• Sketch the filter requirements for a filter which must keep all frequencies $< 30$ kHz (to within $\pm 5\%$) and reject all frequencies above 59 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 $F_s = f_s/f_p = 59/30 = 1.97$

• Design of stage #1:
  $\omega_c = 30 \times 0.343 = 10.29$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.807 = 1.39$

• Design of stage #2:
  $\omega_c = 30 \times 0.623 = 18.69$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.377 = 2.25$

• Design of stage #3:
  $\omega_c = 30 \times 0.878 = 26.34$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.179 = 2.64$

• Design of stage #4:
  $\omega_c = 30 \times 1.021 = 30.63$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.054 = 2.89$
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 30$ kHz and $\zeta = 0.8$. Use $C = 10 \text{nF}$.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (30 \text{ kHz}) = 188496 \text{ rad/s}$

\[
\begin{align*}
\omega_c &= \frac{1}{\sqrt{LC}}, \quad \Rightarrow \quad L = \frac{1}{\omega^2 C} = 2.81 \text{ mH}. \\
\zeta &= \frac{R}{2} \sqrt{\frac{C}{L}}, \quad \Rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 849 \Omega
\end{align*}
\]

![RLC Circuit Diagram](image-url)
• Design a 2\textsuperscript{nd}-order Salen-Key high-pass filter, with \( f_c = 2 \text{kHz} \) and \( \zeta = 0.9 \). Use \( C = 10 \text{nF} \) and \( R_2 = 10 \text{k}\Omega \).

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

• Select cut-off frequency: \( \omega_c = 2\pi f_c = 2\pi (2 \text{kHz}) = 12566 \text{rad/s} \)

\[
G = 3 - 2\zeta = 3 - 2 \times 0.9 = 1.20
\]

\[
G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 2.00 \text{k}\Omega
\]