

Given

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

Want

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

$$A_{V0} = 40$$

Properties

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

→

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

Non inverting gain

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

Analysis

a) If we use a single op-amp

for a gain of $A_{V0} = 40$ & $f_3 = \frac{f_u}{A_{V0}}$

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

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 $A_{V0}(\frac{f}{f_u}) \ll 1$ in order for the experienced gain A_V to equal A_{V0} . Since when $A_{V0}(\frac{f}{f_u}) \ll 1$, $A_V \approx \frac{A_{V0}}{\sqrt{1}}$.

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

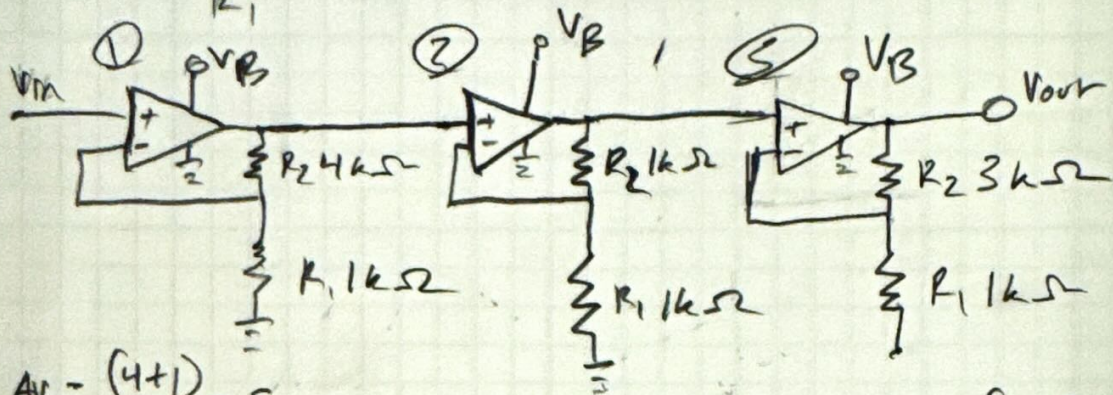
can define the "greatest gain to have an f_3 of"

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

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

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



$$A_{v1} = \frac{(4+1)}{1} = 5$$

$$A_{v2} = \frac{(1+1)}{1} = 2$$

$$A_{v3} = \frac{(3+1)}{1} = 4$$

$$A_v = A_{v1} \cdot A_{v2} \cdot A_{v3} = 40$$

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

at f_3 for this op amp

$$A_v = \frac{A_{v0}}{\sqrt{2}} \rightarrow A_{v0} = 7.071$$

$$f_3 = \frac{f_u}{7.071} = \frac{4 \text{ MHz}}{7.071} = 565 \text{ kHz} > 500 \text{ kHz}$$