*5 large no. of modulation techniques are available

* Draw backs of Pass band modulation :-

*1) modulator / Demodulator Equipment's design is Complex.

*2) not suitable for Short distance Communication {we use Base band digital mods techs for short distances}

* COHERENT BINARY ASK {ON-OFF Key}

* In this method their is only one unit Energy carrier & it is Switched ON or OFF depending upon the i/p binary sequence.

* Note :-

ASK is no longer widely used in DC's Especially in wireless Communications, it is an

Earlier *27/07/17*

* c(t)

*

*

* Earliest form of Digital modulation used in radio telephony.

27/07/17

$$* \; C(t) = A\cos(2\pi f_c t)$$

$$P_s = \frac{A^2}{2}$$

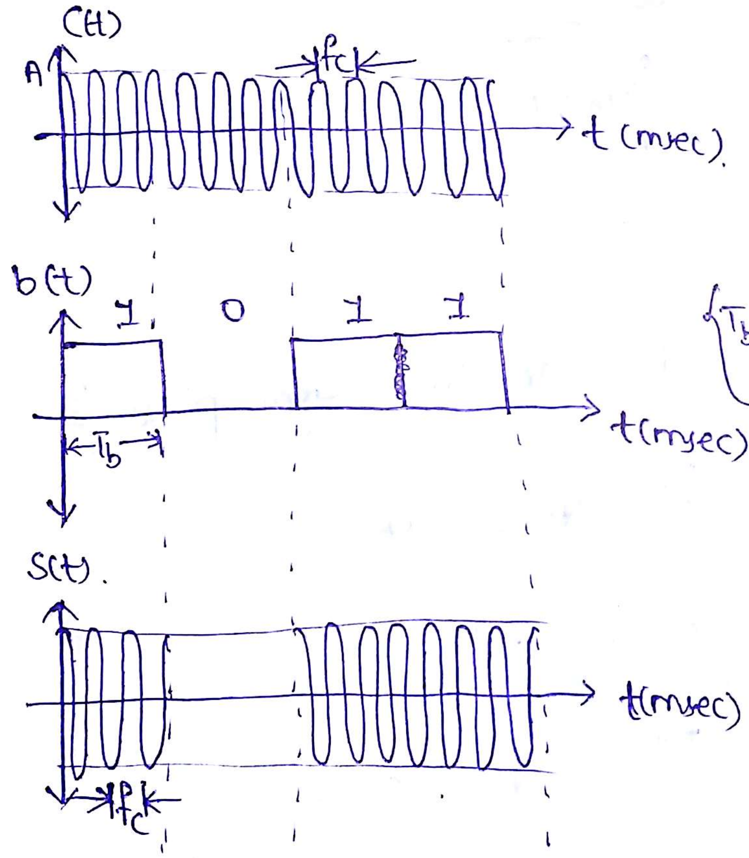
$$A = \sqrt{2P_s}$$

$$\Rightarrow \quad C(t) = \sqrt{2P_s} \cdot \cos(2\pi f_c t)$$

ASK defined as.

$$S(t) = \begin{cases} \sqrt{2P_s} \cdot \cos(2\pi f_c t) & ; b_k = 1 \\ 0 & ; b_k = 0 \end{cases} \longrightarrow (1)$$

* Hence, Switching ON/OFF of a carrier
$\Rightarrow$ ON - OFF keying.



$\left\{ \begin{array}{l} T_b = \text{bit duration} \\ \frac{1}{T_b} = \text{bit rate} = f_b \end{array} \right\}$

* ASK is not used in wireless communications, Especially not used in Satellite Communications because of harmonic distortions

$$* \; S(t) = \begin{cases} \sqrt{P_s T_b} \cdot \sqrt{\frac{2}{T_b}} \cdot \cos(2\pi f_c t) & ; \text{ if } b_K = 1 \\ 0 & ; \text{ if } b_K = 0 \end{cases} \rightarrow ②.$$

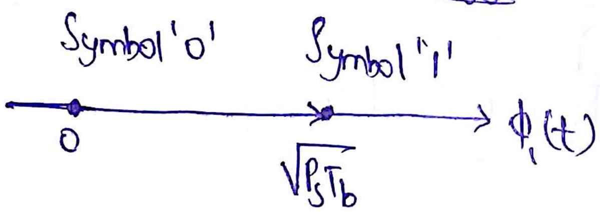
$$\Rightarrow S(t) = \begin{cases} \sqrt{P_s T_b} \cdot \phi_1(t) & ; \text{ if } b_K = 1 \\ 0 & ; \text{ if } b_K = 0 \end{cases} \longrightarrow ③$$

$\{ \because E_b = \sqrt{P_s T_b} \}$ $\qquad \{ \sqrt{P_s T_b} = \sqrt{\text{bit Energy}} \{\sqrt{E_b}\} \}$

* This means that their is only one carrier function "$\phi_1(t)$".

* The signal space diagram will have two points on "$\phi_1(t)$". one will be at zero & other will be at $\sqrt{P_s T_b}$.

* Straight space representation of ASK :-



* The distance b/w the two signal points is

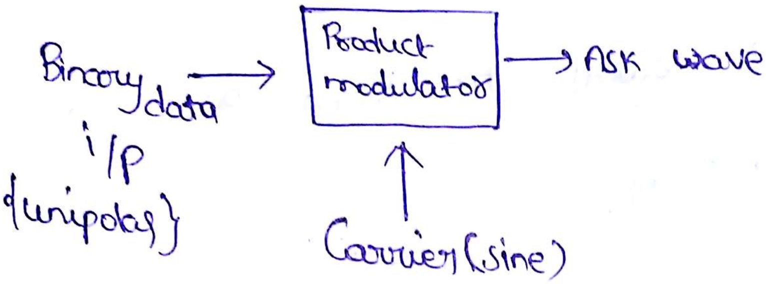
$$d = \sqrt{P_s T_b} - 0$$

$$\Rightarrow d = \sqrt{P_s T_b}.$$

$$\Rightarrow d = \sqrt{E_b}. \longrightarrow ②$$

* Generation of ASK:-

* ASK signal may be generated by simply applying the incoming Binary data {uni polar} & the sinusoidal carrier to the two i/p's of a product modulator. {i.e.. a balanced modulator}, the resulting o/p will be an ASK wave form.

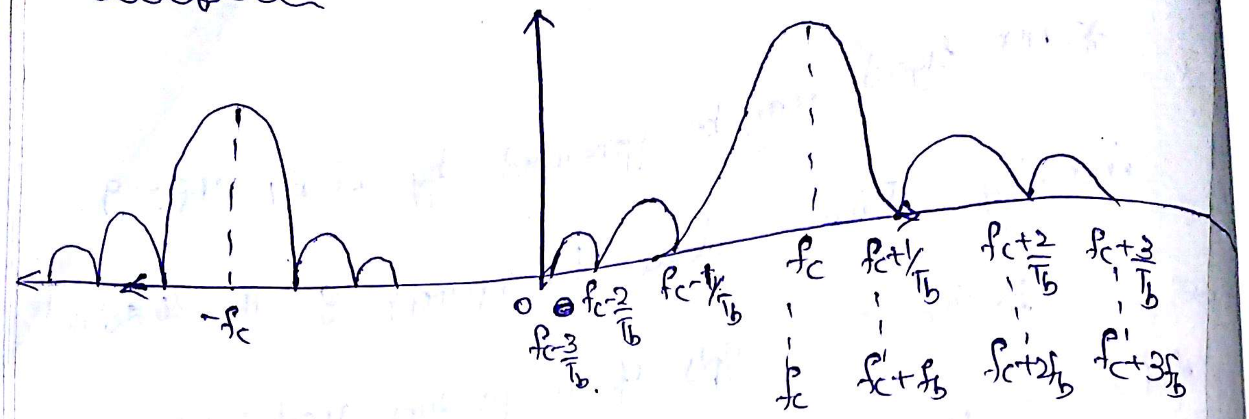


* The modulation causes a shift of Baseband signal spectrum

* The ASK signal is the product of the binary sequence & carrier signal; cause a power spectral density (PSD) same as that of Base band ~~&~~ (ON-OFF signal. But shifted in freq domain by $\pm f_c$

*PSD of ASK:-

PSD of ASK



* BW of ASK = ∞ {theoritically}

Practically it is not possible., so.

* The spectrum of ASK signal has infinite B.W, if we consider 100% power.

* However, for practical purpose, B.W is defined as the B.W of an ideal B.P.F centered at "f_c" whose O/P contains about 95% of the total avg power content of the ASK signal.

* Acc to this B.W of ASK signal is approximately

$$\boxed{BW_{ASK} = 3f_b = \frac{3}{T_b}}$$

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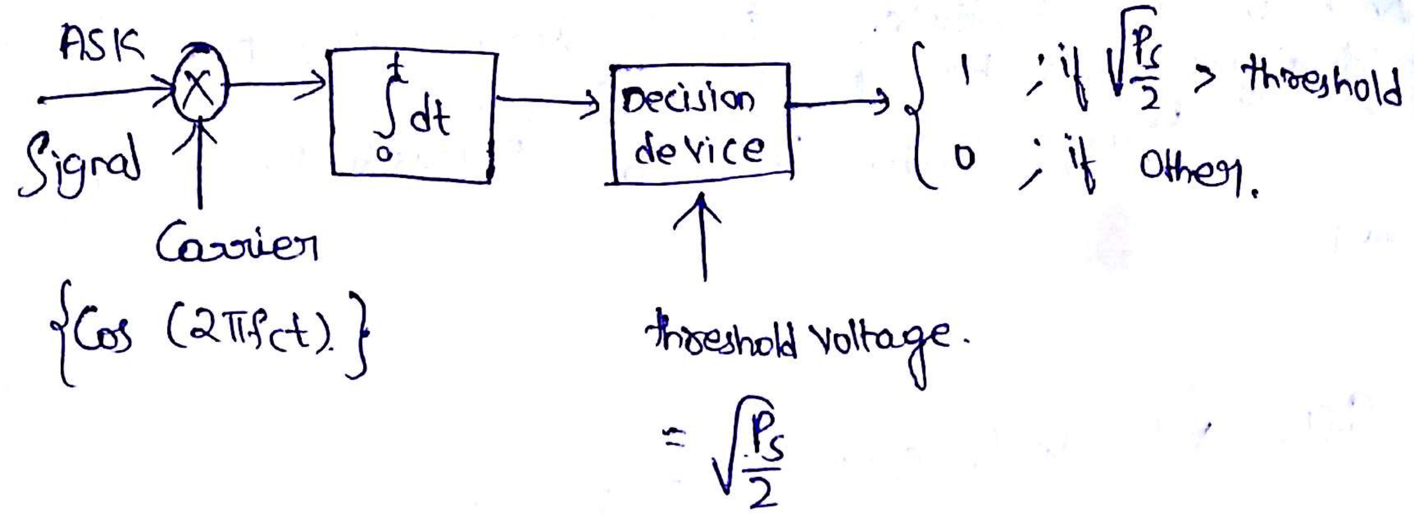
* Coherent detection of Binary ASK :-



* The demodulation of BASK wave form can be achieved with the help of coherent detector as shown in the given fig above.

* It consists of Product modulator followed by an Integrator & a decision making device.

* Integrator operates on the o/p of the multiplier

27/07/2017 ***BPSK***

*Let us assume the carrier as $c(t) = A\cos(2\pi f_c t)$,

where A is peak amplitude, for 1Ω load resistor power dissipiated would be $P_s = A^2/2 \Rightarrow A = \sqrt{2P_s}$

*In BPSK, the binary symbol '1' & '0' modulate the phase of the carrier.

$$S_1(t) = \sqrt{2P_s} \cdot \cos(2\pi f_c t) \; ; \text{ for } b_K = 1$$

$$S_2(t) = \sqrt{2P_s} \cdot \cos(2\pi f_c t + \pi); \text{ for } b_K = 0.$$

i.e.. $S_2(t) = -\sqrt{2P_s}\cos(2\pi f_c t)$; for $b_K = 0$.

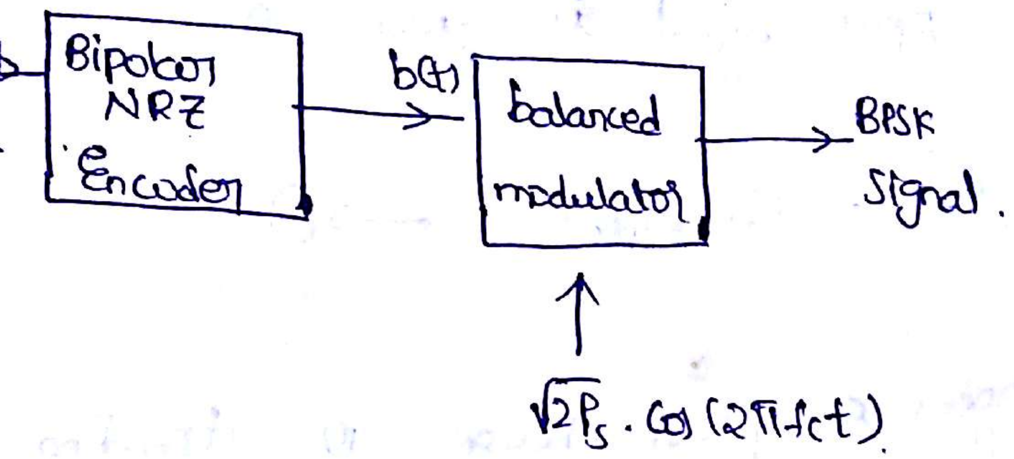
$$\Rightarrow S(t) = b(t) \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t).$$

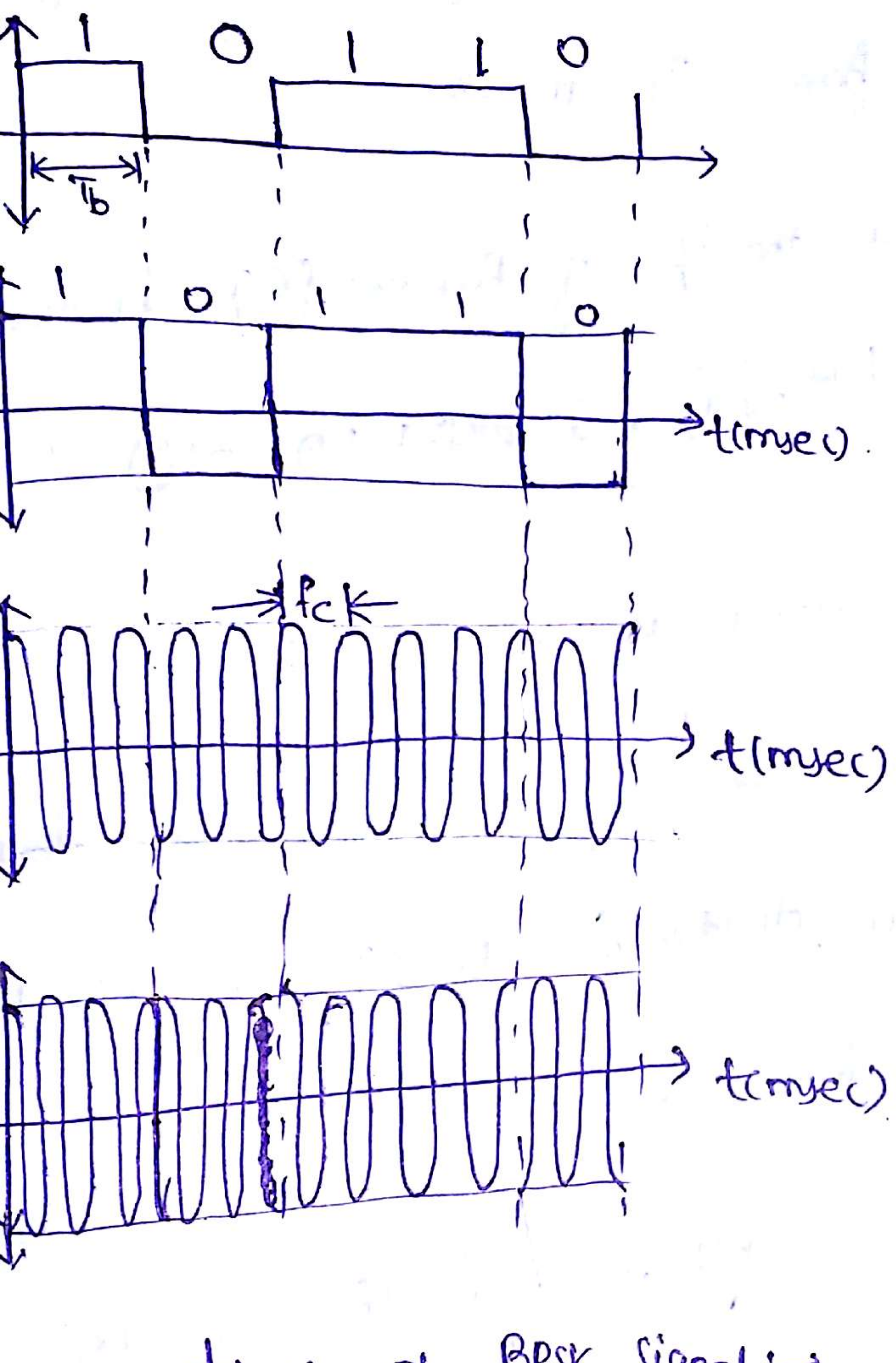
where $b(t) = \begin{cases} 1 \; ; & b_K = 1 \\ -1 \; ; & b_K = 0 \end{cases}$

* Generation of BPSK Signal:-

*The BPSK signal is generated by applying carrier signal & Bi-polar ~~NRZ~~ NRZ data sequence to the balanced modulator.

*Here, the bipolar signal "b(t)" is applied as a modulating signal to the balanced modulator.





rent detection of BPSK signal :→

* The transmitted BPSK signal is given as

$$S(t) = b(t) . \sqrt{2P_s} . \cos(2\pi f_c t) \longrightarrow ①$$

* This signal undergoes a phase change "θ" depending upon the time delay from Tr to Rr.

* ∴ The i/p signal at the i/p of Receiver {Rr} becomes

$$S(t) = b(t) . \sqrt{2P_s} . \cos(2\pi f_c t + \theta) \rightarrow ②$$

* The local reference carrier is retreeved from the received signal {Eq ②} by using a square law device & BPF & freq divider {% by 2}, the o/p the square law device is $S^2(t)$.

$$\Rightarrow S^2(t) = \underbrace{(b(t) . \sqrt{2P_s})^2}_{\text{neglect}} . \cos^2(2\pi f_c t + \theta)$$

{neglection is for math}

$$\Rightarrow S^2(t) = \frac{1 + \cos[2(2\pi f_c t + \theta)]}{2} = \underbrace{\frac{1}{2}}_{\text{remove by BPF}} + \frac{\cos[2(2\pi f_c t + \theta)]}{2}$$

* The o/p of BPF is

$$\Rightarrow \cos[2(2\pi f_c t + \theta)]$$

* The o/p of freq divider is $\cos(2\pi f_c t + \theta)$

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* The o/p of BPF has freq of $2f_c$, hence it should be passed through freq divider networks, which is of "÷2" type.

* The freq divider o/p signal becomes $\cos(2\pi f_c t + \theta)$

* The synchronous demodulator multiplies the i/p signal with recovered carrier.

* Hence, at the o/p of the multiplier, we get.

$$\Rightarrow b(t) \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t + \theta) \cdot \cos(2\pi f_c t + \theta).$$

$$\Rightarrow b(t) \sqrt{2P_s} \cdot \cos^2(2\pi f_c t + \theta)$$

$$\Rightarrow b(t) \sqrt{2P_s} \cdot \left[\frac{1 + \cos[2(2\pi f_c t + \theta)]}{2}\right]$$

$$\Rightarrow b(t) \sqrt{\frac{P_s}{2}} \left\{1 + \cos[2(2\pi f_c t + \theta)]\right\}$$

28/07/17

* This signal is applied to the integrator & Bit synchroniser.

* The bit sync takes care of starting & ending times of a bit.

* At the ~~bit~~ end of the bit duration T_B, the bit-synch closes switch "S_1" temporarily.

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* This connects the o/p of the integrator to the decision device

* Then synch opens switch "S_2" & "S_1" is closed temporarily.

* This results the integrator voltage to a zero value.

then the integrator integrates the next bit.

* let us assume one bit period "T_b". Contains integral number of cycles of carrier

* This means that phase change occurs in the carrier only at <u>zero crossings</u>

* The o/p of the integrator in the K^{th} bit interval is

$$\Rightarrow S_0(KT_b) = b(KT_b) \cdot \sqrt{\frac{P_s}{2}} \cdot \int_{(K-1)T_b}^{KT_b} [1 + \cos[2(2\pi f_c t + \theta)]] \cdot dt$$

$$\Rightarrow S_0(KT_b) = b(KT_b) \cdot \sqrt{\frac{P_s}{2}} \left\{ \int_{(K-1)T_b}^{KT_b} dt + \underbrace{\int_{(K-1)T_b}^{KT_b} \cos[2(2\pi f_c t + \theta)] \cdot dt}_{0} \right\}$$

$$\Rightarrow \boxed{S_0(KT_b) = b(KT_b) \cdot \sqrt{\frac{P_s}{2}} \, [T_b]}$$

i.e., $S_0(KT_b)$ ...

* This signal is applied to a decision making device which decides whether the received symbol is zero or 1.

* Constellation Diagram of BPSK :→

* Eq of BPSK ⇒ $S(t) = b(t) \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t)$

$$= b(t) \cdot \sqrt{P_s T_b} \sqrt{\frac{2}{T_b}} \cdot \cos(2\pi f_c t)$$

let $\phi_1(t) = \sqrt{\frac{2}{T_b}} \cdot \cos(2\pi f_c t)$

$$\Rightarrow \boxed{S(t) = b(t) \cdot \sqrt{P_s T_b} \cdot \phi_1(t)} \rightarrow (1)$$

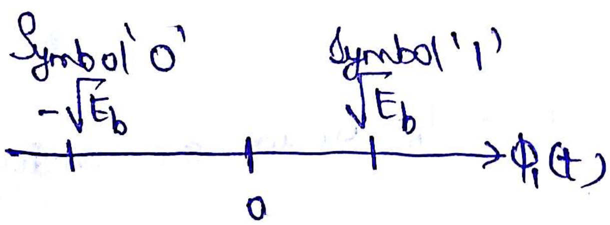
$$E_b = P_s \cdot T_b$$

$$\Rightarrow S(t) = b(t) \cdot \sqrt{E_b} \cdot \phi_1(t)$$

{b(t) can be ±1}

$$\Rightarrow S(t) = \pm\sqrt{E_b} \cdot \phi_1(t)$$

* Thus, on the single axis of $\phi_1(t)$, their will be two points. One point will be located at "$+\sqrt{E_b}$" & other point will be "$-\sqrt{E_b}$"



* Distance b/w two points is (d) $2\sqrt{E_b}$.

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* Spectrum of BPSK:

* b(t) is NRZ signal having rectangular pulses of $\pm V_b$, assume each pulse is $\pm \frac{T_b}{2}$ around its centre, then it becomes easy to find FT of such a pulse.

* The FT of this type of pulse is given as

$$X(f) = V_b T_b \frac{\sin(\pi f T_b)}{\pi f T_b} \longrightarrow (1)$$

* For a large number of such "+ve" & "-ve" pulses the power spectral density (PSD) is expressed as

$$S(f) = \frac{\left|\overline{X(f)}\right|^2}{T_s} \longrightarrow (2)$$

* Here $\overline{X(f)}$ is avg value of $X(f)$ to all the pulses in b(t)

T_s is symbol duration

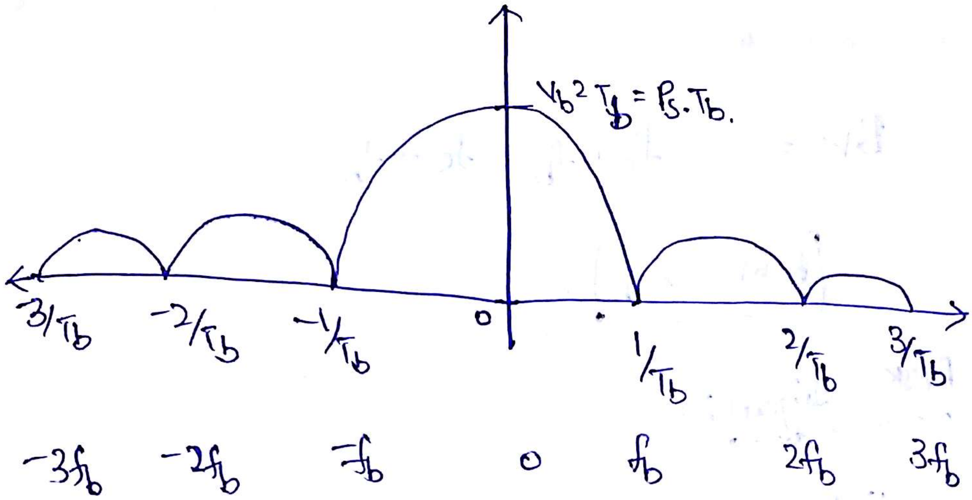
Note:-

* In BPSK $T_s = T_b$ as we are sending +1 or -1.

~~Per each bit~~

$$S(f) = \frac{V_b^2 \cancel{T_b^2} \left[\frac{\sin(\pi f T_b)}{(\pi f T_b)}\right]^2}{\cancel{T_b}}$$

$$\Rightarrow S(f) = V_b^2 T_b \left[\frac{\sin(\pi f T_b)}{\pi f T_b}\right]^2$$



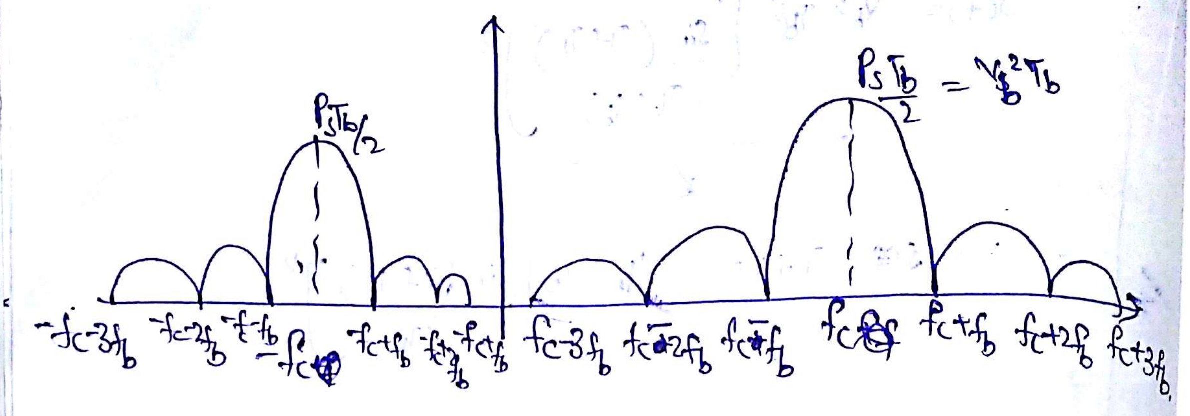
* P.S.D of b(t) signal :-

* The BPSK Signal is generated by modulating a Carrier by the bass band signal b(t).

* Due to the modulation of the Carrier freq "f_c" the Spectral components are translated from. f to $f_c + f$ & $f_c - f_m$.

* The magnitudes of these two components are divided by half

$$\therefore S_{BPSK}(f) = \frac{V_b^2 T_b}{2} \left\{\left(\frac{\sin[\pi(f_c - f)T_b]}{\pi(f_c - f)T_b}\right)^2 + \left(\frac{\sin(\pi(f_c + f)T_b)}{\pi(f_c + f)T_b}\right)^2\right\}$$



$$B.W = f_c + f_b - f_c + f_b$$

$$\boxed{B.W = 2f_b}$$

* B.W for BPSK signal :-

* if " $1/T_b = f_b$ " then the main lobe Extends from " $f_c - 1/T_b$ " to " $f_c + 1/T_b$ " & centered at " f_c "

* B.W of BPSK = $2f_b$.

* Hence, the min B.W of BPSK signal is 2 time of bit rate.

* Drawbacks of BPSK :-

* To generate the carrier in the receiver we start by squaring

03-08-17

$b(t) \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t + \theta)$

* if the received signal is $-b(t) \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t + \theta)$, then the square signal remains the same as before..

* Hence, the received carrier is unchanged even if the i/p signal has changed its sign.

  ∴ it is not possible to determine the received signal is equal to $b(t)$, or $-b(t)$.

  this results in ambiguity in the o/p signal

* This problem can be eliminated by using differential Phase Shift Keying (DPSK)

* Other problems of BPSK are ISI & Inter Channel Interferance.

* But these can be minimised by appropriate design of Band pass filters in the receiver.

*3. Coherent BFSK :-

* In BFSK the frequency of the carrier is shifted according to the binary symbol.

* However, the phase of the carrier is unaffected

* If $b(t) = 1$ then $S_1(t) = \sqrt{2P_s} \cdot \cos[(2\pi f_c + \Omega)t]$.

* If $b(t) = 0$ then $S_2(t) = \sqrt{2P_s} \cdot \cos[(2\pi f_c - \Omega)t]$

* where "Ω" is freq shift

* The following conversion table is used to combine the above two FSK equations.

Tabel 1 : Conversion tabel of BFSK.

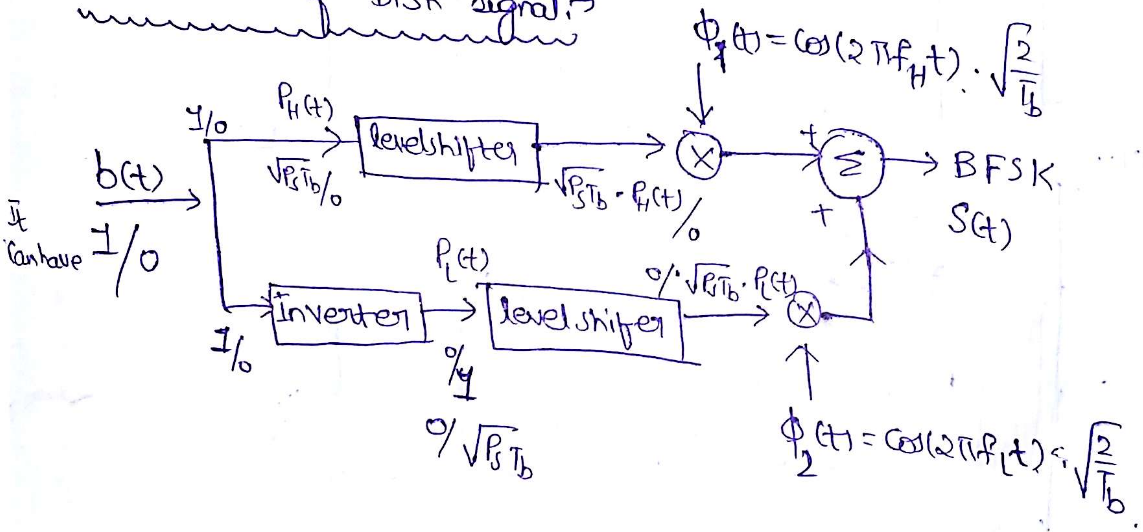
$b(t)$	$d(t)$	$P_H(t)$	$P_L(t)$
1V	+1V	+1V	0V
0V	-1V	0	+1V.

* The mark frequency (f_M or f_H) is used for transmission of symbol "1" & space frequency (f_S or f_L) is used for transmission of symbol "0" & are given by

* f_M or $f_H = f_c + \frac{\Omega}{2\pi}$

* f_S or $f_L = f_c - \frac{\Omega}{2\pi}$

* **Generation of BFSK signal:→**



* The o/p of the level shifter will be either $\sqrt{P_S T_b}$ (if $b(t) = 1$) or 0 (if $b(t) = 0$).

* $\phi_1(t)$ & $\phi_2(t)$ are orthogonal signal & are applied to a product modulator.

* In one bit period "T_b", $\phi_1(t)$ or $\phi_2(t)$ have integral no. of cycles.

* Thus, the modulated signal is having Continous phase.

* O/p's from both the multipliers are not possible at a time.

Since, $P_H(t)$ & $P_L(t)$ are Complementary to Eachother.

$\therefore$ If $P_H(t) = 1$ then o/p will be only due to upper Product modulator (P.M) & then lower P.M o/p will be 0

* Since, $P_L(t) = 0$.

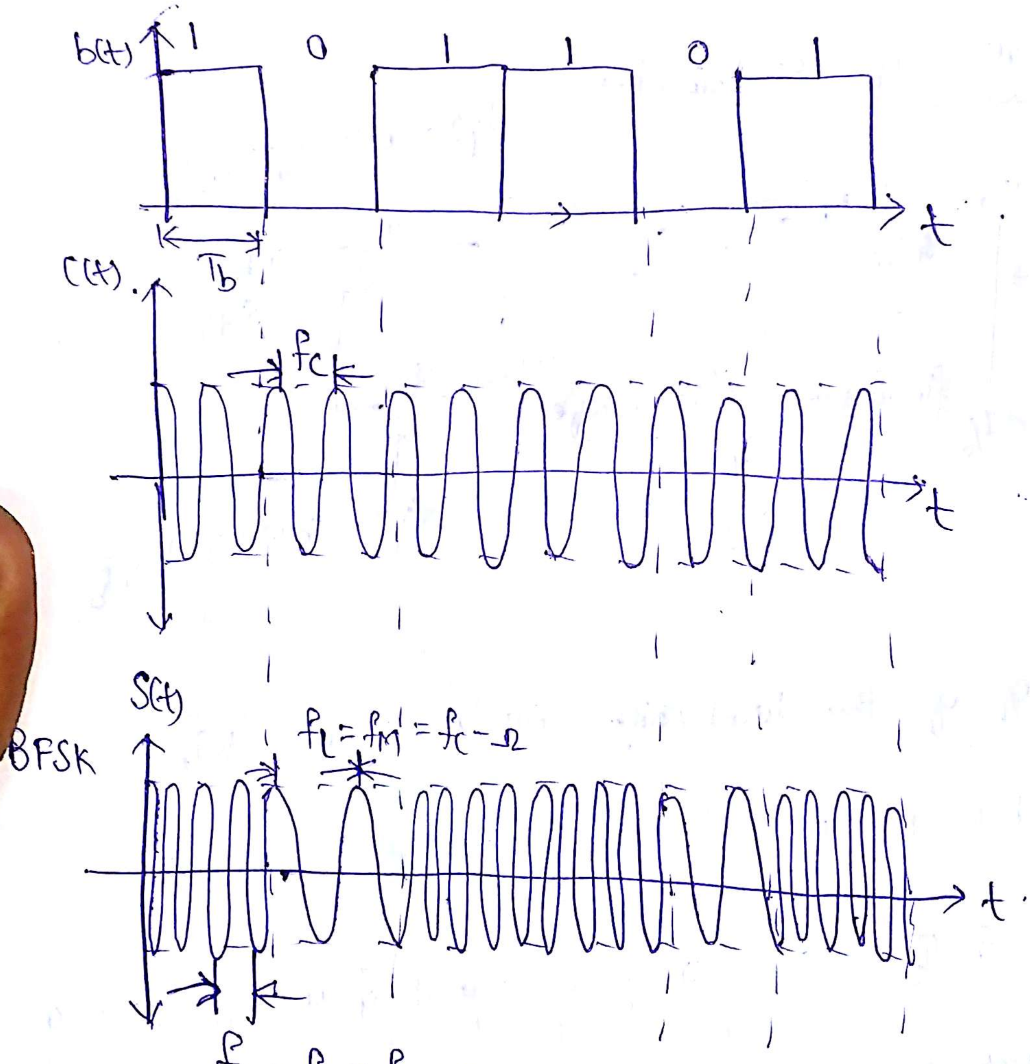


Fig. BFSK WAVEFORMS

* Spectrum of BFSK *

* From the Block diagram of BFSK, S(t) may be written as

$$S(t) = \sqrt{2P_s} \cdot P_H(t) \cdot \cos(2\pi f_H t)$$

$$\cancel{S(t)} = + \sqrt{2P_s} \cdot P_L(t) \cdot \cos(2\pi f_L t) \rightarrow (1)$$

* Now, Consider the Eq of BPSK

$$\underset{BPSK}{S(t)} = \underset{\text{Bipolar}}{b(t)} \cdot \sqrt{2P_s} \cdot \cos(2\pi f_c t)$$

Consider $P_H(t) = \frac{1}{2} + \frac{P_H'(t)}{2}$; $P_L(t) = \frac{1}{2} + \frac{P_L'(t)}{2}$ $\rightarrow (2)$

* from (1), (2) we get

$$\Rightarrow S(t) = \sqrt{2P_s}\left[\left(\frac{1}{2} + \frac{P_H'(t)}{2}\right)\cos(2\pi f_H t) + \left(\frac{1}{2} + \frac{P_L'(t)}{2}\right)\cos(2\pi f_L t)\right]$$

$$\Rightarrow S(t) = \sqrt{2P_s}\left[\underset{\downarrow}{\cdot} + \frac{P_H'(t)}{2}\cos(2\pi f_H t) + \frac{P_L'(t)}{2}\cdot\cos(2\pi f_L t)\right]$$

$$\frac{\cos(2\pi f_H t) + \cos(2\pi f_L t)}{2}$$

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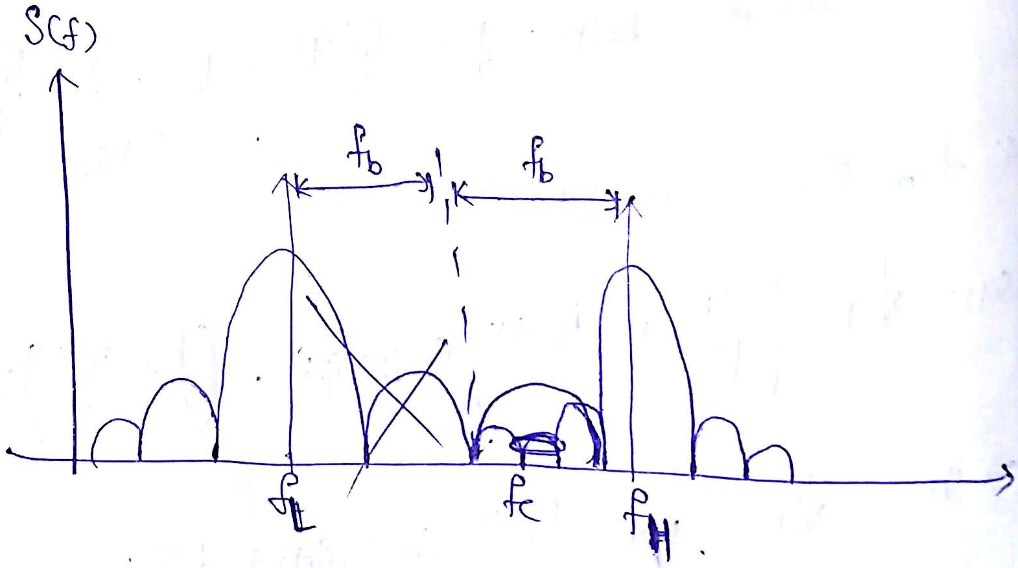
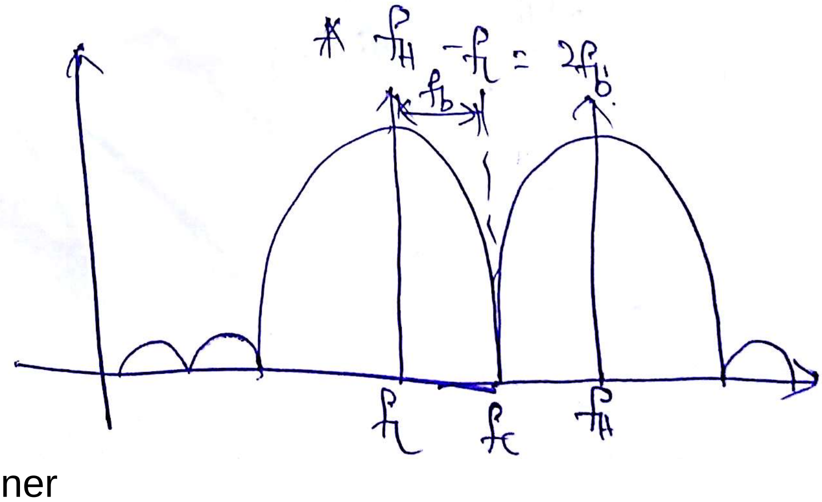
$$S(t) = \sqrt{\frac{P_S}{2}}\cos(2\pi f_H t) + \sqrt{\frac{P_S}{2}}\cdot\cos(2\pi f_L t) + \sqrt{\frac{P_S}{2}}\cdot P_H'(t)\cdot\cos(2\pi f_H t)$$
$$+ \sqrt{\frac{P_S}{2}}\cdot P_L'(t)\cdot\cos(2\pi f_L t).$$

$$S(f) = \sqrt{\frac{P_S}{2}}\left[\delta(f - f_H) + \delta(f + f_L)\right]$$
$$+ \frac{P_S T_b}{2}\left\{\frac{\sin(\pi f_H T_b)}{\pi f_H T_b}\right\}^2 + \frac{P_S T_b}{2}\left\{\frac{\sin(\pi f_L T_b)}{\pi f_L T_b}\right\}^2 \quad (3)$$



$*$ $f_H - f_L = 2f_b$



*B.

* B.W of BFSK Signal:-

* from the PSD of BFSK signal.

* Width of one lobe is $2f_b$; the two main lobes f_H & f_L are placed such that the total width due to both main lobes is 4 times of f_b.

i.e.. $BW_{BFSK} = 2f_b + 2f_b = 4f_b$.

$$\Rightarrow \boxed{B.W = 4f_b}$$

* W.K.T the transmission B.W required for $BPSK = 2f_b$.

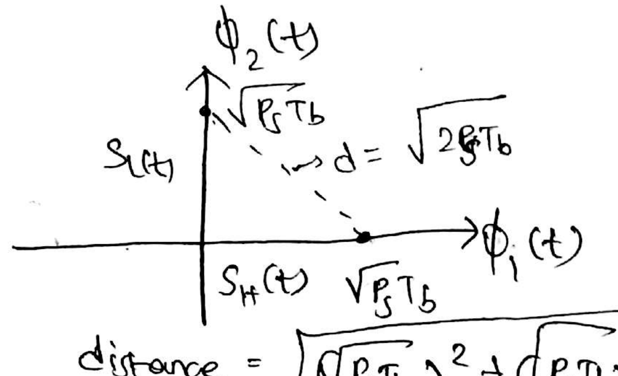
$$\boxed{B.W_{BFSK} = 2\, BW_{BPSK}}$$

* From the block diagram of BFSK generation

$$S_H(t) = \sqrt{P_s T_b} \cdot \sqrt{\frac{2}{T_b}} \cdot \cos(2\pi f_H t) = \sqrt{P_s T_b}\ \phi_1(t)$$

$$S_L(t) = \sqrt{P_s T_b} \sqrt{\frac{2}{T_b}} \cos(2\pi f_L t) = \sqrt{P_s T_b}\ \phi_2(t)$$

$$f_M = f_H = f_c + \frac{\Omega}{2\pi} \ ; \quad f_S = f_L = f_c - \frac{\Omega}{2\pi}$$



$$\text{distance} = \sqrt{(\sqrt{P_s T_b})^2 + (\sqrt{P_s T_b})^2} = \sqrt{2 P_s T_b}$$

$$\Rightarrow d_{BFSK} = \sqrt{2E_b} \quad \{E_b = P_s T_b \Rightarrow \text{bit Energy}\}$$

* W.K.T

$$d_{BPSK} = 2\sqrt{E_b}$$

$$\Rightarrow \boxed{d_{BFSK} < d_{BPSK}}$$

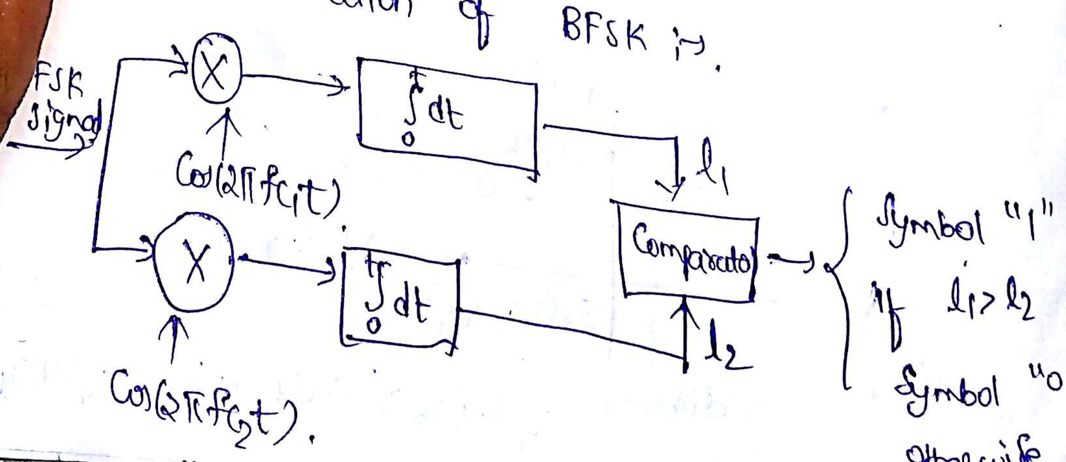
* Advantages & Disadvantages of BFSK :->

→ * Even though the generation of BFSK is Easier but it has disadvantages Compared to BPSK.

→ * BFSK B.W is $4f_b$ which is twice the B.W of BPSK.

→ * The distance "d" b/w the signal point is less for BFSK than BPSK. hence, probability of Error $\{P_e\}$ or BER (Bit Error rate) of BFSK is more than BER or P_e of BPSK.

* Coherent detection of BFSK :->



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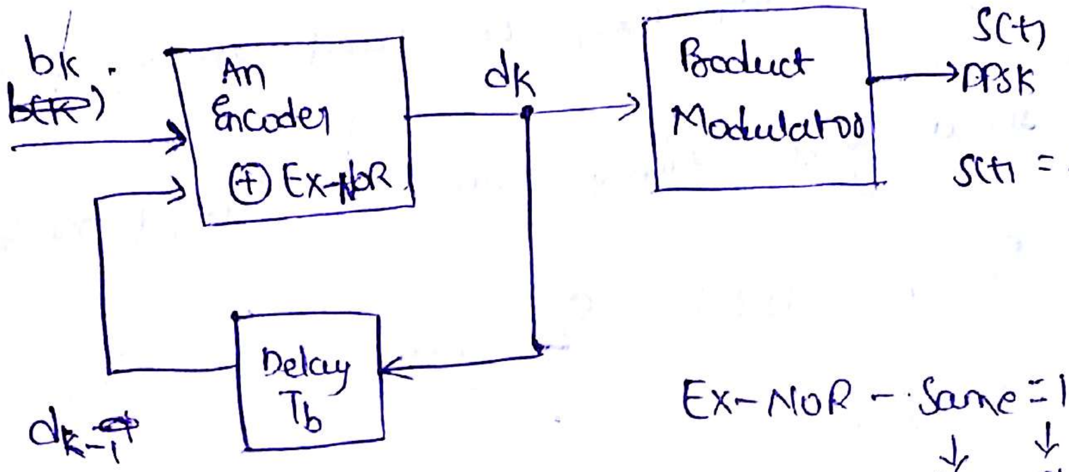
* Non-Coherent BPSK : Differential PSK (DPSK)

Generation of DPSK.



$s(t) = \pm A_c \cos(2\pi f_c t)$

EX-NOR - Same = 1 ; different = 0
i/p's o/p i/p's o/p

Generation of DPSK.

1	Binary data {bk}		0	0	1	0	0	1	0	0	1	1
2	Differentially Encoded data {dk}	1*	0	1	1	0	1	1	0	1	1	1
3	Phase of DPSK	0	π	0	0 π	π	0	0	π	0	0	0

* In order to Eliminate the need for phase synchronization of Coherent receiver of "PSK", a differential Encoding System can be used with PSK.

* The Binary data is Encoded in terms of signal transitions

Ex :-

* Symbol Zero may be used to represent transition in a given binary sequence (w.r.t previous Encoded bit) & symbol 1 to indicate no transition.

* This new signalling technique which combines differential Encoding with PSK is known as DPSK.

* A Schematic arrangment for generation DPSK is shown in figure above.

* The binary sequence b_K is applied to Ex-Nor Encoder, the o/p of the Encoder is applied to a Product modulator

* The other i/p of the Product modulator is a sinusoidal Carrier of fixed amplitude (Ac) & freq (fc).

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* The relation between the binary sequence & differentially Encoded version is given in above table for an assumed data sequence of "0010010011"

* assume that Encoding is done in such as way that transission in the binary sequence w.r.t previous Encoded bit is represented by a symbol "0" & no transission by symbol "1".

* It may be noted that an Extra bit (symbol 1) has been arbitrarally chosen as an initial bit.

* The phase of the generated DPSK signal is shown in 3rd row of the tabel above.

* Detection of DPSK :-

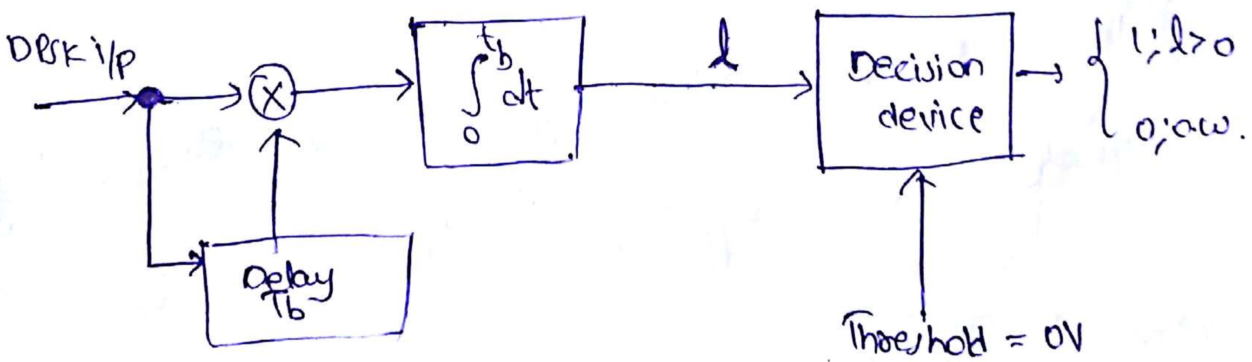


fig. Receiver for detection of DPSK

A binary data stream "0010010011" needs to be transmitted by using DPSK technique. Proove that the reconstruction of the DPSK signal is independant of the choice of the reference bit {0 or 1}

*Sol)

Binary data (b_k)		0	0	1	0	0	1	0	0	1	1
Differentially Encoded (d_k) b_k	0	1	0	0	1	0	0	1	0	0	0
Phase of DPSK	π	0	π	π	0	π	π	0	π	π	π
Shifted (b_k)		0	1	0	0	1	0	0	1	0	0
Shifted (d_k)		π	0	π	π	0	π	π	0	π	π
Phase of Comparision		−	−	+	−	−	+	−	−	+	+
Detected (b_k)		0	0	1	0	0	1	0	0	1	1

10/08/17

* The received DPSK signal & its delayed signal by "T_b" are applied to the multiplier

* The delayed received signal is shown in 4^{th} row of the tabel.

* Assume that the channel Noise is absent in the propagation Channel

* The o/p of the difference is proportional to $\cos\phi$ where, "ϕ" is the difference b/w carrier phase angle of the received & delayed DPSK signals measured in the same bit interval.

* The phase angle of the DPSK signal its delayed version is shown in 3rd & 5th rows respectively.

* The phase difference b/w the two sequences for each bit interval is used to determine the sign of the phase comparator output.

* When "$\phi = 0$" the integrator o/p is "+ve" & when "$\phi = \pi$ radians" the integrator o/p is "-ve"

* By comparing the integrator o/p with a decision - level of zero volts, the decision device can reconstruct the binary sequence by assume a symbol zero for -ve integrator o/p & symbol 1 for +ve o/p.

* The reconstructed binary data is shown in the last Row (7th row) of the tabel.

* Thus, in the absence of channel noise, the receiver Can reconstruct the transmitted binary data Exactly.

*Note:-
* The reconstruction is invarient with choice of the initial reference bit "(0 or 1)" in the Encoded data.

* Transmission B.W of DPSK *

* The Previous bit is used to decide the phase Shift of the next bit

∴ the symbol can said to have 2 bits

~~the~~* Hence, One symbol duration "T_s" is Equivalent to 2 bits duration "T_b"

$$\Rightarrow T_s = 2T_b.$$

* The transmission B.W is Expressed as

$$T_x \, BW = \frac{2}{T_s} = \frac{2}{2T_b} = \frac{1}{T_b} = f_b = r_b$$

$$\Rightarrow BW_{DPSK} = f_b \text{ or } r_b.$$

$$T_x \, BW_{BPSK} = 2f_b$$

$$\Rightarrow \boxed{BW_{DPSK} = \frac{1}{2}(BW_{BPSK})}$$

*Hence, the min B.W of DPSK signal is Equal to f_b or r_b {Bit Rate}, the max Base band signal frequency.

* Advantages of DPSK :-

*1. DPSK doesn't need Carrier at the receiver End.

*2. This means, that, complicated circuitry for receiving local carrier reference is not required as in case of BPSK.

*2. Transmission B.W of DPSK is reduced {f_b} Compared to BPSK {$2f_b$}

~~*3. also~~

* Disadvantages of BPSK :-

*1 The "BER" or "P_e" of DPSK is higher than that of BPSK. Because, DPSK uses two successive bits for its reception, Error in the first bit creates Error in the second bit also.. i.e.. Error propagation is more in DPSK. But in BPSK detection of each bit is independant. Hence, P_e (in BPSK) is less.

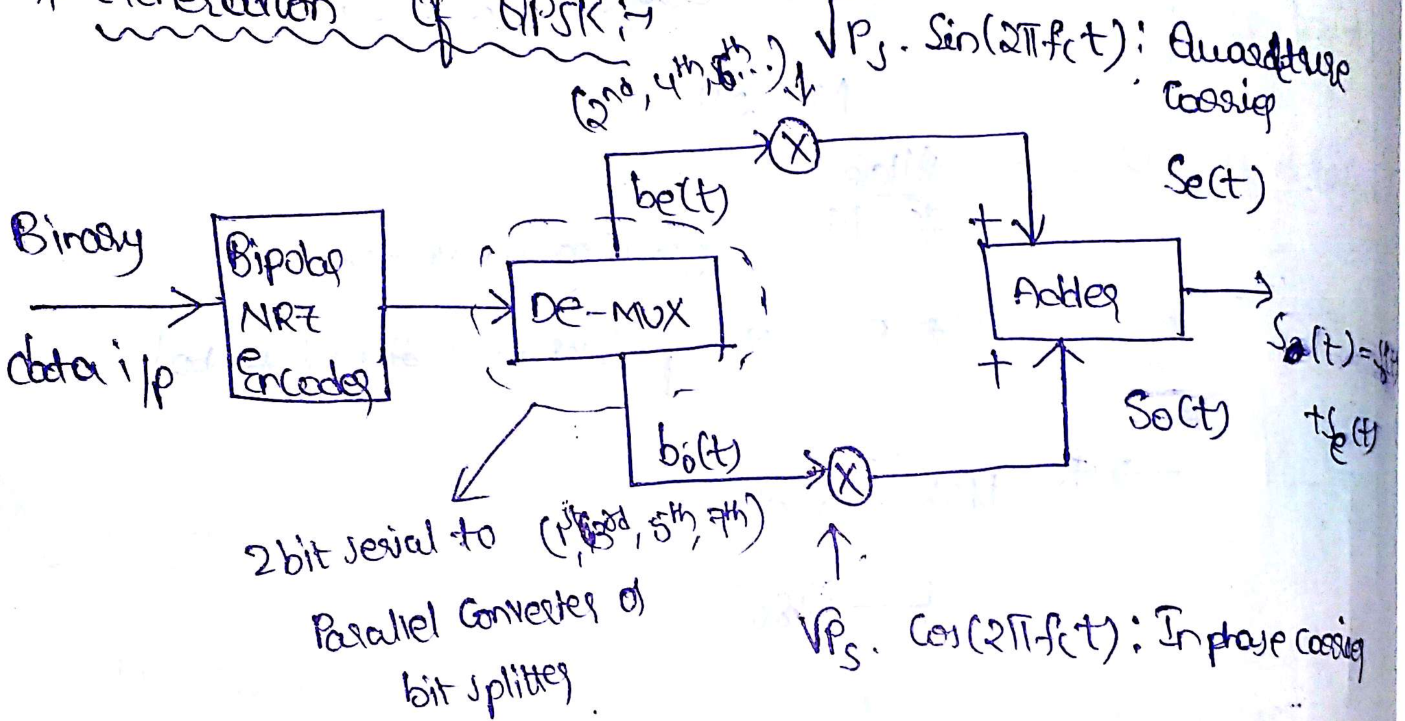
*2. Noise interference is more in DPSK.

* DIFFERENTIALLY ENCODED PHASE SHIFT KEYING :- (DEPSK)

* In DEPSK the ...

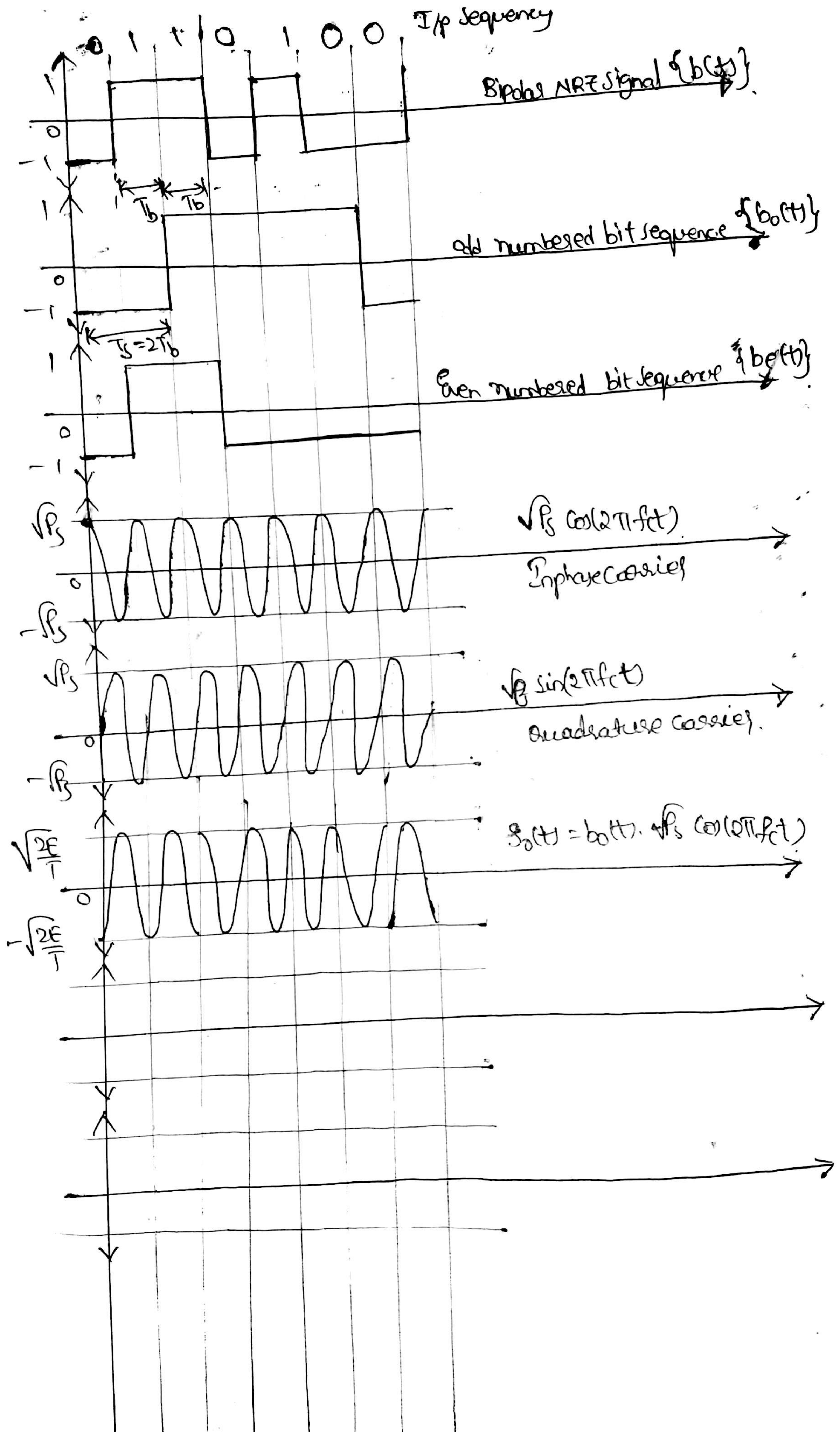
* Their are four symbols & the phase is shifted by $\frac{2\pi}{4} = \pi/2 = 90°$ for Each symbol.

* Generation of QPSK :-



* $S_e(t) = b_e(t) \cdot \sqrt{P_s} \cdot \sin(2\pi f_c t)$

* $S_o(t) = b_o(t) \sqrt{P_s} \cos(2\pi f_c t)$



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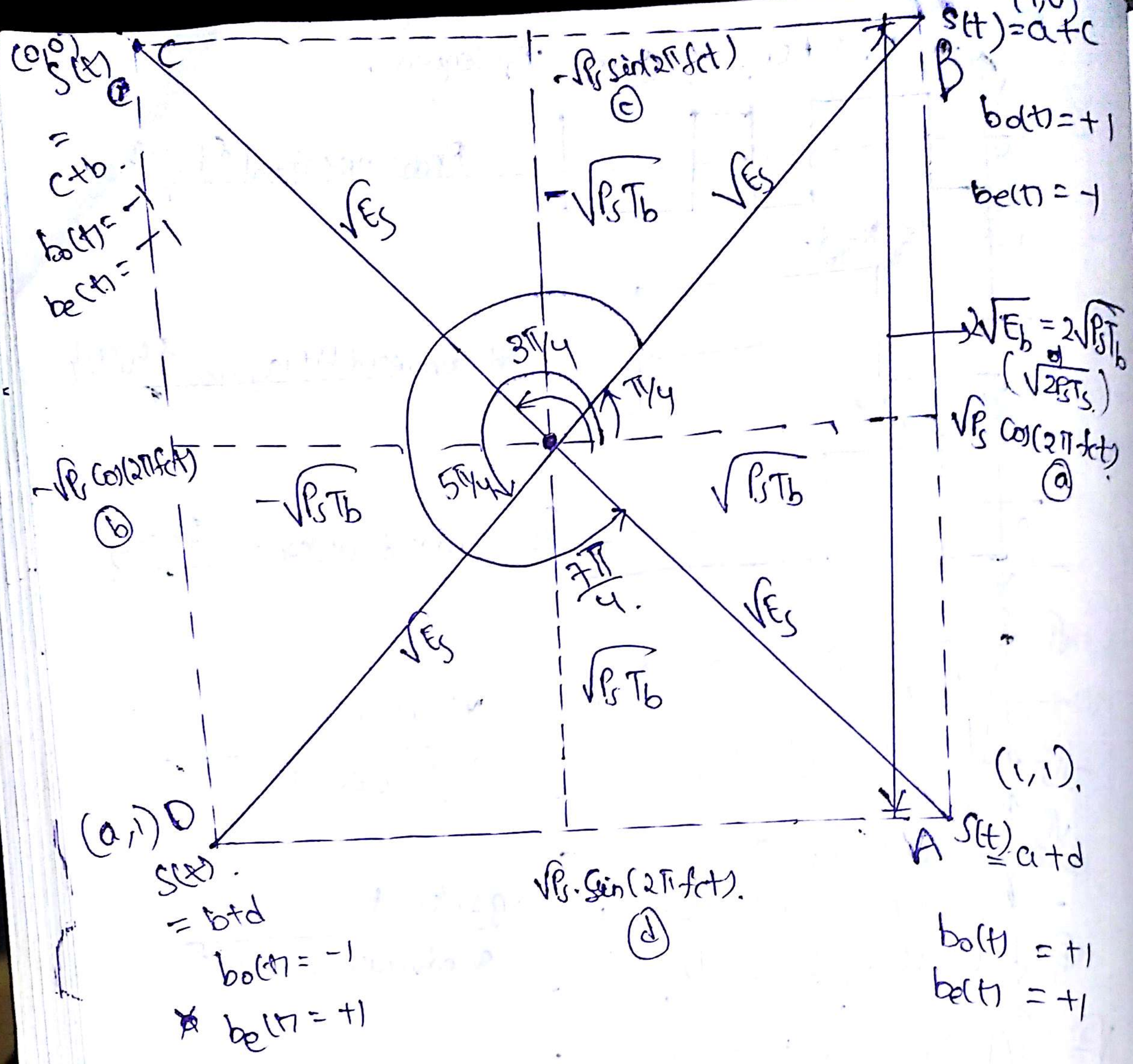

* Depending upon the Combination of 2 Successive bits the phase shift of the carrier changes.

This means that QPSK signal may be represented as

$$S(t) = \sqrt{2P_s}\cdot\cos\left[2\pi f_c t + 2(m+1)\cdot\pi/4\right]$$ where $m = 0,1,2,3.$

$$\Rightarrow S(t) = \sqrt{2P_s}\cdot\cos(2\pi f_c t)\cdot\cos\left[(2m+1)\pi/4\right]$$

$$-\sqrt{2P_s}\cdot\sin(2\pi f_c t)\cdot\sin\left[(2m+1)\cdot\pi/4\right]$$

$$\Rightarrow S(t) = \left\{\sqrt{P_sT_s}\cos\left[(2m+1).\pi/4\right]\right\}\left(\underbrace{\sqrt{\frac{2}{T_s}}\cdot\cos(2\pi f_c t)}_{\phi_1(t)}\right)$$

$$- \left\{\sqrt{P_sT_s}\sin\left[(2m+1).\pi/4\right]\right\}\left(\underbrace{\sqrt{\frac{2}{T_s}}\cdot\sin(2\pi f_c t)}_{\phi_2(t)}\right).$$

$\phi_1(t)$, $\phi_2(t)$ are orthogonal carriers.

~~$\Rightarrow S(t) =$~~

* let $b_o(t) = \sqrt{2}\cos\left[(2m+1).\pi/4\right]$

$b_e(t) = \sqrt{2}.\sin\left[(2m+1)\pi/4\right]$

$$\Rightarrow \boxed{S(t) = \sqrt{\frac{P_sT_s}{2}}\left(b_o(t).\phi_1(t) - b_e(t).\phi_2(t)\right)}$$

$T_s = 2T_b \Rightarrow T_b = \frac{T_s}{2}.$

$\therefore S(t) = \sqrt{P_sT_b}.b_o(t).\phi_1(t) - \sqrt{P_sT_b}\,b_e(t).\phi_2(t).$

$P_sT_b = E_b$ i.e.. Bit Energy.

$$\Rightarrow \boxed{S(t) = \sqrt{E_b}\left[b_o(t).\phi_1(t) - b_e(t).\phi_2(t)\right]}$$

* from Each signal point we obtaine two bits.

Ex:- at point "A" (1, 1); Pt "B" (+1, 0)

* The distance any pt from the origin"o" is given as

* distance $OB = \sqrt{\left(\sqrt{P_sT_b}\right)^2 + \left(\sqrt{P_sT_b}\right)^2}$

$OB = \sqrt{2P_sT_b}.$ $\left\{T_b = \frac{T_s}{2}\right\}$

$OB = \sqrt{P_sT_s}.$

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$P_s T_s = E_s \Rightarrow$ Symbol Energy.

$$\Rightarrow \quad OB = \sqrt{E_s} = \sqrt{P_s T_s}$$

* Hence, the length of each signal pt from to origin is "$\sqrt{E_s}$"

* Distance b/w the signal points.

* The ability to determine a bit without error is measured by the distance between two nearest possible signal points in the signal space

* This distance b...

* The distance represents noise immunity of the system. It shows that noise immunities of BPSK & QPSK are same.

i.e.. P_e or BER are also same.

* Spectrum of QPSK signal :-

* The i/p signal b(t) is of duration "T_b" (bit duration) & it is a NRZ Bipolar signal

* The PSD of such signal is given as

$$S(f) = V_b^2 \cdot T_b \cdot \left[\frac{\sin(\pi f T_b)}{\pi f T_b} \right]^2$$

$$S(f) = P_S \cdot T_b \left[\frac{\sin(\pi f T_b)}{\pi f T_b} \right]^2 \quad \text{at } R = 1\Omega$$

* b(t) signal is divided into $b_e(t)$ & $b_o(t)$ with period of "$T_s = 2T_b$"

* If we assume symbol 1 & 0 are Equi Probable then PSD's of $b_e(t)$ & $b_o(t)$ are given by.

$$S_e(f) = P_s T_s \left[\frac{\sin(\pi f T_s)}{\pi f T_s} \right]^2$$

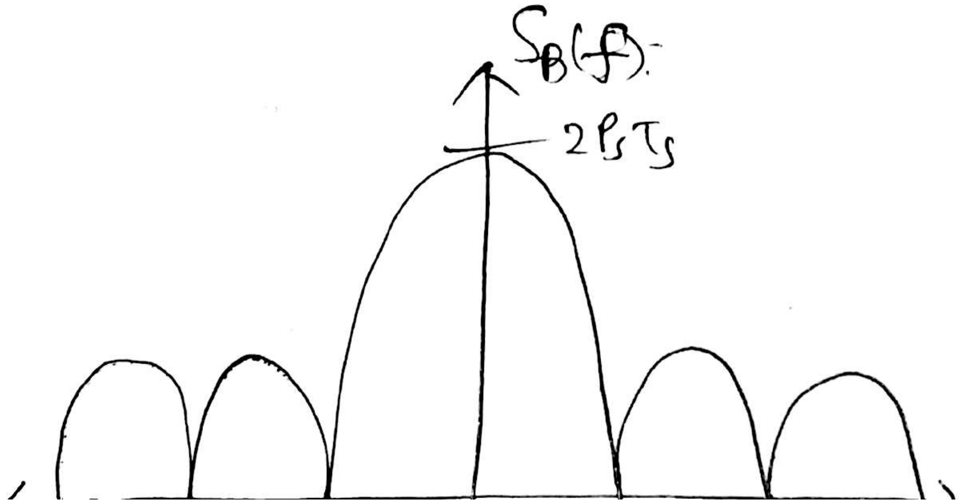
$$S_o(f) = P_s T_s \left[\frac{\sin(\pi f T_s)}{\pi f T_s} \right]^2.$$

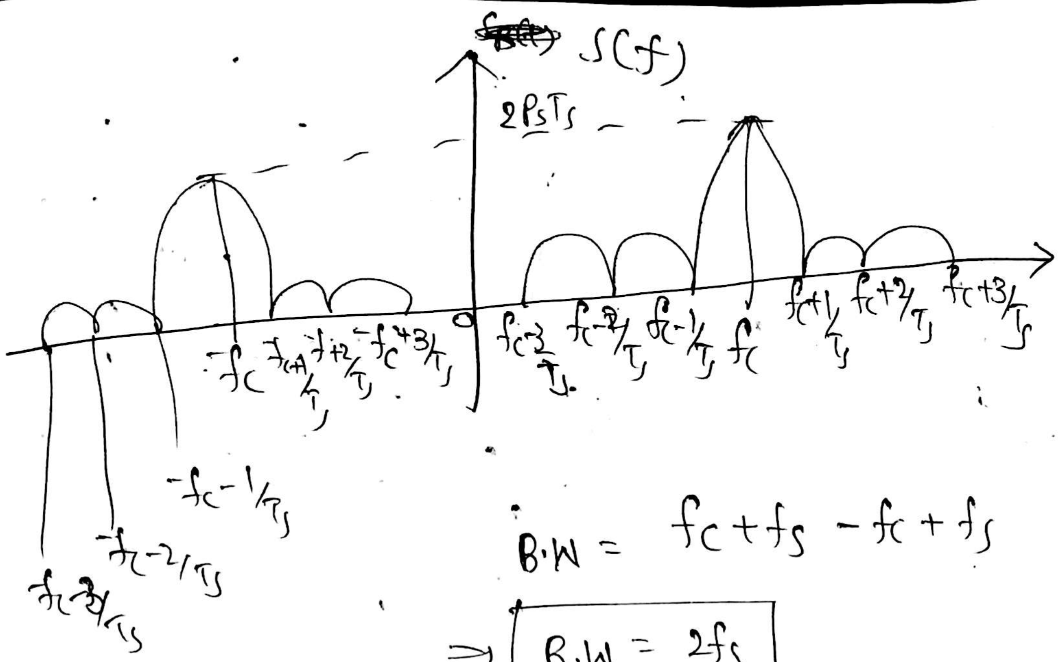
* Because, Inphase & Quadrature Components are statistically independant the base band ~~PSD~~ PSD of b(t) signal Equals the sum of the individual PSD's of $b_e(t)$ & $b_o(t)$

i.e. $S_B(f) = S_e(f) + S_o(f)$

$$\Rightarrow S_B(f) = 2P_sT_s\left[\frac{\sin(\pi f T_s)}{\pi f T_s}\right]^2$$

PSD of Bipolar NRZ Signal i.e. b(t)





$$B.W = f_c + f_s - f_c + f_s$$

$$\Rightarrow \boxed{B.W = 2f_s}$$

$$\Rightarrow B.W = \frac{2}{T_s} = \frac{2}{2T_b} = 1/T_b.$$

$$\Rightarrow \boxed{B.W = f_b}$$

$$B.W_{QPSK} = f_b = r_b.$$

w.k.T. $\boxed{B_{BPSK} = 2f_b = 2r_b}$

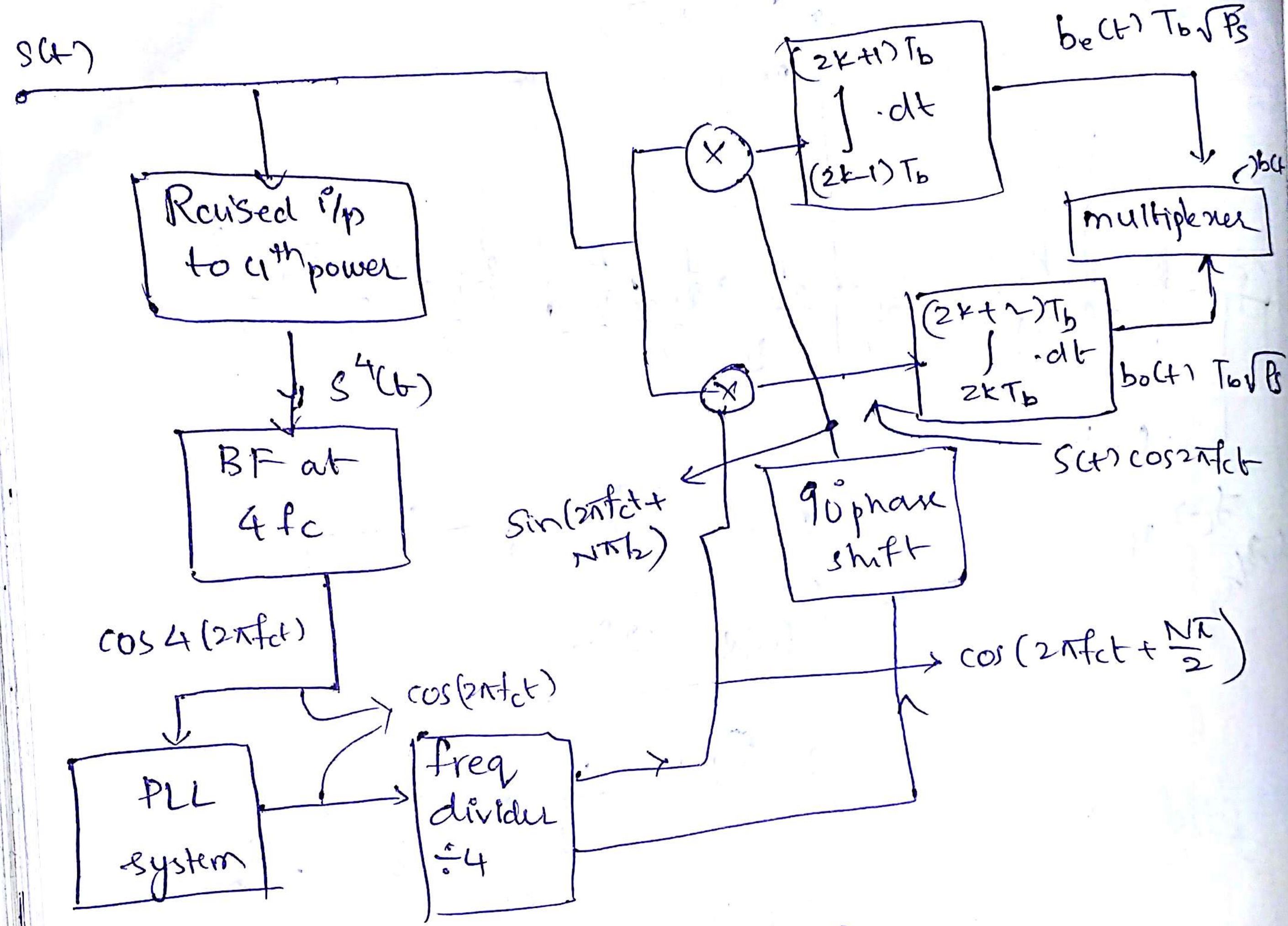
*Hence, the transmission B.W of QPSK is ½ of the tx B.W of BPSK.

$$\cancel{B_{QPSK} = \tfrac{1}{2} B_{BPSK}}$$

$$\boxed{B.W_{QPSK} = \frac{1}{2} B.W_{BPSK}}$$

Similarly $B.W_{8PSK} = \frac{1}{3} BW_{BPSK}$.

$$B.W_{16PSK} = \frac{1}{4} B.W_{BPSK}.$$



QPSK synchronous detection

* 12/08/17 *

* Quadrature amplitude shift keying {QASK}

or

* Quadrature amplitude Modulation {QAM}