Scheme Of Evaluation
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

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

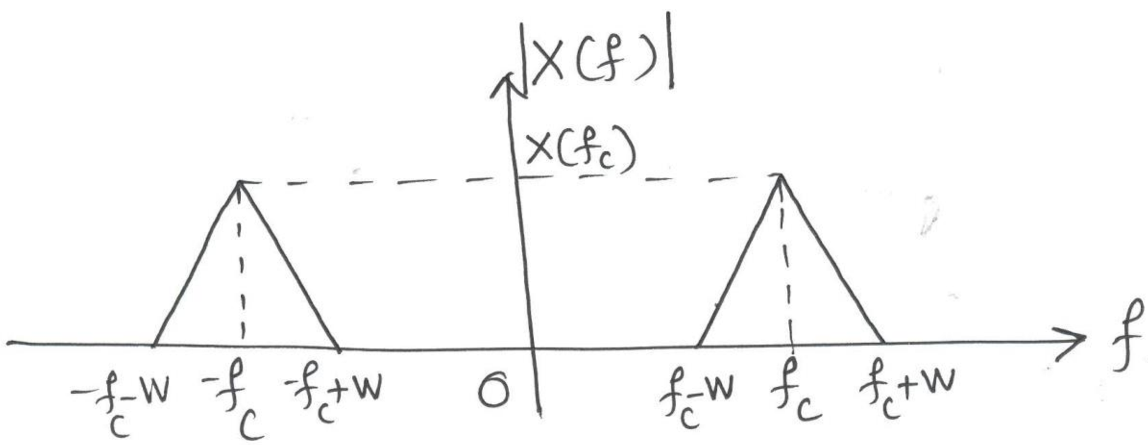
		• Expression in terms of in-phase and quadrature components • Block diagram to get $x_i(t)$ and $x_q(t)$ • Block diagram to construct $x(t)$	5 3 2		
5	a	Sketch the waveforms for the binary sequence "11001100" using the following line coding schemes. i) NRZ Polar ii) RZ Bipolar iii) Manchester ii) NRZ Unipolar		4	10
		• Plotting the waveforms	4		
	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 bipolar signals.		10	10
		• Fourier transform of basic pulse • Autocorrelation function • Simplification	3 3 4		

Solutions
Internal Assessment Test I – May 2021

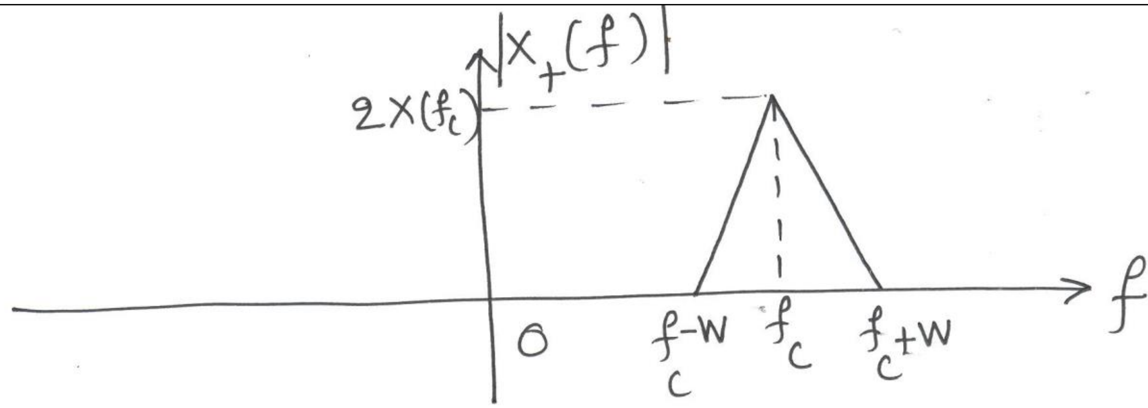
Sub:	DIGITAL COMMUNICATION							Code:	18EC61
Date:	19/05/2021	Duration:	90 mins	Max Marks:	50	Sem:	VI	Branch:	ECE,TCE

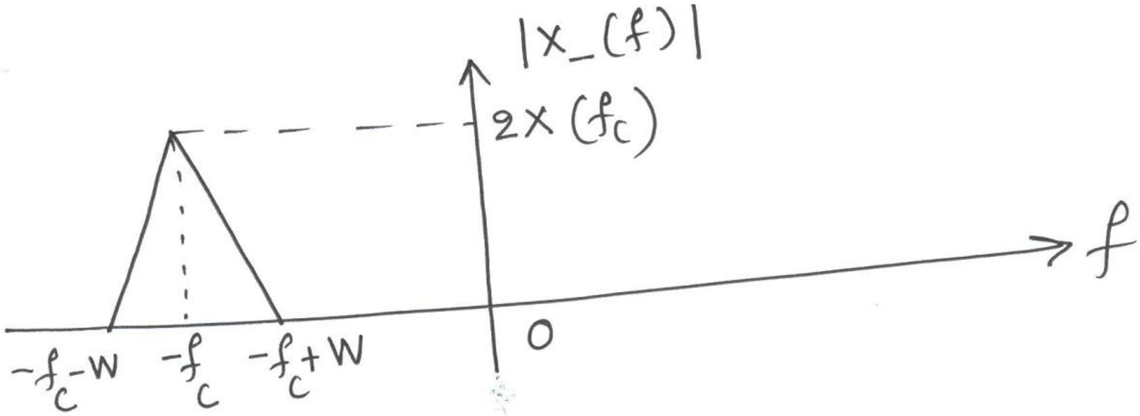
Note: Answer All Questions

Question #		Description	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
		• +ve frequency components are phase shifted by -90 degree and -ve frequency components are phase shifted by 90 degree • $\lvert H(f)\rvert = \begin{cases} 1\ for\ f \neq 0 \\ 0\ for\ f = 0 \end{cases}$ • $< H(f) = \begin{cases} -90\ degree\ for\ f > 0 \\ 0\ at\ f = 0 \\ 90\ degree\ for\ f < 0 \end{cases}$ $$h(t) = \frac{1}{\pi t}$$	
	b	Determine the Hilbert transform of x(t)=sinc(t)	5
		• $X(f) = rect(f)$ • $\widehat{X(f)} = X(f)H(f)$ • $\hat{x}(t) = IFT\ of\ \hat{X}(f)$ $$= \int_{-\frac{1}{2}}^{\frac{1}{2}} X(f)H(f)df$$ $$= \frac{1-\cos(\pi t)}{\pi t}$$	
2	a	State and prove the properties of Hilbert transform.	6
		• A signal and its HT have the same magnitude spectrum Proof : $$\lvert\hat{X}(f)\rvert = \lvert X(f)\rvert\lvert H(f) = \lvert X(f)\rvert$$ • 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	

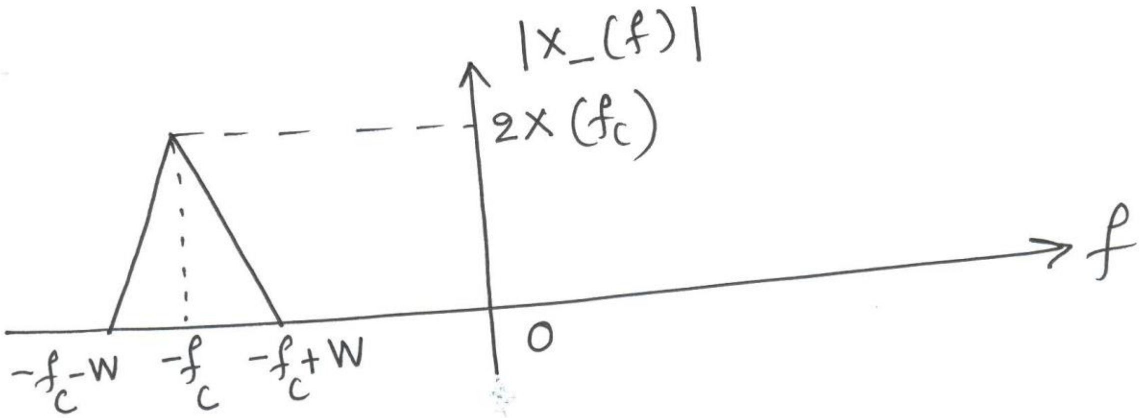
		Therefore, we get $-x(t)$ as HT of HT of $x(t)$ • A signal and its HT are orthogonal to each other. Proof : $\int_{-\infty}^{\infty} X(f)\hat{X}^*(f)df = \int_{-\infty}^{\infty} X(f)X^*(f)j\, sgn(f)df = \int_{-\infty}^{\infty} \lvert X(f)\rvert^2 sgn(f)df = 0$	
	b	Determine the Hilbert transform of the 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
		$\hat{x}(t) = x(t) * h(t)$ $= \int_{-\frac{T}{2}}^{\frac{T}{2}} \frac{1}{\pi(t-\tau)} d\tau$ $= -\frac{1}{\pi} \ln\{t-\tau\} \rvert_{-\frac{T}{2}}^{\frac{T}{2}}$ $= -\frac{1}{\pi} ln\left(\frac{t-\frac{T}{2}}{t+\frac{T}{2}}\right)$	
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.  $x_+(t) = x(t) + j\hat{x}(t)$ $x_-(t) = x(t) - j\hat{x}(t)$	

<table>
<tr>
<td></td>
<td></td>
<td>



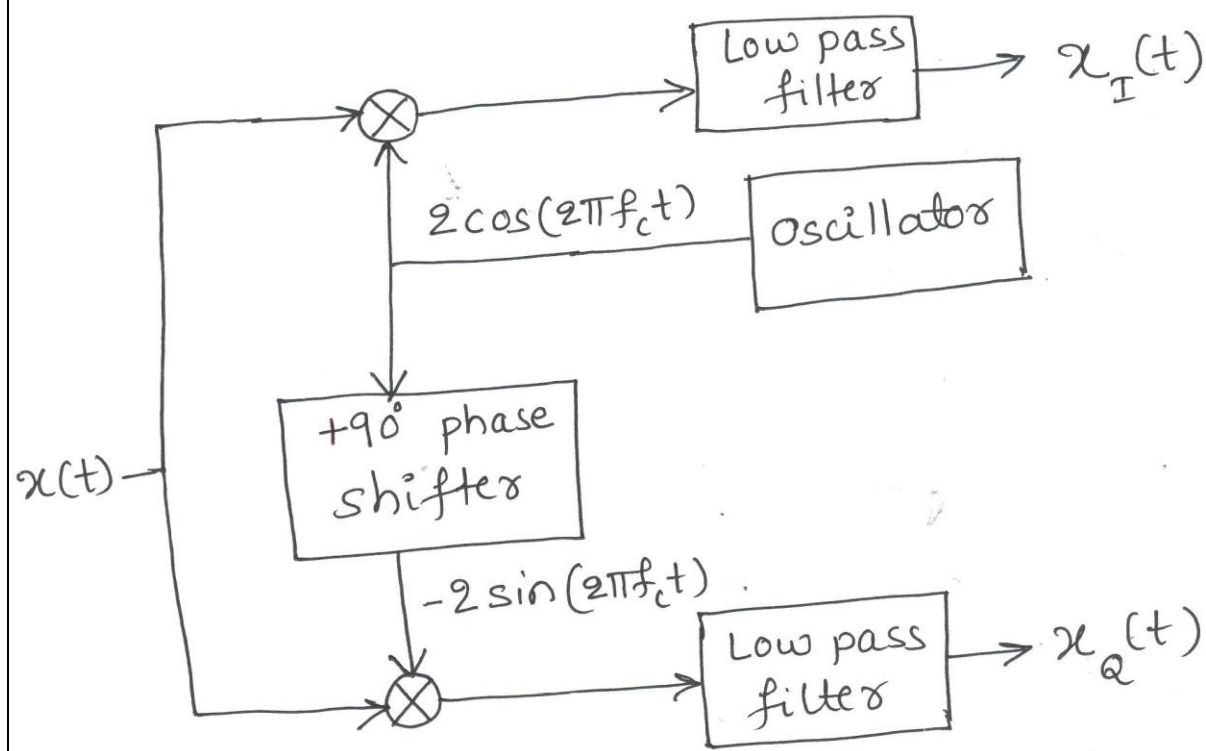


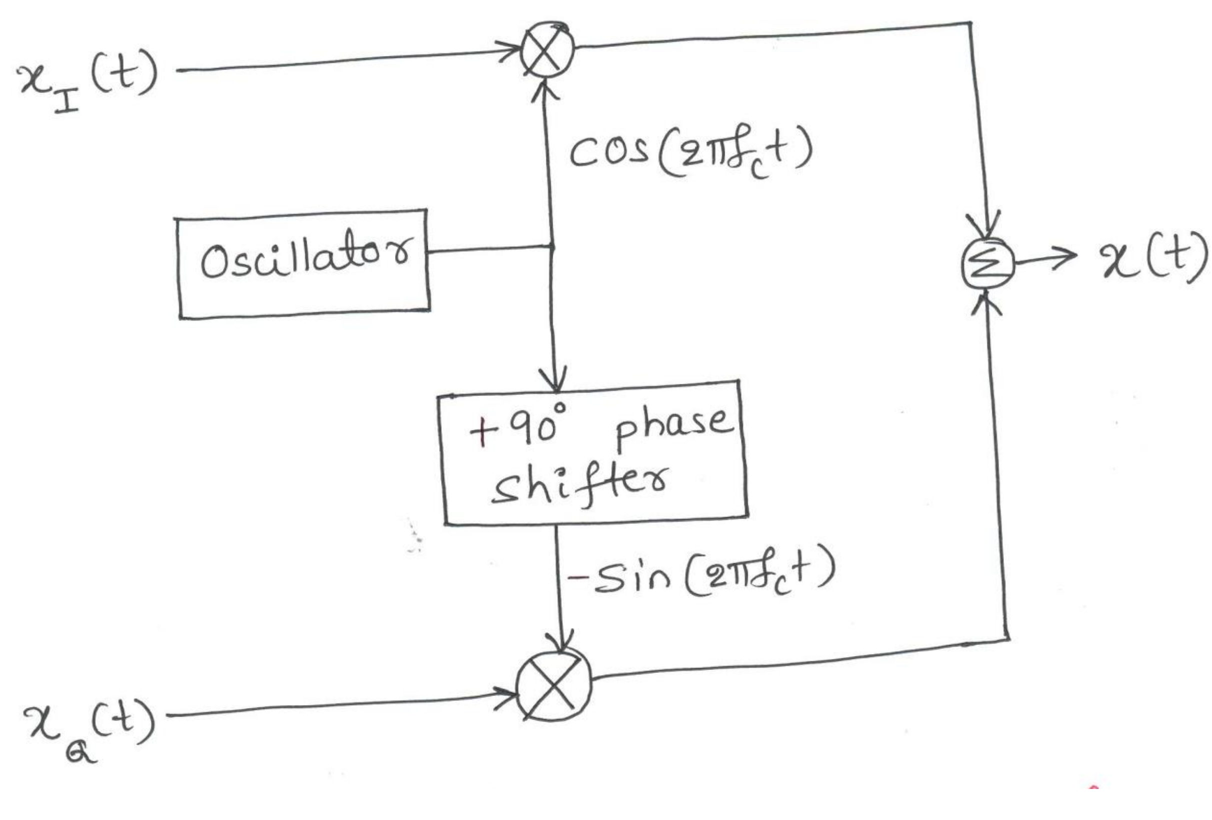
$$\tilde{x}(t) = x_+(t)e^{-j2\pi f_c t}$$

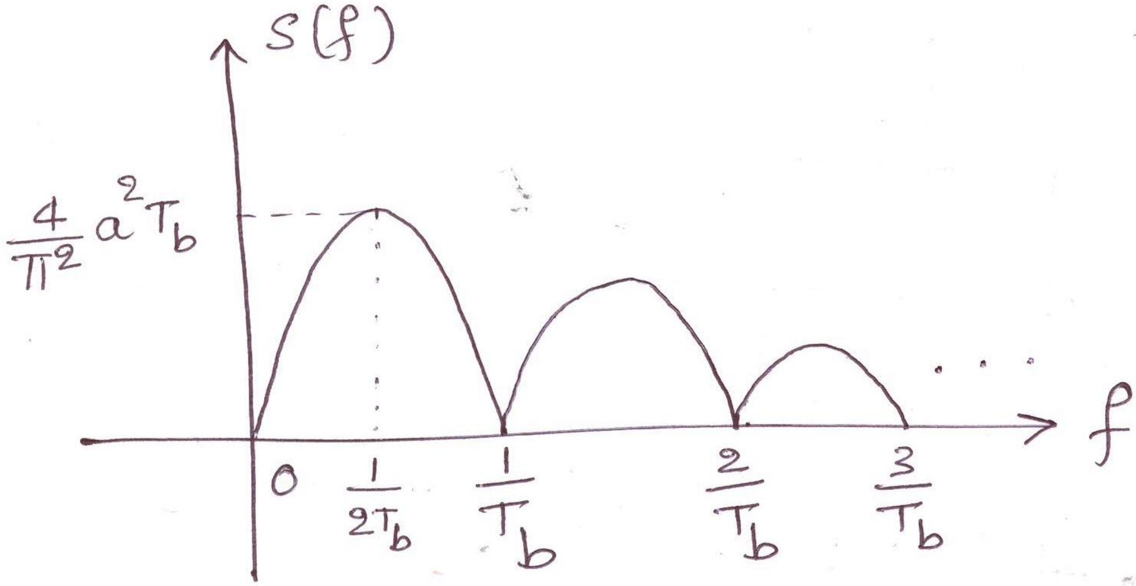


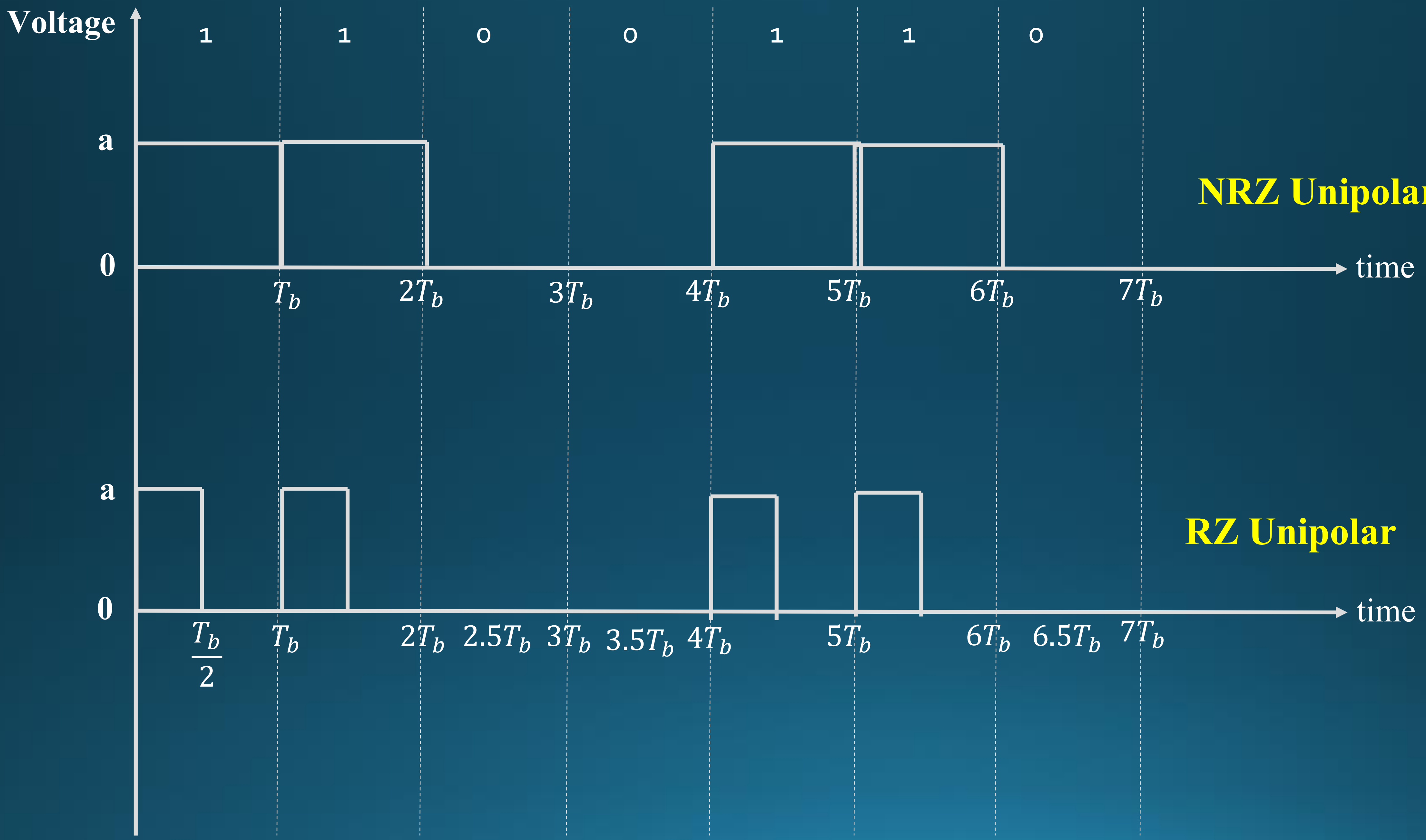
</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Derive an expression for the canonical representation of bandpass signals. Obtain a scheme for extracting in-phase and quadrature components of bandpass signals. Draw the corresponding block diagram.</td>
<td>10</td>
</tr>
</table>

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

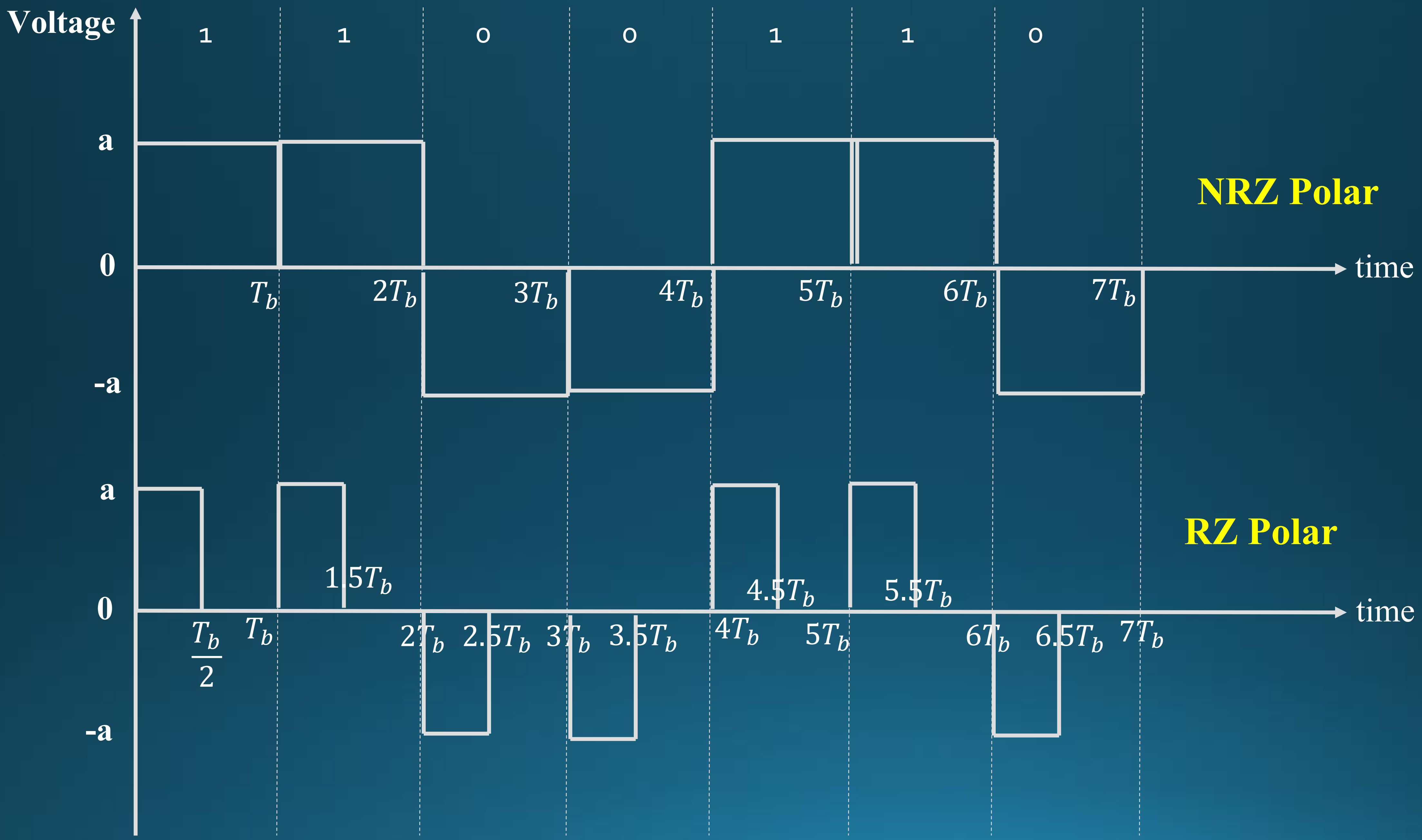




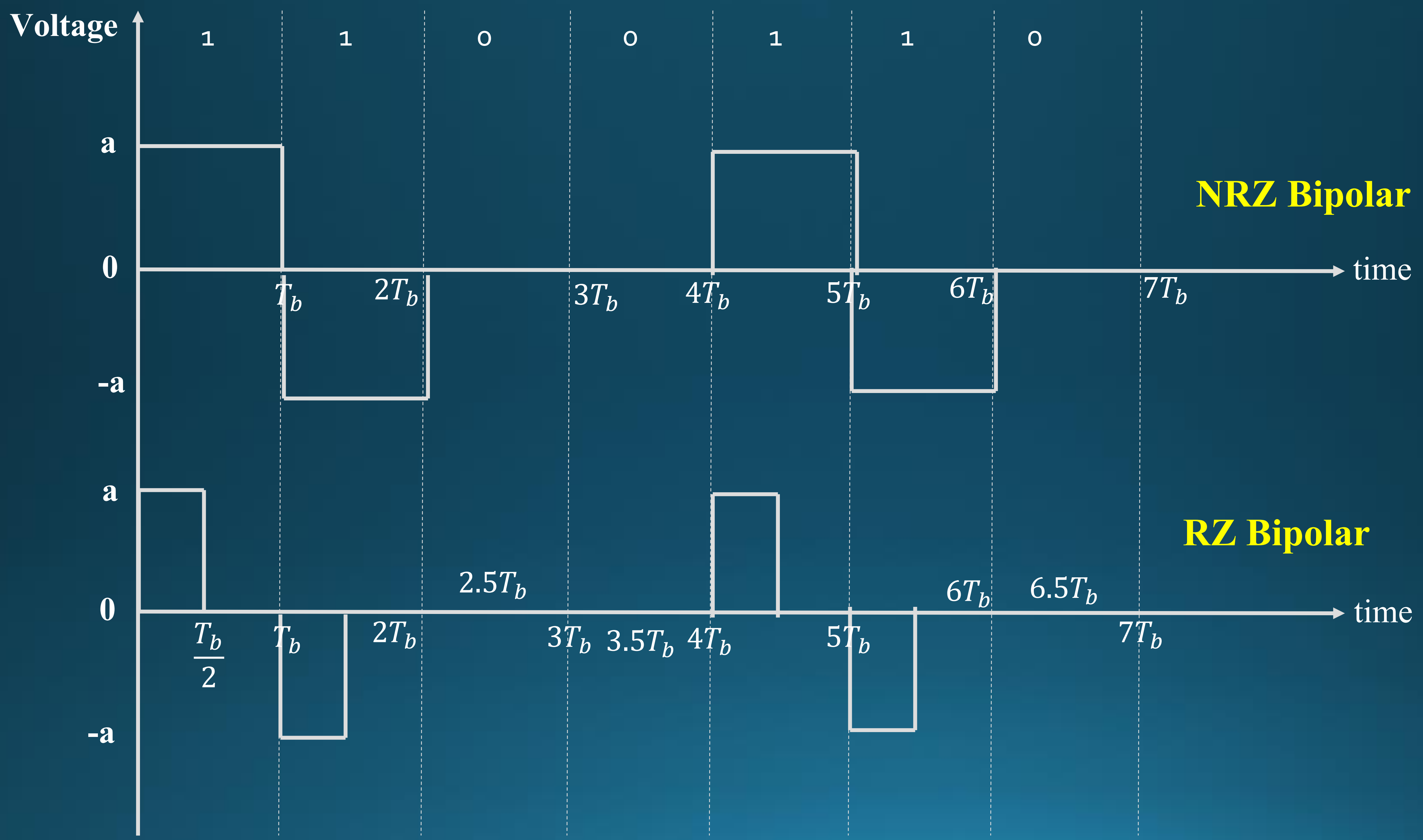
6		Derive an expression for the power spectral density of NRZ bipolar signals.	10
		$$V(f) = T_b sinc(fT_b)$$ $$R_A(n) = \begin{cases} \frac{a^2}{2} \; for \; n = 0 \\ -\frac{a^2}{4} \; for \; n = \pm 1 \\ 0 \; otherise \end{cases}$$ $$S(f) = \frac{1}{T_b}\lvert V(f)\rvert^2 \sum_{n=-\infty}^{\infty} R_A(n) e^{-j2\pi f n T_b}$$ $$= a^2 T_b sinc^2(fT_b) \sin^2(\pi f T_b)$$ 	
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



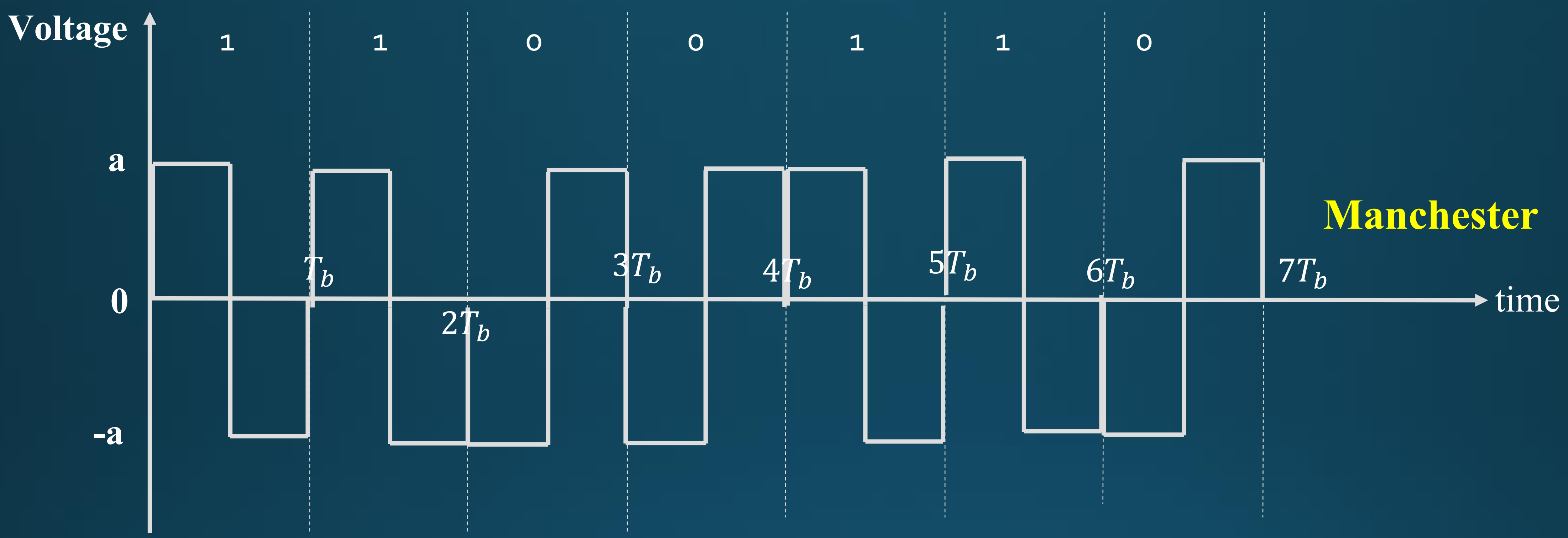
Voltage
1
1
0
0
1
1
0
a
0
NRZ Unipolar
time
T_b
$2T_b$
$3T_b$
$4T_b$
$5T_b$
$6T_b$
$7T_b$
a
0
RZ Unipolar
time
$\frac{T_b}{2}$
T_b
$2T_b$
$2.5T_b$
$3T_b$
$3.5T_b$
$4T_b$
$5T_b$
$6T_b$
$6.5T_b$
$7T_b$



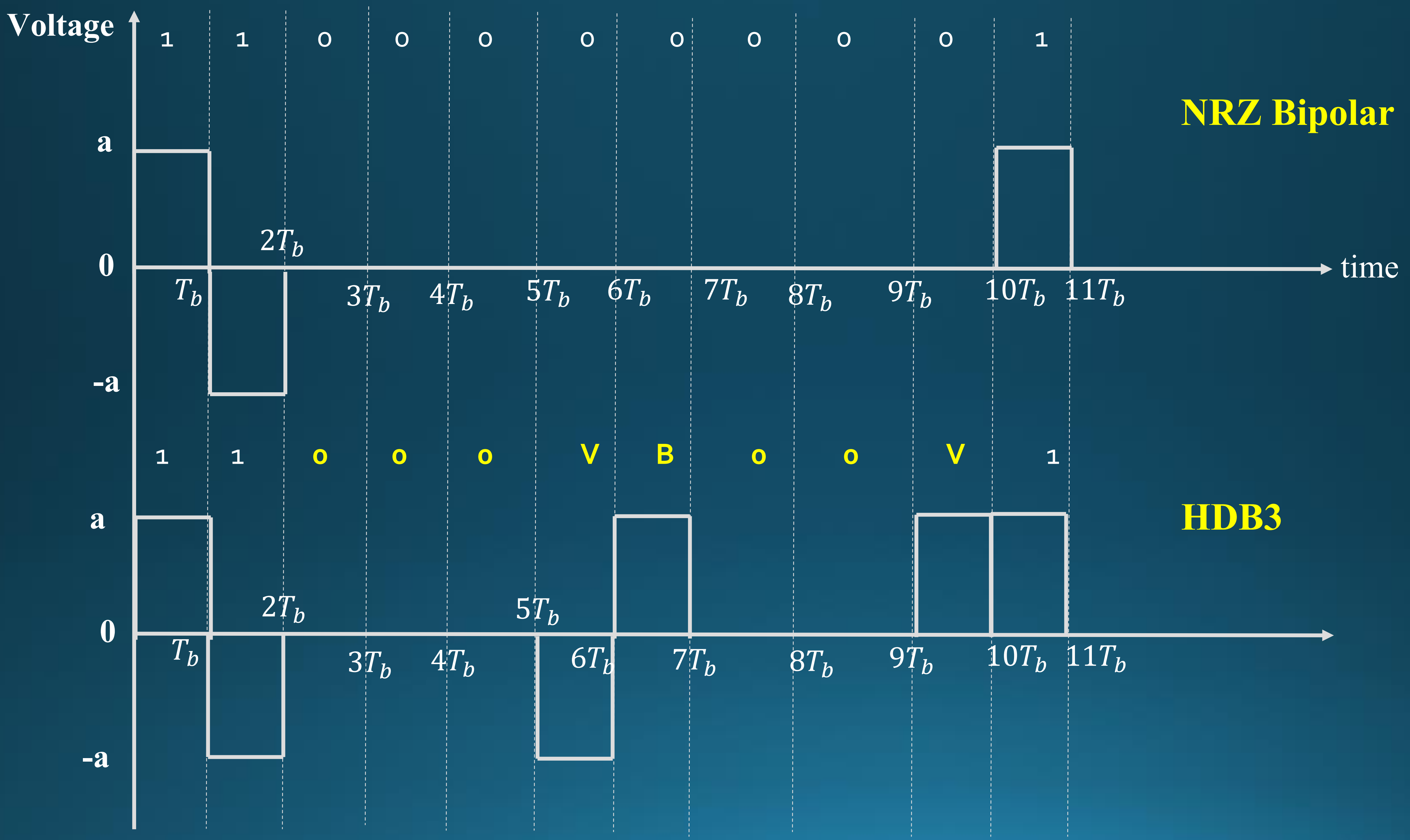
Voltage
1 1 0 0 1 1 0
a
0
-a
T_b $2T_b$ $3T_b$ $4T_b$ $5T_b$ $6T_b$ $7T_b$
time
NRZ Polar
a
0
-a
$1.5T_b$ $4.5T_b$ $5.5T_b$
$\frac{T_b}{2}$ T_b $2T_b$ $2.5T_b$ $3T_b$ $3.5T_b$ $4T_b$ $5T_b$ $6T_b$ $6.5T_b$ $7T_b$
time
RZ Polar



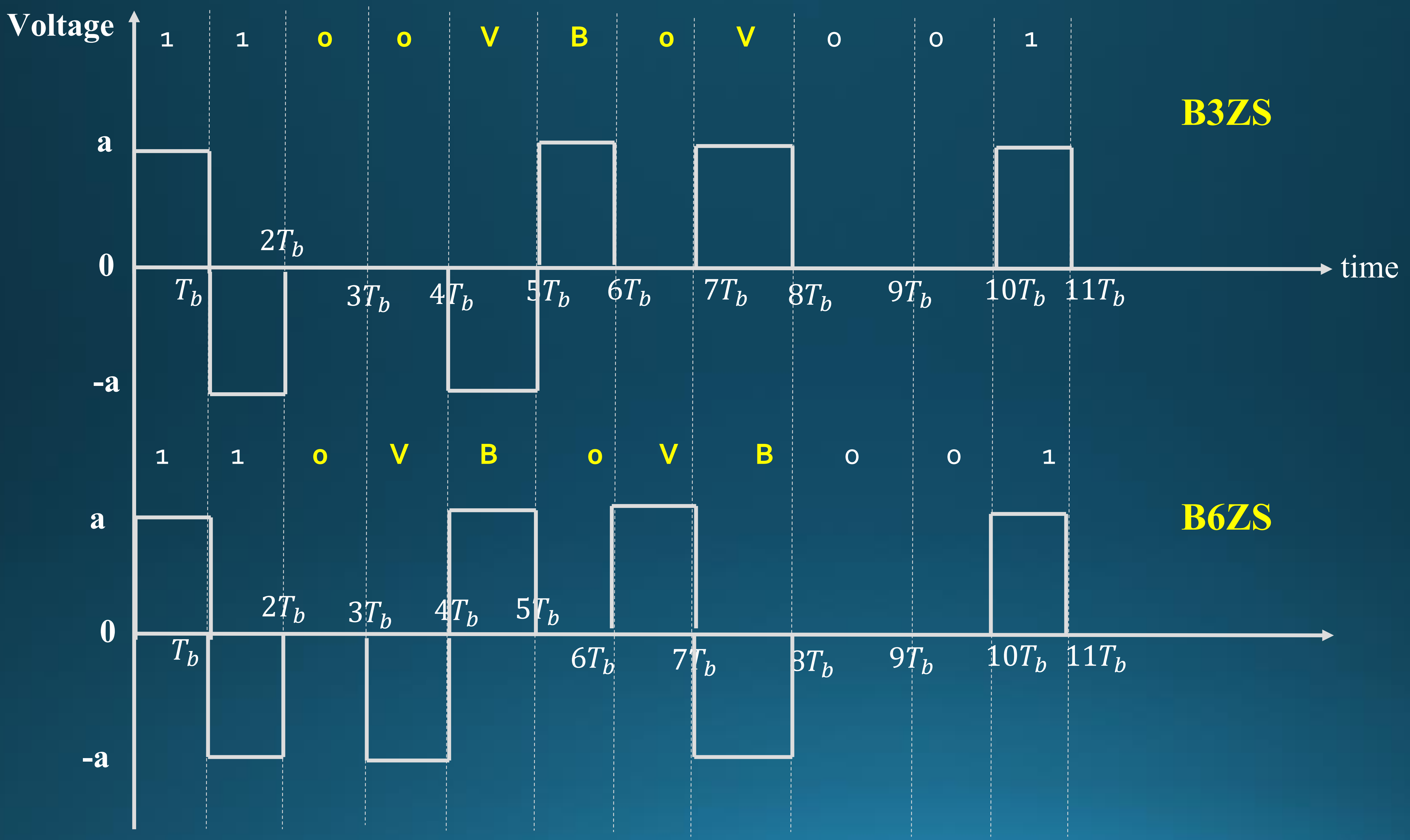
Voltage
1
1
0
0
1
1
0
a
0
-a
NRZ Bipolar
time
T_b
$2T_b$
$3T_b$
$4T_b$
$5T_b$
$6T_b$
$7T_b$
a
0
-a
RZ Bipolar
time
$\frac{T_b}{2}$
T_b
$2T_b$
$2.5T_b$
$3T_b$
$3.5T_b$
$4T_b$
$5T_b$
$6T_b$
$6.5T_b$
$7T_b$



Voltage
1
1
0
0
1
1
0
a
0
-a
T_b
$2T_b$
$3T_b$
$4T_b$
$5T_b$
$6T_b$
$7T_b$
Manchester
time



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



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