• 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:
  \[ \omega_c = 25 \times 0.343 = 8.57 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.807 = 1.39 \]

• Design of stage #2:
  \[ \omega_c = 25 \times 0.623 = 15.57 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.377 = 2.25 \]

• Design of stage #3:
  \[ \omega_c = 25 \times 0.878 = 21.95 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.179 = 2.64 \]

• Design of stage #4:
  \[ \omega_c = 25 \times 1.021 = 25.52 \text{ kHz} \]
  \[ \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.054 = 2.89 \]
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 25$ kHz and $\zeta = 0.7$. Use $C = 10$ nF.

\begin{align*}
\text{Natural frequency: } \omega_c &= 2\pi f_c = 2\pi(25 \text{ kHz}) = 157080 \text{ 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{LC}}, \quad \Rightarrow \quad R = 2\zeta\sqrt{\frac{L}{C}} = 891 \Omega
\end{align*}

\begin{circuit}\begin{circuitikz}
\draw (0,0) to [short, v^=25, name=V] (0,2) ;
\draw (0,2) to [short, i^=2.5] (2,2) ;
\draw (2,2) to [short, i^=2.5] (2,0) ;
\draw (2,0) to [short, name=V2] (0,0) ;
\draw (0,0) to [L, v^=891\text{ \Omega}, name=L] (2,0) ;
\draw (2,0) to [C, v^=10\text{ nF}] (2,2) ;
\draw (2,2) to [L, v^=4.05\text{ mH}] (0,2) ;
\draw (2,2) to [V, v^>=25\text{ kHz}] (2,0) ;
\end{circuitikz}\end{circuit}
• Design a 2nd-order Salen-Key high-pass filter, with $f_c = 2$ kHz and $\zeta = 0.5$. Use $C = 10 \text{nF}$ and $R_2 = 10 \text{k}\Omega$.

• Select cut-off frequency: 

\[ \omega_c = 2\pi f_c = 2\pi (2 \text{ kHz}) = 12566 \text{ rad/s} \]

\[ \omega_c = \frac{1}{RC}, \quad \Rightarrow \quad R = \frac{1}{C \times \omega_c} = \frac{1}{12566 \times 10 \text{nF}} = 7.96 \text{k}\Omega \]

• Select Gain: $2\zeta = 3 - G$

\[ G = 3 - 2\zeta = 3 - 2 \times 0.5 = 2.00 \]

\[ G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 10.00 \text{k}\Omega \]