Scheme Of Evaluation
Internal Assessment Test I – May 2022

Sub:	DIGITAL COMMUNICATION							Code:	18EC61
Date:	06 / 05 / 2022	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE

Note: Answer All Questions

Question #		Description	Marks Distribution		Max Marks
1	a	Define Hilbert transform. Plot the magnitude response and phase response of the ideal Hilbert transformer. What is the impulse response of the ideal Hilbert transformer?		5	10
		• Definition of Hilbert transform • Magnitude Response • Phase Response • Impulse Response	2 1 1 1		
	b	Determine the Hilbert transform of x(t)=sinc(t)		5	
		• Fourier Transform of x(t) • Hilbert transfrom of x(t)	2 3		
2	a	State and prove the properties of Hilbert transform.		6	10
		• 3 properties – statement and proof	6		
	b	Determine the Hilbert transform of the signal $x(t)$ given by $x(t) = \begin{cases} 1 & for\ -\frac{T}{2} \le t \le \frac{T}{2} \\ 0 & otherwise \end{cases}$		4	
		• Convolution of x(t) and h(t)	4		
3		Discuss pre-envelope and complex envelope of bandpass signals with relevant equations. Plot the spectra of a bandpass signal, its pre-envelope and complex envelope.		10	10
		• pre-envelope and complex envelope – definition in time domain • pre-envelope and complex envelope – frequency domain representation • Plotting the spectra	4 4 2		
4		Derive an expression for the canonical representation of bandpass signals. Obtain a scheme for extracting in-phase and quadrature components of bandpass signals. Draw the corresponding block diagram.		10	10

		• Expression in terms of in-phase and quadrature components • Block diagram to get $x_i(t)$ and $x_q(t)$ • Block diagram to construct $x(t)$	5 3 2		
5	a	Find the pre-envelope and complex envelope of $x(t) = A_c[1 + K_a m(t)]\cos(2\pi f_c t)$ where $m(t)$ is a lowpass signal bandlimted to W Hz and $f_c \gg W$.		4	10
		• Finding the pre-envelope • Finding complex envelope	2 2		
	b	Sketch the waveforms for the binary sequence "110000000011" using the following line coding schemes. i) HDB3 ii) B3ZS iii) B6ZS		6	
		• Plotting the waveforms	6		
6		Derive an expression for the power spectral density of NRZ unipolar signals.		10	10
		• Fourier transform of basic pulse • Autocorrelation function • Simplification	3 3 4		

Solutions
Internal Assessment Test I – May 2021

Sub:	DIGITAL COMMUNICATION							Code:	18EC61
Date:	19/05/2021	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE,TCE

Note: Answer All Questions

<table>
<tr><th colspan="2">Question #</th><th>Description</th><th>Marks</th></tr>
<tr><td>1</td><td>a</td><td>Define Hilbert transform. Plot the magnitude response and phase response of the ideal Hilbert transformer. What is the impulse response of the ideal Hilbert transformer?</td><td>5</td></tr>
<tr><td></td><td></td><td>

- +ve frequency components are phase shifted by -90 degree and -ve frequency components are phase shifted by 90 degree
- $|H(f)| = \begin{cases} 1 \; for \; f \neq 0 \\ 0 \; for \; f = 0 \end{cases}$
- $< H(f) = \begin{cases} -90 \; degree \; for \; f > 0 \\ 0 \; at \; f = 0 \\ 90 \; degree \; for \; f < 0 \end{cases}$

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

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<tr><td></td><td>b</td><td>Determine the Hilbert transform of x(t)=sinc(t)</td><td>5</td></tr>
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- $X(f) = rect(f)$
- $\hat{X}(f) = X(f)H(f)$
- $\hat{x}(t) = IFT \; of \; \hat{X}(f)$

$$= \int_{-\frac{1}{2}}^{\frac{1}{2}} X(f)H(f)df$$

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

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<tr><td>2</td><td>a</td><td>State and prove the properties of Hilbert transform.</td><td>6</td></tr>
<tr><td></td><td></td><td>

- A signal and its HT have the same magnitude spectrum

  Proof :

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

- HT of HT of $x(t)$ is $-x(t)$

  Proof :

  Total phase shift after taking HT once is equal to ∓ 90 degree

  Total phase shift after taking HT twice is equal to ∓ 180 degree

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Therefore, we get $-x(t)$ as HT of HT of $x(t)$

- A signal and its HT are orthogonal to each other.

Proof :

$$\int_{-\infty}^{\infty} X(f)\hat{X}^*(f)df = \int_{-\infty}^{\infty} X(f)X^*(f)j\,sgn(f)df = \int_{-\infty}^{\infty} |X(f)|^2 sgn(f)df = 0$$

b Determine the Hilbert transform of the signal $x(t)$ given by **4**

$$x(t) = \begin{cases} 1 & for\ -\frac{T}{2} \le t \le \frac{T}{2} \\ 0 & otherwise \end{cases}$$

$$\hat{x}(t) = x(t) * h(t)$$

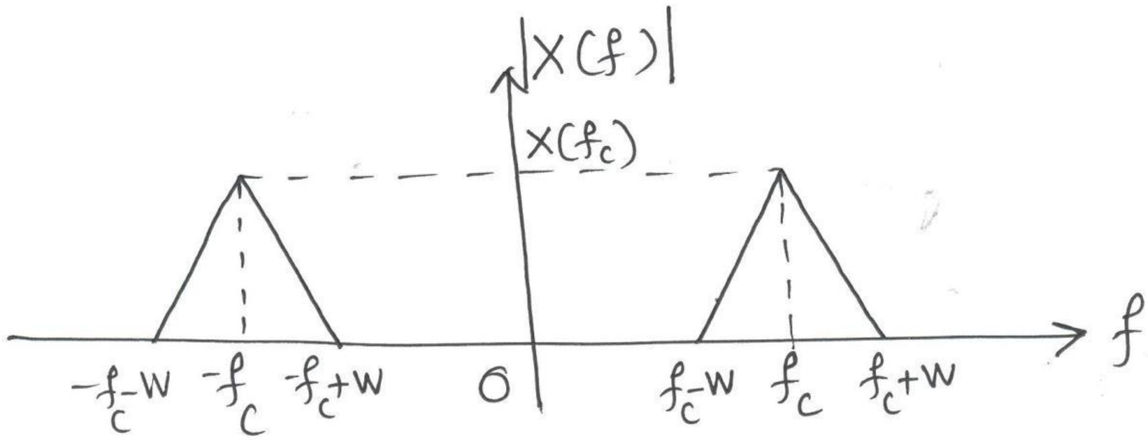
$$= \int_{-\frac{T}{2}}^{\frac{T}{2}} \frac{1}{\pi(t-r)} dr$$

$$= -\frac{1}{\pi} \ln\{t-r\} \Big|_{-\frac{T}{2}}^{\frac{T}{2}}$$

$$= -\frac{1}{\pi} ln\left(\frac{t-\frac{T}{2}}{t+\frac{T}{2}}\right)$$

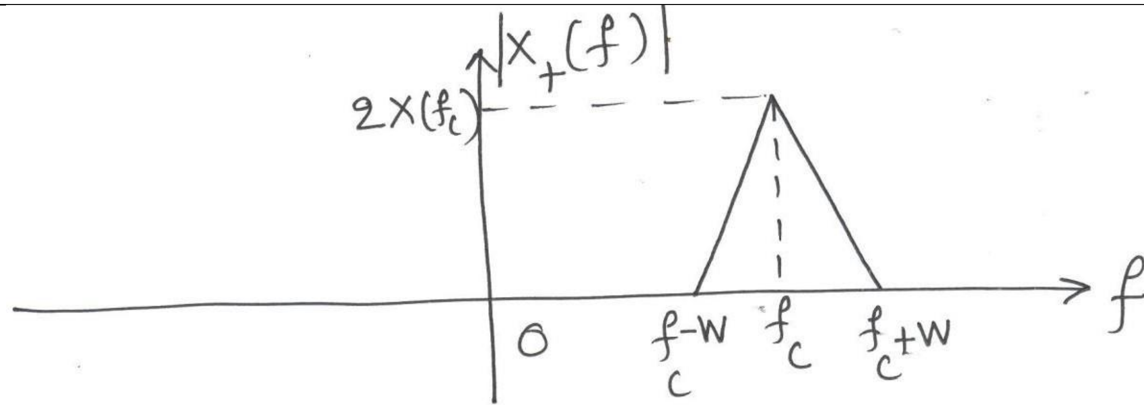
3 Discuss pre-envelope and complex envelope of bandpass signals with relevant equations. Plot the spectra of a bandpass signal, its pre-envelope and complex envelope. **10**

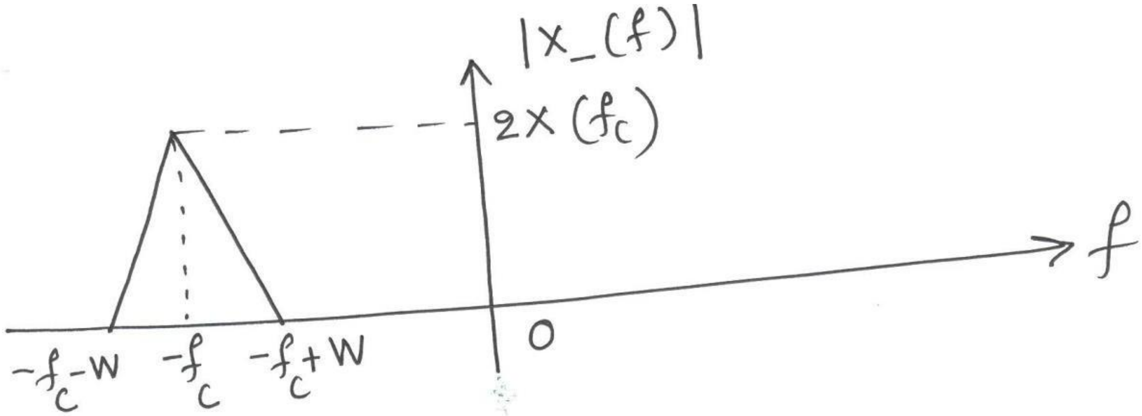
Let $x(t)$ be a bandpass signal.



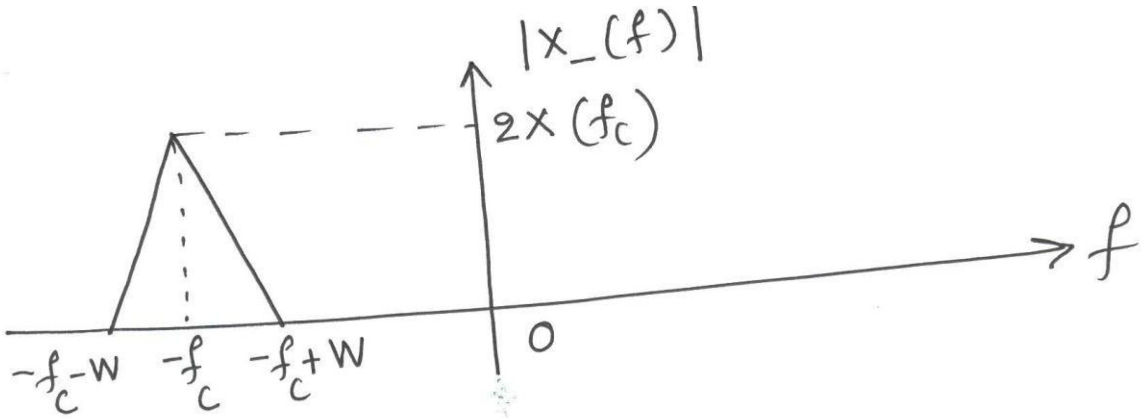
$$x_+(t) = x(t) + j\hat{x}(t)$$

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



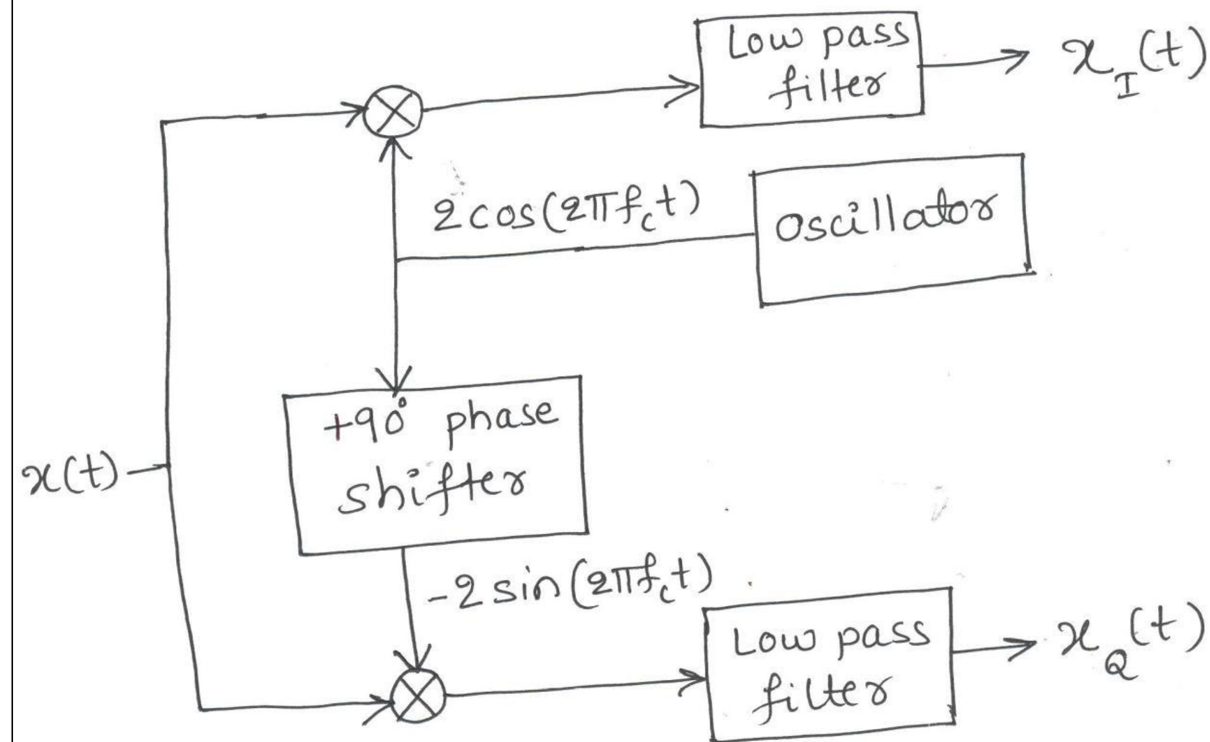


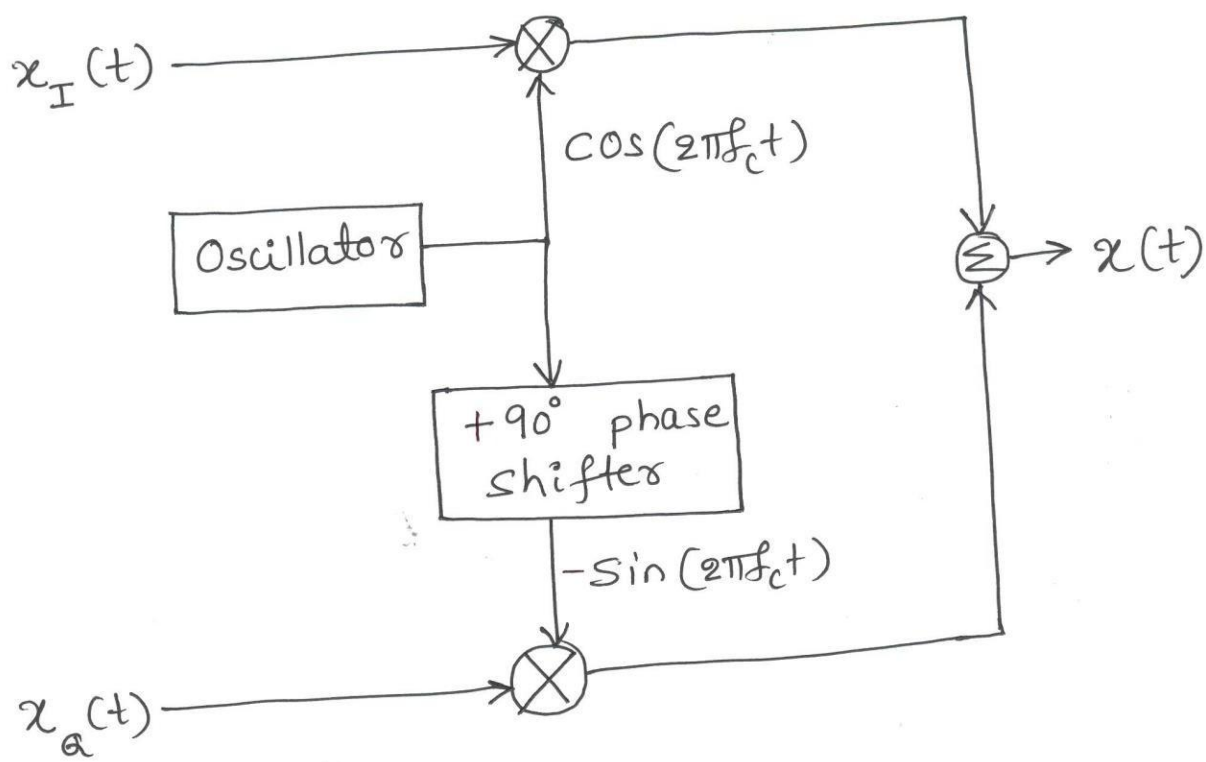
$$\tilde{x}(t) = x_{+}(t)e^{-j2\pi f_c t}$$

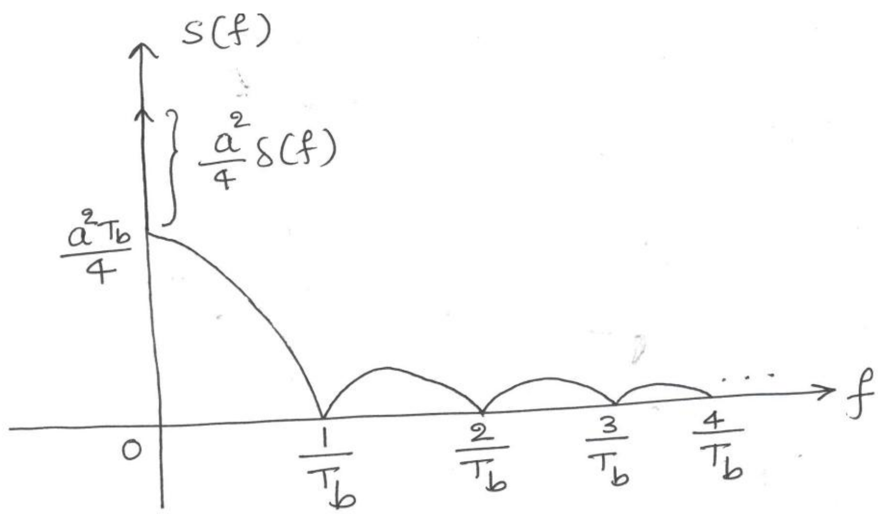


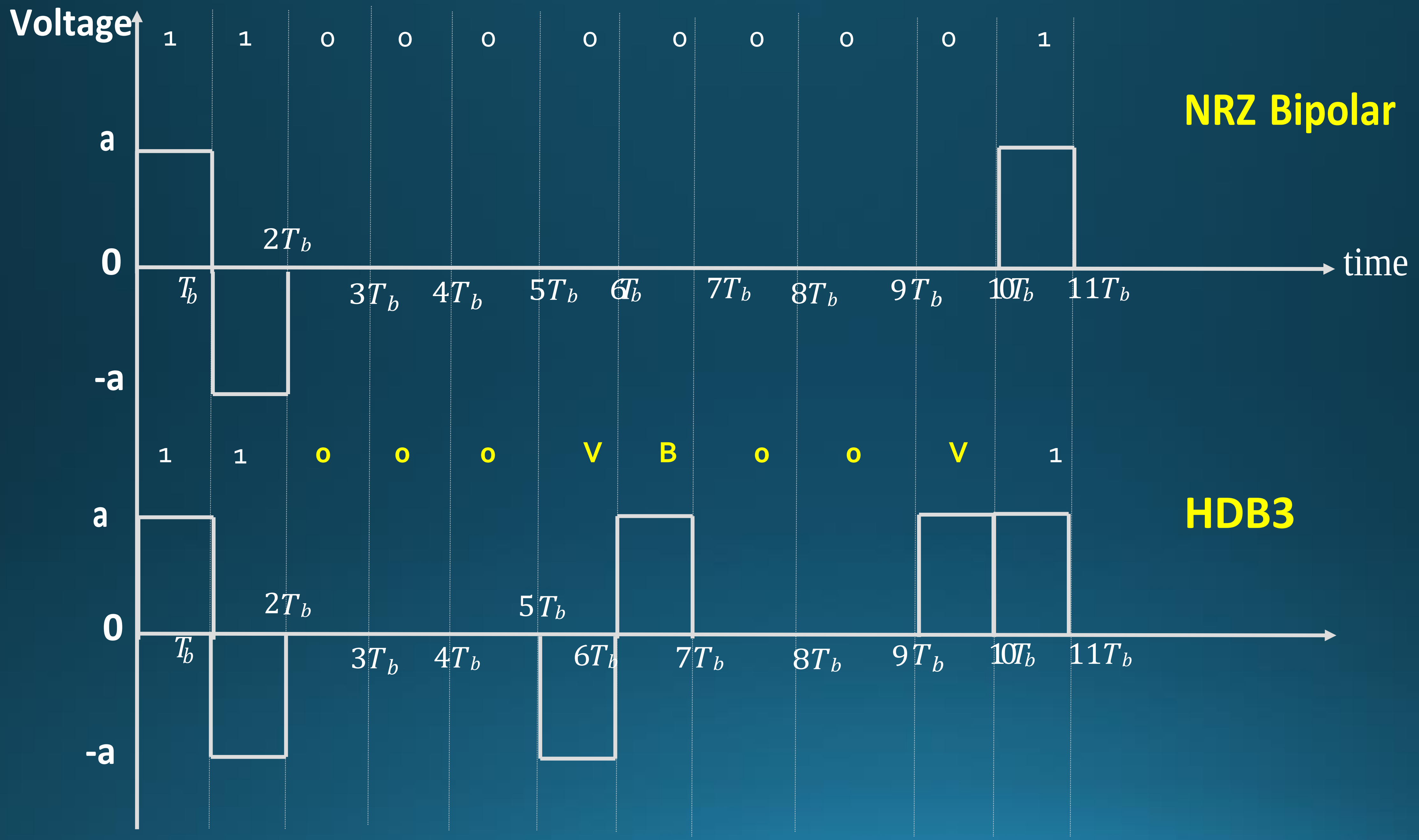
4		Derive an expression for the canonical representation of bandpass signals. Obtain a scheme for extracting in-phase and quadrature components of bandpass signals. Draw the corresponding block diagram.	10

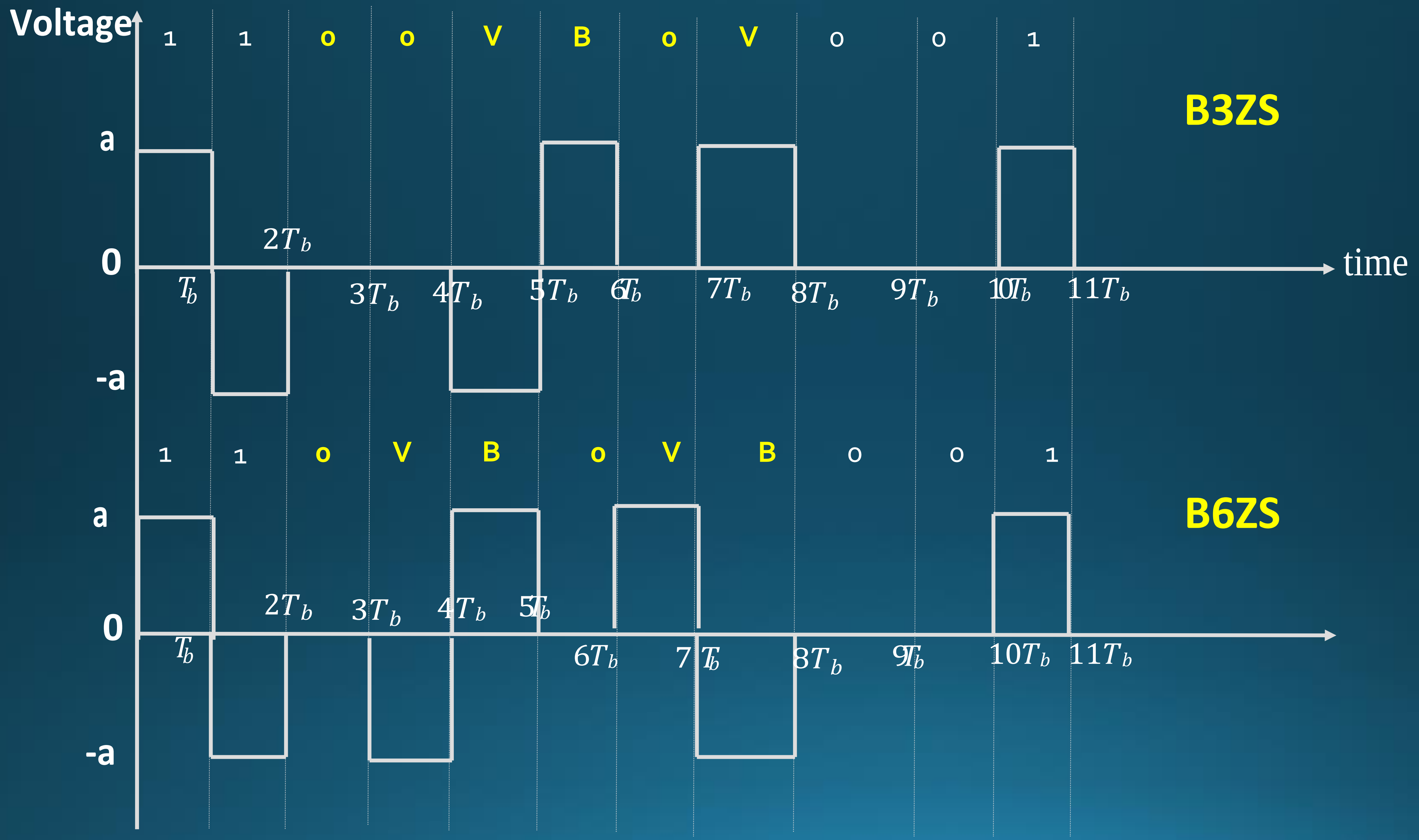
$$x(t) = x_i(t)\cos(2\pi f_c t) - x_Q(t)\sin(2\pi f_c t)$$





6		Derive an expression for the power spectral density of NRZ unipolar signals.	10
		$V(f) = T_b sinc(fT_b)$ $R_A(n) = \begin{cases} \frac{a^2}{2} for\ n = 0 \\ \frac{a^2}{4}\ \text{otherwise} \end{cases}$ $S(f) = \frac{1}{T_b} \lvert V(f) \rvert^2 \sum_{n=-\infty}^{\infty} R_A(n) e^{-j2\pi f n T_b}$ $= \frac{a^2}{4} T_b sinc^2(fT_b) + \frac{a^2}{4}\delta(f)$  	
5	a	Sketch the waveforms for the binary sequence "11001100" using the following line coding schemes. i) NRZ Polar ii) RZ Bipolar iii) Manchester ii) NRZ Unipolar	4
	b	Sketch the waveforms for the binary sequence "110000000011" using the following line coding schemes. i) HDB3 ii) B3ZS iii) B6ZS	6


Voltage
1 1 0 0 0 0 0 0 0 0 1
NRZ Bipolar
a
0
-a
$2T_b$
T_b $3T_b$ $4T_b$ $5T_b$ $6T_b$ $7T_b$ $8T_b$ $9T_b$ $10T_b$ $11T_b$
time
1 1 0 0 0 V B 0 0 V 1
HDB3
a
0
-a
$2T_b$ $5T_b$
T_b $3T_b$ $4T_b$ $6T_b$ $7T_b$ $8T_b$ $9T_b$ $10T_b$ $11T_b$



Voltage
time
a
0
-a
1 1 o o V B o V 0 0 1
B3ZS
1 1 o V B o V B 0 0 1
B6ZS
T_b $2T_b$ $3T_b$ $4T_b$ $5T_b$ $6T_b$ $7T_b$ $8T_b$ $9T_b$ $10T_b$ $11T_b$