

EXTENSION TO NON-LOWPASS FILTERS*

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All of the discussion to this point has focused on lowpass filters. Practical applications require other types, of course, including highpass, bandpass, and bandstop designs. In fact the analysis presented in the previous sections applies to all of these design criteria and the rules for filter length estimation can be used almost directly. In general Equation 1¹ and Equation 2 from the module titled "Filter Sizing"² apply when one of the equal ripple specifications dominates all others and when one of the transition band specifications dominates all others. As a practical matter this means that δ_i dominates if it is less than one-tenth of all other ripple specifications and that Δf_i dominates if it is simply less than all others. Suppose we define δ and Δf by the equations:

$$\begin{aligned}\delta &= \min\{\delta_i\}, \text{ for all pass and stopbands } i, \text{ and} \\ \Delta f &= \min\{\Delta f_k\} \text{ for all transition bands } k \\ \delta &= \min\{\delta_i\}, \text{ for all pass and stopbands } i, \text{ and}\end{aligned}\tag{1}$$

$$\Delta f = \min\{\Delta f_k\} \text{ for all transition bands } k\tag{2}$$

If so then equation Equation 1 from the module titled "Filter Sizing"³ can be used directly and the equation for α becomes

$$\alpha = 0.22 - \frac{\log_e \delta}{\pi}.\tag{3}$$

A final hint - Watch out for the implicit boundary conditions present in the design of linear phase FIR digital filters in two cases: even order, symmetric response and odd order, antisymmetrical response. In both of these cases the underlying equations for the filter's frequency response constrain it to equal exactly zero at $\frac{f_s}{2}$. This is obviously not a problem for lowpass filters, since the desired gain at $\frac{f_s}{2}$ is zero already. However, in the design of multiband and highpass filters an inordinate amount of engineering time has been spent trying to design even-order filters when in fact it is impossible to do so. The Parks-McClellan algorithm will gamely try, but will fail. As a rule, use odd values of N for highpass and multiband filters requiring nonzero response at $\frac{f_s}{2}$ and use even-order filters for differentiators.

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¹"Filter Sizing", (1) <<http://cnx.org/content/m17234/latest/#uid2>>

²"Filter Sizing", (2) <<http://cnx.org/content/m17234/latest/#uid3>>

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