VELAMMAL INSTITUTE OF TECHNOLOGY, PANCHETTI
DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC6801 / WIRELESS COMMUNICATION CLASS:III YEAR/V SEM/IT
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QUESTION BANK

UNIT-I WIRELESS CHANNELS

PART-A

1. What is propagation model?
2. What are the two types of propagation model?
3. What are the two types of path loss model?
4. What is the necessity of Link budget?
5. Explain basic link budget equation?
6. What is free space propagation model?
7. Explain friis free space equation?
8. Explain d^{-4} power law?
9. Explain path loss equation of a free space propagation model.
10. Define EIRP
11. What is path loss model?
12. Define small scale fading?
13. Explain Two Ray ground reflection model?
14. Explain received power of a Two Ray ground reflection model?
15. Explain path loss equation of a Two Ray ground reflection model?
16. What are the factors influencing small scale fading?
17. What flat fading?
18. What is frequency selective fading?
19. Define fast fading channel?
20. Define slow fading channel?
21. Define coherence bandwidth?
22. Define Doppler shift?
23. Define large scale propagation model?
24. Define Small scale propagation model?
25. Differentiate constructive interference and destructive interference?
26. Define Power delay profile?
27. Define mean excess delay?
28. Define RMS delay spread?
29. Define maximum excess delay?
30. Define Doppler spread?
31. Define coherence time?

PART-B

1. a. What you mean by path loss model? Explain large scale path loss,
b).Define propagation model and, explain the two types of propagation model?
2. Explain the free space path loss model, and describe the following a).log-distance path loss model, b).log-normal shading path loss model

c). determination of percentage of coverage area

3. Explain following

a). Explain friis free space equation. b). Explain d^{-4} law?

c). Explain path loss equation for a free space propagation model.

4. Derive the expression for electric field, path loss and received power for a Two Ray model?

5. a). Explain small scale fading and, what are the factors affecting the small scale fading.

b).a mobile is located at 5Kms away from base station and uses a vertical $\lambda/4$ monopole antenna with a gain of 2.55 dB to receive cellular radio signals. The E- field at 1Km from transmitter is measured to 10^{-3}V/m the carrier frequency is 900MHz.Find the length and effective aperture of the effective the receiving antenna

6. a. Explain power delay profile, mean excess delay , RMS delay spread & Maximum excess delay.

b. calculate mean excess delay , RMS delay spread & maximum excess delay for the figure given below . Also estimate the coherence bandwidth of the channel.

Time in micro seconds	power in dB
0	-20
1	-10
2	-10
5	0

7. Explain the following

a. Doppler shift b. Doppler spread c. Coherence time

8. Explain fading due to multipath delay spread?

9. Explain fading due to Doppler spread and coherence time?

10. Define small scale fading, write the detail of following small scale fading a).Time dispersion parameter

b). Coherence band width

11. Compute the rms delay spread for the following delay profile

Time in micro seconds	power
0	1
1	1
2	1

a. Calculate the rms delay spread for the figure.

b. IF BPSK modulation is used , what is the maximum bit rate that can be sent through the channel without needing an equalizer ?

UNIT II Cellular Architecture

PART A

1. What is FDMA?
2. What are the basic units of a Cellular system?
3. What is base station?
4. What is MSC?
5. What do you mean by forward and reverse channel?
6. Define cell
7. What is channel assignment? What are the types?

8. What are the techniques used to expand the capacity of cellular system?
9. What is meant by frequency reuse?
10. What is Multiple Access?
11. What is co channel interference?
12. Define adjacent channel interference.
13. Define Grade of service.
14. What is blocked call clear system?
15. What is blocked call delay system?
16. Define cell splitting.
17. What is cell sectoring?
18. What is TDMA?
19. What is CDMA?
20. Write is microcell zone concept?

PART-B

1. Compare FDMA, TDMA & CDMA?
2. Briefly explain the principle of cellular networks?
3. Write short notes on frequency reuse & channel assignment strategies?
4. Explain Handoff and interference systems?
5. Explain the Multiple Access methods with neat diagrams?
6. Explain Grade of service, blocked calls cleared, blocked calls delay?
7. Explain cell sectoring and cell splitting in detail?
8. Explain “repeaters for range extension” and “microcell zone” concept?
9. Calculate channel capacity of TDMA in cell system.
10. Calculate channel capacity of FDMA in cell system.
11. Calculate channel capacity of CDMA in cell system.
12.Write detail about interference and system capacity of cellular system
13.Write detail about trunking and grade of service of cell system
14. How to improve coverage and capacity of cellular system

Unit – III Digital Signaling For Fading Channels

Part – A

1. What is the principle of staggered QPSK?
2. Draw possible state of Q_k when Q_{k-1} , Q_{k-1} and all possible stages in QPSK .
3. What you mean by continuous phase – frequency shift keying?
4. Define modulation index of FSK? And write the Expression
5. Draw the block diagram of non-coherence FSK receiver.
6. Write the advantage of MSK over GMSK?
7. Define power spectrum of MSK.
8. Define bit error rate of GMSK?
9. Draw the block diagram of GMSK transmitter using direct FM generator.
10. Find the 3dB bandwidth of a Gaussian low pass filter used to produce 0.25 GMSK with a channel data rate of Rb = 270 kbps. What is the 90% power bandwidth in the RF channel? Specify the Gaussian filter parameter.

11. Define Gaussian filter co-efficient in terms of bandwidth?
12. What is the principle of cyclic prefix in frequency selective channels?
13. Define windowing.
14. What is PAPR?
15. List the advantage of QPSK.
16. Draw the structure of a generic optimum receiver.
17. Mention any two criteria for choosing a modulation technique for a specific wireless communication
18. Write the applications of MFSK and OFDM?
19. Why MSK called as fast FSK?
20. Mention the merits and demerits of nonlinear modulation.

Part – B

1. Discuss about QPSK transmitter and receiver with signal space diagram and give an expression for spatial effect
2. Explain $\frac{\pi}{4}$ QPSK transmitter and receiver with signal space diagram and give an Expression for spectral efficiency.
3. Explain windowing techniques in OFDM systems.
4. Explain cyclic prefixing in OFDM system
5. Explain orthogonal frequency division multiplexing with diagram
6. Discuss about the performance of digital modulation in frequency selective fading channels
7. Explain about the performance of digital modulation in flat fading channel
8. Explain GMSK transmitter and receiver with signal spacing diagram and give an expression for spectral efficiency
9. Briefly explain Peak Average Power Ratio(PAPR) in OFDM
10. What is MSK , explain with transmitter and receiver diagram . Explain the various types of demodulation of MSK.

UNIT –IV Multi Path Mitigation Techniques

Part-A

1. What you mean by transversal filter in tinearer equalizer?
2. Write two advantage of lattice equalizer?
3. Draw the structure of maximum like hood sequence estimator (MLSE) in nonlinear equalizer.
4. What are the various factor involved in the adaptive equalizer algorithm?
5. Write the description of zero forcing algorithm?
6. What you mean feed forward filter? Write the advantage of feed forward filter in nonlinear equation?
7. Write the functionality of adaptive equalizer LMS algorithm
8. In digital cellular equalizer, if the carrier frequency is 900 MHz and maximum Doppler shift is 66.67Hz, calculate the maximum mobile velocity for the given Doppler shift.
9. If digital signal processor chip can perform one million multiplication per second, determine the time required between the each iteration.
10. Draw the predicative decision feedback nonlinear equalizer.

11. Write the general expression of adaptive equalizer? write the two operation mode of adaptive equalizer
12. Define least mean square algorithm.
13. Write the expression of folded frequency response of channel in zero force algorithm?
14. Define correlation coefficient of diversity.
15. What are the method to use, to find the micro diversity?

16. What is use of automatic repeat request (ARQ) for temporal filter?
17. Define angle diversity in antenna.
18. Define the term one-frequency repeaters.
19. What is the function of selection and combining diversity?
20. Write the drawback of Bit-Error-rate-Driven diversity?
21. Write the basic principle of combining diversity?

Part –B

1. Derive for the mean square error for linear equalizer during training adaptive equalizer
2. Explain the working principle of nonlinear equalizer based on decision feedback equalizer
3. Derive the expression for least mean square algorithm
4. Write different kind of performance of adaptive equalizer algorithm are determine the various factor and explain.
5. Explain the detail of maximum like hood sequence estimation (MLSE) of Nonlinear equalizer
6. Write detail operation of micro diversity in terms of Special, Temporal, Frequency, Angle polarization
7. What you mean by combining diversity and explain selective, switching combining diversity
8. Explain the following a). Error probability in flat-fading channels

b).Symbol error rate in frequency selective fading channel

9. Write brief explanation of Rake receiver
10. Write combining techniques using combination of signal a. Maximum ratio combining

b. Equal gain combining c. optimum combining

d. Hybrid selection -maximum ratio combining

UNIT-V MULTIPLE ANTENNA TECHNIQUES
PART-A

1. What are the methods to increase the capacity of wireless system, without increasing required spectrum?
2. What are smart antenna systems?
3. Define capacity of a fading channel?
4. What are the different approaches of improving capacity gains?
5. Define MIMO Systems?
6. Draw the structure of a MIMO system model
7. Explain MIMO system model?
8. Define CSI, CSIT, and CSIR?
9. Define spatial multiplexing with diagram?
10. Define Precoding?
11. Define transmit precoding?
12. Define Beamforming?
13. What is spatial filtering?
14. What are the requirements of beam forming?
15. Define Transmit beam forming?
16. Define receive beam forming?
17. Define opportunistic beamforming.
18. Define Transmit Diversity?
19. Define Receive Diversity?
20. Define ergodic capacity?

PART-B

1. With diagram explain the system model for MIMO systems.
2. Discuss about the operation of spatial multiplexing systems.
3. Explain the operation of transmit precoding and receiver precoding schemes?
4. Why is beamforming important for wireless systems, With illustration explain transmit beamforming, receive beamforming and opportunistic beamforming.
5. Using diagrams explain transmit diversity and receive diversity.
6. Derive the capacity of a fading channel for information transmitted from a wireless system.
7. Derive the capacity of a Non fading channel for information transmitted from a wireless system.
8. What is channel state information? Explain the different kinds of channel state information.
9. What are smart antennas? Why are they required for and what are the different approaches for capacity gains?
10. Compare the capacity of a fading and a non fading channel for information transmitted from a wireless system.

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FOCUSSED QUESTION BANK

UNIT-I WIRELESS CHANNELS
(2 Marks Questions and Answers)

1. What are the propagation mechanisms of EM waves?

The four propagation mechanisms of EM waves are

i. Free space propagation
ii. Reflection
iii. Diffraction
iv. Scattering

2. What is the significance of propagation model?

The major significance of propagation model are:

i. Propagation model predicts the parameter of receiver.
ii. It predicts the average received signal strength at a given distance from the transmitter.

3. What do you mean by small scale fading?

Rapid fluctuations of the amplitude, phase as multipath delays of a radio signal over a short period of time is called small scale fading.

4. What are the factors influencing small scale fading?

The factors which influence small scale fading are:
Multipath propagation, Speed of the mobile, Speed of surrounding objects and the transmission bandwidth of the signal.

5. When does large scale propagation occur?

Large scale propagation occurs due to general terrain and the density and height of buildings and vegetation, large scale propagation occurs.

6. Differentiate the propagation effects with mobile radio.

Slow Fading	**Fast Fading**
Slow variations in the signal strength.	Rapid variations in the signal strength.
Mobile station (MS) moves slowly.	Local objects reflect the signal causes fast fading.
It occurs when the large reflectors and diffracting objects along the transmission paths are distant from the terminal. Eg. Rayleigh fading, Rician fading and Doppler shift	It occurs when the user terminal (MS) moves for short distances.

7. Define Doppler shift.

If the receiver is moving towards the source, then the zero crossings of the signal appear faster and the received frequency is higher.The opposite effect occurs if the receiver is moving away from the source. The resulting chance in frequency is known as the Doppler shift (f_D).

$$F_D = f_r - f_0 = -f_0 V/C$$

Where f_0 -> transmission frequency

f_r -> received frequency

8. Differentiate time selective and frequency selective channel.

The gain and the signal strength of the received signal are time varying means then the channel is described as time selective channel. The frequency response of the time selective channel is constant so that frequency flat channel. The channel is time invariant but the impulse response of the channel show a frequency-dependent response so called frequency selective channel.

9. Define coherence time and coherence bandwidth.

Coherence time is the maximum duration for which the channel can be assumed to be approximately constant. It is the time separation of the two time domain samples. Coherence bandwidth is the frequency separation of the two frequency domain samples.

10. What do you mean by WSSUS channels?

In multipath channels, the gain and phase shift at one delay are uncorrelated with another delay is known as uncorrelated scattering of WSSUS.

11. What is free space propagation model?

The free space propagation model is used to predict received signal strength, when unobstructed line-of-sight path between transmitter & receiver. Friis free space equation is given by,

$$P_{RX}(d) = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi d}\right)^2$$

The factor $(\lambda/4\pi d)^2$ is also known as the free space loss factor.

12.Define EIRP.

EIRP (Equivalent Isotropically Radiated Power) of a transmitting system in a given direction is defined as the transmitter power that would be needed, with an isotropic radiator, to produce the same power density in the given direction.

EIRP=PtGt

Where Pt-transmitted power in W

Gt-transmitting antenna gain

13. Explain path loss.

The path loss is defined as the difference (in dB) between the effective transmitted power and the received power. Path loss may or may not include the effect of the antenna gains.

$$PL(dB) = 10 \log P_t / P_r.$$

14. What is intrinsic impedance and Brewster angle?

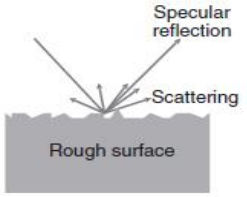
Intrinsic impedance is defined by the ratio of electric to magnetic field for a uniform plane wave in the particular medium.

Brewster angle is the angle at which no reflection occurs in the origin. Brewster angle is denoted by θ_B as shown below,

$$sin(\theta_B) = \sqrt{\frac{\epsilon_1}{\epsilon_1 + \epsilon_2}}.$$

15. What is scattering?

When a radio wave impinges on a rough surface, the reflected energy is spread out in all directions due to scattering.



16. Define radar cross section.

Radar Cross Section of a scattering object is defined as the ratio of the power density of the signal scattered in the direction of the receiver to the power density of the radio wave incident upon the scattering object & has units of squares meters

17. Name some of the outdoor propagation models?

Some of the commonly used outdoor propagation models are i. Longely-Rice model
ii. Durkin's model iii. Okumura model.

18. Define indoor propagation models.

The indoor propagation models are used to characterizing radio propagation inside the buildings. The distances covered are much smaller, and the variability of the environment is much greater for smaller range of Transmitter and receiver separation distances. Features such as lay-out of the building, the construction materials, and the building type strongly influence the propagation within the building.

19. Mention some indoor propagation models?

Some of the indoor propagation models are:

i. Long –distance path loss model
ii. Ericession multiple break point model
iii. Attenuation factor model.

20.What are merits and demerits of Okumara's model?

Merits:
Accuracy in parameter prediction.
Suitable for modern land mobile radio system.
Urban, suburban areas are analyzed.
Demerits:
Rural areas are not analyzed.
Analytical explanation is not enough.

21.List the advantages and disadvantages of Hata model?

Advantages: Suitable for large cell mobile system. Cell radius on the order of 1km is taken for analysis.
Disadvantages: Not suitable for PCS model. This model does not have any path specific correction.

22.What is the necessity of link budget?

The necessities of link budget are:

i. A link budget is the clearest and most intuitive way of computing the required Transmitter power. It tabulates all equations that connect the Transmitter power to the received SNR

ii. It is reliable for communications.
iii. It is used to ensure the sufficient receiver power is available.
iv. To meet the SNR requirement link budget is calculated.

23. State the difference between small-scale fading and large scale fading.

Small-scale Fading	Large scale fading
Rapid fluctuations of received signal in short distances	Mean signal strength at an arbitrary distance between Tx and Rx.
Used to find Signal fluctuations at short time	Used to find radio coverage of the EM waves
Received signal fluctuations are 3 to 4 folds	Less fluctuations
Multipath fading models - Rayleigh model	Free space model- Rician model
Local mean power used	Area mean power used

24. List the properties of wideband channels.M15

- Wide band channels suffer from the Inter Symbol Interference(ISI)
- It can reduce the deter mental effect of fading

25. State the propagation effects in mobile radio.J14

The Large scale fading and small scale fading occur due to attenuation, reflection , refraction and scattering effects in the wireless channel. The effects are rapid fluctuation , random frequency modulation and echoes in the received mobile signal.

26. (i) Interpret the link budget equation.J14 /What is the need for predicting and estimating the path loss during wireless link design?

Received signal power
$Pr(d)dBm = Pt\ (dB)m - P_L(d)\ dB$
Where $P_L(d)$ dB is Path loss exponent

The average large scale path loss is
$P_L(d)\ dB = P_L(d_0) + 10\ n \log(d/d_0)$
Where d_0 d_0-1KM for GSM ,CDMA & 100 meter to 1m Microsystems and

n is the path loss exponent analytically
Line of sight in building -1.6 to 1.8 ,Free space 2, Shadowed urban area – 3 to 5

(ii) Interpret the link budget equation for Free space model .
Then n=2
$Pr(d)dBm = 10 \log [Pr(d_0)/0.001W] + 20 \log (d_0/d) \quad d>d_0>d_f$
Where Pr(d)dBm is received power at distance d from transmitter in dBm and
$Pr(d_0)$ is received power at reference distance d_0-1KM for GSM & 100 meter to 1m microsystem

27. List the different types of radiation mechanisms.D14

Reflection: EM waves falls upon an object which has large dimensions when compared to
wavelength of propagating wave. Ex - Earth surface, buildings and walls.

Diffraction: Radio path between Tx &Rx is obstructed by a surface that has sharp edges.

Scattering: An Objects that are small compared to the wavelength and obstacles per unit volume is large.

28. What are the different fading effects due to Doppler spread?D14

Fast Fading : The doppler spread of the channel is **grate**r than the BW of the baseband signal. i.e. $Bs<B_D$

The channel impulse response(Frequency) changes at a rate **faster** than the transmitted baseband signal i.e Ts>Tc .

Slow fading : The doppler spread of the channel is **much less** than the BW of the baseband

signal. i.e. $Bs>B_D$

The channel impulse response(Frequency) changes at a rate **much slower** than the

transmitted baseband signal i.e Ts<<Tc .

29. What are the fundamental propagation behaviors for radio waves?

Attenuation , Reflection, refraction and diffraction .

30. Define coherence time and highlight its relationship with mobility./ Define Coherence time. d15

The coherence time Tc is defined as the time over which the time correlation function is above 0.5 , then the coherence time is $Tc = 9/16\Pi f_m$. Where Doppler spread $f_m = V/\lambda$

31. Find the far-field distance for an antenna with maximum dimension of 1m and operating at a frequency of 900MHz.

The far-field or Fraunhofer region or distance d_f, of a transmitting antenna is defined as the region beyond the far-field distance $d_f = 2D^2/\lambda$; Where $\lambda=C/f = 3x10^8/ 900x10^6 = .33$ meter

$d_f = 2D^2/\lambda = 2(1)^2/.33 = 6$ m

32. Differentiate the coherence bandwidth and coherence time.

coherence bandwidth(Bc)	coherence time.(Tc)
-Frequency Domain	-Time domain
-Relation derived from the rms delay spread(σ_τ)	-Tc are the dual of Doppler spread (fm =V/λ)
Two frequencies correlation is > 0.9;Bc=1/50σ_τ	Coherence time α(1/ Doppler spread) Tc=1/f_m
Two frequencies correlation is > 0.5;Bc=1/5σ_τ	Time correlation function >0.5;Tc=9/16Πf_m

33. Distinguish between flat and frequency selective fading.

flat fading.	Frequency selective fading
BW of signal< BW of channel (Bs<<Bc)	BW of signal>BW of channel(Bs>>Bc)
Delay spread < Symbol period(Ts>>σ_τ)	Delay spread >>Symbol period (Ts<<σ_τ
Amplitude varying channel	Inter symbol Interferences induces
Rayleigh distribution is model used	Two-ray Rayleigh model is used

34. What is shadowing in mobile communication?

The received signal strength of the mobile station is highly decreased behind the high rise buildings or obstructed constructions due attenuation, diffraction and scattering. This is called shadowing.

35. What is referred as log-normal shadowing?

The log-normal distribution describes the random shadowing effects which occur aver a large number of measurement locations which have the same T-R separation, but have the same T-R separation, but different levels of clutter on the propagation path. This phenomenon is referred to as log-normal shadowing.

36. Define Path loss in a radio link. /Give the equation for average large scale-path loss between the transmitter and receiver as a function of distance D16

It is define as the difference between (indB) between the effective transmitted power and received power and may or may not include the effect of the antenna gain.

The path loss for free space model is

$P_L(d)$ dB = 10 log (Pt/Pr) = -10 log $[G_t G_r \lambda^2/(4\Pi d)^2]$

37. Define mean excess delay and rms delay spread. D15

Mean excess delay is the first moment of the power delay profile and is defined to be

$$\tau = \frac{\sum_k (a_k 2 \tau k)}{\sum_k (a_k 2)}$$

RMS delay spread σ_τ is the square root of trhe second central moment of the power delay profile and defined as $\sigma\tau = \frac{\sum_k (a_k 2 \tau k2)}{\sum_k (a_k 2)}$

38. Define coherence time and coherence bandwidth D15

Coherence time(Tc) is defined as the time over which the time correlation function is above 0.5 , then Tc is = $9/16\Pi f_m$ Where Doppler spread $f_m = V/\lambda$

Coherence Band(Bc) is defined as the BW over which the frequency correlation function is above 0.5 , then Bc is = $1/5\ \sigma_\tau$, Where σ_τ rms spread ; $\sigma\tau - \frac{\sum_k (a_k 2 \tau k2)}{\sum_k (a_k 2)}$

39. What is frequency selective fading?D16

The channel possesses a constant gain and linear phase response over a bandwidth thatis smaller than the bandwidth of transmitted signal, then the channel creates the frequency selective fading on the received signal. Bs>> Bc & Ts<< Tc

40. Find the far-field distance for an antenna with maximum dimension of 2m and operating frequency of 1GHz. D15

The far-field or Fraunhofer region or distance d_f, of a transmitting antenna is defined as the region beyond the far-field distance $d_f = 2D^2/\lambda$; Where λ=C/f =$3x10^8$/ $900x10^6$= .33 meter

$d_f = 2D^2/\lambda$ $2(2)^2/.33 = 24.24$m

UNIT-II CELLULAR ARCHITECTURE

(2 Marks Questions and Answers)

1.What is meant by frequency reuse?

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

2. What are the trends in cellular radio systems?

The trends in personal cellular radio systems are:

i. PCS – Personal Communication Services
ii. PCN – Personal Communication Networks

3. What do you mean by forward and reverse channel?

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

4. 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,

i. Forward control channel
ii. Reverse control channel

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

For efficient utilization of radio spectrum a frequency reuse scheme with increasing capacity and minimizing interference is required. For this channel assignment is used. The types of channel assignment are:

i. Fixed channel assignment
ii. Dynamic channel assignment.

6. What is fixed channel assignment?

If the channels in each cell are allocated to the users within the cell, it will be called as fixed channel assignment. If all channels are occupied, the call will be blocked.

7. What is dynamic channel assignment?

If the voice channels are not allocated permanently in a cell, it will be called as dynamic channel assignment. In this assignment, channels are dynamically allocated to users by the MSC.

8. Define MS, BS and MSC.

MS – Mobile station. A station in the cellular radio service intended for use.

BS – Base Station. A fixed station in a mobile radio system used for radio communication with MS.

MSC – Mobile Switching Centre. Mobile switching centre coordinates the routing of calls in large service area. It connects the base station and mobiles to PSTN. It is also called as MTSO(Mobile telephone switching office.

9. Define hand off and mode 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 well-implemented handoff is important for delivering uninterrupted service to a caller or data session user. Modes of hand off are:

i. MCHO – Mobile Controlled Hand off ii.
NCHO – Network Controlled Hand off
iii. MAHO – Mobile Assisted Hand off

10. Write the types of hand off.

Types of handoff are:

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

11**. Define Cell, Cluster.**

For a large geographic coverage area, a high powered transmitter therefore has to be used. But a high power radio transmitter causes harm to environment. Mobile communication thus calls for replacing the high power transmitters by low power transmitters by dividing the coverage area into small segments, called cells.

Each cell uses a certain number of the available channels and a group of adjacent cells together use all the available channels. Such a group is called a cluster.

12. What do you mean by foot print and dwell time?

The region over which the signal strength lies above this threshold value x dB is known as the coverage area of a BS and it must be a circular region, considering the BS to be isotropic radiator. Such **a circle, which gives this actual radio coverage, is called the foot print of a cell**.The time over which a call may be maintained within a cell without hand off is called the dwell time.

13. What are the major types of cellular interference?

The major types of cellular interferences are as follows

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

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

Cell splitting, Sectoring, Coverage Zone approaches are the techniques used to expand 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.

15. 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 of the cell (R) and the distance between the interfering co-channel cells (D). If D/R ratio is increased, then the effective distance between the co-channel cells will increase and interference will decrease. The parameter Q is called the frequency reuse ratio and is related to the cluster size. For hexagonal geometry

Q = $\frac{D}{R}$

= $\frac{\text{Distance between centres of the nearest co-channel cells}}{\text{Radius of the cell}}$

From the above equation, small of `Q' means small value of cluster size `N' and increase in cellular capacity.

16. Define FDMA, TDMA and CDMA.

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 is allowed to either transmit or receive.

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

17. Define Grade of service.

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

18. What is blocked call clear system (BCC)?

In a system, a user is blocked without access by a system when no channels are available in the system. The call blocked by the system is cleared and the user should try again .This is called BCC system.

19. What is blocked call delay system?

If a channel is not available immediately, the call request may be delayed until a channel becomes available. This is called as blocked call delay system.

20. Define cell splitting.

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

21. What is sectoring?

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

22. What are the features of TDMA?

Features of TDMA are:

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

23. What are the features of FDMA?

Features of FDMA are:

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

(2 Marks Questions and Answers)

1.List the advantages of digital modulation techniques.

The advantages of digital modulation techniques are:

i. Immunity to channel noise and external interference.
ii. Flexibility operation of the system.
iii. Security of information.
iv. Reliable since digital circuits are used.
v. Multiplexing of various sources of information into a common format is possible.
vi. 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:

i. Low BER at low received SNR.
ii. Better performance in multipath and fading conditions.
iii. Minimum bandwidth requirement.
iv. Better power efficiency.
v. Ease of implementation and low cost.

3.Define power efficiency and bandwidth efficiency.

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

$\eta_p = E_b/N_0$ = Bit energy / Noise power spectral density

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

η_B = R/B = Datarate / Bandwidth in bps/Hz

4. What is QPSK?

The Quadrature Phase Shift Keying (QPSK) is a 4-ary PSK signal. The phase of 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.

In offset QPSK the amplitude of data pulses are kept constant. The time alignment of the even and odd bit streams are offset by one bit period in offset QPSK.

In $\pi/4$ QPSK, signaling points of the modulated signal are selected from two QPSK constellations which are shifted by $\pi/4$ with respect to each other. It is differentially encoded and detected so called $\pi/4$ differential QPSK.

6. What is meant by MSK?

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

7. List the salient features of MSK scheme.

Salient features of MSK are:

i. It has constant envelope, smoother waveforms than QPSK.
ii. Relatively narrow bandwidth.

iii. Coherent detection suitable for satellite communications.
iv. 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 much reduced. 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 are improved.

10.Write the advantages of MSK over QPSK.

Advantages of MSK over QPSK:

i. In QPSK the phase changes by 90degree or 180 degree .This creates abrupt amplitude variations in the waveform, Therefore bandwidth requirement of QPSK is more filters of other methods overcome these problems , but they have other side effects.
ii. MSK overcomes those problems. In MSK the output waveform is continuous in 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 more bits are transmitted simultaneously. This is called M-ary transmission.

12.What is quadrature modulation?

Sometimes two or more quadrature carriers are used for modulation. It is called quadrature modulation.

13.What is QAM?

At high bit rates a combination of ASK and PSK is employed in order to minimize the errors in the received data. This method is known as “Quadrature Amplitude Modulation”.

14.Define QPSK

QPSK is defined as the multilevel modulation scheme in which four phase shifts are used for representing four different symbols.

15. What is linear modulation?

In linear modulation technique the amplitude of the transmitted signal varies linearly with the modulating digital signal. In general, linear modulation does not have a constant envelope.

16. Define non linear modulation.

In the non linear modulation the amplitude of the carrier is constant, regardless of the variation in the modulating signals.

Non-linear modulations may have either linear or constant envelopes depending on whether or not the baseband waveform is pulse shaped.

17. What is the need of Gaussian filter?

Need for Gaussian Filter:

i. Gaussian filter is used before the modulator to reduce the transmitted bandwidth of the signal.
ii. It uses less bandwidth than conventional FSK.

18. Mention some merits of MSK.

Merits of MSK:

i. Constant envelope
ii. Spectral efficiency
iii. Good BER performance
iv. Self-synchronizing capability
v. MSK is a spectrally efficient modulation scheme and is particularly attractive for use in mobile radio communication systems.

19. Give some examples of linear modulation.

Examples of linear modulation:

i. Pulse shaped QPSK
ii. OQPSK

UNIT-IV MULTIPATH MITIGATION TECHNIQUES
(2 Marks Questions and Answers)

1. How the link performance can be improved?

Link performance can be improved by various techniques such as

i. Equalization
ii. Diversity
iii. Channel coding

2. Why diversity and equalization techniques are used?

To reduce ISI, Equalization technique is used. Diversity is used to reduce fading effects.

3.What is diversity?

Signal is transmitted by more than one antenna via channel. It ensures that the same information reaches the receiver on statistically independent channels. (OR)

Diversity is used to compensate the fading channel impairments and is usually implemented by using two or more receiving antennas. Diversity improves transmission performance by making use of more than one independently faded version of the transmitted signal.

4.Differentiate selection diversity and combining diversity.

Selection Diversity	**Combining Diversity**
The best signal is selected and processed while all other signals are discarded.	All signals are combined before processing and the combined signal is decoded.
Simple circuits are used.	At individual receiver, phasing circuits are needed.
None of the signal is not in acceptable SNR.	It works well.

5. Define Switched Diversity

If the signal level falls below the threshold, then the receiver switches to a new

antenna which is called as switched diversity.

6. Define feedback or scanning diversity.

All the signals are scanned in a fixed sequence until one signal is found to be above a predetermined threshold.

7. Define temporal diversity.

Wireless propagation channel is time variant, so for sufficient decorrelation, the temporal distance between antennas must be atleast the half of maximum Doppler frequency.

8.What is meant by frequency diversity?

Correlation is increased by transmitting information on more than one carrier frequency. Frequencies are separated by more than one coherence bandwidth of the channel. So the signals will not experience same fades.

9.Differentiate micro and macro diversity.

Micro diversity	**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.
BS-MS are separated by small distance.	BS-MS are separated by large distance.

10.What is transmit diversity?

Diversity effect is achieved by transmitting signals from several transmit antenna.

11.What is an equalizer?

Equalizer is a linear pulse shaping circuit which is used to reduce ISI.

12.What is linear and non-linear equalizer?

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 distorted channel. Noise power signal is enhanced.

Nonlinear equalizer: If the past decisions are correct, then the ISI contributed by present symbol can be cancelled exactly, feedback path is used. Suitable for severely distorted channel. Noise power signal is not enhanced. Complex in structure.

channels with low SNR. Suffers from error propagation.

13. What are the techniques used to improve the received signal quality?

Techniques such as,

- Equalization
- Diversity
- Channel coding

are used to improve the received signal quality.

14. What is the need of equalization?

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

15. Define spatial diversity.

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

16. Define STCM.

Channel coding can also be combined with diversity a technique called Space-Time Coded Modulation. The space-time coding is a bandwidth and power efficient method for wireless communication.

17. Define adaptive equalization?

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

18. Define training mode in an adaptive equalizer?

First, a known fixed length training sequence is sent by the transmitter then the receivers equalizers may adapt to a proper setting of minimum bit error detection where the training sequence is a pseudo random binary signal or a fixed and prescribed bit pattern.

19. 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 channel and estimate filter coefficients to compensate for the distortion created by multipath in the channel.

20. Write a short note on linear equalizers and non linear equalizers?

Linear equalizers: If the output d(t) is not used in the feedback path to adapt the equalizer. This type of equalizers is called linear equalizer.

Nonlinear equalizers: If the output d(t) is fed back to change the subsequent outputs of the equalizers is called non linear equalizers.

21. Why non linear equalizers are preferred?

The linear equalizers are very effective in equalizing channels where ISI is not severe.The severity of the ISI is directly related to the spectral characteristics. In this case that there are spectral noise in the transfer function of the effective channel, the additive noise at the receiver input will be dramatically enhanced by the linear equalizer. To overcome this problem non linear equalizers are used.

22. What are the nonlinear equalization methods used?

Commonly used non linear equalization methods are:

i. Decision feedback equalization
ii. Maximum likelihood symbol detection
iii. Maximum likelihood sequence estimation

23. What are the factors used in adaptive algorithms?

Rate of convergence
Mis adjustments
Computational complexity

24. Define diversity concept.

If one radio path undergoes a deep fade, another independent path may have a strong signal. By having more than one path to select from, both the instantaneous and average SNRs at the receiver may be improved often by as much as 20dB to 30dB. The principle of diversity is to ensure that the same information reaches the receiver on statistically independent channels.

UNIT-V MULTIPLE ANTENNA TECHNIQUES
(2 Marks Questions and Answers)

1. What are the uses of Multiple Element Antennas(MEA)of a MIMO?

(i). Diversity (ii)Spatial multiplexing (transmission of several data streams in parallel) (iii).Beam forming.

2. Distinguish between Space diversity and spatial multiplexing.

Space diversity(Antenna Diversity)	**Spatial multiplexing.**
It is also known as Antenna Diversity	Transmission of several data streams in parallel
The Transmit signal is received at several antenna elements and received signal is further processed.	An original high-data stream is multiplexed into several parallel streams each of which is sent from one transmit antenna element. The channel mixes up. Rx antenna elements see a combination of them.
It is oldest one and simple	New and complex
Based on antenna spacing -3 Types- MS is cellular and cordless systems BS is WLANs and cordless systems BS is cellular system	Nt Number of transmitting antennas Nr Number of receiving antennas
The received signal has less error	Data rate drastically increased to min(Nt.Nr).
Antenna spacing 2-20 wavelengths for angular spreads 1 and 5 degree decorrelation.	.r=Hs+n=x+n, where H is the Channel matrix

3. What are the different types of space diversity systems?

SIMO- Single input -multiple outputs – Receive diversity (One antenna at Tx & Multiple antennas at Rx)

MISO- Multiple inputs- single output- Transmit diversity

MIMO- Multiple inputs- multiple output- Transmit Receive diversity

4. Distinguish between smart antenna and MIMO Technology.

Smart antenna	MIMO Technology
The data is transmitted over a vector channel	The data is transmitted in the matrix channel.
Better performance from LOS	Better performance from NON-LOS
Only Tx or Rx or Both equipped with more than one antenna	Both sides equipped with more than one antennas(2X2) (3x3) , Massive MIMO are different types.

6**. What do you mean by pre coding?**

Precoding is a generalization of beamforming to support multi-stream (or multi-layer) transmission in multi-antenna wireless communications.

In order to maximize the throughput in multiple receive antenna systems, multi-stream transmission is generally required.

7. What are the types of Pre coding?

(i).Point to point MIMO. It is used for single user. (ii).Multi user MIMO

8. What is meant by Breamforming?

Beamforming or spatial filtering is a signal processing technique used in sensor arrays for directional signal transmission or reception. This is achieved by combining elements in a phased array in such a way that signals at particular angles experience constructive interference while others experience destructive interference.

Beamforming can be used at both the transmitting and receiving ends in order to achieve spatial selectivity. The improvement compared with omnidirectional reception/transmission is known as the directivity of the element.

9. Define the channel capacity of the Transmit and receive diversity.

Shannon capacity

Rx Diversity = $C=B \log_2 M^2$.(Signal Power) /[M.Noise]= $B \log_2 (1 + M. SNR)$

Where M-receiving antennas

Tx Diversity = $C=B \log_2 (1 + N. SNR)$ Where N-Transmitting antennas

Outage Capacity

Rx Diversity

$P_{out}(R)^{rx}= P \{ \log (1+ \text{mod } H^2 .SNR)<R \}$Where P- Total power constraint , H Channel matrix, r- Target rate

Tx Diversity

$P_{out}(R)^{tx}= P \{ \log (1+ \text{mod } H^2 .SNR/\mathbf{N})<R \}$Where Where N-Transmitting antennas. N increases Outage capacity

decreases and received signal quality increases.

10. What are the different types of CSI?

Full CSI at the transmitter and full CSI at the receiver.

Average CSI at the transmitter and full CSI at the receiver.

No CSI at the transmitter and full CSI at the receiver.

Noisy CSI

No CSI at the transmitter and No CSI at the receiver.

11.What are the two capacity exist for MIMO systems?

Ergodic (Shannon) Capacity & Outage capacity

12. What is the ergodic capacity in non-fading channels?

$C_{Shannon}=\log_2(1+\gamma.\ |H|^2)$

13. What is the capacity of the non-fading channel with NoCSI at Tx and full CSI at the receiver?

$C= \log_2(|1+(\gamma/N_t).\ H\ H^+)$

C increases linearly with $\min(N_t,N_r)$.

14. Draw the diagram of spatial multiplexing system model.

15. Show the channel matrix for Nt x Nr antennas.

VELAMMAL INSTITUTE OF TECHNOLOGY, PANCHETTI

DEPARTMENT OF ELECTRONICS AND COMMUNICATION

EC6801 / WIRELESS COMMUNICATION CLASS:IV YEAR/VIII SEM/ECE

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QUESTION BANK

UNIT-I WIRELESS CHANNELS
16 MARK QUESTION WITH KEY POINTS

PART-B
UNIT-I

1. With neat diagrams explain the Free Space Propagation Model? (8 marks)

Derivation of the *Friis' law*:

$$P_{RX}(d) = P_{TX} G_{TX} G_{RX} \left(\frac{\lambda}{4\pi d}\right)^2$$

2. Derive the equation of the Path loss using Two-Ray Model with neat diagrams
   Derivation of the following Equation, the power received at a distance d from a transmitter is given by,

$$P_r = P_t G_t G_r \frac{h_t^2 h_r^2}{d^4}$$

For derivation refer (Rappaport Book)

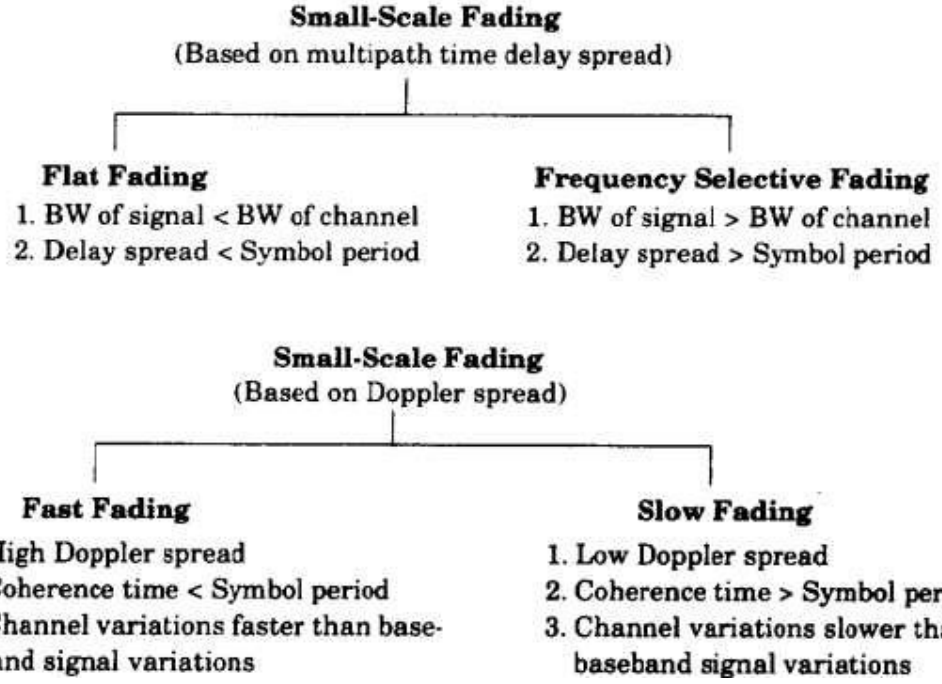
3. Explain knife Edge Diffraction Model

Explain diffraction and Fresnel zones for different knife edge Scenarios using diagrams and derive diffraction gain exp and electric field due to diffraction

4. Derive the Impulse response model of a Multipath channel.
   Explain
   - Impulse response of the mobile radio channels
   - Derive the expression for impulse response of mobile radio channels
   - Refer Rappaport book

5. What is small scale fading? What are the factors influencing small scale fading?
   - Definition
   - Effects of small scale fading
   - Factors influencing
     - Multipath propagation
     - Speed of the mobile
     - Speed of surrounding objects
     - Transmission bandwidth of the signal

6. Explain detail about type of small scale fading?



7. Explain Clarke's model for flat fading?
   It is used to find Doppler spread in Flat fading channels
   Refer Rappopart book

8. Explain different propagation mechanism

In a more realistic scenario, there are dielectric and conducting obstacles (*Interacting Objects* (IOs)).If these IOs have a *smooth* surface, waves are *reflected* and a part of the energy penetrates the IO (*transmission*). If the surfaces are *rough*, the waves are diffusely *scattered*. Finally, waves can also be *diffracted* at the edges of the IOs. Explain the following mechanism

- Reflection and Transmission
- Diffraction
- Scattering

9. Explain the wideband channel models

1. Frequency selective model
2. Time selective models
3. Gaussian models
4. WSSUS model
5. Non stationary channels

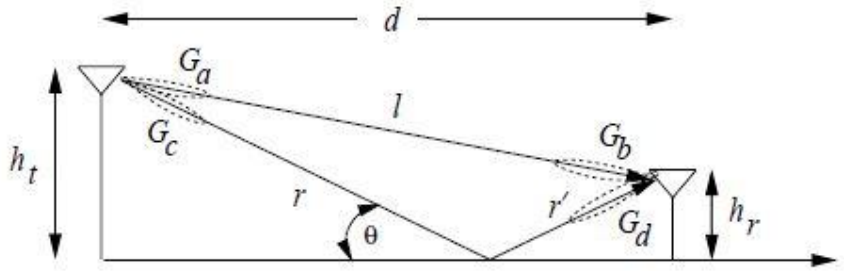
10. Explain different types of wide band and narrow band models

    For a narrowband channel, the impulse response is a delta function with a time-varying attenuation, so that for slowly time-varying channels: $h(t, \tau) = \alpha(t)\delta(\tau)$

11. Construct and derive a Two ray propogation model.

The two-ray model is used when a single ground reflection dominates the multipath effect, as illustrated in the figure below. The received signal consists of two components: the LOS component or ray, which is just the transmitted signal propagating through free space, and a reflected component or ray, which is the transmitted signal reflected off the ground. The received LOS ray is given by the free-space propagation loss formula. The reflected ray is shown in Figure below by the segments *x* and *x0*. If we ignore the effect of surface wave attenuation2 then, by superposition, the received signal for the two-ray model is

$$r_{2ray}(t) = \Re\left\{\frac{\lambda}{4\pi}\left[\frac{\sqrt{G_l}u(t)e^{j(2\pi l/\lambda)}}{l} + \frac{R\sqrt{G_r}u(t-\tau)e^{-j2\pi(x+x')/\lambda}}{x+x'}\right]e^{j(2\pi f_c t+\phi_0)}\right\},$$



The received power of the two-ray model for narrowband transmission is

$$P_r = P_t\left[\frac{\lambda}{4\pi}\right]^2\left|\frac{\sqrt{G_l}}{l} + \frac{R\sqrt{G_r}e^{j\Delta\phi}}{r+r'}\right|^2,$$

$$P_r \approx \left[\frac{\lambda\sqrt{G_l}}{4\pi d}\right]^2\left[\frac{4\pi h_t h_r}{\lambda d}\right]^2 P_t = \left[\frac{\sqrt{G_l}h_t h_r}{d^2}\right]^2 P_t,$$

$$P_r\,(\text{dBm}) = P_t\,(\text{dBm}) + 10\log_{10}(G_l) + 20\log_{10}(h_t h_r) - 40\log_{10}(d).$$

If we average out the local maxima and minima in (2.12), the resulting average power loss in dB versus log-distance can be approximated by dividing the power loss curve of Fig. 2.5 into three straightline segments as follows. For $d < ht$ the average power falloff with distance is constant. For $ht < d < dc$ the average power falloff with distance corresponds to free space where power falls off proportional to distance squared.

UNIT II

1. Explain in detail the different types of services in wireless communication? (16 Marks)

Ans. Explanation of the following services with diagram

Types of Services

1. *Broadcast*
2. *Paging*
3. *Cellular Telephony*
4. *Trunking Radio*
5. *Cordless Telephony*
6. *Wireless Local Area Networks*
7. *Personal Area Networks*
8. *Fixed Wireless Access*
9. *Ad hoc Networks and Sensor Networks*
10. *Satellite Cellular Communications*

2. Discuss briefly about the requirements of services for a wireless system. (8 marks)

Ans. Explanation of following requirement in detail

1. *Data Rate*
2. *Range and Number of Users*
3. *Mobility*

4. *Energy Consumption*
5. *Use of Spectrum*
6. *Direction of Transmission*
7. *Service Quality*

3. Compare and contrast wired and wireless communication (8 marks)

Ans-

Wired communications	Wireless communications
The communication takes place over a more or less stable medium like copper wires or optical fibers. The properties of the medium are well defined and time-invariant.	Due to user mobility as well as multipath propagation, the transmission medium varies strongly with time.
Increasing the transmission capacity can be achieved by using a different frequency on an existing cable,and/or by stringing new cables.	Increasing the transmit capacity must be achieved bymore sophisticated transceiver concepts and smaller cell sizes (in cellular systems), as the amount of available spectrum is limited.
The range over which communications can be performed without repeater stations is mostly	The range that can be covered is limited both by the transmission medium
limited by attenuation by the medium (and thus noise); for optical fibers, the distortion of transmitted pulses can also limit the speed of data transmission.	(attenuation, fading, and signal distortion) and by the requirements of spectral efficiency (cell size).
The delay in the transmission process is also constant, determined by the length of the cable and the group delay of possible repeater amplifiers.	The delay of the transmission depends partly on the distance between base station and Mobile Station (MS), and is thus time-variant.
Interference and crosstalk from other users either do not happen or the properties of the interference are stationary.	Interference and crosstalk from other users are inherent in the principle of cellular communications. Due to the mobility of the users, they also are time-variant
The *Bit Error Rate* (BER) decreases strongly (approximately exponentially) with increasing *Signal-to-Noise Ratio* (SNR). This means that a relatively small increase in transmit power can greatly decrease the error rate.	For simple systems, the average BER decreases only slowly (linearly) with increasing average SNR. Increasing the transmit power usually does not lead to a significant reduction in BER. However, more sophisticated signal processing helps.
Due to the well-behaved transmission medium, the quality of wired transmission is generally high.	Due to the difficult medium, transmission quality is generally low unless special measures are used.
Jamming and interception of dedicated links with wired transmission is almost impossible without consent by the network operator.	Jamming a wireless link is straightforward, unless special measures are taken. Interception of the on-air signal is possible. Encryption is therefore necessary to prevent unauthorized use of the information.
Establishing a link is *location* based. In other words, a link is established from one outlet to another, independent of which *person* is connected to the outlet.	Establishing a connection is based on the (mobile) equipment, usually associated with a specific person. The connection is not associated with a fixed location.

Power is either provided through the communications network itself (e.g., for traditional landline telephones), or from traditional power mains (e.g., fax). In neither case is energy consumption a major concern for the designer of the device.	MSs use rechargeable or one-way batteries. Energy efficiency is thus a major concern.

4. Describe the technical challenges to wireless communication

Ans-

Explain each of the following in details

- multipath propagation: i.e., the fact that a transmit signal can reach the receiver via different paths (e.g., reflections from different houses or mountains);
- spectrum limitations;
- energy limitations;
- user mobility.

5. Explain *Inter symbol Interference* is caused and how it is eliminated

Ans-

In a system with large bandwidth, and thus good resolution in the time domain,3 the major consequence is signal dispersion: in other words, the impulse response of the channel is not a single delta pulse but rather a sequence of pulses (corresponding to different MPCs), each of which has a distinct arrival time in addition to having a different amplitude and phase. This signal dispersion leads to Inter Symbol Interference (ISI) at the RX. Explain using diagram

6. What is frequency Reuse? How this is used in GSM Cellular network?

Ans-

Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage region . Each cellular base station is allocated a group of radio channels to be used within a small geographic area called a *cell*. Base stations in adjacent cells are assigned channel groups which contain completely different channels than neighboring cells. The base station antennas are designed to achieve the desired coverage within the particular cell. By limiting the coverage area to within the boundaries of a cell, the same group of channels may be used to cover different cells that are separated from one another by distances large enough to keep interference levels within tolerable limits. The design process of selecting and allocating channel groups for all of the cellular base stations within a system is called *frequency reuse* or *frequency planning*. Illustrate the concept of cellular frequency reuse, using diagram.

7. Discuss different techniques used for improving coverage and capacity in cellular systems

Ans-

Methods for Increasing Capacity

System capacity is the most important measure for a cellular network. Methods for increasing capacity are

1. *Increasing the amount of spectrum used*: this is the “brute force” method. It turns out to be very expensive, as spectrum is a scarce resource, and usually auctioned off by governments at very high prices.

2. *More efficient modulation formats and coding*: using modulation formats that require less bandwidth (higher order modulation) and/or are more resistant to interference. The former allows an increase in data rate for each user (or an increase in the number of users in a cell while keeping the data rate per user constant). However, the possible benefits of higher order

modulation are limited: they are more sensitive to noise and interference, so that the reuse distance might have to be increased. The use of interference-resistant modulation allows a reduction in reuse distance. The introduction of near-capacity-achieving codes – turbo codes and low-density parity check codes is another way of achieving better immunity to interference, and thus increases system capacity.
3. *Better source coding*: depending on required speech quality, current speech coders need data rates between 32 kbit/s and 4 kbit/s. Better models for the properties of speech allow the data rate to be decreased without decreasing quality. Compression of data files and music/video compression also allows more users to be served.
4. *Discontinuous Voice Transmission* DTX: exploits the fact that during a phone conversation each participant talks only 50% of the time. A TDMA system can thus set up more calls than there are available timeslots. During the call, the users that are actively talking at the moment are multiplexed onto the available timeslots, while quiet users do not get assigned any radio resources.
5. *Multiuser detection*: this greatly reduces the effect of interference, and thus allows more users per cell for CDMA systems or smaller reuse distances for FDMA systems
6. *Adaptive modulation and coding*: employs the knowledge at the TX of the transmission channel, and chooses the modulation format and coding rate that are "just right" for the current link situation. This approach makes better use of available power, and, among other effects, reduces interference
7. *Reduction of cell radius*: this is an effective, but very expensive, way of increasing capacity, as a new BS has to be built for each additional cell. For FDMA systems, it also means that the frequency planning for a large area has to be redone.8 Furthermore, smaller cells also require more handovers for moving users, which is complicated, and reduces spectral efficiency due to the large amount of signaling information that has to be sent during a handover.
8. *Use of sector cells*: a hexagonal (or similarly shaped) cell can be divided into several (typically three) sectors. Each sector is served by one sector antenna. Thus, the number of cells has tripled, as has the number of BS *antennas*. However, the number of BS *locations* has remained the same, because the three antennas are at the same
9. *Use of an overlay structure*: an overlay structure combines cells with different size and different traffic density. Therefore, some locations may be served by several BSs simultaneously.
10. *Multiple antennas*: these can be used to enhance capacity via different scenarios:
(a) diversity increases the quality of the received signal, which can be exploited to increase capacity – e.g., by use of higher order modulation formats, or reduction of the reuse distance;
(b) multiple-input multiple-output systems increase the capacity of each link;
(c) space division multiple access allows several users in the same frequency channel in the same cell to be served.
11. *Fractional loading*: this system uses a small reuse distance, but uses only a small percentage of the available timeslots in each cell. This leads to approximately the same average capacity as the "conventional" scheme with large reuse distance and full loading of each cell.
12. *Partial frequency reuse*: in this scheme, the available spectrum is divided into $N + 1$ subbands. One subband is used in *all* the cell centers, while the other subbands are used at the cell edges, employing a conventional frequency reuse (with cluster size N). The "cell edges" must be large enough so that interference from one cell center to another is sufficiently weak.

8. With neat diagrams explain TDMA & FDMA
   Ans-
   - *Frequency Division Multiple Access* (FDMA), where different frequencies are assigned to different users. Explain the concept using diagram

   The advantages are
   - The transmitter (TX) and receiver (RX) require little *digital signal processing*
   - (*Temporal*) *synchronization is simple*.

   the disadvantages are

Frequency synchronization and stability are difficult
Sensitivity to fading:
Sensitivity to random Frequency Modulation (FM):
Intermodulation

- *Time Division Multiple Access* (TDMA), where different timeslots are assigned to different users.
- *Explain the concept using diagram and explain its ad, disadvantages.*
    - Users occupy a larger bandwidth
    - Temporal guard intervals are required

Each timeslot might require a new synchronization and channel estimation, as transmission is

- not continuous
- For interference-limited systems

9. Explain about noise and interference limited system

Ans

a. Noise limited system

When MS moves further away from the BS, the received signal power decreases, and at a certain distance, the SNR does not achieve the required threshold for reliable communications. Therefore, the range of the system is noise limited; equivalently, we can call it *signal power limited*. Depending on the interpretation, it is too much noise or too little signal power that leads to bad link quality.

Explain the following types of noise

- Thermal noise
- Man made noise
- Receiver noise

And link budget

b. Interference-Limited Systems

The interference is so strong that it completely dominates the performance, so that the noise can be neglected.

10. Write short notes channel assignment . (8 Marks)

Ans-

- Fixed channel assignment
- Dynamic channel assignment

11. Explain the different hand off strategies used in wireless communication (8 Marks)

Ans-

- Concept of Handoff
- Different types of handoff

UNIT-III

1. Explain in detail the generation & detection of MSK technique? (16 Marks)
    - Principle of MSK
    - MSK transmitter block diagram &explanation
    - MSK receiver block diagram &explanation
2. Explain in detail the generation & detection of QPSK technique? (16 Marks)

Quadrature-Phase Shift Keying

A Quadrature-Phase Shift Keying (QPSK)-modulated signal is a PAM where the signal carries bit per symbol interval on both the in-phase and quadrature-phase component. When interpreting QPSK as a *PAM*, the band pass signal reads

$S_{BP}(t) = E_B/T_B[p_{1D}(t)\cos(2\pi f_c t) - p_{2D}(t)\sin(2\pi f_c t)]$

Explain the following for different types of QPSK and its comparison

- Circuit diagram
- Waveform
- Constellation diagram

3. Explain in detail the generation & detection of GMSK modulation? (16 Marks)
   - Principle of GMSK
   - GMSK transmitter block diagram &explanation
   - GMSK receiver block diagram &explanation

4. Explain the performance of digital modulation in slow flat fading channel.(16 Marks)
   - Explanation & comparison of digital modulation
   - Performance results for ASK, FSK,QPSK,MSK
5. Explain error probability of coherent receivers

   The modulation formats can be any of the form and explain error probability for the following signal formats

1. Binary Phase Shift Keying (BPSK) signals are antipodal signals.
2. Binary Frequency Shift Keying (BFSK), and Binary Pulse Position Modulation (BPPM), areorthogonal signals.
3. Quadrature-Phase Shift Keying (QPSK), $\pi/4$-DQPSK (Differential Quadrature-Phase Shift Keying), and Offset Quadrature-Phase Shift Keying (OQPSK) are bi-orthogonal signals

6. Explain Error Probability in Flat-Fading Channels

7. Explain Error Probability in Delay- and Frequency-Dispersive Fading Channels

UNIT-IV

1. Explain the different methods of microdiversity in detail ((16 Marks)

Micro diversity can be used to combat small-scale fading, which are therefore called "microdiversity." The five most common methods are as follows:
1. *Spatial diversity*: several antenna elements separated in space.
2. *Temporal diversity*: transmission of the transmit signal at different times.
3. *Frequency diversity*: transmission of the signal on different frequencies.
4. *Angular diversity*: multiple antennas (with or without spatial separation) with different antenna patterns.
5. *Polarization diversity*: multiple antennas with different polarizations (e.g., vertical and horizontal).

Explain each types of diversity using diagrams (refer book Molisch)

2 .Explain several signal combining techniques in detail ((16 Marks)

Combining Signals - How to use diversity signals in a way that improves the total quality of the signal that is to be detected. In general, we can distinguish two ways of exploiting signals from the multiple diversity branches:
1. *Selection diversity*, where the "best" signal copy is selected and processed (demodulated and decoded), while all other copies are discarded. There are different criteria for what constitutes the "best" signal.
2. *Combining diversity*, where all copies of the signal are combined (before or after the demodulator), and the combined signal is decoded. Again, there are different algorithms for combination of the signals.

Combining diversity leads to better performance, as all available information is

exploited.

On the downside, it requires a more complex RX than selection diversity.

1. *Selection Diversity*
    - Received-Signal-Strength-Indication-Driven Diversity
    - Bit-Error-Rate-Driven Diversity
    - *Switched Diversity*
2. *Combining Diversity*

Principle Selection diversity wastes signal energy by discarding *(N*r − 1*)* copies of the received signal. This drawback is avoided by combining diversity, which exploits *all* available signal copies. Each signal copy is multiplied by a (complex) weight and then added up.

- Maximum Ratio Combining
- Equal Gain Combining
- Optimum Combining
- Hybrid Selection – Maximum Ratio Combining

3. Explain the performance of diversity reception in Fading Channels

a. Error Probability in Flat-Fading Channels

b. Symbol Error Rate in Frequency-Selective Fading Channels

4. Explain linear feedback equalizers in detail ((16 Marks)

Linear equalizers are simple linear filter structures that try to invert the channel in the sense that the product of the transfer functions of channel and equalizer fulfills a certain criterion.

- This criterion can be any one of the following

- Achieving a completely flat transfer function of the channel–filter concatenation - Zero-Forcing Equalizer
- Minimizing the mean-squared error at the filter output - The Mean Square Error Criterion

- *Adaptation Algorithms for Mean Square Error Equalizers*

5. Explain decision feedback equalizer in detail (8 Marks)

A *decision feedback equalizer (DFE)* has a simple underlying premise: once we have detected a bit correctly, we can use this knowledge in conjunction with knowledge of the channel impulse response to compute the ISI caused by this bit. In other words, we determine the effect this bit will have on subsequent samples of the receive signal. The ISI caused by each bit can then be subtracted from these later samples. Types are

- *MMSE Decision Feedback Equalizer*
- *Zero-Forcing Decision Feedback Equalizer*

6. Explain transmitter diversity with and without channel state information (8 Marks)

For the uplink transmission from the MS to BS, multiple antennas can act as receive diversity branches. For the downlink, any possible diversity originates at the *transmitter*.

- *Transmitter Diversity with Channel State Information*
- *Transmitter Diversity Without Channel State Information*

7. Explain the working principle of Linear predictive coder (16 Marks)
    - Block diagram of Linear predictive coder
    - Working principle
    - Advantages

8. Explain the working principle of GSM codec with neat block diagram. (16 Marks)
    - Block diagram of GSM codec
    - Working principle
    - Advantages
9. Explain the following codes in detail. (i) block code. (ii) convolutional code. (iii) turbo codes
10. Explain in detail about the stochastic models for speech.
11. Explain LMS and Recursive Least Square algorithm

UNIT-V

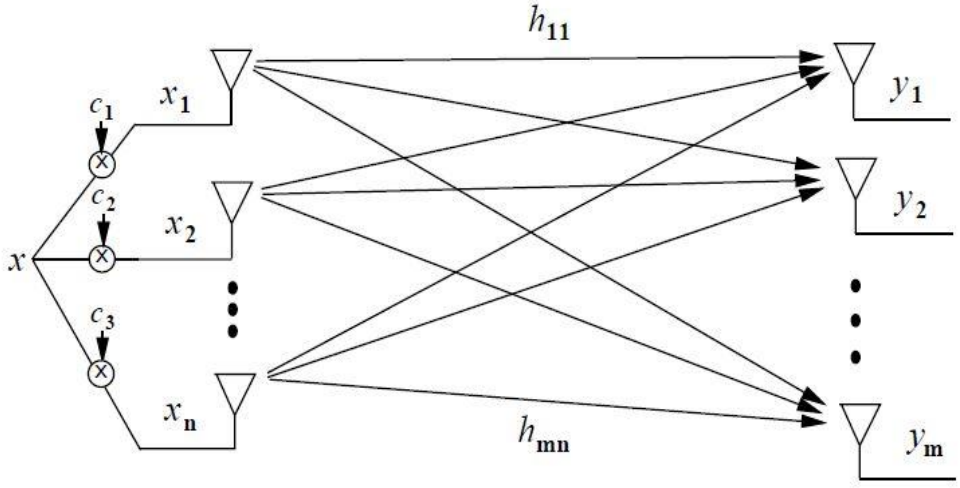
1. Explain the process of Beamforming using multiple antennas.

Ans:

In this section we consider the case when the transmitter does not know the instantaneous channel. It is no longer possible to transform the MIMO channel into non-interfering SISO channels. Since the decoding complexity is exponential in *r*, we can keep the complexity low by keeping *r* small. Of particular interest is the case where $r = 1$. A transmit strategy where the input covariance matrix has unit rank is called *beamforming*. This corresponds to the precoding matrix being just a column vector $M = c$, the beamforming vector.

Spatial matched filtering yields a single SISO AWGN channel as follows.

$$\begin{aligned}\tilde{y} &= \frac{\bar{c}^\dagger H^\dagger}{||\bar{c}^\dagger H^\dagger||} y \\ &= \frac{\bar{c}^\dagger H^\dagger}{||\bar{c}^\dagger H^\dagger||} H\bar{c}x + \frac{\bar{c}^\dagger H^\dagger}{||\bar{c}^\dagger H^\dagger||}\overline{N} \\ &= ||H\bar{c}||x + \tilde{N}\end{aligned}$$



2. Explain the principles of Frequency Hopping spread spectrum technique and direct sequence spread spectrum technique. (16)

- The principles of Frequency Hopping spread spectrum technique

The basic thought underlying FH is to change the carrier frequency of a narrowband transmission system so that transmission is done in one frequency band only for a short while.

The ratio between the bandwidth over which the carrier frequency is hopped and the narrowband transmission bandwidth is the spreading factor.

- *Basic Principle behind the Direct Sequence-Spread Spectrum*

The DS-SS spreads the signal by multiplying the transmit signal by a second signal that has a very large bandwidth. The bandwidth of this total signal is approximately the same as the bandwidth of the wideband spreading signal. The ratio of the bandwidth of the new signal to that of the original signal is again known as the *spreading factor*. As the bandwidth of the spread signal is large, and the transmit power stays constant, the *power-spectral density* of the transmitted signal is very small – depending on the spreading factor and the BS–MS distance, it can lie below the noise power-spectral density. This is important in military applications, because unauthorized listeners cannot determine whether a signal is being transmitted. Authorized listeners, on the other hand, can invert the spreading operation and thus recover the narrowband signal (whose power-spectral density lies considerably *above* the noise power).

3. Explain the principles of Code Division Multiple Access and compared with TDMA

Each user is assigned a different spreading code, which determines the wideband signal that is multiplied by the information symbols. Thus, many users can transmit simultaneously in a wide band

4. Explain about Cellular Code-Division-Multiple-Access Systems and power control

Multiple Access

- In a TDMA/FDMA system, the answer is the limited number of available timeslots/frequencies.
- Users can occupy those slots, and not interfere with each other.
- But when all possible timeslots have been assigned to users, there are no longer free resources available, and no further users can be accepted into the system.

In a CDMA system, this mechanism is subtly different.

- Different users are distinguished by different spreading codes; however, as user separation is not perfect, each user in the cell contributes interference to all other users.
- Thus, as the number of users increases, the interference for each user increases as well.
- Consequently, transmission quality decreases gradually (*graceful degradation*), until users find the quality too bad to place (or continue) calls.
- Consequently, CDMA puts a soft limit on the number of users, not a hard limit like TDMA.
- Therefore, the number of users in a system depends critically on the Signal-to-Interference-and-Noise Ratio (SINR) required by the receiver.
- It also implies that any increase in SINR at the receiver, or reduction in the required SINR, can be immediately translated into higher capacity.

Power control

Distinguish between power control for the uplink and that for the downlink:

• *Power control in the uplink* : for the uplink, power control is vital for the proper operation of CDMA.

- Power control is done by a closed control loop: the MS first sends with a certain power, the BS then tells the MS whether the power was too high or too low, and the MS adjusts its power accordingly.
- An open control loop (where the MS adjusts its transmit power based on its own channel estimate) cannot be used to compensate for small-scale fading in a Frequency Domain
- However, an open loop can be used in conjunction with a closed loop. The open loop compensates for large-scale variations in the channel (path loss and shadowing), which are approximately the same at uplink and downlink frequencies. The closed loop is then used to compensate for small-scale variations.

• *Power control in the downlink*: for the downlink, power control is not necessary for CDMA to function: all signals from the BS arrive at one MS with the same power (the channel is the same for all signals).

- However, it can be advantageous to still use power control in order to keep the total transmit power low. Decreasing the transmit power for all users within a cell by the same amount leaves unchanged the ratio of desired signal power to intra-cell interference – i.e., interference from signals destined for other users in the cell.

5. Effects of Multipath Propagation on Code Division
   - Block diagram of RAKE receiver
   - Working principle

6. Explain the operations of orthogonal frequency division multiplexing and define and list the benefits of cyclic prefix cyclic prefix. (16 Marks)

Orthogonal Frequency Division Multiplexing (OFDM) is a modulation scheme that is especially suited for high-data-rate transmission in delay-dispersive environments. It converts a high-rate data stream into a number of low-rate streams that are transmitted over parallel, narrowband channels that can be easily equalized.

Principle of Orthogonal Frequency Division Multiplexing

OFDM splits a high-rate data stream into *N* parallel streams, which are then transmitted by modulating *N* distinct carriers (henceforth called *subcarriers* or *tones*). Symbol duration on each subcarrier thus becomes larger by a factor of *N*. In order for the receiver to be able to separate signals carried by different subcarriers, they have to be orthogonal.

Implementation of Transceivers

- OFDM can be interpreted in two ways: one is an "analog" –Explain using diagram

Splitting original data stream into *N* parallel data streams, each of which has a lower data rate. We furthermore have a number of local oscillators (LOs) available, each of which oscillates at a frequency $fn = nW/N$, where $n = 0, 1, \ldots, N - 1$. Each of the parallel data streams then modulates one of the carriers.

- An alternative implementation is *digital*. It first divides the transmit data into blocks of *N* symbols. Each block of data is subjected to an *Inverse Fast Fourier Transformation* (IFFT), and then transmitted (see Figure 19.2b). This approach is much easier to implement with integrated circuits. In the following, we will show that the two approaches are equivalent.

Cyclic Prefix Concept

The delay dispersion will have only a small impact on the performance of OFDM we convert the system into a parallel system of narrowband channels, so that the symbol duration on each carrier is made much larger than the delay spread. Delay dispersion also leads to a loss of orthogonality between the subcarriers, and thus to *Inter Carrier Interference* (ICI). Fortunately, both these negative effects can be eliminated by a special type of guard interval, called the *cyclic prefix (CP)*.

7. Detail notes about GSM – system overview, physical and logical channels (16)

- A GSM system consists essentially of three parts – namely, the *Base Station Subsystem* (BSS), the *Network and Switching Subsystem* (NSS), and the *Operation Support System* (OSS). Explain those using diagrams

In addition to the actual payload data, GSM also needs to transmit a large amount of signalling information. These different types of data are transmitted via several *logical channels*. The name stems from the fact that each of the data types is transmitted on specific timeslots that are parts of *physical channels*.

- **Logical and Physical Channels**

- *Logical Channels*
  - **Traffic CHannels (TCHs) - Full-Rate Traffic Channels, Half-Rate Traffic CHannels**
- *Conrol channels*
  - **Broadcast CHannels (BCHs)**
    - ***Frequency Correction CHannels (FCCHs)***
    - ***Synchronization CHannel (SCH)***
    - ***Broadcast Control CHannel (BCCH)***
  - **Common Control CHannels (CCCHs)**
    - ***Paging CHannel (PCH)***
    - ***Random Access CHannel (RACH)***
    - ***Access Grant CHannel (AGCH)***
  - **Dedicated Control CHannels (DCCHs)**
    - ***Standalone Dedicated Control CHannel (SDCCH)***
    - ***Slow Associated Control CHannel (SACCH)***
    - ***Fast Associated Control CHannel (FACCH)***

8. Explain about IS-95 used for wireless communication/ Explain forward & reverse channel parameters of IS-95 CDMA (16)

Interim Standard 95(IS-95).

This system became the first commercial Code Division Multiple Access (CDMA) system that achieved wide popularity.

System Overview

- IS-95 is a CDMA system with an additional Frequency Division Multiple Access (FDMA) component. The available frequency range is divided into frequency bands of 1.25 MHz; duplexing is done in the frequency domain. In the U.S.A., frequencies from 1850–1910MHz are used for the uplink, and 1930–1990MHz are used for the downlink band.1 Within each band, traffic channels, control channels, and pilot channels are separated by the different codes (chip sequences) with which they are spread.
- IS-95 specifies two possible speech coder rates: 13.3 or 8.6 kbit/s. In both cases, coding increases the data rate to 28.8 kbit/s. The signal is then spread by a factor of 64, resulting in a chip rate of 1.2288 Mchip/s. theoretically; each cell can sustain 64 speech users. In practice, this numberis reduced to 12–18, due to imperfect power control, non orthogonality of spreading codes, etc.
- The downlink signals generated by one Base Station (BS) for different users are spread by different Walsh–Hadamard sequences (see Section 18.2.6), and thus orthogonal to each other. This puts an upper limit of 64 channels on each carrier. In the uplink, different users are separated by spreading codes that are not strictly orthogonal. Furthermore, interference from other cells reduces signal quality at the BS and Mobile Station (MS).
- Explain *Spreading and Modulatio in the uplink and downlink*

9. Discuss about 3G standards – WCDMA/UMTS for wireless network.

Explain the following

- *Physical-Layer Overview*
- *Network Structure*
- *Data Rates and Service Classes*
- Air Interface