Subject: Signals and Systems

2 Mark Questions and Answers

1.Define Signal.

Signal is a physical quantity that varies with respect to time , space or any other independent variable.

Or

It is a mathematical representation of the system

Eg $y(t) = t$. and $x(t)= \sin t$.

2. Define system .

A set of components that are connected together to perform the particular task.

3.What are the major classifications of the signal?

(i) Discrete time signal
(ii) Continuous time signal

4.Define discrete time signals and classify them.

Discrete time signals are defined only at discrete times, and for these signals, the independent variable takes on only a discrete set of values.

Classification of discrete time signal:

1.Periodic and Aperiodic signal
2.Even and Odd signal

5.Define continuous time signals and classify them.

Continuous time signals are defined for a continuous of values of the independent variable. In the case of continuous time signals the independent variable is continuous. For example:

(i) A speech signal as a function of time
(ii) Atmospheric pressure as a function of altitude

Classification of continuous time signal:

(i) Periodic and Aperiodic signal
(ii) Even and Odd signal

6.Define discrete time unit step &unit impulse.

Discrete time Unit impulse is defined as

$$\delta[n] = \begin{cases} 0, & n \neq 0 \\ 1, & n=0 \end{cases}$$

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

$U[n]=\{0, n=0$
$\{1, n>= 0$

7. Define continuous time unit step and unit impulse.

Continuous time unit impulse is defined as

$\delta (t)=\{1, t=0$
$\{0, t \neq 0$

Continuous time Unit step signal is defined as

$U(t)=\{0, t<0$
$\{1, t\geq 0$

8. Define unit ramp signal.

Continuous time unit ramp function is defined by

$r(t)=\{0, t<0$
$\{t, t\geq 0$

A ramp signal starts at t=0 and increases linearly with time 't'.

9. Define periodic signal. and nonperiodic signal.

A signal is said to be periodic ,if it exhibits periodicity.i.e.,

$X(t+T)=x(t)$, for all values of t.

Periodic signal has the property that it is unchanged by a time shift of T.

A signal that does not satisfy the above periodicity property is called an aperiodic signal.

10. Define even and odd signal ?

A discrete time signal is said to be even when,

$x[-n]=x[n]$.

The continuous time signal is said to be even when,

$x(-t)= x(t)$

For example,Cosωn is an even signal.

The discrete time signal is said to be odd when

$x[-n]= -x[n]$

The continuous time signal is said to be odd when

$x(-t)= -x(t)$

Odd signals are also known as nonsymmetrical signal.
Sine wave signal is an odd signal.

11. Define Energy and power signal.

A signal is said to be energy signal if it have finite energy and zero power.
A signal is said to be power signal if it have infinite energy and finite power.
If the above two conditions are not satisfied then the signal is said to be neigther energy nor power signal

12.Define unit pulse function.

Unit pulse function $\prod(t)$ is obtained from unit step signals

$$\prod(t)=u(t+1/2)- u(t-1/2)$$

The signals $u(t+1/2)$ and $u(t-1/2)$ are the unit step signals shifted by 1/2units in the time axis towards the left and right ,respectively.

13.Define continuous time complex exponential signal.

The continuous time complex exponential signal is of the form

$$x(t)=Ce^{at}$$

where c and a are complex numbers.

14.What is continuous time real exponential signal.

Continuous time real exponential signal is defined by

$$x(t)=Ce^{at}$$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

15.What is continuous time growing exponential signal?

Continuous time growing exponential signal is defined as

$$x(t)=Ce^{at}$$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

16.What is continuous time decaying exponential?

Continuous time growing exponential signal is defined as

$$x(t)=Ce^{at}$$

where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

17.What are the types of Fourier series?

1. Exponential Fourier series
2. Trigonometric Fourier series

18.Write down the exponential form of the fourier series representation of a periodic signal?

$$x(t)=\sum a_k e^{jk\omega ot}$$

Here the summation is taken from $-\infty$ to ∞.

$$a_k=1/T \int x(t) e^{-jk\omega ot}$$

Here the integration is taken from 0 to T.

The set of coefficients $\{ a_k\}$ are often called the fourier series coefficients or spectral coefficients.

The coefficient a_o is the dc or constant component of x(t).

19.Write down the trigonometric form of the fourier series representation of a periodic signal?

$x(t)= a_o+\sum [a_n \cos n\omega ot + b_n \sin n\omega ot]$

where

$a_o=1/T \int x(t)\, dt$

$a_n =1/T \int x(t)\cos n\omega ot\, dt$

$b_n=1/T \int x(t)\cos n\omega ot\, dt$

20.Write short notes on dirichlets conditions for fourier series.

a. x(t) must be absolutely integrable
b. The function x(t) should be single valued within the interval T.
c. The function x(t) should have finite number of discontinuities in any finite interval of time T.
d. The function x(t) should have finite number of maxima &minima in the interval T.

21.State Time Shifting property in relation to fourier series.

$x(t-to) \xrightarrow{FS} a_k e^{-jk\omega ot}$

Time shifting property states that; when a periodic signal is shifted in time, the magnitudes of its fourier series coefficients, remain unaltered.

22.State parseval's theorem for continuous time periodic signals.

Parseval's relation for continuous time periodic signals is

$1/T \int |x(t)^2|\, dt =\sum| a_k^2|$

Parseval's relation states that the total average power in a periodic signal equals the sum of the average power in all of its harmonic components.

Part B(6 Marks)

1 Explain in detail elementary DT signal.

Discrete time Unit impulse is defined as

$\delta [n]= \{0, n\neq 0$

{1, n=0

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

U[n]={0,n=0

{1,n>= 0

Continuous time unit impulse is defined as

δ (t)={1, t=0

{0, t ≠ 0

Continuous time Unit step signal is defined as

U(t)={0, t<0

{1, t≥0

Continuous time unit ramp function is defined by

r(t)={0,t<0

{t, t≥0

A ramp signal starts at t=0 and increases linearly with time 't'.

2. Find the energy of the signal $x(n) = (½)^n u(n)$.

Given: $x(n) = (½)^n u(n)$

$$E = \underset{N\to\alpha}{Lt} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=-N}^{N} |(½)^n u(n)|^2$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=0}^{N} (½)^{2n}$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=0}^{N} (1/4)^n \quad \alpha$$

$$E= \frac{1}{1-0.25}$$

$$E = \frac{4}{3}$$

2. Explain in detail complex exponential CT signal.

The continuous time complex exponential signal is of the form

$x(t)=Ce^{at}$

where c and a are complex numbers.

Continuous time real exponential signal is defined by

$x(t)=Ce^{at}$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

4.Find the odd and even components of the signal cost + sint + cost sint.

Given:

X(t) = cost + sint + cost sint

X(-t)= cos(-t) + sin(-t) + cos(-t) sin(-t)

= cost - sint - cost sint

$$Xe(t)= \frac{1}{2}\left[x(t)+x(-t)\right]$$

$$= \frac{1}{2}\left[\cos t+\sin t+\cos t\sin t+\cos t-\sin t-\cos t\sin t\right]$$

$$= \frac{1}{2}\left[2\cos t+2\cos t\sin t\right]$$

Xe(t)= cost + cost sint.

$$Xo(t)= \frac{1}{2}\left[x(t)-x(-t)\right]$$

$$=\frac{1}{2}\left[\cos t+\sin t+\cos t\sin t-\cos t+\sin t-\cos t\sin t\right]$$

$$=\frac{1}{2}\left[2\sin t\right]$$

Xo(t)= sint

Xe(t)= cost + cost sint

Xo(t)= sint

5. Find the odd and even components of the x(n)={1,2,2,3,4}.

Given: x(n)={1,2,2,3,4}.

Solution:

x(n) ={1,2,2,3,4}.

X(-n) = {4,3,2,2,1}.

$$X_e(n) = \frac{1}{2}\{x(n)+x(-n)\}$$

$$=\frac{1}{2}\{x(n)+x(-n)\}$$

$$= \frac{1}{2}\{1+4, \quad 2+3, \; 2+2, \; 3+2, \; 4+1\}$$

$$=\frac{1}{2}\{5 \;, 5 \;, 4, 5, 5\}$$

$$= \{2.5, 2.5, 2, 2.5, 2.5\}$$

$$X_o(n) = \frac{1}{2}\{x(n)-x(-n)\}$$

$$=\frac{1}{2}\{x(n)-x(-n)\}$$

$$= \frac{1}{2}\{1-4, \quad 2-3, \; 2-2, \; 3-2, \; 4-1\}$$

$$=\frac{1}{2}\{-3 \;, -1 \;, 0, 1, 3\}$$

$$= \{-1.5, -0.5, 0, 0.5, 1.5\}$$

x (n) ={1, 2, 2, 3, 4 }.

$X_e(n)$ = {2.5, 2.5, 2, 2.5, 2.5}

$X_o(n)$ = {-1.5, -0.5, 0, 0.5, 1.5}

6.Find the energy of the signal e^{-2t} u(t).

Given: $x(t) = e^{-2t} u(t)$

$$E = \underset{T\to\alpha}{Lt} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt} \left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt} \frac{-1}{4}\left[e^{-2T} - 1\right]$$

$$E = \frac{-1}{4}[0 - 1]$$

$$\text{Energy, } E = \frac{1}{4}$$

7.Determine the power of the signal e^{-2t} u(t).

Solution:

$$P = \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_0^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt} \frac{1}{T} \left[\frac{e^{-4t}}{-4} \right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \frac{-1}{4} \left[e^{-2T} - 1 \right]$$

$$P = \underset{T\to\alpha}{Lt} \frac{1}{4T} \left[e^{-2T} - e^{0} \right]$$

P= 0

Power , P = 0

.

8. Test Whether the signal y(t) = ax(t) + b is linear or non linear.

Solution:

y(t) = ax(t) + b

$y_1(t)$ is the output of input signal $x_1(t)$

$y_1(t) = a x_1(t) + b$

similarly, $y_2(t)$ is the output of input signal $x_2(t)$

$y_2(t) = a x_2(t) + b$

Now $x_1(t)$ and $x_2(t)$ related with $x_3(t)$

ie , $x_3(t) = a x_1(t) + b x_2(t)$

The output $y_3(t)$ defined as $y_3(t) = a x_3(t) + b$

$= a [a x_1(t) + b x_2(t)] + b$

$= a . a x_1(t) + a. b x_2(t) + b$

$\neq a \ y_1(t) + b y_2(t)$

Hence the system is non linear.

9. Find the power and rms value of signal x(t)=20cos2πt.

Given: x(t)=20cos2πt.

$$P = \underset{T\to\alpha}{Lt}\frac{1}{2T}\int_{-T}^{T}|x(t)|^2\,dt$$

$$= \underset{T\to\alpha}{Lt}\frac{1}{2T}\int_{-T}^{T}|20\cos 2\pi t.|^2\,dt$$

$$= \underset{T\to\alpha}{Lt}\frac{1}{2T}\int_{-T}^{T}400\cos^2 2\pi t.\,dt$$

$$= \underset{T\to\alpha}{Lt}\frac{400}{4T}\int_{-T}^{T}(1+\cos 4\pi t)(dt\ \alpha$$

$$\underset{T\to\alpha}{Lt}\frac{400}{4T}\int_{-T}^{T}1dt + 0$$

$$= \underset{T\to\alpha}{Lt}\frac{400}{4T}\left[T-(-T)\right]$$

$$P = \underset{T\to\alpha}{Lt}\frac{400}{4T}\left[2T\right]$$

Power P= 200.

The r.m.s value = $\sqrt{200}$ = 14.14.

***10.* Explain the following signals.**

(i) Periodic and aperiodic

(ii) Even and odd

*(i) P*eriodic and aperiodic

A signal is said to be periodic ,if it exhibits periodicity.i.e.,

X(t +T)=x(t), for all values of t.

Periodic signal has the property that it is unchanged by a time shift of T.

A signal that does not satisfy the above periodicity property is called an aperiodic signal.

(ii) Even and odd

A discrete time signal is said to be even when,

x[-n]=x[n].

The continuous time signal is said to be even when, x(-t)= x(t)

For example,Cosωn is an even signal.

The discrete time signal is said to be odd when

x[-n]= -x[n]

The continuous time signal is said to be odd when

x(-t)= -x(t)

Odd signals are also known as nonsymmetrical signal.

Sine wave signal is an odd signal.

Part C (10 marks)

1 .Find the trigonometric fourier series for half wave rectified sine wave.

Solution

$$x(t)= a_o+\sum_{n=1}^{\alpha} a_n \cos n\omega_0 t + \sum_{n=1}^{\alpha} b_n \sin n\omega_0 t$$

where

$a_o=1/T \int x(t)\, dt$

$a_n =1/T \int x(t)\cos n\omega ot\, dt$

$b_n=1/T \int x(t)\cos n\omega ot\, dt$

x(t)={sint, $\pi > t >= 0$

0, $2\pi > t > \pi$

The fundamental period ,T= 2π

The fundamental frequency $\omega_0 = \frac{2\pi}{T} = 1$,

$$a_0 = \frac{1}{T}\int_{t_0}^{t_0+T} x(t)dt$$

$$= \frac{1}{2\pi}\int_{0_0}^{\pi} \sin tdt$$

$$= \frac{1}{2\pi}\left[-\cos t\right] \Big|_0^{\pi}$$

$$= \frac{1}{\pi}$$

$$a_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\cos n\omega_0 t dt$$

$$= \frac{2}{2\pi}\int_{t_0}^{t_0+T} \sin t \cos nt dt$$

$$= \frac{1}{\pi}\int_0^{\pi} \frac{1}{2}\left[\sin(n+1)t + \sin(1-n)t\right]dt$$

$$= \frac{1}{2\pi}\int_0^{\pi} \sin(n+1)t dt + \frac{1}{2\pi}\int_0^{\pi} \sin(1-n)t \, \mathrm{dt}$$

$$= \frac{1}{\pi}\left[\frac{1+(-1)^n}{1-n^2}\right]$$

To find b_n

$$b_n =_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\sin n\omega_0 t dt$$

$$= \frac{2}{2\pi}\int_{t_0}^{t_0+T} \sin t \sin nt dt$$

$$= \frac{1}{\pi}\int_0^{\pi} \frac{1}{2}\left[\cos(n-1)t - \cos(n+1)t\right]dt$$

$$= \frac{1}{2\pi}\int_0^{\pi} \sin(n+1)t dt + \frac{1}{2\pi}\int_0^{\pi} \sin(1-n)t \, \mathrm{dt}$$

$$= \frac{1}{2\pi}\left[\frac{\sin(n-1)\pi - \sin 0}{(n-1)} - \frac{\sin(n+1)\pi - \sin 0}{(n+1)}\right]$$

$$= 0$$

$$\mathrm{X(t)} = \frac{1}{\pi} + \frac{1}{\pi}\sum\left[\frac{1+(-1)^n}{1-n^2}\cos n\omega_0 t\right] + \frac{1}{2}\sin \omega_0 t$$

2.Find the trigonometric fourier series representation of a periodic square wave
x(t) = 1, for the interval (0 , π).
= 0,for the interval (π , 2π)

$$x(t)= a_o+\sum_{n=1}^{\alpha} a_n \cos n\omega_0 t + \sum_{n=1}^{\alpha} b_n \sin n\omega_0 t$$

where

a_o=1/T ∫ x(t) dt

a_n =1/T ∫ x(t)cos nωot dt

b_n=1/T ∫ x(t)cos nωot dt

x(t)={1, $\pi > t >= 0$
-1 , $2\pi > t > \pi$

The fundamental period ,T= 2π

The fundamental frequency $\omega_0 = \frac{2\pi}{T} = 1$,

$$a_0 = \frac{1}{T}\int_{t_0}^{t_0+T} x(t)dt$$

$$= \frac{1}{2\pi}\int_{0_0}^{\pi} 1dt + \frac{1}{2\pi}\int_{\pi}^{2\pi}(-1)dt$$

$$= 0$$

$$a_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\cos n\omega_0 t dt$$

$$= \frac{2}{2\pi}\int_{0_0}^{\pi} 1\cos nt dt + \frac{2}{2\pi}\int_{\pi}^{2\pi}(-1)\cos nt dt$$

$$= \frac{1}{n\pi}\left[(\sin n\pi - \sin 0) - (\sin 2n\pi - \sin n\pi)\right]$$

$$= 0$$

To find b_n

$$b_n =_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\sin n\omega_0 t dt$$

$$= \frac{2}{2\pi} \int_{t_0}^{t_0+T} \sin t \sin ntdt$$

$$= \frac{1}{\pi} \int_{0}^{\pi} 1.\sin ntdt + \frac{1}{\pi} \int_{\pi}^{2\pi} (-1).\sin ntdt$$

$$= \frac{1}{n\pi} \left[-(\cos n\pi - \cos 0) + (\cos n2\pi - \cos n\pi) \right]$$

$$= \frac{1}{n\pi} \left\{ -\left[(-1)^n - 1 \right] + \left[1 - (-1)^n \right] \right\}$$

$$= \frac{2}{n\pi} \left[1 - (-1)^n \right]$$

$$X(t) = \sum_{n=1}^{\alpha} \frac{2}{n\pi} \left[1 - (-1)^n \right] \sin nt$$

3. Test Whether the signal x(n) = (½)^{n} u(n) energy or power signal.

Given: x(n) = (½)^{n} u(n)

$$E = \underset{N \to \alpha}{Lt} \sum_{n=-N}^{N} | x(n) |^2$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=-N}^{N} | (½)^{n} u(n) |^2$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=0}^{N} (½)^{2n}$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=0}^{N} (1/4)^{n} \quad \alpha$$

$$= \frac{1}{1-0.25} = \frac{4}{3} < \alpha$$

$$P = \underset{N\to\alpha}{Lt} \frac{1}{2N+1} \sum_{n=-N}^{N} | x(n) |^2$$

$$= \underset{N\to\alpha}{Lt} \frac{1}{2N+1} \sum_{n=-N}^{N} | (1/2)^n u(n) |^2$$

$$= \underset{N\to\alpha}{Lt} \frac{1}{2N+1} \sum_{n=-N}^{N} (1/2)^{2n}$$

$$= \underset{N\to\alpha}{Lt} \frac{1}{2N+1} \sum_{n=-N}^{N} (1/4)^{n}$$

$$= \frac{1}{\alpha} = 0$$

E=finite and P=0

Hence the signal is Energy signal

Energy, E= $\frac{1}{4}$

4. Test Whether the signal x(t) = e^{-2t} u(t).) energy or power signal.

Given: x(t) = e^{-at} u(t)

$$E = \underset{T\to\alpha}{Lt} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt} \left[\frac{e^{-4t}}{-4} \right]_{0}^{T/2}$$

$$= \underset{T\to\alpha}{Lt} \frac{-1}{4}\left[e^{-2T} - 1\right]$$

$$E= \frac{-1}{4}\left[0 - 1\right]$$

$$\text{Energy, } E= \frac{1}{4}$$

$$P= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{-T/2}^{T/2} \left|x(t)\right|^2 dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} \left|\mathrm{e}^{-2t}\right|^2 dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} \left|\mathrm{e}^{-2t}\right|^2 dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt} \frac{1}{T} \left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \frac{-1}{4}\left[e^{-2T} - 1\right]$$

$$P= \underset{T\to\alpha}{Lt} \frac{1}{4T}\left[e^{-2T} - e^{0}\right]$$

P= 0

Hence the signal is Energy signal

5. Explain in detail different classification of signals.

signal

Signal is a physical quantity that varies with respect to time , space or any other independent variable.

Or

It is a mathematical representation of the system

Eg y(t) = t. and x(t)= sin t.

Signal is mainly classified as

(i).Continuous time signal
(ii).Discrete time signal

continuous time signals

Continuous time signals are defined for a continuous of values of the independent variable. In the case of continuous time signals the independent variable is continuous. For example:

(iii) A speech signal as a function of time
(iv) Atmospheric pressure as a function of altitude

Classification of continuous time signal:

(iii) Periodic and Aperiodic signal
(iv) Even and Odd signal

Discrete time signals

Discrete time signals are defined only at discrete times, and for these signals, the independent variable takes on only a discrete set of values.

Classification of discrete time signal:

1.Periodic and Aperiodic signal
2.Even and Odd signal

Elementary signal

Discrete time Unit impulse is defined as

$$\delta[n] = \begin{cases} 0, & n \neq 0 \\ 1, & n=0 \end{cases}$$

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

$$U[n] = \begin{cases} 0, & n=0 \\ 1, & n>=0 \end{cases}$$

Continuous time unit impulse is defined as

$$\delta(t) = \begin{cases} 1, & t=0 \\ 0, & t \neq 0 \end{cases}$$

Continuous time Unit step signal is defined as

$$U(t) = \begin{cases} 0, & t<0 \\ 1, & t\geq 0 \end{cases}$$

Continuous time unit ramp function is defined by

$$r(t) = \begin{cases} 0, & t<0 \\ t, & t\geq 0 \end{cases}$$

A ramp signal starts at t=0 and increases linearly with time ‘t’

Complex exponential CT signal.

The continuous time complex exponential signal is of the form

$x(t)=Ce^{at}$

where c and a are complex numbers.

Continuous time real exponential signal is defined by

$x(t)=Ce^{at}$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

Continuous time growing exponential signal is defined as

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where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

NOORUL ISLAM UNIVERSITY, KUMARACOIL.

DEPARTMENT OF

ELECTRONICS AND COMMUNICATION ENGINEERING.

QUESTIONS &ANSWERS BANK

SUBJECT CODE: EC 203

SUBJECT NAME: SIGNALS AND SYSTEMS

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Electronics &Communication Engineering

Subject code: EC203

Subject: Signals and Systems

(For IV semester ECE)

Questions Bank

UNIT I

2 Mark Questions and Answers

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Or

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Eg $y(t) = t$. and $x(t)= \sin t$.

2. Define system .

A set of components that are connected together to perform the particular task.

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Discrete time signals are defined only at discrete times, and for these signals, the independent variable takes on only a discrete set of values.

Classification of discrete time signal:

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2.Even and Odd signal

5.Define continuous time signals and classify them.

Continuous time signals are defined for a continuous of values of the independent variable. In the case of continuous time signals the independent variable is continuous.
For example:

(v) A speech signal as a function of time
(vi) Atmospheric pressure as a function of altitude

Classification of continuous time signal:

(v) Periodic and Aperiodic signal
(vi) Even and Odd signal

6.Define discrete time unit step &unit impulse.

Discrete time Unit impulse is defined as

$\delta [n]= \{0, n\neq 0$
$\{1, n=0$

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

$U[n]=\{0,n=0$
$\{1,n>= 0$

12. Define continuous time unit step and unit impulse.

Continuous time unit impulse is defined as

$\delta (t)=\{1, t=0$

{0, $t \neq 0$

Continuous time Unit step signal is defined as

U(t)={0, t<0

{1, t≥0

13. Define unit ramp signal.

Continuous time unit ramp function is defined by

r(t)={0,t<0

{t, t≥0

A ramp signal starts at t=0 and increases linearly with time 't'.

14. Define periodic signal. and nonperiodic signal.

A signal is said to be periodic ,if it exhibits periodicity.i.e.,

X(t +T)=x(t), for all values of t.

Periodic signal has the property that it is unchanged by a time shift of T.

A signal that does not satisfy the above periodicity property is called an aperiodic signal.

15. Define even and odd signal ?

A discrete time signal is said to be even when,

x[-n]=x[n].

The continuous time signal is said to be even when,

x(-t)= x(t)

For example,Cosωn is an even signal.

The discrete time signal is said to be odd when

x[-n]= -x[n]

The continuous time signal is said to be odd when

x(-t)= -x(t)

Odd signals are also known as nonsymmetrical signal.

Sine wave signal is an odd signal.

16. Define Energy and power signal.

A signal is said to be energy signal if it have finite energy and zero power.

A signal is said to be power signal if it have infinite energy and finite power.

If the above two conditions are not satisfied then the signal is said to be neigther energy nor power signal

12.Define unit pulse function.

Unit pulse function ∏(t) is obtained from unit step signals

∏(t)=u(t+1/2)- u(t-1/2)

The signals u(t+1/2) and u(t-1/2) are the unit step signals shifted by 1/2units in the time axis towards the left and right ,respectively.

13.Define continuous time complex exponential signal.

The continuous time complex exponential signal is of the form

$x(t)=Ce^{at}$

where c and a are complex numbers.

14.What is continuous time real exponential signal.

Continuous time real exponential signal is defined by

$x(t)=Ce^{at}$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

15.What is continuous time growing exponential signal?

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

16.What is continuous time decaying exponential?

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

17.What are the types of Fourier series?

1. Exponential Fourier series
2. Trigonometric Fourier series

18.Write down the exponential form of the fourier series representation of a periodic signal?

$x(t)=\sum a_k e^{jk\omega ot}$

Here the summation is taken from -∞ to ∞.

$a_k=1/T \int x(t) e^{-jk\omega ot}$

Here the integration is taken from 0 to T.

The set of coefficients { a_k} are often called the fourier series coefficients or spectral coefficients.

The coefficient a_o is the dc or constant component of x(t).

19.Write down the trigonometric form of the fourier series representation of a periodic signal?

$x(t)= a_o+\sum [a_n \cos n\omega ot + b_n \sin n\omega ot]$

where

$a_o=1/T \int x(t)\, dt$

$a_n = 1/T \int x(t) \cos n\omega ot\, dt$

$b_n=1/T \int x(t) \cos n\omega ot\, dt$

20.Write short notes on dirichlets conditions for fourier series.

a. x(t) must be absolutely integrable
b. The function x(t) should be single valued within the interval T.
c. The function x(t) should have finite number of discontinuities in any finite interval of time T.
d. The function x(t) should have finite number of maxima &minima in the interval T.

21.State Time Shifting property in relation to fourier series.

$x(t-to) \xrightarrow{FS} a_k e^{-jk\omega ot}$

Time shifting property states that; when a periodic signal is shifted in time, the magnitudes of its fourier series coefficients, remain unaltered.

22.State parseval's theorem for continuous time periodic signals.

Parseval's relation for continuous time periodic signals is

$1/T \int |x(t)^2| \, dt = \sum | a_k^2 |$

Parseval's relation states that the total average power in a periodic signal equals the sum of the average power in all of its harmonic components.

Part B(6 Marks)

1 Explain in detail elementary DT signal.

Discrete time Unit impulse is defined as

$\delta [n]= \{0, n\neq 0$
$\{1, n=0$

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

$U[n]=\{0,n=0$
$\{1,n>= 0$

Continuous time unit impulse is defined as

$$\delta(t)=\begin{cases}1, & t=0\\ 0, & t\neq 0\end{cases}$$

Continuous time Unit step signal is defined as

$$U(t)=\begin{cases}0, & t<0\\ 1, & t\geq 0\end{cases}$$

Continuous time unit ramp function is defined by

$$r(t)=\begin{cases}0, & t<0\\ t, & t\geq 0\end{cases}$$

A ramp signal starts at t=0 and increases linearly with time 't'.

2. Find the energy of the signal $x(n) = (½)^n u(n)$.

Given: $x(n) = (½)^n u(n)$

$$E = \underset{N\to\alpha}{Lt} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=-N}^{N} |(½)^n u(n)|^2$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=0}^{N} (½)^{2n}$$

$$= \underset{N\to\alpha}{Lt} \sum_{n=0}^{N} (1/4)^n \quad \alpha$$

$$E= \frac{1}{1-0.25}$$

$$E = \frac{4}{3}$$

3. Explain in detail complex exponential CT signal.

The continuous time complex exponential signal is of the form

$x(t)=Ce^{at}$

where c and a are complex numbers.

Continuous time real exponential signal is defined by

$x(t)=Ce^{at}$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

4.Find the odd and even components of the signal cost + sint + cost sint.

Given:

X(t) = cost + sint + cost sint

X(-t)= cos(-t) + sin(-t) + cos(-t) sin(-t)

= cost - sint - cost sint

$$Xe(t)= \frac{1}{2}[x(t)+x(-t)]$$

$$= \frac{1}{2}[\text{cost}+\text{sint}+\text{cost sint}+\text{cost}-\text{sint}-\text{cost sint}]$$

$$= \frac{1}{2}[2\text{cost}+2\text{costsint}]$$

Xe(t)= cost + cost sint.

$$Xo(t)= \frac{1}{2}[x(t)-x(-t)]$$

$$= \frac{1}{2}[\text{cost}+\text{sint}+\text{cost sint - cost}+\text{sint}-\text{cost sint}]$$

$$= \frac{1}{2}[2\text{sint}]$$

Xo(t)= sint

Xe(t)= cost + cost sint

Xo(t)= sint

5. Find the odd and even components of the x(n)={1,2,2,3,4}.

Given: x(n)={1,2,2,3,4}.

Solution:

$$x(n) = \{1,2,2,3,4\}.$$

$$X(-n) = \{4,3,2,2,1\}.$$

$$X_e(n) = \frac{1}{2}\{x(n) + x(-n)\}$$

$$= \frac{1}{2}\{x(n) + x(-n)\}$$

$$= \frac{1}{2}\{1+4, \quad 2+3, \; 2+2, \; 3+2, \; 4+1\}$$

$$= \frac{1}{2}\{5 \;, 5 \;, 4, 5, 5\}$$

$$= \{2.5, 2.5, 2, 2.5, 2.5\}$$

$$X_o(n) = \frac{1}{2}\{x(n) - x(-n)\}$$

$$= \frac{1}{2}\{x(n) - x(-n)\}$$

$$= \frac{1}{2}\{1-4, \quad 2-3, \; 2-2, \; 3-2, \; 4-1\}$$

$$= \frac{1}{2}\{-3 \;, -1 \;, 0, 1, 3\}$$

$$= \{-1.5, -0.5, 0, 0.5, 1.5\}$$

$$x(n) = \{1, \quad 2, \quad 2, \quad 3, \quad 4\}.$$

$$X_e(n) = \{2.5, \; 2.5, \; 2, \quad 2.5, \; 2.5\}$$

$$X_o(n) = \{-1.5, \; -0.5, \; 0, \quad 0.5, \; 1.5\}$$

6.Find the energy of the signal e^{-2t} u(t).

Given: $x(t) = e^{-2t}\, u(t)$

$$E = \underset{T\to\alpha}{Lt} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \int_{0}^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt} \left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt} \frac{-1}{4}\left[e^{-2T} - 1\right]$$

$$E = \frac{-1}{4}[0 - 1]$$

$$\text{Energy, } E = \frac{1}{4}$$

7.Determine the power of the signal e^{-2t} u(t).

Solution:

$$P = \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} |e^{-2t}|^2 \, dt$$

$$= \underset{T\to\alpha}{Lt} \frac{1}{T} \int_{0}^{T/2} e^{-4t} dt \ \alpha$$

$$\underset{T\to\alpha}{Lt}\frac{1}{T}\left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$=\underset{T\to\alpha}{Lt}\ \frac{1}{T}\ \frac{-1}{4}\left[e^{-2T}-1\right]$$

$$P=\ \underset{T\to\alpha}{Lt}\ \frac{1}{4T}\left[e^{-2T}-e^{0}\right]$$

P= 0

Power , P = 0

.

8. Test Whether the signal y(t) = ax(t) + b is linear or non linear.

Solution:

y(t) = ax(t) + b

$y_1(t)$ is the output of input signal $x_1(t)$

$$y_1(t) = a\,x_1(t) + b$$

similarly, $y_2(t)$ is the output of input signal $x_2(t)$

$$y_2(t) = a\,x_2(t) + b$$

Now $x_1(t)$ and $x_2(t)$ related with $x_3(t)$

ie , $x_3(t) = a\,x_1(t) + b\,x_2(t)$

The output $y_3(t)$ defined as $y_3(t) = a\,x_3(t) + b$

$$= a\,[a\,x_1(t) + b\,x_2(t)] + b$$

$$= a\,.\,a\,x_1(t) + a.\,b\,x_2(t) + b$$

$$\neq a\ y_1(t) + b\ y_2(t)$$

Hence the system is non linear.

9. Find the power and rms value of signal x(t)=20cos2πt.

Given: x(t)=20cos2πt.

$$P = \underset{T\to\alpha}{Lt}\frac{1}{2T}\int_{-T}^{T}\left|x(t)\right|^2 dt$$

$$= \quad \underset{T\to\alpha}{Lt} \frac{1}{2T} \int_{-T}^{T} \left|20\cos 2\pi t.\right|^{2} dt$$

$$= \quad \underset{T\to\alpha}{Lt} \frac{1}{2T} \int_{-T}^{T} 400\cos^{2} 2\pi t.\ dt$$

$$= \underset{T\to\alpha}{Lt} \frac{400}{4T} \int_{-T}^{T} (1+\cos 4\pi t)(dt\ \alpha$$

$$\underset{T\to\alpha}{Lt} \frac{400}{4T} \int_{-T}^{T} 1dt + 0$$

$$= \underset{T\to\alpha}{Lt} \frac{400}{4T} [T-(-T)]$$

$$P = \underset{T\to\alpha}{Lt} \frac{400}{4T} [2T]$$

Power P= 200.

The r.m.s value = $\sqrt{200}$ = 14.14.

***10.* Explain the following signals.**

***(i) P*eriodic and aperiodic**

(ii) Even and odd

*(i) P*eriodic and aperiodic

A signal is said to be periodic ,if it exhibits periodicity.i.e.,

X(t +T)=x(t), for all values of t.

Periodic signal has the property that it is unchanged by a time shift of T.

A signal that does not satisfy the above periodicity property is called an aperiodic signal.

(ii) Even and odd

A discrete time signal is said to be even when,

x[-n]=x[n].

The continuous time signal is said to be even when,

x(-t)= x(t)

For example,Cosωn is an even signal.

The discrete time signal is said to be odd when

$x[-n]= -x[n]$

The continuous time signal is said to be odd when

$x(-t)= -x(t)$

Odd signals are also known as nonsymmetrical signal.
Sine wave signal is an odd signal.

Part C (10 marks)

1 .Find the trigonometric fourier series for half wave rectified sine wave.

Solution

$$x(t)= a_o+\sum_{n=1}^{\alpha} a_n \cos n\omega_0 t + \sum_{n=1}^{\alpha} b_n \sin n\omega_0 t$$

where

$a_o=1/T \int x(t)\, dt$

$a_n =1/T \int x(t)\cos n\omega o t\, dt$

$b_n=1/T \int x(t)\cos n\omega o t\, dt$

$x(t)=\{\sin t, \quad \pi > t >= 0$

$\qquad 0, \quad 2\pi > t > \pi$

The fundamental period ,T= 2π

The fundamental frequency $\omega_0 = \frac{2\pi}{T} = 1$,

$$a_0 = \frac{1}{T}\int_{t_0}^{t_0+T} x(t)dt$$

$$= \frac{1}{2\pi}\int_{0_0}^{\pi} \sin t dt$$

$$= \frac{1}{2\pi}[-\cos t] \Big|_0^{\pi}$$

$$= \frac{1}{\pi}$$

$$a_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\cos n\omega_0 t dt$$

$$= \frac{2}{2\pi}\int_{t_0}^{t_0+T} \sin t \cos nt dt$$

$$= \frac{1}{\pi}\int_0^{\pi} \frac{1}{2}\left[\sin(n+1)t + \sin(1-n)t\right] dt$$

$$= \frac{1}{2\pi}\int_0^{\pi} \sin(n+1)t dt + \frac{1}{2\pi}\int_0^{\pi} \sin(1-n)t \, \mathrm{dt}$$

$$= \frac{1}{\pi}\left[\frac{1+(-1)^n}{1-n^2}\right]$$

To find b_n

$$b_n =_n = \frac{2}{T}\int_{t_0}^{t_0+T} x(t)\sin n\omega_0 t dt$$

$$= \frac{2}{2\pi}\int_{t_0}^{t_0+T} \sin t \sin nt dt$$

$$= \frac{1}{\pi}\int_0^{\pi} \frac{1}{2}\left[\cos(n-1)t - \cos(n+1)t\right] dt$$

$$= \frac{1}{2\pi}\int_0^{\pi} \sin(n+1)t dt + \frac{1}{2\pi}\int_0^{\pi} \sin(1-n)t \, \mathrm{dt}$$

$$= \frac{1}{2\pi}\left[\frac{\sin(n-1)\pi - \sin 0}{(n-1)} - \frac{\sin(n+1)\pi - \sin 0}{(n+1)}\right]$$

$$= 0$$

$$X(t) = \frac{1}{\pi} + \frac{1}{\pi}\sum\left[\frac{1+(-1)^n}{1-n^2}\cos n\omega_0 t\right] + \frac{1}{2}\sin \omega_0 t$$

2.Find the trigonometric fourier series representation of a periodic square wave
x(t) = 1, for the interval (0 , π).
= 0,for the interval (π , 2π)

$$x(t) = a_o + \sum_{n=1}^{\alpha} a_n \cos n\omega_0 t + \sum_{n=1}^{\alpha} b_n \sin n\omega_0 t$$

where

$a_o = 1/T \int x(t)\, dt$

$a_n = 1/T \int x(t) \cos n\omega o t\, dt$

$b_n = 1/T \int x(t) \cos n\omega o t\, dt$

$x(t) = \{1, \quad \pi > t >= 0$

$\quad -1 \quad , \quad 2\pi > t > \pi$

The fundamental period ,T= 2π

The fundamental frequency $\omega_0 = \dfrac{2\pi}{T} = 1$,

$$a_0 = \frac{1}{T} \int_{t_0}^{t_0+T} x(t)dt$$

$$= \frac{1}{2\pi} \int_{0_0}^{\pi} 1dt + \frac{1}{2\pi} \int_{\pi}^{2\pi} (-1)dt$$

$= 0$

$$a_n = \frac{2}{T} \int_{t_0}^{t_0+T} x(t) \cos n\omega_0 t dt$$

$$= \frac{2}{2\pi} \int_{0_0}^{\pi} 1 \cos ntdt + \frac{2}{2\pi} \int_{\pi}^{2\pi} (-1) \cos ntdt$$

$$= \frac{1}{n\pi} \left[(\sin n\pi - \sin 0) - (\sin 2n\pi - \sin n\pi) \right]$$

$= 0$

To find b_n

$$b_n =_n = \frac{2}{T} \int_{t_0}^{t_0+T} x(t) \sin n\omega_0 t dt$$

$$= \frac{2}{2\pi} \int_{t_0}^{t_0+T} \sin t \sin ntdt$$

$$= \frac{1}{\pi}\int_0^{\pi} 1.\sin ntdt + \frac{1}{\pi}\int_{\pi}^{2\pi} (-1).\sin ntdt$$

$$= \frac{1}{n\pi}\left[-(\cos n\pi - \cos 0) + (\cos n2\pi - \cos n\pi)\right]$$

$$= \frac{1}{n\pi}\left\{-\left[(-1)^n - 1\right] + \left[1 - (-1)^n\right]\right\}$$

$$= \frac{2}{n\pi}\left[1 - (-1)^n\right]$$

$$X(t) = \sum_{n=1}^{\alpha} \frac{2}{n\pi}\left[1 - (-1)^n\right]\sin nt$$

3. Test Whether the signal x(n) = (½) ^{n} u(n) energy or power signal.

Given: x(n) = (½) ^{n} u(n)

$$E = \underset{N \to \alpha}{Lt} \sum_{n=-N}^{N} |x(n)|^2$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=-N}^{N} |(½)^n u(n)|^2$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=0}^{N} (½)^{2n}$$

$$= \underset{N \to \alpha}{Lt} \sum_{n=0}^{N} (1/4)^n \quad \alpha$$

$$= \frac{1}{1-0.25} = \frac{4}{3} < \alpha$$

$$P = \underset{N\to\alpha}{Lt}\frac{1}{2N+1}\sum_{n=-N}^{N}|x(n)|^2$$

$$= \underset{N\to\alpha}{Lt}\frac{1}{2N+1}\sum_{n=-N}^{N}|(1/2)^n u(n)|^2$$

$$= \underset{N\to\alpha}{Lt}\frac{1}{2N+1}\sum_{n=-N}^{N}(1/2)^{2n}$$

$$= \underset{N\to\alpha}{Lt}\frac{1}{2N+1}\sum_{n=-N}^{N}(1/4)^{n}$$

$$= \frac{1}{\alpha} = 0$$

E=finite and P=0

Hence the signal is Energy signal

Energy, E= $\frac{1}{4}$

4. Test Whether the signal $x(t) = e^{-2t}$ u(t).) energy or power signal.

Given: $x(t) = e^{-at} u(t)$

$$E = \underset{T\to\alpha}{Lt}\int_{-T/2}^{T/2}|x(t)|^2\,dt$$

$$= \underset{T\to\alpha}{Lt}\int_{0}^{T/2}|e^{-2t}|^2\,dt$$

$$= \underset{T\to\alpha}{Lt}\int_{0}^{T/2}|e^{-2t}|^2\,dt$$

$$= \underset{T\to\alpha}{Lt}\int_{0}^{T/2}e^{-4t}dt\ \alpha$$

$$\underset{T\to\alpha}{Lt}\left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt}\frac{-1}{4}\left[e^{-2T}-1\right]$$

$$E= \frac{-1}{4}[0-1]$$

$$\text{Energy, } E= \frac{1}{4}$$

$$P= \underset{T\to\alpha}{Lt}\frac{1}{T}\int_{-T/2}^{T/2}|x(t)|^2 dt$$

$$= \underset{T\to\alpha}{Lt}\frac{1}{T}\int_{0}^{T/2}|e^{-2t}|^2 dt$$

$$= \underset{T\to\alpha}{Lt}\frac{1}{T}\int_{0}^{T/2}|e^{-2t}|^2 dt$$

$$= \underset{T\to\alpha}{Lt}\frac{1}{T}\int_{0}^{T/2}e^{-4t}dt \ \alpha$$

$$\underset{T\to\alpha}{Lt}\frac{1}{T}\left[\frac{e^{-4t}}{-4}\right]_0^{T/2}$$

$$= \underset{T\to\alpha}{Lt}\ \frac{1}{T}\ \frac{-1}{4}\left[e^{-2T}-1\right]$$

$$P= \underset{T\to\alpha}{Lt}\ \frac{1}{4T}\left[e^{-2T}-e^{0}\right]$$

$$P= 0$$

Hence the signal is Energy signal

5. Explain in detail different classification of signals.

signal

Signal is a physical quantity that varies with respect to time , space or any other independent variable.

Or

It is a mathematical representation of the system

Eg y(t) = t. and x(t)= sin t.

Signal is mainly classified as

(i).Continuous time signal

(ii).Discrete time signal

continuous time signals

Continuous time signals are defined for a continuous of values of the independent variable. In the case of continuous time signals the independent variable is continuous. For example:

(vii) A speech signal as a function of time

(viii) Atmospheric pressure as a function of altitude

Classification of continuous time signal:

(vii) Periodic and Aperiodic signal

(viii) Even and Odd signal

Discrete time signals

Discrete time signals are defined only at discrete times, and for these signals, the independent variable takes on only a discrete set of values.

Classification of discrete time signal:

1.Periodic and Aperiodic signal

2.Even and Odd signal

Elementary signal

Discrete time Unit impulse is defined as

δ [n]= {0, n$\neq$ 0
{1, n=0

Unit impulse is also known as unit sample.

Discrete time unit step signal is defined by

U[n]={0,n=0
{1,n>= 0

Continuous time unit impulse is defined as

δ (t)={1, t=0
{0, t $\neq$ 0

Continuous time Unit step signal is defined as

U(t)={0, t<0
{1, t$\geq$0

Continuous time unit ramp function is defined by

r(t)={0,t<0
{t, t$\geq$0

A ramp signal starts at t=0 and increases linearly with time ‘t’

Complex exponential CT signal.

The continuous time complex exponential signal is of the form

$x(t)=Ce^{at}$

where c and a are complex numbers.

Continuous time real exponential signal is defined by

$x(t)=Ce^{at}$

where c and a are complex numbers. If c and a are real ,then it is called as real exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is positive,as t increases , then x(t) is a growing exponential.

Continuous time growing exponential signal is defined as

$x(t)=Ce^{at}$

where c and a are complex numbers.

If a is negative, as t increases, then x(t) is a decaying exponential.

UNIT I CLASSIFICATION OF SIGNALS AND SYSTEMS

1.Define Signal.

Signal is a physical quantity that varies with respect to time, space or any other independent variable. (or)

A signal is a function of one or more independent variables which contain some information.

Eg: Radio signal, TV signal, Telephone signal etc.

2. Define System.

A system is a set of elements or functional block that are connected together and produces an output in response to an input signal.

Eg: An audio amplifier, attenuator, TV set etc.

3. Define CT signals.

Continuous time signals are defined for all values of time. It is also called as an analog signal and is represented by x(t).

Eg: AC waveform, ECG etc.

4. Define DT signal.

Discrete time signals are defined at discrete instances of time. It is represented by x(n).

Eg: Amount deposited in a bank per month.

5. Give few examples for CT signals.

AC waveform, ECG, Temperature recorded over an interval of time etc.

6. Give few examples of DT signals.

Amount deposited in a bank per month,

7. Define unit step, ramp and delta functions for CT.

Unit step function is defined as

$U(t) = 1$ for $t >= 0$

0 otherwise

Unit ramp function is defined as

$r(t) = t$ for $t>=0$

0 for $t<0$

Unit delta function is defined as

$\delta(t)= 1$ for $t=0$

0 otherwise

8. State the relation between step, ramp and delta functions (CT).

The relationship between unit step and unit delta function is

$\delta\ (t) = u(t)$

The relationship between delta and unit ramp function is

$\delta\ (t).dt = r(t)$

9. State the classification of CT signals.

The CT signals are classified as follows

(i) Periodic and non periodic signals
(ii) Even and odd signals
(iii) Energy and power signals
(iv) Deterministic and random signals.

10. Define deterministic and random signals. [Madras Universtiy, April -96]

A deterministic signal is one which can be completely represented by mathematical equation at any time. In a deterministic signal there is no uncertainty with respect to its value at any time.

Eg: $x(t)=coswt$

$x(n)=2wft$

A random signal is one which cannot be represented by any mathematical equation.

Eg: Noise generated in electronic components, transmission channels, cables etc.

11. Define Random signal. [Madras University, April – 96]

There is no uncertainty about the deterministic signal. It is completely represented by mathematical expression.

12. Define power and energy signals.

The signal x(t) is said to be power signal, if and only if the normalized average power p is

finite and non-zero.
ie. $0<p<\infty$
A signal x(t) is said to be energy signal if and only if the total normalized energy is finite and non-zero.
ie. $0<E<\infty$

13. Compare power and energy signals.

Sl.No.	POWER SIGNAL	ENERGY SIGNALS
1	The normalized average power is finite and non-zero	Total normalized energy is finite and non- zero.
2	Practical periodic signals are power signals	Non-periodic signals are energy signals

14. Define odd and even signal.

A DT signal x(n) is said to be an even signal if $x(-n) = x(n)$ and an odd signal if $x(-n)=-x(n)$.
A CT signal is x(t) is said to be an even signal if $x(t)=x(-t)$ and an odd signal if $x(-t) = -x(t)$.

15. Define periodic and aperiodic signals.

- A signal is said to be periodic signal if it repeats at equal intervals.
- Aperiodic signals do not repeat at regular intervals.
- A CT signal which satisfies the equation $x(t) = x(t+T_0)$ is said to be periodic and a DT signal which satisfies the equation $x(n) = x(n+N)$ is said to be periodic.

16. State the classification or characteristics of CT and DT systems.

The DT and CT systems are according to their characteristics as follows
(i). Linear and Non-Linear systems
(ii). Time invariant and Time varying systems.
(iii). Causal and Non causal systems.
(iv). Stable and unstable systems.
(v). Static and dynamic systems.
(vi). Inverse systems.

17. Define linear and non-linear systems.

A system is said to be linear if superposition theorem applies to that system. If it does not satisfy the superposition theorem, then it is said to be a nonlinear system.

18. What are the properties linear system should satisfy? [Madras Universtiy, April-95]

A linear system should follow superposition principle. A linear system should satisfy,

$f[\, a_1 x_1(t) + a_2\, x_2\,(t)] = a_1 y_1(t) + a_2\, y_2\,(t)$

where $y_1(t) = f[\, x_1(t)\,]$

$y_2(t) = f[\, x_2\,(t)\,]$

19. What is the criterion for the system to possess BIBO stability?

A system is said to be BIBO stable if it produces bounded output for every bounded input.

20. Define shift invariance. [Madras University, April-95, Oct-95]

If the system produces same shift in the output as that of input, then it is called shift invariance or time invariance system. i.e.,

$f[\, x(t - t_1)\,] = y(\, t - t_1)$

21. Define Causal and non-Causal systems. [Madras University, April – 95,99, Oct.-95]

A system is said to be a causal if its output at anytime depends upon present and past inputs only. A system is said to be non-causal system if its output depends upon future inputs also.

22. Define time invariant and time varying systems.

A system is time invariant if the time shift in the input signal results in corresponding time shift in the output. A system which does not satisfy the above condition is time variant system.

23. Define stable and unstable systems.

When the system produces bounded output for bounded input, then the system is called bounded input, bounded output stable. A system which does not satisfy the above condition is called a unstable system.

24. Define Static and Dynamic system.

A system is said to be static or memory less if its output depends upon the present input only. The system is said to be dynamic with memory if its output depends upon the present and past input values.

25. Check causality of the system given by, y(n) = x(n-n_o)[Madras University, April-2002]

If $n_o \geq 0$, then output y(n) depends upon present or past input. Hence the system is causal. If $n_o < 0$, the system become noncausal.

26. Check whether the given system is causal and stable.[Madras University, Oct.-98]
y (n) = 3 x (n - 2) + 3 x (n + 2)

Since y (n) depends upon x(n+2), this system is noncausal. As long as x (n – 2) and x (n + 2) are bounded, the output y(n) will be bounded. Hence this system is stable.

27. When the discrete signal is said to be even? [Madras University, April – 99]

A discrete time signal is said to be even when, x(-n) = x(n).
For example cos(ωn) is an even signal.

28. Is diode a linear device? Give your reason. (Nov/Dec – 2003)

Diode is nonlinear device since it operates only when forward biased. For negative bias, diode does not conduct.

29. Define power signal.

A signal is said to be power signal if its normalized power is nonzero and finite. i.e., $0 < P < \infty$

30. Define signal. What are classifications of signals? (May/June-2006)

A function of one or more independent variables which contain some information is called signal.

31. What is the periodicity of $x(t) = e^{j100\Pi t} + 30^o$?

Here $x(t) = e^{j100\Pi t} + 30^o$
Comparing above equation with $e^{j\omega t+\Phi}$, we get $\omega = 100\ \Pi$. Therefore period T is given as,
$T=2\ \Pi/\ \omega = 2\ \Pi\ /100\ \Pi = 1/50 = 0.02$ sec.

32. Find the fundamental period of the signal $x(n) = 3\ e^{j3\Pi(n+1/2)}$ (Nov./Dec – 2006)

$$X(n) = 3/5\ e^{j\ 3\Pi n}.\ e^{j3\Pi/2}$$
$$= -j3/5\ e^{j3\Pi n}$$

Here, $\omega=3\Pi$, hence, $f=3/2=k/N$. Thus the fundamental period is $N = 2$.

33. Find the fundamental period of the signal. (May/June-2007)

$X[n] = 2\cos(\Pi/4\ n)+\sin(\Pi/8\ n) -2\cos(\Pi/2\ n + \Pi/6\ )$

Here $\omega_1 = \Pi\ /4 \Rightarrow f_1 = \omega_1/2\Pi = \dfrac{\Pi/4}{2\Pi} =1/8$ therefore $N_1 = 8$

$\omega_2 = \Pi/8 \Rightarrow f_2 = \omega_2/2\Pi = \Pi/8$

$$\frac{\Pi/8}{2\Pi} = 1/16 \quad \text{therefore } N_2 = 16$$

$\omega_3 = \Pi/2 \Rightarrow f_3 = \omega_3/2\Pi = \Pi/2$

$$\frac{\Pi/2}{2\Pi} = 1/4 \quad \text{therefore } N_3 = 4$$

and the fundamental period will be least common multiple of N_1,N_2 and N_3 which is 16.
Thus, N = 16.

34. Is the system described by the following equation stable or not? Why?

$$y(t) = \int_{-\infty}^{t} x(\tau)\, d\tau$$

This is unstable system, since it integrates function x (t) from -∞. Hence even though x(t) is bounded, the integration can be unbounded.

35. Is the discrete time system describe by the equation y (n) = x(-n) causal or non causal ? Why?

Here y(n) = x(-n). If n = -2 then,
y(-2)= x(2)
Thus the output depends upon future inputs. Hence system is noncausal.

36. Is the system describe by the equation y(t) = x(2t) Time invariant or not? Why?

Output for delayed inputs becomes,
$y(t,t_1) = x(2t-t_1)$

Delayed output will be,
$y(t-t_1) = x[2(t-t_1)]$
Since y(t,t1) $\neq$ y(t-t1) . The system is shift variant.

37. What is the period T of the signal x(t) = 2cos (n/4)?

Here, x (n) = 2cos (n/4).
Compare x(n) with Acos (2∏ fn). This gives,
2∏fn = n/4 => F =1/8 ∏. Which is not rational.
Hence this is not periodic signal.

38. Is the system y(t) = y(t-1) + 2t y(t-2) time invariant ?

Here y(t-t1) = y(t-1-t1) + 2t y(t-2-t1) and
y(t t1) = y(t-t1-1) + 2(t-t1) y(t-t1-2).
Here y(t-t1) $\neq$ y(t t1). This is time variant system.

39. Check Whether the given system is causal and stable.[Madras University, Oct.-98]

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

Since y (n) depends upon x(n+2), this system is noncausal. As long as x (n – 2) and x(n + 2) are bounded, the output y(n) will be bounded. Hence this system is stable.

40. What is the periodicity of $x(t) = e^{j100\Pi t} + 30^o$?

Here $x(t) = e^{j100\Pi t} + 30^o$

Comparing above equation with $e^{j\omega t+\Phi}$, we get $\omega = 100\,\Pi$. Therefore period T is given as,

$$T = 2\,\Pi / \omega = 2\,\Pi / 100\,\Pi = 1/50 = 0.02 \text{ sec.}$$

41. Find the fundamental period of the signal $x(n) = 3\, e^{j3\Pi(n+1/2)}$ (Nov./Dec – 2006)

$$X(n) = 3/5\, e^{j\,3\Pi n} .\, e^{j3\Pi/2}$$
$$= -j3/5\, e^{j3\Pi n}$$

Here, $\omega = 3\Pi$, hence, $f = 3/2 = k/N$. Thus the fundamental period is $N = 2$.

UNIT II ANALYSIS OF CONTINUOUS TIME SIGNALS

1. What do the Fourier series coefficients represent?

Fourier series coefficients represent various frequencies present in the signal. It is nothing but spectrum of the signal.

2. Define Fourier series.

CT Fourier series is defined as,

$x(t) = \sum_{k=-\infty}^{\infty} X(k) e^{jk\omega ot}$ (Synthesis Equation)

where $X(t) = \frac{1}{T}\int_{<T>} x(t) e^{-jkwot}\, dt$ (Analysis equation)

3. State Dirichlet conditions for Fourier series.

i) The function x(t) should be within the interval T_o.

ii) The function x(t) should have finitie number of maxima and minima in the interval T_o.

iii) The function x(t) should have finite number of discontinuities in the interval T_0.

iv) The function should be absolutely integrable.

i.e., $\int_{<T0>} |x(t)dt < \infty$

4. What are the difference between Fourier series and Fourier transform?

[Oct. Nov.-2002, Nov/Dec-2004]

Sl.No.	Fourier series	Fourier transform
1.	Fourier series is calculated for periodic signals.	Fourier transform is calculated for nonperiodic as well as periodic signals.
2.	Expands the signal in time domain.	Represents the signal in frequency domain.
3.	Three types of Fourier series such as trigonometric, polar and complex exponential.	Fourier transform has no such types.

5. What is the relationship between Fourier transform and Laplace transform?

[April/May-2002]

$X(s)=X(j\omega)$ when $s=j\omega$

This means Fourier transform is same as Laplace transform when $s=j\omega$.

6. State the modulation property and convolution (time) property of Fourier transform. [April/may-2003]

1. Modulation property :

$x(t)\cos(2\pi f_c t+\emptyset) \leftrightarrow e^{j\emptyset}/2\, X(f-f_c) + e^{-j\emptyset}/2\, X(f+f_c)$.

2. **Convolution property:**

$x_1(t) * x_2(t) \overset{FT}{\leftrightarrow} X_1(f).\, X_2(f)$

7. **Write the Fourier transform pair for x(t). [Nov./Dec.-2003,Nov./Dec-2005]**

$x(t) \overset{FT}{\leftrightarrow} X(f)$ or $x(t) \overset{FT}{\leftrightarrow} X(\omega)$

$X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t}\, dt$

$X(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega)\, e^{jwt}\, d\omega$

8. **Determine Laplace transform of $x(t) = e^{-\alpha t}\sin(\omega t)\, u(t)$. [April/May-2004]**

$$L\, e^{-at}\sin\omega t = L \left\{ e^{iat} \left(\frac{e^{jwt} - e^{-ijwt}}{2j} \right) \right\}$$

$= 1/2j\, L\, \{e^{-(a-jw)t} - e^{-(a=jw)t}\}$

$=1/2j\, \{ 1/s+(a-jw) - 1/s+(a+jw)\}$

$= \omega/(s+a)^2 + \omega^2$, ROC : Re(s) >-a

9. **What is the Laplace transform of (a) $e^{-at}\sin\omega t\, u(t)$? [Nov. / Dec.-2004]**

$e^{-at}\sin\omega t \overset{L}{\leftrightarrow} \omega/(s+a)^2 + \omega^2$

10. **A signal $x(t) = \cos 2\pi\, ft$ is passed through a device whose input –output is related by $y(t) = x^2(t)$. What are the frequency components in the output?**

Since an input is squared,

$y(t) = (\cos 2\,\pi\, ft)^2$

$= 1+ \cos 4\pi\, ft/2$

$= ½ + ½ + \cos[2\pi(2f)t]$

Thus the frequency present in the output is '2f'.

11. **Define the Fourier transform pair for continuous time signal. [April/May – 2005]**

Fourier transform : $X(\omega) = \int_{-\infty}^{\infty} x(t)\, e^{-jwt}\, dt$

Inverse Fourier transform : $X(f) = 1/2\pi \int_{-\infty}^{\infty} X(\omega)\, e^{jwt}\, d\boldsymbol{\omega}$

12. **Find the Laplace transform of $x(t) = t\, e^{-at}\, u(t)$, where $a > 0$. [April/May – 2005]**

$e^{-at}\, u(t) \overset{L}{\leftrightarrow} 1/s+a$' ROC : Re (s) > -a

Differentiation in s-domain property gives,

- $tx(t) \overset{L}{\leftrightarrow} d/ds\ X(s)$
- $t\, e^{-at}\, u(t) \overset{L}{\leftrightarrow}\ d/ds\ (1/s+a)$

  $t\, e^{-at}\ u(t) \overset{L}{\leftrightarrow} 1/(s+a)^2$, ROC : Re(s) > -a

13. Obtain the Fourier transform of $x(t) = e^{-at}u(t)$, a> 0.

[Nov./Dec.-2005]

$$X(f) = \int_{-\infty}^{\infty} x(t)\ e^{-j2\pi ft}\, dt$$
$$= \int_{o}^{\infty} e^{-at}\ e^{-j2\pi ft}\, dt$$
$$= \int_{o}^{\infty} e^{-(a+j2\pi f)t}\, dt = 1/a+j2\pi f$$

14. State the initial and final value theorem of Laplace transforms.

[Nov./Dec.-2005]

Initial Value theorem : $f(0+)=\lim_{s\to\infty}(s\,F(s))$

Final value theorem : $\lim_{t\to\infty}(\,f(t) \ = \ \lim_{s\to 0}(s\,F(s))$

15. Find the Laplace transform of signal u(t). **[May/June – 2006]**

$$L\,[u(t)] = \int_{-\infty}^{\infty} u(t)\, e^{-st}\ dt$$
$$= \int_{0}^{\infty} e^{-st}\, dt \ \text{ since } u(t)=0 \text{ for } t<0$$
$$= -\,1/s\, [e^{-st}]^{\infty}_{0}$$
$$= 1/s.$$

16. Define Parseval's relation for continuous time periodic signals.

[Nov./Dec. – 2006]

It states that the total average power of the periodic signal x(t), is equal to the sum of the average powers of its phasor components. i.e.,

$$P = \sum_{n=-\infty}^{\infty} |c_n|^2$$

17. Find the Laplace transform of the signal. **[Nov./Dec.-2006]**

$x(t) = -te^{-2t}\, u(t)$

$$t^{n-1}/(n-1)!\ e^{-at}\, u(t) \overset{L}{\leftrightarrow}\ 1/(s+a)^{n},\ Re(s) > -\,a$$

With n=2, $t/(2-1)!\ e^{-at}\ u(t) \overset{L}{\leftrightarrow} 1/(s+a)^2$

With a=2, $t\, e^{-2t}u(t) \overset{L}{\leftrightarrow} 1/(s+2)^2$

$$-te^{-2t}\ u(t) \overset{L}{\leftrightarrow}\ -\,1/(s+2)^{2},\ Re(s) > -2.$$

18. Let x(t) = t, $0 \le t \le 1$ be a periodic signal with fundamental period T = 1 and Fourier series Coefficients a_k. Find the value of a_o. **[May/June - 2007]**

The fourier coefficient a_0 or c_o is given as,

$$C_o = 1/T_0 \int_{t}^{t+To} x(t)\, dt$$
$$= 1/1 \int_{0}^{1} t\, dt \quad = [t^2/2]^1_0 \quad = ½$$

19. List some properties of continuous-time Fourier transform.

1. Linearity
2. Time reversal
3. Time scaling
4. Conjugation.
5. Parseval's relation
6. Differentiation
7. Integration
8. Convolution
9. Multiplication.

20. Determine the Fourier transform of the unit impulse

Unit impulse signal,

$x(t) = \delta(t)$

$$X(j\omega) = \int_{-\infty}^{\infty} x(\tau)e^{-j\omega t}\,dt$$
$$= \int_{-\infty}^{\infty} \delta(\tau)e^{-j\omega t}\,dt$$
$$= 1.$$

21.How the Laplace Transform can be represented ? (Or)
What are the the representations of Laplace transform? (or)
Define Unilateral & Bilateral Laplace transforms.

1. Unilateral (One-sided) Laplace transforms.
2. Bilateral (two-sided) Laplace transform.

Unilateral Laplace Transform : It is a convenient tool for solving differential equations with initial conditions.

$$X(s) = \int_{0}^{\infty} x(t)e^{-at}\,dt.$$

Bilateral Laplace Transform : It is used to analyze the system characteristics like stability, causality and Frequency response.

UNIT III LINEAR TIME INVARIANT –CONTINUOUS TIME SYSTEMS

1. **Write Convolution integral of x(t).**

   The convolution integral is given as,

   Y(t)= $\int_{-\infty}^{\infty} x(\tau).h(t-\tau).d\tau$

2. **What are the properties of convolution?**

   i. Commutative property: x(t)*h(t)= h(t)*x(t)

   ii. Associative Property : [x(t)*h1(t)]*h2(t) = x(t)*{h1(t)+h2(t)}

   iii. Distributive property : x(t)*h1(t)+h2(t)= x(t)*{h1(t)+h2(t)}

3. **Define impulse response of continuous system**

   The impulse response is the output produced by the system when unit impulse is applied at the input. The impulse response is denoted by h(t).

4. **Find the unit step response of the system given by h (t)=** $\frac{1}{RC}$ **.** $e^{-t/RC}$ **.u(t)**

   The step response can be obtained from impulse response as,

   Y(t)= $\int_{-\infty}^{\infty} h(\tau)d\tau = \int_{-\infty}^{t} \frac{1}{RC} . e^{-t/RC} . u(t) d\tau$

   $= \int_{0}^{t} \frac{1}{RC} . e^{-t/RC} . d\tau$

   =1-$e^{-t/RC}$ **for** $t \geq 0$

   This is the step response.

5. **What is the impulse response of the system y(t)= x(t-to)**

   Take laplace transform of given equation ,

   $Y(s) = e^{-sto} X(s)$

   $H(s) = Y(s)/X(s) = e^{-sto}$

   Taking inverse laplace transform

   $h(t) = \delta(t-to)$

6. **Define eigenvalue and eigenfunction of LTI-CT system.**

    Let the input to LTI-CT systembe a complex exponential e^{st}. Then using the convolution theorem we get the output as, $y(t) = H(s)\, e^{st}$

    Thus output is equal to input multiplied by H(s). Hence e^{st} is called eigen function and H(s) is called eigen value.

7. **The impulse response of the LTI-CT system is given as $h(t) = e^{-t}u(t)$. Determine transfer function and check whether the system is causal and stable.**

    $h(t) = e^{-t}u(t)$
    Taking Laplace Transform ,
    $H(s) = 1/(s+1)$
    Here pole at s=-1 , i.e., located in left half of s-plane. Hence this system is causal and stable.

8. **Give four steps to compute convolution integral.**

    Or

    What are the basic steps involved in convolution integrals?

    i. Folding
    ii. Shifting
    iii. Multiplication
    iv. Integration

9. **What is the overall impulse response h (t) when two systems with impulse response h1 (t) and h2(t) are in parallel and in series?**

    Or

    State the properties needed for interconnecting LTI systems.
    For parallel connection, $h(t)= h1(t) + h2(t)$
    For series connection, $h(t) = h1(t) * h2(t)$

10. **Define linear time invariant system.**

    The output response of linear time invariant system is linear and time invariant

11. **Define impulse response of a linear time invariant system.**

    Impulse response of LTI system is denoted by h(t). It is the response of the system to unit impulse input.

12. **Write down the input-output relation of LTI system in time and frequency domain.**

    $Y(t)= h(t)*x(t)$: Time domain
    $Y(f) = H(f)\, X(f)$: Frequency Domain
    Or $Y(s) = H(S)\, X(s)$: Frequency Domain

13. **Define transfer function in CT systems.**

    Transfer function relates the transforms of input and output i.e.,
    $H(f) = Y(f)/X(f)$, using Fourier transform

Or H(s) = Y(s)/X(s)

14. What is the relationship between input and output of an LTI system?

Input and Output of an LTI system are related by,

Y(t)= $\int_{-\infty}^{\infty} x(\tau).h(t-\tau).d\tau$ i.e convolution

15. What is the transfer function of a system whose poles are at -0.3±j 0.4 and a zero at -0.2?

P1= -0.3 + j 0.4, p2 + -0.3 – j0.4
Z=-0.2
H(s) = (s-z)/(s-p1)(s-p2)
= (s+0.2)/(s+0.3-j0.4)(s+0.3+j0.4)
= $(s+0.2)/((s+0.3)^2+0.4^2)$
= $(s+0.2)/(s^2+0.6s+0.25)$

16. Find the impulse response of the system given by H(S) = 1/(s+9)

e-at u(t) $\leftrightarrow$ 1/(s+a)
hence e-at u(t) $\leftrightarrow$ 1/(s+9)
Thus impulse response $h(t)=e^{-9t}$ u(t)

17. Find the Fourier Transform of impulse response.

Impulse response h(t)= x(t)*h(t)
FT[h(t)] = FT[x(t)*h(t)]
H(f) = X(f).H(f)

18. What is the impulse response of an identity system?

For identity system,
y(t) = x(t) i.e., output is same as input
Then y(t) = h(t) * x(t)
= x(t) only if h(t) = δ(t)
Thus identity system has impulse response of h(t)= δ(t)

UNIT IV ANALYSIS OF DISCRETE TIME SIGNALS

1. **How unit sample response of discrete time system is defined ?**

The unit sample respons of the discrete time system is output of the system is output of the system to unit sample sequence. i.e.,

$T[\delta(N)] = h(n)$

Also $h(n) = z^{-1\,[H(z)\}}$

2. **If x(n) and y(n) are discrete variable functions, what is its convolution sum.**

The convolution sum = $\sum_{k=-\infty}^{\infty} x(k)$ **y(n-k)**

3. **A causal discrete time system is BIBO stable only if its transfer function has…**

A causal discrete time system is stable if poles of its transfer function lie within the unit circle.

4. **How z-transform is related to fourier transform.**

Fourier transform is basically z-transform evaluated on the unit circle. i.e.,

$X(z)|_{z=e^{jw}} = X(w)$ at $|z| = 1$

5. **Define system function of the discrete time system.**

The system function of the the discrete time system is

$H(z) = Y(z)/X(z)$ = z-transform of the output/z-transform of the in input

Or $H(z) = Z\{h(n)\}$ i.e, z-transform of unit sample response.

6. **A system specified by a recursive difference equation is called infinite impulse response system (True/False).**

This statement is true. An IIR system can be represented by recursive difference equation.

7. **If u(n) is the impulse response of the system, what is its step response?**

Here $h(n) = u(n)$ and the input is $x(n) = u(n)$

Hence output y(n) = h(n) *x(n) = u(n)* u(n)

8. Is the output sequence of an LTI system finite or infinite when the input x(n) is finint? Justify your answer.

If the impulse response of the system is infinite, then output sequence is infinite even thorugh input is finite. For example consider,

Input, x(n) = δ(n) finite length

Impulse response, h(n) = a^n u(n) Infinite length

Output sequence, y(n) = h(n) * x(n)

= a^n u(n) * δ(n)

= a^n u(n)

9. Consider an LTI system with impulse response h(n) = δ (n-n_o0 for an input x(n), find Y($e^{j\Omega}$). (Nov. /Dec. – 2003)

Here Y($e^{j\Omega}$) is the spectrum of output. By convolution theorem we can write,

Y($e^{j\Omega}$) = H($e^{j\Omega}$) X ($e^{j\Omega}$)

H($e^{j\Omega}$) = DTFT {δ(n-n_o)} = $e^{j\Omega no}$

Y($e^{j\Omega}$) = $e^{-j\Omega no}$ X($e^{j\Omega}$)

10.Determine the system function of the discrete time system described by the difference equation.

Y(n)-1/2y(n-1) + 1/4y(n-2) = x(n) – x(n-1)

Taking z-transform of both sides,

Y(z) -1/2 z^{-1}Y(z) +1/4z^{-2}Y(z) = X(z) – z^{-1} X(z)

Y(z) / X(z) = 1-z^{-1} / 1-1/2z^{-1} + ¼ z^{-2}

H(z) = 1-z^{-1}/1-1/2z^{-1}+1/4z^{-2}

11.Write the general difference equation relating input and output of a system. (April/May – 2003)

Y(n) = -$\sum_{k=1}^{N} a_k$ y(n-k) + $\sum_{k=0}^{M} b_k$ x(n-k)

Here y(n-k) are previous outputs and x(n-k) are present and previous inputs.

12. Determine the transfer function of the system described by y(n) =

ay(n-1) + x(n) (Nov./Dec.-2005)

$Y(z) = a\, z^{-1}\, Y(z) + X(z)$
$Y(z)\, [1 - az^{-1}] = X(z)$
$H(z) = Y(z)/X(z) = 1/1-az^{-1}$

13.What are all the blocks are used to represent the CT signals by its samples?

* Sampler * Quantizer

14. Define sampling process.

Sampling is a process of converting CT signal into DT signal.

15. Mention the types of sampling.

* Up sampling
* Down sampling

16. What is meant by quantizer?

It is a process of converting discrete time continuous amplitude into discrete time discrete amplitude.

17. List out the types of quantization process.

* Truncation * Rounding

18. Define truncation.

Truncating the sequence by multiplying with window function to get the finite value.

19. What is rounding?

In this we consider the nearest value.

20. State sampling theorem.

The sampling frequency must be atleast twice the maximum frequency present in the signal.

That is $Fs \geq 2fm$

Where, Fs = sampling frequency
Fm = maximum frequency

21. Define nyquist rate.

It is the minimum rate at which a signal can be sampled and still reconstructed from its samples. Nyquist rate is always equal to 2fm.

22. Define aliasing or folding.

The superimposition of high frequency behaviour on to the low frequency behaviour is referred as aliasing. This effect is also referred as folding.

23. What is the condition for avoid the aliasing effect?

To avoid the aliasing effect the sampling frequency must be twice the maximum frequency present in the signal.

24. Define z transform?

The Z transform of a discrete time signal x(n) is defined as,

$$X(z) = \sum_{n=-\infty}^{\infty} x(n) z^{-n}$$

Where, z is a complex variable. In polar form $z=re^{-j\omega}$

25. What is meant by ROC?

The region of convergence (ROC) is defined as the set of all values of z for which X(z) converges.

26. Explain about the roc of causal and anti-causal infinite sequences?

For causal system the roc is exterior to the circle of radius r.

For anti causal system it is interior to the circle of radius r.

27. Explain about the roc of causal and anti causal finite sequences

For causal system the roc is entire z plane except z=0.

For anti causal system it is entire z plane except $z=\alpha$.

28. What are the properties of ROC?

a. The roc is a ring or disk in the z plane centered at the origin.

b. The roc cannot contain any pole.

c. The roc must be a connected region

d. The roc of an LTI stable system contains the unit circle.

29. Explain the linearity property of the z transform

If $z\{x1(n)\}=X1(z)$ and $z\{X2(n)\}=x2(z)$ then, $z\{ax1(n)+bx2(n)\}=aX1(z)+bX2(z)$ a&b are constants.

30. State the time shifting property of the z transform.

If $z\{x(n)\}=X(z)$ then $z\{x(n-k)\}=z^{-k}X(z)$

31. State the scaling property of the z transform

If $z\{x(n)\}=X(z)$ then $z\{a^n x(n)\}=X(a^{-1} z)$

32. State the time reversal property of the z transform

If $z\{x(n)\}=X(z)$ then $z\{x(-n)\}=X(z-1)$

33. Explain convolution property of the z transform

If $z\{x(n)\}=X(z)$ & $z\{h(n)\}=H(z)$ then, $z\{x(n)*h(n)\}=X(z)H(z)$

34. What are the different methods of evaluating inverse z-transform?

It can be evaluated using several methods.

i. Long division method

ii. Partial fraction expansion method

iii. Residue method

iv. Convolution method

35. Define DTFT and IDTFT of a sequence?

The DTFT (Discrete Time Fourier Transform) of a sequence x(n) is defined as,

$$\textbf{DTFT :}\quad X(\omega) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j\omega n}$$

The IDTFT is defined as,

$$x[n] = \frac{1}{2\pi}\int_{-\pi}^{\pi} X(\omega)\cdot e^{i\omega n}\, d\omega$$

$$= T\int_{-\frac{1}{2T}}^{\frac{1}{2T}} X_T(f)\cdot e^{i2\pi f n T}\, df.$$

36. What is the drawback in DTFT?

The drawback in discrete time fourier transform is that it is continuous function of ω and cannot be processed by digital systems.

37. Represent the DTFT pair.

$$x(n) \xleftrightarrow{DTFT} X(\omega)$$

38. Give the Existence of DTFT

In the definition of DTFT , there is summation over infinite range of n. Hence for DTFT to exist, the convergence of this summation is necessary. Ie, for converge if x(n) is absolutely sum able. i.e.,

$$\sum_{n=-\infty}^{\infty} |x(n)| < \infty$$

If x(n) is not absolutely sum able, then it should have finite energy for DTFT to exist. i.e.,

$$\sum_{n=-\infty}^{\infty} |x(n)|^2 < \infty$$

Note that inverse DTFT of equation does not have convergence problem since the integration is over limited range (— Π to Π). Most of the physical signals satisfy above conditions.

39. Give the Z-transform pair.

$$x(n) \xleftrightarrow{z} X(z)$$

40. What is the need for DTFT?

DTFT is used for the analysis of non-periodic signals.

41. What is the need for Z-transform?

Z-transform is used for analysis the both periodic and aperiodic signals.

42. Give the Z-transform of unit sample sequence δ(n).

Z[δ(n)] = 1

43. Define zeros.

The zeros of the system H(z) are the values of z for which H(z) = 0.

44. Define poles.

The poles of the system H(z) are the values of z for which H(z) = α.

45. What is the z-transform of A δ (n-m) ?

Z [A δ (n-m)] =1.

UNIT V LINEAR TIME INVARIANT - DISCRETE TIME SYSTEMS

1. What is meant by step response of the DT system?

The output of the system y(n) is obtained for the unit step input u(n) then it is said to be step response of the system.

2. Define Transfer function of the DT system.

The Transfer function of DT system is defined as the ratio of Z transform of the system output to the input. That is , H(z)=Y(z)/X(z).

3. Define impulse response of a DT system.

The impulse response is the output produced by DT system when unit impulse is applied at the input.The impulse response is denoted by h(n). The impulse response h(n) is obtained by taking inverse Z transform from the transfer function H(z).

4. State the significance of difference equations.

The input and output behaviour of the DT system can be characterized with the help of linear constant coefficient difference equations.

5. Write the difference equation for Discrete time system.

The general form of constant coefficient difference equation is,

Here n is the order of difference equation. x(n) is the input and y(n) is the output.

6. Define frequency response (or) transfer function of the DT system.

The frequency response of the system is obtained from the Transfer function by replacing $z = e^{j\omega}$

ie, H(z)=Y(z)/X(z), Where $z = e^{j\omega}$

7. Write the analysis and synthesis equation of DTFT.

Analysis equation : $X(\Omega) = \sum_{n=-\infty}^{\infty} x(n)\, e^{-j\Omega n}$

Synthesis equation : $x(n) = \frac{1}{2\pi} \int_{-\pi}^{\pi} X(\Omega)\, e^{j\Omega n}\, d\Omega$

8. What are the blocks used for block diagram representation?

The block diagrams are implemented with the help of signal multipliers, adders, delay elements, time advance elements and constant multipliers.

9. State the significance of block diagram representation.

The LTI systems are represented with the help of block diagrams. The block diagrams are more effective way of system description. Block Diagrams indicate how individual calculations are performed. Various blocks are used for block diagram representation.

10.What are the properties of convolution?

i.Commutative ii.Assosiative. iii.Distributive

11.State the Commutative properties of convolution?

Commutative property of Convolution is, $x(n)*h(n) = h(n)*x(n)$

12.State the Associative properties of convolution

Associative Property of convolution is, $[x(n)*h_1 n)]*h_2(n)=x(n)*[h_1(n)*h_2(n)]$

13. State Distributive properties of convolution

The Distributive Property of convolution is,

$\{x(n)*[h_1(n)+ h_2(n)]\}= [x(n)*h_1(n) + x(n)*h_2(n)]$

14. Define causal LTI DT system.

For a LTI system to be causal if h(n)=0, for n<0.

15. How the discrete time system is represented?

The DT system is represented either Block diagram representation or difference equation representation.

16. What are the classification of the system based on unit sample response?

a. FIR (Finite impulse Response) system.

b. IIR (Infinite Impulse Response) system.

17. What is meant by FIR system?

If the system have finite duration impulse response then the system is said to be FIR system.

18. What is meant by IIR system?

If the system have infinite duration impulse response then the system is said to be FIR system.

19. What is recursive system?

If the present output is dependent upon the present and past value of input then the system is said to be recursive system.

20. What is Non recursive system?

If the present output is dependent upon the present and past value of input and past value of output then the system is said to be non-recursive system.

21.What is the difference between recursive and non recursive system

A recursive system have the feed back and the non recursive system have no feed back .And also the need of memory requirement for the recursive system is less than non recursive system.

22. Define realization structure.

The block diagram representation of a difference equation is called realization structure.These diagram indicate the manner in which the computations are performed.

23.What are the different types of structure realization.

i.Direct form I	ii. Direcct form II
iii. Cascade form	iv. Parallel Form.

24. What is natural response?

This is output produced by the system only due to initial conditions . Input is zero for natural response. Hence it is also called zero input Response.

25. What is zero input Response?

This is output produced by the system only due to initial conditions. Input is zero for zero input response.

26. What is forced response?

This is the output produced by the system only due to input. Initial conditions are considered zero for forced response.It is denoted by $y^{(f)}(n)$.

27. What is complete response?

The complete response of the system is equal to the sum of natural response and forced response .Thus initial conditions as well as input both are considered for complete response.

28. What are the steps involved in calculating convolution sum?

The steps involved in calculating sum are

i.Folding ii. Shifting . iii.Multiplication iv. Summation

28. Give the state equations for LTI DT systems.

State equations: $q(n+1) = A\,q(n) + b\,x(n)$ and $y(n) = c\,q(n) + D\,x(n)$

Where, $A=\begin{bmatrix} -a_1 & -a_2 \\ 1 & 0 \end{bmatrix}$ $b=\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ $c=[(b_1-a_1) \quad (b_2-a_2)]$ and $D=[1]$

29. Give the transfer function using state variables.

$H(z) = Y(z) / X(z) = c\,(zI - A)^{-1}\,b + D$

Where, $A=\begin{bmatrix} -a_1 & -a_2 \\ 1 & 0 \end{bmatrix}$ $b=\begin{bmatrix} 1 \\ 0 \end{bmatrix}$ $c=[(b_1-a_1) \quad (b_2-a_2)]$ and $D=[1]$