

Given

$$f_u = 4 \text{ MHz}$$

Want

$$f_3 = 500 \text{ kHz}$$

$$A_{V0} = 40$$

Properties

$$\text{gain} = \frac{V_{out}}{V_m} = A_V \quad f_3 = \frac{f_u}{A_{V0}}$$

→

$$A_V = \frac{A_{V0}}{\sqrt{1 + [A_{V0}(f/f_u)]^2}}$$

Non-inverting gain

$$G = \frac{V_{out}}{V_m} = \frac{R_L + R_2}{R_1} = A_V$$

Analysis

a) If we use a single op-Amp

for a gain 10x, $A_{V0} = 40$ & $f_3 = \frac{f_u}{A_{V0}}$

$$f_3 = \frac{f_u}{A_{V0}} \rightarrow 100 \text{ kHz}$$

Because of the f_3 constraint of 500 kHz

we cannot create a circuit of 40 gain

at 500 kHz f_3 with a single op-amp.

b) However by using multiple op-amps in series
we can create a circuit with multiple gains
that feature an f_3 of 500 kHz or greater

To cleanly do this we need $A_{V0}\left(\frac{f}{f_u}\right) \ll 1$ in
order for the expected gain A_V to equal A_{V0}

Since when $A_{V0}\left(\frac{f}{f_u}\right) \ll 1$, $A_V \approx \frac{A_{V0}}{\sqrt{1}}$

while at f_3 $A_V = \frac{A_{V0}}{\sqrt{2}}$. By this concept we

can define the greatest gain to have an f_3 of

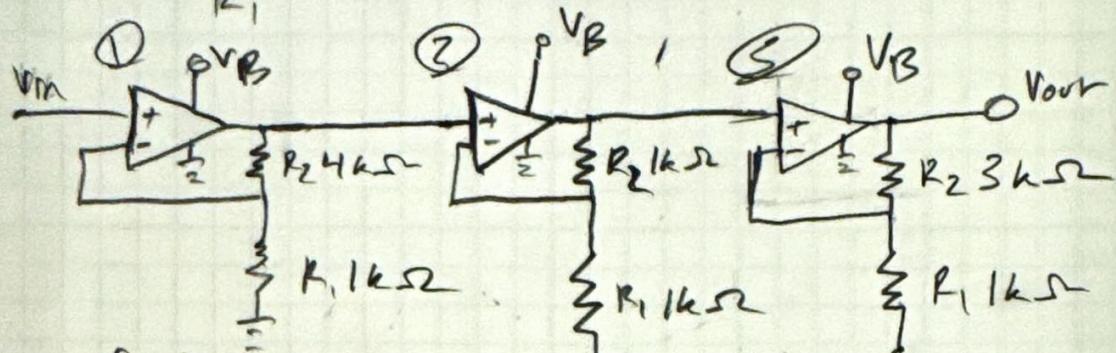
$$500 \text{ kHz}, A_{V0} = \frac{f_3}{f_u} = \frac{500 \text{ kHz}}{4 \text{ MHz}} = 8 \Rightarrow A_V = 8 \cdot \frac{1}{\sqrt{2}} = 5.65$$

In order to get exactly $A_V = 40$ for $f_3 = 500 \text{ kHz}$
series, you would need some wacky gains (whatever 2
order to make this happen nicely we can
use integer gains of ≤ 5.65 that multiply
to 40, $f_3 > 500 \text{ kHz}$ slightly in this case)

numbers multiply
to $\frac{1}{\sqrt{2}} \cdot 10$)

We can use 3 non inverting amplifiers with gains 2, 4, and 5 respectively

$$A_V = \frac{R_1 + R_2}{R_1} \text{ for a non inverting op amp}$$



$$A_{V1} = \frac{(4+1)}{1} = 5$$

$$A_{V2} = \frac{(1+1)}{1} = 2$$

$$A_{V3} = \frac{(3+1)}{1} = 4$$

$$\underline{A_V = A_{V1} \cdot A_{V2} \cdot A_{V3} = 40}$$

The lowest f_3 for this circuit is at the op amp or a gain of 5.

at f_3 for this op amp

$$A_V = \frac{A_{V0}}{\sqrt{2}} \Rightarrow A_{V0} = 7.071$$

$$f_3 = \frac{f_U}{2.07} = \frac{4 \text{ MHz}}{2.07} = 565 \text{ kHz} > 500 \text{ kHz}$$