B2.4 Tutorial: Windows-FFT

1. Given N=4 write out the numerical values for a rectangular window wr[n] and a Blackman window wb[n], n=0,1,2,3.
2. Using the DTFT of wr[n] write out an expression for Wr(Ω) in terms of a sin(x)/sin(y) function where Wr(Ω) is the spectrum of wr[n].
3. Sketch the spectrum | Wr(Ω) | for $0 < \Omega < 2\pi$
4. The 4-point DFT of Wr(Ω) is computed to produce Wr(kΔΩ) = Wr[k] where $\Delta\Omega = 2\pi/N = \pi/2$ is the DFT bin separation.
5. The Scallop Loss is defined as follows

$$SL = 20\ Log_{10}[\ |\ Wr(\Omega)|_{\Omega=2\pi/2N=\pi/N}\ |\ \ /\ \ |\ Wr(\Omega)|_{\Omega=0}\ |\ ]$$

   Use the expression in (2) to compute the SL for the rectangular window.

6. Estimate in dBs the separation between the maximum of the mainlobe and the 1st sidelobe

7. Use the 4-point radix-2 FFT algorithm to compute Wr[k], k = 0 1 2 3.

8. By appending 4 zeros onto wr[n] and taking the 8-point FFT the resulting spectrum will have 8 samples with spacing π/4. Use this spectrum and the formula in (5) to compute the Scallop Loss for this window.

9. Repeat (7) to (8) for the Blackman window wb[n] described in part (1) above. Remember you will only require the 1st two samples of the FFT to compute the Scallop Loss.

10. Use (a) the DFT Matrix method and (b) FFT-IFFT to compute the Cyclic Convolution and Cyclic Correlation between the following two signals

    x[n]= [**<u>1</u>** 0 2 1] and h[n]= [**<u>3</u>** 2 0 1]

    Note y[n]= IFFT[Y[k]] then y*[n]=(1/N) [FFT[Y*[k]]=y[n] as y[n] is real and where * is the complex conjugate operator. So the IFFT can be computed using the FFT of the complex conjugate of Y[k] and scaling the result by (1/N).