• Sketch the filter requirements for a filter which must keep all frequencies < 28 kHz (to within ±5%) and reject all frequencies above 50 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 \( \text{FILTER} = \text{Chebychev 0.2dB} \)

Next, calculate \( F_s = f_s/f_p = 50/28 = 1.79 \)

• Design of stage #1:
  \[
  \omega_c = 28 \times 0.343 = 9.60 \text{ kHz}
  \]
  
  \[
  \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.807 = 1.39
  \]

• Design of stage #2:
  \[
  \omega_c = 28 \times 0.623 = 17.44 \text{ kHz}
  \]
  
  \[
  \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.377 = 2.25
  \]

• Design of stage #3:
  \[
  \omega_c = 28 \times 0.878 = 24.58 \text{ kHz}
  \]
  
  \[
  \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.179 = 2.64
  \]

• Design of stage #4:
  \[
  \omega_c = 28 \times 1.021 = 28.59 \text{ kHz}
  \]
  
  \[
  \text{Gain} = 3 - 2\zeta = 3 - 2 \times 0.054 = 2.89
  \]
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 28$ kHz and $\zeta = 0.5$. Use $C = 10$ nF.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (28$ kHz$) = 175929$ rad/s

$$\omega_c = \frac{1}{\sqrt{LC}}, \quad \rightarrow \quad L = \frac{1}{\omega^2 \times C} = 3.23 \text{ mH}.$$  

$$\zeta = \frac{R}{2L}, \quad \rightarrow \quad R = 2\zeta \sqrt{L \cdot C} = 568 \Omega$$
• Design a 2nd-order Salen-Key high-pass filter, with \( f_c = 2 \text{ kHz} \) and \( \zeta = 0.6 \). 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: \( 2\zeta = 3 - G \)

\[ G = 3 - 2\zeta = 3 - 2 \times 0.6 = 1.80 \]

\[ G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 8.00 \text{ k}\Omega \]