• Sketch the filter requirements for a filter which must keep all frequencies < 30 kHz (to within ±5%) and reject all frequencies above 114 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 $F_s = f_s/f_p = 114/30 = 3.80$

• Design of stage #1:
  $\omega_c = 30 \times 0.46 = 13.80$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.799 = 1.40$

• Design of stage #2:
  $\omega_c = 30 \times 0.803 = 24.09$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.335 = 2.33$

• Design of stage #3:
  $\omega_c = 30 \times 1.038 = 31.14$ kHz
  Gain = $3 - 2\zeta = 3 - 2 \times 0.095 = 2.81$
- Design a 2\textsuperscript{nd}-order RLC low-pass filter, with $f_c = 30$ kHz and $\zeta = 1.4$. Use $C = 10$ nF.

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

\[ \omega_c = \frac{1}{\sqrt{LC}}, \rightarrow L = \frac{1}{\omega^2 \times C} = 2.81 \text{ mH}. \]

\[ \zeta = \frac{R}{2 \sqrt{L/C}}, \rightarrow R = 2\zeta \sqrt{\frac{L}{C}} = 1485 \Omega \]
- Design a 2nd-order Salen-Key high-pass filter, with $f_c = 3$ kHz and $\zeta = 1.0$. 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: $2\zeta = 3 - G$

  $$G = 3 - 2\zeta = 3 - 2 \times 1.0 = 1.00$$

  $$G = 1 + \frac{R_1}{R_2}, \quad \Rightarrow \quad R_1 = R_2 \times (G - 1), \quad \Rightarrow \quad 0.00 \text{k}\Omega$$