• Sketch the filter requirements for a filter which must keep all frequencies < 25 kHz (to within ±5%) and reject all frequencies above 96 kHz by at least 60 dB.

• Using a table, design the filter, and for each 2\textsuperscript{nd}-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 0.2 dB

Next, calculate \(F_s = f_s/f_p = 96/25 = 3.84\)

• Design of stage #1:
  \(\omega_c = 25 \times 0.46 = 11.50\) kHz
  Gain = \(3 - 2\zeta = 3 - 2 \times 0.799 = 1.40\)

• Design of stage #2:
  \(\omega_c = 25 \times 0.803 = 20.07\) kHz
  Gain = \(3 - 2\zeta = 3 - 2 \times 0.335 = 2.33\)

• Design of stage #3:
  \(\omega_c = 25 \times 1.038 = 25.95\) kHz
  Gain = \(3 - 2\zeta = 3 - 2 \times 0.095 = 2.81\)
Design a 2\textsuperscript{nd}-order RLC low-pass filter, with \( f_c = 25 \text{ kHz} \) and \( \zeta = 1.4 \). Use \( C = 10 \text{ nF} \).

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

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

\[
\zeta = \frac{R}{2 \sqrt{LC}}, \quad \rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 1783 \Omega
\]
- Design a 2\textsuperscript{nd}-order Salen-Key high-pass filter, with \( f_c = 3 \text{ kHz} \) and \( \zeta = 0.7 \). 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: \( 2\zeta = 3 - G \)
    \[
    G = 3 - 2\zeta = 3 - 2 \times 0.7 = 1.60
    \]
    \[
    G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 6.00 \text{ k}\Omega
    \]

![Circuit Diagram](image)