**Lab HW: Filter Design via Optimization**

텍스트, 스크린샷, 소프트웨어, 디스플레이이(가) 표시된 사진

자동 생성된 설명텍스트, 스크린샷, 도표, 라인이(가) 표시된 사진

자동 생성된 설명

Using filterdesign GUI two Lowpass filters were made with the order M=30, w\_c=0.4\*pi=2\*pi\*(2000/10000), fs=10000, fc=2000. The first plot shows a plot of a rectangle filter with d\_p = d\_s = 0.1, w\_p = 1.12972, w\_s = 1.34649. The second plot on the right shows a hamming filter with d\_p = d\_s = 0.01, w\_p = 0.941221, w\_s = 1.5664. The w\_c = 0.04\*pi = 0.12566 and from the w\_s and w\_p of the two plot their width were 0.21677 and 0.625179. The first plot’s width/2 was close to the cutoff frequency and the second plot’s width/2 was a bit more off from the cutoff frequency.

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자동 생성된 설명

“When comparing two Mth order filters, the one with a smaller transition width will have larger ripples.” The rectangular filter has a smaller width and a larger ripple showing the comment is true in this case. Designing a new hamming-window LPF with M = 60, and the same w\_c, d\_p = d\_s =0.01 the measurements were w\_p = 1.10019, w\_s = 1.41246, w\_s-w\_p =0.31227, which is smaller and had a larger ripple than M=30. So, when order doubles the delta w becomes almost half. With width = C/L, where L is order+1, C=L\*(w\_s-w\_p), showing an almost linear relationship.

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Setting the data as w\_p = 0.68\*pi, w\_s=0.72\*pi, and d\_p=d\_s=0.01, The ideal filter looks like the figure above. Using the hamming window formula width = C/L, we can predict the M-th order (L = M +1). Cutoff of 2000Hz gives 0.4\*pi, 0.4\*pi/width = M+1, M = (0.4\*pi/w\_s-w\_p)-1=9. Therefore, we can predict that the filter has an order of 9 as the second image shows. The last plot shows the w\_s and w\_p of the predicted filter, which was w\_p = 0.206717, w\_s=2.30467, and width = 2.097953, making the cutoff 1.0489765=0.3338996\*pi different from the given cutoff. This is because ideal LPF does not consider ripples or stopband attenuation, giving only the approximation due to the finite length of the filter.

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자동 생성된 설명

In the practical part of the project, parameters are set as w\_p = 0.68\*pi, w\_s = 0.72\*pi, d\_p = 0.05, d\_s = 0.01. Let fs = 2, f = [w\_p/(2\*pi), w\_s/(2\*pi)], a = [1, 0], dev = [d\_p, d\_s]. Using the [n,fo,ao,w]=firpmord(f,a,dev,fs) and b=firpm(n,fo,ao,w) function we can get the coefficients of the response and plot it with impz(b). The impulse response is plotted as shown above.

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The plot shows the magnitude vs radian of the frequency response or M, M+1, M+2 order. As we did in the first part of the report, we can check whether ripple specs have been met or not. The evaluation is done, using [H,w] = freqz(b,1) function and the plot above. The point goes over 1+d\_p not meeting the specs. To make an M+1 or M+2 order plot, simply write n=n+1 between firpmord() and firpm(). The third plot meets the specs. The slope of the third plot is calculated assuming the slope has a linear phase. Width=L/C, where L = (n+2) + 1, fc=C\*fs/(2\*pi), slope = -1 / (fc\*2) = -0.0828(dB/Hz). Another solution for slope calculation is using polyfit(), which performs an LS approximation leading to slope = -0.0709(dB/Hz). The first method is valid if the slope is linear and this project specifies that this FIR filter will be linear phase.