Unit-2
Comparison of M-ary Modulation Techniques

Staff: **Dr. R.Kalidoss**

Objective

1. To compare various M-ary modulation Techniques

Introduction

- A comparison can be made of the various M-ary modulation techniques with the help of two important parameters, namely bandwidth and power. Efficient utilization of these parameters is very important in any communication system.
- *Bandwidth efficiency*: It is defined as the ratio of data rate to channel bandwidth. It is measured in units of bits per second per hertz. It is also referred to as spectral efficiency. This can be given mathematically as

$$\rho = \frac{R_b}{B} \text{ bits / s / Hz,}$$

- where R_b is the data rate and B the channel bandwidth.

ρ

M-ary PSK

- Bandwidth efficiency of M-ary PSK:

$$\rho = \frac{\log_2 M}{2}$$

- For different values of *M*, bandwidth efficiency can be calculated. Details are given in Table

M	2	4	8	16	32	64
$_B = R_b/B_{null}$	0.5	1.0	1.5	2	2.5	3

- The table shows improvement in bandwidth efficiency when the value of *M* is increased.

- *Power efficiency:*

  Power efficiency refers to the efficient usage of power in modulation operation. The use of power should be to the minimum extent possible. Power efficiency figures are plotted in Table for various values of M.

M	2	4	8	16	32	64
E_b/N_0 (dB) (BER = 10^{-6})	10.5	10.5	14.0	18.5	23.4	28.5

It implies, when the value of *M* is increased, power also increases. Hence, M-ary PSK proves to be poor in power efficiency and better in bandwidth efficiency.

M-ary FSK

- In M-ary FSK, bandwidth efficiency is given by

$$\rho = \frac{2\log_2 M}{M}$$

- Table Bandwidth and power efficiency of M-ary FSK.

M	2	4	8	16	32	64
$\eta_B = R_b/B_{null}$	0.4	0.57	0.55	0.42	0.29	0.18
E_b/N_0 (BER = 10^{-6})	13.5	10.8	9.3	8.2	7.5	6.9

- In M-ary FSK, bandwidth efficiency reduces, whereas power efficiency improves. Hence, M-ary FSK is good for power efficiency and poor in bandwidth efficiency.
-

M-ary QAM

$$\rho = \log_2 M$$

- Bandwidth and power efficiency figures of M-ary QAM are plotted in table for various values of M.
- Table : Bandwidth and power efficiency of M-ary QAM.

M	4	16	64	256	1024	4096
$\eta_B = R_b / B_{null}$	1	2	3	4	5	6
E_b / N_0 (BER = 10^{-6})	10.5	15	18.5	24	28	33.5

The conclusion is that, M-ary QAM and M-ary PSK have identical bandwidth and power efficiency. However, when $M > 4$, these two schemes have different signal constellations in signal space diagram. M-ary PSK is circular in nature, whereas M-ary QAM is rectangular. It shows that the distance between the two points is very small in M-ary PSK, when we increase the value of M compared with M-ary QAM. Hence M-ary QAM outperforms in terms of error performance.