Reg. No.										

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

DEPARTMENT OF MECHATRONICS

V SEMESTER B.TECH. (MECHATRONICS)

END SEMESTER EXAMINATIONS, DECEMBER 2022

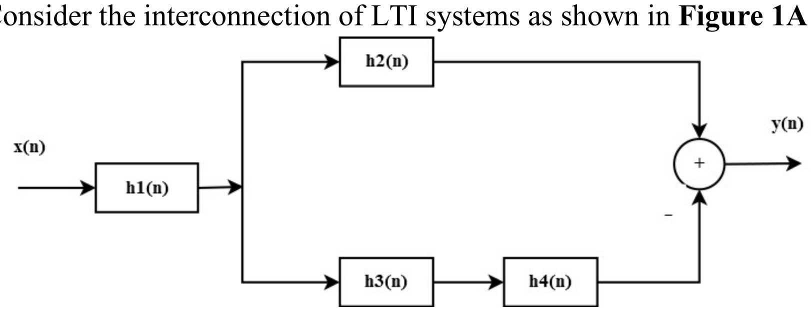
SUBJECT: DIGITAL SIGNAL PROCESSING [MTE 3151]

(01/12/2022)

Time: 3 Hours **MAX. MARKS: 50**

Instructions to Candidates:

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

Q. No		M	CO	PO	LO	BL
1A.	Consider the interconnection of LTI systems as shown in **Figure 1A**  **Figure 1A** Determine the overall response $h(n)$ when $h1(n) = \left\{\frac{1}{2}, \frac{1}{4}, \frac{1}{2}\right\}$ $h2(n) = h3(n) = (n+1)u(n)$ $h4(n) = \delta(n-2)$	5	1	2	2	5
1B.	The desired frequency response of a low-pass filter is $H_d(e^{jw}) = \begin{cases} 1, & -\frac{\pi}{2} \le w \le \frac{\pi}{2} \\ 0, & \frac{\pi}{2} \le \lvert w \rvert < \pi \end{cases}$ Determine $h_d(n)$. Also determine $h(n)$ using the symmetric rectangular window with window length = 7.	3	3	3	5	5
1C.	Develop cascade realization structure for the IIR digital filter transfer function $H(z) = \frac{2(z+2)}{z(z-0.1)(z+0.5)(z+0.4)}$	2	3	3	5	3

2A.	Determine the range of values of a and b for which the linear time-invariant system with impulse response $$h(n) = \begin{cases} a^n, n \geq 0 \\ b^n, n < 0 \end{cases}$$ is stable.	**4**	**1**	**2**	**2**	**5**
2B.	Determine $H(z)$ using the impulse invariant technique for the analog system function $$H(s) = \frac{1}{(s+0.5)(s^2+0.5s+2)}$$ Assume $T = 1s$.	**4**	**3**	**3**	**2**	**5**
2C.	Let $x_p(n)$ be a periodic sequence with fundamental period N. Consider the following DFTs: $$x_p(n) \xleftrightarrow{N\ point\ DFT} X_1(k)$$ $$x_p(n) \xleftrightarrow{3N\ point\ DFT} X_3(k)$$ Establish a relationship between $X_1(k)$ and $X_3(k)$.	**2**	**2**	**2**	**2**	**4**
3A.	Design a digital Butterworth filter that satisfies the following constraint using bilinear transformation. Assume $T = 1s$. $$0.9 \leq \lvert H(e^{jw}) \rvert \leq 1, \quad 0 \leq w \leq \pi/2$$ $$\lvert H(e^{jw}) \rvert \leq 0.2, \quad 3\pi/4 \leq w \leq \pi$$	**5**	**3**	**3**	**5**	**6**
3B.	Convert the analog filter with transfer function $H_a(s)$ to digital filter using bilinear transformation. $$H_a(s) = \frac{(s+0.1)}{(s+0.1)^2+9}$$	**3**	**3**	**2**	**2**	**3**
3C.	Draw the magnitude response of the filter for the given digital specifications Lower stopband edge = 200 Hz Lower passband edge = 100 Hz Upper stopband edge = 300 Hz Upper passband edge = 700 Hz Stopband attenuation = 35 dB Passband ripple = 0.3 dB Sampling frequency = 3kHz	**2**	**3**	**2**	**2**	**3**
4A.	A low frequency hum is getting interfered in a vocal recording, and as a sound engineer, you are asked to design a filter to remove those unwanted signals. The digital specifications of the required filter are given below. Stop band ripple $\leq 10\ dB$ Pass band edge = 150Hz Pass band attenuation > 2dB Stop band edge =100Hz Sampling frequency =1kHz	**5**	**3**	**3**	**5**	**5**

4B.	Consider an LTI system, initially at rest, described by the difference equation $y(n) = 0.25y(n-1) + 0.5y(n-2) + 2x(n) - 0.7x(n-1) + 0.2x(n-2)$ i) Determine the transfer function of the system. ii) Construct the direct form I and direct form II realization of this system and comment on the requirement of delay elements for the realization	**3**	**3**	**3**	**5**	**5**
4C.	Design the transfer function of 4th order LPF using Butterworth approximation.	**2**	**3**	**2**	**5**	**5**
5A.	A linear phase digital filter is to be designed with the following specifications shown as follows is desired. Use bilinear transformation. Passband cut off frequency = 0.50kHz Sampling Frequency = 2 kHz i) Identify whether it a low-pass, high-pass, band-pass, or band-stop filter. Justify your answer ii) Determine the impulse response $h(n)$ for a rectangular window and Hanning window. Comment of the responses.	**4**	**3**	**3**	**5**	**5**
5B.	With proper design steps compute the transfer function of an analog filter using Butterworth approximation method, for the given specifications. Use impulse invariant transformation. $0.8\,6 \leq \mid H(\omega) \mid \leq 1; \quad 0 \leq \mid \omega \mid \leq 0.25\pi$ $\mid H(\omega) \mid \leq 0.3; \quad 0.35\pi \leq \mid \omega \mid \leq \pi$	**3**	**3**	**3**	**5**	**6**
5C.	Condition monitoring (CM) is a significant requirement for ensuring safe and reliable working of machining processes and rotary components. To monitor cylindrical grinding process by an intelligent CM system, the cutting force, vibration and acoustic are been monitored. Describe the various signal processing methods which could be employed for analyzing the inputs for condition monitoring.	**3**	**4**	**2**	**2**	**6**