Ray Kane DSP Problem set 4

2. Impulse Response

1. (a) num of samples $= 2 \cdot 20{,}000$

The 2 second impulse has 40,000 samples.

(b) $20{,}000 \cdot 0.2$

$= 4{,}000$ samples, echoes happen every 4,000th sample.

The non-zero samples are multiples of 4,000 so

0, 4,000, 8,000, 12,000 and so on.

(c) $h[n] = \delta[n] + 0.5[n-4000] + 0.25\delta[n-8000] + \ldots$

The second impulse is 4,000 with an amp of 0.5 and

third impulse is 8,000 with an amp of 0.25

and continuing

(d) When the DSP echo is tested on the o.l s sine-tone, the sine wave has echos at intervals of 0.2 seconds.

(a)

2. $s[n] \cdot (l[n] + h[n])$

$l[n] + h[n] = \delta[n]$

$s[n] \cdot \delta[n] = s[n]$

The sum of outputs of the low and high pass filters is the original input signal.

(b) if $l[n] + h[n] = \delta[n]$

$= h[n] = \delta[n] - l[n]$

(c) A: the f_c of $l[n]$ is lower than that of $h[n]$ is right. The lower cutoff frequency of the low pass filter has to be smaller than the higher cutoff frequency of the high pass filter in order for a band pass filter to be made.

DSP Problem set #4

3. Discrete Fourier transform, Filtering, and Noise

1. (a) $X[K] = \sum_{n=0}^{N-1} (x_1[n] + x_2[n]) e^{-j\frac{2\pi}{N}kn}$

$$X[K] = \sum_{n=0}^{N-1} (Ax[n]) e^{-j\frac{2\pi}{N}kn}$$

$$= A \sum_{n=0}^{N-1} x[n] e^{-j\frac{2\pi}{N}kn}$$

$\boxed{X[K] = AX_1[K]}$, it is homogeneous.

(b) $x[n] = \frac{1}{N} \sum_{k=0}^{N-1} \delta[k-k_0] e^{j\frac{2\pi}{N}kn}$

$$= x[n] = \frac{1}{N} e^{j\frac{2\pi}{N}k_0 n}$$

$$\boxed{f = \frac{k_0}{N} f_s}$$

2. (a) The Fourier spectrum widens as the pulse width narrows due to sharp transitions in the time domain. The narrower pulse indicates the pulse happens over a shorter period of time, So overall the narrower the pulse in time, the wider the spectrum in frequency due to sharp transitions which require a wider range of frequencies.

(b) It is concluded after measuring the widths of time and frequency, their domains are inversely related. The product of time domain width and frequency domain width remain constant which is the uncertainty principle.

$T = 0.01, 0.02$
$0.04, 0.08$

$\Delta f \cdot \Delta t \approx 10$ which is constant.