• Sketch the filter requirements for a filter which must keep all frequencies < 27 kHz (to within ±5%) and reject all frequencies above 91 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 $F_s = \frac{f_s}{f_p} = \frac{91}{27} = 3.37$

• Design of stage #1:
  $\omega_c = 27 \times 0.46 = 12.42$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

• Design of stage #2:
  $\omega_c = 27 \times 0.803 = 21.68$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

• Design of stage #3:
  $\omega_c = 27 \times 1.038 = 28.03$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
Design a 2nd-order RLC low-pass filter, with \( f_c = 27 \text{ kHz} \) and \( \zeta = 1.3 \). Use \( C = 10 \text{ nF} \).

Natural frequency: \( \omega_c = 2\pi f_c = 2\pi (27 \text{ kHz}) = 169646 \text{ rad/s} \)

\[
\omega_c = \frac{1}{\sqrt{LC}}, \quad \Rightarrow \quad L = \frac{1}{\omega^2 \times C} = 3.47 \text{ mH}.
\]

\[
\zeta = \frac{R}{2\sqrt{LC}}, \quad \Rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 1533 \Omega
\]
• Design a 2nd-order Salen-Key high-pass filter, with $f_c = 3$ kHz and $\zeta = 0.8$. Use $C = 10$ nF and $R_2 = 10$ kΩ.

• Select cut-off frequency: $\omega_c = 2\pi f_c = 2\pi (3$ kHz$) = 18850$ rad/s
  
  $\omega_c = \frac{1}{RC}$, $\implies R = \frac{1}{C \times \omega_c} = \frac{1}{18850 \times 10 \text{nF}} = 5.31 \text{kΩ}$

• Select Gain: $2\zeta = 3 - G$
  
  $G = 3 - 2\zeta = 3 - 2 \times 0.8 = 1.40$

  $G = 1 + \frac{R_1}{R_2}$, $\implies R_1 = R_2 \times (G - 1)$, $\implies 4.00 \text{kΩ}$