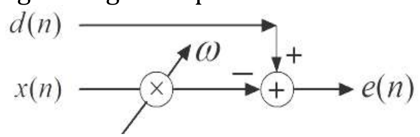
7. (a) What are the applications of Adaptive filters? How it is used for noise cancellation?

(b) Consider the single-weight adaptive filter shown in figure below:



(i) Write down the LMS algorithm for updating the weight ω.

(ii) Suppose that $x(n)$ is a constant: $x(n)=\begin{cases} K & ; \quad n \geq 0 \\ 0 & ; \quad otherwise \end{cases}$.

Find the system function relating $d(n)$ to $e(n)$ using the LMS algorithm, i.e., find $H(z)$ in the figure below.

$$d(n) \longrightarrow \boxed{H(z)} \longrightarrow e(n)$$

(iii) Determine the range of values for μ for which $H(z)$ is stable.

4 + 8 = 12

Group – E

8. (a) What is periodogram? What are the non-parametric methods of power spectrum estimation?

(b) Suppose we have $N = 500$ samples from a sample sequence of random process. Find out the frequency resolution Δf of the Bartlett, Welch and Blackman-Tukey methods of power spectrum estimation. Given that quality factor $Q = 12$ and overlapping in Welch's method is 50%.

(2 + 2) + 8 = 12

9. (a) Consider a moving average $\mathrm{MA}(q)$ process that is generated by the difference equation $y(n) = \sum_{k=0}^{q} b(k)\omega(n-k)$. Where $\omega(n)$ is zero mean white noise with variance σ_ω^2.

(i) Find the unit sample response of the filter that generates $y(n)$ from $\omega(n)$.

(ii) Find the autocorrelation and power spectrum of $y(n)$.

(b) The power spectrum of a wide sense stationary process $x(n)$ is $P_x(e^{j\omega}) = \dfrac{25-24\cos\omega}{26-10\cos\omega}$. Find the whitening filter $H(z)$ that produces unit variance white noise when the input is $x(n)$.

4 + (2 + 2) + 4 = 12

M.TECH/AEIE/1ST SEM/AEIE 5101/2019

ADVANCED DIGITAL SIGNALS AND SYSTEMS (AEIE 5101)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) If F_s is sampling frequency then the highest analog frequency that can be uniquely represented in its sampled version of discrete time signal is,

(a) $\frac{F_s}{2}$ (b) $2F_s$
(c) F_s (d) $\frac{1}{F_s}$.

(ii) An LTI system is stable, if the impulse response is

(a) $\sum_{n=-\infty}^{\infty} |h(n)| = 0$ (b) $\sum_{n=-\infty}^{\infty} |h(n)| < \infty$
(c) $\sum_{n=-\infty}^{\infty} |h(n)| \neq 0$ (d) either (a) or (b).

(iii) In N- point DFT of L- point sequence, the value of N to avoid aliasing in frequency spectrum is

(a) $N \neq L$ (b) $N \geq L$
(c) $N \leq L$ (d) $N = L$.

(iv) If we reverse the directions of all branch transmittances and interchange the input and output in the flow graph, then the resulting structure is called as

(a) direct form-I (b) transposed form
(c) direct form-II (d) none of (a), (b) and (c).

(v) The system $y(n) = \sin[x(n)]$ is,

(a) stable (b) BIBO stable
(c) unstable (d) marginally stable.

(vi) The factor that influence the choice for realization of digital filter structure is,

(a) memory requirements (b) computational complexity
(c) parallel processing and pipelining (d) all the (a), (b) and (c).

(vii) For energy signals, the energy will be finite and the average power will be
(a) infinite (b) finite
(c) zero (d) cannot be defined.

(viii) Twiddle factor is given by
(a) $W = e^{-i\left(\frac{2\pi}{N}\right)}$ (b) $W = e^{i\left(\frac{2\pi}{N}\right)}$
(c) $W = e^{-i\left(\frac{N}{2\pi}\right)}$ (d) $W = e^{i\left(\frac{N}{2\pi}\right)}$.

(ix) For short-time, low-energy transients, the change in the spectrum is easily detected by
(a) Fourier Transform (b) Wavelet Transform
(c) both (a) and (b) (d) none of (a) and (b).

(x) Drawbacks of IIR filters are
(a) phase distortion and ringing (b) prevent phase distortion.
(c) more computation (d) all of (a), (b) and (c).

Group – B

2. (a) Consider the analog signals, $x_a(t) = 6\cos 50\pi t + 3\sin 200\pi t - 3\cos 100\pi t$. Determine the minimum sampled frequency and the sampled version of analog signal at this frequency.

(b) Test whether the signal $x(n) = 2\sin(\frac{6\pi}{7}n + 1)$ is periodic or not. If periodic find the fundamental period.

(c) Determine whether the following system is time variant or time invariant: $y(n) = nx^2(n)$.

4 + 5 + 3 =12

3. (a) Determine whether the following signal is energy or power signal: $x(n) = \left(\frac{1}{4}\right)^n u(n)$.

(b) Check the stability of the system: $h(n) = (4)^n u(4-n)$.

(c) Determine the response of the LTI system whose input $x(n)$ and impulse response $h(n)$ are given by $x(n) = \{\underset{\uparrow}{1}, 2, 3, 1\}$ and $h(n) = \{1, \underset{\uparrow}{2}, 1, -1\}$, respectively.

4 + 4 + 4 = 12

Group – C

4. (a) Differentiate between FIR and IIR filters.

(b) State the disadvantages of Fourier series method off FIR filter designing.

(c) A low pass filter (LPF) is required to be designed with the desired frequency response which is expressed as follows:

$$H_d(e^{j\omega}) = \begin{cases} e^{-j2\omega}, & \text{for } -\frac{\pi}{4} \le \omega \le \frac{\pi}{4} \\ 0, & \text{for } -\frac{\pi}{4} \le |\omega| \le \frac{\pi}{4} \end{cases}$$

Obtain the filter coefficients $h_d(n)$ if the window function is defined as under:

$$\omega(n) = \begin{cases} 1, & \text{for } 0 \le n \le 4 \\ 0, & \text{otherwise} \end{cases}$$

2 + 2 + 8 = 12

5. (a) Give the magnitude of the Butterworth filter. What is the effect of varying order N on magnitude and phase response? Write down the properties of lowpass Butterworth filters.

(b) An analog filter has a following system function: $H_a(s) = \frac{36}{(s+0.1)^2 + 36}$.

Transform it into a digital filter $H(z)$ using the bilinear transformation method. The digital filter must have a resonant frequency of $\omega_r = 0.2\pi$.

5 + 7= 12

Group – D

6. (a) Give some examples of multirate digital systems? How different sampling rates are achieved in these types of systems?

(b) Illustrate functioning of a sub-band coder used for speech signal transmission and storage.

(c) Obtain the polyphase decompositions of the IIR digital system having the following transfer function:

$$H(z) = \frac{1 - 4z^{-1}}{1 + 5z^{1}}.$$

(2 + 2) + 4 + 4 = 12