• Sketch the filter requirements for a filter which must keep all frequencies < 25 kHz (to within ±5%) and reject all frequencies above 45 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 \( F_s = f_s/f_p = 45/25 = 1.80 \)

• Design of stage #1:
  \( \omega_c = 25 \times 0.343 = 8.57 \) kHz
  Gain = 3 - 2\( \zeta \) = 3 - 2 \times 0.807 = 1.39

• Design of stage #2:
  \( \omega_c = 25 \times 0.623 = 15.57 \) kHz
  Gain = 3 - 2\( \zeta \) = 3 - 2 \times 0.377 = 2.25

• Design of stage #3:
  \( \omega_c = 25 \times 0.878 = 21.95 \) kHz
  Gain = 3 - 2\( \zeta \) = 3 - 2 \times 0.179 = 2.64

• Design of stage #4:
  \( \omega_c = 25 \times 1.021 = 25.52 \) kHz
  Gain = 3 - 2\( \zeta \) = 3 - 2 \times 0.054 = 2.89
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 25$ kHz and $\zeta = 0.8$. Use $C = 10$ nF.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (25$ kHz$) = 157080$ rad/s

\[
\omega_c = \frac{1}{\sqrt{LC}}, \quad \Rightarrow \quad L = \frac{1}{\omega^2 \times C} = 4.05 \text{ mH}.
\]

\[
\zeta = \frac{R}{2 \sqrt{C L}}, \quad \Rightarrow \quad R = 2 \zeta \sqrt{\frac{L}{C}} = 1019 \Omega
\]
• Design a 2nd-order Salen-Key high-pass filter, with $f_c = 2$ kHz and $\zeta = 0.7$. 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: $2\zeta = 3 - G$

$G = 3 - 2\zeta = 3 - 2 \times 0.7 = 1.60$

$$G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 6.00 \text{kΩ}$$

![Diagram of the 2nd-order Salen-Key high-pass filter](image)