Homework 8

- **Problem 1** 7.31 from the Textbook
- **Problem 2** Design of a Length-21 FIR filter

  Use MATLAB command *h=remez(20,[0,0.4,0.5,1],[1,1,0,0])* to design a 21-tap filter with a passband from 0 to $\omega_p = 0.4\pi$ and a stopband from $\omega_s = 0.5\pi$ to π, a desired response of 1 in the passband, and 0 in the stopband.

  (a) How many "ripples" are there?

  (b) How many extremal frequencies are there (places where the ripples are the same maximum size)?

  (c) How many "small ripples" are there that do not give extremal frequencies, and if any, are they in the passband or stopband?

  (d) What are the zero locations? Are there any zeros that do not contribute to a ripple?
- **Problem 3** Bilinear Transformation

  (a) Plot the relationship between the analog frequency Ω and the digital frequency ω specified by the bilinear transformation.

$$s = \frac{2}{T}\left(\frac{z-1}{z+1}\right)$$

  Use several values of $\frac{2}{T}$ to plot the curves together. If an analog prototype has a cutoff frequency at $\Omega_c = 1$, how will the digital cut-off frequency change as T increases?

  (b) A fourth-order low-pass discrete time Butterworth filter with a sampling frequency of 40 kHz is to be designed for a band edge of 8 kHz. What is the prewarped analog band edge?

  (c) Use the MATLAB function *buttap* (or by hand) and find the Laplace transform continuous-time transfer function for the fourth order Butterworth filter in (b), using the prewarped band edge.

  (d) Find the Z-transform discrete time transfer function from the continuous time filter of (c) by applying bilinear transform. Do this by hand or by using the MATLAB command *bilinear*.

  (e) Compare the result in (d) with the design done directly by the MATLAB command *butter*.