given

$f_u = 4\,mHz$

Want

$f_3 = 500\,kHz$

$A_{Vo} = 40$

Properties

$$\text{gain} = \frac{V_{out}}{V_{in}} = A_V \qquad f_3 = \frac{f_u}{A_{Vo}}$$

$\rightarrow$

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

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 $A_{Vo} = 40$ & $f_3 = \frac{f_u}{A_{Vo}}$

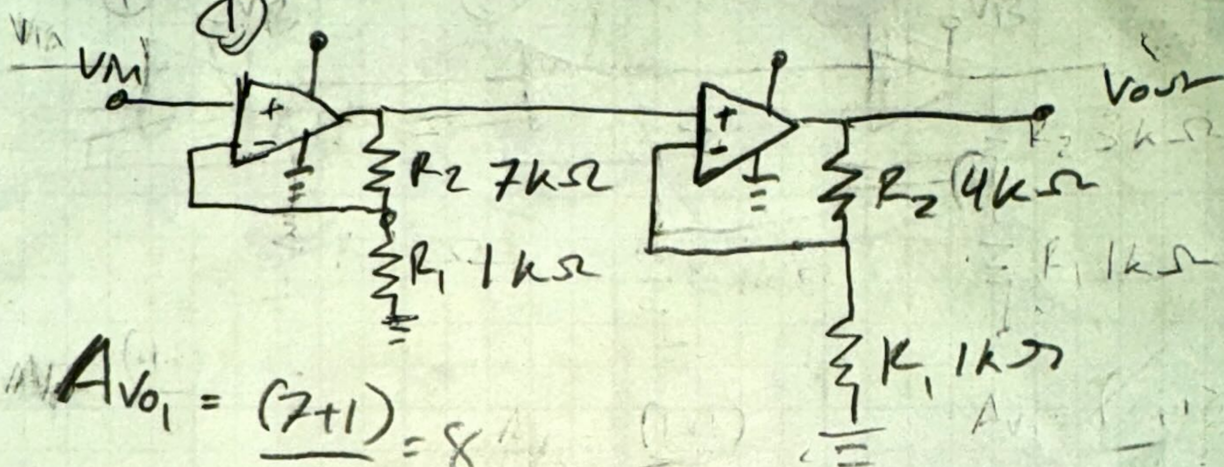
$$f_3 = \frac{f_u}{A_{Vo}} \rightarrow 100\,kHz$$

Because of the f_3 constraint of 500 kHz we cannot create a circuit of 40 gain an 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 $A_{Vo}\left(\frac{f}{f_u}\right) << 1$ in order for the experienced gain A_V to equal A_{Vo} since when $A_{Vo}\left(\frac{f}{f_u}\right) << 1$, $A_V \approx \frac{A_{Vo}}{\sqrt{1}}$, while at f_3 $A_V = \frac{A_{Vo}}{\sqrt{2}}$. By this concept we can define the greatest gain to have an f_3 of 500 kHz, $A_{Vo} = \frac{f_3}{f_u} = \frac{500\,kHz}{4\,MHz} = 8$

We can use 2 non inverting amplifiers with gains 5 and 8 respectively

$Av_0 = \frac{R_1 + R_2}{R_1}$ for a non inverting op amp



$Av_{o_1} = \frac{(7+1)}{1} = 8$

$Av_{o_2} = \frac{(4+1)}{1} = 5$

$\boxed{Av_0 = Av_{01} \cdot Av_{02} = 40}$

The lowest f_3 for this circuit is at the op amp w Avo gain of 8.

at f_3 for this op amp

$f_3 = \frac{4\ MHz}{8} = 500\ kHz$