Ref No: Ex/EE/T/311/2018

# B.E. ELECTRICAL ENGINEERING THIRD YEAR FIRST SEMESTER - 2018

## DIGITAL SIGNAL PROCESSING

Full Marks 100

Time: Three hours (50 marks for each part)

Use a separate Answer-Script for each part

| No. of Question | PART- I | Marks |
|---|---|---|
| | Answer any *THREE* questions<br>**Two marks reserved for neatness and well organized answers** | |
| 1.(a) | A continuous-time signal $x(t) = 2Sin(600\pi t)Cos^2(800\pi t)$ , where $t$ is in second, is uniformly sampled at a rate of 600 samples/ second. The sampled signal is converted back to a continuous-time signal using an ideal DAC. Determine the frequencies of the spectral components of the signal at the output of the DAC. Derive the expression(s) that have been used for determining these frequencies. | 8 |
| (b) | The discrete-time Fourier transform (DTFT) [ *i.e. z-transform evaluated on unit circle*] of the sequence<br>$x[n] = \{-1, 2, -0.5, \underset{\uparrow}{3}, 1, 7, -2, 0.5\}$ is $X(e^{j\Omega})$.<br>Evaluate the following, without explicitly determining the expression for $X(e^{j\Omega})$.<br>Give explanations.<br>(i) $X(1)$ (ii) $\int_{-\pi}^{+\pi} X(e^{j\Omega})\, d\Omega$ (iii) $\int_{-\pi}^{+\pi} \left\|X(e^{j\Omega})\right\|^2 d\Omega$<br>(iv) $X(-1)$. | 8 |
| 2. (a) | Starting from the definition of z-transform, obtain the expression for the z-transform of the sequence $x[n] = e^{-3n}Cos(200n)u[n]$, and its region of convergence (ROC). | 5 |

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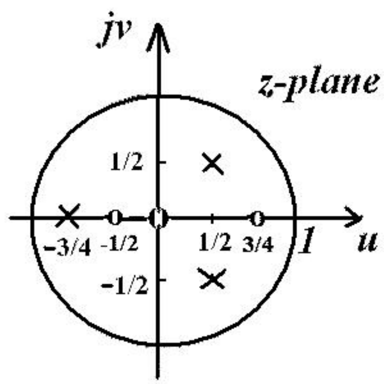
| No. of Questions | PART I | Marks |
|---|---|---|
| (b) | Use your knowledge of the z-transform of $u$[n] and properties of z-transform, to determine the z-transform of the sequence $h[n]=n^2(-2)^n u[n]$. What is the ROC? | 4 |
| (c ) | The pole-zero diagram for the z-transform $F$(z) of a causal sequence $f$[n] is shown in Fig. [A]. If the initial value of $f$[n] is 4, determine the closed form expression for $f$[n].<br><br><br>Fig. [A] | 7 |
| 3.(a) | The z-transfer function of a discrete-time linear time-invariant (DTLTI) system is<br>$H(z)=\dfrac{z^2+0.2}{(z+2)(z^2-0.8z+0.15)}$<br>Identify all ROCs of H(z) and comment on the causality and the stability of the system for each ROC. | 6 |

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| | PART- I | |
|---|---|---|
| (b) | The output $y[n]$ and the input $x[n]$ of a DTLTI system are related through the difference equation $y[n]=x[n]+3x[n-1]+2x[n-2]-\frac{3}{8}y[n-1]+\frac{3}{32}y[n-2]+\frac{1}{64}y[n-3]$ Derive and draw the Direct form-I, the Direct form-II and the cascade realization (using 1st order subsystems with direct form-II structure) of the system. *Give all the relevant sets of difference equations.* | 10 |
| 4.(a) | Derive the difference equation relating the output and the input sequences of a digital lowpass Butterworth filter with the following specifications:<br>• A DC gain of 0 dB.<br>• The gain should be no less than –2 dB over 0 to 0.15π radian, and no greater than –11dB for frequencies above 0.3π radian.<br>Use bilinear transformation preceded by frequency prewarping.<br>Derive the frequency warping relation used. | 10 |
| (b) | How does the jω axis in the s-plane map on to the z-plane for backward-difference transformation? Give necessary derivation and illustration. | 6 |
| 5. | Write short notes on any two of the following.<br>(a) Distortions introduced by practical DACs and their remedies.<br>(b) Modeling uniform sampling as impulse modulation.<br>(c) Recursive and non-recursive DTLTI systems and their impulse responses.<br>(d) Designing digital IIR filters using z-transformation method. | 8+8 |

# B.ELE.ENGG. 3RD YEAR 1ST SEMESTER EXAMINATION, 2018

## SUBJECT: - DIGITAL SIGNAL PROCESSING

Full Marks 100

Time: Three hours (50 marks for each part)

**Use a separate Answer-Script for each part**

| No. of Questions | PART II | Marks |
|---|---|---|
| | *Answer **any three** questions. **TWO** marks are reserved for neat and well organized answers.* | |
| 1.a) | In computing Fourier series of a periodic signal, determine the relationship between the amplitude and phase of the $n$th harmonic component and the complex Fourier coefficients. | 04 |
| (b) | Determine the N-point DFT of the Blackman window: $w_k = 0.42 - 0.5\cos\left(\frac{2\pi k}{N-1}\right) + 0.08\cos\left(\frac{4\pi k}{N-1}\right), \qquad 0 \le k \le (N-1)$ | 08 |
| c) | "The DFT repeats at a frequency which is $m$ times the sampling frequency, with $m = 0,1,2,\ldots$". – Justify or correct the statement citing suitable reasons. | 04 |
| 2. a) | Describe in detail how the bit-reversal procedure can be carried out in 8-point FFT. | 05 |
| b) | How the effect of truncation of impulse response in an FIR digital filter can be expressed using circular complex convolution integral? | 06 |
| d) | Describe the architecture of the TMS320C25 digital signal processor and describe its special features. | 05 |
| 3.a) | Find an expression for frequency response of an $M$-tap causal FIR digital filter having a symmetric and real impulse response. Assume $M$ to be an odd number. | 08 |
| b) | A 5-tap causal linear phase FIR brick-wall type band-pass filter has been designed with unity pass band gain and the passband ranges from 50 Hz to 150 Hz. The sampling frequency is 500 Hz. Determine the filter coefficients, if Hann window is employed for smoothening purpose. Draw the schematic realization of the filter. | 08 |
| 4. a) | "The two-dimensional convolution mask for a low pass FIR image filter can be designed using both positive and negative coefficients". – Justify or correct the statement citing suitable reasons. | 04 |

| | | |
|---|---|---|
| 4. b) | "It is possible to maintain symmetrical separation in output filtered sequence with respect to the input sequence only in those cases where causal FIR filters are utilized." – Justify or correct the statement citing suitable reasons. | 04 |
| c) | Prove that distortion-less transmission of a signal through a filter is possible even if the filter has a linear phase characteristic with offset. | 04 |
| d) | "In FFT computations, computation of each butterfly involves two real additions and two real multiplications." – Justify or correct the statement citing suitable reasons. | 04 |
| 5. | Write short notes on ***any two*** of the following:<br><br>a) Inverse discrete Fourier transform.<br><br>b) FFT based filtering of a finite real data sequence.<br><br>c) Frequency response of a non-causal raised cosine window. | 08+08 |