Reg. No. | | | | | | | | | |

MANIPAL INSTITUTE OF TECHNOLOGY
MANIPAL
(A constituent Institution of MAHE, Manipal)

VII SEMESTER B.TECH (ELECTRICAL & ELECTRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, NOVEMBER 2018

SUBJECT: ADVANCED DIGITAL SIGNAL PROCESSING [ELE 4012]

REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 27, NOVEMBER 2018** **Max. Marks: 50**

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. Consider the multi-rate structure with input transform $X\left(e^{j\omega}\right)$ is shown in Fig. Q 1A. Sketch the following (i) $V_1\left(e^{j\omega}\right)$ (ii) $V_2\left(e^{j\omega}\right)$ (iii) $V_3\left(e^{j\omega}\right)$ (iv) $S\left(e^{j\omega}\right)$; and (v) $Y\left(e^{j\omega}\right)$. ***(04)***

1B. The transform of input signal $x[n]$ is depicted in Fig. Q 1B. The signal $x[n]$ is modulated by signal $s[n]=\cos\left(\omega_o n\right)$ and then up-sampled by factor 2. Sketch the following

(i) $X_M\left(e^{j\omega}\right)$ (ii) $Y\left(e^{j\omega}\right)$ for the modulated frequency $\omega_0=\frac{\pi}{4}$ *and* $\omega_0=\frac{\pi}{2}$ ***(03)***

1C. A multi-rate discrete-time system with input and output shown in Fig. Q1C. Simply the system to where down-sampler with input $x[n]$ is followed by one period sample delay. In case of simplification mention the reasoning. ***(03)***

2A. Design an efficient two stages decimator with two suitable pair of decimation factors for the following specifications:

Input sampling frequency: 8kHz; signal is decimated by factor $M=50$; the highest frequency of interest after decimation: 75Hz; It is specified that the filter has overall passband ripple $\delta_p=0.01$ and a stopband ripple $\delta_s=10^{-4}$. Justify the answer with computational complexities. ***(04)***

2B. Considering the general form of poly-phase representation of interpolator type-1, develop a computationally efficient realization of a factor of 3 interpolator employing a length of 12 linear phase FIR low pass filter. Use the symmetry of the impulse response. ***(04)***

2C Consider a co-sinusoidal random variable so that

$Y=g\left[X\right]=Cos\left(X\right)$. X is random variable uniformly distributed in the interval $\left(-\pi,\pi\right)$. Find the expected value of random variable Y. ***(02)***

3A. Consider the random process $X(t) = A\cos(\omega_c t + \theta)$ where θ is the random variable with uniform distribution in the interval is $(-\pi, \pi)$ and A & ω_c are constants.

Determine (i) Is the process wide sense stationary (WSS)? (ii) If random process $X(t)$ is WSS, find its Power spectral density (PSD) and plot power spectrum. ***(05)***

3B. A continuous random variable X has probability density function given by

$$F_X(x) = \begin{cases} \left(k - \frac{x}{4}\right); & 1 \le x \le 3 \\ 0 & ; \quad otherwise \end{cases}$$

Find

(i) the value of k (ii) $P(X \le 2.5)$ (iii)value of expectation $E(X)$ for value k obtained in (i) ***(03)***

3C. Prove that if the two events A and B are not disjoint then probability of their union event is given by

$$P[A \cup B] = P(A) + P(B) - P(A \cap B)$$

(02)

4A. A linear system is described by difference equation

$y[n] = \frac{4}{5}y[n-1] + x[n] + x[n-1]$, where signal $x[n]$ is wide sense stationary (WSS) random process with zero mean and autocorrelation $R_{xx}(m) = (0.5)^{|m|}$

(a) Determine the power density spectrum of the output $y(n)$

(b) Determine the autocorrelation $R_{yy}(m)$ of the output

(c) Determine the variance σ^2_y ***(04)***

4B. In the application of random process the input-output relation through a linear system is described as shown in fig. Q4B. If the random process $X(t)$ be the input to LTI system is wide sense stationary (WSS), then show that (i) output random process $Y(t)$ is also WSS. (ii)

$$S_{YY}(F) = S_{XX}(F)|H(F)|^2$$

(04)

4C. If the sample sequence of a random process has N=2000 samples. Determine (i) the frequency resolution of the Bartlett, Welch (for 50% overlap), and Blackman-Tukey methods for a quality fact $Q = 20$ (ii) the record lengths (M) for the Bartlett, Welch (for 50% overlap), and Blackman-Tukey methods. ***(02)***

5A. Discuss the properties of Wavelet Transform? ***(02)***

5B. Determine the 2D DWT Haar decomposition of 2D pixel values:

$$\begin{bmatrix} 7 & 3 & 25 & 9 \\ 35 & 1 & 9 & 3 \\ 11 & 15 & 9 & 27 \\ 7 & 33 & 5 & 11 \end{bmatrix}$$

Also reconstruct the pixel values from the decomposed pixel values with threshold value of 5. ***(04)***

5C. Perform system modelling task assuming the unknown system is two coefficient FIR filter.

i. Setup the LMS algorithm to implement the adaptive filter, assuming that initial weights are: $w(0) = w(1) = 0.5$ & $\mu = 0.6$

ii. Perform adaptive filtering to obtain error signal $e[n]$ *for* $n = 0,1,2,3$. Given :

$x(0)=1,\ x(1)=-1,\ x(2)=1,\ x(3)=-1;$

$d(0)=0.5,\ d(1)=0.5,\ d(2)=-0.5,\ d(3)=0.5$ ***(04)***

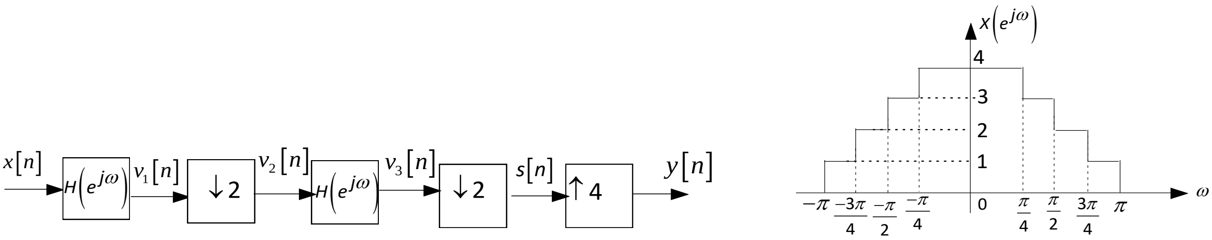

*Fig.*Q1A

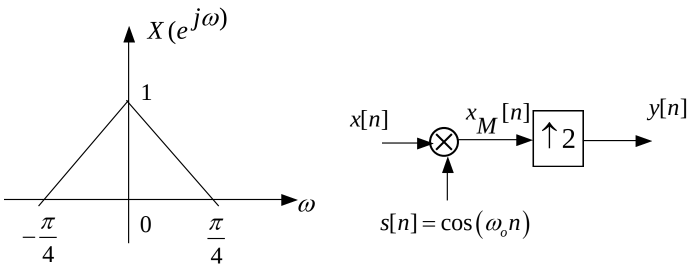

*Fig.*Q1B

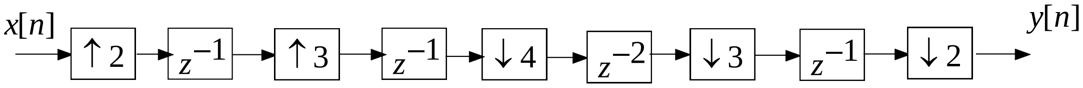

*Fig.*Q1C

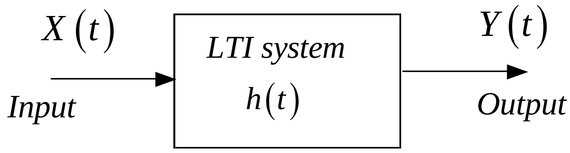

Fig.Q4B

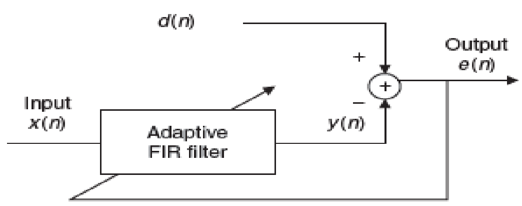

Fig.Q5