M-ary ENCODING

The word binary denotes two-bits. M just denotes a digit that resembles to the number of conditions, levels, or combinations possible for a given number of binary variables.

This is the type of digital modulation method used for data transmission in which in its place of one-bit, two or more bits are transmitted at a time. As a single signal is used for multiple bit transmission, the channel bandwidth is reduced.

M-ary Equation

If a digital signal is given below four situations, such as voltage levels, frequencies, phases and amplitude, then M = 4.

The number of bits essential to create a given number of conditions is expressed mathematically as

$$N=\log 2M$$

Where,

N is the number of bits necessary.

M is the number of conditions, levels, or combinations possible with N bits.

The above equation can be re-arranged as −

$$2^{N} = M$$

For instance, with two bits, $2^2 = 4$ conditions are possible.

Types of M-ary Techniques

In overall, (M-ary) multi-level modulation methods are used in digital communications as the digital inputs with more than two modulation levels permitted on the transmitter's input. Therefore, these methods are bandwidth efficient.

There are several different M-ary modulation techniques. Some of these techniques modulate one parameter of the carrier signal, such as amplitude, phase, and frequency.

M-ary ASK

This is called M-ary Amplitude Shift Keying (M-ASK) or M-ary Pulse Amplitude Modulation (PAM).
The amplitude of the carrier signal, takes on M different levels.

Representation of M-ary ASK

$S_m(t)=A_m\cos(2\pi f_c t)$ $A_m \epsilon (2m-1-M)\Delta$, m=1,2....M and $0 \le t \le Ts$

This technique is also used in PAM. Its application is modest. On the other hand, M-ary ASK is susceptible to noise and distortion.

M-ary FSK

This is called as M-ary Frequency Shift Keying.
The frequency of the carrier signal, takes on M different levels.

Representation of M-ary FSK

$Si(t) = \sqrt{\frac{2Es}{Ts}} Cos\left(\frac{\pi}{Ts}\ (nc + i)t\right)$ $0 \le t \le T_s$ and i =1,2.....M
where $f_c = \frac{nc}{2Ts}$ for certain fixed integer n.
This is not vulnerable to noise as much as ASK. The transmitted M number of signals are equal in energy and duration. The signals are separated by $\frac{1}{2Ts}$ Hz making the signals orthogonal to each other.
Since M signals are orthogonal, there is no crowding in the signal space.
The bandwidth efficiency of an M-ary FSK decreases and the power efficiency increases with the increase in M.