- Sketch the filter requirements for a filter which must keep all frequencies < 29 kHz (to within ±5\%) and reject all frequencies above 85 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 \texttt{FILTER = Chebychev 0.2dB}

Next, calculate $F_s = f_s/f_p = 85/29 = 2.93$

- Design of stage #1:
  \quad $\omega_c = 29 \times 0.46 = 13.34$ kHz
  \quad Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

- Design of stage #2:
  \quad $\omega_c = 29 \times 0.803 = 23.29$ kHz
  \quad Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

- Design of stage #3:
  \quad $\omega_c = 29 \times 1.038 = 30.10$ kHz
  \quad Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
- Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 29$ kHz and $\zeta = 1.1$. Use $C = 10 \text{nF}$.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (29 \text{ kHz}) = 182212 \text{ rad/s}$

\[
\omega_c = \frac{1}{\sqrt{LC}}, \quad \rightarrow \quad L = \frac{1}{\omega^2 \times C} = 3.01 \text{ mH}.
\]

\[
\zeta = \frac{R}{2\sqrt{LC}}, \quad \rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 1207 \Omega
\]
• Design a 2<sup>nd</sup>-order Salen-Key high-pass filter, with $f_c = 3$ kHz and $\zeta = 0.7$. 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

$$\omega_c = \frac{1}{RC}, \quad \Rightarrow \quad R = \frac{1}{C \times \omega_c} = \frac{1}{18850 \times 10 \text{ nF}} = 5.31 \text{ kΩ}$$

• Select Gain: $2\zeta = 3 - G$

$G = 3 - 2\zeta = 3 - 2 \times 0.7 = 1.60$

$$G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 6.00 \text{ kΩ}$$