Matlab Ripple

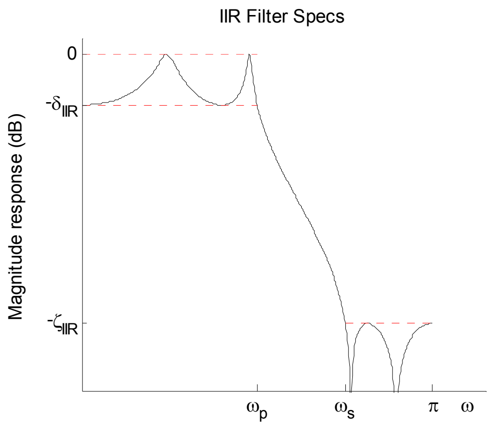
Overview

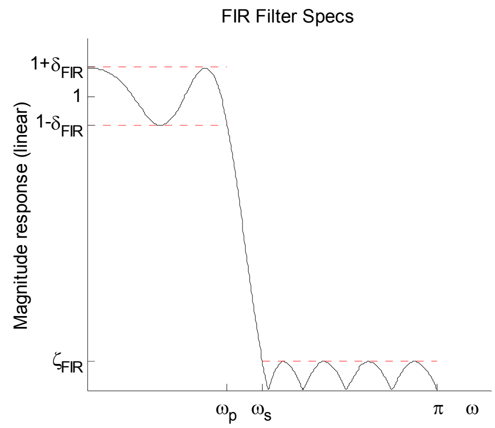
In many of the projects, it may be helpful to use MATLAB's order estimation functions (e.g. `buttord`, `cheb1ord`, ...). Another alternative is MATLAB's `fdatool`, an interesting tool which can read your input specifications and design and plot filters, all in a graphical user interface environment. Either the script-based method or the graphical method may be preferable depending on your needs.

A major cautionary note is in order: there is a difference in the specification definitions for IIR and FIR filters, for example in the definitions used by `fdatool`. This difference is due to historical reasons. Analog filter design techniques were developed in the early 1900s based on passive electrical networks, before gain was readily available. Many IIR filter design techniques are based on passive analog designs, so for IIR filters the definitions of the specifications do not include gain. However, FIR filters were developed exclusively in the context of digital filtering and the specification definitions include gain. In the future if you use a program such as `fdatool`, you will have to convert specs from one set of definitions to the other in order to compare filters.

The following can be used to sort through these differences in convention:

1. In the design of IIR filters, MATLAB takes specifications for ripple magnitude and stopband attenuation as input parameters. A specification of ripple magnitude δ_{IIR} yields an IIR filter design with a maximum passband gain of unity (or 0 dB) and a minimum passband gain of $10^{-\delta_{IIR}/20}$ (or $-\delta_{IIR}$ dB). A specification of stopband attenuation ξ_{IIR} yields an IIR filter design with a maximum stopband gain of $10^{-\xi_{IIR}/20}$ (or $-\xi_{IIR}$ dB).
2. In the design of FIR filters, MATLAB also takes a specification of ripple magnitude as an input parameter. A specification of ripple magnitude δ_{FIR} yields a FIR filter design with a maximum passband gain of $(1 + \delta_{FIR})$ (or $20 \log_{10}(1 + \delta_{FIR})$ dB), and a minimum passband gain of $(1-\delta_{FIR})$ (or $20 \log 10(1- \delta_{FIR})$ dB). A specification of stopband gain ξ_{FIR} yields an FIR filter design with a maximum stopband gain of ξ_{FIR} (or $20 \log_{10}(\xi_{FIR})$ dB).





Clearly, to compare FIR and IIR filters designed with MATLAB, we must find a correspondence between our desired specifications and the input parameters to the filter design functions. Let us thus define $G_{pb_{max}}$ (dB), $G_{pb_{min}}$ (dB), and $G_{sb_{max}}$ (dB) to refer to the desired maximum passband gain, minimum passband gain, and maximum stopband gain, respectively. In order to have free control over each of these parameters, we also introduce k_{FIR} and k_{IIR}, linear scaling terms which are used to normalize our FIR and IIR designs.

Objective

Before beginning the projects that reference this file do (a) and (b) below. Your solutions will be necessary to correctly implement the project.

(a) Find δ_{FIR}, ξ_{FIR}, and k_{FIR} in terms of $G_{pb_{max}}$, $G_{pb_{min}}$, and $G_{sb_{max}}$. These parameters will be used for FIR designs.

(b) Find δ_{IIR}, ξ_{IIR}, and k_{IIR} in terms of $G_{pb_{max}}$, $G_{pb_{min}}$, and $G_{sb_{max}}$. These parameters will be used for IIR designs.