SRM Institute of Science and Technology
College of Engineering and Technology
DEPARTMENT OF ECE
SRM Nagar, Kattankulathur – 603203, Chengalpattu District, Tamilnadu

Academic Year: 2024-2025 (Even)

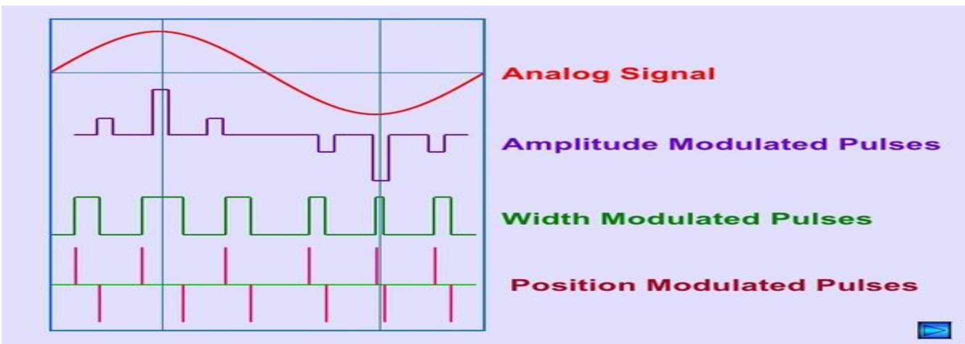
Batch1
Set B

Test: FT- III **Date: 03.04.2025**
Course Code / Title: 21ECC302T/ Analog and Digital Communication **Duration: 08.00 – 9.40 AM**
Year & Sem: III & VI **Max. Marks: 50**
Course Articulation Matrix:

	21ECC302T/ Analog and Digital Communication	PROGRAM OUTCOMES (PO)												PROGRAM SPECIFIC OUTCOMES		
S.NO	COURSE OUTCOMES	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	Explain the Various Analog Modulation Techniques	3	-	-	-	-	-	-	-	-	-	-	2	2	-	-
2	Analyze the Noise performance of Radio transmitters and Receivers	3	3	-	-	-	-	-	-	-	-	-	2	-	3	-
3	Demonstrate the demodulation and detection of received digital data	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3
4	Apply the suitable passband techniques for real time applications	3	-	-	-	3	-	-	-	-	-	-	-	-	-	2
5	Exposed to the concepts of information theory and channel capacity	3	-	3	-	-	-	-	-	-	-	-	-	3	-	-

Part – A (11x1 = 11Marks)
Answer all the questions

Q. No	Question	Marks	BL	CO
1.	Which digital modulation scheme is the most resistant to noise? A) Amplitude Shift Keying (ASK) B) Frequency Shift Keying (FSK) C) Phase Shift Keying (PSK) D) **Pulse Code Modulation (PCM)**	**1**	**1**	**3**
2.	Nyquist theorem states that the sampling frequency must be at least: A) Half the signal bandwidth B) **Twice the highest signal frequency** C) Equal to the signal frequency D) Four times the signal frequency	**1**	**2**	**3**
3.	What is the primary advantage of DPCM over standard PCM? A) Reduced quantization noise B) Less power consumption C) No requirement for synchronization **D) Reduced bit rate**	**1**	**1**	**3**
4.	The output of a matched filter depends on: A) **The shape of the input signal** B) The power of the noise C) The sampling frequency D) The modulation index	**1**	**2**	**3**
5.	What does an open eye pattern indicate in digital communication? A) High noise B) High inter-symbol interference **C) Low error probability** D) Low signal-to-noise ratio	**1**	**1**	**3**

<table>
<tr><td>6.</td><td>What is the main advantage of passband transmission over baseband transmission?
A) Reduced bandwidth usage
B) Better noise immunity and signal integrity
C) Less complexity in implementation
D) Requires fewer components</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td>7.</td><td>The phase difference between adjacent symbols in QPSK is:
A) 90°
B) 45°
C) 180°
D) 60°</td><td>1</td><td>2</td><td>4</td></tr>
<tr><td>8.</td><td>Increasing the value of M in M-ary PSK:
A) Increases the bit error rate (BER)
B) Decreases bandwidth efficiency
C) Increases spectral efficiency
D) Makes demodulation easier</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td>9.</td><td>The probability of error for BPSK in an AWGN channel depends on ______
A) Phase error
B) SNR (Signal-to-Noise Ratio)
C) Frequency offset
D) Signal bandwidth</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td>10.</td><td>A QAM-64 constellation can be used to send ______
A) 4 bits per symbol
B) 5 bits per symbol
C) 6 bits per symbol
D) 7 bits per symbol</td><td>1</td><td>2</td><td>4</td></tr>
<tr><td>11.</td><td>The effect of adding Gaussian noise to a QPSK signal is ______
A) Phase errors only
B) Amplitude errors only
C) Both phase and amplitude errors
D) No effect</td><td>1</td><td>1</td><td>4</td></tr>
<tr><td colspan="5">Part – B (3 x 8 = 24 Marks)
Answer all the Questions</td></tr>
<tr><td>12.(a).</td><td>Compare PAM, PPM and PWM.
<table>
<tr><th>PAM</th><th>PWM</th><th>PPM</th></tr>
<tr><td>Amplitude is varied</td><td>Width is varied</td><td>Position is varied</td></tr>
<tr><td>Bandwidth depends on the width of the pulse</td><td>Bandwidth depends on the rise time of the pulse</td><td>Bandwidth depends on the rise time of the pulse</td></tr>
<tr><td>Instantaneous transmitter power varies with the amplitude of the pulses</td><td>Instantaneous transmitter power varies with the amplitude and width of the pulses</td><td>Instantaneous transmitter power remains constant with the width of the pulses</td></tr>
<tr><td>System complexity is high</td><td>System complexity is low</td><td>System complexity is low</td></tr>
<tr><td>Noise interference is high</td><td>Noise interference is low</td><td>Noise interference is low</td></tr>
<tr><td>It is similar to amplitude modulation</td><td>It is similar to frequency modulation</td><td>It is similar to phase modulation</td></tr>
</table>


</td><td>8</td><td>2</td><td>3</td></tr>
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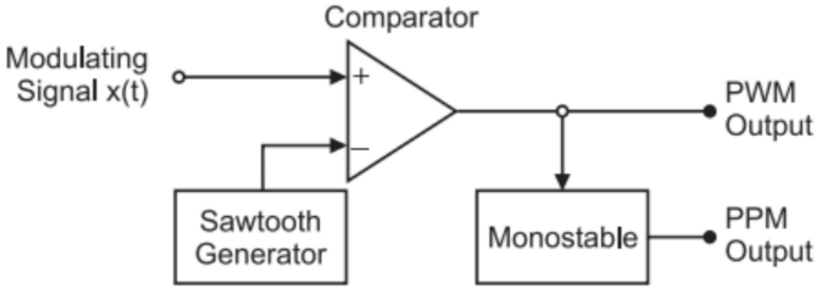
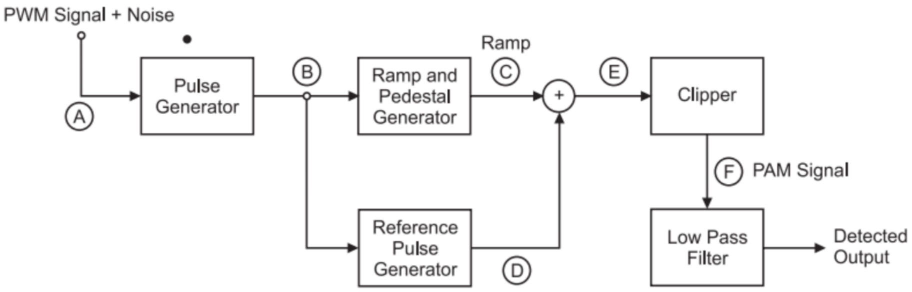
	[OR]			
12.(b)	Discuss the working principles behind PWM signal generation and detection with a neat sketch.	8	3	3

PWM Signal generation and explanation– 4 Marks



- Sawtooth generator generates a sawtooth signal of frequency f_s, and this sawtooth signal in this case is used as a sampling signal.
- It is applied to the inverting terminal of a comparator.
- The modulating signal x (t) is applied to the non-inverting terminal of the same comparator.
- The comparator output will remain high as long as the instantaneous amplitude of x (t) is higher than that of the ramp signal.
- This gives rise to a PWM signal at the comparator output.

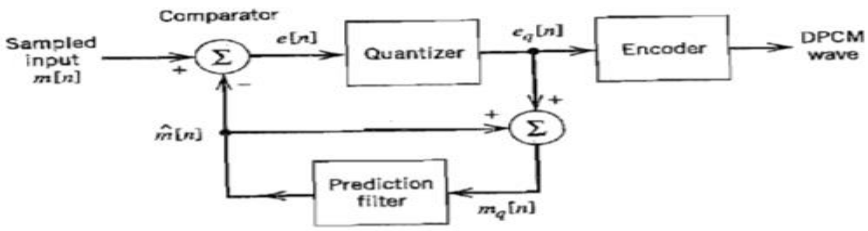
PWM Signal detection and explanation– 4 Marks



- The PWM signal received at the input of the detection circuit is contaminated with noise. This signal is applied to pulse generator circuit which regenerates the PWM signal.
- The regenerated pulses are applied to a reference pulse generator. It produces a train of constant amplitude, constant width pulses.
- The regenerated PWM pulses are also applied to a ramp generator. At the output of it, we get a constant slope ramp for the duration of the pulse. The height of the ramp is thus proportional to the width of the PWM pulses.
- At the end of the pulse, a sample and hold amplifier retains the final ramp voltage until it is reset at the end of the pulse.
- The constant amplitude pulses at the output of reference pulse generator are then added to the ramp signal.
- The output of the adder is then clipped off at a threshold level to generate a PAM signal at the output of the clipper.
- A low pass filter is used to recover the original modulating signal back from the PAM signal.

<table>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>13.(a)</td><td>(i) With a neat diagram, identify and explain the technique in which the difference between the samples is encoded in binary.

➢ DPCM is a technique in which the difference between the samples, rather than the sample values themselves, is encoded in binary.

DPCM transmitter – 02 Marks


Explanation – 02 Marks

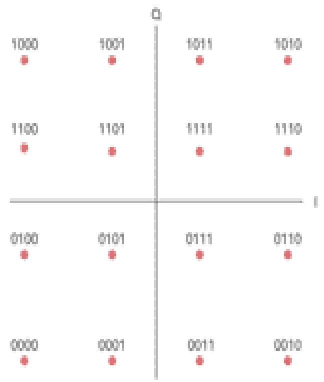
(ii) A base band signal has 20 KHz frequency. If number of bits to be transmitted is 16 bits find the sampling rate and baud rate.
Solution :
Given Data:
• Baseband Signal Frequency = fm=20 kHz
• Number of Bits per Sample = n=16 bits
Sampling rate (f_s)= 2fm = 2*20KHz= 40 KHz 02 Marks
Bit rate = n*f_s= 16*40KHz=640kbps 02 Marks</td><td>4

4</td><td>3

4</td><td>3

3</td></tr>
<tr><td></td><td>[OR]</td><td></td><td></td><td></td></tr>
<tr><td>13.(b)</td><td>Elaborate the concept of QAM system with neat illustration.
Quadrature Amplitude Modulation (QAM) is a digital and analog modulation scheme that combines both amplitude and phase modulation to transmit data efficiently. It is widely used in wireless communication, broadband networks, and digital TV due to its high spectral efficiency.
QAM works by modulating two carrier signals, known as the In-phase (I) component and the Quadrature-phase (Q) component, which are 90° out of phase with each other. These two components are independently amplitude-modulated and then combined. (04 Marks)

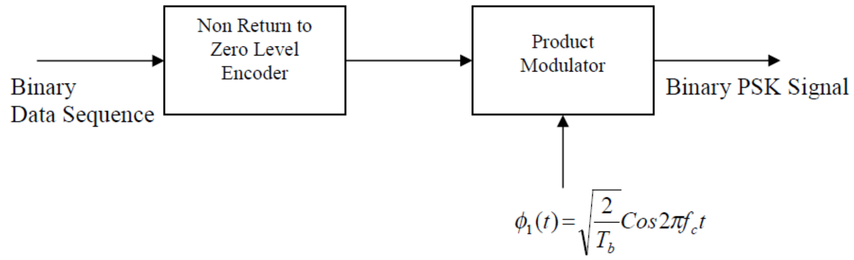
$s(t)=A_I\cos(2\pi fct)+A_Q\sin(2\pi fct)$

where:
• A_I and A_Q are the amplitudes of the In-phase (I) and Quadrature (Q) components.
Constellation diagram: (04 Marks)

</td><td>8</td><td>4</td><td>4</td></tr>
</table>

<table>
<tr><td></td><td>The constellation diagrams show the different positions for the states within different forms of QAM, quadrature amplitude modulation. As the order of the modulation increases, so does the number of points on the QAM constellation diagram.The diagrams are shown with the in-phase and quadrature elements of the signal. The Quadrature or "Q" element is on the vertical axis and the In-phase or "I" element is on the horizontal axis.There are set positions, i.e. a particular combination of I and Q that are used for the different data symbols. The diagrams above show constellation diagrams for a variety of formats of modulation.</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>14.(a)</td><td>

Explain the generation and detection method of PSK waveform with a neat illustration.

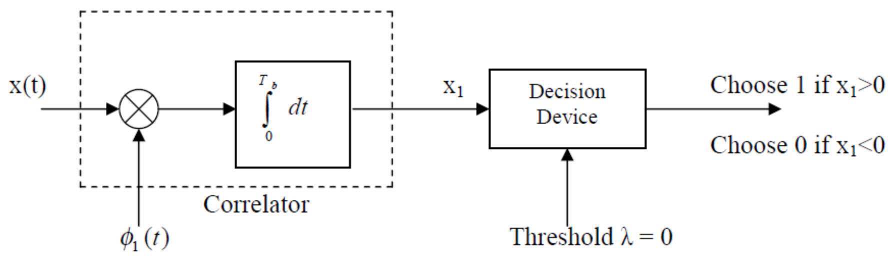
Generation of PSK: **02 Marks**



Explanation : **02 Marks**

- The input binary sequence is represented in polar form with symbol '1' and '0' with constant amplitude levels of $+\sqrt{Eb}$ and $-\sqrt{Eb}$
- Signal transmission encoding is performed by a NRZ level encoder.
- The resulting binary wave [in polar form] and a sinusoidal carrier Φ1(t)re applied to a product modulator.
- The desired BPSK wave is obtained at the modulator output.

Detection of PSK: **02 Marks**



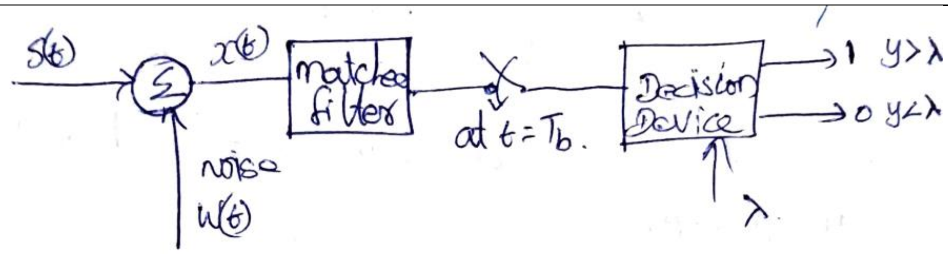
Explanation : **02 Marks**

- The noisy PSK signal x(t) to a Correlator, which is also supplied with a locally generated coherent reference signal Φ1(t).
- The correlator output x1 is compared with a threshold of zero volt.

If x1 > 0, the receiver decides in favor of **symbol 1**.

If x1 < 0, the receiver decides in favor of **symbol 0**

</td><td>8</td><td>3</td><td>4</td></tr>
<tr><td></td><td>[OR]</td><td></td><td></td><td></td></tr>
<tr><td>14.(b)</td><td>Write short notes on error probability of matched filter.</td><td>8</td><td>4</td><td>4</td></tr>
</table>



The received s/g

$$x(t) = \begin{cases} +A + w(t) & \text{1 was sent} \\ -A + w(t) & \text{0 was sent} \end{cases}$$

The Variance is gn by,

$$\sigma_Y^2 = E\left[(Y+A)^2\right]$$

$$= \frac{1}{T_b^2} E\left[\int_0^{T_b}\int_0^{T_b} w(t)\, w(u)\, dt\, du\right]$$

$$= \frac{1}{T_b^2}\int_0^{T_b}\int_0^{T_b} R_W(t,u)\, dt\, du.$$

$$\sigma_Y^2 = \frac{N_0}{2T_b}.$$

$$P_e = p_0 P_{10} + p_1 P_{01}$$

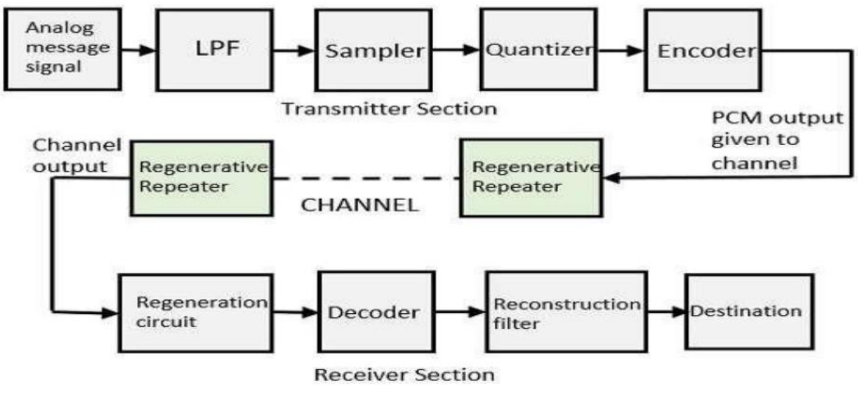
$$= \frac{p_0}{2}\operatorname{erfc}\left(\frac{A+\lambda}{\sqrt{N_0/T_b}}\right) + \frac{p_1}{2}\operatorname{erfc}\left[\frac{A-\lambda}{\sqrt{(N_0/T_b)}}\right]$$

$$\boxed{P_e = \frac{1}{2}\operatorname{erfc}\left(\sqrt{\frac{E_b}{N_0}}\right)}$$

Part - C (1 x 15 = 15 Marks)

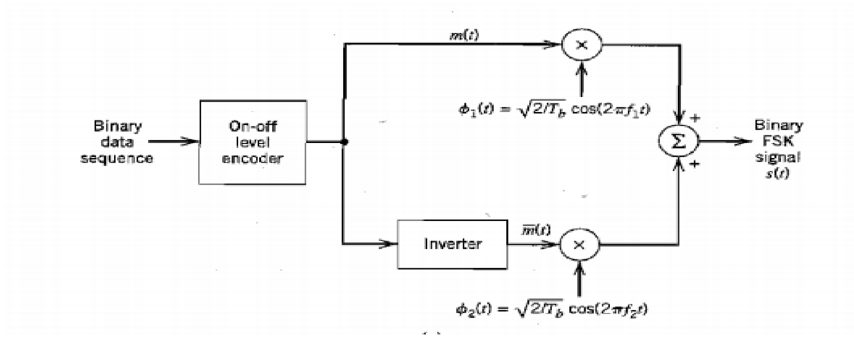
15. (a)	With neat block diagram, explain the process involved in pulse code modulation and mention the advantages and disadvantages with its applications.	**15**	**3**	**3**

Block diagram **(05 Marks)**



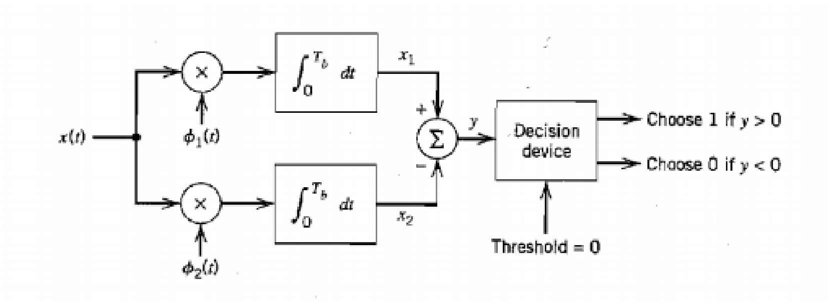
	Explanation (05 Marks) **Advantages and Disadvantages** (04 Marks) **Applications** (01 Mark)			
	[OR]			
15. (b)	Illustrate the BFSK modulation and demodulation process with appropriate diagrams, waveforms, and probability of error analysis with signal space representation.	**15**	**4**	**4**

Generation of BFSK **04 Marks**



- The incoming binary data sequence is applied to on-off level encoder.
- The output of encoder is $\sqrt{Eb}$ volts for symbol 1 and 0 volts for symbol '0'.
- When we have symbol 1 the upper channel is switched on with oscillator frequency f1, for symbol '0', because of inverter the lower channel is switched on with oscillator frequency f2.
- These two frequencies are combined using an adder circuit and then transmitted

Detection of BFSK **04 Marks**



- The detector consists of two correlators.
- The incoming noisy BFSK signal x(t) is common to both correlator.
- The Coherent reference signal $\Phi_1(t)$ *and* $\Phi_2(t)$ are supplied to upper and lower correlators respectively.
- The correlator outputs are then subtracted one from the other and resulting a random vector 'l' (l=x1 - x2).
- The output 'l' is compared with threshold of zero volts.
- If l > 0, the receiver decides in favor of symbol 1.
  l < 0, the receiver decides in favor of symbol 0.

Probability of error **05 marks**

In binary FSK system the basic functions are given by,

$$\phi_1(t) = \sqrt{\frac{2}{T_b}}\, Cos 2\pi f_1 t \qquad 0 \le t \le T_b$$

$$\phi_2(t) = \sqrt{\frac{2}{T_b}}\, Cos 2\pi f_2 t \qquad 0 \le t \le T_b$$

The transmitted signals S1(t) and S2(t) are given by,

$$S_1(t)=\sqrt{E_b}\phi_1(t) \quad \text{for symbol 1}$$

$$S_2(t)=\sqrt{E_b}\phi_2(t) \quad \text{for symbol 0}$$

The two message points are defined by the signal vector,

$$S_1=\begin{bmatrix}\sqrt{E_b}\\0\end{bmatrix} \quad \text{and} \quad S_2=\begin{bmatrix}0\\\sqrt{E_b}\end{bmatrix}$$

$$E\left[\frac{l}{1}\right]=E\left[\frac{x_1}{1}\right]-E\left[\frac{x_2}{1}\right]$$
$$=\sqrt{E_b}-0$$
$$=\sqrt{E_b}$$

$$Var[l]=Var[x_1]+Var[x_2]$$
$$=N_0$$

The probability of error is given by,

$$P_e(1/0)=P_{e0}=\frac{1}{\sqrt{2\pi N_0}}\int_0^\infty \exp\left[-\frac{(l+\sqrt{E_b})^2}{2N_0}\right]dl$$

$$P_{e0}=\frac{1}{\pi}\int_{\sqrt{\frac{E_b}{2N_0}}}^{\infty}\exp(-z^2)dz$$
$$=\frac{1}{2}erfc\left[\sqrt{\frac{E_b}{2N_0}}\right]$$

The total probability of error is,

$$P_e=\frac{1}{2}[P_{e0}+P_{e1}]$$

$$P_e=\frac{1}{2}erfc\left[\sqrt{\frac{E_b}{2N_0}}\right]$$

Signal space representation **02 Marks**