(A)

SCHEME OF VALUATION

(Scoring Indicators)

Revision: 2015 Course Title: **DIGITAL SIGNAL PROCESSING**			Course code: **6044**
Qst No	**Scoring Indicator**	**Split Up Score**	**Sub Total**	**Total**

Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
	PART- A			
I 1)	A signal $x(n)$ is said to be causal if its value is zero for $n<0$.	1	2	
	eg: $x_1(n) = a^n u(n)$. $x_2(n) = \{\underset{\uparrow}{1}, 2, -3, -1, 2\}$	1		
2)	Let $x_1(n)$ and $x_2(n)$ are finite duration sequences both of length N with DFTs $X_1(K)$ and $X_2(K)$	1	2	
	If $X_3(K) = X_1(K).X_2(K)$, then the sequence $x_3(n)$ can be obtained by circular convolution defined as. $x_3(n) = \sum_{m=0}^{N-1} x_1((m))_N \, x_2((n-m))_N$	1		
3)	The Z-transform of a discrete time signal $x(n)$ is defined as	1	2	
	$X(z) = \sum_{n=-\infty}^{\infty} x(n).z^{-n}$. Where z is a complex variable, $z = re^{j\omega}$. r is the radius of the circle	1		
4.	FFT reduces the computation time required to compute discrete Fourier transform.	1	2	
	FFT is based on decomposition and breaking the transform into smaller transforms and combining them to get total transform.	1		

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5.	TMS320C3x, TMS320C67x, ADSP-21xxx	2	2	

Part- B

II 1) Scalar Multiplication.

Here the Signal $x(n)$ is multiplied by a Scalar factor a.

$$x(n) \xrightarrow{a} y(n) = a.x(n).$$

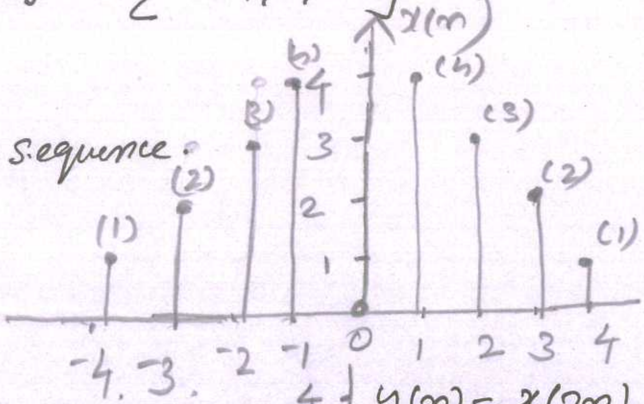
3

eg: if $x(n) = \{1, 2, 1, -1\}$ and $a = 2$. Then the Signal $ax(n) = \{2, 4, 2, -2\}$

6

Time Scaling.

Let $x(n)$ be a sequence.



$y(n) = x(2n)$. 3

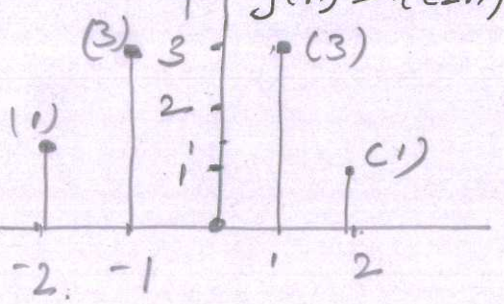
$x(2n)$

$y(0) = x(0) = 0$

$y(1) = x(2) = 3$.

$y(2) = x(4) = 1$

and so on.



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2)	$X(z)=\sum_{n=-\infty}^{\infty} x(n).z^{-n}$ **Unit step signal** $x(n)=u(n)$, $X(z)=\sum_{n=0}^{\infty} z^{-n}$ $u(n)=\begin{cases}1, & \text{for } n>0\\ 0, & \text{for } n<0\end{cases}$ $\Rightarrow X(z)=\sum_{n=0}^{\infty} z^{-n}$ $=\frac{1}{1-z^{-1}}=\frac{z}{z-1}$ $X(z)=\frac{z}{z-1}$.	3	6	
	Unit impulse signal $X(z)=\sum_{n=-\infty}^{\infty} x(n).z^{-n}$, $X(z)=\sum_{n=-\infty}^{\infty} 1$ $X(z)=1$ $\delta(n)=\begin{cases}1, & \text{for } n=0\\ 0, & \text{otherwise.}\end{cases}$	3		
3)	→ Decimation in time algorithm is used to calculate the DFT of a N point sequence.	1		
	→ The idea is to break the N point sequence into two sequences.	1		
	→ Then the DFTs of which can be combined to give the DFT of the original N point sequence.	1		
	→ The N point sequence is divided into two $\frac{N}{2}$ point sequences $x_e(n)$ and $x_o(n)$	1		

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	→ which have even and Odd members of $x(n)$ respectively.	1		
	→ The N/2 point DFTs of these two sequences are evaluated and combined to give the N point DFTs	1	6	
4)	Given $x_1(n) = \{2, 2, 1, 2\}$, $x_2(n) = \{-2, -1, 3, 2\}$.			
	(a) $x_1(n) + x_2(n) = \{2-2, 2-1, 1+3, 2+2\}$ $= \{0, 1, 4, 4\}$.	3	6.	
	(b) $x_1(n) \times x_2(n) = \{2\times-2, 2\times-1, 1\times3, 2\times2\}$ $= \{-4, -2, 3, 4\}$.	3		
5)	Rectangular Window. $w_R(n) = 1$, for $-\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$ $= 0$, otherwise.			

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② Triangular or Bartlett window.

$$w_T(n) = 1 - \frac{2|n|}{N-1}, \text{ for } -\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$$

0, otherwise.

③ Hanning Window.

$$w_{Hn}(n) = 0.5 + 0.5 \cos \frac{2\pi n}{N-1}, \text{ for } -\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$$

0, otherwise.

④ Hamming Window.

$$w_H(n) = 0.54 + 0.46 \cos\left(\frac{2\pi n}{N-1}\right) \text{ for } -\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$$

0, otherwise.

⑤ Blackman window.

$$w_B(n) = 0.42 + 0.5 \cos \frac{2\pi n}{N-1} + 0.08 \cos \frac{4\pi n}{N-1}$$

$$\text{for } -\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}.$$

0, otherwise.

(Any 3)

Each carry 2 mark.

3×2

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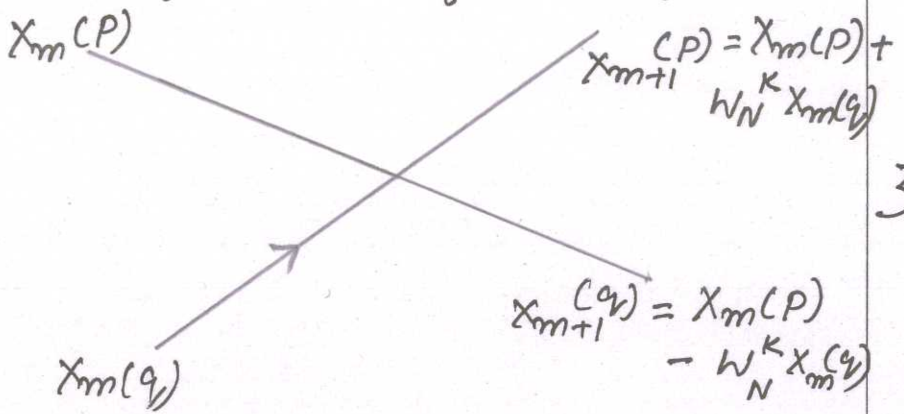
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
	⑥ Raised Cosine Window. $w_\alpha(n) = \alpha + (1-\alpha)\cos\frac{2\pi n}{N-1}$ for $-\frac{(N-1)}{2} \le n \le \frac{(N-1)}{2}$ 0, otherwise.		6	
6)	Applications of DSP. ① Telecommunication ② Instrumentation and Control. ③ Audio Signal processing. ④ Military. ⑤ Medicine. ⑥ Image Processing.	1 1 1 1 1 1	6	
7)	Basic butterfly diagram of DIT algorithm. 	3		

SCHEME OF VALUATION

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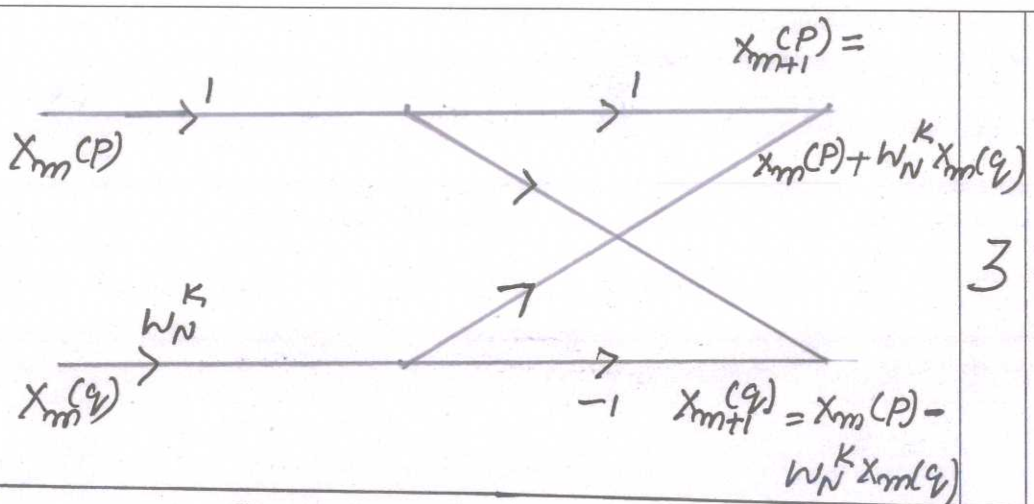
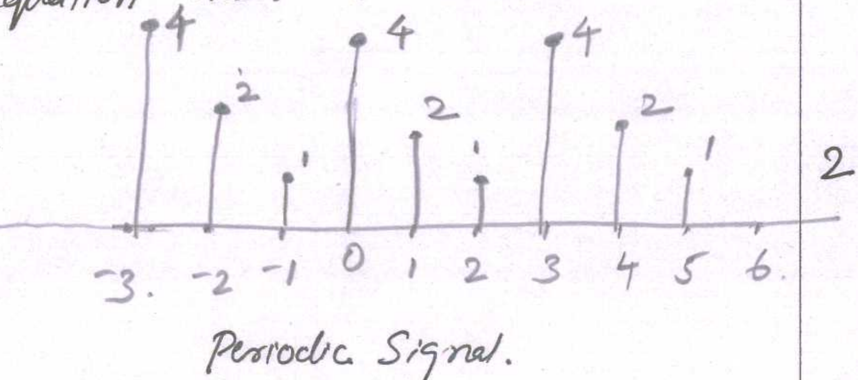
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
		3	6	
	PART-C **UNIT-I**			
III (a)	Periodic Signal. - A discrete-time signal $x(n)$ is said to be periodic with period N if and only if $x(N+n) = x(n)$ for all n. - The smallest value of N for which the above equation holds is known as fundamental period.	2		
	eg:  Periodic Signal.	2		

SCHEME OF VALUATION

(Scoring Indicators)

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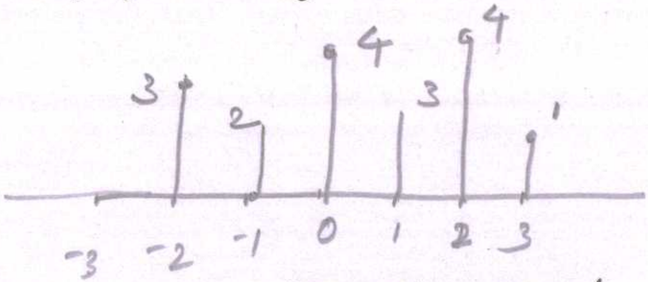
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total

Aperiodic Signal.

Signals which does not obey the equation $x(N+n) = x(n)$ for all n are aperiodic. 2 8



2

Aperiodic Signal.

(b) Given $y(n) = x(n) + x(n-1)$.

(i)

$$y(n) = T[x(n)] = x(n) + x(n-1)$$

If the input is delayed by K units in time

$$y(n,K) = T[x(n-K)] = x(n-K) + x(n-K-1)$$

If we delay the output by K units in time then 4

$$y(n-K) = x(n-K) + x(n-K-1)$$

$\Rightarrow y(n,K) = y(n-K)$. $\therefore$ the System is TIME INVARIANT.

(ii) $y(n) = x(-n)$.

Given $y(n) = T[x(n)] = x(-n)$.

If the input is delayed by K units in time and applied to the S/m.

$$y(n,K) = T[x(n-K)] = x(-n-K)$$

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	If the output is delayed by k samples. $y(n-k) = x(-(n-k)) = x(-n+k)$ $\Rightarrow y(n,k) \neq y(n-k)$. $\therefore$ the system is TIME VARIANT.	3	7	
IV(a)(i)	Given $y(n) = x(n) + \frac{1}{x(n-1)}$ $y_1(n) = T[x_1(n)] = x_1(n) + \frac{1}{x_1(n-1)}$ $y_2(n) = T[x_2(n)] = x_2(n) + \frac{1}{x_2(n-1)}$. o/p due to weighted sum of inputs. $y_3(n) = T[a_1 x_1(n) + a_2 x_2(n)]$ $= a_1 x_1(n) + a_2 x_2(n) + \frac{1}{a_1 x_1(n-1) + a_2 x_2(n-1)}$ Also, linear combination of two o/p. $a_1 y_1(n) + a_2 y_2(n) = a_1 x_1(n) + \frac{a_1}{x_1(n-1)} + a_2 x_2(n) + \frac{a_2}{x_2(n-1)}$ Since $y_3(n) \neq a_1 y_1(n) + a_2 y_2(n)$. System is NON LINEAR. as Superposition principle is not satisfied.	5		

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	(ii) $y(n) = n\,x(n)$. $y_1(n) = n x_1(n)$, $y_2(n) = n x_2(n)$. Weighted sum of outputs is. $a_1 T[x_1(n)] + a_2 T[x_2(n)] = a_1 n x_1(n) + a_2 n x_2(n)$. Now o/p due to weighted sum of inputs. $y_3(n) = T[a_1 x_1(n) + a_2 x_2(n)] = n a_1 x_1(n) + n a_2 x_2(n)$. $\Rightarrow y_3(n) = a_1 y_1(n) + a_2 y_2(n)$ Superposition principle is satisfied Hence the System is LINEAR.	5	10	
(b)	Shifting. The shift operation takes the input sequence and shifts the values by an integer increment of the independent variable. $y(n) = x(n-k)$ The shifting may delay or advance the sequences in time. Time Reversal It is obtained by folding the sequence about $n=0$. $y(n) = x(-n)$ Time Scaling. $y(n) = x(\lambda n)$, $\lambda = 0$ to ∞. eg: $y(n) = x(2n)$	1 1 1 1 1	5	

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	Unit - II			
V (a)	$X(K) = \sum_{n=0}^{N-1} x(n).e^{-j2\pi nK/N}$, $K = 0, 1, \ldots N-1$ $N = 4$.			
	$X(0) = \sum_{n=0}^{3} x(n) = x(0) + x(1) + x(2) + x(3)$. $= 3$	1		
	$X(1) = \sum_{n=0}^{3} x(n).e^{-j\pi n/2} = -j$ $\lvert X(1)\rvert = 1$	2	8	
	$X(2) = \sum_{n=0}^{3} x(n).e^{-j\pi n} = 1$, $\lvert X(2)\rvert = 1$	2		
	$X(3) = \sum_{n=0}^{3} x(n).e^{-j3\pi n/2} = j$, $\lvert X(3)\rvert = 1$	2		
	$X(K) = \{3, -j, 1, j\}$, $\lvert X(K)\rvert = \{3, 1, 1, 1\}$	1		
(b)	If two finite duration sequences $x_1(n)$ and $x_2(n)$ are linearly combined as. $x_3(n) = a x_1(n) + b x_2(n)$ Then the DFT of $x_3(n)$, $X_3(K) = a X_1(K) + b X_2(K)$	4	7	
	$DFT[a_1 x_1(n) + a_2 x_2(n)] = a_1 X_1(K) + a_2 X_2(K)$	3		

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Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
VI (a)	$X(z) = \frac{1}{1+4.5z^{-1}+3.5z^{-2}}$, $\lvert z \rvert > 3.5$			
	$= \frac{z^2}{z^2+4.5z+3.5}$, $\frac{X(z)}{z} = \frac{z}{z^2+4.5z+3.5}$	2		
	$\frac{X(z)}{z} = \frac{z}{(z+1)(z+3.5)} = \frac{A}{z+1} + \frac{B}{z+3.5}$	2		
	$A = (z+1) \cdot \frac{z}{(z+1)(z+3.5)}\Big\rvert_{z=-1} = \frac{-1}{2.5} = \frac{-2}{5}$	3	10	
	$B = (z+3.5) \cdot \frac{z}{(z+1)(z+3.5)}\Big\rvert_{z=-3.5} = 7/5$			
	$X(z) = \frac{-2}{5} \cdot \frac{1}{z+1} + \frac{7}{5} \cdot \frac{1}{z+3.5}$	1		
	$x(n) = -0.4(-1)^n u(n) + 1.4(-3.5)^n u(n)$	2		
(b)	Given $x(n) = \{1, 0, 3, -1, 2\}$.	2	5	
	$X(z) = \sum_{n=-\infty}^{\infty} x(n) \cdot z^{-n}$			
	$X(z) = 1 + 3z^{-2} - z^{-3} + 2z^{-4}$	3		

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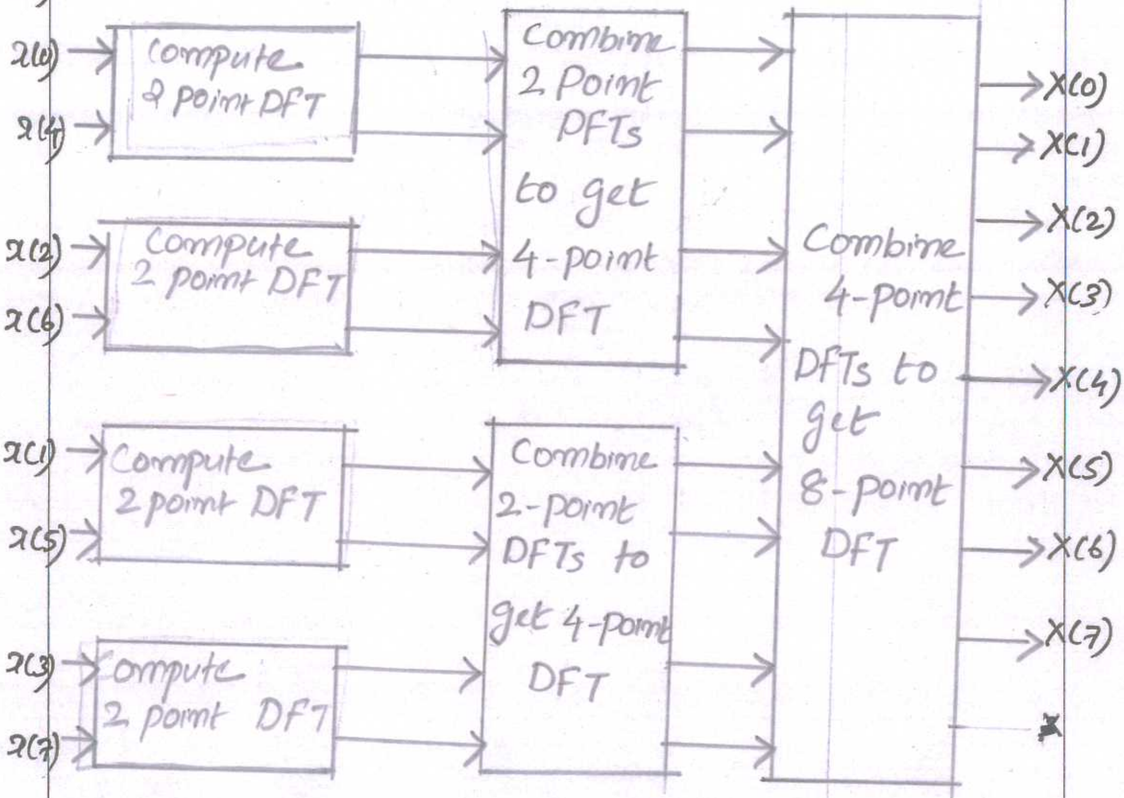
UNIT- III

VIII(a)



Sub Total: 6

The computation of 8 point DFT using radix2 FFT involves three stages of computation. The given 8 point sequence is decimated to 2 point sequences. For each 2 point sequence, the 2 point DFT is computed. From the results of 2 point DFT 4 point DFT can be computed. From the result of 4 point DFT, the 8 point DFT can be computed. x(n) is in bit reversed order.

Sub Total: 2

Total: 8

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Qst No	Scoring Indicator	Split Up Score	Sub Total	Total

Qst No	DIT radix-2 FFT	DIF radix-2 FFT.	Split Up Score	Sub Total	Total
VII(b).	- Time domain sequence is decimated.	The frequency domain sequence is decimated.	1		
	- The input should be in bit reversed order, the output will be in normal order.	The input should be in normal order, the output will be in bit reversed order	2	5	
	- In each stage of computation the phase factors are multiplied before add and subtract operation.	In each stage of computation the phase factors are multiplied after add and subtract operation.	2		

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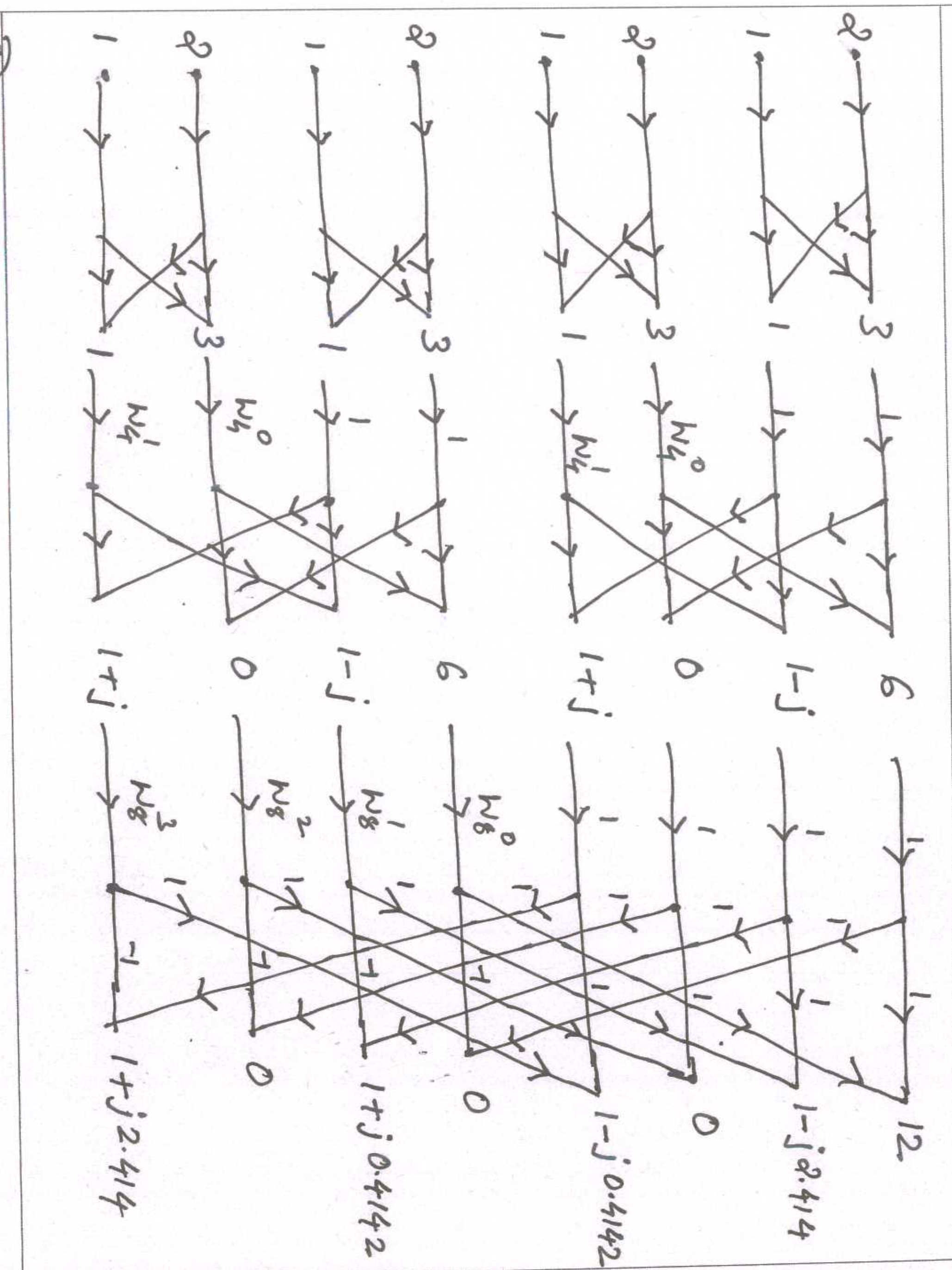
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
VIII(a)		6 8		

$X(K) = \{12, 1-j2.414, 0, 1-j0.4142, 0, 1+j0.4142, 0, 1+j2.414\}$ 2

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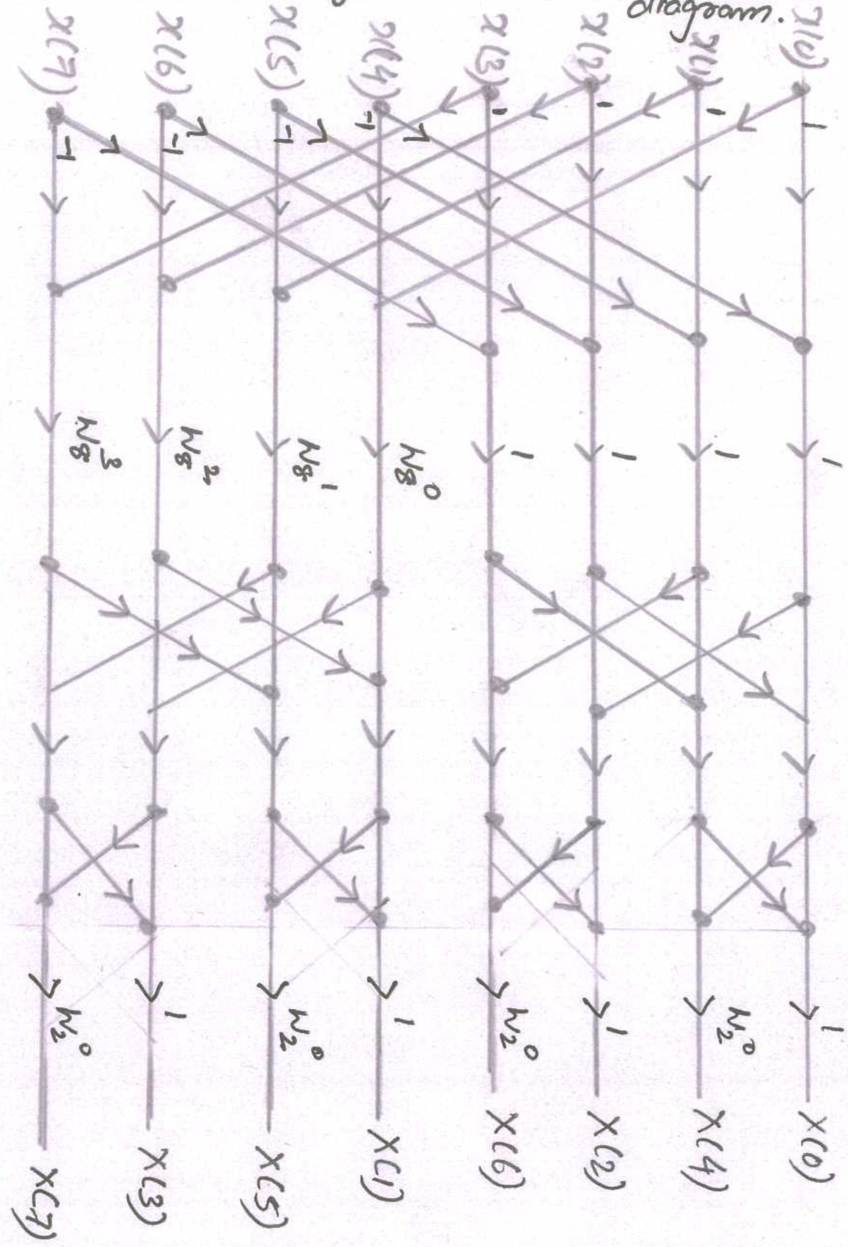
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
VIII(b)	8 point FFT using radix-2 DIF butterfly diagram. 	7		

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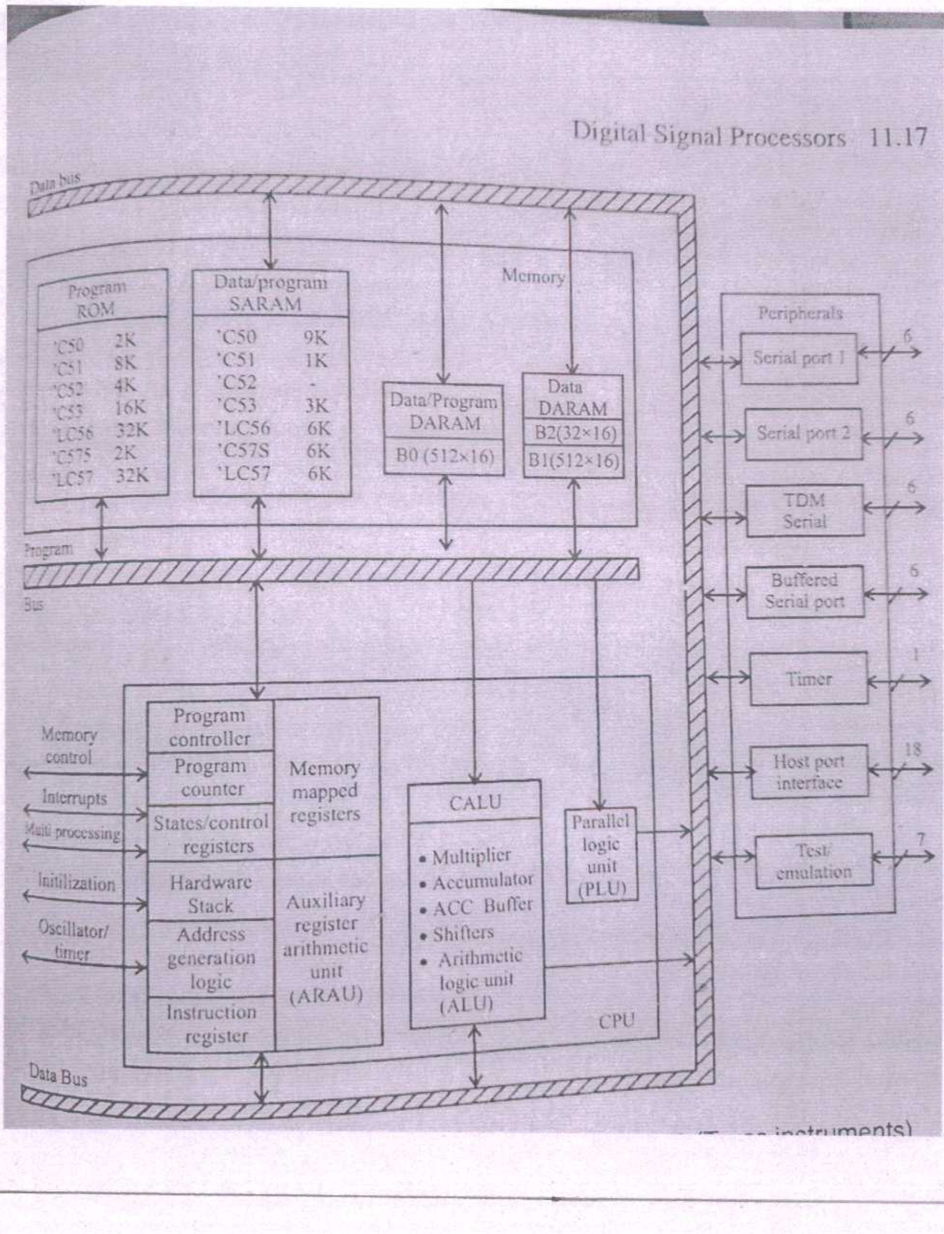
Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
1X(c)	TMX 320c50 DSP Architecture. 		10	

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1X(b)	Advantages of Digital filters. → Unlike analog filter, the digital filter performance is not influenced by component ageing, temperature and power supply variations.	1		
	→ They are highly immune to noise and possesses considerable parameter stability.	1	5	
	→ Multiple filtering is possible only in digital filter.	1		
	→ No problems of input or output impedance matching with Digital filters.	1		
	→ Coefficients of Digital filter can be programmed and altered any time to obtain the desired characteristics.	1		

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Qst No	**Scoring Indicator**	**Split Up Score**	**Sub Total**	**Total**
X(a)	Addressing Modes.			
	The addressing modes of TMX320C50 are			
	① Immediate Addressing.			
	② Indirect addressing.	6		
	③ Register addressing.			
	④ Memory mapped register addressing.			
	⑤ Direct addressing.			
	⑥ Circular addressing.			10
	Seven types of Indirect addressing.			
	① Auto increment.			
	② Auto decrement	2		
	③ Post indexing by adding the contents of AR0.			
	④ Post indexing by subtracting the contents of AR0.		4	
	⑤ Single indirect addressing with no increment.			
	⑥ Single indirect addressing with no decrement.	2		
	⑦ Bit reversal addressing.			

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Qst No	Scoring Indicator	Split Up Score	Sub Total	Total
X(b)	→ Architectural Features. → Execution Speed → Type of Arithmetic → Word length.	2 1 1 1	5	

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