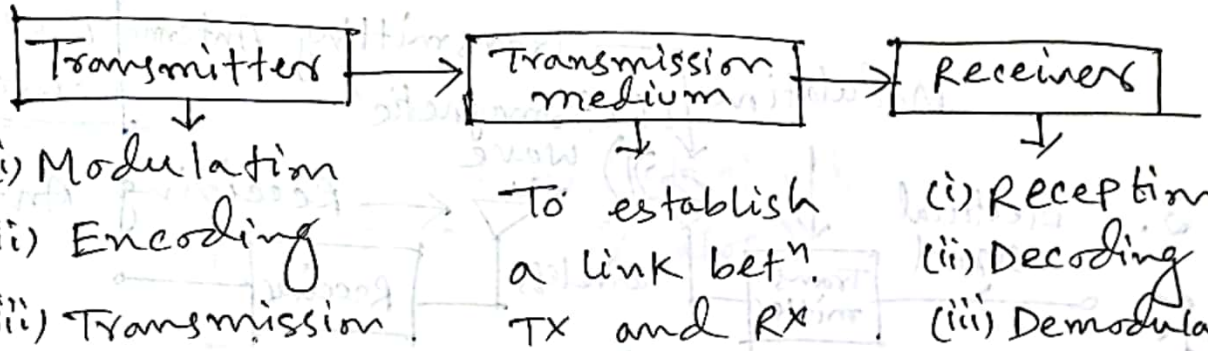
→ Mathematica 5.1 install করতে হবে

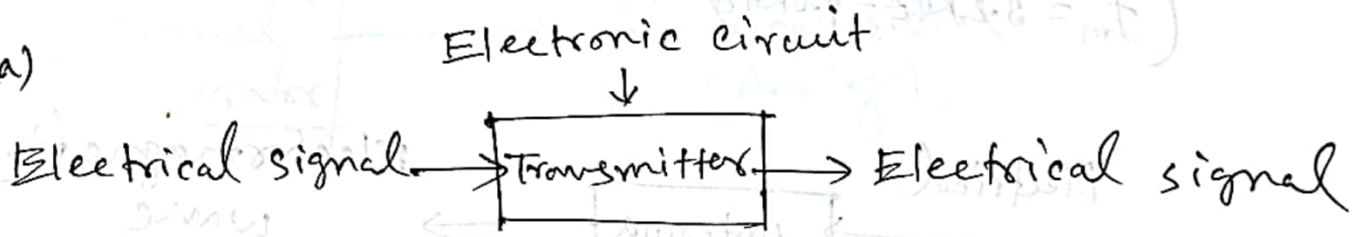
Lec-01; Week-01
Date: 04.03.23

Section - A

1. Basic block diagram of communication system

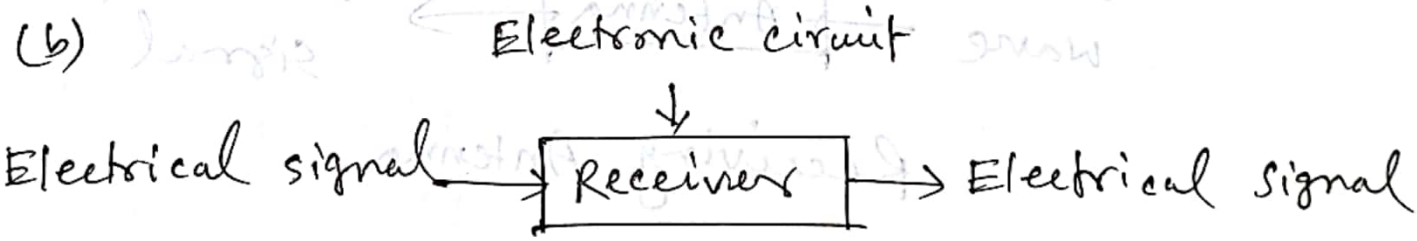


2(a)

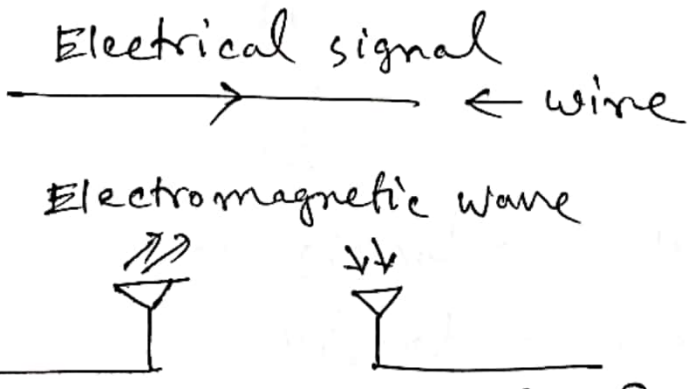


→ Electronic circuit always electrical signal input নেয় এবং output দেয়

(b)



(c)



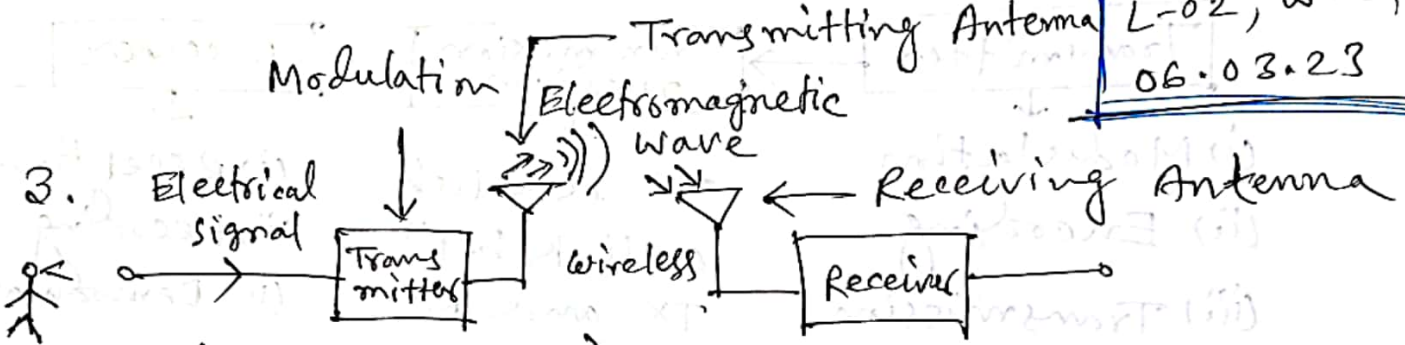
→ যেকোন magnetic field যেটা create হয় সেগুলোকে electromagnetic wave বলা হয়

→ Sound is physical signal not mechanical
It is always analog (by born)

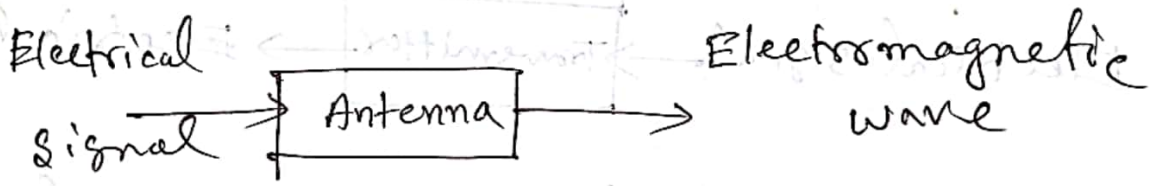
Wireless medium = Radio link

L-02; W-01
06.03.23

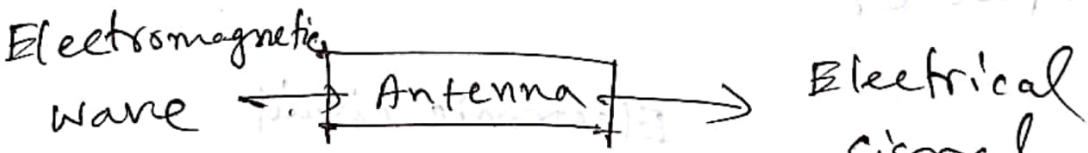
3.



(f_m = 3.2KHz – 4.0KHz)



Transmitting Antenna



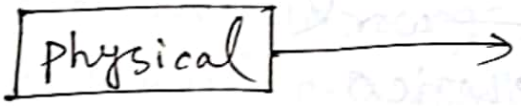
Receiving Antenna

L-03; W-02
11.03.23

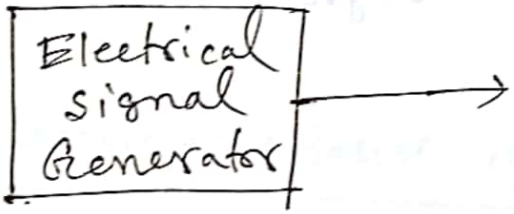
4. Digital communication

(a) Electrical signal two types
(i) Analog signal
(ii) Digital signal

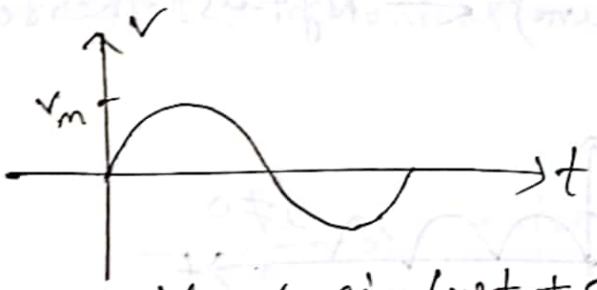
(i) Analog signal



∴ Electrical signal (Analog)



Electrical signal (Analog)



$V = V_m \sin(\omega t + \varphi)$

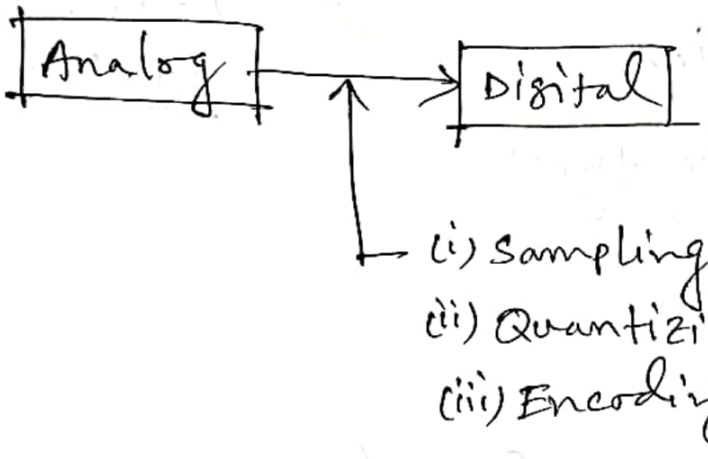
Properties

(i) Amplitude
(ii) Frequency
(iii) Phase

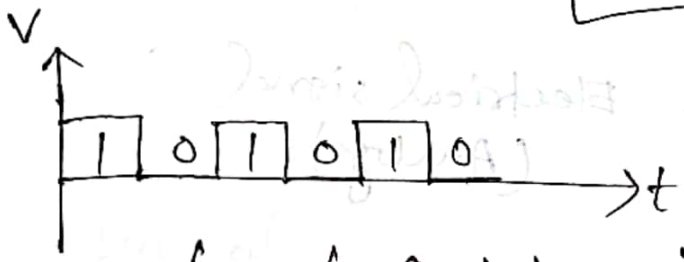
(ii) Digital signal

→ কোনো physical signal বা Electrical signal generator থেকে direct digital signal পাওয়া যায় না।

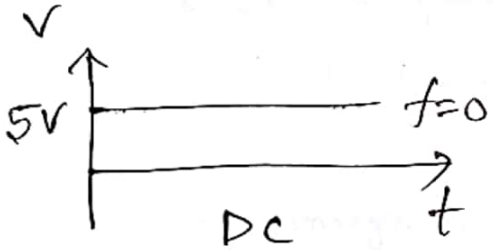
বা, 1. Physical → Analog signal → Digital signal

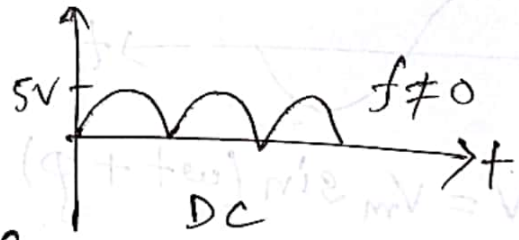


2. Digital : v = 10101010 ← word
- Logic 0
- Logic 1



$f = 2f_m$ (minimum) ← Nyquist theorem

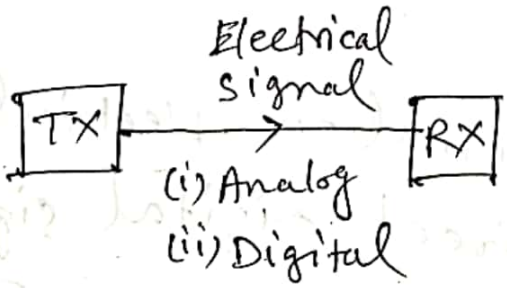


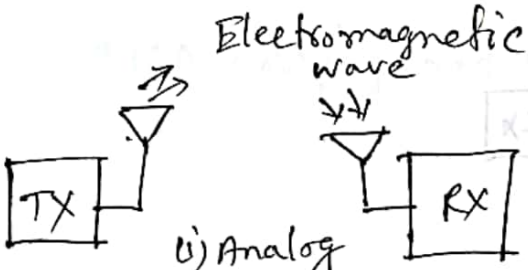


DC = unidirectional

↑ pulsating DC

5. communication





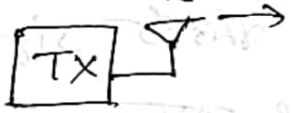
(i) Analog
(ii) Digital

→ Medium ও- Analog signal Pass করলে তবে Analog communication এবং যদি Digital signal Pass করে তবে Digital communication

29.04.23
W-04 ; L-04

Lecture-02 : Basics of wireless communication system

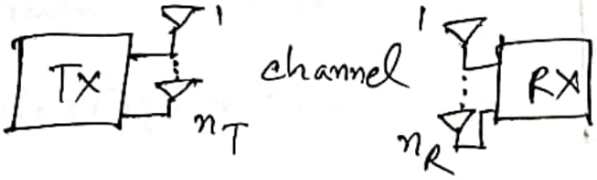
1. Digital communication ⇒ Medium
   (i) wire
   (ii) wireless : channel

2. 

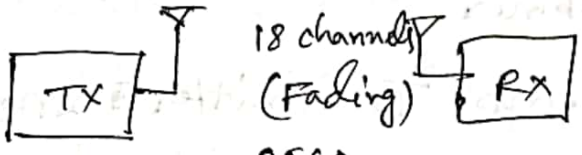
→ Noise ↓ Fading ↓ Interference ↓ → 

→ Practically noiseless system এর হওয়ায় noise এর সাপেক্ষে Antenna এর factor গুলো classification করা হয়

3. Based on antenna configuration

(a) 

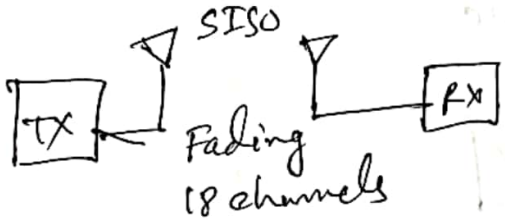
SISO
SIMO
MISO
MIMO

(b) 

SISO

→ Fading channel এ signal ধ্বংস হতে পারে

cc)



cognitive + X + Z = 54

channels

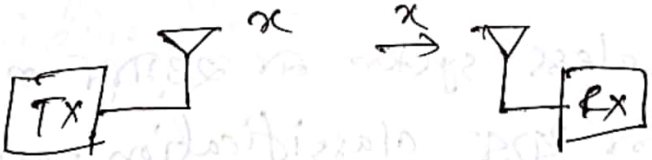
(i) Antenna : 4
(ii) Fading : 18
} 72 Fading channel
(iii) Interference : 3
} 216 Fading - interference channels

→ বন্ধুর যেহেতু খুব তাড়াতাড়ি তথ্য (Ex. resistance ; V=IR) যেহেতু fading খুব হয় (Fading তাড়াতাড়ি বন্ধুর)

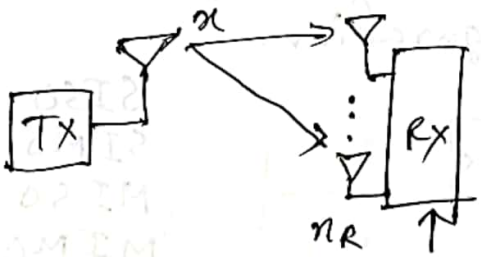
→ Noise signal তুমার add হয়

$$y = hx + z$$

1. কোনো তারের transmitter থেকে যতটুকু signal সমস্ত receiver এ-তোমার receive হয়



2.



Combiner

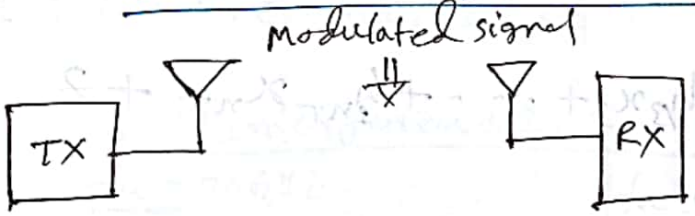
Receiver এ combiner থাকে Transmitter এ থাকে না

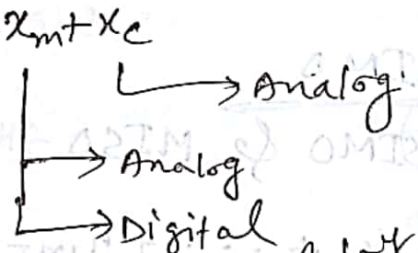
L-05; W-04
02.05.23

SIMO configuration

$$y_1 = h_1 x + z_1$$
$$y_2 = h_2 x + z_2$$
$$y_3 = h_3 x + z_3$$
$$\vdots$$
$$y_{n_R} = h_{n_R} x + z_{n_R}$$
$$\underline{y} = h\underline{x} + \underline{z}$$

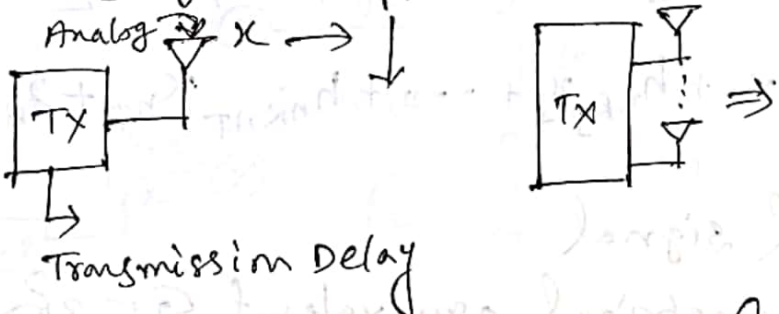
MISO configuration





(i)

x = Bangladesh propagation delay $x = 11010110$



→ Analog এর ক্ষেত্রে transmission delay বেশী হয়

→ Transmitter এ multiple antenna use করলে transmission delay কমে যায়

→ Multiple bit accept এ-ফলে delay না হয়ে সেকেন্ডে

multiplexing ব্যবহার করা হয়

Basic Multiplexing techniques

1. TDM
2. FDM
3. CDM
4. SDM

→ Transmitter এ multiple antenna use করলে capacity বাড়ে। প্রতি সেকেন্ডে যতগুলো bit transmitted হয় সেটাই capacity

(ii) $y = h_{11}x_{1} + h_{12}x_2 + h_{13}x_3 + \cdots + h_{1n_T}x_{n_T} + z$

$$y = hx + z$$

MIMO

→ combination of SIMO & MISO

$y_1 = h_{11}x_1 + h_{12}x_2 + h_{13}x_3 + \cdots + h_{1n_T}x_{n_T} + z_1$

$y_2 = h_{21}x_1 + h_{22}x_2 + h_{23}x_3 + \cdots + h_{2n_T}x_{n_T} + z_2$

$y_{n_R} = h_{n_{R1}}x_1 + h_{n_{R2}}x_2 + h_{n_{R3}}x_3 + \cdots + h_{n_R n_T}x_{n_T} + z_{n_R}$

1. Noise: Unwanted signal

→ যেকোনো signal এর electrical equivalent এর ৩টি property থাকে Amplitude, frequency, phase

External Noise

Established কোনো fre. এর সাথে Produced fre. মিশ্রণের ফলে নয়েজ তৈরি হয়

Internal Noise

Device এর internal equipment থেকে তৈরি হয়

→ 2টা fre. এর same হয়ে গেলে noise তৈরি না হয় সেজন্য modulation করা হয়

Analog signal ⟶ Electrical signal ⟶ f_s (low)

⇓

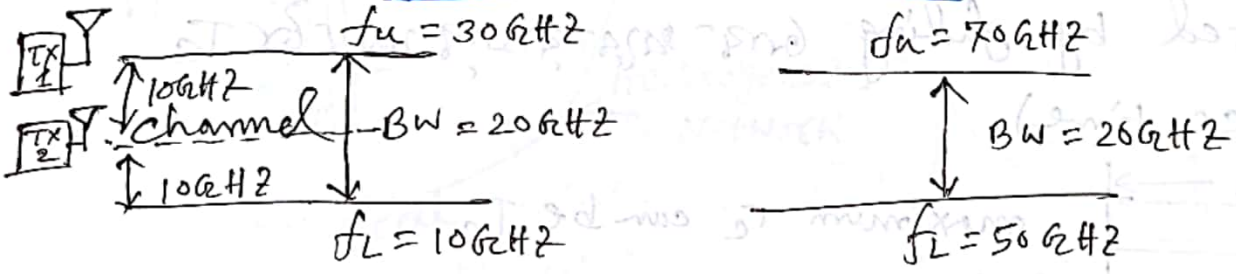
(i) Digital
(ii) Modulation

f_m close to f_s

✱ CT-01 : Leeture - 01, 02, 04 L-06 ; W-05

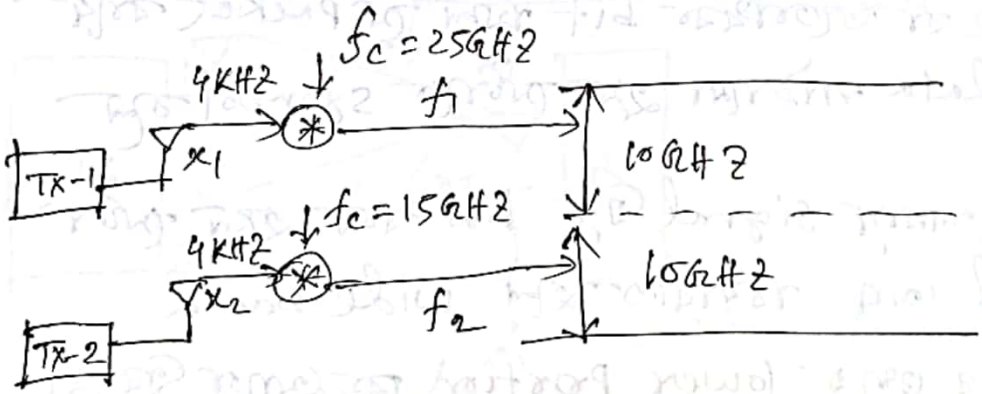
09.05.23

Interference



cost = low

cost = High



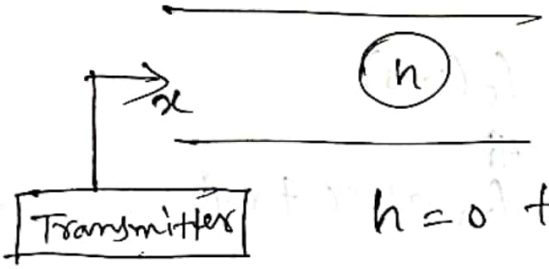
→ Here if $f_1 = f_2$ হলে একটার সাথে আরেকটা লাগার সম্ভাবনা থাকে interference হবে

→ High fre. কে modulate করলে Noise কম হয়

→ Carrier fre. বাড়ালে interference reduced হয়

Fading

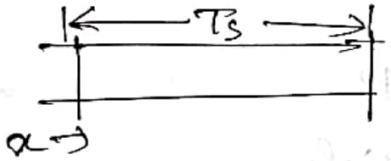
কোনো channel এর মধ্যদিয়ে signal যাওয়ার সময় medium এর যে property signal কে বাধা দেয় তাকে fading বলে



h=0 → No signal ; h=1 → y=x+z

→ উদ্দেশ্য target h=1 করা

→ কোনো signal কে medium এর মধ্যে বাধাকে বলে correlated by fading এবং যতক্ষণ পর্যন্ত T_c (Coherence time)



maximum T_c can be T_s

→ symbol = 2 বা ততোধিক bit সমন্বয়ে যে packet করে data পাঠানো হয় তাকে symbol বলে

→ channel এর তুলনায় signal এর bw কম হলে তাকে narrow band এবং বিপরীতে হলে wide band wide band এর ক্ষেত্রে lower portion কে আলাদা এবং upper portion কে আলাদা transmit করতে হবে

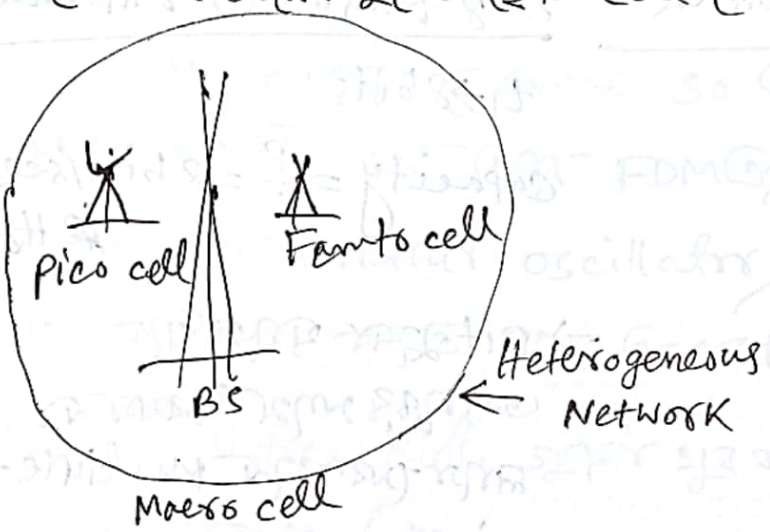
→ একটি channel কে অন্য channel থেকে যে Property গুলোর দ্বারা আলাদা করা হয় তাদেরকে ঐ channel এর measure বলে

$f_\alpha(\alpha) = 2\alpha^2 + 3$ ← Given

→ Base station-এর coverage area-অনুযায়ী cell-গুলো

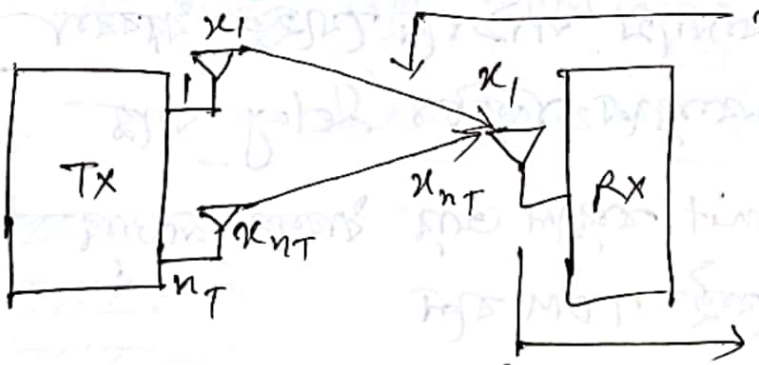
(i) Macro cell
(ii) Micro cell
(iii) Pico-cell
(iv) Femto cell

→ যে cell অনেকগুলো ছোট cell কে নিয়ে গঠিত হবে তাকে Macro cell



L-07; W-06
13.05.23

Multiple Access Techniques



x_1 and x_2 interacts ⇒ correlation

if $d \leq \frac{\lambda}{2}$, correlation

if $d > \frac{\lambda}{2}$, no correlation

d = spacing bet^n two antennas

Problems:
(i) Interference at receiver
(ii) correlation

} Solution: Multiplexing

Multiplexing

1. FDM
2. TDM
3. CDM
4. SDM

Time Division Multiplexing

Bangladesh = 11011011

TDMA - Time আলাদা but fre. Same

1. One transmitter antenna

$t_1 \rightarrow 1$
$t_2 \rightarrow 1$
$t_3 \rightarrow 0$
$t_4 \rightarrow 1$
$t_5 \rightarrow 1$
$t_6 \rightarrow 0$
$t_7 \rightarrow 1$
$t_8 \rightarrow 1$

2. 8 transmitter antenna

$t_1 \rightarrow 8$ bits

$\text{capacity} = \frac{8}{1} = 8$ bits/sec ~~Hz~~

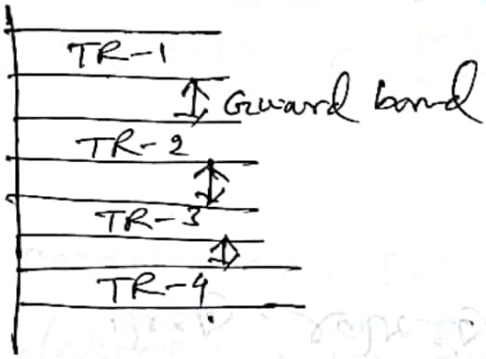
→ Bitগুলোর যাতে একে অন্যের সাথে ব্যবধান না লাগে সেজন্যে Multiplexing করা হয়

→ 8টা antenna থেকে একসাথে পাঠানো যেহেতু ব্যবধান লাগার সম্ভাবনা থাকে সেজন্যে কিছুটা delay করে একে একটা bit transmit করানো যাতে ব্যবধান লাগার সম্ভাবনা থাকে না এটাকেই TDM বলে

capacity

$C = B \log(1+SNR)$
$= B \log_2(1+SNR)$ bits/sec
$= B \log_e(1+SNR)$ nats/symbol

Frequency Division Multiplexing



FDM এ time same fre. অবস্থায়

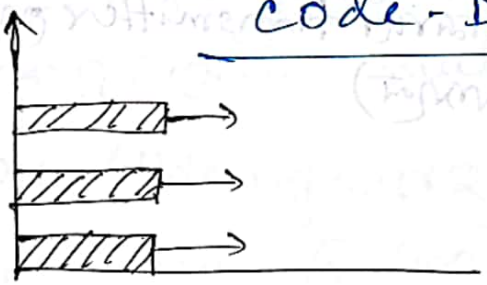
→ TDM তুলনামূলকভাবে slow যেহেতু time delay করে bit গুলো পাঠানো হয়। FDM fast

→ TDM এ fre যেহেতু same so একটা oscillator ব্যবহার use করলেই হয় কিন্তু FDM এর ক্ষেত্রে যেহেতু fre আলাদা so আলাদা আলাদা oscillator প্রয়োজন হয়। সেজন্য TDM এ cost কম FDM এ cost বেশী

→ FDM এ fre. diff. গুলো খুব কম হওয়ায় তেমন delay হয়না, $V = f\lambda$

→ GP start করে TDM এর citycell CDM দিয়ে

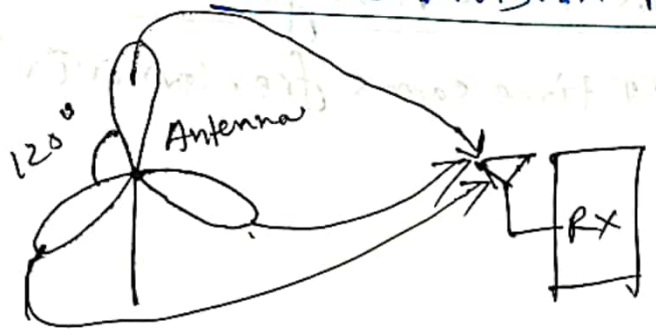
code-Division Multiplexing



→ fre. same

→ প্রত্যেকটা information কে code এ convert করা হয় এবং 2টা code কখনো একসাথে থাকেনা

Space Divisim Multiplexing



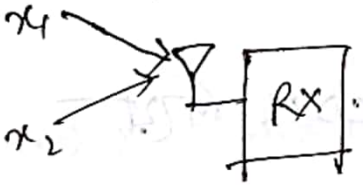
→ SDM এর internal function TDM এর মতো কিন্তু এখানে space কে divide করা হয়ে থাকে...

L-08; W-06
16.05.23

Multiplexing

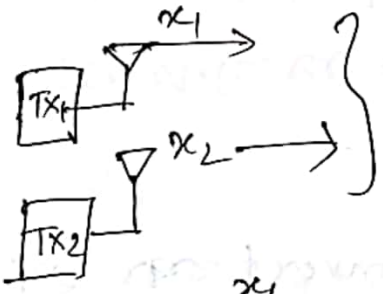
(i) TDM
(ii) FDM
(iii) CDM
(iv) SDM

→ কোনো transmitter থেকে আসা একাধিক signal কে আলাদা করার জন্য ব্যবহৃত প্রক্রিয়াকে correlation বলে



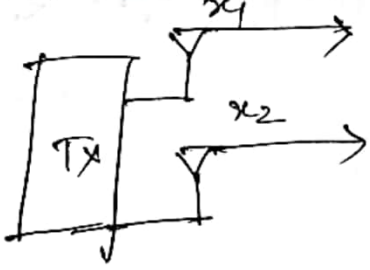
Interaction
$x_1 \Rightarrow x_2$
(i) correlation
(ii) Interference (কোনো transmitter থেকে অন্যটা)

(a)



Interference

(b)



correlation

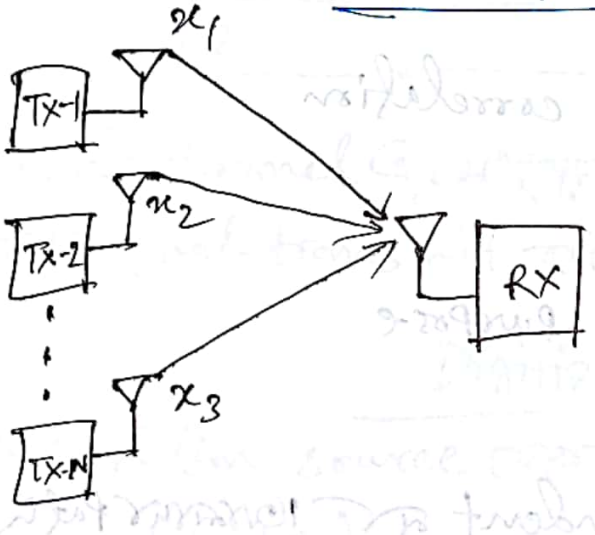
→ correlation & interference এর কারণে capacity কমে

Capacity, $C = \frac{\text{Max. Number of bits}}{\text{Time}}$ (with minimum error Probability)

→ correlation & Interference এর কারণে delay হয় কারণে fading & Noise কেবল affect করবে.

→ একাধিক transmitter এ multiple antenna ব্যবহার করে multiplexing করার হয়

Multiple Access



(i) TDMA.
(ii) FDMA
(iii) CDMA
(iv) SDMA

→ একাধিক transmitter থেকে receiver এ signal transmit করতে যেভাবে multiple access বলে

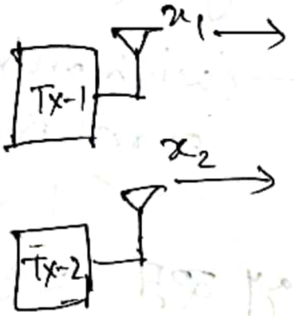
→ Multiplexing করার হয় কারণে correlation না থাকে। সেক্ষেত্রে Multiplexing এ একাধিক transmitter এর একাধিক antenna থেকে signal receiver এ কারণে

⇒ Diff. bet^n correlation & interference?

1(a) correlation → x_1

Interaction bet^n $x_1 \cdots x_{n_T}$

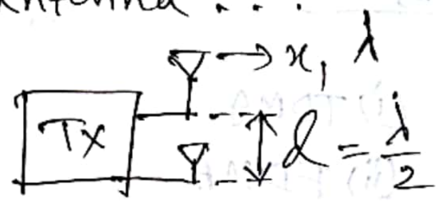
2.(b) Interference:



Interaction betn x_1 & x_2

2. Minimization of correlation
   (i) Antenna spacing adjustment
   (ii) Multiplexing

(i) antenna . . .



No correlation

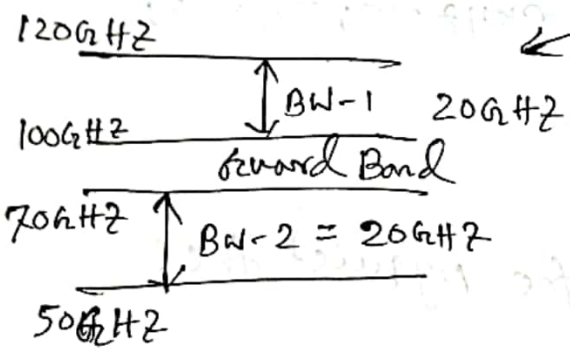
$d > \frac{\lambda}{2}$

It is only for design purpose

(ii) multiplexing
→ wavelength এর উপর dependent না করে বিভিন্ন path দিয়ে signal একই সময়ে ব্যবহার করা হয়

3. ~~(iii)~~ Minimization of interference:
(i) Guard band
(ii) multiple access technique

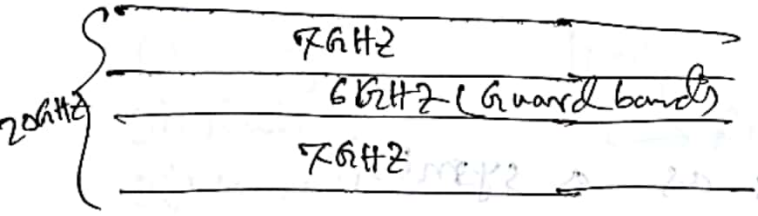
Interference Types:
(i) Co-channel Int.
(ii) Adjacent channel Int.



← speed বেশী

→ Guard band এরকম্ interference হবে না

→ 2টি channel এর মধ্যে interference হতে Guard band exceed করে এলেকে adjacent channel interference বলে



← co-channel Interference

→ একই channel এর ~~একাধিক~~ একাধিক Guard band ব্যবহার করে signal transmit করলে এটাই co-channel Interference

Digitization

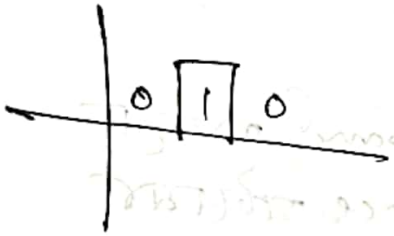
→ Information source থেকে ——→ Electrical signal (Analog)

(Analog) ⇒ Baseband signal

Voice: 3.2KHz - 4KHz
Image:
Text:
Data:
} KHz

→ Baseband signal এর fre. কে double করে এলেকে time এর respect এ ছোট ছোট করে sampling বলে

→ Sampled signal এ continuous অবস্থায় কোটি Amplitude same করাকে quantization বলে



0 এর fre এরমান 8KHz হবে for 4 KHz signal

DC এর fre = 0

Discreter এর fre Nyquist fre.

channel capacity

(i) bits/sec/Hz → $C = B\log_2(1+SNR)$

(ii) nats/symbol

Increasing capacity:

(i) Multiple Antenna

(ii) Transmission of signals as a symbol

(i) $2^2 = 4$ ary symbol

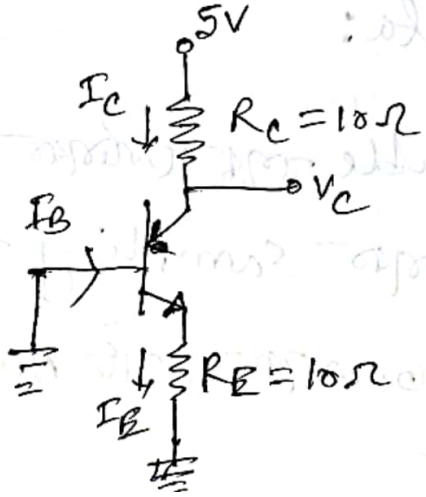
(ii) $2^3 = 8$ ary symbol

(iii) $2^4 = 16$ " "

(iv) $2^5 = 32$ " "

→ symbol এ bit যত বাড়বে power allocation তত বাড়বে এবং loss বেড়ে যাবে

→ Antenna এর সংখ্যা বাড়লে device এর weight বেড়ে যাবে

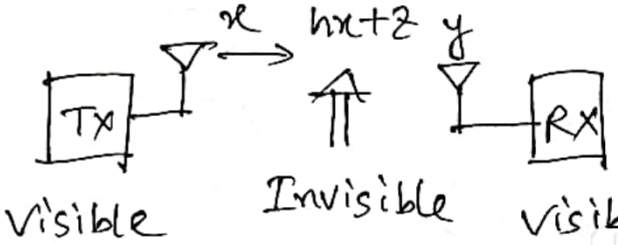


Entropy and Mutual Information

L-09; W-07
23.05.23

Digital communication:

1.



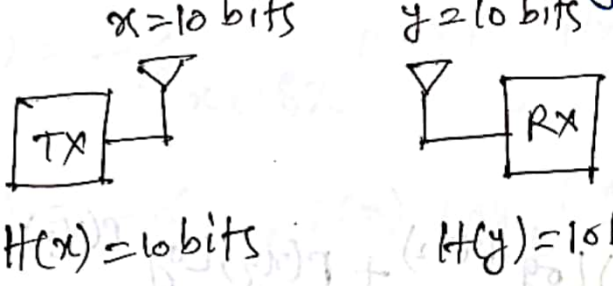
(i) channel
(ii) Information → Information theory (পরবর্তী বড় topic)

Man
(i) Body
(ii) Ruh
(iii) Knowledge

Dead
↳ Ruh + knowledge

2. Information Theory
(i) Entropy
(ii) Mutual Information
(iii) capacity
(a) Engrodic capacity
(b) Outage "

Entropy



→ Transmitter থেকে যে পরিমাণ bit transmit করা হয় receiver এ সেই পরিমাণ bit receive করা যায় না। transmitter এর entropy এবং receiver এর entropy

→ Receiver এর maximum entropy হয় transmitter এর entropy এর সমান

Transmission

(i) Digital → H(x) → H(y)

(ii) Analog → H(x) → y=x H(y)

→ Entropy analog, digital উভয়ের ক্ষেত্রেই হতে পারে

→ x = 11011101 ← Discrete → $H(x) = -\sum_{x \in \mathcal{X}} P(x) \log P(x)$

x = Bangladesh ← continuous

(a) Entropy of Discrete

(ii) $x = \{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8\}$

↑ Belongs to

$\mathcal{X}$ = Matheal x

(i) $x \Rightarrow \{11011101\}$

$\mathcal{X}$

(iii) $x_1 = 1, P(x_1) = 0.5$ (Let)

$x_2 = 1, P(x_2) = 0.6$

$x_3 = 0, P(x_3) = 0.3$

$x_4 = 1, P(x_4) = 0.5$

$x_5 = 1, P(x_5) = 0.7$

$x_6 = 1, P(x_6) = 0.8$

$x_7 = 0, P(x_7) = 1.0$

$x_8 = 1, P(x_8) = 0.9$

$\log 1 = 0$

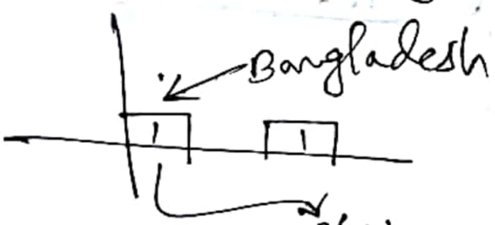
$\log 0 \text{ to } 0.9 = -\{\text{something}\}$

যেকোনো সমান (-) use করা হয়

$$H(x) = -\sum_{x \in \mathcal{X}} P(x) \log P(x)$$

$$= -\left[P(x_1) \log P(x_1) + P(x_2) \log P(x_2) + P(x_3) \log P(x_3) + P(x_4) \log P(x_4) + P(x_5) \log P(x_5) + P(x_6) \log P(x_6) + P(x_7) \log P(x_7) + P(x_8) \log P(x_8)\right]$$

physical meaning of negative sign:



$P(x_1) = 1$ (means transmit হয়েছে কোনো loss হয় নাই)

$P = 0.5$ (signal receive হবে কিন্তু loss হবে)

$= 0$ (signal receive ই হয় নাই)

→ Probability is the measure of the transmission of signal

(b) Entropy of continious random variable

$x \rightarrow P_x(x)$

$H(x) = -\int P_x(x) \log^{P_x(x)} dx$

$H(y) = -\int P_y(y) \log^{P_y(y)} dy$

→ Intigration & diff. is for analog
→ Summation is for digital

continious এ যেহেতু x একাধিক so $P_x(x)$ এর মান হবে একাধিক

Units of Entropy

$H(x) = -\sum_{x \in \mathcal{X}} P(x) \log_2^{P(x)}$ bits

symbol

$H(x) = -\sum_{x \in \mathcal{X}} P(x) \log_e^{P(x)}$ nats

$H(x) = -\sum_{x \in \mathcal{X}} P(x) \log_b^{P(x)}$

স্বল্প-পরিসরের signal এর মধ্যে সকল আছে এমন অংশের জন্য করতে diff. আছে এমন অংশের পার্থক্য কে Delta modulation বলে

$\log_a^b = \log_a^e \times \log_e^b$

Joint and conditional Entropy

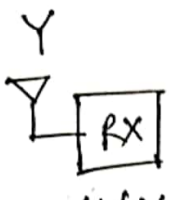
L-10; W-08
13.06.23

Joint:

$H(X)$
↑
Marginal entropy

Before transmitting

$H(X,Y)$
↑
Joint Entropy



$H(Y)$

After completing transmission

→ E_x = expected value গড়মূল্য

Conditional:

$H(X/Y=y) \rightarrow H(X/Y) \rightarrow H(X)$

$H(Y/X=x)$

$$H(X/Y) \triangleq \sum_{y \in \mathcal{Y}} P_Y(y)\, H(X/Y=y)$$

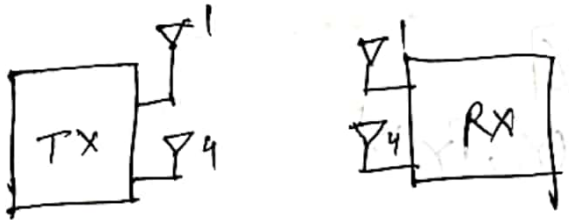
$y = \{1\ 1\ 1\ 1\}$

$$= \sum_{y \in \{1\ 1\ 1\ 1\}} P_Y(y)\, H(X/Y=y)$$

$$= P_{y_1}(y_1)\, H(X/Y=y_1) + \cdots$$

Entropy

1. Marginal
2. Joint
3. conditional



$x \in X$ $\quad$ $y \in Y$

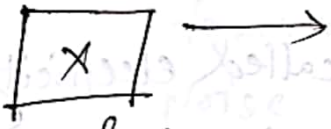
$x \in \{1101\}$ $\quad$ $y \in \{1101\}$

$H(x) = 4$ $\quad$ $H(y) = 4$

→ $H(x,y)$ calculation এর ক্ষেত্রে সবসময় ব্যবহৃত হবে।

$H(X/Y=y)$ } $H(X/Y)$ ⟷ After complete transmission
$H(Y/X=x)$ } $H(Y/X)$

Mutual Information



$I(X;Y)$

$= 1101$

Bangladesh is a developed country. $\quad$ Bangladesh is

$X = 11011111$

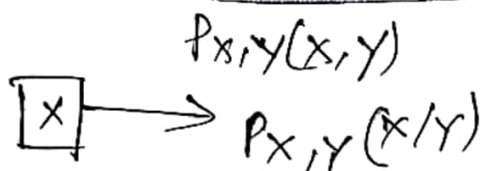
Here mutual info. = Bangladesh is

যখন দুইবার transmit হবে তখন mutual information হবে দুইবারই।

→ Maximum mutual information কে বলে capacity

$$H(X) = -\int P_X(x) \log_2 P_X(x) \log_2 P_X(x)$$

$$P_X(x) P_{Y/X}(Y/X) = P_{X,Y}(x,y)$$



$$H(X) = -\int P_X(X) \log_2 P_X(X)$$

$$P_X(X) \frac{P_{Y/X}(Y/X)}{P_{Y/X}(Y/X=x)} = P_{X,Y}(X,Y) \qquad P_{Y/X}(Y/X=x)$$

$$P_Y(Y)\, P_{X/Y}(X/Y) = P_{X,Y}(X,Y) \qquad P_{X/Y}(X/Y=y)$$

*Prove that $I(X:Y) = H(X) - H(X/Y)$

Entropy + mutual information = capacity

Capacity

The flow of vibration of electron is called electricity

→ কোনো channel এর মধ্যে কোনো সময়ে সর্বোচ্চ যে পরিমাণ info. সেন্ড করতে পারে তাকে channel এর capacity

capacity = Max^m transmission rate, with min^m error probability

$$= \frac{\text{Max}^m \text{ Number of bits}}{\text{Time}}$$

Explaination

(i) I = 10 bits Pe = 0.5 t = 1st sec
(ii) I = 15 bits Pe = 0.75 t = 2nd "
(iii) I = 15 bits Pe = 0.5 t = 3rd "
(iv) I = 10 bits Pe = 0.001 t = 4th "

} capacity = (iii)

→ কোনো channel max. যে পরিমাণ info per sec এ transmit করতে পারে সেই channel এর capacity আর বলতে পারি mutual info.

Relation bet^n mutual information and capacity

$$C = \max_{\underline{Q}} I(X;Y)$$

$$= \max_{\underline{R_x}} I(X;Y)$$

$$\underline{R_x} = \underline{Q} = E[\underline{x}\,\underline{x}^\dagger]$$

↑ Expected value

$\underline{x} \in \mathbb{C}^{n_T \times 1}$

$\underline{x}\,\underline{x}^\dagger \in \mathbb{C}^{n_T \times n_T}$

L-11 ; W-09

08.07.23

MIMO capacity

1. Received signal: $\underline{y} = \underline{H}\underline{x} + \underline{z}$

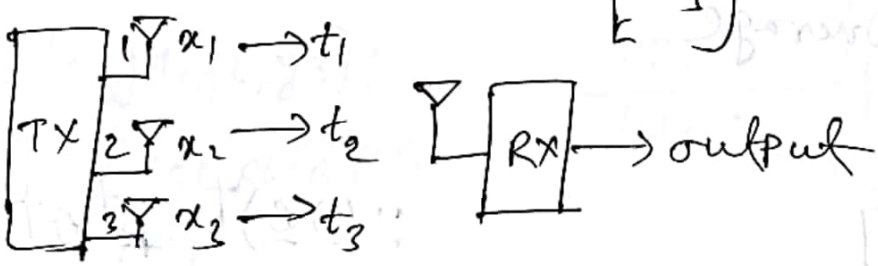
$\underline{x}$ = transmitted

$\underline{z}$ = Noise

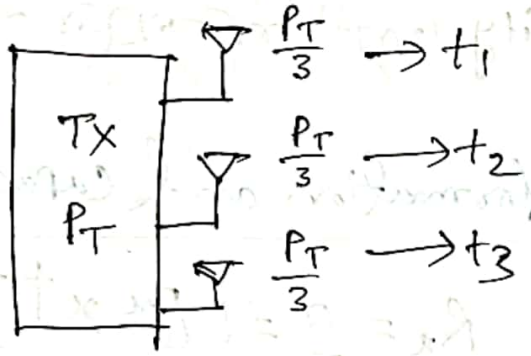
$\underline{H}$ = channel co-efficient

$\underline{y}$ = Received signal

$$\underline{x} = [x_1\ x_2\ x_3]^T = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}$$



2* Power Allocation of $\underline{x}$



(Waterfilling algorithm) ← Antenna

Power allocation t_1 t_2 t_3

$$\frac{P_T}{n_T} \underline{I}_{n_T} = \frac{P_T}{3} \underline{I}_3 = \frac{P_T}{3} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \frac{P_T}{3} & 0 & 0 \\ 0 & \frac{P_T}{3} & 0 \\ 0 & 0 & \frac{P_T}{3} \end{bmatrix}$$

Covariance of Transmit Signal:

$$R_x = E[xx^+] = \frac{P_T}{n_T} I_{n_T}$$

3. $N_0 \underline{I}_{n_R} = N_0 \begin{bmatrix} 1 & 0 & 0 & 0 & \cdots & 0 \\ 0 & 1 & 0 & 0 & \cdots & 0 \\ 0 & 0 & 1 & 0 & \cdots & 0 \end{bmatrix}$

(Power allocation at Noise)

(i) Variance = Power

Co-variance = Co-Power (Power + Power)

(ii) Expectation ⇒ Average

4. covariance of $\underline{y}$

$$\underline{R}_y = E[\underline{y}\,\underline{y}^+] \qquad \because (\underline{A}\underline{B})^+ = \underline{B}^+\underline{A}^+$$

$$= E[(\underline{H}\underline{x} + \underline{z})(\underline{H}\underline{x} + \underline{z})^+]$$

$$= E[(\underline{H}\underline{x} + \underline{z})\{(\underline{H}\underline{x})^+ + \underline{z}^+\}]$$

Linear Alegebra CT-02 (16.07.23)

Vector, matrix এবং physical form নিয়ে analysis

$$= E\left[(\underline{H}\underline{x} + \underline{z})(\underline{x}^{\dagger}\underline{H}^{\dagger} + \underline{z}^{\dagger})\right]$$

$$= E\left[\underline{H}\underline{x}^{\dagger}\underline{x}\underline{H}^{\dagger} + \underline{H}\,\underline{x}\underline{z}^{\dagger} + \underline{z}\underline{x}^{\dagger}\underline{H}^{\dagger} + \underline{z}\underline{z}^{\dagger}\right]$$

(the middle terms $\underline{H}\,\underline{x}\underline{z}^{\dagger}$ and $\underline{z}\underline{x}^{\dagger}\underline{H}^{\dagger}$ are crossed out → 0)

Lecture-14 (Problem Solving)

L-12; W-09
10.07.23

Electromagnetic wave Velocity $= 3\times10^{8}$ m/s

CT-03 : Entropy + Mutual Information
CT-04 : MIMO capacity

L-13; W-10
18.07.23

Report

Report Print করে দেওয়া হবে – 6টা

copy figure করে word এ নিয়ে edit করতে হবে

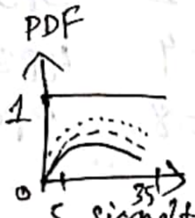
1. Data file
2. Program file
3.

matlab draw

```
x = [0,
 :
 35]
y1 = [ ];
y2 = [ ];
y3 = [ ];
Plot(x,y1,y2,y3);
xlabel("SNR(dB)");
ylabel("PDF");
legend on;
grid on;
hold on;
```

Legend: SNR dB = 5, = 10, = 15

PDF
Fig.1:



color দেওয়ার

Fig.2 CDF

Fig.3. MGF

L-14; W-11
25.07.23

⇒ Problems solving

1. $c = 3 \times 10^8$ m/s

$$T_p = \frac{S}{c} = \frac{S}{3 \times 10^8} \text{ sec}$$

Time slots = 8

Transmission delay → $T_x = 8 \times 1$ Nsec
$= 8$ Nsec

wire ⇒ 2×10^8 m/s
cable ⇒ 2×10^8 "
waveguide ⇒ 3×10^8 m/s
optical fibre ⇒ 3×10^8 m/s
wireless link ⇒ 3×10^8 m/s

References

(i) IEEE conference
(ii) IEEE transaction

* Multimedia communication ← job exam এর question আসে

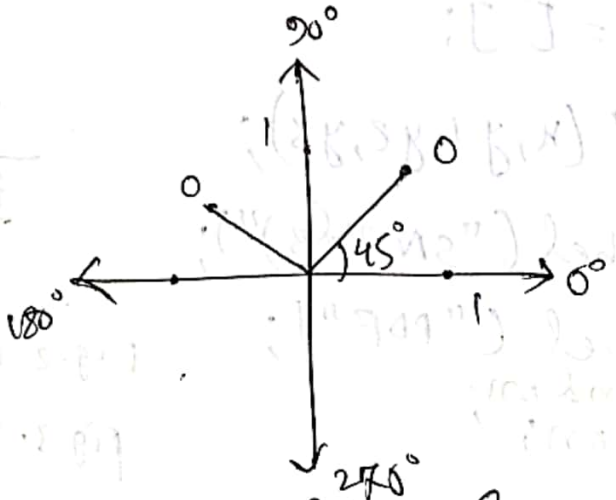
→ Antenna এর data এর speed = Kbps/Mbps
→ Medium এর speed = m/s

Q. 2 প্রশ্নে VoA, SVoA এর unit by default Mbits

⇒ MPSK
↳ M arry PSK
↳ Level of signalling element

M = 2 BPSK 2^1
M = 4 4PSK 2^2
M = 8 8PSK 2^3

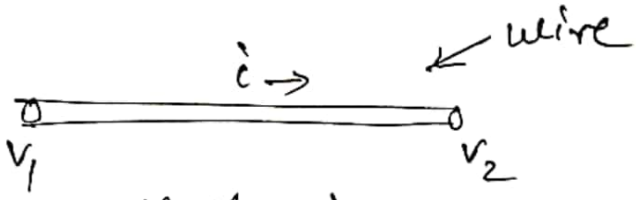
M = 4 → θ = 90°
M = 8 → θ = 45°
M = 16 → θ = 22.5°



constellation diagram

* FDDI এর ক্ষেত্রে by default delay = $1\mu s$

* TTRT



$V_1 - V_2 = iR$

$= i\rho \frac{l}{A} = i \times \rho \times \frac{l}{\pi r^2}$

3টার Property fixed

specific resistance
permittivity
permeability

→ তারের medium এর মধ্যে Light অতিক্রম করতে যে সময় লাগে সেই সময়টাই – TTRT

* Inductance, capacitance এ voltage-current leading, lagging হয় কেন ($L \rightarrow \mu_0 \mu_r$; $C \rightarrow \epsilon_0 \epsilon_r$)

Quiz – 7/8/23

1. PDF, CDF, MGF ← Mathematica
2. Capacity : $\langle c \rangle =$
   MIMO
   MIMO inf
3. $H \in \mathbb{C}^{n_R \times n_T}$ → GSM

$$\langle c \rangle_{MIMO} = \log_2 \det \left[I_{n_R} + \frac{\rho}{n_T N_0} \underline{H} H^{+} \right]$$

$$\langle c \rangle_{MIMO, inf.} = \log_2 \det$$

Viva

(i) Quiz এর question
(ii) capacity Program (MIMO + MIMO Interference)
(iii) capacity MATLAB এ কোনগুলি করেছ
(iv)

Syllabus

PDF, CDF, MGF, MIMO,