• Sketch the filter requirements for a filter which must keep all frequencies < 24 kHz (to within ±5%) and reject all frequencies above 72 kHz by at least 60 dB.

• Using a table, design the filter, and for each 2nd-order stage in the filter, calculate $\omega_c$ and $\zeta$.

First, convert 5% to dB

$$20\log_{10}(1.05) = 0.42,$$  
$$20\log_{10}(1.05) = -0.45$$

In table, choose **FILTER = Chebychev 0.2dB**

Next, calculate $F_s = f_s/f_p = 72/24 = 3.00$

• Design of stage #1:
  $\omega_c = 24 \times 0.46 = 11.04$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

• Design of stage #2:
  $\omega_c = 24 \times 0.803 = 19.27$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

• Design of stage #3:
  $\omega_c = 24 \times 1.038 = 24.91$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 24$ kHz and $\zeta = 1.2$. Use $C = 10$ nF.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (24$ kHz$) = 150796$ rad/s

\[
\omega_c = \frac{1}{\sqrt{LC}}, \quad \rightarrow \quad L = \frac{1}{\omega_c^2 \times C} = 4.40 \, \text{mH}.
\]

\[
\zeta = \frac{R}{2 \sqrt{LC}}, \quad \rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 1592 \, \Omega
\]
Design a 2\textsuperscript{nd}-order Salen-Key high-pass filter, with \( f_c = 3 \text{ kHz} \) and \( \zeta = 0.8 \). Use \( C = 10 \text{ nF} \) and \( R_2 = 10 \text{ k}\Omega \).

- Select cut-off frequency: \( \omega_c = 2\pi f_c = 2\pi(3 \text{ kHz}) = 18850 \text{ rad/s} \)

\[
\omega_c = \frac{1}{RC}, \quad \Rightarrow \quad R = \frac{1}{C \times \omega_c} = \frac{1}{18850 \times 10 \text{ nF}} = 5.31 \text{ k}\Omega
\]

- Select Gain: \( 2\zeta = 3 - G \)

\[
G = 3 - 2\zeta = 3 - 2 \times 0.8 = 1.40
\]

\[
G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 4.00 \text{ k}\Omega
\]