

A thick black L-shaped frame is positioned on the left and bottom edges of the slide, framing the central text.

M-ARY PHASE SHIFT KEYING

Introduction

M-ary PSK

- In BPSK, the output of modulator is one bit a time and it has two symbols.
- Hence whenever the symbol is changed, the phase shift is,
phase shift in BPSK = $2\pi/\text{number of symbols} = \frac{2\pi}{2} = \pi$ or 180 degree
- In QPSK two successive bits are combined to form 4 distinct symbols.
- Hence whenever the symbol is changed, the phase shift is,
phase shift in QPSK = $2\pi/\text{number of symbols} = 2\pi/4 = \pi/2$ or 90 degree
- This can extend further for 'N' bits in symbol. Then there will be 2^N M possible symbols
hence whenever the symbol is changed, the phase shift is,
phase shift in M-ary PSK = $2\pi/\text{number of symbols} = 2\frac{\pi}{M}$
- the duration of each symbol will be, $T_s = N T_b$

continue

- **Since there are M – symbols, this method is called M- ary PSK**
- **The transmitted waveform equation for this M-ary PSK is,**

$$\mathbf{s(t) = \sqrt{2Ps} \text{ Cos } (2\pi Fot + \phi m) \text{ and } m=0,1,2,3\text{-----}M-1,}$$

and the symbol phase angle given as, $\phi m = (2m + 1) \frac{\pi}{M}$

Bandwidth (BW) in M-ary PSK

- **The bandwidth in M-ary PSK is equal to the width of the main lobe, i.e.,**

$$\mathbf{BW = F_s - (-F_s) = 2F_s = 2/T_s \quad \text{since } F_s = 1/T_s}$$

with T_s is the symbol duration and it

is equal to $T_s = N T_b$

hence, $BW = 2 / N T_b$ with $T_b = 1/F_b$

$$\mathbf{Hence \text{ } BW = 2 / N(1/F_b) = 2 F_b / N}$$

M-ary PSK transmitter (generator)

- The shown fig., shows the simplified M-ary PSK transmitter.
- The serial to parallel converter forms a symbol of 'N' successive bits, that means the output of this unit is 'n' bit word.

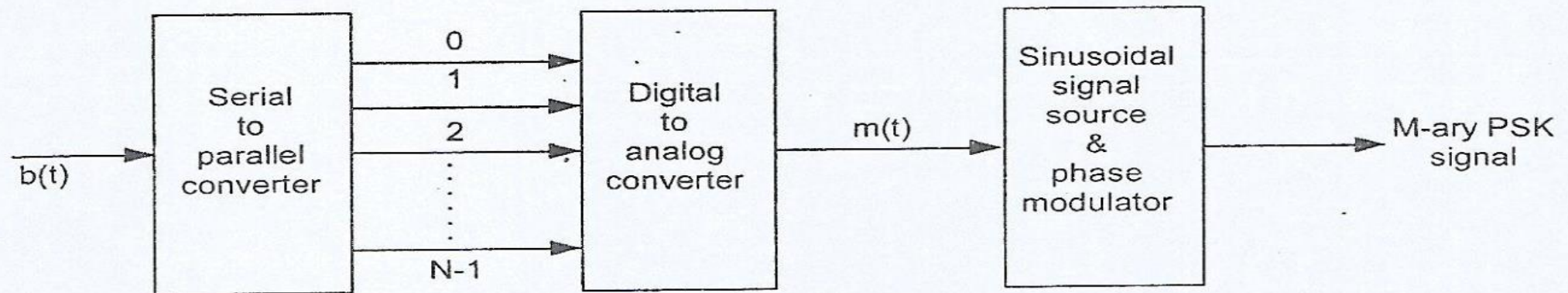
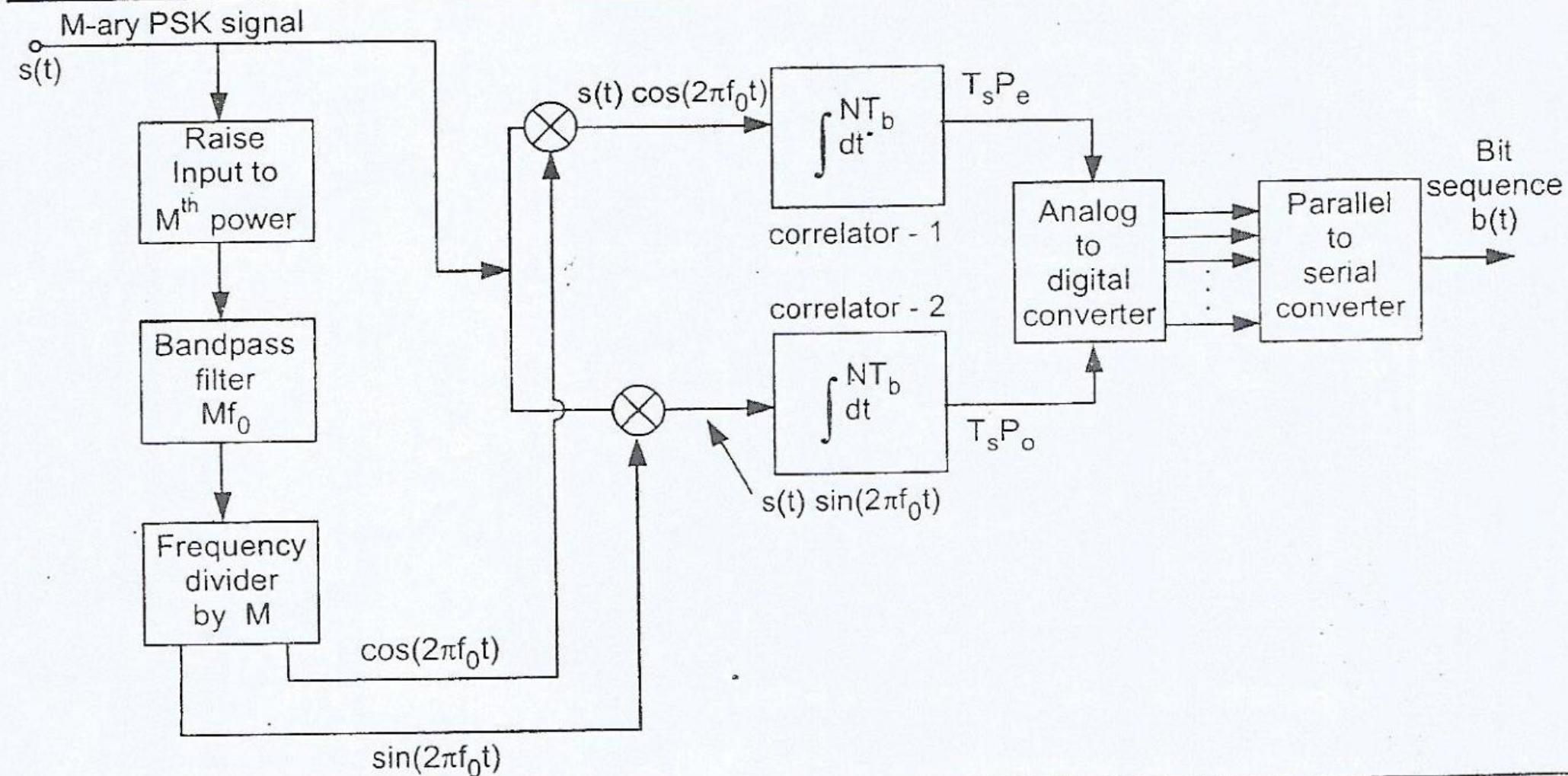


Fig. 8.5.4 Transmitter block diagram

The digital to analog converter output remains unchanged till last N^{th} bit is received. Then depending upon the input 'N' bits, the output of D/A converter is defined. This output is $m(t)$. Again the serial to parallel converter starts taking bits for next 'N' word. The output of D/A converter remain unchanged till last bit is received. Thus $m(t)$ is hold for the period of NT_b . $m(t)$ takes $2^N = M$ different values, depending upon the input bits. The voltage $m(t)$ is applied to modulator. This modulator modulates the phase of sinusoidal carrier depending upon the amplitude of the symbol $m(t)$.

8.5.5.2 M-ary PSK Receiver

Fig. 8.5.5 shows the receiver of M-ary PSK. It is similar to QPSK receiver. The input signal $s(t)$ is raised to M^{th} power. The bandpass filter extracts the frequency component Mf_0 . This frequency is divided by 'M' to obtain carrier frequency f_0 . The coherent carriers are thus generated and applied to the two multipliers.



The outputs of the multipliers are given to the integrators. The integrators integrate over the period of $T_s = NT_b$. The outputs of the integrators are sampled after the period T_s in every cycle and applied to the analog to digital converter. The integrator outputs are proportional to $T_s P_e$ and $T_s P_o$. These voltages are applied to A/D converter, which reconstructs 'N' bit symbol. This 'N' bit symbol is given to the parallel to serial converter. It then generates the bit sequence $b(t)$.

Ex. 8.5.2 In digital CW communication system, the bit rate of NRZ data stream is 1 Mbps and carrier frequency is 100 MHz. Find the symbol rate of transmission and bandwidth requirement of the channel in the following cases of different techniques used.

i) BPSK system ii) QPSK system iii) 16-ary PSK system [Dec-2001, 6 Marks]

Sol. : Given data

The bit rate is, $f_b = 1 \text{ Mbps} = 1 \times 10^6$

Hence
$$T_b = \frac{1}{f_b} = \frac{1}{1 \times 10^6} = 1 \times 10^{-6} \text{ or } 1 \mu\text{s}.$$

Carrier frequency $f_o = 100 \text{ MHz}$

(i) BPSK system

Bandwidth of BPSK system is given by equation 8.1.21 as,

$$\begin{aligned} \text{BW} &= 2f_b \\ &= 2 \times 1 \times 10^6 = 2 \text{ MHz} \end{aligned}$$

In BPSK, one bit is considered as one symbol.

Hence
$$T_s = T_b = 1 \times 10^{-6}$$

$\therefore$ Symbol rate
$$= \frac{1}{T_s} = \frac{1}{1 \times 10^{-6}} = 1 \times 10^6 \text{ symbols/sec.}$$

Note that this rate is same as bits/sec.

(ii) QPSK system

Bandwidth of QPSK is given by equation 8.4.24 as,

$$BW = f_b = 1 \times 10^6 \text{ i.e. 1 MHz}$$

$$\begin{aligned} \text{In QPSK, } T_s &= 2T_b \\ &= 2 \times 1 \times 10^{-6} \text{ or } 2 \mu\text{sec} \end{aligned}$$

$$\begin{aligned} \text{Hence, symbol rate} &= \frac{1}{T_s} \\ &= \frac{1}{2 \times 10^{-6}} = 500 \times 10^3 \text{ symbols/sec} \end{aligned}$$

(iii) 16-ary PSK system

Equation 8.5.13 gives the bandwidth of M-ary PSK as,

$$BW = \frac{2f_b}{N}$$

Here 'N' is the number of bits used to make one symbol. Here there are total 16 symbols.

$$\therefore N = \log_2 M$$

$$= \log_2 16 = \frac{\log_{10} 16}{\log_{10} 2} = 4$$

Thus 4 bits make 16 symbols. Hence bandwidth of the 16-ary PSK becomes,

$$\text{BW} = \frac{2 \times 1 \times 10^6}{4} = 500 \text{ kHz}$$

Symbol duration and bit duration are related as,

$$T_s = NT_b \quad (\text{From equation 8.5.2})$$

$$= 4 \times 1 \times 10^{-6} = 4 \times 10^{-6}$$

$$\text{Symbol rate} = \frac{1}{T_s}$$

$$= \frac{1}{4 \times 10^{-6}} = 250 \times 10^3 \text{ symbols/sec}$$

Ex. 8.5.3 Assume that you are required to transmit $f_b = 90 \text{ Mb/s}$ data in an authorised bandwidth of 20 MHz. Which modulation techniques would you consider? Explain why?

Sol. : For this transmission, M-ary PSK modulation method can be used. From equation 8.5.12 the minimum bandwidth of M-ary PSK is given as,

$$BW \leq \frac{2f_b}{N}$$

Here $BW = 20 \times 10^6 \text{ Hz}$ and $f_b = 90 \times 10^6 \text{ Hz}$

Putting those values in above equation,

$$20 \times 10^6 \leq \frac{2 \times 90 \times 10^6}{N}$$

$$\therefore N = 9 \text{ bits}$$

$$\therefore M = 2^N = 2^9 = 512$$

This shows that 512-ary PSK can transmit the 90 MHz signal in the bandwidth of 20 MHz.