Electrical Engineering Department

Signal Analysis (802321) – G1

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Second Term (1435-1436), Second Exam

Monday 08/07/1436 H

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Q 1. Choose the correct answer: Total 26 *Marks*

1. Which statement is correct? 1½ *Mark*

a) $\delta(t)$ is undefined at $t = \pm\infty$
b) $\delta[n]$ is undefined at $n = 0$
c) $\delta(t) = 1$ at $t = 0$
d) $\delta[n] = 1$ at $n = 0$

2. In the cascade (series) interconnection of systems: 1½ *Mark*

a) The total output is the output of the last system.
b) The output of the second system is fed back and added to external input.
c) The total output is the sum of the outputs of all systems.
d) The input is processed by all systems simultaneously.

3. In non-memoryless (dynamic) systems, the output at any instant depends on input values at: 1½ *Mark*

a) The same or past time.
b) The same and (past and / or future) time.
c) The same time only.
d) The same and past time only.

4. A capacitor system whose input is $i(t)$ and output is $v(t)$ is: 1½ *Mark*

a) Memoryless and causal.
b) Memoryless and non-causal.
c) Non-memoryless and causal.
d) Non-memoryless and non-causal.

5. Given the periodic signal $x(t)$ with the Fourier series representation: 1½ *Mark*

$x(t) = \sum_{k=-\infty}^{\infty} a_k e^{j2k\pi t}$, the fundamental period T of $x(t)$ equals:

a) 1 sec
b) π sec
c) 2 sec
d) 2π sec

6. Fourier series is expressed as: $x(t) = a_o + 2\sum_{k=1}^{\infty} A_k \cos(k\omega_0 t + \phi_k)$ if: 1½ *Mark*

a) $x(t)$ is complex but $\{a_k\}$are real.
b) $x(t)$ and $\{a_k\}$ are real.
c) $x(t)$ and $\{a_k\}$ are complex.
d) $x(t)$ is real but $\{a_k\}$are complex.

7. Fourier series is expressed in terms of sine waves only if: 1½ *Mark*

a) $Re\{a_k\} = 0$ & $Im\{a_k\} = 0$.
b) $Re\{a_k\} = 0$ & $Im\{a_k\} \neq 0$.
c) $Re\{a_k\} \neq 0$ & $Im\{a_k\} = 0$.
d) $Re\{a_k\} \neq 0$ & $Im\{a_k\} \neq 0$.

8. The system $y(t) = x^2(-t)$ is: 1½ *Mark*

a) Invertible and causal.
b) Non-invertible and causal.
c) Invertible and non-causal.
d) Non-invertible and non-causal.

9. Which relation is correct? 1 *Mark*

a) $u[n] = \delta[n] + \delta[n-1]$
b) $\delta[n] = u[n] + u[n-1]$
c) $u[n] = \delta[n] - \delta[n-1]$
d) $\delta[n] = u[n] - u[n-1]$

10. The <u>running sum</u> of the function $x[n]$ is: 1 *Mark*

a) $\sum_{m=-\infty}^{n} x[m]$
b) $\sum_{m=0}^{n} x[m]$
c) $\sum_{m=-\infty}^{\infty} x[m]$
d) $\sum_{m=1}^{\infty} x[m]$

11. Which one of the following systems is <u>causal</u>? 1 *Mark*

a) $y(t) = x(-t+2)$
b) $y(t) = x(-2t)$
c) $x(t) = \sum_{n=t-1}^{\infty} x(n)$
d) $x(t) = \sum_{n=-\infty}^{t-1} x(n)$

12. The system $y(t) = x(4-t)$ is: 1 *Mark*

a) Causal and memoryless.
b) Non-causal and memoryless.
c) Causal and non-memoryless.
d) Non-causal and non-memoryless.

13. The system $y(t) = x(4-t)$ is: 1 *Mark*

a) Linear and time-invariant
b) Nonlinear and time-invariant
c) Linear and time-variant
d) Nonlinear and time-variant

14. Which one of the following systems is linear? 1 *Mark*

a) $y[n] = \cos(x[n])$
b) $y[n] = \log(x[n])$
c) $y[n] = x^3[n]$
d) $y[n] = (n-1)\, x[n]$

15. Given a square wave with the following characteristics: 1 *Mark*

$x(t) = \begin{cases} 1, & |t| \le 1 \\ 0, & 1 \le |t| \le 2 \end{cases}$

The Fourier series coefficients are:

a) $a_0 = ½$, $a_k = (1/k\pi) \sin(k\pi)$ for $k \neq 0$
b) $a_0 = ½$, $a_k = (1/k\pi) \sin(k\pi/2)$ for $k \neq 0$
c) $a_0 = 1$, $a_k = (1/k\pi) \sin(k\pi/2)$ for $k \neq 0$
d) $a_0 = 1$, $a_k = (1/k\pi) \sin(k\pi)$ for $k \neq 0$

16. For the periodic signal: $x(t) = \cos\left(\frac{\pi}{t}\right)$ for $0 < t \le 2$: 1 *Mark*

a) $\omega_0 = \pi$, and $\{a_k\}$ are valid.
b) $\omega_0 = \pi$, and $\{a_k\}$ are invalid.
c) $\omega_0 = \frac{\pi}{t}$, and $\{a_k\}$ are invalid.
d) $\omega_0 = \frac{\pi}{t^2}$, and $\{a_k\}$ are invalid.

17. Which one of the following periodic signals is not absolutely integrable: 1 *Mark*

a) $x(t) = \tan t$, $0 \leq t \leq 1$

b) $x(t) = t^2$, $0 \leq t \leq 1$

c) $x(t) = \ln t$, $½ \leq t \leq 1$

d) $x(t) = \frac{1}{t}$, $0 \leq t \leq 1$

18. Given the impulse train signal $\delta_{T_0}(t)$ whose Fourier series representation is 1 *Mark*

$\delta_{T_0}(t) = \sum_{k=-\infty}^{\infty} a_k e^{jk\pi t}$. The coefficients a_k are:

a) $a_k = ½$ for all values of k.

b) $a_k = 2$ for all values of k.

c) $a_0 = ½$, $a_k = 1$ for $k \neq 0$.

d) $a_0 = ½$, $a_k = (1/k\pi) \sin(k\pi)$ for $k \neq 0$.

19. Given the signal: $x(t) = 1 + \cos\frac{16\pi}{3}t + \frac{1}{2}\cos 4\pi t - \sin\frac{4\pi}{3}t$. 1 *Mark*

The fundamental period of $x(t)$ is:

a) 0.5

b) 0.4

c) 1.5

d) None of the above.

20. In the signal $x(t)$ given in Q19, the harmonics which exist are: 1 *Mark*

a) 1st, 2nd and 3rd.

b) 1st, 2nd and 4th.

c) 2nd, 3rd and 4th.

d) 1st, 3rd and 4th.

21. Fourier series approximates the periodic signal by: 1 *Mark*

a) A summation of finite number of harmonically-related sinusoidal signals.

b) A summation of finite/infinite number of harmonically-related sinusoidal signals.

c) A linear combination of infinite number of harmonically-related sinusoidal signals.

d) A linear combination of finite/infinite number of harmonically-related sinusoidal signals.

22. Fourier series can be used to represent: 1 *Mark*

a) All periodic signals.

b) Almost all periodic signals.

c) Large set of periodic signals.

d) Some periodic signals.

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Q 2. A periodic signal is given by: 3 *Marks*

$$x(t) = 2 + \cos\left(\frac{4\pi}{3}t\right) + \frac{1}{2}\cos\left(\frac{10\pi}{3}t\right)$$

a. What is the fundamental period T ?
b. What is the fundamental frequency ω_0?
c. Find the Fourier series coefficients a_k?

Hints:

1. *The first harmonic does not exist in the signal $x(t)$. So you cannot extract T and ω_0 directly from the equation. You need to calculate them.*
2. *The coefficients a_k can be directly worked out from the equation after finding the harmonics which exist in the signal $x(t)$.*

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Solution of Q2:

a. For $\cos\left(\frac{4\pi}{3}t\right)$: $T_1 = \frac{2\pi}{4\pi/3} = \frac{3}{2} = 1.5$

For $\cos\left(\frac{10\pi}{3}t\right)$: $T_2 = \frac{2\pi}{10\pi/3} = \frac{3}{5} = 0.6$

Fundamental period $= T = LCM(T_1, T_2) = LCM(1.5, 0.6) = 3.0$ (i.e. *LCM is the Least Common Multiple*)

b. $\omega_0 = \frac{2\pi}{T} = \frac{2\pi}{3}$

c. $a_0 = 2,\ a_2 = a_{-2} = \frac{1}{2},\ a_5 = a_{-5} = \frac{1}{4}$

Since:

$2a_2 \cos\left(\frac{4\pi}{3}t\right) = \cos\left(\frac{4\pi}{3}t\right)$, and $2\ a_5 \cos\left(\frac{10\pi}{3}t\right) = \frac{1}{2}\cos\left(\frac{10\pi}{3}t\right)$

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