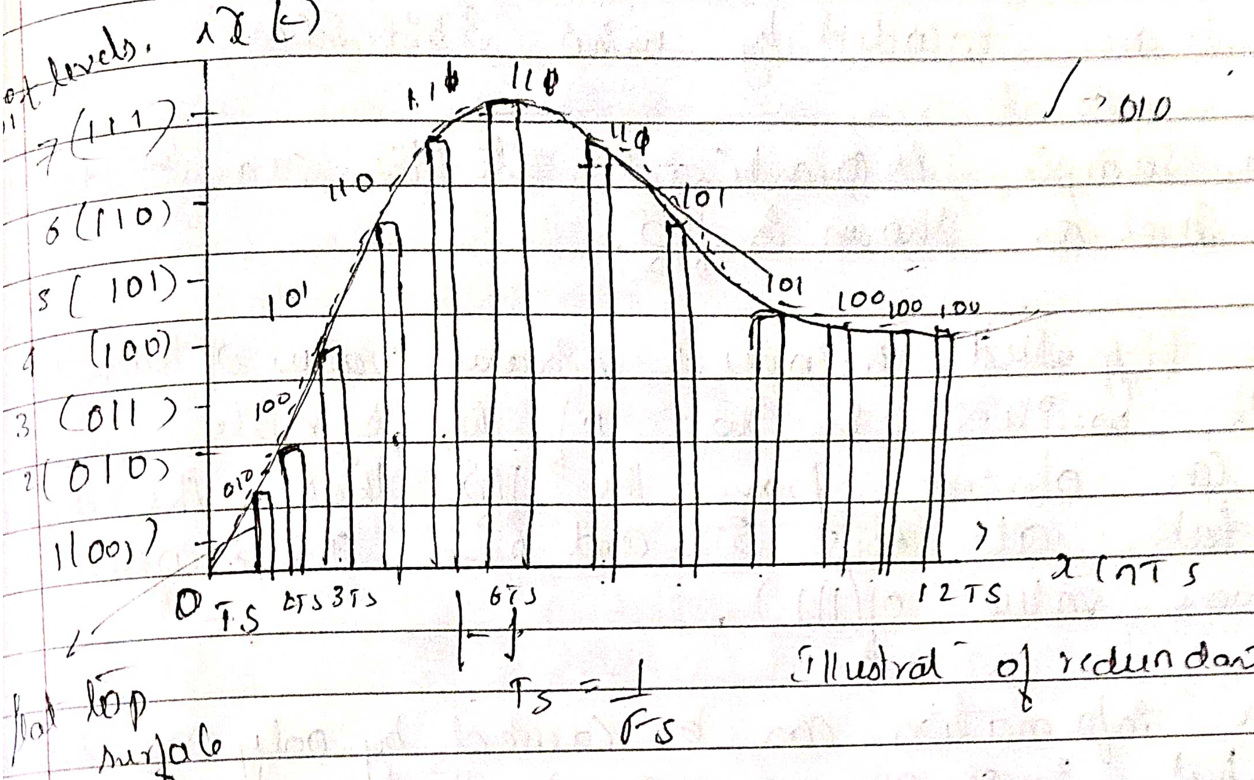
Differential PCM :



Illustrat of redundant infor in fr

(1) It may be observed that the samples of a signals are highly corolated with each other, this is due to the fact that any signal doanot change fast. This means that value from present to next sample does not differ by large amount

(2) The adjacent samples of signal carry the same inform with a little difference. When these samples are encoded by a standard PCM system the result ing encoded signal contain some redundant info signal. Fig illustrate this redundant information

(3) Fig shows a continous time signal x(t) by dotted line this signal is sampled by flat top sampling @ intervals Ts, 2Ts, ... the

Date / /
Page

The Sampling frequency selected to be higher than nequist rate
sample are Encoded by using 3 bit PCM

- The sample is quantized to the nearest digital level as shown in fig.

The (i/p untied) encoded binary value of each sample is written in top of the sample.
we can observe from the fig that the samples taken at 4Ts 5Ts and 6Ts are encoded to same value of (111).

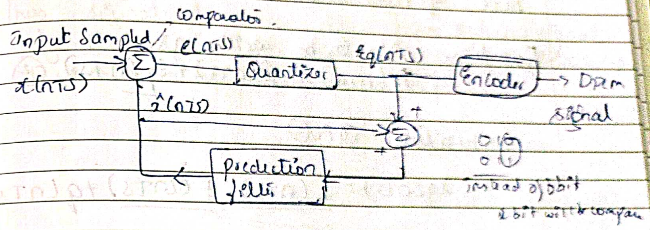
- This information can be carried by only one sample but 3 samples are carring the same information means that it is the redundant.

- Consider another example of samples taken at 12Ts and 13Ts the difference b/w their samples only due to last bit (100)(101) and first 2 bit are redundant.

- If this redundancy is reduced then overall bit rate will ↓ and no of bits required to transmit one sample will also be reduced
this type of DPM scheme is known as Differential pulse code modulation

Date / /
Page

- In fact the DPCM works on the principle of prediction. The value of present sample is predicted from the past samples.
so bcs the prediction may not be exact but it is very close to the actual sample value.



- Fig shows the transmission of the DPCM system the sampled signal is denoted by $x(nT_s)$ and predicted signal is denoted by $\hat{x}(nT_s)$. The comparator finds out the difference b/w actual sample value and predicted sample value. this is known as prediction error and is denoted by
$$e(nT_s) = x(nT_s) - \hat{x}(nT_s)$$
thus Error is diff b/w unquantized i/p signal $x(nT_s)$ and prediction of it $\hat{x}(nT_s)$.

The predicted value is produced by using prediction filter. The Quantizer o/p signal $e_q(nT_s)$ and previous prediction is added and given as input to prediction signal $x_q(nT_s)$
This makes the signal more and more close to the actual signal. and it can encoded by

using small no of bits. Thus no of bits/sample are reduced in DPCM.

⊙ The Quantizer O/p can be written as

$$\varepsilon_q(nT_s) = \varepsilon(nT_s) + q(nT_s) \quad -(1)$$

here $q(nT_s)$ is the Quantization Error

Quantizer o/p can be written as

$$x_q(nT_s) = \hat{x}(nT_s) + \varepsilon_q(nT_s) \quad (2)$$

substitute (1) in (2)

$$x_q(nT_s) = \hat{x}(nT_s) + e(nT_s) + q(nT_s)$$

$$\because \rightarrow \varepsilon(nT_s) = x(nT_s) - \hat{x}(nT_s)$$

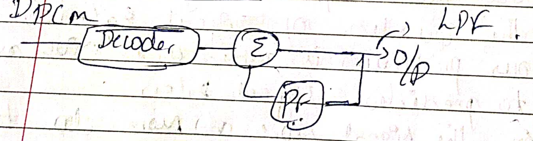
$$e(nT_s) = x(nT_s) - \hat{x}(nT_s)$$
$$x(nT_s) = e(nT_s) + \hat{x}(nT_s)$$

Now $x_q(nT_s) = x(nT_s) + q(nT_s)$

Quantiz^n $x_q(nT_s)$ is sum of original value and Quantiz^n Error $q(nT_s)$.

Reconstruction :-

DPCM



Decoder first reconstruct the Quantized Error signal from incoming Binary signal. The predict^n filter output and Quantized error signals are summed up to give the Quantized version of the original signal.

⊙ Thus signal at reciever differ from actual signal by Quantiz^n Error $q(nT_s)$ which is introduced permanently in the reconstructed signal.

20/07/22

UNIT: 03

DIGITAL MODULATION TECHNIQUE

Using Carrier we have

ASK → 1 -- mm 0 -- —

PSK → 1 -- m 0 -- m

FSK: Each have assigned freq for 1 and 0.

Design specific" (characteristic of any mod" technique)

01 Data rate (Max)

02. Maximum probability of Symbol Error.

03 Minimum transmitter power.

04 Maximum channel Bandwidth (util" max)

05 Max immune to Noise.

06 Minimum Circuit Complexity.

Types of Digital Modul":

(1) Coherent (2) NON coherent

(1) Coherent DM:-

Bor Digital Modul" can be classified into Coherent and NON coherent techniques depending on whether the receiver is equipped with a phase recovery circuit or not.

The phase recovery ckt ensures that the oscillator supplying locally generated carrier wave receiver is synchronized to the oscillator supplying the carrier wave used to originally modulate the incoming data stream in the transmitter.

a.) Coherent DMT are: which employ coherent detection. In coherent detection the local carrier generated at the receiver is phase locked with carrier at the transmitter.

Thus the detection is done by correlating received noise signal and locally generated carrier. It is also called as synchronous detection.

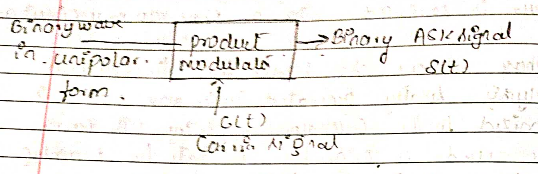
b) NON coherent:- In which the detection process doesn't need receiver carrier to be phase locked with transmitter carrier.

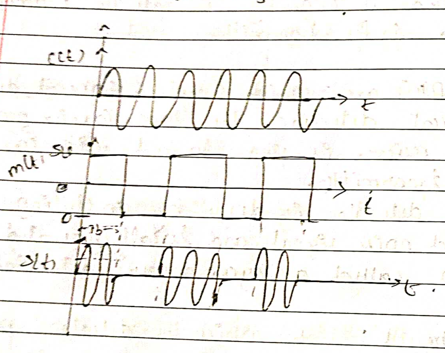
Advantage of such type of system.

(1) The system become simple but the drawback of such a system is that error probability increases.

Coherent Binary modulation technique:-

@. Coherent Binary ASK (On-Off Key)

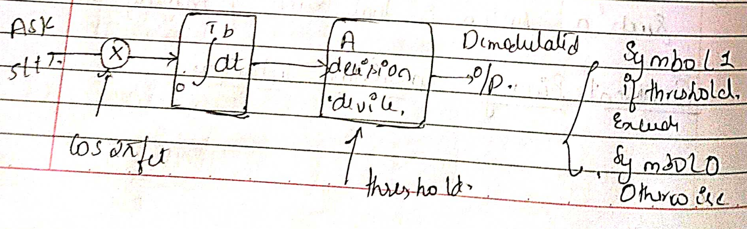


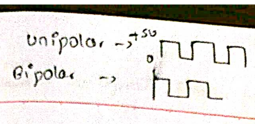


$s(t) = \sqrt{2ps} \cdot \cos(2\pi f_c t)$ ← (transmit '1')

$s(t) = 0$ - (0),

(b). Coherent Demodulation :-





⊙ Coherent Binary Phase shift key

⊙ In a BPSK. Binary symbols 1 and 0 modulate the phase of the carrier. Let us assume that carrier signal is given as $s(t) = A\cos(2\pi f_c t)$. Here A is peak of the sinusoidal carrier.

For the standard $p = \frac{A^2}{2}$ $A = \sqrt{2p}$

now, When the symbol is changed then the phase of the carrier will also be change by an amount 180° or π radian.

⊙ Let us consider for symbol 1. $s_1(t) = \sqrt{2p}\cos 2\pi f_c t$.

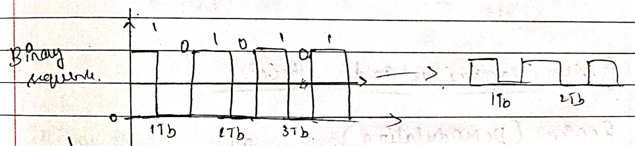
if symbol 0 then we have $s_2(t) = \sqrt{2p}(\cos 2\pi f_c t + \pi)$

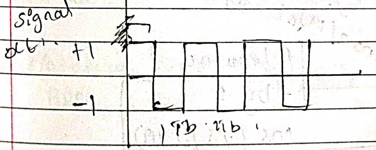
$s_2(t) = -\sqrt{2p}(\cos 2\pi f_c t)$.

$s(t) = b(t)\sqrt{2p}\cos 2\pi f_c t$ ← $(b(t) = 1)$

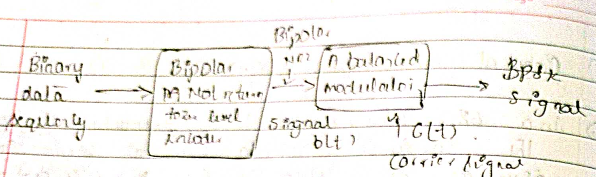
-1 → 0 (-) $(b(t) = 0)$ -1 → $b(t) = 0$ (-) → $-\sqrt{2p}\cos 2\pi f_c t$ (-ve)

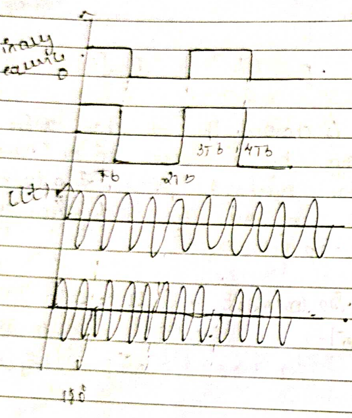
+1 → 1 (+) $b(t) = 1$ → $\sqrt{2p}\cos 2\pi f_c t$.





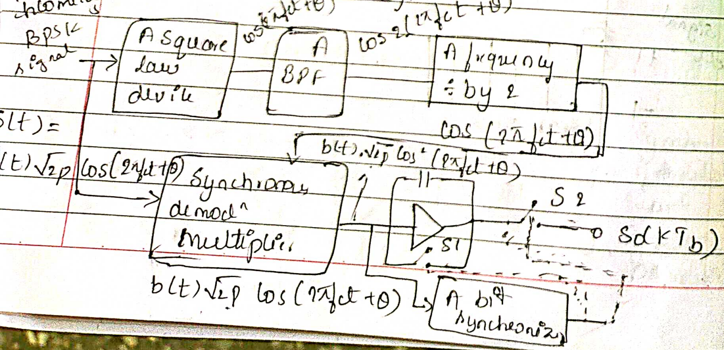
NRZ-





BPSK Transmitter and Receiver.

Receiver (Demodulation).



Square law :- To separate carrier from i/p

Mathematical Exp^n :-

$$s(t) = b(t)\sqrt{2p}\cos(2\pi f_c t + \theta) \quad -①$$

$\longrightarrow \cos^2(2\pi f_c t + \theta) \leftarrow$ o/p of square law device ②

$$\frac{1 + \cos 2(2\pi f_c t + \theta)}{2}$$

$$= \frac{1}{2} + \frac{1}{2}\cos 2(2\pi f_c t + \theta) \leftarrow \text{Sq. law o/p.} \quad -③$$

① $\rightarrow$ $\cos 2(2\pi f_c t + \theta) \rightarrow 2f_c$ o/p BPF ÷ 2

$$= \cos(2\pi f_c t + \theta) \quad -④$$

$= b(t)\sqrt{2p}\cos(2\pi f_c t + \theta) \times \cos(2\pi f_c t + \theta) \rightarrow$ o/p of freq. div.

$$= b(t)\sqrt{2p}\cos^2(2\pi f_c t + \theta)$$

$$= b(t)\sqrt{2p}\,\frac{(1 + \cos 2(2\pi f_c t + \theta))}{2}$$

$$= b(t)\sqrt{\frac{p}{2}}\left(1 + \cos 2(2\pi f_c t + \theta)\right) \quad -⑤$$

S2 → a decision making device.

① Fig shows Block diagram of BPSK receiver. The transmitted BPSK signal is given as $b(t)\sqrt{2p}\cos(2\pi f_c t + \theta)$.

② This signal undergoes a phase change depending upon time delay from transmitter end to a receiver end.

Date / /
Page

⊙ This received signal, carrier is separated because this is coherent detection.

received signal is allowed to pass through a square law device. Output of square law device is given as Eq ①

⊙ Here Y_2 represents a DC level. This signal is then allowed to pass through a BPF whose pass band is centred around $2f_c$. BPF removes the DC level of (Y_2) and at the o/p we obtain eq ④

⊙ This signal is having frequency $2f_c$, hence it is passed through a frq divider by 2.
Thus @ the o/p of frq divider we get a carrier signal whose frq is f_c as given in eq ⑤

⊙ The synchronous/coherent DM multiplies the i/p signal and the recovered carrier hence at the o/p of multiplier we get eq ⑥.

⊙ This signal is then applied to the bit synchronizer and integrator. The integrator integrates the signal over 1 bit period.
The bit synchronizer takes care of starting and ending time of a bit

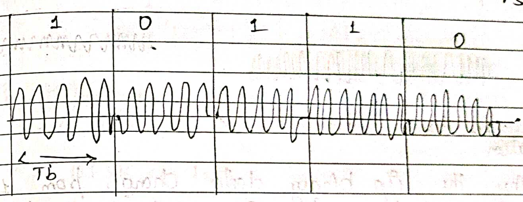
⊙ At end of bit dur^n of T_B Bit synchronizer closes switch S_2 temporarily. This connects the o/p of ∫ to the decision device. The synchronizer then opens switch S_2 and switch

1 → integrator o/p
0 → 0.

Date / /
Page

S_1 is closed temporarily.

⊙ The integrator then integrates the next bit.
Let us assume that one bit period T_B contains integral no. cycles of the carrier. This means that one bit phase change occurs in the carrier only at zero crossing. This is shown in fig ①.



BPSK waveform

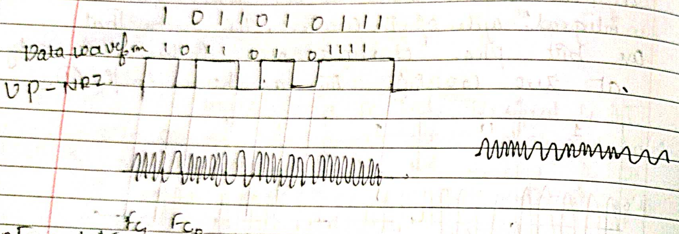
Frequency Shift Key :-

FSK is a type of Digital Modulation technique in which the frequency of sine signal is varied to represent the i/p digital data.
However Amplitude and phase of modulated carrier signal remains constant.

⊙ The FSK signal may be viewed as a sum of 2 interleaved ASK signal but with const^n amplitude one with carrier frq f_{c0} for transmitting '0' and other with another carrier frq f_{c1} by for transmitting '1'.

FSK signal can be expressed as

$$FSK(t) = \begin{cases} \sin 2\pi f_{c0} t & \text{for binary '0'} \\ \sin 2\pi f_{c1} t & \text{for binary '1'} \end{cases}$$



Interpretation

① When the i/p binary data changes from '1' to 0 and vice versa. The BFSK o/p signal frq shifts from f_{c1} to f_{c0} and vice versa.

① It can be seen that when the i/p data changes from a logic 1 to 0 or vice versa there is an abrupt phase discontinuity in the analog binary FSK signal

① Continuous phase frequency shift key is a binary FSK, 2 frq f_{c1} and f_{c0} are separated from the centre frequency f_c by an exact multiple of ½ one half of the bit rate F_B. This ensures a smooth frq phase transition in the BFSK signal when it changes from f_{c1} to f_{c0}

Polar +v −v uni- bitter.

① The time duration of one bit is same as the symbol time duration T_s of the binary FSK signal. Hence the bit rate F_B equals the baud rate

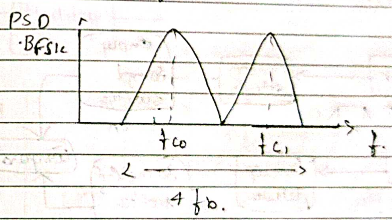
① The minimum BW for BFSK signal is given as

$$B_{BFSK} = |(F_{c1} + F_b) - (F_{c0} - F_b)|$$

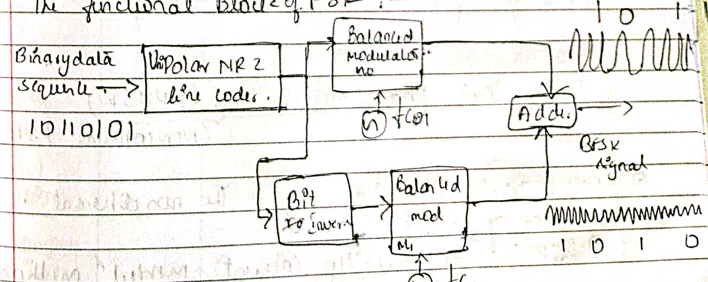
$$= |(F_{c1} - F_{c0})| + \underbrace{2F_b}_{\text{bit rate}}$$

① If the difference f_{c1} and f_{c0} $(f_{c1} - f_0)$ is chosen to be equal to $2F_B$ then BW of BFSK is $2f_b + 2f_b$.

$$BFSK = 4f_b.$$



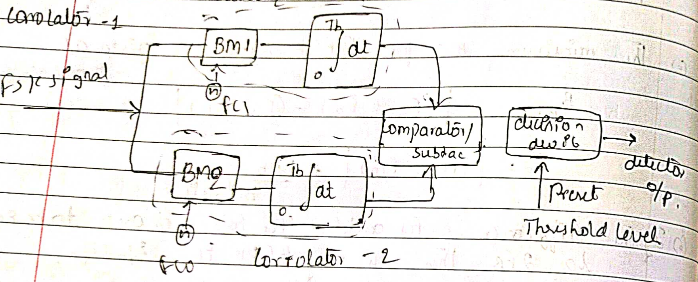
The functional Block of FSK :—



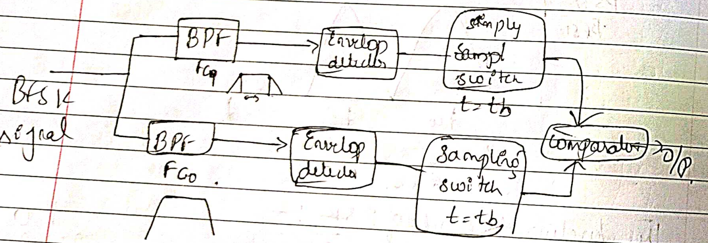
Date ___
Page ___

Detectors :-

Coherent Detectors :- (synchronous carrier @ receiver)



NON-Coherent BFSK



Differential phase key shifting (DPRSK)

(NON coherent PSK)

- Differential phase shift key is the non coherent version of BPSK.
- DPSK is differentially coherent modul^n method

$0 \times 0 \to \pi$
$1 \times 0 \to 0$
$1 \times 1 \to \pi$

$1 \times 1 = 1 = 0 \times 0$

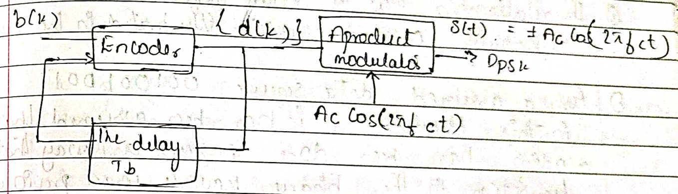
Date ___
Page ___

DPSK doesnot need a synchronous carrier at the demodulator.

The i/p sequence of binary bits is modified such that next bit depends upon the previous bit.

- Therefore in the receiver the previous received bits are used to detect the present bit.

Generation of DPSK



Binary data.		0	0	1	0	0	1	0	0	1	1
Differential Encoder data	1*	0	1	~~1 0 0 1 0 0 0.~~							
	(xnor)			1	0	1	1	0	1	1	1
Phase of (dpsk)	0	π	0	0	0 π	0	0	π	0	0	0
shifted diff encoder dat.		1	0	0 1	1	0	0	1	0	0	0.
Phase of shifted (dpsk		0	π.	0	0	π	0	0	π	0	0
phase comparis.		−	−	+	−	−	+	−	−	+	+
o/p detected binary seque		0	0	1	0	0	1	0	0	1	1

A schematic arrangement for generating DPSK signal as shown in fig.

- Data stream $B(k)$ is applied to the i/p of the encoder. The o/p of encoder is applied to one i/p of product modulator. Other i/p of this product modulator is sinusoidal carrier of fixed amplitude and frequency is applied.

- The relationship b/w the binary sequence and its differentially encoded version illustrated in the table.

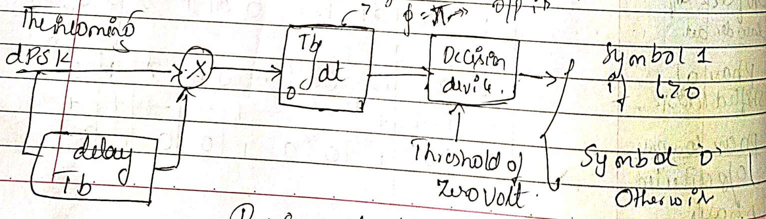
- For a assumed data sequence 0010010011 in this illustration. it has been assumed that encoding has been done in such a way that transition in the binary sequence w.r.t previous encoded bit is represented by a symbol '0' and no transition from symbol 1.

- It may be noted as that extra bit symbol 1 is arbitrarily added as an initial bit this is essential to determine the encoded sequency.

Detection of DPSK :-

$\phi = 0$ integrator o/p is +ve.

$\phi = \pi$ o/p is -ve.



Reciever for the detec^n of DPSK signal.

- The detection of DPSK as shown in the fig. The received DPSK is applied 1 i/p of multiplier other i/p of multiplier, a delayed version of received DPSK signal.
The delayed version of received DPSK signal as been shown in the 4th row of the table.

- The o/p of difference is proportional to $\cos\lambda$ here λ is the difference b/w the carrier phase angle of the received DPSK signal it and its delayed version, measured in the same bit interval.

- The ϕ angle of the DPSK signal and its delayed version have been shown in 3rd and 5th row respectively. The phase diff b/w 2 sequences for each bit interval is used to determine the sign of the phase comparator o/p.

- When ϕ is 0 the integrator o/p is +ve., where as ϕ is π the ∫ o/p is -ve.
By comparing the integrator output with the decision level of 0v. The decision device can reconstruct a binary sequency by assuming a symbol 0 for -ve o/p and a symbol 1 for +ve o/p.

The reconstructed Binary data is shown in last row of the table. it is then seen that in absence of noise the receiver can construct the transmitted binary data exactly.

- DPSK may be known as non coherent version of PSK

Date
Page

It may also be noted that reconstruction is invariant with the choice of initial bit in encoded data.

Advantages :-

① DPSK does not need carrier at the receiver end. This means that circuit complexity is reduced.

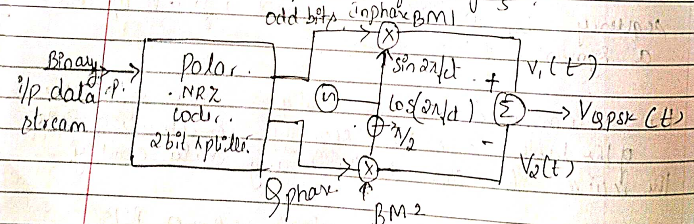
② The BW requirement of DPSK is reduced compared to BPSK.

Disadvantages :-

① Noise interference in DPSK is more.

② Because DPSK uses 2 successive bits for its reception, error in the 1st bit creates error in the 2nd bit; therefore error propagation in DPSK is more.

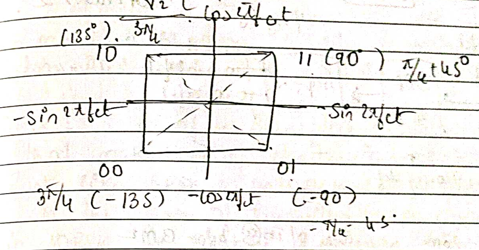
Quadrature phase shift keying :-



Date
Page

O/P → $+\cos 2\pi f_c t + \sin 2\pi f_c t$, $-\cos 2\pi f_c t + \sin 2\pi f_c t$,
$+\cos 2\pi f_c t - \sin 2\pi f_c t$, and $-\cos 2\pi f_c t - \sin 2\pi f_c t$.

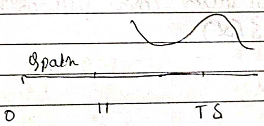
$V_{QPSK}(t) = \frac{1}{\sqrt{2}}\left(I(t)\sin 2\pi f_c t - Q(t)\cos 2\pi f_c t \right)$



OQPSK → insert delay @ Q path (1 bit delay).

Waveform for QPSK :-

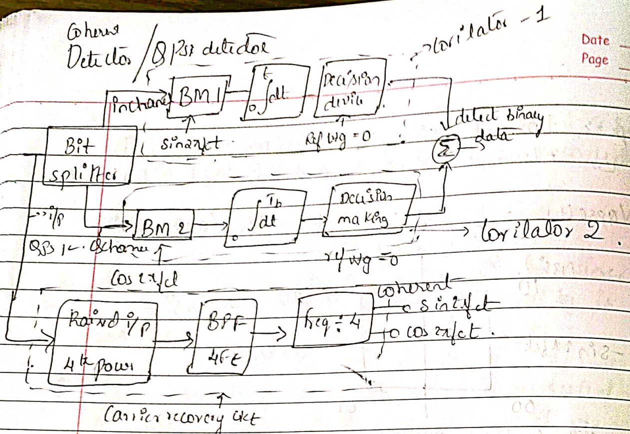
ⓐ OQPSK.



Demodulator of QPSK :- BM ∫ Decision making device

PSK → Square law device → BPF $4f_c$ → ÷ 2 freq divider → 2 carrier.

Coherent Detector / QPSK detector



OQPSK -> same delay of Tb @ before BM2
↳ avoid ±180° of shift / carrier . (amplitude)

① Consider a QPSK system having bit rate of 9600 bits/sec. Determine the BW required by QPSK signal using raised cosine filter with roll off factor of 0.35 and 0.5 (α).

> Rel^n b/w BW and α

Transmitted Signal BW = Symbol rate × (1 + roll of factor)
QPSK, OQPSK

Symbol rate = ½ Bit rate

$BW_{.35} = 4800 \times (1 + 0.35)$
$= 6480 \text{ Hz}$

$= 4800 \times 1.5$
$= 7200 \text{ Hz}$

M array

① M-ary PSK / M-array D.M techniques

-> In Binary PSK we transmit each data bit individually where i/p bit rate $F_b = \frac{1}{T_b}$.

In multi level M-array one of the M possible signals elements are transmitted during each bit interval of Tb second.

① QPSK : is one of the BW efficient DM technique that makes use of Quadrature multiplexing. Just like BPSK, in QPSK too the info is carried in the phase of (transmitted) carrier signal but in QPSK we combine 2 successive bits in a bit stream to form a symbol.

① with 2 bits there are 4 possible cond^n 11, 10, 01, 00 depending on which of the 4 2bit symbols develops in i/p the data stream

we transmit one over the of 4 sinusoid of dur^n 2Tb the sinusoid differing in phase by 90° or 180° with another. Thus in a QPSK modulator each bit generates 4 possible o/p phases (+45°, +135°, -45°, -135°) hence the name Quadrature (4 phases)

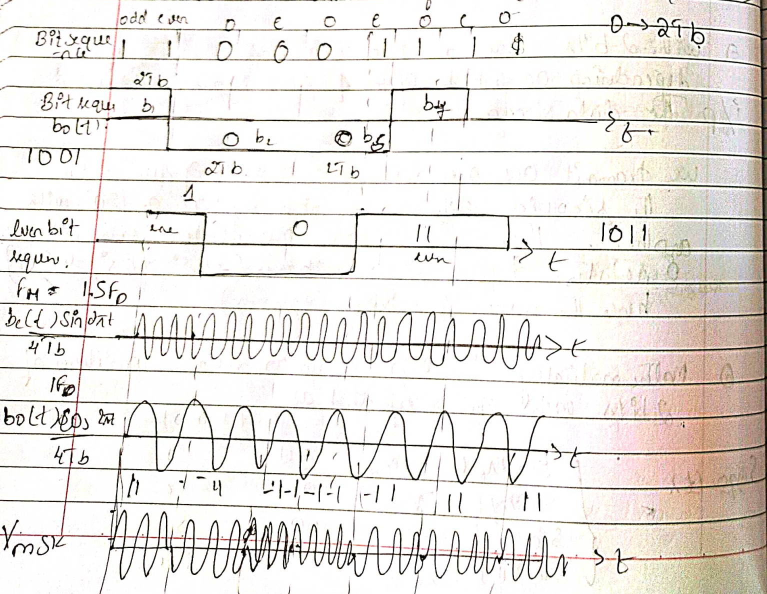
① Mathematically signal for 1 symbol duration consisting of 2 bits each can be expressed as

$$S_{QPSK}(t) = \begin{cases} \sin 2\pi f_c t - 3\pi/4 & 00 & S1 \\ \sin 2\pi f_c t - \pi/4 & 01 & S2 \\ \sin 2\pi f_c t + 3\pi/4 & 10 & S3 \\ \sin 2\pi f_c t + \pi/4 & 11 & S4 \end{cases}$$

(2bit symbol)

Minimum Shift Keying. (MSK)

- The Bandwidth requirement of QPSK is high but they have other side effects. for eg:- filters alter the amplitude of the waveform
- MSK overcome these problems. in MSK the O/P waveform is continuous in phase and hence there are no abrupt changes in amplitude.
- The sidefe/ side lobes of MSK are very small hence BPF is not required.
- To avoid interchannel interference. (BPF is used in other) (not req)



corresponding NRZ

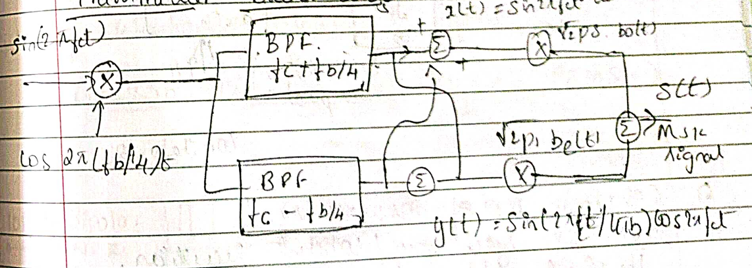
- fig shows the waveform of MSK. The binary bit sequence is $b(t)$.
1010 waveform are generated for odd and evenbits $b_o(t)$ represent odd bits and $b_e(t)$ represent evenbits.

- The duration of each bit in $b_o(t)$ and $b_e(t)$ is $2T_b$
i.e $T_s = 2T_b$.
The waveform $b_o(t)$, $b_e(t)$ have an offset of T_b. this offset is essential in MSK.

- $B_e(t)$ is multiplied by $\sin 2\pi t/4T_b$ and odd $B_o(t)$ is multiplied by $\cos 2\pi t/4T_b$.

These product waveform are shown and the transmitted MSK signal is represented in V_{MSK}.

Transmitter Block diagram



MSK Demodulator

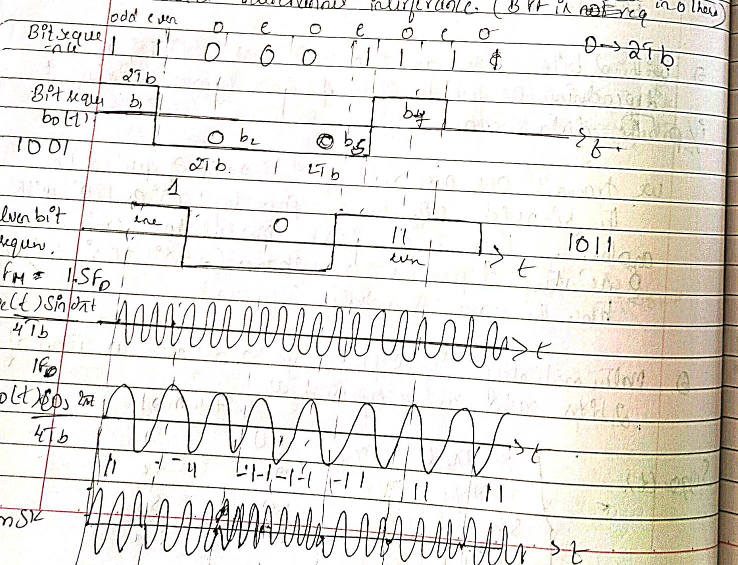
Minimum Shift Keying :- (MSK)

- The Bandwidth requirement of QPSK is high but they have other side effects. for eg:- filters alter the amplitude of the waveform

- MSK overcome these problems. in MSK the O/P waveform is continuous in phase and hence there are no abrupt changes in amplitude.

- The sidefe/ side lobes of MSK are very small hence BPF is not required.

- To avoid interchannel interference. (BPF is ~~not req~~ used in others)



Corresponding NRZ

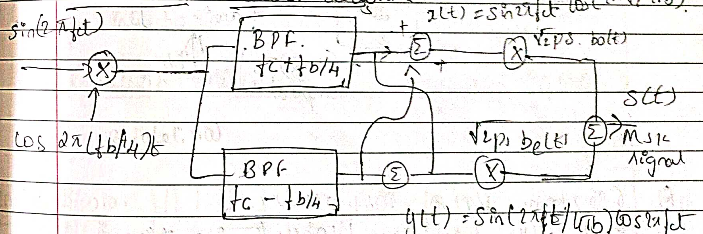
- Fig shows the ^ waveform of MSK. The binary bit sequence is $b(t)$.
Two waveform are generated for odd and even bits. $b_o(t)$ represent odd bits and $b_e(t)$ represent even bits

- The duration of each bit in $b_o(t)$ and $b_e(t)$ is $2T_b$
i.e $T_s = 2T_b$.
The waveform $b_o(t)$, $b_e(t)$ have an offset of T_b. This offset is essential in MSK.

- $B_e(t)$ is multiplied by $\sin 2\pi t / 4T_b$ and odd $B_o(t)$ is multiplied by $\cos 2\pi t / 4T_b$.

Then product waveform are shown and the transmitted MSK signal is represented in V_{MSK}.

Transmitter Block diagram



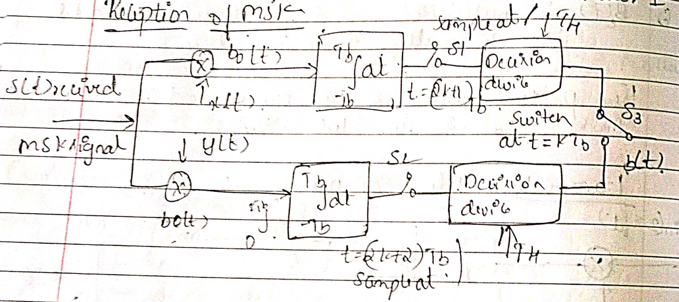
MSK Demodulator

Fig shows BD of MSK.

- 2 sine signal $\sin 2\pi f_c t$ and $\cos \frac{2\pi t}{4T_b}$ are mixed. The BPF @ then pass only sum and difference frequencies. The o/p of BPF are then added and subtracted such that signal $x(t)$ and $y(t)$ are generated.

- Signal $x(t)$ is multiplied by $\sqrt{2P_s} \times b_o(t)$ and $y(t)$ is multiplied by $\sqrt{2P_s}$. The o/p of multipliers are then added to give final MSK signal

Reception of MSK



- Fig shows BD of MSK receiver. MSK uses synchronous/coherent reception. The signal $x(t)$ and $y(t)$ are multiplied with the received MSK signal.

here $x(t)$ and $y(t)$ have same values as shown in

transmitter block diagram.

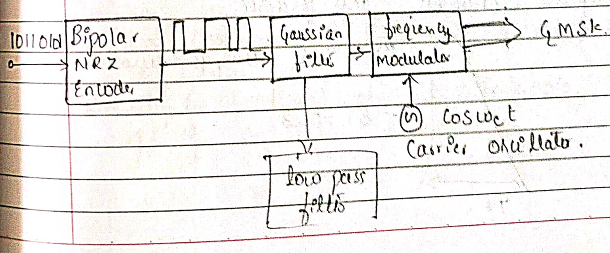
- The o/p of multipliers are $b_o(t)$ and $b_e(t)$. The $\int$ integrator over the period of $2T_b$. For the upper correlator the sampling switch the o/p of $\int$ @ $2(k+2)T_b$. Then the decision device decide $b_o(t)$ is (+1 or -1) ±1.

- Similarly in lower correlator o/p is $b_e(t)$. The o/p of 2 decision device are staggered by T_b. The switch has 3 operates @ $T = kT_b$ and simply multiplexes the 2 (correlated) correlator o/p.

Advantages :-

1. The waveform is smoother than QPSK.
2. MSK wm doesnot have amplitude variation.
3. Power spectral density wider mainlobe. Interchannel interference is reduced.

Gaussian Minimum Shift Keying :- (GMSK).



Date __/__/__
Page ____

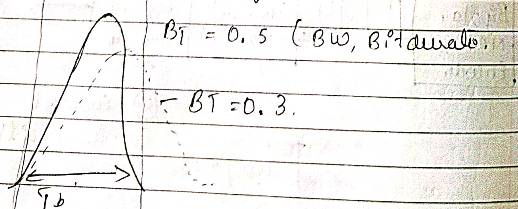
Q. MSK is a continuous phase mod^n scheme, where the modulated carrier contains no phase discontinuity and frequency changes occur at the carrier zero crossings.

MSK is unique due to the relationship b/w the frequency of logic 0 and logic 1.
The difference b/w frequencies of a logic 0 and 1 is always equal to the off half the data rate.
In other words $\Delta f(m_I) = 0.5$ for MSK.

Comparison of GMSK with MSK

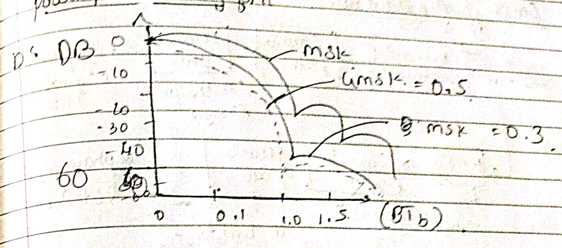
↳ The fundamental problem with MSK is, the spectrum is not compact enough to realise data rate approaching the RF channel BW.
A plot of the spectrum for MSK reveals sidelobes extending well above the data rate.

For wireless data trans^n system, which require more efficient use of RF channel Bandwidth, is necessary to reduce the energy of the MSK side lobes. Because it is not adequate for multi user wireless com^n application.
It requires very stringent specific^n with regards adjacent channel interference.



Date __/__/__
Page ____

power spectral density for it



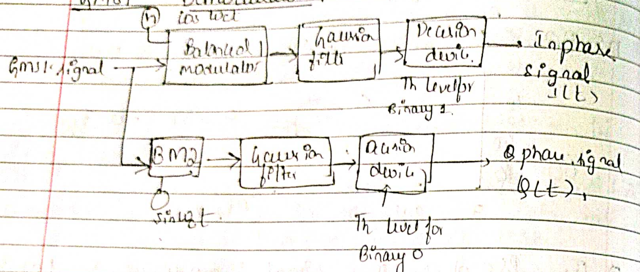
① The PSD of an MSK signal is modified by passing the NRZ binary data stream through a shaping LPF such as Gaussian filter before carrier modul^n.

② The Gaussian filter has narrow BW with sharp cutoff characteristics and negligible over in its impulse response.
∴ Such a modified MSK using Gaussian filter is called GMSK modulation.

Advantages of Gaussian filter

01 Reduct^n in the transmitted BW of the signal.
02 Uniform envelope.
03. Spectral containment i.e Reduct^n of side lobe level of the power spectral
04. Reduct^n in adjacent channel interference.
05. Supp^n of out of band noise.

GMSK Demodulator :-



QAM :-

- Here in multilevel M-array DM technique one of the M possible signal elements are transmitted during each interval to sec.
- The no of possible signal level M is given by 2^m, $M = 2^n$ where n is an integer, which represents the no of bits in each symbol.
- The M signal elements are distinguished by M different pulse amplitude level. In bandpass M-array digital mod M signal element can differ in their amplitude level as in the case of M-array ASK or in their frequencies as in the case of M-array FSK or in their phases and the phase of M-array PSK.
- In M-array DM, M signal elements can differ in their amplitude level as well as in their phases.

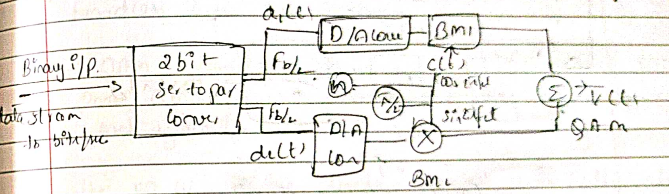
resulting M-array Quadrature amplitude mod (QAM)

- The QAM signal can be expressed as, S(QAM)

$S_{QAM}(t) = d_1(t)\cos 2\pi f_c t + d_2(t)\sin 2\pi f_c t$.

$d_1(t) = 0$, $d_2(t) = 1$ - data (Binary data 0 and 1).

- For an eg of a QAM system let us consider, to transmit a sig symbol for every 4 bit there are $2^4 = 16$ different possible symbols which we have to be able to generate 16 distinguishable signal.

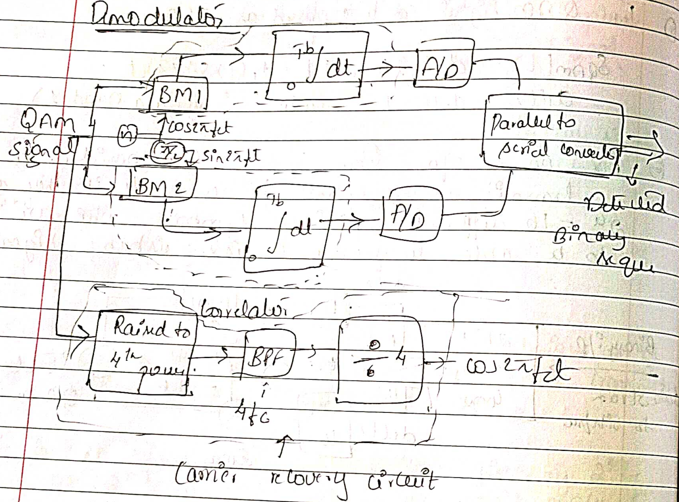


- The i/p is a data stream of binary digits @ a rate of Fb bits/sec.
- The data stream is converted into 2 separate data streams of Fb/2 b/s each. by taking alternate bits for the 2 data streams.
- ASK / One data is ASK modulated on the carrier $\cos 2\pi f_c t$. Other data stream is ASK modulated by the same carrier signal shifted by 90°.

The 2 modulated signals are then added.

and transmitted.

Demodulator



⊙ Fig shows the block schematic of QAM de coherent demodulator that is similar to the QPSK coherent demodulator.

A local set of Quadrature carrier signal is recovered for synchronous detection by raising the received signal to the 4th power.

⊙ The component / frq comp @ $4f_c$ is extracted using a BPF tuned @ $4f_c$ and then dividing the frequency by 4. The available Quadrature carrier signals are applied to 2 correlators each comprising of a BM and an integrator.

⊙ The original inform bits are then recovered by using A to D converter and parallel to serial converter.

QAM is an efficient way to achieve high data rates with a narrow band channel by increasing the no of bits / symbol and uses a combination of Amplitude and phase modulation. (Higher level QAM → 64 QAM & so on more BW efficient and are used for high data rate transm appl in terrestrial microwave digital radio, Digital video broadcast cable and modem).

Q1 A QAM modulator uses 4 diff amplitude and 16 diff phase angles. How many bits does it transfer for each symbol.

⇒ The no of possible levels / symbol is the multiplication of the no of different amplitude level and no of diff ϕ angle in QAM.

For given 4 diff amplitude and 16 diff phases, the no of possible states / symbol

$M = 4 \times 16 = 64$

no of bits / symbol $M = 2^n = 64 = \boxed{n = 6}$

Thus are 6 bits will be transmitted / symbol

Date / /
Page

(2) Compute and tabulate the results for BW efficiency of Marray FSK signal for/and m-array PSK signal for M = 2,4,8,16,32,64

∴ Need to find BW efficiency.

	$B_{\eta MSK}$	$B_{\eta PSK}$	for QAm
	$\frac{2\log_2 M}{M}$	$\frac{\log_2 M}{2}$	$\log_2 M$
M = 2	1 bits/sec/Hz	0.5	1
M = 4	1	1	2
M = 8	0.75	1.5	3
= 16	0.5	2	4
= 32	0.3125	2.5	5
64	0.1875	3 bits/sec/	6

Error performance of 8PSK

(1) For an 8PSK system operating @ 20mega bits/sec with a carrier to noise power ratio of 11dB. Determine the minimum BW required to achieve a probability of Error of 10^{-6} the corresponding minimum $\frac{E_B}{N_0}$ ratio for an 8psk system is a 14 dB

Date / /
Page

∴ f_b = 20M bits/sec. Carrier to noise ratio = 11dB
BW = ?

Energy per bit to noise power ratio

It is used to compare 2 or more Digital mod^n system that uses different marray modul^n technique. (FSK, PSK, QAm) operating @ different transm^n rate (Bits/sec) it is a simple and accurate comparision of their error performance

∴ $\frac{E_b}{n_0}(dB) = \frac{C}{N}(dB) + \frac{B}{f_b}(dB)$

$\frac{B}{f_0} = \frac{E_b}{n_0}(dB) - \frac{C}{N}(dB)$

$= 14 - 11$

$\frac{B}{f_b} = 3dB = \text{antilog}\left(\frac{3}{10}\right) \approx 2$

f_B = 20 Mbit

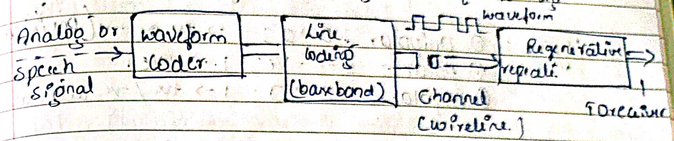
$\boxed{B = 40\,MHz}$

Digital Modul^n	Applic
FSK	⊙ Cardless telephone, Paging service.
BPFSK	⊙ Telemetry
QPSK (4	⊙ Cellular telephoning, satellite com^n, Digital video broadcasting
8PSK	⊙ Satellite commun^n
16/32 level QAM	⊙ Microwave digital radio links, Digital video broadcasting
64 level QAM	⊙ Digital VB, settop boxes, Modem
MSK/GMSK	⊙ Mobile, cellular com^n (GSM appl^n)

12/07/22.

UNIT : 04

Base Band Transmission
(Line Coding techniques:-



Desirable properties of line coders:-

WKT How to convert an Analog signal to a digital data sequence of B.S (1,0). Either by using waveform encoders such as PCM, Δmodul^n etc.

The Digital o/p comprising of a long sequence of binary symbols 1's and 0's. it is neither uniform nor suitable for direct transmission over the comm^n channel.

Then Binary symbols are required to be converted into electrical pulses or waveforms having finite vtg levels. so as to make it compatible for transmission over the commun^n channel.

Line coding is a process by which Digital symbols are transformed into waveforms that are compatible with the characteristics of the Baseband channel.

Unipolar :- if 1 of +v is selected then image +v

Properties of line codes

01 Transmission power efficiency

Types :- ① Unipolar : 0 → 0 ; 1 → +v or -v (+ve One is fixed)
② polar : 0 → -ve ; 1 → +ve
③ Bipolar ; 0 → 0 ; 1 → +ve / -ve alternatively

a. UP :- Represented by only 1 level +v or -v
An UP can be (UP - RZ) or (UP - NRZ)

b. Polar :- Represented by 2 distinct non zero Symmetrical but opposite voltage levels (+v, -v)

c Bipolar :- Also known as pseudoternary (3 vtg level) (+v, -v, 0v) or alternate mark inversion

01 TP Efficiency :- TPE = The ratio of $\frac{\text{Pavg polar}}{\text{Pavg unipolar}} \times 100$

TED : Tvtg level can be categorized as either unipolar or polar. The TPE can be ↑ by using polar vtg levels.

02 Duty cycle : Ratio of Bit duratⁿ for which the Binary pulse defined transmisⁿ voltage to the entire bit duration

In non return to zero the duty cycle is 100% bcz the binary pulse is maintained high for the entire bit duration or Binary pulse is maintained low for binary data zero for entire bit durⁿ.

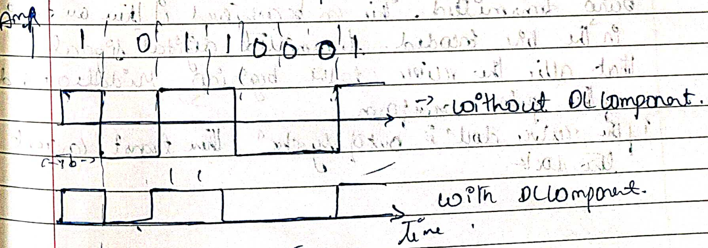
② In return to zero line coding format the binary pulse is maintained high for binary data 1 for 50% of the entire bit duratⁿ only.

When the binary pulse is maintained low for Binary data 0 for the entire bit duration. So Avg duty cycle is less than 100% of specified bit duration

03) DC Component.

Some commⁿ system like telephone system a telephone line cannot pass frequencies below 200 Hz and a long distance link using transformer donot allow transmⁿ of frequency around 0 is called DC component.

This situatⁿ occur when the vtg level is constant for a while the frequency spectrum show very low frq component therefore we need a line coding technique with no dc component.



DC wandering → chance of ↓ in Ampl for continuous 1

Date / /
Page

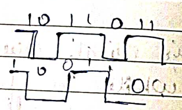
(3) In Digital trans^n a long sequence of either 1's or 0's produced a cond^n in which a receiver may loose its Amplitude referance. This referance is needed for clear cut discriminat^n of received 1's and 0's in the receiver.

Similar cond^n may also araise when there is significant imbalance in the 1's and 0's transmitted. This cond^n causes a drift in the baseline, called base line wandering. This makes difficult for the receiver to decode received data correctly.

04) Bandwidth requirement.

It is desirable that BW of a line code should be as small as possible. this allows more inform^n to be transmitted / unit channel Bandwidth.

(5) Self -synchronization



Lack of synchroniz^n.

A SS Digital signal include timing inform^n in the data being transmitted. This can be achieved if there are transit^n in the line encoded. transmitted digital signal that alert the receiver to the begining, middle or end of the pulse waveform
If the receiver clock is out of synchro^n then transit^n correct the clock.

Date / /
Page

05) Immuenity to noise and interferance.

The line coding format shld be capable to limi minimize the effect of noise and interferance. This will enable to have minimum errors introduced in transmitted data due to external noise and interferance.

06) Error detection capability.

It is desirable that line code shld have built in error detect^n capability which shld enable to detect the errors and correct errors that occur during transmission.