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

FIFTH SEMESTER B.TECH. (ELECTRICAL & ELECTRONICS ENGINEERING)
END SEMESTER EXAMINATIONS, NOVEMBER-DECEMBER 2023

DIGITAL SIGNAL PROCESSING [ELE 3152]
REVISED CREDIT SYSTEM

Time: 3 Hours **Date: 08 December 2023** **Max. Marks: 50**

Instructions to Candidates:
- Answer **ALL** the questions.
- Missing data may be suitably assumed.

Q.No	Questions	Marks
1A.	Given the discrete-time (DT) sequence $x(n) = \|n\|$ for $-3 \leq n \leq 3$, compute, sketch and label the following: i) $x(n)$ ii) $x(2n)$ iii) $x(2-2n)$ iv) $x(3n-1)\delta(n-1)$	***(02)***
1B.	Determine the output of a filter whose impulse response is $h[n] = \delta[n] - 2\delta[n-1] + \delta[n-2]$ and the input signal $x[n] = 3\delta[n+2] - 2\delta[n] + 3\delta[n-1] + 4\delta[n-2] - \delta[n-4] + 5\delta[n-5] + 4\delta[n-6] + 3\delta[n-7]$. Use overlap-add method for linear filtering. Take sub-frame length of 3.	***(04)***
1C.	Calculate the 8-point DT sequence using Radix-2, DIT-FFT algorithm for the given DFT: $X[k] = [20,\ -5.828 - j2.414,\ 0,\ -0.172 - j0.414,\ 0,\ -0.172 + j0.414,\ 0,\ -5.828 + j2.414]$. Draw the Butterfly diagram. Indicate the result at each stage.	***(04)***
2A.	Consider an analog signal $x(t) = 15\cos\left(60\pi t - \frac{\pi}{4}\right) - 12\cos(150\pi t)$ applied to a sampling and reconstruction system. Determine i) Minimum value of sampling rate F_S to ensure $y(t) = x(t)$, where $y(t)$ is the reconstructed signal. ii) Discrete-time signal $x(n)$ for F_S = 450 Hz. iii) Value of F_S so that $y(t) = A + 15\cos\left(60\pi t - \frac{\pi}{4}\right)$. Where A is a constant. Also, determine the value of A.	***(02)***
2B.	Given the linear phase FIR filter $h(n) = \{\underline{1}, 4, -8, a, b\}$. Find the values of a and b for type-1 system (symmetric and odd-length). Realize the filter with minimum number of multipliers.	***(03)***
2C.	Realize the given filter $H(z) = \frac{1+z^{-1}}{(1-0.5z^{-1})(1-3z^{-1}+2z^{-2})}$ using i) Direct form-II ii) Parallel form structure	***(05)***

3A. Consider the z-transform $H(z) = \frac{1}{(2z^{-1}-1)((1/2)z^{-1}-1)}$.

i) Sketch the poles, zeros and the possible ROCs.
ii) For each ROC, determine if the impulse response is stable or unstable.
iii) Compute $h[n]$ considering $H(z)$ with ROC corresponding to the causal impulse response. ***(03)***

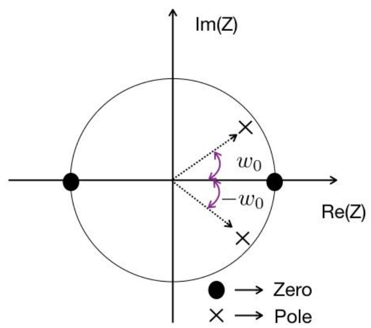
3B. Consider a filter described by the difference equation as below:

$y[n] = 0.1\, x[n] - 0.9\, y[n-1]$.

Determine the frequency at which $|\, H[0]\,| = 0.707$. Is this a low-pass or high-pass filter? ***(04)***

3C. Write short note on FIR and IIR all-pass filters. Mention the system function and pole-zero map for both. ***(03)***

4A. Derive the system function and frequency response equations for the DT system characterized by the pole-zero map shown below:



Given: $'r'$ is the distance between the location of the pole and the origin in the complex Z-plane. The circle shown in figure is an unit radius circle. ***(03)***

4B. A low-pass filter has the desired frequency response

$$H_d(e^{j\omega}) = \begin{cases} e^{-j4\omega}; & 0 < \omega < \frac{\pi}{2} \\ 0; & elsewhere \end{cases}$$

Design a suitable filter using frequency sampling technique. ***(03)***

4C. Design a normalized linear phase FIR low pass filter with a cut-off frequency of 1 radian/sample, having a group delay $\tau = 4$ and maximum attenuation in the stop band using window technique (select an appropriate window to meet the specifications). Draw a suitable structure to implement the same. ***(04)***

5A. List any four differences between all-zero and pole-zero filters. ***(02)***

5B. The transfer function of an analog filter is given by: $H[s] = \frac{1}{s+2}$. Design a digital filter $H[z]$ from $H[s]$ using impulse invariance technique. Use a sampling frequency of 1 Hz. Also, draw the pole-zero plot. ***(03)***

5C. Design a Butterworth filter using Bilinear transformation technique to meet the following specifications:

$$0.75 \le \left|H(e^{j\omega})\right| \le 1\ ; \quad 0 \le \omega \le 0.25\pi$$

$$\left|H(e^{j\omega})\right| \le 0.23\ ; \quad 0.63\pi \le \omega \le \pi$$

Take a sampling frequency of 8 KHz. ***(05)***