Revised

M. Tech. (ECE) Syllabus

[Electronics and Communication Engineering- 2023]

As per NEP-2020

Department of Electronics and Communication Engineering

School of Technology

North-Eastern Hill University

Shillong - 793 022, Meghalaya

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1. M.Tech. (ECE) Syllabus Scheme

1.1 Semester: I

Branch: Electronics and Communication Engineering **Year:** I **Semester:** I

Sl. No.	Course Code	Course Name	Periods (Contact Hours)			Evaluation Scheme (Distribution of Marks)					**Credits**
Papers			**L**	**T**	**P**	**TA**	**CT**	**ST**	**ESE**	**TOT**	
1	EC-CC-500	Advanced Signal Processing	3	1	0	10	15	25	75	100	4
2	EC-CC-501	Machine Learning	3	1	0	10	15	25	75	100	4
3	EC-CC-502	FPGA Implementation Practices	0	0	4	0	20	20	30	50	2
4	EC-DSEC-503xx	Discipline Specific Elective Course Elective - I	3	0	0	5	15	20	55	75	3
5	EC-DSEC-504xx	Discipline Specific Elective Course Elective - II	3	0	0	5	15	20	55	75	3
6	EC-GEC-505xx	Generic Elective Course (Multidisciplinary)	3	1	0	10	15	25	75	100	4
		Total	**15**	**3**	**4**	40	95	**135**	**365**	**500**	20

L - Lecture **T -** Tutorial **P -** Practical **TA -** Assessment by Teacher
CT - Class Test **ST -** Sub-Total **ESE -** End Semester Evaluation **TOT -** Total

Contact Hours: *22* **Total Marks:** *500* **Total Credits:** *20*

DSEC : Elective - I

1. EC-DSEC-50301 Advanced Wireless Communication
2. EC-DSEC-50302 Microwave Theory and Techniques

3. EC-DSEC-50303 Silicon Photonics

A student may select any one of the following 3-credit elective courses available in online mode from the SWAYAM platform in lieu of the above courses.

4. Spread Spectrum Communications and Jamming
5. Fundamentals of Nano and Quantum Photonics
6. Stochastic Modeling and the Theory of Queues
7. Introduction to Embedded System Design
8. Circuit Analysis for Analog Designers

DSEC : Elective - II

1. EC-DSEC-50401 Digital IC Design

A student may select any one of the following 3-credit elective courses available in online mode from the SWAYAM platform in lieu of the above course.

2. Computer Vision and Image Processing - Fundamentals and Applications
3. Discrete Structures
4. Communication Networks
5. Industrial Automation and Control
6. Fiber Optic Communication Technology

Generic Elective Course (Multidisciplinary)

1. EC-GEC-50501 Biosensors and Applications
2. EC-GEC-50502 Fabrication Techniques for MEMs-based Sensors: Clinical Perspective
3. EC-GEC-50503 Biomedical Instrumentation

1.2 Semester: II

Branch: *Electronics and Communication Engineering* **Year:** I **Semester:** II

Sl. No.	Course Code	Course Name	Periods (Contact Hours)			Evaluation Scheme (Distribution of Marks)					**Credits**
Papers			**L**	**T**	**P**	**TA**	**CT**	**ST**	**ESE**	**TOT**	
1	EC-CC-506	Next Generation Communication Techniques	3	1	0	10	15	25	75	100	4
2	EC-CC-507	Modern Digital Control Systems	3	1	0	10	15	25	75	100	4
3	EC-DSEC-508X	Discipline Specific Elective Course (Practical)- III	0	0	4	0	20	20	30	50	2
4	EC-DSEC-509xx	Discipline Specific Elective Course Elective - IV	3	0	0	5	15	20	55	75	3
5	EC-DSEC-5010xx	Discipline Specific Elective Course Elective - V	3	0	0	5	15	20	55	75	3
6	EC-RM-511	Research Methodology and Proposal Writing	3	1	0	10	15	25	75	100	4
6	EC-SEC-512xx	Skill Enhancement Course (SEC)	3	1	0	10	15	25	75	100	4
		Total	**18**	**4**	**4**	50	110	**160**	**440**	**600**	24

L - Lecture **T -** Tutorial **P -** Practical **TA -** Assessment by Teacher
CT - Class Test **ST -** Sub-Total **ESE -** End Semester Evaluation **TOT -** Total

Contact Hours: *26* **Total Marks:** *600* **Total Credits:** *24*

DSEC : Elective - III (Practical)

1. EC-DSEC-5081 Advanced Communication Practices
2. EC-DSEC-5082 Advanced Practices in VLSI Devices and RF Circuits

DSEC : Elective - IV

1. EC-DSEC-50901 Antenna Analysis and Design
2. EC-DSEC-50902 VLSI Devices and Modeling

A student may select any of the following 12 weeks of 3 credit elective courses available online from the SWAYAM platform in lieu of the above courses.

3. Biomedical Signal Processing
4. Engineering Statistics
5. RF and Microwave Networks
6. Photonic Integrated Circuit

DSEC : Elective - V

1. EC-DSEC-501001 PIC Design

A student may select any of the following 12 weeks of 3 credit elective courses available online from the SWAYAM platform in lieu of the above course.

2. Modern Computer Vision
3. Advanced Computer Networks
4. Optical Wireless Communications for Beyond 5G Networks and IoT
5. Multirate DSP

Skill Enhancement Course (SEC)

1. EC-SEC-51201 Advanced Data Visualization and Analytics
2. EC-SEC-51202 Development of MOOC Courses
3. EC-SEC-51203 Project Management for Managers

1.3 Semester: III

Branch: *Electronics & Communication Engineering* **Year:** II **Semester:** III

Sl. No.	Course Code	Course Name	Periods (Contact Hours)			Evaluation Scheme (Distribution of Marks)					Credits
Papers			**L**	**T**	**P**	**TA**	**CT**	**ST**	**ESE**	**TOT**	
1	EC-CC-600	Advanced Digital Communication	3	1	0	10	15	25	75	100	4
2	EC-CC-601	Millimeter-wave and Terahertz Technique	3	1	0	10	15	25	75	100	4
3	EC-CC-602	Minor Project	0	0	8	10	15	25	75	100	4
4	EC-DSEC-603xx	Discipline-Specific Elective Course: Elective-VI	3	0	0	5	15	20	55	75	3
5	EC-DSEC-604xx	Discipline-Specific Elective Course: Elective-VII	3	0	0	5	15	20	55	75	3
6	EC-DSEC-605XX	Discipline-Specific Elective Course: Elective-VIII	3	0	0	5	15	20	55	75	3
7	EC-DSEC-606xx	Discipline-Specific Elective Course: Elective-IX	3	0	0	5	15	20	55	75	3
		Total	**18**	**2**	**8**	50	105	**155**	**445**	**600**	24

L – Lecture **T –** Tutorial **P –** Practical **TA –** Assessment by Teacher
CT – Class Test **ST –** Sub-Total **ESE –** End Semester Evaluation **TOT –** Total

Contact Hours: *28* **Total Marks:** *600* **Total Credits:** *24*

DSEC: Elective – VI

1. EC-DSEC-60301 Analog IC Design
2. EC-DSEC-60302 Speech Processing

A student may select any of the following 12-week 3-credit elective courses available online from the SWAYAM platform in lieu of the above courses.

3. Foundations of Cyber-Physical Systems
4. Foundations of Cryptography
5. Sensors and actuators

6. Fiber Optic Communication Technology

DSEC : Elective – VII

1. EC-DSEC-60401 Image Processing for Computer Vision
2. EC-DSEC-60402 Social Robotics

A student may select any of the following 12-weeks 3-credit elective courses available online from the SWAYAM platform in lieu of the above course.

3. Deep Learning for Visual Computing
4. GPU Architectures and Programming
5. Cloud Computing

DSEC : Elective – VIII

1. EC-DSEC-60501 Spoken Language Identification Techniques
2. EC-DSEC-60502 Embedded System Design with ARM

A student may select any of the following 12-week 3-credit elective courses available online from the SWAYAM platform in lieu of the above courses.

3. Architectural Design of Digital Integrated Circuits
4. Introduction To Industry 4.0 And Industrial Internet Of Things
5. Communication Networks
6. Biophotonics

DSEC: Elective – IX

1. EC-DSEC-60601 Deep Learning

A student may select any of the following 12-week -3 credit elective courses available online from the SWAYAM platform.

1. Advanced Neural Science for Engineers
2. Entrepreneurship Essentials
3. Computer-Aided Decision Systems - Industrial practices using Big Analytics

1.4 Semester: IV

Branch: *Electronics & Communication Engineering* **Year:** II **Semester:** IV

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Sl. No.	Course Code	Course Name	Periods (Contact Hours)			Evaluation Scheme (Distribution of Marks)					Credits
Papers			**L**	**T**	**P**	**TA**	**CT**	**ST**	**ESE**	**TOT**	
1	EC-CC- 603	Dissertation	-	-	32	100	-	100	300	400	16
2	EC-CC-604	Viva-Voce				25	-	25	75	100	4
		Total			**32**	**125**	**-**	**125**	**375**	**500**	**20**

L - Lecture **T -** Tutorial **P -** Practical **TA -** Assessment by Teacher
CT - Class Test **ST -** Sub-Total **ESE -** End Semester Evaluation **TOT -** Total

Contact Hours: *40* **Total Marks:** *500* **Total Credits:** *20*

The Project evaluation will be done based on the following components:

1. Problem Identification and Review of Related Literature
2. Proposal Writing and Presentation
3. Data Collection
4. Data Analysis, Interpretation, and Discussion
5. Report Writing
6. Viva- Voce

Students can also select MOOC courses of equivalent credit under the SWAYAM platform against Discipline Specific Elective Courses and Research Methodology (Applicable to Semesters I, II & III.)

2. M. Tech. (ECE) Syllabus

2.1 First Semester

2.1.1 EC-CC-500 Advanced Signal Processing

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−CC−*500
Course Name	:	*Advanced Signal Processing.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To describe the multi-rate systems and filter banks. The paper, at last, focuses on various wavelet transforms.

Objectives: On completion of the paper, students should

- CO1: Understand various forms of sampling alteration devices
- CO2: Understand filter banks and their significance
- CO3: Understand Hilbert and wavelet transforms

Unit I
Multirate Signal Processing: Sampling Rate Conversion; Decimation and Interpolation; Time and Frequency Domain Characterization; Filters in Sampling Rate Alteration Systems; Multirate Design of Decimator and Interpolator; Poly-phase Techniques; Poly-phase Down-sampler and Interpolator; Poly-phase Filter Design.

Unit II
Filter Banks: Two-channel QMF Banks, Alias free FIR, and IIR QMF Banks; Perfect Reconstruction Two- channel FIR Filter Banks; M-Channel Filter Banks Design; Cosine-Modulated M-Channel Filter Banks Design

Unit III
Discrete Hilbert Transforms: Real and Imaginary Part, Sufficiency of the FT for Causal Sequences, Sufficiency Theorems for Finite length Sequences, Relationship between Magnitude and Phase, HT Relation for Complex Sequences.

Unit IV
Wavelet Transforms: Fourier Transform and Its limitations, Short-Time Fourier Transform, Continuous Wavelet Transform, Discretization of the Continuous Wavelet Transform, Multiresolution Approximations; Wavelet and Scaling Function Coefficients, Harr Wavelets, The Daubechies Wavelets Construction, Fast Wavelet Transform and Image Compression, Denoising using Wavelets, Perfect Reconstruction Filter bank design using Wavelets.

Text Books:

1. S. K. Mitra, *Digital Signal Processing: A Computer Based Approach*, 4/e, TMH, 2013.
2. J. G. Proakis and D. G. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 4/e, Pearson Education Inc., 2007.
3. M. Vetterli and J. Kovacevic, *Wavelets and Subband Coding*, CreateSpace Independent Publishing Plat- form, 2013.
4. G. Strang and T. Nguyen, *Wavelets and Filter Banks*, Wellesley Cambridge Press, 1996.

Reference Books:

1. A.V. Oppenheim and R. W. Schafer, Discrete – Time Signal Processing, 3/e, Prentice-Hall, 2009.
2. R. E. Crochiere and L. R. Rabiner, Multirate Digital Signal Processing, Prentice-Hall Inc., 1983.
3. C.K.Chui, Wavelets: A tutorial in Theory and Applications, Academic Press.
4. C. S. Burrus, R. A. Gopinath and H. Guo, Introduction to Wavelets and Wavelets Transforms, Prentice Hall Inc., 1997.

2.1.2 EC-CC-501 Machine Learning

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−CC−*501
Course Name	:	*Machine Learning*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To obtain a broad overview of existing machine learning methods and to understand their motivations and main ideas from a variety of perspectives.

Objectives: On completion of this paper, students should

- CO1: Understand the fundamentals of machine learning

- CO2: Have a thorough grounding in the methodologies, technologies, mathematics, and algorithms of machine learning

- CO3: To mathematically analyze various machine learning approaches and paradigms

Unit I
Supervised Learning (Regression/Classification): Basic methods: Distance-based methods, Nearest-Neighbours, Decision Trees, Nave Bayes; Linear models: Linear Regression, Logistic Regression, Generalized Linear Models; Support Vector Machines, Nonlinearity, and Kernel Methods; Beyond Binary Classification: Multi-class/Structured Outputs, Ranking.

Unit II
Unsupervised Learning: Clustering: K-means/Kernel K-means; Hidden Markov Models; Dimensionality Reduction: PCA and kernel PCA; Matrix Factorization and Matrix Completion; Generative Models (mixture models and latent factor models).

Unit III
Probabilistic Models: Evaluating Machine Learning algorithms and Model Selection, Introduction to Statistical machine learning (Maximum Likelihood Estimation, MAP, Bayes Classifiers Naive Bayes; Bayes optimal classifiers; Minimum description length principle; Bayesian Networks, Inference in Bayesian Net- works, Bayes Net Structure Learning).

Unit IV
Recent Trends: Sparse Modeling and Estimation, Modeling Sequence/Time-Series Data, Deep Learning and Feature Representation Learning; Recent trends in various learning techniques of machine learning

Text Books:

1. Tom M. Mitchell, *Machine Learning*, 2/e, McGraw Hill, 2010.
2. Alpaydin Ethem, *Introduction to Machine Learning*, 2/e, MIT Press, 2010.
3. Christopher M. Bishop, *Pattern Recognition and Machine Learning*, Sringer, 2007.
4. Duda R. O., Hart P.E. and Stork D.G., *Pattern Classification*, 2/e, Wiley & Sons, 2006.
5. Murphy Kavin. P., *Machine Learning: A Probabilistic Perspective*, The MIT Press, 2012.
6. Trevor Hastie, Robert Tibshirani, Jerome Friedman, *The Elements of Statistical Learning*, Springer 2009.

Reference Books:

1. Peter Flach, *Machine Learning: The Art and Science of Algorithms that Make Sense of Data*, Cambridge Unversity Press,2012.

2. David J. C. MacKay, *Information Theory, Inference, and Learning Algorithms*, the South Asia Edition, Foundation Books, 2003.

3. S. J. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3/e, Pearson Education, 2015.

4. Mohri M., Rostamizadeh A. and Talwalkar A., *Foundations of Machine Learning* the MIT Press, 2012.

5. Ball Rasmussen C. E. and Williams C. K. I., *Gaussian Processes for Machine Learning*, the MIT Press,2006.

2.1.3 EC-CC-502 FPGA Implementation Practices

L	T	P	Cr
0	0	4	=2

Course Code	:	*EC−CC−*502
Course Name	:	FPGA Implementation Practices
Contact Hours per Week	:	*4(Four) Practical.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 30.*
Questions to be Set	:	*Minimum Ten*
Questions to be Answered	:	*Any 1(One) on Lottery Basis.*
Duration of End Semester Examination	:	*3 hours (Practical).*

Aim: The main aim of this course is to give an in-depth understanding of the Digital Designs in an FPGA.

Course Outcomes: On completion of this paper, students will be able to:

- CO1: Implement arbitrary Logic Implementation over FPGA.
- CO2: Synthesize High-Level Algorithms for Production.
- CO3: Learn to produce Digital IP for Consumer Applications.

Hands-on/ Laboratory/ Practical:

1. Simple Combinational Logic implementation in FPGA.
2. Multi-Function Gate implementation in FPGA.
3. Three-Bit Binary Adder implementation in FPGA.
4. Multiplexers in Combinational logic implementation in FPGA.
5. Decoder and Demultiplexer implementation in FPGA.
6. Random Access Memory implementation in FPGA.
7. Flip-Flop implementation in FPGA.
8. Designing with D-Flip flops.
9. Shift Register and Sequence Counter implementation in FPGA.
10. State Machine Implementation implementation in FPGA.
11. Implement IP Cores in an FPGA.
12. Translation of High-Level Codes for FPGA.
13. FPGA System Emulation.

Text Books:

1. Donald Thomas, Logic Design and Verification Using System Verilog, 2016
2. Frank Bruno, FPGA Programming for Beginners, Springer, 2021.
3. Justin Rajewski,Learning FPGAs, Springer, 2017.

2.1.4 EC-DSEC-50301 Advanced Wireless Communication

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC−DSEC−*50301
Course Name	:	Advanced Wireless Communication
Contact Hours per Week	:	3*(Three) Hours*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.5 *(two and half) Hours.*

Aim: To get a well-defined apprehension of modern wireless communication systems which will help the students to design and evaluate wireless systems theoretically.

Course Outcomes:

- CO1: To introduce the concepts of wireless communication.
- CO2: To make the students know about the various propagation methods, Channel models, capacity calculations, multiple antennas and multiple user techniques used in mobile communication.

Unit I
Introduction to Cellular Communication: History of cellular communication, Frequency reuse, multiple access technologies, Channel assignment strategies, Handoff strategies, Interference and system capacity, Trunking and grade of services, Trends in cellular radio and personal communication.

Unit II
Sources and Transmitters: Slow and Fast Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels.
Diversity techniques: Diversity techniques for Wireless Communications, Basic methods of diversity combining, BER Performance Improvement with diversity, Types of Diversity - Frequency, Time, Space.
Unit III
Advanced Techniques for Digital Communication: Model of spread spectrum digital communication system, Direct sequence spread spectrum signals, Frequency Hopped spread spectrum signals, other types of spread spectrum signals, Introduction to MIMO, MIMO Channel Capacity SVD and Eigenmodes of the MIMO Channel, Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix, Channel model and SNR performance, OFDM Issues - PAPR.

Text Books:

1. T. S. Rappaport, *Wireless Communication Principle and Practice*, Prentice-Hall of India, 2007.
2. Andreas Molisch, *Wireless Communications*, Wiley IEEE Press. 2007.
3. S. Haykin, *Communication Systems*, Wiley India, 2006.

4. Arogyaswami Paulraj, *Introduction to Space-Time Wireless Communications*, Cambridge University Press, 2006.

Reference Books:

1. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press. 2005.
2. David Tse and Pramod Viswanath, *Fundamentals of Wireless Communications*, Cambridge University Press, 2005.
3. Mischa Schwartz, *Mobile Wireless Communications*, Cambridge University Press 2005.
4. J. G. Proakis and M. Salehi, *Digital Communications*, 5/e, McGraw-Hill International Edition, 2008.

2.1.5 EC-DSEC-50302 Microwave Theory and Techniques

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC – DSEC –* 50202
Course Name	:	*Microwave Theory and Techniques*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.5 *(two and a half) Hours.*

Aim: To understand the significance of microwave theory and to design modern microwave components.

Objective: On completion of this paper, students should be able to

- CO1: develop the concept of microwave transmission line and networks.
- CO2: design matching circuits and other planar microwave components.
- CO3: design filters for modern communication systems

Unit I

Transmission Line and Networks : Review of electromagnetic field equations, The wave equation, Solution of wave equations, Radio Frequency Transmission Line Theory, Telegrapher's Equations, Concept of Voltage and Current Wave in a Line, Characteristics impedance and characteristics admittance, Power Flow in a Transmission Line , Terminated Lines: Short circuited line, Open Circuited Line, Matrix Representation of network: The impedance matrix, The admittance matrix, ABCD matrix, Matching of Transmission Lines: The Quarterwave Transformer matching, Stub Matching. Introduction to left-handed transmission lines.

Unit II

Planar Transmission Lines: Micro-strip Line: EM field distribution in a Micro-strip Line, Effective Dielec- tric Constant, Characteristic impedance, Coplanar waveguide, Stripline, Microwave resonators: series and parallel resonant circuits, transmission line resonator, Dielectric resonators.

Microwave Passive Components: Planar Power divider, T-junction power divider, Wilkinson power di-vider, Directional coupler: 90-degree Hybrid, 180-degree Hybrid coupler, Lange Coupler, Ferrimagnetic Components, Ferrite Phase Shifter, Ferrite Isolator, Ferrite Circulator

Unit III

Microwave filters : Periodic structures, Filter Design by the Insertion Loss Method, Maximally Flat and Chebyshev Filter design, stepped impedance lowpass filter, Band Pass and High Pass Filters, Filter using coupled line resonators. Multiband and broad banding techniques in modern filter applications.

Text Books:

1. D. M. Pozar, Microwave Engineering, 4/e, John Wiley, 2011.
2. Peter A. Rizzi, Microwave Engineering: Passive Circuits, 1/e, Prentice Hall, 1987.

3. C. Caloz, T. Itoh, Electromagnetic Metamaterials: Transmission Line Theory and Microwave Appli- cations, John Wiley and Sons, 2006.
4. S. M. Liao, Microwave Devices and Circuits, 3/e, Pearson Education, 2003.
5. Jia-Sheng Hong, Microstrip Filters for RF/Microwave Applications, 2/e, John Wiley and Sons, 2011

Reference Books:

1. R. E. Collin, Foundations for Microwave Engineering, 2/e, Wiley-IEEE Press, 2000.
2. R. Ludwig and G. Bogdanov, RF Circuit Design: Theory and Applications, 2/e, Prentice Hall, 2008.

2.1.6 EC-DSEC-50303 Silicon Photonics

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC−DSEC−*50303
Course Name	:	*Silicon Photonics.*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.5 *(two and a half) Hours.*

Aim: To design Silicon Photonics (SiPh) technology-based Interferometer (MZI/MRR/Michelson) with suggested specifications for data-center interconnect and communication applications.

Objectives: On completion of this course, students should be able

- CO1: To recognize and explain Silicon Photonics (SiPh) as an emerging technology to meet the explosive bandwidth demand and computationally efficient systems
- CO2: To Model SiPh technology-based passive photonic devices such as strip waveguides, Y-branch, directional couplers, etc.
- CO3: To design the Layout of passive photonic devices on an open-source GDS-II platform, i.e., KLayout using SiEPIC tools and pdks
- CO4: To evaluate the performance of MZI/MRR/Michelson interferometers for interconnects and PIC applications with given specifications

Unit I

Introduction to Silicon Photonics (SiPh): SiPh as the next fabless semiconductor industry, application of SiPh in data center and communication, technical challenges and state of the art, Opportunities in SiPh engineer as a career

Unit II

Modeling and Design approaches: Introduction to Mode solvers, Physical Layout: different physical layout tools. Introduction and application of KLayout (open-source) for GDS-II design. Introduction to Design workflow. Optical materials and waveguides: SoI, waveguides-slab waveguide, 1-D and 2-D mode profile calculations, compact waveguide models, and waveguide loss.

SiPh-based Passive Devices: Design of Y-branch, strip waveguide grating, Directional Coupler, MZI, MRR, Bragg gratings filters, Lattice filter, Multiplexer/Demultiplexer

Unit III

Design of SiPh-based Circuits on SoI: Optical Input/output Devices: Grating and edge couplers, Lattice filter, Multiplexer/Demultiplexer using SiEPIC pdk on KLayout, DRC, Circuit simulation and characterization

Text Books:

1. Lukas Chrostowski and Michael Hochberg, Silicon Photonics Design: from Devices to Systems, 1/e, 2016, Cambridge University Press, University Printing House, Cambridge CB2 8BS, UK
2. Slawomir Sujecki, Photonics Modeling and Design, 1/e, 2015 CRC Press, Taylor and Francis Group, 6000 Broken Soud Parkway, NW, Suit 300.
3. Daryl Inniss and Roy Rubenstein, Silicon Photonics-Fueling the Next Information Revolution, 1/e, Morgan Kaufmann, USA
4. David J. Lockwood, Lorenzo Pavesi, Silicon Photonics IV: Innovative Frontiers, 1/e, 2021, Springer Cham

Reference Books:

1. Lorenzo Pavesi, David J. Lockwood, *Silicon Photonics, Topics in Applied Physics (TAP, volume 94)*, 1/e, 2004, Springer Berlin, Heidelberg.
2. Graham T. Reed and Andrew P. Knights, *Silicon Photonics: An Introduction*, 1/e, 2004, Wiley.
3. S. J. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 3/e, Pearson Education, 2015.
4. David J. Lockwood and Lorenzo Pavesi., *Silicon Photonics II: Components and Integration: 119 (Topics in Applied Physics)* 1/e, 2010, Springer.
5. Murphy Kavin. P., *Machine Learning: A Probabilistic Perspective*, The MIT Press, 2012.
6. IEEE Journals of Photonics Technology Letters, JLT, Sec. Topics in Quantum Electrons etc
7. Tools: Matlab ,Comsol Multiphysics(https://www.istem.gov.in/rd-infrastructure-map/software-through- istem, visited 26.08.2022), Ansys Lumerical
8. Tools: Python, KLayout, SiEPIC tools, and pdk (https://github.com/SiEPIC, visited 26.08.2022)

2.1.7 EC-DSEC-50401 Digital IC Design

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC−DSEC−*50401
Course Name	:	*Digital IC Design.*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.5 *(two and a half) Hours.*

Aim: To get an understanding of the Synthesis, Optimization, Verification, and Testing of Digital Circuits.

Objectives: On completion of this course, students should be able

- CO1: Understand the Digital Design Flow.
- CO2: Discuss the techniques for the Synthesis of digital circuits.
- CO3: To understand the testing of digital circuits.
- CO4: To understand the verification of digital circuits.

Unit I
CAD tool Flow: Introduction to Digital VLSI Design Flow Specification, High-level Synthesis, RTL Design, Logic Optimization, Verification and Test Planning, Design Representation, Hardware Specific Transformations.

Unit II
High-Level Synthesis: Scheduling, Allocation, and Binding: Problem Specification(Scheduling, Allocation, and Binding), Basic Scheduling Algorithms (Time constrained and Resource Constrained), Allocation Steps: Unit Selection, Functional Unit Binding, Storage Binding, Interconnect Binding, Allocation Techniques: Clique Partitioning, Left-Edge Algorithm, Iterative Refinement.
Gate Level Synthesis and Optimization:: Logic Optimization and Synthesis: Heuristic Minimization of Two-Level Circuits: Espresso, Finite State Machine Synthesis, Multi-Level Logic Synthesis, Multi-Level Minimization, Technology Mapping, Binary Decision Diagram: Introduction and construction, Reduction rules and Algorithms, ROBDDs, Operation on BDDs and its Algorithms, Representation of Sequential Circuits.

Unit III
Verification and testing:: Model Checking: Introduction to Verification, Specification and Modelling, Model Checking Algorithm, Symbolic Model Checking, Automata and its use in Verification, Automata Theoretic Model Checking. Introduction to Digital Testing, Fault Simulation, and Testability Measures, Combinational Circuit Test Pattern Generation, Sequential Circuit Testing and Scan Chains, Built in Self test (BIST).

Text Books:

1. LG. De Micheli, Synthesis and optimization of digital circuits, Tata McGraw-Hill Education, 2003.
2. D. D. Gajski, N. D. Dutt, A. C.-H. Wu and S .Y.-L. Lin, High-Level Synthesis: Introduction to Chip and System Design, 1e, Springer, 1992.
3. M. Huth and M. Ryan, Logic in Computer Science modeling and reasoning about system, 2e, Cam- bridge University Press, 2004.

Reference Books:

1. Bushnell and Agrawal, Essentials of Electronic Testing for Digital, Memory and Mixed-Signal Circuits, Kluwer Academic Publisher,2000.

2.1.8 EC-GEC-50501 Biosensors and Applications

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−GEC−*50501
Course Name	:	*Biosensors and Applications.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: This course is designed with the aim of educating students in microtechnology and its use to fabricate sensors and systems.

Course Outcomes:

- CO1:To understand how to fabricate some of the sensors. To be exposed to fabricate the sensors and its application in the real world.
- CO2: To understand and learn modern-day microsensors and microactuators,
- CO3: To simulate some of the sensors and characterize before fabricating it.

Unit I
Basics of Energy Transformation: Transducers, Sensors and Actuators: Introduction To Sensors, Fabrication of Sensors and Actuators, Techniques and cleanroom protocols, Basics of Microsensor Fabrication and illustration of sensor interfacing for various applications, Silicon as a substrate, Arduino Interfacing for Sensors and Actuators,DC Motor as an actuator.
Unit II
Introduction to COMSOL Multiphysics and Gas Sensor Demonstration: Surface Profilometry and Physical Vapour Deposition Techniques, Introduction to COMSOL Multiphysics and Modelling Examples, Thermal Actuators using COMSOL, Gas sensor using Arduino.
Unit III
Basics of Photolithography, Signal conditioning circuit for temperature sensors: Photolithography, Signal Conditioning Circuit for Temperature Sensors, Microheaters in COMSOL Multiphysics, Introduction to Cleanroom facilities for biomedical applications.
Unit IV
Recent trends in biosensors and 3D Printing: Biosensors for Electrothermal sensor, MEMS based sensor for catheter contact force measurement, Microfluidics based Drug Screening, Basic aspects of 3D Printing, 3D Printing Materials and Demonstration of Remote 3D Printing.

Text Books:

2.1.9 EC-GEC-50502 Fabrication Techniques for MEMs-based Sensors: Clinical Perspective

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−GEC−*50502
Course Name	:	*Fabrication Techniques for MEMs-based Sensors: Clinical Perspective*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To comprehend the area of microtechnology and its use to fabricate sensors and systems with special reference to the clinical perspective

Objectives: On completion of this paper, students should

- CO1: To understand the microfabrication process, Understand sensors used in electronics and biomedical areas Understand Clean Room (Class 1 to Class 10000)
- CO2: To understand Microengineering Technology Design the process flow for fabricating micro-heater required in gas sensors.
- CO3: To design the process flow for fabricating forces sensors for biomedical application
- CO4: To understand fabrication of microfluidic platforms, micro-cantilevers, flexible force sensors, interdigitated electrodes, polymer-glass bonding etc. for clinical research

Unit I
Introduction to microengineering devices and its applications: Clean room, contaminants, wafer cleaning processes (DI water, RCA, metallic impurities, etc.). Introduction to the microheater, force sensors, microfluidic devices, its specifications, and applications.

Unit II
Masks: Types of masks, Types of Photoresists, Spin Coaters Lithography process: optical lithography, x-ray, and e-beam lithography, lift-off techniques, soft lithography, use of resists (spin coating, positive and negative photoresists), photoresist pre-baking, exposure, and development. Etching: Isotropic/anisotropic, selectivity, wet and plasma-assisted etching.

Unit III
Types of wafers and orientations: Techniques of metallization: PVD [(Sputtering – DC, RF, and Magnetron), thermal evaporation, e-beam evaporation]. Chemical Vapor Deposition: Dielectric films (Plasma Enhance Chemical Vapor Deposition (PECVD)), Atomic Layer Deposition. Understanding and designing the process flow for fabricating microengineering devices. Process flow for microheater, force

sensors, and microfluidic devices. Wafer dicing and bonding techniques. Microfluidic Chips

Unit IV

Process Flow for Fabricating: Flexible Force Sensors and Force Sensors on Silicon, Process Flow for Fabricating VOC sensors, Biochips, Clinical Research: Problems and Solutions using Microengineering Device

Text Books:

1. J.D. Plummer, M.D. Deal, P.G. Griffin, *Silicon VLSI Technology*, Pearson Education, 2001.
2. S.A. Campbell, *The Science and Engineering of Microelectronic Fabrication*, Oxford University Press, 2001.
3. S.M. Sze (Ed), *VLSI Technology*,2nd Edition, McGraw Hill, 1988
4. Stephen D. Senturia *Microsystem Design*, Kluwer Academic Publisher, 2001.

Reference Books:

1. Gad-el-Hak, M., Ed. *The MEMS Handbook*, CRC Press: New York, NY, 2002.
2. Marc Madou, *Fundamentals of Microfabrication*,CRC Press, 1997.

2.1.10 EC-GEC-50503 Biomedical Instrumentation

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−GEC−*50503
Course Name	:	*Biomedical Instrumentation*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To obtain a broad overview of various methods applied to Biomedical Instrumentation useful for healthcare .

Course outcomes:

- CO1: To understand anatomy and physiology of the human body and its response to various equipments when interfaced
- CO2: To analyse the scope for measurement of bioelectric potential and various learn about instruments associated to it
- CO3: To investigate about invasive and non-invasive measurements with their merits and demerits
- CO4: To categorise medical various imaging systems with emphasis to justification as per their use for layout design of hospital facilities

Unit I
Physiological systems and signals: Biology of human heart, circulatory and respiratory systems, fundamen- tals of human brain and nervous system, origin of bio-electric signals, electrocardiogram(ECG), electroen- cephalogram(EEC), electromyogram(EMG)

Unit II
Transducers and signal conditioners : Electrodes for ECG, EEG, EMG, Micro-electrodes, different types of transducers and their selection for Bio-medical applications, pre-amplifiers, instrumentation amplifier, biomedical filters, recorders for ECG, EEG and EMG systems

Unit III
Instrumentation for clinical Laboratory: Measurement of pH value of blood, Hemoglobin measurement, oxygen and carbon-dioxide measurement, design of therapeutic equipments like cardiac pacemaker, cardiac defibrillator, ventilators, hemodialysis machine.

Unit IV

Medical imaging and patient monitoring systems: X-ray imaging, Computed tomography, Ultrasonic imag- ing, Magnetic resonance imaging, Intensive cardiac care, patient monitoring through biotelemetry, bedside and central monitoring systems

Text Books:

1. Cromwell, L., Weibell, F. J., Pfeiffer, E. A., and Usselman, L. B. (1973). Biomedical instrumentation and measurements Englewood Cliffs, N. J., Prentice-Hall

Reference Books:

1. Khandpur, R. S. (2014). Handbook of Biomedical Instrumentation. McGraw-Hill Education.
2. Venkatraman, S. S. (2001). Introduction to Biomedical Engineering J. Enderle, S. Blanchard, J. Bronzino, Academic Press

2.2.1 EC-CC-506 Next-Generation Communication Techniques

L	T	P	Cr
3	1	0	=4

Course Code	: *EC−CC−*506
Course Name	: *Next-Generation Communication Techniques.*
Contact Hours per Week	: *4(Four) Hours.*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: The field of wireless communications has witnessed revolutionary technology developments in the last decade. Several radical wireless technologies have been developed to enable broadband wireless access with high data rates. This course will present an elaborate introduction to the principles and performance of the fundamental 3G/ 4G/ 5G wireless technologies.

Course Outcomes:

- CO1: To understand the development in the field of wireless communications.
- CO2: To understand wireless technologies such as CDMA, OFDM, MIMO.
- CO3: To understand the principle of 3G/4G/5G wireless communication systems.
- CO4: To analyse the performance of the fundamental 3G/ 4G/5G wireless technologies.

Unit I
Introduction to Wireless Systems: Evolution of Wireless Communication Technologies, Modeling Wireless Channel, Wireless Fading Channel Model, Fading Channel Distribution, Rayleigh Fading Channel, Bit Error Rate (BER) Performance, Deep Fade Analysis of Wireless Communication, Principle of Diversity, Maximal-Ratio Combining.

Unit II
Multiple Antenna Wireless Systems and Wireless Channel Characterization: BER of Multiple Antenna Wireless Systems, Deep Fade in Multi Antenna Systems, Intuition for Deep Fade in Multi-Antenna System, Definition of Diversity Order, Max Delay Spread, RMS Delay Spread, Delay Spread and Inter Symbol Interference, Coherence Bandwidth of Wireless Channel, Mobility and Doppler Effect in Wireless Channels.

Unit III
Principles of CDMA Wireless Communication: Introduction to Code Division Multiple Access (CDMA), Chip Time and Bandwidth Expansion in CDMA, Code Generation for CDMA, CDMA Codes: Properties

of PN Sequences, BER of CDMA Systems. Analysis of Multi-user CDMA, Multipath Diversity in CDMA Systems, Near-Far Problem in CDMA.

Unit IV

Principles of MIMO, OFDM Wireless Communication: Multiple Input Multiple Output (MIMO) Systems, MIMO Receivers, Transmit Beamforming in MISO Systems, Alamouti Code and Space-Time Block Codes, Singular Value Decomposition (SVD), SVD in MIMO, Orthogonal Frequency Division Multiplexing (OFDM), Transmission in Multicarrier Systems, FFT/IFFT Processing in OFDM, Cyclic Prefix in OFDM Systems, Schematic Representation of OFDM Transmitter and Receiver.

Text Books:

1. David Tse, Pramod Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press, 2005.
2. Andrea Goldsmith, *Wireless Communications*, Cambridge University Press, 2005.

Reference Books:

1. T. S. Rappaport, *Wireless Communications*, 2/e, Pearson, 2010.

2.2.2 EC-CC-507 Modern Digital Control System

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−CC−*507
Course Name	:	*Modern Digital Control Systems.*
Contact Hours per Week	:	*4(Four) Hours.*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To understand the concept of discrete-time systems and to apply the theoretical concepts for designing digital control systems through different techniques.

Objectives:

- CO1: To develop the knowledge of sample and hold circuits and pulse transfer functions.
- CO2: To design the digital controllers and to evaluate the stability of the system.
- CO3: To analyze and design the digital control system using state space representation.

Unit I
Introduction to Discrete Time Control System: Basic building blocks of the discrete-time control system, Quantization and error effects, Data acquisition, conversion and distribution systems, Z transform, Inverse Z transform, Z transform method for solving differential equations, Digital control of processes.

Unit II
Z-Plane Analysis of Discrete-Time Control Systems: Impulse sampling and data hold, Zero Order Hold (ZOH) and First Order Hold (FOH), Determination of pulse transfer function for: cascaded elements, closed-loop digital control system and digital PID controller. Realization of digital controllers and digital filters: Direct programming, Standard Programming, Series and parallel programming.

Unit III
Design of Discrete-Time Control System: Mapping between S plane and Z plane, Stability analysis of closed- loop systems in Z-plane, Jury stability criterion, Transient and steady-state response analysis, design based on root-locus method: Root locus diagrams of digital control systems, Effect of sampling period on transient response characteristics, Design based on frequency response method: Bilinear transformation and w plane, Bode diagrams, Compensator design.
Unit IV
State Space Analysis, Pole placement and Observer design: State space representation of discrete-time systems, Solving discrete-time state space equations, State transition matrix (STM), Computation of STM

by Z transformation method Pulse transfer function matrix, Discretization of continuous-time state space equations, Liapunov stability analysis of discrete-time systems, Controllability and observability, Design via pole placement, State observers

Text Books:

1. K. Ogata, *Discrete Time Control System*, 2/e, Pearson Education, 2007.
2. M. Gopal, *Digital Control & State Variable Methods*, 3/e, Tata McGraw Hill, 2003.
3. Gene F. Franklin, Abbas Emami-Naeini and J. David Powell, *Feedback Control of Dynamic Systems*, 5/e, Pearson Education Inc., 2008.
4. R. G. Jacquot, *Modern Digital Control Systems*, 2/e, Routledge, 2019.

Reference Books:

1. B. C. Kuo, *Digital Control Systems*, Oxford University Press, 2/e, 2003.
2. Richard H. Middleton and Graham C. Goodwin, *Digital Control and Estimation: A Unified Approach*, Prentice Hall Inc., 1990

2.2.3 EC-DSEC-50801 Advanced Communication Practices

L	T	P	Cr
0	0	4	=2

Course Code	:	*EC−DSEC−*50801
Course Name	:	*Advanced Communication Practices*
Contact Hours per Week	:	*4(Four) Practical.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 30.*
Questions to be Set	:	*Minimum Ten*
Questions to be Answered	:	*Any 1(One) on Lottery Basis.*
Duration of End Semester Examination	:	*3 hours (Practical).*

Aim: To develop a communication engineer who can model and design the laboratory based prototype communication devices, circuit and system as per given specifications.

Course outcomes: On completion of this paper, students would be able to:

- CO1: Estimate the path loss in the communication channel -
- CO2: Compute BER and analyse Eye diagram for given modulation scheme -
- CO3: Model and Design of passive Silicon Photonic based Devices - CO4: Model and Design of Photonic Circuits (MZI/MRR) -
- CO5: Develop software based complete Communication link and analyze performance in terms of Bit rate, SNR and power. -
- CO6: Study the characteristics of a microsrtrip antenna and development of microwave passive circuits.

Hands-on/ Laboratory/ Practical:

1. Develop software to get the free space path loss propagation by varying the distances between the transmitter & receiver and Compare the result graphically, using the Matlab.

2. Develop software to get the different pattern of Rayleigh function by using the Matlab.

3. Find out the BER of BPSK and higher modulation scheme over Rayleigh and Rice fading channels using Monte-carlo simulation.

4. Find out the BER of BPSK and higher modulation scheme with selection diversity over Rayleigh and Rice fading channels using Monte-carlo simulation.

5. Analytic calculation of 1D2D strip waveguide mode parameters and effective index

6. To design a uniform Bragg grating with given specifications

7. To design Mach-Zehnder Interferometer (MZI) using SiEPIC tools and pkd on KLayoutmatlab for a given specification

8. To design Micro-Ring Resonator (MRR) using SiEPIC tools and pkd on KLayoutmatlab for a given specification

9. Measurement of impedance of an unknown load.

10. Design and simulation of microstrip antenna

11. Design and simulation of microwave filters.

12. Study the characteristics of a microsrtrip antenna using advance microstrip antenna trainer kit.

Text Books:

1. Lukas Chrostowski and Michael Hochberg, Silicon Photonics Design: from Devices to Systems, 1e, 2016, Cambridge University Press, University Printing House, Cambridge CB2 8BS, UK

2. Slawomir Sujecki, Photonics Modeling and Design, 1e, 2015 CRC Press, Taylor and Francis Group, 6000 Broken Soud Parkway, NW, Suit 300.

3. Lorenzo Pavesi, David J. Lockwood, Silicon Photonics, Topics in Applied Physics (TAP, volume 94), 1e, 2004, Springer Berlin, Heidelberg

4. Graham T. Reed and Andrew P. Knights, Silicon Photonics: An Introduction, 1e, 2004, Wiley

5. David J. Lockwood and Lorenzo Pavesi, Silicon Photonics II: Components and Integration: 119 (Topics in Applied Physics), 1e, 2010, Springer

6. Morris Tischler, Optoelectronics: TextbookLaboratory Manual, McGraw-Hill Inc., 1990.

7. V. Protopopov, Practical Opto-Electronics: An Illustrated Guide for the Laboratory, Springer; 2014.

8. M. L. Sisodia, G. S. Raghuvanshi, Basic Microwave Techniques and Lab. Manual , New Age Int., 1987,

9. J. D. Kraus, Antennas, 3e, McGraw Hill Book Co., 2001.

10. C. A. Balanis, Antenna Theory: Analysis and Design, 3e, John Wiley Sons, 2009

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2.2.4 EC-DSEC-50802 Advanced Practices in VLSI Devices and RF Circuits

L	T	P	Cr
0	0	4	=2

Course Code	:	*EC−DSEC−*50802
Course Name	:	*Advances in VLSI Devices and RF Circuits*
Contact Hours per Week	:	*4(Four) Practical.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 30.*
Questions to be Set	:	*Minimum Ten*
Questions to be Answered	:	*Any 1(One) on Lottery Basis.*
Duration of End Semester Examination	:	*3 hours (Practical).*

Aim: The main aim of this course is to produce world-class professionals with wide knowledge in high-speed semiconductor devices and to enhance their skills in designing of various modern electronic circuits.

Objective: On completion of this paper, students should

- CO1: understand and model advanced nano-scaled VLSI devices.
- CO2: design new architectures of the new MOS devices.
- CO3: to understand the behavior of microwave semiconductor devices
- CO4: design and verify the characteristics of MESFET and HEMT
- CO5: design and simulate various modern electronic circuits

Hands-on/ Laboratory/ Practical:

1. Implementing MOSFET compact model in SPICE.
2. Design a nMOSFET device with a given specification using TCAD.
3. Design a pMOSFET device with a given specification using TCAD.
4. Design a FinFET device with a given specification using TCAD.
5. Design a GAA MOSFET with a given specification using TCAD.
6. Design and verification of HEMT.
7. Design of the A/D converter using CMOS logic.

8. Design and development of an oscillator.

9.. design and development of a mixer.

Text Books:

1. Donald Neamen, Semiconductor physics and Devices, McGraw-Hill, 3rd edition.
2. J.-P. Colinge and C.A. Colinge Physics of Semiconductor Devices, Springer, 2002.
3. Jean-Pierre Colinge ,FinFETs and other multi-gate transistors, Springer, 2008.
4. B.G.Streetman and S.Banerjee ,Solid State Electronic Devices , Prentice Hall India.
5. Guillermo Gonzalez, Foundations of Oscillator Circuit Design, Artech House, INC.
6. Stephen A. Maas, Nonlinear Microwave and RF Circuits, Artech House, INC.
7. Paolo Antognetti and Giuseppe Massobrio, Semiconductor device modelling with SPICE, McGra w– Hill Inc., US.

2.2.5 EC-DSEC-50901 Antenna Analysis and Design

L	T	P	Cr
3	0	0	=3

Course Code	: *EC−DSEC−*50901
Course Name	: *Antenna Analysis and Design.*
Contact Hours per Week	: *3(Three) Hours*
Marks Distribution	: *Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: 2.5*(two and a half) Hours.*

Aim: To develop RF engineers who can design a variety of antennas for a wide range of applications.

Objective: On completion of this paper, students should

- CO1: Understand the radiation mechanism and different parameters of an antenna
- CO2: Analyze and design the antenna arrays.
- CO3: design various antennas for different applications.
- CO4: understand the concept of smart antennas.

Unit I

Antenna Arrays: Array factor for linear arrays, uniformly excited, equally spaced Linear arrays, pattern multiplication, the directivity of linear arrays, nonuniformly excited -equally spaced linear arrays, Mutual coupling, multidimensional arrays, phased arrays, feeding techniques, perspective on arrays.

Unit II

Microstrip antenna : Operating principle, modes of operation, field patterns, Impedance, Feeding techniques, polarization, design of rectangular and circular patch antennas, Arrays and feed network.

Unit III

Concept of smart antenna : Need for Smart Antennas, Smart Antenna Configurations, Beamforming Fundamentals, Adaptive beamforming, Space Division Multiple Access (SDMA), Architecture of a Smart Antenna System.

Text Books:

1. J. D. Kraus, Antennas, 3/e, McGraw Hill Book Co., 2001.
2. C. A. Balanis, Antenna Theory: Analysis and Design, 3/e, John Wiley Sons, 2009.
3. Thomas A. Milligan, Modern Antenna Design, 2/e, Wiley-IEEE Press, 2005.
4. Ahmed El Zooghby, Smart Antenna Engineering, Artech HouseM.J. Bronzel, Smart Antennas, John Wiley, 2004

Reference Books:

1. Jordan and Balmain, Electromagnetic Waves and Radiating Systems, John Wiley, 2002
2. Yi Huang and Kevin Boyles, Antennas: From Theory to Practice, Wiley-IEEE Press, 2008.

2.2.6 EC-DSEC-50902 VLSI Devices and Modeling

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC–DSEC–*50902
Course Name	:	*VLSI Devices and Modeling*
Contact Hours per Week	:	*3(Three) Hours*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.*5(two and a half) Hours.*

Aim: The reader will get acquainted with the modeling techniques of different VLSI Devices.

Course outcomes:

- CO1: To study the basic device physics required to understand the working of the MOS Devices
- CO2: To understand the concept of modeling of the new device structure.
- CO3: Implantation of acquired knowledge to overcome the small dimensional effects.

Unit I

Basic Device Physics: Two terminal MOS Transistor model: Flat-band voltage, Potential balance and charge balance, Effect of Gate-substrate voltage on surface condition, Inversion, Small signal capacitance; Three Terminal Transistor MOS model: Contacting the inversion layer, Body effect, Regions of inversion, Pinch-off voltage.

Unit II

Four Terminal MOS Transistor model: Transistor regions of operation, general charge sheet models, regions of inversion in terms of terminal voltage, strong inversion, weak inversion, moderate inversion, effective mobility, temperature effects, temperature effects, breakdown p - channel MOSFET, enhancement and depletion type, model parameter values, model accuracy etc;

Unit III

Small Dimension Effects:: channel length modulation, barrier lowering, two-dimensional charge sharing and threshold voltage, punch - through, carrier velocity saturation, hot carrier effects, scaling, effects of surface and drain series resistance, effects due to thin oxides and high doping. Subthreshold regions. *CMOS Device Design*: Scaling, Threshold voltage, MOSFET channel length; CMOS Performance Fac- tors: Basic CMOS circuit elements; parasitic elements; sensitivity of CMOS delay to device parameters, performance factors of advanced CMOS devices.

Text Books:

1. Yuan Taur and Tak. H. Ning, Fundamentals of Modern VLSI Devices, 2/e, Cambridge University Press (2013).
2. Yannis Tsividis, Operation and Modeling of the MOS Transistor, 2/e, Oxford University Press, 2003.

Reference Books:

1. S. M. Sze, Physics of Semiconductor Devices, Wiley India Private Limited, 3/e 2008.
2. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, 2/e, Oxford University Press, 2002.

2.2.7 EC-DSEC-501001 PIC Design

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC–DSEC–*501001
Course Name	:	*PIC Design.*
Contact Hours per Week	:	*3(Three) Hours*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	2.*5(two and a half) Hours.*

Aim: To design Photonic Integrated Circuit with suggested specifications for data-center interconnect and communication applications.

Objectives: On completion of this course, students should be able

- CO1: To recognize and explain Photonic Integrated Circuits on SoI along with electronics as an emerging technology to meet the explosive bandwidth demand and computationally efficient systems
- CO2: To Model Passive and Active PICs on SOI platform using SiPh technology
- CO3: To design the Layout of passive and active photonic devices on an open-source GDS-II platform, i.e., KLayout using SiEPIC tools and pdks
- CO4: To evaluate the performance of PIC for data center and communication applications with given specifications

Unit I

Introduction to Photonic Integrated Circuits (PICs): Review of SiPh technology and role of PIC along with Integrated electronic Circuits, Planar Waveguide and its types on SoI, Waveguide design, calculation of the effective index, compact model of a slap-waveguide.

Unit II

Fundamental Building Blocks of PICs: Design of Y-branch, Directional Couplers, Grating, and Edge Couplers, Taper, bend waveguide. *Functional Device and Circuits for PICs*: MZI: Derivation of Transfer Function of MZI, Transfer Function of MRR, Michalson, Derivation of FSR.

Unit III

Active Photonic Devices: Plasma-dispersion effect and pn-junction phase shifter, photo-detector on SoI. *Introduction to SIEPIC tools and PDKs*: CMOS fabrication steps for passive PICs, GDS-II Layout on KLayout design platform, interface with SiEPIC tools, Process Design kits (pdk) associated with e-beam pdk, application of e-beam pdk in designing MZI, MRR and other functional Devices. Design rule check and simulation. SiPh-based Transceiver.

Text Books:

1. Lukas Chrostowski and Michael Hochberg, *Silicon Photonics Design: from Devices to Systems*, 1/e, 2016, Cambridge University Press, University Printing House, Cambridge CB2 8BS, UK, 2016.
2. Richard Osgood jr.,Xiang Meng, *Principles of Photonic Integrated Circuits: Materials, Device Physics, Guided Wave Design*, 1/e, 2021, Springer.
3. Jos´e Capmany; Daniel P´erez, *Programmable Integrated Photonics*, 1/e, 2020, Oxford University Press.
4. David J. Lockwood and Lorenzo Pavesi., *Silicon Photonics III: Components and Integration: 1-19 (Topics in Applied Physics)*, 1/e, 2018, Springer.

Reference Books:

1. Lorenzo Pavesi, David J. Lockwood, *Silicon Photonics, Topics in Applied Physics (TAP, volume 94)*, 1/e, 2004, Springer Berlin, Heidelberg.
2. Graham T. Reed and Andrew P. Knights, *Silicon Photonics: An Introduction*, 1/e, 2004, Wiley
3. David J. Lockwood and Lorenzo Pavesi, *Silicon Photonics II: Components and Integration: 119 (Topics in Applied Physics)*, 1/e, 2010, Springer
4. IEEE Journals of Photonic Technology Letters, JLT, Sec. Topics in Quantum Electrons etc. 2012.
5. Tool, *Matlab ,Comsol Multiphysics(https://www.istem.gov.in/rd-infrastructure-map/software-through- istem, visited 26.08.2022), Ansys Lumerical*
6. Tools: *Python, KLayout, SiEPIC tools, and pdk (https://github.com/SiEPIC, visited 26.08.2022)*

2.2.8 EC-RM-511 Research Methodology and Proposal Writing

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−RM−*511
Course Name	:	*Research Methodology and Proposal Writing.*
Contact Hours per Week	:	*4(Four) Hours*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To understand how to find a research problem and its solution; and how to communicate research findings.

Objectives: On completion of this course, students will be able to

- CO1: Understand research problem formulation.
- CO1: Analyze research-related information.
- CO1: Write a research proposal.

Unit I
Research Problem: Meaning of research problem, Sources of a research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of the research problem.
Unit II
Solution Approaches: Approaches of investigation to solutions for research problem, data collection, analysis, interpretation, and Necessary instrumentations.
Unit III
Literature survey and ethics: Effective literature studies approaches, analysis, Plagiarism, Research ethics.
Unit IV
Writing Research Proposal: Effective technical writing, how to write reports, and Paper. Developing a Research Proposal, Format of a research proposal, a presentation, and assessment by a review committee

Text Books:

1. Ranjit Kumar, 2nd Edition, *Research Methodology: A Step by Step Guide for beginners*.

Reference Books:

1. Stuart Melville and Wayne Goddard, *Research methodology: an introduction for science & engineering*

students.

2. Wayne Goddard and Stuart Melville, *Research Methodology: An Introduction*.

2.2.9 EC-SEC-51201 Advanced Data Visualization and Analytics

L	T	P	Cr
3	1	0	=4

Course Code	: *EC−SEC−*51201
Course Name	: *Advanced Data Visualization and Analytics.*
Contact Hours per Week	: *4(Four) Hours*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: The aim of this course is to provide knowledge on data visualization design principles and deciding the type of visualization chart to choose, creating simple to advanced chart types using python modules and libraries, and giving exposure for exploring, visualizing and analyzing various types of data sets using various visualization tools used in data analytics.

Objective: On completion of this paper, students should

- CO1: Understand the importance of data visualization.
- CO2: Learn to create basic charts by applying visualization design principles.
- CO3: Learn to create advanced visualization charts and analysis.
- CO4: Explore and Analyse Time series, Geospatial and multimodal data.
- CO5: Learn to build interactive/animated dashboards and construct data stories.

Unit I

Overview of Data Visualization: Importance and benefits of good data visualization; Design principles; Introduction to python libraries for visualization: seaborn, plotly express, pygal; Exploring Data; Reduce Items and Attributes: Filter and Aggregate; Creation of basic visualization: Histogram, Bar and Line Chart, Box plot, Scatter plot; Color palettes – Creation of 3D Charts; Creation of Advanced Visualization: Heat Map– Facet Grid.

Unit II

Visualization of Time Series Data: Summary statistics and plotting aggregated views; Visualization of seasonality, trends and noise; working with multiple time series data. Some case studies.

Unit III

Data Analytics Overview: Introduction, benefits, types of data analytics; some data analytics real-world case studies; tools and techniques.

Unit IV

Business Analytics and Visualization Tools: Tableau, PowerBI, Creating Interactive Dashboards and charts to organize data using visualization principles; Data Storytelling.

Text Books:

1. Wes McKinney, "*Python for Data Analysi*, O'Reilly Media, 2012.
2. Tamara Munzner, *Visualization Analysis and Design, A K Peters Visualization Series*, CRC Press, 2014.
3. Scott Murray, *Interactive Data Visualization for the Web*, O'Reilly, 2013.
4. Vander Plas , *Python data science handbook: essential tools for working with data*, O'Reilly Media. Inc, 2016

Reference Books:

1. Alberto Cairo, *The Functional Art: An Introduction to Information Graphics and Visualization*, New Riders, 2012.
2. Nathan Yau, *Visualize This: The Flowing Data Guide to Design, Visualization and Statistics*, John Wiley & Sons, 2011.

2.2.10 EC-SEC-51202 Development of MOOC Courses

L	T	P	Cr
3	1	0	=4

Course Code	: *EC−SEC−*51202
Course Name	: *Development of MOOC Courses.*
Contact Hours per Week	: *4(Four) Hours*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To develop Massive Open Online Courses (MOOCs) that have become a popular avenue for diverse learners to upgrade their knowledge and skills.

Course Outcomes:

- CO1: To be aware of the technology affordances.
- CO2: To focus on the pedagogy of how to use the MOOC features effectively to foster student engagement and learning.
- CO3: To know a set of design principles and guidelines to create a learner-centric and effective MOOCs.

Unit I
The LCM model: Perceptions of MOOC, Learner Expectation, Learner Engagement, Course Introduction, Evolution of MOOCs, Known Challenges, Why LCM? The LCM Model.

Unit II
Creating LeDs: : What is an LeD?, Chunking a Lecture into LeD, Introducing Reflection Spot, Making Your Own LeD, LeDs Takeaway, Reflection Spot.
Unit III
Creating LbDs and LxTs: What is an LbD? Creating LbDs, Constructive Customized Feedback in LbDs, Giving Feedback for Open Ended Questions, Recommendations for effective LbDs, What is an LxT? Creating LxTs, Creating an Assimilation Quiz.

Unit IV
LxIs and Orchestration: What is an LxI?, Creating LxIs with Reflection Quiz, LxI- Sharing Experiences, LxI- How to Achieve Learner-Learner Interaction?, LxI- Types of focus questions, Orchestrating your MOOC, Orchestration Dynamics in LCM, Assessment, From Regular course to LCM, Course Design in MOOC, Maintaining Learner Connect, Implementing the Learner-Centric Approach.
Text Books:

1. Sridhar Iyer, Sahana Murthy, Jayakrishnan M, Sameer Sahasrabudhe, *Designing Learner-Centric MOOCs*, IIT Bombay, 2022.

2.2.11 EC-SEC-51203 Project Management for Managers

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−SEC−*51203
Course Name	:	*Project Management for Managers*
Contact Hours per Week	:	*4(Four) Hours*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To develop essential skills required to manage projects and managerial knowledge and competencies.

Objectives: On completion of this paper, students should be able

- CO1: To describe project life cycles, types, and methods of selecting a project
- CO2: To explain the various risk management techniques and methods and plant capacity analysis
- CO3: To elaborate on project team building, HRM issues, and time management in the project
- CO4: To describe Time and Cost relationship, quality management, and project termination

Unit I
Project Management Fundamentals: Introduction to Project Management, Project Success, Types of Structure Organizations, Project Management Office; Project life cycle analysis: Types of Projects and Project Life Cycle, Methods of Project Selection; Project selection methods: Methods of Project Selection, Market and Demand Analysis, Financial Analysis

Unit II
Capital Budgeting Techniques: Financing of Projects, Risk Management; Risk Management (Control and Documentation); Stand Alone Risk Analysis, Hillier Model, Simulation Analysis; Decision Tree Analysis, Abandonment Analysis, Technical Analysis, Product Mix and Plant Capacity Analysis.

Unit III
Project Team Building: Conflict and Negotiation, HRM Issues and Time Management, Project Time Management-Introduction, Project Time Management (Project Scheduling), Numbering of Nodes, PERT Networks, Laddering in PERT/CPM, Probability Models in Networks.

Unit IV
Time and Cost Relationship: Crashing of Networks, Introduction to Project Cost Management and estimation, Introduction to Quality Management, Quality Management (Source of variability and Six Sigma), Procurement Management, and Project Termination.

Text Books:

1. Roderick A. Munro and Govindarajan Ramu and Daniel J. Zrymiak, *The certified six sigma Green Belt Handbook*, ASQ Quality Press and Infotech Standards India Pvt. Ltd. 2017.
2. S.A. Campbell, *The Certified Six Sigma Black Belt Handbook*, Pearson Publication. 2018.
3. Forrest W. Breyfogle III, *Implementing Six Sigma*,, John Wiley & Sons, INC. 2003
4. Evans, J R and W M Lindsay *An Introduction to Six Sigma and Process Improvement*, CENGAGE Learning.2014

Reference Books:

1. Howard S. Gitlow and David M. Levine *Six Sigma for Green Belts and Champions*, Pearson Education, Inc. 2004.
2. Montgomery, D C, *Design and Analysis of Experiments*,10th Edi. Wiley. 2019.
3. Mitra, Amitava, *Fundamentals of Quality Control and Improvement*,3rd edi. Wiley India Pvt Ltd, 2013.
4. Montgomery D C, *FStatistical Quality Control: A modern introduction*,7th Edi. Wiley. 2013.

2.3.1 EC-CC-600 Advanced Digital Communication

L	T	P	Cr
3	1	0	=4

Course Code	: *EC−CC−*600
Course Name	: *Advanced Digital Communication.*
Contact Hours per Week	: *4(Four) Hours*
Marks Distribution	: *Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *3(Three) Hours.*

Aim: To develop a clear understanding of modern communication system (wire and wireless) based on which student can model their own system and evaluate the performance mathematically.

Course Outcomes:

- CO1: To understand the basics of signal space analysis and digital transmission.
- CO2: To understand the coherent and noncoherent receivers and its impact on different channel characteristics.
- CO3:To understand the different block coded and convolutional coded digital communication systems.
- CO4: To understand the different wireless channel models and their performance.

Unit I
Signal space representation and its use on modulation: Geometric representation of signals, Linear modu- lation technique: Coherent Phase-Shift Keying, QPSK, offset QPSK, Constant envelop technique: MSK, GMSK, Linear and Constant envelop modulation technique advantages and disadvantages, M-ary PSK, M-ary QAM.

Unit II
Spread spectrum techniques: Spread spectrum system, DS-Spread spectrum and frequency Hopped spread spectrum, Pseudo noise sequences, Performance of DS-SS, Frequency Hopping systems, Error performance for Binary signal in AWGN.

Unit III
Band limited channels and equalizers: Band Limited Channels, ISI, Nyquist Criterion, Controlled ISI, Lin- ear equalizer Equalization, Adaptive equalizer, Adaptive Equalization algorithms, Linear Equalizer,Nonlinear Equalizer Maximum likelihood sequence estimation (MLSE) equalizer.

Unit IV
Coding techniques and introduction to wireless channels: Architecture and performance: Binary block codes, Orthogonal, Biorthogonal, Transorthogonal, Fading channels and its modeling: Rayleigh fading, Ricean fading

distribution, Diversity receivers, Performance evaluation of diversity receivers over fading channels.

Text Books:

1. Stephen G. Wilson, *Digital Modulation and Coding*, Pearson Education, 1996.
2. T. S. Rappaport, *Wireless Communications*, 2/e, Pearson, 2010.
3. S. Haykin, *Digital Communication*, Wiley Student Edition, 2006.

Reference Books:

1. J. G. Proakis and M. Salehi, *Digital Communication*, 5/e, McGraw Hill Publication, 2008.

2.3.2 EC-CC-601 Millimeter-wave and Terahertz Techniques

L	T	P	Cr
3	1	0	=4

Course Code	:	*EC−CC−*601
Course Name	:	*Millimeter-wave and Terahertz Techniques*
Contact Hours per Week	:	*4(Four) Hours*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: The aim of the course is to provide students with a wide introduction to millimeter and sub-millimeter (Terahertz) technology for industrial, radio astronomy, environmental science and other applications.

Objective: On completion of this paper, students should

- CO1: understand the characteristics of mm-wave and THz communication technologies.
- CO2: explain and model different mm-wave semiconductor devices.
- CO3: design and develop mm-wave and THz Communication devices and circuits

Unit I
Introduction to mm-wave and THz Technology: mm-Wave and THz wave Characteristics, Regulation, Propagation at mm-Waves, THz Propagation and Channel Modeling.

Unit II
mm-wave semiconductor devices: Transient and ac behavior of P-N junctions, PIN diode, varactor diode, and its applications; Schottky effect, Schottky barrier diode, and its applications; Heterojunctions, high electron mobility transistor.

Unit III
mm-wave and THz components and circuits : mm-Wave and THz Integrated Passive Components, Circuits and Interconnects, Millimetre-wave design considerations, mm-Wave and THz component packaging.

Unit IV
mm-wave and THz Communication : Advanced beam steering technology, Advanced beamforming technology, Advanced antenna ID technology, Millimeter- Wave MIMO: Spatial diversity of antenna arrays.

Text Books:

1. Duixian Liu, Brian Gaucher, Ulrich Pfeiffer and Janusz Grzyb, Advanced Millimeter-wave Technolo- gies Antennas, Packaging and Circuits, John Wiley Sons Ltd, United Kingdom, 2009.
2. Kao-Cheng Huang, Zhaocheng Wang, Millimeter wave communication systems, John Wiley Sons, Inc.,

Hoboken, New Jersey 2011.

3. S. Ahmad, Microwave and Millimeter Wave Semiconductor Materials Technology, Tata McGraw Hill.
4. Wolf W., Modern VLSI Design System on Silicon, 2nd Edition, Pearson Education, 2000.
5. Thomas Kurner, Daniel M. Mittleman and Tadao Nagatsuma, THz Communications. Springer Series in Optical Sciences, vol 234. Springer, Cham.

Reference Books:

1. D. M. Pozar, Microwave Engineering, 4 e, John Wiley, 2011.
2. Peter A. Rizzi, Microwave Engineering: Passive Circuits, 1 e, Prentice Hall, 1987.

2.3.3 EC-CC-602 Minor Project

L	T	P	Cr
0	0	8	=4

Course Code	:	*EC−CC−*602
Course Name	:	*Minor Project*
Contact Hours per Week	:	*8(Eight) Hours*
Marks Distribution	:	*Sessional Works = 25, End Semester Examination = 75.*
Questions to be Set	:	*N/A.*
Questions to be Answered	:	*N/A.*
Duration of End Semester Examination	:	*N/A*

The Project evaluation will be done based on the following components:

1. Problem Identification and Review of Related Literature
2. Proposal Writing and Presentation
3. Data Collection
4. Data Analysis, Interpretation and Discussion
5. Report Writing
6. Viva Voce

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2.3.4 EC-DSEC-60301 Analog IC Design

L	T	P	Cr
3	0	0	=3

Course Code	: *EC–DSEC–*60301
Course Name	: *Analog IC Design*
Contact Hours per Week	: *3(Three) Hours.*
Marks Distribution	: *Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *2.5 (two and a half hours) Hours.*

Aim: Learn the Basic Approach to Design CMOS-Based Analog Building Blocks.

Course outcomes:

- CO1: Learn the various topologies of Analog Design blocks.
- CO2: Complete Design of CMOS-based OPAMP for a desired target specification.
- CO3: Approach to design of specialized circuit architectures for High-speed and Low-power.

Unit I
Introduction to MOS and Basic Building Blocks: Introduction to Analog Design, Basic MOS Device Physics, MOS Device models. Short Channel Effects and Device Models. Single Stage Amplifiers – Basic Concepts, Common Source Stage, Source Follower, Common Gate Stage, Cascode Stage.

Unit II
CMOS Amplifier Design: Differential Amplifiers – Single Ended and Differential Operation, Basic Differential Pair, Common Mode Response, Differential Pair with MOS loads, Gilbert Cell. Passive and Active Current Mirrors – Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors.

Unit III
Feedback Amplifiers:: Frequency Response of Amplifier, Stability and frequency compensation, Compara- tors: Characterization of a Comparator, Operational Amplifiers – General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common–Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, Noise in Op Amps. Stability and Frequency Compensation Techniques. *Low-Power and High-Speed Circuits*: Bandgap References, Introduction to Switched-Capacitor Circuits, Nonlinearity and Mismatch.

Text Books:

1. B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, 2000.
2. Phillip E. Allen and Douglas R. Holberg, CMOS Analog Circuit Design, 3/e, Oxford University Press, 2011.
3. Randall L. Geiger, Phillip E. Allen and Noel Strader, VLSI Design Techniques for Analog and Digital Circuits, McGraw-Hill, 2010.
4. R. Jacob Baker, CMOS Circuit Design, Layout, and Simulation, 3/e, Wiley-IEEE Press, 2010.

Reference Books:

1. Yannis Tsividis and Colin McAndrew, The MOS Transistor, 3/e, Oxford University Press, 2013.
2. R. Jacob Baker, CMOS Mixed-Signal Circuit Design, 2/e, Wiley-IEEE Press, 2009.

2.3.5 EC-DSEC-60302 Speech Processing

L	T	P	Cr
3	0	0	=3

Course Code	: *EC–DSEC–*60302
Course Name	: *Speech Processing*
Contact Hours per Week	: *3(Three) Hours.*
Marks Distribution	: *Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	: *Eight.*
Questions to be Answered	: *Any 5(Five).*
Duration of End Semester Examination	: *2.5 (two and half hours) Hours.*

Aim: To obtain an overview of speech signal processing techniques with an application to speaker recognition

Course outcomes:

- CO1: To understand the speech production system and its digital model
- CO2: To analyze speech signal using digital signal processing techniques
- CO3: To measure various parameters useful for speech recognition
- CO4: To investigate the application of speech processing for speaker recognition

Unit I
Fundamentals of speech: Production and classification of speech sounds, Acoustic phonetics, Speech production mechanism and its digital models

Unit II
Measurement of speech parameters: Feature extraction and digital representation of speech, distortion measurements, Log spectral and Cepstral distances, Likelihood distortions

Unit III
Speech recognition: Pattern comparison techniques, Spectral distortion using warped frequency scale, dynamic time warping, introduction to deep learning based methods. *Speaker recognition*: Basics of speaker recognition, feature selection, hyperparameter optimization, building state of art speaker recognition systems

Text Books:

1. Jurafsky, D., & Martin, J. H. Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition.

2. Rabiner, L. (2003). Biing-hwang Juang'"Fundamentals of speech recognition", Low Price Edition.
3. Quatieri, T. F. (2006). Discrete-time speech signal processing: principles and practice. Pearson Education India.

Reference Books:

1. Deller Jr, J. R. (1993). Discrete-time processing of speech signals. In Discrete-time processing of speech signals (pp. 908-908).
2. Rabiner, L. R. (1978). Digital processing of speech signals. Pearson Education India.

2.3.6 EC-DSEC-60401 Image Processing for Computer Vision

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC−DSEC−*60401
Course Name	:	*Image Processing for Computer Vision*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*2.5 (two and half hours) Hours.*

Aim: To get an in-depth understanding of various Image Processing algorithms with applications

Course outcomes:

- CO1: To understand transforms for image analysis
- CO2: To learn image restoration and segmentation
- CO3: To get an overview of Image reconstruction from projections
- CO4: To understand applications to computer vision

Unit I
Introduction to Image transforms: Review of digital images, 2-D signals and systems, 2-DFT, Cosine and Hadmard transform, Transform operations, Image smoothing and sharpening using frequency domain filters.

Unit II
Image restoration and segmentation : Image restoration techniques, noise models and filter types, geometric transforms, image segmentation, classification techniques.

Unit III
Image Compression and reconstruction: Compression and standards, image reconstruction from projections, back projection operator, projection theorem. *Image recognition applications for computer vision*: Artificial Neural Network for Pattern Classification, Convolutional Neural Networks, Motion Estimation and Object Tracking.

Text Books:

1. Jain, A. K. (1989). Fundamentals of digital image processing. Prentice-Hall, Inc..
2. Prince, S. J. (2012). Computer vision: models, learning, and inference. Cambridge University Press.

3. Gonzalez, R. C. (2009). Digital image processing. Pearson education india.

Reference Books:

1. Joshi, M. A. (2018). Digital image processing: An algorithmic approach. PHI Learning Pvt. Ltd..
2. Szeliski, R. (2010). Computer vision: algorithms and applications. Springer Science & Business Media.

2.3.7 EC-DSEC-60402 Social Robotics

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC–DSEC–*60402
Course Name	:	*Social Robotics*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*2.5 (two and half hours) Hours.*

Aim: To get an in-depth understanding of various challenges and opportunities of social robots along with their with applications

Course outcomes: On completion of this paper, students should be able

- CO1: To analyze the main challenges and opportunities of social robots.
- CO2: To develop the ability to analyze the need for social robots in different scenarios.
- CO3: To predict the possible consequences of social interaction between humans and robots.

Unit I
Introduction to Social Robotics: How is it different from traditional robotics and its applications; Embodi- ment and Design: To be able to understand by humans.

Unit II
Social Robots Skill Set: To understand humans (Social Emotional Intelligence and Socio-Cognitive Skills); Social Robots and Communication Skills: To be able to interact with humans

Unit III
Design Methodology: Involving Humans in HRI Studies. *Case Studies:* Kids with Autism Spectrum Disorder (ASD), Individuals with Intellectual Disability (ID), and Elderly People. Ethical Issues: Ethical, legal and Social Implications of Social Robotics.

Text Books:

1. Breazeal, Cynthia. *Designing sociable robots*. MIT Press, 2004.
2. Bartneck, Christoph, et al. *Human-robot interaction: An introduction*. Cambridge University Press, 2020.

3. Kanda, Takayuki, and Hiroshi Ishiguro. *Human-robot interaction in social robotics*. CRC Press, 2017

Reference Books:

1. Jones, Raya. *Personhood and Social Robotics: A psychological consideration*. Routledge, 2015.

2.3.8 EC-DSEC-60501 Spoken Language Identification Techniques

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC–DSEC–*60501
Course Name	:	*Spoken Language Identification Techniques*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*2.5 (two and half hours) Hours.*

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Aim: To get an in-depth understanding of various spoken language identification techniques.

Course outcomes:

- CO1: To understand the structures of spoken languages
- CO2: To analyze speech signals for language recognition
- CO3: To understand various pattern recognition techniques
- CO4: To investigate language models and use them for spoken language recognition

Unit I
Spoken Language Structure: Sound production and human speech system, phonetics and phonology, syllables and words, syntax and semantics.

Unit II
Review of speech processing for language recognition : Short-term Fourier transforms, acoustic model of speech production, cepstral processing, perceptually motivated representations (MFCC, PLP).

Unit III
Pattern recognition basics: Bayes' decision theory, construction of classifiers, supervised and unsupervised estimation methods. *Language and Statistical Models*: Acoustic and language models, introduction to HMM, isolated word recognition, introduction to shallow and deep features for language recognition.

Text Books:

1. Jurafsky, D., & Martin, J. H. Speech and Language Processing: An Introduction to Natural Language

Processing, Computational Linguistics, and Speech Recognition.

2. Rabiner, L. (2003). Biing-hwang Juang Fundamentals of speech recognition, Low Price Edition.
3. Huang, X., Acero, A., Hon, H. W., & Reddy, R. (2001). Spoken language processing: A guide to theory, algorithm, and system development. Prentice hall PTR.

Reference Books:

1. Deller Jr, J. R. (1993). Discrete-time processing of speech signals. In Discrete-time processing of speech signals (pp. 908-908).
2. Rabiner, L. R. (1978). Digital processing of speech signals. Pearson Education India.
3. Quatieri, T. F. (2006). Discrete-time speech signal processing: principles and practice. Pearson Education India.

2.3.9 EC-DSEC-60502 Embedded System Design with ARM

L	T	P	Cr
3	0	0	=3

Course Code	:	*EC−DSEC−*60502
Course Name	:	*Embedded System Design with ARM.*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*2.5 (two and half hours) Hours.*

Aim: This course will discuss the basic concepts of embedded system design, with particular emphasis on system design using ARM microcontrollers.

Course Outcomes:

- CO1: To familiarize with the concepts of embedded system designs and the system design using ARM microcontrollers.
- CO2: This course will also help to understand the developmental aspects of Internet of Things (IoT) based designs.
- CO3: To understand various interfacing issues with sensors and actuators.
- CO4: To be able to carry out application-based experiments with microcontroller development boards.

Unit I
Introduction to embedded systems and ARM microcontrollers: Introduction To Embedded Systems, Design Considerations Of Embedded Systems, Microprocessors And Microcontrollers, Architecture Of ARM Microcontroller.Instruction set and assembly language programming

Unit II
D/A and A/D converter, sensors, actuators and their interfacing: Instruction set of ARM microcontroller, and assembly language programming, Digital To Analog Converter interfacing, Analog To Digital Converter interfacing, sensors, actuators and their interfacing.

Unit III

Microcontroller development boards and embedded programming platforms: Microcontroller Development Boards, Embed C Programming Environment, Interfacing With Stm32f401 Board, Interfacing With Arduino Uno, Interfacing 7-Segment Led And Lcd Displays. *Object tracking using GPS, GSM and Introduction to Internet of Things*: Introduction To Internet Of Things, GSM And Bluetooth, Design Of A Home Automation System, Design Of A Simple Alarm System Using Touch Sensor. Motion sensing using an accelerometer, control of appliances over SMS.

Text Books:

1. F. Vahid and T. Givargis, *Embedded System Design: A Unified Hardware/Software Introduction*, , Wiley India Pvt. Ltd., 2002.
2. A.N. Sloss, D. Symes and C. Wright, *ARM System Developer's Guide: Design and Optimizing System Software*, Morgan Kaufman Publishers, 2004.

Reference Books:

1. W. Wolf *Computers as Components: Principles of Embedded Computing System Design*, Morgan Kaufman Publishers, 2008.

2.2.1 EC-DSEC-60601 Deep Learning

L	T	P	Cr
3	0	0	= 3

Course Code	:	*EC-DSEC-60601*
Course Name	:	*Deep Learning.*
Contact Hours per Week	:	*3(Three) Hours.*
Marks Distribution	:	*Sessional Works = 20, End Semester Examination = 55.*
Questions to be Set	:	*Eight.*
Questions to be Answered	:	*Any 5(Five).*
Duration of End Semester Examination	:	*3(Three) Hours.*

Aim: To obtain a broad overview of existing deep learning techniques, and to understand their motivations and the main ideas from a variety of perspectives that leads to practical applications.

Course Outcomes:

- CO1: To understand the fundamentals of deep learning.
- CO2: To have a thorough grounding in the methodologies, technologies, mathematics, and algorithms of deep learning.
- CO3: To be capable of applying deep learning for various application domains.

Unit I
Deep Learning Fondamentals: Introduction to Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptron, Perceptron Learning Algorithm, Multilayer Perceptron (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks, Backpropagation, Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition.

Unit II
Deep Learning in Practice: Principal Component Analysis and its interpretations, Singular Value Decomposition, Unsupervised learning with deep network, Autoencoders, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders; Regularization: bias variance trade-off, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layerwise Pre-training; Batch normalization; Learning vectorial representations of words.

Unit III
Recent trends in Deeep Learning: Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art; LSTM Networks; Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network; Encoder Decoder Models, Attention Mechanism, Attention over images.

Text Books:

1. Deep Learning- Ian Goodfellow, Joshua Benjio, Aaron Courville, The MIT Press.
2. Deep Learning with Python, Francois Chollet, Manning Publication Co.

Reference Books:

2. Dr. Adrian Rosebrock, *Deep Learning for Computer Vision with Python*, 1/e, PyImageSearch.com, 2017.

2.4.1 EC-DSEC- 606 Major Project

L	T	P	Cr
0	0	32	=16

Aim: The aim of Dissertation work for M. Tech (ECE) is to obtain an understanding of how to define, plan, undertake and report on an open-ended piece of supervised research or design work.

2.4.1.1 Introduction

The aim of Dissertation work for M. Tech (ECE) is to obtain an understanding of how to define, plan, undertake, and report on an open-ended piece of supervised research or design work. Students will discuss the Dissertation topic with the supervisor(s) and generate a suitable Dissertation research plan with proposed outcomes. They will then conduct a literature survey and background research. Students are asked to write a detailed report on a major research or design project. Some projects will be experimental in nature; others may involve computer-based simulation, feasibility studies or the design, construction, and testing of equipment. In the ordinary course of events, some or all of the theoretical, developmental, and experimental aspects of design or research work will be covered in this unit of study. These aspects may be either directed by the supervisor or be of an original nature, but in any event, the student is responsible for the execution of their practical work and the general Layout and content of the Dissertation document. During this unit of study, the students will learn how to examine published and experimental data, set objectives, organize a work program, and analyze results. They will also be expected to evaluate these results in relation to existing knowledge. The Dissertation will be adjudicated on the extent and quality of the student's original work, particularly how critical, perceptive, and constructive he or she has been in assessing his/her work and that of others. Students will also be required to present the results of their findings to their peers and supervisors in seminars.

2.4.1.2 Learning Outcomes

Learning outcomes are the key abilities and knowledge that will be assessed in this Dissertation. Outcomes are listed according to the Dissertation goals that they support.

Engineering/IT Specialization (Level 5)

1. Development of a higher level of research skills and expertise in the specific area(s)
2. Implementation of the research plan.
3. Ability to plan and undertake major research or design project
4. Ability to design and conduct experiments or tests and to analyze and interpret data from those experiments or tests.
5. Ability to work independently on a substantial project.

Information Seeking (Level 4)

1. Literature survey and in-depth review
2.

Communication (Level 4)

7. Preparation and submission of a dissertation detailing the context of the problem, relevant back ground research and results of the investigation.
8. Development of seminar presentation skills

Professional Conduct (Level 4)

1. Understanding in research ethics, intellectual properties and commercialization potential

2.4.1.3 Assessment Tasks

Assessment Summary

Sl. No.	Assessment Name	Weight	Tentative Due	Learning Outcomes
1	Progress Report	5% + 5% = 10%	March & June	2, 6
2	Presentation/Seminar	10 + 10 + 10 = 30%	March, April and May	3, 6, 8
3	Thesis	60	June	1, 2, 3, 4, 5, 6, 7, 8, 9

2.4.1.4 Assessment Description

Progress Report: A progress report should include a literature review, research plan, and intermediate outcomes in a format developed by the department of ECE regularly as prescribed in the departmental academic calendar.

Presentation/Seminar: Seminar presentations will be given in Semester 4 of about a 20-minute presentation plus 5-minute questions/answers as per the academic timetable.

Thesis/Dissertation: A research dissertation will be submitted to cover (a) Literature review, (b) Methods and materials, (c) Results, (d) Discussion, and (e) a Conclusion, plus a list of references and appendices.

2.4.1.5 Attributes Developed

Sl. No.	Attribute	Method
1	Engineering Specialization (Level 5)	Students are expected to demonstrate initiative and ingenuity in research, pointed and critical analysis of the material, thoroughness of design, and innovative interpretation of evidence.
2	Information Seeking (Level 4)	The results presented, and conclusions drawn are to be presented in the appropriate literature context. Students are expected to seek out information efficiently and effectively and evaluate its relevance and sources to their project.
3	Communication (Level 4)	Written communication will be exercised through the generation of the Progress Report and Thesis. The Seminar will allow students to practice their oral communication and presentation skills.
4	Professional Conduct (Level 4)	A particular emphasis of the Research Dissertation is the student's ability to value their own engineering judgments through the process of engineering design. Students should demonstrate an understanding of the ethical, social, and professional implications of their work.

Text Books:

1. Mark Breach, *Dissertation Writing for Engineers and Scientists* , Prentice Hall (UK); Student edition (January 31, 2009)
2. Derek Swetnam, *Writing Your Dissertation*, Publisher:How To Books; 3 edition (April 1, 2000)
3. Evelyn Hunt Ogden, *Complete Your Dissertation or Thesis in Two Semesters or Less*, Rowman & Littlefield Publishers; 3 edition (December 21, 2006)

4. Carol M. Roberts, *The Dissertation Journey*, Corwin; Second Edition edition (August 23, 2010)

Reference Books:

1. Tonette S. Rocco, Tim Hatcher, *The Handbook of Scholarly Writing and Publishing* , Jossey-Bass; 1 edition (March 22, 2011)
2. Lawrence (Larry) A. (Anthony) Machi, Brenda T. (Tyler) McEvoy *The Literature Review: Six Steps to Success*,Corwin; Second Edition edition (June 8, 2012)
3. E. (Emily) Alana James, Tracesea H. (Heather) Slater, *Writing Your Doctoral Dissertation or Faster: A Proven Map to Success*, SAGE Publications, Inc; 1 edition (November 7, 2013).