• Sketch the filter requirements for a filter which must keep all frequencies $< 26$ kHz (to within $\pm 5\%$) and reject all frequencies above $66$ 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 $F_s = f_s / f_p = 66 / 26 = 2.54$

• Design of stage #1:
  $\omega_c = 26 \times 0.46 = 11.96$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

• Design of stage #2:
  $\omega_c = 26 \times 0.803 = 20.88$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

• Design of stage #3:
  $\omega_c = 26 \times 1.038 = 26.99$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
• Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 26$ kHz and $\zeta = 1.0$. Use $C = 10 \text{nF}$.

Natural frequency: $\omega_c = 2\pi f_c = 2\pi (26 \text{ kHz}) = 163363 \text{ rad/s}$

$$\omega_c = \frac{1}{\sqrt{LC}}, \quad \rightarrow \quad L = \frac{1}{\omega^2 \times C} = 3.75 \text{ mH}.$$ 

$$\zeta = \frac{R}{2\sqrt{LC}}, \quad \rightarrow \quad R = 2\zeta \sqrt{\frac{L}{C}} = 1224 \Omega$$
• Design a 2\textsuperscript{nd}-order Salen-Key high-pass filter, with $f_c = 3$ kHz and $\zeta = 0.6$. Use $C = 10 \text{ nF}$ and $R_2 = 10 \text{ k}\Omega$.

• Select cut-off frequency: $\omega_c = 2\pi f_c = 2\pi (3 \text{ kHz}) = 18850 \text{ rad/s}$

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

• Select Gain: $2\zeta = 3 - G$

$G = 3 - 2\zeta = 3 - 2 \times 0.6 = 1.80$

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