Frequency Shift keying (FSK)

In ~~ka~~ binary FSK, the frequency of the carrier is shifted according to binary symbol. the symbols 1 and 0 are distinguished from each other by transmitting one of two sinusoidal waves that differ in frequency by a fixed amount, with phase is constant.

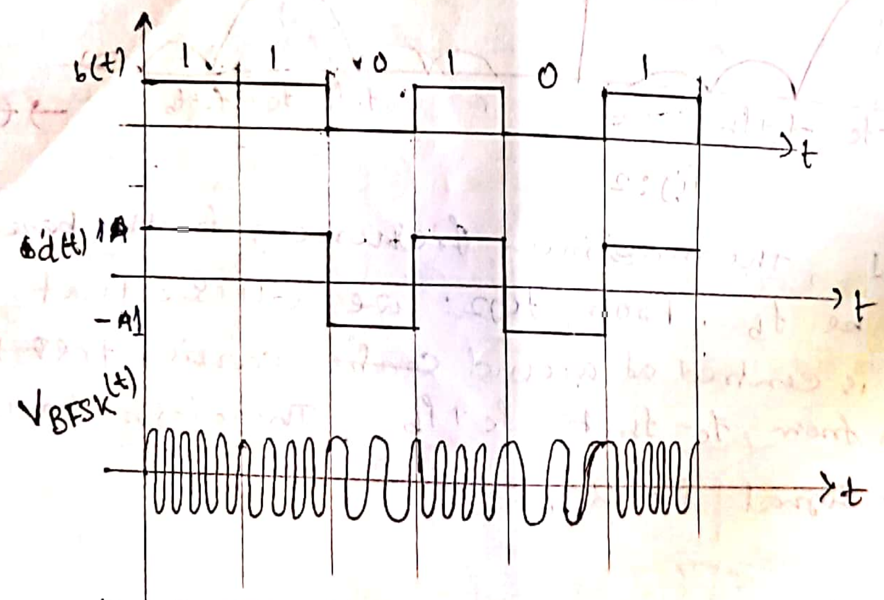
In binary FSK the binary data waveform $d(t)$ generates a binary signal

$$V_{BFSK}(t) = \sqrt{2P_s}\cos\left(\omega_c t + d(t)\Omega t\right)$$ here

$d(t) = +1$ or -1 corresponding to the logic levels 1 and 0 of the data waveform.

Thus
$$S_H(t) = \sqrt{2P_s}\cos(\omega_c + \Omega)t = \sqrt{P_s T_b}\sqrt{\frac{2}{T_b}}\cos 2\pi f_H t = \sqrt{P_s T_b}\,\phi_1(t)$$
$$S_L(t) = \sqrt{2P_s}\cos(\omega_c - \Omega)t = \sqrt{P_s T_b}\,\phi_2(t)$$

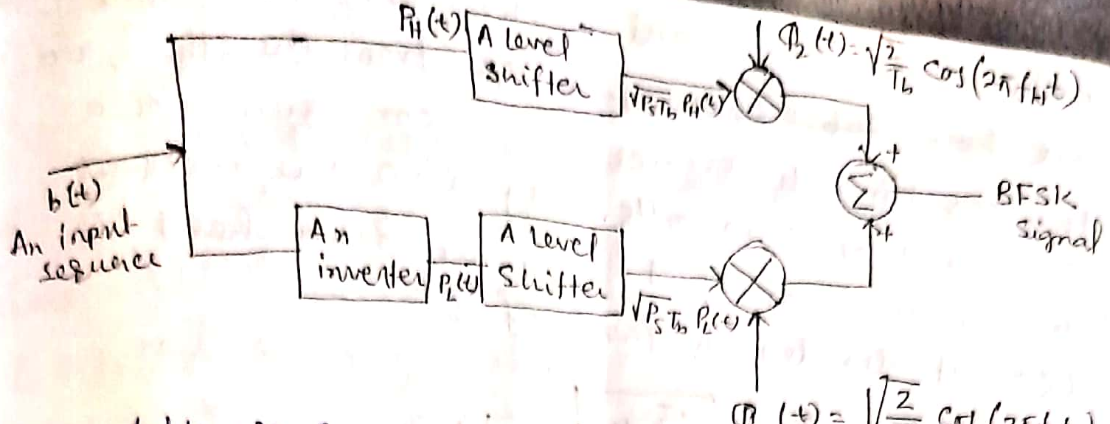
Hence if symbol '1' is to be transmitted, the carrier freq will be : $f_c + \frac{\Omega}{2\pi}$ and if '0' is to be transmitted the carrier freq will be $f_c - \frac{\Omega}{2\pi}$



Generation of BFSK Signal

So for the generation BFSK signal, two ~~bam~~ balanced modulator are used, one ~~which~~ with carrier ω_H and one with carrier ω_L. The voltage values of $P_H(t)$ and $P_L(t)$ are related to the voltage values of $d(t)$ in the following ~~mat~~ manners.

b(t) input	d(t)	$P_H(t)$	$P_L(t)$
1	+1 V	+1 V	0 V
0	~~0V~~ -1 V	0 V	+1 V



From table we see that the input sequence $b(t)$ is same as $P_H(t)$. An inverter is added after $b(t)$ to get $P_L(t)$. The level shifter converts the '+1' level to $\sqrt{P_s T_b}$ and for 0v is unaffected. Then two orthogonal carrier $\phi_1(t)$ and $\phi_2(t)$ signal are used. Thus the modulated signal having continuous phase. The adder then adds the two signal. The two frequencies f_L and f_H are choosen to equal integer multiplies of the ~~#~~ bit rate $1/T_b$.

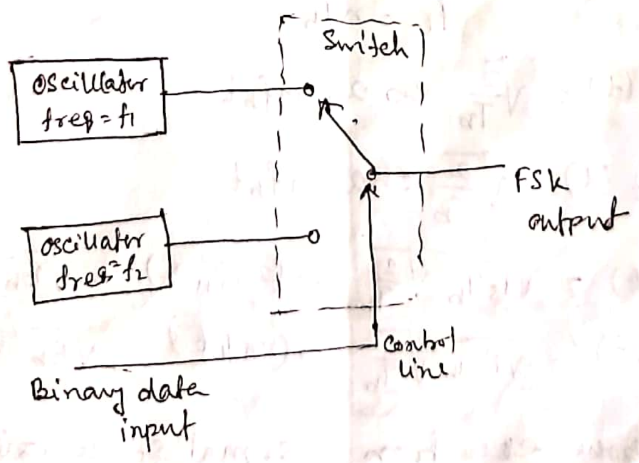
~~$f_{H/L} = f_c \pm d(t)\Omega$~~

$f_{H/L} = f_c \pm d(t)\frac{\Omega}{2\pi}$ → $d(t)$ is function $b(t)$ if is continuous

~~Reception of BFSK~~

[Switching ~~technique~~ the transmitter output line between two adjacent oscillator. It is called discontinuous phase FSK, because $\theta(t)$ phase discontinuous at the switching time.

$$S(t) = A_c \cos(\omega_1 t + \theta_1) \quad 0 \le t \le T_b \text{ for binary } 1$$
$$= A_c \cos(\omega_2 t + \theta_2) \quad 0 < t \le T_b \text{ for binary } 0$$

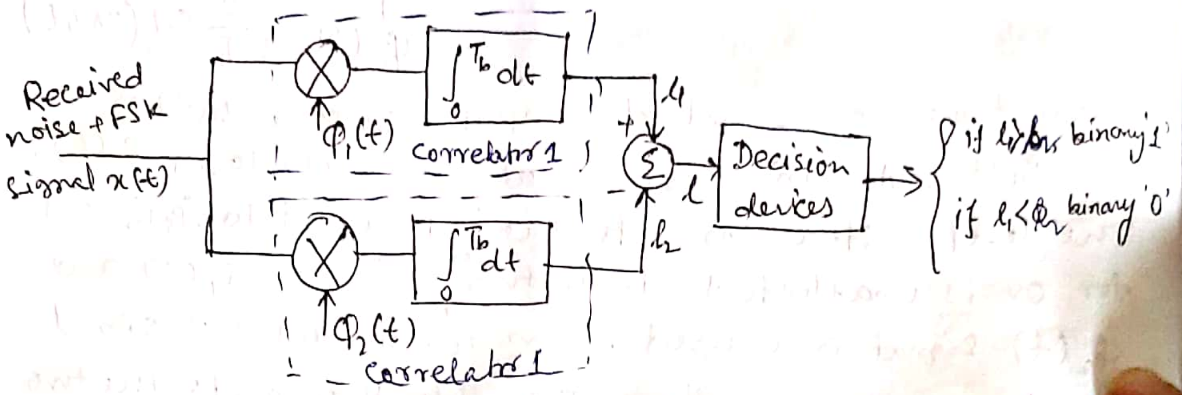


]

FSK Demodulation :

In order to detect the original binary sequence given the noisy received wave $x(t)$, we may use the following receiver. The detector consists of two correlators that are tuned to two different carrier frequencies ~~with a common input~~. which are supplied with locally generated coherent reference signal $\phi_1(t)$ and $\phi_2(t)$

with a common input ... The correlator output are then ~~Subst~~ subtracted one from the other, and the resulting difference l, is compared with a threshold of zero volts. If $l > 0$ the received desides in favor of 1. On the other hand, if $l < 0$ it desides in favor of 0.



Geometrical Representation of orthogonal BFSK

In BFSK we use two orthogonal carrier $\varphi_1(t)$ and $\varphi_2(t)$ of two different frequencies f_H and f_L are used for modulation. To make $\varphi_1(t)$ and $\varphi_2(t)$ orthogonal the frequencies f_H and f_L must be some integer multiple of baseband frequency f_b.

Thus $f_H = m f_b$

$f_L = n f_b$.

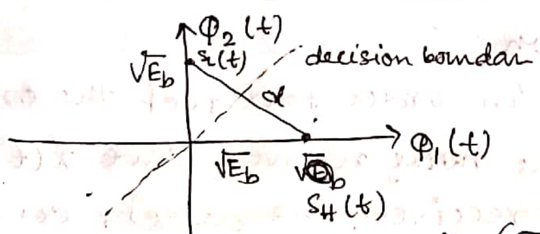
$$\therefore \varphi_1(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi m f_b t$$

$$\varphi_2(t) = \sqrt{\frac{2}{T_b}} \cos 2\pi n f_b t.$$

$$\therefore S_H(t) = \sqrt{P_s T_b} \sqrt{\frac{2}{T_b}} \cos(2\pi f_H t) = \sqrt{E_b}\, \varphi_1(t)$$

$$S_L(t) = \sqrt{P_s T_b} \sqrt{\frac{2}{T_b}} \cos(2\pi f_L t) = \sqrt{E_b}\, \varphi_2(t)$$

baseon above equation signal space diagram is



distant b/w signal points, $d^2 = (\sqrt{E_b})^2 + (\sqrt{E_b})^2 = 2E_b$

$$\therefore d = \sqrt{2E_b}$$

Spectrum of BFSK

The BFSK signal $V_{BFSK}(t)$ may be written as

$$V_{BFSK}(t) = \sqrt{2P_s}\, P_H(t) \cos(2\pi f_H t) + \sqrt{2P_s}\, P_L(t) \cos(2\pi f_L t)$$

Now we know the BPSK signal is $v_{BPSK}(t) = b(t)\sqrt{2P_s}\cos(2\pi f_c t)$ where $b(t)$ is a bipolar signal, while in BFSK signal $P_H(t)$ or $P_L(t)$ are unipolar. Now we convert these value in bipolar variable, that is

$$P_H(t) = \frac{1}{2} + \frac{1}{2} P_H'(t)$$

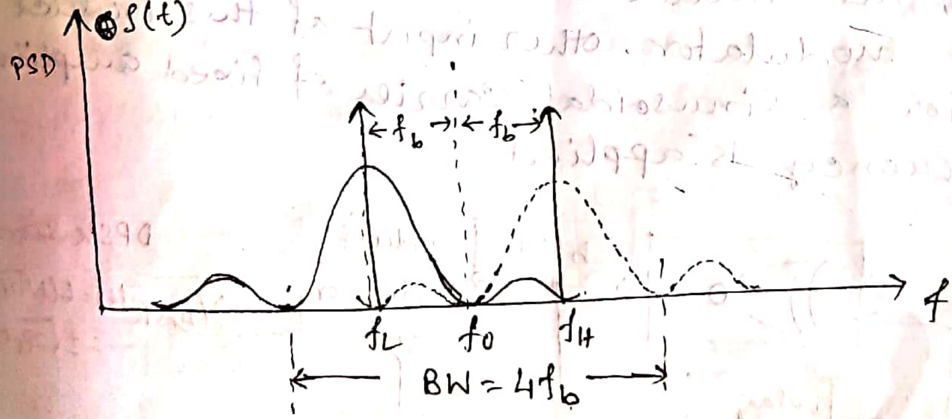
$$P_L(t) = \frac{1}{2} + \frac{1}{2} P_L'(t)$$ where $P_H'(t)$ and $P_L'(t)$

are bipolar.

$$\text{so, } V_{BFSK}(t) = \sqrt{\frac{P_s}{2}} \cos(2\pi f_H t) + \sqrt{\frac{P_s}{2}}\, P_H'(t) \cos(2\pi f_H t) + \sqrt{\frac{P_s}{2}} \cos(2\pi f_L t) + \sqrt{\frac{P_s}{2}}\, P_L'(t) \cos(2\pi f_L t)$$

The first term and third term produce a power spectral density which of two impulses one at f_H and one at f_L. The second ~~and~~ and last term produce the spectrum of two binary PSK signal at centred about f_H and f_L:

$$S(f) = \frac{P_s}{2}\left[\delta(f - f_H) + \delta(f - f_L)\right] + \frac{P_s T_b}{2}\left(\frac{\sin \pi f_H T_b}{\pi f_H T_b}\right)^2 + \frac{P_s T_b}{2}\left(\frac{\sin \pi f_L T_b}{\pi f_L T_b}\right)^2$$



∴ The Bandwidth of BFSK signals is $= 4f_b$ which is twice the bandwidth of BPSK

$$P_e = \frac{1}{2}\operatorname{erfc}\sqrt{\frac{E_b}{2N_0}}$$