

Subject Code: 1RI3000102	Subject Title: Essentials of Disciplinary Research Subject-1 Subject Sub-Title: Basics of 4G and 5G communications
Pre-requisite Subject	Wireless Communication

Objectives of course: The main purpose of this course is to introduce current and future communication technologies, mainly 4G and 5G mobile communication. This will enable the students to acquire a solid understanding of foundations of 4G technologies, systems, network issues as well as economic deployment considerations and also 5G technologies

Learning outcomes: After studying the subject, student shall be able to understand system architecture evaluation, OFDMA, architecture of LTE, procedures of data transmission and reception of LTE. Students shall also be able to acquire a solid foundation of design issues/performance of the 4G communication. Students shall be able to acquire an overview of 5G network.

Teaching Scheme (Credit Distribution)				Assessment Scheme (Weightage)	
Lecture	Tutorial	Practical	Credit	Hall Exam	Continuous Evaluation
4	--	--	4	60%	40%

Continuous evaluation is based on assignments/quiz/presentation/small projects as per the supervisor instructions.

Subject Content			
Unit	Topic	No. of Lecture	Weightage %
1	Introduction: Architectural Review of UMTS and GSM, History of Mobile Telecommunication Systems, The Need for LTE, From UMTS to LTE, From LTE to LTE-Advanced, The 3GPP Specifications for LTE	---	05
2	System Architecture Evolution: Architecture of LTE, Communication Protocols, Bearer Management, State Diagrams, Spectrum Allocation	---	10
3	Orthogonal Frequency Division Multiple Access: Orthogonal Frequency Division Multiplexing, OFDMA in a Mobile Cellular Network, Single Carrier Frequency Division Multiple Access	---	15
4	Multiple Antenna Techniques: Diversity Processing, Spatial Multiplexing, Beamforming,	---	15
5	Architecture of the LTE Air Interface: Air Interface Protocol Stack, Air Interface Protocol Stack, The Resource Grid, Multiple Antenna Transmission, Resource Element Mapping	---	15
6	Data Transmission and Reception: Data Transmission Procedures, Transmission of Scheduling Messages on the PDCCH, Data Transmission on the PDSCH and PUSCH, Transmission of Hybrid ARQ Indicators on the PHICH, Uplink Control Information, Transmission of Uplink Control Information on the PUCCH, Uplink Reference Signals, Uplink Power Control, Discontinuous Reception	---	15
7	Air Interface Layer 2: Medium Access Control Protocol, Radio Link Control Protocol, Packet Data Convergence Protocol	---	10

8	Overview of 5G networks: An overview of 5G requirement, spectrum analysis and regulation of 5G, spectrum sharing of 5G	---	15
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List of References:

- (1) Christopher Cox, Introduction to LTE: LTE, LTE-ADVANCED, SAE AND 4G MOBILE COMMUNICATIONS, A John Wiley & Sons, Ltd., Publication, 2012
- (2) Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, “ 5G Mobile Communication”, Springer International Publishing, Swizerlan, 2017

Continuous Assessment includes assignments, tutorials, literature survey of 5 research papers from peer-reviewed international journals and presentation.

Subject Code: 1RI3000103	Subject Title: Essentials of Disciplinary Research Subject-2 Subject Sub-Title: Antenna Array & Beamforming
Pre-requisite Subject	Electromagnetic Theory

Objectives of course: The objective of this course is to introduce the fundamental principles of antenna array and beamforming engineering and to apply them to the design and analysis of RF systems. Students will learn how to characterize antennas, array, and beamforming and how to use algorithms in beamforming of the antenna. Different types of components and their applications will be introduced, with focus on beamforming. Main focus of the course will be design of various algorithms for beamforming in the array antennas.

Learning outcomes:

- Students would be able to understand fundamentals of array and beamforming.
- Students would be able to characterize beamforming in various antenna arrays

Teaching Scheme (Credit Distribution)				Assessment Scheme (Weightage)	
Lecture	Tutorial	Practical	Credit	Hall Exam	Continuous Evaluation
2	--	--	2	60%	40%

Continuous evaluation is based on assignments/quiz/presentation/small projects as per the supervisor instructions.

Subject Contents			
Unit	Topic	No. of Lecture	Weightage %
1	Introduction: Types of Antennas, Radiation Mechanism, Current Distribution on a Thin Wire Antenna, Historical Advancement.	---	05
2	Antenna parameters and definitions: beam area, beam width- Half- Power Beam width (HPBW) and First Null Beam width (FNBW), Polarization, Radiation Intensity, Beam Efficiency, Directivity and directive gain, radiation resistance, radiation efficiency, resolution, Antenna aperture- physical and effective apertures, effective height, transmission formula, antenna field zones, Transmission loss as a function of frequency. Antenna temperature and signal to noise ratio.	---	10
3	Arrays: Linear, Planar, and Circular: Introduction, Two-Element Array, <i>N</i> -Element Linear Array: Uniform Amplitude and Spacing, <i>N</i> -Element Linear Array: Directivity, Design Procedure, <i>N</i> -Element Linear Array: Three-Dimensional Characteristics, Rectangular-to-Polar Graphical Solution, <i>N</i> -Element Linear Array: Uniform Spacing, Nonuniform Amplitude, Super directivity, Planar	---	15

	Array, Design Considerations, Circular Array.		
4	Antenna Array Basics: Electromagnetics for Array Analysis, Solving for Electromagnetic Fields, Antenna Models, Antenna Array Applications	---	20
5	Array Factor Analysis: The Array Factor, Uniform Arrays, Fourier Analysis of Linear Arrays, Fourier Analysis of Planar Arrays, Array Bandwidth, Directivity, Amplitude Tapers, z Transform of the Array Factor, Circular Arrays, Direction Finding Arrays, Subarrays	---	20
6	Array Beamforming Networks: Transmission Lines, S Parameters, Matching Circuits, Corporate and Series Feeds, Blass Matrix, Butler Matrix, Lenses, Reflect array, Array Feeds for Reflectors, Array Feeds for Horn Antennas, Phase Shifters, Transmit/Receive Modules, Digital Beamforming, Neural Beamforming	---	30

List of References:

- (1) “Antenna Theory: Analysis and design”, C. Balanis Wiley India
- (2) “Antennas for all applications”, J.D. Krauss 3RD Edition (TMH)
- (3) “Smart Antennas – State of the Art”, edited by Thomas Kaiser, Andre Bourdoux, Holder Boche, Javier Rodríguez Fonollosa, Jørgen Bach Andersen, and Wolfgang Utschick, Hindawi Publishing Corporation

Continuous Assessment includes assignments, tutorials, literature survey of 5 research papers from peer-reviewed international journals and presentation`