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

DEPARTMENT OF MECHATRONICS

V SEMESTER B.TECH. (MECHATRONICS)

END SEMESTER EXAMINATIONS, DECEMBER 2021

SUBJECT: DIGITAL SIGNAL PROCESSING [MTE 3151] – PART A

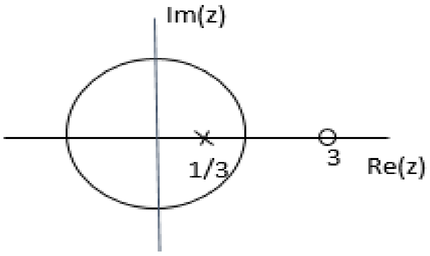
(23/12/2021)

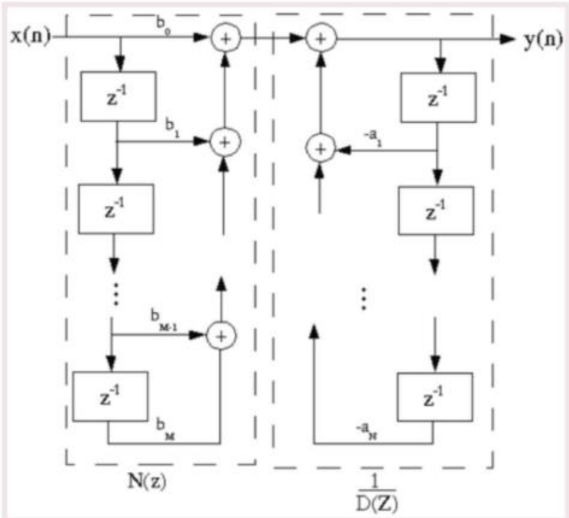
Time: 50 minutes **MAX. MARKS: 30**

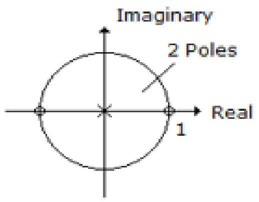
Instructions to Candidates:

- Answer **ALL** the questions.
- *Data not provided, may be suitably assumed*

Q. No		M	CO	PO	LO	BL
1	The input $x(t)$ and the output $y(t)$ of a continuous-time system are related as $y(t) = \int_{t-T}^{t} x(u)du$. The given system is a) Linear and stable b) Non-linear and stable c) Linear and unstable d) Non linear and unstable	1	1	2	2	3
2	The input $x(t)$ and the output $y(t)$ of a continuous-time system are related as $y(t) = \int_{t-T}^{t} x(u)du$. The given system is a) Time invariant and memory b) Time variant and memoryless c) Time invariant and memoryless d) Time variant and memory	1	1	2	2	3
3.	Consider 2 real sequences $x_1[n]$ = { 1 2 3 0}, $x_2[n]$={ 1 3 2 1}. Let $X_1(K)$ and $X_2(K)$ be 4-point DFTs of $x_1[n]$ and $x_2[n]$ respectively. Another sequence $x_3[n]$ is derived by taking 4-point inverse DFT of $X_3(K)= X_1(K) X_2(K)$. The value of $x_3[2]$ is ------------------------ a) 5 b)14 c)11 d)12	1	2	3	3	5

4	If H(s)= $1/(s^2+s+1)$ represent the transfer function of a low pass filter with a pass band of 1 rad/sec, then what is the system function of a low pass filter with a pass band 10 rad/sec? a) $\frac{100}{s^2+10s+100}$ b) $\frac{s^2}{s^2+s+1}$ c) $\frac{s^2}{s^2+10s+100}$ d) None of the mentioned	1	3	3	3	5
5.	What is the one sided z-transform of x(n)=δ(n+k)? a)z^{-k} b)0 c)z^k d)1	1	2	2	2	4
6.	Pole –zero plot of a filter H(z) is given in fig1. Identify the filter.  a)Low pass filter b)High pass filter c)Band pass filter d)Band stop filter e)All pass filter	1	2	2	2	4
7.	Three FIR LPF's are cascaded. The 3 dB cutoff frequency value is __________ a) 0.3 b) $\frac{\pi}{2}$ c) 0.94 d)None of the above	1	3	2	2	5
8	If x_1(n), x_2 (n) and $x_3(n)$ are three sequences each of length N whose DFTs are given as X_1(K), X_2 (K) and $X_3(K)$ respectively and $X_3(K) = X_1$(K) X_2 (K) , then the expression for $x_3(n)$ *is* *a)* $\sum_{n=0}^{N-1} x_1(n)x_2(m+n)$ c) $\sum_{n=0}^{N-1} x_1(n)x_2(m-n)$, b) $\sum_{n=0}^{N-1} x_1(n)x_2((m-n))_N$, d) $\sum_{n=0}^{N-1} x_1(n)x_2((m+n))_N$	1	2	2	2	4

9.	A Digital Filter is defined by the difference equation: $2\,y[n]= 0.99\,x[n-1] + x[n]$, how would you classify this filter? a) FIR-LPF b) FIR-HPF c) FIR-BPF d) None of these, FIR-BSF	1	3	2	2	4
10.	The first five points of the 8-point DFT of a real valued sequence are 5, 1-j3, 0, 3-j4, 0. The last two points of the DFT are respectively a) 0, 1 − j3 b) 0, 1 + j3 c) 1 + j3, 5 d) 1 – j3, 5	1	2	2	2	5
11.	 Which of the following filters have a cascde realization as shown? a) Comb b) FIR filter c) IIR filter d) High pass filter	1	3	2	2	4
12.	For an 2nd order IIR BPF with transfer function $H(z) = \frac{(1-z^{-2})}{1-\beta(1+\alpha)z^{-1}+\alpha z^{-2}}\frac{1-\alpha}{2}$ identify the correct statement a) Different β value gives different center frequency b) Different α value gives different center frequency c) Different bandwidth for single α value d) None of the above	1	3	2	2	4
13.	For an N-point FFT algorithm with $N=2^m$, which one of the following statements is TRUE? a) The number of butterfiles in the m^{th} stage is N/m	1	2	1	1	5

	b) In-place computation requires storage of only 2N node data c) Computation of a butterfly requires only one complex multiplication d) Symmetric property of twiddle factor is not responsible for decrease in computation time.					
14.	The N-point DFT of the sequence $x[n] = \delta(n - n_0)$ where $0 < n_0 < N$ is a) 1 b) $W_N^{n_0 k}$ c) $W_N^{-n_0 k}$ d) 0	1	2	1	1	4
15.	Advantage of IIR filter is a) No statbility issues b) Simpler design compared to FIR filter c) Less computation time to achieve better roll off/3dB decay d) All of the above	1	3	1	1	5
16.	Assume that a complex multiplication takes 2 ns and that the amount of time to compute a DFT is determined by the amount of time it takes to perform all complex multiplications. The time required to compute 100 point DFT using Radix -2 FFT algorithm is a) 100 b) 200 c) 332.19 d) 664.38	1	2	2	2	5
17.	Pole – zero plot is shown in Fig 17. Identify the FIR filter given.  Fig 17 a)Low pass filter b)High pass filter c)Band pass filter d)Band stop filter e)All pass filter	1	3	2	2	4
18.	Identify the number of adders required to realize a 256 point radix 2 FFT using DIT algorithm. a) 2048 b) 1024 c) 616 d) 65536	1	2	2	2	5
19.	For the DFT pair shown, using properties compute values of x_0 and X_1 quantities,	1	2	2	2	5

	$x[n] \leftrightarrow$X[K] $\{x_0, 2, 3, -4\} \leftrightarrow \{ 2\ ,\ X_1\ ,\ 6\ ,\ -2.0000\ +\ 6.0000i\ \}.$					
20.	The impulse response h(t) of a LTI system is described by h(t)=$e^{(\alpha t)}u(t) + e^{(\beta t)}u(-t)$ Where u(t)denotes the unit step function, and α and β are real constants. This system is stable if a) α is positive and β is positive b) α is negative and β is positive c) α is positive and β is negative d) α is negative and β is negative	1	1	2	2	5
21.	________ amount of information is present in zero padded signal compared to original signal a) Same b) More c) Less d) Double	1	1	2	2	4
22.	Consider a real sequence x[n] = {2 4 6 2}. The value of y[1] if Y(k)=X(k-2)$_4$ is ______ a) -4 b) 4 c) - 6 d) 6	1	2	2	2	5
23.	Consider the filter $y[n]$=0.9$y[n-1]$+$bx[n]$ The value of b so that $\|H(0)\|$=1 is a) ± 0.1 b) ± 1 c) 0 d) ± 0.5	1	3	2	2	5
24.	Consider the filter $y[n]$=0.9$y[n-1]$+$bx[n]$. The frequency at which $\|H(\omega)\|=\frac{1}{\sqrt{2}}$is ___ a) 0.105 b) 0.5 c) 1.414 d) 1	1	3	2	2	5
25.	Consider the filter $y[n]$=0.9$y[n-1]$+$bx[n]$, so that $\|H(0)\|$=1 Identify the type of filter a) Low pass filter b) High pass filter	1	3	2	2	4

	c) Band pass filter d) Bans stop filter					
26.	Consider the filter $y[n]=-0.9y[n-1]+bx[n]$, so that $\lvert H(0)\rvert=1$. Identify the type of this filter. a) Low pass filter b) High pass filter c) Band pass filter d) Bans stop filter	1	3	2	2	4
27.	The four phases of the ’C5x pipeline structure are sequenced as a) Fetch(F), Decode (D), Read (R), Execute (E) b) Read (R), Fetch(F), Decode (D), Execute (E) c) Fetch(F), Read (R), Decode (D), Execute (E) d) Read (R), Decode (D), Fetch(F), Execute (E)	1	4	1	1	4
28.	In a non pipeline processor, the instruction fetch, decode and execute take 35 ns, 25 ns, and 40 ns, respectively. Determine the increase in throughput if the instruction steps were pipelined. Assume a 5 ns pipeline overhead at each stage, and ignore other delays. a) 2.67 b) 2.76 c) 2.87 d) 2.96	1	4	2	2	5
29	The 7-bit data memory address (dma) is concatenated with the 9 bits of the data memory page pointer (DP) in status register 0 to form the full 16-bit data memory address in __________ a) Direct Addressing Mode b) Indirect addressing Mode c) Dedicated-register addressing Mode d) Immediate addressing Mode	1	4	1	1	4
30.	$\int_0^\infty cost\, u(t-3)\, \delta(t)\, dt =$ __________________ a) 0 b) 1 c) -1 d) ∞	1	1	2	2	5

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END SEMESTER EXAMINATIONS, DECEMBER 2021

SUBJECT: DIGITAL SIGNAL PROCESSING [MTE 3151] – PART B

(23/12/2021)

Time: 75+10 minutes **MAX. MARKS: 20**

Instructions to Candidates:

- Answer **ALL** the questions.
- *Data not provided, may be suitably assumed*

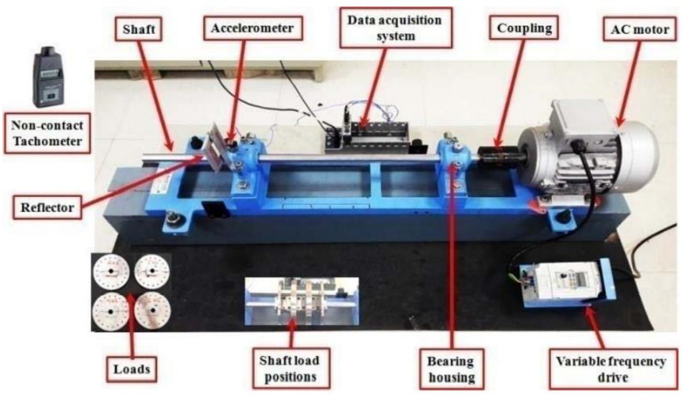
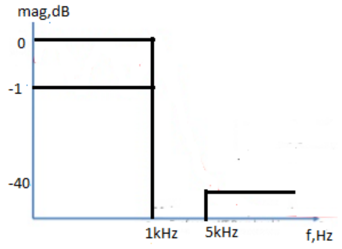
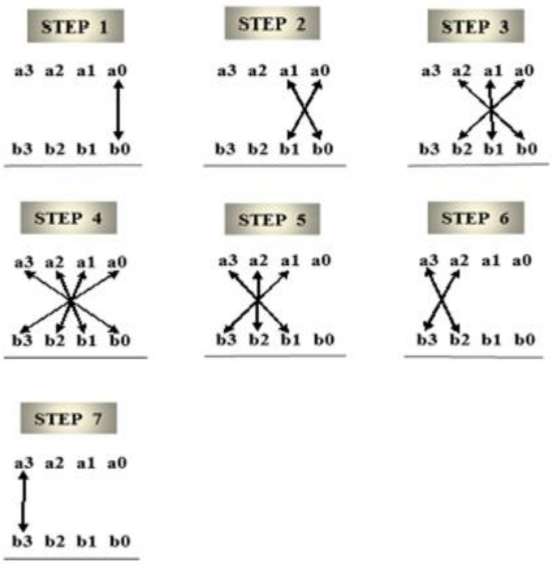
<table>
<tr><th>Q. No</th><th></th><th>M</th><th>CO</th><th>PO</th><th>LO</th><th>BL</th></tr>
<tr><td>1a.</td><td>In a concert recording, it was found that a spurious signal of frequency 2.2 kHz was getting interfered with the recorded music. Design a filter to remove the unwanted signals in the frequency range 2kHz to 2.4kHz with a sampling rate of 8kHz and filter length=5, using Hamming window.</td><td>5</td><td>3</td><td>3</td><td>5</td><td>6</td></tr>
<tr><td>1b.</td><td>Condition monitoring (CM) is a significant requirement for ensuring safe and reliable working of machining processes and rotary components. You are appointed along with a safety officer in an industry to study the conditions of the system components shown in Fig. Q1b. and to develop and automated system for its condition monitoring, fault diagnostics and prognostics. Formulate the major steps required to implement a DSP based CM system for the same. Discuss on the challenges to be tackled in the entire process.


Fig. Q1b: System components for condition monitoring
(courtesy: doi: 10.1109/JSEN.2021.3050718)</td><td>3</td><td>4</td><td>4</td><td>6</td><td>4</td></tr>
</table>

1c.	Hearing aid can be tuned to filter out or amplify either high or low frequency sounds, depending on the frequency range in which the user has suffered hearing loss. Design a Chebyshev filter to satisfy the specifications shown in **Fig. Q1c.**  **Fig. Q1c.**	**2**	**3**	**6**	**5**	**6**
2a.	For sharpening a blurry image, the edges of the image need to be separated and then boosted. Edges are the high frequency intensity variations in an image. Towards this edge detection task, design a digital filter with following specification. • Stopband edge =6 kHz • Passband edge = 4 kHz • Passband attenuation $\geq 40\ dB$ • Stopband attenuation $\leq 1\ dB$ • Sampling frequency =24 kHz The filter is to be designed by performing bilinear transformation on the analog system function.	**5**	**3**	**6**	**5**	**6**
2b.	In any digital signal processors (DSP's) the speed of the multipliers plays a very important role. The precision of the multipliers also plays very important role along with its speed. According to methods used in vedic mathematics, the various steps involved for fast computation of the multiplication of two 4-bit numbers is as in **Fig. Q2b.**  **Fig. Q2b**	**3**	**3**	**4**	**6**	**6**

	Propose the major components and explain the steps included in modelling such multiplier architecture.					
2c.	Determine the magnitude of a low pass Chebyshev-1 filter of order 4 and 5 respectively at Ω=0. Demonstrate the response of these filters with the help of magnitude vs frequency plot. The ripple factor, ϵ is given as 0.8 *Hint:* $$\lvert H_a(j\Omega)\rvert = \frac{1}{\left[1+\epsilon^2 C_N^2\left(\frac{\Omega}{\Omega_p}\right)\right]^{1/2}}$$	**2**	**3**	**2**	**2**	**4**

Chebyshev Filter Design equations

$$N\ is\ odd: \quad H_a(s) = \frac{\Omega_p^N C_0 \prod_{k=1}^{\left(\frac{N-1}{2}\right)} C_k}{(s+\Omega_p C_0)\prod_{k=1}^{\left(\frac{N-1}{2}\right)}(s^2 + b_k \Omega_p s + C_k \Omega_p^2)}$$

$$N\ is\ Even: \quad H_a(s) = \frac{\Omega_p^N C_0 \prod_{k=1}^{\left(\frac{N}{2}\right)} C_k \cdot \frac{1}{\sqrt{1+\epsilon^2}}}{\prod_{k=1}^{\left(\frac{N}{2}\right)}(s^2 + b_k \Omega_p s + C_k \Omega_p^2)}$$

Where, $C_0 = y_N$

$$C_k = y_N^2 + cos^2\frac{(2k-1)\pi}{2N}$$

$$b_k = 2y_N sin\frac{(2k-1)\pi}{2N}$$

$$Y_N = \frac{1}{2}\left\{\left[\sqrt{1+\frac{1}{\epsilon^2}}+\frac{1}{\epsilon}\right]^{1/N} - \left[\sqrt{1+\frac{1}{\epsilon^2}}+\frac{1}{\epsilon}\right]^{-1/N}\right\}$$

$$\epsilon = \sqrt{\frac{1}{\delta_p^2}-1}; \qquad N_c \ge \frac{cosh^{-1}\sqrt{\frac{\delta_s^{-2}-1}{\delta_p^{-2}-1}}}{cosh^{-1}\left(\frac{\Omega_s}{\Omega_p}\right)} \ ; \qquad \frac{1}{1+\epsilon^2 C_N^2\left(\frac{\Omega_s}{\Omega_p}\right)} \le \delta_s^2$$