THE UNIVERSITY OF BURDWAN

SYLLABUS OF TWO YEAR POSTGRADUATE PROGRAMME
IN
ELECTRONICS and COMMUNICATION

Under

Curriculum and Credit Framework for Postgraduate Programme (CCFPP), as per N.E.P. 2020

w.e.f. 2026 – 2027

Introductory Note

The University of Burdwan, in alignment with the National Education Policy (NEP) 2020, presents the Master of Science (M.Sc.) program in Electronics and Communication. This postgraduate program has been meticulously designed under the Curriculum and Credit Framework for Postgraduate Programme (CCFPP) to cater to the evolving demands of the electronics and communication industry and academia. The program is offered in two distinct tracks: a Two-Year M.Sc. program for students with a three-year undergraduate degree, effective from 2026-2027, and a One-Year M.Sc. program for students with a four-year undergraduate degree, effective from 2027-2028.

The curriculum is structured to provide students with a deep, systematic understanding of core and advanced subjects, including Semiconductor Physics, Communication Systems, Integrated Circuits, Signal Processing, and Microwave Engineering. It emphasizes the development of advanced theoretical knowledge, practical skills, and research competence, enabling graduates to independently conceive, design, and execute research and development projects in specialized areas of Electronics and Communication.

The program offers multiple flexible options, allowing students to choose between coursework-intensive pathways and research-oriented trajectories. This flexibility ensures that the program caters to diverse career aspirations, whether in industry, research, or academia. The integration of community engagement as a compulsory non-credit course further underscores the university's commitment to producing socially responsible and ethically grounded professionals.

Program Structure

The M.Sc. program in Electronics and Communication is structured to provide a balanced blend of theoretical foundations, practical applications, and research exposure. The program is divided into semesters with a credit-based system, ensuring a comprehensive and progressive learning experience.

Two-Year M.Sc. Program (for 3-year degree students)

Semester I (Core Courses):

- Signals and Systems
- Electromagnetic Theory and Transmission Lines
- Physics of Semiconductor Devices
- General Practical
- Digital System Design

Semester II (Core Courses):

- Advanced Communication Systems
- Digital Signal Processing
- Control Systems & Network Analysis
- General Practical
- Communication Systems

Semester III & IV Options:

Option	Semester III	Semester IV
Option I	Coursework: Mathematical and Computational Methods, Analog and Digital Integrated Circuits, Microwave Devices and Circuits, Power Electronics, Computational Laboratory	Research Thesis/Project + Community Engagement
Option II	Coursework: Mathematical and Computational Methods, Analog and Digital Integrated Circuits, Microwave Devices and Circuits, Power Electronics, Computational Laboratory	Coursework: Medical Electronics/Quantum Electronics, Elective Paper-I, Elective Paper-II, Term Paper/Project Work, Signal Processing Lab, Community Engagement
Option III	Research Thesis/Project	Research Thesis/Project + Community Engagement

Postgraduate Diploma (One and Half Year)

The program also offers a Postgraduate Diploma pathway, allowing students to complete 50 credits over three semesters, with an internship/project in the final semester.

Pedagogical Philosophy

- **Outcome-Based Education (OBE):** The program is designed with clearly defined Program Outcomes (POs) and Program Specific Outcomes (PSOs). Each course is mapped with specific Course Outcomes (COs) that align with the program-level outcomes, ensuring that every learning activity contributes to the holistic development of the student.
- **Integrated Theory and Practice:** The curriculum seamlessly integrates theoretical knowledge with practical applications through laboratory courses, computational laboratories, and project work. This approach ensures that students not only understand the underlying principles but also develop the skills to apply them in real-world scenarios.
- **Research-Oriented Learning:** The program places a strong emphasis on research and development skills. Students are encouraged to engage in independent research, literature surveys, and project work, culminating in a comprehensive research thesis or project. This fosters a culture of inquiry, critical thinking, and innovation.
- **Flexibility and Choice:** The multiple options within the program allow students to tailor their learning pathway according to their career goals. Whether a student wishes to pursue a research career or seeks

advanced coursework for industrial applications, the program provides the necessary flexibility.

- **Industry and Societal Relevance:** The curriculum includes contemporary topics such as Medical Electronics, Quantum Electronics, Radar and Remote Sensing, and Computational Electromagnetics, ensuring that graduates are equipped with skills relevant to current and future technological challenges. The inclusion of community engagement as a compulsory course reflects the program's commitment to societal development.

Programme Outcomes (POs):

PO1:	Ability to independently carry out research/investigation and development work to solve scientific problems.
PO2:	Ability to communicate effectively, i.e., write and present a substantial scientific report/ document.
PO3:	Ability to demonstrate a degree of mastery at a level higher than that for a bachelor program.
PO4:	Ability to solve scientific (experimental and theoretical) tasks both as a member of a team and as a leader of the team.
PO5:	Ability to identify and use the appropriate knowledge, skills, and tools to offer scientific solutions to the problems.

Programme Specific Outcomes (PSOs):

PSO1:	To equip students with the advanced theoretical knowledge and practical skills necessary to independently conceive, design, and execute research and development projects in specialized areas of Electronics and Communication.
PSO2:	To develop the ability to effectively communicate complex scientific and technical findings through well-structured reports, research theses, and seminar presentations, ensuring graduates can articulate their work to both expert and non-expert audiences.
PSO3:	To provide students with a deep, systematic understanding of core and advanced subjects, including Semiconductor Physics, Communication Systems, and Integrated Circuits, enabling them to master contemporary theories, tools, and techniques in the field.
PSO4:	To foster the ability to collaborate effectively within interdisciplinary teams and demonstrate leadership qualities in planning, executing, and managing complex scientific projects (including Term Papers and Research Theses), from problem formulation to solution delivery.
PSO5:	To ensure graduates can proficiently identify, select, and apply a wide range of analytical methods, computational tools, and simulation software to model, analyze, and provide innovative solutions to real-world scientific and technological challenges.

2- year PG Programme

Semester wise and Course wise Distribution of Credit & Marks under CCFPP as per NEP, 2020

SEM	Course Type	Course Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
I		**PG2ELCN1011 (400-499)**	Signals and systems	6	0 – 6 - 0	75	60 – 0 – 15
		PG2 ELCN 1012 (400-499)	Electromagnetic Theory and Transmission lines	6	0 – 6 - 0	75	60 – 0 – 15
		PG2 ELCN 1013 (400-499)	Physics of Semiconductor Devices	6	0 – 6 - 0	75	60 – 0 – 15
		PG2 ELCN 1014 (400-499)	General Practical	6	0 – 0 - 6	75	0 – 60 – 15
		PG2 ELCN 1021 (300-399)	Digital System Design	4	0 – 4 - 0	75	60 – 0 – 15
				28		**375**	
II		**PG2 ELCN 2011 (400-499)**	Advanced Communication Systems	4	0 – 4 - 0	75	60 – 0 – 15
		PG2ELCN 2012 (400-499)	Digital Signal Processing	4	0 – 4 - 0	75	60 – 0 – 15
		PG2 ELCN 2013 (400-499)	Section-1: Control systems Section-2: Network Analysis	4	0 – 4 - 0	75	60 – 0 – 15
		PG2 ELCN 2014 (400-499)	*GENERAL PRACTICAL*	6	0 – 0 - 6	75	0 – 60 – 15
		PG2 ELCN 2021 (300-399)	Communication Systems	4	0 – 4 - 0	75	60 – 0 – 15
	Total			**22**		**375**	

<u>OPTION-</u> I: Course-work in the 3rdSemester & Research Thesis/Project in the 4thSemester

SEM	Course Type	Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
III	Major/ Core Course	**PG2 ELCN 3011 (500-599)**	Mathematical and Computational methods	4	0 – 4 - 0	50	40 – 0 – 10
	Major/ Core Course	**PG2 ELCN 3012 (500-599)**	Analog and Digital Integrated Circuits	4	0 – 4 - 0	50	40 – 0 – 10
	Major/ Core Course	**PG2 ELCN 3013 (500-599)**	Microwave devices and circuits	4	0 – 4 - 0	50	40 – 0 – 10
	Major/ Core Course	**PG2 ELCN 3014 (500-599)**	Power Electronics	4	0 – 4 - 0	50	40 – 0 – 10
	Major/ Core Course	**PG2 ELCN 3015 (500-599)**	Computational laboratory	4	0 – 0 - 4	50	0 – 40 – 10
	Total			**20**		**250**	
IV	Research Thesis/ Project	**PG2 ELCN 4031 (500-599)**	Research Thesis/ Project	20	0- 0- 20	250	0-250-0 Preparation & Submission of Research Thesis/ Project Report (12 Credits)-150 Marks, Seminar Presentation (50 Marks, 4 credits) & Viva-voce (50 Marks, 4 Credits)-100 Marks, 8 Credits
	Two-credit Compulsory Course	**PG2ELCN 4041 (500-599)**	Community Engagement	(This shall not be taken into consideration in the calculation of SGPA and CGPA)			
	Total			**20**		**250**	

OR

OPTION- II: Only Course- work in 3rd&4th Semesters

SEM	Course Type	Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
III	Major/Core Course	**PG2 ELCN 3011 (500-599)**	Mathematical and Computational methods	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN3012 (500-599)**	Analog and Digital Integrated Circuits	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN3013 (500-599)**	Microwave devices and circuits	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN3014 (500-599)**	Power Electronics	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN3015 (500-599)**	Computational laboratory	4	0 – 0 - 4	50	0 – 40 – 10
	Total			**20**		**250**	
IV	Major/Core Course	**PG2ELCN4011 (500-599)**	Section-1: Medical Electronics Section-2: Quantum electronics	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN 4012 (500-599)**	Elective Paper-I 1. Antenna Design 2. Photonics	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN4013 (500-599)**	Elective Paper II 1. Radar, Remote Sensing and Navigational Systems 2. Computational Electromagnetics	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN4014 (500-599)**	Term Paper/ Project Work	4	0 – 4 - 0	50	40 – 0 – 10
	Major/Core Course	**PG2ELCN4015 (500-599)**	Signal processing lab: Practical	4	0 – 0 - 4	50	0 – 40 – 10
	Two-credit Compulsory Course	**PG2 PHYS 4041 (500-599)**	Community Engagement	(This shall not be taken into consideration in the calculation of SGPA and CGPA)			
	Total			**20**		**250**	

OR

<u>OPTION-</u> III: Only Research Thesis/ Project in 3rd&4th Semesters

SEM	Course Type	Code & Level	Name of the Course	Credit	L – T - P	Marks	Marks Dist. Th. – Pr. - IA
III	Research Thesis/ Project	**PG2 ELCN 3031 (500-599)**	Research Thesis/ Project	20	0-0-20	250	0-250-0 Preparation & Submission of Research Thesis/ Project Report (12 Credits)-150 Marks, Seminar Presentation (4 credits, 50 Marks) & Viva-voce (4 Credits, 50 Marks,)- 8 Credits, 100 Marks
IV	Research Thesis/ Project	**PG2 ELCN 4031 (500-599)**	Research Thesis/ Project	20	0-0-20	250	0-250-0 Preparation & Submission of Research Thesis/ Project Report (12 Credits)-150 Marks, Seminar Presentation (4 credits, 50 Marks) & Viva-voce (4 Credits, 50 Marks,)- 8 Credits, 100 Marks
	Two-credit Compulsory Course	**PG2 ELCN 4041 (500-599)**	Community Engagement	(This shall not be taken into consideration in the calculation of SGPA and CGPA)			
	Total			**40**		**500**	
Grand Total				**90**		**1250**	

Semester-I

PG2ELCN1011: Signals and systems

Course Outcomes (COs):

CO1:	Explain the fundamental concepts of continuous and discrete-time signals and systems, including their mathematical representations and properties.
CO2:	Analyze Linear Time-Invariant (LTI) systems using convolution and differential/ difference equations to determine system responses.
CO3:	Apply Fourier series and Fourier transforms to analyze signals in the frequency domain and understand their properties.
CO4:	Utilize the Laplace transform as a tool for analyzing and solving circuit problems and system responses.
CO5:	Design and evaluate simple frequency-selective filters (e.g., RC high-pass and low-pass filters) based on theoretical analysis.

Theory: 60 Lectures

THEORY

1. Signals and Systems: Continuous and discrete time signals, Transformation of the independent variable, Exponential and sinusoidal signals, Impulse and unit step functions, Continuous-Time and Discrete Time Systems, Basic System Properties.

2. Linear Time -Invariant Systems (LTI): Discrete time LTI systems, the Convolution Sum, Continuous time LTI systems, the Convolution integral. Properties of LTI systems,Commutative, Distributive, Associative.LTI systems with and without memory, Invariability, Causality, Stability, Unit Step response, Differential and Difference equation formulation, Block diagram representation of first order systems.

3. Fourier Series Representation of Periodic Signals: Continuous-Time periodic signals, Convergence of the Fourier series, Properties of continuous-Time Fourier series, Discrete-Time periodic signals, Properties of Discrete-Time Fourier series. Frequency-Selective filters, Simple RC high pass and low pass filters.

Fourier Transform: Aperiodic signals, Periodic signals, Properties of Continuous-time Fourier transform, Convolution and Multiplication Properties, Properties of Fourier transform and basic Fourier transform Pairs.

4. Laplace Transform: Laplace Transform, Inverse Laplace Transform, Properties of the Laplace Transform, Laplace Transform Pairs, Laplace Transform for signals, Laplace Transform Methods in Circuit Analysis, Impulse and Step response of RL, RC and RLC circuits.

Suggested Books:

1. V. Oppenheim, A. S. Wilsky and S. H. Nawab, Signals and Systems, Pearson Education (2007)
2. S. Haykin and B. V. Veen, Signal and Systems, John Wiley & Sons (2004)
3. C. Alexander and M. Sadiku, Fundamentals of Electric Circuits , McGraw Hill (2008)
4. H. P. Hsu, Signals and Systems, Tata McGraw Hill (2007)
5. S. T. Karris, Signal and Systems: with MATLAB Computing and Simulink Modelling, Orchard Publications (2008)
6. W. Y. Young, Signals and Systems with MATLAB, Springer (2009)
7. M. Roberts, Fundamentals of Signals and Systems, Tata McGraw Hill (2007)

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	3	**2.00**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	2	**1.20**
PO5	2	3	3	3	3	**2.80**
PSO1	1	2	2	2	3	**2.00**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	3	3	3	3	**2.80**

PG2ELCN1012: Electromagnetic Theory and Transmission lines

Course Outcomes (COs):

CO1:	Interpret Maxwell's equations in integral and differential forms and their physical significance in the context of electromagnetic fields.
CO2:	Analyze the propagation of plane electromagnetic waves in different media, including the concepts of skin effect, phase, and group velocity.
CO3:	Solve transmission line problems using the telegrapher equations and parameters like input impedance, SWR, and the Smith chart.
CO4:	Characterize wave propagation in rectangular and circular waveguides, including the identification of TEM, TE, and TM modes.
CO5:	Apply the principles of electromagnetic theory to analyze and evaluate practical transmission line and waveguide devices (e.g., couplers, isolators).

Theory: 60 Lectures

1. Introduction to Maxwell's Equations: Review of vector analysis and coordinate systems; gradient, orthogonality, and wave phase fronts; surface and volume integrals; Gauss'law; Gauss' law for magnetism; line integrals, currents and Ampere's law; divergence of a vector and Gauss' law in differential form; the divergence theorem; curl of a vector field and Ampere's law in differential form; Stoke's theorem; the Laplacian operator; Maxwell's equations;displacement current, continuity and Maxwell's equations; charges, conduction, convection, and diffusion currents; introduction to magnetic and electric potentials; Faraday's law

2. Intermediate Aspects of Maxwell's Equations: Scalar and vector potentials; generalizations of the potentials to include retardation; boundary conditions; capacitance and inductance; Poynting's theorem, power flow, and stored energy; Maxwell's equations for the sinusoidal steady-state (phasors); polarization; the steady-state Poynting vector and theorem; propagation in lossy media; forces, torque, and work.

3. Electromagnetic Wave Propagation: Propagation in Good Conductors, Skin Effect, Reflection of uniform Plane Waves at normal incidence, Plane Wave reflection at Oblique Incidence, Wave propagation in dispersive media, concept of phase velocity and group velocity.

4. Transmission Lines: Typical Transmission lines- Co-axial, Two Wire, Microstrip, Coplanar and Slot Lines, Transmission Line Parameters, Transmission Line Equations, Wave propagation in Transmission lines, low loss, lossless line, Distortion less line, Input Impedance, Standing Wave Ratio ,Power. and lossy lines, Shorted Line, Open-Circuited Line, Matched Line, Smith Chart, Transmission Line

Applications.

5. Waveguides and Waveguide Devices: Wave propagation in waveguides, Parallel plate waveguides, TEM, TM and TE modes, Rectangular waveguides, circular waveguides, Power transmission and attenuation, Rectangular cavity resonators, directional couplers, isolator, circulator.

Recommended Books:

1. David J. Griffiths: Introduction to Electrodynamics, PHI 3rd Edition
2. Engineering Electromagnetics: Shen, Kong, Patnaik, Cengage Learning Publications,
3. India Edition
4. J. D. Jackson: Classical Electrodynamics.
5. E. C. Jordan, K. G. Balman: Electromagnetic Waves & Radiating Systems by PHI 2nd
6. Hyatt: Engineering Electromagnetics, TMH.
7. Paul, Whites, Nasar: Introduction to E.M. Fields, TMH.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	3	**2.00**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	3	3	3	3	**2.80**
PSO1	1	2	2	2	3	**2.00**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	3	3	3	3	**2.80**

PG2ELCN1013: Physics of Semiconductor Devices

Course Outcomes (COs):

CO1:	Explain the fundamental principles of quantum mechanics and their application to solid-state physics and semiconductor behavior.
CO2:	Analyze the energy band structure, carrier concentrations, and transport phenomena in intrinsic and extrinsic semiconductors.
CO3:	Describe the physics and operation of P-N junction diodes, including their I-V characteristics, capacitance, and breakdown mechanisms.
CO4:	Explain the operational principles and current-voltage characteristics of BJTs and FETs, including the Ebers-Moll model.
CO5:	Analyze the physical principles and characteristics of advanced devices like HEMTs and MOSFETs for understanding modern electronic applications.

Theory: 60 Lectures

1. Basic Quantum Mechanics: The basic phenomena of quantum physics and experimental background, particles and atomic models. Black-body radiation, line spectra, the photon, photoelectric effect, Compton dispersion. Bohr's atomic model. One-dimensional systems: The eigenvalue problem, stationary states, expectation values, operators. Particle in a box, the harmonic oscillator, transmission and reflection.

Heisenberg's uncertainty relations, Quantum mechanical tunneling, Perturbation theory.

2. Semiconductors: Energy Band and Charge Carriers: Energy bands in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field.

3. Carrier Transport Phenomena: Conductivity, Mobility and Hall Effect, Diffusion and Drift of Excess Carriers, Generation and Recombination Mechanism, Trapping, Shockley–Read–Hall theory, Continuity and Diffusion Equation.

4. P-N Junction Diode: Built in potential barrier, Electric field, Space charge width of the Depletion region, Junction capacitance for an abrupt junction. Current Voltage Characteristics -Shockley diode equation, Equivalent circuit. Photo-Voltaic effect in pn junction, Junction Break down: I-V characteristics of Zener diode and Tunnel diode.

5. Bipolar Junction Transistor (BJT): Principle of operation, Basic current-voltage characteristics, Modes of operation, current gain, Device Modeling: Ebers-Mol model.
Junction Field Effect Transistor (JFET): Basic JFET operation, Device characteristics, Ideal DC current-voltage characteristics, Equivalent circuit of JFET and frequency limitations.

6. Metal semiconductor junction and MOSFET: Metal semiconductor junction, Schottky effect, Ohmic contacts, Heterojunction, 2DEG, HEMT, I-V and C-V characteristics. MOSFET: Two terminal MOS structure, Basic MOSFET operation, Current voltage relationship.

Recommended Books:

1. Donald A. Neamen, “Semiconductor Physics and Devices Basic Principles”, 4th edn. McGraw-Hill, 2012
2. B.G. Streetman and Sanjay Banerjee, “Solid State Electronic Devices”, 7th edn., Prentice Hall, 2016.
3. S. M. Sze and K. K. Ng, “Physics of Semiconductor Devices”, 3rd edn. Wiley, 2007.
4. U. Mishra and J. Singh, “Semiconductor Device Physics and Design”, Springer, 2008.
5. J. H. Davies, “The Physics of Low Dimensional Semiconductors: An Introduction”, Cambridge University Press, 1998.
6. C. Lamberti and G. Agostini, “Characterization of semiconductor heterostructures and nanostructures”, Elsevier, 2013.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	3	**2.00**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	2	2	3	**2.20**
PSO1	1	2	2	2	3	**2.00**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	2	2	3	**2.20**

PG2ELCN1014: General Practical

Course Outcomes (COs):

CO1:	Set up and conduct experiments to analyze the transfer and phase characteristics of passive networks and all-pass filters.

CO2:	Demonstrate the ability to build and test linear and non-linear operational amplifier circuits.
CO3:	Perform experiments to study the principles of amplitude modulation and Schmitt trigger circuits.
CO4:	Analyze and interpret experimental data to draw conclusions about circuit behavior and validate theoretical concepts.
CO5:	Prepare comprehensive laboratory reports documenting experimental procedures, results, and analysis.

1. To study the characteristics of an All Pass Filter using Op-Amp.
2. To study the transfer characteristics of different passive networks and the phase transfer characteristics of a given two-port network (RC).
3. To study amplitude modulation
4. To study linear and nonlinear opamp circuits.
5. To study the input and output voltage characteristics of Schmitt trigger circuit.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	2	3	2	1	**2.20**
PO2	1	1	1	3	3	**1.80**
PO3	2	2	2	2	2	**2.00**
PO4	2	2	2	2	2	**2.00**
PO5	3	3	3	3	2	**2.80**
PSO1	3	2	3	2	1	**2.20**
PSO2	1	1	1	3	3	**1.80**
PSO3	2	2	2	2	2	**2.00**
PSO4	2	2	2	2	2	**2.00**
PSO5	3	3	3	3	2	**2.80**

PG2ELCN1021: Digital System Design

Course Outcomes (COs):

CO1:	Explain and apply number systems, Boolean algebra, and logic gates to simplify and design digital logic circuits.
CO2:	Design and analyze combinational logic circuits such as multiplexers, decoders, and adders.

CO3:	Analyze and design sequential logic circuits, including flip-flops, registers, and counters.
CO4:	Compare and contrast different logic families (TTL and CMOS) based on their characteristic parameters.
CO5:	Write basic VHDL modules to describe and simulate digital circuits, demonstrating an understanding of hardware description languages.

Theory: 60 Lectures

1. Number System and Codes: Decimal, Binary, Hexadecimal, Octal, BCD, Conversions, Complements (1's and 2's), Signed and unsigned numbers, addition and subtraction, multiplication and subtraction, Gray Codes

Boolean algebra and Logic gates: Boolean algebra- Positive and negative logic. Boolean laws. De Morgan's theorems, simplification of Boolean expressions-SOP and POS. Logic gates- basic logic gates AND, OR, NOT, logic symbol and truth table. Derived logic gates (NAND, NOR, XOR & XNOR), Universal property of NOR and NAND gates. K-map-3 and 4 variable expressions. Characteristics of logic families: Fan In and Fan out, power dissipation and noise Immunity, propagation delay, comparison of TTL and CMOS families.

2. Combinational logic analysis and design: Multiplexers and De multiplexers, Adder (half and full) and their use as subtractor, Encoder and Decoder, Code Converter (Binary to BCD and vice versa)

3. Sequential logic design: Latch, Flip flop, S-R FF , J-K FF, T and D type FFs, clocked Ffs, registers, Counters (ripple, synchronous and asynchronous, ring, modulus)

4. VHDL: A Brief History of HDL, Structure of HDL Module, Comparison of VHDL and Verilog, Introduction to Simulation and Synthesis Tools, Test Benches. VHDL.

Suggested books:

1. M. Morris Mano Digital System Design, Pearson Education Asia,(Fourth Edition)
2. Thomas L. Flyod, Digital Fundamentals, Pearson Education Asia (1994)
3. W. H. Gothmann, Digital Electronics: An Introduction To Theory And Practice, Prentice Hall of India(2000)
4. R. L. Tokheim, Digital Principles, Schaum's Outline Series, Tata McGraw- Hill (1994)
5. A Verilog HDL Primer – J. Bhasker, BSP, 2003 II Edition.
6. Verilog HDL-A guide to digital design and synthesis-Samir Palnitkar, Pearson, 2nd edition.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	1	3	**1.80**
PO2	1	1	1	1	3	**1.40**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	2	**1.2**
PO5	3	3	3	2	3	**2.80**
PSO1	1	2	2	1	3	**1.80**
PSO2	1	1	1	1	3	**1.40**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	2	**1.2**
PSO5	3	3	3	2	3	**2.80**

Semester- II

PG2ELCN2011: Advanced Communication Systems

Course Outcomes (COs):

CO1:	Compare and contrast advanced digital modulation techniques (DPCM, DM, QAM) and understand their applications.
CO2:	Explain the principles of optical communication, including fiber types, attenuation, dispersion, and optical power budgeting.
CO3:	Describe the architecture, concepts, and technologies behind cellular communication systems (GSM, CDMA, 2G/3G/4G).
CO4:	Analyze the key components and operational principles of satellite communication systems and GPS services.
CO5:	Understand the basic concepts and protocols of local area networks, including Ethernet, Bluetooth, Wi-Fi, and WiMAX.

Theory: 50 Lectures

1. Advanced Digital Modulation Technique: DPCM, DM, ADM. Binary Line Coding Technique, Multi level coding, QAM (Modulation and Demodulation)

2. Optical Communication: Introduction of Optical Fiber, Types of Fiber, Guidance in Optical Fiber, Attenuation and Dispersion in Fiber, Optical Sources and Detectors, Block Diagram of optical communication system, optical power budgeting.

3. Cellular Communication: Concept of cellular mobile communication – cell and cell splitting, frequency bands used in cellular communication, absolute RF channel numbers (ARFCN), frequency reuse, roaming and hand off, authentication of the SIM card of the subscribers, IMEI number, concept of data encryption, architecture (block diagram) of cellular mobile communication network, CDMA technology, CDMA overview, simplified block diagram of cellular phone handset, Comparative study of GSM and CDMA, 2G, 3G and 4G concepts.

4. Satellite communication: Introduction, need, satellite orbits, advantages and disadvantages of geostationary satellites. Satellite visibility, satellite system – space segment, block diagrams of satellite sub systems, up link, down link, cross link, transponders (C- Band), effect of solar eclipse, path loss, ground station, simplified block diagram of earth station. Satellite access, TDMA, FDMA, CDMA concepts, comparison of TDMA and FDMA, Satellite antenna (parabolic dish antenna).

5. Local area networks (LAN): Primary characteristics of Ethernet-mobile IP, OSImodel, wireless LAN requirements-concept of Bluetooth, Wi-Fi and WiMAX.

Suggested Books:

1. W. Tomasi, Electronic Communication Systems: Fundamentals through Advanced, Pearson Education, 3rd Edition
2. Martin S. Roden, Analog & Digital Communication Systems, Prentice Hall, Englewood Cliffs, 3rd Edition
3. Modern digital and analog Communication systems- B. P. Lathi, 4rd Edition 2009 Oxford University press.
4. ThiagarajanVishwanathan, Telecommunication Switching Systems and Networks, Prentice Hall of India.
5. Theodore S. Rappaport, Wireless Communications Principles and Practice, 2nd Edition, Pearson Education Asia.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	1	**1.60**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO2	1	1	1	1	1	**1.00**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	2	3	2	**2.20**
PSO1	1	2	2	2	1	**1.60**
PSO2	1	1	1	1	1	**1.00**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	2	3	2	**2.20**

ELCN2012: Digital Signal Processing

Course Outcomes (COs):

CO1:	Analyze discrete-time signals and Linear Shift-Invariant (LSI) systems using time-domain representations and the Z-transform.
CO2:	Compute the Discrete Fourier Transform (DFT) and apply the Fast Fourier Transform (FFT) algorithm for spectral analysis.
CO3:	Design and analyze Infinite Impulse Response (IIR) and Finite Impulse Response (FIR) digital filters to meet given specifications.
CO4:	Apply the concepts of correlation and convolution for signal processing tasks.
CO5:	Evaluate the performance of different digital filter structures and understand the effects of finite word length.

Theory: 50 Lectures

1. Discrete Time systems: Discrete sequences linear coefficient difference equation, Representation of DTS, LSI Systems. Stability and causality, frequency domain representations and Fourier transform of DT sequences. [16L]

2. Z-Transform: Definition and properties, Inverse Z Transform and stability, Parsevals Theorem and applications.

System Function: signal flow graph, its use in representation and analysis of Discrete Time Systems. Techniques of representations, Matrix generation and solution for DTS evaluations. [16L]

3. Discrete Fourier Transform: DFT assumptions and Inverse DFT. Matrix relations, relationship with FT and its inverse, circular convolution, DFT theorems, DCT. Computation of DFT, FFT Algorithms and processing gain, Discrimination, interpolation and extrapolation, Gibbs phenomena.FFT of real functions interleaving and resolution improvement, Word length effects. [14L]

4. Digital Filters: Analog filter review. System function for IIR and FIR filters, network representation, Canonical and decomposition networks. IIR filter realization methods and their limitations. FIR filter realization techniques. Discrete correlation and convolution, Properties and limitations. [14L]

Suggested Books:

1. A.V. Oppenheim and Schafer, Discrete Time Signal Processing, Prentice Hall, 1989.
2. John G. Proakis and D.G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, 1997.
3. S. K. Mitra, “Digital Signal Processing: A Computer based Approach”, McGraw Hill

4. S. Salivhahanan, “Digital Signal Processing”, McGraw Hill
5. L. R. Rabiner and B. Gold, “Theory and Application of Digital Signal Processing”, PHI
6. M Hayes, “Digital Signal Processing”, McGraw Hill
7. C. T. Chen, “Digital Signal Processing: Spectral Computation and Filter Design”,

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	2	2	3	2	3	**2.40**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	3	3	3	3	3	**3.00**
PSO1	2	2	3	2	3	**2.40**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	3	3	3	3	3	**3.00**

PG2ELCN2013: Section 1: Control Systems; Section 2: Network Analysis

50 Lectures

Course Outcomes (COs):

CO1:	Explain and apply fundamental principles of control systems (open-loop/closed-loop) and network analysis (circuit theorems) to model and analyze linear systems.
CO2:	Perform time-domain analysis of control systems (first/second-order responses) and transient/steady-state analysis of electrical networks using differential equations and Laplace transforms.
CO3:	Apply frequency-domain techniques, including Bode plots for control systems and network functions for filter design, to evaluate system performance and stability.
CO4:	Characterize systems using appropriate methods—stability criteria (Routh-Hurwitz, Nyquist) for control systems and two-port network parameters (Z, Y, h, ABCD) for electrical networks.
CO5:	Design and synthesize controllers (e.g., PID) for control systems and passive/active filters for networks to meet specified performance requirements.

Section-1: Control systems

1. Input/output relationship: Introduction to open loop and closed loop control systems. Mathematical representation of physical systems. Transfer functions block diagram and signal flow graph. Reduction algebra, masons gain. Time domain performance criterion, Transient response of first order, second order & Higher Order Systems.

2. Error analysis: Static and Dynamic error coefficients. Error criterion, frequency Domain analysis polar and inverse polar plots, bode plot, Frequency domain specifications. Relative stability gain margin and phase margin, correlation with time domain, W & N circles.

3. Stability theory: concept of stability, asymptotic & Conditional stability, Routh Hurwitz criterion, Nyquist stability criterion, Liapunova’s Direct Method, Root Locus plots.

4. Compensation Techniques: Concept Lag and Lead & lag lead Networks, Design of closed loop Systems Using compensation Techniques.

5. State Space Analysis of Control Systems: State Space Representation, Solution to Homogeneous State Equation, State Transition Matrix, Time Invariant State Equations, linear time varying systems, Controllability and Observability, Vandermonde Matrix, Decomposition of Transfer Function.

6. Non Linear Systems:Introduction, Some Common Types of Non-Linearities,Classification of Non-Linearity,Study of Non-Linear Systems, Describing Function method of Analysis, Phase Plane Analysis, Stability Analysis with Describing Functions.

Recommended Books:

1.KUO B.CI Automatic control system/Pill.
2.Ogata Kj Modern Control Engineering / PHI.
3.Nagrath I.J. & Gopal, M/Control Systems Engineering/New Age International.

Section-2: Network Analysis

1. Introduction to graph theory: Definitions- graph, tree, spanning tree, loop, co-tree, cut set, tie set, loop and nodal analysis, introduction to continuous time signal, unit step, ramp, and impulse.

2. Network Transient and steady state analysis, Transient response of simple RL,RC, series and parallel circuits, Transient response of RLC series and parallel circuits for sinusoidal and step input excitation using Laplace transform method. Differential equation formation of linear time invariant continuous systems, block diagram representation of LTI continuous networks and systems, time domain analysis of LTI network using laplace transform. Relation between impulse response and system functions, concepts of transform impedance and synthesis. 3. Network Functions Concept of Complex Frequency, Transform Impedances,Network function of one port and two port networks, Concept of poles and zeros, Relation between locations of poles. Time response and stability. Frequency response and bode plots. Interrelation between frequency response and convolution integral.
4. Two port networks, Two port parameters, Inter-conversion of 2 port parameter, network function- Driving point and transfer function, Inter-connections of 2 port networks, reciprocity ladder networks, Image impedance, Characteristic impedance, T-pi transformation and analysis.
5. Positive real functions and properties, synthesis of LC, RL and RC using Cauer and Fosters first and second form.
6. L-C filters-LPF, HPF, BPF and BRF type constant-k prototype filters; m-derived filters (principle only), Attenuators.

Recommended Books:

1. M.E. Valkenburg: Network Analysis
2.D.R. Choudhary: Network Analysis.
3.Narsingh Deo : Graph theory
4.W.H. Hayt & Jack E-Kemmerly, Engineering Circuit analysis" Tata McGrawHill.
5. Ram Kalyan, Linear Circuits Oxford University Press

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	3	**2.00**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	3	3	3	3	3	**3.00**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PSO1	1	2	2	2	3	**2.00**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	3	3	3	3	3	**3.00**

PGELCN2014: General Practical

Course Outcomes (COs):

CO1:	Conduct experiments to study frequency modulation and demodulation techniques.
CO2:	Perform experiments on analog and digital communication schemes (e.g., AM, FM, digital modulation).
CO3:	Carry out experiments to characterize LDR and study the operation of pre-emphasis and de-emphasis circuits.
CO4:	Analyze and interpret the results of communication experiments to understand signal processing and transmission.
CO5:	Synthesize findings from practical work into well-structured reports.

1. Study of frequency modulation techniques.
2. To draw the LDR characteristics at different intensities and to find out the “b” value and the dark resistance of the LDR.
3. Studies on analog communication schemes.
4. Studies on digital modulation techniques.
5. To study the operation of Pre-emphasis and De-emphasis circuits by plotting frequency response using Op-amp.
6. Studies on digital communication schemes.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	2	3	2	1	**2.20**
PO2	1	1	1	3	3	**1.80**
PO3	2	2	2	2	2	**2.00**
PO4	2	2	2	2	2	**2.00**
PO5	3	3	3	3	2	**2.80**
PSO1	1	2	2	2	3	**2.00**
PSO2	1	1	1	3	3	**1.80**
PSO3	2	2	2	2	2	**2.00**
PSO4	2	2	2	2	2	**2.00**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PSO5	3	3	3	3	2	**2.80**

ELCN2021: Communication Systems

Course Outcomes (COs):

CO1:	Explain the principles of amplitude and frequency modulation and demodulation techniques.
CO2:	Describe the block diagrams and working of AM and FM transmitters and receivers.
CO3:	Analyze sampling theorem and various pulse modulation techniques (PAM, PWM, PPM, PCM).
CO4:	Explain the concepts of digital data transmission, noise, and the principles of TDMA, FDMA, and CDMA.
CO5:	Describe the basic architecture and concepts of cellular and satellite communication systems.

Theory: 50 Lectures

1. Noise and Transmission lines: Noise-Introduction, internal and external noises, signal to noise ratio and noise figure Amplitude Modulation/demodulation techniques: Block diagram of electronic communication system. Modulation-need and types of modulation-AM, FM & PM. Amplitude modulation -representation, modulation index, expression for instantaneous voltage, power relations, frequency spectrum, DSB-FC, DSB-SC and SSB-SC (mention only). Limitations of AM, Demodulation- AM detection: principles of detection, linear diode, principle of working and waveforms. Block diagram of AM transmitter and Receiver.

2. Frequency Modulation/demodulation techniques: Frequency Modulation: definition, modulation index, FM frequency spectrum diagram, bandwidth requirements, frequency deviation and carrier swing, FM generator-varactor diode modulator, FM detector – principle, slope detector-circuit, principle of working and waveforms, Block diagram of FM transmitter and Receiver, Comparison of AM and FM.

3. Digital communication: Introduction to pulse and digital communications, digital radio, sampling theorem, types- PAM, PWM, PPM, PCM – quantization, advantages and applications, digital modulations (FSK, PSK, and ASK). Advantage and disadvantages of digital transmission, characteristics of data transmission circuits – Shannon limit for information capacity, bandwidth requirements, data transmission speed, noise, cross talk, echo suppressors, distortion and equalizer, MODEM– modes, classification, interfacing (RS232). TDMA, FDMA, CDMA concepts, comparison of TDMA and FDMA.

4. **Cellular Communication:** Basic Concept of cellular mobile communication – cell and cell splitting, frequency bands used in cellular communication, absolute RF channel numbers (ARFCN), frequency reuse, roaming and hand off, authentication of the SIM card of the subscribers, IMEI number, concept of data encryption, Comparative study of GSM and CDMA, 2G, 3G and 4G concepts. Satellite communication: Introduction, to Orbit, types of orbits, Block diagram of satellite transponder.

Suggested Books:

1. Electronic Communication, George Kennedy, 3rd edition, TMH.
2. B. C. Sarkar and S. Sarkar, Analog Electronics: Devices and Circuits, Damodar Group (Publishers), Burdwan, ISBN:9385775057 (2016)
3. Electronic Communication, Roddy and Coolen, 4th edition, PHI.
4. Electronic Communication systems, Kennedy & Davis, IV edition-TATA McGraw Hill.
5. Advanced Electronic Communication systems, Wayne Tomasi- 6th edition, Low priced edition- Pearson education

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	1	**1.60**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO2	1	1	1	1	1	**1.00**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	2	3	2	**2.20**
PSO1	1	2	2	2	1	**1.60**
PSO2	1	1	1	1	1	**1.00**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	2	3	2	**2.20**

Semester-III

PG2 ELCN 3011: Mathematical and Numerical methods

Course Outcomes (COs):

CO1:	Apply complex analysis techniques, such as Cauchy's theorem and the residue theorem, to evaluate integrals and infinite series.
CO2:	Solve ordinary and partial differential equations using Fourier and Laplace transforms.
CO3:	Apply the Z-transform to analyze discrete-time systems and solve difference equations with initial conditions.
CO4:	Implement numerical methods (e.g., Newton-Raphson, Gauss elimination, interpolation) to solve mathematical problems.
CO5:	Utilize numerical integration techniques (Trapezoidal, Simpson's rule) and Euler/Runge-

	Kutta methods for solving differential equations.

Theory: 50 Lectures

1. (a) Functions of a complex variable. Brief review: analytic functions, Cauchy-Riemann equations, integration in the Complex plane, Cauchy's theorem, Cauchy's integral formula.
(b) Proof of Taylor and Laurent expansions. Singular Points and their classification. Branch point and branch cut. Riemann sheets. Application of residue theorem to the evaluation of definite integrals and the summation of infinite series. Integrals involving branch point singularity.

2. Fourier and Laplace transforms. Inverse transforms. Convolution theorem. Solution of ordinary and partial differential equations by transform methods.

3. Introduction to Z transform Region of convergence, properties of the Z transform, Inverse transform using counter integration, complex convolution theorem, Parseval's relation. Unilateral Z transform and its application to difference equation with non zero initial condition.

4. Linear vector spaces. Subspaces. Bases and dimension. Linear independence and orthogonality of vectors. Gram-Schmidt orthogonalisation procedure. Matrix representation. The algebra of matrices. Special matrices. Rank of a matrix. Elementary transformations. Elementary matrices. Equivalent matrices. Solution of linear equations. Linear transformations. Change of Basis. Eigenvalues and eigenvectors of matrices. The Cayley-Hamilton theorem. Diagonalisation of matrices. Bilinear and Quadratic forms.

5. Probability and Statistics Basics of probability, Bayes theorem, Random variables, Probability and density functions, Binomial, Poisson and Normal distributions.

6. Numerical Analysis: Representation of real and complex numbers, statistical calculations, factorial, infinite series, iterative methods: logistic map; binary search. Imprecisions in integer and floating point arithmetic. Interpolation of datasets using the Lagrange polynomial**.** Numerical root finding: Bisection method, False position method, Newton-Raphson method. Solution of system of simultaneous linear equations: Gauss elimination, Gauss-Seidel method**,** LU decomposition algorithm. Numerical integration using Newton-Cotes quadratures: Trapezoidal and Simpson's 1/3rd methods. Solutions of Differential Equations: Ordinary Differential Equations: Simple Euler and Runge-Kutta methods.

Recommended Books:

1. M. R. Spiegel (Schaum's outline series) – Theory and Problems of Complex Variables.
2. George B. Arfken and Hans J. Weber (Academic Press) – Mathematical Methods for Physicists.
3. J. Mathews and R. I. Walker (Benjamin) – Mathematical Methods of Physics.
4. P. Dennery and A. Krzywicki (Harper and Row) – Mathematics for Physicists
5. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2005.
6. Numerical Methods for Physics Second edition,CreateSpace Independent Publishing Platform; Second edition, Revised (June 6, 2015)
7. Computational Physics: Problem Solving with Python, 3rd Edition, Rubin H. Landau,
8. Manuel J Páez, Cristian C. Bordeianu, 2015, Wiley.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	2	2	2	3	3	**2.40**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	3	3	3	3	3	**3.00**
PSO1	2	2	2	3	3	**2.40**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PSO4	1	1	1	1	1	**1.00**
PSO5	3	3	3	3	3	**3.00**

PG2ELCN3012: Analog and Digital Integrated Circuits

Course Outcomes (COs):

CO1:	Analyze and design circuits using differential amplifiers and operational amplifiers (OP-AMPs).
CO2:	Design combinational and sequential digital circuits using various logic families (TTL, ECL, CMOS).
CO3:	Explain the functioning and applications of Phase-Locked Loops (PLLs).
CO4:	Describe the architecture and application of programmable logic devices (PAL, GAL, PLA) and gate arrays.
CO5:	Explain the operational principles of different types of semiconductor memories (RAM, ROM, EPROM, EEPROM).

Theory: 50 Lectures

1.IC Technology: Hybrid and monolithic IC; Semiconductor processing diffusion, implanation, oxidation, epitaxy, lithography; Si IC technology-MOS and Bipolar; Packaging and testing.

2. Analog Integrated Circuits. Differential amplifier, OP-AMP; continuous time filters, switched capacitance implementation of sample data filters; analog multiplexers.
Phase-Locked loops: Structure, equation, Acquisition and tracking range, frequency synthesizer.

3. Digital Integrated Circuits: Logic families – TTL, ECL, MOS, MESFET; design of combinational and sequential circuits – MUX, decoder/ encoder, registers, counters, gate arrays; programmable logic devices – PAL, GAL, PLA, Programmable gate arrays.

4. Application specific ICs: ICs for analog communication; Digital signal processing ICs; Speech and image processing.
5. Memories: Sequential and Random access memories; RAM bipolar and MOS static and dynamic memories; programmable memories PROM, EPROM, EEPROM. Microprocessos: structures and programming.

Books Recommended:

1. Milman and Grable, Microelectronics. Tata MacGraw Hill.
2. Geiger, Allen and Strader – VLSI – Design Techniques for Analog and Digital Circuits.
3. Gray and Meyer – Analysis and Design of Analog Integrated Circuits.
4. S Soelof – Applications of Analog Integrated Circuits.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	2	2	1	1	1	**1.40**
PO2	1	1	1	1	1	**1.00**
PO3	3	3	3	3	3	**3.00**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO4	1	1	1	1	1	**1.00**
PO5	3	3	2	2	2	**2.40**
PSO1	2	2	1	1	1	**1.40**
PSO2	1	1	1	1	1	**1.00**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	3	3	2	2	2	**2.40**

PG2ELCN3013: Microwave devices and circuits

Course Outcomes (COs):

CO1:	Explain the physical principles of operation of various microwave tubes (Klystron, TWT, Magnetron).
CO2:	Analyze the characteristics and applications of different microwave solid-state devices (Gunn, IMPATT, Schottky diodes).
CO3:	Apply transmission line theory and S-parameters to analyze microwave networks and components.
CO4:	Use the Smith chart for impedance matching and tuning of microwave circuits.
CO5:	Design and evaluate impedance matching networks using lumped elements, stubs, and quarter-wave transformers.

Theory: 50 Lectures

A. RF and Microwave tubes: Vacuum tube microwave device physics: Beam field interaction; power frequency limitation, device size limitations; special features of microwave tubes.
Non relativistic electron tubes: Parallel field type – Klystron, Reflex Klystron, Helix TWT, coupled cavity TWT, Twystrons; Crossed field type – magnetrons, FWCFA, carcinotron. Relativistic electron tubes: gyrotrons; free electron LASER.
RF and Microwave Devices: Diodes; high-frequency equivalent circuit; Schottky barrier diode; varactor diode; PIN diode; Applications.
Tunnel diodes; Impact ionization; IMPATT and other related diodes; small-signal analysis and model of IMPATT diode; TRAPATT; BARRITT.
Transferred electron devices; differential negative resistance and two-valley model of Gunn effect devices; modes of operation; waveguide cavity Gunn oscillator.
Three terminal devices; BJT, MESFET, MOSFET, HFET, HEMT – device physics, characteristics, model.

B. Network theorem at microwave frequencies; Foster's reactance theorem. Transmission line theory: lumped element circuit model; the telegrapher equations; terminated lossless transmission line; generator and load mismatches; lossy transmission lines. Microwave network analysis: the scattering matrix; the transmission matrix; ABCD matrix techniques; signal flow graph. Smith chart: Impedance and admittance Smith chart; applications.
Waveguides; coaxial line; stripline; microstrip; wave velocities and dispersion; excitation of waveguides; coplanar waveguides; microstrip bends and discontinuities.
Impedance matching and tuning: matching with lumped elements; single-stub tuning; double stub tuning; the quarter wave transformer; theory of small reflections; binomial and Chebyshev matching transformer; tapered lines; the Bode-Fano criterion.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	2	3	**2.20**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	3	3	3	**2.60**
PSO1	1	2	2	2	3	**2.20**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	3	3	3	**2.60**

PG2ELCN3014: Power Electronics

Course Outcomes (COs):

CO1:	Explain the static and dynamic characteristics of various power semiconductor devices (Thyristors, MOSFETs, IGBTs).
CO2:	Analyze the operation of DC-DC converters (choppers) for different load conditions.
CO3:	Analyze the operation of single-phase and three-phase controlled rectifiers.
CO4:	Explain the principles of AC voltage controllers and cyclo-converters.
CO5:	Design and analyze single-phase and three-phase inverters and understand harmonics reduction techniques.

1. Power semiconductor Devices: Power semiconductor devices their symbols and static characteristics. Characteristics and specifications of switches, types of power electronic circuits. BJTO operation steady state and switch characteristics, switching limits. Operation and steady state characteristics of MOSFET and IGBT. Thyristor – Operation V- I characteristics, two transistor model, methods of turn-on Operation of GTO, MCT and TRIAC

2. Power Semiconductor Devices (Contd): Protection of devices. Series and parallel operation of thyristors, Commutation techniques of thyristor DC-DC Converters:Principles of step-down chopper, step down chopper with R-L load,Principle of step-up chopper, and operation with RL load, classification of choppers.

3. Phase Controlled Converters: Single phase half wave controlled, rectifier with resistive and inductive loads, effect of freewheeling diode. Single phase fully controlled and half controlled bridge converters. Performance Parameters, Three phase half wave converters, Three phase fully controlled and half controlled bridge converters, Effect of source impedance, Single phase and three phase dual converters. Resonant converters

4. AC Voltage Controllers: Principle of On-Off and phase controls, Single phase ac voltage controller with resistive and inductive loads. Three phase ac voltage controllers (various configurations and comparison), Single phase transformer tap changer. Cyclo-Converters, Basic principle of operation, single phase to single phase, three phase to single phase and three phase to three phase cyclo-converters, output voltage

equation

5. Inverters: Single phase series resonant inverter, Single phase bridge inverters, Three phase bridge inverters Voltage control of inverters, Harmonics reduction techniques, Single phase and three phase current source inverters.

Recommended Books:

1. M.H. Rashid,"Power Electronics: Circuits, Devices & Applications", Prentice Hall of India Ltd. 3rd Edition,2004.
2. M.D. Singh and K.B.Khanchandani, "Power Electronics"Tata MC Graw Hill, 2005
3. M.S. Jamil Asghar, "Power Electronics" Prentice Hall of India Ltd., 2004

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	2	1	3	**1.80**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	3	3	2	3	**2.60**
PSO1	1	2	2	1	3	**1.80**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	3	3	2	3	**2.60**

PG2ELCN3015: Computational laboratory

Numerical Analysis using Python, Scilab

Course Outcomes (COs):

CO1:	Write programs in Python/Scilab to implement numerical methods for solving mathematical problems.
CO2:	Perform numerical simulations to analyze systems of linear equations and differential equations.
CO3:	Apply numerical techniques for data interpolation and integration.
CO4:	Develop computational solutions for complex physical and engineering problems.
CO5:	Document and present computational experiments and findings in a clear and professional manner.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	3	2	3	2	**2.60**
PO2	1	1	1	1	3	**1.40**
PO3	2	2	2	3	2	**2.20**
PO4	2	2	2	3	2	**2.20**
PO5	3	3	3	3	3	**3.00**
PSO1	3	3	2	3	2	**2.60**
PSO2	1	1	1	1	3	**1.40**
PSO3	2	2	2	3	2	**2.20**
PSO4	2	2	2	3	2	**2.20**
PSO5	3	3	3	3	3	**3.00**

Semester-IV

PG2ELCN4011: Section 1: Medical Electronics; Section 2: Quantum Electronics
Theory: 50 Lectures

Course Outcomes (COs) for Medical Electronics:

CO1:	Explain the origin and characteristics of bioelectric signals and the principles of bioelectricity.
CO2:	Describe the types of electrodes used in biomedical applications and their interaction with biological tissues.
CO3:	Analyze biomedical signal conditioning requirements and the design of biopotential amplifiers.
CO4:	Describe the instrumentation and functional elements of implantable cardiac pacemakers.
CO5:	Analyze techniques for ECG signal processing, noise reduction, and feature extraction for clinical diagnosis.

Course Outcomes (COs) for Quantum Electronics:

CO1:	Explain the principles of nonlinear optics and the concept of nonlinear susceptibility.
CO2:	Analyze second- and third-order nonlinear optical effects (SHG, four-wave mixing, solitons).
CO3:	Quantize the electromagnetic field and describe quantum states of light (coherent, squeezed, Fock states).
CO4:	Explain photon statistics and phenomena like bunching, anti-bunching, and quantum interference.
CO5:	Describe the principles of quantum communication and quantum computation.

Section-1: Medical Electronics

1. Excitable Tissue and Bioelectric Signals: Bioimpedance and Biopermittivity, Bioelectricity, Dielectrics –Introduction, Basic Biomaterials, Tissue-Conductivity, Special Electrical Properties, Cell Polarization, Action Potential, The Neuron, Axon Transmission, Receptors

2. Electrodes: Electrode pair, metals, Contact Electrolytes, Skin Preparation, Electrode double layer, DC Potentials, No Current Flow, Basic Experiment with DC Current Flo, Faraday's Law of Electrolysis, Electrode Polarization, Multiple Electrode System, Electrode Terminology, Electrode design-overview.

3. Biomedical Sensors and Signal conditioning: Introduction, Biopotential amplifiers –Basic requirements, Interferences, Special circuits,Isolation Amplifier and Patient Safety, Surge Protection, Input Guarding, Dynamic Range and Recovery

4. Instrumentation in Implantable Cardiac Pacemakers: Introduction, Indications, Pulse Generators, Block diagram and functional elements of pace makers, Leads, Programmers and Ongoing Follow-Up, System Operation,Performance and Reliability, Future of Pacing Technology

5. Basics of Cardiovascular Signal: The Physiological Basis of the Electrocardiogram: Cellular Processes that Underlie the ECG, The Physical Basis of Electrocardiography, The Normal Electrocardiogram, Introduction to Clinical Electrocardiography, Abnormal Patterns, The Normal Determinants of Heart Rate: The Autonomic Nervous System (Ectopy, Tachycardia, and Fibrillation), Conduction Blocks, Bradycardia, and Escape Rhythms, Cardiac Ischemia, Other Metabolic Disturbances, and Structural Abnormalities, A Basic Approach to ECG Analysis.

6. ECG Statistics, Noise, Artifacts, and Missing Data: Spectral and Cross-Spectral Analysis of the ECG, Extreme Low and High Frequency ECG, The Spectral Nature of Arrhythmias, Standard Clinical ECG Features, Non-stationarities in the ECG, Heart Rate Hysteresis, Arrhythmias, Arrhythmia Detection, Arrhythmia Classification from Beat Typing, Arrhythmia Classification from Power-Frequency Analysis, Arrhythmia Classification from Beat-to-Beat Statistics, Noise and Artifact in the ECG, Noise and Artifact Sources, Measuring Noise in the ECG, Heart Rate Variability, RR Interval Models, The Cardiovascular System, The DeBoer Model, Integral Pulse Frequency Modulation Model, Nonlinear Deterministic Models, RR Interval Models for Abnormal Rhythms, ECG Models, Pathophysiology Guided T-Wave Alternans Measurement,, ECG-Derived Respiratory Frequency Estimation, ST analysis.

7. Measurement, Conventional Electrode Positioning , Conditioning the Signals, Abnormal EEG Patterns, Ageing , Mental Disorders, Dementia , Epileptic Seizure and Non-epileptic Attacks, Psychiatric Disorders. External Effects

8. Neural Signal Analysis: Fundamentals of EEG Signal Processing, EEG Signal modeling, Linear Models, Nonlinear Modeling, Generating EEG Signals Based on modeling the Neuron al Activities, Nonlinearity of the Medium, Non-stationary, Signal Segmentation, Signal Transforms and Joint Time–Frequency Analysis, Wavelet Transform, Ambiguity Function and the Wigner–Ville Distribution

9. Event-Related Potentials: Detection, Separation, Localization, and Classification of P300 Signals, Using ICA, Estimating Single Brain Potential Components by modeling ERP Waveforms, Source Tracking, Localization of the ERP, Time–Frequency Domain Analysis, Adaptive Filtering Approach.

Recommended Books:

1. Advanced Methods and Tools for ECG Data Analysis, Francisco Azuaje, Gari D.
Clifford, and Patrick E. McSharry, ISBN-13: 978-1580539661,
2. EEG Signal Processing, Saied Sanei and J A Chambers, John Wiely and Sons Limited,2007.
3. Introduction to Electrophysilogical methods and instrumentation, Franclin Bretschneider and Jan R De Weille.

Section-2: Quantum Electronics

Nonlinear optics: Nonlinear polarization & susceptibilities, microscopic origin, tensor nature & symmetries, nonlinear optical wave equation. 2nd-order effects: second harmonic generation, sum & difference frequency generation, parametric amplification & oscillation, birefringent & quasi-phase matching. 3rd-order effects: nonlinear refractive index, two-photon absorption, self & cross phase modulation, four wave mixing & phase conjugation, nonlinear pulse
propagation & optical solitons.

Quantum optics: Quantum states of light, quantization of optical field & harmonic oscillator representation, quadrature representation, coherent states, squeezed states, number/Fock states. Photon statistics, bunching & anti-bunching, quantum interference, Hanbury-Brown-Twiss and Hong-Ou-Mandel effects. Generation of squeezed states, single-photons & photon pairs through nonlinear optical processes. Entangled states and their generation, Bell's
inequalities. Quantum communication/key distribution, quantum teleportation.
Quantum Computation: Quantum logic gates, quantum circuits

Reference texts:

1. Nonlinear Optics, 3rd ed; Robert W. Boyd
2. Photonics, 6th ed; Amnon Yariv and Pochi Yeh
3. Introductory Quantum Optics; Christopher C. Gerry and Peter L. Knight
4. Quantum Optics: An Introduction; Mark Fox

Course Articulation Matrix: Medical Electronics

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	1	2	1	3	**1.60**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	3	2	3	**2.40**
PSO1	1	1	2	1	3	**1.60**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	3	2	3	**2.40**

Course Articulation Matrix: Quantum Electronics

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	2	1	1	1	**1.20**
PO2	1	1	1	1	1	**1.00**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	3	2	2	2	**2.20**
PSO1	1	2	1	1	1	**1.20**
PSO2	1	1	1	1	1	**1.00**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	3	2	2	2	**2.20**

PG2ELCN 4012: Elective Paper-I (Section 1: Antenna Design; Section 2: Photonics)
Theory: 50 Lectures

Course Outcomes (COs) for Antenna Design:

CO1:	Analyze and interpret fundamental antenna parameters.
CO2:	Design and simulate broadband, traveling wave, and frequency-independent antennas. .
CO3:	Explain the principles of UWB and compact antenna design.
CO4:	Describe the concepts and benefits of smart antennas, including beamforming and MIMO systems.
CO5:	Analyze and design active antenna arrays for various applications.

Course Outcomes (COs) for Photonics:

CO1:	Explain the fundamental principles of light, ray optics, and wave optics.
CO2:	Analyze the physics of lasers, including pumping schemes, rate equations, and line broadening mechanisms.
CO3:	Explain the principles and applications of Fourier optics and holography.
CO4:	Describe the physical principles behind electro-optic, acousto-optic, and magneto-optic effects and their device applications.
CO5:	Analyze the principles of nonlinear optics and nanophotonics for advanced applications. .

Section 1: Antenna Design

Review of antenna parameters; theorems; and other fundamental issues Miniaturization and bandwidth enhancement; Broad band dipole and matching technique; traveling wave and broad band antenna; frequency independent antenna; planar broad band antennas; UWB antenna Compact antenna

Smart Antenna – benefits; types; fixed & switched beam antenna system; adaptive array system; analog and digital beamforming; multiple antenna design; combining techniques; diversity, multi beam formation; MIMO, Active antenna array.

Recommended Books:

1. C.A. Balanis, “Antenna Theory: Analysis and Design’, Wiley
2. J.D Kraus, R. J. Marhefka and A. Khan, Antennas and Wave Propagation, MGH
3. R. S. Elliot, “Antenna Theory and Design”, Wiley
4. J. R. James and P. S. Hall, “Handbook of Microstrip Antenna”, Peter Peregrinous Ltd
5. R. Garg, P.Bhartia, I. Bhal and A. Ittipiboon, “Microstrip Antenna Design Handbook”, Artech House
6. G. Kumar and K.P. Ray, Broad Band Microstrip Antennas, Artech House

Section-2: Photonics

Introduction: Importance of photonics in electronics and communication; review of electromagnetic theory of light; ray optics; wave optics; beam optics; physics of thin-film optical devices – anti-reflection coating; beam splitter; spectral filters; CD-ROMs etc.

Quantum electronics and statistical optics: photons and atoms – spontaneous emission; abruption; stimulated emission; Einstein coefficient; theory of oscillation; pumping schemes; rate equations; characteristics of laser output; line shape functions; line broadening; laser mode selection; laser cooling and trapping of atoms; hole burning; case studies of He-Ne, Ar, CO_2, ruby, Nd-Yag; X-ray lasers; pulse lasers – Q-switching; mode locked laser; ultrafast laser; case studies of industrial and scientific

applications of laser; statistical optics – statistical properties of random light waves; partially coherent light waves and partial polarization

Fourier optics and holography: review of Fourier transform; two-dimensional Fourier transform and convolutions in optics; Fraunhofer diffraction; Fourier transform properties of lens types of hologram; physics of information recording and reconstruction with hologram; application of holography in microscopy; interferometry; character recognition; quantitative theory of spatial frequency filtering and its applications

Electro-optic, acousto-optic, and magneto-optic effects: review of polarization and crystal optics; principle of elctro-optics – Pockel and Kerr effects; scanner; directional coupler; spatial light modulators; electro-optics of anisotropic materials; liquid crystals; photorefractive materials; Interaction of light with sound – Bragg diffraction of beam; coupled wave theory; acousto-optic modulator, scanner, filter, frequency shifter and isolator; acousto-optics of anisotropic media; basic idea of magneto-optic effect; photonic switching and computing – photonic switch based on electro-optic; acousto-optic effects and magneto-optic effects; all optical switch; bistable switch; optical interconnects and computing

Nonlinear optics and nano-photonics: nonlinear optical media; second and third order non-linear optical effects – wave mixing and conjugation; coupled wave theory; anisotropic and dispersive nonlinear media; optical solitons; nanoparticles; quantum dots; quantum wells; lasers and LED based on quantum dots and quantum wells; photonic crystals (PhC) – basic principles, PhC beam splitter, power combiner, resonator; photonic crystal based fibers as waveguides; negative refractive index based materials; surface plasmon resonance; basic components and devices for integrated optics

Biophotonics: Photobiology; light-matter interaction; biosensors, bioimaging techniques; fluorescence microscopy; confocal microscopy; optical tomography; single-photon and multi-photon microscopy; terahertz spectroscopy and imaging

Recommended books:

1. B. E. A Saleh and M. C. Teich, Fundamentals of Photonics, Wiley Interscience
2. E. R. Pike and R. G. W. Brown, Principles of Nanophotonics, Taylor and Francis
3. J. D. Joannopolous et. al, Photonic Crystal, Princeton University Press
4. K. Iga, Y Kokobun, Integrated Optics, Taylor and Francis

Course Articulation Matrix: Antenna Design

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	3	2	1	3	**2.00**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	3	2	2	3	**2.40**
PSO1	1	3	2	1	3	**2.00**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	3	2	2	3	**2.40**

Course Articulation Matrix: Photonics

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	1	2	1	3	**1.60**
PO2	1	1	1	1	2	**1.20**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	3	2	3	**2.40**
PSO1	1	1	2	1	3	**1.60**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	3	2	3	**2.40**

PG2ELCN4013: Elective Paper II (Section 1: Radar, Remote Sensing and Navigational System; Section 2: Computational Electromagnetics)

Theory: 50 Lectures

Course Outcomes (COs) for Radar, Remote Sensing and Navigational Techniques:

CO1:	Explain the working principles of radar systems, including the radar range equation and different radar types (CW, pulsed, MTI).
CO2:	Describe the principles of remote sensing and techniques for observing the earth's surface and atmosphere.
CO3:	Explain the principles of satellite-based navigation systems (GPS, GLONASS, Galileo).
CO4:	Analyze the concepts of differential GPS and precise point positioning (PPP).
CO5:	Apply radar, remote sensing, and navigation principles to practical applications. .

Course Outcomes (COs) for Computational Electromagnetics:

CO1:	Apply analytical methods for solving electromagnetic problems using separation of variables and Green's functions.
CO2:	Implement the Finite Difference Method (FDM) to solve Laplace's, Poisson's, and wave equations.
CO3:	Develop and analyze computational solutions using the Finite-Difference Time-Domain (FDTD) method for Maxwell's equations.
CO4:	Apply the Method of Moments (MoM) to solve integral equations for electromagnetic scattering and radiation problems.
CO5:	Implement the Finite Element Method (FEM) for complex electromagnetic simulations.

Section 1: Radar, Remote Sensing and Navigational Systems

Radar: Introduction; basic radar range equation and modification; CW, FM and pulsed radar; MTI and pulsed Doppler radars; scanning and tracking radars; receiver; duplexer; display systems; ambiguity diagram; pulse compression; radar antennas; ECM and ECCM .

Remote sensing:

Overview; earth’s atmosphere; land surface; oceans; land and sea ice; radiation budget; climate; radar altimeters; synthetic aperture radars (SAR); wind scatterometers; multispectral imaging; IR and microwave radiometers; concept of GIS.

Satellite based navigational systems: Electronic navigation systems – global and regional; concepts of satellite based navigation systems – GPS, GLONASS, Galileo, Beidou, QZSS, NaVIC; code and carrier phase based measurement techniques; augmentation; relative positioning – DGPS, RTK; Precise Point Positioning (PPP); Satnav applications.

Recommended Books:

1. M. Skolnik, “Introduction to Radar Systems”, McGraw Hill
2. P. Z. Peebles, “Radar Principles”, Wiley
3. E. F. Nathanson, “Radar Design Principles: Signal Processing and the Environment”, PHI
4. M. A. Richards, “Fundamentals of Radar Signal Processings”, McGraw Hill
5. G. Joseph and C. Jeganathan, “Fundamentals of Remote Sensing”, Universities Press
6. B. C. Panda, “Remote Sensing: Principle and Applications”, Viva Books
7. I. H. Woodhouse, “Introduction to Microwave Remote Sensing”, CRC Press
8. P. J. G. Teunissen and O. Montenbruck (Eds) “Springer handbook of global navigation satellite systems”, Springer
9. P. Misra and P. Enge “Global Positioning System: Signals, Measurements and Performance Revised”, Ganga-Jamuna Press.

Section 2: Computational Electromagnetics

Analytical methods: Orthogonal functions and eigenfunction expansions; Sturm-Liouville problems; Separation of variables in rectangular, cylindrical, and spherical coordinate systems; Green's functions: free-space Green's functions, Green's functions for domains with conducting boundaries; Contour integration and conformal mapping techniques; Fourier transform methods and plane-wave spectrum representations.

Finite difference method (FDM): Finite difference schemes: forward, backward, and central differences; Finite differencing of elliptic PDEs (Laplace's and Poisson's equations); Band matrix method and iterative solution techniques (Gauss-Seidel, SOR); Finite differencing of parabolic and hyperbolic PDEs; Accuracy and stability of finite difference solutions.

Finite difference in time domain (FDTD) method: Yee's finite difference algorithm for Maxwell's equations; Numerical stability and dispersion analysis; Lattice truncation conditions and absorbing boundary conditions (ABC); Source modeling and initial field specifications; FDTD in cylindrical and spherical coordinate systems; Application to guided structures: transmission lines and waveguides; Wave scattering problems using FDTD.

Integral equation formulations: Classification of integral equations: Fredholm and Volterra types; Connection between differential and integral equations; Green's functions for free space and domains with conducting boundaries.

Method of moments: Basic principles of MoM and method of weighted residuals; Expansion functions (basis functions) and weighting (testing) functions; Transformation of integral equations to matrix equations (discretization); Evaluation of matrix elements; Solution of the matrix equation; Quasi-static problems; Scattering problems: scattering by conducting cylinder and arbitrary array of parallel wires; Radiation problems: Hallen's and Pocklington's integral equations for wire antennas; Electromagnetic absorption in the human body; Spectral domain MoM for planar microwave structures.

Finite element method (FEM): Basic concepts and steps in finite element analysis; Variational principles and Galerkin's method; Nodal and edge elements; Solution of Laplace's equation: finite element discretization, element governing equations, assembly of elements, and solving the resulting system; Solution of Poisson's equation; Solution of the wave equation for waveguide and cavity problems; Automatic mesh generation for rectangular and arbitrary domains; Bandwidth reduction techniques; Higher order elements: Pascal triangle, local coordinates, shape functions, and fundamental matrices.

Comparative analysis: Strengths and weaknesses of FDM/FDTD, MoM, and FEM; Criteria for selecting appropriate numerical techniques for specific problems; Time-domain vs. frequency-domain analysis; Computational resources and error estimation.

Suggested Reading:

1. Garg, R. Analytical and Computational Methods in Electromagnetics. Artech House
2. Sadiku, M. N. O. Numerical Techniques in Electromagnetics, CRC Press

3. Peterson, A. F., Ray, S. L., and Mittra, R. Computational Methods for Electromagnetics. IEEE Press
4. Jin, J. M. The Finite Element Method in Electromagnetics, Wiley-IEEE Press
5. Taflove, A. and Hagness, S. C. Computational Electrodynamics: The Finite-Difference Time-Domain Method, Artech House
6. Harrington, R. F. Field Computation by Moment Methods. IEEE Press

Course Articulation Matrix: Radar, Remote Sensing and Navigational System

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	1	1	1	2	3	**1.60**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	2	2	3	2	3	**2.40**
PSO1	1	1	1	2	3	**1.60**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	2	2	3	2	3	**2.40**

Course Articulation Matrix: Computational Electromagnetics

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	2	3	3	3	3	**2.80**
PO2	1	1	1	1	2	**1.20**
PO3	3	3	3	3	3	**3.00**
PO4	1	1	1	1	1	**1.00**
PO5	3	3	3	3	3	**3.00**
PSO1	2	3	3	3	3	**2.80**
PSO2	1	1	1	1	2	**1.20**
PSO3	3	3	3	3	3	**3.00**
PSO4	1	1	1	1	1	**1.00**
PSO5	3	3	3	3	3	**3.00**

PG2ELCN4014: Term Paper/ Project Work

Course Outcomes (COs):

CO1:	Identify a specific problem or topic in the field of Electronics and Communication for investigation.
CO2:	Conduct a comprehensive literature survey to understand the state-of-the-art and formulate a methodology.
CO3:	Execute the project using appropriate theoretical, computational, or experimental tools to achieve the objectives.

CO4:	Analyze the results obtained and draw meaningful conclusions.
CO5:	Prepare a detailed technical report and present the findings effectively through a seminar.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	3	3	3	2	**2.80**
PO2	1	2	1	1	3	**1.60**
PO3	3	3	3	3	3	**3.00**
PO4	3	3	3	3	3	**3.00**
PO5	3	3	3	3	2	**2.80**
PSO1	3	3	3	3	2	**2.80**
PSO2	1	2	1	1	3	**1.60**
PSO3	3	3	3	3	3	**3.00**
PSO4	3	3	3	3	3	**3.00**
PSO5	3	3	3	3	2	**2.80**

PG2ELCN4015: Signal processing lab: Practical

Course Outcomes (COs):

CO1:	Implement signal processing algorithms (e.g., convolution, correlation, Z-transform) using software tools.
CO2:	Design, simulate, and analyze FIR and IIR digital filters using appropriate software.
CO3:	Compute DFT and implement FFT algorithms for spectral analysis of real-world signals.
CO4:	Analyze and interpret results from digital signal processing experiments.
CO5:	Prepare clear and concise lab reports that document the design, methodology, and outcomes of signal processing experiments.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	3	3	2	1	**2.40**
PO2	1	1	1	3	3	**1.80**
PO3	2	2	2	2	2	**2.00**
PO4	2	2	2	2	2	**2.00**
PO5	3	3	3	3	2	**2.80**
PSO1	3	3	3	2	1	**2.40**
PSO2	1	1	1	3	3	**1.80**
PSO3	2	2	2	2	2	**2.00**

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PSO4	2	2	2	2	2	**2.00**
PSO5	3	3	3	3	2	**2.80**

PG2 ELCN 3031: Research Thesis/Project

Course Outcomes (COs):

CO1:	Identify and formulate a well-defined research problem or project topic in a specialized area of Electronics and Communication, demonstrating the ability to recognize gaps in existing knowledge.
CO2:	Conduct a comprehensive and systematic literature survey to understand the state-of-the-art, critically evaluate existing methodologies, and establish the context and significance of the proposed research.
CO3:	Formulate a robust research methodology, selecting appropriate theoretical, computational, or experimental tools and techniques to address the identified research problem.
CO4:	Initiate the execution of the research plan by setting up necessary experiments, developing computational models, or conducting theoretical analyses, while maintaining proper documentation.
CO5:	Prepare a preliminary research report and present the research plan, including the problem statement, literature review, and proposed methodology, through a seminar presentation.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	3	3	3	2	**2.80**
PO2	1	3	1	1	3	**1.80**
PO3	3	3	3	3	3	**3.00**
PO4	2	2	2	3	2	**2.20**
PO5	2	2	3	3	2	**2.40**
PSO1	3	3	3	3	2	**2.80**
PSO2	1	3	1	1	3	**1.80**
PSO3	3	3	3	3	3	**3.00**
PSO4	2	2	2	3	2	**2.20**
PSO5	2	2	3	3	2	**2.40**

PG2 ELCN 4031: Research Thesis/Project

Course Outcomes (COs):

CO1:	Execute the complete research plan by carrying out experiments, running simulations, or performing theoretical derivations, demonstrating independence and perseverance in solving

	complex scientific problems.
CO2:	Analyze, interpret, and critically evaluate the research data or results using appropriate analytical and computational tools, drawing meaningful conclusions that address the research objectives.
CO3:	Synthesize the research findings into a comprehensive and well-structured thesis report, demonstrating mastery of the subject matter and the ability to present scientific work in a clear, logical, and professional manner.
CO4:	Defend the research work effectively through a seminar presentation and viva-voce examination, articulating the research significance, methodology, results, and conclusions to expert and non-expert audiences.
CO5:	Contribute original knowledge or innovative solutions to the field of Electronics and Communication, demonstrating the ability to independently carry out research and development work at a level suitable for publication or practical application.

Course Articulation Matrix

POs/ PSOs	CO1	CO2	CO3	CO4	CO5	Course Level Mapping
PO1	3	3	2	2	3	**2.60**
PO2	1	1	3	3	2	**2.00**
PO3	3	3	3	3	3	**3.00**
PO4	3	2	2	3	2	**2.40**
PO5	3	3	2	2	3	**2.60**
PSO1	3	3	2	2	3	**2.60**
PSO2	1	1	3	3	2	**2.00**
PSO3	3	3	3	3	3	**3.00**
PSO4	3	2	2	3	2	**2.40**
PSO5	3	3	2	2	3	**2.60**

PG2 PHYS 4041: Community Engagement

Program Articulation Matrices (PAMs)

Two-year M.Sc. Program

Option I: Coursework in 3rd Semester & Research Thesis/Project in 4th Semester

Semester I:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN1011	Signals and Systems	2.00	1.20	3.00	1.00	2.80

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN1012	Electromagnetic Theory and Transmission Lines	2.00	1.20	3.00	1.00	2.80
PG2ELCN1013	Physics of Semiconductor Devices	2.00	1.20	3.00	1.00	2.20
PG2ELCN1014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN1021	Digital System Design	1.80	1.40	3.00	1.20	2.80

Semester II:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN2011	Advanced Communication Systems	1.60	1.00	3.00	1.00	2.20
PG2ELCN2012	Digital Signal Processing	2.40	1.20	3.00	1.00	3.00
PG2ELCN2013	Control Systems & Network Analysis	2.00	1.20	3.00	1.00	3.00
PG2ELCN2014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN2021	Communication Systems	1.60	1.40	3.00	1.00	2.20

Semester III:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN3011	Mathematical and Computational Methods	2.40	1.20	3.00	1.00	3.00
PG2ELCN3012	Analog and Digital Integrated Circuits	1.40	1.00	3.00	1.00	2.40
PG2ELCN3013	Microwave Devices and Circuits	2.00	1.20	3.00	1.00	2.60
PG2ELCN3014	Power Electronics	1.80	1.20	3.00	1.00	2.60
PG2ELCN3015	Computational Laboratory	2.60	1.40	2.20	2.20	3.00

Semester IV:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN4031	Research Thesis/Project	2.60	2.00	3.00	2.40	2.60

Option II: Only Coursework in 3rd Semester and 4th Semester

Semester I:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN1011	Signals and Systems	2.00	1.20	3.00	1.00	2.80
PG2ELCN1012	Electromagnetic Theory and Transmission Lines	2.00	1.20	3.00	1.00	2.80
PG2ELCN1013	Physics of Semiconductor Devices	2.00	1.20	3.00	1.00	2.20
PG2ELCN1014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN1021	Digital System Design	1.80	1.40	3.00	1.20	2.80

Semester II:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN2011	Advanced Communication Systems	1.60	1.00	3.00	1.00	2.20
PG2ELCN2012	Digital Signal Processing	2.40	1.20	3.00	1.00	3.00
PG2ELCN2013	Control Systems & Network Analysis	2.00	1.20	3.00	1.00	3.00
PG2ELCN2014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN2021	Communication Systems	1.60	1.40	3.00	1.00	2.20

Semester III:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN3011	Mathematical and Computational Methods	2.40	1.20	3.00	1.00	3.00
PG2ELCN3012	Analog and Digital Integrated Circuits	1.40	1.00	3.00	1.00	2.40
PG2ELCN3013	Microwave Devices and Circuits	2.00	1.20	3.00	1.00	2.60
PG2ELCN3014	Power Electronics	1.80	1.20	3.00	1.00	2.60
PG2ELCN3015	Computational Laboratory	2.60	1.40	2.20	2.20	3.00

Semester IV:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN4011	Medical Electronics & Quantum Electronics	1.60/ 1.20	1.20/ 1.00	3.00/ 3.00	1.00/ 1.00	2.40/ 2.20
PG2ELCN4012	Elective Paper-I (1. Antenna Design / 2. Photonics)	2.00/ 1.60	1.20/ 1.20	3.00/ 3.00	1.00/ 1.00	2.40/ 2.40
PG2ELCN4013	Elective Paper-II (1. Radar, Remote Sensing & Navigation / 2.	1.60/ 2.80	1.20/ 1.20	3.00/ 3.00	1.00/ 1.00	2.40/ 3.00

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
	Computational Electromagnetics)					
PG2ELCN4014	Term Paper/ Project Work	2.80	1.60	3.00	3.00	2.80
PG2ELCN4015	Signal Processing Lab: Practical	2.40	1.80	2.00	2.00	2.80

Option III: Only Research Thesis/ Project in 3rd Semester & 4th Semester

Semester I:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN1011	Signals and Systems	2.00	1.20	3.00	1.00	2.80
PG2ELCN1012	Electromagnetic Theory and Transmission Lines	2.00	1.20	3.00	1.00	2.80
PG2ELCN1013	Physics of Semiconductor Devices	2.00	1.20	3.00	1.00	2.20
PG2ELCN1014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN1021	Digital System Design	1.80	1.40	3.00	1.20	2.80

Semester II:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN2011	Advanced Communication Systems	1.60	1.00	3.00	1.00	2.20
PG2ELCN2012	Digital Signal Processing	2.40	1.20	3.00	1.00	3.00
PG2ELCN2013	Control Systems & Network Analysis	2.00	1.20	3.00	1.00	3.00
PG2ELCN2014	General Practical	2.20	1.80	2.00	2.00	2.80
PG2ELCN2021	Communication Systems	1.60	1.40	3.00	1.00	2.20

Semester III:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN3031	Research Thesis/ Project	2.80	1.80	3.00	2.20	2.40

Semester IV:

Course Code	Course Name	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
PG2ELCN4031	Research Thesis/ Project	2.60	2.00	3.00	2.40	2.60

Average of Program Articulation Matrix (PAM) for Two-Year M.Sc. Program in Electronics and Communication

Option	PSO1	PSO2	PSO3	PSO4	PSO5
Option I (Cousework in Semester III and Research Thesis/ Project in Semester IV	2.05	1.32	2.87	1.30	2.66
Option II (Only Cousework in both Semester III and Semester IV	2.00	1.28	2.87	1.24	2.61
Option III (Only Research Thesis/ Project in both Semester III and Semester IV	2.10	1.40	2.92	1.32	2.63
Overall One-Year Program Average	2.05	1.33	2.89	1.29	2.63

Key Observations:

PSO3 (Deep, systematic understanding of core and advanced subjects) has the highest mapping values across almost all theory courses, indicating the program's strong emphasis on developing deep disciplinary knowledge.

PSO5 (Proficient application of analytical methods and computational tools) shows consistently high mapping values across courses with computational and analytical components.

PSO2 (Effective communication of scientific findings) shows lower mapping values for most courses, with higher values only for practical courses, term papers, and research theses, indicating that communication skills are primarily developed through these specific activities.

PSO1 (Advanced theoretical knowledge and practical skills for independent R&D) and PSO4 (Collaborative and leadership skills) show moderate mapping values, with the highest values concentrated in project-based courses (Term Paper/Project Work, Research Thesis/Project, and Computational Laboratory).

The Research Thesis/Project courses (PG2ELCN3031/4031) show the most balanced contribution across all PSOs, making them the most comprehensive courses in terms of PSO coverage.

Graduate Competencies

Upon successful completion of the M.Sc. program in Electronics and Communication, graduates will possess the following competencies:

Advanced Theoretical Knowledge

Graduates will demonstrate a deep, systematic understanding of core and advanced subjects in Electronics and Communication, including:

- Semiconductor Physics and Device Modelling
- Electromagnetic Theory and Transmission Lines
- Analog and Digital Integrated Circuits
- Communication Systems (Advanced and Basic)
- Digital Signal Processing
- Control Systems and Network Analysis
- Microwave Devices and Circuits
- Power Electronics

Research and Development Capabilities

Graduates will be able to:

- Independently identify and formulate research problems
- Conduct comprehensive literature surveys
- Develop robust research methodologies
- Execute research plans using appropriate theoretical, computational, or experimental tools
- Analyze, interpret, and critically evaluate research data
- Contribute original knowledge or innovative solutions to the field

Practical and Computational Skills

Graduates will be proficient in:

- Designing and analyzing electronic circuits and systems
- Implementing signal processing algorithms using software tools
- Performing numerical simulations and computational analysis
- Using industry-standard software such as MATLAB, Python, Scilab, and VHDL
- Conducting experiments and interpreting experimental data

Effective Communication

Graduates will be able to:

- Write well-structured technical reports, research theses, and scientific documents
- Present complex scientific and technical findings effectively through seminars and presentations
- Articulate research significance, methodology, results, and conclusions to both expert and non-expert audiences

Collaborative and Leadership Skills

Graduates will be able to:

- Collaborate effectively within interdisciplinary teams
- Demonstrate leadership qualities in planning, executing, and managing complex scientific projects
- Solve scientific tasks both as a team member and as a team leader

Ethical and Social Responsibility

Graduates will demonstrate:

- An understanding of ethical principles in scientific research and practice
- A commitment to community engagement and societal development
- The ability to apply scientific knowledge for the benefit of society

Lifelong Learning

Graduates will possess:

- The ability to identify and use appropriate knowledge, skills, and tools to offer scientific solutions to problems
- A foundation for lifelong learning and professional development in the rapidly evolving field of Electronics and Communication
- The capacity to adapt to new technologies and methodologies

Concluding Remarks

The M.Sc. program in Electronics and Communication at The University of Burdwan represents a significant step forward in postgraduate education, aligning with the transformative vision of the National Education Policy 2020. The program is meticulously designed to produce graduates who are not only technically proficient but also research-oriented, socially responsible, and ethically grounded.

The program's flexible structure, with multiple options for coursework and research, ensures

that it caters to a diverse range of student aspirations. Whether a student wishes to pursue a career in industry, research, or academia, the program provides the necessary foundation and opportunities for growth.

The comprehensive curriculum, covering both foundational and advanced topics, ensures that graduates possess a deep, systematic understanding of the field. The strong emphasis on practical skills, computational analysis, and research methodology equips students with the competencies required to address real-world scientific and technological challenges.

The inclusion of community engagement as a compulsory component reflects the university's commitment to producing graduates who are not only skilled professionals but also responsible citizens. This holistic approach to education ensures that graduates are well-prepared to contribute meaningfully to society and the nation.

As the program prepares to welcome its first cohort in 2026-2027, it stands as a testament to The University of Burdwan's commitment to excellence in higher education and its dedication to shaping the next generation of leaders in Electronics and Communication.