**Second-Order Sallen-Key Filters**

### S.K. Low-Pass Filter

\[
\omega_c = \frac{1}{RC}, \quad A_v = A, \quad Q = \frac{1}{3-A}
\]

### S.K. High-Pass Filter

\[
\omega_c = \frac{1}{RC}, \quad A_v = A, \quad Q = \frac{1}{3-A}
\]

### S.K. Band-Pass Filter

\[
\omega_p = \frac{1}{RC}, \quad Q = \frac{1}{3-A} \quad A_v = A_Q
\]

### S.K. Band-Reject Filter

\[
\omega_o = \frac{1}{RC}, \quad Q = \frac{1}{4-2A} \quad A_v = A
\]

**Properties of Sallen-Key Filters:**

1. Simplicity of the design
2. Non-Inverting Amplifier (positive Gain)
3. Replication of elements

**Limitations of Sallen-Key Filters:**

1. The Gain and Q are related
2. Q must be > \(\frac{1}{2}\), since A must be > 1
6. Given these filter circuits with associated transfer functions:

\[
\frac{s^2 + 2s/(RC_1) + 1/(R^2C_1C_2)}{s^2 + 2s/(R_3C) + (R_1 + R_2)/(R_1R_2R_3C^2)}
\]

Using the above active filter blocks, design a broadband bandpass filter with corner frequencies of \(\omega_c = 2000\) rad/s and \(\omega_2 = 10^5\) rad/s and a pass-band gain of 200 (46dB). At high frequencies, a drop-off of -20dB/decade is sufficient. However, for low frequencies, the gain must be below 0dB for frequencies below 100 rad/s. Also, the gain at the lower corner frequency (\(\omega_c\)) should be 160. Choose all component values. (30)

\[
\frac{\omega_c}{\omega_s} = \frac{2000}{100} = 20 = 10^{1.3} \quad \frac{46\text{ dB}}{1.3\text{ decades}} = 3.7\text{ dB/decade for HPF}
\]

Thus can use 2nd order HPF \(L/\omega_c = 2000\) rad/s and \(Q = \frac{160}{200} = 0.8\) and 1st order LPF \(L/\omega_2 = 10^5\) and gain of 200

For HPF, \(\omega_c^2 = (2000)^2 = \frac{1}{R^2C_1C_2}\) and \(\omega_1 = \frac{2000}{0.8} = \frac{2}{RC_1}\)

Take \(R = 10k\) \(= 10^4\), then \(C_1 = \frac{2 \times 0.8}{2000 \times 10^4} = 8 \times 10^{-8} F = 80nF\)

\(C_2 = \frac{1}{(2000)(10^4)^2 \times 8 \times 10^{-8}} = \frac{1}{32 \times 10^{-6}} = 3.1 \times 10^{-8} = 31nF\)

For LPF, \(\omega_2 = 10^5 = 1/R_2C\), \(|A_{p1}| = 200 = \frac{R_2}{R_1}\) Use \(R_2 = 200k\)

\(R_1 = 1k\)

\(C = \frac{(2 \times 10^5)(10^5)}{5 \times 10^{-11} F} < 50\ pF\)

End Of Exam