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PERAMBALUR - 621212
Department of Electronics and communication Engineering
EC6801/ Wireless Communication
UNIT 1-WIRELESS CHANNELS

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
v. Transmitter.

2. What are the factors influencing small scale fading? (NOV/DEC-2016)

The factors which influence small scale fading are:

- Multipath propagation
- Speed of the mobile
- Speed of surrounding objects
- Transmission bandwidth of the signal.

3. Differentiate the propagation effects with mobile radio. (NOV/DEC 2017)

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.

4. 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).

$F_D = f_r – f_0 = -f_0V/C$

Where f_0 -> transmission frequency

f_r -> received frequency

5. Differentiate time selective and frequency selective channel. (NOV/DEC 2015)

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.

6. Define coherence time and coherence bandwidth. (MAY/JUNE 2016)

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.

7. 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.

8. What is intrinsic impedance and Brewster angle? (NOV/DEC 2016)

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,

9. 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.

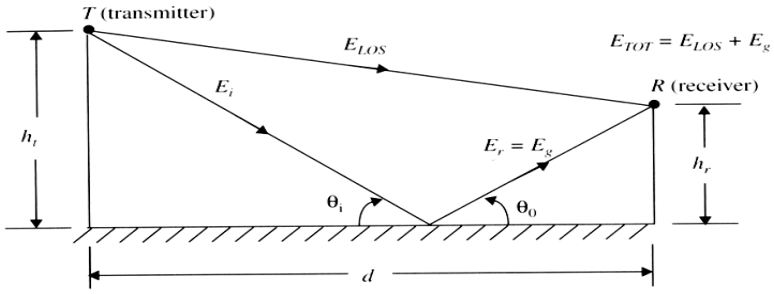
10. Define indoor propagation models.

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.

PART B (Answers as Hint)

1. Describe in detail two ray model propagation mechanism (MAY/JUNE 2012)

Ground Reflection (2-ray) Model



$E_{TOT} = E_{LOS} + E_g$ DIAGRAM---- 3MARK

Let E_0 is the free space E-field (V/m) at a reference distance d_0 from the transmitter, then for $d > d_0$

$$E(d,t) = \frac{E_0 d_0}{d}\cos\left(\omega_c\left(t - \frac{d}{c}\right)\right) \qquad (d > d_0)$$

----- 1 mark

The E-field due to Line of Sight component

$$E_{LOS}(d',t) = \frac{E_0 d_0}{d'}\cos\left(\omega_c\left(t - \frac{d'}{c}\right)\right)$$

The E-field due to Ground reflected component

$$E_g(d'',t) = \Gamma\frac{E_0 d_0}{d''}\cos\left(\omega_c\left(t - \frac{d''}{c}\right)\right)$$

Where Γ = reflection coefficient for ground

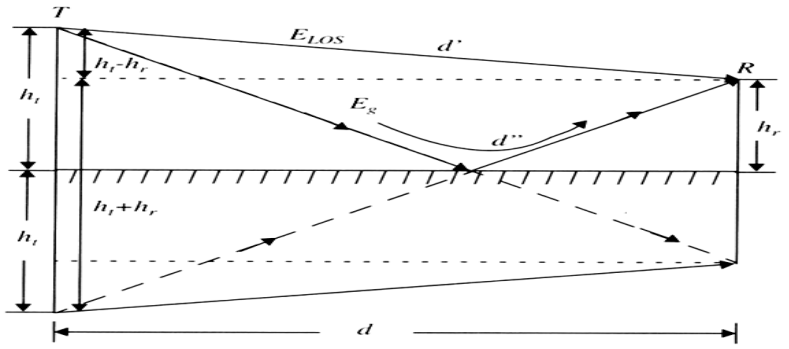
(i.e) reflected wave is equal in magnitude and 180° out of phase with the incident wave

$E_{TOT} = ELOS + E_g$

$$E_{TOT}(d,t) = \frac{E_0 d_0}{d'}\cos\left(\omega_c\left(t - \frac{d'}{c}\right)\right) + (-1)\frac{E_0 d_0}{d''}\cos\left(\omega_c\left(t - \frac{d''}{c}\right)\right)$$

-----2 mark

Method of Images to find Δ = d"- d'



-----3 mark

$$\Delta = d'' - d' = \sqrt{(h_t + h_r)^2 + d^2} - \sqrt{(h_t - h_r)^2 + d^2}$$

And the power loss is

$$PL\,(\text{dB}) = 40\log d - (10\log G_t + 10\log G_r + 20\log h_t + 20\log h_r)$$

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$$

---------1 mark

Explanation -------6 mark

2. **What is the need for link calculation? Explain with suitable example. (NOV/DEC 2017)**

- Long distance path model (4 Mark)

$$\overline{PL}(d) \propto \left(\frac{d}{d_0}\right)^n$$

$$\overline{PL}(\text{dB}) = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right)$$

- Log normal shadowing (4 Mark)

$$PL(d)[dB] = \overline{PL}(d) + X_\sigma = \overline{PL}(d_0) + 10n\log\left(\frac{d}{d_0}\right) + X_\sigma$$

$$Q(z) = \frac{1}{\sqrt{2\pi}}\int_z^\infty \exp\left(-\frac{x^2}{2}\right)dx = \frac{1}{2}\left[1 - erf\left(\frac{z}{\sqrt{2}}\right)\right]$$

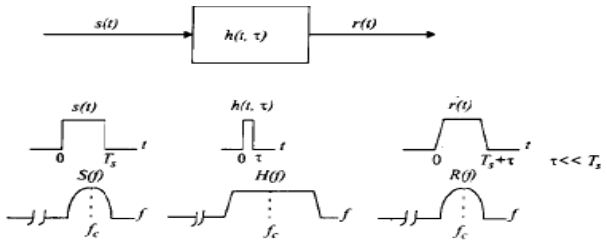
- Determination of percentage of coverage area(5 Mark)

$$U(\gamma) = \frac{1}{\pi R^2}\int Pr\,[P_r(r) > \gamma]\,dA = \frac{1}{\pi R^2}\int_0^{2\pi}\int_0^R Pr\,[P_r(r) > \gamma]\,r\,dr d\theta$$

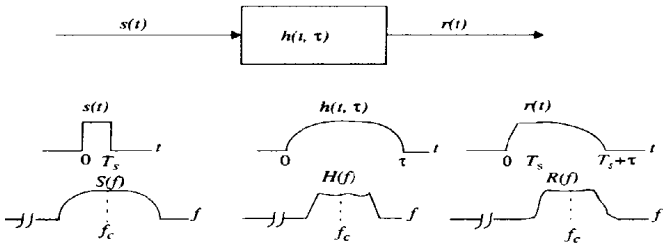
3. **Explain fading effects due to multipath time delay spread and fading effects due to Doppler spread. MAY/JUNE 2015**

Multipath time delay

- Flat fading (4 marks)



- Frequency selective fading (4 marks)

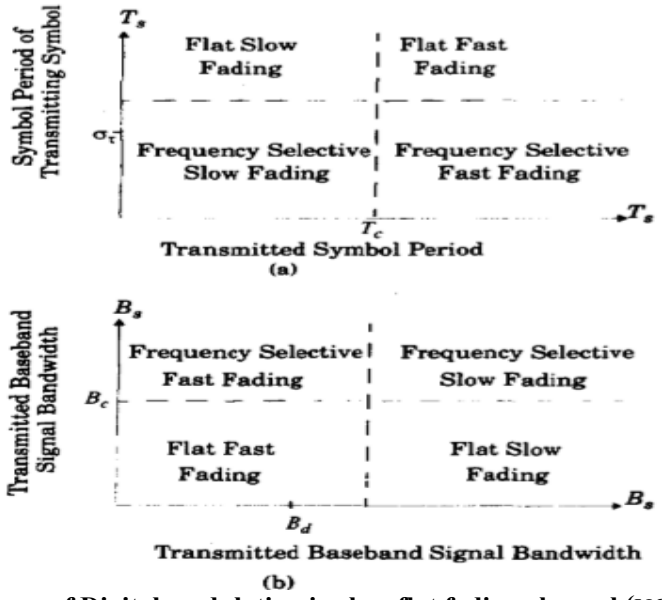


$B_S > B_C$

$$T_S < \sigma_\tau$$

Doppler spread

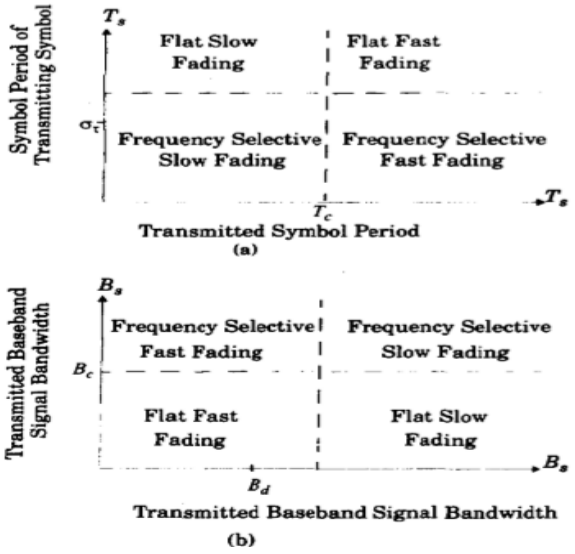
- Fast fading (4 marks)
  - $T_s > T_c$
  - $B_s < B_d$
- Slow fading(4 marks)
  - $T_s \ll T_c$
  - $S_s \gg B_d$



4. **Explain the performance of Digital modulation in slow flat fading channel (NOV/DEC 2013)**

Explanation -6 mark

Diagram – 4 mark



5. **In free space propagation describe how the signals are affected by reflection, diffraction, scattering. NOV/DEC 2015**

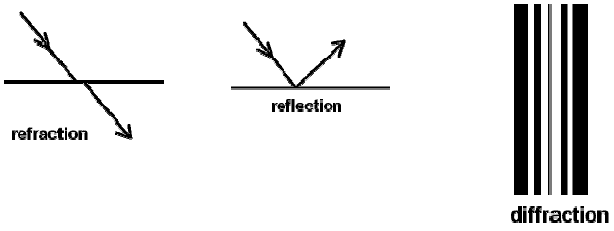


Diagram-------- 4 Mark

Explanation ------12 Mark

Unit -2

1. What is meant by frequency reuse? (MAY/JUNE 2013, NOV/DEC 2016)

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 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.

3. 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

4. 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.

5. 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.

6. 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

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

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

7. Define FDMA, TDMA and CDMA.

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

8. Define Grade of service. (NOV/DEC 2016)

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

9. 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.

10. What is sectoring?

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

11. What are the features of TDMA?

Features of TDMA are:

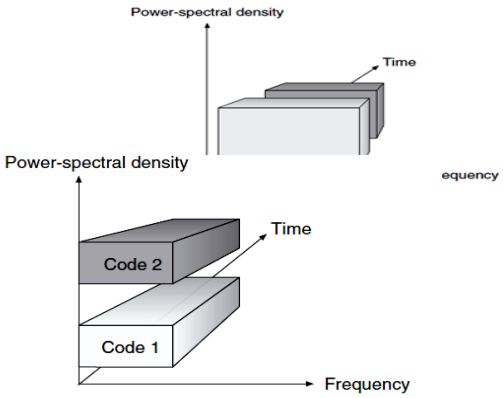
i. TDMA shares a single carrier frequency with several users, where each user makes use of non overlapping time slots.
ii. Data transmission occurs in bursts.
iii. Handoff process is much simpler

iv. Duplexers are not required, since transmission and reception occurs at different time slots.

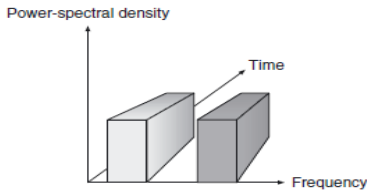
Part –B (Answers as Hint)

1. **Summaries the features of various multiple access techniques used in wireless mobile communication. State the advantage and disadvantages of each technique. (NOV/DEC 2015)**

- TDMA(4 Marks)
- CDMA(6 Marks)



- FDMA(6Marks)



2. **Explain about co-channel interference and adjacent channel interference. Describe the techniques to avoid interference. MAY/JUNE 2014**

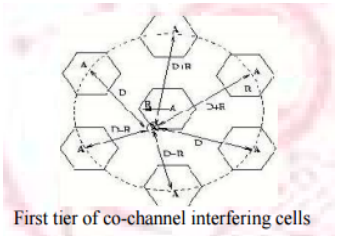
Explanation and equation:(4 Marks +4 Marks)

$$P_r(dB) = P_0(dB) - 10n\log(\frac{d}{d_0})$$

$$\frac{S}{I} = \frac{R^{-4}}{2(D-R)^{-4} + (D+R)^{-4} + (D)^{-4} + (D+R/2)^{-4} + (D-R/2)^{-4}}$$

Adjacent Channel

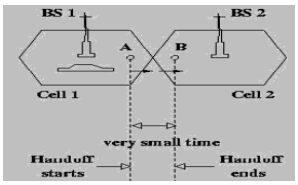
Explanation and diagram (4 Marks +4 Marks)


First tier of co-channel interfering cells

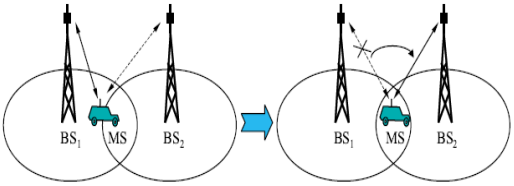
3. **Explain the principle of cellular networks and various types of Hand off techniques.NOV/DEC 2016**

Explanation-8 Mark

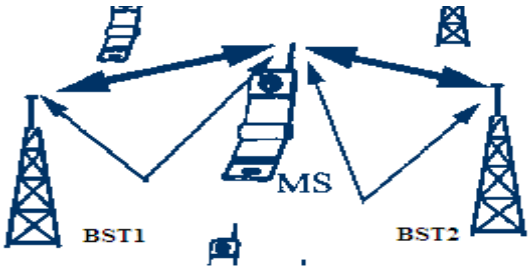
Diagram -8 Mark



Hard hand off

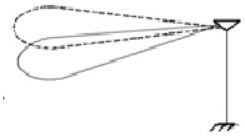


Soft hand off



4. **Explain the method for increasing the capacity of wireless cellular network MAY/JUNE 2013.**
Cell Splitting: (4 Marks)

Beam Tilting: (4 Marks)



Cell sectoring: (4 Marks)

Explanation and Equation (10 Marks + 6 Marks)

$$A_{cluster} = NA_{cell} = N3\sqrt{3}R^2/2.$$

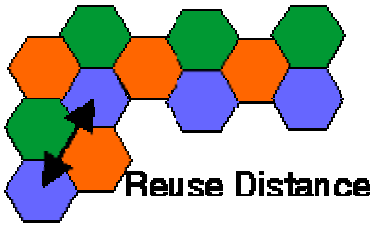
$$M = A_{total}/A_{cluster} = A_{total}/(N3\sqrt{3}R^2/2).$$

5. **Explain in detail about channel assignment strategies** **MAY/JUNE 2013**
Explanation-8 Mark

Diagram -8 Mark

Fixed Channel Assignment (FCA)

Fixed Channel Allocation (FCA) systems allocate specific channels to specific cells. This allocation is static and cannot be changed. For efficient operation, FCA systems typically allocate channels in a manner that maximizes frequency reuse.



Dynamic Channel Assignment (DCA)

Dynamic Channel Allocation (DCA) attempts to alleviate the problem mentioned for FCA systems when offered traffic is non-uniform. In DCA systems, no set relationship exists between channels and cells. Instead, channels are part of a pool of resources. Whenever a channel is needed by a cell, the channel is allocated under the constraint that frequency reuse requirements cannot be violated. There are two problems that typically occur with DCA based systems.

Unit -3

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 is QPSK? MAY/JUNE 2015

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 $7\pi/4$.

3. Define offset QPSK and π/4 differential QPSK. NOV/DEC 2014

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..

4. 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.

5. Why GMSK is preferred for multiuser, cellular communication? Nov/Dec 2017

- It is a simple binary modulation scheme.
- Pre modulation 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.

6. Write the advantages of MSK over QPSK. NOV/DEC 2014

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.

7. 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.

8. Mention some merits of MSK.

Merits of MSK:

i Constant envelope
ii Spectral efficiency
iii Good BER performance
iv. Self-synchronizing capability

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

- Equalization
- Diversity
- Channel coding

10. What is EDGE?

It is Enhanced data rates developed for GSM cellular standard and EDGE upgrades the area of GSM applications. The EDGE also supports IS-136and EDGE uses octal phase shift keying modulation (8-psk) technique along with GMSK scheme. The multiple modulation and coding scheme is possible with EDGE technology.

11. Why non linear equalizers are preferred? NOV/DEC 2014

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.

12. What is the nonlinear equalization methods used? NOV/DEC 2016

Commonly used non linear equalization methods are:

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

Part –B (answers as Hint)

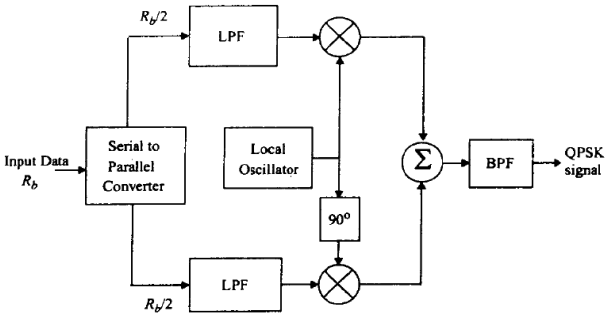
1. **Explain in detail offset QPSK and pi/4 DQPSK linear digital modulation techniques employed in wireless communication**. **MAY/JUNE 2013**

Explanation: 2 Mark

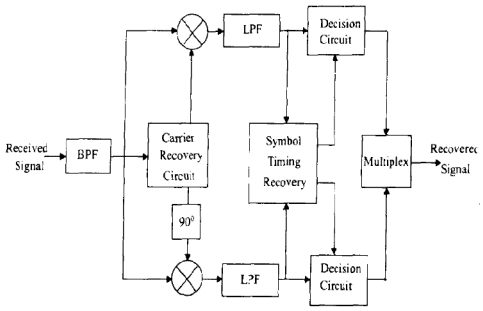
A Quadrature-Phase Shift Keying (QPSK)-modulated signal is a PAM where the signal carries bit per symbol interval on both the in-phase and Quadrature-phase component. The original data stream is split into two streams, b1i and b2i:

$$s_{BP}(t) = \sqrt{E_B/T_B}[p1_D(t)\cos(2\pi f_c t) - p2_D(t)\sin(2\pi f_c t)]$$

QPSK transmission: (3 Mark)



QPSK detection :(3 Mark)



Π/4 QPSK

Explanation- 4 Mark

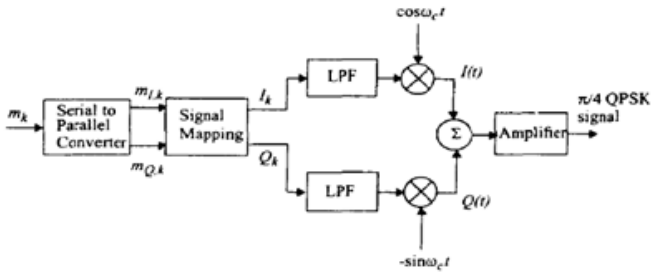


Diagram – 2 Mark

$$I_k = \cos\theta_k = I_{k-1}\cos\phi_k - Q_{k-1}\sin\phi_k$$

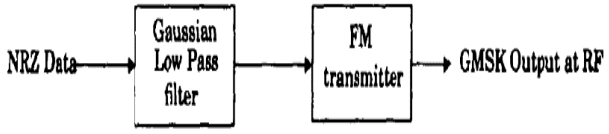
$$Q_k = \sin\theta_k = I_{k-1}\sin\phi_k + Q_{k-1}\cos\phi_k$$

where

$$\theta_k = \theta_{k-1} + \phi_k$$ ------ **2** Mark

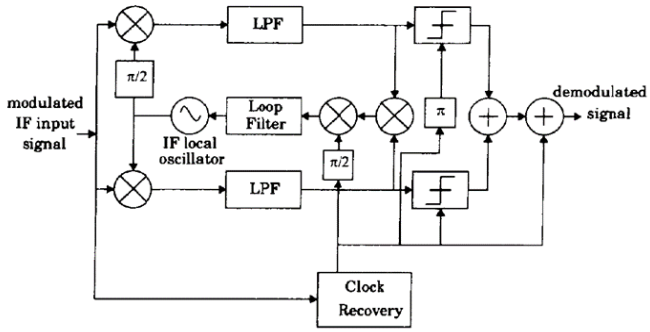
2. Explain in detail Gaussian Minimum shift keying transmission and reception. NOV/DEC 2015

GMSK receiver:
Explanation: 5 Mark
Diagram : 3 Mark



GMSK Receiver

Explanation: 5 Mark
Diagram : 3 Mark



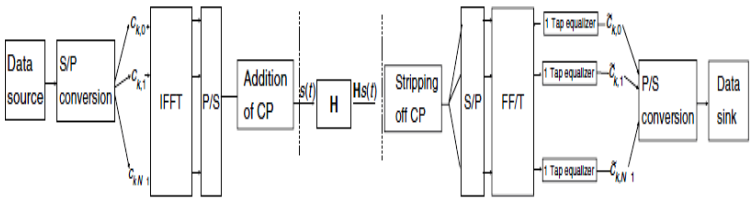
3. Draw the basic arrangement of orthogonal frequency division multiplexing transceivers and discuss its overall operation MAY/JUNE 2013

Definition: (2 Mark)

(OFDM) is a modulation scheme that is especially suited for high-data-rate transmission in delay-dispersive environments.

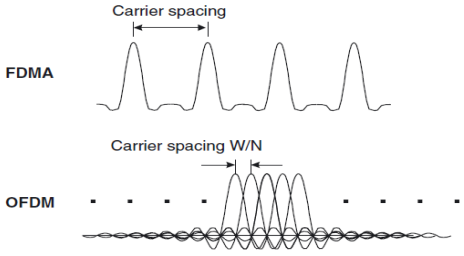
$$\int_{iT_s}^{(i+1)T_S} \exp(j2\pi f_k t)\exp(-j2\pi f_n t)\,dt = \delta_{nk}$$

------ **2** Mark



---4 Mark

Explanation -----6 Mark

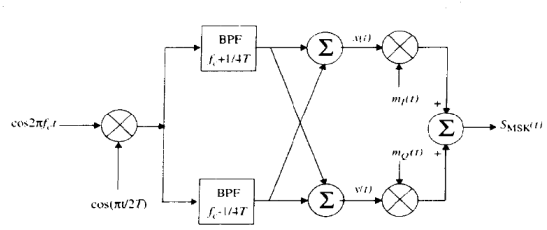


-----2 Mark

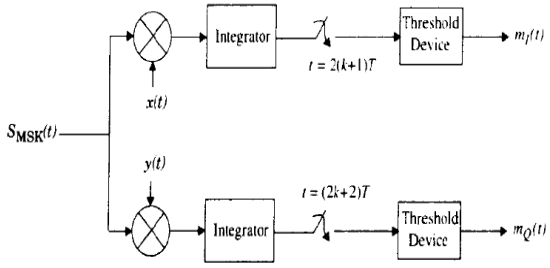
4. Explain the principle of MSK modulation and derive the expression for power spectral density. MAY/JUNE 2013

MSK transmitter:

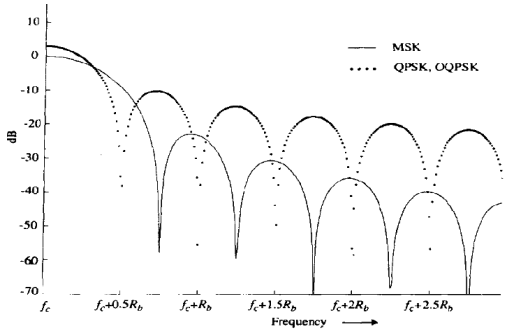
Explanation: 5 Mark
Diagram : 3 Mark



MSK receiver**:**
Explanation: 5 Mark
Diagram : 3 Mark

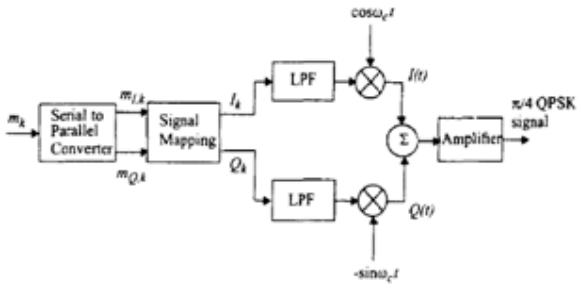


$$P_{MSK} = \frac{16}{\pi^2}\left(\frac{\cos 2\pi(f+f_c)T}{1.16f^2T^2}\right)^2 + \frac{16}{\pi^2}\left(\frac{\cos 2\pi(f-f_c)T}{1.16f^2T^2}\right)^2$$



5. Explain the principle of π/4 –DQPSK from a signal space diagram
Π/4 QPSK.MAY/JUNE 2013

Explanation: 5 Mark
Diagram : 3 Mark



$$I_k = \cos\theta_k = I_{k-1}\cos\phi_k - Q_{k-1}\sin\phi_k$$
$$Q_k = \sin\theta_k = I_{k-1}\sin\phi_k + Q_{k-1}\cos\phi_k$$

where

$$\theta_k = \theta_{k-1} + \phi_k$$

UNIT 4-MULTIPATH MIGITATION TECHNIQUES

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. 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.

3. 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.

4. Differentiate selection diversity and combining diversity. MAY/JUNE 2014

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. Differentiate micro and macro diversity. MAY/JUNE 2015

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.

6. What is linear and non-linear equalizer? MAY/JUNE 2016

- 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.

7. Mention the advantage of RAKE receiver. MAY/JUNE 2015

A RAKE receiver collects the different time delayed versions of original signal so that in multipath environment if any useful information, available in multipath components is not left out. By receiving all possible multiple components with the help of separate correlation receivers for each multipath a better signal to noise ratio is achieved and finally it will lead to signal quality

8. Why diversity and equalization techniques are used?

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

9. What is diversity? NOV/DEC 2013

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

10. What is an equalizer? NOV/DEC 2013

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

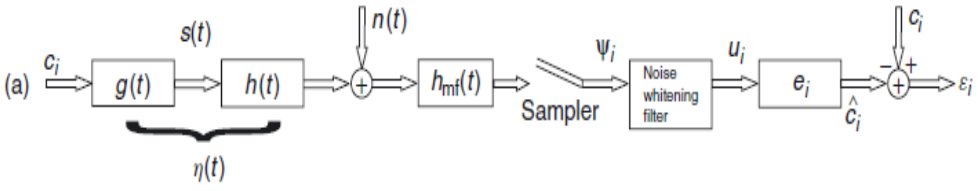
Part –B (Answers as Hint)

1. Explain in detail about: linear equalizer and non-linear equalizer.NOV/DEC 2013

LINEAR EQUALIZERS:

Explanation: 5 Mark

Diagram : 3 Mark

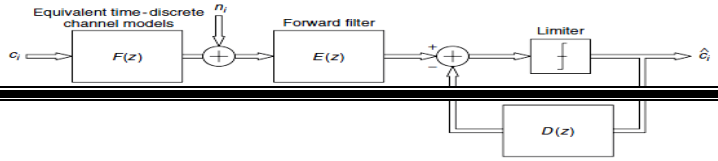


$$\Xi(e^{j\omega T_s}) = \frac{1}{T_S}\sum_{n=-\infty}^{\infty}\left|\hat{\Xi}\left(\omega + \frac{2\pi n}{T_S}\right)\right|^2, \quad |\omega| \le \frac{\pi}{T_S}$$

NON LINEAR EQUALIZER:

Explanation: 5 Mark

Diagram : 3 Mark

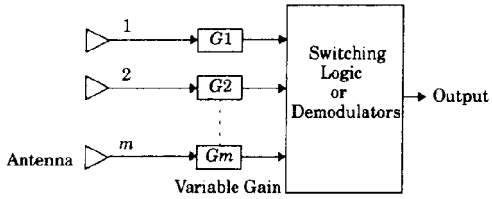


2.
3.
4.
5.
6.

2. Write short notes on: spatial diversity, Frequency diversity, Polarization diversity, Angle diversity, Time Diversity NOV/DEC 2012

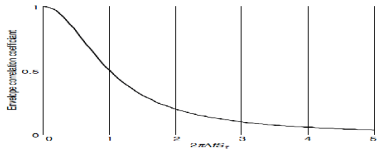
- **spatial diversity**

Explanation: 2 Mark
Diagram : 2 Mark



- **Frequency diversity**

Explanation: 2 Mark
Diagram : 2 Mark

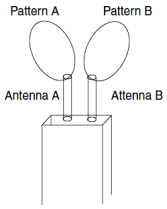


- **Polarization diversity**

Definition: 2 Mark
Explanation: 2 Mark

- **Angle diversity**

Explanation: 2 Mark
Diagram : 2 Mark



- **Time Diversity**

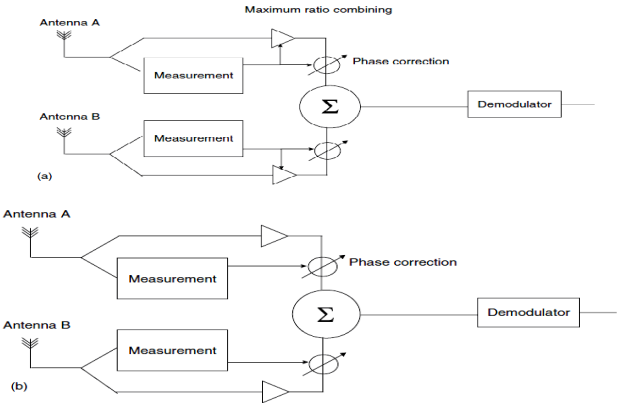
Explanation : 1 Mark

Definition : 1Mark

Time diversity repeatedly transmits information at time spacing that exceeds the coherence time of the channel, so that multiple repetitions of the signal will be received with independent fading conditions, thereby providing diversity.

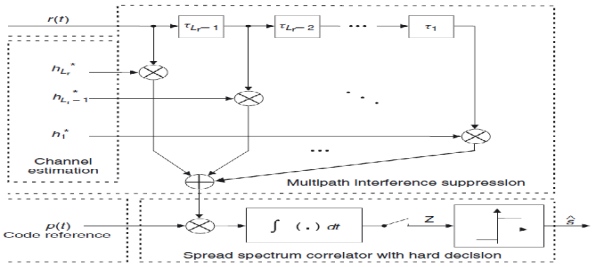
3. **Derive an expression for performance improvement due to Maximal Ratio Combining.MAY/JUNE 2015**

Explanation: 12 Mark
Diagram : 4 Mark



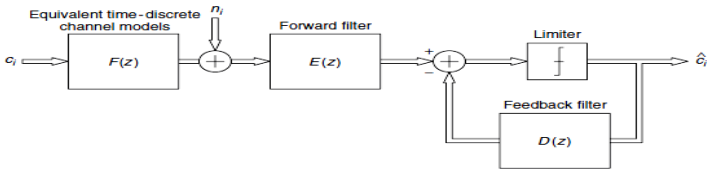
4. **With block diagram, explain the operation of a RAKE receiver.NOV/DEC 2013**

Explanation: 12 Mark
Diagram : 4 Mark



5. **Explain the basic idea about linear and behind decision feedback equalizers and derive an expression for its minimum mean square error.NOV/DEC 2015.**

Explanation: 12 Mark
Diagram : 4 Mark



$$\sigma_n^2(DFE - ZF) = N_0 \exp\left(\frac{T_S}{2\pi}\int_{-\pi/T_s}^{\pi/T_s} \ln\left[\frac{1}{\Xi(e^{j\omega T})}\right] d\omega\right)$$

UNIT 5-MULTIPLE ANTENNA TECHNIQUES

PART - A

1. What is MIMO system?

MIMO is multiple input multiple output system .Here multiple antennas at transmitter and receiver side are being used.

2. What do you mean by processing gain of a spread spectrum?

$$\text{Processing gain} = \frac{\text{Bandwidth of spreaded data signal}}{\text{Bandwidth of unspreaded data signal}} = \frac{\text{Bit duration}}{\text{Chip duration}}$$

3. What is beam forming? NOV/DEC 2014

Beam forming or smart antenna arrangement method allows phased array of antennas for transmitter and receiver .The input bit sequence is given to beam forming.

4. Mention any two diversity techniques in MIMO system.

In MIMO system transmitter diversity and receiver diversity techniques are used in minimize loss and to have more coverage capacity.

5 What is meant by anti-jamming? NOV/DEC 2015

With the help of spread spectrum method, the transmitted signals are spread over the mid frequency band. Hence these signals appear as noise. Then it becomes difficult for the jammers to attack our signal. This method is called anti jamming.

6. List the advantages and disadvantages of FH-SS.

Advantages of FH-SS:

i. High processing gain than DS-SS.
ii. Shorter acquisition time makes the system fast.

Disadvantages of FH-SS:

i. FH-SS requires large bandwidth.
ii. Circuit used for FH-SS is complex. Expensive frequency synthesizers are required.

7.Compare slow and fast FH-SS. MAY/JUNE 2014

Slow FH-SS	Fast FH-SS
More than one symbol is transmitted per hop.	One symbol is transmitted with more than one hops.
Chip rate is equal to the symbol rate.	Chip rate is equal to the hop rate.
Same carrier frequency is used to transmit one or more symbols.	One symbol is transmitted over multiple carriers in different hops.

8.Compare DS-SS and FH-SS.

DS-SS	FH-SS
PN sequence is multiplied with narrow	Data bits are transmitted in different

band signal.	frequency slots which are changed by PN sequence.
Modulation used is BPSK-coherent.	Modulation used is M-ary FSK
	No coherent. Faster than DS-SS.
Fixed chip rate.	Variable chip rate.
Long acquisition time is required.	Short acquisition time.
Effect of distance is high.	Effect of distance is less.

9. How the capacity can be increased in CDMA?

Capacity in CDMA can be increased by

i. A quiet period during speech transmission is shared by many users.
ii. Flexible data rate.
iii. Soft capacity.
iv. Error Correction coding used.

10. Write short notes on OFDM. MAY/JUNE 2015

OFDM splits the information into N parallel streams which are modulated by N In distinct carriers and then transmitted order to separate the subcarriers by the receiver, they have to be orthogonal.

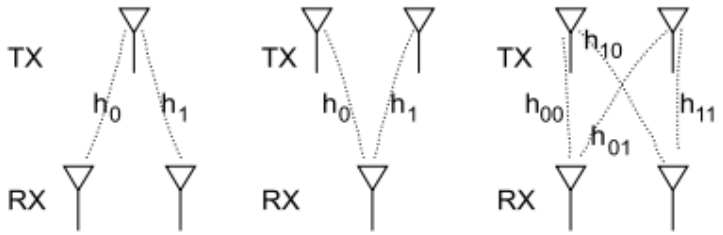
11. Why cyclic prefix?

In delay dispersive channel, inter carrier interference occur. To overcome the effect of inter carrier interference and ISI, cyclic prefix is introduced. It is a cyclically extended guard interval whereby each symbol sequence is preceded by a periodic extension of the sequence itself.

Part B (Answers as Hint)

1. **Discuss in detail the classification of algorithm for MIMO based system.NOV/DEC 2016**

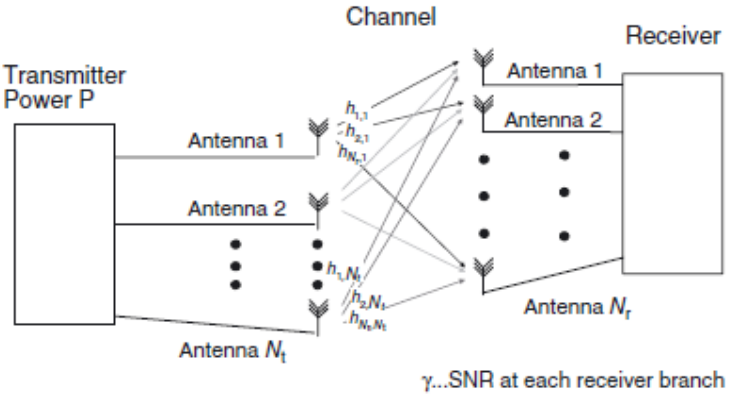
Definition: 2 Mark
Explanation: 10 Mark
Diagram : 4 Mark



2. **With a neat diagram explain the system model for multiple input multiple output systems**.NOV/DEC 2016

Definition :2 Mark
Explanation: 10 Mark

Diagram : 4 Mark



3. **Calculate the capacity of a MIMO system in flat fading and non fading channels. NOV/DEC 2015**

Definition: 2 Mark
Explanation: 10 Mark
Equation : 4 Mark

$$E\{C\} = \int_0^\infty \log_2\left[1 + \frac{\overline{\gamma}}{N_t}\lambda\right] \sum_{k=0}^{m-1} \frac{k!}{(k+n-m)!} \left[L_k^{n-m}(\lambda)\right]^2 \lambda^{n-m} \exp(-\lambda)\, d\lambda$$

4. Explain in detail spatial multiplexing of a MIMO system. NOV/DEC 2015

Definition: 2 Mark
Explanation: 10 Mark
Diagram : 4 Mark

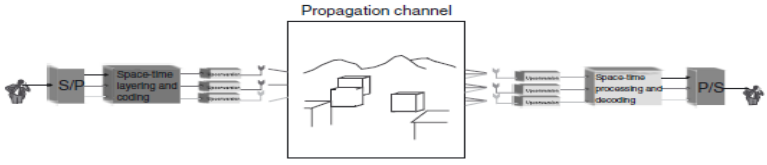


Figure 20.8 Principle behind spatial multiplexing.

5. **Discuss in detail on transmit diversity & receive diversity. NOV/DEC 2015**

Definition: 2 Mark
Explanation: 10 Mark
Equation : 4 Mark

Transmitter diversity

$$h(\tau) = \frac{1}{\sqrt{N_r}} \sum_{n=1}^{N_t} h_n \delta(\tau - nT_s)$$

Receiver diversity

$$\bar{\gamma} = \int_0^\infty \gamma p_M(\gamma)\, d\gamma = \Gamma \int_0^\infty Mx\,(1 - e^{-x})^{M-1} e^{-x} dx$$