Table ① is generated by assuming the initial bit as '0'. Table ② is generated by assuming ... Then DPSK W/F is complement of ... with initial bit as '1'

Fig ① Depicts DPSK Tx. Differentially encoded is generated using logical expression $d_K = b_K \oplus d_{K-1}$. In the above expression d_{K-1} is the previous value of the differentially encoded digit. To generate d_{K-1} a single delay element is interconnected as shown in the fig ①. The sequence d_K is amplitude level shifted and is then used to modulate a carrier of freq 'fc'. There by DPSK W/F is generated.

Demodulation is done using B.D. shown in fig ②. DPSK wave & Delayed DPSK wave is applied to the multiplier. The o/p of multiplier is integrated every bit interval and the o/p is sampled and is compared with $V_{th} = 0$. If the o/p of integrator is −ve the decision is taken in favour of symbol '0'. If the o/p of integrator is +ve, the decision is taken in favour of symbol '1'.

Quadrature Phase Shift Keying

→ In QPSK system information is carried by four phase of the sinusoidal carrier. The phases maintained as $\pi/4$, $\frac{3\pi}{4}$, $\frac{5\pi}{4}$ & $\frac{7\pi}{4}$.

→ These phase values are equally spaced betn the interval 0 to 2π.

→ A QPSK signal can be represented in time domain as

$$S_i(t) = \begin{cases} \sqrt{\frac{2E}{T}} \cos\left\{2\pi f_c t + (2i-1)\frac{\pi}{4}\right\} & 0 \le t \le T. \\ 0, & \text{else.} \end{cases} \quad —①$$

where $i = 1, 2, 3, 4$.

where 'E' energy per symbol of duration 'T'.

→ f_c is the carrier which is integer multiple of '$\frac{1}{T}$'

i.e. $f_c = \frac{n}{T}$, where 'n' is an integer.

→ Since there are four distinct phases, each phase can represent a pair of binary bits known as dibits.

Expanding eqⁿ ① using $\cos(A+B)$.

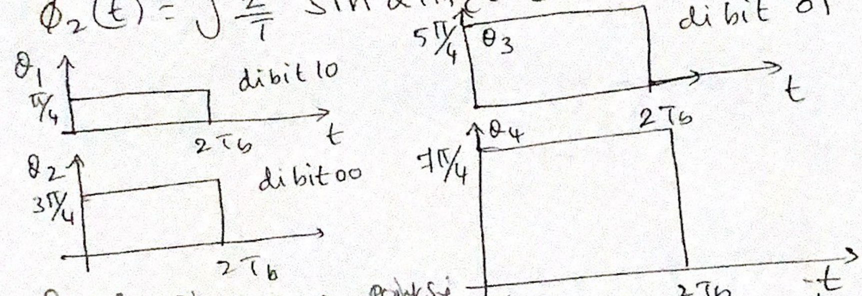
$$\therefore S_i(t) = \begin{cases} \sqrt{\frac{2E}{T}} \cos\left[(2i-1)\frac{\pi}{4}\right] \cos 2\pi f_c t - \sqrt{\frac{2E}{T}} \sin(2i-1)\frac{\pi}{4} \sin(2\pi f_c t) & 0 \le t \le T \\ 0 & \text{else} \end{cases}$$

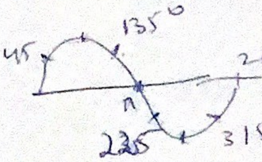
where $i = 1, 2, 3, 4$.

It is possible to represent the four signals $S_i(t)$, $i = 1, 2, 3, 4$, using two orthonormal basis functions $\phi_1(t)$ & $\phi_2(t)$ defined below

$$\phi_1(t) = \sqrt{\frac{2}{T}} \cos 2\pi f_c t \quad 0 \le t < T.$$

$$\phi_2(t) = \sqrt{\frac{2}{T}} \sin 2\pi f_c t \quad 0 \le t \le T.$$





Coordinate of message points S_i

$S_i = (\sqrt{E}\cos(2i-1)\pi/4)\,\phi_1(t)\ \sqrt{E}\sin(2i-1)\pi/4\ \phi_2(t)$

Variation of phase θ_i for different value of $i = 1, 2, 3, 4$.

$S_i(t) = \sqrt{E}\cos(2i-1)\pi/4 - \sqrt{E}\sin(2i-1)\pi/4$.

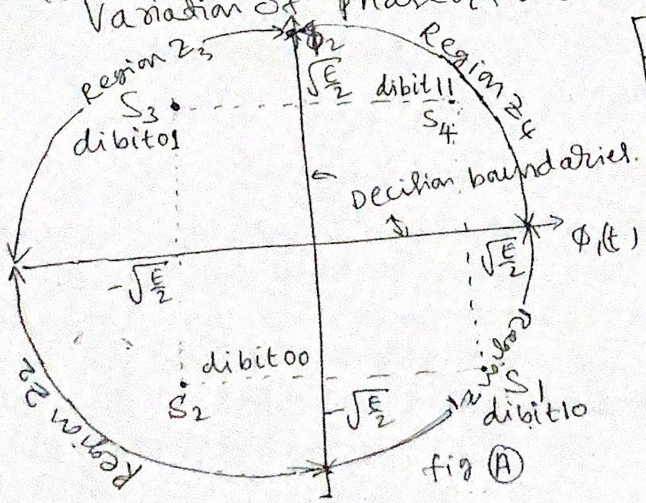


fig Ⓐ

i	$S_i(t)$	θ_i	S_{i1} ($\cos$)	S_{i2} ($\sin$)	Dibit $0 \le t \le T$
1	$S_1(t)$	$\pi/4$ (45)	$\sqrt{\frac{E}{2}}$	$-\sqrt{\frac{E}{2}}$	10
2	$S_2(t)$	$3\pi/4$ (135)	$-\sqrt{\frac{E}{2}}$	$-\sqrt{\frac{E}{2}}$	00
3	$S_3(t)$	$5\pi/4$ (225)	$-\sqrt{\frac{E}{2}}$	$\sqrt{\frac{E}{2}}$	01
4	$S_4(t)$	$7\pi/4$ (315)	$\sqrt{\frac{E}{2}}$	$\sqrt{\frac{E}{2}}$	11

$\cos\pi/4 = \frac{1}{\sqrt{2}}$ $\quad \cos 3\pi/4 = -\frac{1}{\sqrt{2}}$ $\quad \sin 5\pi/4 = -\frac{1}{\sqrt{2}}$

$\sin\pi/4 = +\frac{1}{\sqrt{2}}$ $\quad \sin 3\pi/4 = \frac{1}{\sqrt{2}}$ $\quad \cos 7\pi/4 = \frac{1}{\sqrt{2}}$

$\cos 5\pi/4 = -\frac{1}{\sqrt{2}}$ $\quad \sin 7\pi/4 = -\frac{1}{\sqrt{2}}$

For the signal space diagram shown there are four quadrants bounded by axes $\phi_1(t)$ & $\phi_2(t)$.

→ The decision region Z_i is the set of all points closest to the message point S_i, $i = 1, 2, 3, 4$.

Generation of QPSK signal

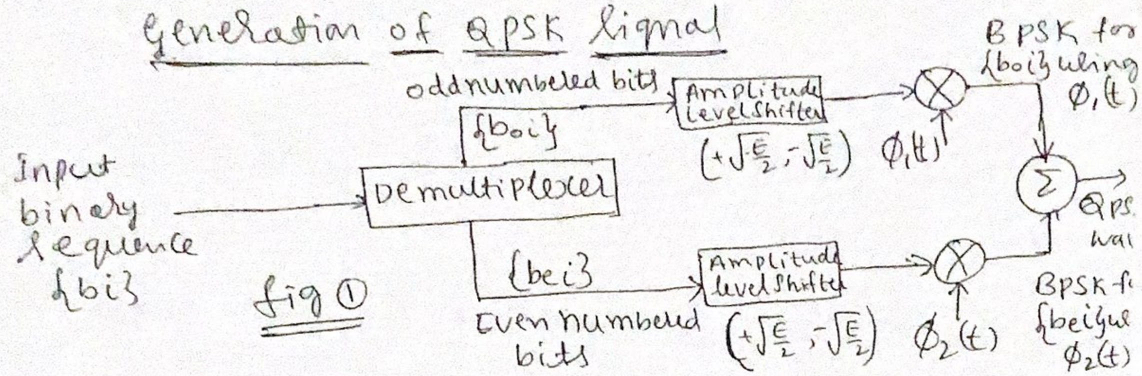


fig ①

Coherent QPSK Receiver

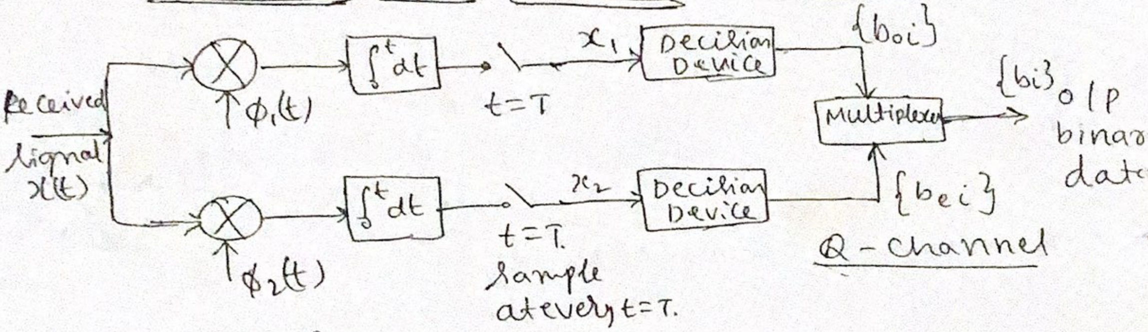


fig ②

→ QPSK generator is shown in the fig ①.

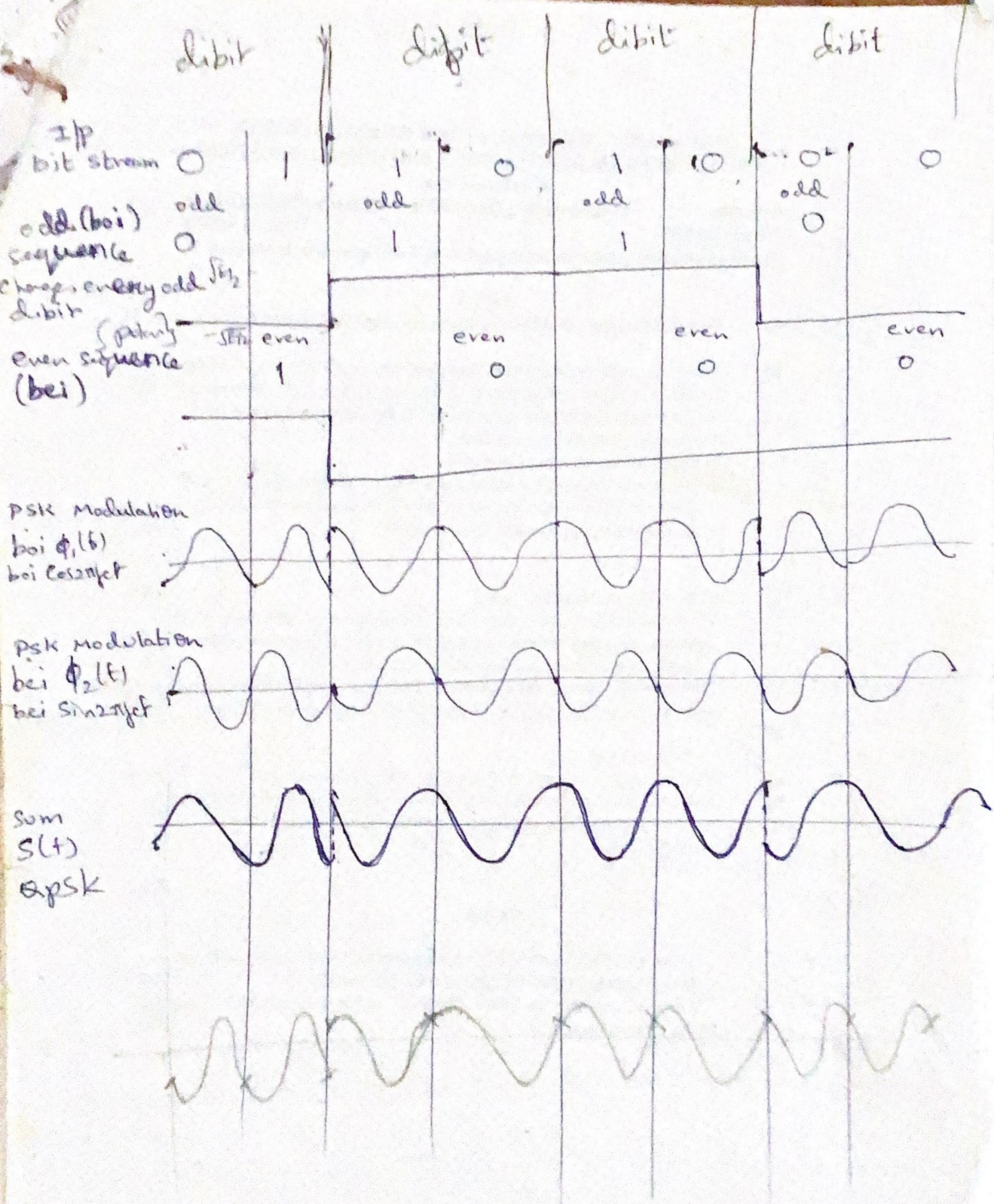
→ I/p data is divided into odd indexed sequence $\{b_{oi}\}$ & even indexed sequence $\{b_{ei}\}$ using demultiplexer ckt

→ If $\{b_i\} = \{b_0, b_1, b_2, b_3, b_4, b_5, b_6 - - -\}$

then $\{b_{oi}\} = \{b_1, b_3, b_5, - - \}$ & $\{b_{ei}\} = \{b_0, b_2, b_4 - -\}$

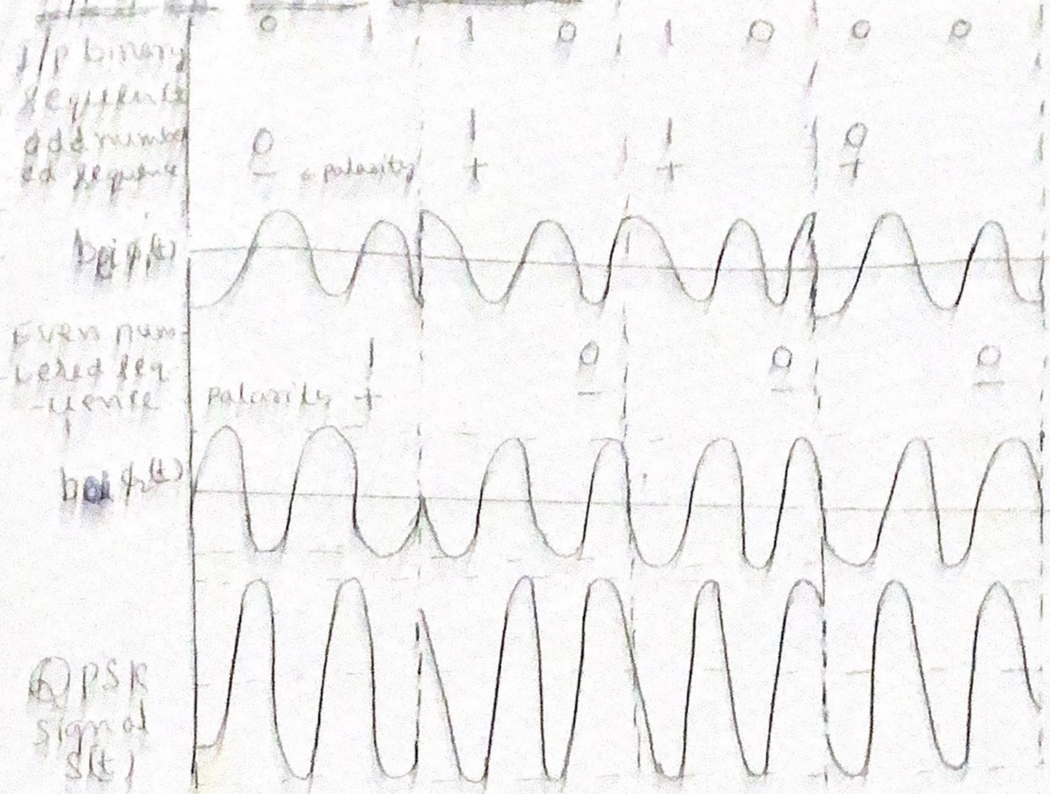
→ These two sequences phase modulate two carrier signal of same freq. but quadrature in phase

→ Since each symbol carries two bits the signalling rate decreases ∴ Bandwidth required is half the BW bandwidth required compared to BPSK or for a given bandwidth datarate of QPSK is double that of BPSK system



dibit
dibit
dibit
dibit
I/p bit stream
0 1 1 0 1 0 0 0
odd (boi) sequence
odd 0
odd 1
odd 1
odd 0
changes every odd dibit
√Eb/2
-√Eb/2
even sequence (bei)
even 1
even 0
even 0
even 0
PSK Modulation boi φ1(t) boi cos2πfct
PSK Modulation bei φ2(t) bei sin2πfct
Sum S(t) QPSK

W/F's of QPSK Generation



The scheme of coherent detection for QPSK signal is as shown in fig ②. It consists of a pair of correlators with locally generated coherent reference signals $\phi_1(t)$ & $\phi_2(t)$. Each correlator o/p is sampled at every $T = 2T_b$ seconds alternately to get x_1 & x_2. A decision is made by comparing x_1 & x_2 with a threshold of '0' volts. If $x_1 > 0$, decision is in favour of symbol '1' otherwise symbol '0'. Illy if $x_2 > 0$, decision is in favour of '1' otherwise symbol '0'. Inphase & quadrature channel o/ps are multiplexed to get an estimate of original binary sequence. Coherent detection scheme ensures min. prob. of error.