**B2.3 Tutorial Questions DTFT and Discrete System Analysis**

**Q1:** (a) Using the Pole Zero Diagram sketch the magnitude of the frequency response for the following discrete systems: 



( |*a*| < 1 ) 

From your sketches deduce what type of filter each discrete system represents. Write down the linear difference equation for each of the above digital filters and make a sketch of the realisation of each filter.

**Q2:**

(a) Show that the discrete system described by the System Function H(z) is non-causal.



(b) Using H(z) design a new causal discrete system that will have the same magnitude frequency response as H(z). Using discrete frequencies Ω=π/2 and Ω=π confirm your design.

(c) Derive the impulse responses of the two systems of part (a) and (b) above and make a sketch of these.

(d) Construct a direct realisation and a canonical realisation of the causal system designed in part (b) above. [This will be covered in the Digital Filters section of the class]

**Q3:** Consider the following processing system:

input

output

A/D

fs

H(Ω)

If fs=2kHz and the input is a 500Hz sinusoid find the output signal if



**Q4:** Using the DTFT, compute the Linear convolution and Linear correlation between x[n] and h[n] where x[n]= [ 1 2 3 4] and h[n] = [ 5 6 7]

Note DTFT[x[n]\*h[n] ] = X(Ω)H(Ω) where \* is Linear Convolution

DTFT[ x[n] Linearly Correlated with h[n] ] = X(Ω)H\*(Ω) where H\*(Ω) is the complex conjugate of H(Ω)

**Q5** A rectangular window w[n]=u[n]-u[N] where N is the length of the window is to be used for signal acquisition.

1. Derive a functional expression for W(Ω) where W(Ω) is the DTFT of w[n]
2. For N=8 plot the two sided Magnitude and Phase of W(Ω) (the frequency spectrum of w[n])
3. Add plots to those in part (ii) for N=4 and N=16. Comment on the relationship between N and the resulting frequency spectra.
4. Using Matlab, plot the magnitude of the spectra for N=4,8 and 16 and (a) compute the separation between the maximum value of the mainlobe and the highest side lobe and (b) compute the 3dB width of the mainlobe

**Q6**

1. A 50 Hz cosine is sampled at twice the Nyquist rate. A rectangular window is used to acquire 8 samples. Make a sketch of the acquired signal in the time domain and a sketch of 1 period of the magnitude of the DTFT of the acquired signal i.e. Ω=[-π, π]

1. Repeat part (i) above for N=4 and N=16 and write critical comments on the plots.