Sri SAI RAM ENGINEERING COLLEGE

INSTITUTE OF TECHNOLOGY

West Tambaram, Chennai - 44

SAIRAM DIGITAL RESOURCES

YEAR II

SEM III

EC8394

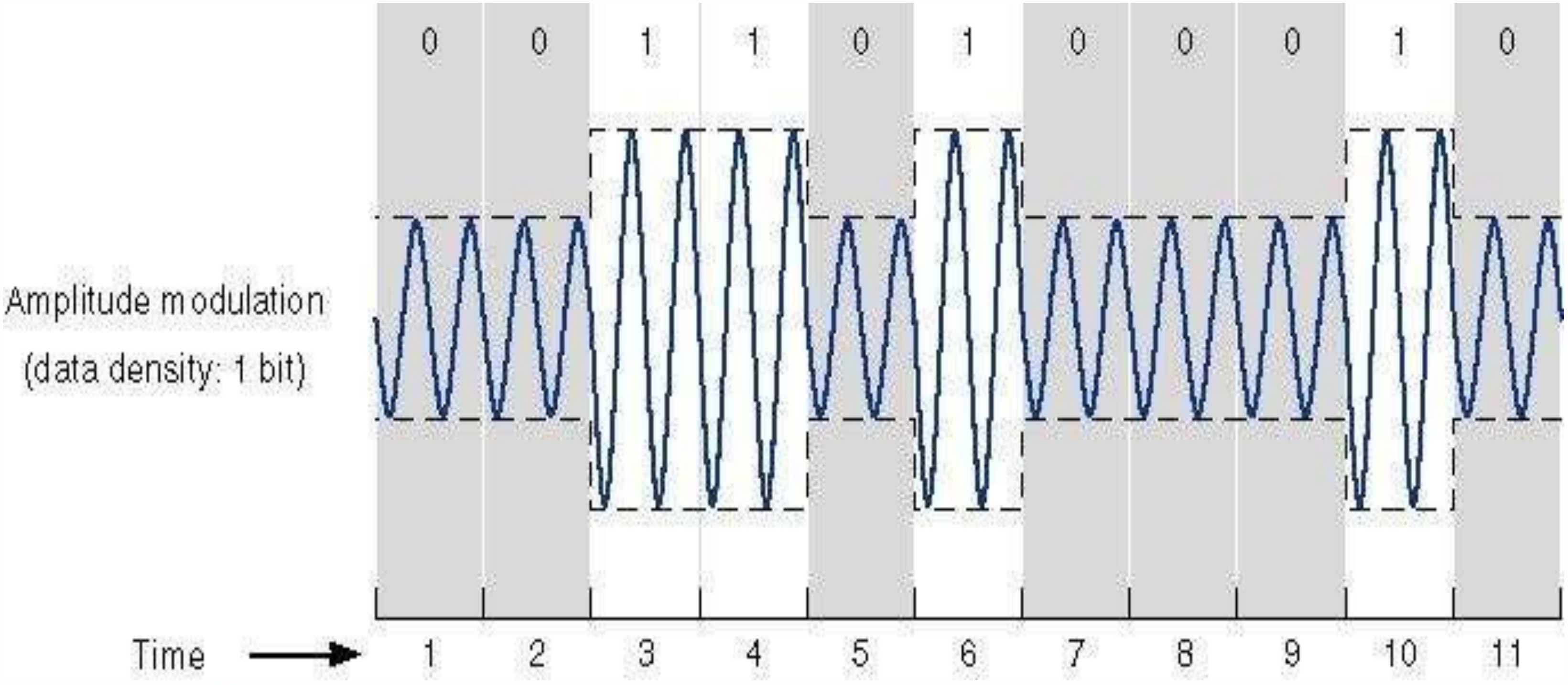
ANALOG AND DIGITAL COMMUNICATION

UNIT NO 1 ANALOG MODULATION

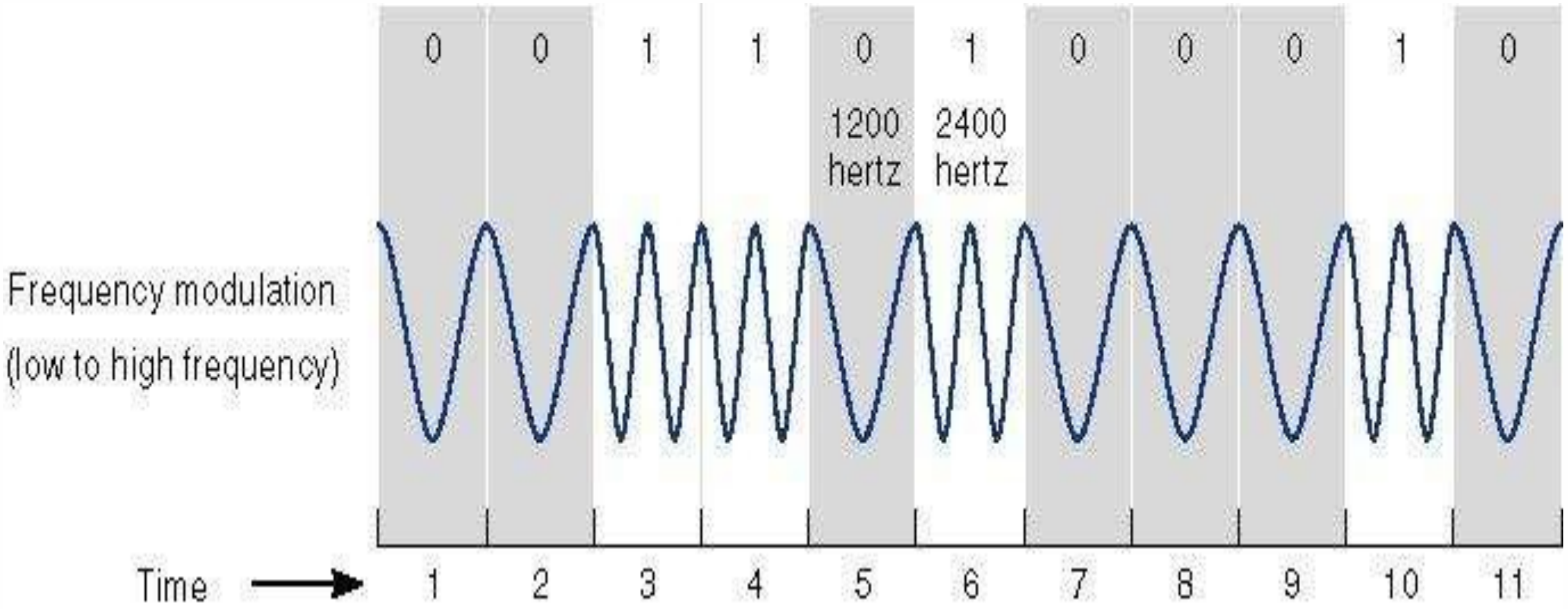
QUDRATURE AMPLITUDE MODULATION

ELECTRONICS & COMMUNICATION ENGINEERING

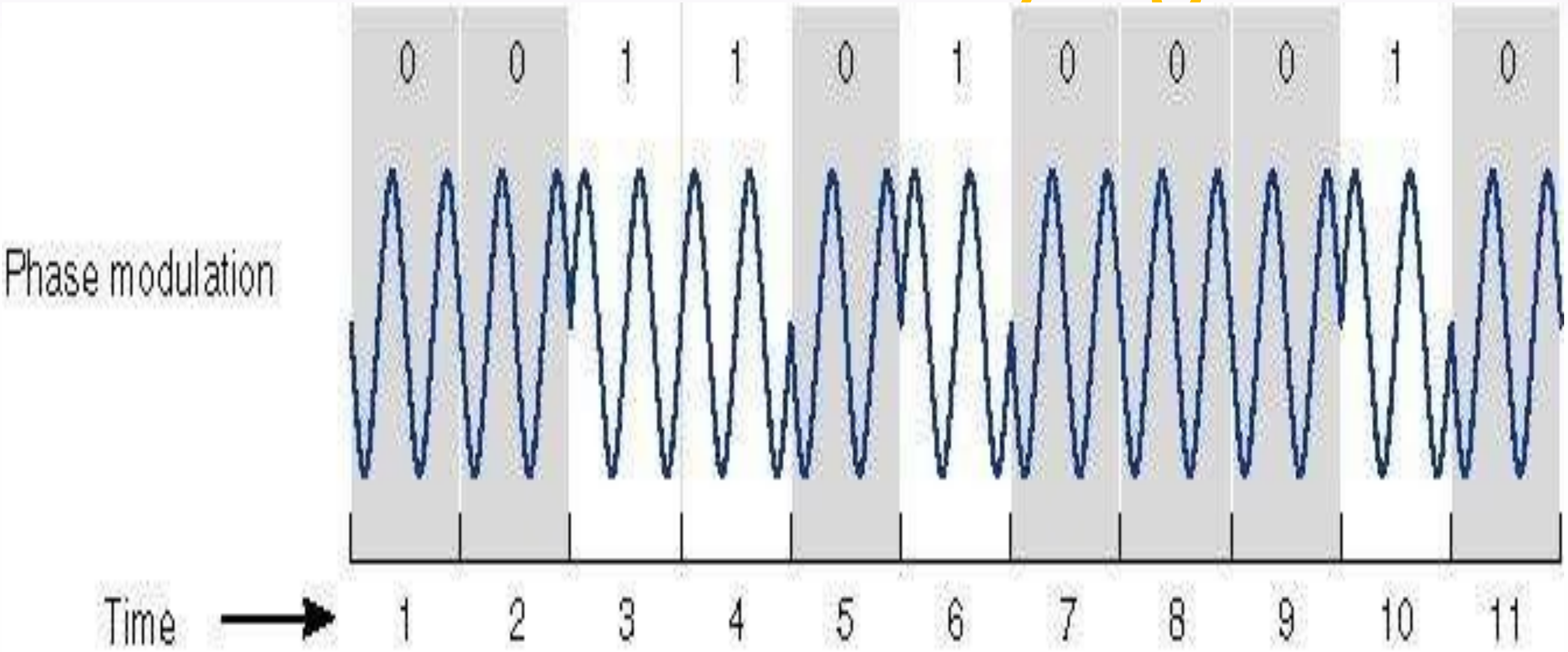
Amplitude Shift Keying ASK



Frequency Shift Keying FSK



Phase Shift Keying



Sending Multiple Bits Simultaneously

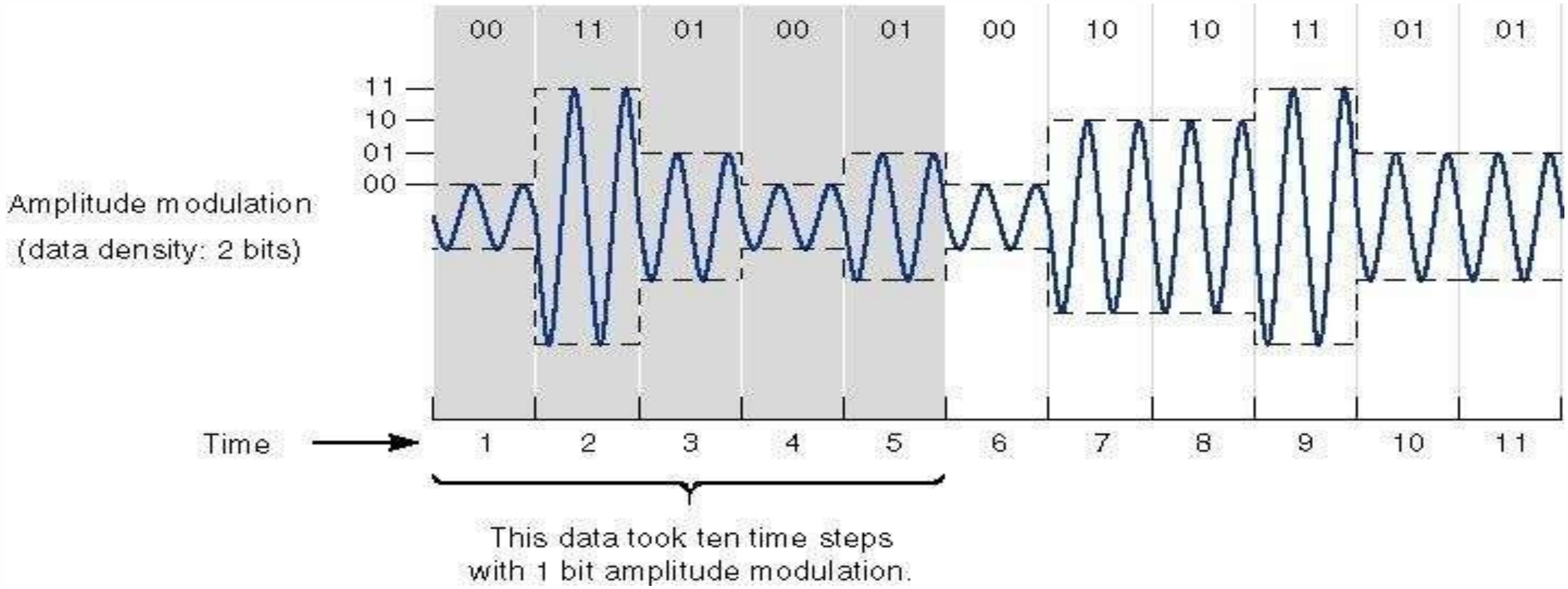
The above techniques are modified to send more than one bit at a time.

For example:

Two bits on single wave can be send by defining four amplitudes, three bits with eight amplitudes and so on.

- This is applicable to other techniques like Frequency modulation and Phase modulation.

Sending Multiple Bits Simultaneously



Why QAM?

Draw backs of ASK,PSK,FSK:

- In practice, the maximum number of bits that can be sent with any one of these techniques is five bits.
- Also the bandwidth required to transmit more bits is more in these (ASK,PSK,FSK) techniques.

In order to meet these kind of limitations we need to have technique that combines the merits of above techniques.

WHAT IS QAM?

- It's a combination of ASK and PSK.
- An extension of QPSK (logically).
- It is both an analog and digital modulation scheme.
- It is a technique in which information is conveyed in both

    amplitude and phase of the carrier signal.
- This technique combines two carriers whose amplitudes are modulated independently with same frequency and phases are shifted by 90° w.r.t each other.
- These carriers are called
- a.) In-phase carriers b.) Quadrature carriers

- A form of modulation which is widely used for modulating data signals onto a carrier used for radio communications.
- QAM is a signal in which two carriers shifted in phase by 90 degrees are modulated.
- The resultant output consists of both amplitude and phase variations.
- Hence it may also be considered as a mixture of amplitude and phase modulation.

WHY QAM?

- The main aim is to save the bandwidth.

HOW?

- Double sideband(DSB) even with a suppressed carrier occupies twice the bandwidth of the modulating signal.
- This is very wasteful of the available frequency spectrum.
- QAM places two independent double sideband suppressed carrier signals in the same spectrum as one ordinary double sideband suppressed carrier signal.

TYPES OF QAM

- It exists in both **analogue** and **digital** formats.
- The analogue versions of QAM are typically used to allow multiple analogue signals to be carried on a single carrier.
- It combines phase modulation and amplitude modulation in a form of modulation known as quadrature amplitude modulation, QAM
- Digital formats of QAM are often referred to as “Quantised QAM”.
- It combines phase shift keying and amplitude keying in a form of modulation known as quadrature amplitude modulation, QAM

QAM THEORY

- Quadrature amplitude theory states that both amplitude and phase change within a QAM signal.
- The basic way in which a QAM signal can be generated is to generate two signals that are 90° out of phase with each other and then sum them.
- This will generate a signal that is the sum of both waves, which has a certain amplitude resulting from the sum of both signals and a phase which again is dependent upon the sum of the signals.

QAM THEORY….

- As there are two RF carrier signals that can be modulated, these are referred to as the **I - In-phase and Q - Quadrature signals.**

- The I and Q signals can be represented by the equations below:

  $I = A\cos(\Psi)$ $Q = A\sin(\Psi)$

- It can be seen that the I and Q components are represented as cosine and sine. This is because the two signals are 90° out of phase with one another.

QAM MODULATOR

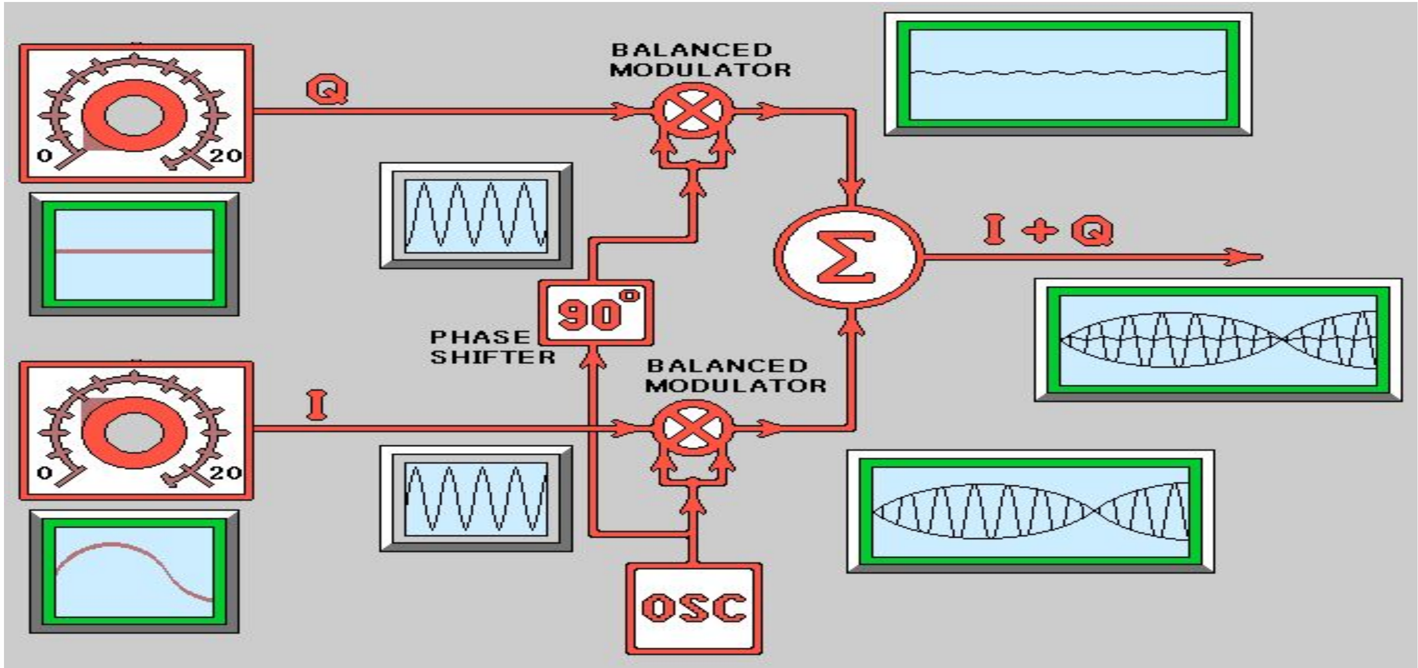
- The modulator is used to encode the signal, often data, onto the radio frequency carrier that is to be transmitted.

- The QAM modulator essentially follows the idea that can be seen from the basic QAM theory where there are two carrier signals with a phase shift of 90° between them.
- These are then amplitude modulated with the two data streams known as the I or In-phase and the Q or quadrature data streams.

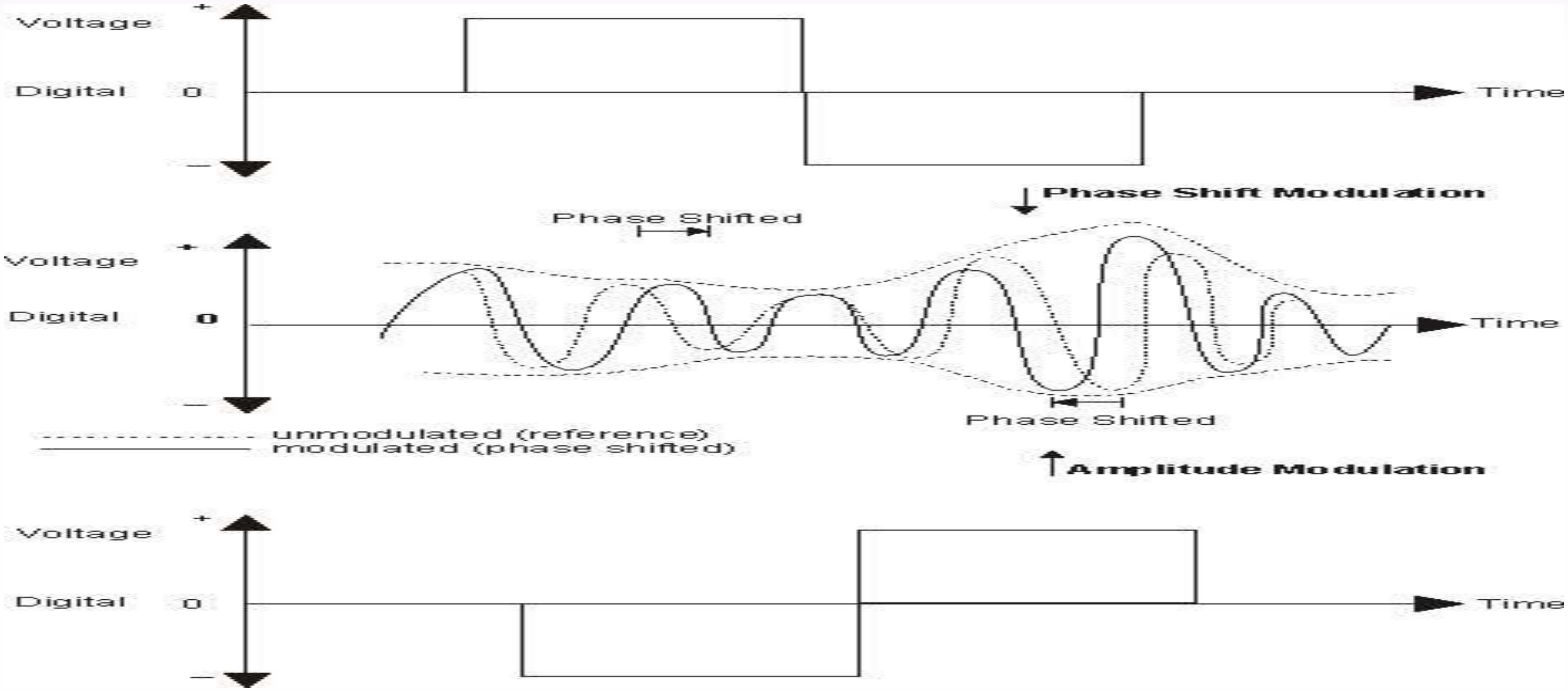
How to generate QAM

- Two modulating signals are derived by special pre-processing from the information bit stream.
- Two replicas of the carrier frequency sine waves are generated in which one is delayed by 90 degrees.
- These two different modulating signals are used to modulate the two carriers.
- The resultant two modulated signals can be added together.
- The result is a sine wave having a constant frequency, but having an amplitude and phase that both vary to convey the information.

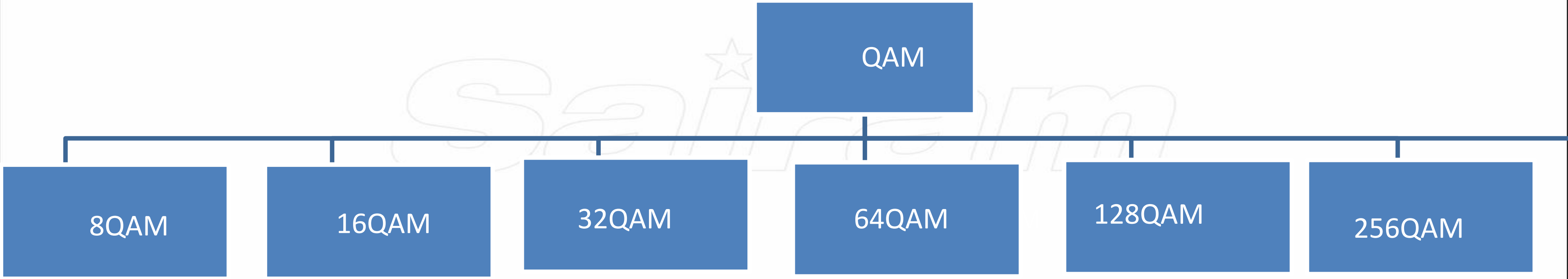
QAM block diagram



Pictorial representation of QAM



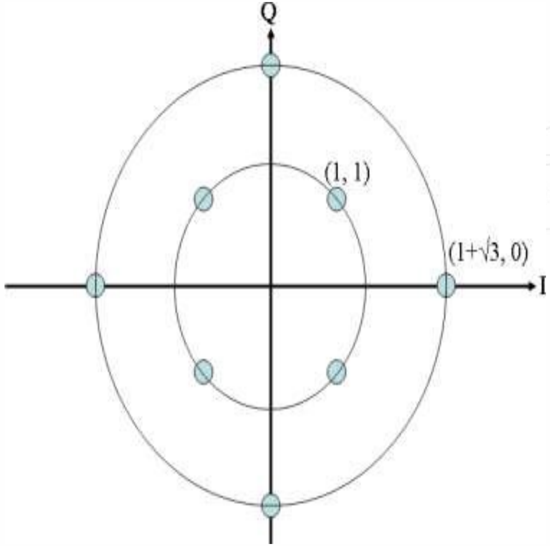
Forms of QAM

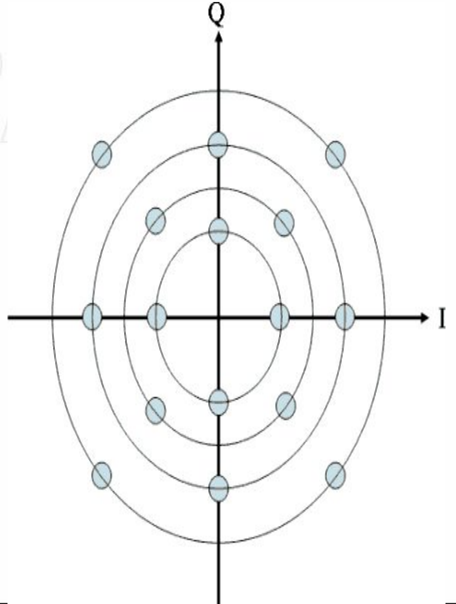


CONSTELLATION DIAGRAMS OF DIFFERENT FORMS OF QAM

CIRCULAR CONSTELLATIONS

8QAM





WHY RECTANGULAR CONSTELLATIONS ?

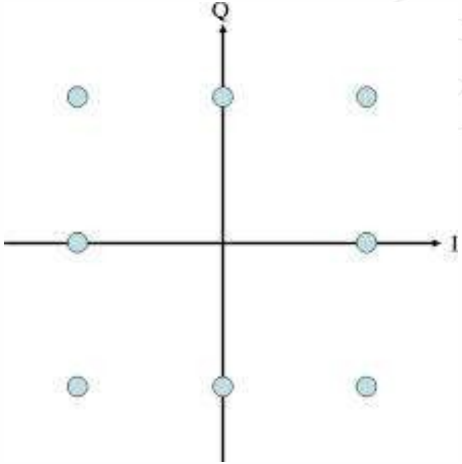
Disadvantages of circular constellations:

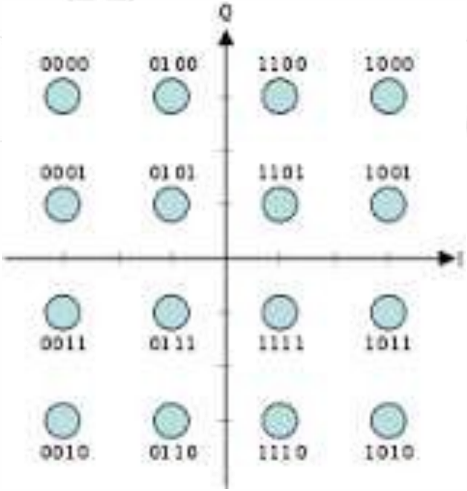
- When the value of M increases, plotting the signal points becomes complicated.
- The distance between the signal points increases which results in complexity.
- As a result of these limitations we are going for Rectangular constellations.

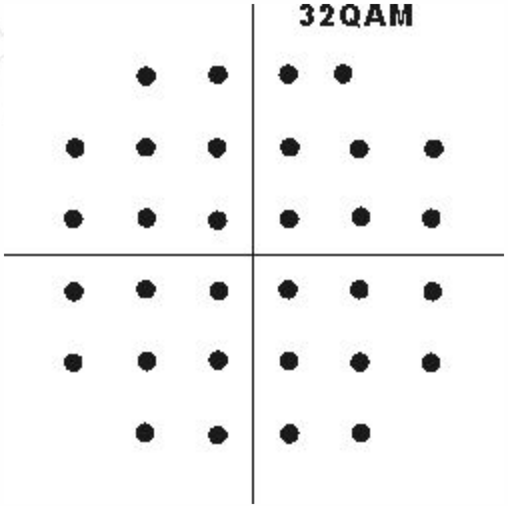
CONSTELLATION DIAGRAMS OF DIFFERENT FORMS OF QAM

RECTANGULAR CONSTELLATIONS

8QAM 16QAM 32QAM

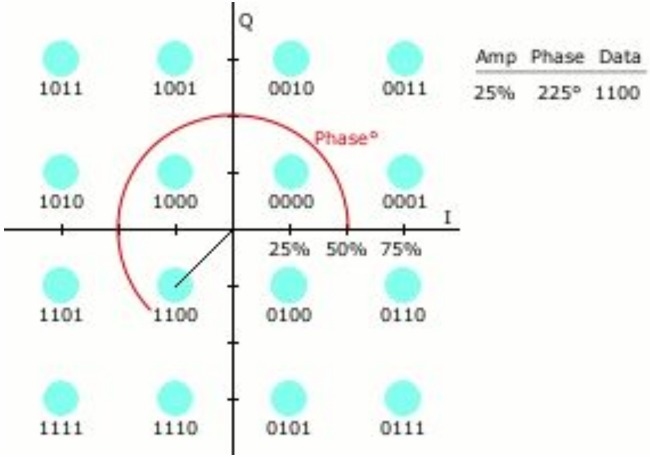




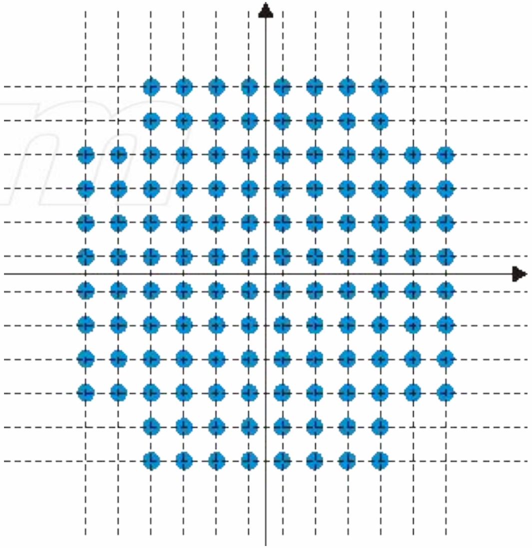


CONSTELLATION DIAGRAMS OF DIFFERENT FORMS OF QAM

64QAM



128QAM



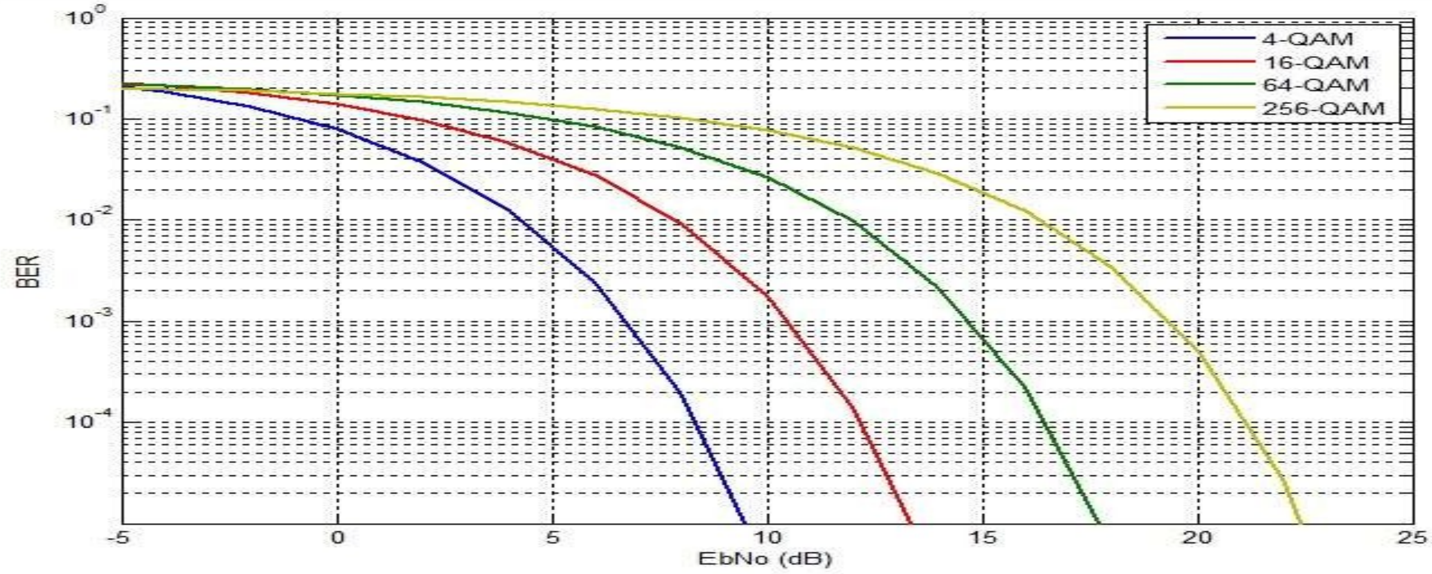
PROBABILITY OF ERROR OF QAM

The probability of error (Pe) for a QAM signal is obtained from a pair of PAM signals each indicating the In-phase and Quadrature component.

The probability of error of QAM is different for different forms of QAM.

- The probability of error for 4-QAM is given by $P_b(e)=1/2*erfc(E_b/N_o)^{1/2}$
- The probability of error for 16-QAM is given by $P_b(e)=3/8*erfc(2E_b/5N_o)^{1/2}$
- The probability of error for 64-QAM is given by $P_b(e)=7/24*erfc(E_b/7N_o)^{1/2}$

Performance characteristics of QAM



ADVANTAGES OF QAM

- It transmits more bits of information per symbol.
- It provides good scope for high bit rates by using higher order forms of QAM.
- It is more spectral efficient technique even as compared to CPM.
- It is the best technique to be employed when it comes to linear region of operations.

APPLICATIONS OF QAM

- 64-QAM and 256-QAM are often used in digital cable television and cable modem applications.
- In the UK, 16 QAM and 64 QAM are currently used for digital terrestrial television using Digital Video Broadcasting.
- In the US, 64 QAM and 256 QAM are the mandated modulation schemes for digital cable as standardized by the SCTE in the standard ANSI/SCTE 07 2000.
- Variants of QAM are used for many wireless and cellular technology applications.
- QAM is being used in optical fiber systems as bit rates increases; QAM16 and QAM64 can be optically emulated with a 3-path interferometer.

VIDEO LINKS

1. QAM Working operation
 https://www.youtube.com/watch?v=C7KXSG7QEsQ

2. QAM
https://www.youtube.com/watch?v=IbUflaeJcU8&t=125s

THANK YOU