①

Reg. No. A U H I P P O . C O M *

Question Paper Code : 50444

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017

Fifth/Sixth Semester

Electronics and Communication Engineering

EC6502 – PRINCIPLES OF DIGITAL SIGNAL PROCESSING

(Common to : B.E. Biomedical Engineering/Medical Electronics)

(Regulations 2013)

Time : Three Hours | Maximum : 100 Marks

Answer ALL questions

PART – A (10×2=20 Marks)

1. What is twiddle factor ?
2. State and prove periodicity property of DFT.
3. List the different types of filters based on frequency response.
4. What are the properties of bilinear transformation ?
5. Write the steps involved in FIR filter design.
6. Draw the block diagram representation of FIR system.
7. Compare the fixed point and floating point number representations.
8. What is meant by finite word length effects in digital system ?
9. Write the input output relationship for a decimator.
10. State the applications of adaptive filtering.

PART – B (5×13=65 Marks)

11. a) Find the 8 point DFT of the sequence x(n) = { 2, 2, 2, 2, 1, 1, 1, 1 } using Decimation in Time FFT algorithm.

(OR)

b) Determine the circular convolution of the sequences $x_1(n)$ = { 1, 2, 3, 1, 1, 2, 3, 1 } and $x_2(n)$ = {4, 3, 2, 2, 2, 2, 3, 4) using DFT and IDFT.

50444

12. a) Enumerate the steps for IIR filter design by impulse invariance with an example.

(OR)

b) Analyze the design of discrete time IIR filter from analog filter.

13. a) Design a FIR filter with the following desired specifications, using Hanning window with $N = 5$.

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

(OR)

b) Explain the design procedure of FIR filter using frequency sampling method.

14. a) Explain the quantization process and errors introduced due to quantization.

(OR)

b) i) Explain the characteristics of limit cycle oscillation with respect to the system described by the difference equation :
$y(n) = 0.95\, y(n-1) + x(n)$; $x(n) = 0$ and $y(-1) = 13$. (8)

ii) Define zero input limit cycle oscillation and explain. (5)

15. a) How does the sampling rate increase by an integer factor I ? Derive the input-output relationship in both time and frequency domains.

(OR)

b) Discuss in detail about any two applications of adaptive filtering with necessary diagrams.

PART – C

(1×15=15 Marks)

16. a) Obtain the direct form I, direct form II and cascade form realization of the following system function
$y(n) = 0.1\, y(n-1) + 0.2\, y(n-2) + 3x(n) + 3.6x(n-1) + 0.6x(n-2)$.

(OR)

b) Convert the given analog transfer function $H(s) = \frac{1}{s+a}$ into digital transfer function by impulse invariant method.

November – December 2017

1. What is twiddle factor?

The N point DFT of $x(n)$ is $X(K) = \sum_{n=0}^{N-1} x(n) \cdot e^{-\frac{j2\pi nk}{N}}$

To simplify the notation, it is desirable to define the complex valued phase factor 'W_N', which is N^{th} root of unity as $W_N = e^{-\frac{j2\pi}{N}}$

2. State and prove periodicity property of DFT.

$$x(n) \xleftrightarrow[DFT]{N} X(K)$$

$$x(n+N) \xleftrightarrow[DFT]{N} X(N+K) = X(K)$$

3. List the different types of filters based on frequency response.

Low Pass Filter
High Pass Filter
Band Pass Filter
Band Reject Filter

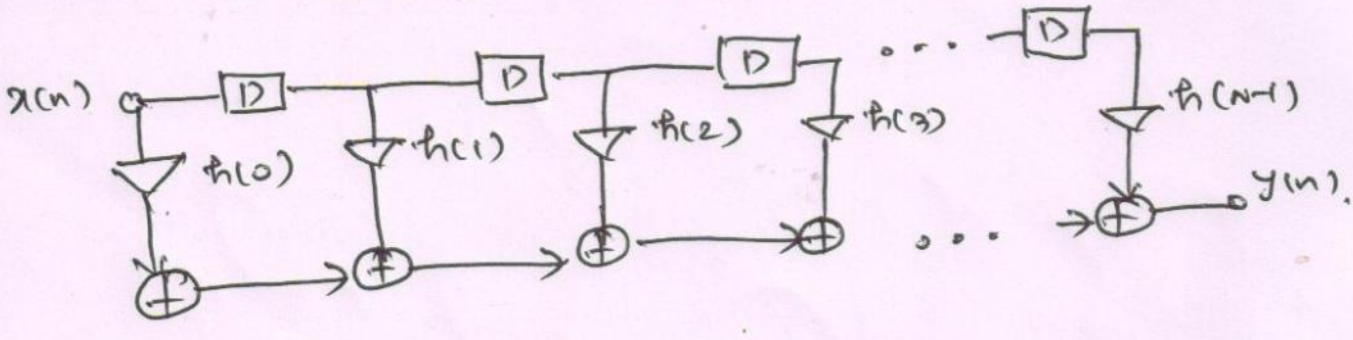
4. What are the properties of bilinear transformation?

a. The bilinear transformation is one to one mapping.
b. There is no aliasing and so the analog filter need not have a band limited frequency response.
c. The effect of warping on amplitude response can be eliminated by pre warping the analog filter.

5. Write the steps involved in the design of FIR filter

1. Choose the desired frequency response
2. Take inverse Fourier transform of Desired frequency response to get $h_d(n)$
3. Convert the infinite duration $h_d(n)$ to finite duration $h(n)$
4. Take Z- transform of $h(n)$ to obtain the transfer function $H(Z)$

6. Draw the block diagram representation of FIR system



7. Compare the fixed point and floating point number representations

Fixed Point Number	**Floating Point Number**
With the use of b – bits , the range of numbers represented is less when compare to floating point representation	With the use of b – bits , the range of numbers represented is large when compare to fixed point representation
The position of binary point is fixed.	The position of binary point is variable
The resolution is uniform throughout the range	The resolution is variable

8. What is meant by finite word length effects in digital system ?

The fundamental operations in digital filters are multiplication and addition. When these operations are performed in a digital system, the input data as well as the product and sum have to be represented in finite word length, which depends the size of the register used to store the data. In digital computation, the input and output data are quantized by rounding or truncation to convert them to a finite word size. This creates error in the output and creates oscillations in the output. These effects due to finite precision representation of numbers in digital system are called finite word length effects.

9. **Write the input and output relation for a decimator.**

$$y(n) = x(Dn)$$

$$x(n) \longrightarrow \boxed{\downarrow D} \longrightarrow y(n) = x(Dn)$$

10. State the applications of adaptive filtering.

1. System Identification
2. Adaptive noise cancellation
3. Adaptive Equalization
4. Adaptive noise cancellation

PART B

11) a) $x(n) = \{2, 2, 2, 2, 1, 1, 1, 1\}$

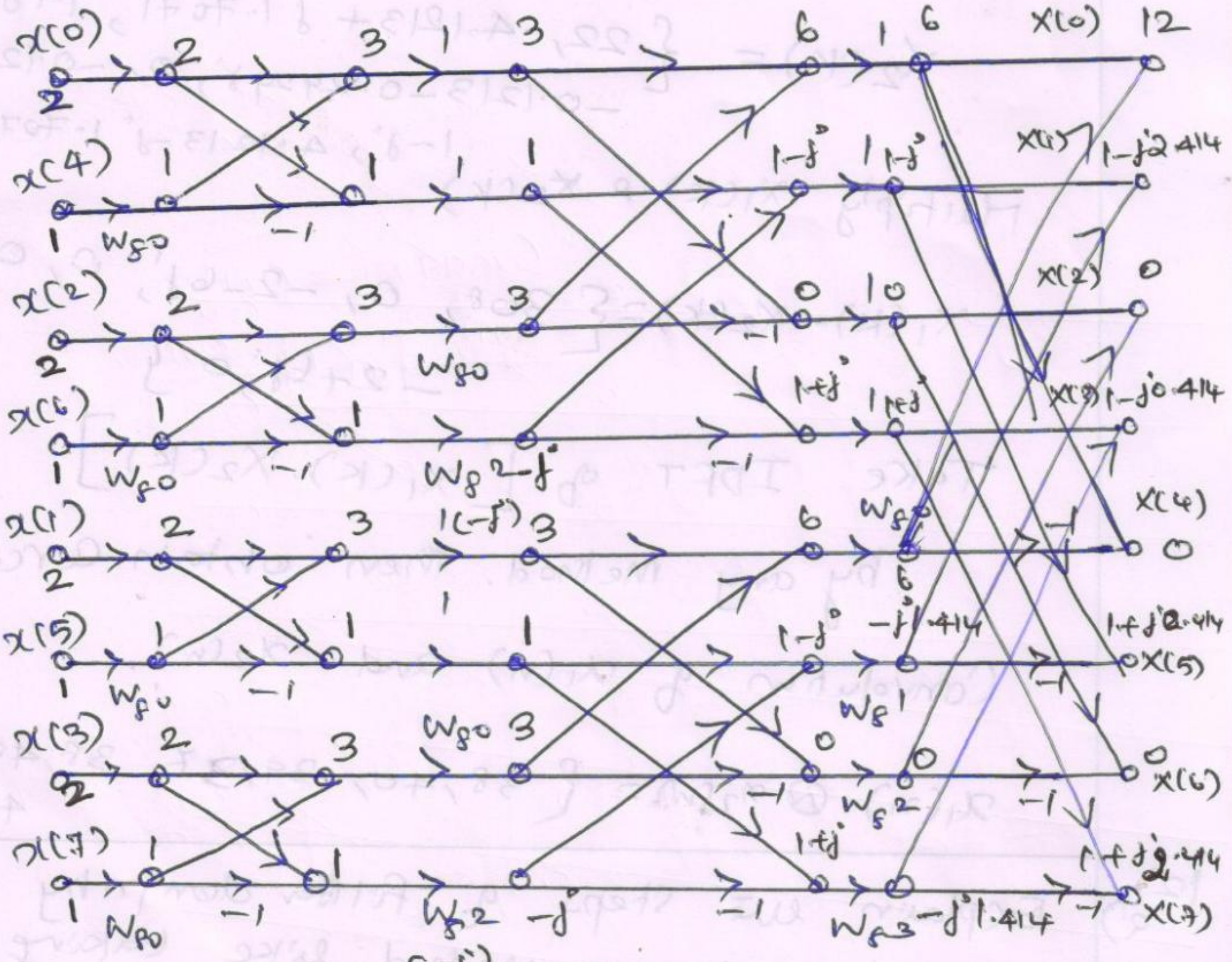
DIT - FFT Algorithm:

$$W_8^0 = \left(e^{-j\frac{2\pi}{8}}\right)^0 = 1$$

$$W_8^1 = \left(e^{-j\frac{2\pi}{8}}\right)^1 = 0.707 - j0.707$$

$$W_8^2 = \left(e^{-j\frac{2\pi}{8}}\right)^2 = -j$$

$$W_8^3 = \left(e^{-j\frac{2\pi}{8}}\right)^3 = -0.707 - j0.707$$



$X(K) = \{12, 1-j2.414, 0, 1-j0.414, 0, 1+j0.414,$

11) b) Circular Convolution through DFT - IDFT approach:

$x_1(n) = \{1, 2, 3, 1, 1, 2, 3, 1\}$

$x_2(n) = \{4, 3, 2, 2, 2, 2, 3, 4\}$

i) Compute 8 Point DFT of $x_1(n)$ (i.e) $X_1(K)$ either by using DIT-FFT (or) DIF-FFT approach

$X_1(K) = \{14, 0, -4-2j, 0, 2, 0, -4+2j, 0\}$

$X_2(K) = \{22, 4.1213 + j1.7071, 1+j, -0.1213 - 0.2929j, 0, -0.1213 + j0.2929, 1-j, 4.1213 - j1.7071\}$

Multiply $X_1(K)$ & $X_2(K)$

$X_1(K) \cdot X_2(K) = \{308, 0, -2-6j, 0, 0, 0, -2+6j, 0\}$

Take IDFT of $[X_1(K) \cdot X_2(K)]$ by any method. then obtain Circular Convolution of $x_1(n)$ and $x_2(n)$.

$x_1(n) \circledast x_2(n) = \{38, 40, 39, 37, 38, 40, 39, 47\}$.

12) a) Explain the steps of filter design by impulse invariance method, like taking filter specifications, finding the desired filter ... cut off frequency Transfer

Take any one problem and solve. Refer class notes (or) DSP book.

---

12) b) Discuss in detail about impulse invariant transformation technique, bilinear transformation technique, and ~~Method~~ Approximation of derivatives method. Explain with example.

---

13) a)

$$H_d(e^{j\omega}) = \begin{cases} 0, & -\frac{\pi}{4} \le \omega \le \pi/4 \\ e^{-2j\omega}, & \frac{-\pi}{4} \le |\omega| \le \pi \end{cases}$$

Window = Hanning & $N=5$

Soln:.

Re write the desired frequency Response

$$H_d(e^{j\omega}) = \begin{cases} 0 & \frac{-\pi}{4} \le \omega \le \pi/4 \\ e^{-2j\omega} & -\pi \le \omega \le -\pi/4 \\ e^{-2j\omega} & \frac{\pi}{4} \le \omega \le \pi \end{cases}$$

$$h_d(n) = \frac{1}{2\pi} \int_{-\pi}^{\pi} H_d(e^{j\omega})\, e^{j\omega n} d\omega$$

$$= \frac{1}{2\pi}\left[\int_{-\pi}^{-\pi/4} e^{-2j\omega} e^{j\omega n} d\omega + \int_{\pi/4}^{\pi} e^{-2j\omega} \cdot e^{j\omega n} d\omega\right]$$

$$= \frac{1}{2\pi}\left[\int_{-\pi}^{-\pi/4} e^{j\omega(n-2)} d\omega + \int_{\pi/4}^{\pi} e^{j\omega(n-2)} d\omega\right]$$

$$= \frac{1}{\pi(n-2)}\left\{\left[\frac{e^{j(n-2)\pi} - e^{-j(n-2)\pi}}{2j}\right] - \left[\frac{e^{j(n-2)\pi/4} - e^{-j(n-2)\pi/4}}{2j}\right]\right.$$

$$h_d(n) = \frac{1}{\pi(n-2)}\left[\sin\pi(n-2) - \sin(n-2)\pi/4\right] \quad n \neq 2$$

Window → Hamming window

$$\omega_{Han}(n) = \begin{cases} 0.5 - 0.5\cos\frac{2\pi n}{N-1} & 0 \le n \le N-1 \\ 0 & \text{other wise} \end{cases}$$

$h(0) = h_d(0) \times \omega_{Han}(0) = -0.159 \times 0 = 0$

$h(1) = h_d(1) \times \omega_{Han}(1) = 0.225 \times 0.5 = 0.1125$

$h(2) = h_d(2) \times \omega_{Han}(2) = 0.75 \times 1 = 0.75$

$h(0) = h(4)$; $h(1) = h(3)$; $h(2)$

$$H(z) = \sum_{n=0}^{4} h(n)\cdot z^{-n}$$

$$H(z) = 0.1125\left[z^{-1} + z^{-3}\right] + 0.75z^{-2}$$

$$H(e^{j\omega}) = e^{-2j\omega}\left[0.75 + 0.225\cos\omega\right]$$

phase Response

Magnitude response.

(3) b) Explain the concept of frequency sampling by taking one ~~four~~ sample problem. Refer the

14) a) Explain about need of quantization.

Explain about type of quantization

i) Truncation

ii) Rounding

with examples.

Explain about quantization errors, and rounding errors.

(Refer class notes (or) Book)

14) b) i) $y(n) = 0.95\, y(n-1) + x(n)$; $x(n) = 0$; $y(-1) = 13$

Type of quantization: Rounding

n	y(n) without quantization	y(n) – Rounded
0	12.35	12
1	11.4	11
2	10.45	10
3	9.5	10
4	9.5	10
5	9.5	10
6	9.5	10
7	9.5	10

Deadband

$$= \frac{\frac{1}{2}}{1-|a|} = \frac{\frac{1}{2}}{1-|0.95|} = \frac{0.5}{0.05} = [-10, 10]$$

14) b) ii) Refer the Book by Salivahanan.

15) a) Refer the class notes (or) Book.

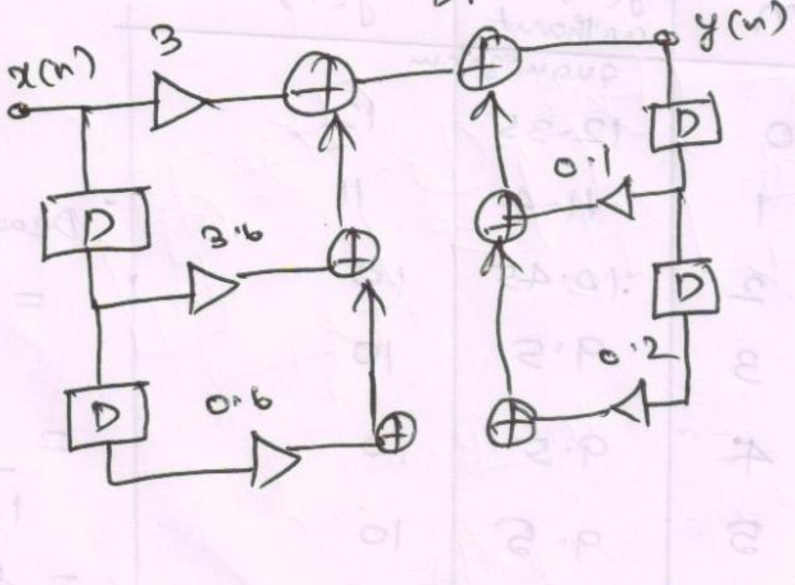
15) b) There are Many applications of adaptive filtering such as

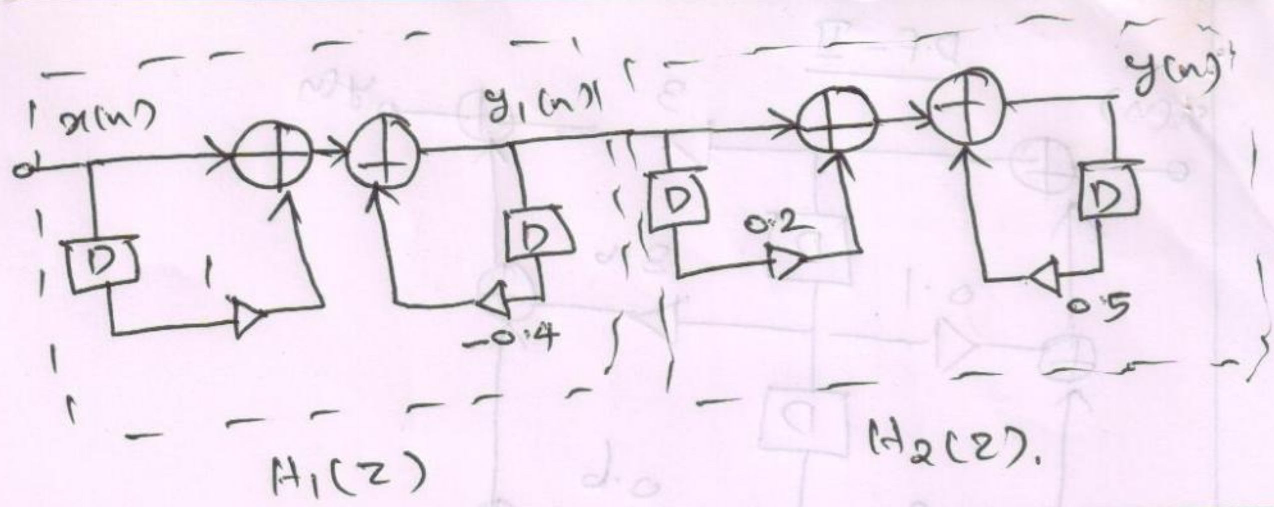
i) Adaptive noise Cancellation.
ii) Adaptive Equalisation.
iii) Adaptive line Enhancer
iv) Data transmission over Telephone Channels.

Explain any two with neat diagrams and theory. (Refer Book)

16) a) $y(n) = 0.1\,y(n-1) + 0.2\,y(n-2) + 3x(n) + 3.6x(n-1) + 0.6x(n-2)$

DF – I





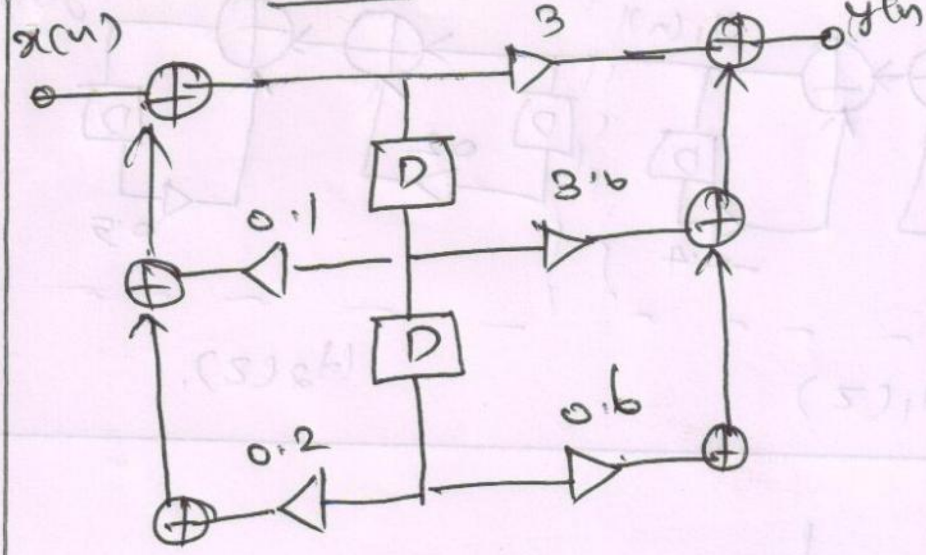
(b) b)

$$H(s) = \frac{1}{(s+a)}$$

$$H(z) = \frac{z}{z - e^{-aT}}$$

→ End ←

D.F – II



Cascade form:

Find Transfer function of the equation by Taking Z-Transform on both sides.

$$Y(z)\left[1-0.1z^{-1}-0.2z^{-2}\right] = X(z)\left[3+3.6z^{-1}+0.6z^{-2}\right]$$

$$\frac{Y(z)}{X(z)} = \frac{3+3.6z^{-1}+0.6z^{-2}}{1-0.1z^{-1}-0.2z^{-2}}$$

$$H(z) = \frac{(1+z^{-1})(1+0.2z^{-1})}{(1+0.4z^{-1})(1-0.5z^{-1})}$$

$$H(z) = H_1(z) \cdot H_2(z)$$

$$H_1(z) = \frac{(1+z^{-1})}{(1+0.4z^{-1})} \quad ; \quad H_2(z) = \frac{(1+0.2z^{-1})}{(1-0.5z^{-1})}$$

$$X(z) \longrightarrow \boxed{H_1(z)} \xrightarrow{Y_1(z)} \boxed{H_2(z)} \longrightarrow Y(z)$$

$$\frac{Y_1(z)}{X(z)} = \frac{(1+z^{-1})}{(1+0.4z^{-1})}$$

$$y_1(n) = -0.4y_1(n-1) + x(n) + \ldots$$

$$H_2(z) = \frac{Y(z)}{X_1(z)} = \frac{1+0.2z^{-1}}{1-0.5z^{-1}}$$

$$y(n) = 0.5y(n-1) + x_1(n) + 0.2x_1(n-1)$$