- Sketch the filter requirements for a filter which must keep all frequencies < 27 kHz (to within ±5%) and reject all frequencies above 75 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**

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

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

Next, calculate $F_s = f_s/f_p = 75/27 = 2.78$

- Design of stage #1:
  $\omega_c = 27 \times 0.46 = 12.42$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

- Design of stage #2:
  $\omega_c = 27 \times 0.803 = 21.68$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

- Design of stage #3:
  $\omega_c = 27 \times 1.038 = 28.03$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
Design a 2nd-order RLC low-pass filter, with \( f_c = 27 \text{ kHz} \) and \( \zeta = 1.1 \). Use \( C = 10 \text{ nF} \).

Natural frequency: \( \omega_c = 2\pi f_c = 2\pi(27 \text{ kHz}) = 169646 \text{ rad/s} \)

\[
\omega_c = \frac{1}{\sqrt{LC}} \rightarrow L = \frac{1}{\omega^2 \times C} = 3.47 \text{ mH}
\]

\[
\zeta = \frac{R}{2 \sqrt{L}} \rightarrow R = 2\zeta \sqrt{\frac{L}{C}} = 1297 \Omega
\]
• Design a 2nd-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: $2\zeta = 3 - G$

$G = 3 - 2\zeta = 3 - 2 \times 0.8 = 1.40$

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