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2019

DIGITAL SIGNAL PROCESSING

Paper : EC 603

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

Answer ***any five*** *questions.*

1. *(a)* Find the impulse response *h(n)* for each of the causal, discrete-time LTI systems satisfying the following difference equations and also indicate whether each system is FIR or IIR system : 5+5+5

   (i) $y(n)=x(n)-2x(n-2)+x(n-3)$

   (ii) $y(n)+2y(n-1)=x(n)+x(n-1)$

   (iii) $y(n)-0{\cdot}5\,y(n-2)=2x(n)-x(n-2)$

   (b) Why is folding operation necessary in linear convolution ? 5

Contd.

2. Discuss and develop the theory behind Decimation in time (DIT) radix-2 FFT algorithm. Choose $N=8$. 20

3. Show that the analog transfer function

$$Ha(s)=\frac{b.s}{s^2+bs+\Omega_0^2} \; ; \; b>0$$

has a bandpass magnitude response with $|Ha(j0)|=|Ha(j\Omega)|=0$ and $|Ha(j\Omega_0)|=1$. Determine the frequencies Ω_1 and Ω_2 at which the gain is $3dB$ below the maximum value of $0dB$ corresponding to Ω_0. Show that $\Omega_0=\sqrt{\Omega_1\Omega_2}$. The difference $(\Omega_2-\Omega_1)$ is called the $3dB$ bandwidth of the bandpass transfer function. Hence show that $b=(\Omega_2-\Omega_1)$. 20

4. In the given problem, the characterstics of analog and digital implementation of a **single-pole low-pass** analog system will be reviewed : 20

$$Ha(s)=\frac{\alpha}{s+\alpha} \Rightarrow ha(t)=e^{-at} \text{ (normalised)}$$

(i) What is the gain at dc ? At what radian frequency is the analog frequency $3dB$ down from its dc value ? At what frequency is the analog frequency response zero ? At what time has the analog impulse response decayed to $(1/e)$ of its initial value ?

(ii) 'Prewarp' the parameter 'α' and perform the bilinear transformation to obtain the digital system function '*H(z)*' from the analog design. What is the gain at dc ? At what frequency (real valued) is the response zero ? Give an expression for the $3dB$ radian frequency. How many samples are there in the unit sample time domain response before it has decayed to $(1/e)$ of its initial value ?

5. *(a)* Determine the lowest order of a transfer function *Ha(s)* having maximally flat low-pass characteristics with a $1dB$ cut-off frequency of $1kHz$ and a minimum attenuation of $40dB$ at $40\,kHz$. 10

(b) Design a digital LPF (Butterworth) using impulse invariant method to meet the following specifications : 10

(i) Passband edge frequency $=1{\cdot}25\ kHz$

(ii) Stopband edge frequency $= 2{\cdot}75\ kHz$

(iii) Passband ripple $\leq 0{\cdot}5dB$

(iv) Stopband attenuation $\geq 15dB$

Sampling frequency is $10kHz$.

6. A causal discrete time LTI system is described by

$$y(n)-\frac{3}{4}y(n-1)+\frac{1}{8}y(n-2)=x(n)\ ;$$

where $x(n)$ and $y(n)$ are the input and the output of the system respectively.

(i) Find the system function $H(z)$. 7

(ii) Find the impulse response *h(n)* of the system. 7

(iii) Find the step response *S(n)* of the system. 6