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# MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

*(A constituent institution of MAHE, Manipal)*

**V SEMESTER B.TECH. (MECHATRONICS ENGINEERING)**

**END SEMESTER EXAMINATIONS, NOV 2018**

**SUBJECT: DIGITAL SIGNAL PROCESSING [MTE 3105]**

**(23/11/2018)**

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:
- Answer **ALL** the questions.
- Data not provided may be suitably assumed
- Use of Transform Table is permitted.

**1A.** Consider the cascade of the following two systems $S_1$ and $S_2$, as depicted in **Fig. Q1A**: **(4)**

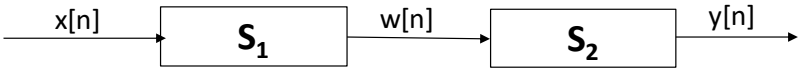


Fig. Q1A

$S_1$: causal linear time invariant,

$$w[n] = \frac{1}{2}w[n-1] + x[n];$$

$S_2$: causal linear time invariant,

$$y[n] = \alpha\, y[n-1] + \beta\, w[n].$$

The difference equation relating $x[n]$ and $y[n]$ is:

$$y[n] = -\frac{1}{8}y[n-2] + \frac{3}{4}y[n-1] + x[n].$$

(a) Determine $\alpha$ and $\beta$.
(b) Compute the impulse response of the cascaded system.

**1B.** Compute energy and power of the signal as given in **Fig. Q1B** having unit amplitude. **(3)**

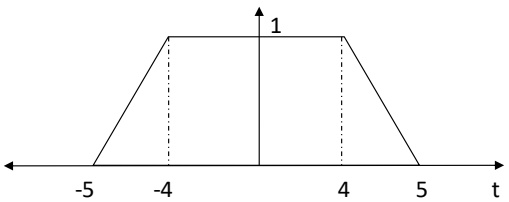


Fig. Q1B

**1C.** Describe the following addressing modes of the digital signal Processor: (i) Indirect addressing mode, and (ii) Memory-Mapped Register Addressing. **(3)**

**2A.** Consider a signal $y[n]$ which is related to two signals $x_1[n]$ and $x_2[n]$ by **(2)**

$$y[n] = x_1[n+3] * x_2[n]$$

$where\ x_1[n] = \left(\frac{1}{2}\right)^n u[n]$ and $x_2[n] = 2\left(\frac{1}{4}\right)^n u[-n]$.

Determine z-transform $Y(z)$ of $y[n]$ and plot the zero-pole diagram.

**2B.** Consider the following continuous-time two sided exponential signal: **(3)**

$$x_a(t) = e^{-A|t|}, where\ A > 0$$

(a) Determine the spectrum of the sampled signal $x(n) = x_a(nT)$, (b) Plot the signals $x_a(t)$ and $x(n) = x_a(nT)$, for T=1/3 sec and T=1 sec, and their spectra.

**2C.** Determine why the Butterworth approximation has maximum flat response in the passband whereas Type I Chebyshev approximation has ripples in the pass band? **(5)**
Determine the $\varepsilon$ and order of type I lowpass Chebyshev filter that has 1 dB ripple in the pass band, a cutoff frequency $\Omega_p = 1000\,\pi$, a stopband frequency of $2000\,\pi$ and an attenuation of 40 dB or more for $\Omega \geq \Omega_s$.

**3A.** Discuss the pipeline operation in a DSP processor 'C5x. **(4)**
Further, 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.

**3B.** State and justify the type of an FIR (finite impulse response) filter shown in the **Fig. Q3B**. Determine the response of the system if step function is given as input. **(3)**

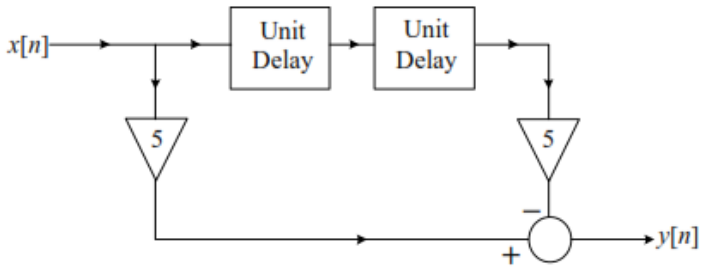


Fig. Q3B

**3C.** Calculate the DFT of a signal $x(n) = (1, 1, -1, -1)$ using 4 point decimation in time (DIT)-FFT radix-2 algorithm. **(3)**

**4A.** Heavy rotating machines are the key component of the power generation of any plant. A small fault in the rotating machine is very difficult to identify, as the signals generating from other sources corrupted the fault signal. In order to record the fault, some sensors were employed. Design an FIR filter using Hamming windows, which can help to get back the original fault signal generated from the rotating machines. The desired frequency response of the filter is given as follows: **(6)**

$$H_d(\omega) = \begin{cases} e^{-j3\omega}, \frac{\pi}{4} \leq |\omega| \leq \pi \\ 0, \quad other\ wise \end{cases}$$

**4B.** Consider the z-transform as follows: **(2)**

$$X(z) = \frac{z}{2z^2 - 3z + 1}$$

Determine the $x[n]$ for the following Region of Convergence $|z| < \frac{1}{2}$.

**4C.** Condition of geometric symmetry should be followed for the transformation of band pass filter from normalized low pass filter. Assume, a user provides the specifications of filter design, which violates the symmetry condition. **(2)**

Suggest a method to make provided specifications symmetrical with the help of an example.

**5A.** Mr. ABC is trying to develop the prosthetic arm controlled by only α, β, θ and δ waveform of electroencephalogram (EEG) signals, which normally have the frequency range below 30 Hz. While capturing the signal using the specified electrodes he is facing the issue of overlapping of Electromyogram (EMG) signal, as it has the frequency range of 50 Hz to 2000 Hz. **(7)**

Help Mr. ABC to design a digital IIR filter using bi-linear transformation that can avoid the above stated problem and can produce maximum flat frequency response to meet the following specifications: (i) Passband ripple ≤ 1.25 dB, (ii) Stopband attenuation ≥ 15 dB. (Provided sampling frequency = 4 kHz, assume stop band and passband edge according to the given situation)

**5B.** Construct the cascade form realization of the following IIR filter: **(3)**

$$H(z) = \frac{0.44z^2 + 0.362z + 0.02}{(z^3 + 0.4z^2 + 0.18z - 0.2)}$$