- Sketch the filter requirements for a filter which must keep all frequencies < 27 kHz (to within ±5%) and reject all frequencies above 49 kHz by at least 60 dB.
- Using a table, design the filter, and for each 2nd-order stage in the filter, calculate ω_c and ζ.

First, convert 5% to dB

\[ 20 \log_{10}(1.05) = 0.42, \quad 20 \log_{10}(1.05) = -0.45 \]

In table, choose \text{FILTER} = \text{Chebychev 0.2dB}

Next, calculate \( F_s = f_s/f_p = 49/27 = 1.81 \)

- Design of stage #1:
  \[ \omega_c = 27 \times 0.343 = 9.26 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.807 = 1.39 \]

- Design of stage #2:
  \[ \omega_c = 27 \times 0.623 = 16.82 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.377 = 2.25 \]

- Design of stage #3:
  \[ \omega_c = 27 \times 0.878 = 23.71 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.179 = 2.64 \]

- Design of stage #4:
  \[ \omega_c = 27 \times 1.021 = 27.57 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.054 = 2.89 \]
- Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 27$ kHz and $\zeta = 0.5$. Use $C = 10 \text{nF}$.

\begin{align*}
\text{Natural frequency: } \omega_c &= 2\pi f_c = 2\pi (27 \text{ kHz}) = 169646 \text{ rad/s} \\
\omega_c &= \frac{1}{\sqrt{LC}}, \quad \rightarrow \quad L = \frac{1}{\omega^2 \times C} = 3.47 \text{ mH}.
\end{align*}

\begin{align*}
\zeta &= \frac{R}{2} \sqrt{\frac{C}{L}}, \quad \rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 589 \Omega
\end{align*}
- Design a 2\textsuperscript{nd}-order Salen-Key high-pass filter, with $f_c = 2$ kHz and $\zeta = 0.6$. Use $C = 10$ nF and $R_2 = 10$ kΩ.

- Select cut-off frequency: $\omega_c = 2\pi f_c = 2\pi(2$ kHz) = 12566 rad/s

$$\omega_c = \frac{1}{RC}, \quad \Rightarrow \quad R = \frac{1}{C \times \omega_c} = \frac{1}{12566 \times 10 \text{ nF}} = 7.96 \text{ kΩ}$$

- Select Gain: $2\zeta = 3 - G$

$$G = 3 - 2\zeta = 3 - 2 \times 0.6 = 1.80$$

$$G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 8.00 \text{ kΩ}$$