FREQUENCY SHIFT KEYING → (FSK)

It is a form of constant amplitude angle modulation similar to frequency modulation (FM) except the modulating signal is a binary signal that varies between two discrete voltage levels.

FSK is also called as binary FSK (BFSK)

The FSK modulated wave is expressed as;

$$v_{fsk}(t) = V_c \cos\{2\pi[f_c + v_m(t)\Delta f]t\} \quad \text{— (2)}$$

where $v_{fsk}(t)$ = Binary fsk wave form

$V_c$ = Peak analog carrier amplitude (V)

$f_c$ = analog carrier center freq. (Hz)

$\Delta f$ = Peak change or shift in the analog carrier freq. (Hz)

$v_m(t)$ = Binary input modulating signal (V)

Case I : Logic 1

$$v_m(t) = +1 \quad \text{(suppose)}$$

eqn (2),

$$v_{fsk}(t) = V_c \cos\{2\pi[f_c + \Delta f]t\}$$

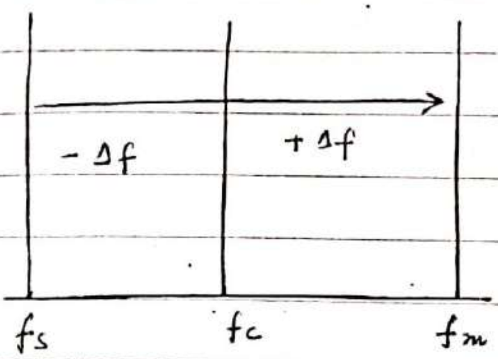
⇒ freq. increases for binary input = 1

Case II : Logic 0

$$v_m(t) = -1$$

$$v_{fsk}(t) = V_c \cos\{2\pi(f_c - \Delta f)t\}$$

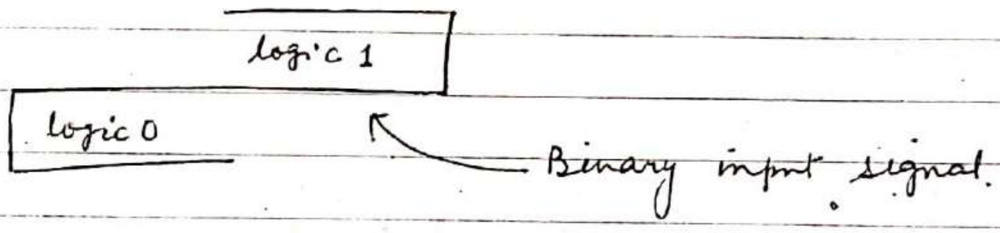
$\Rightarrow$ frequency decreases for binary input = 0.




$f_s$ = Space frequency = $f_c - \Delta f$

$f_m$ = Mark freq. = $f_c + \Delta f$

Difference b/w $f_s$ and $f_m = 2\Delta f$

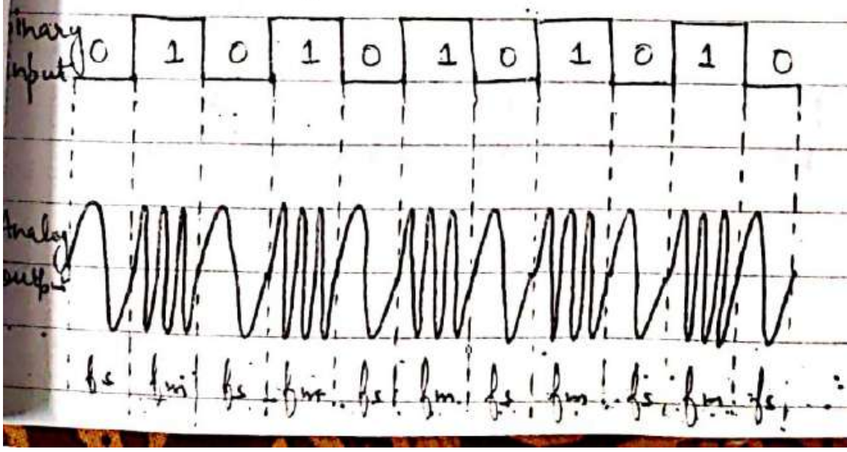



Frequency deviation is defined as the difference between either the mark or space frequency and center frequen[cy]

OR

Difference between the Mark and space frequencies / 2

$$\Rightarrow \Delta f = |f_c - f_s| = |f_c - f_m| = \left|\frac{f_m - f_s}{2}\right| \quad \text{— (3)}$$




| Binary input | Frequency output |
|---|---|
| 0 | space ($f_s$) |
| 1 | mark ($f_m$) |

$$\text{Baud} = \frac{f_B}{1} = f_b = \text{freq. for one bit transmiss.}$$

$$\text{Minimum Bandwidth} = |(f_s - f_b) - (f_m - f_b)|$$

$$= |f_s - f_m| + 2f_b$$

Now ~~...~~ $|f_s - f_m| = 2\Delta f$

$\Rightarrow$ Minimum Bandwidth

$$B = 2(\Delta f + f_b) \quad \text{--- (4)}$$

$\hookrightarrow$ Minimum Nyquist Bandwidth

$\Delta f \rightarrow$ frequency deviation

$f_b \rightarrow$ input bit rate

Problem 1 :- Determine

(a) The peak freq. deviation,

(b) Minimum bandwidth,

(c) ~~Bod~~ Baud for a binary FSK signal with a Mark frequency of 49 kHz, a Space freq. of 51 kHz and an input bit rate of 2 kbps.

Solution

1(a) $f_m = 49$ kHz $f_s = 51$ kHz

Peak freq. deviation $= \Delta f = \left|\frac{49 - 51}{2}\right|$ kHz

$= 1$ kHz

(b) Minimum Bandwidth $= B = 2.(\Delta f + f_b)$

$f_b = 2$ kbps $= 2$ kHz

$\Rightarrow B = 2(1 + 2)$ kHz $= 3 \times 2$ kHz

$= 6$ kHz.

(c) For FSK

$N = 1$

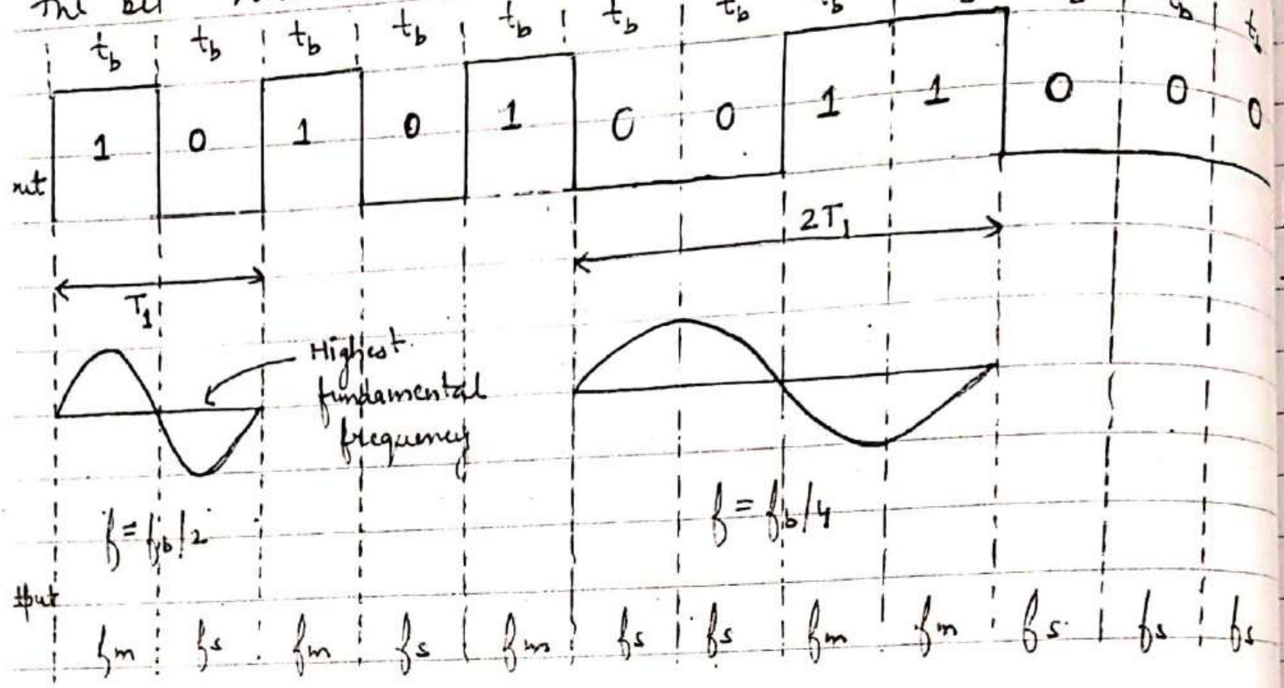
$\Rightarrow$ Baud $= \frac{f_b}{1} = 2000$

The highest fundamental freq. of the binary input signal is given by

$$f_a = \frac{f_b}{2}$$

where $f_b$ = input bit rate

$\Rightarrow$ The highest fundamental frequency present in a square wave equals the repetition rate of the square wave which with a binary signal is equal to half the bit rate.




Modulation index in FM is same as that for FSK. Th

$$h = \frac{\Delta f}{f_a} \quad \text{—— (5)}$$

$h \rightarrow$ Modulation index

$f_a \rightarrow$ fundamental frequency of the binary modulating signal

$\Delta f \rightarrow$ Peak frequency deviation

The worst case modulation index $\Rightarrow$ widest band

$\Rightarrow$ peak freq. deviat and modulating s freq. have max.

for highest $h$, both $\Delta f$ and $f_a$ will have max value but $\Delta f$ will dominate.

$$\Rightarrow h = \frac{|f_m - f_s|/2}{f_b/2} \quad \begin{array}{l} \leftarrow \text{Max. value of } \Delta f \\ \rightarrow \text{Max value of } f_a \end{array}$$

—— (6)

$$\Rightarrow h = \frac{|f_m - f_s|}{f_b} \quad \text{—} \quad (7)$$

roblem → . Determine the minimum bandwidth and modulation index for the FSK signal with a mark frequency of 49kHz, space frequency of 51 kHz and input bit rate of 2kbps.

$f_M = 49 kHz$

$f_s = 51 kHz$

$f_b = 2 kbps = 2 k Hz$

$$h = \frac{|f_m - f_s|}{f_b}$$

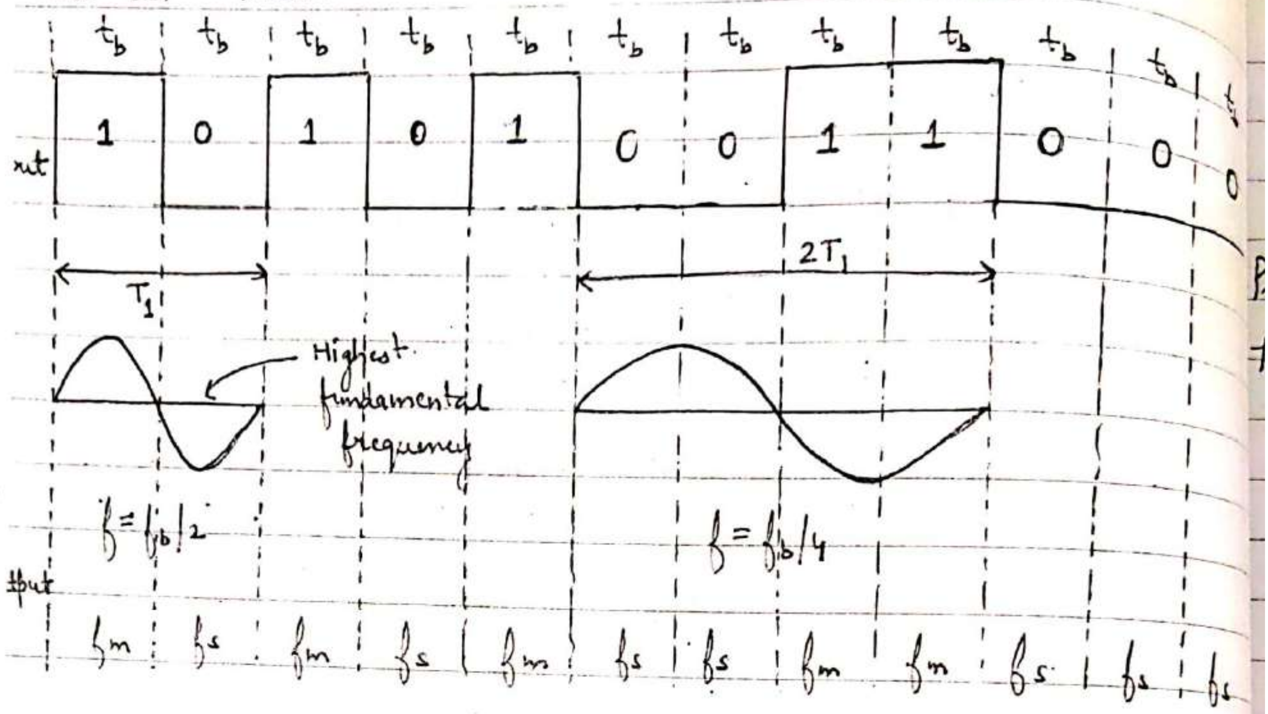
$$= 2/2 = 1$$

Min Bandwidth : $B = 2(\Delta f + f_b)$

$\Rightarrow \quad \Delta f = |f_m - f_s| / 2 = 1 kHz$

So, $B = 6 kHz$

the bit rate.

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$\Rightarrow$ peak freq. deviat and modulating s freq. have max.

$$\Rightarrow h = \frac{|f_m - f_s|/2}{f_b/2}$$

$|f_m - f_s|/2 \leftarrow$ Max. value of $\Delta f$

$f_b/2 \longrightarrow$ Max value of $f_a$.

$$\Rightarrow h = \frac{|f_m - f_s|}{f_b} \quad \text{—— (7)}$$

Problem → Determine the minimum bandwidth and modulation index for the FSK signal with a mark frequency of 49kHz, space frequency of 51 kHz and input bit rate of 2kbps.

$f_M = 49\text{kHz}$

$f_s = 51 \text{ kHz}$

$f_b = 2 \text{ kbps} = 2 \text{ kHz}$

$$h = \frac{|f_m - f_s|}{f_b}$$

$$= 2/2 = 1$$

Min Bandwidth : $B = 2(\Delta f + f_b)$

$$\Rightarrow \Delta f = |f_m - f_s|/2 = 1 \text{ kHz}$$

So, $B = 6 \text{ kHz}$

## PHASE SHIFT KEYING → (PSK) →

It is similar to conventional phase modulation except with PSK, the input is a binary digital signal and there are a limited no. of possible output phases.

Input binary information is encoded into group of bits before modulating the carrier. No. of bits in a group ranges from 1 to 12 or more.

Consider the no. of bits given by N and the no. of output phases is defined by

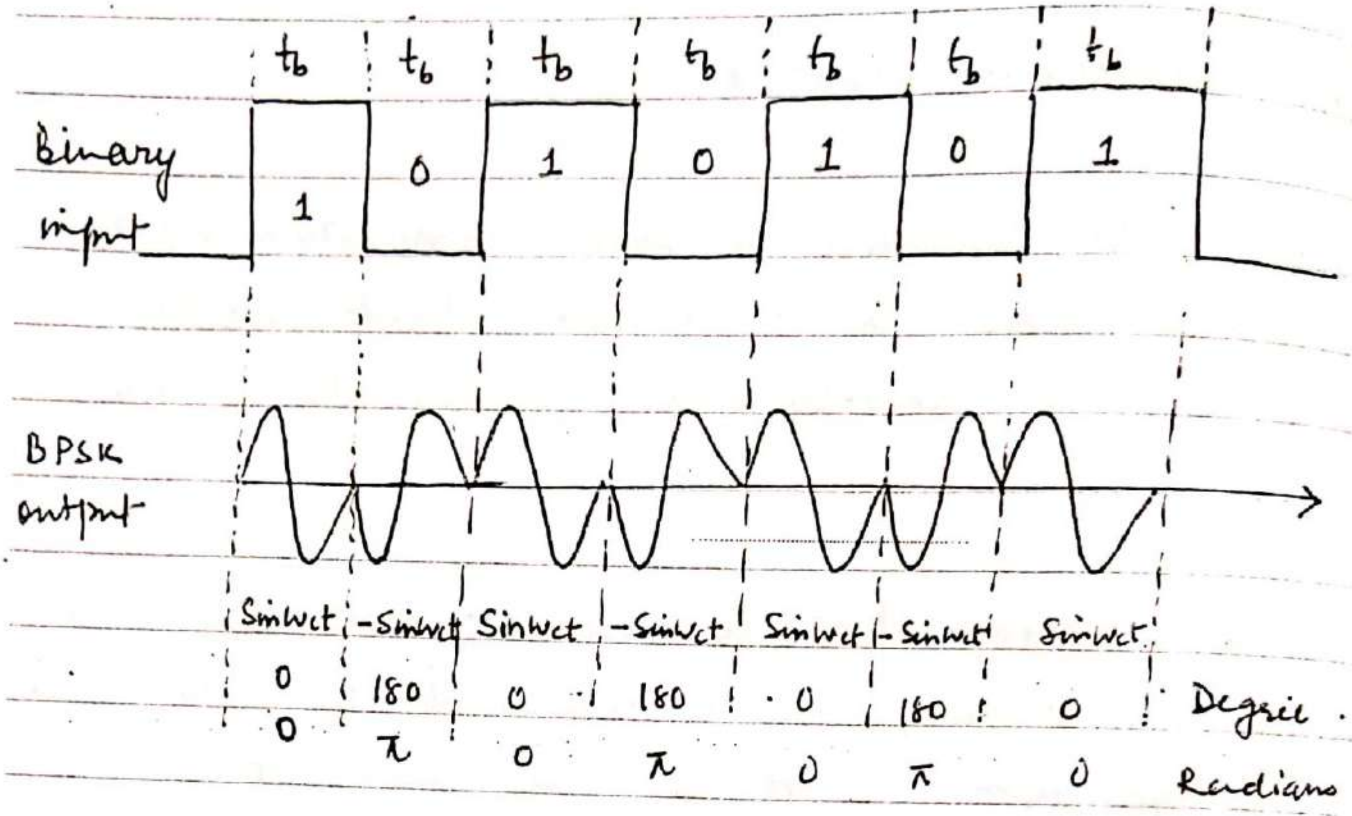
$$M = 2^N$$

e.g. for $N = 1$ ; output $= 2^1 = 2$
for $N = 2$ ; output $= 2^2 = 4$

## Binary Phase Shift Keying (BPSK) →

For BPSK, $N = 1$ and $M = 2$ i.e. two phases ($2^1 = 2$) are possible for the carrier.
One phase represents logic 1
other phase represents a logic 0

When input digital signal changes state from 1 to 0 or 0 to 1 output carrier shifts between two angles separated by 180°, hence it is called as Phase Reversal Keying (PRK) and Biphase Modulation.



$t_b$ $t_b$ $t_b$ $t_b$ $t_b$ $t_b$ $t_b$
Binary input
1 0 1 0 1 0 1
BPSK output
Sin$\omega_c t$ -Sin$\omega_c t$ Sin$\omega_c t$ -Sin$\omega_c t$ Sin$\omega_c t$ -Sin$\omega_c t$ Sin$\omega_c t$
0 180 0 180 0 180 0 Degree
0 $\pi$ 0 $\pi$ 0 $\pi$ 0 Radians