} W_u - 4.301 = \frac{-100}{-20} \longrightarrow \boxed{W_u = 10^{9.301}} \text{ rad/s}$$

(c)

$$\text{slope} = +20dB/dec = \frac{100dB - 0}{\log_{10}(300) - \log_{10}(W_u)} \Rightarrow \log_{10} 300 - \log_{10} W_u = 5$$

$$\log_{10} W_u = -2.522$$

$$\boxed{W_u = 10^{-2.522} \text{ rad/s}}$$

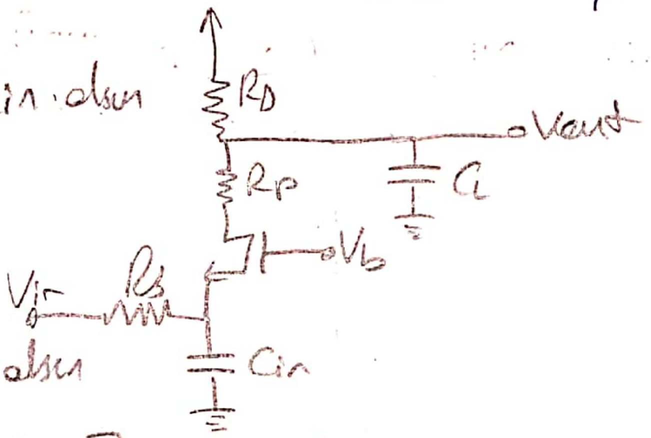
d) $A\left(\frac{j\omega}{100000}\right) = 20dB$

$$-60dB/dec = \frac{0 - 20dB}{\log_{10}(\omega) - \underbrace{\log_{10}(100000)}_{5}} \Rightarrow \log_{10}\omega - 5 = \frac{1}{3}$$

$$\log_{10}\omega_u = 5.33$$

$$\boxed{W_3 = 10^{5.33}}$$

Q5. Assume the capacitors are small valued, comparable to the internal capacitances of the transistor. Compute the 3dB corner frequency by the OCTC Method.



C_{in} in gördüğü direnç R_{in} olsun

$$R_{in} = R_S \parallel \frac{1}{g_m}$$

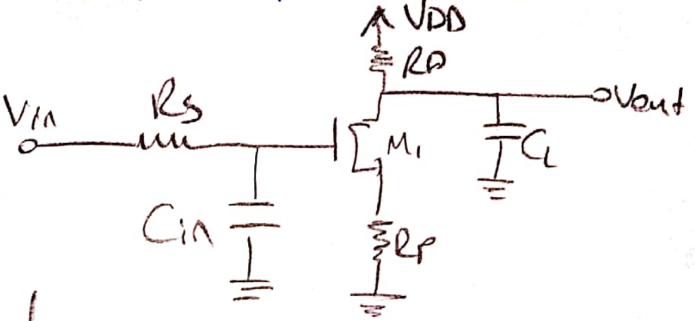
C_L nin gördüğü direnç R_L olsun

$$R_L = R_D \parallel \left[R_p + r_o(1+g_m r_o)R_S\right]$$

$$W_{3dB} = \frac{1}{C_{in}R_{in} + C_L R_L} \rightarrow \text{OCTC Method.}$$

$$\boxed{W_{3dB} = \frac{1}{C_{in}\cdot\left(R_S \parallel \frac{1}{g_m}\right) + C_L\left(R_D \parallel \left[r_o(1+g_m r_o)R_S\right]\right)}}$$

Q6. Assume the capacitors are small valued, comparable to the internal capacitances of the transistor. Compute the 3dB corner frequency by the OCTC method.



C_{in}'in gördüğü direnç R_{in} olsun

$R_{in} = R_S$

C_L'nin gördüğü direnç R_L olsun

$R_L = R_D \parallel [r_o + (1 + g_m r_o) R_P]$

$$W_{3dB} = \frac{1}{C_{in} R_{in} + C_L R_L} \rightarrow \text{OCTC Method}$$

$$W_{3dB} = \frac{1}{C_{in} \cdot R_S + C_L \cdot (R_d \parallel [r_o + (1 + g_m r_o) R_P])} \quad //$$