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INTERNAL ASSESSMENT TEST – I

Sub:	DIGITAL COMMUNICATION							Code:	15EC61
Date:	12/ 03 / 2018	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE,TCE

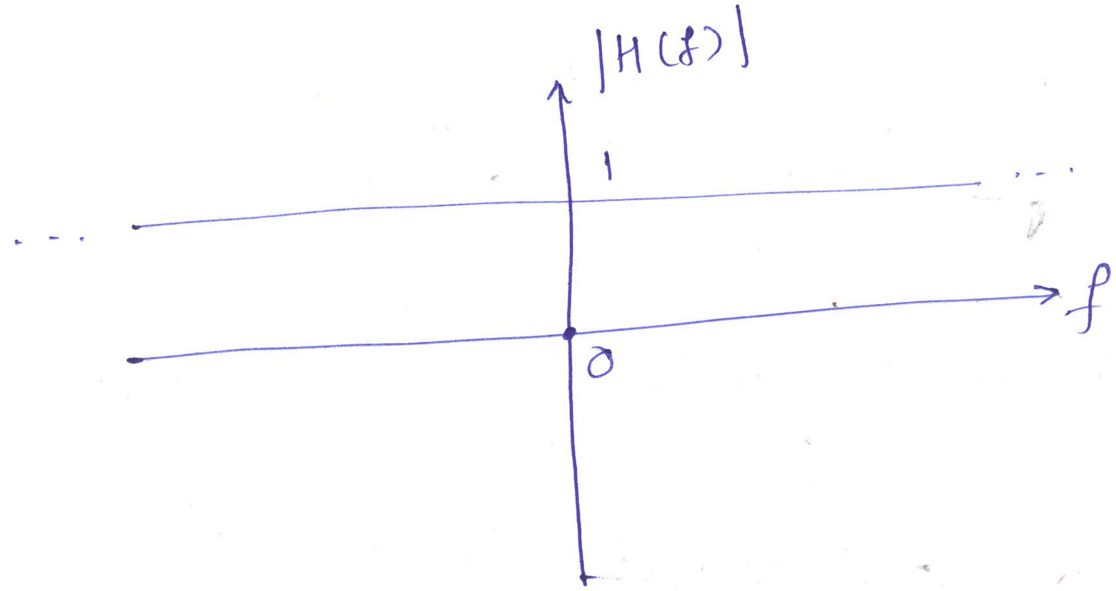
Answer any 5 full questions

		Marks	CO	RBT
1.	Define Hilbert transform. Plot the magnitude response and phase response of an ideal Hilbert transformer. Derive the impulse response of the ideal Hilbert transformer.	[10]	CO1	L3
2(a).	State and prove the properties of ideal Hilbert transformer.	[06]	CO1	L2
2(b)	Determine the Hilbert transform of $m(t)\cos(2\pi f_c t)$ assuming that $m(t)$ is a low pass signal bandlimited to W Hz and $f_c \gg W$.	[04]	CO1	L2
3(a)	Determine the Hilbert transform of the signal $x(t)$ where $x(t) = \begin{cases} A & for\ -\frac{T_b}{2} \leq t \leq \frac{T_b}{2} \\ 0 & otherwise \end{cases}$	[05]	CO1	L2
3(b)	Determine the Hilbert transform of $x(t) = sinc(t)$.	[05]	CO1	L2
4	Discuss pre-envelope with positive frequencies and complex envelope of bandpass signals with relevant equations and waveforms. Determine the pre-envelope and complex envelope of $x(t) = sinc(t)$.	[10]	CO1	L2
5	Derive an expression for the canonical representation of bandpass signals. Obtain a scheme for extracting in-phase and quadrature components of bandpass signals.	[10]	CO1	L2
6(a)	For the binary data "101101" plot the following waveforms. i) NRZ Unipolar ii) NRZ Polar iii) RZ Polar iv) RZ Unipolar v) NRZ Bipolar vi) Manchester	[06]	CO1	L2
6(b)	Perform differential encoding on the binary data "101101". Show that original binary data can be decoded even in the presence of polarity inversion.	[04]	CO1	L2
7	Derive an expression for power spectral density of NRZ bipolar format assuming equiprobable and statistically independent 0s and 1s. Plot the resulting power spectral density.	[10]	CO1	L3

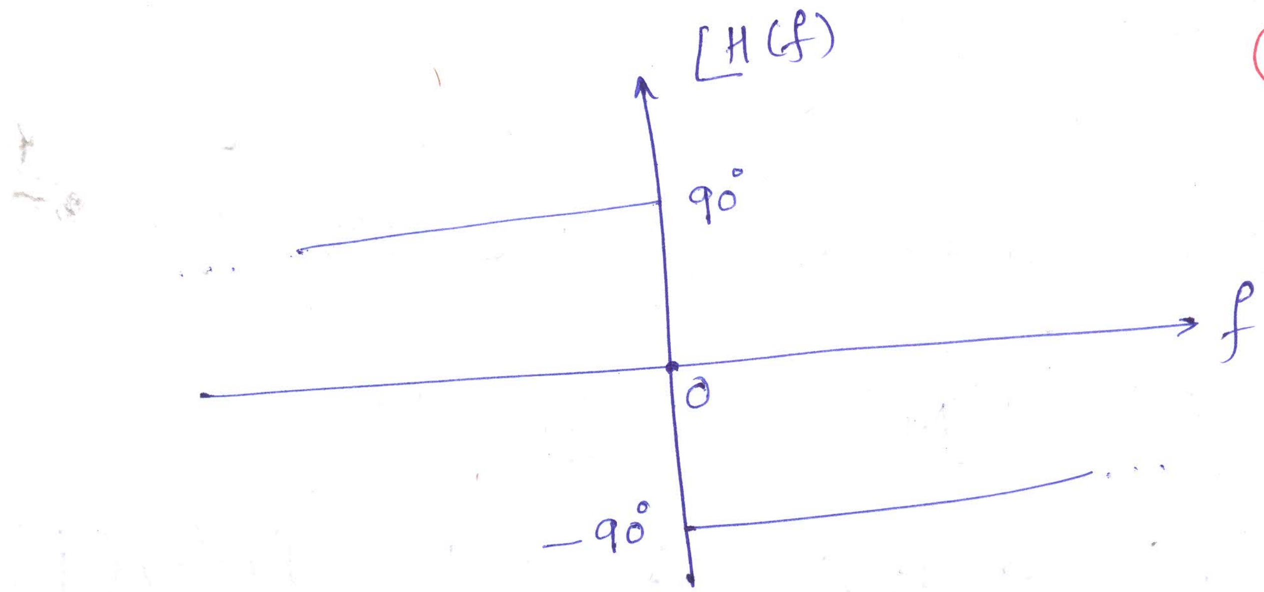
Solution and Scheme of Evaluation ①

1) When +ve frequency components are phase shifted by -90° and $-$ve frequency components are phase shifted by 90°, the resulting time domain signal is called HT of the signal (2)

(1)



(1)



$$h(t) = \frac{1}{\pi t}$$ (6)

2a) i) $\hat{H}(f) = -j\,\mathrm{sgn}(f)$

$$\hat{X}(f) = X(f)\,H(f)$$

$$\therefore |\hat{X}(f)| = |X(f)\,(-j\,\mathrm{sgn}(f))|$$

$$= |X(f)|$$ (2)

ii) $\hat{X}(f) = X(f)\,(-j\,\mathrm{sgn}(f))$

$$\hat{\hat{X}}(f) = X(f)\,(-j\,\mathrm{sgn}(f))\,(-j\,\mathrm{sgn}(f))$$

$$= -X(f)$$ (2)

$$\therefore \hat{x}(t) = -x(t)$$

iii) $\int_{-\infty}^{\infty} x(t)\,\hat{x}(t)\,dt = 0$ (2)

2b) $x(t) = \cancel{m(t)\sin(}\ m(t)\cos(2\pi f_c t)$

$$X(f) = \frac{1}{2}M(f-f_c) + \frac{1}{2}M(f+f_c)$$

$$\hat{X}(f) = \frac{1}{2}M(f-f_c)(-j) + \frac{1}{2}M(f+f_c)(j)$$ (2)

$$\hat{x}(t) = m(t)\sin(2\pi f_c t)$$ (2)

3a.

$$\hat{x}(t) = \int_{-\frac{T_b}{2}}^{\frac{T_b}{2}} A \frac{1}{\pi(t-\tau)} \, d\tau$$

$$= \frac{A}{\pi} \left[\frac{-1}{} \ln\left(t-\tau\right) \right]_{-\frac{T_b}{2}}^{\frac{T_b}{2}}$$

$$= -\frac{A}{\pi} \ln\left(\frac{t-\frac{T_b}{2}}{t+\frac{T_b}{2}}\right)$$ (5)

3b.

$$X(f) = \begin{cases} 1 & -\frac{1}{2} \le f \le \frac{1}{2} \\ 0 & \text{otherwise} \end{cases}$$ (1)

$$\hat{X}(f) = \begin{cases} j & -\frac{1}{2} \le f < 0 \\ 0 & f = 0 \\ -j & 0 < f \le \frac{1}{2} \end{cases}$$ (2)

$\hat{x}(t) =$ IFT of $\hat{X}(f)$ (2)

$$= \frac{1 - \cos(\pi t)}{\pi t}$$

4.

$$x_+(t) = x(t) + j\,\hat{x}(t)$$

$$X_+(f) = X(f) + j\,\hat{X}(f)$$

$$= X(f) + j\left(-j\,\mathrm{sgn}(f)\,X(f)\right)$$

$$= X(f) + \mathrm{sgn}(f)\,X(f)$$

$$= \begin{cases} 2X(f) & \text{for } f>0 \\ X(0) & \text{for } f=0 \\ 0 & \text{for } f<0 \end{cases}$$

$$\tilde{x}(t) = x_+(t)\, e^{-j2\pi f_c t}$$

$$\tilde{X}(f) = X_+(f+f_c)$$

$$x(t) = \mathrm{sinc}(t)$$

$$\hat{x}(t) = \frac{1-\cos(\pi t)}{\pi t}$$

$$\therefore x_+(t) = \frac{\sin(\pi t)}{\pi t} + j\,\frac{1-\cos(\pi t)}{\pi t}$$

$$= \frac{\sin(\pi t) + j - j\cos(\pi t)}{\pi t}$$

$$= \frac{-j\left(\cos(\pi t) + j\sin(\pi t)\right) + j}{\pi t}$$

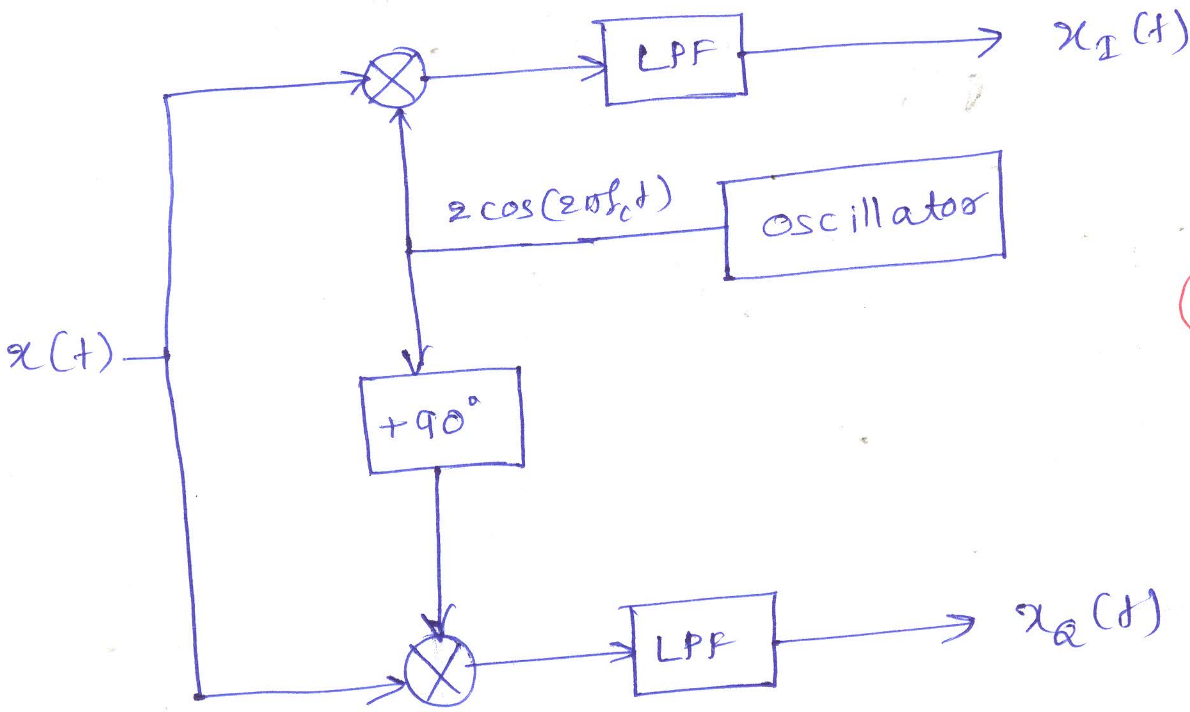
$$= \frac{-j\,e^{j\pi t} + j}{\pi t}$$

$$\tilde{x}(t) = x_+(t)\, e^{-j2\pi f_c t}$$ (5)

5. $$x(t) = x_I(t)\cos(2\pi f_c t) - x_Q(t)\sin(2\pi f_c t)$$ (4)

$$x(t)\cos(2\pi f_c t) = x_I(t)\cos^2(2\pi f_c t) - x_Q(t)\frac{1}{2}\sin(4\pi f_c t)$$ (2)

$$x(t)\sin(2\pi f_c t) = x_I(t)\frac{1}{2}\sin(4\pi f_c t) - x_Q(t)\sin^2(2\pi f_c t)$$ (2)



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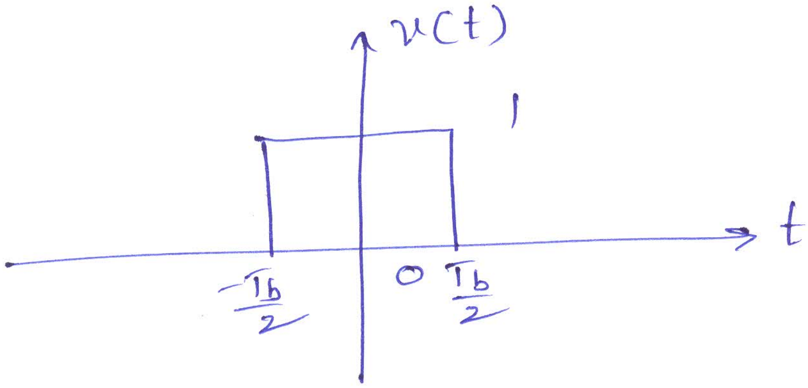
b_k		1	0	1	1	0	1
d_k	1	0	0	1	0	0	1
$\hat{d}_k = \overline{d_k}$	0	1	1	0	1	1	0
$\hat{b}_k$		1	0	1	1	0	1

(2)

(2)

⑥

7. NRZ Bipolar format



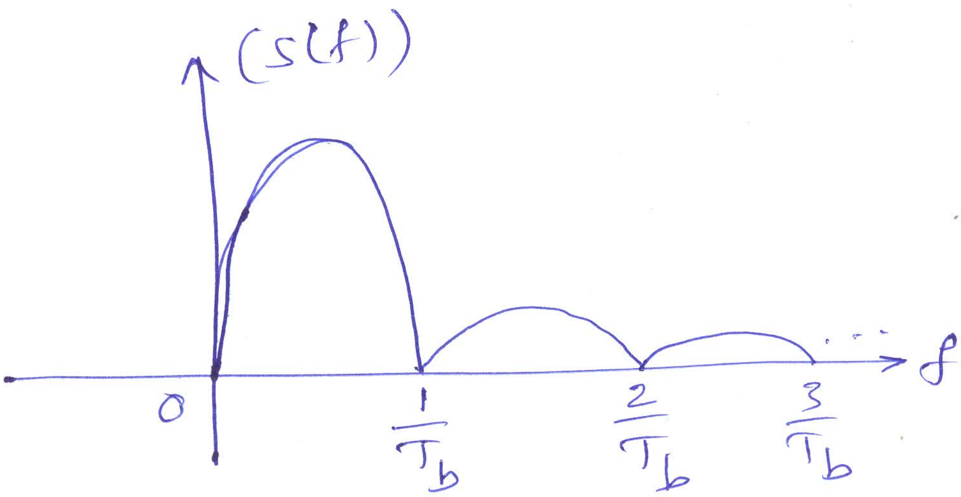
$$V(f) = T_b \operatorname{sinc}(fT_b)$$ (2)

$$R_A(n) = \begin{cases} \frac{a^2}{2}, & n = 0 \\ -\frac{a^2}{4}, & n = \pm 1 \\ 0 & \text{otherwise} \end{cases}$$ (3)

$$\therefore S(f) = \frac{1}{T_b} |V(f)|^2 \sum_{n=-\infty}^{\infty} R_A(n)\, e^{-j2\pi f n T_b}$$

$$= T_b \operatorname{sinc}^2(fT_b)\, \frac{a^2}{2} \left[1 - \cos(2\pi f T_b)\right]$$

$$= a^2 T_b \operatorname{sinc}^2(fT_b) \sin^2(\pi f T_b)$$ (3)



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