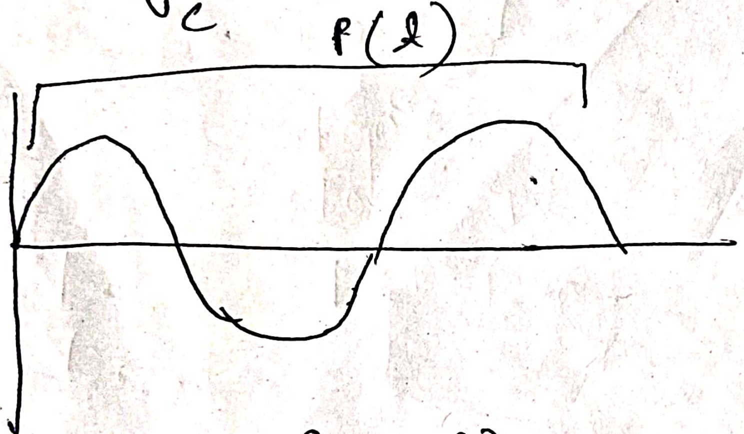
BPSK.

means sending signal by changing phase.

$$p(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_c t)$$

$$T = \frac{K}{f_c}$$



$T = 2$

Energy of p(t)

$$\mathcal{E}_p = \int_{-\infty}^{\infty} p^2(t)\, dt.$$

$$= \int_0^T \sqrt{\frac{2}{T}} \cos(2\pi f_c t)$$

$$= 1.$$

$$\therefore \mathcal{E}_p = 1.$$

$$x(t) = a_0 \, p(t)$$

$$a_0 = \pm A.$$

$$a_0 = \frac{1}{2} \mathcal{E}_p A^2 + \frac{1}{2} \mathcal{E}_p A^2$$

$$= \mathcal{E}_p A^2.$$

$$= A^2.$$

$$A^2 = \mathcal{E}_b.$$

$$A = \sqrt{\mathcal{E}_b}.$$

0 bit $a_0 = +A = \sqrt{\mathcal{E}_b}.$

$$x(t) = \sqrt{\mathcal{E}_b} \sqrt{\frac{2}{T}} \cos(2\pi f_c t)$$

1 bit $a_0 = -A = -\sqrt{\mathcal{E}_b}$

$$x(t) = \sqrt{-\frac{2\mathcal{E}_b}{T}} \cos(2\pi f_c t)$$

$r(T) \geq 0 \Rightarrow a_0 = A$ bit 0

$r(T) \leq 0 \Rightarrow a_0 = -A$ bit 1.

~~Problem of~~

Probability of error

$$P_e = Q\left(\sqrt{\frac{A^2 \mathcal{E}_p}{N_0/2}}\right).$$

$A = \sqrt{\mathcal{E}_b}$. $\mathcal{E}_p = 1$

$$P_e = Q\left(\sqrt{\frac{2\mathcal{E}_b}{N_0}}\right).$$

P_e for BPSK avg energy

$$Q(x) = \int_x^\infty \frac{1}{\sqrt{2\pi}} e^{-t^2}$$

ASK (Amplitude Shifting Keying)

$$P(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_c t)$$

$$T = \frac{K}{f_c}$$

Energy

$$\mathcal{E}_p = \int_{-\infty}^{\infty} p^2(t)\, dt$$

$$\mathcal{E}_p = 1$$

$$a_0 \in \{0, A\}$$

0 bit $\Rightarrow$ A

1 bit $\Rightarrow$ 0

0 bit $\begin{cases} x(t) = a_0 P(t) \\ \quad = A\sqrt{\frac{2}{T}} \cos(2\pi f_c t) \end{cases}$

1 bit $\{ x(t) = a_0 P(t) = 0$

Avg energy per bit

$$\frac{1}{2}\mathcal{E}_p A^2 + 0$$

$$= \frac{1}{2}\mathcal{E}_p A^2$$

$$\frac{1}{2}A^2 = \mathcal{E}_b.$$

$$A^2 = 2\mathcal{E}_b.$$

$$A = \sqrt{2\mathcal{E}_b}.$$

At receiver

$$y(t) = x(t) + n(t)$$

0 bit $= A\,p(t) + n(t).$

1 bit $= n(t)$

for 0 bit match filter:

$$r(t) = A\mathcal{E}_p + \tilde{n}(t).$$

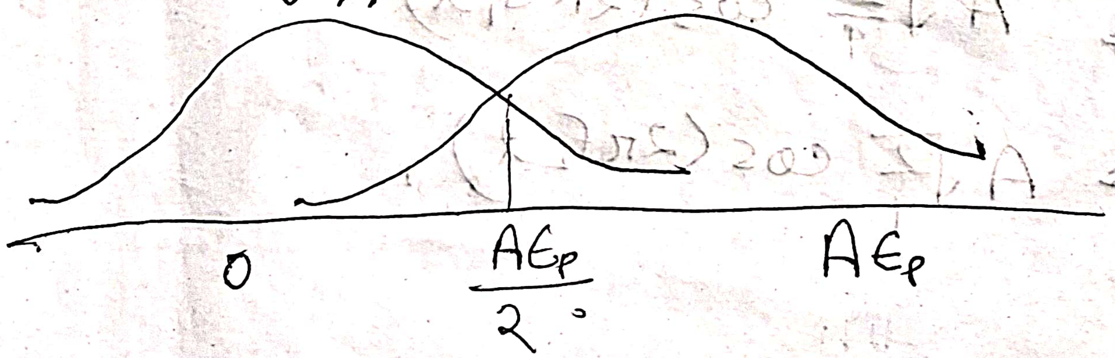
for 1 bit match filter

$$r(t) = \tilde{n}(t)$$

Usually

$r(t) = 0$ for 1 bit

$r(t) > 0$ for 0 bit.



FSK.

$$P_1(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_1 t).$$

$$P_2(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_2 t).$$

$$T_1 = \frac{K}{f_1} \quad T_2 = \frac{K}{f_2}.$$

Energy per bit

$$\mathcal{E}_P = \int_{-\infty}^{\infty} P_1^2(t) = \int_{-\infty}^{\infty} P_2^2(t) = 1.$$

$$a_0 \begin{cases} 0 \text{ bit} = A \\ 1 \text{ bit} = A \end{cases}$$

$$x(t) = a_0 P_1(t).$$

$$= A P_1(t)$$

$$x(t) = A P_2(t)$$

$$x(t) \begin{cases} \xrightarrow{0} A\sqrt{\frac{2}{T}} \cos(2\pi f_1 t) \\ \xrightarrow{1} A\sqrt{\frac{2}{T}} \cos(2\pi f_2 t). \end{cases}$$

$$\text{Avg energy} = \frac{1}{2}\mathcal{E}_p A^2 + \frac{1}{2}\mathcal{E}_p A^2$$

$$\mathcal{E}_b = \mathcal{E}_p A^2.$$

$$\mathcal{E}_p A^2 = \mathcal{E}_b.$$

$$\therefore A = \sqrt{\mathcal{E}_b}$$

$$x(t) \xrightarrow{0} \sqrt{\frac{2\mathcal{E}_b}{T}} \cos(2\pi f_1 t)$$

$$x(t) \xrightarrow{1} \sqrt{\frac{2\mathcal{E}_b}{T}} \cos(2\pi f_2 t),$$

Re

$x(t)$

$y(t) = \cancel{\quad} + n(t)$

match filter

$$\tilde{y}(t) = y(t) - A\left(\frac{P_1(t) + P_2(t)}{2}\right).$$

0 bit =

$$y(t) = AP_1(t) + n(t)$$

$$\tilde{y}(t) = AP_1(t) + \tilde{n}(t) - A\left(\frac{P_1(t) + P_2(t)}{2}\right)$$

$$= A\tilde{P}(t) + \tilde{n}(t)$$

$$\tilde{y}(t) = \begin{cases} 0\,\text{bit} & A\tilde{p}(t) + n(t) \\ 1\,\text{bit} & -A\tilde{p}(t) + n(t) \end{cases}$$

QPSK:

$$P_1(t) = \sqrt{\frac{2}{T}} \cos(2\pi f_c t)$$

$$P_2(t) = \sqrt{\frac{2}{T}} \sin(2\pi f_c t)$$

$$x(t) = a_1 P_1(t) + a_2 P_2(t).$$

$a_1 = \pm A \quad a_2 = \pm A$

$$x(t) = A P_1(t) + A P_2(t)$$

$$= A P_1(t) - A P_2(t)$$

$$= -A P_1(t) + A P_2(t)$$

$$= -A P_1(t) - A P_2(t).$$

$A = \sqrt{\varepsilon_b}$.

$$A P_1(t) + A P_2(t).$$

$$= A\sqrt{\frac{2}{T}} \cos(2\pi f_c t) + A\sqrt{\frac{2}{T}} \sin(2\pi f_c t)$$

$$= \frac{2A}{\sqrt{T}} \times \frac{1}{\sqrt{2}} \cos(2\pi f_c t) + \frac{2A}{\sqrt{T}} \frac{1}{\sqrt{2}} \sin(2\pi f_c t)$$

$$= \frac{2A}{\sqrt{T}} \cos\frac{\pi}{4} \cdot \cos 2\pi f_c t + \frac{2A}{\sqrt{T}} \sin\frac{\pi}{4} \sin 2\pi f_c t$$

$$= \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t - \frac{\pi}{4}\right)$$

$$x(t) = \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t - \frac{\pi}{4}\right)$$

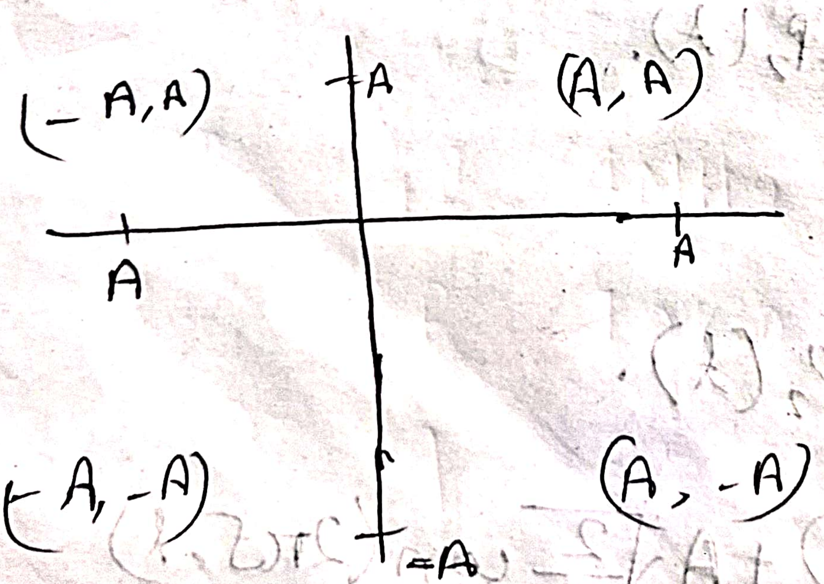
$$\pi/2$$

$$\cancel{AP_1(t)}\ AP_2(t) = \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \pi/4\right)$$

$$-AP_1(t) + AP_2(t) = \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \frac{3\pi}{4}\right)$$

$$-AP_1(t) - AP_2(t) = \frac{2A}{\sqrt{T}} \cos\left(2\pi f_c t + \frac{5\pi}{4}\right)$$

Constellation Diagram



Source Coding.

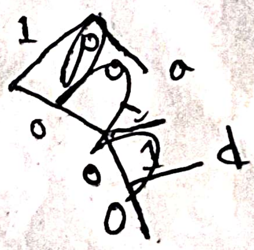
Definition: Source Coding means representing inform[ation] using least number of codes without losing information.

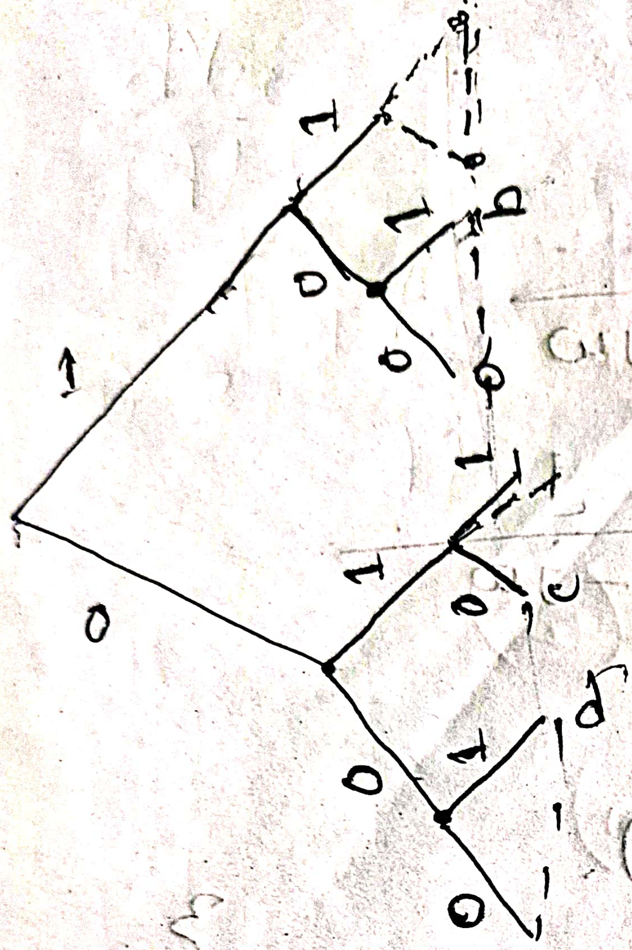
Fixed length code: Each Symbol is represented by same number of bits.

Variable length code: Different Symbol is represe[nted by] different number of bits.

Uniqeruely Decodable.

a = 100 b = 101 c = 010 d = 001 .





$$\sum 2^{-l_i}$$

$$2^{-3} + 2^{-3} + 2^{-3} + 2^{-3}$$

$= 0.5.$

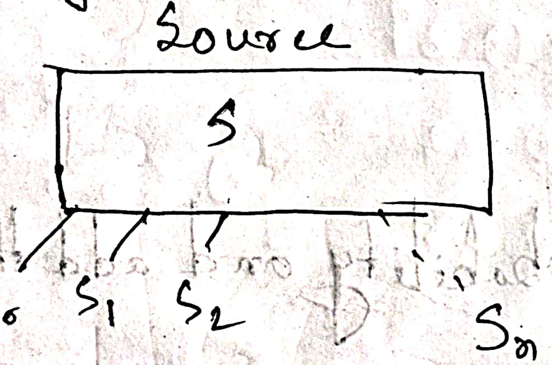
Decodable.

Huffman Code.

→ Very simple algorithm

→ Very efficient to construct prefix free code for a given source with probability distribution of source alphabet.

Let us consider an example to observe the process of Huffman coding.



$$X = \{S_0, S_1, S_2, \dots S_n\}.$$

$$x \in S = \{S_0, S_1, S_2 \dots S_n\}.$$

Suppose five ~~source~~ symbol generated by source.

$S_0 = 0.15$ $\quad$ $S_4 = 0.25$

$S_1 = 0.2$

$S_2 = 0.15$

$S_3 = 0.25$

Probability.

Step 1:

Organize the symbols with decreasing probability.

$S_3 = 0.25$

$S_4 = 0.25$

$S_1 = 0.2$

$S_2 = 0.15$ 0

             0.3.

$S_0 = 0.15.$ 1

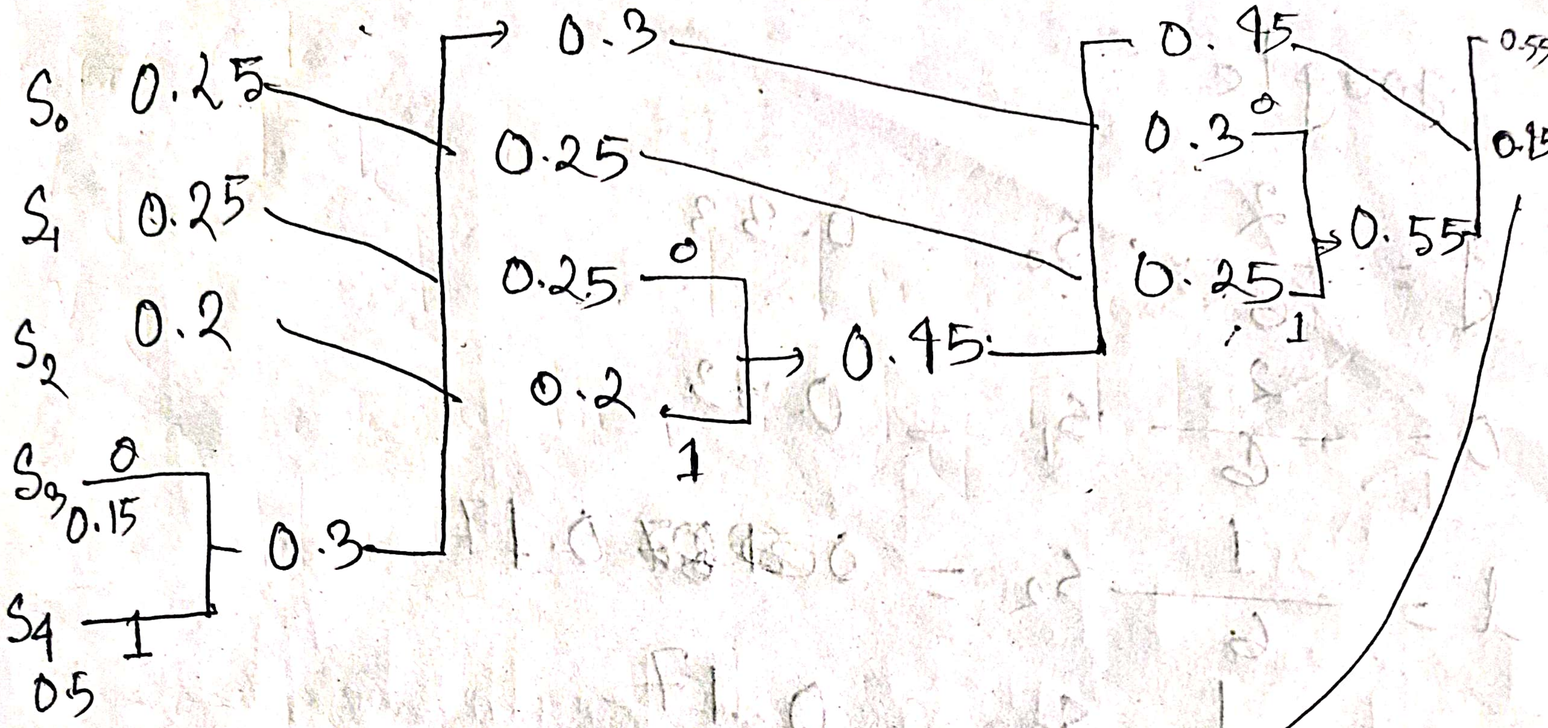
Step 2

Combine the lowest 2 probability and add them.

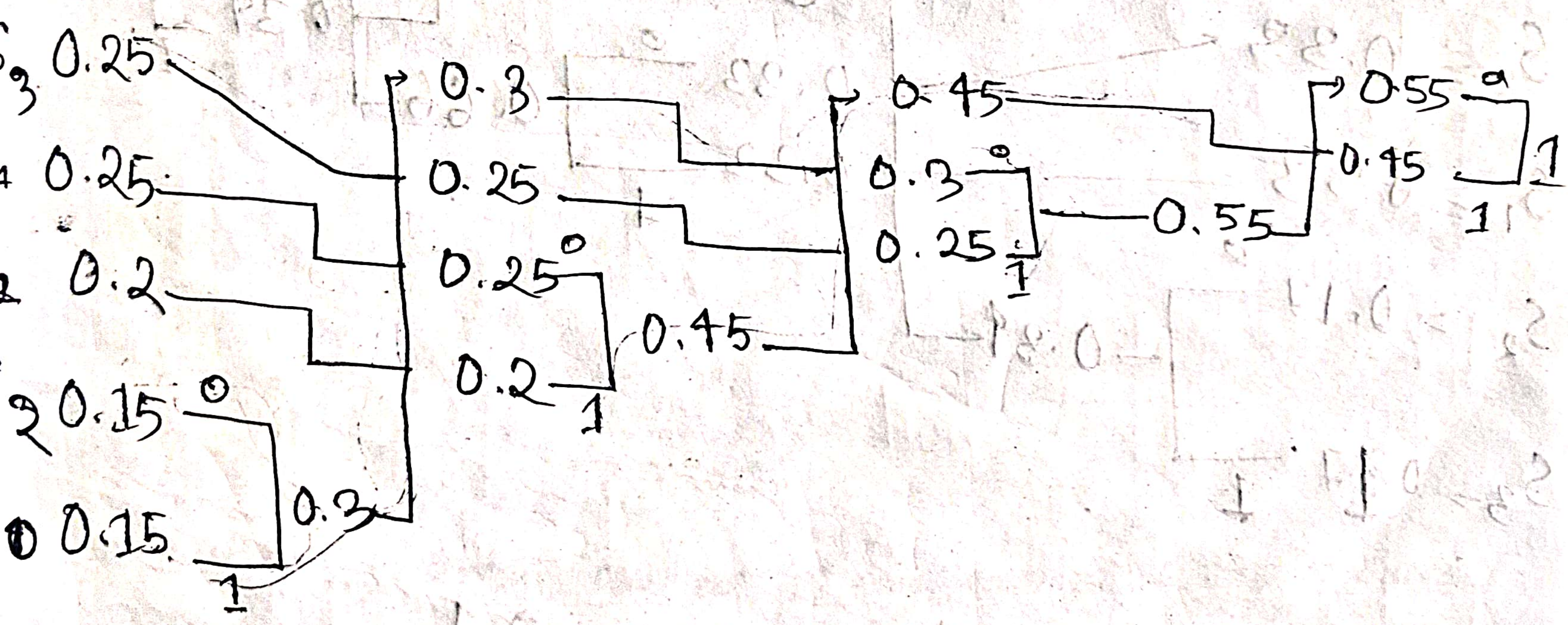
$S_2 + S_0 = 0.3.$

Step 3 Assign each branch with 0, 1.

Step 4 Repeat 1 to 3



⇒



$S_0 = 001$ $S_1 = 11$

$S_2 = 000$ $S_4 = 10$

$S_3 = 01$

Symbols	P_r	Code	Length.
S_0	0.15	001	3
S_1	0.2	11	2
S_2	0.15	000	3
S_3	0.25	01	2
S_4	0.25	10	2

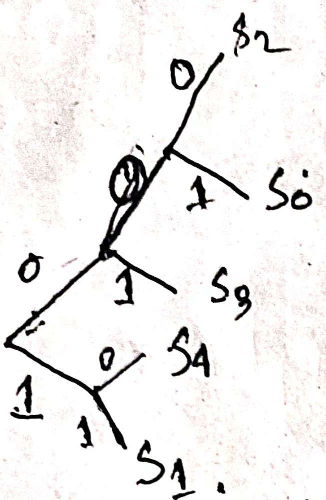
$$\overleftrightarrow{L} = \sum P_r \times l_i$$

$$= 0.15 \times 3 + 0.2 \times 2 + 0.15 \times 3 * 0.25 \times 2 + 0.25 \times 2$$

$$= 2.3 \text{ bits/symbols.}$$

Entropy → How much efficient the symbol.

$$\bar{H} = \sum p_i \log_2 1/p_i$$



Difference between entropy and avg code length should less for efficient source coding.

0.1, 0.2, 0.6 এর নিচে থাকলে better.

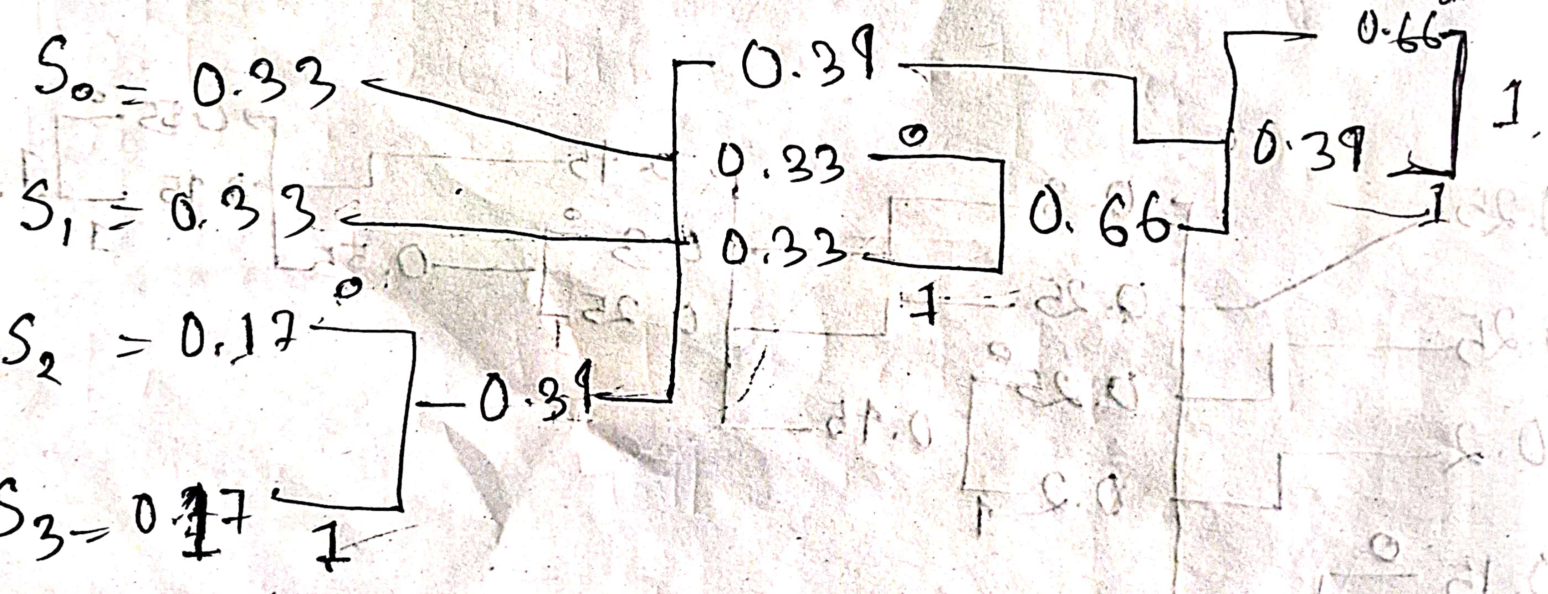
google

$g = \frac{2}{6}$ $S_0 = 0.33$

$o = \frac{2}{6}$ $S_1 = 0.33$

$l = \frac{1}{6}$ $S_2 = 0.17$

$e = \frac{1}{6}$ $S_3 = 0.17$

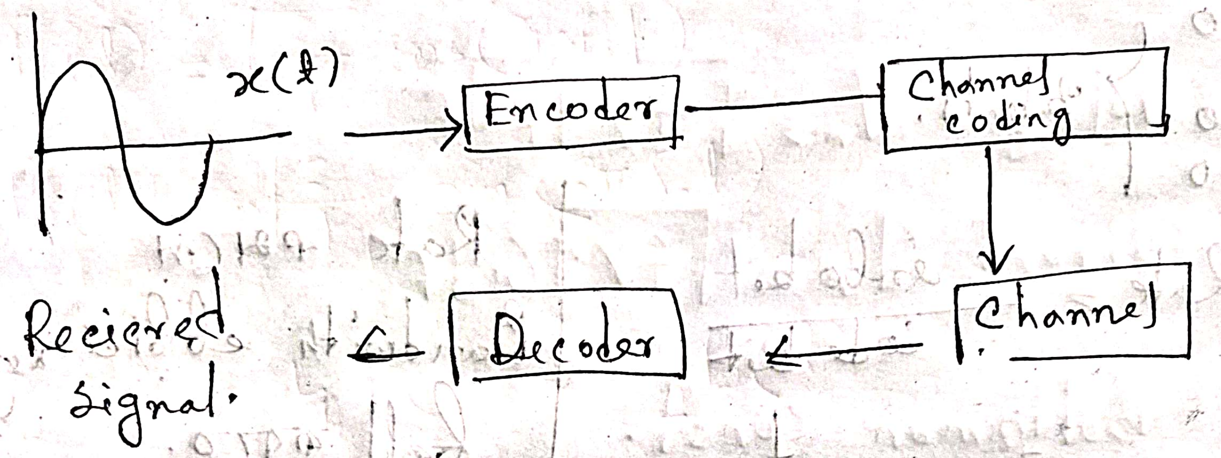


$S_3 = 11$ $S_1 = 01$

$S_2 = 10$ $S_0 = 00$

~~9d~~ 8 (4)

Channel coding.



Transmitted T. → 0 1 1 0 0 1.

Reciered R → 0 1 1 1 0 1.

↳ error channel noise.

0 1 1 0 0 1.

3 bit repeat. ~~representation~~

000 ~~001~~ ~~001~~ 000 000 ~~001~~.

111 111 111

000 011 011 000 000 110

due to noise bit changes.

0 1 1 0 0 1. Depends on bit priority

This is called Majority Decision Rule.

$$0 \to \left.\begin{matrix} 0 \\ 0 \\ 0 \end{matrix}\right\} \text{3 bits.}$$

$$\text{Rate} = \frac{\text{info bit}}{\text{code bit}} = \frac{1}{3}$$

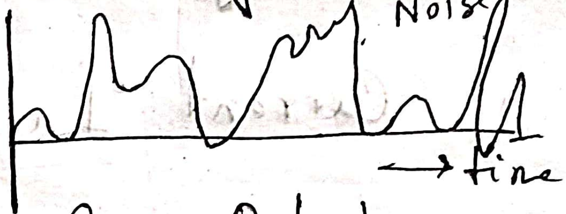
Rate কমলে Bandwith effi fall করছে.

→ 1 bit error → Detected + corrected

→ 2 bit " → " + not "

Noise

Noise is an unwanted disturbance that spoils or changes message while it is being sent.



Types of noise.

⇒ External noise → comes from Outside

- Traffic Sound.
- Thunder • Machine.

⇒ Internal noise → Comes from electronic device

- Heat in circuits
- Electronic Components.

⇒ Channel Noise → Happens during transmission

- Weak Signal
- Long Distance

Thermal Noise.

Noise voltage $V_n = \sqrt{4KTRdf}$.

" Current $I_n = \sqrt{4KTGdf}$

K = Boltzman const.

T = Temp (K).

R = Resistance.

df = Bandwith.

$G = \frac{1}{R}$.

Ex

Given,

$df = 4MHz = 4 \times 10^{6}$

$R = 10K\Omega = 100\Omega$.

$T = 25^{\circ}c = 298K$.

$K = 1.38 \times 10^{-23} J/K$.

$$V_{in} = \sqrt{4KTRdf}.$$

$$= 2.56 \times 10^{-6} V.$$