Filters Design

Ex.

1. Requirements - 5T
2. Look up solutions
   - $2T \times 3 = 6T$
   - $10T \times 1 = 10T$
3. Choose and Implement

This is the same process for filters.

Filtering in Pics:

have

\[ \begin{array}{c}
\text{want} \\
\text{LF} \\
\text{HF}
\end{array} \]

Low Pass Filter
**LPF Ex**

1. Accept all \( f < 100 \) Hz
   (within 10%)
   
   \[
   \begin{align*}
   20 \log (1.1) & = 0.83 \text{ dB} \\
   20 \log (1.0) & = 0 \text{ dB} \\
   20 \log (0.9) & = -0.92 \text{ dB}
   \end{align*}
   \]

2. Reject all \( f > 500 \) Hz
   (\(< 0.1\%\))
   
   \[
   20 \log (0.001) = -60 \text{ dB} = \text{gain}
   \]
   
   \[
   \uparrow
   \]
   
   \[
   \text{attenuation of } 60 \text{ dB}
   \]

**HPF Ex**

1. Accept ±17% all \( f > 100 \) Hz

2. Reject (\(<1\%) of \( f < 60 \) Hz
   
   \[
   \begin{align*}
   20 \log (0.01) & = -40 \text{ dB} \\
   20 \log (1.01) & = +0.086 \text{ dB} \\
   20 \log (0.99) & = -0.088
   \end{align*}
   \]
   
   \[
   \text{amount of deviation allowed, but can vary}
   \]
Low Pass

Use chebyshev 0.5 dB ✓
(0.5 < 0.88)

\[
N & \quad -60\ dB \quad \text{req.} \quad F_s = \frac{f_s}{f_p} = \frac{500\ Hz}{100\ Hz} = 5 \\
2 & \quad 3.7 \quad \text{x} \\
4 & \quad 4.4 \quad \text{✓ (already attenuated by } 4.4 \times f_p = 440\ Hz, \text{ we need} \\
6 & \quad 3.2 \quad \text{500 Hz, so ok!)} \\
8 & \quad 1.6
\]

Choose lowest \(N\) which meets req.
Two High Pass Filters

\[ \omega_c = \frac{1}{\sqrt{LC}} \]

\[ \zeta = \frac{R}{2L} \]

High Pass

choose .05 dB Chebyshev

\[(0.05 \text{ dB} < 0.086 \text{ dB})\]

\[ N = \frac{21}{2} \]

\[ 4 \]

\[ 4 \]

\[ 8 \]

\[ f_c = 237 \text{ Hz} \]

\[ f_c = \frac{f_p}{F_n} = 100 \text{ Hz} = 149 \text{ Hz} \]
Low Pass
\[(f_c)_{\text{Stage}} = f_p \times \frac{1}{F_N}\]

High Pass
\[(f_c)_{\text{Stage}} = \frac{f_p}{F_N}\]

Now, design the HPF:

\[RC = \left(2\pi \times 237 \text{ Hz}\right)^{-1}\]

Stage 1
\[RC = \left(2\pi \times 149 \text{ Hz}\right)^{-1}\]

Stage 2

\[\int = \frac{1}{2} \left(3 - 4\right) = \frac{1}{2} \left[3 - \left(1 + \frac{R_1}{R_2}\right)\right]\]

\[= 1 - \frac{R_1}{2R_2}\]

\[\frac{R_1}{R_2} = 2 - 2^{\frac{\int}{2}} = 2 - 2^{\frac{1}{2}} = 2 - 2^{0.87}\]