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PROGRESS THROUGH KNOWLEDGE

ECE Department

1st Semester ⊙ 2nd Semester ⊙ 3rd Semester ⊙ 4th Semester ⊙

5th Semester ⊙ 6th Semester ⊙ 7th Semester ⊙ 8th Semester ⊙

Click on Subject/Paper under Semester to enter.

1st Semester

- Professional English - I - HS3152
- Matrices and Calculus - MA3151
- Engineering Physics - PH3151
- Engineering Chemistry - CY3151
- Problem Solving and Python Programming - GE3151

2nd Semester

- Professional English - II - HS3252
- Statistics and Numerical Methods - MA3251
- Engineering Graphics - GE3251
- Physics for Electronics Engg - PH3254
- Basic Electrical & Instru Engg - BE3254
- Circuit Analysis - EC3251

3rd Semester

- Random Process and Linear Algebra - MA3355
- C Programming and Data Structures - CS3353
- Signals and Systems - EC3354
- Electronic Devices and Circuits - EC3353
- Control Systems - EC3351
- Digital Systems Design - EC3352

4th Semester

- Electromagnetic Fields - EC3452
- Networks and Security - EC3401
- Linear Integrated Circuits - EC3451
- Digital Signal Processing - EC3492
- Communication Systems - EC3491
- Environmental Sciences and Sustainability - GE3451

5th Semester

- Wireless Communication - EC3501
- VLSI and Chip Design - EC3552
- Transmission Lines and RF Systems - EC3551
- Elective 1
- Elective 2
- Elective 3

6th Semester

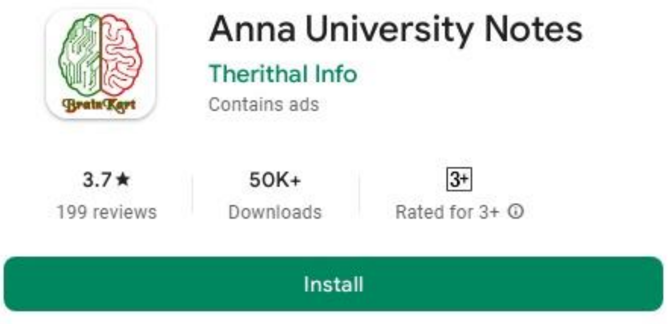
- Embedded Systems and IOT Design - ET3491
- Artificial Intelligence and Machine Learning - CS3491
- Open Elective-1
- Elective-4
- Elective-5
- Elective-6

7th Semester

- Human Values and Ethics - GE3791
- Open Elective 2
- Open Elective 3
- Open Elective 4

8th Semester

- Project Work / Intership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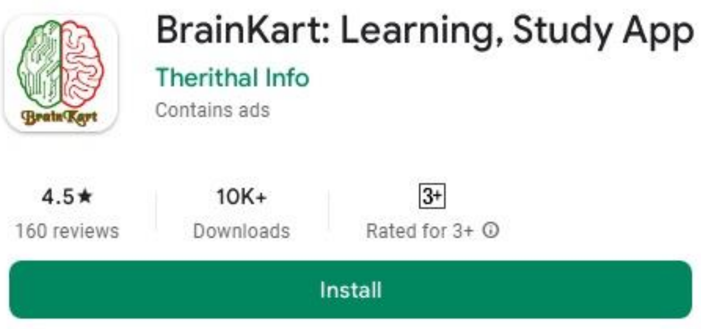
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All ECE Engg Subjects - [B.E., M.E.,] (Click on Subjects to enter)

Circuit Analysis	Digital Electronics	Communication Theory
Basic Electrical and Instrumentation Engineering	Electrical Engineering and Instrumentation	Principles of Digital Signal Processing
Electronic Devices	Linear Integrated Circuits	Signals and Systems
Electronic Circuits I	Electronic Circuits II	Digital Communication
Transmission Lines and Wave Guides	Control System Engineering	Microprocessors and Microcontrollers
Computer Architecture	Computer Networks	Operating Systems
RF and Microwave Engineering	Medical Electronics	VLSI Design
Optical Communication and Networks	Embedded and Real Time Systems	Cryptography and Network Security
Probability and Random Processes	Transforms and Partial Differential Equations	Physics for Electronics Engineering
Engineering Physics	Engineering Chemistry	Engineering Graphics
Problem Solving and Python Programming	Object Oriented Programming and Data Structures	Environmental Science and Engineering
Principles of Management	Technical English	Total Quality Management
Professional Ethics in Engineering	Engineering Mathematics I	Engineering Mathematics II

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

B.E. Electronics and Communication Engineering

Anna University Regulation: 2021

EC3491 –COMMUNICATION SYSTEMS

II Year / IV Semester

Hand Written Notes

Unit – V

DEMODULATION TECHNIQUES

Prepared by,

Mrs. E. M. Uma selvi , AP/ECE

UNIT - 5 Demodulation Techniques.

Elements of Detection Theory:

Concept of Detection:

→ The modulator / transmitter sends one of the 'M' possible signals in the given time slot.

→ These signals are $s_1(t), s_2(t), \dots s_M(t)$

→ When the signals travels along the channel, Additive White Gaussian Noise (AWGN) interferes & changes the signal's shape.

s_i → transmitted signal

x → Received signal

w → noise vector

$x = s_i + w \quad , \quad i = 1, 2, \dots M$

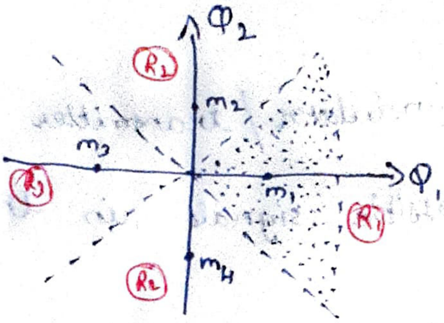
→ Based on the received observation vector 'x', the mapping is made to an estimate $\hat{m}$ of the transmitted symbol m_i, in such a way that probability of error is minimum.

Maximum Likelihood Decoding:-

→ Observation vector be x. The decision is made as $\hat{m} = m_i$. The average probability of symbol error in this decision is,

$P_e(m_i, x) = P(m_i \text{ not sent}/x) = 1 - P(m_i \text{ sent}/x)$

Set $\hat{m} = m_i$, if $P(m_i \text{ sent}/x) \geq P(m_k \text{ sent}/x)$ for all $k \neq i$



Example of maximum likelihood decision $N=2$; $M=4$.

→ There are four regions R_1, R_2, R_3, R_4

→ Messages m_1, m_2, m_3, m_4

→ vectors falls in region R_1 then message m_1 is selected.

Maximum Likelihood Detection process:

$P(x_1)$ = probability of receiving symbol x_1

$P(x_2)$ = " " " " x_2

$f_x(v/x_1)$ = P.D.F of receiving voltage 'v' when x_1 is sent.

$f_x(v/x_2)$ = P.D.F of receiving voltage 'v' when x_2 is sent

λ = Decision threshold.

$v > \lambda_1$, symbol 'x_1' is selected.

$v < \lambda_1$, " x_2 is selected.

$$P_e = \int_{v<\lambda} P(x_1) f_x(v/x_1)dv + \int_{v>\lambda} P(x_2) f_x(v/x_2)dv$$

$$P(x_1) f_x(v/x_1) > P(x_2) f_x(v/x_2)$$

(or)

$$\frac{P(v/x_1)}{P(v/x_2)} > \frac{P(x_2)}{P(x_1)}.$$

This equation called maximum likelihood detector.

— x —

Optimum filter (Receiver) Design:

→ The optimum filter is used to detect the baseband signals and unmodulated passband signals.

→ Transmitted signal sequence is 10011. Pulse checked at the point 'T'.

Requirements of signal receiver:-

→ Signal to noise ratio must be improved.

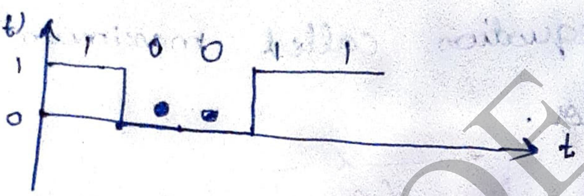
→ Signal must be checked when signal to noise ratio is maximum.

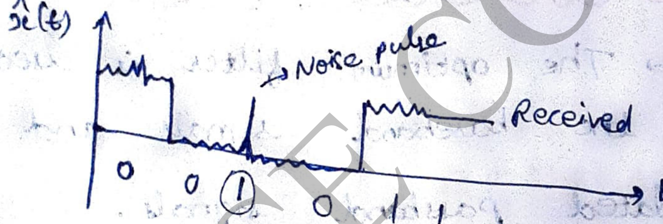
→ error probability should be minimum.

Matched filter:-

→ It statisfies all the above requi requirements.

→ It is called matched filter sinc its impulse response is matched to shape of input signal.





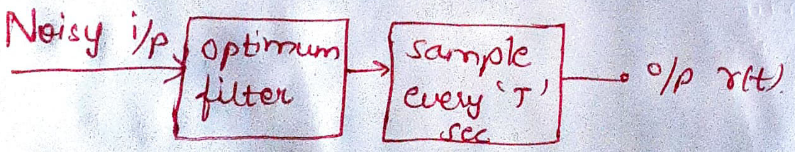
↳ error due to noise.

Decision threshold in optimum filter:-

→ binary 1 ; $x_1(t) = +A$

→ binary 0 ; $x_2(t) = -A$

→ Thus the i/p S/l $x(t)$ will be either $x_1(t)$ or $x_2(t)$ depending upon the polarity of the NRZ signal.



→ i/p to the receiver $= x(t) + n(t)$

→ o/p from the receiver $= x_{01}(T) + n_0(T)$

(or)

$x_{02}(T) + n_0(T)$

When noise is absent:-

$r(t) = x_{01}(T)$; $x(t) = x_1(t)$

$r(t) = x_{02}(T)$; $x(t) = x_2(t)$

When noise is present:

$$\text{Decision boundary} = \frac{x_{01}(T) + x_{02}(T)}{2}$$

Error condition:

→ $x_{01}(T) > x_{02}(T)$

$$n_0(T) \geq \frac{x_{01}(T) + x_{02}(T)}{2} - x_{02}(T)$$

$$n_0(T) \geq \frac{x_{01}(T) - x_{02}(T)}{2}$$

$x_{02}(T) > x_{01}(T)$

$$n_0(T) \leq \frac{-x_{01}(T) + x_{02}(T)}{2} - x_{01}(T)$$

$$n_0(T) \leq \frac{x_{02}(T) - x_{01}(T)}{2}$$

Error Probability:-

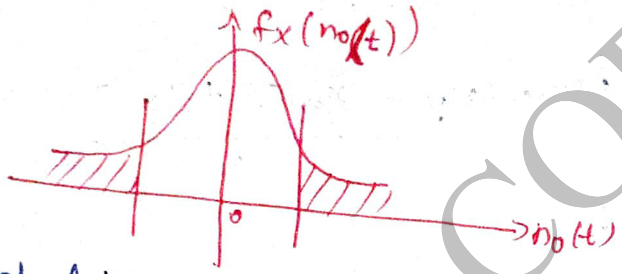
Gaussian Noise:-

$$f_X(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-m)^2/2\sigma^2}$$

$f_X(x)$ is the pdf of random variable x

$m \rightarrow$ mean value

$\sigma \rightarrow$ standard deviation



Probability that $n_o(t)$ takes value is shaded area.

$$P\left[n_o(t) \geq \frac{x_{o1}(T) - x_{o2}(T)}{2}\right] = P\left[n_o(t) \leq \frac{-x_{o2}(T) - x_{o1}(T)}{2}\right]$$

Error Probability

$$P_e = P\left[n_o(t) \geq \frac{x_{o1}(T) - x_{o2}(T)}{2}\right] = P\left[n_o(t) \leq \frac{-x_{o2}(T) - x_{o}(}{2}\right.$$

$$P_e = \frac{1}{2}\,\mathrm{erfc}\left[\frac{x_{o1}(T) - x_{o2}(T)}{2\sqrt{2}\,\sigma}\right]$$

—— x ——

Matched filter:-

→ The optimum filter becomes matched filter when white Gaussian noise is present.

Max s/l to noise power Ratio:

→ standard deviation

$\sigma = [\text{Mean square value} - \text{square of mean value}]^{1/2}$

$\sigma = \overline{x}^2 = \overline{n_0^2(t)}$

→ signal power, the erfc function is the monotonically decreasing function, therefore 'Pe' decreases as the ratio $\dfrac{x_{01}(T) - x_{02}(T)}{\sigma}$

$$\rho = \frac{x_0^2(T)}{\sigma^2}$$

$$x_0(T) = x_{01}(T) - x_{02}(T)$$

$$x_0(f) = H(f)\, x(f)$$

$$x_0(T) = \text{IFT}\{X_0(f)\}$$

$$= \int_{-\infty}^{\infty} X_0(f)\, e^{j2\pi f t}\, df$$

$$= \int_{-\infty}^{\infty} H(f)\, X(f)\, e^{j2\pi f T}\, df$$

I/p & o/p power spectral densities of noise are related as

$$S_{no}(f) = |H(f)|^2 S_{ni}(f)$$

$$S_{ni}(f) = \frac{N_0}{2}$$

$$S_{no}(f) = |H(f)|^2 \cdot \frac{N_0}{2}$$

$$\rho = \frac{x_0^2(T)}{\sigma^2}$$

$$= \frac{\left| \int_{-\infty}^{\infty} H(f)\, X(f)\, e^{j2\pi f T} df \right|^2}{\int_{-\infty}^{\infty} |H(f)|^2 \frac{N_0}{2} df}$$

use of schwarz's inequality

$$\theta_1(f) = \sqrt{\frac{N_0}{2}}\, H(f)$$

$$\theta_2(f) = \frac{1}{\sqrt{\frac{N_0}{2}}} X(f)\, e^{j2\pi f T}$$

$$P = \frac{\left| \int_{-\infty}^{\infty} \theta_1(f) \cdot \theta_2(f)\, df \right|^2}{\int_{-\infty}^{\infty} |\theta_1(f)|^2 df}$$

Max error probability of a Matched filter

$$P_{max} = \left[\frac{x_{01}(T) - x_{02}(T)}{\sigma} \right]^2$$

Parseval's power theorem states that,

$$\int_{-\infty}^{\infty} |X(f)|^2 df = \int_{-\infty}^{\infty} x^2(t)\, dt = \int_{0}^{T} x^2(t)\, dt$$

$$P_e = \frac{1}{2} \operatorname{erfc} \sqrt{\frac{E}{N_0}}$$

———x———

Impulse Response of a matched filter:-

→ Impulse response can be obtained from the transfer function of the matched filter.

Transfer function of matched filter:-

→ Transfer function of the matched filter should be maximize the s/l to nois power ratio.

$$P \leq \int_{-\infty}^{\infty} \frac{|X(f)|^2}{\frac{N_0}{2}} df.$$

$$H(f) = K . \frac{X^*(f)}{\frac{N_0}{2}} e^{-j2\pi fT}.$$

Transfer function of matched filter

$$H(f) = \frac{2K}{N_0} X^*(f) \, e^{-j2\pi ft}$$

Impulse response:-

Impulse response can be obtained by taking inverse fourier tranform of the transfer function of matched filter.

$$H(f) = \frac{2K}{N_0} X(f) \, e^{-j2\pi ft}$$

$$h(t) = IFT\{H(f)\}$$

$$= IFT\left\{ \frac{2K}{N_0} X(-f) \, e^{-j2\pi fT} \right\}$$

$$F.T\{x(-T)\} = X(f)$$

$$F.T\{x(T-t)\} = X(-f)\, e^{-j2\pi f T}$$

Impulse response of matched filter

$$h(t) = \frac{2K}{N_0}\{x_1(T-t) - x_2(T-t)\}$$

Properties of matched filter:-

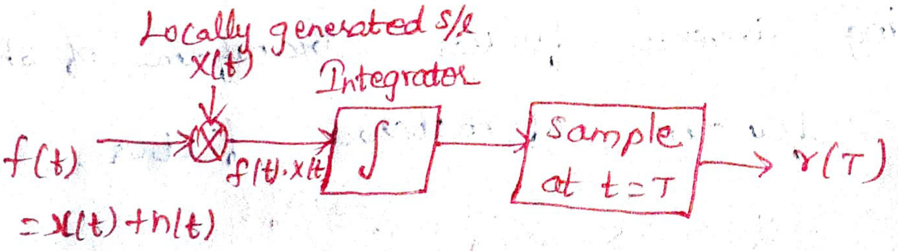
→ signal to noise ratio of the matched filter depends only upon the ratio of signal energy.

→ The o/p s/l of a matched filter is proportional to a shifted version of the autocorrelation function of the i/p s/l to which the filter is matched.

—x—

Correlation Receiver:-

Different types of receiver is called correlator.



→ The adjacent figure f(t) represents i/p noisy s/l, f(t) = x(t)+n(t).

→ f(t) multiplied with $x(t)$ & it is integrated by integrator.

→ Then based on the sampled value decision is made.

$$r(t) = \int_0^T f(t) \cdot x(t)\, dt$$

$$t = T$$

$$r(T) = \int_0^T f(t) \cdot x(t)\, dt.$$

fig:- Matched filter receiver.

$$r(t) = f(t) * h(t) = \int_{-\infty}^{\infty} f(\tau) \cdot h(t-\tau)\, d\tau.$$

$$h(t) = \frac{2K}{N_0} x(T-t)$$

$$h(t-\tau) = \frac{2K}{N_0} x(T-t+\tau)$$

$$r(t) = \int_{-\infty}^{\infty} f(\tau) \frac{2K}{N_0} x(T-t+\tau)\, d\tau.$$

$$r(T) = \frac{2K}{N_0} \int_0^T f(t)\, x(t)\, dt$$

———— x ————

Probability of error for coherently detected BPSK:-

→ In binary PSK (BPSK), the phase of the carrier is shifted by 180° for two symbols.

binary 1 ⇒ $x_1(t) = \sqrt{2P}\cos(2\pi f_0 t)$

binary 0 ⇒ $x_2(t) = -\sqrt{2P}\cos(2\pi f_0 t)$

$$x_2(t) = -x_1(t)$$

$$P_e = \frac{1}{2}\operatorname{erfc}\left\{\frac{x_{01}(T) - x_{02}(T)}{2\sqrt{2}\,\sigma}\right\}$$

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{2}{N_0}\int_0^T x^2(t)\,dt.$$

$$x(t) = 2x_1(t)$$

$$= \frac{8}{N_0}\int_0^T x_1^2(t)\,dt$$

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]^2_{max} = \frac{8}{N_0}\cdot E$$

$$\left[\frac{x_{01}(T) - x_{02}(T)}{\sigma}\right]_{max} = \sqrt{\frac{8E}{N_0}}$$

$$P_e = \frac{1}{2}\operatorname{erfc}\sqrt{\frac{E}{N_0}}$$

$$\boxed{P_e = Q\sqrt{\frac{2E}{N_0}}}$$

Error probability of binary FSK:-

Probability of error for coherently detected binary orthogonal FSK:-

→ In the binary FSK transmission, two different carrier frequencies are used to transmit two binary levels.

binary 1 ⇒ $x_1(t) = \sqrt{2P}\cos(2\pi f_0 + \Omega)t$

binary 0 ⇒ $x_2(t) = \sqrt{2P}\cos(2\pi f_0 - \Omega)t$

$$x_1(t) - x_2(t) = \sqrt{2P}\left\{\cos(2\pi f_0 + \Omega)t - \cos(2\pi f_0 - \Omega)t\right\}$$

$$\left[x_1(t) - x_2(t)\right]^2 = 2P\left[\cos(2\pi f_0 + \Omega)t - \cos(2\pi f_0 - \Omega)t\right]^2$$

$$= 2P\left[-2\sin 2\pi f_0 t \sin \Omega t\right]^2$$

$2\pi f_0 = \omega_0$

$$= 2P\left[4\sin^2\omega_0 t \cdot \sin^2\Omega t\right]$$

$$= 2P\left[(2\sin^2\omega_0 t)(2\sin^2\Omega t)\right\}$$

$$\left\{x_1(t) - x_2(t)\right\}^2 = 2P\left\{(1 - \cos 2\omega_0 t)(1 - \cos 2\Omega t)\right\}$$

$$= 2P\left\{1 - \cos 2\Omega t - \cos 2\omega_0 t + \cos 2\omega_0 t \cos 2\Omega t\right\}$$

$$\int_0^T \left[x_1(t) - x_2(t)\right]^2 dt = \int_0^T 2P\left\{1 - \cos 2\Omega t - \cos 2\omega_0 t + \frac{1}{2}\left[\cos 2(\omega_0 - \Omega)t + \cos 2(\omega_0 + \Omega)t\right\}dt\right.$$

$$\int_0^T [x_1(t) - x_2(t)]^2 dt = 2PT\left\{1 - \frac{\sin 2\Omega T}{2\Omega T}\right\}$$

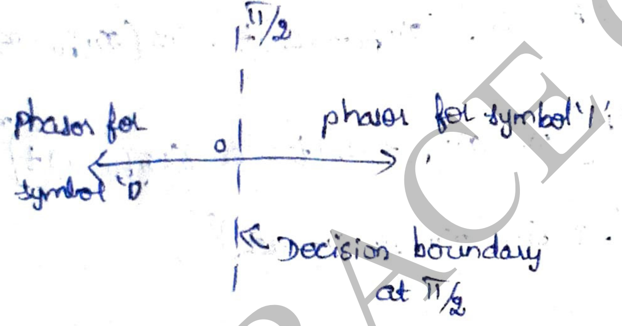
$$P_e = \frac{1}{2}\,\text{erfc}\sqrt{\frac{0.6E}{N_0}}$$

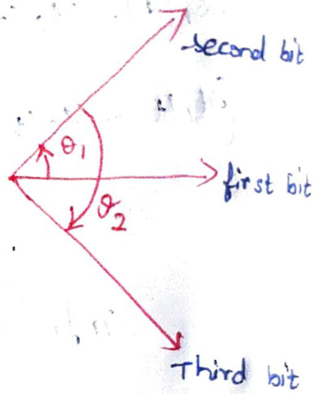
Probability of error for Non-Coherently detected binary orthogonal FSK :-

$$P_e = \frac{1}{2}\, e^{-E/2N_0}$$

→ it depends on signal energy.

Probability of error for binary orthogonal Di





→ Decision device '1'

difference b/w two consecutive bits differs by $< \pi/2$

→ Decision device '0'

difference b/w two consecutive bits differs by $> \pi/2$

$$E = 2E_b$$

$$P_e = \frac{1}{2}\, e^{-E_b/N_0}$$

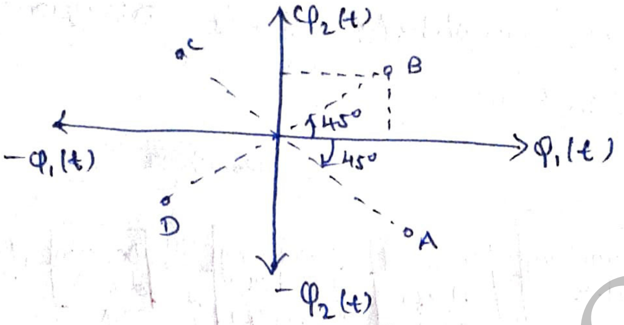
This is called average probability of error.

Probability of error for QPSK:-

$$P_e = \frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{E_s\cos^2\theta}{N_0}}$$

→ consider the receiver for QPSK s/l.

$$P_{e1} = \frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{E_s\cos^2\theta}{N_0}}$$



$$P_{e2} = \frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{E_s\cos^2\theta}{N_0}}$$

$$P_{e1} = P_{e2} = \frac{1}{2}\,\mathrm{erfc}\sqrt{\frac{E_s\cos^2 45^\circ}{N_0}}$$

$$= \mathrm{erfc}\sqrt{\frac{E_s}{2N_0}}$$

Error Probability of QPSK $P_e = \mathrm{erfc}\sqrt{\frac{E_s}{2N_0}}$

$$\boxed{P_e = 2Q\sqrt{\frac{2E_b}{N_0}}} \quad \because E_s = 2E_b$$

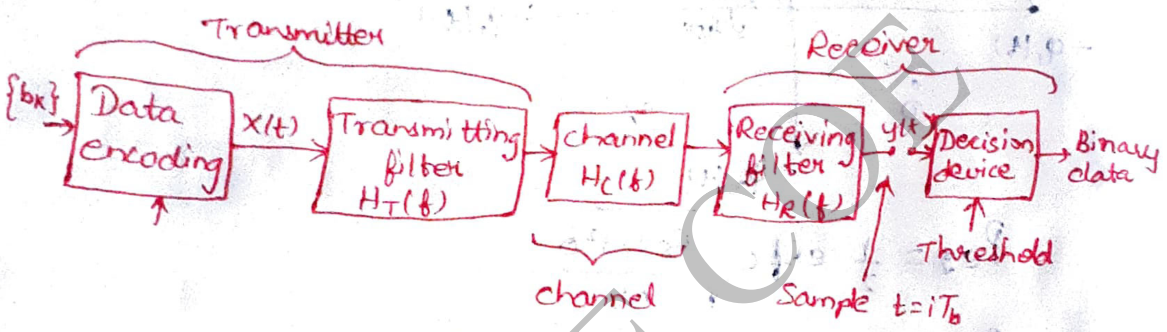
——— x ———

Intersymbol Interference (ISI) :-

Baseband Transmission of binary data:

→ In baseband transmission, there is no modulation of high frequency carrier.

→ Two amplitude levels corresponding to binary 1 and 0.



→ These signals transmitted over the channel in baseband transmission

$$x(t) = \sum_{k=-\infty}^{\infty} A_k \, g(t - kT_b)$$

$$A_k = \begin{cases} +a & \text{if } b_k = 1 \\ -a & \text{if } b_k = 0 \end{cases}$$

T_b → Duration of each i/p binary bit

$g(t)$ → shaping pulse.

$x(t)$ passed through transmitting filter $H_T(f)$

The signal then passed to $H_C(f)$ receiving filter. Combined ~~together~~ transfer function $H_R(f)$

Output is $y(t)$.

$y(t_i) > \lambda \Rightarrow$ symbol '1'

$y(t_i) \leq \lambda \Rightarrow$ symbol '0'

ISI:

→ The presence of outputs due to other bits interfere with the o/p of required bit. This effect is called ISI.

$$y(t_i) = \mu A_i$$

→ ISI can be reduced by proper design of pulse spectrum $G(f)$, $H_R(f)$ & $H_C(f)$.

ISI Problem:

$$y(t) = \mu \sum_{k=-\infty}^{\infty} A_k \, p(t - kT_b)$$

μ → scaling factor

$p(t)$ → shape different from $g(t)$.

$$\mu A_k P(f) = H(f) A_k G(f)$$

$\Downarrow$

Fourier transform of $g(t)$ be $G(f)$.

" " " $P(t)$ be $P(f)$

$H(f)$ combined transfer function of transmitting filter,

$$H(f) = H_T(f) \cdot H_C(f) \cdot H_R(f)$$

$$y(t_i) = \mu A_i P(0) + \mu \sum_{k=-\infty}^{\infty} A_k P[(i-k)T_b]$$

$$i = 0, \pm 1, \pm 2, \ldots$$

——— x ———

Nyquist criterion for Distortionless transmission

Nyquist pulse shaping criterion:

Time domain criterion:

→ To eliminate ISI second term of summation must be zero, p(t) is

$$p[(i-k)T_b] = \begin{cases} 1 & , \text{ for } i=k \\ 0 & , \text{ for } i \neq k \end{cases}$$

p(t) satisfies the above conditions

$$y(t_i) = \mu A_i$$

Frequency domain:

$$P_\delta(f) = f_b \sum_{n=-\infty}^{\infty} P(f - nf_b)$$

→ p(t) → periodic with period f_b.

$$P_\delta(t) = \sum_{n=-\infty}^{\infty} p(nT_b)\,\delta(t - nT_b)$$

Take F.T.

$$P_\delta(f) = \int_{-\infty}^{\infty} P_\delta(t) \cdot e^{-j2\pi f t}\,dt$$

$$= \int_{-\infty}^{\infty} \left[\sum_{n=-\infty}^{\infty} p(nT_b) \cdot \delta(t - nT_b) \right] e^{-j2\pi f t}\,dt$$

$n = i - k$

$$P_\delta(f) = \int_{-\infty}^{\infty} \sum_{K=-\infty}^{\infty} p[(i-k)T_b] \cdot \delta[t - (i-k)T_b]\, e^{-j2\pi f t}\,dt$$

$$P_\delta(f) = \begin{cases} \int_{-\infty}^{\infty} p(0)\, \delta(t)\, e^{-j2\pi f t}\, dt & ; \text{for } i=k \\ \int_{-\infty}^{\infty} 0\, \delta(t)\, e^{-j2\pi f t}\, dt & ; \text{for } i \neq k \end{cases}$$

$$P_\delta(f) = \int_{-\infty}^{\infty} p(0)\, \delta(t)\, e^{-j2\pi f t}\, dt$$

$$P_\delta(f) = p(0) \; ; \text{for } i=k.$$

$$\sum_{n=-\infty}^{\infty} P(f - n f_b) = \frac{1}{f_b}$$

$$\frac{1}{f_b} = T_b$$

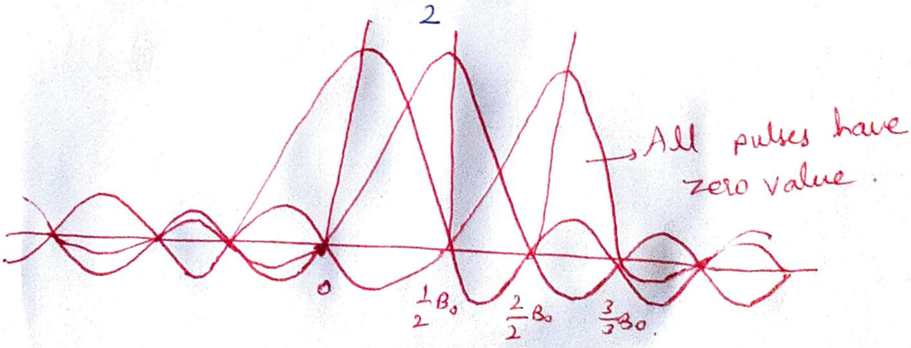
Nyquist Bandwidth:-

B_0 is called Nyquist Bandwidth. It is the minimum transmission bandwidth for zero ISI.

$$\text{Bit period } T_b = \frac{1}{2B_0}$$

$$\text{Nyquist Bandwidth } B_0 = \frac{1}{2T_b}$$

$$B_0 = \frac{\text{Bitrate}}{2}$$



Ideal sinc pulse physically not possible

$$p(t) = \text{sinc}(2B_0 t)$$

$$P(f) = \frac{1}{2B_0} \text{rect}\left(f/2B_0\right)$$ ⇒ fourier transfor

$$P(f) = \begin{cases} \frac{1}{2B_0} & \text{for } -B_0 < f \leq B_0 \\ 0 & \text{elsewhere} \end{cases}$$

Merits:-

→ it eliminates ISI

→ easy method.

Limitations:-

The transmission of escact sinc pulse is physically not possible.

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PROGRESS THROUGH KNOWLEDGE

ECE Department

1st Semester | 2nd Semester | 3rd Semester | 4th Semester

5th Semester | 6th Semester | 7th Semester | 8th Semester

Click on Subject/Paper under Semester to enter.

1st Semester

- Professional English - I - HS3152
- Matrices and Calculus - MA3151
- Engineering Physics - PH3151
- Engineering Chemistry - CY3151
- Problem Solving and Python Programming - GE3151

2nd Semester

- Professional English - II - HS3252
- Statistics and Numerical Methods - MA3251
- Engineering Graphics - GE3251
- Physics for Electronics Engg - PH3254
- Basic Electrical & Instru Engg - BE3254
- Circuit Analysis - EC3251

3rd Semester

- Random Process and Linear Algebra - MA3355
- C Programming and Data Structures - CS3353
- Signals and Systems - EC3354
- Electronic Devices and Circuits - EC3353
- Control Systems - EC3351
- Digital Systems Design - EC3352

4th Semester

- Electromagnetic Fields - EC3452
- Networks and Security - EC3401
- Linear Integrated Circuits - EC3451
- Digital Signal Processing - EC3492
- Communication Systems - EC3491
- Environmental Sciences and Sustainability - GE3451

5th Semester

- Wireless Communication - EC3501
- VLSI and Chip Design - EC3552
- Transmission Lines and RF Systems - EC3551
- Elective 1
- Elective 2
- Elective 3

6th Semester

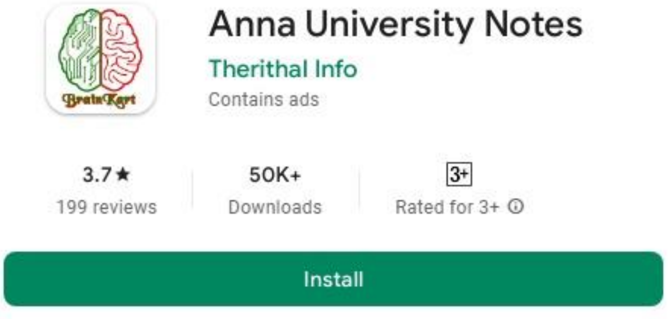
- Embedded Systems and IOT Design - ET3491
- Artificial Intelligence and Machine Learning - CS3491
- Open Elective-1
- Elective-4
- Elective-5
- Elective-6

7th Semester

- Human Values and Ethics - GE3791
- Open Elective 2
- Open Elective 3
- Open Elective 4

8th Semester

- Project Work / Intership



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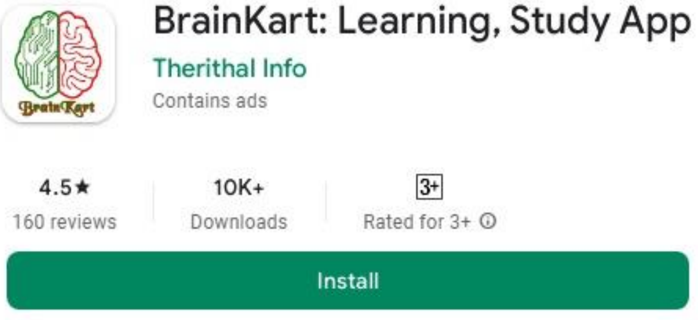

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All ECE Engg Subjects - [B.E., M.E.,] (Click on Subjects to enter)

Circuit Analysis	Digital Electronics	Communication Theory
Basic Electrical and Instrumentation Engineering	Electrical Engineering and Instrumentation	Principles of Digital Signal Processing
Electronic Devices	Linear Integrated Circuits	Signals and Systems
Electronic Circuits I	Electronic Circuits II	Digital Communication
Transmission Lines and Wave Guides	Control System Engineering	Microprocessors and Microcontrollers
Computer Architecture	Computer Networks	Operating Systems
RF and Microwave Engineering	Medical Electronics	VLSI Design
Optical Communication and Networks	Embedded and Real Time Systems	Cryptography and Network Security
Probability and Random Processes	Transforms and Partial Differential Equations	Physics for Electronics Engineering
Engineering Physics	Engineering Chemistry	Engineering Graphics
Problem Solving and Python Programming	Object Oriented Programming and Data Structures	Environmental Science and Engineering
Principles of Management	Technical English	Total Quality Management
Professional Ethics in Engineering	Engineering Mathematics I	Engineering Mathematics II