DE2 Electronics 2 for Design Engineers

Tutorial Sheet 5 – Discrete signal processing, impulse response and digital filters

(Lectures 10, 11, 13)

* indicates level of difficulty

1.* The continuous time signal $x(t) = A\cos(\omega_0 t + \phi)$ shown in Figure 1 is digitised at a sampling frequency of *fs*, where *fs* = 8000Hz.

(i) What is the maximum frequency ω_0 that the sampling process will not corrupt the signal? What is this frequency known as?

(ii) Write down the equation for the sampled version of x(t) as x[n].

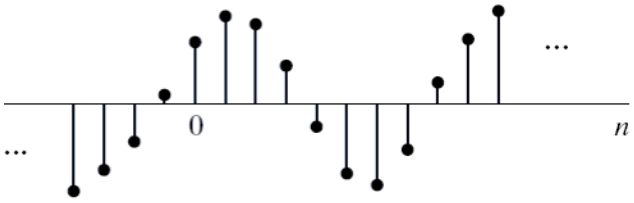

Figure 1

2.* The causal signal x[n] in Figure 2 only has four values that are non-zero. Derive the z-transform representation X[z] for the signal.

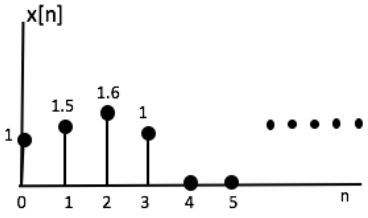

Figure 2

3. * A system T takes a discrete input x[n] and produces an output y[n] as shown in Figure 3. If T is shift-invariant, draw the output of T if the input x[n] is delayed by three sample periods.

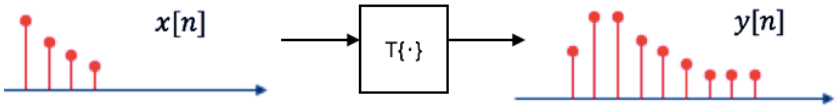

Figure 3

4.* A system D delays the input signal by one sample period, otherwise leaving the signal unchanged. What is the transfer function D[z] (in terms of z) of the system?

5.** A discrete time system T produces an output y[n] from input x[n] as described by the following difference equation. Derive transfer function T[z] in the z-domain (using z-transform).

$$y[n] = 0.2\ x[n] + 0.3*x[n-1] + 0.3*x[n-2] + 0.1*x[n-3])$$

6.** An FIR filter has a transfer function $H[z] = 1 + 0.2z^{-1} - 0.7z^{-2} + 0.2z^{-3}$. Derive in the form of difference equation, the input vs output relationship of the filter in the time domain. What is the impulse response in time domain of this system?

7. ** A IIR filter has a transfer function $H[z] = 0.2/(1 - 0.8z^{-1})$. Derive in the form of difference equation, the input vs output relationship of the filter in the time domain. What is the impulse response in time domain of this system for the first 10 sample periods?

8.*** Certain medical treatment of a disease D requires a patient taking 3 pills on day one, 2 pills on day two, and 1 pill on day three.

a) Assume that this treatment regime is modelled as a linear system H, what is the impulse response h[n] of the system?

b) A hospital admission profile of patients with D is shown below. How many pills are required to treat these patients?