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Name : Shah Raza
Reg no: 18PWCSE1658
Section: "B"
Exam : Final term

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(Question 1)

Formula of bandwidth $= \frac{2\pi}{\tau}$ —— (1)

i) $\tau = 0.5\,\mu sec$

$$\text{bandwidth} = \frac{2\pi}{0.5\,\mu sec} = \frac{2 \times 3.14}{0.5 \times 10^{-6}}$$

$$= 12.56 \times 10^{6}$$

ii) $\tau = 1\,\mu sec$

$$\text{bandwidth} = \frac{2\pi}{1\,\mu sec} = \frac{2 \times 3.14}{1 \times 10^{-6}}$$

$$= 6.28 \times 10^{6}$$

iii) $\tau = 2\,\mu sec$

$$\text{bandwidth} = \frac{2\pi}{2\,\mu sec} = \frac{2 \times 3.14}{2 \times 10^{-6}}$$

$$= 3.14 \times 10^{6}$$

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Q2. What do you mean by scaling property? Discuss the significance of the scaling property.

(Ans) Scaling Property:

The scaling property of a signal states that the time compression of a signal results in its spectural expansion and time expansion of a signal results in its spectural compression.

Significance of scaling Property:

The function $g(at)$ represents function $g(t)$ compressed in time by factor a. similarly, a function $G(\omega/a)$ represents the function $G(\omega)$ expanded in frequency by the same factor a. Compression in time by a factor a means that the signal is rapidly varying by the same factor. To synthesize such signal, the frequencies of its sinusoidal components must be increased by factor a. Similarly, a signal expanded in time varies more slowly. Hence, the frequencies of its components are lowered, implying that its frequency spectrum is compressed.

Q3. Describe Time-Shifting property and its physical explanation.

Time Shifting Property:

Time shifting property is the property where the signal is advanced or delayed and we have to find its fourier transform or we have to do different operations on it.

→ The signal $x(t)$ is delayed by τ to get $x(t-\tau)$ and advance by τ to get $x(t+\tau)$.

→ This property is:

if $g(t) \longleftrightarrow G(\omega)$

Then $g(t-t_0) \longleftrightarrow G(\omega)e^{-j\omega t_0}$

Proof:

$$\int_{-\infty}^{\infty} g(t-t_0)e^{-j\omega t}\,dt$$

let $x = t - t_0$

$t = x + t_0$

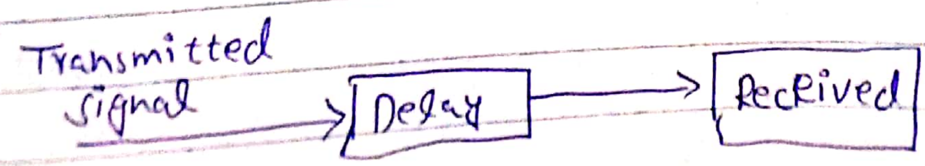
$dt = dx$

$$\Rightarrow \int_{-\infty}^{\infty} g(x)e^{-j\omega(x+t_0)}\,dx$$

$$= \int_{-\infty}^{\infty} g(x)e^{-j\omega x}\, e^{-j\omega t_0}$$

$$= e^{-j\omega t_0}\int_{-\infty}^{\infty} g(x)e^{-j\omega x} = e^{-j\omega t_0}\cdot G(\omega).$$

Physical explaination:



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(Question 4)

As given that

$$g(t) = \cos \omega_0 t \quad \text{—— (1)}$$

we can also write it as

$$\cos \omega_0 t = \frac{e^{j\omega_0 t} + e^{-j\omega_0 t}}{2}$$

putting values in eq (1)

$$g(t)\left(\frac{e^{j\omega_0 t} + e^{-j\omega_0 t}}{2}\right)$$

$$\Rightarrow \int_{-\infty}^{\infty} g(t)\left(\frac{e^{j\omega_0 t} + e^{-j\omega_0 t}}{2}\right) dt$$

$$= \frac{1}{2}\left[\int_{-\infty}^{\infty} g(t)\, e^{j\omega_0 t} dt + \int_{-\infty}^{\infty} g(t)\, e^{-j\omega_0 t} dt\right] \quad \text{—— (2)}$$

As we know that

$$\int_{-\infty}^{\infty} g(t)\, e^{j\omega_0 t} = G(\omega - \omega_0)$$

putting values in equation (2)

$$g(t) \cos \omega_0 t = \frac{1}{2}\left(G(\omega - \omega_0) + G(\omega + \omega_0)\right)$$

$$g(t) \cos \omega_0 t = \frac{1}{2}\left(G(\omega - \omega_0) + G(\omega + \omega_0)\right)$$

(Ans)

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(Question 5)

(Ans) For linear time invarient continuous system, the input and output relation is

$$y(t) = g(t) * h(t)$$

Signal Distortion:

When a signal passes from any system and its output waveforms are not same replica of input then it is called signal distortion. Signal distortion can occur because of multipath or thermal noise etc.

Distortionless transmission:

When a signal passes from any system and its output waveforms are same replica of input then it is called signal distortionless transmission.

Example of distortionless transmission is Email or mobile messages.

Intuitive Explaination.

Imagine $g(t)$ is composed of various sinusoids which are being passed through distortionless system. For distortionless case, the output signal is the input signal multiplied and delayed by t_0. To synthesize such signal we need exactly the same components as those of $g(t)$ with each component multiplied by k and delayed by t_d. This means that the system transfer function $H(\omega)$ should be such that each sinusoid component suffers the same attenuation k and each component undergoes the same time delay t_d seconds.

(Question 6)

$h(t) = e^{-2t}u(t)$

$H(\omega) = ?$

$H(\omega) = \int_{-\infty}^{\infty} e^{-2t} u(t).e^{-j\omega t} dt$

because function is $u(t)$ limit moves from $0 \to \infty$ $H(\omega)$ $\int_0^{\infty} e^{-2t} u(t).e^{-j\omega t} dt$

(1) $= \int_0^{\infty} e^{-2t}.e^{-j\omega t}(1).dt \Rightarrow \int_0^{\infty} e^{-2t-j\omega t}$

$= e^{-t(2+j\omega)}$

(2) $= \frac{-1}{2+j\omega}.e^{-(2+j\omega)t}\Big|_0^{\infty} = \frac{1}{2+j\omega}(0-1)$

$H(\omega) = \frac{1}{2+j\omega}$ > if $a>0$

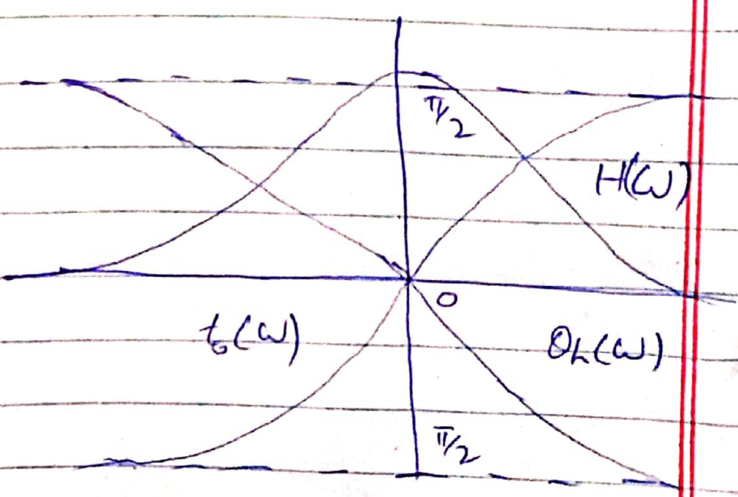
(b) Sketch $H(\omega)$, $\theta_b(\omega)$ and $t_o(\omega)$

$H(\omega) = \frac{1}{\sqrt{2^2+\omega}} e^{-j\tan^{-1}(\omega/2)}$

$|H(\omega)| = \frac{1}{\sqrt{4+U^2}}$

$\theta_b(\omega) = -\tan^{-1}(\omega/2)$

$t_o(\omega) = \frac{d\,\theta_h(\omega)}{d\omega} = -\frac{d(-\tan^{-1}(\omega/2)}{d\omega}$



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(c) if amp response is 2% and time ~~del~~. variation under 5% is tolerase, the transformission delay is

$$|H(\omega)| = \frac{1}{\sqrt{4+\omega^2}} \times \frac{2}{100}$$

$$|H(\omega)| = \frac{0.02}{\sqrt{4+\omega^2}}$$

$$t_0(\omega) = \frac{d}{d\omega} \tan^{-1}(\omega/2)$$

time delay by 5%

$$\frac{d}{d\omega} \tan^{-1}(\omega/2) \times \frac{5}{100}$$

$$t_0(\omega) = 0.05 \frac{d}{d\omega} \tan^{-1}(\omega/2)$$

$$BW = \frac{2\pi}{\tau} \qquad t = 0.05 \qquad = \frac{6.28}{0.05}$$

$$\boxed{BW = 125.6 Hz}$$

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Q7. Discuss the phenomena of the multipath.

(Ans) For wireless communication, if there are no objects in-between or around the transmitting and recEiving antennas, an ideal line of sight can be achieved with a proper setup. However thats not always the case, there will always be objects like trees, building etc in-between the transmitting and recieving antennas. Wireless signals reflect off these objects on their way from the transmitting antenna to the receiving antenna, creating multipaths for the signal to travel. This phenomenon is known as multipath Propagation.

The receiving antenna recEives the transmitted waves via multiple signals due to reflecting off of objects and therefore the signal is picked up multiple times. The reflected has a longer distance to travel than the direct line of sight, which could cause the signal to arrive at different phase and cause deconstructive interference.

(Question 8)

Solution:

Range from base station = 2 km

Area of hexagonal cell = ?

We know that

$$A = \frac{3\sqrt{3}}{2} R^2 \quad \text{——— (A)}$$

Here $R = 2\,km = 2000\,m$

$$\text{Area of cell} = \frac{3\sqrt{3}}{2} (2000)^2$$

$$\Rightarrow 3\sqrt{3} \times 2000,000$$

$$\Rightarrow 10392304.85\,m$$

$$\Rightarrow \boxed{10392.30485\ Km^2}$$

(Ans)

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(Question 9)

Solution:

Spectrum = 14 MHz
Cluster size = N = 7

No. of GSM voice channel allocated to signal = ?

we know that

$$S = KN \quad —(1)$$

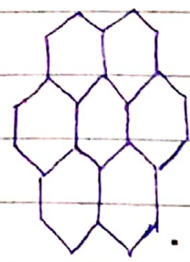
$$14 \times 10^6 = K(7)$$

$$K = \frac{14 \times 10^6}{7}$$

$$\boxed{K = 2 \times 10^6}$$

(Question 10)

1st tier:



As we know that

$$K = S/N$$

$$S = 7 \times 6 = 42$$

$$K = 6.$$

There are 6 co-channels cells in the first tier and total cells are 42 in number.

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(Question 11)

Correlation technique:

In this technique, we correlate the received signal s2 and the signal s1, which is sent from the sending end.

$$R(t) = \int_0^{T} s_1(t).s_2(t)\,dt$$

But $s_2(t)$ should be advanced because it is delayed meanwhile communication.

so $\quad s_2(t+\tau)$

$$R(t) = \int_0^{\tau} s_1(t)\,s_2(t+\tau)\,dt \quad \text{——} (1)$$

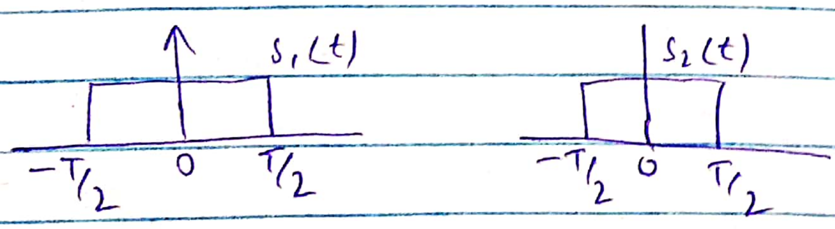
In case of ideal transformation, the delay would be $\tau = 0$ then eq(1) can be written as

$$R(t) = \int_0^{T} s_1(t)\,s_2(t)\,dt$$

$$R(t) = \int_0^{T} s_1(t).s_1(t)\,dt = \int_0^{T} s_1^2(t)\,dt \quad \text{——} (B)$$

$\therefore s_1(t) = s_2(t)$

Equation (B) shows 100 % correlation.



$$R(t) = \int_{-T/2}^{T/2} s_1(t).s_2(t)\,dt = \int_{-T/2}^{T/2} s_1^2(t)\,dt$$

Proved.

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Question #12

Orthogonal mem Signal Energy = 1

$$\int_{-T/2}^{T/2} x(t)^2 \, dt = \int_{-T/2}^{T/2} rect(t/T)^2$$

$$E = \int_{-T/2}^{T/2} A^2 \, dt = A^2 dt \Big|_{-T/2}^{T/2}$$

$$= A^2 T$$

Now

$$A^2 T = 1$$

$$A^2 = 1/T \Rightarrow A = \sqrt{1/T}$$

Ans

So the Magnitude will be $1/\sqrt{T}$ when Signal Energy is 1.

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Q13

Ans: Given data:

$P_e = 10^{-4}$

$N_0 = 10^{-8}$ watt/Hz

$\rho = 0$ (orthogonal)

$R = ?$

Solution:

$Q(z) = 10^{-4}$

$z = 3.625$

$$3.625 = \sqrt{\frac{E_b(1-0)}{10^{-5}}}$$

$$13.14 \times 10^{-8} = E_b$$

$$E_b = \int_0^T |100 \times 10^{-3}|^2$$

$$13.14 \times 10^{-8} = (100 \times 10^{-3}) \times \frac{T}{2}^2$$

$$\Rightarrow T = \frac{3.628 \times 10^{-7}}{(100 \times 10^{-3})^2}$$

$$T = 2.628 \times 10^{-8}$$

$$R = \frac{1}{T} \Rightarrow \frac{1}{2.628 \times 10^{-3}}$$

$$\boxed{R = 38051 \text{ bit/s}}$$

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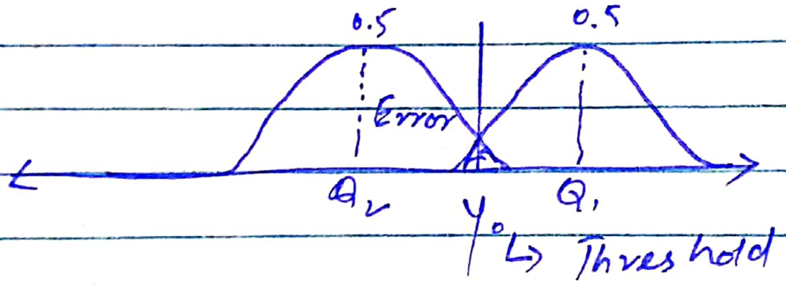
Q.No4: Prove the formula for Probabil—.?

Ans **Probability Error:**

Mean while communication of signals there is alwayes the probabity of error in the communication process i.e; if the sender set 'S_1' where (S_2) is recived at the recieving end then it is sand to be an error in the communication. It can be illustrated via below given diagram



$$P(H_2/S_1) = P(e/S_1)$$

So

$$P(e/S_1) = \int_{-\infty}^{\delta} p(z/S_1)\,dz$$

If S_2 is sent while S_1 is obtained

the $P(H_1/S_2) = P(e/S_2)$

$$\text{And } P(e/S_2) = \int_{y_0}^{\infty} p(z/S_2)\,dz$$

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