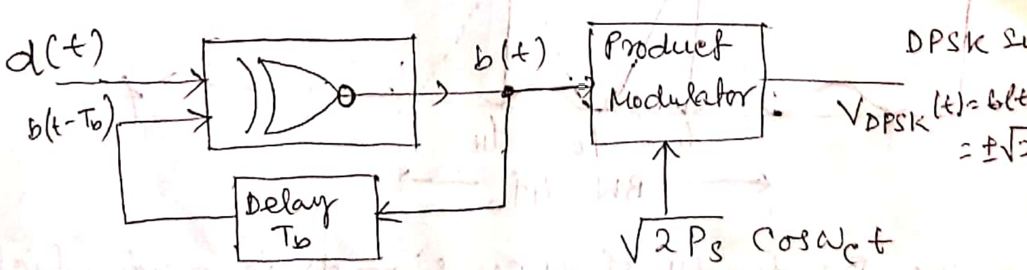
## Differential Phase shift keying

In BPSK, to regenerate the carrier we start by squaring $b(t)\sqrt{2P_s}\cos\omega_c t$. Accordingly, if the received signal were instead $-b(t)\sqrt{2P_s}\cos\omega_c t$, recovered carrier would remain as before. Therefore we shall not be able to determine whether the received baseband signal is the transmitted signal $b(t)$ or its negative $-b(t)$.

DPSK as the non coherent version of the PSK. DPSK avoids the need to provide the synchronous carrier required at demodulator for detecting a BPSK signal by combining two basic operation at the transmitter.

1. Differential encoding of input binary wave
2. Phase shift keying.

**Generation of DPSK** The data stream to be transmitted $d(t)$, is applied to one input of an differential encoder the other input is applied the output of the differential encoder $b(t)$ delayed by the $T_b$ allocated to one bit. The second input is then $b(t-T_b)$. The output of the encoder is applied to one input of the product modulator, other input of this product modulator a sinusoidal carrier of fixed amplitude and frequency is applied.




$V_{DPSK}(t) = b(t)\sqrt{2P_s}\cos\omega_c t$
$= \pm\sqrt{2P_s}\cos\omega_c t$.

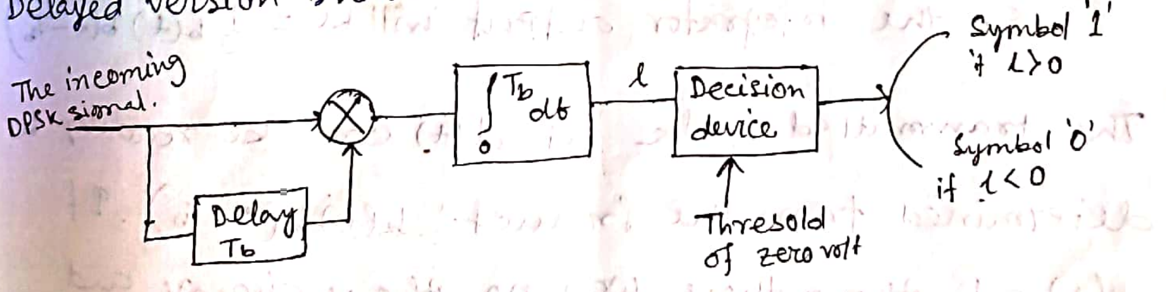
$\sqrt{2P_s}\cos\omega_c t$

For the generation DPSK signal, we choose first bit in $b(t)$ are arbitarily ~~set~~. The subsequent bits in $b(t)$ are determined on the basis ~~oth~~ of the rule that when $d(t)$ is a 1, $b(t)$ does not change its value and $d(t)$ is a 0, $b(t)$ changes its value.

Corresponding to the bit stream, a waveform $v(t)$ is generated where $v(t) = +1$ for $b(t)=1$ and $v(t) = -1$ for $b(t)=0$. The waveform is applied to a ~~balanced mod~~ Product modulator whose carrier input is $A\cos\omega_c t$. So, the DPSK signal is $v_{DPSK} = \pm A\cos\omega_c t = \pm\sqrt{2P_s}\cos\omega_c t$ and is transmitted over the channel. Let the data sequence 0010010110, the Phase of ~~dB~~ DPSK signal shown in third row.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Binary data $d(t)$ | | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |
| Differentially encoded data $b(t)$ | 1* | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| Phase of DPSK | 0 | $\pi$ | 0 | 0 | $\pi$ | 0 | 0 | $\pi$ | $\pi$ | $\pi$ | 0 |
| Shifted differentially encoded data $b(t-T_b)$ | | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 |
| Phase of Shifted DPSK | | 0 | $\pi$ | 0 | 0 | $\pi$ | 0 | 0 | $\pi$ | $\pi$ | $\pi$ |
| Phase Comparison output | | − | − | + | − | − | + | − | + | + | − |
| Detected binary sequence | | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 |

**Detection of DPSK**: Method of recovering the data bit stream from DPSK signal, the received signal and the received signal delayed by the bit time $T_b$ are applied to a multiplier. Delayed version shown in 4th row of the table.




The output of the difference is proportional to $\cos\phi$, where $\phi$ is the difference between the carrier phase of the received DPSK signal and its delayed version, measured is the same bit interval. The Phase angle of the DPSK signal and its delayed version are shown in 3rd and 5th rows respectively.

The phase difference between two sequences for each bit interval is used to determine the sign of the phase comparator output. When $\phi = 0$, the integrator output is positive, whereas when $\phi = \pi$ the integrator output is negative. By comparing the integrator output with a decision level to zero volt, the decision device can reconstruct the binary sequence by assigning a symbol '0' for negative output and a symbol '1' for positive output.

The output of the synchronous multiplier is

$$v_o = b(t)\cos\omega_c t \cdot b(t-T_b)\cos\omega_c(t-T_b)$$

$$= \frac{1}{2} b(t)\, b(t-T_b)\left[\cos\omega_c T_b + \cos 2\omega_c\left(t-\frac{T_b}{2}\right)\right]$$

This one pass through the ~~Ssd~~ Integrator or LPF

we get $= \frac{1}{2} b(t)\, b(t-T_b)\cos\omega_c T_b$

$$= \frac{1}{2} b(t)\, b(t-T_b)\cos\phi \qquad [\phi = \omega_c T_b]$$

where we should select $\phi = \omega_c T_b = 2n\pi$ with $n$ an integer.

So the integrator output will be $= \frac{1}{2} b(t)\, b(t-T_b)$

The transmitted data bit $d(t)$ can be readily be determined from the product $b(t)\, b(t-T_b)$. If $d(t) = 1$ there there was no phase change and $b(t) = b(t-T_b)$ both being $+1$V or both being $-$V. In this case $b(t)\, b(t-T_b) = 1$. If however $d(t) = 0$, then there was a phase change and either $b(t) = 1$V with $b(t-T_b) = -1$V or vice versa. In either case $b(t)\, b(t-T_b) = -1$

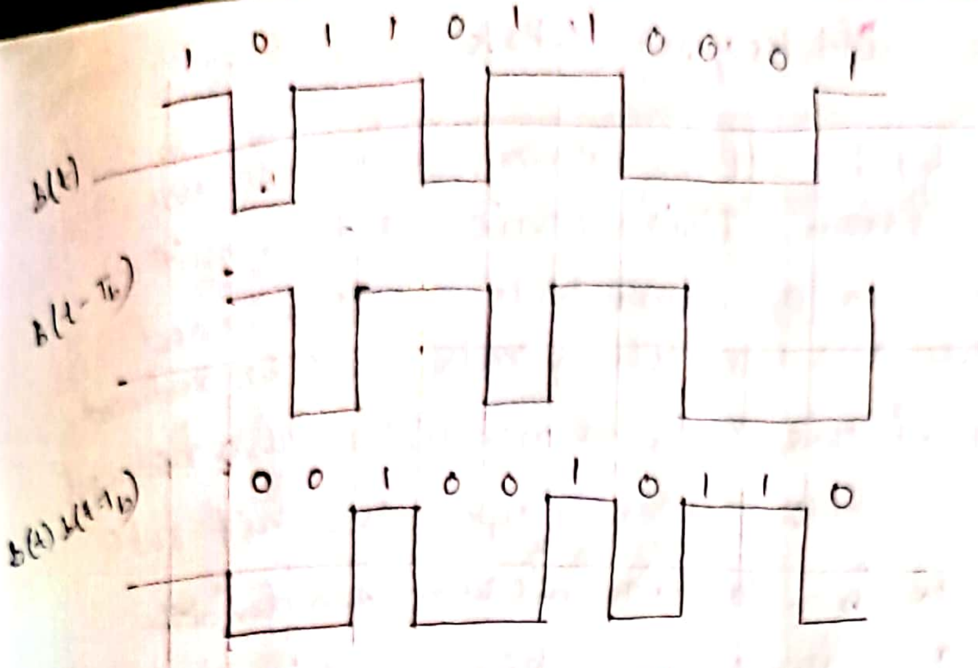



Fig: Waveform showing Recovery of binary message

**Advantage:** ① DPSK does not need carrier at the receiver and, hence complicated circuit for carrier recovery is not required.

② Bandwidth ($f_b$) requirement in DPSK is reduced as compared to BPSK

**Disadvantage:** ① Probability of bit error for DPSK is higher than that of BPSK. Because DPSK uses two successive bits for its reception, the error in first bit creates error in the second bit. Therefore error propagation in DPSK is more

② Noise interference in DPSK is more.

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