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DAYANANDA SAGAR COLLEGE OF ENGINEERING

(An Autonomous Institute Affiliated to VTU, Belagavi)

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Department of Telecommunication Engineering

Internal Assessment Test - I

Course: MIMO Communication
Course Code: TE814
Semester: VIII 'A' &'B'

Date; 24/02/2020
Maximum marks: 50
Duration: 90 Min

Note: Answer 5 full questions.

1 a) A ________ which process the redundancy received signals
i)Combiner ii)Equalizer iii) PCM iv) All of mentioned

b) Diversity is used to combat
i)Fading ii) Co channel interference iii) Error burst iv) all of mentioned

c) Diversity techniques may exploit the _________ propagation, resulting in a diversity gain
i)Single path ii) Multipath iii) Narrow path iv) Fading path

d) The path loss exponent of the free space environment i.e. when only line of sight exists , no scatters is ________
i)2 ii) 3 iii) 6 iv) None of the above

e) In _________ combiner, the first fully received and valid data packet will be immediately further processed, whereas the later arriving redundant packets will be immediately discarded after reception.
i)Max-Ratio ii) Equal gain iii) Scanning/Switching iv) Selection

f) Space diversity means using different physical parts for the signal, at a ______ frequency
i)Multiple ii) Single iii) Co channel iv) Orthogonal

g) __________ order means how many degrees of freedom you can have in your design
i)Rank ii) Selection iii)Diversity iv) Uplink/Downlink

h) The multipath spread is basically the _________ difference between the shortest and the longest paths that the transmitted signal goes through
i)Time ii) Frequency iii) Both time and frequency iv)None of the above

i) If the channel is said to be frequency selective fading channel, then it exhibits ________ interference
i)Intersymbol interference ii) No Intersymbol interference iii) Both a and b iv) none of the above

j) Channel capacity , which is defined as the __________ rate at which we can transmit information with an arbitrary ________ probability of error
i)Maximum, High ii) Maximum, Low iii) Minimum, Low iv) None of the above

2 a) Define Channel Fading. Also discuss the wireless propagation mechanism
b) Describe about Soft Decision Decoding and Hard Decision Decoding.

3 a) Focus on Capacity of Noisy Channel.
b) Analyze the information Rate of Noisy Channel.

4 Discuss the classification in Channel Fading

(OR)

5 Elaborate Diversity Techniques in Wireless Communication

6 Discuss Beamforming technique with Smart Antennae

(OR)

7 Briefly explain demodulation of signal from set of received signals in MIMO.

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Solution Scheme

Subject: MIMO Comm.
Code: TE814
Sem 8th A & B

Date: 24/02/2020
Prepared by: Dr. Sayed Abdullayan
Ist CIE

Q1.

(a) (i) Combiner — (i)

(b) all of mentioned — (iv)

(c) Multipath — (ii)

(d) 2 — (i)

(e) Selection — (iv)

(f) Single — (ii)

(g) Diversity ~~Rank~~ — (iii)

(h) Time — (i)

(i) Intersymbol Interference (i)

(j) Maximum; Low

$\boxed{1 \times 10}$

(2)

Q2. (a) Channel Fading:

The time variation of received signal power due to changes in transmission medium or path is known as fading. Fading depends on atmospheric conditions and path obstackles.

Wireless channels, signals are receive through multiple paths. There is significant time variations caused by the relative motion of transmitter and receiver.
Electromagnetic waves travel through three different mechanisms:

3

- Reflection
- Refraction
- Scattering

2.b)

Soft Decision Coding	Hard Decision Decoding
1) Difficult to Implement	HDD is relatively simple to Implement
2) Gives the best performance	2) Does not gives the best performance.
3) Receiver is complex	3) Receiver is simple.
4) Channel decoder directly works with the matched filter output to perform max likelihood decoding	4) Max likelihood decoder picks the codeword closest to the received sequence in Hamming distance sense as the decoder output
5) Here Code constraints are ~~used~~ considered	5) Tentative Hard decisions are made based on matched filter or correlator outputs without using code constraints.

5

3.a) Capacity of Noisy channel

W = message

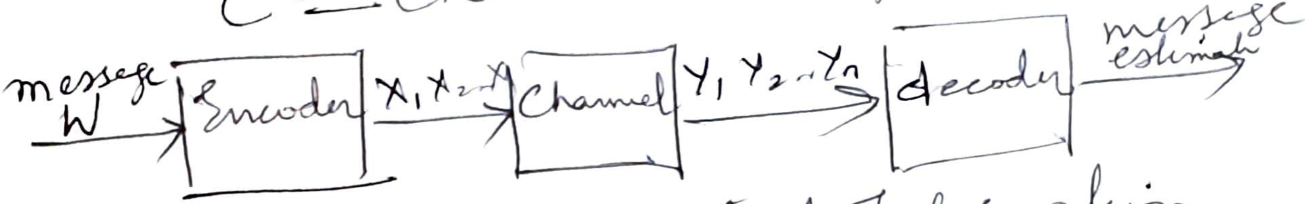
W = message

n = no of channel

$X_1, X_2 \ldots$ = Input Channels

$Y_1, Y_2 \ldots$ = Output channels

C = Channel Capacity



$I(\;;\;) \rightarrow$ Mutual Information

- $$C' = \lim_{n \to \infty} \frac{1}{n} \max_{p(x_1 \ldots x_n)} I(X_1, X_2 \ldots X_n ; Y_1 \ldots Y_n)$$

$$C = \max_{p(x)} I(X, Y)$$

$$C = \log(1 + P)$$

5

Q3(b) Information Rate of Noisy Channel

- $$C' = \lim_{n \to \infty} \frac{1}{n} \max_{p(x_1, x_2 \ldots x_n)} I(X_1 \ldots X_n ; Y_1 \ldots Y_n)$$

Maximum mutual Information

For memoryless channels i.e if the output-input relationship can be written as

$$p(y_1, y_2 \ldots y_n \mid x_1, x_2 \ldots x_n) = \prod_{i=1}^{n} p(y_i / x_i)$$

$$C = \max_{p(x)} I(X;Y) \Rightarrow \text{mutual Information}$$

$$I(X;Y) = E\left[\log \frac{P(X,Y)}{P(X), P(Y)}\right]$$

5

$E \rightarrow$ expectation is over joint density of X and Y

Q 4. ~~2~~. Classification of Channel Fading

Path Loss Fading :- It is Large Scale fade

We can write received Power P_r as

$$\bar{P_r} = \frac{c}{d^n} P_t$$

$d \rightarrow$ Separation between transmitter and receiver.

$P_t \rightarrow$ transmitted power.

$c \rightarrow$ constant

$n \rightarrow$ Path loss exponent. in range of 2 to 6.

Shadowing :- It is Large scale fading

Here received Signal strength is averaged over a long period of time of order of few seconds or minutes.

$$P_r \, dBm = \bar{P_r} \, dBm + X_\sigma \, dB$$

dBm, $X_\sigma \rightarrow$ Zero mean random variable.

X_σ has SD $= \sigma$

σ = SD can be 3 dB – 12 dB.

2

~~Flat~~ Frequency ~~Fading~~ Selective Fading

B.W = W.

B_c = coherence B.W

If Signal Bandwidth W is Significantly Smaller than the coherence B.W B_c of Channel all frequency components see the same effective channel, i.e $C(f;t)$ for the frequency range of interest will be independent of f.

$$y_l(t) = C(0;t)\int_{-\infty}^{\infty} X_L(f)\, e^{j2\pi ft}\,df$$
$$= C(0;t)\, x_l(t)$$

$W \ll B_c \Rightarrow$ multipath spread of channel is significantly smaller than signal time duration.

→ No Inter Symbol Interference between consecutive symbols.

→ Different frequency components undergo different channel fades.

2

- **Flat Frequency fading**

$W > B_c$; $C(0;t) \approx C(0, nT)$ = constant

$T_m > T_s \Rightarrow$ Symbol time duration is is smaller than signal time.

→ All frequency components of signal undergo same channel fades.

2

Slow Fading / Fast Fading

- Slow Fading
  - → Symbol duration T_s is significantly smaller than coherence time of channel.
  - → Channel remains the same over entire symbol period.

Fast Fading

→ Symbol duration T_s is greater than coherence time of channel.

→ Channel differs over same symbol period

2

Rayleigh Fading

Rayleigh Fading

Channel coefficient has zero mean.
Channel gain has absolute value Rayleigh
C = Complex Gaussian Random variable

Rician Fading 2

Channel gain has non zero mean
C = multiplicative term = Complex Gaussian
random variable

Q5 Diversity techniques in a

Diversity techniques collectively refer to methods of improving this performance by effectively transmitting the same information multiple times where each replica sees a different ideally independent channel. 2

- Frequency Diversity
- Space Diversity
- Time Diversity
- Transmit Diversity
- Receive Diversity
- Channel Coding

2

Explanations 6

Q6. Beam Forming techniques with Smart Antenna
Consider a Scenario of small number of local scatterers and comm by LOS.

page-6.

In such scenario multiple antenna elements can be employed at transmitter in order to provide directionality for electromagnetic waves, hence improving the effective SNR of channel.

A fundamental approach ~~also~~ is the transmission of same signal from each of antenna elements with a certain gain and phase shift.

This can be implemented Analog or Digital. Digital Beam forming is more flexible

Different techniques can be used to find suitable coefficients ~~and~~ of antenna beam, coefficients got from feedback can be computed to make effective antenna pattern have main beam in ~~this~~ required directions.

4

4

Also Interference suppression can be accomplished using beam forming.

Q 7. Demodulation from signal received from set of MIMO

Maximum Ratio Combining.

Assum channel coefficients are perfectly available at receiver.

Maxi Likelihood decision rule on symbol transmitted is

$$\hat{x} = \underset{i=1,2..M}{\arg\max}\ P(y_1 y_2 .. y_L / h_1 h_2 .. h_L, x_i)$$

$p(\cdot|\cdot) \rightarrow$ conditional joint pdf

Since channel gains, transmitted signal, received signal are independent. 4

$$\boxed{\hat{x} = \underset{j=1,2 \cdots M}{\arg\min} \, Re\left\{\left(\sum_{l=1}^{L} h_l^* y_l\right) x_j^*\right\} - \frac{1}{2}\sqrt{P}\left(\sum_{l=1}^{L} |h_l|^2\right) |x_j|^2}$$

SNR of L branch diversity with MRC is the sum of instantaneous SNR's of each branch. Hence error probabilities and outage will be reduced.

Selection Combining :-

Works with branch with best channel conditions for any given transmission i.e highest SNR branch is picked. 2

Equal Gain Combining :-

- Signals of all branches are cophased by multiplying with $e^{-j\angle h_l}$ using baseband rotation
- Signals summed together to form equivalent channel output 2

Switch and Stay Combining :-

We use particular branch for demodulation until SNR of it falls below threshold, then the other branch which has largest SNR is choosen and maintained till it also falls below threshold. This procedure is carried. 2