KOLEJ UNIVERSITI TEKNOLOGI TUN HUSSEIN ONN

PEPERIKSAAN AKHIR
SEMESTER I
SESI 2006/07

NAMA MATA PELAJARAN	:	PEMPROSESAN ISYARAT DIGIT
KOD MATA PELAJARAN	:	BEE 3213
KURSUS	:	3 BER / 3 BET / 3 BEM / 3 BEP
TARIKH PEPERIKSAAN	:	NOVEMBER 2006
JANGKA MASA	:	3 JAM
ARAHAN	:	JAWAB **LIMA (5)** SOALAN SAHAJA DARIPADA ENAM (6) SOALAN.

KERTAS SOALAN INI MENGANDUNGI 12 MUKA SURAT

SOALAN DALAM BAHASA MELAYU

S1 (a) Apakah takrifan bagi isyarat diskret kausal? Lakarkan isyarat tersebut.

(5 markah)

(b) Huraikan isyarat pada Rajah S1(b) dalam bentuk:

(i) satu jujukan berangka.
(ii) satu hasil tambah dedenyut teranjak.
(iii) satu hasil tambah tangga dan tanjakan.

(9 markah)

(c) Huraikan isyarat pada Rajah S1(c) dalam bentuk:

(i) satu jujukan berangka.
(ii) satu hasil tambah dedenyut teranjak.
(iii) isyarat diskret segiempat tepat.

(6 markah)

S2 (a) Bagaimanakah anda menggambarkan proses pelingkaran berkala dengan menggunakan kaedah kitar? Apakah kelebihan menggunakan teknik ini? Cari pelingkaran berkala bagi $x[n] = \{\overset{\Downarrow}{1}, -3, 3, 5, -1, 2\}$ dan $h[n] = \{-\overset{\Downarrow}{1}, -1, 5, 2, 7, 3\}$ dengan kala $N = 6$ menggunakan kaedah kitar.

(12 markah)

(b) Kira autosekaitan $r_{xx}[n]$ dan $r_{hh}[n]$, sekaitan silang $r_{xh}[n]$ dan $r_{hx}[n]$ bagi setiap pasangan isyarat yang diberikan di bawah:

(i) $x[n] = \{-3, -2, -\overset{\Downarrow}{1}, 2\}$, $h[n] = \{\overset{\Downarrow}{4}, 3, 2\}$

(ii) $x[n] = \{3, 2, \overset{\Downarrow}{1}, 1, 2\}$, $h[n] = \{4, \overset{\Downarrow}{2}, 3, 2\}$

(8 markah)

S3 (a) Diberi kadar pensampelan Nyquist $S_N = 2B$ di mana B ialah frekuensi jalur-terhad. Terangkan mengapa kadar pensampelan Nyquist juga dikenali sebagai kadar pensampelan genting. Diberi $x_p(t) = 2\cos(3\pi\, t) + 5\cos(7\pi\, t) + 14\sin(28\pi\, t) + 6\sin(47\pi\, t) + 0.5\cos(60\pi\, t) + \sin(80\pi\, t)$ dan frekuensi pensampelan S ialah 30 Hz.

(i) Kira frekuensi Nyquist.

(ii) Tentukan sama ada samaran berlaku atau tidak untuk frekuensi setiap komponen sinus dan tuliskan isyarat sepadan. Tuliskan frekuensi samaran jika ia berlaku.

(iii) Tuliskan isyarat yang terbina.

(iv) Bagaimanakah samaran boleh dielakkan untuk memulihkan $x_p(t)$?

(13 markah)

(b) Fungsi ketumpatan kebarangkalian $f(\varepsilon)$ bagi satu isyarat ditunjukkan pada Rajah S3. Tunjukkan bahawa kuasa hingar diberikan oleh

$$P_N = \frac{\Delta^2}{12}$$

di mana Δ ialah saiz langkah pengkuantuman. Diberi $L = 2^B$ di mana L ialah aras pengkuantuman dan B ialah nombor bit bagi pengkuantum. Tunjukkan bahawa anggaran statistik SNR diberikan oleh

$$SNR_S(\text{dB}) = 10 \log P_S + 10.8 + 6B - 20 \log D$$

di mana D ialah julat dinamik dan P_S ialah kuasa isyarat.

(7 markah)

S4 (a) Terangkan dengan ringkas algoritma desimasi masa (DIT) Penjelmaan Fourier Pantas (FFT). Lakarkan struktur kupu-kupu bagi algoritma DIT FFT.

(5 markah)

(b) Diberi $x[n] = \{\overset{\Downarrow}{1}, 2, 3, 4, 5, 6, 7, 8\}$ dengan $N = 8$. Cari Penjelmaan Fourier Diskret (DFT) bagi jujukan tersebut dengan menggunakan algoritma DIT FFT.

(15 markah)

S5 (a) Satu isyarat analog $x(t)$ boleh diungkapkan sebagai satu hasil tambah dedenyut teranjak $\delta(t-k)$ yang mempunyai kekuatan $x(t)$ sepadan dengan nilai isyarat pada $n = k$, di mana

$$x(t) = \sum_{n=-\infty}^{\infty} x(t)\delta(t-k) = \sum_{n=-\infty}^{\infty} x(t)\delta(t-nT)$$

Tentukan jelmaan-z bagi isyarat analog $x(t) = e^{-aT}$ yang dikenakan pada satu penapis digit.

(9 markah)

(b) Apakah tujuan penggunaan kaedah pengembangan pecahan separa dalam menentukan jelmaan-z songsang? Dengan menggunakan kaedah ini, cari jelmaan-z songsang

$$H(z) = \frac{-10 - 20z^{-1}}{1 + 26z^{-1} + 153z^{-2}}$$

(11 markah)

S6 Nyatakan tiga kelebihan menggunakan penjelmaan dwilelurus dalam merekabentuk penapis Sambutan Dedenyut Tak Terhingga (IIR). Satu penapis Bessel diberikan oleh

$$H(s) = \frac{3}{s^2 + 3s + 3}$$

Rekabentuk satu penapis digit yang mempunyai magnitud pada $f_0 = 3$ kHz bersamaan dengan magnitud $H(s)$ pada $\omega_A = 4$ rad/s jika kadar pensampelan $S = 12$ kHz. Tunjukkan magnitud $H(s)$ pada $s = j4$ adalah sepadan dengan magnitud $H(z)$ pada $z = j$.

(20 markah)

SOALAN DALAM BAHASA INGGERIS

Q1 (a) What is the definition of causal discrete signal? Sketch the signal.

(5 marks)

(b) Describe the signal in Figure Q1(b) in terms of:

(i) a numeric sequence.
(ii) a sum of the shifted impulses.
(iii) a sum of the steps and ramps.

(9 marks)

(c) Describe the signal in Figure Q1(c) in terms of:

(i) a numeric sequence.
(ii) a sum of the shifted impulses.
(iii) rectangular discrete signal.

(6 marks)

Q2 (a) How do you visualize the process of periodic convolution by using the cyclic method? What is the advantage of using this technique? Find the periodic convolution of $x[n] = \{\overset{\Downarrow}{1}, -3, 3, 5, -1, 2\}$ and $h[n] = \{\overset{\Downarrow}{-1}, -1, 5, 2, 7, 3\}$ with the period of $N = 6$ using cyclic method.

(12 marks)

(b) Compute the autocorrelation $r_{xx}[n]$ and $r_{hh}[n]$, the cross-correlation $r_{xh}[n]$ and $r_{hx}[n]$ for each pair of the signals given below:

(i) $x[n] = \{-3, -2, \overset{\Downarrow}{-1}, 2\}$, $h[n] = \{\overset{\Downarrow}{4}, 3, 2\}$

(ii) $x[n] = \{3, 2, \overset{\Downarrow}{1}, 1, 2\}$, $h[n] = \{4, \overset{\Downarrow}{2}, 3, 2\}$

(8 marks)

Q3 (a) The Nyquist sampling rate is given by $S_N = 2B$ where B is the band-limited frequency. Explain why the Nyquist sampling rate is also called the critical sampling rate. Given $x_p(t) = 2\cos(3\pi\, t) + 5\cos(7\pi\, t) + 14\sin(28\pi\, t) + 6\sin(47\pi\, t) + 0.5\cos(60\pi\, t) + \sin(80\pi\, t)$ and the sampling frequency S is 30 Hz.

(i) Calculate the Nyquist frequency.

(ii) Determine whether aliasing occur or not for the frequency of each sinusoid components and write down the corresponding signal. Write down the aliased frequency if it occurs.

(iii) Write down the reconstructed signal.

(iv) How aliasing can be avoided to recover $x_p(t)$?

(13 marks)

(b) The probability density function $f(\varepsilon)$ of a signal is shown in Figure Q3. Show that the noise power is given by

$$P_N = \frac{\Delta^2}{12}$$

where Δ is the quantization step size. Given that $L = 2^B$ where L is the quantization level and B is the number of bit of the quantizer. Show that the statistical estimate of the SNR is given by

$$SNR_S(\text{dB}) = 10\log P_S + 10.8 + 6B - 20\log D$$

where D is the dynamic range and P_S is the signal power.

(7 marks)

Q4 (a) Briefly explain the decimation in time (DIT) Fast Fourier Transform (FFT) algorithm. Sketch a butterfly structure for the DIT FFT algorithm.

(5 marks)

(b) Given $x[n] = \{\overset{\Downarrow}{1}, 2, 3, 4, 5, 6, 7, 8\}$ with $N = 8$. Find the Discrete Fourier Transform (DFT) of the sequence by using DIT FFT algorithm.

(15 marks)

Q5 (a) An analog signal $x(t)$ can be expressed as a sum of shifted impulses $\delta\ (t - k)$ whose strength $x(t)$ correspond to the signal values at $n = k$, where

$$x(t) = \sum_{n=-\infty}^{\infty} x(t)\delta(t-k) = \sum_{n=-\infty}^{\infty} x(t)\delta(t-nT)$$

Determine the z-transform for the analog signal $x(t) = e^{-aT}$ applied to a digital filter.

(9 marks)

(b) What is the purpose of using partial fraction expansion method in determining the inverse z-transform? By using this method, find the inverse z-transform of

$$H(z) = \frac{-10-20z^{-1}}{1+26z^{-1}+153z^{-2}}$$

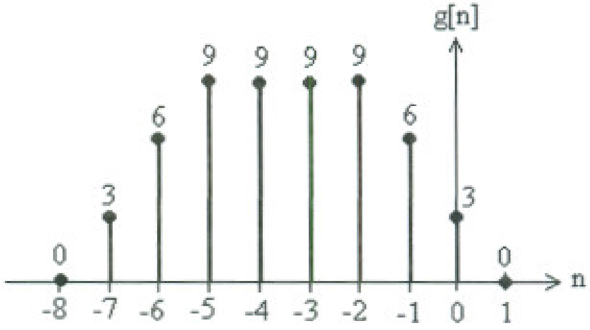
(11 marks)

Q6 State three advantages of using bilinear transformation in designing Infinite Impulse Response (IIR) filter. A Bessel filter is described by

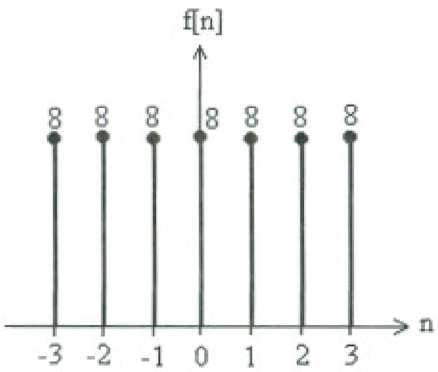
$$H(s) = \frac{3}{s^2+3s+3}$$

Design a digital filter whose magnitude at $f_0 = 3$ kHz equals the magnitude of $H(s)$ at $\omega_A = 4$ rad/s if the sampling rate $S = 12$ kHz. Show that the magnitude of $H(s)$ at $s = j4$ matches the magnitude of $H(z)$ at $z = j$.

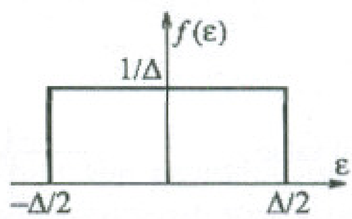
(20 marks)



Rajah S1(b) / Figure Q1(b)



Rajah S1(c) / Figure Q1(c)



Rajah S3 / Figure Q3

Identiti Euler / Euler's Identity

$e^{\pm j\pi/2} = \pm j$

$e^{\pm jk\pi} = \cos(k\pi)$

$\cos\theta = \frac{1}{2}\left(e^{j\theta} + e^{-j\theta}\right)$

$A\angle \pm\theta = Ae^{\pm j\theta}$

$e^{\pm j\theta} = \cos\theta \pm j\sin\theta$

$\sin\theta = \frac{1}{j2}\left(e^{j\theta} - e^{-j\theta}\right)$

Fungsi Sinc / Sinc Function

$$\text{sinc}(k) = \frac{\sin(\pi k)}{\pi k} = 1 - \frac{1}{3!}(\pi k)^2 + \frac{1}{5!}(\pi k)^4 - \frac{1}{7!}(\pi k)^6 + \ldots$$

Rumus Hasil Tambah Terhingga / Finite Summation Formula

$$\sum_{k=0}^{n} \alpha = \frac{n(n+1)}{2}$$

$$\sum_{k=0}^{n} \alpha^2 = \frac{n(n+1)(2n+1)}{6}$$

$$\sum_{k=0}^{n} \alpha^3 = \frac{n^2(n+1)^2}{4}$$

$$\sum_{k=0}^{n} \alpha^k = \frac{1-\alpha^{n+1}}{1-\alpha}, \quad \alpha \neq 1$$

$$\sum_{k=0}^{n} k\alpha^k = \frac{\alpha\left[1-(n+1)\alpha^n + n\alpha^{n+1}\right]}{(1-\alpha)^2}$$

$$\sum_{k=0}^{n} k^2\alpha^k = \frac{\alpha\left[(1+\alpha)-(n+1)^2\alpha^n + (2n^2+2n-1)\alpha^{n+1} - n^2\alpha^{n+2}\right]}{(1-\alpha)^3}$$

Rumus Hasil Tambah Tak Terhingga / Infinite Summation Formula

$$\sum_{k=0}^{\infty} \alpha^k = \frac{1}{1-\alpha}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} \alpha^k = \frac{\alpha}{1-\alpha}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} k\alpha^k = \frac{\alpha}{(1-\alpha)^2}, \qquad |\alpha| < 1$$

$$\sum_{k=1}^{\infty} k^2\alpha^k = \frac{\alpha^2+\alpha}{(1-\alpha)^3}, \qquad |\alpha| < 1$$

$$\sum_{k=-\infty}^{\infty} e^{-\alpha|k|} = \frac{1+e^{-\alpha}}{1-e^{-\alpha}}, \qquad \alpha > 0$$

Jadual 1 / Table 1: Pasangan Jelmaan-z / z-Transform Pairs

Signal $x(t)$	Sequence $x(n)$	z-Transform $X(z)$	ROC
$\delta(t)$	$\delta(n)$	1	All z-plane
$\delta(t-k)$	$\delta(n-k)$	z^{-k}	$\lvert z\rvert > 0, k > 0$ $\lvert z\rvert < \infty, k < 0$
$u(t)$	$u(n)$	$\frac{1}{1-z^{-1}} = \frac{z}{z-1}$	$\lvert z\rvert > 1$
	$-u(-n-1)$	$\frac{1}{1-z^{-1}} = \frac{z}{z-1}$	$\lvert z\rvert < 1$
$r(t) = tu(t)$	$nu(n)$	$\frac{z^{-1}}{(1-z^{-1})^2} = \frac{z}{(z-1)^2}$	$\lvert z\rvert > 1$
	$a^n u(n)$	$\frac{1}{1-az^{-1}} = \frac{z}{z-a}$	$\lvert z\rvert > \lvert a\rvert$
	$-a^n u(-n-1)$	$\frac{1}{1-az^{-1}} = \frac{z}{z-a}$	$\lvert z\rvert < \lvert a\rvert$
	$na^n u(n)$	$\frac{az}{(z-a)^2}$	$\lvert z\rvert > \lvert a\rvert$
	$-na^n u(-n-1)$	$\frac{az}{(z-a)^2}$	$\lvert z\rvert < \lvert a\rvert$
e^{-at}	e^{-an}	$\frac{1}{1-e^{-a}z^{-1}} = \frac{z}{z-e^{-a}}$	$\lvert z\rvert > \lvert e^{-a}\rvert$
t^2	$n^2 u(n)$	$z^{-1}\frac{(1+z^{-1})}{(1-z^{-1})^3} = \frac{z(z+1)}{(z-1)^3}$	$\lvert z\rvert > 1$
te^{-at}	ne^{-an}	$\frac{z^{-1}e^{-a}}{(1-e^{-a}z^{-1})^2} = \frac{ze^{-a}}{(z-e^{-a})^2}$	$\lvert z\rvert > \lvert e^{-a}\rvert$
$\sin\omega_o t$	$\sin\omega_o n$	$\frac{z\sin\omega_o}{z^2 - 2z\cos\omega_o + 1}$	$\lvert z\rvert > 1$
$\cos\omega_o t$	$\cos\omega_o n$	$\frac{z(z-\cos\omega_o)}{z^2 - 2z\cos\omega_o + 1}$	$\lvert z\rvert > 1$

Jadual 2 / Table 2: Jelmaan Laplace / Laplace Transform

Signal $x(t)$	**Laplace Transform $X(s)$**
$\delta(t)$	1
$u(t)$	$\frac{1}{s}$
$r(t) = tu(t)$	$\frac{1}{s^2}$
$t^2u(t)$	$\frac{2}{s^3}$
$t^n u(t)$	$\frac{n!}{s^{n+1}}$
$e^{-\alpha t}u(t)$	$\frac{1}{s+\alpha}$
$te^{-\alpha t}u(t)$	$\frac{1}{(s+\alpha)^2}$
$t^n e^{-\alpha t}u(t)$	$\frac{n!}{(s+\alpha)^{n+1}}$