(19) From eq. (8.31),

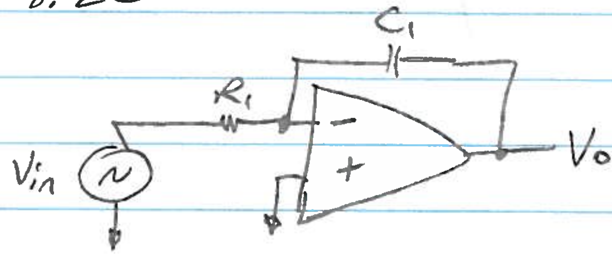
$$V_{out} = -\frac{1}{R_1 C_1} \int V_{in}\, dt$$

$$= -\frac{1}{R_1 C_1} \int V_0 \sin \omega t \, dt$$

$$= \frac{V_0}{R_1 C_1 \omega} \cos \omega t$$

$\therefore$ Amplitude of output $= \dfrac{V_0}{R_1 C_1 \omega}$

8.20



$$\frac{V_o(s)}{V_{in}(s)} = -\frac{1}{sR_1C_1}$$

$$\left|\frac{V_o(j\omega)}{V_{in}(j\omega)}\right| = \frac{1}{\omega R_1 C_1} = 10$$

$$\omega = \frac{1}{10R_1C_1} = \frac{1}{10(10ns)} = 10M\,rad/s$$

$$\boxed{\omega = 10M\,rad/s = 1.59MHz}$$

(24) $\because A_o = \infty$

$$|A_v| = \frac{R_1}{\frac{1}{\omega C_1}}$$

$$= \omega R_1 C_1$$

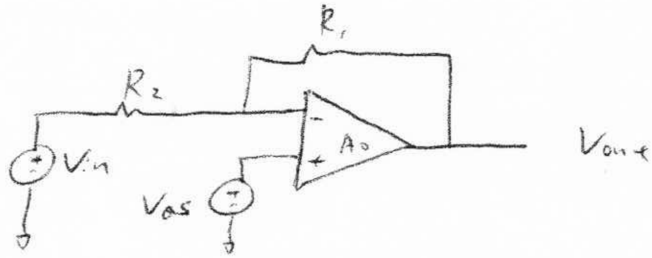
$$= 5$$

$$\therefore R_1 C_1 = \frac{5}{\omega}$$

$$= \frac{5}{2\pi \times 10^6}$$

$$= 7.958 \times 10^{-7}$$

48



By KCL,

$$\frac{V_{in} - V_{os}}{R_2} = -\frac{V_{out} - V_{os}}{R_1}$$

$$V_{out} = -\frac{R_1}{R_2}\left(V_{in} - V_{os}\right) + V_{os}$$

(49) In Fig. (8.25),

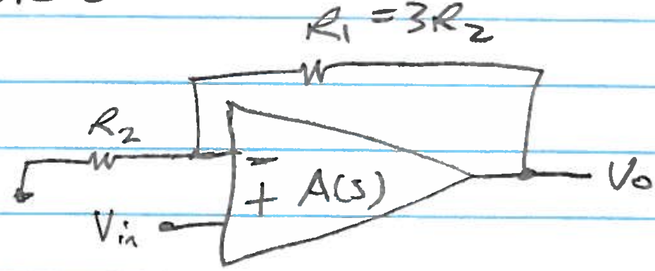
Assuming input is zero.

$$V_x = 10 \times V_{os,A_1}$$
$$= 30mV$$

$$\therefore V_{out} = 10 \times (V_{os,A_2} + V_x)$$
$$= 330mV$$

Thus, the maximum offset error is 330mV.

8.55



$$A(s) = \frac{A_o}{1+\frac{s}{\omega_1}}$$

$$\frac{V_o}{V_{in}} = \frac{1+\frac{R_1}{R_2}}{\frac{s}{\omega_1}\left(\frac{1+\frac{R_1}{R_2}}{A_o}\right)+1+\frac{1+\frac{R_1}{R_2}}{A_o}} \overset{\text{w/ high } A_o}{\simeq} \frac{1+\frac{R_1}{R_2}}{1+\frac{s}{\omega_{PNI}}}$$

where $\omega_{PNI} = \frac{\omega_1}{1+\frac{R_1}{R_2}}$

a, $A_o = 1000$, $f_1 = 50\,Hz \Rightarrow \omega_{PNI} = \frac{2\pi(50kHz)}{4} = 2\pi(12.5kHz)$

Find Magnitude Response at $\omega = 2\pi(100MHz)$

$$\left|\frac{V_o(j2\pi 100M)}{V_{in}(j2\pi 100M)}\right| \simeq \frac{4}{\sqrt{1+\left(\frac{2\pi(100MHz)}{2\pi(12.5kHz)}\right)^2}} = 5\times10^{-4}$$

$\Rightarrow$ This is much less than 4 !!

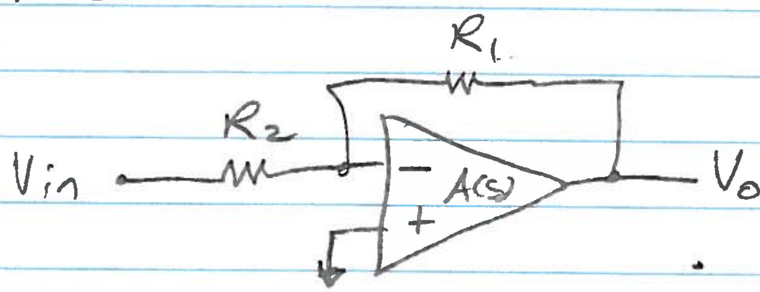
b. $A_o = 500$, $f_1 = 1MHz \Rightarrow \omega_{PNI} = \frac{2\pi(500MHz)}{4} = 2\pi(125MHz)$

$$\left|\frac{V_o(j2\pi 100M)}{V_{in}(j2\pi 100M)}\right| \simeq \frac{4}{\sqrt{1+\left(\frac{2\pi(100M)}{2\pi(125M)}\right)^2}} = 3.12$$

$\Rightarrow$ Much closer to ideal gain of 4

$$\boxed{\text{We should use OpAmp (b) with } A_o = 500,\ f_1 = 1MHz \Rightarrow f_u = 500MHz}$$

8.56



Open-Loop OpAmp: $A(s) = \frac{A_o}{1 + \frac{s}{\omega_1}}$

Closed-Loop Amplifier Transfer Function

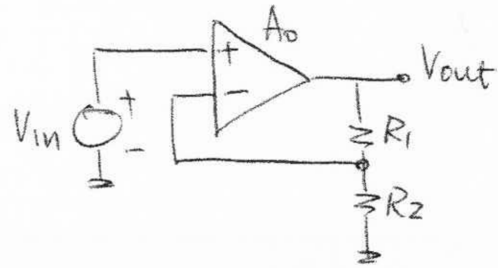
$$\frac{V_o}{V_{in}} = \frac{-\frac{R_1}{R_2}}{1 + \frac{1+\frac{R_1}{R_2}}{A(s)}} = \frac{-\frac{R_1}{R_2}}{1 + \frac{1+\frac{R_1}{R_2}}{A_o}\left(1+\frac{s}{\omega_1}\right)}$$

$$\boxed{\frac{V_o}{V_{in}} = \frac{-\frac{R_1}{R_2}}{\frac{s}{\omega_1}\left(\frac{1+\frac{R_1}{R_2}}{A_o}\right) + 1 + \frac{1+\frac{R_1}{R_2}}{A_o}}}$$

The bandwidth of the closed-loop amplifier is equal to the pole frequency.

$$\boxed{\left|\omega_{PI,closed}\right| = \left(1 + \frac{A_o}{1+\frac{R_1}{R_2}}\right)\omega_1 \underset{\text{if } A_o \text{ is very large}}{\simeq} \frac{A_o\omega_1}{1+\frac{R_1}{R_2}}}$$

59



Nominal Gain $= 4$
Slew Rate $= 1 V/ns$
$V_p = 0.5 V$

$$V_{in}(t) = 0.5 \sin wt \Rightarrow V_{out} = 0.5 \times \overbrace{\left(1 + \frac{R_1}{R_2}\right)}^{=4} \sin wt.$$

$$\frac{dV_{out}}{dt} = 0.5\left(1 + \frac{R_1}{R_2}\right) w \cdot \cos wt.$$

= maximum when $\cos wt = 1$

$$\Rightarrow \left.\frac{dV_{out}}{dt}\right|_{max} = 0.5w\left(1 + \frac{R_1}{R_2}\right) = 2w$$

$\therefore$ Highest frequency $\Rightarrow 2w = 1 V/ns$

$\Rightarrow w = 0.5$ rad/ns $\Rightarrow f_{MAX} \simeq 79.6$ MHz