

SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING QUESTION BANK



I SEMESTER

**CU3163 – ADVANCED WIRELESS COMMUNICATION
Regulation: 2023**

Academic Year: 2026– 2027

Prepared by

Dr. C. AMALI, Associate Professor/ECE

UNIT I - WIRELESS CHANNEL PROPAGATION AND MODELS

Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-free space, two ray. Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading –shadowing Distributions, Link power budget Analysis.

PART A

No	Questions	BT Level	Competence
1.	Write the equation for average large scale-path loss between the transmitter and receiver as a function of distance.	BTL -2	Understanding
2.	What is multipath propagation?.	BTL -1	Remembering
3.	Point out the three basic propagation mechanisms.	BTL -2	Understanding
4.	What are the factors that contribute to the rapid fluctuations of the signal amplitude?	BTL -1	Remembering
5.	State two differences between Rayleigh and Rician fading.	BTL -2	Understanding
6.	Define coherence time.	BTL -1	Remembering
7.	What is meant by coherence bandwidth?	BTL -1	Remembering
8.	Point out the differences between small-scale fading and large-scale fading.	BTL -2	Understanding
9.	Write the Friis free space equation.	BTL -1	Remembering
10.	Compare fast and slow fading.	BTL -2	Understanding
11.	What is flat and frequency selective fading?	BTL -1	Remembering
12.	Define the term “Fresnel Zone”.	BTL -1	Remembering
13.	What is the need for outdoor propagation model?	BTL -1	Remembering
14.	Solve the Brewster Angle, θ_B for a wave impinging on poor ground having a permittivity of $\epsilon_r = 4$ at the frequency of 100 MHz. Also calculate the same for typical ground with permittivity of $\epsilon_r = 15$.	BTL -2	Understanding
15.	Compare the difference between delay spread and Doppler spread.	BTL -2	Understanding
16.	Classify the various parameters used in Link Budget calculation.	BTL -2	Understanding
17.	Mention the different types of outdoor propagation model?	BTL -1	Remembering
18.	Express the term Doppler Shift with respect to wireless communication.	BTL -2	Understanding
19.	Compare Small scale fading based on multi path time delay and Doppler spread.	BTL -2	Understanding
20.	Summarize how flat fading is experienced in wireless communication.	BTL -2	Understanding

21.	List the factors to be considered for link budget design.	BTL -1	Remembering
22.	Give examples for indoor propagation model.	BTL -1	Remembering
23.	How to determine the partition losses between floors in indoor propagation model.	BTL -2	Understanding
24.	What is the significance of COST 231 Hata model?.	BTL -1	Remembering
PART B (16 marks)			
1.	Derive the free space propagation model in detail with no obstacle in between the TX and RX.	BTL -4	Analyzing
2.	Categorize small scale fading and parameters of mobile multipath channels with suitable expressions.	BTL -4	Analyzing
3.	Assume if a transmitter produces 50W of power, express the transmit power in units of dBm and dBW. 50W is applied to a unity gain antenna with a 900 MHz carrier frequency. Solve for the received power in dBm at a free space distance of 100m from the antenna also justify the analytical expression by computing the received power at 10km.	BTL -3	Applying
4.	In digital cellular system if $f_c=900\text{MHz}$ and the mobile velocity is 70km/hr, evaluate the received carrier frequency if the mobile is (i) Directed towards the transmitter (positive Doppler shift) (ii) Directed away from the transmitter (negative Doppler shift) In the direction perpendicular to the direction of the arrival of the transmitted signal.	BTL -3	Applying
5.	If the transmitter power is 1W and carrier frequency is 2.4GHz and the receiver is at a distance of 1 mile (1.6km) from the transmitter. Assume that the transmitter and receiver antenna gains are 1.6. Determine the received power in dBm in the free space of a signal, the path loss in dB and the transmission delay?	BTL -3	Applying
6.	Compare COST-231 Hata and Longley-Rice models. Explain their applications.	BTL -4	Analyzing
7.	Illustrate Doppler shift when a mobile move with constant velocity. List the factors influencing small scale fading and explain the factors.	BTL -4	Analyzing
8.	Analyze Doppler spread and coherence time that describe the time varying nature of the channel in a small-scale region. Calculate the Doppler spread if the carrier frequency is 1900 MHz and velocity is 50 m/s.	BTL -4	Analyzing
9.	Analyze the process to achieve a balanced link budget and obtain the received power and EIRP.	BTL -4	Analyzing
10.	Derive the of the two-ray ground reflection model and obtain the path loss.	BTL -3	Applying
11.	Assess the parameters of mobile multipath channels with their significance.	BTL -4	Analyzing
12.	Classify the small scale fading in wireless channel based on multipath time delay spread and explain its features.	BTL -4	Analyzing
13.	Illustrate the terrain profile of outdoor propagation using COST - 231 Hata model	BTL -3	Applying

14.	Discuss Rayleigh, Rician, and Nakagami fading models. Derive their PDFs and applications.	BTL -3	Applying
15.	(i) Examine in detail about fast fading and slow fading in wireless channel. (ii) Summarize the effects of fading with respect to symbol period and baseband signal bandwidth	BTL -4	Analyzing
16.	Illustrate the impact of basic propagation mechanisms in mobile communication system with necessary diagrams and equations.	BTL -3	Applying
17.	Describe the role of indoor propagation models in mobile radio propagation using two models.	BTL -3	Applying

UNIT II - CAPACITY OF WIRELESS CHANNELS

Capacity in AWGN, Channel capacity theorem, capacity of flat fading channels, capacity of frequency selective fading channels. Key factors affecting channel capacity, Channel state information, Channel capacity optimization techniques.

PART A

Q.No	Questions	BT Level	Competence
1.	What is the significance of channel state information (CSI)?	BTL -2	Understanding
2.	Define AWGN channel model.	BTL -1	Remembering
3.	Sketch the MIMO Channel Model.	BTL -2	Understanding
4.	Write the function of Frequency selective model.	BTL -2	Understanding
5.	Discriminate Ergodic and outage capacity.	BTL -2	Understanding
6.	Illustrate the Capacity of MIMO channels.	BTL -2	Understanding
7.	When does the propagation model is termed as small scale model?	BTL -2	Understanding
8.	Outline the features of correlated channels.	BTL -1	Remembering
9.	State Shannon's capacity theorem.	BTL -1	Remembering
10.	Classify the MIMO Channel models types.	BTL -2	Understanding
11.	Define Multiplexing gain.	BTL -1	Remembering
12.	Differentiate between flat fading and frequency selective fading channels.	BTL -2	Understanding
13.	Summarize channel properties.	BTL -2	Understanding
14.	Interpret the properties of MIMO channels.	BTL -2	Understanding
15.	What is narrowband MIMO system?	BTL -1	Remembering
16.	Write the expression for capacity of an AWGN channel.	BTL -1	Remembering
17.	Determine the equation for Outage Capacity.	BTL -2	Understanding
18.	Explain the advantages and disadvantages of MIMO.	BTL -2	Understanding
19.	Develop the Ergodic Capacity.	BTL -2	Understanding

20.	Define the demodulation technique required for optimal decoding of the received signal in MIMO system.	BTL -1	Remembering
21.	List the factors affecting channel capacity.	BTL -1	Remembering
22.	Mention the impact of SNR and bandwidth on channel capacity.	BTL -1	Remembering
23.	Name one technique used to optimize channel capacity.	BTL -1	Remembering
24.	What is water-filling algorithm used for in channel capacity optimization?	BTL -1	Remembering
PART B			
1.	Deduce the capacity of the frequency flat deterministic MIMO channel, considering a MIMO channel with MT transmit antenna and MR receive antenna.	BTL -4	Analyzing
2.	Justify that the capacity of the MIMO channel as the sum of the capacities of the SISO channel. Explain with necessary diagrams and equations.	BTL -4	Analyzing
3.	Describe the water-filling algorithm and demonstrate how it is used to maximize capacity in a fading channel with power constraints.	BTL -3	Applying
4.	Analyze the fading and non-fading channel with respect to capacity and discuss each in detail.	BTL -4	Analyzing
5.	Explain how CSI affects capacity and discuss optimization techniques.	BTL -3	Applying
6.	Explain in detail about the capacity of flat fading fading channels.	BTL -3	Applying
7.	Determine the capacity of slow fading channel and obtain the outage probability for receive diversity system with L receive antennas.	BTL -1	Remembering
8.	Derive the Shannon capacity theorem for AWGN channels.	BTL -3	Applying
9.	Describe the capacity of frequency selective fading channels with necessary diagrams.	BTL -4	Analyzing
10.	Consider a flat-fading channel with i.i.d. channel gain $g[i]$ which can take on three possible values: $g_1 = .05$ with probability $p_1 = .1$, $g_2 = .5$ with probability $p_2 = .5$, and $g_3 = 1$ with probability $p_3 = .4$. The transmit power is 10 mW, the noise spectral density is $N_0 = 10^{-9}$ W/Hz, and the channel bandwidth is 30 KHz. Assume the receiver has knowledge of the instantaneous value of $g[i]$ but the transmitter does not. Find the Shannon capacity of this channel and compare with the capacity of an AWGN channel with the same average SNR.	BTL -3	Applying
11.	Categorize the basic channel model types and explain the influence of channel properties on the capacity.	BTL -4	Analyzing
12.	Consider a flat-fading channel with i.i.d. channel gain $g[i]$ with a bandwidth of 30 KHz and three possible received SNRs: $\gamma_1 = .8333$ with $p(\gamma_1) = .1$, $\gamma_2 = 83.33$ with $p(\gamma_2) = .5$, and $\gamma_3 = 333.33$ with $p(\gamma_3) = .4$. Find the ergodic capacity of this channel assuming both transmitter and receiver have instantaneous CSI.	BTL -3	Applying

13.	(i) List and Explain different types of Transmit Precoding. (8) (ii) Demonstrate about the receiver shaping of parallel decomposition of the MIMO channel. (8)	BTL -3	Applying
14.	Analyze the key factors that affect the wireless channel capacity.	BTL -4	Analyzing
15.	Formulate the channel capacity when the channel is known at the transmitter and the channel unknown at the transmitter.	BTL -3	Applying
16.	Discuss various channel capacity optimization methods including adaptive modulation, power allocation, and diversity schemes, highlighting their practical implementation challenges.	BTL -3	Applying
17.	Analyze the capacity of frequency selective MIMO channel and express it as sum of the capacity of frequency flat sub channels.	BTL -4	Analyzing

UNIT III DIVERSITY TECHNIQUES

Realization of independent fading paths, Receiver Diversity: Selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain Combining. Transmitter Diversity: Channel known at transmitter, Channel unknown at the transmitter.

PART A

Q.No	Questions	BT Level	Competence
1.	Why are independent fading paths important in diversity systems?	BTL -2	Understanding
2.	Differentiate between correlated and independent fading.	BTL -2	Understanding
3.	Compare coding gain and diversity gain	BTL -2	Understanding
4.	Define selection combining.	BTL -1	Remembering
5.	Write the basic rule used in threshold combining.	BTL -2	Understanding
6.	What is the principle behind Maximum Ratio Combining (MRC)?	BTL -1	Remembering
7.	State one difference between MRC and Equal Gain Combining (EGC).	BTL -2	Understanding
8.	Which receiver diversity scheme provides the best SNR performance?	BTL -1	Remembering
9.	Why is threshold combining less complex than MRC?	BTL -2	Understanding
10.	What is transmitter diversity?	BTL -1	Remembering
11.	Differentiate between transmitter diversity with CSI and without CSI.	BTL -2	Understanding
12.	Compare the average probability of bit error of BPSK under MRC and EGC two-branch diversity with i.i.d. Rayleigh fading with average SNR of 10 dB on each branch.	BTL -2	Understanding
13.	What is the advantage of knowing channel state information at the transmitter?	BTL -1	Remembering
14.	What is meant by diversity combining gain and diversity order?	BTL -1	Remembering
15.	What is beamforming?	BTL -1	Remembering
16.	What is the difference between channel known and unknown at the transmitter?	BTL -2	Understanding
17.	Name an advantage of using space-time codes.	BTL -2	Understanding
18.	What is the main performance measure improved by receiver diversity?	BTL -1	Remembering
19.	What is the role of feedback delay in transmitter diversity?	BTL -2	Understanding
20.	What happens to capacity when channel is perfectly known at the	BTL -1	Remembering

	transmitter?		
21.	Give one example of a practical transmitter diversity system.	BTL -1	Remembering
22.	What is the main challenge in implementing transmitter diversity with CSI?	BTL -1	Remembering
23.	What are the advantages of Alamouti scheme?	BTL -1	Remembering
24.	How many transmit antennas are needed in Alamouti's space-time block code?	BTL -2	Understanding
Part B			
1.	Explain the importance of realizing independent fading paths for diversity schemes and describe various methods to achieve it.	BTL -3	Applying
2.	Find the outage probability of BPSK modulation at $P_b = 10^{-3}$ for two-branch SSC diversity with i.i.d. Rayleigh fading on each branch for threshold values of $\gamma_T = 3, 7$, and 10 dB. Assume the average branch SNR is $\bar{\gamma} = 15$ dB. Discuss how the outage probability changes with γ_T . Also compare outage probability under SSC with that of SC.	BTL -3	Applying
3.	Explain the working of selection combining (SC) with neat diagrams and equations.	BTL -3	Applying
4.	Analyze the transmitter diversity techniques when CSI is known at the transmitter. Illustrate with examples such as beamforming.	BTL -4	Analyzing
5.	Discuss the principle of threshold combining (TC). Derive the probability of error for TC in fading channels.	BTL -3	Applying
6.	Examine selection combining, threshold combining, maximum-ratio combining, and equal gain combining techniques in detail with their respective advantages and limitations.	BTL -4	Analyzing
7.	With mathematical derivation, explain Maximum Ratio Combining (MRC) and show how it improves SNR.	BTL -4	Analyzing
8.	Explain Equal Gain Combining (EGC). Compare it with MRC and SC in terms of performance and complexity.	BTL -4	Analyzing
9.	Explain transmitter diversity methods when CSI is not known at the transmitter. Discuss practical implementations.	BTL -4	Analyzing
10.	Compare the performance and complexity of transmit diversity with channel known and unknown at the transmitter.	BTL -4	Analyzing
11.	Discuss the effect of imperfect CSI and limited feedback on beamforming performance.	BTL -4	Analyzing
12.	Discuss the implementation of beamforming and opportunistic transmission techniques when channel state information is available at the transmitter.	BTL -3	Applying
13.	Discuss how transmit antenna selection works and its advantages when CSI is known at the transmitter.	BTL -3	Applying
14.	Compare transmitter and receiver diversity in terms of complexity, channel requirements, and performance improvement.	BTL -4	Analyzing
15.	Discuss the trade-offs between CSI-based and non-CSI-based transmitter diversity schemes.	BTL -3	Applying
16.	Derive the capacity gain expressions for MIMO systems with and without channel knowledge at the transmitter.	BTL -3	Applying
17.	Explain the concept and application of Alamouti's scheme in transmit diversity with appropriate mathematical formulation.	BTL -3	Applying

UNIT IV - MIMO COMMUNICATIONS			
Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures.			
PART A			
Q.No	Questions	BT Level	Competence
1.	Define a narrowband MIMO channel.	BTL -1	Remembering
2.	How is the narrowband MIMO channel represented mathematically?	BTL -2	Understanding
3.	Define spatial multiplexing in MIMO systems.	BTL -1	Remembering
4.	What is the difference between narrowband and wideband MIMO channels?	BTL -1	Remembering
5.	What distribution is typically assumed for the elements of the MIMO channel matrix H?	BTL -2	Understanding
6.	How does narrowband assumption simplify MIMO system analysis?	BTL -1	Remembering
7.	Define spatial multiplexing in MIMO systems.	BTL -1	Remembering
8.	State the channel model equation for a narrowband MIMO system.	BTL -1	Remembering
9.	What is parallel decomposition of a MIMO channel?	BTL -2	Understanding
10.	Define Singular Value Decomposition (SVD).	BTL -1	Remembering
11.	How does parallel decomposition assist in precoding?	BTL -2	Understanding
12.	What happens to MIMO channel capacity after decomposition?	BTL -2	Understanding
13.	How is noise modeled in parallel decomposed sub-channels?	BTL -1	Remembering
14.	What is the purpose of beamforming using SVD?	BTL -2	Understanding
15.	What factors influence MIMO channel capacity?	BTL -1	Remembering
16.	Explain the diversity-multiplexing trade-off (DMT).	BTL -2	Understanding
17.	What is the impact of Doppler spread on diversity gain?	BTL -2	Understanding
18.	Define spatial multiplexing gain in BLAST.	BTL -1	Remembering
19.	How is channel estimation handled in BLAST receivers?	BTL -2	Understanding
20.	How does the number of antennas affect capacity?	BTL -2	Understanding
21.	How does beamforming improve link reliability?	BTL -2	Understanding
22.	How does MIMO improve spectral efficiency through multiplexing gain?	BTL -2	Understanding
23.	What are the limitation of BLAST architectures?	BTL -1	Remembering
24.	What is the typical code rate of Alamouti STBC?	BTL -1	Remembering
PART B			

1.	Derive the mathematical model of a narrowband MIMO system and explain the significance of each term.	BTL -4	Analyzing
2.	Compare the narrowband and wideband MIMO channel models and discuss their applications.	BTL -4	Analyzing
3.	Analyze how spatial correlation affects the narrowband MIMO capacity and system performance.	BTL -4	Analyzing
4.	Explain Singular Value Decomposition (SVD) of the MIMO channel matrix and its role in parallel decomposition of channels.	BTL -4	Analyzing
5.	Derive the MIMO channel capacity using parallel decomposition and water-filling power allocation.	BTL -3	Applying
6.	Consider a 2×2 MIMO system whose channel matrix is $H = \begin{bmatrix} 1 & .5 \\ .5 & 1 \end{bmatrix}$ a) Determine the eigenvalues of HH^H (6) b) Obtain the singular values of the channel matrix. (5) c) Assuming equal power allocation and an SNR of 20 dB, calculate the MIMO channel capacity. (5)	BTL -3	Applying
7.	Derive the ergodic capacity expression of a MIMO Rayleigh fading channel assuming perfect CSI at the receiver.	BTL -3	Applying
8.	Discuss the effect of antenna correlation and channel rank deficiency on MIMO channel capacity.	BTL -4	Analyzing
9.	Explain the principles behind beamforming and how it achieves diversity gain in MIMO systems.	BTL -3	Applying
10.	Derive and explain the diversity-multiplexing trade-off (DMT) for MIMO systems.	BTL -3	Applying
11.	Consider a MIMO channel with gain matrix $H = \begin{bmatrix} .7 & .9 & .8 \\ .3 & .8 & .2 \\ .1 & .3 & .9 \end{bmatrix}$ Find the capacity of this channel under beamforming assuming channel knowledge at the transmitter and receiver, B = 100 KHz, and $\rho = 10$ dB.	BTL -3	Applying
12.	Develop the mathematical model for transmitting independent data streams simultaneously from multiple antennas.	BTL -3	Applying
13.	Describe the principles of Space-Time Block Coding (STBC) with derivation of the Alamouti scheme.	BTL -4	Analyzing
14.	Explain Space-Time Trellis Coding (STTC) and compare it with STBC in terms of complexity and performance.	BTL -4	Analyzing
15.	Discuss the operation and advantages of BLAST architectures for spatial multiplexing in MIMO systems.	BTL -3	Applying
16.	Evaluate how space-time coding and spatial multiplexing can be combined to achieve both diversity and multiplexing gains in MIMO systems.	BTL -3	Applying
17.	Compare diversity gain and multiplexing gain in MIMO systems with examples of application scenarios.	BTL -4	Analyzing

UNIT V - MULTI USER SYSTEMS

Review of Multiple Access Techniques, Scheduling, power control, Uplink and Downlink channel capacity, multiuser diversity, MIMO-MU systems.

PART A			
Q.No	Questions	BT Level	Competence
1.	What are the main types of multiple access techniques used in wireless communication?	BTL -1	Remembering
2.	What is the main advantage of CDMA over TDMA?	BTL -1	Remembering
3.	Why is power control important in wireless systems?	BTL -2	Understanding
4.	Write the differences between uplink and downlink channel capacity.	BTL -2	Understanding
5.	What is multiuser diversity in wireless communication?	BTL -2	Understanding
6.	What is open-loop power control?	BTL -1	Remembering
7.	What is the main purpose of scheduling in wireless communication networks?	BTL -2	Understanding
8.	Distinguish between uplink and downlink channels.	BTL -1	Remembering
9.	Define spatial multiplexing in MIMO systems.	BTL -1	Remembering
10.	What is proportional fairness in scheduling?	BTL 1	Remembering
11.	How does OFDMA improve spectral efficiency?	BTL -2	Understanding
12.	Name two types of scheduling algorithms.	BTL -1	Remembering
13.	Define multiuser MIMO.	BTL -1	Remembering
14.	What is the impact of fading on channel capacity?	BTL -2	Understanding
15.	How does multiuser diversity improve performance?	BTL -2	Understanding
16.	What is MIMO beamforming?	BTL -1	Remembering
17.	Differentiate between open loop and closed loop power control.	BTL -2	Understanding
18.	What is the near-far effect?	BTL -1	Remembering
19.	Mention any two factors affecting uplink capacity.	BTL -1	Remembering
20.	What is the difference between SU-MIMO and MU-MIMO?	BTL -2	Understanding
21.	Mention the condition required to exploit multiuser diversity.	BTL -1	Remembering
22.	Differentiate between round robin and max C/I scheduling.	BTL -2	Understanding
23.	Give an example of multiuser diversity application.	BTL -2	Understanding
PART B			
1.	Explain the principles, advantages, and disadvantages of FDMA, TDMA, CDMA, and OFDMA.	BTL -3	Applying
2.	Compare and contrast scheduling algorithms like round-robin, max C/I, and proportional fair.	BTL -4	Analyzing
3.	Discuss open-loop and closed-loop power control mechanisms and their importance in cellular networks.	BTL -3	Applying
4.	Derive the Shannon capacity formula for a single-user uplink channel and discuss the impact of noise and interference.	BTL -3	Applying
5.	Explain the differences in channel capacity and design considerations between uplink and downlink in cellular systems.	BTL -3	Applying
6.	Describe the concept of multiuser diversity, how it arises, and how it can be exploited in scheduling.	BTL -4	Analyzing
7.	Explain the architecture and working of MU-MIMO systems with neat	BTL -3	Applying

	block diagrams.		
8.	Describe the role of scheduling in exploiting multiuser diversity and its impact on system throughput.	BTL -4	Analyzing
9.	Analyze the impact of power control on link reliability and interference in a multi-cell environment.	BTL -4	Analyzing
10.	Consider a MAC channel in AWGN with transmit power $P_1 = P_2 = 100$ mW for both users, and channel gains $g_1 = .08$ for user 1 and $g_2 = .001$ for user 2. Assume the receiver noise has $N_0 = 10^{-9}$ W/Hz and the system bandwidth is $B = 100$ KHz. Find the corner points of the MAC capacity region. Also find the rate that user 1 can achieve if user 2 requires a rate of $R_2 = 100$ Kbps and of $R_2 = 50$ Kbps.	BTL -3	Applying
11.	Derive the capacity expressions for MIMO channels using singular value decomposition.	BTL -3	Applying
12.	Provide a detailed explanation of how scheduling and power control interact to optimize uplink channel capacity.	BTL -4	Analyzing
13.	Analyze how multiuser diversity influences the design of scheduling algorithms with examples.	BTL -4	Analyzing
14.	Compare uplink and downlink power control requirements and strategies in cellular networks.	BTL -4	Analyzing
15.	Discuss the challenges and solutions for practical implementation of multiuser MIMO systems.	BTL -4	Analyzing
16.	Explain MU-MIMO precoding and user scheduling techniques.	BTL -3	Applying
17.	Derive the capacity of MU-MIMO systems and explain the factors affecting it.	BTL -4	Analyzing