

INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
AVD611 Modern Signal Processing

Assignment 2

1. Design one stage and two stage interpolators to meet the following specifications:

$I=20$;

Input sampling rate = 10,000 Hz;

Passband: $0 \leq F \leq 90$;

Transition band: $90 \leq F \leq 100$;

Ripple: $\delta_1=10^{-2}$; $\delta_2=10^{-3}$.

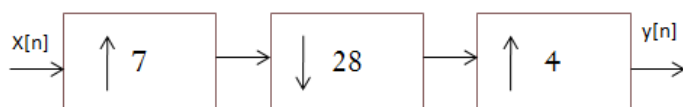
2. Consider the signal $x(n) = a^n u(n)$, $|a| < 1$.

(a) Determine the spectrum of $X(\omega)$.

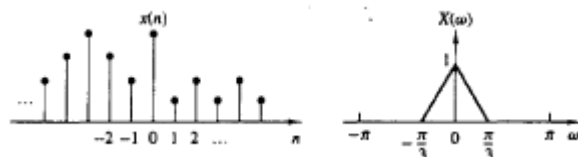
(b) The signal $x(n)$ is applied to a decimator that reduces the rate by a factor of 2. Determine the output spectrum.

(c) Show that the spectrum in part (b) is simply the Fourier transform of $x(2n)$.

3. Develop an expression for the output $y[n]$ for the multirate as a function of input $x[n]$.



4. Consider a signal and its Fourier transform given by $X(\omega)$. Sample $x(n)$ with sample period $D=5$. Compute and sketch $x_D(n)$ and its Fourier transform $X_D(\omega)$, can we reconstruct $x(n)$ from $x_D(n)$? How?



5. The analysis filters of a three channel QMF bank are given below. Determine the synthesis filter for implementing a perfect reconstruction filter bank.

$$[H_0(z)H_1(z)H_2(z)] = [1z^{-1}z^{-2}] \begin{bmatrix} 2 & 4 & 1 \\ -1 & 4 & -2 \\ 2 & -1 & 2 \end{bmatrix}$$

6. Show that down sampler is a time varying discrete time system.

7. Show that the following FIR linear phase transfer functions are lowpass half band filters: $H(z) = -3 + 19z^{-2} + 32z^{-3} + 19z^{-4} - 39z^{-6}$, $H(z) = 3 - 25z^{-2} + 150z^{-4} + 256z^{-5} + 150z^{-6} - 25z^{-8} + 3z^{-10}$

8. Determine the synthesis filters of a four channel perfect reconstruction QMF bank whose analysis filters are given by

$$\begin{bmatrix} H_0(z) \\ H_1(z) \\ H_2(z) \\ H_3(z) \end{bmatrix} = \begin{bmatrix} 1 & -2 & 3 & -1 \\ 2 & 1 & 1 & 0 \\ 0 & 3 & -1 & 1 \\ 1 & 1 & -1 & \end{bmatrix} \begin{bmatrix} 1 \\ z^{-1} \\ z^{-2} \\ z^{-3} \end{bmatrix}$$