

Specialized FIR filters (Lab. Exercise 6)

Matched filter¹

A distance measuring tool transmits a signal and measures the time delay of echoes reflected from distant objects. In this example, the transmitted signal is a Barker code² of length 13.

Lab_06_matched_filter.vi could represent the receiver part of such a system. The echo is very weak and is buried in noise as shown in the upper window. The x-axes of the windows represent the number of samples in time domain.

The signal echo should be extracted by a matched filter. Put in the correct FIR coefficients for such a filter and find the delay measured in samples³. What will the distance be when the sampling rate is 10000 samples/second and when the signal is transmitted in free air (with velocity 330 m/s)?

Interpolated FIR filter⁴

Lab_06_interpol_filter.vi can be used to demonstrate the efficiency of interpolated filters. The block “spectrum” can be used to find the amplitude response. Connect this block and the waveform graph to relevant points in the diagram to analyze different parts of the vi.

We want a FIR filter with the following specifications:

Sampling rate 20000 samp/s

LP with Hanning window

< 3dB attenuation at 600 Hz

> 40 dB attenuation at 800 Hz

- a) Try to find a direct implementation of a FIR filter that meets the spec, and note the number of coefficients of the filter.
- b) Find the optimum expansion factor for an interpolated FIR filter. (Use

$$M_{opt} = \frac{1}{f_{pass} + f_{stop} + \sqrt{f_{stop} - f_{pass}}}$$

with normalized frequencies.)

- c) Find a prototype filter for the interpolated FIR filter implementation.
- d) Find an image reject FIR filter with as few coefficients as possible.
- e) Document all filters by their frequency and impulse responses.
- f) How many multiplications must be performed each second for the direct FIR implementation and for the interpolated FIR implementation?

¹More information can be found in section 7.3 in Understanding Digital Signal Processing.

²See http://en.wikipedia.org/wiki/Barker_code.

³If a correct code is given, there will be a peak in the signal after the matched filter, which can be observed in the bottom window.

⁴More information about interpolated FIR filter can be found in section 7.4 in Understanding Digital Signal Processing.