SNS COLLEGE OF TECHNOLOGY

An Autonomous Institution

Coimbatore-35

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DEPARTMENT OF ELECTRONICS & COMMUNICATION ENGINEERING

19ECB301-ANALOG AND DIGITAL COMMUNICATION

III YEAR/ V SEMESTER

UNIT 4 – DIGITAL MODULATION TECHNIQUES

TOPIC – QAM

QUADRATURE AMPLITUDE MODULATION (QAM)

- 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.

QUADRATURE AMPLITUDE MODULATION (QAM)

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

- 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

- 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:

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

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

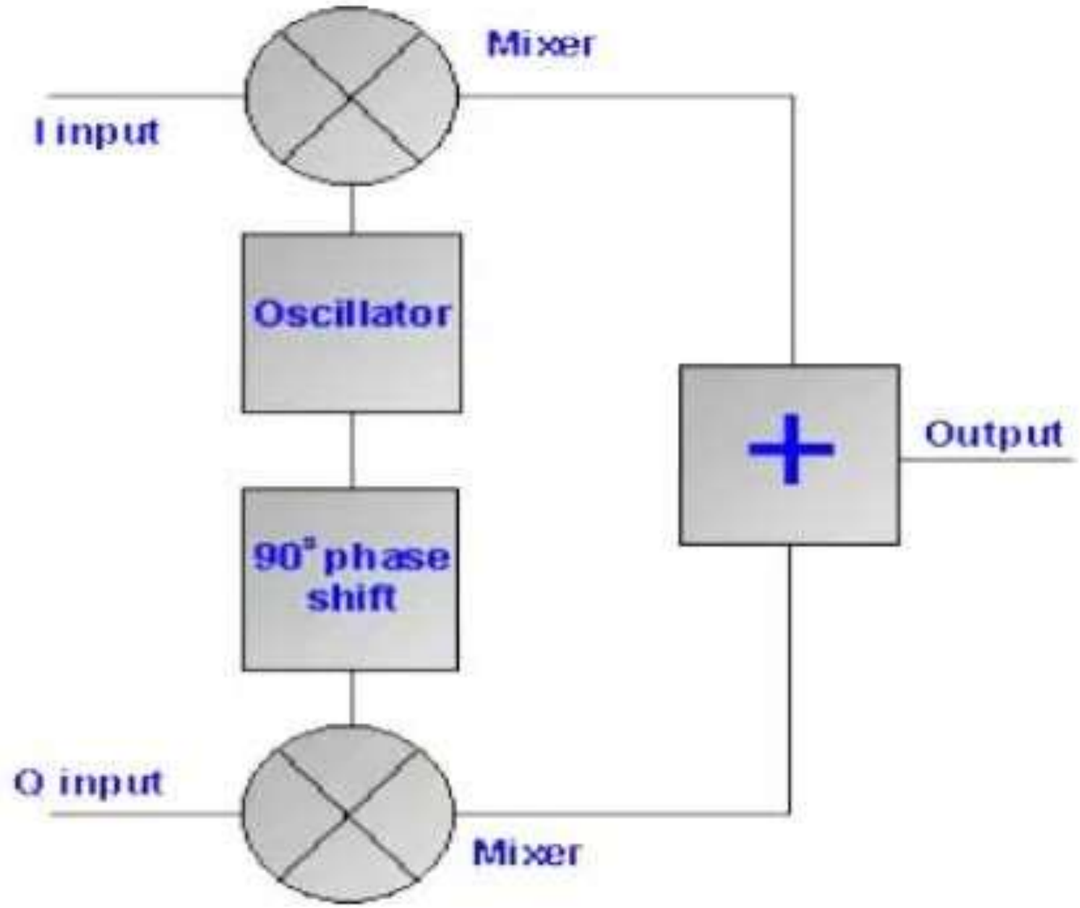
- It can be seen that the I and Q components are represented as cosine and sine. This is because the two signals are 90° out of phase with one another.

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.

QAM MODULATOR



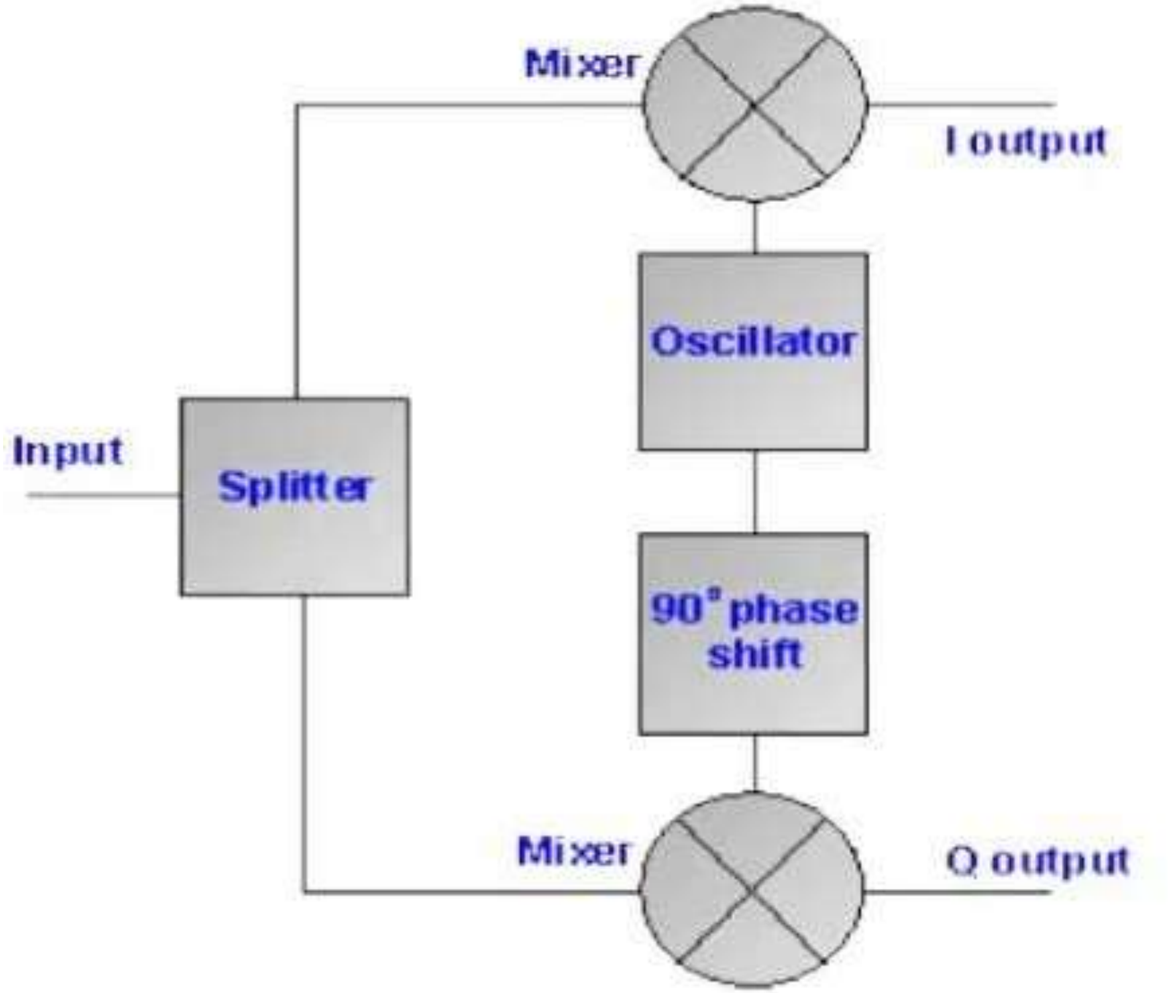
QAM MODULATOR

- The two resultant signals are summed and then processed as required in the RF signal chain, typically converting them in frequency to the required final frequency and amplifying them as required.
- It is worth noting that as the amplitude of the signal varies any RF amplifiers must be linear to preserve the integrity of the signal.
- Any non-linearities will alter the relative levels of the signals and alter the phase difference, thereby distorting the signal and introducing the possibility of data errors.

QAM DEMODULATOR

- The QAM demodulator is very much the reverse of the QAM modulator.
- The signals enter the system, they are split and each side is applied to a mixer.
- One half has the in-phase local oscillator applied and the other half has the quadrature oscillator signal applied.

QAM DEMODULATOR



CONSTELLATION DIAGRAM

- 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.

QAM

- The advantage of using QAM is that it is a higher order form of modulation.
- As a result it is able to carry more bits of information per symbol.
- By selecting a higher order format of QAM, the data rate of a link can be increased.

ADVANTAGES

- Bandwidth Efficiency: Transmit two signals (each of bandwidth B) at 2B.
- More data can be transferred.
- Bit rate is increased without increasing the bandwidth by increasing the value of M.
- If data-rates beyond those offered by 8-PSK are required, it is more usual to move to QAM since it achieves a greater distance between adjacent points in the I-Q plane by distributing the points more evenly

DISADVANTAGES

- It is susceptible to noise because the states are closer together so that a lower level of noise is needed to move the signal to a different decision point.
- When using QAM that contains an amplitude component, linearity must be maintained. Unfortunately linear amplifiers are less efficient and consume more power, and this makes them less attractive for mobile applications.
- Requires coherent demodulation with exact phase and frequency.

APPLICATIONS

- Quadrature multiplexing is used in color television to multiplex the so-called chrominance signals which carry the information about colors.
- QAM Scheme is used on telephone lines for data transmission. At each end of the telephone line, we need a modulator and a demodulator to transmit as well as receive data.
- ADSL technology for copper twisted pairs, whose constellation size goes up to 32768-QAM.
- Ultra-high capacity Microwave Backhaul Systems also use 1024-QAM.

APPLICATIONS

- Digital QAM are being increasingly used for data communications often within radio communications systems.
- Radio communications systems ranging from cellular technology as in the case of LTE through wireless systems including WiMAX, and Wi-Fi 802.11 use a variety of forms of QAM.
- For domestic broadcast applications, 64 QAM and 256 QAM are often used in digital cable television and cable modem applications.

BANDWIDTH EFFICIENCY

- Spectral efficiency, spectrum efficiency or bandwidth efficiency refers to the information rate that can be transmitted over a given bandwidth in a specific communication system. It is a measure of how efficiently a limited frequency spectrum is utilized

- QAM needs to operate in the linear region of a power amplifier to avoid any signal compression and hence degradation.

THANK YOU