GRT INSTITUTE OF ENGINEERING AND TECHNOLOGY, Tiruttani.

(Approved by AICTE, New Delhi Affiliated to Anna University, Chennai.)

Department of Electronics & Communication Engineering

III Year - VIth Semester

MINIMUM LEARNING MATERIAL

REGULATION – 2017

III Year/VI Semester

Department of Electronics and communication Engineering

Sub. Code /Sub. Name: EC8652 WIRELESS COMMUNICATION

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UNIT I WIRELESS CHANNELS 9

Large scale path loss – Path loss models: Free Space and Two-Ray models -Link Budget design – Small scale fading- Parameters of mobile multipath channels – Time dispersion parameters-Coherence bandwidth – Doppler spread & Coherence time, Fading due to Multipath time delay spread – flat fading – frequency selective fading – Fading due to Doppler spread – fast fading – slow fading.

UNIT II CELLULAR ARCHITECTURE 9

Multiple Access techniques – FDMA, TDMA, CDMA – Capacity calculations–Cellular concept- Frequency reuse – channel assignment- hand off- interference & system capacity- trunking & grade of service – Coverage and capacity improvement.

UNIT III DIGITAL SIGNALING FOR FADING CHANNELS 9

Structure of a wireless communication link, Principles of Offset-QPSK, π/4-DQPSK, Minimum Shift Keying, Gaussian Minimum Shift Keying, Error performance in fading channels, OFDM principle – Cyclic prefix, Windowing, PAPR.

UNIT IV MULTIPATH MITIGATION TECHNIQUES 9

Equalisation – Adaptive equalization, Linear and Non-Linear equalization, Zero forcing and LMS Algorithms. Diversity – Micro and Macrodiversity, Diversity combining techniques, Error probability in fading channels with diversity reception, Rake receiver,

UNIT V MULTIPLE ANTENNA TECHNIQUES 9

MIMO systems – spatial multiplexing -System model -Pre-coding – Beam forming – transmitter diversity, receiver diversity- Channel state information-capacity in fading and non-fading channels.

TOTAL: 45 PERIODS

TEXTBOOKS:

T1. Rappaport,T.S., “Wireless communications”, Second Edition, Pearson Education, 2010.
T2. Andreas.F. Molisch, “Wireless Communications”, John Wiley – India, 2006.

REFERENCES:

R1. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2005.
R2. Upena Dalal, “ Wireless Communication”, Oxford University Press, 2009.
R3. Van Nee, R. and Ramji Prasad, “OFDM for wireless multimedia communications”, Artech House, 2000.

MINIMUM LEARNING MATERIALS

UNIT-I: WIRELESS CHANNELS

1. What is meant by multipath propagation?

The presence of reflecting objects and scatterers in the channel creates a constantly changing environment that dissipates the signal energy in amplitude, phase, and time. These effects result in multiple versions of the transmitted signal that arrive at the receiving antenna, displaced with respect to one another in time and spatial orientation and this is called Multipath propagation.

2. Write the effects of fading.

- Rapid changes in signal strength over a small travel distance or time interval
- Random frequency modulation due to varying Doppler shifts on different multipath signals
- Time dispersion caused by multipath propagation delays.

3. Define coherence bandwidth and coherence time.

- The coherence bandwidth is related to the specific multipath structure of the channel.
- The coherence bandwidth is a measure of the maximum frequency difference for which signals are still strongly correlated in amplitude.
- This bandwidth is inversely proportional to the rms value of time delay spread.
- The coherence time is defined as the required time interval to obtain an envelope correlation of 0.9 or less.

4. Define Doppler shift and Doppler spread.

The shift in received signal frequency due to motion is called the Doppler shift. The Doppler spread is defined as the range of frequencies over which the received Doppler spectrum isessentially non-zero.

5. What is flat fading? Write its conditions. (2017 Nov)

If the mobile radio channel has a constant gain and linear phase response over a bandwidth which is greaterthan the bandwidth of the transmitted signal, then the received signal will undergo flat fading.

Conditions: BW of signal<<BW of channel

Symbol period>>Delay spread

6. What is frequency selective fading? Write its conditions. (2016 Nov)

If the channel possesses a constant gain and linear phase response over a bandwidth that is, smaller than thebandwidth of transmitted signal, then the channel creates frequency selective fading on the received signal.

Conditions: BW of signal>BW of channel

Symbol period< Delay

7. Define fast fading channel and slow fading channel. (2018 Nov)

- The channel impulse response changes rapidly within the symbol duration. This type of channel is

called fast fading channel.

- The channel impulse response changes at a rate much slower than the transmitted baseband signal. This type ofchannel is called slow fading channel.

8. What is meant by time dispersion and frequency dispersion?

The received signal has a longer duration than that of the transmitted signal, due to the different delays of the signal paths. This is known as time dispersion.

The received signal has a larger bandwidth than that of the transmitted signal, due to the different Doppler shiftsintroduced by the components of the multipath. This is known as frequency dispersion.

9. Calculate the Brewster Angle for wave impinging on ground having a permittivity $\varepsilon_r = 4$(2016 May)

The Brewster angle can he found by substituting the values for Cr in equation

$$\sin(\theta_i) = \frac{\sqrt{(4)-1}}{\sqrt{(4)^2-1}} = \sqrt{\frac{3}{15}} = \sqrt{\frac{1}{5}}$$

$$\theta_i = \sin^{-1}\sqrt{\frac{1}{5}} = 26.56^o$$

Thus Brewster angle for $\varepsilon_r = 4$ is equal to 26.56°.

10. What is the need of propagation model?(May/June 2012)

Propagation models have traditionally focused on predicting the average received signal strength at a given distance from the transmitter, as well as the variability of the signal strength in close spatial proximity to aparticular location. Propagation models that predict the mean signal strength for an arbitrary transmitterreceiverseparationdistanceareusefulinestimatingtheradiocoverageareaofa transmitter.

11. Find the far-field distance from antenna with maximum dimension of 1m and operating frequency of 900MHz. (2015 Nov)

Given:

Largest dimension of antenna, $D = 1$ m

Operating frequency $f = 900$ MHz, $\lambda = c/f = \frac{3 \times 10^8 \text{ m/s}}{900 \times 10^6 \text{ Hz}}$ m

far-field distance is obtained as

$$d_f = \frac{2D^2}{\lambda}$$

$$d_f = \frac{2(1)^2}{0.33} = 6 \text{ m}$$

12. What is the need of path loss models in link budget design?

The path loss models are used to estimate the received signal level as the function of distance it becomes possible to predict the SNR for a mobile communication system.

13. Differentiate Flat fading & Frequency selective fading. (2018 May)

Flat Fading	Frequency Selective Fading
Bandwidth of the signal is lesser than the bandwidth of the channel	Bandwidth of the signal is greater than the bandwidth of channel
Delay spread is lesser than symbol period	Delay spread is greater than symbol period.

14. State the difference between small scale and large scale fading? (2019 May)

Small Scale Fading	Large Scale Fading
The rapid fluctuations of the amplitudes, phases, or multipath delays of a radio signal over a shortperiod of time or travel distance is known as small scale fading.	The rapid fluctuations of the amplitudes, phases, or multipath delays of a radio signal over a long period of time or travel distance is known as large scale fading.

15. Differentiate Fast fading & slow fading. (2018 May)

Fast Fading	Slow fading
High Doppler spread.	Low Doppler Spread.
Coherence time is lesser than symbol period.	Coherencetime is greater than symbol period.
Channel variations faster than base band signal variations.	Channel variations slower than base band signalvariations.

16. State the propagation effects in mobile radio. (May/June 2014)

The type of fading experienced by a signal propagating through a mobile communication channel depends on the nature of the transmitted signal with respect to the characteristics of the wireless channel. Fading effects in a mobile environment can be classified as,

- Fading effects due to multiple path time delay spread.
- Fading effects due to Doppler spread.

17. Interpret link budget equation. (May/June 2014)

A link budget equation: $\mathbf{P_{rx} = P_{tx} + G_{tx} - L_{tx} - L_{fs} - L_m + G_{rx} - L_{rx}}$

P_{rx} = received power (dBm)
P_{tx} = transmitter output power (dBm)
G_{tx}= transmitter antenna gain (dBi)
L_{tx} = transmitter losses (coax, connectors...) (dB)
L_{fs}= free space loss or path loss (dB)
L_m= miscellaneous losses (fading margin, body loss, polarization mismatch, other losses...) (dB)

G_{rx} = receiver antenna gain (dBi)
L_{rx}= receiver losses (coax, connectors...) (dB)

18. What are the different fading effects due to Doppler spread? (Nov/Dec 2014)
Fast fading and Slow fading.

19. What are the two factors that contribute to the rapid fluctuations of the signal amplitude? (2019 May)
- Multipath Propagation
- Speed of the mobile
- Speed of surrounding objects
- The transmission bandwidth of the signal

20. What is shadow fading? Why it is called so? (2019 Nov)
Weather (particularly rain), or shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. It is called so because fading of signal due to shadowing effects of the obstacles in its propagation paths.

21. Which factors does diffraction depend on at high frequencies?(2019 Nov)
At high frequencies, diffraction, like reflection, depends on the geometry of the object, as well as the amplitude, phase, and polarization of the incident wave at the point of diffraction

PART B & CQuestions

1. **Examine the advantages and disadvantages of the two-ray ground reflection model in the analysis of path loss. (4) (2015 Nov)**
T1: Page No (120-125)
2. **Analyze the following cases tell whether the two-ray model could be applied, and justify why or why not:**
Case (i) h1 = 35m , hr = 3m, d = 250m
Case (ii) h1 = 30m , hr= 1.5m , d = 450m (6)(2015 Nov)
T1: Page No (120-125)
3. **Prove that in the two-ray ground reflected model**
$\Delta = d'' - d' = 2h_t h_r / d$ **(6)(2015 Nov)**
T1: Page No (120-125)
4. **Derive the Impulse response model of a multipath channel and also obtain the relationship between Bandwidth and Received power.(16)(2015 Nov)**
T1: Page No (181-189)
5. **Explain the time variant two-path model of a wireless propagation channel. (16) (2016 Nov)**
T1: Page No (120-125)
6. **Explain fading effects due to multipath time delay spread and fading effects due to Doppler spread. (10)(2016 Nov)**
T1: Page No (205-210)
7. **What are the factors influencing Small scale fading? (6)(2016 Nov)T1: Page No (205-210)**
8. **If a transmitter produces 50W of power, which is applied to a unity gain antenna with a 900**

MHz carrier frequency, find the received power in dBm at a free space distance of 100m from the antenna. What is received power at a distance of 10 km? Assume unity gain for the receiver antenna. (5)(2017 May)

T1: Page No (109-110)

9. **Derive the path loss considering a Two-Ray Model for the propagation mechanism in a wireless channel. Is considering just two rays alone sufficient? Why?(2017 May) (2018 May)**
   T1: Page No (120-125)
10. **Compare and contrast fast fading and slow fading. "In practice fast fading only occurs for very low data rate (communications)", Why?(5)(2017 May) (2017 Nov)**
    T1: Page No (205-210)
11. **What is the need for link calculation? Explain with suitable example. (2017 Nov)**
    T1: Page No (138-141)
12. **Consider a transmitter which radiates a sinusoidal carrier frequency of 1850MHz. For a vehicle moving 60 mph, compute the received carrier Frequency if the mobile is moving directly toward the transmitter. (2018 May)**
    T1: Page No (180)
13. **Given that the coherence bandwidth is approximated by equation $B_c = \frac{1}{\sigma_\tau}$ Show that a flat fading channel occurs when $T_S \geq \sigma_\tau$ (2018 May)**
    T1: Page No (197-205)
14. **What do you mean by path loss model? Explain the various path loss models for large scale fading.(2017 Nov) (2018 Nov)**
    T1: Page No (138-156)
15. **Describe small scale fading and derive expressions for parameters of mobile multipath channels. (2017 May) (2018 Nov)**
    T1: Page No (192-205)
16. **Describe the free space propagation model and derive the loss in the signal strength. (7) (2018 May) (2019 May) (2019 Nov)**
    T1: Page No (107-110)
17. **If the transmit power is 1W and carrier frequency is 2.4GHz and the receiver is at a distance of I mile from the transmitter. Assume that the transmitter and receiver antenna gains are 1.6. (6) (2019 May)**
    T1: Page No (109-110)
    - **(i). What is the received power in dBm in the free space of a signal?**
    - **(ii). What is the path loss in dB?**
    - **(iii). What is the transmission delay in ns?**
18. **Discuss the flat fading channel characteristics with relevant diagrams. (8) (2019 May)**
    T1: Page No (205-208)
19. **Describe the classification of small-scale fading with respect to Doppler spread. (5) (2019 May)**
    T1: Page No (208-210)
20. **Determine the proper spatial sampling interval required to make small scale propagation measurements which assume that consecutive samples are highly correlated in time. How many samples will be required over 10m travel distance if fc=1900MHz and v=50 m/s. How long would it take to make these measurements, assuming they could be made in real time for a moving vehicle? What is the Doppler spread for the channel? (2017 May) (2019 Nov) (2019**

May)
T1: Page No (204-205)

21. **Compare and contrast wired and wireless communication. (5) (2019 May) (2019 Nov)T1: Page No (1-9)Examine the effectiveness of flat fading and frequency selective fading. (15) (2018 Nov) (2019 Nov)**T1: Page No (205-208)

UNIT- II: CELLULAR ARCHITECTURE

1. What is meant by frequency reuse? (2017 Nov) (2018 May).

If an area is served by a single Base Station, then the available spectrum can be dividedinto N frequency channels that can serve N users simultaneously. If more than N users are tobe served, multiple BSs are required, and frequency channels have to be reused in differentlocations. Since spectrum is limited, the same spectrum has to be used for different wirelessconnections in different locations. This method of reusing the frequency is called asfrequency reuse.

2. What do you mean by forward and reverse channel? (2017 Nov)

Forward channel is a radio channel used for transmission of information from basestation to mobile.Reverse channel is a radio channel used for transmission from mobile tobase station.

3. What is the function of control channel? What are the types?

The function of control channel is to transmit call setup, call request, call initiation and Control. There are two types of control channels,

- Forward control channel
- Reverse control channel

4. What is channel assignment? What are the types?

For efficient utilization of radio spectrum a frequency reuse scheme with increasingcapacity and minimizing interference is required. For this channel assignment is used. Thetypes of channel assignment are:

- Fixed channel assignment (channels are allocated permanently to a cell)
- Dynamic channel assignment. (channels are not allocated permanently to a cell

5. Define hand off and list the modes of hand off.

A handoff refers to the process of transferring an active call or data session from one cell in a cellular network to another or from one channel in a cell to another. A wellimplementedhandoff is important for delivering uninterrupted service to a caller or datasession user. Modes of hand off are:

- MCHO – Mobile Controlled Hand off
- NCHO – Network Controlled Hand off
- MAHO – Mobile Assisted Hand off

6. Write the types of hand off.

Types of handoff are:

- Hard hand off – Mobile monitors BS and new cell is allocated to a call with strongsignal.
- Soft hand off – MS with 2 or more calls at the same time and find which is thestrongest signal BS, the MSC automatically transfers the call to that BS.

7. Define Cell, Cluster.

For a large geographic coverage area, a high powered transmitter therefore has to beused. But a high power radio transmitter causes harm to environment. Mobile communicationthus calls for replacing the high power transmitters by low power transmitters by dividing thecoverage area into small segments, called cells. Each cell uses a certain number of the available channels and a group of adjacent cellstogether use all the available channels. Such a group is called a cluster.

8. What are the major types of cellular interference?

The major types of cellular interferences are as follows

- CCI – Co-channel interference is the interference between signals from co-channelcells.
- ACI – Adjacent channel interference resulting from signals which are adjacent in frequency to the desired signal.

9. What are the techniques used to expand the capacity of cellular system?

Cell splitting, Sectoring, Coverage Zone approaches are the techniques used toexpand the capacity of cellular system.

- Cell splitting – Cell-splitting is a technique which has the capability to add new smaller cells in specific areas of the system. i.e. divide large cell size into small size.
- Sectoring – use of directional antennas to reduce Co-channel interference.
- Coverage Zone approaches – large central BS is replaced by several low power transmitters on the edge of the cell.

10. What is frequency reuse ratio?

If the cell size and the power transmitted at the base stations are same then co-channel interference will become independent of the transmitted power and will depend on radius ofthe cell (R) and the distance between the interfering co-channel cells (D). If D/R ratio isincreased, then the effective distance between the co-channel cells will increase andinterference will decrease. The parameter Q is called the frequency reuse ratio and is relatedto the cluster size. For hexagonal geometry

11. Define FDMA, TDMA and CDMA. (2018 May)

FDMA - the total bandwidth is divided into non-overlapping frequency subbands.

TDMA – divides the radio spectrum into time slots and in each slot only one user isallowed toeither transmit or receive.

CDMA – many users share the same frequency same tome with different coding.

12. State the principles of CDMA.

Principles of CDMA:

- Many users share the same frequency.
- Each user is assigned a different spreading code.

13. How the capacity can be increased in CDMA?

Capacity in CDMA can be increased by Quiet periods during speech transmission is shared by many users.

(i). Flexible data rate.
(ii). Soft capacity.
(iii). Error Correction coding used.

14. Define Grade of service. (2015 Nov) (2016 Nov)

Grade of service is defined as the measure of the ability of a user to access a trunkedsystem during the busiest hour.

15. Define cell splitting.

Cell splitting is the process of subdividing congested cells into smaller cells each withits own base stations and a corresponding reduction in antenna height and transmitter power.It increases the capacity of cellular system.

16. What is sectoring?

Sectoring is a technique for decreasing co-channel interference and thus increasingthe system performance by using directional antennas.

17. What are the features of TDMA?

Features of TDMA are:

- TDMA shares a single carrier frequency with several users, where each user makes use ofnon overlapping time slots.
- Data transmission occurs in bursts.
- Handoff process is much simpler
- Duplexers are not required, since transmission and reception occurs at different time slots.

18. What are the features of FDMA? (2019 Nov)

Features of FDMA are:

- FDMA channel carries only one phone circuit at a time
- The bandwidth of FDMA channels are relatively narrow as each channel supports only one circuit per carrier.

19. What is soft hand off in mobile communication?(2016 May)

Soft handoff is a "Make before break" handoff. That is, the mobile station (MS) is up on a call and moves from one base station (BS) to another, but the MS starts communicating with a new BS before terminating communications with the old BS. Soft handoffs can only be used between BSs on the same frequency.

20. What is multiple access techniques (2016 May)

Multiple Access is the use of multiplexing techniques to provide communication service to multiple users over a single channel. It allows for many users at one time by sharing a finite amount of spectrum.

21. State advantages of CDMA over FDMA. (2016 Nov)

All Users in CDMA system use the same frequency and may transmit simultaneously but in FDMA systems each users use different frequencyand CDMA system has a soft capacity limit opposed FDMA systems that has fixed maximum capacity.

22. In a cellular network, among a handoff call and a new call, which one is given priority? Why?(2017 May)

Handoff call is given priority in a cellular network than newhavingacallabruptly terminatedin middle of a conversation is more annoying than being blocked occasionally onnew call attempt.

23. List the features of Cellular concept. (2018 Nov)

- Increase the capacity of wireless systems
- Decrease the transmission power of the base station and mobile station
- Effectively uses the allocated spectrum

24. How is frequency reuse distance measured in cellular system? (2018 Nov)

Frequency reuse distance is measured in cellular system using the following expression:
D/R=sqrt(3N)
Where D- the distance between the two co-channel cells (frequency reuse distance).
R- cell radius
N- Cluster size

25. CDMA handles near-far problem? (2019 May)

To combat the near-far problem,power control is used in most CDMA implementations. Powercontrol is providedby each base station in a cellular system and assures that each mobilewithin the base station coverage area provides the same signal level to the basestation receiver. This solves the problem of a nearby subscriber overpowering thebase station receiver and drowning out the signals of far away subscribers.

26. What do you mean by mobile-assisted handoff? (2019 May)

Mobile assisted handoff (MAHO) is a process used in GSM cellular networks where a mobile phone assists/helps the cellular base station to transfer a call to another base station with stronger signal strength and improved channel quality. Mobile assisted handoff can also be referred as mobile assisted handover.

27. What are the disadvantages of TDMA? (2019 Nov)

- In TDMA each user has a predefined time slot so that users roaming from one cell to another are not allotted a time slot.
- It is subjected to multipath distortion.
- Network and spectrum planning is intensive.
- Too few users result in ideal channels rural versus urban environment.
- High synchronization overhead.

28. Why is cellular concept used for mobile telephony?(2017 May)

Cellular concept used for mobile telephone because it offers very high capacity in a limited spectrum allocation without any major technological changes.

PART B & C Questions

1. A cellular service provider decides to use a digital TDMA scheme which can tolerate a signal-to-interference ratio of 15dB in the worst case. Find the optimal value of N for,

(1) Omni-directional antennas
(2) 120º sectoring
(3) 60º sectoring
(4) Should sectoring be used? If so, which case (60º or 120º should be used? (Assume a path

loss exponent of n==4 and consider trunking efficiency). (2015 Nov)
T1: Page No (490)

2. **If a signal-to-interference ratio of 15 dB is required for satisfactory forward channel performance of a cellular system, what is the frequency reuse factor and cluster size that should be used for maximum capacity, if path loss exponent (i) n=4, (ii) n=3. (2015 Nov)**
T1: Page No (490)
3. **A hexagonal cell within a four-cell system has a radius of 1.387km. A total of 60channels are used within the entire system. If the load per user is 0.029Erlangs, and λ=1 call/hour, Compute the following for an Erlang C system that has a 5% probability of a delayed call:**
(i). **How many users per square kilometer will this system support?**
(ii). **What isthe probability that a delayed call will have to wait for more than10 sec?**
(iii). **What is the probability that a call will be delayed for morethan10 sec?**
[Data: From Erlang C chart, for 5% probability of delay with C=15, traffic intensity:9.0 Erlangs.](2015 Nov)
(T1: Page No 490)
4. **Explain about co-channel interference and adjacent channel interference. Describe the techniques to avoid interference. (2016 Nov)**
T1: Page No (67-76)
5. **Explain in detail how frequency is efficiently allocated in a cellular radio system. (2016 Nov)**
T1: Page No (451-455)
6. **Describe the Channel Assignment strategies and Hand-off strategies. (2017 May) (2018 May) (2019 May)**
T1: Page No (62-66)
7. **If a total of 33MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25kHz simplex channels to provide duplex voice and control channels, compute the number of channels available per cell if a system uses,**
(1) four-cell reuse
(2) seven-cell reuse and
(3)twelve-cell reuse.
If 1 MHz of the allocated spectrums is dedicated to control channel, determine the equitable distribution of control channels and voice channels in each cell of each of the three systems. (2017 May)
T1: Page No (97)
8. **Derive the expressions for Cellular CDMA schemes for both noise limited and interference limited scenarios. (2017 May)**
T1: Page No(460)
9. **Consider Global System for Mobile, which is a TDMA/FDD system that uses 25 MHz for the forward link, which is broken into radio channels of 200MHz. If 8 speech signals are supported on a single radio channel and if no guard band is assumed find the number of simultaneous users that can be accommodated in GSM. (2017 May)**
T1: Page No (490)
10. **If GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bits, and data is transmitted at 270.833 kbps in the channels, find,**
(1) the time duration of a bit
(2) the time duration of a slot
(3) the time duration of a frame and

(4) how long must user occupying single time slot wait between two successive transmissions?(2017 May)

T1: Page No (490)

11. **Identify the channel capacity of TDMA in cell system. (2017 Nov)**
    T1: Page No (451-455)
12. **Write short note on (i) Trunking (ii) Grade of service of cell system (ii) Cell splitting (2017 Nov) (2019 May) (2019 Nov)**
    T1: Page No (77-90)
13. **Consider a time invariant frequency selective block fading channel consisting of 3 sub channels of B =1MHz. The frequency response associated with each channel is H1 = I, H2 = 2, H3 = 3. The transmit power constraint is P = 10mw and noise power spectral density is No = 10-9 W/Hz. Find the Shannon capacity of the channel and optimal power allocation that achieves this capacity. (2018 May)**
    T1: Page No (490)
14. **How is Hand-off in a cellular system implemented? Explain the different types of Hand-offs. (2016 Nov) (2018 Nov) (2019 May) (2019 Nov)**
    T1: Page No (62-65)
15. **How can capacity of a cellular communication system be improved? Explain any two capacity expansion techniques. (2018 Nov) (2019 Nov)**
    T1: Page No (67-74)
16. **Compare and contrast TDMA and CDMA. (2018 Nov)**
    T1: Page No (451-460)
17. **Discuss the impact of interference in a cellular system and system capacity. (2018 Nov)**
    T1: Page No (67-72)
18. **Describe the principle of CDMA. (2019 May)**
    T1: Page No (460)
19. **If a total of 33 MHz of bandwidth is allocated to a particular FDD cellular telephone system which uses two 25KHz simplex channels to provide full duplex voice and control channels, compute the number of channels available per cell if a system uses**
    (I) 4-cell reuse,
    (2) 7-cell reuse. (2019 May)
    T1: Page No (97)
20. **A certain city has an area of 1,300 square miles and is covered by a cellular system using a 7-cell reuse pattern. Each cell has a radius of 4 miles and the City is allocated 40 MHz of spectrum with a full duplex channel bandwidth of 60 kHz. Assume that a GOS is 2% and traffic intensity per cell A = 84 Erlangs/cell. If the offered per user is 0.03 Erlangs, compute**
    i) the number of cells in the service area,
    ii) the number of channels per cell,
    iii) the maximum carried traffic;
    iv) the total number Of users that can be served for 2% GOS,
    v) the number of mobiles per channel, and
    vi) the theoretical maximum number of users that could be sewed at one time by the system. (2019 Nov)
    T1: Page No (97)
21. **If W= 1.25 MHz, R = 9600 bps, and a minimum acceptable Eb/No is found to be 10 dB, determine the maximum number of users that can be supported in a single-cell CDMA system**

using

1) Omni-directional base station antennas and no voice activity detection, and

2) 3-sectors at the base station and activity detection with α=3/8. Assume the system is interference limited. (2019 Nov)

T1: Page No (490)

UNIT- III: DIGITAL SIGNALING FOR FADING CHANNELS

1. List the advantages of digital modulation techniques.

The advantages of digital modulation techniques are:

- Immunity to channel noise and external interference.
- Flexibility operation of the system.
- Security of information.
- Reliable since digital circuits are used.
- Multiplexing of various sources of information into a common format ispossible.
- Error detection and correction is easy.

2. What are the factors that influence the choice of digital modulation?

The factors that influence the choice of digital modulation are:

- Low BER at low received SNR.
- Better performance in multipath and fading conditions.
- Minimum bandwidth requirement.

3. Define power efficiency and bandwidth efficiency.

Power efficiency describes the ability of a modulation technique to preservethe fidelity of the digital message at low power levels.

$\eta_p = E_b/N$= Bit energy / Noise power spectral density

Ability of a modulation scheme to accommodate data within a limited bandwidth iscalled bandwidth efficiency.

$\eta_{B0} = R/B$

= Datarate / Bandwidth in bps/Hz

4. What is QPSK?

The Quadrature Phase Shift Keying (QPSK) is a 4-ary PSK signal. The phaseof the carrier in the QPSK takes 1 of 4 equally spaced shifts.Two successive bits in the data sequence are grouped together.

1 symbol = 2 bits

This reduces bit rate and bandwidth of the channel.

Coherent QPSK = 2 x coherent BPSK system

The phase of the carrier takes on one of four equally spaced values such as $\pi/4, 3\pi/4, 5\pi/4$ and $7\pi/4$.

5. Define offset QPSK and π/4 differential QPSK.(2017 May)

In offset QPSK the amplitude of data pulses are kept constant. The timealignment of the even and odd bit streams are offset by one bit period in offset QPSK.In π /4 QPSK, signaling points of the modulated signal are selected from two QPSKconstellations which are shifted by p/4 wit h respect to each other. It is differentiallyencoded and detected so called π /4 differential QPSK.

6. What is meant by MSK?

A continuous phase FSK signal with a deviation ratio of one half is referred toas MSK. It is a spectrally efficient modulation scheme.

7. List the salient features of MSK scheme.

Salient features of MSK are:

- It has constant envelope, smoother waveforms than QPSK.
- Relatively narrow bandwidth.
- Coherent detection suitable for satellite communications.
- Side lobes are zero outside the frequency band, so it has resistance to co-channel interference.

8. Why GMSK is preferred for multiuser, cellular communication?

It is a simple binary modulation scheme. Premodulation is done by Gaussian pulse shaping filter, so side lobe levels are muchreduced. GMSK has excellent power efficiency and spectral efficiency than FSK. For the above reasons GMSK is preferred for multiuser, cellular communication.

9. How can we improve the performance of digital modulation under fading channels?

By the using of diversity technique, error control coding and equalization techniques performance of the digital modulation under fading channels areimproved.

10. Write the advantages of MSK over QPSK.

Advantages of MSK over QPSK:

- In QPSK the phase changes by 90degree or 180 degree .This creates abruptamplitude variations in the waveform, Therefore bandwidth requirement ofQPSK is more filters of other methods overcome these problems , but theyhave other side effects.
- MSK overcomes those problems. In MSK the output waveform is continuousin phase hence there are no abrupt changes in amplitude.

11. Define M-ary transmission system?

In digital modulations instead of transmitting one bit at a time, two or morebits are transmitted simultaneously. This is called M-ary transmission.

12. What is QAM?

At high bit rates a combination of ASK and PSK is employed in order tominimize the errors in the received data. This method is known as "QuadratureAmplitude Modulation".

13. Define QPSK.

QPSK is defined as the multilevel modulation scheme in which four phaseshifts are used for representing four different symbols. Examples of linear modulation:

- Pulse shaped QPSK
- OQPSK

14. What is linear modulation?

In linear modulation technique the amplitude of the transmitted signal varies linearlywith the modulating digital signal. In general, linear modulation does not have aconstant envelope.

15. Define non linear modulation.

In the nonlinear modulation the amplitude of the carrier is constant, regardless of thevariation in the modulating signals.Non-linear modulations may have either linear or constant envelopes depending onwhether or not the baseband waveform is pulse shaped.

16. What is the need of Gaussian filter?

Need for Gaussian Filter:

- Gaussian filter is used before the modulator to reduce the transmittedbandwidth of the signal.
- It uses less bandwidth than conventional FSK.

17. Mention some merits of MSK. (2017 May)

Merits of MSK:

- Constant envelope
- Good BER performance
- Self-synchronizing capability
- MSK is a spectrally efficient modulation scheme and is particularly attractive for use in mobile radio communication systems.

18. Define cyclic prefix? ?(2016 Nov) (2018 May)

In delay dispersive channel, inter carrier interference occur. To overcome theeffect of inter carrier interference and ISI, cyclic prefix is introduced. It is a cyclicallyextended guard interval whereby each symbol sequence is preceded by a periodicextension of the sequence itself.

19. Find the 3dB bandwidth for a Gaussian low pass filter used to produce 0.25 GMSK with a channel data rate of R_b=300kbps. (2015 Nov)

From the problem statement it is clear that $T = 1/R_b = 1/300x10^3 = 3.33\mu sec$

Solving for B where BT = 0.25,

B = 0.25/T = 75.08kHz.

Thus, the 3dB bandwidth is 75.08kHz.

20. An 900MHz carrier signal is frequency modulated usinga100 kHz sinusoidal modulating waveform. The peak deviation of the FM signal is 500 kHz. If this FM signal is received by a super heterodyne receiver having an IF frequency of 5MHz, determine the IF bandwidth necessary to pass the signal.(2015 Nov)

Modulating signal frequency,

fm =100kHz

Peak frequency deviation,

$\Delta f = 500KHz$

By Carson rule Bandwidth,

=2(Δf+fm) =2(500+100) kHz
=1200kHz

21. Why is MSK referred to as fast FSK? (2016 May)

MSK is sometimes referred to as fast FSK, as the frequency spacing used is only half as that used in conventional noncoherent FSK.

MSK is a spectrally efficient modulation scheme and is particularly attractive for use in mobile radio communication systems. It possesses properties such as constant envelope, spectral efficiency, good BER performance, and self-synchronizing capability.

22. What is windowing? (2016 May)

Windowing is a popular method of reducing the spectral sidelobes of OFDM.Windowing is a technique proposed to help reduce sensitivity to frequency offers in an OFDM systems. This process involves cylindrically extending the time domain signal associated with each symbol by samples. The resulting signal is then shaped with window function.

23. Give the function of Gaussian filter in GMSK. (2016 Nov)

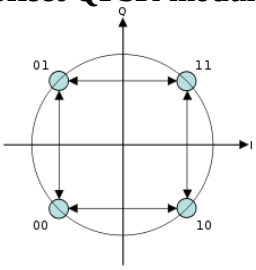
Gaussian Minimum Shift Keying, or to give it its full title Gaussian filtered Minimum Shift Keying, GMSK, is a form of modulation used in a variety of digital radio communications systems.

It has advantages of being able to carry digital modulation while still using the spectrum efficiently. One of the problems with other forms of phase shift keying is that the sidebands extend outwards from the main carrier and these can cause interference to other radio communications systems using nearby channels.

24. What is the basic advantage of using Multicarrier schemes such as OFDM? (2017 May)

One of the main advantages of MultiCarrier Modulation (MCM) schemes for broadband wireless communications is their robustness to multipath propagation channels, stemming from the fact that they divide the channel spectrum into very narrow subbands, and, in the extreme case, no frequency selectivity, i.e., only flat fading, is observed in each of them.

25. Draw the constellation diagram for offset QPSK modulation scheme. (2018 May)



26. Define PAPR. Is it high or low in OFDM? (2018 Nov) (2017 Nov)

PAPR (Peak to average power ratio), is the relation between the maximum power of a sample in a given OFDM transmit symbol divided by the average power of that OFDM symbol. In simple terms, PAPR is the ratio of peak power to the average power of a signal. It is expressed in the units of dB.

In the OFDM signal it is obtained by summing many different subcarrier signals (up to M), its PAPR can be very high.

27. State the advantages of GMSK. (2018 Nov)

- achieving good receiver sensitivity.
- PAPR is maintained low due to no phase continuities and occurrence of frequency changes at zero cross over of RF carrier. Due to this, highly linear PA (Power Amplifier) is not required.
- Spectral efficiency is better and higher while demodulator is less complex.
- GMSK provides constant envelope over the entire bandwidth. Hence it offers excellent power efficiency.
- It provides good BER performance.
- GMSK offers self-synchronizing capabilities.
- GMSK is good choice for voice modulation.

28. List the features of offset QPSK. (2019 May) (2019 Nov)

- The main purpose of OQPSK is to limit the maximum phase change possible in QPSK.
- Offset QPSK, which involves adding a delay to one of two digital data streams used in the modulation process, reduces the maximum phase jump to 90°.
- Offset QPSK is thus superior with respect to reducing phase discontinuities,

29. What are the differences between zero-forcing and mean squared error equalizer? (2019 May)

To minimize the inter symbol interference and additive noise effects, the equalizer coefficients can be optimized using the minimum mean squared error (MMSE) criterion. When the SNR has elevated values the MMSE equalizer works as Zero Forcing does, but when the SNR has lower values, the fact that MMSE equalizer takes into account the noise and signal variance, makes to not amplify the noise as Zero Forcing does.

when the Signal to Noise Ratio (SNR) has high values, the MMSE equalizer works as the Zero Forcing does, but for the rest of values that SNR can take, the MMSE equalizer works better in terms of distortion.

30. What is MSK? Why it is named so? (2019 Nov)

Minimum shift keying (MSK) is a special type of continuous phase-frequency shift keying (CPFSK) with h=0.5. A modulation index of 0.5 corresponds to the minimum frequency spacing that allows two FSK signals to be coherently orthogonal, and the name minimum shift keying implies the minimum frequency separation (i.e. bandwidth) that allows orthogonal detection.

PART B & C Questions

1. **Explain in detail about Gaussian Minimum Shift Keying (GMSK)Transmission and Reception with necessary block diagrams.(2015 Nov)**
   T2: Page No (215)
2. **A zero mean sinusoidal message is applied to a transmitter that radiates an AM signal with10kWpower.Compute the carrier power if the modulationindexis0.6. What percentage of the total power is in the carrier? Calculate the power in each sideband. (2015 Nov)**
   T2: Page No
3. **What is MSK? Also derive the expression of MSK signal as a special type of FSK signal and explain its power spectral density. (2015 Nov) (2016 Nov) (2017 Nov)**

T2: Page No (212)

4. **Why are constant envelope modulation schemes such as MSK and GMSK used in a wireless communication system? Compare and contrast these two modulation techniques.(2017 May)**
   T2: Page No (212,215)
5. **Describe OFDM scheme and state the reason behind using cyclic prefix in OFDM scheme. What is PAPR? Why is it normally larger in a OFDM technique? (2017 May)**
   T2: Page No (417-420)
6. **Discuss the error performance of different modulation schemes in fading channels.(2017 May)**
   T2: Page No (219)
7. **What is offset-QPSK? What is its advantage? Describe the offset-QPSK Scheme. (2017 May)**
   T2: Page No (204)
8. **Describe with neat diagram, the modulation technique of QPSK. (2017 Nov)**
   T2: Page No (196)
9. **List the advantages and applications of BFSK. (2017 Nov)**
   T2: Page No (208)
10. **Prove that the OFDM system converts the delay spread channel into a set of parallel fading channels, using the concept of cyclic prefix. (2018 May)**
    T2: Page No (417)
11. **Derive the bit error rate for binary phase shift keying modulation for frequency flat fading channels. (2018 May)**
    T2: Page No (221)
12. **With neat block diagram, explain the OFDM transmitter and receiver. List out its advantages and disadvantages. (2016 Nov) (2018 Nov) (2019 Nov)**
    T2: Page No (417)
13. **Explain the MSK system and its importance in a wireless communication system. (2018 Nov)**
    T2: Page No (212)
14. **Why is O-QPSK preferred in wireless communication system? Justify. (2018 Nov)**
    T2: Page No (204)
15. **Explain the principle of an $\frac{\pi}{4}$ -DQPSK scheme and compare it withtraditional QPSK scheme. (10 + 5). (2018 May) (2018 Nov)**
    T2: Page No (201)
16. **Explain the principle of OFDM by comparing it with FDMA with a sketch. (2019 May)**T2: Page No (417)
17. **Discuss any four reasons for the physical cause of error floors in delay and frequency dispersive fading channels. (2019 May)**
    T2: Page No (221)
18. **Explain in detail about $\frac{\pi}{4}$QPSK transmission and detection with necessary block diagram. (2019 May) (2019 Nov)**
    T2: Page No (201-206)

UNIT- IV: MULTIPATH MITIGATION TECHNIQUES

1. How the link performance can be improved?

Link performance can be improved by various techniques such as

- Equalization
- Diversity
- Channel coding

2. What are the techniques used to improve the received signal quality? (2019 May)

The following techniques are used to improve the received signal quality:

- Equalization
- Diversity
- Channel coding

3. What is an equalizer? Name the types (2019 Nov)

Equalizer is a pulse shaping circuit which is used to reduce ISI. The two types of equalizer are: Linear equalizer and non linear equalizer.

4. What is linear and non-linear equalizer? (2016 Nov)

Linear equalizer: the current and past values of the received signal are linearly weighted by the filter coefficients and summed to produce the output.

- No feedback path is used.
- Simple and easy to implement.
- Not suitable for severely distortedchannel.
- Noise power signal is enhanced.

Nonlinear equalizer: If the past decisions are correct, then the ISI contributed bypresent symbol can be cancelled exactly,

- Feedback path is used.
- Suitable for severelydistorted channel.
- Noise power signal is not enhanced.
- Complex in structure.
- Channels with low SNR.
- Suffers from error propagation.

5. What is the need of equalization? (2019 Nov)

Equalization can be used to compensate the Inter Symbol Interference createdby multipath within time dispersion channel.

6. What is diversity? (2017 May)

Diversity is used to compensate the fading channel impairments and is usuallyimplemented by using two or more receiving antennas. Diversity improvestransmission performance by making use of more than one independently fadedversion of the transmitted signal.

7. Define spatial diversity. (2017 Nov)

The most common diversity technique is spatial diversity, whereby multipleantennas are strategically spaced and connected to a common receiving system. Whileone antenna sees a signal null, one of the other antenna may sees a signal peak, andthe receiver is able to select the antenna with the best signals at any time.

8. Define adaptive equalization? (2016 May)

To combine Inter Symbol Interference, the equalizer coefficients shouldchange according to the channel status so as to break channel variations. Such anequalizer is called an adaptive equalizer since it adapts to the channel variations.

9. Define training mode in an adaptive equalizer?

First, a known fixed length training sequence is sent by the transmitter then thereceivers equalizers may adapt to a proper setting of minimum bit error detectionwhere the training sequence is a pseudo random binary signal or a fixed andprescribed bit pattern.

10. What is tracking mode in an adaptive equalizer?

Immediately following this training sequence the user data is sent and the adaptive equalizer at the receiver utilizes a recursive algorithm to evaluate the channeland estimate filter coefficients to compensate for the distortion created by multipath inthe channel.

11. What are the nonlinear equalization methods used?

Commonly used non linear equalization methods are:

- Decision feedback equalization
- Maximum likelihood symbol detection
- Maximum likelihood sequence estimation

12. What are the factors used in adaptive algorithms?

- Rate of convergence
- Misadjustments
- Computational complexity
- Numerical properties

13. If a digital signal processing chip can perform one million multiplications per second, determine the time required between each iteration for the following adaptive equalizer algorithms.

- **Square root RLS DFE**
- **Gradient lattice DFE(2015 Nov)**

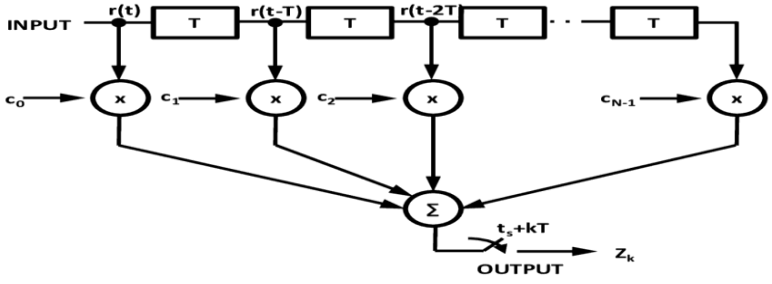
For Square root RLS DFE

Number of multiply operation per iteration=$1.5N^2+6.5N$

For Gradient lattice DFE

Number of multiply operation per iteration=31N-8

14. Draw the structure of a linear transversal equalizer.(2015 Nov)



15. What are the benefits of RAKE receiver? (2016 May)

A Rake Receiver is a radio receiver which is designed for the purpose to counter the effects of multipath fading. Due to reflections from multiple obstacles in the environment, the radio channel can consist of multiple copies of the transmitted signal having different amplitude, phases or delays.

16. What is Macro diversity?(2016 Nov)(2018 Nov)(2019 May)

Diversity to mitigate the effects of shadowing from buildings and objects is called macro diversity. Macro diversity is generally implemented by combining signals received by several base stations or access points.

17. Define STCM. (2017 Nov)

STCM is a technique used in wireless communications to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of the data to improve the reliability of data transfer. In fact, space–time coding combines all the copies of the received signal in an optimal way to extract as much information from each of them as possible.

18. Distinguish between diversity gain versus array gain. (2018 May)

Arraygain means a power gain of transmitted signals that is achieved by using multiple-antennas at transmitter and/or receiver, with respect to single-input single-output case.

19. Diversitygain is dependent on spatial correlation coefficients between antenna signals.**Differentiate micro from macro diversity. (2019 Nov)**

Micro diversity	**Macro diversity.**
Small scale fading results in a Rayleigh distribution of signal strength over small distances. This causes Micro diversity.	Large-scale fading is caused by shadowing due to variations in both the terrain profile. This causes Macro diversity.
Used to reduce small scale fading effects	Used to reduce large scale fading effects
Multiple reflection causes deep fading. This effect is reduced.	Deep Shadow causes fading. This effect is reduced.

PART B & C Questions

1. Consider a single branch Rayleigh fading signal has a 20% chance of being6dB below some mean SNR threshold.

(i) DeterminethemeanoftheRayleighfadingsignalasreferencedtothethreshold.

(ii) Find the likelihood that a two-branch selection diversity receiver will be 6dB below the mean SNR threshold.

(iii) Find the likelihood that a three-branch selection diversity receiver will be 6dB below the mean SNR threshold.

(iv) Find the likelihood that a four branch selection diversity receiver will be 6 dB below the mean SNR threshold.

(v) Based on your answers above, is there a law of diminishing returns when diversity is

used? (2015 Nov)
T1: Page No (226)

2. **Derive the mean square error for a Generic Adaptive Equalizer.(2015 Nov)**
   T1: Page No (374)
3. **With relevant diagrams explain Rake receiver. Also discuss how time diversity is achieved in a CDMA technique using Rake receiver.(2016 Nov) (2017 May)(2018 May)(2018 Nov)(2019 May) (2019 Nov)**
   T1: Page No (391)
4. **Explain in detail the various factors to determine the algorithm for adaptive equalizer. Also derive the Least Mean Square Algorithm for adaptive equalizer. (2016 Nov)**
   T1: Page No (374)
5. **Assume four branch diversity is used, where each branch receives an independent Rayleigh fading signal. If the average SNR is 20 dB, determine the probability that the SNR will drop below 10dB. Compare this with the case of a single receiver without diversity.(2017 May)**
   T1: Page No(226)
6. **Derive an expression for performance improvement due to Maximal Ratio combining. (2017 May)**
   T1: Page No (370)
7. **Describe the role played by Equalization and diversity as Multipath mitigation techniques compare and contrast these two techniques.(2017 May)**
   T1: Page No (363)
8. **Consider the design of the US Digital Cellular equalizer, where f= 900MHz the mobile velocity v = 80 km/hr. Determine the maximum Doppler shift, the coherence time of the channel and the maximum number of symbols that could be transmitted without updating the equalizer assuming that the symbol rate is 24.3 k symbols/sec. (2017 May)**
   T1: Page No (355)
9. **Describe in detail about i) Linear equalizers ii) Non-linear equalizers. (2017 Nov)**
   T1: Page No (366,368)
10. **Analyze various diversity techniques used in wireless communication. (2017 Nov)**
    T1: Page No (380)
11. **With valid statements, analytically prove that the adaptive equalizers exhibit superior performance over the conventional equalizers. (2017 Nov)**
    T1: Page No (359)
12. **Analyze and compare the error performance in fading channels with and without diversity reception techniques. (2017 Nov)(2018 May)**
    T1: Page No (380)
13. **Consider uncoded spatial multiplexing over a MIMO channel with $M_R \geq M_T$ Show that the ML, MMSE and ZF receivers perform equally well if the channel is orthogonal, i.e., $H^H H = \eta I_{MR}$, where $\eta$is constant. What is the per-stream SNR? (2018 May)**
    T1: Page No (412)
14. **What is Equalization? Why is the equalization in a wireless system required to be Adaptive? (2018 Nov)**
    T1: Page No (356)
15. **Describe any two diversity combining techniques stating their respective merits. (2018 Nov)**
    T1: Page No (380)
16. **What is Zero Forcing Equalizer Algorithm? Explain. (2018 Nov)**

T1: Page No (372)

17. **With neat diagrams, explain and analyze linear equalization procedure. (2018 Nov)**
    T1: Page No (366)
18. **Draw and explain a simplified communication system using an adaptive equalizer at the receiver. (2019 May)**
    T1: Page No (359)
19. **Write a brief note on categories of space diversity reception methods. (2019 May)**
    T1: Page No (380)
20. **Draw the chart showing the classification of equalizers. (2019 May)**
    T1: Page No (364)
21. **Write down the purpose of algorithms for adaptive equalization and also state on what factors the performance of these algorithms depend on. (2019 Nov)**
    T1: Page No (374)
22. **Explain selection combining technique in detail. (2019 Nov)**
    T1: Page No (380)
23. **Write down the three small scale fading effects and also name the techniques that are used to mitigate the effects of small-scale fading. (2019 Nov)**
    T1: Page No (205)

UNIT-V: MULTIPLE ANTENNA TECHNIQUES

1. **Differentiate selection diversity and combining diversity**

Selection diversity	**Combining diversity**
The best signal is selected and processedwhile all other signals are discarded.	All signals are combined before processingand the combined signal is decoded.
Simple circuits are used.	At individual receiver, phasing circuits areneeded.

2. **Define MIMO Systems. (2016 May)**

   MIMO systems are systems with Multiple Element Antennas (MEAs) at both transmitter and receiver. MIMO system offers high data rates and lower error rates.

3. **Define spatial multiplexing. (2017 Nov) (2018 Nov)(2019 Nov) (2017 May)**

   Spatial multiplexing uses MEAs at the TX for transmission of parallel datastreams. An original high-rate data stream is multiplexed into several parallelstreams, each of which is sent from one transmit antenna element. A basiccondition is that the number of receive antenna elements is at least as large asthe number of transmit data streams.

4. **What is Pre-coding? (2019 May)**

   Pre-coding scheme is designed to minimize the mean-squared error between the transmitted and

received data with a per-user power constraint. Pre-coding allows toperform many complex processing at BS or Access Point(AP).It reduces computational complexities and provides better performance.

5. Define Beamforming?

Beam forming or smart antenna system uses phased array of antennas for transmitter and receiver. It can be used in any antenna system to create a required antenna directive pattern to give the required performance under the given conditions.

6. Define SDMA?

Space division multiple access controls the radiated energy for each user inspace. It serves different users by using spot beam antennas.

7. Define Transmit diversity. (2016 May)

Diversity effect is achieved by transmitting signals from several transmit antenna. Two main cases are considered in transmit diversity. They are, 1.Transmitter diversity with the CSI(Channel State information) 2. Transmitter diversity without the CSI(Channel State information).

8. What is meant by frequency diversity?

Correlation is increased by transmitting information on more than one carrierfrequency. Frequencies are separated by more than one coherence bandwidth ofthe channel. So the signals will notexperience same fades.

9. Define Receiver diversity. (2017 Nov)

Receiver diversity uses two separate, collocated antennas for receive functions. Such a configuration eliminates the need for a duplexer and can protect sensitive receiver components from the high power used in transmit.

10. Name the different types of systems where beamforming is implemented.

- Point to Point MIMO
- Point to Multipoint MIMO
- Multipoint MIMO to Multipoint MIMO.

11. What is antenna diversity? (2015 Nov)

Antenna diversity is a transmission method using more than one antenna to receiver or transmit signals along different propagation paths to compensate for multipath interferences.

12. What is Channel state information?(2017 May)(2018 Nov)

Channel state information(CSI) is information which presents the state of communication link from Transmit Source to Receiver Source.

13. What are Smart antenna systems?

Smart Antennas(MIMO) are antenna arrays with smart signal processing algorithms used to identify spatial signal signature such as DOA(Direction of Arrival) of the signal and used to calculate beamforming vectors, to track and locate antenna beam on mobile/target.

14. Define D BLAST?

The symbols which are to be transmitted are arranged on the diagonals of the space-timetransmission matrix where elements under diagonals are padded with zeros.

15. Define V BLAST?

Incoming data stream is demultiplexed into N streams each of which is encoded and modulated independently and sent on an antenna of its own.

16. Define T BLAST?

The data stream bits are demultiplexed into N parallel streams which are encoded independently using the block encoder. The output streams of outer encoder are interleaved independently and passed to the inner-encoder.

17. Write down the expression for the probability error for BPSK modulation techniques, with coherent detection for the following case (a) AWGN; (b)Raleigh fading. (2015 Nov)

(a). $P_b = Q\left(\frac{2\sqrt{E_b}}{\sqrt{2N_o}}\right) = Q\left(\sqrt{\frac{2E_b}{N_o}}\right)$

(b). $P_b = \frac{1}{2}\left(1 - \sqrt{\frac{(E_b/N_o)}{(E_b/N_o)+1}}\right)$

18. How does spatial multiplexing work? (2016 Nov)

Spatial multiplexing in wireless communications is based on multi-input and multiple-output (MIMO) technology where multiple antennas at both the transmitter and receiver are used to carry multiple data streams simultaneously within the same frequency band.

19. What is ergodic and outage capacity of a flat fading channel. (2016 Nov)

Ergodic capacity of a MIMO flat fading channel is achieved by averaging over the variation of channel over time.

20. State true or false: Justify your answer: (2018 May)

(i). Channel knowledge at the transmitter is not required in MIMO channels to extract multiplexing gain.

(ii). Channel knowledge at the transmitter is required in MIMO channels to extract diversity gain.

(i). TRUE

(ii). FALSE

21. List different types of diversity schemes. (2018 May)

(i). Time Diversity, (ii). Antenna Diversity, (iii) Frequency Diversity.

22. Assume four branch diversity is used, where each branch receives an independent Rayleigh fading signal. If the average SNR is 20dB, determine the probability that the SNR will drop below 10dB. Compare this with the case of a single receiver without diversity. (2019 Nov)

Here, $\gamma_T = 10$ dB, $\Gamma = 20$ dB and $M = 4$

Using $P_M(\gamma_T) = \left(1 - e^{-\gamma_T/\Gamma}\right)^M$, we find

$$P_4(10 \text{ dB}) = \left(1 - e^{-0.1}\right)^4 = 0.000082$$

Without diversity, $M = 1$ and thus

$$P_1(10 \text{ dB}) = \left(1 - e^{-0.1}\right)^1 = 0.095$$

Note: Without diversity the SNR drops below the specified threshold with a probability that is three orders of magnitude greater than if four branch diversity is used

PART B & C Questions

1. **Determine the capacity of frequency selective fading channel and explain the concept of water filling/water pouring.(2015 Nov)**
   T2: Page No (420,316)
2. **Determine the capacity of slow fading channel and prove that the outage Probability for receive diversity system with L receiving antennas is $P_{out}(R) = \frac{\left(2^R - 1\right)^L}{L!SNR^L}$ Where R is the data rate.(2015 Nov)**
   T2: Page No(462)
3. **Calculate the capacity ofa MIMO system in flat fading and non fading channels.(2016 Nov)(2017 May) (2018 Nov)**
   T2: Page No(470)
4. **Discuss in detail the classification of algorithms for MIMO based system?(2016 Nov)**
   T2: Page No(464)
5. **Describe MIMO systems with emphasis on n their requirement in a wireless communication environment. (2016 Nov) (2017 May)(2018 Nov) (2019 Nov)**
   T2: Page No(464)
6. **Describe the concepts of Pre-coding and Beam forming. (2017 May)(2018 Nov) (2019 Nov)**
   T2: Page No (462)
7. **What is meant by MIMO systems? Explain the system model with necessary diagrams. (2017 Nov) (2019 Nov)**
   T2: Page No (464)
8. **Distinguish between different beam forming techniques. (2017 Nov)**
   T2: Page No (462)
9. **Prove that 2x2 MIMO system (without channel state information) at the transmitter provides the diversity gain of 4 and array gain of 2 using Alamouti Scheme. (2018 May)**
   T2: Page No(464)
10. **Derive an expression for the capacity of the following systems.**
    (a) SIMO system assuming that the channel is known at Receiver.
    (b) MISO system assuming that the channel is known at transmitter.
    (c) MIMO system assuming that channel is unknown at the transmitter. (2018 May)

11. **Describe Transmitter diversity and Receiver diversity. (2018 Nov)**
    T2: Page No (464)
12. **Explain clearly how spatial multiplexing works with a neat diagram and write down the expression for the channel matrix and received signal vector. (2019 May)**
    T2: Page No (480)
13. **In a cellular MIMO system: let the BS have 8 antenna elements, and each MS have 2 antenna elements. The system has 5MHz bandwidth centered at 2GHz carrier frequency, and operates in a channel with 250 kHz coherence bandwidth. The coherence time is 5 ms, corresponding to typical vehicular speeds. With 30 users in the cell, what is the total overhead data rate for the feedback?**
    (Assume that real and imaginary parts are quantized with 6 bits each, and a rate 2/3 code is used to protect the feedback information.) Justify with the answer why the feedback reduction techniques are important?(2019 May)
    T2: Page No (462)
14. **What is capacity of flat fading channel and explain CSI known at the Transmitter and Receiver with necessary diagrams. (2019 May) (2019 Nov)**
    T2: Page No (470)

PREVIOUS YEARS ANNA UNIVERSITY QUESTION PAPERS

Question Paper Code : 91464

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2019
Fifth/Eighth Semester
Electronics and Communication Engineering
EC 6801 – WIRELESS COMMUNICATION
(Common to Robotics and Automation Engineering/Information Technology)
(Regulations 2013)
(Also common to PTEC 6801 – Wireless Communication for B.E. (Part-Time)
Sixth Semester – Electronics and Communication Engineering – Regulations 2014)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. What is shadow fading ? Why it is called so ?
2. Which factors does diffraction depend on at high frequencies ?
3. Write any three features of FDMA.
4. What are the disadvantages of TDMA ?
5. What is MSK ? Why it is named so ?
6. State the features of offset QPSK.
7. What is the use of equalization technique ? Name the types.
8. Differentiate micro from macro diversity.
9. What is meant by spatial multiplexing ?
10. Assume four branch diversity is used, where each branch receives an independent Rayleigh fading signal. If the average SNR is 20 dB, determine the probability that the SNR will drop below 10 dB. Compare this with the case of a single receiver without diversity.

PART – B **(5×13 = 65 Marks)**

11. a) i) Determine the proper spatial sampling interval required to make small-

14. a) i) Explain the working of RAKE receiver with a neat sketch (8)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 52929

PART B — (5 × 13 = 65 marks)

11. (a) (i) Describe the free space propagation model and derive the loss in the signal strength. (7)

14. (a) Draw and explain a simplified communication system using an adaptive equalizer at the receiver.

Or

Question Paper Code : 20430

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2018.

Fifth/Eighth Semester

Electronics and Communication Engineering

EC 6801 — WIRELESS COMMUNICATION

(Common to Robotics and Automation Engineering and Information Technology)

(Regulations 2013)

(Also common to PTEC 6801 – Wireless Communication for B.E. (Part-Time) – Sixth Semester – Electronics and Communication Engineering – Regulations 2014)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is fast fading?
2. Define Coherence time.
3. List the features of Cellular concept.
4. How is frequency reuse distance measured in cellular system?
5. Define PAPR. Is it high or low in OFDM?
6. State the advantages of GMSK.
7. Distinguish linear and non linear equalization.
8. What is Macro-diversity?
9. What is meant by spatial multiplexing and spatial diversity?
10. What is Channel State Information? How is it obtained?

PART B — (5 × 13 = 65 marks)

11. (a) (i) Explain the various path loss models for large scale fading. (7)

(ii) What is frequency selective fading? Explain. (6)

15. (a) (i) Derive and explain the Capacity of non-fading channels with related sketches. (6)

(ii) Explain Beam forming with neat diagrams. (7)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 40974

B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2018
Fifth/Eighth Semester
Electronics and Communication Engineering
EC 6801 – WIRELESS COMMUNICATION
(Common to Robotics and Automation Engineering/Information Technology)
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions

PART – A **(10×2=20 Marks)**

1. Compare fast and slow fading.
2. Give the differences between frequency flat and frequency selective fading.
3. Define frequency re-use.
4. Differentiate between FDMA, TDMA and CDMA technologies.
5. What do you mean by cyclic prefix ?
6. Draw the constellation diagram for offset QPSK modulation scheme.
7. Design a three tap zero forcing linear equalizer so that the output is

$$q_m = \begin{cases} 1 & m = 0 \\ 0 & m = \pm 1 \end{cases} \text{ and for the input } x_m = \begin{cases} 0.3 & m = 1 \\ 0.9 & m = 0 \\ 0.3 & m = -1 \\ 0 & \text{elsewhere} \end{cases}$$

8. Distinguish between diversity gain versus array gain.
9. State true or false : Justify your answer :
   - Channel knowledge at the transmitter is not required in MIMO channels to extract multiplexing gain.
   - Channel knowledge at the transmitter is required in MIMO channels to extract diversity gain.
10. List different types of diversity schemes.

PART – B **(5×13=65 Marks)**

11. a) i) Describe briefly about Free space propagation model. **(3)**

ii) Consider a transmitter which radiates a sinusoidal carrier frequency of 1850MHz. For a vehicle moving 60 mph, compute the received carrier Frequency if the mobile is moving directly toward the transmitter. **(4)**

iii) Given that the coherence bandwidth is approximated by equation $B_c = \frac{1}{5\sigma_\tau}$. Show that a flat fading channel occurs when $T_s \geq 10\sigma_\tau$. **(6)**

(OR)

b) Explain briefly about Two Ray Ground reflection model.

12. a) Consider a time invariant frequency selective block fading channel consisting of 3 subchannels of B =1MHz. The frequency response associated with each channel is $H_1 = 1$, $H_2 = 2$, $H_3 = 3$. The transmit power constraint is P = 10mw and noise power spectral density is $N_0 = 10^{-9}$W/Hz. Find the Shannon capacity of the channel and optimal power allocation that achieves this capacity.

(OR)

b) Explain channel assignment and handoff strategies in detail.

13. a) Prove that the OFDM system converts the delay spread channel into a set of parallel fading channels, using the concept of cyclic prefix.

(OR)

b) Derive the bit error rate for binary phase shift keying modulation for frequency flat fading channels.

14. a) Explain the principles of RAKE receiver in detail.

(OR)

b) Consider uncoded spatial multiplexing over a MIMO channel with $M_R \geq M_T$. Show that the ML, MMSE and ZF receivers perform equally well if the channel is orthogonal, i.e., $H^H H = \eta I_{MR}$, where η is a constant. What is the per-stream SNR ?

15. a) Prove that 2×2 MIMO system (without channel state information) at the transmitter provides the diversity gain of 4 and array gain of 2 using Alamouti Scheme.

(OR)

b) Derive an expression for the capacity of the following systems.

a) SIMO system assuming that the channel is known at Receiver. **(4)**

b) MISO system assuming that the channel is known at transmitter. **(4)**

c) MIMO system assuming that channel is unknown at the transmitter. **(5)**

PART – C **(1×15=15 Marks)**

16. a) Determine the error probability for different fading channels with diversity reception.

(OR)

b) With neat diagrams, explain the modulation and demodulation of $\frac{\pi}{4}$ DQPSK modulation technique.

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 50456

B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2017
Fifth/Eighth Semester
Electronics and Communication Engineering
EC 6801 – WIRELESS COMMUNICATION
(Common to Robotics and Automation Engineering/Information Technology)
(Regulations 2013)

Time : Three Hours Maximum : 100 Marks

Answer ALL questions.

PART – A **(10×2=20 Marks)**

1. What is meant by multipath propagation ?
2. What is flat fading ?
3. What do you mean by forward and reverse channel ?
4. Define frequency reuse.
5. Define offset QPSK and $\pi/4$ differential QPSK.
6. Define PAPR.
7. Define spatial diversity.
8. Define STCM.
9. Define spatial multiplexing.
10. Define receiver diversity.

PART – B **(5×13=65 Marks)**

11. a) i) What do you mean by path loss model ? Explain in detail about log-distance path loss model.

    ii) What is the need for link calculation ? Explain with suitable example.

    (OR)

    b) Distinguish fast fading and slow fading in wireless channel and explain in detail.

50456

12. a) Identify the channel capacity of TDMA in cell system.

(OR)

b) Write short note on i) Trunking ii) Grade of service of cell system.

13. a) i) Describe with neat diagram, the modulation technique of QPSK.

ii) List the advantages and applications of BFSK.

(OR)

b) Examine the principle of MSK modulation and derive the expression for power spectral density.

14. a) Describe in detail about i) Linear equalizers ii) Non-linear equalizers.

(OR)

b) Analyze various diversity techniques used in wireless communication.

15. a) What is meant by MIMO systems ? Explain the system model with necessary diagrams.

(OR)

b) Distinguish between different beamforming techniques.

PART – C **(1×15=15 Marks)**

16. a) Analyze and compare the error performance in fading channels with and without diversity reception techniques.

(OR)

b) With valid statements, analytically prove that the adaptive equalisers exhibit superior performance over the conventional equalisers. **(15)**

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 71747

B.E/B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Fifth/Eighth Semester

Electronics and Communication Engineering

EC 6801 — WIRELESS COMMUNICATION

(Common to Robotics and Automation Engineering, Information Technology)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the major advantage of wireless communication?

2. Define Coherence time. In what way does this parameter decide the behavior of wireless channel?

3. Why is cellular concept used for mobile telephony?

4. In a cellular network, among a handoff call and a new call, which one is given priority? Why?

5. What is the basic advantage of using Multicarrier schemes such as OFDM?

6. State any two advantages of MSK.

7. Why is an adaptive equalizer required?

8. What is diversity? Why is it employed?

9. What is spatial multiplexing?

10. What is Channel State Information? What is its benefit?

PART B — (5 × 16 = 80 marks)

11. (a) (i) If a transmitter produces 50W of power, which is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received

(b) (i) Derive the expressions for Cellular CDMA schemes for both noise limited and interference limited scenarios. (10)

(ii) Consider Global System for Mobile, which is a TDMA/FDD system that uses 25 MHz for the forward link, which is broken into radio channels of 200 MHz. If 8 speech signals are supported on a single radio channel and if no guard band is assumed find the number of simultaneous users that can be accommodated in GSM. (2)

(iii) If GSM uses a frame structure where each frame consists of eight time slots, and each time slot contains 156.25 bits, and data is transmitted at 270.833 kbps in the channel, find (1) the time duration of a bit (2) the time duration of a slot (3) the time duration of a frame and (4) how long must a user occupying a single time slot wait between two successive transmissions? (4)

13. (a) (i) Why are constant envelope modulation schemes such as MSK and GMSK used in a wireless communication system? Compare and contrast these two modulation techniques. (8)

(ii) Describe OFDM scheme and state the reason behind using cyclic prefix in OFDM scheme. What is PAPR? Why is it normally larger in a OFDM technique? (8)

Or

(b) (i) Discuss the error performance of different modulation schemes in fading channels. (10)

(ii) What is Offset–QPSK? What is its advantage? Describe the Offset–QPSK scheme. (6)

14. (a) (i) Describe the role played by Equalisation and diversity as Multipath mitigation techniques. Compare and contrast these two techniques. (10)

(ii) Consider the design of the US Digital Cellular equalizer, where f = 900 MHz and the mobile velocity v = 80 km/hr, determine the maximum Doppler shift, the coherence time of the channel and the maximum number of symbols that could be transmitted without updating the equalizer assuming that the symbol rate is 24.3 k symbols/sec. (6)

Or

(b) (i) With a sketch, describe RAKE receiver. (6)

(ii) Assume four branch diversity is used, where each branch receives an independent Rayleigh fading signal. If the average SNR is 20 dB, determine the probability that the SNR will drop below 10 dB. Compare this with the case of a single receiver without diversity. (4)

(iii) Derive an expression for performance improvement due to Maximal Ratio combining. (6)

15. (a) Discuss in detail, the capacity in fading and non–fading channels. (16)

Or

(b) (i) Describe MIMO systems with emphasis on their requirement in a wireless communication environment. (8)

(ii) Describe the concepts of Pre–coding and Beam forming. (8)

Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 40453

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2021.

Sixth Semester

Electronics and Communication Engineering

EC 8652 – WIRELESS COMMUNICATION

(Common to: Computer and Communication Engineering/Electronics and Telecommunication Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. What is Small Scale fading?
2. Write the significance of link budget.
3. Define frequency reuse.
4. What is the trade off that exists between system capacity and coverage?
5. How PAPR issue can be addressed?
6. Why GMSK is better than QPSK?
7. How equalization is achieved through Zero Forcing Algorithm?
8. How error probability is computed for fading channel in SISO system?
9. Define Pre-coding.
10. How beam forming can improve performance of communication system?

PART B — ($5 \times 13 = 65$ marks)

11. (a) Derive the two ray ground model expressing the relationship between received power and path loss component.

Or

(b) (i) Find the Fraunhofer distance for an antenna with maximum dimension of 1 m and operating frequency of 60 GHz. If antennas have unity gain, calculate the path loss. (3)

(ii) If a transmitter produces 50W of power, express the transmit power in units of dBm, dBW. If 50 W is applied to a unity gain antenna with a 900 MHz carrier frequency, find the received power in dBm at a free space distance of 100m from the antenna. What is Pr (10 Km)? Assume unity gain for the receiver antenna. (10)

12. (a) With neat sketch, illustrate the first tier co-channel interference caused in a cluster size of 7. Also derive the expression that relates the system capacity in terms of co-channel reuse ratio.

Or

(b) How many users can be supported for 0.5% blocking probability for following the trunked channels in a blocked calls cleared systems? 1,5,10, 20, 100. Assume each user generates 0.1 Erlangs of traffic.

13. (a) Compare and contrast QPSK, p/4 QPSK, MSK and GMSK.

Or

(b) Explain the working principal of OFDM, also the significance of cyclic prefix and windowing.

14. (a) Explain the working mechanism of Equalizer with a simplified communication system that uses adaptive equalizer at the receiver.

Or

(b) Write short note on

(i) Rake receiver (4)

(ii) Space Diversity and (4)

(iii) Frequency diversity (5)

15. (a) Discuss about the Space Time Block codes and Derive Alamouti Block Codes for a 2×1 MIMO system.

Or

(b) Compare the error performance of digital modulation techniques for AWGN channel, wireless fading channels and discuss the impact made by diversity techniques in the performance.

PART C — ($1 \times 15 = 15$ marks)

16. (a) Given a foot print by the service provider, prepare and illustrate the frequency planning addressing all practical limitations that can be envisaged. (Hint: N=7).

Or

(b) Design a cellular network in a hilly terrain using knife edge Diffraction geometry.

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